References

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<3: Análisis Programa de Desarrollo de Empresa de Servicios Sanitarios de Tarapaca, February 1991 for ESSAT by Bustamante y Schudeck Ingenieros Consultores Ltda.

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Table B-III, 3.1. Ground Water Extraction (Pampa del Tamarugal)

<Extracción de Agua Suterránea (Pampa del Tamarugal)>

(Pampa Area)

Water Use	Well No. (BNA)	Well Name	Extraction Rate (m3/year)	Extraction Rate (l/sec)	Total
Agriculture	381	CONAF	986	0.03	
	412	CONAF	654	0.02	
	363	Luis Quispe	394	0.30	0.35
Domestic	426	Esteban Lucic	1,314	0.04	
	316	David Chiang	263	0.20	
	312	Guillermo Araya	329	0.17	
	128	CORFO	183	0.01	
	-	Dupliza	1,892,160	60.00	
		Pta. Canchones (ESSAT)	18,914,508	599.78	
		Pta. Dolores (ESSAT)	14,622	0.46	660.65
Mining	984 or 985	ACF Minera	157,680	5.00	
		Oficina Mapocho	946,080	30.00	35.00
Total			21,929,173	696.00	696.00

(Other Area: Pica, Matilla, Esmeralda and Cascada)

Water Use	Well No. (BNA)	Well Name	Extraction Rate (m3/year)	Extraction Rate (l/sec)	Total
Agriculture		Pica/Matilla	3,500,496	111.00	111.00
Domestic		Pica/Chintaguay (ESSAT)	1,630,430	51.70	51.70
Mining	221	Cia. Minera La Cascada	432,000	13.70	
	222	Cia. Minera La Cascada	648,000	20.55	34.25
Total			6,210,926	196.95	196.95

Table B-III, 3.2. Variation of Groundwater Level (Pampa del Tamarugal)

<Variación de Nivel Estático (Pampa del Tmarugal)>

DGA	11	21		30	10	18	20	25	28	13	31	32	45	57
BNA	171-K	164-7	473-5	104-3	170-1	101-9	179-5	102-7	103-5	173-6	105-1	106-K	191-4	131-0
CORFO	1930-6950	1940-6940	1940-6940	1940-6940	1940-6950	1940-6950	1940-6950	1940-6950	1940-6950	1940-6950	1950-6940	1950-6940	2000-6930	2010-6930
DATE	A-1	A-1	AN-3	C-3	A-3	B-3	B-5	D-1	D-2	A-6	A-2	A-3	C-1	A-1
81/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11				14.03		8.40	8.16	7.33	9.45		20.54	24.73		
12				14.24		8.15	8.29	7.00	9.30		20.92	25.03		
82/1				13.72		7.95	7.29		9.21		20.78	24.92		
2				14.32		7.24	8.40		9.24		20.67	25.00		
3				13.87		7.28	8.41		9.27		19.98	24.44		
4				13.96		7.97	8.31		9.37		20.01	24.74		
5				13.92		8.00	8.39		9.40		20.05	24.79		
6				14.48		7.98	8.36		9.42		20.75	25.36		
7				14.31		7.99	8.30		9.12		20.78	25.32		
8				14.10		7.81	8.00		9.00		21.00	26.00		
9				13.68		8.31	8.64		9.70		20.11	24.58		
10				14.64		8.24	8.67		9.66		21.12	25.32		
11				14.32		8.08	8.38		9.40		20.93	25.54		
12				11.60		8.26	8.60		9.41		20.92	22.24		
83/1				11.62			8.66		11.64		20.96	24.24		
2														
3				14.07		8.34	8.64		9.71		21.00	24.65		
4				14.10		8.37	8.68		9.77		21.04	24.73		
5				14.72		8.42	8.74		9.84		21.06	25.30		
6				14.65		8.43	8.75		9.84		21.05	25.52		
7				14.62		8.43	8.72		9.85		21.03	25.50		
8				14.15		8.30	8.65		9.65		19.70	25.00		
9				14.20		8.20	8.55		10.00		20.00	24.90		
10				14.35		8.20	8.50		10.80		20.85	24.83		
11				14.57		8.15	8.70		9.85			25.20		
12				14.50		8.35	8.78		9.80		20.89	25.20		
85/1				14.03	6.74	8.04	8.43		9.91		21.41	24.57		20.30
2				14.05	6.78	8.02	8.40		9.89		21.38	24.61		20.26
3				14.00	6.76	8.04	8.40		9.86		21.38	24.58		20.28
4				14.07	6.76	8.02	8.40		9.93		21.38	24.62		20.28
5				14.10	6.81	8.08	8.50		9.97		21.46	24.64		20.31
6				14.15	6.82	8.11	8.54		9.99		21.38	24.59		20.25
7				14.12	6.77	8.09	8.49		9.92		21.43	24.61		20.25
8				14.12	6.79	8.13	8.47		9.95		21.38	24.64		20.27
9				14.11	6.74	8.08	8.46		9.93		21.41	24.62		20.26
10				14.12	6.71	8.03	8.42		9.93		21.38	24.56		20.28
11				14.10	6.71	8.04	8.40		9.91		21.38	24.54		20.25
12				14.08		8.10	8.47		9.97		20.39	24.59		20.31
86/1	6.94			14.15		8.14	8.58				20.25	24.41		20.30
2														
3	7.00			14.09		8.14	8.54				20.31	24.60		20.40
4	6.98			14.13		8.18	8.56				20.34	24.63		20.40
5														
6	6.17			13.55		7.58	7.76				19.58	24.75		20.42
7														
8	6.80			14.08		8.18	8.66				20.39	24.92		20.42
9														
10	7.01			14.12		8.19	8.68				20.37	24.64		20.44
11														
12														
87/1														
2	6.91			14.16		8.24	8.71				20.38	24.64		20.44
3														
4	7.19			14.18		8.31	8.87				20.37	24.64		20.50
5														
6	7.16			14.18		8.33	8.89				20.36	24.63		20.46
7														
8														
9														
10	6.91			14.19		8.37	9.02				-			20.53
11														
12														
88/1														
2														

Table B-III, 3.2. Variation of Groundwater Level (Pampa del Tamarugal)

<Variación de Nivel Estático (Pampa del Tmarugal)> (2)

DGA	11	21		30	10	16	20	25	28	13	31	32	45	57
BNA	171-K	164-7	473-5	104-3	170-1	101-9	179-5	102-7	103-5	173-6	105-1	106-K	191-4	131-0
CORFO	1930-6960	1940-6940	1940-6940	1940-6940	1940-6950	1940-6950	1940-6950	1940-6950	1940-6950	1940-6950	1950-6940	1950-6940	2000-6930	2010-6030
DATE	A-1	A-1	AN-3	C-3	A-3	B-3	B-5	D-1	D-2	A-6	A-2	A-3	C-1	A-1
3	6.95			14.23		8.40								20.54
4	6.98			14.23		8.34								20.54
5														
6	6.96			14.23		8.38								20.53
7														
8	6.70			14.26		8.49								20.57
9														
10	6.94			14.23		8.38								20.58
11														
12														
89/1														
2														
3		15.38	12.06	14.83		8.59				8.08				
4														
5														
6														
7		15.37	12.06			8.60				8.55				
8		15.37	12.06	14.82		8.60				8.55	-			
9														
10		15.37	12.06	14.83		8.60				8.55	-			
11														
12		15.37	12.05			8.60				8.55	-			
90/1														
2				14.86		8.49				8.51				
3														
4														
5				14.86						8.36	-			
6														
7														
8											-			
9														
10														
11				14.87						8.74	-			
12														
91/1		15.41	12.04	14.48						8.72	-			
2		15.43	11.99	14.80						8.74	-			
3		15.41	11.99	14.80						8.74	-			
4		15.46	11.94	14.91						8.92	-			
5		14.28	12.05	14.48						8.80	-			
6														
7		15.41	12.06	14.35						8.73	-			
8		15.40	12.06	14.35						8.72	-			
9		15.37	12.06	14.34						8.96	-			
10		15.40	12.05	14.35						8.96	-			
11		15.38	12.06	14.38						8.18	-			
12		15.38	12.05	14.35						8.21	-			
92/1		15.38	12.05	14.37						8.67	-			
2				14.32										
3		15.43	12.08	14.38										
4		15.40		14.38										
5				14.39										
6		15.53	12.05	14.38										
7														
8				14.36										
9														
10				14.37										
11				14.36										
12				14.36										
93/1				14.38										
2		15.40	12.13	14.37										
3			12.09	14.40										
4														
5														
6			12.09	14.39										
7				14.40										
8			12.09	14.39						8.85				
9				14.41						8.87				
10			12.13	14.40						9.09				
11										9.12				
12														

SOURCE: OBSERVATION RECOEDS BY DGA

Table B-III, 3.2. Variation of Groundwater Level (Pampa del Tamarugal)

<Variación de Nivel Estático (Pampa del Tmarugal)> (3)

DGA	59	60	64	77	65	61	58	66	62	72		223	170	174
SNA	204-K	132-9	222-8	230-9	107-8	133-7	234-1	235-K	109-4	129-9	260-0	252-K	263-5	265-1
CORFO	2010-6930	2010-6930	2010-6930	2010-6940	2010-6940	2010-6940	2010-6940	2010-6940	2010-6940	2010-6940	2020-6910	2020-6910	2020-6920	2020-6920
DATE	C-3	C-4	D-2	D-6	C-2	D-10	D-12	D-13	D-16	D-5	C-13	C-5	A-2	A-4
81/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11									16.75					
12									21.14					
82/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
83/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
84/1	24.03			10.22			25.96			20.40				
2	24.07			10.20			25.98			20.44				
3	24.06			10.25			25.96			20.40				
4	24.11			10.26			25.97			20.40				
5	24.05			10.18			25.95			20.48				
6	24.10			10.16			25.86			20.48				
7	24.05			10.15			25.90			20.40				
8	24.09			10.20			25.93			20.45				
9	24.07			10.20			25.89			20.43				
10	24.03			10.18			25.91			20.36				
11	24.04			10.18			25.90			20.33				
12	24.00			10.13			25.92			20.49				
86/1	24.02			10.35		14.81	25.81							
2														
3	24.19			10.39		14.80	25.98			20.48				
4	24.20			10.37			26.02			20.55				
5														
6	23.92			10.37			26.11			20.59				
7														
8	24.27			10.41			26.01			20.61				
9														
10	24.27			10.37			26.02			20.66		40.09		
11														
12														
87/1														
2	24.26			10.44			26.04			20.66		39.60		
3														
4	24.32			10.48			26.09			20.68		39.61		
5														
6	24.32			10.55			26.07			20.69				
7														
8														
9														
10	24.36			10.51			26.13			20.70				
11														
12														
88/1														
2														

Table B-III, 3.2. Variation of Groundwater Level (Pampa del Tamarugal)

<Variación de Nivel Estático (Pampa del Tmarugal)> (4)

DGA	59	60	64	77	65	81	58	66	82	72		223	170	174
BNA	204-K	132-9	222-8	230-9	107-8	133-7	234-1	235-K	109-4	129-9	260-0	252-K	263-5	265-1
CORPO	2010-6930	2010-6930	2010-6930	2010-6940	2010-6940	2010-6940	2010-6940	2010-6940	2010-6940	2010-6940	2020-6910	2020-6910	2020-6920	2020-6920
DATE	C-3	C-4	D-2	D-8	C-2	D-10	D-12	D-13	D-16	D-5	C-13	C-5	A-2	A-4
3	24.61			10.56			26.13			20.72				
4	24.38			10.56			26.13			20.54				
5														
6	24.33			10.58			26.12			20.53				
7														
8	24.39			10.56			26.15			20.57				
9														
10	24.38			10.61			26.14		10.04	20.58				
11														
12														
89/1														
2														
3		24.53						20.64		20.93			19.48	16.50
4														
5														
6														
7		24.53						20.56		20.90			19.45	16.50
8		24.53						20.56		20.90			19.45	16.50
9														
10		24.53						20.56		20.90			19.45	16.50
11														
12														
90/1														
2														
3					8.92			20.56					19.16	16.49
4														
5		24.53			8.98			20.56		21.05			19.15	16.40
6														
7														
8		24.62			8.98			20.64		24.80			19.10	16.80
9														
10														
11		24.61			8.96			20.61		24.78			19.13	16.78
12														
91/1		24.61			8.95			20.61					19.11	16.77
2		24.58			9.00			20.66					19.08	16.75
3		24.56						20.68					19.06	16.74
4		24.60						20.68					19.07	16.76
5		24.57			9.06			20.69					19.10	16.86
6														
7		24.66			8.37			20.72					19.20	16.89
8		24.66			8.39			20.71					19.18	16.88
9		24.66			8.37			20.72					19.21	16.89
10		24.65			8.39			20.70					19.20	16.89
11					8.40								19.20	16.89
12					8.42			20.69					19.21	16.89
92/1		24.75			8.45			20.71					19.23	16.90
2		24.73						20.80		21.00			19.08	
3		24.76						20.62		21.31			19.07	17.04
4		24.75						20.63		21.00			19.07	17.02
5		24.61			8.49	14.55		20.61		21.35				
6														
7		24.79			8.47	14.55		20.61		21.32			19.08	17.02
8		24.75			8.48	14.57		20.77		21.32			19.40	17.15
9														
10		24.75			18.47	15.53		20.81		21.07			19.42	17.15
11		24.76			8.50	15.55		20.78		21.33	38.67		19.48	17.22
12		24.73			8.47			20.77		21.30			19.45	17.20
93/1		24.61			8.52	15.58		20.80		21.36	38.72		19.50	17.40
2		24.79			8.55	15.58		20.77		21.35	38.75		19.45	17.40
3		24.63			8.54	15.61		20.63		21.38	38.73		19.43	17.46
4														
5														
6		25.14						20.68					19.40	
7		24.66				15.65				21.39			19.35	
8		24.90				15.65				21.40			19.32	
9		24.91				15.71				21.41			19.28	
10		24.83				15.69				21.36			19.30	
11														
12														

Table B-III, 3.2. Variation of Groundwater Level (Pampa del Tamarugal)

<Variación de Nivel Estático (Pampa del Tmarugal)> (5)

DGA	212	224	183	185	209-B	197	200	203	226	210			77-B	107
BNA	135-3	267-8	277-5	279-1	280-5	293-7	296-1	299-6	179-3	273-2	148-5	466-2	311-9	316-K
CORFO	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6930	2020-6930	2020-6930	2020-6930
DATE	C-1	C-2	D-11	D-13	D-14	D-27	D-30	D-33	D-6	D-7	A-10	A-13	A-3	A-8
81/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
82/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
83/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
85/1	29.24													8.50
2	29.24													8.51
3	29.19													8.51
4	29.22													8.50
5	29.18													8.48
6	29.16													8.39
7	29.18													8.45
8	29.21													8.45
9	29.18													8.40
10	29.16													8.40
11	29.15													8.40
12	29.12													8.36
86/1	31.13													8.82
2														
3	31.54													8.71
4	29.38													8.70
5														
6	29.91								39.90					8.70
7														
8	30.65													8.64
9														
10														8.90
11														
12														
87/1														
2														9.11
3														
4														8.98
5														
6	30.62													8.91
7														
8														
9														
10	31.79													8.89
11														
12														
88/1														
2														

Table B-III, 3.2. Variation of Groundwater Level (Pampa del Tamarugal)

<Variación de Nivel Estático (Pampa del Tmarugal)> (6)

DGA	212	224	193	186	209-B	197	200	203	226	210			77-B	107
SNA	135-3	267-8	277-5	279-1	280-5	293-7	296-1	299-6	179-3	273-2	148-5	486-2	311-8	316-K
CORPO	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6920	2020-6930	2020-6930	2020-6930	2020-6930
DATE	C-1	C-2	D-11	D-13	D-14	D-27	D-30	D-33	D-6	D-7	A-10	A-13	A-3	A-8
3	32.53													8.96
4	32.82													8.97
5														
6	32.38													8.90
7														
8	32.36													8.96
9														
10	33.08													8.99
11														
12														
89/1														
2														
3			24.19	70.02	45.76	49.02	39.17				10.90		10.76	
4														
5														
6														
7			24.19		45.74	49.11	39.17				10.87		10.77	
8			24.19		45.76	49.10	39.17				10.87		10.77	
9														
10			24.31		47.56	49.15	39.32				10.87		10.77	
11														
12			24.30		45.74	49.15	39.34							
90/1														
2													10.80	
3			24.30		45.74	49.15	39.32							
4														
5			24.29		45.77	49.19	39.32				10.75		10.80	
6														
7														
8					45.77	49.14	39.32				10.75		10.90	
9														
10														
11			24.30		45.74	49.14	39.31				10.89		10.90	
12														
91/1			24.30		45.77	40.16					10.85	8.95	10.89	
2			24.35			40.14					10.97	8.94	10.94	
3			24.41			40.14					10.95	8.95	10.90	
4			24.48			40.16	49.56	45.68			11.04	8.94	11.01	
5			24.56			40.06	49.17	45.52			11.00		11.02	
6														
7			24.42			40.15	48.91	45.18			11.02	12.25	10.99	
8			24.40			40.14	48.94	45.58			11.00	12.27	10.99	
9			24.41			40.14	48.89	45.51			11.00	12.23	11.00	
10			24.40			40.14	48.90	45.50			11.00	12.24	11.00	
11											11.02	12.23	11.01	
12			24.40	40.14		40.13	48.70				11.09	12.24	11.07	
92/1			24.45			40.13	48.88	45.54			11.09	12.23	11.12	
2										8.81	11.17	12.59	11.14	
3										8.97	11.14	12.28	11.16	
4			24.44	40.00	49.25	45.46				8.46	11.13	12.30	11.15	
5										8.14			11.21	
6										8.12				
7			24.42			40.00	48.67	45.46			11.13	12.26	11.13	
8										9.44			11.18	
9														
10			24.45			40.00	48.67	45.46		9.43	11.13	11.26		
11										8.21	11.12	12.22	11.17	
12										8.22	11.11	12.21	11.17	
93/1										8.28	11.20	12.70	11.22	
2										8.26	11.18	12.70	11.22	
3			24.52	42.69	42.98	40.09	48.60	45.57		9.30	11.27	12.69	11.33	
4														
5														
6			24.50	41.76	44.94	40.05	48.59	45.63			11.27	11.27	11.36	
7				45.00				45.60					11.36	
8						40.05	48.50	45.55			11.25	12.60	11.38	
9				45.17	60.88	40.19	48.74	45.66			11.21	12.66	11.38	
10			24.50		60.80	40.90	48.66	45.60			11.20	12.66	11.39	
11														
12														

Table B-III, 3.2. Variation of Groundwater Level (Pampa del Tamarugal)

<Variación de Nivel Estático (Pampa del Tmarugal)> (7)

DGA	111	140	141	134	148			97	98	121	162	113	123	124
BNA	134-5	323-2	324-0	354-2	365-8	458-1	460-3	367-4	147-7	110-8	112-4	136-1	139-6	376-3
CORPO	2020-6930	2020-6930	2020-6930	2020-6930	2020-6930	2020-6930	2020-6930	2020-6940	2020-6940	2020-6940	2020-6940	2020-6940	2020-6940	2020-6940
DATE	B-5	C-2	C-3	D-17	D-26	D-34	D-36	A-1	B-1	C-1	C-2	D-1	D-10	D-11
81/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
82/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
83/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
84/1	7.78										7.55	12.08	12.85	7.79
2	7.80										7.52	12.10	12.86	7.79
3	7.79										7.55	12.09	12.81	7.78
4	7.80										7.57	12.12	12.77	7.81
5	7.66										7.60	12.12	12.76	7.87
6	7.64										7.50	12.09	12.81	7.86
7	7.69										7.56	12.09	12.85	7.90
8	7.73										7.57	12.09	12.90	7.85
9	7.74										7.55	12.05	12.87	7.82
10	7.71										7.55	12.04	12.86	7.81
11	7.70										7.58	12.10	12.86	7.85
12	7.65										7.54	12.04	12.86	7.78
85/1	8.31													
2														
3	8.31										7.71	12.24	13.32	7.98
4	8.35										7.75	12.23	13.35	8.00
5														
6	7.75										7.76	12.06	12.81	7.85
7														
8	8.07										7.78	12.14	13.31	8.04
9														
10	8.27										7.77	12.20	13.10	8.01
11														
12														
87/1														
2	8.47										7.81	12.19	13.44	8.09
3														
4											7.83		13.47	8.20
5														
6											7.88	12.34	13.42	8.27
7														
8														
9														
10											7.93	12.55	13.25	8.34
11														
12														
88/1														
2														

Table B-III, 3.2. Variation of Groundwater Level (Pampa del Tamarugal)

<Variación de Nivel Estático (Pampa del Tmarugal)> (8)

DGA	111	140	141	134	148			97	98	121	162	113	123	124
BNA	134-5	323-2	324-0	354-2	365-8	458-1	460-3	367-4	147-7	110-8	112-4	136-1	139-8	376-3
CORFO	2020-6930	2020-6930	2020-6930	2020-6930	2020-6930	2020-6930	2020-6930	2020-6940	2020-6940	2020-6940	2020-6940	2020-6940	2020-6940	2020-6940
DATE	B-5	C-2	C-3	D-17	D-28	D-34	D-36	A-1	B-1	C-1	C-2	D-1	D-10	D-11
3											7.95	12.64		8.48
4											7.98	12.64	13.41	8.46
5														
6											7.93	12.67	13.42	8.48
7														
8											7.99	12.66	13.42	
9														
10	12.65										8.99	12.65	13.42	
11														
12														
90/1														
2														
3		7.97				9.70	22.76				7.90			
4														
5														
6														
7						9.90	22.77				8.15			
8						9.90	22.78				8.16			
9														
10						9.90	22.78				8.16			
11														
12			2.36				22.78							
90/1														
2						9.90	22.77							
3														
4														
5						9.92	22.75							
6														
7														
8						9.90	22.77							
9														
10														
11						10.02	22.77							
12														
91/1						10.00								
2						10.10								
3											8.20			
4						10.10					8.20			
5						10.31					8.23			
6														
7						10.68	24.44				8.25			
8						10.64	24.41				8.25			
9						10.23					8.24			
10						10.25					8.26			
11														
12						10.24					8.25			
92/1						10.24					8.30			
2														
3		8.31												
4		8.31				10.20								
5		8.35			18.80									
6														
7		8.35			18.80	10.20								
8		8.33			18.80	10.79								
9														
10		8.35			19.77	10.20								
11		8.34		32.11	19.30	10.46								
12		8.30				10.44								
93/1		8.40		32.46	18.76	10.27								
2		8.42		32.44	18.76	10.25								
3		8.45		32.11	19.50	10.77								
4														
5														
6		8.49			19.51	10.75								
7		8.49			19.26	10.77					8.56			
8		8.49		31.50	19.30	10.76					8.55			
9		8.49		32.16	20.78	10.81					8.57			
10		8.49		32.10	20.78	10.83					9.30			
11														
12														

