FEASIBILITY REPORT

ON

WADI JIZZI AGRICULTURAL DEVELOPMENT PROJECT

IN

THE SULTANATE OF OMAN

(APPENDIX-II)

JANUARY 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

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APPENDIX II

Appendix	F.	Alternative Study
	G.	Irrigation
	H.	Agriculture
	I.	Structures and Facilities
	J.	Cost Estimate
	K.	Project Implementation
	L.	Agro – Economy
	M.	Environment Assessment

APPENDIX F. ALTERNATIVE STUDY

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F-1. Estimation of Intake Volume to the Farmpound and Irrigable Area

F-2. Storage Pound Plan, Cost Estimate and Implementation Schedule

F-3. Economic Evaluation of the Alternative Study

Table F-1 Intake Volume to the Farmpond in MCM (Q=1.0 cu.m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1974	-	0.21	-	-	-	-	-	-	-	-	-	-	0.21
1975	-	0.05 0.39 0.44	-	-	-	-	-	0.03	-	-	-	-	0.47
1976	0.13	(0.28) (0.22) (0.49) 0.99	(0.11) (0.25) (0.49) 0.85	(0.26) (0.02) 0.28	-	-	-	(0.05) (0.03) 0.08	-	-	0.05	-	2.38
1977	0.08	0.12	-	0.27	0.22	(0.03) (0.02) 0.05	-	-	-	-	0.01	-	0.75
1978	-	0.25	-	-	-	-	-	0.05	-	-	-	-	0.30
1979	0.04	-	-	-	-	-	-	-	-	-	-	0.03	0.07
1980	-	0.03	0.10	-	-	-	-	-	-	-	-	-	0.13
1981	-	-	-	-	0.08	0.02	-	-	-	-	-	-	0.10
Mean													0.55

Table F-2 Intake Volume to the Farmpond in MCM (Q=2.0 cu.m/sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1974	-	0.37	-	-	-	-	-	-	-	-	-	-	0.37
1975	-	(0.08) (0.71) 0.79	-	-	-	-	-	0.05	-	-	-	-	0.84
1976	0.23	(0.50) (0.40) (0.89) 1.79	(0.19) (0.45) (0.89) 1.53	(0.58) (0.04) 0.62	-	-	-	(0.09) (0.05) 0.14	-	-	0.08	-	4.39
1977	0.14	0.20	-	0.50	0.40	(0.05) (0.04) 0.09	-	-	-	-	0.01	-	1.34
1978	-	0.45	-	-	-	-	-	0.08	-	-	-	-	0.53
1979	0.06	-	-	-	-	-	-	-	-	-	-	0.05	0.11
1980	-	0.05	0.17	-	-	-	-	-	-	-	-	-	0.22
1981	-	-	-	-	0.13	-	0.04	-	-	-	-	-	0.17
Mean													1.00

Table F-3 Intake Volume to the Farmpond in MCM (Q=3.0 cum./sec)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1974	-	0.52	-	-	-	-	-	-	-	-	-	-	0.52
1975	-	(0.11, 0.99) 1.10	-	-	-	-	-	0.06	-	-	-	-	1.16
1976	0.31	(0.69, 0.55, 1.23) 2.47	(0.27, 0.62, 1.23) 2.12	(0.81, 0.05) 0.86	-	-	-	(0.12, 0.06) 0.18	-	-	0.11	-	6.05
1977	0.21	0.27	-	0.68	0.55	(0.06, 0.05) 0.11	-	-	-	-	0.01	-	1.83
1978	-	0.65	-	-	-	-	-	0.11	-	-	-	-	0.76
1979	0.10	-	-	-	-	-	-	-	-	-	-	0.06	0.16
1980	-	0.06	0.24	-	-	-	-	-	-	-	-	-	0.30
1981	-	-	-	-	0.18	-	0.05	-	-	-	-	-	0.23
Mean													1.38

Table F-4 Intake Volume to the Farmpond in MCM (Q=4.0 cu.m/sec)

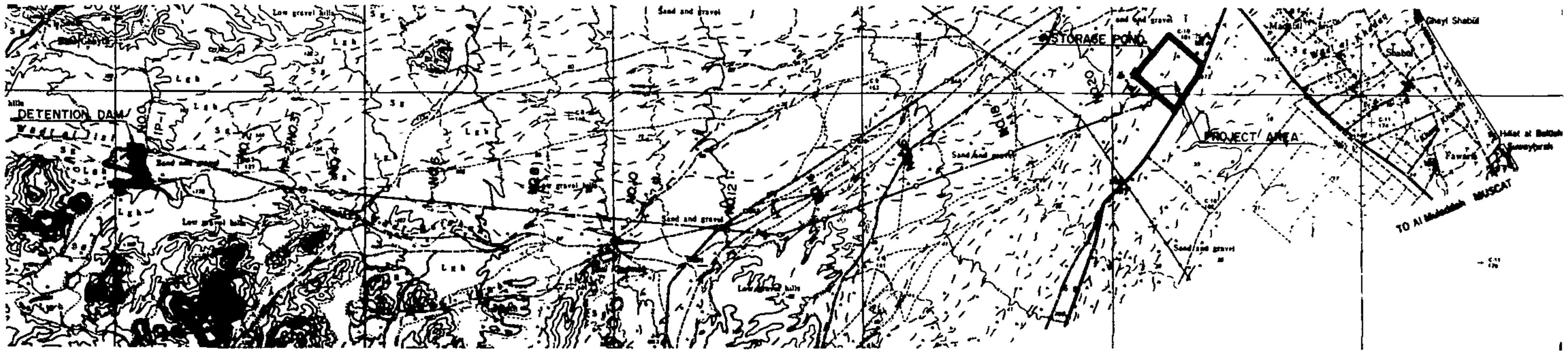
Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1974	-	0.62	-	-	-	-	-	-	-	-	-	-	0.62
1975	-	(0.12) (1.21) 1.33	-	-	-	-	-	0.07	-	-	-	-	1.40
1976	0.37	(0.84) (0.66) (1.51) 3.01	(0.32) (0.75) (1.51) 2.58	(0.98) (0.06) 1.04	-	-	-	(0.13) (0.07) 0.20	-	-	0.12	-	7.32
1977	0.23	0.32	-	0.84	0.66	(0.07) (0.06) 0.13	-	-	-	-	0.01	-	2.19
1978	-	0.75	-	-	-	-	-	0.12	-	-	-	-	0.87
1979	0.10	-	-	-	-	-	-	-	-	-	-	0.07	0.17
1980	-	0.07	0.27	-	-	-	-	-	-	-	-	-	0.34
1981	-	-	-	-	0.20	-	0.06	-	-	-	-	-	0.26
Mean													1.65

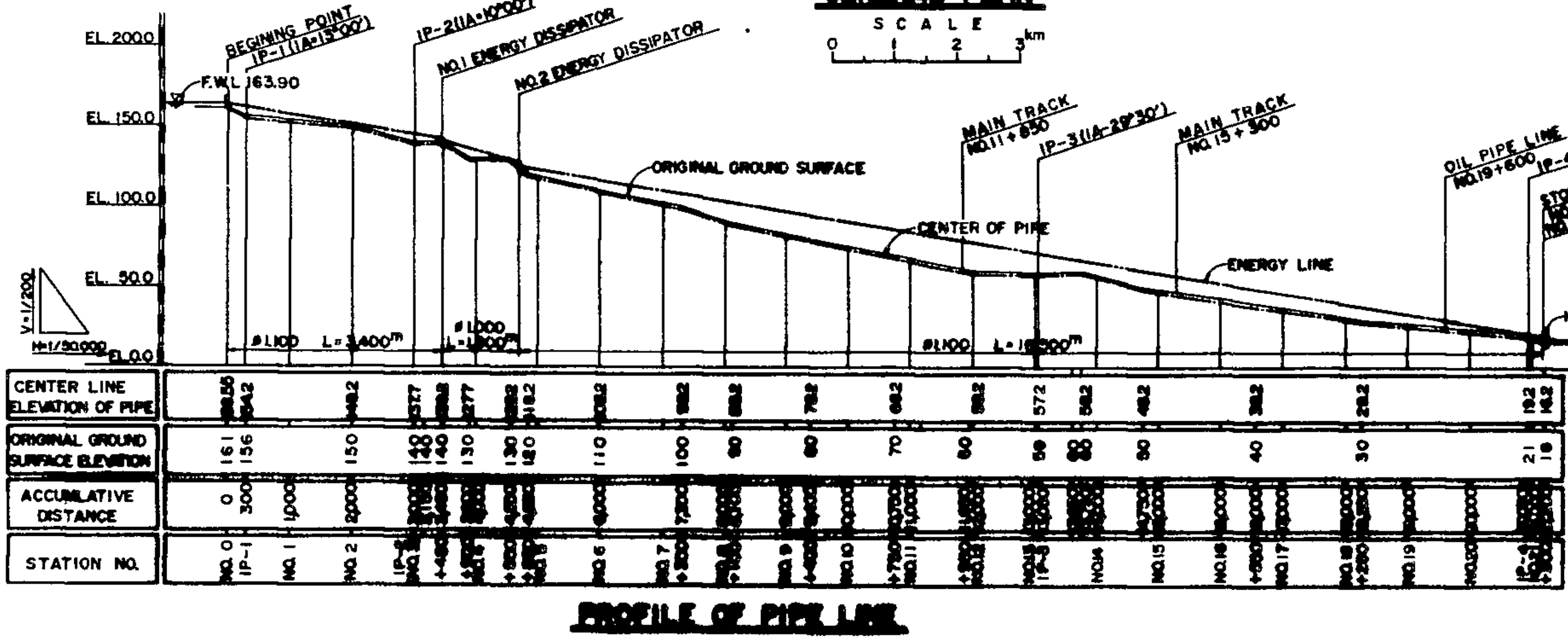
Table F-5 Annual Intake Volume and Irrigable Area

