7.2 Hydrogeology

7.2.1 General Hydrogeological Feature of the Study Area

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

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

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

Graben Type

- Río las Vacas-Lago Amatitlán basin (Guatemala Valley).

Compound Type of Local Grabens

- Río Plátanos Basin (Guatemala)
- Río Samalá Basin (Quetzaltenango)
- Río Aguacapa Basin (Guatemala)
- Río Pixcayá Basin (Chimaltenango-Guatemala)

River Basin Type

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

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

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

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

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

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

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

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

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

However, test drilling activities conducted in this Study have revealed that the production of wells of the lower aquifer is not small at all as it ranges from 10 to 30 liters/second. Conclusively, the development of the lower aquifer is possible as long as the well site is properly located based on duly conducted hydrogeological investigations.

7.2.2 Local Hydrogeological Structure and Aquifer Characteristics

(1) Local Hydrogeological Features

Aerial photograph interpretation, geological field reconnaissance, and a water quality survey were conducted in and around the 54 municipalities. These surveys were focused on the following points.

a) Classification of rock facies and hydrogeological features of the basement rocks, Tertiary volcanic rocks, and Quaternary volcanic rocks and sediments;

b) Confirmation and discrimination of hydrogeological characteristics of faults (lineaments), fractured zones, weathered zones and basin structure, which were observed on aerial photographs;

c) Confirmation of various information obtained from existing geological data;

d) Confirmation of actual conditions of existing water sources such as springs and wells, and estimation of the probability of groundwater development in terms of quantity and quality.

Based on all the hydrogeological information obtained through the above surveys, the hydrogeological maps (1/50,000) were prepared categorizing groundwater basins and sub-basins, and the potential for groundwater development was assessed by area and municipality. Results of the above survey are summarized in Table 7.2.2.

A printed final hydrogeological map was prepared for each of the unit hydrogeological basins, where the prioritized municipalities are located, at a scale of 1/50,000. The reduced hydrogeological maps are shown in Fig.7.2.1((1)-(4)).

(2) Geophysical Prospecting

In this Study, electrical resistivity sounding was conducted at 3 to 5 selected points in the 15 prioritized municipalities employing the equally spaced 4-electrode arrangement and McOHM type resistivity meter. The breakdown of the field works in Phase I and Phase II is shown in Table 7.2.3.

The drilling sites and the depth of the test wells were determined mainly based on the resistivity sounding results. The results were compared with each other to determine the well site showing the highest probability of success.

(3) Test Well Drilling Works

1) Test well drilling

After completion of hydrogeological investigations in Phase I and Phase II, 10 points were selected for test drilling. The purposes of the test drilling were:

- To confirm groundwater occurrence and aquifer characteristics and to evaluate the potential for groundwater development in the 10 prioritized municipalities.

- To examine suitability of groundwater as drinking water, and also to study groundwater flow mechanism by comparing the chemical components of groundwater of different aquifers in the groundwater basins or sub-basins.

- To formulate the groundwater development plan and the project implementation plan.

Test well construction followed by pumping tests commenced on August 22, 1994 and was completed on December 16, 1994. The cumulative drilling depth of the 10 test wells was 1,950 meters. The results are summarized in Table 7.2.4. The results of pumping tests are summarized in Table 7.2.5.

7.2.3 Analysis of Ion Component in Groundwater

The ion component in water quality was analyzed to evaluate the groundwater flow system (i.e., analysis of chemical compound of groundwater).

Water samples were taken from 9 test wells and the 10 points shown in the following table.The results of analysis are shown in Table 7.2.6.

Location	Type and Number
San José Pinula	Spring - 4 Shallow Well - 1
Comalapa	Spring - 2 (Small spring about 1 km from the town on the way to Panabajal, same way at the crossing point with Quebrada de Xetonex)
Sololá	Spring - 1 (spring water collected in the Existing Tank) Waterfall - 1 (Waterfall on the way to Panajachel)
San Pedro Sacatepéquez	Spring - 1 (Spring water used for irrigation in Vista Hermosa)

7.2.4 Inventory of Wells and Springs

Surveys were conducted on the present condition of the shallow wells and springs located in the vicinity of the proposed boreholes. The following items were surveyed by area.

- Number of shallow wells and springs in the vicinity of the proposed boreholes
- Water right and utilization of the above shallow wells and springs
- Hydrogeological conditions such as aquifer characteristics, water level and water quality of the above shallow wells and springs

The results are summarized in Table 7.2.7. As shown in this table, there are many shallow wells and springs in the area, which are used for domestic and agricultural purposes. However, no impact is presumed to occur on the utilization of shallow wells and springs as a result of the construction of deep wells, due to the following hydrogeological condition.

(a) The water of the existing shallow wells and springs in the area is discharged from the shallow (upper) aquifers consisting of alluvial deposits (Qa), pumice sediments (Qp) and weathered upper zone of Tertiary volcanic rocks.

(b) The screen of the deep wells are installed in the lower aquifers which belong to the formation of Tertiary volcanic rocks (Qv).The lower aquifer is the unconfined and/or semi-confined aquifer.

(c) An unsaturated dry zone separates the upper and lower aquifers.

(d) A partial leakage of groundwater will occur from the upper aquifer to the lower aquifer through the unsaturated dry zone, but the artificial leakage can be mostly avoided by cementing.

Table 7.2.1 Existing Well Record

Groundwater Basin	Aquifer	Discharge(Q=ℓ/s)			Number of Wells	Remarks : Sc(m³/day/m) of Existing Data
		Average	Maximum	Minimum		
Rio Platanos Basin ①	Tv : Tertiary Volcanics	4.44	9.46	0.76	4	
Rio Acuacapa Basin ②	Tv : Tertiary Volcanics	0.95	0.95	0.95	1	Sc(m³/day/m): 1.34
Rio Las Vacas & Lago de Amatitlan Basin ③	Qa : Alluvial Sediments	31.62	61.00	20.50	5	Sc(m³/day/m):233.05—483.84
	Qp : Pleistocene Volcanics	14.23	22.67	1.58	26	Sc(m³/day/m): 2.18—893.95
	Tv : Tertiary Volcanics	13.39	36.09	1.73	10	Sc(m³/day/m): 11.41-4980.00
	Qp/Tv:Ple./Tertiary Volcanics	14.27	28.01	5.80	12	Sc(m³/day/m): 4.24—357.89
	Br : Basement Rocks	3.41	3.41	3.41	1	Sc(m³/day/m): 3.00
Rio Pixcaya Basin ④	Tv : Tertiary Volcanics	7.52	15.14	0.32	7	
	Qp/Tv:Ple./Tertiary Volcanics	8.53	15.77	1.89	9	Sc(m³/day/m): 4.87— 78.52
Rio Guacalate Basin ⑤	Qa : Alluvial Sediments	14.24	31.55	6.62	9	Sc(m³/day/m): 55.78—544.89
	Qv : Holocene Volcanics	13.81	31.54	6.00	7	Sc(m³/day/m): 27.39— 88.09
	Tv : Tertiary Volcanics	7.89	15.14	1.70	6	Sc(m³/day/m): 2.57—817.34
	Qp/Tv:Ple./Tertiary Volcanics	9.84	17.70	3.78	4	Sc(m³/day/m): 54.11—490.32
Lago de Atitlan Basin ⑦	Qa : Alluvial Sediments	27.13	27.13	27.13	1	Sc(m³/day/m):200.34
Rio Samala Basin ⑨	Qp : Pleistocene Volcanics	20.86	68.81	3.15	32	Sc(m³/day/m): 25.18—726.91
Others	Tv : Tertiary Volcanics	7.89	17.41	1.89	7	
	Qv : Holocene Volcanics	9.27	9.27	9.27	1	
	Qp : Pleistocene Volcanics	14.51	14.51	14.51	1	
	Br : Basement Rocks	4.20	10.09	1.13	3	

Table 7.2.2 Result of Hydrogeological Survey by Municipality (1)
(Probability of New Water Sources Development)

Hydrogeological Conditions

GUATEMALA

No.	Municipality	Water Sources (l/s)			Water Quality		Hydrogeological Conditions				Class
		N	P	R	PH	Ec (25°C)	Productivity of Existing Well (l/s)		Lithofacies	Geological Structure	
1	Santa Catarina Pinula	8.67	20.51	-	6.0	140	11.04	a	a(Qp)>b	a	A
2	San Jose Pinula	-	17.78	-	6.2	92	5.68	b	b>a(Qp)	c	B
3	San Jose del Golfo	0.31	5.46	-	6.2	320	5.93	b	b·c	b	B
4	Palencia										
5	Chinautla	0.05	1.72	-	7.0	410			a(Qp)>b	a	A
6	San Pedro Ayampuc	2.03	5.18	-	7.6	587	2.59	c	b	b·c	B
7	Mixco	5.79	30.75	-	7.0	180	7.69	b	b>a(Qp)	b·c	B
8	San Pedro Sacatepequez	4.24	3.40	-	6.3	149	3.40	c	b>a(Qp)	b·c	B
9	San Juan Sacatepequez	10.00	12.00	-	7.0	509	12.00	a	b>a(Qp)	b·c	A
10	San Raymundo	-	22.08	-	7.5	305	11.04	a	a(Qp)·b·c	a·b	A
11	Chuarrancho	0.01	-	11.11	6.5	550			c	c	C
12	Fraijanes										
13	Amatitlan										
14	Villa Nueva	4.98	61.51	-	7.0	308	12.30	a	a(Qp)>b	a	A
15	Villa Canales	45.00	128.70	-	7.0	266	64.35	a	a(Qa>Qp)	a	A
16	San Miguel Petapa										