Table B-III, 3.2. Variation of Groundwater Level (Pampa del Tamarugal)

<Variación de Nivel Estático (Pampa del Tmarugal)> (9)

DGA	137		163	122	315	320	301	302				323	238	237
BNA	140-K	137-K	383-6	138-8	114-0	143-4	142-6	117-5	469-7	470-0	471-9	404-2	113-2	411-5
CCHFO	2020-6940	2020-6940	2020-6940	2020-6940	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6930	2030-6930
DATE	D-15	D-20	D-19	D-9	A-2	A-2	B-1	B-2	BN-9	BN-10	BN-11	D-1	A-1	A-9
81/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11						54.73								
12	13.20													
82/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
83/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
85/1	12.11				70.06	55.01							4.65	
2	12.12				70.10	55.04							4.65	
3	12.10				70.14	55.00							4.65	
4	12.11				70.16	55.04							4.70	
5	12.05				70.08	54.98							4.56	
6	12.10				70.04	55.00							4.59	
7	12.05				70.08	55.04							4.65	
8	12.07				70.11	55.04							4.65	
9	12.05				70.11	55.00							4.62	
10	12.05				70.12	54.98							4.63	
11	12.10				70.13	54.98							4.66	
12	12.05				70.09	54.94							4.59	
86/1					69.10	54.24								
2														
3	12.22				70.24	55.22							4.75	
4	12.26				70.28	55.35							4.78	
5														
6	12.32				70.33	55.37							4.80	
7														
8	12.30				70.57	55.43							4.81	
9														
10					70.30	55.44	13.65						4.91	
11														
12														
87/1														
2	12.38				70.34	55.45	13.41						4.91	
3														
4	12.43				70.41	55.50							4.97	
5														
6	12.42				70.40	55.52							4.99	
7														
8														
9														
10	12.29				70.48	55.57							5.03	
11														
12														
88/1														
2														

Table B-III, 3.2. Variation of Groundwater Level (Pampa del Tamarugal)

<Variación de Nivel Estático (Pampa del Tmarugal)> (10)

DGA	137		183	122	315	320	301	302				323	238	237
BNA	140-K	137-K	383-6	138-8	114-0	143-4	142-6	117-5	469-7	470-0	471-9	404-2	113-2	411-5
CORPO	2020-6940	2020-6940	2020-6940	2020-6940	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6920	2030-6930
DATE	D-15	D-20	D-19	D-9	A-2	A-2	B-1	B-2	BN-9	BN-10	BN-11	D-1	A-1	A-9
3					70.49	55.58							5.01	
4					69.79	55.65							5.02	
5														
6					70.48	55.57							5.01	
7														
8					70.32	55.67							5.19	
9														
10					70.55	50.46							4.38	
11														
12														
89/1														
2														
3	12.56				71.18	55.91			21.22	28.35	20.01			
4														
5														
6														
7	12.46		5.73		71.18	55.95			21.85	28.42	20.01			
8	12.46				71.18	55.95			21.84	28.42	21.01			
9														
10	12.36		5.73		71.18	55.86				28.39	20.01			5.70
11														
12					71.18	55.86			21.84	28.45				
90/1														
2														
3	12.35		5.72											5.39
4														
5									22.27	29.35	18.81			
6														
7														
8	12.50		5.85		71.26			56.30						5.56
9														
10														
11	12.47		6.65		71.24			56.25	22.89	29.75				5.53
12														
91/1	12.50		5.80		71.26			56.25	22.88	29.75				5.50
2	12.49				71.25			56.21	22.88					5.53
3									22.89					
4	12.48				71.25			56.20	22.91					5.55
5	12.63				71.18			56.26	22.26		20.00			5.56
6														
7	12.58				70.84			55.81	21.76	30.80	20.85			5.64
8	12.61				70.83			55.80	21.70	30.81	20.88			5.64
9	12.60				70.94			55.85	21.73	30.78				5.64
10	12.60				70.09			55.83	21.70	30.76	20.86			5.63
11	12.45				70.90			55.85	32.36	31.44	20.30			5.66
12	12.62				70.90			55.91	39.46		21.00			5.71
92/1	12.67				70.88			55.89	23.52		21.10			5.73
2					70.80	55.95					20.36			
3					70.98	56.05					20.84			5.78
4					70.94	56.00				30.60				5.78
5					70.92	56.09			21.10	30.94	20.88			5.79
6														
7					70.90	56.05								5.78
8	12.52				70.95	55.97			22.14	30.83	19.43			5.79
9														
10	12.52				70.93	55.97			22.61	31.03	20.27			5.79
11	12.50				71.00	56.00			22.33	31.38	19.80			5.80
12	12.50				71.00	55.98			22.50	31.40	19.80			5.79
93/1					71.03	52.06				31.03	19.98			5.83
2					71.05	52.05				31.00	19.98			5.83
3					71.07	56.05			21.30	31.00	19.60	19.90		5.86
4														
5														
6					71.09				21.37	31.43	20.22			5.91
7					71.07	56.12					20.51			5.91
8					71.07	56.12					20.50	19.90		5.89
9					71.11	56.14						19.90		
10					71.13	56.12						19.90		5.91
11														
12														

Table B-III, 3.2. Variation of Groundwater Level (Pampa del Tamarugal)

<Variación de Nivel Estático (Pampa del Tmarugal)> (11)

DGA	230	254	258	257	265	249	259	253	260	263	264		235	247
BNA	412-3	118-3	141-8	144-2	151-5	120-5	119-1	121-3	426-3	150-7	427-1	116-7	430-1	145-0
CORFO	2030-8930	2030-8930	2030-8930	2030-8930	2030-8930	2030-8930	2030-8930	2030-8930	2030-8930	2030-8930	2030-8930	2030-8930	2030-8940	2030-8940
DATE	A-10	C-1	C-3	C-4	C-6	C-7	D-1	D-2	D-5	D-6	D-7	D-9	B-2	B-3
81/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11		4.44	7.25			3.14	16.15	28.46	9.24	4.03			4.50	
12			7.08			3.85	16.40			4.02				
82/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
83/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
85/1		3.90	7.11	7.69		3.70	16.21	28.78	10.40				4.70	2.33
2		3.90	7.13	7.65		3.73	16.19	28.75	10.40				4.74	2.31
3		3.85	7.15	7.67		3.75	16.15	28.78	10.41				4.73	2.28
4		3.86	7.20	7.69		3.78	16.18	28.78	10.44				4.76	2.30
5		3.81	7.02	7.64		3.59	16.14	28.81	10.48				4.78	2.26
6		3.77	7.04	7.58		3.63	16.13	28.77	10.46				4.70	2.26
7		3.84	7.12	7.65		3.70	16.15	28.75	10.44				4.78	2.31
8		3.86	7.17	7.70		3.75	16.19	28.77	10.46				4.75	2.35
9		3.85	7.12	7.68		3.70	16.17	28.75	10.45				4.74	2.31
10		3.86	7.13	7.70		3.70	16.15	28.75	10.42				4.73	2.32
11		3.85	7.12	7.73		3.70	16.11	28.78	10.41				4.73	2.31
12		3.81	7.16	7.73		3.70	16.11	28.75	10.38				4.69	2.26
86/1				8.37			16.26		10.30	17.57				
2														
3		4.01	7.51	7.90		3.84	16.25	29.04	11.65	17.63			4.92	2.51
4		3.98	7.51	7.90		3.85		29.06	10.50	17.68			4.97	2.55
5														
6		4.04	7.50	7.92		3.90	16.27	29.08	11.04	17.67			4.98	2.56
7														
8		4.06	7.37	7.94		3.95	16.31	29.10	11.62	17.68			4.99	2.58
9														
10		4.05	7.37	7.95		4.00	16.45	29.14	10.60	17.65			4.98	2.55
11														
12														
87/1														
2		4.09	7.39	8.00		4.08	16.31	29.18	11.39	17.65			5.04	2.57
3														
4		4.14	7.40			4.11	16.33	29.28	10.53	17.69			5.07	2.66
5														
6		4.13	7.42	8.04		4.18	16.38	29.33	11.63	17.68			5.05	2.66
7														
8														
9														
10		4.25	7.47	8.04		4.28	16.43	29.29	10.40	17.69			5.17	2.73
11														
12														
88/1														
2														

Table B-III, 3.2. Variation of Groundwater Level (Pampa del Tamarugal)

<Variación de Nivel Estático (Pampa del Tmarugal)> (12)

DGA	230	254	256	257	265	249	259	253	260	263	264		235	247
BNA	412-3	119-3	141-9	144-2	151-5	120-5	119-1	121-3	426-3	150-7	427-1	116-7	430-1	145-0
CCHO	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6930	2030-6940	2030-6940
DATE	A-10	C-1	C-3	C-4	C-6	C-7	D-1	D-2	D-5	D-6	D-7	D-9	E-2	E-3
3		4.26	7.50	8.02		4.34	16.44	29.35	10.49	17.92			5.16	2.76
4		4.26	7.48	8.02		5.18	16.37	29.37	10.59	17.80			5.15	2.75
5														
6		4.26	7.49	8.04		4.33	16.43	29.35	10.48	17.89			5.17	2.73
7														
8		4.32	7.66	8.05		4.56	16.35	29.44	10.53	17.91			5.40	2.83
9														
10		4.20	7.50	8.09		4.38	16.36	29.41	10.55				5.18	2.83
11														
12														
89/1														
2														
3	10.90	4.29	7.73			4.59	16.52	29.64			0.75		5.61	
4														
5														
6														
7	10.96	4.42	7.98			4.59	16.55	29.71			0.75		5.85	
8	10.96	4.42	7.98			4.59	16.55	29.71			0.75		5.85	
9														
10	10.94	4.41	7.98				16.55	29.68			0.75		5.85	
11														
12			7.98				16.55	29.68			0.75			
90/1														
2			7.88					29.68						
3	10.94	4.52											5.89	
4														
5		4.61											6.04	
6														
7														
8	10.90	4.59	7.91					29.64					6.00	
9														
10														
11	11.02	4.55	7.94					29.61					6.00	
12														
91/1	11.00	4.55	7.92					29.59				18.05	6.00	
2	11.00	4.61	7.93					29.56					6.04	
3														
4	11.05	4.57	7.94					28.81				18.10	6.05	
5	11.03	4.67	7.95					29.64				18.04	6.09	
6														
7	10.97	4.67	8.05					29.67				18.07	5.60	
8	10.99	4.69	8.05					29.70				18.04	5.57	
9	11.02	4.68	8.04					29.66				18.10	5.57	
10	11.00	4.69	8.04					29.68				10.07	5.59	
11	11.02	4.73	8.06					29.71				18.13	5.57	
12	11.09	4.74	8.09					29.73				18.10	5.67	
92/1	11.11	4.74	8.11					29.77				18.15	5.66	
2			8.34					29.75				18.09		
3	11.10	4.76	8.11					29.82				18.13	5.62	
4	11.08	4.76						29.80				18.15	5.62	
5		4.76	8.11					29.81					5.66	
6														
7		4.74	8.16					29.75				18.13	5.65	
8		4.78	8.13					29.80				18.10	5.64	
9														
10		4.76	8.11					27.78				18.18	5.65	
11		4.81	8.14									18.17	5.73	
12		4.81	8.11									18.15	5.72	
93/1		4.83	8.17									18.20	5.75	
2		4.83	8.16									18.20	5.72	
3		4.83	8.19									18.22	5.74	
4														
5														
6	11.10	4.89	8.22									18.24	5.76	
7		4.87	8.23									18.20	5.81	
8	11.10	4.89	8.23									18.21	5.82	
9		4.89	8.22									18.22	5.81	
10		4.88	8.22									18.22	5.83	
11														
12														

. Table B-III, 3.2. Variation of Groundwater Level (Pampa del Tamarugal)

<Variación de Nivel Estático (Pampa del Tmarugal)> (13)

DGA	236	326	267	269	271	275	276	280	283	287	281	286	284	
BNA	146-9	122-1	125-6	126-4	434-4	436-0	157-4	128-0	152-3	440-9	444-1	127-2	449-2	461-1
CCHO	2040-6940	2040-6910	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6940	2040-6940
DATE	B-4	A-1	A-1	A-3	A-4	A-6	A-7	C-1	C-2	C-4	D-3	D-5	D-2	D-2
81/1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12											17.19	19.02	0.70	
82/1														
2												19.49		
3														
4												19.04		
5												19.39		
6												19.39		
7														
8														
9														
10												19.12		
11														
12														
83/1														
2														
3														
4												18.94		
5														
6														
7														
8														
9														
10														
11														
12														
85/1	1.27		9.92				15.60		1.83		17.98	19.39	0.70	
2	1.25		9.90				15.62		1.81		17.96	19.29	0.71	
3	1.25		9.90				15.63		1.83		17.99	19.33	0.68	
4	1.26		9.93				15.65		1.84		17.98	19.34	0.68	
5	1.23		9.88				15.57		1.80		17.95	19.39	0.74	
6	1.20		9.82				15.71		1.80		18.06	19.34	0.70	
7	1.26		9.89				15.66		1.85		18.03	19.38	0.73	
8	1.23		9.92				15.60		1.85		18.02	19.35	0.70	
9	1.23		9.90				15.55		1.78		17.99	19.36	0.72	
10	1.22		9.91				15.55		1.81		17.99	19.34	0.70	
11	1.25		9.86				15.52		1.80		17.95	19.34	0.68	
12	1.26		9.81				15.56		1.84		18.40	19.39	0.70	
86/1														
2														
3	1.26		9.95				15.63		1.85		18.10	19.36	0.70	
4	1.41		9.95				15.63		1.84		18.10	19.36	0.74	
5														
6	1.45		9.99				15.63		1.87		18.11	19.35	0.50	
7														
8	1.44		10.00				15.64		1.88		18.11	19.34	0.50	
9														
10	1.47		10.01				15.63		1.91		18.10	19.41	0.45	
11														
12														
87/1														
2	1.48		10.00				15.63		1.92		18.10	19.38	0.45	
3														
4	1.59		10.00				15.65		1.94		18.10	19.39	0.51	
5														
6	1.60		10.01				15.65		1.94		18.14	19.40	0.49	
7														
8														
9														
10	1.62		10.03				15.65		1.95		18.14	19.39	0.50	
11														
12														
88/1														
2														

Table B-III, 3.2. Variation of Groundwater Level (Pampa del Tamarugal)

<Variación de Nivel Estático (Pampa del Tmarugal)> (14)

DGA	236	326	267	269	271	275	276	280	283	287	281	288	284	
BNA	148-9	122-1	125-6	126-4	434-4	436-0	157-4	128-0	152-3	440-9	444-1	127-2	449-2	461-1
CORFO	2030-6940	2040-6910	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6930	2040-6940	2040-6940
DATE	B-4	A-1	A-1	A-3	A-4	A-6	A-7	C-1	C-2	C-4	D-3	D-5	D-2	D-2
3	1.68		10.03	39.29			15.66		1.96		18.14	19.40		
4	1.66		10.10	39.26			15.65				18.12	19.08		
5														
6	1.66		10.03	39.30			15.66		1.95		18.11	19.39		
7														
8	1.74		10.03	39.29			15.69		1.95		18.16	19.41		
9														
10	1.68		0.54	17.90			15.69		1.89		18.15	19.39		
11														
12														
89/1														
2														
3		89.30			10.84	10.65	15.82	7.66		1.97	18.27	19.57		10.73
4														
5														
6														
7		89.26			10.86	10.64	15.73	7.31		1.97	18.27	19.57		10.33
8		89.26			10.86	10.64	15.73	7.30		1.97	18.27	19.57		10.33
9														
10		89.24			10.86	10.64	15.73	7.30		1.97	18.26	19.55		10.33
11														
12		89.20				10.65	15.73	7.31		1.97	18.25	19.57		
90/1														
2						10.67	15.55	7.30		1.96	18.25	19.43	0.86	
3		88.90			10.84									10.31
4														
5		88.70												10.30
6														
7														
8		88.70			10.83	10.67	15.76	7.55		2.04	18.24	19.51	0.77	11.08
9														
10														
11		88.68			10.83	10.65	15.70	7.53		2.02	18.23	19.50	0.77	11.10
12														
91/1		88.70				10.64	15.70	7.50			18.23	19.50	0.77	11.08
2		88.68				10.68	15.73	7.49			18.22	19.52	0.77	11.05
3							15.75	7.44			18.20	19.51	0.76	
4		87.55				10.66	15.77	7.44			18.19	19.57	0.76	
5		87.71				10.69	15.73	8.32			18.18	19.50	0.76	
6														
7		87.86			10.91		15.75	7.97			18.20	19.51	0.79	11.52
8		87.86			10.90	10.69	15.73	7.97			18.18	19.50	0.79	11.51
9		88.87			10.93	10.69	15.80	8.03			18.22	19.57	0.78	11.51
10		87.85			10.92	11.24	15.78	8.00			18.19	19.55	0.78	11.53
11		87.60			10.92	11.25	15.78	8.02			18.22	19.54	0.79	
12		87.30			10.92		15.79	8.11			18.20	19.56	0.79	11.50
92/1		87.46			10.95	11.28	15.78	8.15			18.22	19.55	0.80	11.52
2		87.20			10.91	10.71	15.76	8.44			18.21	19.54	0.82	
3					10.93	10.73	15.76	8.43			18.23	19.53	0.81	11.51
4		87.40			10.94	10.74	15.75	8.40			18.19	19.50	0.80	11.50
5					10.93	10.73	15.70	8.24			18.21	19.53	0.83	
6														
7		86.75			10.93	10.70	15.70	8.24			18.19	19.52	0.80	11.45
8		86.55			10.91	10.70	15.73	8.30			18.19	19.51	0.81	
9														
10		86.55			10.94	10.72	15.73	8.29			18.19	19.51	0.80	11.48
11					10.02	10.71	15.75	8.56			18.20	19.51	0.80	11.51
12					10.90	10.71	15.73	8.55			18.20	19.50	0.80	11.50
93/1					10.93	10.72	15.75	8.52			18.20	19.51	0.81	
2		86.55			10.90	10.70	15.75	8.60			18.19	19.53	0.80	
3		86.33			11.34	10.73	15.76	9.27			18.20	19.52	0.83	
4														
5														
6		86.79			10.98	10.75	15.77	8.76			18.19	19.55		
7					10.95	10.75	15.76	8.53			18.21	19.53		
8		86.13			10.97	10.74	15.78	8.50			18.22	19.53		
9		85.93			10.96	10.75	15.76	8.61			18.21	19.54		
10		85.90			10.96	10.75	15.78	8.59			18.22	19.54		
11														
12														

Table B-III, 3.2. Variation of Groundwater Level (Pampa del Tamarugal)

<Variación de Nivel Estático (Pampa del Tmarugal)> (15)

DGA	296	298	292	294	299	290
BNA	153-1	451-4	453-0	155-8	160-4	124-8
CONFO	2050-6930	2050-6930	2050-6930	2050-6930	2050-6930	2050-6940
DATE	A-1	A-2	B-3	B-4	D-1	B-1
81/1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						2.31
12						
82/1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
83/1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
85/1	18.90		36.78	26.85		2.35
2	18.85		36.76	26.80		2.30
3	18.88		36.77	26.81		2.29
4	18.86		36.80	26.84		2.30
5	18.88		36.76	26.88		2.27
6	18.88		36.70	26.88		2.38
7	18.93		36.75	26.80		2.42
8	18.90		36.80	26.85		2.35
9	9.85		36.78	26.80		2.31
10	18.89		36.75	26.83		2.35
11	18.85		36.72	26.80		2.40
12	18.90		36.78	26.77		2.44
86/1						
2						
3	18.95		36.80	26.80		2.33
4	19.00		36.80	26.89		2.34
5						
6	19.01		36.83	26.89		2.34
7						
8	19.19		36.86	26.88		2.34
9						
10	19.00		36.80	26.90		2.32
11						
12						
87/1						
2	19.10		36.85	26.89		2.33
3						
4			36.34	26.89		2.38
5						
6			36.84	26.90		2.39
7						
8						
9						
10			36.87	26.91		2.39
11						
12						
88/1						
2						

Table B-III, 3.2. Variation of Groundwater Level (Pampa del Tamarugal)

<Variación de Nivel Estático (Pampa del Tmarugal)> (16)

DGA	296	298	292	294	299	290
BNA	153-1	451-4	453-0	155-8	160-4	124-8
CORPO	2050-6930	2050-6930	2050-6930	2050-6930	2050-6930	2050-6940
DATE	A-1	A-2	B-3	B-4	D-1	B-1
3			36.85	26.94		2.38
4			36.84	26.91		2.40
5						
6			36.81	26.93		2.38
7						
8			37.38	26.96		2.43
9						
10			36.84	26.97		2.40
11						
12						
89/1						
2						
3				27.21	13.28	2.39
4						
5						
6						
7				27.03	13.28	2.38
8				27.02	13.28	2.39
9						
10				27.02	13.28	2.39
11						
12				27.03	13.28	
90/1						
2				27.03	13.30	2.47
3						
4						
5						
6						
7						
8				26.78	13.28	2.46
9						
10						
11				26.83	13.27	2.47
12						
91/1				26.86	13.29	2.45
2				26.90	13.35	2.48
3				26.98	13.32	2.46
4				27.03	13.29	2.47
6				27.01	13.32	2.32
6						
7				26.99	13.33	2.68
8				26.99	13.32	2.68
9				27.02	13.34	2.49
10				27.04	13.34	2.53
11				27.00	13.33	2.54
12				27.00	13.32	2.54
92/1				26.98	13.36	2.49
2		12.35		26.97	13.35	2.60
3		12.37		26.96	13.31	2.51
4		12.37		26.94	13.31	2.47
5		12.47		27.01	13.36	2.51
6						
7		12.45		26.99	13.31	2.50
8		12.43		26.94	13.33	2.50
9						
10		12.32		26.93	13.31	2.50
11		12.34		26.92	13.33	2.51
12		12.35		26.88	13.31	2.49
93/1		12.34		26.93	13.33	2.50
2		12.36		26.95	13.33	2.52
3		12.33		26.94	13.34	2.51
4						
5						
6		12.37		26.96	13.32	2.49
7		12.36		26.94	13.36	2.52
8		12.35		26.96	13.39	2.52
9		12.36		26.94	13.37	2.54
10		12.30		26.94	13.35	2.54
11						
12						

