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INSTITUTO NICARAGÜENSE DE
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INSTITUTO NICARAGÜENSE DE ACUEDUCTOS Y ALCANTARILLADOS
REPUBLIC OF NICARAGUA
THE STUDY ON WATER SUPPLY PROJECT IN MANAGUA
SUPPORTING REPORT
SEPTEMB

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SUPPORTING REPORT

SEPTEMBER 1993

Kokusai Kogyo Co., Ltd., Tokyo

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IN
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国際協力事業団
26730

SUPPORTING REPORT

1. GEOPHYSICAL PROSPECTING
2. TEST DRILLING AND PUMPING TEST
3. HYDROLOGY
4. DRAWINGS OF WATER SUPPLY SYSTEM DESIGN

1. GEOPHYSICAL PROSPECTING

1. GEOPHYSICAL PROSPECTING

In this Study, 83 points of electric resistivity sounding were carried out. This electric prospecting employed the Gish-Rooney method with Wenner's and Schlumberger's electrode configurations and McOHM type resistivity meter. An outline of this prospecting method is given in Figure 1.1.1 and the breakdown of the field work is as follows:

<u>Wenner's electrode configuration</u>

	Prospecting depth (Gl-m)	Survey points
Phase I	100 - 200	44
Phase II	215	6
Total	(10,005 m)	50

<u>Schlumberger's electrode configuration</u>

	Prospecting depth (Gl-m)	Survey points
Phase I	400 - 500	8
Phase II	500 - 750	25
Total	(20,250 m)	33

These survey points were selected based on the hydrogeological conditions resulting from geological and hydrogeological reconnaissance with aero-photo interpretation and the reviewal and analysis of existing hydrogeological data (Fig.1.1.2). The major purposes of this electric prospecting work are:

- To investigate the hydrogeological conditions of an old valley fully distributed with Masaya Group Volcanics.

- To get detailed information on aquifers of the Middle Las Sierras Group.

- To project hydrogeological characteristics of the El Salto Formation and other Tertiary sedimentary rocks within hydrogeologically impermeable basal layers of the Managua geohydrolic area.

The electric prospecting results were hydrogeologically analyzed and the outcome of the analysis were correlated with the apparent electric resistivity values and lithofacies, as shown in Table 1.1.1. The result of the correlation was used as a basis in the formulation of hydrogeological cross sections.

The top elevation map of hydrogeologically impermeable basal layers underlying the Las Sierras Group shown in Figure 1.1.3 should be based mainly on the results of electric prospecting and its geological and hydrogeological analyses (Table 1.1.2).
The basic data(ρ-a curve) of the prospecting are presented in the Data Book.

Table 1.1.1 CORRELATION BETWEEN RESISTIVITY AND LITHOFACIES IN THE STUDY AREA

INFORMATINO	LITHOFACIES	Grade humidity (ohm/m)			Remarks
		Dry	Capillary Wet	Saturate	
Alluvium Deposits with Quaternary Pyroclastic Materials	Clayey bed	45 - 90			
	Sandy bed	60 - 800		8 - 25	
	Gravelly bed		100 - 200	- 25	
	Pumice or Scoria		100 - 200	- 25	
Masaya Group Volcanics	Pyroclastic fall deposits (mainly Scoria)	170 - 880			
	Pyroclastic flow	90 - 120		25 - 50	
	Lava flow (Brecciated)	100 - 200		10 - 20	Affected by hydrothermal solution
	Lava flow (compact)		270 - 500	25 - 200	
Upper Las Sierras Group	Alternatione of pyroclastics	250 - 700			
Middle Las Sierras Group	Massive and compact agglomerate with tuffbreccia and tuff	110 - 400	40 - 60		
	Weathered tuffbreccia with fossil soil and pyroclastic plow			10 - 80	
El Salto Formation	Low consolidated tuffaceous sandstone and siltstone			1 - 25	Affected by hydrothermal solution
Brito Formation (?)	Sandstone and shale			57 - 456	

Table 1.1.2 Result of Electrical Prospecting (1) (Schlumberger's)

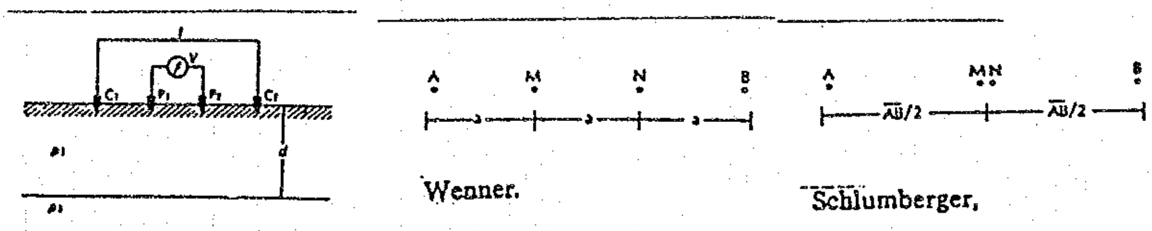
Prospecting		Geologic division of resistivity														Elevation	
NO.	depth	I layer		II layer		III layer		IV layer		V layer		VI layer		VII layer		(m)	
	(m)	m~m	ρ-a	m~m	ρ-a	m~m	ρ-a	m~m	ρ-a	m~m	ρ-a	m~m	ρ-a	m~m	ρ-a	GL	Base
S- 1	400	0~3	14	3~ 7	122	7~ 20	55	20~135	23	135~400	1.3					58	-77
S- 2	400	0~7.4	12	7.4~32	35	32~180	15	180~300	5	300~400	L< 5					48	-252
S- 3	500	0~3	140	3~16	70	16~ 18	9	18~140	20	140~170	4	170~270	28	270~500	1	72	-198
S- 4	500	0~6	102	6~18	189	18~160	126	160~320	68	320~500	14					160	-160
S- 5	400	0~3.1	78	3.1~13.5	702	13.5~ 66	120	66~360	28	360~400	210					100	-260
S- 6	500	0~7	15	7~41	45	41~ 60	23	60~165	8	165~370	10	370~500	190			50	-320
S- 7	400	0~2.8	41	2.8~35	96	35~240	24	24~350	10	350~400	57					80	-270
S- 8	500	0~5	88	5~26	108	26~ 41	700	41~130	408	130~170	3	170~500	3			148	-22
S- 9	750	0~6	70	6~25	130	25~ 52	87	52~ 84	161	84~160	69	160~320	17	320~750	153	110	-50
S-10	750	0~6	113	6~9.6	61	9.6~ 27	142	27~ 86	116	86~170	29	170~500	7	500~750	133	140	-30
S-11	750	0~6	82	6~42	410	42~130	137	130~450	24	450~750	456					170	+40
S-12	500	0~5	206	5~13.5	833	13.5~ 68	313	68~160	78	160~400	16	400~500	H			175	+15
S-13	750	0~4.5	158	4.5~9	53	9~ 39	158	39~150	40	150~410	10	410~750	990			240	+90
S-14	400	0~6	33	6~14	18	14~ 49	72	49~ 86	39	86~160	117	160~290	63	290~400	9	50	-240
S-15	750	0~4.5	56	4.5~5.8	224	5.8~ 36	149	36~180	223	180~260	96	260~440	96	440~750	19	210	-50
S-16	750	0~6	87	6~7.2	261	7.2~ 72	140	72~340	210	340~480	210	480~750	23			260	-80
S-17	750	0~4	103	4~19	412	19~ 66	176	66~280	59	280~370	59	370~750	10			200	-80
S-18	750	0~5	120	5~26	180	26~170	120	170~220	180	220~370	60	370~750	3			160	-210
S-19	400	0~6	1000	6~19	176	19~ 33	528	33~ 45	226	45~ 98	528	98~320	105	320~400	6	160	-160
S-20	750	0~6	65	6~7.4	325	7.4~ 19	604	19~ 80	151	80~140	50	140~470	27	470~750	8	202	+62
S-21	500	0~4.6	136	4.6~60	253	60~180	63	180~500	9							175	-5

Table 1.1.2 Result of Electrical Prospecting (2) (Schlumberger's)

Prospecting		Geologic division of resistivity														Elevation (m)	
NO.	depth (m)	I layer		II layer		III layer		IV layer		V layer		VI layer		VII layer			
		m~m	ρ-a	m~m	ρ-a	m~m	ρ-a	m~m	ρ-a	m~m	ρ-a	m~m	ρ-a	m~m	ρ-a	GL	Base
S-22	750	0~6	171	6~7.6	513	7.6~64	220	64~370	31	370~750	3					99	-271
S-23	750	0~6	69	6~9	12	9~56	10	56~150	12	150~195	4	195~330	12	330~750	4	70	-260
S-24	500	0~5	133	5~8	399	8~42	100	42~140	25	140~330	31	330~500	13			74	-256
S-25	500	0~3	30	3~12	13	12~62	30	62~80	16	80~130	24	130~360	6	360~500	5	58	-302
S-26	750	0~3	22	3~12	44	12~24	36	24~70	44	70~130	22	130~195	18	195~750	4	80	-115
S-27	750	0~6	128	6~15	156	15~43	52	43~145	13	145~250	16	250~350	7	350~750	21	85	-165
S-28	750	0~3	110	3~7.4	220	7.4~31	1246	31~240	415	240~750	13					110	-130
S-29	750	0~6	29	6~74	54	74~280	18	280~750	4							215	-65
S-30	750	0~5	50	5~32	117	32~160	50	160~750	9							128	-32
S-31	500	0~5	35	5~6.4	105	6.4~18	57	18~34	63	34~70	42	72~135	78	135~500	20	78	-57
S-32	500	0~4	58	4~8.2	232	8.2~35	58	35~120	15	120~380	6	380~500	L< 6			71	-49
S-33	750	0~4	64	4~23	119	23~54	97	54~88	119	88~165	40	165~750	10			200	+35

Los dispositivos de medida Schlumberger y Wenner

Los dispositivos electródicos más empleados son el Schlumberger y el Wenner. Ambos son rectilíneos y simétricos: los cuatro electrodos están alineados y el punto O es el centro común de AB y MN (fig. ··).



La relación AB/MN es constantemente igual a 3 en el dispositivo Wenner, mientras que en el Schlumberger se mantiene tan grande como sea posible. En la práctica, para este último dispositivo, es $4 \leqslant AB/MN \leqslant 20$. Cuando la medida de la diferencia de potencial ΔV, que es proporcional a distancia MN, se hace muy difícil por su pequeñez, se aumenta la distancia MN.

Durante largo tiempo, algunos prospectores han preferido el dispositivo Wenner ya que con él, la medida de la diferencia de potencial ΔV resulta más fácil al ser mayor la distancia MN. Sin embargo, con el instrumental disponible actualmente, esta ventaja ha perdido su razón de ser y el dispositivo Schlumberger es cada día más empleado por las razones siguientes:

— en general, entre dos medidas sucesivas sólo se desplazan dos electrodos, lo que supone un ahorro de tiempo;

— las perturbaciones debidas a heterogeneidades locales en la proximidad de los electrodos MN, o AB, son limitadas y fácilmente comprobables por lo que no supone ninguna dificultad la eliminación de su influencia. En la figura puede, por ejemplo, comprobarse cómo con un dispositivo Wenner estas perturbaciones pueden inducir a pensar en la existencia de capas realmente inexistentes.

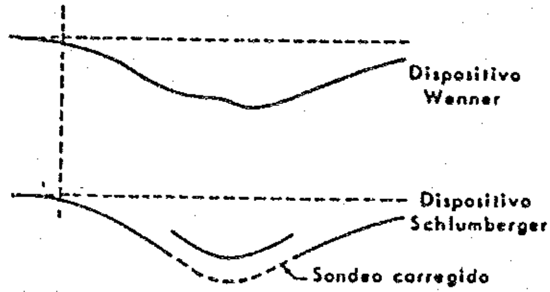


FIG. .—*Efecto de los electrodos en sondeos eléctricos con dispositivos Schlumberger y Wenner.*

Para los dispositivos Schlumberger y Wenner, el coeficiente de dispositivo K vale:

— dispositivo Schlumberger

$$K = \frac{\pi}{4} \cdot \frac{(AB)^2 - (MN)^2}{MN}$$

— dispositivo Wenner

$$K = 2\pi a$$

Fig.1.1.1. Outline of Electrical Prospecting Method

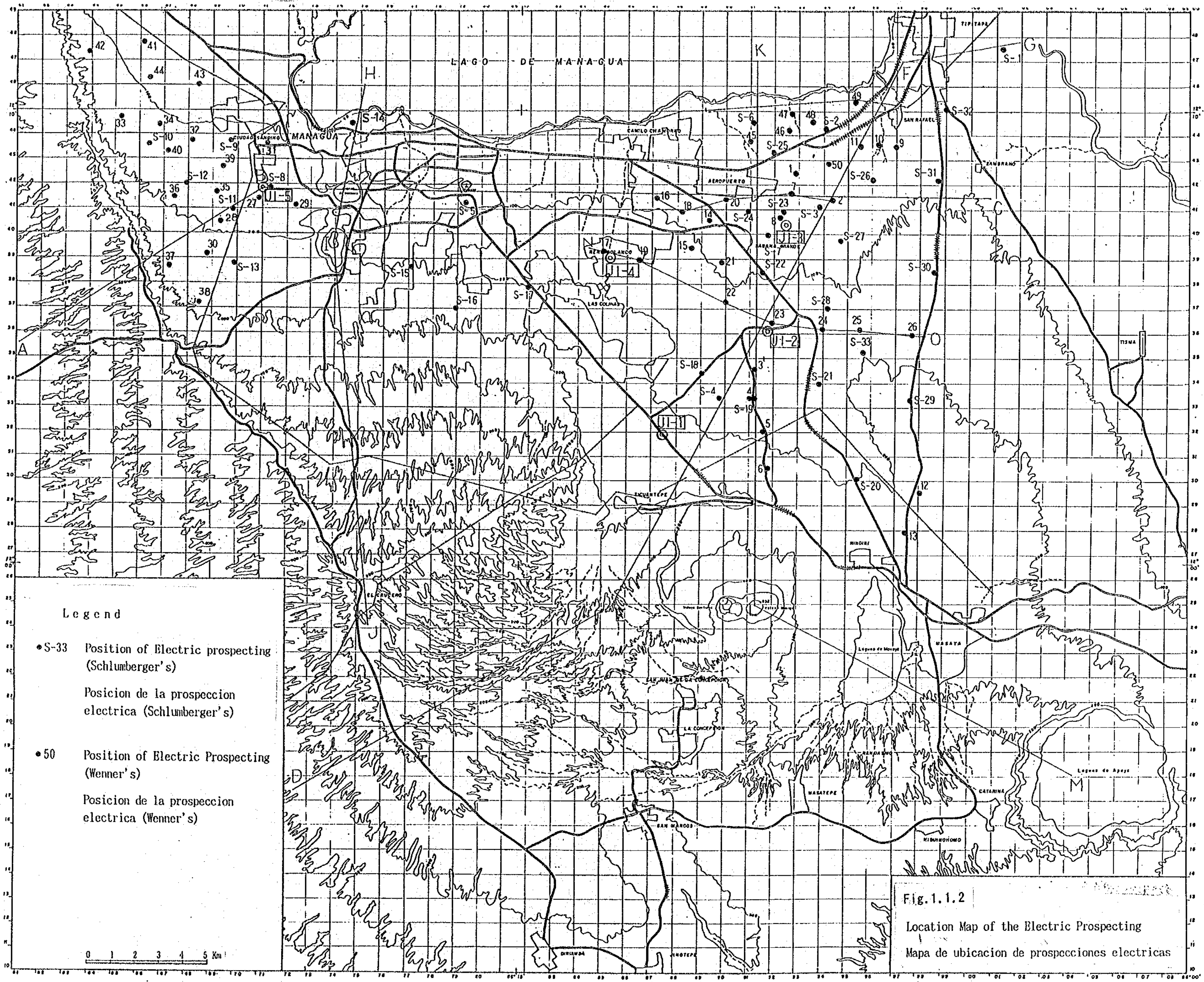


Fig.1.1.2

Location Map of the Electric Prospecting

Mapa de ubicacion de prospecciones electricas

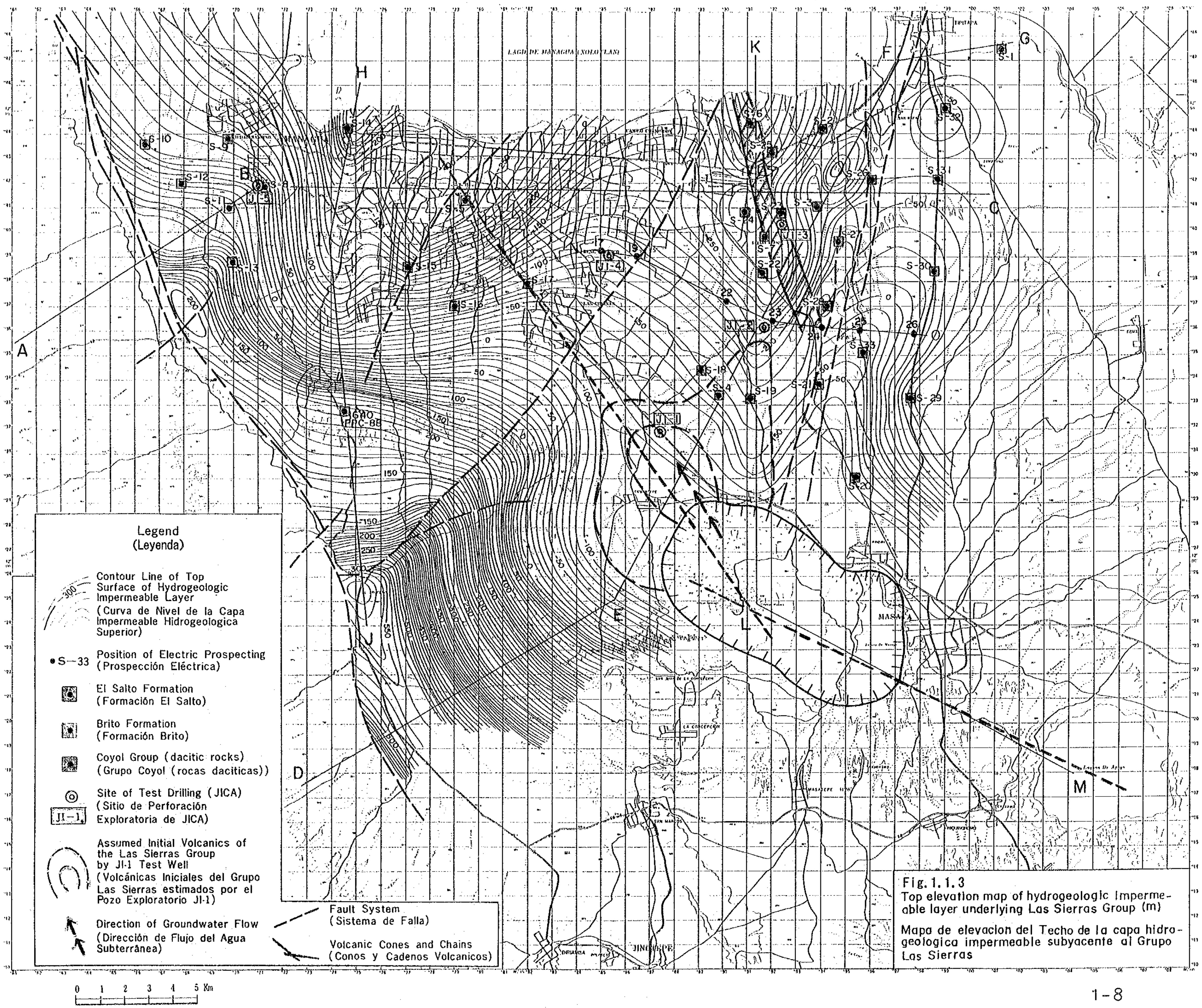


Fig. 1.1.3
Top elevation map of hydrogeologic Impermeable layer underlying Las Sierras Group (m)
Mapa de elevacion del Techo de la capa hidrogeologica impermeable subyacente al Grupo Las Sierras

2. TEST DRILLING AND PUMPING TEST

2. TEST DRILLING AND PUMPING TEST

2.1 Test drilling

After the completion of the necessary investigations for Phase I and Phase II, the target sites for test drilling were finally selected, as shown in Figure 2.1.1, according to the following purposes:

a) To investigate groundwater occurrence and hydraulic aquifer characteristics and to evaluate the overall potential of groundwater resources in the Study area.

b) To examine groundwater suitable as drinking water source, and to clarify groundwater flow mechanism by comparing the chemical components of groundwater in different geohydrologic sub-areas and aquifers.

c) To select priority areas and to formulate a groundwater development plan for the selected priority areas.

This test well construction accompanied by pumping test started on June 10, 1992 and was completed in November 18th 1992. The cumulative drilling depth of 5 test wells is 1,266 meters.

The test drilling results are summarized in Table 2.1.1 and 2.1.2, and the detailed drilling records are described in the well logs shown in Figures 2.1.2 - 2.1.7.

(1) JI-1 Well

This test well was drilled to investigate groundwater occurrence and hydraulic aquifer characteristics of the Middle Las Sierras Group, and to confirm existence of hydrogeologically impermeable basal layers from electric prospecting results.

