REPUBLIC OF SRI LANKA

FEASIBILITY REPORT
ON
THE INGINIMITIYA RESERVOIR PROJECT

VOLUME [illegible] ANNEXES

OCTOBER 197[illegible]

[illegible] JAPAN INTERNATIONAL [illegible]

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FEASIBILITY REPORT
ON
THE INGINIMITIYA RESERVOIR PROJECT

VOLUME II : NOTES

OCTOBER 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

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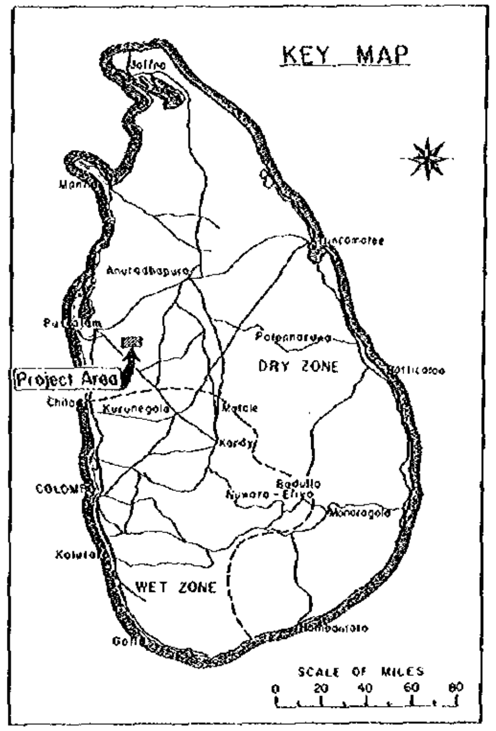
GENERAL PLAN OF THE INGINIMITIYA RESERVOIR PROJECT



LEGEND

- ; Main Canal
- ; Existing Paddy Field
- ; Existing Tank
- ; Road
- ; Project Area

SCALE OF MILES

0 0.5 1.0 1.5 2.0

INGINIMITIYA RESERVOIR PROJECT THE REPUBLIC OF SRI LANKA	
GENERAL PLAN	
Date: Jun. 1977	D.W.G. No. 1

I CLIMATE AND HYDROLOGY

1.1 General

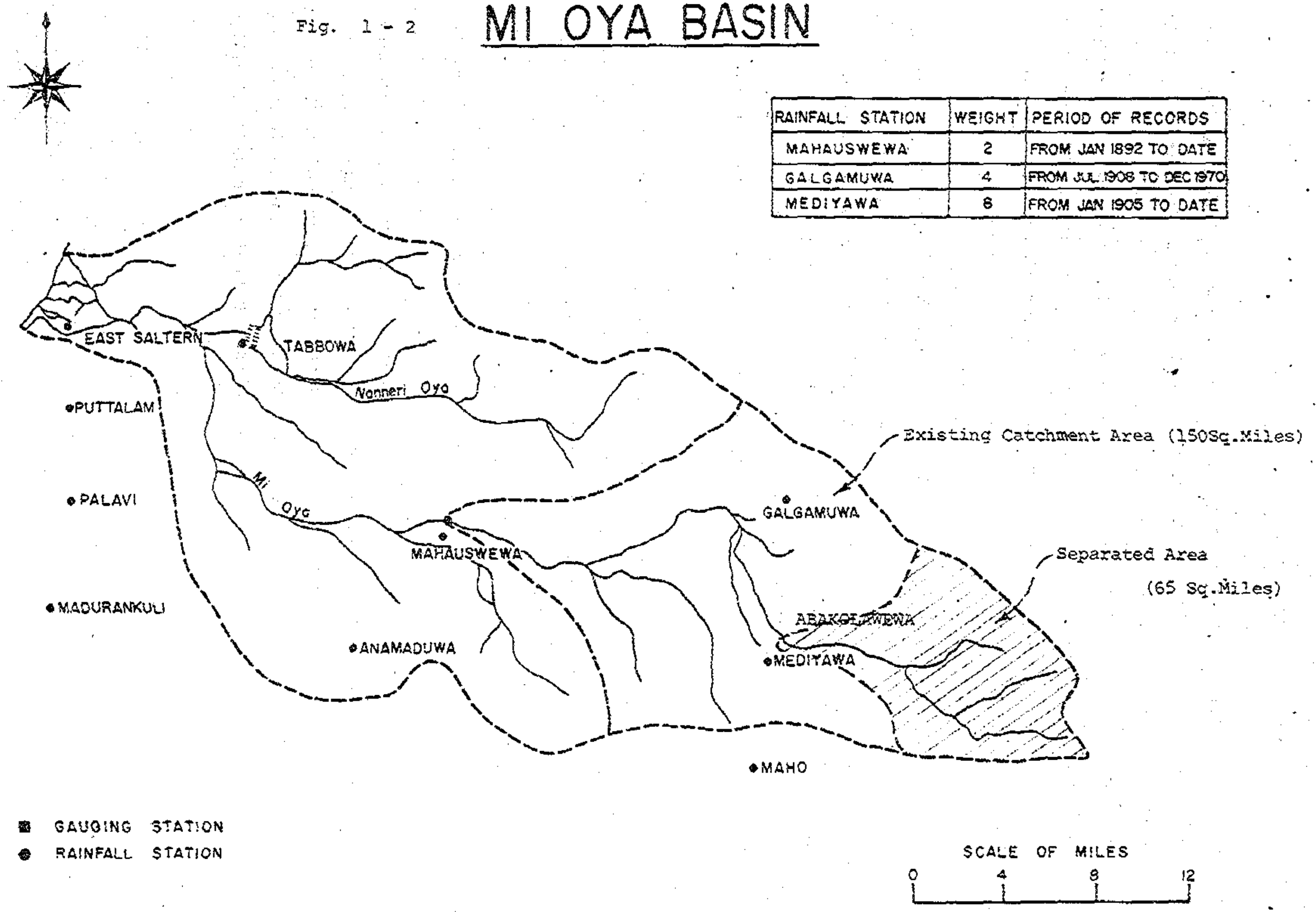
Sri Lanka is a tropical island in the Indian Ocean located between 5°55' ~ 9°50' N and 79°40' ~ 82°0' E, separated from the Indian sub-continent by the Bay of Bengal in the north, the Palk Strait in the northwest, and the Arabian Sea in the west. Its climate is characterized by nearly constant temperatures but with large variations in rainfall. Based on precipitation, the island can be divided into two distinct zones: the wet zone (average annual rainfall over 75 inches), situated in the southwest quadrant and covering about 30% of the land area, and the dry zone (average annual rainfall 35 to 75 inches) covering the remainder of the island. The Project area lies in the latter, obtaining more than two-thirds of its annual precipitation during the northeastern monsoon season called "Maha" (October ~ March). The rest of the year (April ~ September) is under the influences of the southwestern monsoon and is called "Yala" season with little rain, extremely dry during three months of July through September.

The Project area is situated in the basin of the Mi-Oya, the 14th in size among Sri Lanka rivers, which originates at a 1,000 feet-level height between Dambulla and Maho and, after running in westward direction for about 68 miles, flows into Puttalam Lagoon. There are two rainfall stations (at Galgamuwa and Mediyawa) in the upper-stream of the proposed dam and one rainfall station at Mahauswewa which is located at the centre of the Project area. A gauging station along the Mi-Oya is also situated at Mahauswewa. Records available at Mahauswewa rainfall station date back to 1921 (for about 55 years) and those of Mahauswewa gauging station, to 1946 (for about 30 years). Location of the meteorological stations in the Mi-Oya's basin is shown in Fig. 1-2. As for the meteorological data excepting rainfall, the records kept at either Puttalam or Maha-Illuppallama are conveniently referred to.

Fig. 1 - 2

MI OYA BASIN

RAINFALL STATION	WEIGHT	PERIOD OF RECORDS
MAHAUSWEWA	2	FROM JAN 1892 TO DATE
GALGAMUWA	4	FROM JUL 1908 TO DEC 1970
MEDIYAWA	6	FROM JAN 1905 TO DATE



1.2 Climate

(1) Rainfall: Mean monthly rainfalls at Mahauswewa, Galgamuwa and Mediyawa for the last 20 years are given in Tables 1-1, 1-2, and 1-3, respectively.

(2) Temperature: Monthly mean, maximum, and minimum temperatures at Puttalam are given in Table 1-4.

(3) Evaporation: Evaporation records have been kept at Tabbowa in the lower-stream of the Mi-Oya which are given in monthly averages in Table 1-5.

(4) Sun Shine Hours: Monthly mean percentages of sun-shine hours at Maha-Illuppallama for the last 19 years are given in Table 1-6.

(5) Humidity: Monthly mean relative humidity at Puttalam and Maha-Illuppallama for the last 20 years are given in Tables 1-7 and 1-8, respectively.

(6) Wind Direction and Wind Velocity: Wind directions have been observed at Puttalam, and the wind velocity at both Puttalam and Maha-Illuppallama. Table 1-9 gives the percentages of wind direction in 1965 and Table 1-10 and 1-11 give the monthly mean daily wind velocity in miles at Puttalam and Maha-Illuppallama, respectively.

Table 1-1 Mean Monthly Rainfall at Maha Uswewa

-: Not Available

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1955/56	8.82	11.72	1.99	0.72	0.70	9.79	4.30	0.58	3.14	0	0	0.17	41.93
1956/57	5.71	15.70	5.42	1.57	2.52	0.42	4.61	5.82	3.82	0	0	0	45.59
1957/58	10.18	15.32	23.95	1.75	0.55	13.18	16.18	-	-	0.50	5.45	0	87.06
1958/59	6.48	7.00	2.96	4.17	0.16	0.05	11.31	10.34	2.20	1.77	0.80	3.59	50.83
1959/60	9.26	10.23	3.41	2.93	3.83	0.87	11.06	4.84	0.35	5.65	0	0	52.43
1960/61	7.57	16.47	1.57	7.47	1.55	2.44	6.07	2.93	4.84	3.36	0.99	3.57	58.83
1961/62	9.55	5.45	5.14	4.23	3.79	2.00	4.29	9.79	2.55	1.54	2.01	1.98	52.32
1962/63	25.08	9.06	5.86	8.18	3.46	3.40	6.19	6.36	2.12	1.46	0.16	3.32	74.65
1963/64	8.21	18.66	8.61	1.14	1.13	1.13	5.02	2.25	0.31	4.23	1.40	7.03	59.12
1964/65	6.44	10.30	5.75	0.59	-	0.46	10.84	5.45	0.25	0	5.68	0.50	46.26
1965/66	5.89	6.60	9.23	1.24	0.60	1.55	14.14*	-	0	0.20	0.40	2.81	42.66
1966/67	11.33	14.75	5.96	2.20	0.85	6.33	6.55	2.46	2.63	1.50	0	1.13	55.69
1967/68	11.37	8.74	8.37	1.24	0.85	5.08	6.64	0.18	1.20	1.63	0	2.20	47.50
1968/69	10.85	4.34	8.27	1.62*	1.36*	0.45*	7.25*	2.02	0.42	0	3.56	0	40.14
1969/70	19.33	5.65	8.71	2.61	3.17	4.42	16.27	7.98	0	1.20	0	3.01	72.35
1970/71	8.66	8.29	-	2.82	3.08	3.04	10.76	3.43	3.25	0.32	-	-	43.65
1971/72	-	-	-	0	0	2.71	7.23	13.25	0	0.29	0	5.47	28.95
1972/73	14.55	12.72	5.16	0	0.32	5.02	7.46	1.03	2.93	1.10	0.49	2.74	53.52
1973/74	10.39	7.23	12.49	0	2.32	4.13	11.74	1.44	0.33	1.01	1.44	1.01	53.53
1974/75	0.32	2.70	3.31	0.08	3.16	1.60	5.50	4.30	0.49	4.83	0.61	2.94	29.84
Mean	10.00	10.05	7.01	2.23	1.76	3.40	8.67	4.69	1.62	1.53	1.21	2.18	54.35

Table 1-2 Mean Monthly Rainfall at Galgamuwa

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1955/56	13.64	8.64	4.31	1.06	0.00	7.34	4.41	2.23	2.70	0.00	0.37	0.00	44.70
1956/57	4.22	12.44	7.27	2.00	2.73	1.31	9.28	5.07	2.52	0.89	0.00	0.00	47.73
1957/58	11.80	17.18	30.84	1.06	0.50	8.91	15.52	4.30	3.15	0.00	3.36	0.00	96.62
1958/59	6.74	9.30	4.25	3.95	0.21	0.00	13.43	8.20	1.99	0.58	0.00	1.46	50.11
1959/60	8.27	11.61	5.07	1.68	3.20	1.82	8.60	2.55	0.81	8.27	0.00	0.17	52.05
1960/61	3.83	50.40	4.26	7.43	3.09	1.00	5.60	7.95	5.81	2.55	0.61	1.44	93.97
1961/62	17.52	8.31	5.23	4.53	1.56	10.97	6.99	4.54	0.24	0.21	0.30	5.18	65.59
1962/63	22.60	5.97	4.96	8.95	4.19	3.48	5.12	3.74	2.58	2.22	0.63	5.05	69.49
1963/64	13.34	14.44	10.48	1.84	0.79	2.41	6.13	1.48	0.71	4.69	1.31	2.63	60.25
1964/65	5.10	12.32	3.45	1.42	2.42	0.78	12.56	6.14	0.00	0.00	4.18	0.00	48.37
1965/66	17.07	13.32	11.71	3.14	0.00	3.52	9.57	1.35	0.00	0.27	0.00	4.26	64.21
1966/67	13.83	15.43	8.57	1.15	2.20	4.54	4.19	2.87	2.04	0.53	0.00	0.98	56.33
1967/68	17.20	7.03	9.57	1.74	0.00	6.91	6.33	0.21	1.16	1.32	0.00	3.51	54.98
1968/69	10.22	10.42	9.63	1.14	0.52	0.67	5.65	1.69	0.00	0.00	5.79	0.21	45.94
1969/70	15.54	2.34	10.67	2.32	6.48	1.21	11.46	4.42	0.00	0.50	0.00	3.41	58.35
1970/71	7.29	5.57	4.29										17.15
1971/72													
1972/73													
1973/74													
1974/75													
Mean	11.76	12.80	8.41	2.89	1.86	3.66	8.32	3.78	1.58	1.47	1.10	1.89	59.52

Table 1-3 Mean Monthly Rainfalll at Mediyawa

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1955/56	16.80	10.18	1.72	0.00	0.00	4.14	3.65	1.32	1.64	0.00	0.13	0.20	39.78
1956/57	5.06	12.34	8.15	2.81	2.76	0.00	17.31	2.23	5.06	1.49	0.07	0.00	57.28
1957/58	8.58	14.23	25.21	1.47	0.65	7.50	13.47	2.37	1.00	0.54	0.79	0.00	75.81
1958/59	2.68	6.13	3.89	2.21	0.92	0.37	11.04	6.30	3.36	2.16	0.84	2.58	42.48
1959/60	13.31	10.78	3.13	2.70	3.78	0.45	11.02	2.97	1.57	8.92	0.32	0.74	59.69
1960/61	4.52	16.41	2.75	3.68	2.09	1.89	2.30	5.22	5.62	2.23	1.08	0.71	48.50
1961/62	6.61	7.29	3.42	3.89	0.45	4.19	13.78	6.52	1.08	2.09	1.85	4.44	55.61
1962/63	24.25	6.75	3.78	9.00	2.55	4.06	4.09	5.15	2.31	2.63	0.39	3.51	68.47
1963/64	10.41	12.92	7.84	1.77	2.36	1.54	5.73	0.98	0.84	3.43	2.37	4.27	54.46
1964/65	5.23	6.65	2.94	1.48	3.42	0.27	18.05	7.49	0.85	0.20	7.33	0.39	54.30
1965/66	11.97	11.65	9.80	1.46	0.05	4.03	7.50	0.49	0.71	0.72	0.30	6.06	54.74
1966/67	12.17	12.60	6.08	1.41	1.98	4.62	5.46	2.90	3.53		0.80	1.20	52.75
1967/68	21.58	8.35	10.09	1.52	0.00	5.80	7.24	2.05	4.76	0.82	0.00	1.10	62.81
1968/69	14.20	8.97	8.29	1.38	1.62	0.88	8.12	5.40	0.92	0.07	4.81	0.20	54.86
1969/70	18.29	4.80	12.61	4.77	4.13	3.82	10.15	5.71	0.28	1.41	0.00	4.53	70.50
1970/71	7.49	7.91	3.99	7.04	2.59	2.08	14.06	0.96	1.40	0.46	4.75	3.14	55.87
1971/72	9.32	4.75	7.54	0.57	0.00	2.31	5.72	10.31	0.00	0.64	0.00	3.65	44.81
1972/73	9.88	8.89	5.63	0.00	0.81	2.04	4.52	4.86	0.61	4.23	0.54		42.01
1973/74	5.63	4.35	12.55	0.00	6.61	2.17	11.39	3.32	0.43	2.62	0.87	2.51	52.45
1974/75	0.12	3.05			3.02	2.26	10.15	5.49	1.87	3.66	0.33	5.71	35.66
Mean	10.41	8.95	4.34	2.48	1.99	2.72	9.24	4.10	1.87	2.02	1.38	2.37	54.87

Table 1-4 Monthly Mean, Maximum and Minimum Temperature at Puttalam in °C

Month	Maximum	Minimum	Mean
Jan.	29.8 (85.7)	21.2 (70.2)	25.4 (77.8)
Feb.	31.3 (88.3)	21.3 (70.4)	26.3 (79.4)
Mar.	32.3 (90.1)	22.8 (73.0)	27.4 (81.3)
Apr.	31.9 (89.5)	24.5 (76.1)	28.2 (82.7)
May	31.4 (88.6)	26.6 (79.8)	28.6 (83.4)
Jun.	30.4 (86.7)	26.3 (79.3)	28.2 (82.7)
Jul.	30.2 (86.4)	25.7 (78.3)	27.8 (82.0)
Aug.	30.4 (86.8)	25.6 (78.0)	27.8 (82.1)
Sep.	30.7 (87.3)	25.6 (78.0)	27.9 (82.2)
Oct.	30.3 (86.6)	25.7 (78.3)	27.2 (80.9)
Nov.	29.9 (85.8)	25.7 (78.2)	26.3 (79.4)
Dec.	29.4 (84.9)	25.8 (78.4)	25.6 (78.0)
Year	30.7 (87.2)	25.7 (78.2)	27.2 (81.0)

Table 1-5 Monthly Average Evaporation in inches at Tabbowa

Month	Pan. evaporation	Surface evaporation
Jan.	4.37	3.50
Feb.	4.64	3.71
Mar.	5.95	4.76
Apr.	5.54	4.43
May	5.70	4.56
Jun.	6.02	4.82
Jul.	6.04	4.83
Aug.	6.88	5.50
Sep.	6.46	5.17
Oct.	5.30	4.24
Nov.	4.00	3.20
Dec.	4.09	3.27
Year Total	64.99	51.99

Table 1-6 Monthly Mean Percentage of Sun Shine hours at Maha-Illuppalluma (%)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1957													
1958	72	86	84	85	79	69	82	73	94	59	61	75	77
1959	85	92	111	86	85	54	71	92	76	72	50	60	78
1960	62	55	94	79	68	83	68	89	65	81	40	64	71
1961	81	68	88	85	72	79	-	-	-	-	-	-	79
1962	55	89	91	94	73	95	77	86	75	63	65	67	78
1963	51	75	84	89	89	90	81	85	82	66	41	46	73
1964	67	75	87	97	94	82	79	86	69	77	66	67	79
1965	79	77	90	85	79	96	95	78	91	70	63	44	79
1966	75	92	80	83	96	99	79	76	75	60	72	59	79
1967	74	84	92	99	80	83	75	86	83	73	68	53	79
1968	75	50	76	91	102	67	69	91	64	78	66	81	76
1969	73	91	100	85	78	88	67	84	89	63	65	52	78
1970	72	78	92	87	78	87	78	84	81	73	52	46	76
1971	56	90	87	92	75	73	83	82	73	66	66	27	73
1972	86	99	95	93	69	77	84	88	88	62	71	61	81
1973	88	92	97	79	73	73	77	64	68	62	60	42	73
1974	89	88	98	86	81	89	83	83	67	76	80	51	81
1975	70	94	86	84	90	64	85	74	70	67	46	57	74
1976	68	99	97	90	98	99	84	78	86	75	55	57	82
Mean	73	83	91	88	82	81	75	82	78	69	60	56	77

Table 1-7 Monthly Mean Relative Humidity at Puttalam

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1957	65	72	59	65	72	74	69	69	75	72	80	81	71
1958	71	68	68	70	74	72	71	72	65	71	76	69	71
1959	66	62	58	70	72	72	70	65	67	69	76	73	68
1960	71	66	64	72	74	71	72	68	68	68	77	60	69
1961	67	66	65	69	69	70	70	68	65	66	72	70	68
1962	72	64	58	64	69	66	67	64	75	72	66	68	66
1963	71	64	64	66	68	66	66	62	64	68	74	70	67
1964	66	61	62	63	63	62	63	62	64	65	66	64	63
1965	58	58	55	61	66	65	62	66	64	70	68	73	64
1966	66	61	61	62	65	63	68	66	68	74	68	68	66
1967	66	63	62	65	71	71	73	69	69	73	75	75	69
1968	66	61	69	73	67	74	74	74	70	73	74	76	71
1969	70	67	65	72	76	74	74	72	71	78	76	81	73
1970	76	72	71	77	82	77	76	72	71	74	81	75	75
1971	80	64	69	69	78	74	71	72	71	72	71	80	73
1972	67	64	62	69	79	76	79	75	75	80	77	76	73
1973	66	64	66	72	74	77	75	74	75	76	74	81	73
1974	67	63	68	76	76	76	76	73	75	72	67	71	72
1975	69	71	74	78	78	76	76	80	78	78	85	76	77
1976	71	68	68	74	75	70	76	75	71	77	85	83	74
Mean	69	65	64	69	72	71	71	70	70	72	74	74	70

Table 1-8 Monthly Mean Relative Humidity at Maha-Illuppalluma (1957 ~ 1976)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1957	73	69	57	64	74	75	68	63	58	71	84	87	70
1958	78	68	70	75	76	72	65	70	56	71	79	74	71
1959	74	63	50	69	74	74	65	57	60	65	82	78	68
1960	76	80	66	72	73	66	70	64	61	62	80	74	70
1961	72	70	64	67	70	66	66	60	58	61	74	76	67
1962	75	68	58	70	69	62	63	62	69	77	78	81	69
1963	82	76	72	66	62	68	67	61	63	74	86	86	73
1964	77	72	68	64	70	64	65	66	69	70	80	77	70
1965	71	69	58	66	70	65	58	68	61	72	78	81	68
1966	74	68	67	70	66	62	62	60	65	75	74	76	68
1967	72	69	62	62	69	67	63	60	56	64	74	76	66
1968	68	56	63	64	60	67	64	57	61	68	74	74	65
1969	74	60	57	70	70	64	60	63	58	74	72	78	66
1970	71	71	62	67	72	65	64	60	63	73	77	75	68
1971	74	62	62	66	68	67	62	61	63	67	71	80	67
1972	66	57	51	58	70	62	60	56	57	73	70	73	63
1973	62	60	50	64	65	64	60	60	57	65	68	76	63
1974	61	56	58	68	75	70	67	64	67	62	63	75	66
1975	69	63	65	71	72	73	67	69	69	76	86	79	72
1976	76	65	58	72	71	63	66	69	60	70	83	82	70
Mean	72	66	61	67	70	67	64	63	62	70	77	78	68

Table 1-9 Percentage of Wind Direction in 1965 at Puttalam

Month		N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	CALM.
Jan.	8:30	16	68	15	2	0	0	0	0	0
	17:30	31	55	6	0	0	0	0	5	3
Feb.	8:30	18	39	20	9	4	0	0	0	11
	17:30	21	27	16	0	0	7	4	18	7
Mar.	8:30	13	15	26	6	24	10	0	0	6
	17:30	32	5	0	0	0	11	34	18	0
Apr.	8:30	5	10	7	5	27	8	0	5	33
	17:30	5	8	0	0	5	27	37	12	7
May	8:30	0	3	0	10	15	63	0	0	10
	17:30	0	0	0	0	3	85	5	0	6
Jun.	8:30	0	0	0	0	2	93	5	0	0
	17:30	0	0	0	0	0	100	0	0	0
Jul.	8:30	0	0	3	0	13	83	0	0	0
	17:30	0	0	0	0	0	100	0	0	0
Aug.	8:30	0	0	0	0	0	45	52	0	3
	17:30	0	0	0	0	0	42	58	0	0
Sep.	8:30	0	0	0	0	5	95	0	0	0
	17:30	0	0	0	0	3	90	7	0	0
Oct.	8:30	0	0	6	3	23	23	3	3	39
	17:30	10	2	0	3	6	32	26	11	10
Nov.	8:30	5	35	13	10	7	3	0	3	23
	17:30	23	32	2	0	3	2	15	3	20
Dec.	8:30	11	37	6	3	6	6	3	3	23
	17:30	21	23	0	3	3	10	10	2	29

Table 1-10 Monthly Mean Daily Wind Mileage at Puttalam

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1957	160	150	161	138	171	314	289	314	302	176	106	143	202
1958	151	129	122	99	197	317	289	274	260	187	129	139	191
1959	150	140	147	136	178	259	290	282	262	181	123	135	190
1960	140	143	128	116	230	292	227	266	301	181	110	129	189
1961	137	115	126	129	230	266	240	282	239	171	122	140	183
1962	129	141	136	130	183	267	286	269	283	167	126	125	187
1963	136	136	116	87	135	299	263	281	260	170	107	144	178
1964	145	142	112	120	264	307	283	298	303	211	138	144	206
1965	151	140	153	134	244	325	287	262	287	144	121	121	197
1966	134	140	120	102	284	277	262	224	215	132	119	128	178
1967	137	150	141	138	208	237	241	249	212	161	146	142	180
1968	154	150	136	123	203	265	274	272	250	152	122	138	187
1969	154	146	140	134	197	263	237	196	252	141	110	130	175
1970	138	136	131	114	185	234	237	226	214	178	120	150	172
1971	140	145	118	124	199	258	228	231	220	164	131	140	175
1972	165	138	147	132	202	218	227	240	211	128	107	151	172
1973	146	161	129	123	188	225	208	233	213	144	106	128	167
1974	148	155	124	123	188	241	233	236	180	189	121	160	175
1975	163	158	136	109	280	351	261	301	273	263	174	163	219
1976	168	184	144	158	306	297	315	312	282	174	136	144	218
Mean	147	145	133	123	214	276	259	262	251	171	124	140	187

Table 1-11 Monthly Mean Daily Wind Mileage at Maha-Illuppalluma

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1957	114	95	90	82	98	255	268	292	239	148	76	98	154
1958	98	64	49	28	114	282	232	216	223	126	64	90	132
1959	95	71	56	59	113	196	256	267	231	132	58	76	134
1960	62	60	50	74	198	273	199	239	284	147	87	-	152
1961	118	89	105	110	193	231	213	250	211	148	110	100	157
1962	102	116	108	97	100	176	238	215	206	120	83	93	138
1963	105	126	94	80	109	218	195	199	181	116	74	96	133
1964	107	121	102	76	192	221	199	208	210	140	77	105	147
1965	112	120	101	80	178	246	192	183	221	104	87	95	143
1966	109	122	85	88	220	219	236	204	187	98	72	79	143
1967	82	106	99	80	170	212	226	232	200	134	112	113	147
1968	108	110	111	86	167	238	250	253	223	112	82	94	153
1969	111	96	82	72	166	238	234	169	210	87	74	95	136
1970	112	110	92	65	170	211	220	-	-	-	-	-	140
1971	-											-	-
1972	-	.... Wind Mileage data not available from Aug.1970 to Aug.1975										-	-
1973	-											-	-
1974	-											-	-
1975	-							-	267	268	139	112	-
1976	137	143	128	121	305	306	348	341	313	159	97	96	208
Mean	104	103	90	81	166	237	235	233	224	127	82	95	148

1.3 Hydrology

1.3.1 Rainfall Analysis

(1) Probable Rainfall

Mean monthly rainfalls at Mahauswewa for the last 20 years (Table 1-1) have been computed by Gumbel method to identify the probable rainfalls as per Table 1-12:

Table 1-12 Probable Rainfalls (at Mahauswewa)

Probability	Rainfall
1/1,000	122.64
1/500	115.13
1/200	105.21
1/100	97.68
1/50	90.13
1/20	80.05
1/10	72.26
1/5	64.15
1/2	51.89

The duration curve of annual rainfall is shown in Fig. 1-3.

(1) Maximum Daily Rainfall

Maximum daily rainfalls for the last 20 years at Mahauswewa which is located at the centre of the Project area are given in Table 1-14, and those in different probabilities are given in Table 1-13 below:

Table 1-13 Probable Maximum Daily Rainfall

Probability	Daily Rainfall
1/1,000	12.14
1/500	11.26
1/200	10.09
1/100	9.20
1/50	8.31

(continued)

Probability	Daily Rainfall
1/20	7.12
1/10	6.20
1/5	5.24
1/2	3.80

(3) Continuous Drought Days

Continuous drought days for the last 20 years at Mahauswewa which are given in Table 1-14 have been computed by Gumbel method into different probabilities as per Table 1-15 below:

Table 1-15 Probable Continuous Drought Days

Probability	Continuous Drought Days
1/200	196
1/100	178
1/50	160
1/30	146
1/20	136
1/10	117
1/5	97
1/3	82
1/2	68

Fig. 1-3 Annual Rainfall - Duration Cnrve (1956~1975)

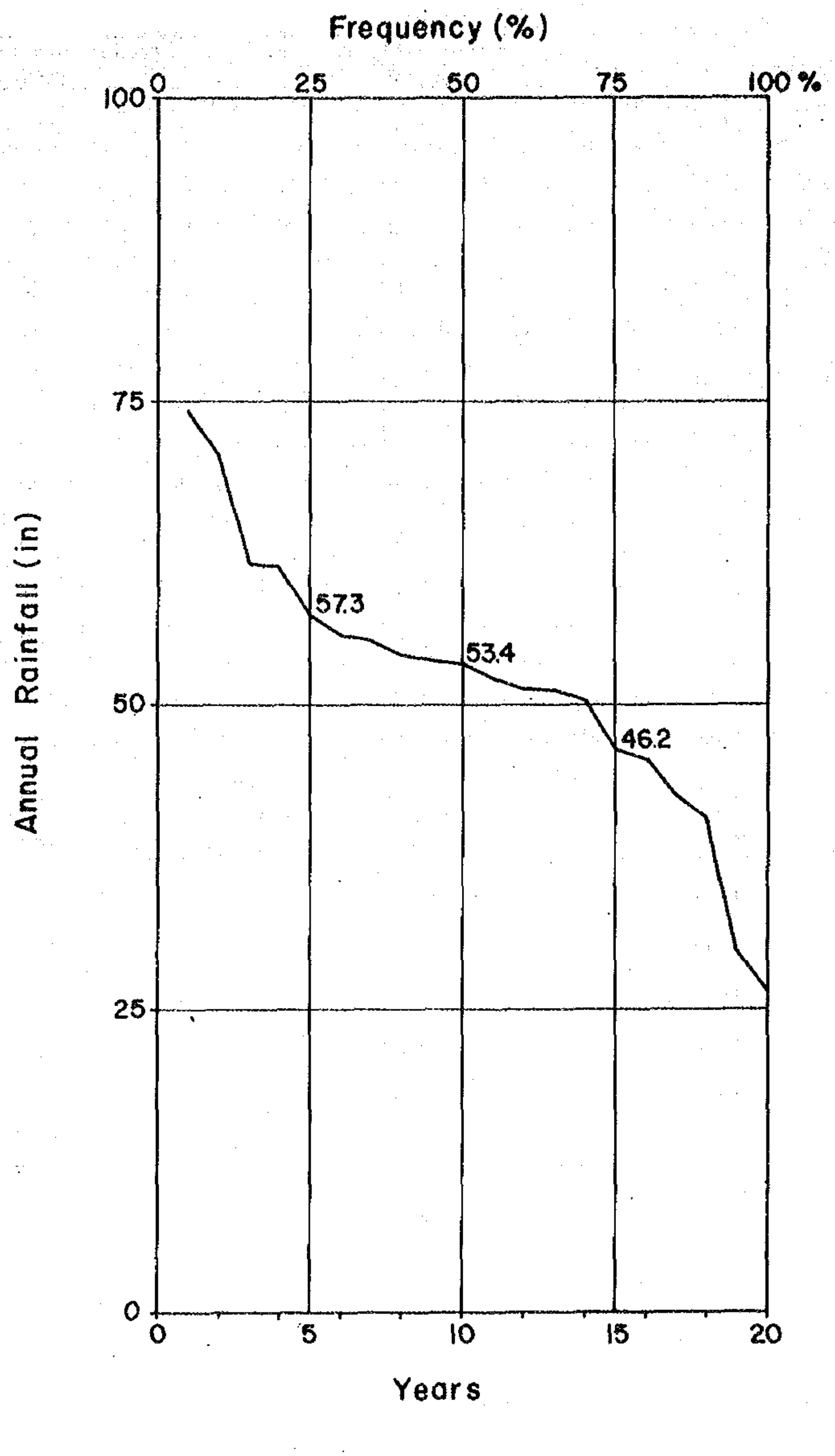


Table 1-14 Maximum Daily Rainfall and Continuous Drought Days (Maha Uswewa)

Year	Maximum Daily Rainfall (inches)	Continuous Drought Days (days)
1956	3.45	102
1957	4.53	134
1958	3.30	60
1959	3.25	74
1960	3.88	92
1961	6.50	30
1962	4.54	51
1963	6.56	70
1964	3.50	62
1965	3.00	91
1966	6.90	67+α
1967	5.02	58
1968	3.50	63
1969	1.60	50
1970	4.35	103
1971	3.55	30+α
1972	3.26	122
1973	4.00	85
1974	2.04	54
1975	3.21	46

1.3.2 Yield of the River

The Project intends to build a dam at the existing site of Inginimitiya Tank across the Mi-Oya which originates at 1,000 feet-level height between Dambulla and Maho and runs down along the central line of its basin during its 68 miles' westward journey into Puttalam Lagoon. It will create a new source of irrigation water to benefit agricultural development in the Project area which occupies the central part of the Mi-Oya's basin, at the foot of the proposed dam.

The discharge of the Mi-Oya has been recorded at Mahauswewa for the last 30 years since 1946; its data available for the last 20 years are given on monthly basis as per Table 1-16. The maximum monthly discharge recorded during these 20 years reads 15,739 Ac.ft., and the minimum, zero. As for the total annual discharge, the gap between the maximum (336,906 Ac.ft. in 1957/58) and the minimum (10,869 Ac.ft. in 1974/75) is extremely big.

The catchment area at Mahauswewa is recorded as 215 sq.miles but the diversion at Abakolawewa to the extent of 65 sq.miles makes its net catchment area to 150 sq.miles only. The discharge figures in Table 1-16 show those from this net catchment area of 150 sq.miles. The gauging figures recorded at Mahauswewa are given in daily means in cusecs and their probable daily discharges in cusecs are given in Table 1-18. The annual runoff duration curve for the last 20 years is shown in Fig. 1-4.

Table 1-16 Mean Monthly Yield Figures for Maha Uswewa

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Total
1955/56	26,453	27,846	43,537	9,225	1,368	16,478	455	222	367	369	369	178	126,867
1956/57	20	5,641	6,617	366	141	145	11,375	860	2,891	190	61	41	28,348
1957/58	6,461	59,382	157,391	24,459	6,991	16,111	52,464	6,659	1,210	1,394	1,681	2,703	336,906
1958/59	2,597	2,620	6,327	1,443	267	712	Nil	4,978	1,661	640	346	250	21,941
1959/60	10,694	19,030	20,263	5,742	3,045	1,473	3,230	2,334	988	5,928	927	165	73,819
1960/61	473	30,183	8,973	6,785	3,287	1,857	632	695	719	1,141	576	303	55,624
1961/62	2,475	20,721	13,884	6,770	3,463	2,905	2,457	7,660	2,010	738	3,310	1,055	67,498
1962/63	88,666	20,582	12,211	88,518	10,817	5,350	4,162	3,926	2,043	1,485	812	550	239,122
1963/64	2,647	52,912	62,382	15,430	5,934	5,696	1,772	1,388	1,141	990	1,055	822	152,169
1964/65	832	13,316	6,278	2,348	1,836	859	9,389	21,069	2,560	719	4,439	784	64,449
1965/66	8,332	13,446	47,762	4,503	4,330	1,598	13,127	3,012	1,893	505	333	700	99,541
1966/67	9,680	39,953	15,721	7,801	4,499	2,366	4,025	1,572	709	416	297	1,210	88,249
1967/68	17,091	9,882	40,049	6,585	2,624	10,274	5,619	2,101	1,076	1,307	459	259	97,326
1968/69	1,610	30,500	18,982	5,532	3,000	2,166	2,230	1,206	422	87	392	154	66,281
1969/70	9,356	8,902	12,662	15,254	7,968	3,632	18,275	10,740	2,604	881	1,030	1,148	92,452
1970/71	4,085	7,510	6,665	4,570	2,776	2,875	5,657	5,471	1,562	826	982	560	43,539
1971/72	5,683	12,058	31,011	2,582	2,101	944	3,491	28,122	2,241	1,800	752	1,241	92,025
1972/73	12,999	40,851	12,805	2,728	1,847	2,160	7,486	1,005	792	396	293	198	83,560
1973/74	2,447	3,528	12,591	4,714	772	2,132	18,869	1,552	1,653	1,146	226	46	49,676
1974/75	Nil	172	212	44	3,400	190	1,420	2,435	196	2,800	Nil	Nil	10,869
Mean	10,635	20,952	26,811	10,770	3,523	3,996	8,307	5,350	1,437	1,190	918	618	94,513

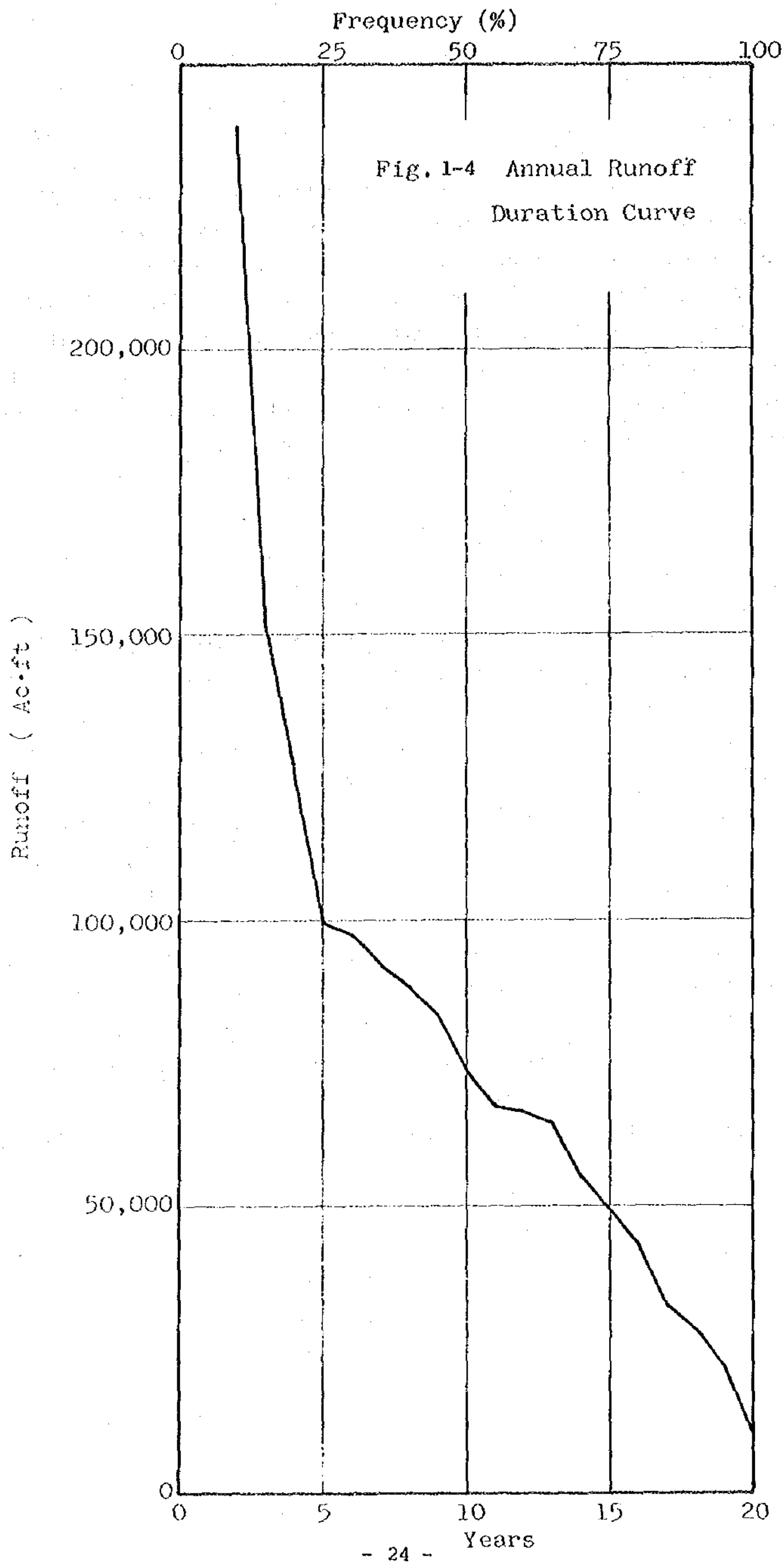
Table 1-17 Maximum Discharge at Maha Uswewa Gauging Station (Daily Mean)

(cusecs.)

Year	Month	Date	Discharge
1945	11	14	5,694
1946	12	23	18,575
1947	4	2	4,088
1948	8	3	4,852
1949	1	2	7,970
1950	12	22	1,580
1951	11	22	9,025
1952	1	3	4,938
1953	4	9	860
1954	1	11	2,506
1955	12	1	5,500
1956	12	27	2,085
1957	11	30	5,320
1958	4	29	5,200
1959	11	5	1,730
1960	11	24	1,710
1961	11	2	2,470
1962	10	12	8,750
1963	1	10	15,304
1964	11	15	820
1965	5	8	2,944
1966	11	10	9,823
1967	12	8	4,483
1968	11	20	10,001
1969	12	31	1,324
1970	5	5	1,698
1971	12	16	2,208
1972	5	14	2,651
1973	12	28	1,560
1974	4	10	1,235
1975	5	26	432
1976	4	3	1,698

Table 1-18 Probable Discharge
(By Gumbel Method)

Probability	Discharge
1/200	22,514.5 cusecs.
1/100	19,903.5
1/75	18,817.4
1/50	17,282.9
1/30	15,340.1
1/20	13,785.9
1/10	11,084.2
1/5	8,267.7
1/3	6,026.2
1/2	4,013.7


Frequency (%)
0
25
50
75
100
Fig. 1-4 Annual Runoff
Duration Curve
200,000
150,000
100,000
50,000
0
Runoff (Ac·ft)
0
5
10
15
20
Years

1.3.3 Flood Discharge

As the rainfall stations at Galgamuwa and Mediyawa in the Mi-Oya's basin in the upper-stream of the proposed dam have been recording rainfall on daily and monthly basis and no hourly rainfall record is available, the peak discharge has been computed from the hourly rainfall records which have been kept at Puttalam, Maha-Illuppallama and Kurunegala. Average rainfall in the entire basin of the Mi-Oya has been computed by use of Thiessen Polygon. The weighted ratio of each one of these three as determined through Thiessen Polygon is as follows:

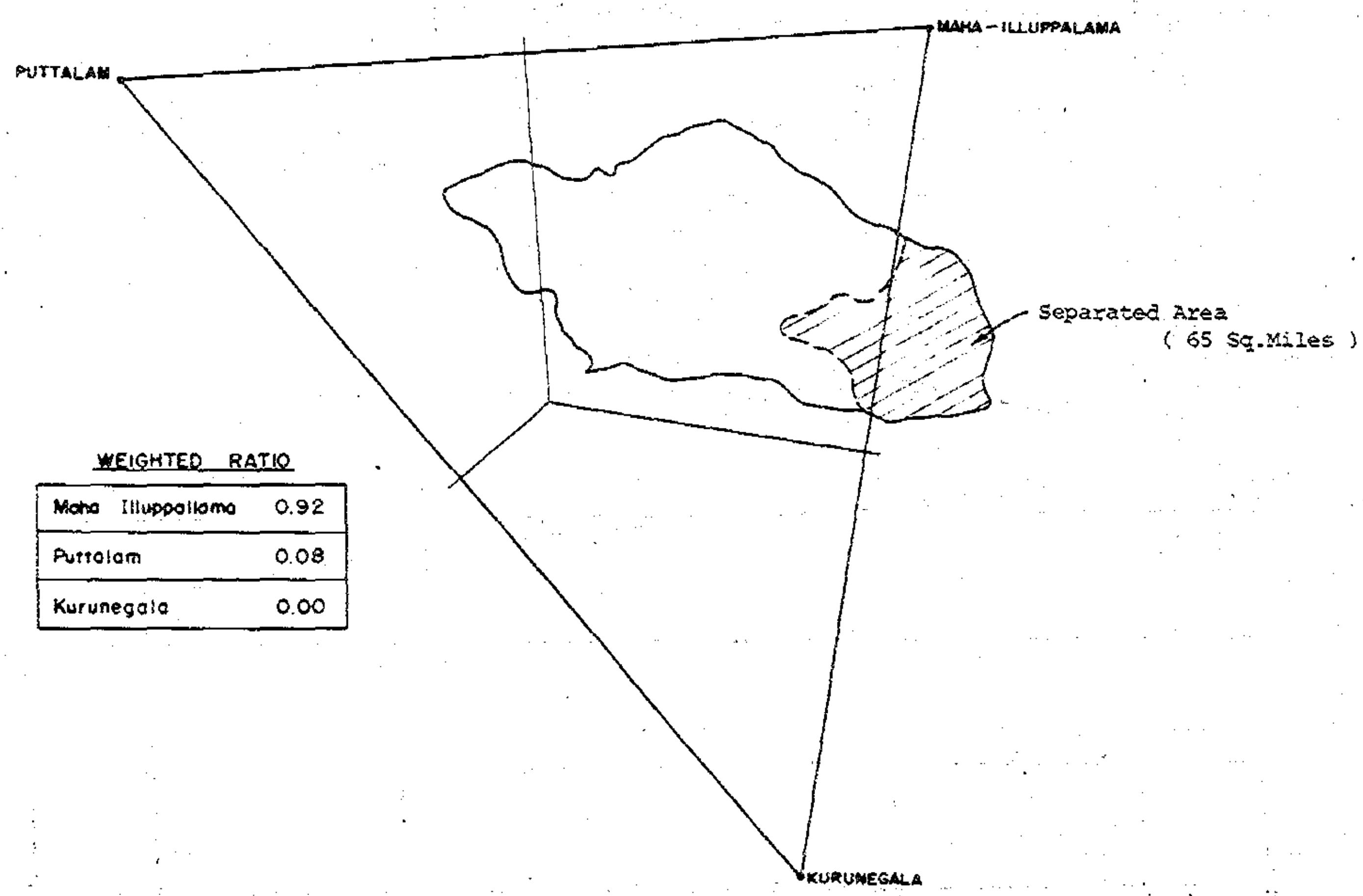
Maha-Illuppallama	0.92
Puttalam	0.08
Kurunegala	0.00

The flood peak discharge has, therefore, been computed from the data available at Maha-Illuppallama and Puttalam. Their data cover the period of 22 years since 1953. Fig. 1-6 has been drawn from the records of the flood which took place in October 1967, and Fig. 1-7 shows the results of hydrographing at 6 hour unit. 6 hour unit hydrograph has been translated into 3 hour unit hydrograph by use of the standard formula: $2u(6,t) = u(3,t) + u(3,t-3)$. Its calculation sheet is given in Table 1-19, and its illustration in Fig. 1-8.

Depth duration curves in the catchment area have been arrived at from those at Puttalam and Maha-Illuppallama by use of the weighted ratios obtained by Thiessen Polygon, as shown in Fig. 1-9. Depth duration curves and 3 hour unit hydrograph given in Table 1-19 bring the flood hydrograph in different probabilities of 1/100, 1/200 and 1/1000, as is calculated in Tables 1-20 ~ 1-22, and illustrated in Fig. 1-10. The peak discharges will be as follows:

Probability	Peak Discharge
1/100	60,100 cusecs
1/200	65,600 "
1/1000	78,600 "

Fig. 1-5 THIESSEN POLYGON



WEIGHTED RATIO

Maha Illuppallama	0.92
Puttalam	0.08
Kurunegala	0.00

Fig. 1-6 OCTOBER 1967 FLOOD

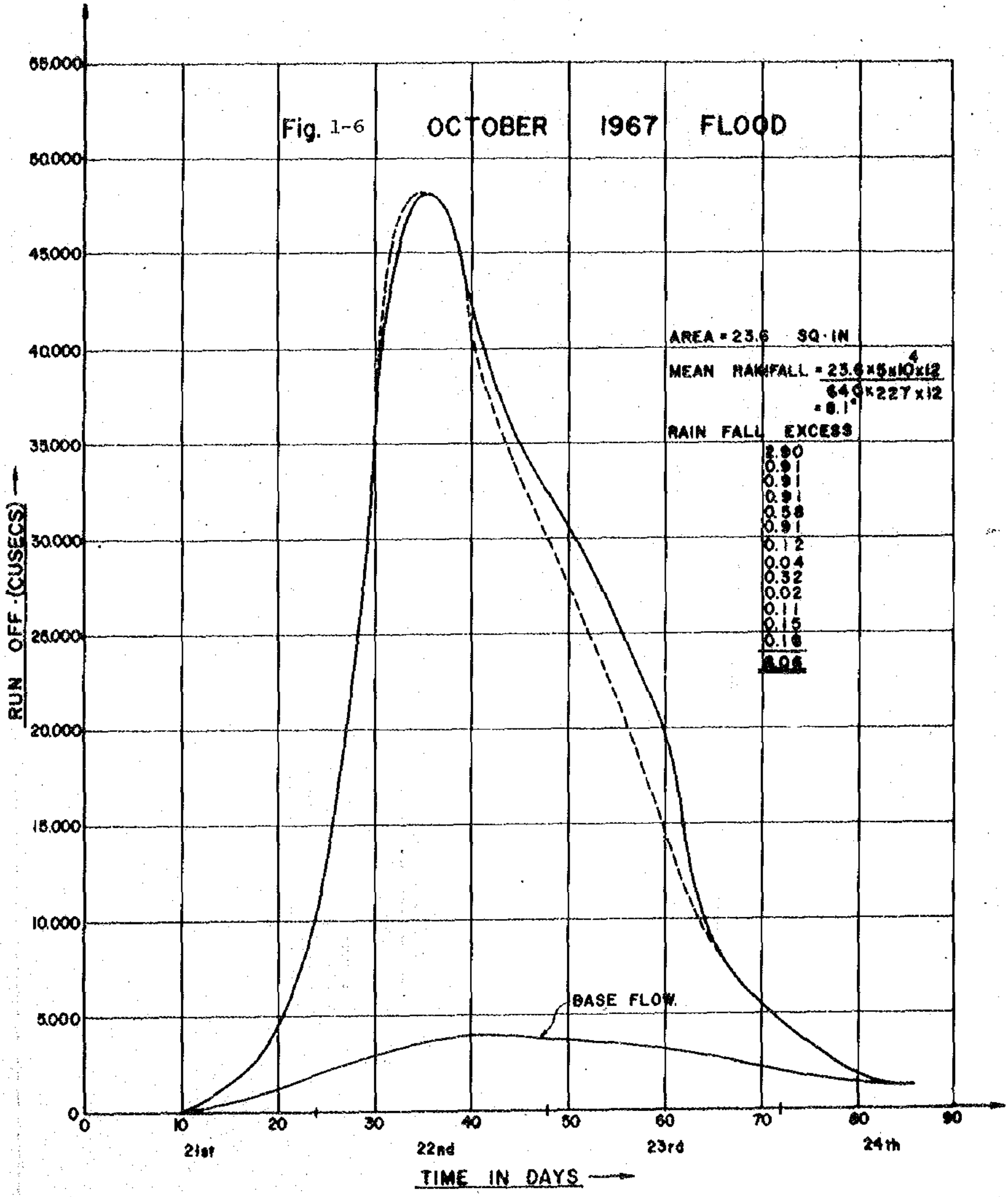


Fig. 1-7 6hr UNIT HYDROGRAPH

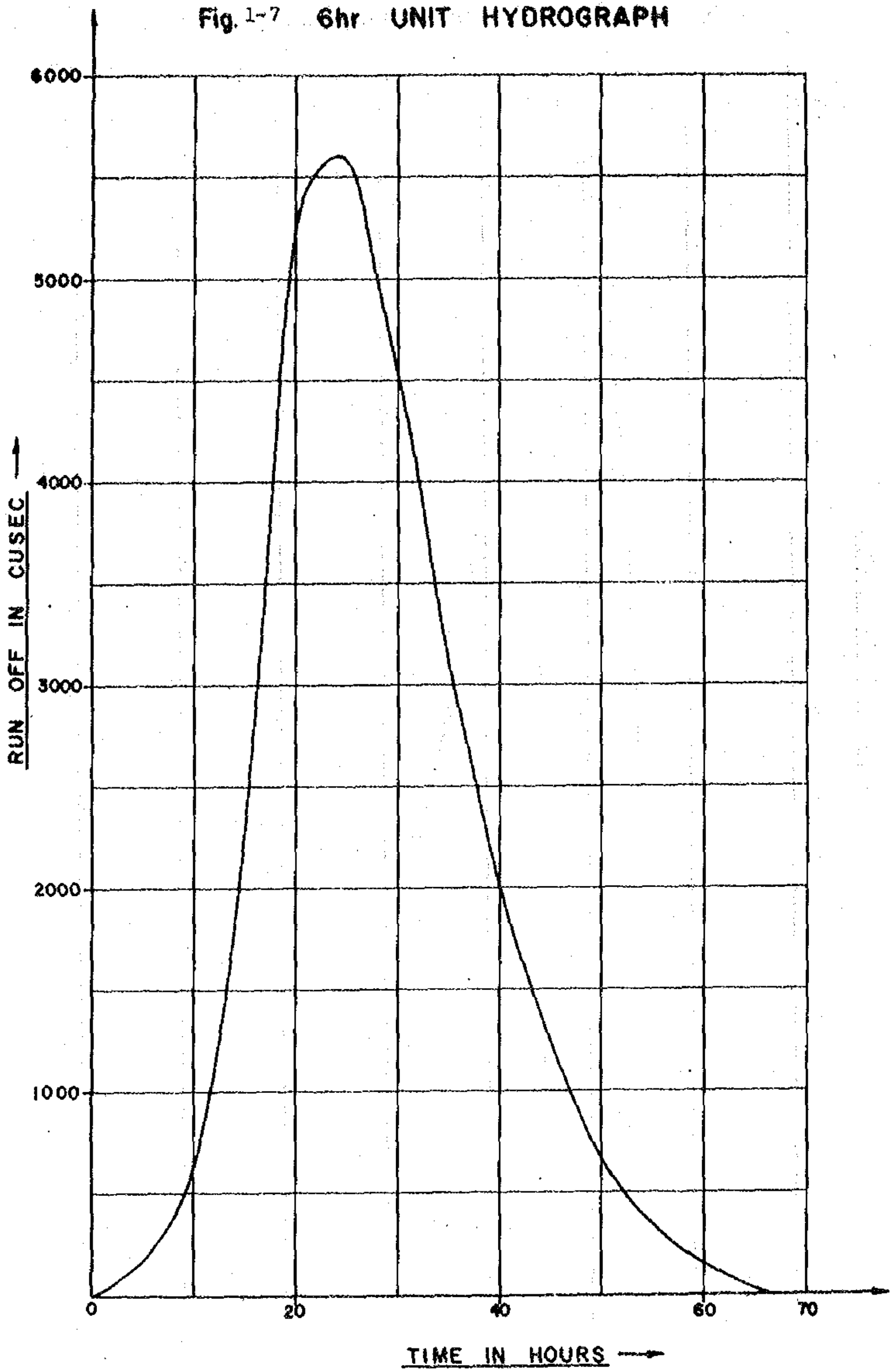
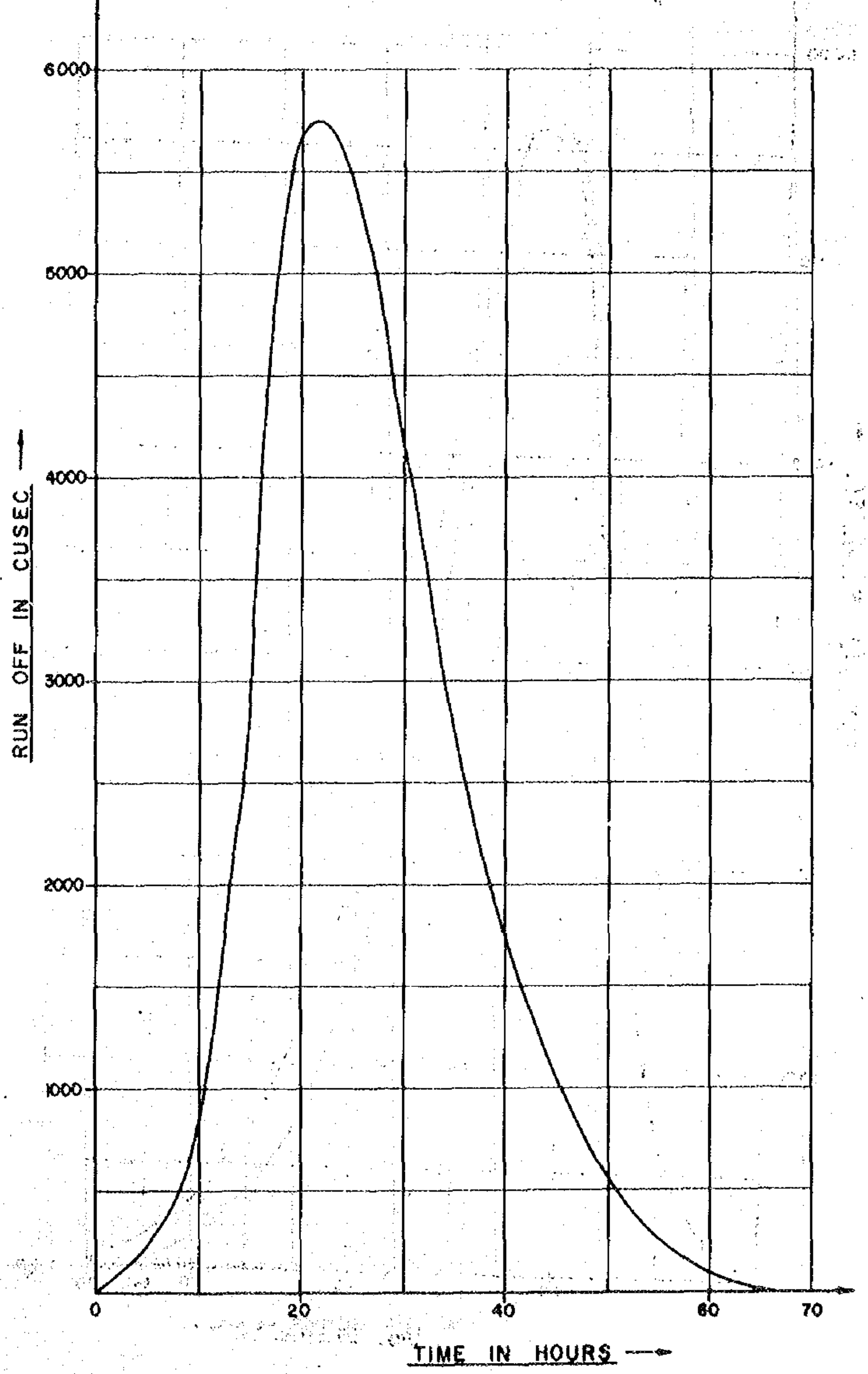


