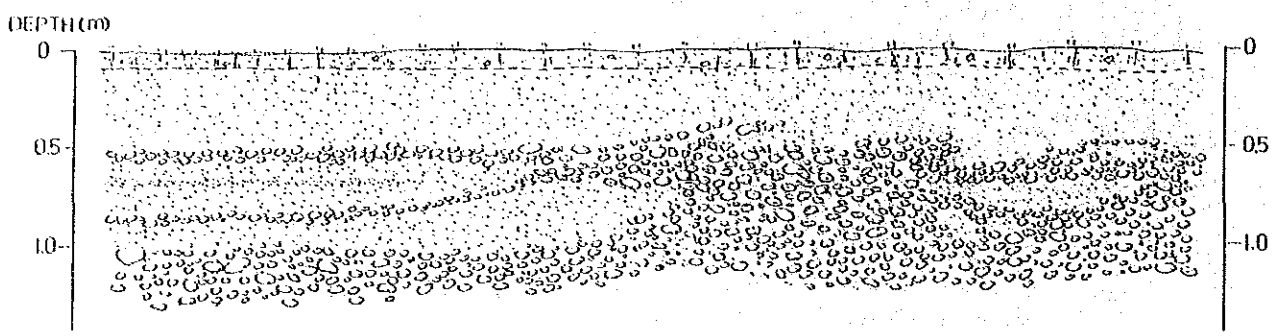
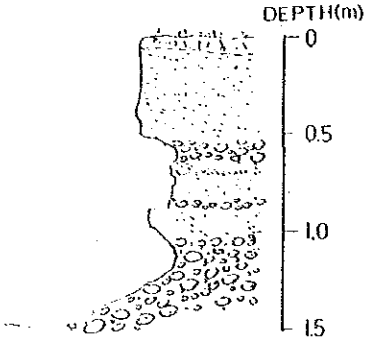
FIGURE C – 21 LOGS OF TEST PITS ALONG CANAL ALIGNMENT (4/4)

RIVER BANK AT Kc-1 SITE

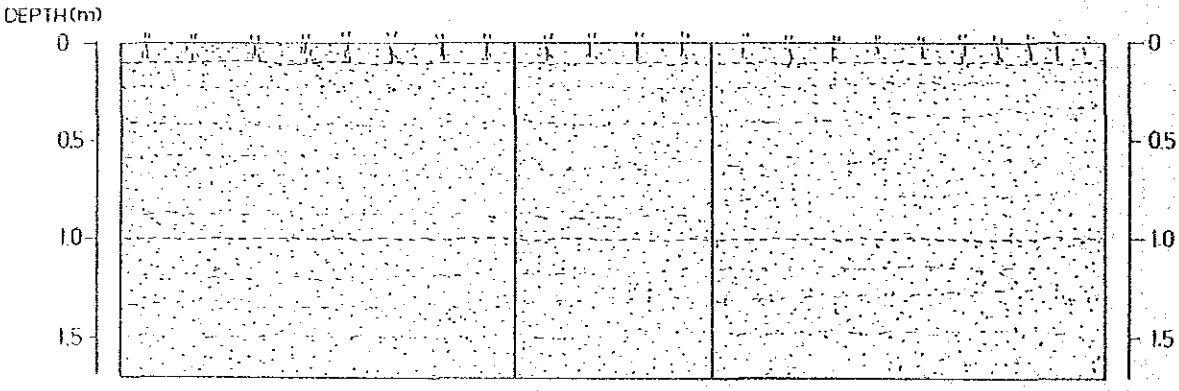




River bank at Kc-1 site

DEPTH (meter)	SOIL TYPE	GEOLOGIC CLASSOLOCATION	COLOR	DESCRIPTION
0 ~ 0.5	fine~ medium SAND	ALLUVIALS	Brownish Gray	0~ 0.1m ; Contains many grass-root. Contains little subrounded~ subangular fine gravels. A little loose.
0.5~ 1.0	GRAVEL-SAND mixtures		Brown	Gravel and sand interfinger. Sand ; fine ~medium size.
1.0~	GRAVEL			Dia of Gravel ; 2~15cm. Gravel type ; sandstone and siliclous stone.

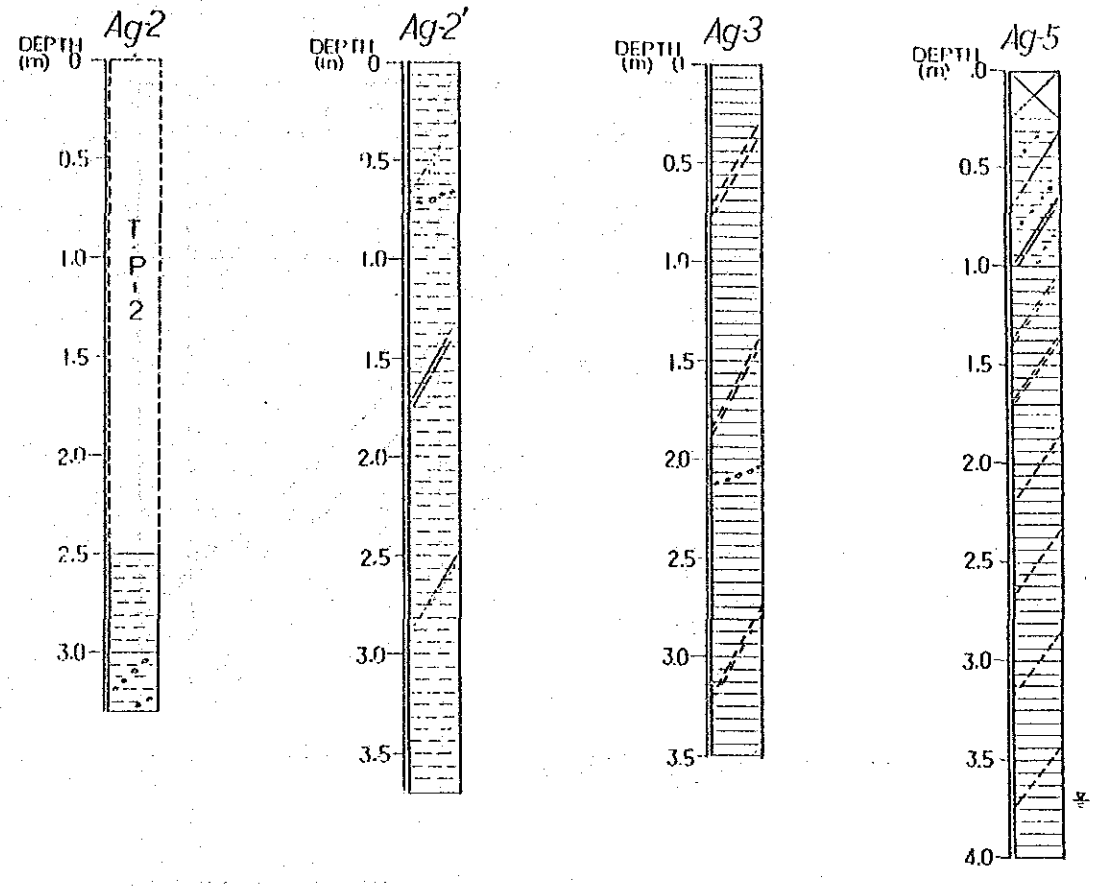
TP No.7

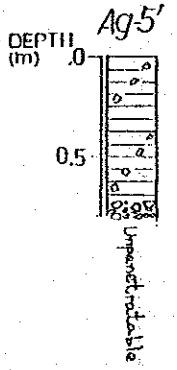


TP No.7

DEPTH (meter)	SOIL TYPE	GEOLEGIC CLASSIFICSATION	COLOR	DESCRIPTION
0~ 0.1	SAND	TOP SOIL	Dark Brown	Contains many grass-root.
0.1~ 1.7	silty fine~ medium SAND	ALLUVIALS	Dark Brown	Relatively loose. Very thin layer(thickness 1mm) of silt intercalated. Free Ground water level ; GL-1.0m The part deeper than 1.0m very loose.

FIGURE C－22 LOGS OF HAND AUGER HOLES FOR BORROW AREA

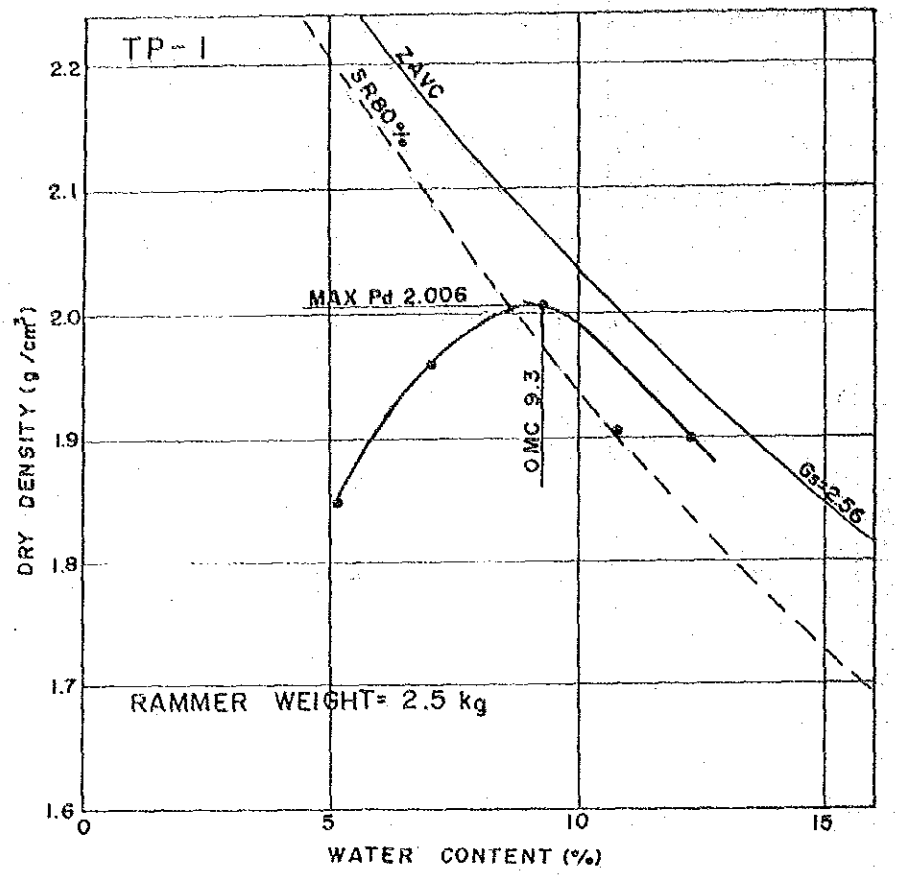




THE RESULT OF AUGER BORING LOGGING

No	DEPTH (meter)	SOIL TYPE	GEOLOGIC CLASSIFICATION	COLOR	DESCRIPTION
Ag 2	0～ 3.0	Clayey SILT	LOESS	Tan	Deeper Part than 2.7m of depth : has high moisture content.
	3.0～	Gravelly Silty CLAY		Light Reddish Brown	3.0～ 3.3m Dia of Gravel ; less than 1cm 3.3m～ A little larger Dia of Gravel than the part of 3.0～ 3.3m(approx. 3cm) Gravel type ; hard & angular sandstone.
Ag 2'	0～ 3.7	Clayey SILT	LOESS	Reddish Brown	Wholly homogeneous. Aperox. the depth 0.7m, Gravel included, Dia is Approx. 1cm
Ag 3	0～ 3.5	Silty CLAY	LOESS	Reddish Brown	Wholly homogeneous. When wetted it can be lengthened like string. At the depth 2.10m, small size of gravel included.
Ag 5	0～ 0.25	SILT	TOP SOIL	Gray	Contains many grass-root.
	0.25 ～ 1.00	Gravelly Clayey SILT	LOESS	Light Brown	Relatively dry. Soft rock fragment included.
	1.0～ 1.7	Silty CLAY		Reddish Brown	Low moisture content. High coonsistency.
	1.7～ 2.1	Silty CLAY		Light Brown	Moisture content gradually increasing to the deeper Part. Consistency gradually decreasing in proportion to moisture content.
	2.1～			Reddish Brown	The part deeper than 2.8m : very high moisture content. Water level : GL-3.7m
Ag 5'	0～ 0.75	Granule CLAY	STREAM DEPOSIT	Light Reddish Brown	Dia of Gavel ; 2～ 3mm
	0.75 ～	GRAVEL			Gravel type ; Subangular gravel. Unable to penetrate by hand auger.

FIGURE C – 23 RESULT OF COMPACTION TEST (1/4)



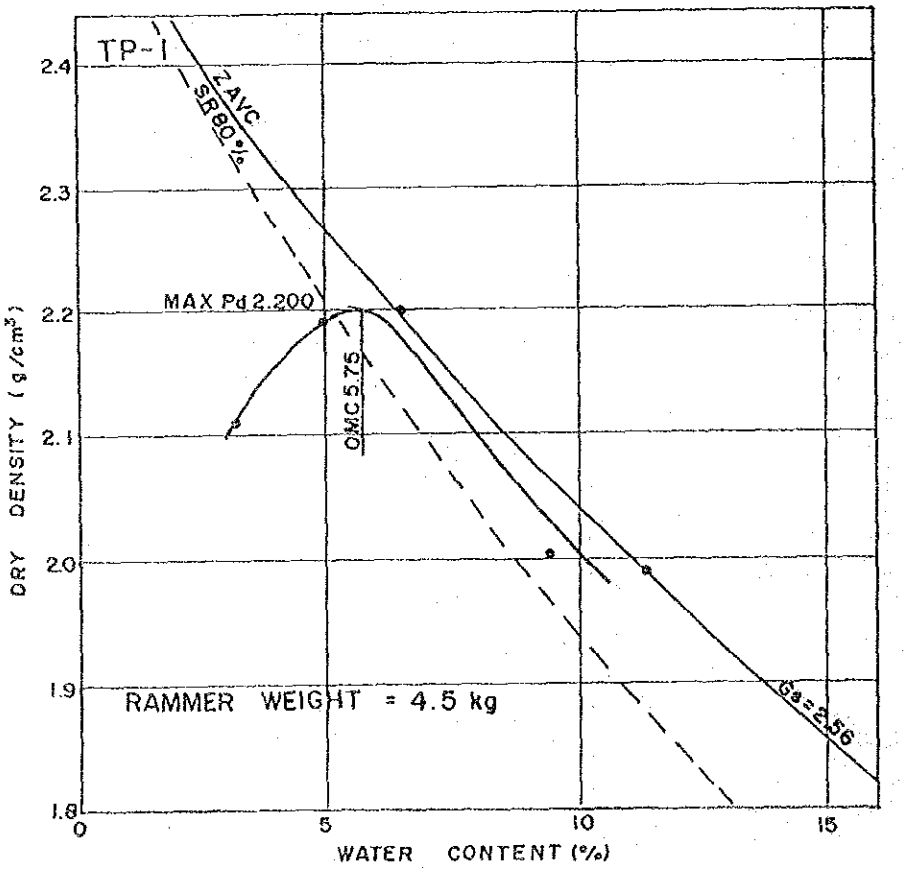
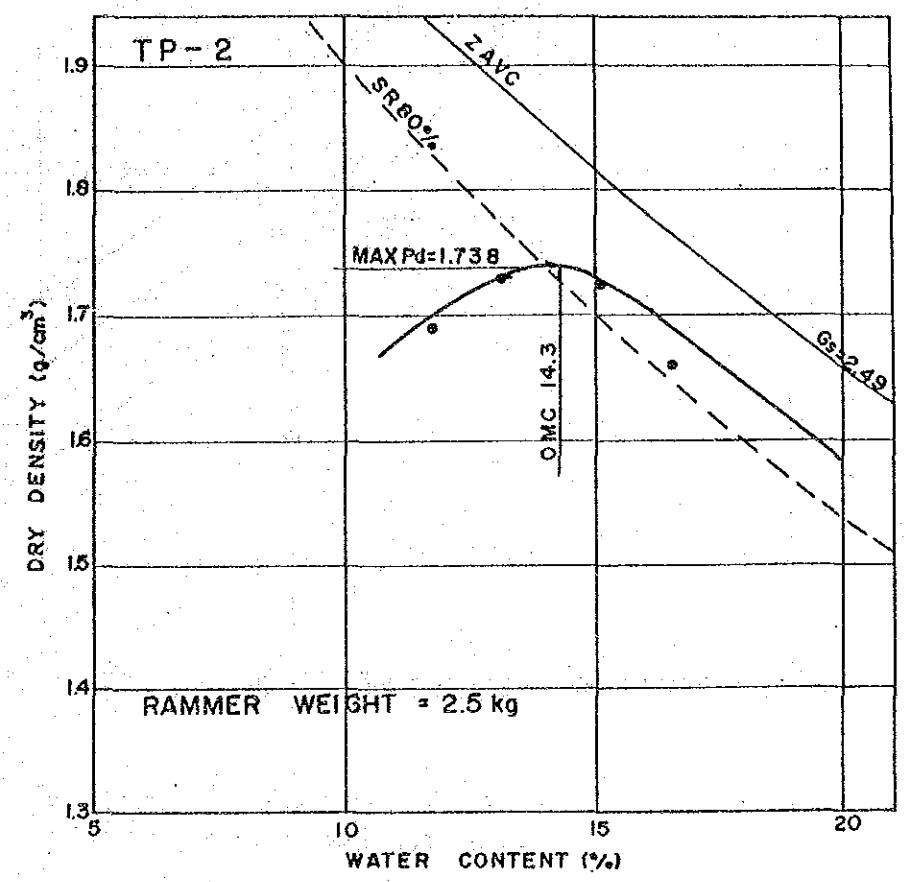


FIGURE C – 24 RESULT OF COMPACTION TEST (2/4)



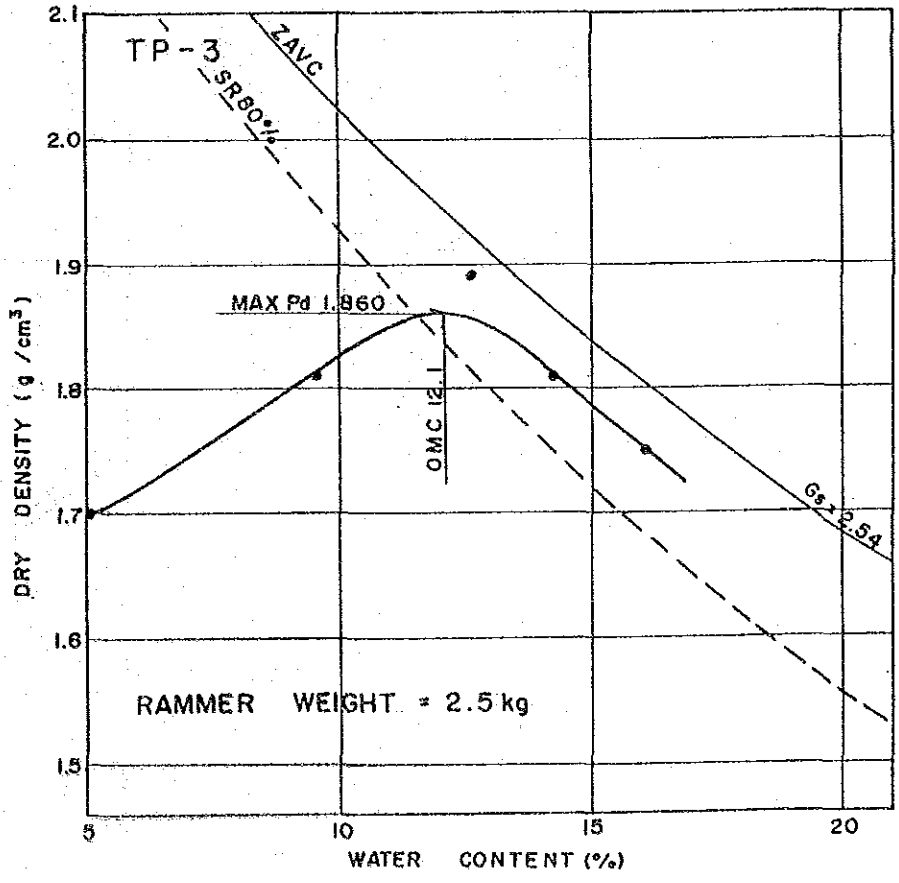
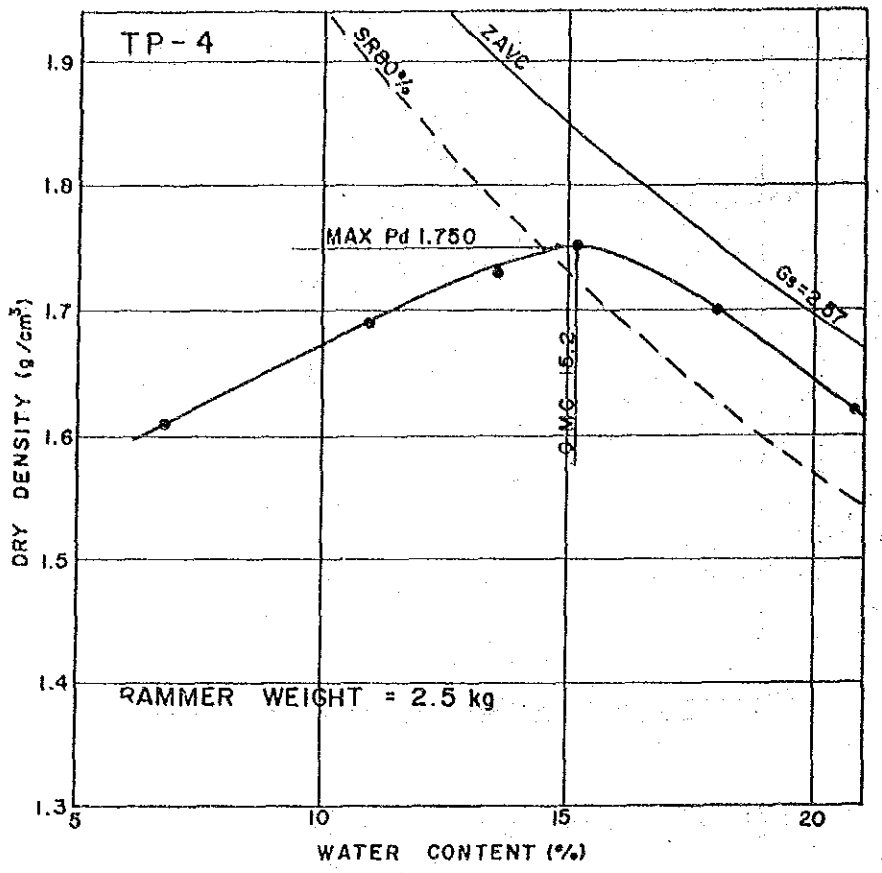