Although this test well drilled from June 10, 1992 was supposed to be 400 meters, it was only drilled to a depth of 300 meters due mainly to very unstable formation of very loose ash flow of more than 150 meters thick. Therefore, the existence of a hydrogeologically impermeable basal layer was not confirmed, but new geological findings were obtained.

(2) JI-2 Well

This test well was drilled to investigate groundwater occurrence and hydraulic aquifer characteristics of the Masaya Group Volcanics and Middle Las Sierras Group.

The drilling works started on June 17, 1992 and was finished on November 18, 1992. The target depth was 200 meters. The drilling of this test well entailed about 59 days to penetrate hard rock formations such as basaltic lavas and compact tuff breccia, and due to delays caused by repairing equipment that was frequently damaged from the hardness of the rocks.

This test drilling work confirmed that the principal water bearing formation in the area is the Masaya Group Volcanics composed of fissured and porous basaltic lava, auto-brecciated basaltic lava and pyroclastic flows such as porous scoria and ash beds.

(3) JI-3 Well

Test well drilling was carried out mainly due to the following three reasons:

a) To investigate groundwater occurrence and hydraulic aquifer characteristics of the Masaya Group Volcanics and Middle Las Sierras Group.

b) To confirm existence of hydrogeologically impermeable basal layers from electric prospecting results.

c) To investigate geothermal conditions at the deeper portion of the area in connection with the hot spring at Tipitapa and its surroundings.

The drilling works of this test well started on June 15, 1992 and was finished on November 4, 1992. Although a depth of 400 meters was primarily intended, the actual drilled depth was only 366 meters because of the achievements of the above mentioned study purposes.

(4) JI-4 Well

This drilling site was selected to investigate the hydraulic aquifer characteristics of a zone in the Middle Las Sierras Group with a low yielding capacity.

The main aquifers of the area are weathered agglomerate with fossil soil beds, with a total thickness of 28.10 meters, and fractured agglomerate below.

(5) JI-5 Well

This test well was drilled to investigate hydrogeological structure of the Los Brasiles Valley and aquifer characteristics of the Middle Las Sierras Group, and to investigate lithological conditions of El Salto Formation supposedly clarified from prospecting results.

The main aquifers of the area are weathered agglomerate with fossil soil beds (30.50m), fractured agglomerate (37.75 m) and basal layer of tuffaceous coarse sandstone and fine conglomerate on top surface of the El Salto Formation (6m).

The existence of the El Salto Formation has been confirmed at depths between 167.64 and 200 meters, and was found to consist of tuffaceous sandstone and siltstone with sandy tuff, tuffaceous fine sandstone with fine fragments of shell fossil, and tuffaceous fine conglomerate with calcareous gravel.

Since the estimated depth of El Salto Formation was proven accurate by the electric prospecting results, this prospecting method is sure to be very useful to confirm the depth of the Tertiary formations such as El Salto and Brito underlying the Las Sierras Group.

2.2 Pumping test

Step drawdown, the constant rate and recovery test were carried out in the 5 drilled wells and in the 2 existing wells, using submersible motor pump provided by JICA and vertical turbine pump prepared by the contractor, in order to estimate aquifer properties.

The number of steps, the pumping duration and other pumping conditions are as follows:

(a) Step Drawdown Test

In principle, five (5) step drawdown tests were conducted in order to estimate optimum discharge, formation loss and well loss of a single well. During the test, the pumping rate was increased in all five (5) steps at regular intervals. This pumping rate at each interval was determined based on the results of the preliminary pumping test. The pumping duration of each step was 2 hours.

(b) Constant Rate Test

This test was conducted after the step drawdown test when the water level recovered up to the original static water level. The constant pumping rate was determined from the results of the step drawdown test. The pumping duration was 48 and 24 hours in principle.

(c) Recovery Test

Time-recovery measurement of water level was carried out for 24 hours immediately after constant rate pumping was stopped.

Prior to the normal pumping test on the borehole mentioned above, swabbing and bailing were carried out as parts of well development work. Bailing work lasted for about 24 hours.

Time-drawdown and time-recovery measurements were plotted on log-log and semi-log graph paper in order to calculate transmissivity, permeability, and storage coefficients. Methods of analysis used in this study were Theis' and Jacob's which are applicable to unconfined aquifers in unstable conditions.

The detailed pumping test results are given in next tables and figiures.

The main aquifer properties in the study area are described in the section "Hydrogeological Features of the Study Area" of the Main Report.

Cuadro 2.1.1 Avance de el Trabajo de Perforacion y Bombeo
Table 2.1.1 Actual advancement of drilling Work and Pumping Test

Nombre de Pozo / Well Name		J-1	J-2	J-3	J-4	J-5
1.Profundidad(Well Depth)	(m)	300	200	366	200	200
2.Fecha de Inic. de la Perfor(Commencement date of Drilling)	(1992)	Jun.10	Jun.17	Jun.15	Jun.19	Jun.18
3.Fecha de Terminal(Completion Date)	(1992)	Nov.16	Nov.18	Nov.14	Oct.20	Oct.23
4.Fecha de no Trabajo(No Working Days)	dias(days)	0	0	0	8	62
5.Dias de Trabajo de Perforacion(Dates for Drilling)	dias(days)	157	152	150	107	62
6.Dias de Bombeo(Dates for Pumping Test)	dias(days)	3	3	3	9	4
7.Todos Dias(Total Days)	dias(days)	160	155	153	124	128
8.Horas de Medio de Trabajo por Dia (Average Working Hours per Day)	h/d	9.20	9.76	8.24	9.14	8.35
9.Racio de Perforacion(Drilling Rate)	m/d	1.91	1.32	2.44	1.87	3.23

10.Todos Profundidad(Total Depth)	metro(meter)	1,266
11.Todos Dias de Trabajo de Perforacion (Total Dates of Drilling)	dias(days)	628
12.Medio de Trabajo de Perforacion (Average Drilling Rate)	m/d	2.016

Cuadro 2.1.2 Dias de Perforacion
Table 2.1.2 Days of drilling Work

Nombre de Pozo / Well Name		J-1	J-2	J-3	J-4	J-5
Profundidad(Well Depth)	(m)	300	200	366	200	200
1.Preparacion(Preparation)	dias(days)	4.5	2.0	4.0	3.5	1.0
	%	(2.5)	(1.1)	(2.6)	(2.9)	(1.3)
2.Perforacion(Perforation)	dias(days)	91.5	53.5	75.0	53.0	33.0
	%	(50.7)	(28.8)	(48.5)	(44.0)	(42.9)
3.Ampliando(Enlargement of Borehole)	dias(days)	20.0	31.5	19.0	26.5	7.5
	%	(11.1)	(17.0)	(12.3)	(22.0)	(9.8)
4.Afilando Broca(Repaire of Drilling Bit)	dias(days)	24.0	28.5	8.0	4.5	3.5
	%	(13.3)	(15.4)	(5.2)	(3.7)	(4.5)
5.Rectifando(Correct of Dogleg)	dias(days)	9.5	19.5	5.0	6.5	3.5
	%	(5.3)	(10.5)	(3.2)	(5.4)	(4.5)
6.Cheque de Equipo(Check of Rigs)	dias(days)	22.0	31.0	23.0	13.5	15.5
	%	(12.2)	(16.7)	(14.9)	(11.2)	(20.1)
7.Cambio Broca(Change of Drilling Bit)	dias(days)	2.0	4.5	5.5	3.5	1.5
	%	(1.1)	(2.4)	(3.6)	(2.9)	(1.9)
8.Pescando(Fishing)	dias(days)	0.0	2.0	6.0	4.5	0.0
	%	(0.0)	(1.1)	(3.9)	(3.7)	(0.0)
9.Lluvia(Rain,etc.)	dias(days)	7.0	13.0	9.0	5.0	7.5
	%	(3.8)	(7.0)	(5.8)	(4.2)	(9.7)
Sub Total	dias(days)	180.5	185.5	154.5	120.5	77.0
	%	(100)	(100)	(100)	(100)	(100)
(calculated as 8 hours working equal 1 day working)						
10.Logging,Casing Pipes Installation,Gravel Packing and Well Development	dias(days)	38	7	31	12	8

Table 2.2.1 Summarized results of pumping test

Nombre de Pozo (Well Name)	JICA No. 1	JICA No. 2	JICA No. 3	JICA No. 4	JICA No. 5	Joan Ramon Robles	No. 1285
1. Profundidad (Well depth) (m)	300	200	366	200	200	138	—
2. Longitud de rejilla (Total Screen Length) (m)	84.13	81.14	101.25	71.00	54.00	—	—
3. Principal formacion acuifera (Main Formation of Aquifer)	TQps(M)	QvM, TQps(M)	QvM, TQps(M)	TQps(M)	TQps(M)	QvM	TQps(M)
4. Fecha de bombeo (Pumping Test Date)	Nov.14~16 1992	Nov.16~18 1992	Nov.12~14 1992	Oct.14~18 1992	Oct.21~23 1992	Oct.03~05 1992	Jul.08 1992
5. Nivel estatico de agua (Static Water Level) (G.L.-m)	104.24	43.47	14.52	94.28	100.18	39.80	96.73
6. Caudal (Discharge Rate) (m³/d)	1,483	2,469	2,998	1,472	1,472	2,470	87
7. Descenso (Drawdown) (m)	0.076	3.59	2.68	11.89	1.83	8.37	0.47
8. Capacidad Especifica (C.E.) (Specific Capacity) (m³/d)	19,464	688	1,119	124	804	295	183
9. Transmisivilidad (Transmissivity)							
1) a. Theis	—	915	—	147	50	123	323
b. Jacob	—	1,291	3,658	150	267	192	354
2) Recuperacion (Recovery Test)	—	1,290	3,429	112	—	105	332
3) T=1.22×C.E.	23,746	839	1,364	151	981	360	223
10. Storage Coefficient	—	3.24×10^{-3}	—	1.82×10^{-4}	—	—	—
11. Aquifer Loss Coefficient (d/m²)	—	—	5.92×10^{-4}	4.42×10^{-3}	—	—	—
12. Well Loss Coefficient (d^2/m^5)	—	—	1.10×10^{-7}	2.57×10^{-4}	—	—	—

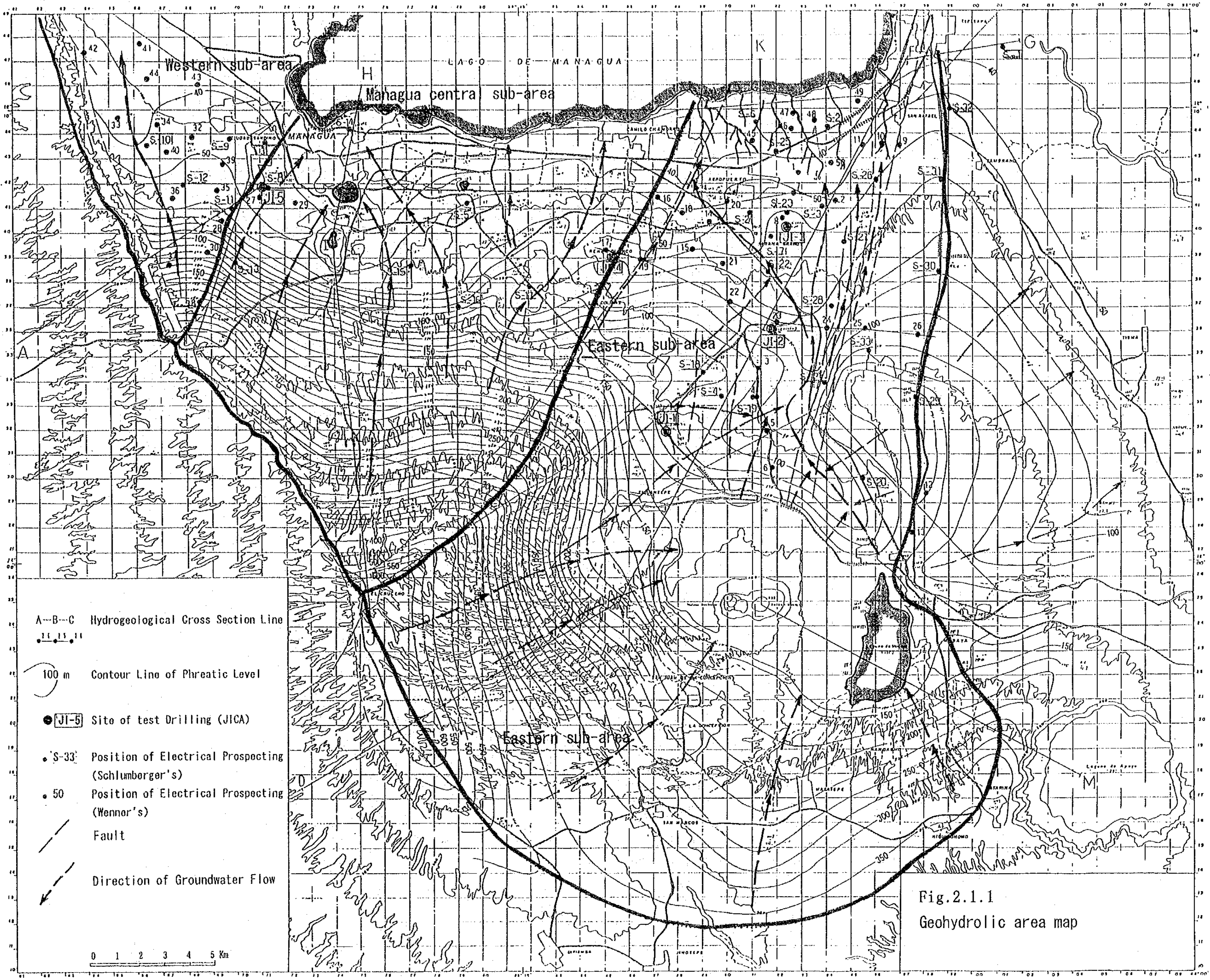
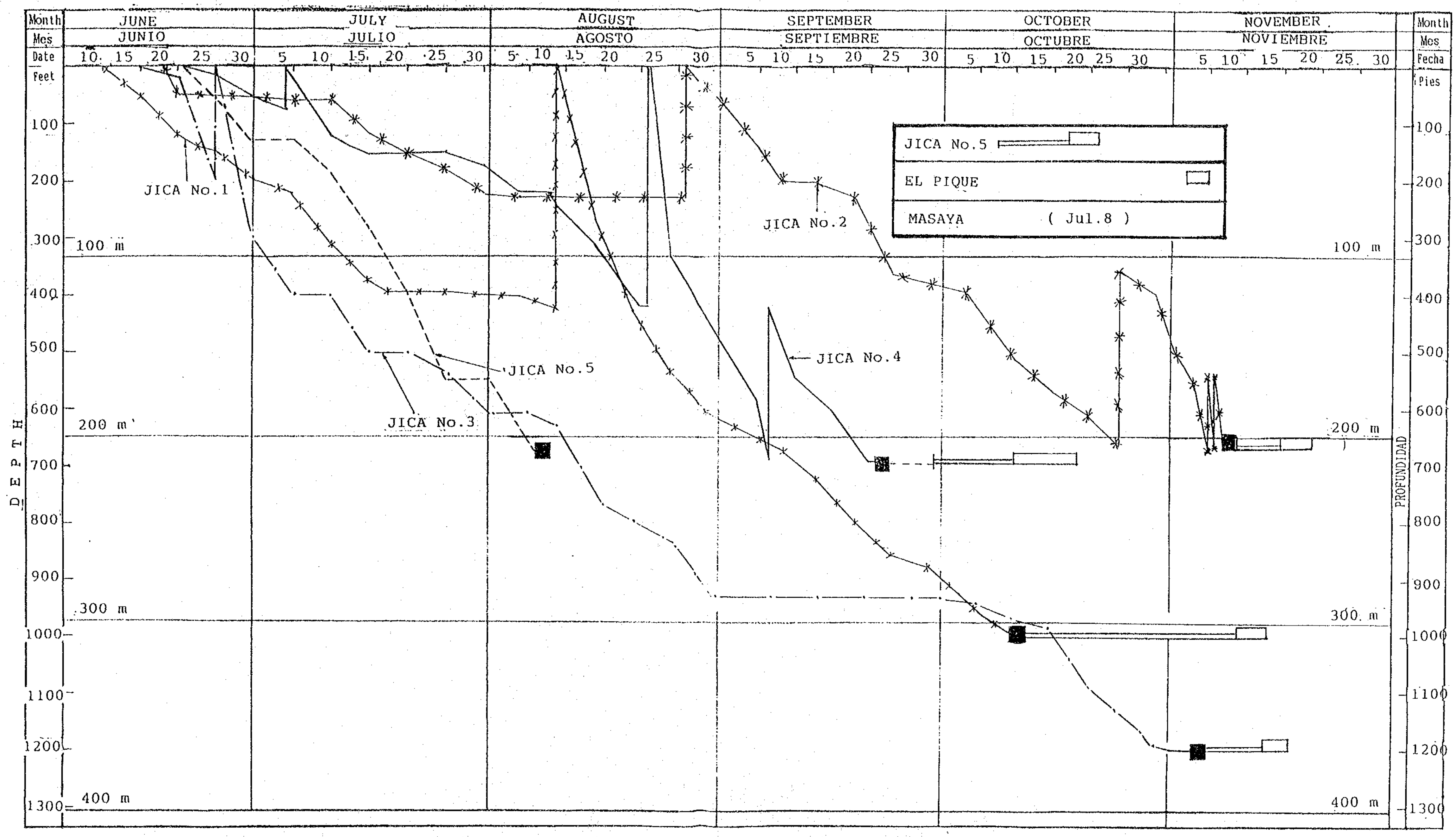


Fig.2.1.1
Geohydrolic area map



LEGEND LECTURA			
JICA No.1	—✶—✶—✶—	JICA No.5	— — —
JICA No.2	✶✶✶✶✶✶		
JICA No.3	—·—·—		
JICA No.4	———		

Drilling Work (Trabajo de Perforacion)

Casing Installation Work / Trabajo de Instalacion de la Tuberia de Ademe)