Table B-III, 3.3 Groundwater Quality (Pampa del Tamarugal) (Nov. 1993 - Feb. 1994)

<Calidad de Agua Subterránea (Pampa del Tamarugal) (Nov. 1993 - Feb. 1994)>

		B.N.A CODE	DGA CODE	NAME		TEMP.	pH	TDS	Cond. µS	Turb.	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	SO4 mg/l	Cl mg/l	CO3 mg/l	HCO3 mg/l	HEALTH SIGNIFICANCE NO3 mg/l	As mg/l	F mg/l	Cd mg/l	Cr mg/l	Pb mg/l	B mg/l	Fe mg/l	Mn mg/l	Zn mg/l	Cu mg/l	Al mg/l
				(STANDARD)			6.0-8.5	1000		5					250.0	250			10.000	0.050	1.50	0.005	0.050	0.05		0.30	0.100	5.00	1.000	0.20
A	ZAPIGA	173	13	PTA. AP. DOLORES 6	Nov-93	20.0	8.34	636	1100	166	13.8	4.6	190.1	28.2	62.0	253.1		81.2	3.100	0.005		0.005		0.01	5.60	0.47	0.007		0.007	
					Feb-94		7.95	622	1126		12.7	4.5	186.7	31.0	48.0	256.7		82.4	0.089	0.034		0.001		0.02	7.59	8.22			0.011	0.30
					Average	20.0	8.15	629	1113	166	13.3	4.6	188.4	29.6	55.0	254.9		81.8	1.595	0.020		0.003		0.02	6.60	4.35	0.007		0.009	0.30
		178	19	SALAR DE ZAPIGA	Nov-93	25.5	8.87	976	1600	129	109.0	9.8	158.2	37.5	309.8	274.7	4.2	63.5	12.400	1.383		0.028		0.33	4.76	36.80	4.310		0.222	
					Feb-94		8.54	806	1415		84.0	12.5	156.4	32.5	201.7	278.3	3.0	36.0	1.662	0.319		0.001		0.06	3.97	1.35			0.021	2.70
					Average	25.5	8.71	891	1508	129	96.5	9.7	157.3	35.0	255.8	276.5	3.6	49.8	7.031	0.851		0.015		0.20	4.37	19.08	4.310		0.122	2.70
		165	23	SALAR DE ZAPIGA	Nov-93	25.0	9.07	856	1600	265	95.8	10.4	174.8	32.1	116.2	308.1		105.6	13.400	0.027		0.009		0.05	0.46	7.84	0.312		0.086	
		104	30	SALAR DE ZAPIGA	Nov-93	24.2	10.45	1881	2700	990	209.8	0.2	460.0	64.9	283.4	822.8	21.0	15.3	3.600	0.071		0.017		0.08	11.62	6.86	0.173		0.050	
					Feb-94		10.07	1959	3385		218.0	0.5	453.1	77.3	312.2	847.6	49.8		0.319	0.143		0.001		0.07	10.07	2.28			0.053	3.10
					Average	24.2	10.26	1920	3043	990	213.9	0.4	456.6	71.1	297.8	835.2	35.4	7.7	1.960	0.107		0.009		0.08	10.85	4.57	0.173		0.052	3.10
		931		JOSEFINA 1	Nov-93	23.2	8.25	1879	2500	120	134.7	32.6	473.8	57.5	307.4	785.2		66.5	21.100	0.158		0.014		0.04	39.87	18.20	0.250		0.015	
					Feb-94		8.36	1820	3100		113.0	30.5	460.0	62.3	283.4	801.9		67.7	0.878	0.304		0.001		0.01	20.14	8.75			0.018	0.50
					Average	23.2	8.31	1849	2800	120	123.9	31.6	466.9	59.9	295.4	793.6		67.1	10.989	0.231		0.008		0.03	30.01	13.48	0.250		0.017	0.50
		947		POZO POCHA 1	Nov-93	23.6	8.73	1606	2900	171	64.9	36.8	450.8	60.6	312.2	547.3		82.4	50.500	0.007		0.014		0.04	19.31	35.50	0.620		0.021	
					Feb-94		7.97	1759	2875		102.5	37.9	427.8	68.5	487.5	585.0		59.8	0.288	0.040		0.001		0.01	10.41	19.65			0.025	0.60
					Average	23.6	8.35	1687	2888	171	83.7	37.4	439.3	64.6	399.9	566.2		71.1	25.394	0.024		0.008		0.03	11.86	27.58	0.620		0.023	0.60
	HUARA		45-B-D	POZO DUPLISA	Nov-93	24.5	7.74	1308	2100	143	166.5	26.4	207.0	28.9	509.1	247.4		114.7	8.200	0.029		0.011		0.05	5.28	0.05	0.007		0.011	
					Feb-94		8.13	1355	1965		173.5	26.5	213.9	34.0	487.5	251.7		161.1	7.058	0.041		0.002		0.01	4.47	0.03			0.011	0.30
					Average	24.5	7.94	1332	2033	143	170.0	26.5	210.5	31.5	498.3	249.6		137.9	7.629	0.035		0.007		0.03	4.88	0.04	0.007		0.011	0.30
	AVERAGE - A					23.7	8.65	1344	2182	284	115.2	17.7	308.7	47.3	286.2	481.5	6.5	72.0	9.430	0.197		0.008		0.06	10.58	11.23	0.811		0.042	1.25
B		196	46	BAQUEDANO No. 3	Nov-93	25.2	8.46	1611	3500	193	79.9	29.3	535.9	54.3	12.5	939.8		153.2	6.000	0.015		0.015		0.03	6.67	4.05	0.402		0.024	
					Feb-94		7.91	1764	3255		83.6	30.5	506.0	13.0	<0.5	958.0		171.5	0.924	0.021		0.001		0.02	13.21	3.53			0.018	1.30
					Average	25.2	8.19	1787	3378	193	81.8	29.9	521.0	33.7	12.5	948.9		162.4	3.462	0.018		0.008		0.03	9.94	3.79	0.402		0.021	1.30
		226	50	HUMBERSTONE 2	Nov-93	26.0	7.30	2025	2900	161	230.5	6.8	448.5	50.1	525.9	594.5		156.8	9.400	0.088		0.018		0.06	10.78	3.54	0.027		0.020	
					Feb-94		7.60	2299	3770		229.5	44.0	473.8	59.3	456.7	882.4		150.1	3.209	0.258		0.001		0.02	20.91	8.35			0.019	0.40
					Average	26.0	7.45	2162	3335	161	230.0	26.4	461.2	54.7	491.3	738.5		153.5	6.305	0.173		0.010		0.04	15.85	5.95	0.027		0.020	0.40
	HUARA	955		NORIA Nº95	Nov-93	18.3	7.59	2782	4200	146	244.1	19.7	710.7	55.1	658.0	863.6		227.6	3.500	0.731		0.022		0.07	5.94	0.08	0.008		0.028	
					Feb-94		8.28	2936	4280		236.5	39.5	657.8	63.3	830.9	883.4		223.3	0.831	0.581		0.001		0.02	11.17	0.22			0.040	0.50
					Average	18.3	7.94	2859	4240	146	240.3	29.6	684.3	59.2	744.5	873.5		225.5	2.166	0.656		0.012		0.05	8.56	0.15	0.008		0.034	0.50
				SONDAJE DE HUARA	Nov-93	29.0	7.98	2944	4400	221	468.9	31.6	434.7	39.1	1450.5	451.3		61.0	6.500	0.028		0.018		0.10	9.52	4.86	0.250		0.130	
		-	-	POZO PORVENIR A	Nov-93	26.2	8.12	1157	1500	116	148.3	18.8	187.7	28.2	451.5	254.9		63.5	4.100	0.005		0.009		0.03	7.55	0.76	0.248		0.011	
					Feb-94		7.62	1171	1770		138.0	23.5	197.8	29.5	451.5	264.1		66.5	0.463	0.007		0.001		0.04	7.28	2.68			0.014	0.40
					Average	26.2	7.87	1164	1635	116	143.2	21.2	192.8	28.9	451.5	259.5		65.0	2.282	0.006		0.005		0.04	7.42	1.72	0.248		0.013	0.40
		202	53	PORVENIR	Nov-93	22.6	7.68	1104	1300	277	136.3	20.4	187.7	22.7	403.5	207.0		117.2	9.200	0.057		0.008		0.03	4.26	2.53	0.032		0.007	
					Feb-94		7.90	1142	1650		137.0	20.0	184.0	25.5	401.0	241.7		129.4	3.065	0.022		<0.001		<0.01	9.05	2.23			0.029	0.60
					Average	22.6	7.79	1123	1475	277	136.7	20.2	185.9	24.1	402.3	224.4		123.3	6.133	0.040		0.008		0.03	6.66	2.38	0.032		0.018	0.60
		240	81A	SARA TIRANA	Nov-93	23.8	8.56	2951	4000	107	155.5	34.8	892.4	84.5	17.3	1696.6		62.9	7.300	0.005		0.023		0.06	10.15	4.77	0.265		0.020	
					Feb-94		8.26	2660	5345		28.7	6.9	901.6	97.0	13.9	1548.4		62.8	0.219	0.010		0.001		0.02	18.15	2.04			0.018	0.50
					Average	23.8	8.41	2805	4673	107	92.1	20.9	897.0	90.8	15.6	1622.5		62.9	3.760	0.008		0.012		0.04	14.15	3.41	0.265		0.019	0.50
		311	77B	LA TIRANA 104 A	Nov-93	24.4	8.98	866	1600	186	23.0	3.6	257.6	41.1	104.7	348.1		85.4	2.700	0.005		0.007		0.01	5.60	0.17	0.005		0.005	
					Feb-94		8.12	886	1511		19.7	3.3	266.8	48.5	90.0	362.3		94.6	1.284	0.021		0.001		<0.01	4.01	0.36			0.004	0.80
					Average	24.4	8.55	876	1556	186	21.4	3.5	262.2	44.8	97.4	355.2		90.0	1.992	0.013		0.004		0.01	4.81	0.27	0.005		0.005	0.80
		316	107	BOSQUE JUNOY 15	Nov-93	19.2	7.58	994	1500	144	152.3	23.2	138.5	30.5	331.4	211.3		102.5	3.900	0.034		0.006		0.03	2.70	0.05	0.004		0.007	
					Feb-94		8.14	1022	1570		137.5	23.0	144.9	32.5	355.5	224.0		103.1	1.284	0.056		0.001		<0.01	3.14	0.06			0.006	0.20
					Average	19.2	7.86	1008	1535	144	144.9	23.1	141.7	31.5	343.5	217.7		102.8	2.592	0.045		0.004		0.03	2.92	0.06	0.004		0.007	0.20
		381	149	BOSQUE JUNOY	Nov-93	23.9	7.40	2693	4700	178	367.0	66.3	455.4	63.3	494.7	1152.8		89.1	4.400	0.200		0.023		0.08	6.67	0.60	0.036		0.020	
		354	134	P. CANCHONES H	Nov-93	26.3	7.70	1299	2100	158	146.7	6.8	262.2	19.2	619.6	158.1		76.3	10.100	0.035		0.012		0.03	1.73	0.07	0.900		0.009	
					Feb-94		8.15	1312	1905		136.5	14.0	262.2	26.4	620.0	174.4		71.4	7.058	0.043		0.002		<0.01	3.22	0.08			0.007	0.20
					Average	26.3	7.93	1305	2003	158	141.6	10.4	262.2	22.8	619.8	166.3		73.9	8.579	0.039		0.007		0.03	2.48	0.08	0.900		0.008	0.20
		323	140	PTA. AP. HISPANIA	Nov-93	26.6	7.65	1446	2500	196	214.4	34.7	188.6	37.5	451.5	391.7		116.6	11.100	0.021		0.009		0.05	10.78	14.80	1.050		0.018	
					Feb-94		8.15	1494	2230		199.0	35.5	225.4	41.5	437.1	410.5		142.8	1.806	0.047		0.001		0.01	8.84	12.40			0.011	0.20
					Average	26.6	7.90	1470	2365	196	206.7	35.1	207.0	39.5	444.3	401.1		129.7	6.453	0.034		0.005		0.03	9.81	13.60	1.050		0.015	0.20
		113	238	PINTADOS RADIO	Nov-93	25.2	9.65	19200	31900	166	620.0	130.0	5612.0	450.0	2862.6	9363.8		157.4	4.100	1.131		0.201		0.31	4.55	0.72	0.330		0.130	
					Feb-94		7.39	19964	35325		655.0	125.0	6670.0	54.5	2641.5	9642.4		175.0	0.377	0.250		0.006		0.10	6.05	9.30			0.165	1.90
					Average	25.2	8.52	19582	33613	166	638	127.5	6141.0	252.3	2752.1	9503.1		166.2	2.239	0.696		0.104		0.21	5.30	5.01	0.330		0.148	1.90
		146	236	MOSQUITOS 1	Nov-93	23.2	9.20	1418	2100	183	62.5	11.1	414.0	44.2	155.6	676.4		50.6	3.900	0.021		0.012		0.03	12.25	1.66	0.017		0.009	
					Feb-94		7.81	2707	4430		361.5	66.0	471.5	76.5	456.3	1173.4		97.6	3.801	0.114		0.002		0.02	15.08	0.34			0.018	0.40
					Average	23.2	8.51	2062	3265	183	212.0	38.6	442.8	60.4	306.0	924.9		74.1	3.851	0.068		0.007		0.03	13.67	1.00	0.017		0.014	0.40

Table B-III, 3.3 Groundwater Quality (Pampa del Tamarugal) (Nov. 1993 - Feb. 1994)

<Calidad de Agua Subterránea (Pampa del Tamarugal) (Nov. 1993 - Feb. 1994)>

		B.N.A CODE	DGA CODE	NAME		TEMP.	pH	TDS	Cond. µS	Turb.	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	SO4 mg/l	Cl mg/l	CO3 mg/l	HCO3 mg/l	HEALTH SIGNIFICANCE NO3 mg/l	As mg/l	F mg/l	Cd mg/l	Cr mg/l	Pb mg/l	B mg/l	Fe mg/l	Mn mg/l	Zn mg/l	Cu mg/l	Al mg/l
				(STANDARD)			6.5-8.5	1000		5					250.0	250			10.000	0.050	1.50	0.005	0.050	0.05		0.30	0.100	5.00	1.000	0.20
B	PINTADOS	144	257	SALAR PINTADOS 3	Nov-93	25.4	4.11	1087	2500	335	24.6	3.0	351.9	32.8	17.3	628.5			28.500	0.005		0.007		0.06	3.52	51.70	3.950		0.087	
					Feb-94		4.91	1066	2050		21.6	3.0	356.5	36.5	1.0	643.4			1.612	0.016		0.001		<0.01	4.42	45.80			0.050	0.40
					Average	25.4	4.51	1076	2275	335	23.1	3.0	354.2	35.7	9.2	636.0			15.056	0.011		0.004		0.06	3.97	48.75	3.950		0.069	0.40
		421	251	SALAR PINTADOS 1	Nov-93	25.7	9.35	742	1300	434	3.0	0.2	233.5	13.7	8.6	212.7	13.2	247.7	9.100	0.020		0.008		0.02	9.80	9.53	0.030		0.012	
					Feb-94		8.65	736	1110		1.9	0.1	241.5	17.8	2.9	215.5		256.3	0.403	0.016		0.002		<0.01	1.18	11.80			0.032	1.20
					Average	25.7	9.00	739	1205	434	2.5	0.2	237.5	15.8	5.8	214.1	13.2	252.0	4.752	0.018		0.005		0.02	9.99	9.17	0.030		0.022	1.20
		415	231	SALAR PINTADOS 2	Nov-93	28.6	8.75	465	700	408	9.4	1.5	119.6	12.5	12.5	86.5		215.4	7.200	0.005		0.006		0.19	0.48	17.50	0.185		0.027	
					Feb-94		7.81	477	835		10.0	1.4	125.4	14.7	8.2	94.3		222.7	0.331	0.013		0.002		0.06	1.10	12.14			0.014	0.80
					Average	28.6	8.28	471	668	408	9.7	1.5	122.5	13.6	10.4	90.4		219.1	3.766	0.009		0.004		0.13	0.79	14.82	0.185		0.021	0.80
		222	64	O.J. MORALES	Nov-93	29.4	7.62	903	1700	147	179.4	9.2	100.3	21.5	353.0	141.8		87.3	10.100	0.008		0.007		0.03	1.25	0.02	0.005		0.007	
																				0.028										
		143	320	PINTADOS PICA 2	Nov-93	?	9.66		1091																1.46					
					Feb-94		9.75	635	955		1.6	0.1	209.3	26.0	61.0	128.0	77.4	131.8	0.059	0.042					1.46					
					Average		9.71	635	1023		1.6	0.1	209.3	26.0	61.0	128.0	77.4	131.8	0.059	0.035										
		114	315	PINTADOS PICA 3	Nov-93	31.0	8.07	641	800	112	27.5	3.0	161.0	17.6	157.5	96.4		173.3	4.400	0.018		0.007		0.09	0.85	0.91	0.043		0.045	
					Feb-94		7.87	560	920		27.5	3.1	140.7	18.9	61.6	101.4		186.7	0.132	0.016		0.002		0.06	1.49	0.44			0.019	0.40
					Average	31.0	7.97	600	860	112	27.5	3.1	150.9	18.3	119.6	98.9		180.0	2.266	0.017		0.005		0.08	1.17	0.68	0.043		0.032	0.40
		AVERAGE - B				25.3	7.99	2415	4027	105	154.3	24.2	641.3	48.7	444.4	984.4	2.4	122.4	4.658	0.108		0.012		0.05	6.37	6.14	0.210		0.029	0.28
C		447	272	SALAR BELLAVISTA	Nov-93	23.8	11.35	13870	24400	182	1025.0	5.0	3772.0	509.9	1037.4	7423.9		91.5	4.800	0.028		0.141		0.28	14.46	0.25	0.061		0.092	
					Feb-94		11.20	14259	25960		1020.0	0.1	4140.0	63.3	1537.0	7373.6	124.8		0.420	0.302		0.003		0.16	20.30	0.49			0.102	1.20
					Average	23.8	11.28	14064	25180	182	1023	2.6	3956.0	286.6	1287.2	7398.8	62.4	45.8	2.610	0.165		0.072		0.22	17.38	0.33	0.061		0.097	1.20
		440	287	SALAR BELLAVISTA	Nov-93	24.8	9.24	56311	66300	212	576.9	304.0	18998.0	1910.0	13160.2	21121.1	144.6	87.9	8.300	13.815		0.530		0.71	118.32	3.02	0.680		0.345	
					Feb-94		9.41	55352	87690		330.0	258.0	17940.0	1930.0	12487.8	22191.7	213.6		1.122	8.671		0.018		0.19	112.97	1.50			0.310	1.70
					Average	24.8	9.33	55832	77095	212	453.5	281.0	18469.0	1920.0	12824.0	21656.4	179.1	44.0	4.711	11.243		0.273		0.45	115.65	2.26	0.680		0.328	1.70
		157	276	SALAR BELLAVISTA	Nov-93	20.5	8.70	581	864	168	11.0	2.1	158.2	16.0	135.4	79.8	4.8	167.8	5.100	1.214		0.008		0.06	2.25	1.17	0.032		0.031	
					Feb-94		8.45	546	810		9.5	1.9	147.2	16.0	133.0	69.1		169.0	0.942	0.685		0.002		0.07	2.93	5.39			0.035	5.40
					Average	20.5	8.58	563	837	168	10.3	2.0	152.7	16.0	134.2	74.0	4.8	168.4	3.521	0.950		0.004		0.07	2.60	3.28	0.032		0.033	5.40
		442	278	OF. VICTORIA - 2	Nov-93	20.6	7.80	728	900	173	28.7	6.2	175.7	15.6	153.7	128.7		216.7	2.800	0.230		0.006		0.05	1.99	0.17	0.015		0.006	
		444	281	SALAR BELLAVISTA	Nov-93	26.2	8.85	712	900	268	13.7	3.0	207.0	15.2	148.9	167.7	1.8	140.3	14.300	0.388		0.006		0.05	2.00	3.40	0.039		0.025	
					Feb-94		8.51	728	1095		13.1	3.3	213.4	17.9	152.7	171.2		155.0	1.525	0.504		0.001		0.03	2.82	13.35			0.038	4.10
					Average	26.2	8.68	720	998	268	13.4	3.2	210.2	16.6	150.8	169.5	1.8	147.7	7.913	0.446		0.004		0.04	2.41	8.38	0.039		0.031	4.10
		453	292	CHALLACOLLO 2	Nov-93	27.0	8.38	1080	1400	182	60.1	8.4	287.5	28.2	210.4	310.2		169.7	5.600	0.471		0.008		0.07	2.52	1.31	0.036		0.017	
					Feb-94		8.01	1152	1745		57.4	8.2	303.6	33.3	228.6	320.1		199.5	1.541	0.217		<0.001		0.04	1.75	2.56			0.021	1.20
					Average	27.0	8.20	1116	1573	182	58.8	8.3	295.6	30.8	219.5	315.2		184.6	3.571	0.344		0.008		0.06	2.14	1.94	0.036		0.019	1.20
		122	228	CHACARILLA	Nov-93	30.2	9.52	944	1300	370	2.2	0.2	306.2	15.2	249.8	137.2	9.8	209.9	11.400	0.611		0.007		0.05	10.38	42.80	0.215		0.030	
					Feb-94		8.95	919	1350		2.6	0.1	303.6	11.0	245.0	142.2	28.8	185.0	0.547	0.654		0.001		0.01	8.74	17.27			0.015	0.30
					Average	30.2	9.24	931	1325	370	2.4	0.2	305.9	13.1	247.4	139.7	19.2	197.5	5.974	0.633		0.004		0.03	9.55	30.04	0.215		0.023	0.30
		-	-	POZO SAN GENARO - ENAP	Nov-93	25.8	7.95	583	800	152	53.3	6.0	90.6	70.2	169.2	61.7		111.7	4.000	0.039		0.003		0.01	0.31	0.23	0.116		0.008	
		AVERAGE - C				24.7	9.11	11322	16532	222	242.3	46.2	3611.9	352.4	2298.5	4587.3	52.8	137.9	4.569	2.138		0.081		0.14	23.19	7.12	0.154		0.082	2.32
D	(JICA WELLS)			JICA J-3	Nov-93		7.95	442	736		33.1	4.4	99.4	16.1	108.1	98.9		80.5	1.380	0.087		0.002	0.02	0.01	2.38	0.04	0.050	0.90	0.004	0.10
					Feb-94		9.42	397	690	236	22.6	0.2	104.0	22.2	113.0	103.5	13.2	18.3	0.482	0.026		<0.001		0.03	2.16	1.84			0.007	0.80
					Average		9.24	420	713	236	27.9	2.3	101.7	19.2	110.6	101.2	13.2	49.4	0.921	0.057		0.002	0.02	0.02	2.27	0.94	0.050	0.90	0.006	0.43
				JICA J-4	Nov-93		7.47	2875	4700		208.0	43.0	736.8	74.0	450.0	1124.5		238.1	0.515	0.754		0.018	0.02	0.04	26.82	0.04	0.120	1.20	0.014	0.10
					Feb-94		8.06	2627	4319	250	179.0	51.5	625.8	99.5	477.9	1036.2		187.3	0.429	0.125		<0.001		0.01	31.18	4.88			0.021	0.30
					Average		7.77	2751	4503	250	193.5	47.3	682.2	71.8	464.0	1080.4		211.7	0.488	0.440		0.018	0.02	0.03	29.00	2.51	0.120	1.20	0.018	0.20
				JICA J-5	Nov-93		7.19	2686	4440		337.0	58.5	501.4	80.0	500.0	1095.1		130.6	1.916	0.054		0.015	0.02	0.03	25.14	0.22	0.009	1.47	0.014	0.10
					Feb-94		7.90	2673	4210	328	319.0	58.5	901.4	86.0	600.4	1055.3		73.8	0.319	0.013		<0.001		<0.01	5.61	17.05			0.019	0.30
					Average		7.55	2679	4325	328	328.0	58.0	901.4	83.0	550.2	1075.2		102.2	1.118	0.034		0.015	0.02	0.05	15.38	8.64	0.009	1.47	0.017	0.20
				JICA J-6	Nov-93		7.74	549	846		22.8	2.4	137.1	23.0	199.8	50.7		111.7	1.042	0.077		0.005	0.01	0.01	1.15	0.18	0.018	1.11	0.008	0.10
					Feb-94		8.31	520	800	300	14.4	1.8	139.8	25.0	204.1	51.4		83.0	0.253	0.016		<0.001		0.01	1.31	7.83			0.004	0.20
					Average		8.03	534	823	300	18.6	2.1	138.5	24.0	202.0	51.1		97.4	0.648	0.047		0.005	0.01	0.01	1.23	3.90	0.018	1.11	0.005	0.15
				JICA J-7	Nov-93		7.84	1889	3160		102.0	43.3	303.6	49.0	300.2	748.7		120.8	1.418	0.058		0.011	0.01	0.04	7.30	0.06	0.004	1.54	0.008	0.10
					Feb-94		8.06	1111	1840	254	112.5	22.0	216.2	43.5	221.0	391.0		104.3	0.535	0.015		<0.001		0.02	4.44	6.58			0.005	0.20
					Average		7.95	1390	2500	254	107.3	32.8	259.9	46.3	260.6	569.9		112.6	0.977	0.037		0.011	0.01	0.03	5.87	3.32	0.004	1.54	0.007	0.15
				JICA J-8	Nov-93		8.09	550	821		6.5	0.4	159.2	22.0	105.2	88.6		167.2	0.645	0.292		0.005	0.02	0.01	1.76	0.11	0.380	0.80	0.008	0.10
					Feb-94		8.08	657	1080	322	17.5	1.8	178.5	19.7	123.0	167.7		147.0	1.734	0.078		<0.001		0.02	2.61	2.40			0.004	0.02
					Average		8.08	603	941	322	12.0	1.1	168.9	20.9	114.1	128.2		157.1	1.190	0.185		0.005	0.02	0.02	2.18	1.28	0.380	0.80	0.006	0.08
				JICA J-9	Nov-93		7.07	3722	6040		351.5	80.5	851.0	63.5	800.2	1469.0		124.5	1.345	0.217		0.023	0.02	0.70	9.41	8.70	0.055	1.50	0.022	0.10
					Feb-94		7.68	3443	5600	532	253.0	40.5	874.0	62.0	1071.1	1063.3		77.0	2.058	0.126		0.001		0.01	5.97	33.00			0.043	0.30
					Average		7.38	3582	5820	532	302.3	60.5	862.5	62.8	935.7	1266.3		100.8	1.702	0.172		0.012	0.02	0.36	7.69	20.85	0.055	1.50	0.033	0.20

