TABLE B—28. MONTHLY RAINFALL AT SHAH ALLADITTA STATION

(UNIT:MM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1952	******	******	******	******	******	******	******	******	******	******	******	******	******
1953	66.0	30.7	5.3	20.8	25.1	11.2	305.8	199.6	48.3	5.3	0.0	9.4	727.7
1954	138.4	101.1	34.0	11.2	19.8	0.0	64.8	305.8	54.4	44.4	3.6	0.0	777.5
1955	21.3	0.0	67.1	44.7	52.3	16.3	108.2	259.3	152.9	14.0	0.0	******	******
1956	24.1	52.8	108.5	32.3	0.0	60.2	304.3	439.4	23.6	0.0	0.0	1.8	1047.0
1957	128.0	15.2	89.7	85.3	57.4	35.8	52.6	154.4	6.6	156.0	64.0	93.0	938.0
1958	0.0	5.1	140.5	20.6	0.0	9.7	292.4	299.2	72.6	17.3	5.8	185.2	1048.3
1959	142.2	145.5	42.2	23.6	65.0	12.7	492.0	424.7	95.8	64.3	165.4	28.2	1701.5
1960	67.8	0.0	126.7	57.1	2.8	10.7	129.8	198.4	38.9	0.0	0.0	41.1	673.4
1961	100.1	73.2	26.4	151.4	15.2	28.4	420.1	237.0	503.9	23.6	46.2	7.1	1632.7
1962	15.2	57.1	72.6	30.7	34.0	59.9	297.9	402.6	129.0	20.1	19.8	83.8	1223.0
1963	0.0	25.4	75.4	49.0	******	******	******	******	******	******	******	******	******
1964	******	******	******	******	******	******	******	******	******	******	******	******	******
1965	******	******	******	******	******	******	******	******	******	******	******	******	******
1966	******	******	******	******	******	******	307.8	204.2	64.5	28.4	0.0	22.4	******
1967	1.3	91.9	157.5	28.2	51.6	26.4	203.7	351.8	34.8	20.1	******	159.8	******
1968	69.1	71.4	88.9	29.2	16.3	22.9	160.3	373.6	8.6	17.3	0.0	67.1	924.6
1969	******	******	******	******	******	******	******	******	******	******	******	******	******
1970	******	******	******	******	******	******	******	******	******	******	******	******	******
1971	******	******	******	******	******	******	******	******	******	******	******	******	******
1972	******	******	******	******	******	******	******	******	******	******	******	******	******
1973	******	******	******	******	******	******	******	******	******	******	******	******	******
1974	******	******	******	******	******	******	******	******	******	******	******	******	******
1975	******	******	******	******	******	******	******	******	******	******	******	******	******
1976	******	******	******	******	******	******	******	******	******	******	******	******	******
1977	******	******	******	******	******	******	******	******	******	******	******	******	******
1978	******	******	******	******	******	******	******	******	******	******	******	******	******
1979	******	******	******	******	******	******	******	******	******	******	******	******	******
1980	******	******	******	******	******	******	******	******	******	******	******	******	******
1981	******	******	******	******	******	******	******	******	******	******	******	******	******
1982	******	******	******	******	******	******	******	******	******	******	******	******	******
1983	******	******	******	******	******	******	******	******	******	******	******	******	******
1984	******	******	******	******	******	******	******	******	******	******	******	******	******
1985	******	******	******	******	******	******	******	******	******	******	******	******	******
1986	******	******	******	******	******	******	******	******	******	******	******	******	******
MEAN	59.5	51.5	79.6	44.9	28.3	24.5	241.5	296.2	94.9	31.6	25.4	58.2	1069.4
MAX	142.2	145.5	157.5	151.4	65.0	60.2	492.0	439.4	503.9	156.0	165.4	185.2	1701.5
MIN	0.0	0.0	5.3	11.2	0.0	0.0	52.6	154.4	6.6	0.0	0.0	0.0	673.4

TABLE B–29. MONTHLY RAINFALL AT TAMAIR STATION

(UNIT:MM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1952	******	******	******	******	******	******	******	******	26.2	11.4	1.3	15.0	******
1953	84.6	35.3	16.3	46.2	37.1	65.5	552.2	197.4	29.5	11.4	0.0	30.5	1105.9
1954	160.5	107.7	43.2	15.2	******	8.1	269.7	228.6	119.6	70.4	0.8	0.0	******
1955	3.8	20.3	63.5	30.0	38.4	18.5	192.0	463.3	241.3	59.7	0.0	12.7	1143.5
1956	50.5	20.8	183.9	30.0	2.0	128.3	314.5	351.8	73.7	47.0	0.0	******	******
1957	176.3	53.8	127.0	100.3	62.2	21.6	40.6	94.0	36.1	******	71.1	250.2	******
1958	1.3	3.3	78.7	5.1	1.3	22.9	291.3	442.7	118.1	34.3	0.0	204.5	1203.5
1959	91.4	212.1	20.3	80.0	62.2	21.1	482.9	208.8	206.8	51.3	97.0	22.4	1556.3
1960	64.8	0.0	100.3	72.4	6.3	8.9	333.8	363.7	59.7	******	0.8	25.1	******
1961	529.1	134.9	102.9	367.8	41.9	28.4	809.8	678.9	468.1	110.5	69.1	5.1	3346.4
1962	7.1	167.4	433.3	49.3	18.5	57.9	209.3	289.8	110.0	14.0	43.2	62.0	1461.8
1963	2.5	49.0	86.4	51.8	35.6	6.9	169.2	207.3	130.3	14.5	35.3	85.9	874.5
1964	******	17.0	24.9	62.7	35.3	0.5	362.5	264.9	101.9	******	0.0	10.4	******
1965	47.2	109.2	71.6	224.5	125.2	19.8	168.4	138.4	******	8.9	******	******	******
1966	170.2	******	97.0	47.2	45.7	70.4	245.1	111.8	******	45.7	0.0	29.2	******
1967	0.0	79.2	215.9	71.1	39.9	11.4	292.1	266.2	121.9	29.2	20.3	132.1	1279.4
1968	69.1	75.7	48.3	11.4	11.4	15.7	162.6	265.4	0.0	40.6	******	48.8	******
1969	******	******	******	******	******	******	******	******	******	******	******	******	******
1970	******	******	******	******	******	******	******	******	******	******	******	******	******
1971	******	******	******	******	******	******	******	******	******	******	******	******	******
1972	******	******	******	******	******	******	******	******	******	******	******	******	******
1973	******	******	******	******	******	******	******	******	******	******	******	******	******
1974	******	******	******	******	******	******	******	******	******	******	******	******	******
1975	******	******	******	******	******	******	******	******	******	******	******	******	******
1976	******	******	******	******	******	******	******	******	******	******	******	******	******
1977	******	******	******	******	******	******	******	******	******	******	******	******	******
1978	******	******	******	******	******	******	******	******	******	******	******	******	******
1979	******	******	******	******	******	******	******	******	******	******	******	******	******
1980	******	******	******	******	******	******	******	******	******	******	******	******	******
1981	******	******	******	******	******	******	******	******	******	******	******	******	******
1982	******	******	******	******	******	******	******	******	******	******	******	******	******
1983	******	******	******	******	******	******	******	******	******	******	******	******	******
1984	******	******	******	******	******	******	******	******	******	******	******	******	******
1985	******	******	******	******	******	******	******	******	******	******	******	******	******
1986	******	******	******	******	******	******	******	******	******	******	******	******	******
MEAN	97.2	72.4	107.1	79.1	37.5	31.6	306.0	285.8	122.9	39.2	22.6	62.2	1496.4
MAX	529.1	212.1	433.3	367.8	125.2	128.3	809.8	678.9	468.1	110.5	97.0	250.2	3346.4
MIN	0.0	0.0	16.3	5.1	1.3	0.5	40.6	94.0	0.0	8.9	0.0	0.0	874.5

TABLE B-30. MONTHLY RAINFALL AT TRET STATION

(UNIT:MM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1952	******	******	******	******	******	******	******	314.2	76.5	157.5	3.0	29.5	******
1953	120.6	48.3	52.1	88.4	29.2	59.7	407.7	246.4	74.9	40.6	0.0	34.3	1202.2
1954	203.2	159.3	86.4	22.9	37.6	14.0	203.2	259.1	189.0	95.2	7.6	0.0	1277.4
1955	26.7	11.4	91.4	55.9	95.2	26.7	186.7	668.0	160.0	33.0	0.0	33.0	1388.1
1956	67.3	45.7	221.0	77.5	0.0	95.2	538.5	440.7	61.0	116.8	0.0	72.4	1736.1
1957	31.7	66.0	193.0	200.7	50.8	95.2	39.4	154.9	57.1	191.8	119.4	141.0	1341.1
1958	22.9	27.9	58.4	******	34.3	24.1	235.7	509.3	65.3	43.2	5.1	163.1	******
1959	114.8	224.3	53.3	98.6	94.5	27.2	472.7	183.6	386.8	76.2	77.5	41.4	1850.9
1960	77.0	0.0	172.2	64.3	6.6	48.8	277.9	367.8	68.6	16.5	0.0	42.7	1142.2
1961	257.0	96.8	57.4	201.2	34.0	17.8	295.1	281.4	166.4	39.6	99.8	0.0	1546.6
1962	11.4	59.4	******	******	******	******	******	******	******	******	0.0	19.8	******
1963	******	******	******	******	******	******	******	******	******	******	******	******	******
1964	******	******	******	******	******	******	******	******	******	******	******	******	******
1965	133.3	137.2	******	129.3	214.6	0.0	160.0	283.2	25.4	0.0	62.5	29.5	******
1966	0.0	164.3	110.2	95.0	54.6	57.1	387.6	232.7	123.2	138.9	0.0	17.8	1381.5
1967	0.0	132.1	227.1	122.4	73.7	20.8	342.4	430.5	162.6	27.9	14.7	105.4	1659.6
1968	287.0	121.9	92.7	90.2	106.7	74.9	******	350.5	10.2	16.5	0.0	10.2	******
1969	******	******	******	******	******	******	******	******	******	******	******	******	******
1970	******	******	******	******	******	******	******	******	******	******	******	******	******
1971	******	******	******	******	******	******	******	******	******	******	******	******	******
1972	******	******	******	******	******	******	******	******	******	******	******	******	******
1973	******	******	******	******	******	******	******	******	******	******	******	******	******
1974	******	******	******	******	******	******	******	******	******	******	******	******	******
1975	******	******	******	******	******	******	******	******	******	******	******	******	******
1976	******	******	******	******	******	******	******	******	******	******	******	******	******
1977	******	******	******	******	******	******	******	******	******	******	******	******	******
1978	******	******	******	******	******	******	******	******	******	******	******	******	******
1979	******	******	******	******	******	******	******	******	******	******	******	******	******
1980	******	******	******	******	******	******	******	******	******	******	******	******	******
1981	******	******	******	******	******	******	******	******	******	******	******	******	******
1982	******	******	******	******	******	******	******	******	******	******	******	******	******
1983	******	******	******	******	******	******	******	******	******	******	******	******	******
1984	******	******	******	******	******	******	******	******	******	******	******	******	******
1985	******	******	******	******	******	******	******	******	******	******	******	******	******
1986	******	******	******	******	******	******	******	******	******	******	******	******	******
MEAN	96.6	92.5	117.9	103.8	64.0	43.2	295.6	337.3	116.2	71.0	26.0	49.3	1452.6
MAX	287.0	224.3	227.1	201.2	214.6	95.2	538.5	668.0	386.8	191.8	119.4	163.1	1850.9
MIN	0.0	0.0	52.1	22.9	0.0	0.0	39.4	154.9	10.2	0.0	0.0	0.0	1142.2

1.3. Runoff Data

Runoff data available in the vicinity of the Project Area are tabulated in Figure B-3, and out of these data, three runoff discharge data observed at Khanpur, Cherah and Chahan stations are collected as shown in Table B-31 to Table B-33, of which location is shown in Figure B-4.

These data on daily basis will be necessary to build the Tank Model for analyzing runoff discharge in the Kurang River basin, of which detail descriptions are given in subsequent chapter.

FIGURE B-3. LIST OF HYDROLOGICAL STATIONS AND COLLECTED DATA

River System		Station	Catchment Area sq.km	Observation Period	Data Collected	1960s										1970s										1980s							Remarks
Main	Tributary					0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	
Soan	Kurang	Bari Kangran	45.4	Feb. 1960 – Cont.	1971 – 1981											●	●	●	●	●	●	●	●	●	●	●	●						DHF (P)
		Chattar	29.7	Jun. 1969 – Cont.	1971 – 1981											●	●	●	●	●	●	●	●	●	●	●	●						DHF (P)
		Rawal Dam	272.0	Sep. 1965 – Dec. 68	Sep. – 1965 – Dec. 68							●	●	●																		SWH
		Dhok Khanna	321.1	Sep. 1965 – Jun. 67	Sep. – 1965 – Jun. 67							●	●																			SWH
		Lohi Bher	558.8	Feb. 1960 – Cont.	1971 – 1981											●	●	●	●	●	●	●	●	●	●	●	●						DHF (P)
	Gumreh Kas	Dhok Khanna	125.0	Sep. 1965 – Jun. 67	Sept. – 1965 – Jun. 67							●	●																			SWH
	Sil	Chahan	241.0	May 1962 – Cont.	Mar. 1962 – 1980			●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●						SWH
	Soan	Cherah	326.0	Apr. 1960 – Cont.	Apr. 1960 – 1980			●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●						SWH
Haro	Haro	Khanpur	778.0	Jan. 1960 – Cont.	1960 – 1980			●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●						SWH

Note: DHF (P); Directorate of Hydrology and Floods, Irrigation and Power Department, Punjab Prov.
SWH (P); Surface Water Hydrology, WAPDA

FIGURE B-4. HYDROLOGICAL STATION AROUND PROJECT AREA

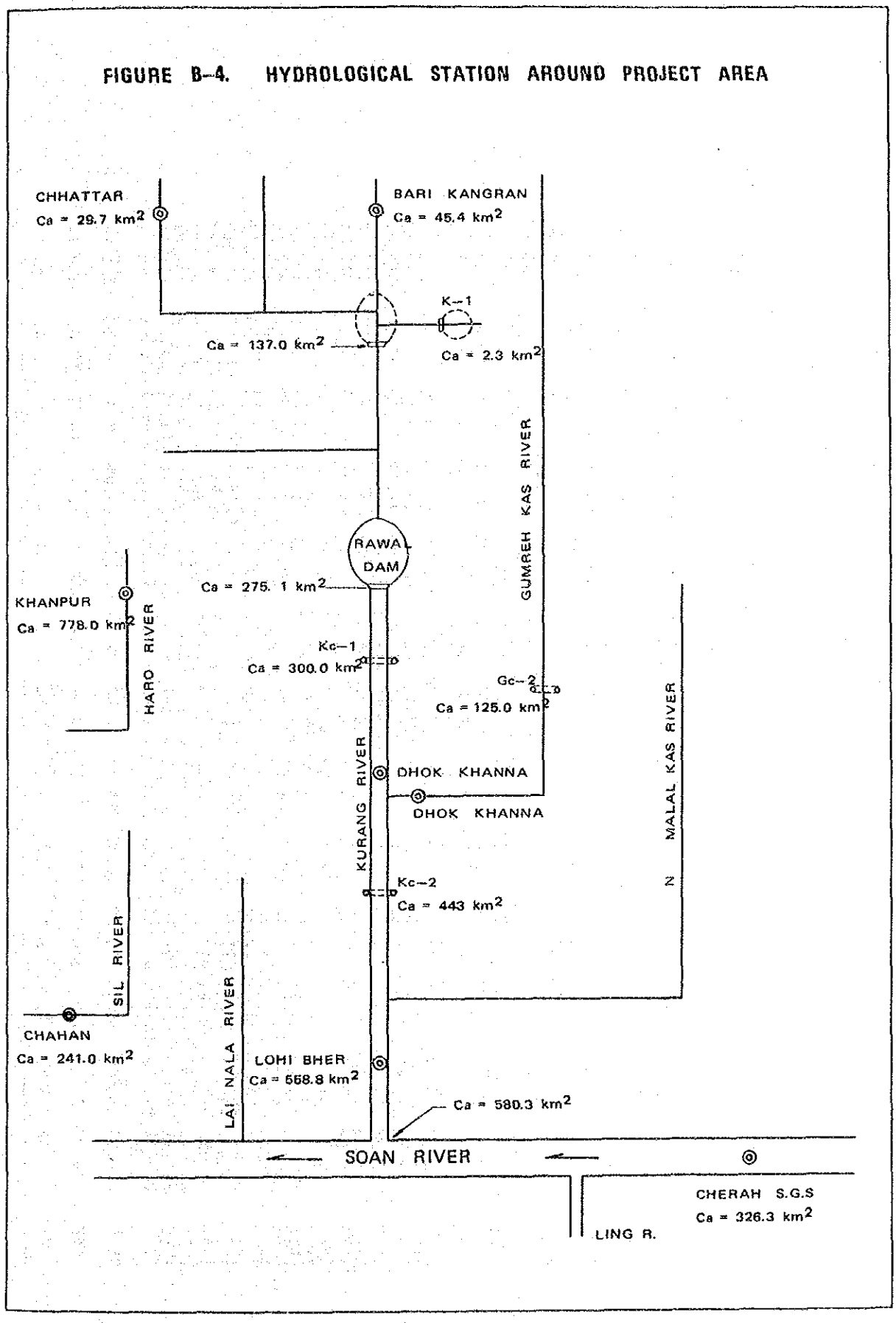


TABLE B-31. MONTHLY DISCHARGE AT KHANPUR STATION IN HARO RIVER

CATCHMENT AREA: 770.0 SQ.KM

(UNIT:MCM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1952	******	******	******	******	******	******	******	******	******	******	******	******	******
1953	******	******	******	******	******	******	******	******	******	******	******	******	******
1954	******	******	******	******	******	******	******	******	******	******	******	******	******
1955	******	******	******	******	******	******	******	******	******	******	******	******	******
1956	******	******	******	******	******	******	******	******	******	******	******	******	******
1957	******	******	******	******	******	******	******	******	******	******	******	******	******
1958	******	******	******	******	******	******	******	******	******	******	******	******	******
1959	******	******	******	******	******	******	******	******	******	******	******	******	******
1960	15.52	13.74	21.73	20.07	13.09	8.25	42.18	49.45	35.26	15.28	8.81	5.75	249.14
1961	19.30	26.71	17.10	40.79	22.23	14.13	43.74	50.12	138.99	32.39	17.24	10.43	433.16
1962	6.87	7.40	30.07	19.14	8.32	6.88	24.94	44.54	33.91	15.12	7.31	6.12	210.63
1963	5.70	6.34	29.86	19.81	12.36	6.49	21.59	60.21	40.82	13.99	9.48	7.27	233.91
1964	39.05	25.55	19.80	13.96	7.23	4.48	22.29	60.14	37.92	15.39	8.04	6.86	260.71
1965	6.70	21.79	40.04	116.93	77.94	28.01	22.29	44.88	19.99	11.22	6.32	6.33	402.43
1966	5.52	10.98	22.26	27.51	26.22	10.27	30.78	48.54	38.37	23.27	10.55	7.46	261.74
1967	5.98	35.42	70.34	49.94	27.79	8.72	12.57	45.53	45.20	14.67	6.74	19.81	342.70
1968	26.15	35.93	37.93	21.24	11.10	5.91	17.35	86.83	16.89	12.86	7.28	7.07	286.56
1969	5.99	15.04	18.70	19.13	8.59	5.57	7.64	33.63	16.58	22.71	6.72	3.87	164.17
1970	6.25	5.68	43.79	13.65	4.46	4.12	13.39	67.12	119.08	31.51	9.61	5.26	323.92
1971	5.12	7.80	13.30	6.68	3.17	78.22	78.47	121.89	41.41	15.83	7.17	4.40	383.45
1972	6.98	12.51	36.53	21.94	24.19	9.79	10.69	23.69	26.35	11.09	7.03	12.57	203.37
1973	18.38	21.38	74.84	22.78	10.27	11.84	42.80	134.28	80.25	24.95	10.43	7.41	459.63
1974	8.06	18.53	10.98	6.30	3.87	5.53	19.90	25.96	13.17	7.22	4.18	3.19	126.89
1975	4.82	9.63	16.39	17.91	11.26	8.51	18.75	80.77	29.99	12.50	7.58	4.66	222.79
1976	10.33	39.73	65.64	42.77	19.04	11.52	45.08	243.89	95.80	32.98	14.18	8.42	629.39
1977	12.78	12.72	9.74	19.77	16.89	11.92	98.63	136.55	79.51	56.79	18.38	10.57	484.25
1978	15.60	12.99	38.07	19.12	8.62	8.95	157.39	191.34	64.82	28.28	15.84	8.38	569.41
1979	10.99	24.87	101.15	47.17	19.63	9.03	18.27	48.63	17.76	7.69	4.67	3.01	312.87
1980	15.93	21.39	45.80	25.54	9.52	26.11	28.59	72.22	30.42	15.21	9.02	4.83	304.58
1981	******	******	******	******	******	******	******	******	******	******	******	******	******
1982	******	******	******	******	******	******	******	******	******	******	******	******	******
1983	******	******	******	******	******	******	******	******	******	******	******	******	******
1984	******	******	******	******	******	******	******	******	******	******	******	******	******
1985	******	******	******	******	******	******	******	******	******	******	******	******	******
1986	******	******	******	******	******	******	******	******	******	******	******	******	******
MEAN	12.00	18.39	36.38	28.20	16.47	13.53	37.02	79.53	48.69	20.05	9.36	7.32	326.94
MAX	39.05	39.73	101.15	116.93	77.94	78.22	157.39	243.89	138.99	56.79	18.38	19.81	629.39
MIN	4.82	5.68	9.74	6.30	3.17	4.12	7.64	23.69	13.17	7.22	4.18	3.01	126.89