Pumping Test / Prueba de Bombeo

Fig.2.1.2

Table of Actual Advacement of Drilling Work and Pumping Test

Cuadro de Avance de el Trabajo de Perforacion y Bombeo

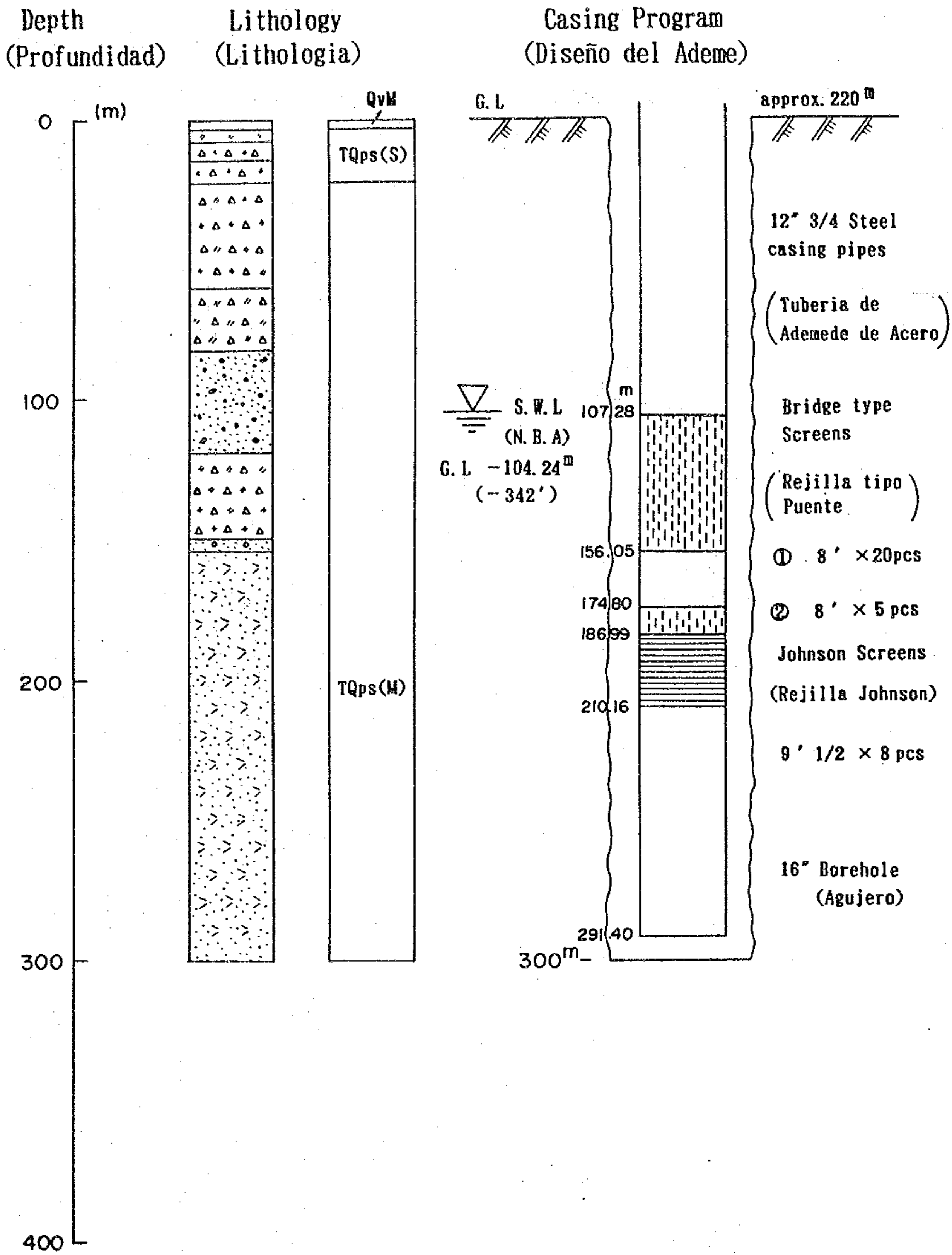


Fig.2.1.3 Casing Program and Lithology of JICA No.1 Well

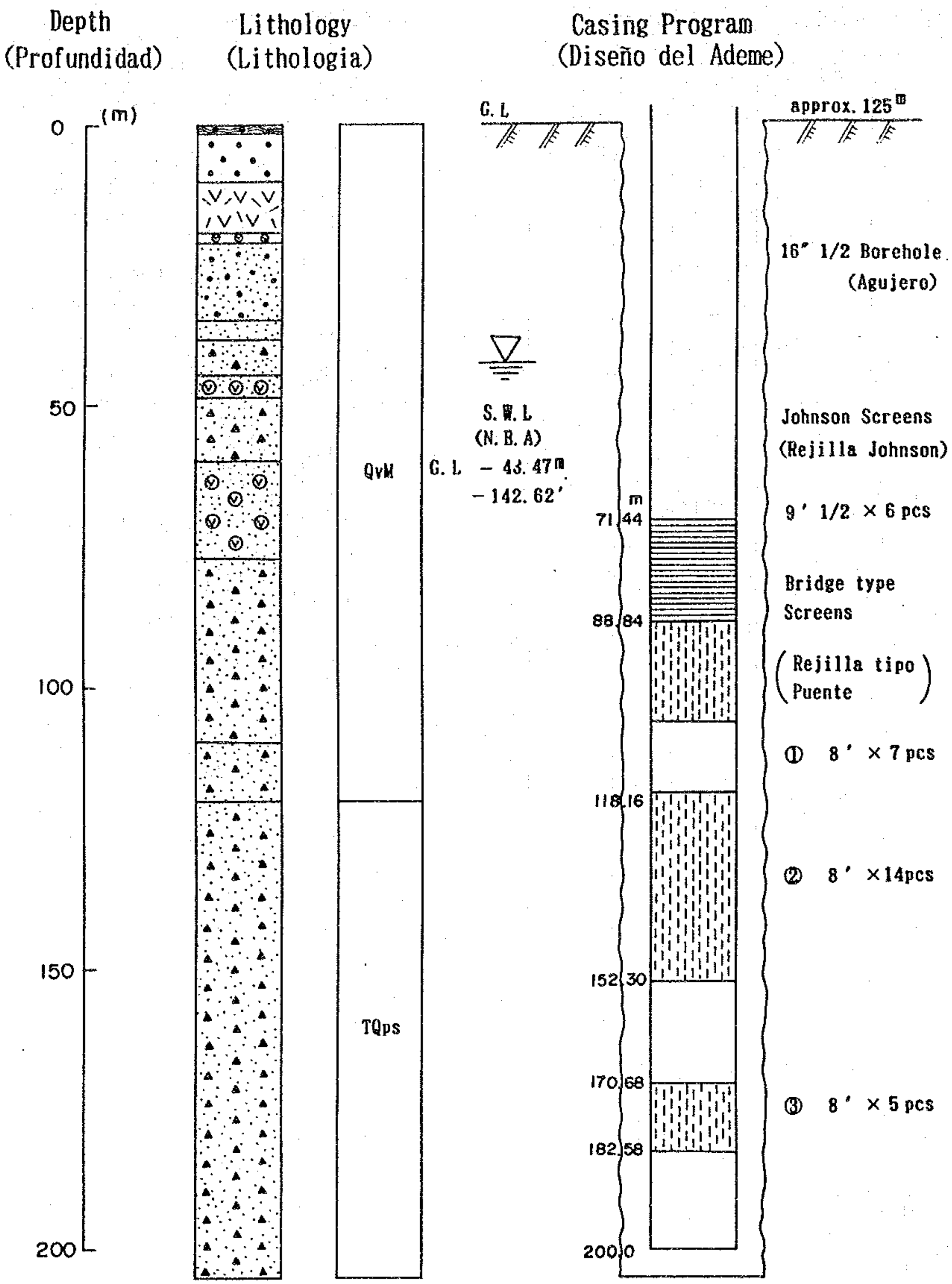


Fig. 2.1.4 Casing Program and Lithology of JICA No.2 Well

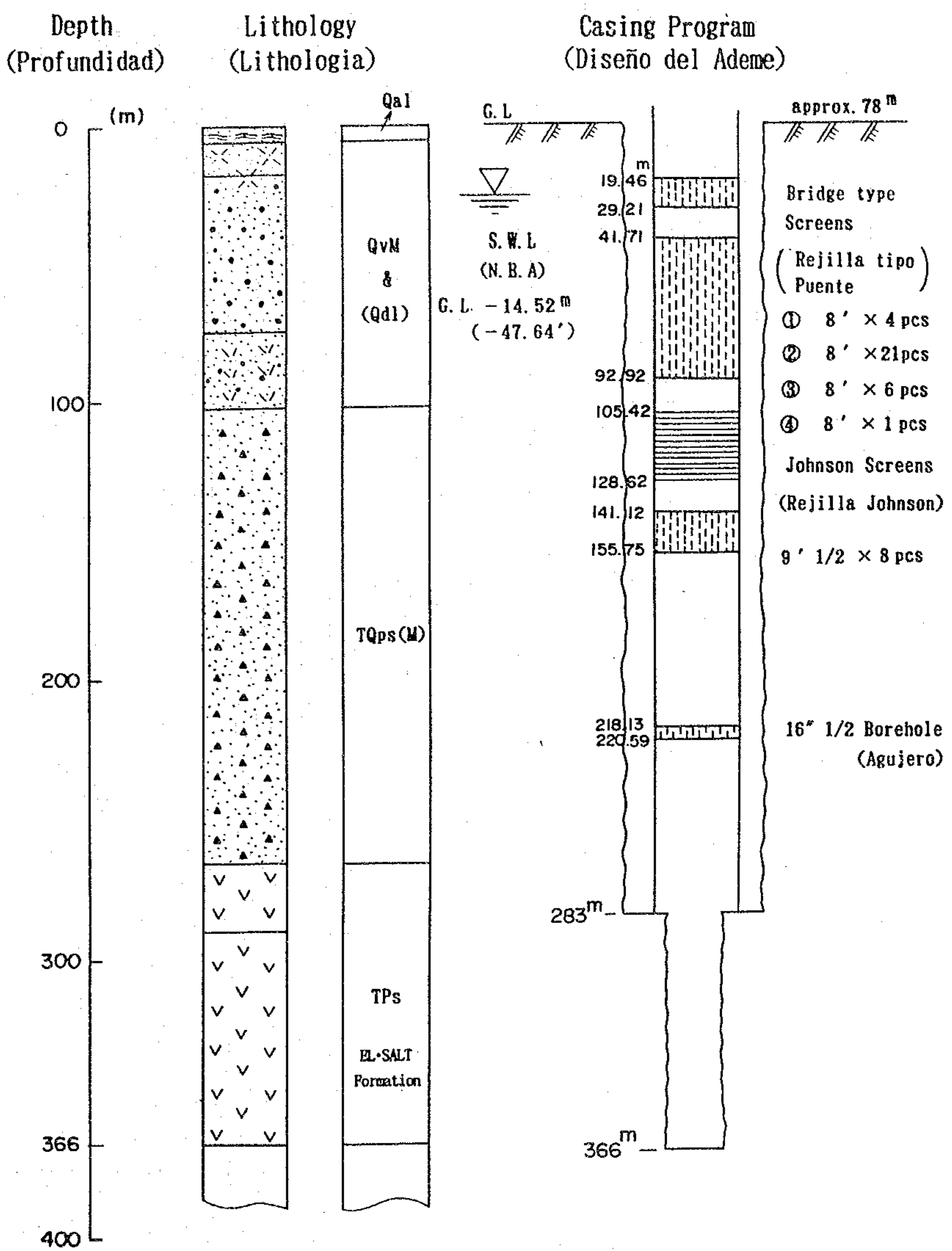


Fig.2.1.5 Casing Program and Lithology of JICA No.3 Well

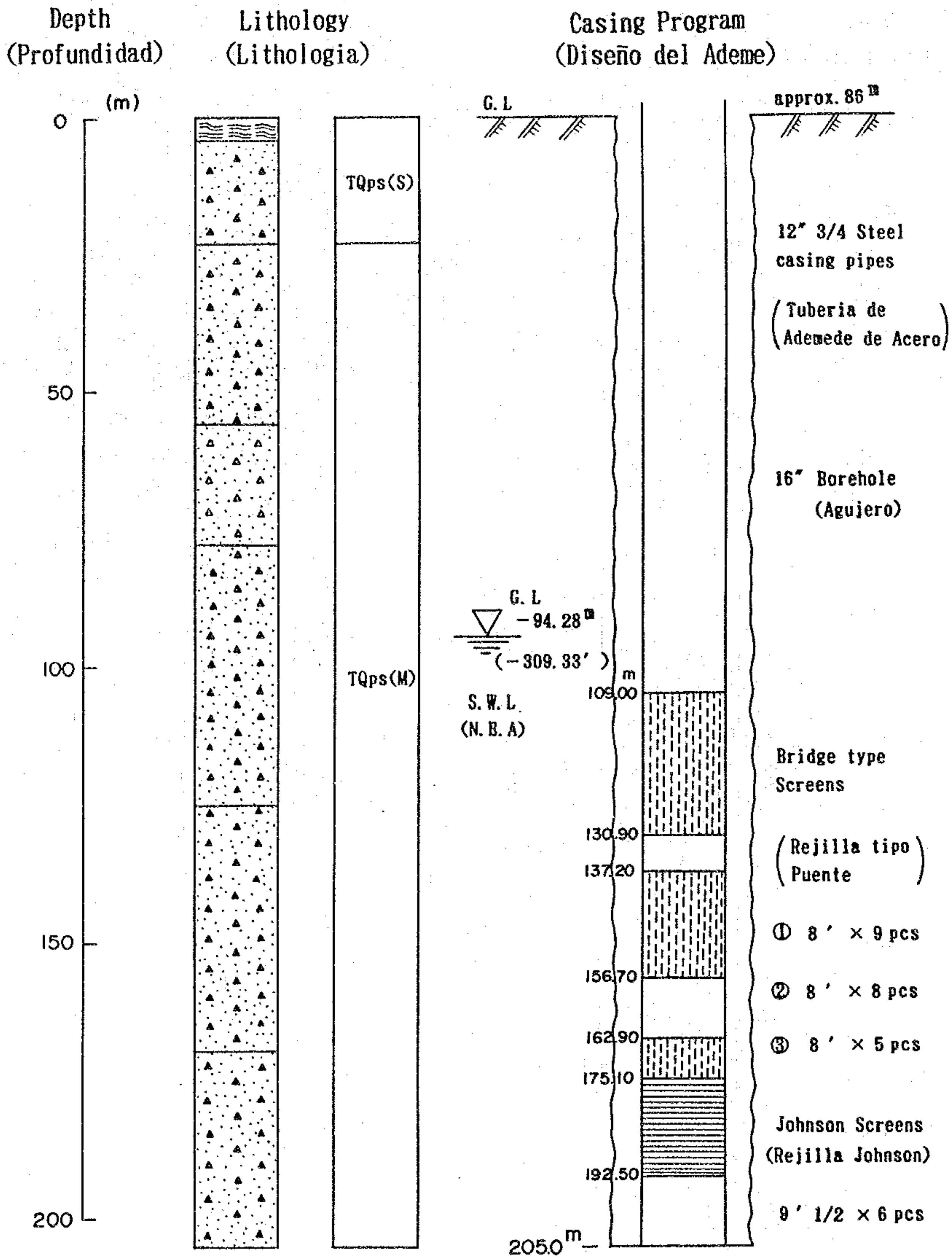


Fig.2.1.6 Casing Program and Lithology of JICA No.4 Well

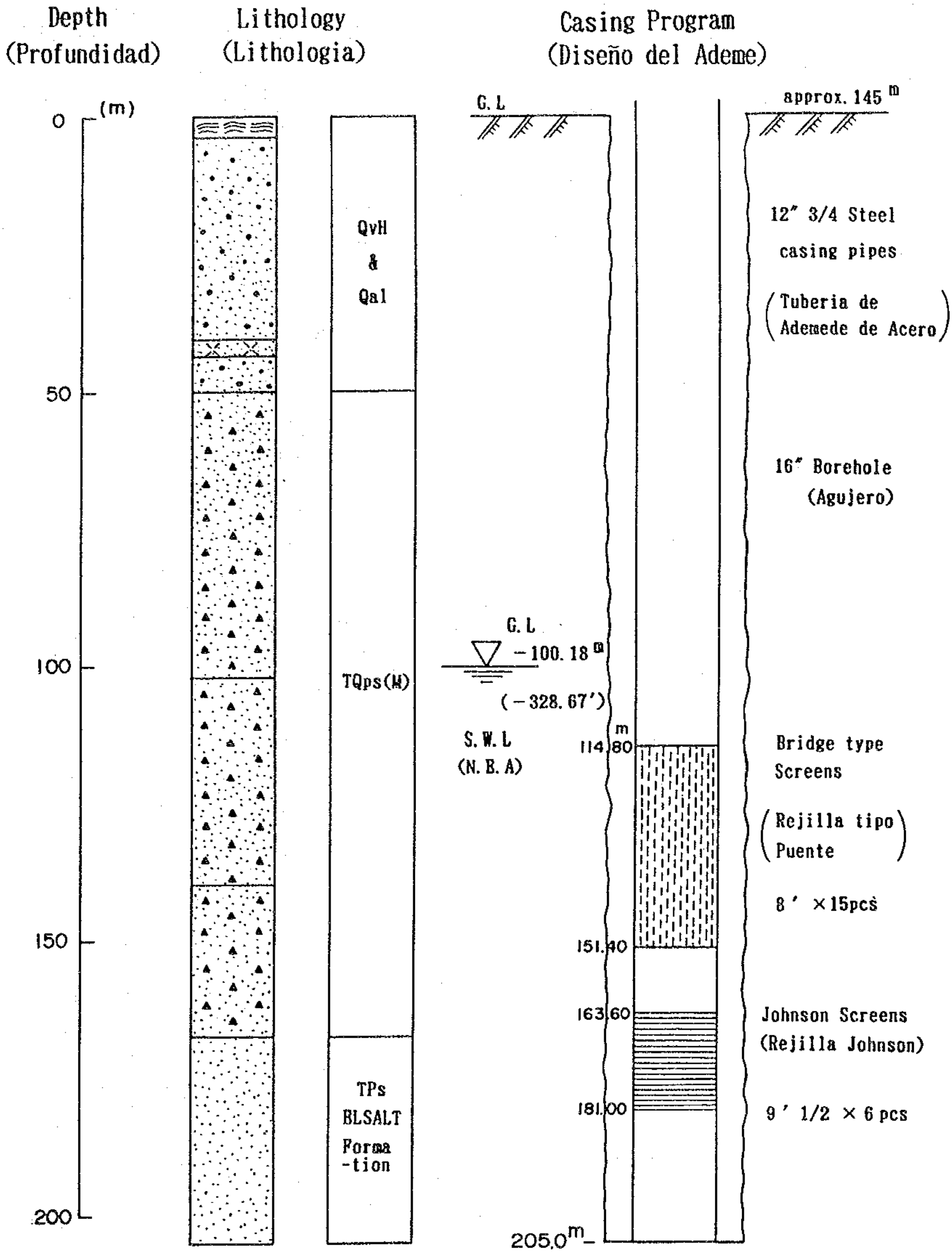


Fig.2.1.7 Casing Program and Lithology of JICA No.5 Well

WELL LOG

PROJECT NAME	The Study on Water Supply Project in Managua		JICA WELL NO. 1
AREA AND LOCATION	Los Madrigales		
ELEVATION appr	220m	LATITUDE 12° 03' 30" LONGITUDE 86° 11' 43"	
TOTAL DEPTH	300m	DLILLING RIG Ford F-600 22-W Series Three	
DRILLING STARTED	11-6-1992	DRILLED BY JICA Study Team-ESAASA	
WELL COMPLETED	16-11-1992	LOGGED BY Juan Carlos Valle	

STATIC WATER LEVEL	104.24m	WATER TEMPERATURE	
DYNAMIC WATER LEVEL	104.32m	CONDUCTIVITY	
PUMPING RATE	1,483m³/day	pH	
SPECIFIC CAPACITY	19,464m²/day	TOTAL HARDNESS	

Boundary (m)	Lithology	Litologia	Formation
1.52	Brown surface soil	Suelo superficial de color café	QvM
3.05	Alternation of black scoria and brown fossil soil	Alternancia de escoria negra y suelo fósil café	
7.62	Dark gray basaltic compact tuff breccia	Toba brechosa compacta de color gris oscura	TQps (S)
13.72	Dark gray basaltic compact agglomerate	Aglomerados compactos basálticos de color gris oscuro	
15.24	Dark gray basaltic tuff breccia and tuff	Toba brechosa y toba basáltica de color gris oscura	
16.76			
22.86	Alternation of dark gray compact agglomerate, tuff breccia and tuff (with few scoria and pumice)	Alternancia de aglomerados compactos de color gris oscuro, toba brechosa y toba con alguna escoria y pómez.	
24.38	Brown fossil soil and brownish dark gray weathered agglomerate	Suelo fósil café y aglomerados meteorizados de color gris oscuro y café.	
	Brown fossil soil, basaltic agglomerate with thin scoria and pumice beds	Suelo fósil café, aglomerados basálticos con capas de escoria delgadas y capas de pómez.	
59.44	Brownish dark gray weathered basaltic agglomerate with partially tuff breccia and tuff	Aglomerados basálticos meteorizados de color gris oscuro y café con toba brechosa y toba parcialmente.	
60.96			
62.48	Brownish dark gray weakly weathered fine tuff	Toba fina ligeramente meteorizada de color gris oscuro café.	
	Brownish dark gray weakly weathered basaltic agglomerate (compact)	Aglomerados basálticos compactos ligeramente meteorizados de color gris-oscuro-café.	SAND
83.82	Brownish dark gray weakly weathered basaltic compact agglomerate	Aglomerados basálticos compactos ligeramente meteorizados de color gris oscuro café.	
85.34	Brownish fossil soil	Suelo fósil café	
117.35	Dark gray - dark black, porous pyroclastic flow dominated scoria (scoria flow with rock fragments)	Flujos de piroclastos porosos de colores gris-oscuro y gris-negro, escoria dominada (Flujos de escoria con fragmentos de roca).	
118.87	Dark brown - brownish dark gray fossil soil and weathered basaltic agglomerate	Suelo fósil de color café-oscuro, gris oscuro café y aglomerados basálticos meteorizados.	TQps (M)
129.54	Black porous volcanic fragments (basaltic lava)	Fragmentos volcánicos porosos de color negro (lava ?)	
152.40	Brown agglomerate with volcanic fragments	Aglomerados café con fragmentos volcánicos.	BRIDGE SCREENS
156.97	Brown agglomerate with fine gravel and quartz	Aglomerados café con grava fina y cuarzo.	
161.54	Gray - black a little compact sand (ash flow)	Arena fina compacta de colores gris y negra.	
167.64	Black sand with pisolites (ash flow)	Arena negra con pisolitas	
175.26	Gray fine sand (ash flow)	Arena gris fina	
185.93	Gray sand with green and red gravel (ash flow)	Arena gris con grava de color verde y rojo	BRIDGE SCREENS
222.50	Gray course sand with volcanic fragments (ash flow)	Arena gruesa gris con fragmentos volcánicos	JOHNSON SCREENS
234.70	Gray calcareous sand (ash flow)	Arena gris (con Calcio)	
300.22	Gray - black sand with volcanic fragments (ash flow)	Arena gris con fragmentos volcánicos.	GRAVEL

Casing Program: CEMENT; 16½"; 12¾"; SAND; 104.24 (water level ▽); 107.27; BRIDGE SCREENS to 156.04; 174.79; BRIDGE SCREENS to 186.98; JOHNSON SCREENS to 210.14; GRAVEL; 291

Depth Profundidad (m): 0–300

in Managua — WELL NO. 1

AREA AND LOCATION	Los Madrigales		
ELEVATION appr	220m	LATITUDE 12° 03' 30" LONGITUDE 86° 11' 43"	
TOTAL DEPTH	300m	DRILLING RIG Ford F-600 22-W Series Three	
DRILLING STARTED	11-6-1992	DRILLED BY JICA Study Team-ESSASA	
WELL COMPLETED	16-11-1992	LOGGED BY Juan Carlos Valle	

STATIC WATER LEVEL	104.24m	WATER TEMPERATURE	
DYNAMIC WATER LEVEL	104.32m	CONDUCTIVITY	
PUMPING RATE	1,483m³/day	pH	
SPECIFIC CAPACITY	19.464m³/day	TOTAL HARDNESS	

