AES GENER S.A.

PROYECTO HIDROELÉCTRICO ALTO MAIPO (PHAM)

ANALYSIS OF THE POTENTIAL IMPACT OF THE PROJECT ON AQUIFERS IN THE PROJECT'S AREA OF INFLUENCE IN THE MAIPO RIVER

MARCH 2008

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1. OBJECTIVES AND SCOPES

This report analyzes the eventual effects of a reduction in flow rates on the aquifers associated to the Maipo River valley in the zone of influence of the PHAM, i.e. between the El Volcán River and the El Manzano Stream

To this end, the aquifers associated to the Maipo River valley likely to be present in the project's area of influence were identified. The maximum flow-conveyance capacity of each aquifer was also determined. A comparison of said flow-conveyance capacity and the surface flows that drain through the river in the 'with project' situation made it possible to quantify such effects, the particulars and results of which are discussed in this report.

2. IDENTIFICATION OF AQUIFER SECTORS IN THE ZONE OF INFLUENCE OF THE PROJECT

Considering the baseline information provided by environmental studies, as well as topographic and satellite information about the area, the existence of aquifers of not negligible magnitude and with some degree of available water potential is to be expected in the zone of influence of the project, only in the Maipo River valley, between the confluence of this river with the El Volcán River or, more precisely, up to the point where the waters will be returned.

To identify the potential aquifers associated to the Maipo River valley in the sector of influence, both project-generated information and EIA baseline studies were used. The use of satellite images, spatially processed by ArcView, along with topographic information generated by the Geographical Military Institute (IGM), made it possible to delimit the potential aquifer sectors and their main geometric characteristics.

Figure 2-1 shows the stretches of the aquifer associated to the Maipo River valley between El Volcán River and El Manzano Stream. These stretches were numbered in an upstream / downstream order, yielding a total of nine aquifer elements.

The subdivision was made taking into consideration the rocky spots where the valley narrows down, which constitute singularities or irregular points at which the ground flow tends to come to the surface. Thus, each stretch operates independently of each other as a separate unit.

Table 2-1 shows the geometric properties of each aquifer, i.e. the surface area, average width, length in the direction of drainage, maximum depth or strength, grade associated to the bottom of the valley and average cross section. Maximum depth was determined based on a projection of the slopes of rocky formations lying on both sides of the valley, which represent the impervious boundary of each aquifer. In that manner, aquifers are modeled as prism-shaped elements with the characteristics shown in the table.

Table 2-1 Geometric Properties of each Identified Aquifer

Maipo River Aquifer	Length (m)	Average Width (m)	Aquifer Depth (m)	Grade (%)	Aquifer Stretch Area (m2)
1	2303.02	668	59	1.74%	19539
2	5562.26	610	78	1.37%	23773
3	4229.05	168	23	1.84%	1949
4	3243.57	382	38	0.43%	7165
5	7164.72	630	74	0.68%	23383
6	5750.69	949	119	0.92%	56567
7	3273.38	435	52	0.89%	11251
8	6964.97	674	76	0.88%	25542
9	3011.96	531	53	0.70%	14138

Source: In-house preparation.

Figure 2-1

3. MAIPO RIVER IN THE ‘WITH PROJECT’ SITUATION

For the purpose of this analysis, information on series of monthly average flow rates generated by project studies at various points (pluviometric stations) and stretches of the river for the 'with project' situation was used.

Table 3-1 shows these series for three points or stretches of the river which correspond to the 'with project’ situation, i.e. disregarding the flows that will be diverted and conveyed by the tunnels to each planned power plant. These points are the following: Maipo River, downstream of the confluence with El Volcán River, Maipo River pluviometric station in San Alfonso and Maipo River Pluviometric Station in El Manzano.

Based on these series, minimum monthly flows series were generated for the full statistical period (from 1950 to 2005), as shown in Table 3-2 and Figure 3-1.

Table 3-1a Monthly Average Flows Series for the 'With Project' Condition.

