THE REPUBLIC OF COLOMBIA

FEASIBILITY STUDY ON

[redacted]

FINAL REPORT APPENDIX

JUNE, 1984

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE REPUBLIC OF COLOMBIA

FEASIBILITY STUDY ON
THE PAMPLONITA RIVER BASIN
AGRICULTURAL DEVELOPMENT PROJECT
FINAL REPORT APPENDIX

JUNE, 1984

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

CONTENTS

APPENDIX 1. BACKGROUND

LIST OF TABLES

LIST OF FIGURES

1.1 National Data

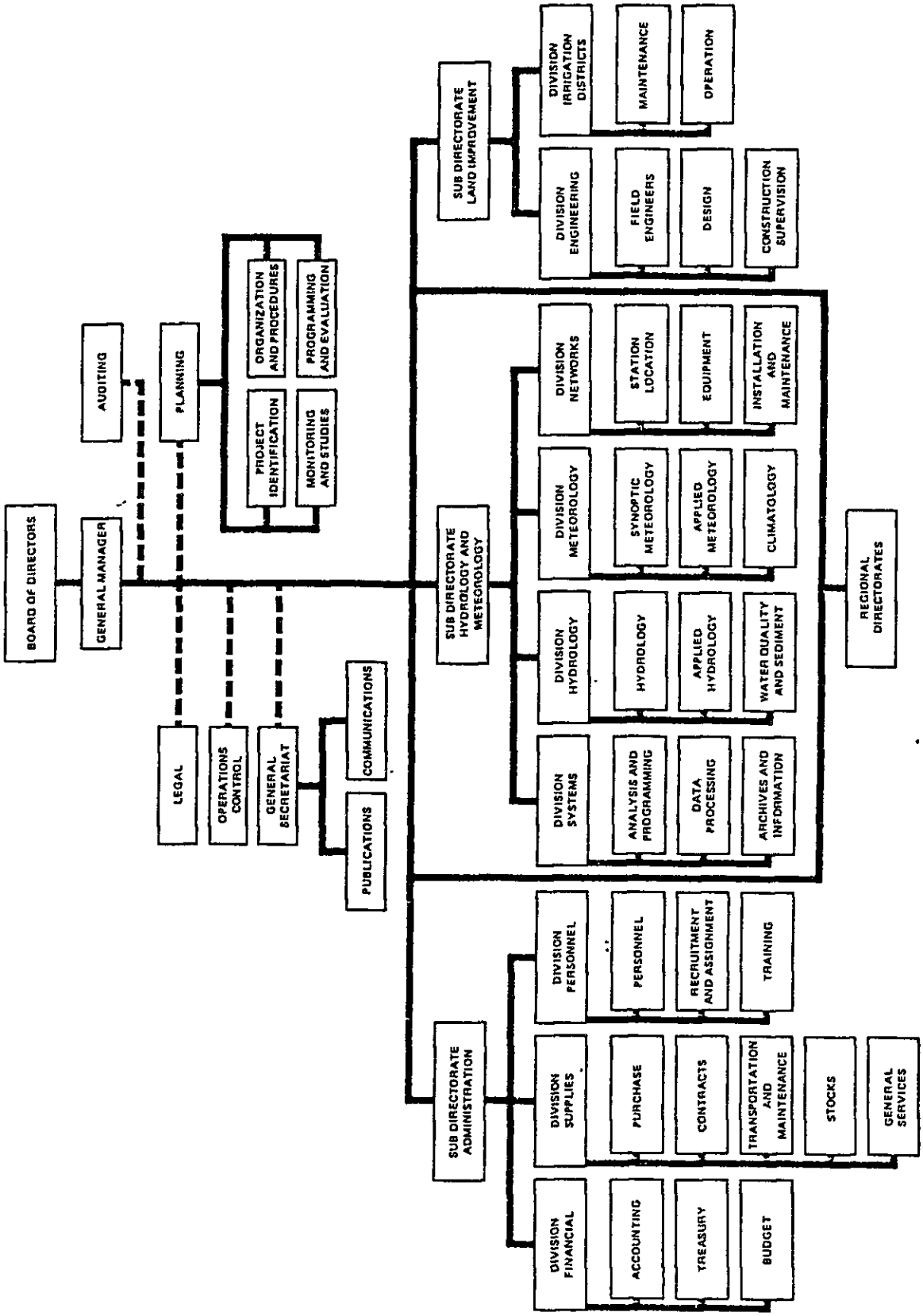


Fig. 1–1–1 Organization Chart of HIMAT

Table 1–1–1 Gross Domestic Product by Sectors

(10^6 COL$)

Year	GDP	Agri-culture forestry	Manu-facturing	Construc-tion	Mining	Commerce	Others
1960	75,895	22 473	13,160	3,147	1,948	12,730	22,620
1965	99,940	27,341	18 045	4,411	2,135	16,920	30,960
1970	131,603	33,268	24,745	6,184	2,339	22,500	42,390
1975	173,298	40,469	33,932	8,669	2,563	29,900	58,030
1980	228,203	49,235	46,569	12,152	2,808	39,750	79,450
1985	300,504	59,900	64,803	17,035	3,077	52,840	108,760
1990	395,710	72,872	87,492	23,880	3,372	70,250	148,900
1995	516,350	86,185	120,765	36,672	3,767	92,320	197,140

Source: La Economia Colombiana en Decada de los Ochenta

(%)

Year	GDP	Agri-culture forestry	Manu-facturing	Construc-tion	Mining	Commerce	Others
1960	100.00	29.61	17.34	4.15	2.57	16.77	29.80
1965	100.00	27.36	18.06	4.41	2.14	16.93	30.98
1970	100.00	25.28	18.80	4.70	1.78	17.09	32.21
1975	100.00	23.25	19.58	5.00	1.48	17.26	33.48
1980	100.00	21.68	20.39	5.33	1.23	17.42	34.81
1985	100.00	19.93	21.23	5.67	1.02	17.58	36.19
1990	100.00	18.42	22.11	6.03	0.85	17.75	37.63
1995	100.00	16.69	23.69	7.10	0.73	17.88	38.18

Source: La Economia Colombiana en Decada de los Ochenta

Table 1–1–2 Exportation and Importation Balance

(10^8US$)

Year	Exportation	Importation	Deficit
1975	14.9	14.7	0.2
1980	46.6	39.45	7.15
1981	60.9	30.3	30.6
1982*	61.6	30.5	31.1

*Estimated

Source: DANE, 1982

Table 1–1–3 National Population in Urban and Rural

Year	Total population (1)		Urban population (2)			Rural population (3)		
	10^3	Growth rate (%)	10^3	Growth rate (%)	(2)/(1) %	10^3	Growth rate (%)	(3)/(1) %
1951*	11,548		4,468		38.6	7,080		61.4
		3.14		5.38			1.29	
1964*	17,485		9,093		52.0	8,391		48.0
		2.84		4.28			1.02	
1973*	22,773		13,550		59.5	9,223		40.5
1978**	24,922		15,664		62.8	9,258		37.2
		1.97		3.01			0.06	
1983**	27,503		18,217		66.2	9,286		33.8
		1.82		2.66			0.05	
1988**	30,123		20,814		69.1	9,309		30.9
		1.75		2.47			0.04	
1993**	32,878		23,551		71.6	9,327		28.4
		1.55		2.13			0.03	
1998**	35,544		26,201		73.7	9,343		26.3
		1.26		1.68			0.03	
2008**	37,863		28,507		75.3	9,355		24.7

* Census
** Estimated number by DNP

Resource: Plan de Integracion Nacional 1979-1982

Table 1–1–4 Population by Department

Department	Population (10^3) 1977	Area (Km^2)	GDP (1970 Value 10^6COL$) 1960	1975
Antioquia	3,435	63,612	10,637.1	23,772.1
Atlantico	1,165	3,388	3,768.2	9,865.3
Bolivar	1,008	25,978	3,249.3	7,321.9
Boyaca	1,167	23,189	3,868.3	6,158.2
Caldas	750	7,888	3,121.0	4,568.9
Caqueta	-	88,965	-	-
Cauca	792	29,308	1,624.0	2,705.9
Cesar	463	22,905	1,281.4	4,049.3
Cordoba	859	25,020	2,128.6	4,664.1
Cundinamarca	4,732	24,210	16,828.6	46,771.4
Choco	246	46,530	247.3	409.9
Guajira	248	20,848	500.1	1,676.3
Huila	532	19,890	1,464.8	2,908.1
Magdalena	668	23,188	1,812.0	3,765.5
Meta	307	85,635	785.9	2,592.8
Narino	984	33,268	1,961.7	3,314.1
Norte de Santander	824	21,658	2,251.7	3,593.4
Quindio	350	1,845	1,244.7	1,800.1
Risaralda	509	4,140	1,805.6	3,574.6
Santander	1,276	30,537	4,407.4	9,000.5
Sucre	457	10,917	995.8	2,555.2
Tolima	1,005	23,562	3,532.6	7,103.0
Valle del Cauca	2,652	22,140	9,677.9	20,804.4
National	24,429	1,141,748*	77,714.4*	176,477.6*

* Incluye comisario

Resource: Colombia Economic Structure and Plan de Integracion Nacional 1979-82

Table 1–1–5 Land Scale

Land scale (ha)	No. of landowner	%	Rate of varing to 1960	Area (10^3ha)	%	Rate varing to 1960
5	700,225	59.7	7.4	1,146	3.7	7.5
5 - 9.9	156,659	13.3	5.6	1,088	3.5	6.6
10.0 - 49.9	217,873	18.6	8.4	4,653	15.0	10.5
50.0 - 99.9	47,763	4.1	19.4	3,198	10.3	19.3
100.0 - 499.9	42,897	3.6	19.1	8,253	26.6	18.1
500.0 - 999.9	4,927	0.4	19.0	3,229	10.4	18.3
1000 -	3,467	0.3	25.6	9,426	30.5	13.3
Total	1,173,811	100.0	2.7	30,993	100.0	13.4

Source: Estructura Economica Colombiana, 1972

Table 1–2–1 Variation of Gross Production by Sector (10^6 COL$)

Sector	1973	74	75	76	77	78	79	80	81
1. Agriculture Forestry	1,049	1,114	1,201	1,231	1,264	1,321	1,356	1,397	1,416
2. Mining	299	249	223	235	237	242	245	247	248
3. Manufacturing	312	285	291	304	319	348	365	381	390
4. Construction	157	137	128	132	137	147	152	157	160
5. Commerce	725	747	734	749	764	794	811	826	835
6. Transports	119	121	136	153	173	206	231	256	273
7. Communication	30	34	39	42	45	51	56	60	63
8. Electricity and Others	153	52	55	58	62	70	75	79	82
9. Finance, Insurance	80	89	99	105	111	123	131	137	141
10. Other Services	617	646	679	707	738	790	826	863	883
Total	3,539	3,474	3,593 (100)	3,716 (103)	3,852 (107)	4,090 (114)	4,246 (118)	4,402 (123)	4,491 (125)
National (10^8 COL$)			1,752 (100)	1,833 (105)	1,922 (110)	2,094 (120)	2,201 (126)		

Source: Norte de Santander; URPA National; DANE.

Table 1–2–2 Farm Household and Average Scale by Farm Scale

Land scale	No. of Farm houshold (%)	Average scale (ha)
0 - 50ha	37,000 (93)	7.8
50 - 500ha	3,000 (7)	76.7
500 -	170 (0.4)	1,471.0
Total	40,000 (100)	19.25 ha

Source: Departamento de Norte de Santander, 1983

APPENDIX 2. METEOROLOGY AND HYDROLOGY

LIST OF TABLES

LIST OF FIGURES

2.1 Meteorology

Table 2–1–1 Monthly Mean Temperature

(°C)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Average	Period
Santa Isabel	26.2	26.2	26.7	26.9	27.4	27.3	27.2	27.3	27.3	27.2	26.8	26.2	26.9	1969-1983
Cinera	26.0	25.9	26.6	26.9	27.7	27.7	27.9	28.0	28.0	27.2	26.8	26.1	27.1	1968-1983
San Faustino	25.2	25.5	25.8	25.9	26.9	26.9	26.8	27.3	27.3	26.6	26.0	25.2	26.3	1969-1983
Camilo Daza	26.9	27.1	27.7	27.4	28.3	28.2	28.2	28.8	28.9	28.5	27.7	27.1	27.9	1941-1983
La Esperanza	15.7	15.8	16.7	16.9	17.4	17.1	16.9	17.2	17.1	17.0	16.8	15.9	16.7	1973-1981

Table 2–1–2 Monthly Mean Relative Humidity

(%)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Average	Period
Santa Isabel	85	85	85	85	84	83	82	82	82	83	84	85	85	1970-1983
Cinera	84	84	82	83	80	79	75	77	76	81	83	84	81	1968-1983
San Faustino	85	84	84	84	82	81	77	78	80	81	84	86	82	1969-1983
Camilo Daza	70	69	68	71	66	63	61	60	60	66	70	71	66	1941-1983
La Esperanza	85	86	86	88	84	85	83	83	84	86	89	88	86	1973-1981

Table 2–1–3 Monthly Mean Evaporation

(mm)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Total	Period
Santa Isabel	116.7	112.1	119.4	115.8	134.5	140.3	145.7	148.3	140.9	134.6	119.0	116.9	1844.2	1969-1980
Cinera	103.9	92.5	114.3	107.2	126.8	126.3	144.7	149.7	127.6	113.2	99.0	96.5	1401.7	1968-1980
San Faustino	102.8	91.4	106.2	95.8	117.9	117.9	131.9	139.1	125.9	107.9	89.4	83.2	1309.4	1969-1980
Camilo Daza	162.5	148.2	140.3	146.8	174.2	210.7	255.5	236.9	189.2	162.2	94.9	120.1	2041.5	1973-1983
La Esperanza														

Table 2–1–4 Monthly Mean Wind Velocity

(m/s)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Average	Period
Santa Isabel	1.2	1.1	1.6	1.4	1.7	1.5	1.6	1.5	1.4	1.2	1.3	1.4	1.4	1973-1976
Cinera	1.2	1.0	0.7	0.6	0.5	1.1	1.2	1.1	1.3	0.9	0.9	1.7	1.0	1973-1977
San Faustino	1.0	0.9	0.9	1.1	1.0	1.0	1.2	1.1	1.3	0.8	0.9	1.0	1.0	1971-1977
Camilo Daza	3.3	3.3	3.5	3.5	4.6	6.3	7.2	6.3	5.6	3.9	3.1	3.1	4.5	1944-1977
La Esparenza	1.7	1.6	1.5	1.6	1.6	1.5	1.7	1.8	1.5	1.6	1.5	1.6	1.6	1973-1979

Table 2–1–5 Monthly Mean Sunshine Hours

(hr)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Total	Period
Santa Isabel	166.6	137.8	116.9	110.3	171.9	180.5	206.8	203.3	184.6	180.7	152.2	148.8	1960.4	1970-1971
Cinera	160.6	127.1	96.4	100.8	167.6	188.4	204.6	215.3	190.6	188.9	160.2	147.8	1948.3	1970-1978
San Faustino	145.5	104.9	106.0	93.5	164.0	175.4	199.3	197.1	171.6	178.2	139.5	150.7	1825.7	1970-1978
Camilo Daza	209.9	171.1	157.7	140.3	175.8	163.8	205.3	202.7	204.3	198.7	198.6	181.5	2209.7	1975-1979
La Esparenza														

2.2 Rainfall

Table 2–2–1 Recurrence of Daily Maximum Rainfall

(Unit:mm)

Station	Rainfall Days	Return Periods (year)					
		2	5	10	20	30	50
Pto. León	1	122	144	160	175	184	196
	2	160	205	239	273	295	322
	3	189	249	249	339	367	403
Santa Isabel	1	112	138	153	168	175	185
	2	136	170	190	209	219	232
	3	159	202	227	250	263	278
La Jarra	1	94	125	142	156	163	172
	2	132	170	191	210	219	231
	3	157	196	217	234	243	254
Alto Viento	1	121	147	163	177	185	194
	2	150	195	222	248	263	281
	3	181	223	248	269	280	294
Cienra	1	133	164	182	198	207	218
	2	161	201	224	243	254	267
	3	181	231	263	293	310	331
San Faustino	1	111	131	142	151	155	161
	2	135	161	177	191	198	208
	3	145	176	201	228	245	268
Aeropuerto Camilo Daza	1	73	89	99	108	113	119
	2	85	106	124	145	158	177
	3	92	111	126	141	151	164
La Esperanza	1	52	66	73	79	83	86
	2	75	95	109	122	130	141
	3	97	125	141	157	166	176

Table 2–2–2 1–day Maximum Rainfall by Year

(mm)

Type	Station \ Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Average
I	Pto Leon	97.0	142 0	110.0	120 0	122.0	-	113.0	112.0	185.0	140.0	-	(126.8)
	Santa Isabel	-	135 5	136.0	135.7	90.6	135.2	140.4	71.2	87.1	121.3	100.0	(115.3)
	La Jarra	58 0	41.0	78 0	137 0	77.0	-	130 0	140.0	87.0	108.0	-	(95.1)
	Alto Viento	95.0	109.0	128.0	133.0	105.0	-	150.0	150.0	81.0	160.0	-	(123.4)
	Cinera	108.0	122 3	191.7	135.0	133.1	187.0	147.0	-	84.8	-	110.0	(135.4)
	Average	(89.5)	115.0	128 7	132.1	105.5	(161.1)	136.1	(118.3)	105.0	(132.3)	(105.0)	120.0
	San Faustino	97 8	100 0	135.8	114.6	140.2	-	-	-	-	-	80.0	(111.4)
II	Aeropuerto Camilo Daza	61.0	-	-	95.2	76 0	101.0	54.7	-	74 6	-	65.0	(75.4)
III	La Esperanza	-	-	-	61.6	55.0	-	34.8	31 1	63.2	-	70.0	(52.6)
	ISER Pamplona	-	-	-	-	-	-	-	-	50.0	-	46.9	(48.5)
	Average	-	-	-	-	-	-	-	-	56.6	-	58.5	57.6

Table 2–2–3 2–day Maximum Rainfall by Year

(mm)

Type	Station \ Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Average
I	Pto. León	147.0	167.0	115 0	144.0	214.0	-	143.0	164.0	305.0	150.0	-	(172.1)
	Santa Isabel	-	137.8	209 0	150.2	140.6	162 7	167.6	94.6	87.1	139.2	114.3	(140.3)
	La Jarra	93 0	58.0	122.0	209 0	123.0	-	160.0	154.0	153.0	130.0	-	(133.6)
	Alto Viento	117 0	127.0	187.0	208.0	165 0	-	150.0	175.0	81.0	198.0	-	(156.4)
	Cinera	165.3	134.1	238.9	170.3	152.0	230.0	147.0	-	95.0	-	143.4	(164.0)
	Average	(130.5)	124 8	174.4	176 3	158 9	(196.9)	153.5	(146.9)	144.2	(116.8)	(128.9)	155.4
	San Faustino	100.5	137 8	159.3	122.0	168.9	-	-	-	-	-	86.0	(129.1)
II	Aeropuerto Camilo Daza	94.0	-	-	136.3	76.0	115.1	72.8	-	76.9	-	74.9	(92.3)
III	La Esperanza	-	-	-	100.4	64.5	-	63.4	57.2	76.4	-	110.0	(78.7)
	ISER Pamplona	-	-	-	-	-	-	-	-	59.3	-	54.1	(56.7)
	Average	-	-	-	-	-	-	-	-	67.9	-	82.1	75.0

Table 2–2–4 3–day Maximum Rainfall by Year

(mm)

Type	Station \ Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Average
I	Pto. León	192 0	167.0	125 0	210 0	235.0	-	156.0	171.0	380.0	200.0	-	(204.0)
	Santa Isabel	-	152.4	243.3	175 0	160.6	192.4	170.2	105.3	94.4	211.0	124.2	(162.9)
	La Jarra	118.0	72 0	140 0	234 0	178 0	-	180.0	164.0	153.0	179.0	-	(157.6)
	Alto Viento	161 0	134 0	225.0	267 0	190.0	-	185.0	175 0	106.0	208.0	-	(183.4)
	Cinera	248 9	181.2	248 8	207.1	167 4	230 0	175.0	-	100 0	-	146.4	(187.2)
	Average	(180 0)	132 3	196.4	218 6	186 2	(211 2)	173 4	(153 8)	166 7	(199.5)	(135.3)	179.8
	San Faustino	124 8	140 2	160.0	125 1	213 0	-	-	-	-	-	116.0	(147.7)
II	Aeropuerto Camilo Daza	94.0	-	-	141 2	84.7	115 1	87 1	-	82 2	-	76.3	(97.2)
III	La Esperanza	-	-	-	141 8	74 0	-	87.8	61 9	112.9	-	120.0	(99.7)
	ISER Pamplona	-	-	-	-	-	-	-	-	68.4	-	62 6	(65.5)
	Average	-	-	-	-	-	-	-	-	90.7	-	91.3	91.0

Table 2–2–5 Monthly Rainfall

Station PUERTO LEON

(mm)

Year	Jan.	Feb	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1963	-	-	-	-	-	-	-	-	-	-	-	170
1964	40	80	10	412	316	152	82	324	88	172	260	142
1965	246	46	30	354	388	164	174	198	496	100	207	271
1966	17	106	93	212	262	328	67	332	319	327	494	104
1967	168	133	101	473	248	209	158	140	169	115	386	127
1968	91	156	136	475	362	165	152	259	133	291	66	98
1969	321	140	150	432	164	289	221	212	196	503	358	392
1970	177	181	136	124	170	68	317	223	294	201	478	338
1971	226	131	236	129	480	65	69	203	362	280	289	320
1972	170	70	140	571	82	40	256	277	232	70	234	120
1973	37	50	106	92	142	152	165	113	333	192	618	321
1974	190	225	260	409	321	11	300	171	287	349	341	86
1975	62	53	137	100	412	145	123	372	482	272	639	438
1976	77	399	148	195	201	51	148	248	186	377	218	81
1977	164	1	116	215	291	185	130	50	325	258	201	0
1978	66	116	322	797	395	48	-	106	303	304	213	144
1979	100	143	167	542	307	230	229	78	239	377	207	209
1980	57	46	0.0	-	-	-	-	-	571	847	245	-
1981												
1982	373											

Station SANTA ISABEL

(mm)

Year	Jan	Feb.	Mar	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1971	225.3	138.6	238.4	193.3	469.4	59.5	130 0	161.4	268.6	220.7	141.3	199.7
1972	166 1	71.6	184.7	608.5	191.5	144.6	59.6	178.1	93.9	245.4	230.8	97.4
1973	19.9	15.4	(52.0)	92.6	170.0	96.7	103.5	160.8	319 5	306.4	642.3	378.7
1974	187 2	146.5	314.4	236 4	300.2	64.0	102.8	318 6	267.8	285.0	392.4	304.5
1975	27.4	216.6	71 1	218.7	234.6	99.8	108.1	163.6	358.5	404.9	563.0	579.5
1976	196.2	294 4	314 3	194.8	139.2	79.5	113.0	143.2	273.9	362.7	186.9	44.2
1977	83.9	1.6	94 1	91.3	148.5	190 4	160 2	95 7	131 2	262.1	235.7	0.5
1978	36.4	106.2	205 8	380.9	85.2	75.0	169.3	115.1	236.2	329 6	160.1	192.9
1979	67.2	49 9	234.0	184.1	181.6	222 0	192 1	137.9	266.3	287.5	299.3	344.3
1980	101 2	100.3	4 5	132.7	114.1	109.0	159.5	175.3	261.9	251.6	398.1	262.4
1981	168.3	238 8	154 0	886.9	489.1	244 8	136.6	271.5	307.2	348.9	392.6	x

Station: LA JARRA

(mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec
1963	x	x	x	x	202.0	x	246.0	196.0	184.0	262.0	274.0	82.0
1964	25.0	76.0	10.0	407.0	381.0	159.0	135.0	127.0	142.0	274.0	296.0	306.0
1965	379.0	81.0	22.0	336.0	325.0	142.0	46.0	128.0	136.0	462.0	199.0	191.0
1966	61.0	23.0	157.0	205.0	211.0	197.0	245.0	239.0	150.0	455.0	398.0	470.0
1967	136.0	218.0	115.0	492.0	174.0	218.0	118.0	130.0	239.0	235.0	328.0	177.0
1968	156.0	74.0	163.0	447.0	255.0	240.0	92.0	128.0	134.0	339.0	80.0	58.0
1969	281.0	215.0	153.0	411.0	138.0	128.0	84.0	110.1	94.1	146.0	165.0	186.0
1970	90.0	85.0	80.0	46.0	119.0	33.0	83.0	96 0	108.0	160.0	374.0	145.0
1971	123.0	74.0	112.0	93.0	210.0	20.0	55.0	137.0	135.0	109.0	54.0	123.0
1972	56.0	37.0	103.0	380.0	77.0	77.0	25.0	58.0	57.0	149.0	114.0	21.0
1973	10.0	3.0	41.0	43.0	77.0	67.0	55.0	48.0	311.0	126.0	687 0	445.0
1974	215.0	208.0	287.0	230.0	268.0	62.0	161.0	277.0	322.0	296.0	370.0	265.0
1975												
1976	156.0	346.0	398.0	154.0	97.0	87.0	71.0	108.0	175.0	430.0	136.0	71.0
1977	101.0	0.0	117.0	97.0	138.0	142.0	213.0	43.0	100.0	249.0	252.0	0.0
1978	57.0	112.0	230.0	525.0	104.0	54.0	157.0	93.0	176.0	375.0	139.0	191.0
1979	48.0	225.0	384.0	248.0	188.0	213.0	170.0	140.0	246.0	389.0	240.0	245.0
1980	106.0	69.0	0.0	115.0	104.0	81.0	53.0	170.0	x	x	x	x

Station: ALTO VIENTO

(mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1964	x	x	x	126.0	194.0	128.0	177.0	141.0	168.0	217.0	268.0	253.0
1965	264.0	60.0	22.0	360.0	373.0	100.0	15.0	96.0	x	384.0	223.0	165.0
1966	0.0	58.0	88.0	185.0	245.0	247.0	218.0	251.0	105.0	555.0	435.0	424.0
1967	162.0	148.0	197.0	398.0	198.0	83.0	164.0	65.0	146.0	221.0	486.0	331.0
1968	220.0	101.0	179.0	409.0	267.0	232.0	77.0	84.0	185.0	271.0	157.0	85.0
1969	252.0	293.0	148.0	361.0	101.0	120.0	50.0	154.0	201.0	416.0	469.0	399.0
1970	296.0	234.0	184.0	72.0	194.0	122.0	94.0	176.0	166.0	106.0	641.0	197.0
1971	351.0	97.0	206.0	209.0	486.0	26.0	87.0	235.0	138.0	228.0	101.0	216.0
1972	223.0	101.0	140.0	576.0	143.0	130.0	13.0	94.0	115.0	238.0	195.0	47.0
1973	0.0	21.0	47.0	116.0	144.0	159.0	99.0	59.0	324.0	293.0	735.0	395.0
1974	271.0	325.0	410.0	207.0	165.0	39.0	88.0	293.0	312.0	217 0	403.0	308.0
1975												
1976	227.0	368.0	351.0	181.0	83.0	31.0	56.0	25.0	291.0	503.0	96.0	75.0
1977	70.0	4.0	64.0	293.0	110.0	124.0	92.0	34.0	106.0	265.0	166.0	0.0
1978	33.0	84.0	219.0	379.0	79.0	45.0	167.0	67.0	92.0	286.0	119.0	125.0
1979	57.0	155.0	294.0	147.0	169.0	201.0	85.0	87.0	479.0	375.0	317.0	117.0
1980	75.0	62.0	0.0	128.0	128.0	30.0	15.0	45.0	x	x	x	x
1981	142.0	81.0	103.0	562.0	194.4	114.3	47.5	182.0	91.5	121.0	361.0	162.0
1982	204.0	101.8	120.0	440.0	99.0	135.0	44.0	54.0	12.0	45.0	126.0	143.0

Station: CINERA

(mm)

Year	Jar	Feb	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct	Nov.	Dec.
1968	x	x	x	x	x	x	x	x	141.7	278.8	175.1	x
1969	x	207.0	194.5	283.1	4.0	44.4	29.6	187.9	x	x	x	396.6
1970	161.9	172.2	146.8	40.4	161.3	139.4	27.0	160.5	130.8	117.6	641.5	195.1
1971	241 9	86.3	139.9	216.1	397.7	29.7	115.8	230.3	101.3	140.6	137.6	353.2
1972	141.8	112.9	158.3	555.2	167.0	99.6	12.3	35.4	97.4	153.4	159.6	69.6
1973	12 8	42.4	146.4	105.6	130.1	125.1	65.4	89.3	365.7	380.7	633.9	349.6
1974	19.2	(33.1)	26.0	148.8	184.3	17.0	71.0	285.0	299.1	313.6	429.3	262.2
1975	46.2	71.3	31.5	215.7	212.7	98.0	176.5	88.9	231.8	249.2	776.2	546.5
1976	230.0	269.4	274.9	225.6	66.1	67.7	33.2	63.2	125.4	381.1	109.4	93.2
1977	x	x	84.1	253.4	168.6	124.1	85.2	64.2	67.9	244.2	271.8	0.5
1978	8.0	143.8	331.0	222.4	93.6	42.3	177.9	64.9	139.3	237.5	196.4	218.1
1979	89.1	194.0	235.5	133.4	103.0	117.2	148.3	69.5	384.0	237.3	356.1	184.0
1980	74.9	45.9	2 0	142.5	141.2	46.4	63.5	57.9	241.4	313.3	431.6	236.6
1981	154.7	109.5	109.6	820.4	495.0	197.1	98.3	140.0	295.8	235.1	369.8	220.9
1982	157.9	243.8	117.7	527.8	220 0	15.4	189.6	61.8	135.2	328.6	226.2	188.7

Station: SAN FAUSTINO

(mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1969	126.6	164.4	74.7	239.0	54.1	123.0	6.0	x	x	x	337.2	296.6
1970	91.3	344.9	169.1	53.2	87.2	262.0	97.9	117.4	141.8	174.6	479.0	147.5
1971	366 0	251.5	90.1	202.7	258.7	16.3	43.9	192.2	144.4	207.9	193.4	217.8
1972	223.2	248.2	200.5	441.5	103.8	70.8	26.6	23.2	45.5	298.2	84.3	90.4
1973	1.4	54.7	38.1	150.4	34.1	84.4	71.2	160.5	161.2	340.5	466.5	265.7
1974	157.2	146.7	444.8	144.1	136.9	62.4	37.1	127.1	266.3	193.2	409.4	189.8
1975	112.6	36 5	11.1	68.3	x	x	x	20.0	225.0	457.0	387.1	485.0
1976	133.7	225.1	276.7	200.4	90.4	36.1	8.9	37.5	100.0	x	165.1	53.6
1977	74.8	27.0	136 6	307.0	71.0	x	44.1	40.3	(19.5)	x	x	x
1978	x	(73.0)	237.0	399.0	181.0	76.0	51.0	12.0	182.2	316.0	110.8	142.6
1979	148.0	82.8	341.5	97.4	246.9	143.7	144.5	x	x	x	x	x
1980	152.0	136.4	17.4	138.8	25.0	33.0	21.7	54.5	166.1	239.8	144.5	121.4
1981												
1982	182.3	213.0	192.5	604.07	191.0	36.2	51.3	15.3	30.0	214.3	119.0	146.0

Station: CAMILO DAZA

(mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1960	0.7	3.1	7.5	33.1	10.2	1.1	3.1	46.9	0.4	5.0	6.2	71.3
1961	8.2	1.0	5.0	16.4	0.8	6.1	12.4	23.8	5.2	14.6	32.1	15.0
1962	21.9	15.2	32.2	7.8	20.0	2.2	15.8	1.5	19.0	99.0	50.4	14.0
1963	113.0	23.7	8.3	78.5	74.9	0.6	6.0	17.2	0.3	38.7	124.7	30.2
1964												
1965	38.0	37.1	0.5	57.2	55.7	10.4	28.2	33.4	49.2	128.6	92.4	45.1
1966	0.0	1.8	24.2	45.6	62.0	36.9	12.0	6.4	24.1	137.6	222.1	166.0
1967	22.6	24.5	97.5	217.4	121.5	37.5	40.7	12.2	25.6	13.2	88.3	33.0
1968	95.0	x	6.4	160.3	117.6	95.0	25.9	35.7	58.0	106.1	41.8	36.0
1969	14.6	33.1	52.1	137.7	21.3	27.8	10.9	54.5	88.0	139.0	120.3	33.4
1970	10.9	39.4	35.8	16.1	57.1	8.8	18.0	7.6	146.2	148.7	238.1	37.0
1971	89.1	48.6	46.1	12.0	216.1	37.2	37.7	32.9	x	231.2	63.8	39.9
1972	101.4	45.5	108.1	x	99.4	45.1	83.8	31.6	59.0	157.9	104.0	29.0
1973	21.2	40.5	16.8	157.4	36.8	30.7	50.6	17.8	195.0	128.5	129.4	208.8
1974	27.5	33.0	64.4	69.0	102.2	22.9	24.8	63.0	163.5	56.9	173.4	113.3
1975	30.8	5.4	9.8	113.7	52.2	65.2	20.2	16.7	85.7	139.9	255.8	284.4
1976	96.4	44.4	140.9	140.9	53.7	46.3	33.2	54.3	71.6	277.4	85.1	21.8
1977	30.7	4.5	92.6	x	71.4	68.0	52.8	44.6	32.4	87.5	183.4	16.9
1978	0.8	19.3	112.5	180.7	51.7	31.0	43.6	36.0	69.8	154.8	83.4	40.6
1979	23.8	31.2	135.7	101.2	x	133.3	11.9	27.2	24.2	227.3	115.4	x
1980	43.3	52.7	29.9	34.5	37.0	27.6	12.6	27.3	145.2	75.3	85.5	81.8
1981	6.3	112.5	26.6	345.4	226.1	77.6	75.1	64.9	131.3	99.4	45.7	23.7
1982	-	x	24.0	x	139.3	x	-	29.8	83.8	86.3	41.6	32.8

Station: LA ESPERANZA

(mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1973	8.0	1.4	23.0	57.3	71.3	159.7	101.8	144.2	86.0	91.1	391.2	78.7
1974	55.5	103.7	73.1	(99.0)	157.5	53.1	81.3	81.1	266.0	272.0	239.0	8.0
1975	x	8.0	29.0	170.0	193.0	87.5	109.4	125.2	236.5	208.1	199.2	x
1976	77.4	152.1	155.3	144.0	56.1	(123.4)	63.1	72.2	159.2	194.5	91.8	36.3
1977	7.6	0.1	29.7	62.2	153.7	x	135.3	80.3	120.5	148.8	60.8	2.6
1978	11.5	19.7	135.8	287.9	150.1	138.0	97.1	92.1	147.7	225.6	40.8	x
1979	x	x	x	x	119.4	233.3	135.2	x	x	x	x	20.4
1980	188.5	97.0	14.8	70.2	178.4	160.3	104.4	89.1	136.1	179.2	147.5	66.3
1981	21.4	34.8	94.8	530.1	469.3	171.9	63.1	136.4	169.8	341.8	64.4	38.5
1982	89.5	159.49	112.6	592.70	133.8	113.9	80.9	73.73	245.75	164.03	127.04	34.15

Station: ISER PAMPLONA

(mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1978	0.8	19.4	107.2	154.2	60.8	97.4	44.4	70.1	55.2	101.9	(42 6)	20.9
1979	x	x	x	x	x	x	x	62.9	x	x	x	65.1
1980	48.6	31.6	31.7	79.5	93.3	79.0	49.6	71.0	101.9	59.4	86.9	55.0
1981	4.1	21.1	34.9	263.1	333.8	51.0	108.4	99.8	108 4	170.8	38.7	9.0
1982	51.0	60.2	112.4	342.9	29.3	50.9	32.5	36.3	59.9	118.4	75.4	24 5

2.3 Hydrology

Table 2–3–1 Monthly Discharge

Station: Puerto León (Unit: m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1969													
1970													
1971													
1972	-	-	-	-	-	-	-	-	-	-	89.3	41.6	-
1973	30.6	23.8	20.8	25.0	36.3	37.2	38.4	53.1	148.6	181.4	285.1	192.4	90.2
1974	117.7	115.6	115.8	134.1	221.9	86.5	63.9	78.1	144.7	157.1	237.2	117.7	132.5
1975	59.3	41.9	61.1	76.6	-	76.0	88.9	48.9	156.9	230.8	-	-	-
1976	-	187.0	251.8	209.5	(140.3)	(92.4)	(76.5)	-	56.0	208.5	194.1	93.9	-
1977	43.0	34.1	34.5	72.3	83.2	90.0	76.6	-	-	106.7	153.0	50.0	-
1978	32.5	41.2	84.8	277.0	156.2	87.0	61.4	47.6	63.9	142.6	105.9	92.6	99.4
1979	-	-	-	144.1	201.3	214.5	66.2	70.9	147.6	170.1	369.5	177.2	-
1980*	72.8+	91.8+	32.4+	44.7+	45.0+	64.1+	43.8+	52.6	95.7	114.1	141.6	97.6	74.7+
1981*	65.5	67.8	61.3	328.7	449.0	210.3	82.2+	77.9+	158.5	151.6	238.8	145.9+	169.8+
1982	101.0	97.0	99.0	421.0	312.0	135.0	91.0	38.0	54.0	135.0	107.0	93.0	140.0
Average*	60.2	75.4	82.8	146.9	166.7	106.4	66.4	61.3	121.5	162.5	201.6	112.1	113.7

* Average from 1973 to 1981.

Station: Pajarito (Unit: m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1960	32	33	31	54	215	117	46	63	50	64	90	174	81
1963	-	-	-	-	-	-	-	-	-	-	115	41	-
1964	27	22	18	54	45	104	72	52	43	66	80	65	54
1965	80	43	28	66	96	55	26	44	r2	113	95	82	64
1966	38	26	20	-	-	98	-	61	46	140	232	-	83
1967	-	-	-	-	-	-	-	34	57	66	85	52	-
1968	36	50	34	156	156	127	74	66	81	83	77	55	83
1969	41	51	38	160	97	54	37	58	79	175	187	115	91
1970	52	44	36	38	73	50	40	43	61	130	209	196	82
1971	86	85	88	104	253	86	60	65	96	129	112	30	103
1972	96	68	82	196	189	84	48	37	30	53	77	42	82
1973	27	34	20	61	85	80	37	43	96	147	197	127	79
1974	66	64	64	88	149	64	46	42	79	120	214	78	89
1975	42	34	35	62	143	72	71	42	114	165	326	286	116
1976	131	121	137	114	101	72	56	31	37	163	104	92	97
1977	31	25	29	39	59	68	40	35	30	65	111	33	47
1978	21	24	53	211	139	66	50	31	53	92	71	56	72
1979	34	27	43	116	140	140	53	55	83	112	206	116	94
1980	49	65	34	39	38	44	26	42	44	74	56	60	48
Average	53	48	47	97	124	81	49	47	62	109	139	97	79

Table 2-3-1 Monthly Discharge

Station: Agua Clara (Unit: m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1966	-	-	-	-	-	29.5	13.4	9.8	4.8	-	-	-	-
1967	-	-	-	-	-	-	-	11.0	-	-	-	-	-
1968	-	-	-	-	-	69.0	39.9	22.5	17.5	23.4	26.6	16.4	-
1969	-	-	-	57.5	21.6	11.8	7.6	9.9	-	-	-	-	-
1970													
1971	40.2	33.5	24.5	60.8	-	29.0	25.3	21.9	21.0	16.5	-	11.4	(28.3)
1972													
1973	4.7	7.8	3.4	9.8	8.1	13.2	-	6.9	43.1	-	-	-	-
1974	32.4	40.8	34.7	-	-	14.4	8.1	8.1	30.9	41.2	-	26.2	-
1975	9.4	5.1	3.1	13.9	34.9	14.5	20.1	7.4	29.3	-	-	-	-
1976	46.0	54.0	79.9	62.7	28.4	26.3	21.3	8.3	7.6	64.6	45.0	13.2	(38.0)
1977	5.74	4.34	3.97	17.77	9.59	11.84	15.12	8.56	-	11.45	25.98	4.35	-
1978	3.0	4.1	10.9	76.0	14.8	12.6	7.1	5.3	6.9	26.8	9.1	12.2	(15.7)
1979	4.8	3.7	22.7	21.1	(28.8)	51.1	11.2	8.8	20.5	47.1	(80.9)	(52.3)	(29.4)
1980*	16.0	(14.7)	11.1	18.6	31.2	35.3	(6.6)	5.5	8.5	18.2	11.6	8.2	(15.5)
1981	5.6	4.4	5.3	(90.9)	41.9	36.8	10.1	7.0	28.3	22.2	39.6	14.1	-
1982	21.0	22.0	21.0	95.0	59.0	-	-	-	-	25.0	13.0	14.0	207.0
Average*	14.2	15.4	19.5	38.9	24.7	24.0	12.5	7.4	21.9	33.1	35.4	18.7	22.1

* Average from 1973 to 1981.

Station: La Donjuana (Unit: m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1973	3.5	3.6	2.9	3.2	2.9	3.6	3.0	2.7	5.2	5.7	11.2	7.3	4.6
1974	4.0	4.2	4.2	6.1	16.3	8.8	6.6	5.6	6.5	6.6	14.0	7.0	7.6
1975	5.4	4.6	4.2	6.0	11.8	6.3	5.5	3.7	5.9	9.6	18.3	24.1	8.8
1976	14.5	14.2	14.8	16.3	10.6	8.6	7.6	5.7	4.8	11.6	12.4	7.8	11.0
1977	4.9	3.8	3.5	4.3	5.4	4.9	4.4	3.7	2.8	4.1	7.5	3.6	4.4
1978	2.6	2.8	3.8	12.2	7.8	5.5	4.1	3.3	4.5	6.3	5.3	4.4	5.2
1979	3.7	3.0	4.0	6.3	7.9	11.4	6.6	5.2	6.1	8.8	23.6	13.0	8.3
1980	8.5	8.0	6 4	6.0	5.1	4.6	3.4	3.4	2.9	3.2	3.5	4.3	4.9
1981	4.8	2.9	2.0	6.7	24.0	16.0	11.2	5.9	12.0	12.5	12.5	10.8	10.1
1982	8.6	9.9	11.0	25.4	19.8	12.1	8.4	8.6	5.6	7.2	6.8	6.8	10.7
Average	6.1	5.8	5.7	9.3	11.2	8.2	6.1	4.6	5.6	7.6	11.5	8.9	7.6

Table 2–3–2 Discharge Variations

(Unit m^3/s)

Year	Agua Clara					Pto. León				
	95-day	195-day (Ordinary)	275-day (Low)	355-day (Droughty)	Annual Average	95-day	185-day (Ordinary)	275-day (Low)	355-day (Droughty)	Annual Average
1973	28.8	9.5	3.7	1.8	24.4*	135	38	23	15	90
1974	41.1	24.3	12.8	4.2	31.9*	165	110	84	50	132
1975	35.7	9.5	5.5	1.8	29.5*	-	-	-	38	-
1976	47.0	26.3	15.1	4.0	38.0	192	122	79	39	153
1977	10.5	6.0	4.4	3.7	10.0*	82	56	40	24	70
1978	12.8	7.2	4.2	2.9	15.7	123	70	47	29	99
1979	36.1	12.4	7.5	3.0	28.7*	195	94	46	31*	140*
1980	10.0	10.5	6.1	4.0	14.9*	92	62	40	24	75
1981	22.2	7.5	2.8	2 5	20.7	229	125	63	31*	170
1982	-	-	-	7.5*	-	277	79	83	29	140
Average	27.1	13.6	6.9	3.5	23.8	166	84	56	31	119

Note: * Estimated Value

Table 2–3–3 Estimate of River Capacities

River	Location	Slope	Roughness Coefficient	Water Level (m.a.s.l.)	Water Level (m)	Water Depth (m)	Cross-sectional Area of Flow (m^2)	Velocity (m/s)	Discharge (m^3/s)
Pamplonita	P_1	1/2,000	0.03	55.8	-	3.5	140	1.5	210
"	P_2 National Road Bridge	1/2,000	0.04	57.0	-	5.0	230	1.0	230
"	P_3 El Dorado	1/1,600	0.03	64.2	-	4.5	200	1.6	320
"	P_4 Agua Clara	1/1,500	0.03	67.9	2.5	3.0	167	1.8	300
"	P_5 Proposed Siphon Spot	1/240	0.05	-	-	3.3	224	2.4	540
"	P_6 San Faustino Bridge	1/100	0.06	-	6.2	8.5	290	4.0	1,150
Zulia	Z_1 Pto. León	1/2,400	0.03	52.7	4.9	5.2	490	1.8	900
Grita	G_1* Pto. Sandander Bridge	1/2,500	0.04	49.0	-	7.0	350	1.4	500
"	G_2	1/1,200	0.04	51.1	-	4.0	190	1.6	300
"	G_3	1/1,200	0.04	52.0	-	3.5	230	1.6	370
Guaramito	G_4 Upstream from confluence with Grita River	1/1,200	0.04	54.5	-	4.3	120	1.3	150

* At W.L. 47.0 (Q = 260), overflow occurs near this spot.

Table 2–3–4 Estimated Overflow Discharge to Inside Area from Pampolnita River

1-day duration,
5-year recurrance interval

Location	Overflow Discharge (m^3/s)
Southern Area; Right Bank	20
Middle Area; Right Bank	100
Northern Area; Right Bank	40
Middle to Northern Area; Left Bank	40
Total	200

Table 2-3-5 Estimate of Flood Discharge

Year	Agua Clara				Pto. León			
	Max. Daily Water Level		Max. Daily Discharge		Max. Daily Water Level		Max. Daily Discharge	
	(m)	(m.a.s.l.)	(m^3/s) 1/	(m^3/s) 2/	(m)	(m.a.s.l.)	(m^3/s) 1/	(m^3/s) 2/
1973	2.87	68.31	294+	360	4.58	52.39	512	760
1974	2.32	67.66	270	-	3.90	51.71	407	510
1975	3.09	68.53	341+	390	5.56	53.37	906+	1,160
1976	2.23	67.67	295	-	3.57	51.38	564	420
1977	1.19	66.63	71	-	3.15	50.96	280	310
1978	1.93	67.37	196	-	4.34	52.15	552	630
1979	2.05	67.49	183	-	4.13	51.94	579	600
1980	1.41	66.85	97	-	3.08	50.89	302	300
1981	3.40+	68.84+	375+	450+	4.58	52.39	726	760
1982	1.88	67.32	189	-	4.45	52.26	680	680
Order								
1	3.40+	68.84	375+	450+	5.56	53.37	906+	1,160
2	3.09	68.53	341+	390	4.58	52.39	726	760
3	2.87	68.31	295	360	4.58	52.39	680	760
4	2.23	67.67	294+	295	4.45	52.26	579	680
5	2.22	67.66	270	270	4.34	52.15	564	630
6	2.05	67.49	196	196	4.13	51.94	552	600
7	1.93	67.37	189	189	3.90	51.71	512	710
8	1.88	67.32	183	183	3.57	51.38	407	420
9	1.41	66.85	97	97	3.15	50.96	302	310
10	1.19	66.63	71	71	3.08	50.89	280	300

Npte: 1/; Existing Data

2/; Estimated Value assuming that stage-discharge relation has not changed considerably in last 10 years.

+; Max. Value is considered to be more than the value with this mark (+).

Table 2–3–6 Discharge Measurement

Station: Aqua Clara

No	Date	H Water Level (m)	Q Discharge (m^3/s)	Remarks $\sqrt{Q}$
1	1973 Mar. 10	0 51	4 022	2.00
2	Mar. 11	0.46	2.743	1.66
3	Mar 11	0 46	2.922	1.71
4	Apr 5	0 40	1.549	1.24
5	Apr 5	0.80	11.710	3.42
6	July 2	0.56	4.063	2.02 201
7	Aug 13	0.43	1.425	1.20
8	Oct 3	0.62	7.459	2.73
9	Nov 21	1.20	63 953	8.00
10	Nov 21	1.20	66.063	8 13
11	1974 Feb. 22	0.84	24.566	4.96
12	Aug 7	0 49	6.472	2.54
13	Aug. 7	0.49	7.075	2.66
14	Sep 17	0 66	11.044	3.32
15	Sep 17	0.74	16.885	4.11
16	Sep. 17	0.89	24.781	4.98
17	Nov. 19	1.22	48.694	6.98
18	Nov 19	1 20	48 031	6.93
19	1975 Apr. 15	0 39	4.683	2.16
20	Apr 15	0.39	4.819	2.20
21	May 24	0.61	12.754	3.57
22	May 24	0.64	14.560	3.82
23	Jul, 17	0.57	10.447	3 23

Station: Aqua Clara

No.	Date	H Water Level (m)	Q Discharge (m^3/s)	Remarks $\sqrt{Q}$
24	1975 July 17	0 59	10.291	3.21
25	Sep. 1	0.60	11.180	3.34
26	Sep 1	0 61	11.248	3.35
27	Oct. 17	1.12	40.165	6.34
28	1976 Feb. 15	1 48	120.833	10 99
29	Feb. 15	1 51	117.098	10.82
30	Mar. 26	1 09	55.173	7.43
31	Mar. 26	1 09	58 446	7.65
32	Apr. 26	0 78	43.623	6.60
33	Apr. 26	0.98	45.716	6.76
34	June 26	0 62	19.767	4.45
35	June 26	0.61	17 156	4.15
36	July 6	0.87	32.875	5.73
37	Aug. 26	0.49	8.989	3.00
38	Aug. 26	0 49	9.054	3.00
39	Oct. 2	1.18	66.001	8.12
40	Oct. 18	1.18	61.920	7.87
41	Oct. 18	1.12	55.424	7.44
42	Nov. 5	2.44	344.327	18.56
43	1977 Jan. 20	0.39	7.169	2.68
44	Feb. 21	0.32	4.786	2.19
45	Feb. 21	0 32	4.829	2.20
46	Mar. 16	0.20	1.593	1.39

Station: Agua Clara

No.	Date	H Water Level (m)	Q Discharge (m^3/s)	Remarks $\sqrt{Q}$
47	1977 Mar. 16	0.30	3.701	1.92
48	May 5	0.50	12,536	3.54
49	Sep. 5	0.32	2.700	1.64
50	Nov. 2	0.62	16.204	4.02
51	1978 Mar. 10	0.40	5.204	2.28
52	May 30	0.55	18.183	4.26
53	Oct. 18	0.84	29.617	5.44
54	Nov. 30	0.38	7.683	2.77
55	1979 Apr. 2	0.45	8.188	2.86
56	June 12	1.19	56.548	7.52
57	July 30	0.44	12.895	3.59
58	Nov. 6	1.00	42.707	6.54
59	1980 Feb. 14	0.55	16.704	4.05
60	July 28	0.35	4.856	2.20
61	Oct. 13	0.48	10.396	3.22
62	1981 May 19	0.94	48.496	6.96
63	July 29	0.35	8.980	3.00
64	Sep. 4	1.18	69.363	8.33
65	Oct. 30	1.11	73.051	8.55
66	1982 Jan. 20	0.39	10.456	3.23
67	Feb. 19	0.57	22.791	4.77

Station: Agua Clara

No.	Date	H Water Level (m)	Q Discharge (m^3/s)	Remarks $\sqrt{Q}$
68	1982 Apr. 21	1.20	100.685	10.03
69	Apr. 26	1.01	67.694	8.23
70	June 2	0.77	28.018	5.29
71	July 8	0.73	26.450	5.14
72	July 21	0.50	13.922	3.73
73	Aug. 10	0.31	8.213	2.87
74	Aug. 30	0.28	11.756	3.43
75	Oct. 21	0.92	45.511	6.75
76	Nov. 24	0.48	16.434	4.05
77	1983 Feb. 17			
78	Mar. 30			

Station: Pto. León

No	Date	H Water Level (m)	Q Discharge (m^3/s)	Remarks
				$\sqrt{Q}$
32	1975 Oct 18	2 97	278	16.67
33	Oct 18	2 65	253	15 90
34	Nov. 24	2 86	275	16.59
35	1976 Feb. 1	2.29	156	12.47
36	Feb. 1	2.27	156	12.48
37	Feb. 19	2.25	146	12.06
38	Feb. 19	2.24	150	12.24
39	Mar 1	2.74	231	15.20
40	Mar. 25	2.76	241	15.53
41	Mar.	2.74	235	15.34
42	Mar. 14	2.73	230	15.16
43	Apr. 22	2.79	224	14.95
44	Apr. 22	2.62	222	14.86
45	May 23	1.91	113	10.65
46	June 5	1.76	96	9.45
47	July 6	1.80	89	9.45
48	July 22	1.51	64	8.02
49	Aug. 24	2.26	155	12.04
50	Sep. 12	1.17	34	5.86
51	Oct. 2	3.55	557	23.57
52	Oct. 18	2.18	138	11.76
53	Oct. 2	3.43	537	21.16
54	1977 Jan. 20	1.38	44	6.65

Station: Pto. León

No.	Date	H Water Level (m)	Q Discharge (m^3/s)	Remarks
				$\sqrt{Q}$
55	1977 Jan. 20	1.38	46	6.78
56	Jan. 29	1.35	33	5.74
57	Feb 21	1.31	33	5.74
58	Mar. 16	1.44	48	6.75
59	Mar. 16	1.42	43	6.56
60	May 10	1.46	39	6.28
61	July 7	1.68	64	8.02
62	Nov. 3	2.53	165	12.82
63	1978 Mar. 10	1.48	34	5.84
64	May 30	2.03	103	10.14
65	Oct. 19	3.25	336	18.34
66	Nov. 30	1.82	77	8.76
67	1979 Mar. 29	1.77	60	7.71
68	June 12	2.95	277	16.64
69	Aug. 30	1.62	58	7.18
70	Nov. 26	4.10	552	23.48
71	1980 Feb. 15	1.74	59	7.67
72	Aug. 1	1.47	31	5.58
73	Oct. 16	1.88	62	7.89
74	1981 Apr. 4	1.47	28	5.30
75	May 13	4.36	630	25.07
76	Sep. 2	2.77	225	15.00

Station: Pto. León

No.	Date	H Water Level (m)	Q Discharge (m^3/s)	Remarks
				$\sqrt{Q}$
77	1981 Nov. 2	3.11	317	17.80
78	1982 Feb. 26	2.02	120	10.96
79	Apr. 29	4.14	564	23.75
80	June 3	2.55	167	12.92
81	July 22	1.88	83	9.09
82	Aug. 12	1.40	43	6.54
83	Nov. 6	2.07	114	10.65
84	Nov. 23	1.91	83	9.12

Note: Data of No. 1 to No. 31 are not obtained.