Table B-III, 3.3. Groundwater Quality (Pampa del Tamarugal) (Nov. 1993 - Feb. 1994)

<Calidad de Agua Subterránea (Pampa del Tamarugal) (Nov. 1993 - Feb. 1994)>

		B.N.A CODE	DGA CODE	NAME		TEMP.	pH	TDS	Cond. µS	Turb.	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	SO4 mg/l	Cl mg/l	CO3 mg/l	HCO3 mg/l	HEALTH SIGNIFICANCE NO3 mg/l	As mg/l	F mg/l	Cd mg/l	Cr mg/l	Pb mg/l	B mg/l	Fe mg/l	Mn mg/l	Zn mg/l	Cu mg/l	Al mg/l
				(STANDARD)			6.5-8.5	1000		5					250.0	250			10.000	0.050	1.50	0.005	0.050	0.05		0.30	0.100	5.00	1.000	0.20
D				JICA J-C	Nov-93		7.43	2316	3680		331.5	31.5	409.4	45.5	699.8	719.6		78.1	0.705	0.039		0.013	0.02	0.05	8.97	0.13	0.840	0.57	0.013	0.10
					Feb-94		7.54	3223	3850	245	556.5	10.5	428.3	26.3	1801.0	360.5		39.7	0.295	0.102		0.002		<0.01	5.65	5.52			0.025	0.70
					Average		7.49	2770	3765	245	444.0	21.0	418.9	35.9	1250.4	540.1		58.9	0.500	0.071		0.008	0.02	0.05	6.18	2.83	0.840	0.57	0.019	0.40
				JICA J-D	Nov-93		7.71	2562	4280		310.0	57.5	501.4	59.0	450.0	1052.5		130.6	1.440	0.005		0.014	0.02	0.05	23.24	3.90	0.018	1.17	0.019	0.10
					Feb-94		8.19	2498	4000	358	322.0	48.5	446.2	64.0	542.7	1021.0		52.5	1.230	0.014		0.001		<0.01	19.32	22.43			0.018	0.60
					Average		7.95	2530	4140	358	316.0	53.0	473.8	61.5	496.4	1036.8		91.6	1.335	0.010		0.008	0.02	0.05	21.28	13.17	0.018	1.17	0.019	0.35
				JICA J-E	Nov-93		7.28	2597	4290		354.0	56.0	437.0	60.0	699.8	855.4		130.6	2.450	0.038		0.013	0.02	0.06	24.50	0.04	0.030	1.11	0.012	0.10
					Feb-94		8.00	2303	3770	292	304.5	56.0	393.3	63.0	476.5	941.6		67.7	0.131	0.008		0.003		0.01	14.82	16.25			0.014	0.20
					Average		7.64	2450	4030	292	329.3	57.0	415.2	61.5	588.2	898.5		99.2	1.291	0.023		0.008	0.02	0.04	19.66	8.15	0.030	1.11	0.013	0.15
				JICA J-F	Nov-93		7.56	1290	2180		73.0	24.0	322.0	36.5	199.8	487.1		147.1	0.918	0.197		0.005	0.01	0.03	3.51	0.11	1.400	1.20	0.007	0.10
					Feb-94		8.07	1627	2480	303	100.9	27.9	377.2	70.0	408.3	432.5		209.0	0.907	0.397		0.002		0.01	4.98	1.55			0.010	0.20
					Average		7.82	1459	2330	303	87.0	26.0	349.6	53.3	304.1	459.8		178.1	0.913	0.297		0.004	0.01	0.02	4.25	0.83	1.400	1.20	0.009	0.15
				AVERAGE - D			7.81	1924	3081	311	196.9	31.9	397.5	47.3	479.6	655.2	13.2	114.4	1.005	0.124		0.008	0.02	0.06	10.45	6.03	0.264	1.12	0.014	0.22
				AVERAGE (A + B + C + D)		24.6	8.39	4251	6455	230	177.2	30.0	1238.8	123.9	877.2	1677.1	18.7	111.7	4.916	0.642		0.022	0.01	0.08	12.65	7.63	0.360	0.56	0.042	1.02
	PICA	252	223	POZO CONCOVA	Nov-93	32.6	8.35	229	400	201	18.4	0.2	46.5	1.6	33.1	25.9		97.6	5.600	0.005		0.004		20.01	0.02	0.92	0.015		0.007	
					Feb-94		8.44	228	312		17.2	0.2	47.8	1.6	32.0	27.6	2.4	97.6	1.158	<0.005		0.002		<0.01	0.30	0.85			0.001	0.20
					Average	32.6	8.40	228	356	201	17.8	0.2	47.2	1.6	32.6	26.8	1.2	97.6	3.379	0.005		0.003		20.01	0.16	0.89	0.015		0.004	0.20
		263	170	LA CALERA Nº3	Nov-93	29.8	8.05	1462	2700	148	81.8	7.7	408.3	15.6	614.8	220.5		70.2	43.500	0.027		0.010		0.02	13.94	0.63	0.034		0.009	
					Feb-94		8.39	1186	1890		9.0	0.8	404.8	19.5	298.0	322.0		130.6	1.468	0.053		0.001		<0.01	3.86	0.56			0.007	0.40
					Average	29.8	8.22	1324	2295	148	45.4	4.3	406.6	17.6	456.4	271.3		100.4	22.484	0.040		0.006		0.02	8.90	0.60	0.0		0.0	0.40
		270	213	ESMERALDA 7	Nov-93	32.2	8.82	601	1300	165	19.8	0.5	175.7	5.1	261.8	75.9		54.9	7.000	0.059		0.007		0.01	1.57	1.56	0.025		0.005	
				AVERAGE		31.5	8.41	741	1320	171	29.2	1.9	216.6	8.7	247.9	134.4	0.6	90.2	11.745	0.036		0.005		6.68	3.94	0.90	0.025		0.006	0.30

SAMPLED AND ANALYZED BY DGA AND JICA STUDY TEAM IN NOVEMBER 1993.
SAMPLES OF JICA WELLS WERE TAKEN AFTER PUMPING TEST. OTHERS WERE SAMPLED WITHOUT PUMPING (WELLS WERE NOT IN USE.).
TDS IS CALCULATED FROM CONDUCTIVITY BY USING EQUATION MENTIONED IN CHAPTER 3, B-I (SEE FIG. B-I, 3.3.2).

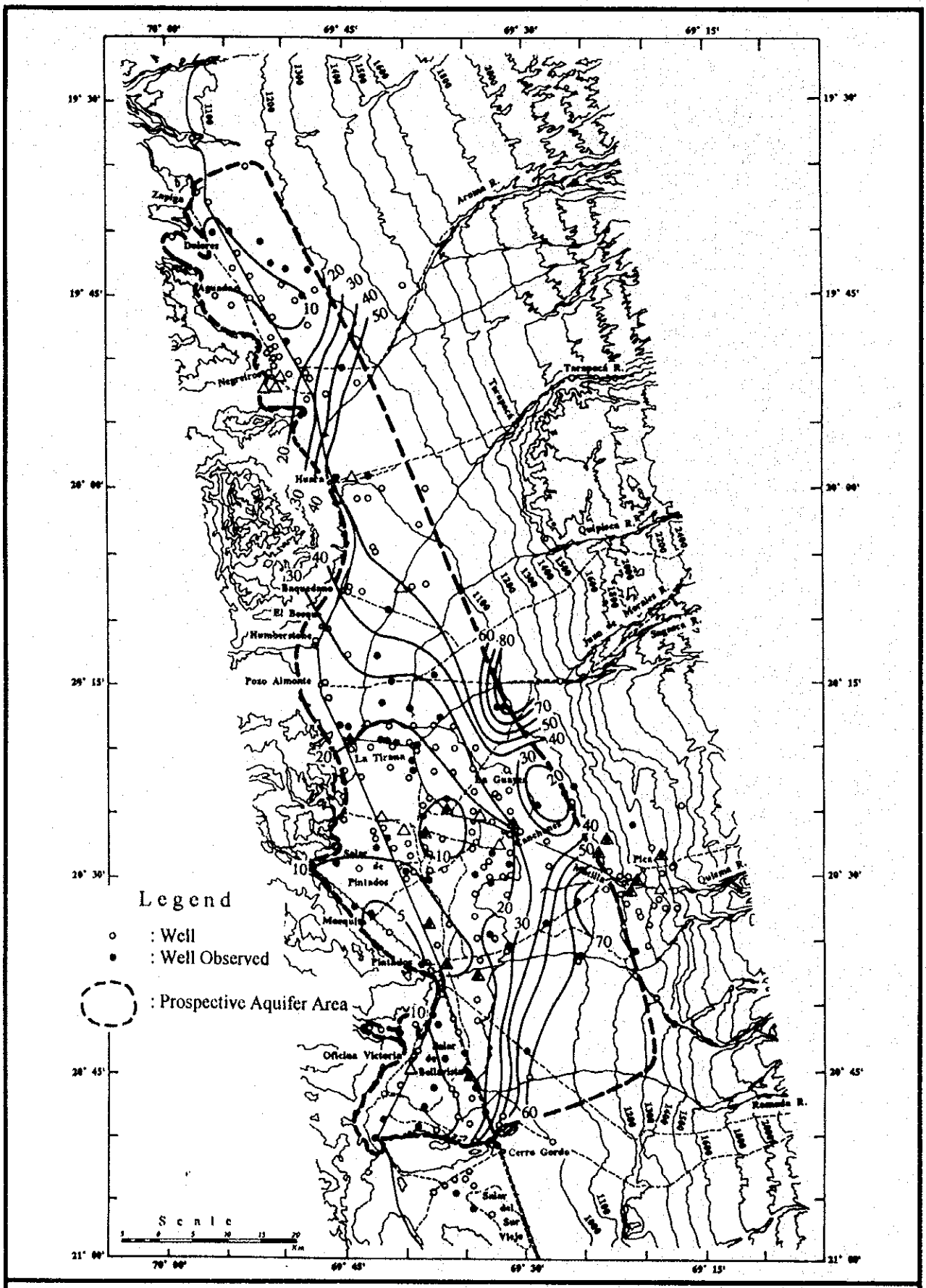

Fig. B-III, 3.1 Static Water Level (1993)

< Nivel Estático (1993) >

Unit : m BGL

THE STUDY ON THE DEVELOPMENT OF WATER RESOURCES IN NORTHERN CHILE | JICA

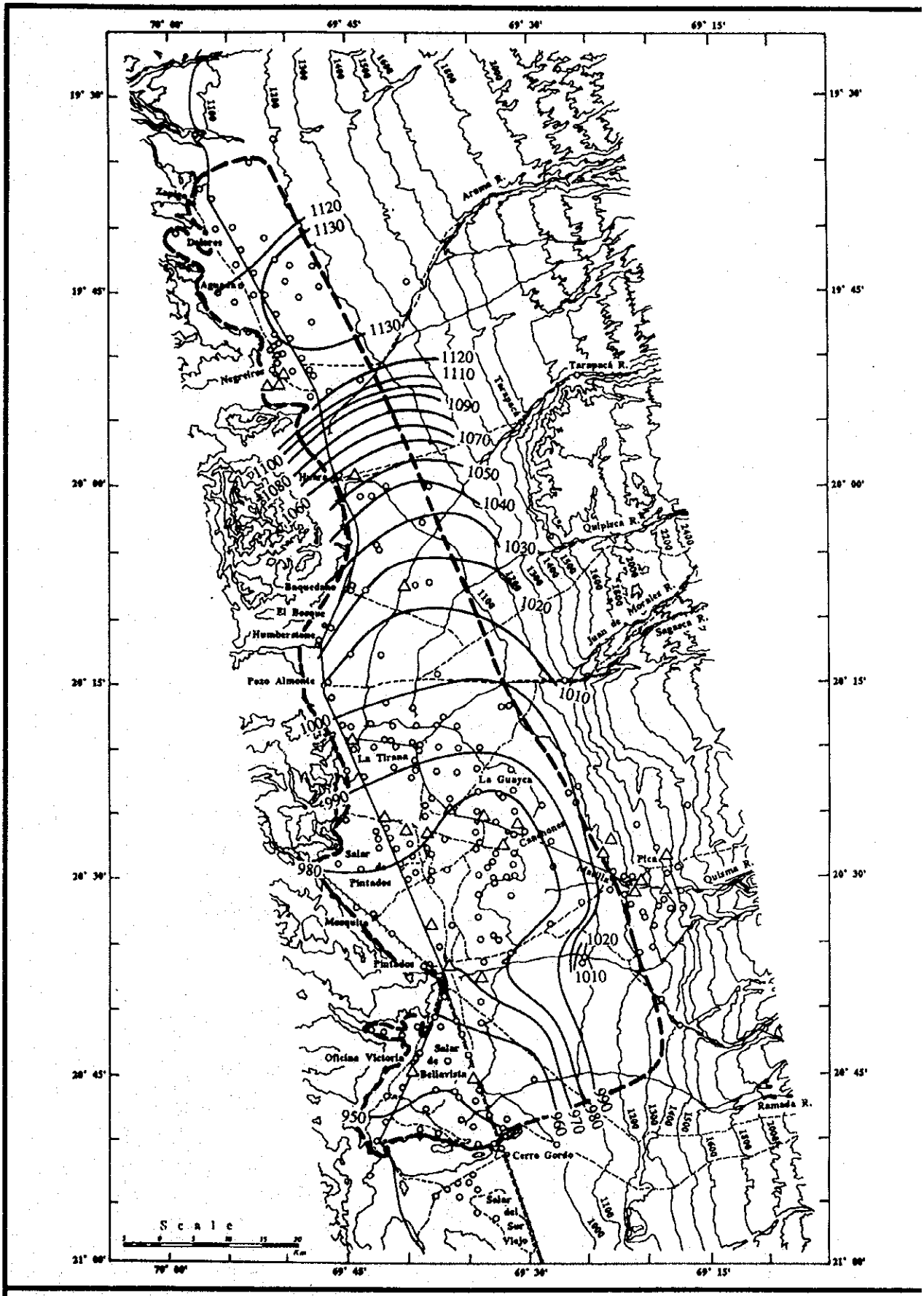

Fig. B-III, 3.2 Static Water Level (1993)

<Nivel Estático (1993) >

Unit : m MSL

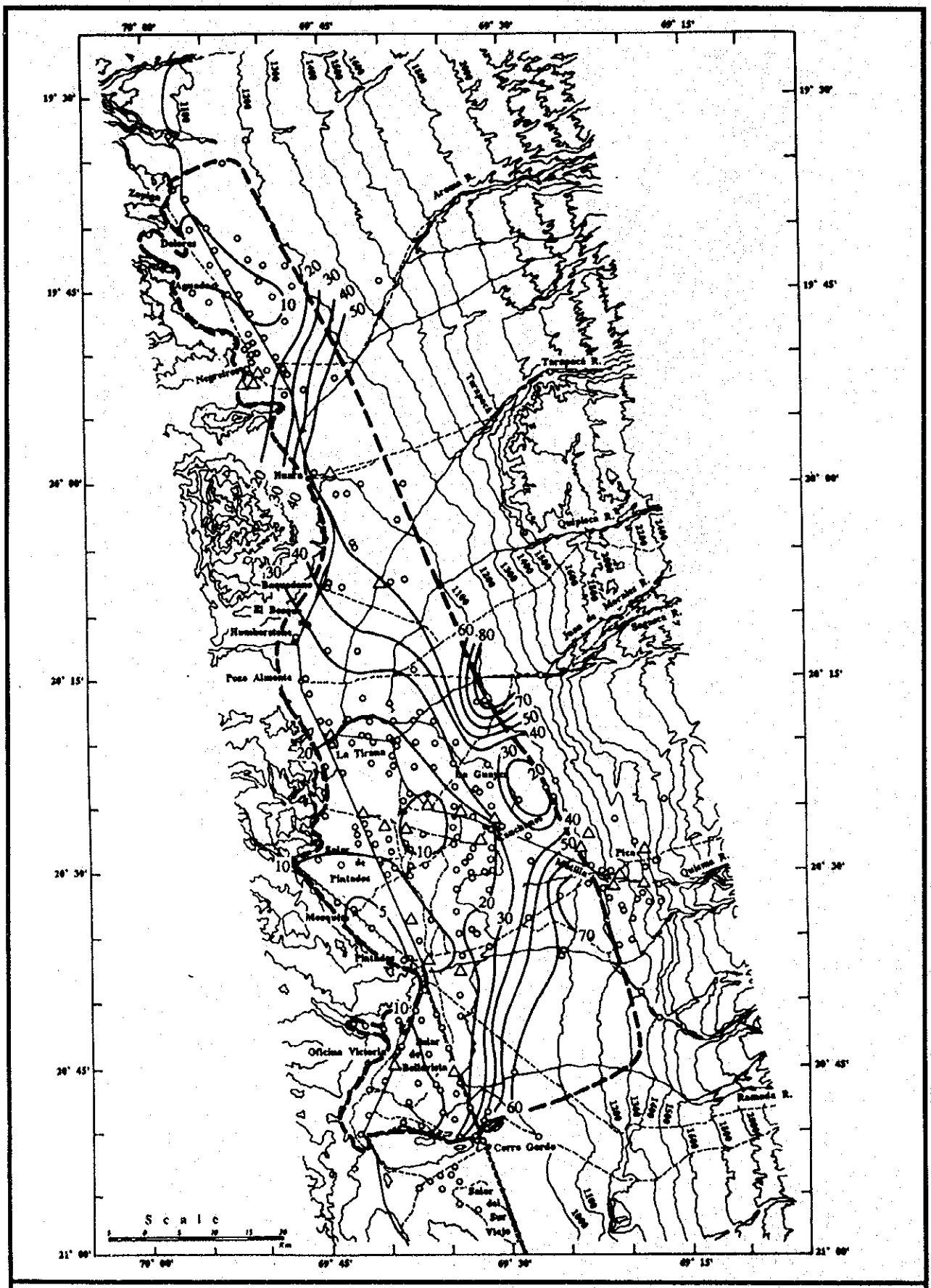

Fig. B-III, 3.3 Static Water Level (1960's)