RÍO MAIPO INMEDIATAMENTE AGUAS ABAJO CONFLUENCIA CON RÍO VOLCÁN
CAUDALES MEDIOS MENSUALES (m3/s)
SITUACIÓN CON PROYECTO

AÑO	ABR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DIC	ENE	FEB	MAR	ANUAL
1950/51	24,58	21,28	15,67	15,67	16,22	20,88	33,54	55,11	96,82	60,42	48,53	37,13	37,15
1951/52	24,00	19,85	22,70	22,61	24,11	24,31	36,18	64,23	97,04	71,71	41,10	43,71	40,96
1952/53	23,33	21,85	21,03	22,34	23,48	26,14	29,30	50,25	86,09	58,08	52,44	33,44	37,31
1953/54	28,67	19,00	19,75	19,84	26,50	38,24	44,47	115,09	169,14	131,59	90,75	56,55	63,30
1954/55	33,68	23,98	24,78	29,04	31,73	34,28	52,63	94,51	88,83	59,89	46,65	35,76	46,31
1955/56	23,68	21,67	16,32	13,57	14,37	15,82	22,98	59,96	62,52	50,05	43,92	27,93	31,06
1956/57	25,19	24,38	18,88	21,66	23,18	23,78	32,15	76,86	66,32	48,60	36,22	29,89	35,59
1957/58	26,30	17,77	15,27	18,03	16,03	19,40	34,93	78,47	99,82	95,04	58,97	49,02	44,09
1958/59	32,01	28,47	25,98	21,50	17,85	29,09	58,85	69,88	90,36	50,74	41,66	38,01	42,03
1959/60	24,68	24,05	22,66	24,00	27,62	29,49	38,98	89,69	148,20	88,44	41,60	31,21	49,22
1960/61	25,65	23,60	21,67	20,81	23,83	27,79	39,24	81,68	97,06	59,33	38,84	54,31	42,82
1961/62	29,04	28,00	31,19	19,85	32,82	24,92	51,29	104,92	163,13	119,09	80,12	52,35	61,39
1962/63	31,70	24,00	21,33	20,32	22,17	24,95	39,46	83,01	85,47	48,63	39,87	38,93	39,99
1963/64	24,76	20,66	19,13	21,58	21,67	29,87	34,05	60,19	206,66	208,85	100,53	59,26	67,27
1964/65	34,72	26,12	29,39	19,91	20,69	23,56	33,25	48,20	55,39	59,04	44,58	37,65	36,04
1965/66	33,41	21,22	20,38	19,13	25,63	30,20	52,60	110,87	115,55	142,12	98,49	54,46	60,34
1966/67	34,57	23,65	22,85	23,96	18,98	24,72	52,23	75,73	102,94	74,27	64,09	35,86	46,15
1967/68	26,19	21,51	14,70	14,94	17,81	15,07	31,88	51,52	79,66	52,19	46,36	28,13	33,33
1968/69	23,45	19,20	17,13	15,38	14,11	13,67	15,39	29,42	16,71	20,59	28,59	24,66	19,86
1969/70	12,53	13,22	18,78	15,91	15,98	19,54	23,95	57,33	138,40	68,15	44,02	32,57	38,37
1970/71	23,80	19,99	13,58	16,46	16,46	18,88	29,51	52,03	62,17	36,29	28,65	20,53	28,20
1971/72	16,86	14,03	13,54	16,01	18,14	23,23	47,60	100,53	91,15	66,70	39,38	30,87	39,83
1972/73	16,58	37,72	47,92	27,45	34,53	41,11	55,13	91,21	171,36	265,52	131,44	110,75	85,89
1973/74	49,65	29,45	27,75	26,24	23,12	22,84	34,44	75,54	98,87	94,95	57,79	40,78	48,45
1974/75	24,80	20,28	19,41	24,74	19,18	25,26	54,80	104,53	121,44	125,49	73,47	44,15	54,80
1975/76	29,13	18,30	18,30	17,29	17,87	20,92	30,96	54,28	97,08	58,85	48,90	34,98	37,24
1976/77	19,33	14,80	16,66	16,27	16,27	20,45	28,44	61,44	72,74	64,74	38,07	30,37	33,30
1977/78	20,76	20,32	20,19	29,80	27,62	37,78	74,22	114,44	165,33	117,66	73,77	48,21	62,51
1978/79	30,78	24,80	23,75	30,68	28,90	32,88	47,39	93,55	230,44	206,97	99,00	55,72	75,41
1979/80	35,59	25,20	18,80	22,41	24,99	29,01	38,94	78,04	106,42	145,08	88,29	56,50	55,77
1980/81	55,72	52,72	42,64	37,93	29,84	38,19	52,06	101,64	198,44	128,13	97,09	61,62	74,67
1981/82	36,72	31,93	27,66	22,39	23,42	25,43	39,58	78,91	84,06	70,24	49,39	35,59	43,78
1982/83	24,13	22,27	44,15	44,54	40,31	57,50	65,19	133,56	317,47	356,10	229,62	126,20	121,75
1983/84	64,40	44,28	32,45	30,69	30,18	28,88	55,96	113,88	152,68	117,62	84,01	57,83	67,74
1984/85	33,18	24,83	19,88	22,95	22,93	28,89	57,81	93,28	169,02	177,13	112,63	70,47	69,42
1985/86	37,59	32,62	27,91	25,21	22,75	22,33	32,46	81,41	98,69	73,45	56,33	38,48	45,77
1986/87	27,15	25,89	81,53	29,74	27,26	35,90	56,72	73,06	175,68	167,21	124,80	77,74	75,22
1987/88	38,21	28,95	27,40	41,82	39,19	38,71	62,19	147,95	229,07	208,04	141,39	83,10	90,50
1988/89	46,94	30,82	24,61	21,34	23,28	23,75	38,37	78,08	72,71	61,66	55,71	45,96	43,60
1989/90	22,63	19,62	17,33	15,99	28,21	35,54	46,18	108,78	126,12	78,34	43,48	34,86	48,09
1990/91	26,22	22,71	20,03	18,42	18,42	23,64	36,41	67,73	73,41	57,83	42,89	33,08	36,73
1991/92	34,52	33,10	32,75	42,58	27,31	40,15	50,02	116,68	122,78	150,81	103,52	73,95	69,01
1992/93	40,34	33,36	31,58	28,81	26,48	32,19	62,77	111,13	140,90	130,55	91,89	58,61	65,72
1993/94	47,30	33,38	39,88	34,86	27,26	35,29	48,67	74,80	126,26	137,93	68,34	47,21	60,10
1994/95	32,46	26,18	25,95	30,43	26,12	32,52	44,23	91,02	150,97	93,37	58,21	50,82	55,19
1995/96	36,77	29,24	28,03	22,42	22,52	32,02	41,39	102,05	122,97	64,66	50,02	41,01	49,43
1996/97	23,74	19,89	16,99	15,86	16,67	15,15	25,55	50,98	43,91	22,96	27,87	29,21	25,73
1997/98	21,94	12,81	29,75	26,20	30,62	46,43	53,35	114,96	202,57	222,37	125,52	73,10	79,97
1998/99	47,44	34,47	26,88	21,70	18,43	17,33	31,66	43,70	52,42	43,35	37,79	28,70	33,65
1999/2000	20,54	17,11	15,86	14,54	14,84	23,69	43,31	82,78	87,10	66,60	43,36	29,93	38,30
2000/01	24,87	19,88	35,42	34,62	24,54	25,95	64,91	110,48	220,92	163,63	122,34	66,22	76,15
2001/02	41,64	34,51	24,90	33,81	39,21	41,49	61,31	92,50	196,28	108,47	75,22	54,79	67,01
2002/03	32,81	28,05	30,81	26,41	36,43	30,76	44,37	82,30	151,74	157,90	108,08	78,85	67,38
2003/04	48,09	32,72	33,83	31,29	28,15	33,80	47,02	84,68	94,18	85,50	61,58	46,80	52,30
2004/05	33,65	23,86	22,03	20,20	21,83	30,16	39,91	57,65	84,86	74,35	47,21	40,46	41,35
2005/06													

PROMEDIO	31,06	25,16	25,45	24,04	24,15	28,43	43,64	83,21	123,24	104,86	69,53	48,33	52,59
MÁXIMO	64,40	52,72	81,53	44,54	40,31	57,50	74,22	147,95	317,47	356,10	229,62	126,20	121,75
MÍNIMO	12,53	12,81	13,54	13,57	14,11	13,67	15,39	29,42	16,71	20,59	27,87	20,53	19,86

Source: Studies by AES Gener and EIA.

