## 3. WATER SUPPLY CONDITION IN THE STUDY AREA

### 3.1 Administrative Organization

The water supply and sanitation sector in Guatemala is not unified under the jurisdiction of a single authority. Rather, it falls under the fragmented responsibility of several government offices and decentralized institutions, serving either urban or rural areas.

The Ministry of Public Health and Social Welfare (MSPAS) is in charge of the rural area through two offices:

- the Environmental and Sanitation Division (DSM), within the General Bureau of Health Services, is in charge of planning, design and construction of water systems and sewerage in small dispersed towns of less than 500 inhabitants. It also advises local committees on the operation and maintenance of aqueducts in the rural area. DSM has an executing office known as PAYSA (Projects of Potable Water and Sewerage in the Plateau Area); and

- UNEPAR (Executing Body of Rural Aqueduct Programs) has similar responsibilities. It builds and supervises water and sewerage projects in towns with over 500 inhabitants, financially supported by external resources. Assistance to the communities includes operation and maintenance of water systems and sanitary education.

According to the Municipal Code, the municipalities are responsible for the administration, operation and maintenance of the urban water supply and sewerage systems, financing it partially with their own funds.

A large proportion of municipal populations of Guatemala City and neighboring municipalities, such as Mixco, are supplied with drinking water and sewerage services by EMPAGUA (Municipal Water Supply Corporation of Guatemala City).

In the area surrounding Guatemala City, these services are provided by five (5) municipalities and several private companies, for instance the "Compañía de Agua Mariscal", which controls about 10% of the water connections in the municipality of Guatemala. A very high percentage of the water volume supplied to the metropolitan area of Guatemala City is provided by the National Aqueduct Xayá-Pixcayá Project.

Currently, the coordination, planning, management, supervision and administration of national water resources are supervised by the Secretariat of Hydraulic Resources (SRH), established in April 1992 to formulate water development strategies in the country and to regulate the use, preservation and protection of water. The SRH carries

out these activities through national agreements and aid from international organizations.

A Permanent Committee for the Coordination of Potable Water and Sewerage (COPECAS) was established in 1985, with the participation of INFOM, EMPAGUA, UNEPARN. It coordinates the activities of public institutions concerned with potable water supply and sanitation services.

## 3.2 Water Quality

### 3.2.1 Water Quality Standard

Water Quality Standard was established in Guatemala by the Guatemalan Committee of Standard -COGUANOR- in 1984, which fixes drinking water quality values (Data book: Chapter 3).

Acceptable Maximum Limits (AML) and Permissible Maximum Limits (PML) are established for each quality characteristic.

AML: The highest acceptable degree of concentration of water properties. When concentration exceeds this level, it does not necessarily harm users, but may be intolerable to some in terms of taste.

PML: The highest degree of concentration of water properties. A degree of concentration higher than this is not acceptable.

In 1983, INFOM established its own water quality standards, which are slightly different from the AML and PML set by COGUANOR (Data book: Chapter 3).

INFOM's standards include Chemical Quality Parameters such as Dissolved Oxygen and Ammonium Nitrogen, as well as Chemical Indicators for Pollution (C.O.D., B.O.D., Total Nitrogen, Ammonia and Grease).

### 3.2.2 Quality of Water from the Existing Sources

By applying simple analytical methods, several parameters were used as indicators to determine the appropriateness of the water from existing sources for drinking and domestic purposes (Data book: Chapter 3).

General and coliform bacterial numbers indicate how inadequate for drinking is the water from many existing sources.

INFOM occasionally checks the quality of the supplied water and advises on how to treat water, improve sanitary conditions, among others (Data book: Chapter 3).

A lot of children suffer from and die of diarrhea due to poor water quality. Except for a few municipalities in the

Study Area, drinking water is supplied without any treatment, whereby bacterial contamination is not prevented. Bacteria was also detected even in treated water due to insufficient treatment.

INFOM advises the operators of the treatment plants on the water treatment methods, especially in places plagued with cholera. This advice is only followed up once, regardless of their knowledge that diarrhea and other intestinal infections result from poor water quality. The continuous implementation of water treatment measures is usually hampered by financial reasons.

### 3.2.3 Drinking Water Quality in Ten Municipalities

Water analysis was conducted in order to determine the potability of water from different sources in the ten municipalities, using the established drinking water quality standards.

Ten samples from each of the existing water supply sources and newly drilled wells were collected and analyzed.

The following physical and chemical parameters were measured and analyzed: appearance, taste, odor, color, temperature, pH, EC, turbidity, total-hardness, COD (Mn), chloride, $No_2$-N, $NO_3$-N, $NH_4$-N, $Cr^{6+}$, T-Fe, Cu, Pb, Zn, As, Cd, Mn, general bacterial number, total coliform number and positive or negative fecal coliform.

The results are summarized with the comments on the suitability of drinking water supply in accordance with the criteria of COGUANOR (Tables 3.2.1 and 3.2.2, Data Book: Chapter 3).

**(1) Quality of water collected from the distribution tanks**

EC in water from the tanks was quite low, varying from 55 to 340 µS/cm. These values do not exceed the established standard values.

The water from Santa María de Jesús was not generally hard (30.52 - 63.05 mg/ℓ as $CaCO_3$), although the values were slightly higher (138.30 mg/ℓ) than the AML and much lower than PML.

Almost all of the water samples, except those from Sololá, were colored, ranging from 5 to 10 µ. Especially in San Pedro Sacatepéquez, the value, at 10 µ was higher than AML. The water samples from all tanks, however, showed 0 turbidity. Therefore, these color occurrences are not caused by organic matter, in particular humus soil. All color values are lower than PML.

Although lower than AML, the value of total solids found in water samples from tanks was relatively high (92.8 - 250.8 mg/ℓ) and composed of organic and inorganic matters. COD

(Mn), which is used to indicate organic matter concentration, was not detected in water samples from tanks.

COD (Mn) does not always represent the weight of actual organic matter because of the presence of $KMnO_4$, which is usually lower than the actual organic weight. Nevertheless, this does not mean that water samples from all tanks are free of organic matter. A large part of the total solids seems to be composed of inorganic matters and crystallized and occluded water.

The concentration of other chemical parameters ($NO_3$-N, T-Fe, Chloride and Zinc) was low.

Chlorine treatment at the reservoir tank is operated in three (S.J. Pinula, S.J. Comalapa and Sololá) of 10 municipalities, where water, at least from the distribution tanks, is considered to be suitable for drinking.

Although water in Santa Lucía Utatlán does not undergo treatment, it is considered free of bacteria because general bacteria was detected at 10 CFU/mℓ and total coliform was lower than 2 MPN/100 mℓ.

Water samples from other tanks, on the other hand, were measured to have high concentrations of general bacteria (63 - 4,610 CFU/mℓ) and total coliform (23 - 1,100 MPN/100 mℓ). Except for samples from Génova where the water supply system seems to be contaminated with human waste, fecal coliform concentration was not detected.

**(2) Water quality of newly drilled wells**

Except for samples from Santa María de Jesús (460 CFU/mℓ), water from test wells contained considerably high concentrations of bacteria (1,400 - 4,353 CFU/mℓ).

Total coliform concentration was relatively low (3 - 23 MPN/100 mℓ) at all wells, although higher than AML, except in San Pedro Sacatepéquez (1,100 MPN/100 mℓ). Fecal coliform was not detected in water samples from wells.

The presence of bacteria is probably due to the use of surface water for drilling activities. The wells should be thoroughly cleaned before use. Conclusively, the water from newly drilled wells has physical and chemical qualities which makes it suitable enough for drinking.

Table 3.2.1 Suitability of the Existing Supplied Water as Drinking Water

| Municipality | Characteristics of Quality | Comments for Suitability according to Guatemala Standard |
|---|---|---|
| S. J. Pinula | Hardness - soft water (32.54 mg/l)<br>Residual Chlorine - 0 mg/l<br>Color (5 u) - lowest value of MAL<br>Total iron (0.12 mg/l) - slightly higher than MAL | Residual Chlorine was not found, but all bacterial numbers were lower then MAL. Water at the Distribution Tank-1 is acceptable as a drinking water. |
| S. P. Sacatepéquez | No Cl- treatment<br>Hardness - moderate water (52.88 mg/l)<br>Color (10 u) - higher than MAL<br>General bacteria (1450 CFU/ml) and Total coliforms (93 MPN/100ml) - very much higher than the limit | Although Fecal coliforms were not detected, it is recommended to treat with chlorine, ozon and/or charcoal. |
| S. M. de Jesús | No Cl- treatment<br>Total Hardness (138.3 mg/l) - slightly higher than MAL<br>General bacteria (4610 CFU/ml) and Total coliforms (110 MPN/100ml) - very much higher than the limit | Same as above |
| S. M. Jilotepeque | No Cl- treatment<br>Hardness - moderate water (63.05 mg/l)<br>Total iron (0.39 mg/l) - slightly higher than MAL, but lower than MPL<br>General bacteria (1030 CFU/ml) and Total coliforms (1110 MPN/100ml) - much higher, specially coliforms, than the limit | Same as above |
| S. J. Comalapa | Cl- gas treatment<br>Hardness - soft water (32.54 mg/l)<br>Total iron (0.11 mg/l) - slightly higher than MAL<br>General bacteria (21 CFU/ml) and Total coliforms (<2 MPN/100ml) - lower than the limit | Although Color was detected (5 u), the supplied water at the tank is suitable for drinking water. |
| Sololá | Cl- gas treatment<br>Residual Chlorine (1.0 mg/l) - the highest value of MPL<br>Hardness - soft water (44.76 mg/l)<br>NO3-N (5 mg/l) - detected<br>General bacteria (4 CFU/ml) and Total coliforms (<2 MPN/100ml) - lower than the limit | The supplied water at the tank is suitable for drinking water. However, it is recommended to make residual chlorine not being higher than 0.5 mg/l. |
| S. L. Utatlán | No Cl- treatment<br>Hardness - soft water (30.52 mg/l)<br>General bacteria (10 CFU/ml) and Total coliforms (<2 MPN/100ml) - lower than the limit | Although the water is not trated, the supplied water at the tank is suitable for drinking. |
| Momostenango | No Cl- treatment<br>hardness - soft water (24.41 mg/l)<br>Color (5 u) - detected<br>General bacteria (616 CFU/ml) - slightly higher than the limit<br>Total coliforms (460 MPN/100ml) - much higher than the limit | Although Fecal coliforms were not detected, it is recommended to treat with chlorine, ozon and/or charcoal. |
| S. F. La Unión | No Cl- treatment<br>Hardness - moderate water (54.97 mg/l)<br>Total iron (0.18 mg/l) and Mn (0.16 mg/l) - higher than MAL, but lower tne MPL<br>General bacteria (1336 CFU/ml) and Total coliforms (290 MPN/100ml) - much higher than the limit | Same as above |
| Génova | No Cl- treatment<br>Hardness - soft water (32.54 mg/l)<br>Mn (0.16 mg/l) - higher than MAL<br>NO3-N (10 mg/l) - detected<br>General bacteria (63 CFU/ml) - much lower than the limit<br>Total coiliforms (29 MPN/100ml) - higher than the limit<br>Fecal coliforms - positive | Fecal coliforms were positive. It is strongly recommended to cut-off the effect of human waste on the supplied water and to treat it with chlorine, ozon and/or charcoal. |