Hydrogeological Conditions

SACATEPEQUEZ

No.	Municipality	Water Sources (l/s)			Water Quality		Hydrogeological Conditions				Class
		N	P	R	PH	Ec (25°C)	Productivity of Existing Well (l/s)		Lithofacies	Geological Structure	
1	Antigua Guatemala										
2	Jocotenango	-	39.40	-	6.5	284	13.13	a	a(Qa)	a	A
3	Pastores										
4	Sumpango										
5	Sto. Domingo Xenacoj										
6	Santiago Sacatepequez										
7	San Bartolome M. Altas	0.40	13.00	-	7.0	143	6.50	b	b	b	B
8	San Lucas Sacatepequez										
9	Santa Lucia M. Altas	-	8.00	-	6.5	238	4.00	c	b>a(Qp)	c	C
10	Magdalena Milpas Altas	0.81	9.40	-	6.5	173	9.40	b	b>a(Qp)	b	B
11	Santa Maria de Jesus	1.50	6.00	-	7.0	328	6.00	b	a(Qa·Qv)	c	B
12	Ciudad Vieja	0.55	40.12	-	6.5	270	13.37	a	a(Qv)	a	A
13	San Miguel Duenas										
14	San Juan Alotenango										
15	San Antonio Aguas Cal.	8.45	1.70	-			1.70	c	b>a(Qa)	b·c	B
16	Santa Catarina Barahona	17.58	-	-					b>a(Qa)	b·c	B

1. Productivity of Existing Well
   - a: More than 10 l/sec
   - b: 5-10 l/sec
   - c: Less then 5 l/sec

2. Lithofacies
   - a: Upper Aquifer (Qa·Qp·Qv)
   - b: Lower Aquifer (Tv)
   - c: Basement Rocks

3. Geological Structure
   - a: Basin Structure
   - b: Fractured Zone, Deep Weathered Zone
   - c: Local Basin / Weathering

4. Class: Availability of Groundwater in Terms of Quantity/Quality
   - A: High
   - B: Medium
   - C: Low

Table 7.2.2 Result of Hydrogeological Survey by Municipality (2)
(Probability of New Water Sources Development)

Hydrogeological Conditions
CHIMALTENANGO

No.	Municipality	Water Sources (l/s)			Water Quality		Hydrogeological Conditions				Class
		N	P	R	PH	Ec (25°C)	Productivity of Existing Well (l/s)		Lithofacies	Geological Structure	
1	Chimaltenango										
2	San Jose Poaquil	0.93	-	2.15	6.3	91			b·c(Lim)	b	B
3	San Martin Jilotepeque	-	18.90	-	7.0	167	18.90	a	a(Qp)>b	a	A
4	San Juan Comalapa	34.00	5.80	-	6.3	140	5.80	b	a(Qp)·b	c	B
5	Santa Apolonia										
6	Tecpan Guatemala										
7	Patzun	16.90	-	-	6.5	511			a(Qp)·b	c	B
8	San Miguel Pochuta										
9	Patzicia	8.58	(10.00)	-	6.5	149			b>a(Qp)	b·c	B
10	Santa Cruz Balanya										
11	Acatenango										
12	San Pedro Yepocapa										
13	San Andres Itzapa										
14	Parramos										
15	Zaragoza	10.42	3.15	-	6.0	155	3.15	c	b>a(Qp)	b·c	B
16	El Tejar	-	30.70	-	6.5	223	10.23	a	a(Qp)·b	a	A

Hydrogeological Conditions
SOLOLA

No.	Municipality	Water Sources (l/s)			Water Quality		Hydrogeological Conditions				Class
		N	P	R	PH	Ec (25°C)	Productivity of Existing Well (l/s)		Lithofacies	Geological Structure	
1	Solola	30.4	-	-	6.0	106			a(Qp)·b	b·c	B
2	San Jose Chacaya										
3	Santa Maria Visitacion										
4	Santa Lucia Utatlan	1.88	-	-	6.0	82			b>a(Qp)	b·c	B
5	Nahuala	3.47	-	-	-	-			b·a(Qp)	b·c	B
6	Sta.Catarina Ixtahuacan	7.29	-	-	6.5	125			b>a(Qp)	b	B
7	Santa Clara la Laguna										
8	Concepcion										
9	San Andres Semetabaj	0.95	-	-	-	-			b	c	C
10	Panajachel										
11	Sta. Catarina Palopo	3.12	-	-	7.0	238			b>a(Qa)	c	C
12	San Antonio Palopo	0.42	-	-	6.5	181			b>a(Qa)	c	C
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										

1. Productivity of Existing Well
   a:More than 10 l/sec
   b: 5-10 l/sec
   c:Less than 5 l/sec

2. Lithofacies
   a:Upper Aquifer(Qa·Qp·Qv)
   b:Lower Aquifer(Tv)
   c:Basement Rocks

3. Geological Structure
   a:Basin Structure
   b:Fractured Zone
   Deep Weathered Zone
   c:Local Basin / Weathering

4. Class:Availability of Groundwater in Terms of Quantity/Quality
   A:High
   B:Medium
   C:Low

Table 7.2.2 Result of Hydrogeological Survey by Municipality (3)
(Probability of New Water Sources Development)

Hydrogeological Conditions
TOTONICAPAN

No.	Municipality	Water Sources (l/s)			Water Quality		Hydrogeological Conditions				Class
		N	P	R	PH	Ec (25°C)	Productivity of Existing Well (l/s)		Lithofacies	Geological Structure	
1	Totonicapan										
2	San Cristobal Totonic.										
3	San Francisco el Alto	6.7	-	-	6.5	68			b>a(Qa)	b	C
4	San Andres Xecul	2.3	-	-	6.0	104			b·a(Qp)	a	A
5	Momostenango	14.2	-	-	6.5	94			b	b	B
6	Santa Maria Chiquimula										
7	Santa Lucia la Reforma										
8	San Bartolo Aguas Cal.										

Hydrogeological Conditions
QUETZALTENANGO

No.	Municipality	Water Sources (l/s)			Water Quality		Hydrogeological Conditions				Class
		N	P	R	PH	Ec (25°C)	Productivity of Existing Well (l/s)		Lithofacies	Geological Structure	
1	Quetzaltenango										
2	Salcaja										
3	Olintepeque	0.94	11.13	-	6.5	207	11.13	a	a(Qp)	a·b	A
4	San Carlos Sija	2.80	-	-	6.2	100			b>a(Qp)	b·c	B
5	Sibilia										
6	Cabrican										
7	Cajola	1.84	-	-	6.0	62			a(Qa)·b	a	A
8	San Miguel Siguila										
9	San Juan Ostuncalco										
10	San Mateo										
11	Cpcion. Chiquirichapa	11.57	-	-	6.0	220			b>a(Qp)	b·c	B
12	San M. Sacatepequez	3.15	-	-					a(Qv)·b	a	A
13	Almolonga	23.87	36.90	-	6.5	356	12.30	a	b>a(Qa·Qv)	a	A
14	Cantel										
15	Huitan	0.91	-	-	-	-			b>c	c	C
16	Zunil										
17	Colomba								a(Qv)	a	A
18	San Francisco la Union	0.59	-	-	6.5	127			a(Qp)b	b·c	B
19	El Palmar										
20	Coatepeque										
21	Genova	3.03	-	-	6.0	89			a(Qv)	c	B
22	Flores Costa Cuca	2.25	(9.27)	-	6.5	98	9.27	b	a(Qv)	c	B
23	La Esperanza										
24	Palestina	-	13.89	-	6.5	146	13.89	a	b	b	B

1. Productivity of Existing Well
   a:More than 10 l/sec
   b: 5-10 l/sec
   c:Less than 5 l/sec

2. Lithofacies
   a:Upper Aquifer(Qa·Qp·Qv)
   b:Lower Aquifer(Tv)
   c:Basement Rocks

3. Geological Structure
   a:Basin Structure
   b:Fractured Zone
   Deep Weathered Zone
   c:Local Basin / Weathering

4. Class:Availability of Groundwater in Terms of Quantity/Quality
   A:High
   B:Medium
   C:Low

Table 7.2.3 Resalt of Electrical Resistivity Sounding (carried out in Phase I)