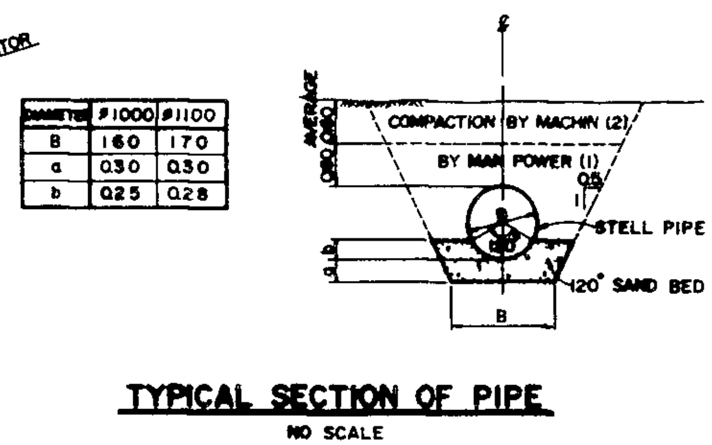
Year	Intake Discharge Q = 1.0 cu.m/sec		Intake Discharge Q = 2.0 cu.m/sec		Intake Discharge Q = 3.0 cu.m/sec		Intake Discharge Q = 4.0 cu.m/sec	
	Intake Volume V(MCM)	Irrigable Area, A(%) 1/	Intake Volume V(MCM)	Irrigable Area, A(%)	Intake Volume V(MCM)	Irrigable Area, A(%)	Intake Volume V(MCM)	Irrigable Area, A(%)
1974	0.21	15.7	0.37	27.6	0.52	38.8	0.62	46.3
1975	0.47	35.1	0.84	62.7	1.16	86.6	1.40	100.0
1976	2.38	100.0	4.39	100.0	6.05	100.0	7.32	100.0
1977	0.75	56.0	1.34	100.0	1.83	100.0	2.19	100.0
1978	0.30	22.4	0.53	39.5	0.76	56.7	0.87	64.9
1979	0.07	5.2	0.11	8.2	0.16	11.9	0.17	12.7
1980	0.13	9.7	0.22	16.4	0.30	22.4	0.34	25.4
1981	0.10	7.5	0.17	12.7	0.23	17.2	0.26	19.4
Average	0.55	31.5	1.00	45.9	1.38	54.2	1.64	58.6

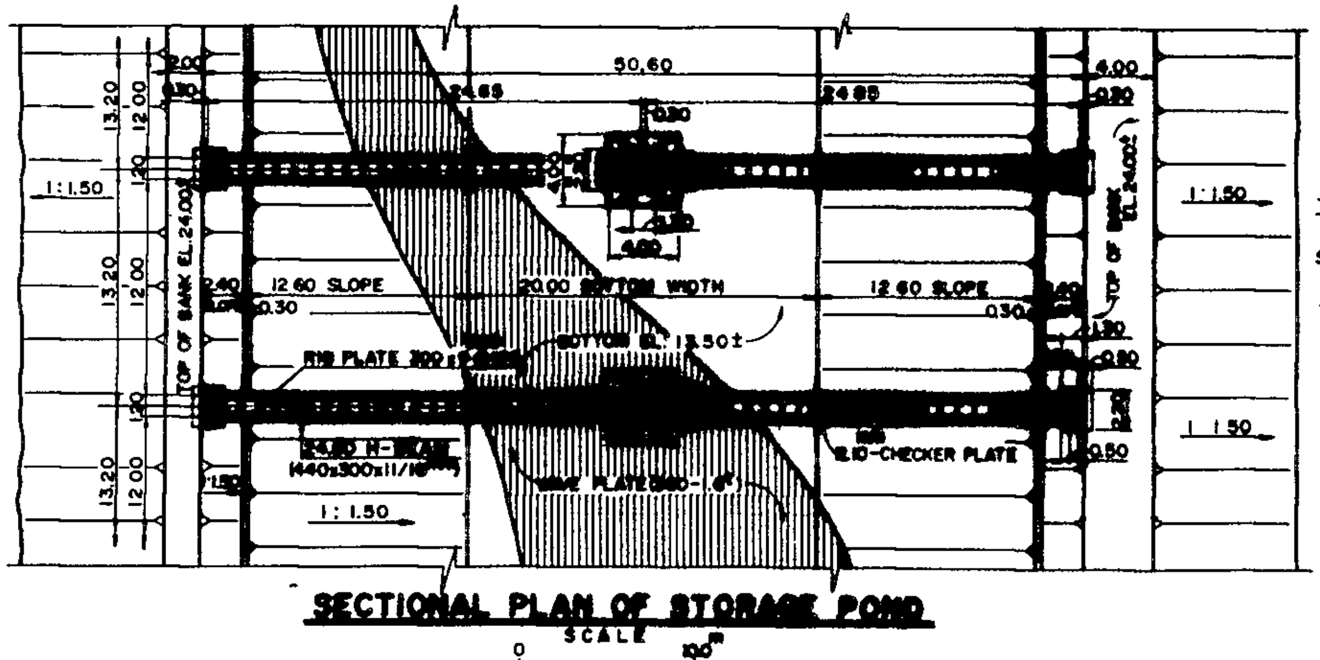
Note: 1/ : Annual percentage of irrigable area = Intake volume/Annual total demand

Annual total demand: Irrigation requirement for 85ha: 1.34 MCM









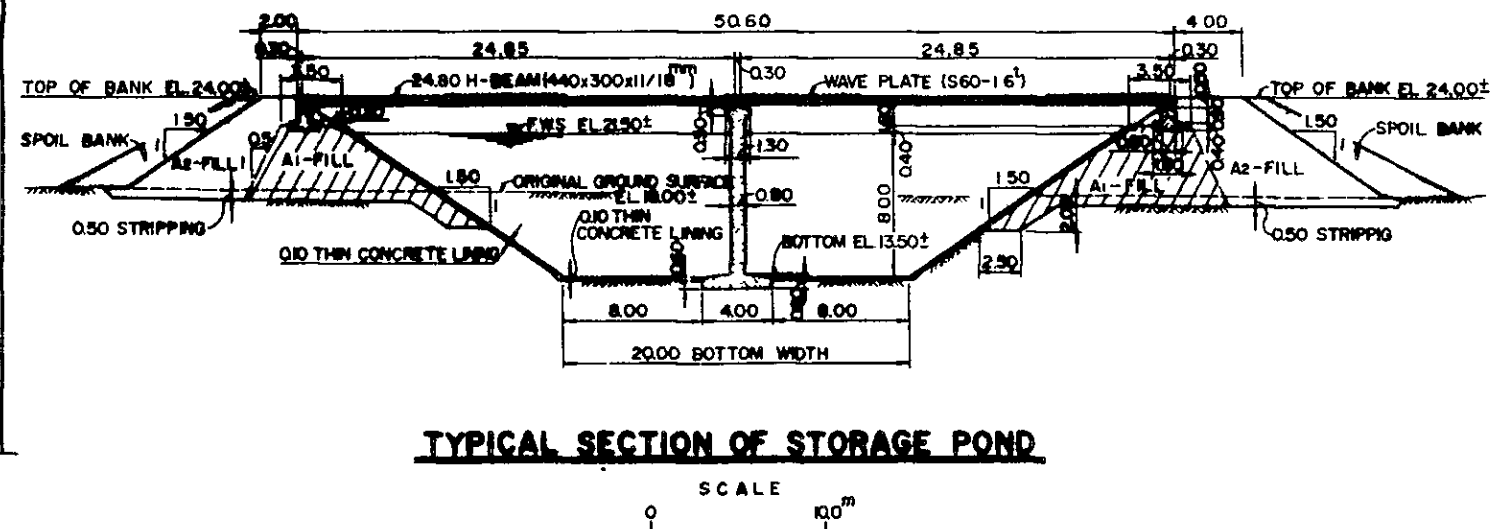


FIGURE F-1 DESIGN OF CONVEYANCE FACILITY AND STORAGE POND

Table F-6 Investment Cost of Project (Alternative)

Description	Total		Foreign Currenty		Local Currency	
	R.O.'000	(US$ '000)	R.O.'000	(US$ '000)	R.O.'000	(US$ '000)
1. Construction Works						
1-1. Preparation	692	2,023	570	1,667	122	356
1-2. Dam	3,159	9,237	2,744	8,023	415	1,214
1-3. Conveyance Facilities	2,422	7,082	2,391	6,991	31	91
1-4. Storage Pond	7,234	21,152	6,631	19,389	603	1,763
1-5. Farm and Related Facilities	1,186	3,468	1,014	2,965	172	503
1-6. Overhead	2,939	8,594	2,670	7,809	269	787
Sub-total	17,632	51,556	16,020	46,842	1,612	4,714
2. Pre-engineering Works	177	518	152	444	25	74
3. Administration Cost	49	143	0	0	49	143
4. Consulting Services	1,400	4,094	1,115	3,260	285	834
Sub-total (1 - 4)	19,258	56,311	17,287	50,546	1,971	5,765
5. Contingency	2,887	8,442	2,593	7,582	294	860
Sub-total (1 - 5)	22,145	64,753	19,880	58,128	2,265	6,625
6. Price Escalation	5,565	16,272	4,939	14,442	626	1,830
Total (1 - 6)	27,710	81,025	24,819	72.570	2,891	8,455

Table 1-7 Disbursement Schedule of Investment Cost (Alternative)

(Unit: R O '000)

Description	Total			1983			1984			1985			1986		
	Total	F.C.1/	L.C.2/	Total	F.C	L.C.	Total	F.C	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.
1 Construction Works															
1-1. Preparation	692	570	122				692	570	122						
1-2. Dam	3,159	2,711	115				790	686	104	2,369	2,058	311			
1-3. Conveyance Pipe	2,422	2,391	31							1,211	1,196	15	1,211	1,195	6
1-4. Storage Pond	7,234	6,631	603							3,617	3,316	301	3,617	3,315	[illegible]
1-5. Farm and Related Facilities	1,186	1,014	172				654	518	136	532	496	36			
1-6. Overhead	2,939	2,670	269				429	355	74	1,545	1,413	132	965	902	3
Sub-total	17,632	16,020	1,612				2,565	2,129	436	9,274	8,479	795	5,793	5,412	381
2. Pre-engineering Works	177	152	25	177	152	25									
3. Administration Cost	49	0	49	1	0	1	12	0	12	24	0	24	12	0	12
4. Consulting Services	1,400	1,115	285	545	434	111	221	176	45	464	370	94	170	135	35
Sub-total (1 - 4)	19,258	17,287	1,971	723	586	137	2,798	2,305	493	9,762	8,849	913	5,975	5,547	428
5. Contingency	2,887	2,593	294	109	88	21	387	318	69	1,369	1,245	124	896	832	64
Sub-total (1 - 5)	22,145	19,880	2,265	832	674	158	3,215	2,651	564	11,227	10,176	1,051	6,871	6,379	492
6. Price Escalation	5,565	4,939	626	34	27	7	533	427	106	2,773	2,463	310	2,225	2.022	203
Total (1 - 6)	27,710	24,819	2,891	866	701	165	3,748	3,078	670	14,000	12,639	1,361	9,096	8,401	[illegible]

Note: 1/ F.C.: Foreign Currency

2/ F.C.: Local Currency

FIGURE F – 2 IMPLEMENTATION SCHEDULE OF THE PROJECT (ALTERNATIVE)