Boundary (m)	Lithology	Litologia	Formation
0 – 1.52	Brown surface soil	Suelo superficial de color café	QvM
1.52 – 3.05	Alternation of black scoria and brown fossil soil	Alternancia de escoria negra y suelo fosil café	
3.05 – 7.62	Dark gray basaltic compact tuff breccia	Toba brechosa compacta de color gris oscuro	TQps (S)
7.62 – 13.72	Dark gray basaltic compact agglomerate	Aglomerados compactos basálticos de color gris oscuro	
13.72 – 15.24	Dark gray basaltic tuff breccia and tuff	Toba brechosa y toba basáltica de color gris oscuro	
16.76 – 22.86	Alternation of dark gray compact agglomerate, tuff breccia and tuff (with few scoria and pumice)	Alternancia de aglomerados compactos de color gris oscuro, toba brechosa y toba con algunas escoria y pómez.	
22.86 – 24.38	Brown fossil soil and brownish dark gray weathered agglomerate	Suelo fósil café y aglomerados meteorizados de color gris oscuro y café.	
24.38 –	Brown fossil soil, basaltic agglomerate with thin scoria and pumice beds	Suelo fósil café, aglomerados basálticos con capas de escoria delgadas y capas de pómez.	
– 59.44	Brownish dark gray weathered basaltic agglomerate with partially tuff breccia and tuff	Aglomerados basálticos meteorizados de color gris oscuro y café con toba brechosa y toba parcialmente.	
60.90 – 62.40	Brownish dark gray weakly weathered fine tuff	Toba fina ligeramente meteorizada de color gris oscuro café.	SAND
62.40 –	Brownish dark gray weakly weathered basaltic agglomerate (compact)	Aglomerados basálticos compactos ligeramente meteoriza dos de color gris-oscuro-café.	
– 83.82	Brownish dark gray weakly weathered basaltic compact agglomerate	Aglomerados basálticos compactos ligeramente meteoriza dos de color gris oscuro café.	
83.82 – 85.34	Brownish fossil soil	Suelo fósil café	
85.34 – 117.35	Dark gray - dark black, porous pyroclastic flow dominated scoria (scoria flow with rock fragments)	Flujos de piroclastos porosos de colores gris-oscuro y gris-negro, escoria dominada (Flujos de escoria con fragmentos de roca).	
117.35 – 118.87	Dark brown - brownish dark gray fossil soil and weathered basaltic agglomerate	Suelo fósil de color café-oscuro, gris oscuro café y aglomerados basálticos meteorizados.	TQps (M)
118.87 – 129.54	Black porous volcanic fragments (basaltic lava)	Fragmentos volcánicos porosos de color negro (lava ?)	
129.54 – 152.40	Brown agglomerate with volcanic fragments	Aglomerados café con fragmentos volcánicos.	
152.40 – 156.97	Brown agglomerate with fine grvel and quartz	Aglomerados café con grava fina y cuarzo.	
156.97 – 161.54	Gray - black a little compact sand (ash flow)	Arena fina compacta de colores gris y negra.	
161.54 – 167.64	Black sand with pisolites (ash flow)	Arena negra con pisolitas	
167.64 – 175.26	Gray fine sand (ash flow)	Arena gris fina	
175.26 – 185.93	Gray sand with green and red gravel (ash flow)	Arena gris con grava de color verde y rojo	
185.93 – 222.50	Gray course sand with volcanic fragments(ash flow)	Arena gruesa gris con fragmentos volcánicos	
222.50 – 234.70	Gray calcareous sand(ash flow)	Arena gris (con Calcio)	
234.70 – 300.22	Gray -black sand with volcanic fragments(ash flow)	Arena gris con fragmentos volcánicos.	

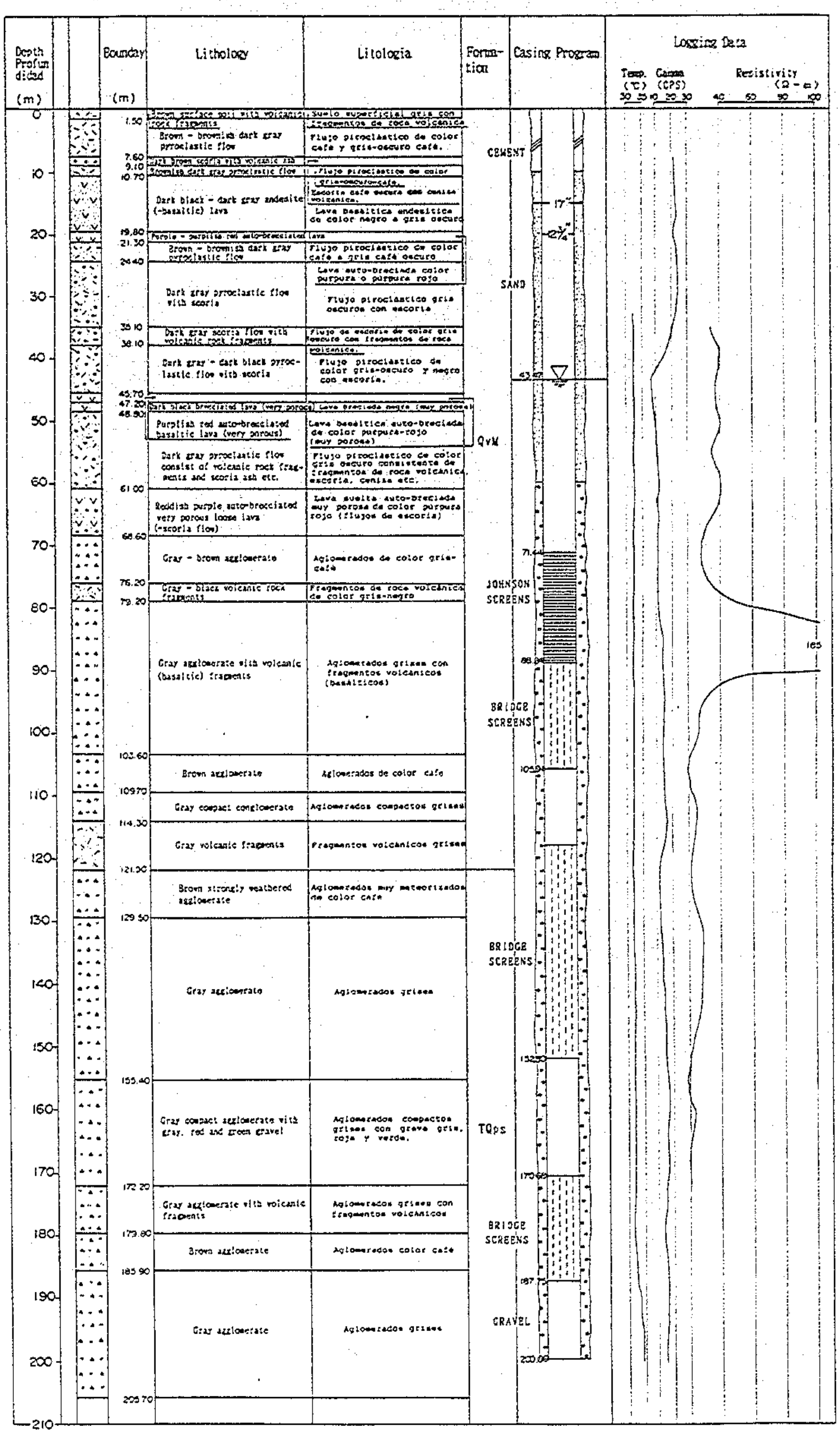
Casing Program: CEMENT; 16½"; 12¾"; SAND; 104.24; 107.27; BRIDGE SCREENS; 156.04; 174.70; BRIDGE SCREENS; 186.98; JOHNSON SCREENS; 210.14; GRAVEL; 291; 300.22

Depth Profundidad (m): 0 – 310

WELL LOG

PROJECT NAME	The Study on Water Supply Project in Managua		JICA WELL NO. 2
AREA AND LOCATION	Veracruz		
ELEVATION appr	125m	LATITUDE 12° 06' 08" LONGITUDE 86° 09' 22"	
TOTAL DEPTH	200m	DRILLING RIG Bucyrus-Erie	
DRILLING STARTED	18-6-1992	DRILLED BY JICA Study Team-ESAASA	
WELL COMPLETED	18-11-1992	LOGGED BY Juan Carlos Valle	

STATIC WATER LEVEL	43.47m	WATER TEMPERATURE	28.6°C
DYNAMIC WATER LEVEL	47.06m	CONDUCTIVITY	1.180 μs/cm
PUMPING RATE	2.469m³/day	pH	
SPECIFIC CAPACITY	688m³/day	TOTAL HARDNESS	



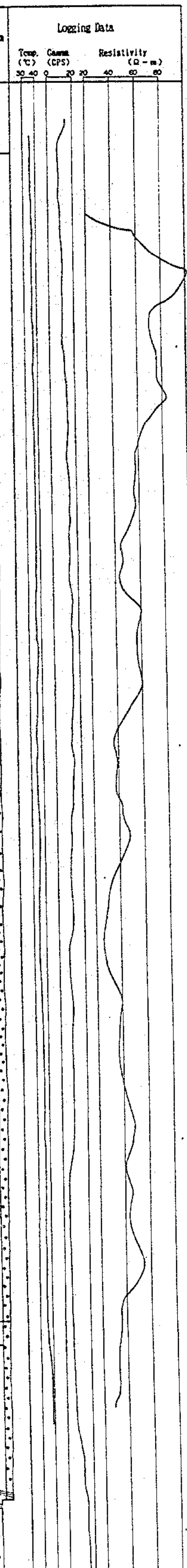
WELL LOG

PROJECT NAME	The Study on Water Supply Project in Managua	JICA WELL NO. 3	
AREA AND LOCATION	Sabana Grande		
ELEVATION appr	78m	LATITUDE 12° 08' 50" LONGITUDE 86° 08' 59"	
TOTAL DEPTH	306m	DRILLING RIG Bucyrus Erie Model P-S300 (diamond Red)	
DRILLING STARTED	18-6-1992	DRILLED BY JICA Study Team BSAASA	
WELL COMPLETED	14-11-1992	LOGGED BY Juan Carlos Valle	

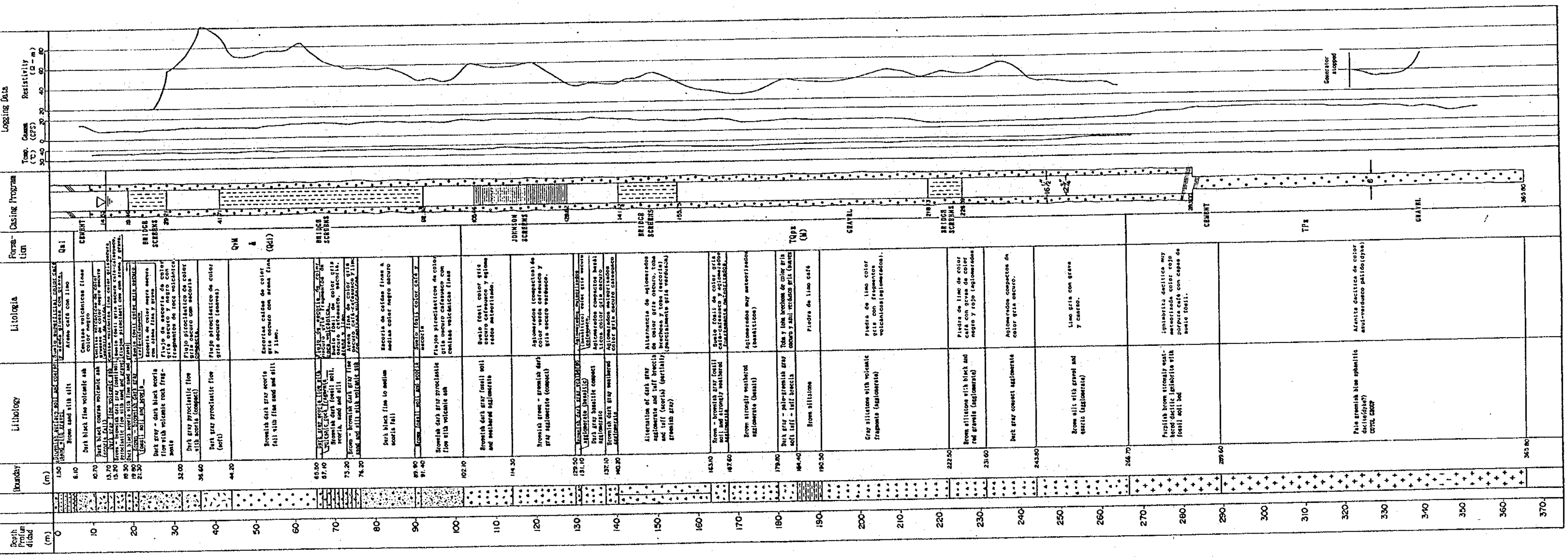
STATIC WATER LEVEL	14.52m	WATER TEMPERATURE	33.5°C
DYNAMIC WATER LEVEL	17.20m	CONDUCTIVITY	
PUMPING RATE	2.998m³/day	pH	
SPECIFIC CAPACITY	1.119m³/day	TOTAL HARDNESS	

Boundary (m)	Lithology	Litologia	Formation
1.50	Brownish surface soil and coarse sand with gravel	Suelo superficial color café y arena gruesa con grava.	Qal
6.10	Brown sand with silt	Arena café con limo	Qal
10.70	Dark black fine volcanic ash	Cenizas volcánicas finas color negro	QvM & (Qdl)
13.70	Dark black coarse volcanic ash (scoria fall)	Cenizas volcánicas de color gruesas de color negro oscuro (escoria de caída)	
15.20	Dark gray fine volcanic ash	Ceniza volcánica fina color gris oscura.	
18.30	Brown - brownish dark gray fossil soil, pyroclastic flow with sand and gravel	Suelo fósil gris oscuro café-cafesuaco, flujos piroclásticos con arena y grava.	
19.80	Dark black scoria with fine sand and gravel	Escoria de color negro oscuro con arena fina y grava	
21.30	Brown - brownish dark gray fossil soil and scoria	Suelo fósil color gris oscuro café-cafesuaco	
32.00	Dark gray - dark black scoria flow with volcanic rock fragments	Flujo de escoria de color gris oscuro y negro con fragmentos de roca volcánica.	
36.60	Dark gray pyroclastic flow with scoria (compact)	Flujo piroclástico de color gris oscuro con escoria compacta.	
44.20	Dark gray pyroclastic flow (soft)	Flujo piroclástico de color gris oscuro (suaves)	
65.50	Brownish dark gray scoria fall with fine sand and silt	Escorias caídas de color gris oscuro con arena fina y limo.	
67.10	Dark gray scoria flow with volcanic rock fragments	Flujo de escoria de color oscuro gris fragmentos de roca volcánica.	
73.20	Brownish dark fossil soil, scoria, sand and silt	Suelo fósil de color gris oscuro cafesuaco, escoria, arena y limo.	
76.20	Brown - brownish dark gray fine sand and silt with volcanic ash	Arena fina de color gris oscuro café-cafesuaco y limo con cenizas volcánicas.	
89.90	Dark black fine to medium scoria fall	Escoria de caídas finas a medias color negro oscuro	
91.40	Brown fossil soil and scoria	Suelo fósil color café y escoria	
102.10	Brownish dark gray pyroclastic flow with volcanic ash	Flujos piroclásticos de color gris oscuro cafesuaco con cenizas volcánicas finas	
114.30	Brownish dark gray fossil soil and weathered agglomerate	Suelo fósil color gris oscuro cafesuaco y aglomerados meteorizados.	TQps (M)
129.50	Brownish green - greenish dark gray agglomerate (compact)	Aglomerados (compactos) de color verde cafesuaco y gris oscuro verduzco.	
131.10	Brownish dark gray weathered agglomerate (basaltic)	Aglomerados meteorizados (basálticos) color gris oscuro cafesuaco.	
137.10	Dark gray basaltic compact agglomerate	Aglomerados compactos basálticos color gris oscuro	
140.20	Brownish dark gray weathered agglomerate	Aglomerados meteorizados color gris oscuro cafesuaco	
163.10	Alternation of dark gray agglomerate and tuff breccia and tuff (scoria) (partially greenish gray)	Alternancia de aglomerados de color gris oscuro, toba brechosa y toba (escoria) (parcialmente gris verdusca)	
167.60	Brown - brownish gray fossil soil and strongly weathered agglomerate	Suelo fósil de color gris café-cafesuaco y aglomerados fuertemente meteorizados.	
179.80	Brown strongly weathered agglomerate (basalt)	Aglomerados muy meteorizados (basálticos)	
184.40	Dark gray - pale-greenish gray soft tuff - tuff breccia	Toba y toba brechosa de color gris oscuro y azul verdusco gris (suaves)	
190.50	Brown siltstone	Piedra de limo café	
222.50	Gray siltstone with volcanic fragments (agglomerate)	Piedra de limo color gris con fragmentos volcánicos (aglomerados).	
231.60	Brown siltstone with black and red gravels (agglomerate)	Piedra de limo de color café con gravas de color negro y rojo (aglomerados)	
243.80	Dark gray compact agglomerate	Aglomerados compactos de color gris oscuro.	
266.70	Brown silt with gravel and quartz (agglomerate)	Limo gris con grava y cuarzo.	
289.60	Purplish brown strongly weathered dacitic ignimbrite with fossil soil bed	Ignimbrita dacítica muy meteorizada color rojo púrpura café con capas de suelo fósil.	

Casing Program: CEMENT; 14.52 (static water level); BRIDGE SCREENS 19.46–29.2; BRIDGE SCREENS 41.7–92.3; JOHNSON SCREENS 108.46–128.62; BRIDGE SCREENS 141.7–155.75; GRAVEL; BRIDGE SCREENS 218.3–226; 16½"; 12¼"; CEMENT 283.0



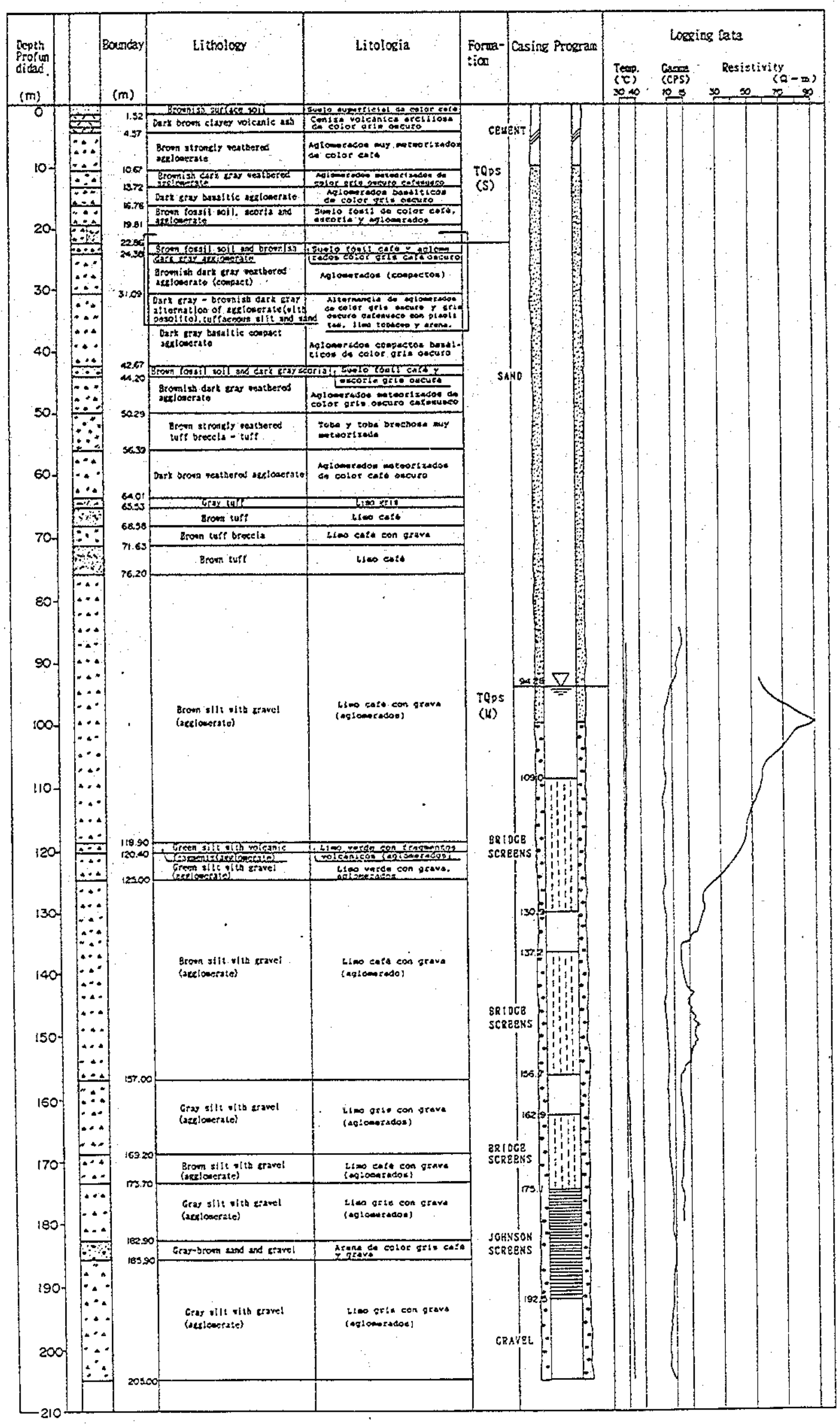
Depth Profundidad (m): 0–290


Logging Data
Resistivity
Casing Program
Litologia
Lithology
CEMENT
BRIDGE SCREENS
JOHNSON SCREENS
GRAVEL