Fig. 1-8 3HOUR UNIT HYDROGRAPH



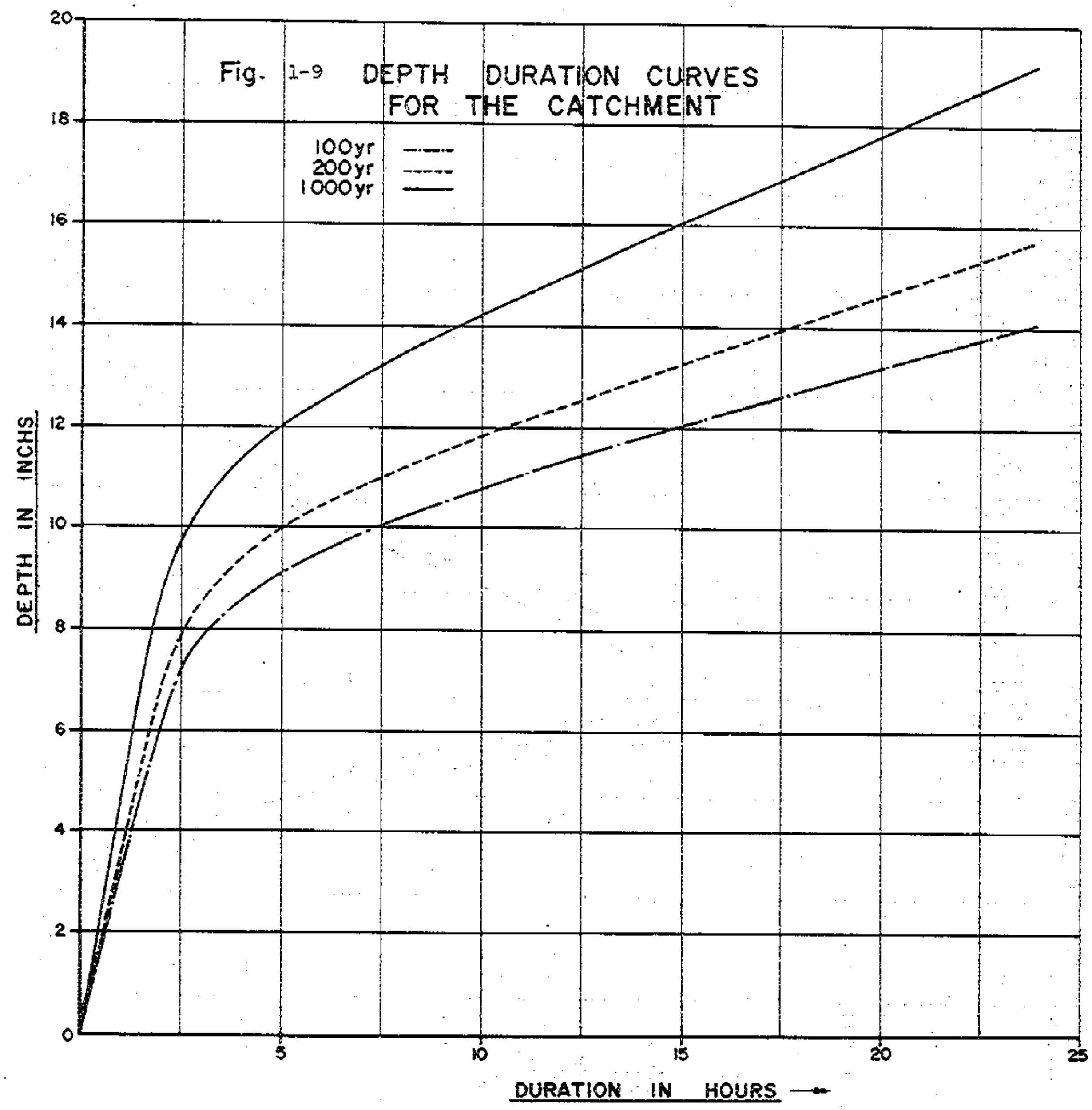


Fig. 1-9 DEPTH DURATION CURVES FOR THE CATCHMENT

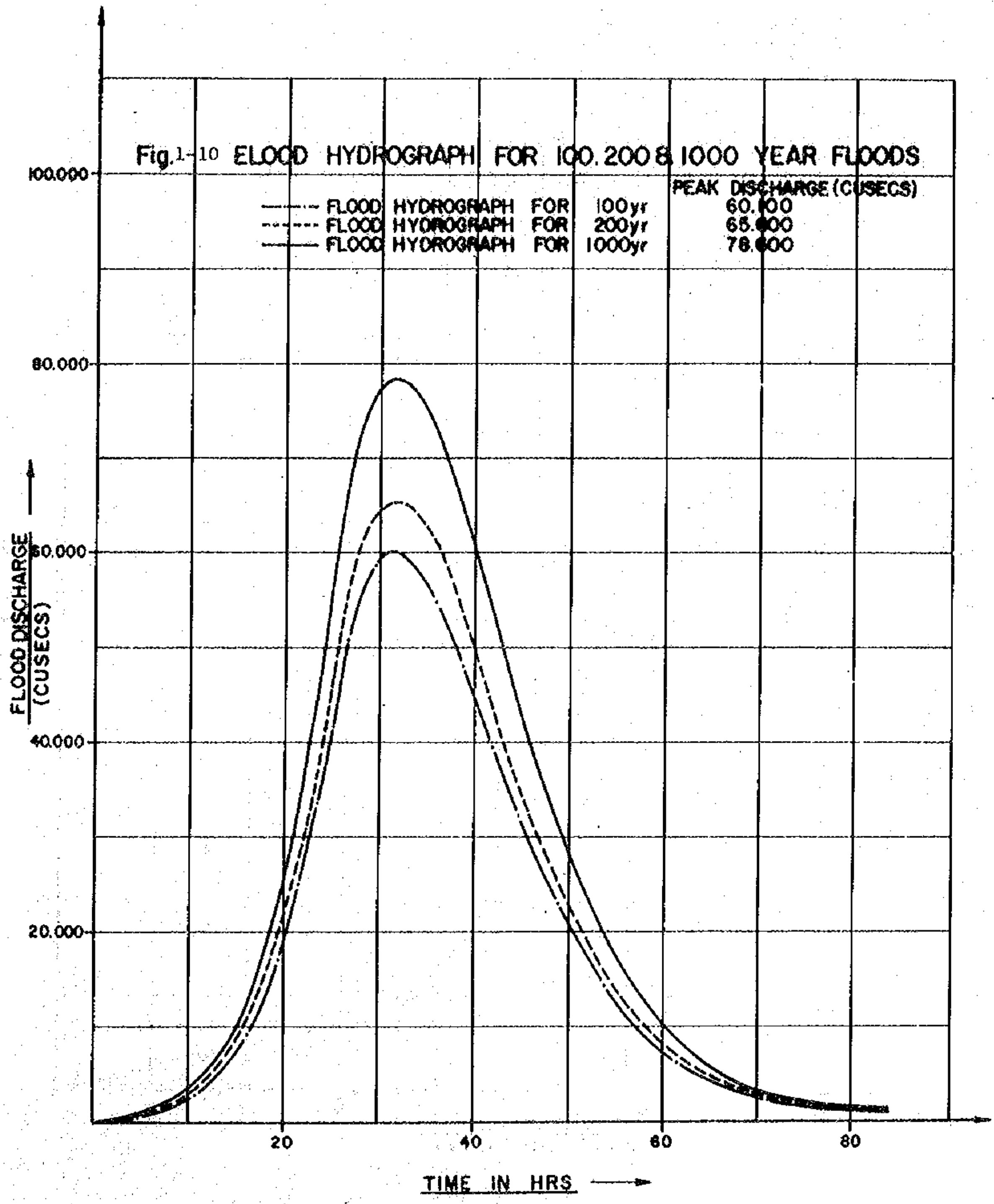


Fig.1-10 FLOOD HYDROGRAPH FOR 100.200 & 1000 YEAR FLOODS

Table 1-19 Derivation of 3 Hours Unit Hydrograph

t(hrs)	U(6,t)	2U(6,t)	U(3,t-3)	U(3,t)
0	0	0	-	0
3	75	150	0	150
6	225	450	150	300
9	475	950	300	650
12	1,110	2,220	650	1,570
15	2,310	4,620	1,570	3,050
18	4,080	8,160	3,070	5,110
21	5,430	10,860	5,110	5,750
24	5,600	11,200	5,750	5,470
27	5,295	10,590	5,470	5,120
30	4,570	9,140	5,120	4,020
33	3,675	7,350	4,020	3,330
36	2,900	5,800	3,330	2,470
39	2,190	4,380	2,470	1,910
42	1,700	3,400	1,910	1,490
45	1,250	2,500	1,490	1,010
48	875	1,750	1,010	740
51	600	1,200	740	460
54	390	780	460	340
57	250	500	340	160
60	130	260	160	100
63	65	130	100	30
66	0	0	30	0
69			0	

$2U(6,t) = U(3,t) + U(3,t-3)$

Table 1-20 100 Year Flood Hydrograph

t	R \ t, U(3,t)	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	Total	Base flow	Flood Volume (cusecs)
		0	140	300	650	1,570	3,050	5,120	5,750	5,600	5,080	4,020	3,325	2,470	1,910	1,490	1,010	740	460	300	160	100	30	0			
0	0	0																							0	0	0
3	0.42		58.8																						58.8	400	459
6	0.56		78.4	126																					204.4	750	954
9	1.32		184.8	168	273																				625.8	1,300	1,926
12	6.49		908.6	396	364	659.4																			2,328	1,600	3,928
15	0.66		92.4	1,947	858	879.2	1,281																		5,057.6	2,300	7,358
18	0.49		68.6	198	4,218.5	2,072.4	1,708	2,146.2																	10,411.7	2,750	13,162
21	0.41		57.4	147	429	10,189.3	4,026	2,861.6	2,415																20,125.3	3,100	23,225
24	0.40		56.0	123	318.5	1,036.2	19,794.5	6,745.2	3,220	2,352															33,645.4	3,500	37,145
27				120	266.5	769.3	2,013	33,163.9	7,590	3,136	2,133.6														49,192.3	3,800	52,992
30					260	643.7	1,494.9	3,372.6	37,317.5	7,892	2,844.8	1,688.4													55,513.5	4,000	59,513
33						628	1,250.5	2,503.9	3,795	36,344	6,705.6	2,251.2	1,396.5												54,874.4	3,800	58,224
36							1,220	2,095.1	2,817.5	3,696	32,969.2	5,306.4	1,862	1,037.4											51,003.6	3,400	54,403
39								2,044	2,357.5	2,744	3,352.8	26,089.8	4,389	1,383.2	802.2										43,162.5	3,000	46,162
42									2,300	2,296	2,489.2	2,653.2	21,579	3,260.4	1,069.6	625.8									36,273.2	3,800	39,073
45										2,240	2,082.8	1,969.8	2,194.5	16,030	2,521.2	834.4	424.2								28,296.9	2,500	30,793
48											2,032	1,648.2	1,629	1,630	12,396	1,966.8	565.6	510.8							22,178.4	2,200	24,378
51												1,608	1,363	1,210.3	1,260.6	9,670.1	1,333.2	414.4	193.2						17,052.8	1,950	19,002
54													1,330	2,012.7	935.9	983.4	6,554.9	976.8	257.6	126					12,177.3	1,550	13,727
57														988	783	730.1	666.6	4,802.6	607.2	168	67.2				8,812.7	1,400	10,212
60															764	610.9	494.9	488.4	2,985.4	396	89.6	42			5,872.2	1,400	7,272
63																596	414.1	362.6	303.6	1,947	211.2	56	12.6		3,903.1	1,400	5,303
66																	404	303.4	225.4	198	1,038.4	132	16.8		2,318	1,400	3,718
69																		296	188.6	147	105.6	649	39.6		1,425.8	1,400	2,826
72																			184	123	78.4	66	194.7		646.1	1,400	2,046
75																				120	65.6	49	19.8		254.4	1,400	1,654
78																					64	41	14.7		119.7	1,400	1,519
81																						40	12.3		52.3	1,400	1,452
84																							12.0		12.0	1,400	1,412
																										1,400	1,400

Table 1-21 200 Year Flood Hydrograph

t	t / U(3,t) / R	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	Total	Base flow	Flood Volume (cumecs)
		0	240	300	650	1,570	3,050	5,110	5,750	5,600	5,080	4,020	3,325	2,470	1,910	1,490	1,010	740	460	300	160	100	30	0			
0	0	0																							0	0	0
3	0.49		68.6																						68.6	400	468
6	0.62		85.4	147																					232.4	750	982
9	1.42		198.8	183	318.5																				700.3	1,300	2,000
12	7.13		998.2	426	396.5	769.3																			2,590	1,400	4,300
15	0.77		107.8	2,139	923	257.7	1,494.5																		5,622.3	2,300	7,922
18	0.58		81.2	231	4,634	2,229	1,860.5	2,504																	11,530.7	2,700	14,200
21	0.53		74.2	174	500.5	11,194	4,331	3,117.1	2,817.5																22,208.3	3,100	25,308
24	0.49		68.6	159	377	1,208.9	21,746.5	7,256	3,507.5	2,744															37,067.5	3,500	40,567
27				147	344	910.6	2,348.5	36,434	8,165	3,416	2,489														54,254.1	3,800	58,054
30					318.5	832	1,769	3,934.7	40,997.5	7,952	3,098.8	1,969.8													60,872.3	4,000	64,872
33						769	16,165	2,963.8	4,427.5	39,928	7,213.6	2,452.2	1,629.2												60,900.8	3,800	64,900
36							1,494.5	2,708.3	3,335	4,312	36,220	5,708.4	2,028.2	1,210.3											57,016.7	3,400	60,437
39								25,039	3,047.5	3,248	3,911.6	28,662.6	4,721.5	1,506.7	935.9										48,537.7	3,000	51,538
42									2,817.5	2,968	2,946	3,095	23,707.2	3,507.4	1,165.1	730.1									40,936.3	2,600	42,736
45										2,744	2,692	2,331.6	2,560	17,611	2,712.2	908.9	494.9								32,054.6	2,500	34,586
48											2,489	2,130.6	1,928	1,902	13,618	2,115.8	616.1	362.6							25,162.1	2,200	27,362
51												1,969.8	1,762.2	1,432.6	1,470.7	10,623.7	1,434.2	451.4	225.4						19,370	1,900	21,300
54													1,629	1,309	1,107.8	1,147.3	7,201	1,050.8	280.6	147					13,878.5	1,550	15,482
57														1,210	1,012.3	864.2	777.7	5,276	653.2	183	78.4				10,054.8	1,400	11,495
60															936	789.7	585.8	569.8	3,280	426	97.6	49			6,733.9	1,400	8,134
63																730	535.5	429.2	354.2	2,139	227.2	62	14.7		4,400.8	1,400	[illegible]
66																	494.9	392.2	266.8	231	1,140.8	142	18.3		[illegible]	1,400	[illegible]
69																		362.6	243.8	174	123.2	713	42.6		[illegible]	1,400	[illegible]
72																			225.4	159	92.8	77.0	213.9		[illegible]	1,400	[illegible]
75																				147	84.8	58.0	23.1		[illegible]	1,400	[illegible]
78																					78.4	53.0	17.4		[illegible]	1,400	[illegible]
81																						49.0	15.9		64.9	1,400	[illegible]
84																							14.7		14.7	1,400	[illegible]
																									0		[illegible]

Table 1-22 1000 Year Flood Hydrograph

t \ t′	R	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	Total	Base flow	Flood Volume (cusecs)
Q(3,t)		0	140	300	650	1,570	3,050	5,110	5,750	5,600	5,080	4,020	3,325	2,470	1,910	1,490	1,010	740	460	300	160	100	30	0			
0	0	0																							0	0	0
3	0.71	0	99.4																						99.4	400	849.4
6	0.80		112.0	213																					325	750	1,625
9	1.64		229.6	240	461.5																				931.1	1,300	2,531
12	8.55		1,190.0	492	520.0	1,114.7																			3,316.7	1,600	5,617
15	0.93		130.2	2,565	1,066	1,256	2,165.5																		7,182.7	2,300	9,933
18	0.79		110.6	279	5,557.5	2,574.8	2,440	3,628.1																	14,590	2,750	17,690
21	0.75		105.0	237	604.5	13,423.5	5,002	4,088	4,082.5																27,542	3,100	31,042
24	0.70		98.0	225	513.5	1,460.1	26,077.5	5,380.4	4,600	3,976															15,330	3,500	49,130
27				210	487.5	1,240.3	2,836.5	43,690.5	9,430	4,480	3,606.8														65,982	3,800	69,982
30					455	2,177.5	2,409.5	4,752.3	49,162.5	9,184	4,064	2,854													76,059	4,000	77,859
33						1,099	2,287.5	4,036.9	5,347.5	47,880	8,331.2	3,216	2,360.7												76,558	3,800	77,956
36							2,135	3,832.5	4,542.5	5,208	43,434	6,592.8	2,660	1,753.7											70,158	3,400	73,158
39								3,577	4,312.5	4,424	4,724	34,371	5,453	1,976	1,356.1										60,194	3,000	62,994
42									4,025	4,200	4,013.2	3,738.6	28,428	40,508	1,528	1,057.9									51,061	2,800	53,541
45										3,920	3,810	3,175.8	3,092	21,118.5	3,132.4	1,192	717.1								40,158	2,500	42,358
48											3,556	3,015	2,626.7	2,297.1	16,330.5	2,443.6	808	525.4							31,602	2,200	33,552
51												2,814	2,493.7	1,951.3	1,776	12,739.5	1,656.4	592	326.6						24,369	1,900	25,809
54													2,327.5	1,852.5	1,508.9	1,385.7	8,635.5	1,213.6	368	213					17,306	1,500	18,506
57														1,729	1,432.5	1,177.1	939.3	6,327	754.4	240	113.6				12,713	1,400	14,113
60															1,337	1,117.5	797.9	686.2	3,933	492	128	71.0			8,985	1,400	9,965
63																1,043	757.5	584.6	427.8	2,565	262.4	80	22.3	0	5,342	1,400	7,342
66																	707.0	555	363.4	279	1,368	164	36	0	3,488.6	1,400	4,888
69																		518	345	237	148.8	855	48.2	0	2,153	1,400	3,552
72																			322	225	126.4	93	256.5	0	2,023	1,400	2,423
75																				210	120	79	39.0	0	427	1,400	1,827
78																					112	75	23.7	0	212	1,400	1,612
81																						70	22.5	0	92.5	1,400	1,482
84																							21.0	0	21.0	1,400	1,421
																								0			

II TOPOGRAPHY AND GEOLOGY

2.1 General

Mi-Oya which provides the source of irrigation water for the agricultural development in the Project area meanders from east to west and the proposed dam will be constructed across the river at a point 21 miles southeast of Puttalam, almost at the midst of Tonigala and Galgamuwa. The Project area is spreading on the peneplain on both banks of the Mi-Oya. Apart from the patches of paddyfield having been developed at the foot of several tanks, the area is generally covered by jungles where chena cultivation sporadically takes place at present. Geological base of the Project area is made out of the ancient rock which is classifiable into granite and gneiss which exposes itself here and there in the horse-back shaped outcrops. The alluvium covering the foundation rock contains fragments of the host rocks which have been reduced into so many round-shaped, small-sized gravels.

2.2 Topography

Mi-Oya meanders within a belt of 0.3 mile (0.48 km) and the difference between the river-bed and the flood plain is about 15 ft. (4.5 m). There is no oxbow lake in and around the Project area. The gradient of the river is 1/1,066. The wave length of the Mi-Oya's meander is about 0.8 ~ 1.0 mile (1.3 ~ 1.6 km), almost 40 times as big as its river width (about 120 ft. or 36.6 m). Bed load in the river consists of sandy soil. The alluvial flood plain has a width of about 0.4 mile, 1.3 times the river's meandering belt. As sepcified in the above, the Project area exists in a mature valley.

2.3 Geology

Fairly large outcrops at Tonigala, Kuntaniyagama and Mullegama inside the Project area disclose the existence of pink granite and gneiss under the surface soil. The outcrop on the right abutment of Inginimitiya Tank runs intermittently towards NE; the huge rocks scattering on the ground at Peddogama are made of pink granite, and biotite gneiss which exposes itself in the outcrop at Mayilewa runs till it reappears at Palugalla outcrop. While pink microcline gneiss and granite gneiss exist in the Project area, the catchment area of Inginimitiya Tank is made of leucoratic biotite/hornblends gneiss and granite gneiss (see Fig. 2-1).

2.4 Individual Geological Characteristics

Reddish brown soil extensively develops in the Dry Zone with annual precipitation of less than 75 inches (1903 mm). Its host rock is made up of ferromanganesian materials: mica, hornblends, pyroxene and garnet. Apparent specific gravities of the samples collected from the outcrops are shown in Table 2-1. Pink granite collected at Tonigala is the hardest though with low gravity; granite gneiss at Mullegama and biotite gneiss at Mayilewa are soft, crumbling down into many fine sands if hammered on.

Table 2-1 Apparent Specific Gravity

Tonigala	:	2.53 ~ 2.58
Müllegama	:	2.54 ~ 2.81
Mayilewa	:	2.60 ~ 2.73
Test Pit No. 2 (Cobble)	:	2.79 ~ 2.97
Dam Site (Gravel)	:	2.80

The results of the boring tests at dam-site are shown in Fig. 2.2. Maiority of the cores collected through boring are smaller than 4 inches (10.16 cm) and most of them are 1 inch (2.54 cm). Their rock quality description (R.Q.D.) given by the following formula is mostly below 5%:

$$R.Q.D. = \frac{\text{Total logs} > 4 \text{ in}}{\text{Total logs}} \times 100\%$$

Although no sound rock could have been encountered at within the limit of the boring depth on the field, its existence can be estimated at about 20 ft. below the ground surface. The outcropped rock at the spillway site has enough bearing capacity, though cracked, as the foundation of spillway. Permeability coefficient of the foundation rock has been measured by injection method by use of the boring holes, as shown in Fig. 2-2. All the data shown there are the results of 10 minutes injection except DH.16, and their values have been multiplied 1.5 times to obtain those at steady state; the modified values are given in Fig. 2-2.

2.5 Embankment Materials and Aggregates

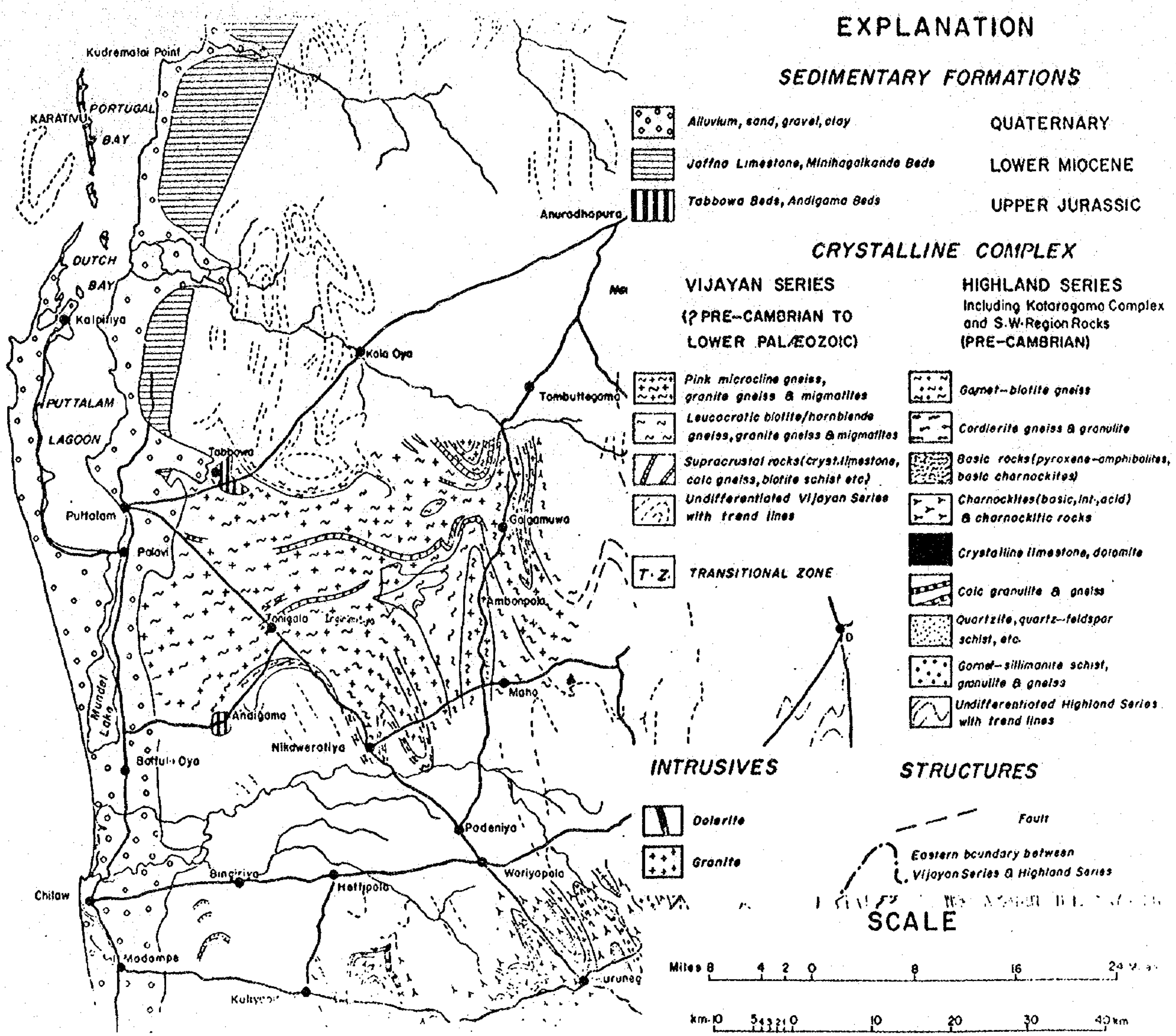
Test Pits each measuring 5' x 5' (1.524 m x 1.542 m) were dug at three places, as shown in Fig. 2-3. Their profile sections are given in Figs. 2-4 through 2-6. Although Test Pit No. 1 disclosed the existence of sandy and clayey soils to the depth of 10 ft., it is supposed that the same material as was identified by other pits on the right bank is available because of the existence of reddish brown soil in its vicinity. At Test Pits No. 2 and No. 3, it was discovered that below 5 ft. deep hard clay and gravel layer, there develops the weathered rock. The materials encountered at all the test pits are useful for embankment. Excavation of the weathered rock may require the use of Ripperdozer.

Three borrow areas have been selected as shown in Fig. 2-3 which also shows the spots where the samples were collected for both laboratory and insitu tests by Sri Lanka engineers; the test results are given in Table 2-2. The findings obtained by the grain size analysis, the compaction test and the triaxial compression test are respectively shown in Figs. 2-7, 2-8 and 2-9, and the plasticity chart is attached as Fig. 2-10.

The sand on the Mi-Oya's river-bed can be used for toe drain. The materials of the gravel layer underneath the Riprap will be available from the alluvial gravel layer in the upstream of Borrow Area No. 1, as shown in Fig. 2-3. The said gravel layer contains a lot of biotite and is made up of plenty of fine grains; they can be used after necessary treatment such as sieving and washing-out.

The cobble materials for the Riprap and Toe drain are available in Tonigala, Mullegama and Mayilewa. Mayilewa has been selected because of its nearness to the dam-site and the evenness of its topography which makes the construction and maintenance of the transport road easier. The broken rocks available in the same area can be substituted for the gravels required for Toe drain. As the rock available at Mullegama and Mayilewa is not satisfactory as the concrete aggregate, Tonigala rock is to be used as concrete aggregate unless better quarry site is identified.

Fig. 2 - 1 GEOLOGICAL MAP



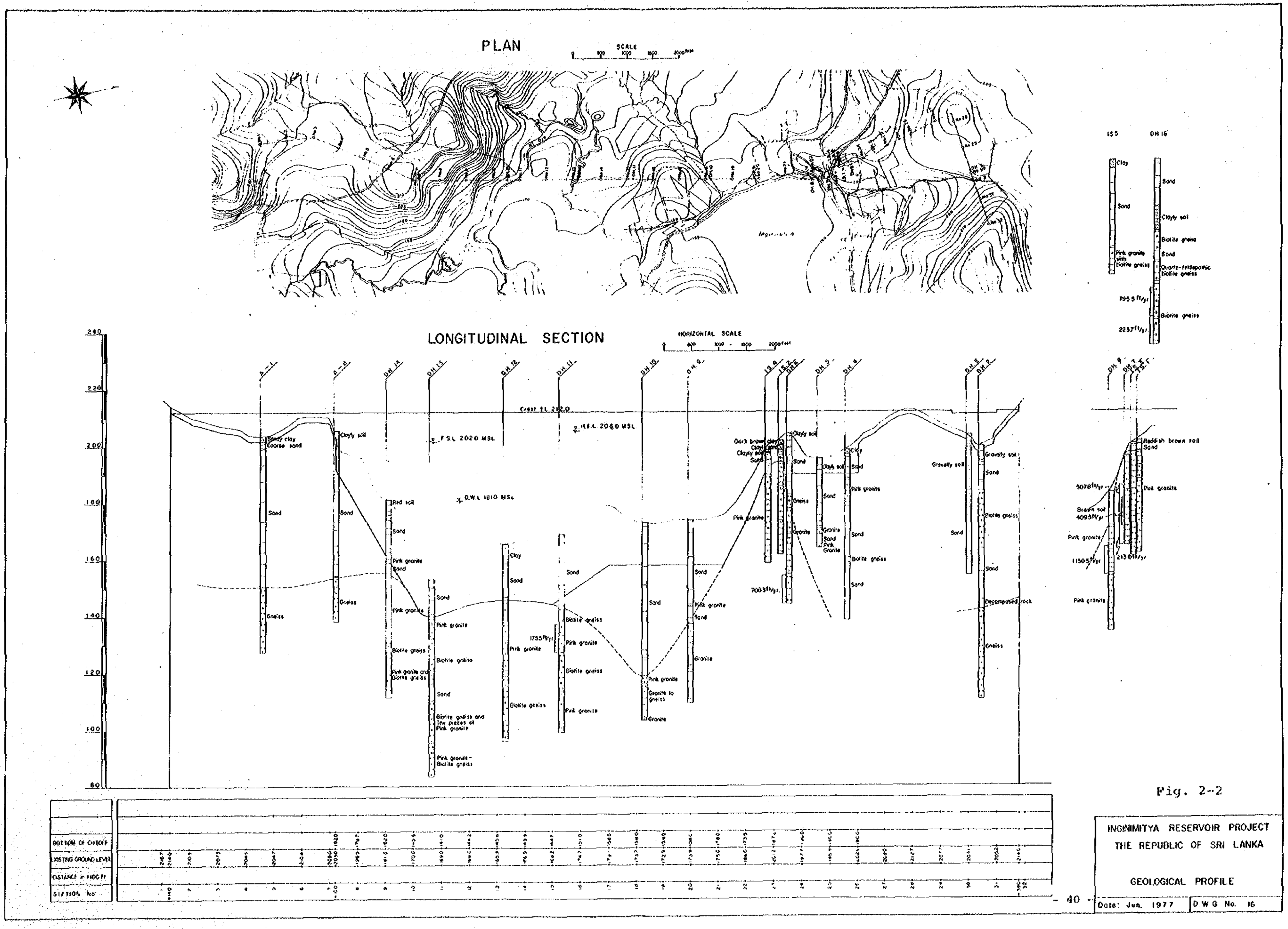

PLAN
LONGITUDINAL SECTION
HORIZONTAL SCALE
Crest EL 212.0
H.F.L 208.0 MSL
F.S.L 202.0 MSL
D.W.L 181.0 MSL
BOTTOM OF CUTOFF
EXISTING GROUND LEVEL
DISTANCE in x100 FT
STATION No.
INGINIMITYA RESERVOIR PROJECT
THE REPUBLIC OF SRI LANKA
GEOLOGICAL PROFILE
Date: Jun. 1977
DWG No. 16

Fig. 2-2

Fig. 2-3 PROPOSED DAM AXIS AND BORROW AREA

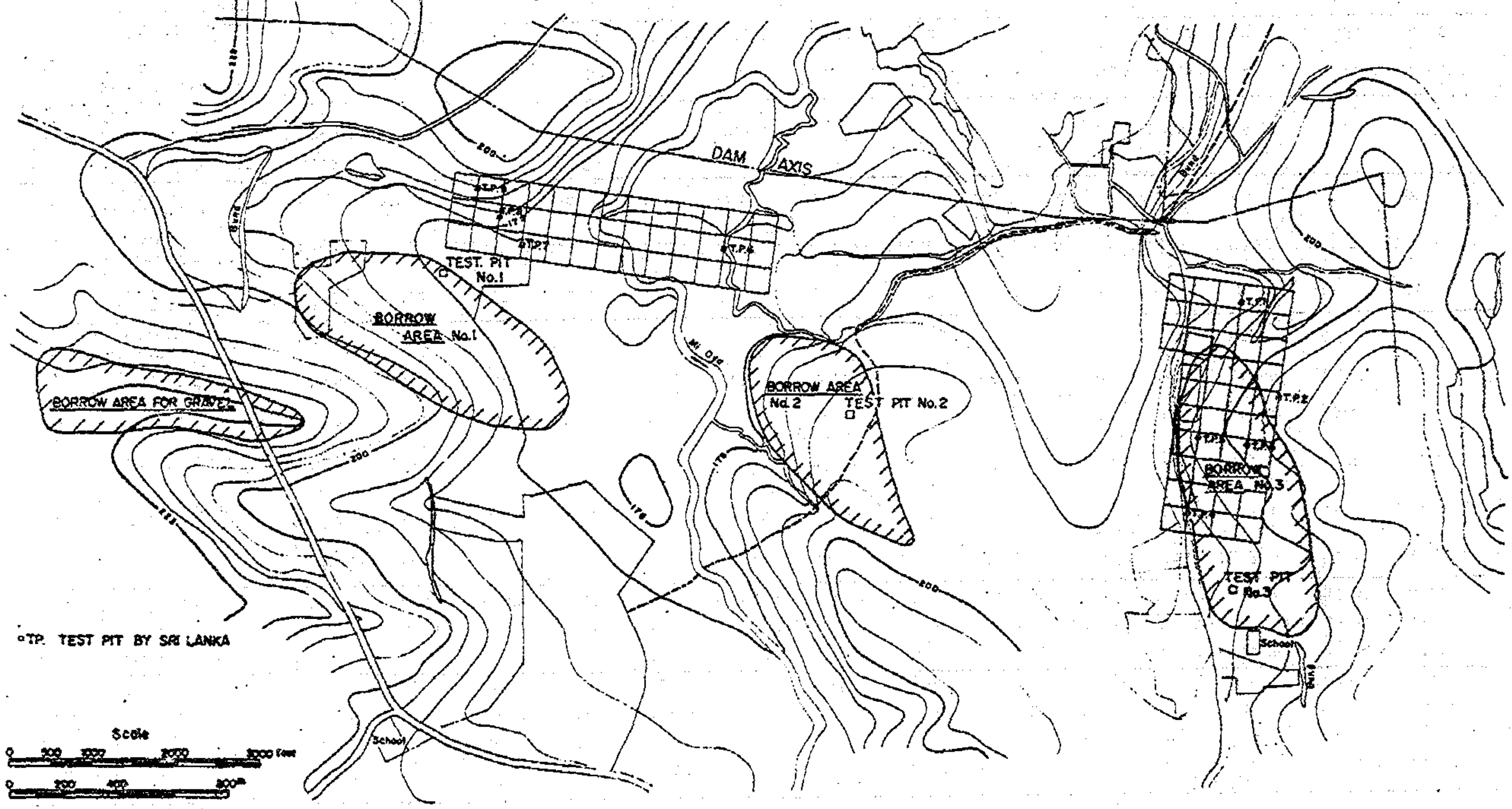


Table 2-2 Summary of Laboratory Tests and Insitu Tests

	Sample No.	IM.3	IM.5	IM.6	IM.7	IM.9	IM.10	IM.13	IM.14	IM.15	IM.16	IM.17	IM.18	IM.19	IM.20
	Pit No.	2	3	3	4	5	5	7	7	8	8	9	9	10	10
	Depth in Feet below G.L.	3"-3'	4"-2'	2'-6'	3"-3'	4"-2'6"	2'6"-6'	3"-2'6"	2'6"-6'	3"-2'6"	2'6"-6'	3"-3'	3'-6'	3"-2'6"	2'6"-6'
	Classification	SC	CL	GC	GC	CL	SC	SC	SC	SC	GC	SM	GC	SC	GC
ATTERBERG LIMITS	Liquid Limit	37.0	43.4	54.10	43.0	43.00	51.30	26.70	48.30	40.40	53.30	60.70	41.80	35.70	47.40
	Plastic Limit	20.3	19.89	23.25	18.45	18.60	21.12	13.11	19.10	18.61	23.68	34.30	17.90	17.65	21.98
	Plasticity Ind.	16.7	23.51	30.85	24.55	24.40	30.18	13.59	29.20	21.79	29.62	26.40	23.90	18.05	25.42
GRAIN SIZE ANALYSIS	Clay <0.002mm %	8.1	20.3	16.6	8.2	7.1	16.0	16.0	15.6	10.7	14.3	18.3	7.1	9.6	14.3
	Silt 0.002-0.006mm %	6.6	5.9	7.4	4.8	2.5	4.0	1.0	3.2	5.6	3.0	2.2	2.3	5.0	2.7
	Sand 0.006-2.0mm %	77.0	72.8	68.1	40.6	44.5	74.1	82.2	68.7	77.7	69.0	74.3	44.6	82.4	75.2
	Gravel >2.0mm %	8.3	1.0	7.9	46.4	46.0	5.9	0.8	12.5	6.0	13.7	5.2	46.0	3.0	7.8
	Pass 200 Mesh %	43.5	54.9	47.2	33.8	51.1	47.0	44.0	39.7	46.0	41.9	48.5	22.7	41.6	38.0
	Uniformity Coefficient Cu	80			904					74			288	97	
COMPACTION & PENETRATION	Optimum Moist. Content %	13.9	17.2	12.7	12.0	15.4	14.4	12.8	13.7	15.3	13.8	19.7	12.6	13.2	14.0
	Maximum Dry Density LBS/CUFT	114.1	107.8	117.9	119.7	111.7	112.3	115.6	114.9	110.4	113.5	101.7	115.6	114.7	111.6
	Penetration Resist. LBS/SQFT	750	375	700	550	725	600	525	450	460	450	600	500	575	660
TRIAXIAL COMPRESS	Cohesion LBS/SQFT	11.3					8.1					11.3	6.1		
	Angle of Internal friction	17°50'					20°30'					22°00'	26°35'		
PER-COLATION	Percolation Rate FT/YR.	0.0112	0.0075	1.20	0.008	0.041	0.032	0.0114	0.0056	0.0018	0.0113	0.103	0.012	0.0079	0.0027
	Consolidation %	9.15	6.12	8.70	5.23	6.20	6.00	6.78	7.32	6.22	6.57	5.92	5.3	6.22	7.68
INSITU TEST	Moisture Content %			TP.1 DEPTH 4'0" - 6'9"		7.8			TP.2 DEPTH 4'0" - 6'9"		8.4	6.3			
	Bulk Density LBS/CUFT.					124.5					122.2	135.0			
	Percolation Rate FT/YR.					313.6					31.0				

Fig. 2-4 CONDITION OF BORROW AREA
—TEST PIT No.1

SCALE 1:30

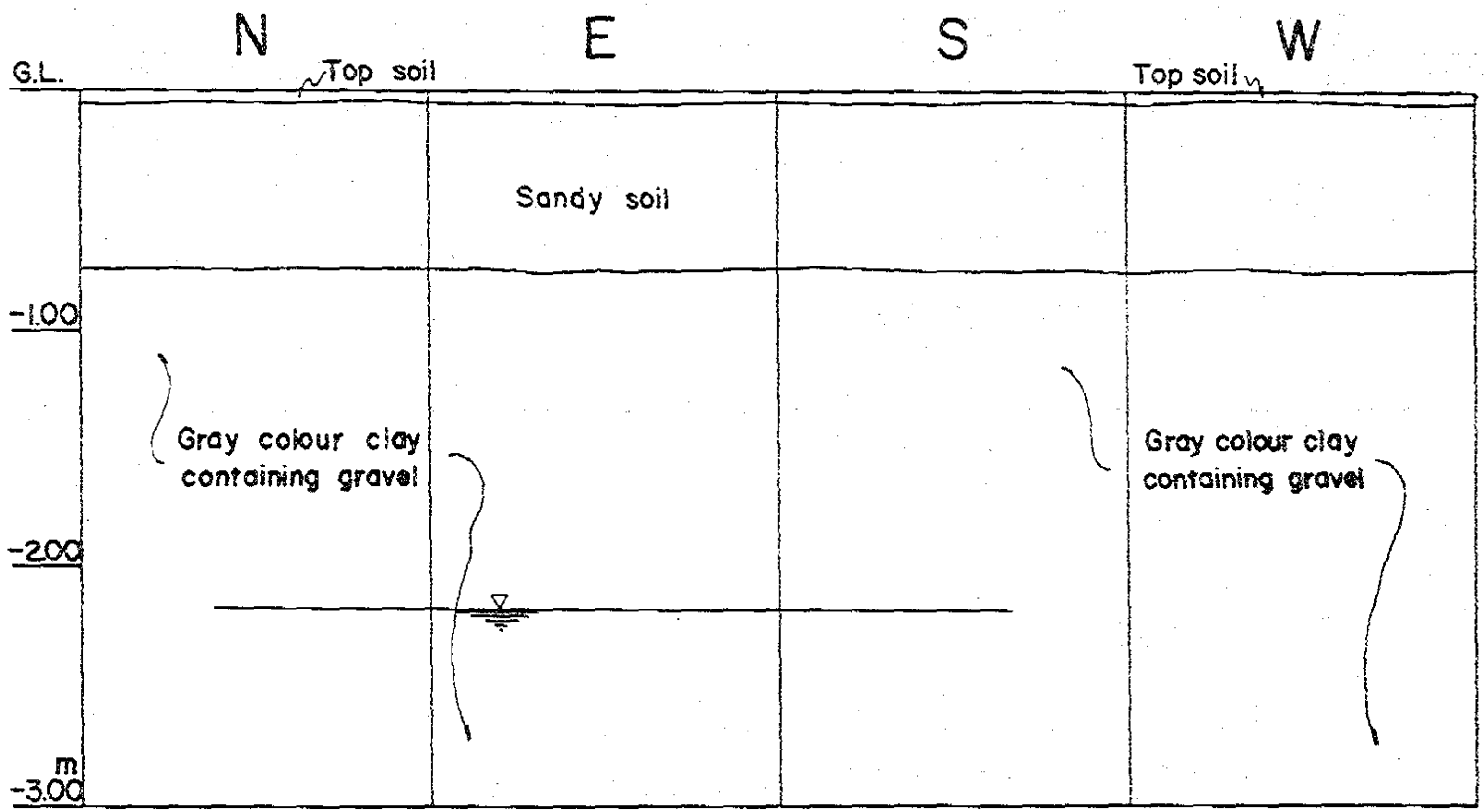


Fig. 2−5 CONDITION OF BORROW AREA −TEST PIT No.2

SCALE 1:30

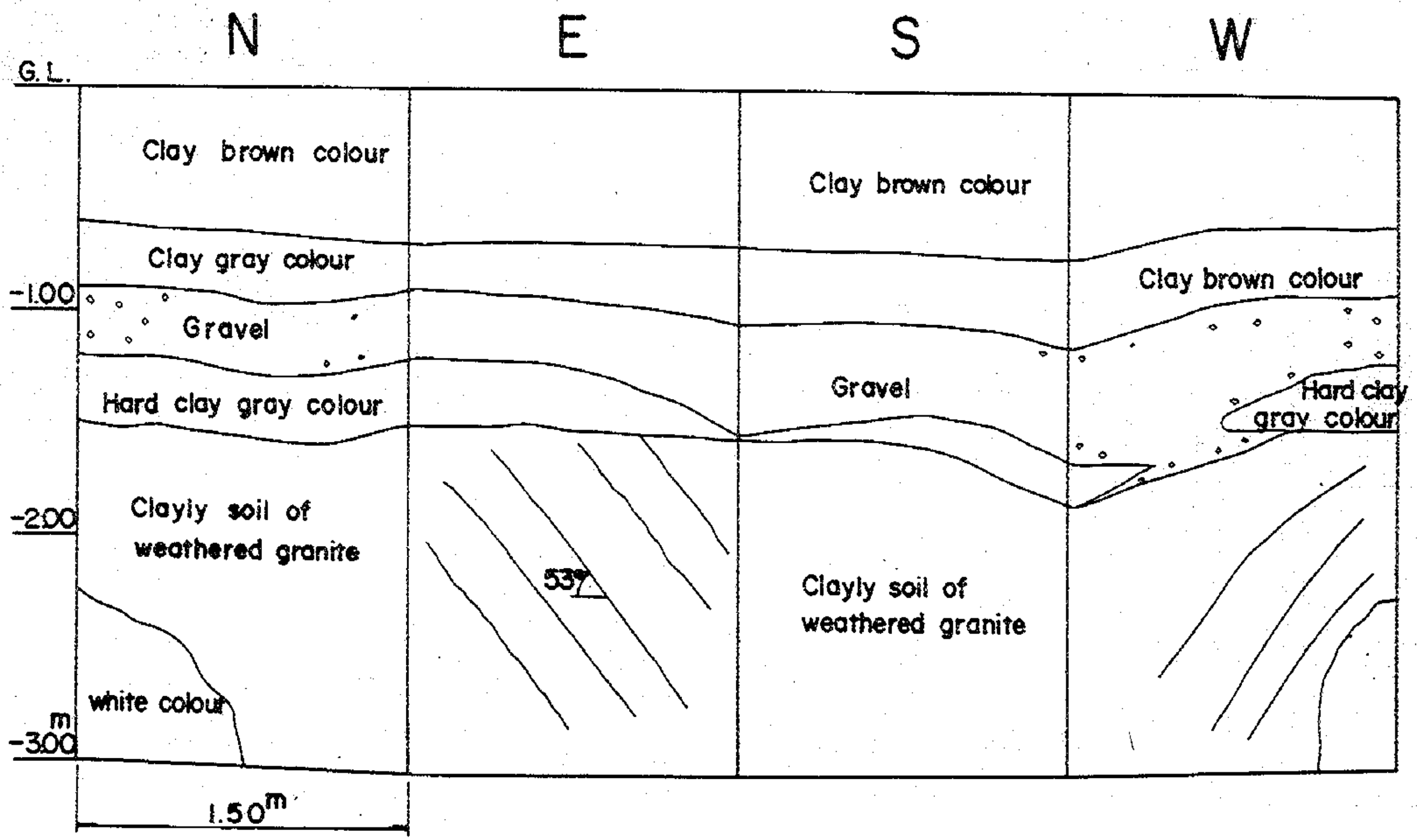


Fig. 2-6 CNDITION OF BORROW AREA
-TEST PIT No.3

SCALE 1:30

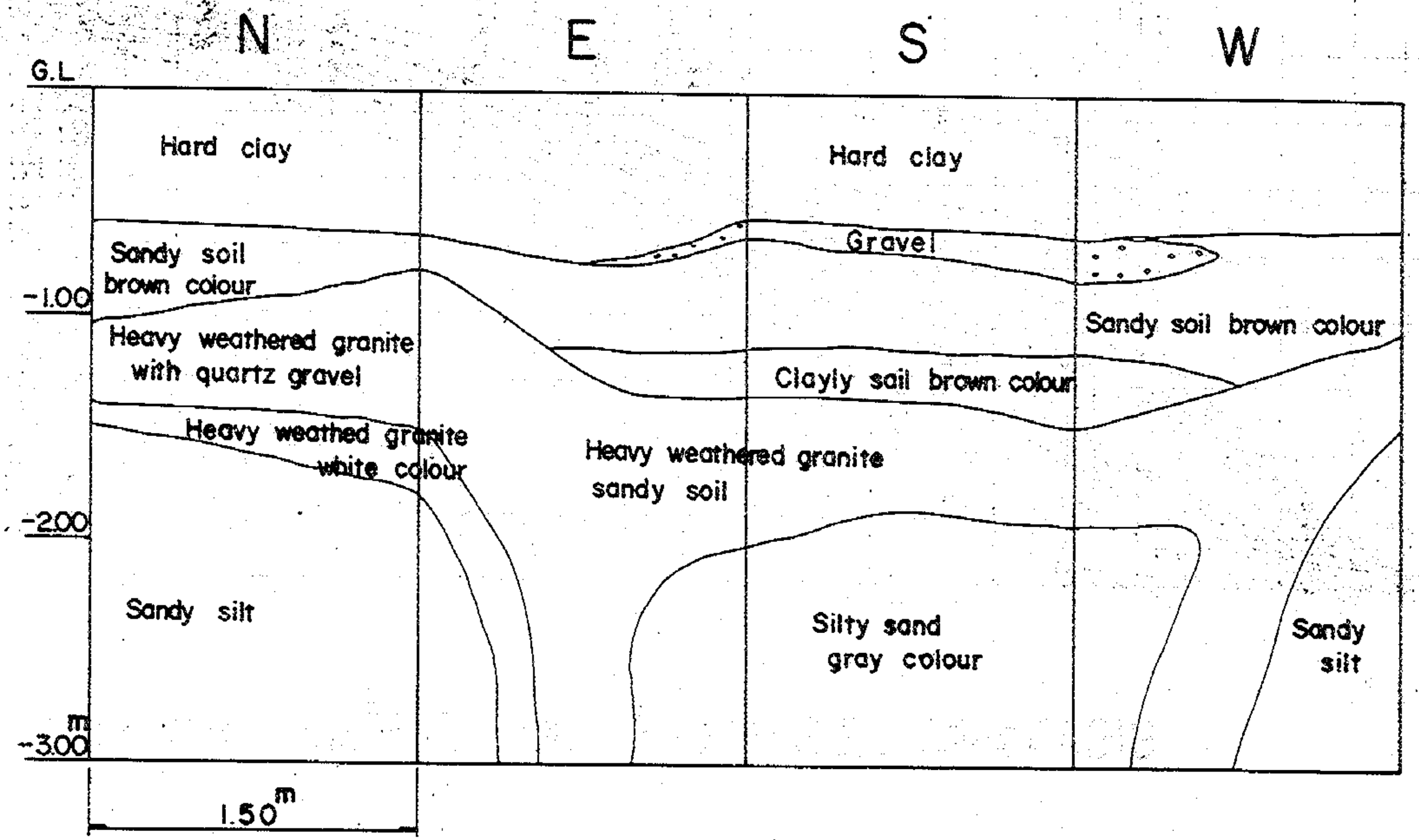


Fig. 2-7 RESULT OF GRAIN-SIZE ANALYSIS

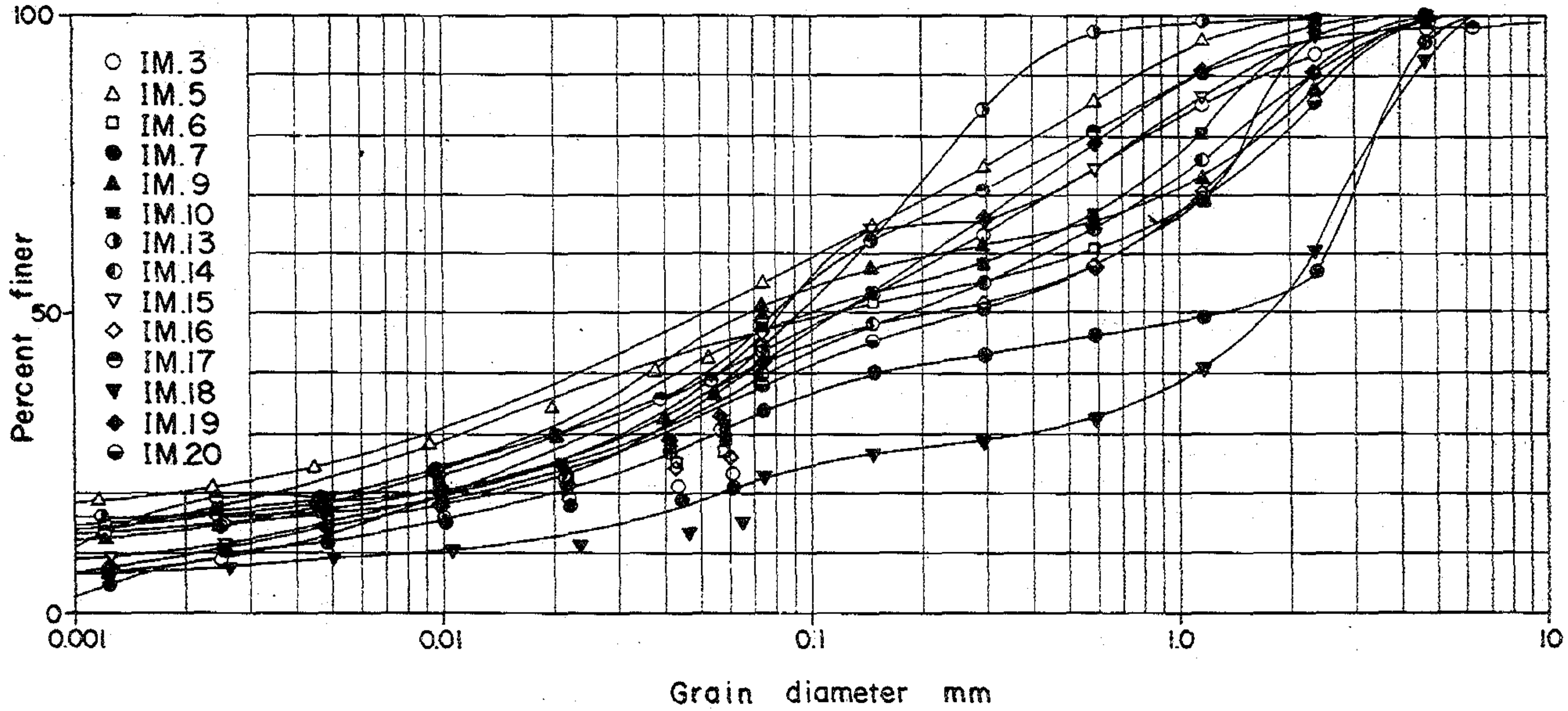


Fig. 2-8
RESULT OF COMPACTION TESTS

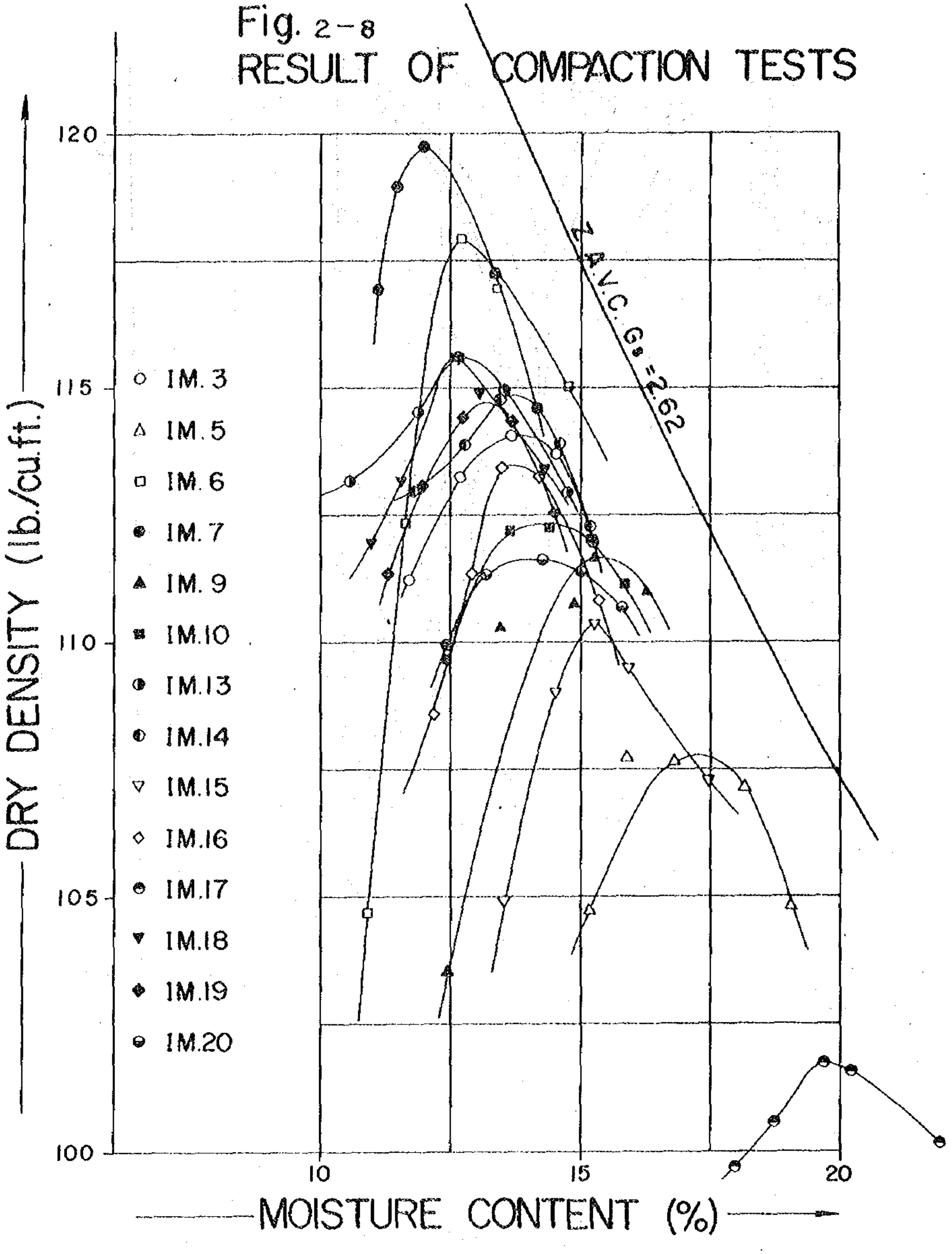


Fig. 2-9 RESULT OF TRIAXIAL COMPRESSION TESTS
CONSOLIDATED UNDRAIN CONDITION

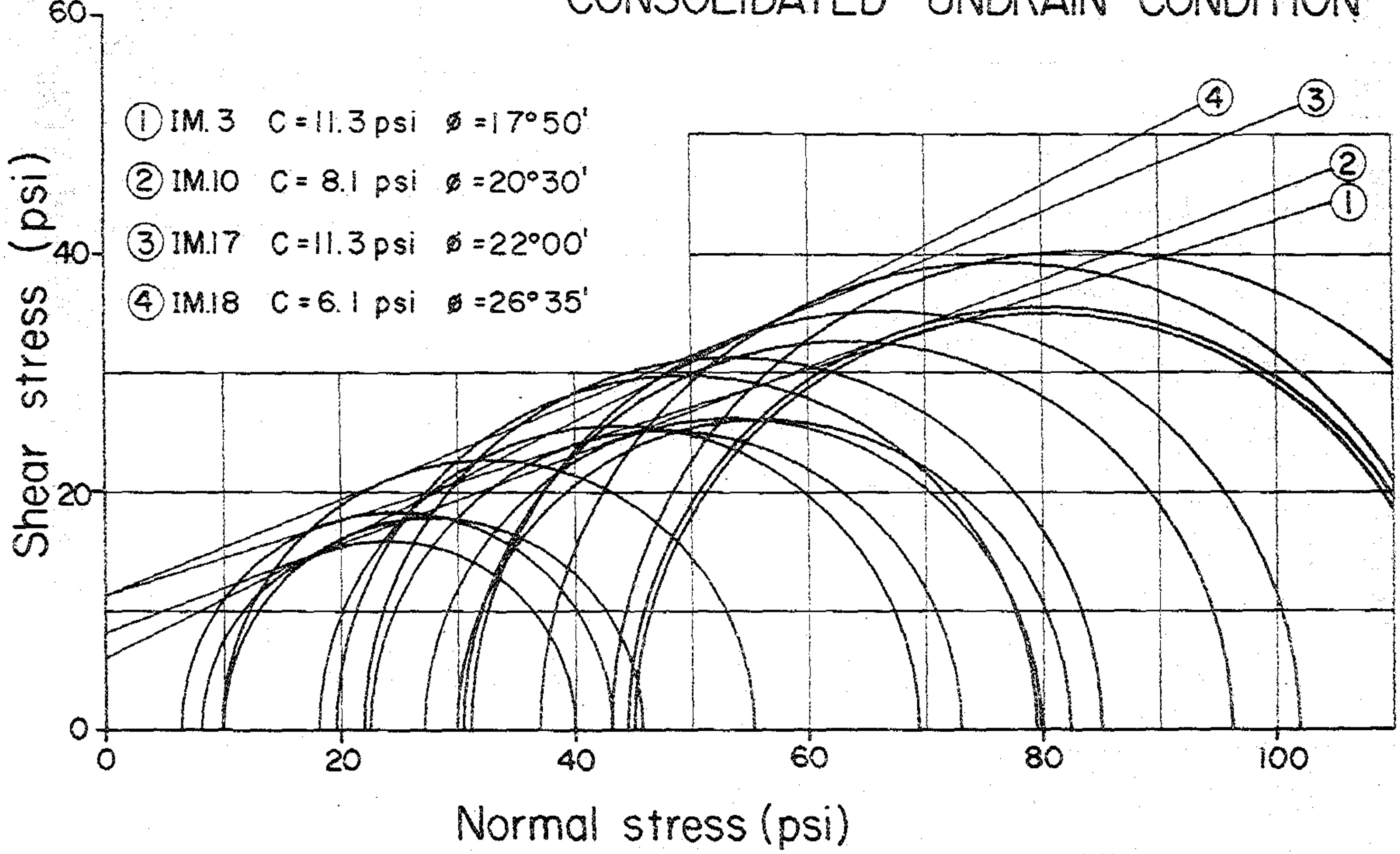
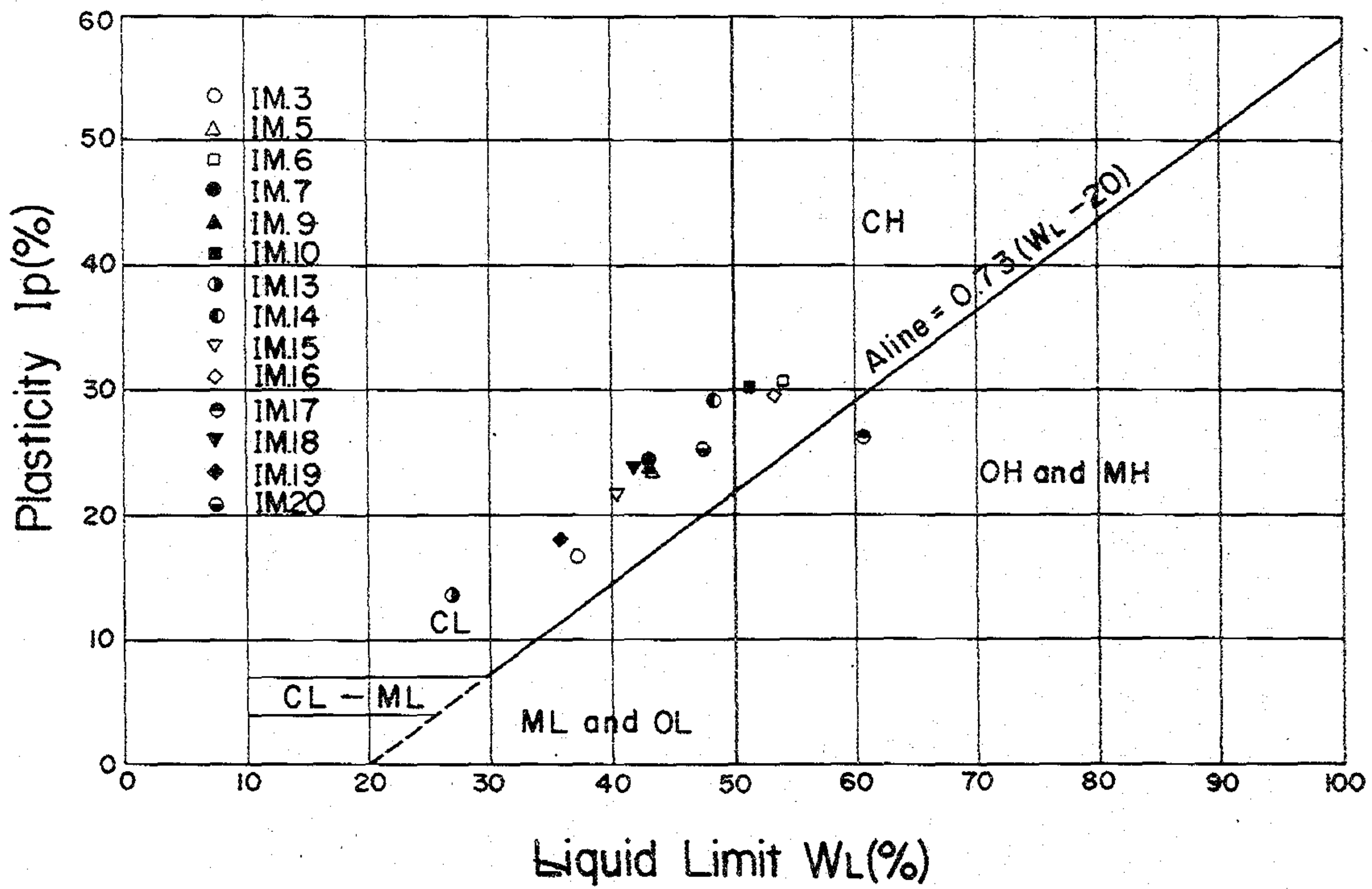


Fig. 2-10 Plasticity Chart



III SOILS & SOIL CLASSIFICATION

3.1 Physico-chemical Property of Soil

In order to provide effective irrigation during the upland cropping season and improve the farm management in the project area, the establishment of irrigation method suitable to the field conditions, physico-chemical property of soil, topography and characteristics of crops, should be carried out. On the basis of the above field conditions, it should be necessary to enforce the complete consolidation of farm conditions including irrigation net work from field plotting, water distribution system and related structures.