No.	Municipality	Number & Depth of E/R Sounding		Main Aquifer Characteristics			Recommended Site & Depth for Test Well		Productivity of existing Well
		Number	Depth	Lithofacies	Apparent Resistivity	Thickness	Site	Depth	
		(points)	(GL-m)		(Ωm)	(m)		(m)	(l/sec)
Gu 2	San Jose Pinula	5	180~300	Upper rhyolitic welded tuff with thin lava flows (Tv)	32~312	120	About 300ms. South of E-2 (Fig 2.1.2)	150~(200)	5.68
Gu 8	San Pedro Sacatepequez	3	360~380	Pumice sediments (Qp) and pyroclastic rocks with lava flows and waterlain sediments (Tv)	7~140	70~90	Between E-2 and E-3 (Fig 2.1.3)	200	3.40
				Andesitic/Basaltic fractured lava flow (Tv)	532~600	250±			–
Sa11	Santa Maria de Jesus	8	180~340	Andesitic/Basaltic fractured lava flow with pyroclastic rocks (Qv)	700~1,460	200±	E-3 point (Fig 2.1.4)	150~(200)	6.00
Ch 3	San Martin Jilotepeque	4	260~320	Tuffaceous sandstone/ Sandstone with tuffbreccia and tuff (Miocene)	26~504	70~90	About 100ms. S.W.of E-2 (Fig 2.1.5)	200	18.90
Ch 4	San Juan Comalapa	5	260~320	Dacitic/Andesitic tuffbreccia with lava flows and tuffs (Tv)	116~675	300±	About 140ms. South of E-2 (Fig 2.1.6)	200	5.80
So 1	Solola	8	260~360	Dacitic/Andesitic/Basaltic fractured lava flow with pyroclastic rocks (Tv)	405~1,125	90~200	E-4 point (Fig 2.1.7)	200	–
So 4	Santa Lucia Utatlan	5	260~360	Dacitic/Andesitic lava flow with pyroclastic rocks (Tv)	410~720	260	Between E-1 and E-3 (Fig 2.1.8)	200	–
To 5	Momostenango	2	300~340	Andesitic/Basaltic fractured lava flow with pyroclastic rocks (Tv)	568~1,530	200±	About 500ms. N.E.of E-1 (Fig 2.1.9)	(200)~250	–
Qu18	San Francisco la Union	6	340~400	Andesitic/Basaltic fractured lava flow with pyroclastic rocks (Tv)	448~1,600	250±	About 350ms. East of E-2 (Fig 2.1.10)	(200)~250	–

Table 7.2.3 Resalt of Electrical Resistivity Sounding (carried out in Phase II)

No.	Municipality	Number & Depth of E/R Sounding		Main Aquifer Characteristics		Recommended Drilling Depth
		Number	Depth	Lithofacies	Apparent Resistivity	
		(points)	(GL-m)		(Ωm)	(m)
Gu 3	San Jose del Golfo	3	200~240	Pyroclastic rocks with lava flow (Tv)	56~416	150
So 5	Nahuala	3	140~180	Pyroclastic rocks with lava flow (Tv)	23~700	200
Qu 4	San Carlos Sija	3	300	Andesitic lava flow (Tv)	53~700	200
Qu 7	Cajola	3	320~340	Pumice sediments (Qp) and Andesitic lava flow (Tv)	840~1,500	200
Qu21	Genova	3	200~300	Pyroclastic (Volcanimud) flow (Qv)	20~140	180
Qu22	Flores Costa Cuca	4	140~300	Pyroclastic (Volcanimud) flow (Qv)	63~344	180
To 5	Momostenango	1	160	Andesitic lava flows with Pyroclastics	68~1,080	150

Table 7.2.4 Results of Test Well Drilling Works

Nobre de Pozo (Well Name)	San Jose Pinula	San Pedoro Sacatepequez	Santa Maria de Jesus	San Martin Jilotepeque	San Juan Comalapa	Solola	Santa Lucia Utatlan	Momostenango	San Fransisco la Union	Genova
1. Profundidad (Well depth) (m)	180	250	212	196	215	170	199	183	190	152
2. Latitud(North Latitude) Longitud(West Longitude)	14° 32′ 29″ 90° 25′ 10″	14° 41″ 05″ 90° 39′ 08″	14°29′10″ 90°41′45″	14° 47′ 05″ 90° 47′ 10″	14° 44′ 44″ 90° 53′ 14″	14° 47′ 35″ 91° 10′ 58″	14° 46′ 40″ 91° 16′ 40″	15° 02′ 49″ 91° 25′ 20″	14° 55′ 15″ 91° 32′ 37″	14° 37′ 17″ 91° 49′ 58″
3. Elevacion (Elevation) (m)	1728	2090	1880	1760	2090	2370	2408	2216	2714	380
4. Diametro del ademe (Diameter of Casing Pipes)	8″	8″	8″	8″	8″	8″	8″	8″	8″	8″
5. Perforado por (Drilled by)	JICA Study Team									
6. Fecha de inic.y final de la perfor (Biginning and Completion Date of Drilling)	Aug.24 ~Sep.30 1994	Aug.22 ~ Sep.22 1994	Sep. 3 ~Oct.11 1994	Sep. 1 ~Oct. 3 1994	Oct.16 ~Nov.20 1994	Oct.13 ~Nov. 9 1994	Oct.16 ~Nov.12 1994	Nov.18 ~Dec. 4 1994	Nov.14 ~Dec.16 1994	Nov.15 ~Dec. 4 1994
7. Tiempo que tomo (Spent days)	38	38	39	33	36	28	28	17	33	20
8. Posicion de rejilla(Screen Position) 1) Tipo Puente(Bridge Type) (Nivel de tierra : -m) (Ground Level : -m)	33.5~ 39.6 42.7~ 54.9 91.4~ 97.5 103.6~109.7 140.2~146.3	182.0~189.0 213.4~219.5 231.6~237.7	140.2~146.3 182.9~189.0 201.2~207.3	115.8~121.9 134.1~146.3 164.6~182.9	109.7~121.9 128.0~140.2 152.4~158.5 176.8~189.0	152.4~170.2	115.8~121.9 152.4~164.6 182.9~190.2	85.3~103.6 126.5~132.6 134.1~140.2 146.3~158.5	79.2~103.6 115.8~152.4	103.6~121.9 134.1~146.3
2) Tipo Johnson(Johnson Type)	21.3~ 27.4 79.3~ 85.4 115.8~121.9	164.6~182.9	152.4~164.6	82.4~ 91.5 103.6~109.7 146.3~152.4	164.6~170.7		170.7~182.9	164.8~170.7 176.8~179.8	103.61~15.82 152.41~76.78 182.91~85.9	91.4~103.6 146.4~149.4
3) Ranurado(Slot Type)	97.5~103.6 125.0~131.1 134.1~140.2 158.5~164.6	109.7~115.8 121.9~128.0 195.1~201.2 237.7~244.7	82.3~ 94.5 137.2~142.6 146.3~152.4 164.6~167.6 170.7~182.9 189.0~201.1	97.5~103.6 121.9~134.1 152.4~164.6	30.4~36.6 73.1~85.3 91.4~103.6 146.3~152.4 189.0~201.2 210.3~213.4	109.7~131.1 140.2~143.3 149.4~152.4	146.3~152.4			85.4~91.5
9. Longitud de rejilla(Screen Length) 1) Tipo Puente(Bridge Type) (m)	36.6	18.3	18.3	36.6	42.7	17.8	25.6	42.7	61.0	30.5
2) Tipo Johnson(Johnson Type)(m)	18.3	18.3	12.2	15.2	6.1	0	12.2	9.1	39.6	15.1
3) Ranurado(Slot Type) (m)	21.3	18.3	48.6	30.5	51.9	27.5	6.1	0	0	6.1
10. Componente quimico de Agua (Water quality) ① pH	7.0	6.8	7.0	7.2	5.7	7.2	7.0	7.0	-	8.0
② Temperatura de agua : ℃) (Temperature of Water : ℃)	20.0	23.4	19.8	20.3	19.8	21.2	16.6	20.0	-	21.5
③ Conductividad (μs/cm) (Conductivity : μs/cm)	263.0	198.3	298.0	563.0	92.0	191.2	154.7	53.0	-	182.0

Tabie 7.2.5 Results of Pumping Test

Nobre de Pozo (Well Name)	San Jose Pinula	S.P.Saca-tepequez	S.Maria de Jesus	S.M.Jilo-tepeque	San Juan Comalapa	Solola	Santa Lu. Utatlan	Momoste-naogo	S.F.la Union	Genova
1. Profundidad (Well depth) (m)	180	250	212	196	215	170	199	183	190	152
2. Longitud de rejilla (Total Screen Length) (m)	79.27	60.97	81.68	82.32	100.6	48.78	43.91	59.9	100.5	51.82
3. Formation del Aquifero principal (Formation of Main Aquifer)	Tv	Tv	Qv	Tv	Tv	Tv	Tv	Tv	Tv	Qv
4. Fecha de Bombeo (Pumping Test Date)	Oct. 5 1994	Oct. 7 1994	Nov. 2 1994	Oct.28 1994	Nov.30 1994	Nov.19 1994	Nov.25 1994	Dec. 8 1994	—	Dec.11 1994
5. Nivel estatico de Agua (Static Water Level) (G.L.-m)	6.84	43.71	163.16	80.35	28.94	71.63	131.54	53.50	—	29.85
6. Caudal (GPM)	495	320	282	401	250	390	162	200		201
(Pumping Rate) (m³/day)	2698	1744	1537	2185	1363	2125	883	1090		1096
7. Abatimiento (Drawdown) (m)	11.9	67.29	3.53	9.63	156.4	54.86	9.13	70.3	—	88.36
8. Capacidad Especifica : C.F. (Specific Capacity : Sc)(m³/day/m)	227	26	435	227	8.7	39.7	96.7	15.5	—	12.4
9. Transmisibilidad (Transmissivity) (m³/day) a. Theis	299	33	150	510	5.51	25.22	228	15.43	—	10.74
b. Jacob	180	37	612	333	5.31	25.09	359	7.12	—	9.55
c. Recuperacion (Recovery)	190	68	937	834	7.34	35.35	538	8.67	—	15.42
Promedio(Average)	223	46	567	559	6.05	28.55	375	10.41	—	11.99