WELL LOG

PROJECT NAME	The Study on Water Supply Project in Managua		JICA WELL NO. 4
AREA AND LOCATION Socrates Sandino			
ELEVATION appr	86m	LATITUDE 12° 06' 43" LONGITUDE 86° 02' 51"	
TOTAL DEPTH	200m	DRILLING RIG Obrinsa(Russian made)	
DRILLING STARTED	28-6-1992	DRILLED BY JICA Study Team-ESAASA	
WELL COMPLETED	18-10-1992	LOGGED BY Juan Carlos Valle	

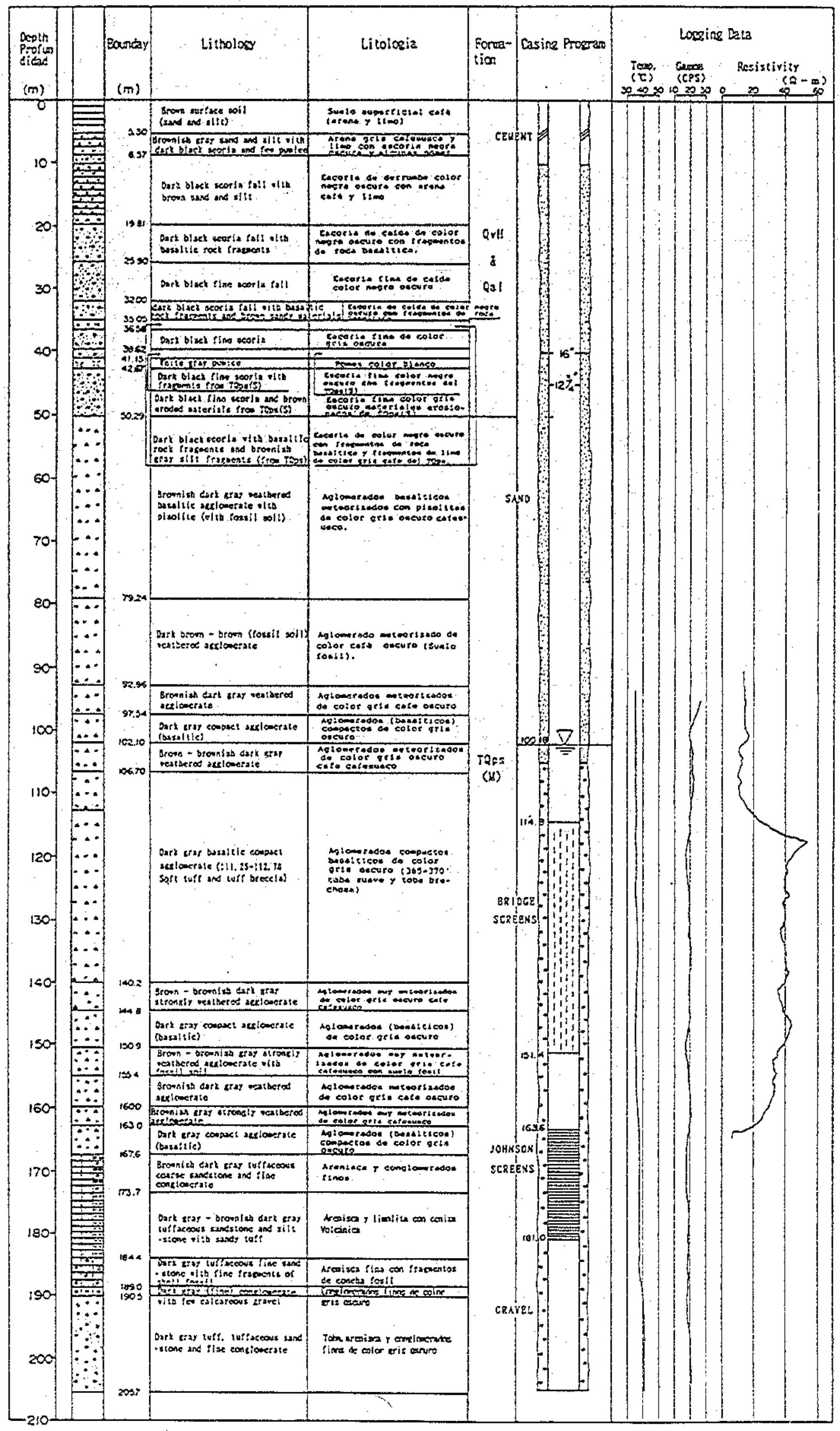
STATIC WATER LEVEL	94.28m	WATER TEMPERATURE	28.2°C
DYNAMIC WATER LEVEL	106.17m	CONDUCTIVITY	508 μs/cm
PUMPING RATE	1,472m³/day	pH	
SPECIFIC CAPACITY	124m²/day	TOTAL HARDNESS	



WELL LOG

PROJECT NAME The Study on Water Supply Project in Managua	JICA WELL NO. 5
AREA AND LOCATION Bello Amanecer	
ELEVATION appr 145m	LATITUDE 12° 08' 22" LONGITUDE 86° 20' 51"
TOTAL DEPTH 200m	DRILLING RIG Ford F-600 22-W series Three Bucyrus-Erie percusion type
DRILLING STARTED 21-6-1992	DRILLED BY JICA Study Team-ENACAL
WELL COMPLETED 23-10-1992	LOGGED BY JICA Study Team

STATIC WATER LEVEL 100.18m	WATER TEMPERATURE 35.2℃
DYNAMIC WATER LEVEL 102.01m	CONDUCTIVITY 1,000 μs/cm
PUMPING RATE 1,472m³/day	pH
SPECIFIC CAPACITY 804m³/day	TOTAL HARDNESS



Well logs of 5 test wells

TECHNICAL SPECIFICATION OF TEST DRILLING

9'

TECHNICAL SPECIFICATIONS

FOR

TEST WELL CONSTRUCTION

AND

PUMPING TEST

FOR

THE STUDY ON GROUNDWATER DEVELOPMENT

FOR MANAGUA WATER SUPPLY PROJECT

IN

MANAGUA, NICARAGUA

June , 1992

JICA STUDY TEAM

Technical Specification for Test Well Construction and Pumping Test

1. General

The test well construction work is one part of the groundwater development study for the Managua Water Supply Project planned by INAA and being executed by the joint study team of INAA and JICA (Japan International Cooperation Agency).

The major purposes of the test well construction are:

- to confirm the geological composition and sequence by drill cuttings and geophysical logging;
- to know the geothermal gradient by conducting geothermal logging;
- to determine the hydrological constants of the aquifer by conducting the pumping test; and
- to analyze water quality by taking samples from different aquifers.

Five wells are to be constructed in the 3 sub-areas of the groundwater catchment area, as shown in the attached location map. One each in the Western and Managua central sub-area, and 3 wells in the Eastern sub-area which is presumed to be the most promising area for groundwater development.

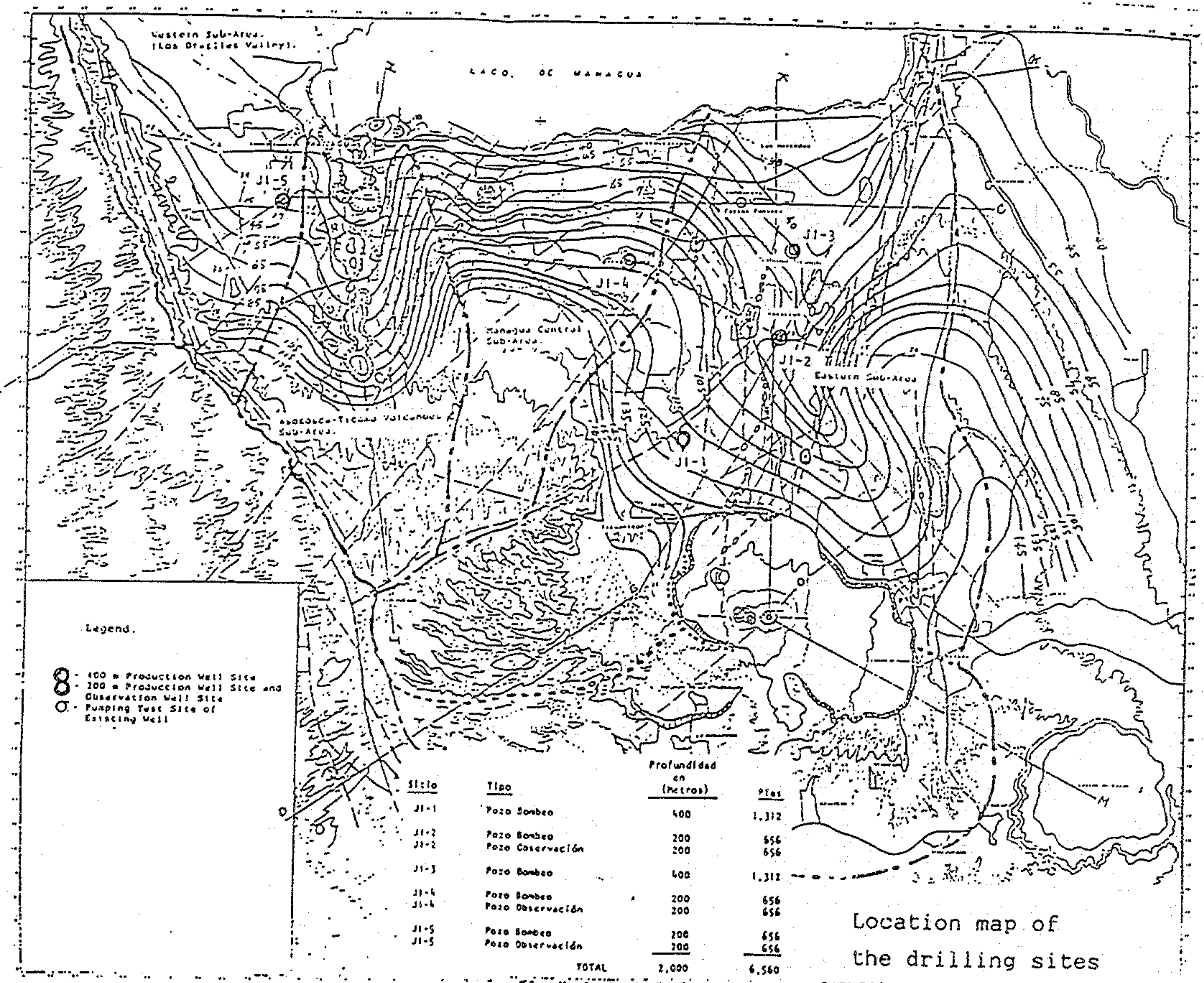
2. Scope of the Work

The work comprises of drilling and completion of five (5) boreholes with a total drilling depth of 1,400m and six (6) series of pumping test, 5 in the newly drilled wells and 1 in one of the existing wells. The work shall be completed within four and a half (4.5) months after the signing of the contract documents.

The contractor shall provide all necessary equipment and materials for execution of the work, except the submersible motor pump and diesel engine generator for pumping test and the geophysical logging apparatus, which are to be provided by the JICA Study Team.

The location and structure of each well are tabulated below, and shown in the Location map and the Figure of Well Structure.

Well No.	Location		Target drilling depth	Drilling		Casing diameter	Screen	Pumping test
	Area name	Coordinate		diameter	Section			
J-1	Eastern sub-area	32.00N 87.57E	400m	16"> 6">	0 - 300m 300-400m	12" —	J-screen 24m S-pipe 60m	○
J-2		36.25N 91.85E	200m	16">	0 - 200m	12"	J-screen 18m S-pipe 54m	○
J-3		40.00N 92.15E	400m	16"> 6">	0 - 300m 300-400m	12" —	J-screen 24m S-pipe 60m	○
J-4	Managua central sub-area	39.00N 85.25E	200m	16">	0 - 200m	12"	J-screen 18m S-pipe 54m	○
J-5	Western sub-area	41.10N 70.90E	200m	16">	0 - 200m	12"	J-screen 18m S-pipe 54m	○
	Eastern sub-area	41.70N 89.75E	—	—	—			○



Sitio	Tipo	Profundidad en (Metros)	Pies
J1-1	Pozo Bombeo	400	1,312
J1-2	Pozo Bombeo	200	656
J1-2	Pozo Observación	200	656
J1-3	Pozo Bombeo	400	1,312
J1-4	Pozo Bombeo	200	656
J1-4	Pozo Observación	200	656
J1-5	Pozo Bombeo	200	656
J1-5	Pozo Observación	200	656
	TOTAL	2,000	6,560

Location map of
the drilling sites

3. Technical Specifications

3-1 Work procedure

The work procedure for construction of each well shall be as follows:

a. Mobilization and site preparation;

b. Digging and surface casing installation;

c.* Drilling to a target depth accompanied by c-1 and c-2 works for drilling shallower than 300m. As for drilling deeper than 300m, 2 cases are noted in c-3;

d. Geophysical logging (S.P., resistivity, radioactive and temperature logging);

e. Casing and screen installation accompanied by 1" strainer pipe for water level measurement;

f. Gravel and sand packing of the annular space surrounding the casing / screen;

g. Well cleaning and development;

h. Pumping test (step, continuous and recovery test);

i. Additional sand packing and surface sealing by cement grouting;

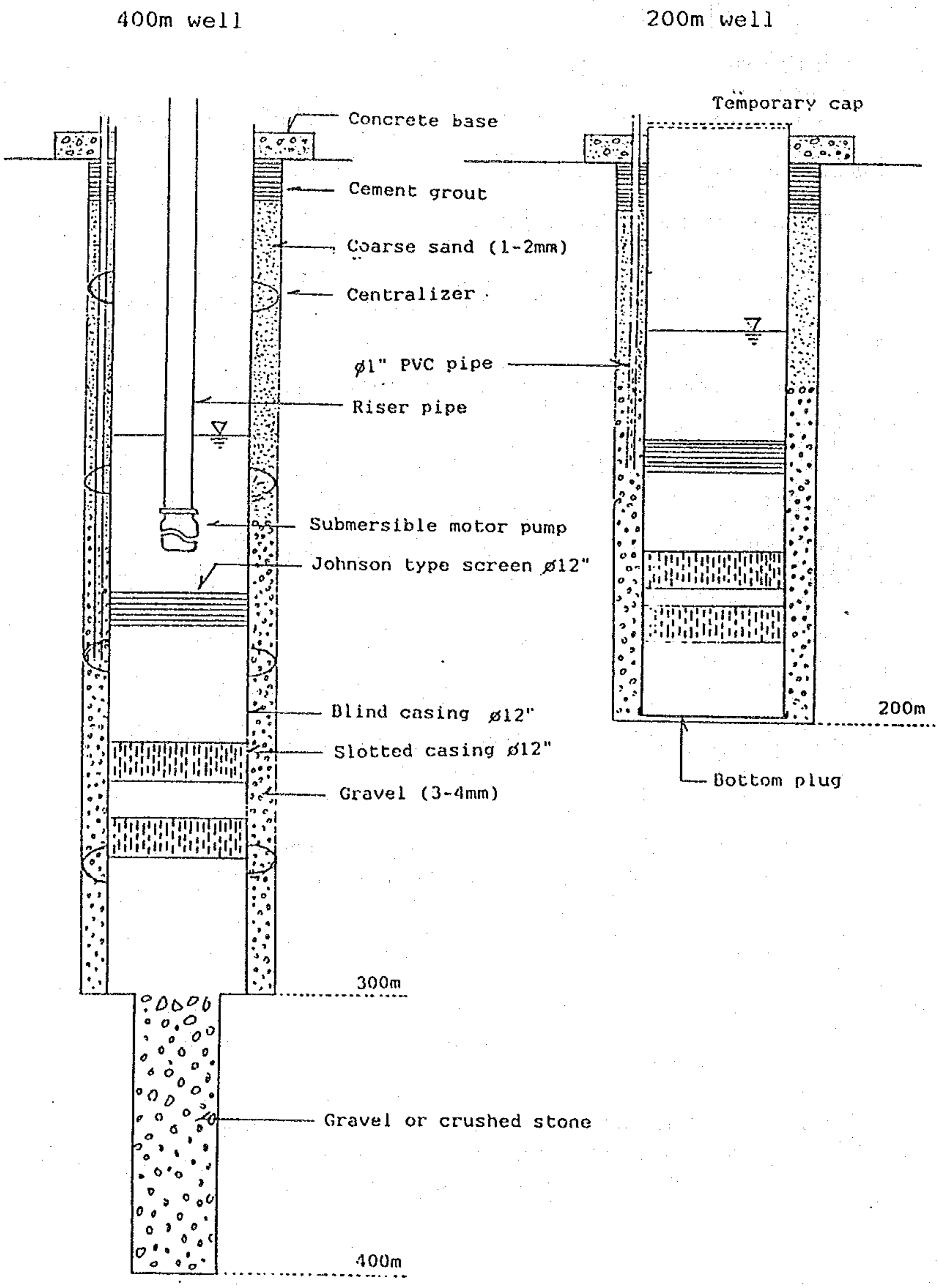
j. Concrete base construction and temporary capping.

*c-1 Static water level measurement just after finishing the day's drilling work, and before starting the next day's drilling work.

*c-2 Observation and arrangement of soil / rock samples taken from drill cuttings.

*c-3 Case 1 Drilling down to the depth of 300m with a diameter bigger than 16" followed by the drilling of diameter bigger than 6" after 300m.

Case 2 Drilling down to the depth of 300m followed by the procedures after (d), then continue drilling deeper than 300m through the installed casing and screen.



WELL STRUCTURE

3-2 Work Schedule

In order to complete the work within a very short period of only four (4) and a half months, the number of drilling rigs to be prepared by the contractor must correspond with the number of wells.

The contractor shall submit the detailed work schedule immediately after the signing of the contract.

3-3 Drilling depth

For each 200m and 400m test wells, an increase in drilling depth will not be ordered by the Engineers, however, drilling will be likely stopped for 400m deep test wells before reaching 400m, if the hydrogeological basement (El Salto Formation) is encountered at less than 380m deep. But, if the geothermal gradient seems bigger than ordinary value, drilling shall be continued down to 400m to conduct geothermal logging.

3-4 Drilling method and diameter

Cable tool percussion drilling method is considered most preferable for the area due to its leaky formation, and open hole drilling method shall be used for a depth of 300m, except at collapsible surface portion.

In order to construct more than 2 inches of annular space around the casing/screen, the drill hole diameter shall be bigger than 16 inches.

As for drilling deeper than 300m, the drilling diameter shall be less than 8 inches so that drilling can be continued even after the installation of casing/screen between 0 and 300m. Since it is necessary to drill deeper than 300m to confirm the lithologic sequence and to take the geothermal gradient, drilling diameter of less than 8 inches is applicable.

3-5 Geophysical logging

Prior to installation of casing and screen in the drilled well, the following 4 types of geophysical logging shall be conducted by use of the logging apparatus provided by the JICA Study Team, in order to determine the casing program, and to collect data on geothermal gradient.

- Spontaneous potential logging

- Electrical resistivity logging

- Gamma - gamma logging

- Geothermal logging

The logging work and the analytic work are to be done by the JICA - INAA Team members, with the assistance of the contractor.

3-6 Water level detection

The actual water level in the borehole shall be measured accurately by the use of a water level detector 2 times everyday during the drilling work, that is, before starting the day's drilling work and right after finishing the day's work.

3-7 Soil / rock sample collection

While drilling, the drill cuttings shall carefully be observed to prepare the geologic columnar section. The casing / screen program shall be mainly determined by this section which shall be supplemented by the above logging data.

Soil sample shall be taken from the drill cuttings with progress of every one meter drilling, and shall be put into transparent vinyl bags where the hole No. and depth are written, and they shall be arranged in order.

3-8 Daily drilling record

The chief operator of every drilling team shall prepare the daily drilling record, which covers the following items below, and submit it to the Engineer every weekend.

- Working hour and progress of drilling;

- Water level (morning, evening);

- Type and weight of drill bit and stem used;

- Stroke per minutes;

- Drilling speed (actual and the day's average);

- Description of drilling sample.

3-9 Casing / screen installation

Casing and screen shall be lowered to the drilled borehole in accordance with the casing / screen program prepared by the Engineer. Before lowering them, the casing and screen shall be placed in order on the ground surface. They shall be marked with the serial No. and the markings shall be in chalk. The centralizer shall be attached to every 6 casings or every 40m of lined casing / screen, so that the line of the casings comes to the center of the drilled borehole.

A line of 1 inch PVC pipe for water level measurement shall be attached to the casing from the depth of about 10 meters deeper than the presumed dynamic water level.

3-10 Gravel and coarse sand packing

The rounded gravel and coarse sand shall be packed at the annular space between the casing / screen and drilled borehole, to elongate the lifespan of the well. The grain size of the gravel shall be 3 - 4 mm and that of coarse sand shall be 1 - 2mm.

3-11 Casing and screen material

The well casing shall be steel made with an inner diameter of 12 inches and a thickness of more than 5 millimeters.