FIGURE C – 25 RESULT OF COMPACTION TEST (3/4)



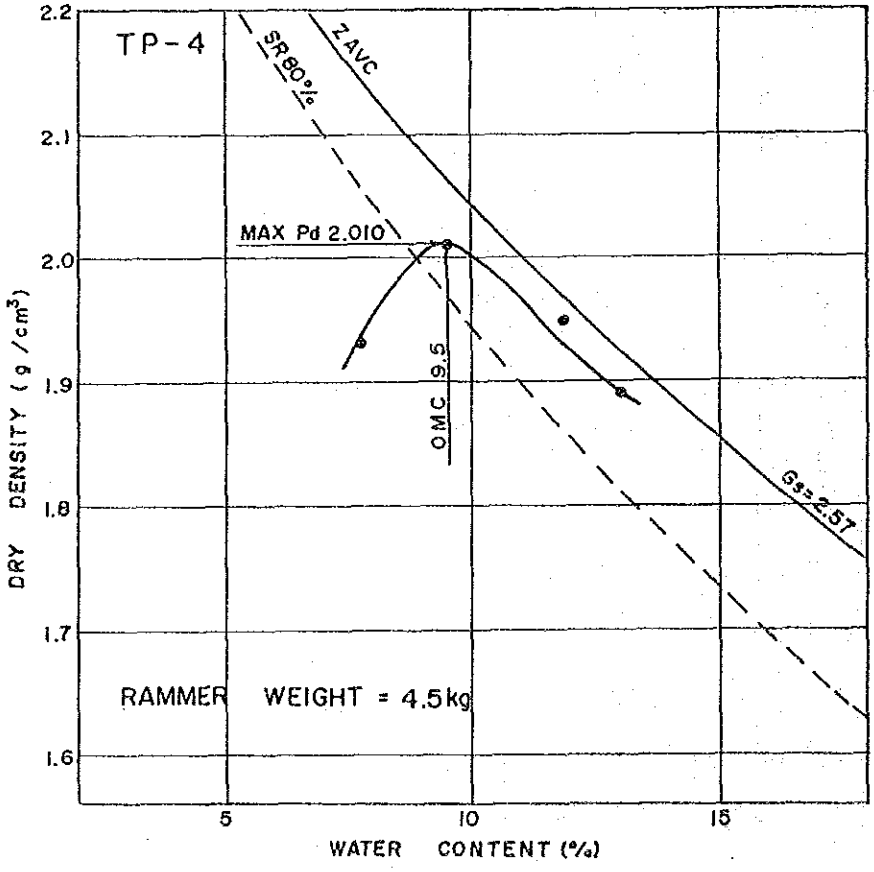


FIGURE C – 26 RESULT OF COMPACTION TEST (4/4)

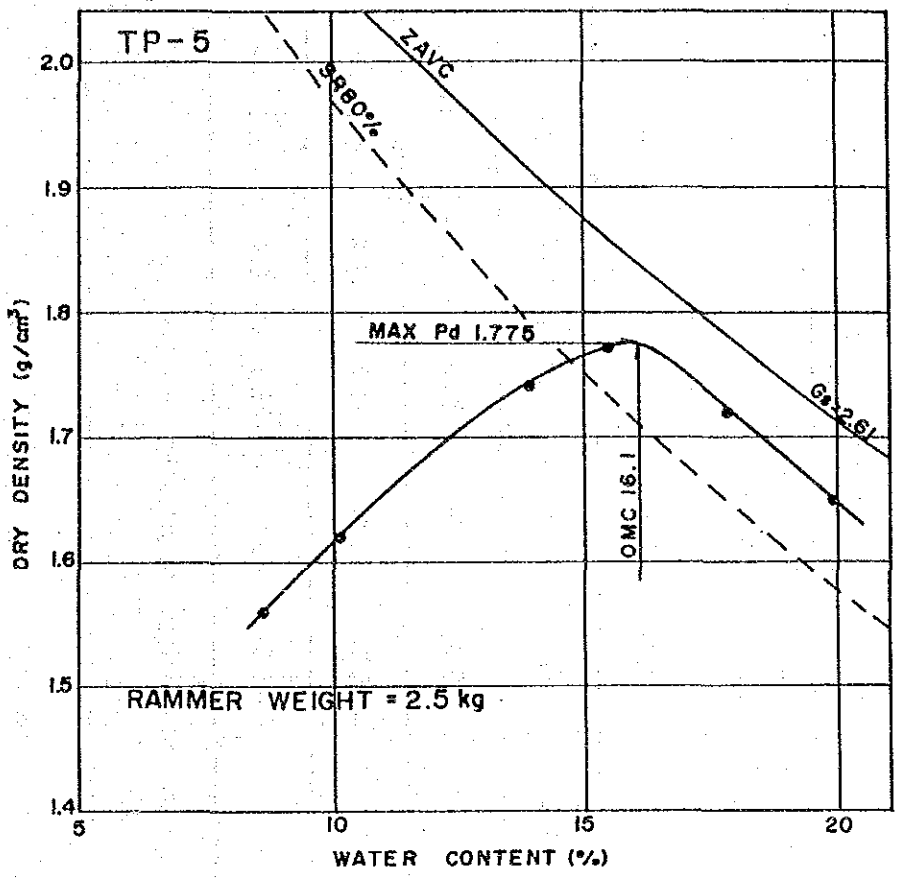


TABLE C－1 RESULT OF SOIL TEST (1/2) PHYSICAL TEST

(PHYSICAL TEST)

Sample No.	Specific Gravity	Moisture Content (%)	Gradation % retained (%)						Atterberg Limit (%)			Soil Classification
			1 in 25.4mm	No.4 4.76mm	No.10 2.00mm	No.40 0.42mm	No.200 0.074mm	under 0.074mm	L. L	P. L	P. I	
TP-1	2.56	2.92	27.50	37.30	9.20	6.2	4.6	15.2	30.4	20.5	9.9	GM
TP-2	2.49	26.35	0	0	0	0.5	4.5	95.0	31.0	19.5	12.5	CL
TP-3	2.54	15.23	4.8	14.0	4.7	1.3	6.3	75.4	26.3	17.9	8.40	CL
TP-4	2.57	4.29	7.2	11.3	0.5	1.8	9.1	70.1	31.7	18.6	13.7	* (GM)
TP-5	2.61	21.35	0	0	0	0	2.0	98.0	32.8	20.4	12.8	CL

* The soil classification of sample TP-4 is judged and infered from the situation in site.

TABLE C－2 RESULT OF SOIL TEST (2/2) MECHANICAL TEST

(MECHANIC TEST)

Sample No.	* Compaction		Coefficient of Permeability (cm/sec)		
	ρd max (g/cm³)	O. M. C (%)	Dry of O.M.C (95% of ρd max)	at O.M.C (100% of ρd max)	Wet of O.M.C (95% of ρd max)
TP-1	2.006	9.3	6.746×10^{-7}	4.471×10^{-7}	3.476×10^{-7}
	** 2.200	5.75	———	———	———
TP-2	1.738	14.3	6.533×10^{-7}	5.365×10^{-7}	1.147×10^{-7}
TP-3	1.860	12.1	3.895×10^{-7}	3.071×10^{-7}	2.284×10^{-7}
TP-4	1.750	15.2	4.358×10^{-7}	3.088×10^{-7}	2.718×10^{-7}
	** 2.010	9.5	———	———	———
TP-5	1.775	16.1	1.679×10^{-7}	1.292×10^{-7}	9.592×10^{-8}

notes * Compaction test is carried out by 1st method except the sample marked **

** This sample is carried out by 2nd method

TABLE C－3 RESULT OF ROCK TEST － No. BD－1

Borehole No-BD-1

Sample No.	Depth (m)	Rock Type	Specific Gravity	Water Absorption (%)	Diameter of Core －cm (-in)	Area of Core －cm² (-sq・in)	Failing Load －Kg (-Lbs)	Compressiue Strength －Kgf / cm² (-PSI)
1	7.5	Mudstone	2.51	——	4.920 (1.937)	19.012 (2.947)	1,349 (2,974)	71 (1,009)
2	12.5	Mudstone	2.50	——	〃	〃	1,374 (3,030)	72 (1,028)
3	13.5	Mudstone	2.51	——	〃	〃	1,441 (3,177)	76 (1,078)
4	39.5	Silty Sandstone	2.52	——	〃	〃	1,517 (3,345)	80 (1,135)

TABLE C－4 RESULT OF ROCK TEST － No. BD－2

Borehole No.－BD－2

Sample No.	Depth (m)	Rock Type	Specific Gravity	Water Absorption (%)	Diameter of Core －cm (-in)	Area of Core －cm^2 (-sq・in)	Failing Load －kg (-lbs)	Compressiue Strength －kgf / cm^2 (-PSI)
1	2.7	Sandstone	2.72	0.06	4.920 (1.937)	19.012 (2.947)	21,770 (48,000)	1,145 (16,287)
2	6.0	Mudstone	2.71	2.09	〃	〃	680 (1,500)	36 (509)
3	9.5	Mudstone	2.50	——	〃	〃	395 (870)	21 (293)
4	23.5	Sandstone	2.72	2.29	〃	〃	907 (2,000)	48 (679)

TABLE C－5 RESULT OF ROCK TEST － No. BD－3

Borehole No-BD-3

Sample No.	Depth (m)	Rock Type	Specific Gravity	Water Absorption (%)	Diameter of Core —cm (-in)	Area of Core —cm² (-sq・in)	Failing Load —Kg (-lbs)	Compressiue Strength —Kgf / cm² (-PSI)
1	13.2	Sandy Mudstone	2.46	——	4.920 (1.937)	19.012 (2.947)	1,695 (3,737)	86 (1,268)
2	16.2	Sandy Mudstone	2.56	——	〃	〃	1,923 (4,240)	101 (1,439)
3	35.8	Muddy Sandstone	2.56	——	〃	〃	2,230 (4,916)	117 (1,668)
4	36.7	Muddy Sandstone	2.55	——	〃	〃	2,810 (6,195)	148 (2,102)

ANNEX D. SOIL SURVEY

LIST OF TABLE

LIST OF FIGURE

ANNEX D. SOIL SURVEY

Soil Survey

The soil survey for the proposed beneficial area has been carried out on 12 survey points for six soil series by two point each according to the soil maps prepared in the Master Plan Study. At each point, test pits were dug for visual investigation, and soil sampling for physio-chemical analyses of the soils. The location of those 12 test pits are shown in Figure D-1.

Soil sampling has been made at each soil layer of every soil profile at all the test pits so as to make survey on soil colors, compactness (hardness), gravel contents, pH, and electric conductivity (EC).

The soil samples taken from the test pits were sent to the National Agricultural Research Center (NARC) for the physio-chemical analyses.

- The results of analyses on the soil texture (sand, silt, clay) and the soil properties can be referred to Table D-1.
- The data on pH, EC, Ca + Mg, T-N, NO_3 - N, P_2O_5, Na and Fe can be referred to Table D-2.
- The soils profiles, information on soil colors, spots, gravels, and other properties can be referred to Table D-2.

TABLE D-1. MECHANICAL COMPOSITION AND TEXTURE CLASSIFICATION OF SOIL

Test Pit No.	Location (Village)	Layer No.	Depth (cm)	Mechanical Composition(%) Clay	Silt	Sand	Soil texture
1.	DHOK JABA	AP1	0 - 15	27.2	24.0	48.8	SiC
		AP2	15 - 25	24.5	31.7	44.8	CL
		B1	25 - 68	27.2	24.0	48.8	LiC
		B2	68 - 100	13.2	6.0	80.8	SL
2.	BARMA (Tarlai)	AP1	0 - 10	17.2	19.0	63.8	SCL
		AP2	10 - 22	17.2	19.8	63.0	SCL
		B1	22 - 56	17.2	19.0	63.8	SCL
		B2	56 - 90	11.2	16.0	72.8	SL
		B3	90 - 100	-	-	-	S
3.	TARLAI KALAN	AP1	0 - 10	15.2	42.0	42.8	CL
		AP2	10 - 25	17.2	28.0	54.8	CL
		B1	25 - 60	26.2	25.0	48.8	LiC
		B2	60 - 100	31.5	29.7	38.8	LiC
4.	KHANA DAK	AP1	0 - 15	21.2	29.0	49.8	CL
		AP2	15 - 25	11.2	16.0	72.8	SL
		B1	25 - 70	17.5	27.7	54.8	CL
		B2	70 - 100	22.5	40.7	36.8	CL
5.	BANIGALA	AP1	0 - 10	9.5	7.7	82.8	SL
		AP2	10 - 22	13.2	6.7	80.1	SL
		B1	22 - 50	19.2	13.0	67.8	SCL
		B2	50 - 100	17.5	11.7	70.8	SCL
6.	SANW (ATHAL)	AP1	0 - 10	-	-	-	SL
		AP2	10 - 20	-	-	-	L
		B1	20 - 55	-	-	-	SiL
		B2	55 - 100	-	-	-	CL
7.	BALAGH	A	0 - 11	25.2	31.8	43.0	LiC
		B1	11 - 45	29.2	30.0	40.8	LiC
		B2	45 - 100	25.5	43.7	31.8	LiC
8.	MUHRANUR	AP1	0 - 10	39.5	39.7	20.8	LiC
		AP2	10 - 22	25.2	36.0	38.8	LiC
		B1	22 - 54	26.5	38.7	34.8	LiC
		B2	54 - 100	24.5	30.7	44.8	CL
9.	KOT HATHIAL (Bharakaku)	AP1	0 - 13	26.5	38.7	34.8	LiC
		AP2	13 - 20	29.5	45.7	24.8	SiC
		B1	20 - 55	26.5	38.7	34.8	LiC
		B2	55 - 100	27.2	24.0	48.8	LiC
10.	SHAHPUR (Phulgram)	AP1	0 - 12	21.2	26.0	52.8	CL
		AP2	12 - 22	27.2	45.0	24.8	SiC
		B1	22 - 45	32.5	40.7	26.8	LiC
		B2	45 - 100	17.5	29.7	52.8	CL
11.	SAKRILA	AP1	0 - 10	28.5	32.7	38.8	LiC
		AP2	10 - 22	17.5	70.8	11.7	SCL
		B1	22 - 55	24.5	30.7	44.8	CL
		B2	55 - 100	33.2	37.0	29.8	LiC
12.	DHOKALI	AP1	0 - 12	32.5	40.7	26.8	LiC
		AP2	12 - 20	12.5	22.7	64.8	SCL
		B1	20 - 60	17.5	35.7	46.8	CL
		B2	60 - 100	27.2	45.0	27.8	SiC

Notes: Tested by Soil Advisory Service Land Resources Section, NARC

TABLE D-2. RESULT OF SOIL CHEMICAL TEST

Test Pit No.	Location (Village)	Layer No.	Depth (cm)	PH (1:5)	EC (mms) (1:5)	Ca+Mg (mg/ℓ)	T-N (%)	NO_3-N (ppm)	P_2O_5 (ppm)	K_2O (ppm)	Na (ppm)	Fe (ppm)
1.	DHOK JABA	AP1	0-15	7.5	0.14	0.6	0.12	1.0	13.4	23.0	28.0	17.0
		AP2	15-25	8.7	0.16	1.8	0.10	1.8	1.4	28.0	31.0	29.0
		B1	25-68	8.2	0.44	2.0	0.10	1.6	0.5	39.0	37.0	10.5
		B2	68-100	8.3	0.17	1.4	0.62	0.4	0.95	31.0	18.4	3.7
2.	BARMA (Tarlai)	AP1	0-10	8.4	0.14	1.2	0.10	1.3	12.0	55.0	78.0	14.0
		AP2	10-22	8.1	0.13	2.8	0.11	1.5	1.3	39.0	32.0	33.0
		B1	22-56	8.3	0.21	1.2	0.06	0.2	3.3	31.0	23.0	13.0
		B2	56-90	8.3	0.02	1.6	0.60	0.5	1.9	23.0	41.5	19.2
		B3	90-100	8.2	0.20	1.0	0.04	0.5	6.4	16.0	37.0	2.1
3.	TARLAI KALAN	AP1	0-10	8.0	0.18	2.0	0.70	1.2	2.7	47.0	19.0	14.3
		AP2	10-25	8.1	0.17	1.2	0.05	1.0	1.3	55.0	9.2	26.0
		B1	25-60	8.7	0.08	1.6	0.04	0.6	1.0	47.0	9.2	11.3
		B2	60-100	8.1	0.14	1.2	0.04	0.8	0.7	70.0	14.0	26.0
4.	KHANA DAK	AP1	0-15	8.2	0.32	2.0	0.65	1.5	36.2	218.4	13.6	0.65
		AP2	15-25	8.5	0.11	1.2	0.09	2.5	9.1	40.0	17.0	25.0
		B1	25-70	8.4	0.19	2.6	0.04	0.65	12.1	38.0	16.4	10.3
		B2	70-100	8.4	0.17	2.2	0.04	1.0	8.6	94.0	28.0	8.3
5.	BANIGALA	AP1	0-10	6.4	0.25	2.2	0.06	0.64	4.0	47.0	14.0	23.0
		AP2	10-22	6.0	0.13	1.1	0.07	0.8	9.0	31.0	18.0	29.6
		B1	22-50	7.1	0.32	3.0	0.04	0.5	2.3	31.0	9.2	19.0
		B2	50-100	7.6	0.11	1.4	0.02	0.5	1.6	31.0	14.0	14.0
6.	SANW (ATHAL)	AP1	0-10	6.6	0.20	1.8	0.04	2.0	32.0	40.0	16.0	13.0
		AP2	10-20	8.1	0.27	2.0	0.11	2.2	11.1	55.0	18.0	11.0
		B1	20-55	8.2	0.21	1.2	0.03	0.6	1.7	47.0	18.4	12.0
		B2	55-100	8.3	0.15	1.4	0.04	1.0	0.96	39.0	28.0	10.4
7.	BALAGH	A	0-11	6.6	1.02	2.0	0.12	2.24	15.0	164.0	32.0	11.4
		B1	11-45	8.2	0.21	1.3	0.03	0.5	1.7	47.0	18.4	12.0
		B2	45-100	8.3	0.15	1.4	0.04	1.0	0.96	39.0	28.0	10.4
8.	MUHRANUR	AP1	0-10	8.1	0.20	1.8	0.10	1.7	2.7	70.0	18.4	14.0
		AP2	10-22	8.1	0.15	2.5	0.08	0.9	0.5	47.0	14.0	12.0
		B1	22-54	8.2	0.10	1.3	0.06	0.5	0.7	47.0	14.0	10.5
		B2	54-100	8.0	0.11	1.4	0.08	1.3	0.5	62.0	18.4	15.3
9.	KOT HATHIAL (Bharakahu)	AP1	0-13	8.1	0.08	1.8	0.04	2.0	3.2	40.0	16.0	13.0
		AP2	13-20	7.6	0.14	2.0	0.04	1.0	1.1	31.0	14.0	9.3
		B1	20-55	8.2	0.13	1.4	0.04	0.64	1.1	39.0	14.0	24.0
		B2	55-100	8.3	0.10	1.2	0.10	0.4	2.7	65.0	124.4	26.0
10.	SHAHPUR (Phulgram)	AP1	0-12	7.9	0.20	1.8	0.06	3.0	2.4	39.0	37.0	12.0
		AP2	12-22	7.3	0.10	1.0	0.04	2.0	4.0	39.0	14.0	34.0
		B1	22-45	8.2	0.14	1.6	0.08	0.6	1.5	39.0	14.0	25.6
		B2	45-100	8.1	0.17	1.3	0.08	0.5	4.8	47.0	143.0	14.0
11.	SAKRILA	AP1	0-10	8.2	0.15	1.6	0.08	2.0	5.8	24.0	13.8	19.0
		AP2	10-22	8.4	0.11	1.0	0.07	0.64	1.5	72.0	43.0	17.0
		B1	22-55	8.3	0.14	0.8	0.04	0.3	0.6	47.0	119.6	14.4
		B2	55-100	8.2	0.11	1.2	0.02	0.4	1.3	31.0	18.0	12.0
12.	DHOK ALI	AP1	0-12	8.5	0.13	0.6	0.06	0.2	21.7	94.0	14.0	10.0
		AP2	12-20	7.8	0.20	2.2	0.01	1.6	1.0	94.0	18.0	17.0
		B1	20-60	8.3	0.14	1.2	0.06	0.4	1.2	55.0	23.0	6.3
		B2	60-100	8.1	0.09	1.6	0.06	0.9	1.44	55.0	64.0	6.0

Note: Tested by Soil Advisory Service Land Resoures Section, NARC.