This survey is made in order to clarify the above problems mainly in Inginimitiya area. The outline of survey methods and their results are as follows.

3.1.1 Selection of Survey Sites

The survey sites are selected on the basis of respective soil type shown on the soil map provided by the Irrigation Department, Government of Sri Lanka. The survey sites are shown in Fig. 3-1.

3.1.2 Survey Items and Methods

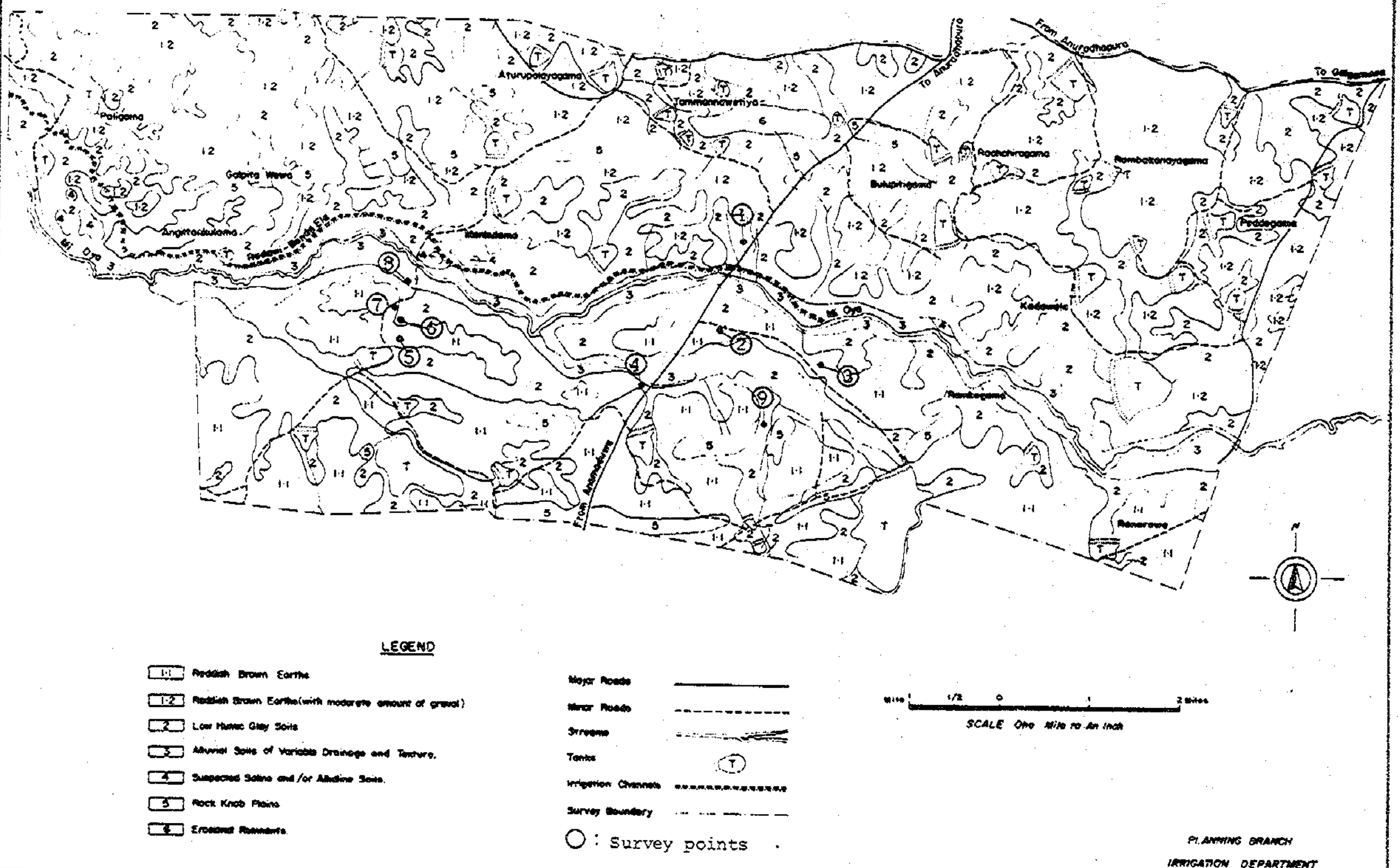
(1) Measurement of (a) apparent specific gravity, porosity, three phase distribution, hardness and etc. of soil in respective soil strata on the selected points of eight survey sites by using quantitative soil sampling method (100 cc), and (b) the estimations of field capacity, available moisture (= field capacity - wilting point moisutre) and others.

(2) The values of intake rate are taken from the tentative data of Maha-Illuppallama. The measurement with cylinder infiltro-meter was omitted because of the time reason. It is necessary to measure the actual values of the intake rate at the earliest convenience.

(3) The surface irrigation will be adopted for upland crops in the Yala period. However, the furrow stream test was omitted because of the lack of test apparatus and the time.

Fig. 3-1 SOIL MAP OF INGINIMITIYA RESERVOIR PROJECT

(Based On Aerial Photo Interpretation & National Soil Survey Data)



(4) Examination of chemical property of soil is made regarding PH (Kcℓ), P_2O_5, NH_4-N, K_2O and others by simplified soil test.

3.1.3 Results and Consideration

(1) Physical Property of Soil

Physical property of soil at the survey site are shown in Table 1. The vapor phase ratio in the field capacity period is generally superior with over 10% except alluvial and L.H.G. type. The hardness is mostly under 23 in the range which the extension of roots would not be disturbed. (Fig. 3-2)

(2) Available Moisture

Assuming the available moisture is obtained by the difference between the values of field capacity (FC) and wilting point (Wp), AM to each depth of soil structure (d) is expressed by the following formula:

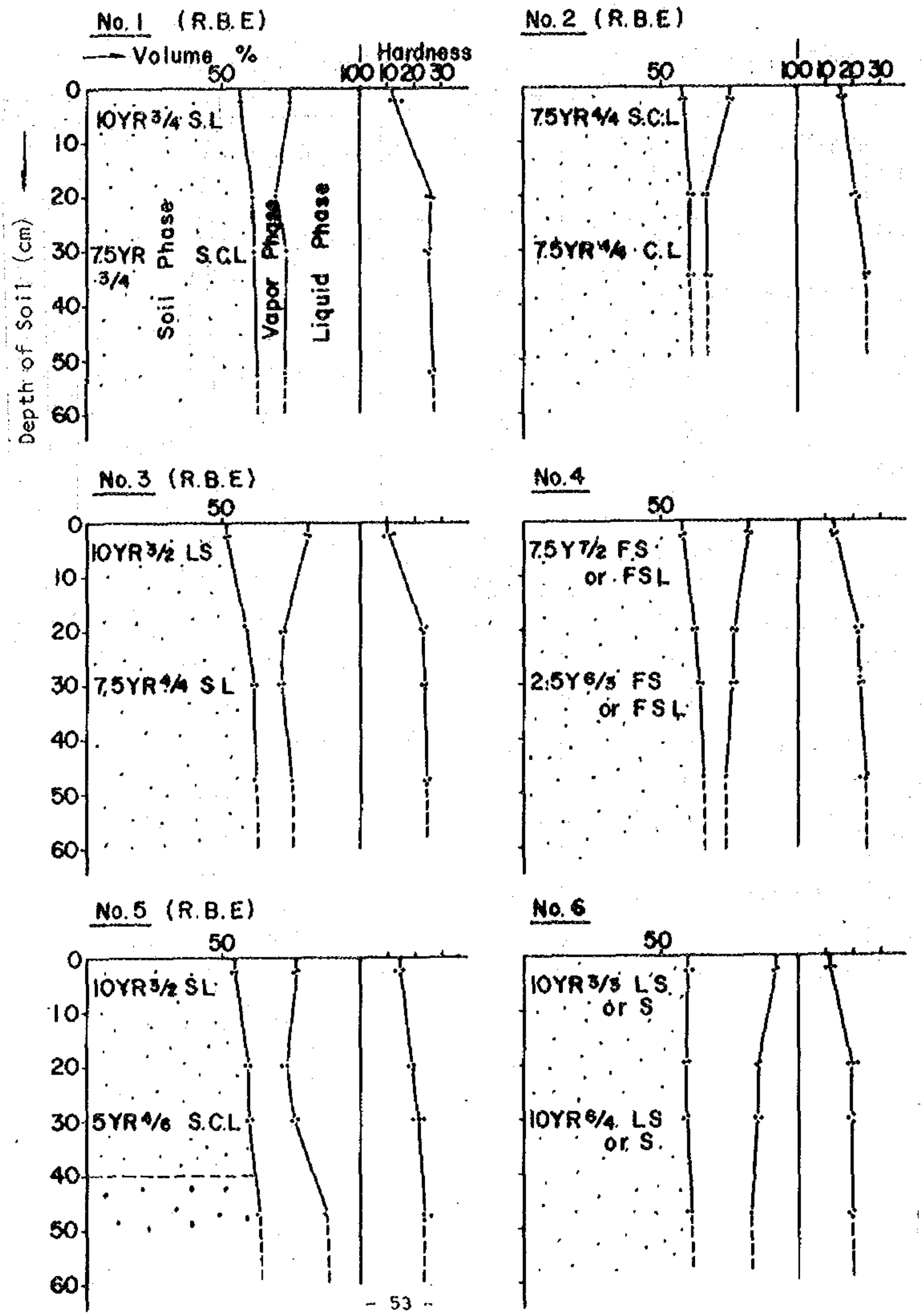
$$AM = \frac{1}{10}(FC - Wp)d$$

In this survey, FC value is the amount of moisture measured after about 24 hours fully watered. The value of Wp is calculated by

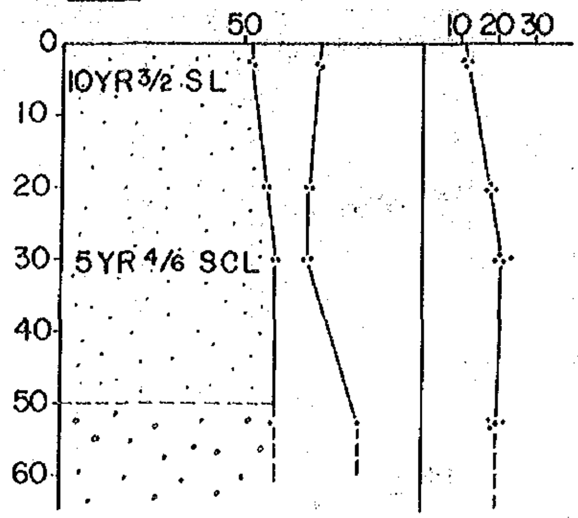
$$Wp = 0.36\ FC^{1.08}$$

which is specified by Leonard J. Erie (U.S.A.), since actual value of Wp could not be measured. The available moisture per 10 cm is in between 10 ~ 20 mm except sandy soil and sandy loam.

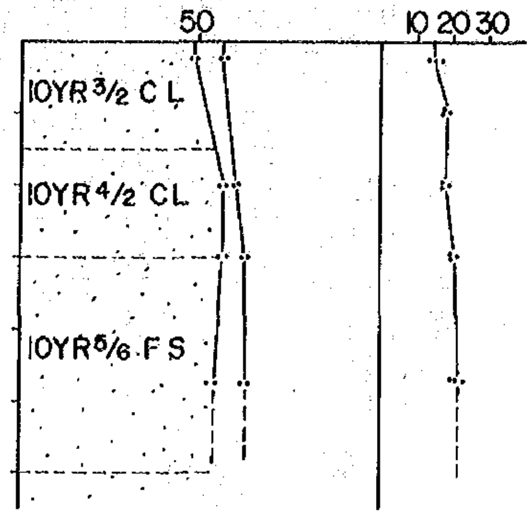
Fig 3-2 THREE PHASES OF SOIL IN INGININITIYA DEVELOPMENT AREA



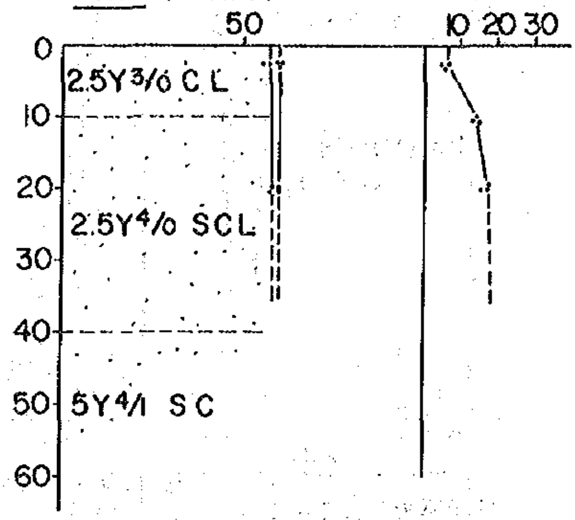
No.7 (R.B.E)



No.8 (Alluvial)



No.9 (L.H.G)



Notes

SCL: Sandy clay loam
CL : Clay loam
SL : Sandy loam
LS : Loamy sand
FS : Fine sand
FSL: Five sandy loam
S : Sand
SiC: Silty clay

(3) Total Readily Available Moisture (TRAM)

The value is mainly determined by AM of soil and soil moisture extraction pattern dependent on effective root zone and respective crops.

The water quantity per irrigation (Wd) is obtained by the following formula:

First layer	$Wd_1 = (AM)_1 \frac{d_1}{a_1}$
Second layer	$Wd_2 = (AM)_2 \frac{d_2}{a_2}$
⋮	⋮
⋮	⋮
N-th layer	$Wd_n = (AM)_n \frac{d_n}{a_n}$

where available moisture of soil in respective horizon indicated as $(AM)_1$, $(AM)_2$, ... $(AM)_n$, effective root zone as d and the moisture extraction pattern (shown by decimal point) to the n sections are indicated as a_1, a_2, ... a_n.

Crops gets physiological obstacles that the growth of crops is suspended, where the minimum value within values obtained by the above is the supremum value of the water quantity per irrigation and when the moisture content in the horizon corresponding to the minimum value becomes Wp. The irrigation period is determined by the moisture content of the first layer.

Since the moisture extraction pattern, on the other hand, depends on kind of crops, stage of growth, kind of soils and etc., no decision can be made in generally. Here, the computation was made on the assumption that the moisture consumptive ratio of the first layer is 40% of the whole and the root zone is 30, 45 and 60 cm. The water quantity per irrigation has been shown in Table 3-1. The water quantity per irrigation being less except alluvial soil, the design value of the surface irrigation such as furrow irrigation necessary to be examined by the field test.

(4) Intake Rate

This is a proportion which rain or irrigation water is absorbed by soil, usually showed by mm/hr, and is the most significant as a factor of determining the irrigation method and irrigation period. The intake rate is the most important factor in planning of the irrigation project.

The measured result is expressed by $D = CT^n$ (D: accumulated amount of infiltration-mm, c,n: constant depended on test, T: time elapsed after the starting of water supply-min.). Since this value is altered by several factors as kind of soils, soil layer structure, soil moisture condition, existence of coverings, temperature of supply water, land temperature and turbidity of water and etc., the decision of the representative value will accompany many troubles.

Data of Mahaveli Stage II were provisionally used because direct measurement could not be carried out this time. (Fig. 3-3)

The intake rate reduces gradually conformable to the time elapsed from the beginning of irrigating or suppling water, and finally keeps almost constant value. The intake rate in this condition is called basic intake rate (I_B), and generally used as index of the permeability of soils. This value is usually decided as the intake rate when the variation ratio of the intake rate becomes 10% of the intake rate at that time. In this case, the time reaching to the intake rate is not related to the kind of soils, but equal to the time multiplied by 600 of index indicated by the intake rate formula.

$$I_B = 60 \text{ cm} \{600 \ (1-n)\}^{n-1}$$

(5) Checmical Property of Soils

The results of measurement with simplified soil measuring instrument is as Table 3-2.

Table 3-1 Physical Property of Soils

No.	Soil Series	Depth	Texture	Apparent Density	Total Pore Space	Soil Moisture			TRAM*			Three phases of Soil			Hardness
						F.C	W.P 1)	AM/10cm	R=30cm 2)	R=45 3)	R=60 4)	Soil Phase	liquid Phase	Vapor Phase	
				gm/cm³	%	Vol.%	Vol.%	mm	mm	mm	mm	%	%	%	
1	R.B.E.	0∿5	SL	1.52	43.1	24.9	11.6	13.3	24.9	37.4	50.8	56.1	24.9	19.0	12.7
		20		1.66	38.5	29.6	14.0	15.6				61.5	29.6	8.9	25.0
		30	SCL	1.67	38.3	26.4	12.3	14.1				61.7	26.4	12.0	25.3
		50∿55		1.71	36.4	26.3	12.3	14.0				63.4	26.3	10.3	26.3
2	R.B.E.	0∿5	SCL	1.57	41.9	25.0	11.6	13.4	25.1	37.7	55.1	58.1	25.0	16.9	16.0
		20		1.66	38.6	33.0	15.7	17.3				61.4	33.0	5.6	20.3
		35	CL	1.67	38.0	33.0	15.7	17.3				62.0	33.0	5.0	24.3
3	R.B.E.	0∿5	LS	1.40	48.2	18.7	8.5	10.2	18.1	20.7	43.8	51.8	18.7	29.5	10.0
		20		1.59	41.3	27.5	12.9	14.6				58.7	27.5	13.8	23.0
		30	SL	1.62	39.9	25.5	11.9	13.6				60.1	27.3	12.6	23.7
		45∿50		1.66	38.4	22.3	10.3	12.0				61.6	24.1	14.0	25.0
4		0∿5	FS	1.58	41.6	18.7	8.5	10.2	19.1	28.7	41.6	58.4	18.7	22.9	12.7
		20		1.69	37.4	24.0	11.1	12.9				62.6	24.0	13.4	21.3
		30	FS or FSL	1.76	34.8	23.8	11.0	12.8				65.2	23.8	11.0	22.0
		45∿50		1.79	33.7	27.0	12.7	14.3				68.4	27.0	6.7	24.0
5	R.B.E.	0∿5	SL	1.47	45.7	22.7	10.4	12.3	23.1	34.6	48.8	54.3	22.7	23.0	14.3
		20		1.61	40.4	27.2	12.8	14.4				59.6	27.2	13.2	18.3
		30	SCL	1.60	40.6	23.4	10.8	12.6				59.4	23.4	17.2	20.7
		45∿50		1.72	36.2	12.3	5.4	4.9				63.8	12.3	23.9	23.7
6		0∿5	LS	1.64	39.5	8.8	3.8	5.0	9.4	14.1	22.9	60.5	8.8	30.7	11.7
		20		1.58	41.6	15.1	6.8	8.3				58.4	15.1	26.5	19.7
		30	LS or S	1.58	41.6	15.7	7.0	8.7				58.4	15.7	25.9	19.3
		45∿50		1.67	38.3	16.1	7.2	8.9				61.7	16.1	20.3	19.3
7	R.B.E.	0∿5	SL	1.40	48.1	29.5	13.9	15.6	29.3	43.9	60.0	51.9	29.5	18.6	11.6
		20		1.53	43.6	31.9	15.1	16.8				56.4	31.9	11.7	18.3
		30	SCL	1.60	40.8	32.3	15.4	16.9				59.2	32.3	8.5	21.3
		50∿55		1.56	42.2	18.0	8.2	9.8				57.8	18.0	24.2	19.3
8	Alluvial	0∿5	CL	1.31	51.4	44.4	21.7	22.7	42.6	63.9	83.0	48.6	44.4	7.0	14.7
		20	CL	1.54	43.1	40.7	19.7	21.0				56.9	40.7	2.4	17.7
		30	FS	1.58	42.8	37.6	18.1	19.5				57.2	37.6	5.2	20.3
		45∿50	FS	1.59	45.4	38.2	18.4	19.8				54.6	38.2	7.2	21.3
9	L.H.G.	0∿5	CL	1.24	42.8	40.0	19.3	20.7	38.8	58.2	77.8	57.2	40.0	2.8	5.7
		20	SCL	1.64	42.5	40.3	19.5	20.8				57.5	40.3	2.2	16.3

NOTE: 1) $W.P = 0.36FC^{1.08}$

2) Pulses (Root Depth 1.0')

3) Soya Bean and Chillies (Root Depth 1.5')

4) Cotton (Root Depth 2.0')

* TRAM: Total readily available moisture

Table 3-2 Soil Examination Data

No	DEPTE (cm)	PH(kcℓ)	P_2O_5 mg/100g	P2O5 Coefficient	NH4-N	K_2O mg/100g
1	5-10	6.5	0.1	-500	1	3
2	5-10	5.5	1.0	-500	1	3
	25-30	6.0	0.1		1	0
3	5-10	6.0	0.1	-500	1	15
4	5-10	6.5	1.0	-500	1	8
5	5-10	6.5	10.0	600	1	15
	25-30	6.0	1.0		1	3
6	5-10	6.0	0.1	-500	1	3
7	5-10	7.0	1.0	600	1	30
	25-30	6.0	0.1		1	8
8	5-10	7.0∿7.5	5.0	700	1	8
	25-30	5.5	0.1		1	0

No. 1 WANNIYAGAMA

2 MAHAUSWEWA

3 MAHUSWEWA

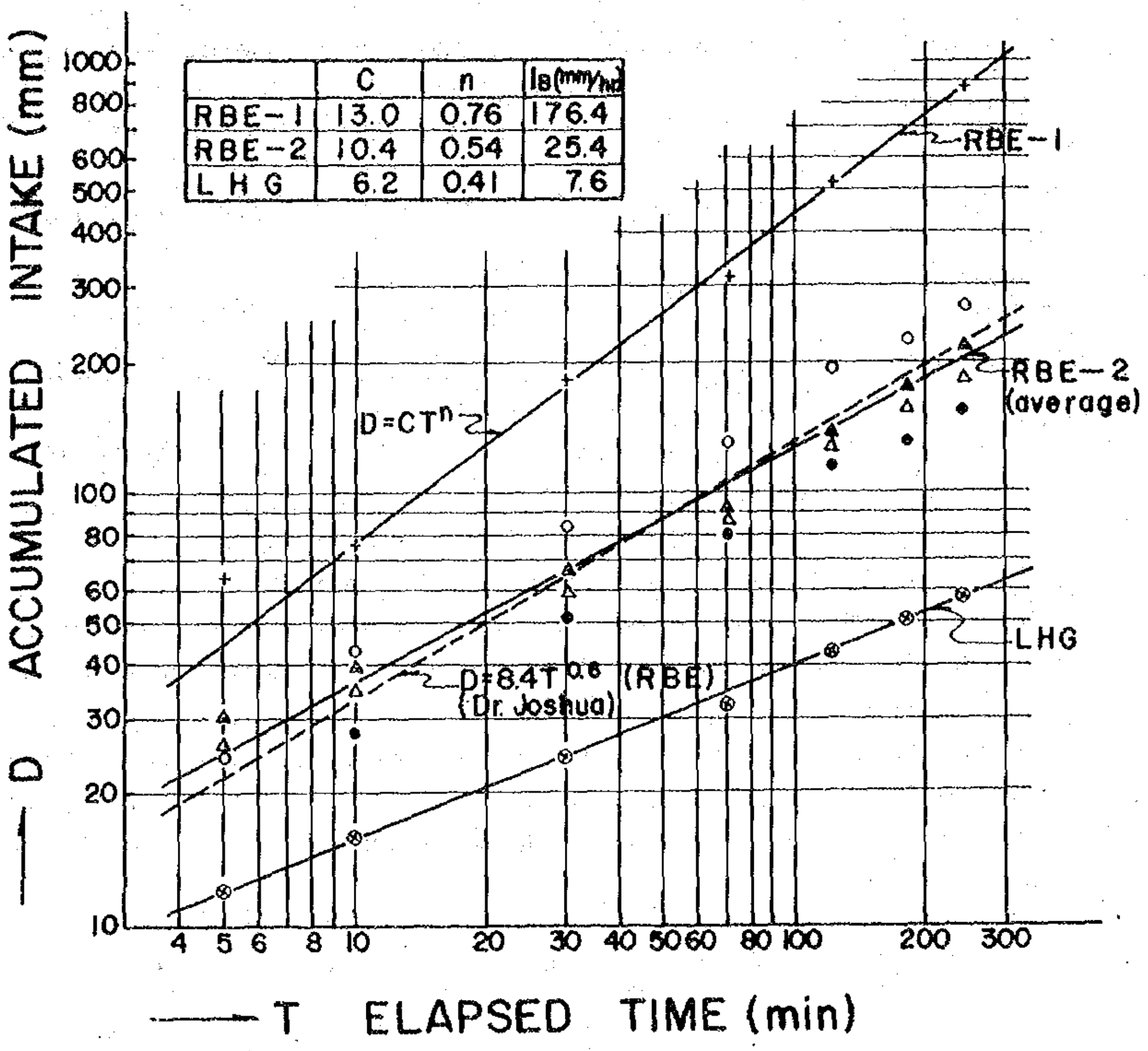
4

5 KOLLANKULAMA, INGINIMITIYA

6 KOTTAGAMA

7 INGINIMITIYA

Fig. 3-3 INTAKE CURVES



3.2 Irrigation Method

3.2.1 Applicability of Irrigation Methods

In relation to the basic intake rate, topography and crops, the classification of the irrigation methods will be as follows:

Irrigation Method	Slope of Lands	Extent of Basic Intake Rate	Objective Crops
Furrow method	under 5%	5 ~ 100 mm/h	Furrow crop, orchard
Cotton furrow method	5 ~ 27%	100 mm/h under	- do -
Strip border method	under 5%	75 mm/h hour	Forage crop, pasture
Contour ditch method	14 ~ 50%	Excessively not restricted	Pasture
Basin method	0.2% under	under 75 mm/h	Orchard, pasture
Sprinkling method	Excessively not restricted	above 5 mm/h	All kinds of crops

In this project, the irrigation for the upland crop in the Yala period except some parts being objected. The respective farm may be considered to be flat lands. Accordingly, the irrigation method in such areas is determined only by crops and the basic intake rate. However, from economic and technical considerations, the surface irrigations such as furrow irrigation, border irrigation and basin irrigation are the effective method. When classified with respective land class, the following can be obtained:

Low land	Where water source is favored	- gravity irrigation
	where water demand is short	- intermittent irrigation (water is saved in 30 ~ 40%)
High land	Furrow irrigation or furrow basin	- maize, cotton, chillies (stage II)
	Border irrigation	- upland rice
	Corrugation irrigation	- chillies (stage I)

3.2.2 Furrow Irrigation

Furrow irrigation can be applied to all furrow crops in this area. In order to carry out this method effectively, the operation of relevant irrigation shall be made considering relation of the furrow stream and the advance rate of the flow of water. For the sake of this, it is recommended the flowing method (quartering method) with 1/4 of the required irrigation time (T), that is, the irrigation water reaches from the starting furrow to the terminal furrow in T/4 time.

(1) Relationship of Furrow Stream and Advance Rate of Water Flow

In general, when the furrow discharge and inclination are in between appropriate range, the reaching time of the flow of water is a function of the reaching distance as follows:

$$t = \alpha L \beta$$

t : Time to be required for the flow of water to reach to L (min)

L : Reaching distance of the flow of water (m)

α, β : Constants

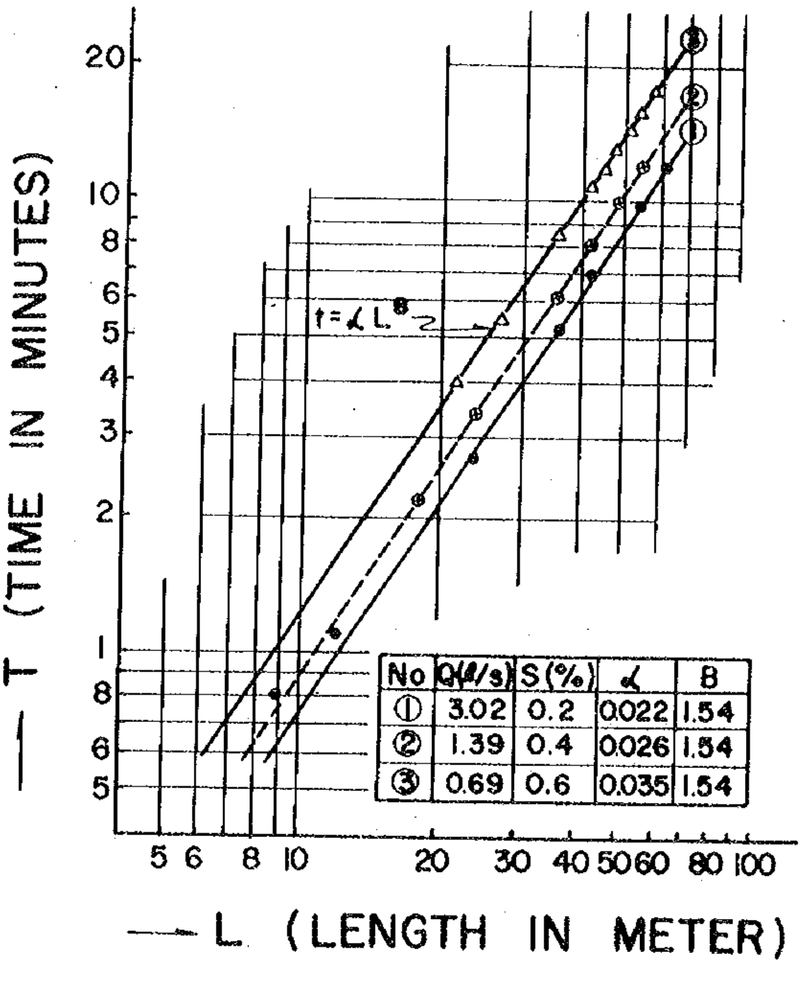
α, the coefficient of water flow is the time to be required for flowing down 1 m at the beginning. β shows the inclination in straight line. To conform with this value becoming less, the concentration time becomes short the indential furrow length. Fig. 3-4 shows the relation of furrow discharge and the advance rate of the flow of water, which was measured in Mahaveli project. (Upon the detail design of this area, actual survey in respective soil type is required.)

(2) Furrow Intake Rate

The approximation of the infiltration rate of the water in the water pressure condition of the furrow stream can be obtained from the value of cylinder intake rate. For anticipating correctness, furrow stream method is desirable to be adopted.

The expression of the intake rate of the furrow stream is ordinary showed by infiltration water-meter per length of ridge (ℓ/min/10m) or infiltration water depth per hour (mm/hr). Though the measurement

Fig. 3-4 ADVANCE CURVES



No	Q(ℓ/s)	S (%)	α	β
①	3.02	0.2	0.022	1.54
②	1.39	0.4	0.026	1.54
③	0.69	0.6	0.035	1.54

Drawing from Fig. 6A, 6B, 6C in Mahaveli Stage II could not be carried out because of the surveying period, the actual measurement will be necessary in respective soil type upon the detail design.

(3) Time of Furrow Stream (Tr)

Time of furrow stream can be determined by $T = (\frac{D}{C})^{\frac{1}{n}}$ which is transformation of the furrow intake formula $D = CT^n$ (mentioned above). The concentration time (t) of the flow of water has not been considered yet. The following will be gotten to consider this:

$$Tr = T + t = (\frac{D}{C})^{\frac{1}{n}} + t$$

Now, assuming furrow length, (L) 50 m, furrow width, 60 cm, the maximum time of water stream of the furrows is as Table 3-3:

Table 3-3 Time of Water Stream of Furrow

	Water Quantity per Irrigation (D)				
	20 mm	30 mm	40 mm	50 mm	60 mm
T (min)	4.2	8.3	13.5	19.5	26.5
t (min)	10.7	10.7	10.7	10.7	10.7
Tr (min)	14.9	19.0	24.2	30.2	37.2

Note: assuming

$C = 8.4$, $n = 0.6$

$\alpha = 0.026$, $\beta = 1.5$

$L = 50$ m

(4) Limit of Furrow Length

In the irrigation under the surface irrigation method, a side of a plot, furrow length, is restricted by the flow length (length of run) in which water can be supplied with high irrigation efficiency. After all, this length is determined by considering the water quantity per irrigation, furrow inclination, furrow stream, soil intake rate and etc.

Generally, if the speed of the flow of water is fast, the distribution efficiency of infiltration water in each part of the furrow becomes preferable. It is desirable as for irrigation efficiency. That the concentration time of the flow of water has parabola curve expressed by $t = \alpha L\beta$. If considering such adjustment in discharge quantity and inclination, the allowable length of furrow (L) can be determined by following formula:

$$L = \left(\frac{t}{\alpha}\right)^{\frac{1}{\beta}}$$

If applying the view point of the cut-back division method to the relation of the concentration time of the flow of water (t) and required irrigation time (T), the concentration time of the flow of water becomes $t = \frac{T}{m}$.

Further, since the irrigation time (T) becomes $T = \left(\frac{D}{C}\right)^{\frac{1}{n}}$ as described above, from the result of the measurement of the intake rate indicating the water quantity per irrigation (D), the limited length of furrow (L) can be obtained by the following formula to substitute T, D, t and coefficients into the formula $L = \left(\frac{t}{\alpha}\right)^{\frac{1}{\beta}}$.

$$L\ (m) = \left\{\frac{1}{\alpha} \cdot \frac{1}{m}\left(\frac{D}{C}\right)^{\frac{1}{n}}\right\}^{\frac{1}{\beta}}$$

The length of furrow shown in Table 3-4 is the value when $m = 1 \sim m = 4$, that is, when over 80% in irrigation efficiency. Accordingly, if reducing the irrigation efficiency to the extent of 60%, the limited length of furrow could be extended up to 50 m.

Table 3-4 Limited Length of Ridge

No.	T.R.A.M. (mm)			L max (m) R=30			R=45			R=60		
	R=30	R=45	R=60	m=1	m=2	m=4	m=1	m=2	m=4	m=1	m=2	m=4
1	24.9	37.4	50.8	34.6	22.1	14.1	53.7	34.3	21.9	74.8	47.7	30.4
2	25.1	37.7	55.1	34.9	22.3	14.2	54.2	34.6	22.0	81.7	52.1	33.2
3	19.1	28.7	43.8	26.0	16.6	10.7	40.4	25.7	16.4	63.7	40.7	25.9
5	23.1	34.6	48.8	31.9	20.3	13.0	49.4	31.5	20.1	71.7	45.7	29.1
7	29.3	43.9	60.0	41.3	26.3	16.8	63.9	40.8	26.0	89.6	57.1	36.4

Note: $C=8.4$, $n=0.6$ } depended on Dr. Joshua's data

$\alpha=0.026$, $\beta=1.54$ } calculated from Mahaveli Stage II. Fig. 6B

($Q=1.39$ ℓ/sec, $S=0.4\%$)

Where: m=1 - $\dot{Ea}$≈80%

m=2 - $\dot{Ea}$≈88%) Where n = 0.6

m=4 - $\dot{Ea}$≈93%

(5) Irrigation Efficiency

The water application efficiency can be determined by the following formula on the basis of each constant mentioned so far:

$$Ea\ (\%) = \frac{200 \times D}{C\ (T = \alpha L\beta) + D}$$

The water application efficiency is shown below in the Table 3-5.

Table 3-5 Water Application Efficiency

No.	T R A M (mm)			Ea (%)					
				L = 50 m			L = 100 m		
	R=30	R=45	R=60	R=30	R=45	R=60	R=30	R=45	R=60
1	24.9	37.4	50.8	70.5	81.1	87.2	50.5	63.4	72.6
2	25.1	37.7	55.1	70.7	81.3	88.5	50.7	63.6	74.8
3	19.1	28.7	43.8	62.4	75.4	84.5	42.3	55.0	68.2
5	23.1	34.6	48.8	68.3	79.3	86.5	48.1	61.0	71.4
7	29.3	43.9	60.0	75.0	84.5	89.8	55.7	68.3	77.0

IV AGRICULTURE

4.1 General

4.1.1 Present Land Use and Production Patterns

The entire area now covered by the Project cover 6,300 acres, of which about 1,640 acres is the existing agricultural land (paddyfield) and 4,600 acres is for new development. As a stable agricultural production takes place in the Dry Zone only through tank irrigation - supplementarily during Maha season but exclusively during Yala season - the extent of irrigability is synonymous with the entirety of land which can be productively used for cultivation of paddy which is the staple food of the people. The existing agricultural land, therefore, has its own sources of irrigation which, in our case, is Mahauswewa Tank and several other smaller village tanks. In the command area of Mahauswewa Tank which is the biggest and the most dependable in the region, the irrigable area has been limited to about 80% during Maha season and to about 40% during Yala season for the last 15 years or so; apart from paddy production, cultivation of some subsidiary food crops like cow peas, green gram, and the like is nevertheless possible and is actually tried out in the gardens and upland fields during Maha season. The pattern of irrigability and correspondingly the pattern of cropping in the command area of Mahauswewa Tank is supposed to be duplicated, though in much less favourable ratios, in the rest of the existing agricultural land.

The present land-use and production patterns in the existing agricultural land have not yet been studied in necessary details (some hearing from the farmers who happened to be living in the neighbourhood of the soil sampling spots are tabulated in the following part of this Chapter). It could, however, be said that by and large the farming is of subsistent level even within the existing agricultural land, to say nothing of the agricultural productivity in the area which will be newly developed that is almost negligible excepting some Chena cultivation during Maha seasons.

4.1.2 Agricultural Development under the Project

It is intended under the Project to clear, develop and consolidate some 4,600 acres of land which has not been systematically used for agricultural purposes and divide it into the small market oriented family farm of 2.5 acres each. The existing agricultural land which spreads over some 1,640 acres will also be consolidated, but no radical changes to its land distribution and tenure is anticipated. The development of both the existing and newly developed farms beyond subsistence level and within market oriented structures will require that the scientific agricultural techniques including the use of proper amounts of fertilizers, other agro-chemicals and the farm machinery be extended among the farmers side by side with organization and management of the appropriate farmers' institutions for water-management, procurement of credits and facilitating for supply of agricultural input materials and marketing of the produce.

4.1.3 Land Use and Cropping Patterns

The broad patterns of land-use and agricultural production would be governed by topographic and soil conditions in the Project area: low land (5,200 acres) which is comprised of 1,640 acres of the existing agricultural land and 3,560 acres of the newly developed land covers 83% of the entire Project area and is meant for paddy cultivation during both Maha and Yala seasons while, in agreement with land classification patterns, artificially and naturally well-drained highland (1,100 acres) will be used for cultivation of paddy during Maha season and of subsidiary food crops such as soya beans and pulses and cash crop like dried chillies during Yala season. Cropping patterns on the lowland and highland are shown in Fig. 4-1.

4.1.4 Future Project Output and Development Schedule

Project implementation would be phased over 5 years and the full project benefits would be achieved 5 years after project implementation in the newly developed land. In the meanwhile, with special attention given to water management, extension work and credit/input supply guidance, it is expected that the average yields of the crops will steadily increase from the moderate level to much higher and constant level as the farmers would be equipped with suitable agricultural machinery and obtain proper experience in managing their own farms and institutions. The output expected per acre in the newly developed land in the 6th and the 11th year will be as follows:

	Paddy	Soya bean	Pulses	Chillies (dry)
6th year	45 bushels	6 cwt	5 cwt	7 cwt
11th year	80 "	12 "	10 "	15 "

The estimated agricultural inputs and outputs in the newly developed land under the Project are given in Table 4-1.

Due to the experiences in crop cultivation and water control previously accumulated among the farmers, plus intensive water-management and extension services as well as institutional trainings under the Project, the yield-increase would start in the existing agricultural land from the 5th year when the headworks including main canals should be ready for operation. The average yields of the proposed crops which are expected in the newly developed land only in the 11th year are supposed to be obtained in the 7th year in the command area of Mahauswewa Tank, and in the 8th year in the rest of the existing agricultural land. The agricultural inputs and outputs estimated in the existing agricultural land during the construction period and under the Project are given in Tables 4-2 and 4-3.

4.2 Farm Equipments

The supply of farm machinery will be indispensable to allow the farmers upkeep the cropping patterns given above; the use of draught animals would require the production of fodder on irrigated land and would reduce the expected output of the Project - compared with the cost of combined use of 4-wheel and 2-wheel tractors the operation of draught animals does not appear significantly more profitable. It is therefore suggested that the farm machinery as specified in Table 4-4 will be supplied to the Project and systematically used for smooth operation under the supervision of the Agricultural Production Unit. 2-wheel tractors and their attachments and sprayers will be sold to the farmers' co-ops., after 2 years training of the farmers on their use. Sprayers may be sold directly to the farmers particularly those who are engaged in upland crop cultivation after they would have good knowledge in their use and maintenance.

4.3 Farm Requisites

Agricultural input requirements have been estimated roughly along the recommendations given by the Department of Agriculture (Table 4-5) which will be given in monetary terms as follows:

	Paddy	Chillies	Soya bean	Pulses
Seeds & Chemicals 1/	Rs. 530	Rs. 1,150	Rs. 220	Rs. 170
Farm Machinery & Hired Labour 2/	520	1,080	480	520
Miscellaneous 3/	135	160	80	80
	Rs. 1,185	Rs. 2,390	Rs. 780	Rs. 770

At the start of the agricultural development, it would be hazardous to invite inexperienced farmers to use high amounts of inputs which would result in heavy loss if crops were to fail. Thus, in the first year, it is expected that only 20 per cent of the recommended applications of fertilizers and agro-chemicals will be used; their dozage may increase as farmers will get experience and learn their value.

- Expected Tempo of Input Increase

Project Year :	6th	7th	8th	9th	10th	11th
Percentage :	20	30	40	60	80	100

4.4 Agricultural Labour

Based on an equivalent of 2.0 full time adult workers per household (5.5 persons) working on average of 250 days per year, the requirement of hired labour per acre during the "peak months" would be:

40 days for paddy cultivation during Maha & Yala each;

60 days for subsidiary food crops, and 90~120 days for chillie cultivation during Yala;

The labour wage is estimated at Rs. 8 per day.

Fig. 4-1 Proposed Cropping Pattern

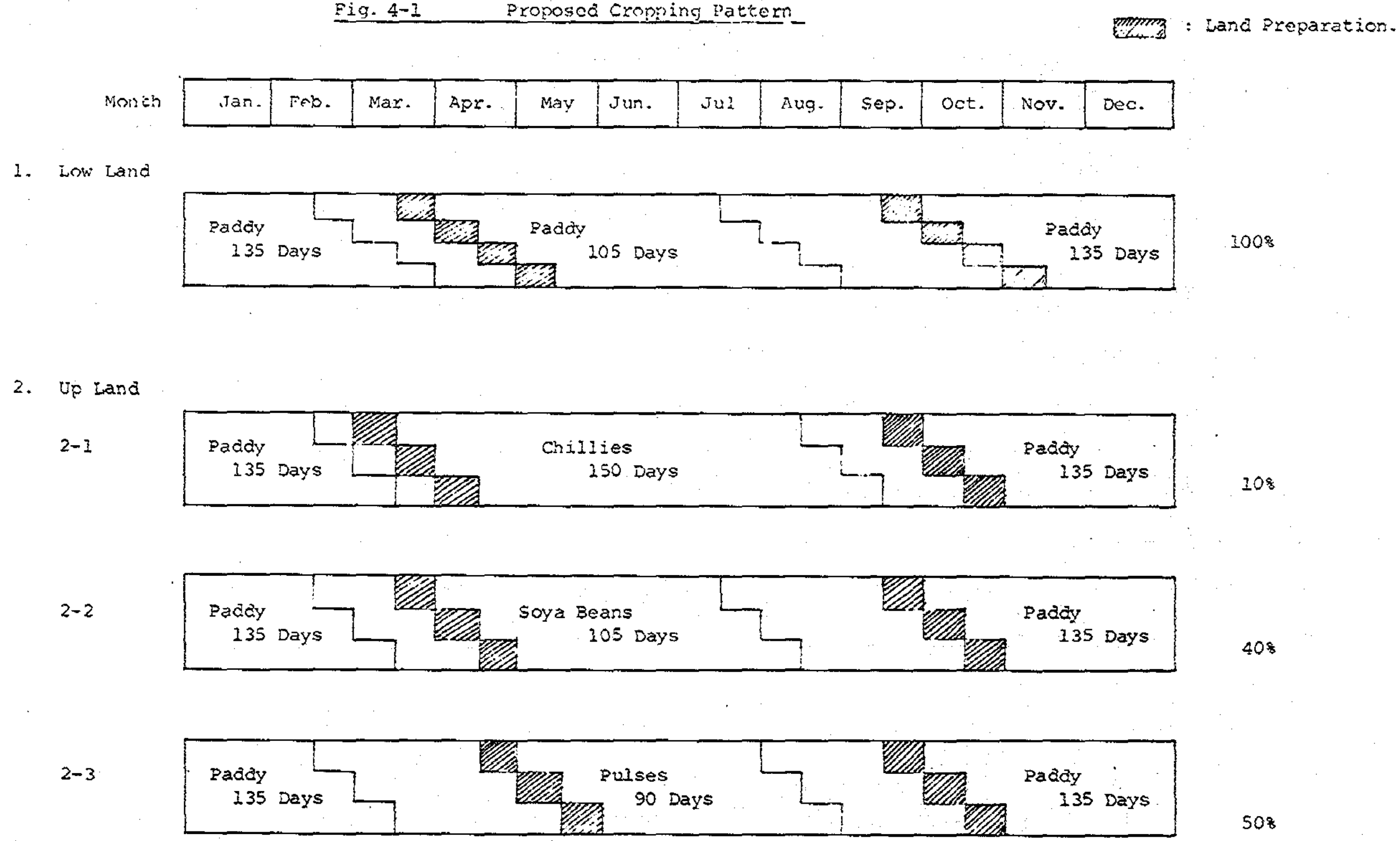


Table 4-1 Agricultural Production in The Newly Developed Area under The Project (Financial)

Type of Land			Low Land			High Land				
Size			3,560 acres			1,100 acres				
Irrigability			85% during Maha & 80% during Yala			85% during Maha & 80% during Yala				
Cropping Pattern			Paddy		Total	Paddy	Upland Crops (during Yala)			Total
			(during Maha)	(during Yala)		(during Maha)	Soya Beans	Pulses	Chillies	
Area under Crops			3,026Ac.	2,848Ac.	5,874Ac.	935Ac.	352Ac. (40%)	440Ac. (50%)	88Ac. (10%)	880Ac. (100%)
6th Year	Production	Yield per Acre	45bu	45bu		45bu	6cwt	5cwt	7cwt	
		Production (Rs1,000)	136.2	128.2	264.4	42	2,112	2,200	616	
		Unit Price (Rs)	33	33		33	84	128	1,000	
		G.P.V. (Rs1,000)	4,494.5	4,230.6	8,725.1	1,386	177.4	281.6	616	2,461
	Cost	Cost per Acre (Rs)	579	579		579	410	390	1,289	
		Total Cost (Rs1,000)	1,752	1,649	3,401	541.4	144.3	171.6	113.4	970.4
		N.P.V. (Rs1,000)	2,743	2,582	5,325	844.6	33.1	110	502.6	1,490.3
7th Year	Production	Yield per Acre	52bu	52bu		52bu	7.2cwt	6cwt	8.6cwt	
		Production (Rs1,000)	157.4	148.1	305.5	48.6	2,534	2,640	757	
		Unit Price (Rs)	33	33		33	84	128	1,000	
		G.P.V. (Rs1,000)	5,194.2	4,887.3	10,081.5	1,603.8	212.9	337.9	857	2,911.6
	Cost	Cost per Acre (Rs)	650	650		650	483	460	1,428	
		Total Cost (Rs1,000)	1,966.9	1,851.2	3.818.1	607.8	170	202.4	125.7	1,105.9
		N.P.V. (Rs1,000)	3,227.3	3,036.1	6,263.4	996	42.9	135.5	631.3	1,805.7
8th Year	Production	Yield per Acre	59bu	59bu		59bu	8.4cwt	7cwt	10.2cwt	
		Production (Rs1,000)	178.5	168	346.5	55.2	2,957	3,080	897.6	
		Unit Price (Rs)	33	33		33	84	128	1,000	
		G.P.V. (Rs1,000)	5,890.5	5,544	11,434.5	1,821.6	248.4	394.2	897.6	3,361.8
	Cost	Cost per Acre (Rs)	746	746		746	535	530	11,583	
		Total Cost (Rs1,000)	2,257.4	2,124.6	4,382	697.5	188.3	233.2	139.3	1,258.3
		N.P.V. (Rs1,000)	3,633.1	3,419.4	7,052.5	1,124.1	60.1	161.0	758.3	2,103.5
9th Year	Production	Yield per Acre	66bu	66bu		66bu	9.6cwt	8cwt	11.8cwt	
		Production (Rs1,000)	199.7	188	387.7	61.7	3,379	3,520	1,038.4	
		Unit Price (Rs)	33	33		33	84	124	1,000	
		G.P.V. (Rs1,000)	6,590.1	6,204	12,794.1	2,036.1	283.9	436.5	1,038.4	3,794.9
	Cost	Cost per Acre (Rs)	906	906		906	631	634	1,839	
		Total Cost (Rs1,000)	2,741.6	2,580.3	5,321.9	847.1	222.1	279.0	161.8	1,510.0
		N.P.V. (Rs1,000)	3,848.5	3,623.7	7,472.2	1,189	61.8	157.5	876.6	2,284.9
10th Year	Production	Yield per Acre	73bu	73bu		73bu	10.8cwt	9cwt	13.4cwt	
		Production (Rs1,000)	220.9	207.9	428.8	68.3	3,802	3,960	1,179.2	
		Unit Price (Rs)	33	33		33	84	128	1,000	
		G.P.V. (Rs1,000)	7,289.7	6,860.7	14,150.4	2,253.9	319.3	506.9	1,179.2	4,259.3
	Cost	Cost per Acre (Rs)	1,043	1,043		1,043	705	701	2,116	
		Total Cost (Rs1,000)	3,156.1	2,970.5	6,126.6	975.2	248.2	308.4	186.2	1.718.0
		N.P.V. (Rs1,000)	4,133.6	3,890.2	8,023.8	1,278.7	71.1	198.5	993	2,541.3
11th Year	Production	Yield per Acre	80bu	80bu		80bu	12cwt	10cwt	15cwt	
		Production (Rs1,000)	242.1	227.8	469.9	74.8	4,424	4,400	1,320	
		Unit Price (Rs)	33	33		33	84	128	1,000	
		G.P.V. (Rs1,000)	7,989.3	7,517.4	15,506.7	2,468.4	354.8	563.2	1,320	4,706.4
	Cost	Cost per Acre (Rs)	1,185	1,185		1,185	780	770	2,390	
		Total Cost (Rs1,000)	3,585.8	3,374.9	6,960.7	1,108	274.6	338.8	210.3	1,931.7
		N.P.V. (Rs1,000)	4,403.5	4,142.5	8,546	1,360.4	80.2	224.4	1,109.7	2,774.7

Table 4-2 Paddy Production in The Existing Agricultural Lands during The Construction Period (in Financial Prices)

		Command Area of Mahauswewa Tank		The Rest of The Existing Agricultural Land	
	Total Area	850 acres		790 acres	
	Irrigability	80% during Maha Season	40% during Yala Season	80% during Maha Season	40% during Yala Season
	Area under Paddy	680 acres	340 acres	632 acres	316 acres
Production	Yield per Acre	59 bushels	59 bushels	52 bushels	52 bushels
	Total Production	40,120 bl.	20,060 bl.	32,864 bl.	16,432 bl.
	Unit Price	Rs33	Rs33	Rs33	Rs33
	G.P.V. (Rs1,000)	Rs1,324	Rs662	Rs1,085	Rs542
Cost	Seed & Chemicals	Rs256	"	Rs206	"
	Farm Machinery/Labour	Rs400	"	Rs360	"
	Miscellaneous	Rs90	"	Rs84	"
	Cost per Acre	Rs746	Rs746	Rs650	Rs650
	Total Cost (Rs1,000)	Rs507	Rs254	Rs411	Rs205
	N.P.V. (Rs1,000)	Rs817	Rs408	Rs674	Rs337

Table 4-3 Paddy Production in The Existing Agricultural Lands under The Project (in Financial Prices)

	Diviison of Area	Command Area of Mahauswewa Tank						The Rest of The Existing Agricultural Lands							
	Total Area	850 acres						790 acres							
	Irrigability	85% during Maha			80% during Yala			85% during Maha Seaosn				80% during Yala Season			
	Area under Paddy	723 acres			680 acres			672 acres				632 acres			
	Project Year	6th Yr.	7th Yr.	8th Yr.	6th Yr.	7th Yr	8th Yr.	6th Yr.	7th Yr.	8th Yr.	9th Yr.	6th Yr.	7th Yr.	8th Yr.	9th Yr.
Production	Yield per Acre (bu)	66	73	80	66	73	80	59	66	73	80	59	66	73	80
	Total Production (bu)	47,718	52.779	57.840	44,880	49,640	54,400	39,648	44,352	49,056	53,760	37,288	41,712	46,136	50,560
	Unit Price (Rs)	Rs33/bushel			Rs33/bushel			Rs33/bushel				Rs33/bushel			
	G.P.V. (Rs1,000)	1,575	1,742	1.909	1,481	1,638	1,795	1,308	1,464	1,619	1,774	1,230	1,377	1,523	1,669
Cost	Seeds/Chemicals (Rs)	346	436	530	346	436	530	256	346	436	530	256	346	436	530
	Farm Machinery/Labour	440	480	520	440	480	520	400	440	480	520	400	440	480	520
	Miscellaneous	120	127	135	120	127	135	90	120	127	135	90	120	127	135
	Cost per Acre (Rs)	906	1,043	1,185	906	1,043	1,185	746	906	1.043	1,185	746	906	1,043	1,185
	Total Cost (Rs1,000)	655	754	857	616	709	806	501	609	701	796	472	573	659	749
	N.P.V. (Rs1,000)	920	988	1,052	865	929	989	807	855	918	978	758	804	864	920

Table 4-4 Farm Equipment List (for 6,300 Ac. Project Area)

	Item	Quantity	Estimated Unit Cost (cif Colombo)	Total Cost
			..........(US$1,000)......	
A.	4-wheel tractor[1/]	20	7.0	140
	Tyre Tiller	20	1.0	20
	Heavy Duty Cultivator	20	0.9	18
	Disc Plough	5	1.2	6
	Offset Disc Harrow	5	1.6	8
	2 Ton Trailor	20	0.9	18
	Spare Parts (25%)[2/]		LS	53
				263
B.	2-wheel Tractor[3/]	50	3.0	150
	Spare Parts (25%)		LS	38
				188
C.	Equipment for Repair and maintenance facilities		LS	50
D.	Sprayers			
	Knapsack Power (duster/mister)	25	0.3	7.5
	Knapsack Hand	50	0.1	5
	Duster Hand	20	0.1	2
	Spare Parts (25%)		LS	4
				18.5
	Grand Total			519.5 (say 520)

1/ Including Rotavator, Plough, Puddling Wheels, Level Board, etc.