<Nivel Estático (1960's) >

unit: *BGL*

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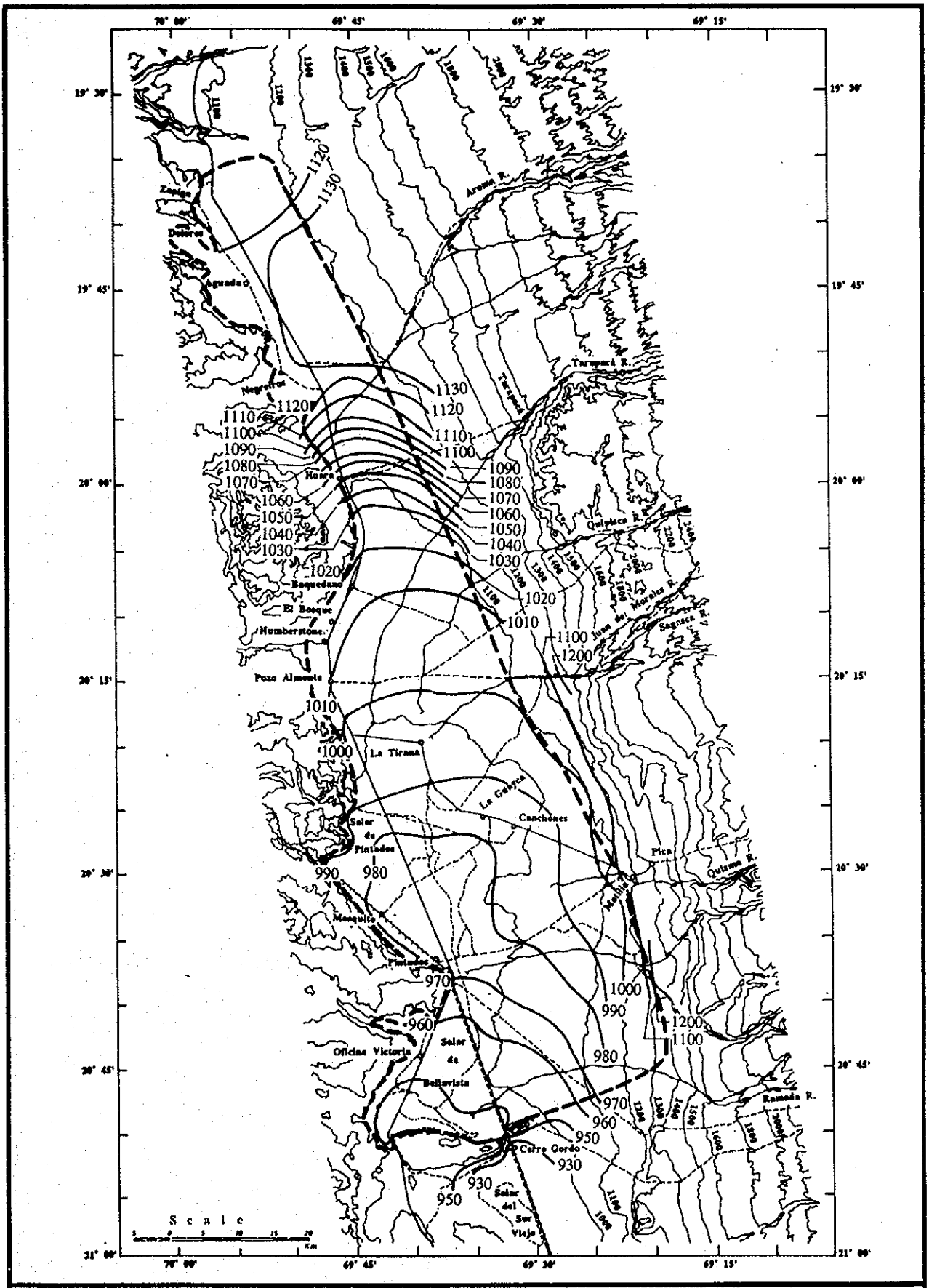
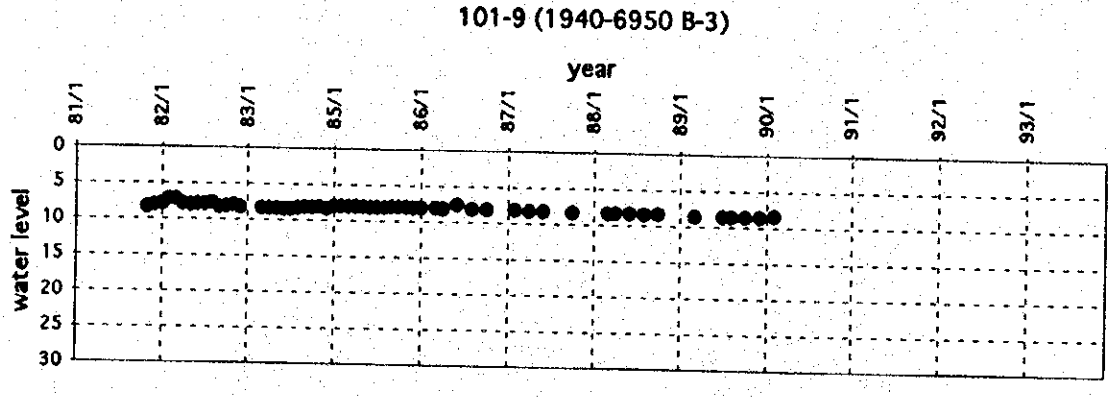


Fig. B-III, 3.4 Static Water Level (1960's) unit: m*BGL*

<Nivel Estático (1960's) > *unidad: mBGL* Unit.: MSL

(ZAPIGA)



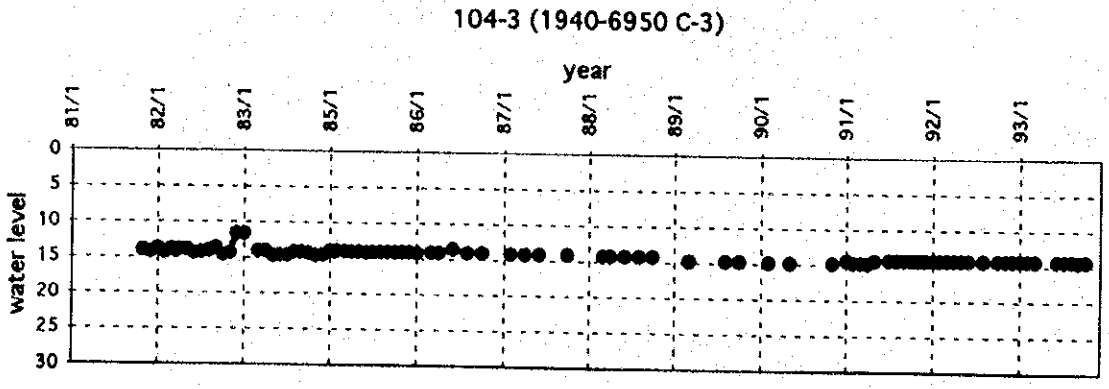


Fig. B-III, 3.5 (1) Variation of Groundwater Table in Pampa del Tamarugal

< Variación de Nivel Estatico en Pampa del Tamarugal >

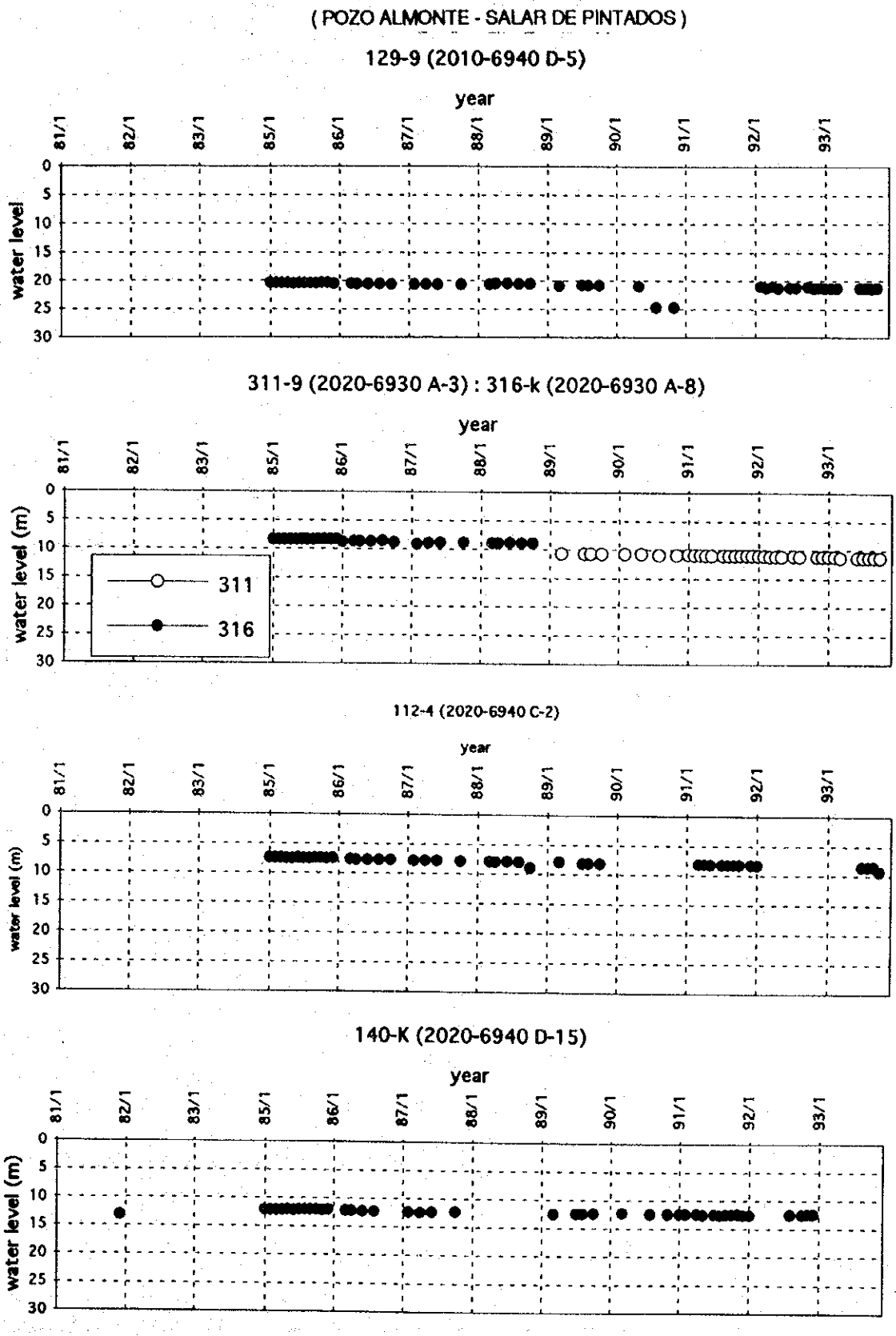


Fig. B-III, 3.5 (2) Variation of Groundwater Table in Pampa del Tamarugal

< Variación de Nivel Estatico en Pampa del Tamarugal >

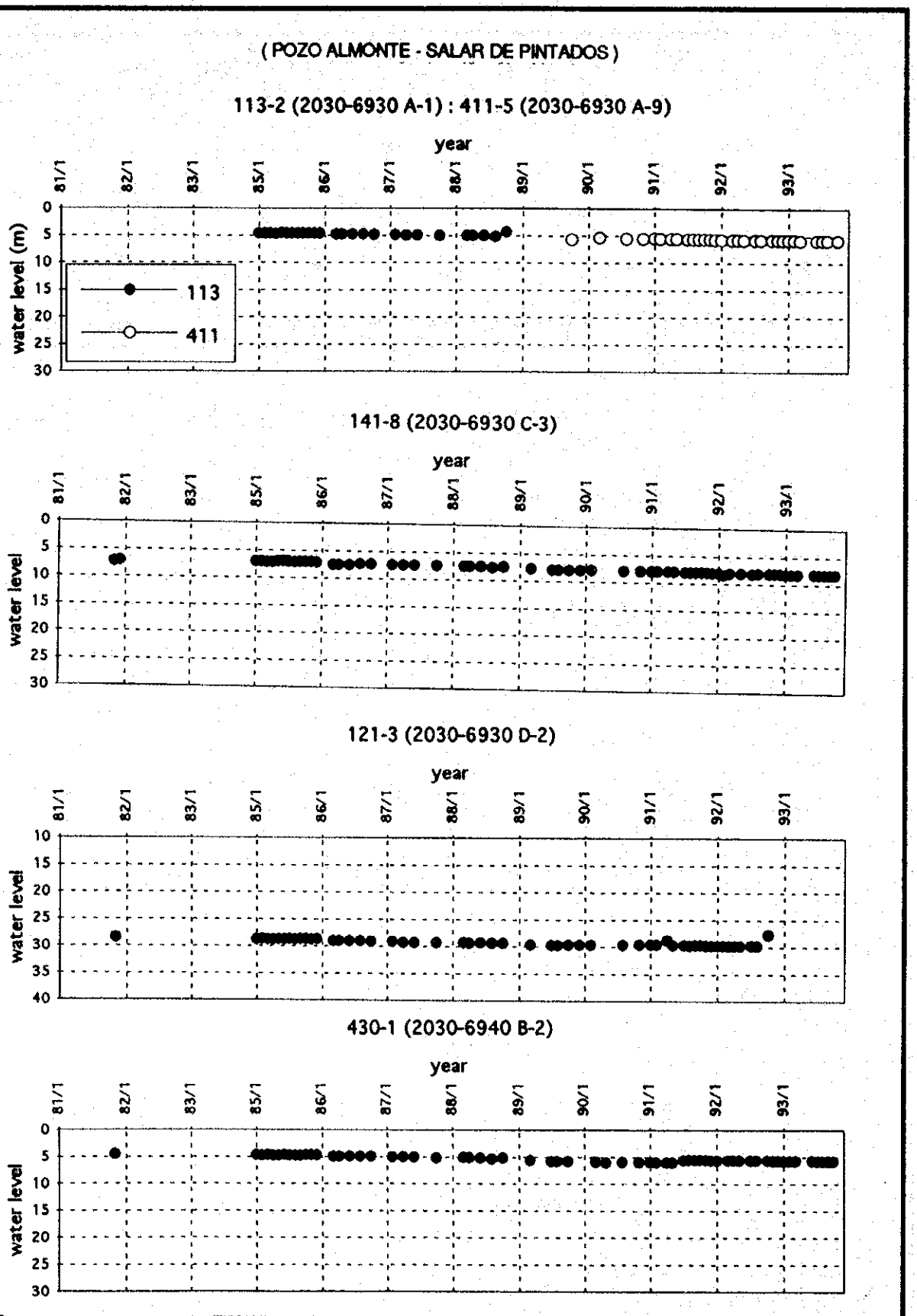
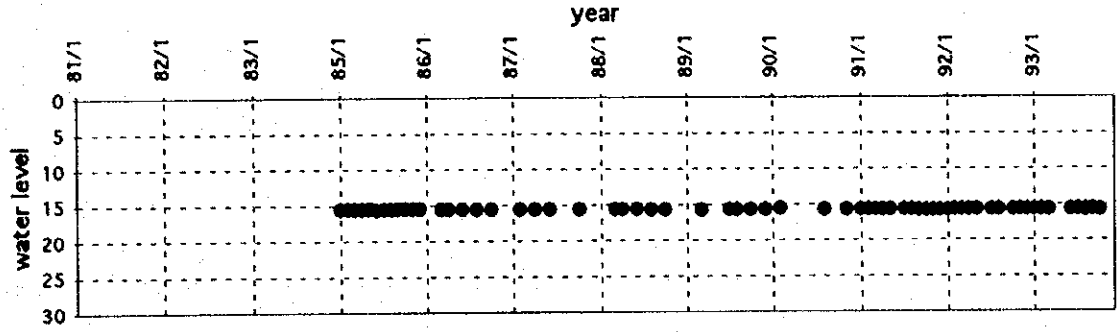


Fig. B-III, 3.5 (3) Variation of Groundwater Table in Pampa del Tamarugal

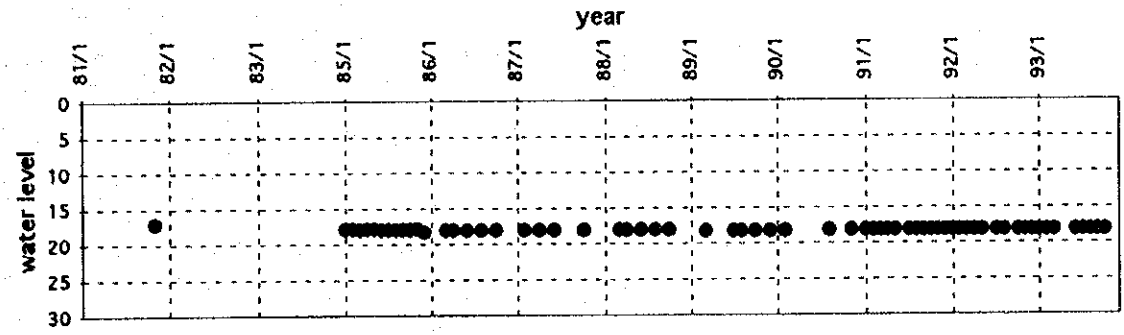
< Variación de Nivel Estatico en Pampa del Tamarugal >

(OFICINA VICTORIA - SALAR DE BELLAVISTA)

157-4 (2040-6930 A-7)



444-1 (2040-6930 D-3)



127-2(2040-6930 D-5)

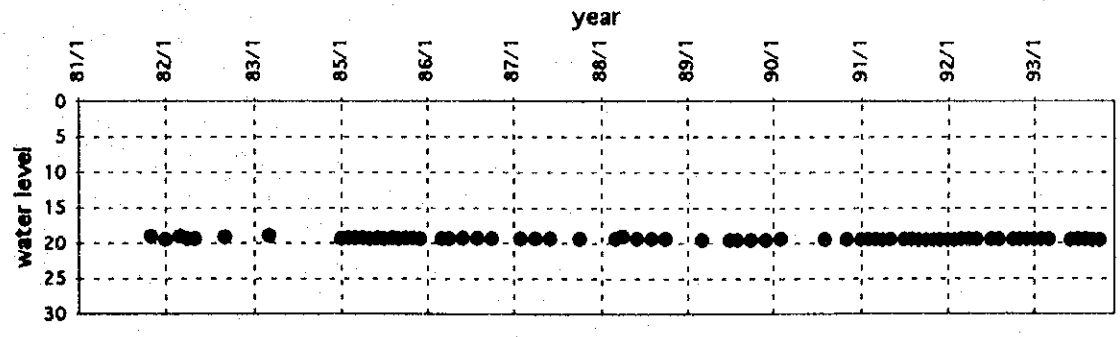


Fig. B-III, 3.5 (4) Variation of Groundwater Table in Pampa del Tamarugal

< Variación de Nivel Estatico en Pampa del Tamarugal >

(OFICINA VICTORIA - SALAR DE BELLAVISTA)

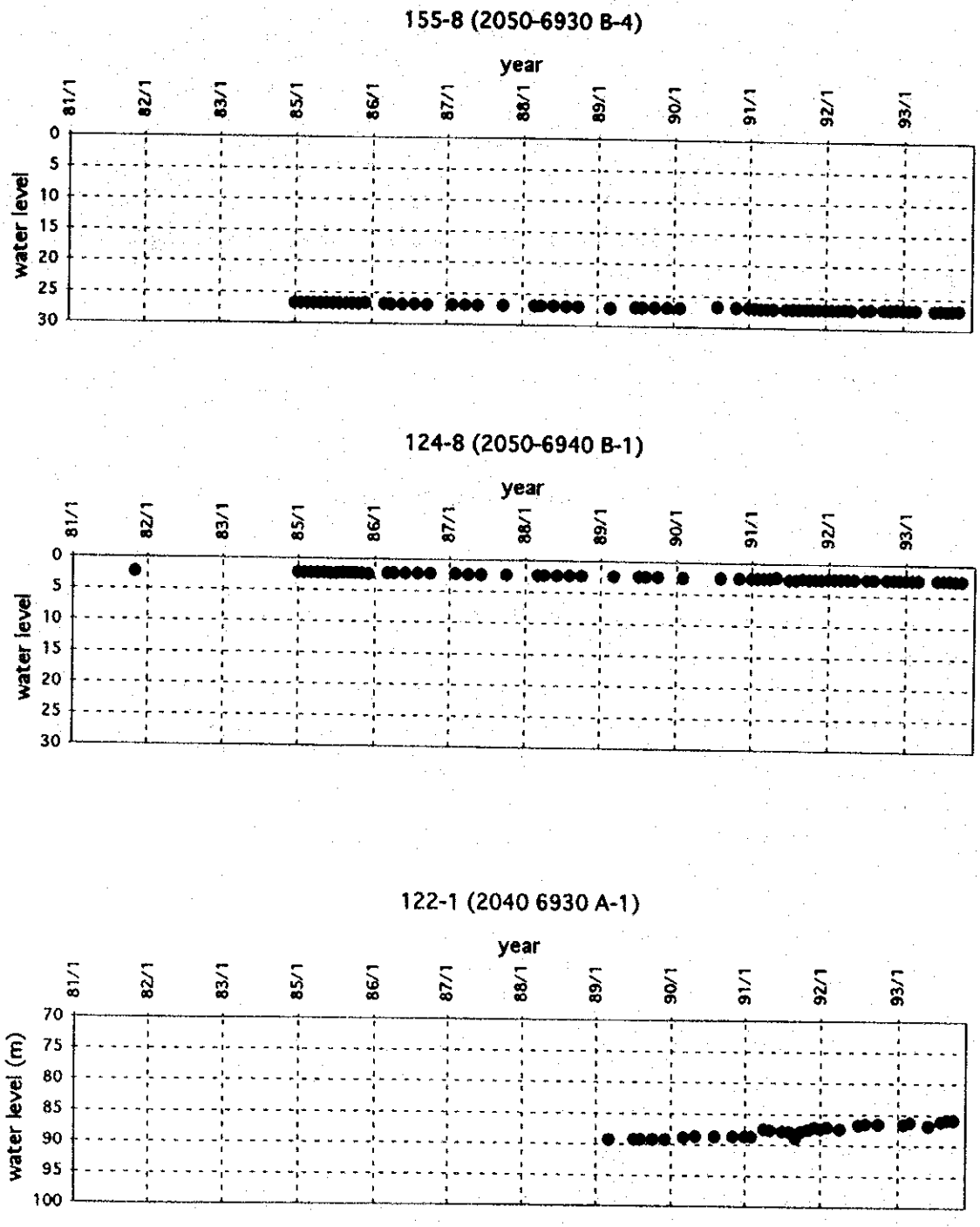


Fig. B-III, 3.5 (5); Variation of Groundwater Table in Pampa del Tamarugal

< Variación de Nivel Estatico en Pampa del Tamarugal >

(PICA)