FIGURE D–1. LOCATION OF SOIL TEST PITS

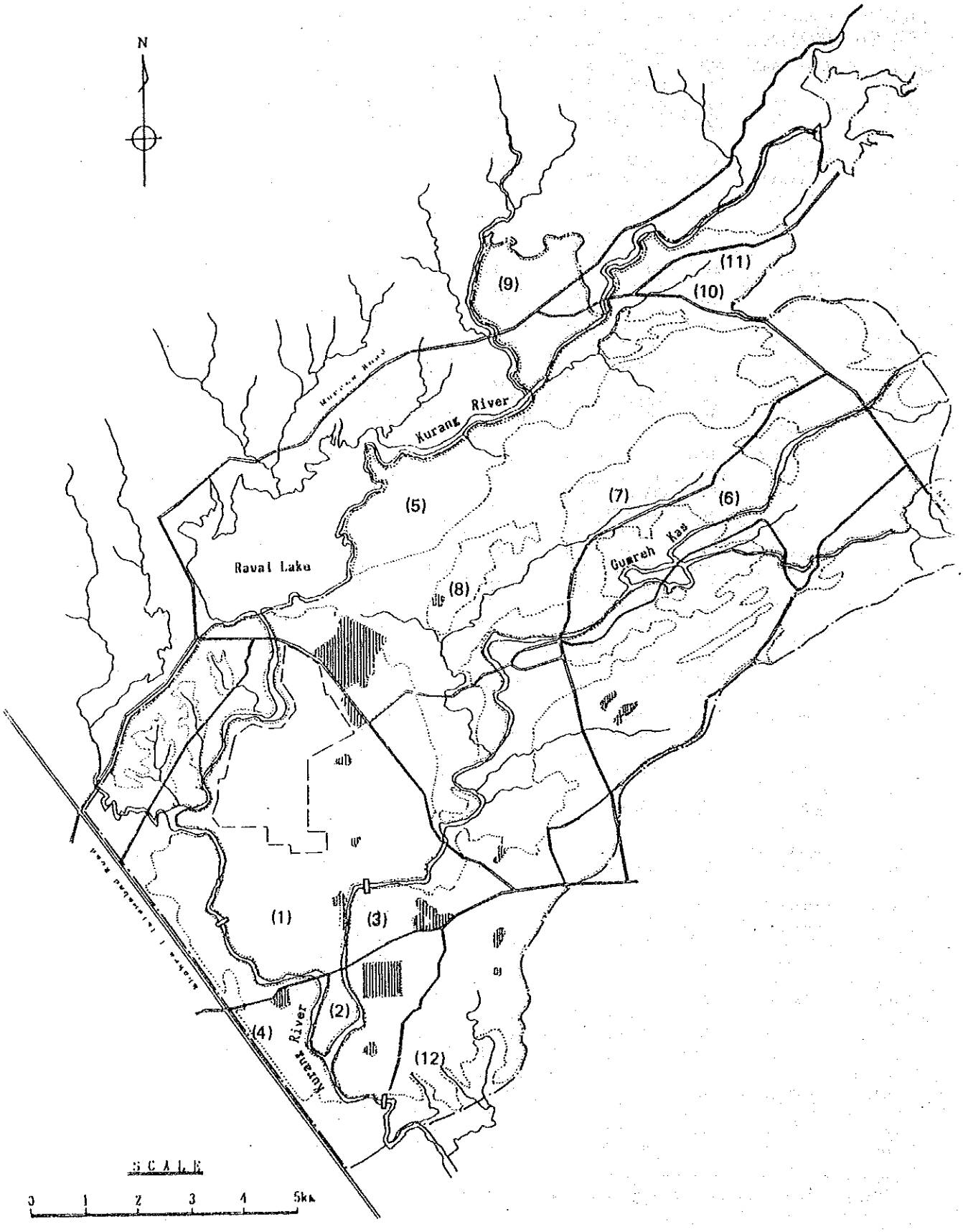
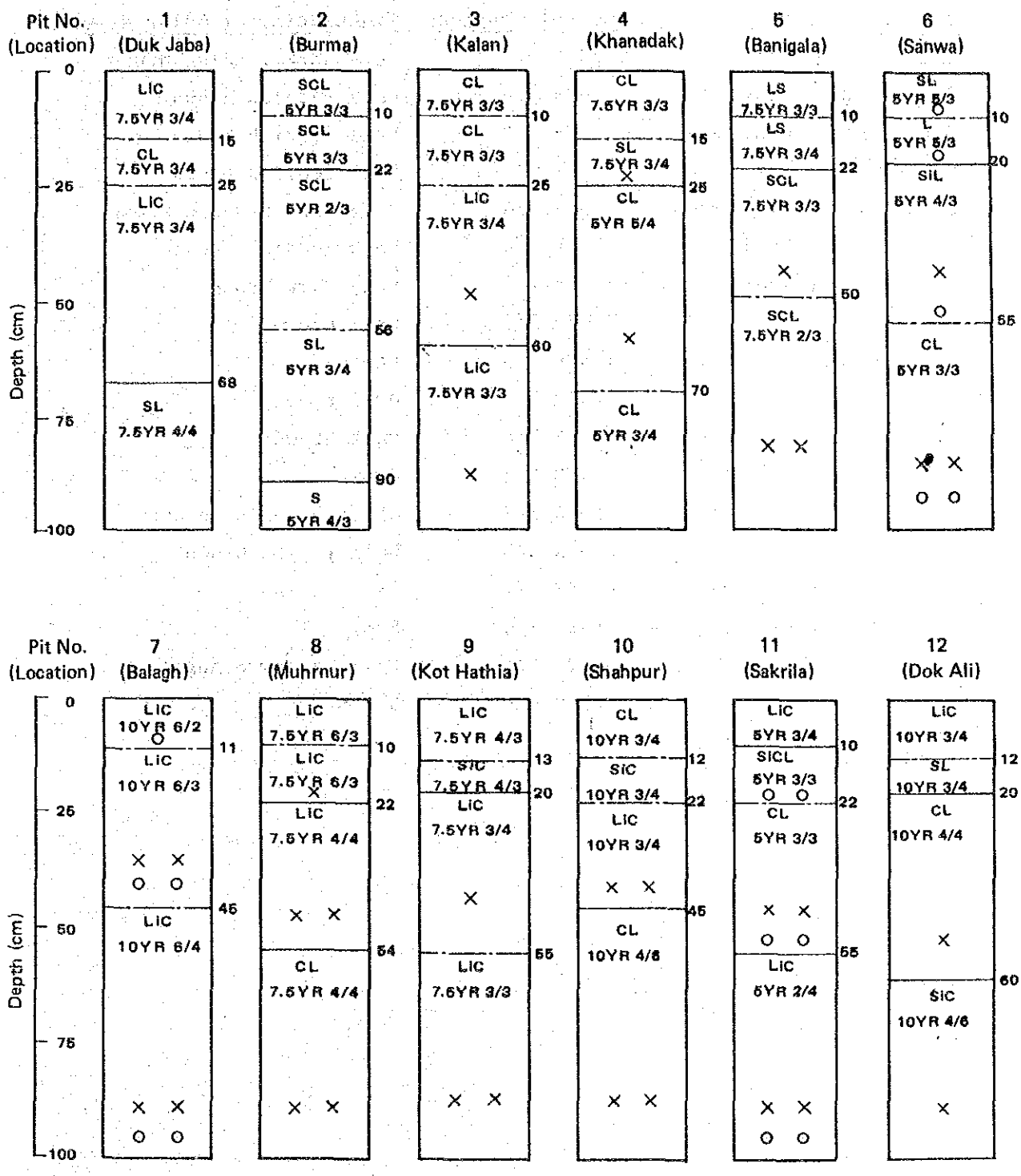


FIGURE D-2. COLUMNAR DIAGRAM OF TYPICAL SOIL PROFILES



LEGEND

Color Mottlings:

× Few (<2%)

× × Common (2 – 20%)

Gravels:

o Very Few (<5%)

o o Few (5 – 15%)

Source: Soil Survey in the Project Area, 1987, JICA Study Team

Texture Differentiation	Munsell Nation	Translation of Color Names
LiC : Light Clay	5YR 2/3	Very dark reddish brown
SiC : Silty Clay	5YR 3/3	Dark reddish brown
SCL : Sandy Clay Loom	5YR 4/3	Dull reddish brown
CL : Clay Loom	5YR 5/3	Dull reddish brown
SiCL: Silty Clay Loom	5YR 2/4	Very dark reddish brown
LS : Loomy Sand	5YR 3/4	Dark reddish brown
SL : Sandy Loom	7.5YR 2/3	Very dark brown
L : Loom	7.5YR 3/3	Dark brown
S : Sand	7.5YR 4/3	Brown
	7.5YR 6/3	Dull brown
	7.5YR 3/4	Dark brown
	7.5YR 4/4	Brown
	10YR 6/2	Grayish yellow brown
	10YR 6/3	Dull yellow brown
	10YR 3/4	Dark brown
	10YR 4/4	Brown
	10YR 6/4	Dull yellow orange
	10YR 4/6	Brown

ANNEX E. IRRIGATION AND DRAINAGE

ANNEX E. IRRIGATION AND DRAINAGE

LIST OF TABLE

LIST OF FIGURE

CHAPTER I. COMMANDED AREA AND PROPOSED CROPPING PATTERN

TABLE E-1. ESTIMATION OF TOTAL PROJECT AREA

(Unit : ha)

Item	Present Area			On-Farm			Road			Canal			Farm Pond			Planning Area		
	Up-stream	Down-stream	Total	Up-stream	Down-stream	Total	Up-stream	Down-stream	Total	Up-stream	Down-stream	Total	Up-stream	Down-stream	Total	Up-stream	Down-stream	Total
1. Cultivable Commanded Area	4,230	3,070	7,300	-390	-250	-640	-10	0	-10	-30	-10	-40	-10	0	-10	3,790	2,810	6,60(
2. Wasted Land	2,450	950	3,400							-10	-10	-20				2,440	940	3,38(
3. Mountain/ Hilly Area	1,370	230	1,600							-30	-20	-50				1,340	210	1,55(
4. River, Road, Villages	250	350	600	+390	+250	+640	+10	0	+10	+70	+40	+110	+10	0	+10	730	640	1,37(
Total	8,300	4,600	12,900													8,300	4,600	12,9(

TABLE E-2. CROPPING INTENSITY

(Unit: %)

	TYPE			Case 1				Case 2				Case 3			
	A	B	C	A	B	C	Total	A	B	C	Total	A	B	C	Total
				66	10	24	100	54	8	38	100	42	6	52	100
Rabi Wheat	50	-	80	33.0		19.2	52.2	27.0		30.4	57.4	21.0		41.6	62.6
Rabi Fodders	-	-	20			4.8	4.8			7.6	7.6			10.4	10.4
Rabi Vegetable	50	-	-	33.0			33.0	27.0			27.0	21.0			21.0
Kharif Vegetable (I)	50	-	-	33.0			33.0	27.0			27.0	21.0			21.0
Kharif Vegetable (II)	50	-	-	33.0			33.0	27.0			27.0	21.0			21.0
Perennial Orchard	-	100	-		10.0		10.0		8.0		8.0		6.0		6.0
Kharif Maize	-	-	(25)			(6.0)	(6.0)			(9.5)	(9.5)			(13.0)	(13.0)
Kharif Pulses	-	-	(25)			(6.0)	(6.0)			(9.5)	(9.5)			(13.0)	(13.0)
Total	200	100	100 (150)				166.0 (178.0)				154.0 (173.0)				142.0 (168.0)

NOTE : Kharif Maise : Without Irrigaiton
Kharif Pulses : Without Irrigaiton

CHAPTER II. IRRIGATION WATER REQUIREMENT

2.1. Crop Water Requirement

Potential evaporation(ETo) was estimated by applying the Penman Method using climatiological data observed at Chaklala Station. Table E-2 shows thus estimated ETo.

On the basis of the crop coefficient (Kc) and ETo, 10-days crop water requirement is calculated. Table E-4 to Table E-10 show crop water requirement, and Table E-11 gives 10-days crop water requirement. Table E-12 shows 10-days crop water requirement of Case 3 having cropping intensity of 142 percent.

Back data to determine crop coefficient (Kc) are attached in Table E-13 and Table E-14.

TABLE E-3. CALCULATION SHEET OF PENMAN REFERENCE CROP EVAPOTRANSPIRATION (ETo)

Factor	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Note/Equation
T mean	°C	10.00	12.30	17.20	22.70	27.70	31.60	29.90	28.80	27.30	22.60	16.50	11.60	given data
RH mean	%	70.70	68.80	64.10	53.60	41.00	41.30	66.10	74.70	68.90	63.00	66.50	70.80	- do -
ea	mbar	12.30	14.30	19.64	27.59	37.17	46.52	42.17	39.64	36.33	27.42	18.80	13.64	
ed	mbar	8.70	9.84	12.59	14.79	15.24	19.21	27.87	29.61	25.03	17.27	12.50	9.66	ea x RH mean/100
(ea-ed)	mbar	3.60	4.46	7.05	12.80	21.93	27.31	14.30	10.03	11.30	10.15	6.30	3.98	(1)
u	km/day	97.89	133.49	151.29	151.29	155.74	151.29	137.94	106.79	88.99	75.64	71.19	75.64	
U_2	km/day	97.89	133.49	151.29	151.29	155.74	151.29	137.94	106.79	88.99	75.64	71.19	75.64	u at 2m height
f(u)	-	0.53	0.63	0.68	0.68	0.69	0.68	0.64	0.56	0.51	0.47	0.46	0.47	0.27(H U_2/100)
1 - w	-	0.43	0.40	0.34	0.28	0.23	0.20	0.21	0.22	0.23	0.27	0.35	0.41	
(1-w)f(u)(ea-ed)	mm/day	0.83	1.13	1.61	2.39	3.44	3.62	1.92	1.22	1.33	1.33	1.01	0.77	(2)
Ra	mm/day	8.38	9.88	12.48	14.48	16.50	17.98	16.80	15.52	13.44	10.88	8.61	7.33	
n	hr/day	6.40	6.80	6.80	8.50	10.10	10.20	8.50	8.50	8.60	9.00	8.10	6.50	given data
N	hr/day	10.20	11.00	11.90	14.48	13.90	14.40	14.20	13.40	12.40	11.40	10.40	9.90	
Rs	mm/day	4.72	5.52	6.69	8.35	10.12	10.86	9.23	8.80	8.02	7.01	5.51	4.24	(0.25+0.50/N)Ra
Rns	mm/day	3.54	4.14	5.01	6.27	7.59	8.15	6.92	6.60	6.02	5.26	4.13	3.18	0.75Rs
f(T mean)	-	12.70	13.16	14.04	15.14	16.24	17.02	16.68	16.46	16.16	15.12	13.90	13.02	
f(ed)	-	0.21	0.20	0.18	0.17	0.17	0.15	0.11	0.10	0.12	0.16	0.18	0.20	0.34-0.044 ed
f(n/N)	-	0.66	0.66	0.61	0.69	0.75	0.74	0.64	0.67	0.72	0.81	0.80	0.69	0.1 + 0.9 n/N
Rnl	mm/day	1.77	1.74	1.59	1.78	2.05	1.85	1.15	1.11	1.40	1.93	2.05	1.82	f(T mean).f(ed).f(n/N)
Rn	mm/day	1.77	2.40	3.43	4.49	5.54	6.30	5.77	5.49	4.62	3.34	2.07	1.35	Rns - Rnl
W	-	0.57	0.60	0.66	0.72	0.77	0.80	0.79	0.78	0.77	0.72	0.65	0.59	1 - (1-w)
W·Rn	mm/day	1.00	1.44	2.27	3.25	4.28	5.07	4.57	4.30	3.55	2.41	1.36	0.80	(3)
Adj Fact (c)	-	0.98	0.96	0.95	0.98	0.96	0.97	1.03	1.04	1.02	1.01	1.00	0.99	
ETo	mm/day	1.80	2.46	3.69	5.53	7.41	8.42	6.68	5.74	4.98	3.78	2.36	1.56	(2) + (3)

TABLE E-4. CONSUMPTIVE USE OF WATER FOR CROPS

MONTH		OCT			NOV			DEC			JAN			FEB			MAY			APR			MAY		
10 DAY		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CROPPING PATTERN								WHEAT (RABI)																	
1. ELEMENT	% OF GROWING SAESON			6	12	18	24	29	35	41	47	53	59	65	71	76	82	88	94	100					
	CROP COEFFICIENT (Kc)			0.39	0.45	0.52	0.59	0.65	0.75	0.84	0.88	0.92	0.96	1.00	1.02	0.99	0.87	0.59	0.39						
					0.39	0.45	0.52	0.59	0.66	0.76	0.84	0.89	0.93	0.97	1.00	1.02	0.99	0.83	0.54	0.37					
						0.39	0.45	0.52	0.59	0.66	0.76	0.84	0.89	0.93	0.97	1.01	1.02	0.98	0.78	0.49	0.35				
							0.39	0.45	0.52	0.59	0.66	0.78	0.85	0.89	0.94	0.98	1.01	1.01	0.98	0.73	0.47	0.30			
								0.39	0.45	0.53	0.60	0.68	0.78	0.85	0.89	0.94	0.98	1.02	1.01	0.97	0.68	0.42	0.27		
									0.39	0.45	0.53	0.60	0.68	0.78	0.85	0.89	0.94	0.99	1.02	1.00	0.92	0.59	0.39		
	AVERAGE Kc			0.39	0.42	0.45	0.49	0.52	0.56	0.64	0.71	0.79	0.85	0.90	0.95	0.97	0.97	0.90	0.79	0.71	0.61	0.44	0.33	0	
	ETo (MM/DAY)	3.8			2.4			1.6			1.8			2.5			3.7			5.5			7.4		
	ET (MM/DAY)			1.5	1.0	1.1	1.2	0.8	0.9	1.0	1.3	1.4	1.5	2.2	2.4	2.4	3.6	3.3	2.9	3.9	3.4	2.4	2.4	0	
2. EQUATION	IRRIGATION			1/6	2/6	3/6	4/6	5/6	6/6										5/5	4/5	3/5	2/5	1/5		
3. WATER REQUIREMENT	IRRIGATION (MM/DAY)			0.3	0.3	0.6	0.8	0.7	0.9	1.0	1.3	1.4	1.5	2.2	2.4	2.4	3.6	3.3	2.9	3.1	2.0	1.0	0.5	0	
	MM/10DAYS			3	3	6	8	7	9	10	13	14	15	22	24	24	36	33	29	31	20	10	5	0	
	MM/MONTH	3			17			26			42			70			98			61			5		

NOTE : ▨ : Without Irrigation

TABLE E-5. CONSUMPTIVE USE OF WATER FOR CROPS

MONTH		SEP			OCT			NOV			DEC			JAN			FEB			MAR			APR			MAY	
10 DAY		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2
CROPPING PATTERN										FODDERS (RABI)																	
1. ELEMENT	% OF GROWING SAESON			5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100				
	CROP COEFFICIENT (Kc)			0.38	0.40	0.44	0.48	0.50	0.57	0.62	0.70	0.75	0.82	0.90	0.99	1.03	1.05	1.03	0.98	0.86	0.75	0.65					
					0.38	0.40	0.44	0.48	0.50	0.57	0.62	0.70	0.75	0.82	0.90	0.99	1.03	1.05	1.03	0.98	0.86	0.75	0.65				
						0.38	0.40	0.44	0.48	0.50	0.57	0.62	0.70	0.75	0.82	0.90	0.99	1.03	1.05	1.03	0.98	0.86	0.75	0.65			
							0.38	0.40	0.44	0.48	0.50	0.57	0.62	0.70	0.75	0.82	0.90	0.99	1.03	1.05	1.03	0.98	0.86	0.75	0.65		
	AVERAGE Kc			0.38	0.39	0.41	0.43	0.46	0.50	0.54	0.60	0.66	0.72	0.79	0.87	0.94	0.99	1.03	1.02	0.98	0.91	0.81	0.75	0.70	0.65	0	
	ETo (MM/DAY)	5.0			3.8			2.4			1.6			1.8			2.5			3.7			5.5			7.4	
	ET (MM/DAY)			1.9	1.5	1.6	1.6	1.1	1.2	1.3	1.0	1.1	1.2	1.4	1.6	1.7	2.5	2.6	2.6	3.6	3.4	3.0	4.1	3.9	3.6	0	
2. EQUATION	IRRIGATION			1/4	2/4	3/4	4/4															4/4	3/4	2/4	1/4		
3. WATER REQUIREMENT	IRRIGATION (MM/DAY)			0.5	0.8	1.2	1.6	1.1	1.2	1.3	1.0	1.1	1.2	1.4	1.6	1.7	2.5	2.6	2.6	3.6	3.4	3.0	3.1	2.0	0.9	0	
	MM/10DAYS			5	8	12	16	11	12	13	10	11	12	14	16	17	25	26	26	36	34	30	31	20	9	0	
	MM/MONTH	5			36			36			33			47			77			100			60			0	

NOTE : ▨ : Without Irrigation

TABLE E-6. CONSUMPTIVE USE OF WATER FOR CROPS

MONTH		AUG			SEP			OCT			NOV			DEC			JAN			FEB			MAR		
10 DAY		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CROPPING PATTERN											VEGETABLE (RABI)														
1. ELEMENT	% OF GROWING SAESON			7	13	20	27	33	40	47	53	60	67	73	80	87	93	100							
	CROP COEFFICIENT (Kc)			0.36	0.42	0.50	0.59	0.68	0.78	0.88	0.94	1.00	1.04	1.02	0.95	0.88	0.82	0.75							
					0.36	0.42	0.50	0.59	0.69	0.78	0.88	0.95	1.01	1.04	1.01	0.94	0.88	0.81	0.75						
						0.36	0.43	0.50	0.59	0.69	0.79	0.89	0.95	1.01	1.04	1.00	0.93	0.87	0.80	0.75					
							0.36	0.43	0.51	0.59	0.69	0.79	0.89	0.96	1.01	1.05	1.00	0.93	0.86	0.79	0.75				
								0.36	0.43	0.51	0.60	0.71	0.81	0.91	0.96	1.01	1.05	0.99	0.92	0.85	0.78	0.75			
									0.36	0.43	0.51	0.60	0.71	0.81	0.91	0.97	1.02	1.05	0.98	0.91	0.84	0.77	0.75		
										0.36	0.43	0.51	0.60	0.71	0.81	0.92	0.98	1.02	1.04	0.97	0.90	0.83	0.76	0.75	
											0.36	0.43	0.51	0.62	0.72	0.82	0.92	0.98	1.02	1.04	0.96	0.89	0.82	0.75	
	AVERAGE Kc			0.36	0.39	0.43	0.47	0.51	0.56	0.60	0.64	0.74	0.82	0.89	0.93	0.95	0.95	0.93	0.91	0.89	0.85	0.81	0.78	0.75	
	ETo (MM/DAY)	5.7			5.0			3.8			2.4			1.6			1.8			2.5			3.7		
	ET (MM/DAY)			2.1	2.0	2.2	2.4	1.9	2.1	2.3	1.5	1.8	2.0	1.4	1.5	1.5	1.7	1.7	1.6	2.2	2.1	2.0	2.9	2.8	
2. EQUATION	IRRIGATION			1/8	2/8	3/8	4/8	5/8	6/8	7/8	8/8						7/7	6/7		5/7	4/7	3/7	2/7	1/7	
3. WATER REQUIREMENT	IRRIGATION (MM/DAY)			0.3	0.5	0.8	1.2	1.2	1.6	2.0	1.5	1.8	2.0	1.4	1.5	1.5	1.7	1.7	1.4	1.6	1.2	0.9	0.8	0.4	
	MM/10DAYS			3	5	8	12	12	16	20	15	18	20	14	15	15	17	17	14	16	12	9	8	4	
	MM/MONTH	3			25			48			53			44			48			37			12		