2/ Particularly Rotavator Blader, Tyres & Tubes, Engine Parts like piston rings, injectors, etc.

3/ Including Rotavator, Leveller, Puddling Wheels, Ploughs, Spring Blader, 1.5 ton Treilor, etc.

A. To be put in custody, operation and maintenance of the Project HQ(i/c Agric. Prod. Unit);

B. To be put in custody, operation and maintenance of the Project HQ(i/c Agric. Prod. Unit) for 2 years after completion of the Project, then sold to the Farmers' Co-op. and separated by those who will have obtained enough training and experience in driving & repair/maintenance;

C. To be allocated among 4 Farm Machinery Centers which are under the control of the Project HQ (i/c Agric. Prod. Unit);

D. Same as above, but after the settlers will have good knowledge in their use sold to the Farmers' Co-op. for joint use or directly to the settlers particularly those who are engaged in upland crop cultivation.

Table 4-5 Details of Input Requirements at Full Development (Per Ac.)

	Paddy (130 days) Lowland	Paddy (100 days) Lowland	Chillies	Soya Bean	Pulses
Seeds	2 bushels	2 bushels	1 lb.	0.35 cwt. (60 lbs) Inoculated with Nitrogen Culture	0.1 cwt.
Fertilizers	Urea 1.6 cwt. N Superphosphate 0.8 cwt. P_2O_5 Potash 1.2 cwt. K_2O	1.2 cwt. N 0.8 cwt. P_2O_5 1.2 cwt. K_2O	Ammon. -Sulph. 1.0 cwt. N 0.8 cwt. P_2O_5 0.6 cwt. K_2O	Ammon. -Sulph. 1.0 cwt. N 1.0 cwt. P_2O_5 0.5 cwt. K_2O	Ammon. -Sulph. 0.2 cwt. N 0.5 cwt. P_2O_5 0.5 cwt. K_2O
Pesticides	Gamma BHC 6% 100 lbs Sumithion 50% 60 fl. OZ.	70 lbs 30 fl. OZ.	Sumithion 50% 180 OZS Thicvit 270 OZS Manazate D 80% 20 OZS	Malathion 50% 60 OZS	Malathion 50% 60 OZS Ceresan Wet SD 1 kg
Weedicides	3.4 DPA 3.5 Pints MCPA 40% 1.5 Pints Dalapon 80% 1 lb.	3.5 Pints 1.5 Pints 1 Pints	Lasso 40% 10 Pints	Linuron 50% 1.5 lbs	-

(Mahaweli Development Project)

4.5 Interview at Project Site

4.5.1 Land Use of Paddy and Yields of Encouraged Varieties

The results showed in Table 4-6 are derived from the survey of paddy cultivation in the Maha season in 1976 ~ 1977 in Mahauswewa benefited area. Cultivated varieties are mostly 3 ~ 3.5 month varieties of BG group, and occupy about 70% of the project area. The average yield is 80 ~ 100 bu/Ac and indicates considerably high value. Table 4-7 is the result of the yiled survey of encouraging varieties, and Table 4-8 is the result of farm households. Table 4-9 is encouraging varieties of paddy and their characteristics.

Table 4-6 Practical Survey of Paddy Rice Cultivation (MAHAUSWEWA District)

Variety	Cultivated Area		Yield			
			Average		Maximum*	
	Acres	%	bu/Ac	kg/ha	bu/Ac	kg/ha
BG 11-11 (4 months)	62	7.1	100	5,045	119.0	6,003
H4 (" ")	5	0.6	80	4,036	77.9	3,930
H8 (")	-	-	-	-	-	-
BG 90-2 (")	10	1.2	140	7,062	-	-
BG 94-1 (3 1/2 months)	106	12.2	100	5,045	-	-
BG 34-6 (")	127	14.6	80	4,036	128.8	6,497
BG 34-8 (3 months)	387	44.6	80	4,036	140.4	7,082
I.R 8 (4 ~ 4 1/2 months)	-	-	-	-	154.7	7,804
BG 96-3 (4 months)	-	-	-	-	-	-
62-355 (3 months)	171	19.7	45	2,270	102.1	5,150
	868Ac.	100.0%				

* From The BIWEEKLY MAGAZINE "NAVAYUGAYA" dated 26th April 1977.

Table 4-7 Results of Extension Field Trials on Rice - Maha 1976/77

Zones: Dry District: Puttalam

D.R.O. Division Anamaduwa

Name of A.I S.A.L Senanayaka

Name of Farmer K.A Wickramasinghe

Addrees of Farmer Mahauswewa Soil: Sandy

1.

Paddy Varieties	Date Sown	Date of heading	Date of harvest	Age in Days	Lodging % at 2 weeks before hurvest Low Fert.	High Fert.
BG 90-2	76.12.04	77.3.10	77.4.23	140	0	0
BG 96-3	"	77.3.14	"	"	0	0
BG 11-11	"	77.3.04	"	"	0	0
LD 125	"	77.3.13	"	"	0	0

2. Yield

Varieties	Low Fert. Level		High Fert. Level	
	Dry Vol (bu/ac)	Dry Wt. (Ib/ac)	Dry Vol. (bu/ac)	Dry Wt. (Ib/ac)
BG 90-2	70.8	3,228	84.9	3,965
BG 96-3	76.1	3,681	77.9	3,775
BG 11-11	65.5	3,038	69.7	3,322
LD 125	67.8	3,059	76.7	3,624

3. Amount of Fertilization

Fertilizer	Quantity (Lb/ac.) Low	High	Recommended Quantity by The Dept. of Agri.
Nitrogen	20	40	100 Lb/ac.
Phosphate	12 1/2	25	80
Potash	10	20	50

Table 4-8 Farm Household Survey at Soil Survey Points

	No.2	No.3	No.5	No.6	No.7
Place	MAHAUSWEWA	MAHAUSWEWA	KOLLANUKLAMA	KOTTAGAMA	KOTTAGAMA
Yala of settlement	1969	1958	1960		1975
Name of Farm Housegold	HERATHBANDA	W.N.R.JINADASA	C.M.CHANDRADASA	JAYASINGHE	DHARMASENA
Family Structure	People 9 (couple -2 children -7) Labor Power -6	People 5 (couple -2 children -3)	People 4 (couple -2 children -2) Labor Power -2	People -3 (couple -2 children -1) Labor Power -2	People 2 (couple -2 children -0)
Farming Area	Paddy Field 3Ac. (In case of families 9, 5Ac is need in minimum)	Paddy Field 3Ac. Upland 8Ac.	Paddy Field 1.5Ac. Upland 3.0Ac.	Paddy Field 2.0Ac. Upland 3.0Ac.	Upland 2.5Ac. Paddy Field 0
Cultivated Crop	Paddy Rice (BG34-8) 3 months varieties	Paddy Field, Paddy Rice Upland Cowpea	Upland (Manioc Green Gram) Paddy Field Rice	Paddy Field (Fallowland) water demand short Upland (Cowpea Manioc)	Cowpea Manioc
Yield	Paddy Rice 50∿55 bu/Ac.	Cowpea 35 bu/Ac. (18.8 cwt/Ac.)	Manioc 200∿300 ib/Ac. Green Gram 12 bu/Ac. Rice 40∿60 bu/Ac.		
Others	Size of block average average 0.25Ac. Water maintenance Plantation; irrigation everyday for a month. Then, to irrigate for days and 3 days suspension in a week.		After the completion of Inginimitiya Project, wishing the introduction of chillie and onion as cash crop.	After the completion of Inginimitiya Project, wishing the introduction of nuts.	After the completion of Inginimitiya Project wishing mainly to introduce pulses, and paddy for the place enough water available.

Table 4-9 Encouraging Varieties and Features of Paddy Rice (Dry Zone)

VARIETY	DURATION (months)	Maximum Yield (bu/Ac)	HEIGHT	RICE (%)	COLOUR OF RICE
BG 34-8	3	140.4	22.7	73.6 ∿ 71.1	white
BG 34-11	"	102.1	21.3	71.3	"
BG 34-12	"				
62 - 355	"	102.1	32.3	60.1	light red
BG 34-6	3 1/2	128.8	23.8	71.2	red
BG 94-1	"				
IR - 262	"	138.8	18.4	71.1	white
H - 7	"	85.8	34.5	73.5	"
IR - 8	4 4 1/2	154.7	22.0	72.2	"
IR - 20	"				
BG 11-11	"	119.0	27.8	72.3	"
BG 90- 2	"				
H - 4	"	77.9	39.4	71.8	red

Note: From THE BIWEEKLY MAGAZIME " NAVAYUGAYA" 26th April 1977.

4.5.2 Time of Irrigation and Water Requirement

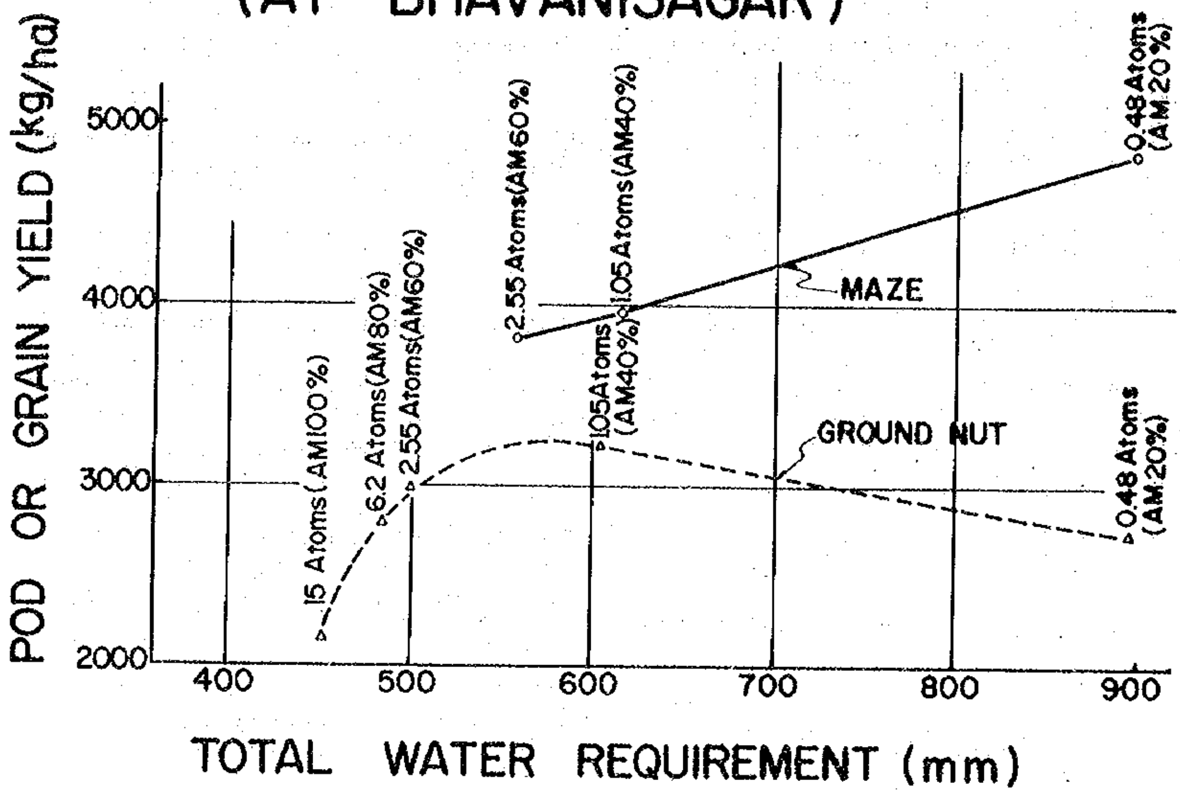
In the cultivation of upland crops, the tension of soil moisture in the irrigation gives a great influence to the water requirement and thus the yield. Dr. T. Sivanayagm (Research officer) carried out an experiment at Bhavanisager on the irrigation to begin when 20% (0.48 At.), 40% (1.05 At.), 60% (2.55 At.), 80% (6.2 At.), 100% (15.0 At.) of the available moisture consumption, and obtained a result as in Fig. 4-2 about the relationship of the yeild and water requirement.

Concerning maize, a result with high yield is obtained when the moisture tension is low in irrigation time. However, a result on ground nut shows that high yield can be realized when the irrigation frequency is extended to maintain the condition in high moisture tension (1.05 At. ~ 2.55 At.).

Although neither maize nor ground nut are the subjective crop to this project, a valuable suggestion would give to know the relationship of the crop production and water requirement.

It is necessary to clear these relationship regarding the intended crops in this project such as cowpea and chillie occasion as soon as possible for making a relevant source of the water management.

Fig.4-2 WATER USE AND FIELD AT DIFFERENT MOISTURE REGIMES. (AT BHAVANISAGAR)



Water Relations of Pulse Crops
Drawing from Dr. T. Sivanayagm, Research Officer

4.5.3 Lift Irrigation Survey in Rejangana Project District

(1) General Condition

Irrigation area	4,000 Ac.
Pumping station	240 places (average 167 Ac. per pumping station)
Amount of water conveyance to the terminal block	56 ℓ/sec (6" P/V/C/pipe)
Objective crops for irrigation	Chillie, onion, cowpea, green gram, black gram, soya bean and etc.

(2) Farm Household

Name of farm household	Piyadasa (Kokmaduwa, Rajangana)		
Family structure	8 people (couple, children 6, labour 4)		
Land tenure	Lift irrigation land	1.5 Ac.	4.0 Ac.
	Paddy field	2.0 Ac.	
	Building lot and etc.	0.5 Ac.	
Crops	Chille (90 days variety)	1.0 Ac.	
	Semami	0.5 Ac.	
	Paddy rice	2.0 Ac.	

Rotation system	Present	Irrigated
Maha	Maize	Maize
Yala	Cowpea	Chille, soya bean, peanut

Field condition and water management:

Average area per plot - about 0.06 Ac.

Irrigation (8 hours/day/Ac.) for 3 days, corresponding to about 120 mm, for land-grading a week before plantation. After plantation, 50 ~ 60 mm is irrigated once in every 5 ~ 7 days according to the degree of drought.

(3) Problems in Water Management

Irrigation water is conveyed with P/V/C/pipes (6") from the pumping station to the terminal block, and concrete lines canal after the terminal block. The water diversions are directly made from the terminal canal into each farm. Because of the open canal it is difficult to intake the water where the gradient is steep.

The construction of the pumping station and the terminal facilities are in charge of the Irrigation Bureau, the Government of Sri Lanka while the water management and instruction in farm management are under the Ministry of Agriculture. Many facilities have been put out of operation due to poor cooperation. In the fields not directly connected with canals, the irrigation water is distributed from plots to plots to cross uplands. Further, due to that surface irrigation such as furrow irrigation is employed in no relation to the water holding capacity and permeability of soils and the cultivation pattern, the most of irrigation water about 70 ~ 80% have been washed. In order to make the surface irrigation such as furrow and border irrigation in high efficiency, ridge inclination, furrow stream, and length of ridge shall be decided rationally on the basis of the relation of topography, soil and crop combining to the well-planned farm consolidation.

The surface irrigation method seems simple but requires quite high technique. It is necessary to provide experiment farms and various values necessary for the design for the future farming in the project area.

Since Rajangana lift irrigation district has quite favorable conditions for studying these matters, it is desirable to commence experiments urgently to cooperate with each authority concerned.

V IRRIGATION PLAN

5.1 General

Irrigation Plan has been worked out on the availability of a new source of water through construction of Inginimitiya Reservoir on the one hand and its effective use for agricultural development in the Project area, on the other. The reservoir will have a live (effective) capacity of 48,800 Ac.ft. out of a gross capacity of 53,000 Ac.ft., and the Project area has a gross acreage of 9,200, out of which topographically irrigable area would be 6,300 acres which is made up of 1,640 acres existing paddy-field and 4,660 acres for new reclamation.

Cultivation of paddy in two seasons of a year is proposed on the low land which represents a major part of the net irrigable area of 6,300 acres while, on the highland, paddy during Maha season and upland crops (soya beans, pulses and dry chillies) during Yala season.

Irrigation Plan covers several important items such as the construction of (1) Inginimitiya Reservoir, including spillway, outlets and tail channel, of (2) main canals, and (3) structures related to canals and channels, as well as (4) land development (jungle-clearing, land levelling and consolidation).

5.2 Identification of the Project Area

The Project area consists of the area which is embraced by two main canals running from right bank outlet and left bank outlet of the proposed dam (181 M.S.L.), being pierced by the Mi-Oya almost at its centre. It is bordered by the right bank main canal in the north, the left bank main canal in the south, the proposed dam in the east, and the tapering point of the right bank main canal and some brooklets in the west. Having an average width of 2 1/2 miles and the length of 9 1/2 miles, its gross area is about 9,200 acres, of which 800 acres is made up of non-irrigable heights and water surface. Out of the irrigable area of 8,400 acres, a net 6,300 acres will be directly benefited; the remaining 2,100 acres (25%) has been excluded because some is already occupied as coconut gardens, orchards, and village settlements and some other must be kept aside for future settlements, public utilities and natural green. 1,640 acres out of this 6,300 acres is the existing paddyfield and the remaining 4,660 acres is covered by jungles.

The net irrigable area fed by the right bank and left bank main canals consists of:

Main Canal	Existing Paddyfield	New Development Area	Total
Left bank	1,165 acres	2,835 acres	4,000 acres
Right bank	475 "	1,825 "	2,300 "
	1,640 acres	4,660 acres	6,300 acres

5.3 Water Demands

5.3.1 Effective Rainfall

Monthly effective rainfall has been estimated according to the same procedures as have been adopted by the Mahaweli Development Board and many other Irrigation Schemes in Sri Lanka, as follows:

(a) Lowland Paddy

$ER = (R - 1) \times 0.67$ (inches)

$ER \geq 9''$ $\quad$ $ER = 9''$

$R \leq 1''$ $\quad$ $ER = 0$

(b) Upland Crops

$ER = (R - 0.25) \times 0.67$ (inches)

$ER \geq 3''$ $\quad$ $ER = 3''$

$R \leq 0.25''$ $\quad$ $ER = 0$

Note: ER = Monthly Effective Rainfall
R = Monthly Rainfall

5.3.2 Water Requirement for Land Preparation

(a) Lowland Paddy = 7"

(b) Upland Crops = 1.5"
(including upland rice)

5.3.3 Percolation and Dyke Leakage for Lowland Paddy

In the light of the soil texture (low humic gley soils and alluvial soils of variable drainage and texture), these losses are estimated at 6 inches per month.

5.3.4 Irrigation Efficiency

Irrigation efficiency of 50% is applied for cultivation of upland crops, including upland rice.

5.3.5 Crop Water Requirement

Crop water required is defined as the sum of evapo-transpiration and percolation or irrigation losses. Evapo-transpiration is obtained from the folloiwng formula:

ET (Crop) = Eto x Crop factor

where ET (Crop) : Evapo-transpiration
ETo : Reference evapo-transpiration (not adjusted)

ETo values can be obtained by the modified Penman Method which was developed by FAO; the monthly Eto which were used for Mahaweli Scheme will be adopted for our Plan as follows:

• Monthly Eto Values

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Eto:	4.7	5.0	6.2	5.9	6.4	6.9	7.5	7.6	7.5	6.2	4.3	4.5

Crop factors varying according to the crops' growing periods are shown in Table 5-1.

Irrigation requirement has been calculated as per Table 5-2 and 5-3, based on the Cropping Patterns (shown in Fig. 4-1) and the monthly and bi-monthly crop water requirements resulting from the proposed Cropping Patterns.

5.3.6 Irrigation Requirement

Irrigation requirement is defined as: Crop Requirement + Farm Waste - Effective Rainfall. Monthly and 5 days period irrigation requirements are given in Tables 5-4 and 5-5.

5.3.7 Diversion Requirement

Diversion requirement is defined as the sum of irrigation requirement and conveyance and diversion losses; the loss due to conveyance and diversion is estimated at 30% of the irrigation requirement. Monthly and bi-monthly diversion requirements are computed as per Table 5-6 and 5-7.

Table 5-1 Crop Factor

Crop and Crop factor	Initial Stage	Crop Development Stage	Mid Stage	Late Stage
Lowland Rice				
(135 days)	30 days	40 days	45 days	20 days
Crop factor	1.00	1.15	1.20	0.90
Lowland Rice				
(100 days)	20 days	30 days	30 days	20 days
Crop factor	1.00	1.15	1.20	0.90
Lowland Rice				
(90 days)	20 days	25 days	30 days	15 days
Crop factor	1.00	1.15	1.20	0.90
Upland Rice				
(100 days)	20 days	30 days	30 days	20 days
Crop factor	0.90	1.00	1.05	0.90
Upland Rice				
(90 days)	20 days	25 days	30 days	15 days
Crop factor	0.90	1.00	1.05	0.90
Green Gram				
(75 days)	15 days	20 days	25 days	15 days
Crop factor	0.50	0.80	1.05	0.70
Chillies				
(150 days)	25 days	25 days	75 days	25 days
Crop factor	0.65	0.85	1.00	0.90
Ground Nuts				
(110 days)	20 days	30 days	40 days	20 days
Crop factor	0.65	0.80	1.00	0.80
Soya Bean				
(105 days)	15 days	20 days	50 days	20 days
Crop factor	0.65	0.85	1.05	0.75
Cowpea				
(90 days)	15 days	25 days	35 days	15 days
Crop factor	0.70	0.90	1.10	1.00
Pulses				
(95 days)	15 days	30 days	35 days	15 days
Crop factor	0.50	0.80	1.05	0.50
Cotton				
(165 days)	25 days	45 days	55 days	40 days
Crop factor	0.65	0.90	1.05	0.90

Tabel 5-2 Crop Requirement and Irrigation Requirement (Monthly)

(a) Lowland

(1) Lowland Rice (135 Days) : Maha

	S	O	N	D	J	F	M
Crop Factor		0.38	0.93	1.14	1.17	0.95	0.36
E.To		6.2	4.3	4.5	4.7	5.0	6.2
E.T.		2.36	4.00	5.13	5.50	4.75	2.23
Percolation etc.		2.25	5.25	6.00	6.00	5.25	2.25
Land Preparation	1.75	3.50	1.75	-	-	-	-
Total	1.75	8.11	11.00	11.13	11.50	10.00	4.48

(2) Lowland Rice (105 Days) : Yala

	M	A	M	J	J	A
Crop Factor		0.39	0.96	1.16	0.95	0.36
E.To		5.9	6.4	6.9	7.5	7.6
E.T.		2.30	6.14	8.00	7.13	2.74
Percolation etc.		2.25	5.25	6.00	5.25	2.25
Land Preparation	1.75	3.50	1.75	-	-	-
Total	1.75	8.05	13.14	14.00	12.38	4.99

(b) Upland

(1) Upland Rice (135 Days) : Maha

	S	O	N	D	J	F	M
Crop Factor		0.45	0.95	1.02	1.04	0.81	0.15
$E.T_O$		6.2	4.3	4.5	4.7	5.0	6.2
E.T.	-	2.79	4.09	4.59	4.89	4.05	0.93
$E.T. \times \frac{100}{50}$		5.58	8.18	9.18	9.78	8.10	1.86
Land Preparation	0.50	1.00					
Total	0.50	6.58	8.18	9.18	9.78	8.10	1.86

(2) Chillies (150 Days) : Yala

	M	A	M	J	J	A	S
Crop Factor	0.11	0.60	0.89	0.99	0.99	0.78	0.15
$E.T_O$	6.2	5.9	6.4	6.9	7.5	7.6	7.5
E.T.	0.68	3.54	5.70	6.83	7.43	5.93	1.13
$E.T. \times \frac{100}{50}$	1.36	7.08	11.40	13.66	14.86	11.86	2.26
Land Preparation	1.00	0.50	-	-	-	-	-
Total	2.36	7.58	11.40	13.66	14.86	11.86	2.26
10%	0.24	0.76	1.14	1.37	1.49	1.19	0.23

(3) Soya Bean (105 Days) : Yala

	M	A	M	J	J	A
Crop Factor		0.36	0.89	1.02	0.74	0.13
$E.T_o$		5.9	6.4	6.9	7.5	7.6
E.T.		2.12	5.70	7.04	5.55	0.99
$E.T. \times \frac{100}{50}$	-	4.24	11.40	14.08	11.10	1.98
Land Preparation	0.50	1.00	-	-	-	-
Total	0.50	5.24	11.40	14.08	11.10	1.98
40%	0.20	2.10	4.56	5.63	4.44	0.79

(4) Pulses (90 Days) : Yala

	A	M	J	J	A
Crop Factor	-	0.30	0.79	0.92	0.34
$E.T_o$	5.9	6.4	6.9	7.5	7.6
E.T.	-	1.92	5.45	6.90	2.58
$E.T. \times \frac{100}{50}$	-	3.84	10.90	13.80	5.16
Land Preparation	0.50	1.00	-	-	-
Total	0.50	4.84	10.90	13.80	5.16
50%	0.25	2.42	5.45	6.90	2.58

Table 5-3 Crop Requirement and Irrigation Requirement (5 days period)

(a) Lowland

(1) Lowland Rice (135 Days) : Maha

	S						O						N						D					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Crop Factor							0.042	0.042	0.042	0.083	0.083	0.083	0.131	0.131	0.131	0.179	0.179	0.179	0.185	0.185	0.188	0.194	0.194	0.196
$E.T_O$										6.2						4.3						4.5		
E.T.							0.26	0.26	0.26	0.51	0.51	0.51	0.56	0.56	0.56	0.77	0.77	0.77	0.83	0.83	0.85	0.87	0.87	0.88
Percolation							0.25	0.25	0.25	0.5	0.5	0.5	0.75	0.75	0.75	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Land Preparation				0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	-	-	-	-	-	-	-	-	-
Total	-	-	-	0.58	0.58	0.58	1.09	1.09	1.09	1.59	1.59	1.59	1.89	1.89	1.89	1.77	1.77	1.77	1.83	1.83	1.85	1.87	1.87	1.88

	J						F						M					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Crop Factor	0.196	0.196	0.198	0.198	0.198	0.188	0.188	0.188	0.175	0.138	0.138	0.125	0.088	0.088	0.075	0.038	0.038	0.038
$E.T_O$				4.7						5.0						6.2		
E.T.	0.92	0.92	0.93	0.93	0.93	0.88	0.94	0.94	0.88	0.69	0.69	0.63	0.55	0.55	0.47	0.24	0.24	0.24
Percolation	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.75	0.75	0.75	0.5	0.5	0.5	0.25	0.25	0.25
Land Preparation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.92	1.92	1.93	1.93	1.93	1.88	1.94	1.94	1.88	1.44	1.44	1.38	1.05	1.05	0.97	0.49	0.49	0.49

(2) Lowland Rice (105 Days) : Yala

	M						A					
	1	2	3	4	5	6	1	2	3	4	5	6
Crop Factor							0.042	0.042	0.042	0.083	0.090	0.090
E.To										5.9		
E.T.							0.25	0.25	0.25	0.49	0.53	0.53
Percolation							0.25	0.25	0.25	0.5	0.5	0.5
Land Preparation	-	-	-	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
Total				0.58	0.58	0.58	1.08	1.08	1.08	1.57	1.61	1.61

	M						J					
	1	2	3	4	5	6	1	2	3	4	5	6
Crop Factor	0.131	0.138	0.138	0.179	0.188	0.188	0.188	0.196	0.196	0.196	0.198	0.185
E.To				6.4						6.9		
E.T.	0.84	0.88	0.88	1.15	1.20	1.20	1.30	1.35	1.35	1.35	1.37	1.28
Percolation	0.75	0.75	0.75	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Land Preparation	0.58	0.58	0.58	-	-	-	-	-	-	-	-	-
Total	2.17	2.21	2.21	2.15	2.20	2.20	2.30	2.35	2.35	2.35	2.37	2.28

	J						A					
	1	2	3	4	5	6	1	2	3	4	5	6
Crop Factor	0.185	0.188	0.175	0.138	0.138	0.125	0.088	0.088	0.075	0.038	0.038	0.038
E.To				7.5						7.6		
E.T.	1.39	1.41	1.31	1.04	1.04	0.94	0.67	0.67	0.57	0.29	0.29	0.29
Percolation	1.0	1.0	1.0	0.75	0.75	0.75	0.5	0.5	0.5	0.25	0.25	0.25
Land Preparation	-	-	-	-	-	-	-	-	-	-	-	-
Total	2.39	2.41	2.31	1.79	1.79	1.69	1.17	1.17	1.07	0.54	0.54	0.54

(b) Upland

(1) Upland Rice (135 Days) : Maha

	S						O						N						D					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Crop Factor							0.050	0.050	0.050	0.100	0.100	0.100	0.156	0.156	0.156	0.161	0.161	0.161	0.167	0.167	0.169	0.169	0.169	0.172
$E.T_O$										6.2						4.3						4.5		
E.T.							0.31	0.31	0.31	0.62	0.62	0.62	0.67	0.67	0.67	0.69	0.69	0.69	0.75	0.750	0.76	0.76	0.76	0.77
$E.T. x \frac{100}{50}$							0.62	0.62	0.62	1.24	1.24	1.24	1.34	1.34	1.34	1.38	1.38	1.38	1.50	1.50	1.52	1.52	1.52	1.54
Land Preparation				0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	0.17	0.17	0.17	0.79	0.79	0.79	1.41	1.41	1.41	1.34	1.34	1.34	1.38	1.38	1.38	1.50	1.50	1.52	1.52	1.52	1.54

	J						F						M					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Crop Factor	0.172	0.172	0.175	0.175	0.175	0.167	0.167	0.167	0.158	0.108	0.108	0.100	0.050	0.050	0.050	-	-	-
$E.T_O$				4.7						5.0						6.2		
E.T.	0.81	0.81	0.82	0.82	0.82	0.78	0.84	0.84	0.79	0.54	0.54	0.50	0.31	0.31	0.31	-	-	-
$E.T. x \frac{100}{50}$	1.62	1.62	1.64	1.64	1.64	1.56	1.68	1.68	1.58	1.08	1.08	1.00	0.62	0.62	0.62	-	-	-
Land Preparation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.62	1.62	1.64	1.64	1.64	1.56	1.68	1.68	1.58	1.08	1.08	1.00	0.62	0.62	0.62	-	-	-

(2) Chillies (150 Days) : Yala

	M						A						M						J					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Crop Factor				0.036	0.036	0.036	0.072	0.072	0.083	0.119	0.119	0.131	0.131	0.139	0.150	0.150	0.158	0.158	0.158	0.167	0.167	0.167	0.167	0.167
E.To				6.2						5.9						6.4						6.9		
E.T.				0.22	0.22	0.22	0.42	0.42	0.49	0.70	0.70	0.77	0.84	0.89	0.96	0.96	1.01	1.01	1.09	1.15	1.15	1.15	1.15	1.15
E.T. x $\frac{100}{50}$				0.44	0.44	0.44	0.84	0.84	0.98	1.40	1.40	1.54	1.68	1.78	1.92	1.92	2.02	2.02	2.18	2.30	2.30	2.30	2.30	2.30
Land Preparation	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	0.17	0.17	0.17	0.61	0.61	0.61	1.01	1.01	1.15	1.40	1.40	1.54	1.68	1.78	1.92	1.92	2.02	2.02	2.18	2.30	2.30	2.30	2.30	2.30
10%	0.017	0.017	0.017	0.061	0.061	0.061	0.101	0.101	0.115	0.140	0.140	0.154	0.168	0.178	0.192	0.192	0.202	0.202	0.218	0.230	0.230	0.230	0.230	0.230

	J						A						S					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Crop Factor	0.167	0.167	0.167	0.167	0.161	0.161	0.161	0.156	0.156	0.106	0.100	0.100	0.050	0.050	0.050			
E.To				7.5						7.6						7.5		
E.T.	1.25	1.25	1.25	1.25	1.21	1.21	1.22	1.19	1.19	0.81	0.76	0.76	0.38	0.38	0.38			
E.T. x $\frac{100}{50}$	2.50	2.50	2.50	2.50	2.42	2.42	2.44	2.38	2.38	1.62	1.52	1.52	0.76	0.76	0.76			
Land Preparation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Total	2.50	2.50	2.50	2.50	2.42	2.42	2.44	2.38	2.38	1.62	1.52	1.52	0.76	0.76	0.76			
10%	0.250	0.250	0.250	0.250	0.242	0.242	0.244	0.238	0.238	0.162	0.152	0.152	0.076	0.076	0.076			

(3) Soya Bean (105 Days) : Yala

	M						A					
	1	2	3	4	5	6	1	2	3	4	5	6
Crop Factor							0.036	0.036	0.036	0.083	0.083	0.083
E.To							5.9					
E.T.							0.21	0.21	0.21	0.49	0.49	0.49
E.T x $\frac{100}{50}$							0.42	0.42	0.42	0.98	0.98	0.98
Land Preparation				0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Total				0.17	0.17	0.17	0.59	0.59	0.59	1.15	1.15	1.15
40%				0.068	0.068	0.068	0.236	0.236	0.236	0.460	0.460	0.460

	M						J					
	1	2	3	4	5	6	1	2	3	4	5	6
Crop Factor	0.131	0.142	0.142	0.153	0.164	0.164	0.164	0.175	0.175	0.175	0.175	0.158
E.To	6.4						6.9					
E.T.	0.84	0.91	0.91	0.98	1.05	1.05	1.13	1.21	1.21	1.21	1.21	1.09
E.T x $\frac{100}{50}$	1.68	1.82	1.82	1.96	2.10	2.10	2.26	2.42	2.42	2.42	2.42	2.18
Land Preparation	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.68	1.82	1.82	1.96	2.10	2.10	2.26	2.42	2.42	2.42	2.42	2.18
40%	0.672	0.728	0.728	0.784	0.840	0.840	0.904	0.968	0.968	0.968	0.968	0.872

	J						A					
	1	2	3	4	5	6	1	2	3	4	5	6
Crop Factor	0.158	0.158	0.142	0.100	0.100	0.083	0.042	0.042	0.042			
E.To	7.5						7.6					
E.T.	1.19	1.19	1.07	0.75	0.75	0.62	0.32	0.32	0.32			
E.T. x $\frac{100}{50}$	2.38	2.38	2.14	1.50	1.50	1.24	0.64	0.64	0.64			
Land Preparation	-	-	-	-	-	-	-	-	-			
Total	2.38	2.38	2.14	1.50	1.50	1.24	0.64	0.64	0.64			
40%	0.952	0.952	0.856	0.600	0.600	0.496	0.256	0.256	0.256			

(4) Pulses (90 Days) : Yala

	A						M					
	1	2	3	4	5	6	1	2	3	4	5	6
Crop Factor							0.028	0.028	0.028	0.072	0.072	0.072
$E.T_O$	5.9						6.4					
E.T.							0.18	0.18	0.18	0.46	0.46	0.46
$E.T. \times \frac{100}{50}$							0.36	0.36	0.36	0.92	0.92	0.92
Land Preparation				0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Total				0.17	0.17	0.17	0.53	0.53	0.53	1.09	1.09	1.09
50%				0.085	0.085	0.085	0.265	0.265	0.265	0.545	0.545	0.545

	J						J					
	1	2	3	4	5	6	1	2	3	4	5	6
Crop Factor	0.117	0.117	0.117	0.147	0.147	0.147	0.161	0.161	0.161	0.144	0.144	0.144
$E.T_O$	6.9						7.5					
E.T.	0.81	0.81	0.81	1.01	1.01	1.01	1.21	1.21	1.21	1.08	1.08	1.08
$E.T. \times \frac{100}{50}$	1.62	1.62	1.62	2.02	2.02	2.02	2.42	2.42	2.42	2.16	2.16	2.16
Land Preparation	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.62	1.62	1.62	2.02	2.02	2.02	2.42	2.42	2.42	2.16	2.16	2.16
50%	0.810	0.810	0.810	1.010	1.010	1.010	1.210	1.210	1.210	1.080	1.080	1.080

	A					
	1	2	3	4	5	6
Crop Factor	0.086	0.086	0.086	0.028	0.028	0.028
$E.T_O$	7.6					
E.T.	0.65	0.65	0.65	0.21	0.21	0.21
$E.T. \times \frac{100}{50}$	1.30	1.30	1.30	0.42	0.42	0.42
Land Preparation	-	-	-	-	-	-
Total	1.30	1.30	1.30	0.42	0.42	0.42
50%	0.650	0.650	0.650	0.210	0.210	0.210

Table 5-4 Monthly Irrigation Requirement

(a) Lowland

(Note; excluding effective rainfall)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Rice: Maha	11.50	10.00	4.48						1.75	8.11	11.00	11.13	57.97"
Rice: Yala			1.75	8.05	13.14	14.00	12.38	4.99					54.31"
Total	11.50	10.00	6.23	8.05	13.14	14.00	12.38	4.99	1.75	8.11	11.00	11.13	
	v	v	v	v	v	v	v	v	v	v	v	v	
	11.5	10.0	6.2	8.1	13.1	14.0	12.4	5.0	1.8	8.1	11.0	11.1	112.3" (2,852.4 mm)

(b) Upland

Crops	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Rice (Maha)	9.78	8.10	1.86						0.50	6.58	8.18	9.18	44.2"
Chillies(10%)			0.24	0.76	1.14	1.37	1.49	1.19	0.23				6.4"
Soya-Beans(40%)			0.20	2.10	4.56	5.63	4.44	0.79					17.7"
Pulses(50%)				0.25	2.42	5.45	6.90	2.58					17.6"
Total	9.78	8.10	2.30	3.11	8.12	12.45	12.83	4.56	0.73	6.58	8.18	9.18	85.9"
	v	v	v	v	v	v	v	v	v	v	v	v	v
	9.8	8.1	2.3	3.1	8.1	12.5	12.8	4.6	0.7	6.6	8.2	9.2	86.0" (2,184 mm)

Table 5-5 Irrigation Requirement (5 days period)

(a) Lowland

	Jan.						Feb.						Mar.						Apr.						May					
Maha Rice	1.92	1.92	1.93	1.93	1.93	1.88	1.94	1.94	1.88	1.44	1.44	1.38	1.05	1.05	0.97	0.49	0.49	0.49												
Yala Rice													-	-	-	0.58	0.58	0.58	1.08	1.08	1.08	1.57	1.61	1.61	2.17	2.21	2.21	2.15	2.20	2.20
Total	1.92	1.92	1.93	1.93	1.93	1.88	1.94	1.94	1.88	1.44	1.44	1.38	1.05	1.05	0.97	1.07	1.07	1.07	1.08	1.08	1.08	1.57	1.61	1.61	2.17	2.21	2.21	2.15	2.20	2.20

	Jun.						Jul.						Aug.						Sep.						Oct.					
Maha Rice																			-	-	-	0.58	0.58	0.58	1.09	1.09	1.09	1.59	1.59	1.59
Yala Rice	2.30	2.35	2.35	2.35	2.37	2.28	2.39	2.41	2.31	1.79	1.79	1.69	1.17	1.17	1.07	0.54	0.54	0.54												
Total	2.30	2.35	2.35	2.35	2.37	2.28	2.39	2.41	2.31	1.79	1.79	1.69	1.17	1.17	1.07	0.54	0.54	0.54	-	-	-	0.58	0.58	0.58	1.09	1.09	1.09	1.59	1.59	1.59

	Nov.						Dec.						Total
Maha Rice	1.89	1.89	1.89	1.77	1.77	1.77	1.83	1.83	1.85	1.87	1.87	1.88	57.96
Yala Rice													54.32
Total	1.89	1.89	1.89	1.77	1.77	1.77	1.83	1.83	1.85	1.87	1.87	1.88	112.28

Irrigation Requirement

(b) Upland

	Jan.						Feb.						Mar.						Apr.					
Rice:Maha	1.62	1.62	1.64	1.64	1.64	1.56	1.68	1.68	1.58	1.08	1.08	1.00	0.62	0.62	0.62									
Chillies													0.017	0.017	0.017	0.061	0.061	0.061	0.101	0.101	0.115	0.140	0.140	0.154
Soya Bean																0.068	0.068	0.068	0.236	0.236	0.236	0.460	0.460	0.460
Pulses																						0.085	0.085	0.085
Total	1.62	1.62	1.64	1.64	1.64	1.56	1.68	1.68	1.58	1.08	1.08	1.00	0.64	0.64	0.64	0.13	0.13	0.13	0.34	0.34	0.35	0.69	0.69	0.70

	May						Jun.						Jul.						Aug.					
Rice:Maha																								
Chillies	0.168	0.178	0.192	0.192	0.202	0.202	0.218	0.230	0.230	0.230	0.230	0.230	0.250	0.250	0.250	0.250	0.242	0.242	0.244	0.238	0.238	0.162	0.152	0.152
Soya Bean	0.672	0.728	0.728	0.784	0.840	0.840	0.904	0.968	0.968	0.968	0.968	0.872	0.952	0.952	0.856	0.600	0.600	0.496	0.256	0.256	0.256			
Pulses	0.265	0.265	0.265	0.545	0.545	0.545	0.810	0.810	0.810	1.010	1.010	1.010	1.210	1.210	1.210	1.080	1.080	1.080	0.650	0.650	0.650	0.210	0.210	0.210
Total	1.11	1.17	1.19	1.52	1.59	1.59	1.93	2.01	2.01	2.21	2.21	2.11	2.41	2.41	2.32	1.93	1.92	1.82	1.15	1.14	1.14	0.37	0.36	0.36

	Sep.						Oct.						Nov.						Dec.						Total
Rice:Maha	-	-	-	0.17	0.17	0.17	0.79	0.79	0.79	1.41	1.41	1.41	1.34	1.34	1.34	1.38	1.38	1.38	1.50	1.50	1.52	1.52	1.52	1.54	
Chillies	0.076	0.076	0.076																						
Soya Bean																									
Pulses																									
Total	0.08	0.08	0.08	0.17	0.17	0.17	0.79	0.79	0.79	1.41	1.41	1.41	1.34	1.34	1.34	1.38	1.38	1.38	1.50	1.50	1.52	1.52	1.52	1.54	85.83

Table 5-6 Calculation Sheet for Total Water Requirement (Monthly)

(1) Lowland

Month	ETo	I.R. (in)	Total Irrigation Water Requirement		Total Diversion Water Requirement	
			(Ac.ft.)	(ft^3/Sec)	(Ac.ft.)	(ft^3/Sec)
Jan.	4.7	11.5	4,983	83.7	6,478	108.8
Feb.	5.0	10.0	4,333	72.8	5,633	94.6
Mar.	6.2	6.2	2,687	45.2	3,493	58.8
Apr.	5.9	8.1	3,510	59.0	4,563	76.7
May	6.4	13.1	5,677	95.4	7,380	124.0
Jun.	6.9	14.0	6,067	102.0	7,887	132.6
Jul.	7.5	12.4	5,373	90.3	6,985	117.4
Aug.	7.6	5.0	2,167	36.4	2,817	47.3
Sep.	7.5	1.8	780	13.1	1,014	17.0
Oct.	6.2	8.1	3,510	59.0	4,563	76.7
Nov.	4.3	11.0	4,767	80.1	6,197	104.1
Dec.	4.5	11.1	4,810	80.8	6,253	105.0
Total	72.7	112.3	48,664		63,263	

(2) Upland

Month	ETo	I.R. (in)	Total Irrigation Water Requirement		Total Diversion Water Requirement	
			(Ac.ft.)	(ft^3/Sec)	(Ac.ft.)	(ft^3/Sec)
Jan.	4.7	9.8	898	15.1	1,167	19.6
Feb.	5.0	8.1	743	12.5	966	16.3
Mar.	6.2	2.3	211	3.5	274	4.6
Apr.	5.9	3.1	284	4.8	369	6.2
May	6.4	8.1	743	12.5	966	16.3
Jun.	6.9	12.5	1,146	19.3	1,490	25.1
Jul.	7.5	12.8	1,173	19.7	1,525	25.6
Aug.	7.6	4.6	422	7.1	549	9.2
Sep.	7.5	0.7	64	1.1	83	1.4
Oct.	6.2	6.6	605	10.2	787	13.3
Nov.	4.3	8.2	752	12.6	978	16.4
Dec.	4.5	9.2	843	14.2	1,096	18.5
Total	72.7	85.9	7,884		10,250	

(3) Total

Month	Lowland		Upland		Total	
	D.W.R. (Ac.ft.)	D.W.R. (ft^3/Sec)	D.W.R. (Ac.ft.)	D.W.R. (ft^3/Sec)	D.W.R. (Ac.ft.)	D.W.R. (ft^3/Sec)
Jan.	6,478	108.8	1,167	19.6	7,645	128.4
Feb.	5,633	94.6	966	16.3	6,599	110.9
Mar.	3,493	58.8	274	4.6	3,767	63.4
Apr.	4,563	76.7	369	6.2	4,932	82.9
May	7,380	124.0	966	16.3	8,346	140.3
Jun.	7,887	132.6	1,490	25.1	9,377	157.7
Jul.	6,985	117.4	1,525	25.6	8,510	143.0
Aug.	2,817	47.3	549	9.2	3,366	56.5
Sep.	1,014	17.0	83	1.4	1,097	18.4
Oct.	4,563	76.7	787	13.3	5,350	90.0
Nov.	6,197	104.1	978	16.4	7,175	120.5
Dec.	6,253	105.0	1,096	18.5	7,349	123.5
Total	63,263		10,250		73,513	

Note: The above Tables do not include the effective rainfalls; those including the effective rainfalls are given in Tables 5-8 through 5-17 in Volume II: Notes.

Table 5-7 Calculation Sheet for Total Water Requirement

Month		Lowland (5,200 Ac) I.R. (in)	Lowland Irrigation Water Requirement ft³/sec	Lowland Irrigation Water Requirement Ac.ft	Lowland Diversion Water Requirement ft³/sec	Lowland Diversion Water Requirement Ac.ft	Upland (1,100 Ac) I.R. (in)	Upland Irrigation Water Requirement ft³/sec	Upland Irrigation Water Requirement Ac.ft	Upland Diversion Water Requirement ft³/sec	Upland Diversion Water Requirement Ac.ft	Total Diversion Water Requirement Ac.ft	Total Diversion Water Requirement ft³/sec
J	1	1.92	83.9	832	109.1	1,082	1.62	15.0	149	19.5	194	1,276	128.6
	2	1.92	83.9	832	109.1	1,082	1.62	15.0	149	19.5	194	1,276	128.6
	3	1.93	84.3	836	109.6	1,087	1.64	15.1	150	19.6	195	1,282	129.2
	4	1.93	84.3	836	109.6	1,087	1.64	15.1	150	19.6	195	1,282	129.2
	5	1.93	84.3	836	109.6	1,087	1.64	15.1	150	19.6	195	1,282	129.2
	6	1.88	82.2	815	106.9	1,060	1.56	15.2	151	19.8	196	1,256	126.7
F	1	1.94	84.8	841	110.2	1,093	1.68	15.5	154	20.2	200	1,293	130.4
	2	1.94	84.8	841	110.2	1,093	1.68	15.5	154	20.2	200	1,293	130.4
	3	1.88	82.2	815	106.9	1,060	1.58	14.6	145	19.0	189	1,249	125.9
	4	1.44	62.9	624	81.8	811	1.08	10.0	99	13.0	129	940	94.8
	5	1.44	62.9	624	81.8	811	1.08	10.0	99	13.0	129	940	94.8
	6	1.38	60.3	598	78.4	777	1.00	9.3	92	12.1	120	897	90.5
M	1	1.05	45.9	455	59.7	592	0.64	5.9	59	7.7	77	669	67.4
	2	1.05	45.9	455	59.7	592	0.64	5.9	59	7.7	77	669	67.4
	3	0.97	42.3	420	55.0	546	0.64	5.9	59	7.7	77	623	62.7
	4	1.07	46.8	464	60.8	603	0.13	1.2	12	1.6	16	619	62.4
	5	1.07	46.8	464	60.8	603	0.13	1.2	12	1.6	16	619	62.4
	6	1.07	46.8	464	60.8	603	0.13	1.2	12	1.6	16	619	62.4
A	1	1.08	47.2	468	61.4	608	0.34	3.1	31	4.0	40	648	65.4
	2	1.08	47.2	468	61.4	608	0.34	3.1	31	4.0	40	648	65.4
	3	1.08	47.2	468	61.4	608	0.35	3.2	32	4.2	42	650	65.6
	4	1.57	68.6	680	89.2	884	0.69	6.4	63	8.3	82	966	97.5
	5	1.61	70.4	698	91.5	907	0.69	6.4	63	8.3	82	989	99.8
	6	1.61	70.4	698	91.5	907	0.70	6.5	64	8.5	83	990	100.0
M	1	2.17	94.8	940	123.2	1,222	1.11	10.3	102	13.4	133	1,355	136.6
	2	2.21	96.6	958	125.6	1,245	1.17	10.8	107	14.0	139	1,384	139.6
	3	2.21	96.6	958	125.6	1,245	1.19	11.0	109	14.3	142	1,387	139.9
	4	2.15	94.0	932	122.2	1,212	1.52	14.0	139	18.2	181	1,393	140.4
	5	2.20	96.1	953	124.9	1,239	1.59	14.0	139	18.2	181	1,420	143.1
	6	2.20	96.1	953	124.9	1,239	1.59	14.0	139	18.2	181	1,420	143.1
J	1	2.30	100.5	997	130.7	1,296	1.93	17.8	177	23.1	230	1,526	153.8
	2	2.35	102.6	1,018	133.4	1,323	2.01	18.6	184	24.2	239	1,562	157.6
	3	2.35	102.6	1,018	133.4	1,323	2.01	18.6	184	24.2	239	1,562	157.6
	4	2.35	102.6	1,018	133.4	1,323	2.21	20.5	203	26.7	264	1,587	160.1
	5	2.37	103.6	1,027	134.7	1,335	2.21	20.5	203	26.7	264	1,599	161.4
	6	2.28	99.6	988	129.5	1,284	2.11	19.5	193	25.4	251	1,535	154.9
J	1	2.39	104.5	1,036	135.9	1,347	2.41	22.3	221	29.0	287	1,634	164.9
	2	2.41	105.3	1,044	136.8	1,357	2.41	22.3	221	29.0	287	1,644	165.8
	3	2.31	100.9	1,001	131.2	1,301	2.32	21.5	213	28.0	277	1,578	159.2
	4	1.79	78.2	776	106.7	1,009	1.93	17.8	177	23.1	230	1,239	129.8
	5	1.79	78.2	776	101.7	1,009	1.92	17.7	176	23.0	229	1,238	124.7
	6	1.69	73.8	732	95.9	952	1.82	16.8	167	21.8	217	1,169	117.7
A	1	1.17	51.1	507	66.4	659	1.15	10.6	105	13.8	137	796	80.2
	2	1.17	51.1	507	66.4	659	1.14	10.6	105	13.8	137	796	80.2
	3	1.07	46.8	464	60.8	603	1.14	10.6	105	13.8	137	740	74.6
	4	0.54	23.6	234	30.7	304	0.37	3.4	34	4.4	44	348	35.1
	5	0.54	23.6	234	30.7	304	0.36	3.3	33	4.3	43	347	35.0
	6	0.54	23.6	234	30.7	304	0.36	3.3	33	4.3	43	347	35.0
S	1	-	-	-	-	-	0.08	0.7	7	0.9	9	9	0.9
	2	-	-	-	-	-	0.08	0.7	7	0.9	9	9	0.9
	3	-	-	-	-	-	0.08	0.7	7	0.9	9	9	0.9
	4	0.58	25.3	251	32.9	326	0.17	1.6	16	2.1	21	347	35.0
	5	0.58	25.3	251	32.9	326	0.17	1.6	16	2.1	21	347	35.0
	6	0.58	25.3	251	32.9	326	0.17	1.6	16	2.1	21	347	35.0
O	1	1.09	47.6	472	61.9	614	0.79	7.3	72	9.5	94	708	71.4
	2	1.09	47.6	472	61.9	614	0.79	7.3	72	9.5	94	708	71.4
	3	1.09	47.6	472	61.9	614	0.79	7.3	72	9.5	94	708	71.4
	4	1.59	69.5	689	90.4	896	1.41	13.0	129	16.9	168	1,064	107.3
	5	1.59	69.5	689	90.4	896	1.41	13.0	129	16.9	168	1,064	107.3
	6	1.59	69.5	689	90.4	896	1.41	13.0	129	16.9	168	1,064	107.3
N	1	1.89	82.6	819	107.4	1,065	1.34	12.4	123	16.1	160	1,225	123.5
	2	1.89	82.6	819	107.4	1,065	1.34	12.4	123	16.1	160	1,225	123.5
	3	1.89	82.6	819	107.4	1,065	1.34	12.4	123	16.1	160	1,225	123.5
	4	1.77	77.3	767	100.5	997	1.38	12.8	127	16.6	165	1,162	117.1
	5	1.77	77.3	767	100.5	997	1.38	12.8	127	16.6	165	1,162	117.1
	6	1.77	77.3	767	100.5	997	1.38	12.8	127	16.6	165	1,162	117.1
D	1	1.83	80.0	793	104.0	1,031	1.50	13.9	138	18.1	179	1,210	122.1
	2	1.83	80.0	793	104.0	1,031	1.50	13.9	138	18.1	179	1,210	122.1
	3	1.85	80.9	802	105.2	1,043	1.52	14.0	139	18.2	181	1,224	123.4
	4	1.87	81.7	810	106.2	1,053	1.52	14.0	139	18.2	181	1,234	124.4
	5	1.87	81.7	810	106.2	1,053	1.52	14.0	139	18.2	181	1,234	124.4
	6	1.88	82.2	815	106.9	1,060	1.54	14.2	141	18.5	183	1,243	125.4
Total		112.28	4,906.1	48,654	6,383.6	63,250	85.83	792.6	7,864	1,030.8	10,231	73,481	7,414.4

5.4 Water Balance between Supply and Demand

5.4.1 Computation Method

Water balance computation has been made through the following procedures:

(1) Estimation of the volume of in-flow to the dam on the basis of the Mi-Oya's discharge data obtained at Mahauswewa for the last 20 years;

(2) Rainfall has been identified from the observation records kept at Mahauswewa;

(3) Calculation has been made on monthly basis;

(4) Evaporation loss has been computed from the surface area of the dam as estimated from the storage capacity; the monthly evaporation loss has been accumulated to obtain the total evaporation loss;

(5) Evaporation has been computed from the observation data obtained at Tabbowa; surface evaporation equates to 80% of Pan evaporation;

(6) Seepage losses through and/or around the dam-body are negligible (less than 0.05% of the storage on a rough estimation);

(7) Total demand is the sum of irrigation demand and evaporation loss; and

(8) Gross total storage capacity of the dam is 53,000 Ac.ft., and the minimum storage, including dead water, is 8,450 Ac.ft.

5.4.2 Water Balance Computation

Water balance computation results are given in Tables 5-8 through 5-17.