Table 7.2.6 Results of Ion Component Analysis

Location	Ca	Mg	Na	K	Cl	SO4	Alcalinity pH 8.3	pH 4
TEST DRILLING WELLS								
1 S.P.SACATEPEQUEZ	16.29	6.94	21.8	8.67	8.37	0	0	97.7
2 S.J.PINULA	52.12	24.5	11.36	12.12	18.83	0	0	146.55
3 S.M. DE JESUS	44.79	20.33	17.11	6.18	9.76	0	0	140.91
4 S.M.JILOTEPEQUE	22.8	9.82	17.1	7.92	8.37	0	0	112.73
5 S.J.COMALAPA	14.66	6.35	9.16	3.11	7.67	0	0	74.09
6 SOLOLA	16.29	7.93	16.23	7.21	8.37	0	0	111.13
7 S.L.UTITLAN	20.36	8.43	12.32	4.16	6.28	0	0	76.15
8 MOMOSTENANGO	13.03	2.28	7.92	5.66	4.88	0	0	53.51
9 S.F. LA UNION								
10 GENOVA	19.55	12.6	22.36	16.11	13.25	0	12.35	158.47
OTHERS								
S.J.PINULA								
SPRING NO.1	13.03	5.75	5.13	0.86	8.37	0	0	48.85
SPRING NO.2	42.35	20.44	15.1	11.03	36.26	0	0	84.55
SPRING NO.3	19.55	8.63	12	12.3	22.32	0	0	46.97
SPRING NO.4	16.29	8.43	11.1	1.35	11.16	0	0	56.36
DUG WELL	50.49	31.81	18.7	3.9	65.55	0	0	92.06
COMALAPA								
SPRING NO.1	17.92	8.53	6.46	4.58	9.07	0	0	61.74
SPRING NO.2	13.85	5.06	13.7	4.92	10.46	0	0	74.09
SOLOLA								
EXISTING TANK	30.95	1.88	6.74	3.11	9.76	0	0	59.68
WATER FALL	30.95	11.11	16.6	5.11	9.76	36.92	0	92.61
S.P. SACATEPEQUEZ								
SPRING	21.28	13.69	5.97	2.31	22.32	0	0	100.84

Table 7.2.7 Existing Shallow wells and Springs

Municipality	Shallow wells						Springs			
	Number	W/Level (GL-m)	Well depth (m)	W/Quality	W/Right	Water Use	Number	W/Quality	W/Right	Water Use
S. J. Pinula	3	3-25	-	Poor	Private	Agriculture-1 Bathing and washing-2	8	Poor	Public	Bathing & washing
S. P. Sacatepéquez	10	1-10	2.6-9	Good	Private	Agriculture-2 Domestic use-8	10	Good-7 Poor-3	Public-5 Private-5	W/S for city-5 Agriculture-3 Domestic use-2
S. M. de Jesús	0	-	-	-	-	-	0 *-1	-	-	-
S. M. Jilotepeque	3	3-20	6-22	Good-2 Poor-1	Private	Domestic use-2 Stand by-1	5	Good	Public-4 Private-1	Domestic use
S. J. Comalapa	26	3.6-10	4-12	Quite-good	Private	Agriculture-2 Domestic use-24	1	Quite-good	Public & private	Washing Drinking & domestic use
Sololá	3 *-3	0.6-26	1.6-28	Quite-good	Private	Aguriculture-1 Drinking & domestic use-1 Washing, bathing & cleaning-1	3	Quite-good	Public-3	Drinking & domestic use Agriculture
S. L. Utatlán	4	8.5-14.5	10-17	Good-1 *-4 Quite-good-3	Private	Drinking & domestic use-4	2	Good-2	Public-1 Private-1	Drinking Washing & domestic use
Momostenango	15<	3-16	6.5-18	Good & quite-good	Private	Drinking & domestic use	1	Quite-good	Public	Drinking
S. F. la Unión	8	5-18	9-22	Quite-good	Private-8 Public-1	Drinking & domestic use Only drinking	2	Quite-good	Public	Drinking, washing & domestic use
Génova	200	5-10	7-15	Quite-good	Private	Drinking & domestic use	0	-	-	-

*-1: One spring existed, but it has already dried.
*-2: People drink raw water - good, boiled water - quite-good and do not use for drinking - poor
*-3: One was used until 1993, but it has alredy dried.
*-4: However, 2 % of population have stomach problems every month, and ca. 25 children/month have diarrhea.

LEYENDA (LEGEND)

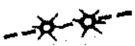
A. Estratigrafia y Litologia (Stratigraphy and Lithology)

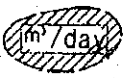
Edad Geologica (Geologic Age)	Unidades Hidrogeologicas (Hydrogeologic Units)			Litologia (Lithology)
Cuaternario (Quaternary)	Acuifero Super (Upper Aquifer)	Qa	Sedimentos Aluviales (Alluvial Sediments)	Sedimentos secundarios de materiales volcanicos (Secondary sediments of volcanic materials)
		Qv	Volcanicos Holocenicos (Holocene Volcanics)	Flujos de lava, lodo, tobas y cenizas (Lava flows, mud flows, tuffs and ashes)
		Qp	Volcanicos Pleistocenicos (Pleistocene Volcanics)	Sedimentos de Pomez con depositos lacustres (Pumice sediments with lake deposits)
Terciario (Tertiary)	Acuifero Infer (Lower Aquifer)	Tv	Volcanicos Terciarios (Tertiary Volcanics)	Flujos de lava y materiales piroclasticos (Lava flows and pyroclastic materials)
				Latita / Dacita y toba soldada (Latitic / Dacitic welded tuffs)
Cretacico (Cretaceous)	Rocas de Basamento (Basement Rocks)		Rocas Intrusivas (Intrusive Rocks)	Graniodiorita, cuarzo diorito etc. (Granodiorite, quartz diorite, etc.)
		Kc	Serie Cretacico (Cretaceous Series)	Rocas calcareas y rocas volcanicas (Calcareous rocks and volcanic rocks)
Paleozoico (Paleozoic)		Pm	Rocas Metamorficas (Metamorphic Rocks)	Pilita y Esquisto (Phyllite and schists)

B. Estructura Geologica (Geological Structure)


Sistema de falla, lineamientos y zonas de fractura.
(Faults, lineaments and fractured zone)

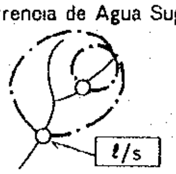

Paredes de calderas y crateres
(Caldera and crater walls)


Conos y cadenas volcanicas
(Volcanic cones and chains)



Cuenca de agua subterránea usada para la evaluación tentativa : Potencial presumido
(Groundwater basin used for the tentative evaluation : Presumed potential)

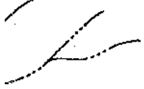
C. Ocurrencia de Agua Superficial (Occurrence of Surface water)



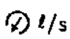
Cuenca y sub-cuenca de rio
(River basin and Sub-basin)

Descarga en estacion seca (1994)
(Discharge in dry season)


Corriente perenne
(Perenial stream)

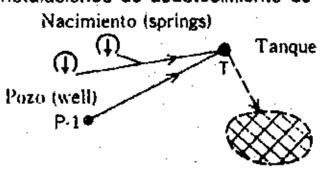

Corriente estacional
(Seasonal stream)


Area humeda o pantanosa
(Marsh or swampy area)



Manantial : Descarga en la estacion seca 1994
(Spring Discharge in dry season)

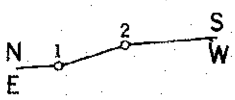
D. Instalaciones de abastecimiento de agua existentes (Existing water supply facilities)



Tanque de distribucion (Distribution tank)

Area de la Ciudad (City area)

E. Otros (Others)



Puntos de Sondeos de Resistividad y Seccion transversal hidrologica
(Electrical resistivity sounding points and hydrological cross section)

Perforación Exploratoria de JICA
(JICA test drilling well)