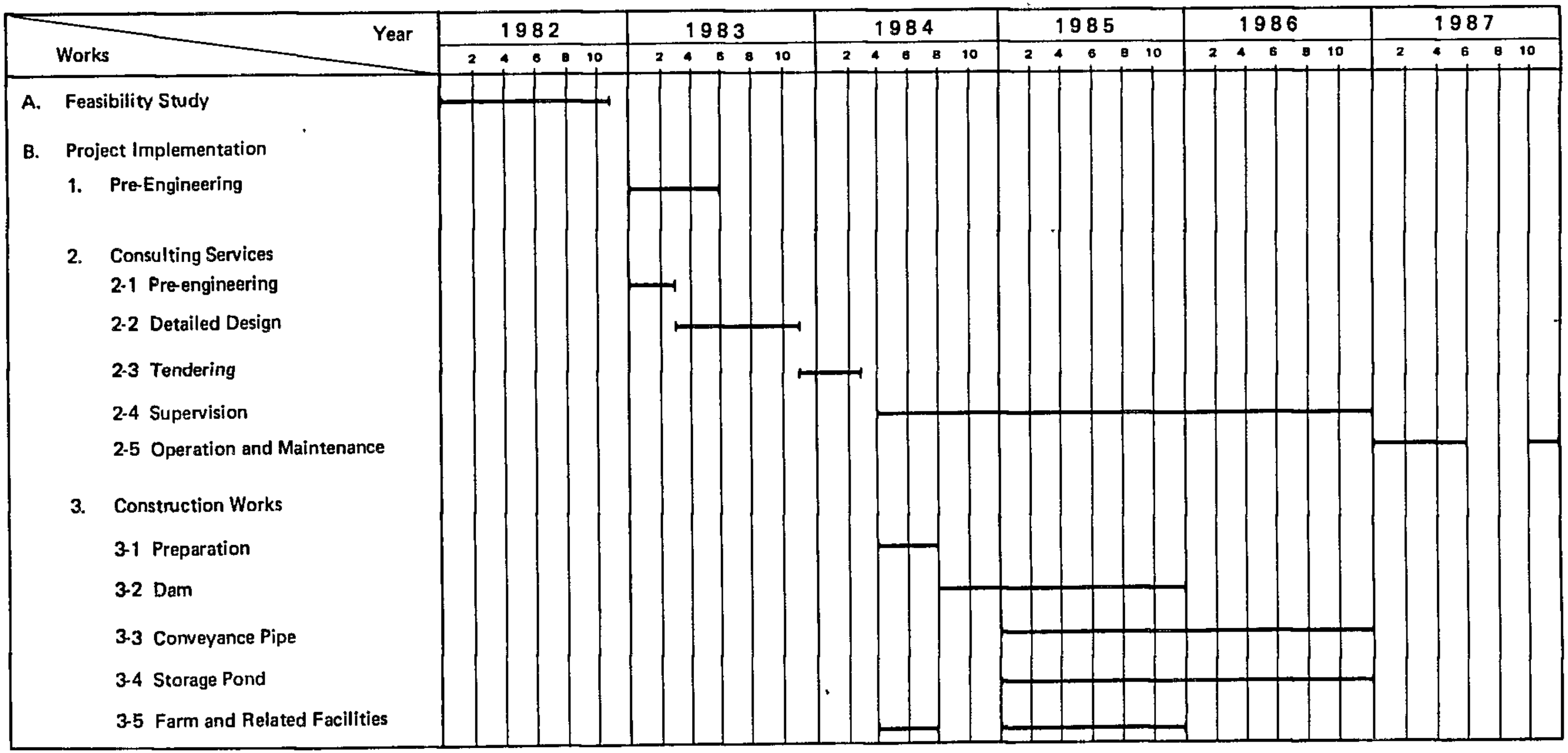


Table F-8 Net Production Value - Groundwater Recharge Method

(Unit: '000 R.O.)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Gross Production Value	133	213	276	324	324	394	394	394	394	394	532
Production Cost	90	83	99	112	112	103	103	103	103	103	103
Net production Value	43	130	177	212	212	291	291	291	291	291	429

Net Production Value - Storage Pond Method

(Unit: '000 R.O.)

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Gross Production Value	72	115	150	176	176	213	213	213	213	213	287
Production Cost	49	45	54	61	61	56	56	56	56	56	56
Net Production Value	23	70	96	115	115	157	157	157	157	157	231

Note: Figures in the case of storage pond method are calculated using the ratio (0.542) of irrigable area 46ha to 85ha in the case of groundwater recharge method.

Table F-9 Gross Production and Gross Production Value

— Groundwater Recharge Method —

P.Q.: Production Quantities (ton)
G.P.V.: Gross Production Value ('000 R.O.)

Crop	Unit Price (R.O/ton)		1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Dates	494	P.Q.	-	-	-	-	-	80	80	80	80	80	120
		G.P.V.	-	-	-	-	-	40	40	40	40	40	60
Lime	593	P.Q.	-	-	-	80	80	200	200	200	200	200	400
		G.P.V.	-	-	-	48	48	119	119	119	119	119	237
Banana	148	P.Q.	-	100	130	130	130	130	130	130	130	130	130
		G.P.V.	-	15	19	19	19	19	19	19	19	19	19
Tomato	197	P.Q.	100	150	200	200	200	200	200	200	200	200	200
		G.P.V.	20	30	40	40	40	40	40	40	40	40	40
Cabbage	247	P.Q.	65	95	125	125	125	125	125	125	125	125	125
		G.P.V.	16	23	31	31	31	31	31	31	31	31	31
Watermelon (Winter)	197	P.Q.	40	60	75	75	75	75	75	75	75	75	75
		G.P.V.	8	12	15	15	15	15	15	15	15	15	15
Watermelon (Summer)	197	P.Q.	25	40	50	50	50	50	50	50	50	50	50
		G.P.V.	5	8	10	10	10	10	10	10	10	10	10
Eggplant	98	P.Q.	78	114	150	150	150	150	150	150	150	150	150
		G.P.V.	8	11	15	15	15	15	15	15	15	15	15
Redpepper	247	P.Q.	48	72	90	90	90	90	90	90	90	90	90
		G.P.V.	12	18	22	22	22	22	22	22	22	22	22
Alfalfa	69	P.Q.	600	900	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
		G.P.V.	41	62	83	83	83	83	83	83	83	83	83
Cauliflower	296	P.Q.	60	90	108	108	108	-	-	-	-	-	-
		G.P.V.	18	27	32	32	32	-	-	-	-	-	-
Onion	98	P.Q.	48	72	90	90	90	-	-	-	-	-	-
		G.P.V.	5	7	9	9	9	-	-	-	-	-	-
Total		P.Q.	1,064	1,693	2,218	2,298	2,298	2,300	2,300	2,300	2,300	2,300	2,540
		G.P.V.	133	213	276	324	324	394	394	394	394	394	532

Table F-10 Gross Production and Gross Production Value

—— Storage Pond Method ——

P.Q.: Production Quantities (ton)
G.P.V.: Gross Production Value ('000 R.O.)

Crop	Unit Price (R.O/ton)		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Dates		P.Q.	-	-	-	-	-	44	44	44	44	44	65
	494	G.P.V.	-	-	-	-	-	22	22	22	22	22	32
Lime		P.Q.	-	-	-	43	43	108	108	108	108	108	217
	593	G.P.V.	-	-	-	26	26	64	64	64	64	64	128
Banana		P.Q.	-	54	70	70	70	70	70	70	70	70	70
	148	G.P.V.	-	8	10	10	10	10	10	10	10	10	10
Tomato		P.Q.	54	81	108	108	108	108	108	108	108	108	108
	197	G.P.V.	11	16	22	22	22	22	22	22	22	22	22
Cabbage		P.Q.	35	51	68	68	68	68	68	68	68	68	68
	247	G.P.V.	9	12	17	17	17	17	17	17	17	17	17
Watermelon (Winter)		P.Q.	22	33	41	41	41	41	41	41	41	41	41
	197	G.P.V.	4	7	8	8	8	8	8	8	8	8	8
Watermelon (Summer)		P.Q.	14	22	27	27	27	27	27	27	27	27	27
	197	G.P.V.	3	4	5	5	5	5	5	5	5	5	5
Eggplant		P.Q.	42	62	81	81	81	81	81	81	81	81	81
	98	G.P.V.	4	6	8	8	8	8	8	8	8	8	8
Redpepper		P.Q.	26	39	49	49	49	49	49	49	49	49	49
	247	G.P.V.	7	10	12	12	12	12	12	12	12	12	12
Alfalfa		P.Q.	325	488	650	650	650	650	650	650	650	650	650
	69	G.P.V.	22	34	45	45	45	45	45	45	45	45	45
Cauliflower		P.Q.	32	49	58	58	58	-	-	-	-	-	-
	296	G.P.V.	10	15	18	18	18	-	-	-	-	-	-
Onion		P.Q.	26	39	49	49	49	-	-	-	-	-	-
	98	G.P.V	3	4	5	5	5	-	-	-	-	-	-
Total		P.Q.	576	918	1,201	1,244	1,244	1,181	1,181	1,181	1,181	1,181	1,376
		G.P.V.	73	116	150	176	176	213	213	213	213	213	213

Table F-11 Production Cost —— Groundwater Recharge Method

		1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Dates	A. Cropped area (ha)	(20)	(20)	(20)	(20)	(20)	20	.20	20	20	20	20
	B. Production cost (R.O./ha)	427	262	314	407	448	750	750	750	750	750	750
	C. Total Pro. cost ('000 R.O.)	8.5	5.2	6.3	8.1	9.0	15	15	15	15	15	15.7
Lime	A.	(20)	(20)	(20)	20	20	20	20	20	20	20	20
	B.	353	292	354	900	907	919	919	919	919	919	919
	C.	7.1	5.8	7.1	18	18.1	18.4	18.4	18.4	18.4	18.4	18.4
Banana	A.	(10)	10	10	10	10	10	10	10	10	10	10
	B.	451	620	1,029	1,077	1,077	1,077	1,077	1,077	1,077	1,077	1,077
	C.	4.5	6.2	10.3	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8
Tomato	A.	5	5	5	5	5	5	5	5	5	5	5
	B.	1,067	1,351	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602
	C.	5.3	6.8	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Cabbage	A.	5	5	5	5	5	5	5	5	5	5	5
	B.	843	918	1,032	1,032	1,033	1,033	1,033	1,033	1,033	1,033	1,033
	C.	4.2	4.6	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
Watermelon (Winter)	A.	5	5	5	5	5	5	5	5	5	5	5
	B.	540	609	689	689	689	689	689	689	689	689	689
	C.	2.7	3.1	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Watermelon (Summer)	A.	5	5	5	5	5	5	5	5	5	5	5
	B.	594	690	764	764	764	764	764	764	764	764	764
	C.	3.0	3.5	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Eggplant	A.	6	6	6	6	6	6	6	6	6	6	6
	B.	1,075	1,198	1,315	1,315	1,315	1,315	1,315	1,315	1,315	1,315	1,315
	C.	6.5	7.2	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9	7.9
Redpepper	A.	6	6	6	6	6	6	6	6	6	6	6
	B.	708	789	884	884	884	884	884	884	884	884	884
	C.	4.2	4.7	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Alfalfa	A.	20	20	20	20	20	20	20	20	20	20	20
	B.	1,415	999	1,245	1,245	1,245	1,245	1,245	1,245	1,245	1,245	1,245
	C.	28.3	20.0	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9
Cauliflower	A.	6	6	6	6	6	-	-	-	-	-	-
	B.	1,026	1,063	1,104	1,104	1,104	-	-	-	-	-	-
	C.	6.2	6.4	6.6	6.6	6.6	-	-	-	-	-	-
Onion	A.	6	6	6	6	6	-	-	-	-	-	-
	B.	1,605	1,646	1,683	1,683	1,683	-	-	-	-	-	-
	C.	9.6	9.9	10.1	10.1	10.1	-	-	-	-	-	-
Total	A.	114	114	114	114	114	102	102	102	102	102	102
	C.	90.1	83.4	98.9	112.1	112.1	102.7	102.7	102.7	102.7	102.7	103.4

Note: Figures in the parenthies are area of non-production trees.