TABLE B-32. MONTHLY DISCHARGE AT CHERAH STATION IN SOAN RIVER

CATCHMENT AREA: 326.3 SQ.KM

(UNIT:MCM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1952	******	******	******	******	******	******	******	******	******	******	******	******	******
1953	******	******	******	******	******	******	******	******	******	******	******	******	******
1954	******	******	******	******	******	******	******	******	******	******	******	******	******
1955	******	******	******	******	******	******	******	******	******	******	******	******	******
1956	******	******	******	******	******	******	******	******	******	******	******	******	******
1957	******	******	******	******	******	******	******	******	******	******	******	******	******
1958	******	******	******	******	******	******	******	******	******	******	******	******	******
1959	******	******	******	******	******	******	******	******	******	******	******	******	******
1960	******	******	******	4.98	1.04	0.57	19.01	20.06	12.30	2.42	0.93	0.92	******
1961	19.78	9.69	3.06	22.24	2.54	2.30	38.32	56.21	63.22	8.92	4.03	1.95	232.26
1962	1.24	1.85	7.36	2.95	0.87	0.65	21.74	33.40	9.13	1.10	1.97	2.22	84.48
1963	0.74	4.33	8.73	2.14	1.40	0.47	28.64	38.37	26.50	0.99	0.94	0.70	113.95
1964	15.69	4.32	1.89	2.84	1.17	0.66	29.09	49.20	31.93	3.22	1.21	1.18	142.38
1965	2.08	14.70	9.65	36.37	15.27	3.95	29.55	16.83	3.04	1.27	0.79	0.49	134.00
1966	0.36	7.92	8.97	6.32	1.66	2.70	28.69	37.41	14.05	3.63	1.36	0.90	113.96
1967	0.40	8.10	39.30	17.31	3.35	0.81	13.73	48.16	25.76	3.35	1.09	11.22	172.60
1968	11.27	14.38	11.08	4.49	2.22	0.82	17.23	57.61	5.00	2.31	1.15	1.06	128.64
1969	0.74	5.66	4.14	2.27	1.71	0.31	9.58	17.34	3.77	5.43	0.55	0.17	51.67
1970	2.52	3.13	10.01	0.63	0.08	1.31	19.02	95.19	96.57	8.45	1.64	0.74	239.30
1971	0.53	5.13	0.67	10.85	2.76	65.13	33.89	99.13	16.87	1.69	1.42	0.53	238.60
1972	2.28	6.85	12.95	8.83	2.41	1.59	9.80	27.40	22.96	3.16	1.37	4.82	104.43
1973	4.50	5.70	45.00	3.14	1.35	4.99	28.55	62.29	15.03	3.34	0.94	0.85	175.67
1974	1.00	3.42	1.62	0.48	0.34	1.20	24.80	37.45	4.51	0.87	0.22	0.49	76.40
1975	0.32	3.25	2.44	3.00	1.48	0.96	34.80	128.00	52.69	3.50	1.22	0.57	232.22
1976	6.38	31.84	39.53	7.47	2.33	1.90	44.65	154.42	61.06	8.47	1.71	1.12	360.90
1977	3.56	1.16	0.48	8.90	2.10	6.04	145.56	104.15	21.90	17.76	9.86	2.85	324.34
1978	6.58	4.66	10.78	3.10	0.60	3.53	72.35	148.13	39.50	6.33	5.49	1.14	302.17
1979	21.23	49.43	28.74	8.52	2.20	1.62	20.32	32.09	6.71	0.91	0.79	0.66	173.22
1980	2.76	5.30	16.07	5.12	0.84	29.22	51.06	44.36	17.92	7.52	1.51	1.29	182.97
1981	******	******	******	******	******	******	******	******	******	******	******	******	******
1982	******	******	******	******	******	******	******	******	******	******	******	******	******
1983	******	******	******	******	******	******	******	******	******	******	******	******	******
1984	******	******	******	******	******	******	******	******	******	******	******	******	******
1985	******	******	******	******	******	******	******	******	******	******	******	******	******
1986	******	******	******	******	******	******	******	******	******	******	******	******	******
MEAN	5.20	9.54	13.12	7.71	2.27	6.23	34.30	62.25	26.21	4.51	1.91	1.71	179.21
MAX	21.23	49.43	45.00	36.37	15.27	65.13	145.56	154.42	96.57	17.76	9.86	11.22	360.90
MIN	0.32	1.16	0.48	0.48	0.08	0.31	9.58	16.83	3.04	0.87	0.22	0.17	51.67

TABLE B-33. MONTHLY DISCHARGE AT CHAHAN STATION IN SILL RIVER

CATCHMENT AREA: 240.1 SQ.KM

(UNIT:MCM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1952	******	******	******	******	******	******	******	******	******	******	******	******	******
1953	******	******	******	******	******	******	******	******	******	******	******	******	******
1954	******	******	******	******	******	******	******	******	******	******	******	******	******
1955	******	******	******	******	******	******	******	******	******	******	******	******	******
1956	******	******	******	******	******	******	******	******	******	******	******	******	******
1957	******	******	******	******	******	******	******	******	******	******	******	******	******
1958	******	******	******	******	******	******	******	******	******	******	******	******	******
1959	******	******	******	******	******	******	******	******	******	******	******	******	******
1960	******	******	******	******	******	******	******	******	******	******	******	******	******
1961	******	******	******	******	******	******	******	******	******	******	******	******	******
1962	******	******	******	******	******	0.32	80.37	9.38	3.21	0.71	0.64	0.83	******
1963	0.59	1.08	0.59	0.60	0.86	0.26	3.68	16.13	5.96	0.35	0.51	0.82	31.44
1964	1.60	0.50	0.49	0.52	0.35	1.18	16.94	5.64	3.13	0.21	0.26	0.33	31.15
1965	0.44	2.78	8.12	4.88	8.54	0.44	10.90	13.60	0.76	0.38	0.38	0.35	51.58
1966	0.36	4.75	1.47	1.19	1.01	4.10	12.95	9.51	2.64	0.32	0.29	0.46	39.06
1967	0.38	0.70	4.78	0.39	0.33	0.21	12.59	28.90	1.86	0.52	0.50	3.89	55.06
1968	1.00	2.14	2.95	0.49	0.31	0.51	10.92	25.65	0.74	0.82	0.75	1.89	48.16
1969	0.52	0.77	1.47	0.40	2.55	0.19	9.56	28.10	2.61	2.39	0.46	0.51	49.52
1970	1.10	1.10	4.90	0.30	0.45	1.98	11.02	19.42	17.04	3.16	0.59	0.54	61.60
1971	0.56	2.18	0.69	1.83	2.59	4.43	5.96	24.77	2.88	0.47	0.50	0.44	47.29
1972	0.56	0.65	4.67	0.63	0.26	0.15	1.60	9.22	0.57	0.72	0.29	0.64	19.95
1973	1.16	0.75	1.15	0.28	0.28	1.44	21.16	24.53	6.16	0.90	0.58	0.56	58.95
1974	0.62	0.63	0.50	0.43	0.32	0.62	12.39	8.04	0.66	0.40	0.31	0.50	25.42
1975	0.41	0.47	1.03	1.10	0.63	0.69	9.70	28.35	1.49	0.28	0.27	0.35	44.77
1976	0.66	1.80	2.59	0.97	0.48	1.41	21.04	33.42	8.50	1.18	0.88	0.86	73.78
1977	1.36	0.77	0.66	0.67	1.28	1.83	34.82	25.41	3.82	2.09	1.04	0.91	74.66
1978	1.11	0.82	3.34	0.58	0.44	2.01	13.38	46.22	8.81	3.45	2.68	1.52	84.36
1979	2.38	4.99	3.89	1.23	0.87	1.09	9.97	8.84	3.09	1.10	1.41	1.23	40.08
1980	1.08	1.60	4.42	1.81	0.60	1.49	15.62	15.87	2.95	1.29	1.23	1.22	49.19
1981	******	******	******	******	******	******	******	******	******	******	******	******	******
1982	******	******	******	******	******	******	******	******	******	******	******	******	******
1983	******	******	******	******	******	******	******	******	******	******	******	******	******
1984	******	******	******	******	******	******	******	******	******	******	******	******	******
1985	******	******	******	******	******	******	******	******	******	******	******	******	******
1986	******	******	******	******	******	******	******	******	******	******	******	******	******
MEAN	0.88	1.58	2.65	1.02	1.23	1.28	16.56	20.05	4.05	1.09	0.71	0.94	49.22
MAX	2.38	4.99	8.12	4.88	8.54	4.43	80.37	46.22	17.04	3.45	2.68	3.89	84.36
MIN	0.36	0.47	0.49	0.28	0.26	0.15	1.60	5.64	0.57	0.21	0.26	0.33	19.95

CHAPTER II. RUNOFF ANALYSIS

2.1. Runoff Discharge Estimated by SDO

Small Dams Organization (SDO) dealing with water management and control of the Rawal Dam since 1962 has an estimated inflow discharge to the Rawal Dam on the daily basis for the period of 25 years, 1962 to 1986. These inflow discharges are estimated based on the daily observation data such as released discharges from the Rawal Dam, spilled discharges and variation of storage volume of Rawal Reservoir as expressed in the following equation;

$$\text{Inflow Discharge } (Qi) = \Delta V + Ql + Qs$$

where; ΔV = Variation of Storage Volume
Ql = Released Discharge
Qs = Spilled Discharge

Table B-34 tabulates the estimated inflow discharge to the Rawal Dam on monthly basis. Out of these inflow discharges, five-years data, 1962 to 1966, are of monthly basis and the remaining 20-years data, 1967 to 1986, are of daily basis. According to these data, inflow discharge to the Rawal Dam is estimated at about 81.7 MCM on average for the period of 25 years, 1963 to 1986. Based on these data, runoff discharge at the Rawal damsite could be estimated at about 100.9 MCM on average as shown in Table B-38, depending upon the following considerations;

- Water losses in the Rawal Dam consisting of water seepage and evaporation are assumed to be 9.2 MCM in total, 0.9 MCM of seepage and 8.3 MCM of evaporation.
- Diverted water of 7.6 MCM/annum at the upstream of Rawal Dam for the domestic water supply purposes should be added to inflow discharge thus estimated.
- Negative inflow discharge in the tabulation of daily calculation prepared by SDO is assumed as follows;
    - If total discharge adding water losses to negative inflow is smaller than zero, inflow discharge is assumed to be zero.

2.2. Estimation of Runoff Discharge by Tank Model Method

Runoff discharges of the Kurang River at the Rawal and proposed K-2 damsites, which have the catchment area of 275.1 sq.km and 137.0 sq.km respectively have been estimated by applying the theoretical method so as called Tank Model Method because reliable long term observation data are not available at the both sites. Subsequent paragraph discusses the estimation of runoff discharge by Tank Model Method.

2.2.1. Procedures of Runoff Analysis

The catchment area of the Kurang River has a fault between the Kurang River and Margalla Hill. Northern parts of the fault in the Kurang River basin consist of limestone in geology and is quite similar to those of upstream area of Khanpur in the Haro River basin. On the other hand, southern parts of the fault consist of sand stone and mudstone, and their topography is formed with complicated formation by mountain and alluvial plain. These mountainous areas are similar to those in the upstream of Cherah in the Soan River. Furthermore, alluvial plain areas are similar to those in Chahan of the Sil River.

Taking into consideration the above mentioned, the runoff discharges of the Kurang River were analyzed for a 35-year period from 1952 to 1986 by the Tank Model Method, which was designed for the stations of Khanpur in the Haro River, Cherah in the Soan River and Chahan in the Sil River. Their results were applied to estimate the runoff discharge of the Kurang River, considering the following elements of each river basin.

Element of Run-off Discharge Estimation

Classification of Kurang River Basin	Catchment Area (sq.km)	Areal Rainfall (mm)	Northern Parts of Fault: Mountainous Area Haro River, Khanpur Model (%)	Southern Parts of Fault: Mountainous Area Soan River, Cherah Model (%)	Southern Parts of Fault: Plain Area Sil River, Chahan Model (%)
Upstream of Rawal Dam[1/]	138.1	1,267	33.1	26.6	40.3
Upstream of K-2 Dam	137.0	1,556	22.0	67.7	10.3

1/: exclusive of K-2 Dam catchment area.

Figure B-5 shows the Tank Model built in three river basins mentioned above, which are formulated based on the verification between rainfall and discharge in each river basin. Figure B-6 to Figure B-8 indicate the relationship between computed and observed runoff discharge in the three river basins.

2.2.2. Areal Rainfall

Areal rainfalls in each catchment area of Rawal Dam and K-2 Dam was estimated on the daily basis for the periods of 35 years, 1952 to 1986, by applying Thiessen method as shown in Table B-39 and Table B-41, and they are summarized as follows;

Estimated Areal Rainfall

Item	Catchment Area of Rawal Dam	Catchment Area of K-2 Dam	Total
Catchment Area (sq.km)	138.1	137.0	275.1
Annual Areal Rainfall (mm)[1/]	1,267.4	1,555.6	1,410.9

1/: Used rainfall stations;
Rawal Dam: Rawal Damsite and Barkot
K-2 Dam : Rawal Damsite, Barkot and Murree

2.2.3. Results of Runoff Analysis

By using the above mentioned procedures, the runoff discharges at the both damsites are analyzed for the periods of 35 years as shown in Table B-42 to Table B-44, and they are summarized as follows;

Estimated Runoff Discharges

Item	Rawal Damsite	K-2 Damsite	Total
Catchment Area (sq.km)	138.1	137.0	275.1
Annual Runoff Discharge (MCM)	40.9	62.1	103.0

2.3. Evaluation of Estimated Runoff Discharge

Runoff discharges estimated by the both methods mentioned above are summarized as shown belows;

Estimated Runoff Discharges in Kurang River

Item	W/O Project	W/Project		
	Rawal Damsite	Rawal Damsite	D-2 Damsite	Total
Catchment Area (sq.km)	275.1	138.1	137.0	275.1
Annual Areal Rainfall (mm)	1,410.9	1,267.4	1,555.6	1,410.9
Annual Runoff Discharge (MCM)				
By SDO Estimation	100.9	-	-	-
By Tank Model Estimation	103.0	40.9	62.1	103.0

As is observed in the above figures, about 2.1 MCM of runoff discharges equivalent about two percent of the estimated discharge are different between both figures. However, it can be considered that the usage of the runoff discharges estimated by applying Tank Model Method would be more practicable and reasonable in case that the project plan inclusive of K-2 Dam is formulated, because of the following reasons;

- Runoff discharge at the proposed K-2 Dam could not be estimated by using the specific discharge based on the Rawal damsite data calculated by SDO, because the rainfall magnitude in the catchment area of K-2 Dam is quite different from that of Rawal Dam catchment area.
- Considerable unreliable observed and calculated data are included in the SDO record.
- Unreasonable runoff discharges are observed in SDO data during the periods of January and February as shown in Figure B-10.
- Difference of estimated discharge of about two percent is deemed to be permissible extent in the terms of calculation.

In the project plan, therefore, the estimated runoff discharge by the Tank Model Method will be used for hydrological study such as reservoir operation study.

TABLE B-34. MONTHLY INFLOW DISCHARGE AT RAWAL DAM

CATCHMENT AREA : 275.1 SQ.KM

(UNIT:MCM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1962	******	******	******	******	******	-3.06	8.78	45.10	4.26	-1.50	-1.62	-0.41	******
1963	-1.92	0.44	1.21	-0.62	-1.40	-2.93	14.55	14.76	0.25	-1.26	-1.82	-0.96	20.30
1964	7.11	0.00	0.26	-1.12	-2.08	-2.82	28.20	29.12	7.47	-1.03	-1.74	-2.42	60.95
1965	-0.16	4.54	5.36	9.39	11.99	-0.02	18.00	33.78	0.39	-2.02	-2.43	-1.86	76.96
1966	-2.20	5.42	-0.13	-0.08	-1.80	2.19	16.94	11.50	1.88	3.02	-1.36	-1.03	34.35
1967	-1.16	4.01	10.90	4.32	-0.08	-0.98	12.98	39.82	13.06	-0.13	-0.89	4.02	85.87
1968	2.87	2.57	5.25	0.61	-1.76	-2.34	16.84	47.64	1.23	0.54	0.14	0.16	73.75
1969	-0.41	1.61	1.08	-2.37	-0.51	-1.83	8.20	11.76	0.90	3.97	-2.22	-1.51	18.67
1970	1.07	1.62	5.47	-1.49	-1.67	0.06	4.90	40.21	2.25	2.62	-0.22	-1.51	53.31
1971	-2.32	-0.24	-1.60	-1.17	-0.16	25.18	18.01	67.45	10.68	-0.24	-0.94	-0.48	114.17
1972	0.45	0.84	3.26	0.74	-0.48	0.54	1.28	7.84	0.95	-0.84	-1.17	0.60	14.01
1973	1.25	2.08	6.39	-0.69	-0.28	1.81	16.76	46.56	11.09	1.86	-1.91	-0.94	83.98
1974	-0.73	0.71	-0.66	-0.65	-1.57	0.60	25.12	8.50	0.67	-1.71	-0.02	0.52	30.78
1975	0.10	0.50	0.17	0.23	0.37	-0.50	7.94	35.69	2.56	-0.88	-2.90	-1.11	42.17
1976	0.38	8.03	10.22	3.80	-3.80	1.75	22.56	83.60	32.78	2.36	0.29	-1.10	160.87
1977	0.40	-0.19	-0.54	-2.02	1.36	0.45	64.32	5.62	2.97	3.03	2.59	-3.28	74.71
1978	0.38	-0.32	0.37	1.39	-0.37	3.14	20.03	112.92	10.21	3.07	3.20	-2.94	151.08
1979	3.02	7.50	20.23	1.36	-1.42	-0.09	2.13	14.97	0.55	0.81	0.91	-0.47	49.50
1980	-0.76	0.48	4.85	0.36	-0.34	10.12	24.03	28.64	11.50	0.72	-1.36	-0.51	77.73
1981	-1.24	3.80	12.43	6.88	1.24	-1.37	30.00	39.61	5.86	0.08	2.86	-1.95	98.20
1982	-1.33	4.80	10.17	10.16	12.72	-1.76	19.72	44.11	8.89	2.98	2.87	-1.31	112.02
1983	1.36	2.24	4.68	30.15	6.42	1.10	10.95	30.16	39.56	5.50	1.62	-0.86	132.88
1984	-0.73	2.32	5.92	-0.21	-0.24	6.96	10.71	93.36	78.83	4.43	0.70	-0.53	201.52
1985	-0.52	-0.87	-0.59	0.22	-0.10	-0.33	29.04	34.94	6.40	7.03	-1.97	12.46	85.71
1986	2.05	7.56	14.28	6.13	2.46	-0.91	13.10	32.70	7.33	9.45	5.86	6.28	106.29
MEAN 1/	0.29	2.48	4.96	2.72	0.77	1.58	18.18	38.14	10.76	1.81	0.00	-0.03	81.66
MAX 1/	7.11	8.03	20.23	30.15	12.72	25.18	64.32	112.92	78.83	9.45	5.86	12.46	201.52
MIN 1/	-2.32	-0.87	-1.60	-2.37	-3.80	-2.93	1.28	5.62	0.25	-2.02	-2.90	-3.28	14.01

Source; Rawal Dam operation record prepared by SDO.

Note ; 1/ : No inclusive of 1962 data in mean, max. and min. figures.

TABLE B-35. MONTHLY RELEASED DISCHARGE FROM RAWAL DAM

(UNIT:MCM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1962	******	******	******	******	******	1.24	1.30	1.30	2.16	1.45	1.67	1.69	******
1963	1.78	1.55	1.72	1.72	2.10	2.65	2.73	1.72	1.32	1.67	1.54	1.77	22.27
1964	1.66	1.52	1.71	1.68	1.76	1.76	1.51	1.76	1.89	2.11	0.92	1.03	19.31
1965	2.41	1.90	2.21	1.93	1.80	2.20	2.12	1.54	1.06	1.51	1.71	1.56	21.95
1966	1.25	1.11	1.24	1.42	1.65	1.90	3.08	2.86	2.84	3.24	2.97	3.47	27.03
1967	3.42	2.94	3.27	3.40	3.81	3.69	3.49	1.91	3.28	3.18	3.24	2.90	38.53
1968	2.59	1.56	2.56	3.12	3.93	4.33	4.80	3.71	3.80	4.31	3.63	2.72	41.06
1969	3.00	2.70	3.23	3.42	3.99	3.67	3.90	3.68	3.34	2.85	2.30	2.36	38.44
1970	2.36	1.99	1.94	2.52	2.83	2.72	2.70	2.38	2.41	3.30	3.41	2.91	31.47
1971	2.67	2.31	2.70	2.80	3.65	3.28	3.53	2.97	2.98	4.04	3.74	4.88	39.55
1972	3.22	2.39	2.76	3.32	3.90	5.00	4.69	3.33	2.05	1.73	1.36	1.28	35.03
1973	1.21	1.07	1.35	1.91	3.06	3.50	3.36	3.36	2.80	3.83	4.03	4.16	33.64
1974	4.02	2.32	3.24	3.26	3.51	3.22	3.59	3.52	3.30	3.85	3.46	3.27	40.56
1975	2.94	2.57	2.89	2.59	2.71	2.72	2.81	2.79	2.56	2.64	2.59	2.77	32.58
1976	2.65	2.33	2.49	2.41	2.71	3.44	3.13	2.79	2.71	2.97	3.18	3.18	33.99
1977	3.18	2.84	3.31	2.67	3.12	3.36	2.60	2.49	2.37	3.03	3.31	3.41	35.69
1978	3.42	3.09	3.31	3.31	3.42	3.31	3.03	2.75	2.66	3.07	2.66	3.95	37.98
1979	3.03	2.74	3.03	2.91	3.09	3.61	4.12	4.11	3.98	3.99	3.71	3.83	42.15
1980	3.55	3.13	3.34	3.24	3.34	3.23	3.34	3.34	3.23	3.34	3.85	3.65	40.58
1981	3.37	3.04	3.44	3.49	3.54	3.35	3.46	3.46	3.35	3.46	3.35	3.46	40.77
1982	3.46	3.13	3.46	3.35	3.46	3.35	3.46	3.46	3.35	3.46	3.35	3.23	40.52
1983	3.23	2.92	3.23	3.13	3.85	3.72	3.59	3.23	3.13	3.23	3.31	3.85	40.42
1984	3.85	3.09	3.37	3.34	3.59	3.62	3.48	3.34	3.23	3.65	3.53	3.65	41.74
1985	3.42	2.92	3.22	3.03	3.13	3.03	3.13	3.13	3.09	3.17	3.32	3.33	37.92
1986	2.92	2.70	3.14	3.33	3.60	3.33	2.92	2.92	2.96	3.30	3.12	2.78	37.02
MEAN 1/	2.86	2.41	2.76	2.80	3.15	3.25	3.27	2.94	2.82	3.12	2.98	3.06	35.42
MAX 1/	4.02	3.13	3.46	3.49	3.99	5.00	4.80	4.11	3.98	4.31	4.03	4.88	42.15
MIN 1/	1.21	1.07	1.24	1.42	1.65	1.76	1.51	1.54	1.06	1.51	0.92	1.03	19.31

Source; Rawal Dam operation record prepared by SDO.

Note ; 1/ : No inclusive of 1962 data in mean, max. and min. figures

TABLE B-36. MONTHLY SPPILLED DISCHARGE AT RAWAL DAM

(UNIT:MCM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1962	******	******	******	******	******	35.28	0.00	0.00	0.00	0.00	0.00	0.00	******
1963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1964	0.00	0.00	1.43	0.00	0.00	0.00	12.46	27.58	6.23	0.00	0.00	0.00	47.70
1965	0.00	0.00	0.00	0.00	5.42	0.00	14.05	32.74	9.10	0.00	0.00	0.00	61.31
1966	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1967	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.37	8.96	0.00	0.00	0.00	43.33
1968	0.00	0.00	0.00	0.00	3.96	0.00	0.00	40.33	0.00	0.00	0.00	0.00	44.29
1969	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1970	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.68	0.00	0.00	0.00	4.68
1971	0.00	0.00	0.00	0.00	0.00	0.00	10.50	62.28	8.29	0.00	0.00	0.00	81.07
1972	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1973	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.23	9.28	0.00	0.00	0.00	29.51
1974	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1975	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00	16.20	74.90	29.83	0.00	0.00	0.00	120.93
1977	0.00	0.00	0.00	0.00	0.00	0.00	38.15	0.00	0.00	0.00	0.00	0.00	38.15
1978	0.00	0.00	0.00	0.00	0.00	0.00	0.00	112.81	7.06	1.29	0.00	0.00	121.16
1979	0.00	0.00	12.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.17
MEAN 1/	0.00	0.00	0.80	0.00	0.55	0.00	5.37	23.84	4.91	0.08	0.00	0.00	35.55
MAX 1/	0.00	0.00	12.17	0.00	5.42	0.00	38.15	112.81	29.83	1.29	0.00	0.00	121.16
MIN 1/	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source ; Rawal Dam operation record prepared by SDO.

Note ; 1/ : No inclusive of 1962 data in mean, max. and min. figures.

2/ : Spilled discharges for seven years, 1980–1986, are not included in the above data due to no available data.

