Appendix 15: Project Implementation

LIST OF TABLE

LIST OF FIGURES

Table A-15-1 Operation and Maintenance Equipment Cost

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Bulldozer (15t, 141 Hp)	Unit	2	22,000,000		22,000,000	44,000,000		44,000,000	
2. Back Hoe ($0.6m^3$, 102 Hp)	"	2	27,300,000		27,300,000	54,600,000		54,600,000	
3. Motor Grader (3.7m, 130 Hp)	"	1	19,800,000		19,800,000	19,800,000		19,800,000	
4. Drag Line ($0.6-0.8m^3$, 105 Hp)	"	1	32,000,000		32,000,000	32,000,000		32,000,000	
5. Dump Truck (8t)	"	6	20,800,000		20,800,000	124,800,000		124,800,000	
Total						275,200,000		275,200,000	

Table A-15-2 Administration Cost

Description	Unit	Q'ty	Unit Rate			Amount			Remarks
			F/C	L/C	Total	F/C	L/C	Total	
1. Temporary Office Rental	Month	4		150,000	150,000		600,000	600,000	
2. Construction of Project	m^2	200		40,000	40,000		8,000,000	8,000,000	
3. Office Equipment and Facilities	L.S	1					2,000,000	2,000,000	
4. Motor Pool	m^2	600		10,000	10,000		6,000,000	6,000,000	
Sub-total							(16,600,000)	(16,600,000)	
5. Salaries									
Officer in charge	M/M	60		180,000	180,000		10,800,000	10,800,000	
Civil Engineer	"	120		100,000	100,000		12,000,000	12,000,000	60 x 2
Asst. Civil Engineer	"	120		45,000	45,000		5,400,000	5,400,000	60 x 2
Secretary	"	60		35,000	35,000		2,100,000	2,100,000	
Driver	"	180		26,000	26,000		4,680,000	4,680,000	60 x 3
6. Postage and Others	month	60		50,000	50,000		3,000,000	3,000,000	
7. O/M of Vehicles	month	60		450,000	450,000		27,000,000	27,000,000	
8. O.H. (20% of 1)							6,996,000	6,996,000	
Sub-total							(71,976,000)	(71,976,000)	
Grand Total							(88,576,000)	(88,576,000)	

Table A-15-3 Estimated Consulting Services Cost

(Unit: 10^6 Ch$)

Item	Detailed Design Phase			Construction Phase			Total		
	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1. Mobilization and De-mobilization	26.8	0.2	27.0	37.8	0.1	37.9	64.6	0.3	64.9
2. Professional Services	269.9	41.8	311.7	438.2	88.2	526.4	708.1	130.0	838.1
3. Fixed Cost incl. Boring, Topo-Survey, etc.	3.2	52.7	55.9	8.7	6.6	15.3	11.9	59.3	71.2
4. Reimbursable Cost	10.0	17.8	27.8	10.0	53.2	63.2	20.0	71.0	91.0
5. Equipment and Vehicle	44.0	-	44.0	-	-	-	44.0	-	44.0
6. Miscellaneous 5% of (1-4)	15.5	5.6	21.1	24.7	7.4	32.1	40.2	13.0	53.2
Total	369.4	118.1	487.5	519.4	155.5	674.9	888.8	273.6	1,162.4

Fig.A-15-1 Assignment of Consulting Services (Detailed Design Phase)

Personnel \ Year and Month	1987 JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total M/M Foreign	Local	Trip
1.Project Director													2.0		4
2.Team Leader													12.0		1
3.Planning Engineer (A)													7.0		1
4.Planning Engineer (B)														7.0	
5.Senior Design Engineer													12.0		1
6.Design Engineer(A)													9.0		1
7.Design Engineer(B)													9.0		1
8.Design Engineer(C)														8.0	
9.Design Engineer(D)														8.0	
10.Structural Engineer													9.0		1
11.Hydraulic Engineer													8.0		1
12.Hydrologist													4.0		1
13.Geologist(A)													4.0		1
14.Geologist(B)														6.0	
15.Soil Mechanical Engineer													4.0		1
16.Topo-Surveyor(A)													8.0		1
17.Topo-Surveyor(B)													7.0		1
18.Topo-Surveyor(C)														8.0	
19.Topo-Surveyor(D)														7.0	
20.Topo-Surveyor(E)														7.0	
21.Topo-Surveyor(F)														7.0	
22.Agronomist													3.0		1
23.Construction Planning Engineer													4.0		1
24.Technical Specification Engineer(A)													4.0		1
25.Technical Specification Engineer(B)														4.0	
26.Mechanical Engineer													4.0		1
27.Operation/Maintenance Engineer													4.0		1
28.Economist													4.0		1
29.Specialists as required													12.0		3
30.Home office support													8.0		
Total													138.0	62.0	25

Fig.A-15-2 Assignment Schedule of Consulting Services (Construction Phase)

Personnel / Year	1987	1988	1989	1990	1991	1992	Total M/M Foreign	Total M/M Local	Trip
1.Project Director							4.0		4
2.Team Leader							48.0		4
3.Construction Engineer(A)							48.0		4
4.Construction Engineer(B)							48.0		4
5.Construction Engineer(C)							42.0		3
6.Construction Engineer(D)								42.0	
7.Construction Engineer(E)								42.0	
8.Construction Engineer(F)								36.0	
9.O/M Expert							3.0		1
10.Specialist as Required							20.0		4
11.Home Office Support							5.0		
Total							218.0	120.0	24

Table A-15-4 Annual Operation and Maintenance Cost

(Unit: 10^3 Ch$)

Item	Block-1	Block-2	Block-3 & 4	Total
1. Personnel	1,903	3,782	8,127	13,812
2. Depreciation of O/M Equipment	3,720	4,420	20,130	28,270
3. Maintenance of Facilities	475	565	2,560	3,600
4. Electricity for Treatment Plant	1,311	8,194	0	9,505
5. Chlorine	8,060	11,200	0	19,260
6. Office and General Expenses	1,800	2,150	9,850	13,800
7. Miscellaneous	100	100	300	500
Total	17,369	30,411	40,967	88,747

Table A-15-5 Replacement Cost

(Unit: 10^3 Ch$)

Item	Durability (Year)	Block-1	Block-2	Blocks-3 and 4	Total
1. Gate	20	5,090	777	14,505	20,372
2. Treatment Plant Facilities					
(1) Aerator	20	68,103	423,780	-	49,883
(2) Float	10	48,478	301,665	-	350,143
(3) Chlorinator	10	12,432	74,602	-	87,034
(4) Switch Board	20	8,715	38,377	-	47,092
Total	20	81,908	462,934	14,505	559,347
	10	60,910	376,267	-	437,177

Appendix 16 : PROJECT JUSTIFICATION

16.1 Justification Concept

16.2 Project Benefits

16.3 Economic Evaluation

16.4 Financial Evaluation

LIST OF TABLES

LIST OF FIGURE

16.1 Justification Concept

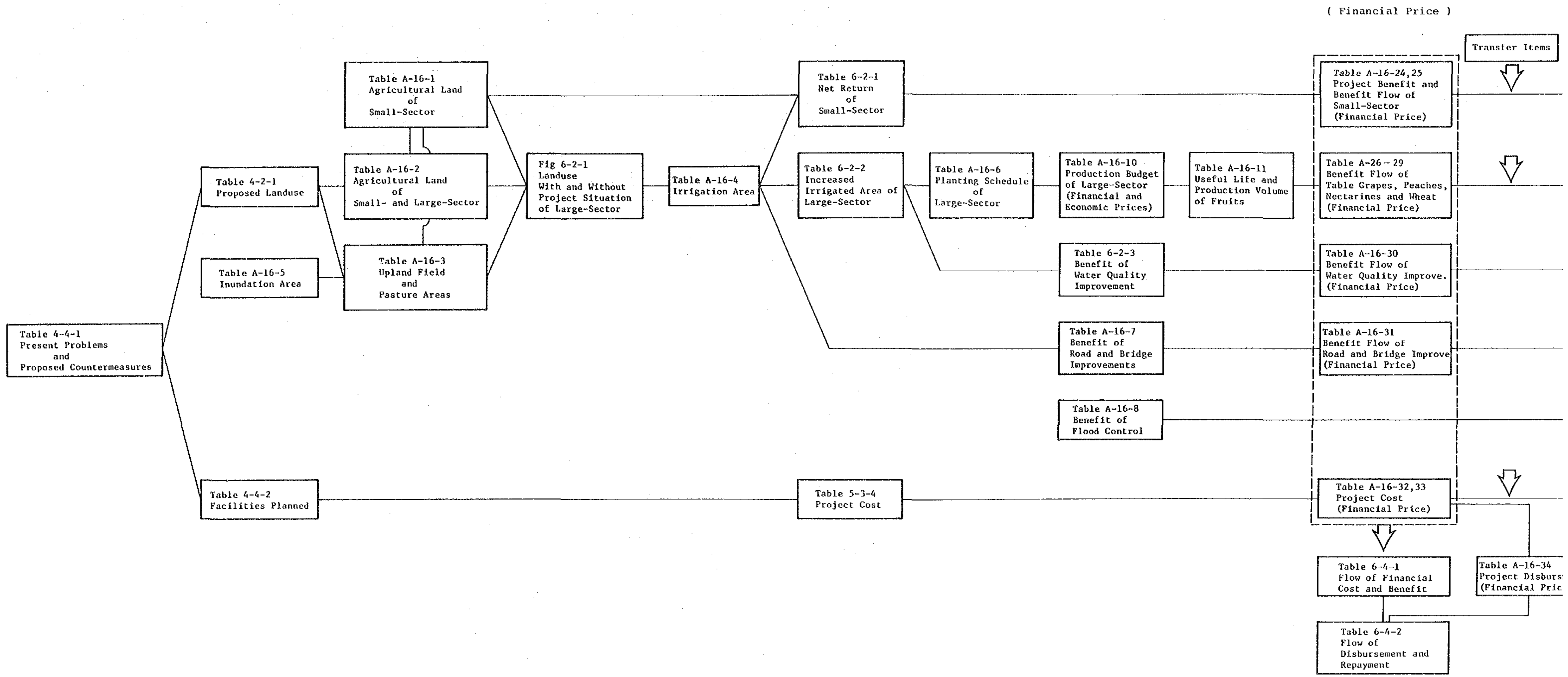
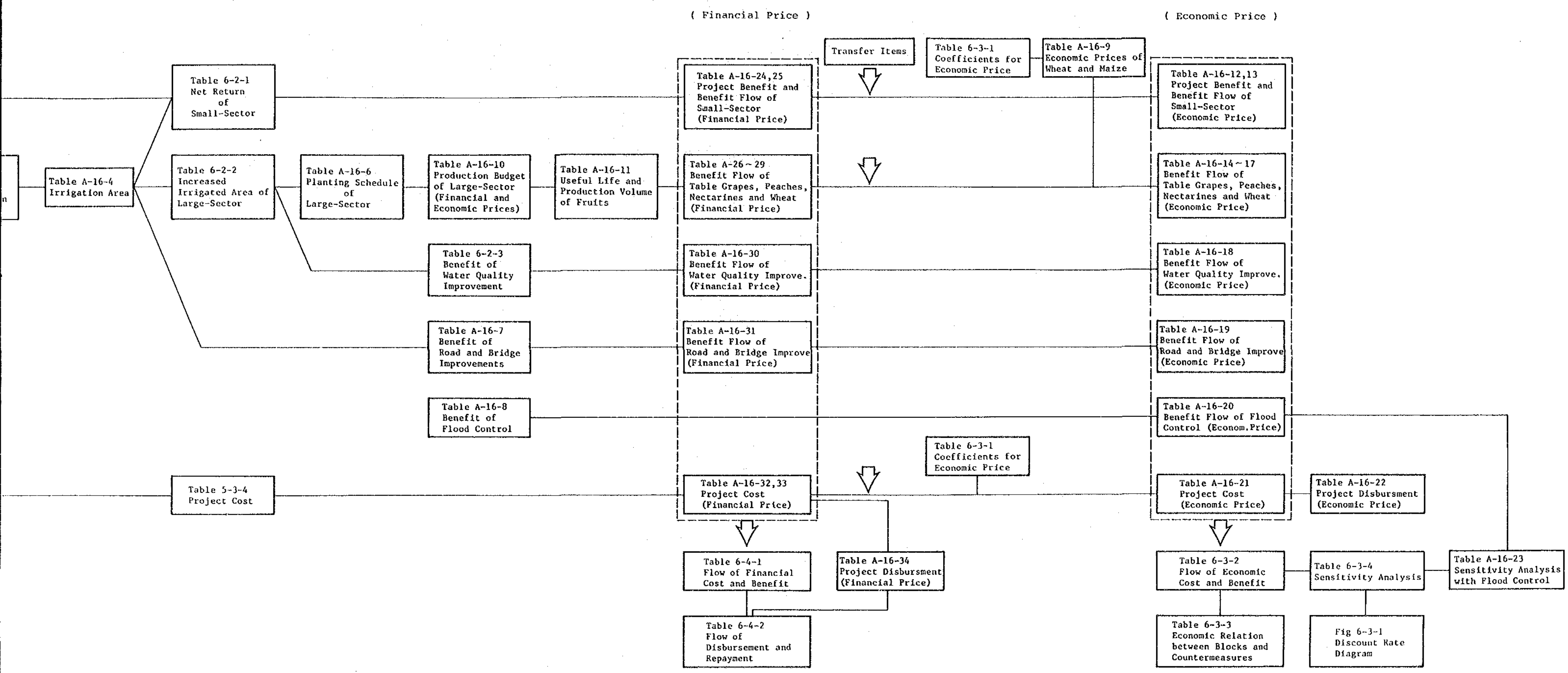


Fig A-16-1 Flow of Project Justification


(Financial Price)
(Economic Price)
Transfer Items
Table 6-3-1 Coefficients for Economic Price
Table A-16-9 Economic Prices of Wheat and Maize
Table 6-2-1 Net Return of Small-Sector
Table A-16-24,25 Project Benefit and Benefit Flow of Small-Sector (Financial Price)
Table A-16-12,13 Project Benefit and Benefit Flow of Small-Sector (Economic Price)
Table A-16-4 Irrigation Area
Table 6-2-2 Increased Irrigated Area of Large-Sector
Table A-16-6 Planting Schedule of Large-Sector
Table A-16-10 Production Budget of Large-Sector (Financial and Economic Prices)
Table A-16-11 Useful Life and Production Volume of Fruits
Table A-26 ~ 29 Benefit Flow of Table Grapes, Peaches, Nectarines and Wheat (Financial Price)
Table A-16-14 ~ 17 Benefit Flow of Table Grapes, Peaches, Nectarines and Wheat (Economic Price)
Table 6-2-3 Benefit of Water Quality Improvement
Table A-16-30 Benefit Flow of Water Quality Improve. (Financial Price)
Table A-16-18 Benefit Flow of Water Quality Improve. (Economic Price)
Table A-16-7 Benefit of Road and Bridge Improvements
Table A-16-31 Benefit Flow of Road and Bridge Improve (Financial Price)
Table A-16-19 Benefit Flow of Road and Bridge Improve (Economic Price)
Table A-16-8 Benefit of Flood Control
Table A-16-20 Benefit Flow of Flood Control (Econom.Price)
Table 6-3-1 Coefficients for Economic Price
Table 5-3-4 Project Cost
Table A-16-32,33 Project Cost (Financial Price)
Table A-16-21 Project Cost (Economic Price)
Table A-16-22 Project Disbursment (Economic Price)
Table 6-4-1 Flow of Financial Cost and Benefit
Table A-16-34 Project Disbursment (Financial Price)
Table 6-3-2 Flow of Economic Cost and Benefit
Table 6-3-4 Sensitivity Analysis
Table A-16-23 Sensitivity Analysis with Flood Control
Table 6-4-2 Flow of Disbursement and Repayment
Table 6-3-3 Economic Relation between Blocks and Countermeasures
Fig 6-3-1 Discount Rate Diagram

16.2 Project Benefits

Table A-16-1 Agricultural Land of Small-Sector

(Unit: ha)

	Block	No. of Farm	Upland Field	Pasture	Sub-Total	Agricul. Infra. Area	Total
	Present	68	299	136	435	14	449
1	Without project	68	299	136	435	14	449
	With Project	68	360	75	435	14	449
	Present	184	626	276	902	36	938
2	Without Project	128	435	192	627	26	653
	With Project	128	627	0	627	26	653
	Present	105	483	221	704	21	725
3	Without Project	85	391	179	570	17	587
	With Project	85	570	0	570	17	587
	Present	693	2,772	1,247	4,019	139	4,158
4	Without Project	549	2,196	988	3,184	110	3,294
	With Project	549	3,184	0	3,184	110	3,294
Total							
	Present	1,050	4,180	1,880	6,060	210	6,270
	Without Project	1,050	3,321	1,495	4,816	210	4,983
	With Project	830	4,741	75	4,816	167	4,983

Source: Table 4-3-1, 4-3-2

Table A-16-2 Agricultural Land of Small- and Large-Sector

(Unit: ha)

	Block	Total Block	Others	Agricul. Infra. Area	Upland Field + Pasture Total	Small-Sector	Large-Sector
	Present	2,870	120	90	2,660	435	2,225
1	Without Project	2,870	120	90	2,660	435	2,225
	With project	2,870	120	90	2,660	435	2,225
	Present	4,910	320	200	4,390	902	3,488
2	Without Project	4,910	1,490	150	3,270	627	2,643
	With Project	4,910	1,490	150	3,270	627	2,643
	Present	5,660	480	120	5,060	704	4,356
3	Without Project	5,660	1,110	110	4,440	570	3,870
	With Project	5,660	1,110	110	4,440	570	3,870
	Present	22,500	2,430	450	19,620	4,019	15,601
4	Without Project	22,500	4,610	400	17,490	3,184	14,306
	With Project	22,500	4,610	400	17,490	3,184	14,306
Total							
	Present	35,940	3,530	860	31,730	6,060	25,670
	Without Project	35,940	7,330	750	27,860	4,816	23,044
	With Project	35,940	7,330	750	27,860	4,816	23,044

Source: Table 4-2-1, A-16-1

Urbanization after 1991: Block-1 would not be encroached. Block-2 may be saved by special legislation. Otherwise, 100 ha of field a year would be reduced. In Block-3, 30 ha for 5 years, then 10 ha a year throughout the rest of the project life. Block-4; 350 ha in 1992, 300 ha in 1993, 250 in 94, 200 in 95, 150 in 96, then 50 ha for the rest of the project life.