Table 3-1b Monthly Average Flows Series for the 'With Project' Condition.

ESTACIÓN: RÍO MAIPO EN SAN ALFONSO
CAUDALES MEDIOS MENSUALES (m3/s)
SITUACIÓN CON PROYECTO

AÑO	ABR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DIC	ENE	FEB	MAR	ANUAL
1950/51	29,08	27,34	20,73	21,35	21,35	27,10	41,18	62,48	103,58	64,55	52,43	39,90	42,59
1951/52	28,42	25,35	30,06	30,61	31,66	31,60	44,53	72,63	103,94	76,61	44,46	47,00	47,24
1952/53	27,57	28,11	27,71	30,20	30,85	33,98	35,73	56,85	92,16	62,00	56,52	35,97	43,14
1953/54	33,87	24,22	25,83	26,57	34,77	49,79	54,77	129,80	187,00	151,38	101,89	60,29	73,35
1954/55	39,60	30,38	32,20	39,36	41,87	44,77	65,17	107,04	95,27	64,06	50,29	38,40	54,03
1955/56	27,94	28,01	21,61	18,33	18,83	20,51	28,25	67,64	67,11	53,62	47,54	30,13	35,79
1956/57	30,07	31,46	24,90	29,59	30,58	30,98	39,52	86,57	71,05	51,77	38,74	32,05	41,44
1957/58	31,10	22,83	19,87	24,37	20,71	24,91	42,86	88,64	106,77	104,78	63,96	52,81	50,30
1958/59	38,12	37,05	34,73	29,11	23,20	37,52	72,49	77,46	96,48	54,21	44,95	40,94	48,85
1959/60	28,97	30,78	29,84	32,37	36,12	37,94	47,38	100,25	161,84	94,20	44,17	32,85	56,39
1960/61	30,39	30,46	28,86	28,16	31,42	35,58	48,30	91,88	103,72	63,47	42,06	58,34	49,39
1961/62	34,08	36,19	41,85	26,55	43,71	32,32	62,62	117,30	181,85	131,20	86,24	55,69	70,80
1962/63	37,39	30,72	27,95	27,24	29,04	32,30	48,62	93,55	91,44	60,43	47,69	41,99	47,36
1963/64	29,40	26,63	25,23	29,25	28,59	38,82	47,65	76,05	226,69	230,99	108,86	62,88	77,58
1964/65	39,81	32,89	38,91	26,47	24,35	32,51	41,01	54,45	59,63	63,27	48,09	39,25	41,72
1965/66	36,86	27,07	26,62	25,44	33,11	38,76	64,29	123,54	128,41	156,92	103,24	58,16	68,53
1966/67	40,48	29,98	29,70	31,82	24,39	31,72	58,38	85,10	123,28	79,52	69,13	38,61	53,51
1967/68	30,93	27,57	18,15	20,00	20,91	19,48	41,58	59,18	84,95	62,69	52,63	30,48	39,05
1968/69	30,57	24,01	19,22	20,97	16,35	16,03	23,69	33,60	18,30	22,36	31,14	26,81	23,59
1969/70	15,18	17,17	24,95	19,10	19,77	22,35	33,04	68,82	150,95	73,19	54,51	35,22	44,52
1970/71	29,12	24,90	17,84	19,90	18,61	24,13	37,40	64,32	66,55	39,49	31,40	21,92	32,96
1971/72	19,78	18,23	16,79	21,57	21,69	25,63	55,07	105,20	98,44	71,50	42,73	33,31	44,16
1972/73	19,64	47,90	66,90	41,18	47,30	53,55	71,32	110,16	192,02	307,56	148,59	116,14	101,86
1973/74	57,41	37,09	36,76	35,66	30,48	29,54	41,32	85,20	106,21	103,09	62,30	43,81	55,74
1974/75	29,39	26,03	25,43	33,18	24,65	32,63	66,92	117,73	129,84	136,20	75,87	47,32	62,10
1975/76	34,40	23,52	24,21	23,34	23,41	27,09	38,02	63,26	99,85	63,05	52,33	37,64	42,51
1976/77	23,01	18,90	21,92	21,86	21,24	26,60	35,21	69,49	86,87	69,18	41,30	32,73	39,03
1977/78	24,53	26,15	26,70	40,21	35,71	49,98	85,52	128,85	187,24	132,17	83,48	51,66	72,68
1978/79	35,60	30,93	28,36	53,67	39,16	42,76	53,76	110,60	259,31	239,81	108,60	60,99	88,63
1979/80	41,48	31,60	24,20	30,34	31,67	37,99	56,10	88,79	111,82	164,46	94,07	60,38	64,41
1980/81	65,01	67,33	56,26	51,22	43,81	49,70	60,68	103,57	216,50	143,51	108,28	65,71	85,97
1981/82	43,08	40,91	36,53	30,22	30,69	33,13	48,69	89,08	90,15	75,10	53,17	38,26	50,75
1982/83	28,58	28,53	59,68	59,73	52,57	74,68	80,54	151,28	356,20	408,18	266,71	140,14	142,23
1983/84	74,41	56,41	42,57	41,39	39,52	37,32	68,90	128,37	169,01	129,37	89,99	61,74	78,25
1984/85	38,75	31,66	25,89	30,91	29,75	37,12	70,69	105,25	185,00	196,56	123,81	74,96	79,20
1985/86	43,66	43,95	36,47	33,60	29,44	28,70	40,05	91,79	105,65	78,50	60,86	41,38	52,84
1986/87	31,94	33,09	109,19	39,30	35,60	46,64	69,91	82,31	199,87	192,53	141,73	82,82	88,74
1987/88	44,68	36,84	35,70	56,28	51,41	50,31	76,42	169,47	259,39	239,82	159,65	88,92	105,74
1988/89	54,68	39,18	32,21	28,56	30,40	31,22	47,11	88,10	77,98	65,93	59,96	49,38	50,39
1989/90	26,77	25,19	22,87	21,60	37,26	46,37	56,61	122,22	134,77	89,84	46,95	37,01	55,62
1990/91	33,16	29,45	25,54	26,49	24,75	30,91	42,49	73,12	77,26	61,92	48,78	38,94	42,73
1991/92	41,03	45,32	42,45	53,62	35,37	49,62	65,26	131,96	134,35	171,93	112,40	78,63	80,16
1992/93	45,80	40,88	42,91	40,52	36,52	45,16	78,27	123,01	153,84	147,05	97,61	62,50	76,17
1993/94	55,26	41,71	52,17	46,07	34,98	45,45	58,79	83,91	135,36	149,52	73,55	50,45	68,94
1994/95	38,12	33,46	34,23	41,54	34,00	42,53	54,24	101,63	165,09	99,34	63,49	54,48	63,51
1995/96	43,28	37,70	37,32	30,28	29,52	41,45	50,78	115,13	131,56	69,20	54,78	44,03	57,09
1996/97	27,92	25,39	22,47	21,24	21,84	19,56	31,76	58,38	47,65	23,98	30,17	31,66	30,17
1997/98	26,20	16,27	39,54	35,38	39,84	59,36	66,07	129,86	218,57	252,48	141,68	78,01	91,94
1998/99	55,23	43,76	35,32	28,99	24,00	22,36	38,94	49,47	56,69	46,76	41,74	31,10	39,53
1999/2000	24,53	22,07	20,98	19,60	19,37	30,98	53,33	93,57	93,40	71,46	46,90	32,41	44,05
2000/01	29,42	25,44	47,78	47,28	32,02	33,53	79,72	124,86	243,32	183,45	137,52	70,69	87,92
2001/02	48,97	44,43	32,64	46,21	51,61	53,81	75,26	102,86	216,66	118,09	81,45	58,54	77,55
2002/03	38,35	35,48	40,78	35,01	46,56	38,65	53,61	92,17	166,06	177,14	120,92	83,98	77,39
2003/04	56,22	41,67	44,68	42,41	36,70	43,77	57,32	95,53	101,06	91,32	67,11	50,14	60,66
2004/05	39,78	30,70	29,13	27,32	28,62	39,04	48,85	65,26	90,98	79,50	51,03	43,57	47,82
2005/06													