Station: La Donjuana

No	Date	H Water Level (m)	Q Discharge (m^3/s)	Remarks $\sqrt{\delta}$
1	1972 Aug 26	0.78	5.3	2.30
2	Oct 31	0 77	5.5	2.35
3	Dec 8	0.78	4.2	2.04
4	1973 Feb. 5	0.70	3.1	1.75
5	Mar. 13	0 70	3.2	1.78
6	Mar. 13	0 70	3.0	1.72
7	Apr. 10	0 67	2.3	1.50
8	Apr. 25	0.76	4.2	2.06
9	July 3	0.70	2.6	1.60
10	Aug. 8	0.67	1 9	1 39
11	Oct. 5	0.80	6.4	2.53
12	1974 June 11	0.83	9.1	3.02
13	June 11	0.85	9.4	3.14
14	July 27	0.72	6.7	2.58
15	July 27	0.72	6.6	2.57
16	Aug. 7	0 68	4 9	2.22
17	Aug 7	0.68	5.2	2.28
18	Sep. 20	0.76	8.2	2.86
19	Sep. 20	0.76	8.0	2.82
23	1975 Mar. 26	0.63	4.5	2.11
24	Apr. 14	0 57	3.2	1.79
25	May 22	0.70	6.7	2.59
26	May 22	0.70	6.6	2.56

Station: La Donjuana

No.	Date	H Water Level (m)	Q Discharge (m^3/s)	Remarks $\sqrt{\delta}$
27	1975 June 20	0 65	5 6	2.38
28	July 31	0.61	5.2	2.27
29	July 31	0.60	5.0	2.26
30	Aug. 7	0.56	4.2	2 06
31	Aug. 30	0.54	3.9	1.98
33	Sep. 10	0.59	4.9	2.22
34	Oct. 16	0.86	12 2	3.50
35	Oct. 22	0.73	8 5	2 92
16	Dec. 3	0.88	16.7	4.09
37	Dec. 3	0.87	16.1	4.02
38	1976 Feb. 2	0.77	11.9	3.45
39	Feb. 2	0.77	12.3	3.50
40	Feb. 20	0.81	13.2	3.63
41	Feb. 20	0.81	12.8	3.57
42	Mar. 15	0.83	15.2	3.90
43	Mar. 15	0.83	13.3	3.64
44	Mar. 22	0.78	13.9	3.72
45	Mar. 22	0.78	13.5	3.68
46	Apr. 14	0.83	14.9	3.86
47	Apr. 14	0.83	15.2	3.90
48	Apr. 27	0.83	15.0	3.88
49	May 26	0.70	10.1	3.17
50	June 9	0.65	6.0	2 33

Station: La Donjuana

No.	Date	H Water Level (m)	Q Discharge (m^3/s)	Remarks $\sqrt{Q}$
51	1976 June 9	0.65	8.1	2.84
52	July 3	0.62	8.1	2.85
53	Sep. 26	0.50	4.0	2.00
54	Oct. 5	0.74	12.3	3.51
55	Oct. 5	0.76	13.7	3.70
56	Oct. 11	0.73	11.7	3.42
57	Nov. 22	0.67	9.0	3.00
58	Nov. 22	0.67	8.6	2.94
59	Dec. 2	0.63	7.6	2.76
60	Dec. 2	0.62	7.7	2.78
61	1977 Jan. 21	0.52	4.7	2.16
62	Jan. 21	0.52	4.6	2.15
63	Feb. 25	0.46	4.3	2.06
64	Feb. 25	0.46	2.9	1.71
65	Mar. 15	0.45	3.5	1.86
66	Mar. 15	0.45	3.8	1.95
67	May 9	0.49	4.1	2.03
68	July 5	0.51	5.2	2.28
69	Nov. 2	0.65	8.8	2.96
70	1978 Mar. 13	0.42	1.9	1.37
71	May 31	0.60	3.1	1.76
72	Oct. 27	0.71	11.3	3.36
73	Dec. 2	0.50	5.7	2.38

Station: La Donjuana

No.	Date	H Water Level (m)	Q Discharge (m^3/s)	Remarks $\sqrt{Q}$
74	1979 Mar. 31	0.48	3.8	1.94
75	June 11	0.94	21.4	4.62
76	Aug. 31	0.60	5.4	2.32
77	Nov. 6	0.80	14.7	3.83
78	1980 Feb. 16	0.71	7.1	2.66
79	July 29	0.59	3.4	1.83
80	Oct. 15	0.58	2.5	1.59
81	1981 Apr. 6	0.59	3.6	1.91
82	Apr. 23	0.90	12.9	3.59
83	May 14	0.92	28.3	5.32
84	Aug. 10	0.33	6.0	2.45
85	Aug. 20	0.33	5.4	2.33
86	Sep. 7	0.52	10.0	3.17
87	Oct. 27	0.47	11.1	3.34
88	1982 Jan. 16	0.43	7.0	2.65
89	Jan. 21	0.43	5.3	2.38
90	Apr. 21	0.90	35.4	5.95
91	Apr. 26	0.81	22.9	4.78
92	June 2	0.57	13.1	3.61
93	July 8	0.44	8.5	2.92
94	Aug. 10	0.32	5.9	2.43
95	Oct. 21	0.42	10.1	3.17

Station: La Donjuana

No	Date			H Water Level (m)	Q Discharge (m^3/s)	Remarks
						/Q
96	1982	Nov	9	0.29	5.7	2.38
97		Nov	24	0 29	6.1	2.46
98	1983	Feb	17			
99		Mar	30			

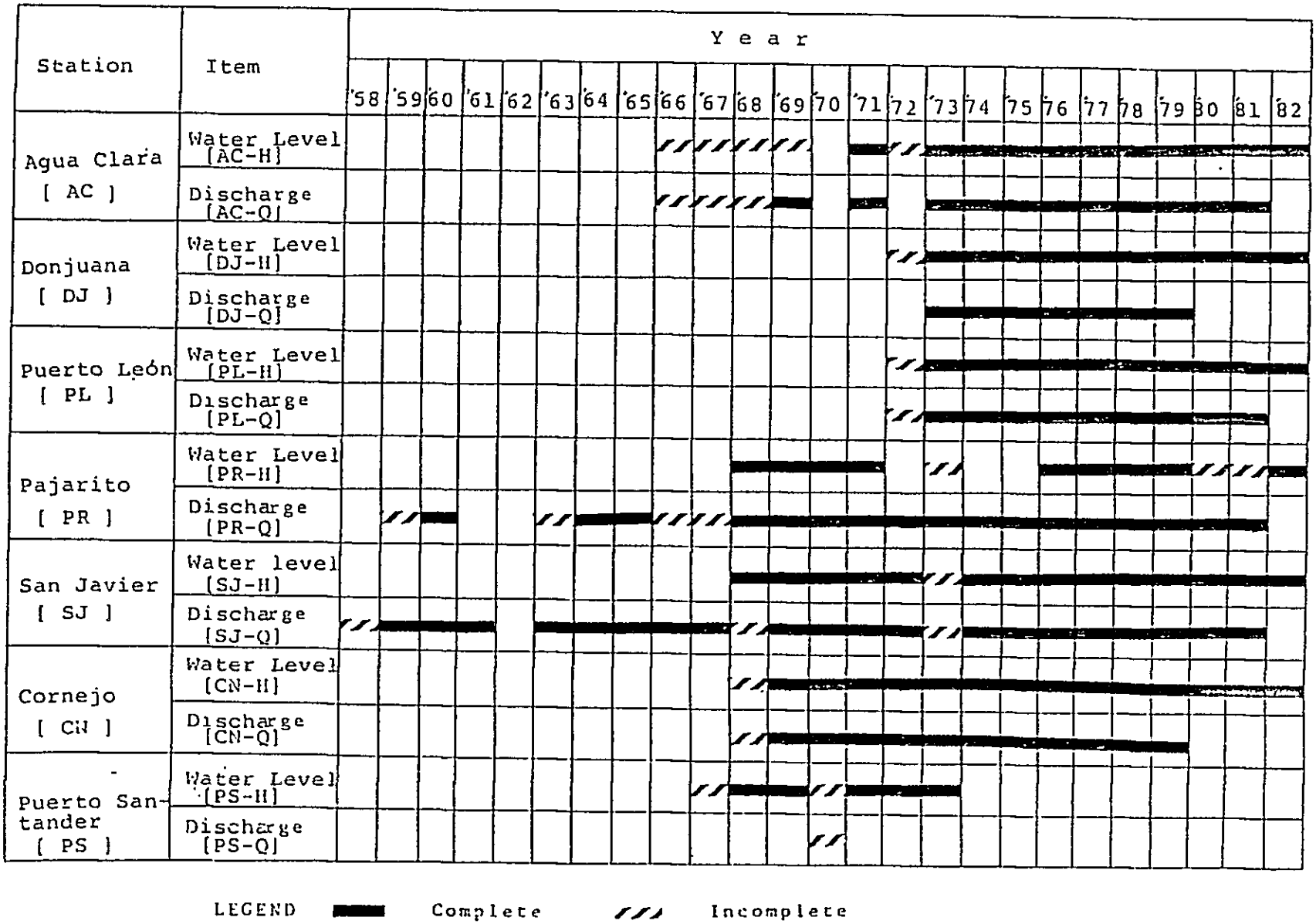


Fig. 2–3–1 Available Daily Hydrological Records

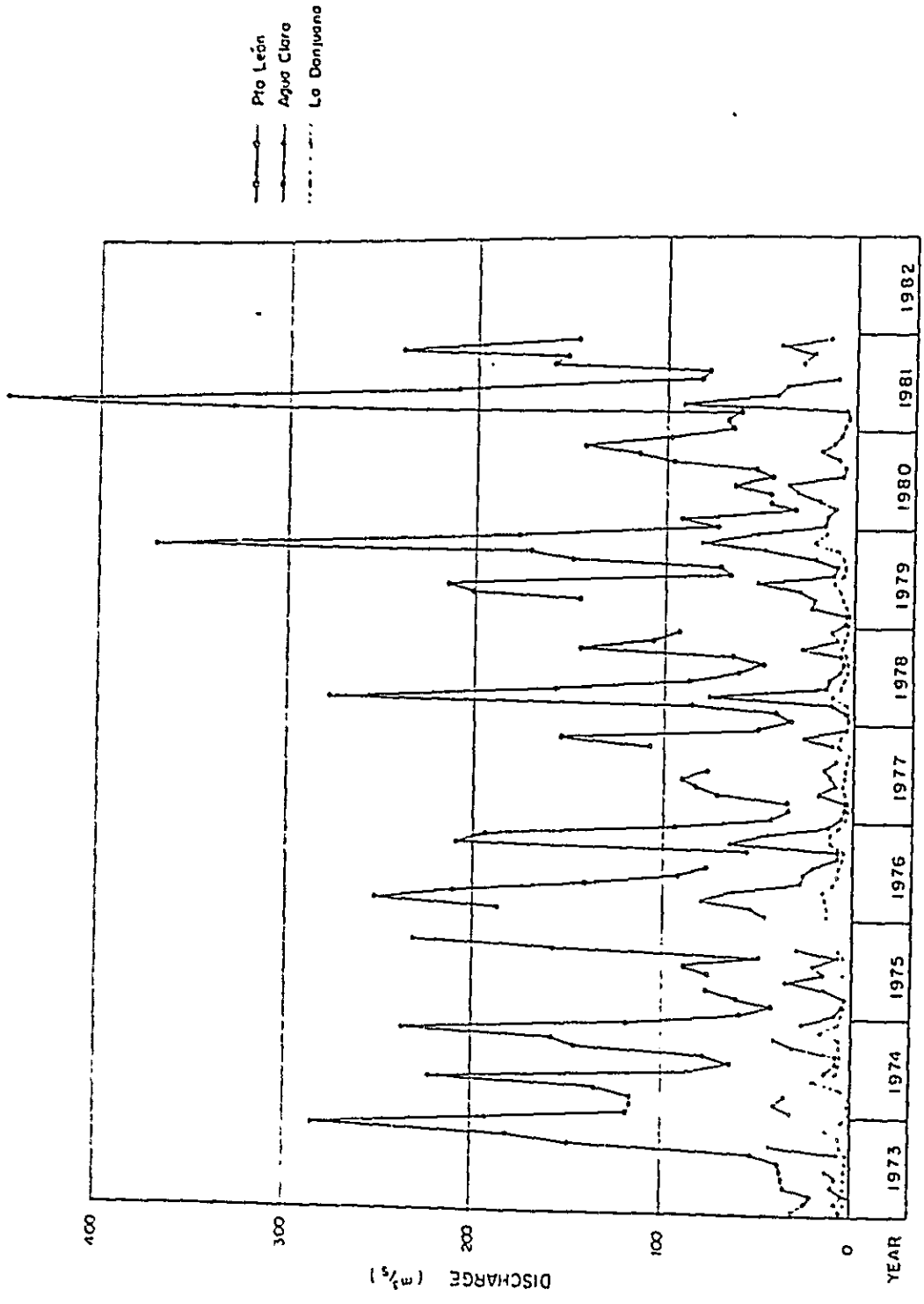
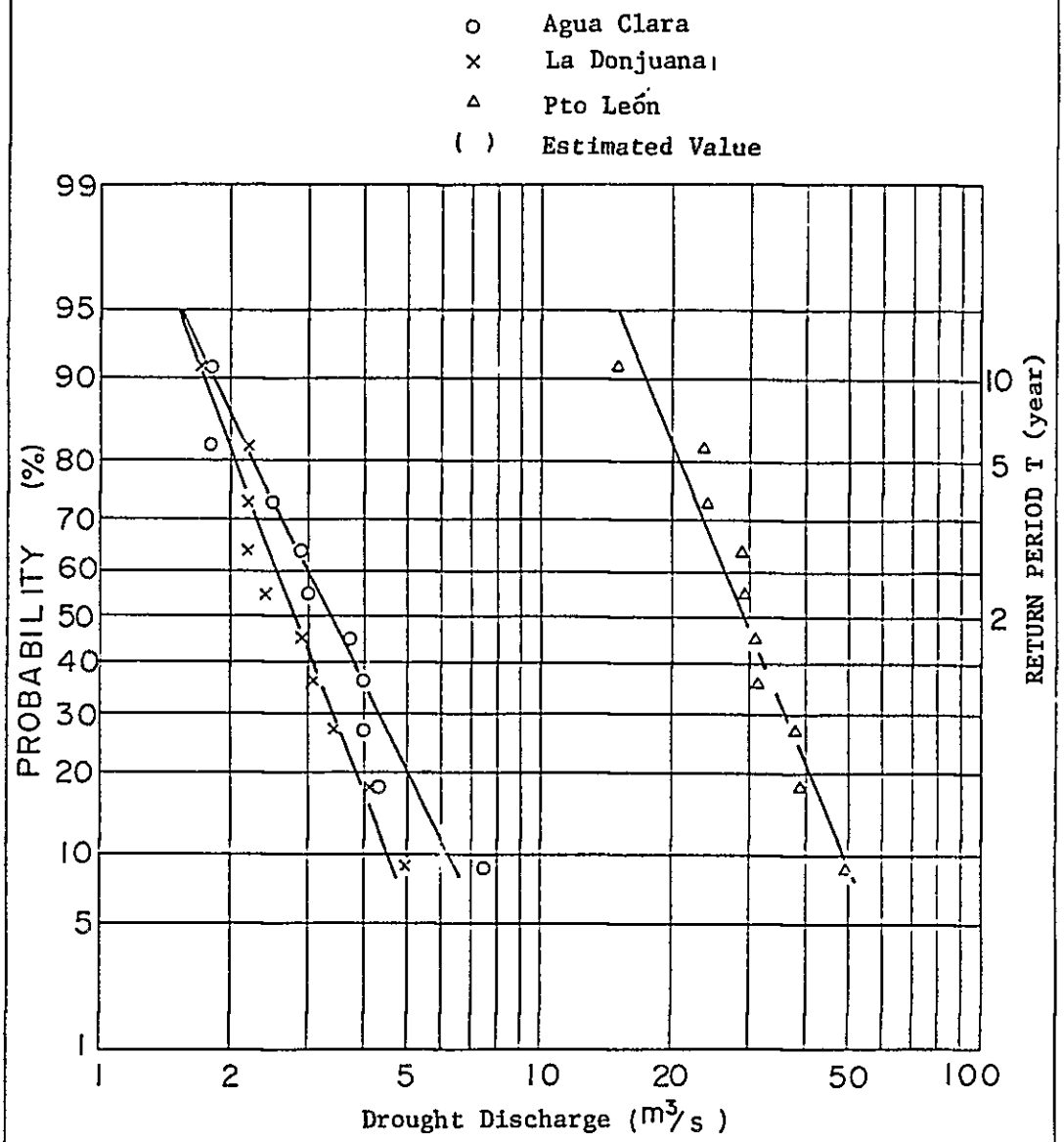


Fig. 2–3–2 Monthly Discharge



(m³/s)

T(year)	Agua Clara	La Donjuana	Pto. Leon
2	3.4	2.8	29
5	2.0	2.2	21
10	1.7	1.8	17

Fig. 2–3–3 Drought Discharge Probability

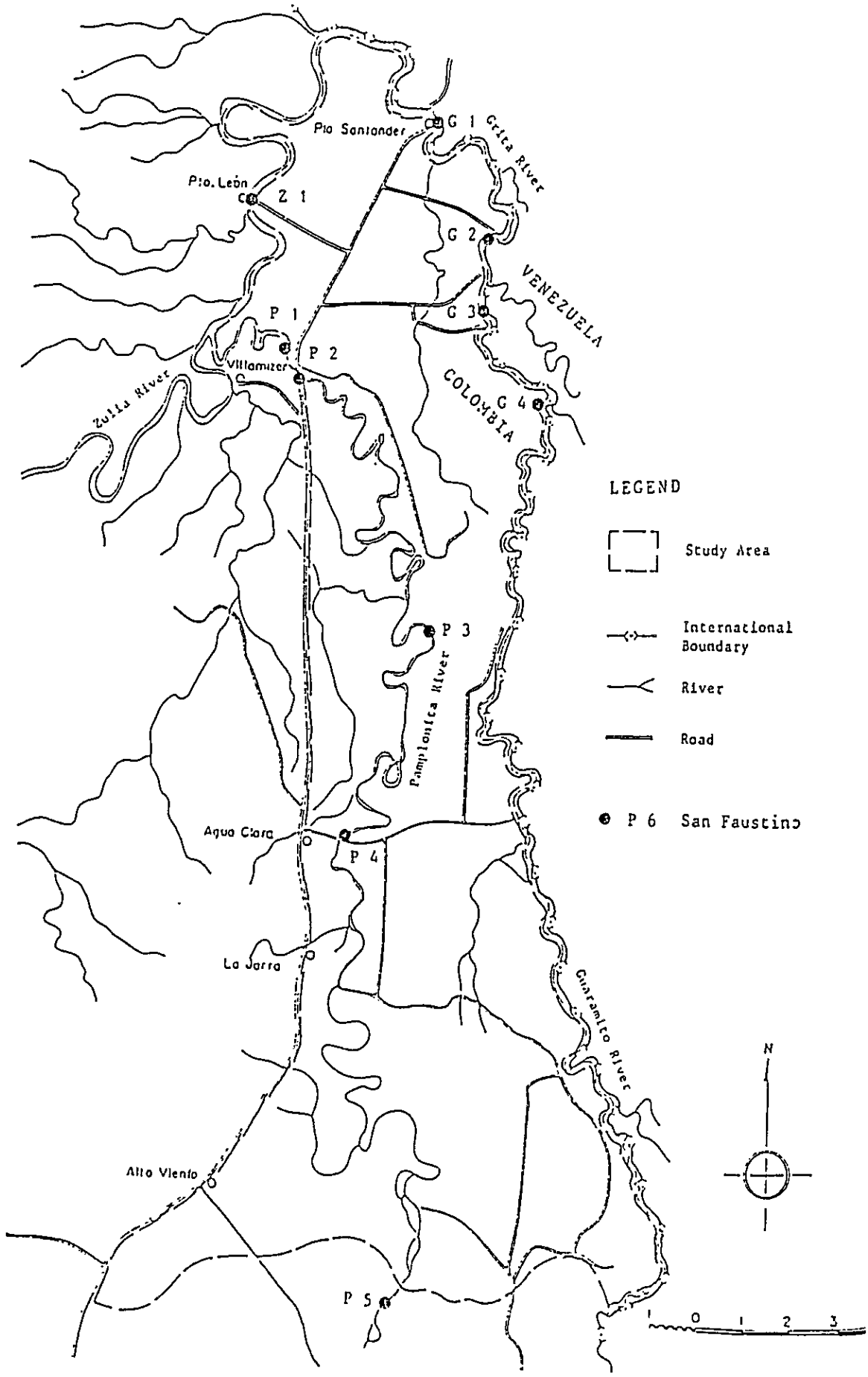


Fig. 2–3–4 Location of River Cross-Section

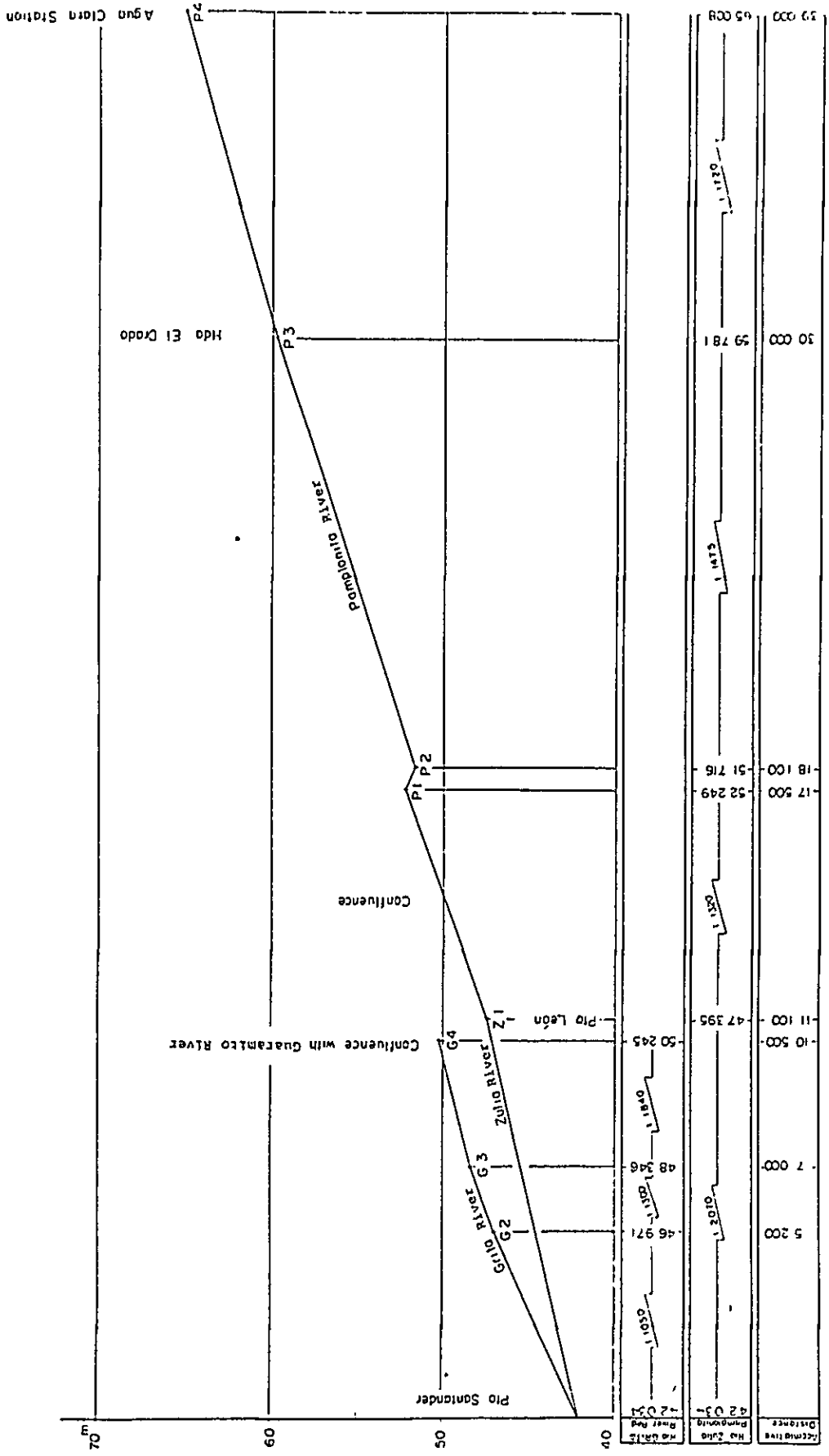


Fig. 2–3–5 Longitudinal Cross-Sections of Rivers

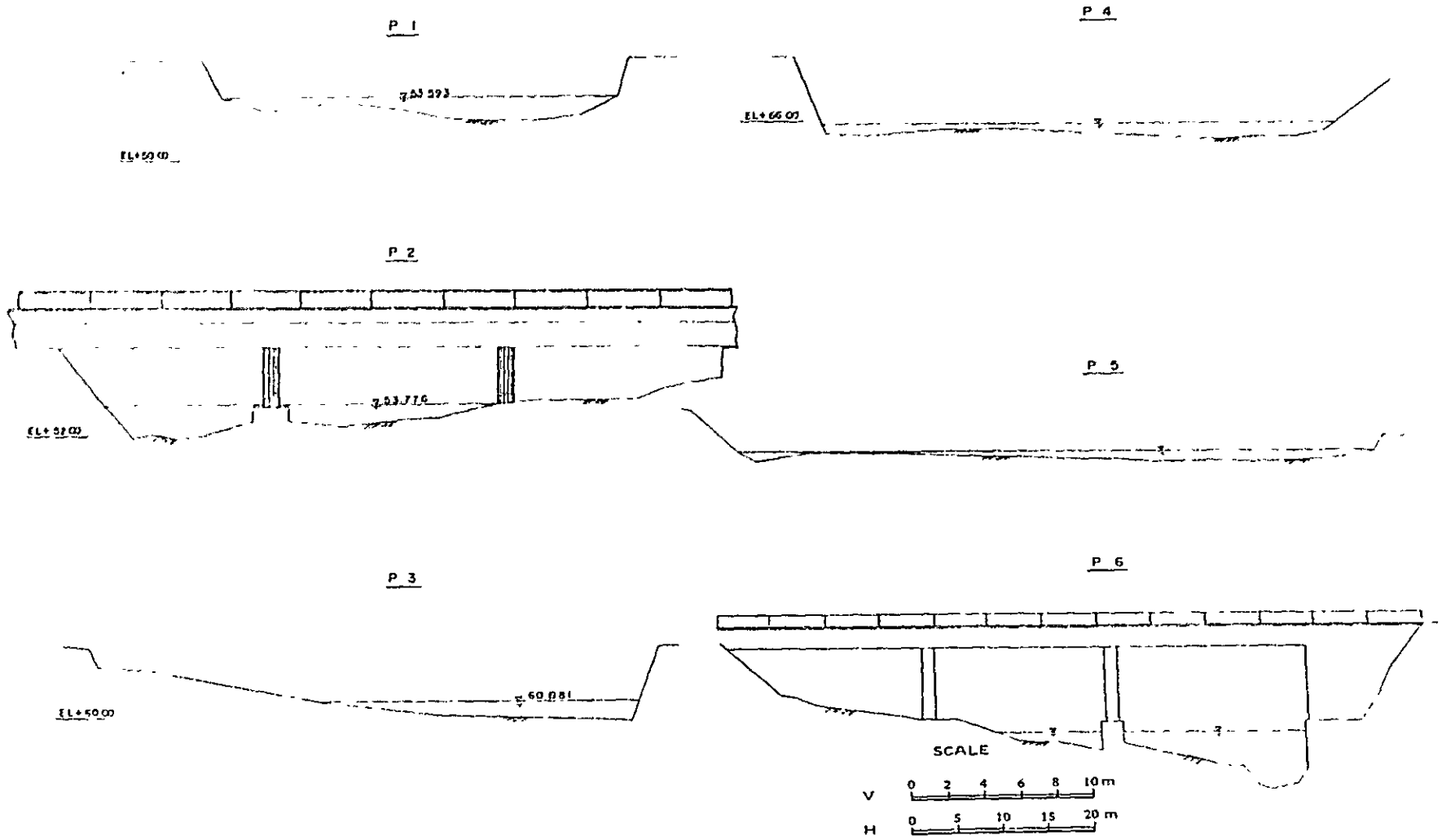


Fig. 2–3–6 Cross-Section of Pamplonita River

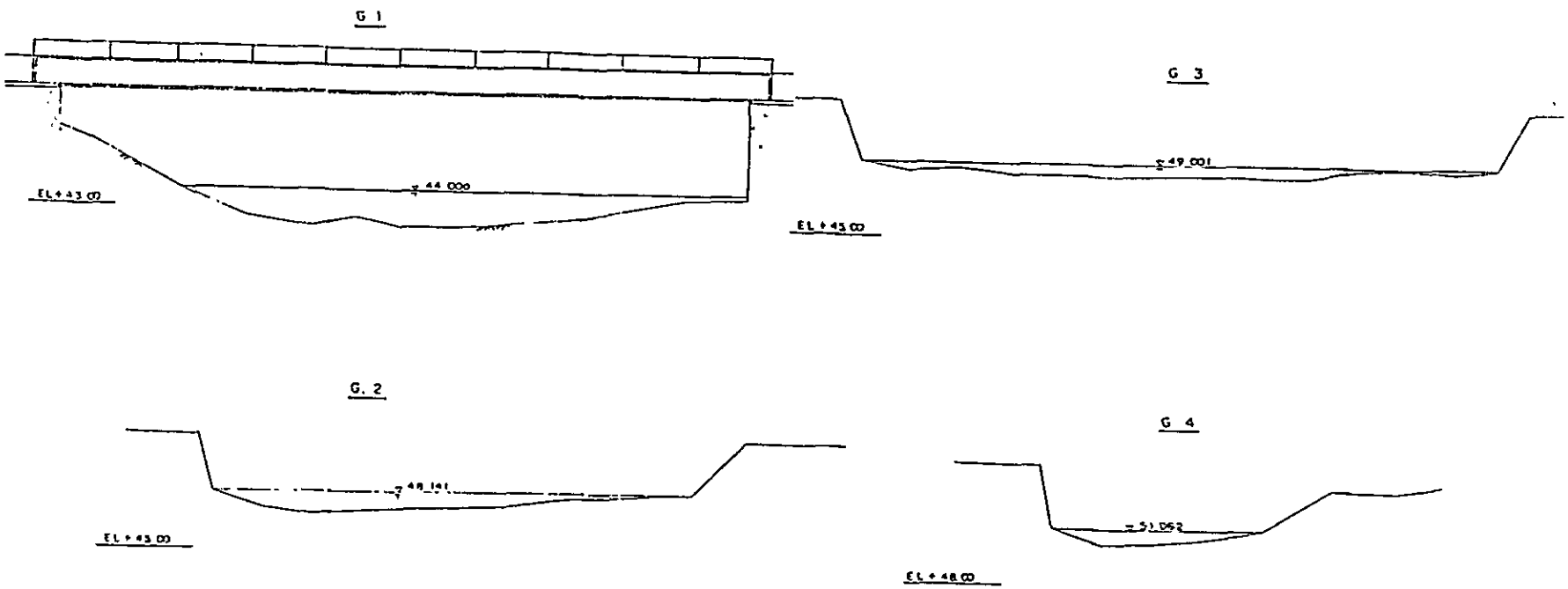


Fig. 2–3–7 Cross-Section of Grita River

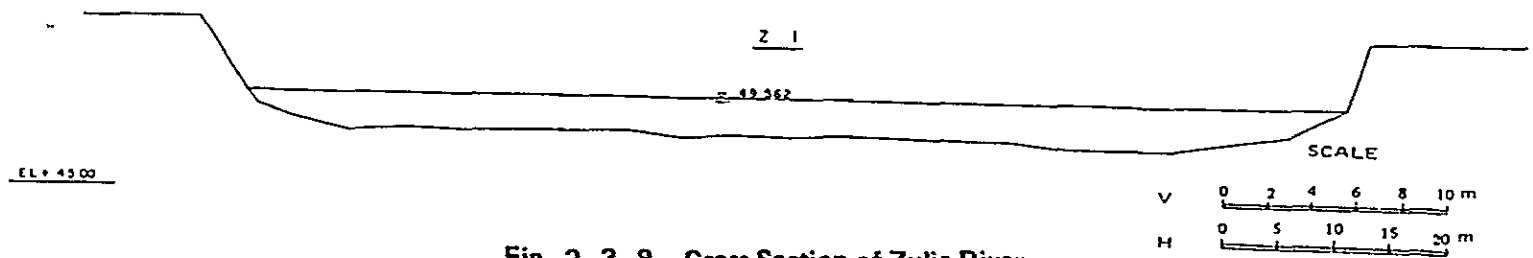


Fig. 2–3–8 Cross-Section of Zulia River

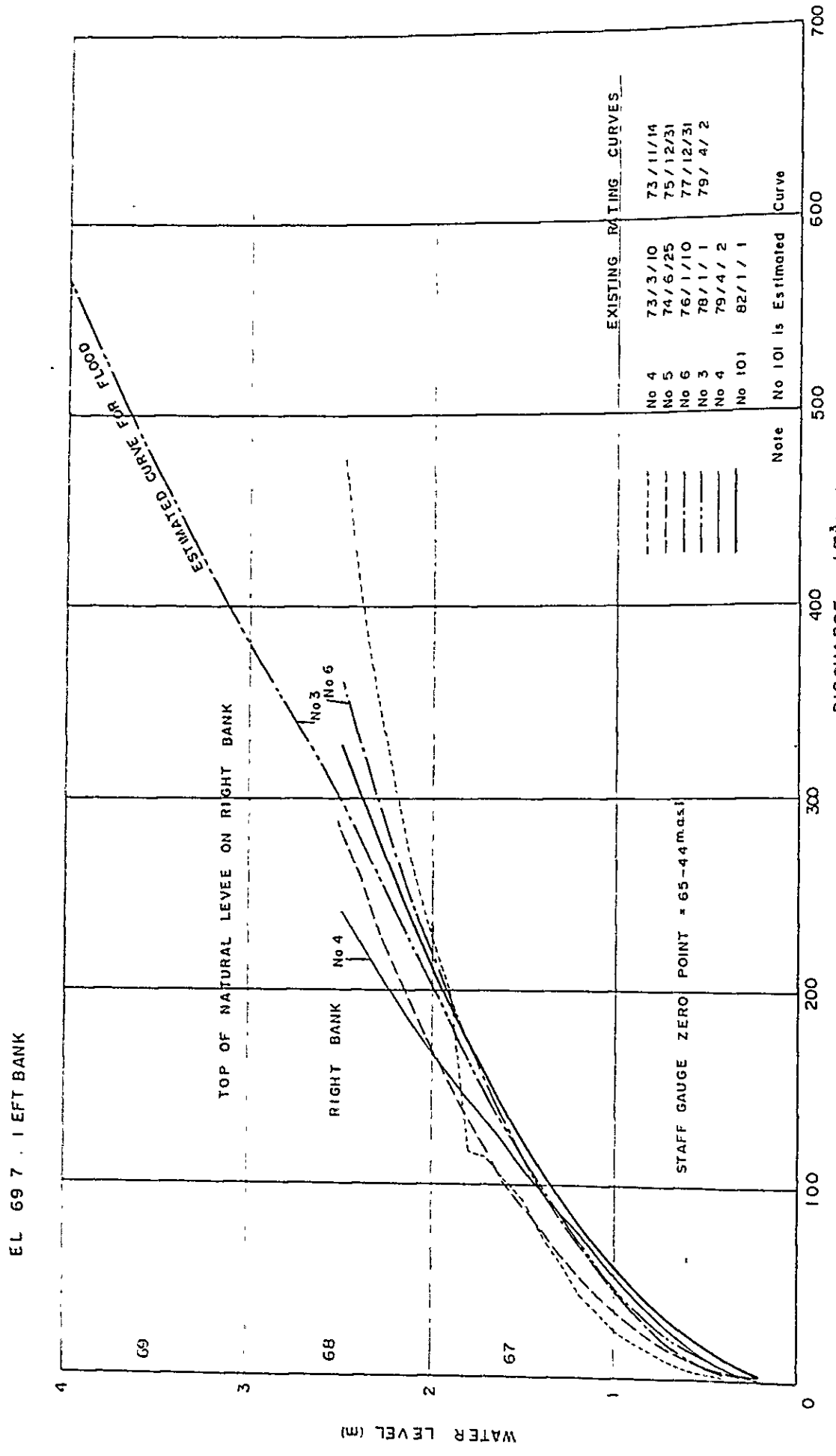


Fig. 2–3–9 Rating Curve at Agua Clara

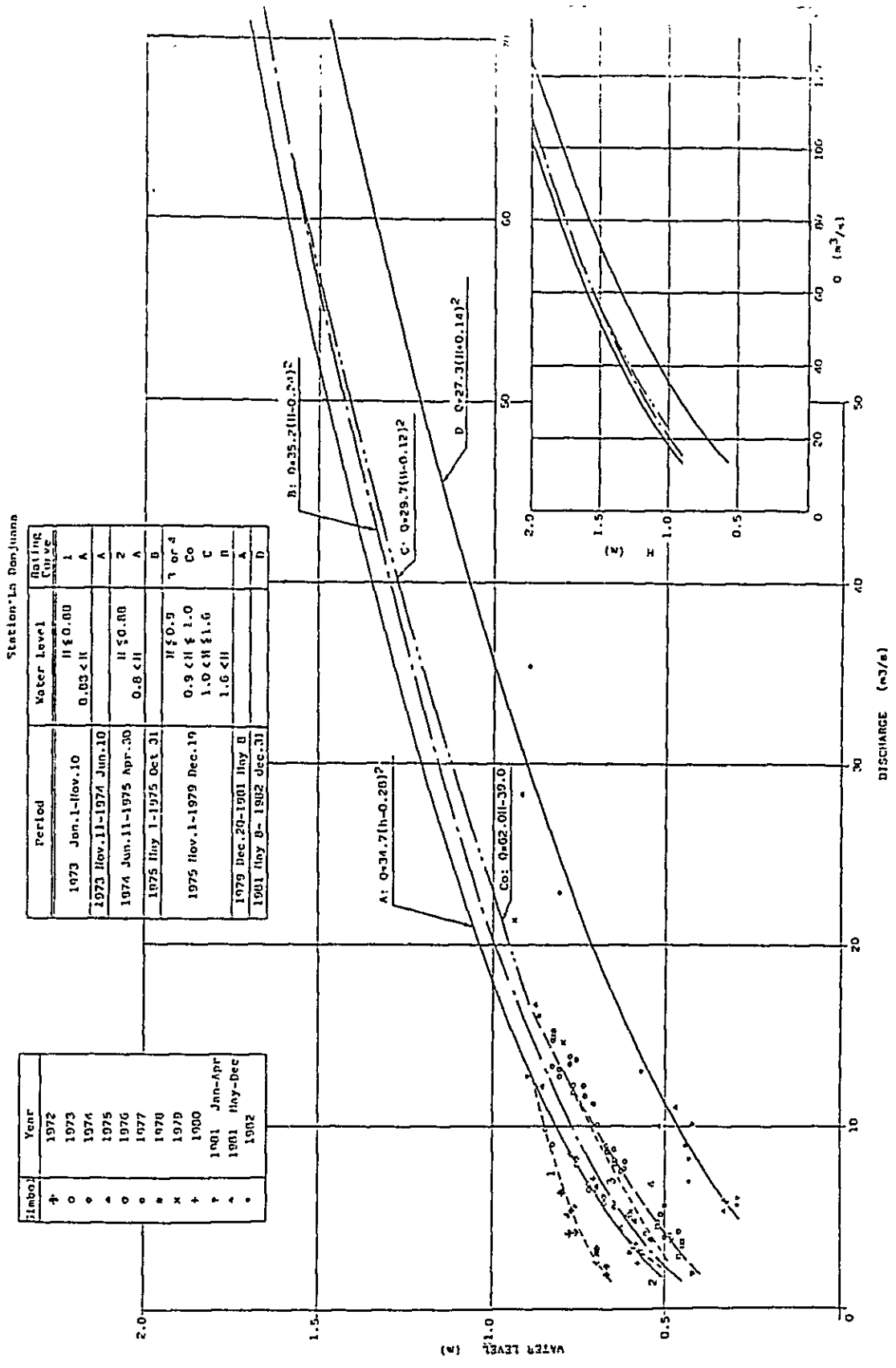


Fig. 2–3–10 Rating Curve at La Donjuana

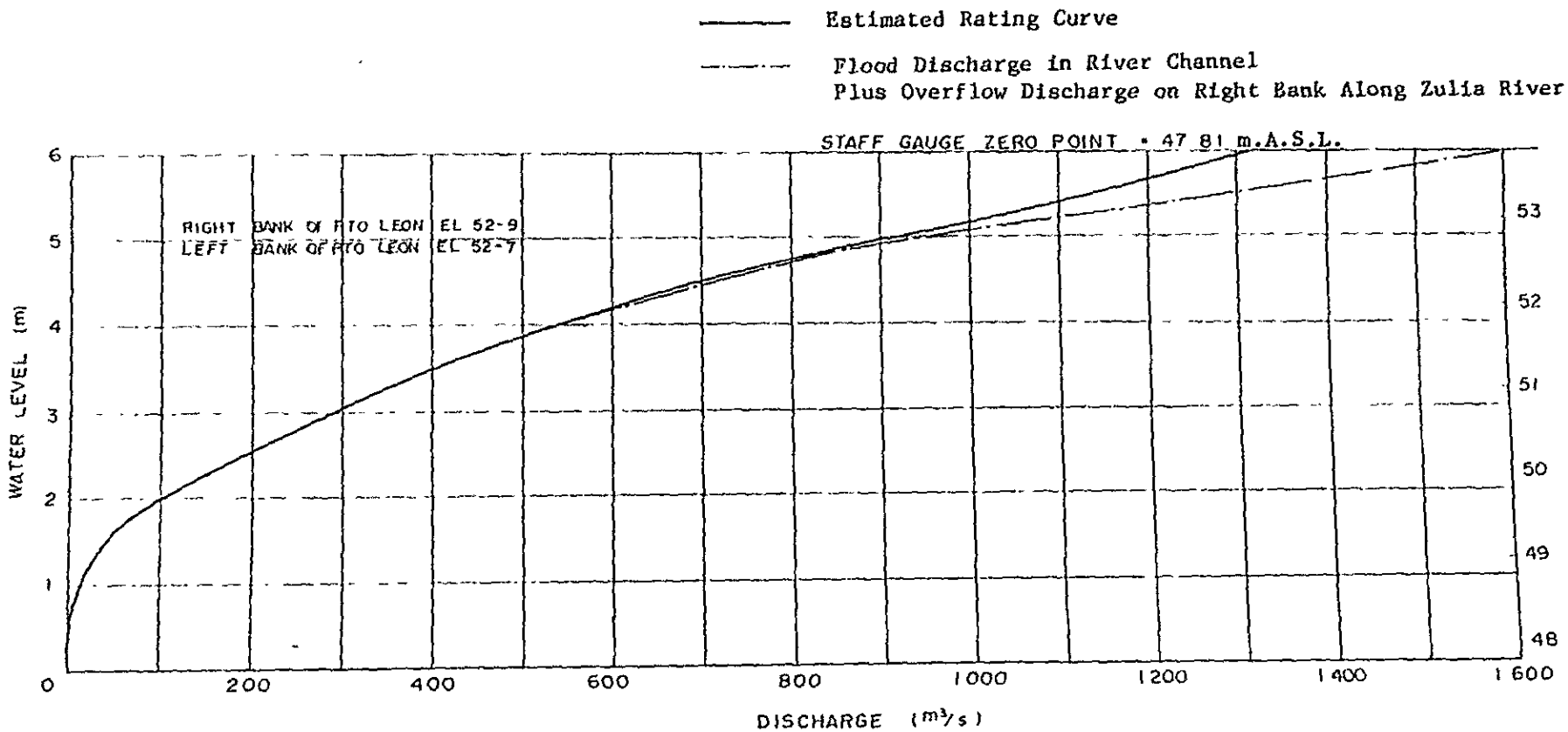
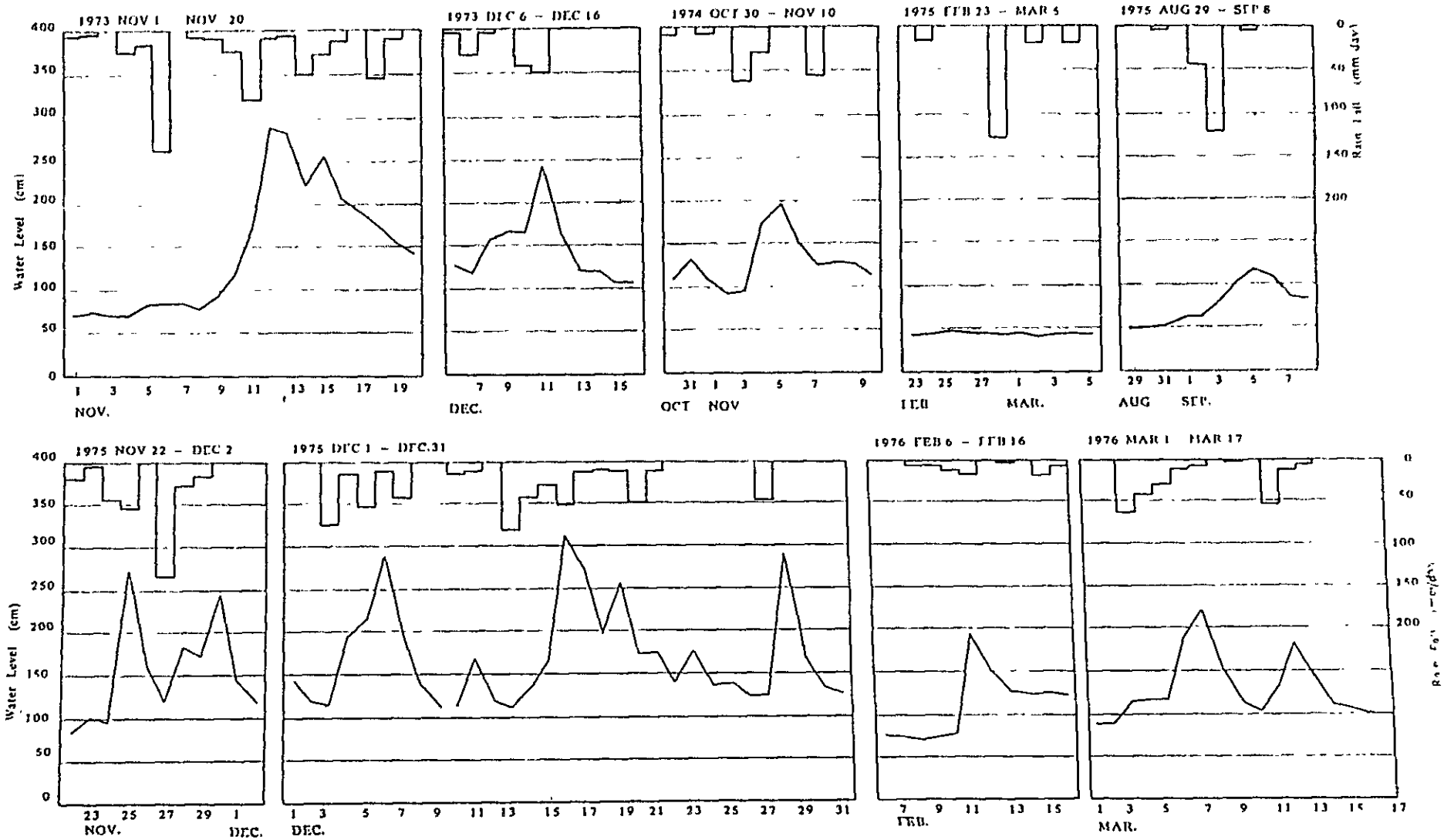


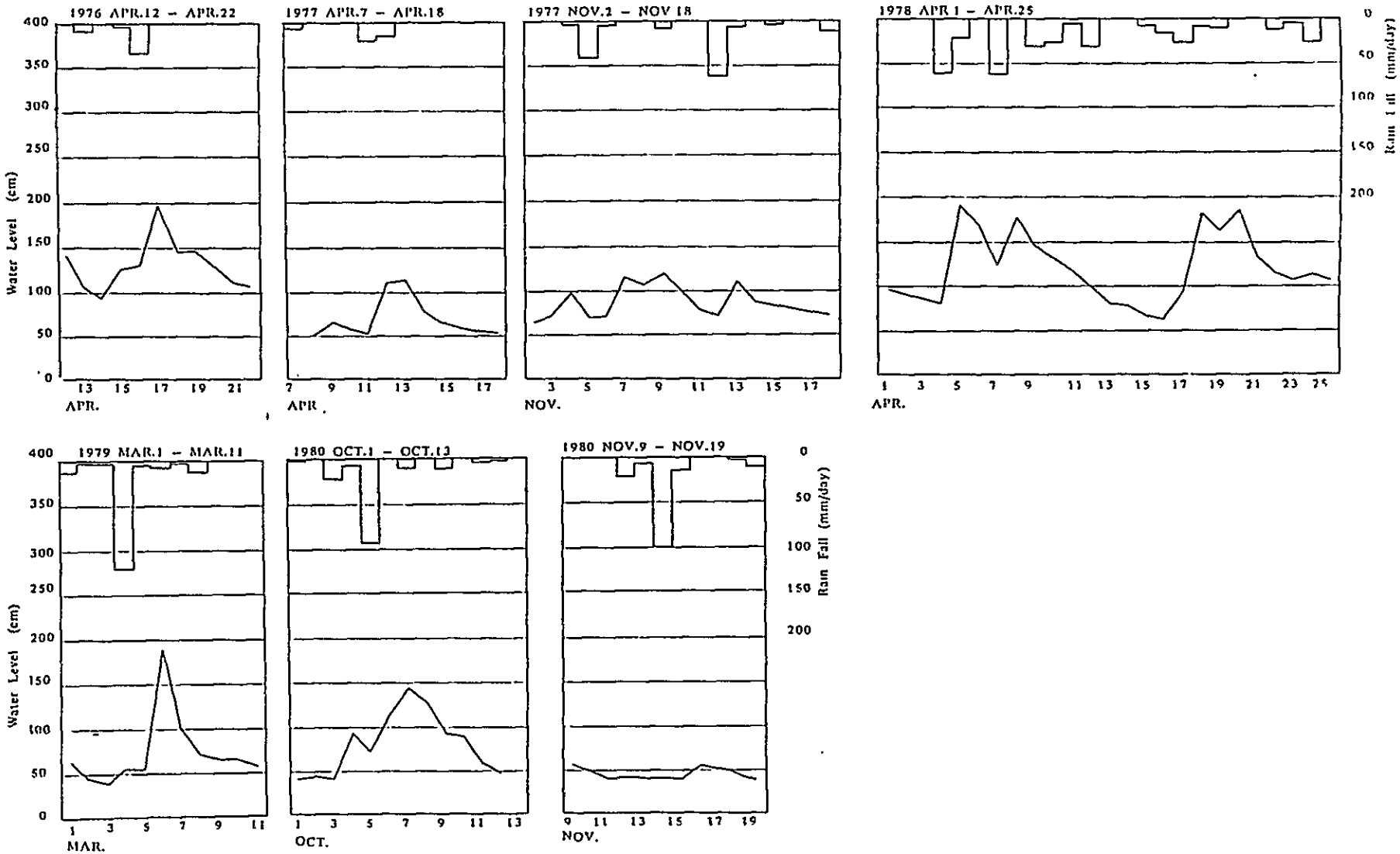
Fig. 2–3–11 Rating Curve at Puerto Leon

Fig. 2–3–12 Hyeto-Hydrograph

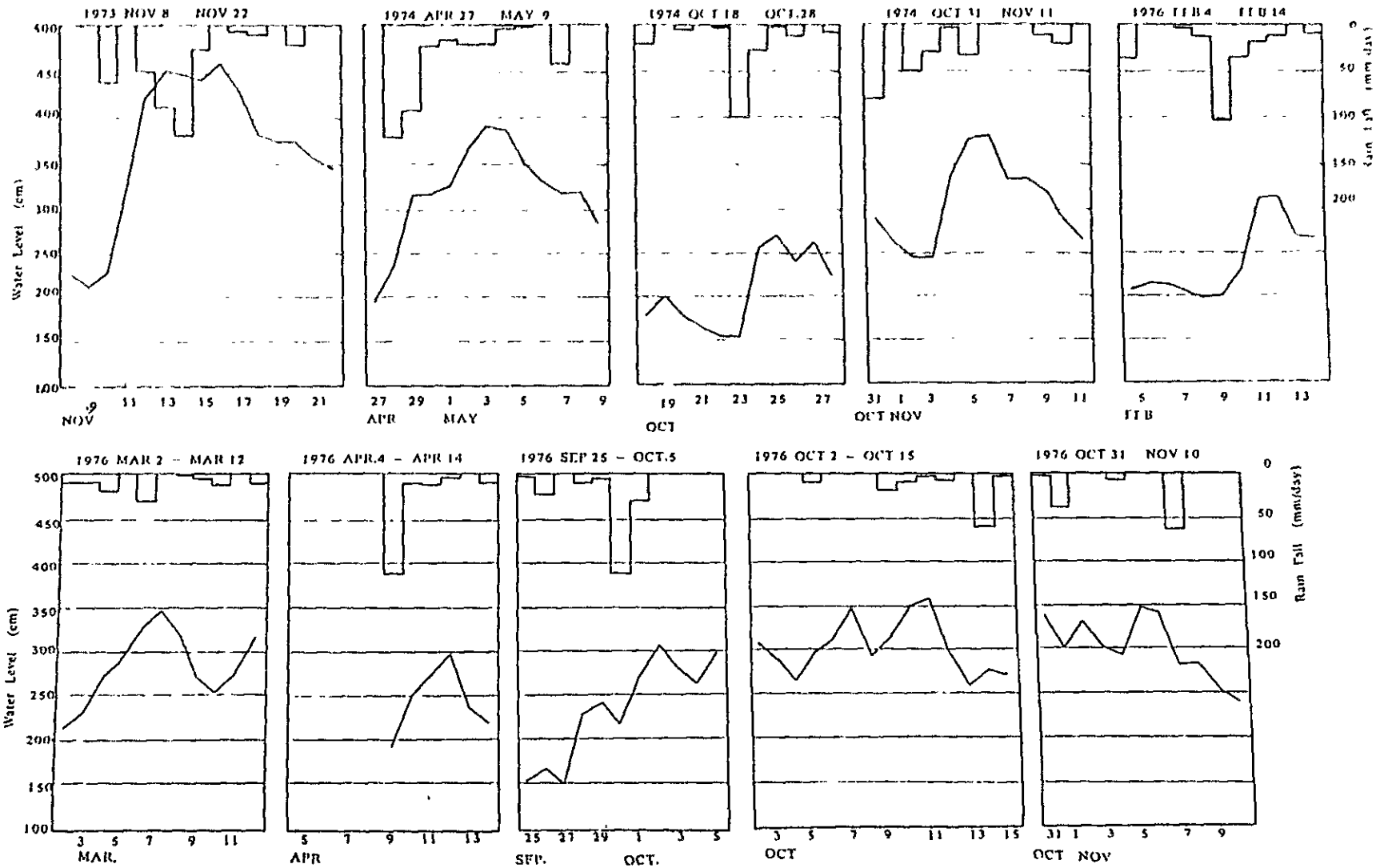
WATER LEVEL & RAINFALL (Agua Clara)



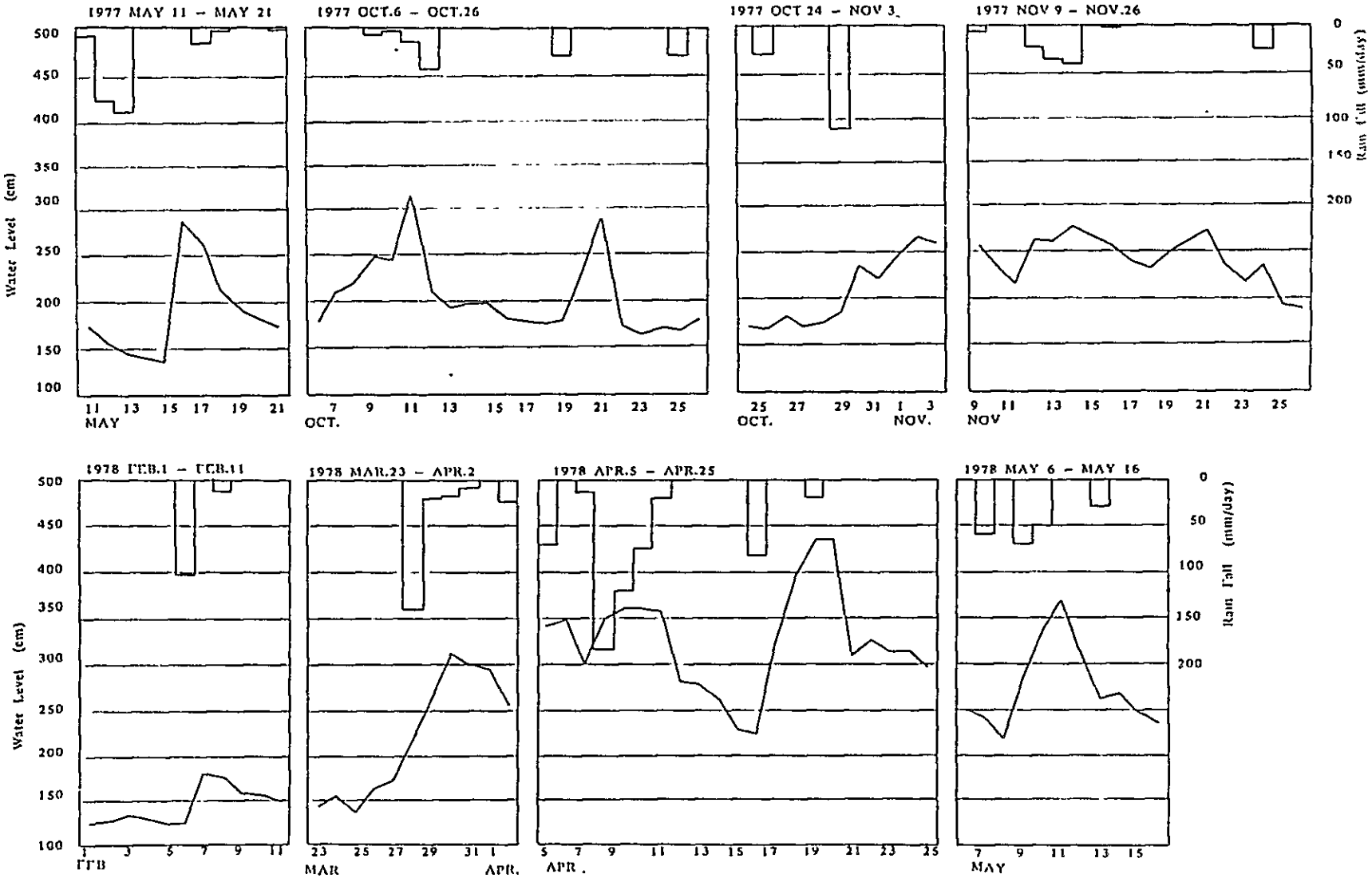
WATER LEVEL & RAINFALL (Agua Clara)