Table A-16-3 Upland Field and Pasture Areas

(Unit: ha)

Block		Upland Field			Pasture		
		Small-Sector	Large-Sector	Total	Small-Sector	Large-Sector	Total
1	Present	299	1,461	1,760	136	764	900
	Without Project	299	1,461	1,760	136	764	900
	With project	360	1,710	2,070	75	515	590
2	Present	626	3,104	3,730	276	384	660
	Without Project	435	2,293	2,728	192	350	542
	With Project	627	2,293	2,920	0	350	350
3	Present	483	1,817	2,300	221	2,539	2,760
	Without Project	391	1,470 1/	1,861	179	2,400	2,579
	With Project	570	2,580	3,150	0	1,290	1,290
4	Present	2,772	5,828	8,600	1,247	9,773	11,020
	Without Project	2,196	5,828	8,024	988	8,478	9,466
	With Project	3,184	8,066	11,250	0	6,240	6,240
Total							
	Present	4,180	12,210	16,390	1,880	13,460	15,340
	Without Project	3,321	11,052	14,373	1,495	11,992	13,487
	With Project	4,741	14,649	19,390	75	8,395	8,470

Source: Table 4-2-1, A-16-1

Note: 1/ No reach to 1,817 ha because of the inundation influence.

Table A-16-4 Irrigation Area

(Unit: ha)

Block		Irrigable Area Total	Small-Sector	Large-Sector	Irrigated Area Large-Sector	Increase
	Present	950	299	651	651	
1	Without Project	950	299	651	651	
	With project	1,190	360	830	830	179
	Present	2,920	626	2,294	2,294	
2	Without Project	2,920	435	2,485	2,293 1/	
	With Project	2,920	627	2,293	2,293	0
	Present	2,170	483	1,687	1,687	
3	Without Project	2,170	391	1,779	1,470 1/	
	With Project	3,150	570	2,580	2,580	1,110 (801) 2/
	Present	4,740	2,772	1,968	1,968	
4	Without Project	4,740	2,196	2,544	2,544	
	With Project	10,080	3,184	6,896	6,896	4,352
	Total					
	Present	11,080	4,180	6,900	6,600	
	Without Project	11,080	3,321	7,759	6,958	
	With Project	17,340	4,741	12,599	12,599	5,641 (5,332) 2/

Source: Table 4-2-8, A-16-1, Fig 6-2-1
Note : 1/ Landuse limitation Table A-16-3
2/ Only irrigation effect.

In any case, urbanization would occur regardless of with or without project situation. Logically, a volume of irrigation water squeezed by urganization would be utilized to irrigate the periphery of the irrigated field at the time.

Table A-16-5 Inundation Area

(Unit: ha)

Block	1	2	3	4	Total
Present	300	0	1,650	3,990	5,640
Without Project	300	0	1,650	3,990	5,640
With Project	0	0	0	0	0

Source: 3.5.2 Drainage Facilities and Related Problems, Table A-13-6

Table A-16-6 Planting Schedule of Large-Sector

(Unit: ha)

Block		1	3		4			Total
Countermeasures		Irrigation	Irrigation	Flood Control	Irrigation			
Crop		Table Grapes	Table Grapes		Table Grapes	Peachs	Nectarines	
	1992	179	200	150	600	500	300	1,929
Year	1993	-	200	159	600	500	350	1,809
	1994	-	401	-	652	500	350	1,903
Total		179	801	309	1,852	1,500	1,000	5,641

Source: Table 6-2-2

Table A-16-7 Benefit of Road and Bridge Improvements

(Unit : ha) (Unit : t) (Unit : 10^3 Ch$)

Block	Large-Sector 1/	Small-Sector 2/					Weight 4/						Benefit		
			Orchard & Vineyard		Ordinary Field		to Valparaiso			to Santiago 5/					
	Orchard & Vineyard	No. of Farm	per Farm	Area 3/	per Farm	Area	Fruits of Large-Sec.	Fruits of Small-Sec.	Total	Fruits of Small-Sec.	Others of Small-Sec.	Total	to Valparaiso	to Santiago	Total
1	830	68	1.1	75	8.4	571	12,450	900	13,350	225	5,710	5,935	2,670	712	3,382
2	2,293	128	1.0	128	7.8	998	34,395	1,536	35,931	384	9,980	10,364	7,186	1,244	8,430
3	2,580	85	1.3	111	10.8	918	38,700	1,332	40,032	333	9,180	9,513	8,006	1,142	9,148
4	6,896	549	1.2	659	9.2	5,051	103,440	7,908	111,348	1,977	50,510	52,487	22,270	6,298	28,568
Total	12,599	830	-	973	-	7,538	188,985	11,676	200,661	2,919	75,380	78,299	40,132	9,396	49,528

Note:
1/ Table A-16-4
2/ Table 4-3-2
3/ 80% for export, 20% for domestic
4/ Mean yield of fruits is 15t/ha and mean yield of other crops, cereal and vegetables is 10t/ha.
5/ Benefit can also be applied to return trips.

Table A-16-8 Benefit of Flood Control

(Unit : 10^3 Ch$)

Year	Damage of Houses	Damage of Road	Loss of Product.	Consumption of Combustible	Total
1985	72,080	51,457	52,861	36,263	212,661
1996	93,200	65,001	65,856	57,057	281,114
2010	129,120	87,516	87,506	76,598	380,740
1991	83,600	58,845	59,949	47,605	249,999

Source : Plan Maestro, Alcantarillado del Gran Santiago, EMOS, 1984

16.3 Economic Evaluation

Table A-16-9 Economic Prices of Wheat and Maize

(1985 Price)

Item	Unit	Wheat	Maize
Projected Price 1/ (Average of 1990 - 95)	US$/ton	151	116
Quality Adjustment	%	100	100
Freight and Insurance	US$/ton	26	26
CIF at San Antonio 2/	US$/ton	177	142
	Ch$/ton	36,547	29,320
Port Fee 3/	Ch$/ton	1,424	1,424
Transport to Santiago	Ch$/ton	953	953
Local Transport 3/	Ch$/ton	-500	-500
Farm Gate Price	Ch$/ton	38,424	31,197

Note: 1/Commodity prices projection given by the world bank are as follows:

Year	1983	1985	1990	1995
Wheat (1983 price)	170	168	153	149
Wheat (current)	170	164	213	259

Canadian, No.1 WRS 13.5%, FOB St. Lawrence

Year	1983	1985	1990	1995
Maize (1983 price)	136	120	113	113
Maize (current)	136	136	158	196

US No.2, Yellow, FOB Gulf Ports

2/Ch$ = US$ x 178 x 1.16

3/Value added tax (20%) is excluded.

Financial farm gate prices (producer's price) of the agricultural products are given in Chapters 3 and 4. The economic farm gate prices of wheat and maize are calculated from probable 1990 and 1995 world market prices forcasted by the World Bank, which was up-dated in June 1985. The base year is changed from 1985 in this report. Economic prices of vegetables and fruits are assumed to be equal to their financial price.

Table A-16-10 Production Budget of Large-Sector (Financial and Economic Praices)

(Unit: Ch$/ha)

Crop		Price (Ch$/Kg)	Yield (t/ha)	Gross Production Value	Direction Production Cost			Net Production Value	Indirect Production Cost	Agricultural Net Return
					Planting	Formation	Production			
Wheat	Financial	30.0	6.5	195,000	-	-	77,800	117,200	23,000	94,200
	Economic	38.4	6.5	249,600	-	-	67,500	182,100	21,000	161,100
Table Grapes	Financial	69.0	Table A-16-11		480,500	116,100	186,000	G.P.V. - D.P.C.	23,000	N.P.V. - I.P.C.
	Economic	69.0			397,600	98,200	165,100		21,000	
Peaches	Financial	77.0			112,600	85,000	138,400		23,000	
	Economic	77.0			94,200	71,800	1119,400		21,000	
Nectarines	Financial	62.0			106,600	97,400	132,100		23,000	
	Economic	62.0			89,600	82,000	115,000		21,000	

Source: Table A-16-9, A-10-8 to 14, A-10-24

Table A-16-11 Useful Life and Production Volume of Fruits

(Unit : t/ha)

Year No.	Table Grapes	Peachs	Nectarines
1	0	0	0
2	0	0	0
3	4.0	0	0
4	5.5	0	0
5	11.5	8.5	10.5
6	12.5	9.5	11.5
7	13.5	10.5	12.5
8	14.5	12.0	13.5
9	15.5	13.5	15.0
10	16.5	15.0	16.5
11	15.9	14.5	16.0
12	15.3	14.5	16.0
13	14.7	14.5	16.0
14	14.1	14.5	16.0
15	13.4	14.0	15.5
16	12.6	13.5	15.0
17	11.8	13.0	14.0
18	10.9	12.0	13.0
19	9.6	11.0	12.0
20	8.2	10.0	11.0
21	7.0	9.5	10.5
22	6.0	9.0	10.0
23	5.0	8.5	9.5
24	4.5	8.0	9.0
25	4.0	7.5	8.5

Source : Table A-10-18

Table A-16-12 Project Benefit of Small-Sector (Economic Price)

(Unit : Ch$)

Block		Cropped Area(ha)		Grass Production Value		Direct Production Cost		Net Production Value		Indirect Production Cost		Agricultural Net Return			No. of Farm	Total Benefit (10^3)
		W.P.	W/O P.	W.P.	W/O P.	W.P.	W/O P.	W.P.	W/O P.	W.P.	W/O P.	W.P.	W/O P.	With-W/O		
1	Wheat	2.5	0.4	241,900	172,800	67,500	54,900	174,400	117,900							
	Maize	1.7	0.3	271,400	234,000	80,400	72,400	191,000	161,600							
	Vegetables	4.2	3.3	187,100	187,100	96,900	96,900	90,200	90,200							
	Fruits	1.1	0.4	781,100	518,300	130,800	130,800	650,300	387,500							
	Total	9.5	4.4	-	-	-	per Farm	1,854,900	548,300	116,900	113,500	1,738,000	434,800	1,303,200	68	88,618
2	Wheat	2.3	0.3	249,600	176,600	67,500	54,900	182,100	121,700							
	Maize	1.6	0.2	252,700	215,300	80,400	72,400	172,300	142,900							
	Vegetables	3.9	2.6	187,100	187,100	96,900	96,900	90,200	90,200							
	Fruits	1.0	0.3	781,100	518,300	130,800	130,800	650,300	387,500							
	Total	8.8	3.4	-	-	-	per Farm	1,696,600	415,900	108,500	87,700	1,588,100	328,200	1,259,900	128	161,267
3	Wheat	3.2	0.4	249,600	176,600	67,500	54,900	182,100	121,700							
	Maize	2.2	0.3	252,700	215,300	80,400	72,400	172,300	142,900							
	Vegetables	5.4	3.4	187,100	187,100	96,900	96,900	90,200	90,200							
	Fruits	1.3	0.5	781,100	518,300	130,800	130,800	650,300	387,500							
	Total	12.1	4.6	-	-	-	per Farm	2,294,300	592,000	146,300	118,700	2,148,000	473,300	1,674,700	85	142,350
4	Wheat	2.8	0.4	184,300	130,600	54,900	43,700	129,400	86,900							
	Maize	1.8	0.2	193,400	168,500	72,400	62,600	121,000	105,900							
	Vegetables	4.6	3.0	187,100	187,100	96,900	96,900	90,200	90,200							
	Fruits	1.2	0.4	781,100	518,300	130,800	130,800	650,300	387,500							
	Total	10.4	4.0	-	-	-	per Farm	1,775,400	481,500	127,400	89,600	1,648,000	391,900	1,256,100	549	689,599
Total															830	1,081,834

Note : W.P. = With Project, W/O P. = Without Project

Table A-16-13 Benefit Flow of Small-Sector (Economic Price)

(Unit : 10^3 Ch$)

No.	Year	Block-1	Block-2	Block-3	Block-4	Total
1	1987					
2	1988					
3	1989					
4	1990					
5	1991					
6	1992	88618	161267	142350	689599	1081834
7	1993	88618	161267	142350	689599	1081834
8	1994	88618	161267	142350	689599	1081834
9	1995	88618	161267	142350	689599	1081834
10	1996	88618	161267	142350	689599	1081834
11	1997	88618	161267	142350	689599	1081834
12	1998	88618	161267	142350	689599	1081834
13	1999	88618	161267	142350	689599	1081834
14	2000	88618	161267	142350	689599	1081834
15	2001	88618	161267	142350	689599	1081834
16	2002	88618	161267	142350	689599	1081834
17	2003	88618	161267	142350	689599	1081834
18	2004	88618	161267	142350	689599	1081834
19	2005	88618	161267	142350	689599	1081834
20	2006	88618	161267	142350	689599	1081834
21	2007	88618	161267	142350	689599	1081834
22	2008	88618	161267	142350	689599	1081834
23	2009	88618	161267	142350	689599	1081834
24	2010	88618	161267	142350	689599	1081834
25	2011	88618	161267	142350	689599	1081834
26	2012	88618	161267	142350	689599	1081834
27	2013	88618	161267	142350	689599	1081834
28	2014	88618	161267	142350	689599	1081834
29	2015	88618	161267	142350	689599	1081834
30	2016	88618	161267	142350	689599	1081834

Surce : Table A-16-12

Table A-16-14 Benefit Flow of Table Grapes (Economic Price)

(Unit : Ch$/ha)

No. of Year	Gross Production Value	Direct Production Cost	Indirect Production Cost	Agricul. Net Return *
1	0	397600	21000	-418600
2	0	98200	21000	-119200
3	276000	165100	21000	89900
4	379500	165100	21000	193400
5	793500	165100	21000	607400
6	862500	165100	21000	676400
7	931500	165100	21000	745400
8	1000500	165100	21000	814400
9	1069500	165100	21000	883400
10	1138500	165100	21000	952400
11	1097100	165100	21000	911000
12	1055700	165100	21000	869500
13	1014300	165100	21000	828200
14	972900	165100	21000	786800
15	924600	165100	21000	738500
16	869400	165100	21000	683300
17	814200	165100	21000	628100
18	752100	165100	21000	566000
19	662400	165100	21000	476300
20	565800	165100	21000	379700
21	483000	165100	21000	296900
22	414000	165100	21000	227900
23	345000	165100	21000	158900
24	310500	165100	21000	124400
25	276000	165100	21000	89900

Source : Table A-16-10, A-16-11

(Unit : 10^3 Ch$)

No.	Yera	Block-1 Irrigation 179 ha	Block-3 Irrigation 200 ha	Block-3 Irrigation 200 ha	Block-3 Irrigation 401 ha	Block-3 Sub-Total	Block-3 Flood Control 150 ha	Block-3 Flood Control 159 ha	Block-3 Sub-Total	Block-4 Irrigation 600 ha	Block-4 Irrigation 600 ha	Block-4 Irrigation 652 ha	Block-4 Sub-Total
1	1987												
2	1988												
3	1989												
4	1990												
5	1991												
6	1992	-74929	-83720			-83720	-62790		-62790	-251160			-251160
7	1993	-21337	-23840	-83720		-107560	-17880	-66557	-84437	-71520	-251160		-322680
8	1994	16092	17980	-23840	-167859	-173719	13485	-18953	-5468	53940	-71520	-272927	-290507
9	1995	34619	38680	17980	-47799	8861	29010	14294	43304	116040	53940	-77718	92262
10	1996	108725	121480	38680	36050	196210	91110	30751	121861	364440	116040	58615	539095
11	1997	121076	135280	121480	77553	334313	101460	96577	198037	405840	364440	126097	896377
12	1998	133427	149080	135280	243567	527927	111810	107548	219358	447240	405840	396025	1249105
13	1999	145778	162880	149080	271236	583196	122160	118519	240679	488640	447240	441013	1376893
14	2000	158129	176680	162880	298905	638465	132510	129490	262000	530040	488640	486001	1504681
15	2001	170480	190480	176680	326574	693734	142860	140461	283321	571440	530040	530989	1632469
16	2002	163069	182200	190480	354243	726923	136650	151432	288082	546600	571440	575977	1694017
17	2003	155658	173920	182200	381912	738032	130440	144849	275289	521760	546600	620965	1689325
18	2004	148248	165640	173920	365311	704871	124230	138266	262496	496920	521760	593972	1612652
19	2005	140837	157360	165640	348710	671710	118020	131684	249704	472080	496920	566979	1535979
20	2006	132192	147700	157360	332108	637168	110775	125101	235876	443100	472080	539986	1455166
21	2007	122311	136660	147700	315507	599867	106595	117422	224016	409980	443100	512994	1366074
22	2008	112430	125620	136660	296139	558419	97984	108645	206628	376860	409980	481502	1268342
23	2009	101314	113200	125620	274003	512823	88296	99868	188164	339600	376860	445512	1161972
24	2010	85258	95260	113200	251868	460328	74303	89994	164297	285780	339600	409521	1034901
25	2011	67966	75940	95260	226966	398166	59233	75732	134965	227820	285780	369032	882632
26	2012	53145	59380	75940	190996	326316	46316	60372	106689	178140	227820	310548	716508
27	2013	40794	45580	59380	152260	257220	35552	47207	82760	136740	178140	247564	562444
28	2014	28443	31780	45580	119057	196417	24788	36236	61025	95340	136740	193579	425659
29	2015	22268	24880	31780	91388	148048	19406	25265	44672	74640	95340	148591	318571
30	2016	16092	17580	24880	63719	106579	14024	19780	33804	53940	74640	103603	232183

Source : * x Table A-16-6

Table A-16-15 Benefit Flow of Peaches (Economic Price)

(Unit : Ch$/ha)