TABLE E-7 CONSUMPTIVE USE OF WATER FOR CROPS

MONTH		FEB			MAR			APR			MAY			JUN		
10 DAY		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CROPPING PATTERN				VEGETABLE KHARIF (I)												
1. ELEMENT	% OF GROWING SEASON			14	29	43	57	71	86	100						
	CROP COEFFICIENT (Kc)			0.43	0.62	0.82	0.98	1.04	0.89	0.75						
					0.43	0.62	0.82	0.98	1.04	0.89	0.75					
						0.43	0.62	0.82	0.98	1.04	0.89	0.75				
							0.43	0.62	0.82	0.98	1.04	0.89	0.75			
								0.43	0.62	0.82	0.98	1.04	0.89	0.75		
									0.43	0.62	0.82	0.98	1.04	0.89	0.75	
										0.43	0.62	0.82	0.98	1.04	0.89	0.75
	AVERAGE (Kc)			0.43	0.53	0.62	0.71	0.78	0.80	0.75	0.85	0.90	0.92	0.89	0.82	0.75
	ETo (MM/DAY)	2.5			3.7			5.5			7.4			8.4		
	ET (MM/DAY)			1.1	2.0	2.3	2.6	4.3	4.4	4.1	6.3	6.7	6.8	7.5	6.9	6.3
2. EQUATION	IRRIGATION			1/7	2/7	3/7	4/7	5/7	6/7	7/7	6/7	5/7	4/7	3/7	2/7	1/7
3. WATER REQUIREMENT	IRRIGATION(MM/DAY)			0.2	0.6	1.0	1.5	3.1	3.8	4.1	5.4	4.8	3.9	3.2	2.0	0.9
	MM/10DAYS			2	6	10	15	31	38	41	54	48	39	32	20	9
	MM/MONTH	2			31			110			141			61		

TABLE E-8 CONSUMPTIVE USE OF WATER FOR CROPS

MONTH		JUN			JUL			AUG			SEP			OCT		
10 DAY		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CROPPING PATTERN		VEGETABLE KHARIF (II)														
1. ELEMENT	% OF GROWING SEASON	17	33	50	67	83	100									
	CROP COEFFICIENT (Kc)	0.47	0.68	0.92	1.04	0.92	0.75									
			0.45	0.65	0.86	1.01	0.98	0.83	0.75							
				0.43	0.62	0.82	0.98	1.04	0.89	0.75						
					0.42	0.59	0.78	0.94	1.04	0.95	0.82	0.75				
						0.42	0.57	0.75	0.92	1.02	1.00	0.87	0.75			
							0.41	0.55	0.71	0.88	0.99	1.04	0.93	0.81	0.75	
								0.40	0.53	0.68	0.84	0.97	1.04	0.97	0.86	0.75
	AVERAGE (Kc)	0.47	0.57	0.67	0.74	0.75	0.75	0.75	0.81	0.86	0.91	0.91	0.91	0.89	0.81	0.75
	ETo (MM/DAY)	8.4			6.7			5.7			5.0			3.8		
	ET (MM/DAY)	3.9	4.8	5.6	5.0	5.0	5.0	4.3	4.6	4.9	4.6	4.6	4.6	3.4	3.1	2.9
2. EQUATION	IRRIGATION	1/7	2/7	3/7	4/7	5/7	6/7	9/10	8/10	7/10	6/10	5/10	4/10	3/10	2/10	1/10
3. WATER REQUIREMENT	IRRIGATION(MM/DAY)	0.6	1.4	2.4	2.9	3.6	4.3	3.9	3.7	3.4	2.8	2.3	1.8	1.0	0.6	0.3
	MM/10DAYS	6	14	24	29	36	43	39	37	34	28	23	18	10	6	3
	MM/MONTH	44			108			110			69			19		

TABLE E-9. CONSUMPTIVE USE OF WATER FOR CROPS

MONTH		APR			MAY			JUN			JUL			AUG			SEP			OCT			NOV			DEC		
10 DAY		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
CROPPING PATTERN		ORCHARD (PERNNIAL)																										
1. ELEMENT	% OF GROWING SAESON																											
	CROP COEFFICIENT (Kc)																											
	AVERAGE Kc	0.85																								0.85	0.86	0.88
	ETo (MM/DAY)	5.5			7.4			8.4			6.7			5.7			5.0			3.8			2.4			1.6		
	ET (MM/DAY)	4.7	4.7	4.7	6.3	6.3	6.3	7.1	7.1	7.1	5.7	5.7	5.7	4.8	4.8	4.8	4.3	4.3	4.3	3.2	3.2	3.2	2.0	2.0	2.0	1.4	1.4	1.4
2. EQUATION	IRRIGATION																											
3. WATER REQUIREMENT	IRRIGATION (MM/DAY)	4.7	4.7	4.7	6.3	6.3	6.3	7.1	7.1	7.1	5.7	5.7	5.7	4.8	4.8	4.8	4.3	4.3	4.3	3.2	3.2	3.2	2.0	2.0	2.0	1.4	1.4	1.4
	MM/10DAYS	47	47	47	63	63	63	71	71	71	57	57	57	48	48	48	43	43	43	32	32	32	20	20	20	14	14	14
	MM/MONTH	141			189			213			171			144			129			96			60			42		

TABLE E-10. CONSUMPTIVE USE OF WATER FOR CROPS

MONTH		JAN			FEB			MAR		
10 DAY		1	2	3	1	2	3	1	2	3
CROPPING PATTERN		ORCHARD (PERENNIAL)								
1. ELEMENT	% OF GROWING SAESON									
	CROP COEFFICIENT (Kc)									
	AVERAGE Kc	0.89	0.90	0.90	0.90	0.90	0.88	0.88	0.86	0.85
	ETo (MM/DAY)	1.8			2.5			3.7		
	ET (MM/DAY)	1.6	1.6	1.6	2.3	2.3	2.3	3.3	3.2	3.1
2. EQUATION	IRRIGATION									
3. WATER REQUIREMENT	IRRIGATION (MM/DAY)	1.6	1.6	1.6	2.3	2.3	2.2	3.3	3.2	3.1
	MM/10DAYS	16	16	16	23	23	22	33	32	31
	MM/MONTH	48			68			96		

TABLE E-11. 10-DAYS CONSUMPTIVE USE OF WATER FOR EACH CROP

(Unit : mm)

		Rabi Wheat	Rabi Fodders	Rabi Vegetables	Kharif Vegetable(I)	Kharif Vegetable(II)	Perennial Orchard
JAN	I	13	14	17			16
	II	14	16	17			16
	III	15	17	14			16
FEB	I	22	25	16			23
	II	24	26	12			23
	III	24	26	9	2		22
MAR	I	36	36	8	6		33
	II	33	34	4	10		32
	III	29	30		15		31
APR	I	31	31		31		47
	II	20	20		38		47
	III	10	9		41		47
MAY	I	5	0		54		63
	II	0			48		63
	III				39		63
JUN	I				32	6	71
	II				20	14	71
	III				9	24	71
JUL	I					29	57
	II					36	57
	III					43	57
AUG	I					39	48
	II					37	48
	III			3		34	48
SEP	I			5		28	43
	II			8		23	43
	III		5	12		18	43
OCT	I		8	12		10	32
	II		12	16		6	32
	III	3	16	20		3	32
NOV	I	3	11	15			20
	II	6	12	18			20
	III	8	13	20			20
DEC	I	7	10	14			14
	II	9	11	15			14
	III	10	12	15			14
Total		322	394	270	345	350	1,397

TABLE E-12. 10 DAYS CONSUMPTIVE USE OF WATER

Month	10 days	Rabi Wheat (62.6%) (mm)	Rabi Fodders (10.4%) (mm)	Rabi Vegetables (21.0%) (mm)	Kharif Vegetable(I) (21.0%) (mm)	Kharif Vegetable (II) (21.0%) (mm)	Perennial Orchard (6.0%) (mm)	10 days Total (mm)	10 days (MCM/1,000ha)	10 days Average (cu.m/sec/1,000ha)	Monthly (mm)	Monthly (MCM/1,000 ha)
	I	8.1	1.5	3.6			1.0	14.2	0.237	0.274		
JAN	II	8.8	1.7	3.6			1.0	15.1	0.252	0.292	44.4	0.741
	III	9.4	1.8	2.9			1.0	15.1	0.252	0.292		
	I	13.8	2.6	3.4			1.4	21.2	0.353	0.409		
FEB	II	15.0	2.7	2.5			1.4	21.6	0.360	0.417	64.1	1.068
	III	15.0	2.7	1.9	0.4		1.3	21.3	0.355	0.411		
	I	22.5	3.7	1.7	1.3		2.0	31.2	0.520	0.602		
MAR	II	20.7	3.5	0.8	2.1		1.9	29.0	0.483	0.559	86.6	1.443
	III	18.2	3.1		3.2		1.9	26.4	0.440	0.509		
	I	19.4	3.2		6.5		2.8	31.9	0.532	0.616		
APR	II	12.5	2.1		8.0		2.8	25.4	0.423	0.490	75.9	1.265
	III	6.3	0.9		8.6		2.8	18.6	0.310	0.359		
	I	3.1	0		11.3		3.8	18.2	0.303	0.351		
MAY	II				10.1		3.8	13.9	0.232	0.269	44.1	0.735
	III				8.2		3.8	12.0	0.200	0.231		
	I				6.7	1.3	4.3	12.3	0.205	0.237		
JUN	II				4.2	2.9	4.3	11.4	0.190	0.220	34.9	0.582
	III				1.9	5.0	4.3	11.2	0.187	0.216		
	I					6.1	3.4	9.5	0.158	0.183		
JUL	II					7.6	3.4	11.0	0.183	0.212	32.9	0.548
	III					9.0	3.4	12.4	0.207	0.240		
	I					8.2	2.9	11.1	0.185	0.214		
AUG	II					7.8	2.9	10.7	0.178	0.206	32.4	0.540
	III			0.6		7.1	2.9	10.6	0.177	0.205		
	I			1.1		5.9	2.6	9.6	0.160	0.185		
SEP	II			1.7		4.8	2.6	9.1	0.152	0.176	28.1	0.469
	III		0.5	2.5		3.8	2.6	9.4	0.157	0.182		
	I		0.8	2.5		2.1	1.9	7.3	0.122	0.141		
OCT	II		1.2	3.4		1.3	1.9	7.8	0.130	0.150	25.4	0.424
	III	1.9	1.7	4.2		0.6	1.9	10.3	0.172	0.199		
	I	1.9	1.1	3.2			1.2	7.4	0.123	0.142		
NOV	II	3.8	1.2	3.8			1.2	10.9	0.167	0.193	29.2	0.487
	III	5.0	1.4	4.2			1.2	11.8	0.197	0.228		
	I	4.4	1.0	2.9			0.8	9.1	0.152	0.176		
DEC	II	5.6	1.1	3.2			0.8	10.7	0.178	0.206	31.3	0.522
	III	6.3	1.2	3.2			0.8	11.5	0.192	0.222		
Total		201.7	40.7	56.9	72.5	75.5	84.0	529.3	8.824		529.3	8.824

TABLE E-13. CROP COEFFICIENT (Kc) (Rabi Season)

		Crop Growing Stage (%)									
		10	20	30	40	50	60	70	80	90	100
Wheat	1	0.60	0.94	1.25	1.40	1.46	1.40	1.25	1.00	0.80	0.65
	2	0.43	0.54	0.66	0.83	0.90	0.97	1.03	0.97	0.49	0.08
	3	0.38	-	-	-	-	-	1.05	-	-	0.25
	4	0.43	0.54	0.66	0.83	0.90	0.97	1.03	0.97	0.49	0.25
Fodders	1	0.36	0.60	0.97	1.05	1.14	1.18	1.20	1.20	1.18	1.10
	2	0.40	0.48	0.57	0.70	0.92	0.98	0.92	0.62	0.25	0.03
	3	0.33	-	-	-	-	1.00	1.05	-	-	0.55
	4	0.40	0.48	0.57	0.70	0.82	0.99	1.05	0.98	0.75	0.55
Vegetable	1	0.27	0.36	0.52	0.73	0.96	1.08	1.10	1.03	0.92	0.79
	2	0.39	0.50	0.63	0.78	0.92	0.98	0.92	0.62	0.25	0.03
	3	0.33	-	-	-	-	-	1.05	-	-	0.75
	4	0.39	0.50	0.63	0.78	0.92	1.00	1.05	0.95	0.85	0.75

Note:
1 : On Farm Water Management Field Manual
2 : Irrigation Requirements of Crops in Punjab
3 : FAO Technical Paper No. 24
4 : Adjusted

TABLE E-14. CROP COEFFICIENT (Kc) (Kharif Season)

Crop Growing Stage (%)

		10	20	30	40	50	60	70	80	90	100
Vegetable	1	0.27	0.36	0.52	0.73	0.96	1.08	1.10	1.03	0.92	0.79
	2	0.39	0.50	0.63	0.78	0.92	0.98	0.92	0.62	0.25	0.03
	3	0.53	-	-	-	-	-	1.05	-	-	0.75
	4	0.39	0.50	0.63	0.78	0.92	1.00	1.05	0.95	0.85	0.75

Crop Growing Stage (%) (Perennial)

		10	20	30	40	50	60	70	80	90	100
Orchard	1	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	-	-	-
	3	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.90	0.90	0.85
	4	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.90	0.90	0.85

Note: 1 : On Farm Water Management Field Manual
2 : Irrigation Requirements of Crops in Punjab
3 : FAO Technical Paper No. 24
4 : Adjusted

2.2. Study on Application Irrigation Effeciency for Furrow Irrigation

1) Field Manual of On-Farm Water Management

In the above manual published by the Ministry of Food, Agriculture & Cooperatives of the Government of Pakistan, irrigation efficiency is expressed as follows;

SIE = System Irrigation Efficiency (expressed as a decimal).
The following are SIE values for different types of irrigation systems:

Irrigation System Type	SIE
Surface	30 - 60%
Sprinkler	70 - 90%
Trickle	80 - 90%

Source: On-Farm Water Management Field Manual, Volume IV.

Considering that all the on-farm facilities under the Project are newly constructed, the maximum irrigation efficiency of 60 percent for the surface irrigation system in the above table could be adopted for the project.

According to "FAO Technical Paper No.24", conveyance efficiency and operation efficiency are expressed as follows;

- Conveyance efficiency (Ec) 0.9
- Operation efficiency (Eb) 0.9

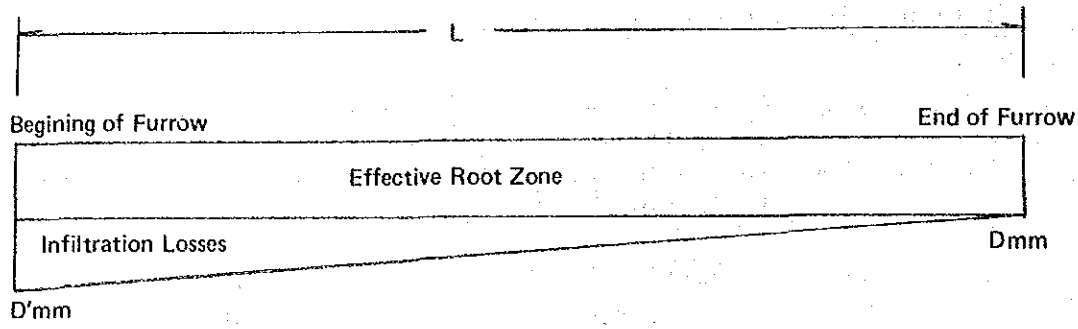
If application efficiency (Ea) is assumed to be 0.75, irrigation efficiency (E) is calculated as follows;

$$E = 0.9 \times 0.9 \times 0.75 = 0.6$$

Accordingly, the application efficiency (Ea) of 0.75 could be considered to be acceptable.

2) Intake Rate

Water Infiltration Losses in Furrow Irrigation



In the above figure, if T minutes are required to obtain water infiltration depth of D mm at the end of the furrow, elapsed time for water infiltration at the beginning of the furrow is (T + t) minutes and water infiltration depth at the beginning of the furrow (D') is expressed as follows;

$$D' = C \times (T + t)^{n}$$

Accordingly, application efficiency (Ea) is expressed as follows;

$$Ea = \frac{D}{1/2\ (D' + D)} \times 100$$

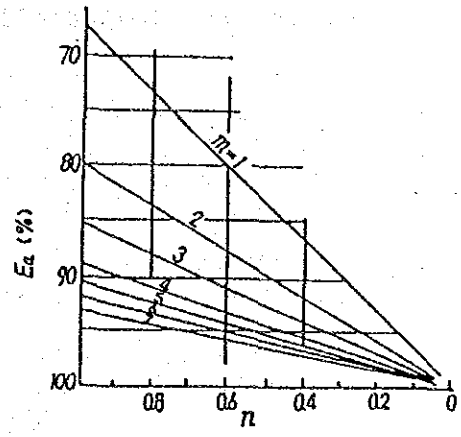
In general, irrigation method in which irrigation water reaches at the end of furrow in T/m minutes is employed considering actual irrigation practices in the field. In this case, t = P/m and m is determined by constant rate of C for soil intake and n.

Where;

$$D' = C\ (m+1)^n\ t^n$$
$$D = C\ m^n\ t^n$$

$$Ea = \frac{2m}{(m+1)\ + m} \times 100$$

Monograph for Application Efficiency



n Value Obtained Through Intake Rate Tests

Location	n Value
No.1 Dhok Hayat	0.674
No.4 Khanna Dak	0.689
No.5 Banigala	0.592
No.7 Balagh	0.786
No.10 Shahpur	0.800

The maximum n value in the Project Area is 0.800, and also considering that the m value is generally in the range of three to four, application efficiency of Ea = 0.88 is obtained.

3) Conclusion

As the results, application efficiency of 0.75 is deemed to be reasonable rate.

2.3. Diversion Water Requirement

Diversion water requirements of the three cases of alternative cropping pattern (Case 1, Case 2 and Case 3) were estimated for the periods of 35-years (1952 - 1986) and they are tabulated in Table E-16 to Table E-18. Probable diversion water requirement is presented in Figure E-1.

Diversion water requirements by crops in case of probability of 1/2, 1/5 and 1/10 are shown in Table E-19 and E-20.

TABLE E-15. RESULT OF CALCULATED DIVERSION WATER REQUIREMENT

(Unit:MCM/1,000ha)

Year	Case 1	Case 2	Case 3
1952	5.158	4.666	4.173
1953	6.021	5.494	4.967
1954	5.220	4.669	4.118
1955	6.328	5.852	5.375
1956	5.436	4.986	4.536
1957	3.229	2.794	2.359
1958	6.030	5.484	4.939
1959	3.646	3.219	2.791
1960	5.628	5.086	4.544
1961	4.133	3.718	3.302
1962	4.351	3.904	3.457
1963	4.741	4.329	3.917
1964	5.480	5.023	4.567
1965	3.936	3.451	2.966
1966	4.558	4.119	3.679
1967	4.489	4.039	3.588
1968	4.630	4.066	3.502
1969	5.185	4.691	4.196
1970	5.269	4.797	4.325
1971	5.516	5.170	4.823
1972	3.994	3.480	2.966
1973	4.783	4.419	4.055
1974	5.242	4.797	4.353
1975	5.348	4.908	4.467
1976	4.375	3.883	3.392
1977	4.720	4.413	4.105
1978	4.474	4.078	3.682
1979	4.377	3.854	3.331
1980	3.822	3.328	2.834
1981	3.752	3.389	3.025
1982	3.544	3.029	2.513
1983	3.994	3.668	3.342
1984	5.497	5.076	4.654
1985	5.256	4.789	4.322
1986	4.405	3.997	3.590
MEAN	4.759	4.305	3.850

TABLE E-16. DIVERSION WATER REQUIREMENT (CASE 1)

CROPPING PATTERN WHEAT =0.522 FODDERS =0.048 VEGET(R) =0.330 VEGET(K1)=0.330 VEGET(K2)=0.330
ORCHARD =0.100 MAIZE(K)=0.060 PULSES(K=0.060
CROPPING INTENSITY = 178.0% IRRIGATION EFFICIENCY = 60.0%

(UNIT...MCM/1000HA)

YEAR	(JAN)	(FEB)	(MAR)	(APR)	(MAY)	(JUN)	(JUL)	(AUG)	(SEP)	(OCT)	(NOV)	(DEC)	ANNUAL
1952	0.077	0.162	0.368	1.070	0.974	0.329	0.177	0.122	0.317	0.396	0.577	0.589	5.158
1953	0.004	0.313	1.103	0.876	0.856	0.892	0.285	0.135	0.255	0.235	0.577	0.490	6.021
1954	0.064	0.010	0.606	1.094	0.970	0.756	0.278	0.118	0.197	0.213	0.520	0.392	5.220
1955	0.687	0.721	0.683	0.828	0.795	0.806	0.323	0.196	0.067	0.336	0.577	0.309	6.328
1956	0.277	0.889	0.308	0.875	1.120	0.264	0.055	0.013	0.433	0.212	0.501	0.489	5.436
1957	0.038	0.184	0.431	0.166	0.643	0.464	0.666	0.138	0.313	0.090	0.068	0.028	3.229
1958	0.363	0.820	0.469	1.024	1.068	0.893	0.140	0.171	0.248	0.277	0.347	0.208	6.030
1959	0.055	0.027	0.719	0.704	0.654	0.651	0.261	0.123	0.008	0.190	0.122	0.132	3.646
1960	0.003	0.768	0.318	0.700	1.063	0.845	0.218	0.141	0.201	0.278	0.577	0.518	5.628
1961	0.133	0.247	0.934	0.408	1.000	0.604	0.224	0.116	0.007	0.150	0.103	0.207	4.133
1962	0.245	0.322	0.425	0.768	0.901	0.523	0.228	0.046	0.065	0.365	0.330	0.133	4.351
1963	0.544	0.966	0.321	0.497	0.707	0.753	0.346	0.020	0.034	0.350	0.081	0.122	4.741
1964	0.119	0.454	0.822	0.369	0.862	0.743	0.172	0.202	0.140	0.463	0.577	0.556	5.480
1965	0.362	0.083	0.424	0.053	0.494	0.601	0.415	0.204	0.421	0.424	0.160	0.297	3.936
1966	0.557	0.339	0.362	0.402	0.882	0.606	0.301	0.069	0.055	0.134	0.392	0.458	4.558
1967	0.407	0.460	0.444	0.696	0.823	0.811	0.162	0.017	0.225	0.129	0.278	0.038	4.489
1968	0.226	0.060	0.569	0.781	1.044	0.703	0.237	0.065	0.469	0.246	0.116	0.114	4.630
1969	0.598	0.106	0.658	0.894	0.798	0.765	0.336	0.120	0.142	0.128	0.193	0.448	5.185
1970	0.506	0.352	0.506	1.094	1.073	0.573	0.251	0.038	0.026	0.237	0.342	0.272	5.269
1971	0.559	0.674	0.843	0.718	0.839	0.142	0.404	0.102	0.148	0.360	0.273	0.454	5.516
1972	0.133	0.194	0.344	0.316	0.898	0.588	0.600	0.258	0.135	0.152	0.328	0.049	3.994
1973	0.290	0.585	0.601	0.759	0.897	0.405	0.106	0.052	0.053	0.161	0.566	0.308	4.783
1974	0.354	0.207	0.783	1.017	0.921	0.330	0.189	0.194	0.239	0.294	0.577	0.137	5.242
1975	0.697	0.145	0.352	1.001	0.754	0.610	0.164	0.108	0.080	0.480	0.412	0.545	5.348
1976	0.301	0.052	0.292	0.433	1.097	0.607	0.140	0.049	0.087	0.182	0.518	0.616	4.375
1977	0.253	0.661	1.336	0.324	0.771	0.379	0.045	0.066	0.263	0.151	0.185	0.285	4.720
1978	0.391	0.283	0.570	0.889	0.914	0.586	0.033	0.016	0.048	0.266	0.121	0.358	4.474
1979	0.035	0.511	0.383	0.685	0.854	0.566	0.476	0.050	0.221	0.195	0.246	0.155	4.377
1980	0.011	0.030	0.136	0.793	0.969	0.496	0.117	0.234	0.071	0.223	0.431	0.311	3.822
1981	0.087	0.159	0.152	0.438	0.700	0.606	0.116	0.019	0.112	0.263	0.484	0.616	3.752
1982	0.130	0.043	0.102	0.545	0.524	0.652	0.634	0.074	0.302	0.199	0.224	0.115	3.544
1983	0.493	0.240	0.359	0.206	0.881	0.416	0.136	0.124	0.045	0.046	0.431	0.616	3.994
1984	0.804	0.525	0.620	0.554	1.027	0.502	0.091	0.066	0.067	0.411	0.507	0.322	5.497
1985	0.022	0.584	0.892	1.033	0.817	0.856	0.153	0.080	0.263	0.126	0.306	0.123	5.256
1986	0.441	0.358	0.508	0.774	0.794	0.498	0.287	0.088	0.238	0.113	0.281	0.024	4.405
MEAN	0.293	0.358	0.536	0.680	0.868	0.595	0.250	0.104	0.171	0.242	0.352	0.310	4.759