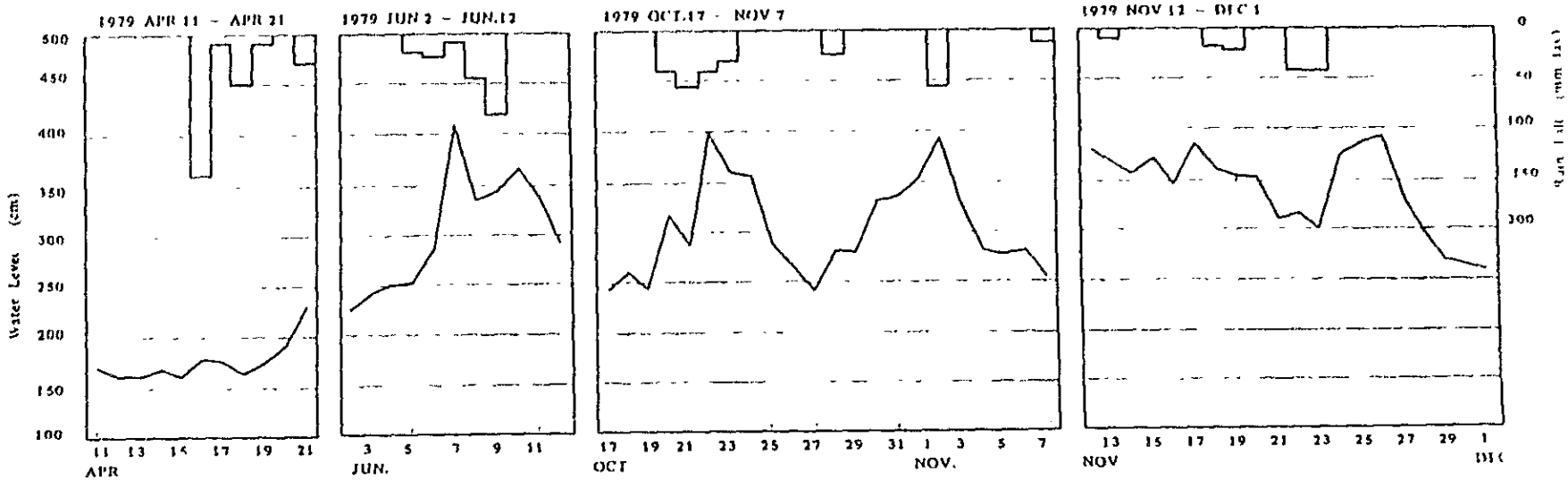
WATER LEVEL & RAINFALL (Puerto Leon)

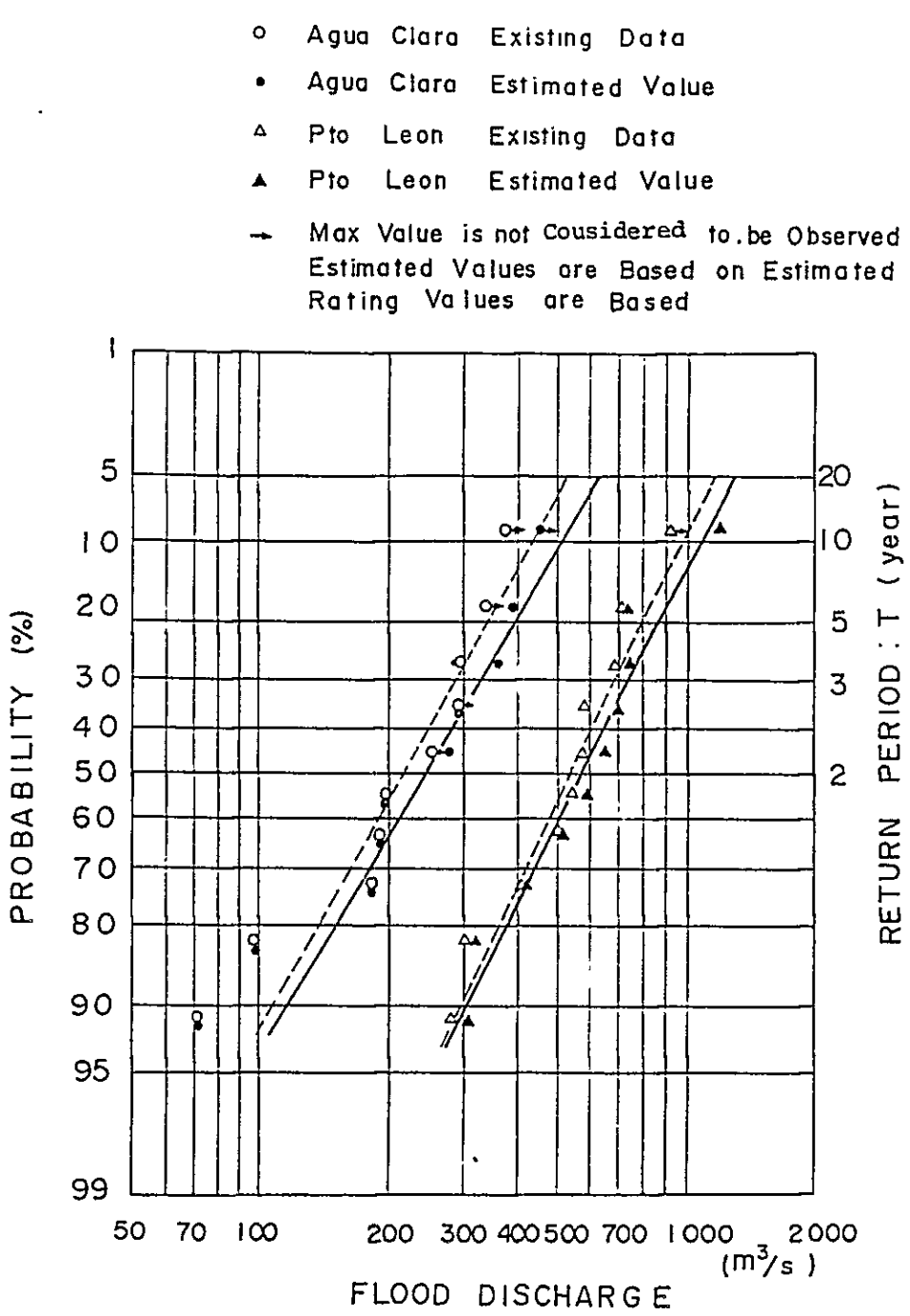


WATER LEVEL & RAINFALL (Puerto Leon)



WATER LEVEL & RAINFALL (Puerto Leon)





Estimated Flood Discharge (m^3/s)

T (year)	Agua Clara	Pto Leon
2	250	570
5	400	860
10	500	1000

Fig. 2–3–13 Flood Discharge Probability

APPENDIX 3. DRAINAGE

LIST OF TABLES

LIST OF FIGURES

Table 3–1–1 Frequency of Consecutive Days of High Water Levels

Recorded Year	PTO. LEON											AGUA CLARA										
	H ≧ 4.0 m							H ≧ 4.5 m				H ≧ 2.0 m						H ≧ 2.5 m				
	Number of Consecutive Days						Total Days	Number of Consecutive Days			Total Days	Number of Consecutive Days					Total Days	Number of Consecutive Days				Total Days
	1	2	3	4	6	8		1	2	3		1	2	3	4	5		1	2	3	4	
1973	–	–	–	–	–	–	1	1	–	–	1	2	–	–	–	1	7	2	–	–	–	2
1974	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	2	–	–	–	–	–
1975	1	3	–	–	–	1	15	–	2	1	7	4	3	–	–	–	10	5	1	–	–	7
1976	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	1	–	–	–	–	–
1977	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1978	–	1	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1979	2	–	–	–	–	–	2	–	–	–	–	1	–	–	–	–	1	–	–	–	–	–
1980	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1981	3	1	1	1	1	–	18	–	1	–	2	1	–	–	1*	–	5*	1	–	–	1*	5*
1982	5	3	–	–	–	–	11	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Total	12	8	1	1	1	1	49	1	3	1	10	9	4		1*	1	26*	8	1		1*	14*

Remarks: H: Water Level Observed

*: Data indicated by * are assumed to be much higher than the recorded level.

Table 3-1-2 Present Flooding Area Variations

(Unit: ha)

Probability	Zone	Consecutive Day			
		1-day	3-day	5-day	7-day
2-year	A	690	-	-	-
	B	230	-	-	-
	C	130	-	-	-
	D	-	-	-	-
	Total	1,050	-	-	-
5-year	A	1,650	350	230	-
	B	1,680	280	80	-
	C	880	370	30	-
	D	90	470	-	-
	Total	4,300	1,470	340	-
10-year	A	1,850	1,390	990	500
	B	2,980	1,270	675	260
	C	1,590	670	355	130
	D	140	70	30	10
	Total	6,560	3,400	2,050	900

Table 3–1–3 Present Flooding Area in Detail

Zone			Flooding Area (ha)	
(1)		EL $\leqq$ 50 m	500	
		EL > 50 m	640	
		Sub-total		1,140
(2)	(3)	EL $\leqq$ 50 m	360	
		50 m < EL $\leqq$ 55 m	940	
		55 m < EL $\leqq$ 60 m	290	
		60 m < EL	420	
		Sub-total		2,010
	(4)			250
(5)				190
(6)				710
Total				4,300

Notes:

(1) Area between Zulia River and National Road.

(2) Right bank of Pamplonita River.

(3) Area between National Road and existing drain in Campo Alegre.

(4) Area between existing drain in Campo Alegre and soughern boundary.

(5) Left bank of Pamplonita River boundary.

(6) Low-land along Pamplonita River.

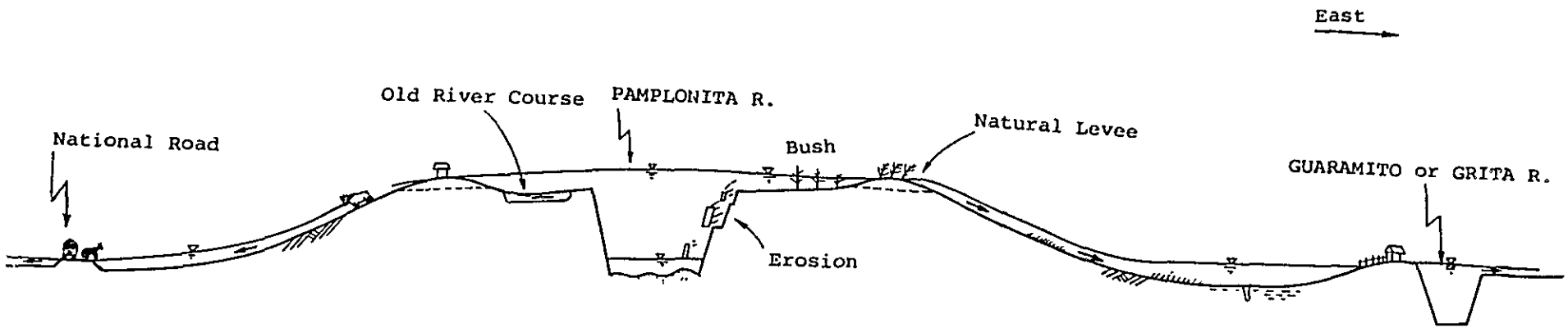
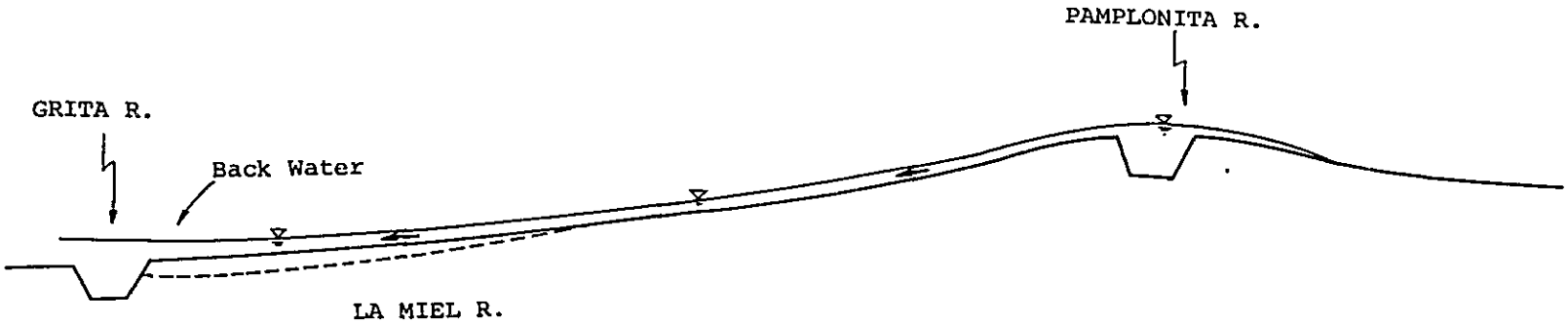
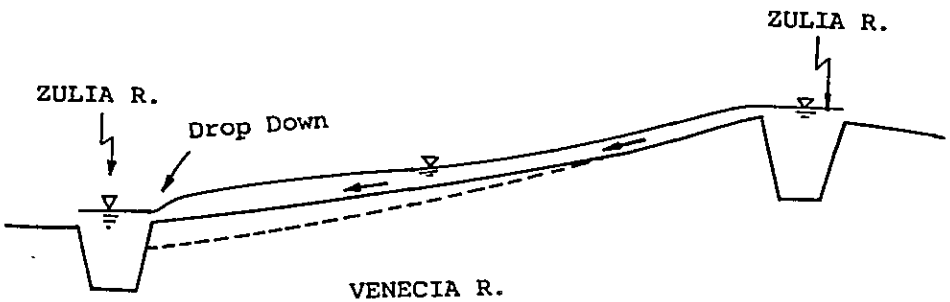


Fig. 3—1—1 Cross-Section of Study Area



FLOODING ALONG LA MIEL RIVER



FLOODING ALONG VENECIA RIVER

Fig. 3—1—2 Flooding Along Small Rivers

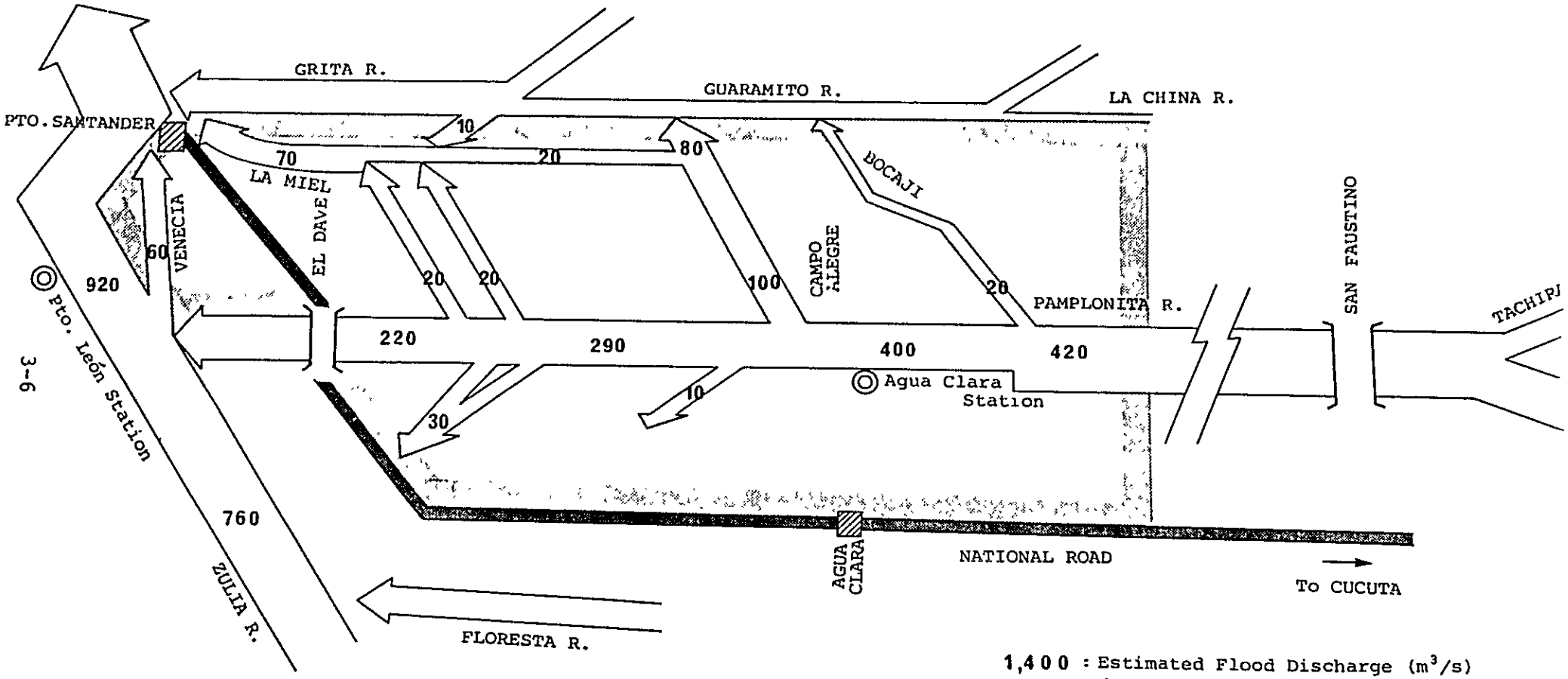


Fig. 3–1–3 Flooding System Model

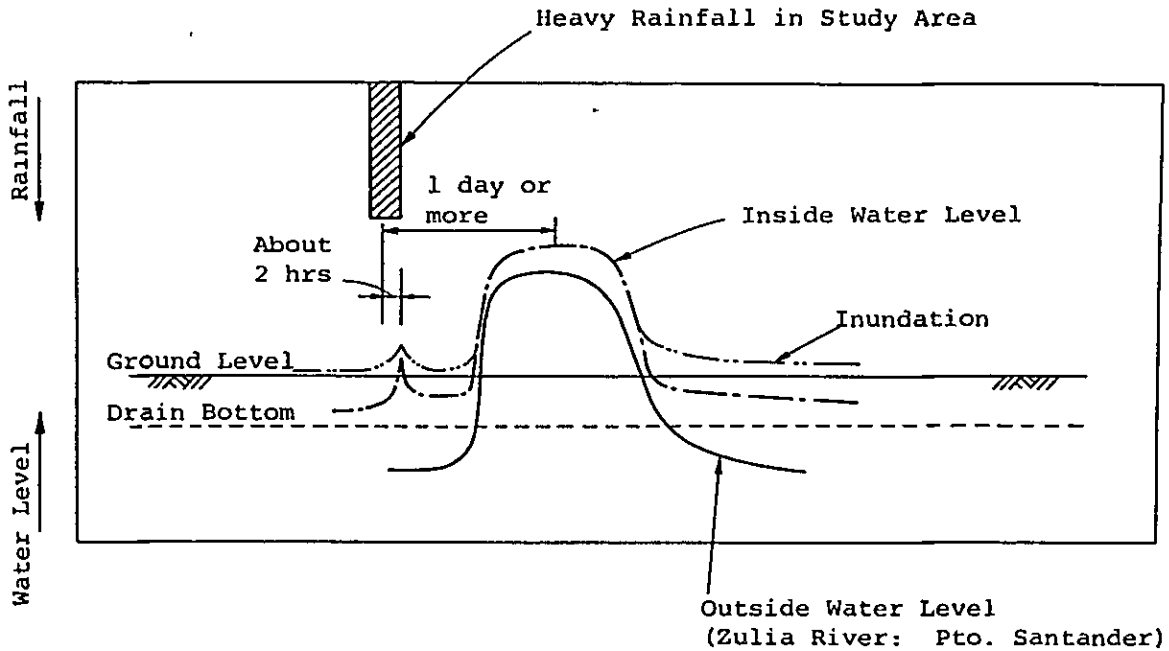
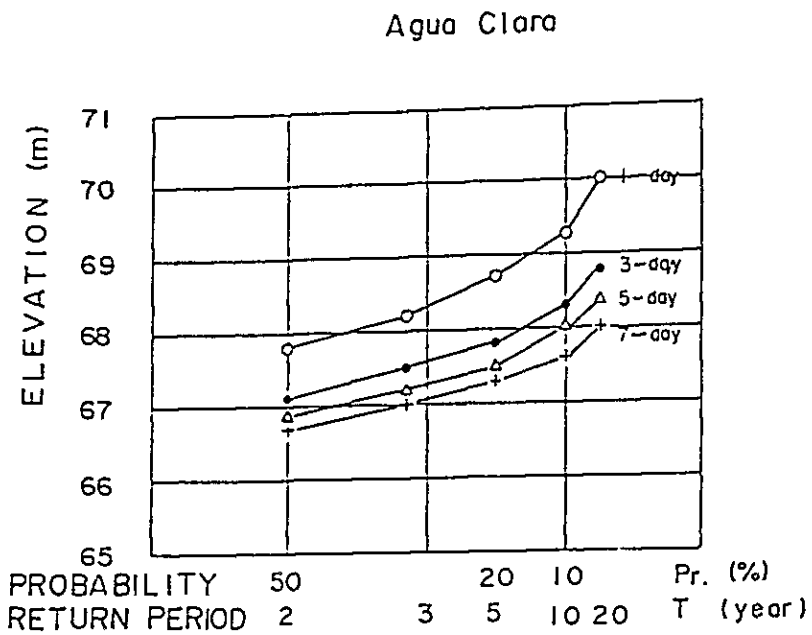


Fig. 3–1–4 Inside-Outside Water Level Relation



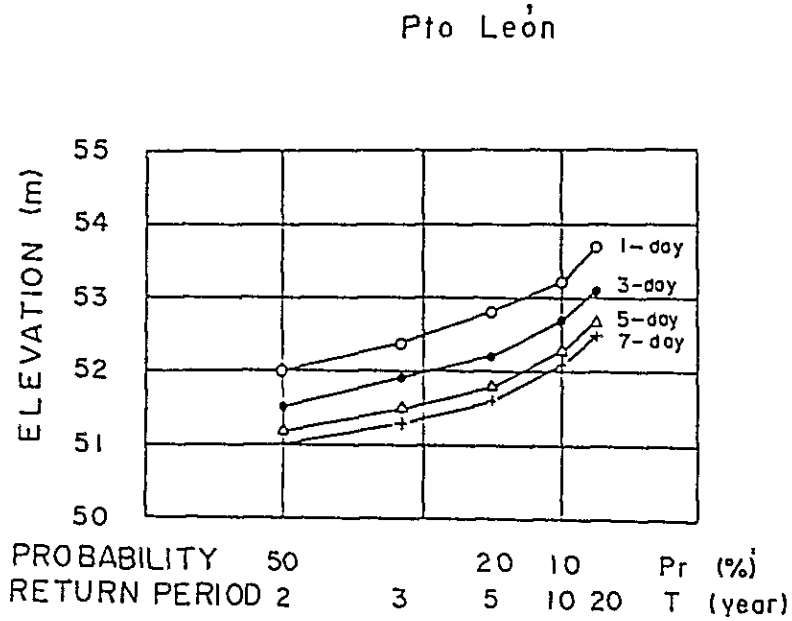


Fig. 3–1–5 Consecutive Flood Water Level

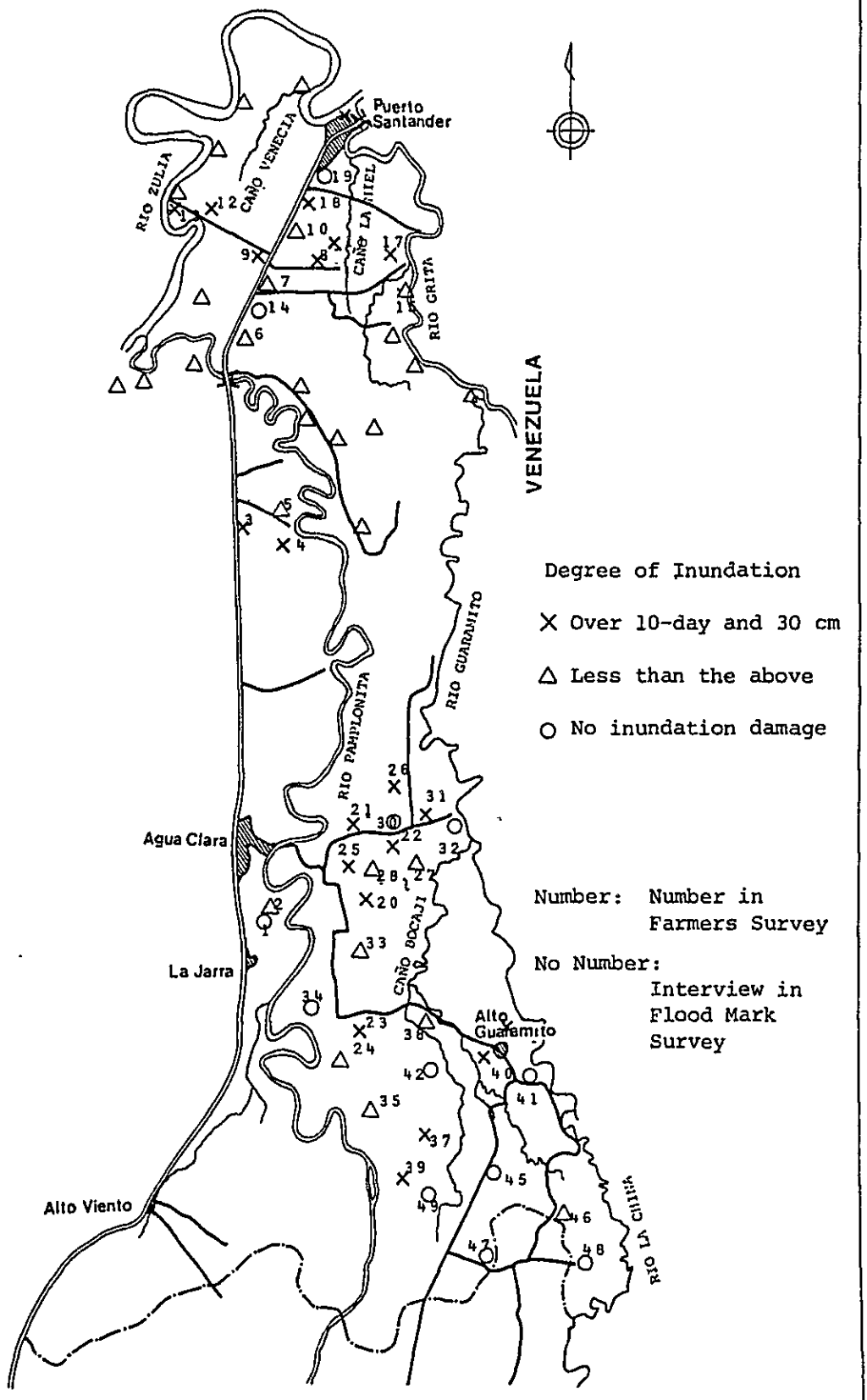


Fig. 3–1–6 INundation Information from Interview

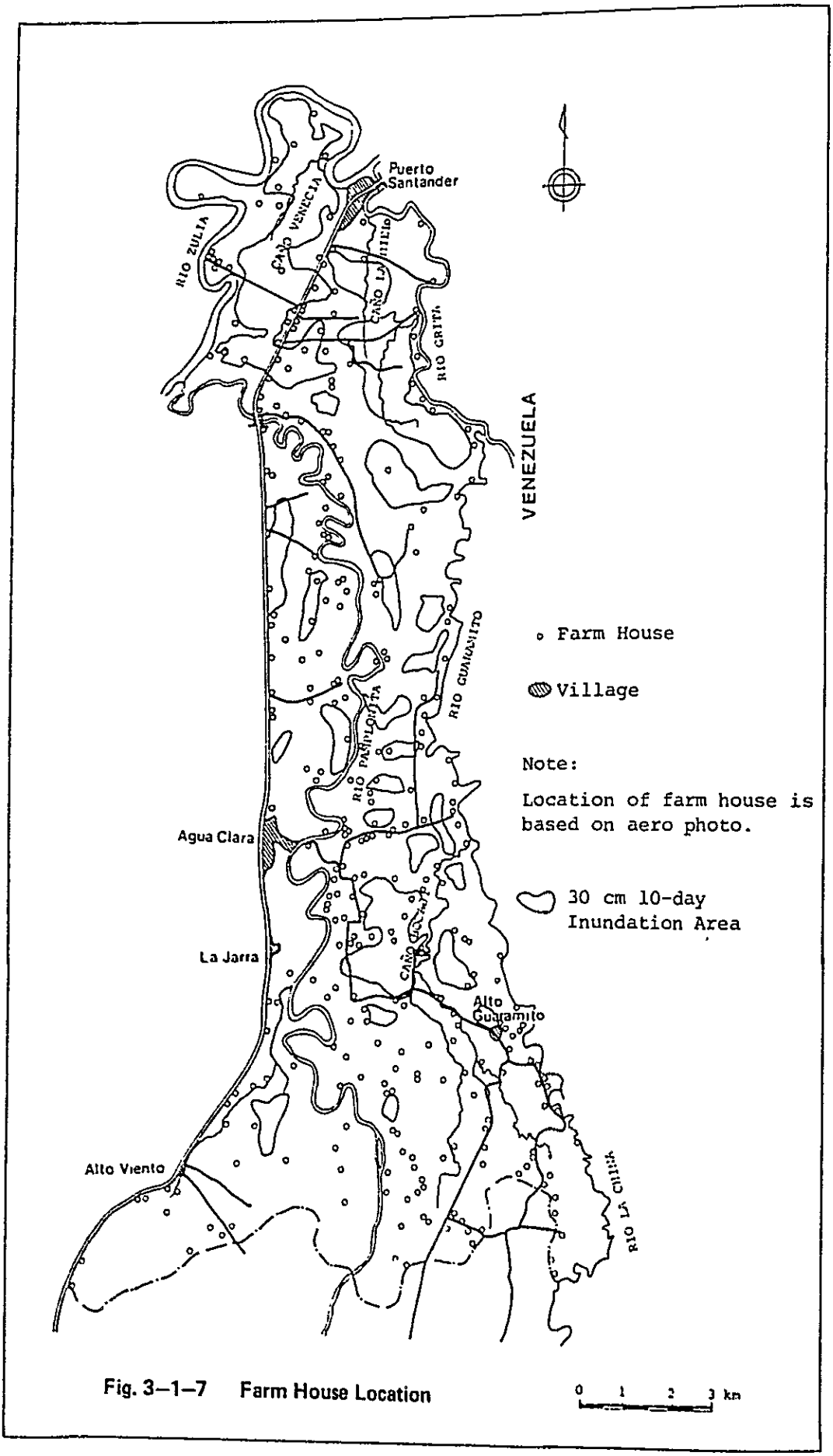


Fig. 3–1–7 Farm House Location

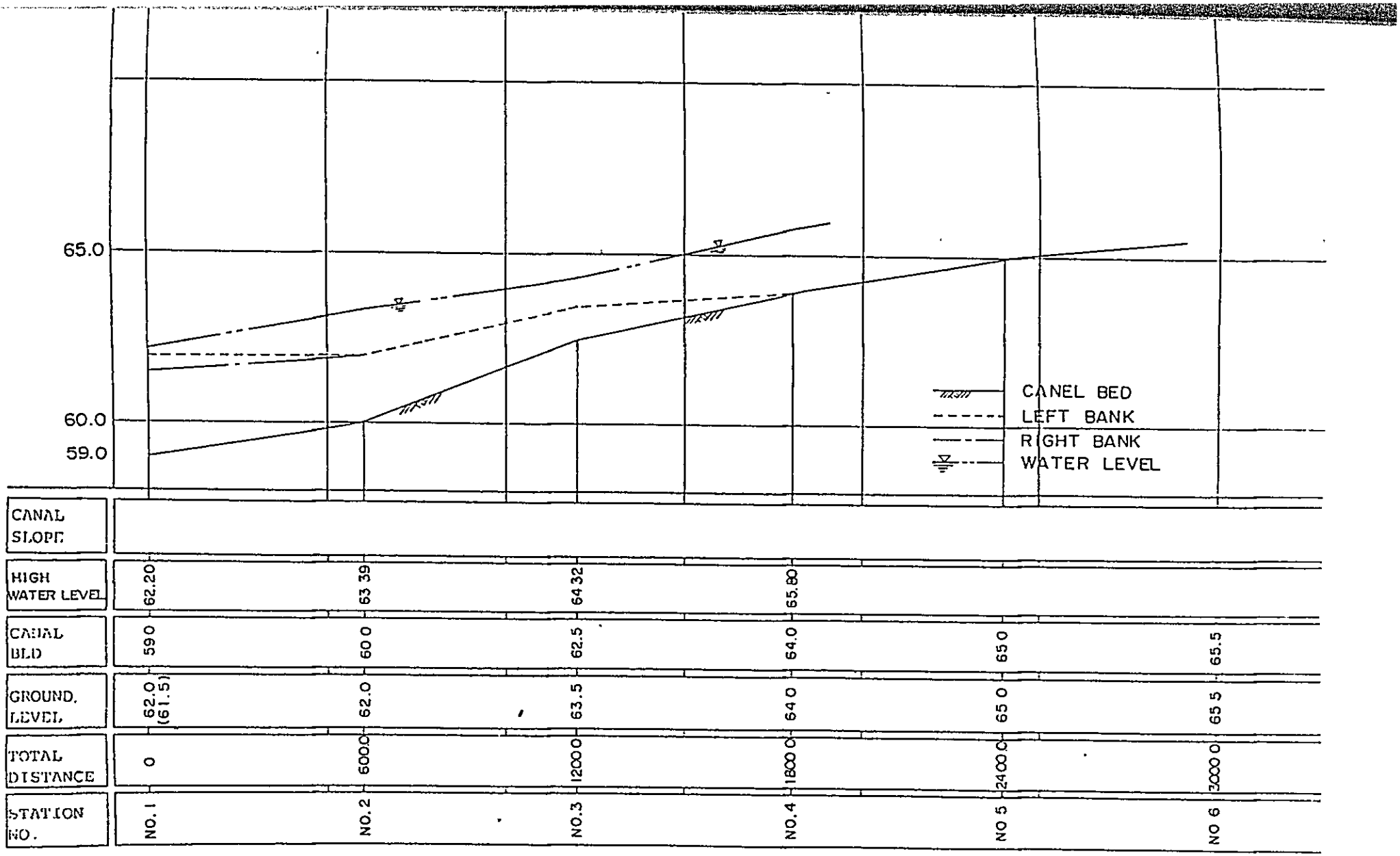


Fig. 3—1—8 Profile of Present Flooding Water Table

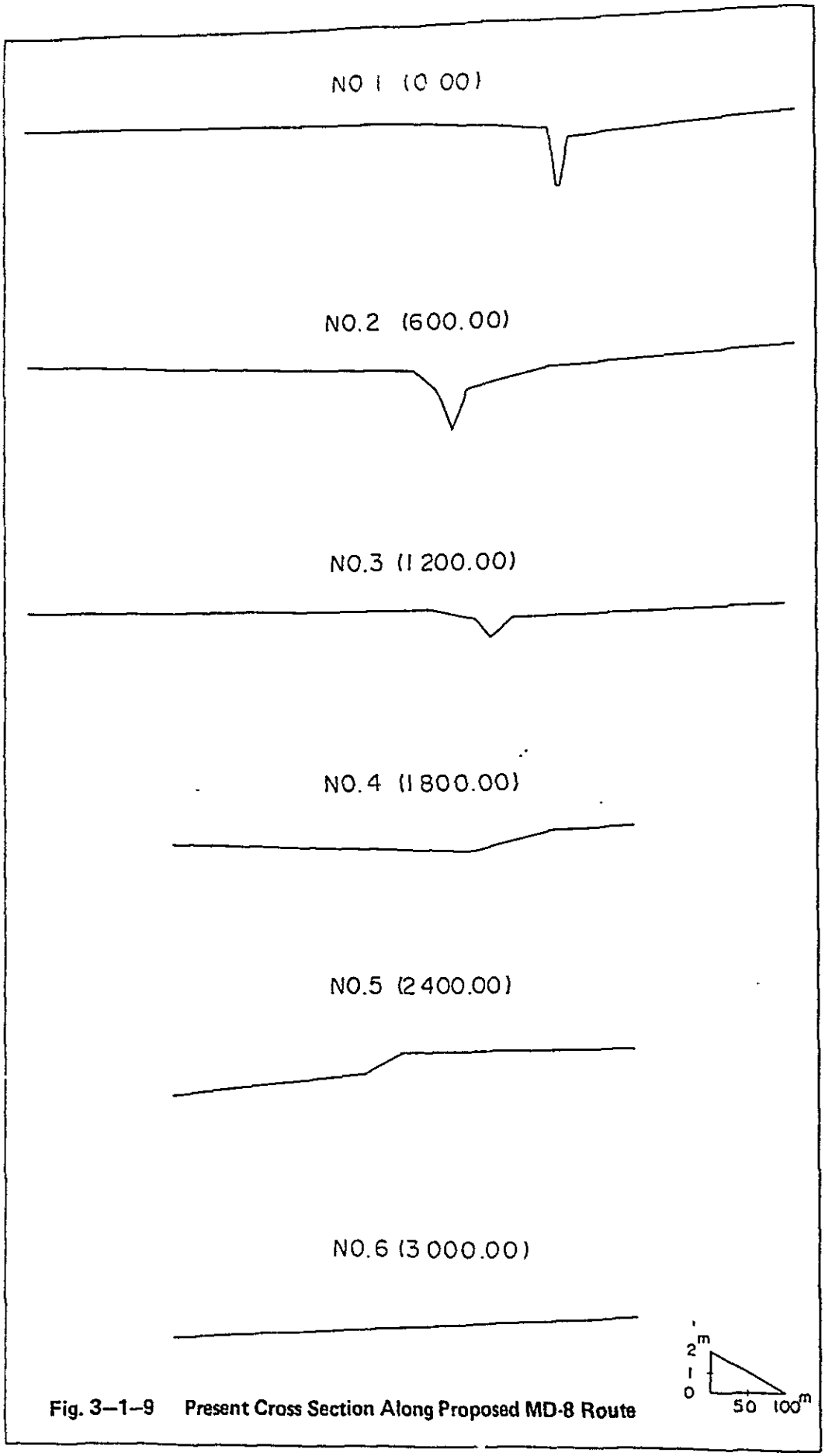


Fig. 3–1–9 Present Cross Section Along Proposed MD-8 Route

Table 3–2–1 Controlled Flooding Area

(Unit: ha)

	2-year Probability (I) 1-day			5-year Probability (II) (III) 1-day		
Zone	(1)	(2)	Total	(1)	(2)	Total
A	-	520	520	-	1,310	1,310
B	100	-	100	100	610	710
C	80	-	80	450	-	450
D	-	-	-	90	-	90
Total	180	520	700	640	1,920	2,560

Note: (1) Low-land along river channel

(2) Flooding area excluding low-land along river channel

Table 3–2–2 Discharge and Type of Main Drain

5-Year Probability — f = 0.4, R24 = 144 mm

No	Length L (km)	Area A (ha)	Elevation Eo (m)	Elevation Eu (m)	Fall H (m)	Time of Concentration T (hr)	Rate of Rainfall r (mm/hr)	Specific Discharge q ($m^3/s/ha$)	Discharge Q (m^3/s)	Average Slope I (0/00)		Type of Cross-section	Remarks
MD- 1	3 00	376	47 0	51 5	4.5	1.8	22	0.024	9.02	1.500	1/670	III	
2	3 30	887	46 5	51.6	5 1	1 9	21	0 023	20 40	1 545	1/650	II	
3	5.65	742	51.0	58 8	7 8	2 9	17	0 019	14 10	1 381	1/720	II	For flood
4	2.55	443	52.5	55 6	3.1	1.7	23	0.026	11.52	1.216	1/820	III	
5	4.00	340	58.0	64 5	6 5	2 1	20	0.022	7 48	1 625	1/620	IV	
6	5 60	304	57.0	65 9	8 9	2 7	18	0 020	6.08	1.589	1/630	IV	
7	4 90	559	57 7	67 0	9.3	2 3	19	0.021	11.74	1.898	1/530	III	
8	4.10	375	60 8	67 0	6.2	2 2	20	0 022	8.25	1.512	1/660	*	
9	2.75	433	64.9	67.0	2 1	2.1	20	0.022	9.53	0.764	1/1,310	III	
10	9 80	2.433	65.0	92.0	27 0	3.3	16	0.018	43 79	2.755	1/360	I, III, IV, V	
11	4 90	462	72.0	88.0	16 0	1 9	21	0.023	10.63	3.265	1/310	III, IV, V	
Total	50.55	7,354											

2-Year Probability — f = 0 4, R24 = 144 mm

No.	Length L (km)	Area A (ha)	Elevation Eo (m)	Elevation Eu (m)	Fall H (m)	Time of Concentration T (hr)	Rate of Rainfall r (mm/hr)	Specific Discharge q (m3/s/ha)	Discharge Q (m^3/s)	Average Slope I (0/000)		Type of Cross-section	Remarks
MD- 1	3 00	376	47.0	51 5	4 5	1.8	18	0.020	7.52	1.500	1/670	IV	
2	3.30	887	46 5	51 6	5.1	1.9	17	0.019	16.85	1.545	1/650	II	
3	5 65	742	51 0	58.8	7.8	2.9	14	0 016	11.87	1.381	1/720	III	
4	2.55	443	52.5	55 6	3.1	1.7	18	0.020	8.86	1.216	1/820	III	
5	4.00	340	58 0	64 5	6 5	2 1	16	0 018	6.12	1.625	1/620	IV	
6	5 60	304	57 0	65 9	8.9	2 7	14	0 016	4 86	1.589	1/630	IV	
7	4.90	559	57.7	67.0	9 3	2.3	16	0.018	10.06	1.898	1/530	III	
8	4.10	375	60 5	67 3	6 8	2.1	16	0 018	6.75	1.659	1/660	IV	
9	(2 75)*	433	64.9	67 0	2.1	2 1	16	0 018	7 79	0.764	1/1.310	III	
10	9.80	2.433	65.0	92.0	27 0	3.3	13	0.014	34.06	2.755	1/360	I, III, IV, V	
11	4 90	462	72.0	88 0	16.0	1.9	17	0.019	8.78	3.265	1/310	IV, V	
Total	47 80 (2.75)*	7,354											

*: Improvement of existing drainage canal

Table 3–2–3 Discharge and Type of Secondary Drain

5-Year Probability — f = 0.4, R24 = 144 mm

No.	Length	Area	Elevation		Fall	Time of Concentration	Rate of Rainfall	Specific Discharge	Discharge	Average Slope		Type of Cross-section	Remarks
	L (km)	A (ha)	Eo (m)	Eu (m)	H (m)	T (hr)	r (mm/hr)	q (m3/s/ha)	Q (m2/s)	I (0/00)			
SD- 1	1.60	137	47.0	49.0	2.0	1.2	27	0.030	4.11	1.250	1/800	IV	
2	1.20	90	48.7	50.1	1.4	1.0	29	0.032	2.88	1.167	1/860	V	
3	2.20	130	47.0	51.3	4.3	1.3	26	0.029	3.77	1.955	1/510	V	
4	1.45	75	52.0	52.8	0.8	1.5	24	0.027	2.03	0.552	1/1,920	V	
5	1 60	70	52.0	53 6	1.6	1.3	26	0 029	2.03	1.000	1/1,000	V	
6	1.35	70	52.0	54.4	2.4	1.0	29	0.032	2.24	1.778	1/560	V	
7	1.20	14	47.0	49.0	2.0	0.9	31	0.034	0.48	1.667	1/600	V	
8	0.90	66	47 0	49.0	2.0	0.7	35	0 039	2.57	2 222	1/450	V	
9	2.05	102	46.5	50.5	4.0	1.2	27	0.030	3.06	1.951	1/510	V	
10	1.50	186	56.0	60.8	4.8	0.8	33	0.037	6.88	3 200	1/310	IV	
11	2.10	165	55.7	59.7	4.0	1.3	26	0.029	479	1.905	1/520	IV	
12	0.85	50	57.3	58.8	1.5	0 7	35	0.039	1 95	1.765	1/570	V	
13	1.70	93	65.0	66.5	1.5	1.4	25	0.028	2.60	0 882	1/1,130	V	
14	1.00	68	66.0	68.0	2.0	0,7	35	0.039	2.65	2.000	1/500	V	
15	0.80	55	79.5	81.0	1.5	0,7	35	0.039	2.15	1.875	1/530	V	
16	3.55	326*	77.8	95.0	17.2	1.3	26	0.029	9.45	4.845	1/210	IV	*including non-Project area
17	3.35	457	73.9	95.0	21.1	1.2	27	0.030	13.71	6.299	1/160	II, III, IV, V	
18	3.00	125	75.0	85.0	10.0	1.3	26	0.029	3.63	3.333	1/300	V	
19	2.25	159	84.0	95.0	11.0	1.0	29	0.032	5.09	4.889	1/200	V	
20	1.20	420	88.0	95.0	7.0	0.6	38	0.042	17.64	5.833	1/170	II, III	
21	1.00	260	91.0	97.0	6.0	0.5	42	0.047	12.22	6.000	1/170	III, IV	
22	0.40	480	96.0	98 0	2.0	0.3	54	0.060	28.80	5.000	1/200	I	
23	2.70	42	70.1	100.0	9.9	1.2			1.26	3.667	1/270	V	
Total	38.95	3,640											

2-Year Probability — f = 0.4, R24 = 144 mm

No.	Length	Area	Elevation		Fall	Time of Concentration	Rate of Rainfall	Specific Discharge	Discharge	Average Slope		Type of Cross-section	Remarks
	L (km)	A (ha)	Eo (m)	Eu (m)	H (m)	T (hr)	r (mm/hr)	q (m3/s/ha)	Q (m2/s)	I (0/00)			
SD- 1	1.60	137	47.0	49.0	2.0	1.2	22	0.024	3.29	1.250	1/800	V	
2	1.20	90	48.7	50.1	1.4	1.0	24	0.027	2.43	1.167	1/860	V	
3	2.20	130	47.0	51.3	4.3	1.3	21	0.023	2.99	1.955	1/510	V	
4	1.45	75	52.0	52.8	0.8	1.5	19	0.021	1.58	0.552	1/1,920	V	
5	1.60	70	52.0	53.6	1.6	1.3	21	0.023	1.61	1.000	1/1,000	V	
6	1.35	70	52.0	54.4	2.4	1.0	24	0.027	1.89	1.778	1/560	V	
7	1.20	14	47.0	49.0	2.0	0.9	25	0.028	0.39	1.667	1/600	V	
8	0.90	66	47.0	49.0	2.0	0.7	28	0.031	2.05	2.222	1/450	V	
9	2.05	102	46.5	50.5	4.0	1.2	22	0.024	2.45	1.951	1/510	V	
10	1.50	186	56.0	60.8	4.8	0.8	25	0.027	5.02	3.200	1/310	V	
11	2.10	165	55.7	59.7	4.0	1.3	21	0.023	3.80	1.905	1/520	V	
12	0.85	50	57.3	58.8	1.5	0.7	28	0.031	1.55	1.765	1/570	V	
13	1.70	93	65.0	66.5	1.5	1.4	20	0.022	2.05	0.882	1/1,130	V	
14	1.00	68	66.0	68.0	2.0	0.7	28	0.031	2.11	2.000	1/500	V	
15	0.80	55	79.5	81.0	1.5	0.7	28	0.031	1.71	1.875	1/530	V	
16	3.55	326	77.8	95.0	17.2	1.3	21	0.023	7.50	4.845	1/210	IV	1/350 including non-Project area
17	3.35	457	73.9	95.0	21.1	1.2	22	0.024	10.97	6.299	1/160	III, IV, V	
18	3.00	125	75.0	85 0	10.0	1.3	21	0.023	2.88	3.333	1/300	V	
19	2 25	159	84.0	95.0	11.0	1.0	24	0.027	4.29	4.889	1/200	V	
20	1.20	420	88.0	95.0	7.0	0.6	31	0.034	14.28	5.833	1/170	III, IV	
21	1.00	260	91.0	97.0	6.0	0.5	33	0.036	9.38	6 000	1/170	IV	
22	0 40	480	96.0	98.0	2 0	0.3	43	0.048	23.04	5.000	1/200	II	
23	2.70	42	70 1	100.0	9.9	1.2	22	0.024	1.08	3.667	1/270	V	
Total	38.95	3,640											

Table 3–2–4 Discharge and Type of Lateral Drain

5-Year Probability

No of Main Drain	No. of Lateral Drain		Specific Discharge of MD $8(m^3/s/ha)$	Catchment Area of Lateral Drain A (ha)	Discharge $Q(m^3/s)$	Length L (km)	Type of Cross-Section	Remarks
MD-1	LD	1-1	0.024	25	0.60	0.60	V	
		1-2	"	28	0.67	0.40	"	
		1-3	"	35	0.84	0.60	"	
		1-4	"	40	0.96	0.70	"	
		1-5	"	28	0.67	0.20	"	
		1-6	"	45	1.08	0.80	"	
		1-7	"	39	0.94	0.60	"	
		1-8	"	80	1.92	1.60	"	
	Total					5.50		
MD-2	LD	2-1	0.023	55	1.27	0.95	V	
		2-2	"	41	0.94	1.30	"	
		2-3	"	66	1.52	1.20	"	
		2-4	"	63	1.45	1.20	"	
		2-5	"	78	1.79	1.45	"	
		2-6	"	33	0.76	1.20	"	
		2-7	"	90	2.07	1.65	"	
		2-8	"	28	0.64	0.60	"	
		2-9	"	105	2.42	1.95	"	
		2-10	"	19	0.44	0.70	"	
		2-11	"	115	2.65	2.25	"	
		2-12	"	137	3.15	1.20	"	
		2-13	"	66	1.52	1.55	"	
		2-14	"	40	0.92	1.20	"	
	Total					18.40		

5-Year Probability

No. of Main Drain	No. of Lateral Drain		Specific Discharge of MD $8(m^3/s/ha)$	Catchment Area of Lateral Drain A (ha)	Discharge $Q(m^3/s)$	Length L (km)	Type of Cross-Section	Remarks
MD-3	LD	3-1	0.019	30	0.57	0.40	V	
		3-2	"	38	0.72	0.80	"	
		3-3	"	93	1.77	2.20	"	
		3-4	"	43	0.82	0.60	"	
		3-5	"	88	1.67	1.90	"	
		3-6	"	76	1.44	1.65	"	
		3-7	"	65	1.24	1.40	"	
		3-8	"	60	1.14	1.20	IV	for flood
		3-9	"	63	1.20	1.25	"	
		3-10	"	56	1.06	1.20	"	
		3-11	"	33	0.63	1.05	"	
	Total					13.65		
MD-4	LD	4-1	0.026	50	1.30	0.80	V	
		4-2	"	50	1.30	0.80	"	
		4-3	"	37	0.96	0.60	"	
		4-4	"	50	1.30	0.80	"	
		4-5	"	40	1.04	0.60	"	
		4-6	"	50	1.30	0.80	"	
		4-7	"	27	0.70	0.60	"	
		4-8	"	50	1.30	0.80	"	
		4-9	"	20	0.52	0.20	"	
		4-10	"	50	1.30	0.80	"	
	Total					6.80		
MD-5	LD	5-1	0.022	178	3.92	1.90	1/560 V	
		5-2	"	34	0.75	0.90	"	
	Total					2.80		

Table 3–2–4 Discharge and Type of Lateral Drain

5-Year Probability

No. of Main Drain	No. of Lateral Drain	Specific Discharge of MD B(m^3/s/ha)	Catchment Area of Lateral Drain A (ha)	Discharge Q(m^3/s)	Length L (km)	Type of Cross-Section	Remarks
MD-6	LD 6-1	0.020	29	0.58	0.90	IV	for flood
	6-2	"	38	0.76	0.90	"	
	6-3	"	47	0.94	1.30	"	
	6-4	"	36	0.72	0.80	V	
	Total				3.90		
MD-7	LD 7-1	0.021	50	1.05	0.90	V	
	7-2	"	54	1.13	0.80	"	
	7-3	"	60	1.26	1.00	"	
	7-4	"	51	1.07	1.00	"	
	7-5	"	37	0.78	0.60	"	
	7-6	"	37	1.20	0.90	"	
	7-7	"	40	0.84	0.60	"	
	Total				5.80		
MD-8	LD 8-1	0.022	169	3.72	2.40	1/600 V	
MD-9	LD 9-1	0.022	84	1.85	1.00	V	
	9-2	"	171	3.76	(2.40) *	1/250 "	
	9-3	"	123	2.71	(2.40) *	"	
	Total				1.00 (4.80) *		* existing drain
MD-10	LD 10-1	0.018	393	7.07	3.80	IV	IV··1.8km V··2.0km
	10-2	"	225	4.05	1.60	V	
	10-3	"	679	12.22	5.35	III	III··1/470 3.0km IV..1.9km V··1/2
	10-4	"	238	4.28	1.60	V	Drop··11.0m 0.4
	10-5	"	264	4.75	3.55	III	
	10-6	"	144	2.59	1.40	III	
	10-7	"	100	1.80	0.80	V	
	Total				18.10		
MD-11	LD 11-1	0.023	117	2.69	1.00	V	

Table 3–2–4 Discharge and Type of Lateral Drain

2-Year Probability

No. of Main Drain	No. of Lateral Drain		Specific Discharge of MD B(m^3/s/ha)	Catchment Area of Lateral Drain A (ha)	Discharge Q(m^3/s)	Length L (km)	Type of Cross-Section	Remarks
MD-1	LD	1- 1	0.020	25	0.50	0.60	V	
		1- 2	"	28	0 56	0.40	"	
		1- 3	"	35	0 70	0.60	"	
		1- 4	"	40	0.80	0.70	"	
		1- 5	"	28	0.56	0.28	"	
		1- 6	"	45	0.90	0 80	"	
		1- 7	"	39	0.78	0.60	"	
		1- 8	"	80	1.60	1.60		
	Total					5.50		
MD-2	LD	2- 1	0.019	55	1.04	0.95	V	
		2- 2	"	41	0.78	1.30	"	
		2- 3	"	66	1.25	1.20	"	
		2- 4	"	63	1.20	1.20	"	
		2- 5	"	78	1.48	1.45	"	
		2- 6	"	33	0.63	1.20	"	
		2- 7	"	90	1.71	1.65	"	
		2- 8	"	28	0.53	0.60	"	
		2- 9	"	105	1.99	1.95	"	
		2-10	"	19	0.36	0.70	"	
		2-11	"	115	2.18	2.25	"	
		2-12	"	137	2.60	1.20	"	
		2-13	"	66	1.23	1 55	"	
		2-14	"	40	0.76	1.20	"	
	Total					1.84		
MD-3	LD	3- 1	0.016	30	0.48	0.40	V	
		3- 2	"	38	0 61	0.80	"	
		3- 3	"	93	1.49	2.2	"	
		3- 4	"	43	0.69	0.60	"	
		3- 5	"	88	1.41	1.90	"	
		3- 6	"	76	1.22	1.65	"	
		3- 7	"	65	1.04	1.60	"	