No. of Year	Gross Production Value	Direct Production Cost	Indirect Production Cost	Agricul. Net Return *
1	0	94200	21000	-115200
2	0	71800	21000	-92800
3	0	71800	21000	-92800
4	0	71800	21000	-92800
5	654500	119400	21000	514100
6	731500	119400	21000	591100
7	808500	119400	21000	668100
8	924000	119400	21000	783600
9	1039500	119400	21000	899100
10	1155000	119400	21000	1014600
11	1116500	119400	21000	976100
12	1116500	119400	21000	976100
13	1116500	119400	21000	976100
14	1116500	119400	21000	976100
15	1078000	119400	21000	937600
16	1039500	119400	21000	899100
17	1001000	119400	21000	860600
18	924000	119400	21000	783600
19	847000	119400	21000	706600
20	770000	119400	21000	629600
21	731500	119400	21000	591100
22	693000	119400	21000	552600
23	654500	119400	21000	514100
24	616000	119400	21000	475600
25	577500	119400	21000	437100

Source : Table A-16-10, A-16-11

(Unit : 10^3 Ch$)

No.	Year	Block-4 Irrigation 500 ha	500 ha	500 ha	Total
1	1987				
2	1988				
3	1989				
4	1990				
5	1991				
6	1992	-57600			-57600
7	1993	-46400	-57600		-104000
8	1994	-46400	-46400	-57600	-150400
9	1995	-46400	-46400	-46400	-139200
10	1996	257050	-46400	-46400	164250
11	1997	295550	257050	-46400	506200
12	1998	334050	295550	257050	886650
13	1999	391800	334050	295550	1021400
14	2000	449550	391800	334050	1175400
15	2001	507300	449550	391800	1348650
16	2002	488050	507300	449550	1444900
17	2003	488050	488050	507300	1483400
18	2004	488050	488050	488050	1464150
19	2005	488050	488050	488050	1464150
20	2006	468800	488050	488050	1444900
21	2007	449550	468800	488050	1406400
22	2008	430300	449550	468800	1348650
23	2009	391800	430300	449550	1271650
24	2010	353300	391800	430300	1175400
25	2011	314800	353300	391800	1059900
26	2012	295550	314800	353300	963650
27	2013	276300	295550	314800	886650
28	2014	257050	276300	295550	828900
29	2015	237800	257050	276300	771150
30	2016	218550	237800	257050	713400

Source ; * x Table A-16-6

Table A-16-16 Benefit Flow of Nectarines (Economic Price)

(Unit : Ch$/ha)

No. of Year	Gross Production Value	Direct Production Cost	Indirect Production Cost	Agricul. Net Return *
1	0	89600	21000	-110600
2	0	82000	21000	-103000
3	0	82000	21000	-103000
4	0	82000	21000	-103000
5	651000	115000	21000	515000
6	713000	115000	21000	577000
7	775000	115000	21000	639000
8	837000	115000	21000	701000
9	930000	115000	21000	794000
10	1023000	115000	21000	887000
11	992000	115000	21000	856000
12	992000	115000	21000	856000
13	992000	115000	21000	856000
14	992000	115000	21000	856000
15	961000	115000	21000	825000
16	930000	115000	21000	794000
17	868000	115000	21000	732000
18	806000	115000	21000	670000
19	744000	115000	21000	608000
20	682000	115000	21000	546000
21	651000	115000	21000	515000
22	620000	115000	21000	484000
23	589000	115000	21000	453000
24	558000	115000	21000	422000
25	527000	115000	21000	391000

Source : Table A-16-10, A-16-11

(Unit : 10^3 Ch$)

No.	Year	Block-4 Irrigation 300 ha	350 ha	350 ha	Total
1	1987				
2	1988				
3	1989				
4	1990				
5	1991				
6	1992	-33180			-33180
7	1993	-30900	-38710		-69610
8	1994	-30900	-36050	-38710	-105660
9	1995	-30900	-36050	-36050	-103000
10	1996	154500	-36050	-36050	82400
11	1997	173100	180250	-36050	317300
12	1998	191700	201950	180250	573900
13	1999	210300	223650	201950	635900
14	2000	238200	245350	223650	707200
15	2001	266100	277900	245350	789350
16	2002	256800	310450	277900	845150
17	2003	256800	299600	310450	866850
18	2004	256800	299600	299600	856000
19	2005	256800	299600	299600	856000
20	2006	247500	299600	299600	846700
21	2007	238200	288750	299600	826550
22	2008	219600	277900	288750	786250
23	2009	201000	256200	277900	735100
24	2010	182400	234500	256200	673100
25	2011	163800	212800	234500	611100
26	2012	154500	191100	212800	558400
27	2013	145200	180250	191100	516550
28	2014	135900	169400	180250	485550
29	2015	126600	158550	169400	454550
30	2016	117300	147700	158550	423550

Source : * x Table A-16-6

Table A-16-17 Benefit Flow of Wheat (Economic Price)

(Unit : 10^3 Ch$)

No.	Year	Block-3 Irrigation 601 ha 401 ha	Block-3 Flood 159 ha	Block-4 Irrigation 2,952 ha 1,502 ha	Total 3,712 ha 1,903 ha
1	1987				
2	1988				
3	1989				
4	1990				
5	1991				
6	1992	96821	25615	475567	598003
7	1993	64601		241972	306573
8	1994				
9	1995				
10	1996				
11	1997				
12	1998				
13	1999				
14	2000				
15	2001				
16	2002				
17	2003				
18	2004				
19	2005				
20	2006				
21	2007				
22	2008				
23	2009				
24	2010				
25	2011				
26	2012				
27	2013				
28	2014				
29	2015				
30	2016				

Source : Table A-16-6, A-16-10

Table A-16-18 Benefit Flow of Water Quality Improvement (Economic Price)

(Unit : 10^3 Ch$)

No.	Yera	Block-1	Block-2	Block-3	Total	Total Benefit of Large-Sector (Economic Price)
1	1987					0
2	1988					0
3	1989					0
4	1990					0
5	1991					0
6	1992	3125	11006	7056	21187	55811
7	1993	3125	11005	7056	21187	-381864
8	1994	3125	11006	7056	21187	-688475
9	1995	3125	11006	7056	21187	-41968
10	1996	3125	11006	7056	21187	1233727
11	1997	3125	11006	7056	21187	2394489
12	1998	3125	11006	7056	21187	3611553
13	1999	3125	11006	7056	21187	4025032
14	2000	3125	11006	7056	21187	4467061
15	2001	3125	11006	7056	21187	4939190
16	2002	3125	11006	7056	21187	5183328
17	2003	3125	11006	7056	21187	5229742
18	2004	3125	11006	7056	21187	5069604
19	2005	3125	11006	7056	21187	4939567
20	2006	3125	11006	7056	21187	4773189
21	2007	3125	11006	7056	21187	4566404
22	2008	3125	11006	7056	21187	4301906
23	2009	3125	11006	7056	21187	3992210
24	2010	3125	11006	7056	21187	3614471
25	2011	3125	11006	7056	21187	3175916
26	2012	3125	11006	7056	21187	2745895
27	2013	3125	11006	7056	21187	2367605
28	2014	3125	11006	7056	21187	2047180
29	2015	3125	11006	7056	21187	1780445
30	2016	3125	11006	7056	21187	1546795

Source : Table 6-2-3

Source : Table A-16-14 to A-16-18

Table A-16-19 Benefit Flow of Road and Bridge Improvements (Economic Price)

(Unit : 10^3 Ch$)

No.	Yera	Block-1	Block-2	Block-3	Block-4	Total
1	1987					
2	1988					
3	1989					
4	1990					
5	1991					
6	1992	3382	8430	9148	28568	49528
7	1993	3382	8430	9148	28568	49528
8	1994	3382	8430	9148	28568	49528
9	1995	3382	8430	9148	28568	49528
10	1996	3382	8430	9148	28568	49528
11	1997	3382	8430	9148	28568	49528
12	1998	3382	8430	9148	28568	49528
13	1999	3382	8430	9148	28568	49528
14	2000	3382	8430	9148	28568	49528
15	2001	3382	8430	9148	28568	49528
16	2002	3382	8430	9148	28568	49528
17	2003	3382	8430	9148	28568	49528
18	2004	3382	8430	9148	28568	49528
19	2005	3382	8430	9148	28568	49528
20	2006	3382	8430	9148	28568	49528
21	2007	3382	8430	9148	28568	49528
22	2008	3382	8430	9148	28568	49528
23	2009	3382	8430	9148	28568	49528
24	2010	3382	8430	9148	28568	49528
25	2011	3382	8430	9148	28568	49528
26	2012	3382	8430	9148	28568	49528
27	2013	3382	8430	9148	28568	49528
28	2014	3382	8430	9148	28568	49528
29	2015	3382	8430	9148	28568	49528
30	2016	3382	8430	9148	28568	49528

Source : Table A-16-7

Table A-16-20 Benefit Flow of Flood Control (Economic Price)

(Unit : 10^3 Ch$)

No.	Year	Damage of Houses	Damage of Road	Loss of Product	Consumptiom of Combustible	Total
1	1987					
2	1988					
3	1989					
4	1990					
5	1991					
6	1992	85520	60076	61131	49496	256222
7	1993	87440	61307	62312	51386	262445
8	1994	89360	62539	63493	53276	268668
9	1995	91280	63770	64675	55167	274891
10	1996	93200	65001	65856	57057	281114
11	1997	95766	66610	67402	58453	288231
12	1998	98331	68218	68949	59849	295347
13	1999	100897	69826	70495	61244	302463
14	2000	103463	71434	72042	62640	309579
15	2001	106029	73042	73588	64036	316695
16	2002	108594	74650	75135	65432	323811
17	2003	111160	76259	76681	66828	330927
18	2004	113726	77867	78227	68223	338043
19	2005	116291	79475	79774	69619	345159
20	2006	118857	81083	81320	71015	352275
21	2007	121423	82691	82867	72411	359392
22	2008	123989	84299	84413	73806	366508
23	2009	126554	85908	85960	75202	373624
24	2010	129120	87516	87506	76598	380740
25	2011	131686	89124	89052	77994	387856
26	2012	134251	90732	90599	79390	394972
27	2013	136817	92340	92145	80785	402088
28	2014	139383	93948	93692	82181	409204
29	2015	141949	95557	95238	83577	416320
30	2016	144514	97165	96785	84973	423436

Source : Table A-16-8

Table A-16-21 Project Cost (Economic Price)

(Unit : 10^6 Ch$)

Item	Local Currency: Land Acquisition	Local Currency: Unskilled Labour	Local Currency: Semiskilled Labour	Local Currency: Skilled Labour	Local Currency: Material	Local Currency: Transportation	Local Currency: Sub-Total	Foreign Currency	Total
Construction Cost									
Block 1									
I ESP HDWKS									
I ESP CANAL									
I ESP DVS									
I ESP CHUTE									
I TER CANAL	.0	11.6	1.2	.8	57.6	12.6	83.8	257.8	341.6
Q TREATMENT	.0	18.0	2.5	1.4	22.7	5.2	49.8	265.7	315.6
F EST FRIO	.0	2.4	.3	.2	.0	1.3	4.1	26.1	30.2
T BRIDGE	.0	.5	.1	.1	2.9	.4	3.9	8.2	12.1
Block 2									
Q ORTUZANO									
Q RINCONADA									
Q LOMA BLNC									
Q ENCANADO	.0	40.2	6.4	4.8	6.7	17.3	75.5	883.9	959.4
T BRIDGE	.0	.8	.2	.1	1.9	.4	3.4	7.8	11.2
Block 3 & 4									
IQ PUNTA CNL									
IQ SIPHON									
IQ SIPHON									
IQ SIPHON									
IQ CARMN CNL									
I CARMEN(B)									
IQ DIVERSION									
I TUNNEL									
I TUNNEL									
I TUNNEL									
I SANCARLOS									
I TER CANAL	.0	240.2	62.1	43.7	1,512.7	232.5	2,091.2	4,741.4	6,832.6
F LAMPA(1)									
F LAMPA(2,3)									
F MEMB BRDG									
F NOVC BRDG									
F BOZA BRDG									
F COLINA									
F CSQR BRDG									
F PRMV BRDG									
F CHORO(A)									
F CAREN (A)									
F CAREN (B)									
F CHOROS(B)									
F CHOROS(C)									
F DRAIN C-1									
F DRAIN C-2									
F SABO DAM									
F TEM MPCHO	.0	214.5	32.4	40.8	988.5	189.3	1,465.5	3,859.9	5,325.4
T ROAD (A)									
T ROAD (B)									
T BR A,B,C	.0	28.1	2.8	2.8	50.8	15.6	100.2	317.1	417.3
Sub-Total	.0	556.3	108.0	94.7	2,643.8	474.6	3,877.4	10,367.8	14,245.3
Procurement of O/M Equipment						.0	.0	257.2	257.2
Administration Cost		9.1		79.2			88.3		88.3
Consulting Services				301.0			301.0	1,104.8	1,405.7
Sub-Total		9.1	.0	380.2	.0	.0	389.3	1,362.0	1,751.3
Total							4,266.8	11,729.8	15,996.6

Source : Table 5-3-4, 6-3-1

Note : Land Acquisition = F.P. x 0, Unskilled Labour = F.P. x 0.5
Semiskilled Labour = F.P. x 0.52, Skilled Labour = F.P. x 1.0
Material = F.P. - IVA(0.2), Transportation = F.P. - IVA(0.2)
Foreign Currency = F.P. x Shadow Price(1.13) - Import Duty(0.3) - Sale Tax(0.03)
F.P. = Financial Price

Table A-16-22 Project Disbursment (Economic Price)

(Unit : 10^3 Ch$)

Item	1987 F/C	1987 L/C	1987 TOTAL	1988 F/C	1988 L/C	1988 TOTAL	1989 F/C	1989 L/C	1989 TOTAL
Block-1 Irrigation			0	2037	932	2969	247615	79140	326755
Water Quality			0	0	0	0	0	0	0
Flood Control			0	2008	316	2323	8031	1261	9292
Transportation			0	912	434	1345	3645	1733	5378
Block-2 Water Quality			0	0	0	0	0	0	0
Transportation			0	867	378	1246	3467	1511	4978
Block-3,4 Irrigation			0	109660	53681	163341	1502733	664622	2167356
Flood Control			0	282710	105287	387997	1130835	421148	1551983
Transportation			0	35233	11133	46366	140933	44533	185467
Total Construction Cost				433426	172161	605587	3037259	1213949	4251208
Procurement of O/M Equipment	0	0	0	0	0	0	0	0	0
Administration Cost	0	15840	15840	0	24940	24940	0	15840	15840
Consulting Services	459173	129927	589100	126664	25523	152188	163209	48406	211616
Sub-Total	459173	145767	604940	126664	50463	177128	163209	64246	227456
Total	459173	145767	604940	560091	222625	782715	3200468	1278195	4478663

Item	1990 F/C	1990 L/C	1990 TOTAL	1991 F/C	1991 L/C	1991 TOTAL	TOTAL F/C	TOTAL L/C	TOTAL TOTAL
Block-1 Irrigation	8148	3728	11876				257,800	83,800	341,600
Water Quality	132849	24900	157749	132851	24900	157751	265,700	49,800	315,500
Flood Control	8031	1261	9292	8031	1261	9292	26,100	4,100	30,200
Transportation	3645	1733	5378	0	0	0	8,200	3,900	12,100
Block-2 Water Quality	441950	37750	479700	441950	37750	479700	883,900	75,500	959,400
Transportation	3467	1511	4978	0	0	0	7,800	3,400	11,200
Block-3,4 Irrigation	1502733	664622	2167356	1626274	708274	2334548	4,741,400	2,091,200	6,832,600
Flood Control	1315520	517918	1833437	1130835	421148	1551983	3,859,900	1,465,500	5,325,400
Transportation	140933	44533	185467	0	0	0	317,100	100,200	417,300
Total Construction Cost	3557276	1297956	4855232	3339942	1193332	4533274	10,367,900	3,877,400	14,245,300
Procurement of O/M Equipment	0	0	0	257200	0	257200	257,200	0	257,200
Administration Cost	0	15840	15840	0	15840	15840	0	88,300	88,300
Consulting Services	170543	48406	218949	185211	48736	233947	1,104,800	301,000	1,405,800
Sub-Total	170543	64246	234789	442411	64576	506987	1,362,000	389,300	1,751,300
Total	3727819	1362202	5090022	3782353	1257909	5040261	11,729,900	4,266,700	15,996,600

Source : Table 5-6-2, A-16-21

Table A-16-23 Sensitivity Analysis with Flood Control Benefit (Economic Price)

(Unit : 10^3 Ch$)

No.	Year	Flood Control Benefit	Project Benefit	Total Benefit	Project Cost & Replacement Cost	O/M Cost	Total Cost	Benefit - Cost	Present Value (10%,1987:12%) Benefit	Present Value (10%,1987:12%) Cost
1	1987		0	0	604940		604940	-604940	0	540125
2	1988		0	0	782715		782715	-782715	0	646872
3	1989		0	0	4478663		4478663	-4478663	0	3364886
4	1990		0	0	5090022		5090022	-5090022	0	3476554
5	1991		0	0	5040261		5040261	-5040261	0	3129606
6	1992	256222	1187173	1443395		52700	52700	1390696	814759	29747
7	1993	262445	749498	1011943		52700	52700	959244	519287	27043
8	1994	268668	442888	711556		52700	52700	658856	331946	24585
9	1995	274891	1089394	1364285		52700	52700	1311586	578590	22350
10	1996	281114	2365089	2646203		52700	52700	2593504	1020226	20318
11	1997	288231	3525851	3814082		52700	52700	3761382	1336812	18471
12	1998	295347	4742915	5038262		52700	52700	4985563	1605346	16792
13	1999	302463	5156394	5458857		52700	52700	5406158	1581236	15265
14	2000	309579	5598423	5908002		52700	52700	5855303	1555762	13877
15	2001	316695	6070552	6387247	371436	52700	424136	5963112	1529056	101535
16	2002	323811	6314690	6638501		52700	52700	6585801	1444731	11469
17	2003	330927	6361104	6692031		52700	52700	6639331	1323983	10426
18	2004	338043	6200966	6539009		52700	52700	6486310	1176098	9478
19	2005	345159	6070929	6416088		52700	52700	6363389	1049082	8617
20	2006	352275	5904551	6256827		52700	52700	6204127	930037	7833
21	2007	359392	5697766	6057158		52700	52700	6004458	818507	7121
22	2008	366508	5433268	5799775		52700	52700	5747076	712479	6474
23	2009	373624	5123572	5497196		52700	52700	5444496	613917	5885
24	2010	380740	4745833	5126573		52700	52700	5073873	520478	5350
25	2011	387856	4307278	4695134	846671	52700	899370	3795764	433342	83008
26	2012	394972	3877257	4272229		52700	52700	4219529	358463	4422
27	2013	402088	3498967	3901055		52700	52700	3848355	297563	4020
28	2014	409204	3178542	3587747		52700	52700	3535047	248786	3654
29	2015	416320	2911807	3328127		52700	52700	3275428	209803	3322
30	2016	423436	2678157	3101593	-542144	52700	-489445	3591038	177748	-28049
								Total	21188039	11591057