PROMEDIO	36,53	32,19	33,52	32,59	31,48	36,73	53,75	93,97	134,89	116,55	76,54	51,87	60,88
MÁXIMO	74,41	67,33	109,19	59,73	52,57	74,68	85,52	169,47	356,20	408,18	266,71	140,14	142,23
MÍNIMO	15,18	16,27	16,79	18,33	16,35	16,03	23,69	33,60	18,30	22,36	30,17	21,92	23,59

Source: Studies by AES Gener and EIA.

Table 3-1c Monthly Average Flows Series for the 'With Project' Condition.

ESTACIÓN: RÍO MAIPO EN EL MANZANO
CAUDALES MEDIOS MENSUALES (m3/s)
SITUACIÓN CON PROYECTO

ANO	ABR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DIC	ENE	FEB	MAR	ANUAL
1950/51	29,91	29,64	25,31	25,13	25,47	36,24	53,43	71,63	116,08	77,15	57,94	48,75	49,72
1951/52	36,82	33,21	37,98	43,31	44,16	43,58	56,97	95,82	128,24	131,17	58,95	53,59	63,65
1952/53	34,55	37,67	34,70	38,50	42,38	47,27	56,39	68,45	102,25	72,51	70,46	44,43	54,13
1953/54	37,98	29,79	30,46	36,12	50,80	66,40	88,51	152,89	240,00	196,20	133,24	79,97	95,20
1954/55	52,59	36,12	40,85	54,53	57,42	60,10	80,64	129,49	101,97	93,56	58,61	41,93	67,32
1955/56	34,90	33,31	27,37	24,73	26,72	30,43	42,50	75,86	77,89	57,72	49,88	31,98	42,77
1956/57	35,14	45,16	28,76	38,55	41,83	44,61	51,10	100,18	71,62	61,93	46,73	38,60	50,35
1957/58	34,31	26,08	28,84	31,90	28,99	32,41	54,57	100,61	127,44	138,05	71,78	68,74	61,98
1958/59	48,29	43,79	38,57	39,41	29,27	46,62	101,06	92,47	110,33	62,56	53,74	50,72	59,74
1959/60	41,64	39,19	35,07	46,31	46,64	49,10	65,53	121,99	190,98	120,06	57,50	39,43	71,12
1960/61	35,44	33,41	41,59	41,46	28,79	49,40	68,41	120,08	143,72	87,27	58,69	60,19	64,04
1961/62	50,75	42,04	54,66	32,84	59,73	44,11	90,22	144,12	234,66	171,72	100,24	69,44	91,21
1962/63	42,20	36,09	40,09	35,44	45,65	43,39	65,36	124,48	125,44	86,08	57,94	46,67	62,40
1963/64	36,75	32,00	32,72	37,68	44,77	52,53	74,28	89,74	271,69	294,20	160,24	88,27	101,24
1964/65	47,97	37,23	47,31	35,45	29,96	35,53	46,00	60,39	65,58	65,67	54,11	49,14	47,86
1965/66	39,21	30,96	34,13	32,07	55,79	53,79	82,97	143,06	154,46	212,20	123,64	71,59	86,16
1966/67	44,40	34,24	41,91	42,31	40,72	55,88	69,89	103,67	133,28	103,52	93,45	48,60	67,66
1967/68	38,27	34,32	19,98	22,73	24,73	27,46	55,57	67,96	97,56	73,10	64,05	38,22	47,00
1968/69	37,30	31,49	28,04	26,26	24,71	22,38	32,83	42,10	32,18	34,80	39,96	36,68	32,39
1969/70	19,60	25,85	34,55	24,80	29,44	32,28	41,31	72,44	183,54	90,30	68,77	42,63	55,46
1970/71	34,74	29,20	24,96	28,36	24,97	28,30	53,63	70,75	81,01	53,90	43,55	29,71	41,92
1971/72	24,93	23,43	21,70	26,77	27,58	33,26	65,37	131,64	122,76	92,93	45,94	39,11	54,62
1972/73	24,81	64,57	92,69	56,44	77,37	81,89	101,55	147,33	254,02	431,50	209,05	155,47	141,39
1973/74	68,78	44,78	46,07	54,26	45,42	38,28	50,84	118,32	133,73	130,70	70,73	53,23	71,26
1974/75	36,12	32,21	32,44	43,37	40,45	42,96	87,41	138,83	159,33	179,20	87,27	56,84	78,04
1975/76	41,24	29,05	29,81	29,17	39,62	38,92	45,93	72,77	109,48	83,76	60,16	43,10	51,92