Table 3.2.2 Suitability of Water from the Newlly Drilled Well as Drinking Water

| Municipality | Characteristics of Quality | Comments for Suitability according to Guatemala Standard |
|---|---|---|
| S. J. Pinula | Water is quite hard (152.54 mg/l), which is higher than MAL.<br>Total residue at 104°C - although lower than MAL, quite high (309.2 mg/l)<br>General bacteria (2200 CFU/ml) - extremely high | General and coliform bacterial numbers were very high, however, it is due to the effect of polluted river water used when the new well was drilled. Physical and chemical qualities indicate this water is suitable for drinking water. |
| S. P. Sacatepéquez | EC (380 uS/cm) - quite high<br>Color (5 u) - detected<br>General bacteria (2360 CUF/ml) and Total coliforms (1100 MPN/100ml) - much higher, especially coliforms, than the limit | Same as above |
| S. M. de Jesús | Total Hardness (128.1 mg/l) - slightly higher than MAL<br>Total residue at 104°C (230.4 mg/l) - quite high, although lower than MAL<br>General bacteria (460 CFU/ml) - lower than the limit<br>Total coliforms (3 MPN/100ml) - slightly higher than the limit | Suitable for drinking water |
| S. M. Jilotepeque | Color (5 u) - detected<br>Total residue at 104°C (223.6 mg/l) - quite high, although lower than MAL<br>General bacteria (2250/ml) - much higher than the limit<br>Total coliforms (23 MPN/100ml) - slightly higher than the limit | General and coliform bacterial numbers were very high, however, it is due to the effect of polluted river water used when the new well was drilled. Physical and chemical qualities indicate this water is suitable for drinking water. |
| S. J. Comalapa | General bacteria (1400 CFU/ml) and Total coliforms (39 MPN/ml) - much hgiher than the limit | Same as above |
| Sololá | EC (710 uS/cm) - higher than MAP, although lower than MPL<br>General bacteria (4353 CFU/ml) - much higher than the limit<br>Total coliforms (14 MPN/ml) - higher than the limit | Same as above |
| S. L. Utatlán | Hardness - moderate water (54.19 mg/l)<br>Color (5 U) - detected<br>General bacteria (1680 CFU/ml) - much higher than the limit<br>Total coliforms (9.1 MPN/100ml) - slightly higher than the limit | |
| Momostenango | Hardness - soft water (22.39 mg/l)<br>General bacteria (2130 CFU/ml) - much higher than the limit<br>Total coliforms (11 MPN/100ml) - slightly higher than the limit | Same as above |
| Génova | Hardness - moderate water (22.39 mg/l)<br>T-Fe (0.09 mg/l) - deetected<br>General bacteria (2500 CFU/ml) - much higher than the limit<br>Total coliforms (3 MPN/100ml) - barely higher than the limit | General bacterial number was very high, however, it seems the effect of polluted river water used when the new well was drilled. Physical and chemical qualities indicate this water is suitable for drinking water. |

## 3.3 Water Supply System

### 3.3.1 Water Source

Due to the limited capacity of existing water supply sources, most of the municipalities, except the following, use the majority of these sources for drinking water supply:

a) Domestic and agricultural use

- Villa Canales (Gu) . . . . . (Spring)
- San Pedro Sacatepéquez . . . . . (Spring)
- Santa Catarina Barahona (Sa) . . . . . (Spring)
- San José Poaquil (Sa) . . . . . (Spring)
- Sololá (So) . . . . . (Spring)
- Santa Catarina Ixtahuacán (So) . . . . . (River)
- Nahualá (So) . . . . . (River)
- San Carlos Sija (Qu) . . . . . (River)
- Cajolá (Qu) . . . . . (River)
- Almolonga (Qu) . . . . . (Spring)

b) Domestic, Industrial and Commercial use

- Villa Nueva (Gu) . . . . . (Well)
- Mixco (Gu) . . . . . (Well/Spring)
- El Tejar(Ch) . . . . . (Well)

The sources for domestic water use are classified into spring, tube well, and river water. The percentage of each source is as follows.

| | |
|---|---|
| Spring: | 67.78 % |
| Tube well: | 31.11 % |
| River water: | 1.11 % |

**(a) Spring Water**

A total of 44 municipalities are using spring water as water source. Average spring production is 2.5 ℓ/sec. Water is generally collected in a concrete chamber and conveyed by natural flow to the distribution tank located at an elevation higher than the service area. Since such convenient spring sources have been fully exploited, pumping from lower places should be taken into consideration for additional spring source development.

**(b) Groundwater**

In 26 municipalities, groundwater is pumped up from tube wells, which yield an average of 9.8 ℓ/sec. Since the electricity rate was doubled in 1994, most of the well pumps are operated for a very short time, 2-3 hours a day.

The Study Area may have potential for groundwater development, but the extraction of water from deep aquifers requires high energy cost. This is one of the major

problems, particularly in the Central Plateau Area where groundwater level is generally very deep.

**(c) River water**

Two municipalities (San Jose Poaquil and Chuarrancho) use river water because of the unavailability of other sources. The use of river water as a source, however, entails the following problems:

. unstable year-round supply, and
. deterioration of quality by contamination.

### 3.3.2 Water Supply Facilities

All of the 96 municipalities have water supply facilities, although the type and scale are all different, as shown in Table 3.3.1.

The water supply system consists basically of intake, transmission, and distribution facilities. Only a few municipalities have water treatment facilities.

**(a) Intake Facilities**

Intake facilities differ according to water source.

| | |
|---|---|
| Spring and River Water : | Water is collected in a concrete chamber and piped to distribution tanks by natural flow or by pump pressure |
| Groundwater : | Water is extracted by motorized pumping, and directly transmitted to the distribution tank |

In most municipalities, distribution tanks are installed in places higher than the residential area so as to lower distribution costs. If the production well is drilled at a lower elevation, a pump of greater capacity is required.

**(b) Distribution System**

Distribution facilities are composed of tanks and pipe network connected to individual houses or to public standposts.

The distribution network of most municipalities have serious leakage problems due mainly to dilapidated pipes, especially of asbestos-cement, and high internal pressure brought about by the large head of natural flow systems.

The replacement of these dilapidated pipes or the installation of pressure reduction valves would be a more effective solution for some of the municipalities, rather than the development of new water sources.

The majority of municipalities utilizes spring water and

groundwater, sources with generally good water quality. However, water quality analyses have indicated the existence of bacteria-related problems which may be attributed to the poor sanitary environment around the intake, storage, and distribution facilities. Only 16 of the 96 municipalities are equipped with disinfection systems, but the majority is not functioning.

Table 3.3.1 Result of Survey on Existing Water Supply Systems (1)

GUATEMALA

| No. | Municipality | Water Sources | | | | | Water supply Facilities and Functioning | | | | | | | | | | Supply Time (hs) | Operation Cost | | W/Charge (Q/C/M) | M/Income (Q/Month) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Capacity (m3/day) | | C/Tank | | D/Tank | | Disinf-ection | House Connect. | Pub. Con. & Cistern | Functioning | | | | Electr. C. (Q/Month) | Man. C. (Q/Month) | | |
| | | N | P | R | MAX | Probable | Num. | Vol. (m3) | Num. | Vol. (m3) | | | | C/F | T/S | D/S | | | | | |
| 1 | Santa Catarina Pinula | 2 | 2 | - | 2.521 | 1.635.12 | - | - | 1 | 610 | CL | 1.700 | | A | B | B | 12.0 | 13.500 | 800 | 3.00 | 5.100 |
| 2 | San Jose Pinula | - | 4 | - | 1.536 | 768.10 | - | - | 2 | 750 | CL | 1.557 | | B | A | B | 4.0 | 12.800 | 800 | 1.00 | 1.557 |
| 3 | San Jose del Golfo | 1 | 2 | - | 499 | 262.66 | - | - | 2 | 570 | CL | 330 | | A | A | B | 6.5~12.0 | 6.000 | 800 | 5.00 | 1.650 |
| 4 | Palencia | | | | | | | | | | | | | A | B | B | 12.0 | 0 | 1.600 | 2.00 | |
| 5 | Chinautla | 2 | 1 | - | 153 | 78.62 | - | - | 1 | 130 | - | | | B | B | B | 5days 3.0h | 6.000 | 800 | 3.00 | 1.620 |
| 6 | San Pedro Ayampuc | 2 | 2 | - | 623 | 399.17 | - | - | 2 | 240 | - | 540 | | B | A | B | 2days 4.0h | 85.000 | 2.000 | 10.00 | 25.000 |
| 7 | Mixco | 9 | 4 | - | 3.157 | 2.658.91 | - | - | 3 | 1.500 | CL | 2.500 | 10 | B | A | B | 8.0~16.0 | 3.000 | 800 | 1.50 | |
| 8 | San Pedro Sacatepequez | 3 * | 1 | - | 660 | 330.05 | - | - | 2 | 580 | CL | | | B | A | B | 12.0 | 6.940 | 3.674 | 2.00 | 3.250 |
| 9 | San Juan Sacatepequez | 3 | 5 | - | 1.901 | 1.382.40 | - | - | 2 | 780 | CL | 1.625 | | B | B | B | 3.0 | 6.000 | 800 | 6.00 | 4.950 |
| 10 | San Raymundo | - | 2 | - | 1.908 | 953.86 | - | - | 1 | 250 | CL | 825 | | B | A | B | 24.0 | | 800 | 10.00 | 2.500 |
| 11 | Chuarrancho | 1 | - | 1 | 961 | 480.82 | | | 1 | 320 | - | 250 | | A | A | B | | | | | |
| 12 | Fraijanes | | | | | | | | | | | | | | | | | | | | |
| 13 | Amatitlan | | | | | | | | | | | | | | | | | | | | |
| 14 | Villa Nueva | 1 | 5 | - | 5.745 | 4.858.99 | | | 2 | 2.100 | CL | 5.647 | 53 | B | A | B | 20.0 | 128.000 | 32.000 | 15.00 | 84.705 |
| 15 | Villa Canales | 1 | 3 | - | 15.008 | 9.447.84 | | | 2 | 150 | - | | | B | A | B | 4.0 | 6.000 | 800 | 1.50 | |
| 16 | San Miguel Petapa | | | | | | | | | | | | | | | | | | | | |