Source : Table 6-3-2, A-16-20

EIRR= .1610647
ENPV(10%)= 9596982 x 10^3 Ch$
(1987:12%)
B/C(10%)= 1.827964
(1987:12%)

16.4 Financial Evaluation

Table A-16-24 Project Benefit of Small-Sector (Financial Price)

(Unit : Ch$)

Block	Cropped Area(ha)		Grass Production Value		Direct Production Cost		Net Production Value		Indirect Production Cost		Agricultural Net Return			No. of Farm	Total Benefit (10^3)
	W.P.	W/O P.	W.P.	W/O P.	W.P.	W/O P.	W.P.	W/O P.	W.P.	W/O P.	W.P.	W/O P.	With-W/O		
Wheat	2.5	0.4	189,000	135,000	77,800	62,200	111,200	72,800							
Maize	1.7	0.3	169,700	146,300	91,900	80,900	77,800	65,400							
1 Vegetables	4.2	3.3	187,100	187,100	106,600	106,600	80,500	80,500							
Fruits	1.1	0.4	781,100	518,300	148,300	148,300	632,800	370,000							
Total	9.5	4.4	-	-	-	per Farm	1,444,400	462,400	130,100	126,700	1,314,300	335,700	978,600	68	66,545
Wheat	2.3	0.3	195,000	138,000	77,800	62,200	117,200	75,800							
Maize	1.6	0.2	158,000	134,600	91,900	80,900	66,100	53,700							
Vegetables	3.9	2.6	187,100	187,100	106,600	106,600	80,500	80,500							
Fruits	1.0	0.3	781,100	518,300	148,300	148,300	632,800	370,000							
Total	8.8	3.4	-	-	-	per Farm	1,322,100	353,800	118,700	97,900	1,203,400	255,900	947,500	128	121,280
Wheat	3.2	0.4	195,000	138,000	77,800	62,200	117,200	75,800							
Maize	2.2	0.3	158,000	134,600	91,900	80,900	66,100	53,700							
3 Vegetables	5.4	3.4	187,100	187,100	106,600	106,600	80,500	80,500							
Fruits	1.3	0.5	781,100	518,300	148,300	148,300	632,800	370,000							
Total	12.1	4.6	-	-	-	per Farm	1,777,800	505,100	160,100	132,500	1,617,700	372,600	1,245,100	85	105,834
Wheat	2.8	0.4	144,000	102,000	62,200	49,100	81,800	52,900							
Maize	1.8	0.2	120,900	105,300	80,900	69,900	40,000	35,400							
4 Vegetables	4.6	3.0	187,100	187,100	106,600	106,600	80,500	80,500							
Fruits	1.2	0.4	781,100	518,300	148,300	148,300	632,800	370,000							
Total	10.4	4.0	-	-	-	per Farm	1,430,700	417,700	139,400	101,600	1,291,300	316,100	975,200	549	535,385
Total														830	829,044

Note : W.P. = With Project, W/O P. = Without Project

Table A-16-25 Benefit Flow of Small-Sector (Financial Price)

(Unit : 10^3 Ch$)

No.	Year	Block-1	Block-2	Block-3	Block-4	Total
1	1987					
2	1988					
3	1989					
4	1990					
5	1991					
6	1992	66545	121280	105834	535385	829044
7	1993	66545	121280	105834	535385	829044
8	1994	66545	121280	105834	535385	829044
9	1995	66545	121280	105834	535385	829044
10	1996	66545	121280	105834	535385	829044
11	1997	66545	121280	105834	535385	829044
12	1998	66545	121280	105834	535385	829044
13	1999	66545	121280	105834	535385	829044
14	2000	66545	121280	105834	535385	829044
15	2001	66545	121280	105834	535385	829044
16	2002	66545	121280	105834	535385	829044
17	2003	66545	121280	105834	535385	829044
18	2004	66545	121280	105834	535385	829044
19	2005	66545	121280	105834	535385	829044
20	2006	66545	121280	105834	535385	829044
21	2007	66545	121280	105834	535385	829044
22	2008	66545	121280	105834	535385	829044
23	2009	66545	121280	105834	535385	829044
24	2010	66545	121280	105834	535385	829044
25	2011	66545	121280	105834	535385	829044
26	2012	66545	121280	105834	535385	829044
27	2013	66545	121280	105834	535385	829044
28	2014	66545	121280	105834	535385	829044
29	2015	66545	121280	105834	535385	829044
30	2016	66545	121280	105834	535385	829044

Source : Table A-16-24

Table A-16-26 Benefit Flow of Table Grapes (Financial Price)

(Unit : Ch$/ha)

No. of Year	Gross Production Value	Direct Production Cost	Indirect Production Cost	Agricul. Net Return *
1	0	480500	23000	-503500
2	0	116100	23000	-139100
3	276000	186000	23000	67000
4	379500	186000	23000	170500
5	793500	186000	23000	584500
6	862500	186000	23000	653500
7	931500	186000	23000	722500
8	1000500	186000	23000	791500
9	1069500	186000	23000	860500
10	1138500	186000	23000	929500
11	1097100	186000	23000	888100
12	1055700	186000	23000	846700
13	1014300	186000	23000	805300
14	972900	186000	23000	763900
15	924600	186000	23000	715600
16	869400	186000	23000	660400
17	814200	186000	23000	605200
18	752100	186000	23000	543100
19	662400	186000	23000	453400
20	565800	186000	23000	356800
21	483000	186000	23000	274000
22	414000	186000	23000	205000
23	345000	186000	23000	136000
24	310500	186000	23000	101500
25	276000	186000	23000	67000

Source : Table A-16-10, A-16-11

(Unit : 10^3 Ch$)

No.	Yera	Block-1 Irrigation 179 ha	Block-3 Irrigation 200 ha	Block-3 Irrigation 200 ha	Block-3 Irrigation 401 ha	Block-3 Sub-Total	Flood Control 150 ha	Flood Control 159 ha	Sub-Total	Block-4 Irrigation 600 ha	Block-4 Irrigation 600 ha	Block-4 Irrigation 652 ha	Block-4 Sub-Total
1	1987												
2	1988												
3	1989												
4	1990												
5	1991												
6	1992	-90127	-100700			-100700	-75525		-75525	-302100			-302100
7	1993	-24899	-27820	-100700		-128520	-20865	-80057	-100922	-83460	-302100		-385560
8	1994	11993	13400	-27820	-201904	-216324	10050	-22117	-12067	40200	-83460	-328282	-371542
9	1995	30520	34100	13400	-55779	-8279	25575	10653	36228	102300	40200	-90693	51807
10	1996	104626	116900	34100	26867	177867	87675	27110	114785	350700	102300	43684	496684
11	1997	116977	130700	116900	68371	315971	98025	92936	190961	392100	350700	111166	853966
12	1998	129328	144500	130700	234385	509585	108375	103907	212282	433500	392100	381094	1206694
13	1999	141679	158300	144500	262054	564854	118725	114878	233603	474900	433500	426082	1334482
14	2000	154030	172100	158300	289723	620123	129075	125849	254924	516300	474900	471070	1462270
15	2001	166381	185900	172100	317392	675392	139425	136820	276245	557700	516300	516058	1590058
16	2002	158970	177620	185900	345061	708581	133215	147791	281006	532860	557700	561046	1651606
17	2003	151559	169340	177620	372730	719690	127005	141208	268213	508020	532860	606034	1646914
18	2004	144149	161060	169340	356128	686528	120795	134625	255420	483180	508020	579041	1570241
19	2005	136738	152780	161060	339527	653367	114585	128043	242628	458340	483180	552048	1493568
20	2006	128092	143120	152780	322925	618825	107340	121460	228800	429360	458340	525056	1412756
21	2007	118212	132080	143120	306324	581524	99060	113780	212840	396240	429360	498063	1323663
22	2008	108331	121040	132080	286956	540076	90780	105004	195784	363120	396240	466571	1225931
23	2009	97215	108620	121040	264820	494480	81465	96227	177692	325860	363120	430581	1119561
24	2010	81159	90680	108620	242685	441985	68010	86353	154363	272040	325860	394590	992490
25	2011	63867	71360	90680	217783	379823	53520	72091	125611	214080	272040	354101	840221
26	2012	49046	54800	71360	181813	307973	41100	56731	97831	164400	214080	295617	674097
27	2013	36695	41000	54800	143077	238877	30750	43566	74316	123000	164400	232634	520034
28	2014	24344	27200	41000	109874	178074	20400	32595	52995	81600	123000	178648	383248
29	2015	18169	20300	27200	82205	129705	15225	21624	36849	60900	81600	133660	276160
30	2016	11993	13400	20300	54536	88236	10050	16139	26189	40200	60900	88672	189772

Source : * x Table A-16-6

Table A-16-27 Benefit Flow of Peaches (Financial Price)

(Unit : Ch$/ha)

No. of Year	Gross Production Value	Direct Production Cost	Indirect Production Cost	Agricul. Net Return *
1	0	112600	23000	-135600
2	0	85000	23000	-108000
3	0	85000	23000	-108000
4	0	85000	23000	-108000
5	654500	138400	23000	493100
6	731500	138400	23000	570100
7	808500	138400	23000	647100
8	924000	138400	23000	762600
9	1039500	138400	23000	878100
10	1155000	138400	23000	993600
11	1116500	138400	23000	955100
12	1116500	138400	23000	955100
13	1116500	138400	23000	955100
14	1116500	138400	23000	955100
15	1078000	138400	23000	916600
16	1039500	138400	23000	878100
17	1001000	138400	23000	839600
18	924000	138400	23000	762600
19	847000	138400	23000	685600
20	770000	138400	23000	608600
21	731500	138400	23000	570100
22	693000	138400	23000	531600
23	654500	138400	23000	493100
24	616000	138400	23000	454600
25	577500	138400	23000	416100

Source : Table A-16-10, A-16-11

(Unit : 10^3 Ch$)

No.	Year	Block-4 Irrigation 500 ha	500 ha	500 ha	Total
1	1987				
2	1988				
3	1989				
4	1990				
5	1991				
6	1992	-67800			-67800
7	1993	-54000	-67800		-121800
8	1994	-54000	-54000	-67800	-175800
9	1995	-54000	-54000	-54000	-162000
10	1996	246550	-54000	-54000	138550
11	1997	285050	246550	-54000	477600
12	1998	323550	285050	246550	855150
13	1999	381300	323550	285050	989900
14	2000	439050	381300	323550	1143900
15	2001	496800	439050	381300	1317150
16	2002	477550	496800	439050	1413400
17	2003	477550	477550	496800	1451900
18	2004	477550	477550	477550	1432650
19	2005	477550	477550	477550	1432650
20	2006	458300	477550	477550	1413400
21	2007	439050	458300	477550	1374900
22	2008	419800	439050	458300	1317150
23	2009	381300	419800	439050	1240150
24	2010	342800	381300	419800	1143900
25	2011	304300	342800	381300	1028400
26	2012	285050	304300	342800	932150
27	2013	265800	285050	304300	855150
28	2014	246550	265800	285050	797400
29	2015	227300	246550	265800	739650
30	2016	208050	227300	246550	681900

Source ; * x Table A-16-6

Table A-16-28 Benefit Flow of Nectarines (Financial Price)

(Unit : Ch$/ha)

No. of Year	Gross Production Value	Direct Production Cost	Indirect Production Cost	Agricul. Net Return *
1	0	106600	23000	-129600
2	0	97400	23000	-120400
3	0	97400	23000	-120400
4	0	97400	23000	-120400
5	651000	132100	23000	495900
6	713000	132100	23000	557900
7	775000	132100	23000	619900
8	837000	132100	23000	681900
9	930000	132100	23000	774900
10	1023000	132100	23000	867900
11	992000	132100	23000	836900
12	992000	132100	23000	836900
13	992000	132100	23000	836900
14	992000	132100	23000	836900
15	961000	132100	23000	805900
16	930000	132100	23000	774900
17	868000	132100	23000	712900
18	806000	132100	23000	650900
19	744000	132100	23000	588900
20	682000	132100	23000	526900
21	651000	132100	23000	495900
22	620000	132100	23000	464900
23	589000	132100	23000	433900
24	558000	132100	23000	402900
25	527000	132100	23000	371900

Source : Table A-16-10, A-16-11

(Unit : 10^3 Ch$)

No.	Year	Block-4 Irrigation 300 ha	350 ha	350 ha	Total
1	1987				
2	1988				
3	1989				
4	1990				
5	1991				
6	1992	-38880			-38880
7	1993	-36120	-45360		-81480
8	1994	-36120	-42140	-45360	-123620
9	1995	-36120	-42140	-42140	-120400
10	1996	148770	-42140	-42140	64490
11	1997	167370	173565	-42140	298795
12	1998	185970	195265	173565	554800
13	1999	204570	216965	195265	616800
14	2000	232470	238665	216965	688100
15	2001	260370	271215	238665	770250
16	2002	251070	303765	271215	826050
17	2003	251070	292915	303765	847750
18	2004	251070	292915	292915	836900
19	2005	251070	292915	292915	836900
20	2006	241770	292915	292915	827600
21	2007	232470	282065	292915	807450
22	2008	213870	271215	282065	767150
23	2009	195270	249515	271215	716000
24	2010	176670	227815	249515	654000
25	2011	158070	206115	227815	592000
26	2012	148770	184415	206115	539300
27	2013	139470	173565	184415	497450
28	2014	130170	162715	173565	466450
29	2015	120870	151865	162715	435450
30	2016	111570	141015	151865	404450

Source : * x Table A-16-6

Table A-16-29 Benefit Flow of Wheat (Financial Price)

(Unit : 10^3 Ch$)

No.	Year	Block-3 Irrigation 601 ha 401 ha	Block-3 Flood 159 ha	Block-4 Irrigation 2,952 ha 1,502 ha	Total 3,712 ha 1,903 ha
1	1987				
2	1988				
3	1989				
4	1990				
5	1991				
6	1992	56614	14978	278078	349670
7	1993	37774		141488	179263
8	1994				
9	1995				
10	1996				
11	1997				
12	1998				
13	1999				
14	2000				
15	2001				
16	2002				
17	2003				
18	2004				
19	2005				
20	2006				
21	2007				
22	2008				
23	2009				
24	2010				
25	2011				
26	2012				
27	2013				
28	2014				
29	2015				
30	2016				

Source : Table A-16-6, A-16-10

Table A-16-30 Benefit Flow of Water Quality Improvement (Financial Price)

(Unit : 10^3 Ch$)

No.	Yera	Block-1	Block-2	Block-3	Total	Total Benefit of Large-Sector (Financial Price)
1	1987					0
2	1988					0
3	1989					0
4	1990					0
5	1991					0
6	1992	3125	11006	7056	21187	-304274
7	1993	3125	11006	7056	21187	-642731
8	1994	3125	11006	7056	21187	-866172
9	1995	3125	11006	7056	21187	-150938
10	1996	3125	11006	7056	21187	1118188
11	1997	3125	11006	7056	21187	2275456
12	1998	3125	11006	7056	21187	3489025
13	1999	3125	11006	7056	21187	3902504
14	2000	3125	11006	7056	21187	4344533
15	2001	3125	11006	7056	21187	4816662
16	2002	3125	11006	7056	21187	5060799
17	2003	3125	11006	7056	21187	5107213
18	2004	3125	11006	7056	21187	4947075
19	2005	3125	11006	7056	21187	4817038
20	2006	3125	11006	7056	21187	4650660
21	2007	3125	11006	7056	21187	4439776
22	2008	3125	11006	7056	21187	4175608
23	2009	3125	11006	7056	21187	3866285
24	2010	3125	11006	7056	21187	3489084
25	2011	3125	11006	7056	21187	3051109
26	2012	3125	11006	7056	21187	2621584
27	2013	3125	11006	7056	21187	2243708
28	2014	3125	11006	7056	21187	1923698
29	2015	3125	11006	7056	21187	1657170
30	2016	3125	11006	7056	21187	1423727

Note : Equal in Table A-16-18 (Economic Price)

Source : Table A-16-26 to A-16-30

Table A-16-31 Benefit Flow of Road and Bridge Improvements (Financial Price)

(Unit : 10^3 Ch$)

No.	Yera	Block-1	Block-2	Block-3	Block-4	Total
1	1987					
2	1988					
3	1989					
4	1990					
5	1991					
6	1992	3382	8430	9148	28568	49528
7	1993	3382	8430	9148	28568	49528
8	1994	3382	8430	9148	28568	49528
9	1995	3382	8430	9148	28568	49528
10	1996	3382	8430	9148	28568	49528
11	1997	3382	8430	9148	28568	49528
12	1998	3382	8430	9148	28568	49528
13	1999	3382	8430	9148	28568	49528
14	2000	3382	8430	9148	28568	49528
15	2001	3382	8430	9148	28568	49528
16	2002	3382	8430	9148	28568	49528
17	2003	3382	8430	9148	28568	49528
18	2004	3382	8430	9148	28568	49528
19	2005	3382	8430	9148	28568	49528
20	2006	3382	8430	9148	28568	49528
21	2007	3382	8430	9148	28568	49528
22	2008	3382	8430	9148	28568	49528
23	2009	3382	8430	9148	28568	49528
24	2010	3382	8430	9148	28568	49528
25	2011	3382	8430	9148	28568	49528
26	2012	3382	8430	9148	28568	49528
27	2013	3382	8430	9148	28568	49528
28	2014	3382	8430	9148	28568	49528
29	2015	3382	8430	9148	28568	49528
30	2016	3382	8430	9148	28568	49528

Note : Equal in Table A-16-19 (Economic Price)