TABLE E-17. DIVERSION WATER REQUIREMENT (CASE 2)

CROPPING PATTERN WHEAT =0.574 FODDERS =0.076 VEGET(R) =0.270 VEGET(K1)=0.270 VEGET(K2)=0.270
ORCHARD =0.080 MAIZE(K)=0.095 PULSES(K=0.095
CROPPING INTENSITY = 173.0% IRRIGATION EFFICIENCY = 60.0%

(UNIT...MCM/1000HA)

YEAR	(JAN)	(FEB)	(MAR)	(APR)	(MAY)	(JUN)	(JUL)	(AUG)	(SEP)	(OCT)	(NOV)	(DEC)	ANNUAL
1952	0.077	0.180	0.408	0.992	0.792	0.265	0.143	0.099	0.258	0.344	0.538	0.569	4.666
1953	0.004	0.340	1.168	0.798	0.695	0.723	0.231	0.110	0.210	0.205	0.538	0.471	5.494
1954	0.062	0.011	0.664	1.016	0.789	0.613	0.225	0.096	0.160	0.178	0.481	0.373	4.669
1955	0.687	0.765	0.749	0.750	0.646	0.654	0.262	0.159	0.057	0.296	0.538	0.289	5.852
1956	0.275	0.930	0.343	0.797	0.914	0.212	0.045	0.010	0.353	0.178	0.460	0.469	4.986
1957	0.031	0.204	0.470	0.135	0.522	0.374	0.541	0.112	0.254	0.073	0.055	0.023	2.794
1958	0.353	0.864	0.515	0.954	0.868	0.725	0.114	0.139	0.203	0.243	0.308	0.198	5.484
1959	0.047	0.030	0.777	0.615	0.535	0.527	0.211	0.100	0.007	0.158	0.100	0.111	3.219
1960	0.002	0.815	0.339	0.655	0.864	0.685	0.176	0.114	0.164	0.235	0.538	0.499	5.086
1961	0.125	0.273	0.998	0.354	0.812	0.489	0.182	0.094	0.006	0.128	0.084	0.171	3.718
1962	0.237	0.341	0.470	0.688	0.733	0.423	0.184	0.037	0.054	0.323	0.302	0.110	3.904
1963	0.531	1.008	0.350	0.459	0.574	0.610	0.281	0.016	0.029	0.303	0.066	0.101	4.329
1964	0.117	0.491	0.886	0.326	0.700	0.602	0.139	0.164	0.116	0.407	0.538	0.537	5.023
1965	0.358	0.091	0.463	0.043	0.400	0.486	0.337	0.166	0.342	0.370	0.136	0.260	3.451
1966	0.553	0.351	0.401	0.357	0.716	0.492	0.244	0.056	0.045	0.114	0.349	0.442	4.119
1967	0.401	0.482	0.492	0.635	0.668	0.657	0.131	0.013	0.184	0.108	0.235	0.031	4.039
1968	0.207	0.069	0.627	0.714	0.848	0.570	0.192	0.053	0.384	0.212	0.095	0.096	4.066
1969	0.598	0.120	0.711	0.824	0.648	0.620	0.273	0.098	0.117	0.112	0.159	0.412	4.691
1970	0.500	0.383	0.561	1.015	0.877	0.464	0.203	0.031	0.023	0.208	0.289	0.243	4.797
1971	0.557	0.716	0.920	0.671	0.682	0.113	0.327	0.083	0.123	0.314	0.232	0.433	5.170
1972	0.122	0.214	0.378	0.289	0.730	0.476	0.487	0.210	0.112	0.132	0.290	0.040	3.480
1973	0.280	0.619	0.662	0.671	0.733	0.327	0.085	0.042	0.043	0.138	0.524	0.293	4.419
1974	0.346	0.230	0.856	0.934	0.751	0.266	0.153	0.158	0.195	0.251	0.538	0.121	4.797
1975	0.696	0.161	0.387	0.949	0.612	0.494	0.133	0.088	0.068	0.422	0.373	0.525	4.908
1976	0.297	0.058	0.328	0.368	0.892	0.491	0.114	0.040	0.073	0.150	0.477	0.597	3.883
1977	0.245	0.706	1.393	0.297	0.627	0.306	0.037	0.053	0.216	0.126	0.152	0.255	4.413
1978	0.389	0.312	0.625	0.811	0.746	0.474	0.027	0.013	0.039	0.225	0.102	0.315	4.078
1979	0.032	0.539	0.422	0.595	0.694	0.458	0.386	0.041	0.182	0.168	0.209	0.129	3.854
1980	0.009	0.035	0.154	0.710	0.795	0.401	0.095	0.190	0.061	0.194	0.393	0.292	3.328
1981	0.082	0.181	0.169	0.421	0.568	0.490	0.094	0.016	0.093	0.232	0.445	0.597	3.389
1982	0.116	0.046	0.116	0.521	0.425	0.528	0.515	0.060	0.245	0.166	0.198	0.094	3.029
1983	0.489	0.266	0.398	0.196	0.716	0.336	0.110	0.101	0.038	0.037	0.385	0.597	3.668
1984	0.804	0.551	0.683	0.481	0.835	0.406	0.074	0.054	0.055	0.364	0.468	0.302	5.076
1985	0.018	0.629	0.945	0.946	0.669	0.694	0.124	0.065	0.217	0.106	0.259	0.117	4.789
1986	0.425	0.378	0.546	0.730	0.645	0.403	0.232	0.072	0.194	0.100	0.252	0.020	3.997
MEAN	0.288	0.383	0.582	0.620	0.706	0.482	0.203	0.084	0.141	0.209	0.317	0.290	4.305

TABLE E-18. DIVERSION WATER REQUIREMENT (CASE 3)

CROPPING PATTERN WHEAT =0.626 FODDERS =0.104 VEGET(R) =0.210 VEGET(K1)=0.210 VEGET(K2)=0.210
ORCHARD =0.060 MAIZE(K)=0.130 PULSES(K=0.130
CROPPING INTENSITY = 168.0% IRRIGATION EFFICIENCY = 60.0%

(UNIT...MCM/1000HA)

YEAR	(JAN)	(FEB)	(MAR)	(APR)	(MAY)	(JUN)	(JUL)	(AUG)	(SEP)	(OCT)	(NOV)	(DEC)	ANNUAL
1952	0.076	0.198	0.447	0.914	0.610	0.201	0.109	0.076	0.200	0.293	0.498	0.549	4.173
1953	0.004	0.367	1.233	0.720	0.535	0.555	0.177	0.085	0.165	0.176	0.498	0.452	4.967
1954	0.060	0.013	0.723	0.939	0.608	0.469	0.173	0.074	0.124	0.142	0.441	0.354	4.118
1955	0.686	0.808	0.815	0.673	0.497	0.501	0.201	0.122	0.048	0.256	0.498	0.269	5.375
1956	0.273	0.972	0.378	0.719	0.708	0.160	0.034	0.008	0.274	0.144	0.418	0.449	4.536
1957	0.024	0.224	0.509	0.103	0.401	0.285	0.416	0.086	0.195	0.056	0.042	0.018	2.359
1958	0.343	0.908	0.561	0.885	0.668	0.556	0.087	0.107	0.157	0.209	0.270	0.189	4.939
1959	0.039	0.032	0.835	0.526	0.416	0.403	0.162	0.077	0.006	0.127	0.077	0.090	2.791
1960	0.002	0.862	0.361	0.609	0.665	0.525	0.135	0.088	0.126	0.192	0.498	0.481	4.544
1961	0.116	0.299	1.062	0.301	0.625	0.374	0.139	0.072	0.006	0.106	0.065	0.136	3.302
1962	0.229	0.360	0.515	0.608	0.565	0.323	0.141	0.029	0.042	0.281	0.275	0.088	3.457
1963	0.518	1.050	0.379	0.422	0.441	0.467	0.215	0.012	0.024	0.256	0.051	0.080	3.917
1964	0.115	0.527	0.949	0.283	0.538	0.461	0.107	0.126	0.093	0.352	0.498	0.517	4.567
1965	0.354	0.098	0.501	0.033	0.307	0.371	0.259	0.127	0.262	0.316	0.113	0.223	2.966
1966	0.548	0.363	0.440	0.311	0.551	0.377	0.187	0.043	0.035	0.094	0.306	0.426	3.679
1967	0.395	0.504	0.540	0.573	0.514	0.504	0.100	0.010	0.142	0.088	0.193	0.025	3.588
1968	0.188	0.078	0.686	0.646	0.653	0.436	0.147	0.040	0.299	0.177	0.074	0.077	3.502
1969	0.597	0.134	0.764	0.754	0.499	0.475	0.209	0.075	0.093	0.096	0.125	0.376	4.196
1970	0.494	0.415	0.615	0.936	0.681	0.354	0.156	0.023	0.021	0.179	0.237	0.213	4.325
1971	0.554	0.758	0.997	0.623	0.524	0.085	0.251	0.064	0.098	0.267	0.191	0.412	4.823
1972	0.112	0.234	0.412	0.262	0.561	0.363	0.374	0.162	0.090	0.112	0.252	0.031	2.966
1973	0.270	0.653	0.723	0.584	0.569	0.250	0.065	0.033	0.034	0.115	0.482	0.279	4.055
1974	0.338	0.254	0.928	0.851	0.581	0.202	0.117	0.121	0.151	0.207	0.498	0.104	4.353
1975	0.694	0.178	0.423	0.897	0.470	0.378	0.101	0.068	0.056	0.363	0.333	0.505	4.467
1976	0.292	0.065	0.364	0.303	0.686	0.375	0.087	0.030	0.058	0.119	0.435	0.577	3.392
1977	0.238	0.750	1.449	0.270	0.482	0.234	0.028	0.041	0.169	0.101	0.119	0.225	4.105
1978	0.387	0.341	0.680	0.734	0.578	0.362	0.020	0.010	0.031	0.185	0.083	0.272	3.682
1979	0.028	0.567	0.462	0.504	0.534	0.350	0.297	0.032	0.142	0.140	0.173	0.103	3.331
1980	0.007	0.039	0.172	0.627	0.621	0.307	0.073	0.146	0.050	0.165	0.354	0.274	2.834
1981	0.078	0.203	0.187	0.404	0.437	0.375	0.072	0.012	0.075	0.201	0.405	0.577	3.025
1982	0.101	0.049	0.129	0.497	0.326	0.404	0.396	0.046	0.187	0.133	0.172	0.073	2.513
1983	0.486	0.293	0.437	0.186	0.551	0.255	0.084	0.078	0.030	0.028	0.339	0.577	3.342
1984	0.804	0.576	0.746	0.408	0.642	0.310	0.056	0.041	0.042	0.318	0.428	0.283	4.654
1985	0.014	0.674	0.997	0.859	0.521	0.533	0.095	0.050	0.170	0.086	0.212	0.112	4.322
1986	0.410	0.398	0.584	0.685	0.496	0.308	0.178	0.055	0.150	0.086	0.224	0.015	3.590
MEAN	0.282	0.407	0.629	0.561	0.545	0.368	0.156	0.065	0.110	0.176	0.282	0.269	3.850

TABLE E-19. DIVERSION WATER REQUIREMENT (1)

(Unit : MCM/1,000ha)

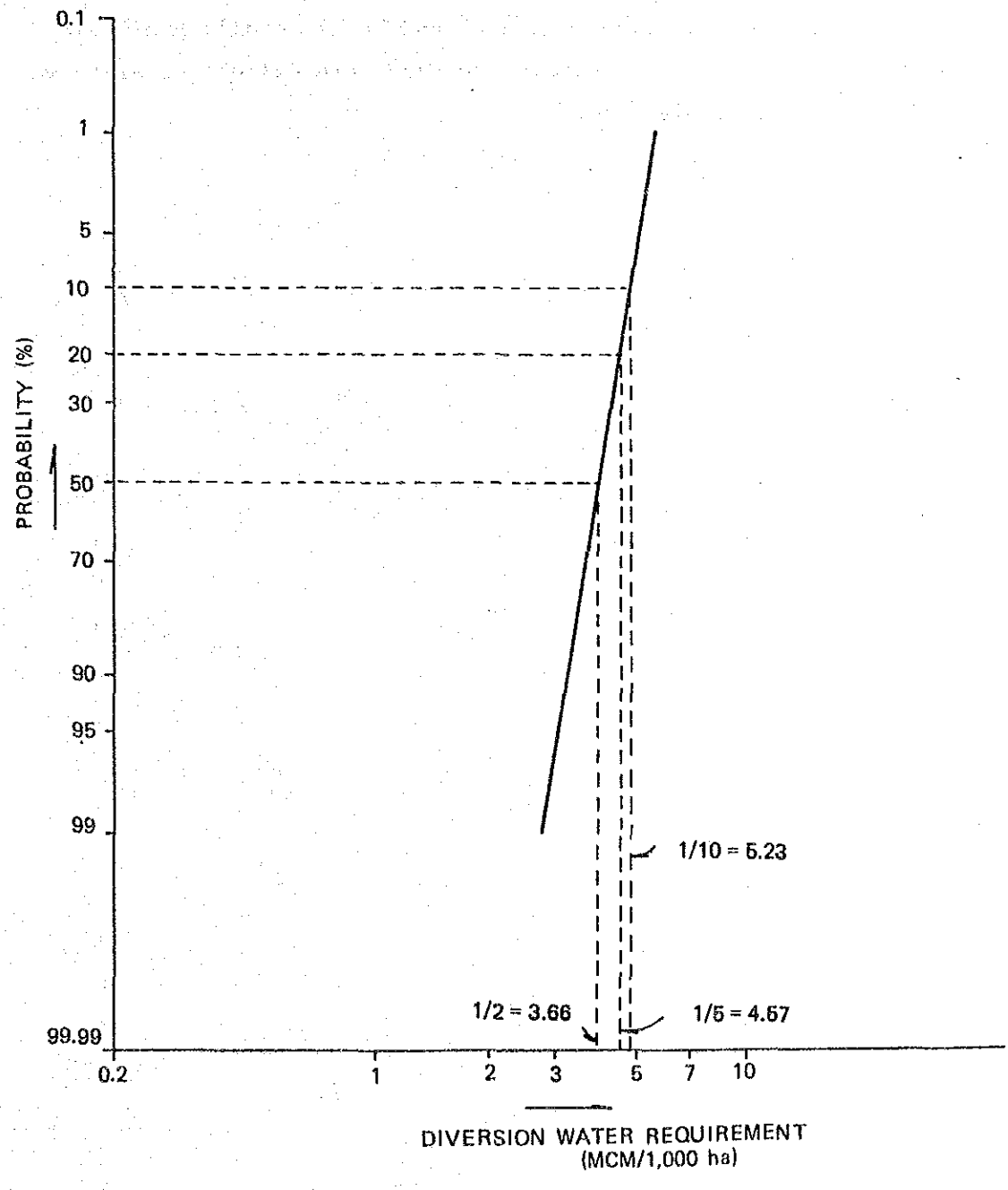
Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1. Probability 1/2 Year													
Rabi Crop													
Wheat	0.319	0.248	0.361	0.101	0	-	-	-	-	0.016	0.083	0.221	1.349
Fodders	0.064	0.046	0.058	0.017	0	-	-	-	0.002	0.006	0.030	0.046	0.269
Vegetables	0.128	0.048	0	-	-	-	-	0	0	0.017	0.135	0.125	0.453
Perennial Orchard	0.037	0.021	0.021	0.065	0.167	0.153	0.068	0.023	0.027	0.055	0.058	0.034	0.729
Kharif Crop													
Vegetable (I)	-	0	0	0.127	0.384	0.149	-	-	-	-	-	-	0.660
Vegetable (II)	-	-	-	-	-	0.074	0.119	0.020	0.006	0	-	-	0.219
Total	0.548	0.363	0.440	0.310	0.551	0.376	0.187	0.043	0.035	0.094	0.306	0.426	3.679
2. Probability 1/5 Year													
Rabi Crop													
Wheat	0.066	0.395	0.730	0.089	0	-	-	-	-	0.034	0.193	0.270	1.777
Fodders	0.012	0.077	0.124	0.015	0	-	-	-	0.010	0.067	0.062	0.055	0.422
Vegetable	0.029	0.029	0	-	-	-	-	0	0	0.129	0.184	0.152	0.523
Perennial Orchard	0.008	0.025	0.070	0.063	0.164	0.194	0.043	0.038	0.056	0.098	0.059	0.040	0.858
Kharif Crop													
Vegetable (I)	-	0.001	0.025	0.116	0.375	0.149	-	-	-	-	-	-	0.666
Vegetable (II)	-	-	-	-	-	0.118	0.064	0.088	0.027	0.024	-	-	0.321
Total	0.115	0.527	0.949	0.283	0.539	0.461	0.107	0.126	0.093	0.352	0.498	0.517	4.567

TABLE E-20. DIVERSION WATER REQUIREMENT (2)

(Unit : MCM/1,000ha)

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1. Probability 1/10 Year													
Rabi Crop													
Wheat	0.416	0.590	0.653	0.261	0	-	-	-	-	0.034	0.194	0.114	2.262
Fodders	0.080	0.107	0.109	0.044	0	-	-	-	0.010	0.044	0.062	0.028	0.484
Vegetable	0.145	0.057	0	-	-	-	-	0.001	0	0.089	0.184	0.103	0.579
Perennial Orchard	0.045	0.051	0.053	0.116	0.152	0.201	0.075	0.039	0.038	0.084	0.059	0.024	0.937
Kharif Crop													
Vegetable (I)	-	0.003	0	0.252	0.345	0.160	-	-	-	-	-	-	0.760
Vegetable (II)	-	-	-	-	-	0.140	0.126	0.082	0	0.005	-	-	0.353
Total	0.686	0.808	0.815	0.673	0.497	0.501	0.201	0.122	0.048	0.256	0.499	0.269	5.375

FIGURE E-1. PROBABLE DIVERSION WATER REQUIREMENT
(Case 3)

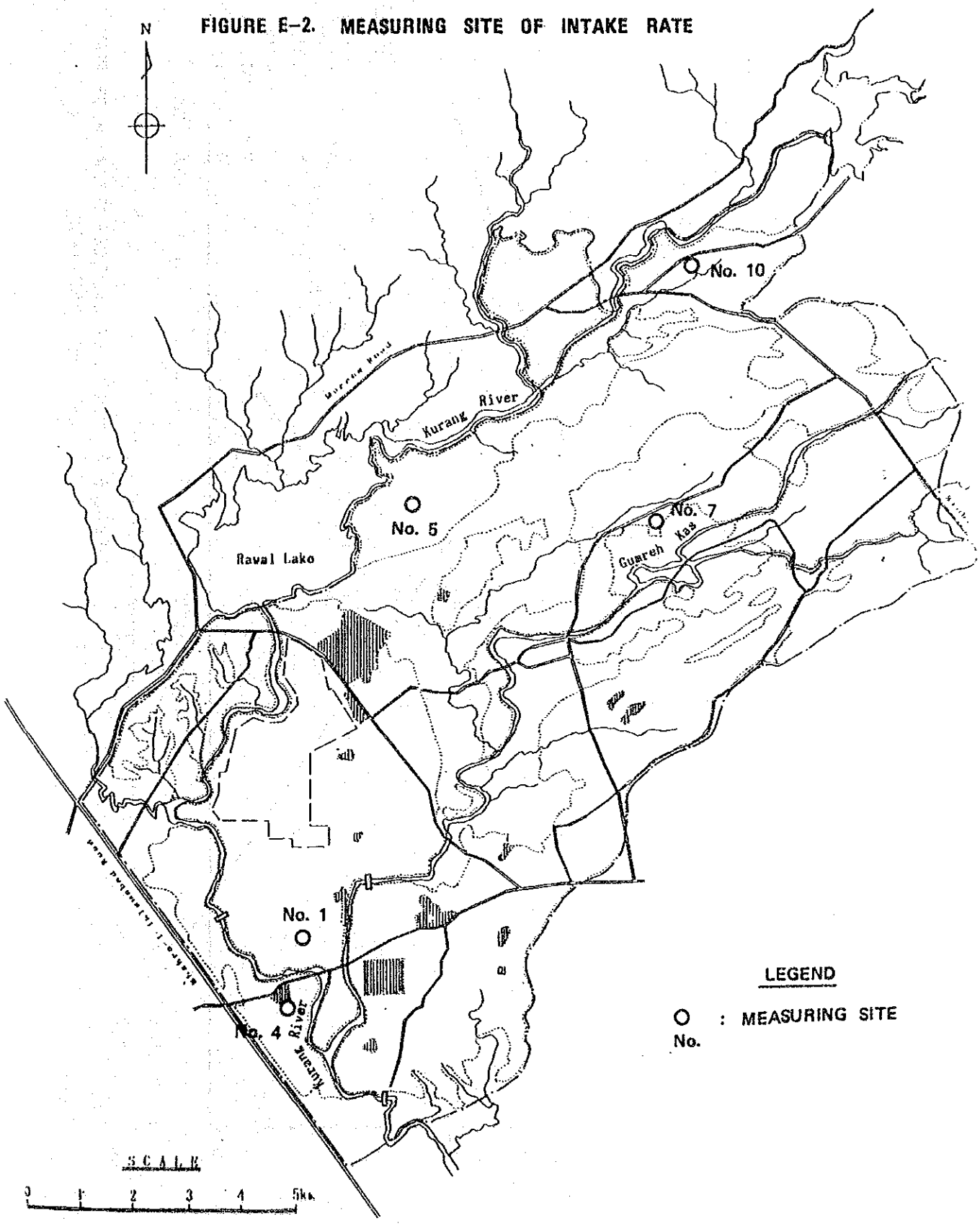


CHAPTER III. IRRIGATION WATER SUPPLY PLAN

Soil physical properties were measured for soil samples collected at site, where measurements of intake rate were conducted. The results of measurements are shown in Table E-21.