The well screen to be used shall be of the following two types.

- 6m long slotted steel pipe of 12 inches diameter. The slot size shall be less than 2 millimeters and the total opening ratio shall be more than 6%. 9 pieces each (54m long in total) of this pipe are to be used for 200m wells, and 10 pieces each (60m long in total) are to be used for 400m wells.

- 3m long stainless steel made and continuous slot by wedged wire wound (Johnson screen or similar) with a slot size of less than 1mm, and an opening ratio of more than 20%. 6 pieces each (18m long in total) are to be used for 200m wells and 8 pieces each (24m long in total) are to be used for 400m wells. The diameter of the screen shall be 12 inches, same as in the above slotted pipes. The contractor shall purchase this type of screen from INAA.

3-12 Well development

Well development shall be continued until water from the well turns apparently clean. Any type of development method such as bailing, air lifting / surging or by use of submersible motor pump can be selected. If mud was used during drilling, the development shall be continued for at least 10 hours after water turns clean in order to remove the mud from the hole wall completely.

Considerable amount of water is expected to flow out during the development and pumping test, therefore, drainage shall be properly arranged.

3-13 Pumping test

The following three types of pumping test shall be carried out under the direction of the Engineer by use of the submersible motor pump and diesel engine generator provided by the JICA Study Team.

- Step draw down test:
  5 steps per 2 hours of pumping

- Continuous draw down test :
  Pumping duration shall be more than 24 hours at the pumping rate of so directed by the Engineer, but if the water level comes stabilized in earlier time, the test can be discontinued by the direction of the Engineer.

- Recovery test:
  After continuous pumping, the recovery of the water level shall be measured for more than 8 hours, however if the water level returns to the initial level at an earlier time, the measurement can be discontinued.

Data records for water level changes and its time shall be informed to the Engineer in order.

The pumping tests shall be conducted in the 5 new drilled wells and in one of the existing wells in Sabana Grande Area.

3-14 Well completion

The additional coarse sand shall be packed up to 5m below ground surface after finishing the pump test, then the annular space of about 5m long shall be sealed with cement. A round steel plate shall be point welded to the casing of each well as a temporary cap. A concrete base with a dimension of 30cm (H) × 50cm (W) ×50cm (L) shall be constructed at the ground surface after surface sealing by cement grouting.

4. Adjustment of contract price in accordance with the quantity variation of the works or materials

The quantity of the works and materials are likely changed, if so directed by the Engineer, from the quantity specified in this technical specifications. The equitable adjustment is to be made in accordance with the price schedule and the equation below. The adjustment is to be made on the final payment.

Case of increase:

- Probale increase of screen:
  Increase of the cost is calculated by
  (Cost of screen increased – Cost of blind casing decreased) × 1.3

Case of decrease:

- Decrease of drilling depth after 300m directed by the Engineer:
  (Unit drilling cost × length decreased) × 1.3
- Shortage of drilling caused by the Contractor's fault:
  (Unit drilling cost + Unit cost of well completion materials per meter) × well depth decreased × 1.3

3. HYDROLOGY

3. HYDROLOGY

3.1 Monitoring

In order to evaluate groundwater table, seasonal movement and reaction due to rainfall, pumping extraction and other functions, the monitoring survey on rainfall and groundwater level were conducted. Fig. 3.1.1 shows the location of existing stations and monitoring instruments.

(1) Rainfall

The rainfall record form existing meteorological station were principally collected from the meteorological section of the Instituto Nicaraguense de Estudios Territoriales(INETER). Research was conducted on the twelve stations shown in Fig.4.2.1, located in the Study Area. The station with the lowest elevation, 56m above sea level, is at A.C. Sandino (Airport) and the highest, 910m, is at Hacienda Casa Colorada.

The observation period was very limited and records were missing in many cases. Observations were only continually and accurately conducted at the A.C. Sandino and Masatepe Stations. Monthly rainfalls of these stations are attached in Data Book.

In order to graspe supplementary data in the area considered lack of existing record, the automatic rainfall gage was installed. The location of equipment was selected in La Concepción by mentioned reasons.

<u>Specification of the Automatic Rainfall Recorder</u>:

- A completely self contained tipping bucket rain gage
- One or 3 months operating event recorder

Maintenance of the equiment was conducted at least once a month, with following check points:

(1) Cleaning of the rainfall pan
(2) Check of the clock and pen
(3) Check of the paper
(4) Check of the time order

When the recording paper was collected, analog data was converted into daily rainfall. INETER fixed the hydrological observation time from 7:00 a.m. to 7:00 a.m.. Table 3.1.1 shows the daily rainfall at La Concepción Station.

The following table in next page shows the monthly rainfall of existing stations and of the monitored station at La Concepción in 1992.

Rainfall in 1992 unit:mm

Station	EL.	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	SUM
La Concepción	540	0	0	80	255	147	44	138	262	926
Airport	56	0	0	87	159	139	62	143	111	701
Masaya	210	1	0	85	252	166	50	203	116	873
San Ishidro	290	0	0	89	291	115	86			
Masatepe	450	1	29	128	-	148	64			
Casa Colorada	910	0	35	64	188	133	79	166		

The following observations regarding the rainy condition in 1992 were made from the above results.

(a) This year was relatively drier than the others.

(b) A maximum daily rainfall of 206 mm was observed at La Concepción in October; the second maximum daily rainfall of about 60 mm was observed at the Airport and San Isidro in May, and at Masaya in October.

(c) Rainfall hardly varies due to local conditions, however, the annual rainfall is roughly linear in elevation except at Casa Colorada Station.

Heavy rainfalls were observed to concentrate within a very limited period of few days. Because the measurement of river discharge was particularly difficult in the Area, the final recharge to the groundwater shall be determined by investigating the variation of the groundwater level in the downstream area.

(2) Water Level

Records collected at the 3 stations, namely Christian Perez, Masaya and Sabana Grande, were used as daily water level values (see Table 3.1.2 (1)-(3)).

Christian Perez station is located in the center of Managua City, and its water level is observed to continuously decrease even in June and July, the rainy season. A very slight increase is observed in the end of July though. The water level measured during the simultaneous leveling works was 44.3 m below sea level, while 45.5 m below sea level was recorded in November. One of the reasons may be attributed to the short rainfall in this year.

Another factor to consider is the location of the well. The amount of pumping discharge in the central part of Managua City has rapidly increased in the recent years. Although the Christian Perez Station is also surrounded by many production wells, it is still difficult to analyze this relationship in detail because of the absence of continuous water level records concerning the area.

Masaya station, which is located southwest of Lake Masaya, has a water level of around 15.5 m below sea level. The lowest water level was in March, and an increase was observed until the end of July. Water level was observed to decrease in September and rapidly increase at the end of October by 200 mm of the daily rainfall amount observed in the La Concepcion station in October 3, 1992. The change in the water level corresponds to the amount of rainfall in the recharged area, but the increase from March to the end of April is unexplainable. It is, therefore, important to check the water level until March 1993.

Sabana Grande station is located south of the Airport and has a water level of around 22 m below sea level. The water level of this station varies according to rainfall amount.

The water level was observed to decrease until the middle of May, but was observed to increase after the first heavy rain (around 60mm) in May. Nevertheless, only 20-30mm increase was observed based on the still dry condition of the soil. This rainfall amount is recorded in A.C. Sandino Station.

(a) Bench mark survey of the Masaya Lake

Date: Oct.10, 1992

Location	Elevation (m)	Remarks
BM-LM-1965	126.609	
TBM.1	128.240	(Pena)
TBM.2	130.589	(Pena)
Water Level Recorder	135.928	

Note: This elevation is on the reading point of the recorder.

Location	Elevation (m)	Remarks
BM-LM-1965	126.609	
Water Level of Lake Masaya	135.928	

(b) Specifications of Water Level Recorder

- for 3 months records
- Floating Type (groundwater type: 0-100 m)
(Surface water type: 0-10 m)

Maintenance was conducted 1-2 times a month and the following points were checked:

- Battery
- Clock and pen
- Recording paper

(3) Streamflow (Mocuana and Sapamaspa River)

(a) Continuous monitoring

- Mocuana River

An automatic water level recorder is installed at the intersection of Mocuana river and Managua-Tipitapa road.

Observation works started in March,1992.

The collected water level records at the Mocuana river station were used for monthly discharge estimation.

Table 3.1.3 shows the reading of the water level recorder, gage height and calculated discharge. Fig.3.1.2 shows a stage-discharge rating curve based on the monthly discharge measurements conducted until October.

However, this result does not show the actual response of the runoff and rainfall, because the observation point has two dams upstream, one for the swimming pool at Trapiche park and the other for the irrigation of the El Panama agricultural scheme. Discharge at this point is controlled by gate operation of these facilities. The total amount of discharge, therefore, has to be evaluated instead of a flooding analysis.

Table 3.1.4 shows the average monthly discharge which is estimated at 1.01 m^3/sec and considered to have increased around 1.3 m^3/sec in July, September and October.

By the results, a minimum discharge of 1.00 m^3/sec is evaluated as the base flow at this point presently.

- Monitoring of Sapasmapa River

In order to estimate the general runoff amount to Lake Masaya, a staff gauge was installed in Sapasmapa river, around 100 m up from the lake. Gauge reading was performed when flow was observed. Discharge was estimated by using the Manning method with an estimated cross section. The results are shown in Table 4.3.2, including the daily rainfall at Masaya and la Concepción stations. River cross section is also very small in the whole catchment area and the discharge amount was observed to be quite small for a catchment area of around 80 Km^2, because of the presence of numerous banks and planes on the way where water is stored or spread.

(b) Simultaneous discharge measurement

Simultaneous discharge measurements were conducted in October 21, 1992, and are shown in Fig.3.1.1. The results of the measurement in the dry (February) and rainy (October) seasons are summarized below.

unit: m3/sec

Place	Feb.	Oct.	
Santa Elena	0.146	( )	Dam leakage is not estimated in October.
El Rodeo Pla.	0.052	0.010	
IRENA	0.074	0.097	
El Zapotal	0.093	0.242	
Rio Mocuana	(0.86)	0.108	Different current meters were used.
Las Cruces	N.S.	0.068	

The results clearly show a slight increase in the discharge measured in most of the places. However, the wet condition in spring zones is observed to spread in comparison to the conditions in the dry season.

Table 3.1.1 Daily Rainfall at La Concepcion Station

YEAR: 1992 UNIT: mm

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	-	-	-	0.00	0.00	0.00	0.00	0.00	4.00	-	0.00	0.00
2	-	-	-	0.00	0.00	0.00	5.00	2.00	0.50	4.50	0.00	0.00
3	-	-	-	0.00	0.00	0.00	11.00	1.50	0.50	206.00	2.50	0.00
4	-	-	-	0.00	0.00	0.00	1.00	1.50	0.00	27.00	0.50	0.00
5	-	-	-	0.00	0.00	6.50	0.00	1.00	0.00	0.00	0.00	0.00
6	-	-	-	0.00	0.00	0.00	4.00	0.00	0.00	0.50	0.00	0.00
7	-	-	-	0.00	0.00	0.00	33.00	0.00	0.00	5.00	0.00	0.00
8	-	-	-	0.00	0.00	2.50	6.50	1.50	0.00	7.50	0.00	0.00
9	-	-	-	0.00	0.00	0.50	2.50	0.50	0.00	0.50	0.00	0.00
10	-	-	-	0.00	0.00	0.00	0.00	0.00	0.50	3.00	0.00	0.00
11	-	-	-	0.00	0.00	17.00	7.00	5.00	0.00	1.00	0.00	0.00
12	-	-	-	0.00	0.00	0.00	0.00	2.00	3.00	0.00	0.00	0.00
13	-	-	-	0.00	0.00	0.00	13.50	0.50	0.00	0.00	0.00	0.00
14	-	-	-	0.00	0.00	0.00	0.00	2.50	0.10	0.00	0.00	0.00
15	-	-	-	0.00	0.00	0.00	16.50	0.50	0.00	0.00	0.00	0.00
16	-	-	-	0.00	0.00	1.00	1.00	6.50	0.00	0.00	0.00	0.00
17	-	-	-	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00
18	-	-	-	0.00	29.00	1.00	5.00	0.00	5.50	0.00	0.00	0.00
19	-	-	-	0.00	0.00	7.00	1.00	2.00	0.50	0.00	0.00	0.00
20	-	-	0.00	0.00	0.00	52.00	0.00	2.50	2.00	2.50	0.00	0.00
21	-	-	0.00	0.00	0.00	2.50	0.00	2.00	0.00	4.50	0.00	0.00
22	-	-	0.00	0.00	39.00	8.00	2.50	0.00	0.00	0.00	0.00	0.00
23	-	-	0.00	-	0.00	1.50	10.50	0.50	0.00	4.50	0.00	0.00
24	-	-	0.00	0.00	9.50	25.50	0.50	0.00	57.00	0.00	0.00	0.00
25	-	-	0.00	0.00	0.00	34.00	6.00	0.50	5.00	0.00	0.00	0.00
26	-	-	0.00	0.00	0.00	0.50	1.50	5.00	0.50	0.00	0.00	0.00
27	-	-	0.00	0.00	0.00	9.00	8.00	4.00	45.00	0.50	0.00	0.00
28	-	-	0.00	0.00	0.00	36.50	0.00	0.00	3.50	0.00	0.00	0.00
29	-		0.00	0.00	0.00	41.50	5.00	2.50	0.00	0.00	0.00	0.00
30	-		0.00	0.00	0.00	7.00	1.00	0.00	10.50	15.50	0.00	0.00
31	-		0.00		0.00		5.00	0.00		1.00		0.00
TOTAL			0.00	0.00	80.00	255.00	147.00	44.00	138.10	283.50	3.00	0.00

Table 3.1.3 Discharge Monitoring (1)

STATION:MOCUANA RIVER

YEAR:1992

READING OF RECORDING HEIGHT

DATE	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1		1.89	1.9	1.83	-	1.9	1.83	1.84
2		1.89	1.895	1.84	1.812	1.9	1.84	1.85
3		1.885	1.885	-	-	1.89	1.84	1.85
4		1.89	1.885	-	-	1.885	1.87	1.82
5		1.88	1.78	-	-	1.88	1.88	1.8
6		1.87	1.88	1.86	1.82	1.84	1.88	1.835
7		1.78	1.9	1.82	1.84	1.835	1.83	1.75
8		1.86	1.9	1.84	1.84	1.84	1.84	1.795
9		1.875	1.89	1.84	1.81	1.83	1.79	1.84
10		1.9	1.885	1.855	1.85	18.75	1.85	1.87
11		1.89	1.895	1.84	-	-	1.91	1.855
12		1.885	1.895	1.83	-	-	1.9	1.825
13		1.89	1.885	1.835	-	-	1.89	1.74
14		1.885	1.88	1.86	-	-	1.89	1.86
15		1.89	1.88	1.88	-	-	1.89	1.855
16		1.88	1.89	1.88	-	-	1.845	1.89
17	1.75	1.89	1.885	1.885	-	1.88	1.835	1.9
18	1.9	1.885	1.89	1.88	-	1.76	1.88	1.885
19	1.93	1.875	1.78	1.91	-	1.85	1.885	1.885
20	1.9	1.875	1.85	-	1.825	1.89	1.8	
21	1.9	1.79	1.84	-	1.85	1.9	1.88	
22	1.89	1.85	1.82	-	-	1.89	1.87	
23	1.88	1.89	1.8	-	-	1.895	1.86	
24	1.905	1.815	1.81	-	-	1.88	1.78	
25	1.92	1.91	1.835	-	-	1.875	1.8	
26	1.88	1.905	1.835	-	-	1.88	1.78	
27	1.89	1.9	1.84	-	-	1.86	1.785	
28	1.89	1.81	1.85	-	-	1.895	1.81	
29	1.895	1.9	1.855	-	-	1.87	1.76	
30	1.895	1.905	1.85	-	1.87	1.75	1.77	
31	1.99		1.85	-	1.87	1.84		
MONTHLY AVERAGE	1.894333	1.874666	1.861774	-	-	-	1.842333	-

Table 3.1.3 Discharge Monitoring (2)

(2) Gage HEIGHT

DATE	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1	-	0.24	0.23	0.30	-	0.23	0.30	0.29
2	-	0.24	0.24	0.29	0.32	0.23	0.29	0.28
3	-	0.25	0.25	-	-	0.24	0.29	0.28
4	-	0.24	0.25	-	-	0.25	0.26	0.31
5	-	0.25	0.35	-	-	0.25	0.25	0.33
6	-	0.26	0.25	0.27	0.31	0.29	0.25	0.30
7	-	0.35	0.23	0.31	0.29	0.30	0.30	0.39
8	-	0.27	0.23	0.29	0.29	0.29	0.29	0.34
9	-	0.26	0.24	0.29	0.32	0.30	0.34	0.29
10	-	0.23	0.25	0.28	0.28	-	0.28	0.26
11	-	0.24	0.24	0.29	-	-	0.22	0.28
12	-	0.25	0.24	0.30	-	-	0.23	0.31
13	-	0.24	0.25	0.30	-	-	0.24	0.40
14	-	0.25	0.25	0.27	-	-	0.24	0.27
15	-	0.24	0.25	0.25	-	-	0.24	0.28
16	-	0.25	0.24	0.25	-	-	0.29	0.24
17	0.39	0.24	0.25	0.25	-	0.25	0.30	0.23
18	0.23	0.25	0.24	0.25	-	0.37	0.25	0.25
19	0.20	0.26	0.35	0.22	-	0.28	0.25	0.25
20	0.23	0.26	0.28	-	0.31	0.24	0.33	-
21	0.23	0.34	0.29	-	0.28	0.23	0.25	-
22	0.24	0.28	0.31	-	-	0.24	0.26	-
23	0.25	0.24	0.33	-	-	0.24	0.27	-
24	0.22	0.32	0.32	-	-	0.25	0.35	-
25	0.21	0.22	0.30	-	-	0.26	0.33	-
26	0.25	0.22	0.30	-	-	0.25	0.35	-
27	0.24	0.23	0.29	-	-	0.27	0.35	-
28	0.24	0.32	0.28	-	-	0.24	0.32	-
29	0.24	0.23	0.28	-	-	0.26	0.37	-
30	0.24	0.22	0.28	-	0.26	0.39	0.36	-
31	0.14	***	0.28	***	0.26	0.29	***	-

Table 3.1.3 Discharge Monitoring (3)

(3) CALCULATED DISCHARGE

DATE	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
1	-	1.02	0.97	1.34	-	0.97	1.34	1.28
2	-	1.02	0.99	1.28	1.45	0.97	1.28	1.23
3	-	1.04	1.04	-	-	1.02	1.28	1.23
4	-	1.02	1.04	-	-	1.04	1.12	1.40
5	-	1.07	1.65	-	-	1.07	1.07	1.52
6	-	1.12	1.07	1.17	1.40	1.28	1.07	1.31
7	-	1.65	0.97	1.40	1.28	1.31	1.34	1.84
8	-	1.17	0.97	1.28	1.28	1.28	1.28	1.55
9	-	1.09	1.02	1.28	1.46	1.34	1.58	1.28
10	-	0.97	1.04	1.20	1.23	-	1.23	1.12
11	-	1.02	0.99	1.28	-	-	0.92	1.20
12	-	1.04	0.99	1.34	-	-	0.97	1.37
13	-	1.02	1.04	1.31	-	-	1.02	1.91
14	-	1.04	1.07	1.17	-	-	1.02	1.17
15	-	1.02	1.07	1.07	-	-	1.02	1.20
16	-	1.07	1.02	1.07	-	-	1.26	1.02
17	1.84	1.02	1.04	1.04	-	1.07	1.31	0.97
18	0.97	1.04	1.02	1.07	-	1.78	1.07	1.04
19	0.82	1.09	1.65	0.92	-	1.23	1.04	1.04
20	0.97	1.09	1.23	-	1.37	1.02	1.52	-
21	0.97	1.58	1.28	-	1.23	0.97	1.07	-
22	1.02	1.23	1.40	-	-	1.02	1.12	-
23	1.07	1.02	1.52	-	-	0.99	1.17	-
24	0.94	1.43	1.46	-	-	1.07	1.65	-
25	0.87	0.92	1.31	-	-	1.09	1.52	-
26	1.07	0.94	1.31	-	-	1.07	1.65	-
27	1.02	0.97	1.28	-	-	1.17	1.61	-
28	1.02	1.46	1.23	-	-	0.99	1.46	-
29	0.99	0.97	1.20	-	-	1.12	1.78	-
30	0.99	0.94	1.23	-	1.12	1.84	1.71	-
31	0.57	***	1.23	***	1.12	1.28	***	-
AVE.(M3/s)	1.008249	1.101861	1.171424	1.202564	1.294175	1.166096	1.282375	1.299933
M3	2700496.	2856023.	3137543.	3117048.	3466320.	3123274.	3323916.	3481741.