Table F-12 Economic Project Cost

—— Groundwater Recharge Method ——

(Unit: '000 R.O.)

	Total			1983			1984			1985		
	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.
1. Financial Project Cost Excluding Price Escalation	8,302	7,062	1,240	693	561	132	2,809	2,355	474	4,800	4,166	634
2. Resident Building Cost	689	550	139	-	-	-	689	550	139	-	-	-
3. (1 - 2)	7,613	6,512	1,101	693	561	132	2,120	1,785	335	4,800	4,166	634
4. Dam Cost - Financial	3,633	3,156	477	-	-	-	909	789	120	2,724	2,367	357
5. - Economic	3,407	2,967	440	-	-	-	852	742	110	2,555	2,225	330
6. Overhead Cost - Financial	1,176	1,014	162	-	-	-	438	367	71	738	647	91
7. - Economic	587	507	80	-	-	-	219	184	35	369	324	45
8. Project Cost Revised on Tax, Interest and Unskilled Labor Cost (3-4-6+5+7)	6,799	5,816	982	693	561	132	1,844	1,555	289	4,262	3,701	561
9. Standard Conversion Factor 0.988		-	0.988		-	0.988		-	0.988		-	0.988
10. Economic Project Cost	6,785	5,816	969	691	561	130	1,840	1,555	285	4,255	3,701	554

Table F-13 Economic Project Cost —— Storage Pond Method

(Unit: '000 R.O.)

	Total			1983			1984			1985			1986		
	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.
1. Financial Project Cost Excluding Price Escalation	22,144	19,879	2,265	832	674	158	3,215	2,650	565	11,226	10,176	1,050	6,871	6,379	492
2. Resident Building Cost	689	550	139	-	-	-	689	550	139	-	-	-	-	-	-
3. (1 - 2)	21,455	19,329	2,126	832	674	158	2,526	2,100	426	11,226	10,176	1,050	6,871	6,379	492
4. Dam, Conveyance Pipe and Storage Pond Cost															
4-1. Financial Cost	14,737	13,531	1,206	-	-	-	909	789	120	8,277	7,556	721	5,552	5,187	365
4-2. Economic Cost	14,120	13,000	1,120	-	-	-	852	742	110	7,910	7,243	667	5,357	5,015	342
5. Overhead Cost															
5-1. Financial Cost	3,380	3,070	310	-	-	-	491	408	83	1,777	1,625	152	1,110	1,037	73
5-2. Economic Cost	1,690	1,535	155	-	-	-	246	204	42	889	813	76	555	519	36
6. Project Cost Revised on Tax, Interest and Unskilled Labor Cost 3-(4-1)-(5-1)+(4-2)+(5-2)	19,148	17,263	1,885	832	674	158	2,224	1,849	375	9,971	9,051	920	6,121	5,689	432
7. Standard Conversion Factor 0.988			0.988			0.988			0.988			0.988			0.988
8. Economic Project Cost	17,965	16,103	1,862	830	674	156	2,007	1,637	370	9,144	8,235	909	5,984	5,557	427

Table F-14 Economic Internal Rate of Return —— Groundwater Recharge Method

(Unit: '000 R.O.)

Project Year	Project Cost	O & M Cost	Replace-ment Cost	Total Cost	Agri-culture (85 ha)	Flood Protect	Salt Protect	Water Supply	Total Benefit	Incremental Benefit	Present Worth Value 11 %	Present Worth Value 12 %
1(1983)	691	-	-	691	-	-	-	-	-	-691	-623	-617
2 ('84)	1,840	-	-	1,840	-	-	-	-	-	-1,840	-1,493	-1,467
3 ('85)	4,255	-	-	4,255	-	-	-	-	-	-4,255	-3,111	-3,029
4 ('86)	-	140	-	140	43	32	109	563	747	607	400	386
5 ('87)	-	140	-	140	130	32	109	563	834	694	412	394
6 ('88)	-	140	-	140	177	32	109	563	881	741	396	375
7 ('89)	-	140	-	140	212	32	109	563	916	776	374	351
8 ('90)	-	140	-	140	212	32	109	563	916	776	337	313
9 ('91)	-	140	-	140	291	32	109	563	995	855	334	308
10 ('92)	-	140	-	140	291	32	109	563	995	855	301	275
11 ('93)	-	140	-	140	291	32	109	563	995	855	271	246
12 ('94)	-	140	-	140	291	32	109	563	995	855	244	220
13 ('95)	-	140	244	384	291	32	109	563	995	611	157	140
14 ('96)	-	140	-	140	429	32	109	563	1,133	993		
"	-	"	-	"	"	"	"	"	"	"	$\sum_{22}^{14}$1,416	$\sum_{22}^{14}$1,213
23(2005)	-	140	244	384	429	32	109	563	1,133	749	68	55
"	-	"	-	140	"	"	"	"	"	993	$\sum_{32}^{24}$499	$\sum_{32}^{24}$390
33(2015)	-	140	244	384	429	32	109	563	1,133	749	24	18
"	-	"	-	140	"	"	"	"	"	993	$\sum_{42}^{34}$176	126
43(2025)	-	140	244	384	429	32	109	563	1,133	749	8	6
"	-	"	-	140	"	"	"	"	"	993	$\sum_{50}^{44}$53	35
50(2032)	-	140	-	140	429	32	109	563	1,133	993		
Total	6,785	6,580	1,220	14,585	15,873	1,504	5,123	26,461	48,961	34,376	243	-262

$$\text{IERR} = 0.11 + \frac{243}{243+262} \times 0.01 = 0.115 = 11.5\ \%$$

Table F-15 Economic Internal Rate of Return —— Storage Pond Method

(Unit: '000 R.O.)

Project Year	Project Cost	O & M Replace-ment Cost	Total Cost	Agri-culture (46 ha)	Flood Project	Salt Project	Water Supply	Total Benefit	Incremental Benefit	Present Worth Value 2 %	Present Worth Value 3 %
1(1983)	830	-	830	-	-	-	-		-830	-814	-806
2 ('84)	2,007	-	2,007	-	-	-	-		-2,007	-1,929	-1,892
3 ('85)	9,144	-	9,144	-	-	-	-		-9,144	-8,616	-8,368
4 ('86)	5,984	-	5,984	-	-	-	-		-5,984	-5,528	-5,317
5 ('87)	-	147	147	23	32	109	563	727	580	525	500
6 ('88)	-	147	147	70	32	109	563	774	627	557	525
7 ('89)	-	147	147	96	32	109	563	800	653	569	531
8 ('90)	-	147	147	115	32	109	563	819	672	574	530
9 ('91)	-	147	147	115	32	109	563	819	672	562	515
10 ('92)	-	147	147	157	32	109	563	861	714	586	531
11 ('93)	-	147	147	157	32	109	563	861	714	574	516
12 ('94)	-	147	147	157	32	109	563	861	714	563	501
13 ('95)	-	147	147	157	32	109	563	861	714	552	486
14 ('96)	-	297	147	157	32	109	563	861	564	427	373
15 ('97)	-	147	147	231	32	109	563	935	788		
"		"	"	"	"	"	"	"	"	$\sum_{23}^{15}$ 4,875	4,056
24(2005)	-	297	297	"	"	"	"	"	564	350	277
"		147	147	"	"	"	"	"	788	$\sum_{33}^{25}$ 3,999	3,018
34(2015)	-	297	297	"	"	"	"	"	564	288	206
"		147	147	"	"	"	"	"	788	$\sum_{43}^{35}$ 3,280	2,246
44(2025)	-	297	297	"	"	"	"	"	564	236	154
"		147	147	"	"	"	"	"	788	$\sum_{50}^{45}$ 1,847	1,163
50(2032)	-	147	147	231	32	109	563	935	788		
Total	17,965	7,362	25,327	9,520	1,472	5,014	25,898	41,904	16,577	+3,477	-255

$$\text{IERR} = 0.02 + \frac{3,477}{3,477+255} \times 0.01 = 0.0293 = 2.9\ \%$$

APPENDIX G. IRRIGATION

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Present Irrigation Conditions

1. Existing Irrigation System

The irrigation system in the area is predominantly basin irrigation. Each basin is either circular one meter to three meters in diameter and 10 centimeters to 60 centimeters deep holding one tree, or rectangular five square meters to 30 square meters in size and a few centimeters lower than the conveyance canal holding one or two trees and occasionally undergrown by feed crops. The latter may almost be called the border-strip irrigation.

There are three types of water conveyance systems to lead water to these basins.

i) direct diversion from the main and lateral canals.

ii) a series of basins used as a conveyance canal.

iii) combination of i) and ii).

No. i) is the system where the water is directly diverted from the conveyance canal to the basin. A few farms adopt this system. However, seldom is the main canal straight or well kept for efficient conveyance of water, causing excessive seepage and evaporation losses from the canal. Yet this system has the potentiality to be most efficient of the three, as far as the water saving is concerned, because there is no intermediate conveyance losses before the cropping area. No. ii) is the system where water is fed directly into the first basin. After filling the first basin the water flows into the second one and then the third to the last basin. This is the most inefficient method of the three as the percolation loss at the beginning of the system is enormous and application rate towards the end of the system is insufficient. There are varying degrees of combination of the above two. If sensibly laid out this No. iii) system proves to be the most economical of the three as this saves the expensive construction of the long main and lateral canals and also the spaces occupied by them. Most of the farm lands employ the last system. But the basin-to-basin conveyance distance is usually too much (30 meters to 60 meters) resulting in the deficiency described above for No. ii).