On the basis of the results, available moisture in each soil layer within the effective root zone and Total Readily Available Moisture (TRAM) in the effective root zone are calculated as shown in Table E-22 to Table E-26.

FIGURE E-2. MEASURING SITE OF INTAKE RATE



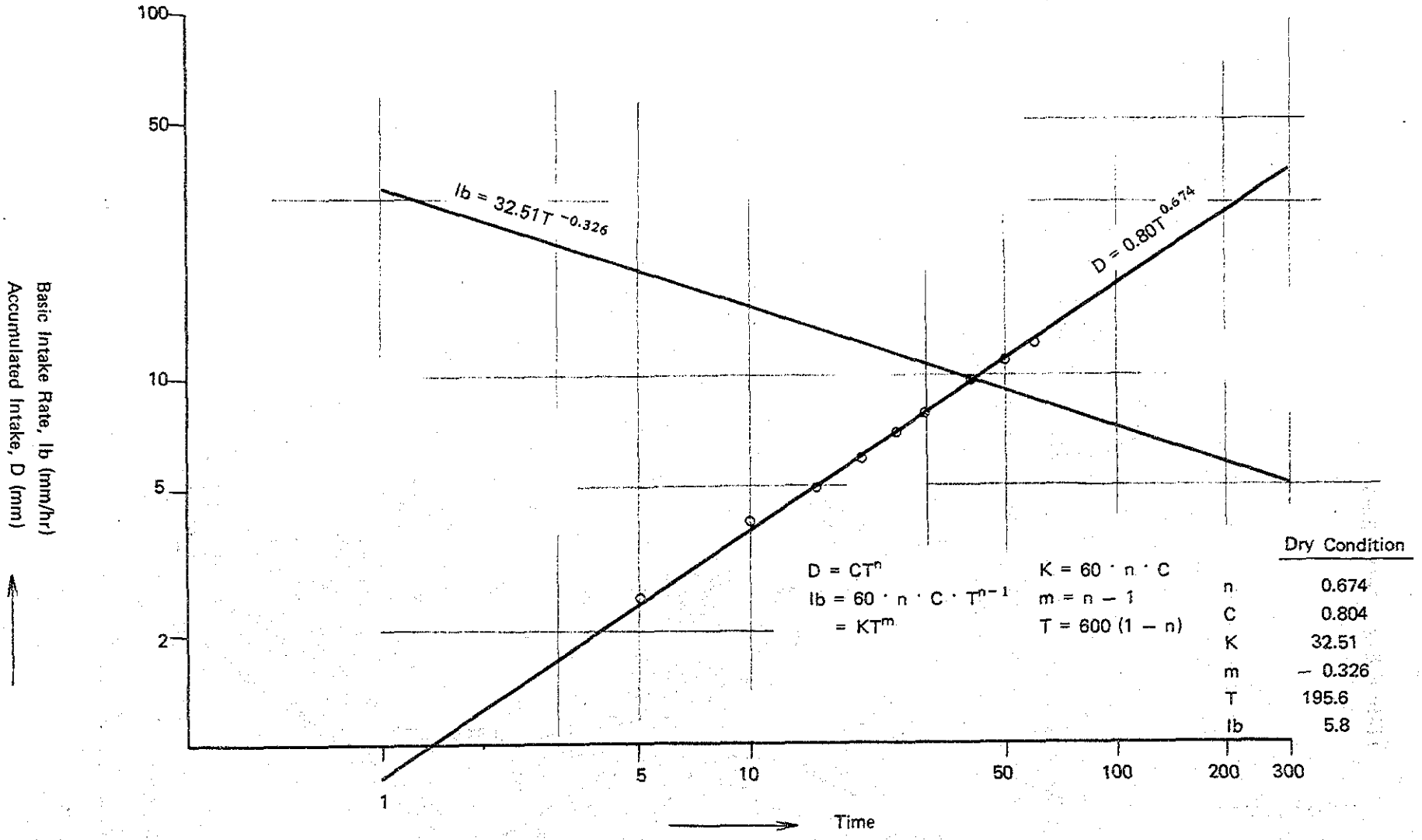


FIGURE E–3. RESULT OF CYLINDER INTAKE RATE TEST (NO. 1 SOIL TEST PITS)

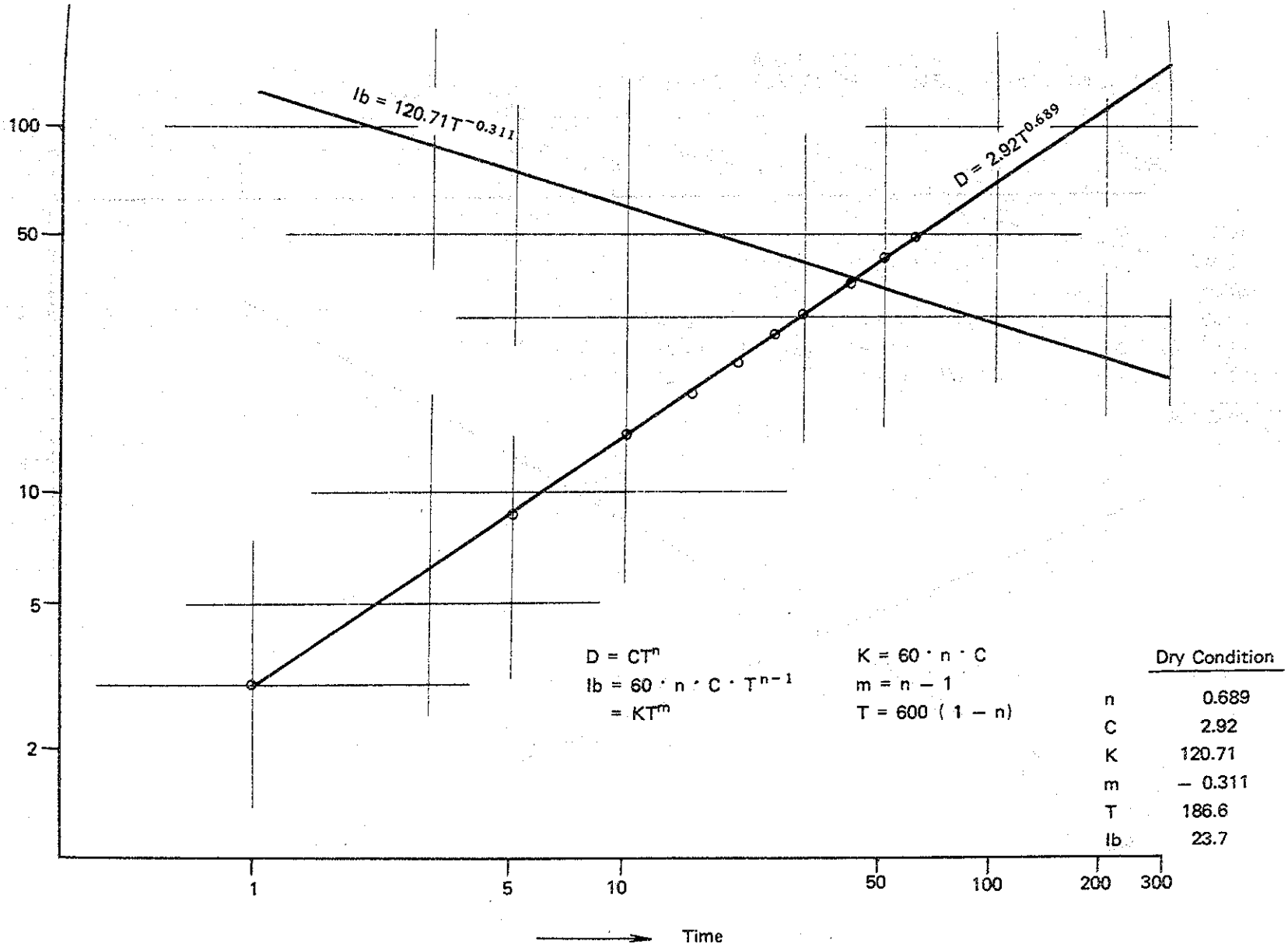


FIGURE E–4. RESULT OF CYLINDER INTAKE RATE TEST (NO. 4 SOIL TEST PITS)

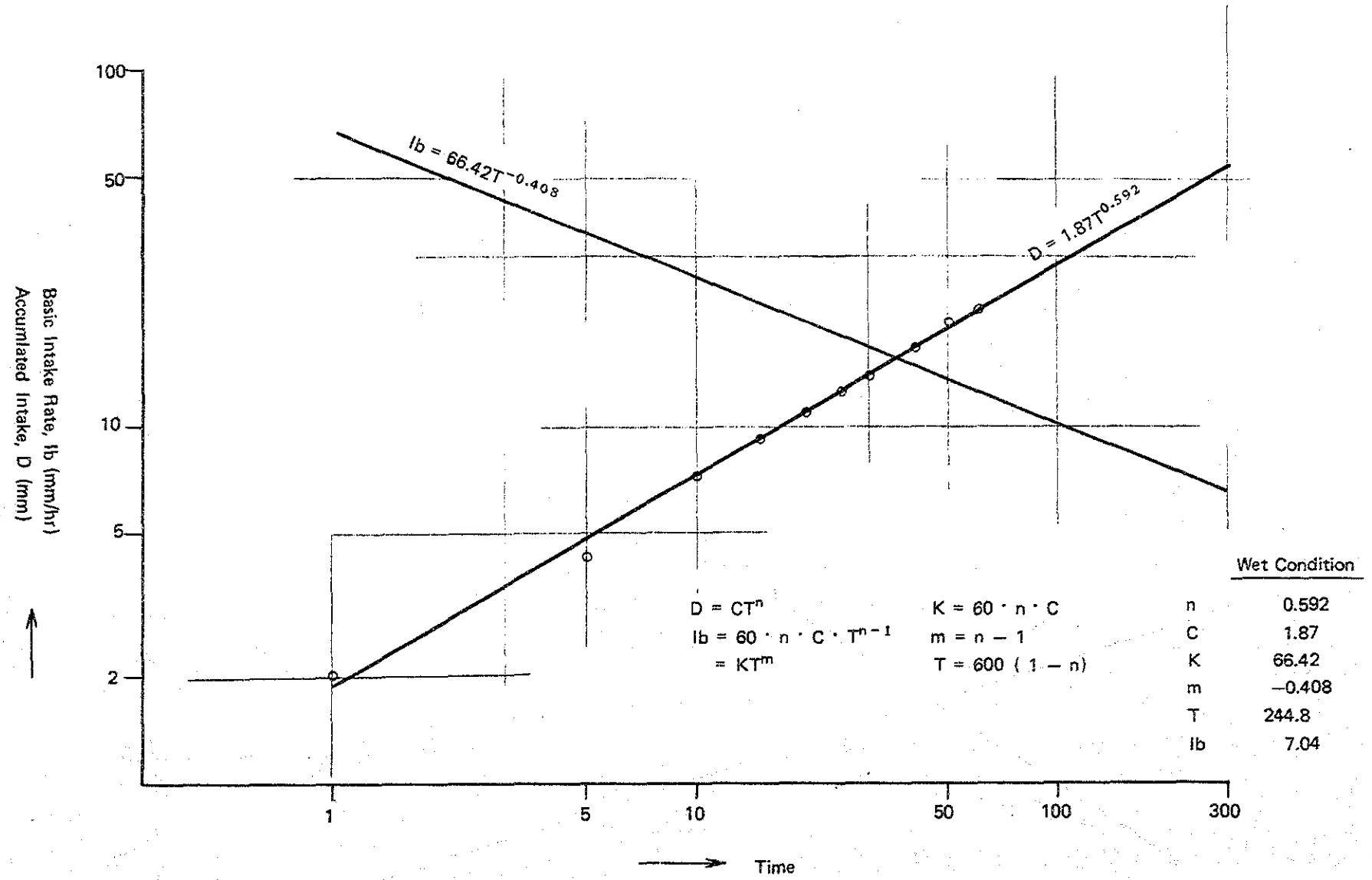


FIGURE E–5. RESULT OF CYLINDER INTAKE RATE TEST (NO. 5 SOIL TEST PITS)

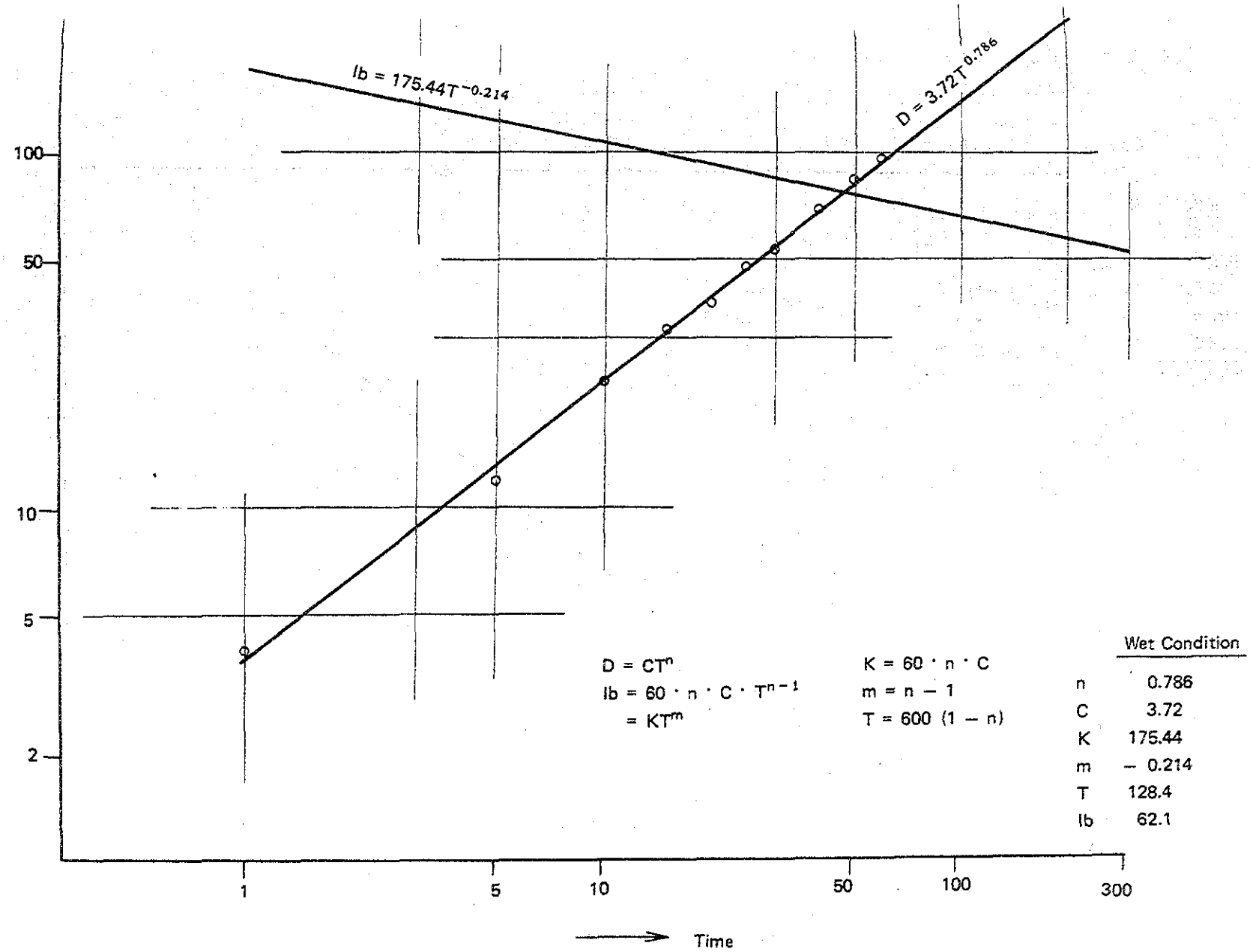


FIGURE E–6. RESULT OF CYLINDER INTAKE RATE TEST (NO. 7 SOIL TEST PITS)

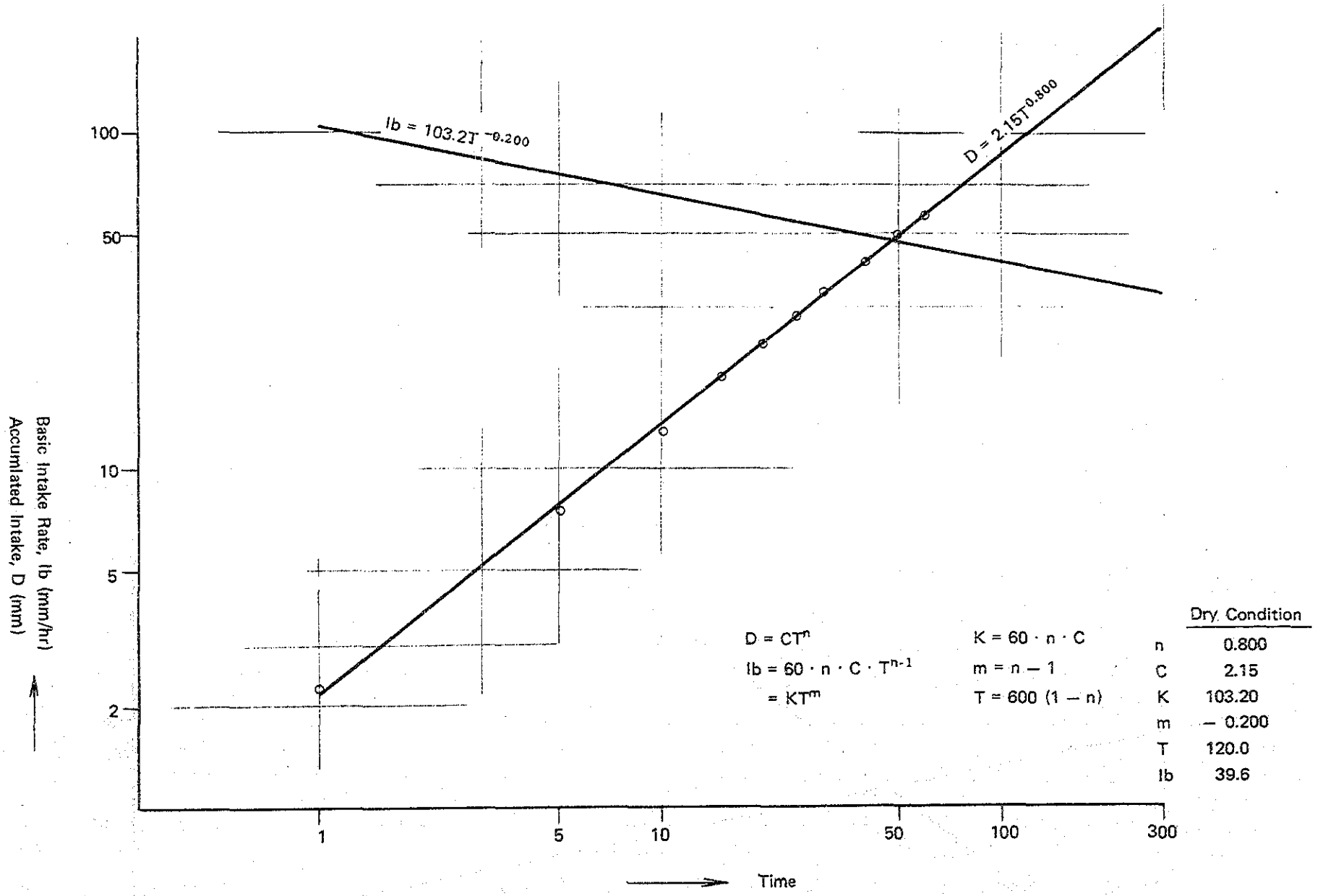


FIGURE E–7. RESULT OF CYLINDER INTAKE RATE TEST (NO.10 SOIL TEST PITS)

TABLE E-21. PHYSICAL FEATURES OF SOIL FOR UPLAND IRRIGATION

Location	Condition	Soil Depth (cm)	Real Specific Gravity (Sr) (g/cm^3)	Aparent Specific Gravity (Sa) (g/cm^3)	1/ Porosity (P) (%)	Field Capacity (Fc) (%)	Wilting Point (Wp) (%)
1. Dhok Hayat (No.1)	Dry Condition	7.5	2.45	1.42	42.0	23.2	18.9
		22.5	2.45	1.49	39.2	22.5	20.9
		37.5	2.45	1.66	32.2	20.0	18.7
2. Khanna Dak (No.4)	Dry Condition	7.5	2.51	1.35	46.2	17.2	7.4
		22.5	2.51	1.57	37.5	13.6	7.6
		37.5	2.51	1.51	39.8	15.7	8.1
3.Banigala (No.5)	Wet Condition	7.5	2.50	1.64	34.4	14.4	5.8
		22.5	2.50	1.75	30.0	13.8	9.9
		37.5	2.50	1.67	33.2	14.2	9.7
4. Balagh (No.7)	Wet Condition	7.5	2.49	1.56	37.3	22.8	17.5
		22.5	2.49	1.44	42.2	23.0	20.2
		37.5	2.49	1.49	40.2	22.9	21.6
5.Shahpur (No.10)	Dry Condition	7.5	2.55	1.43	43.9	18.9	11.2
		22.5	2.55	1.40	45.1	18.1	14.3
		37.5	2.55	1.60	37.3	19.5	17.7
Average		7.5	2.50	1.48	40.8	19.3	12.1
		22.5	2.50	1.53	38.8	18.2	14.6
		37.5	2.50	1.59	36.4	18.5	15.2