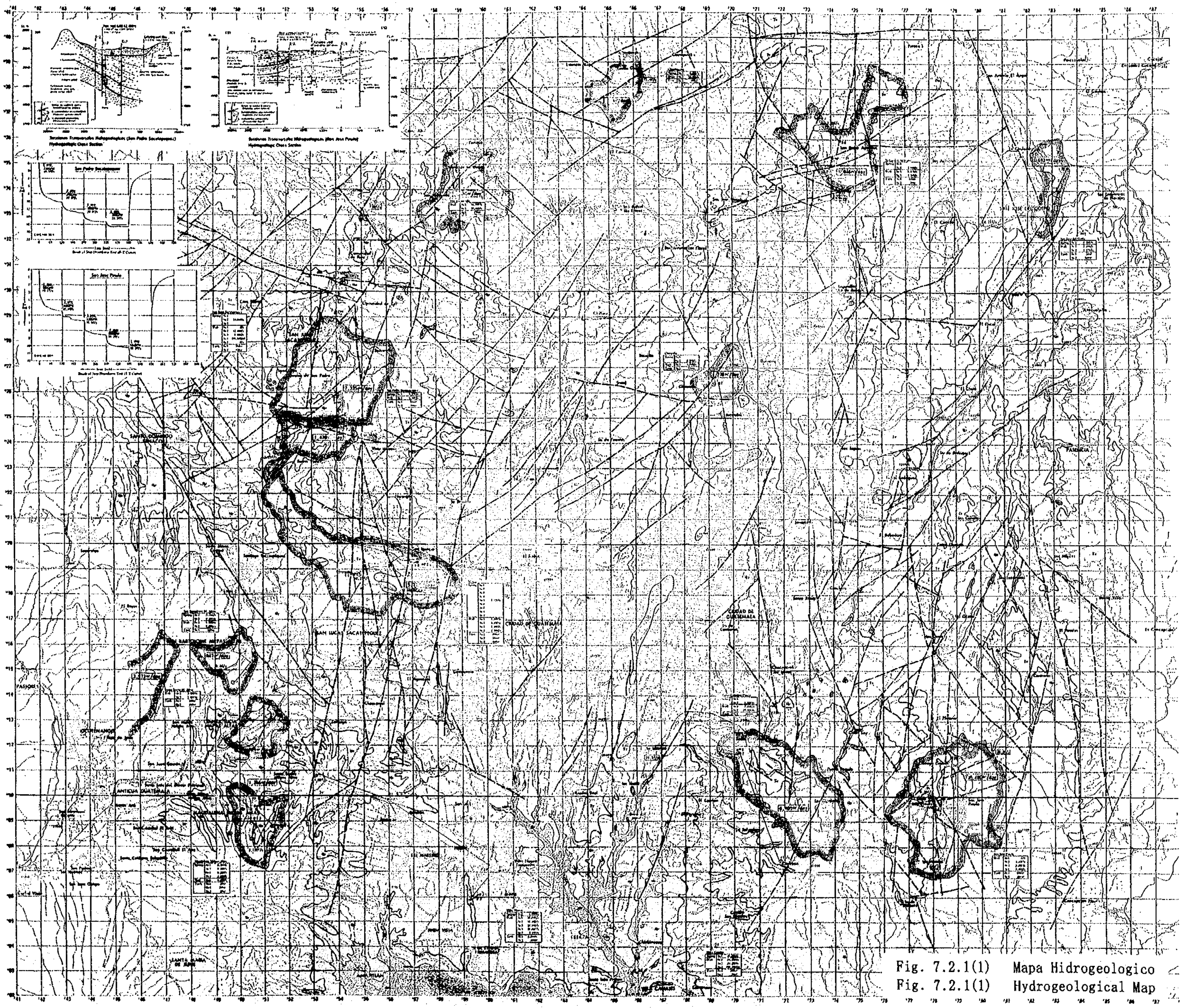


Fig. 7.2.1(1) Mapa Hidrogeologico
Fig. 7.2.1(1) Hydrogeological Map

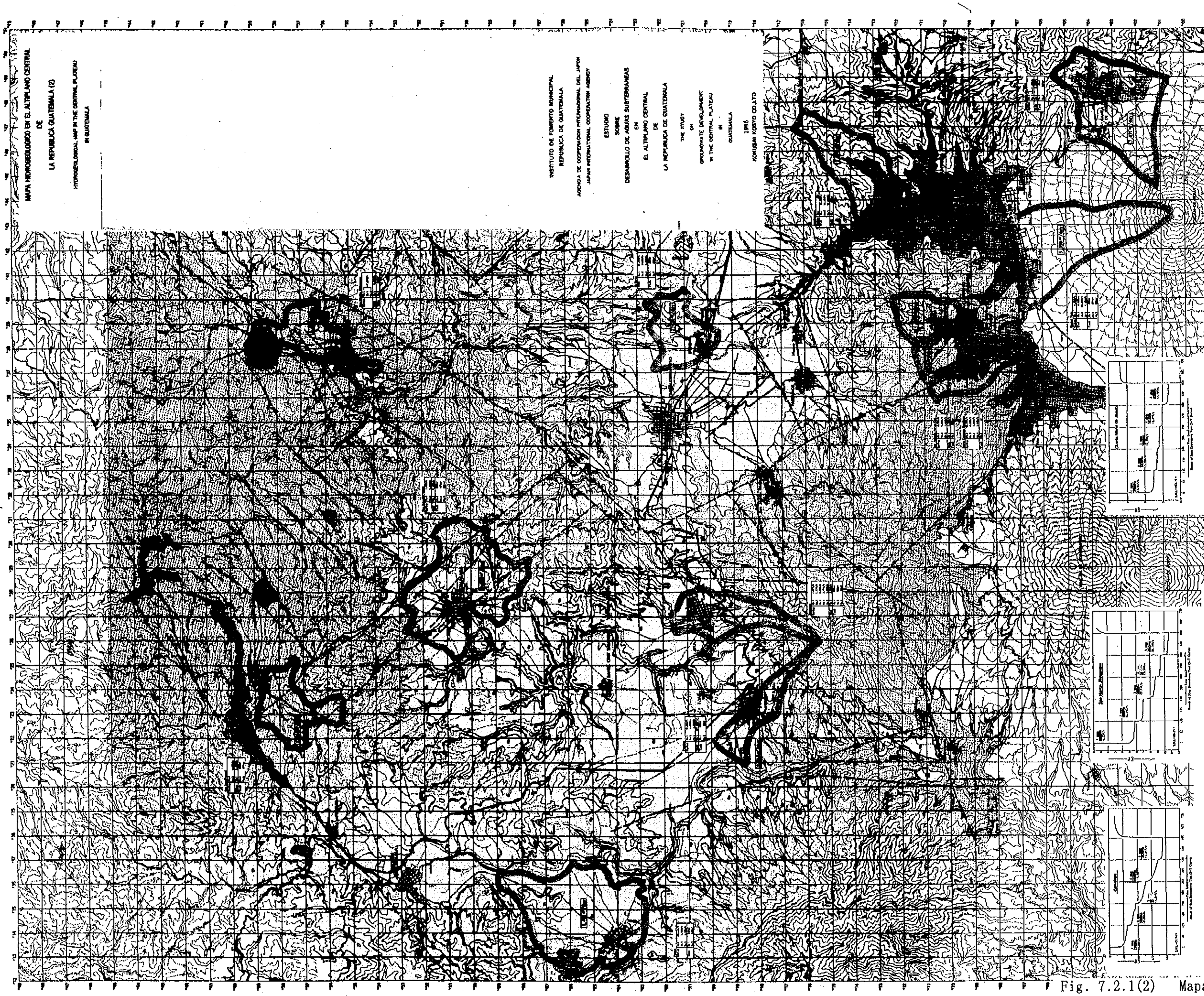


Fig. 7.2.1(2) Mapa Hidrogeologico

Fig. 7.2.1(2) Hydrogeological Map

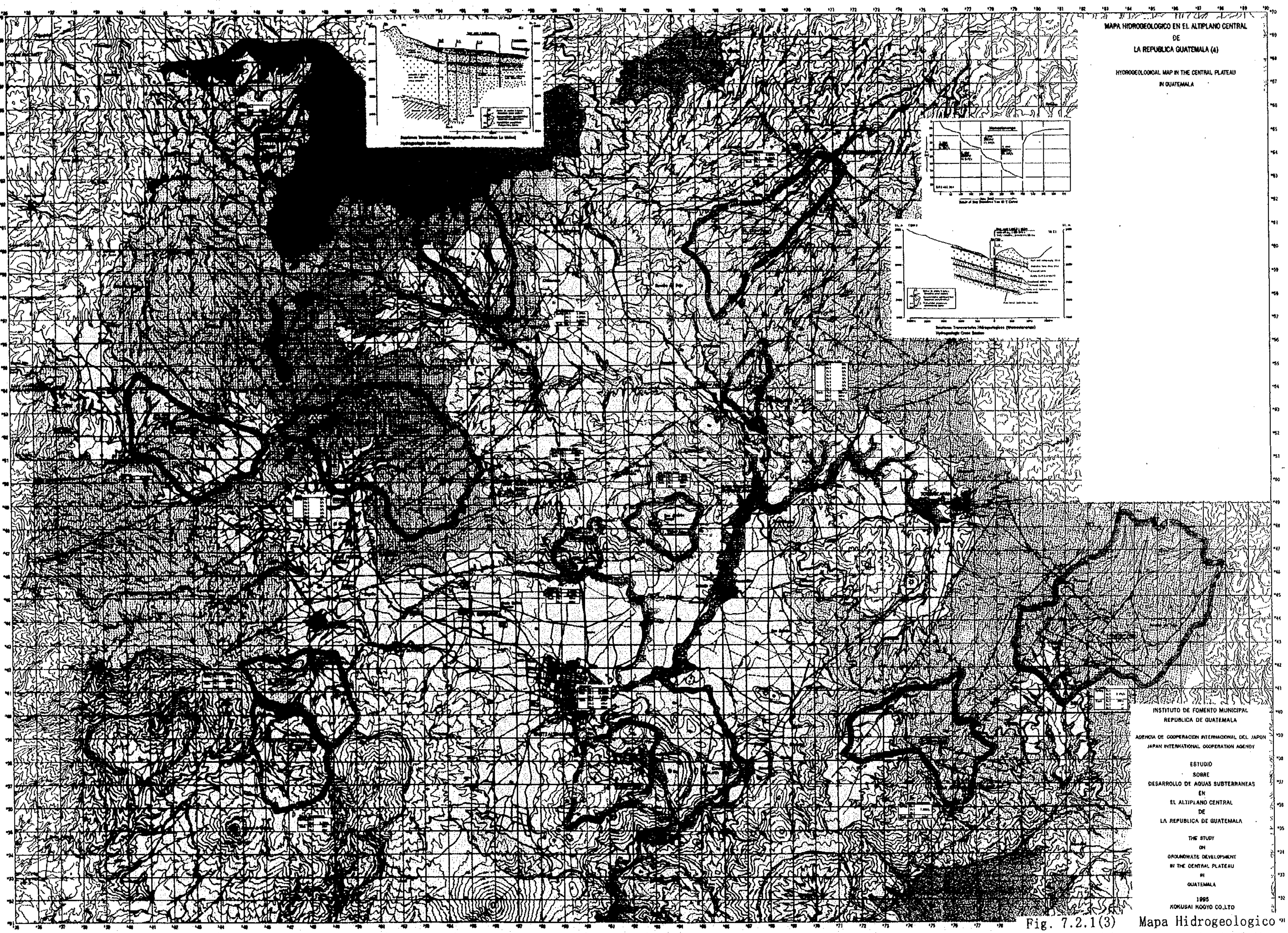


Fig. 7.2.1(3) Mapa Hidrogeologico

Fig. 7.2.1(3) Hydrogeological Map

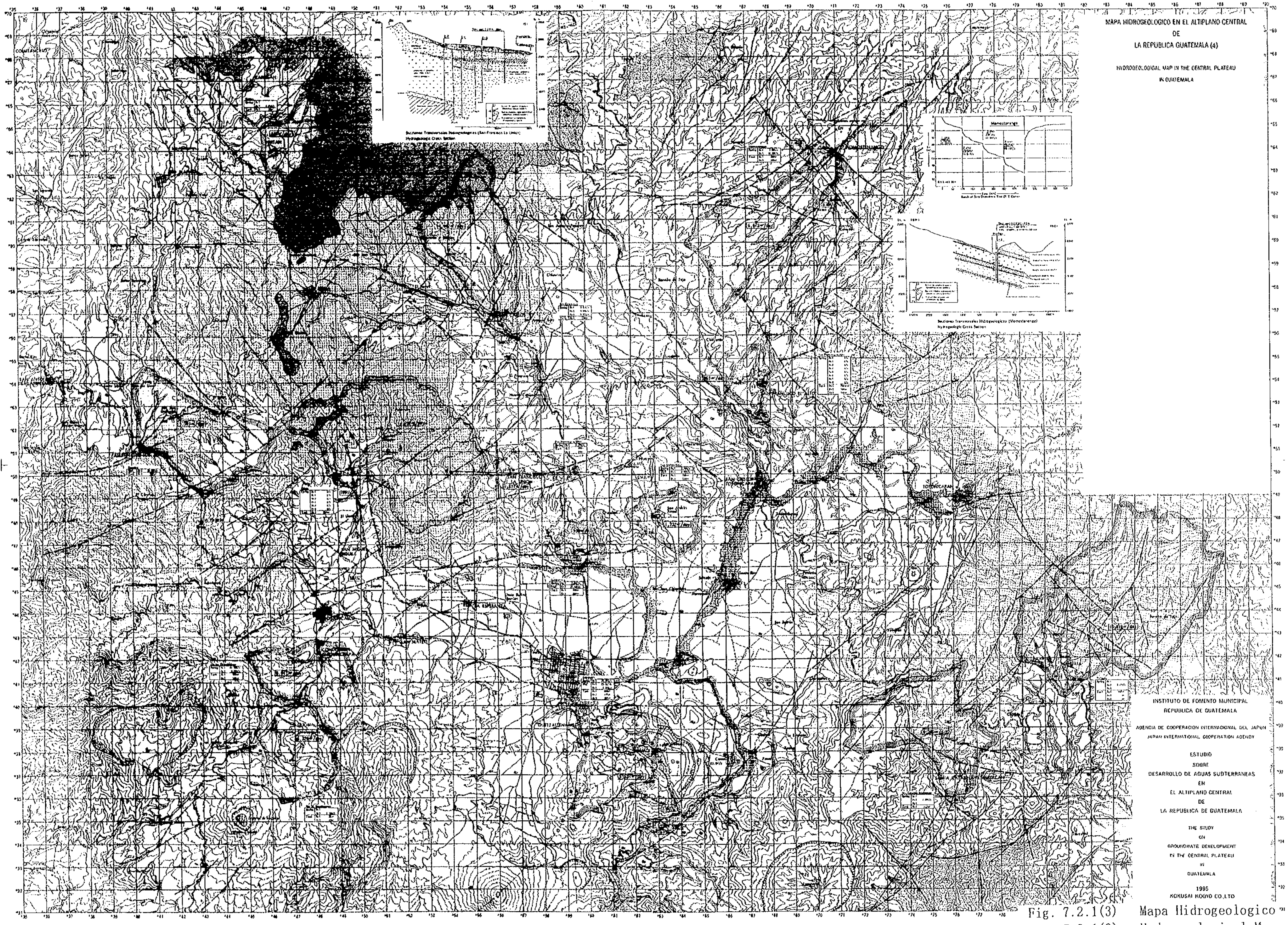


Fig. 7.2.1(3) Mapa Hidrogeologico

Fig. 7.2.1(3) Hydrogeological Map

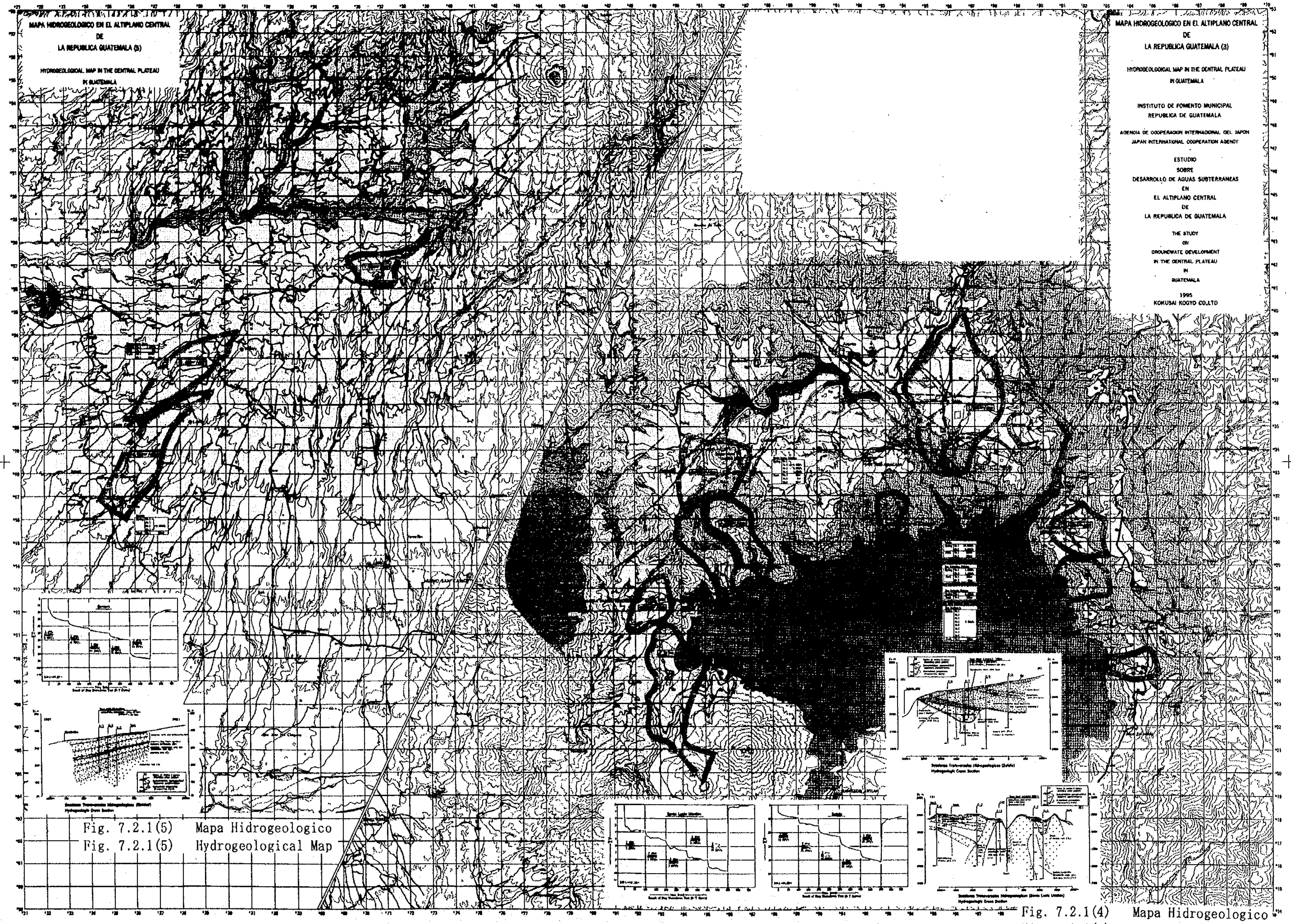


Fig. 7.2.1(5) Mapa Hidrogeologico
Fig. 7.2.1(5) Hydrogeological Map

Fig. 7.2.1(4) Mapa Hidrogeologico
Fig. 7.2.1(4) Hydrogeological Map

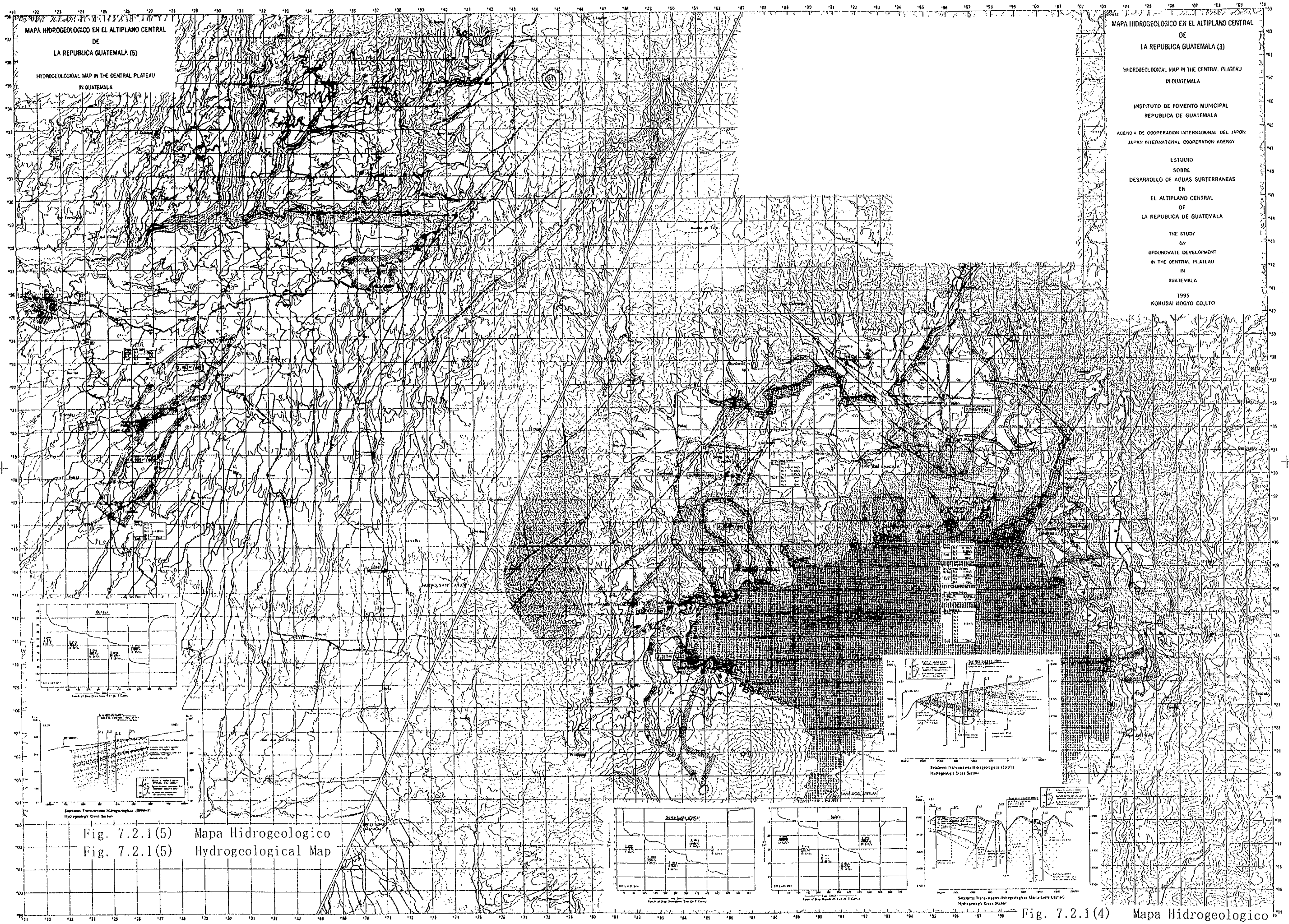


Fig. 7.2.1(5) Mapa Hidrogeologico
Fig. 7.2.1(5) Hydrogeological Map

Fig. 7.2.1(4) Mapa Hidrogeologico
Fig. 7.2.1(4) Hydrogeological Map

7.3 Groundwater Development Potential

7.3.1 Estimation of Groundwater Development Potential

Little experience has been accumulated on the groundwater development in the Study Area. Hence, insufficient data on hydrogeological information like drilling logs, results of pumping tests and continuous monitoring of the groundwater level and rainfall preclude detailed evaluation of the development scale.

Groundwater development in the Study Area will have to be based on the upper and lower aquifers in the Pleistocene volcanic and the Tertiary volcanic rocks, respectively.

The aquifer in the Pleistocene volcanic is expected to be especially productive, but its thickness is insufficient for a stable extraction. Therefore, the Tertiary volcanic will have to be the principal target for future water source development.

For tentative potential evaluation, two methods were applied: the assumed infiltration ratio into the aquifer by geological condition, and the base flow in the dry season.

(1) Estimation of infiltration ratio

Annual rainfall in the municipalities was estimated from the rainfall record. When the municipality did not have a rainfall station, a neighboring station was chosen and its records were adopted for analysis.

Each recharge area was demarcated on the topographic map with a scale of 1:50,000. This area was used for the calculation of groundwater potential. The river basin is basically used as recharge area, but when the river basin is very big, like Villa Canales and Villa Nueva, 50 km2 is applied as the upper bound.