SACATEPEQUEZ

| No. | Municipality | Water Sources | | | | | Water supply Facilities and Functioning | | | | | | | | | | Supply Time (hs) | Operation Cost | | W/Charge Q/C/M | M/Income Q/Month |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Capacity (m3/day) | | C/Tank | | D/Tank | | Disinf-ection | House Connect. | Pub. Con. & Cistern | Functioning | | | | Electr. C. Q/Month | Man. C. Q/Month | | |
| | | N | P | R | MAX | Probable | Num. | Vol. (m3) | Num. | Vol. (m3) | | | | C/F | T/S | D/S | | | | | |
| 1 | Antigua Guatemala | 1 | 3 | - | 3.404 | 1.702.08 | - | - | 1 | 450 | | 1.258 | | A | A | B | 12.0 | | 800 | 4.50 | 5.661 |
| 2 | Jocotenango | | | | | | | | | | | | | | | | | | | | |
| 3 | Pastores | | | | | | | | | | | | | | | | | | | | |
| 4 | Sumpango | | | | | | | | | | | | | | | | | | | | |
| 5 | Sto. Domingo Xenacoj | | | | | | | | | | | | | | | | | | | | |
| 6 | Santiago Sacatepequez | | | | | | | | | | | | | | | | | | | | |
| 7 | San Bartolome M. Altas | 2 | 2 | - | 1.158 | 596.16 | - | - | 1 | 140 | - | 750 | | B | B | B | 20.0 | 3.000 | 700 | 7.00 | 5.250 |
| 8 | San Lucas Sacatepequez | | | | | | | | | | | | | | | | 4.0 | 4.000 | 3.710 | 4.00 | 3.780 |
| 9 | Santa Lucia M. Altas | - | 2 | - | 691 | 345.60 | - | - | 2 | 300 | - | 700 | - | | | | 6.0 | 10.000 | 3.190 | 6.00 | 3.300 |
| 10 | Magdalena Milpas Altas | 4 | 1 | - | 882 | 476.06 | - | - | 3 | 370 | - | 550 | | B | B | B | 5days 1.5h | 3.160 | 2.840 | 10.00 | 7.800 |
| 11 | Santa Maria de Jesus | 2 | 1 | - | 648 | 388.80 | 1 | 20 | 1 | 240 | - | 780 | 5 | A | A | B | 24.0 | 24.345 | 3.000 | 5.00 | 16.500 |
| 12 | Ciudad Vieja | 1 | 3 | - | 3.514 | 1.780.70 | - | - | 3 | 1.050 | CL | 3.300 | | A | A | B | | | | | |
| 13 | San Miguel Duenas | | | | | | | | | | | | | | | | | | | | |
| 14 | San Juan Alotenango | | | | | | | | | | | | | | | | | | | | |
| 15 | San Antonio Aguas Cal. | 3 | 1 | - | 877 | 803.52 | - | - | 1 | 200 | - | 600 | | B | B | C | 24.0 | 0 | 580 | 1.00 | 600 |
| 16 | Santa Catarina Barahona | 4 | - | - | 1.519 | 759.63 | | | | | - | | | A | A | B | | 0 | 800 | | |

Probable Capacity
Water source of gravity type 24hr/day operation
Water source of pumping type 12hr/day operation

Water Sources
N:Spring
*:Pumping type
P:Well
R:River

Water supply Facilities
C/Tank:Collection Tank
D/Tank:Distribution Tank

Functioning
C/F:Collection Facility
T/S:Transmission System
D/S:Distribution System

Functioning
A:Good
B:Fair
C:Poor

**Table 3.3.1** Result of Survey on Existing Water Supply Systems (2)

CHIMALTENANGO

| No. | Municipality | Water Sources | | | | | Water supply Facilities and Functioning | | | | | | | | | | Supply Time (hs) | Operation Cost | | W/Charge Q/C/M | M/Income Q/Month |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Capacity (m3/day) | | C/Tank | | D/Tank | | Disinf- | House | Pub. Con. & | Functioning | | | | Electr. C. Q/Month | Man. C. Q/Month | | |
| | | N | P | R | MAX | Probable | Num. | Vol. (m3) | Num. | Vol. (m3) | ection | Connect. | Cistern | C/F | T/S | D/S | | | | | |
| 1 | Chimaltenango | | | | | | | | | | | | | | | | | | | | |
| 2 | San Jose Poaquil | 2 | - | 1 | 266 | 266.11 | - | - | 2 | 220 | CL | 845 | | B | B | B | 24.0 | 0 | 1,300 | 0.40 | 338 |
| 3 | San Martin Jilotepeque | 3 | 1 | - | 1,633 | 816.48 | - | - | 1 | 600 | CL | 1,300 | | B | B | B | 5.5 | 3,000 | 2,100 | 2.50 | 3,250 |
| 4 | San Juan Comalapa | 2 * | 1 | - | 3,439 | 1,719.36 | - | - | 3 | 750 | - | 1,164 | 71 | C | B | C | 4.0 | 3,000+ 2,500(G) | 6,060 | 2.00 | 2,328 |
| 5 | Santa Apolonia | | | | | | | | | | | | | | | | | | | | |
| 6 | Tecpan Guatemala | | | | | | | | | | | | | | | | | | | | |
| 7 | Patzun | 3 * | - | - | 1,460 | 730.08 | 2 | 85 | 2 | 720 | CL | 1,150 | | B | B | B | 2days 4.0h | 7,500(G) | 4,000 | 4.00 | 4,600 |
| 8 | San Miguel Pochuta | | | | | | | | | | | | | | | | | | | | |
| 9 | Patzicia | 3 * | - | - | 1,605 | 802.66 | - | - | 2 | 460 | - | 687 | | C | C | C | 2days 2.0h | 5,400(G) | 600 | 0.85 | 584 |
| 10 | Santa Cruz Balanya | | | | | | | | | | | | | | | | | | | | |
| 11 | Acatenango | | | | | | | | | | | | | | | | | | | | |
| 12 | San Pedro Yepocapa | | | | | | | | | | | | | | | | | | | | |
| 13 | San Andres Itzapa | | | | | | | | | | | | | | | | | | | | |
| 14 | Parramos | | | | | | | | | | | | | | | | | | | | |
| 15 | Zaragoza | 5 | 1 | - | 1,172 | 1,036.37 | - | - | 3 | 580 | CL | 1,500 | | A | A | A | 6.0 | 15,000 | 1,000 | 3.00 | 4,500 |
| 16 | El Tejar | - | 3 | - | 2,652 | 1,326.24 | - | - | 2 | 500 | - | 104 | | B | B | B | 19.0 | 12,000 | 1,700 | 15.00 | 1,560 |

(G):Gasoline

SOLOLA

| No. | Municipality | Water Sources | | | | | Water supply Facilities and Functioning | | | | | | | | | | Supply Time (hs) | Operation Cost | | W/Charge Q/C/M | M/Income Q/Month |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Capacity (m3/day) | | C/Tank | | D/Tank | | Disinf- | House | Pub. Con. & | Functioning | | | | Electr. C. Q/Month | Man. C. Q/Month | | |
| | | N | P | R | MAX | Probable | Num. | Vol. (m3) | Num. | Vol. (m3) | ection | Connect. | Cistern | C/F | T/S | D/S | | | | | |
| 1 | Solola | 2 | - | - | 2,627 | 2,626.56 | - | - | 2 | 590 | - | 1,449 | - | B | B | B | 12.0 | 0 | 2,500 | 3.25 | 4,709 |
| 2 | San Jose Chacaya | | | | | | | | | | | | | | | | | | | | |
| 3 | Santa Maria Visitacion | | | | | | | | | | | | | | | | | | | | |
| 4 | Santa Lucia Utatlan | 4 | - | - | 162 | 162.43 | - | - | 3 | 90 | - | 149 | | B | B | B | 2days 1.0h | 0 | 700 | 3.00 | 447 |
| 5 | Nahuala | 3 | - | - | 300 | 299.81 | - | - | 3 | | - | 550 | | B | B | B | 5.0 | 0 | 800 | 0.25 | 138 |
| 6 | Sta. Catarina Ixtahuacan | 3 | - | - | 630 | 629.86 | - | - | 1 | 125 | - | 450 | | B | A | B | 24.0 | 0 | 800 | 1.00 | 450 |
| 7 | Santa Clara la Laguna | | | | | | - | - | 1 | 200 | | 600 | - | | | | | | | | |
| 8 | Concepcion | | | | | | - | - | 1 | 50 | | 128 | 5 | | | | | | | | |
| 9 | San Andres Semetabaj | 8 | - | - | 82 | 82.08 | - | - | 1 | 140 | - | 350 | - | B | B | B | 6.0 | 0 | 420 | 0.50 | 175 |
| 10 | Panajachel | | | | | | - | - | 1 | 633 | | 1,560 | 8 | | | | | | | | |
| 11 | Sta. Catarina Palopo | 2 | - | - | 270 | 269.57 | - | - | 2 | 160 | - | 220 | 9 | B | B | B | 3.0 | 0 | 500 | 1.00 | 220 |
| 12 | San Antonio Palopo | 1 | - | - | 36 | 36.29 | - | - | 1 | 122 | - | 300 | 18 | B | B | B | 6.0 | 0 | 500 | 1.00 | 300 |
| 13 | San Lucas Toliman | | | | | | | | | | | | | | | | | | | | |
| 14 | Santa Cruz la Laguna | | | | | | - | - | 1 | 100 | | 170 | 1 | | | | | | | | |
| 15 | San Pablo la Laguna | | | | | | - | - | 1 | 50 | | 500 | - | | | | | | | | |
| 16 | San Marcos la Laguna | | | | | | - | - | 3 | 54 | | 316 | 10 | | | | | | | | |
| 17 | San Juan la Laguna | | | | | | - | - | 1 | 200 | | 550 | - | | | | | | | | |
| 18 | San Pedro la Laguna | | | | | | | | | | | | | | | | | | | | |
| 19 | Santiago Atitlan | | | | | | | | | | | | | | | | | | | | |

Probable Capacity
- Water source of gravity type 24hr/day operation
- Water source of pumping type 12hr/day operation

Water Sources
- N:Spring
- *:Pumping type
- P:Well
- R:River

Water supply Facilities
- C/Tank:Collection Tank
- D/Tank:Distribution Tank

Functioning
- C/F:Collection Facility
- T/S:Transmission System
- D/S:Distribution System

Functioning
- A:Good
- B:Fair
- C:Poor

Table 3.3.1 Result of Survey on Existing Water Supply Systems (3)

TOTONICAPAN

| No. | Municipality | Water Sources | | | Capacity (m3/day) | | Water supply Facilities and Functioning | | | | | | | | | | Supply Time | Operation Cost | | W/Charge | M/Income |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | C/Tank | | D/Tank | | Disinf- | House | Pub. Con. & | Functioning | | | | Electr. C. | Man. C. | | |
| | | N | P | R | MAX | Probable | Num. | Vol. (m3) | Num. | Vol. (m3) | ection | Connect. | Cistern | C/F | T/S | D/S | (hs) | Q/Month | Q/Month | Q/C/M | Q/Month |
| 1 | Totonicapan | | | | | | | | | | | | | | | | | | | | |
| 2 | San Cristobal Totonic. | | | | | | | | | | | | | | | | | | | | |
| 3 | San Francisco el Alto | 8 | - | - | 579 | 578.88 | - | - | 3 | 564 | - | 600 | | B | B | B | 2.0 | 0 | 700 | 0.60 | 360 |
| 4 | San Andres Xecul | 1 | 1 | - | 199 | 198.72 | - | - | 2 | 300 | - | 608 | | B | B | B | 1.0 | 0 | 3.500 | 0.50 | 304 |
| 5 | Momostenango | 2 * | - | - | 1.227 | 786.24 | - | - | 2 | 700 | - | 600 | | B | B | B | 3.0~12.0 | 1.500 | 600 | 3.00 | 1.800 |
| 6 | Santa Maria Chiquimula | | | | | | | | | | | | | | | | | | | | |
| 7 | Santa Lucia la Reforma | | | | | | | | | | | | | | | | | | | | |
| 8 | San Bartolo Aguas Cal. | | | | | | | | | | | | | | | | | | | | |