Table A-16-32 Project Cost (Financial Price)

(Unit : 10^6 Ch$)

Item	Local Currency: Land Acquisition	Local Currency: Unskilled Labuor	Local Currency: Semiskilled Labour	Local Currency: Skilled Labuor	Local Currency: Material	Local Currency: Transportation	Local Currency: Sub-Total	Foreign Currency	Total
Construction Cost									
Block 1									
I ESP HDWKS	1.6	18.8	1.9	.7	65.8	14.1	102.8	281.8	384.6
I ESP CANAL	2.1	3.3	.3	.1	.7	.8	7.2	16.2	23.4
I ESP DVS	.0	.2	.1	.0	1.1	.1	1.6	3.0	4.6
I ESP CHUTE	.0	.2	.0	.0	.7	.1	1.1	2.4	3.5
I TER CANAL	.0	.7	.1	.0	.8	.0	1.5	.0	1.5
Q TREATMENT	2.7	36.0	4.8	1.4	27.3	6.3	78.5	312.7	391.2
F EST FRIO	.0	4.8	.5	.2	.0	1.5	7.0	30.7	37.7
T BRIDGE	.0	1.0	.2	.1	3.4	.5	5.2	9.6	14.8
Block 2									
Q ORTUZANO	1.4	26.1	4.4	1.7	1.5	6.7	41.7	333.3	375.0
Q RINCONADA	1.8	32.2	5.0	1.8	3.7	8.7	53.2	433.6	486.7
Q LOMA BLNC	.6	11.9	1.8	.7	.4	2.6	18.1	132.1	150.2
Q ENCANADO	.6	10.2	1.1	.6	2.5	2.8	17.9	141.4	159.3
T BRIDGE	.0	1.6	.4	.1	2.3	.5	4.9	9.1	14.0
Block 3 & 4									
IQ PUNTA CNL	10.5	51.8	7.8	4.2	65.7	34.8	174.7	695.8	870.5
IQ SIPHON	.0	2.5	.2	.1	6.0	1.0	9.9	19.4	29.3
IQ SIPHON	.0	1.6	.2	.1	3.4	.6	5.7	11.1	16.9
IQ SIPHON	.0	14.6	3.2	1.7	15.5	5.7	40.7	114.9	155.6
IQ CARMN CNL	.0	76.0	8.4	5.2	240.1	23.5	353.2	469.7	822.9
I CARMEN (B)	.0	51.8	5.9	3.1	232.5	20.8	314.1	415.4	729.4
IQ DIVERSION	.0	1.2	.3	.1	.1	.2	1.8	3.8	5.6
I TUNNEL	.0	2.4	.5	.2	9.0	.9	13.2	18.2	31.4
I TUNNEL	.0	5.4	1.0	.5	17.3	2.6	26.8	51.8	78.6
I TUNNEL	.0	3.3	.6	.3	12.3	1.2	17.6	23.3	40.9
I SANCARLOS	.0	252.8	89.6	27.6	1,185.6	187.9	1,743.5	3,757.3	5,500.8
I TER CANAL	.0	16.9	1.7	.6	27.6	.0	46.9	.0	46.9
F LAMPA (1)	.0	45.1	5.4	2.3	40.4	31.1	124.2	621.1	745.3
F LAMPA (2,3	.0	92.5	11.1	4.6	97.4	68.5	274.1	1,370.5	1,644.6
F MEMB BRDG	.0	5.6	.8	.3	24.4	2.1	33.2	41.1	74.3
F NOVC BRDG	.0	6.0	.9	.3	28.0	2.3	37.5	46.0	83.5
F BOZA BRDG	.0	5.1	.8	.2	21.3	1.7	29.2	34.2	63.4
F COLINA	.0	3.2	2.2	16.5	18.3	13.4	53.6	268.1	321.7
F CSQR BRDG	.0	3.9	.6	.2	14.1	1.4	20.2	27.9	48.1
F PRMV BRDG	.0	4.4	.6	.2	14.1	1.4	20.7	27.9	48.6
F CHORO (A)	.0	3.7	.4	.2	5.3	2.7	12.3	54.1	66.4
F CAREN (A)	.0	2.9	.3	.2	1.0	1.2	5.7	24.8	30.4
F CAREN (B)	.0	1.8	.2	.1	6.0	2.3	10.3	45.1	55.4
F CHOROS (B)	.0	1.4	.2	.1	9.2	3.0	13.9	60.8	74.7
F CHOROS (C)	.0	2.1	.3	.1	6.3	2.5	11.3	49.6	60.9
F DRAIN C-1	3.7	70.0	10.5	3.6	348.6	32.7	469.1	654.2	1,123.3
F DRAIN C-2	13.1	139.6	20.9	8.4	477.8	48.8	708.6	976.6	1,685.2
F SABO DAM	.0	39.1	6.6	3.5	72.6	10.9	132.7	217.4	350.0
F TEM MPCHO	.0	2.7	.3	.1	1.2	1.2	5.5	23.9	29.4
T ROAD (A)	12.5	33.0	2.9	1.6	40.9	8.5	99.5	169.8	269.3
T ROAD (B)	16.2	20.4	1.8	.9	13.7	9.1	62.1	182.0	244.1
T BR A,B,C	.0	2.9	.7	.3	6.4	1.1	11.3	21.3	32.7
Sub-Total	66.7	1,112.6	207.6	94.7	3,172.6	569.5	5,223.9	12,202.9	17,426.7
Procurement of O/M Equipment						.0		302.7	302.7
Administration Cost		18.3		79.2			97.5		97.5
Consulting Services				301.0			301.0	977.7	1,278.6
Sub-Total		18.3	.0	380.2	.0	.0	398.4	1,280.4	1,678.8
Total									19,105.5

Source : Table 5-3-4

Table A-16-33 Project Cost -Measure Wise- (Financial Price)

(Unit : 10^6 Ch$)

Item	Local Currency: Land Acquisition	Local Currency: Unskilled Labuor	Local Currency: Semiskilled Labour	Local Currency: Skilled Labuor	Local Currency: Material	Local Currency: Trans-portation	Local Currency: Sub-Total	Foreign Currency	Total
Construction Cost									
Block 1									
I ESP HDWKS									
I ESP CANAL									
I ESP DVS									
I ESP CHUTE									
I TER CANAL	3. 7	23. 1	2. 4	. 8	69. 1	15. 2	114. 3	303. 4	417. 7
Q TREATMENT	2. 7	36. 0	4. 8	1. 4	27. 3	6. 3	78. 5	312. 7	391. 2
F EST FRIO	. 0	4. 8	. 5	. 2	. 0	1. 5	7. 0	30. 7	37. 7
T BRIDGE	. 0	1. 0	. 2	. 1	3. 4	. 5	5. 2	9. 6	14. 8
Block 2									
Q ORTUZANO									
Q RINCONADA									
Q LOMA BLNC									
Q ENCANADO	4. 4	80. 5	12. 3	4. 8	8. 1	20. 8	130. 8	1, 040. 4	1, 171. 2
T BRIDGE	. 0	1. 6	. 4	. 1	2. 3	. 5	4. 9	9. 1	14. 0
Block 3 & 4									
IQ PUNTA CNL									
IQ SIPHON									
IQ SIPHON									
IQ SIPHON									
IQ CARMN CNL									
I CARMEN (B)									
IQ DIVERSION									
I TUNNEL									
I TUNNEL									
I TUNNEL									
I SANCARLOS									
I TER CANAL	10. 5	480. 3	119. 4	43. 7	1, 815. 2	279. 0	2, 748. 1	5, 580. 6	8, 328. 7
F LAMPA (1)									
F LAMPA (2, 3)									
F MEMB BRDG									
F NOVC BRDG									
F BOZA BRDG									
F COLINA									
F CSQR BRDG									
F PRMV BRDG									
F CHORO (A)									
F CAREN (A)									
F CAREN (B)									
F CHOROS (B)									
F CHOROS (C)									
F DRAIN C-1									
F DRAIN C-2									
F SABO DAM									
F TEM MPCHO	16. 7	429. 0	62. 2	40. 8	1, 186. 2	227. 2	1, 962. 1	4, 543. 1	6, 505. 2
T ROAD (A)									
T ROAD (B)									
T BR A, B, C	28. 7	56. 3	5. 4	2. 8	61. 0	18. 7	172. 9	373. 2	546. 1
Sub-Total	66. 7	1, 112. 6	207. 6	94. 7	3, 172. 6	569. 5	5, 223. 9	12, 202. 9	17, 426. 7
Procurement of O/M Equipment						. 0		302. 7	302. 7
Administration Cost		18.3		79.2			97.5		97.5
Consulting Services				301. 0			301. 0	977. 7	1, 278. 6
Sub-Total					. 0	. 0	398. 4	1, 280. 4	1, 678. 8
Total		18. 3	. 0	380. 2			5, 622. 3	13, 483. 3	19, 105. 5

Source : Table A-16-32

Table A-16-34 Project Disbursment (Financial Price)

(Unit : 10^3 Ch$)

Item	1987 F/C	1987 L/C	1987 TOTAL	1988 F/C	1988 L/C	1988 TOTAL	1989 F/C	1989 L/C	1989 TOTAL
Block-1 Irrigation			0	2397	1271	3667	291398	107917	399315
Water Quality			0	0	0	0	0	0	0
Flood Control			0	2364	540	2904	9456	2157	11613
Transportation			0	1070	578	1647	4278	2310	6588
Block-2 Water Quality			0	0	0	0	0	0	0
Transportation			0	1015	542	1557	4058	2163	6221
Block-3,4 Irrigation			0	129069	69343	198411	1768704	858535	2627239
Flood Control			0	332749	144337	477085	1330990	577346	1908336
Transportation			0	41467	19213	60680	165870	76854	242725
Total Construction Cost				510129	235822	745951	3574754	1627282	5202036
Procurement of O/M Equipment	0	0	0	0	0	0	0	0	0
Administration Cost	0	15840	15840	0	34100	34100	0	15840	15840
Consulting Services	406340	129910	536250	112090	25520	137610	144430	48400	192830
Sub-Total	406340	145750	552090	112090	59620	171710	144430	64240	208670
Total	406340	145750	552090	622219	295442	917661	3719184	1691522	5410706
With Economic Contingency*	414467	173297	587764	644619	393529	1038148	3916301	2478080	6394381
* : Total x	1.020	1.189		1.036	1.332		1.053	1.465	

Item	1990 F/C	1990 L/C	1990 TOTAL	1991 F/C	1991 L/C	1991 TOTAL	TOTAL F/C	TOTAL L/C	TOTAL TOTAL
Block-1 Irrigation	9589	5083	14673	0	0	0	303,384	114,271	417,655
Water Quality	156366	39230	195597	156368	39230	195598	312,734	78,460	391,194
Flood Control	9456	2157	11613	9456	2157	11613	30,731	7,013	37,744
Transportation	4278	2310	6588	0	0	0	9,625	5,198	14,823
Block-2 Water Quality	520185	65424	585608	520185	65424	585608	1,040,369	130,848	1,171,217
Transportation	4058	2163	6221	0	0	0	9,130	4,868	13,998
Block-3,4 Irrigation	1768704	858536	2627240	1914111	914922	2829034	5,580,587	2,701,336	8,281,923
Flood Control	1548363	710007	2258370	1330990	577346	1908336	4,543,092	2,009,036	6,552,128
Transportation	165870	76854	242725	0	0	0	373,208	172,921	546,129
Total Construction Cost	4186868	1761766	5948634	3931110	1599080	5530190	12,202,861	5,223,950	17,426,811
Procurement of O/M Equipment	0	0	0	302720	0	302720	302,720	0	302,720
Administration Cost	0	15840	15840	0	15840	15840	0	97,460	97,460
Consulting Services	150920	48400	199320	163900	48730	212630	977,680	300,960	1,278,640
Sub-Total	150920	64240	215160	466620	64570	531190	1,280,400	398,420	1,678,820
Total	4337788	1826006	6163794	4397730	1663650	6061380	13,483,261	5,622,370	19,105,631
With Economic Contingency*	4641433	2943521	7584954	4780332	2949651	7729983	14,397,152	8,938,077	23,335,230
* : Total x	1.070	1.612		1.087	1.773				

Source : Table 5-6-2, A-16-32

Appendix 17: Study On the Mapocho River Basin

17.1 Diagnosis of the Mapocho River Basin

17.2 Erosion Control of the Mapocho River Upper Basin and Surrounding Areas

LIST OF TABLE

LIST OF FIGURE

17.1 Diagnosis of the Mapocho River Basin

(1) Introduction

The basin consists of three major river systems, namely, the Mapocho, the Lampa and the Colina. The Mapocho river originates in the Andean range which form the eastern border of the basin. Excepting one, the major tributaries of the Mapocho river: Molina, Yerba Loca, San Francisco and Arrayán, flow towards the south before they join the Mapocho river. The direction of flow of the Mapocho river is east-west till the point of confluence with the Lampa river. From this point, it flows towards the south-west until it joins the Maipo river. The Colina river originates in the pre-Andean range, and flows towards the south-west till it joins the Lampa river. The Lampa river originates in the small hills which form the northern boundary of the basin, and flows towards the south along the Coastal Range in the western boundary. Besides these rivers, there are three rivulets worth mentioning, because of their locations and steepness. They are Apoquindo, San Ramón and Macul. They originate in the pre-Andean range located to the east of Santiago city, and their torrents during heavy rainfall have the potential of causing great damage to the city.

Total catchment area at the confluence with the Maipo river is approx. 5,270 km^2. Of these, the First Phase Study included approx. 61,000 ha and the feasibility study in the Second Phase, approx. 36,000 ha.

(2) Geomorphology and the Change in Pattern of Landuse

The total catchment area can be divided geomorphologically into three parts: the upstream region, the piedmont and the central valley. The upstream region covers about 28.4% of the total basin, i.e., a little less than 1500 km^2. The entire Study Area lies in the central valley.

The landuse of the basin in 1960, 1977 and 1984 is given in Table A-17-1 and Figs A-17-1 and 2. The type of landuse is classified into seven categories: 1 and 2: urban area (densely populated and less densely populated), 3 and 4: agricultural land (for annual and perennial crops), 5: thicket and pasture, 6: forest and 7: unusable land.

Urban area had sprawled dramatically during 1962 - 1977, and the urban area of category 1 in 1977 was 3.4 times larger than the one in 1966. Since then, the growth rate has decreased. In the process, some of the area of category 2 was absorbed into the area of category 1 with the growth of population density. The total urban area (1 + 2) in 1984 reached 48,600 ha with an annual growth rate of 0.76% since 1977. The area occupies 9.2% of the total basin.

The area of agricultural land has been decreasing since 1962. The rate of decrease up to 1977 was 0.125 %, and about 0.5% since then. The area of category 3 and 4 was 112,900 ha in 1984, 21.4% of the total basin. The area destined for annual crops was 85% of the total agricultural land in 1984, the rest consisted of perennial crops. In absolute terms, the area of agricultural land for annual crops had decreased by 6,100 ha in 7 years, whereas that of perennial crops have increased by 1,600 ha. The latter have felt the market forces, and together with an increase of the area, there has been a change of crops. However, 1962 levels have not been reached.

The area of thicket and pasture was 241,800 ha in 1984, covering 45.9% of the total basin. There has been a loss of about 1,400 ha in 7 years, at an annual rate of 0.08%. Forestland covered 5,300 ha, making up for only 1% of the total basin area. Still, this is the result of a remarkable increase in forested area: 2,100 ha in 7 years, with an annual growth rate of 7.6%. This is a clear indication of the effort made by CONAF.

Un-usable land was 118,600 ha in 1984, making up for 22.5% of the total area of the basin area. This area lies mostly in the upstream region. There has been a slight increase in the un-usable land area 1,200 ha in 7 years with an annual increase rate of 0.14%.

Areas of categories 1+2, 6 and 7 have increased, while 3+4 and 5 have decreased. Table A-17-2 and Fig A-17-3 show this trend. Average yearly variation is represented, with in the period between 1977 and 1984. In general terms, urban sprawling has penetrated into agricultural land, and a major part of forestation has also occured on agricultural land. Most of the decrease in thicket and and pasture areas has been towards un-usable land; a very small portion has turned into forested land.

If we observe macroscopically the change in landuse, by comparing the two circular diagrams for 1977 and 1984 in Fig A-17-1, the change may be overlooked. But it is also the fact, as Fig A-17-3 shows, that each year there is a change in the type of landuse in a total area of 830 ha. This may seem insignificant, but if this trend continues, the consequences will be felt.

Forests have not shown a spontaneous increase. Forestation in agricultural land, even if it is marginally productive, needs some non-economic long range investment program. Urban area grows even in the absence of a development project, at the expense of agricultural land, because of population increase. In order to forecast the situation in 2000, we have used the same annual increase rate as the one during 1977 and 1984, i.e., 0.76%. In the absence of a development project, thicket and pasture land will also decreased, and at a slightly bigger rate than the one during 1977 and 1984, because there will be no effort for forestation. We set, therefore, an annual rate of increase of -0.7%. The whole area will turn into un-usable land because of over grazing, for example. Table A-17-1 and Fig A-17-1 show the landuse trend in 2000 in the absence of a development project, using the figures given here.

(3) Water Resources, Rivers and Canals

Among such resources as land, water and human work force required for agricultural production, the primary constraint to productivity in the basin is water resources. Located in a semi-arid zone, the Mapocho river basin does not get enough rain to satisfy all the needs for irrigation and water supply. The existence of mineral resources in the basin, though it has contributed to the national economy, further limits the use of water because of unavoidable mineral pollution, despite attempts to reduce pollution. Thus, water supply for the city and the irrigation water for the surrounding agricultural land have long depended on the Maipo river.

In the north, the waters from the Aconcagua river are brought into the Huechún dam to increase the irrigation water for the agricultural land immediately downstream of the river. The Lampa river has a dam at Rungüe which has helped to increase the cultivation of perennial crops in the downstream area. Along the Colina river, in the eastern marginal area of the northern part of the Central Valley, groundwater is utilized as a source of irrigation and for water supply.