2-Year Probability

No. of Main Drain	No. of Lateral Drain		Specific Discharge of MD B(m^3/s/ha)	Catchment Area of Lateral Drain A (ha)	Discharge Q(m^3/s)	Length L (km)	Type of Cross-Section	Remarks
MD-3	LD	3- 8	0.016	60	0.96	1.20	V	
		3- 9	"	63	1.01	1.25	"	
		3-10	"	56	0.90	1.20	"	
		3-11	"	33	0.53	1.05	"	
	Total					13.65		
MD-4	LD	4- 1	0 020	50	1.00	0.80	V	
		4- 2	"	50	1.00	0.80	"	
		4- 3	"	37	0.74	0.60	"	
		4- 4	"	50	1.00	0.80	"	
		4- 5	"	40	0.80	0.60	"	
		4- 6	"	50	1.00	0.80	"	
		4- 7	"	27	0.54	0.60	"	
		4- 8	"	50	1.00	0.80	"	
		4- 9	"	20	0.40	0.20	"	
		4-10	"	50	1.00	0.80	"	
	Total					6.80		
MD-5	LD	5-1	0.018	178	3.20	1.90	V	
		5-2	"	34	0 61	0.90	"	
	Total					2.80		
MD-6	LD	6-1	0.016	29	0.46	0.90	V	
		6-2	"	38	0 61	0.90	"	
		6-3	"	47	0.75	1.30	"	
		6-4	"	36	0.58	0.80	"	
	Total					3 90		

Table 3–2–4 Discharge and Type of Lateral Drain

2-Year Probability

No. of Main Drain	No. of Lateral Drain		Specific Discharge of MD $q(m^3/s/ha)$	Catchment Area of Lateral Drain A (ha)	Discharge $Q(m^3/s)$	Length L (km)	Type of Cross-Section	Remarks
MD-7	LD	7-1	0.018	40	0.90	0.90	V	
		7-2	"	54	0.97	0.80	"	
		7-3	"	60	1.08	1.00	"	
		7-4	"	51	0.91	1.00	"	
		7-5	"	37	0.67	0.60	"	
		7-6	"	57	1.03	0.90	"	
		7-7	"	40	0.72	0.60	"	
	Total					5.80		
MD-8	LD	8-1	0.018	169	3.04	2.40	V	
MD-9	LD	9-1	0.018	84	1.51	1.00	V	
		9-2	"	171	3.08	(2.40)*	"	* existing drain
		9-3	"	123	2.21	(2.40)*	"	
	Total					1.00 (4.80)*		
MD-10	LD	10-1	0.014	393	5.50	3.80	IV	IV··1.00km V··2.80km
		10-2	"	225	3.15	1.60	V	
		10-3	"	679	9.51	5.35	IV	1/400··4.9km V··0.45km
		10-4	"	238	3.33	1.60	V	
		10-5	"	264	3.70	3.55	IV	
		10-6	"	144	2.07	1.40	"	
		10-7	"	100	1.40	0.80	V	
	Total					18.10		
MD-11	LD	11-1	0.019	117	2.22	1.00	V	

Table 3–2–5 Discharge and Type of Intercepting Drain

5-Year Probability

No. of Main Drain	No. of Lateral Drain	Specific Discharge of MD $\beta(m^3/s/ha)$	Catchment Area of Lateral Drain A (ha)	Discharge $Q(m^3/s)$	Length L (km)	Type of Cross-Section	Remarks
-	ID - 1	0.030 *	22	0.66	0.50	VI	* estimated value
MD-10	ID - 2	0.018	63	1.13	1.00	VI	
	3	"	59	1.06	1.10	"	
	4	"	59	1.06	0.95	"	
	5	"	2	0.04	0.15	"	
	Total				3.20		
MD-11	ID - 6	0.023	5	0.12	0.30	VI	
	7	"	9	0.21	0.25	"	
	Total				0.55		
-	ID - 8	0.030 *	34	1.02	0.35	VI	* estimated value
	9	"	6	0.18	0.45	"	
	10	"	19	0.57	1.20	"	
	11	"	44	1.32	1.05	"	
	Total				3.05		
SD-17	ID -12	0.029	100	2.90	0.50	V	
	13	"	98	2.84	0.90	"	
	Total				1.40		
SD-18	ID -14	0.030	14	0.42	0.50	VI	
	15	"	25	0.75	0.60	"	
	Total				1.10		
SD-20	ID -16	0.032	59	1.89	0.90	V	
SD-21	ID -17	0.042	66	2.77	0.80	V	

5-Year Probability

No. of Main Drain	No. of Lateral Drain	Specific Discharge of MD $\beta(m^3/s/ha)$	Catchment Area of Lateral Drain A (ha)	Discharge $Q(m^3/s)$	Length L (km)	Type of Cross-Section	Remarks
SD-22	ID - 18	0.047	10	0.47	0.45	VI	
	19	"	94	4.42	0.90	V	1/600
	Total				1.35		
SD-23	ID - 20	0.060	122	7.32	0.70	IV	1/700
	21	"	144	8.64	1.10	"	1/500
	Total				1.80		

Table 3-2-5 Discharge and Type of Intercepting Drain

2-Year Probability

No. of Main Drain	No. of Lateral Drain	Specific Discharge of MD θ(m^3/s/ha)	Catchment Area of Lateral Drain A (ha)	Discharge Q(m^3/s)	Length L (km)	Type of Cross-Section	Remarks
-	ID - 1	0.024*	22	0.53	0.50	VI	* estimated value
MD-10	ID - 2	0.014	63	0.88	1.00	VI	
	3	"	59	0.83	1.10	"	
	4	"	59	0.83	0.95	"	
	5	"	2	0.03	0.15	"	
	Total				3.70		
MD-11	ID - 6	0.019	5	0.10	0.30	VI	
	7	"	9	0.17	0.25	"	
	Total				0.55		
-	ID - 8	0.024*	34	0.82	0.35	VI	* estimated value
	9	"	6	0.14	0.45	"	
	10	"	19	0.46	1.20	"	
	11	"	44	1.06	1.05	"	
	Total				3.05		
SD-17	ID - 12	0.023	100	2.30	0.50	V	
	13	"	98	2.25	0.90	"	
	Total				1.40		
SD-18	ID - 14	0.024	14	0.34	0.50	VI	
	15	"	25	0.60	0.60	"	
	Total				1.10		
SD-20	ID - 16	0.027	59	1.59	0.90	V	
SD-21	ID - 17	0.034	66	2.24	0.80	V	

2-Year Probability

No. of Main Drain	No. of Lateral Drain	Specific Discharge of MD θ(m^3/s/ha)	Catchment Area of Lateral Drain A (ha)	Discharge Q(m^3/s)	Length L (km)	Type of Cross-Section	Remarks
SD-22	ID - 18	0.036	10	0.36	0.45	VI	
	19	"	94	3.38	0.90	V	
	Total				1.35		
SD-23	ID - 20	0.048	122	5.86	0.70	IV	
	21	"	144	6.91	1.10	"	
	Total				1.80		

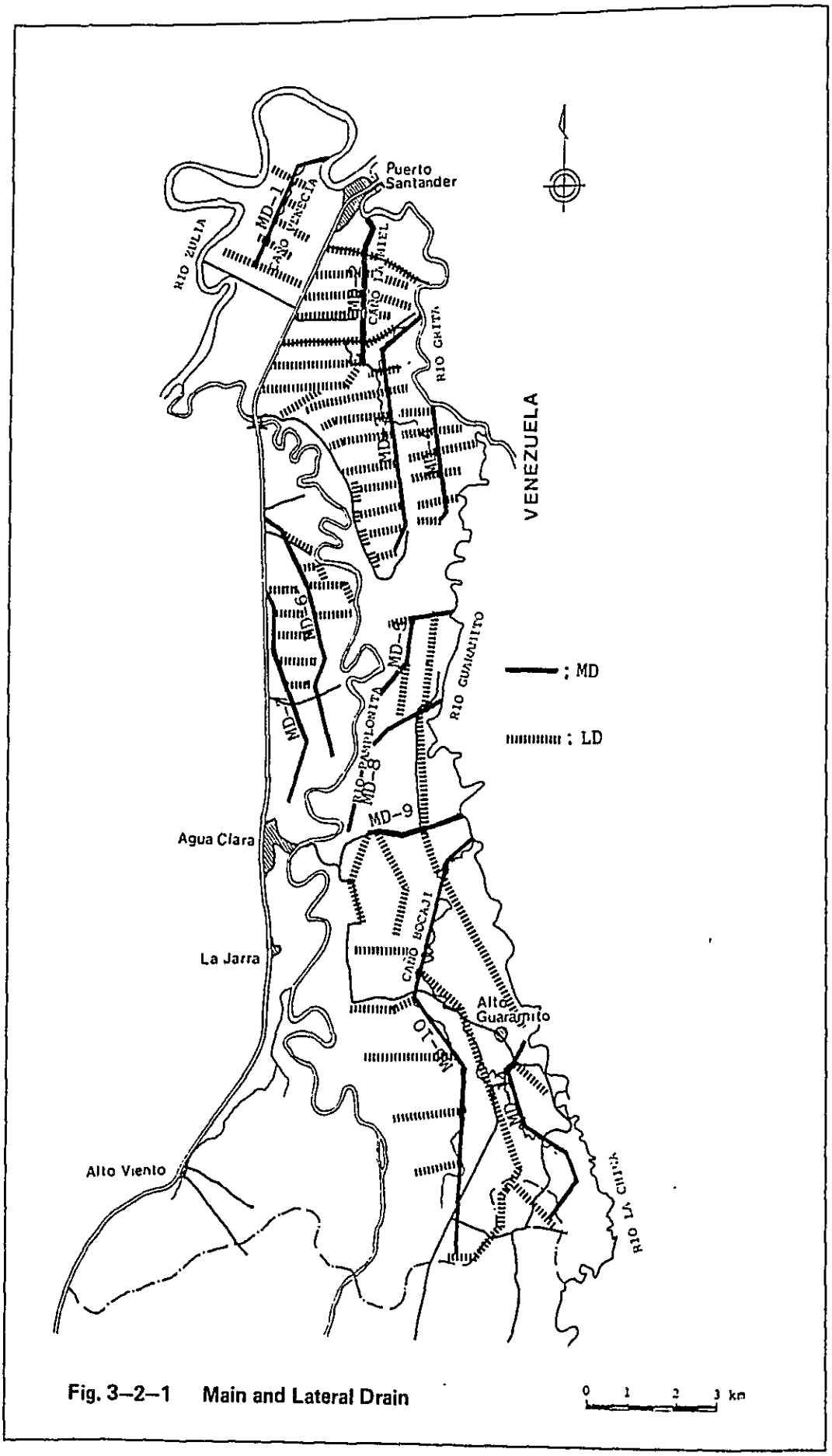
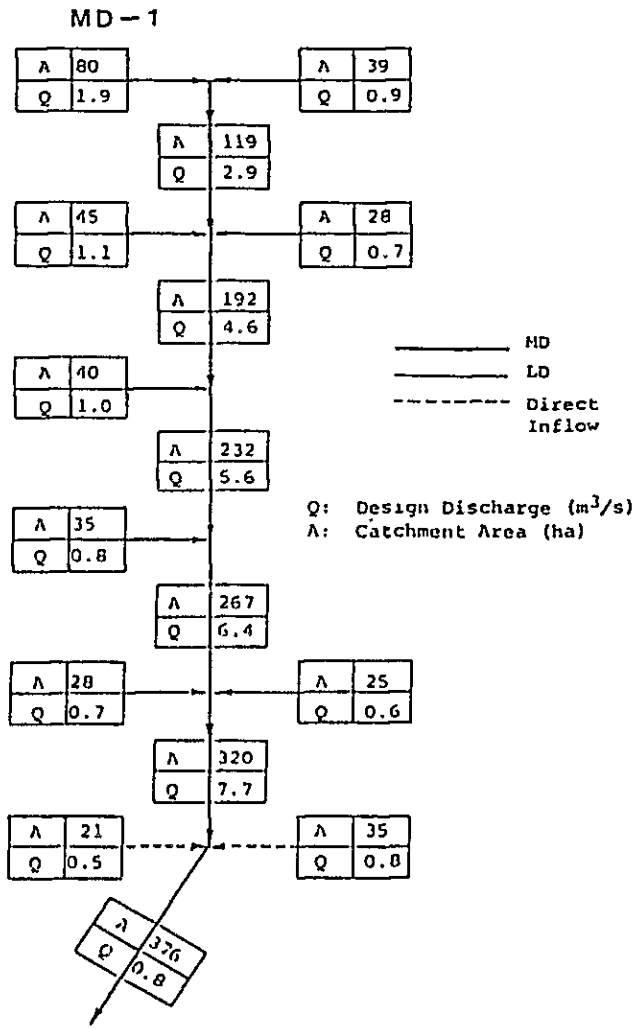
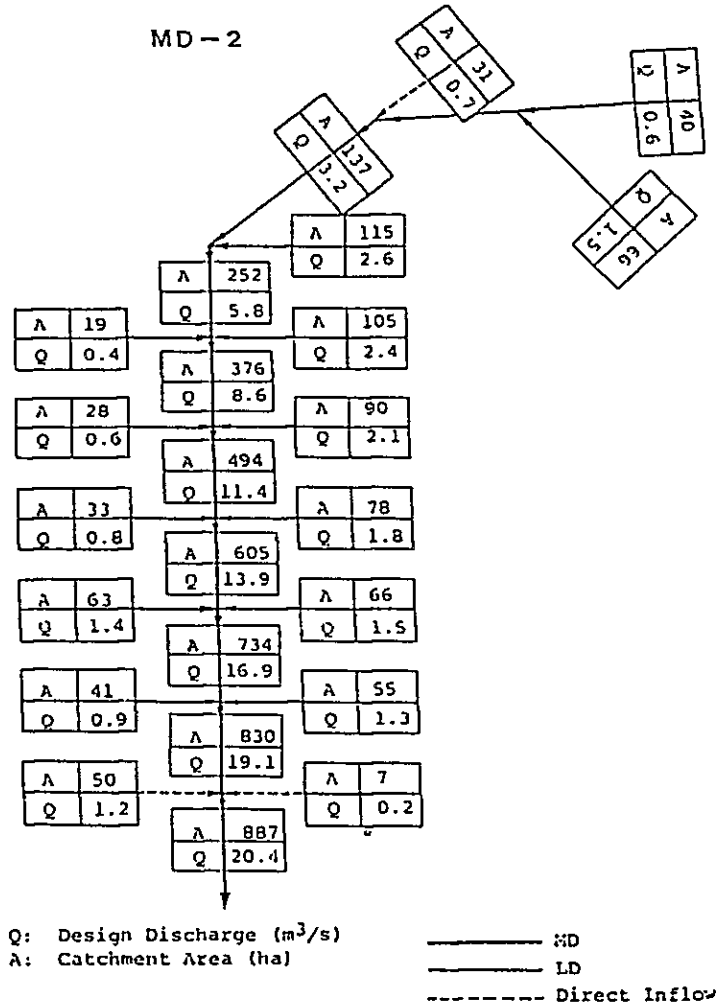


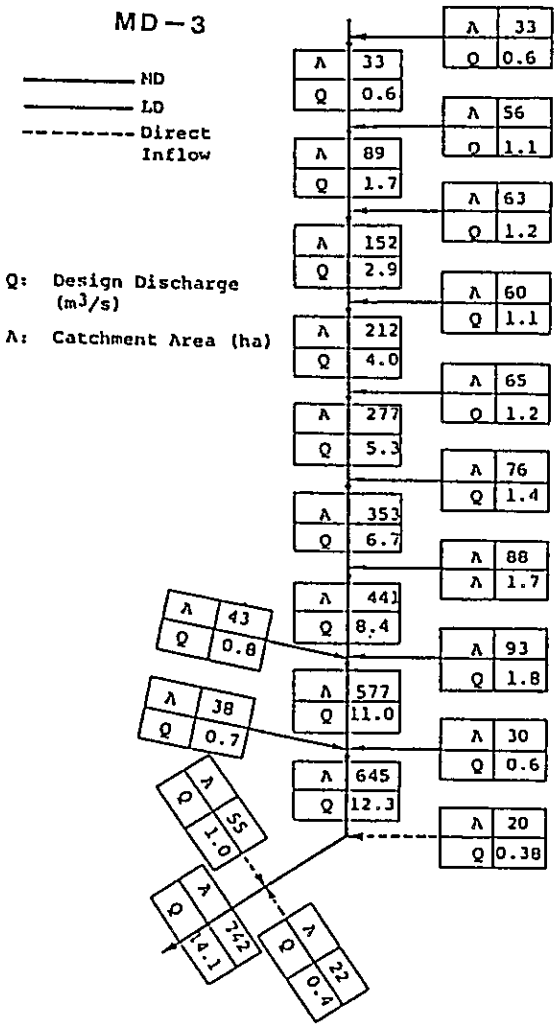
Fig. 3–2–1 Main and Lateral Drain

Fig. 3–2–2 Discharge Distribution of Main and Lateral Drain

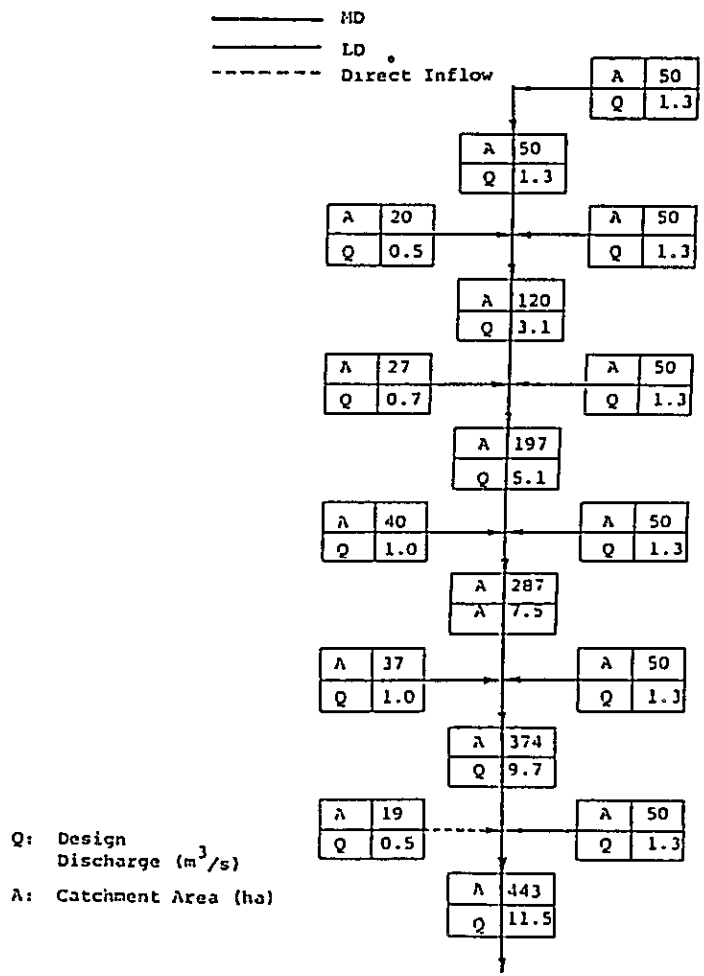

MD－1
A 80
Q 1.9
A 39
Q 0.9
A 119
Q 2.9
A 45
Q 1.1
A 28
Q 0.7
A 192
Q 4.6
A 40
Q 1.0
A 232
Q 5.6
A 35
Q 0.8
A 267
Q 6.4
A 28
Q 0.7
A 25
Q 0.6
A 320
Q 7.7
A 21
Q 0.5
A 35
Q 0.8
A 376
Q 0.8
MD
LD
Direct Inflow
Q: Design Discharge (m3/s)
A: Catchment Area (ha)


MD－2
A 31
Q 0.7
A 137
Q 3.2
A 40
Q 0.6
A 115
Q 2.6
A 252
Q 5.8
A 19
Q 0.4
A 105
Q 2.4
A 376
Q 8.6
A 28
Q 0.6
A 90
Q 2.1
A 494
Q 11.4
A 33
Q 0.8
A 78
Q 1.8
A 605
Q 13.9
A 63
Q 1.4
A 66
Q 1.5
A 734
Q 16.9
A 41
Q 0.9
A 55
Q 1.3
A 830
Q 19.1
A 50
Q 1.2
A 7
Q 0.2
A 887
Q 20.4
Q: Design Discharge (m3/s)
A: Catchment Area (ha)
MD
LD
Direct Inflow

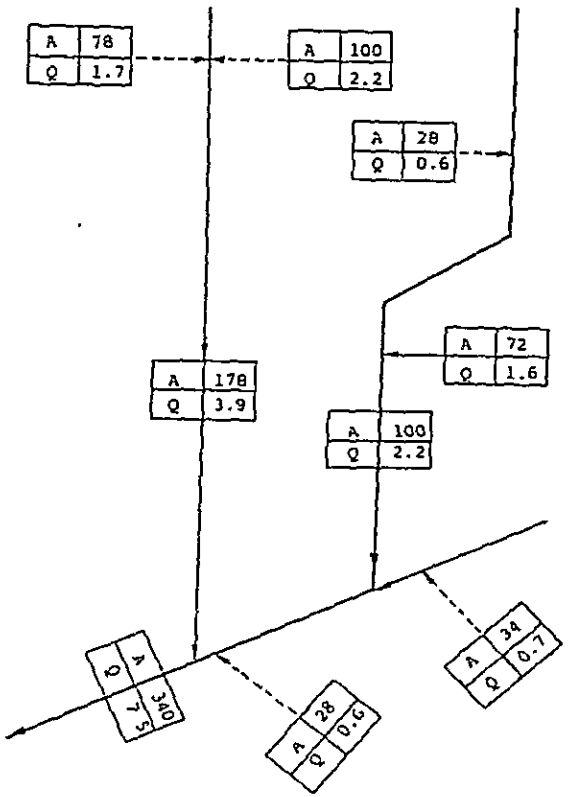
MD－3


MD
LD
Direct Inflow
Q: Design Discharge (m3/s)
A: Catchment Area (ha)
A 33
Q 0.6
A 56
Q 1.1
A 89
Q 1.7
A 63
Q 1.2
A 152
Q 2.9
A 60
Q 1.1
A 212
Q 4.0
A 65
Q 1.2
A 277
Q 5.3
A 76
Q 1.4
A 353
Q 6.7
A 88
A 1.7
A 441
Q 8.4
A 93
Q 1.8
A 577
Q 11.0
A 30
Q 0.6
A 645
Q 12.3
A 20
Q 0.38
A 43
Q 0.8
A 38
Q 0.7
A 55
Q 1.0
A 242
Q 14.1
A 22
Q 0.4

MD－4


MD
LD
Direct Inflow
Q: Design Discharge (m3/s)
A: Catchment Area (ha)
A 50
Q 1.3
A 50
Q 1.3
A 20
Q 0.5
A 50
Q 1.3
A 120
Q 3.1
A 27
Q 0.7
A 50
Q 1.3
A 197
Q 5.1
A 40
Q 1.0
A 50
Q 1.3
A 287
A 7.5
A 37
Q 1.0
A 50
Q 1.3
A 374
Q 9.7
A 19
Q 0.5
A 50
Q 1.3
A 443
Q 11.5

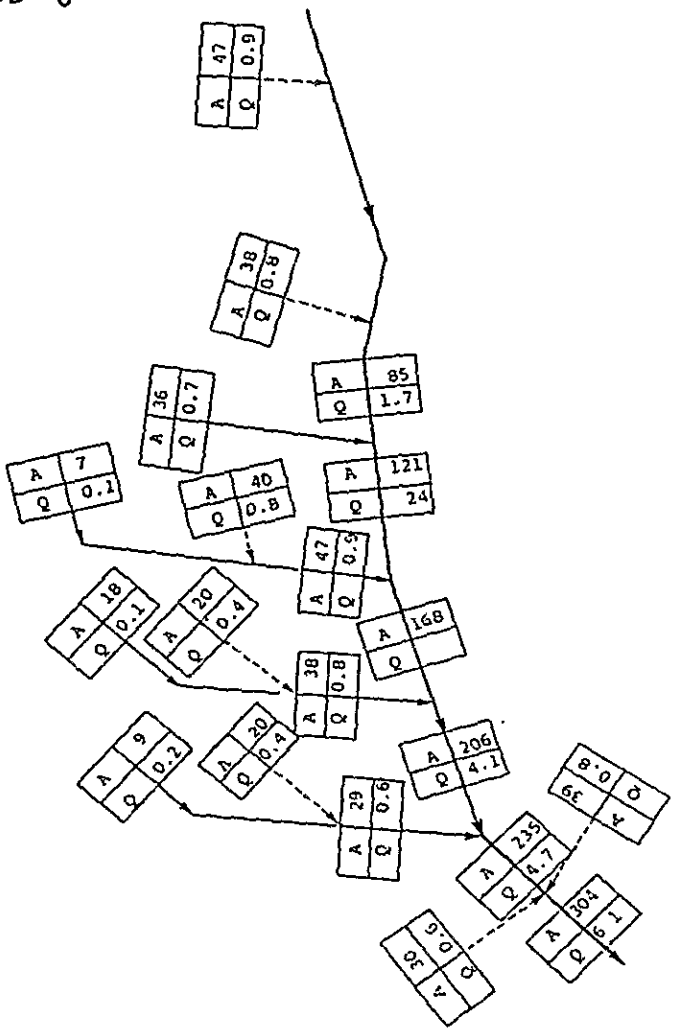
MD-5



Q: Design Discharge (m^3/s)
A: Catchment Area (ha)

——— MD
——— LD
--------- Indirect Inflow

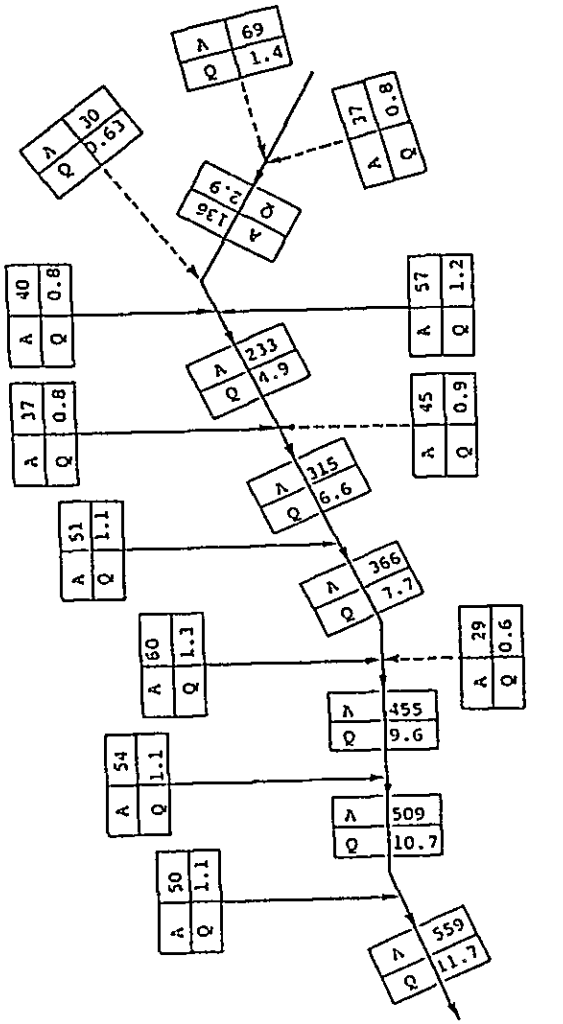
MD-6



——— MD
——— LD
--------- Direct Inflow

Q: Design Discharge (m^3/s)
A: Catchment Area (ha)

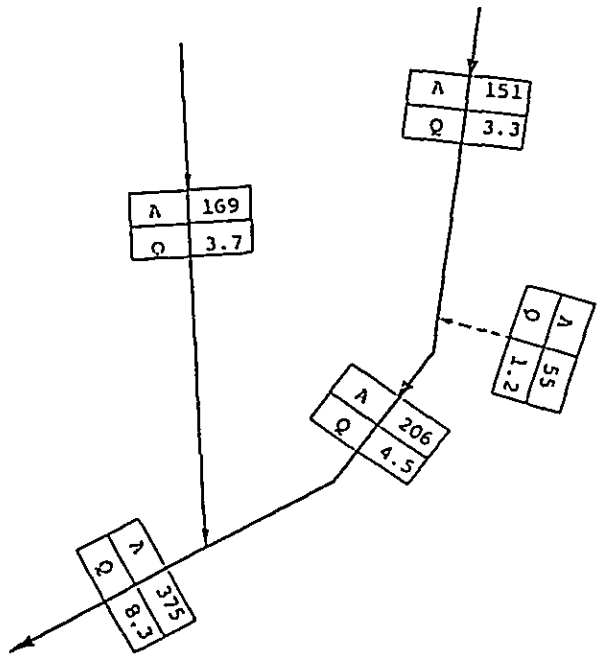
MD−7



Q: Design Discharge (m^3/s)
A: Catchment Area (ha)

MD
LD
Direct Inflow

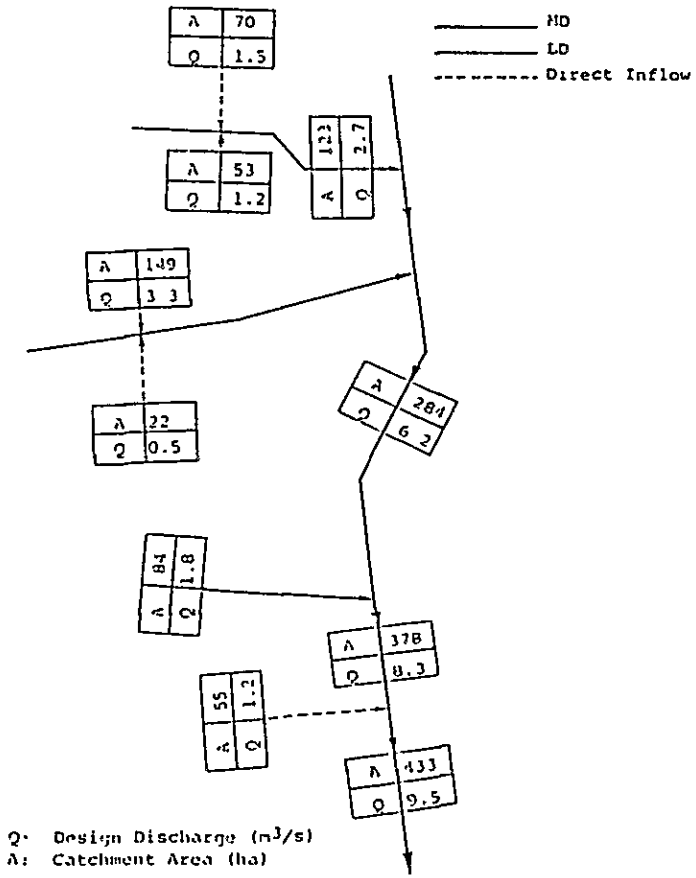
MD−8



Q: Design Discharge (m^3/s)
A: Catchment Area (ha)

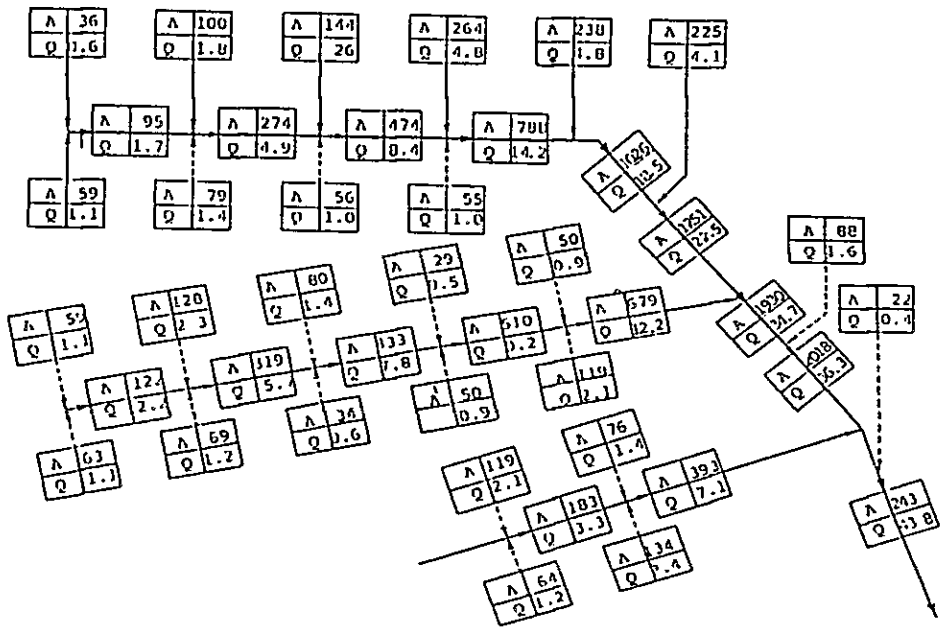
MD
LD
Direct Inflow

MD－9



Q: Design Discharge (m^3/s)
A: Catchment Area (ha)

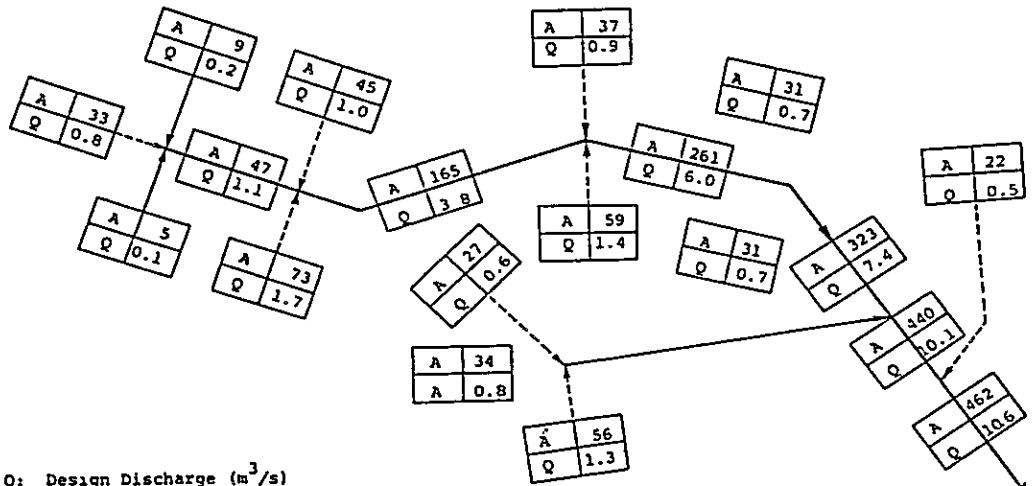
MD－10



MD
LD
Direct Inflow

Q: Design Discharge (m^3/s)
A: Catchment Area (ha)

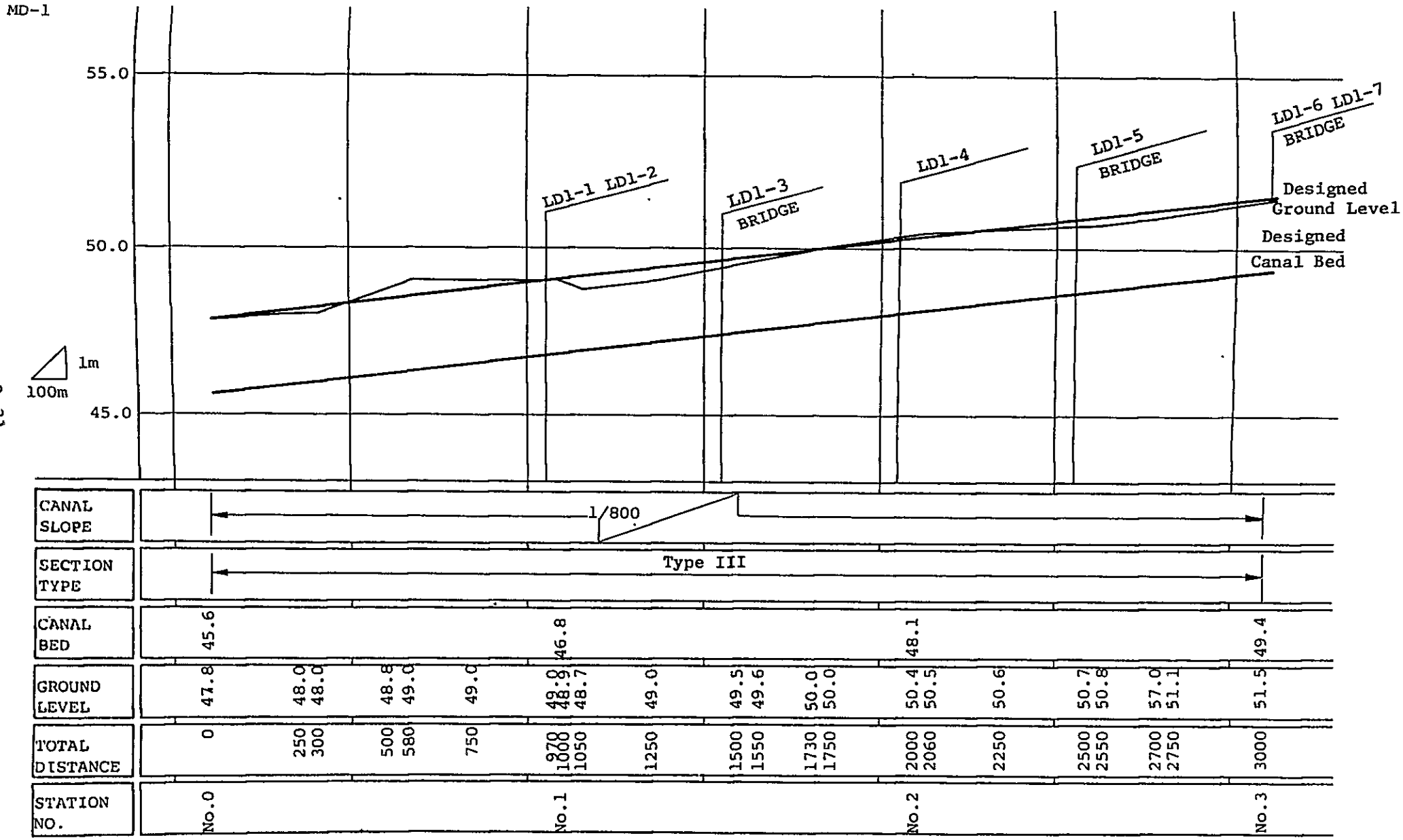
MD－11

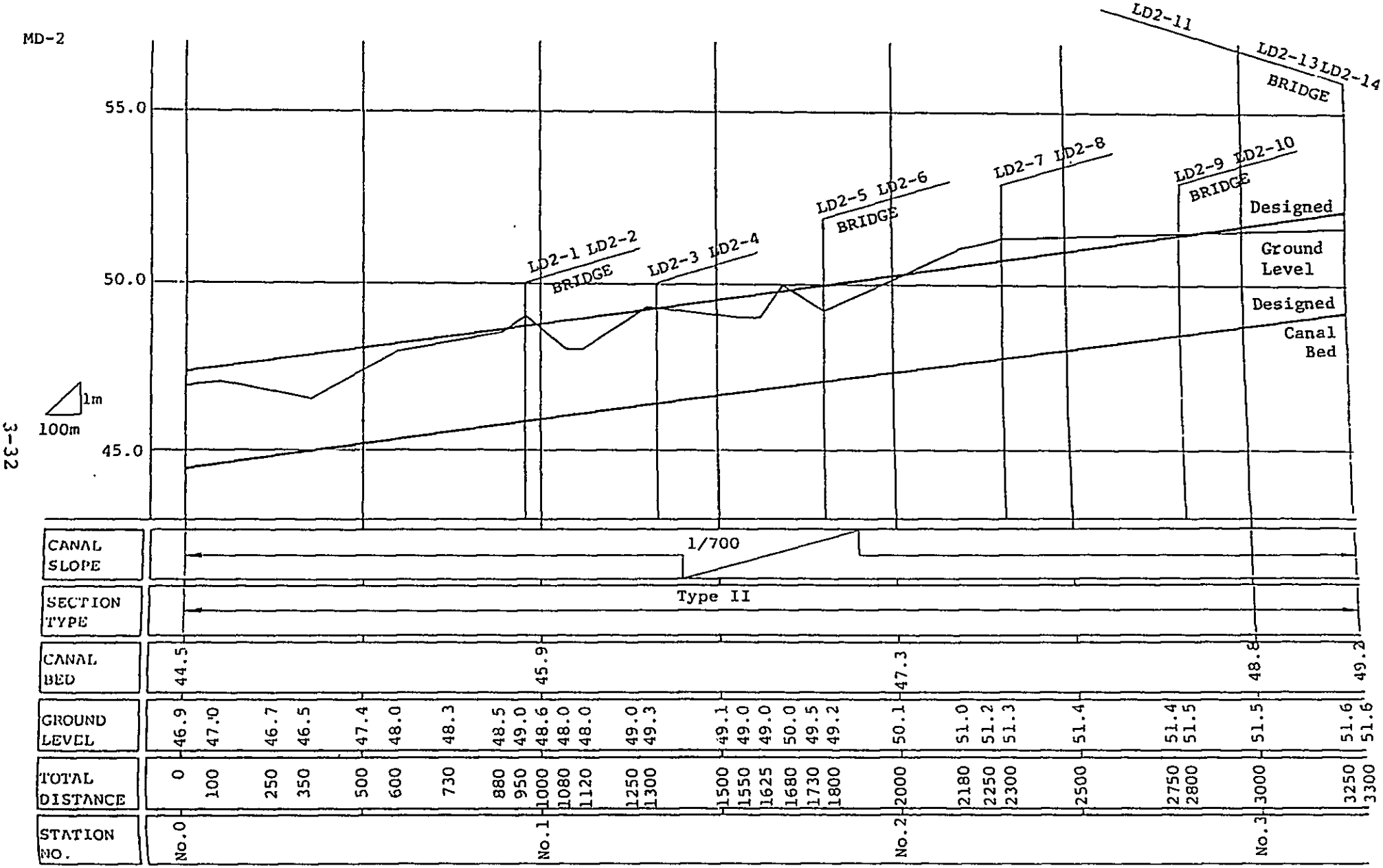


Q: Design Discharge (m^3/s)
A: Catchment Area (ha)

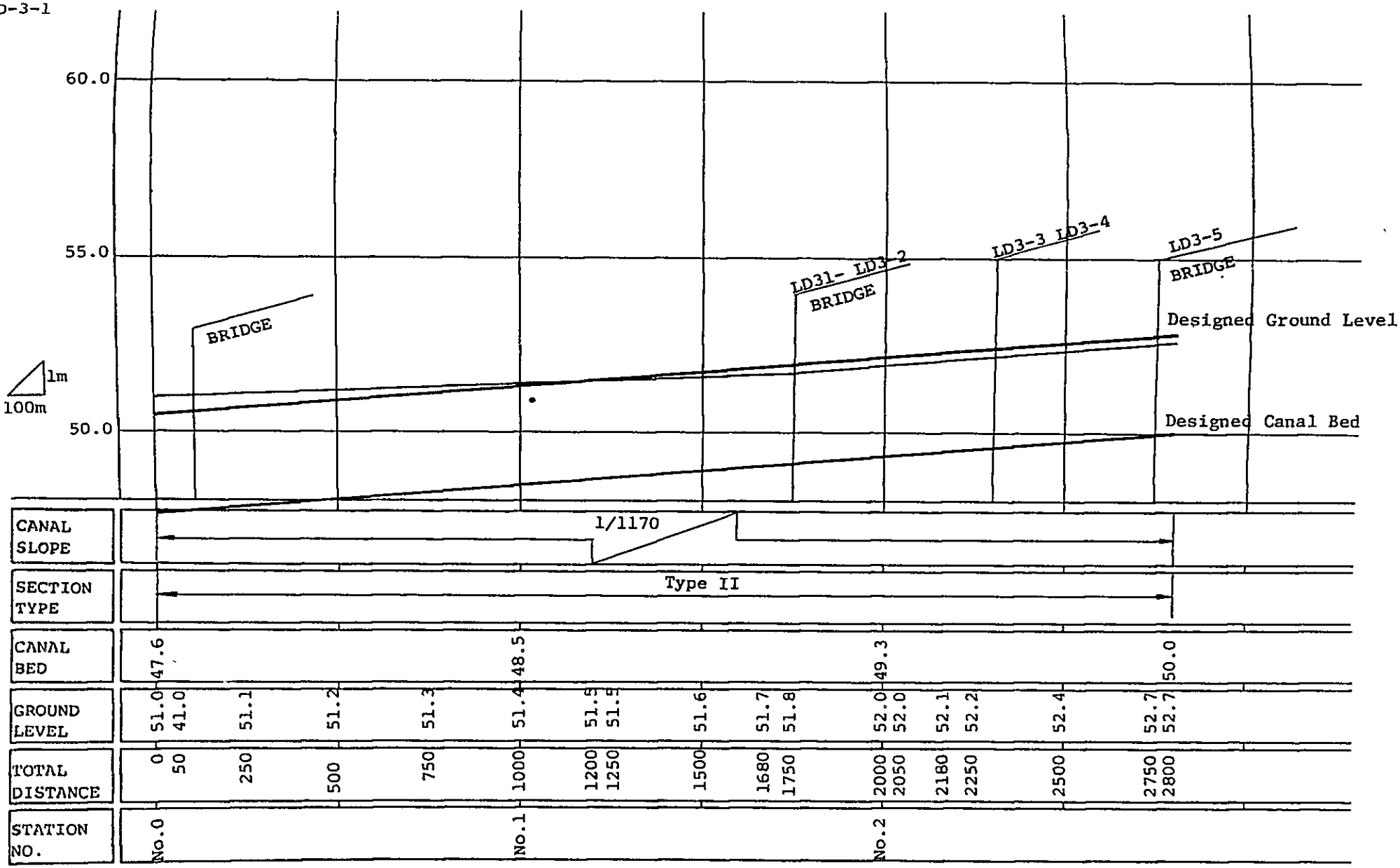
——— MD
——— LD
--------- Direct Inflow

Fig. 3–2–3 Profile of Main Drain

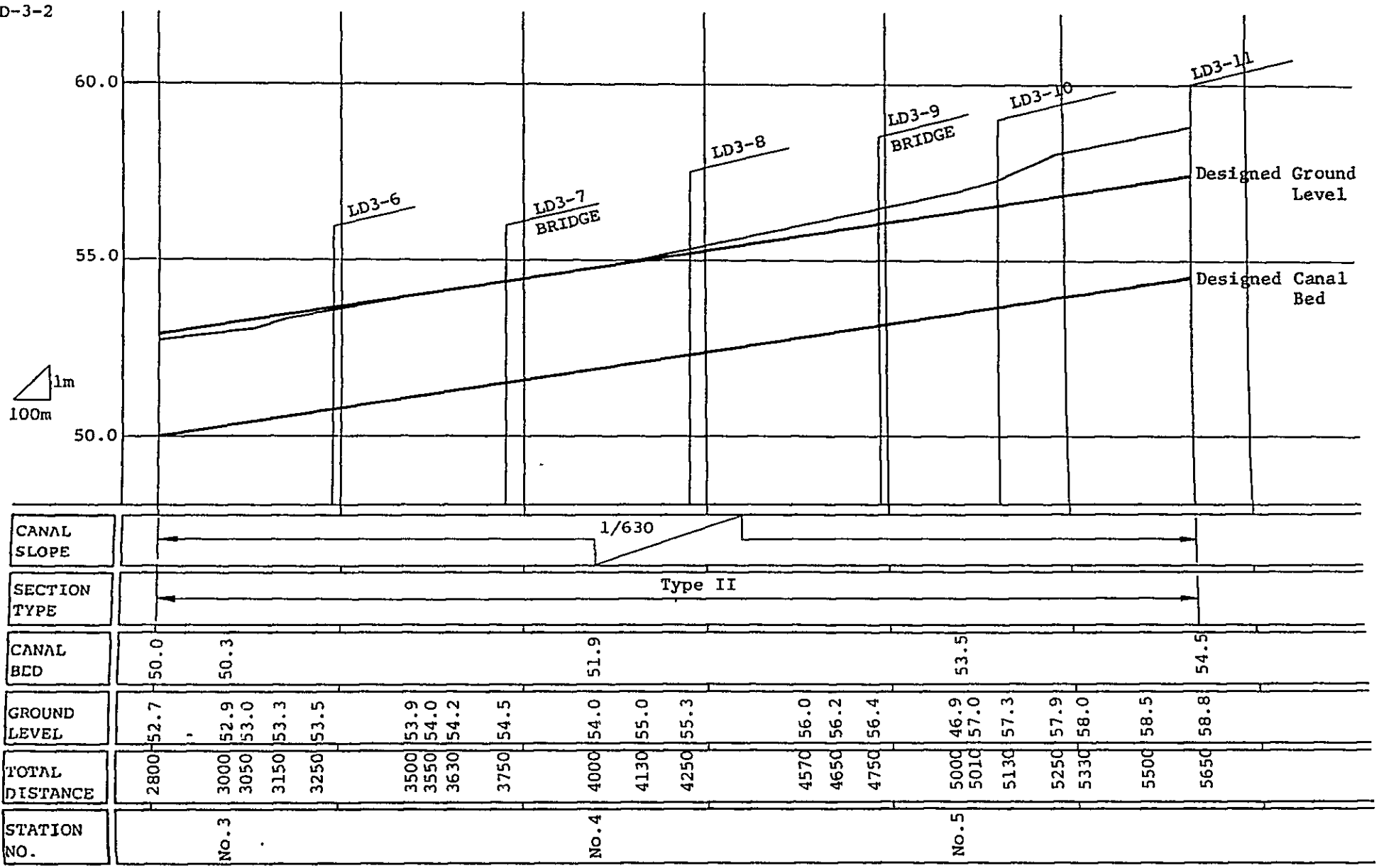

MD-1
55.0
50.0
45.0
LD1-1 LD1-2
LD1-3
BRIDGE
LD1-4
LD1-5
BRIDGE
LD1-6 LD1-7
BRIDGE
Designed
Ground Level
Designed
Canal Bed
1m
100m
CANAL SLOPE
1/800
SECTION TYPE
Type III
CANAL BED
45.6
46.8
48.1
49.4
GROUND LEVEL
47.8
48.0
48.0
48.8
49.0
49.0
49.0
48.9
48.7
49.0
49.5
49.6
50.0
50.0
50.4
50.5
50.6
50.7
50.8
57.0
51.1
51.5
TOTAL DISTANCE
0
250
300
500
580
750
970
1000
1050
1250
1500
1550
1730
1750
2000
2060
2250
2500
2550
2700
2750
3000
STATION NO.
No.0
No.1
No.2
No.3


MD-2
55.0
50.0
45.0
1m
100m
LD2-1 LD2-2
BRIDGE
LD2-3 LD2-4
LD2-5 LD2-6
BRIDGE
LD2-7 LD2-8
LD2-9 LD2-10
BRIDGE
LD2-11
LD2-13LD2-14
BRIDGE
Designed
Ground
Level
Designed
Canal
Bed
CANAL SLOPE
1/700
SECTION TYPE
Type II
CANAL BED
44.5
45.9
47.3
48.8
49.2
GROUND LEVEL
46.9 47.0 46.7 46.5 47.4 48.0 48.3 48.5 49.0 48.6 48.0 48.0 49.0 49.3 49.1 49.0 49.0 50.0 49.5 49.2 50.1 51.0 51.2 51.3 51.4 51.4 51.5 51.5 51.6 51.6
TOTAL DISTANCE
0 100 250 350 500 600 730 880 950 1000 1080 1120 1250 1300 1500 1550 1625 1680 1730 1800 2000 2180 2250 2300 2500 2750 2800 3000 3250 3300
STATION NO.
No.0
No.1
No.2
No.3

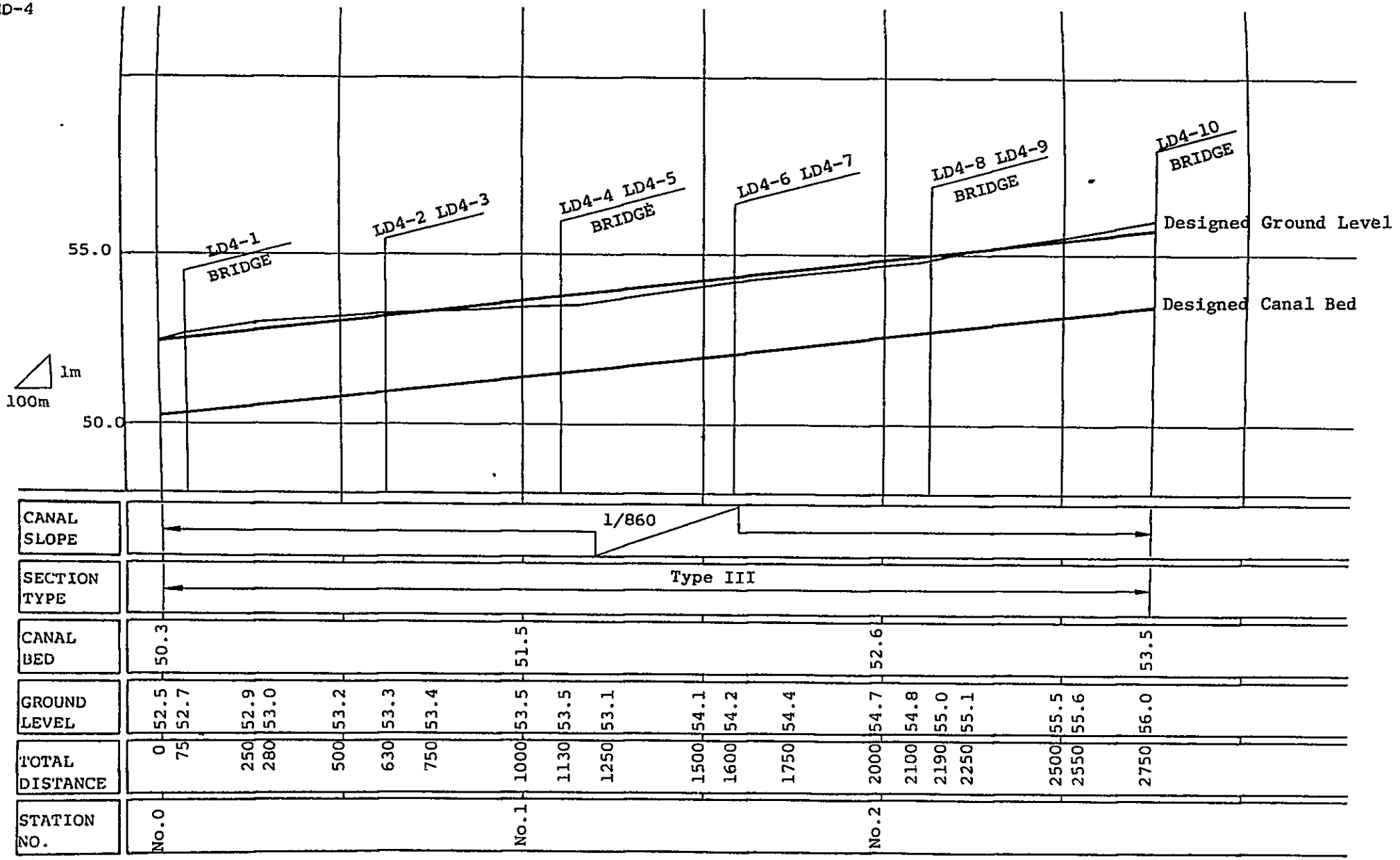
MD-3-1


60.0
55.0
50.0
BRIDGE
LD31- LD3-2
BRIDGE
LD3-3 LD3-4
LD3-5
BRIDGE
Designed Ground Level
Designed Canal Bed
1m
100m
CANAL SLOPE
1/1170
SECTION TYPE
Type II
CANAL BED
47.6
48.5
49.3
50.0
GROUND LEVEL
51.0
41.0
51.1
51.2
51.3
51.4
51.5
51.5
51.6
51.7
51.8
52.0
52.0
52.1
52.2
52.4
52.7
52.7
TOTAL DISTANCE
0
50
250
500
750
1000
1200
1250
1500
1680
1750
2000
2050
2180
2250
2500
2750
2800
STATION NO.
No.0
No.1
No.2