QUETZALTENANGO

| No. | Municipality | Water Sources | | | Capacity (m3/day) | | Water supply Facilities and Functioning | | | | | | | | | | Supply Time | Operation Cost | | W/Charge | M/Income |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | C/Tank | | D/Tank | | Disinf- | House | Pub. Con. & | Functioning | | | | Electr. C. | Man. C. | | |
| | | N | P | R | MAX | Probable | Num. | Vol. (m3) | Num. | Vol. (m3) | ection | Connect. | Cistern | C/F | T/S | D/S | (hs) | Q/Month | Q/Month | Q/C/M | Q/Month |
| 1 | Quetzaltenango | | | | | | | | | | | | | | | | | | | | |
| 2 | Salcaja | | | | | | | | | | | 1.900 | | | | | | | | 6.00 | 11.400 |
| 3 | Olintepeque | 1 | 1 | - | 1.043 | 562.03 | - | - | 2 | 400 | - | 360 | | B | B | B | 2.0~4.0 | 1.400 | 1.000 | 5.00 | 1.800 |
| 4 | San Carlos Sija | 3 | - | - | 242 | 241.92 | - | - | 1 | 110 | - | 450 | | B | B | B | 2.0 | 0 | 800 | 1.00 | 450 |
| 5 | Sibilia | | | | | | | | | | | | | | | | | | | | |
| 6 | Cabrican | | | | | | | | | | | 200 | | | | | | | | 5.00 | 1.000 |
| 7 | Cajola | 6 | - | - | 159 | 158.98 | - | - | 1 | 250 | - | 400 | - | B | B | B | 5.0 | 0 | 1.000 | 0.50 | 200 |
| 8 | San Miguel Sigula | | | | | | | | | | | | | | | | | | | | |
| 9 | San Juan Ostuncalco | | | | | | | | | | | | | | | | | | | | |
| 10 | San Mateo | | | | | | | | | | | 596 | | | | | | | | 1.50 | 894 |
| 11 | Cpcion. Chiquirichapa | 2 | - | - | 1.000 | 999.65 | - | - | 2 | 360 | CL | 890 | - | B | B | B | 3.0 | 0 | 740 | 1.00 | 890 |
| 12 | San M. Sacatepequez | 2 | - | - | 272 | 272.16 | - | - | 2 | 120 | - | ? | | B | B | B | | 0 | 600 | 0.83 | |
| 13 | Almolonga | 1 | 3 | - | 5.251 | 3.656.45 | - | - | 3 | 1.200 | CL | 865 | | A | A | B | 8.0~10.0 | 20.500 | 3.550 | 6.00 | 5.190 |
| 14 | Cantel | | | | | | | | | | | | | | | | | | | 0.25 | |
| 15 | Huitan | 2 | - | - | 79 | 78.62 | - | - | 1 | 50 | - | 85 | | B | B | B | 6.0 | 0 | 542 | 0.50 | 43 |
| 16 | Zunil | | | | | | | | | | | | | | | | | | | | |
| 17 | Colomba | 2 | - | - | 1.501 | 1.500.77 | | | | | | | | B | B | B | | | | | |
| 18 | San Francisco la Union | 1 * | - | - | 51 | 25.49 | 1 | 60 | 1 | 55 | - | 100 | | B | B | B | 2days 1.0h | 700 | 960 | 5.00 | 500 |
| 19 | El Palmar | | | | | | | | | | | | | | | | | | | | |
| 20 | Coatepeque | | | | | | | | | | | 5.441 | | | | | | | | 7.00 | |
| 21 | Genova | 7 | | - | 262 | 261.79 | - | - | 1 | 140 | CL | 358 | 8 | B | B | B | 2.0 | 0 | 2.270 | 0.60 | 215 |
| 22 | Flores Costa Cuca | 1 | (1) | - | 675 | 354.59 | - | - | 2 | 250 | - | 300 | | C | B | B | 0.25~4.0 | 0 | 840 | 0.75 | 225 |
| 23 | La Esperanza | | | | | | | | | | | | | | | | | | | | |
| 24 | Palestina | - | 1 | - | 1.200 | 600.05 | - | - | 1 | 100 | - | 300 | - | A | A | B | 24.0 | 1.000 | 700 | 10.00 | 3.000 |

Probable Capacity
Water source of gravity type 24hr/day operation
Water source of pumping type 12hr/day operation

Water Sources
N:Spring
*:Pumping type
P:Well
R:River

Water supply Facilities
C/Tank:Collection Tank
D/Tank:Distribution Tank

Functioning
C/F:Collection Facility
T/S:Transmission System
D/S:Distribution System

Functioning
A:Good
B:Fair
C:Poor

## 3.4 Operation and Maintenance of Facilities

Operation and maintenance of the water supply facilities are undertaken by the municipal governments. Most of the municipalities assign persons to be in charge of facility maintenance and such daily operation as valve control, chlorination, pumping rate control, etc.

However, this maintenance work is conducted without a permanent support from INFOM or any other organization. Moreover, information concerning the water supply system, for example, distribution network and construction drawings, are not kept in the municipal offices, making systematic operation and maintenance difficult. Further, the technical level and basic knowledge of the operators in many of the municipalities, particularly in terms of sanitation, is not satisfactory.

Daily water supply is generally limited to less than 8 hours in 50 of the 54 surveyed municipalities, mainly due to two reasons: shortage of water source, and shortage of funds. In 7 of the municipalities, even with pumping restriction, the cost of electricity is higher than the income from collected water charges (Table 3.3.1).

The method used for water charge collection is unique in the Study Area. The water charge must be paid at the Municipal Treasury Office, in accordance with an INFOM regulation approved by the Municipal Corporation. However, the municipalities are partly autonomous and can revise their own water service rates. Either before or after the resolution, representatives of the beneficiaries are called to approve the new water tariffs. If they disagree, a new tariff will be fixed by mutual agreement. Finally, the mutually acceptable water service rates are approved by the Ministry of Government and published in the Official Gazette.

Currently, the monthly water tariff in the Study Area ranges from Q0.25 (Nahualá, the lowest) to Q15.00 (Villa Nueva, the highest).

The level of tariff depends mostly on the type of water transmission system, being low when the natural flow system is used, and high when motorized pump system is in use.

Table 3.4.1 shows the water service rates, the daily water service hours, and the supply source in the concerned municipalities.

# Table 3.4.1 Water service Rate by Municipality

GUATEMALA

| No. | Municipality | Water Charge M/Charge Q/C/M | Water Charge Total Q/Month | Service Hours h/day | Water Sources N | P | R |
|---|---|---|---|---|---|---|---|
| 1 | Santa Catarina Pinula | 3.00 | 5,100 | 12.0 | 2 | 2 | - |
| 2 | San Jose Pinula | 1.00 | 1,557 | 3.0 | - | 4 | - |
| 3 | San Jose del Golfo | 5.00 | 1,650 | 12.0 | 1 | 2 | - |
| 4 | Palencia | | | | | | |
| 5 | Chinautla | 2.00 | | | 2 | 1 | - |
| 6 | San Pedro Ayampuc | 3.00 | 1,620 | 2h/e.3d | 2 | 2 | - |
| 7 | Mixco | 10.00 | 25,000 | 4h/e.2d | 9 | 4 | - |
| 8 | San Pedro Sacatepequez | 1.50 | | 20.0 | 3 | 1 | - |
| 9 | San Juan Sacatepequez | 2.00 | 3,250 | 6.0 | 3 | 5 | - |
| 10 | San Raymundo | 6.00 | 4,950 | 3.0 | - | 2 | - |
| 11 | Chuarrancho | 10.00 | 2,500 | | 1 | - | 1 |
| 12 | Fraijanes | | | | | | |
| 13 | Amatitlan | | | | | | |
| 14 | Villa Nueva | 15.00 | 84,705 | 20.0 | 1 | 5 | - |
| 15 | Villa Canales | 1.50 | | 24.0 | 1 | 3 | - |
| 16 | San Miguel Petapa | | | | | | |

SACATEPEQUEZ

| No. | Municipality | Water Charge M/Charge Q/C/M | Water Charge Total Q/Month | Service Hours h/day | Water Sources N | P | R |
|---|---|---|---|---|---|---|---|
| 1 | Antigua Guatemala | 12.00 | 69,600 | | | | |
| 2 | Jocotenango | 4.50 | 5,661 | 7.0-12.0 | 1 | 3 | - |
| 3 | Pastores | | | | | | |
| 4 | Sumpango | | | | | | |
| 5 | Sto. Domingo Xenacoj | | | | | | |
| 6 | Santiago Sacatepequez | | | | | | |
| 7 | San Bartolome M. Altas | 7.00 | 5,250 | 19.0 | 2 | 2 | - |
| 8 | San Lucas Sacatepequez | | | | | | |
| 9 | Santa Lucia M. Altas | 4.00 | 3,780 | 3.5 | - | 2 | - |
| 10 | Magdalena Milpas Altas | 6.00 | 3,300 | 3.0-6.0 | 4 | 1 | - |
| 11 | Santa Maria de Jesus | 10.00 | 7,800 | 1.5 | 2 | 1 | - |
| 12 | Ciudad Vieja | 5.00 | 16,500 | 19.0-24.0 | 1 | 3 | - |
| 13 | San Miguel Duenas | | | | | | |
| 14 | San Juan Alotenango | | | | | | |
| 15 | San Antonio Aguas Cal. | 1.00 | 600 | 24.0 | 3 | 1 | - |
| 16 | Santa Catarina Barahona | | | | 4 | - | - |

CHIMALTENANGO

| No. | Municipality | Water Charge M/Charge Q/C/M | Water Charge Total Q/Month | Service Hours h/day | Water Sources N | P | R |
|---|---|---|---|---|---|---|---|
| 1 | Chimaltenango | | | | | | |
| 2 | San Jose Poaquil | 0.40 | 338 | 24.0 | 2 | - | 1 |
| 3 | San Martin Jilotepeque | 2.50 | 3,250 | 5.5 | 3 | 1 | - |
| 4 | San Juan Comalapa | 2.00 | 2,328 | 1.0-4.0 | 2 | 1 | - |
| 5 | Santa Apolonia | | | | | | |
| 6 | Tecpan Guatemala | | | | | | |
| 7 | Patzun | 4.00 | 4,600 | 9h/e.2d | 3 | - | - |
| 8 | San Miguel Pochuta | | | | | | |
| 9 | Patzicia | 0.85 | 584 | 2.0 | 3 | - | - |
| 10 | Santa Cruz Balanya | | | | | | |
| 11 | Acatenango | | | | | | |
| 12 | San Pedro Yepocapa | | | | | | |
| 13 | San Andres Itzapa | | | | | | |
| 14 | Parramos | | | | | | |
| 15 | Zaragoza | 3.00 | 4,500 | 2.0 | 5 | 1 | - |
| 16 | El Tejar | 15.00 | 1,560 | 19.0 | - | 3 | - |