Apart from the basin irrigation on the border-strip and furrow irrigation seem to gain popularity especially among the newly developed large scale farms along the highway. The conveyance canals are generally straight and well kept. But there is still a lot of room for improvement in canal routing and quality as well as for introduction of other irrigation facilities.

2. Present Irrigation Practices

The procedure of irrigation in the survey area varies little from place to place, be it of different efficiency, i.e., pumped water is let to the crop area by gravity through ditches, furrows and basins. All the irrigation water in the area is presently supplied by well water including in the village of Falaj Al Awhi on the north-western corner where the irrigation water was formerly supplied by the Falaj. The pumps are usually installed singly or in a pair in a pit about five meters deep. Suction pipes extend into the adjoining well of 80 centimeters to 120 centimeters diameter. The depth to the water surface was observed to be about seven to 10 meters below ground surface. The pump sizes are mainly 3" x 3" and sometimes 4" x 3".

Water is first poured into a rectangular concrete basin of the size 1.2 m x 1.8 m to 2 m x 3 m and 20 centimeters to 50 centimeters deep. The top rim of the basin is 60 centimeters to 70 centimeters higher than the ground. Water is then let out through an elevated concrete ditch 15 centimeters to 20 centimeters wide and 10 centimeters to 15 centimeters deep. The length of this concrete ditch is usually less than 10 meters and from there on a crude earth ditch continues. The earth ditch is usually winding and not of a uniform shape. Water is diverted by breaking a side of the ditch and clogging the immediate downstream by filling mud into the ditch. This daily operation helped in deforming and deteriorating the ditch, such a ditch will cause more evaporation losses due to low speed of flow and much seepage due to constantly disturbed and softened ditch surfaces.

Farmers seem to know approximately the right way of irrigating each crop after many years or generations of experience. Basin irrigation is adopted for tree crops, border-strip for fodder crops and furrow irrigation for various vegetables. However, it was almost always the case that the conveyance route was arranged in a rather complicated and wasteful way with a lot of detours which could be simplified and rationalized. These detours are possibly the consequence of the efforts to achieve best results in uniform water distribution. By the time the purpose was achieved the conveyance route was apparently grossly elongated. It is therefore important to study the topography carefully when rectifying the canal route.

3. Irrigation Efficiency

The classification according to the crop condition described in previous paragraph is reconsidered here in terms of irrigation intensity.

In No. 1 (good condition) area it was observed that water was abundantly applied both in quantity and frequency. In some cases water was applied every day or every other day, where the quantity was estimated to be from 100 percent up to even 500 percent of the consumptive use. On these locations plant growth generally looked good. Possible reasons for it is ample application of fertilizers and good leaching of hazardous salts coupled with sufficient supply of water and favourable soil conditions. Further study on harmful effect of over-irrigation should be made.

In No. 2 (moderate condition) area water application was estimated at between 50 percent to 100 percent of the consumptive use of water. On these farms the irrigation method and facilities were usually poor to fair. Only the beginning part of the irrigation system received ample to excessive supply of water and the end part of it suffered from water deficiency.

No. 3 (poor condition) area obtained only 20 percent to 50 percent of water compared to the consumptive use of the plants. In these areas the farmers attended the farm only occasionally or only part of the farm due to lack of sufficient available water.

The summary of water consumption of each of these areas is given below:

Classification	Area Percentage (%)	Water Application Percentage of Consumptive Use (%)	Average (%)
Good area	20	100 - 500	300
Moderate area	49	50 - 100	75
Poor area	31	20 - 50	35

Under these conditions the overall irrigation efficiencies are considered to be between 30 percent - 40 percent. Most of the losses occur through deep percolation and evaporation caused by inefficient and deficient conveyance canals and partly due to over-irrigation.

4. Present Irrigation Water Requirement

From the hydrogeological study, about 17 kilometers long coastal plain extending from the Wadi Khadaq to the Village of Majis was determined to be beneficial areas covered by the Wadi Jizzi river basin. The gross cultivated area within this coastal plain is about 3,830 hectares and its net cultivation area is 2,640 hectares. The water resources for irrigation in these areas are wells with a depth of 20 meters to 30 meters on average, and numerous small scale pumps are installed for lifting groundwater as irrigation water.

Since the estimation of present annual amounts used for irrigation by means of pumping operation during a year was found out to be difficult due to numerous pump installation as explained above, the amounts were estimated based upon the cropping areas and consumptive use of each crop.

a) Present Cropping Area and Cropping Pattern

According to the field survey and collected data on the existing land use, the existing cropping acreage is summarized as shown below and its cropping pattern is shown in Figure G-1.

Existing Cropping Acreage

Vegetable			
Onion	:	51.0 ha	
Garlic	:	13.5	
Tomato	:	8.7	
Potato	:	8.1	
Okra	:	4.5	
Others	:	12.0	
Fruit Crop			
Dates	:	1,820	
Lime	:	309	
Banana	:	128	
Mango	:	83	
Feed Crop			
Alfalfa	:	112.2	
Sorghum	:	54.0	
Total		2,604.0	(excluding fallow land of 36 hectares)

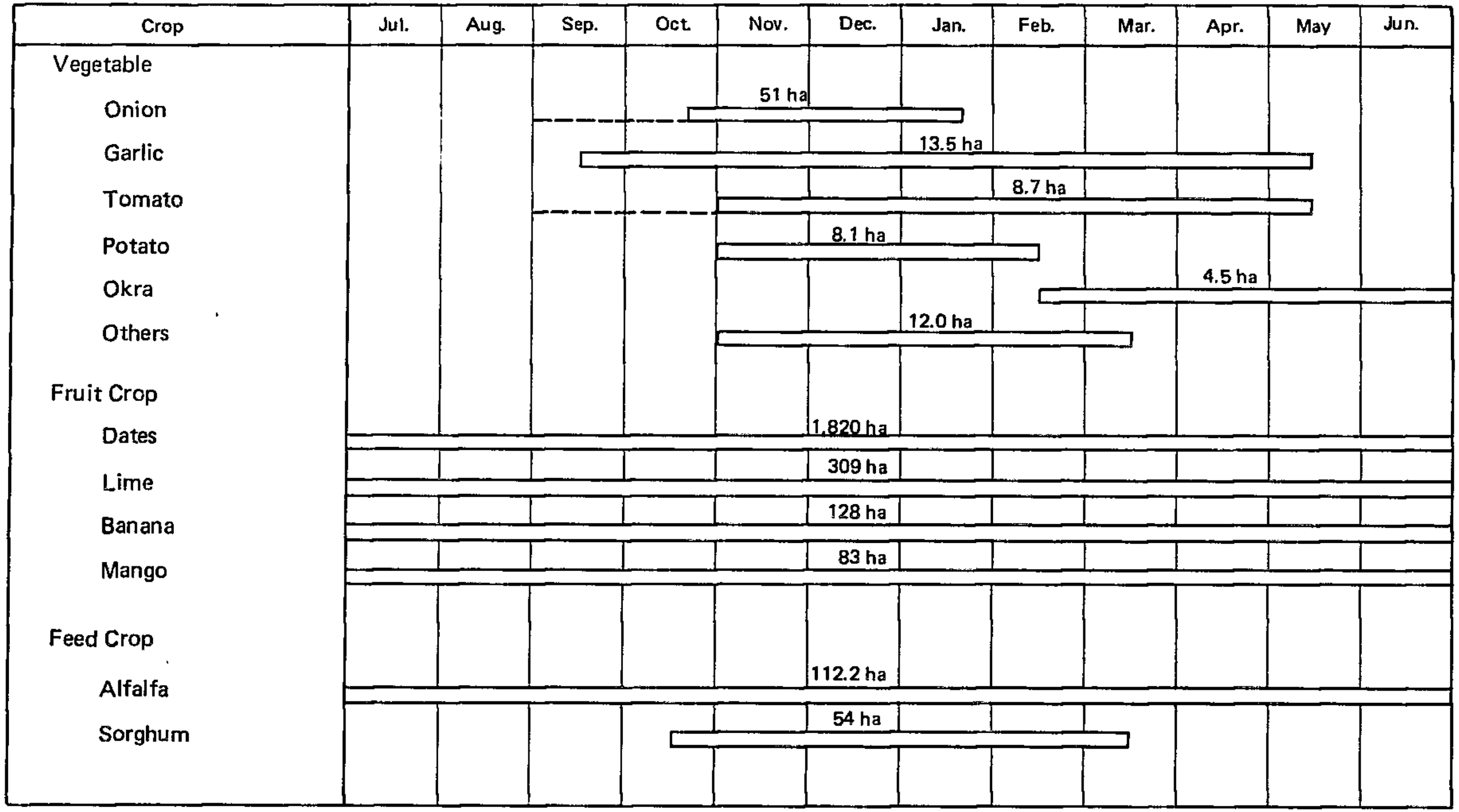


FIGURE G-1 PRESENT CROPPING PATTERN

b) Irrigation Water Requirement

Same procedures as used in the estimation of irrigation water requirement in the development plan (refer to paragraph 4.5.3 Irrigation and Appendix G-3, has been adoped to estimate the present annual amounts of irrigation water, so that references to the said paragraph shall be made, when details are need.

Potential Evapo-transpiration

Reference crop potential evapo-transpiration (ETPc) has been estimated by the both methods of modified Penman and Blaney-Criddle and their average values have been decided at the proposed one. Following table indicates the estimated potential evapo-transpiration.

Potential Evapo-transpiration (ETPc)

(unit: mm/month)

Month	Penman Method	B - C Method	Average
Jan.	74.4	97.0	85.7
Feb.	89.6	98.7	94.2
Mar.	120.9	138.6	130.0
Apr.	147.0	179.7	163.4
May	176.7	242.1	209.4
Jun.	189.0	260.0	224.5
Jul.	186.0	267.4	226.7
Aug.	170.5	243.8	207.2
Sep.	153.0	197.4	175.2
Oct.	127.1	171.9	149.5
Nov.	81.0	124.0	102.5
Dec.	74.4	110.3	92.4
Total	1,589.6	2,130.9	1,860.7

Note: Refer to Appendix G-3.

Crop Water Supply Requirement

Crop water supply requirement has been estimated by applying the following equation:

$$V = \frac{10}{EP}\left[\frac{A(ETc - RE)}{1 - LR}\right]$$

where; A: area (ha)

ETc: crop evapo-transpiration (mm)
= ETPc x crop coefficient

RE: effective rainfall (mm) (see Table G-1)

EP: irrigation efficiency, 0.35

LR: leaching requirement (referred to Table G-2)

$$= \frac{EC(W)}{2MAX.EC(E)} \cdot \frac{1}{LE}$$

EC(W): electric conductivity of irrigation water, 0.56 mm hos/cm (average of five sampled waters, see Table G-9)

Max.EC(E): maximum tolerable electrical conductivity of the soil saturation extract for crops, derived from FAO Irrigation and Drainage Paper No.24, Table 36 (see Table G-2 to G-5.)