Infiltration factor was applied in the calculation of the groundwater potential. This factor is the ratio of the rainfall that has infiltrated into the aquifer. Adopted to represent this factor is the value indicated in the report "Plan Maestro de Riego y Drenaje, Caracterización Hidroclimática & Hidrogeologia" by Ministerio de Agricultura, Ganadería y Alimentación in 1990. The assumed aquifer recharge from the annual rainfall by geology is as follows.

- Basement Rock 2%
- Tertiary Volcanic Rocks (Tv) 10%
- Pleistocene Volcanic (Qp) 15%
- Alluvial Deposit (Qa) 10%
- Holocene Volcanic (Qv) 15%

Therefore, the annual groundwater potential is calculated as follows:

Annual Groundwater Potential	=	Annual Rainfall	x	Recharge Area	x	Infiltration Factor

(2) Estimation by river base flow

The value of a river base flow in the dry season is generally regarded as groundwater recharge. Therefore, the groundwater potential is simply estimated from this value and the recharge area.

From the results of the discharge records during 1960 - 1980 and spot measurements in April - May of 1994, specific discharge of the base flow is estimated at about 5 ℓ/sec/km2 in most of the Study Area which has about 1,000 mm of annual rainfall, and around 10 ℓ/sec/km2 in the southern part of Quetzaltenango which has an annual rainfall of about 3,000 mm.

Annual Groundwater Potential	=	Base Flow	x	Recharge Area

Table 7.3.1 shows the results of both calculations. These values represent a tentative evaluation, and the values calculated by infiltration are shown in the hydrogeological map (Fig.7.2.1). This potential should be revised with the monitoring data indicated in Section 7.3.3.

This potential is calculated for the recharge area of each municipality, and corresponds to the total production in the area.

The yielding capacity of one well is estimated at about 5 ℓ/sec, the same as the value of base flow, because 1 km^2 is generally regarded as the unit of the recharge area for one well, and, this capacity corresponds to the records of existing wells.

However, the test drilling results showed that the capacity of one well is much higher than this value, as described in Section 7.2., because of the peculiar hydrogeological features of the area, specially of the fault system.

Detailed development potential of the 10 municipalities selected for the Feasibility Study is discussed in the next section.

7.3.2 Groundwater Development Strategy of 10 Municipalities

Based on the groundwater development potential and the results of test drilling conducted at 10 municipalities, the groundwater development strategy was formulated by municipality, as summarized in Table 7.3.2.