NOTE : 1/ : $P = (Sr - Sa) / Sr \times 100$

TABLE E-22. NET AMOUNT OF WATER TO BE REPLACED

(No. 1)

(1) Depth (cm)	(2) Available Moisture (AM) 1/ (mm)	(3) Ratio of Moisture Extraction	(4) (2)/(3) (mm)	(5) Restricting Layer of Moisture	(6) TRAM 2/ (mm)	(7) Net Amount of Water to by Replaced (mm)
0 - 15	9.2	0.50	18.4	*	18.4	18.4
15 - 30	9.2	0.35	26.3			
30 - 45	9.2	0.15	61.3			

NOTE : 1/ : AM = 1/100 (Fc-Wp) .. Sa . D
Fc : Field Capacity (%)
Wp : Wilting Point (%)
Sa : Aparent Specific Gravity (g/cm^3)
D : Depth (mm)

AM = 1/100 (23.2-18.9) x 1.42 x 150 = 9.2 mm

2/ : TRAM : Total Readily Available Moisture

TABLE E-23. NET AMOUNT OF WATER TO BE REPLACED

(No. 4)

(1) Depth (cm)	(2) Available Moisture (AM) [1/] (mm)	(3) Ratio of Moisture Extraction	(4) (2)/(3) (mm)	(5) Restricting Layer of Moisture	(6) TRAM [2/] (mm)	(7) Net Amount of Water to by Replaced (mm)
0 - 15	19.8	0.50	39.6	*	39.6	39.6
15 - 30	19.8	0.35	56.6			
30 - 45	19.8	0.15	132.0			

NOTE : 1/ : AM = 1/100 (Fc-Wp) .. Sa . D
Fc : Field Capacity (%)
Wp : Wilting Point (%)
Sa : Aparent Specific Gravity (g/cm^3)
D : Depth (mm)

AM = 1/100 (17.2-7.4) x 1.35 x 150 = 19.8 mm

2/ : TRAM : Total Readily Available Moisture

TABLE E-24. NET AMOUNT OF WATER TO BE REPLACED

(No. 5)

(1) Depth (cm)	(2) Available Moisture (AM) 1/ (mm)	(3) Ratio of Moisture Extraction	(4) (2)/(3) (mm)	(5) Restricting Layer of Moisture	(6) TRAM 2/ (mm)	(7) Net Amount of Water to by Replaced (mm)
0 - 15	21.2	0.50	42.4	*	42.4	42.4
15 - 30	21.2	0.35	60.6			
30 - 45	21.2	0.15	141.3			

NOTE : 1/ : AM = 1/100 (Fc-Wp) .. Sa . D
Fc : Field Capacity (%)
Wp : Wilting Point (%)
Sa : Aparent Specific Gravity (g/cm^3)
D : Depth (mm)

AM = 1/100 (14.4- 5.8) x 1.64 x 150 = 21.2 mm

2/ : TRAM : Total Readily Available Moisture

TABLE E-25. NET AMOUNT OF WATER TO BE REPLACED

(No. 7)

(1) Depth (cm)	(2) Available Moisture (AM) 1/ (mm)	(3) Ratio of Moisture Extraction	(4) (2)/(3) (mm)	(5) Restricting Layer of Moisture	(6) TRAM 2/ (mm)	(7) Net Amount of Water to by Replaced (mm)
0 - 15	12.4	0.50	24.8	*	24.8	24.8
15 - 30	12.4	0.35	35.4			
30 - 45	12.4	0.15	82.7			

NOTE : 1/ : AM = 1/100 (Fc-Wp) .. Sa . D
Fc : Field Capacity (%)
Wp : Wilting Point (%)
Sa : Aparent Specific Gravity (g/cm^3)
D : Depth (mm)

AM = 1/100 (22.8-17.5) x 1.56 x 150 = 12.4 mm

2/ : TRAM : Total Readily Available Moisture

TABLE E-26. NET AMOUNT OF WATER TO BE REPLACED

(No.10)

(1) Depth (cm)	(2) Available Moisture (AM) [1/] (mm)	(3) Ratio of Moisture Extraction	(4) (2)/(3) (mm)	(5) Restricting Layer of Moisture	(6) TRAM [2/] (mm)	(7) Net Amount of Water to by Replaced (mm)
0 - 15	16.5	0.50	33.0	*	33.0	33.0
15 - 30	16.5	0.35	47.1			
30 - 45	16.5	0.15	110.0			

NOTE : 1/ : AM = 1/100 (Fc-Wp) .. Sa . D
Fc : Field Capacity (%)
Wp : Wilting Point (%)
Sa : Aparent Specific Gravity (g/cm^3)
D : Depth (mm)

AM = 1/100 (18.9-11.2) x 1.43 x 150 = 16.5 mm

2/ : TRAM : Total Readily Available Moisture

ANNEX F. RESERVOIR OPERATION STUDY

ANNEX F. RESERVOIR OPERATION STUDY

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CHAPTER I. RAWAL DAM RESERVOIR OPERATION STUDY UNDER PRESENT CONDITIONS (WITHOUT K-2 DAM)

1.1. Reservoir Operation Study by SDO Data

In order to review the present situation of the Rawal Dam operation, three cases of water balance study, present, Stage-I and Stage-II conditions, were made on daily basis for the periods of 24 years from 1963 to 1986, based on the following conditions;

- Annual average runoff discharge at the Rawal damsite having the catchment area of 275.1 sq.km is 100.9 MCM (see Table B-38), which was obtained by SDO estimated data.
- Annual average domestic water supply diverted by head works located on the upstream of the Rawal Dam is 7.5 MCM at present, 8.5 MCM in Stage-I and 10.5 MCM in Stage-II respectively (see Table F-4).
- Reservoir water losses at present conditions are 9.2 MCM/annum (see Table B-37), but those losses at Stage-I and Stage-II are calculated based on the following criteria;

  Water seepage: 2 percent x Effective Storage Capacity
  Evaporation : Pan Evaporation Rate x 0.7 x Water Surface Area

- Average release discharges from the Rawal Dam for domestic and irrigation water supplies is 35.4 MCM/annum at present conditions (see B-35), 47.7 MCM/annum in Stage-I conditions and 56.1 MCM in Stage-II respectively (see Table F-4).

The results of study are tabulated in Table F-1, and they are summarized as shown below;

Results of Reservoir Operation Study by SDO Data

(unit: MCM)

Item	Case Study		
	Present	Stage-I	Stage-II
Runoff Discharge	100.9	100.9	100.9
Diverted Water at Upstream Head Works			
Diverted Water	7.5	8.5	10.5
Shortage Water	0.0	-0.2	-0.8
Inflow Discharge	93.4	92.6	91.2
Reservoir Losses	9.2	9.2	8.7
Relead Discharge from Rawal Dam			
Irrigation Water (Left Canal))	35.4	5.2	5.2
Domestic Water (Right Canal))		42.5	50.9
Shortage Water	0.0	-1.1	-5.0
Spillage	48.8	36.8	31.4

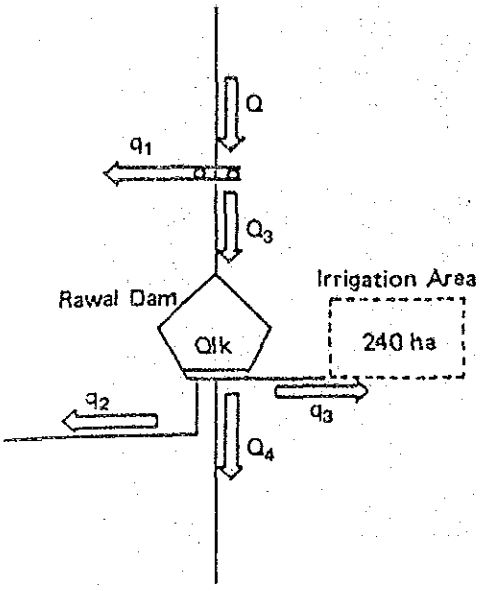
As is seen in the above table, the Rawal Dam reservoir operation reveals the following facts;

- Present Rawal Dam has enough capacity to meet an annual demand of 35.4 MCM with an annual spilled discharge of 48.8 MCM, although spilled discharge for 17 years from 1963 to 1979 is estimated at 37.6 MCM as shown in Table F-1.

- In cases of the expansion plans of water demand (Stage-I and stage II Plans), the Rawal Dam could not meet the expansion plan of water demand, that is, water shortage of 1.3 MCM in Stage-I and 5.8 MCM in Stage-II will occur respectively.

Figure F-1 indicates the results of water balance study in the above three cases, and furthermore, Figure F-2 shows the Rawal Dam reservoir behavior in case of present condition.

FIGURE F–1. RESULT OF WATER BALANCE STUDY UNDER PRESENT CONDITIONS (BY SDO DATA)



Item			Case Study		
			Present (MCM)	Stage–I (MCM)	Stage–II (MCM)
Q	:	Runoff (275.1 sq.km)	100.9	100.9	100.9
q_1	:	H. W Release (Domestic)	7.5	8.3	9.7
Q_3	:	Inflow	93.4	92.6	91.2
Qlk	:	Reservoir Loss	9.2	9.2	8.7
q_3	:	Left Canal (Irrigation)	35.4	46.6	51.1
q_2	:	Right Canal (Domestic)			
Q_4	:	Spillage	48.8	36.8	31.4

TABLE F–1. RESULT OF WATER BALANCE STUDY AT RAWAL DAM UNDER PRESENT CONDITION BY SDO DATA

CATCHMENT AREA: 275.1 SQ.KM

UNIT : MCM

	*********	PRESENT	*********	*********	STAGE-1	*********	*********	STAGE-2	*********
YEAR	INFLOW	SPILL	SHORT	INFLOW	SPILL	SHORT	INFLOW	SPILL	SHORT
1963	35.19	5.16	0.00	34.70	0.00	0.00	33.75	0.00	5.88
1964	76.21	45.84	0.00	75.73	5.45	7.96	74.79	8.38	25.34
1965	90.94	61.27	0.00	90.15	37.31	0.00	88.73	28.57	0.00
1966	47.56	12.92	0.00	46.88	0.00	0.00	45.54	0.00	1.29
1967	96.32	46.22	0.00	95.45	20.87	0.00	93.79	9.48	7.23
1968	84.25	40.63	0.00	83.42	32.34	0.00	81.85	23.60	0.00
1969	32.72	0.00	0.00	32.13	0.00	0.00	30.97	0.00	10.24
1970	64.70	5.37	0.00	63.94	0.00	8.94	62.49	0.00	22.91
1971	127.25	84.67	0.00	126.63	61.30	0.00	125.46	58.89	4.16
1972	24.01	0.00	0.00	23.14	0.00	0.00	21.52	0.00	17.24
1973	95.21	30.39	0.00	94.34	15.09	12.35	92.78	18.02	18.34
1974	41.68	0.00	0.00	40.99	0.00	0.00	39.71	0.00	1.41
1975	54.73	4.21	0.00	53.94	0.00	2.22	52.47	0.00	23.07
1976	173.34	127.77	0.00	172.49	99.16	0.00	170.85	92.51	0.00
1977	87.98	40.76	0.00	87.11	28.82	0.00	85.58	19.97	0.00
1978	162.85	115.69	0.00	161.89	103.36	0.00	160.21	92.59	0.00
1979	58.97	17.69	0.00	58.12	14.15	0.00	56.49	9.63	0.00
1980	88.43	35.59	0.00	87.63	24.16	0.00	86.11	11.90	2.92
1981	109.90	56.85	0.00	109.02	49.75	0.00	107.52	40.19	0.00
1982	123.43	70.68	0.00	122.66	63.00	0.00	121.18	53.28	0.00
1983	142.57	94.38	0.00	141.61	84.80	0.00	139.80	73.84	0.00
1984	211.29	161.45	0.00	210.41	154.51	0.00	208.72	145.31	0.00
1985	97.07	43.39	0.00	96.30	32.36	0.00	94.92	20.56	0.00
1986	115.44	69.28	0.00	114.40	57.59	0.00	112.45	47.37	0.00
MEAN	93.42	48.76 (37.56)1/	0.00	92.63	36.83	1.31	91.15	31.42	5.83

1/: Average spilled discharge for 17 years from 1963 – 1979.

TABLE F-2. DOMESTIC WATER DEMAND FROM UPPER KURANG RIVER

Name of Facility	Present Capacity and Production		Future Production	
	Facility capacity	Production (Jan. 1987)	Stage-I	Stage-II
1. Kurang Head Works (CDA)	2.5MGD	0	2.00MGD(2.50x0.80)	3.20MGD(4.00x0.80)
2. Shahdara Head Works (CDA)	2.5MGD 1/	2.00MGD(2.5x0.80) 2/	2.40MGD(3.00x0.80)	2.40MGD(3.00x0.80)
3. Nurpur Head Works (CDA)	0.7MGD	0.56MGD(0.7x0.80)	0.80MGD(1.0x0.80)	0.80MGD(1.0x0.80)
4. Rawal Dam Left Irrigation(SDO)	18 cusec 3/	6 cusec x 11.6/12 4/	18 cuses x 11.6/12	18 cusec x 11.6/12
5. Rawal Dam Right Canal	2.7MGD 5/	2.00MGD	2.00MGD	2.00MGD
6. Rawalpindi Filt. Plant(PHED)	21.0MGD	17.96MGD (21.0MGDx0.855)	23.94MGD (28.0x0.855)	29.07 MGD (34.0x0.855)

Data source: JICA Master Plan Study for Water Resources Development potential for the Metropolitan Area of Islamabad - Rawalpindi.

Note: 1/: Capacity of Shahdara H.W. was increase from 1.7 to 2.5 MGD recently.

2/: 0.80 is the ratio of total production of CDA Head Works by their capacity.

3/: Informed by SDO. Rawal Dam completion Report say that it was 40 cusecs irrigable for 1,355 ha. 18 cusec = 9.7 MGD

4/: Annual continuous supply except 80% for July and August = 11.6 months

5/: 2.7 MGD includes capacities of 3 tube wells connected to New Golf Course Water Works.

TABLE F-3. ESTIMATION OF REQUIRED WATER DEMAND FROM RAWAL DAM

1) Annual Average

Urban Domestic Water Demand

(unit: MGD)

Item	Alternative Plan					
	Present		Stage-I		Stage-II	
Kurang Head Works (CDA)	-	(2.50)	2.00	(2.50)	3.20	(4.00)
Shahdara Head Works (CDA)	2.00	(2.50)	2.40	(3.00)	2.40	(3.00)
Nurpur Head Works (CDA)	0.56	(0.70)	0.80	(1.00)	0.80	(1.00)
Rawal Dam Right Canal (CDA)	2.00	(2.00)	2.00	(2.00)	2.00	(2.00)
Rawal Dam Filt. Plant (PHED)	17.96	(21.00)	39.90	(46.00)	29.07	(34.00)
Total	22.52	(28.70)	47.10	(54.50)	37.47	(44.00)

Note: The figures in parenthesis indicate production capacity of filtration plant.

Irrigation Water Demand

3.23 MGD (6 cusecs x 86,400 sec/day x 28.32/4,546)

2) Monthly Water Demand

(unit: MCM)

Month	Urban Domestic Water Demand				Irrigation Water Demand	
	Ratio	Present	Stage-I	Stage-II	MGD	MCM
Jan.	0.80	2.46	3.40	4.09	3.23	0.46 5/
Feb.	0.85	2.61	3.61	4.34	3.23	0.41
Mar.	0.90	2.76	3.83	4.60	3.23	0.46
Apr.	1.00	3.07 1/	4.25 2/	5.11 3/	3.23	0.44
May	1.15	3.53	4.89	5.88	3.23	0.46
June	1.25	3.84	5.31	6.39	3.23	0.44
July	1.05	3.22	4.46	5.37	2.59 4/	0.36
Aug.	1.00	3.07	4.25	5.11	2.59 4/	0.36
Sep.	1.05	3.22	4.46	5.37	3.23	0.44
Oct.	1.05	3.22	4.46	5.37	3.23	0.46
Nov.	1.00	3.07	4.25	5.11	3.23	0.44
Dec.	0.90	2.76	3.83	4.60	3.23	0.46
Total	1.00	36.83	51.00	61.34	37.48	5.19

Note: 1/ ... 22.52 MGD x 4.546 l/gal x 30 day = 3.07 MCM
2/ ... 31.14 MGD x 4.546 l/gal x 30 day = 4.25 MCM
3/ ... 37.47 MGD x 4.546 l/gal x 30 day = 5.11 MCM
4/ ... 80% of annual average
5/ ... 3.23 MGD x 4.546 l/gal x 31 days = 0.46 MCM

TABLE F-4. MONTHLY WATER DEMAND FROM KURANG RIVER

1) Urban Domestic Water diverted by Head Works[1/] located on the Upstream of Rawal Dam

(unit: MCM)

Month	Ratio	Present	Alternative Plan Stage-I	Alternative Plan Stage-II
Jan.	0.80	0.28 (0.49)[2/]	0.57	0.70
Feb.	0.85	0.30 (0.53)	0.60	0.74
Mar.	0.90	0.31 (0.56)	0.64	0.78
Apr.	1.00	0.35 (0.62)	0.71	0.87
May	1.15	0.40 (0.71)	0.82	1.00
Jun.	1.25	0.44 (0.78)	0.89	1.09
Jul.	1.05	0.37 (0.66)	0.74	0.92
Aug.	1.00	0.35 (0.62)	0.71	0.87
Sep.	1.05	0.37 (0.66)	0.74	0.92
Oct.	1.05	0.37 (0.66)	0.74	0.92
Nov.	1.00	0.35 (0.62)	0.71	0.87
Dec.	0.90	0.31 (0.56)	0.64	0.78
Total	12.00	4.20 (7.47)	8.51	10.46

1/: Kurang Head Works, Shahdara Head Works, Nurpur Head Works.
2/: ( ) includes water demand by Kurang Head Works.

2) Water Demand from Rawal Dam

(unit: MCM)

Month	Ratio	Urban Domestic Water Demand[1/] Present	Stage-I	Stage-II	Irrigation Water Demand[2/]
Jan.	0.80	2.18 (2.64)[3/]	2.83 (3.29)[3/]	3.39 (3.85)[3/]	0.46
Feb.	0.85	2.31 (2.72)	3.01 (3.42)	3.60 (4.01)	0.41
Mar.	0.90	2.45 (2.91)	3.19 (3.65)	3.82 (4.28)	0.46
Apr.	1.00	2.72 (3.16)	3.54 (3.98)	4.24 (4.68)	0.44
May	1.15	3.13 (3.59)	4.07 (4.53)	4.88 (5.34)	0.46
Jun.	1.25	3.40 (3.84)	4.42 (4.86)	5.30 (5.74)	0.44
Jul.	1.05	2.85 (3.21)	3.72 (4.08)	4.45 (4.81)	0.36
Aug.	1.00	2.72 (3.08)	3.54 (3.90)	4.24 (4.60)	0.36
Sep.	1.05	2.85 (3.29)	3.72 (4.16)	4.45 (4.89)	0.44
Oct.	1.05	2.85 (3.31)	3.72 (4.18)	4.45 (4.91)	0.46
Nov.	1.00	2.72 (3.16)	3.54 (3.98)	4.24 (4.68)	0.44
Dec.	0.90	2.45 (2.91)	3.19 (3.65)	3.82 (4.28)	0.46
Total	12.00	32.63(37.82)	42.49(47.68)	50.88(56.07)	5.19

1/: Rawal Dam Right Canal, Rawal Dam Filt. Plant
2/: Rawal Dam Left Canal
3/: ( ) includes irrigation water demand by Rawal Dam Left Canal
Note: Back data of above figures are given in Table F-2 and Table F-3.