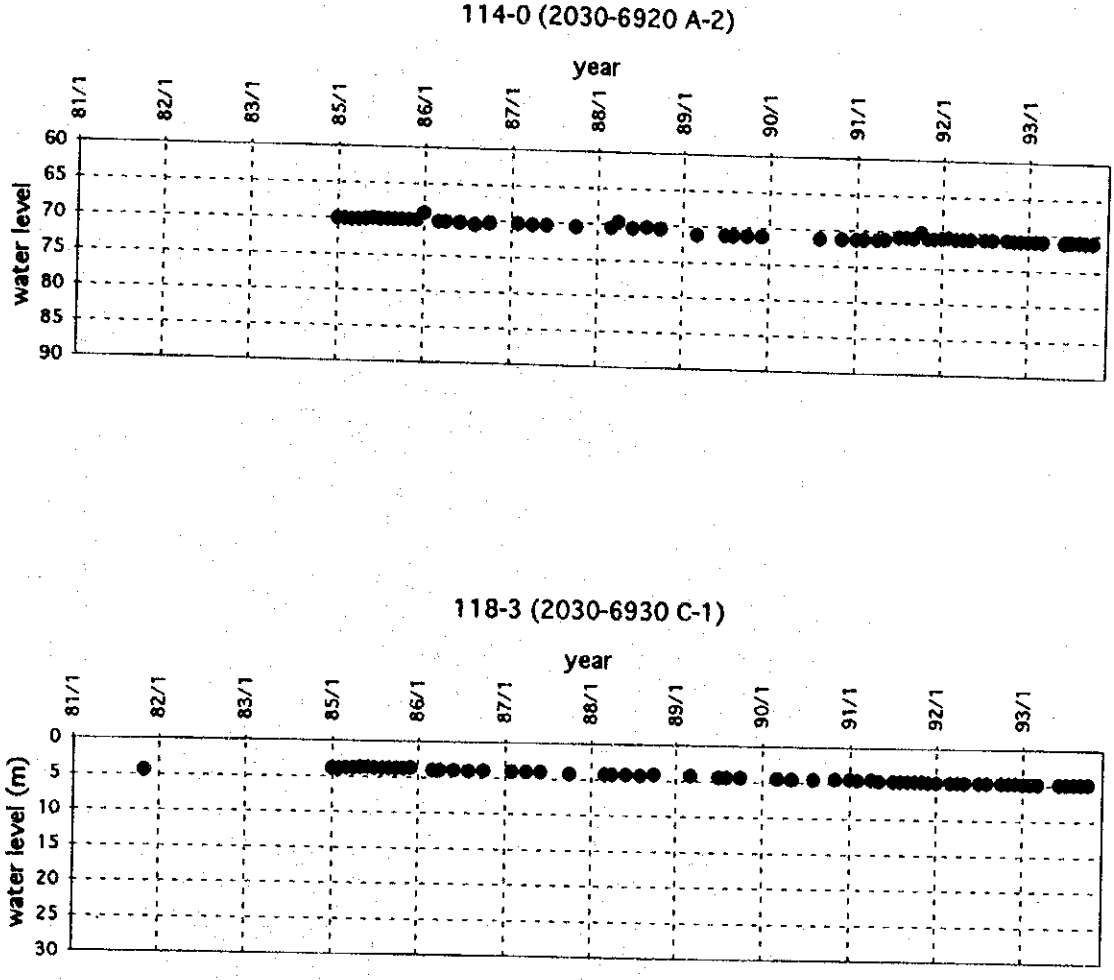


Fig. B-III, 3.5 (6) Variation of Groundwater Table in Pampa del Tamarugal

< Variación de Nivel Estatico en Pampa del Tamarugal >

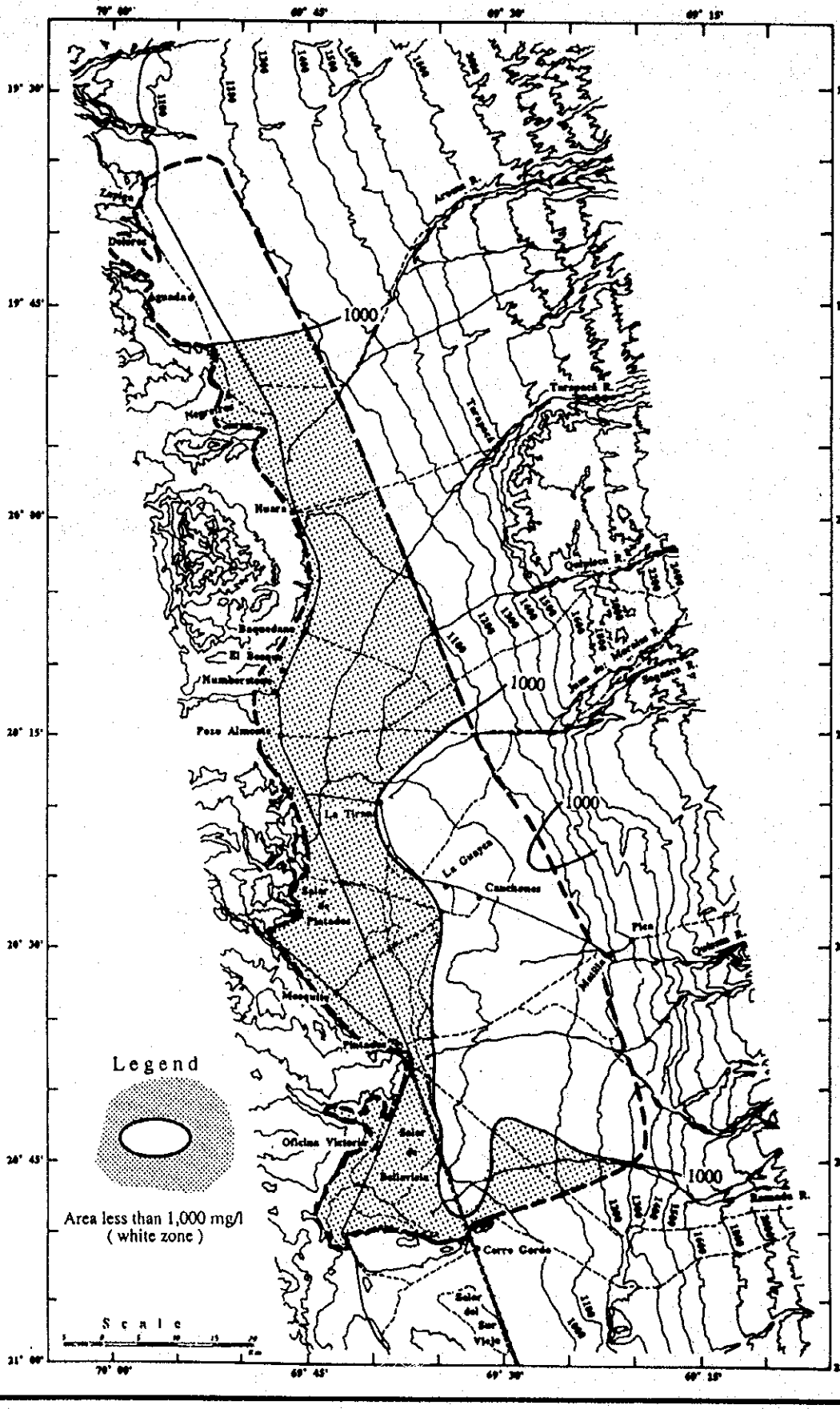


Fig. B-III, 3.6 Distribution of TDS (Pampa del Tamarugal)

< Distribución de TDS (Pampa del Tamarugal) >

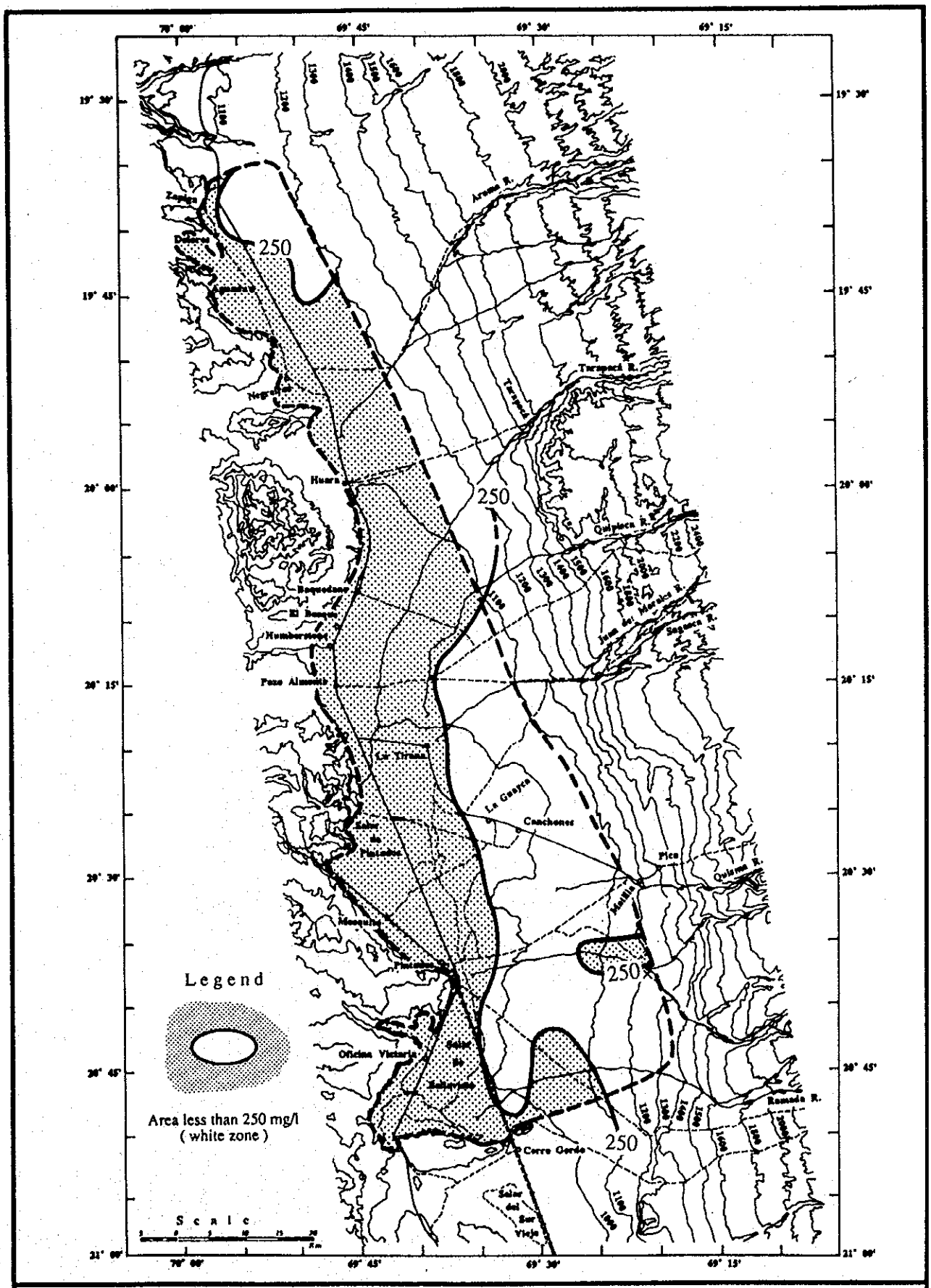


Fig. B-III, 3.7 Distribution of Cl (Pampa del Tamarugal)

< Distribución de Cl (Pampa del Tamarugal) >

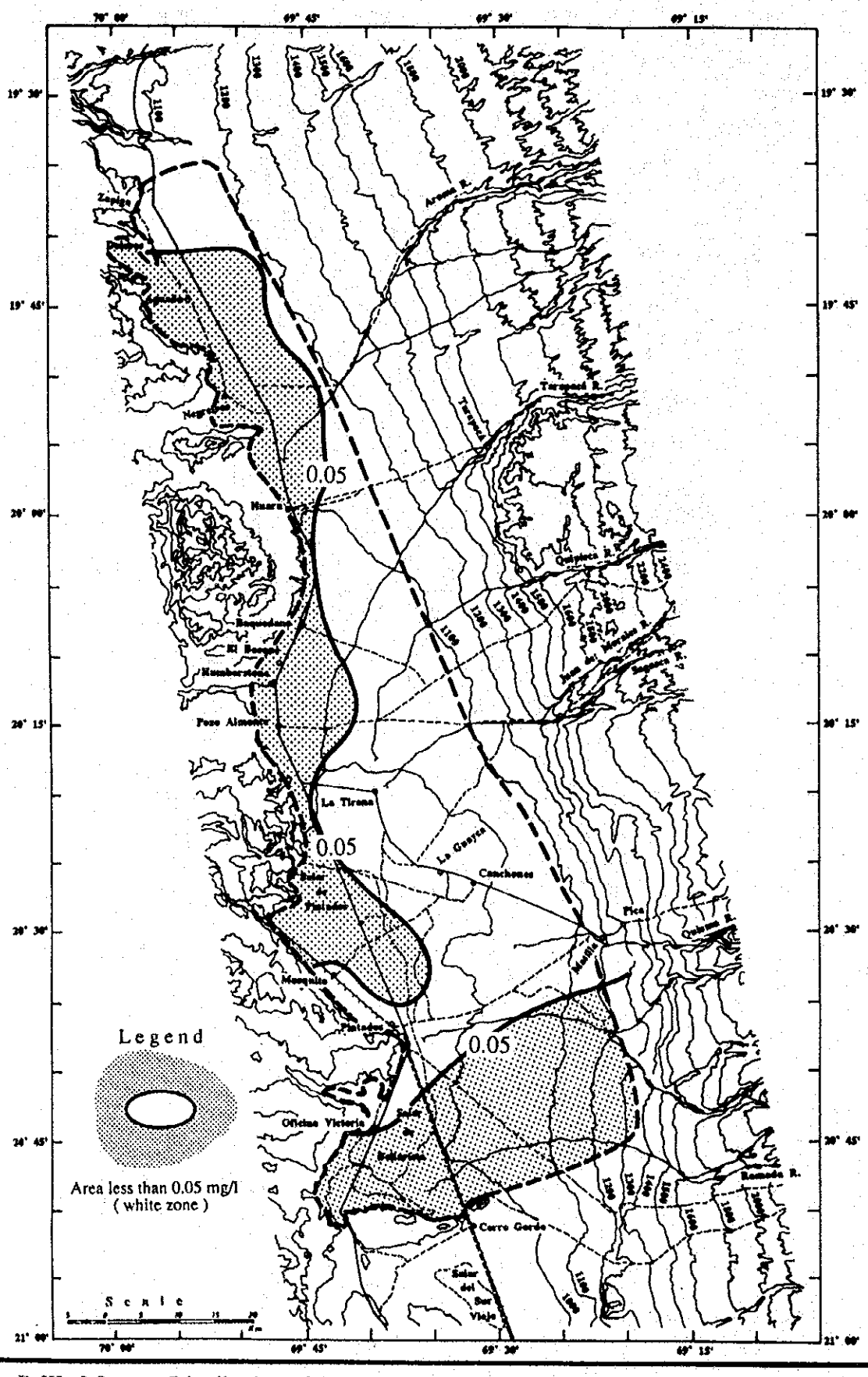


Fig. B-III, 3.8 Distribution of As (Pampa del Tamarugal)

< Distribución de As (Pampa del Tamarugal) >

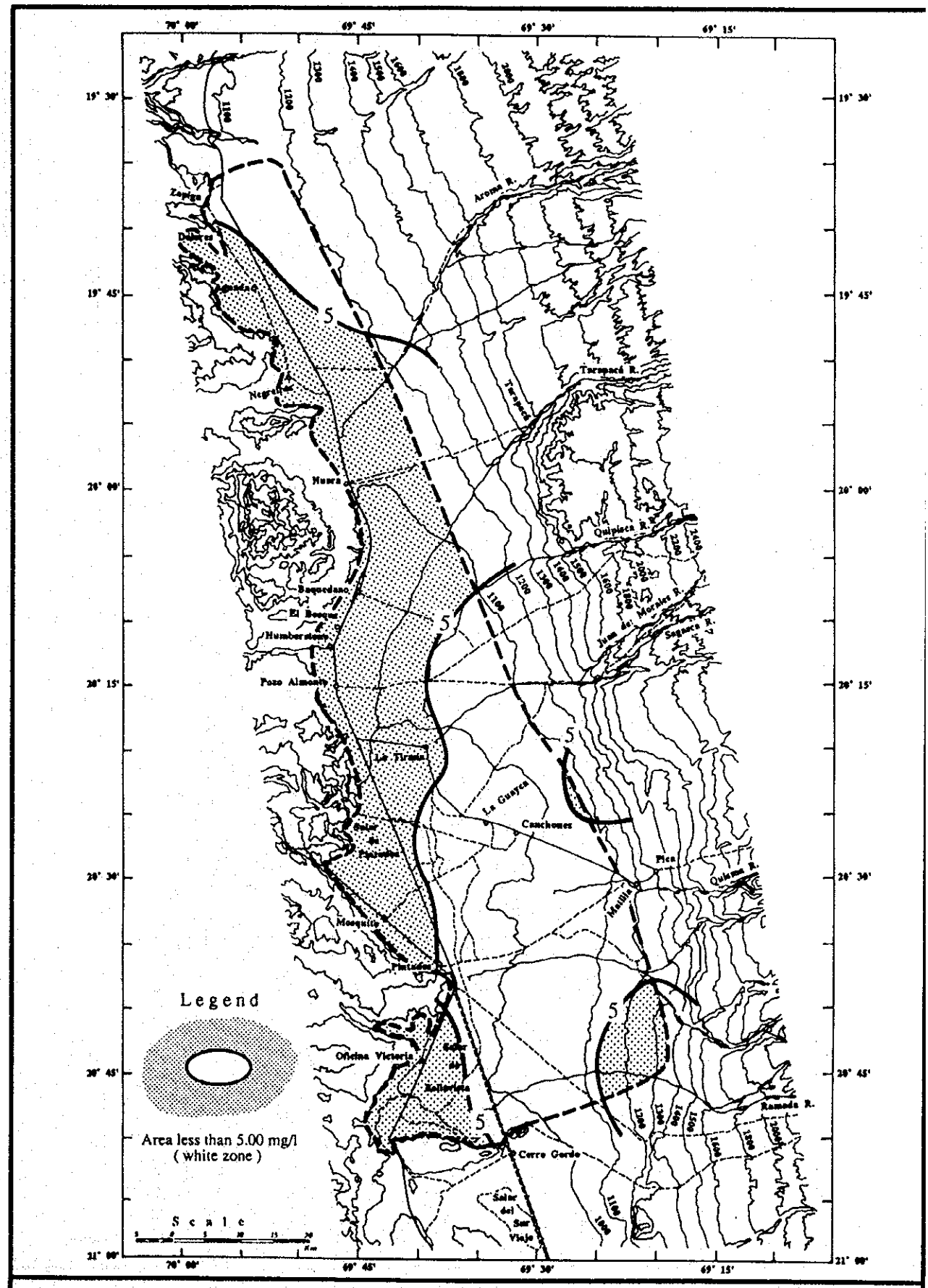


Fig. B-III, 3.9 Distribution of B (Pampa del Tamarugal)

< Distribución de B (Pampa del Tamarugal) >

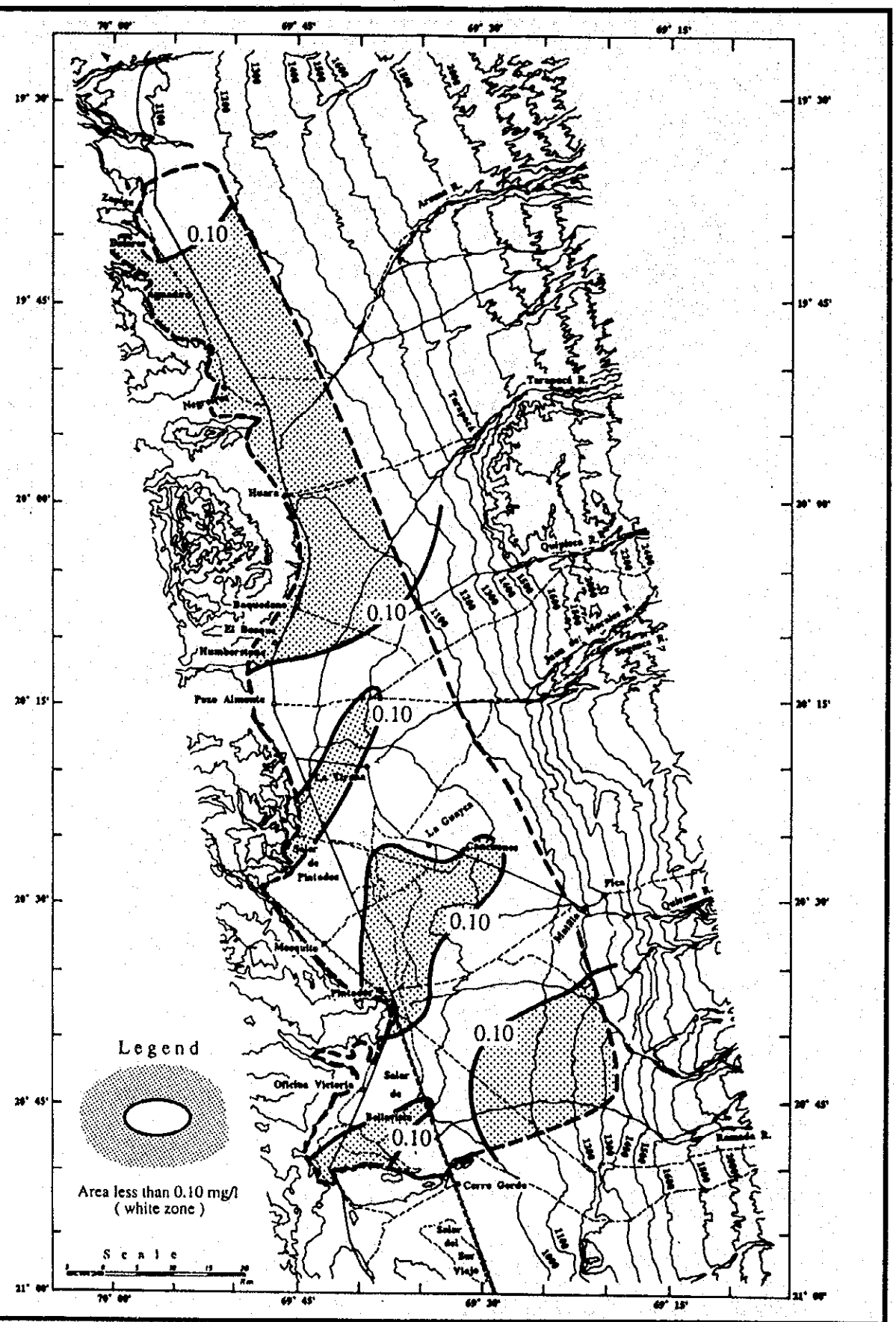


Fig. B-III, 3.10 Distribution of Mn (Pampa del Tamarugal)