TABLE B-37. MONTHLY LOSSED DISCHARGE AT RAWAL DAM

(UNIT:MCM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1962	******	******	******	******	******	1.50	1.07	0.86	0.77	0.72	0.44	0.33	******
1963	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1964	0.31	0.42	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.17
1965	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1966	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1967	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1968	0.31	0.42	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.17
1969	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1970	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1971	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1972	0.31	0.42	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.17
1973	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1974	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1975	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1976	0.31	0.42	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.17
1977	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1978	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1979	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1980	0.31	0.42	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.17
1981	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1982	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1983	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1984	0.31	0.42	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.17
1985	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
1986	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15
MEAN 1/	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.16
MAX 1/	0.31	0.42	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.17
MIN 1/	0.31	0.40	0.64	0.86	1.25	1.50	1.07	0.86	0.77	0.72	0.44	0.33	9.15

Note: Water losses are estimated by following criteria:

Water seepage: 2 percent x Effective storage capacity (47.0 MCM)

Evaporation : Pan evaporation rate x 0.7 x water surface area (6 sq.km)

1/ : No inclusive of 1962 data in mean, max. and min. figures.

TABLE B-38. MONTHLY RUNOFF DISCHARGE OF KURANG RIVER AT RAWAL DAMSITE

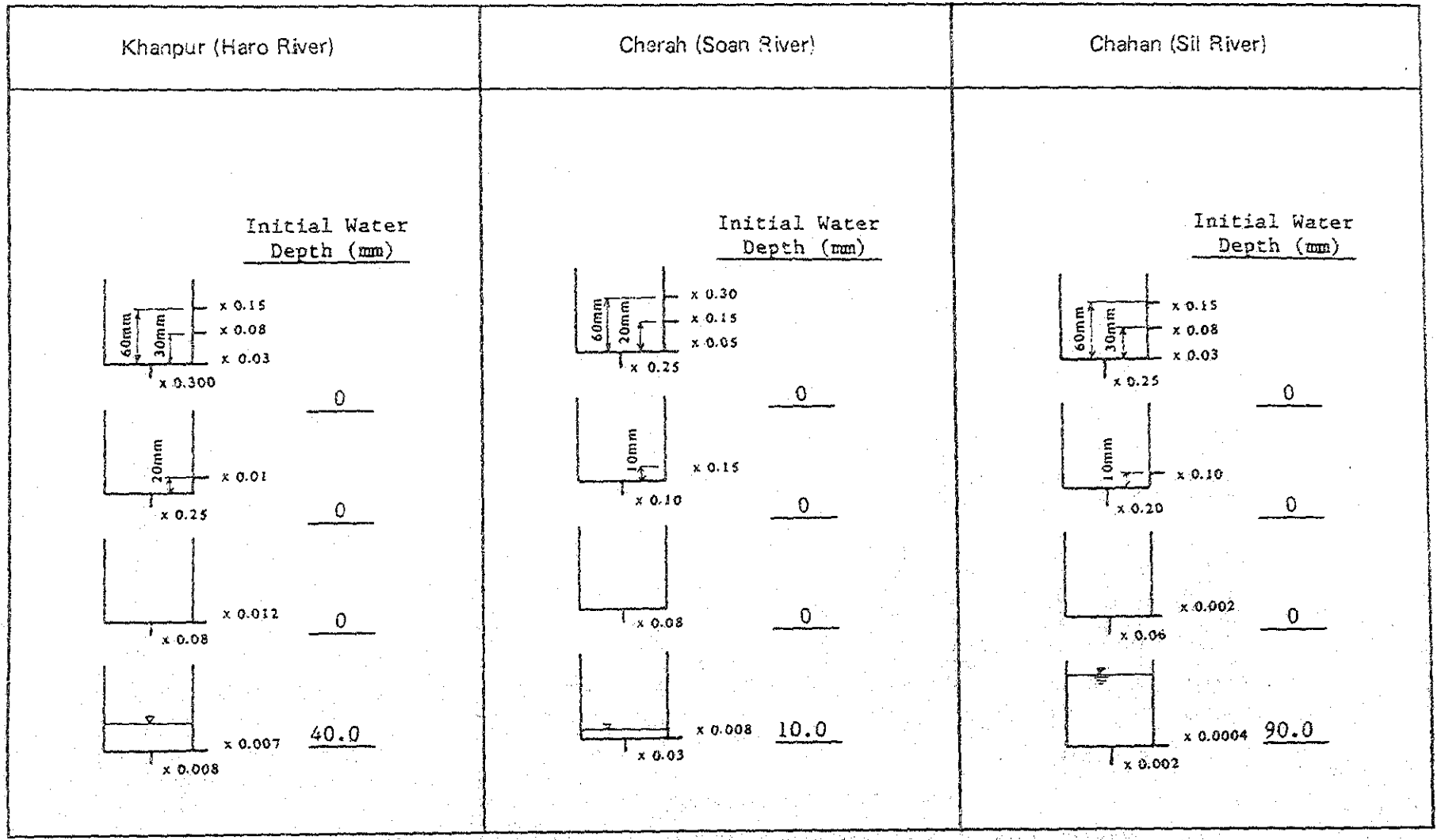
CATCHMENT AREA : 275.1 SQ.KM

(UNIT:MCM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1962	******	******	******	******	******	0.78	10.51	46.58	5.69	0.66	0.62	0.56	******
1963	0.49	1.37	2.41	0.86	0.71	0.78	16.28	16.24	1.68	0.66	0.62	0.56	42.66
1964	7.91	0.95	1.46	0.62	0.71	0.78	29.93	30.60	8.90	0.66	0.62	0.56	83.70
1965	0.64	5.47	6.56	10.87	13.95	2.26	19.73	35.26	1.82	0.66	0.62	0.56	98.41
1966	0.49	6.35	1.07	1.40	0.71	4.47	18.67	12.98	3.31	4.40	0.62	0.56	55.03
1967	0.49	4.94	12.10	5.80	1.88	1.30	14.71	41.30	14.49	1.25	0.62	4.91	103.79
1968	3.67	3.52	6.45	2.09	0.71	0.78	18.57	49.12	2.66	1.92	1.20	1.05	91.74
1969	0.49	2.54	2.28	0.62	1.45	0.78	9.93	13.24	2.33	5.35	0.62	0.56	40.19
1970	1.87	2.55	6.67	0.62	0.71	2.34	6.63	41.69	3.68	4.00	0.84	0.56	72.17
1971	0.49	0.69	0.56	0.62	1.80	27.46	19.74	68.93	12.11	1.14	0.62	0.56	134.72
1972	1.25	1.79	4.46	2.22	1.48	2.82	3.01	9.32	2.38	0.66	0.62	1.49	31.50
1973	2.05	3.01	7.59	0.79	1.68	4.09	18.49	48.04	12.52	3.24	0.62	0.56	102.68
1974	0.49	1.64	0.56	0.83	0.71	2.88	26.85	9.98	2.10	0.66	1.04	1.41	49.15
1975	0.90	1.43	1.37	1.71	2.33	1.78	9.67	37.17	3.99	0.66	0.62	0.56	62.20
1976	1.18	8.98	11.42	5.28	0.71	4.03	24.29	85.08	34.21	3.74	1.35	0.56	180.83
1977	1.20	0.74	0.66	0.62	3.32	2.73	66.05	7.10	4.40	4.41	3.65	0.56	95.45
1978	1.18	0.61	1.57	2.87	1.59	5.42	21.76	114.40	11.64	4.45	4.26	0.56	170.32
1979	3.82	8.43	21.43	2.84	0.71	2.19	3.86	16.45	1.98	2.19	1.97	0.56	66.44
1980	0.49	1.43	6.05	1.84	1.62	12.40	25.76	30.12	12.93	2.10	0.62	0.56	95.91
1981	0.49	4.73	13.63	8.36	3.20	0.91	31.73	41.09	7.29	1.46	3.92	0.56	117.37
1982	0.49	5.73	11.37	11.64	14.68	0.78	21.45	45.59	10.32	4.36	3.93	0.56	130.90
1983	2.16	3.17	5.88	31.63	8.38	3.38	12.68	31.64	40.99	6.88	2.68	0.56	150.04
1984	0.49	3.27	7.12	1.27	1.72	9.24	12.44	94.84	80.26	5.81	1.76	0.56	218.78
1985	0.49	0.53	0.61	1.70	1.86	1.95	30.77	36.42	7.83	8.41	0.62	13.35	104.54
1986	2.85	8.49	15.48	7.61	4.42	1.37	14.83	34.18	8.76	10.83	6.92	7.17	122.91
MEAN 1/	1.51	3.43	6.20	4.36	2.96	4.04	19.91	39.62	12.19	3.33	1.71	1.64	100.89
MAX 1/	7.91	8.98	21.43	31.63	14.68	27.46	66.05	114.40	80.26	10.83	6.92	13.35	218.78
MIN 1/	0.49	0.53	0.56	0.62	0.71	0.78	3.01	7.10	1.68	0.66	0.62	0.56	31.50

Note: 1/ : No inclusive of 1962 data in mean, max. and min. figures.

FIGURE 3-5. STRUCTURE OF TANK MODEL[1/]



Note: 1/ Report for the Regional Study for Water Resources Development Potential for the Metropolitan Area of Islamabad – Rawalpindi, 1987, JICA

FIGURE B-6. RESULT OF RUNOFF ANALYSIS (TANK MODEL METHOD) (1967)

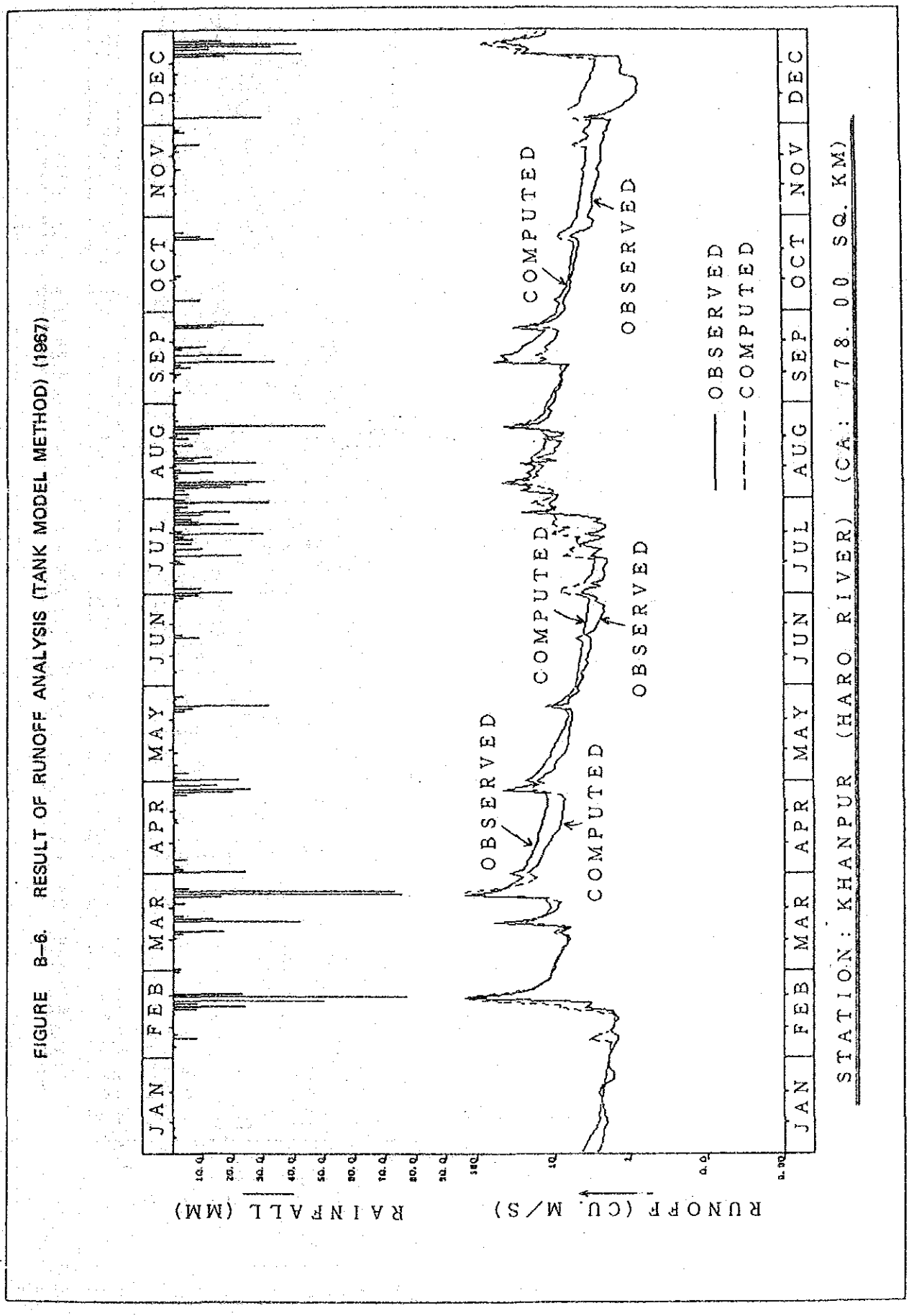
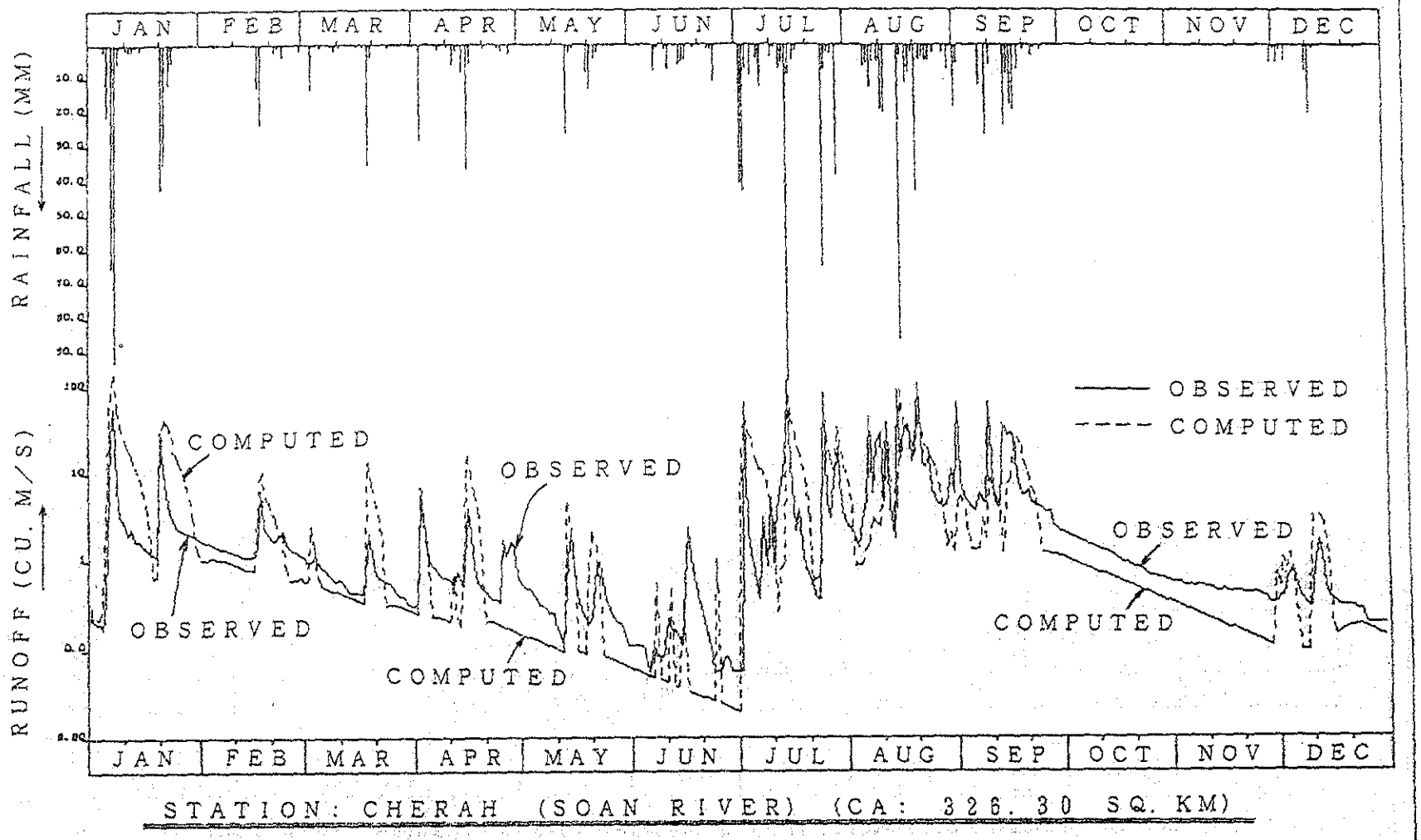


FIGURE B-7. RESULT OF RUNOFF ANALYSIS (TANK MODEL METHOD) (1964)



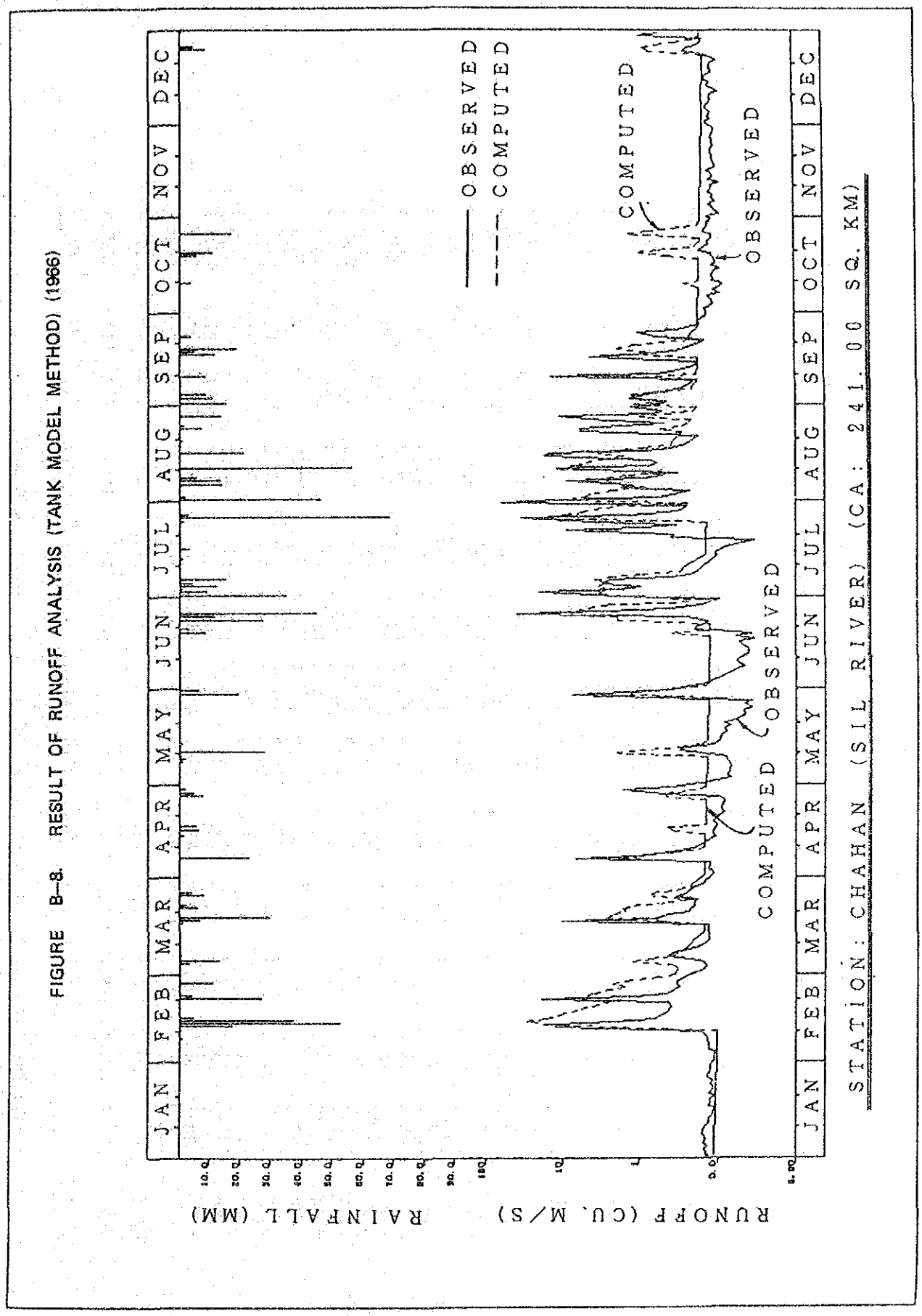


FIGURE B-8. RESULT OF RUNOFF ANALYSIS (TANK MODEL METHOD) (1966)

TABLE 8-39. MONTHLY AREAL RAINFALL AT RAWAL DAM BASIN 1/

CATCHMENT AREA : 138.1 SQ.KM

(UNIT:MM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1952	69.9	110.7	87.7	11.5	23.3	110.4	296.5	277.4	42.5	3.4	1.0	8.0	1042.5
1953	117.8	45.1	24.4	51.2	42.7	16.7	403.7	203.4	69.0	31.4	0.5	20.6	1026.5
1954	187.8	152.1	68.2	20.8	28.2	24.2	204.3	204.7	154.6	86.9	6.8	10.3	1148.9
1955	21.0	2.8	79.2	34.6	48.7	26.0	200.3	403.9	160.0	20.0	0.0	30.6	1027.2
1956	47.1	63.6	125.4	35.2	0.3	134.4	345.1	368.9	76.5	45.5	0.3	24.7	1266.9
1957	163.9	37.0	121.5	142.3	78.1	54.2	74.4	250.6	40.4	127.6	79.1	83.1	1252.1
1958	14.2	11.9	108.9	27.7	15.0	13.2	267.9	267.5	129.6	22.2	11.5	145.2	1035.0
1959	95.7	106.3	64.6	50.4	98.1	59.6	385.7	237.3	281.2	53.5	93.1	31.5	1557.0
1960	92.9	1.8	114.1	49.3	15.3	14.8	257.0	214.8	87.9	11.5	1.6	39.7	900.7
1961	144.8	62.4	34.1	160.2	29.4	42.9	270.5	198.0	280.7	53.8	52.3	13.1	1342.1
1962	15.7	66.7	86.7	50.0	38.8	61.1	220.9	372.1	98.8	7.4	33.0	112.8	1164.1
1963	0.0	32.0	118.6	62.3	50.4	19.4	279.1	505.0	219.2	8.1	44.8	62.2	1401.0
1964	231.5	29.8	40.0	82.0	45.2	25.6	393.6	280.0	144.9	0.0	1.6	7.1	1281.4
1965	49.8	137.6	131.6	262.6	131.1	30.2	142.2	178.9	7.9	18.2	33.1	16.7	1140.0
1966	0.0	210.6	92.6	65.0	70.9	104.6	212.2	228.2	140.5	55.5	0.0	27.6	1207.7
1967	0.0	125.1	216.1	58.9	39.2	15.5	250.8	254.4	101.8	34.7	15.2	187.4	1299.0
1968	89.5	118.4	69.8	33.2	14.8	28.2	328.9	424.4	13.1	36.1	47.1	85.5	1289.0
1969	14.4	122.3	71.3	34.4	46.5	24.3	151.6	248.8	85.7	146.2	8.1	0.0	953.7
1970	85.1	86.9	93.6	9.6	8.1	52.2	151.4	511.0	376.1	54.3	0.6	16.7	1445.7
1971	20.1	87.6	7.0	80.9	25.4	317.3	223.7	379.4	88.7	26.3	12.0	13.9	1282.4
1972	117.6	59.7	150.2	95.4	32.6	37.5	66.2	149.7	77.2	61.6	33.9	80.1	961.8
1973	83.9	78.1	91.8	33.3	56.0	113.4	232.9	409.6	86.2	26.8	0.0	31.2	1243.3
1974	42.4	65.0	23.8	18.2	31.3	101.5	328.2	189.5	76.4	0.0	0.0	38.0	914.2
1975	40.3	99.0	82.3	41.0	65.9	48.7	228.8	397.7	178.9	0.0	13.8	5.5	1202.0
1976	118.4	202.8	155.2	80.7	8.9	44.8	416.3	464.5	205.7	36.4	0.0	1.4	1735.1
1977	111.9	9.5	15.4	122.0	65.4	157.0	494.7	278.9	43.7	89.8	60.0	27.2	1475.4
1978	62.0	33.3	92.1	21.6	50.0	142.9	459.7	457.2	143.5	9.1	52.6	3.8	1527.9
1979	89.6	131.5	203.6	35.6	36.4	39.7	259.5	287.4	46.5	21.1	44.4	35.5	1230.5
1980	102.0	112.5	146.5	17.8	23.4	138.3	315.2	209.0	100.5	38.4	14.3	24.1	1242.1
1981	175.7	87.1	207.1	130.1	129.0	39.0	537.8	276.9	124.4	17.6	4.7	0.0	1729.4
1982	115.1	102.2	197.9	192.0	105.8	35.2	168.2	541.5	34.6	34.0	81.2	37.9	1645.8
1983	174.1	52.7	104.9	240.6	41.7	52.7	254.9	511.8	162.4	68.8	2.8	2.0	1669.5
1984	0.9	159.1	79.7	59.2	19.4	194.3	292.5	296.8	129.5	0.6	11.8	22.6	1266.5
1985	70.5	10.5	51.2	19.4	47.6	24.3	430.4	268.8	66.0	64.0	13.3	139.3	1205.2
1986	22.0	134.1	186.7	81.5	47.5	106.8	143.8	248.4	83.9	73.5	56.2	61.4	1245.8
MEAN	79.7	84.2	101.3	71.7	46.0	70.0	276.8	314.2	118.8	39.6	23.7	41.3	1267.4
MAX	231.5	210.6	216.1	262.6	131.1	317.3	537.8	541.5	376.1	146.2	93.1	187.4	1735.1
MIN	0.0	1.8	7.0	9.6	0.3	13.2	66.2	149.7	7.9	0.0	0.0	0.0	900.7