5.4.3 Success Percentage

Success percentage of crop cultivation in Maha and Yala is given as follows:

Cropping Season	Success Percentage
Maha	85
Yala	80

Table 5-8 Operation Study of Inginimitiya Reservoir Project (1)

F.W.R. : Field Water Requirment
I.W.R. : Irrigation Water Requirment

Year	Month	Inflow	Rainfall	Irrigation Demand										Evaporation Loss	Total Demand	Storage	End of Month Storage	Spill
				Lowland (5,200 Ac)				Upland (1,100 Ac)				Total						
				F.W.R.	Effective Rainfall		I.W.R	F.W.R.	Effective Rainfall		I.W.R.	T	1.3 × T					
		Ac-ft	in	Ac-ft	in	Ac-ft	Ac-ft	Ac-ft	in	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft
1955	Oct	26,453	8.82	3,510	5.24	2,271	1,239	605	3.00	550	55	1,294	1,682	920	2,602	23,851	23,851	
	Nov	27,846	11.72	4,767	7.18	3,111	1,656	752	3.00	550	202	1,858	2,415	670	3,085	24,761	48,612	
	Dec	43,537	1.99	4,810	0.66	286	4,524	843	1.17	214	629	5,153	6,699	1,070	7,769	35,768	53,000	31,380
1956	Jan	9,225	0.72	4,983	0	0	4,983	898	0.31	57	841	5,824	7,571	1,200	8,771	454	53,000	454
	Feb	1,368	0.70	4,333	0	0	4,333	743	0.30	55	688	5,021	6,527	1,270	7,797	-6,429	46,571	
	Mar	16,478	9.79	2,687	5.89	2,552	135	211	3.00	550	0	135	176	1,500	1,676	14,802	53,000	8,373
	Apr	455	4.30	3,510	2.21	958	2,552	284	2.71	497	0	2,552	3,318	1,520	4,838	-4,383	48,617	
	May	222	0.58	5,677	0	0	5,677	743	0.22	40	703	6,380	8,294	1,470	9,764	-9,542	39,075	
	Jun	367	3.14	6,067	1.43	620	5,447	1,146	1.94	356	790	6,237	8,108	1,350	9,458	-9,091	29,984	
	Jul	369	0	5,373	0	0	5,373	1,173	0	0	1,173	6,546	8,510	1,150	9,660	-9,291	20,693	
	Aug	369	0	2,167	0	0	2,167	422	0	0	422	2,589	3,366	1,080	4,446	-4,077	16,616	
	Sep	178	0.17	780	0	0	780	64	0	0	64	844	1,097	910	2,007	-1,829	14,787	
	Total	126,867	41.93	48,664	22.61	9,798	38,866	7,884	15.65	2,869	5,567	44,433	57,763	14,110	71,873			
	Oct	20	5.71	3,510	3.16	1,369	2,141	605	3.00	550	55	2,196	2,855	710	3,565	-3,545	11,242	
	Nov	5,641	15.70	4,767	9.00	3,900	867	752	3.00	550	202	1,069	1,390	430	1,820	3,821	15,063	
	Dec	6,617	5.42	4,810	2.96	1,283	3,527	843	3.00	550	293	3,820	4,966	560	5,526	1,091	16,154	
1957	Jan	366	1.57	4,983	0.38	165	4,818	898	0.88	161	737	5,555	7,222	610	7,832	-7,466	8,688	
	Feb	141	2.52	4,333	1.02	442	3,891	743	1.52	279	464	4,355	5,662	380	6,042	-5,901	8,450	
	Mar	145	0.42	2,687	0	0	2,687	211	0.11	20	191	2,878	3,741	500	4,241	-4,096	8,450	
	Apr	11,375	4.61	3,510	2.42	1,049	2,461	284	2.92	535	0	2,461	3,199	460	3,659	7,716	16,166	
	May	860	5.82	5,677	3.23	1,400	4,277	743	3.00	550	193	4,470	5,811	800	6,611	-5,751	10,415	
	Jun	2,891	3.82	6,067	1.89	819	5,248	1,146	2.39	438	708	5,956	7,743	610	8,353	-5,462	8,450	
	Jul	190	0	5,373	0	0	5,373	1,173	0	0	1,173	6,546	8,510	500	9,010	-8,820	8,450	
	Aug	61	0	2,167	0	0	2,167	422	0	0	422	2,589	3,366	570	3,936	-3,875	8,450	
	Sep	41	0	780	0	0	780	64	0	0	64	844	1,097	540	1,637	-1,596	8,450	
	Total	28,348	45.59	48,664	24.06	10,427	38,237	7,884	19.82	3,633	4,502	42,739	55,562	6,670	62,232			

Table 5-9 Operation Study of Inginimitiya Reservoir Project (2)

F.W.R. : Field Water Requirment
I.W.R. : Irrigation Water Requirment

Year	Month	Inflow	Rainfall	Irrigation Demand: Lowland (5,200 Ac) F.W.R.	Lowland Effective Rainfall	Lowland Effective Rainfall	Lowland I.W.R	Upland (1,100 Ac) F.W.R.	Upland Effective Rainfall	Upland Effective Rainfall	Upland I.W.R.	Total T	Total 1.3 × T	Evaporation Loss	Total Demand	Storage	End of Month Storage	Spill
		Ac-ft	in	Ac-ft	in	Ac-ft	Ac-ft	Ac-ft	in	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft
1957	Oct	6,461	10.18	3,510	6.15	2,665	845	605	3.00	550	55	900	1,170	440	1,610	4,851	13,301	
	Nov	59,382	15.32	4,767	9.00	3,900	867	752	3.00	550	202	1,069	1,390	490	1,880	57,502	53,000	17,803
	Dec	157,391	23.95	4,810	9.00	3,900	910	843	3.00	550	293	1,203	1,564	1,120	2,684	54,707	53,000	154,707
1958	Jan	24,459	1.75	4,983	0.50	217	4,766	898	1.01	185	713	5,479	7,123	1,200	8,323	16,136	53,000	16,136
	Feb	6,991	0.55	4,333	0	0	4,333	743	0.20	37	706	5,039	6,551	1,270	7,821	-830	52,170	
	Mar	16,111	13.18	2,687	8.16	3,536	0	211	3.00	550	0	0	0	1,620	1,620	14,491	53,000	13,661
	Apr	52,464	16.18	3,510	9.00	3,900	0	284	3.00	550	0	0	0	1,520	1,520	50,944	53,000	50,944
	May	6,659	4.69	5,677	2.47	1,070	4,607	743	2.97	544	199	4,806	6,248	1,560	7,808	-1,149	51,851	
	Jun	1,210	1.62	6,067	0.42	182	5,885	1,146	0.92	169	977	6,862	8,921	1,630	10,551	-9,341	42,510	
	Jul	1,394	0.50	5,373	0	0	5,373	1,173	0.17	31	1,142	6,515	8,470	1,430	9,900	-8,506	34,004	
	Aug	1,681	5.45	2,167	2.98	1,291	876	422	3.00	550	0	876	1,139	1,410	2,549	-868	33,136	
	Sep	2,703	0	780	0	0	780	64	0	0	64	844	1,097	1,300	2,397	306	33,442	
	Total	336,906	93.37	48,664	47.68	20,661	29,242	7,884	23.27	4,266	4,351	33,593	43,673	14,990	58,663			
	Oct	2,597	6.48	3,510	3.67	1,590	1,920	605	3.00	550	55	1,975	2,568	1,070	3,638	-1,041	32,401	
	Nov	2,620	7.00	4,767	4.02	1,742	3,025	752	3.00	550	202	3,227	4,195	790	4,985	-2,365	30,036	
	Dec	6,327	2.96	4,810	1.31	568	4,242	843	1.82	334	509	4,751	6,176	780	6,956	-629	29,407	
1959	Jan	1,443	4.17	4,983	2.12	919	4,064	898	2.63	482	416	4,480	5,824	820	6,644	-5,201	24,206	
	Feb	267	0.16	4,333	0	0	4,333	743	0	0	743	5,076	6,599	790	7,389	-7,122	17,084	
	Mar	712	0.05	2,687	0	0	2,687	211	0	0	211	2,898	3,767	850	4,617	-3,905	13,179	
	Apr	Nil	11.31	3,510	6.91	2,994	516	284	3.00	550	0	516	671	680	1,351	-1,351	11,828	
	May	4,978	10.34	5,677	6.26	2,713	2,964	743	3.00	550	193	3,157	4,104	630	4,734	244	12,072	
	Jun	1,661	2.20	6,067	0.80	347	5,720	1,146	1.31	240	906	6,626	8,614	680	9,294	-7,633	8,450	
	Jul	640	1.77	5,373	0.52	225	5,148	1,173	1.02	187	986	5,134	7,974	500	8,474	-7,834	8,450	
	Aug	346	0.80	2,167	0	0	2,167	422	0.37	68	354	2,521	3,277	570	3,847	-3,501	8,450	
	Sep	250	3.59	780	1.74	754	26	64	2.24	411	0	26	34	540	574	-324	8,450	
	Total	21,841	50.83	48,664	27.35	11,852	36,812	7,884	21.39	3,427	4,575	41,387	52,427	8,700	62,503			

F.W.R. : Field Water Requirment
I.W.R. : Irrigation Water Requirment

Table 5-10 Operation Study of Inginimitiya Reservoir Project (3)

Year	Month	Inflow	Rainfall	Irrigation Demand											Evaporation Loss	Total Demand	Storage	End of Month Storage	Spill
				Lowland (5,200 Ac)				Upland (1,100 Ac)				Total							
				F.W.R.	Effective Rainfall		I.W.R	F.W.R.	Effective Rainfall		I.W.R.	T	1.3 × T						
		Ac-ft	in	Ac-ft	in	Ac-ft	Ac-ft	Ac-ft	in	Ac-ft	Ac-ft	Ac-ft	Ac-ft		Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft
1959	Oct	10,694	9.26	3,510	5.53	2,396	1,114	605	3.00	550	55	1,169	1,520		440	1,960	8,734	17,184	
	Nov	19,030	10.23	4,767	6.18	2,678	2,089	752	3.00	550	202	2,291	2,978		570	3,548	15,482	32,666	
	Dec	20,263	3.41	4,810	1.61	698	4,112	843	2.12	389	454	4,566	5,936		820	6,756	13,507	46,173	
1960	Jan	5,742	2.93	4,983	1.29	559	4,424	898	1.80	330	568	4,992	6,490		1,070	7,560	-1,818	44,355	
	Feb	3,045	3.83	4,333	1.90	823	3,510	743	2.40	440	303	3,813	4,957		1,130	6,087	-3,042	41,313	
	Mar	1,473	0.87	2,687	0	0	2,687	211	0.42	77	134	2,821	3,667		1,380	5,047	-3,574	37,739	
	Apr	3,230	11.06	3,510	6.74	2,921	589	284	3.00	550	0	589	766		1,210	1,976	1,254	38,993	
	May	2,334	4.84	5,677	2.57	1,114	4,563	743	3.00	550	193	4,756	6,183		1,270	7,453	-5,119	33,874	
	Jun	988	0.35	6,067	0	0	6,067	1,146	0.07	13	1,133	7,200	9,360		1,230	10,590	-9,602	24,272	
	Jul	5,928	5.65	5,373	3.12	1,352	4,021	1,173	3.00	550	623	4,644	6,037		1,030	7,067	-1,139	23,133	
	Aug	927	0	2,167	0	0	2,167	422	0	0	422	2,589	3,366		1,150	4,516	-3,589	19,544	
	Sep	165	0	780	0	0	780	64	0	0	64	844	1,097		990	2,087	-1,922	17,622	
	Total	73,819	52.43	48,664	28.94	12,541	36,123	7,884	21.81	3,999	4,151	40,274	52,357		12,290	64,647			
	Oct	473	7.57	3,510	4.40	1,907	1,603	605	3.00	550	55	1,658	2,155		770	2,925	-2,452	15,170	
	Nov	30,183	16.47	4,767	9.00	3,900	867	752	3.00	550	202	1,069	1,390		540	1,930	28,253	43,423	
	Dec	8,973	1.57	4,810	0.38	165	4,645	843	0.88	161	682	5,327	6,925		980	7,905	1,068	44,491	
1961	Jan	6,785	7.47	4,983	4.33	1,876	3,107	898	3.00	550	348	3,455	4,492		1,070	5,562	1,223	45,714	
	Feb	3,278	1.55	4,333	0.37	160	4,173	743	0.87	159	584	4,757	6,184		1,160	7,344	-4,057	41,657	
	Mar	1,857	2.44	2,687	0.96	416	2,271	211	1.47	269	0	2,271	2,952		1,390	4,342	-2,485	39,172	
	Apr	632	6.07	3,510	3.40	1,473	2,037	284	3.00	550	0	2,037	2,648		1,250	3,898	-3,266	35,906	
	May	695	2.93	5,677	1.29	559	5,118	743	1.80	330	413	5,531	7,190		1,210	8,400	-7,705	28,201	
	Jun	719	4.84	6,067	2.57	1,114	4,953	1,146	3.00	550	596	5,549	7,214		1,110	8,324	-7,605	20,596	
	Jul	1,141	3.36	5,373	1.58	685	4,688	1,173	2.08	381	792	5,480	7,124		950	8,074	-6,933	13,663	
	Aug	576	0.99	2,167	0	0	2,167	422	0.50	92	330	2,497	3,246		860	4,106	-3,530	10,133	
	Sep	303	3.57	780	1.72	745	35	64	2.22	407	0	35	46		610	656	-353	9,780	
	Total	55,624	58.83	48,664	30.00	13,000	35,664	7,884	24.82	4,549	4,002	39,666	51,566		11,900	63,466			

F.W.R. : Field Water Requirment
I.W.R. : Irrigation Water Requirment

Table 5-11 Operation Study of Inginimitiya Reservoir Project (4)

Year	Month	Inflow	Rainfall	Irrigation Demand: Lowland (5,200 Ac) F.W.R.	Lowland Effective Rainfall	Lowland Effective Rainfall	Lowland I.W.R	Upland (1,100 Ac) F.W.R.	Upland Effective Rainfall	Upland Effective Rainfall	Upland I.W.R.	Total T	Total 1.3 × T	Evaporation Loss	Total Demand	Storage	End of Month Storage	Spill
		Ac-ft	in	Ac-ft	in	Ac-ft	Ac-ft	Ac-ft	in	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft
1961	Oct	2,475	9.55	3,510	5.73	2,483	1,027	605	3.00	550	55	1,082	1,407	490	1,897	578	10,358	
	Nov	20,721	5.45	4,767	2.98	1,291	3,476	752	3.00	550	202	3,678	4,781	390	5,171	15,550	25,908	
	Dec	13,884	5.14	4,810	2.77	1,200	3,610	843	3.00	550	293	3,903	5,074	720	5,794	8,090	33,998	
1962	Jan	6,770	4.23	4,983	2.16	936	4,047	898	2.67	489	409	4,456	5,793	900	6,693	77	34,075	
	Feb	3,463	3.79	4,333	1.87	810	3,523	743	2.37	434	309	3,832	4,982	950	5,932	-2,469	31,606	
	Mar	2,905	2.00	2,687	0.67	290	2,397	211	1.17	214	0	2,397	3,116	1,160	4,276	-1,371	30,234	
	Apr	2,457	4.29	3,510	2.20	953	2,557	284	2.71	497	0	2,557	3,324	1,050	4,374	-1,917	28,318	
	May	7,660	9.79	5,677	5.89	2,552	3,125	743	3.00	550	193	3,318	4,313	1,050	5,363	2,297	30,615	
	Jun	2,010	2.55	6,067	1.04	451	5,616	1,146	1.54	282	864	6,480	8,424	1,160	9,584	-7,574	23,041	
	Jul	788	1.54	5,373	0.36	156	5,217	1,173	0.86	158	1,015	6,232	8,102	1,000	9,102	-8,314	14,727	
	Aug	3,310	2.01	2,167	0.68	295	1,872	422	1.18	216	206	2,078	2,701	920	3,621	-311	14,416	
	Sep	1,055	1.98	780	0.66	286	494	64	1.16	213	0	494	642	850	1,492	-437	13,979	
	Total	67,498	52.32	48,664	27.01	11,703	36,961	7,884	25.66	4,703	3,546	40,507	52,659	10,640	63,299			
	Oct	88,666	25.08	3,510	9.00	3,900	0	605	3.00	550	55	55	72	680	752	87,914	53,000	48,893
	Nov	20,582	9.06	4,767	5.40	2,340	2,427	752	3.00	550	202	2,629	3,418	1,090	4,508	16,074	53,000	16,074
	Dec	12,211	5.86	4,810	3.26	1,413	3,397	843	3.00	550	293	3,609	4,797	1,120	5,917	6,294	53,000	6,294
1963	Jan	88,518	8.18	4,983	4.81	2,084	2,899	898	3.00	550	348	3,247	4,221	1,200	5,421	83,097	53,000	83,097
	Feb	10,817	3.46	4,333	1.65	715	3,618	743	2.15	394	349	3,967	5,157	1,270	6,427	4,390	53,000	4,390
	Mar	5,350	3.40	2,687	1.61	698	1,989	211	2.11	387	0	1,989	2,586	1,650	4,236	1,114	53,000	1,114
	Apr	4,162	6.19	3,510	3.48	1,508	2,002	284	3.00	550	0	2,002	2,603	1,520	4,123	39	53,000	39
	May	3,926	6.36	5,677	3.59	1,556	4,121	743	3.00	550	193	4,314	5,608	1,560	7,168	-3,242	49,758	
	Jun	2,043	2.12	6,067	0.75	325	5,742	1,146	1.25	229	917	6,659	8,657	1,590	10,247	-8,204	41,554	
	Jul	1,485	1.46	5,373	0.31	134	5,239	1,173	0.81	148	1,025	6,264	8,143	1,400	9,543	-8,058	33,496	
	Aug	812	0.16	2,167	0	0	2,167	422	0	0	422	2,589	3,366	1,400	4,766	-7,854	25,642	
	Sep	550	3.32	780	1.55	672	108	64	2.06	378	0	108	140	1,130	1,270	-720	24,922	
	Total	239,122	74.65	48,664	35.41	15,345	33,709	7,884	26.38	4,836	3,804	37,513	48,768	15,610	64,378			

Table 5-12 Operation Study of Inginimitiya Reservoir Project (5)

F.W.R. : Field Water Requirment
I.W.R. : Irrigation Water Requirment

Year	Month	Inflow	Rainfall	Irrigation Demand: Lowland (5,200 Ac) F.W.R.	Lowland Effective Rainfall		Lowland I.W.R	Upland (1,100 Ac) F.W.R.	Upland Effective Rainfall		Upland I.W.R.	Total T	Total 1.3 × T	Evaporation Loss	Total Demand	Storage	End of Month Storage	Spill
		Ac·ft	in	Ac·ft	in	Ac·ft	Ac·ft	Ac·ft	in	Ac·ft	Ac·ft	Ac·ft	Ac·ft	Ac·ft	Ac·ft	Ac·ft	Ac·ft	Ac·ft
1963	Oct	2,647	8.21	3,510	4.83	2,039	1,417	605	3.00	550	55	1,472	1,914	910	2,824	-177	24,745	
	Nov	52,912	18.66	4,767	9.00	3,900	867	752	3.00	550	202	1,069	1,390	680	2,070	50,842	53,000	22,587
	Dec	62,382	8.61	4,810	5.10	2,210	2,600	843	3.00	550	293	2,893	3,761	1,120	4,881	57,501	53,000	57,501
1964	Jan	15,430	1.14	4,983	0.09	39	4,944	898	0.60	110	788	5,732	7,452	1,200	8,652	6,778	53,000	6,778
	Feb	5,934	1.13	4,333	0.09	39	4,294	743	0.59	108	635	4,929	6,408	1,270	7,678	-1,744	51,256	
	Mar	5,696	1.13	2,687	0.09	39	5,648	211	0.59	108	103	5.751	7,476	1,630	9,106	-3,410	47,846	
	Apr	1,772	5.02	3,510	2.69	1,166	2,344	284	3.00	550	0	2,344	3,047	1,420	4,467	-2,695	45,151	
	May	1,388	2.25	5,677	0.84	364	5,313	743	1.34	246	497	5,810	7,553	1,400	8,953	-7,565	37,586	
	Jun	1,141	0.31	6,067	0	0	6,067	1,146	0.04	7	1,139	7,206	9,368	1,310	10,678	-9,537	28,049	
	Jul	990	4.23	5,373	2.16	936	4,437	1,173	2.67	489	684	5,121	6,657	1,110	7,767	-6,777	21,272	
	Aug	1,055	1.40	2,167	0.27	117	2,050	422	0.77	141	281	2,331	3,030	1,100	4,130	-3,075	18,197	
	Sep	822	7.03	780	4.04	1,751	0	64	3.00	550	0	0	0	960	960	-138	18,059	
	Total	152,169	59.12	48,664	29.20	12,654	39,981	7,884	21.60	3,959	4,677	44,658	58,056	14,110	72,166			
	Oct	832	6.44	3,510	3.64	1,577	1,933	605	3.00	550	55	1,988	2,584	780	3,364	-2,532	15,527	
	Nov	13,316	10.30	4,767	6.23	2,700	2,067	752	3.00	550	202	2,269	2,950	550	3,500	9,816	25,343	
	Dec	6,278	5.75	4,810	3.18	1,378	3,432	843	3.00	550	293	3,725	4,843	710	5,553	725	26,068	
1965	Jan	3,248	0.59	4,983	0	0	4,983	898	0.23	42	856	5,839	7,591	770	8,361	-5,113	20,955	
	Feb	1,836	1.76	4,333	0.51	221	4,112	743	1.01	185	558	4,670	6,071	740	6,811	-4,975	15,980	
	Mar	659	0.46	2,687	0	0	2,687	211	0.14	26	185	2,872	3,734	830	4,564	-3,705	12,275	
	Apr	9,389	10.84	3,510	6.59	2,856	654	284	0.40	73	211	865	1,125	640	1,765	7,624	19,899	
	May	21,069	5.45	5,677	2.98	1,291	4,386	743	3.00	550	193	4,579	5,953	880	6,833	14,236	34,135	
	Jun	2,560	0.25	6,067	0	0	6,067	1,146	0	0	1,146	7,213	9,377	1,240	10,617	-8,057	26,078	
	Jul	719	0	5,373	0	0	5,373	1,173	0	0	1,173	6,546	8,510	1,060	9,570	-8,851	17,227	
	Aug	4,439	5.68	2,167	3.14	1,361	806	422	3.00	550	0	806	1,048	990	2,038	2,401	19,628	
	Sep	784	0.50	780	0	0	780	64	0.17	31	33	813	1,057	990	2,047	-1,263	18,365	
	Total	65,329	48.02	48,664	26.27	11,384	37,280	7,884	16.95	3,107	4,905	42,185	54,843	10,180	65,023			

Table 5-13 Operation Study of Inginimitiya Reservoir Project (6)

F.W.R. : Field Water Requirment
I.W.R. : Irrigation Water Requirment

Year	Month	Inflow	Rainfall	Irrigation Demand: Lowland (5,200 Ac) F.W.R.	Lowland Effective Rainfall		Lowland I.W.R	Upland (1,100 Ac) F.W.R.	Upland Effective Rainfall		Upland I.W.R.	Total T	Total 1.3 × T	Evaporation Loss	Total Demand	Storage	End of Month Storage	Spill
		Ac·ft	in	Ac·ft	in	Ac·ft	Ac·ft	Ac·ft	in	Ac·ft	Ac·ft	Ac·ft	Ac·ft	Ac·ft	Ac·ft	Ac·ft	Ac·ft	Ac·ft
1965	Oct	8,332	5.89	3,510	3.28	1,421	2,089	605	3.00	550	55	2,144	2,787	790	3,577	4,755	23,120	
	Nov	13,446	6.60	4,767	3.75	1,625	3,142	752	3.00	550	202	3,344	4,347	670	5,017	8,429	31,549	
	Dec	47,762	9.23	4,810	5.51	2,388	2,422	843	3.00	550	293	2,715	3,530	800	4,330	43,432	53,000	21,981
1966	Jan	4,503	1.24	4,983	0.16	69	4,914	898	0.66	121	777	5,691	7,398	1,200	8,598	-4,095	48,905	
	Feb	4,330	0.60	4,333	0	0	4,333	743	0.23	42	701	5,034	6,544	1,210	7,754	-3,424	45,481	
	Mar	1,598	1.55	2,687	0.37	160	2,527	211	0.87	159	52	2,579	3,353	1,470	4,823	-3,225	42,256	
	Apr	13,127	14.14	3,510	8.80	3,813	0	284	3.00	550	0	0	0	1,300	1,300	11,827	53,000	1,083
	May	3,012	4.69	5,677	2.47	1,070	4,607	743	2.97	544	199	4,806	6,248	1,560	7,808	-4,796	48,204	
	Jun	1,893	0	6,067	0	0	6,067	1,146	0	0	1,146	7,213	9,377	1,550	10,927	-9,034	39,170	
	Jul	505	0.20	5,373	0	0	5,373	1,173	0	0	1,173	6,546	8,510	1,350	9,860	-9,355	29,815	
	Aug	333	0.40	2,167	0	0	2,167	422	0.10	18	404	2,571	3,342	1,300	4,642	-4,309	25,506	
	Sep	700	2.61	780	1.21	524	256	64	1.72	315	0	256	333	1,130	1,463	-763	24,743	
	Total	99,541	47.35	48,664	25.55	11,070	37,897	7,884	18.55	3,399	5,002	42,899	55,769	14,330	70,099			
	Oct	9,680	11.33	3,510	6.92	2,999	511	605	3.00	550	55	566	736	910	1,646	8,034	32,777	
	Nov	39,955	14.75	4,767	9.00	3,900	867	752	3.00	550	202	1,069	1,390	800	2,190	37,765	53,000	17,542
	Dec	15,721	5.96	4,810	3.32	1,439	3,371	843	3.00	550	293	3,664	4,763	1,120	5,883	9,838	53,000	9,838
1967	Jan	7,801	2.20	4,983	0.80	347	4,636	898	1.31	240	658	5,294	6,882	1,200	8,082	-281	52,719	
	Feb	4,499	0.85	4,333	0	0	4,333	743	0.40	73	670	5,003	6,504	1,260	7,764	-3,265	49,454	
	Mar	2,366	6.33	2,687	3.57	1,547	1,140	211	3.00	550	0	1,140	1,482	1,560	3,042	-676	48,778	
	Apr	4,025	6.55	3,510	3.72	1,612	1,898	284	3.00	550	0	1,898	2,467	1,440	3,907	118	48,896	
	May	1,572	2.46	5,677	0.98	425	5,252	743	1.48	271	472	5,724	7,441	1,480	8,921	-7,349	41,547	
	Jun	709	2.63	6,067	1.09	472	5,595	1,146	1.59	291	855	6,450	8,385	1,400	9,785	-9,076	32,471	
	Jul	416	1.50	5,373	0.34	147	5,226	1,173	0.84	154	1,019	6,245	8,119	1,210	9,329	-8,913	23,558	
	Aug	297	0	2,167	0	0	2,167	422	0	0	422	2,589	3,366	1,160	4,526	-4,229	19,329	
	Sep	1,210	1.13	780	0.09	39	741	64	0.59	108	0	741	963	990	1,953	-743	18,586	
	Total	88,251	55.69	48,664	29.83	12,927	35,737	7,884	21.21	3,887	4,646	40,383	52,498	14,530	67,028			

Table 5-14 Operation Study of Inginimitiya Reservoir Project (7)

F.W.R. : Field Water Requirment
I.W.R. : Irrigation Water Requirment

Year	Month	Inflow	Rainfall	Irrigation Demand										Evaporation Loss	Total Demand	Storage	End of Month Storage	Spill
				Lowland (5,200 Ac)				Upland (1,100 Ac)				Total						
				F.W.R.	Effective Rainfall		I.W.R	F.W.R.	Effective Rainfall		I.W.R.	T	1.3 × T					
		Ac·ft	in	Ac·ft	in	Ac·ft	Ac·ft	Ac·ft	in	Ac·ft	Ac·ft	Ac·ft	Ac·ft	Ac·ft	Ac·ft	Ac·ft	Ac·ft	Ac·ft
1967	Oct	17,091	11.37	3,510	6.95	3,012	498	605	3.00	550	55	553	719	790	1,509	15,582	34,168	
	Nov	9,882	8.74	4,767	5.19	2,249	2,518	752	3.00	550	202	2,720	3,536	830	4,366	5,516	39,684	
	Dec	40,049	8.37	4,810	4.94	2,141	2,669	843	3.00	550	293	2,962	3,851	930	4,781	35,268	53,000	21,952
1968	Jan	6,585	1.24	4,983	0.16	69	4,914	898	0.66	121	777	5,691	7,398	1,200	8,598	-2,013	50,987	
	Feb	2,624	0.85	4,333	0	0	4,333	743	0.40	73	670	5,003	6,504	1,240	7,744	-5,120	45,867	
	Mar	10,274	5.08	2,687	2.73	1,183	1,504	211	3.00	550	0	1,504	1,955	1,480	3,435	6,839	52,706	
	Apr	5,619	6.64	3,510	3.78	1,638	1,872	284	3.00	550	0	1,872	2,434	1,510	3,944	1,675	53,000	1,381
	May	2,101	0.18	5,677	0	0	5,677	743	0	0	743	5,420	8,346	1,560	9,906	-7,805	45,195	
	Jun	1,076	1.20	6,067	0.13	56	6,011	1,146	0.64	117	1,029	7,040	9,152	1,480	10,632	-9,556	35,639	
	Jul	1,307	1.63	5,373	0.42	182	5,191	1,173	0.92	169	1,004	6,195	8,054	1,270	9,324	-8,017	27,622	
	Aug	459	0	2,167	0	0	2,167	422	0	0	422	2,589	3,366	1,250	4,616	-4,157	23,465	
	Sep	259	2.20	780	0.80	347	433	64	1.31	240	0	433	563	1,080	1,643	-1,384	22,081	
	Total	97,326	47.50	48,664	25.10	10,877	37,787	7,884	18.93	3,470	5,195	42,982	55,878	14,620	70,498			
	Oct	1,610	10.85	3,510	6.60	2,860	650	605	3.00	550	55	705	917	860	1,777	-167	21,914	
	Nov	30,500	4.34	4,767	2.24	971	3,796	752	2.74	502	250	4,046	5,260	640	5,900	24,600	46,514	
	Dec	18,982	8.27	4,810	4.87	2,110	2,700	843	3.00	550	293	2,993	3,891	1,030	4,921	14,061	53,000	7,575
1969	Jan	5,532	1.62	4,983	0.42	182	4,801	898	0.92	169	729	5,530	7,189	1,200	8,389	-2,857	50,143	
	Feb	3,000	1.36	4,333	0.24	104	4,229	743	0.74	136	607	4,836	6,287	1,230	7,517	-4,517	45,626	
	Mar	2,166	0.45	2,687	0	0	2,687	211	0.13	24	187	2,874	3,736	1,470	5,206	-3,040	42,586	
	Apr	2,230	7.25	3,510	4.19	1,816	1,694	284	3.00	550	0	1,694	2,202	1,310	3,512	-1,282	41,304	
	May	1,206	2.02	5,677	0.68	295	5,382	743	1.19	218	525	5,907	7,679	1,320	8,999	-7,793	33,511	
	Jun	422	0.42	6,067	0	0	6,067	1,146	0.11	20	1,126	7,193	9,351	1,230	10,581	-10,159	23,352	
	Jul	87	0	5,373	0	0	5,373	1,173	0	0	1,173	6,546	8,510	1,010	9,520	-9,433	13,919	
	Aug	392	3.56	2,167	1.72	745	1,422	422	2.22	407	0	1,422	1,849	870	2,719	-2,327	11,592	
	Sep	154	0	780	0	0	780	64	0	0	64	844	1,097	700	1,797	-1,643	9,949	
	Total	66,281	40.14	48,664	21.06	9,083	39,581	7,884	17.05	3,126	5,009	44,590	57,968	12,870	70,838			

Table 5-15 Operation Study of Inginimitiya Reservoir Project (8)

F.W.R. : Field Water Requirment
I.W.R. : Irrigation Water Requirment

Year	Month	Inflow	Rainfall	Irrigation Demand: Lowland (5,200 Ac) F.W.R.	Lowland Effective Rainfall	Lowland Effective Rainfall	Lowland I.W.R	Upland (1,100 Ac) F.W.R.	Upland Effective Rainfall	Upland Effective Rainfall	Upland I.W.R.	Total T	Total 1.3 × T	Evaporation Loss	Total Demand	Storage	End of Month Storage	Spill
		Ac-ft	in	Ac-ft	in	Ac-ft	Ac-ft	Ac-ft	in	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft
1969	Oct	9,356	19.33	3,510	9.00	3,900	0	605	3.00	550	55	55	72	490	562	8,794	18,743	
	Nov	8,902	5.65	4,767	3.12	1,352	3,415	752	3.00	550	202	3,617	4,702	600	5,302	3,147	21,890	
	Dec	12,662	8.71	4,810	5.17	2,240	2,570	843	3.00	550	293	2,863	3,722	660	4,382	8,280	30,170	
1970	Jan	15,254	2.61	4,983	1.08	468	4,515	898	1.58	290	608	5,123	6,660	830	7,490	7,764	37,934	
	Feb	7,968	3.17	4,333	1.45	628	3,705	743	1.96	359	384	4,089	5,316	1,010	6,326	1,642	39,576	
	Mar	3,632	4.42	2,687	2.29	792	1,895	211	2.79	511	0	1,895	2,464	1,340	3,804	-172	39,404	
	Apr	18,275	16.27	3,510	9.00	3,900	0	284	3.00	550	0	0	0	1,250	1,250	17,025	53,000	3,429
	May	10,740	7.98	5,677	4.68	2,028	3,649	743	3.00	550	193	3,842	4,995	1,560	6,555	4,185	53,000	4,185
	Jun	2,604	0	6,067	0	0	6,067	1,146	0	0	1,146	7,213	9,377	1,650	11,027	-8,423	44,577	
	Jul	881	1.20	5,373	0.13	56	5,317	1,173	0.64	117	1,056	6,373	8,285	1,470	9,755	-8,874	35,703	
	Aug	1,030	0	2,167	0	0	2,167	422	0	0	422	2,589	3,366	1,450	4,816	-3,786	31,917	
	Sep	1,148	3.01	780	1.35	585	195	64	1.85	339	0	195	254	1,270	1,524	-376	31,541	
	Total	92,452	72.35	48,664	37.27	12,639	33,495	7,884	23.82	4,366	4,359	37,854	49,213	13,580	62,793			
	Oct	4,085	8.66	3,510	5.13	2,223	1,287	605	3.00	550	55	1,342	1,745	1,040	2,785	1,300	32,841	
	Nov	7,510	8.29	4,767	4.88	2,115	2,652	752	3.00	550	202	2,854	3,710	800	4,510	3,000	35,841	
	Dec	6,665	7.01	4,810	4.03	1,746	3,064	843	3.00	550	293	3,357	4,364	860	5,224	1,441	37,282	
1971	Jan	4,570	2.82	4,983	1.22	529	4,454	898	1.72	315	583	5,037	6,548	960	7,508	-2,938	34,344	
	Feb	2,776	3.08	4,333	1.39	602	3,731	743	1.90	348	395	4,126	5,364	960	6,324	-3,548	30,796	
	Mar	2,875	3.04	2,687	1.37	594	2,093	211	1.87	343	0	2,093	2,721	1,150	3,871	-996	29,800	
	Apr	5,657	10.76	3,510	6.54	2,834	676	284	3.00	550	0	676	879	1,040	1,919	3,738	33,538	
	May	5,471	3.43	5,677	1.63	706	4,971	743	2.13	390	353	5,324	6,921	1,160	8,081	-2,610	30,928	
	Jun	1,562	3.25	6,067	1.51	654	5,413	1,146	2.01	368	778	6,191	8,048	1,170	9,218	-7,656	23,272	
	Jul	826	0.32	5,373	0	0	5,373	1,173	0.05	9	1,164	6,537	8,498	1,010	9,508	-8,682	14,590	
	Aug	982	0	2,167	0	0	2,167	422	0	0	422	2,589	3,366	900	4,266	-3,284	11,306	
	Sep	560	0	780	0	0	780	64	0	0	64	844	1,097	680	1,777	-1,217	10,089	
	Total	43,539	50.66	48,664	27.70	12,003	36,661	7,884	21.68	3,973	4,309	40,970	53,261	11,730	64,991			

Table 5-16 Operation Study of Inginimitiya Reservoir Project (9)

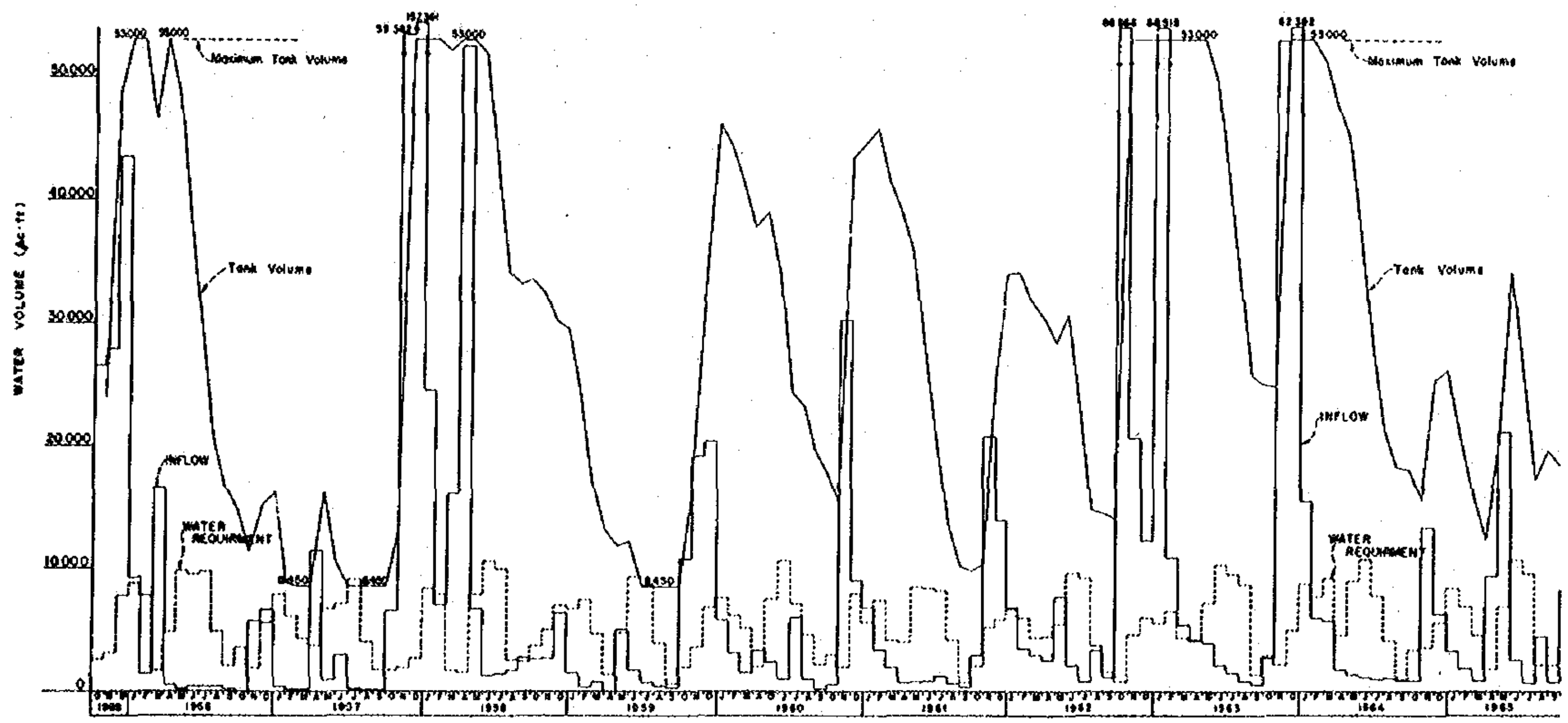
F.W.R. : Field Water Requirment
I.W.R. : Irrigation Water Requirment

Year	Month	Inflow	Rainfall	Irrigation Demand: Lowland (5,200 Ac) F.W.R.	Lowland Effective Rainfall		Lowland I.W.R	Upland (1,100 Ac) F.W.R.	Upland Effective Rainfall		Upland I.W.R.	Total T	Total 1.3 × T	Evaporation Loss	Total Demand	Storage	End of Month Storage	Spill
		Ac-ft	in	Ac-ft	in	Ac-ft	Ac-ft	Ac-ft	in	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft	Ac-ft
1971	Oct	5,683	10.00	3,510	6.03	2,613	897	605	3.00	550	55	952	1,238	500	1,738	3,945	14,034	
	Nov	12,058	10.05	4,767	6.06	2,626	2,141	752	3.00	550	202	2,343	3,046	510	3,556	8,502	22,536	
	Dec	31,011	7.01	4,810	4.03	1,746	3,064	843	3.00	550	293	3,357	4,364	670	5,034	25,977	48,513	
1972	Jan	2,582	0	4,983	0	0	4,983	898	0	0	898	5,881	7,645	1,120	8,765	-6,183	42,330	
	Feb	2,101	0	4,333	0	0	4,333	743	0	0	743	5,076	6,599	1,090	7,689	-5,588	36,742	
	Mar	944	2.71	2,687	1.82	789	1,898	211	1.65	302	0	1,898	2,467	1,280	3,747	-2,803	33,939	
	Apr	3,491	7.23	3,510	4.17	1,807	1,703	284	3.00	550	0	1,703	2,214	1,130	3,344	147	34,086	
	May	28,122	13.25	5,677	8.21	3,558	2,119	743	3.00	550	193	2,312	3,006	1,170	4,176	23,946	53,000	5,032
	Jun	2,241	0	6,067	0	0	6,067	1,146	0	0	1,146	7,213	9,377	1,650	11,027	-8,786	44,214	
	Jul	1,800	0.29	5,373	0	0	5,373	1,173	0.03	5	1,168	6,541	8,503	1,470	9,973	-8,173	36,041	
	Aug	752	0	2,167	0	0	2,167	422	0	0	422	2,589	3,366	1,460	4,826	-4,074	31,967	
	Sep	1,241	5.47	780	2.99	1,296	0	64	3.00	550	0	0	0	1,270	1,270	-29	31,938	
	Total	92,026	56.01	48,664	33.31	14,435	34,745	7,884	19.68	3,602	5,120	39,865	51,825	13,320	65,145			
	Oct	12,999	14.55	3,510	9.00	3,900	0	605	3.00	550	55	55	72	1,040	1,112	11,887	43,825	
	Nov	40,851	12.72	4,767	7.85	3,402	1,365	752	3.00	550	202	1,567	2,037	960	2,997	37,854	53,000	28,679
	Dec	12,805	5.16	4,810	2.79	1,209	3,601	843	3.00	550	293	3,894	5,062	770	5,832	6,973	53,000	6,973
1973	Jan	2,728	0	4,983	0	0	4,983	898	0	0	898	5,881	7,645	1,200	8,845	-6,117	46,883	
	Feb	1,847	0.32	4,333	0	0	4,333	743	0.05	9	734	5,067	6,587	1,170	7,757	-5,910	40,973	
	Mar	2,160	5.02	2,687	2.69	1,166	1,521	211	3.00	550	0	1,521	1,977	1,370	3,347	-1,187	39,786	
	Apr	7,486	7.46	3,510	4.33	1,876	1,634	284	3.00	550	0	1,634	2,124	1,250	3,374	4,112	43,898	
	May	1,005	1.03	5,677	0.02	9	5,668	743	0.52	95	648	6,316	8,211	1,380	9,591	-8,586	35,312	
	Jun	792	2.93	6,067	1.29	559	5,508	1,146	1.80	330	816	6,324	8,221	1,270	9,491	-8,699	26,613	
	Jul	396	1.10	5,373	0.07	30	5,343	1,173	0.57	104	1,069	6,412	8,336	1,070	9,406	-9,010	17,603	
	Aug	293	0.49	2,167	0	0	2,167	422	0.16	29	393	2,560	3,328	1,000	4,328	-4,035	13,568	
	Sep	198	2.74	780	1.17	507	273	64	1.67	306	0	273	355	810	1,165	-967	12,601	
	Total	83,560	53.52	48,664	29.21	12,658	36,396	7,884	19.77	3,623	5,108	41,504	53,955	13,920	67,245			

Table 5-17 Operation Study of Inginimitiya Reservoir Project (10)

F.W.R. : Field Water Requirment
I.W.R. : Irrigation Water Requirment

Year	Month	Inflow	Rainfall	Irrigation Demand											Evaporation Loss	Total Demand	Storage	End of Month Storage	Spill
				Lowland (5,200 Ac)				Upland (1,100 Ac)				Total							
				F.W.R.	Effective Rainfall		I.W.R	F.W.R.	Effective Rainfall		I.W.R.	T	1.3 × T						
		Ac·ft	in	Ac·ft	in	Ac·ft	Ac·ft	Ac·ft	in	Ac·ft	Ac·ft	Ac·ft	Ac·ft		Ac·ft	Ac·ft	Ac·ft	Ac·ft	Ac·ft
1973	Oct	2,447	10.39	3,510	6.29	2,726	784	605	3.00	550	55	839	1,091		620	1,711	736	13,337	
	Nov	3,528	7.23	4,767	4.17	1,807	2,960	752	3.00	550	202	3,162	4,111		490	4,601	-1,073	12,264	
	Dec	2,591	12.46	4,810	7.68	3,328	1,482	843	3.00	550	293	1,775	2,308		500	2,808	-217	12,047	
1974	Jan	4,714	0	4,983	0	0	4,983	898	0	0	898	5,881	7,645		500	8,145	-3,431	8,616	
	Feb	772	2.32	4,333	0.88	381	3,952	743	1.39	255	488	4,440	5,772		390	6,162	-5,390	8,450	
	Mar	2,132	4.13	2,687	2.10	910	1,777	211	2.60	477	0	1,777	2,310		500	2,810	-678	8,450	
	Apr	18,869	11.74	3,510	7.20	3,120	390	284	3.00	550	0	390	507		460	967	17,902	26,352	
	May	1,552	1.44	5,677	0.29	126	5,551	743	0.80	147	596	6,147	7,991		1,010	9,001	-7,449	18,903	
	Jun	1,653	0.33	6,067	0	0	6,067	1,146	0.05	9	1,137	7,204	9,365		910	10,275	-8,622	10,281	
	Jul	1,146	1.01	5,373	0.01	4	5,369	1,173	0.51	93	1,080	6,449	8,384		620	9,004	-7,858	8,450	
	Aug	226	1.44	2,167	0.29	126	2,041	422	0.80	147	275	2,316	3,011		570	3,581	-3,355	8,450	
	Sep	46	1.01	780	0.01	4	776	64	0.51	93	0	776	1,009		540	1,549	-1,503	8,450	
	Total	39,676	53.50	48,664	28.92	12,532	36,132	7,884	18.66	3,421	5,024	41,156	53,504		7,110	60,614			
	Oct	Nil	0.32	3,510	0	0	3,510	605	0.05	9	596	4,106	5,338		440	5,778	-5,778	8,450	
	Nov	172	2.70	4,767	1.14	494	4,273	752	1.64	301	451	4,724	6,141		330	6,471	-6,299	8,450	
	Dec	212	3.31	4,810	1.55	672	4,138	843	2.05	376	467	4,605	5,987		340	6,327	-6,115	8,450	
1975	Jan	44	0.08	4,983	0	0	4,983	898	0	0	898	5,881	7,645		370	8,015	-7,971	8,450	
	Feb	3,400	3.16	4,333	1.45	628	3,705	743	1.95	357	386	4,091	5,318		390	5,708	-2,308	8,450	
	Mar	190	1.60	2,687	0.40	173	2,514	211	0.90	165	46	2,560	3,328		500	3,828	-3,638	8,450	
	Apr	1,420	5.50	3,510	3.02	1,309	2,201	284	3.00	550	0	2,201	2,861		460	3,321	-1,901	8,450	
	May	2,435	4.30	5,677	2.21	958	4,719	743	2.71	497	246	4,965	6,455		470	6,925	-4,490	8,450	
	Jun	196	0.49	6,067	0	0	6,067	1,146	0.16	29	1,117	7,184	9,339		500	9,839	-9,623	8,450	
	Jul	2,800	4.83	5,373	2.57	1,114	4,259	1,173	3.00	550	623	4,882	6,347		500	6,847	-4,047	8,450	
	Aug	Nil	0.61	2,167	0	0	2,167	422	0.24	44	378	2,545	3,309		570	3,879	-3,879	8,450	
	Sep	Nil	2.94	780	1.30	563	217	64	1.80	330	0	217	282		540	822	-822	8,450	
	Total	10,869	29.84	48,664	13.64	5,911	42,753	7,884	17.50	3,208	5,208	47,961	62,350		5,410	67,760			



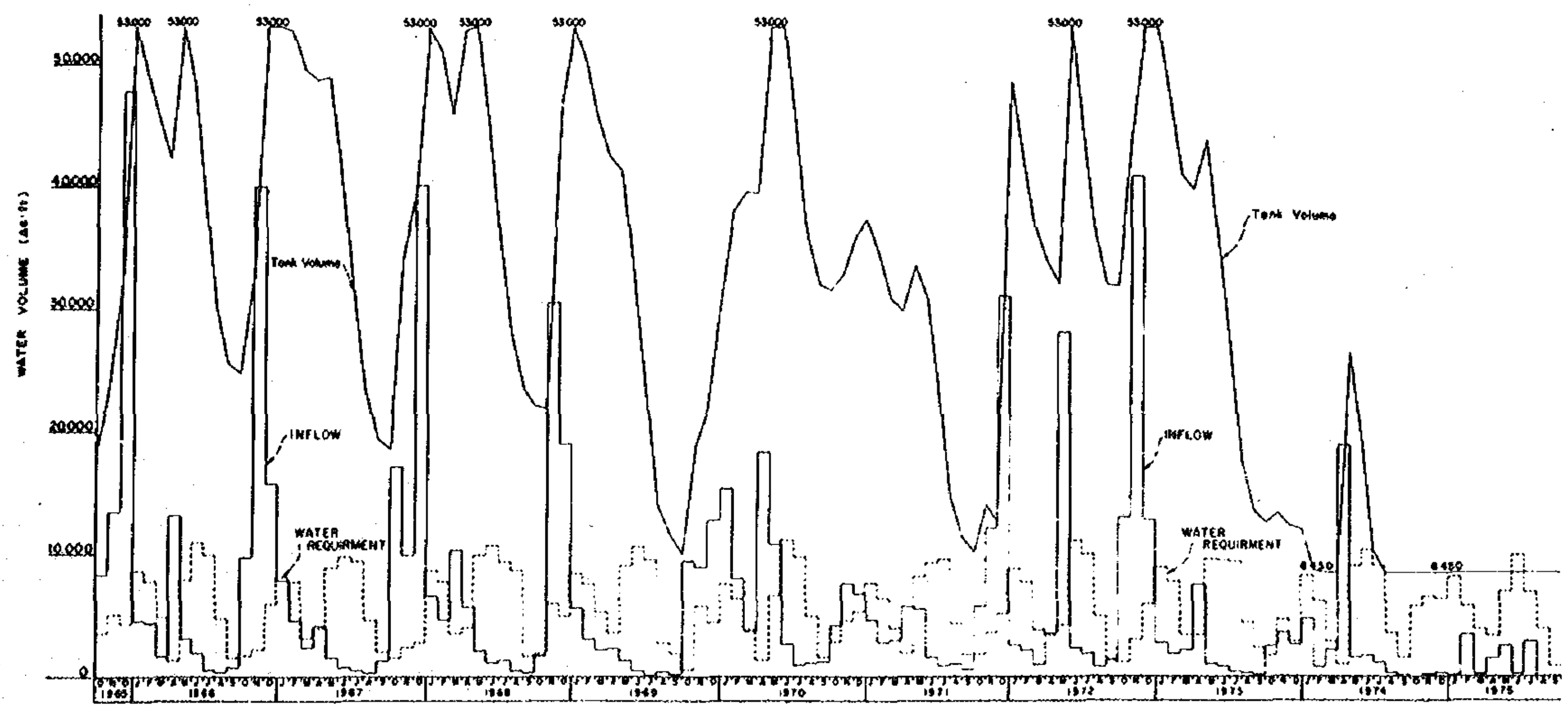


Fig. 5-1 WATER BALANCE STUDY
FOR
INGINIMITIYA RESERVOIR PROJECT

VI DAM CONSTRUCTION

6.1 Selection of Dam-Axis

Several dam sites were investigated and ultimately the present dam site was chosen by the Irrigation Department as the most suitable one from such considerations as of geology, storage capacity and, particularly, the availability of foundation rock at the site proposed for spillway, etc. After field exploratory surveys, the Feasibility Study Team endorsed the ID's decision.

6.2 Reservoir Parameters

Water balance computation between the water requirement for irrigating 6,300 acres, in consideration of the proposed cropping patterns, and the storage capacities (at different F.W.Ls ranging from 200 to 206 M.S.L.) having been done in Chapter V, 202 M.S.L. has ultimately been identified as the Full Water Level for the most appropriate storage capacity. The reservoir parameters are given as follows:

Drainage area at Dam-site	: Total	:	215 sq.miles
	: between Inginimitiya and Abakolawewa	:	150 sq.miles
Maximum annual yield (for 150 sq.miles)		:	336,906 Acre-feet
Maximum monthly yield (-do-)		:	157,391 "
Minimum annual yield (-do-)		:	10,869 "
Minimum monthly yield (-do-)		:	0 "
Maximum water surface elevation 1/		:	206.0 ft.MSL
Normal maximum operating pool W.S EL 2/		:	202.0 ft.MSL
Minimum water surface EL 3/		:	181.0 ft.MSL
Capacity at EL 206.0 MSL		:	72,000 Acre-feet
Capacity at EL 202.0 MSL		:	53,000 "
Capacity at EL 181.0 MSL 4/		:	4,200 "
Effective storage capacity EL 202-EL 181.0		:	48,800 "

(continued)

1/ High flood level
2/ Full supply level
3/ Sill level of sluice (outlet)
4/ Dead storage

Area at EL 206.0 MSL	:	5,030 Acres
Area at EL 202.0 MSL	:	4,100 Acres
Area at EL 181.0 MSL	:	850 Acres

6.3 Selection of Dam-Type

In view of the availability of homogenous and suitable embankment materials in the vicinity of the dam-site, the type of this earth dam has been decided to be "homogenous type" which is justifiable from both the technical as well as the economic considerations.

6.4 Embankment Design

6.4.1 Freeboard

Earth dam must be provided with sufficient freeboard so that there is no possibility whatever of the embankment being overtopped. Necessary freeboard is calculated by assuming that the maximum river flood will occur when the reservoir is full and that the highest possible waves will develop at the same time. The minimum freeboard equals the computed head on the spillway crest at maximum flood discharge, plus runup on riprapped slopes, plus a safety factor. The physical fetch extends for 6 miles (9,670 m) but as the reservoir is located on the eastern side of the embankment and the wind direction at flood time is either NW or SE, 2.6 miles (4,180 m) along the dam-axis is taken as an actual fetch for calculating the freeboard. However, it is necessary to ascertain that no overtopping will take place due to the wind from the eastern direction

The safety factor, which is generally varies between 2 feet (0.601 m) to 10 feet (3.048 m), is selected by considering the size of the reservoir, the dam height, and the reliability of the data from which the flood computations are made. As an emergency spillway, 300 feet (243.84 m) in length and 1 foot (0.304 m) below the dam crest, is designed on the right abutment, the safety factor is decided as 2 feet (0.6096 m).

Head on the spillway crest — 24 feet (7.3152 m)

Runup on riprapped slope (see Fig. 6-1)

- Wind velocity — 60 m.p.h (26.67 m/sec)
- Fetch — 2.6 miles (4,180 m)

$$\text{Runup} = 0.7 + \frac{1.1 - 0.7}{10} \times 0.67 = 0.97 \text{ m } (3.17 \doteqdot 3.2 \text{ ft})$$

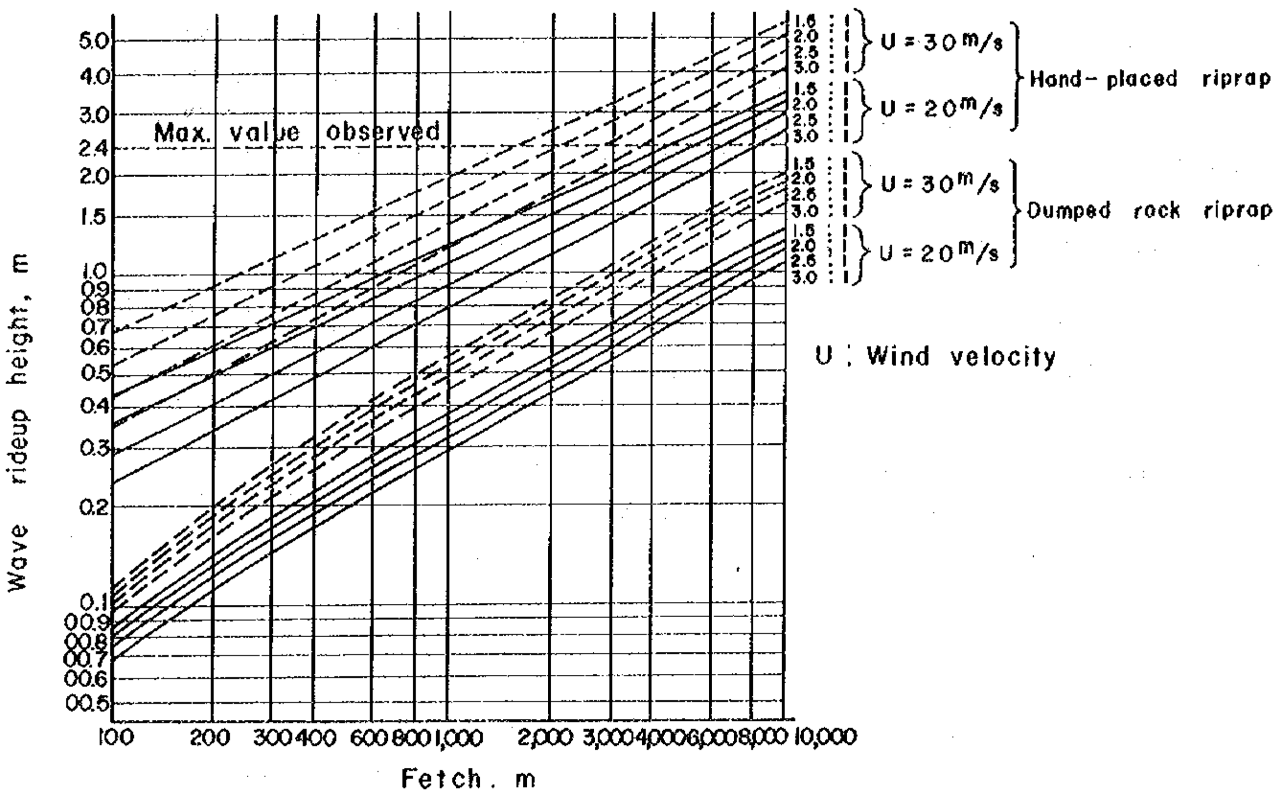


Fig. 6-1 Relationship of wave rideup height to fetch, wind velocity, slope of the upstream face, and type of riprap

The proposed dam is provided with a spillway which is equipped with radial gate (20' x 20' = 6.096 m x 6.096 m) and the spillway crest is fixed at EL. 182.0 MSL, which does not equate to F.W.L. Dam crest can be determined through the following formula:

Dam Crest Elevation = Spillway crest elevation + Head on the spillway crest + Runup on riprapped slope + Safety factor

= EL.182.0 + 24.0 + 3.2 + 2.0 = EL.211.2 ≒ EL.212.0

Accordingly, the elevation of dam crest is determined as EL. 212.0 MSL.

It is confirmed through the following calculation that no over-topping will take place when wind blows from the eastern direction:

Runup on riprapped slope

Wind velocity	60 m.p.h. (26.67 m/sec)
Fetch	6 miles (9,670 m)

Runup = $1.2 + \frac{1.76 - 1.2}{10} \times 6.67 = 1.57$ (5.15 ft ≒ 5.2 ft)

Maximum Height of the waves during non-flood season

= F.W.L. + Runup over riprapped slope

= EL.202.0 + 5.2 = EL.207.2 < EL.212.0 = Dam Crest EL.

6.4.2 Dam Height

The height of the dam is a balance between the dam crest elevation (EL. 212.0) and the river-bed elevation of the Mi-Oya (153.0):

212.0 - 153.0 = 59 ≒ 60 feet

6.4.3 Crest Width of Dam

Crest width of dam has been determined at 20 feet (6.096 m), by taking into consideration the stability against waves and seepage, and the efficiency of construction as well as its use as a road.

6.4.4 Gradient of Slopes

The original slopes of the dam which were made 1 on 3 and 1 on 2.5 on the upstream and down-stream by the Irrigation Department have been altered to 1 on 2.5 and 1 on 2.0, respectively, on the abutment. Such alterations have been made on the ground as explained in the below.

According to the proposals made by ID, the distribution of pore pressure immediately after construction of the dam and the flownets at the time of a full storage and under a rapid drawdown condition will be shown as per Fig. 6-2, 6-3 and 6-4, respectively; on these basis the Bishop's pore pressure coefficient immediately after construction of the dam is assumed to be 60% and the ratio between the coefficient of permeability in the vertical direction (kv) and that in the horizontal direction(kh) is assumed at 1:5, with the use of a sheep's foot roller for compaction. According to the results of laboratory tests the dam-body's density and strength in design is given in the values as given in Table 6-1, which also shows those of its foundation and drain. Slope stability analysis with computer has been made on these data with three cases of fill completed condition, at full reservoir time, and under the rapid drawdown condition. As its results given in Fig. 6-5 to 6-7 and in Table 6-2 show, in all cases the calculated safety factors are larger than the tolerable safety factors adopted in Sri Lanka; accordingly, the slopes could safely be made steeper to reduce the embankment volume. The stability of embankment, of which slopes are 1 on 2.5 and 1 on 2 on the upstream and downstream, has been analyzed by the use of the equi-pore pressure lines and the flownets at the time of full reservoir and under a rapid drawdown conditions as shown in Figs. 6-8, 6-9 and 6-10, respectively, and the results as shown in Figs. 6-11 to 6-13 have been obtained. They also show that the minimum safety factors are above the tolerable ones and that the dam-body will have enough resistance to sliding. The inclinations of the slope are, thus, determined at 1:25 on the upstream and 1:2.0 on the downstream.