SOLOLA

| No. | Municipality | Water Charge M/Charge Q/C/M | Water Charge Total Q/Month | Service Hours h/day | Water Sources N | P | R |
|---|---|---|---|---|---|---|---|
| 1 | Solola | 3.25 | 4,709 | 3.0-13.0 | 2 | - | - |
| 2 | San Jose Chacaya | | | | | | |
| 3 | Santa Maria Visitacion | | | | | | |
| 4 | Santa Lucia Utatlan | 3.00 | 447 | 1h/e.2d | 4 | - | - |
| 5 | Nahuala | 0.25 | 138 | 4.0-5.0 | 3 | - | - |
| 6 | Sta.Catarina Ixtahuacan | 1.00 | 450 | 24.0 | 3 | - | - |
| 7 | Santa Clara la Laguna | 0.50 | 300 | | | | |
| 8 | Concepcion | 1.00 | 128 | | | | |
| 9 | San Andres Semetabaj | 0.50 | 175 | 6.0 | 8 | - | - |
| 10 | Panajachel | 6.00 | 9,360 | | | | |
| 11 | Sta. Catarina Palopo | 1.00 | 220 | 3.0 | 2 | - | - |
| 12 | San Antonio Palopo | 1.00 | 300 | 4.0 | 7 | - | - |
| 13 | San Lucas Toliman | | | | | | |
| 14 | Santa Cruz la Laguna | 1.00 | 170 | | | | |
| 15 | San Pablo la Laguna | 0.50 | 250 | | | | |
| 16 | San Marcos la Laguna | 0.30 | 94.8 | | | | |
| 17 | San Juan la Laguna | 0.50 | 275 | | | | |
| 18 | San Pedro la Laguna | 1.00 | 1,060 | | | | |
| 19 | Santiago Atitlan | | | | | | |

TOTONICAPAN

| No. | Municipality | Water Charge M/Charge Q/C/M | Water Charge Total Q/Month | Service Hours h/day | Water Sources N | P | R |
|---|---|---|---|---|---|---|---|
| 1 | Totonicapan | | | | | | |
| 2 | San Cristobal Totonic. | | | | | | |
| 3 | San Francisco el Alto | 0.60 | 360 | 2.0 | 8 | - | - |
| 4 | San Andres Xecul | 0.50 | 304 | 1.0 | 1 | 1 | - |
| 5 | Momostenango | 3.00 | 1,800 | 3.0 | 2 | - | - |
| 6 | Santa Maria Chiquimula | | | | | | |
| 7 | Santa Lucia la Reforma | | | | | | |
| 8 | San Bartolo Aguas Cal. | 1.00 | 425 | | | | |

QUETZALTENANGO

| No. | Municipality | Water Charge M/Charge Q/C/M | Water Charge Total Q/Month | Service Hours h/day | Water Sources N | P | R |
|---|---|---|---|---|---|---|---|
| 1 | Quetzaltenango | | | | | | |
| 2 | Salcaja | 6.00 | 11,400 | | | | |
| 3 | Olintepeque | 5.00 | 1,800 | 3.0 | 1 | 1 | - |
| 4 | San Carlos Sija | 1.00 | 450 | 2.0 | 3 | - | - |
| 5 | Sibilia | | | | | | |
| 6 | Cabrican | 5.00 | 1,000 | | | | |
| 7 | Cajola | 0.50 | 200 | 5.0 | 6 | - | - |
| 8 | San Miguel Siguila | | | | | | |
| 9 | San Juan Ostuncalco | | | | | | |
| 10 | San Mateo | 1.50 | 894 | | | | |
| 11 | Cpcion. Chiquirichapa | 1.00 | 890 | 3.0 | 2 | - | - |
| 12 | San M. Sacatepequez | 0.83 | | | 2 | - | - |
| 13 | Almolonga | 6.00 | 5,190 | 8.0 | 1 | 3 | - |
| 14 | Cantel | 0.25 | | | | | |
| 15 | Huitan | 0.50 | 101 | 6.0 | 2 | - | - |
| 16 | Zunil | | | | | | |
| 17 | Colomba | | | | 2 | - | - |
| 18 | San Francisco la Union | 5.00 | 500 | 1h/e.2d | 1 | - | - |
| 19 | El Palmar | | | | | | |
| 20 | Coatepeque | 7.00 | | | | | |
| 21 | Genova | 0.60 | 215 | 2.0 | 7 | | - |
| 22 | Flores Costa Cuca | 0.75 | 225 | 15min-4h | 1 | 1 | - |
| 23 | la Esperanza | | | | | | |
| 24 | Palestina | 10.00 | 3,000 | 24.0 | - | 1 | - |

# 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 purposes of water demand projection.

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 9 municipalities listed below, with comparatively sufficient supply sources, were excluded from the 54 candidate municipalities. The remaining 45 municipalities became the subjects for the formulation of water source development plan, under a new assumption in which the unit supply amount 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 Barohona |
| 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 (up to 2010) 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 population projection, 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 varies greatly 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 Phase I of the Study.

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.<br>P.T. 40 ℓ/c/d 100% | 40 ℓ/c/d |
| II | 500 - 2,000 | H.C. 100 ℓ/c/d 50%<br>P.T. 40 ℓ/c/d 50% | 70 ℓ/c/d |
| III | 2,000 - 10,000 | H.C. 150 ℓ/c/d 60%<br>P.T. 40 ℓ/c/d 40% | 106 ℓ/c/d |
| IV | 10,000 - 50,000 | H.C. 200 ℓ/c/d 70%<br>P.T. 50 ℓ/c/d 40% | 155 ℓ/c/d |
| V | 50,000 - | H.C. 225 ℓ/c/d 85%<br>P.T. 50 ℓ/c/d 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 Levels III and IV of the 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 as 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 | 5,865 | 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 | 3,550 | 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 | 6,751 | 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 | 3.60 | 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 * | 4,448 | 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 | 6.35 | 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 | 2,566 | 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 | 3.63 | 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 |

# 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 Andrés 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 were 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 reasons. 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 lower water charges, rather than improved services with higher O/M cost.

Therefore, socioeconomic condition was determined as one of the most important factors in establishing the criteria for categorization. Classification of the municipalities was made based on results from 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 in the year 2010

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

Projected municipal population was categorized as follows.

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 water supply shortage in the year 2010 was categorized as follows.

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 categories were established to determine water source development potential, based on the results of the hydrogeological field survey conducted during 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 Overall Categorization

The following procedure was applied for categorization and classification, and for setting the priorities of the 35 municipalities.

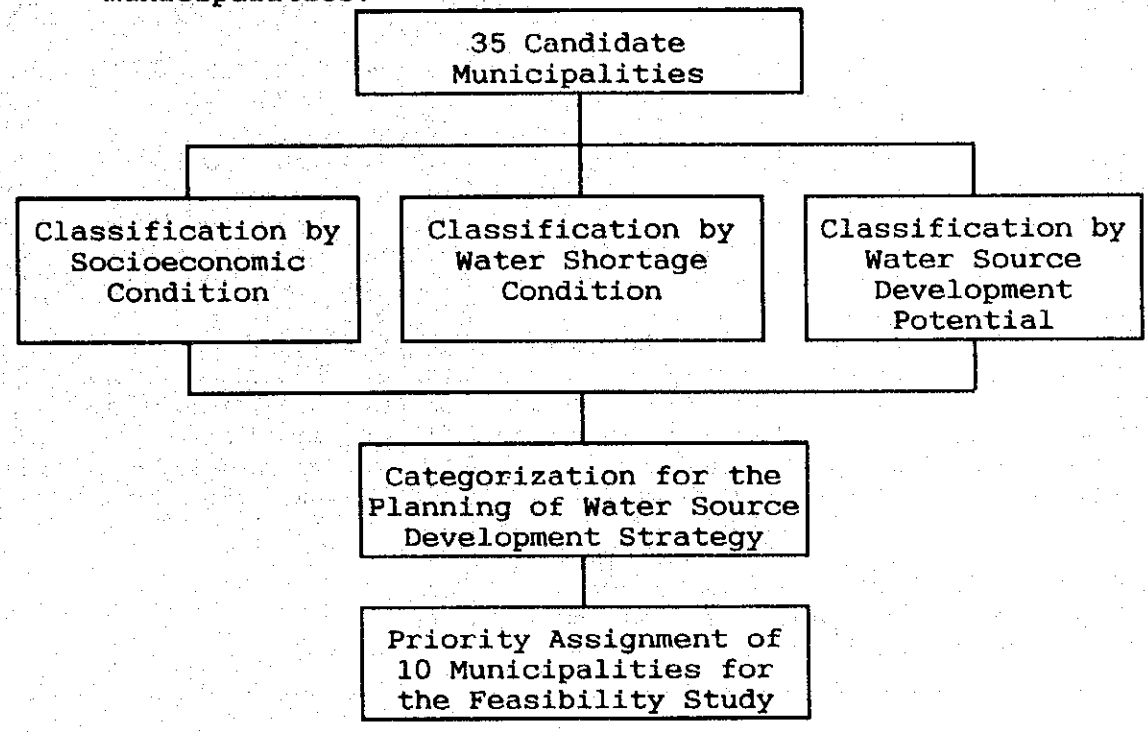


Table 5.1.1 Population Categorization (2010)

| 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 size 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 are 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 two socioeconomic factors; (1) intensity of desire for new water source development and willingness to pay for O-M cost; (2) projected population size.

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

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 were 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 were classified under group A, Patzun and Patzicía were deemed to have sufficient water supply capacity until 2010, as long as the existing water service level, be it satisfactory or otherwise, was maintained. In addition, 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. Therefore, these four municipalities were not assigned high priorities, taking various factors into consideration, even though supply shortage was evident.