1/: ESTIMATED BY THIESSEN METHOD ON THE BASIN OF RAINFALL STATIONS OF RAWAL DAMSITE AND BARKOT

TABLE B-40. MONTHLY AREAL RAINFALL AT K-2 DAM BASIN 1/

CATCHMENT AREA : 137.0 SQ.KM

(UNIT:MM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1952	111.3	127.8	129.4	29.5	35.4	91.4	370.6	252.3	66.1	2.8	3.6	19.7	1240.1
1953	153.2	59.9	50.3	105.9	67.5	49.3	300.1	244.1	176.6	46.3	2.0	33.5	1288.7
1954	230.8	196.8	135.7	42.6	53.9	50.4	300.4	230.0	214.8	101.8	14.9	5.7	1578.0
1955	31.6	6.0	126.7	48.2	77.4	67.3	363.5	747.6	110.2	39.2	0.0	58.0	1675.8
1956	74.8	32.3	212.1	82.6	1.1	167.4	543.7	453.8	72.8	112.7	1.1	69.7	1824.0
1957	216.8	38.9	190.1	229.3	115.3	64.8	177.7	244.7	69.3	204.4	137.8	75.4	1764.6
1958	25.8	22.8	136.0	58.8	42.5	14.0	283.2	461.8	117.3	60.9	6.0	216.4	1445.4
1959	84.6	144.2	109.9	108.6	153.7	154.6	497.4	211.0	268.0	63.6	93.4	41.3	1930.3
1960	100.0	6.5	163.0	71.5	40.1	32.4	383.4	233.8	107.0	11.1	5.9	42.8	1197.4
1961	135.2	103.1	63.8	240.1	69.3	81.8	315.1	298.6	269.9	86.3	71.7	22.9	1757.8
1962	19.2	93.7	124.6	105.8	73.8	79.7	268.7	225.4	144.7	13.1	43.8	114.2	1306.8
1963	0.0	107.9	210.1	94.5	67.7	49.7	250.0	315.6	191.7	11.1	58.0	58.9	1415.0
1964	296.8	54.3	64.5	110.4	62.9	57.6	375.2	263.8	178.6	0.0	6.2	62.0	1532.4
1965	48.5	185.5	151.9	371.7	174.2	54.1	243.6	247.4	18.3	51.7	35.4	23.0	1605.4
1966	0.1	238.5	141.0	115.5	91.4	108.6	227.9	232.5	197.1	123.3	0.0	40.4	1516.3
1967	2.7	216.9	261.6	123.0	91.2	30.5	230.6	256.5	141.1	42.1	24.0	182.7	1603.1
1968	171.3	142.3	79.0	55.7	60.4	65.3	282.8	285.1	18.7	63.7	44.7	102.4	1371.3
1969	30.3	134.7	95.7	83.7	83.3	45.2	191.7	207.3	118.3	177.2	17.6	0.0	1185.1
1970	115.3	107.5	146.0	29.3	17.6	68.8	215.9	419.9	330.0	57.3	0.0	21.0	1528.7
1971	13.9	143.9	21.3	139.0	21.8	414.3	199.3	263.1	34.4	11.9	13.1	22.7	1298.8
1972	143.9	95.5	178.7	105.6	52.8	68.3	138.7	199.8	150.9	90.5	40.8	102.5	1368.1
1973	166.4	118.9	175.0	57.3	85.8	97.3	286.8	419.5	79.9	43.5	0.6	44.8	1575.8
1974	94.5	168.3	21.0	38.9	58.1	140.5	266.0	165.7	68.7	0.4	0.0	118.2	1140.2
1975	54.0	162.0	107.2	78.6	84.8	97.8	319.4	446.9	121.4	0.0	18.8	12.3	1503.4
1976	211.7	295.1	167.5	111.6	43.6	61.4	439.0	490.8	194.7	83.4	0.0	8.4	2107.2
1977	215.7	44.7	26.9	199.0	134.9	188.0	497.9	301.5	138.7	174.3	69.7	51.7	2043.0
1978	189.8	88.3	162.0	34.9	53.0	161.1	553.0	307.6	213.1	9.7	69.0	8.0	1849.4
1979	134.5	149.3	252.1	55.3	82.7	63.8	218.7	309.0	87.6	23.2	75.1	45.2	1496.6
1980	120.1	151.7	188.7	21.5	21.2	283.2	313.8	251.5	130.3	41.9	10.7	41.8	1576.5
1981	208.3	116.8	276.3	120.8	175.2	85.3	410.8	103.3	101.0	35.6	3.1	0.0	1636.5
1982	214.7	134.3	249.0	185.9	114.3	74.7	184.2	305.0	16.7	53.9	74.1	68.7	1675.5
1983	275.8	52.4	159.9	163.3	77.8	55.0	230.3	311.1	74.2	51.3	2.8	7.4	1461.4
1984	3.5	271.3	85.7	104.5	40.9	164.8	241.5	399.4	117.1	2.4	32.2	37.7	1501.2
1985	108.4	25.0	57.5	70.1	44.3	64.8	347.7	384.2	135.0	82.5	18.2	120.3	1457.9
1986	46.6	88.1	367.6	114.8	88.9	139.2	287.3	447.6	106.4	110.9	94.5	96.7	1988.8
MEAN	115.7	117.9	145.4	105.9	73.1	99.8	307.3	312.5	130.9	59.6	31.1	56.5	1555.6
MAX	296.8	295.1	367.6	371.7	175.2	414.3	553.0	747.6	330.0	204.4	137.8	216.4	2107.2
MIN	0.0	6.0	21.0	21.5	1.1	14.0	138.7	103.3	16.7	0.0	0.0	0.0	1140.2

1/: ESTIMATED BY THIESSEN METHOD ON THE BASIN OF RAINFALL STATIONS OF RAWAL DAMSITE, BARKOT AND MURREE

TABLE B-41. MONTHLY AREAL RAINFALL AT RAWAL DAM BASIN 1/

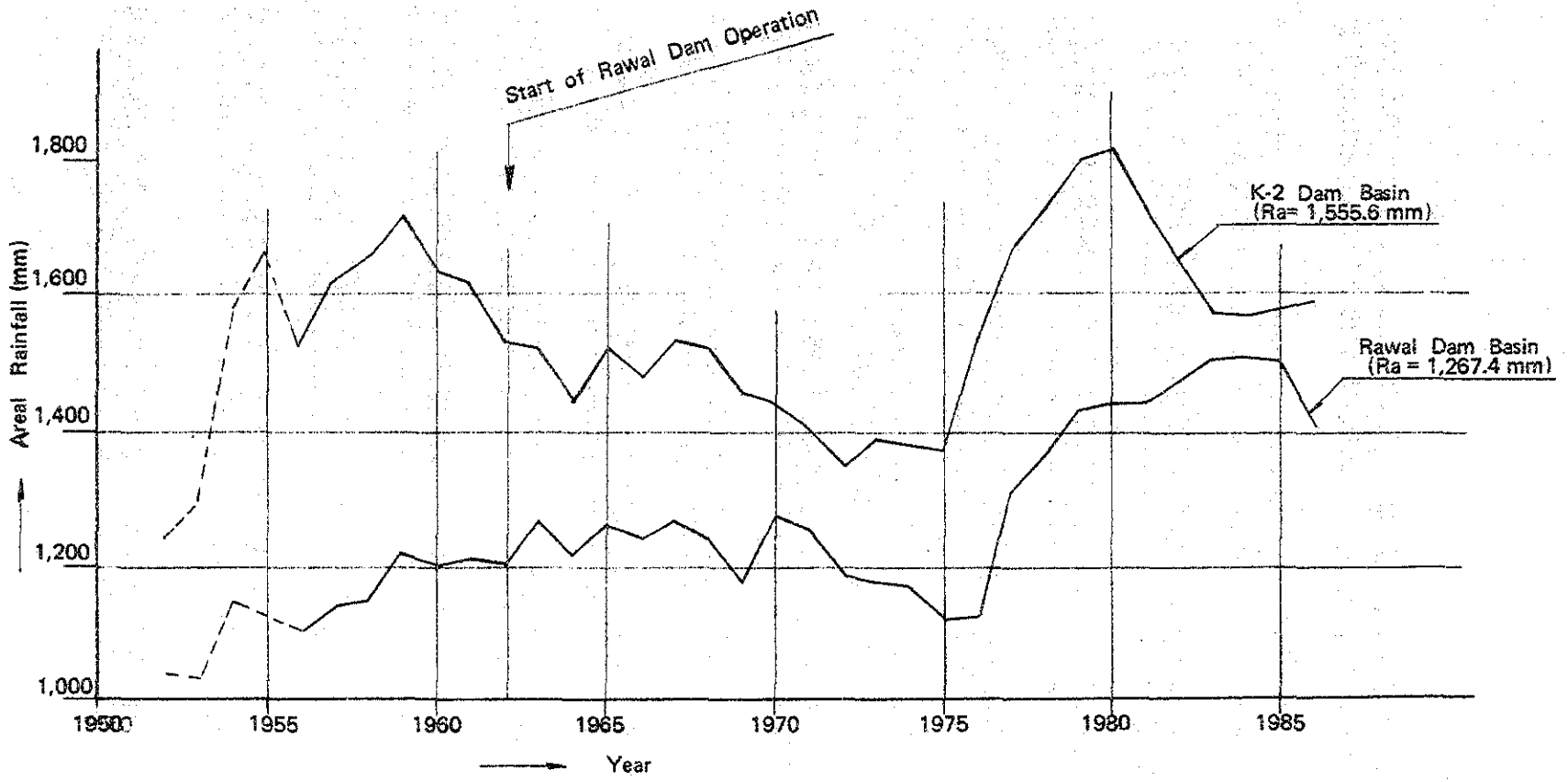
CATCHMENT AREA : 275.1 SQ.KM

(UNIT:MM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1952	90.5	119.3	108.5	20.5	29.3	100.9	333.4	264.9	54.3	3.1	2.3	13.8	1140.9
1953	135.5	52.5	37.3	78.4	55.0	32.9	352.1	223.7	122.6	38.9	1.2	27.0	1157.1
1954	209.2	174.4	101.8	31.7	41.0	37.2	252.2	217.3	184.6	94.3	10.9	8.0	1362.6
1955	26.3	4.4	102.9	41.4	63.0	46.6	281.6	575.1	135.2	29.6	0.0	44.2	1350.2
1956	60.9	48.0	168.6	58.8	0.7	150.8	444.0	411.2	74.6	79.0	0.7	47.2	1544.4
1957	190.2	38.0	155.6	185.6	96.6	59.5	125.9	247.7	54.8	165.8	108.3	79.3	1507.3
1958	20.0	17.3	122.4	43.2	28.7	13.6	275.5	364.2	123.5	41.5	8.8	180.7	1239.4
1959	90.2	125.2	87.2	79.4	125.8	106.9	441.3	224.2	274.6	58.6	93.2	36.3	1742.9
1960	96.4	4.1	138.5	60.4	27.6	23.6	320.0	224.2	97.4	11.3	3.7	41.2	1048.4
1961	140.0	82.6	48.9	200.0	49.3	62.3	292.7	248.1	275.3	70.0	62.0	18.0	1549.1
1962	17.5	80.2	105.6	77.8	56.2	70.4	244.7	299.1	121.7	10.3	38.4	113.5	1235.1
1963	0.0	69.8	164.1	78.3	59.0	34.5	264.6	410.7	205.5	9.6	51.3	60.5	1408.0
1964	264.0	42.0	52.2	96.2	54.0	41.6	384.4	271.9	161.7	0.0	3.9	34.5	1406.4
1965	49.2	161.4	141.7	316.9	152.6	42.1	192.7	213.0	13.1	34.9	34.2	19.9	1371.8
1966	0.1	224.5	116.7	90.2	81.1	106.6	220.0	230.3	168.7	89.3	0.0	34.0	1361.4
1967	1.3	170.8	238.7	90.8	65.1	23.0	240.7	255.5	121.4	38.4	19.6	185.1	1450.5
1968	130.2	130.3	74.4	44.4	37.5	46.7	306.0	355.0	15.9	49.9	45.9	93.9	1330.0
1969	22.3	128.5	83.5	59.0	64.8	34.7	171.6	228.1	101.9	161.7	12.9	0.0	1068.9
1970	100.2	97.2	119.7	19.4	12.8	60.5	183.5	465.6	353.2	55.8	0.3	18.9	1487.0
1971	17.0	115.6	14.1	109.9	23.7	365.6	211.6	321.5	61.7	19.1	12.6	18.3	1290.6
1972	130.7	77.5	164.4	100.5	42.7	52.9	102.3	174.7	113.9	76.0	37.3	91.2	1164.2
1973	125.0	98.4	133.2	45.3	70.8	105.4	259.8	414.6	83.0	35.1	0.3	37.9	1408.9
1974	68.3	116.4	22.4	28.5	44.6	120.9	297.2	177.6	72.5	0.2	0.0	78.0	1026.7
1975	47.1	130.4	94.7	59.7	75.3	73.2	274.0	422.2	150.3	0.0	16.3	8.9	1352.1
1976	164.9	248.8	161.3	96.1	26.2	53.1	427.6	477.6	200.2	59.8	0.0	4.9	1920.4
1977	163.6	27.0	21.1	160.3	100.1	172.4	496.3	290.2	91.0	131.9	64.8	39.4	1758.1
1978	125.7	60.7	126.9	28.2	51.5	152.0	506.1	382.7	178.2	9.4	60.8	5.9	1688.0
1979	111.9	140.4	227.7	45.4	59.5	51.7	239.1	298.1	67.0	22.2	59.7	40.3	1363.0
1980	111.0	132.0	167.6	19.7	22.3	210.5	314.5	230.2	115.3	40.1	12.5	32.9	1408.7
1981	191.9	101.9	241.6	125.5	152.0	62.0	474.6	190.4	112.7	26.6	3.9	0.0	1683.1
1982	164.7	118.2	223.4	189.0	110.0	54.9	176.2	423.7	25.7	43.9	77.7	53.2	1660.6
1983	224.7	52.6	132.3	202.1	59.7	53.8	242.7	411.8	118.5	60.1	2.8	4.7	1565.9
1984	2.2	215.0	82.7	81.7	30.1	179.6	267.1	347.9	123.3	1.5	22.0	30.1	1383.4
1985	89.4	17.7	54.3	44.6	45.9	44.5	389.2	326.3	100.3	73.2	15.8	129.8	1331.0
1986	34.3	111.2	276.8	98.1	68.2	123.0	215.3	347.6	95.1	92.1	75.3	79.0	1615.8
MEAN	97.6	101.0	123.2	88.8	59.5	84.8	292.0	313.3	124.8	49.5	27.4	48.9	1410.9
MAX	264.0	248.8	276.8	316.9	152.6	365.6	506.1	575.1	353.2	165.8	108.3	185.1	1920.4
MIN	0.0	4.1	14.1	19.4	0.7	13.6	102.3	174.7	13.1	0.0	0.0	0.0	1026.7

1/: ESTIMATED BY THIESSEN METHOD ON THE BASIN OF RAINFALL STATIONS OF RAWAL DAMSITE, BARKOT AND MURREE

FIGURE B-9 5-YEAR MOVING AVERAGE OF AREAL RAINFALL



Note ; Areal rainfall above mentioned both basins are estimated by applying Thiessen method based on the following data ;

K - 2 Dam Basin ; Dam site and Barkot

Rawal Dam Basin ; Dam site, Barkot and Murree

TABLE B-42. MONTHLY RUNOFF DISCHARGE OF KURANG RIVER AT RAWAL DAMSITE 1/

CATCHMENT AREA : 138.1 SQ.KM

(UNIT:MCM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1952	1.67	2.77	1.13	0.43	0.29	0.98	6.82	9.67	1.70	0.94	0.59	0.45	27.44
1953	3.83	1.13	0.57	0.54	0.33	0.19	12.87	7.58	2.19	1.14	0.63	0.60	31.58
1954	5.60	5.60	2.34	0.97	0.70	0.44	3.50	4.63	4.28	3.87	0.74	0.59	33.25
1955	0.44	0.35	1.02	0.39	0.28	0.19	3.26	14.11	6.70	1.60	0.93	0.89	30.15
1956	1.49	1.07	3.77	0.76	0.48	1.21	7.29	12.75	2.94	2.90	0.96	0.91	36.51
1957	3.93	2.30	1.79	3.29	0.93	0.70	0.71	6.80	0.91	3.95	1.88	3.24	30.43
1958	0.86	0.51	2.46	0.52	0.35	0.25	5.57	10.07	4.28	1.14	0.70	5.96	32.66
1959	2.80	3.42	1.59	1.11	1.40	0.61	14.01	5.80	11.30	2.68	4.22	1.37	50.30
1960	3.26	0.88	1.82	0.82	0.48	0.34	4.22	4.73	2.40	0.84	0.52	0.68	20.98
1961	4.08	4.74	1.00	4.30	0.73	0.51	4.77	5.40	8.98	2.17	1.66	0.94	39.28
1962	0.65	0.89	1.57	0.53	0.36	0.49	4.04	13.64	2.85	1.28	1.13	3.99	31.44
1963	1.07	0.90	1.92	0.72	0.50	0.28	7.12	25.48	9.86	2.37	1.72	2.54	54.48
1964	11.27	1.84	1.31	1.21	0.79	0.43	12.12	10.37	5.04	1.51	0.96	0.72	47.55
1965	1.29	4.22	3.07	8.65	2.94	1.09	2.18	3.24	0.81	0.59	0.61	0.47	29.18
1966	0.28	8.43	2.58	1.15	1.80	1.80	4.22	7.18	3.38	1.29	0.63	0.75	33.49
1967	0.42	4.29	8.33	1.90	0.97	0.51	3.98	7.87	2.80	1.13	0.67	6.99	39.86
1968	3.84	3.98	2.76	0.97	0.60	0.45	8.72	22.23	2.43	1.62	1.68	3.32	52.60
1969	0.94	3.18	1.65	0.71	0.71	0.40	1.54	6.57	2.18	3.92	1.38	0.58	23.76
1970	3.12	1.72	4.04	0.68	0.47	0.51	1.27	20.45	19.26	3.55	1.73	1.33	58.13
1971	0.95	1.79	1.59	1.06	0.43	7.80	7.10	16.30	4.23	1.69	1.04	0.81	44.78
1972	3.42	3.01	4.34	1.44	0.74	0.54	0.48	1.83	0.89	1.04	0.66	1.93	20.31
1973	2.98	2.26	3.73	0.79	1.28	0.82	4.12	14.23	3.59	1.44	0.82	1.05	37.11
1974	1.03	1.02	0.52	0.33	0.25	0.67	11.17	4.47	1.91	0.89	0.53	0.69	23.47
1975	0.54	2.56	1.60	0.79	0.96	0.35	3.88	16.02	6.60	1.66	1.08	0.71	36.76
1976	3.77	7.81	6.01	2.64	1.03	0.77	12.99	29.04	9.26	2.35	1.35	0.95	77.98
1977	4.16	1.11	0.70	1.44	0.76	1.90	20.63	10.16	2.33	3.36	2.62	1.09	50.25
1978	1.33	0.85	1.86	0.48	0.82	2.71	19.69	21.80	5.64	2.30	2.18	1.08	60.74
1979	3.61	6.53	7.58	1.65	0.97	0.72	7.25	8.38	1.98	1.14	1.20	0.98	41.99
1980	3.88	2.22	3.27	1.08	0.70	1.91	7.01	4.90	2.26	1.38	0.74	0.72	30.07
1981	5.94	3.78	5.37	3.60	2.74	0.90	18.70	13.34	4.85	1.86	1.15	0.82	63.05
1982	3.16	2.87	6.12	5.97	2.30	0.96	3.39	29.67	2.60	1.72	3.95	1.40	64.12
1983	6.58	3.36	2.79	8.41	1.32	0.82	5.43	22.72	7.80	2.56	1.33	0.93	64.05
1984	0.66	6.48	2.53	1.09	0.61	4.74	9.04	8.97	5.33	1.57	1.02	0.90	42.94
1985	1.41	0.63	0.68	0.36	0.39	0.24	14.88	9.27	2.20	2.04	0.91	4.63	37.65
1986	1.71	5.27	6.31	2.35	1.07	1.12	1.61	6.17	1.33	2.13	1.17	2.21	32.47
MEAN	2.74	2.96	2.85	1.80	0.90	1.10	7.30	11.88	4.49	1.93	1.29	1.64	40.88
MAX	11.27	8.43	8.33	8.65	2.94	7.80	20.63	29.67	19.26	3.95	4.22	6.99	77.98
MIN	0.28	0.35	0.52	0.33	0.25	0.19	0.48	1.83	0.81	0.59	0.52	0.45	20.31