Table 6-1 Design Parameter

		Embankment	Sand Blanket & Toe Drain	Foundation
Wet density	lb/ft^3	133	119	-
	t/m^3	2.131	1.906	-
Saturated density	lb/ft^3	135.7	-	132
	t/m^3	2.173	-	2.115
Cohesion	lb/ft^2	1,150	0	1,035
	t/m^3	5.615	0	5,054
Angle of internal friction	DEG	23°30'	30°00'	21°09'
	RAD	0.4103	0.523599	0.36928

Table 6-2 Slope Stability Analysis

Safety Factor / Case	Sri Lanka Proposals		Revised Proporsals		Tolerable Safety Factor
	Upstream	Downstream	Upstream	Downstream	
Fill completed condition	1.89	1.77	1.83	1.62	1.5
Full storage time	2.19	1.93	1.91	1.78	1.3 ∿ 1.5
Rapid drawdown time	2.05	-	1.86	-	1.2

Fig. 6-2 Fill Completed Condition Alternative

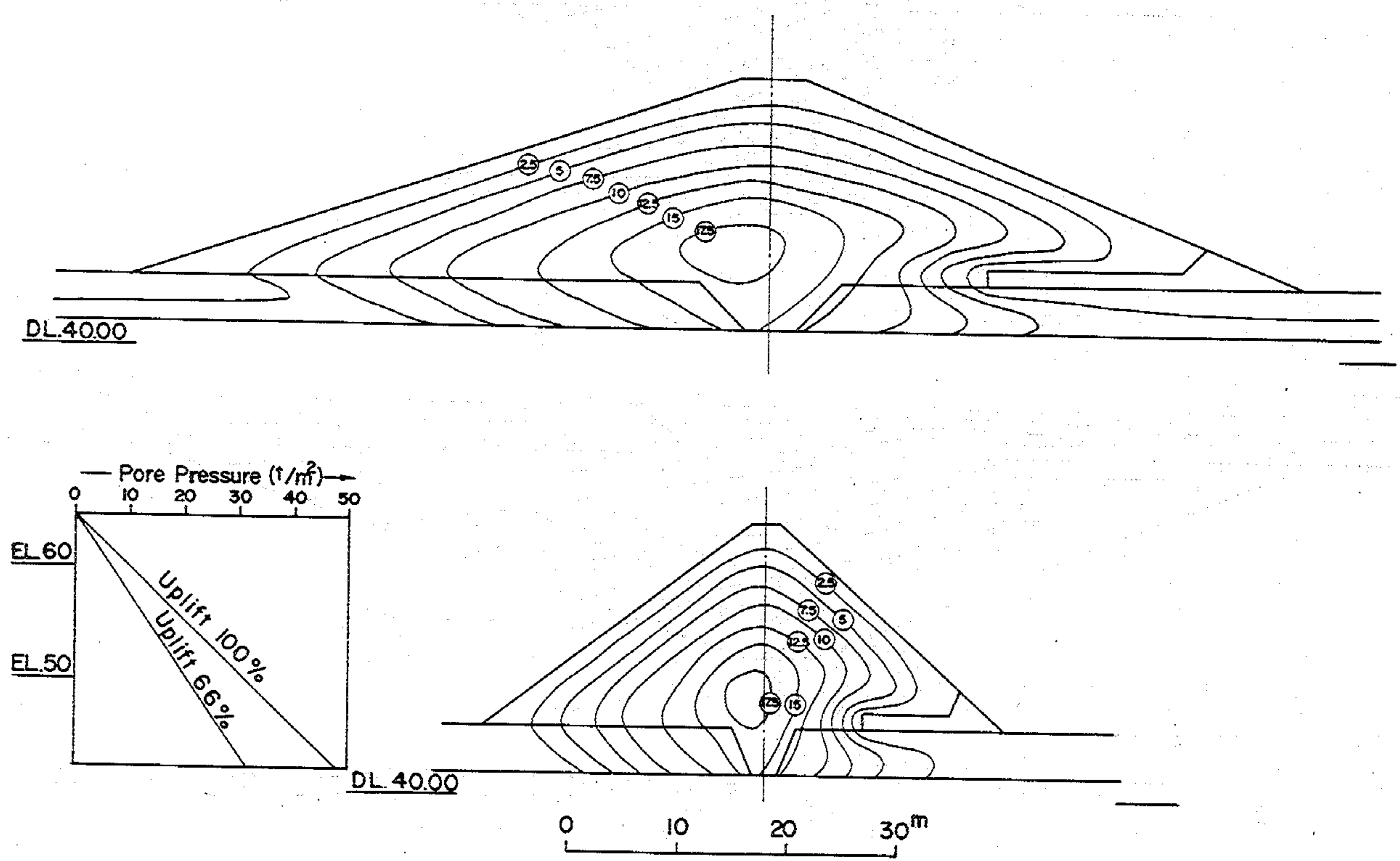
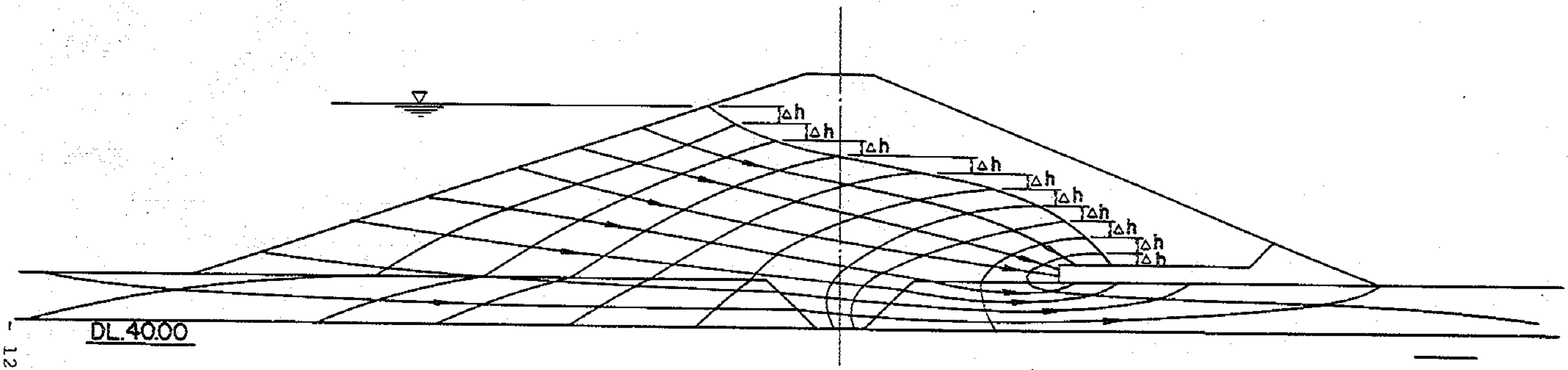


Fig. 6-3 Full Reservoir Alternative



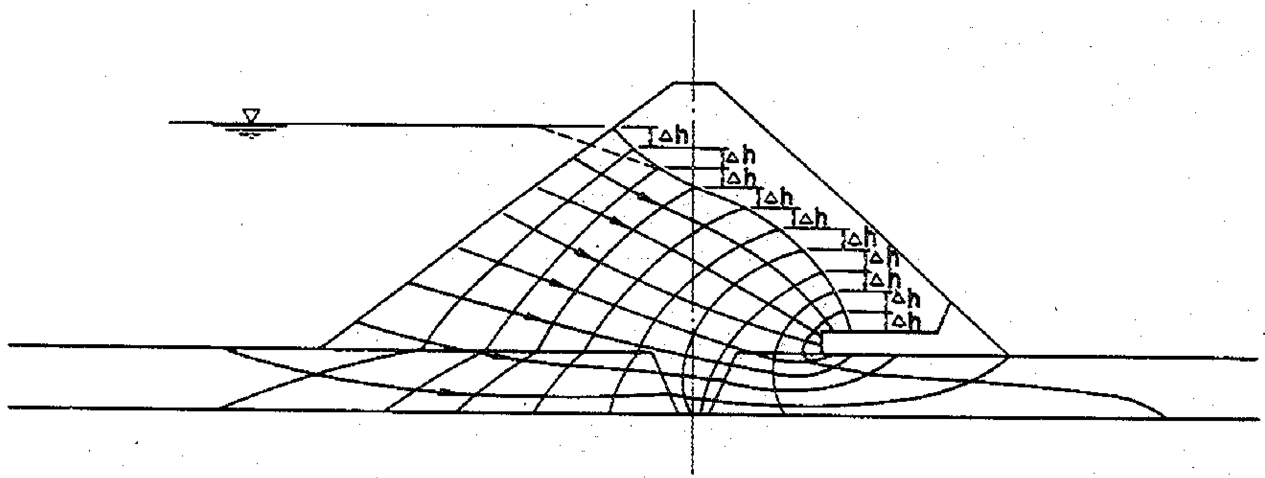


Fig. 6-4 Rapid Drawdown Condition Alternative

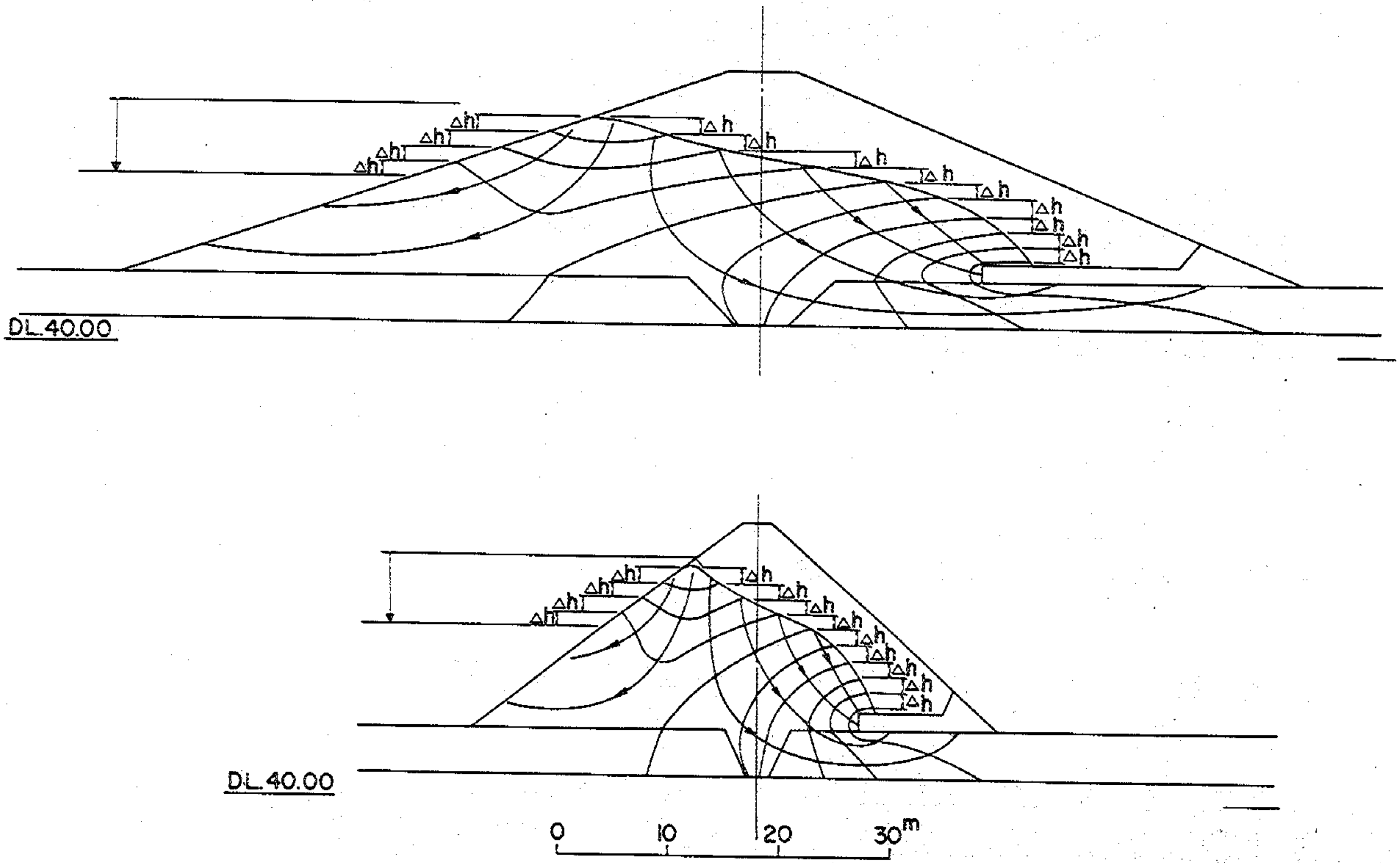


Fig. 6-5 SLOPE STABILITY ANALYSIS-FILL COMPLETED CONDITION ALTER.

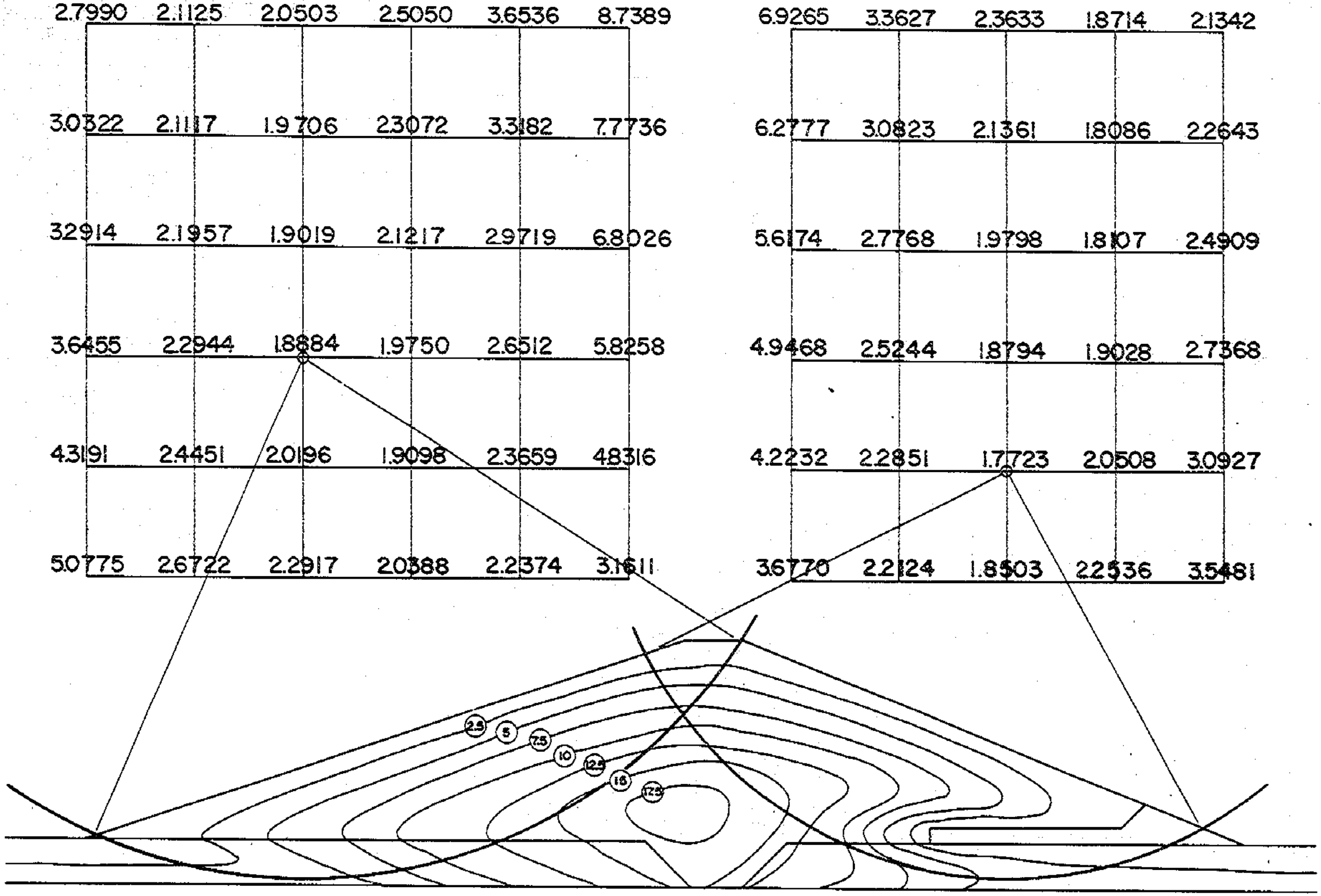


Fig. 6-6 SLOPE STABILITY ANALYSIS - FULL RESERVOIR ALTERNATIVE

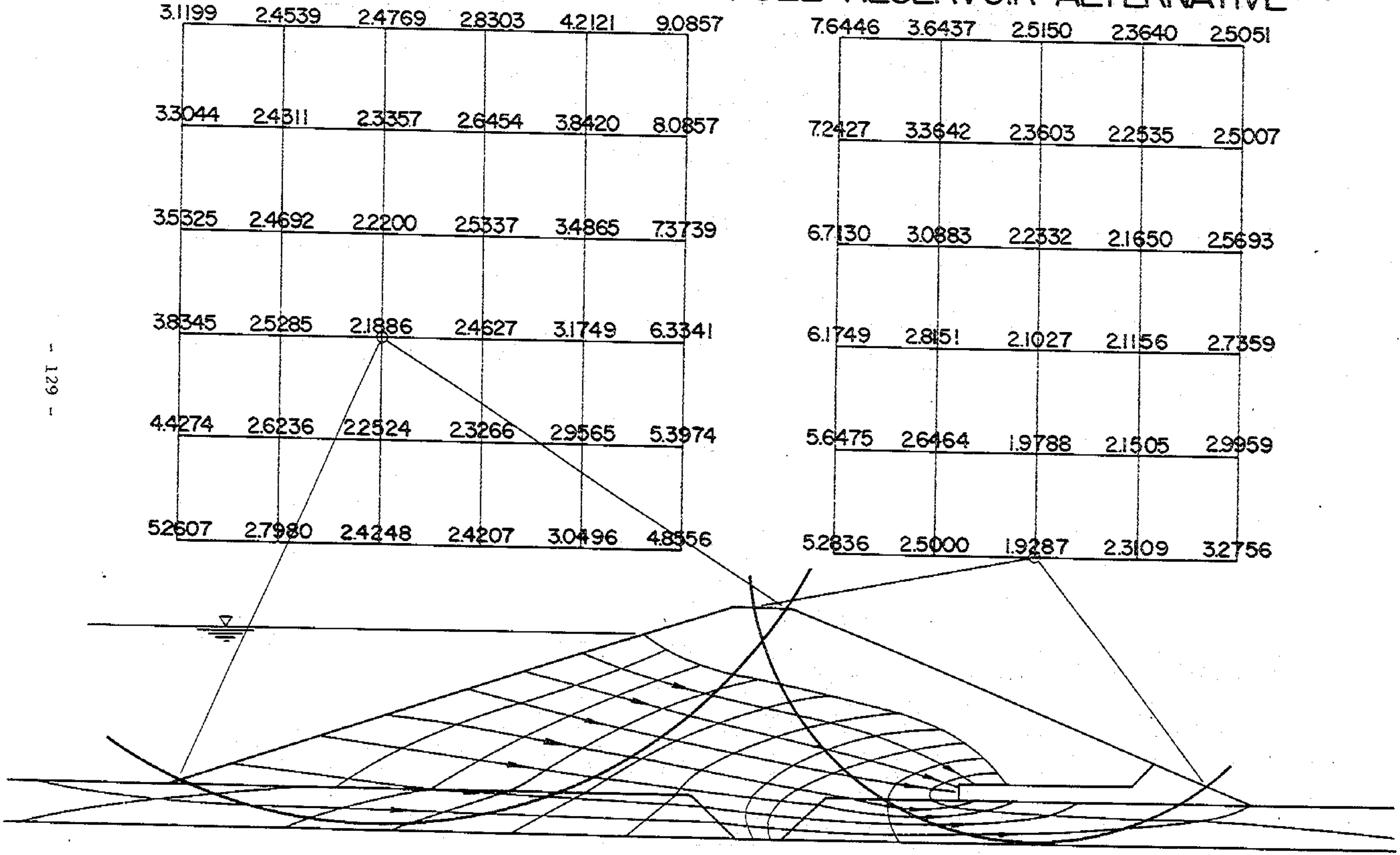


Fig. 6-7

SLOPE STABILITY ANALYSIS
RAPID DRAWDOWN CONDITION
ALTERNATIVE

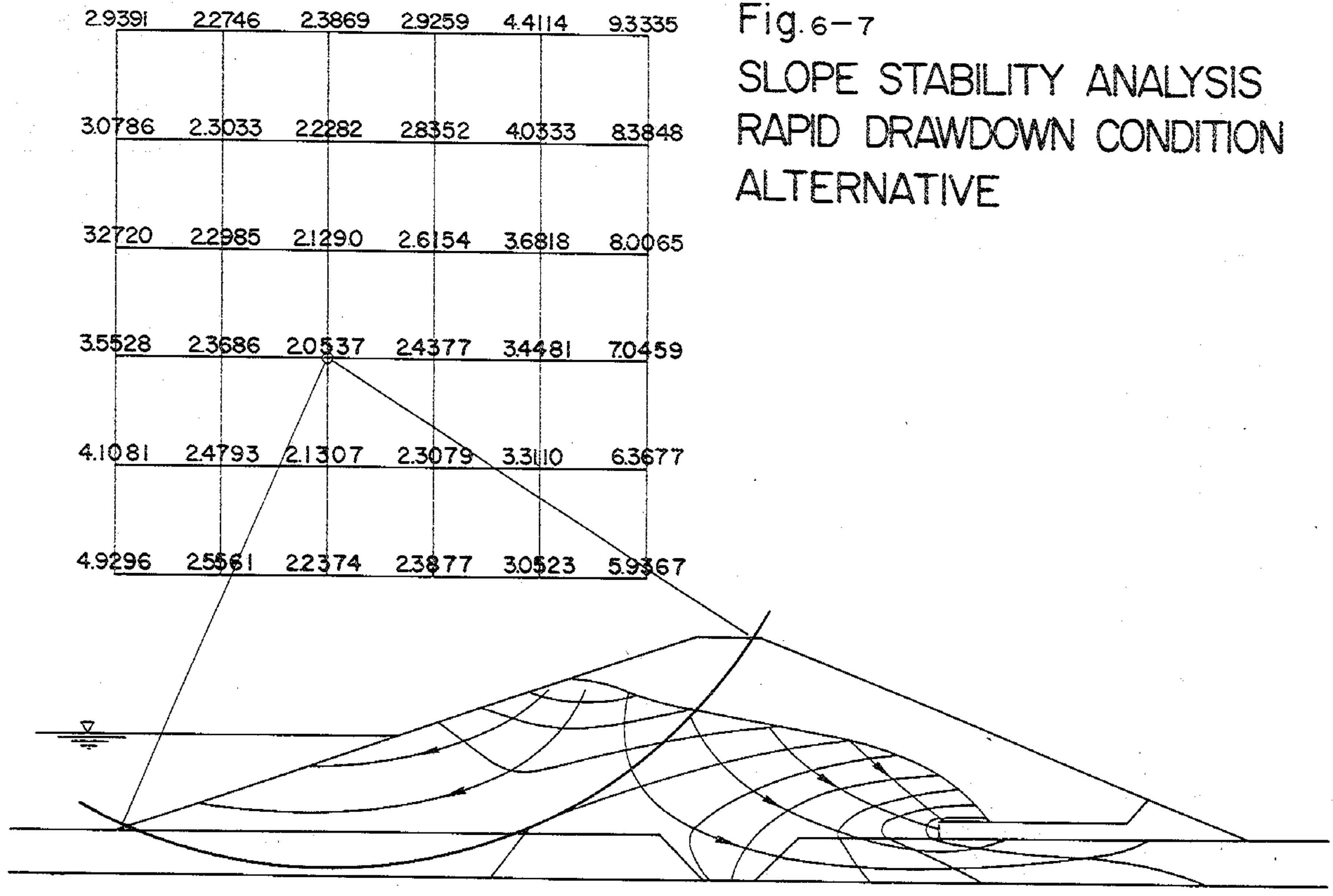


Fig. 6-8 Fill Completed Condition

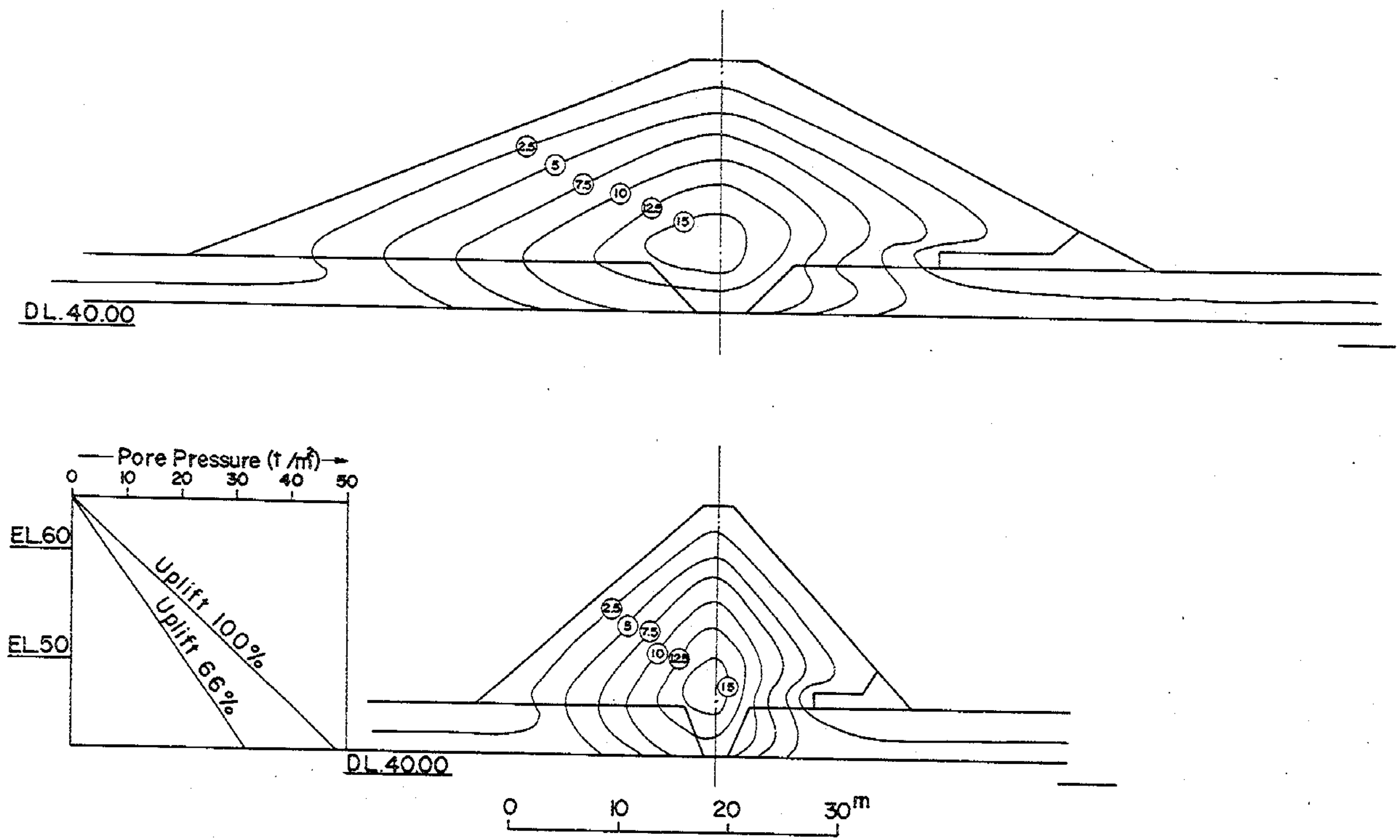


Fig. 6-9 Full Reservoir

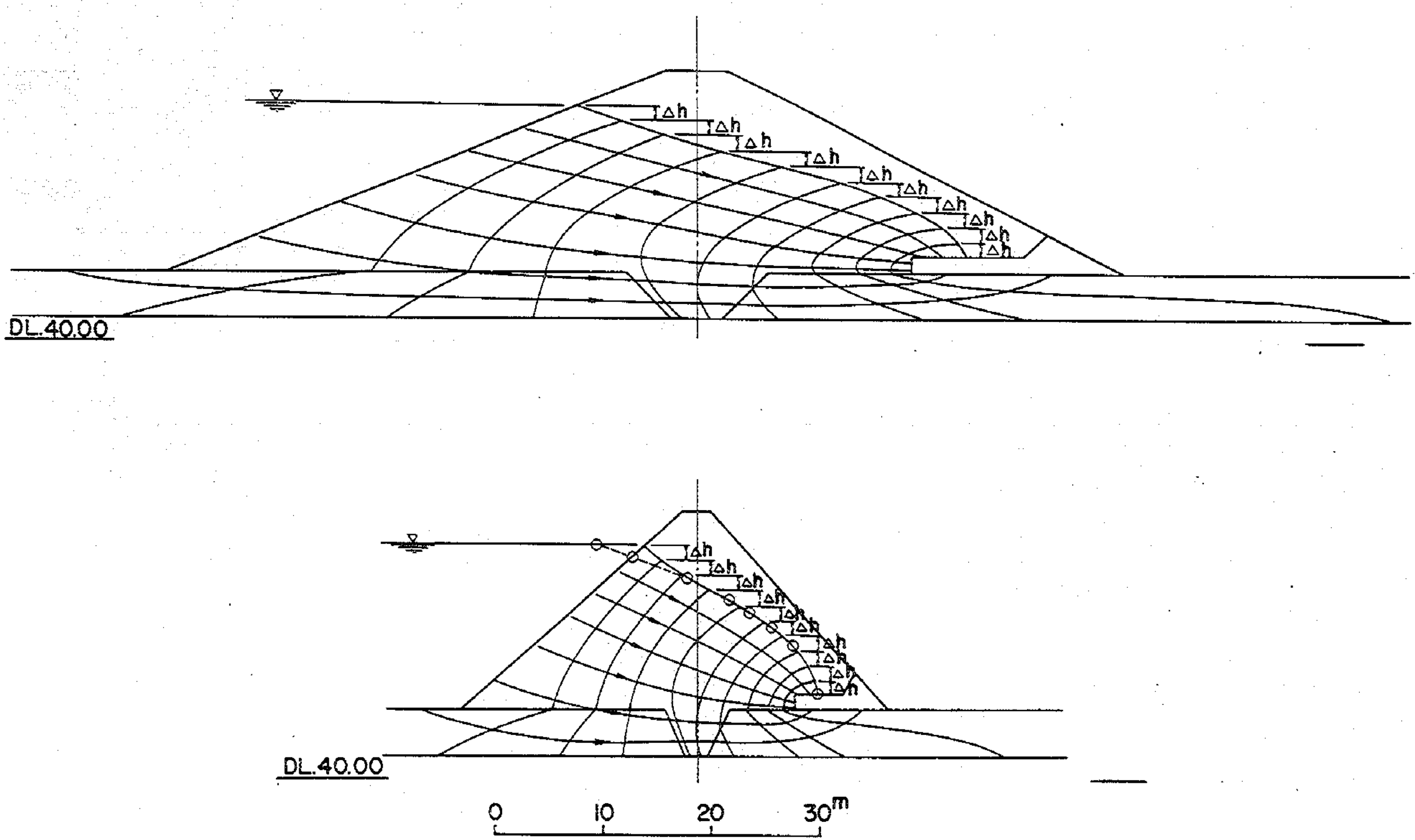


Fig. 6-10 Rapid Drawdown Condition

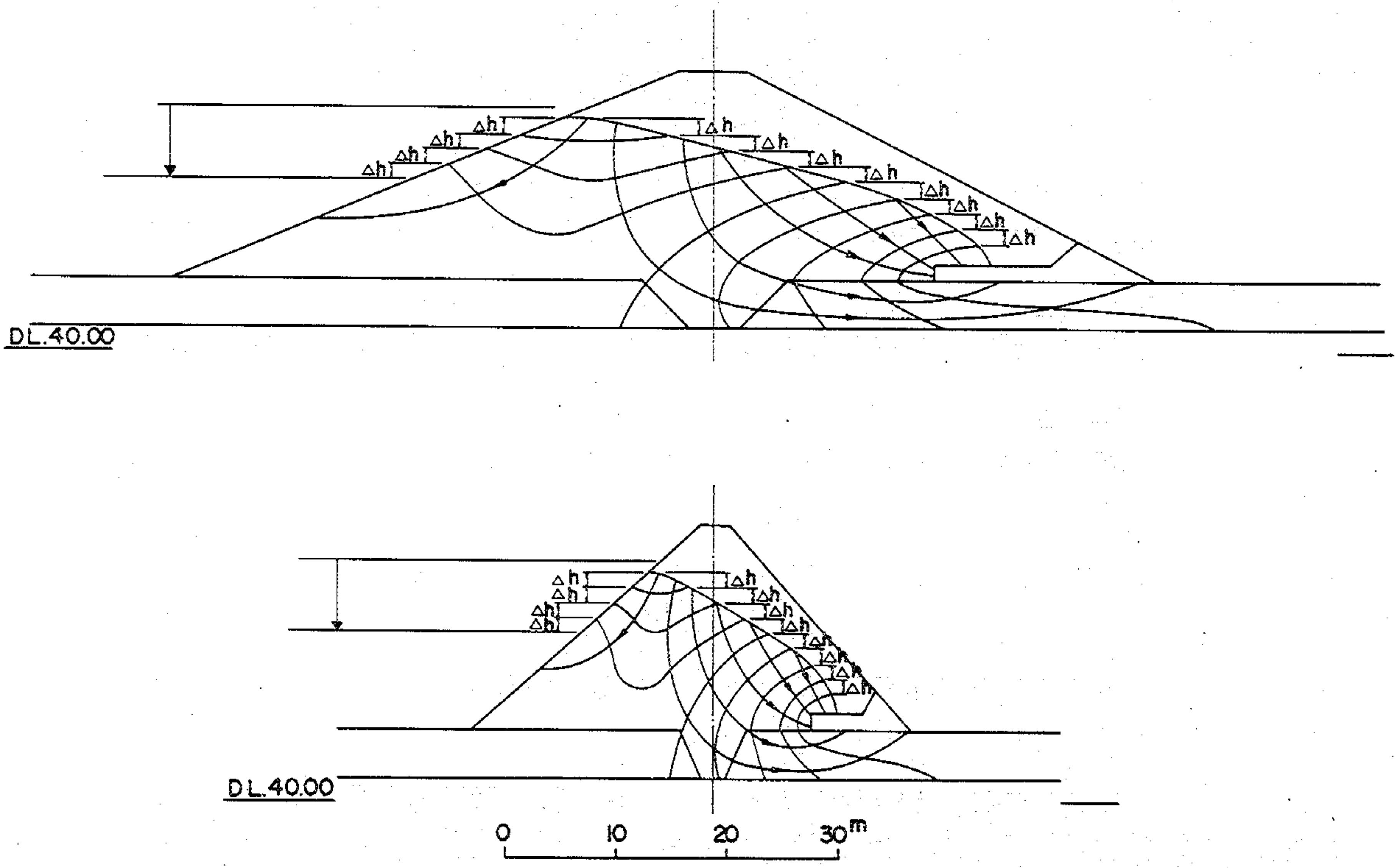


Fig. 6-11 SLOPE STABILITY ANALYSIS - FILL COMPLETED CONDITION

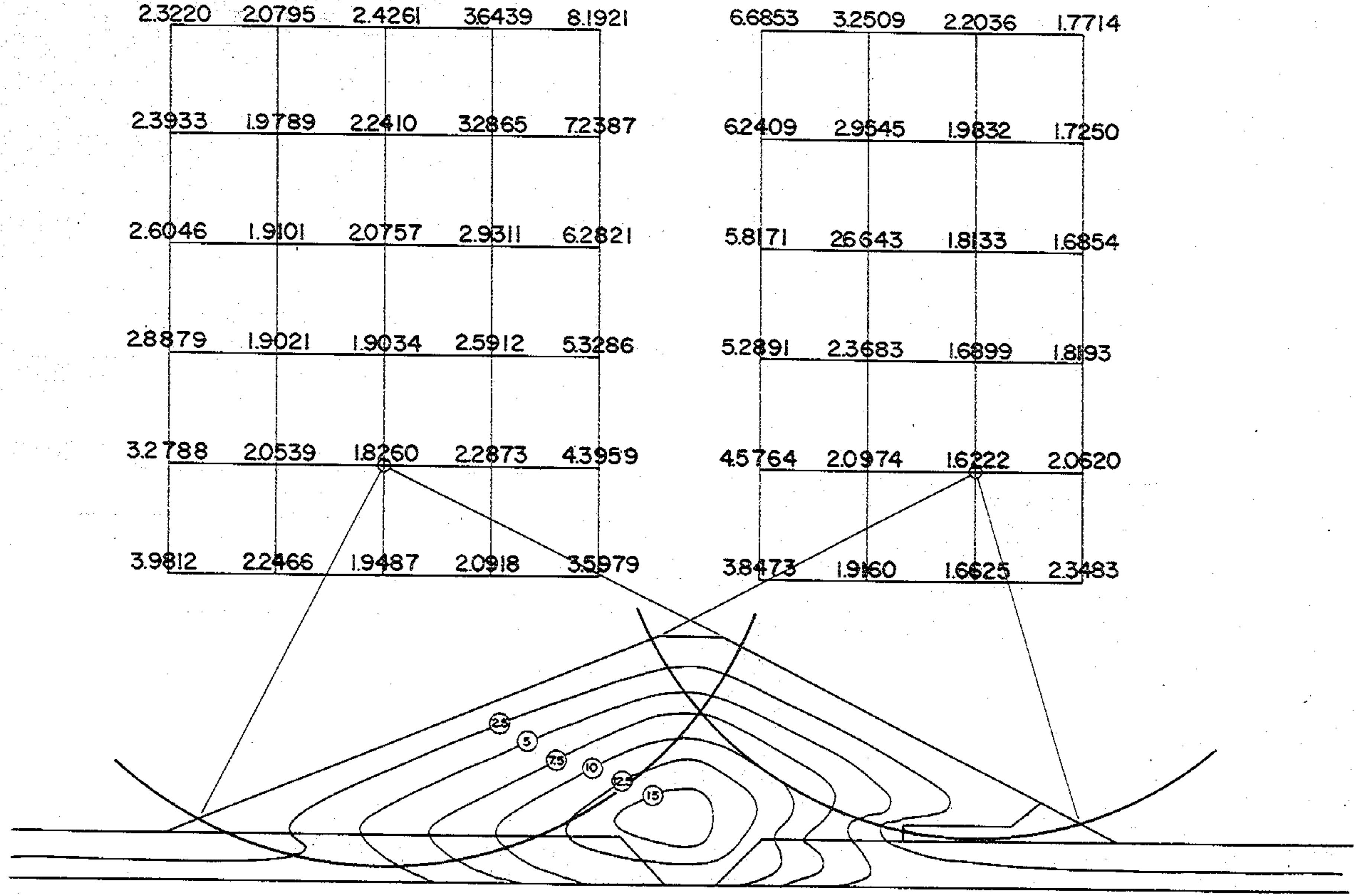


Fig. 6-12 SLOPE STABILITY ANALYSIS – FULL RESERVOIR

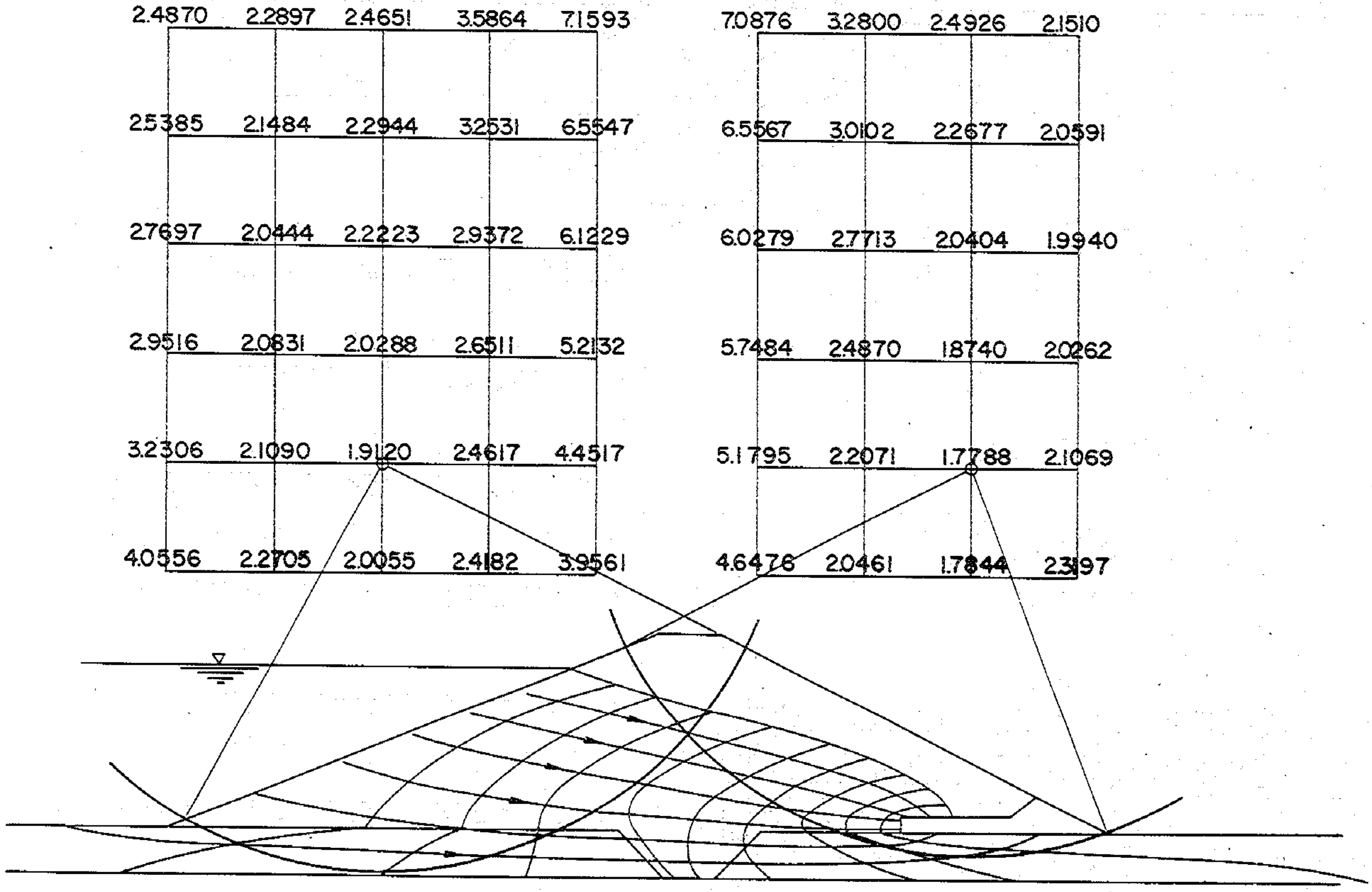
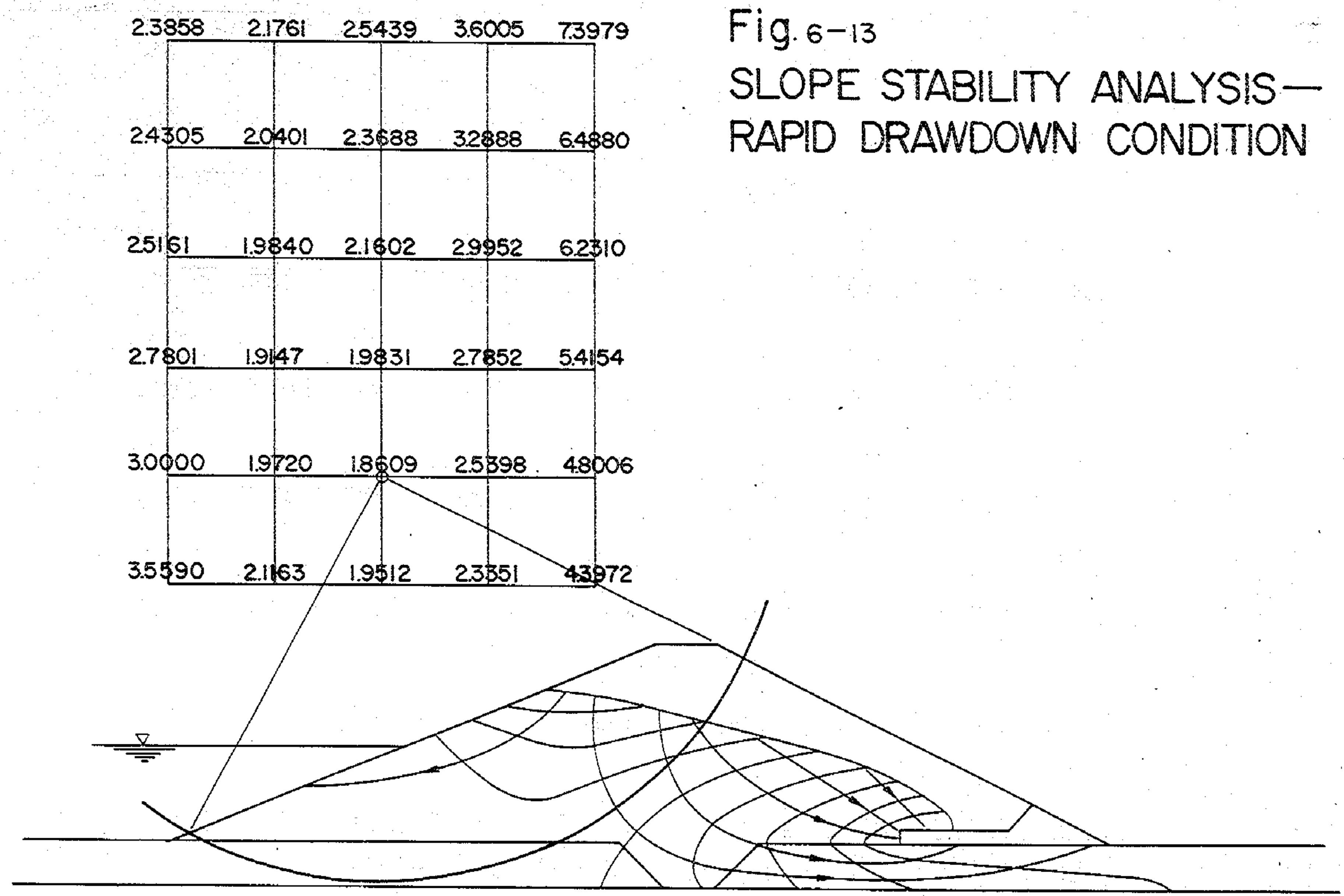


Fig. 6-13

SLOPE STABILITY ANALYSIS—
RAPID DRAWDOWN CONDITION



6.4.5 Slope Protection Designing

Riprap needs to be provided to prevent washing-out of the upstream slope by the waves which may develop at the flood time. The fetch at the full storage time is about 6 miles (9,670 m) and Sri Lanka's design wind velocity is 60 m.p.h. (26.67 m/sec). The highest-possible wave which may develop under these conditions would be about 7 feet (2.134 m). (see Fig. 6-14). The relationship among the highest wave, the riprap layer thickness, and an average rock size is shown Table 6-3 below:

Table 6-3 Recommended Riprap Design Criteria

Maximum Height of Wave (ft)	Minimum Average Rock Size D50 (in)	Layer Thickness (in)
0 ~ 2	10	12
2 ~ 4	12	18
4 ~ 6	15	24
6 ~ 8	18	30
8 ~ 10	21	36

However, as the reservoir is situated on the eastern side of the dam-body and the strong winds would blow only from NW or SW directions, the riprap with an average rock size of 15 inches and 2-feet layer thickness against 4 ~ 6 feet high waves is recommended. The thickness of filter under riprap is designed at 1 foot (0.3048 m). Riprap is provided inbetween 6 feet (1.829 m) below the dead water level and 5 feet (1.524 m) above the F.W.L. The downstream slope will be protected by turfing.

6.4.6 Design of the Detailed Parts of the Dam

The top soil will be removed by 2 feet thickness. 10 feet (3.048 m)-wide bern is provided at the lower end of riprap. After removal of the top soil, the portion levelling lower than F.W.L. (202.0 MSL) needs to be provided with Toe Drain to expedite flowdown of the seepage water through dam-body and its foundation. Generally speaking, Chimney Drain is most suitable to this type of homogeneous earth dam because it can best solve the problem of unisotropic seepage and thus increases the stability of the downstream part of the dam-body. However, Toe Drain has been adopted instead of Chimney Drain due to the difficulties in obtaining filter materials, and paucity of working experiences with this type of drain, in Sri Lanka.

Sand Blanket is provided at the downstream of the crossing-point of the gradient line of 1:1.5 from the downstream edge of the crest and the surface of sand blanket itself. Its thickness varies according to the permeability coefficient of the dam-body but is decided at 5 feet from the construction viewpoint.

Standard cross sections of the dam are shown in Fig. 6-15.

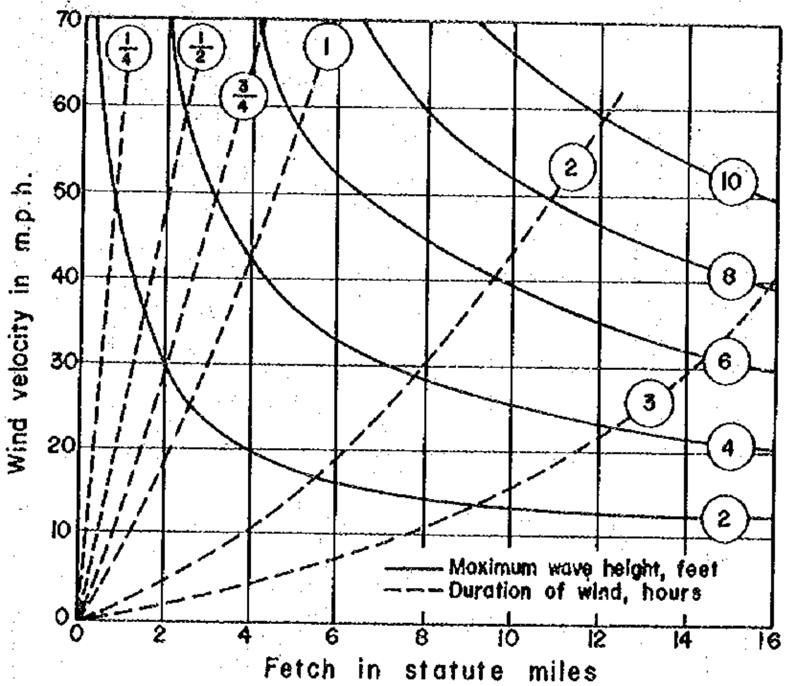
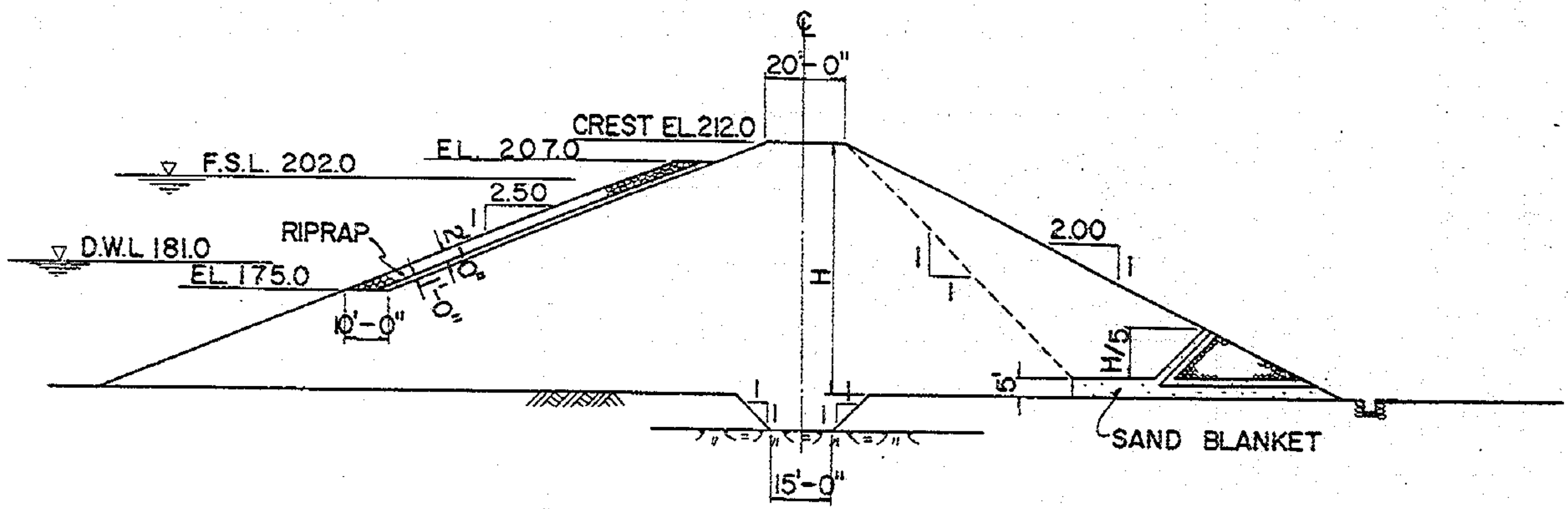


Fig. 6-14 Relationship of wave height to fetch, wind velocity, and wind duration

Fig. 6-15 PROPOSED DAM SECTION

SCALE : 40 FEET TO AN INCH



6.5 Foundation Design

The geological conditions of dam foundation are shown in Fig. 1-16; the existence of sandy soils and weathered rocks with high coefficient of insitu permeability between 200 ∿ 1,200 feet (1.9×10^{-4} ∿ 1.2×10^{-3} cm/sec) per year, from the surface down to about 100 feet (30.48 m) where there is supposed to be sound rock, requires some sort of foundation treatment. In designing homogeneous dam, the length of the seepage path right beneath dam-body is longer than that of other types of dam and, in consideration of that the permeability coefficient along the horizontal direction is many time bigger than that along the vertical direction, cutoff needs to be provided to slow down the flow speed of seepage water which occurs right beneath the dam-body, in view of preventing the danger of piping and increasing the stability of dam against seepage. The original ID's plan was to construct the cutoff through excavation to the depth of one-third the dam height but to facilitate for construction, the proposed elevation of the bottom of excavation is shown in Fig. 6-16. The bottom-width is fixed at 15 feet (4.572 m) from the workability of the construction machinery, and the excavation gradient is determined at 1.0:1.

Because of high degree of evaporation from the water surface of the reservoir in the Dry Zone of Sri Lanka, its seepage loss must be minimized: grouting becomes necessary if seepage from the reservoir should be more than 0.05%/day of its effective storage. Therefore, computation of the amount of possible seepage loss has been made.

. Estimation of Seepage Loss

On the left abutment, the seepage around the embankment is supposed to be negligible as the groundwater level there would considerably rise and the groundwater should flow into the reservoir. On the right abutment, however, it could occur as the groundwater level would be situated lower than the storage level in a considerable extent of the abutment (the groundwater level was identified - in April 1977 - at 16 ∿ 20 feet (4.88 ∿ 6.10 m) below the ground surface and is supposed to further drop by another 4 feet (1.22 m) during dry season. Therefore, the seepage problem must be analyzed in the right abutment from various angles. The plane seepage flownet of right abutment is shown in Fig. 6-17; the seepage flownet through the dam-body, in Fig. 6-9, and that through the dam-foundation, in Fig. 6-18.

- Seepage around the Dam-body: Q_1

$$Q_1 = K_1 \frac{Nf_1}{Np_1} H \cdot D$$

where, K_1 : Permeability coefficient of abutment

Nf_1 : Number of flow channels of the plane flownet

N_{p1} : Number of equal potentional drops of the plane flownet

H : Head

D : Depth of pervious layer of abutment

K_1 = 800 ft/yr (7.7 x 10^{-4} cm/sec), Nf_1 = 5, N_{p1} = 5,

H = 50 ft (15.24 m), D = 50 ft (15.24 m),

$$Q = 800 \times \frac{5}{5} \times 50 \times 50 = 2{,}000{,}000 \text{ cu.ft/yr } (56{,}640 \text{ m}^3\text{/yr}).$$

- Seepage through the Dam-body: Q_2

$$Q_2 = K_2 \frac{Nf_2}{Np_2} H \cdot L$$

where, K_2 : Permeability coefficient of dam-body

$K_2 = \sqrt{kv\ kh}$

kv : Permeability coefficient along vertical direction

1.2 ft/yr (1.2 x 10^{-6} cm/sec)

kh : Permeability coefficient along horizontal direction

kh = 5 kv (assumed)

Nf_2 : Number of flow channels

N_{p2} : Number of equal potentional drops

H : Total head loss

L : Longitudinal length

$K_2 = \sqrt{5\ kv}$ = 2.7 ft/yr (2.6 x 10^{-6} cm/sec), N_{p2} = 10,

Nf_2 = 4,5, H = 45 ft (13.716 m), L = 9,500 ft (2,895.6 m),

$$Q_2 = 2.7 \times \frac{4.5}{10} \times 45 \times 9{,}500 = 519{,}412.5 \text{ cu.ft/yr } (1{,}471 \text{ m}^3\text{/yr}).$$

• Seepage through Dam-Foundation: Q_3

$$Q_3 = K_3 \frac{Nf_3}{Np_3} H \cdot L$$

where, K_3 : Permeability coefficient of dam-foundation

K_3 = 700 ft/yr (6.8×10^{-4} cm/sec),

Nf_3 = 5.6, N_{p3} = 10, H = 60 ft, L = 9,500 ft.

$Q = Q_1 + Q_2 + Q_3 = 225,959,412.5 \doteqdot 226,000,000$ cu.ft/yr
($6,327,820.8\ m^3/yr$)

Effective storage = Ve = 48,800 Ac.ft = 2,125,728 cu.ft
($60,194,800\ m^3$)

Seepage loss $= \frac{Q}{Ve} = 0.1063/yr = 0.029\%/day$

The seepage loss has been calculated at 0.03%/day through the above computation; hence no grouting is planned.