STATION: CRISTIAN PEREZ

Table 3.1.2 Daily Groundwater Level (1)

YEAR: 1992 | YEAR: 1993

JUNE		JULY		AUG		SEP		OCT		NOV		DEC		JAN		FEB	
DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)
1		1	45.2	1	45.22	1	45.31	1	45.418	1	45.456	1	45.549	1	45.614	1	45.659
2		2	45.2	2	45.22	2	45.312	2	45.417	2	45.456	2	45.55	2	45.617	2	45.659
3	45.11	3	45.21	3	45.215	3	45.324	3	45.415	3	45.455	3	45.55	3	45.62	3	45.659
4	45.115	4	45.21	4	45.21	4	45.33	4	45.415	4	45.5	4	45.555	4	45.619	4	45.66
5	45.11	5	45.21	5	45.21	5	45.33	5	45.417	5	45.498	5	45.556	5	45.618	5	45.673
6	45.13	6	45.21	6	45.205	6	45.356	6	45.418	6	45.5	6	45.554	6	45.618	6	45.677
7	45.135	7	45.215	7	45.215	7	45.341	7	45.419	7	45.501	7	45.565	7	45.618	7	45.682
8	45.135	8	45.22	8	45.225	8	45.343	8	45.42	8	45.502	8	45.568	8	45.619	8	45.688
9	45.135	9	45.22	9	45.24	9	45.345	9	45.423	9	45.505	9	45.56	9	45.618	9	45.688
10	45.14	10	45.225	10	45.26	10	45.357	10	45.426	10	45.51	10	45.56	10	45.63	10	45.688
11	45.145	11	45.225	11	45.265	11	45.36	11	45.429	11	45.51	11	45.565	11	45.624	11	45.68
12	45.145	12	45.235	12	45.27	12	45.364	12	45.432	12	45.512	12	45.568	12	45.63	12	45.692
13	45.15	13	45.23	13	45.275	13	45.369	13	45.435	13	45.518	13	45.564	13	45.632	13	45.702
14	45.15	14	45.235	14	45.28	14	45.372	14	45.435	14	45.52	14	45.566	14	45.633	14	45.586
15	45.155	15	45.235	15	45.29	15	45.375	15	45.431	15	45.521	15	45.572	15	45.632	15	45.69
16	45.16	16	45.24	16	45.29	16	45.384	16	45.431	16	45.523	16	45.57	16	45.633	16	45.67
17	45.165	17	45.245	17	45.295	17	45.38	17	45.435	17	45.53	17	45.586	17	45.65	17	
18	45.17	18	45.245	18	45.3	18	45.38	18	45.44	18	45.533	18	45.587	18	45.65	18	
19	45.165	19	45.25	19	45.3	19	45.38	19	45.445	19	45.535	19	45.59	19	45.651	19	
20	45.17	20	45.255	20	45.305	20	45.382	20	45.45	20	45.525	20	45.591	20	45.646	20	
21	45.175	21	45.26	21	45.31	21	45.384	21	45.455	21	45.524	21	45.594	21	45.642	21	
22	45.18	22	45.26	22	45.31	22	45.384	22	45.46	22	45.525	22	45.598	22	45.64	22	
23	45.185	23	45.255	23	45.31	23	45.384	23	45.455	23	45.526	23	45.596	23	45.64	23	
24	45.19	24	45.25	24	45.315	24	45.386	24	45.458	24	45.532	24	45.598	24	45.64	24	
25	45.2	25	45.24	25	45.325	25	45.39	25	45.458	25	45.545	25	45.598	25	45.642	25	
26	45.205	26	45.235	26	45.325	26	45.392	26	45.458	26	45.546	26	45.599	26	45.65	26	
27	45.205	27	45.23	27	45.33	27	45.398	27	45.457	27	45.545	27	45.6	27	45.662	27	
28	45.2	28	45.23	28	45.335	28	45.411	28	45.458	28	45.549	28	45.6	28	45.66	28	
29	45.2	29	45.225	29	45.34	29	45.413	29	45.457	29	45.549	29	45.599	29	45.658	29	
30	45.2	30	45.22	30	45.345	30	45.416	30	45.457	30	45.549	30	45.599	30	45.66	30	
31		31	45.22	31	45.333			31	45.457	31		31	45.58	31	45.66	31	
MONTHLY AVERAGE	45.16160	MONTHLY AVERAGE	45.23032	MONTHLY AVERAGE	45.27961	MONTHLY AVERAGE	45.3684	MONTHLY AVERAGE	45.43809	MONTHLY AVERAGE	45.51666	MONTHLY AVERAGE	45.577	MONTHLY AVERAGE	45.63532	MONTHLY AVERAGE	45.67206

STATION: MASAYA LAKE

Table 3.1.2 Daily Groundwater Level (2)

YEAR:1992.

MARCH		APRIL		MAY		JUNE		JULIO		AGOSTO		SEPT.		OCT.		NOV.	
DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)
1		1	15.608	1	15.496	1	15.455	1		1	15.32	1	15.409	1	15.385	1	15.323
2		2	15.607	2	15.491	2	15.45	2	15.345	2	15.32	2	15.41	2	15.382	2	15.326
3		3	15.602	3	15.486	3	15.45	3	15.35	3	15.325	3	15.411	3	15.32	3	15.33
4		4	15.6	4	15.481	4	15.455	4		4	15.33	4	15.414	4	15.27	4	15.333
5		5	1.595	5	15.475	5	15.455	5		5	15.335	5	15.417	5	15.24	5	15.333
6		6	15.592	6	15.47	6	15.44	6		6	15.338	6	15.419	6	15.24	6	15.337
7		7	15.587	7	15.468	7	15.437	7		7	15.34	7	15.421	7	15.245	7	15.342
8		8	15.582	8	15.467	8	15.437	8		8	15.345	8	15.426	8	15.243	8	15.346
9		9	15.577	9	15.466	9	15.438	9		9	15.35	9	15.429	9	15.246	9	15.349
10		10	15.574	10	15.465	10	15.437	10		10	15.353	10	15.429	10	15.248	10	15.353
11		11	15.57	11	15.465	11	15.435	11		11	15.354	11	15.43	11	15.25	11	15.357
12		12	15.567	12	15.465	12	15.442	12		12	15.357	12	15.428	12	15.251	12	15.36
13		13	15.561	13	15.465	13	15.442	13		13		13	15.43	13	15.256	13	15.365
14		14	15.558	14	15.464	14	15.44	14		14		14	15.431	14	15.26	14	15.368
15		15	15.555	15	15.464	15	15.434	15		15		15	15.437	15	15.265	15	15.382
16	15.654	16	15.551	16	15.464	16	15.435	16		16		16	15.445	16	15.27	16	15.387
17	15.654	17	15.548	17	15.464	17		17		17	15.37	17	15.446	17	15.274	17	15.39
18	15.652	18	15.546	18	15.463	18		18		18	15.37	18	15.447	18	15.28	18	15.397
19	15.65	19	15.544	19	15.456	19		19		19	15.376	19	15.448	19	15.282	19	15.4
20	15.648	20	15.54	20	15.457	20		20	15.33	20	15.38	20	15.45	20	15.288	20	15.402
21	15.644	21	15.538	21	15.456	21		21	15.335	21	15.383	21	15.454	21	15.292	21	15.405
22	15.641	22	15.536	22	15.456	22		22	15.335	22	15.388	22	15.458	22	15.3	22	15.407
23	15.64	23	15.531	23	15.457	23		23	15.325	23	15.393	23	15.456	23	15.3	23	15.41
24	15.639	24	15.528	24	15.46	24		24	15.32	24	15.4	24	15.429	24	15.304	24	15.413
25	15.637	25	15.522	25	15.46	25		25	15.32	25	15.4	25	15.424	25	15.308	25	15.416
26	15.633	26	15.517	26	15.46	26		26	15.315			26	15.425	26	15.31	26	15.418
27	15.627	27	15.512	27	15.462	27						27	15.41	27	15.311	27	15.423
28	15.623	28	15.507	28	15.46	28				28	15.4	28	15.405	28	15.316	28	15.428
29	15.618	29	15.503	29	15.46	29				29	15.4	29	15.4	29	15.32	29	15.435
30	15.614	30	15.5	30	15.46	30		30	15.32	30	15.405	30	15.392	30	15.321	30	15.441
31		31		31	15.46	31		31		31	15.405	31		31	15.321	31	
MONTHLY AVERAGE	15.63826	MONTHLY AVERAGE	15.0866	MONTHLY AVERAGE	15.46590	MONTHLY AVERAGE	15.44262	MONTHLY AVERAGE	15.3295	MONTHLY AVERAGE	15.36548	MONTHLY AVERAGE	15.42768	MONTHLY AVERAGE	15.28703	MONTHLY AVERAGE	15.3792

Table 3.1.2 Daily Groundwater Level (2)

STATON : MASAYA LAKE
YEAR : 1992~1993

DEC		JAN		FEB		MAR	
DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)
1	15.443	1	15.558	1	15.598	1	15.722
2	15.447	2	15.558	2	15.608	2	15.724
3	15.454	3	15.56	3	15.61	3	15.728
4	15.457	4	15.564	4	15.615	4	15.73
5	15.46	5	15.568	5	15.617	5	
6	15.462	6	15.571	6	15.62	6	
7	15.458	7	15.574	7	15.627	7	
8	15.46	8	15.573	8	15.631	8	
9	15.464	9	15.54	9	15.637	9	
10	15.468	10	15.53	10	15.64	10	
11	15.473	11	15.527	11	15.641	11	
12	15.477	12	15.528	12	15.646	12	
13	15.482	13	15.53	13	15.648	13	
14	15.486	14	15.532	14	15.651	14	
15	15.489	15	15.536	15	15.657	15	
16	15.49	16	15.538	16	15.66	16	
17	15.491	17	15.54	17	15.67	17	
18	15.494	18	15.545	18	15.676	18	
19	15.499	19	15.55	19	15.684	19	
20	15.505	20	15.55	20	15.69	20	
21	15.508	21	15.55	21	15.692	21	
22	15.51	22	15.553	22	15.696	22	
23	15.513	23	15.567	23	15.698	23	
24	15.516	24	15.563	24	15.702	24	
25	15.524	25	15.56	25	15.705	25	
26	15.53	26	15.568	26	15.71	26	
27	15.533	27	15.577	27	15.713	27	
28	15.534	28	15.58	28	15.717	28	
29	15.537	29	15.582	29		29	
30	15.546	30	15.589	30		30	
31	15.553	31	15.594	31		31	
MONTHLY AVERAGE	15.49241	MONTHLY AVERAGE	15.55661	MONTHLY AVERAGE	15.65925	MONTHLY AVERAGE	15.726

Table 3.1.2 Daily Groundwater Level (3)

STATION: SABANA GRANDE

YEAR:1992

MAR	
DATE	LEVEL (m)
16	
17	
18	
19	
20	
21	
22	
23	
24	21.81
25	21.81
26	21.81
27	21.81
28	21.815
29	21.815
30	21.815
31	21.815
MONTHLY AVERAGE:	21.8125

APR		MAY		JUN		JUL		AUG	
DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)
1	21.81	1	21.825	1	21.87	1	21.855	1	21.85
2	21.805	2	21.828	2	21.874	2	21.855	2	21.849
3	21.775	3	21.829	3	21.877	3	21.855	3	21.849
4	21.76	4	21.829	4	21.9	4	21.855	4	21.848
5	21.76	5	21.832	5	21.89	5	21.85	5	21.84
6	21.77	6	21.838	6	21.89	6	21.855	6	21.843
7	21.78	7	21.845	7	21.892	7	21.855	7	21.844
8	21.79	8	21.848	8	21.89	8	21.85	8	21.843
9	21.795	9	21.855	9	21.89	9	21.845	9	21.845
10	21.802	10	21.858	10	21.886	10	21.845	10	21.847
11	21.805	11	21.861	11	21.886	11	21.84	11	21.85
12	21.805	12	21.858	12	21.885	12	21.84	12	21.852
13	21.807	13	21.864	13	21.89	13	21.84	13	21.854
14	21.8	14	21.868	14	21.898	14	21.84	14	21.854
15	21.8	15	21.875	15	21.9	15	21.835	15	21.854
16	21.8	16	21.883	16	21.9	16	21.833	16	21.86
17	21.78	17	21.881	17	21.9	17	21.83	17	21.863
18	21.797	18	21.881	18	21.9	18	21.83	18	21.86
19	21.794	19	21.883	19	21.9	19	21.83	19	21.86
20	21.794	20	21.885	20	21.9	20	21.83	20	21.86
21	21.795	21	21.883	21	21.896	21	21.83	21	21.86
22	21.795	22	21.86	22	21.891	22	21.83	22	21.86
23	21.795	23	21.86	23	21.89	23	21.83	23	21.865
24	21.795	24	21.86	24	21.89	24	21.835	24	21.865
25	21.805	25	21.865	25	21.87	25	21.84	25	21.875
26	21.806	26	21.867	26	21.86	26	21.845	26	21.875
27	21.815	27	21.868	27	21.86	27	21.85	27	21.875
28	21.817	28	21.872	28	21.86	28	21.85	28	21.87
29	21.82	29	21.874	29	21.858	29	21.85	29	21.87
30	21.824	30	21.865	30	21.855	30	21.855	30	21.865
31		31	21.863	31		31	21.852	31	21.865
MONTHLY AVERAGE:	21.79653	MONTHLY AVERAGE	21.86009	MONTHLY AVERAGE	21.88496	MONTHLY AVERAGE	21.84306	MONTHLY AVERAGE	21.85709

Table 3.1.2 Daily Groundwater Level (3)

YEAR:1992

SEP		OCT		NOV		DEC		JAN	
DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)	DATE	LEVEL (m)
1	21.88	1	21.87	1	21.845	1	21.948	1	21.984
2	21.875	2	21.87	2	21.86	2	21.955	2	21.986
3	21.87	3	21.855	3	21.88	3	21.956	3	21.988
4	21.88	4	21.85	4	21.89	4	21.952	4	22.003
5	21.885	5	21.84	5	21.89	5	21.954	5	22.017
6	21.89	6	21.82	6	21.89	6	21.954	6	22.032
7	21.89	7	21.82	7	221.886	7	21.955	7	22.046
8	21.89	8	21.82	8	212.886	8	21.956	8	22.061
9	21.9	9		9	21.89	9	21.966	9	22.076
10	21.905	10		10	21.893	10	21.967	10	22.09
11	21.9	11		11	21.9	11	21.962	11	22.105
12	21.9	12		12	21.908	12	21.966	12	22.12
13	21.91	13		13	21.92	13	21.967	13	22.134
14	21.9	14		14	21.926	14	21.967	14	22.149
15	21.915	15		15	21.927	15	21.967	15	22.163
16	21.915	16		16	21.928	16	21.969	16	22.178
17	21.905	17		17	21.93	17	21.969	17	22.193
18	21.91	18		18	21.933	18	21.97	18	22.207
19	21.91	19		19	21.943	19	21.972	19	22.222
20	21.915	20	21.825	20	21.942	20	21.972	20	
21	21.9	21	21.815	21	21.938	21	21.972	21	
22	21.89	22	21.803	22	21.937	22	21.973	22	
23	21.895	23	21.802	23	21.935	23	21.974	23	
24	21.89	24	21.801	24	21.933	24	21.974	24	
25	21.89	25	21.801	25	21.934	25	21.973	25	
26	21.905	26	21.801	26	21.936	26	21.969	26	
27	21.895	27	21.802	27	21.938	27	21.97	27	
28	21.895	28	21.806	28	21.939	28	21.971	28	
29	21.88	29	21.812	29	21.941	29	21.973	29	
30	21.87	30	21.825	30	21.944	30	21.975	30	
31		31	21.835			31	21.978	31	
MONTHLY AVERAGE	21.89516	MONTHLY AVERAGE	21.82365	MONTHLY AVERAGE	34.94806	MONTHLY AVERAGE	21.966	MONTHLY AVERAGE	22.09231

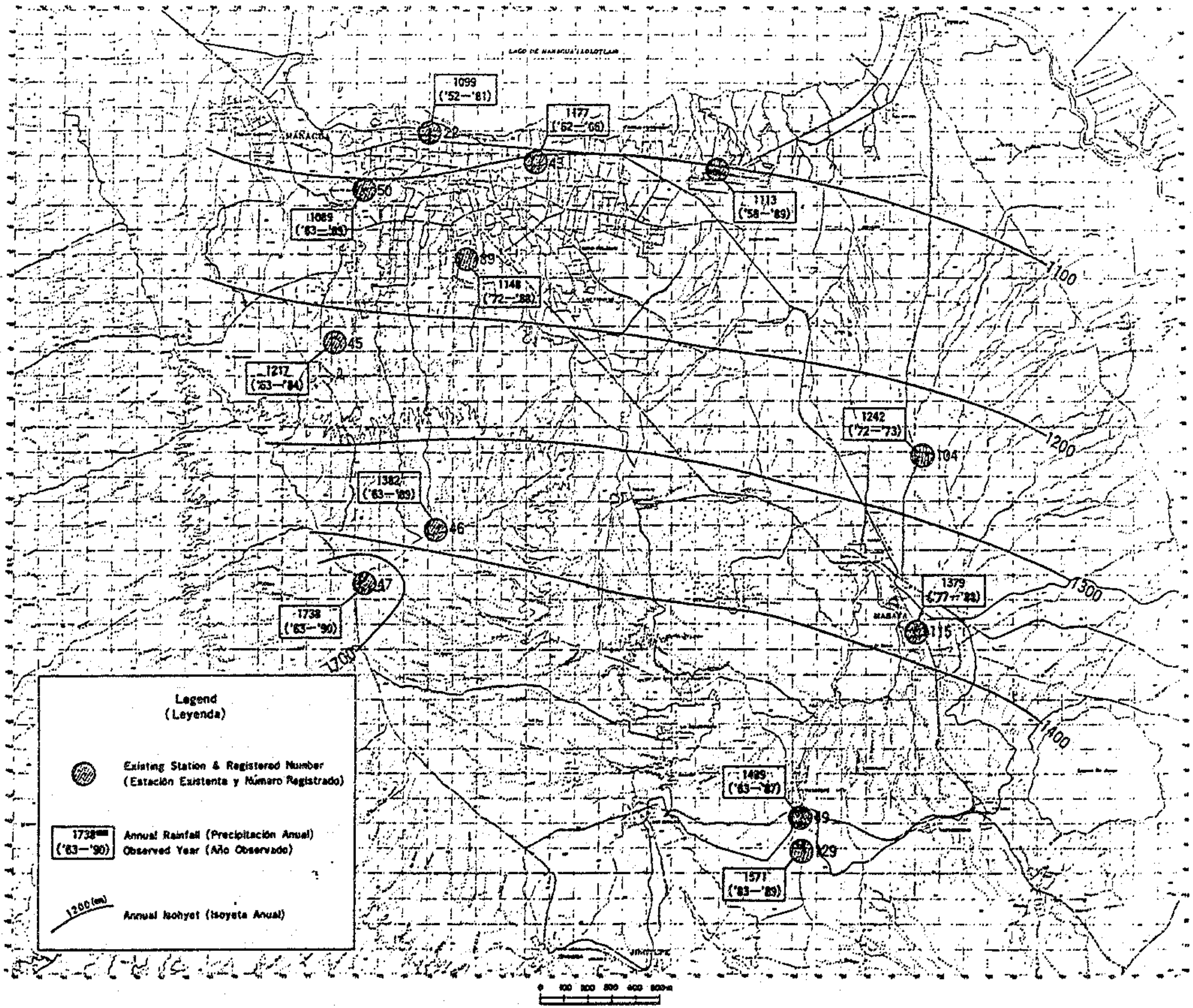
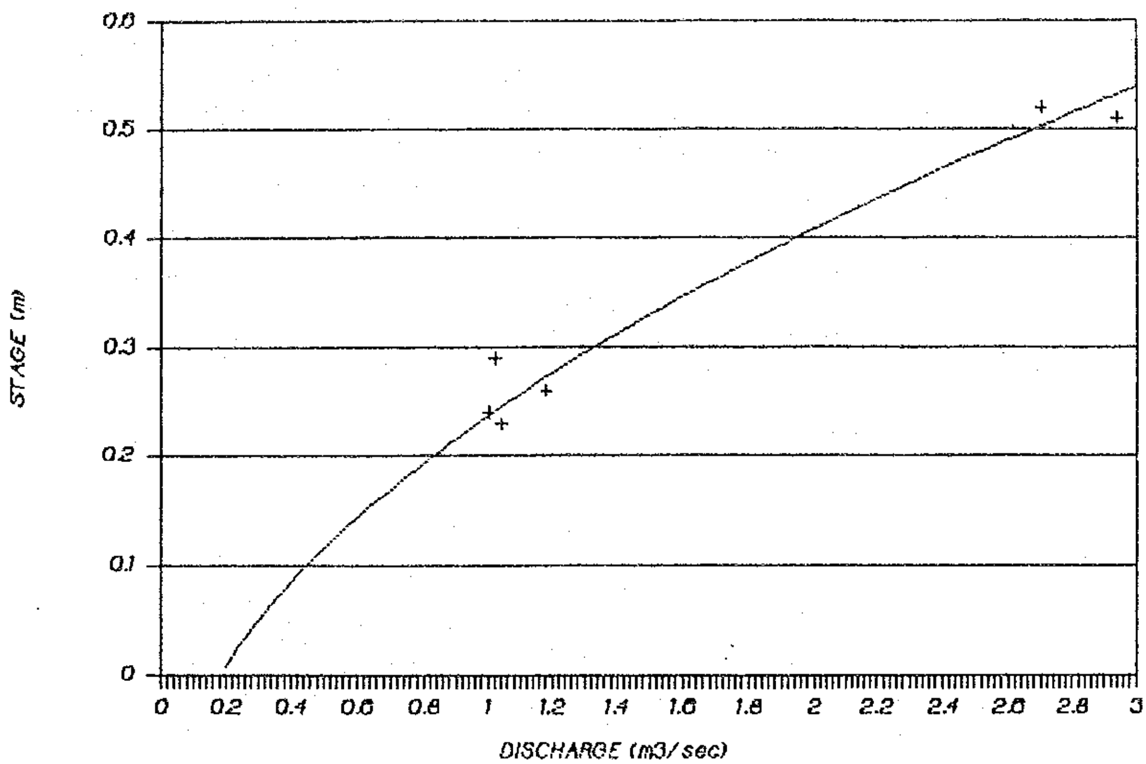


Fig 3.1.1 Location of the Monitoring Instruments

STAGE-DISCHARGE RATING CURVE



(a) RESULTS OF DISCHARGE MEASUREMENT

FECHA	DESCARGA (m3/seg) Q	ALTURA LIMNIMETRICA h
20/5/92	2.71	0.52
30/6/92	1.19	0.26
17/8/92	1.04	0.23
31/8/92	2.94	0.51
16/9/92	1	0.24
1/10/92	1.1	0.29

Q= (a H + b)**2

SQRT(Q)	H
1.646207	0.52
1.090871	0.26
1.019803	0.23
1.714642	0.51
1	0.24
1.048808	0.29

Regression Output:

Constant	0.426338981
Std Err of Y Est	0.057799621
R Squared	0.975882850
No. of Observations	6
Degrees of Freedom	4
X Coefficient(s)	2.420634
Std Err of Coef.	0.190266

SQRT(Q)= (H*2.4206+0.4263)**2

(b) RELATION OF RECORDER & GAGE HEIGHT

DATE	RECORDER	GAGE HEIGHT	
JULY 30	1.87	0.27	0.260198
AUG 28	1.896	0.235	0.233328
AUG 17	1.893	0.23	0.236429
JUN 8	1.84	0.3	0.291202
JUL 6	1.77	0.36	0.363543
OCT 9	1.855	0.27	0.275700
OCT 20	1.885	0.24	0.244696

Regression Output:

Constant	2.192752139
Std Err of Y Est	0.007545971
R Squared	0.977569401
No. of Observations	7
Degrees of Freedom	5
X Coefficient(s)	-1.03345
Std Err of Coef.	0.070009

H = -1.033 x h + 2.193

Fig 3.1.2 Stage Discharge Rating Curve

3.2 Rainfall Probability

It is difficult to forecast future natural phenomenon, even rainfall. According to the 5-year average tendency, important decreasing or increasing tendencies were not observed in the Study Area, however, it shall be pointed out that future planning has to be made by giving consideration to the safety side. Annual rainfall records of A.C. Sandino Station and Masatepe Station were used in the probability analysis carried out by the Hazen plot method.