1976/77	28,01	24,31	31,55	26,21	25,76	35,98	45,33	89,59	98,80	74,43	42,73	39,77	46,87
1977/78	29,58	28,78	33,01	57,19	55,86	69,81	128,15	171,29	274,24	186,17	104,58	60,73	99,95
1978/79	42,33	35,73	33,52	78,90	56,81	61,03	88,73	162,50	353,50	335,57	155,60	78,38	123,55
1979/80	48,80	43,30	33,46	33,64	47,09	53,10	79,62	106,03	146,64	213,46	110,07	70,88	82,17
1980/81	86,70	87,58	67,64	68,49	57,08	65,28	81,69	126,36	285,61	185,15	143,30	74,04	110,74
1981/82	51,87	59,39	52,45	40,30	38,06	38,39	52,19	103,41	110,73	104,37	62,97	35,43	62,46
1982/83	28,70	34,27	85,50	83,47	75,78	111,14	113,69	181,79	484,20	540,18	395,31	200,14	194,51
1983/84	98,55	71,35	52,85	55,26	57,71	54,30	113,07	174,73	249,01	186,37	139,74	70,69	110,30
1984/85	42,64	36,21	28,93	45,16	40,25	50,18	93,22	124,14	248,00	241,60	153,64	91,38	99,61
1985/86	54,89	52,81	45,40	39,30	42,92	40,30	47,68	107,59	125,65	103,90	74,14	42,84	64,78
1986/87	34,85	39,93	146,39	57,69	52,07	53,28	83,50	123,59	261,14	288,50	208,20	101,45	120,88
1987/88	50,38	40,31	45,16	72,12	97,86	79,02	112,58	227,59	344,61	328,96	216,09	123,29	144,83
1988/89	70,66	45,10	38,69	36,03	42,28	39,05	54,65	104,61	88,73	88,83	88,20	58,41	62,94
1989/90	39,07	37,45	31,08	25,76	56,49	67,09	94,39	169,77	180,38	125,05	65,16	44,23	77,99
1990/91	41,41	38,23	33,26	32,83	36,50	44,62	58,21	85,19	86,36	77,42	54,51	36,43	52,08
1991/92	51,91	56,97	59,39	77,20	58,85	77,87	90,80	169,45	166,35	212,93	140,40	98,67	105,07
1992/93	56,02	53,72	54,96	49,84	45,39	58,69	101,81	151,83	180,84	221,05	127,33	68,05	97,46
1993/94	74,49	52,64	65,34	62,43	51,94	52,59	81,52	103,68	170,81	199,36	93,27	57,77	88,82
1994/95	40,34	39,12	41,38	52,70	52,20	62,45	75,81	118,97	213,50	121,64	76,43	63,18	79,81
1995/96	51,39	41,20	42,51	37,37	39,64	55,65	66,94	129,35	158,96	76,18	59,28	53,36	67,65
1996/97	38,76	32,61	27,73	27,68	22,36	25,96	35,77	62,67	54,94	34,05	32,76	40,00	36,27
1997/98	32,00	22,45	49,76	48,77	65,84	95,38	92,35	166,01	275,55	355,74	171,27	92,93	122,34
1998/99	70,81	49,77	40,42	33,91	29,37	25,92	43,59	56,47	63,19	62,24	47,49	38,55	46,81
1999/2000	27,76	24,86	24,67	24,66	27,23	42,26	67,99	107,91	108,29	91,44	55,57	35,66	53,19
2000/01	35,45	32,14	65,75	63,95	54,75	46,68	111,61	148,16	309,17	264,23	169,52	82,35	115,31
2001/02	60,55	54,40	41,33	64,38	74,18	68,67	97,64	128,91	273,01	155,68	103,37	69,67	99,32
2002/03	44,62	42,04	57,10	51,03	72,91	54,85	79,80	124,69	240,23	273,08	195,90	123,40	113,30
2003/04	63,07	47,80	52,50	49,63	50,24	49,80	76,06	117,39	112,60	118,98	81,57	61,25	73,41
2004/05	47,96	38,08	33,11	31,99	36,04	49,50	53,17	78,60	99,80	96,80	59,27	50,86	56,27
2005/06													
PROMEDIO	44,59	39,59	43,01	43,20	45,40	50,29	72,80	115,99	169,71	155,73	98,62	63,47	78,53
MÁXIMO	98,55	87,58	146,39	83,47	97,86	111,14	128,15	227,59	484,20	540,18	395,31	200,14	194,51
MINIMO	19,60	22,45	19,98	22,73	22,36	22,38	32,83	42,10	32,18	34,05	32,76	29,71	32,39