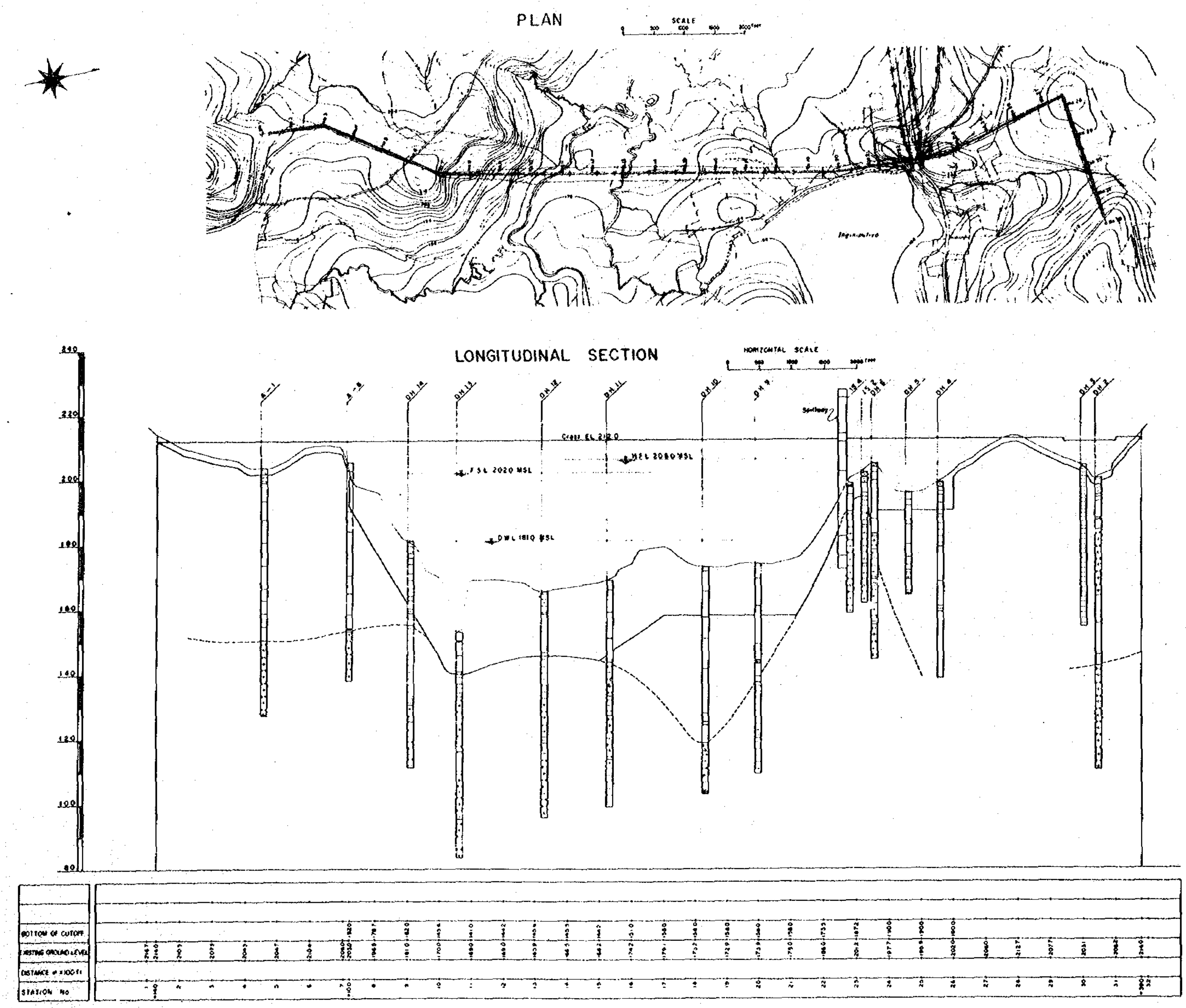


Fig. 6 - 16

INGINIMITYA RESERVOIR PROJECT
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DAM
PLAN & LONGITUDINAL SECTION

Date Jun 1977 | DWG No. 2

Fig. 6-17 SEEPAGE AROUND THE RIGHT ABUTMENT

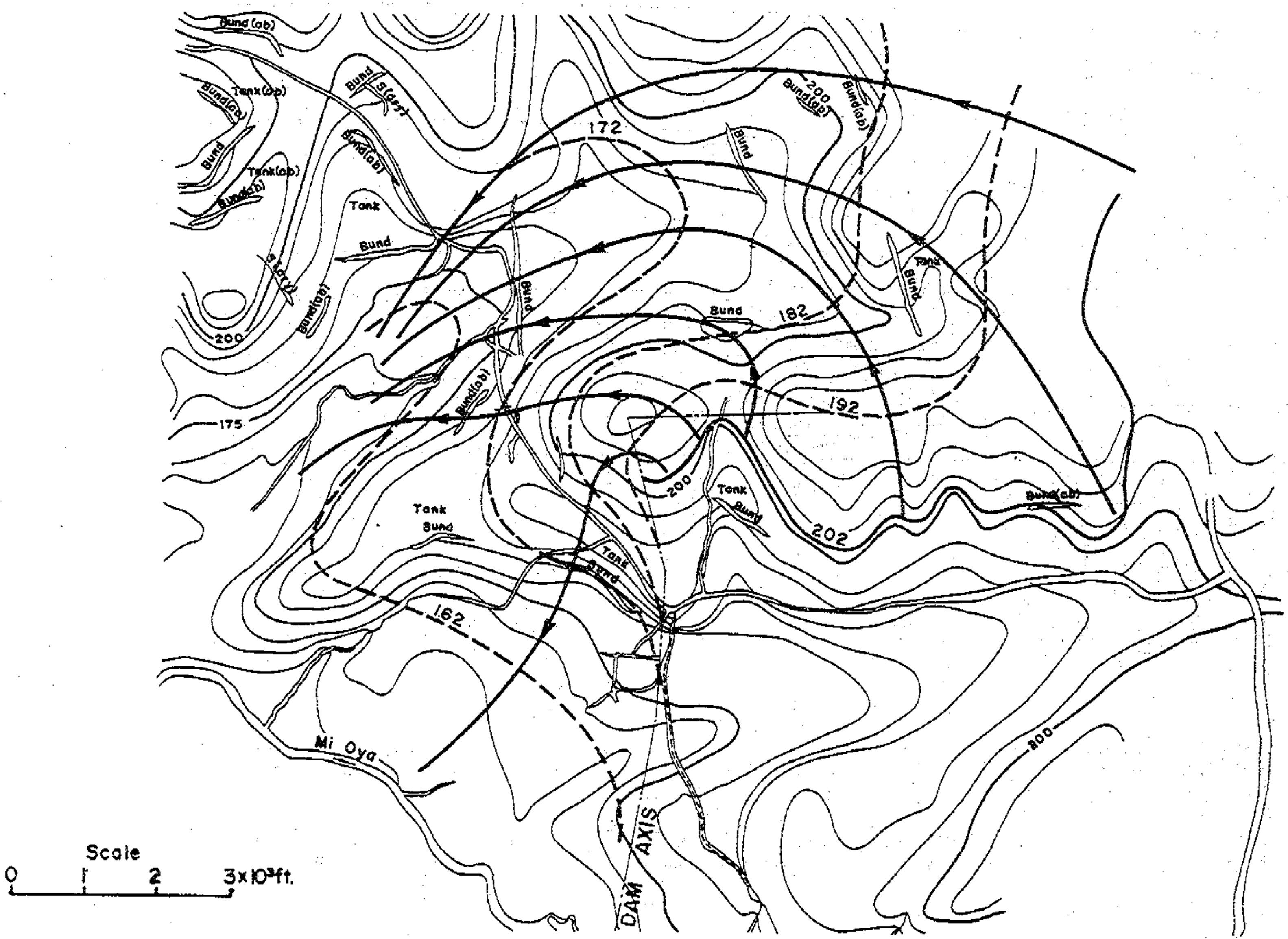
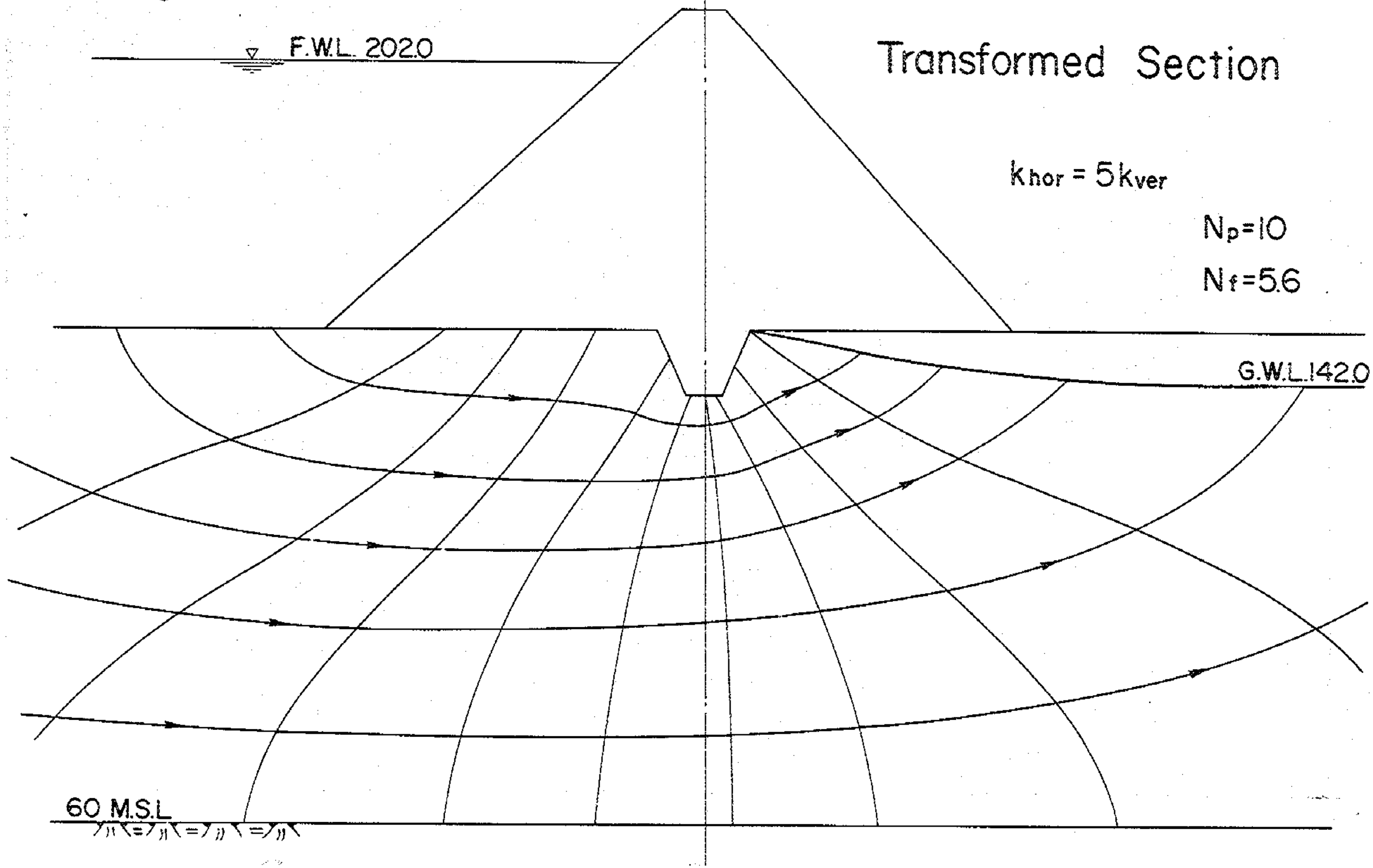


Fig. 6-18 FLOW NETS UNDER EMBANKMENT



6.6 Spillway

6.6.1 Location

Among the conditions necessary to be taken into consideration when selecting the site for spillway, the most important is the availability of proper foundation rock. From such viewpoint, the vicinity of Station No. 23 on the right bank had been proposed as the site for spillway by ID and it has been accepted as final on the ground of the engineering, the structural, and the operation/management advantages.

6.6.2 Type of Spillway

There are two broad types of the controlled and the uncontrolled. After studying (a) uncontrolled - overflow weir type, (b) uncontrolled - side channel type, (c) controlled - all gate system, and (d) controlled and uncontrolled - a combined type, the controlled type (c) has eventually been adopted. Principally speaking, the uncontrolled type would be more suitable and yet it has been rejected due to the following reasons:

(a) Spillway crest is to be longer (2,000 feet);

(b) Foundation rock is not running evenly; assuming a mountainlike shape, it is going down at two ends;

(c) Connection with tail channel requires a large-scale work;

(d) Either a bridge over the spillway or a round-about road leading from the tail channel is required for control; and

(e) Construction cost and the required facilities become very large due to the above reasons.

An alternative idea of combining a solid weir with gates has also been dropped [1/] from the undermentioned reasons.

(a) Discharge flow over the radial gate is to be avoided as a rule;

(b) The longer is the crest line, the deeper becomes the foundation rock;

1/ Data on hand on the geological conditions which are indispensable for such comparative study are unfortunately poor; the final decision as for the preference of the fully controlled type over the combined system of solid weir plus gates should be made in the detail designing stage, upon obtaining all the required data.

(c) With the width of gate being fixed at 20', the length of solid weir will be as follows, if the number of gate should be diminished by one:

Radial gate	w20 feet x h20 feet	Weir length	= 280 feet
-do-	w20 feet x h15 feet	-do-	= 196 feet

(d) Related structures, particularly the tail channel and control bridge, will become large-scaled if the combined system be adopted;

(e) The combined system requires more construction cost.

On the other hand, a fully controlled type will make obligatory the special attention and care as follows:

(a) When the spill discharge does not require full opening of one of the gates, an experienced skill is required in controlling the gate. In this case, (i) partial opening of a gate, or (ii) installation of an adjustable gate, will become necessary;

(b) Counter measures in case of unexpected breakdown of gate(s);

i) when gate(s) fail to open;

ii) when flood wood or other floating material blocks proper flow between piers even if gate opens;

iii) when gate(s) fail to close.

(c) Emergency spillway is required.

The gate system of the controlled type spillway thus requires a full and constant O & M order which is prepared to meet any one of the emergency cases as follows:

(a) Stationing of a residential engineer who is held responsible for overall water management and operation of facilities including spillway;

(b) Regular inspection and check of the gates so that they will be maintained in operational condition at all the times;

(c) Daily check of the water level and round-the-clock observation of the fluctuation of the water level after the reservoir water goes up beyond the F.W.L.;

(d) Institutional preparedness for immediate mobilization, in case of emergency, of operators and labourers who are drilled in opening and closing of the gates, demolition of the emergency spillway, and other counter-measures;

(e) Appropriate facilities to prevent the suspended materials, particularly large-sized lumbers, to approach the spillway; and

(f) Stock-piling of the necessary articles for operation of the gates.

6.6.3 Design Flood Discharge

Flood peak discharge analysis under 1.3.3: Flood Discharge in Chapter I: CLIMATE & HYDROLOGY estimated the flood peak discharges in different probabilities as follows:

Probability	Peak Discharge
1/100 years	60,100 cusec
1/200 "	65,600 "
1/1000 "	78,600 "

Among the above, 65,600 cusec in 1/200 years has been adopted as inflow design flood discharge.

The ratio between the area of water surface of Inginimitiya reservoir and its drainage area is 1:19 and the time required for the arrival of flood is considerable, hence is conspicuous the flood regulating capacity of the reservoir. The reservoir helps make the maximum outflow smaller than inflow as the inflow flood discharge will be partially and temporarily held on the fully stored water in it.

• Size of Spillway Gate

Hydrological computation with two alternative sizes (alternative 1: 20 feet x 20 feet and alternative 2: 20 feet x 15 feet) of the spillway gate has been made as per shown in Tables 6-4 to 6-7, with the maximum outflow discharges as follows:

Alternative 1: (20 feet x 20 feet) Max. Q = 50,000 cusec
Alternative 2: (20 feet x 15 feet) Max. Q = 52,000 cusec

6.6.4 Type and Scale of Spillway Gate

Among various types of the gate, the one for whose operation no power is required, or a man-handling type, is preferred. Radial gate is the one which has been extensively used in Sri Lanka. Radial gate, however, is rather weak to vibration and several years' hard use may sometimes makes its smooth operation difficult because of loosening at its fixture with weir. Therefore, a good care is required in its installation to use parts and accessories which have liberal allowances over and above the calculated capacities.

Size of the gate will be regulated by the locally available capacities in its manufacturing, transportation and operation (physical strength of the operators): the maximum width would be 20 feet and the maximum height, upto 20 feet. Although its width has been determined at 20 feet, the decision as of its height needs to be made after further studies involving, first of all, identification of the geological conditions of the spillway site in more details. Thus the final decision about the size of the gate rests on future comparative studies which take into consideration the pattern of the foundation rock layer, the quality of the gate material, the permeability, etc., in detail design stage.

There may be three alternative proposals as follows:

Alternative (Alt.)		Width of Gate	Height of Gate	No. of Gates
1		20'	20'	6
2		20'	15'	9
3	Combination of (	20'	20'	5
		20'	11'	2)

Alt-1 is proposed by ID and Alt-3 is primarily meant to solve the difficulties experienced with gate system in regulating a smaller spill discharge. However, as both Alt-1 and Alt-2 now visualize partial adoption of adjustable gate for spill discharge regulation, the Alt-3 may be ignored.

Thus, Alt-1 and Alt-2 will be compared from the hydrological, foundation, economic and O & M angles as follows:

(a) Hydrological

As has been calculated under 6.7.3, the maximum outflow discharges would be:

Alt-1. W=20' x H=20' 6 gates Max. Q = 50,000 cusec

Alt-2. W=20' x H=15' 9 " Max. Q = 52,000 cusec

The bigger discharge with Alt-2 necessitates a larger cross section of the tail channel. However, the bigger grows the depth of flow over the spillway, the greater becomes the flow capacity of Alt-2 and thus the safety against flood increases when Alt-2 is adopted.

(b) Foundation rock

According to the available data, Alt-1 is safter and more dependable.

(c) Construction cost

Alt-2 is more costly, including a slightly costlier construction cost of its spillway tail channel, as per Table 6-8 below:

Table 6-8 Cost of the Spillway

Item	Unit	Alt-1.(20'x20'=6 Nos.)			Alt-2.(20'x15'=9 Nos.)		
		Q'ty	Cost	Amount (Rs.000)	Q'ty	Cost	Amount (Rs.'000)
Earth excavation	Cubes	25,500	40	1,020	30,600	40	1,224
Rock "	"	25,800	100	2,580	28,380	100	2,838
Concrete works	"	2,500	1,100	2,750	2,700	1,100	2,970
Radial gate	sq.ft	2,400	1,540	3,696	2,700	1,750	4,725
Total				10,046			11,757

(d) Operation & Maintenance

Alt-2 is easier and, though each two adjustable gates will be equipped in both cases, Alt-2 will be manageable with comparatively more severeness.

Table 6-4   Discharge over an ogee crest (A.L.T.-1)

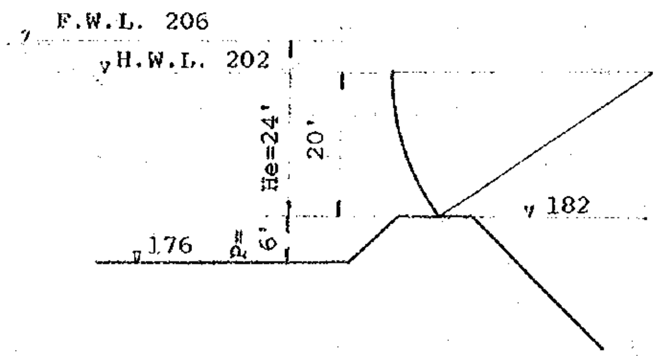
$$Q = CLHe^{3/2}$$

where: Q = discharge,

C = a variable coefficient of discharge,

L = effective length of crest, and

H = total head on the crest.



Gates: 6 Nos - 20' x 20' High

Discharge over an uncontrolled overflow ogee crest

(1) Reservoir elevation	(2) He (ft)	(3) He/Ho	(4) C/Co	(5) Ci	(6) ℓ (ft)	(7) $He^{\frac{3}{2}}$	(8) $q=Ci\ell He^{\frac{3}{2}}$ (cfs/gate.)	(9) Q=q x 6 (cfs)
202	20	0.83	0.978	3.64	19.20	89.44	6,251	37,510
203	21	0.88	0.985	3.66	19.16	96.23	6,748	40,490
204	22	0.92	0.990	3.68	19.12	103.19	7,261	43,570
205	23	0.96	0.995	3.70	19.08	110.30	7,787	46,720
206	24	1.00	1.00	(5)' 3.72	19.04	117.58	8,328	49,970
207	25	1.04	1.005	3.74	19.00	125.00	8,883	53,300

Note: (2) The approach losses are small. So they can be neglected in this case.

(4) Use of figure 190 (Design of Samll Dam, page 276)

(5)' From figure 189, the value of Co for a P/Ho value of 0.23 is 3.61. Next, from figure 191, the ratio of Cinclined/Cvertical for a 1:1 upstream slope is 1.031. Then, Ci=3.61 x 1.031=3.72.

(6) Effective length of crest of a gate (ℓ)=20.0 - 0.04He

Table 6-5 Flood Routing Computations (ALT-1)

(1) Time, hours	(2) Δt hours	(3) Average rate of inflow Q² for Δt, second-feet	(4) Average inflow acre-feet	(5) Trial reservoir Storage elevation end of Δt	(6) Average rate of outflow Qo. second-feet	(7) Average outflow for Δt. acre-feet	(8) Incremental storage ΔS, acre-feet	(9) Total storage, Acre-feet	(10) Reservoir elevation end of Δt	(11) Remarks
0										
3	3	234	59	202.0	234	59	0	53,000	202.0	
6	3	725	181	202.0	725	181	0	53,000	202.0	
10	4	1,966	655	202.0	1,966	655	0	53,000	202.0	
15	5	5,436	2,264	202.0	5,436	2,264	0	53,000	202.0	
20	5	14,461	6,025	202.0	14,461	6,025	0	53,000	202.0	
25'	5	34,800	14,500	202.0	34,800	14,500	0	53,000	202.0	
27	2	57,325	9,554	202.4	38,700	6,450	3,104	56,104	202.6	Low
				202.5	39.000	6,500	3,054	56,054	202.6	Low
				202.6	39,300	6,550	3,004	56,004	202.6	OK
29	2	60,662	10,110	203,5	42,030	7,005	3,105	59,109	203.3	High
				203.3	41,410	6,902	3,208	59,212	203.3	OK
30	1	64,073	5,339	203.6	42,340	3,528	1,811	61,023	203.7	Low
				203.7	42,650	3,554	1,785	60,997	203.7	OK
31	1	65,236	5,436	204.1	43,890	3,657	1,779	62,776	204.2	Low
				204.2	44,200	3,683	1,753	62,750	204.2	OK
32	1	65,675	5,473	204,6	45,460	3,788	1,685	64,435	204.6	OK
33	1	65,325	5,443	204.9	46,405	3,867	1,576	66,011	204.9	OK
34	1	64,275	5,356	205.2	47,070	3,923	1,433	67,444	205.2	OK
35	1	62,750	5,230	205.4	48,020	4,002	1,228	68,672	205.4	OK
36	1	61,133	5,094	205.6	48,670	4,056	1,038	69,710	205.6	OK
37	1	58,958	4,913	205.8	49.320	4,110	803	70,513	205.8	OK
38	1	56,125	4,677	206.0	49,970	4,164	513	71,026	205.9	High
				205.9	49,645	4,137	540	71,053	205.9	OK
39	1	53,144	4.428	206.0	49,970	4,164	264	71,317	205.9	High
				205.9	49,645	4,137	291	71,344	205.9	OK
40	1	50,269	4,189	205.9	49,645	4,137	52	71,396	205.9	OK
41	1	47,550	3,962	205.9	49,645	4,137	-175	71,221	205.9	OK
42	1	44,850	3,737	205.9	49,645	4,137	-400	70,821	205.8	High
				205.8	49,320	4,110	-373	70,848	205.8	OK
45	3	38,833	9,708	205.4	48,020	12,405	-2,297	68,551	205.4	OK
48	3	31,200	7,800	204.6	45,460	11,365	-3,565	64,986	204.7	Low
				204.7	45,775	11,444	-3,644	64,907	204.7	OK

Note: Column (4) = Column (3) x Column (2) ÷ 12 (1 second-feet for 12 hours = 1 acre-feet)

Column (10) corresponding to storage in column (9) from figure "Reservoir capacity curve".

Table 6-6 Discharge over an ogee crest (A.L.T. -2)

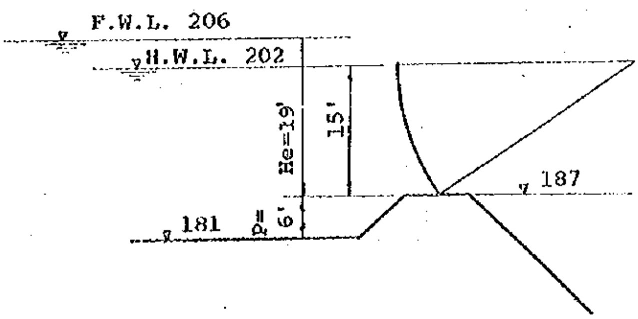
$$Q = CLHe^{3/2}$$

where: Q = discharge,

C = a variable coefficient of discharge,

L = effective length of crest, and

H = total head on the crest.



Gates: 9 Nos - 20' x 15' High

Discharge over an uncontrolled overflow ogee crest

(1) Reservoir elevation	(2) He (ft)	(3) He/Ho	(4) C/Co	(5) Ci	(6) ℓ (ft)	(7) $He^{\frac{3}{2}}$	(8) $q = Ci\ell He^{\frac{3}{2}}$ (cfs/gate.)	(9) Q=q x 9 (cfs)
202	15	0.79	0.972	3.67	19.40	58.09	4,136	37,220
203	16	0.84	0.979	3.70	19.36	64.00	4,584	41,260
204	17	0.89	0.986	3.73	19.32	70.09	5,051	45,460
205	18	0.95	0.993	3.76	19.28	76.37	5,522	49,700
206	19	1.00	1.00	(5) 3.78	19.24	82.82	6,023	54,210
207	20	1.05	1.006	3.80	19.20	89.44	6,526	58,730

Note: (2) The approach losses are small. So they can be neglected in this case.

(4) Use of figure 190 (Design of Samll Dam, page 276)

(5)' From figure 189, the value of Co for a P/Ho value of 0.32 is 3.70. Next, from figure 191, the ratio of Cinclined/Cvertical for a 1:1 upstream slope is 1.023. Then, Ci=3.70 x 1.023=3.78.

(6) Effective length of crest of a gate (ℓ)=20.0 - 0.04He

Table 6-7 Flood Routing Computations (20' x 15' gates 9 Nos.) (ALT-2)

(1) Time, hours	(2) Δt hours	(3) Average rate of inflow Q^2 for Δt, second-feet	(4) Average inflow acre-feet	(5) Trial reservoir Storage elevation end of Δt	(6) Average rate of outflow Qo. second-feet	(7) Average outflow for Δt. acre-feet	(8) Incremental storage ΔS, acre-feet	(9) Total storage, acre-feet	(10) Reservoir elevation end of Δt	(11) Remarks
0										
3	3	234	59	202.0	234	59	0	53,000	202.0	
6	3	725	181	202.0	725	181	0	53,000	202.0	
10	4	1,966	655	202.0	1,966	655	0	53,000	202.0	
15	5	5,436	2,264	202.0	5,436	2,264	0	53,000	202.0	
20	5	14,461	6,025	202.0	14,461	6,025	0	53,000	202.0	
25'	5	34,800	14,500	202.0	34,800	14,500	0	53,000	202.0	
27	2	57,325	9,554	202.5	39,240	6,540	3,014	56,014	202.6	Low
				202.6	39,644	6,607	2,947	55,947	202.6	OK
29	2	60,662	10,110	203.2	42,100	7,017	3,093	59,040	203.3	Low
				203.3	42,520	7,087	3,023	58,970	203.3	OK
30	1'	64,073	5,339	203.6	43,780	3,648	1,691	60,661	203.7	Low
				203.7	44,200	3,683	1,656	60,626	203.7	OK
31	1	65,236	5,436	204.1	45,884	3,824	1,612	62,238	204.1	OK
32	1	65,675	5,473	204.4	47,156	3,930	1,543	63,781	204.4	OK
33	1	65,325	5,443	204.7	48,428	4,036	1,407	65,188	204.7	OK
34	1	64,275	5,356	205.0	49,700	4,142	1,214	66,402	205.0	OK
35	1	62,750	5,230	205.2	50,602	4,217	1,013	67,415	205.2	OK
36	1	61,133	5,094	205.4	51,504	4,292	802	68,217	205.4	OK
37	1	58,958	4,913	205.5	51,955	4,330	583	68,800	205.5	OK
38	1	56,125	4,677	205.6	52,406	4,367	310	69,110	205.5	High
				205.5	51,955	4,330	347	69,147	205.5	OK
39	1	53,144	4.428	205.6	52,406	4,367	61	69,208	205.5	High
				205.5	51,965	4,330	98	69,245	205.5	OK
40	1	50,269	4,189	205.5	51,955	4,330	-141	69,104	205.5	OK
41	1	47,550	3,962	205.5	51,955	4,330	-368	68,736	205.4	OK
42	1	44,850	3,737	205.4	51,504	4,292	-555	68,219	205.3	High
				205.3	51,053	4,254	-517	68,257	205.3	OK
45	3	38,833	9,708	204.8	48,852	12,213	-2,505	65,752	204.8	OK
48	3	31,200	7,800	204.0	45,460	11,365	-3,565	62,187	204.0	OK

Note: Column (4) = Column (3) x Column (2) : 12 (1 second-feet for 12 hours = 1 acre-feet)

Column (10) corresponding to storage in column (9) from figure "Reservoir capacity curve".

Fig. 6-19 SPILLWAY DISCHAGE CURVE

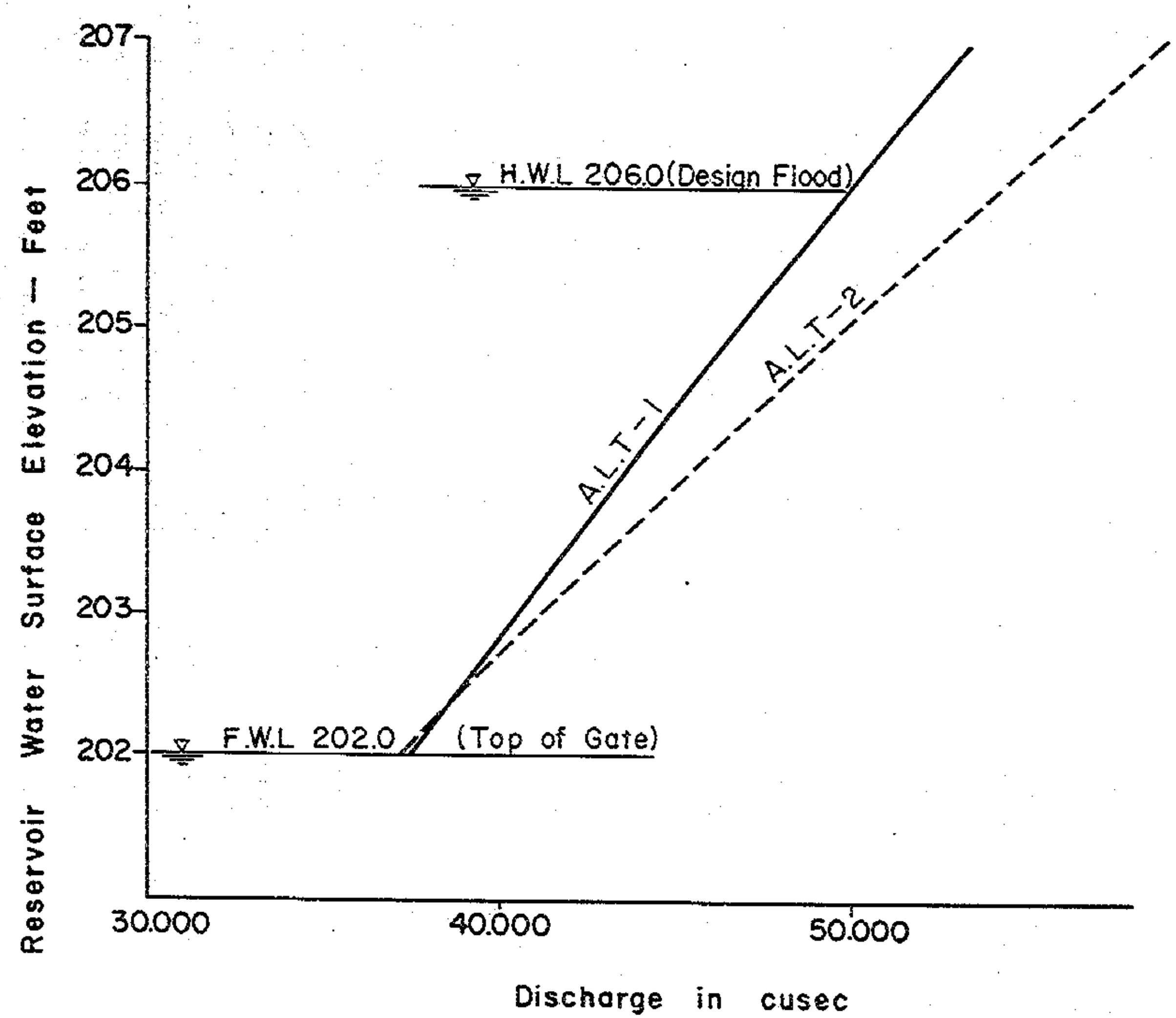
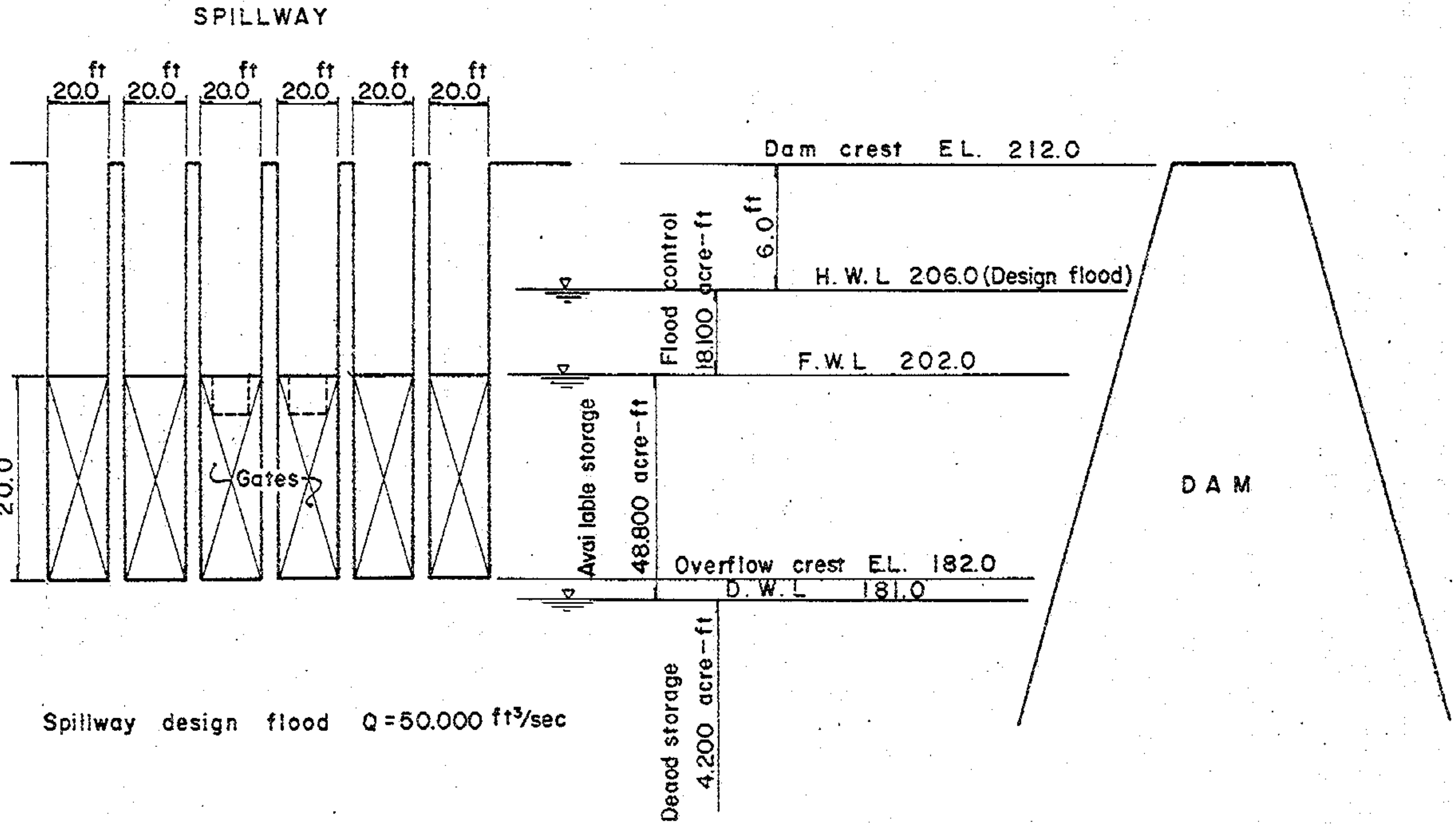


Fig. 6-20 WATER STAGE AND STORAGE CAPACITY OF RESERVOIR



Although the Alternative-2 proves to be more advantageous through the above comparative sutdy, Alternative-1 which is strongly supported by ID is tentatively adopted for design, pending on the further studies and final decision in the detail design stage.

6.6.5 Cross Section of the Spillway

As discussed in the above paragraph, radial gates (W=20'x H=20') in 6 Nos. will be adopted and 2 out of 6 gates will be equipped with adjustable gates. Water Stage and Storage Capacity of Reservoir according to this plan is shown in Fig. 6-20.

6.6.6 Emergency Spillway

Provision of an emergency spillway is designed due to the following reasons:

(a) The main spillway is designed with a fully controllable gate system and proper spill discharge may happen to be jeopardized either due to the mechanical breakdown of the gate(s) or jamming by the flood woods, etc.;

(b) The fluctuation of precipitation and the gap between the maximum and the minimum rainfall is extremely big, and the historical records of the past rainfall alone would not warrant the safety of the dam.

The emergency spillway is located on the right bank for the distance of about 800 feet, 1 foot below the dam crest line.

6.7 Spillway Tail Channel Section

6.7.1 Flood Water Level of the Mi-Oya

The water level of the Mi-Oya when 50,000 cusec of the design flood discharge of the spillway flows down has been sought by calculating the uniform flows at two points: the one at the confluence of the Tail Channel with the Mi-Oya (Section A-A) and the other, about 1.5 miles (7,800 feet) downstream of Section A-A which forms a bottleneck for the flow from the topographical reasons. The Mi-Oya's cross section is shown in Fig. 6-21, and H-Q rating curve of Mi-Oya is shown in Fig. 6-22. If the gradient of the spillway tail channel is designed at 1/1000, the maximum spillway tail water level would not rise higher than 175 feet MSL. As the design spillway crest elevation is made at 182 feet MSL, the possible back water of the Mi-Oya should not affect the spillway.

6.7.2 Tail Channel Section

Upon completion of the reservoir, the discharge over the spillway will take place only during Maha season of an exceptionally heavy rainfall. To meet with a wide fluctuation of the discharge between the normal year and the flood year, it has been designed as a double section channel. The design cross-sections which are shown in Fig. 6-3 have been arrived at by considering the following conditions:

(a) Spillway design flood discharge is 50,000 cusec;

(b) The present river channel of the Mi-Oya annually overfloods; the present width of the river-bed, that is, about 100 feet will be maintained;

(c) The Mi-Oya's river-bed in the vicinity of its confluence with the Tail Channel is 10 ~ 15 feet below the river side elevation;

(d) Coefficient of roughness (n) is:

low-water channel	n = 0.03
high-water channel	n = 0.05

(e) Average flow speed along the low-water channel = less than 10 feet/sec.

The flow capacity of the design low-water channel is 12,500 cusec. The total design length is 6,460 feet.

Fig. 6-21 Mi Oya cross section

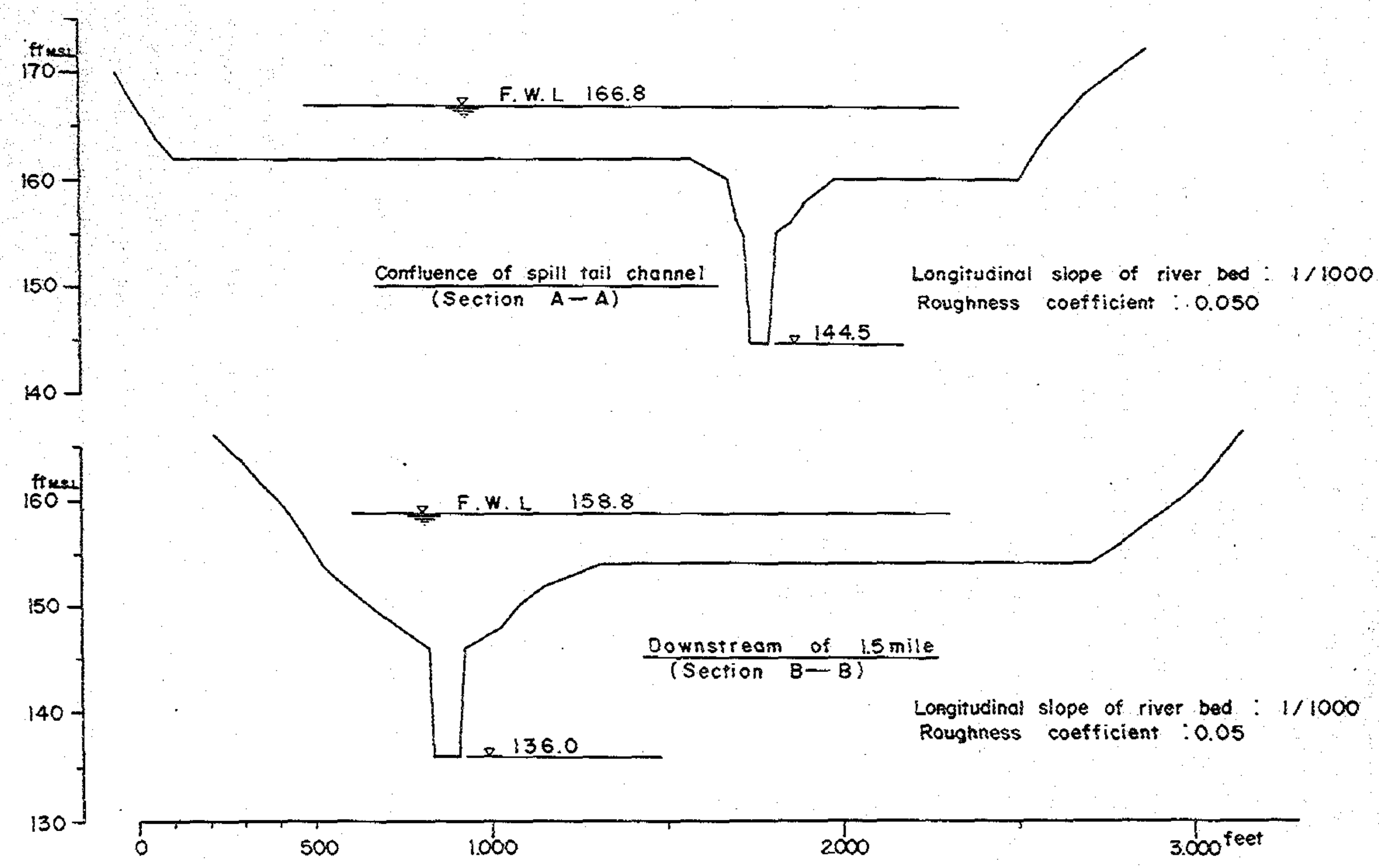


Fig. 6-22 Rating curve at Mi Oya

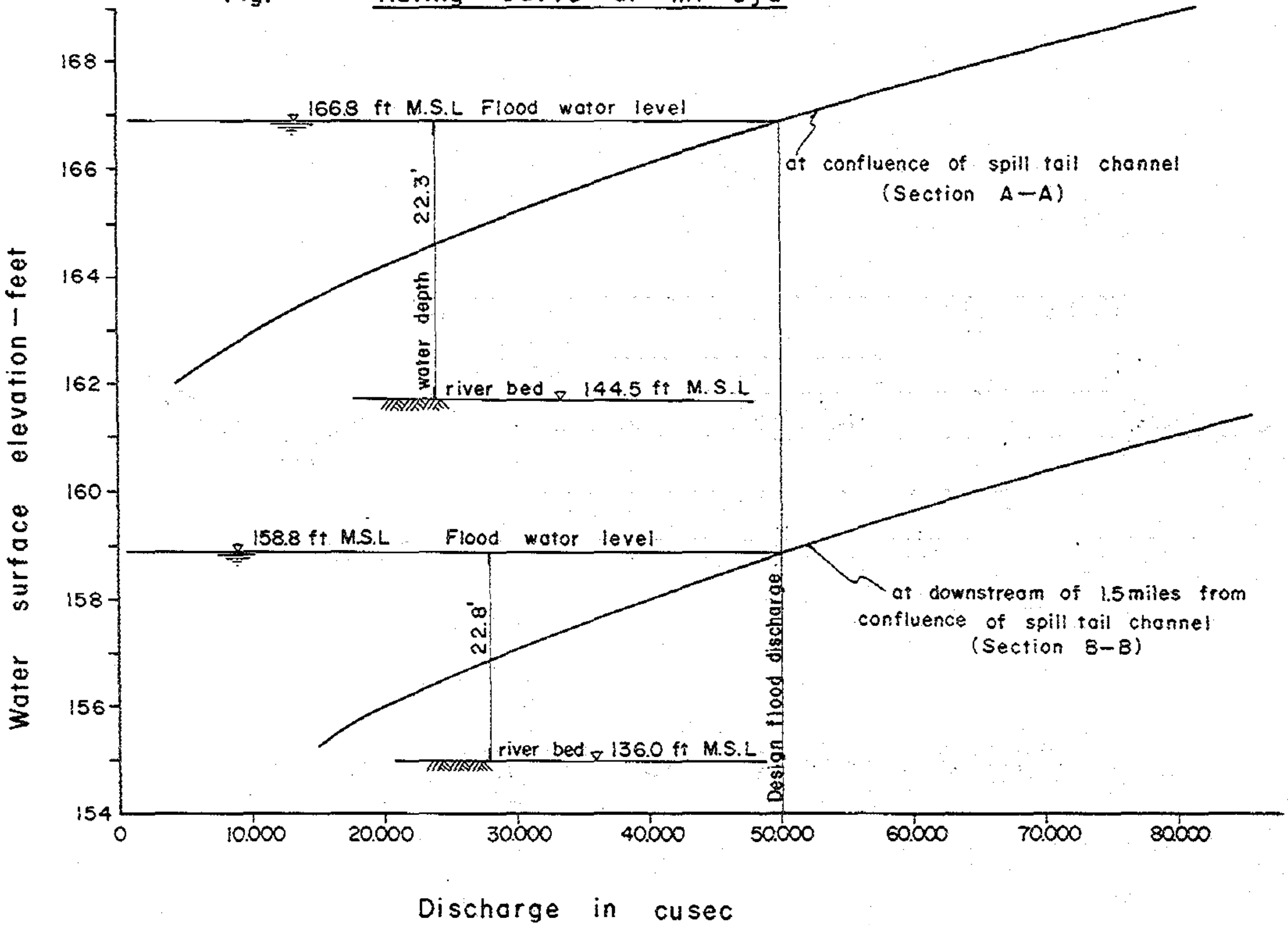
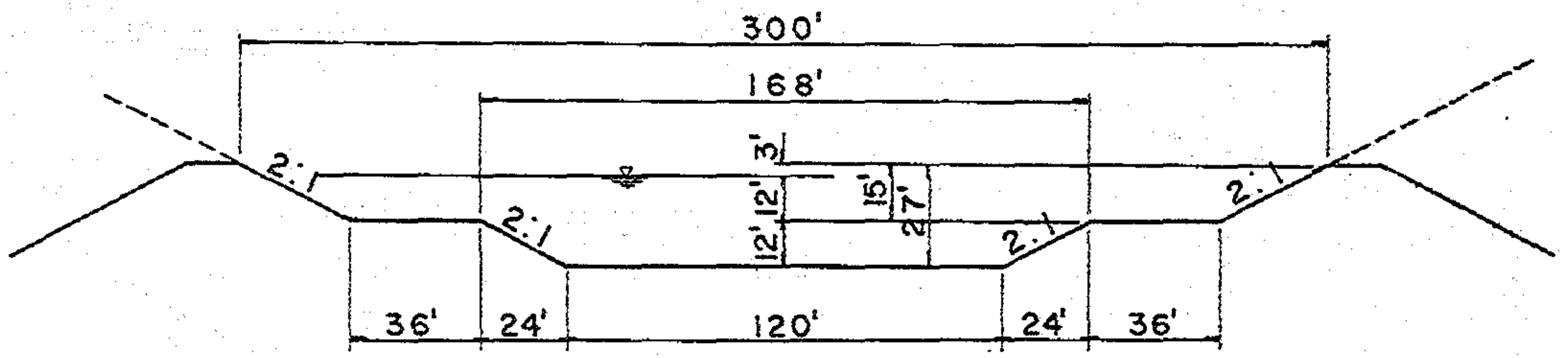


Fig. 6-23 Spillway Tail Channel Section



6.8 Intake Facilities

Tower-type sluice will be provided on both banks, and their sill level is 181 MSL.

6.8.1 Location

The elevation of the foundation rock is 180 MSL on the left bank, and the sluice will be built at the place where it is easily connectable to the main canal. The right bank sluice will be built adjacent to the spillway being connected with the intake tower by headrace which runs from the spillway approaching canal.

6.8.2 Structure

Intake, as specified below, will be regulated by operating the slide gate:

	Irrigable Area	Discharge
Right bank outlet	2,300 acres	61.0 cusecs
Left bank outlet	4,000 acres	105.0 cusecs

6.9 Coffer Dam

Coffer dam is built on the upstream of the embankment and its construction takes place during July. The height of its crest is so designed as to hold the maximum gross discharge for three months of July through September during the last 20 years. Crest height is fixed at 184 MSL from H-Q curve; the crest width, 10 feet; and the up/downstream slope, 1:2.5.

VII IRRIGATION FACILITIES

The irrigable area totalling 6,300 acres can be divided into the left bank (4,000 acres) and the right bank (2,300 acres); in each area a main canal, the related structures, the lateral channels and the farm facilities (farm ditches, farm drainages, farm roads, etc.) are planned.

7.1 Main Canal

7.1.1 Route of Main Canal

The selection of the main canal routes has been made through the field exploratory surveys and they are drawn tentatively on the 4-chain and 8-chain maps; as parts of these topographical maps are incomplete, the routes drawn on them are not final ones requiring reconfirmation after additional surveying: minor alterations of the main canal routes may become necessary. The main canal routes have been selected by paying due attention to the following points:

(i) To select straight course, as far as possible, to shorten the distance;

(ii) To balance the volume of excavation and embankment to minimize the earth work cost; and

(iii) To maintain the highest water level to facilitate for gravity irrigation.

7.1.2 Canal Type and Design Discharge

The main canal type is the open earth canal which is economically justifiable. The maximum water requirement (see Table 5-7) for the entire irrigable area has been allocated among both banks according to the size of their command areas, with the following discharges:

Left bank	Q = 105 cusecs
Right bank	Q = 61 cusecs

7.1.3 Cross Section and Length

The main canal cross-section has been decided by the following calculations, and the maximum flow speed has been regulated less than 2 feet/second to prevent wash-out of its slopes:

(a) Feedboard

$F = (1 + d/4)$

where, F : Freeboard

d : hydraulic depth

(b) Inside slope

1:1.5

(c) Bank width

Width of the bank has been designed at 5 m so as to make it accessible to motor vehicles meant for operation and maintenance purposes, while that of its opposite bank, 2.5m.

(d) Flow formula:

The manning formula is generally used for open channel flow in calculating its discharge, as follows:

$Q : A \cdot V$

$V : \frac{1}{n} R\ 2/3\ I\ 1/2$

where, Q : Design discharge

A : Cross sectional area

V : Velocity of water

n : Roughness coefficient

R : Hydraulic radius

I : Slope of the water surface and channel bottom

Left Bank Canal will have 4 types and the right bank canal, 3 types; the bank width has been fixed at 16.6 feet on the Project area side and 8.3 feet on the opposite side; the Project area side bank is meant for operation and maintenance purposes. Canal Network is shown in Fig. 7-1, and the cross sectional calculations as per Table 7-1.

• Particulars of the Main Canal

Canal	Type	Discharge (cusec)	Length (mile)
L.B. Canal	1	105.0	3.0
	2	79.0	4.0
	3	45.1	3.0
	4	14.6	3.3
Total			13.3
R.B. Canal	1	61.0	7.0
	2	38.2	6.0
	3	14.3	3.2
Total			16.2

7.2 Related Structures

Crossings (aqueducts, culverts, bridges, etc.) over the streams, drainage channels, and roads, and water management facilities such as turnouts, check-gates and water measurement facilities are planned. Among the crossings, aqueducts will be preferred to siphons as far as possible.

Fig. 7-1

Canal Network and Discharge Assignment

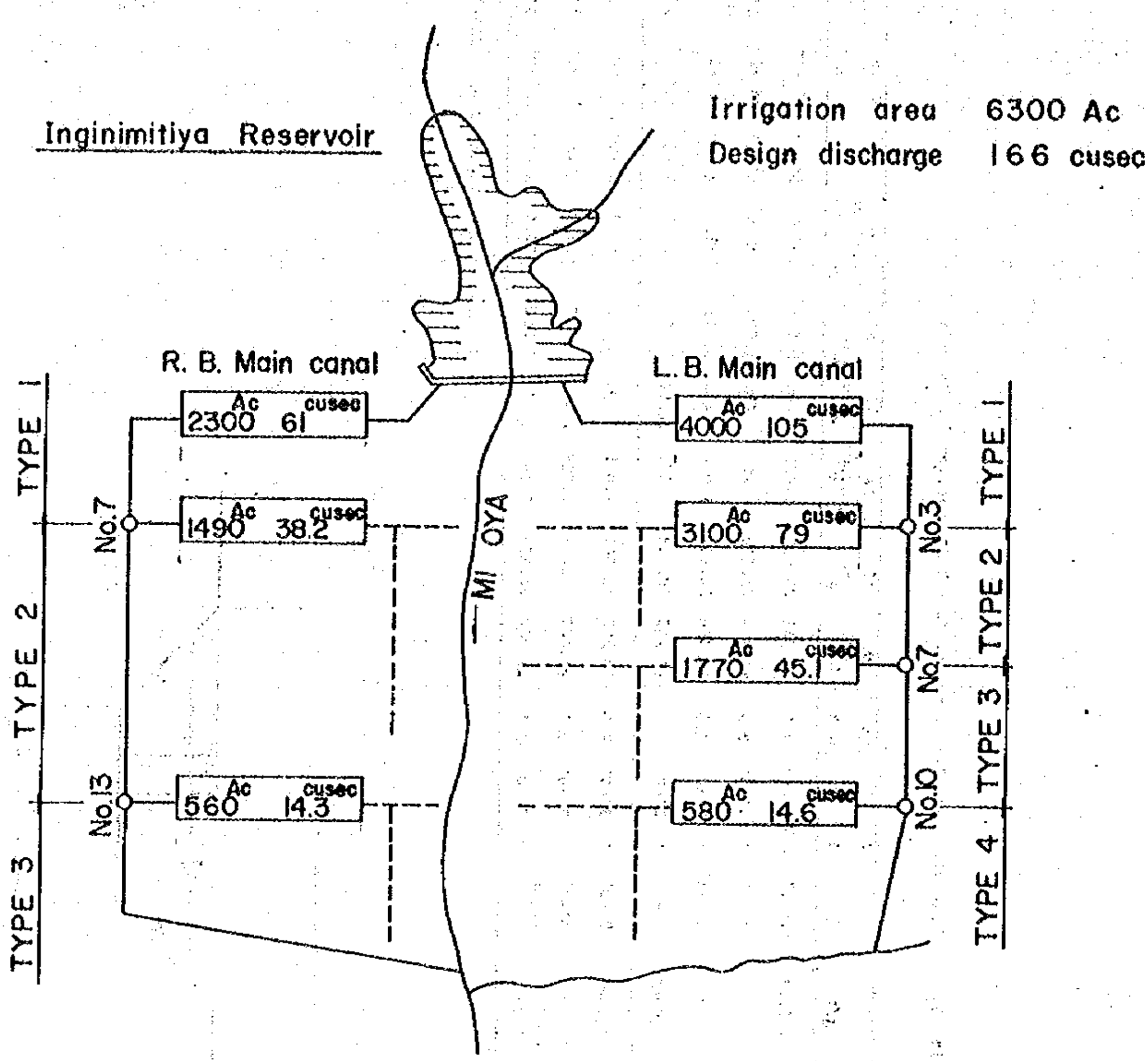
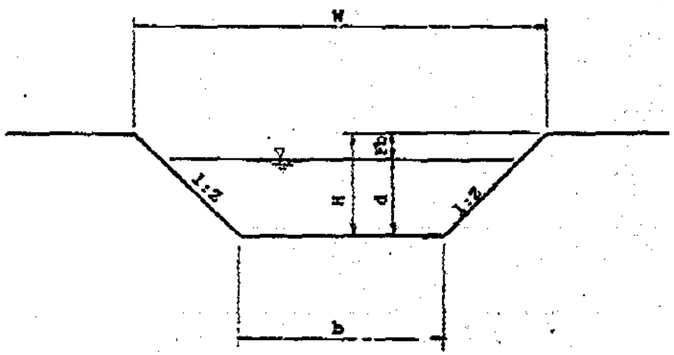


Table 7-1 Hydroulic Calculation of Standard Cross Section for Main Canal

	Type	1 Qd cuft/s	2 I	3 n	4 $\frac{1}{n}\sqrt{I}$	5 b	6 z	7 d	8 b/d	9 A ft^2	10 P ft	11 R(=$\frac{A}{P}$) ft	12 $R^{2/3}$	13 V ft/s	14 cuft/s Qc(=A.V)	15 H	16 W	17 Fb	18 *L
Left Bank Main Canal	1	105.0	1/3500	0.0168	1.0061	11'-4"	1.5	3'-6"	3.2	58.041	23.952	2.423	1.804	1.815	105.4	5'-5"	27'-7"	1'-11"	3.0
	2	79.0	"	"	"	9'-6"	"	3'-3"	2.9	46.719	21.218	2.202	1.692	1.703	79.6	5'-1"	24'-9"	1'-10"	4.0
	3	45.1	"	"	"	6'-11"	"	2'-9"	2.5	30.366	16.832	1.804	1.482	1.491	45.3	4'-5"	20'-2"	1'-8"	3.0
	4	14.6	1/3000	"	1.0868	3'-1"	"	2'-0"	1.5	12.166	10.294	1.182	1.118	1.215	14.8	3'-6"	13'-7"	1'-6"	3.3
Right Bank Main Canal	1	61.0	1/3500	"	1.0061	8'-3"	"	3'-0"	2.8	38.250	19.067	2.006	1.591	1.600	61.2	4'-9"	22'-6"	1'-9"	7.0
	2	38.2	"	"	"	6'-0"	"	2'-8"	2.3	26.667	15.615	1.708	1.429	1.437	38.3	4'-4"	19'-0"	1'-8"	6.0
	3	14.3	1/3000	"	1.0868	3'-0"	"	2'-0"	1.5	12.000	10.211	1.175	1.114	1.210	14.5	3'-6"	13'-6"	1'-6"	3.2

* L: Length of Main Canal (Miles)



VIII LAND CONSOLIDATION

Except the existing paddyfields and the hamlets scattering around them, the Project area is generally covered by jungles of medium-density which would not cause special difficulties in clearing. The area for land consolidation can be divided into (a) mild slope (s = 1/50), and (b) flat openings (s = 1/300 ~ 1/500) spreading on both banks of the Mi-Oya.

8.1 Blocking of the Reclaimed Land

The standard size for each liyadde will be 1/4 acre, if topography permits. However, field sizes may be varied in order to achieve efficient use of farm machinery and good water management. The farmland allocated to each family will be 2.5 acres, measuring 310 feet by 70 feet.

8.2 Laterals and Farm Road Network

Irrigation and drainage laterals are provided independently per family farm. For efficient water use, however, the drainage laterals will be connected to irrigation laterals in the downstream to enable repeated use of water. Farm roads lead from the settlers' villages to their farms, running along the irrigation channels to make water management easier.

• Particulars of the Network

Farm road	Width	:	13 feet
	Elevation	:	1 foot or more
	Longitidinal slope	:	upto 12%
Laterals	Type	:	open ditch
	Cross section	:	Trapezoid section allowing peak discharges for both irrigation and drainage
	Slope	:	1 : 1

8.3 Land Consolidation

Land levelling of the paddyfield will be maintained within ±2 inches, and the gradient of the field surface will be either horizontal or a little inclined toward drainage lateral.

8.4 Model Farm

A model farm will be established between Galkulama Tank and the Mi-Oya in the vicinity of R.B. Canal No. 12. It will cover 220 acres to be managed by 88 settlers' families.

IX CONSTRUCTION PROGARMME

9.1 Overall Plan

9.1.1 Basic Considerations

The basic considerations for the Project implementation are as follows:

(1) Workable Days

280 working days a year is feasible proposition judging from the daily rainfall data in the past; the work will be done on two shifts in a day.