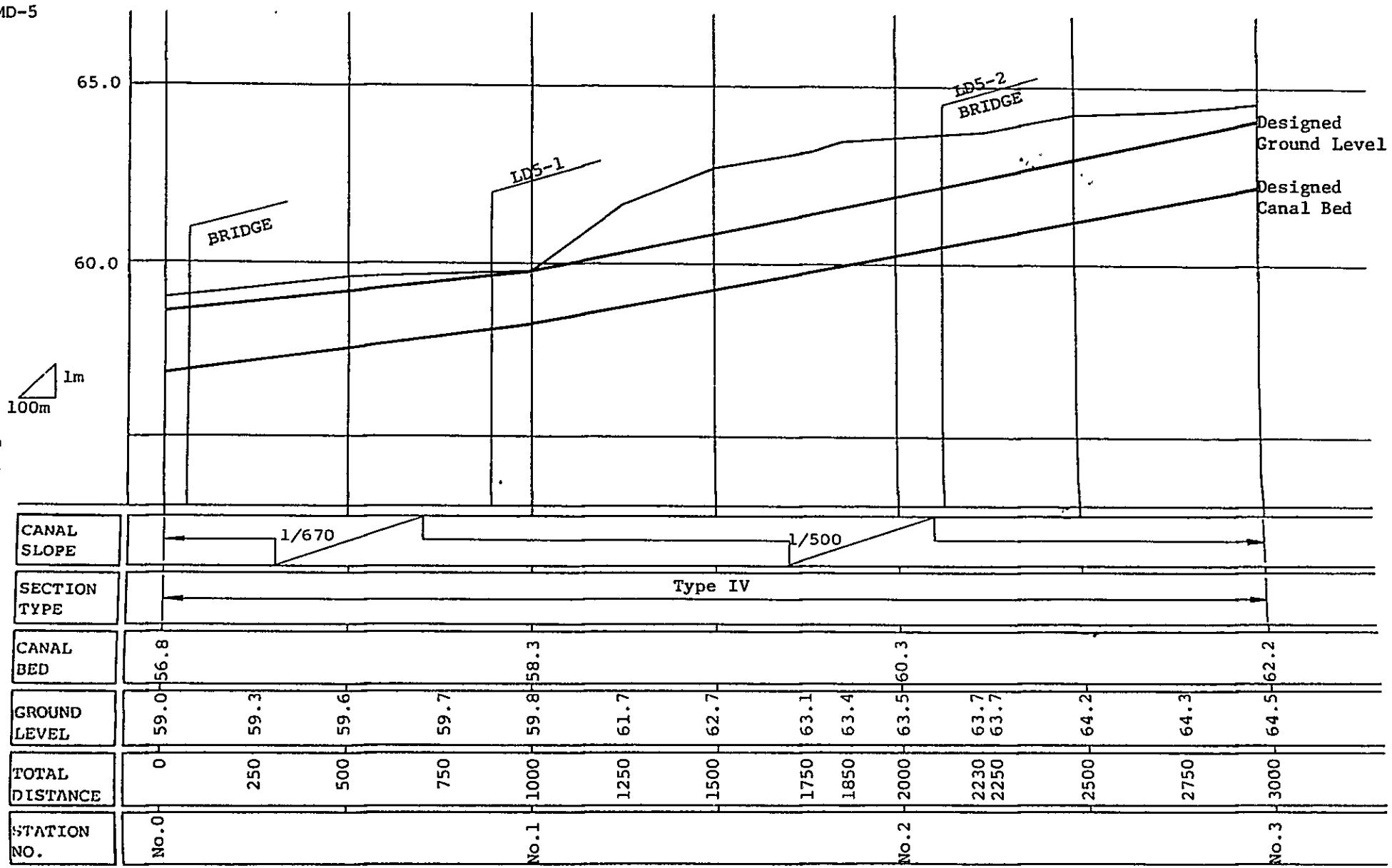
MD-3-2


60.0
55.0
50.0
LD3-6
LD3-7
BRIDGE
LD3-8
LD3-9
BRIDGE
LD3-10
LD3-11
Designed Ground Level
Designed Canal Bed
1m
100m
CANAL SLOPE
1/630
SECTION TYPE
Type II
CANAL BED
50.0 50.3 51.9 53.5 54.5
GROUND LEVEL
52.7 52.9 53.0 53.3 53.5 53.9 54.0 54.2 54.5 54.0 55.0 55.3 56.0 56.2 56.4 46.9 57.0 57.3 57.9 58.0 58.5 58.8
TOTAL DISTANCE
2800 3000 3050 3150 3250 3500 3550 3630 3750 4000 4130 4250 4570 4650 4750 5000 5010 5130 5250 5330 5500 5650
STATION NO.
No.3 No.4 No.5

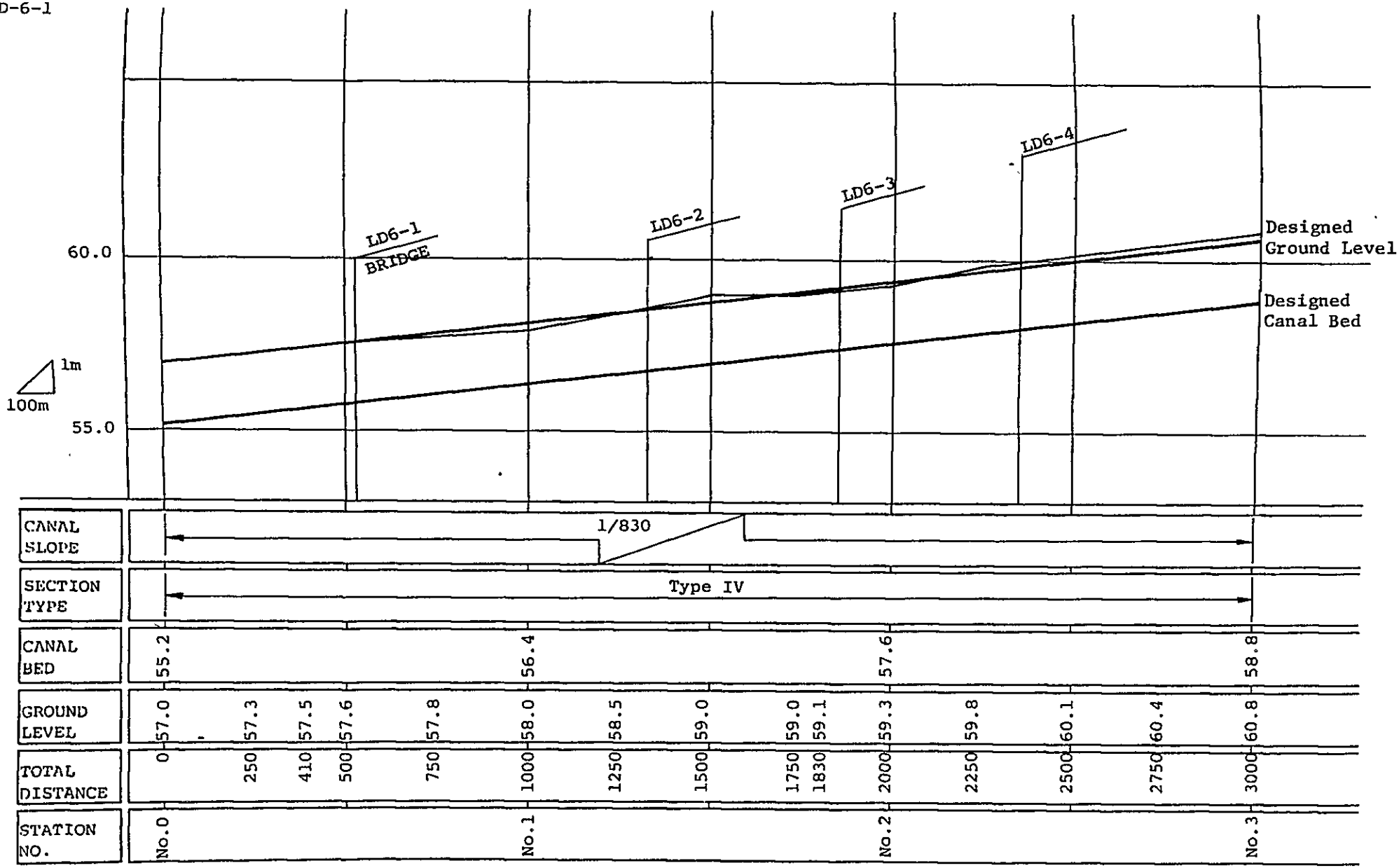
MD-4


55.0
50.0
1m
100m
LD4-1 BRIDGE
LD4-2 LD4-3 BRIDGE
LD4-4 LD4-5 BRIDGE
LD4-6 LD4-7 BRIDGE
LD4-8 LD4-9 BRIDGE
LD4-10 BRIDGE
Designed Ground Level
Designed Canal Bed
CANAL SLOPE
1/860
SECTION TYPE
Type III
CANAL BED
50.3
51.5
52.6
53.5
GROUND LEVEL
52.5
52.7
52.9
53.0
53.2
53.3
53.4
53.5
53.5
53.1
54.1
54.2
54.4
54.7
54.8
55.0
55.1
55.5
55.6
56.0
TOTAL DISTANCE
0
75
250
280
500
630
750
1000
1130
1250
1500
1600
1750
2000
2100
2190
2250
2500
2550
2750
STATION NO.
No.0
No.1
No.2

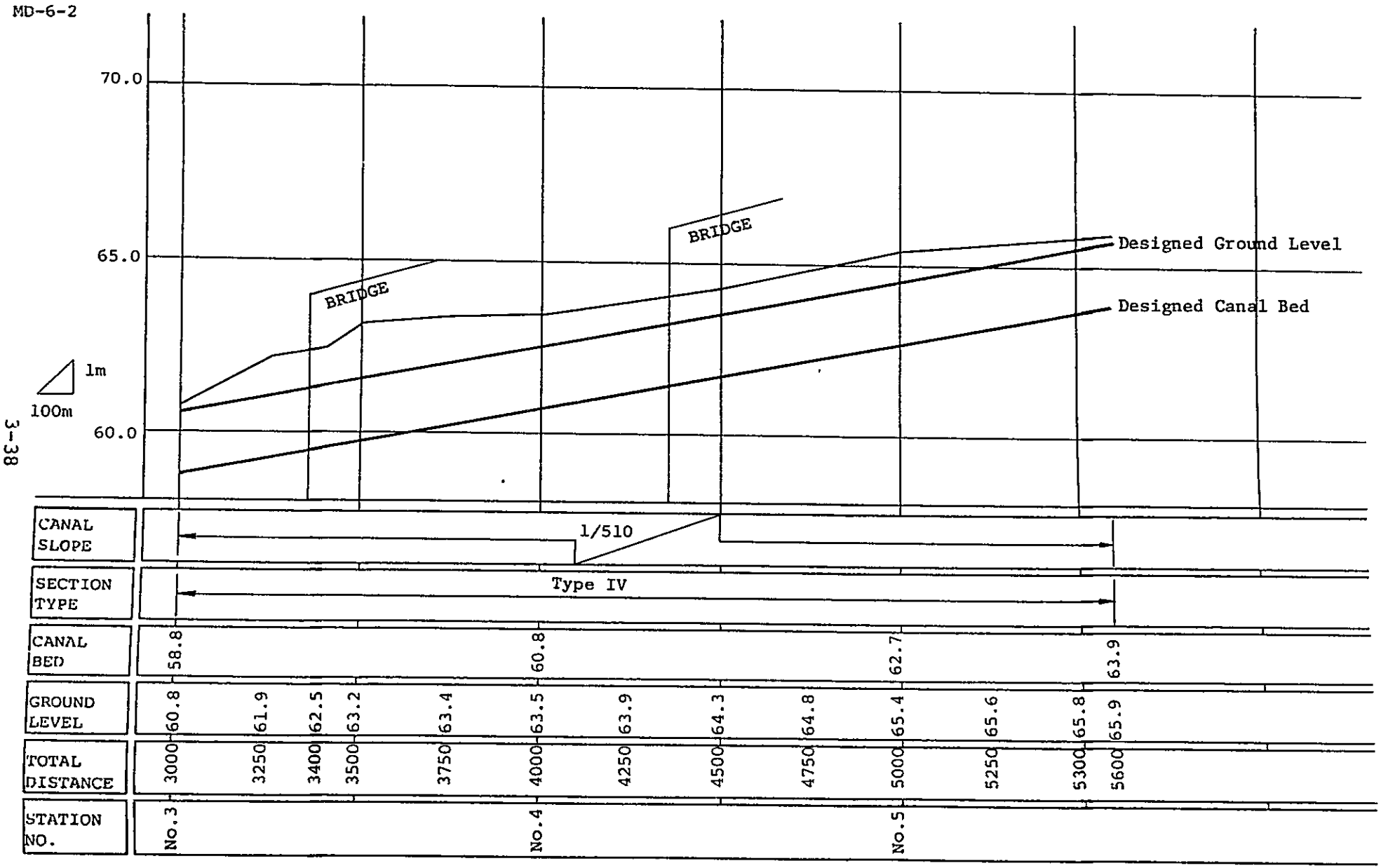
MD-5


65.0
60.0
BRIDGE
LD5-1
LD5-2
BRIDGE
Designed Ground Level
Designed Canal Bed
1m
100m
CANAL SLOPE
1/670
1/500
SECTION TYPE
Type IV
CANAL BED
56.8
58.3
60.3
62.2
GROUND LEVEL
59.0
59.3
59.6
59.7
59.8
61.7
62.7
63.1
63.4
63.5
63.7
63.7
64.2
64.3
64.5
TOTAL DISTANCE
0
250
500
750
1000
1250
1500
1750
1850
2000
2230
2250
2500
2750
3000
STATION NO.
No.0
No.1
No.2
No.3

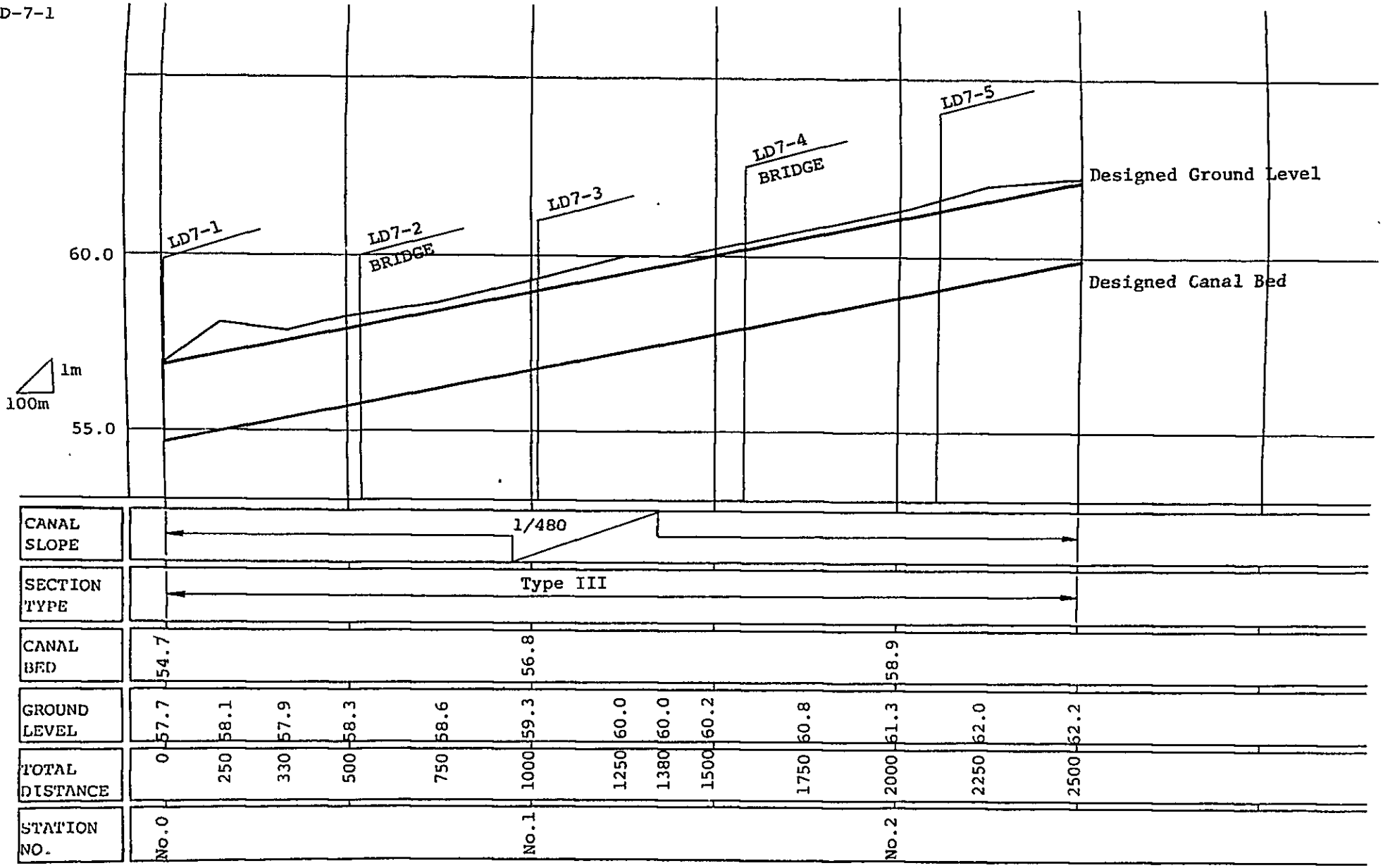
MD-6-1


60.0
55.0
1m
100m
LD6-1
BRIDGE
LD6-2
LD6-3
LD6-4
Designed
Ground Level
Designed
Canal Bed
CANAL
SLOPE
1/830
SECTION
TYPE
Type IV
CANAL
BED
55.2
56.4
57.6
58.8
GROUND
LEVEL
57.0
57.3
57.5
57.6
57.8
58.0
58.5
59.0
59.0
59.1
59.3
59.8
60.1
60.4
60.8
TOTAL
DISTANCE
0
250
410
500
750
1000
1250
1500
1750
1830
2000
2250
2500
2750
3000
STATION
NO.
No.0
No.1
No.2
No.3

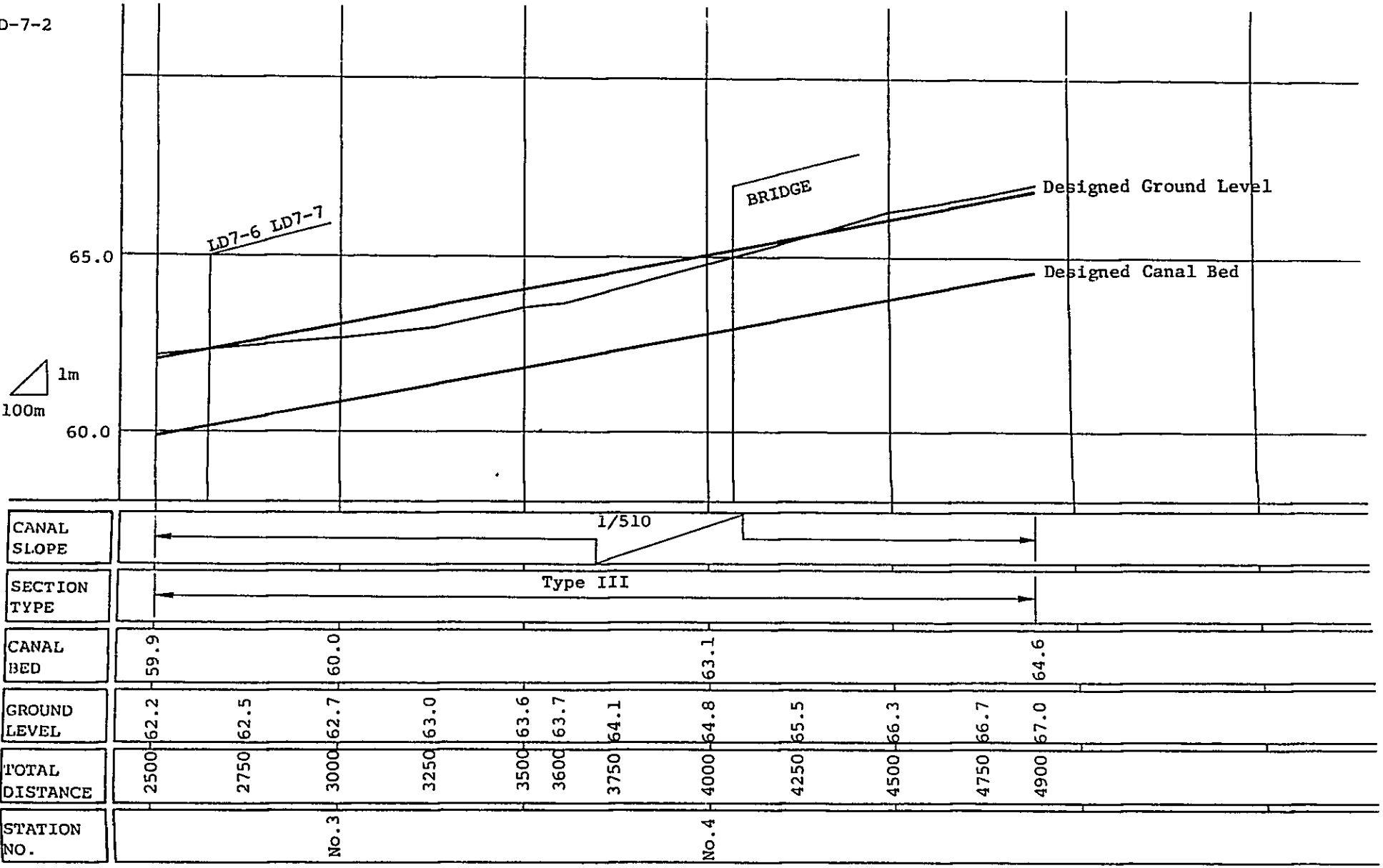
MD-6-2


70.0
65.0
60.0
BRIDGE
BRIDGE
Designed Ground Level
Designed Canal Bed
1m
100m
CANAL SLOPE
1/510
SECTION TYPE
Type IV
CANAL BED
58.8
60.8
62.7
63.9
GROUND LEVEL
60.8
61.9
62.5
63.2
63.4
63.5
63.9
64.3
64.8
65.4
65.6
65.8
65.9
TOTAL DISTANCE
3000
3250
3400
3500
3750
4000
4250
4500
4750
5000
5250
5300
5600
STATION NO.
No.3
No.4
No.5

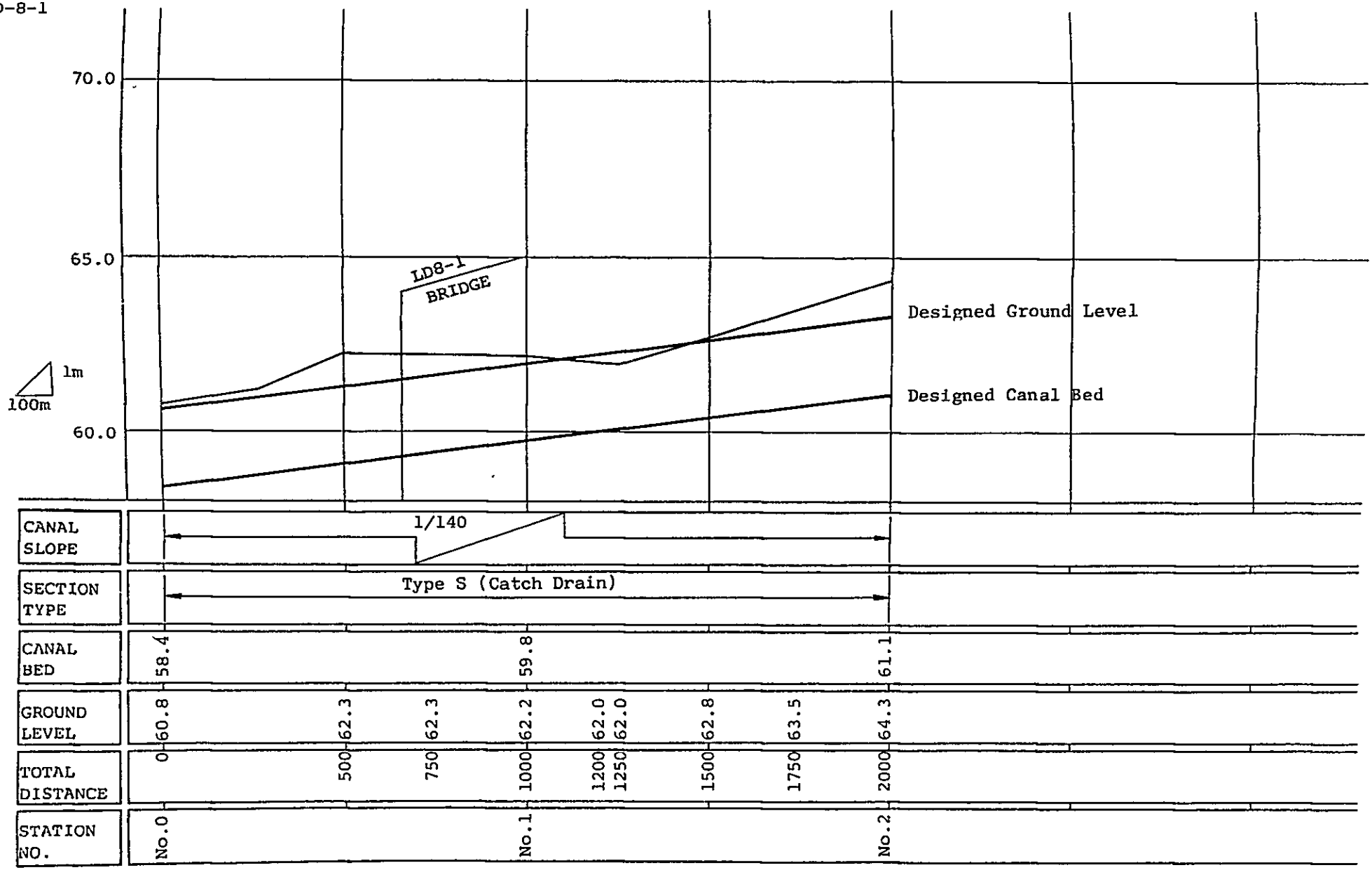
MD-7-1


LD7-1
LD7-2
BRIDGE
LD7-3
LD7-4
BRIDGE
LD7-5
Designed Ground Level
Designed Canal Bed
60.0
55.0
1m
100m
CANAL SLOPE
1/480
SECTION TYPE
Type III
CANAL BED
54.7
56.8
58.9
GROUND LEVEL
57.7
58.1
57.9
58.3
58.6
59.3
60.0
60.0
60.2
60.8
61.3
62.0
62.2
TOTAL DISTANCE
0
250
330
500
750
1000
1250
1380
1500
1750
2000
2250
2500
STATION NO.
No.0
No.1
No.2

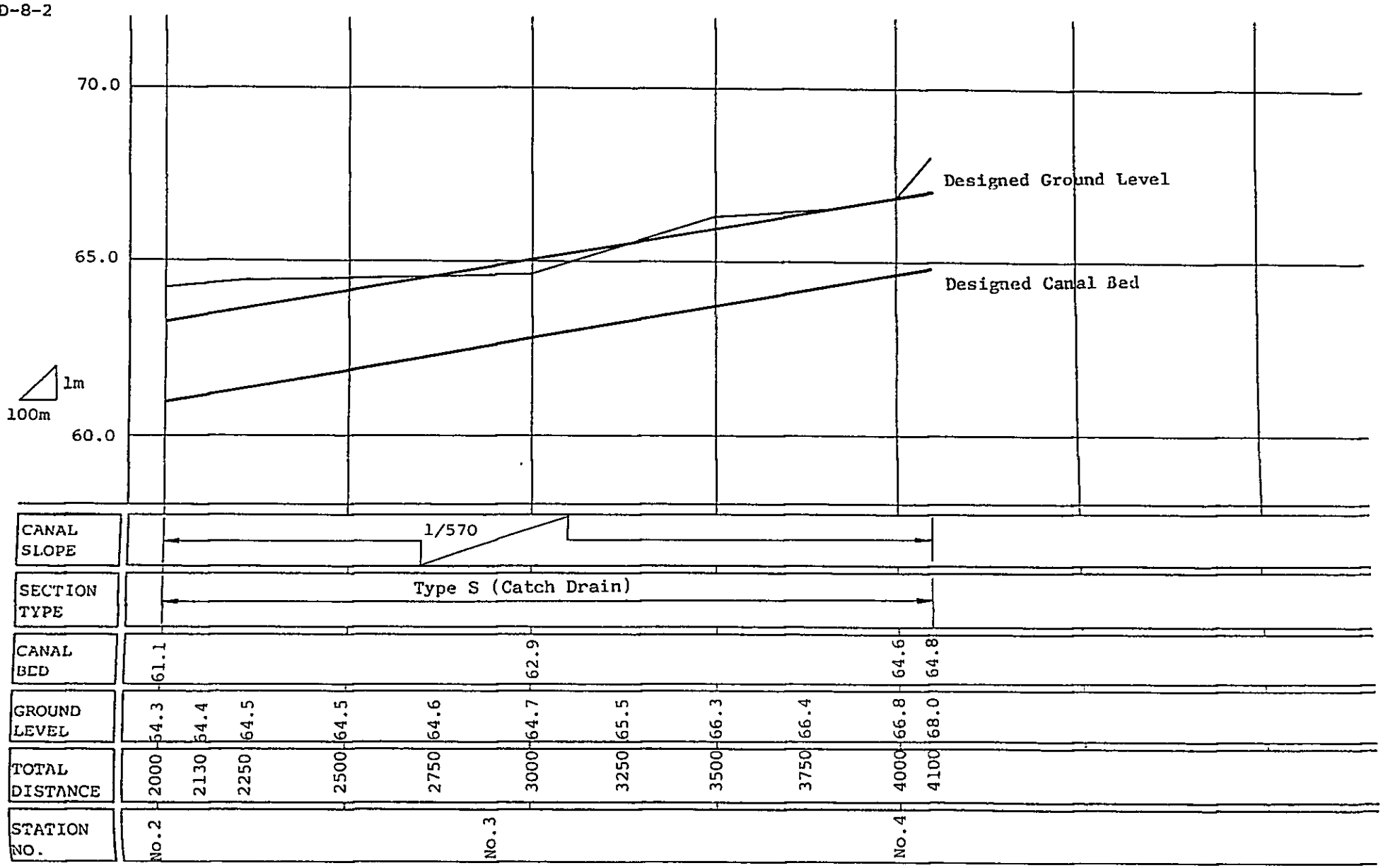
MD-7-2


LD7-6 LD7-7
BRIDGE
Designed Ground Level
Designed Canal Bed
65.0
60.0
1m
100m
CANAL SLOPE
1/510
SECTION TYPE
Type III
CANAL BED
59.9
60.0
63.1
64.6
GROUND LEVEL
62.2
62.5
62.7
63.0
63.6
63.7
64.1
64.8
65.5
66.3
66.7
67.0
TOTAL DISTANCE
2500
2750
3000
3250
3500
3600
3750
4000
4250
4500
4750
4900
STATION NO.
No.3
No.4

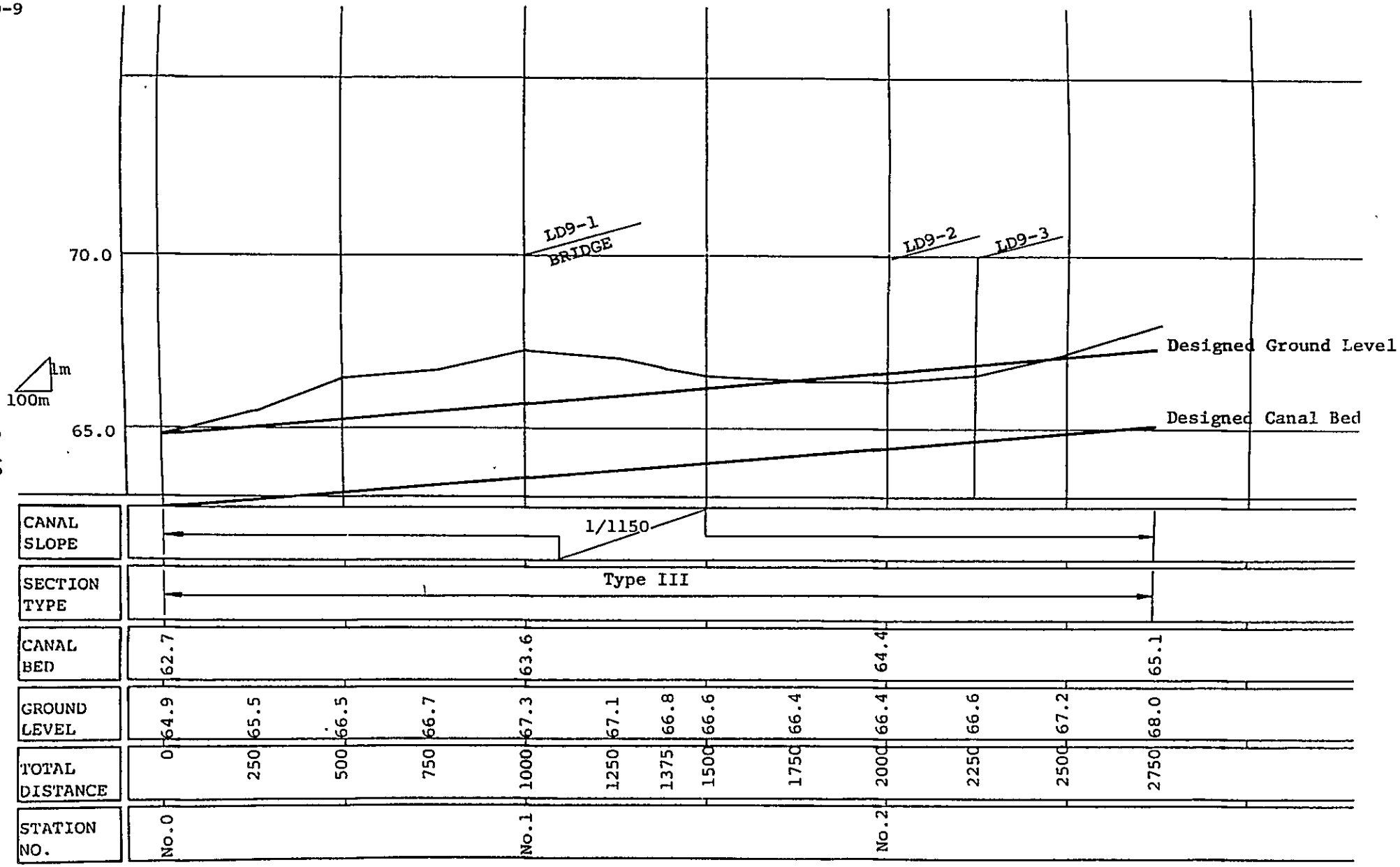
MD-8-1

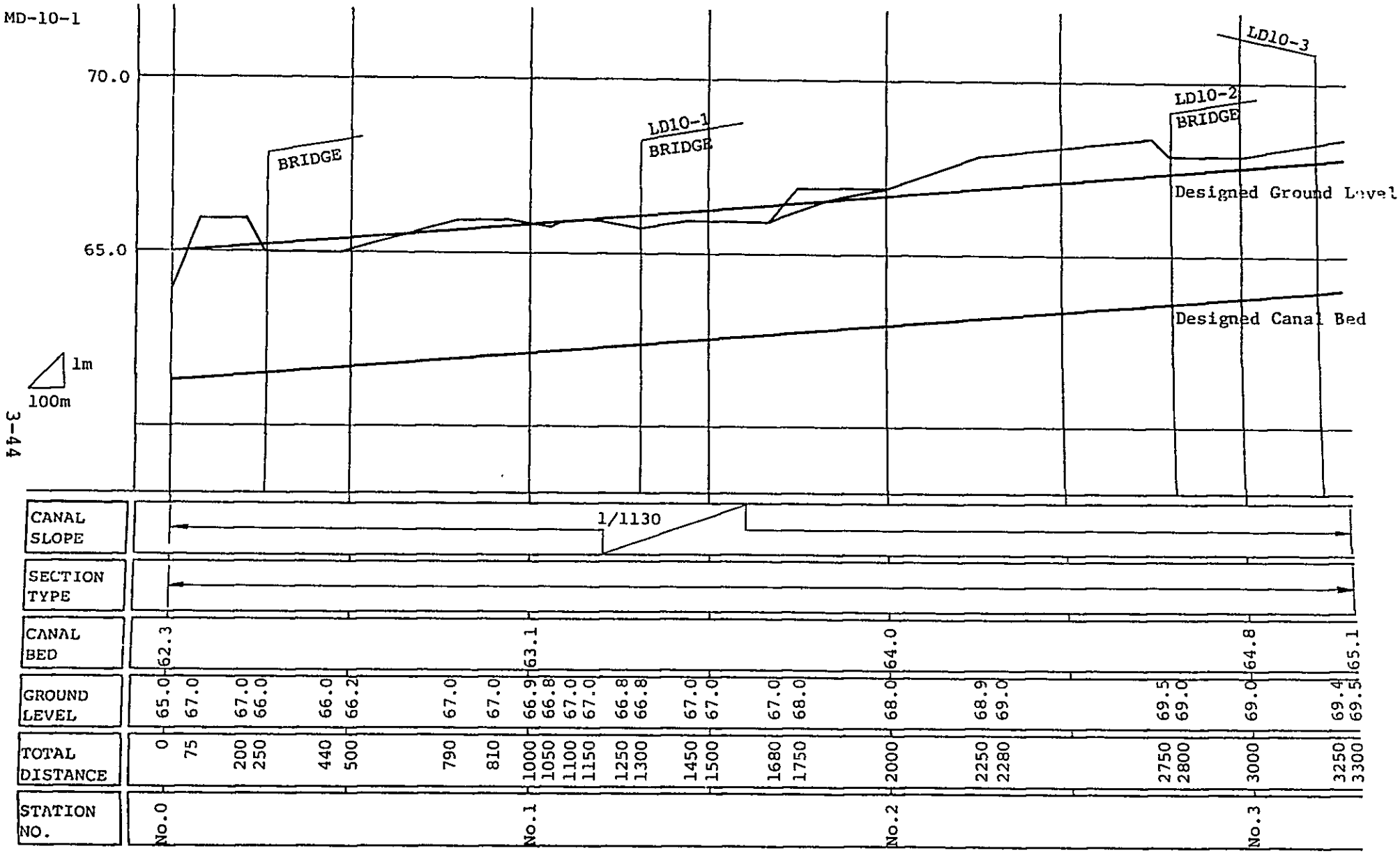

70.0
65.0
60.0
LD8-1
BRIDGE
Designed Ground Level
Designed Canal Bed
1m
100m
CANAL SLOPE
1/140
SECTION TYPE
Type S (Catch Drain)
CANAL BED
58.4
59.8
61.1
GROUND LEVEL
60.8
62.3
62.3
62.2
62.0
62.0
62.8
63.5
64.3
TOTAL DISTANCE
0
500
750
1000
1200
1250
1500
1750
2000
STATION NO.
No.0
No.1
No.2

MD-8-2

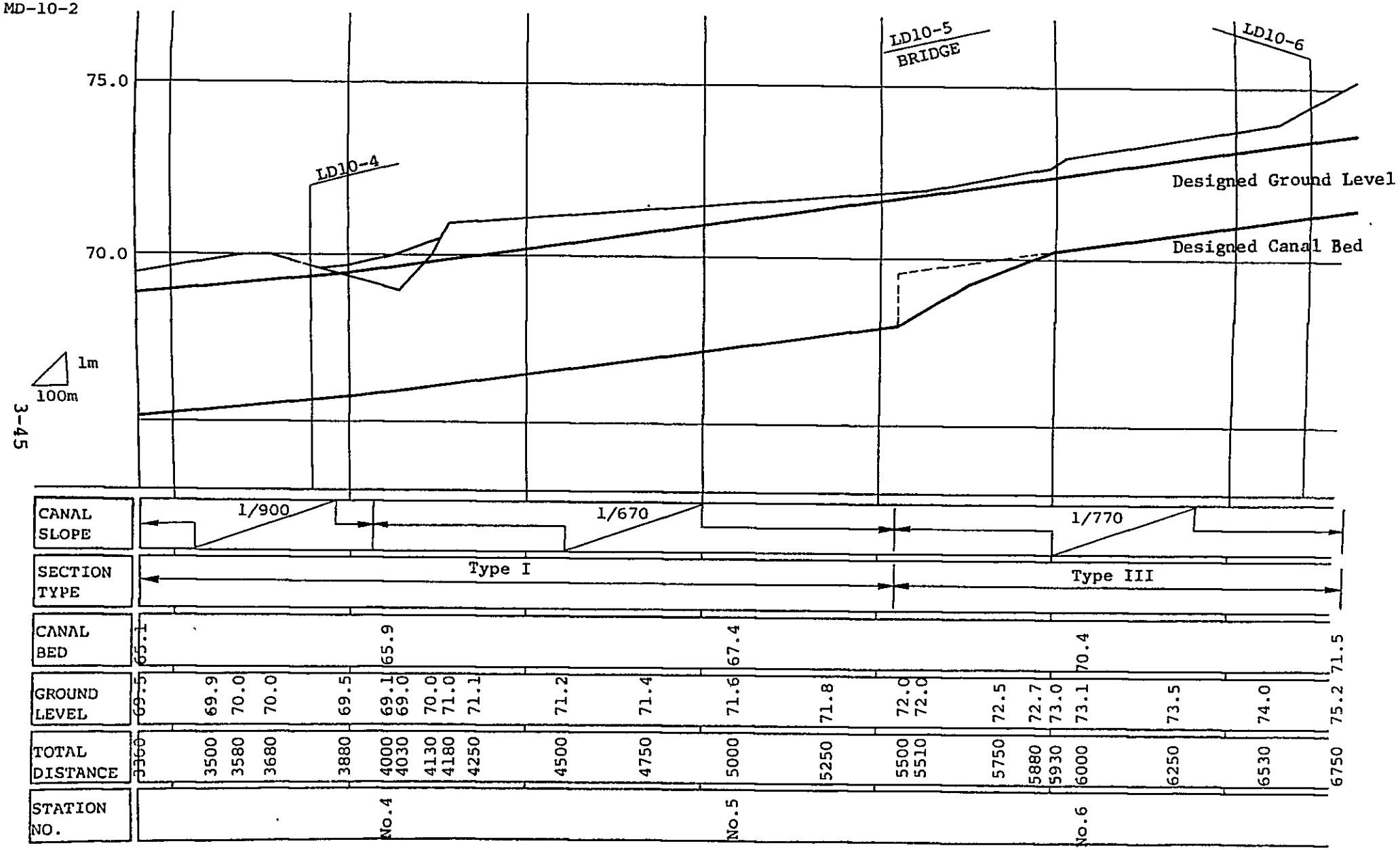

70.0
65.0
60.0
Designed Ground Level
Designed Canal Bed
1m
100m
CANAL SLOPE
1/570
SECTION TYPE
Type S (Catch Drain)
CANAL BED
61.1
62.9
64.6
64.8
GROUND LEVEL
64.3
64.4
64.5
64.5
64.6
64.7
65.5
66.3
66.4
66.8
68.0
TOTAL DISTANCE
2000
2130
2250
2500
2750
3000
3250
3500
3750
4000
4100
STATION NO.
No.2
No.3
No.4

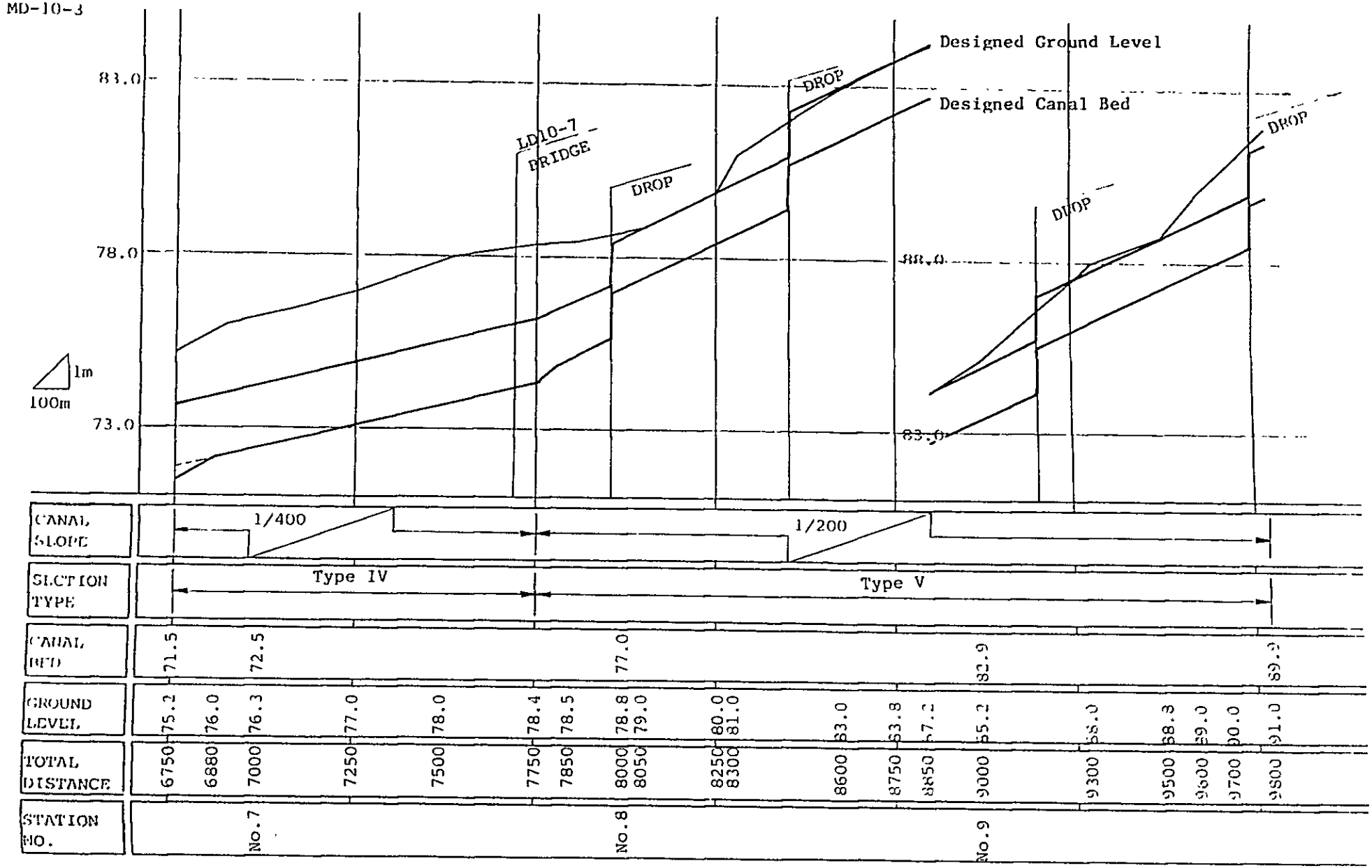
MD-9


70.0
65.0
1m
100m
LD9-1
BRIDGE
LD9-2
LD9-3
Designed Ground Level
Designed Canal Bed
CANAL SLOPE
1/1150
SECTION TYPE
Type III
CANAL BED
62.7
63.6
64.4
65.1
GROUND LEVEL
64.9
65.5
66.5
66.7
67.3
67.1
66.8
66.6
66.4
66.4
66.6
67.2
68.0
TOTAL DISTANCE
0
250
500
750
1000
1250
1375
1500
1750
2000
2250
2500
2750
STATION NO.
No.0
No.1
No.2

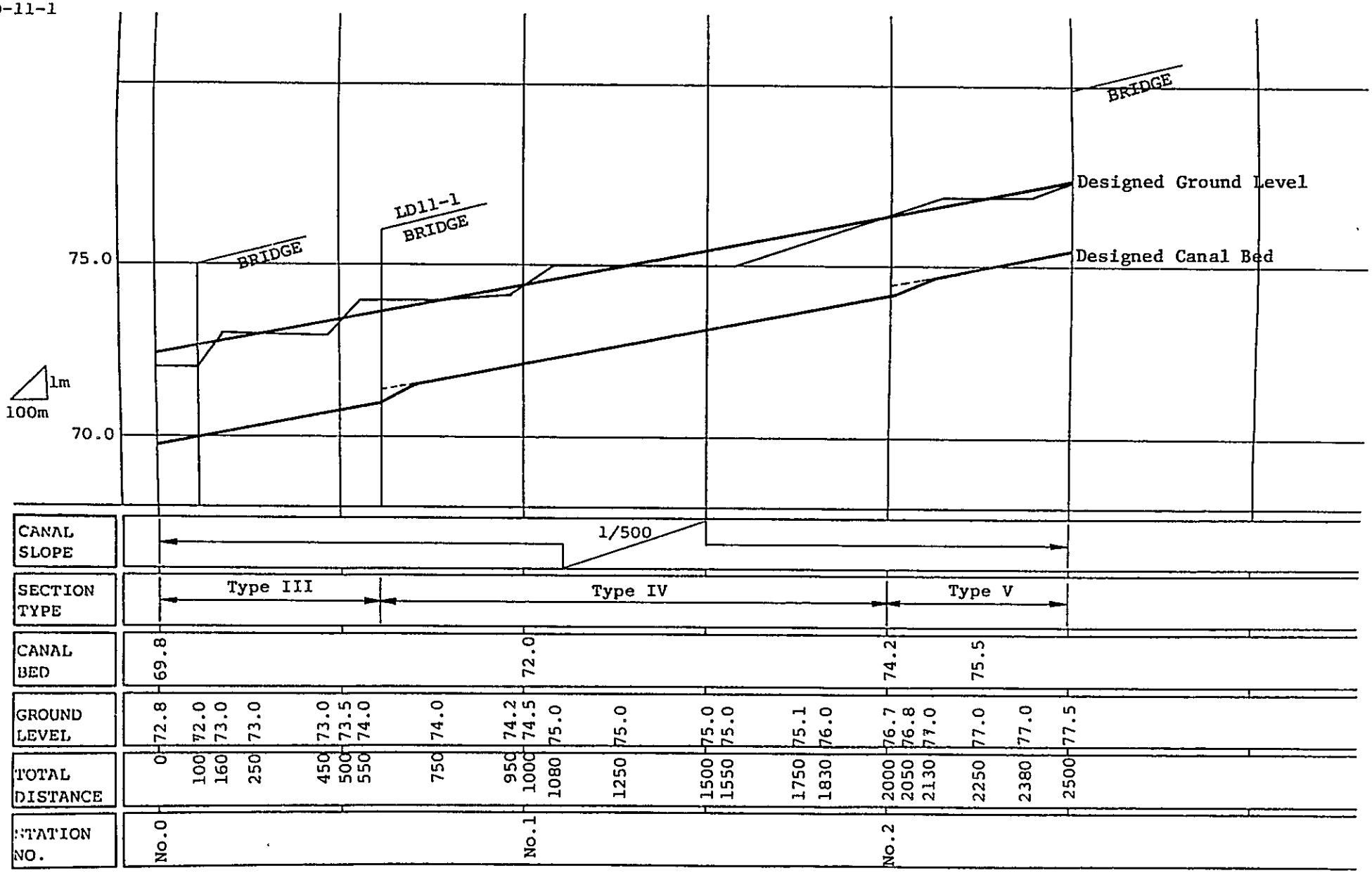

MD-10-1
70.0
65.0
BRIDGE
LD10-1
BRIDGE
LD10-2
BRIDGE
LD10-3
Designed Ground Level
Designed Canal Bed
1m
100m
CANAL SLOPE
1/1130
SECTION TYPE
CANAL BED
GROUND LEVEL
TOTAL DISTANCE
STATION NO.
No.0
No.1
No.2
No.3
62.3
63.1
64.0
64.8
65.1
65.0 67.0 67.0 66.0 66.0 66.2 67.0 67.0 66.9 66.8 67.0 67.0 66.8 66.8 67.0 67.0 67.0 68.0 68.0 68.9 69.0 69.5 69.0 69.0 69.4 69.5
0 75 200 250 440 500 790 810 1000 1050 1100 1150 1250 1300 1450 1500 1680 1750 2000 2250 2280 2750 2800 3000 3250 3300

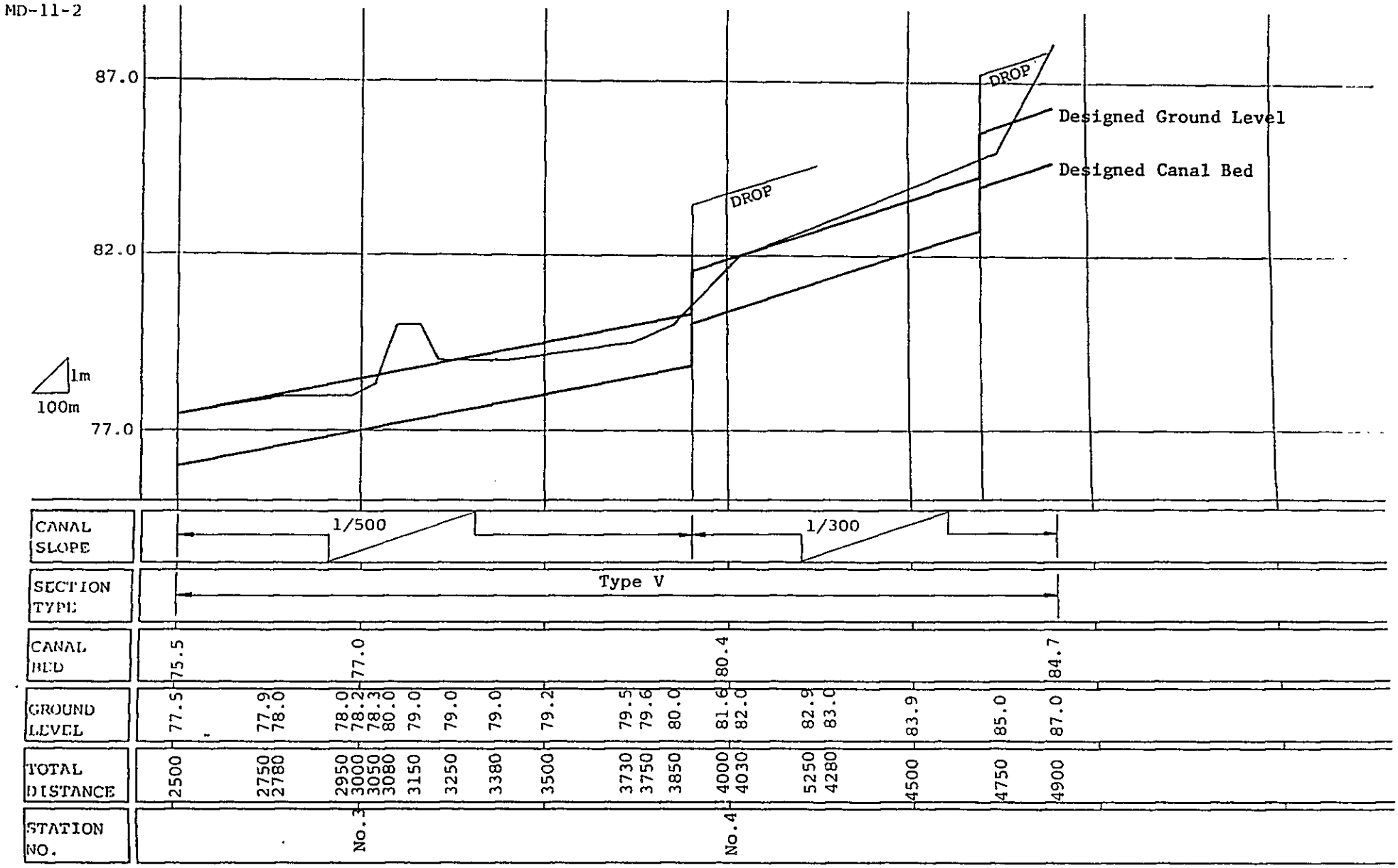
MD-10-2


75.0
70.0
LD10-4
LD10-5
BRIDGE
LD10-6
Designed Ground Level
Designed Canal Bed
1m
100m
CANAL SLOPE
1/900
1/670
1/770
SECTION TYPE
Type I
Type III
CANAL BED
65.1
65.9
67.4
70.4
71.5
GROUND LEVEL
69.5
69.9
70.0
70.0
69.5
69.1
69.0
70.0
71.0
71.1
71.2
71.4
71.6
71.8
72.0
72.0
72.5
72.7
73.0
73.1
73.5
74.0
75.2
TOTAL DISTANCE
3360
3500
3580
3680
3880
4000
4030
4130
4180
4250
4500
4750
5000
5250
5500
5510
5750
5880
5930
6000
6250
6530
6750
STATION NO.
No.4
No.5
No.6