**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 | Huitan | 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

| Population (2010) | A | B | C |
|---|---|---|---|
| A | Gu 2 San José Pinula<br>Gu 8 San Pedro Sacatepéquez<br>Sa 11 Santa María de Jesús<br>So 1 Sololá<br>To 5 Momostenango | Ch 3 San Martín Jilotepéque<br>Ch 4 San Juan Comalapa | Gu 1 Santa Catarina Pinula<br>Gu 9 San Juan Sacatepéquez<br>Ch 9 Patzicía<br>Ch 7 Patzún<br>So 15 San Pablo La Laguna<br>To 3 San Francisco el Alto |
| B | | So 5 Nahuala<br>Qu 21 Génova<br>Qu 22 Flores Costa Cuca | Gu 6 San Pedro Ayampuc<br>Gu 11 Chuarrancho<br>Sa 9 Santa Lucía M. Altas<br>Ch 2 San José Poaquil<br>So 7 Santa Clara la Laguna<br>So 17 San Juan la Laguna<br>Qu 3 Olitepéque<br>Qu 24 Palestina |
| C | Qu 18 San Francisco la Unión | Gu 3 San José del Golfo<br>So 4 Santa Lucía Utatlán<br>Qu 4 San Carlos Sija<br>Qu 7 Cajola | So 9 San Andres Semetabaj<br>So 11 Sta. Catarina Palopo<br>So 12 San Antonio Palopo<br>So 14 Santa Cruz la Laguna<br>So 16 San Marcos la Laguna<br>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

| Water Shortage | A | B | C |
|---|---|---|---|
| A | Gu 2 San José Pinula<br>To 5 Momostenango<br>Sa 11 Santa María de Jesús<br>Gu 8 San Pedro Sacatepéquez<br>Qu 18 San Francisco la Unión | Qu 21 Genóva<br>Ch 3 San Martín Jilotepeque<br>Ch 4 San Juan Comalapa | To 3 San Francisco el Alto<br>Ch 7 Patzún<br>Ch 9 Patzicía<br>So 15 San Pablo la Laguna |
| B | So 1 Sololá | So 5 Nahuala<br>So 4 Santa Lucía Utatlán<br>Qu 4 San Carlos Sija<br>Qu 7 Cajola<br>Qu 15 Huitan<br>Qu 22 Flores Costa Cuca | Gu 6 San Pedro Ayampuc<br>Ch 2 San José Poaquil<br>Gu 9 San Juan Sacatepéquez<br>So 7 Santa Clara la Laguna<br>Sa 9 Santa Lucía M. Altas<br>So 9 San Antonio Palopó<br>So 17 San Juan la Laguna |
| C | | Gu 3 San José del Golfo | Gu 11 Chuarrancho<br>Gu 1 Santa Catarina Pinula<br>So 11 Sta. Catarina Palopó<br>So 14 Santa Cruz la Laguna<br>So 16 San Marcos la Laguna<br>Qu 3 Olintepeque<br>Qu 24 Palestina |

## Table 5.2.4 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 |

## 5.3 Classification by Water Source Development Potential

The water source development potential of the 35 municipalities were hydrogeologically classified into the following 3 groups.

Group I:

The following 5 municipalities were 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 were 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 Comalapa |
| 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 | Patzicía | 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 were classified as a group with low groundwater development potential by deep well construction, but were deemed to have 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.

## 5.4 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 worsening in the Study Area, the river water of the following 5 municipalities is still 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. Of the 35 candidate municipalities, 30 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, 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 (24) of the municipalities were categorized in this group, and further 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 were not very high.

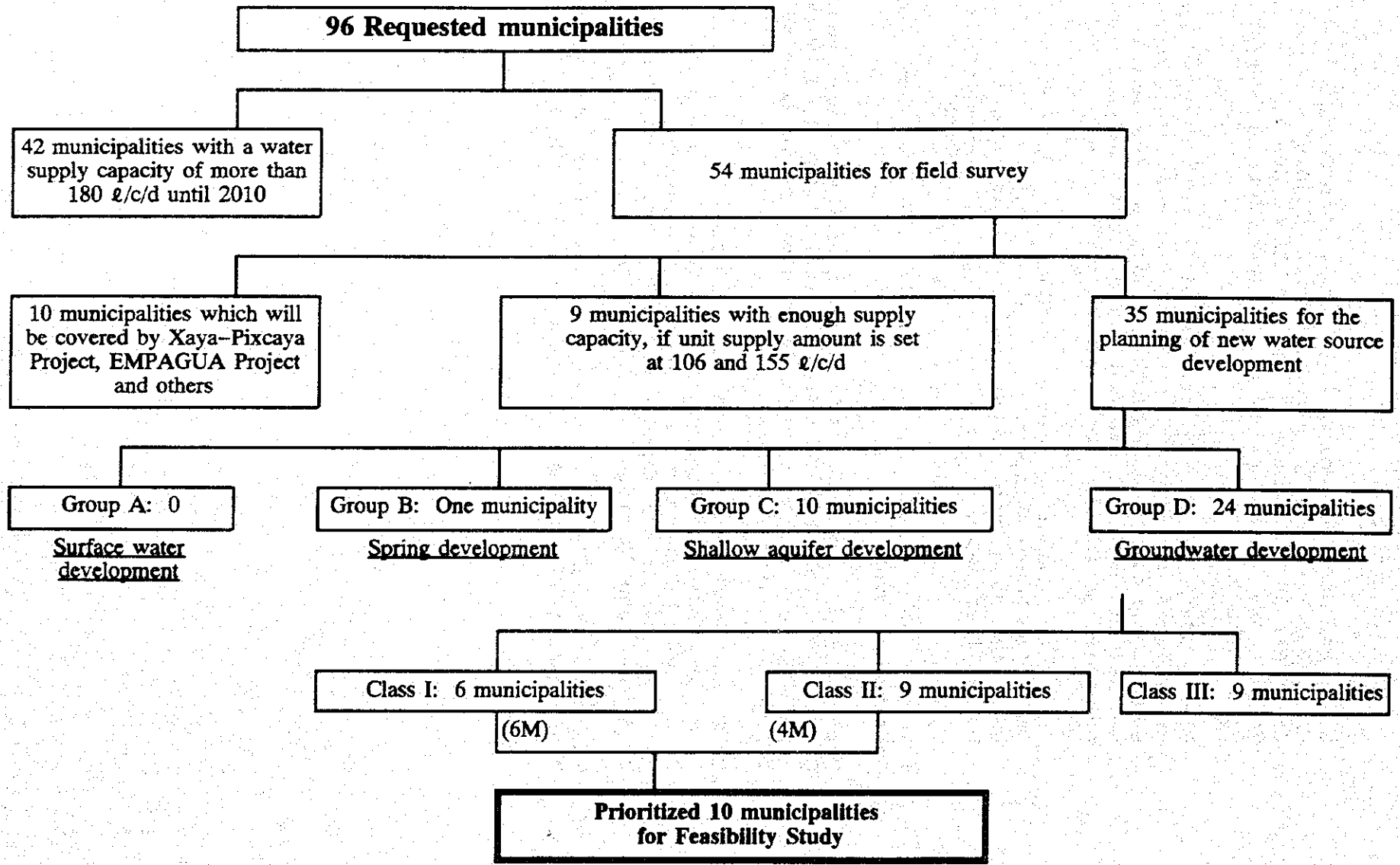
| | | | |
|---|---|---|---|
| Gu 1 | Santa Catarina Pinula | Ch 2 | San José Poaquil |
| Gu 6 | San Pedro Ayampuc | Ch 7 | Patzún |
| Gu 9 | San Juan Sacatepéquez | Ch 9 | Patzicía |
| Gu 11 | Chuarrancho | Qu 3 | Olintepeque |
| | | Qu 24 | Palestina |

## 5.5 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

## 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 givrn 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 nearby 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 increasingly difficult for the majority of the areas.

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 it difficult the prospect of increasing river water intake activities in the future.

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, so as to secure 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 source however, because the contamination of surface water in the area is gradually 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 undoubtedly worsening.

## 6.2 Spring Water Utilization

Of the 35 candidate municipalities, 30 use spring water as public water supply source. There are also many springs which are utilized, either privately or jointly by members of a community, for domestic and agricultural purposes.

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

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

| | |
|---|---|
| Patzún (Ch): | 3 springs (16.90 ℓ/sec)* |
| Patzicía (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 Clala 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

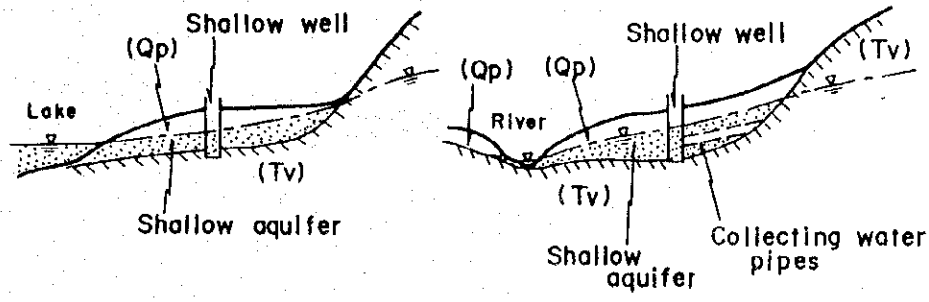
As mentioned above, spring water has been the most important and economical water supply source in the "Central Plateau Area", and has been almost fully exploited by the inhabitants. With a growing population, these springs will not be able to meet the water demand, except for San Antonio Palopó where 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 into 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 Clara 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 (Qu)*: 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 targeted 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, 5 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 recommended 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<br>San José del Golfo<br>(Group D – Class I) | 2.10 | Pyroclastic rocks with lava flow and weathered granitic rocks (Tv) | 6.0 | 1 | 150 |
| So 6<br>Nahualá<br>(Group D – Class I) | 5.73 | Pyroclastic rocks with lava flow (Tv) | 6.0 | 1 | 200 |
| Qu 4<br>San Carlos Sija<br>(Group D – Class I) | 3.18 | Fractured andesitic lava flow (Tv) | 7.5 | 1 | 200 |
| Qu 7<br>Cajola<br>(Group D – Class I) | 4.02 | Pumice sediments (Qp) and fractured andesitic lava low (Tv) | 7.5 | 1 | 200 |
| Qu 22<br>Flores Costa Cuca<br>(Group D – Class I) | 4.95 | Pyroclastic & volcanic mud flow (Qv) | 9.0 | 1 | 180 |
| Gu 1<br>Santa Catarina Pinula<br>(Group D – Class III) | 6.44 | Pumice sediments (Qp) and pyroclastic rocks with lava flow (Tv) | 10.0 | 1 | 200 |
| Gu 6<br>San Pedro Ayampuc<br>(Group D – Class II) | 4.91 | Pyroclastic rocks with fractured lava flow (Tv) | 5.0 | 1 | 200 |
| Gu 9<br>San Juan Sacatepéquez<br>(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<br>Chuarrancho<br>(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<br>Santa Lucía M. Altas<br>(Group D – Class II) | 5.26 | Pyroclastic rocks with fractured lava flow (Tv) | 6.0 | 1 | 200 |
| Ch 2<br>San José Poaquil<br>(Group D – Class II) | 3.93 | Pyroclastic rocks with fractured lava flow (Tv) and fractured limestone | 6.0 – 30.0 | 1 | 200 |
| Ch 7<br>Patzún<br>(Group D – Class II) | 26.36 | Pyroclastic rocks with lava flow and clastic sediments (Tv) | 10.0 | 3 | 600<br>(200m x 3) |
| Ch 9<br>Patzicía<br>(Group D – Class II) | 19.71 | Pumice sediments (Qp) and Pyroclastic rocks with lava flow and clastic sediments (Tv) | 10.0 | 2 | 400<br>(200m x 2) |
| Qu 3<br>Olintepeque<br>(Group D – Class II) | 0.50 | Pumice sediments (Qp) and fractured lava flow (Tv) | 10.0 | 1 | 200 |
| Qu 24<br>Palestina<br>(Group D – Class II) | 1.88 | Pyroclastic rocks with fractured lava flow | 13.0 | 1 | 200 |

# 7. SURVEYS FOR GROUNDWATER DEVELOPMENT

## 7.1 Hydrological Survey

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 collected and kept by INSIVUMEH, and other reports on the Study Area, were reviewed and analyzed.