Erosion takes place in the upstream region and sedimentation in the valley. Thanks to the small precipitation, the volume of earth removed by erosion is manageable; on the average, 140 ton per year per km^2 at Los Almendros in the Mapocho river. Sediments clogg the rivers, especially at the confluence of the Mapocho and Lampa rivers. The area, particularly the lowlands downstream of the Lampa river, is easily flooded in the rainy season.

The San Carlos canal is a life-line of the Metropolitan Area. It produces electricity and feeds Santiago and the surrounding agricultural land with the waters from the Maipo river.

(4) Agricultural land and Pasture

The agricultural land in the basin has several natural and man-made constraints for its further development. Shortage of irrigation water is, above all, the most important. The potential volume of water to be developed in the basin is quite limited, far less than what is required. The only alternative is, to get water from the Maipo and the Aconcagua rivers. The excessive use of groundwater tends to lower its level, and thus increase the price of water. Sedimentation of alkaline/saline soil in the low lying areas is another natural problem for agricultural land. The area is often flooded for days in the rainy season. The agricultural land located downstream of Santiago receives untreated sewage water for irrigation. This has resulted in the contamination of irrigation water. On the other hand, the agricultural land has the advantage of being near the Metropolitan Area which is a huge consumption center of agricultural products in the basin. Pasture greatly depends on rainfall. Therefore, the number of cattle should be kept within the reproductive capacity of the grass.

(5) Urban Area (Habitat for Human Resources)

Most of the basic economic factors of the city are destined to be determined by the national economy and policies, beyond the control of the basin's own economic potentials. Population growth is a typical example. Investment tends to delay the provision of necessary infrastructures; the lack of sewage treatment plants is one example.

Urban area sprawls into the adjacent agricultural land. Some urban development schemes are located in the east, in the piedmont zone, where there is great danger from flashfloods during (or after) heavy rainfall. The San Carlos canal makes a lower channel or rivulets; Apoquindo and San Ramón.

The Macul flushes into the Zanjón de la Aguada. Thus, in addition to improvement of channel structure and restruction of urban development, formulation of the coordinated management program in case of emergency is vital to minimize damages.

(6) Upstream Region and Piedmont

The upstream region of the Mapocho river basin provides water for the flora and fauna in the valley, though not enough to maintain the present level of human activity. The region prodeces copper and accomodates resort industries. It also has aesthetic value for the people in the Central Valley. Because of the poor vegetation and of adverse climatic and geomorphological conditions, there is no forestry production in the region.

Table A-17-3 and Fig A-17-4 show the types and area covered by natural vegetation in the basin in 1983. Natural vegetation (including quasi-natural vegetation and bare land) covers 37.6% of the total basin, mostly distributed in the upstream region, piedmont and prairie. Bare land consists of 1.6% of the total basin. It is distributed, besides in the andean zone, in the periphery of the agricultural and pasture land as a result of excessive human use.

La Disputada copper mine is located at the head of the San Francisco river at an altitude of 3,450 m. A.S.L. With an excavation rate of some five million tons per year, the copper reserve of a billion tons will last for 200 years. After the ore concentrates are removed, residuum has been and will continue to accumulate in the downstream area of the San Francisco river. The waters of the river are contaminated with heavy metals, but after the tributary joins with the Mapocho river, the polluted waters are gradually diluted.

Farellones, Colorado and La Parva are excellent winter sports centers. They are built on the barren gentle slopes between 3,300 and 2,500 m of altitude, above the tributary Manzanito. These resorts are totally dormant when the area is not covered with snow. During these periods, the road to Farellones and La Disputada is repaired, widened or improved. Earth removed at construction sites is dumped to the bottom of the valley, suggesting that the danger of sedimentation in the Central Valley is not recognized by the public. Near Farellones, the road is paved, and the houses and flats in the ski-resort are beginning to be surrounded by poplar trees, in contrast to La Disputada mine and downstream in the San Francisco river where not a single tree is found. Snow accumulates 2 to 3 m deep.

Mining and tourism are the two major economic activities. They produce a taxable income, a part of which can be allocated to a basin management program. It is one thing to say that watershed management is necessary to reduce erosion, sedimentation and flooding, but quite another to do something about it in this very frail environment. The existence of a forestry station in the lower reach of the Yerba Loca river is worth mentioning here. The station is managed by CONAF. There is a tree nursery, experimental station, and educational and recreational facilities for the public. In the experimental station, some seventy species of trees are grown for studies on their adaptability. The aim is the propagation and conservation of forests wherever possible, and also to make known the idea of proper watershed management through education.

The major benefits derived from well managed forests are the production of oxygen, prevention of erosion, and conservation of water resources. In a recent study, the Forestry Agency in Japan has calculated the monetary benefit brought by the forests in Japan. It amounts to about US$4,000/ha on the average in 1979 prices.

The piedmont region shows the most drastic change in the whole of the basin because of its easy access. This has resulted in the loss of the delicate balance of the eco-system. Human intrusion is most notable in the form of over-grazing by cattle or new urban development.

Table A-17-1 LANDUSE OF MAPOCHO RIVER BASIN

(unit:ha)

	1962		1977			1984			2000		
	ha	%	ha	%	A.R.I(%) '62-'72	ha	%	A.R.I.(%) '77-'84	ha	%	A.R.I.(%) '84-2,000
1.Urban Area	10,603.2	(51.8)	36,331.5	(78.8)	8.6	40,201.8	(82.7)	1.5			
2. -do- (less dense)	9,883.7	(48.2)	9,795.3	(21.2)	-0.06	8,420.0	(17.3)	-2.1			
1+2	20,486.9	(100)	46,126.8	(100) 8.7	5.6	48,621.8	(100) 9.2	0.76	54,883.5	10.4	0.76
3.Agricultural Land(annual crop)	101,223.6	(84.8)	102,477.1	(87.3)	0.08	96,415.5	(85.4)	-0.87			
-do-	18,208.4	(15.2)	14,896.0	(12.7)	-1.3	16,532.8	(14.6)	1.5			
3+4	119,432.0	(100) —	117,373.1	(100) 22.3	-0.12	112,948.3	(100) 21.4	-0.55	106,686.6	20.3	-0.36
5. Thicket & Pasture	226,105.2	—	243,142.9	46.1	—	241,776.3	45.9	-0.08	237,936.8	45.1	-0.1
6.Forest	2,220.9	—	3,142.2	0.6	—	5,257.5	1.0	7.6	5,257.5	1.0	0
7.Unusable Land	9,076.4	—	117,430.4	22.3	—	118,611.5	22.5	0.14	112,451.0	23.2	0.2
Total	377,321.4	—	527,215.4	100.0	—	527,215.4	100.0	—	527,215.4	100.0	—

1. About 150 thousand ha.of upstream area is not included

2. A Projection made by the Team

note:A.R.I.=Annual Rate of Increase

Source:The Basic Cartography for the Basin of Mapocho river

Table A-17-2 AVERAGE ANNUAL CHANGE IN LANDUSE(1977-1984)

(ha)

Type of Use	Increase	Type of Use	Decrease
Urban Area 1+2	356.4	Agricultural Land 3+4	632.1
Forest	302.2	Thicket and Pature	195.2
Total	827.3	Total	827.3

Table A-17-3 TYPE AND AREA OF NATURAL VEGETATION

(ha)

	(i)	(ii)
1. Scanty Shrubland	71,662.7	
2. Dense Shrubland	31,612.2	103,274.9
3. Scanty Acacia Caven Savannah	27,341.7	
4. Dense Acacia Caven Savannah	8,597.9	35,939.6
5. Open forest	2,672.2	
6. Dense forest	2,596.9	5,269.1
7. Andean vegetation	26,296.2	26,295.2
8. Succulent scrubs Matovial de sucullutas	21,377.3	21,377.3
9. Bare land	5,237.2	5,237.2
10. Oak Tree	886.9	886.9
Total natural Vegetation	198,280.2	198,280.2
Others		328,935.2
Total Basin		527,215.4

Note: (i) Vegetated area only

(ii) Total basin

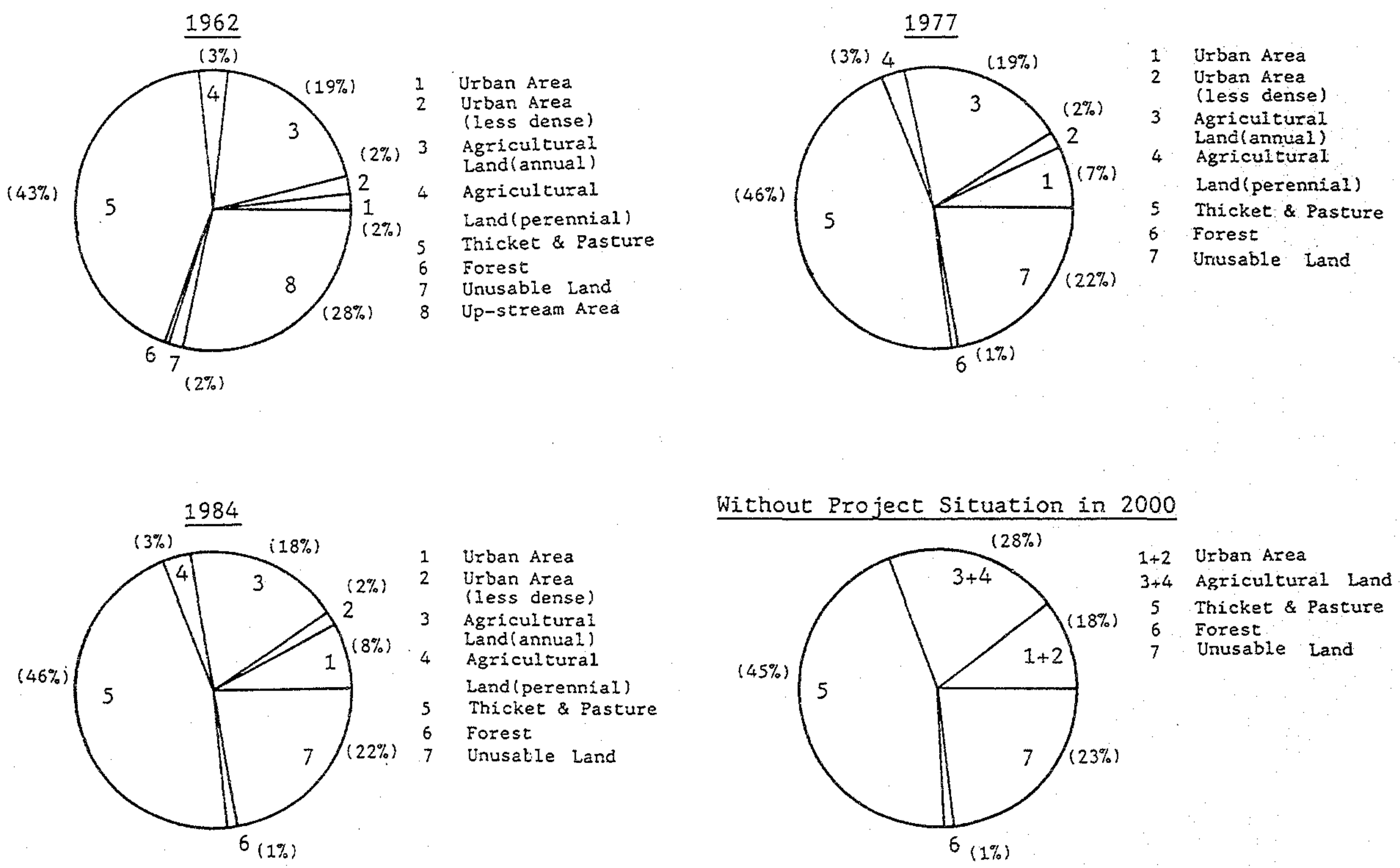


Fig A-17-1 LANDUSE TYPES OF THE MAPOCHO RIVER BASIN

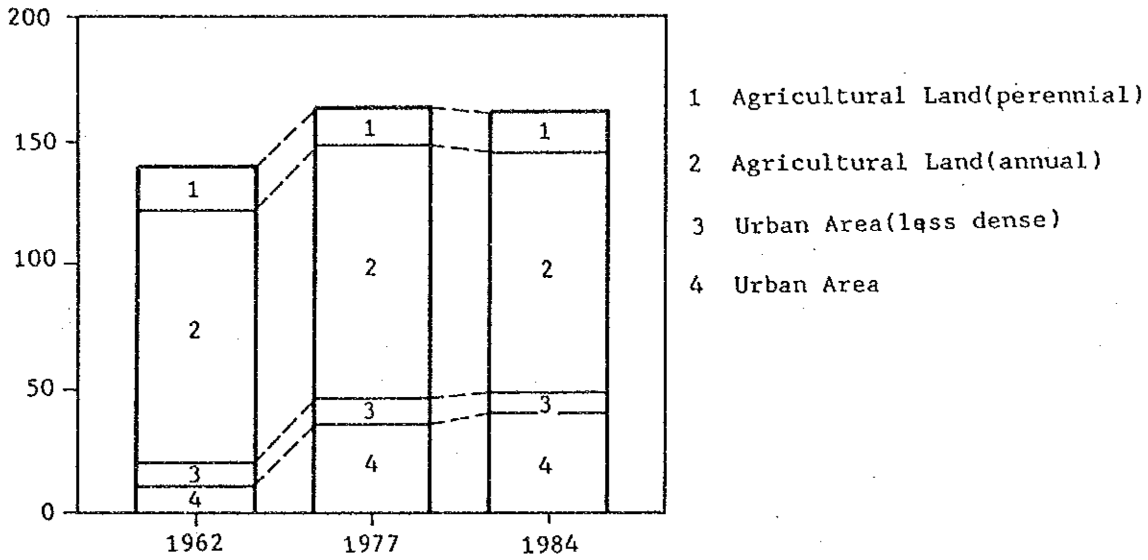


Fig A-17-2 CHANGES IN SPACE OF URBAN AREA AND AGRICULTURAL LAND

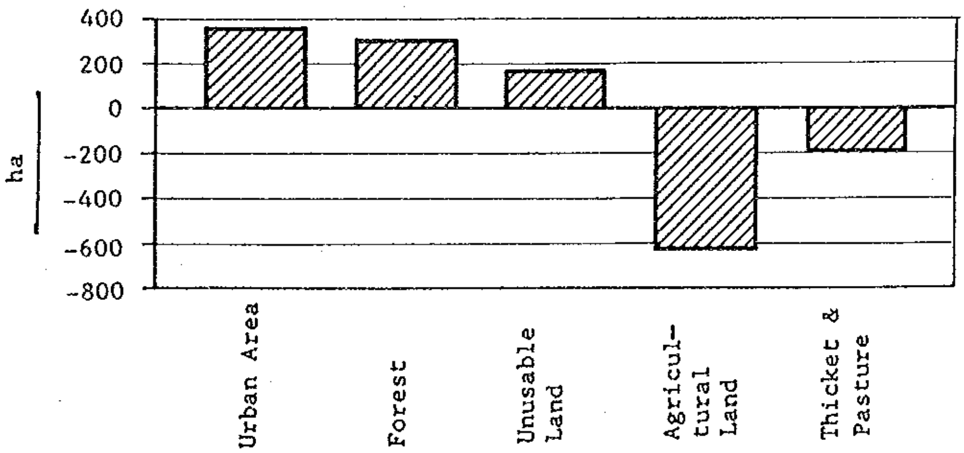
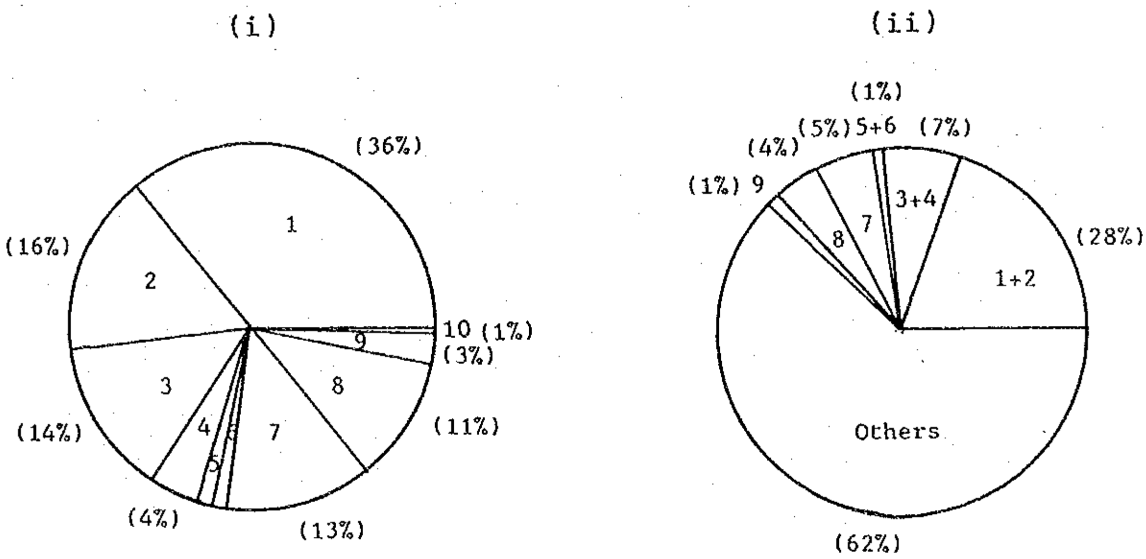


Fig A-17-3 AVERAGE ANNUAL CHANGES OF LANDUSE DURING 1977 AND 1984



1. Scanty Shrubland
2. Dense Shrubland
3. Scanty Acacia Caven Savannah
4. Dense Acacia Caven Savannah
5. Open forest
6. Dense forest
7. Andean vegetation
8. Succulent scrubs
   Matovial de sucullutas
9. Bare land
10. Oak Tree

Note: (i) Vegetation area only
(ii) Total basin

Fig A-17-4 TYPE AND AREA OF NATURAL VEGETATION

17.2 Erosion Control of the Mapocho River Upper Basin and Surrounding Areas

This Study was done in connection with the Mapocho River Basin Agriculture Development Project. The objectives are: describe the present condition of the Study Area, analyse the cause and effect of slope failures, and discuss the methodology of disaster prevention.

(1) Study Area

The area of this Study covers the upper reach of the Mapocho river and its tributaries which flow through the eastern part of Santiago. The mountain area above the timberline, EL + 2,000m, is excluded from the Study, as it is too remote to have a direct effect on the Project Area.