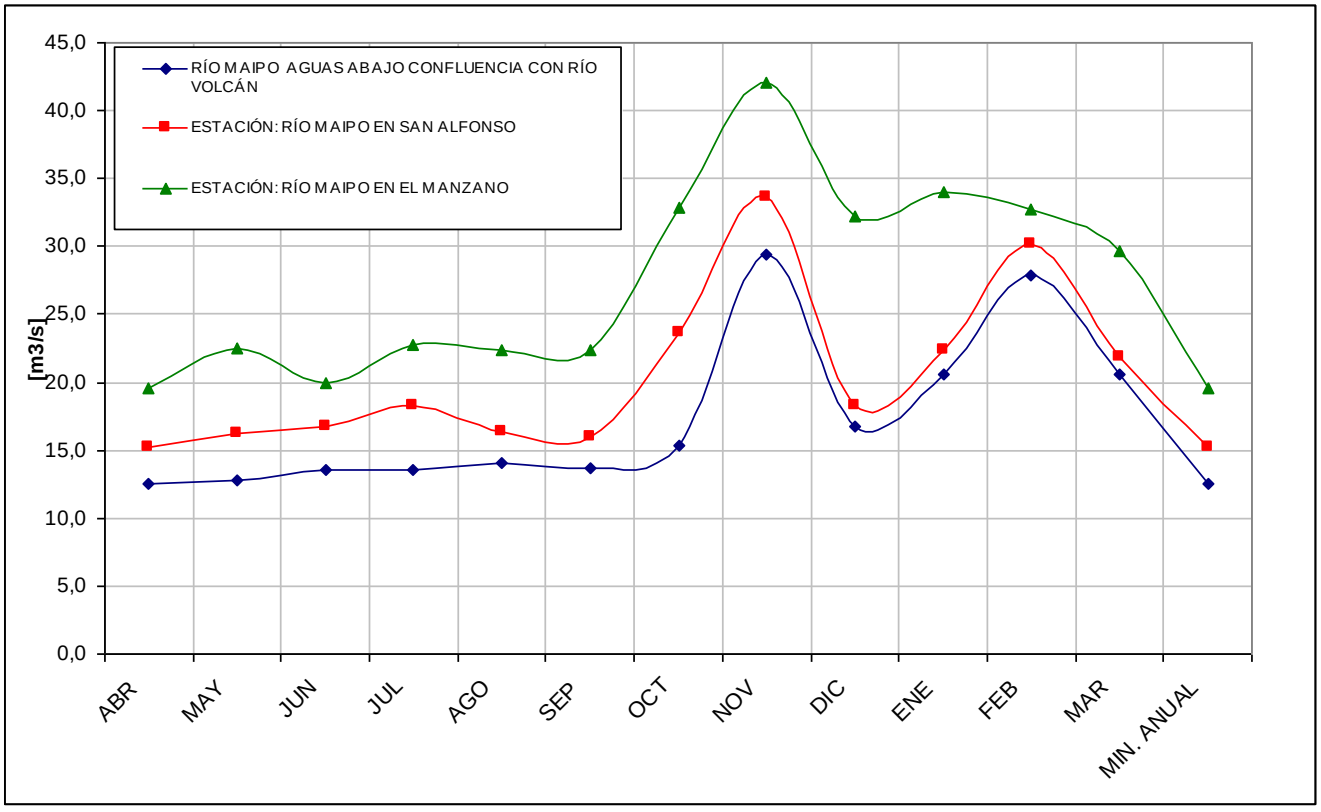
Source: Studies by AES Gener and EIA.

Table 3-2 Minimum Monthly Average Flows Series. Historical Period 1950/2005. With Project Situation (m3/s). (2)

Maipo River Station or Stretch	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	ANNUAL MIN.
MAIPO RIVER, DOWNSTREAM OF CONFLUENCE W / EL VOLCÁN RIVER	12.5	12.8	13.5	13.6	14.1	13.7	15.4	29.4	16.7	20.6	27.9	20.5	**12.5**
STATION: MAIPO RIVER IN SAN ALFONSO	15.2	16.3	16.8	18.3	16.4	16.0	23.7	33.6	18.3	22.4	30.2	21.9	**15.2**
STATION: MAIPO RIVER IN EL MANZANO	19.6	22.4	20.0	22.7	22.4	22.4	32.8	42.1	32.2	34.0	32.8	29.7	**19.6**

Source: In-house preparation.

Figure 3-1 Minimum Monthly Average Flows Series.



Source: In-house preparation.

4. ANALYSIS OF THE IMPACT ON EACH AQUIFER AND CONCLUSIONS

To analyze the impact of a reduction in flow rates on the identified aquifers, the following procedure and associated hypotheses were considered:

- The identified aquifers are of small magnitude and directly associated with the surface river drainage. This means that there is a very good direct connection between the surface flow and ground flow.
- The aquifers consist of a combination of highly permeable material associated to the current river bed and other less permeable material associated with older terraces, as well as colluvial and alluvial sediments that might lie interspersed with the rest.
- Aquifers under these conditions respond very quickly to changes in surface flows. This means that as long as the surface flow is greater than or equal to the conveyance capacity of the respective aquifer, the aquifer will remain or tend to become saturated and will remain in equilibrium with the drainage of the riverbed. If the river dries out, the aquifer will tend to drain up to the level of the riverbed, although it will not dry out totally.

In line with the foregoing, an aquifer will undergo an adverse effect only in the event that river flows are lower than the conveyance capacity of the respective aquifer.

In this regard, what this study did was to compare the conveyance capacities of each identified aquifer and the minimum flows that will drain in each stretch for the 'with project' condition. To this end, the river stretches were split up into sectors using river flow information, and were then associated with the respective aquifer groups, as shown below:

Maipo River Aquifer	Maipo River Station or Associated Stretch
1	MAIPO RIVER, DOWNSTREAM OF CONFLUENCE W / EL VOLCÁN RIVER
2	
3	
4	STATION: MAIPO RIVER IN SAN ALFONSO
5	
6	
7	STATION: MAIPO RIVER IN EL MANZANO
8	
9	

In addition, the conveyance capacity of each aquifer was calculated using Darcy's coefficient, which required calculating the permeability ratios.

This was done by considering the worst case scenario. That is, the largest value to be expected, given the nature of the aquifers, was assumed for the calculation. This

value was set between 0.01 and 0.001 m/s, i.e. a value corresponding to a clean and highly permeable river bed. In actual fact, the expected permeability value representative of all the aquifer should be lower, given the presence of less permeable material, as mentioned earlier.

Table 4-1 below summarizes the calculations, and shows the comparison between minimum (monthly and annual) surface flows and conveyance capacities for each aquifer.

It may be noticed that the minimum river flows that could be expected for the 'with project' condition are much larger than the maximum conveyance capacities of each respective aquifer. This is valid even in the case of an equivalent permeability of 0.01 m/s, which is very high.

Actually, the abovementioned conveyance capacities are much lower than the ecological flow rates set out by the Water Department (DGA) and cited in the EIA, as shown in the same table.

In line with the foregoing, it is possible to conclude with certainty that the expected reduction in river flows as a result of the project coming into operation will not have an adverse impact on the existing aquifers in the stretch of influence of the project.