< Distribución de Mn (Pampa del Tamarugal) >

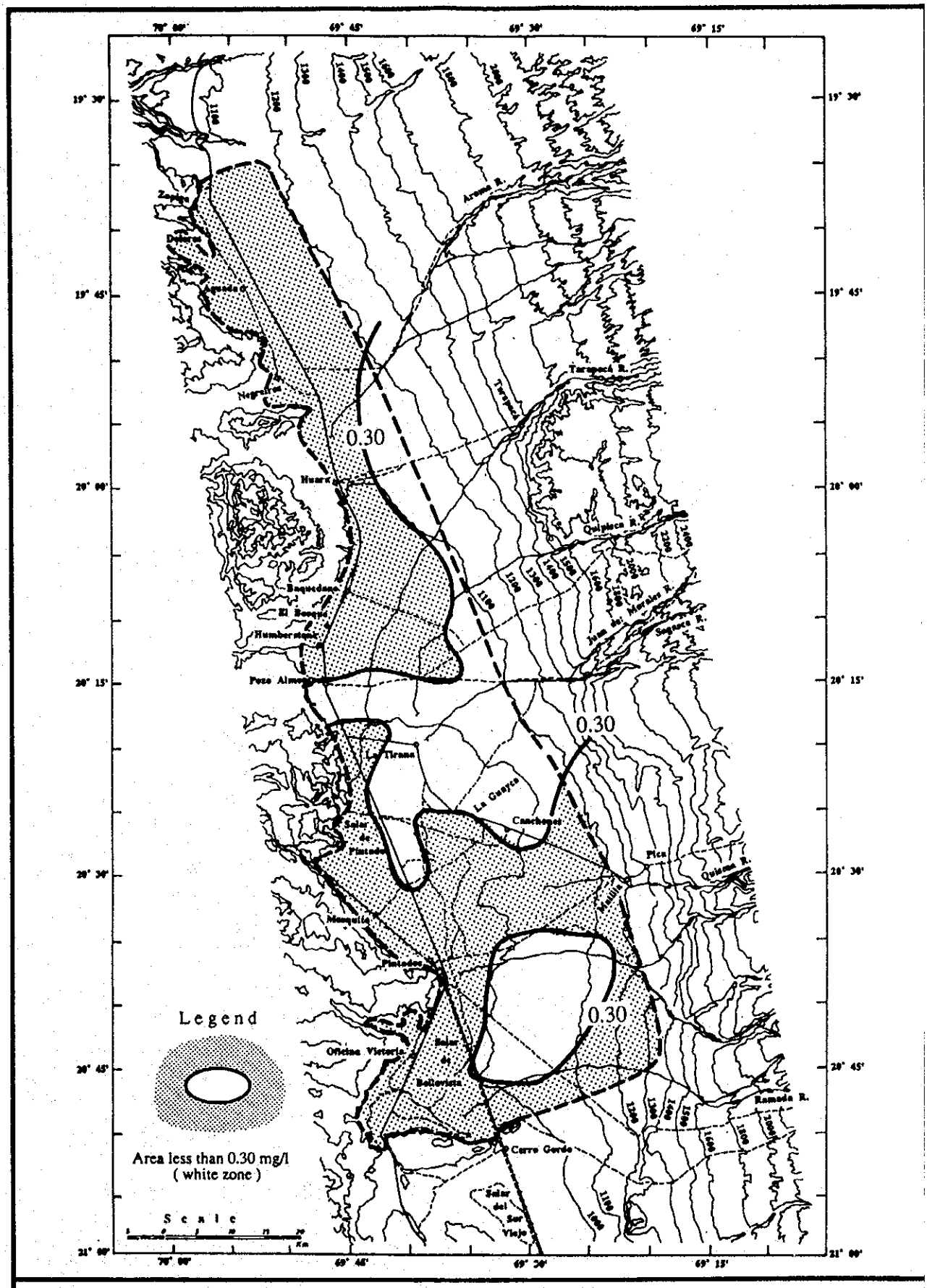


Fig. B-III, 3.11 Distribution of Fe (Pampa del Tamarugal)

< Distribución de Fe (Pampa del Tamarugal) >

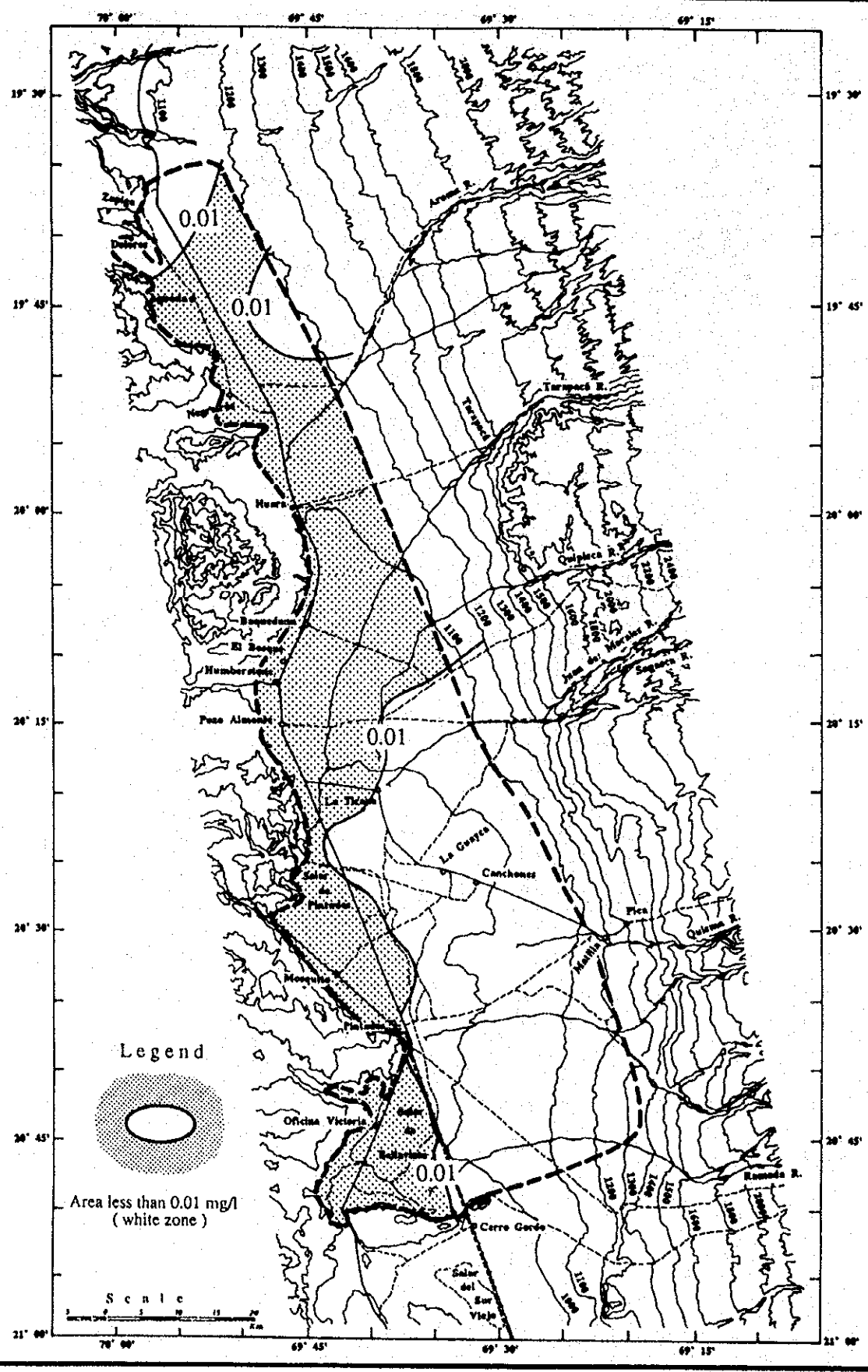
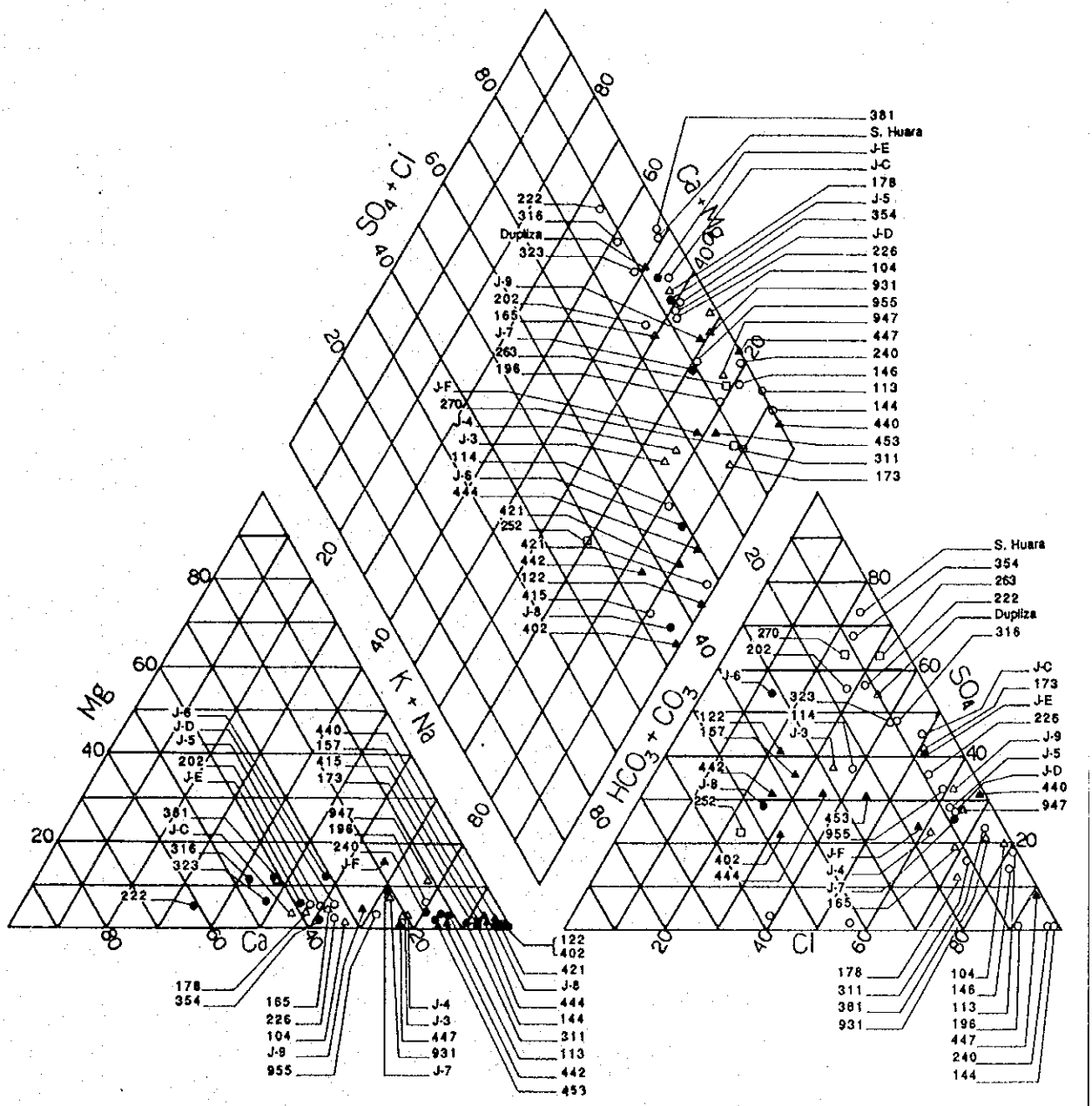


Fig. B-III, 3.12 Distribution of Cd (Pampa del Tamarugal)

< Distribución de Cd (Pampa del Tamarugal) >



L E G E N D

- △ ZONE 1: Dolores- Zapiga- Huara
- ○ ZONE 2: Huara- Baquedano- Pozo Almonte
- ● ZONE 3: Pozo Almonte- Canchones- Pintados
- ▲ ZONE 4: Bellavista
- □ ZONE 5: Pica- Matilla- Calera

Fig. B-III, 3.13 Tri-linear Diagram of Major Ions (Pampa del Tamarugal)

< Diagrama Tri-Lineal de Iones Mayores (Pampa del Tamarugal)>

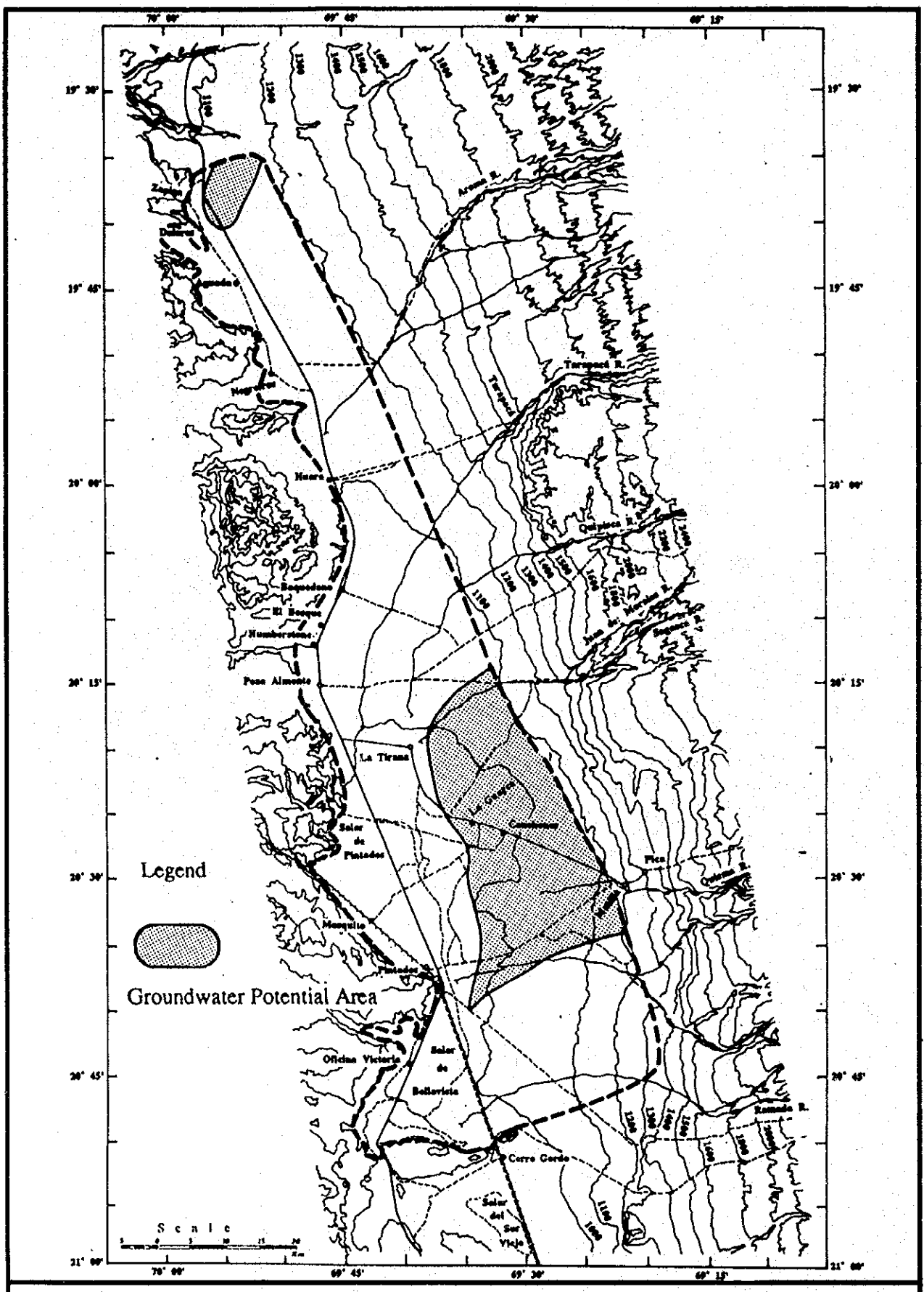


Fig. B-III, 3.14 Prospective Aquifer Area

< Area de Acuíferos Probables >

Chapter IV. GROUNDWATER DEVELOPMENT POTENTIAL

4.1 Existing Water Balance

4.1.1 Recharge to Groundwater

Recharging sources to the groundwater in the Pampa del Tamarugal Baasin are the surface water of quebradas (small rivers) and fissure water from the east (Altiplano). Several rivers flow into Pampa and recharge the groundwater with their surface water. Surface flow rate of each river are estimated in the Supporting Report C (Surface Water). Main rivers are Qdas. Aroma, Tarapacá, Quipisca, Juan de Morales, Sagasca, Quisma, Chacarilla and Ramada from north to east. Total flow rate of these rivers is estimated to be 967 l/sec (Ref., Chapter III of Supporting Report C: Surface Water).

Besides the above, it must be taken into consideration that the fissure water flows into the aquifers in Pampa from Altiplano. It is estimated to be 289 l/sec (Ref., Chapter II of B-IV in this report).

4.1.2 Discharge from Groundwater

Groundwater in Pampa discharges from the Basin by pumping and evaporation/ evapotranspiration through Tamarugo forests and Salars.

ESSAT pumped up 547 l/sec of groundwater at the Canchones and Dolores well fields in 1992. Real consumption in Pampa is assumed to be 47 l/sec. Irrigation in Pampa also depends on groundwater. Its real consumption is estimated to be 119 l/sec (Chapter VI of Supporting Report C; Water Use). Real consumption of mining water is estimated to be 17 l/sec (Chapter VII of Supporting Report C; Water Use). Groundwater evaporates at Salar de Pintados and Bellavista. The average evaporation rate from Salars between 1985 and 1993 is estimated to be 145 l/sec on the basis of the static water level. Evapotranspiration from Tamarugo trees is estimated to be 904 l/sec by averaging the evapotranspiration rates from 1985 to 1993 based on the Fig. E.2.4 (<1) in the Supporting Report E: Environment. Evaporation rate from the Salars is estimated to be 145 l/sec by using the table shown below.

S.W.L (mBGL)	Evaporation Rate (mm/day)
1m<	1.00
1-2m	0.36
2-3m	0.086
3-4m	0.02
4-5m	0.0048
5-6m	0.0011

source: <1 (Grill, Vidaly and Grain (1986))

Static water level of wells in Pampa del Tamarugal has been depressed as mentioned in Chapter III of this report. Their average drawdown rate between 1985 and 1993 is estimated to be 7 cm/year on the basis of the data measured by DGA. This drawdown rate is equivalent to the 514 l/sec of water storage since groundwater storage between 0 m and 10 m BGL is estimated as 2.316×10^9 m^3.

4.1.3 Water Balance

Pampa del Tamarugal is a hydrogeologically closed basin and no surface water flows out from the Basin. Therefore, the water balance of the basin is expressed by the following formula.

$$\Delta Q = (R_R + R_{FH} + R_{FO}) - (P + D + I + M + E_T + E_S)$$

where,

- ΔQ : change of groundwater storage (514 l/sec)
- R_R : recharge from the rivers (976 l/sec, Supporting Report C)
- R_{FH} : recharge from the fissure water from Salar del Huasco and the other basin (X l/sec)
- P : pumping rate by ESSAT (547 l/sec, Supporting Report C)
- D : real consumption of domestic water (47 l/sec, Supporting Report C)
- I : real consumption of irrigation (119 l/sec, see Supporting Report C)
- M : real consumption of mining (17 l/sec, see Supporting Report C)
- E_T : evapotranspiration from Tamarugo (904 l/sec, Supporting Report E)
- E_S : evaporation from Salars (145 l/sec)

Then,

$$-514 = (976 + X) - (547 + 47 + 119 + 17 + 145 + 904)$$
$$X = 289 \text{ (l/sec)}$$

This result shows that the aquifers of Pampa del Tamarugal Basin receive an amount of 289 l/sec of water through fissures of Basement Rocks from Altiplano including Salar del Huasco Basin.

4.2 Evaluation of Groundwater Development Potential

Groundwater storage in Pampa del Tamarugal Basin is estimated to be 26.9 x 10^9 m^3 (Ref. Chapter II). As mentioned in Chapter III, the static water level in Pampa del Tamarugal has been lowered. It is 7 cm/year in average for the whole Pampa area. This is equal to a 16.2 x 10^6 m^3 of reduction of storage (0.06 % of total storage volume).

Future total water demand in Pampa del Tamarugal Basin is estimated in Supporting Report C. Evaporation from Salar and evapotranspiration from Tamarugo trees are also estimated in 4.1, Chapter IV of this Report. The existing and future yearly reduction of the groundwater storage in 1992 and 2015 are estimated to be 16.2 million m^3/year and 63.0 million m^3/year. Then, the total reduction of the groundwater storage during 23 years until 2015 is estimated at 911 x 10^6 m^3 (3.4% of the existing groundwater storage of 26.9 x 10^9 m^3).

If future demand after 2015 is same as that of 2015, it needs 676 years to completely consume the whole groundwater storage in Pampa del Tamarugal.