(2) Present Condition of Slope Disaster

1) Types of slope disaster

Systematic recording of past slope disasters are not available. However, the type of disaster dealt with in this Study was identified as steep slope failure through interpretation of 1:40,000 scale aerial photos and site investigation.

2) Location

The location of slope failures identified by interpretation of aerial photos and site investigation are shown in Fig A-17-5. Most of these is small scale slope failures of surface strata.

(3) Site Investigation

1) Methodology

High potential areas of slope failure were chosen for site investigation from those identified, in Fig A-17-5.

The investigation dealt mainly with slope environments due to technical limitations. Nonetheless, observations were made on soil, rock structure and water, whenever it was possible.

2) Slope Environment Study

a. Study on slope micro-morphology.

A preliminary study with 1:40,000 scale aerial photos was carried out. For a more detailed investigation, however, aerial photos of 1:20,000 scale should be used.

b. Study on vegetation

The main concern of this part of the Study is to assess the existing vegetation so to plan a suitable replanting scheme for the recovery of slopes.

The vegetation was sampled except for the San Francisco and Yerba Loca rivers. For trees and shrubs the size of quadrangles was set in 10 x 10m, and for herbaceous plant, 1 x 1m. The latter was done within the 10 x 10m quadrangles.

3) Study of Soil and Rock Structure

a. Soil Survey

The thickness and permeability of surface soil were studied.

b. Geological Survey

The geological formation of the area is related to the nature of the slope failure. Special attention was paid to the following aspects.

- Strike/dip, types of fractures of stratum
- Weathering band and distribution of rolling stones

4) Water Survey

Observations were made of surface and spring waters.

(4) Actual Situation of Steep Slope Failures

The slope failure is a type of landslip, in which the material forming the hill slope moves. In general, this happens at a small scale, but the movement of earth is rapid and violent.

Slope failure causes two types of problems in the areas located downhill.

Type 1: It produces unstable debris, which will further derange the river course and can potentially ruin it.

Type 2: It sometimes becomes a direct threat to the inhabited houses and man-made facilities in the vicinity.

All the slope failures in the study area except the ones in the ravine of San Ramón belong to type 1.

1) Sites investigated

Site investigations were carried out in the following five localities:

a. Covarrubias Tributary flowing into the Molina river 3 km above the confluence of the Molina and San Francisco rivers.

b. The Mapocho river near the confluence with the ravine of Los Potrerillos

c. Basin of the San Francisco river

d. Yerba Loca river

e. Eastern part of Santiago

(5) Description of Existing Slope Failures

1) Covarrubias Tributary

a. Geomorphology

Flat terraces are formed at a height of 10 to 15m above the river bed. In many instances, steep slopes continue up from the terrace, which suggests a past slope disaster. Beneath the terrace loosely sedimented soil and gravels susceptible to erosion are found. This is the critical area for a failure.

The big deposits of earth at the confluence with the tributary Los Recauquenes are supposed to be eroded earth transported from these spurs. Many slope failures are relatively recent having slid the upper parts of the surface stratum of the slopes.

There are some failures near the ridge area, which have been caused presumably by the earthquake of March 1985. The earthquake has not initiated new failures, rather, it has triggered the activity of the dormant ones.

b. Geology and Soil

The geology of the locality consists of Abanico Formation, mainly formed by alternate stratum of hard andesitic lava and with terrestrial deposits and rhyolite. Weathering of andesite has not developed so much so that slope failure has not penetrated deep into the earth.

The thickness of the soil is about 25cm of which the upper 10cm are of black colour.

c. Vegetation

The gist of the survey is as follows:

- Altitude	:	EL + 1,300m
- Gradient	:	33°
- Slope aspect	:	East
- Height of trees	:	2.5 to 4.5 m
- Species	:	Species number
		Bollén 10
		Guayacán 1
		Quillay 1

The vegetation can be described as a pure stand of Bollén. This species grows well in this area. It is found up to an altitude of 1,800m in the Andes Range, and is adaptable to dry or slightly humid soil. It also regenerates well from seed, so it may be used for replanting. An ecological study of Bollén should be carried out at the Yerba Loca Experimental Station.

d. Rainfall and Hydrology

Annual rainfall is approximately 600mm according to CNR estimation. There was no trace of damage caused by rain in the slope failure in September 1985 as it has been a dry year. Neither surface nor spring waters were visible on the slope.

e. Damage

Many boulders of various sizes are found in the torrential valley down to the confluence with the tributary of Los Recauquenes. Erosion of the lower part of the hillside, at the border of the riverbed, is conspicuous. From the confluence downwards, not many boulders are found, because the deposits at the confluence have been functioning as a dam. The few houses located on the terrace at the confluence with the Molina river will remain unharmed. If flooded, low lying fields and pastures along the river will be intruded with sand and stones. Yet, as a whole, the slope failures of this tributary would not cause big damages to the Molina river.

2) <u>The Mapocho river near the confluence with the ravine of Los Potrerillos</u>

a. Geomorphology

All the slope failures are of small scale except one located 1 km from the confluence up the Los Potrerillos ravine. The place is a depression, where rain water flows in. The failure starts from near the ridge; the length of the slope is about 320m. The part of the failure near the ridge is still active. The crests of many failures are located near the ridge, which means that logistically countermeasures are very difficult to carry out.

b. Geology and Soil

The geology of the area consists of a typical Abanico Formation. The ratio of composition of the three commons elements, andesitic lava, clastic andesite and sedimentary rock, is approximately 65:30:5. Hard andesitic lava is fairly new. Joints develop in it, and fine gypsum veins are found, too. Weathering of andesite is advanced so that with a slight impact rocks may crumble down to pieces. Intrusion of water to the andesite stratum is presumed to accelerate the process. Surface soil is dry, sandy, and very thin. It is of reddish brown colour.

c. Vegetation

The gist of the survey is as follows:

The Survey Site is located 50m North of the large scale failure on the same slope.

- Altitude: EL + 1,050m; Gradient: 35^{o}; Slope aspect: East

- Species:

name	number	height(m)
Colliguay	6	1 - 2
Mitique	1	1 - 2
Quisco	1	1 - 2
Litre	1	1 - 2

Colliguay, an evergreen shrub, is abundant in this region. The average height of the plant is between 1 and 1.5 m. It is well adopted to the dry rocky substrate, and generates well from seeds.

No ecological study of the species has been carried out.

d. Rainfall and Hydrology

Annual rainfall is approximately 500 mm according to CNR estimation. No trace of surface or spring waters was found at the time of the field survey.

The following factors may have contributed to the development of such a large scale failure:

i. The failure may have been initiated when the andesite stratum reached the surface, because it is liable to be weathered quickly.

ii. If joints develop in alternate beds of hard andesitic lava, and fine gypsum veins develop along the joints, this cannot stand long even with little rain. The surface of failure could have grown in this way.

iii. As the rainy season coincides with winter, although rainfall may be little, freezing and thawing is common, which triggers the crumbling process.

e. Damage

As the surface soil is thin and all sediments are clastic. At the lower tip of the failure a big boulder with a diameter of more than 3mis located. Clastic rocks are distributed by sizes, and transported not more than 30 m from the failure because of the topography of the site. An irrigation canal crosses the lower tip of the failure. No big damage is observed in it except for some traces of the falling of stones probably triggered by the earthquake in March 1985.

3) San Francisco River

a. Geomorphology

The hillside slopes are very steep, with many rocky outcrops, and very few slope failures. A fairly big reddish brown failure can be seen in a depression at the altitude of EL + 2,400m, far above the timberline.

b. Geology

Abanico Formation's andesite beds have fewer joints and a lesser degree of weathering than the ones in the above mentioned other localities. This explains that in spite of the fact that there are many rocky outcrops, failures are very few.

The failure just mentioned is located in the hydrothermal alteration belts which includes the deposit zone of porphyry copper.

c. Vegetation

In this case the quadrangle method was not used. By simple observation, 9 species were identified of which three, Frangel, Colliguay, and Muchi, are commonly found in the region. The area studied is located close to the river, at EL + 1,650m, facing the North-West.

Frangel, the dominant species, seldom grows more than 4 meters tall. Closer to the timberline, the density of this species increases and it grows better in humid soil. Muchi also prefers humid soil, so it is not suitable for replanting on dry barren soil.

The San Francisco river area has very poor vegetation, except close to the river stream or in depressions where snow remains till late in spring.

d. Rainfall and Hydrology

In the Andean zone above the timberline, it seldom rains; but it snows.

e. Damage

The torrential river course is not due to slope failures, but to a cheaply constructed road leading to the mine. In some places this road occupies half of the river. Every time there is high water the slope of the road is washed away.

4) Yerba Loca River

a. Geomorphology

Yerba Loca retains the feature of a glacial valley. The slopes are gentle with few failures. Loose slopes of the side moraines have given into the gullies little rain, yet rich and stable vegetation will prevent the gullies from short and long term erosion.

b. Geology and Soil

Farellones Formation of Tertiary(Miocene) is found in the valley. The Farellones Formation consists mainly of andesite and welded tuff with a small portion of a Paleozoic sedimentary bed. The relatively young age of the Formation explains the slight weathering. An anticline is found near the river course. There is also an acidic rock which intrudes the Formation. Thickness of the surface soil is 24cm in average.

c. Vegetation

Observations without setting up the quadrangle frame were conducted at 3 points. The vegetation is comparatively rich is species and cover, considering the altitude. Four factors have contributed to this: gentle slope, thick surface soil, high soil moisture and gentle micro-climate.

The gist of the observation is as follows:

- On the slope facing South EL + 1,500m
  Bollén, Quillay, Frangel, Gundillo and Muchi

- On the slope facing North, EL + 1,500m
  Bollén, Quillay, Frangel, Gundillo and Espino

- On the slope facing Southwest, EL + 1,800m
  The presence of guillay indicates the gentle climate of the Yerba Loca valley. The species, except Espino, grow better on humid soil.

5) <u>Eastern part of Santiago</u>

a. Geomorphology

The area consists of many basins of ravines originated in the pre-Andean range. The main ravines are Apoquindo, San Ramón, and Macul, from north to south. These ravines have steep stream gradient ($>$ 12.5%) and have been eroded due to poor vegetation. The pre-Andean range is situated just 7 km east of the eastern boundary of urban area of Santiago, rising from the plan into an altitude of over EL + 2,000 (Table A-17-4).

Table A-17-4 Features of Main Ravines in Eastern Part of Santiago

Ravine	Catchment Area(km^2)	Average Altitud (m.A.S.L)	Stream Length (km)	Average Stream Gradient (%)	Max.preci pitation (m/24 hr)	Regarding Time (hr)
Apoquindo	20.97	1,050	8.7	12.5	70	1.8
San Ramón	15.70	1,050	8.1	13.5	75	1.8
Macul	12.90	1,150	7.6		70	1.6

Source: MINVIV (1985), Areas de Riesgo por Inundatión

We shall deal with San Ramón only, as the slope failures of the area concentrate in this ravine. San Ramón ravine originates from area near the San Ramón mountain. (3,253 m.A.S.L) the highest peak of the pre-Andean ridge. It has the largest basin in the area with the largest stream flow.

The failure in San Ramón closely resembles those in Los Potrerillos. The difference is the gradient of the slopes. Here the average gradient of the slopes is 38°. The upper portion of the failure was activated by the earthquake in March 1985 and the surface is very fresh.

b. Geology

The principal geological features in this area are classified into following three components:

- Unconsolidated sediments: Fluvioglacial, alluvial, colluvial and volcanic ash origen of Quaternary.

  They consist of débris,alluvial cone, mudflow and volcanic ash. These sediments are found in a band with north-south direction between EL+900 and +600m. The lithological facies are heterogeneous mixtures of gravel, sand, silt and clay. They are permeable because of consolidation of them.

- Volcanoclastic rocks: Abanico Formation of Cretaceous sup. - Terciary

  They distribute in the piedmont of the pre-Andean Range higher than EL+900m.

  The principal petrological facies are andesites, breccias and sedimentary rocks. The outcrop of rock of this type shows many fracutures, high weathering and alteration. These are many semi vertical faults with north-south direction. Erosions occur in many places of this components.

- Plutonic intrusive bodies: Diorite and granodirite of Terciary

  They ocupay small area in upper parts of small ravine (Quebrada) basins and show moderate weathering and fracturing.

  The distribution ratio of these three components is approximately 60 : 25 : 15, respectively

c. Vegetation

A quadrangle was set at an altitude of EL + 930m, facing North, with a gradient of 30°, just above the failure. The gradient is less steep than that of the failure. The surface soil is very thin and dry. As a result, the vegetation in this locality is very simple; 14 Colliguays and 1 Litre. The height of Colliguay ranges between 1 and 2 m and Litre 5 m.

d. Rainfall and Hydrology

Annual rainfall is approximately 600 mm according to the estimation of CNR. A record indicates that the maximum hourly precipitation in the city of Santiago is 12 mm with a probability of 10 years, and 16 mm in 100 years. Taking into account these data, the maximum hourly precipitation in this area, though mountanous, should be less than 15mm. This suggests that a localized torrential downpour is hardly expected. On the contrary, fine rains fall continuously throughout the rainy season. No trace of surface or spring waters was found at the time of the investigation.

e. Problems and Damages

The San Ramón vaine has small catchment area but poor vegetations. Its stream gradient is steep, approx. 13.5%. Due to these natural conditions, a huge amount of sediments has been transported and deposited in its downstream area around the ravine during flood.

The clastic sediments containing fine grained materials deposited in the urban area and around the cross of the San Ramón ravine with the Perdices canal have formed low permiable layers. In addition, the flow capacity of the ravine is reducing annually due to the sedimentation of the ravine.

The construction of the paved roads and the development of urban areas in the piedmont have increased the inundation in such areas as Principe de Gales, Aguas Claras, La Cañada and Loveley. A further development upwards may reduce the recharging potentials of the bill area and increase the supply of unstable sediments.

(6) Countermeasures against Slope Failure

1) Prevention Work

There are two types of prevention work, one is stabilizing works and the other, slide check works. The former seeks to stabilize the slope, by trying to remove the factors which will cause the failure, like rainwater before reaching the spot. The latter checks directly the movement of earth with the means of man-made structures in the spot where the failure takes place.

The following is a list of works to be done for disaster prevention.

a. Stabilizing Works

(a) drainage works (against surface water and ground water accumulation)

(b) replanting works

(c) spraying works (with mortar or concrete)

(d) pitching works (with stone block or concrete)

(e) frame works (with stone, block or concrete)

(f) masonry (with stone or block)

(g) cutting of unstable earth blocks

b. Slide Check Works (slide prevention works)

(h) sheathing wall works (with block, concrete or concrete frame)

(i) anchor method

(j) pile method

(k) counterweight fill method

c. Others

(l) skeleton works and (m) gabion works are used for satisfying both of the above-mentioned purposes.

2) Selection of Works

There are two pre-requisites to chose a particular type of works. The first is an analysis of the factors causing the failure and its shape. The second is clarifying the objectives of the work, i.e., what is to be protected from the failure.

A final choice should be made by taking into account the conditions of construction and of the surrounding environment. Normally, a slide check work is first chosen, and then a suitable stabilizing work is selected.

Table A-17-5 gives the criteria for the selection of protection works for slope surface.

3) Countermeasure Works

All the slope disasters in the basins of the upper reach of the Mapocho river and its tributaries in the eastern part of Santiago, as has been found by the site investigation, are steep slope rock failures. They belong either to the type N° 5 or 6 of Table A-17-5. The range of choices of countermeasures is limited, and construction is difficult. According to the matrix of the slope, the methods generally used now are concrete pitching works with anchor works, mortar or concrete spraying works. The following are some of the points to be observed in the execution of the prevention works.

a. Concrete Pitching Works

Standard gradient of the slope must be 1:0.5. It can be designed, though, up to 1:0.3, if the slope condition allows it. Maximum height of the slope should be 20m. When a stepping method is used, the height of one step should be kept around 15 m with a small flight in-between the slopes. Normally, the plain concrete pitching method is used when the slope gradient is approximately 1:1.0, and reinforced concrete

Table A-17-5 Prevention Works ageinst Slope Failure

N°	Water	Gradient	Characteristics	Type of Works 1/
1	O	<1:1.0		ⓑ (block) or ⓔ
2	O	>1:1.0	Weathered rock long slope	ⓔ (concrete)
3	—	<1:1.0	Sand, soil, talus crumbly clay	ⓓ (stone or block)
4	—	>1:1.0	- do -	ⓕ (stone or block) or ⓗ (concrete frame)
5	—	—	Rock with many joints	ⓓ (concrete) or ⓘ
6	X	—	Weathered rock	—
7	O	—	Sand or soil (liable to be washed away)	ⓑ and ⓜ
8	—	—	Sand or soil	ⓑ and ⓛ

1/ ⓓ corresponds to the works listed in Section (6), 1) pitching when 1:0.5. The thickness of concrete should be between 20 and 80cm. Anchor works are usually carried out together with pitching in order to solidify the original matrix. Crest lining should carefully be carried out so that water will not infiltrate into the back.

b. Concrete or Mortar Spraying Works

The standard thickness with mortar spraying is 5 - 10cm, and concrete 10 - 25cm. In the localities where freezing and thawing alternate, the thickness of mortar should be more than 10cm and concrete, minimum 20cm. In order to further increase the durability and safety of the spraying works, reinforcing bars and steel nets should be place in the sprayed layer.

4) <u>Construction Planning</u>

As is the case with any other project execution, the construction of preventive works against slope failure cannot escape from an appraisal of the economic effect. Construction usually needs big machinery and a large volume of material. A large volume of earth is also to be transported by dump trucks on behalf of the river flow itself. It is not realistic to plan these works on sites far away from existing access roads.

However, when immediate danger affects the lives of human being, i.e., when potential slope failure is found just above railways, roads, houses, etc., cost; and benefit ratio should give in to human lives. Durable structures should be constructed immediately at all costs.

a. <u>Mapocho River Upper Basin</u>

There are no particular tributaries or slope failures from which a big amount of earth is transported. Therefore, to provide preventive works for each failures is out of the question because the effect would be minimal.