Guillermo Cabrera Fajardo
Civil Engineer

Santiago, March 2008

Table 4-1a Comparison of Minimum River Flows and Maximum Conveyance Capacity of Each Aquifer Case of K=0.001 m/s

	Calculation of Maximum Flow Conveyance in Each Aquifer (1)							Minimum Monthly Average Flows Series. Historical Period 1950/2005. 'With Project' Situation (m3/s). (2)														DGA Ecological Flow Rate (m3/s) (3)
Maipo River Aquifer	Length	Average Width (m)	Aquifer Depth (m)	Grade (%)	Aquifer Stretch Area (m2)	Max. K (m/s)	Max. Ground Flow Rate (m3/s)	Maipo River Station or Stretch	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	ANNUAL MIN.	
1	2303.02	668	59	1.74%	19539	0.001	**0.340**	MAIPO RIVER. DOWNSTREAM OF CONFLUENCE W / EL VOLCÁN RIVER	12.5	12.8	13.5	13.6	14.1	13.7	15.4	29.4	16.7	20.6	27.9	20.5	**12.5**	**5.7**
2	5562.26	610	78	1.37%	23773	0.001	**0.326**															
3	4229.05	168	23	1.84%	1949	0.001	**0.036**															
4	3243.57	382	38	0.43%	7165	0.001	**0.031**	STATION: MAIPO RIVER IN SAN ALFONSO	15.2	16.3	16.8	18.3	16.4	16.0	23.7	33.6	18.3	22.4	30.2	21.9	**15.2**	**7.2**
5	7164.72	630	74	0.68%	23383	0.001	**0.159**															
6	5750.69	949	119	0.92%	56567	0.001	**0.520**															
7	3273.38	435	52	0.89%	11251	0.001	**0.100**	STATION: MAIPO RIVER IN EL MANZANO	19.6	22.4	20.0	22.7	22.4	22.4	32.8	42.1	32.2	34.0	32.8	29.7	**19.6**	**11.1**
8	6964.97	674	76	0.88%	25542	0.001	**0.225**															
9	3011.96	531	53	0.70%	14138	0.001	**0.099**															

Notes:

(1) In-house preparation.

(2) Source: AES Gener's EIA and studies associated to the PHAM Project.

(3) Flow rate set out by the DGA and reported in the EIA for the PHAM Project, Annex 4, Arcadis.

Table 4-1b Comparison of Minimum River Flows and Maximum Conveyance Capacity of Each Aquifer Case of K=0.01 m/s

	Calculation of Maximum Flow Conveyance in Each Aquifer (1)							Minimum Monthly Average Flows Series. Historical Period 1950/2005. 'With Project' Situation (m3/s). (2)														DGA Ecological Flow Rate (m3/s) (3)
Maipo River Aquifer	Length	Average Width (m)	Aquifer Depth (m)	Grade (%)	Aquifer Stretch Area (m2)	Max. K (m/s)	Max. Ground Flow Rate (m3/s)	Maipo River Station or Stretch	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	ANNUAL MIN.	
1	2303.02	668	59	1.74%	19539	0.01	**3.400**	MAIPO RIVER. DOWNSTREAM OF CONFLUENCE W / EL VOLCÁN RIVER	12.5	12.8	13.5	13.6	14.1	13.7	15.4	29.4	16.7	20.6	27.9	20.5	**12.5**	**5.7**
2	5562.26	610	78	1.37%	23773	0.01	**3.257**															
3	4229.05	168	23	1.84%	1949	0.01	**0.359**															
4	3243.57	382	38	0.43%	7165	0.01	**0.308**	STATION: MAIPO RIVER IN SAN ALFONSO	15.2	16.3	16.8	18.3	16.4	16.0	23.7	33.6	18.3	22.4	30.2	21.9	**15.2**	**7.2**
5	7164.72	630	74	0.68%	23383	0.01	**1.590**															
6	5750.69	949	119	0.92%	56567	0.01	**5.204**															
7	3273.38	435	52	0.89%	11251	0.01	**1.001**	STATION: MAIPO RIVER IN EL MANZANO	19.6	22.4	20.0	22.7	22.4	22.4	32.8	42.1	32.2	34.0	32.8	29.7	**19.6**	**11.1**
8	6964.97	674	76	0.88%	25542	0.01	**2.248**															
9	3011.96	531	53	0.70%	14138	0.01	**0.990**															

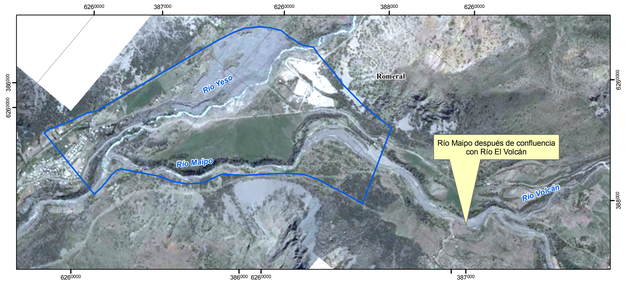
(1) In-house preparation.

(2) Source: AES Gener's EIA and studies associated to the PHAM Project.

(3) Flow rate set out by the DGA and reported in the EIA for the PHAM Project. Annex 4. Arcadis.

FIGURA 2-1
ZONA DE ESTUDIO; SECCIONES ACUIFERASEN EL RÍO MAIPO

SECCIÓN Nº1



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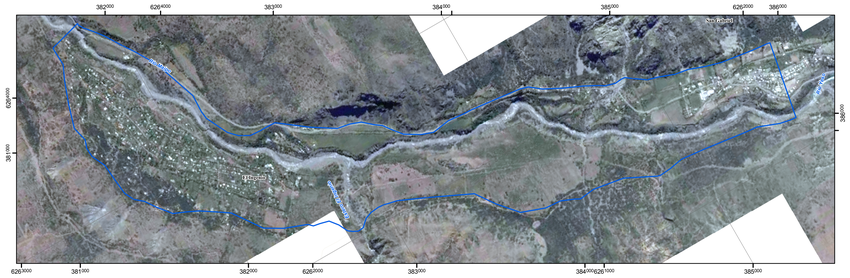