FIGURE F-2 RESULT OF RAWAL DAM OPERATION STUDY UNDER PRESENT CONDITIONS BY SDO DATA (WITHOUT K-2 DAM) (1/2)

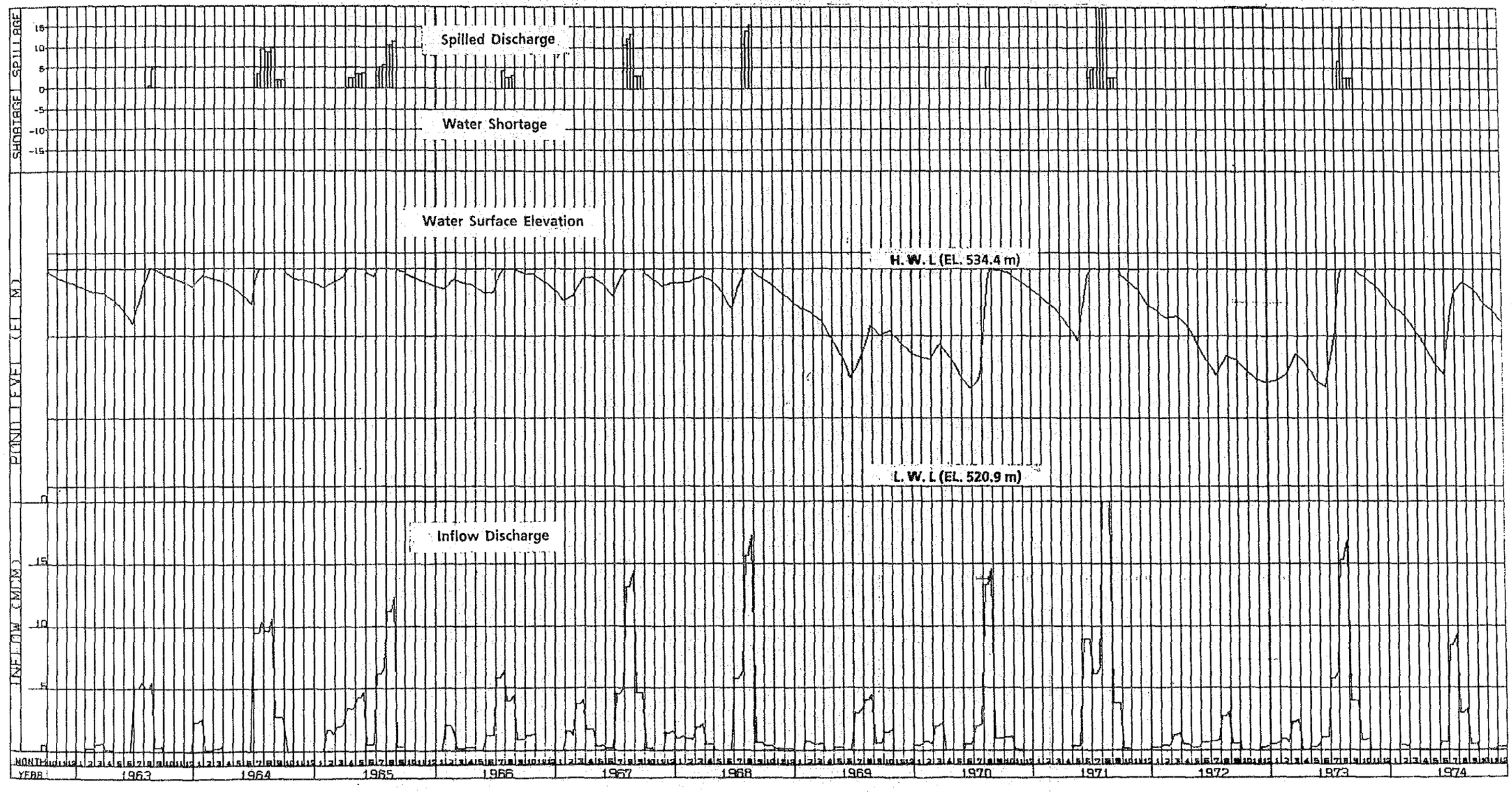
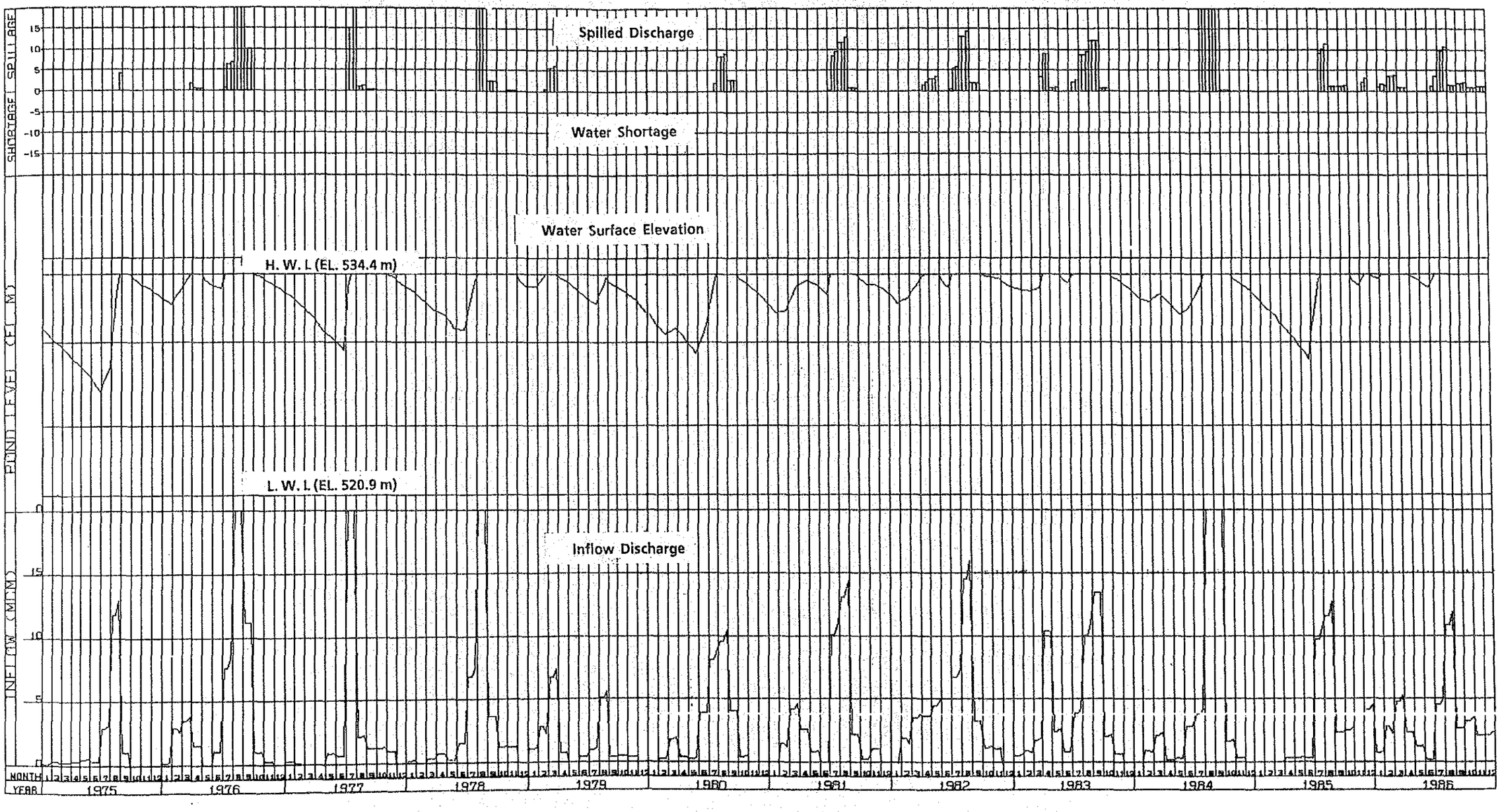


FIGURE F-2 RESULT OF RAWAL DAM OPERATION STUDY UNDER PRESENT CONDITIONS BY SDO DATA (WITHOUT K-2 DAM) (2/2)



1.2. Reservoir Operation Study by Tank Model Method

Rawal reservoir operation study using the estimated runoff discharges of 103.0 MCM applying Tank Model Method was also made for the periods of 35 years, 1952 to 1986. The conditions of the study are as follows;

- Annual average runoff discharge at Rawal damsite is 103.0 MCM (see Table B-44), which was obtained by applying Tank Model Method depending upon daily areal rainfall.
- Annual average domestic water supply to be diverted at the upstream of the Rawal Dam is 7.5 MCM at present, 8.5 MCM in Stage-I and 10.5 MCM in Stage-II conditions (see Table F-4).
- Reservoir water losses are estimated based on the same criteria mentioned in Paragraph 1.1.
- Annual release discharge from the Rawal Dam is 37.8 MCM at present, 47.7 MCM in Stage-I and 56.1 MCM in Stage-II respectively (see Table F-4).

The results of study are tabulated in Table F-5, and they are summarized as shown below;

Results of Reservoir Operation Study by Tank Model Method

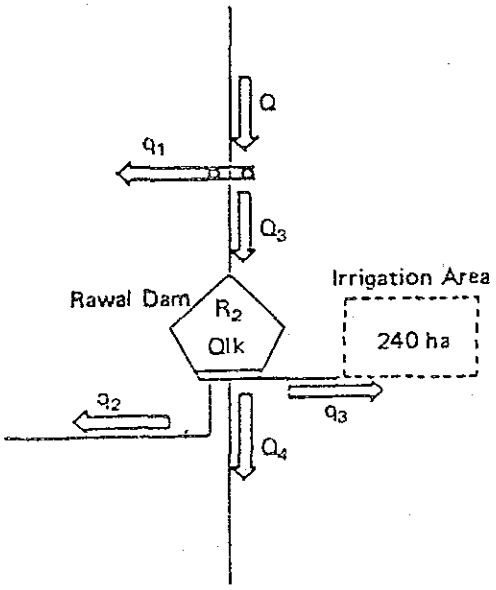
(unit: MCM)

Item	Case Study		
	Present	Stage-I	Stage-II
Runoff Discharge	103.0	103.0	103.0
Diverted Water at Upstream Head Works			
Diverted Water	7.5	8.5	10.5
Shortage Water	0.0	-0.1	-0.3
Inflow Discharge	95.5	94.6	92.8
Reservoir Balance			
Reservoir Losses	9.2	9.1	8.9
Rainfall in Reservoir	7.3	7.3	7.3
Released Discharge from Rawal Dam			
Irrigation Water (Left Canal)	5.2	5.2	5.2
Domestic Water (Right Canal)	32.6	42.5	50.9
Shortage Water	0.0	0.0	0.0
Spillage	55.9	45.1	35.1

As the results, it will be revealed that the Rawal Dam could meet the expansion plan of water supply for domestic water supply, although some water shortage for upstream diversion will be observed in case of expansion plan as same as those reservoir operation studies by SDO data.

Figure F-3 indicates the results of water balance study in the above three cases, and also Figure F-4 and Figure F-5 show the Rawal Dam reservoir behavior in cases of present and Stage-I conditions.

FIGURE F-3. RESULT OF WATER BALANCE STUDY UNDER PRESENT CONDITIONS BY TANK MODEL METHOD



Item			Case Study		
			Present (MCM)	Stage–I (MCM)	Stage–II (MCM)
Q	:	Runoff (275.1 sq.km)	103.0	103.0	103.0
q_1	:	H.W Release (Domestic)	7.5	8.4	10.2
Q_3	:	Inflow	95.5	94.6	92.8
Qlk	:	Reservoir Loss	9.2	9.1	8.9
R_2	:	Rainfall in Reservoir	7.3	7.3	7.3
q_3	:	Left Canal (Irrigation)	5.2	5.2	5.2
q_2	:	Right Canal (Domestic)	32.6	42.5	50.9
Q_4	:	Spillage	55.9	45.1	35.1

TABLE F-5. RESULT OF WATER BLANCE STUDY AT RAWAL DAM UNDER PRESENT CONDITIONS BY TANK MODEL METHOD

UNIT : MCM

	********* PRESENT *********			********* STAGE-1 *********			********* STAGE-2 *********		
YEAR	INFLOW	SPILL	SHORT	INFLOW	SPILL	SHORT	INFLOW	SPILL	SHORT
1952	62.87	31.80	0.00	61.94	24.48	0.00	60.24	17.90	0.00
1953	68.27	24.66	0.00	67.41	13.54	0.00	65.83	3.17	0.00
1954	92.46	50.87	0.00	91.46	39.41	0.00	89.64	28.76	0.00
1955	103.10	58.60	0.00	102.25	47.96	0.00	100.65	38.37	0.00
1956	110.71	68.05	0.00	109.66	56.96	0.00	107.74	46.58	0.00
1957	90.53	48.97	0.00	89.49	36.20	0.00	87.54	24.06	0.00
1958	92.03	50.35	0.00	91.16	39.36	0.00	89.54	29.24	0.00
1959	121.97	85.29	0.00	120.93	75.52	0.00	118.98	66.37	0.00
1960	55.25	20.03	0.00	54.32	11.00	0.00	52.65	3.09	0.00
1961	100.99	54.86	0.00	99.95	43.48	0.00	98.03	32.44	0.00
1962	60.74	19.08	0.00	59.81	7.62	0.00	58.04	0.00	0.00
1963	99.84	62.15	0.00	98.93	52.45	0.00	97.30	40.56	0.00
1964	103.83	69.25	0.00	102.86	58.42	0.00	101.11	48.40	0.00
1965	81.37	45.89	0.00	80.34	35.96	0.00	78.51	26.66	0.00
1966	78.20	31.88	0.00	77.20	19.38	0.00	75.40	8.58	0.00
1967	97.97	54.00	0.00	96.93	41.19	0.00	95.02	28.52	0.00
1968	98.56	59.59	0.00	97.52	50.46	0.00	95.61	43.68	0.00
1969	50.51	12.99	0.00	49.55	1.86	0.00	47.84	0.00	0.00
1970	119.25	79.52	0.00	118.26	69.00	0.00	116.53	49.66	0.00
1971	86.15	52.03	0.00	85.13	42.46	0.00	83.25	33.22	0.00
1972	52.46	11.49	0.00	51.46	6.29	0.00	49.59	1.58	0.00
1973	93.30	50.20	0.00	92.26	33.43	0.00	90.31	18.09	0.00
1974	48.84	8.87	0.00	47.97	0.00	0.00	46.47	0.00	0.00
1975	91.16	51.18	0.00	90.15	38.76	0.00	88.35	19.10	0.00
1976	183.39	144.27	0.00	182.34	132.91	0.00	180.39	122.09	0.00
1977	129.79	87.78	0.00	128.75	75.95	0.00	126.80	64.86	0.00
1978	142.61	106.20	0.00	141.60	95.35	0.00	139.74	85.83	0.00
1979	92.51	55.39	0.00	91.47	46.32	0.00	89.52	37.58	0.00
1980	82.72	43.08	0.00	81.68	31.61	0.00	79.77	20.54	0.00
1981	119.23	84.64	0.00	118.19	74.07	0.00	116.24	64.16	0.00
1982	122.92	79.77	0.00	121.88	67.52	0.00	119.93	57.92	0.00
1983	114.69	83.64	0.00	113.65	73.55	0.00	111.70	62.74	0.00
1984	95.93	56.79	0.00	94.91	46.49	0.00	93.02	36.32	0.00
1985	86.34	40.52	0.00	85.45	26.86	0.00	83.81	15.23	0.00
1986	114.80	74.22	0.00	113.76	63.62	0.00	111.81	52.66	0.00
MEAN	95.58	55.94	0.00	94.59	45.13	0.00	92.77	35.08	0.00

FIGURE F-4 RESULT OF RAWAL DAM OPERATION STUDY UNDER PRESENT CONDITIONS BY TANK MODEL METHOD (WITHOUT K-2 DAM) (1/2)

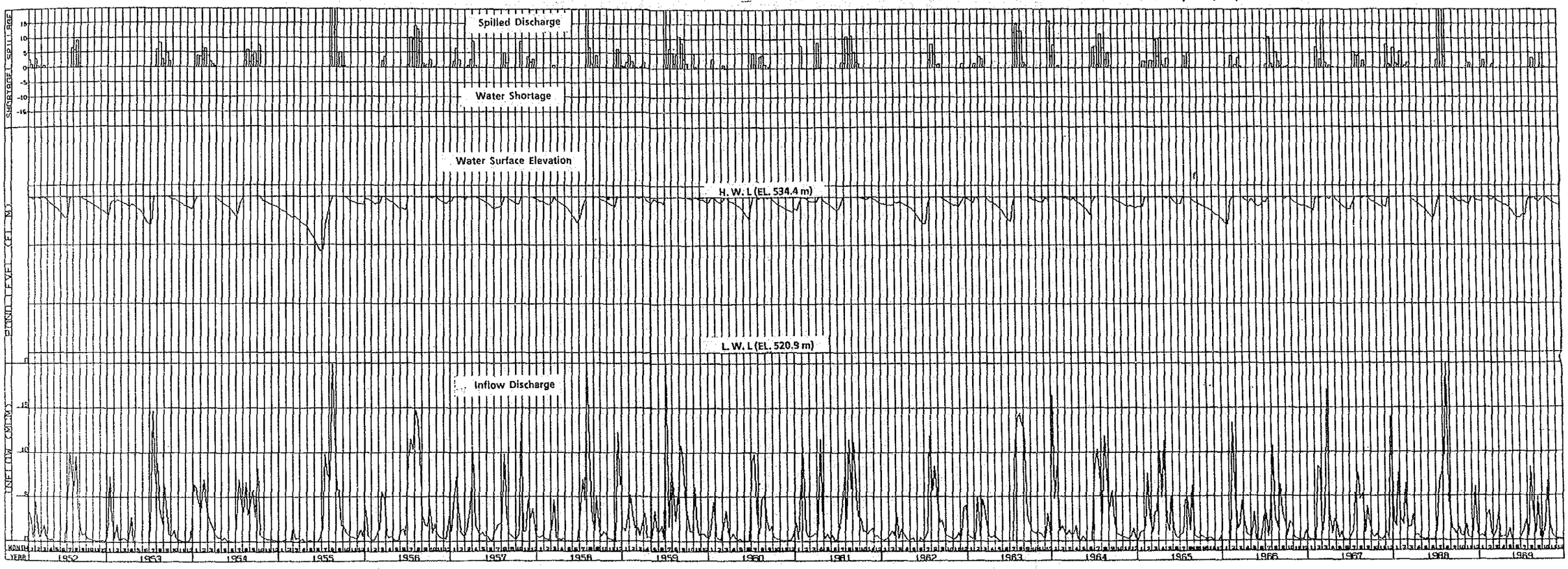


FIGURE F-4 RESULT OF RAWAL DAM OPERATION STUDY UNDER PRESENT CONDITIONS BY TANK MODEL METHOD (WITHOUT K-2 DAM) (2/2)

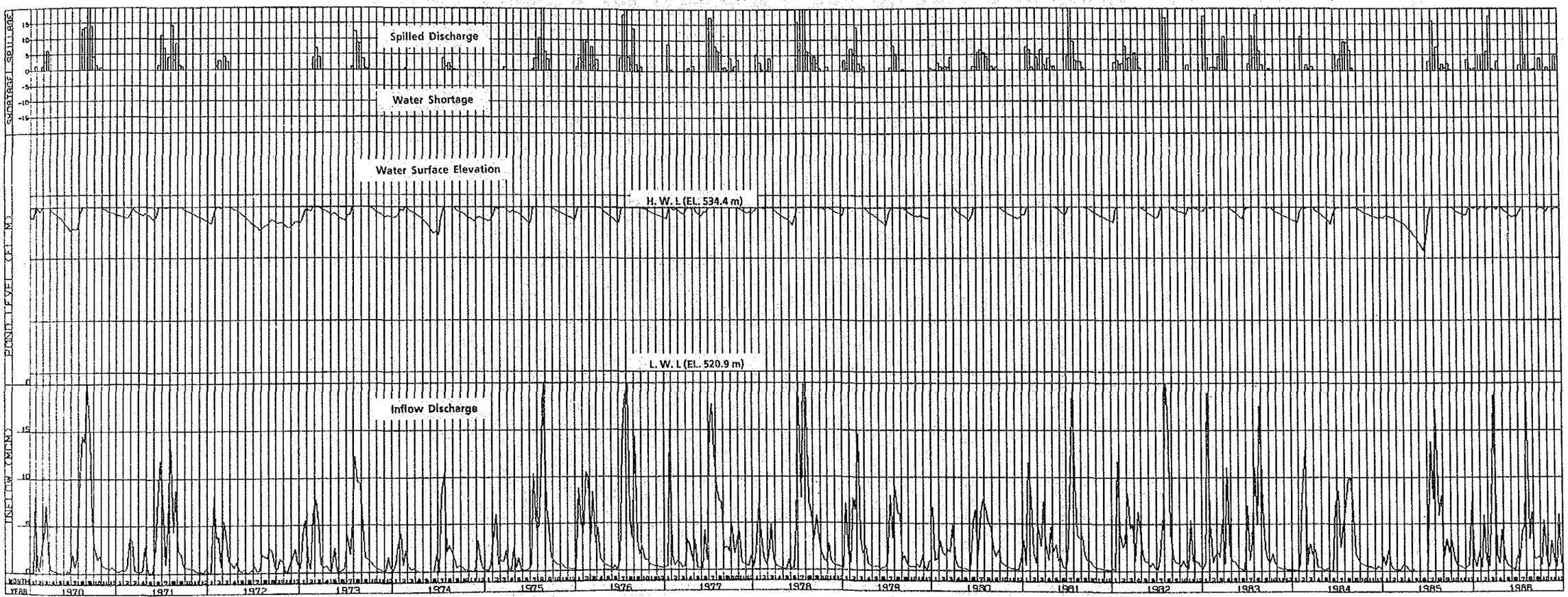


FIGURE F-5 RESULT OF RAWAL DAM OPERATION STUDY UNDER STAGE-1 CONDITIONS BY TANK MODEL METHOD (WITHOUT K-2 DAM) (1/2)

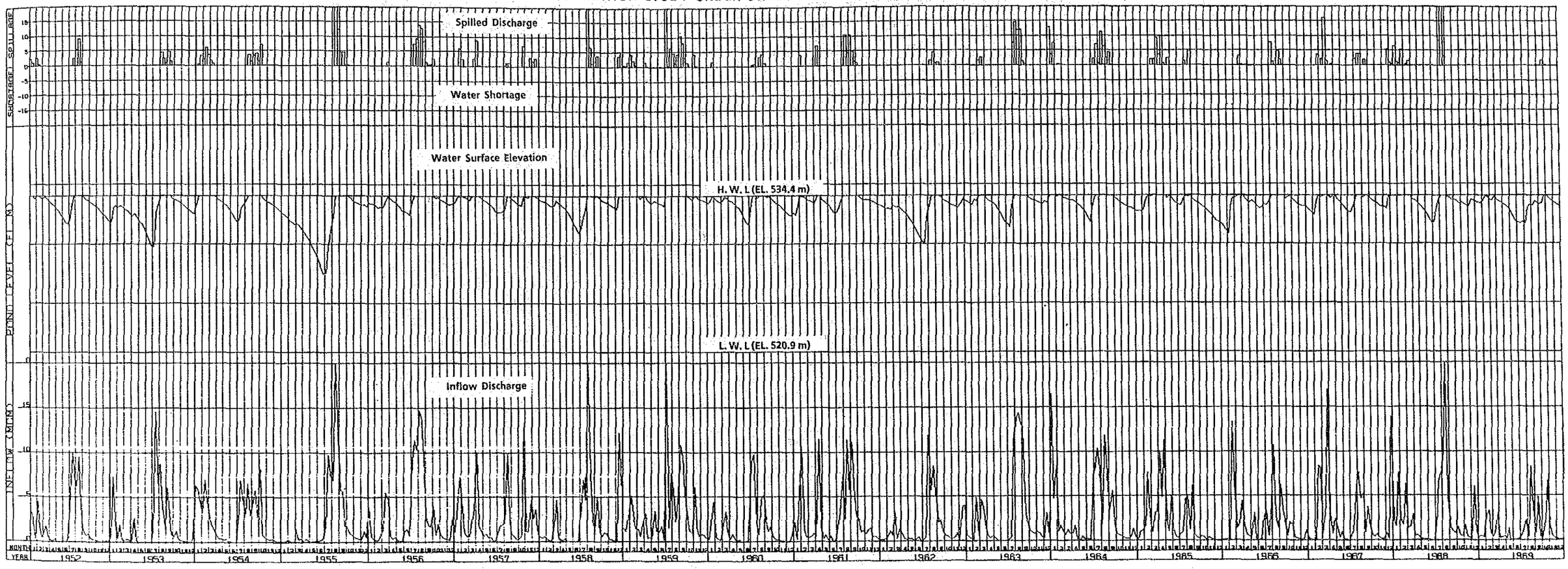


FIGURE F-5 RESULT OF RAWAL DAM OPERATION STUDY UNDER STAGE-1 CONDITIONS BY TANK MODEL METHOD (WITHOUT K-2 DAM) (2/2)