The field survey covered most of the 54 municipalities selected for the detailed survey, except for a 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 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 had 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 drawn with the average annual rainfall data from 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 generated by the 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 a 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 during the 1948 - 1976 period is included 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 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 lowest and peak discharge values correspond to the 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 that of Candelaria is 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. These stations are located downstream of the concerned municipalities, and the discharge records were observed in different years. Therefore, these discharge data only generalize the 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 between 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 7.1.2 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 the 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 reduced recharge and increased 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 Nahualá, 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 7.1.4 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, but rised since October.

## Table 7.1.1 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 |
| | | | | 47 | | Flores Costa Cuca | 3640 |
| 21 | Chimaltenango | Comalapa | 1414 | 48 | | Genova | 3640 |
| 22 | | El Tejar | 1234 | 49 | | Huitan | 936 |
| 23 | | Patzicia | 1283 | 50 | | Olintepeque | 843 |
| 24 | | Patzun | 1283 | 51 | | Palestina de los Altos | 1027 |
| 25 | | San Jose Poaquil | 1272 | 52 | | San Carlos Sija | 1027 |
| 26 | | San Martin Jilotepeque | 1272 | 53 | | San Francisco la Union | 843 |
| 27 | | Zaragoza | 1283 | 54 | | San M. Sacatepequez | 2100 |

## Table 7.1.2 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 | 4.616 | 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 7.1.3 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 Miagro | 3.4 | 3 | 0.88 | 18.2 | 5.35 |
| | | | Rio El Miagro | 5.16 | 34.75 | 6.73 | 205.4 | 39.81 |
| 21 | Chimaltenango | Comalapa | Rio Picaya | 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 7.1.4 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,P5 | 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 7.1.4 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 | 7 | 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.: Quetzaltenango | | | | | | | | |
| 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 | |

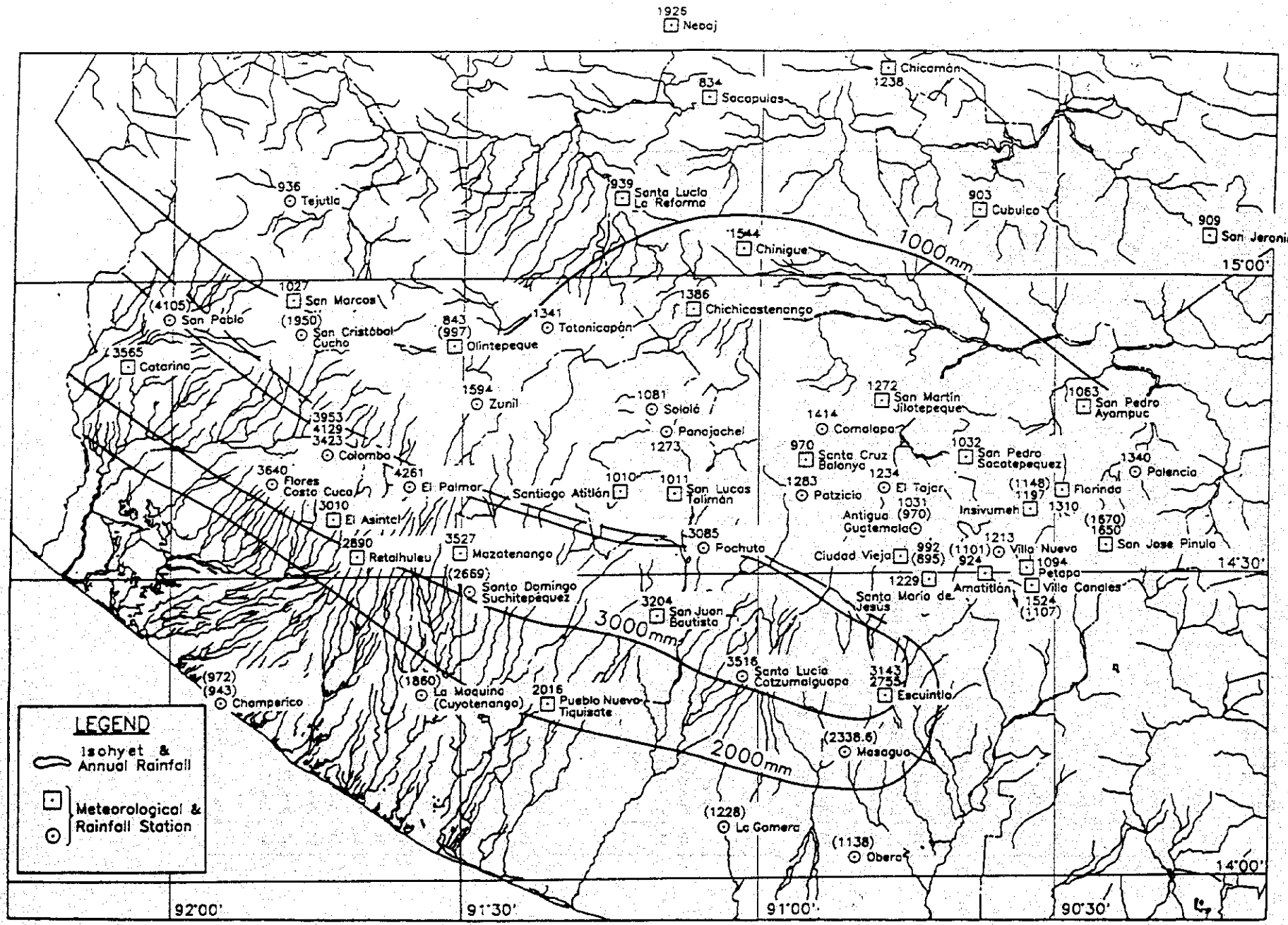



**Fig. 7.1.1 Isohyet-Meteorological & Rainfall Stations**

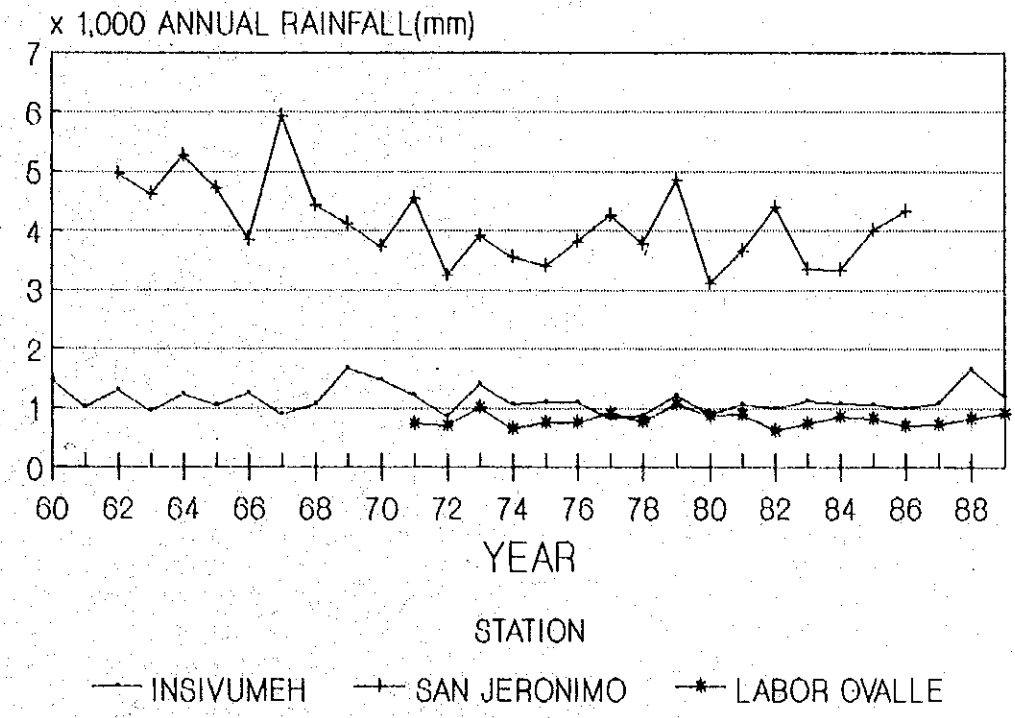



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**Fig. 7.1.2 Annual Rainfall in the 1960-1989 Period**