LE: leaching efficiency, 0.8 (sandy loam)

Water supply requirements for each crop have been calculated by applying the above mentioned procedures and its result is shown in Table G-2 to Table G-5. Based upon these water supply requirements, present total consumption of irrigation water has been calculated at about 21.1 Million Cubic Meters as shown in Table G-8.

Table G-1 Estimation of Effective Rainfall

(Unit : mm)

Month	Rainfall	Onion			Garlic			Tomato			Potato			Okra			Others			Dates		
		ET(C)	R(E)	RER	ET(C)	R(E)	RER	ET(C)	R(E)	RER	ET(C)	R(E)	RER	ET(C)	R(F)	RER	ET(C)	R(E)	RER	ET(C)	R(E)	RER
Jan.	12.7	37.1	0	0	68.6	8.5	8.8	72.8	8.7	9.0	115.7	9.6	10.0				72.8	8.8	9.2	60.0	8.3	9.2
Feb.	37.1				75.4	26.2	27.2	94.2	27.5	28.6	58.9	12.8	13.3	18.8	11.6	12.1	75.4	26.3	27.4	65.9	25.7	26.7
Mar.	8.8				104.0	6.1	6.3	110.5	5.8	6.0				91.0	5.8	6.0	39.0	0	0	91.0	6.1	6.3
Apr.	14.8				114.4	11.4	11.9	114.4	11.3	11.8				138.9	11.8	12.3				114.4	11.3	11.8
May	2.9				104.7	0	0	68.1	0	0				167.5	0	0				146.6	0	0
Jun.	0													134.7	0	0				157.2	0	0
Jul.	0.5																			158.7	0	0
Aug.	0.8																			145.0	0	0
Sep.	0	175.2	0	0	30.7	0	0	175.2	0	0										122.6	0	0
Oct.	5.6	149.5	0	0	74.8	0	0	149.5	0	0										104.7	0	0
Nov.	2.4	71.8	0	0	71.8	0	0	46.1	0	0	46.1	0	0				41.0	0	0	71.8	0	0
Dec.	9.8	69.3	6.1	6.3	69.3	6.7	7.0	50.8	6.2	6.4	97.0	6.9	7.2				64.7	6.8	7.1	64.7	6.7	7.0
Total	95.4	502.9	6.1	6.3	713.7	58.9	61.2	881.6	59.5	61.8	317.7	29.3	30.5	550.9	29.2	30.4	292.9	41.9	43.7	1,302.6	58.1	60.4

Month	Rainfall	Lime			Banana			Mango			Alfalfa			Sorghum		
		ET(C)	R(E)	RER	ET(C)	R(E)	RER	ET(C)	R(E)	RER	ET(C)	R(E)	RER	ET(C)	R(E)	RER
Jan.	12.7	42.9	7.9	8.2	77.1	9.0	9.4	60.0	8.3	8.6	72.8	8.9	9.3	85.7	8.5	8.8
Feb.	37.1	47.1	24.5	25.5	84.8	27.2	28.3	65.9	25.7	26.7	80.1	26.7	27.8	70.7	26.0	27.0
Mar.	8.8	65.0	5.2	5.4	117.0	6.1	6.3	91.0	6.1	6.3	110.5	6.1	6.3	39.0	0	0
Apr.	14.8	81.7	10.7	11.1	147.1	11.8	12.3	114.4	11.3	11.8	138.9	11.7	12.2			
May	2.9	104.7	0	0	188.5	0	0	146.6	0	0	178.0	0	0			
Jun.	0	112.3	0	0	202.1	0	0	157.2	0	0	190.8	0	0			
Jul.	0.5	113.4	0	0	204.0	0	0	158.7	0	0	192.7	0	0			
Aug.	0.8	103.6	0	0	186.5	0	0	145.0	0	0	176.1	0	0			
Sep.	0	87.6	0	0	157.7	0	0	122.6	0	0	148.9	0	0			
Oct.	5.6	74.8	0	0	134.6	0	0	104.7	0	0	127.1	0	0	26.2	0	0
Nov.	2.4	51.3	0	0	92.3	0	0	71.8	0	0	87.1	0	0	61.5	0	0
Dec.	9.8	46.2	5.9	6.1	83.2	6.6	6.9	64.7	6.7	7.0	78.5	6.6	6.9	92.4	6.5	6.8
Total	95.4	930.6	54.2	56.3	1,674.9	60.7	63.2	1,302.6	58.1	60.4	1,581.5	60.0	62.5	375.5	46.2	42.6

Note: Effective rainfall, R(E) is estimated based upon Figure G-4
Rainfall less than 8 mm is decided to be no effective rainfall (zero).

Remarks:

ET(C): Reference Crop Evapo-transpiration (mm/month)

R(E): Effective Rainfall (mm/month)

RER: Revised Effective Rainfall (mm/month) = RE x 1.04

1.04: Correction factor Porosity (50%) x soil moisture (35%) x cultivation depth (400mm) = 130mm, so, correction factor is 1.04

Table G-2 Estimation of Water Supply Requirement per Hectare

Crop : Onion
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m³)
Jan	57.1	0.65	0.56	8	0.8	0.35	1.00	0	37.1	0.044	1,108.9
Feb											
Mar											
Apr											
May											
Jun											
Jul											
Aug											
Sep.	175.2	1.00	0.56	8	0.8	0.35	0.10	0	175.2	0.044	523.5
Oct.	149.5	1.00	0.56	8	0.8	0.35	0.10	0	149.5	0.044	446.7
Nov.	102.5	0.70	0.56	8	0.8	0.35	1.00	0	71.8	0.044	2,143.8
Dec	92.4	0.75	0.56	8	0.8	0.35	1.00	6.3	69.3	0.044	1,882.4
Total	576.7							6.3	502.9	0.22	6,105.3

Crop : Garlic
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m³)
Jan.	85.7	0.80	0.56	15	0.8	0.35	1.00	8.8	68.6	2.333	1,748.2
Feb.	94.2	0.80	0.56	15	0.8	0.35	1.00	27.2	75.4	2.333	1,408.9
Mar.	130.0	0.80	0.56	15	0.8	0.35	1.00	6.3	104.0	2.333	2,858.1
Apr.	163.4	0.70	0.56	15	0.8	0.35	1.00	11.9	114.4	2.333	2,298.0
May	209.4	0.50	0.56	15	0.8	0.35	1.00	0	104.7	2.333	3,062.9
Jun.											
Jul.											
Aug.											
Sep.	87.6	0.35	0.56	15	0.8	0.35	1.00	0	30.7	2.333	896.9
Oct.	149.5	0.50	0.56	15	0.8	0.35	1.00	0	74.8	2.333	2,186.7
Nov.	102.5	0.70	0.56	15	0.8	0.35	1.00	0	71.8	2.333	2,099.0
Dec	92.4	0.75	0.56	15	0.8	0.35	1.00	7.0	69.3	2.333	1,822.5
Total	1,114.7							61.2	713.7	20.997	18,381.2

Crop : Tomato
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m³)
Jan.	85.7	0.85	0.56	13	0.8	0.35	1.00	9.0	72.8	2.692	1,874.6
Feb.	94.2	1.00	0.56	13	0.8	0.35	1.00	28.6	94.2	2.692	1,926.1
Mar.	130.0	0.85	0.56	13	0.8	0.35	1.00	6.0	110.5	2.692	3,068.3
Apr.	163.4	0.70	0.56	13	0.8	0.35	1.00	11.8	114.4	2.692	3,011.9
May	104.7	0.65	0.56	13	0.8	0.35	1.00	0	68.1	2.692	1,998.2
Jun.											
Jul.											
Aug.											
Sep.	175.2	1.00	0.56	13	0.8	0.35	0.10	0	175.2	2.692	514.4
Oct.	149.5	1.00	0.56	13	0.8	0.35	0.10	0	149.5	2.692	439.0
Nov.	102.5	0.45	0.56	13	0.8	0.35	1.00	0	46.1	2.692	1,354.3
Dec.	92.4	0.55	0.56	13	0.8	0.35	1.00	6.4	50.8	2.692	1,304.3
Total	1,907.6							61.8	881.6	24.228	15,491.1

$$V = \frac{10}{EP}\left[\frac{A(ETcrop - RE)}{1 - LR}\right] \quad (m^3/month)$$

ET : Evapo-transpiration (mm/month)

KC : Crop coefficient

EC(W) : Electric conductivity of irrigation water (mmhos/cm)

MEC(E) : Maximum tolerable electrical conductivity of soil saturation extract (mmhos/cm)

LE : Leaching efficiency

EP : Irrigation efficiency

A : Area (ha)

R(E) : Effective rainfall (mm/month)

ET(C) : Reference crop evapo-transpiration (mm/month)

LR : Leaching requirement

V : Water supply requirement (m^3/month)

Table G-3 Estimation of Water Supply Requirement

Crop : Potato
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan.	85.7	1.35	0.56	10	0.8	0.35	1.00	10.0	115.7	0.035	3,129.4
Feb.	47.1	1.25	0.56	10	0.8	0.35	1.00	13.3	58.9	0.035	1,349.4
Mar.											
Apr.											
May											
Jun.											
Jul.											
Aug.											
Sep.											
Oct.											
Nov.	102.5	0.45	0.56	10	0.8	0.35	1.00	0.0	46.1	0.035	1,365.7
Dec.	92.4	1.05	0.56	10	0.8	0.35	1.00	7.2	97.0	0.035	2,659.4
Total	327.7							30.5	317.7	0.140	8,503.9

Crop : Okra
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan.											
Feb.	47.1	0.40	0.56	10	0.8	0.35	1.00	12.1	18.8	0.035	199.6
Mar.	130.0	0.70	0.56	10	0.8	0.35	1.00	6.0	91.0	0.035	2,516.7
Apr.	163.4	0.85	0.56	10	0.8	0.35	1.00	12.3	138.9	0.035	3,748.0
May	209.4	0.80	0.56	10	0.8	0.35	1.00	0.0	167.5	0.035	4,959.9
Jun.	224.5	0.60	0.56	10	0.8	0.35	1.00	0.0	134.7	0.035	3,988.2
Jul.											
Aug.											
Sep.											
Oct.											
Nov.											
Dec.											
Total	774.4							30.4	550.9	0.175	15,412.4