1/: EXCLUDING THE CATCHMENT AREA OF PROPOSED K-2 DAMSITE OF 137.0 SQ.KM

TABLE B-43. MONTHLY RUNOFF DISCHARGE OF KURANG RIVER AT K-2 DAMSITE

CATCHMENT AREA : 137.0 SQ.KM

(UNIT:MCM)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1952	4.67	4.48	3.07	0.87	0.40	0.76	15.19	9.54	2.04	0.80	0.43	0.49	42.75
1953	7.23	2.10	0.91	3.06	0.56	0.30	10.11	7.72	8.67	1.90	0.61	0.71	43.87
1954	11.73	9.96	4.66	1.55	0.96	0.51	10.93	8.96	9.57	6.41	0.89	0.53	66.66
1955	0.43	0.40	1.80	0.77	0.57	0.69	16.44	45.74	7.35	2.79	1.16	1.84	79.97
1956	3.97	0.79	8.59	1.59	0.61	2.95	24.25	25.63	4.15	4.63	1.46	3.07	81.68
1957	8.99	3.63	5.60	10.31	2.06	0.92	4.64	8.56	1.61	11.08	5.73	4.43	67.57
1958	1.16	0.65	5.02	0.84	0.46	0.23	9.50	29.09	3.62	2.07	0.65	13.25	66.53
1959	3.03	6.82	3.00	3.71	4.42	3.26	23.53	8.20	13.87	2.98	4.96	1.36	79.13
1960	4.21	0.73	4.76	1.30	0.61	0.32	17.34	6.74	3.53	0.93	0.46	0.71	41.64
1961	4.34	8.26	1.59	10.10	1.41	1.23	8.15	15.08	11.90	3.29	2.60	1.23	69.18
1962	0.61	2.01	4.00	1.56	1.00	0.87	9.29	6.75	3.64	1.08	1.20	4.65	36.66
1963	0.96	5.40	8.67	1.54	0.83	0.43	5.20	16.37	8.46	1.39	1.31	2.17	52.73
1964	18.85	2.62	2.05	2.27	0.81	0.35	14.67	11.27	6.85	1.31	0.68	2.01	63.73
1965	1.59	8.47	5.02	18.23	6.07	1.92	4.72	9.81	1.31	1.20	0.75	0.58	59.66
1966	0.24	11.89	5.76	2.47	2.52	1.84	4.45	8.15	8.78	3.88	0.88	1.29	52.16
1967	0.50	12.80	13.82	4.96	2.96	0.63	4.37	10.41	4.54	1.33	0.63	8.63	65.57
1968	8.18	7.18	3.82	1.14	0.62	0.63	8.12	14.70	1.55	1.62	1.42	4.47	53.45
1969	0.94	4.33	3.28	1.09	1.58	0.38	3.19	6.44	4.64	5.97	1.85	0.48	34.16
1970	5.62	2.75	8.75	0.94	0.47	0.60	3.78	18.61	21.65	3.25	1.16	0.96	68.55
1971	0.52	3.48	3.09	2.87	0.54	15.62	7.36	11.72	1.73	0.79	0.53	0.59	48.83
1972	5.34	5.85	6.69	1.85	0.87	0.64	1.37	4.00	5.17	2.81	1.22	3.83	39.64
1973	7.54	5.88	10.72	1.52	2.48	0.87	7.82	17.66	5.04	1.72	0.66	1.76	63.67
1974	3.37	6.64	1.40	0.66	0.39	2.12	8.12	3.15	1.27	0.62	0.26	4.73	32.72
1975	1.05	7.99	3.31	2.73	1.65	0.59	12.39	22.28	6.89	1.49	0.96	0.56	61.87
1976	10.64	16.94	8.84	4.71	1.20	0.89	20.18	33.90	10.68	3.21	1.01	0.68	112.89
1977	11.92	2.51	1.28	6.01	3.82	4.41	25.48	13.61	5.05	6.89	4.00	2.03	87.01
1978	8.54	5.43	6.56	1.14	1.20	3.09	31.55	18.17	7.57	2.39	2.91	0.79	89.34
1979	5.99	9.16	12.79	2.92	1.07	0.85	5.79	13.29	2.12	0.86	2.08	1.07	57.99
1980	5.78	5.18	6.48	1.73	0.67	10.65	9.18	12.30	4.63	1.46	0.79	1.29	60.14
1981	9.93	7.03	10.05	5.99	4.04	2.33	16.06	4.05	2.38	1.15	0.39	0.25	63.65
1982	9.41	7.43	12.35	6.60	2.39	1.49	5.40	13.16	1.34	1.30	3.52	1.88	66.26
1983	14.05	5.05	6.88	5.63	1.91	0.62	6.58	11.40	3.46	1.72	0.49	0.32	58.11
1984	0.20	15.44	3.46	2.71	0.78	3.13	7.30	18.54	5.78	1.39	0.96	0.79	60.47
1985	3.72	1.04	0.90	1.17	0.46	0.72	10.33	22.46	5.46	3.99	1.07	4.47	55.79
1986	2.75	2.76	20.69	5.17	2.20	1.80	9.16	26.35	3.63	5.56	4.12	5.61	89.80
MEAN	5.37	5.80	5.99	3.48	1.56	1.96	10.91	14.68	5.71	2.72	1.54	2.39	62.11
MAX	18.85	16.94	20.69	18.23	6.07	15.62	31.55	45.74	21.65	11.08	5.73	13.25	112.89
MIN	0.20	0.40	0.90	0.66	0.39	0.23	1.37	3.15	1.27	0.62	0.26	0.25	32.72

TABLE B—44. MONTHLY RUNOFF DISCHARGE OF KURANG RIVER AT RAWAL DAMSITE

CATCHMENT AREA : 275.1 SQ.KM

(UNIT:MCM)

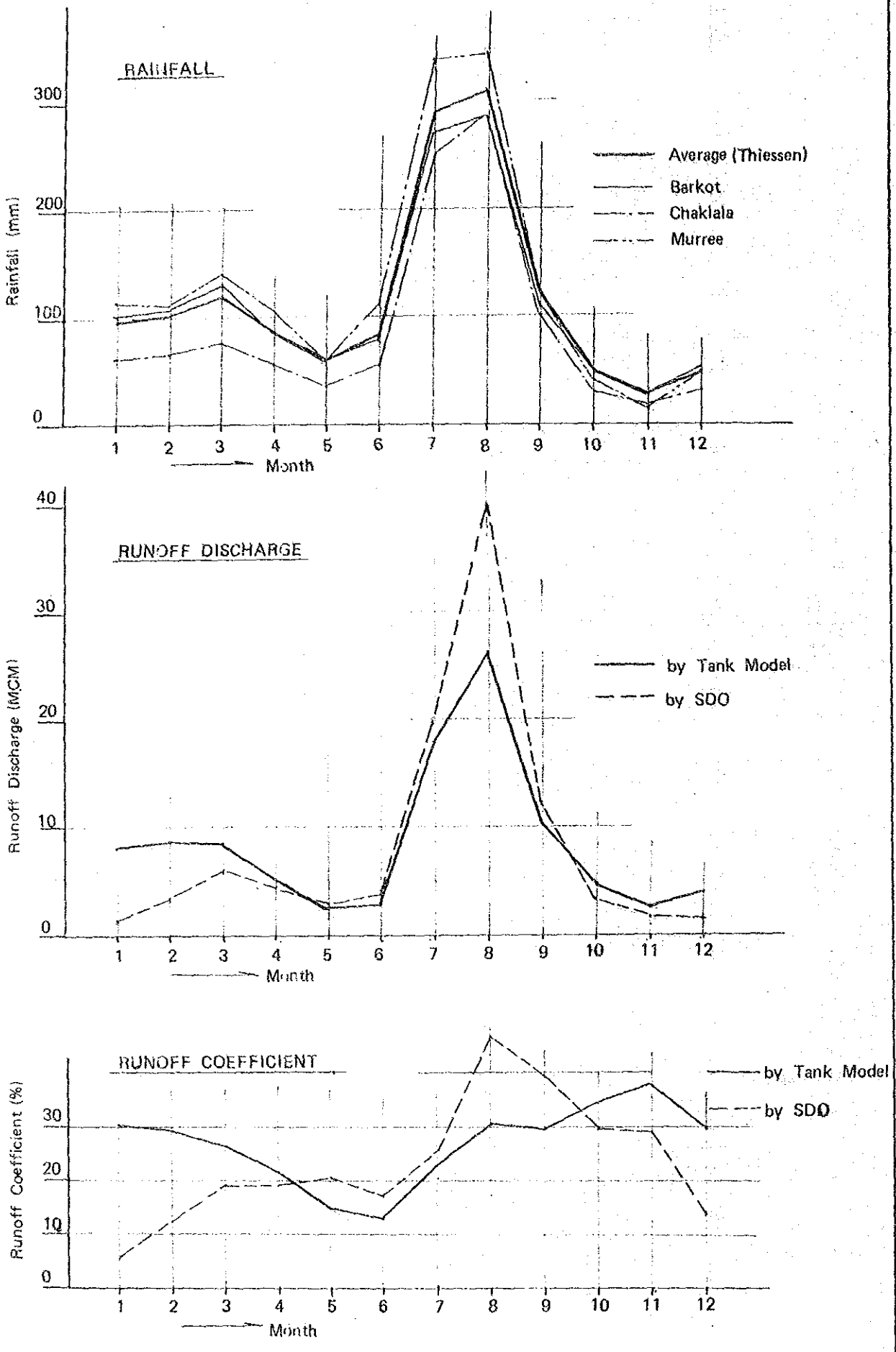
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1952	6.34	7.25	4.21	1.31	0.69	1.75	22.01	19.21	3.74	1.74	1.02	0.94	70.19
1953	11.06	3.23	1.48	3.60	0.88	0.48	22.97	15.30	10.86	3.03	1.24	1.31	75.43
1954	17.33	15.56	7.00	2.51	1.66	0.95	14.43	13.59	13.85	10.28	1.63	1.12	99.91
1955	0.87	0.74	2.82	1.16	0.85	0.87	19.71	59.85	14.04	4.39	2.09	2.73	110.12
1956	5.46	1.86	12.37	2.35	1.08	4.16	31.53	38.37	7.09	7.53	2.42	3.97	118.19
1957	12.92	5.94	7.39	13.60	2.99	1.62	5.35	15.37	2.52	15.04	7.61	7.67	98.01
1958	2.03	1.15	7.48	1.36	0.81	0.48	15.06	39.16	7.90	3.21	1.35	19.21	99.20
1959	5.83	10.24	4.59	4.81	5.82	3.86	37.54	14.00	25.17	5.66	9.18	2.73	129.44
1960	7.46	1.61	6.58	2.11	1.09	0.66	21.56	11.47	5.93	1.77	0.98	1.39	62.61
1961	8.42	13.00	2.59	14.41	2.13	1.74	12.92	20.48	20.88	5.46	4.26	2.17	108.46
1962	1.27	2.90	5.57	2.09	1.37	1.36	13.33	20.39	6.49	2.36	2.33	8.64	68.10
1963	2.02	6.30	10.59	2.27	1.33	0.71	12.32	41.85	18.32	3.76	3.03	4.71	107.20
1964	30.11	4.45	3.35	3.48	1.60	0.77	26.79	21.64	11.88	2.82	1.64	2.73	111.27
1965	2.88	12.70	8.10	26.87	9.01	3.01	6.91	13.05	2.12	1.79	1.35	1.05	88.84
1966	0.52	20.31	8.34	3.63	4.33	3.65	8.67	15.33	12.16	5.17	1.51	2.04	85.66
1967	0.92	17.09	22.15	6.86	3.93	1.14	8.34	18.28	7.33	2.46	1.31	15.62	105.45
1968	12.02	11.16	6.58	2.11	1.22	1.08	16.84	36.92	3.98	3.24	3.10	7.80	106.06
1969	1.88	7.51	4.93	1.81	2.29	0.78	4.73	13.00	6.82	9.89	3.23	1.06	57.92
1970	8.74	4.47	12.79	1.63	0.94	1.10	5.05	39.06	40.91	6.79	2.89	2.30	126.69
1971	1.47	5.27	4.68	3.93	0.98	23.41	14.46	28.02	5.96	2.47	1.57	1.39	93.62
1972	8.75	8.85	11.03	3.29	1.61	1.18	1.84	5.84	6.06	3.85	1.87	5.75	59.94
1973	10.53	8.14	14.45	2.31	3.76	1.69	11.94	31.90	8.63	3.16	1.48	2.80	100.79
1974	4.39	7.66	1.92	0.99	0.64	2.79	19.29	7.62	3.18	1.51	0.79	5.42	56.20
1975	1.59	10.55	4.92	3.52	2.61	0.93	16.27	38.30	13.48	3.15	2.04	1.27	98.63
1976	14.41	24.75	14.85	7.36	2.23	1.67	33.17	62.94	19.94	5.56	2.36	1.63	190.87
1977	16.07	3.62	1.98	7.45	4.58	6.31	46.11	23.77	7.38	10.25	6.62	3.12	137.26
1978	9.87	6.28	8.42	1.61	2.02	5.81	51.24	39.98	13.21	4.69	5.09	1.87	150.09
1979	9.60	15.68	20.36	4.58	2.04	1.58	13.04	21.68	4.09	2.00	3.28	2.05	99.99
1980	9.65	7.40	9.75	2.82	1.37	12.56	16.18	17.20	6.89	2.83	1.53	2.02	90.21
1981	15.87	10.81	15.42	9.59	6.78	3.23	34.76	17.39	7.24	3.00	1.55	1.07	126.70
1982	12.57	10.30	18.47	12.57	4.70	2.45	8.79	42.82	3.94	3.02	7.47	3.28	130.39
1983	20.64	8.41	9.66	14.03	3.24	1.43	12.01	34.12	11.26	4.27	1.82	1.25	122.15
1984	0.86	21.92	5.99	3.79	1.39	7.88	16.34	27.51	11.11	2.96	1.98	1.69	103.42
1985	5.13	1.67	1.58	1.53	0.85	0.97	25.22	31.73	7.66	6.03	1.97	9.11	93.44
1986	4.46	8.03	27.01	7.52	3.27	2.92	10.77	32.53	4.96	7.70	5.29	7.82	122.28
MEAN	8.11	8.77	8.84	5.28	2.46	3.06	18.21	26.56	10.20	4.65	2.83	4.02	102.99
MAX	30.11	24.75	27.01	26.87	9.01	23.41	51.24	62.94	40.91	15.04	9.18	19.21	190.87
MIN	0.52	0.74	1.48	0.99	0.64	0.48	1.84	5.84	2.12	1.51	0.79	0.94	56.20

TABLE B-45. COMPARISON OF RAINFALL, RUNOFF DISCHARGE AND RUNOFF COEFFICIENT BETWEEN SDO DATA AND TANK MODEL DATA

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1. Monthly Rainfall (mm)													
° Barkot	101.6	108.3	134.8	89.3	61.9	80.8	269.7	288.0	112.9	50.9	28.3	53.4	1,380.0
° Chaklala	62.3	67.8	78.2	57.2	37.8	57.3	254.0	287.6	101.5	30.3	19.6	32.2	1,085.8
° Murree	115.6	113.3	142.4	107.1	58.3	113.6	341.2	346.5	123.9	41.6	16.1	48.0	1,555.3
Mean	93.2	96.5	118.5	84.5	52.7	83.9	288.3	307.4 (22.8) 1/	112.8	40.9	21.3	44.5	1,344.5
° Areal Rainfall (mm)	97.6	110.0	123.2	88.8	59.5	84.8	292.0	313.3 (22.2) 1/	124.8	49.5	27.4	48.9	1,410.9
2. Runoff Discharge (MCM)													
° SDO Runoff	1.51	3.43	6.20	4.36	2.96	4.04	19.91	39.62 (39.3) 1/	12.19	3.33	1.71	1.64	100.89
° Tank Model Runoff	8.11	8.77	8.84	5.28	2.46	3.06	18.21	26.56 (25.8) 1/	10.20	4.65	2.83	4.02	102.99
3. Runoff Coefficient (%)													
° SDO Runoff	5.9	12.9	19.0	18.8	20.4	17.5	25.1	46.9	39.3	29.6	29.2	13.4	27.3
° Tank Model Runoff	30.2	29.0	26.1	21.6	15.0	13.1	22.7	30.8	29.7	34.1	37.5	29.9	26.5

Note: 1/: Monthly proportion of rainfall, runoff discharge and runoff coefficient against their annual figures.

FIGURE B-10 COMPARISON OF RUNOFF DISCHARGE



CHAPTER III. WATER QUALITY ANALYSIS

Water quality analyses for the Kurang River and its related water were made by the Study Team in the course of field work from irrigation and bacteriological view points. As the results, following data are collected;

i) Results of water quality analysis for two samples for irrigation purposes (see Table B-46)

ii) Results of water quality analysis for five samples for domestic water purposes (see Table B-47)

iii) Results of water quality analysis for nine samples for domestic water purposes (see Table B-48 and Table B-49)

TABLE B-46. RESULT OF WATER QUALITY ANALYSIS

Item		Results of Analysis No.1	No.2
pH			
Conductivity	mmhos/cm	0.29	0.32
Nitrate (N)	ppm	0.50	1.20
Phosphate (P)	ppm	0.003	0.050
Potassium (K)	ppm	21.00	28.00
Natrium (Na)	ppm	1.40	1.40
Iron	ppm	0.20	0.01
Calcium + Magnesium	mg/lit	0.40	0.44
Chloride	mg/lit	1.80	3.00

Note: 1/... Chemical analysis of above items was conducted by National Agriculture Research Center(NARC)

2/... Above water is sampled at the following points by Study Team;

No.1: A little upstream of the proposed K-2 damsite

No.2: Proposed Kc-2 head work

TABLE B-47. RESULTS OF CHEMICAL ANALYSIS OF KURANG RIVER WATER

Item	Results of Analysis				
	No.1	No.2	No.3	No.4	No.5
1. Temperature	12.0°C	12.0°C	12.0°C	12.0°C	12.0°C
2. Appearance	Clear	Clear	Clear	Clear	Clear
3. Turbidity	2	2	2	2	2
4. Odor	-	-	-	-	-
5. Taste	-	-	-	-	-
6. pH Value	8.3	8.4	8.1	8.2	8.2
7. Electrical Conductivity	353	333	330	560	484
8. Free Residual Chlorine	Nil	Nil	Nil	Nil	Nil
9. Free Carbon Dioxide (ppm)	4.2	4.5	4.0	4.0	4.2
10. Free Ammonia	Nil	Nil	Nil	Nil	Nil
11. Chlorides (ppm)	18	15	16	18	20
12. Alkalinity (M)(ppm)	116	108	110	185	162
13. Total Hardness (ppm)	180	176	172	288	260
14. Calcium Hardness (ppm)	115	112	100	195	178
15. Magnesium Hardness (ppm)	65	64	72	93	82
16. Oxygen Consumed (ppm) (1/2 hr. at 100°C)	1.25	1.2	1.35	1.2	1.5
17. Nitrites-N (ppm)	0.002	0.002	0.0025	0.0018	0.001
18. Nitrates-N (ppm)	0.45	0.4	0.5	0.35	0.4
19. Total Dissolved Solids (ppm)	272	266	264	448	357

Note: 1/ Chemical analysis on the above items was conducted by Central Engineering Laboratory, CDA on December 23 - 27, 1987.

2/ Above water is sampled at the following points by JICA Study Team;
- No.1: Immediately downstream of Rawal Dam
- No.2: Inside of Rawal Dam
- No.3: - do -
- No.4: Small tributary flowing into Rawal Dam
- No.5: Immediate upstream of Rawal Dam

TABLE B-48. CHEMICAL AND BACTERIOLOGICAL ANALYSIS REPORT OF WATER

	Item	WHO Desirable Level	WHO Max. Permissible Levels	Results of Analysis No.1	No.2	No.3	No.4
1.	Temperature °C			33°C	33°C	33°C	30°C
2.	pH	7.6 - 8.5	6.5 - 9.2	6.8	7.0	7.0	7.0
3.	Odor	Unobjectionable (U.0)	U.0	U.0	U.0	U.0	U.0
4.	Color	5 units	50 units	Colorless	Colorless	Colorless	Colorless
5.	Test	Unobjectionable (U.0)	U.0	U.0	U.0	U.0	U.0
6.	Turbidity ppm Silca, Unit of N.T.U.	5 units	25 units	Nil	Nil	Nil	Clear
7.	Total Dissolved Solids	500.0	1,500.0	292.0	292.0	270.0	536
8.	Calcium	75.0	200.0	30.4	32.0	32.0	40
9.	Magnesium	50.0	150.0	8.5	7.5	7.5	46
10.	Total Hardness, mg/lit as $CaCo_3$	100.0	500.0	110.0	110.0	110.0	284
11.	Total Alkalinity, mg/lit as $CaCo_3$			184.0	172.0	164.0	322
12.	Sulfate	200.0	400.0	52.5	56.0	42.0	77
13.	Chloride	200.0	600.0	15.0	18.0	18.0	25
14.	Iron Total	0.10	1.00	Nil	Nil	Nil	Nil
15.	Conductivity, um/cm or cs/cm			325.0	325.0	300.0	550
16.	Bacteriological Analysis	MF/100 ml		fit for con.	fit for con.	fit for con.	fit for

Data Source; Regional Research Laboratory, Public Health Engineering Department (PHED)

Note; Sampled Water:

No.1: Sampled at overhead tank of Ayub Park on August 4, 1987
No.2: Sampled at Topi Water Works on August 4, 1987
No.3: Sampled at bifurcation point on August 4, 1987
No.4: Sampled at Tret on June 1, 1987

TABLE B-49. BACTERIOLOGICAL ANALYSIS OF KURANG RIVER WATER

	Most Probable Number of Coliforms per 100 ml of Sampled Water
No.1 1/	Infinite
No.2	300
No.3	100
No.4	Infinite
No.5	200

Note: Analyses were made by Central Engineering Laboratory, CDA on February 14, 1988.

1/: Location of water sampling sites is same to the site mentioned in Table B-47.

ANNEX C. GEOLOGY AND CONSTRUCTION MATERIALS

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ANNEX C. GEOLOGY AND CONSTRUCTION MATERIALS

In this Feasibility study stage, the following investigation was conducted to obtain information relating to dam foundation and to the property of construction materials.

1) Core Drilling

- Core Drilling

Left Abutment	Depth	40 m	(131 ft)
River Bed	"	51.3	(168 ")
Right Abutment	"	40	(131 ")
Right Abutment, Saddle	"	30	(98 ")
Total		161.3 m	(528 ft)

- Permeability Tests in Drill Holes 30 Nos.
- Rock Tests of Rock Cores

Specific Gravity/Absorption Test	12 Nos.
Unconfined Compression Test	12 Nos.

2) Test Pits and Hand Auger Borings

- Test Pits

in Borrow area	5 Nos.
along Canal Alignment	7 Nos.

- Hand Auger Boring

in Borrow Area	5 Nos.

3) Soil Tests

- Physical Tests

Specific Gravity	ASTM D854	5 Nos.
Moisture Content	ASTM D2216	5 Nos.
Gradation	ASTM D422	5 Nos.
Liquid Limit	ASTM D423	5 Nos.
Plastic Limit	ASTM D242	5 Nos.

- Mechanical Tests

Compaction Test	ASTM D698	5 Nos.
Compaction Test	ASTM D1557	2 Nos.
Permeability Test	ASTM D2434	5 Nos.