Total water consumption of stored water in Pampa increases up to 302.6 x 10^3 m^3/day, if all the water application in Pampa del Tamarugal is adopted. It is 2.54 x 10^3 m^3 of consumption volume and is equal to the 9.4 % of total storage of groundwater in Pampa. In this case, the life of aquifers in Pampa del Tamarugal is estimated to be approximately 245 years.

It is, therefore, concluded that the groundwater development potential is large enough to meet the future water demand.

The future groundwater level distribution resulted by the groundwater development is estimated in next Clause.

4.3 Construction of Simulation Model

4.3.1 Mathematical Model

In this study, the computer program " UNISSF "; Unified Normal and Inverse Sub-Surface Flow analysis program was applied to simulate groundwater and assess the impact of the groundwater development plan in Pampa del Tamarugal. The UNISSF

was developed by the Information -Technology Promotion Agency, Japan (IPA) by entrusting to Century Research Center Co, Ltd. (CRC).

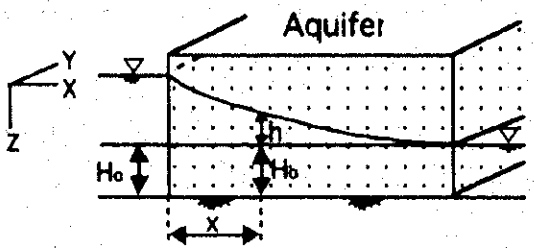
This program is based on the finite element method widely used in numerical analysis and quasi-three-dimensional groundwater analysis. Mathematical model of the program is shown as excerpt from the user's manual report.

1) Dominant equation

The dominant equation relating to infiltration handled here is based on Dupuit's hypothesis* that the head is equal on the perpendicular section of the aquifer.

Using Dupuit's hypothesis, the continuation formula relating to three-dimensional (x, y, z) flow is, from $Vz = 0$ is, as follows.

$$S\frac{\partial h}{\partial t}+\frac{\partial}{\partial x}\{(H0+h)Vx\}+\frac{\partial}{\partial y}\{(H0+h)Vy\}=0 \quad \text{..... (1)}$$



S : *coefficient of storage*

Vx, Vy, Vz : *apparent flow velocity in* x, y, z *directions*

q : spring flow or discharge per unit time

Putting Darcy's formula of motion (equation 2) into equation (1) yields:

$$\left.\begin{aligned} Vx &= -Kx\frac{\partial h}{\partial x} \\ Vy &= -Ky\frac{\partial h}{\partial y} \\ Vz &= -Kz\frac{\partial h}{\partial z} \end{aligned}\right\} \quad \text{..... (2)}$$

* This hypothesis means that the direction of infiltration flow is mainly on the horizontal plane, that is, the perpendicular components of flow are very small. Therefore, when the perpendicular components are too large to be ignored as compared with the horizontal components, the analysis based on Dupuit's hypothesis is not applicable.

$$S\frac{\partial h}{\partial t} = \frac{\partial}{\partial x}\left\{Kx(Ho+h)\frac{\partial h}{\partial x}\right\} + \frac{\partial}{\partial y}\left\{Ky(Ho+h)\frac{\partial h}{\partial y}\right\} + q$$

$$= \frac{\partial}{\partial x}\left(Tx(h)\frac{\partial h}{\partial x}\right) + \frac{\partial}{\partial y}\left(Ty(h)\frac{\partial h}{\partial y}\right) + q \quad \text{..... (3)}$$

Where Tx, Ty : coefficients of transmissivity in x, y directions, being functions of heard h

This is the dominant equation relating to infiltration using Dupuit's hypothesis.

From equation (3), after finite element formulation by using the weighted remainder method, the solution is obtained under proper initial conditions and environmental conditions.

2) Quasi-three-dimensional handling

The analysis by the dominant equation shown here can be easily applied in the multi-stratum ground, and it is called the quasi-three-dimensional infiltration flow analysis.

That is, using the coefficient of transmissivity and coefficient of storage as the function of level, the multi-stratum ground can be handled, and not only the confined aquifer but also the unconfined aquifer and transference between the two can be also handled, which is different from the conventional horizontal two-dimensional infiltration flow analysis.

The coefficient of transmissivity T is defined as the sum of products of coefficient of permeability Ki and layer thickness b_i of each aquifer. That is,

$$T = \sum_{i=0}^{n} K_i \cdot b_i$$

Meanwhile, the coefficient of storage S is, in the case of a confined aquifer, defined as the product of the coefficient of specific storage S_S * and the aquifer thickness b of the stratum to be analyzed, and in the case of an unconfined aquifer, it is defined as the volume of water discharged from the gap in the soil of unit volume (= effective porosity) due to lowering of the level.

The stratum section and columnar section of a typical aquifer are shown in following figure.

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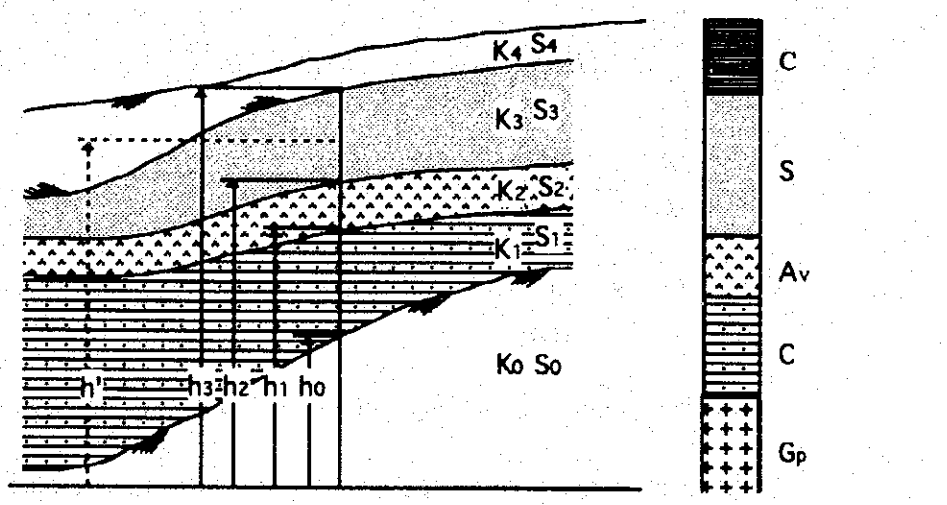
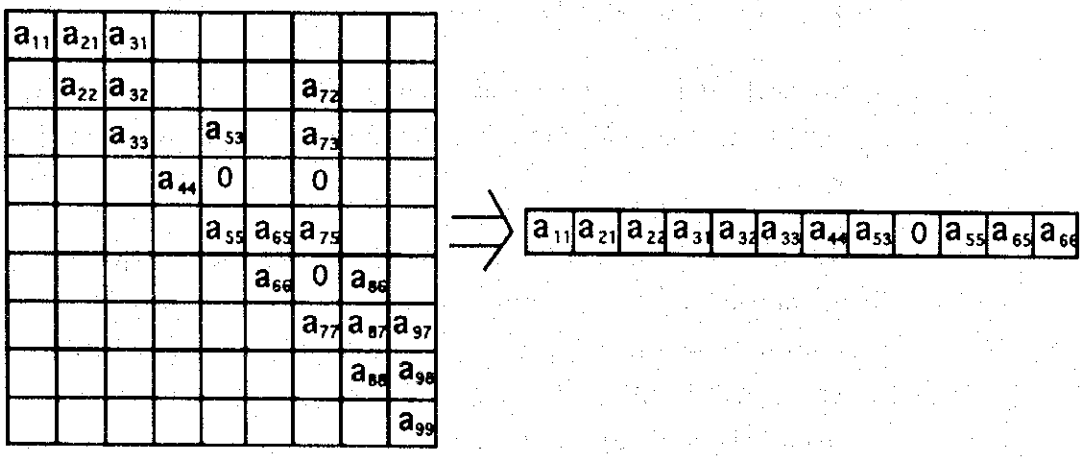
* Equal to the coefficient of volumetric compression, being expressed as Ss = 0.001 ρh (cm^{-1})



The coefficient of transmissivity, regarding as the function of level, can be expressed as shown below.



When handled similarly, the coefficient of storage is as shown above.

(1) Confined aquifer

When the free water surface reaches the upper end of the permeable bed, the permeable bed is confined. In the above figures, h is greater than h_3. In this region, the coefficient of transmissivity T is constant, and is expressed as follows.

$$T = K_o b_o + K_1 b_1 + K_2 b_2 + K_3 b_3 (= CONST)$$

Also the coefficient of storage S is constant, being the sum of the products of coefficient of specific storage Ss and layer thickness of each layer, and is expressed as follows.

$$S = S_4 = Ss_0 b_0 + Ss_1 b_1 + Ss_2 b_2 + Ss_3 b_3 (= CONST)$$

(2) Unconfined aquifer

When the free water surface is lowered (h becomes less than $h3$ in Figs. 2 and 3) and the permeable bed becomes unconfined, the coefficient of transmissivity T decreases as the water level drops as the function of groundwater level, and the coefficient of storage becomes the value of the effective porosity* in the area of the location of the level (stratum).

For example, when the level is h' ($h2 < h' < h3$), T and S' are :

$$T' = K_o b_o + K_1 b_1 + K_2 b_2 + K_3 b_3 (h - h_2)$$

$S' = S3$

When the free water surface is further lowered to the basement (h is less then ho), the coefficient of transmissivity and coefficient of storage become zero at that point. Such phenomenon is a problem of wide-area groundwater, and is often experienced at the boundary of the mountain and plain field.

3) Initial conditions and boundary conditions

The theoretical solution is obtained under proper initial conditions and boundary conditions.

(1) Initial condition

$h\ (x_i,\ 0) = h\ (x_i)$

(2) Boundary conditions

(i) Boundary with known head

$h\ (x_i,\ t) = h_b\ (x_i,\ t)$

..... When the level is constant, or the periodic change of level is known, such as the boundary facing the river, lake or sea.

---

* The coefficient of storage S of the unconfined aquifer is expressed as follows.

S = Sy + Ssb•b

where Sy : specific yield, synonymous with effective porosity

Ss : coefficient of specific storage

b : layer thickness

(Sy >> Ss•b)

(ii) Boundary with known in-out flow

$$Q(X_i, t) = Q_b(X_i, t)$$

4) Finite element method

(1) Formulation

Dominant equation

$$\frac{\partial}{\partial x}\left(Tx(h)\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(Ty(h)\frac{\partial h}{\partial y}\right)+q=S(h)\frac{\partial h}{\partial t} \quad \cdots\cdots (1)$$

When the entire region is divided into a finite number of elements, as far as the structure is continuous, equation (1) is approximately established in each element.

When the weighted remainder method is applied in formulation, it follows that

$$R=\frac{\partial}{\partial x}\left(Tx(h)\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(Ty(h)\frac{\partial h}{\partial y}\right)+q-S(h)\frac{\partial h}{\partial t} \quad \cdots\cdots (2)$$

The optimal approximate solution of equation (1) is obtained by minimizing this remainder R in all elements.

The following equation is established by the Galerkin method selecting the shape function as the weight.

$$\iint_s \{N\}Rds = 0 \quad \cdots\cdots (3)$$

Where N : shape function

Solving equation (3) yields finally the following equation.

$$\left(\frac{1}{4t}[C]+[K]\right)\{h\}_{t+\Delta t}=\{F\}_{t+\Delta t}+\frac{1}{\Delta t}[C]\{h\}_t \quad \cdots\cdots (4)$$

where

$$[C]=\iint_{se} S^e\{N\}\{N\}^T ds$$
$$[K]=\iint_{se}[B]^T[\ \ ][B]ds$$
$$[C]=\iint_s Q\{N\}ds-\int r_2 q\{N\}ds$$

For handling of the time term, however, the regression difference was used. Analysis is possible by solving equation (4) with respect to the total head h.

Since the materials constants handled here, *T, S,* are the functions of water level, it is necessary to improve the solution by iterative calculation.

To solve the simultaneous linear equations of (4), basically, the Gaussian elimination method is used, but in consideration of saving of memory and increase of calculation speed, the skyline method is employed.

The skyline method is briefly described below.

(2) Skyline method

The skyline method is a kind of band matrix, but it is different from the band matrix in the following points.

1) Data is handled in row unit.
2) Those corresponding to the band width are variable in each row.
3) The product sum type calculation formula is used.

calculation formula ([a] · {x} = [b])

i) LU splitting

K = in the sequence of 2, 3, ..., N

J =in the sequence of 1, ..., K-1

$$a^{\star}_{jk} = a_{jk} - \sum_{i=1}^{j-1} a'ij \; a^{*}ik$$

$$a'_{jk} = a^{\star}_{jk} / a'ij$$

$$a'_{kk} = a_{kk} - \sum_{i=1}^{k-1} a'ik \; a^{*}ik$$

where $a^{\star}_{jk}$: the value before dividing by pivot $a'ii$
(equivalent to component of U of LU splitting)

a'_{jk} the value after dividing by pivot $a'ii$
(equivalent to component of L of Lu splitting)

ii) Calculation of right side

Forward elimination

K = in the sequence of 2, 3, ..., n

$$b'_k = \left(b_k - \sum_{i=1}^{k-1} l_{ki} b'_i \right) / l_{kk}$$

Regression substitution

K = in the sequence of n, n-1, ..., 2

Xk = (b'k at that point)

i =in the sequence of 1, ..., K-1

$New\ \ b'_i = b'_i - U_{ki} X_k$

$X_1 = (final\ \ b_1)$

4.3.2 Parameter of Groundwater Basin

1) Shape of Basin and Calculation Mesh System

An area of Pampa del Tamarugal for groundwater simulation is shown as Fig. B-III, 4.1. The boundary of the area is sharply cut by the basement rocks of the Andes Mountains in the east and the Coastal Range in the north. On the other hand, the northern and southern boundaries don't like that but the basement rocks are located in shallow underground around them. However, it can be assumed that both boundaries are bordered with the basement rocks completely in terms of groundwater simulation. The simulation area is approximately 5,500Km^2.

Fig. B-III, 4.2 shows a calculation network for the groundwater simulation. The network consists of 348 elements and 301 nodes. The interval of basic mesh is 5Km and finer one is half of basic mesh: 2.5Km. The fine mesh networks are mainly set in the areas where JICA test wells are located or great fluctuation of groundwater level caused by withdrawals, transpiration, influent streams and so forth is predicted.

2) Boundary Condition

It seems that there's no recharge of groundwater from the Coastal Range alone the west boundary. However, the recharge from the Andes Mountains, Salar del Huasco

Basin in particular is expected, while the recharge from northern or southern boundary can be neglected in the groundwater simulation model.

3) Distribution of Aquifer

Data about horizontal and vertical distribution of aquifers was established using the illustrated figures listed as follows based on bowling inventory including JICA test wells, existing geological materials and so forth.

- Geological profile (Pampa del Tamarugal) Fig. B-III, 1.5-1.6
- Isopach Map of Aquifer Q_3 (Pampa del Tamarugal) Fig. B-III, 2.51
- Top of Aquifer Q_3 (Pampa del Tamarugal) Fig. B-III, 2.52
- Base of Aquifer (Pampa del Tamarugal) Fig. B-III, 2.53

The data was set up as a kind of geological input data at all calculation nodes. Two kind of aquifers: Q_3 and Q_4 in ascending order are recognized from a hydrogeological point of view. A distribution of Q_4's thickness was regarded as a difference between surface level and top level of aquifer Q_3. A conceptual geological section for simulation is illustrated as Fig. B-III, 4.3. Q_3 and Q_4 can be regarded as conglomeratic facies and sandy facies respectively, although each of aquifers varies in lithofacies. They are conformable to each other without continuous impermeable layer. Therefore, it seems that they are unconfined aquifers as a whole.

4) Coefficient of Aquifer

In general, coefficient of aquifer is determined by the analysis of boring logs, pumping test results and so on. However, in this case, it is difficult to classify Q_3 and Q_4 into many sections based on coefficient of aquifer. Because there's not enough data unfortunately to do reasonably. In case of this simulation, the coefficient of aquifer was adopted as follows.

- Permeability
  Q_3: $K=1.0\times10^{-3}$ cm/sec
  Q_4: $K=1.0\times10^{-4}$ cm/sec

- Strativity
  Q_3: S=0.35
  Q_4: S=0.30

5) Discharge of Groundwater

Discharge of groundwater in the study area consists of transpiration from Tamarugo forest and groundwater withdrawal. There is no surface discharge to the out of the basin because all rivers there infiltrate into the basin. Since a distribution of Tamarugo forest is recognized within simulation area as shown in Fig. B-III, 4.4, the discharged volume (1,019 l/s) was input at related nodes after dividing it equally. The divided volume of transpiration at each nodes in 1993 is 2,257m3/day/node.

Then, groundwater withdrawal volume estimated as 696 l/s in total was distributed at related nodes on the basis of the interview. Some of pumped up groundwater volume is restored to underground again. It is assumed that 30% of agriculture water use or 60% of domestic and mining water use is restored except for Canchones where pumping up water is supplied to Iquique city directly. Discharge condition is shown in Fig. B-III, 4.4.

6) Recharge of Groundwater

Recharge of groundwater to the area comes from seven influent streams and basement rocks, since precipitation in Pampa del Tamarugal is negligible. The recharged water volume from influent streams was divided somewhat among nodes along each stream lines. The total recharged water volume through them is estimated at 976 l/sec on the basis of hydrological analysis.

Recharge from basement rocks may be regarded as so called "Black Box", but it is assumed that the major source of it is fault system or fissures of Altiplano and its value is estimated about 288 l/sec on the basis of analysis of water balance in the study area as shown in 4.1. The groundwater recharge along the simulation boundary including it from the basement rocks was calculated in the simulation program automatically in order to reproduce the present groundwater level there in stead of inputting recharge volume in calculation nodes directly. In the case of this groundwater simulation, it is better way to construct the simulation model.

7) Initial Groundwater Level

Initial groundwater level was input according to the static water level contour map in 1993. (see, Fig. B-III, 3.2 Static Water Level (1993))

4.3.3 Reproducibility of Model

On the basis of above mentioned simulation conditions, the establishment of groundwater simulation model was conducted. At that time, reproducibility of simulation model is judged by the present static water level. In general,

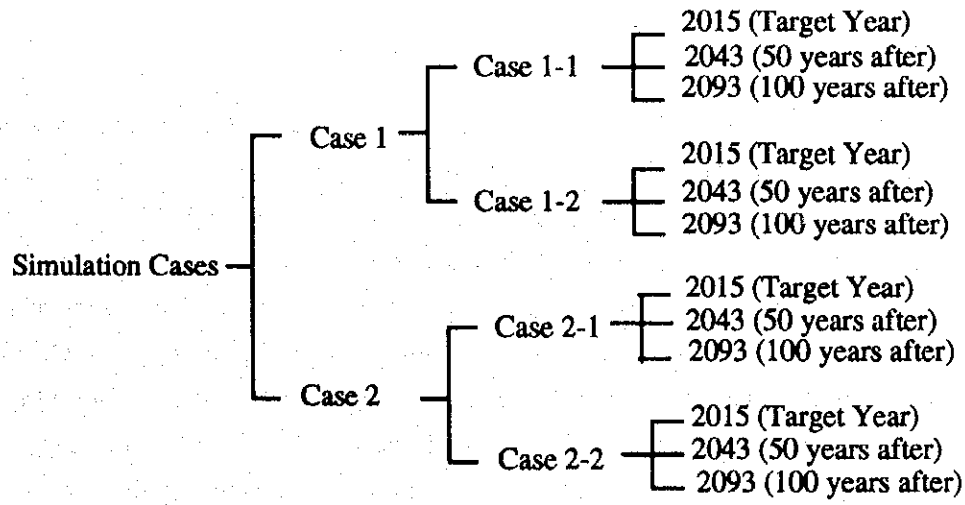
reproducibility of the model is checked by the degree of accordance between present condition and simulated one after steady analysis of groundwater fluctuations. The groundwater simulation model for Pampa del Tamarugal shown as follow was established by a process of trial and error. The result of simulation seems to be almost satisfied with reproducibility of present groundwater condition.

The reason why Pampa del Tamarugal is regarded as steady stage in terms of groundwater condition is that there's almost no fluctuation by years and even no seasonal change. Although drawdown of groundwater level per year on average in Pampa del Tamarugal is in approximately 10cm, this doesn't interrupt above mentioned assumption.

4.4 Simulation Result of Future Groundwater Condition

Two future groundwater simulation cases were conducted using the constructed groundwater simulation model. Case 1 is the case that water rights in the simulation area selected by the study team from which have been applied to the government by present would be adopted in the target year 2015. Case 2 is all of them would be adopted by the target year 2015.

These cases have also two sub-cases respectively. Sub-case 1 is the case that 40% of groundwater withdrawal volume for mining would be consumed actually. Sub-case-2 is 60 % of it would be consumed. Furthermore, above mentioned each case consists of 3 time-cases: 2015 as the target year, 2043 as 50 years after and 2093 as 100 years after. The simulation condition after the target year is assumed as the same of the year.



4.4.1 Input Data for Future Groundwater Simulation

1) Groundwater Discharge in Future

Groundwater discharge of each case in the target year 2015 is shown in Fig. B-III, 4.7 to 4.10. The recharge in these figures means that the return to the groundwater again at different sites after consumption of distributed water from groundwater sources. As for transpiration, it is assumed that the area of Tamarugo would be almost same as present but its transpiration would be increased approximately 45% with growing up in future.

2) Recharge of Groundwater in Future

Recharge of each case from influent streams in future is shown in Fig. B-III, 4.5. The variation of influent values aren't due to climate change but water-use change in the up-stream area.

4.4.2 Result of Future Groundwater Simulation

Result of total 12 cases of future groundwater simulation is illustrated in Fig. B-III, 4.11 to 4.21. It's better to express drawdown of groundwater between present (1993) and future in order to evaluate an impact of groundwater development plan. Table B-III, 4.1 shows a degree of impact by each case as maximum drawdown of groundwater.

4.4.3 Evaluation of Groundwater Simulation Results

1) Case 1

Impact magnitude of Case 1-1 and Case 2-2 are almost same in the target year. Their greatest impact: 8 m drawdown is shown near the project site. However, the impact magnitude and effected area would deteriorate in 2043 and 2093 than the target year. Thirty meter drawdown of groundwater is predicted near the project site in 2093. Since there are about 6 shallow wells near the project site at present which their depth is less than 13m, it is feared that they might be dried-up. On the other side, it seems that an impact to Tamarugo forest would be slight, because the project site is located away from the forest and groundwater level in the forest areas would not become deeper than the limit groundwater level for Tamarugo's growth.