7.3.3 Groundwater Level and Monitoring Plan

(1) Objectives of Monitoring

Groundwater resource development in this Study Area is in the initial stage, therefore, no monitoring system has been installed in any of the candidate municipalities.

The objectives of the groundwater monitoring required in the Study Area are summarized below:

- to collect basic hydrological data to analyze water balance in the hydrogeological basin, and to evaluate future groundwater development potential

- to collect basic hydrological and water quality data, as well as their long term variations, for a rational river basin management

(2) Installation of Groundwater Level and Rainfall Recorders

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

Table 7.3.1 Tentative Evaluation of the Groundwater Development Potential (1/2)

No.	Department	Municipality	A.RAIN (mm)	P.Area (km2)	Geology Type	Percentage BR	Tv	Qv	Qp	Qa	Potential (m3/day) by filtration	by base flow
1	Guatemala	Chinautla	1135	3	TVQP	10	-	-	90	-	1278	1296
2		Chuarrancho	1063	4	BR	-	-	-	-	-	-	-
3		Mixco	1197	16	TVQP2	-	80	-	20	-	5772	6912
4		San José del Golfo	1063	3.5	BR	40	60	-	-	-	693	1512
5		San José Pinula	1650	16	TVQP2	-	10	-	90	-	10488	6912
6		San Juan Sacatepéquez	1032	14	BR	70	-	-	30	-	2335	6048
7		San Raymundo	1122	7	BR	10	30	-	60	-	2626	3024
8		Santa Catarina Pinula	1343	12	TVQP	-	10	-	90	-	6400	5184
9		Villa Canales	1524	50	TVAL	-	60	-	40	-	25052	21600
10		Villa Nueva	1213	50	TVQP	-	-	-	100	-	24925	21600
11		San Pedro Ayampuc	1063	10	BR	80	20	-	-	-	1048	4320
12		San Pedro Sacatepéquez	1032	4	TVQP2	-	40	-	60	-	1470	1728
13	Sacatepéquez	Ciudad Vieja	992	15	QV	-	30	40	-	40	5300	6480
14		Jocotenango	1031	11.5	TVAL	-	80	-	20	-	3573	4968
15		Magdalena Milpas Altas	1031	4		-	60	-	40	-	1356	1728
16		San Antonio Aguas C.	992	5	TVAL	-	90	-	-	10	1359	2160
17		San Bartolome M. Altas	1031	3	TV	-	100	-	-	-	847	1296
18		Santa Lucía M. Altas	1031	2.5	TVQP2	-	20	-	80	-	989	1080
19		Santa María de Jesus	1229	14	QV	-	-	100	-	-	7071	6048
20		Santa Catarina Barahona	992	3	TVAL	-	70	-	-	30	815	1296
21	Chimaltenango	Comalapa	1414	16	TVQP2	-	40	-	60	-	8058	6912
22		El Tejar	1234	6	TVQP	-	60	-	40	-	2434	2592
23		Patzicia	1283	5.5	TVQP2	-	30	-	70	-	2610	2376
24		Patzun	1283	18	TVQP2	-	-	-	100	-	9491	7776
25		San Jose Poaquil	1272	6.5	TV	-	100	-	-	-	2266	2808
26		San Martín Jilotepeque	1272	7		-	-	-	100	-	3659	3024
27		Zaragoza	1283	7	TVQP2	-	60	-	40	-	2953	3024