On the other hand, a fairly large amount of sedimentation is found on the riverbed of the Mapocho river, between the confluence with the Arrayán and the point where the river flows through the central part of the city of Santiago. This is a proof that a large volume of earth is transported during high water, though the scarcity of data on sedimentation deprives us of analyzing the phenomenon. So, from the view point disaster prevention, the construction of riverbed stabilizing structures to check the sediment, such as debris barriers or Sabo dams, is an effective means to maintain the necessary river section at its lower reach.

b. Eastern Part of Santiago

The basin of San Ramón covers 37% (approx. 10,000 ha) of the total area of the eastern part of Santiago. This is the biggest ravine in the area, and is potentially the most dangerous. The area above EL + 2,000m is barren and rocky.

The debris from this area is transported directly to the alluvial fan. The slope is steep, the distance is short and, to make matters worse, the river flows through an urban zone just after its gradient becomes less steep. Therefore, the planning of a prevention strategy is very difficult.

(i) Countermeasures against Slope Failure

In this basin there are quite a few failures. The most dangerous one is, the only one which is able to be attended. As a preliminary work, a 500 m access road is required for the carrying of material. Mortar spraying works would be the most appropriate. To reduce further possibilities of failure damage to the water supply facilities and the housing zone, construction of a debris barrier in the upper reach of San Ramón is thought to be an adequate countermeasure.

(ii) River Improvement

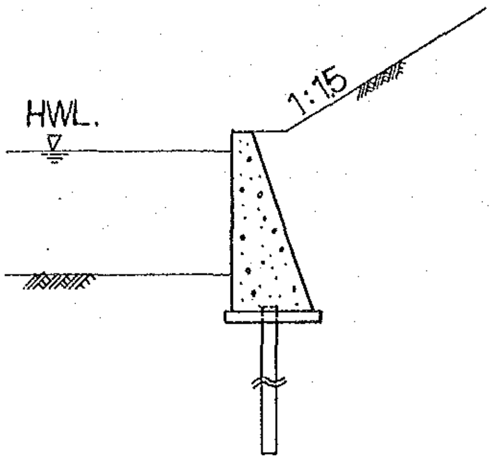
With sedimentation flows under the ground at the alluvial fan, though the gradient of the ravine bed is still steep. Since the flood in 1982, banks have been partially protected by gabion works, and small debris barriers have been provided. Unfortunately, the design of the levee section has not taken into account the future rise of the riberbed due to the barriers, so the river width will become, when more ravine flow down. This is really dangerous. It is necessary to enlarge the river section and raise the river banks so that it may be enough flow area according to the channel planning.

(iii) Regulations on Ill-planned Development in Mountainous Areas

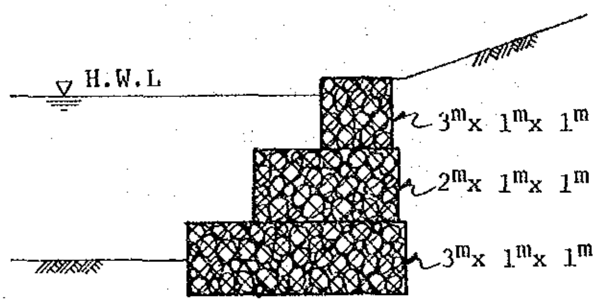
Ill-planned development not only destroys the environment, but also lessens the storage capacity, increases peak discharge and generates sediments and water pollution. Regulation on ill-planned development is required.

(7) Sediment Run-Off Caused by Road Construction

A mountain road is being constructed along the Mapocho river from near the confluence with the Arrayán. In some places, the cuttings are being thrown into the river section without proper precautions. These man-made slopes, of both cutting and banking, are liable to erosion. If left unattended, it may lead to road or river disaster. Prevention steps need to be taken urgently. One of the best methods is to construct concrete retaining walls. Gabion works is also recommendable, but water would infiltrate into the slope, so it is not 100 percent proof against erosion.



Concrete Retaining Wall



Gabion Works

Prevention works are hardly carried out on the slopes of cuttings and bankings. Replanting on banking slopes should be done by using the sprayed sodding method. Natural vegetation will not intrude into the rain-short, rock-rich banking slope by itself. Seeds of several species of grass should be mixed taking into account both the slope environment and the characteristics of the selected grasses.

When heavy-duty bulldozers are used for road construction on solid rocky slopes, rock cuttings cannot but slip down the slope into the bed river, spoiling it. An ideal combination of equipment to avoid this kind of unfortunate consequence is shovel-type excavators and dump trucks. This combination will enable the remain of cuttings to be transported to a deposit area free from the danger of further erosion.

Construction of mountain roads is a necessity for a mountainous country like Chile. Still, once the environment is destroyed it seldom returns to the previous equilibrium state. Short-sighted cheaper construction surely will have to be followed by unnecessary spending in countermeasures. So, in the long run, the situation will prove to follow the truth found in an old saying, "penny wise, pound foolish."

(8) Recommendations

1) Countercheck against Slope Failure

It is desirable to carry out mortar spraying works in the slope failure which is located in the upper basin of the San Ramón river.

2) River Improvement and Prevention Measures against Sediment Runoff

In order to prevent sediment runoff, it is advisable to construct debris barriers or Sabo dam in the mid-stream of the Mapocho river and in that of the San Ramón ravine.

As the river section of the San Ramón becomes smaller, the more ravine flows down. So, it is also advisable to carry out river improvement works which take into account the flow area according to the channel planning.

3) Regulation of Development

The following measures for the development in mountain regions are proposed.

a. Carry out revetment or slope replanting works in the area devastated by the construction of the existing mountain road;

b. Conduct investigation and research on the designing and execution of future mountain road construction; and

c. As ill-planned housing development at the piedmont not only reduces the precious vegetation, but also devastates the hillside and river channel, the establishing of countermeasures, like enacting of regulations, is of the almost urgency.

4) Promotion of Basic Studies

It is advisable to conduct the following basic research and data collection in order to grasp the present situation of slope failures and to study its countermeasures.

a. Topographic Maps

An essential prerequisite for the analysis, is a set of 1:5,000 scale topographic maps, without which no meaningful analysis can successfully be carried out.

b. Studies on soil and vegetation

The CONAF research station in Yerba Loca is conducting ecological studies at higher altitude with foreign trees mainly. But no study is being done on suitable species for erosion and torrent control. Ecological studies should be made on the selection of trees suitable for the replanting of slopes.

c. Data on River Sedimentation

The data on sedimentation, such as total volume of sediments, flowing down volume of materials per year and changes of elevation of riverbed, are important for analysis and countermeasures.

d. Meteorological and Hydrological Data

Meteorological and hydrological data of the upper basins are also important factors for the analysis of the phenomenon of erosion.

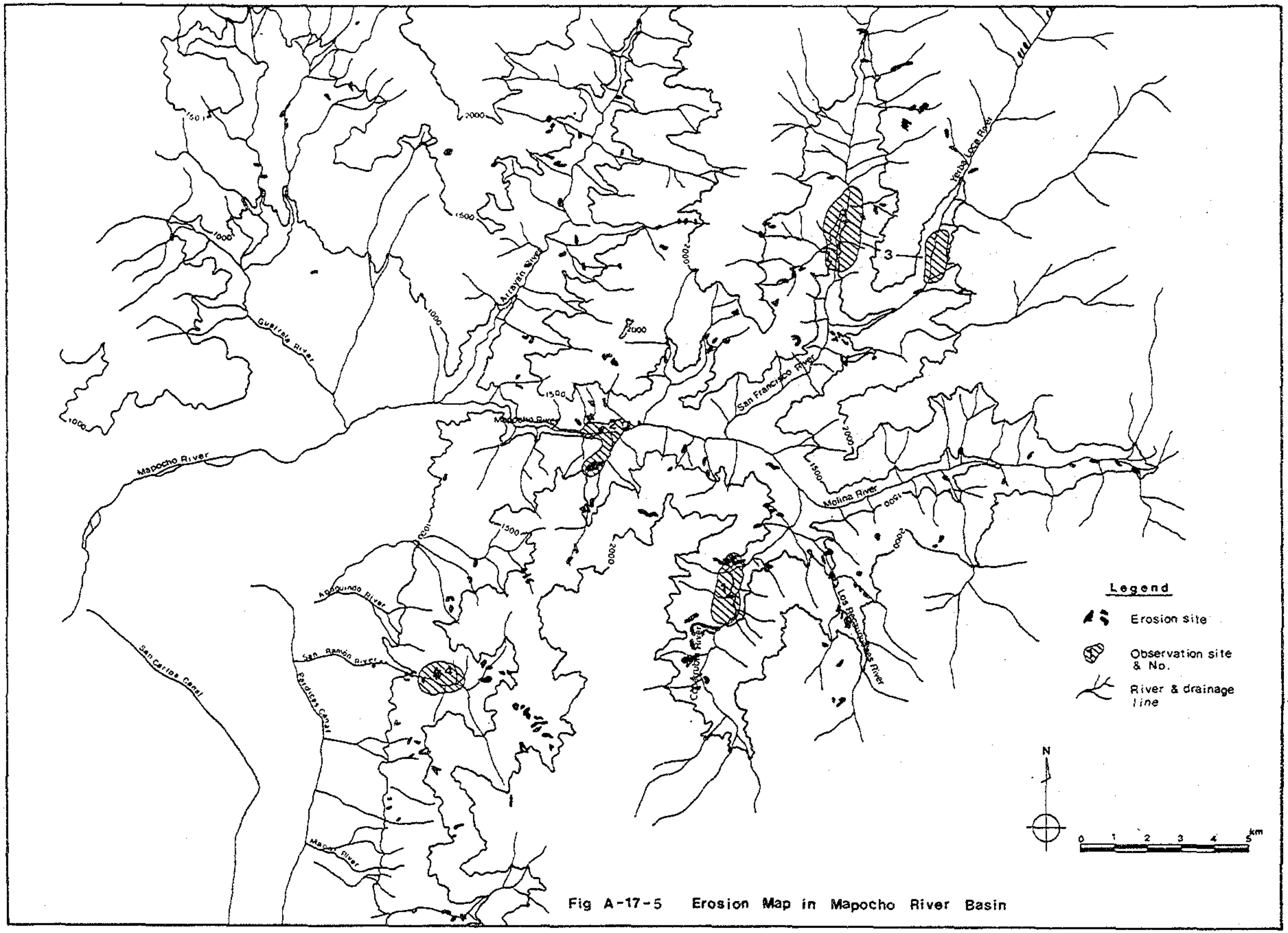


Fig A-17-5 Erosion Map in Mapocho River Basin

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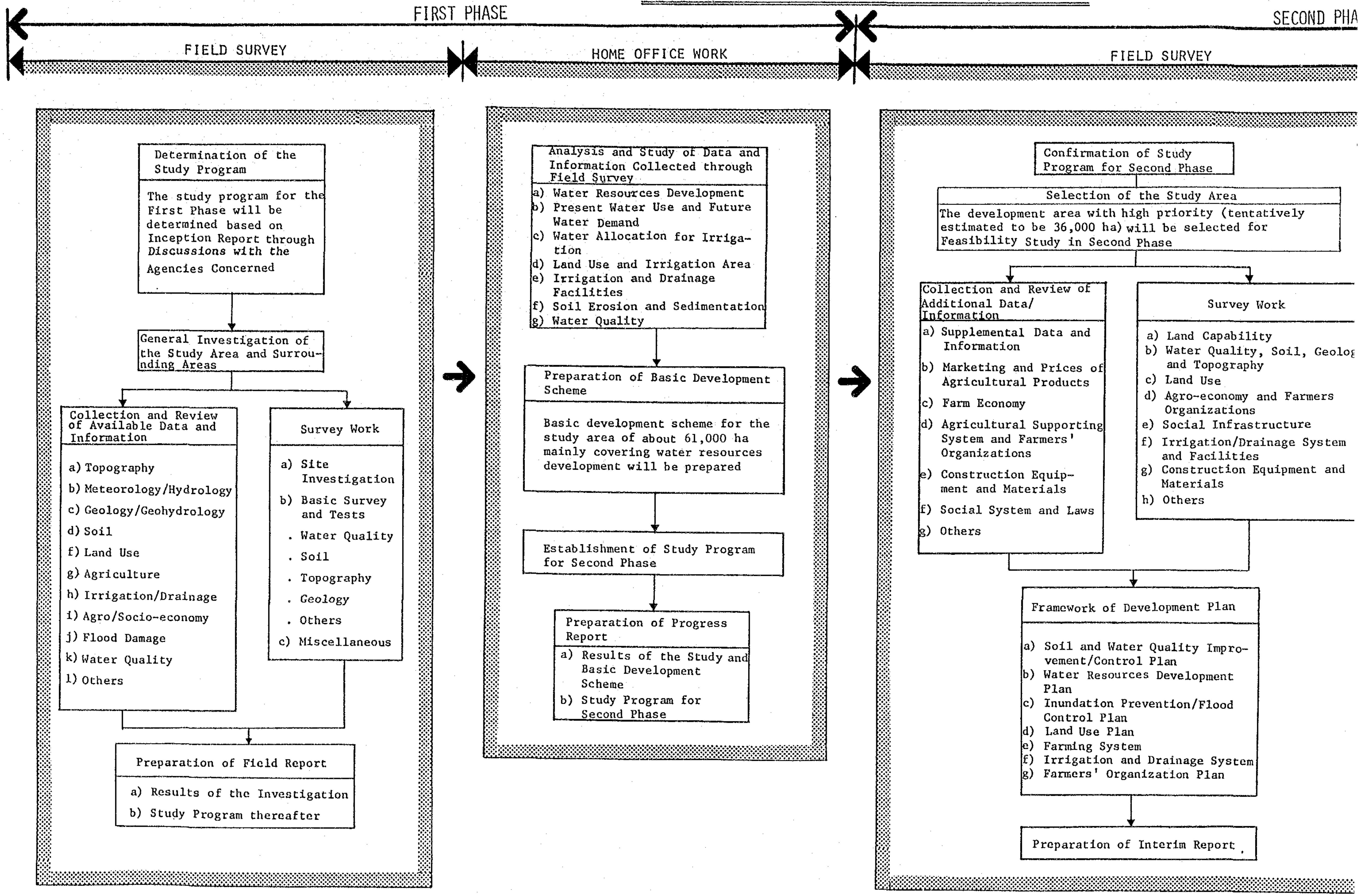
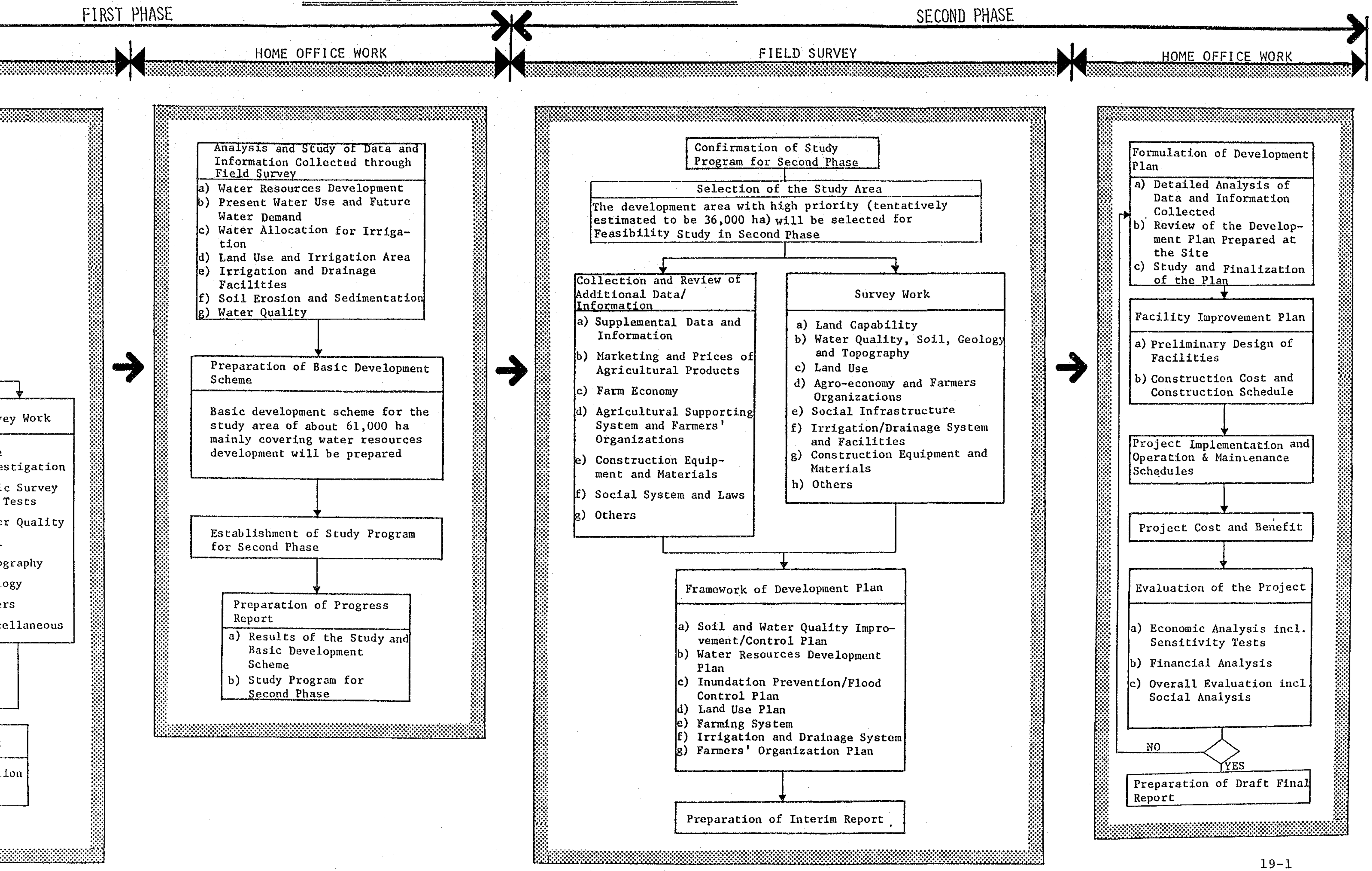
Appendix 19 Work Flow Chart

WORK FLOW CHART



WORK FLOW CHART



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