FIGURE C – 1 LOCATION OF EXPLORATIONS FOR DAMSITE & BORROW AREA

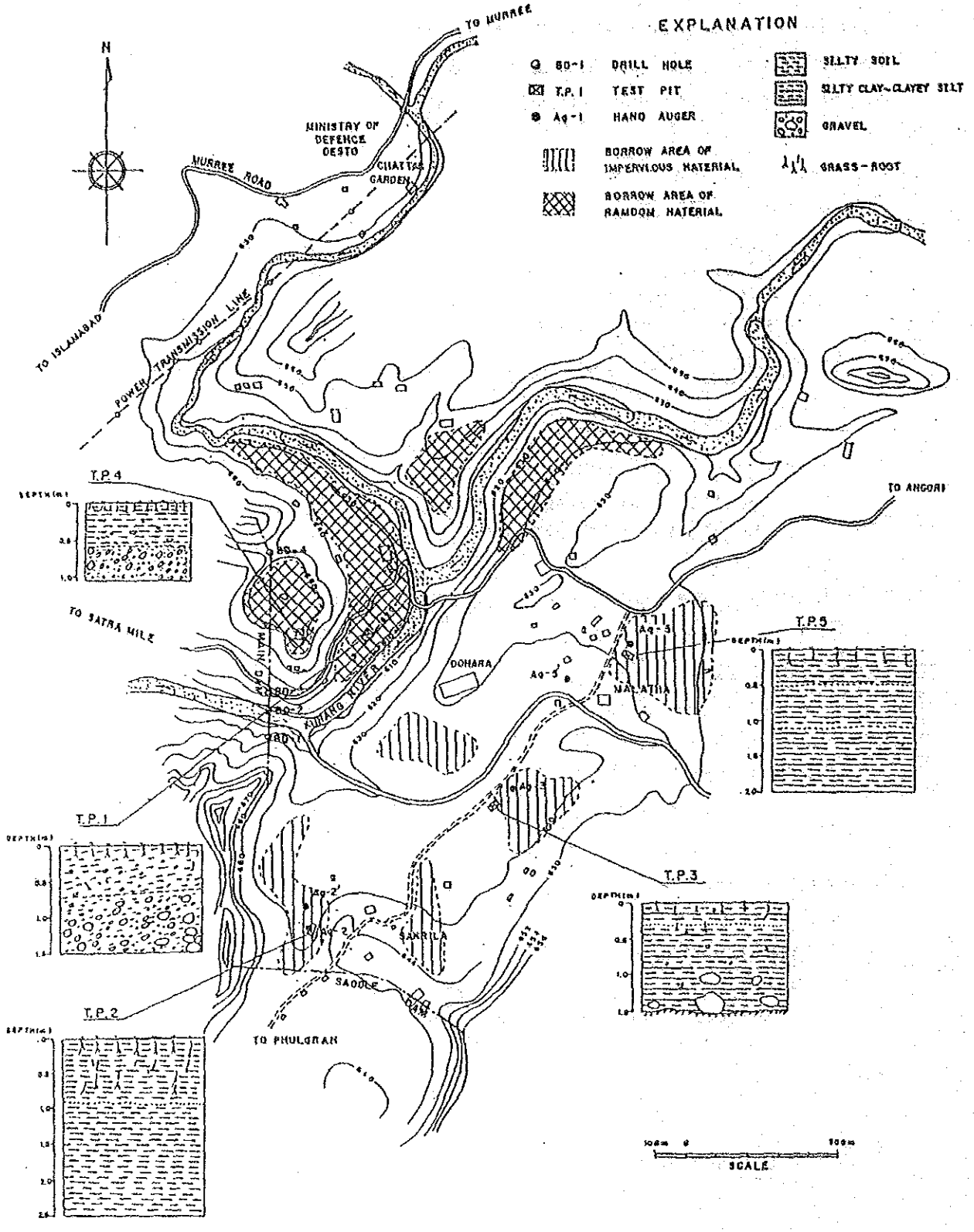


FIGURE C－2 LOG OF GEOLOGY EXPLORATION DRILL HOLE BD－1

NAME OF PROJECT: U.K.I.P　NAME OF PLACE : SAKRILA　MACHINE: KANO JR-150H　DIA OF HOLE φ66㎜

HOLE No. BD－1　LOCATION: LEFT BANK　GROUND ELEVATION: 627.5 m　ANGLE FROM VERTICAL: 0

BEGIN : 10.DEC.1987　FINISHED: 18.DEC.1987　THICKNESS OF SURFACE SOIL: 1.4 m　TOTAL DEPTH: 40 m

DEPTH OF WATER TABLE: 5.7 m　ELEVATION OF WATER TABLE: 621.8m　RECORDED BY: M. SUGA　HOLE LOGGED BY: M.SUGA

DEPTH (m)	ELEVATION (m)	THICKNESS (m)	COLUMN SECTION	COLOR	ROCK TYPE OR FORMATION	DESCRIPTION	CORE RECOVERY 50%	R. Q. D 20 40 60 80%	LUGEON VALUE 5 10 15 20 25
				red Br	Residuals	*Silty soil with soft gravel of weathered* sand-stone etc. Gravel can be crushed easily.			
1.4	626.1	1.4				0.9～1.4m ; clayey.			
				red Br	Mudstone (Granule bearing)	1.4～1.6m, 2.0～2.5m ; Gravel-like core. Medium dia is 1 ～ 3cm 40° ～50° of crack angle predominant, but the depth of 3.5 ～ 4.5m ; highly inclined crack cut the drilling core. Shallower than 2.5m ; *weathered.* Deeper than 2.5 m ; sound.			Lu' 2.9 Pc 2.5
7.0	620.5	5.6				Very soft as a whole, easily injured by finger nail. *Bears numerous angular granule, dia being* 1 to 2mm. Some part of bearing granule unrounded. Drilling core has very few crack and is long columnar, but because of very soft and weak, can be broken easily. Has no slickenside or filled material in crack.			Lu' 2.0 Pc 2.5
						7.0～35.7m ; Partly bears the few angular granule. Homogeneous as a whole. Three sets of crack angle; 70 ° ～90° , 45° ～60° , approx. 30° . Has very few crack and is long columnar as a whole, especially12.5～19.0m almost no crack Soft and weak.			Lu' 0 Pc >10
				red Br	Mudstone	15.2m, 16.25 ～16.7m ; contains greenish gray sandy patch, approx. 5mm to dia. *Deeper than 19m ; Has two 20° ～30° and 10°* ～90° of hair crack. 25.0～31.25m; though core is long columnar, comparing to the other part, relatively *brittle, cutted face of core not clean.* 33.5m, 34.15 m ; has greyish green silty sand vein (thickness 5mm) Can be found few slickenside in part. 28.55 ～28.65 m ,29.25 ～29.45 m ; gravel-like core. 32.0～33.4m, 34.0～34.8m;contains numerous granule and mudstone patch in part. Only 30° ～50° of crack can be found. 34.45m; has a thin calcite vein (thickness 0.5mm) 35～35m ; A little harder than the other part. Deeper than 36.7m ; Bears numerous granule and pebble or rock-*fragment, dia being* 2 ～30mm Conglomerate-like. Relatively hard comparing to the other part. Has a high angle half crack. *Each strata gradually changing.* Boundary ambiguous.			Lu' 0 Pc 3.5 Lu' 0.2 Pc 5.2 Lu' 0 Pc 6.5 Lu' 0.4 Pc 7.2
33.5	594.0	20.5							
				red Br	Sandy Mudstone				
36.7	590.8	3.2							
				red Br	Sandy Mudstone & Silty Sandstone (Granule and Pebble bearing)				Lu' 0.6 Pc 8.0
40.0	587.5	3.3							

notes : The abbreviation of the column of color means as followings

Gr → Gray　Br → Brown

red → reddish　Lt → Light

FIGURE C－3 LOG OF GEOLOGY EXPLORATION DRILL HOLE BD－2

NAME OF PROJECT: U.K.I.P NAME OF PLACE : SAKAILA MACHINE KANO 18-150 H DIA OF HOLE φ66㎜

HOLE No. BD－2 LOCATION: RIVER BED GROUND ELEVATION: 603.5 m ANGLE FROM VERTICAL: 0

BEGIN : 5 OCT . 1987 FINISHED: 6 DEC . 1987 THICKNESS OF SURFACE SOIL: 0.9 m TOTAL DEPTH: 51.3 m

DEPTH OF WATER TABLE: 0.73m ELEVATION OF WATER TABLE: 602.8m RECORDED BY: H. SUGA HOLE LOGGED BY: H. SUGA

DEPTH (m)	ELEVATION (m)	THICKNESS (m)	COLUMN SECTION	COLOR	ROCK TYPE OR FORMATION	DESCRIPTION	CORE RECOVERY 50%	R. Q. D 20 40 60 80%	LUGEON VALUE 5 10 15 20 25
0.0	603.5								
					River Deposit	Well graded sand-gravel-silt mixtures. Approx. 20% rounded ~subrounded gravels (by volume) to 8cm maximum size.			
0.9	602.6	0.9							
					Mudstone	Soft, soft and brittle gouge.			
2.1	601.4	1.25							
					Sandstone	Very hard, Coarse ~medium grain size, has a white 0.5~1mm Quartz or Clay vein. 70~90° crack dipping			
3.4	600.1	1.25							
					Sandy Mudstone	Very finely laminated, dip angle of laminae : approx. 60°			Lu' 0 Pc 1.3
4.6	599.9	1.2				Has pseudo-conglomerate patch.			
						4.50 ~ 4.60 m : brittle and fissured.			
						Fair, partly good, partly poor.			
						4.60 ~ 5.00 m : Very finely laminated.			
						Has slickenside at the depth of 6.50,6.70,			
						7.00 , 8.15, 8.20, 8.30, 8.50, 9.50 ~10.00			Lu' 1.7 Pc 1.8
						11.10, 12.30, 12.40, 12.50, 12.60,			
						15.10 ~15.20 metre.			
						Dip of crack and slickenside : approx. 60~ 80°			
						Has many hair crack and closed crack,			
						Has calcite veins.			
						Soft, can be injured easily by finger nail			
					Mudstone	separate easily along hair crack by a			Lu' 1.2 Pc 4.4
						little shock.			
						20.90 ~ 21.40 m Sheared and brittle,			
						Core sample is very poor. .			
									Lu' 0.5 Pc >10
21.5	582.05	16.95							
						Hard			
						Fair~Good			
						23.55 ~24.20 m ; Muddy,			Lu' 4.7 Pc 5.2 7.1
						very finely laminated with 1mm or 2mm muddy			
						laaina.			
						Dip of laminae ; 50~60°			
						21.90 m Pseudo- conglomerate (thickness 5 cm)			
					Sandstone	The other laminated part ; the depth of			Lu' 1.6 Pc 5.2
						25.30, 25.80, 26.50, 27.70, 28.30, 30.55			
						~30.80, 31.50 ~32.00 metre.			
						23.90 ~24.00 m ; has many slickenside.			
						The other parts of slickenside are at 31.50			
						32.60, 32.35 m			
						Has numerous muddy patch in the same alignment.			
32.5	570.95	11.0				Dip of crack ; 60~70°			Lw 6.0 Pc 6.5
						poor~Very Poor			
						Core recovery percentage very bad.			
						Non-recovery part seems to be brittle and			
						fractured consisting of angular rock frag-			
						ment and reddish brown muddy sand judged			
						from drilled slime and some part of drill-			
						ing core.			
						Partially recovered core as hard sandstone			Lu' 2.9 Pc >6.6
						dy be horse rock			
						As a representative core is 44 ~45m which			
						is comprised of sandy silt as matrix and of			
						angular sandstone gravel as coarse grain,			
					Sheared Zone	that demonstrate the typical cataclastic			
						rock.			
						As a whole, core is gravell-like or short			Lu' 1.7 Pc 5.2
						columnar of hard siliceous sandstone and			
						sandy siltstone.			
						Reddish brown sandy silt infills along the			
						laminae, joint and crack of sandstone.			
						47~48m ; oxidized in part , some part			
						silicified, or quartz vein found.			
48.1	555.7	15.05							Lu' 1.0 Pc >1.0
						Deeper than 48.2 m : columnar.			
						Core-recovery good as a whole.			
					Sandstone	Crack angle : 15° ~20° and 50° ~70°			
						Between 50.4~50.5m is Pseudo conglomerate			
						Shallower than 51m : Laminated.			
51.3	552.2	3.2				Along laina a lot of muddy patch.			

notes : the abbreviation of the colour of color means as followings

Gr → Gray Br → Brown

red → reddish lt → light

FIGURE C-4 LOG OF GEOLOGY EXPLORATION DRILL HOLE BD-3

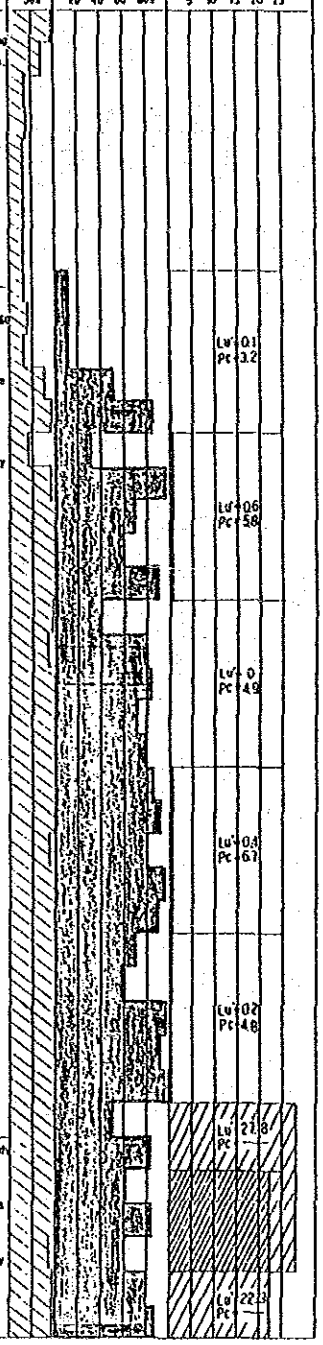
NAME OF PROJECT: U.K.I.P NAME OF PLACE: SAKRILA MACHINE: KANDIR-150H DIA OF HOLE φ 66%

HOLE No BD-3 LOCATION: RIGHT ABUTMENT GROUND ELEVATION: 624.0 m ANGLE FROM VERTICAL: 0

BEGUN: 19.Dec.1987 FINISHED: 07, Jan.1988 THICKNESS OF SURFACE SOIL: 8.5 m TOTAL DEPTH: 40 m

DEPTH OF WATER TABLE: 0.0 m ELEVATION OF WATER TABLE: 525.0m RECORDED BY: M. SUGA HOLE LOGGED BY: G. HUSSAIN

DEPTH (m)	ELEVATION (m)	THICKNESS (m)	COLUMN SECTION	COLOR	ROCK TYPE OR FORMATION	DESCRIPTION
				red Gr ~ Gr	Terrace Deposit	Consist of mainly silt as matrix and of rounded or subrounded pebble and boulder being gray hard sandstone and black siliceous rock. approx. 50~60cm to maximum dia. Percentage of gravel: 60~70%. Compacted. Dry and hard.
8.5	615.5	8.5		red Br	Mudstone	Reddish brown mudstone. The hair crack are present and it separate easily. Dipping at 60~75°. At some places along the joint or cracks the calcite is deposited. 9.5~19.5m: no or very bad core-recovery. Supposed to be a brittle and fractured part. Almost all core is long columnar, but easily broken by hand and easily injured by finger nail. 14~19m: relatively hard.
34.1	589.9	25.6		red Br ~ Br Gr	Muddy Sandstone	34.1~35.0m: A lot of angular granule~sand rock- fragments heared. Pseud - conglomerate - like. 35.0~40.0m Medium hard, fine to medium grain. Calcite is present along the joints. The dip is about 60~70°. 37.5~39.5m: laminated. Water loss is remarked. A thin layer of clay is present at 39.5m.
40.5	584.0	5.9				



notes: The abbreviation of the column of color means as followings

Gr → Gray Br → Brown

red → reddish Ll → Light

FIGURE C – 5 LOG OF GEOLOGY EXPLORATION DRILL HOLE BD – 4

NAME OF PROJECT: U·K·I·P NAME OF PLACE : SAKRILA MACHINE: HIRISON KANO DIA OF HOLE : φ66m/m

HOLE No BD-4 LOCATION: RIGHT SADDLE GROUND ELEVATION: ANGLE FROM VERTICAL: 0

BEGUN : 10. JAN. 1988 FINISHED: 19. JAN. 1988 THICKNESS OF SURFACE SOIL: NIL TOTAL DEPTH: 30 METE

DEPTH OF WATER TABLE: GL-17.0 m ELEVATION OF WATER TABLE: RECORDED BY: G.HUSSAIN HOLE LOGGED BY: G.HUSSAIN

DEPTH (m)	ELEVATION (m)	THICKNESS (m)	COLUMN SECTION	COLOR	ROCK TYPE OR FORMATION	DESCRIPTION	CORE RECOVERY 50%	R. Q. D 20 40 60 80%	LUGEON VALUE 5 10 15 20 25
				red Br	Mudstone	Hard, reddish brown mud stone the hair cracks are present and it separate easily along the hair cracks. Dipping at 45° to 60° at some places slicken sides are present, along the weak surface joints the calcite is deposited.			Lu' =0.4 Pc =1.3
12.2		12.2							
				Br S Gr	Sandstone	Medium hard, fine grain light brown and grey fractured sand store, calcite present along the fractures. Dipping at 40° –60° drilling failed loss is 100g.			Lu' =23.0 Pc = —
16.7		4.5							
				red Br	Mudstone	Hard, reddish brown mud stone.			Lu' =2.0 Pc =7.8
20.1		3.4							
				Br S Gr	Sandstone	Medium hard, fine grain light brown and grey sand stone.			Lu' =10.7 Pc =5.8
25.9		5.8							
				red Br	Mudstone	Hard, reddish brown mud stone.			Lu' =19.8 Pc = —
28.7		2.8							
				red Br	Sandstone	Medium hard, fine grain light brown sand stone.			
30.0		1.3							

FIGURE C-6 RESULT OF WATER PRESSURE TESTS IN DRILL HOLES

BOREHOLE	STRATA	DEPTH (m)	LUGEON VALUE (ℓ/m/min)	COEFICINT OF PERMEABILITY (cm/sec)	CRITICAL PRESSURE (Kgf/cm²)	REMARKS
BD-1	Mudstone	4-8	2.9	4.613×10^{-5}	2.5	
		7-12	2.0	2.664×10^{-5}	2.5	
		12-17	0	0	>10	
		17-22	0	0	3.5	
		22-27	0.2	2.664×10^{-6}	5.2	Leak
		27-32	0	0	6.5	
	Sandy Mudstone	32-37	0.4	5.327×10^{-6}	7.2	
	Silty Sandstone	35-40	0.6	7.991×10^{-6}	8.0	
BD-2	Sandy Mudstone	3.5-5	0	0	1.3	
	Mudstone	5-10	1.7	5.737×10^{-5}	1.8	
		10-15	1.2	1.598×10^{-5}	5.4	
		15-20	0.5	6.659×10^{-6}	>10	
	Sandstone	20-25	4.7	6.259×10^{-5}	5.2-2.7	
		25-30	1.6	2.131×10^{-5}	5.2	
		30-35	6.0	7.991×10^{-5}	6.5	
	Sheared Zone	35-40	2.9	3.862×10^{-5}	> 6.6	
		40-45	1.7	2.264×10^{-5}	5.2	
		45-50	1.0	1.332×10^{-5}	>10	
BD-3	Mudstone	8-13	0.1	1.332×10^{-6}	3.2	
		13-18	0.6	7.991×10^{-6}	5.8	
		18-23	0	0	4.9	
		23-28	0.4	5.327×10^{-6}	6.7	
		28-33	0.2	2.335×10^{-6}	4.8	
	Muddy Sandstone	33-38	27.8	3.702×10^{-4}	—	
		35-40	22.3	2.970×10^{-4}	—	
BD-4	Mudstone	5-10	0.4	2.327×10^{-6}	1.3	Leak
	Sandstone	10-17	23.0	2.335×10^{-4}	—	fractured Sandstone
	Mudstone	17-22	2.0	2.664×10^{-5}	7.8	
	Sandstone	21.5-26.5	10.7	1.425×10^{-4}	5.8	
	Mudstone Sandstone	25-30	19.8	2.637×10^{-4}	—	