Table 7.3.1 Tentative Evaluation of the Groundwater Development Potential (2/2)

No.	Department	Municipality	A.RAIN (mm)	P.Area (km2)	Geology Type	Percentage BR	Tv	Qv	Qp	Qa	Potential (m3/day) by filtration	by base flow
28	Sololá	Sololá	1081	18.5	TVQP2	-	10	-	90	-	7945	7992
29		Nahualá	1341	41	TVQP2	-	90	-	10	-	15816	17712
30		San Andres Semetabaj	1010	4	TVQP2	-	50	-	50	-	1384	1728
31		San Antonio Palopo	1010	2.5	TV	-	70	-	30	-	796	1080
32		San Juan la Laguna	1010	13		-	50	-	40	10	4317	5616
33		San Marcos la Laguna	1010	6	TVAL	-	90	-	-	10	1660	2592
34		San Pablo la Laguna	1010	6	TVAL	-	90	-	-	10	1660	2592
35		Santa Catarina Ixtahuaca	1341	16	TV	-	70	-	30	-	6760	6912
36		Santa Catarina Palopo	1010	3.5	TV	-	90	-	10	-	1017	1512
37		Santa Clara la Laguna	1010	3	TVQP2	-	10	-	90	-	1204	1296
38		Santa Cruz la Laguna	1010	2	TVAL	-	5	-	95	-	816	864
39		Santa Lucia Utatlán	1341	5	TVQP2	-	30	-	70	-	2480	2160
40	Totonicapan	Momostenango	1341	18	TV	-	100	-	-	-	6613	7776
41		San Andres Xecul	843	6	TVQP	-	50	-	50	-	1732	2592
42		San Francisco el Alto	1341	4.5	TVQP2	-	50	-	50	-	2067	1944
43	Quezaltenango	Almolonga	1594	11	TVQP	-	70	-	30	-	5524	4752
44		Colomba	3423	5	QV	-	-	100	-	-	7034	2160
45		Concepcion Chiquirichapa	2100	10.5	TVQP2	-	70	-	30	-	6947	4536
46		Cajola	1057	34	TVQP	-	95	-	5	-	10092	14688
47		Flores Costa Cuca	3640	9	QV	-	-	100	-	-	13463	3888
48		Génova	3640	10	QV	-	-	100	-	-	14959	4320
49		Huitan	936	5.5	BR	50	50	-	-	-	846	2376
50		Olintepeque	843	3.5	TVQP	-	70	-	30	-	930	1512
51		Palestina de los Altos	1027	17	TV	-	70	-	30	-	5501	7344
52		San Carlos Sija	1027	18	TVQP2	30	30	-	40	-	4862	7776
53		San Francisco la Union	843	6	TVQP2	-	30	-	70	-	1871	2592
54		San M. Sacatepéquez	2100	10	TVQP	-	80	-	20	-	6329	4320

Table 7.3.2 Groundwater Development Potential of and Strategies for the 10 Municipalities

Municipality	Groundwater Development Potential (m^3/day)	Water Demand in 2010	Outline of Test Drilling and Pumping Test Results				Groundwater Development Strategy	Remaining Potential (m^3/day)
		Supply Shortage (m^3/day)	Geological Composition of the Major Aquifer	Static Water Level (m – G.L)	Pumping Rate (m^3/day)	Drawdown		
San José Pinula (Gu 2)	10,488	3,095 2,277	Basaltic to rhyolitic fractured lava (Tv), and gravel beds with quartz sand	6.84	2,696	11.90	Pumping of 2,277 m^3/day from the well formerly used as a test well	7,393
San Pedro Sacatepéquez (Gu 8)	1,470 – 1,728	1,572 1,278	Partially fractured basaltic to andesitic lava (Tv)	41.56	1,744	67.29	Pumping of 1,278 m^3/day from the well formerly used as a test well	–290 (–32)
Santa María de Jesus (Sa 11)	7,071	2,308 1,617	Volcanic rocks (Qv) and lake deposits (Qa) which fill up the crater. Basement is impermeable (Tv).	163.16	(3,041) 1,537	(11.84) 3.53	Pumping of 1,617 m^3/day from the well formerly used as a test well	4,763
San Martín Jilotepeque (Ch 4)	3,659	1,855 1,337	Fractured and auto–brecciated andesitic to basaltic lava (Tv)	82.00	2,163	9.63	Pumping of 1,337 m^3–day from the well formerly used as a test well	2,109
San Juan Comalapa (Ch 4)	8,058	2,493 1,954	Partially fractured welded tuff (Tv)	28.94	1,363	156.40	Pumping of 1,000 m^3/day each from the well to be constructed and the well formerly used as a test well	4,265
Sololá (So 1)	7,945	4,799 2,172	Partially fractured welded tuff (Tv)	71.63	2,125	54.86	Pumping of 1,100 m^3/day each from the well to be constructed and the well formerly used as a test well	1,885
Santa Lucía Utatlán (So 4)	2,480	506 344	Fractured and auto–brecciated dacitic rocks (Tv)	131.45	883	9.13	Pumping of 344 m^3/day from the well formerly used as a test well	1,974
Momostenango (To 5)	6,613	2,595 1,955	Fractured dacitic and andesitic lava (Tv), and tuffaceous sandstone	63.50	1,090	70.30	Pumping of 1,000 m^3/day each from the test well and the new well	3,431
San Francisco la Unión (Qu 21)	1,871	271 271	Upper aquifer: Pumice sediments (Qp), Lower aquifer: Fractured andesite (Tv)	–	–	–	Produce 271 m^3/day from 2 dug wells (new), or from 1 borehole well (new)	1,600
Génova (Qu 21)	14,959	770 770	Pyroclastic rocks, volcanic mudflow, andesitic tuffbreccia (Tv)	27.85	1,096	88.36	Pumping of 770 m^3/day from the well formerly used as a test well	14,189

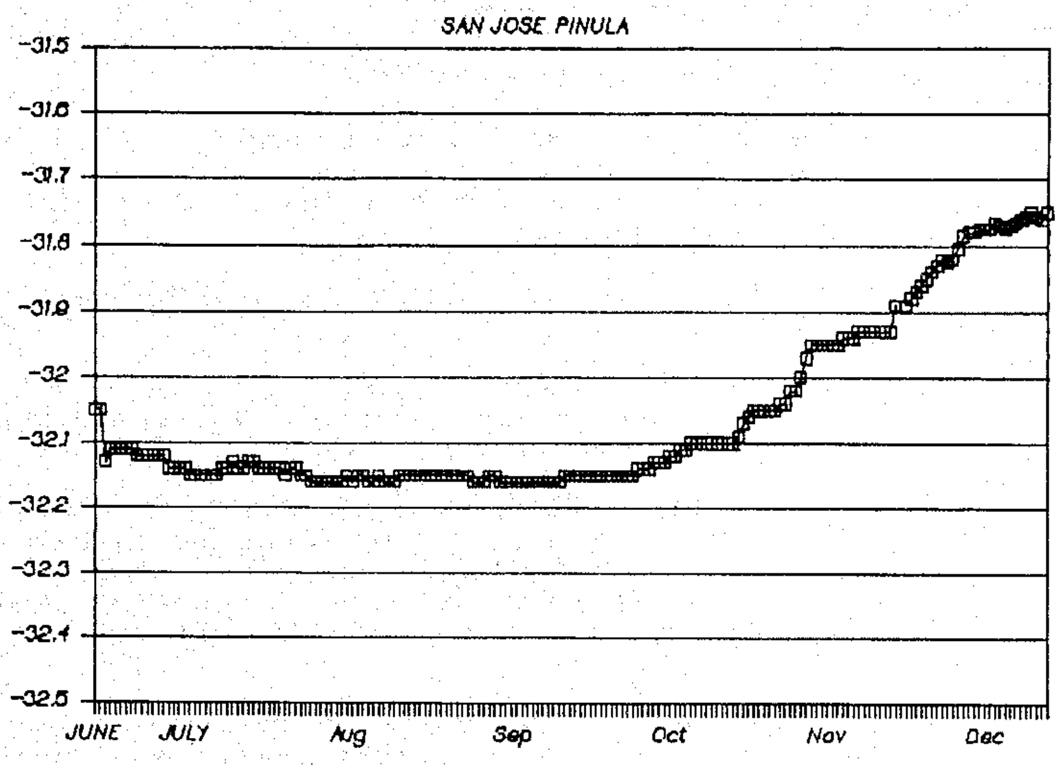


Fig 7.3.1 Daily Groundwater Level in San Jose Pinula