The formula of non-exceedance probability of the Hazen plot is as follows:

$$Fn = 1 - Wn = 1 - (2n - 1/2N)$$

Outline of the calculation is as follows:

(a) All the annual rainfall records are ordered

(b) Calculation of probability Fn

(c) Plot Results of (b) logistic probability paper

(d) To create the line which pass by the center of the plotted points

(e) To interpret the relationship between annual rainfall and return period

Table 3.2.1 (1)-(2) shows the calculation sheets of both area.

Fig. 3.2.1 shows the Hazen plot method calculation in each station. A 50% probability was achieved, that is, 1100 mm and 1400 mm in A.C. Sandino and Masatepe stations respectively. The 20, 33, 50, 67 and 80% of annual rainfall probability in both stations and the estimated rainfall in other stations are listed in the same table.

The 50% probability (mode value) is almost equal to the simple average and the return period is 2 years.

This value is used in the model simulation as the assumed annual rainfall. According to the rainfall data collected during 20 years, annual rainfalls have been varying with a 40-60% variability coefficient. When the simulation is set for a long term of several years, the final results are inferred to cross the line of average value.

For the rough estimation of the water balance, safety side (safty percentage) should be considered because continuous dry years may occur during a short-term period.

The following table shows the 20% and 50% probability rainfalls in Masatepe and A.C. Sandino stations.

Location	Non-exceedance probability 20%	50%
A.C. Sandino	880	1100
Masatepe	1100	1400

The 20% probability rainfalls are 880 mm and 1100 mm in A.C. Sandino and Masatepe stations, respectively. These values represent approximately 80% of the 50% probability rainfall assumed in both stations. 80% of annual rainfall is utilized as a tentative safety coefficient for the balance calculation.

Table 3.2.1 Probability Rainfall

Provability Calculation

(1) Airport N=29

No.	Rain	Fn(%)
1	2185	98.27
2	1742.	94.82
3	1448	91.37
4	1423.	87.93
5	1383.	84.48
6	1368.	81.03
7	1365	77.58
8	1352.	74.13
9	1286.	70.68
10	1276.	67.24
11	1267.	63.79
12	1260.	60.34
13	1151.	56.89
14	1103	53.44
15	1082	50
16	1058.	46.55
17	1008.	43.10
18	935.5	39.65
19	856	36.20
20	822.2	32.75
21	816.1	29.31
22	806.7	25.86
23	780.7	22.41
24	776.2	18.96
25	774.2	15.51
26	763.3	12.06
27	746.6	8.620
28	744.4	5.172
29	693.5	1.724

Av. 1113.

(2) Masatepe N=21

No.	Rain	Fn(%)
1	2155	97.61
2	2068	92.85
3	1986	88.09
4	1875	83.33
5	1846	78.57
6	1834	73.80
7	1701	69.04
8	1688	64.28
9	1541	59.52
10	1502	54.76
11	1466	50
12	1448	45.23
13	1289	40.47
14	1235	35.71
15	1200	30.95
16	1198	26.19
17	1178	21.42
18	1093	16.66
19	1068	11.90
20	915	7.142
21	827	2.380

Av. 1481.

Probability Rainfall by Hazen Plot

Unit:mm

Block Location No.	Return Period Non-exceedance 20%	33%	50%	Exceedance 67%	80%
1. Asososca	880	980	1100	1250	1350
2. Las Jinotepes	960	1070	1200	1360	1470
3. La Primavera	1100	1250	1400	1650	1800
4. Casa Colorada	1180	1340	1500	1770	1930
5. A.C. Sandino	880	980	1100	1250	1350
6. Ave. of 5&7	960	1070	1200	1360	1470
7. Masaya	1040	1160	1300	1480	1600
8. Masatepe	1100	1250	1400	1650	1800

STATION:A.C.SANDINO
No. : 27
EL. : 56m

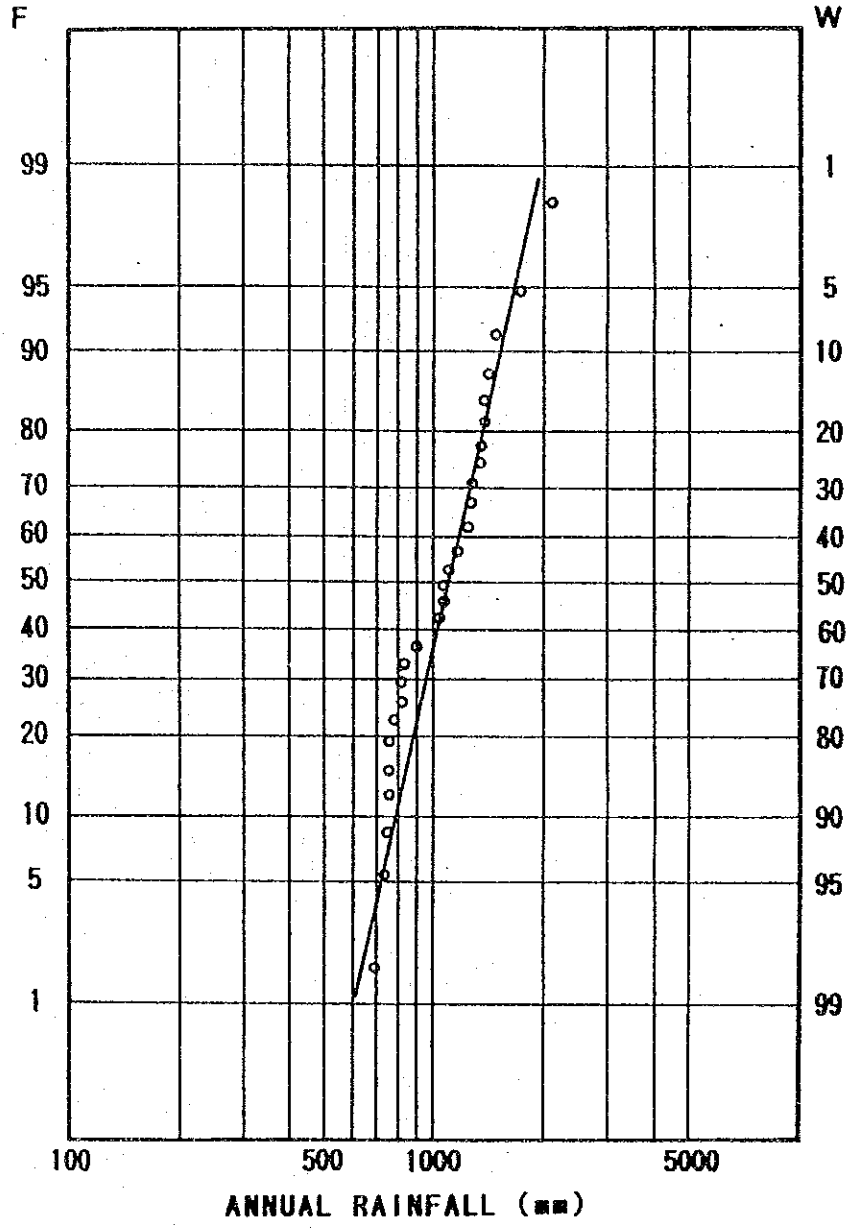


Fig. 3. 2. 1 PROBABILITY RAINFALL (1)

STATION: MASATEPE
No. : 49
EL. : 450m

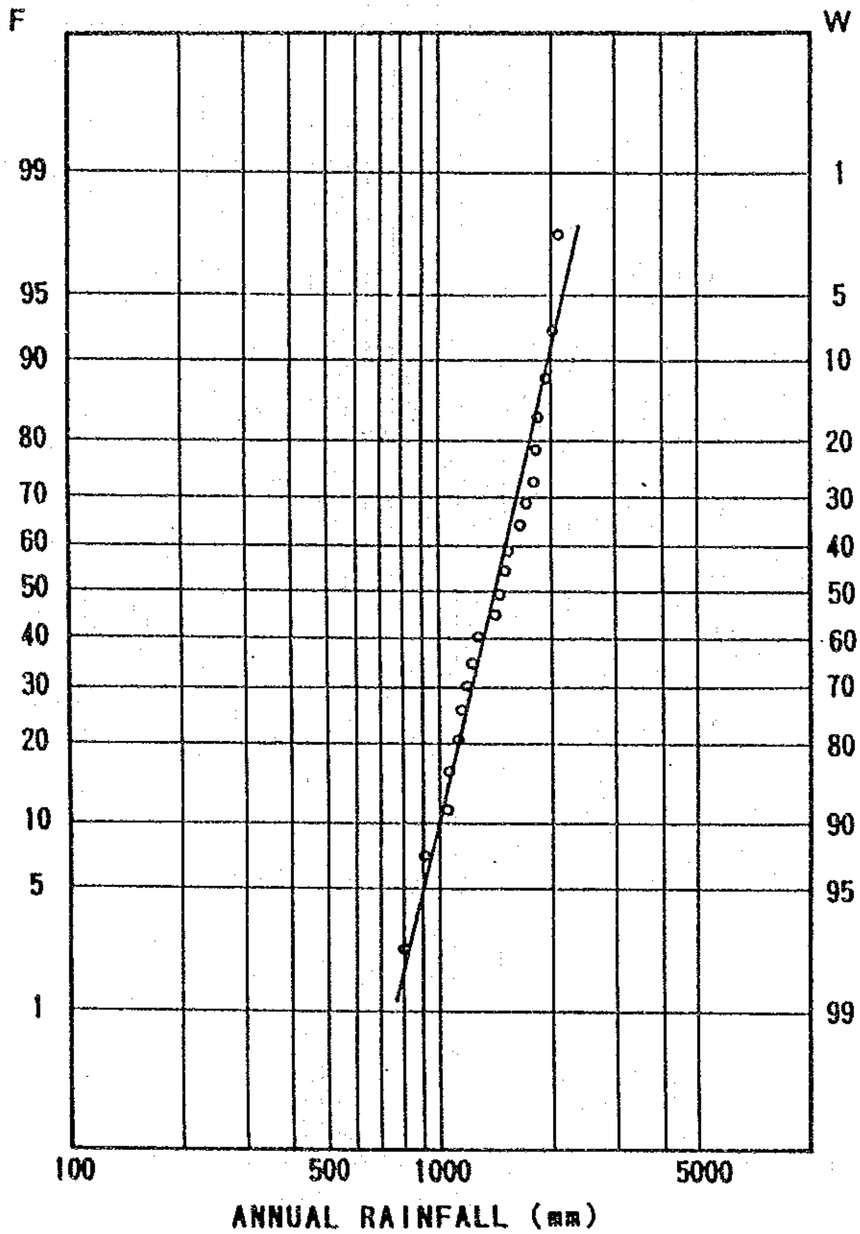


Fig. 3. 2. 1 PROBABILITY RAINFALL (2)

3.3 Evapotranspiration

Evaporation record was available in A.C Sandino (Airport:1969-'89) Station, Managua Plantel de Carretera (1954-'67), R.U.R.D. (1972-'88), Santa Rosa (1962-'66), Masaya (1977-'89) and Masatepe(1963-'87) Stations. Their monthly records are attached in the Data Book.

The results obtained from Blaney Craiddle, Radiation and Thornthwaite methods are compared in Table 3.3.1, using the records of Airport, Masaya and masatepe stations.

This result is summarized below;

Annual Evapotranspiration unit:mm

	Masatepe ('74-'87)	A.C. Sandino ('57-'89)
Blaney Criddle	1505	1865
Radiation	1849	1902
Thornthwaite	1240	1728

Even if meteorological data are the same, the results vary very much. Though it is necessary to find the most suitable method to be applied in this area, back-up data for this comparison was not available. Potential evapotranspiration is generally considered to be 80% of A-class pan evaporation.

The following table summarizes the annual potential evapotranspiration and rainfall in the Airport, Masaya and Masatepe stations.

unit:mm

Year	Airport		Masaya		Masatepe	
	ET	Rain	ET	Rain	ET	Rain
1970	1776	1082	-	-	1470	2155
1971	2001	1276	-	-	1333	1701
1972	1757	694	-	-	1509	1198
1973	1873	1742	-	-	1610	1986
1974	1727	856	-	-	1435	1502
1975	1770	1365	-	-	1332	1466
1976	2045	744	-	-	1417	827
1977	2066	816	-	-	1456	915
1978	1936	1008	1667	1110	1424	1093
1979	1794	1058	-	-	-	-
1980	1870	1448	-	-	1321	1445
1981	1996	1286	1480	1721	1454	1541
1982	2121	1352	1536	1532	1384	1688
1983	2060	807	1687	1204	1520	1289
1984	2068	1151	1613	1346	1488	1448
1985	1967	1260	1664	1138	1540	1200
1986	1873	774	1560	902	1509	1235
1987	1963	1103	1756	1458	-	-
1988	1734	2185	1648	1964	-	-

Potential evapotranspiration itself is higher than the annual rainfall. Evaporation is considered to continue even in the dry season, and consumes a high percentage of rain water.

Table 3.3.1 Evapotranspiration (1)

AAA: BLANEY CRIDDLE

MASATEPE BY AV. TEMPATATURE IN 74-87

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
TEMP	23.1	23.8	24.9	25.8	26	24.8	24.5	24.6	24.5	24.1	23.6	23.2	
P	0.26	0.27	0.27	0.28	0.28	0.29	0.29	0.28	0.28	0.27	0.26	0.26	
P(.46*T+8)	4.842	5.115	5.252	5.563	5.588	5.628	5.588	5.408	5.395	5.153	4.902	4.854	
C	0.86	0.86	0.86	0.86	0.71	0.71	0.71	0.71	0.71	0.71	0.86	0.86	
ETO	4.164	4.399	4.517	4.784	3.968	3.996	3.967	3.840	3.830	3.658	4.216	4.175	
DAY	31	28	31	30	31	30	31	31	30	31	30	31	
METO	129.1	123.1	140.0	143.5	123.0	119.8	122.9	119.0	114.9	113.4	126.4	129.4	1505.

A.C.SANDINO BY AV. TEMPARATURE IN 57-89

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
TEMP	25.8	26.6	27.9	28.8	28.7	26.8	26.4	26.5	26.3	26.1	26	25.6	
P	0.26	0.27	0.27	0.28	0.28	0.29	0.29	0.28	0.28	0.27	0.26	0.26	
P(.46*T+8)	5.165	5.463	5.625	5.949	5.936	5.895	5.841	5.653	5.627	5.401	5.189	5.141	
C	1	1	1	1	0.86	0.86	0.86	0.86	0.86	0.86	0.86	1	
ETO	5.165	5.463	5.625	5.949	5.105	5.069	5.023	4.861	4.839	4.645	4.463	5.141	
DAY	31	28	31	30	31	30	31	31	30	31	30	31	
METO	160.1	152.9	174.3	178.4	158.2	152.0	155.7	150.7	145.1	144.0	133.8	159.3	1865.

Table 3.3.1 Evapotranspiration (2)

BBB: RADIATION METHOD

MASATEPE BY AV. TEMPATATURE IN 74-87

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
TEMP	22.7	23.4	24.3	25.5	25.6	24.3	23.8	23.8	23.7	23.6	23.5	22.8	
RH	81	75	71	70	77	87	87	86	89	87	86	84	
n:MONTH	267.8	240.2	264.5	239.8	229.5	172.6	166.7	198.1	179.3	207.4	196.1	207.8	
DAY	31	28	31	30	31	30	31	31	30	31	30	31	
n	8.638	8.578	8.532	7.993	7.403	5.753	5.377	6.390	5.976	6.690	6.536	6.703	
WV	5.3	4.9	3.5	3.7	3.2	3.2	3.7	3.7	3.6	3.2	3.8	4.8	
WV DAY 2m	5.744	5.311	3.793	4.010	3.468	3.468	4.010	4.010	3.902	3.468	4.119	5.202	
N	11.6	11.8	12	12.3	12.6	12.7	12.6	12.4	12.1	11.8	11.6	11.5	
Ra	12.8	13.9	15.1	15.7	15.7	15.5	15.5	15.6	15.2	14.4	13.3	12.5	
W	0.717	0.724	0.733	0.745	0.746	0.733	0.728	0.728	0.727	0.726	0.725	0.718	
Rs	7.966	8.527	9.143	9.026	8.537	7.385	7.182	7.919	7.553	7.682	7.072	6.768	
W*Rs	5.711	6.174	6.701	6.724	6.368	5.413	5.228	5.765	5.491	5.577	5.127	4.859	
C	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	
ETO	5.026	5.433	5.897	5.917	5.604	4.764	4.601	5.073	4.832	4.908	4.512	4.276	
ETOMONTH	155.8	152.1	182.8	177.5	173.7	142.9	142.6	157.2	144.9	152.1	135.3	132.5	1849.

A.C.SANDINO BY AV. TEMPARATURE IN 57-89

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
TEMP	25.8	26.6	27.9	28.8	28.7	26.8	26.4	26.5	26.3	26.1	26	25.6	
RH	71	67	66	65	72	82	82	82	84	84	80	75	
n:MONTH	227.3	231.6	263.1	238.7	208.3	147.6	164.6	185.4	171.5	187.3	210.8	223.1	
DAY	31	28	31	30	31	30	31	31	30	31	30	31	
n	7.332	8.271	8.487	7.956	6.719	4.92	5.309	5.980	5.716	6.041	7.026	7.196	
WV	3.2	3.6	3.8	3.6	2.8	2.1	2.4	2.2	1.8	1.4	1.8	2.6	
WV DAY 2m	3.468	3.902	4.119	3.902	3.035	2.276	2.601	2.384	1.951	1.517	1.951	2.818	
N	11.6	11.8	12	12.3	12.6	12.7	12.6	12.4	12.1	11.8	11.6	11.5	
Ra	12.8	13.9	15.1	15.7	15.7	15.5	15.5	15.6	15.2	14.4	13.3	12.5	
W	0.748	0.756	0.769	0.778	0.777	0.758	0.754	0.755	0.753	0.751	0.75	0.746	
Rs	7.245	8.346	9.114	9.003	8.111	6.877	7.140	7.662	7.390	7.286	7.353	7.036	
W*Rs	5.419	6.310	7.009	7.004	6.302	5.213	5.384	5.784	5.565	5.472	5.514	5.249	
C	0.88	0.92	0.92	0.92	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	
ETO	4.769	5.805	6.448	6.444	5.546	4.587	4.738	5.090	4.897	4.815	4.853	4.619	
ETOMONTH	147.8	162.5	199.9	193.3	171.9	137.6	146.8	157.8	146.9	149.2	145.5	143.1	1902.