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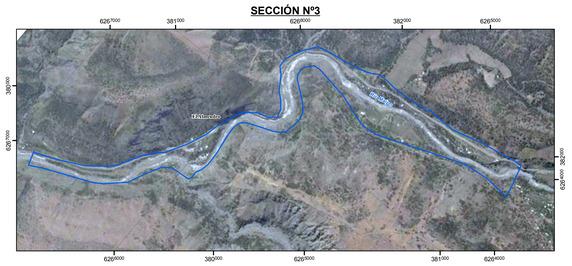

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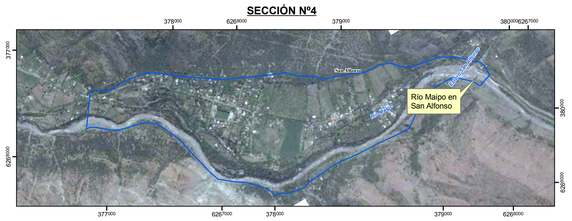

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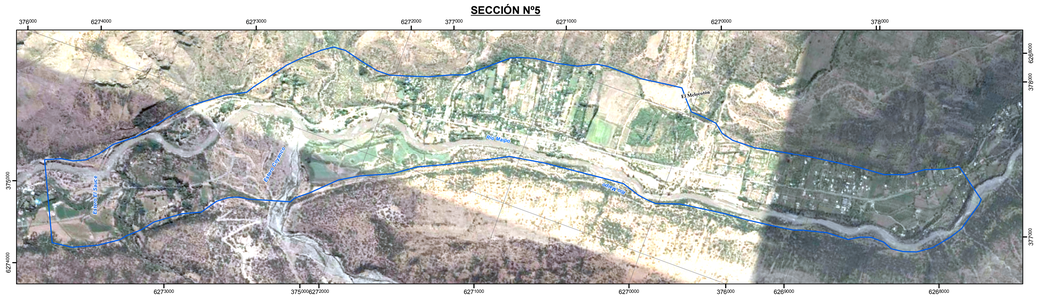

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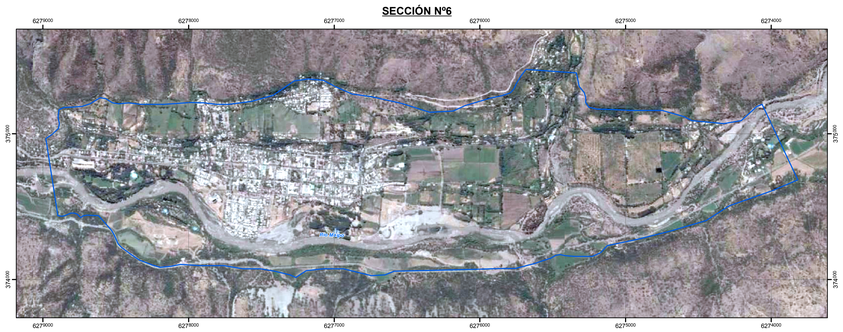

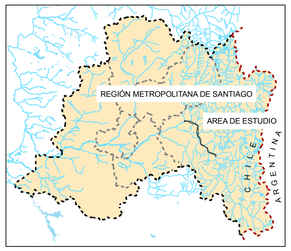

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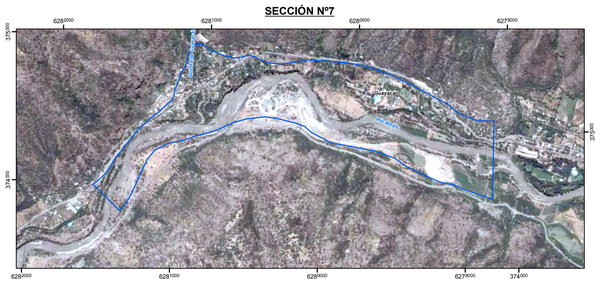

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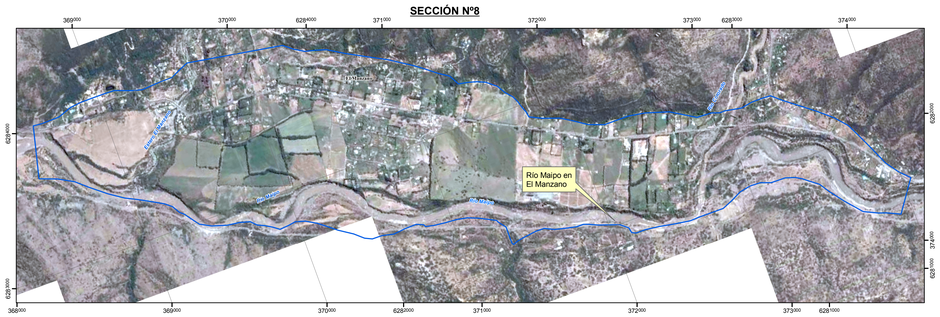
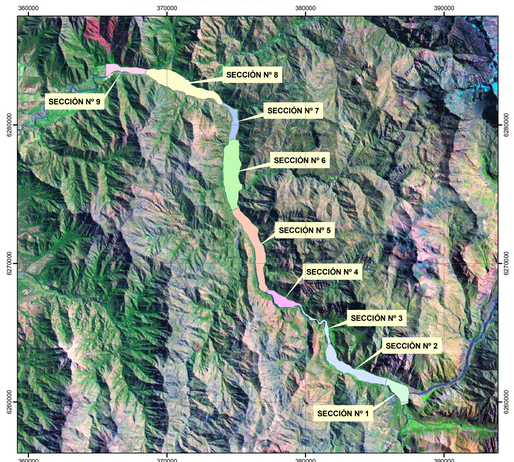


SECCIÓN Nº9

ESQUICIO DE SECCIONES DEL ACUÍFERO



Fuente imagen satelital: Landsat ETM 2000.

SIMBOLOGÍA

Acuífero del Río Maipo

Datos Cartográficos y Geodésicos:
Proyección Universal Transversal de Mercator
Huso 19 Sur.
Datum Provisional Sudamericano de 1956.

Imagenes satelitales para cada sección: Quick Bird II

0 1,000 2,000 4,000 m

ESCALA 1:15.000

CONSULTOR:
GCF
Ingenieros Consultores Ltda.

AES GENER S.A.