MD-10-3
83.0
78.0
73.0
1m
100m
LD10-7
BRIDGE
DROP
DROP
DROP
DROP
Designed Ground Level
Designed Canal Bed
CANAL SLOPE
1/400
1/200
SECTION TYPE
Type IV
Type V
CANAL BED
71.5
72.5
77.0
82.9
89.9
GROUND LEVEL
75.2
76.0
76.3
77.0
78.0
78.4
78.5
78.8
79.0
80.0
81.0
83.0
83.8
87.2
85.2
88.0
88.3
89.0
90.0
91.0
TOTAL DISTANCE
6750
6880
7000
7250
7500
7750
7850
8000
8050
8250
8300
8600
8750
8850
9000
9300
9500
9600
9700
9800
STATION NO.
No.7
No.8
No.9

MD-11-1


BRIDGE
LD11-1
BRIDGE
BRIDGE
Designed Ground Level
Designed Canal Bed
75.0
70.0
1m
100m
CANAL SLOPE
1/500
SECTION TYPE
Type III
Type IV
Type V
CANAL BED
69.8
72.0
74.2
75.5
GROUND LEVEL
72.8
72.0
73.0
73.0
73.0
73.5
74.0
74.0
74.2
74.5
75.0
75.0
75.0
75.0
75.1
76.0
76.7
76.8
77.0
77.0
77.0
77.5
TOTAL DISTANCE
0
100
160
250
450
500
550
750
950
1000
1080
1250
1500
1550
1750
1830
2000
2050
2130
2250
2380
2500
STATION NO.
No.0
No.1
No.2


MD-11-2
87.0
82.0
77.0
DROP
DROP
Designed Ground Level
Designed Canal Bed
1m
100m
CANAL SLOPE
1/500
1/300
SECTION TYPE
Type V
CANAL BED
75.5
77.0
80.4
84.7
GROUND LEVEL
77.5
77.9
78.0
78.0
78.2
78.3
80.0
79.0
79.0
79.0
79.2
79.5
79.6
80.0
81.6
82.0
82.9
83.0
83.9
85.0
87.0
TOTAL DISTANCE
2500
2750
2780
2950
3000
3050
3080
3150
3250
3380
3500
3730
3750
3850
4000
4030
5250
4280
4500
4750
4900
STATION NO.
No.3
No.4

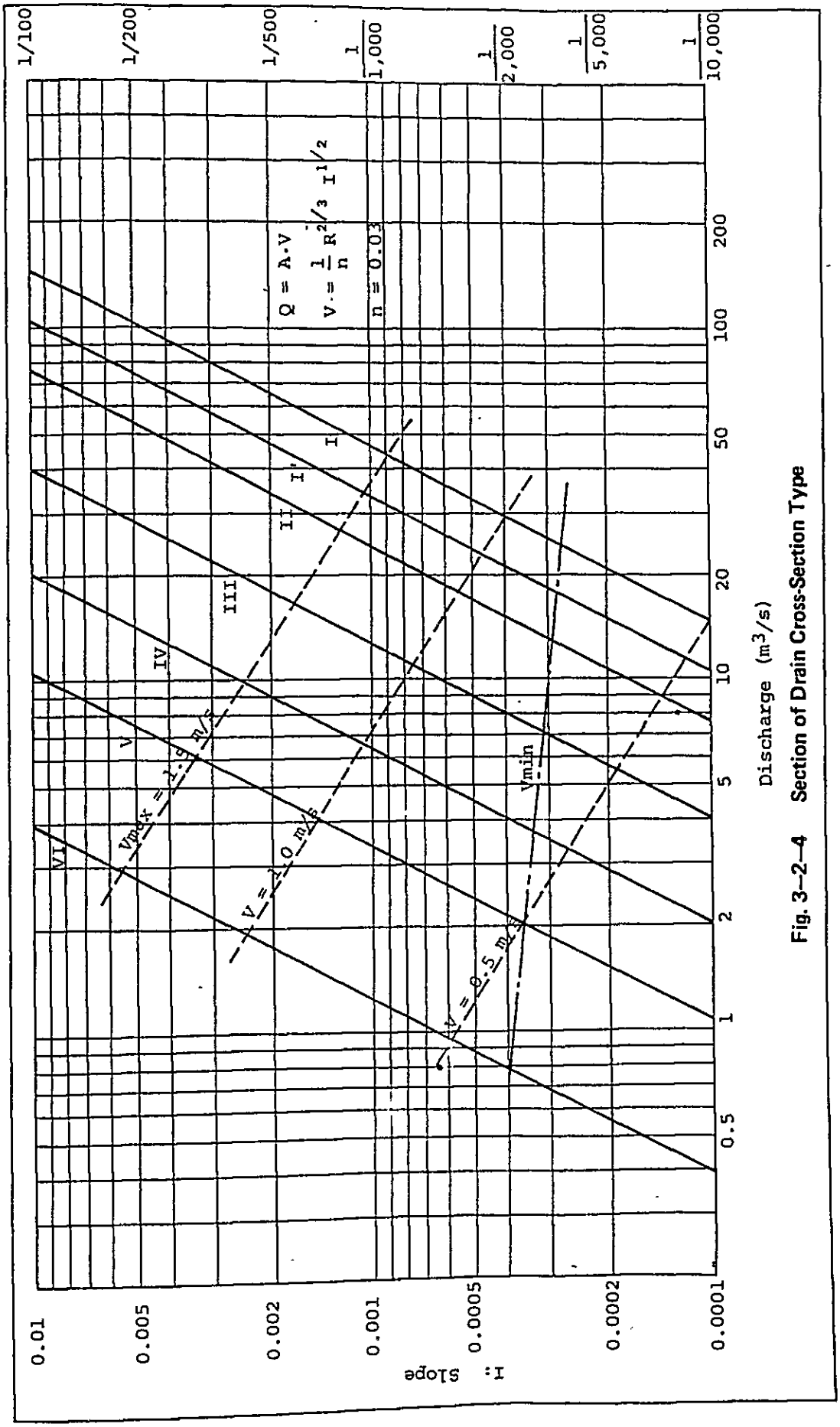


Fig. 3–2–4 Section of Drain Cross-Section Type

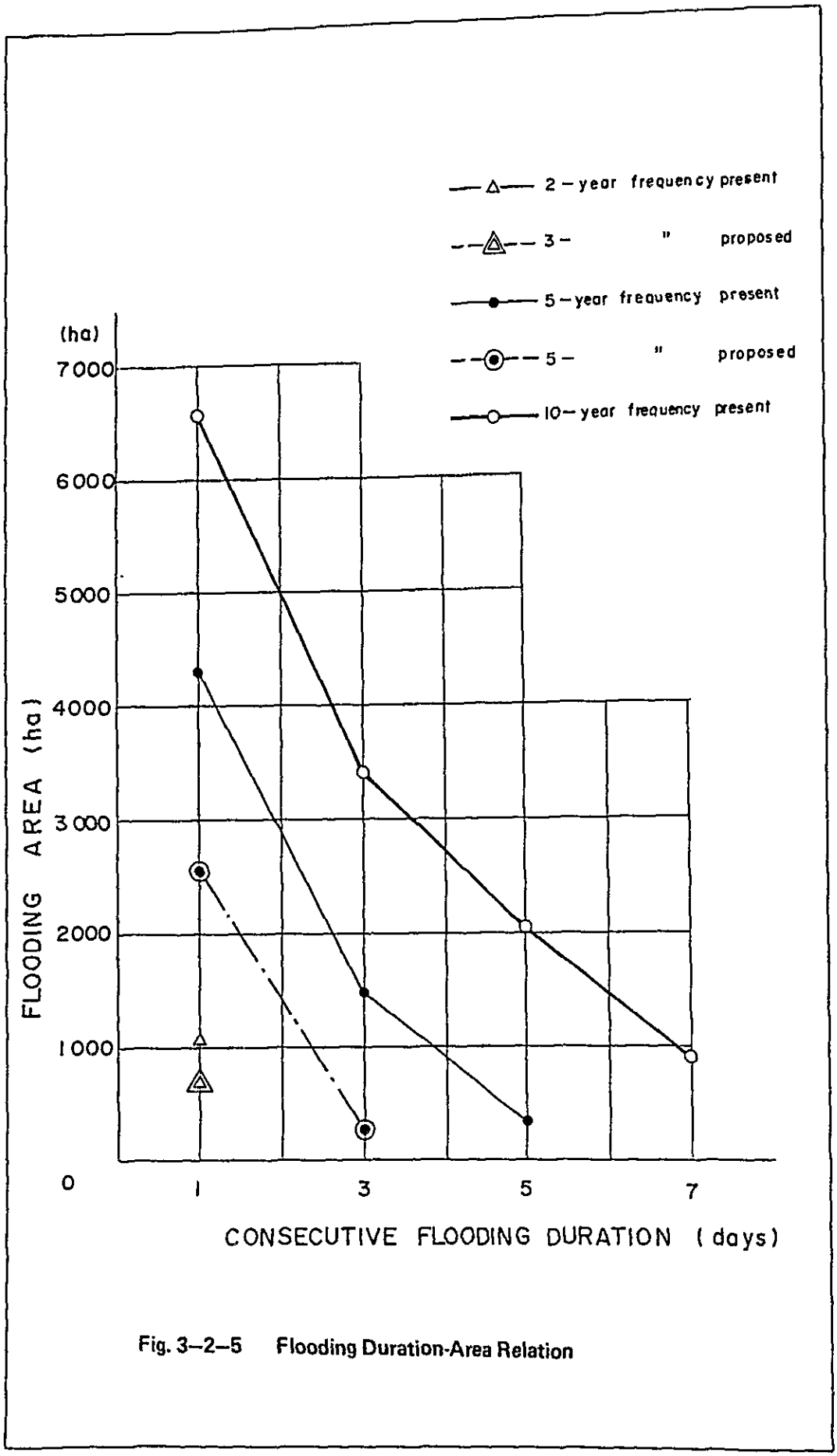


Fig. 3–2–5 Flooding Duration-Area Relation

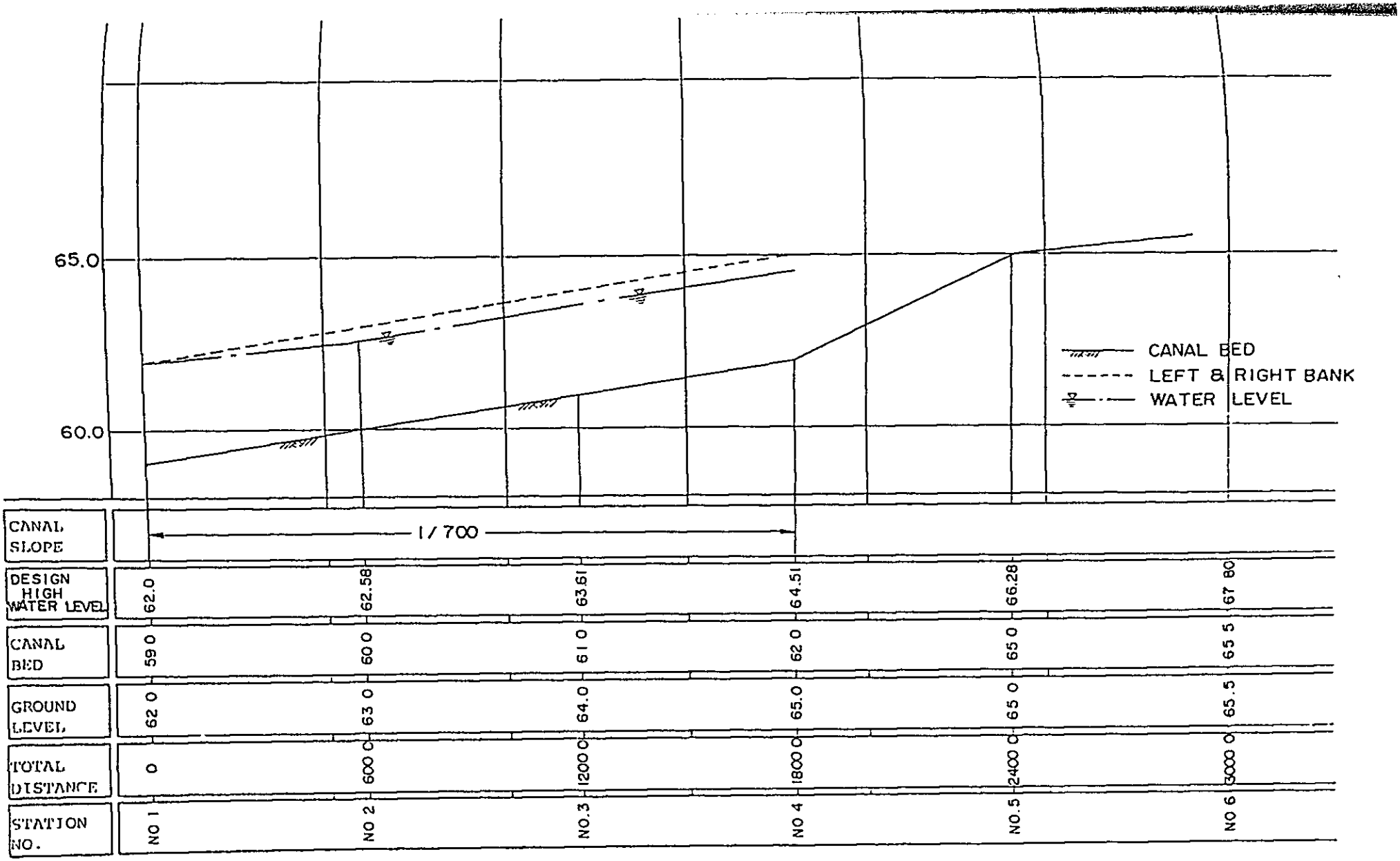


Fig. 3–2–6 Profile of Design Flooding Water Table

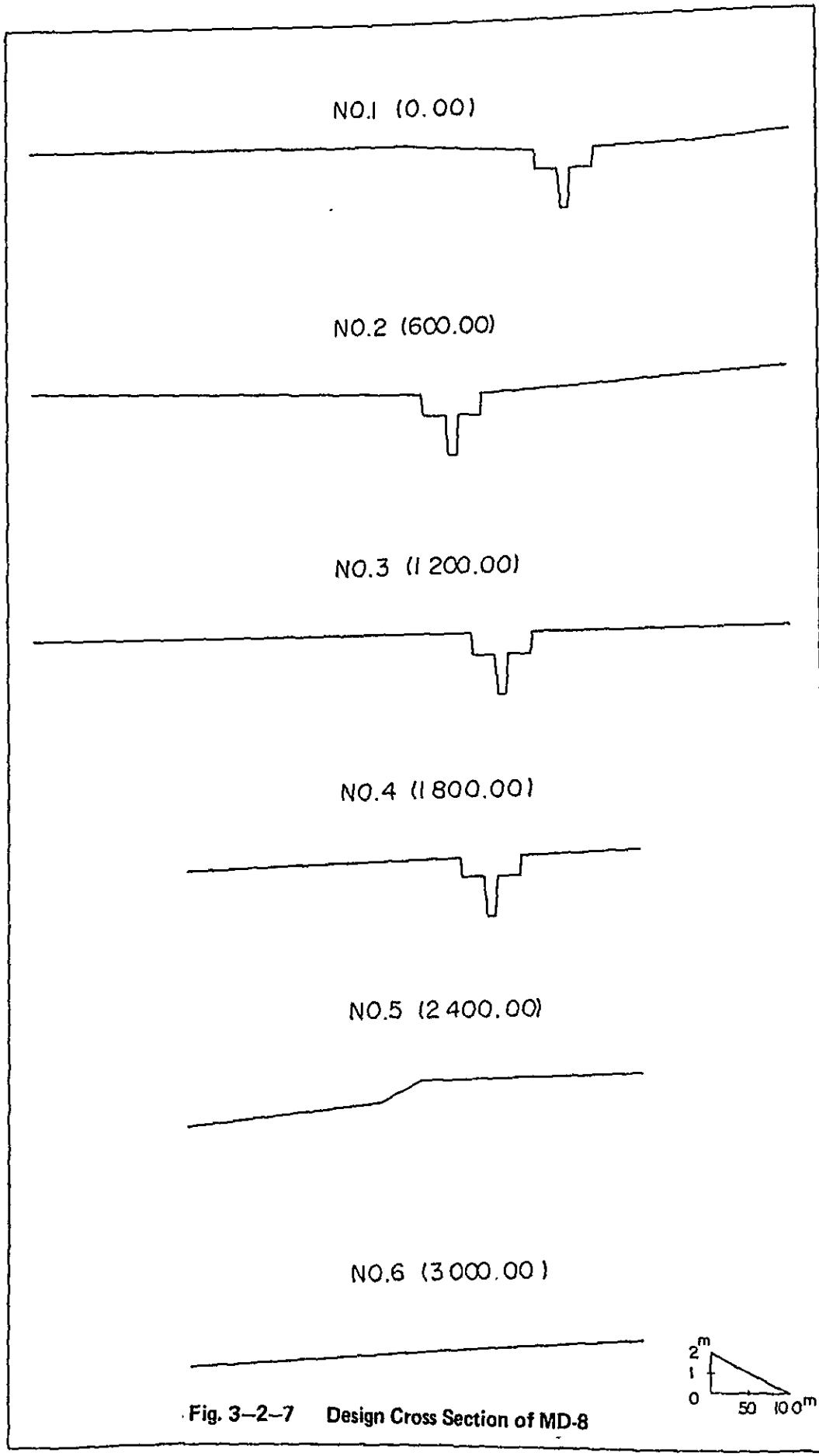


Fig. 3–2–7 Design Cross Section of MD-8

APPENDIX 4. IRRIGATION

LIST OF TABLES

LIST OF FIGURES

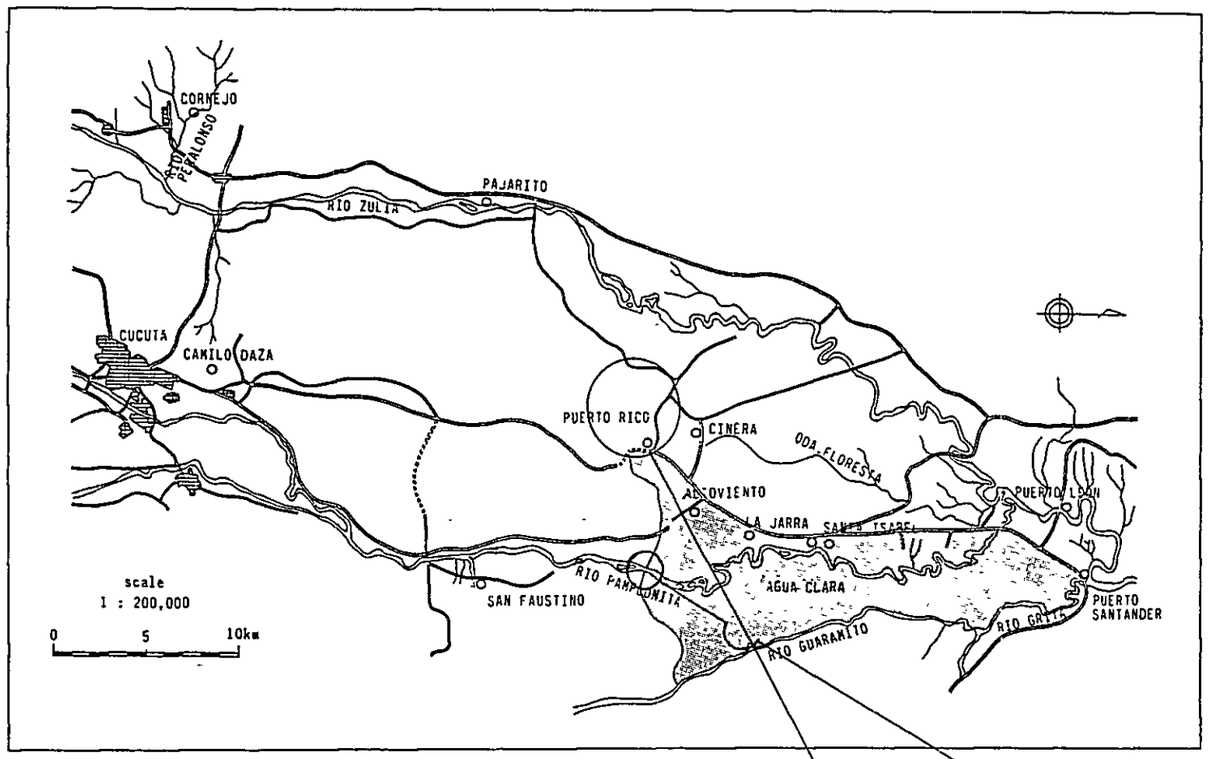
4. Irrigation

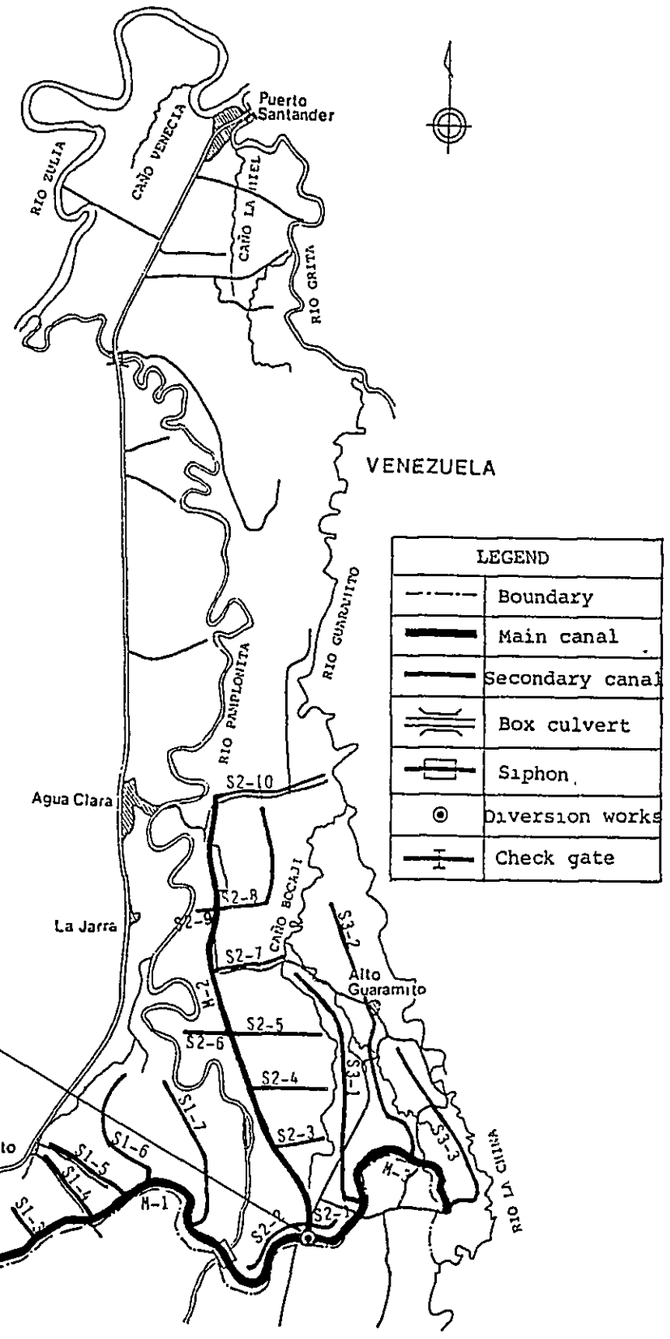
4.1 Alternatives

Two alternatives are considered concerning irrigation canal. One is a tunnel, along the driving canal between diversion works of Canal Zulia and left side of La Floresta River to compare with open canal. The other is aqueduct which is planned same point with siphon cros-Sing The Pamplonita River (Refer to Fig. 4-1-1).

Alternative	Tunnel	Aqueduct
Location	About 150 m to the East from diversion works of Canal Zulia	Crossing point of Pamplo-nita River, south of pro-ject area
Specification	Slope of Canal 1/600 Discharge 6 m^3/s Lined by concrete horseshoe type R=1.25 m	Discharge 4.5 m^3/s Lined by concrete, offective width 4.0 m Bridge span 25 m @ x 10 pier 9 abutment 2
Construction cost	COL$ 137,119,000	COL$ 72,409,000
Remarks	Construction cost of open canal COL$ 38,875,000	Construction cost of siphon COL$ 21,768,000

Summary of them are shown as Fig. 4-1-2, 4-1-3.





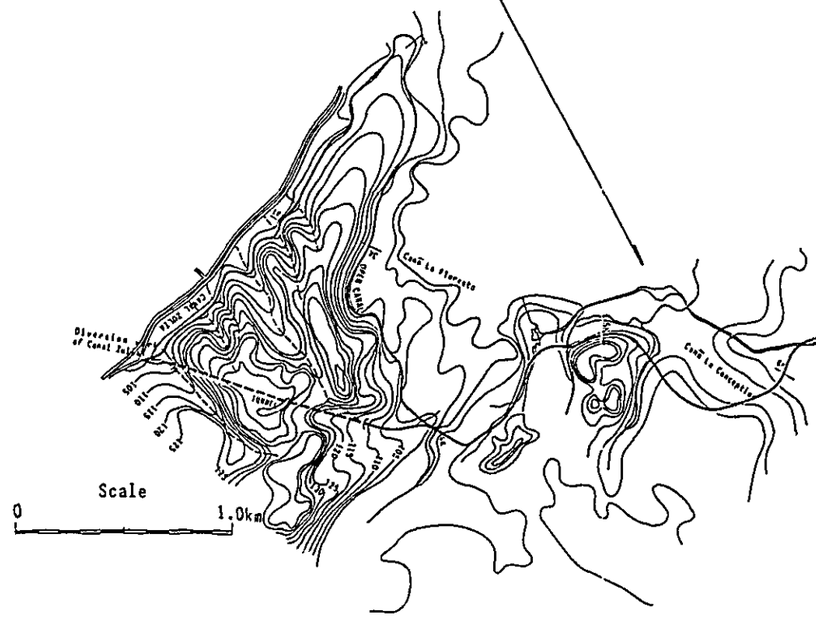
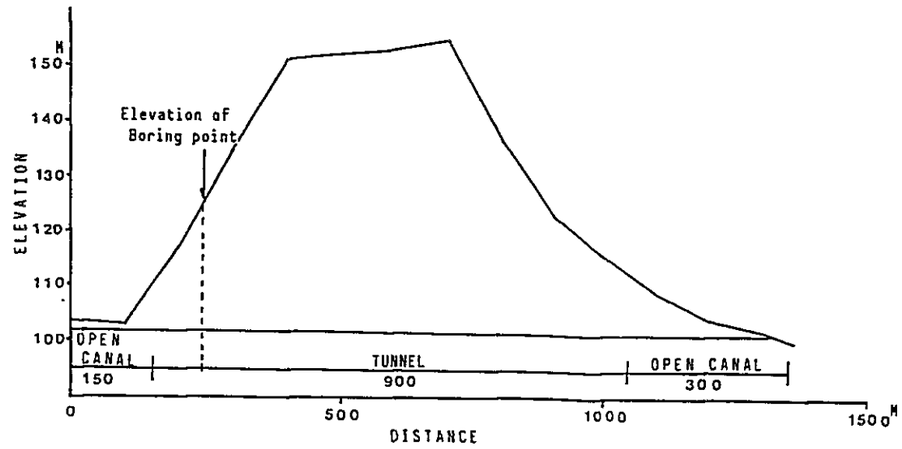
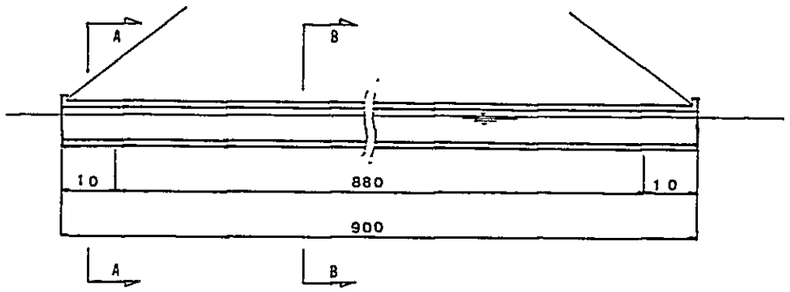


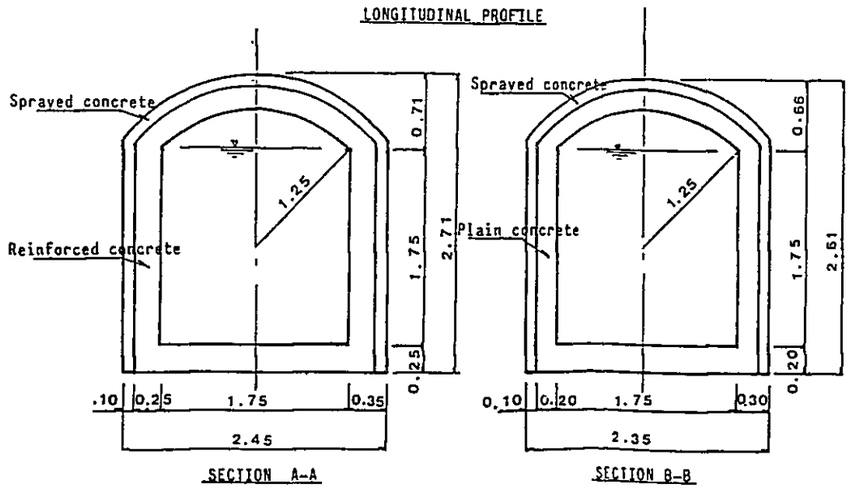
Fig. 4–1–1 Location and Plan for Irrigation

Fig. 4–1–2 Summary of Tunnel





LONGITUDINAL PROFILE



SECTION A-A SECTION B-B

BORING LOG

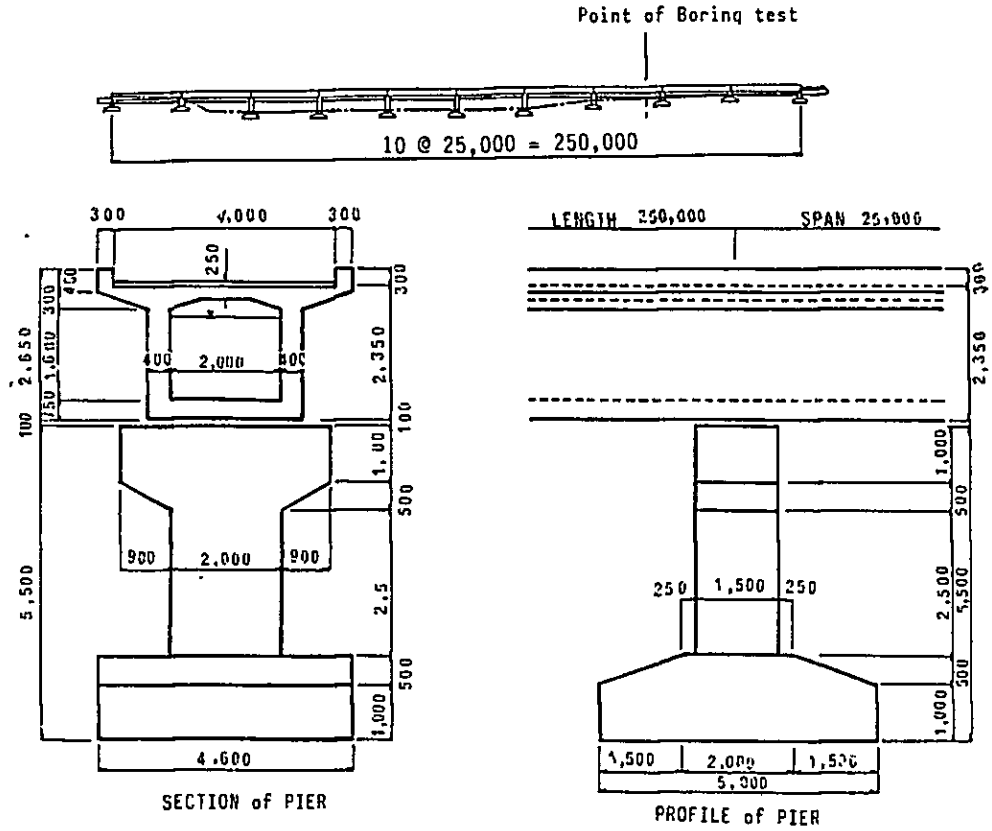
Boring No. S - 2 Ground Elevation 125.0 m

Boring Point Proposed sight of tunnel, east of Canal Zulia diversion works Total Depth 30.15 m

Date November 3, 1983

Scale (m)	Elevation (m)	Depth (m)	Thickness (m)	Graphic Symbol	Color	Observation	Sample	Standard Penetration Test
	125.0	0.0						N value 0 10 20 30 40 50
			1.2		Gray + reddish brown	Pebbly mudstone with fine quartz pebble pumice	□	
1.0	123.8	-1.2				fine hard sand stone layer		20
2.0	123.4	-1.6	0.4		Gray	Mudstone with sandstone		
			2.2		Gray + reddish brown	Hard mudstone with fine ~ medium subrounded sandstone	□	29
3.0								
4.0	121.2	-3.8				and carbon fragment		
5.0			3.4		Grayish brown	Hard mudstone with subrounded pebble (max. 1 cm)	□	33
6.0								
7.0	117.8	-7.2					□	
8.0			2.1		Yellowish gray	Fine very hard sandstone		
9.0	115.7	-9.3					□	
10.0					Yellowish gray	Hard mudstone with fine ~ medium hard sandstone layer & carbon fragment	□	
11.0			4.7					
12.0							□	
13.0					Reddish brown			
14.0	111.0	-14.0						
15.0			2.2		Reddish brown	Hard mudstone	□	
16.0	108.0	-16.2						
17.0			1.4		Yellowish gray	Fine very hard sandstone with hard mudstone layer	□	
18.0	107.4	-17.6						
19.0					Gray + reddish purple	Hard mudstone with fine sandstone layer	□	
20.0								
21.0							□	
22.0								
23.0			12.55			Hard mudstone	□	
24.0					Reddish purple			
25.0						Hard mudstone with fine quartz sandstone layer	□	
26.0								
27.0							□	
28.0					Gray + reddish purple	Hard mudstone with fine sandstone layer	□	
29.0								
30.0	94.85	-30.15					□	

Fig. 4–1–3 Summary of Aqueduct



BORING LOG

Boring No. S - 1 Ground Elevation 92.0m

Boring Point : Proposed site of siphon at right side of Rio Pamplonita Total Depth 14.4m

Date : 3 November 1981

m Scale	m Elevation	m Depth	m Thickness	Graphic Symbol	Color	Observation	Sample	Standard Penetration Test
		0.0	0.0					N Value 0 10 20 30 40
		0.5–0.9	0.5		Yellowish brown	Seminarn silt with fine sand layer		
1.0		0.5–1.4	0.9		Yellowish brown	Softfine-medium quartz sand (0.2–0.5mm)	□	4
2.0							□	
3.0							□	
4.0							□	
5.0							□	
6.0							□	
7.0		1.4 – 14.4	13.0		Light brown	Hard conglomerate (fine-coarse) quartz sand (fine-coarse subangular igneous rocks of max. 230cm) with siltlayer	□	
8.0							□	
9.0							□	
10.0							□	
11.0							□	
12.0							□	
13.0							□	
14.0								

4.2 Irrigation water requirement

(1) General

The water requirement for field irrigation is estimated on the basis of the proposed cropping pattern.

The following procedures were adopted:

- Estimation of Crop evapotranspiration
- Estimation of effective rainfall
- Estimation of net irrigation water requirement
- Estimation of gross irrigation water requirement

It is noted that the estimate is made on the basis of a fifteen-day interval.

(2) Crop evapotranspiration

Crop evapotranspiration (ET crop) is estimated on the basis of reference crop evapotranspiration (ETo) and crop coefficient (Kc).

a) Reference crop evapotranspiration (ETo)

In estimating reference crop evapotranspiration (ETo) climatic data such as temperature, humidity, wind speed and sunshine hours obtained at the Santa Isabel meteorological station have been referred.t Among the various methods for estimating reference crop evapotranspiration, the modified Penman method is applied in this case considering the level of accuracy of the results obtained from this method. The Calculation is made on a monthly basis for a period of 10 years from 1971 to 1980, as shown in Table 4-2-1.

b) Crop coefficient (Kc)

Crop coefficient (Kc) changes by crops, time of planting or sowing, stage of crop growth and climatic conditions. The coefficient in this study is determined in accordance with the FAO guideline. As typical crops, Maize and Sorghum are selected in considering planted acreage and rooting depth. Crop coefficient curves are estimated on a 15-day basis, as presented in Fig. 4-2-1.

c) Crop evapotranspiration (ET crop)

Crop evapotranspiration is calculated by the following formula:

$$ETcrop = Kc \times ETo$$

(3) Effective rainfall

By applying daily rainfall records at Santa Isabel, the effective rainfall for Maize and Sorghum has been estimated by means of the daily water balance method with the following assumptions:

1) Rainfall of less than 5 mm/day is considered as ineffective, because of it is localized.

2) Effective rainfall ranges from 5 mm/day up to 50mm/day considering relation between rainfall hour and basic intake rate, because the excess rainfall will be drained and thus be ineffective.

On the basis of the daily water balance calculations, the effective rainfall has been estimated on a 15-day basis for the proposed cropping pattern, as indicated in Table 4-2-2.

(4) Irrigation water requirement

Net irrigation water requirement has been calculated by deducting effective rainfall from the crop water requirement. The results are shown on Table 4-2-2.

Gross water requirement is estimated by dividing the net irrigation water requirement by overall irrigation efficiency, which is estimated considering the FAO guideline (refer to Table 4-2-3) and Zulia Project in the vecinity of the project area.

Each efficiency is determined as shown below:

Conveyance efficiency	85%
Field canal efficiency	80%
Field application efficiency	60%

Consequently a irrigation efficiency of 40% is used in this study.

Gross water requirement in depth on 15-day basis is calculated for the proposed cropping pattern, indicated on Table 4-2-2. The probable peak gross irrigation requirement is estimated at 11.5 mm/day or 1.33 l/sec/ha for the return period of 5 years as shown in Fig. 4-2-2.

YEAR : 1971

Latitude : 8°N

Table 4–2–1 Calculation of Reference Crop Evapotranspiration (1/10)

Altitude : 50 - 100 m.a.m.s.

Method : Modified Penman Method

ITEM	UNIT	JAN.	FEB.	MAR	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	REMARKS
MONTHLY MEAN DATA														
i Air Temperature	°C	25.5	25.8	25.8	26.3	26.5	27.4	27.2	27.2	27.1	27.0	26.6	25.9	
ii Relative Humidity	%	86	87	89	86	86	81	82	82	84	84	86	88	
iii Sunshine Hours	hr/day	4.5	4.8	2.5	4.9	5.0	5.7	7.1	7.2	7.5	6.8	6.1	4.7	
iv Wind Speed	m/s	1.4	1.4	1.6	1.6	1.7	1.6	1.8	1.7	1.7	1.5	1.4	1.3	Average
	Uday m/s	2.6	2.5	3.3	2.8	2.7	2.7	3.0	3.0	2.8	2.7	2.6	2.5	
	Uday/Unight	7.5	5.6	5.6	5.7	2.4	2.5	2.7	3.0	2.6	3.4	10.4	8.3	
CALCULATION														
1. Saturation Vapour Pressure, ea	mbar	32.7	32.7	33.2	34.2	34.7	36.5	36.1	36.1	35.9	35.7	34.9	33.4	
2. Actual Vapour Pressure, ed	mbar	28.1	28.4	29.5	29.4	29.8	29.6	29.6	29.6	30.2	30.0	30.0	29.4	
3. ea - ed		4.6	4.3	3.7	4.8	4.9	6.9	6.5	6.5	5.7	5.7	4.9	4.0	
4. Wind Function, f(u)		0.6	0.6	0.64	0.64	0.67	0.64	0.69	0.67	0.67	0.62	0.60	0.57	
5. Weighting Factor, 1-W	mm/day	0.26	0.26	0.25	0.25	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.25	
6. Aerodynamic Term	mm/day	0.7	0.7	0.6	0.8	0.8	1.1	1.1	1.0	0.9	0.8	0.7	0.6	
7. Extra-Tertestrial Radiation, Ra	hr/day	13.6	14.5	15.3	15.6	15.3	15.0	15.1	15.4	15.3	14.8	13.9	13.3	
8. Max. Possible Sunshire Hours, N		11.7	11.8	12.0	12.3	12.5	12.6	12.5	12.4	12.1	11.9	11.7	11.6	
9. n/N		0.38	0.41	0.21	0.40	0.40	0.45	0.57	0.58	0.62	0.57	0.52	0.41	
10. (0.25 + 0.50 n/N)		0.44	0.46	0.36	0.45	0.45	0.48	0.54	0.54	0.57	0.54	0.51	0.46	
11. Solar Radiation, Rs	mm/day	6.0	6.7	5.5	7.0	6.9	7.2	8.2	8.3	8.7	8.0	7.1	6.1	
12. Net Shortwave Rad., Rns	mm/day	4.5	5.0	4.1	5.3	5.2	5.4	6.2	6.2	6.5	6.0	5.3	4.6	
13. Effect on Longwave Rad.														
a. f (T)		15.8	15.8	15.9	16.0	16.0	16.2	16.1	16.1	16.1	16.1	16.0	15.9	
b. f (ed)		0.11	0.11	0.10	0.10	0.00	0.10	0.10	0.10	0.10	0.10	0.10	0.10	
c. f (n/N)		0.44	0.47	0.29	0.46	0.46	0.50	0.61	0.62	0.66	0.61	0 57	0.47	
14. Net Longwave Rad., Rnl	mm/day	0.8	0.8	0.5	0.7	0.7	0.8	1.0	1.0	1.1	1.0	0.9	0.7	
15. Net Radiation, Rn	mm/day	3.5	4.2	3.6	4.6	4.5	4.6	5.2	5.2	5.4	5.0	4.4	3.8	
16. Weighting Factor, W		0.74	0.74	0.75	0.75	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.75	
17. Energy Term	mm/day	2.6	3.1	2.7	3.5	3.4	3.5	4.0	4.0	4.1	3.8	3.3	2.9	
18. 6 + 17	mm/day	3.3	3.8	3.3	4.3	4.2	4.6	5.1	5.0	5.0	4.6	4.0	3.5	
19. Adjustment Factor, C		1.09	1.13	1.10	1.16	1.03	1.04	1.11	1.14	1.16	1.17	1.15	1.09	
20. Ref. Crop Evapotrans., ETo	mm/day	3.6	4.3	3.6	5.0	4.3	4.8	5.7	5.7	5.8	5.4	4.6	3.8	
- ditto -	mm/month	112	120	112	150	133	144	177	177	174	162	141	118	1722mm/year

Table 4—2—1 Calculation of Reference Crop Evapotranspiration (2/10)

YEAR : 1972

Latitude : 8°N Altitude : 50 - 100 m.a.m.s.

Method : Modified Penman Method

ITEM	UNIT	JAN.	FEB.	MAR	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	REMARKS
MONTHLY MEAN DATA														
i Air Temperature	°C	25.3	25.4	26.3	26.5	27.6	27.7	27.6	27.8	27.7	27.5	27.2	26.7	
ii Relative Humidity	%	90	88	86	87	84	83	82	78	81	81	82	84	
iii Sunshine Hours	hr/day	4.0	5.3	4.9	5.1	6.6	6.6	6.1	6.0	6.1	6.6	6.4	5.8	
iv Wind Speed	m/s	1.4	1.4	1.6	1.6	1.7	1.6	1.8	1.7	1.7	1.5	1.4	1.3	Average
	Uday m/s	2.6	2.5	3.3	2.8	2.7	2.7	3.0	3.0	2.8	2.7	2.6	2.5	
	Uday/Unight	7.5	5.6	5.6	5.7	2.4	2.5	2.7	3.0	2.6	3.4	10.4	8.3	
CALCULATION														
1. Saturation Vapour Pressure, ea	mbar	32.3	32.5	34.2	34.7	37.0	37.2	37.0	37.4	37.2	36.8	36.1	35.1	
2. Actual Vapour Pressure, ed	mbar	29.1	28.6	29.4	30.2	31.1	30.9	30.3	29.2	30.1	29.8	29.6	29.5	
3. ea - ed		3.2	3.9	4.8	4.5	5.9	6.3	6.7	8.2	7.1	7.0	6.5	5.6	
4. Wind Function, f(u)		0.60	0.60	0.64	0.64	0.67	0.64	0.69	0.67	0.67	0.62	0.60	0.57	
5. Weighting Factor, 1-W	mm/day	0.26	0.26	0.25	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.24	0.24	
6. Aerodynamic Term	mm/day	0.5	0.6	0.8	0.7	0.9	0.9	1.1	1.3	1.1	1.0	0.9	0.8	
7. Extra-Tertestrial Radiation, Ra	hr/day	13.6	14.5	15.3	15.6	15.3	15.0	15.1	15.4	15.3	14.8	13.9	13.3	
8. Max. Possible Sunshire Hours, N		11.7	11.8	12.0	12.3	12.5	12.6	12.5	12.4	12.1	11.9	11.7	11.6	
9. n/N		0.34	0.45	0.41	0.41	0.53	0.52	0.49	0.48	0.50	0.55	0.55	0.50	
10. (0.25 + 0.50 n/N)		0.42	0.48	0.46	0.46	0.52	0.51	0.50	0.49	0.50	0.53	0.53	0.50	
11. Solar Radiation, Rs	mm/day	5.7	7.0	7.0	7.2	8.0	7.7	7.6	7.5	7.7	7.8	7.4	6.7	
12. Net Shortwave Rad., Rns	mm/day	4.3	5.3	5.3	5.4	6.0	5.8	5.7	5.6	5.8	5.9	5.6	5.0	
13. Effect on Longwave Rad.														
a. f (T)		15.7	15.8	16.0	16.0	16.2	16.2	16.2	16.3	16.2	16.2	16.1	16.0	
b. f (ed)		0.10	0.11	0.10	0.10	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10	
c. f (n/N)		0.41	0.51	0.47	0.47	0.58	0.57	0.54	0.53	0.55	0.60	0.60	0.55	
14. Net Longwave Rad., Rnl	mm/day	0.6	0.9	0.8	0.8	0.8	0.9	0.9	0.9	0.9	1.0	1.0	0.9	
15. Net Radiation, Rn	mm/day	3.7	4.4	4.5	4.6	5.2	4.9	4.8	4.7	4.9	4.9	4.6	4.1	
16. Weighting Factor, W		0.74	0.74	0.75	0.76	0.77	0.77	0.77	0.77	0.77	0.77	0.76	0.76	
17. Energy Term	mm/day	2.7	3.3	3.4	3.5	4.0	3.8	3.7	3.6	3.8	3.8	3.5	3.1	
18. 6 + 17	mm/day	3.3	3.9	4.2	4.2	4.9	4.7	4.8	4.9	4.9	4.8	4.4	3.9	
19. Adjustment Factor, C		1.09	1.14	1.15	1.16	1.10	1.10	1.08	1.11	1.10	1.16	1.17	1.14	
20. Ref. Crop Evapotrans., ETo	mm/day	3.6	4.4	4.8	4.9	5.4	5.2	5.2	5.4	5.4	5.6	5.1	4.4	
- ditto -	mm/month	112	128	149	147	167	156	161	167	162	174	153	136	1812mm/year

YEAR : 1973

Latitude : 8°N

Table 4–2–1 Calculation of Reference Crop Evapotranspiration (3/10)

Altitude : 50 - 100 m.a.m.s.

Method : Modified Penman Method

ITEM	UNIT	JAN.	FEB.	MAR	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	REMARKS
MONTHLY MEAN DATA														
i Air Temperature	°C	27.2	26.9	27.5	27.9	27.6	27.3	27.2	27.2	27.0	27.1	25.9	24.8	
ii Relative Humidity	%	83	82	81	80	82	82	79	81	83	83	88	89	
iii Sunshine Hours	hr/day	6.7	4.4	2.7	3.6	6.4	5.2	5.7	6.6	5.5	5.5	3.4	3.6	
iv Wind Speed	m/s	1.4	1.4	1.6	1.2	1.2	1.4	1.6	1.4	1.4	1.2	1.2	1.1	Average
	Uday m/s	2.6	2.5	3.3	2.9	2.4	2.7	3.0	2.7	2.5	2.2	2.2	2.2	
	Uday/Unight	7.5	5.6	5.7	9.7	4.8	4.5	4.3	3.4	4.2	7.3	3.7	22.0	
CALCULATION														
1. Saturation Vapour Pressure, ea	mbar	36.1	35.5	36.8	37.6	37.0	36.3	36.1	36.1	35.7	35.9	33.4	31.3	
2. Actual Vapour Pressure, ed	mbar	30.0	29.1	29.8	30.1	30.3	29.8	28.5	29.2	29.6	29.8	29.4	27.9	
3. ea - ed		6.1	6.4	7.0	7.5	6.7	6.5	7.6	6.9	6.1	6.1	4.0	3.4	
4. Wind Function, f(u)		0.60	0.60	0.64	0.55	0.55	0.60	0.64	0.60	0.60	0.55	0.55	0.53	
5. Weighting Factor, 1-W	mm/day	0.24	0.24	0.23	0.23	0.23	0.24	0.24	0.24	0.24	0.24	0.25	0.26	
6. Aerodynamic Term	mm/day	0.9	0.9	1.0	1.0	0.8	0.9	1.2	1.0	0.9	0.8	0.6	0.5	
7. Extra-Tertestrial Radiation, Ra	hr/day	13.6	14.5	15.3	15.6	15.3	15.0	15.1	15.4	15.3	14.8	13.9	13.3	
8. Max. Possible Sunshire Hours, N		11.7	11.8	12.0	12.3	12.5	12.6	12.5	12.4	12.1	11.9	11.7	11.6	
9. n/N		0.57	0.37	0.23	0.29	0.51	0.41	0.46	0.53	0.45	0.46	0.29	0.31	
10. (0.25 + 0.50 n/N)		0.54	0.44	0.37	0.40	0.51	0.46	0.48	0.52	0.48	0.48	0.39	0.41	
11. Solar Radiation, Rs	mm/day	7.3	6.4	5.6	6.2	7.8	6.9	7.2	8.0	7.3	7.1	5.4	5.5	
12. Net Shortwave Rad., Rns	mm/day	5.5	4.8	4.2	4.7	5.9	5.2	5.4	6.0	5.5	5.3	4.1	4.1	
13. Effect on Longwave Rad.														
a. f (T)		16.1	16.1	16.2	16.3	16.2	16.2	16.1	16.1	16.1	16.1	15.9	15.6	
b. f (ed)		0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.10	0.10	0.10	0.10	0.11	
c. f (n/N)		0.61	0.43	0.31	0.36	0.56	0.47	0.51	0.58	0.51	0.51	0.36	0.38	
14. Net Longwave Rad., Rnl	mm/day	1.0	0.7	0.5	0.6	0.9	0.8	0.9	0.9	0.8	0.8	0.6	0.7	
15. Net Radiation, Rn	mm/day	4.5	4.1	3.7	4.1	5.0	4.4	4.5	5.1	4.7	4.5	3.5	3.4	
16. Weighting Factor, W		0.76	0.76	0.77	0.77	0.77	0.76	0.76	0.76	0.76	0.76	0.75	0.74	
17. Energy Term	mm/day	3.4	3.1	2.8	3.2	3.9	3.3	3.4	3.9	3.6	3.4	2.6	2.5	
18. 6 + 17	mm/day	4.3	4.0	3.8	4.2	4.7	4.2	4.6	4.9	4.5	4.2	3.2	3.0	
19. Adjustment Factor, C		1.16	1.10	1.10	1.10	1.19	1.16	1.16	1.17	1.16	1.13	1.10	1.09	
20. Ref. Crop Evapotrans., ETo	mm/day	5.0	4.4	4.2	4.6	5.6	4.9	5.3	5.7	5.2	4.7	3.5	3.3	
- ditto -	mm/month	155	123	130	138	174	147	164	177	156	146	105	102	1717mm/year

Table 4—2—1 Calculation of Reference Crop Evapotranspiration (4/10)

YEAR : 1974
Latitude : 8°N Altitude : 50 - 100 m.a.m.s.
Method : Modified Penman Method

ITEM	UNIT	JAN.	FEB.	MAR	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	REMARKS
MONTHLY MEAN DATA														
i Air Temperature	°C	24.6	25.1	25.1	26.0	26.9	27.0	26.5	26.9	26.6	26.8	26.2	25.8	
ii Relative Humidity	%	88	88	89	88	85	83	82	82	84	84	86	86	
iii Sunshine Hours	hr/day	3.7	3.3	2.7	1.5	5.7	6.9	6.7	6.7	5.8	3.7	4.6	5.4	
iv Wind Speed	m/s	1.4	1.2	2.8	1.0	1.6	1.3	1.9	1.8	1.7	1.4	1.1	0.9	
	Uday m/s	2.8	2.2	6.2	1.9	1.2	2.4	3.2	3.5	2.6	2.8	2.3	2.0	
	Uday/Unight	9.3	11.0	12.4	19.0	0.4	3.4	2.7	3.2	1.9	4.0	23.0	10.0	
CALCULATION														
1. Saturation Vapour Pressure, ea	mbar	30.9	31.9	31.9	33.6	35.5	35.7	34.7	35.5	34.9	35.3	34.0	33.2	
2. Actual Vapour Pressure, ed	mbar	27.2	28.1	28.4	29.6	30.2	29.6	28.5	29.1	29.3	29.7	29.2	28.6	
3. ea - ed		3.7	3.8	3.5	4.0	5.3	6.1	6.2	6.4	5.6	5.6	4.8	4.6	
4. Wind Function, f(u)		0.60	0.55	0.92	0.50	0.64	0.57	0.71	0.69	0.67	0.60	0.53	0.48	
5. Weighting Factor, 1-W	mm/day	0.26	0.26	0.26	0.25	0.24	0.24	0.24	0.24	0.24	0.24	0.25	0.25	
6. Aerodynamic Term	mm/day	0.6	0.5	0.8	0.5	0.8	0.8	1.1	1.1	0.9	0.8	0.6	0.6	
7. Extra-Tertestrial Radiation, Ra	hr/day	13.6	14.5	15.3	15.6	15.3	15.0	15.1	15.4	15.3	14.8	13.9	13.3	
8. Max. Possible Sunshire Hours, N		11.7	11.8	12.0	12.3	12.5	12.6	12.5	12.4	12.1	11.9	11.7	11.6	
9. n/N		0.32	0.28	0.23	0.12	0.46	0.55	0.54	0.54	0.48	0.31	0.39	0.47	
10. (0.25 + 0.50 n/N)		0.41	0.39	0.37	0.31	0.48	0.53	0.52	0.52	0.49	0.41	0.45	0.49	
11. Solar Radiation, Rs	mm/day	5.6	5.7	5.7	4.8	7.3	8.0	7.9	8.0	7.5	6.1	6.3	6.5	
12. Net Shortwave Rad., Rns	mm/day	4.2	4.3	4.3	3.6	5.5	6.0	5.9	6.0	5.6	4.6	4.7	4.9	
13. Effect on Longwave Rad.														
a. f (T)		15.6	15.7	15.7	15.9	16.1	16.1	16.0	16.1	16.0	16.1	15.9	15.9	
b. f (ed)		0.11	0.11	0.11	0.10	0.10	0.10	0.11	0.10	0.10	0.10	0.10	0.11	
c. f (n/N)		0.39	0.35	0.31	0.21	0.51	0.60	0.59	0.59	0.53	0.38	0.45	0.52	
14. Net Longwave Rad., Rnl	mm/day	0.7	0.6	0.5	0.3	0.8	1.0	1.0	0.9	0.8	0.6	0.7	0.9	
15. Net Radiation, Rn	mm/day	3.5	3.7	3.8	3.3	4.7	5.0	4.9	5.1	4.8	4.0	4.0	4.0	
16. Weighting Factor, W		0.74	0.74	0.74	0.75	0.76	0.76	0.76	0.76	0.76	0.76	0.75	0.75	
17. Energy Term	mm/day	2.6	2.7	2.8	2.5	3.6	3.8	3.7	3.9	3.6	3.0	3.0	3.0	
18. 6 + 17	mm/day	3.2	3.2	3.6	3.0	4.4	4.6	4.8	5.0	4.5	3.8	3.6	3.6	
19. Adjustment Factor, C		1.09	1.09	1.10	1.08	1.04	1.09	1.09	1.13	1.05	1.10	1.10	1.10	
20. Ref. Crop Evapotrans., ETo	mm/day	3.5	3.5	4.0	3.2	4.6	5.0	5.2	5.7	4.7	4.2	4.0	4.0	
- ditto -	mm/month	109	98	124	96	143	150	161	177	141	126	120	124	1569mm /year

YEAR : 1975

Latitude : 8°N

Table 4–2–1 Calculation of Reference Crop Evapotranspiration (5/10)

Altitude : 50 - 100 m.a.m.s.