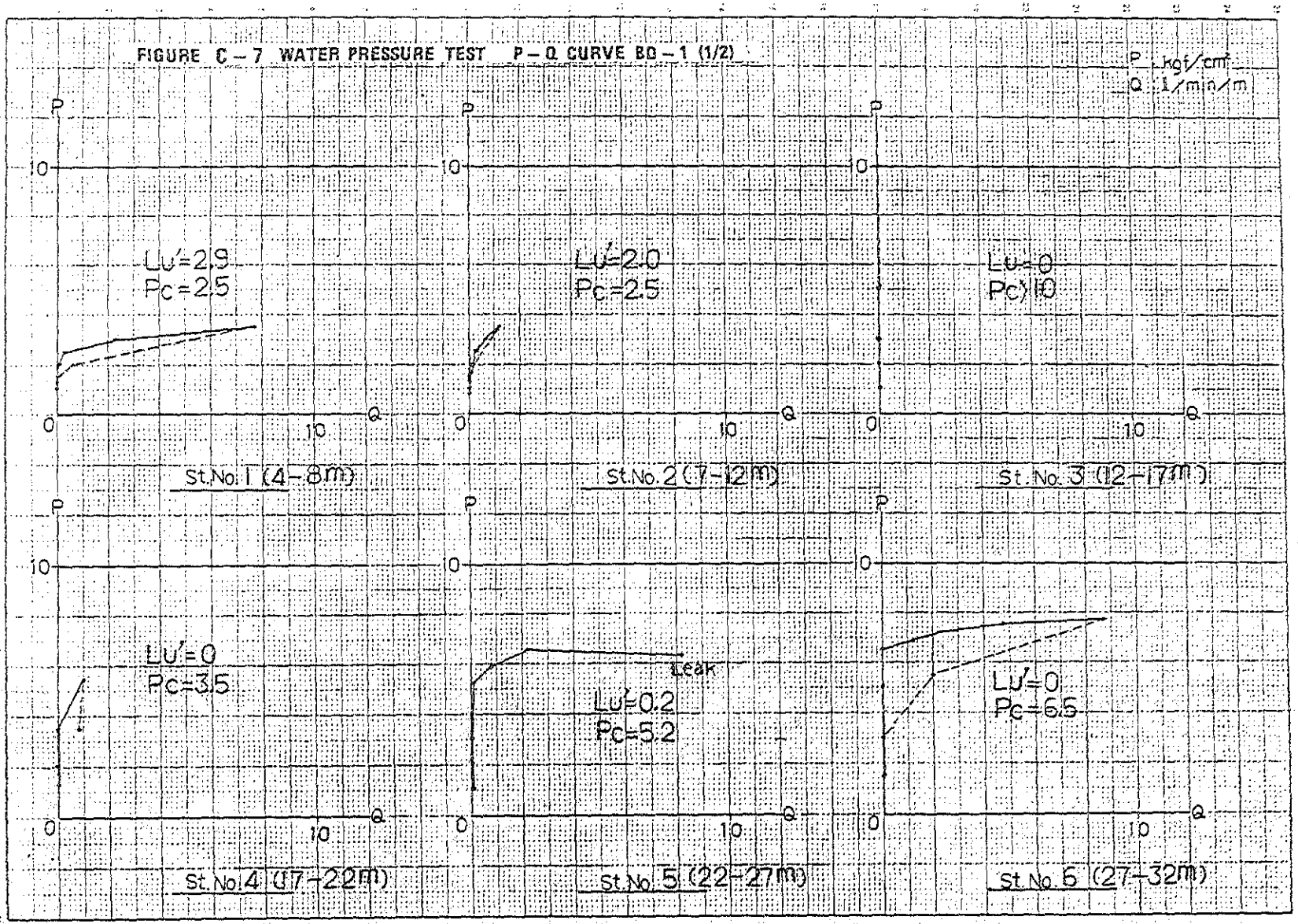


FIG. P-Q Curve BNo.BD-1

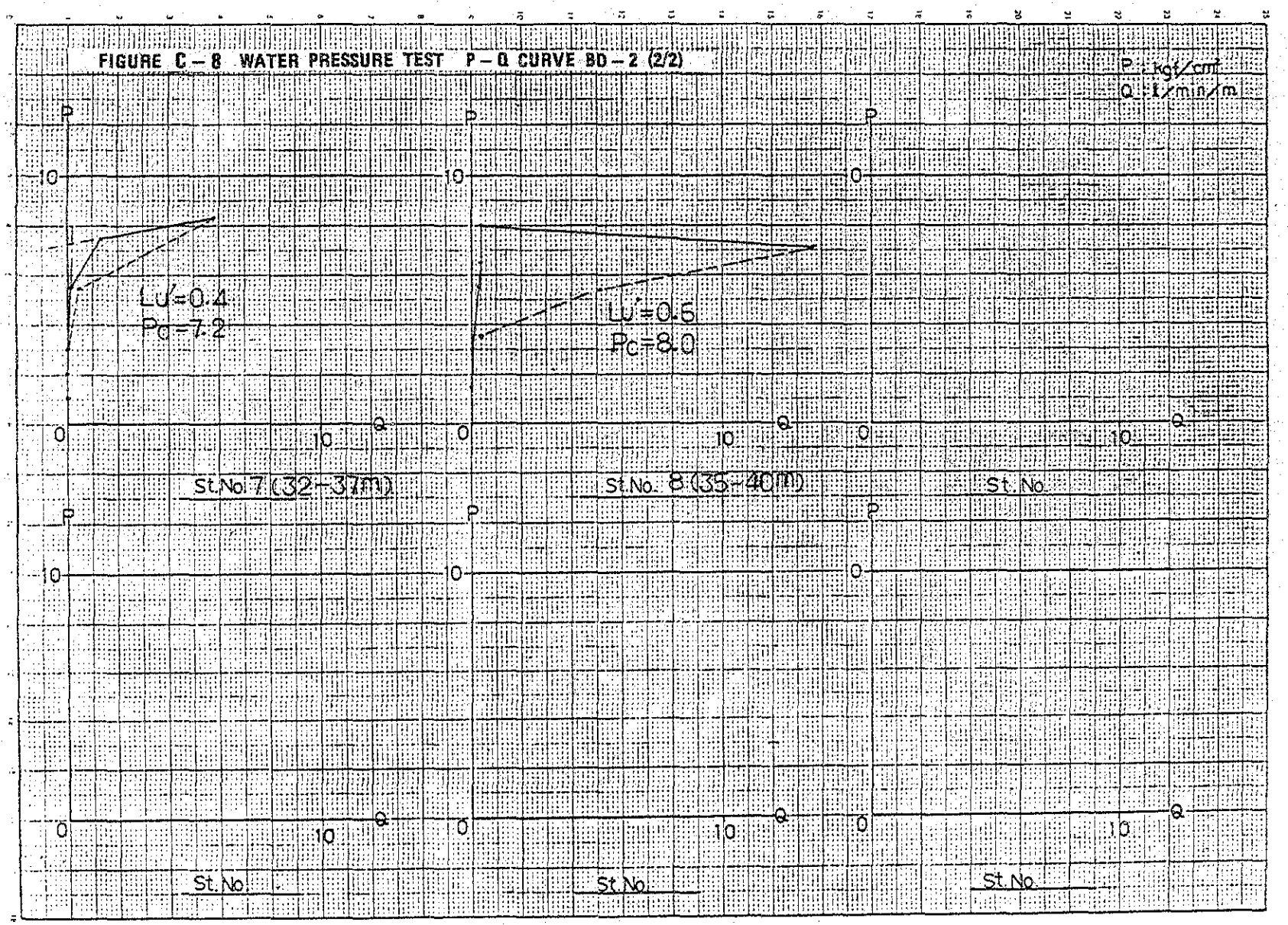


Fig. P-Q Curve BNo.BD-1

FIG. P-Q Curve BN. BD-2

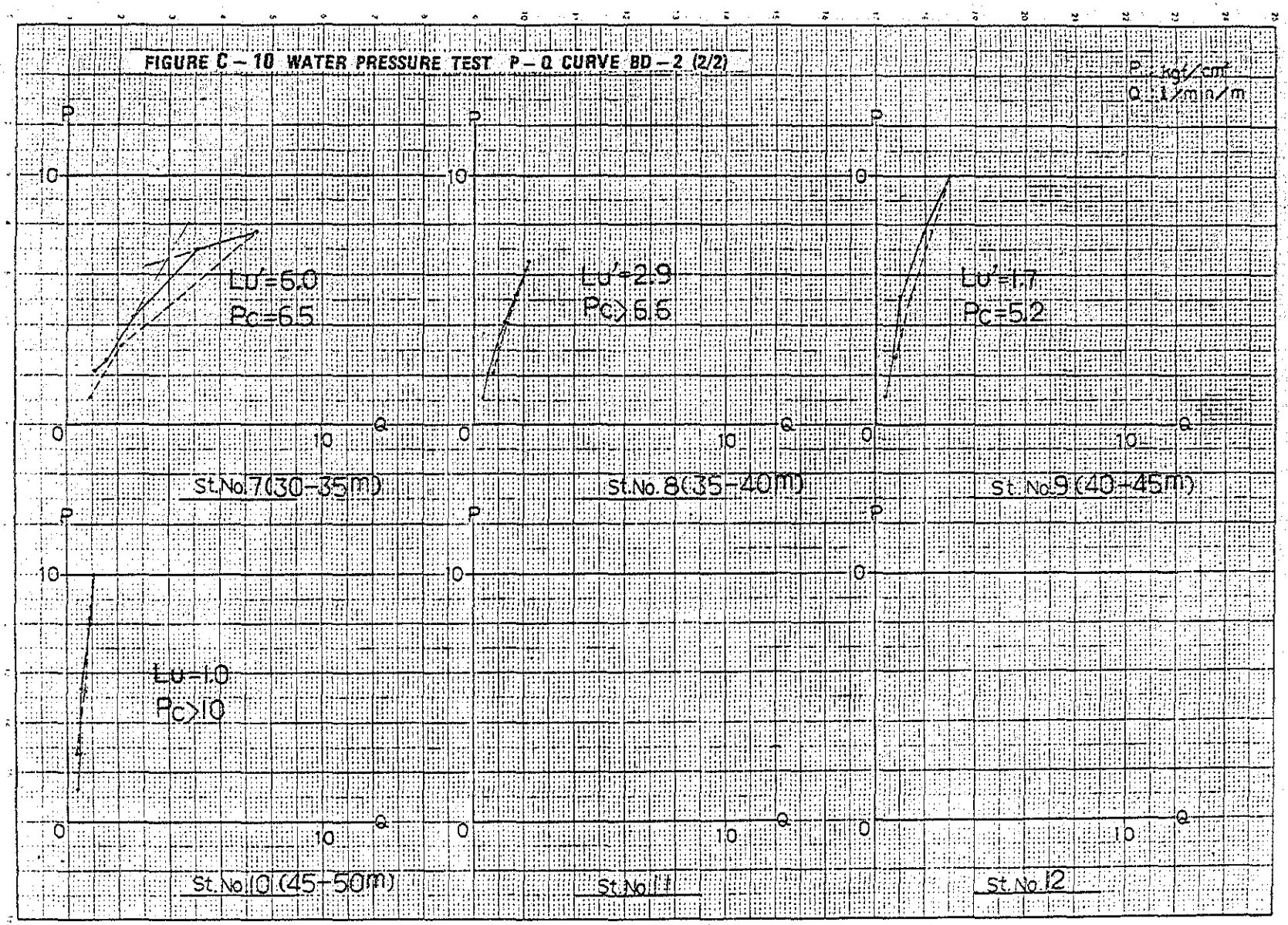


FIG. P-Q Curve BNo. BD-2

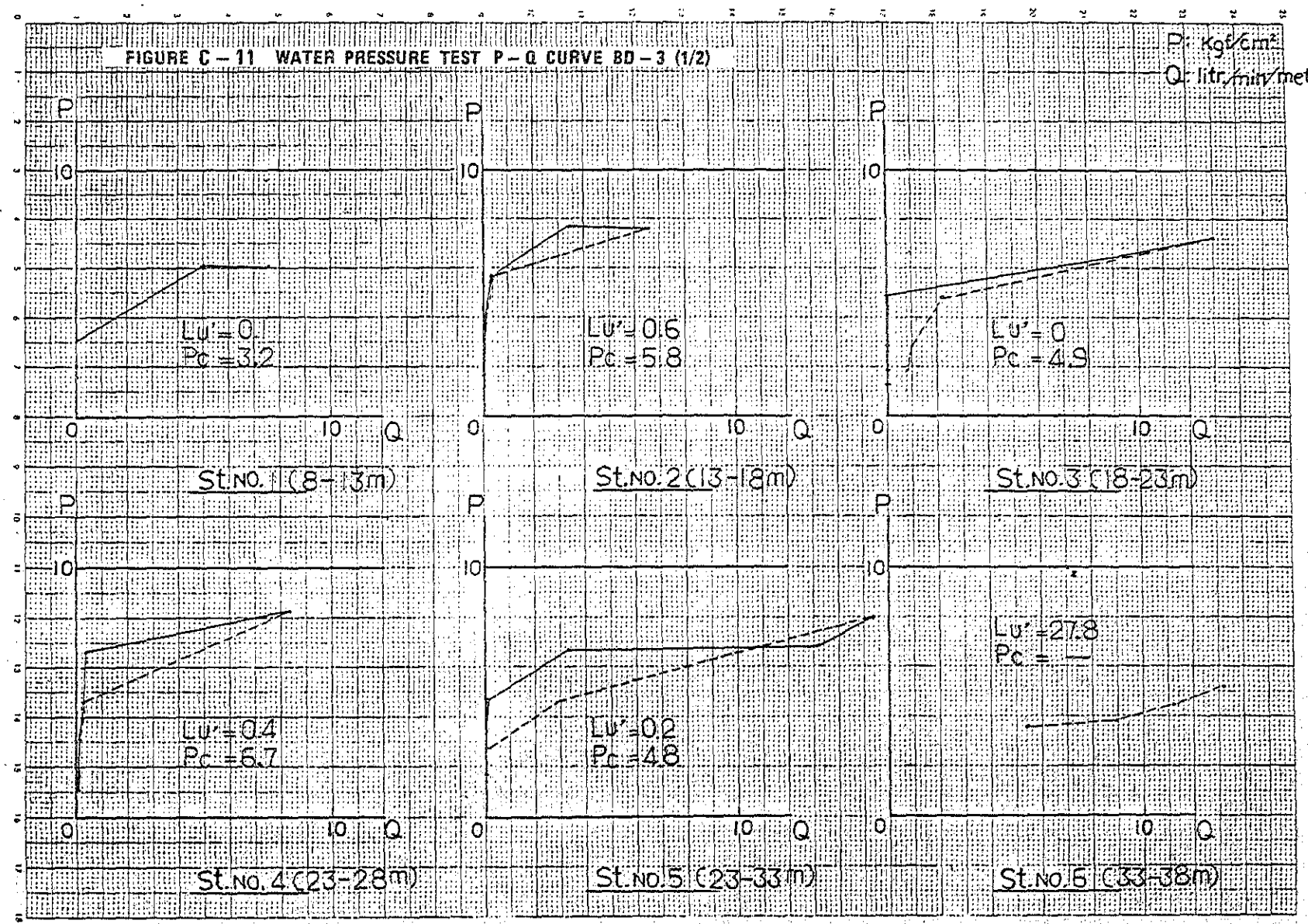


Fig. P–Q Curve BNo.BD-3

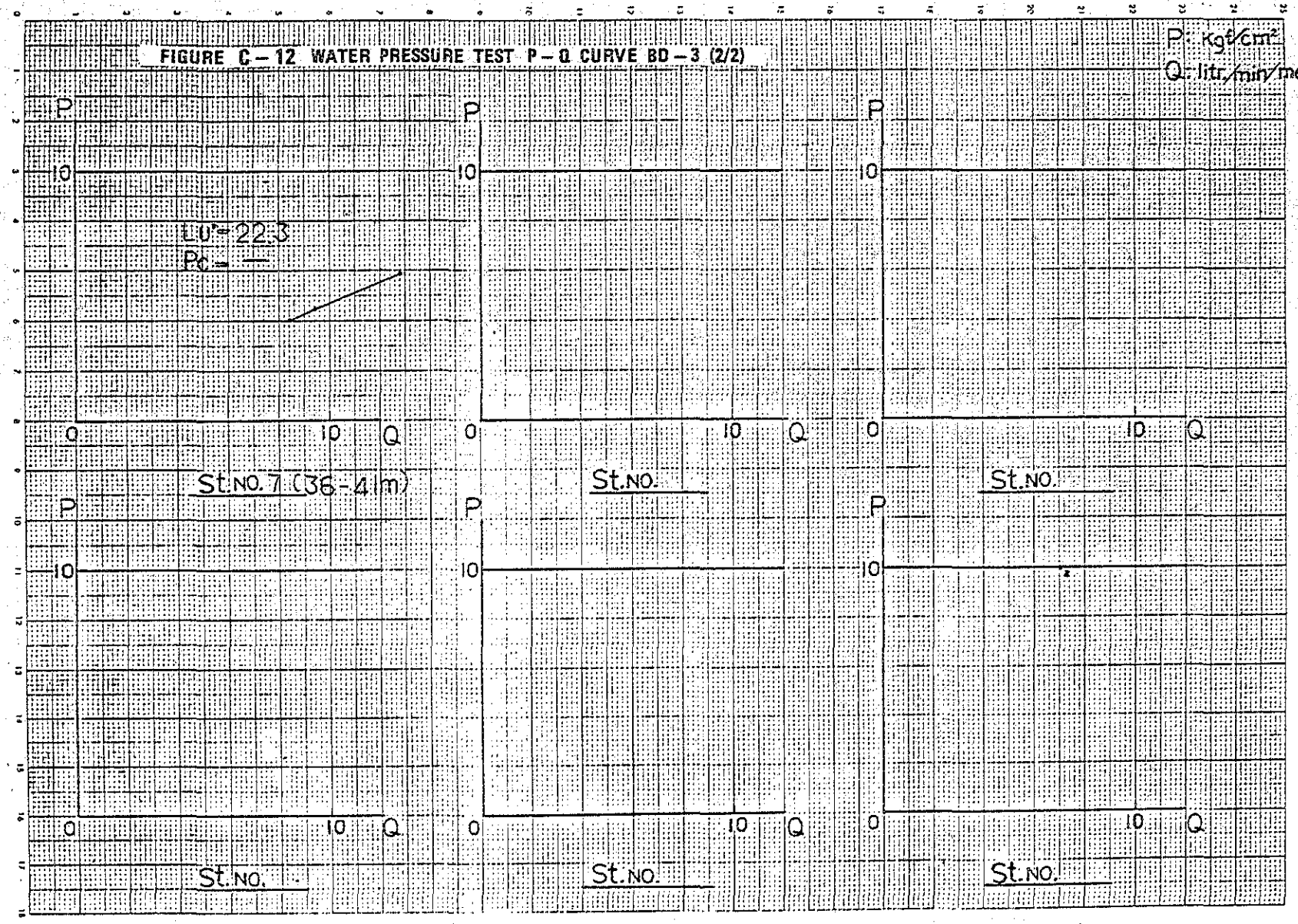
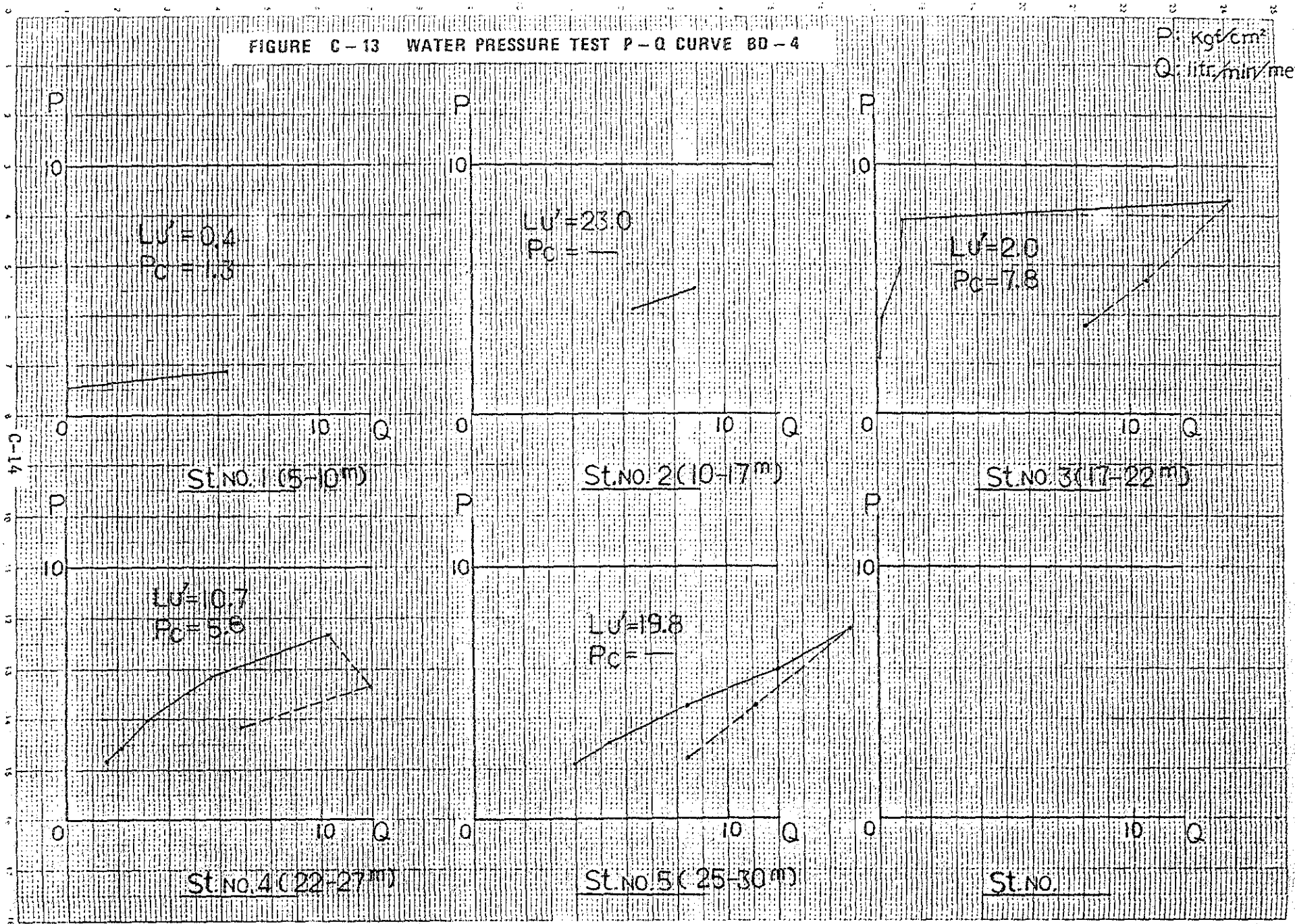


FIG. P-Q Curve BNo. BD-3

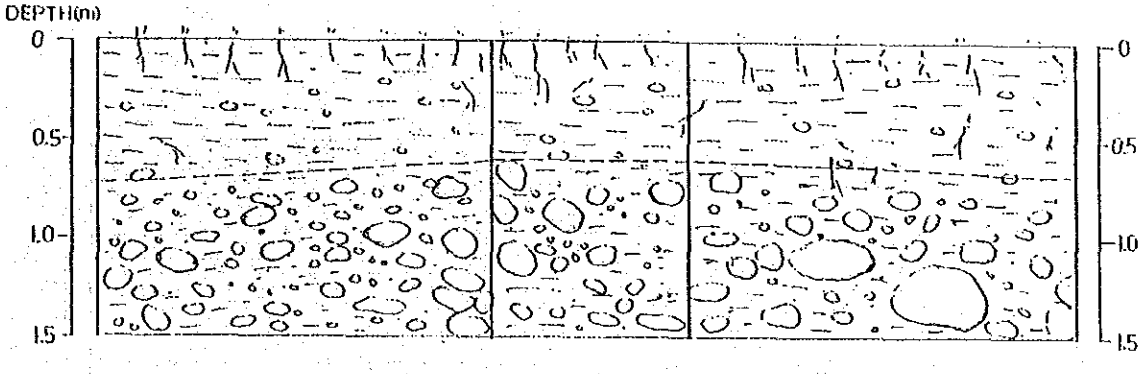
FIGURE C – 13 WATER PRESSURE TEST P – Q CURVE BD – 4



B No. BD-4

FIGURE C－14 LOGS OF TEST PITS FOR BORROW AREA (1/3)

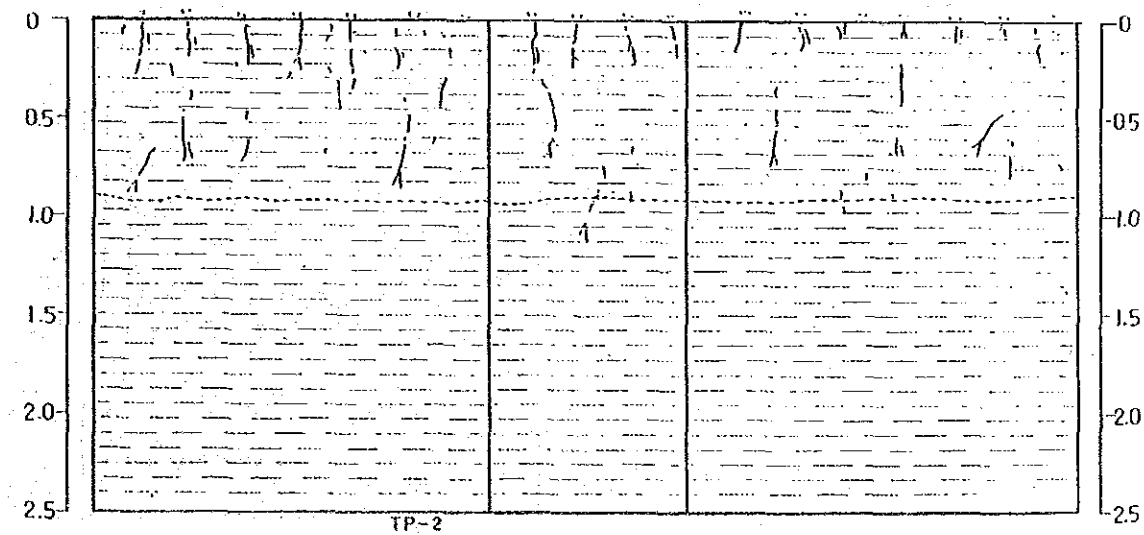
T.P. 1



TP－1

DEPTH (meter)	SOIL TYPE	GEOLOGIC CLASSIFICATION	COLOR	DESCRIPTION
0 ～ 0.65	Gravelly SILT	Lower TERRACE DEPOSIT	Light Brown	Contains grass-root. Firm and Dry. Percent of Gravel ; 10 ～20% Dia of Gravel ; 5～10cm Gravel Type ; Dark gray ～gray silicious rock・sandstone, generally hard and tight , rounded-subrounded.
0.65 ～ 1.50	Silty GRAVEL		Brown	Firm and Dry. Percent of Gravel ; approx. 70% average Dia of Gravel ; 20～25cm Maximum Dia of Gravel ; approx. 50cm Gravel Type ; Dark gray ～gray silicious rock・sandstone etc . hard and tight. rounded ～subrounded.