Crop : Others
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan.	85.7	0.85	0.56	10	0.8	0.35	1.00	9.2	72.8	0.035	1,884.4
Feb.	94.2	0.80	0.56	10	0.8	0.35	1.00	27.4	75.4	0.035	1,420.0
Mar.	65.0	0.60	0.56	10	0.8	0.35	1.00	0.0	39.0	0.035	1,154.7
Apr.											
May											
Jun.											
Jul.											
Aug.											
Sep.											
Oct.											
Nov.	102.5	0.40	0.56	10	0.8	0.35	1.00	0.0	41.0	0.035	1,213.9
Dec.	92.4	0.70	0.56	10	0.8	0.35	1.00	7.1	64.7	0.035	1,704.8
Total	439.8							43.7	292.9	0.175	7,337.8

$$V = \frac{10}{EP}\left[\frac{A(ETcrop - RE)}{1-LR}\right] \quad (m^3/month)$$

ET : Evapo-transpiration (mm/month)

KC : Crop coefficient

EC(W) : Electric conductivity of irrigation water (mmhos/cm)

MEC(E) : Maximum tolerable electrical conductivity of soil saturation extract (mmhos/cm)

LE : Leaching efficiency

EP : Irrigation efficiency

A : Area (ha)

R(E) : Effective rainfall (mm/month)

ET(C) : Reference crop evapo-transpiration (mm/month)

LR : Leaching requirement

V : Water supply requirement (m^3/month)

Table G-4 Estimation of Water Supply Requirement per Hectare

Crop : Dates
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan.	85.7	0.70	0.56	32	0.8	0.35	1.00	8.6	60.0	0.011	1,484.5
Feb.	94.2	0.70	0.56	32	0.8	0.35	1.00	26.7	65.9	0.011	1,133.5
Mar.	130.0	0.70	0.56	32	0.8	0.35	1.00	6.3	91.0	0.011	2,446.6
Apr.	163.4	0.70	0.56	32	0.8	0.35	1.00	11.8	114.4	0.011	2,963.3
May	209.4	0.70	0.56	32	0.8	0.35	1.00	0	146.6	0.011	4,234.3
Jun.	224.5	0.70	0.56	32	0.8	0.35	1.00	0	157.2	0.011	4,539.7
Jul.	226.7	0.70	0.56	32	0.8	0.35	1.00	0	158.7	0.011	4,584.1
Aug.	207.2	0.70	0.56	32	0.8	0.35	1.00	0	145.0	0.011	4,189.8
Sep.	175.2	0.70	0.56	32	0.8	0.35	1.00	0	122.6	0.011	3,542.7
Oct.	149.5	0.70	0.56	32	0.8	0.35	1.00	0	104.7	0.011	3,023.1
Nov.	102.5	0.70	0.56	32	0.8	0.35	1.00	0	71.8	0.011	2,072.7
Dec.	92.4	0.70	0.56	32	0.8	0.35	1.00	6.7	64.7	0.011	1,674.9
Total	1,860.7							58.1	1,302.6	0.132	35,889.4

Crop : Lime
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan.	85.7	0.50	0.56	8	0.8	0.35	1.00	8.2	42.9	0.044	1,035.3
Feb.	94.2	0.50	0.56	8	0.8	0.35	1.00	25.5	47.1	0.044	645.4
Mar.	130.0	0.50	0.56	8	0.8	0.35	1.00	5.4	65.0	0.044	1,780.8
Apr.	163.4	0.50	0.56	8	0.8	0.35	1.00	11.1	81.7	0.044	2,109.4
May	209.4	0.50	0.56	8	0.8	0.35	1.00	0	104.7	0.044	3,128.3
Jun.	224.5	0.50	0.56	8	0.8	0.35	1.00	0	112.3	0.044	3,353.9
Jul.	226.7	0.50	0.56	8	0.8	0.35	1.00	0	113.4	0.044	3,386.7
Aug.	207.2	0.50	0.56	8	0.8	0.35	1.00	0	103.6	0.044	3,095.4
Sep.	175.2	0.50	0.56	8	0.8	0.35	1.00	0	87.6	0.044	2,617.4
Oct.	149.5	0.50	0.56	8	0.8	0.35	1.00	0	74.8	0.044	2,233.4
Nov.	102.5	0.50	0.56	8	0.8	0.35	1.00	0	51.3	0.044	1,531.3
Dec.	92.4	0.50	0.56	8	0.8	0.35	1.00	6.1	46.2	0.044	1,198.1
Total	1,860.7							56.3	930.6	0.528	26,115.4

Crop : Banana
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan.	85.7	0.90	0.56	8	0.8	0.35	1.00	9.4	77.1	0.044	2,023.7
Feb.	94.2	0.90	0.56	8	0.8	0.35	1.00	28.3	84.8	0.044	1,687.5
Mar.	130.0	0.90	0.56	8	0.8	0.35	1.00	6.3	117.0	0.044	3,307.6
Apr.	163.4	0.90	0.56	8	0.8	0.35	1.00	12.3	147.1	0.044	4,026.4
May	209.4	0.90	0.56	8	0.8	0.35	1.00	0	188.5	0.044	5,630.9
Jun.	224.5	0.90	0.56	8	0.8	0.35	1.00	0	202.1	0.044	6,037.0
Jul.	226.7	0.90	0.56	8	0.8	0.35	1.00	0	204.0	0.044	6,096.1
Aug.	207.2	0.90	0.56	8	0.8	0.35	1.00	0	186.5	0.044	5,571.8
Sep.	175.2	0.90	0.56	8	0.8	0.35	1.00	0	157.7	0.044	4,711.3
Oct.	149.5	0.90	0.56	8	0.8	0.35	1.00	0	134.6	0.044	4,020.2
Nov.	102.5	0.90	0.56	8	0.8	0.35	1.00	0	92.3	0.044	2,756.3
Dec.	92.4	0.90	0.56	8	0.8	0.35	1.00	6.9	83.2	0.044	2,278.5
Total	1,860.7							63.2	1,674.9	0.528	48,147.3

$$V = \frac{10}{EP}\left[\frac{A(ETcrop - RE)}{1 - LR}\right] \quad (m^3/month)$$

ET : Evapo-transpiration (mm/month)

KC : Crop coefficient

EC(W) : Electric conductivity of irrigation water (mmhos/cm)

MEC(E) : Maximum tolerable electrical conductivity of soil saturation extract (mmhos/cm)

LE : Leaching efficiency

EP : Irrigation efficiency

A : Area (ha)

R(E) : Effective rainfall (mm/month)

ET(C) : Reference crop evapo-transpiration (mm/month)

LR : Leaching requirement

V : Water supply requirement (m^3/month)

Table G-5 Estimation of Water Supply Requirement per Hectare

Crop : Mango
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m³)
Jan.	85.7	0.70	0.56	8	0.8	0.35	1.00	8.6	60.0	0.044	1,535.5
Feb.	94.2	0.70	0.56	8	0.8	0.35	1.00	26.7	65.9	0.044	1,172.4
Mar.	130.0	0.70	0.56	8	0.8	0.35	1.00	6.3	91.0	0.044	2,530.7
Apr.	163.4	0.70	0.56	8	0.8	0.35	1.00	11.8	114.4	0.044	3,064.9
May	209.4	0.70	0.56	8	0.8	0.35	1.00	0	146.6	0.044	4,379.6
Jun.	224.5	0.70	0.56	8	0.8	0.35	1.00	0	157.2	0.044	4,695.4
Jul.	226.7	0.70	0.56	8	0.8	0.35	1.00	0	158.7	0.044	4,741.4
Aug.	207.2	0.70	0.56	8	0.8	0.35	1.00	0	145.0	0.044	4,333.6
Sep.	175.2	0.70	0.56	8	0.8	0.35	1.00	0	122.6	0.044	3,664.3
Oct.	149.5	0.70	0.56	8	0.8	0.35	1.00	0	104.7	0.044	3,126.8
Nov.	102.5	0.70	0.56	8	0.8	0.35	1.00	0	71.8	0.044	2,143.8
Dec.	92.4	0.70	0.56	8	0.8	0.35	1.00	6.7	64.7	0.044	1,732.4
Total	1,860.7	0.70						58.1	1,302.6	0.528	37,120.8

Crop : Alfalfa
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m³)
Jan.	85.7	0.85	0.56	16	0.8	0.35	1.00	9.3	72.8	0.022	1,856.2
Feb.	94.2	0.85	0.56	16	0.8	0.35	1.00	27.8	80.1	0.022	1,526.8
Mar.	130.0	0.85	0.56	16	0.8	0.35	1.00	6.3	110.5	0.022	3,043.7
Apr.	163.4	0.85	0.56	16	0.8	0.35	1.00	12.2	138.9	0.022	3,700.7
May	209.4	0.85	0.56	16	0.8	0.35	1.00	0	178.0	0.022	5,199.2
Jun.	224.5	0.85	0.56	16	0.8	0.35	1.00	0	190.8	0.022	5,574.1
Jul.	226.7	0.85	0.56	16	0.8	0.35	1.00	0	192.7	0.022	5,628.7
Aug.	207.2	0.85	0.56	16	0.8	0.35	1.00	0	176.1	0.022	5,144.5
Sep.	175.2	0.85	0.56	16	0.8	0.35	1.00	0	148.9	0.022	4,350.0
Oct.	149.5	0.85	0.56	16	0.8	0.35	1.00	0	127.1	0.022	3,711.9
Nov.	102.5	0.85	0.56	16	0.8	0.35	1.00	0	87.1	0.022	2,545.0
Dec.	92.4	0.85	0.56	16	0.8	0.35	1.00	6.9	78.5	0.022	2,092.6
Total	1,860.7							62.5	1,581.5	0.264	44,373.4

Crop : Sorghum
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m³)
Jan.	85.7	1.00	0.56	18	0.8	0.35	1.00	8.8	85.7	1.944	2,240.7
Feb.	94.2	0.75	0.56	18	0.8	0.35	1.00	27.0	70.7	1.944	1,271.9
Mar.	65.0	0.60	0.56	18	0.8	0.35	1.00	0	39.0	1,944	1,136.4
Apr.											
May											
Jun.											
Jul.											
Aug.											
Sep.											
Oct.	74.8	0.35	0.56	18	0.8	0.35	1.00	0	26.2	1,944	762.8
Nov.	102.5	0.60	0.56	18	0.8	0.35	1.00	0	61.5	1,944	1,792.0
Dec.	92.4	1.00	0.56	18	0.8	0.35	1.00	6.8	92.4	1,944	2,494.2
Total	514.6							42.6	375.5	11.664	9,698.0

$$V = \frac{10}{EP}\left[\frac{A(ETcrop - RE)}{1 - LR}\right] \quad (m^3/\text{month})$$

ET : Evapo-transpiration (mm/month)

KC : Crop coefficient

EC(W) : Electric conductivity of irrigation water (mmhos/cm)

MEC(E) : Maximum tolerable electrical conductivity of soil saturation extract (mmhos/cm)

LE : Leaching efficiency

EP : Irrigation efficiency

A : Area (ha)

R(E) : Effective rainfall (mm/month)

ET(C) : Reference crop evapo-transpiration (mm/month)