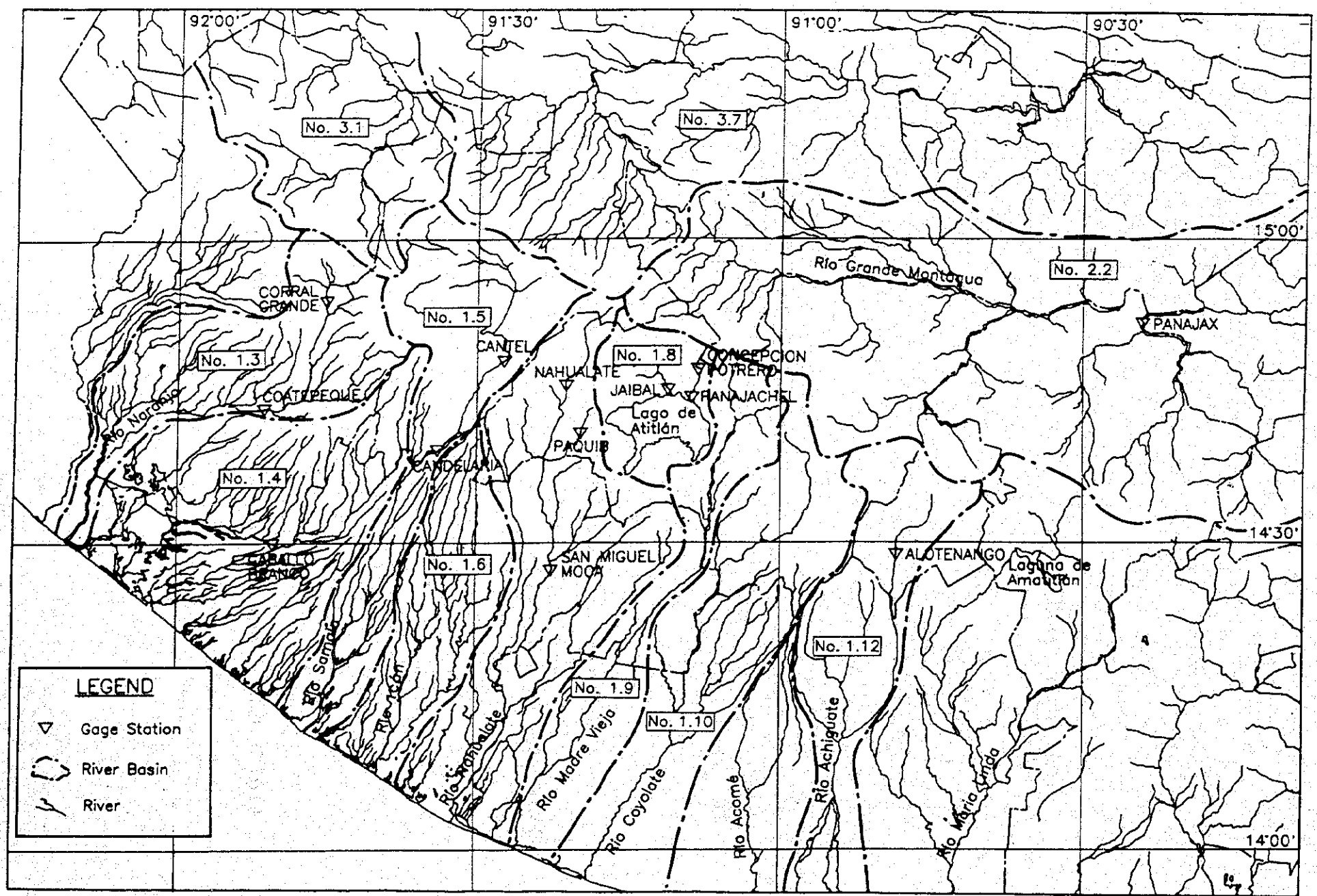


**Fig. 7.1.3 Gauge Station**

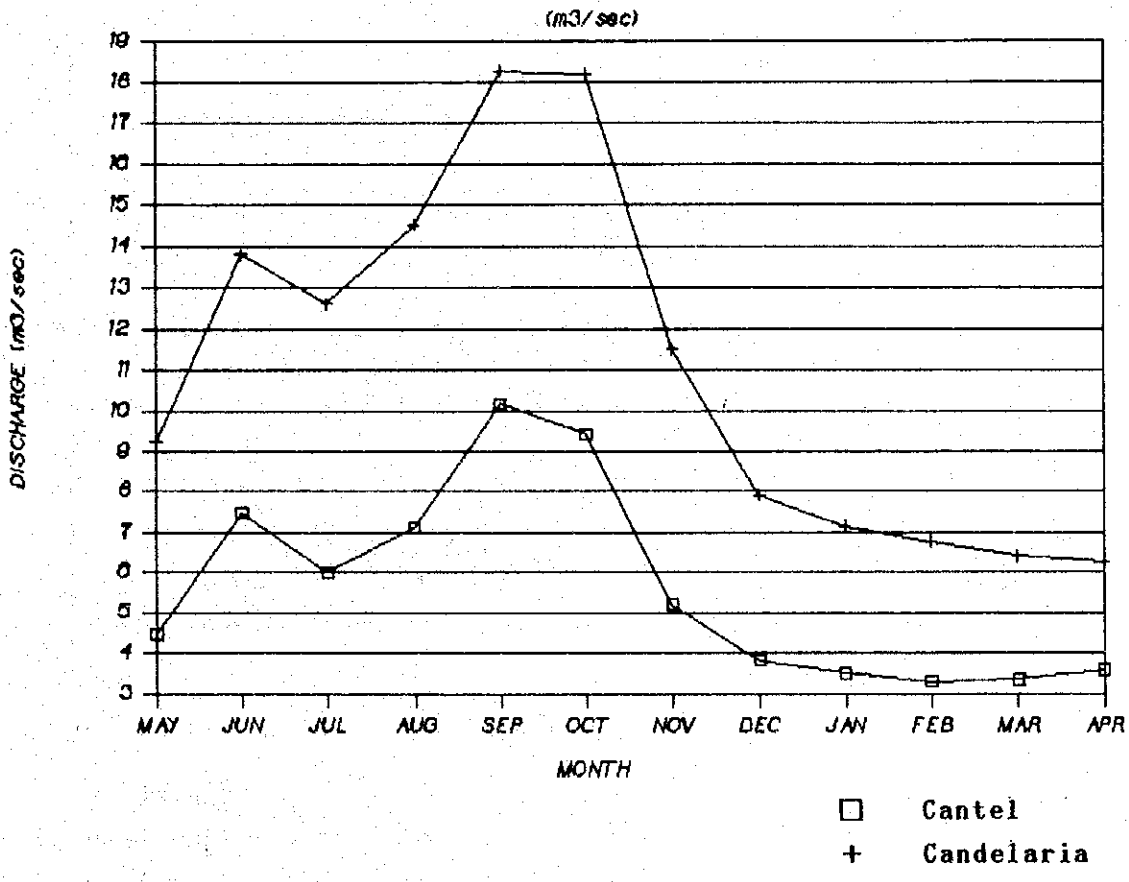


Fig. 7.1.4 Monthly Discharge in Cantel & Candelaria Stations

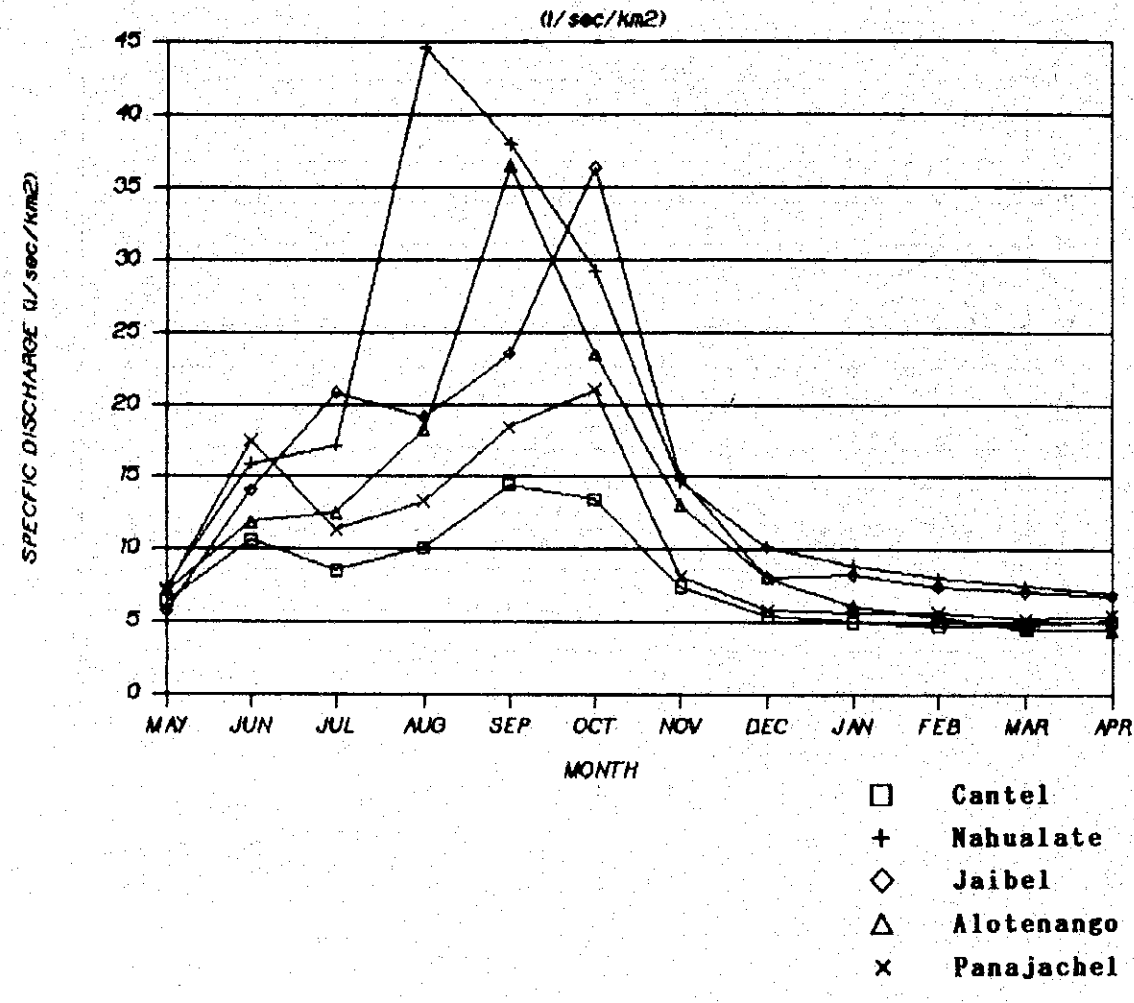


Fig. 7.1.5 Specific Discharge in 5 Stations

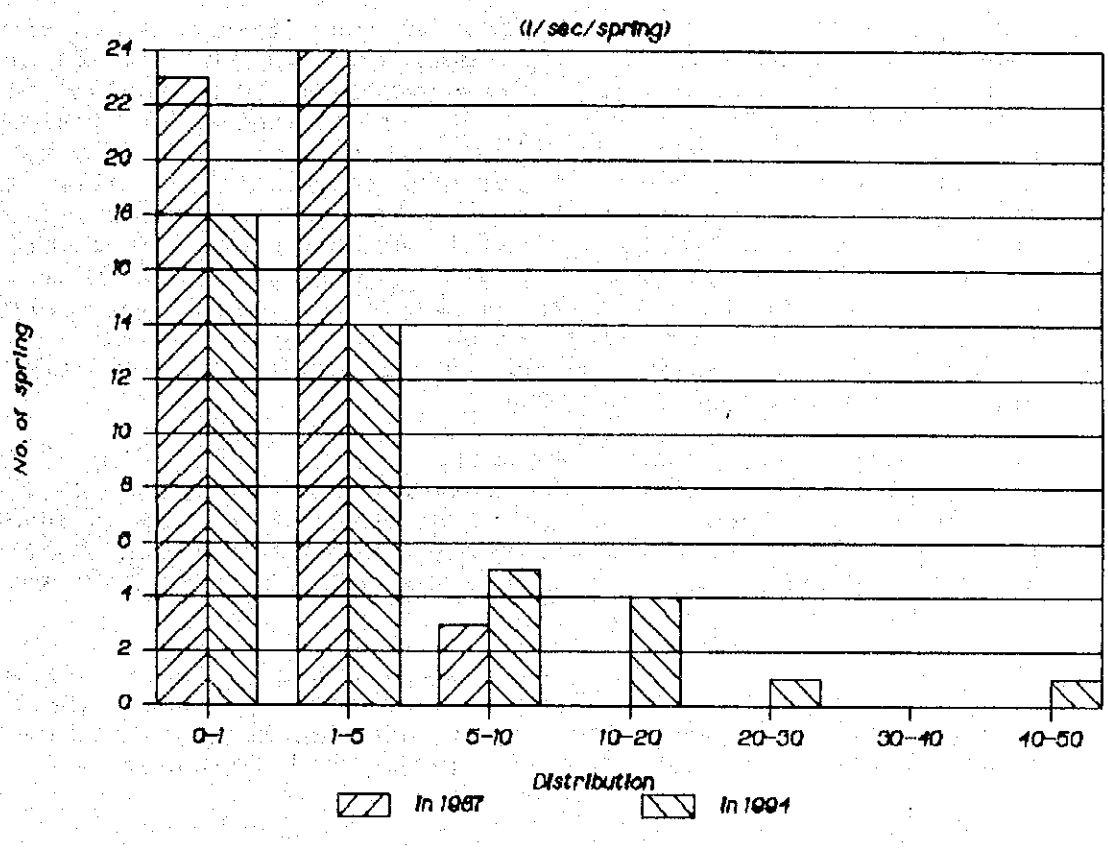


Fig. 7.1.6 Distribution of the Spring Source & its Discharge