(2) Construction Peirod

The construction will take full five years, following the detail design work which would be completed within 8 months.

9.1.2 Dam Body

Prior to the commencement of dam construction work, it is necessary to complete the access roads, field office, accommodation facilities for the staff, motor pool, stores and depots for construction equipment and materials. Jungle clearing at the dam-site and the borrow areas comes first, then comes the excavation of the surface soil at dam-axis, to be followed by digging of trenches. The excavated soils (the spoil) are to be used for embankment either on the upstream side or the downstream side according to their nature.

As and when trenches will have been dug, embankment work of the dam-body will be commenced by using the spoil from the spillway tail channel and/or the material obtainable from the borrow areas. The toe drain and horizontal drain on the downstream side need to be completed before embankment. When the embankment work will have reached 1/2 of the dam height, riprap will be built on the upstream slope; the remainder will be worked upon after the completion of the embankment work. Turfing will be effected on both the upstream and downstream slopes after dam-body will assume the regulated shape.

The construction work will proceed on both banks of the Mi-Oya and completed except about 500 feet of the Mi-Oya's river-bed. The closing of the Mi-Oya takes place in the last stage, during the dry months of July to September. The dam will be completed after construction of a coffer dam on its upstream; the coffer dam will remain where it would have been built.

9.1.3 Spillway and Laterals

Excavation work at spillway site will start after the surface soil at the dam-site will have been removed; rock cutting at the spillway site will follow. Excavation and embankment of the laterals can be undertaken simultaneously with the above work; the surplus spoil will be utilized as embankment material for dam-body.

Concrete pitching starts as soon as rock will have been cut at the spillway site and then attachment of radial gates will follow.

9.1.4 Outlet Facilities

Simultaneously with excavation at the dam-site, that at the sites for tower sluices and box culverts will take place, to be followed by their concrete works at the lower part of the tower sluices and the box culverts. The upper part of the tower sluices and the connecting bridge will be completed after fulll embankment of the dam. Provision of headrace channel and excavation of the foundation rock is required for completion of the right bank outlet facilities.

9.1.5 Irrigation Facilities

Excavation and embankment work will start according to the specified cross-sections after jungle-clearing is over, from the upstream side. Careful compaction is required at the embankment portion to avoid seepage or crumbling down.

9.1.6 Land Development

Land development work will proceed by the order of: jungle-clearing - land levelling - removal of debris - road construction - lateral construction - border construction - levelling of the field surface and blocking of the farm. Jungle-clearing work is limited to 4,660 acres of the newly reclaimed land.

To maintain the best working conditions all through the construction period, a particular attention needs to be paid to construction and maintenance of the appropriate drainage facilities to treat the inflow water from outside the Project area and to quickly remove the rainwater falling inside the Project area.

9.2 Selection of Construction Machinery

The combination of the construction machinery has been so arranged that the daily work duty can be fulfilled within the given construction period. Machinery-wise duty and the combination of machinery set for execution of each item of the construction work are given on Tables 9-1∿9-3.

Construction machinery and vehicles generally fall in the same categories as proposed by ID but a minor alteration has been made in their size and number. The working hour of each machinery per work item has been estimated as per Table 9-1; the net working hour has been fixed at 80% 8 hours/day. Deployment of construction machinery and vehicles will follow the Schedule as given in Table 9-2. The number of machinery has been calculated from the sets of machinery combined for execution of each item of the construction work, and the machinery will shift from one item of the construction work to another according to the Schedule.

The machinery deployment programme has been worked out from the viewpoint of full and continuous use of the given numbers with no surplus machinery on waiting list; the number and specifications of the construction machinery and vehicles required during each year of the construction period have been stipulated in Table 9-3; extra number of the machinery which will be required for specific duty or duties and replacement of those expiring their workable life (10,000 hrs) are given in parenthesis: these denote the kinds and number to be additionally imported.

9.3 Construction Schedule

Schedule on which the above mentioned construction programme shall be implemented is given in Fig. 9-1.

Table 9 - 1 Operation Time of Equipment

Works / Quantities or Equipment	Quantities	Unit	Cl. 1 Tractor	Cl. 2 Tractor		Cl. 8 Tractor		Motor Scraper	Motor Grader	Excavation	Air Compresser	Jack Hammer	Shovel Loader	Euclid Rear Damp	Crusher	Water Bowser	Concrete Mixer	Farm Tractor	Lorry Tipper	Notes
			Dozer	Dozer	S.F. Roller	Roller Dozer	Scraper													
					2.9^t-5.5^t	N = 3	12 m^3	11 m^3 210 x 2^{PS}	2.2 m 53^{PS}	0.6 m^3 100^{PS}	m^3/min 10.5 105 kg	m^3/min 3.4 39 kg	1.2 m^3 70^{PS}	15^t 210^{PS}	50 t/k 75^{PS}		0.3 m^3 5.5^{PS}	5^t	4^t 100^{PS}	
Item 1. Acquisition Access and Road Deviation																				
1. Jungle Clearing in the Access Roads	24	Acres	124																	
2. Embankment	11,900	Cubes					264		219											
3. Bedding Material (gravel)	2,800	"									722	1,443	307	2,333	397	219			1,261	
Item 2. Dam Body																				
1. Jungle Clearing in Dam Area	55	Acres	285																	
2. Jungle Clearing in Borrow Area	141	"	731																	
3. Stripping 24" Top Soil for Filling Dam	42,800	Cubes	3,741																	
4. Stripping 12" Top Soil in the Borrow Area	61,000	"	5,332																	
5. Excavation Common in Core Trenches and Spoil to Waste	14,700	"	543	631			639													
6. Excavation Common in Core Trenches and for the Dam	34,400	"			1,026	1,139		1,274	633							633				
7. Earth Work in Formation of Dam from Borrow Area	249,300	"			7,433	8,258		25,310	4,588							4,588				
8. Riprap Protection for U/S Slope of Dam (rock)	13,800	"									3,557	7,113	1,515	11,500						
9. Riprap Protection for U/S Slope of Dam(gravel)	6,900	"											757	5,750	977					
10. Toe Filter with Sans, Gravel Metal and Rubble for Dam	24,000	"									3,067	6,134	1,306	9,917	850				5,450(sand) 2,703(gravel)	sand 12,100 gravel 6,000 rock 5,900
11. Coffer Damming Dealing with Water, etc.	7,100	"			212	235		721	131							131				
Item 3. Spillway																				
1. Earth Excavation in Foundation	25,500	Cubes	942				877													
2. Loose Rock Excavation in Foundation	25,800	"									6,650	13,299	2,832	6,247						
3. Cement Concrete with Nominal Reinforcement, etc.	concrete 2,500	"													199		1,773		631	gravel 2,500 × $\frac{4}{7}$ = 1,400
4. Earthwork in Spill Tail Channel (spoil to waste)	74,800	"	2,633				2,574													
5. Earthwork in Spill Tail Channel (for the dam)	109,300	"			3,259	3,620		11,096	2,011							2,011				
6. Earthwork in Spill Tail Channel (training fund)	34,500	"	1,676		1,029		1,187		635							635				
Item 4. Sluice (Outlet Works)																				
1. Construction of L.B. Sluices	concrete 120	Cubes													10		85		31	
2. Construction of R.B. Sluices	80	"													7		57		21	
Item 5. Irrigation Facilities																				
1. Earthwork in L.B. Main Channel	33,000	Cubes	472	1,146	984		513		607	808						607			1,011	Jungle Clearing 91 Acres
2. Earthwork in R.B. Main Channel	36,800	"	544	1,280	1,097		573		677	897						677			1,124	Jungle Clearing 105 Acres
3. Construction of Distributory Channel, Field Channel, etc.																				
Item 6. Land Development																				
1. Jungle Clearing	4,660	Acres	24,145																	
2. Land Levelling	6,300	"				18,584														
3. Ripping and Cross Ripping	6,300	"																23,162		
Total			41,168	3,057	15,040	31,836	6,627	38,401	9,501	1,705	13,996	27,987	6,717	35,747	2,440	9,501	1,315	23,162	12,232	

Table 9 - 2 Progressive Schedule of Equipment

	Schedule (1st Year – 6th Year) / Equipment	Remarks
Item 1. ACQUISITION ACCESS and ROAD DEVIATIONS	6 M	
1. Jungle Clearing in the Access Roads	1T.D(1)	
2. Embankment	ST.S(1), M.G(1), W.B(1)	
3. Bedding Material (gravel)	A.C(1), J.H(2), S.L(1), E.R.D(3), Cr(1), L.T(2)	
Item 2. DAM BODY	30 M	
1. Jungle Clearing in Dam Area	1T.D(2)	
2. Jungle Clearing in Borrow Area	1T.D(1)	
3. Stripping 24" Top Soil for Filling Dam	1T.D(3)	
4. Stripping 12" Top Soil in the Borrow Area	1T.D(2)	
5. Excavation Common in Core Trenches and Spoil to Waste	1T.D(1), ST.S(1), 2T.D(1)	
6. Excavation Common in Core Trenches and for the Dam	ST.R(2), M.S(2), M.G(2), 2T.S.R(2), W.B(2)	
7. Earth Sork in Formation of Dam From Borrow Area	S.T.R(2), M.S(6), M.G(2), 2T.S.R(2), W.B(2)	
8. Riprap Protection for U/S Slope of Dam (rock)	A.C(2), J.H.(4), S.L(1), E.R.D(5)	
9. Riprap Protection for U/S Slope of Dam (gravel)	S.L(1), E.R.D(3)	
10. Toe Filter with Sand Gravel Metal and Rubble for Dam	A.C(3), J.H(6), S.L(1), E.R.D(8), Cr(1), L.T(3)	
11. Coffer Damming, Dealing with Water, etc.	including 7	
Item 3. SPILLWAY	18 M	
1. Earth Excavation in Foundation	1T.D(2), ST.S(2)	
2. Louse Rock Excavation in Foundation	A.C(4), J.H(8), S.L(2), E.R.D(4)	
3. Cement Concrete with Nominal Reinforcement, etc.	Cr(1), L.T(1), C.M(2)	
4. Earthwork in Spillway Tail Channel (spoil to waste)	1T.D(2), ST.S(2)	
5. Earthwork in Spillway Tail Channel (for the dam)	ST.R(2), M.S(6), M.G(2), 2T.S.R(2), W.B(2)	
6. Earthwork in Spillway Tail Channel (training bunds)	1T.D(1), ST.S(1), M.G(1), 2T.S.R(1), W.B(1)	
Item 4. SLUICES (outlet works)	11 M	
1. Construction of L.B. Sluices	Cr(1), L.T(1), C.M(1)	
2. Construction of R.B. Sluices		
Item 5. IRRIGATION FACILITIES	39 M	
1. L.B. Main Channel	J/C E/W 1T.D(1), 2T.D(1), ST.S(1), Exc(1), L.T(1) M.G(1), 2T.S.R(1), W.B(1)	
2. R.B. Main Channel	J/C E/W 1T.D(1), 2T.D(1), ST.S(1), Exc(1) L.T(1), M.G(1), 2T.S.R(1), W.B(1)	
3. Construction of Distributory Channel, Field Channel, etc.		
Item 6. LAND DEVELOPMENT	45 M	
1. Jungle Clearing	1T.D(5)	
2. Land Levelling	ST.R(4)	
3. Ripping and Cross Ripping	F.T(3)	4th Year 23% 1,450 Acres

Remarks:

1T.D	;	Cl.1 Tractor will Dozer
2T.D	;	Cl.2 Tractor with Dozer
2T.S.R	;	Cl.2 Tractor with Sheep Foot Roller
ST.R	;	Cl.S Tractor with Rooter
ST.S	;	Cl.S Tractor with Scraper
M.S	;	Motor Scraper
M.G	;	Motor Grader
Exc	;	Excavator
S.L	;	Shovel Loader
E.R.D	;	Euclid Rear Damp
L.T	;	Lorry Tipper
A.C	;	Air Compresser
J.H	;	Jack Hammer
Cr	;	Crusher
W.B	;	Water Bowser
C.M	;	Concrete Mixer
F.T	;	Farm Tractor

Table 9-3 Machinery Programme

Equipment & Machinery	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	Notes
Cℓ.1 Tractor (21^t, 180∿$200^{p.s.}$)	0	4	(5)	5	0	0	
Dozer ($4,265^B$ x $1,013^H$mm)	0	4	(5)	5	0	0	Cℓ.1 Tractor
Cℓ.2 Tractor (15^t, $130^{p.s.}$)	0	3	(4)	4	0	0	
Dozer (3,825 x 923 mm)	0	(1)	1	1	0	0	Cℓ.2 Tractor
Cℓ. S Tractor (32^t, $300^{p.s.}$)	0	(4)	4	4	4	1	
Dozer (4,065 x 1,360 mm)	0	2	3	(4)	4	1	Cℓ.S Tractor
Rooter (N=3)	0	2	3	(4)	4	1	"
Scraper (12 m^3)	0	(2)	2	1	0	0	"
Moter Scraper (11 m^3)	0	2	(6)	6	0	0	
Sheep foot roller (2.9∿5.6^t)	0	2	(3)	3	0	0	Cℓ.2 Tractor
Moter grader (B=2.2m, 53Hp)	0	2	(3)	3	0	0	
Excavator (1.2m^3, $145^{p.s.}$)	0	0	(1)	1	0	0	
Lorry Tipper (4^t, $100^{p.s.}$)	0	6	(7)	2	0	0	
Compresser	0	3	(4)	2	0	0	
Jack Hammer	0	6	(8)	4	0	0	
Shovel Loader (1.2m^3, $70^{p.s.}$)	0	1	(2)	2	0	0	
Euclid Rear Damp (15^t, $210^{p.s.}$)	0	(8)	8	8	0	0	
Crusher (50∿90t/hr, $75^{p.s.}$)	0	(1)	1	1	0	0	
Pump	0	0	(4)	4	4	0	
Water Bowser	0	2	(3)	3	0	0	
Fuel Bowser	0	(2)	2	2	2	1	
Jeep	0	(4)	4	4	4	4	
Concrete Mixer (0.3m^3, $5.5^{p.s.}$)	0	0	(2)	2	0	0	
Farm Tractor (5^t)	0	0	0	(3)	3	3	
Disk harrow (24" x 20)	0	0	0	(3)	3	3	offset type

(   ) Max Nos

Fig. 9-1 Proposed Construction Schedule

Work	Item	Unit	Quantity	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
Designs & Specifications		Item	1						
Procurement of Machinery		Item	1						
Acquisition Access & Road Deviations		Item	1						
Dam Body	Jungle Clearing	Acres	196						
	Stripping	Cubes	103,800						
	Excavation	Cubes	49,100						
	Embankment	Cubes	249,300						
	Riprap	Cubes	20,700						
Spillway & Tail Channel	Excavation	Cubes	244,100						
	Rock Excavation	Cubes	25,800						
	Concrete	Cubes	2,500						
	Radial Gate	sq.ft	2,400						
Outlet Works	L.B. Sluices Concrete Works	Cubes	120						
	R.B. Sluices Concrete Works	Cubes	80						
Irrigation Distributory System	L.B. Main Canal Jungle Clearing	Acres	91						
	L.B. Main Canal Earth Works	Cubes	33,000						
	R.B. Main Canal Jungle Clearing	Acres	105						
	R.B. Main Canal Earth Works	Cubes	36,800						
	Distributory & Field Channel	Acres	6,300						
Land Development	Jungle Clearing	Acres	4,660						
	Land Leveling	"	6,300						
	Ripping & Cross Ripping	"	6,300						
Land Settlement	Settlement of Colonists	Acres	6,300						
Land Acquistion		Item	1						

X CONSTRUCTION COST

10.1 Construction Cost Whose Foreign Exchange Portion Consists of Both "Direct" and "Indirect" Foreign Exchange Components

From the original cost estimation made by ID on job basis have been isolated the land acquisition cost, construction machinery cost, repairs and maintenance cost of the machinery and price contingency has been added. As a result, the sum-total of the construction cost has experienced a considerable rise to Rs144,952,000 (US$19,911,000 @US$1.00 = Rs7.28) which is made up of Rs66,819,000 (US$9,178,500) in foreign currency and Rs78,133,000 (US$10,733,000) in local currency. The details of the construction cost is given in Table 10-1.

10.2 Alternative Construction Cost Estimates Allocating Some "Indirect" Foreign Exchange Component(s) to the Local Currency Portion

Alternative A: Fuel Cost being allocated to Local Currency Portion As shown in Table 10-4.

Alternative B: Fuel, Cement, Steel & Spillway Gates Costs being allocated to Local Currency Portion
As shown in Table 10-5.

10.3 Unit Cost

The unit cost used for calculating the construction cost has primarily been taken from the "Evaluation of Unit Prices and Rate Analysis" which is the standard document adopted by Sri Lanka Government. The unit cost given in this document, however, includes the depreciations and spare parts of the construction machinery and vehicles. Therefore, machinery and their spare parts have been isolated from them and put together under a cost item of "Construction Machinery." The unit costs which are not covered by the said standards have been computed from the similar lists and tables.

10.4 Machinery Cost

Necessary kinds of construction machinery and vehicles have been determined for each item of the construction work and their number has been estimated from the viewpoint of full and continuous use all through the construction period according to the Construction Schedule shown in Fig. 9-1. Their life times have been determined according to ID's standard. Their prices are given in cif. Colombo, plus local handling charges rated at 8% of the machinery price. Depreciation cost has been computed by the following formula:

$$\text{Depreciation Cost} = \text{Unit price} \times \frac{\text{unused life time}}{\text{total life time}}$$

$$\text{Spare parts and overhaul} = (\text{cif Colombo} + \text{Local handling Charges}) \times 25\%$$

Apart from the construction machinery cost, costs for the labour of repairs and the maintenance and general supervision have been calculated at 25% and 8%, respectively, according to Sri Lanka standards.

10.5 Physical Contingencies

10.5% of the civil works cost has been computed as the physical contingencies.

10.6 Price Contingencies

"Evaluation of Unit Prices and Rate Analysis" quoted in the above specifies the inflation rate (1969-73) of 6.7% as applicable to the construction works (irrigation, highways, water supply, etc.). The Price contingencies have, therefore, been calculated assuming this rate for the initial year and the incremental rates for the ensuing years as follows:

	Year					
	1978	1979	1980	1981	1982	1983
Inflation Rate (%)	6.7	13.8	21.4	29.5	38.2	47.4

Price contingencies have been calculated for each year of the construction period excepting for land acquisition and land settlement.

Table 10-1 Cost Estimate (Financial)

(Unit 1,000 Rs)

Item	Total	Foreign	Local
I. Civil Works	59,300	16,740	42,560
Access & Road deviations	500	69	431
Dam structure	9,000	2,534	6,466
Spillway & Tail channel	12,000	3,874	8,126
Outlet works	900	313	587
Irrigation facilities	20,600	7,107	13,493
Land development	7,000	2,843	4,157
Repairs & Maintenance of machinery	9,300	-	9,300
II. Construction Machinery	35,600	33,500	2,100
III. Land Acquisition	1,000	-	1,000
IV. Land Settlement	5,300	2,650	2,650
Sub Total (I ∿ IV)	101,200	52,890	48,310
V. Engineering, Administration & Overhead Charge	10,000	1,500	8,500
VI. Physical Contingency (I) x 10%	5,930	1,674	4,256
Sub Total (I ∿ VI)	117,130	56,064	61,066
VII. Prices Contingency (I + II + V + VI) x 25%	27,822	10,755	17,067
Total	144,952	66,819	78,133

Table 10-2 Cost Estimate (1)

Description	Units	Quantities	Rate	Total Amount	Foreign Rate	Foreign Cost	Local Rate	Local Cost	Unit Cost No.
			(Rs.)	(1,000Rs)	(Rs.)	(1,000Rs)	(Rs.)	(1,000Rs)	
Item 1. Access and Road Deviations				500		69.2		430.8	
Jungle clearing in the access road	Acres	24	263	6.3	83	2.0	180	4.3	1
Embankment	Cubes	11,900	2.6	30.9	0.8	9.5	1.8	21.4	2
Bedding material (gravel)	"	2,800	53	148.4	15	42.0	38	106.4	3
Others	Item	1	Sum	314.4		15.7		298.7	
Item 2. Dam body				9,000		2,533.9		6,466.1	
Jungle clearing in the dam area	Acres	55	263	14.5	83	4.6	180	9.9	1
Jungle clearing in the borrow area	"	141	263	37.1	83	11.7	180	25.4	1
Stripping 24" top soil for filling of dam	Cubes	42,800	4.4	188.3	1.4	59.9	3.0	128.4	4
Stripping 12" top soil in the borrow area	"	61,000	4.4	268.4	1.4	85.4	3.0	183.0	4
Excavation common in the core trenches and spoil to waste	"	14,700	7.3	107.3	2.3	33.8	5.0	73.5	5
Excavation common in the core trenches and spoil for the dam	"	34,400	8.1	278.6	2.6	89.4	5.5	189.2	6
Earthwork in for mation of dam from borrow area	"	249,300	11.2	2,792.2	3.6	897.5	7.6	1,894.7	7
Earthwork in formation of dam form spillway tail channel	"	109,300	-	-	-	-	-	-	
Riprap protection for U/S slope of dam(rock)	"	13,800	122	1,683.6	37	510.6	85	1,173.0	8
Riprap bedding material (gravel)	"	6,900	73	524.4	11	75.9	65	448.5	9
Toe filter with sand	"	12,100	45	544.5	1.5	18.2	43.5	526.3	10
" gravel	"	6,000	125	750.0	37	222.0	88	528.0	11
" rock	"	5,900	111	654.9	34	200.6	77	454.3	12
Turfing slopes of dam	"	5,700	20	114.0	-	-	20	114.0	13
Coffer dam	"	7,100	11.2	79.5	3.6	25.6	7.6	53.9	7
Dealing with water and others	Item	1	Sum	962.7		298.7		664.0	

Cost Estimate (2) Continued

Description	Units	Quantities	Rate	Total Amount	Foreign Rate	Foreign Cost	Local Rate	Local Cost	Unit Cost No.
			(Rs.)	(1,000Rs)	(Rs)	(1,000Rs)	(Rs)	(1,000Rs)	
Item 3. Spillway & Tail Channel				12,000		3,873.5		8,126.5	
Earth excavation in foundation	Cubes	25,500	4.5	114.8	1.5	38.3	3.0	76.5	14
Loose rock excavation	"	25,800	79	2,038.2	29	748.2	50	1,290.0	15
Concrete with nominal reinforcement etc.	"	2,500	1,059	2,647.5	188	470.0	871	2,177.5	16
Earthwork in spill tail channel (to waste)	"	74,800	6.3	471.2	2	149.6	4.3	321.6	17
" (for the dam)	"	109,300	11.2	1,224.2	3.6	393.5	7.6	830.7	7
" (training bund)	"	34,500	10	345.0	3.2	110.4	6.8	234.6	18
Radial gate (20' x 20 6Nos)	sq-ft	2,400	1,540	3,696.0		1,478.4		2,217.6	
Grout	ft	680	200	136.0		54.4		81.6	
Other (reserve of gate etc.)	Item	1	Sum	1,327.1		418.7		908.4	
Item 4. Sluices (Outlet works)				900		312.9		587.1	
Construction of L.B sluice (concrete works)	Cubes	120	1,067	128.0	190	22.7	877	105.3	19
" others	Item	1	Sum	372.0		149.0		223.0	
Construction of R.B sluice (concrete works)	Cubes	80	1,067	85.4	190	15.3	877	70.1	19
" others	Item	1	Sum	314.6		125.9		188.7	
Item 5. Irrigation Facilities				20,600		7,107.2		13,492.8	
Cost of 13.3 miles of L.B main canal									
" jungle clearing	Acres	91	263	23.9	83	7.5	180	16.4	1
" earthwork (1)	Cubes	23,100	9.8	226.4	3.1	71.6	6.7	154.8	20
" " (2)	"	9,900	14.3	141.6	4.1	40.6	10.2	101.0	21
" lelated structures	Item	1	Sum	1,332.7		799.6		533.1	
Cost of 16.2 miles of L.B main canal									
" jungle clearing	Acres	105	263	27.6	83	8.7	180	18.9	1

Cost Estimate (3) Continued

Description	Units	Quantities	Rate (Rs)	Total Amount (1,000Rs)	Foreign Rate (Rs)	Foreign Cost (1,000Rs)	Local Rate (Rs)	Local Cost (1,000Rs)	Unit Cost No.
Cost of 16.2 miles of earthwork (1)	Cubes	25,800	9.8	252.8	3.1	80.0	6.7	172.8	20
" Earthwork (2)	"	11,000	14.3	157.3	4.1	45.1	10.2	112.2	21
" Lelated structures	Item	1	sum	1,742.7		1,045.6		697.1	
Construction of distributory channels	Acres	6,300	900	5,670.0		1,701.0		3,969.0	
" Field channels	"	6,300	1,500	9,450.0		2,835.0		6,615.0	
" drainage channels	"	6,300	250	1,575.0		472.5		1,102.5	
Item 6. Land Development				7,000		2,842.9		4,157.1	
Jungle clearing (New Land)	Acres	4,660	263	1,225.6	83	386.8	180	838.8	1
Land leveling	"	6,300	217	1,367.1	74	466.2	143	900.9	22
Ripping and cross ripping	"	6,300	49	308.7	15	94.5	34	214.2	23
Border, Tidying up and unforeseen expenses	Item	1	sum	4,098.6		1,895.4		2,203.2	
Item 7. Repairs & Maintenance of Machinery				9,300	-	-		9,300	
Repairs (Machinery cost x 25%)	Item			7,100.0	-	-		7,100.0	
Maintenancy and general supervision (Machinery cost x 25%)	"			2,200.0	-	-		2,200.0	
Sub Total (Item 1 ∿ 7)				59,300		16,739.6 ≒16,740		42,560.4 ≒42,560	
Item 8. Construction Machinery				35,600		33,500		2,100	
Machinery cost (C.I.F. + Local Handling)	Item	1	sum	28,500.0		26,400.0		2,100.0	
Overhaul & spares (Machinery x 25%)	"	1	"	7,100.0		7,100.0		-	
Item 9. Land Acquisition	Item	1	sum	1,000		-		1,000	

Cost Estimate (4) Continued

Description	Units	Quantities	Rate	Total Amount	Foreign Rate	Foreign Cost	Local Rate	Local Cost	Unit Cost No.
			(Rs)	(1,000Rs)	(Rs)	(1,000Rs)	(Rs)	(1,000Rs)	
Item 10. Land Settlement				5,300		2,650		2,650	
Settlement of colonists	Acres	6,300	400	2,520.0		1,260.0		1,260.0	
Social infrastructure	"	6,300	430	2,709.0		1,354.5		1,354.5	
Others	Item	1		71.0		35.5		35.5	
Sub Total (I∿10)				101,200		52,890		48,310	
Item 11. Engineering, Administration & Overhead Charge		1	sum	10,000		1,500		8,500	
Item 12. Physical Contingency (Item 1∿7) x 10%	Item	1	sum	5,930		1,674		4,256	
Sub Total (Item 1∿12)				117,130		56,064		61,066	
Item 13. Prices Contingency (Item 1∿8.11.12) x 24.8%	Item	1	sum	27,822		10,755		17,067	
Total				144,952		66,819		78,133	

Table 10-3 Annual Disbursement of Financial Cost

Unit Rs.1,000

Works	Total	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
I. Civil Works	59,300	-	2,010	14,000	18,170	15,050	10,070
Foreign Currency	16,740	-	600	3,560	5,030	4,610	2,940
Local Currency	42,560	-	1,410	10,440	13,140	10,440	7,130
II. Construction Machinery	35,600	-	35,600	-	-	-	-
Foreign Currency	33,500	-	33,500	-	-	-	-
Local Currency	2,100	-	2,100	-	-	-	-
III. Land Acquisition	1,000	1,000	-	-	-	-	-
Foreign Currency	-	-	-	-	-	-	-
Local Currency	1,000	1,000	-	-	-	-	-
IV. Land Settlement	5,300	-	-	1,760	1,780	1,760	
Foreign Currency	2,650	-	-	880	890	880	
Local Currency	2,650	-	-	880	890	880	
V. Engineering, Administration & Overhead Charge	10,000	5,000	1,000	1,000	1,000	1,000	1,000
Foreign Currency	1,500	1,500	-	-	-	-	-
Local Currency	8,500	3,500	1,000	1,000	1,000	1,000	1,000
VI. Physical Contingency	5,930	-	201	1,400	1,817	1,505	1,007
Foreign Currency	1,674	-	60	356	503	461	294
Local Currency	4,256	-	141	1,044	1,314	1,044	713
Sub Total (I + II + V + IV)	110,830	5,000	38,811	16,400	20,987	17,555	12,077
Foreign Currency	53,414	1,500	34,160	3,916	5,533	5,071	3,234
Local Currency	57,416	3,500	4,651	12,484	15,454	12,484	8,843
VI. Prices Contingency	27,822	335	5,356	3,510	6,191	6,706	5,724
Foreign Currency	10,755	101	4,714	838	1,632	1,937	1,533
Local Currency	17,067	234	642	2,672	4,559	4,769	4,191
Total	144,952	6,335	44,167	21,670	28,958	26,021	17,801
Foreign Currency	66,819	1,601	38,874	5,634	8,055	7,888	4,767
Local Currency	78,133	4,734	5,293	16,036	20,903	18,133	13,034

Table 10-4 Alternative Construction Cost Estimate (A)

(Fuel cost being allocated to Local Currency portion)

(unit: '000 Rs.)

	Item	Total	Foreign	Local
I	Civil works	59,300	7,140	52,160
	Access & Road deviations	500	-	500
	Dam structure	9,000	669	8,331
	Spillway & Tail channel	12,000	2,834	9,166
	Outlet works	900	155	745
	Irrigation facilities	20,600	2 839	17,761
	Land development	7,000	643	6,357
	Repairs & Maintenance of Machinery	9,300	-	9,300
II	Construction Macninery	35,600	33,500	2,100
III	Land Acquisition	1,000	-	1,000
IV	Land Settlement	5,300	1,450	3,850
	Sub Total (I ∿ IV)	101,200	42,090	59,110
V	Engineering, Administration & Overhead charge	10,000	1,500	8,500
VI	Physical Constingency (I) x 10%	5,930	714	5,216
	Sub Total (I ∿ VI)	117,130	44,304	72,826
VII	Prices Contingency (I+II+V+VI) x 25%	27,822	8,506	19,316
	Total	144,952	52,810	92,142

Table 10-5 Alternative Construction Cost Estimate (B)[1/]

(Unit: 1,000 Rs)

Item		Total	Foreign	Local
I.	Civil Works	59,300	2,590	56,710
	Access & Road diviations	500	-	500
	Dam structure	9,000	669	8,331
	Spillway & Tail channel	12,000	700	11,300
	Outlet works	900	-	900
	Irrigation facilities	20,600	678	19,922
	Land development	7,000	543	6,457
	Repairs & Maintenance of machinery	9,300	-	9,300
II.	Construction Machinery	35,600	33,500	2,100
	Sub-total (I ~ II)	94,900	36,090	58,810
III.	Land Acquisition	1,000	-	1,000
IV.	Land Settlement	5,300	-	5,300
	Sub-total (I ~ IV)	101,200	36,090	65,110
V.	Engineering, Administration & Overhead Charges	10,000	1,500	8,500
VI.	Physical Contingencies (I) x 10%	5,930	259	5,671
	Sub-total (I ~ VI)	117,130	37,849	79,281
VII.	Price Contingencies (I+II + V + VI) x 25%	27,822	5,600	22,222
	Total	144,952	43,449	101,503

1/ In this Construction Cost Estimate, such "indirect" foreign exchange components as fuels, cement, steel, spillway gates, etc. are allocated to the local currency portion.

Table 10-6 Unit Cost

Item No.	Work	Unit	Quantity	Total Unit Price	Local Currency Portion	Foreign Currency Portion
1	Jungle clearing (medium)	Ac	1	263.00	180.00	83.00
2	Embankment	Cu	1	2.60	1.80	0.80
3	Bedding Material (gravel)	"	1	53.00	38.00	15.00
4	Stripping of top soil (12",24" depth)	"	1	4.40	3.00	1.40
5	Excavation common in the core trenches and and spoil to waste	"	1	7.30	5.00	2.30
6	Excavation common in the core trenches for the dam	"	1	8.10	5.50	2.60
7	Earthwork in formation of dam from borrow area	"	1	11.20	7.60	3.60
8	Riprap protection for U/S slope of dam (rock)	"	1	122.00	85.00	37.00
9	Riprap protection for U/S slope of dam (gravel)	"	1	76.00	65.00	11.00
10	Toe filter with sand gravel metal and rubble for dam (sand)	"	1	45.00	43.00	1.50
11	Toe filter with sand gravel metal and rubble for dam (gravel)	"	1	75.00	38.00	37.00
12	Toe filter with sand gravel metal and rubble for dam (rock)	"	1	111.00	77.00	34.00
13	Turfing slopes of dam	Sq	100	20.00	20.00	-
14	Earth excavation in foundation	Cu	1	4.50	3.00	1.50
15	Loose rock excavation in foundation	"	1	79.00	50.00	29.00

Item No.	Work	Unit	Quantity	Total Unit Price	Local Currency Portion	Foreign Currency Portion
16	Cement concrete with nominal reinforcement etc.	Cu	1	1,059.00	871.00	188.00
17	Earthwork in spill tail channel (spoil to waste)	"	1	6.30	4.30	2.00
18	Earthwork in spill tail channel (traning bunds)	"	1	10.00	6.80	3.20
19	Construction of L.B. sluices (concrete works)	"	1	1,067.00	877.00	190.00
20	L.B. main channel (earthwork 1)	"	1	9.80	6.70	3.10
21	L.B. main channel (earthwork 2)	"	1	14.30	10.20	4.10
22	Land leveling	"	1	217.00	143.00	74.00
23	Ripping and cross ripping	Ac	1	49.00	34.00	15.00

Table 10-7 Depreciation Cost of Equipment & Machinery

(Unit US$)

Equipment & Machinery	Size & Capacity	Unit	Quantity (1)	Total Price		Total Life	Used time		Depreciation cost
				Unit price(2)	Amount (3)=(1)x(2)	Time(4)	Time(5)	% (6)=(5)/(4)	(7)=(3)x(6)
(1) C.I.F. Price									
Tractor (cℓ =1)	21^t 180 200P.S		5	76,300	381,500	50,000	41,168	82.3	313,974
Dozer	4,265B x 1,013H		5	5,700	28,500	"	"	"	23,455
Tractor (cℓ =2)	15^t 130P.S		4	61,100	244,400	40,000	18,199	45.5	111,202
Dozer	3,825B x 923H		1	3,900	3,900	10,000	3,057	30.6	1,193
Sheep foot Roller	$2.9\sim5.6^t$		3	10,000	30,000	30,000	15,042	50.1	15,030
Tractor (cℓ =S)	32t $300^{P.S}$		4	139,000	556,000	40,000	38,466	96.2	534,872
Dozer	4,065B x 1,360H		4	10,000	40,000	40,000	31,838	79.6	31,840
Rooter	N=3		4	11,000	44,000	"	"	"	35,024
Scraper	$12m^3$		2	37,400	74,800	20,000	6,628	33.1	24,758
Moter Scraper	$11m^3$		6	182,000	1,092,000	60,000	38,402	64.0	698,880
Moter grader	$2.2B^m$ $65^{P.S}$		3	25,300	75,900	30,000	9,501	31.7	24,060
Excavator	$0.6m^3$ 100P.S		1	63,000	63,000	10,000	1,705	17.1	10,773
Lorry Tipper	4^t 100P.S		7	15,400	107,800	70,000	12,238	17.5	18,865
Compresser	$10.5m^2/m$ $105^{P.S}$		4	13,800	55,200	(12,000x4) 48,000	13,962	29.1	16,063
Jack Hammer	$3.4m^2/m$		8	800	6,400	(5,000x8) 40,000	27,924	69.8	4,467
Shovel Loader	$1.2m^3$ $70^{P.S}$		2	25,100	50,200	20,000	6,719	33.6	16,867
Enchid Rear Damp	15^t $210^{P.S}$		8	66,400	531,200	80,000	35,745	44.7	237,446
Crusher	$50\sim90t/h$		1	32,000	32,000	10,000	2,440	24.4	7,808
Pump	150mm		4	1,800	7,200	(5,000x4) 20,000	6,000	30.0	2,160
Water Bowser	6,000ℓ		3	17,500	52,500	30,000	9,501	31.7	16,642
Fuel Bowser	"		2	17,500	35,000	20,000	10,000	50.0	17,500
Jeep			4	6,800	27,200	40,000	40,000	100.0	27,200
Concrete Mixer	$0.28\sim0.4m^3$		2	7,600	15,200	20,000	6,000	30.0	4,560
Farm Tractor	5^t 50P.S		3	22,000	66,000	30,000	7,721	77.2	50,952
Disk harrow	24" x 20^{nos}		3	3,000	9,000	30,000	7,721	77.2	6,948
Sub Total					3,628,900				2,252,539(62%)
					=26,418,392 Rs ≒26,400,000				=16,398,483Rs ≒16,400,000
(2) Local Handling (Total price) x 8%					2,100,000 Rs				2,100,000 Rs
Total					28,500,000 Rs				18,500,000 Rs

* US$1.00 = Rs7.28

Table 10-8 Foreign Exchange Cost of the Project

Item				Amount M. Rs	D. (direct) I.D. (indirect)
1.	Cost of Machinery	79 Nos		26.40	D.
2.	Cost of Fuel	M.gal	M.Rs		
	Disesel	3.33 @Rs 3	9.99		
	Iubricant	81,000gal @Rs 10	0.81	10.80	I.D.
3.	Foreign Component of Cement and Steel				
	21,000 Cubes of Concrete for Spillway, Outlet, Main Canal & Other Structures		M.Rs		
	21,000 x 13bag/cubes x 10Rs/bag		2.73		
	Steel - allow sum		0.87	3.60	I.D.
4.	Spares for Machinery and Equipment			7.10	D.
5.	Tools, Accessories and Surveying Instruments			1.25	D.
6.	Blasting Material			1.05	D.
7.	Generators, Electrical Fittings and Other Accessories for Buildings, etc.			0.75	D.
8.	Foreign Component of Sluice (gates, l fting gear, etc)			1.270	I.D.
9.	Others Material			1.130	I.D.
10.	Engineering Service (detail design)			1.50	D.
11.	Contingency (physical)			1.67	
12.	" (prices)			10.76	
	Total			66.82	

XI ECONOMIC EVALUATION

11.1 Prices for Economic and Financial Analysis

(1) General

The future farm gate prices of agricultural outputs (paddy, soya beans, pulses and chillies) have been estimated, together with those of agricultural inputs (fertilizers, agro-chemicals, etc.) from projected 1985 world market prices in 1976 currency values, with appropriate adjustments for freight, handling and processing as well as by applying price ratio prevailing among various relevant commodities.

(2) Exchange Rate

The Sri Lanka Rupee, which was linked to a basket of currencies with the initial parity rate based on the prevailing (May 1976) Rupee/Pound rate, equated to about US$1.00 = Rs8.66 or Rs8.70 if rounded. To promote "non-traditional" exports while cutting down on non-essential imports, a dual exchange rate system through the sale and purchase of Foreign Exchange Entitlement Certificates (FEECs) was introduced by the Government. Despite this, Sri Lanka has not been able to solve severe balance of payments problems for the last several years experiencing thereby widespread shortages of essential materials, spare parts and capital equipment. Judging from these phenomena, the official exchange rate clearly understated the real value of foreign exchange to the Sri Lanka economy. Yet the official rate was recently fixed at US$1.00 = Rs7.28, but the FEECs system still continues. Under such circumstances, the Irrigation Department proposed to use double the exchange rate for economic evaluation. However, we are of the opinion that a rate of US$1.00 = Rs12.00 (equal to the current FEEC rate) seems to more reasonably reflect the value of foreign exchange to the Sri Lanka economy. Therefore, the economic analysis is based on this assumption.

(3) Crops

<u>Paddy</u>: The projected 1985 price used as a basis for economic anylysis is US$235 per metric ton of low-to-medium quality rice (25% - 35% broken) fob Bangkok. Adding shipping and insurance costs results in a projected price of US$265 per metric ton cif Colombo. By adding to this the estimated average handling, transportation and marketing costs between Colombo and the likely "deficit areas", US$300 per ton is obtained for an estimated local market price of milled rice. Assuming US$25 per ton for the costs of the marketing, processing and transportation between the farm and the urban areas close to the project, a farm gate price per ton rice equivalent is US$275. At an estimated milling yield of 65%, this is equivalent to a paddy farm gate price of about US$180. However, not unforgetful of the shortage-related prices which averaged not many years ago more than US$400 per metric ton, the economic price of paddy has been fixed at US$200.

Cultivation of soya beans, pulses and dried chillies is subsidiary to paddy production. <u>Soya Beans</u>: The economic farm gate price has been estimated at US$165 per ton. <u>Pulses</u>: Historical comparisons of rice prices with those for pulses indicate that the price ratio remains fairly stable, with pulses commanding a 50 - 70% premium over the paddy prices. A 50% premium over paddy price will make an average price of US$300 per ton for pulses. <u>Chillies</u>: US$840 per ton has been assumed as an appropriate economic farm gate price of dried chillies.

(4) Crop Inputs

<u>Fertilizers</u>: The 1985 fertilizer price per ton has been projected for different nutrients at various ports of shipment. Nitrogen nutrient (fob Persian Gulf) would be about US$350, phosphate nutrient (fob Morocco) US$470, and SU$95 for potassium nutrient (fob Vancouver). Shipping, insurance, handling and local marketing would add an average of about US$80 per ton nutrient. Accordingly, the per ton farm gate prices for the three nutrients would be US$430, US$550 and US$175, respectively. For both the commonly used basal

mixture of 3-30-13 NPK and for urea (46% N) used as top dressing, the price would be about US$200 per ton.

Agro-chemicals: Different kinds of agro-chemicals are being recommended and practically used at different prices. To save complicated estimation of their economic farm gate prices, comparison of fertilizer price with the average price of agro-chemicals particularly in terms of the gap between their market price and economic price with a result that while the gap between the market price and economic price is as big as 1:2.5 with fertilizers, that of the agro-chemicals remains inconsiderable, that is, roughly about 1:1.3 - 1.5. Therefore, the economic cost of the fertilizers and agro-chemicals combined has been computed as twice the market price.

Mechanized Farming: Farm machinery, its spare parts and fuels for its operation will need to be imported for the time being. Mechanization cost has therefore been computed as twice the market cost or rental charges.

Farm Labour: In view of the unemployment and underemployment situation prevailing in the area, the market wage rate of Rs8 per day is considered inappropriate for economic analysis. Accordingly, the economic cost of all farm labour is assumed to be one-third its market price.

Both the financial and economic prices of the essential agricultural outputs and inputs will be recapitulated as follows:

Item		Prices Financial	Prices Economic	
Crops				
Paddy	(Rs/bushel)	33	50	(US$200/ton)
Soya Beans	(Rs/cwt)	84	100	(US$165/ton)
Pulses	(Rs/cwt)	128	180	(US$300/ton)
Chillies (dry)	(Rs/cwt)	1,000	500	(US$840/ton)
Fertilizers				
Basal (3-30-13 NPK)	(Rs/50 kg)	50	120	(US$200/ton)
Urea (46% N)	(Rs/50 kg)	50	120	(US$200/ton)
Mechanization Cost				
Combined Use of 4-wheel & 2-wheel Tractors	(Rs/hr)	40	80	
Farm Labour	(Rs/day)	8	2.7	

11.2 Internal Rate of Return

Based on the following assumptions, the project's economic rate of return is estimated at about 18%:

(a) a five year project implementation and a 50 year project life;

(b) full agricultural development five years after project completion;

(c) Projected 1985 world market prices in terms of 1976 dollars for construction machinery, construction materials, etc. and agricultural inputs and outputs;

(d) allowance for the shortage of foreign exchange by using a shadow rate of US$1.00 = Rs12.00;

(e) all farm labour valued at about 33% of the average market wage rate of Rs8 per man-day and construction labour at the market wage; and

(f) only the project related agricultural production is included in the benefits. Benefits from improved roads, and other improvements are not included in the analysis.

11.3 Sensitivity Tests

Further sensitivity tests indicate that the project remains viable under a variety of adverse assumptions about costs and benefits. Results from some of the important tests are given below:

	Alternative	Rate of Return
(a)	Basic case	18%
(b)	A decrease of 10% in net benefits	15%
(c)	An increase of 10% in project investment costs	17%
(d)	A two year delay in realizing the full project benefits	16%
(e)	Combination of (b) and (c)	14%
(f)	Combination of (c) and (d)	15%
(g)	Combination of (b), (c) and (d)	12%

Table 11-1 Paddy Production in The Existing Agricultural Lands during The Construction Period (in Economic Prices)

		Command Area of Mahauswewa Tank		The Rest of The Existing Agricultural Land	
	Total Area	850 acres		790 acres	
	Irrigability	80% during Maha Season	40% during Yala Season	80% during Maha Season	40% during Yala Season
	Area under Paddy	680 acres	340 acres	632 acres	316 acres
Production	Yield per Acres	59 bushels	59 bushels	52 bushels	52 bushels
	Total Production	40,120 bl.	20,060 bl.	32,864 bl.	16,432 bl.
	Unit Price	Rs50	Rs50	Rs50	Rs50
	G.P.V. (Rs1,000)	Rs2,006	Rs1,003	Rs1,643	Rs822
Cost	Seed & Chemicals	Rs446	"	Rs346	"
	Farm Machinery/Labour	Rs267	"	Rs187	"
	Miscellaneous	Rs90	"	Rs84	"
	Cost per Acre	Rs803	Rs803	Rs617	Rs617
	Total Cost (Rs1,000)	Rs546	Rs273	Rs390	Rs195
	N.P.V. (Rs1,000)	Rs1,460	Rs730	Rs1,253	Rs627

Table 11-2 Paddy Production in The Existing Agricultural Lands under The Project (in Economic Prices)

	Division of Area	Command Area of Mahauswewa Tank						The Rest of The Existing Agricultural Lands							
	Total Area	850 acres						790 acres							
	Irrigability	85% during Maha			80% during Yala			85% during Maha Season				80% during Yala Season			
	Area under Paddy	723 acres			680 acres			672 acres				632 acres			
	Project Year	5th Yr.	6th Yr.	7th Yr.	5th Yr.	6th Yr.	7th Yr.	5th Yr.	6th Yr.	7th Yr.	8th Yr.	5th Yr.	6th Yr.	7th Yr.	8th Yr.
Production	Yield per Acre (bu)	66	73	80	66	73	80	59	66	73	80	59	66	73	80
	Total Production(bu)	47,718	52,779	57,840	44,880	49,640	54,400	39,648	44,352	49,056	53,760	37,288	41,712	46,136	50,560
	Unti Price (Rs)	Rs50/bushel			Rs50/bushel			Rs50/bushel				Rs50/bushel			
	G.P.V. (Rs1,000)	2,386	2,639	2,892	2,244	2,482	2,720	1,982	2,218	2,453	2,688	1,864	2,086	2,307	2,528
Cost	Seeds/Chemicals (Rs)	626	806	994	626	806	994	446	626	806	994	446	626	806	994
	Farm Machinery/Labour	347	427	507	347	427	507	267	347	427	507	267	347	427	507
	Miscellaneous	119	127	135	119	127	135	90	119	127	135	90	119	127	135
	Cost per Acre (Rs)	1,092	1,360	1,636	1,092	1,360	1,636	803	1,092	1,360	1,636	803	1,092	1,360	1,636
	Total Cost (Rs1,000)	790	983	1,183	743	925	1,112	540	734	914	1,099	507	690	860	1,034
	N.P.V.(Rs1,000)	1,596	1,656	1,709	1,501	1,557	1,608	1,442	1,484	1,539	1,589	1,357	1,396	1,447	1,494

Table 11-3 Agricultural Production in the Newly Developed Area under the Project (Economic)

Year		Type of Land	Low Land			High Land				
		Size	3,560 acres			1,100 acres				
		Irrigability	85% during Maha & 80% during Yala			85% during Maha & 80% during Yala				
		Cropping Pattern	Paddy (during Maha)	Paddy (during Yala)	Total	Paddy (during Maha)	Upland Crops (during Yala) Soya Beans	Pulses	Chillies	Total
		Area under Crops	3,026ac.	2,848ac.	5,874ac.	935ac.	352ac. (40%)	440ac. (50%)	88ac. (10%)	880ac. (100%)
6th Year	Production	Yield per Acre	45bu	45bu		45bu	6cwt	5cwt	7cwt	
		Production (Rs1,000)	136.2	128.2	264.4	42	2,112	2,200	616	
		Unit Price (Rs)	50	50		50	100	180	500	
		G.P.V. (Rs1,000)	6,810	6,410	13,220	2,100	211	396	308	3,015
	Cost	Cost per Acre (Rs)	479	479		479	275	249	895	
		Total Cost (Rs1,000)	1,449	1,364	2,813	448	97	110	79	734
		N.P.V. (Rs1,000)	5,361	5,046	10,407	1,652	114	286	229	2,281
7th Year	Production	Yield per Acre	52bu	52bu		52bu	7.2cwt	6cwt	8.6cwt	
		Production (Rs1,000)	157.4	148.1	305.5	48.6	2,534	2,640	757	
		Unit Price (Rs)	50	50		50	100	180	500	
		G.P.V. (Rs1,000)	7,870	7,405	15,275	2,430	253	475	379	3,537
	Cost	Cost per Acre (Rs)	617	617		617	360	327	1,165	
		Total Cost (Rs1,000)	1,867	1,757	3,624	577	127	144	103	951
		N.P.V. (Rs1,000)	6,003	5,648	11,651	1,853	126	331	276	2,586
8th Year	Production	Yield per Acre	59bu	59bu		59bu	8.4cwt	7cwt	10.2cwt	
		Production (Rs1,000)	178.5	168	346.5	55.2	2,957	3,080	897.6	
		Unit Price (Rs)	50	50		50	100	180	500	
		G.P.V. (Rs1,000)	8,925	8,400	17,325	2,760	295.7	554.4	449	4,059.1
	Cost	Cost per Acre (Rs)	803	803		803	464	442	1,467	
		Total Cost (Rs1,000)	2,430	2,287	4,717	751	163.3	194.5	129	1,237.8
		N.P.V. (Rs1,000)	6,495	6,113	12,608	2,009	132.4	359.9	320	2,821.3
9th Year	Production	Yield per Acre	66bu	66bu		66bu	9.6cwt	8cwt	11.8cwt	
		Production (Rs1,000)	119.7	188	387.7	61.7	3,379	3,520	1,038.4	
		Unit Price (Rs)	50	50		50	100	180	500	
		G.P.V. (Rs1,000)	9,985	9,400	19,385	3,085	337.9	633.6	519	4,575.5
	Cost	Cost per Acre (Rs)	1,092	1,092		1,092	628	585	2,012	
		Total Cost (Rs1,000)	3,304	3,110	6,414	1,021	221.1	257.4	177	1,676.5
		N.P.V. (Rs1,000)	6,681	6,290	12,971	2,064	116.8	376.2	342	2,899
10th Year	Production	Yield per Acre	73bu	73bu		73bu	10.8cwt	9cwt	13.4cwt	
		Production (Rs1,000)	220.9	207.9	428.8	68.3	3,802	3,960	1,179.2	
		Unit Price (Rs)	50	50		50	100	180	500	
		G.P.V. (Rs1,000)	11,045	10,395	21,440	3,415	380.2	712.8	590	5,098.0
	Cost	Cost per Acre (Rs)	1,360	1,360		1,360	772	715	2,551	
		Total Cost (Rs1,000)	4,115	3,873	7,989	1,872	271.7	314.6	224	2,082.3
		N.P.V. (Rs1,000)	6,930	6,522	13,451	2,143	108.5	398.2	366	3,015.7
11th Year	Production	Yield per Acre	80bu	80bu		80bu	12cwt	10cwt	15cwt	
		Production (Rs1,000)	242.1	227.8	469.9	74.8	4,424	4,400	1,320	
		Unit Price (Rs)	50	50		50	100	180	500	
		G.P.V. (Rs1,000)	12,105	11,390	23,495	3,740	422.4	792.0	660	5,614.4
	Cost	Cost per Acre (Rs)	1,636	1,636		1,636	916	845	3,082	
		Total Cost (Rs1,000)	4,951	4,659	9,610	1,530	322.4	371.8	271	2,495.2
		N.P.V. (Rs1,000)	7,154	6,731	13,885	2,210	100	420.2	389	3,119.2

Table 11-4 G.P.V. Production Cost and N.P.V. under the Project (Market Price)

(Unit: Rs'000)

	G.P.V.			Production Cost			N.P.V.		
	Paddy	Upland crops	Total	Paddy	Upland crops	Total	Paddy	Upland crops	Total
Newly Developed Area									
6	10,111	1,075	11,186	3,942	429	4,371	6,169	646	6,815
7	11,685	1,408	13,093	4,426	498	4,924	7,259	910	8,169
8	13,256	1,540	14,796	5,080	561	5,641	8,176	979	9,155
9	14,830	1,759	16,589	6,169	663	6,832	8,661	1,096	9,757
10	16,404	2,005	18,409	7,102	743	7,845	9,302	1,262	10,564
11	17,975	2,238	20,213	8,069	824	8,893	9,906	1,414	11,320
Existing Agricultural Land									
1	3,613	-	3,613	1,377	-	1,377	2,236	-	2,236
2 (without the Project)									
4	3,613	-	3,613	1,377	-	1,377	2,236	-	2,236
5	5,594	-	5,594	2,244	-	2,244	3,350	-	3,350
6	6.221	-	6,221	2,645	-	2,645	3,576	-	3,576
7	6,846	-	6,846	3,023	-	3,023	3,823	-	3,823
8	7,147	-	7,147	3,208	-	3,208	3,940	-	3,940
Total Development Area									
6	16,332	1,075	17,407	6,587	429	7,016	9,745	646	10,391
7	18,531	1,408	19,939	7,449	498	7,947	11,082	910	11,992
8	20,403	1,540	21,943	8,288	561	8,849	12,116	979	13,095
9	21,977	1,759	23,736	9,377	663	10,040	12,601	1,096	13,697
10	23,551	2,005	25,556	10,310	743	11,053	13,242	1,262	14,504
11	25,122	2,238	27,360	11,277	824	12,101	13,846	1,414	15,260

Table 11-5 G.P.V. Production Cost and N.P.V. under the Project (Opportunity Price)

(Unit: Rs'000)

	G.P.V.			Production Cost			N.P.V.		
	Paddy	Upland crops	Total	Paddy	Upland crops	Total	Paddy	Upland crops	Total
Newly Developed Area									
6	15,320	915	16,235	3,261	286	3,547	12,059	629	12,688
7	17,705	1,107	18,812	4,201	374	4,575	13,504	733	14,237
8	20,085	1,299	21,384	5,468	487	5,955	14,617	812	15,429
9	22,470	1,491	23,961	7,435	656	8,091	15,035	835	15,870
10	24,855	1,683	26,538	9,260	810	10,070	15,595	873	16,468
11	27,235	1,874	29,109	11,140	965	12,105	16,095	909	17,004
Existing Agricultural Land									
1									
2 (without the Project)	5,474	-	5,474	1,404	-	4,070	4,070	-	4,070
4									
5	8,476	-	8,476	2,580	-	2,580	5,896	-	5,896
6	9,425	-	9,425	3,332	-	3,332	6,093	-	6,093
7	10,372	-	10,372	4,069	-	4,069	6,303	-	6,303
8	10,828	-	10,828	4,428	-	4,428	6,400	-	6,400
Total Development Area									
6	24,745	915	25,660	6,593	286	6,879	18,152	629	18,781
7	28,077	1,107	29,184	8,270	374	8,644	19,807	733	20,540
8	30,913	1,299	32,212	9,896	487	10,383	21,017	812	21,829
9	33,298	1,491	34,789	11,863	656	12,519	21,435	835	22,270
10	35,683	1,683	37,366	13,688	810	14,498	21,995	873	22,868
11	38,063	1,874	39,937	15,568	965	16,533	22,495	909	23,404

Table 11-6 Internal Rate of Return (Financial)

(Unit: Rs '000)

	COSTS									BENEFITS					
Year	Land Acquisition	Construction Machinery	Civil Works	Engineering & Administration	Land Settlement	O & M	Cultivation Cost	Replacement	Total	Existing Land	Newly Developed Land	Total	N.P.V.	D.F. at 10%	12%
1	1,000			5,000					8,000			2,236	-3,764	-3,421	-3,361
2		35,600	2,211	1,000					38,811				-36,575	-30,211	-29,150
3			15,400	1,000	1,760	250			18,410				-16,174	-12,147	-11,516
4			19,987	1,000	1,780	500			23,267			2,236	-21,031	-14,364	-13,376
5			16,555	1,000	1,760	750	2,244		22,309	5,594		5,594	-16,715	-10,380	-9,477
6			11,077	1,000		1,000	7,016		20,093	6,221	11,186	17,409	-2,686	-1,515	-1,362
7						1,000	7,947		8,947	6,846	13,093	19,939	10,992	5,639	4,968
8						1,000	8,849		9,849	7,147	14,796	21,943	12,094	5,648	4,886
9						1,000	10,040		11,040		16,589	23,736	12,696	5,383	4,583
10						1,000	11,053		12,053		18,409	25,556	13,503	5,212	4,348
11						1,000	12,101		13,101		20,213	27,360	14,259		
12						1,000	12,101								
13						1,000	12,101							17,424	13,945
14						1,000	12,101		13,101				14,259		
15						405	12,101		12,506				14,854		
														36,868	24,494
44									12,506				14,854		
45								4,000	16,506				10,854	152	65
46									12,506				14,854		
														772	312
50						405	12,101		12,506	7,147	20,213	27,360	14,854		
														5,060	-10,641

$$10 + 2\left(\frac{5,060}{15,701}\right) = 10.64$$

Table 11-7 Internal Rate of Return (Economic)

(Unit: Rs'000)

Year	COSTS									BENEFITS					
	Land Acquisition	Construction Machinery	Civil Works	Engineering & Administration	Land Settlement	O & M	Cultivation Cost	Replacement	Total	Existing Land	Newly Developed Land	Total	N.P.V.	D.F. at 18%	20%
1	1,000			5,979					6,979			4,070	-2,909	-2,464	-2,423
2		21,360	2,640	1,000					25,000				-20,930	-15,028	-14,525
3			17,945	1,000		325			19,280				-15,210	-9,263	-8,807
4			23,583	1,000		650			25,233			4,070	-21,163	-10,920	-10,201
5			19,851	1,000		975	2,580		24,406	8,476		8,476	-15,930	-6,961	-6,404
6			13,179	1,000		1,300	6,879		22,358	9,425	16,235	25,660	3,302	1,222	1,106
7						1,300	8,644		9,944	10,372	18,812	29,184	19,240	6,041	5,368
8						1,300	10,383		11,683	10,828	21,384	32,212	20,529	5.461	4,783
9						1,300	12,519		13,819		23,961	34,789	20,970	4,718	4,068
10						1,300	14,499		15,799		26,538	37,366	21,567	4,119	3,494
11						1,300	16,533		17,833		29,109	39,937	22,104		
12						1,300									
13						1,300								11,361	9,262
14						1,300			17,833				22,104		
15						527			17,060				22,877		
16															
														12,422	8,876
44									17,060				22,877		
45								6,000	23,060				16,877	17	0
46									17,060				22,877		
														46	0
50						527	16,533		17,060	10,828	29,109	39,937	22,877		
		60% of the Financial Cost + 65% for F/C	+ 65% for F/C including 10% contingencies			+ 30%								772	-5,403

$$18 + 2\left(\frac{772}{6,174}\right) = 18.25$$