Method : Modified Penman Method

ITEM	UNIT	JAN.	FEB.	MAR	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	REMARKS
MONTHLY MEAN DATA														
i Air Temperature	°C	25.5	25.8	26.5	26.2	26.9	26.9	26.4	26.8	26.8	26.6	26.2	24.6	
ii Relative Humidity	%	85	83	85	87	86	82	81	83	83	85	86	88	
iii Sunshine Hours	hr/day	5.8	4.6	3.7	2.8	5.1	6.3	6.9	5.6	5.1	5.1	4.5	3.6	
iv Wind Speed	m/s	0.9	1.1	1.0	2.4	2.6	2.0	1.6	1.1	1.1	0.9	1.5	1.2	
	Uday m/s	2.2	2.3	2.3	4.5	5.0	3.6	3.0	2.5	2.3	1.9	3.6	2.4	
	Uday/Unight	22.0	7.7	11.5	2.6	3.6	2.6	2.5	5.0	3.8	3.8	36.0	12.0	
CALCULATION														
1. Saturation Vapour Pressure, ea	mbar	32.7	33.2	34.7	34.0	35.5	35.5	34.4	35.3	35.3	34.9	34.0	30.9	
2. Actual Vapour Pressure, ed	mbar	27.8	27.6	29.5	29.6	30.5	29.1	27.9	29.3	29.3	29.7	29.2	27.2	
3. ea - ed		4.9	5.6	5.2	4.4	5.0	6.4	6.5	6.0	6.0	5.2	4.8	3.7	
4. Wind Function, f(u)		0.48	0.53	0.50	0.83	0.88	0.74	0.64	0.53	0.53	0.48	0.62	0.55	
5. Weighting Factor, 1-W	mm/day	0.25	0.25	0.24	0.25	0.24	0.24	0.25	0.24	0.24	0.24	0.25	0.26	
6. Aerodynamic Term	mm/day	0.6	0.7	0.6	0.9	1.1	1.1	1.0	0.8	0.8	0.6	0.7	0.5	
7. Extra-Tertestrial Radiation, Ra	hr/day	13.6	14.5	15.3	15.6	15.3	15.0	15.1	15.4	15.3	14.8	13.9	13.3	
8. Max. Possible Sunshire Hours, N		11.7	11.8	12.0	12.3	12.5	12.6	12.5	12.4	12.1	11.9	11.7	11.6	
9. n/N		0.50	0.39	0.31	0.23	0.41	0.50	0.55	0.45	0.42	0.43	0.38	0.31	
10. (0.25 + 0.50 n/N)		0.50	0.45	0.41	0.37	0.46	0.50	0.53	0.48	0.46	0.47	0.44	0.41	
11. Solar Radiation, Rs	mm/day	6.8	5.3	6.2	5.8	7.0	7.5	8.0	7.4	7.0	7.0	6.1	5.5	
12. Net Shortwave Rad., Rns	mm/day	5.1	4.0	4.7	4.4	5.3	5.6	6.0	5.6	5.3	5.3	4.6	4.1	
13. Effect on Longwave Rad.														
a. f (T)		15.8	15.9	16.0	15.9	16.1	16.1	16.0	16.1	16.1	16.0	15.9	15.6	
b. f (ed)		0.11	0.11	0.10	0.10	0.10	0.10	0.11	0.10	0.10	0.10	0.10	0.11	
c. f (n/N)		0.55	0.51	0.47	0.43	0.51	0.55	0.60	0.51	0.48	0.49	0.44	0.38	
14. Net Longwave Rad., Rnl	mm/day	1.0	0.9	0.8	0.7	0.8	0.9	1.1	0.8	0.8	0.8	0.7	0.7	
15. Net Radiation, Rn	mm/day	4.1	3.1	3.9	3.7	4.5	4.7	4.9	4.8	4.5	4.5	3.9	3.4	
16. Weighting Factor, W		0.75	0.75	0.76	0.75	0.76	0.76	0.75	0.76	0.76	0.76	0.75	0.74	
17. Energy Term	mm/day	3.J	2.3	3.0	2.8	3.4	3.6	3.7	3.6	3.4	3.4	2.9	2.5	
18. 6 + 17	mm/day	3.7	3.0	3.6	3.7	4.5	4.7	4.7	4.4	4.2	4.0	3.6	3.0	
19. Adjustment Factor, C		1.13	1.09	1.09	0.98	1.09	1.06	1.10	1.18	1.17	1.13	1.10	1.09	
20. Ref. Crop Evapotrans., ETo	mm/day	4.2	3.3	3.9	3.6	4.9	5.0	5.2	5.2	4.9	4.5	4.0	3.3	
- ditto -	mm/month	130	92	121	108	152	150	161	161	147	140	120	102	1584mm/year

Table 4—2—1 Calculation of Reference Crop Evapotranspiration (6/10)

YEAR : 1976
Latitude : 8°N Altitude : 50 - 100 m.a.m.s.

Method : Modified Penman Method

ITEM	UNIT	JAN.	FEB.	MAR	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	REMARKS
MONTHLY MEAN DATA														
i Air Temperature	°C	25.0	24.2	24.6	26.1	26.9	26.9	26.5	27.5	28.5*	26.7	27.0	26.3	*Correction with Cinera
ii Relative Humidity	%	87	87	89	87	84	81*	80*	82**	84*	85	83	83	** Average
iii Sunshine Hours	hr/day	4.6***	4.2***	3.0***	3.8*	4.8***	5.3***	5.6***	7.6*	6.4*	5.1***	4.5***	4.2***	*** From Cloudiness
iv Wind Speed	m/s	1.2	1.0	1.0	1.1	1.2	1.2	1.4	1.2	1.7**	1.5**	1.4**	1.3**	
	Uday m/s	2.4	1.8	1.9	1.9	2.1	2.0	2.8	2.6	2.8	2.7	2.6	2.5	
	Uday/Unight	6.0	6.0	3.1	2.7	2.6	2.5	4.7	5.2	2.6	9.4	10.4	8.3	
CALCULATION														
1. Saturation Vapour Pressure, ea	mbar	31.7	30.2	30.9	33.8	35.5	35.5	34.7	36.8	39.0	35.1	35.7	34.2	
2. Actual Vapour Pressure, ed	mbar	27.6	26.3	27.5	29.4	29.8	28.8	27.8	30.2	32.8	29.8	29.6	28.4	
3. ea - ed		4.1	3.9	3.4	4.4	5.7	6.7	6.9	6.6	6.2	5.3	6.1	5.8	
4. Wind Function, f(u)		0.55	0.50	0.50	0.53	0.55	0.55	0.60	0.55	0.67	0.62	0.60	0.57	
5. Weighting Factor, 1-W	mm/day	0.26	0.27	0.26	0.25	0.24	0.24	0.24	0.23	0.23	0.24	0.24	0.25	
6. Aerodynamic Term	mm/day	0.6	0.5	0.4	0.6	0.8	0.9	1.0	0.8	1.0	0.8	0.9	0.8	
7. Extra-Tertestrial Radiation, Ra	hr/day	13.6	14.5	15.3	15.6	15.3	15.0	15.1	15.4	15.3	14.8	13.9	13.3	
8. Max. Possible Sunshire Hours, N		11.7	11.8	12.0	12.3	12.5	12.6	12.5	12.4	12.1	11.9	11.7	11.6	
9. n/N		0.39	0.36	0.25	0.31	0.38	0.42	0.45	0.61	0.53	0.43	0.38	0.36	
10. (0.25 + 0.50 n/N)		0.45	0.43	0.38	0.41	0.44	0.46	0.48	0.56	0.52	0.47	0.44	0.43	
11. Solar Radiation, Rs	mm/day	6.1	6.2	5.8	6.4	6.7	6.9	7.3	8.6	8.0	7.0	6.1	5.7	
12. Net Shortwave Rad., Rns	mm/day	4.6	4.7	4.4	4.8	5.0	5.2	5.5	6.5	6.0	5.3	4.6	4.3	
13. Effect on Longwave Rad.														
a. f (T)		15.7	15.5	15.6	15.9	16.1	16.1	16.0	16.2	16.4	16.0	16.1	16.0	
b. f (ed)		0.11	0.12	0.11	0.10	0.10	0.11	0.11	0.10	0.09	0.10	0.10	0.11	
c. f (n/N)		0.45	0.42	0.33	0.38	0.44	0.48	0.51	0.65	0.58	0.49	0.44	0.42	
14. Net Longwave Rad., Rnl	mm/day	0.8	0.8	0.6	0.6	0.7	0.9	0.9	1.1	0.9	0.8	0.7	0.7	
15. Net Radiation, Rn	mm/day	3.8	3.9	3.8	4.2	4.3	4.3	4.6	5.4	5.1	4.5	3.9	3.6	
16. Weighting Factor, W		0.74	0.73	0.74	0.75	0.76	0.76	0.76	0.77	0.77	0.76	0.76	0.75	
17. Energy Term	mm/day	2.8	2.8	2.8	3.2	3.3	3.3	3.5	4.2	3.9	3.4	3.0	2.7	
18. 6 + 17	mm/day	3.4	3.3	3.2	3.8	4.1	4.2	4.5	5.0	4.9	4.2	3.9	3.5	
19. Adjustment Factor, C		1.10	1.09	1.05	1.03	1.03	1.05	1.13	1.16	1.10	1.10	1.08	1.08	
20. Ref. Crop Evapotrans., ETo	mm/day	3.7	3.6	3.4	3.9	4.2	4.4	5.1	5.8	5.4	4.6	4.2	3.8	
- ditto -	mm/month	115	104	105	117	136	132	158	180	162	143	126	118	1590mm/year

Table 4–2–1 Calculation of Reference Crop Evapotranspiration (7/10)

YEAR : 1977

Latitude : 8°N Altitude : 50 ~ 100 m.a.m.s.

Method : Modified Penman Method

ITEM	UNIT	JAN.	FEB.	MAR	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	REMARKS
MONTHLY MEAN DATA														
i Air Temperature	°C	26.4	27.6	27.2	26.5	26.9	26.6	26.4	26.6	26.8	27.0	27.1	27.0	
ii Relative Humidity	%	81	77	80	84	84	83	83	82	80	81	83	79	
iii Sunshine Hours	hr/day	6.5	6.9	3.8	2.3	5.4	5.4*	6.9*	6.9**	4.7**	6.1***	5.4***	6.2***	* Correction with Cinera
iv Wind Speed	m/s	1.4	1.4	1.6	1.6	1.7	1.6	1.7	1.9	1.8	1.9	1.5	1.2	** Correction with San Fanstino
	Uday m/s	2.6	25	33	28	27	27	2.5	3.2	3.2	3.4	2.7	2.7	***From Cloudiness
	Uday/Unight	7.5	56	56	57	24	25	1.8	2.5	2.7	3.8	5.4	9.0	Average
CALCULATION														
1. Saturation Vapour Pressure, ea	mbar	34.4	37.0	36.1	34.7	35.5	34.9	34.4	34.9	35.3	35.7	35.9	35.7	
2. Actual Vapour Pressure, ed	mbar	27.9	28.5	28.9	29.1	29.8	29.0	28.6	28.6	28.2	28.9	29.8	28.2	
3. ea - ed		6.5	6.5	7.2	5.6	5.7	5.9	5.8	6.3	7.1	6.8	6.1	7.5	
4. Wind Function, f(u)		0.60	0.60	0.64	0.64	0.67	0.64	0.67	0.71	0.69	0.71	0.62	0.55	
5. Weighting Factor, 1-W	mm/day	0.25	0.23	0.24	0.24	0.24	0.24	0.25	0.24	0.24	0.24	0.24	0.24	
6. Aerodynamic Term	mm/day	1.0	0.9	1.1	0.9	0.9	0.9	1.0	1.1	1.2	1.2	0.9	1.0	
7. Extra-Tertestrial Radiation, Ra	hr/day	13.6	14.5	15.3	15.6	15.3	15.0	15.1	15.4	15.3	14.8	13.9	13.3	
8. Max. Possible Sunshire Hours, N		11.7	11.8	12.0	12.3	12.5	12.6	12.5	12.4	12.1	11.9	11.7	11.6	
9. n/N		0.56	0.58	0.32	0.19	0.43	0.43	0.55	0.56	0.39	0.51	0.46	0.53	
10. (0.25 + 0.50 n/N)		0.53	0.54	0.41	0.35	0.47	0.47	0.53	0.53	0.45	0.51	0.48	0.52	
11. Solar Radiation, Rs	mm/day	7.2	6.4	6.3	5.5	7.2	7.1	8.0	8.2	6.9	7.5	6.7	6.9	
12. Net Shortwave Rad., Rns	mm/day	5.4	4.8	4.7	4.1	5.4	5.3	6.0	6.2	5.2	5.6	5.0	5.2	
13. Effect on Longwave Rad.														
a. f (T)		16.0	16.2	16.1	16.0	16.1	16.0	16.0	16.0	16.1	16.1	16.1	16.1	
b. f (ed)		0.11	0.11	0.11	0.10	0.10	0.11	0.11	0.11	0.11	0.11	0.10	0.11	
c. f (n/N)		0.60	0.62	0.39	0.27	0.49	0.49	0.60	0.50	0.51	0.56	0.51	0.58	
14. Net Longwave Rad., Rnl	mm/day	1.1	1.1	0.7	0.4	0.8	0.9	1.1	0.9	0.9	1.0	0.8	1.0	
15. Net Radiation, Rn	mm/day	4.3	3.7	4.0	3.7	4.6	4.4	4.9	5.3	4.3	4.6	4.2	4.0	
16. Weighting Factor, W		0.75	0.77	0.76	0.76	0.76	0.76	0.75	0.76	0.76	0.76	0.76	0.76	
17. Energy Term	mm/day	3.2	2.8	3.0	2.8	3.5	3.3	3.7	4.0	3.3	3.5	3.2	3.0	
18. 6 + 17	mm/day	4.2'	3.7	4.1	3.7	4.4	4.2	4.7	5.1	4.5	4.7	4.1	4.0	
19. Adjustment Factor, C		1.15	1.11	1.11	1.10	1.06	1.06	1.08	1.10	1.06	1.18	1.10	1.11	
20. Ref. Crop Evapotrans., ETo	mm/day	4.8	4.1	4.6	4.1	4.7	4.5	5.1	5.6	4.8	5.5	4.5	4.4	
- ditto -	mm/month	149	115	143	123	146	135	158	174	144	171	135	136	1729mm/year

Table 4–2–1 Calculation of Reference Crop Evapotranspiration (8/10)

YEAR : 1978
Latitude : 8°N Altitude : 50 - 100 m.a.m.s.

Method : Modified Penman Method

ITEM	UNIT	JAN.	FEB.	MAR	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	REMARKS
MONTHLY MEAN DATA														
i Air Temperature	°C	26.7	26.5	26.4	26.5	27.0	26.9	26.9	27.3	27.0	27.1	26.9	25.8	
ii Relative Humidity	%	76	80	81	83	82	82	81	79	81	81	81	83	
iii Sunshine Hours	hr/day	7.3	5.8	4.3	3.6	5.3	5.9	6.3	7.3	6.0	6.3	5.5	4.8	
iv Wind Speed	m/s	1.2	1.1	1.2	1.3	1.4	1.4	1.1	1.4	1.3	1.3	1.2	1.5	
	Uday m/s	2.4	2.3	2.0	2.2	2.2	2.1	2.0	2.1	2.4	2.3	2.2	2.5	
	Uday/Unight	4.0	4.6	1.5	2.0	1.7	1.4	1.7	1.6	2.4	1.8	1.8	2.1	
CALCULATION														
1. Saturation Vapour Pressure, ea	mbar	35.1	34.7	34.4	34.7	35.7	35.5	35.5	36.3	35.7	35.9	35.5	33.2	
2. Actual Vapour Pressure, ed	mbar	26.7	27.8	27.9	28.8	29.3	29.1	28.8	28.7	28.9	29.1	28.8	27.6	
3. ea - ed		8.4	6.9	6.5	5.9	6.4	6.4	6.7	7.6	6.8	6.8	6.7	5.6	
4. Wind Function, f(u)		0.55	0.53	0.55	0.57	0.60	0.60	0.53	0.60	0.57	0.57	0.55	0.62	
5. Weighting Factor, 1-W	mm/day	0.24	0.25	0.25	0.25	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.25	
6. Aerodynamic Term	mm/day	1.1	0.9	0.9	0.8	0.9	0.9	0.9	1.1	0.9	0.9	0.9	0.9	
7. Extra-Tertestrial Radiation, Ra	hr/day	13.6	14.5	15.3	15.6	15.3	15.0	15.1	15.4	15.3	14.8	13.9	13.3	
8. Max. Possible Sunshire Hours, N		11.7	11.8	12.0	12.3	12.5	12.6	12.5	12.4	12.1	11.9	11.7	11.6	
9. n/N		0.62	0.49	0.36	0.29	0.42	0.47	0.50	0.59	0.50	0.53	0.47	0.41	
10. (0.25 + 0.50 n/N)		0.56	0.50	0.43	0.40	0.46	0.49	0.50	0.55	0.50	0.52	0.49	0.46	
11. Solar Radiation, Rs	mm/day	7.6	7.3	6.6	6.2	7.0	7.4	7.6	8.5	7.7	7.7	6.8	6.1	
12. Net Shortwave Rad., Rns	mm/day	5.7	5.5	5.0	4.7	5.3	5.6	5.7	6.4	5.8	5.8	5.1	4.6	
13. Effect on Longwave Rad.														
a. f (T)		16.0	16.0	16.0	16.0	16.1	16.1	16.1	16.2	16.1	16.1	16.1	15.9	
b. f (ed)		0.12	0.11	0.11	0.11	0.10	0.10	0.11	0.11	0.11	0.10	0.11	0.11	
c. f (n/N)		0.66	0.54	0.42	0.36	0.48	0.52	0.55	0.63	0.55	0.58	0.52	0.47	
14. Net Longwave Rad., Rnl	mm/day	1.3	1.0	0.7	0.6	0.8	0.8	1.0	1.1	1.0	0.9	0.9	0.8	
15. Net Radiation, Rn	mm/day	4.4	4.5	4.3	4.1	4.5	4.8	4.7	5.3	4.8	4.9	4.2	3.8	
16. Weighting Factor, W		0.76	0.75	0.75	0.75	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.75	
17. Energy Term	mm/day	3.3	3.4	3.2	3.1	3.4	3.6	3.6	4.0	3.6	3.7	3.2	2.9	
18. 6 + 17	mm/day	4.4	4.3	4.1	3.9	4.3	4.5	4.5	5.1	4.5	4.6	4.1	3.8	
19. Adjustment Factor, C		1.06	1.05	1.00	1.00	1.01	1.02	1.02	1.04	1.08	1.05	1.04	1.00	
20. Ref. Crop Evapotrans., ETo	mm/day	4.7	4.5	4.1	3.9	4.3	4.6	4.6	5.3	4.9	4.8	4.3	3.8	
- ditto -	mm/month	146	126	127	117	133	138	143	164	147	149	129	118	1637mm/year

YEAR : 1979

Latitude : 8°N

Table 4–2–1 Calculation of Reference Crop Evapotranspiration (9/10)

Altitude : 50 - 100 m.a.m.s.

Method : Modified Penman Method

ITEM	UNIT	JAN.	FEB.	MAR	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	REMARKS
MONTHLY MEAN DATA														
i Air Temperature	°C	25.5	26.3	25.8	27.1	27.4	27.2	27.4	27.0	27.5	27.5	27.2	26.5	
ii Relative Humidity *	%	84	86	84	81	81	81	81	84	81	81	84	84	* Rough
iii Sunshine Hours	hr/day	4.9**	5.7**	3.1	4.4	5.6	5.9	6.5**	6.0**	5.0**	4.9**	4.0**	4.0**	** Ready by the Team
iv Wind Speed	m/s	1.8	.1.9	1.6	2.0	1.9	1.9	2.1	2.0	2.1	2.0	1.6	1.5	
	Uday m/s	2.9	3.3	2.0	3.1	3.2	3.1	3.2	3.1	3.3	3.2	2.4	2.4	
	Uday/Unight	1.6	2.5	3.0	2.2	2.1	2.1	1.8	1.8	1.7	2.1	1.5	1.5	
CALCULATION														
1. Saturation Vapour Pressure, ea	mbar	32.7	34.2	33.2	35.9	36.5	36.1	36.5	35.7	36.8	36.8	36.1	34.7	
2. Actual Vapour Pressure, ed	mbar	27.5	29.4	27.9	29.1	29.6	29.2	29.6	30.0	29.8	29.8	30.3	29.1	
3. ea - ed		5.2	4.8	5.3	6.8	6.9	6.9	6.9	5.7	7.0	7.0	5.8	5.6	
4. Wind Function, f(u)		0.69	0.71	0.64	0.74	0.71	0.71	0.76	0.74	0.76	0.74	0.64	0.62	
5. Weighting Factor, 1-W	mm/day	0.26	0.25	0.25	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	
6. Aerodynamic Term	mm/day	0.9	0.9	0.8	1.2	1.2	1.2	1.3	1.0	1.3	1.2	0.9	0.8	
7. Extra-Tertestrial Radiation, Ra	hr/day	13.6	14.5	15.3	15.6	15.3	15.0	15.1	15.4	15.3	14.8	13.9	13.3	
8. Max. Possible Sunshire Hours, N		11.7	11.8	12.0	12.3	12.5	12.6	12.5	12.4	12.1	11.9	11.7	11.6	
9. n/N		0.42	0.48	0.26	0.36	0.45	0.47	0.52	0.48	0.41	0.41	0.34	0.34	
10. (0.25 + 0.50 n/N)		0.46	0.49	0.38	0.43	0.48	0.49	0.51	0.49	0.46	0.46	0.42	0.42	
11. Solar Radiation, Rs	mm/day	6.3	7.1	5.8	6.7	7.3	7.4	7.7	7.5	7.0	6.8	5.8	5.6	
12. Net Shortwave Rad., Rns	mm/day	4.7	5.3	4.4	5.0	5.5	5.6	5.8	5.6	5.3	5.1	4.4	4.2	
13. Effect on Longwave Rad.														
a. f (T)		15.8	16.0	15.9	16.1	16.2	16.1	16.2	16.1	16.2	16.2	16.1	16.0	
b. f (ed)		0.11	0.10	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	
c. f (n/N)		0.48	0.53	0.33	0.42	0.51	0.52	0.57	0.53	0.47	0.47	0.41	0.41	
14. Net Longwave Rad., Rnl	mm/day	0.8	0.8	0.6	0.7	0.8	0.8	0.9	0.9	0.8	0.8	0.7	0.7	
15. Net Radiation, Rn	mm/day	3.9	4.5	3.8	4.3	4.7	4.8	4.9	4.7	4.5	4.3	3.7	3.5	
16. Weighting Factor, W		0.74	0.75	0.75	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	
17. Energy Term	mm/day	2.9	3.4	2.9	3.3	3.6	3.6	3.7	3.6	3.4	3.3	2.8	2.7	
18. 6 + 17	mm/day	3.8	4.3	3.7	4.5	4.8	4.8	5.0	4.6	4.7	4.5	3.7	3.5	
19. Adjustment Factor, C		0.98	1.06	1.05	1.03	1.04	1.05	1.05	1.05	0.98	1.04	0.90	0.90	
20. Ref. Crop Evapotrans., ETo	mm/day	3.7	4.6	3.9	4.6	5.0	5.0	5.0	4.8	4.6	4.7	3.3	3.2	
- ditto -	mm/month	115	129	121	138	155	150	155	149	138	146	99	99	1594mm/year

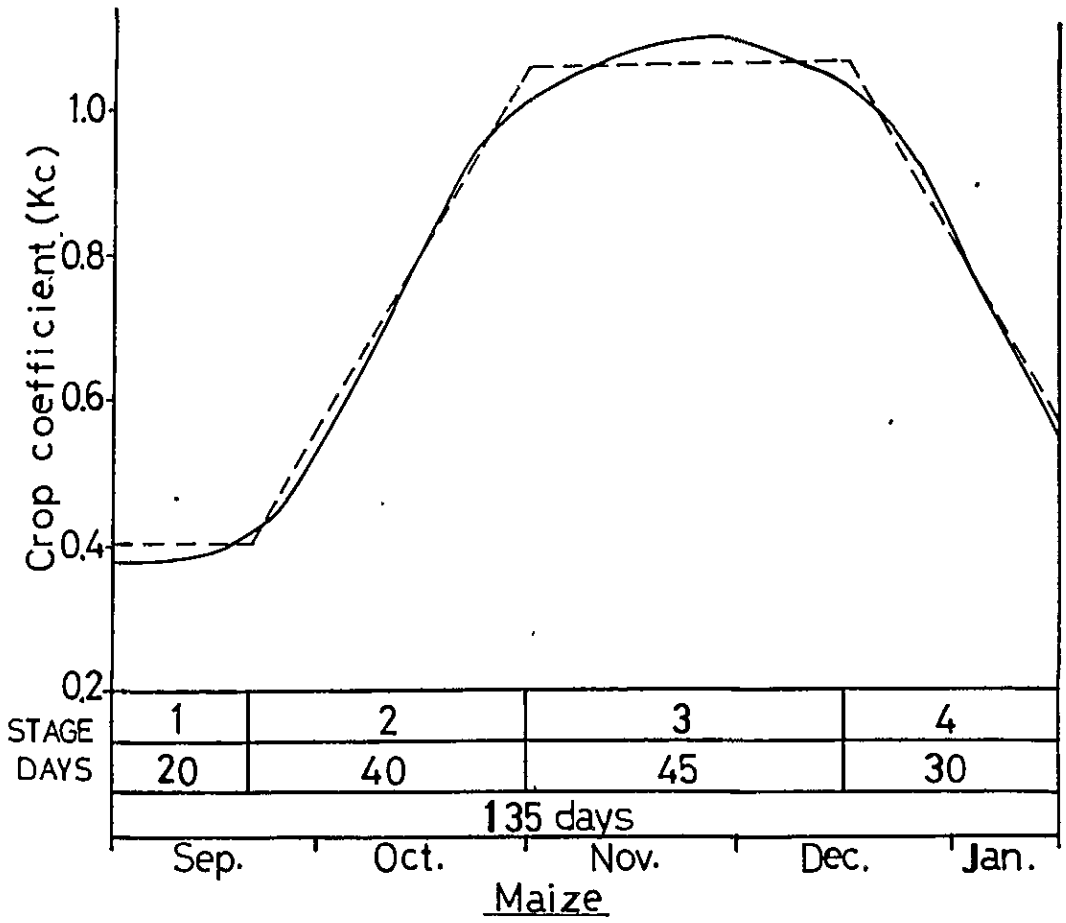
Table 4—2—1 Calculation of Reference Crop Evapotranspiration (10/10)

YEAR : 1980

Latitude : 8°N Altitude : 50 - 100 m.a.m.s.

Method : Modified Penman Method

ITEM	UNIT	JAN.	FEB.	MAR	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	REMARKS
MONTHLY MEAN DATA														
i Air Temperature	°C	26.6	26.2	27.6	27.6	27.6	27.5	27.9	27.6	28.2	27.5	27.0	27.2	
ii Relative Humidity	%	85	84	82	81	82	81	80	82	85	86	86	87	
iii Sunshine Hours	hr/day	5.3	4.9	3.7	5.2	5.3	6.2	7.6	7.4	7.3	6.4	4.9	3.8	
iv Wind Speed	m/s	1.7	1.8	2.2	2.0	1.9	1.9	2.8	2.4	2.3	2.1	1.8	1.8	
	Uday m/s	2.8	3.3	4.2	3.3	2.8	2.9	4.6	3.9	3.4	3.2	2.9	3.0	
	Uday/Unight	2.2	1.7	2.3	1.4	1.3	1.3	1.8	1.6	1.4	1.2	1.4	1.6	
CALCULATION														
1. Saturation Vapour Pressure, ea	mbar	34.9	34.0	37.0	37.0	36.8	36.8	37.6	37.0	38.3	36.8	35.7	36.1	
2. Actual Vapour Pressure, ed	mbar	29.7	28.6	30.3	30.0	29.8	29.8	30.1	30.3	32.6	31.6	30.7	31.4	
3. ea - ed		5.2	5.4	6.7	7.0	7.0	7.0	7.5	6.7	5.7	5.2	5.0	4.7	
4. Wind Function, f(u)		0.67	0.69	0.78	0.74	0.71	0.71	0.92	0.83	0.81	0.76	0.69	0.69	
5. Weighting Factor, 1-W	mm/day	0.24	0.25	0.24	0.24	0.24	0.24	0.23	0.24	0.23	0.24	0.24	0.24	
6. Aerodynamic Term	mm/day	0.8	0.9	1.3	1.2	1.1	1.2	1.6	1.3	1.1	0.9	0.8	0.8	
7. Extra-Tertestrial Radiation, Ra	hr/day	13.6	14.5	15.3	15.6	15.3	15.0	15.1	15.4	15.3	14.8	13.9	13.3	
8. Max. Possible Sunshire Hours, N		11.7	11.8	12.0	12.3	12.5	12.6	12.5	12.4	12.1	11.9	11.7	11.6	
9. n/N		0.45	0.42	0.31	0.42	0.42	0.49	0.61	0.60	0.60	0.54	0.42	0.33	
10. (0.25 + 0.50 n/N)		0.48	0.46	0.41	0.46	0.46	0.50	0.56	0.55	0.55	0.52	0.46	0.42	
11. Solar Radiation, Rs	mm/day	6.5	6.7	6.3	7.2	7.0	7.5	8.5	8.5	8.4	7.7	6.4	5.6	
12. Net Shortwave Rad., Rns	mm/day	4.9	5.0	4.7	5.4	5.3	5.6	6.4	6.4	6.3	5.8	4.8	4.2	
13. Effect on Longwave Rad.														
a. f (T)		16.0	15.9	16.2	16.2	16.2	16.2	16.1	16.2	16.3	16.2	16.1	16.1	
b. f (ed)		0.10	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.10	0.09	
c. f (n/N)		0.51	0.48	0.38	0.48	0.48	0.54	0.65	0.64	0.64	0.59	0.48	0.40	
14. Net Longwave Rad., Rnl	mm/day	0.8	0.8	0.6	0.8	0.8	0.9	1.0	1.0	0.9	0.9	0.8	0.6	
15. Net Radiation, Rn	mm/day	4.1	4.2	4.1	4.6	4.5	4.7	5.4	5.4	5.4	4.9	4.0	3.6	
16. Weighting Factor, W		0.76	0.75	0.76	0.76	0.76	0.76	0.77	0.76	0.77	0.76	0.76	0.76	
17. Energy Term	mm/day	3.1	3.2	3.1	3.5	3.4	3.6	4.2	4.1	4.2	3.7	3.0	2.7	
18. 6 +·17	mm/day	3.9	4.1	4.4	4.7	4.5	4.8	5.8	5.4	5.3	4.6	3.8	3.5	
19. Adjustment Factor, C		1.02	0.98	1.00	0.97	0.99	1.00	1.05	1.03	1.02	1.00	0.97	0.95	
20. Ref. Crop Evapotrans., ETo	mm/day	4.0	4.0	4.4	4.6	4.5	4.8	6.1	5.6	5.4	4.6	3.7	3.3	
- ditto -	mm/month	124	116	136	138	140	144	189	174	162	143	111	102	1679 mm/year



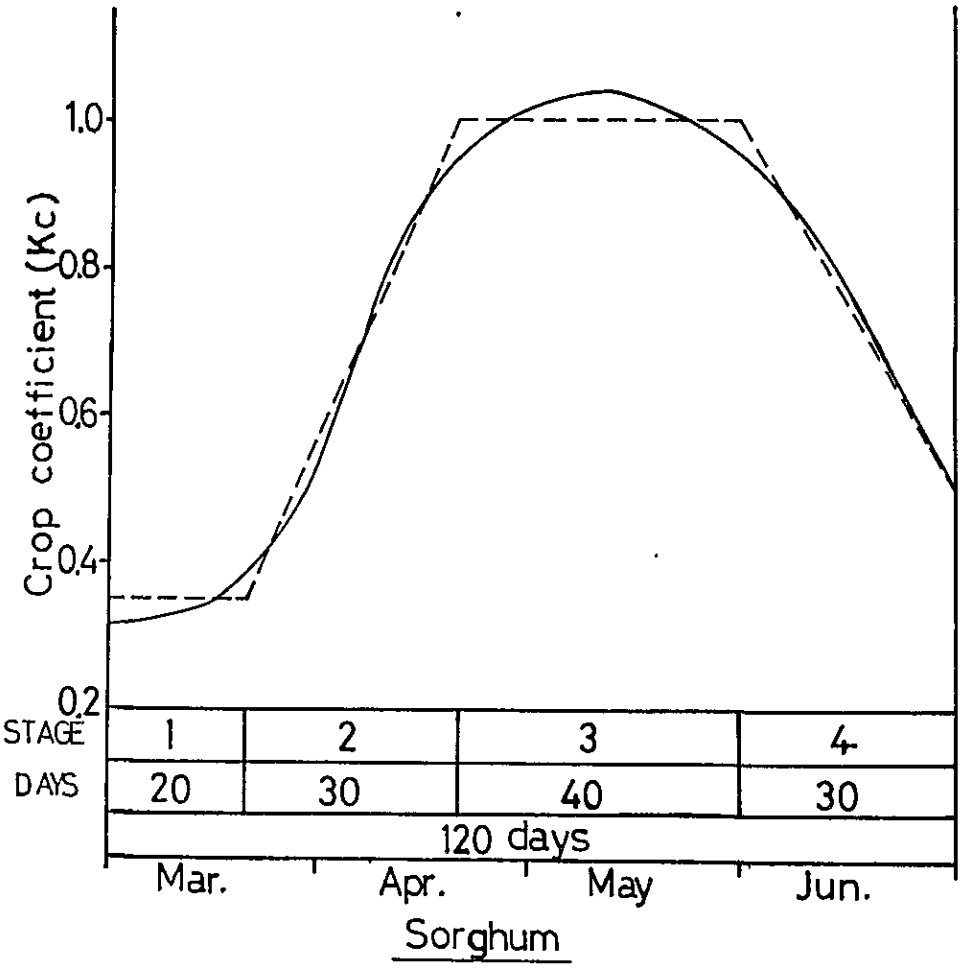


Fig. 4–2–1 Crop Coefficient Curve

Table 4—2—2 Calculation of Irrigation Water Requirements (1/10)

Year 1971

Month		Jan.	Feb.	Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.		Jan.		Feb
				15	16	15	15	15	16	15	15	15	16	15	16	15	15	15	16	15	15	15	16	15	16	15
(1) Cropping Patten				Sorghum												Maize										
(2) Cropping Intensity	1.			1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4	
	2.				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4
	Total			1/4	3/4	1	1	1	1	1	1	3/4	1/4			1/4	3/4	1	1	1	1	1	1	1	3/4	1/4
(3) Crop Coefficient	1.																									
(Kc)	2.																									
Weighted Average				0.32	0.34	0.45	0.73	0.97	1.03	0.99	0.86	0.68	0.59			0.38	0.39	0.47	0.68	0.91	1.04	1.08	1.05	0.92	0.71	0.60
(4) Ref. Crop Evapotranspitation	mm/day			3.6	3.6	5.0	5.0	4.3	4.3	4.8	4.8	5.7	5.7			5.8	5.8	5.4	5.4	4.6	4.6	3.8	3.8	3.6	3.6	4.4
(ETo)	mm																									
(5) Crop Evapotranspitation	mm/day			1.15	1.22	2.25	3.65	4.17	4.43	4.75	4.13	3.88	3.36			2.20	2.26	2.54	3.67	4.19	4.78	4.10	3.99	3.31	2.56	
(ETcrop=Kc x ETo=(3)x(4))				17.3	19.5	33.8	54.8	62.6	70.9	71.3	62.0	58.2	53.8			33.0	33.9	38.1	58.7	62.9	71.7	61.5	63.8	49.7	41.0	39.6
(6) Precipitation	mm			103.6	134.8	53.2	140.1	96.3	374.6	42.2	17.3	140.0	0			114.7	153.9	54.2	176.5	82.2	58.9	71.2	108.5	74.9	91.2	33.7
(7) Effective Rainfall (Pe)	mm			90.0	113.4	49.7	135.7	76.3	242.9	39.6	10.0	135.3	0			109.4	133.0	43.4	168.4	77.9	52.5	50.0	98.8	69.9	87.1	24.2
(8) Net Irrigation Requirements (Ino=ETcrop-Pe=(5)-(7))	mm									31.7	52.0		53.8								19.2	11.5				15.4
(9) Average Net Irrigation Requirements In = (8) x (2)	mm									31.7	52.0		13.45								19.2	11.5				3.85
(10) Irrigation Requirement	mm									79.25	130.0		33.63								48.0	28.75				9.63
(In/E)	mm/day									5.28	8.67		2.10								3.2	1.92				0.64
(11) Irrigation Requirement	l/s/ha									0.61	1.00		0.24								0.37	0.22				0.07

Table 4–2–2 Calculation of Irrigation Water Requirements (2/10)

Year 1972																								
Month	Jan.	Feb.	Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.		Jan.		Feb.
			15	16	15	15	15	16	15	15	15	16	15	16	15	15	15	16	15	15	15	16	15	16	15
(1) Cropping Pattern			Sorghum												Maize										
(2) Cropping Intensity 1.			1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4	
2.				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4
Total			1/4	3/4	1	1	1	1	1	1	3/4	1/4			1/4	3/4	1	1	1	1	1	1	1	3/4	1/4
(3) Crop Coefficient 1.																									
(Kc) 2.																									
Weighted Average			0.32	0.34	0.45	0.73	0.97	1.03	0.99	0.86	0.68	0.59			0.38	0.39	0.47	0.68	0.91	1.04	1.08	1.05	0.92	0.71	0.60
(4) Ref. Crop Evapotranspitation (ETo)	mm/day		4.8	4.8	4.9	4.9	5.4	5.4	5.2	5.2	5.2	5.2			5.4	5.4	5.6	5.6	5.1	5.1	4.4	4.4	5.0	5.0	4.4
	mm																								
(5) Crop Evapotranspitation (ETcrop=KcxETo= (3)x(4))	mm/day		1.54	1.63	2.21	3.58	5.24	5.56	5.15	4.47	3.54	3.07			2.05	2.11	2.63	3.81	4.64	5.30	4.75	4.62	4.60	3.55	2.64
	mm		23.1	26.1	33.2	53.7	78.6	89.0	77.3	67.1	53.1	49.1			30.8	31.7	39.5	61.0	69.6	79.5	71.3	73.9	69.0	56.8	39.6
(6) Precipitation	mm		55.7	131.6	103.9	504.6	149.2	42.3	98.7	45.9	39.4	20.2			36.2	57.7	85.3	160.1	214.8	16.0	39.1	58.3	0	19.9	13.5
(7) Effective Rainfall (Pe)	mm		46.8	125.7	99.0	335.1	125.2	37.4	95.6	27.9	32.7	6.7			29.5	55.1	84.3	110.4	211.3	5.3	34.0	55.6	0	18.9	10.9
(8) Net Irrigation Requirements (Ino=ETcrop-Pe=(5)-(7))	mm							51.6		39.2	20.4	42.4			1.3					74.2	37.3	18.3	69.0	37.9	28.7
(9) Average Net Irrigation Requirements In=(8)x(2)	mm							51.6		39.2	15.3	10.6			0.33					74.2	37.3	18.3	69.0	28.43	7.2
(10) Irrigation Requirement	mm							129.0		98.0	38.25	26.5			0.83					185.5	93.25	47.75	172.5	71.08	18.0
(In/E)								8.06		6.53	2.55	1.66			0.06					12.37	6.22	2.86	11.5	4.44	1.2
(11) Irrigation Requirement	ℓ/s/ha							0.94		0.76	0.30	0.19			6.98					1.43	0.72	0.33	1.33	0.52	0.14

Table 4—2—2 Calculation of Irrigation Water Requirements (3/10)

Year 1973																													
Month		Jan.		Feb.		Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.		Jan.		Feb.	
		15	16	15	16	15	16	15	15	15	16	15	15	15	16	15	16	15	15	15	16	15	15	15	16	15	16	15	13
(1) Cropping Pattern						Sorghum												Maize											
(2) Cropping Intensity	1.					1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4		
	2.						1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4	
	Total					1/4	3/4	1	1	1	1	1	1	3/4	1/4			1/4	3/4	1	1	1	1	1	1	1	3/4	1/4	
(3) Crop Coefficient (Kc)	1.					0.32	0.35	0.54	0.91	1.02	1.03	0.95	0.77	0.59				0.38	0.40	0.54	0.81	1.01	1.07	1.08	1.02	0.82	0.60		
	2.						0.32	0.35	0.54	0.91	1.02	1.03	0.95	0.77	0.59				0.38	0.40	0.54	0.81	1.01	1.07	1.08	1.02	0.82	0.60	
	Weighted Average					0.32	0.34	0.45	0.73	0.97	1.03	0.99	0.86	0.68	0.59			0.38	0.39	0.47	0.68	0.91	1.04	1.08	1.05	0.92	0.71	0.60	
(4) Ref. Crop Evapotranspitation (ETo)	mm/day					4.2	4.2	4.6	4.6	5.6	5.6	4.9	4.9	5.3	5.3	5.7	5.7	5.2	5.2	4.7	4.7	3.5	3.5	3.3	3.3	3.5	3.5	3.5	
	mm																												
(5) Crop Evapotranspitation (ETcrop = Kc x ETo = (3) x (4))	mm/day					1.34	1.43	2.07	3.36	5.43	5.77	4.85	4.21	3.60	3.13			1.98	2.03	2.21	3.20	3.19	3.64	3.56	3.47	3.22	2.49	2.10	
	mm					20.2	22.8	31.1	50.4	81.5	92.3	72.8	63.2	54.0	50.1			29.7	30.5	33.2	51.2	47.9	54.6	53.4	55.5	48.3	39.8	31.5	
(6) Precipitation	mm					42.6	9.4	41.0	51.6	141.2	29.4	36.5	60.2	5.7	97.8	84.3	76.5	204.2	115.3	223.2	83.2	407.6	234.1	158.8	219.4	53.8	133.4	122.0	
(7) Effective Rainfall (Pe)	mm					39.1	6.8	40.2	49.8	100.8	21.5	32.6	56.4	0	62.2	79.2	66.2	154.5	109.9	187.6	72.3	290.5	215.4	155.6	158.8	47.6	107.1	111.1	
(8) Net Irrigation Requirements (Ino = ETcrop - Pe = (5) - (7))	mm						16.0		0.6		70.8	40.2		6.8	54.0												0.7		
(9) Average Net Irrigation Requirements In = (8) x (2)	mm						12.0		0.6		70.8	40.2		6.8	40.5												0.7		
(10) Irrigation Requirement	mm						30.0		1.5		177.0	100.5		17.0	101.25												1.75		
(In/E)							1.88		0.1		11.06	6.7		1.13	6.75												0.12		
(11) Irrigation Requirement	l/s/ha						0.22		0.01		1.28	0.78		0.13	0.78												0.01		

Table 4–2–2 Calculation of Irrigation Water Requirements (4/10)

Year 1974																												
Month		Jan.		Feb.		Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.		Jan.		Feb.	
						15	16	15	15	15	16	15	15	15	16	15	16	15	15	15	16	15	15	15	16	15	16	15	15
(1) Cropping Pattern						Sorghum												Maize										
(2) Cropping Intensity	1.					1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4		
	2.						1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4		
	Total					1/4	3/4	1	1	1	1	1	1	3/4	1/4			1/4	3/4	1	1	1	1	1	1	3/4	1/4		
(3) Crop Coefficient	1.																												
(Kc)	2.																												
Weighted Average						0.32	0.34	0.45	0.73	0.97	1.03	0.99	0.86	0.68	0.59			0.38	0.39	0.47	0.68	0.91	1.04	1.08	1.05	0.92	0.71	0.60	
(4) Ref. Crop Evapotranspitation	mm/day					4.0	4.0	3.2	3.2	4.6	4.6	5.0	5.0	5.2	5.2			4.1	4.1	4.2	4.2	4.0	4.0	4.0	4.0	4.2	4.2	3.3	
(ETo)	mm																												
(5) Crop Evapotranspitation	mm/day					1.28	1.36	1.44	2.34	4.46	4.74	4.95	4.30	3.54	3.07			1.56	1.60	1.97	2.86	3.64	4.16	4.32	4.20	3.86	2.98	1.98	
(ETcrop = Kc x ETo = (3) x (4))	mm					19.2	21.8	21.6	35.1	66.9	75.8	74.3	64.5	53.1	49.1			23.4	24.0	29.6	45.8	54.6	62.4	64.8	67.2	57.9	47.7	29.7	
(6) Precipitation	mm					180.7	133.7	156.9	79.5	191.7	111.5	29.5	34.5	43.6	59.2			99.9	167.9	56.2	228.8	218.4	174.0	267.6	36.9				
(7) Effective Rainfall	mm					152.6	116.3	156.1	76.0	138.3	86.4	23.2	28.2	40.8	38.0			91.7	159.7	51.2	169.3	196.2	171.1	174.8	20.5	0	17.7	34.5	
(Pe)																													
(8) Net Irrigation Requirements	mm											51.1	36.3	12.3	11.1										46.7	57.9	30.0		
(Ino = ETcrop - Pe = (5) - (7))																													
(9) Average Net Irrigation Requirements	mm											51.1	36.3	9.23	2.78										46.7	57.9	22.5		
In = (8) x (2)																													
(10) Irrigation Requirement	mm											127.75	90.75	23.08	6.95										144.75 116.75		56.25		
(In/E)												8.52	6.05	1.54	0.43										7.30	9.65	3.52		
(11) Irrigation Requirement	l/s/ha											0.99	0.70	0.18	0.05										0.84	1.12	0.41		

Table 4–2–2 Calculation of Irrigation Water Requirements (5/10)

Year 1975																													
Month		Jan.		Feb.		Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.		Jan.		Feb.	
		15	16	15	15	16	15	15	16	15	15	16	15	16	15	16	15	15	15	16	15	15	15	16	15	16	15	13	
(1) Cropping Pattern					Sorghum												Maize												
(2) Cropping Intensity	1.			1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4					1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4			
	2.				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4					1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4		
	Total			1/4	3/4	1	1	1	1	1	1	3/4	1/4				1/4	3/4	1	1	1	1	1	1	1	3/4	1/4		
(3) Crop Coefficient (Kc)	1.																												
	2.																												
	Weighted Average			0.32	0.34	0.45	0.73	0.97	1.03	0.99	0.86	0.68	0.59				0.38	0.39	0.47	0.68	0.91	1.04	1.08	1.05	0.92	0.71	0.60		
(4) Ref. Crop Evapotranspitation	mm/day			3.9	3.9	3.6	3.6	4.9	4.9	5.0	5.0	5.2	5.2				4.9	4.9	4.5	4.5	4.0	4.0	3.3	3.3	3.7	3.7	3.6		
(ETo)	mm																												
(5) Crop Evapotranspitation	mm/day			1.25	1.33	1.62	2.63	4.75	5.05	4.95	4.30	3.54	3.07				1.86	1.91	2.12	3.06	3.64	4.16	3.56	3.47	3.40	2.63	2.16		
(ETcrop = Kc x ETo = (3) x (4))	mm			18.8	21.3	24.3	39.5	71.3	80.8	74.3	64.5	53.1	49.1				27.9	28.7	31.8	49.0	54.6	62.4	53.4	55.5	51.0	42.1	32.4		
(6) Precipitation	mm																												
(7) Effective Rainfall (Pe)	mm			11.9	49.0	112.2	85.7	174.2	48.2	13.1	69.8	67.8	30.3				121.7	148.9	204.5	122.5	184.4	248.2	312.1	193.0	105.3	78.6	103.3		
(8) Net Irrigation Requirements (Ino = ETcrop - Pe = (5) - (7))	mm			6.9					32.6	61.2			18.8																
(9) Average Net Irrigation Requirements In = (8) x (2)	mm			1.73					32.6	61.2			4.7																
(10) Irrigation Requirement	mm			4.33					81.5	153.0			11.75																
(In/E)				0.29					5.09	10.2			0.73																
(11) Irrigation Requirement	ℓ/s/ha			0.03					0.59	1.18			0.08																

Table 4–2–2 Calculation of Irrigation Water Requirements (6/10)

Year 1976																											
Month		Jan.	Feb.	Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.		Jan.		Feb.	
				15	16	15	15	15	16	15	15	15	16	15	16	15	15	15	16	15	15	15	16	15	16	15	13
(1) Cropping Pattern				Sorghum												Maize											
(2) Cropping Intensity	1.			1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1.4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4		
	2.				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4	
	Total			1/4	3/4	1	1	1	1	1	1	3/4	1/4			1/4	3/4	1	1	1	1	1	1	1	3/4	1/4	
(3) Crop Coefficient (Kc)	1.																										
	2.																										
Weighted Average				0.32	0.34	0.45	0.73	0.97	1.03	0.89	0.86	0.68	0.59			0.38	0.39	0.47	0.68	0.91	1.04	1.08	1.05	0.92	0.71	0.60	
(4) Ref. Crop Evapotranspitation	mm/day			3.4	3.4	3.9	3.9	4.2	4.2	4.4	4.4	5.1	5.1			5.4	5.4	4.6	4.6	4.2	4.2	3.8	3.8	4.8	4.8	4.1	
(ETo)	mm																										
(5) Crop Evapotranspitation	mm/day			1.09	1.16	1.76	2.85	4.07	4.33	4.36	3.78	3.47	3.01			2.05	2.11	2.16	3.13	3.82	4.35	4.10	3.99	4.42	3.41	2.46	
(ETcrop = Kc x ETo = (3) x (4))	mm			16.4	18.6	26.4	42.8	61.1	69.3	65.4	56.7	52.1	48.2			30.8	31.7	32.4	50.1	57.3	65.3	61.5	63.8	66.3	54.6	36.9	
(6) Precipitation	mm																										
(7) Effective Rainfall (Pe)	mm	206.8	73.9	123.9	61.1	34.4	97.6	15.8	49.0	36.5	68.2					32.4	135.3	184.6	129.9	161.8	17.6	33.2	6.0	8.0	66.3	0	
(8) Net Irrigation Requirements (Ino = ETcrop - Pe = (5) - (7))	mm						26.7		49.6	7.7	15.6										47.7	28.3	57.8	58.3		36.9	
(9) Average Net Irrigation Requirements In = (8) x (2)	mm						26.7		49.6	7.7	11.7										47.7	28.3	57.8	58.3		9.23	
(10) Irrigation Requirement	mm						66.75		124.0	19.25	29.25										119.25	70.75	144.5	145.75		23.08	
(In/E)							4.45		8.27	1.28	1.95										7.95	4.72	9.03	9.72		1.54	
(11) Irrigation Requirement	l/s/ha						0.52		0.96	0.15	0.23										0.92	0.55	1.05	1.12		0.18	

Table 4—2—2 Calculation of Irrigation Water Requirements (7/10)

Year 1977																											
Month		Jan.	Feb.	Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.		Jan.		Feb.	
				15	16	15	15	15	16	15	15	15	16	15	16	15	15	15	16	15	15	15	16	15	16	15	13
(1) Cropping Pattern				Sorghum												Maize											
(2) Cropping Intensity	1.			1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4		
	2.				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4	
	Total			1/4	3/4	1	1	1	1	1	1	3/4	1/4			1/4	3/4	1	1	1	1	1	1	1	3/4	1/4	
(3) Crop Coefficient (Kc)	1.																										
	2.																										
	Weighted Average			0.32	0.34	0.45	0.75	0.97	1.03	0.99	0.86	0.68	0.59			0.38	0.59	0.47	0.68	0.91	1.04	1.08	1.05	0.92	0.71	0.60	
(4) Ref. Crop Evapotranspitation	mm/day			4.6	4.6	4.1	4.1	4.7	4.7	4.5	4.5	5.1	5.1			4.8	4.8	5.5	5.5	4.5	4.5	4.4	4.4	4.7	4.7	4.5	
(ETo)	mm																										
(5) Crop Evapotranspitation	mm/day			1.47	1.56	1.85	2.99	4.56	4.84	4.46	3.87	3.47	3.01			1.82	1.87	2.59	3.74	4.10	4.68	4.75	4.62	4.32	3.34	2.70	
(ETcrop = Kc x ETo = (3) x (4))	mm			22.1	25.0	27.8	44.9	68.4	77.4	66.9	58.1	52.1	48.2			27.3	28.1	38.9	59.8	61.5	70.2	71.3	73.9	64.8	53.4	40.5	
(6) Precipitation	mm																										
(7) Effective Rainfall (Pe)	mm			12.7	133.7	63.9	18.2	87.3	19.2	79.3	88.7	96.2	44.6			83.6	30.5	81.2	150.4	104.9	89.1	0	0	0	33.5	79.9	
(8) Net Irrigation Requirements (Ino = ETcrop - Pe = (5) - (7))	mm			9.4		26.7		58.2				3.6										71.3	73.9	64.8	19.9		
(9) Average Net Irrigation Requirements In = (8) x (2)	mm			2.35		26.7		58.2				0.9										71.3	73.9	64.8	14.93		
(10) Irrigation Requirement	mm			5.88		66.75		145.5				2.25										184.75 178.25		162.0	37.33		
(In/E)				0.39		4.45		9.09				0.14										11.88	11.55	10.8	2.33		
(11) Irrigation Requirement	l/s/ha			0.05		0.52		1.06				0.02										1.38	1.34	1.26	0.27		

Table 4–2–2 Calculation of Irrigation Water Requirements (8/10)

Year 1978																													
Month		Jan.	Feb.	Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.		Jan.		Feb.	
				15	16	15	15	15	16	15	15	15	16	15	16	15	15	15	16	15	15	15	16	15	16	15	13
(1) Cropping Pattern				Sorghum												Maize											
(2) Cropping Intensity	1.			1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4		
	2.				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4	
	Total			1/4	3/4	1	1	1	1	1	1	3/4	1/4			1/4	3/4	1	1	1	1	1	1	1	3/4	1/4	
(3) Crop Coefficient (Kc)	1.																										
	2.																										
	Weighted Average			0.32	0.34	0.45	0.73	0.97	1.03	0.99	0.86	0.68	0.59			0.38	0.39	0.47	0.68	0.91	1.04	1.08	1.05	0.92	0.71	0.60	
(4) Ref. Crop Evapotranspitation	mm/day			4.1	4.1	3.9	3.9	4.3	4.3	4.6	4.6	4.6	4.6			4.9	4.9	4.8	4.8	4.3	4.3	3.8	3.8	3.7	3.7	4.6	
(ETo)	mm																										
(5) Crop Evapotranspitation	mm/day			1.31	1.39	1.76	2.85	4.17	4.43	4.55	3.96	3.13	2.71			1.86	1.91	2.26	3.26	3.91	4.47	4.10	3.99	3.40	2.63	2.76	
(ETcrop = Kc x ETo = (3) x (4))	mm			19.7	22.4	26.4	42.8	62.6	70.9	68.3	59.4	47.0	43.4			27.9	28.7	33.9	52.2	53.7	67.1	61.5	63.8	51.0	42.1	41.4	
(6) Precipitation	mm																										
(7) Effective Rainfall (Pe)	mm			65.4	122.4	218.7	119.7	52.4	13.0	15.0	44.5	14.5	145.6			111.3	114.1	141.2	133.5	29.4	100.7	134.0	42.7	14.2	40.4	0	
(8) Net Irrigation Requirements (Ino = ETcrop - Pe = (5) - (7)]	mm							10.2	57.9	53.3	14.9	32.5								29.3			21.1	36.8	1.7	41.4	
(9) Average Net Irrigation Requirements In = (8) x (2)	mm							10.2	57.9	53.3	14.9	24.38								29.3			21.1	36.8		10.35	
(10) Irrigation Requirement	mm							25.5	144.75	133.25	37.25 : 60.95									73.25			52.75	92.0		25.88	
(In/E)								1.7	9.05	8.88	2.48	4.06								4.88			3.30	6.13		1.73	
(11) Irrigation Requirement	l/s/ha							0.20	1.05	1.03	0.29	0.47								0.57			0.38	0.71		0.20	

Table 4-2-2 Calculation of Irrigation Water Requirements (9/10)