T.P.2

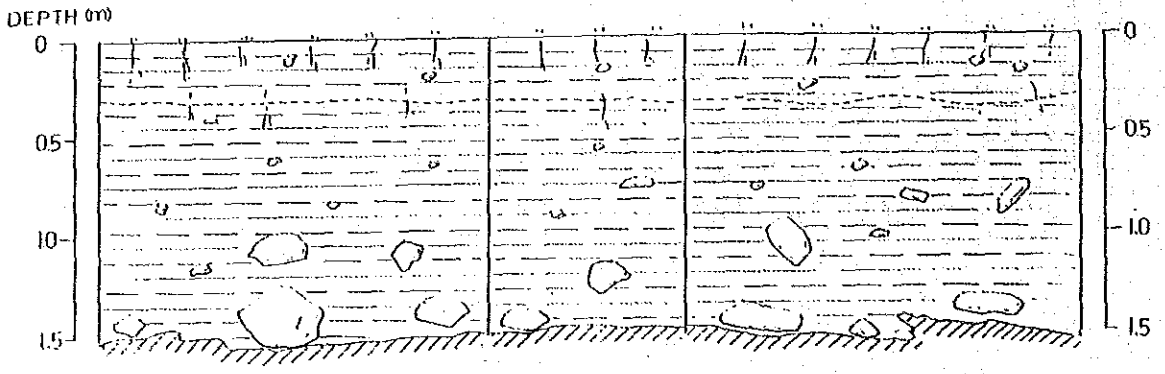


TP－2

DEPTH (meter)	SOIL TYPE	GEOLOGIC CLASSIFICATION	COLOR	DESCRIPTION
0 ～ 2.50	Clayey SILT	LOESS	Tan	0～ 0.3m ; Contains substantial amounts of grass-root. 0～ 0.9m ; very dry & Firm. 0.9～ 2.5m ; A little higher moisture content than upper part When wet, possible to make it ball, but impossible to make it string.

FIGURE C – 15 LOGS OF TEST PITS FOR BORROW AREA (2/3)

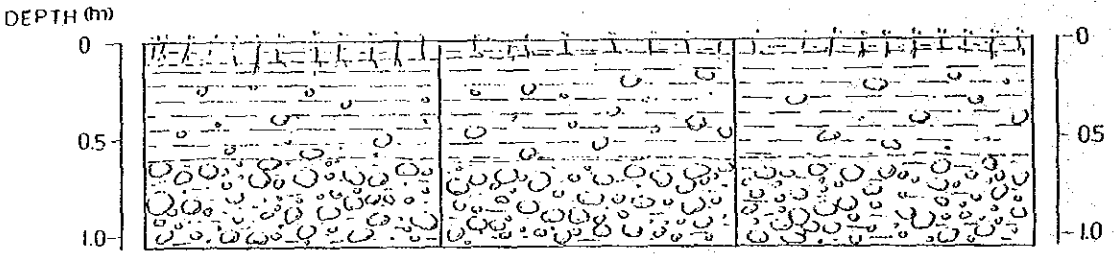
T.P.3



TP-3

DEPTH (meter)	SOIL TYPE	GEOLOGIC CLASSIFICATION	COLOR	DESCRIPTION
0 1.50	Gravelly silty CLAY	RESIDUALS	Reddish Brown	0~ 0.3m : Plowed Soil Contains substantial amounts of grass-root. A small quantity of rock fragment. Percent of rock fragment : 5~10% Dia of rock fragment : 1~20cm very dry and Firm. 0.3~ 1.5m : Partly rock-block included. Dia of rock-block : 10~35cm A little higher moisture content than upper part.
1.50		SANDSTONE	Reddish Brown	1.5m~ : Very hard and tight. High cementation.

T.P.4

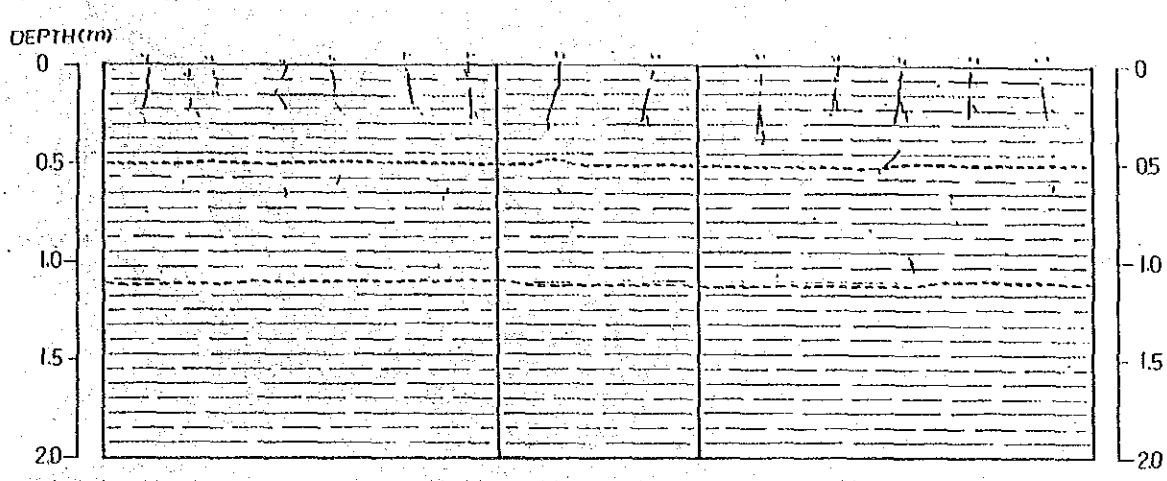


TP-4

DEPTH (meter)	SOIL TYPE	GEOLOGIC CLASSIFICATION	COLOR	DESCRIPTION
0 0.60	Gravelly Clayey SILT			0~ 0.10 m : Contains grass-root. Very dry and Firm. Percent of Gravel : 30~40% Dia of Gravel : 2~10cm
0.60 1.05	Silty or Clayey GRAVEL	Upper TERRACE DEPOSIT	Reddish Brown	Very dry and Firm. Percent of Gravel : 60~65% Dia of Gravel : 2~10cm Maximum Dia of Gravel : approx.25 cm Gravel type;hard salicious rock-sandstone-ratolite etc. surface of gravels is a little weathered but wholly very hard. rounded.

FIGURE C – 16 LOGS OF TEST PITS FOR BORROW AREA (3/3)

T.P.5



TP-5

DEPTH (meter)	SOIL TYPE	GEOLOGIC CLASSIFICATION	COLOR	DESCRIPTION
0 ⟩ 0.50	Clayey SILT	LOESS	Light Brown	0~ 0.5m : TOP Soil Oxidized and brownized Some part is organic and dark grayized Contains a little grass-root. Relatively loose and wet a little.
0.50 ⟩ 1.10			Tan	Relatively dry. Very firm and hard. Impossible to breake it by hand. Contains a lot of ant's nest Soil mass becomes approx. 20cm Dia of soil block. Contains many Pin-holes.
1.10 ⟩ 2.00	Silty CLAY		Reddish Brown	Relatively wet. High viscosity. Possible to make it string.

FIGURE C – 17 LOCATION OF TEST PITS ALONG CANAL ALIGNMENT

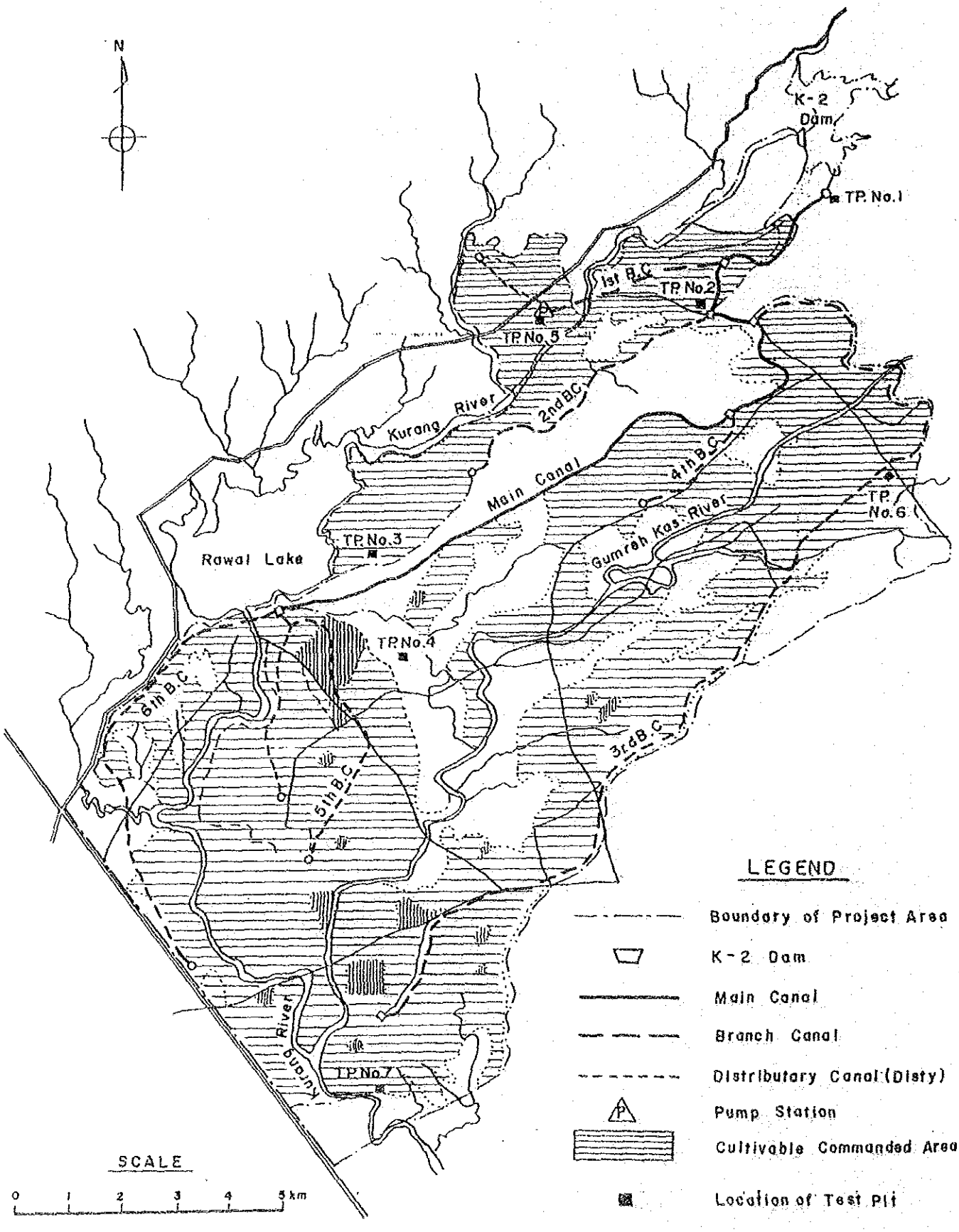
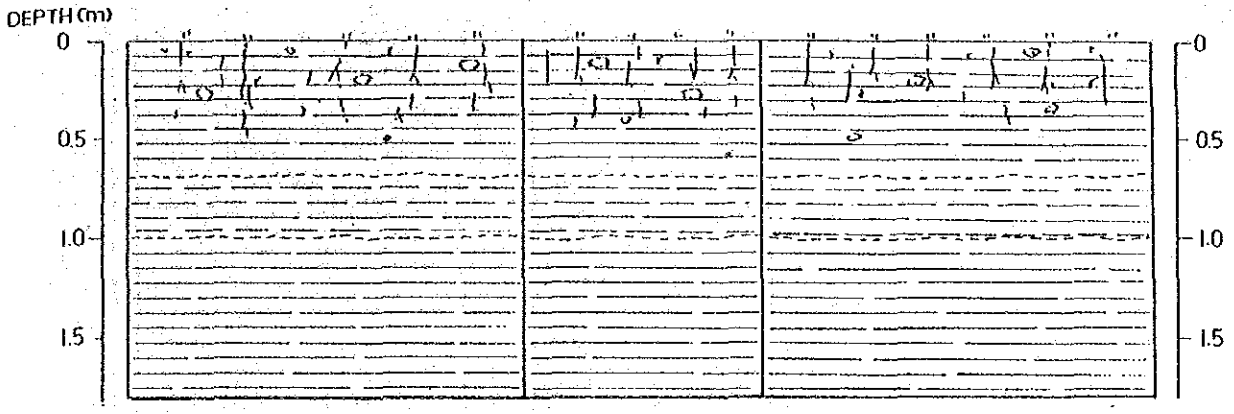


FIGURE C－18 LOGS OF TEST PITS ALONG CANAL ALIGNMENT (1/4)

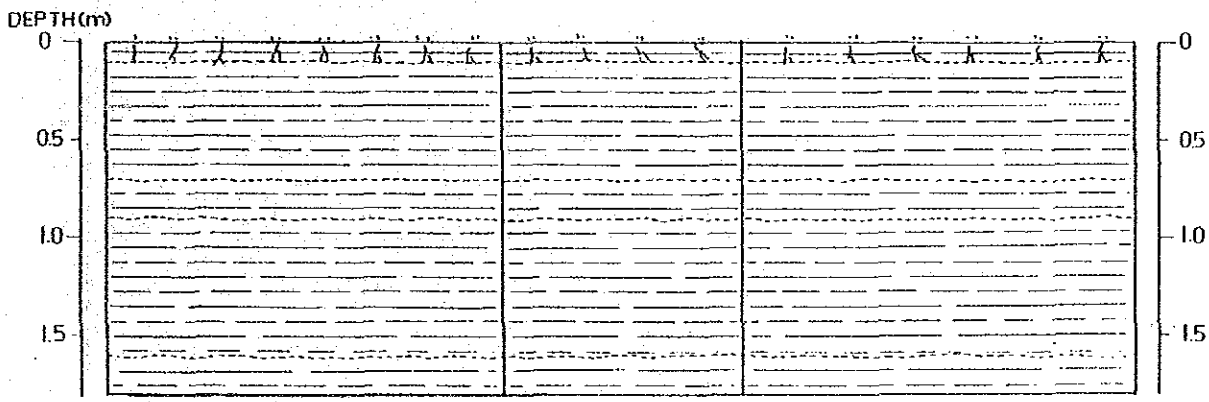
TP No.1



TP No－1

DEPTH (meter)	SOIL TYPE	GEOLOGIC CLASSIFICATION	COLOR	DESCRIPTION
0～ 0.7	CLAY	RESIDUALS	Reddish Brown	A little organic material included. Contains many grass-root. Relatively loose. few percent of small subangular gravel. Dia 1～2cm. sandstone.
0.7～ 1.0	Clayey SILT	LOESS	Reddish Brown	A little loose.
1.0～ 1.8	CLAY			Very firm. High consistency.

TP No.2

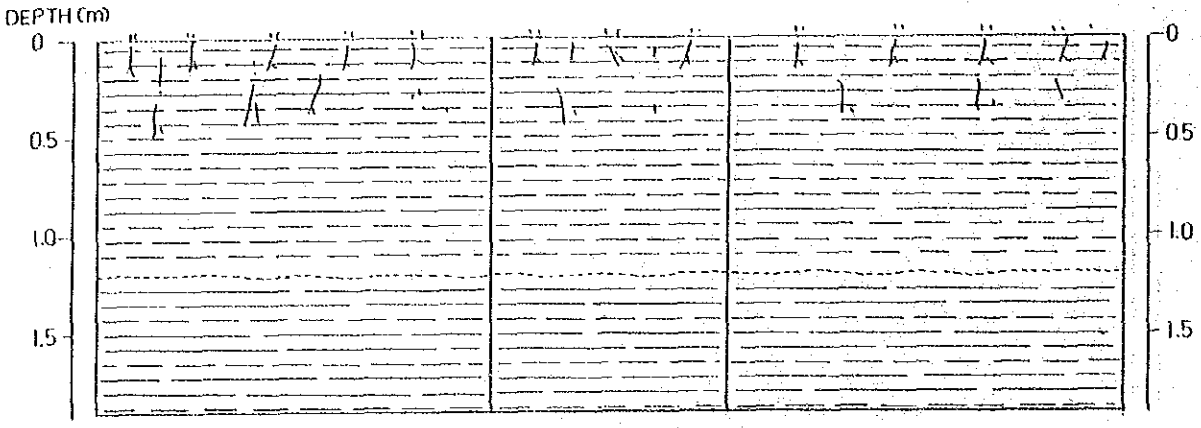


TP No－2

DEPTH (meter)	SOIL TYPE	GEOLOGIC CLASSIFICATION	COLOR	DESCRIPTION
0～ 0.1	Silty CLAY	TOP SOIL	Reddish Brown	Contains many grass-root. Loose.
0.1～ 0.7	Silty CLAY	LOESS	Tan	firm.
0.7～ 0.9			Reddish Brown	0.1～ 0.9m ; a little clay-rich.
0.9～ 1.6			Riddish Brown ～ Tan	A lot of small hole. Dia being less than 1 mm.
1.6～ 1.8			Reddish Brown	

FIGURE C－19 LOGS OF TEST PITS ALONG CANAL ALIGNMENT (2/4)

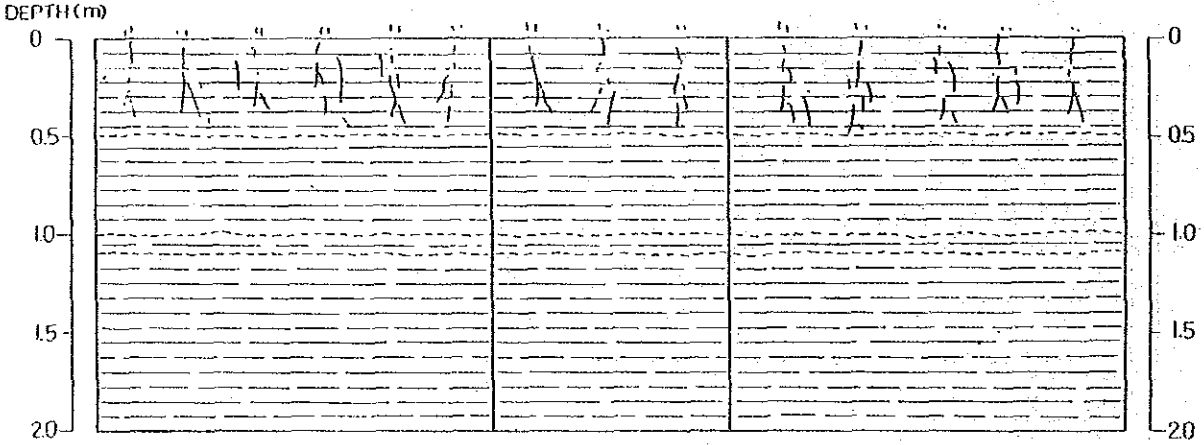
TP No.3



TP No.3

DEPTH (meter)	SOIL TYPE	GEOLOGIC CLASSIFICATION	COLOR	DESCRIPTION
0～ 1.2	Clayey SILT	LOESS	Reddish Brown	0～ 0.5m Contains many grass-root. Relatively loose.
1.2～ 1.9	Silty CLAY		Dark Brown	High Consistancy. A lot of small hole.

TP No.4

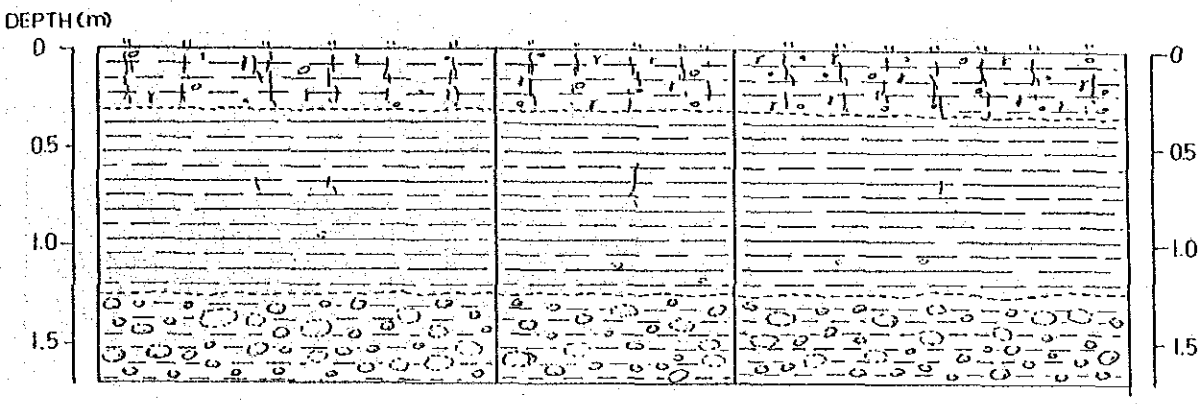


TP No.－4

DEPTH (meter)	SOIL TYPE	GEOLOGIC CLASSIFICATION	COLOR	DESCRIPTION
0～ 0.5	Silty CLAY	TOP SOIL	Reddish Brown	Contains many grass-root, a lot of grass-root.
0.5～ 1.0	Silty CLAY	ALLUVIALS	Brownish Gray	Relatively high Viscousty. Interlinger with Organic Soils.
1.0～ 1.1			Reddish Brown	Relatively loose.
0.1～ 2.0			Brownish Gray	

FIGURE C – 20 LOGS OF TEST PITS ALONG CANAL ALIGNMENT (3/4)

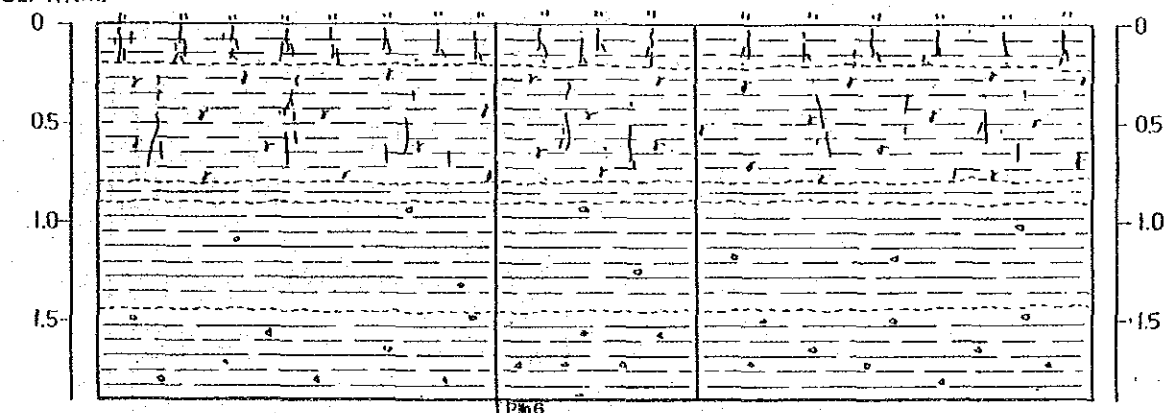
TP No.5



TP No.5

DEPTH (meter)	SOIL TYPE	GEOLOGIC CLASSIFICATION	COLOR	DESCRIPTION
0~ 0.3	Organic SILT	TOP SOIL	Light Brown	Contains many grass-root. Relatively loose. Contains angular fine gravels; approx. 5%
0.3~ 1.25	Silty CLAY	LOESS	Brownish Gray	Dry and very firm. Contains a little grass-root. Numerous vertical partings. Contains soft angular fine gravels.
1.25 ~ 1.7	Silty GRAVEL	TERRACE DEPOSIT	Dark Brown	Percent of Gravel ; 60 ~70% Dia of Gravel ; 5~15cm Rounded ~Subrounded Contions appreciable amount of weathered sandstone gravels which are easily broken by weak hammer shock. Gravel type ; black hard siliclous rock, sandstone etc. Average dia of hard pebble ; approx. 5cm

TP No.6



TP No.6

DEPTH (meter)	SOIL TYPE	GEOLOGIC CLASSIFICATION	COLOR	DESCRIPTION
0~ 0.2	SILT	PLOWED SOIL	Reddish Brown	Contains many grass-root. Loose.
0.2~ 0.8	Organic SILT	TOP SOIL	Blackish Brown Dark Brown	A lot of rude vertical partings opening width being 0.2~ 0.5mm. Very dry & firm Contains little grass-root.
0.8~ 0.9	Clayey SILT	LOESS	Reddish Brown	Very dry and very firm.
0.9~ 1.4	Silty CLAY	RESIDUALS	Reddish Brown	Very dry and very firm. Contains little rock-fragment.
1.4~ 1.9	Gravelly silty CLAY			Very dry and very firm. Dia of Gravel ; approx. 1cm Gravel type ; Angular ~ hard clay or weathered sandstone.