Year 1979																													
Month		Jan.	Feb.	Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.		Jan.		Feb.	
				15	16	15	15	15	16	15	15	15	16	15	16	15	15	15	16	15	15	15	16	15	16	15	13
(1) Cropping Pattern				Sorghum												Maize											
(2) Cropping Intensity	1.			1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4		
	2.				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4	
	Total			1/4	3/4	1	1	1	1	1	1	3/4	1/4			1/4	3/4	1	1	1	1	1	1	1	3/4	1/4	
(3) Crop Coefficient (Kc)	1.																										
	2.																										
	Weighted Average			0.32	0.34	0.45	0.73	0.97	1.03	0.99	0.86	0.68	0.59			0.38	0.39	0.47	0.68	0.91	1.04	1.08	1.05	0.92	0.71	0.60	
(4) Ref. Crop Evapotranspitation	mm/day			3.9	3.9	4.6	4.6	5.0	5.0	5.0	5.0	5.0	5.0			4.6	4.6	4.7	4.7	3.3	3.3	3.2	3.2	4.0	4.0	4.0	
(ETo)	mm																										
(5) Crop Evapotranspitation	mm/day			1.25	1.33	2.07	3.36	4.85	5.15	4.95	4.30	3.40	2.95			1.75	1.79	2.21	3.20	3.00	3.43	3.46	3.36	3.68	2.84	2.40	
(ETcrop = Kc x ETo = (3) x (4))	mm			18.8	21.3	31.1	50.4	72.8	82.4	74.3	64.5	51.0	47.2			26.3	26.9	33.2	51.2	45.0	51.5	51.9	53.8	55.2	45.4	36.0	
(6) Precipitation	mm																										
(7) Effective Rainfall (Pe)	mm			114.9	33.4	47.6	97.8	57.2	89.0	182.3	34.7	105.6	78.5			141.1	115.9	33.2	196.7	114.2	103.2	63.9	198.4	23.0	68.2	73.0	
(8) Net Irrigation Requirements (Ino = ETcrop - Pe = (5) - (7))	mm							15.6			29.8							0							32.2		
(9) Average Net Irrigation Requirements In = (8) x (2)	mm							15.6			29.8							0							32.2		
(10) Irrigation Requirement	mm							39.9			74.5							0							80.5		
(In/E)								2.6			4.97							0							5.37		
(11) Irrigation Requirement	ℓ/s/ha							0.30			0.58							0							0.62		

Table 4–2–2 Calculation of Irrigation Water Requirements (10/10)

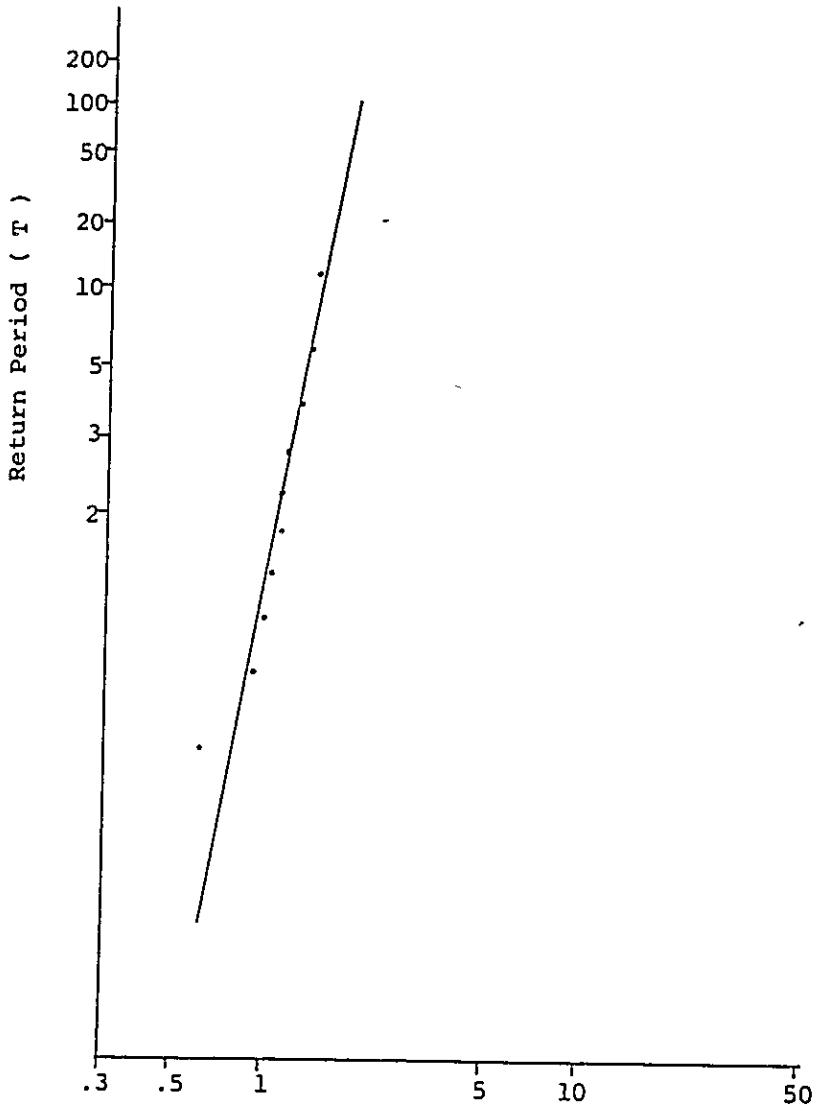
Year 1980																												
Month		Jan.		Feb.		Mar.		Apr.		May		Jun.		Jul.		Aug.		Sep.		Oct.		Nov.		Dec.		Jan.		Feb.	
		15		16		15		15		15		15		15		15		15		15		15		15		15		13
(1) Cropping Pattern						Sorghum												Maize										
(2) Cropping Intensity	1.					1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4		
	2.						1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4				1/4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/4	
	Total					1/4	3/4	1	1	1	1	1	1	3/4	1/4			1/4	3/4	1	1	1	1	1	1	1	3/4	1/4	
(3) Crop Coefficient (Kc)	1.																											
	2.																											
	Weighted Average					0.32	0.34	0.45	0.73	0.97	1.03	0.99	0.86	0.68	0.59			0.38	0.39	0.47	0.68	0.91	1.04	1.08	1.05	0.92	0.71	0.60	
(4) Ref. Crop Evapotranspitation	mm/day					4.4	4.4	4.6	4.6	4.5	4.5	4.8	4.8	6.1	6.1			5.4	5.4	4.6	4.6	3.7	3.7	3.3	3.3	4.1	4.1	4.1	
(ETo)	mm																											
(5) Crop Evapotranspitation	mm/day					1.41	1.50	2.07	3.36	4.37	4.64	4.75	4.13	4.15	3.60			2.05	2.11	2.16	3.13	3.37	3.85	3.56	3.47	3.77	2.91	2.46	
(ETcrop = Kc x ETo = (3) x (4))	mm					21.2	24.0	31.1	50.4	65.6	74.2	71.3	62.0	62.3	57.6			30.8	31.7	32.4	50.1	50.6	57.8	53.4	55.5	56.6	43.7	36.9	
(6) Precipitation	mm																											
(7) Effective Rainfall (Pe)	mm					0	0	14.8	102.4	27.3	73.8	78.3	14.2	22.0	98.0			107.8	99.4	115.3	71.3	187.3	109.5	168.4	65.4	66.0	72.0	36.5	
(8) Net Irrigation Requirements (Ino = ETcrop - Pe = (5) - (7))	mm					21.2	24.0	16.3		38.3	0.4		47.8	40.3														0.4	
(9) Average Net Irrigation Requirements In = (8) x (2)	mm					5.3	18.0	16.3		38.3	0.4		47.8	30.23														0.1	
(10) Irrigation Requirement	mm					13.25	45.0	40.75		95.75			119.5	75.58														0.25	
(In/E)						0.88	2.81	2.72		6.38			7.97	5.04														0.02	
(11) Irrigation Requirement	ℓ/s/ha					0.10	0.33	0.32		0.74			0.92	0.59														2.33	

Table 4–2–3 Conveyance (Ec), Field Canal (Eb), Distribution (Ed) and Field Application Efficiency (Ea)

				ICID/ILRI
Conveyance Efficiency (Ec)				
Continuous supply with no substantial change in flow				0.9
Rotational supply in projects of 3,000 - 7,000 ha and rotation areas of 70 - 300 ha, with effective management				0.8
Rotational supply in large schemes (>10,000 ha) and small schemes (<1,000 ha) with respective problematic communication and less effective management:				
	based on predetermined schedule			0.7
	based on advance request			0.65
Field Canal Efficiency (Eb)				
Blocks larger than 20 ha:	unlined			0.8
	lined or piped			0.9
Blocks up to 20 ha:	unlined			0.7
	lined or piped			0.8
Distribution Efficiency (Ed = Ec.Eb)				
Average for rotational supply with management and communication adequate				0.65
	sufficient			0.65
	insufficient			0.55
	poor			0.30
Field Application Efficiency (Ea)		USDA	US(SCS)	
Surface methods				
	light soils	0.55		
	medium soils	0.70		
	heavy soils	0.60		
graded border			0.60 - 0.75	0.53
basin and level border			0.50 - 0.80	0.58
contour ditch			0.50 - 0.55	
furrow			0.55 - 0.70	0.57
corrugation			0.50 - 0.70	
Subsurface			up to 0.80	
Sprinkler,	hot dry climate		0.60	
	moderate climate		0.70	0.67
	humid and cool		0.80	
Rice				0.32

Sources: FAO Guideline [Crop Water Requirement - Irrigation and Drainage No. 24]

Fig. 4–2–2 Peak Gross Irrigation Requirements



Year	Max. Water Requirement (ℓ/s/ha)	Year	Max. Water Requirement (ℓ/s/ha)	Return Period	Max. Water Requirement (ℓ/s/ha)
1971	1.000	1972	1.430	2	1.08
1972	1.430	1977	1.380	5	1.33
1973	1.280	1973	1.280	10	1.47
1974	1.120	1975	1.180	20	1.61
1975	1.180	1974	1.120	30	1.68
1976	1.120	1976	1.120	40	1.73
1977	1.380	1978	1.050	50	1.77
1978	1.050	1971	1.000	80	1.86
1979	0.620	1980	0.920	100	1.89
1980	0.920	1979	0.620	200	2.01
				500	2.16
				1,000	2.26

4.3 Project Design

(1) Method of Irrigation

Border irrigation is determined as method of irrigation considering land slope, soil type, basic intake rate, type of crop, cost and others.

(2) Depth of Irrigation Application

Depth of irrigation application is estimated by following formula.

$$d = P.Sa.\ D/Ea$$

where:

d : Depth of irrigation application (mm)

P : Fraction of available moisture, fraction

Sa : Total Available moisture (mm/m soil depth)

D : Rooting depth (m)

Ea : Field application efficiency, fraction

Result of calculation indicated that the depth of irrigation application is 114.5 mm.

(3) Irrigation Interval

The irrigation interval can be obtained from:

$$i = P.Sa.D/ET\ crop$$

The efficiency of irrigation application is not considered when determining "i". "i" is obtained 14 days as results of calculation.

(4) Size of Field

Field size is planned as shown Fig. 4-3-1 size of rotation block is 20 ha which is irrigated 14 days.
Width of border strip is planned 18 m considering FAO Guideline and Table 4-3-1.
Length of border strip is determined 200 m by the following formula.

$$L = \frac{\text{allowable max discharge (ref table 4-3-2)}}{m^3/10m\ \text{(length of border strip)}}\ m$$

(5) Stream Size

The field supply is:

$$g.t = \frac{10}{Ea}.P.Sa.D.A$$

where,

g = stream size in l/sec

t = supply duration in seconds

Ea = application efficiency, fraction

Sa = total available moisture in mm/m soil depth

P = fraction of total available moisture, fraction

D = Rooting depth, m

A = acreage, ha

Duration of irrigation is planned with continuous supply, consequently, 19.1l/sec is determined as stream size.

(6) Duration of Irrigation

Duration of irrigation per one border strip is planned for 6 hours.
Number of border strip per one day is planned 4 border strips.

Fig. 4–3–1 Standard Model of Field

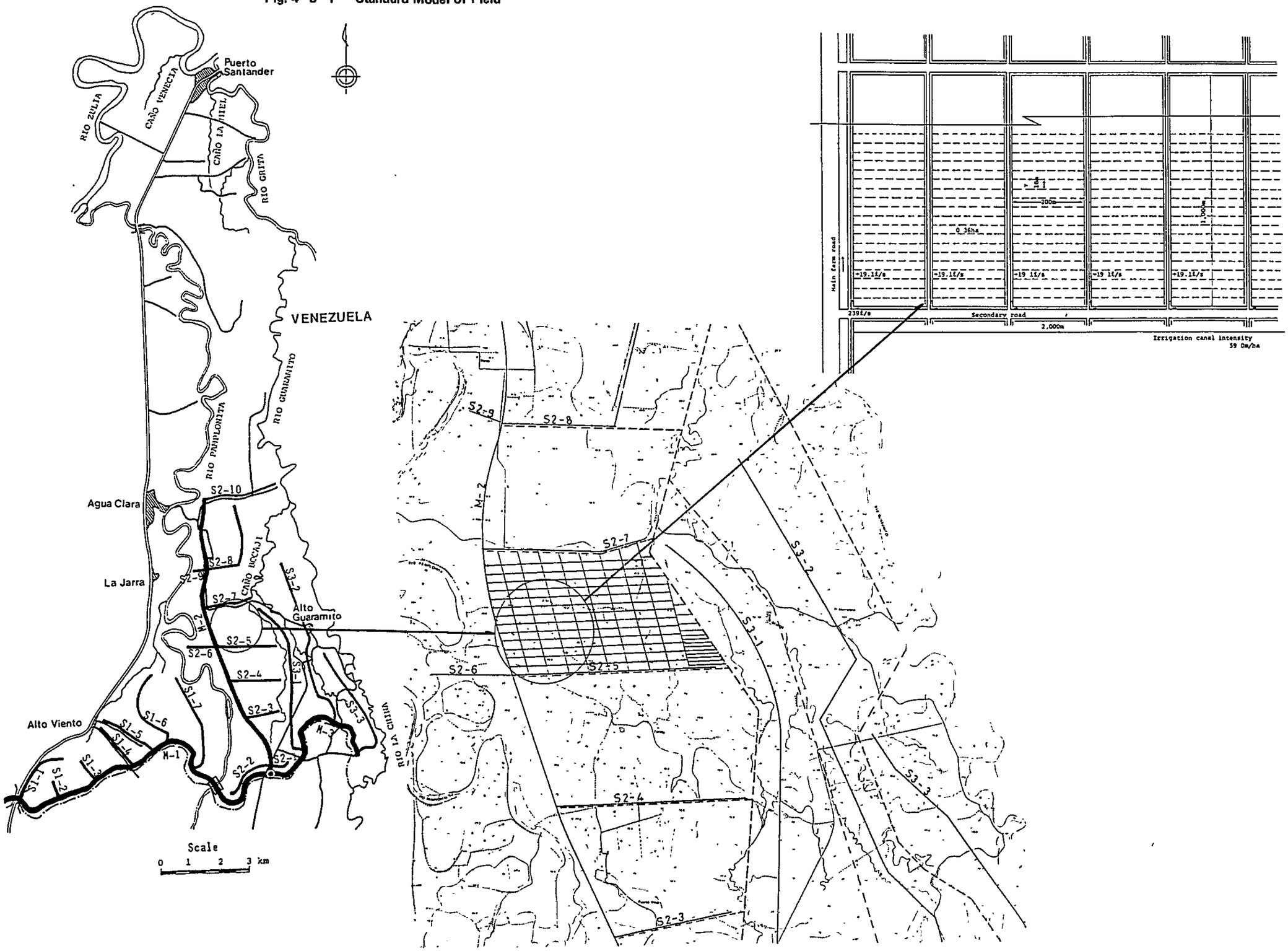


Table 4–3–1 Relation of Land Slope and Max. Width of Border Strip

Slope (%)	Max. border width (m)
0.0	36
0.1 - 0.5	18
0.5 - 1.0	15
1.0 - 2.0	12
2.0 - 4.0	9
4.0 - 6.0	6

Resource : Field Irrigation Handbook

Table 4-3-2

Max. stream size per 1m in width of border strip

Slope (S)%	Max. Stream Size (Q) ℓ/s	Slope (S)%	Max. Stream Size (Q) ℓ/s
0.3	13.92	1.0	5.57
0.4	11.14	1.5	3.95
0.5	9.24	2.0	3.24
0.6	7.98	2.5	2.78
0.7	7.14	3.0	2.41
0.8	6.49	4.0	1.94
0.9	5.93	5.0	1.67

Resource : Field Irrigation Handbook

Note : Original formula is :

$$Q = 5.57S^{-0.75} \text{ (l/s)}$$

4.4 Water Supply Canal

Irrigation water is diverted at diversion of canal Zulia and conveyed to the site through Puerto Rico (Refer to Fig. 4-1-1).
Based on the mentioned project design, calculation of water discharge is executed. Irrigation water requirements is 6.0 m^3/s. Irrigation network is shown as Fig. 4-4-1. Summary of irrigation canal is shown as below and Table 4-4-1.

Driving canal	6,400 m
Main canal	26,700 m
Secondary canal	50,350 m
Tertiary canal	203,350 m
Total	286,800 m

Results of calculation of canal section and standard cross section are shown as Fig. 4-4-2, 4-4-3.

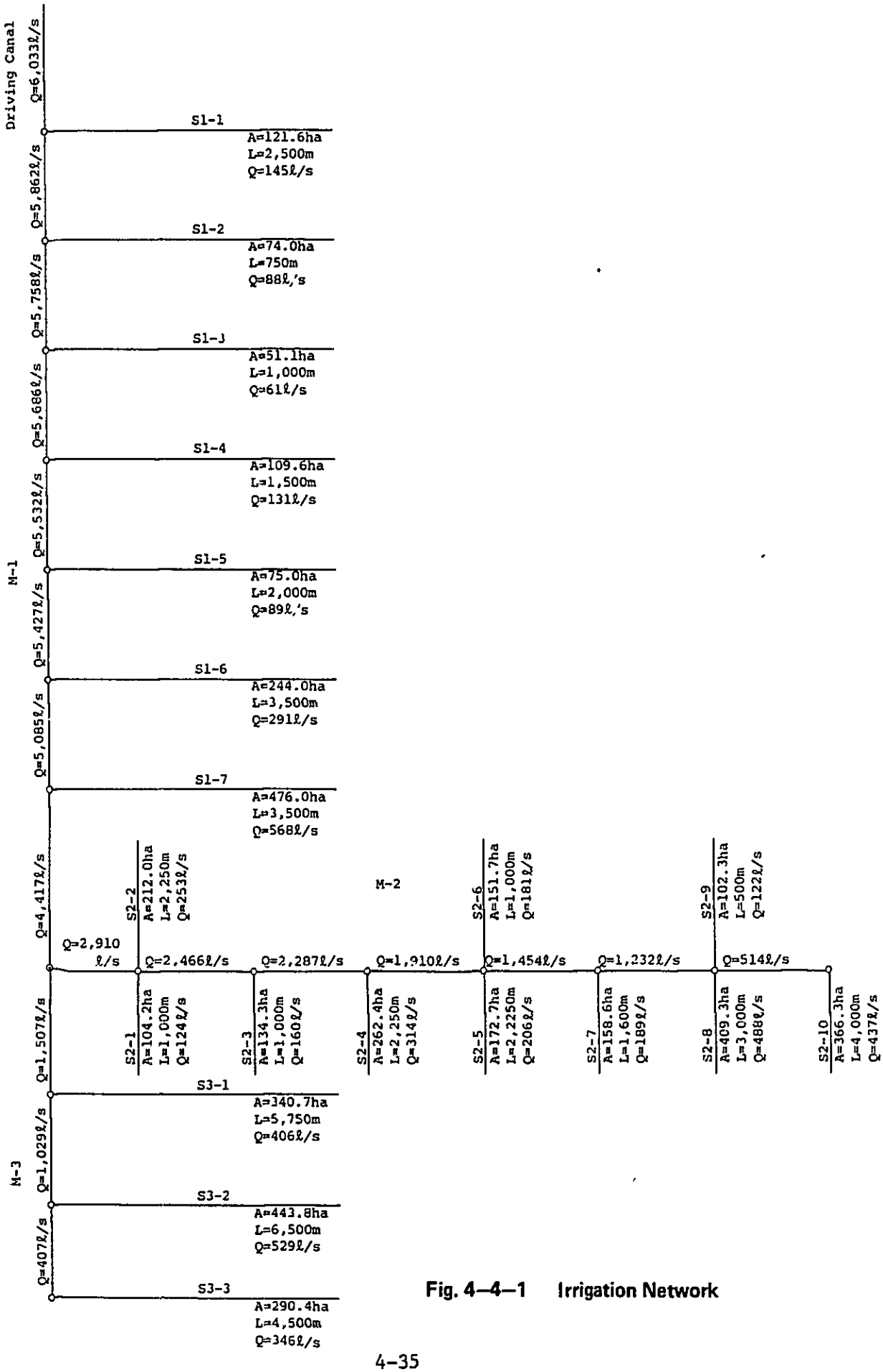
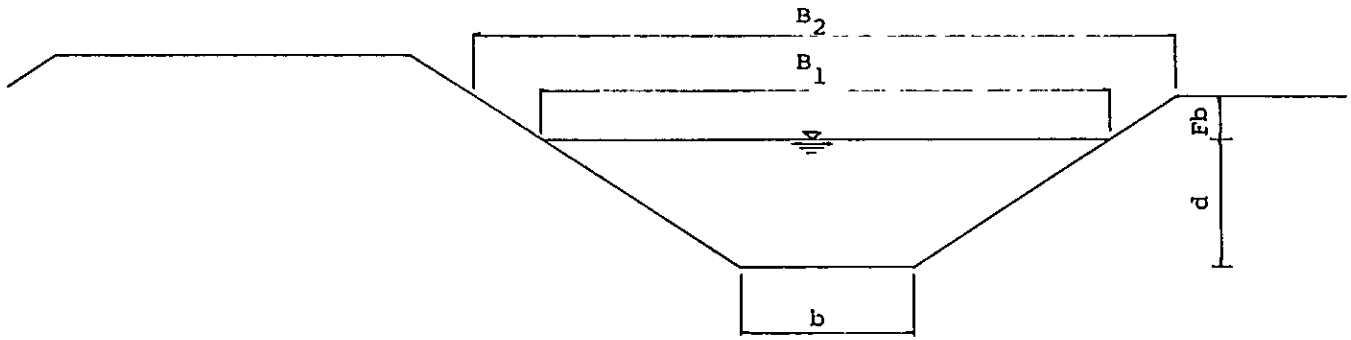


Fig. 4–4–1 Irrigation Network

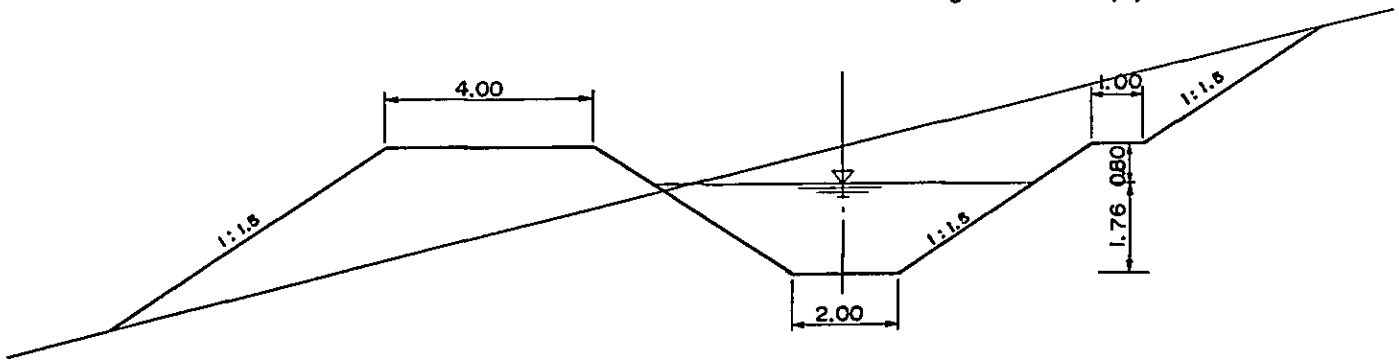
Fig. 4–4–2 Study of Canal Section



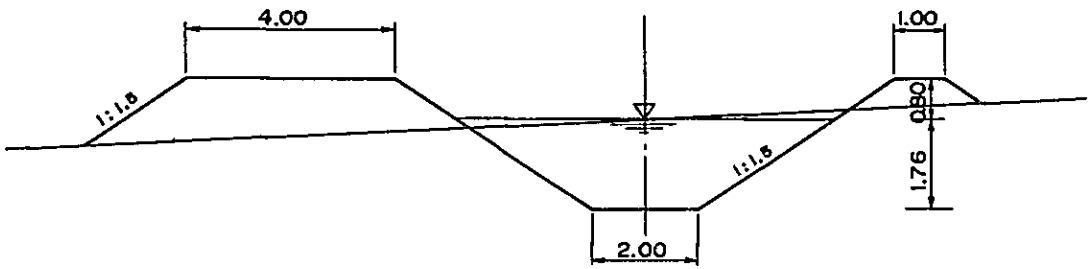
Coefficient of roughness: 0.03 (unlined canal)

Canal Type			I	II	III	IV	V	VI	Remarks
Slope Gradient			1:1.5					1:1	
Slope of Canal Bed			1/2,000	1/1,000					
Discharge			6.0 m^3	3.0 m^3	1.5 m^3	0.6 m^3	0.3 m^3	0.02 m^3	
Canal bed width	b	(m)	2.00	2.00	1.00	0.50	0.50	0.30	
Water depth	d	(m)	1.76	1.05	0.93	0.70	0.50	0.18	
Width of water surface	B_1	(m)	7.28	5.15	3.79	2.60	2.00	0.66	
Flow area	A	(m)	8.1664	3.754	2.2274	1.085	0.625	0.0864	
Wetted perimeter	P	(m)	8.3458	5.786	4.353	3.024	2.303	0.809	
Hydraulic mean depth	R		0.9785	0.6488	0.5117	0.3588	0.2714	0.1068	
R2/3			0.9856	0.7494	0.6397	0.505	0.4192	0.2251	
Velocity	V	(m/s)	0.735	0.790	0.674	0.532	0.442	0.237	
Discharge	Q	(m^3s)	6.00	2.96	1.50	0.58	0.28	0.02	
Freeboard	Fb	(m)	0.30	0.30	0.30	0.30	0.30	0.30	
Width of canal	B_2	(m)	8.18	6.05	4.69	3.50	2.90	1.26	

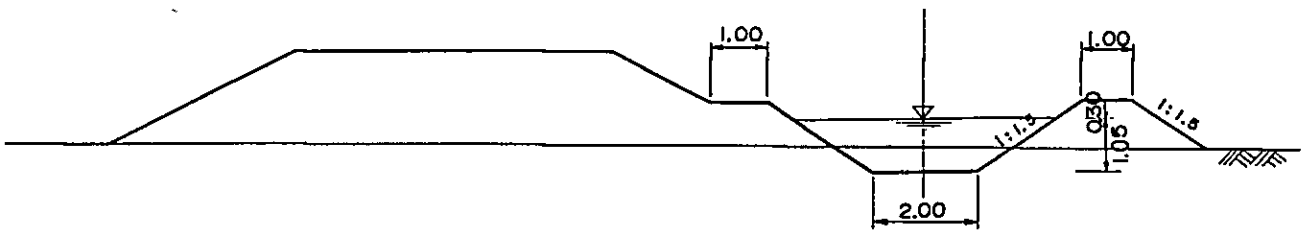
Fig. 4–4–3 Standard Cross Section of Irrigation Canal (1)



Driving canal

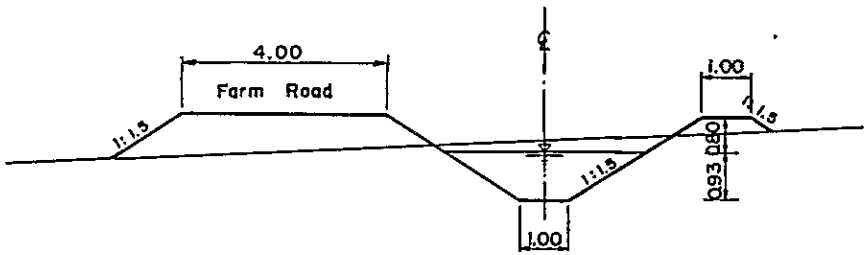


Main canal (M-1)

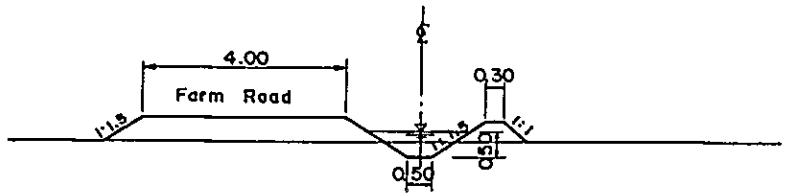


Main canal (M-2)

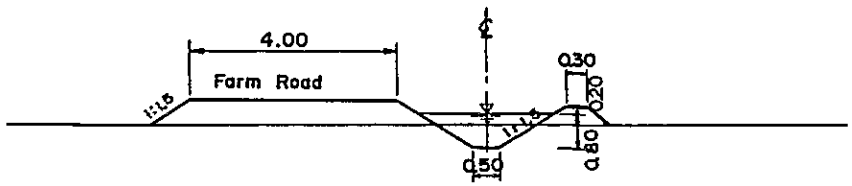
Fig. 4–4–3 Standard Cross Section of Irrigation Canal (2)



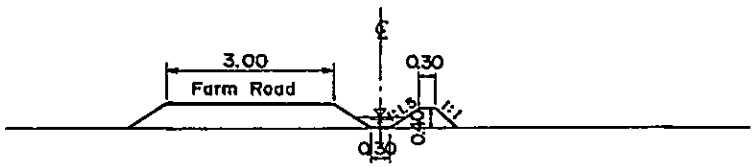
Main canal (M-3)



Secondary canal



Secondary canal



Tertiary canal

Fig. 4-4-4 Longitudinal Profile of Driving Canal & Main Canal (1)

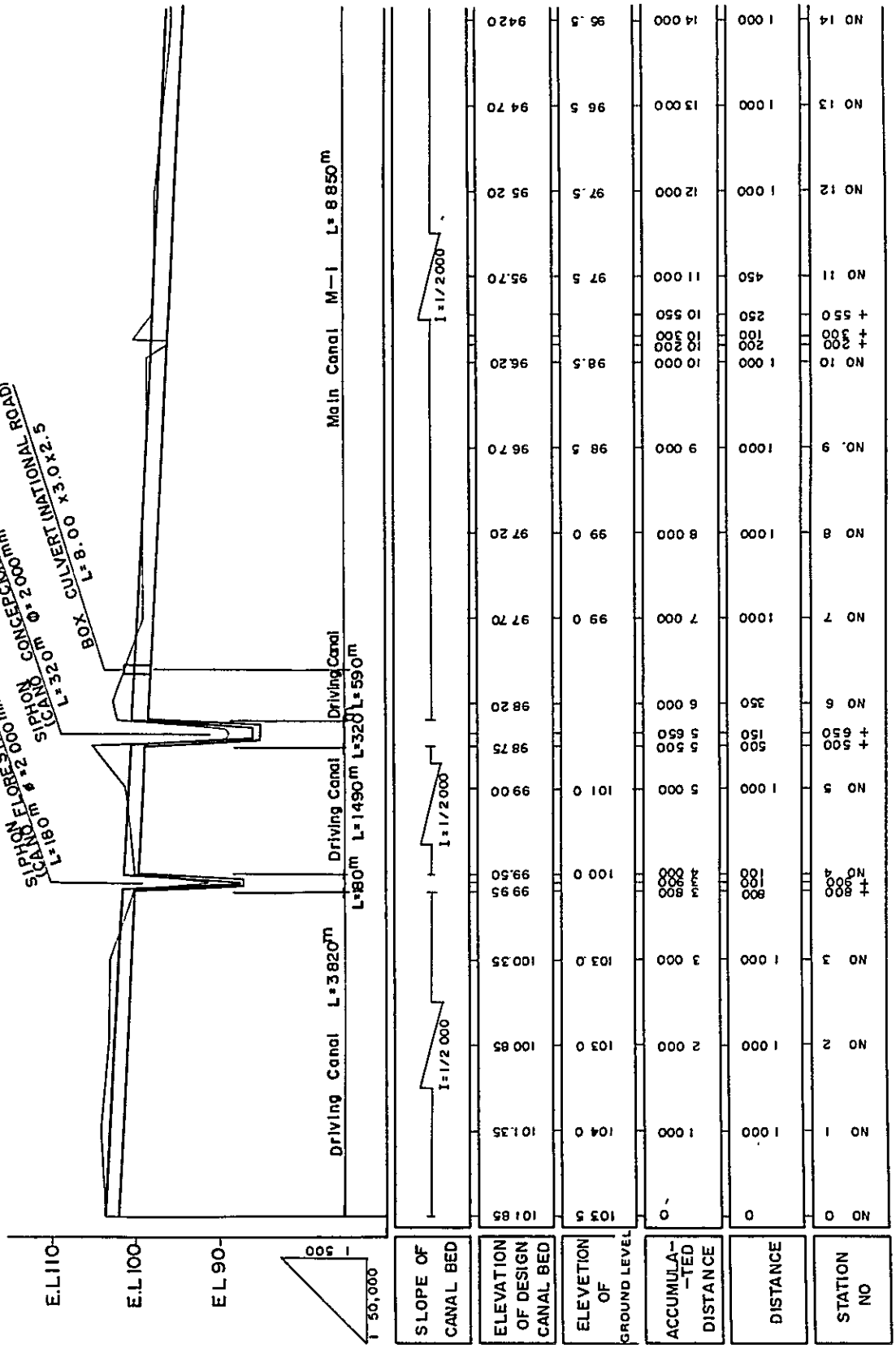


Fig. 4-4-4 Longitudinal Profile of Driving Canal & Main Canal (2)

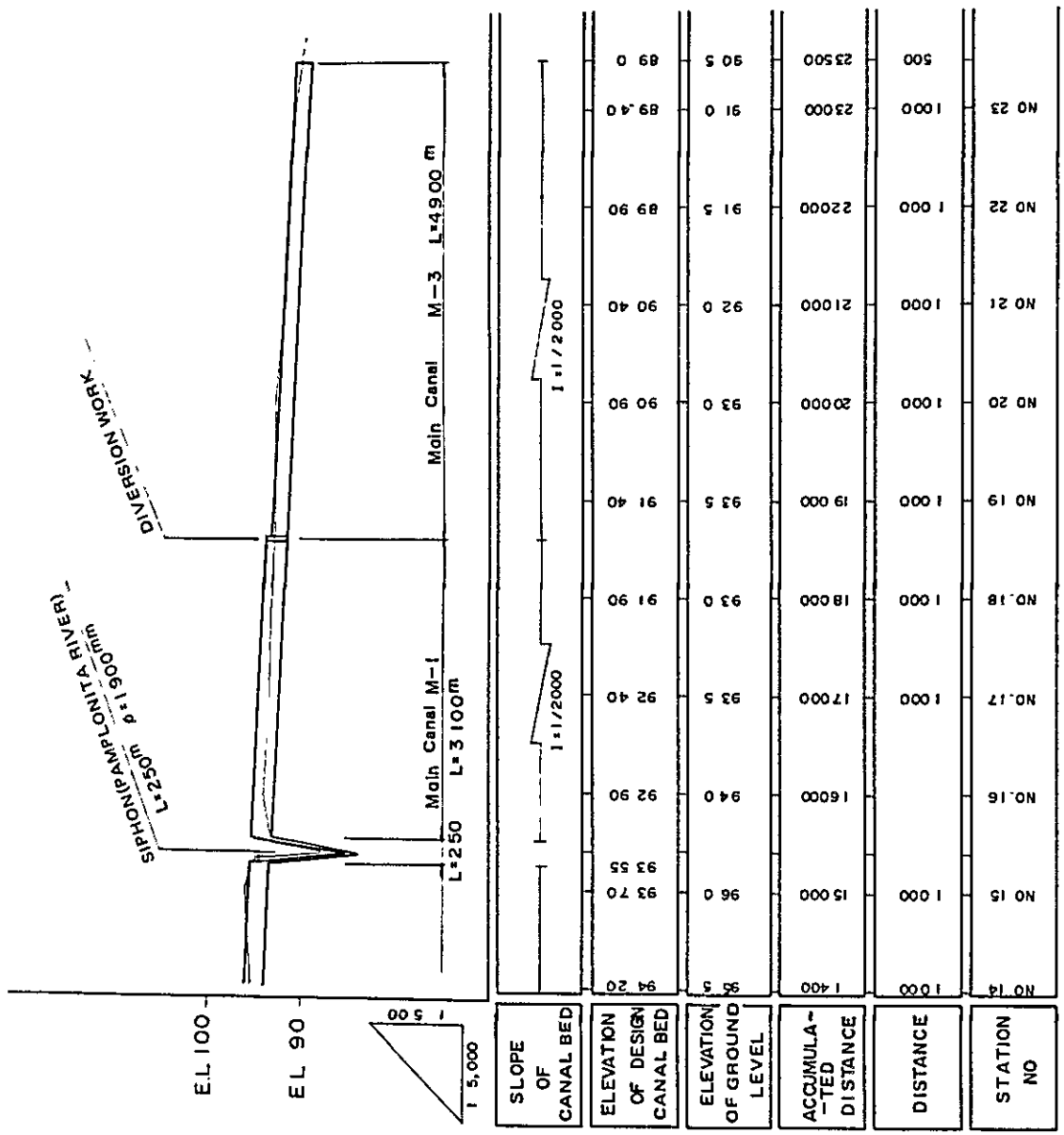


Fig. 4–4–4 Longitudinal Profile Nain Canal (M–2)

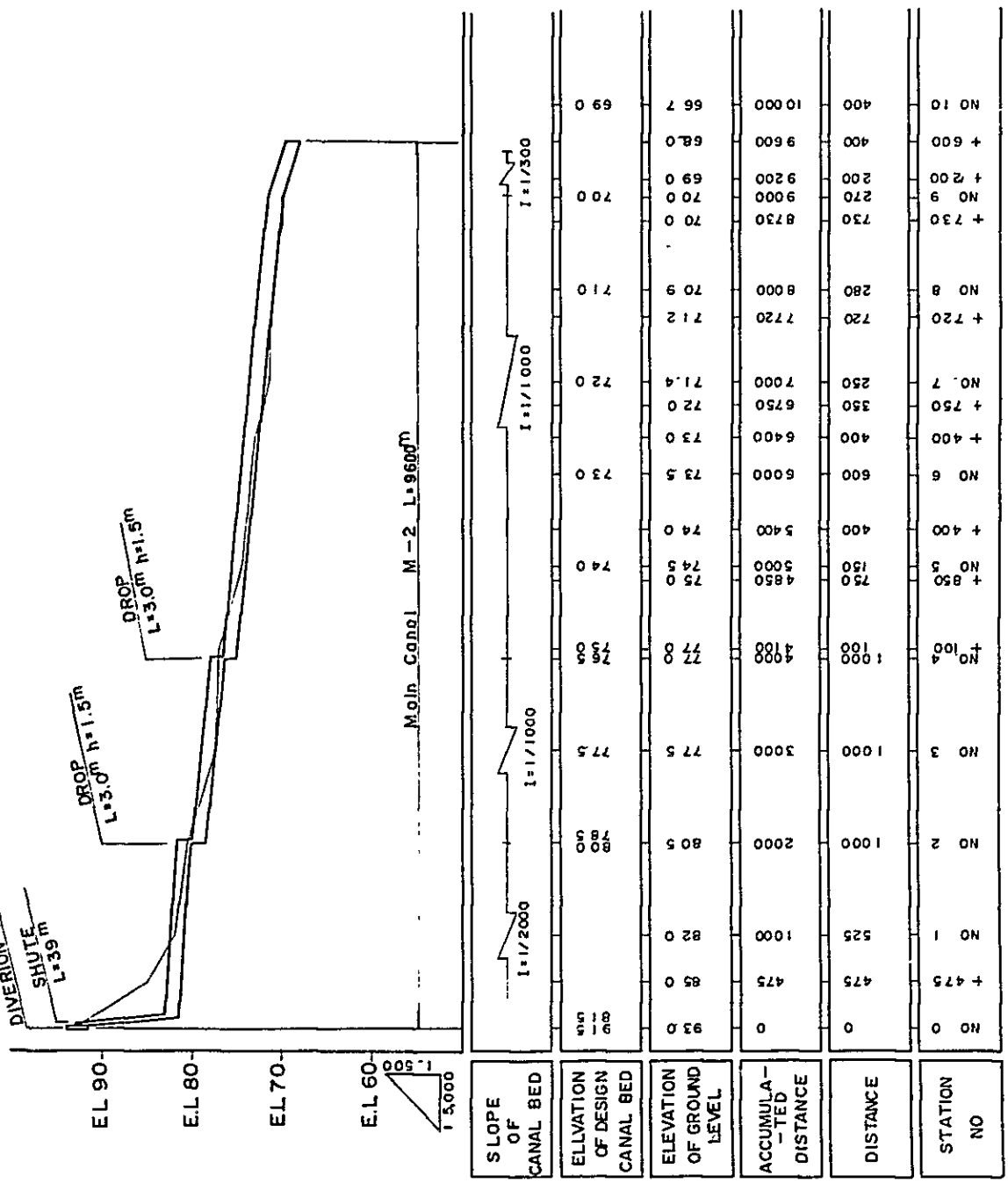


Table 4–4–1 Summary of Irrigation Canal

Canal	Irrigation Area (ha)	Discharge Q (ℓ)	Distance of Canal (m)				
			Driving	Main	Secondary	Tertiary	Total
Driving Canal			6,400				6,400
Main Canal - 1	1,151.3			12,200			12,200
S1-1	121.6	145			2,500	4,674	7.174
S1-2	74.0	88			750	3,616	4,366
S1-3	51.1	61			1,000	2,015	3,015
S1-4	109.6	131			1,500	4,966	6,466
S1-5	75.0	89			2,000	2,425	4,425
S1-6	244.0	291			3,500	10,896	14,396
S1-7	476.0	568			3,500	24,584	28,084
Sub-total				12,200	14,750	53,176	80,126
Main Canal - 2	2,073.8			9,600			9,600
S2-1	104.2	124			1,000	5,148	6,148
S2-2	212.0	253			2,250	10,258	12,508
S2-3	134.3	160			1,000	6,924	7,924
S2-4	262.4	314			2,250	13,232	15,482
S2-5	172.7	206			2,250	7,939	10,189
S2-6	151.7	181			1,000	7,950	8,950
S2-7	158.6	189			1,600	7,757	9,357
S2-8	409.3	488			3,000	21,148	24,148
S2-9	102.3	122			500	5,536	6,036
S2-10	366.3	437			4,000	17,612	21,612
Sub-total				9,600	18,850	103,504	131,954
Main Canal - 3	1,074.9			4,900			4,900
S3-1	340.7	406			5,750	14,351	20,101
S3-2	443.8	529			6,500	19,684	26,184
S3-3	290.4	346			4,500	12,634	17,134
Sub-total				4,900	16,750	46,669	68,319
Total			6,400	26,700	50,350	203,349	286,799

APPENDIX 5. SOIL, LAND CLASSIFICATION, GROUNDWATER AND WATER QUALITY

LIST OF TABLES

LIST OF FIGURES

5.1 General

Soil and land classification of the project area were surveyed and reported by INCORA in 1970 (ref. "Estudio Detallado de Suelos y Clasification de Tierras para Riego, Proyecto Norte de Santander No. 1, 1970").

The field survey was excuted in this study at the following main points;

1) reviewing and checking the INCORA's study
2) additional investigation for the preparation of irrigation and drainage plan
3) re-testing of the present soil condition

The survey area covers 13,500ha of the whole project area. The survey is prepared based on the 1 to 10,000 scale new topographic map with refering aerial photographs in scale 1 to 10,000.

New 75 pits are surveyed in addition with 36 points of INCORA's survey, these points are selected based on the topographic, drainage, vegetation and soil conditions.

Test pits are excavated and inspected 1.5 meter depth. Chemical analysis of 70 soil samples are executed by the laboratory of ICA.

5.2 Soil

5.2.1 General Description

Soils in the study area is classified into the following 10 series by INCORA.

Location		Series (Abbreviation)
Alluvial Plain	Natural Levee	1) Javilla soil (JA) 2) Cambulos soil(CA) 3) Pamplonita soil(PA)
	Central Plain	4) Zulia soil (ZU) 5) La Union soil (LU) 6) Guaramito soil (GU)
River Terrace		7) La Jarra soil (LJ) 8) Alto Viento soil (AV) 9) Fortaleza soil (FO) 10) Maranõn soil (MA)

Soil series on natural levee shows silty soil and soil series on central plain is clayey to silty soil. These are located topographically on rather flat plain. Soil series on River terrace shows sandy soil except LJ series, and they are located topographically on flat to slightly hilly land.

Mapping unit for soil map are classified into 14 soil type based on soil series and soil texture. Mapping units and classified area are shown in Table 5-2-1 and Fig. 5-2-1.

Table 5–2–1 Hectarage of Classified Soils

Soil Series	Texture	Area (ha)	Percentage (%)
A) Soils on natural levee			
Javilla	CL	1,760	13.0
Javilla	SiL	430	3.2
Cambulos	L	370	2.7
Cambulos	SiCL	1,010	7.5
Pamplonita	SL	310	2.3
Sub-total		3,880	28.7
B) Soils on central plain			
Zulia	SiCL	1,100	8.2
La Union	L	250	1.9
La Union	SiCL	1,300	9.6
Guaramito	C	1,830	13.6
Guaramito	SiCL	2,390	17.7
Sub-total		6,870	50.9
C) Soils on Terrace			
La Jarra	C	220	1.6
Alto Viento	SL	330	2.5
Fortaleza	LS	1,210	9.0
Marañon	LS	270	2.0
Sub-total		2,030	15.1
Residential Area, roads & rivers		720	5.3
Total		13,500	100.0

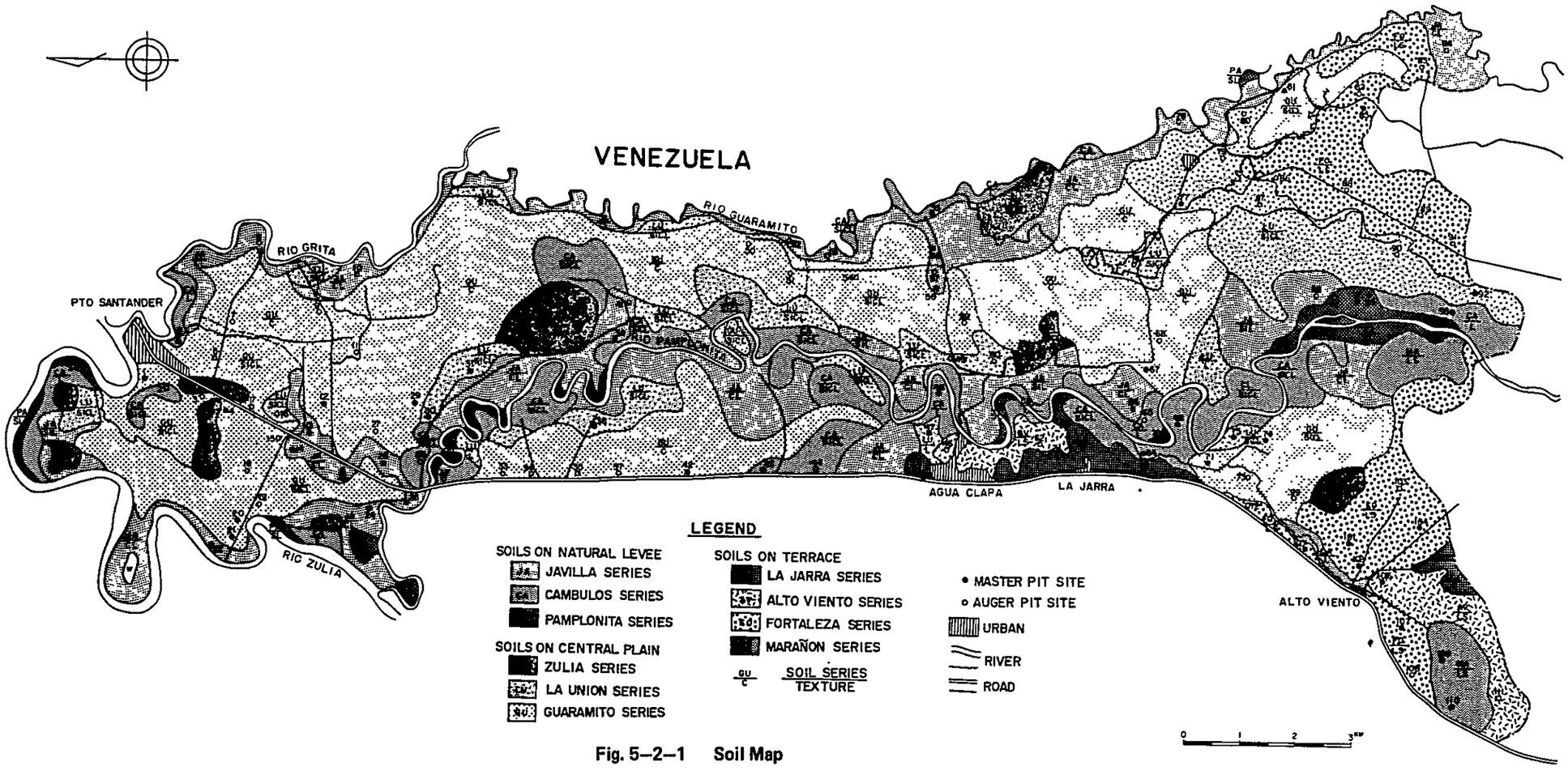


Fig. 5–2–1 Soil Map

5.2.2 Description of Soil Series

(1) Javilla (JA) Series

This soil series are shown on the natural levee of the Zulia, Pamplonita, Grita and Guaranito river, and the acreage is 2,170ha. This soil series are similar to CA and PA series, but JA series locate on the oldest river levees. These are imperfectly to proofly drained and groundwater table raises less than 1 meter from ground surface therefore clay horizon and Zuro erosion appear partially. The soil productivity shows moderate to high. pH of this soil series show medium to slightly acidicy and permeability and infiltration capacity show moderate to low. Mapping units of the series are divided into clay loam and silty loam by their textures.

At present, land use is pasture land, but the area that is not effected by the flood, is cultivated as cassava, plantain (banana), maize and cacao field. Theis soil series area needs flood protection, drainage improvement and Zuro removal for the agricultural development.

(2) Cambulos (CA) Series

This soil series is similar to JA series, but they locate on younger river levees and acreage is 1,780ha. These are imperfectly to poorly drained and locate on the area where the groundwater table raise less than 1 meter and are effected the flood, therefore, same as JA series, clay horizon and Zuro erosion appear partially.

Soil productivity of the series shows moderate to low and pH is slightly acidicy. The permeability and infiltration ratio show moderate to low. Mapping units of this series are divided into loam and silty clay loam.

At present, these areas are mostly used as a pasture and partially cultivated for cassava, plantain and maize. This soil series area needs flood protection, drainage improvement and Zuro removal for the future development as same as JA soil series.

(3) Pamplonita (PA) Series

This soil series is youngest alluvium soil and distributed along the main rivers and the acreage is 310ha. They are located on young natural levee and composed with coarse grain soil. The permeability and infiltration show moderately or moderately high but the area is occasionally submerged by the flood. Because of the soil texture is sandy loam, the soil productivity is moderate to slightly low. pH shows neutral and no Zuro erosion is observed. At present, because of frequent flooding, the area is not used so much. By introducing flood protection and irrigation for the area, it has high development potential.

(4) Zulia (ZU) Series

This Zulia soil series scattered at the old river channel and is mixed with JA and CA series. Acreage of the series is estimated

1,100ha in the project area.

They are very poorly drained and they are always saturated. During rainy season, they are casually inundated. Under these conditions, clay horizon is clearly found out. Soil productivity is moderate to low. pH of the series is neutral. They show low permeability and infiltration ratio. Zuro erosion is not found out. At present, they are used as a pasture. After improving the drainage, they can be developed as an intensive pasture land.

(5) La Union (LU) Series

This soil series locates at transition area between the soil series on natural levee (JA, CA, PA) and the soil series on central plain, and the acreage is estimated 1,550ha.

At groundwater table of the series is usually very high and imperfectly to poorly drained, therefore, the clay horizon is developed and the Zuro erosion is found out at many places. Soil class grade is estimated at the 4th grade. Their pH show low acidity to neutral, with usually imperfect permeability and infiltration. The mapping unit of this series is deveded into loam and silty clay loam by their soil texture. At present, they are used almost as a pasture, after improving drainage, they can be possible to be an internsive pasture.

(6) Guaramito (GU) Series

This soil series covers most part of the central plain in the low land and the acreage is estimated at 4,220ha.

They are similar to LU series, but they are harder and finer than LU series. They are imperfectly and poorly drained and clear clay horizon is found. The soil pH shows neutral to low acidity. They show low permeability and infiltration ratio. The Zuro type erosion is found at many places. The mapping unit of the series is devided into clay and silty clay by their soil texture. They show poor tillage, and the soil productivity seems to be moderate. At present, they are mostly used as a pasture land, and it is indispensable to improve the drainage and remove the Zuro for the future agricultural development. Especially, the improvement of drainage using pan breaker is recommended.

(7) La Jarra (LJ) Series

This soil series appears only a part on south-west hilly land of the Project area, and the acreage is estimated 220ha. Comparing with other soil series, the soil layer is thick, about 1.5 meter. They are composed with clay, therefore, they show imperfect to poor drainage. The soil erosion is found at the sloping ground. The soil pH shows high acidity, and the soil productivity is estimated moderate to low because of the shortage of phosphoric and other nutrients. At present, they are used as a pasture. After improving the drainage by pan breaking and changing the soil chemical property by lime and othe chemicals, they can be developed as an intensive farm land. At the steep sloping ground which has steeper than 10 percent gradient, the forest shall be conserved against soil erosion.

(8) Alto Viento (AV) Series

This soil series is sandy soil and, as same as FO and MA series, is distributed on the river terrace. The acreage is estimated 330ha. Their texture are sandy loam, in contrast, other soil series on the river terrace (FO and MA series) shows loamy sand. They are disturbed by the erosion and sedimentation. They are well drained and the groundwater table is below 2-3 meter from ground surface. Soil pH shows low to high acidity, and cation-exchange capacity is small. The soil productivity is estimated moderate to low. The infiltration ratio is rather high. At present, they are used as a pasture land. After introduction of irrigation, soil improvement by lime, etc. and fertilization, they have high production potential.

(9) Fortaleza (FO) Series

This soil series is loamy sand, and widely distributed on the river terrace. The acreage is estimated 1,210ha. Similar to MA series, but this series is spread higher area river terrace, and is rather dry and the groundwater table is very low. The eluviation and desorption of the soil is remarkable, and the cation-saturation degree is very low. The soil pH shows high acidity and cation exchange capacity is low. Because of low moisture holding capacity, their soil productivity is low but the tillage is better than soils in lower land. The infiltration ratio is generally high. At present, they are used as a pasture and a cashew nuts field. Neutralization of soil by chemicals, fertilization and introduction of irrigation are required for the future development.

(10) Maranõn (MA) Series

This soil series is spread on the lower river terrace. The acreage is estimated 270ha. They are well drained in general, but during flood season the groundwater table raises up. Therefore, the eluviation is remarkable on the soil, the cation-saturation degree is low and the soil pH shows very high acidity. Soil production is moderate to low, as same as FA series. The permeability and infiltration ratio shows high and the tillage is superior. The cation exchage capacity is low. At present, they are used as a pasture. After improvement of acidic soil, fertilization and introduction of irrigation, they can be expected higher productivity.

5.2.3 Chemical Properties

Results on soil chemical analysis of each series are shown in Table 5-2-2.

The top soil of the lower land contains carbon and nitrogen 1 to 2 and 0.1 to 0.25 percent, respectively, and organic matter contents a little. The soil on the river terrace contents carbon and nitrogen 0.5 to 1 and 0.05 to 0.1 percent, respectively. The soil pH of the lower land shows 5.5 to 7.5. On the other hand, the soils on the river terrace show pH 4.0 to 5.0, these high acidity are caused by heavy eluviation and lack of base. The cation exchange (CEC) of the lower land soil is 10 to 25 me/100g, relatively high, and they contain many basis. On the other hand, CEC of the river