LR : Leaching requirement

V : Water supply requirement (m^3/month)

Table G-6 Average Monthly Water Supply Requirement per Hectare by Crops

(Unit: cu.m/ha)

Month	Vegetable							Fruit Crop					Feed Crop		
	Onion 51ha	Garlic 13.5ha	Tomato 8.7ha	Potato 8.1ha	Okra 4.5ha	Others 12.0ha	Average 97.8ha	Dates 1,820ha	Lime 309ha	Banana 128ha	Mango 83ha	Average 2,340ha	Alfalfa 112.2ha	Sorghum 54ha	Average 166.2ha
Jan.	1,108.9	1,748.2	1,874.6	3,129.4		1,884.4	1,477.3	1,484.5	1,035.3	2,023.7	1,535.5	1,456.6	1,856.2	2,240.7	1,981.2
Feb.		1,408.9	1,926.1	1,349.4	199.6	1,420.0	661.7	1,133.5	645.4	1,687.5	1,172.4	1,100.9	1,526.8	1,271.9	1,444.0
Mar.		2,858.1	3,068.3		2,516.7	1,154.7	925.3	2,446.8	1,780.8	3,307.6	2,530.7	2,409.2	3,043.7	1,136.4	2,423.8
Apr.		2,298.0	3,011.9		3,748.0		757.6	2,963.3	2,109.4	4,026.4	3,064.9	2,912.6	3,700.7		2,498.0
May		3,062.9	1,998.2		4,959.9		828.7	4,234.3	3,128.3	5,630.9	4,379.6	4,170.2	5,199.2		3,509.5
Jun.					3,988.2		183.5	4,539.7	3,353.9	6,037.0	4,695.4	4,471.0	5,574.1		3,762.5
Jul.								4,584.1	3,386.7	6,096.1	4,741.4	4,514.7	5,628.7		3,799.4
Aug.								4,189.8	3,095.4	5,571.8	4,333.6	4,126.4	5,144.5		3,472.5
Sep.	523.5	896.9	514.4				442.3	3,542.7	2,617.4	4,711.3	3,664.3	3,489.1	4,350.0		2,936.3
Oct.	446.7	2,186.7	439.0				573.6	3,023.1	2,233.4	4,020.2	3,126.8	2,977.3	3,711.9	762.8	2,753.4
Nov.	2,143.8	2,099.0	1,354.3	1,365.7		1,213.9	1,789.8	2,072.7	1,531.3	2,756.3	2,143.8	2,041.3	2,545.0	1,792.0	2,300.3
Dec.	1,882.4	1,822.5	1,304.3	2,659.4		1,704.8	1,778.7	1,674.9	1,198.1	2,278.5	1,732.4	1,647.2	2,092.6	2,494.2	2,223.1
Total	6,105.3	18,381.2	15,491.1	8,503.9	15,412.4	7,377.8	9,418.4	35,889.4	26,115.4	48,147.3	37,120.8	35,316.5	44,373.4	9,698.0	33,104.0

Table G-7 Average Monthly Water Supply Requirement per Hectare by Land Use

(Unit: cu.m/ha)

Month	Orchard					Upland Crop								
	Dates 1,820ha	Lime 309ha	Banana 128ha	Mango 83ha	Average 520ha	Onion 51ha	Garlic 13.5ha	Tomato 8.7ha	Potato 8.1ha	Okra 4.5ha	Others 12.0ha	Alfalfa 112.2ha	Sorghum 54ha	Average 264ha
Jan.	1,484.5	1,035.3	2,023.7	1,535.5	1,358.5	1,108.9	1,748.2	1,874.6	3,129.4		1,884.4	1,856.2	2,240.7	1,795.1
Feb.	1,133.5	645.4	1,687.5	1,172.4	986.1		1,408.9	1,926.1	1,349.4	199.6	1,420.0	1,526.8	1,271.9	1,154.2
Mar.	2,446.8	1,780.8	3,307.6	2,530.7	2,276.4		2,858.1	3,068.3		2,516.7	1,154.7	3,043.7	1,136.4	1,868.3
Apr.	2,963.3	2,109.4	4,026.4	3,064.9	2,733.9		2,298.0	3,011.9		3,748.0		3,700.7		1,853.1
May	4,234.3	3,128.3	5,630.9	4,379.6	3,944.1		3,062.9	1,998.2		4,959.9		5,199.2		2,516.1
Jun.	4,539.7	3,353.9	6,037.0	4,695.4	4,228.6					3,988.2		5,574.1		2,436.8
Jul.	4,584.1	3,386.7	6,096.1	4,741.4	4,270.7							5,628.7		2,392.2
Aug.	4,189.8	3,095.4	5,571.8	4,333.6	3,902.7							5,144.5		2,186.4
Sep.	3,542.7	2,617.4	4,711.3	3,664.3	3,300.0	523.5	896.9	514.4				4,350.0		2,012.5
Oct.	3,023.1	2,233.4	4,020.2	3,126.8	2,815.9	446.7	2,186.7	439.0				3,711.9	762.8	1,946.2
Nov.	2,072.7	1,531.3	2,756.3	2,143.8	1,930.7	2,143.8	2,099.0	1,354.3	1,365.7		1,213.9	2,545.0	1,792.0	2,111.4
Dec.	1,674.9	1,198.1	2,278.5	1,732.4	1,549.4	1,882.4	1,822.5	1,304.3	2,659.4		1,704.8	2,092.6	2,494.2	2,059.1
Total	35,889.4	26,115.4	48,147.3	37,120.8	33,296.1	6,105.3	18,381.2	15,491.1	8,503.9	15,412.4	7,377.8	44,373.4	9,698.0	24,331.4

Table G-8 Present Consumption of Irrigation Water

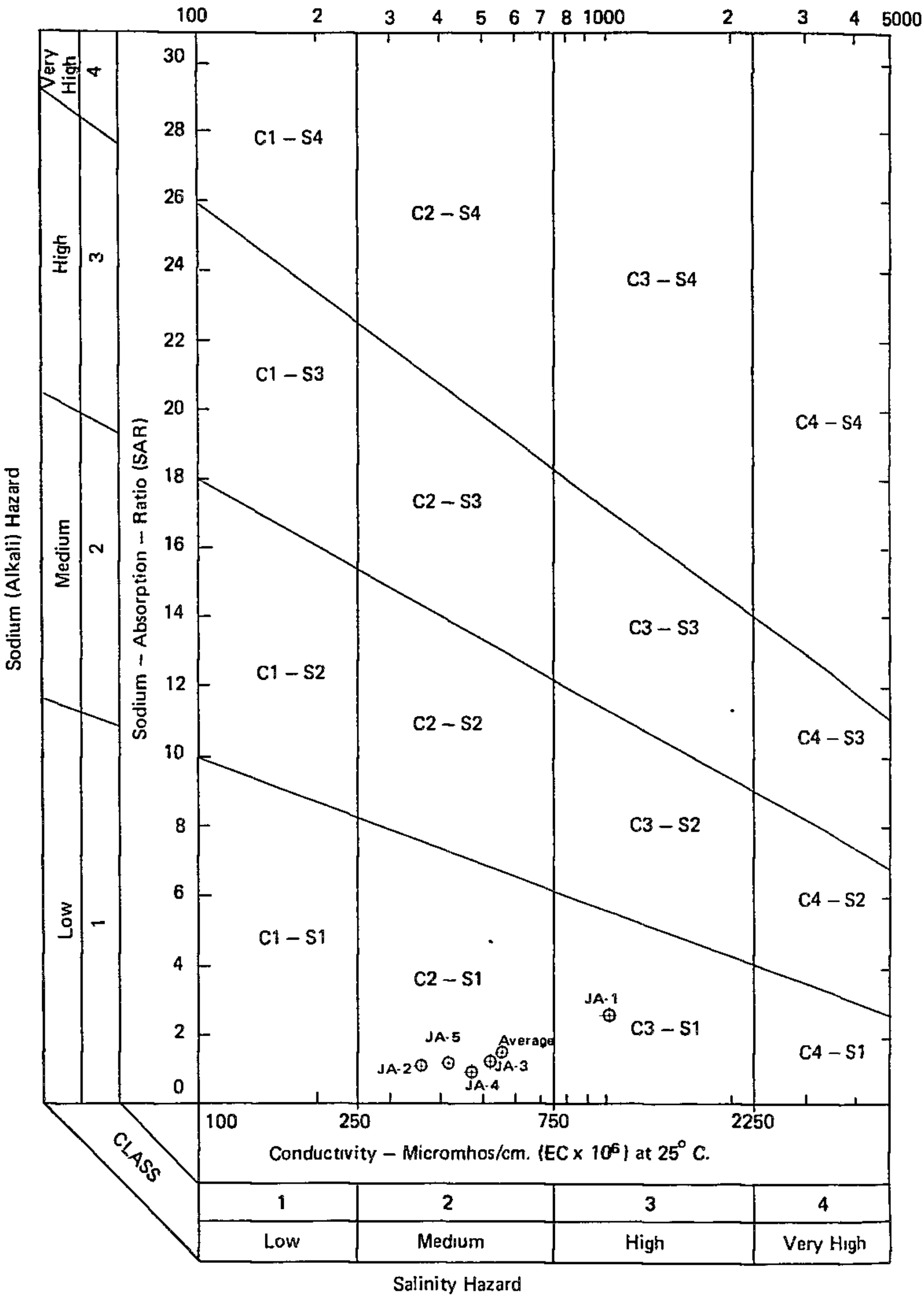
Classification	Cropped Area 1/ (ha) (1)	Water Application (2)	Water Requirement per Hectare 2/ (cu.m/ha) (3)	Water Application Area (4)	Water Consumption 4/ (MCM) (5)
1. Dates (1,820 ha)					
Good area	364	3.00	35,889.4	0.16 3/	6.27
Moderate area	892	0.75	35,889.4	0.16	3.84
Poor area	564	0.35	35,889.4	0.16	1.13
Sub-total	1,820				11.24
2. Orchard (520 ha)					
Good area	104	3.00	33,296.1	0.16	1.66
Moderate area	255	0.75	33,296.1	0.16	1.02
Poor area	161	0.35	33,296.1	0.16	0.30
Sub-total	520				2.98
3. Upland Crop (264 ha)					
Good area	53	3.00	24,331.4	1.00	3.87
Moderate area	129	0.75	24,331.4	1.00	2.35
Poor area	82	0.35	24,331.4	1.00	0.70
Sub-total	264				6.92
Total	2,604				21.14

Note: 1/ Cultivation area x Area percentage
2/ See Table G-7
3/ Irrigation area rate: 0.16 ($3.14 \times 1.0^2/5 \times 4$) (Dates and orchard)
1.00 (Upland crop)
4/ (5) = (1)x(2)x(3)x(4) [Annual water requirement]

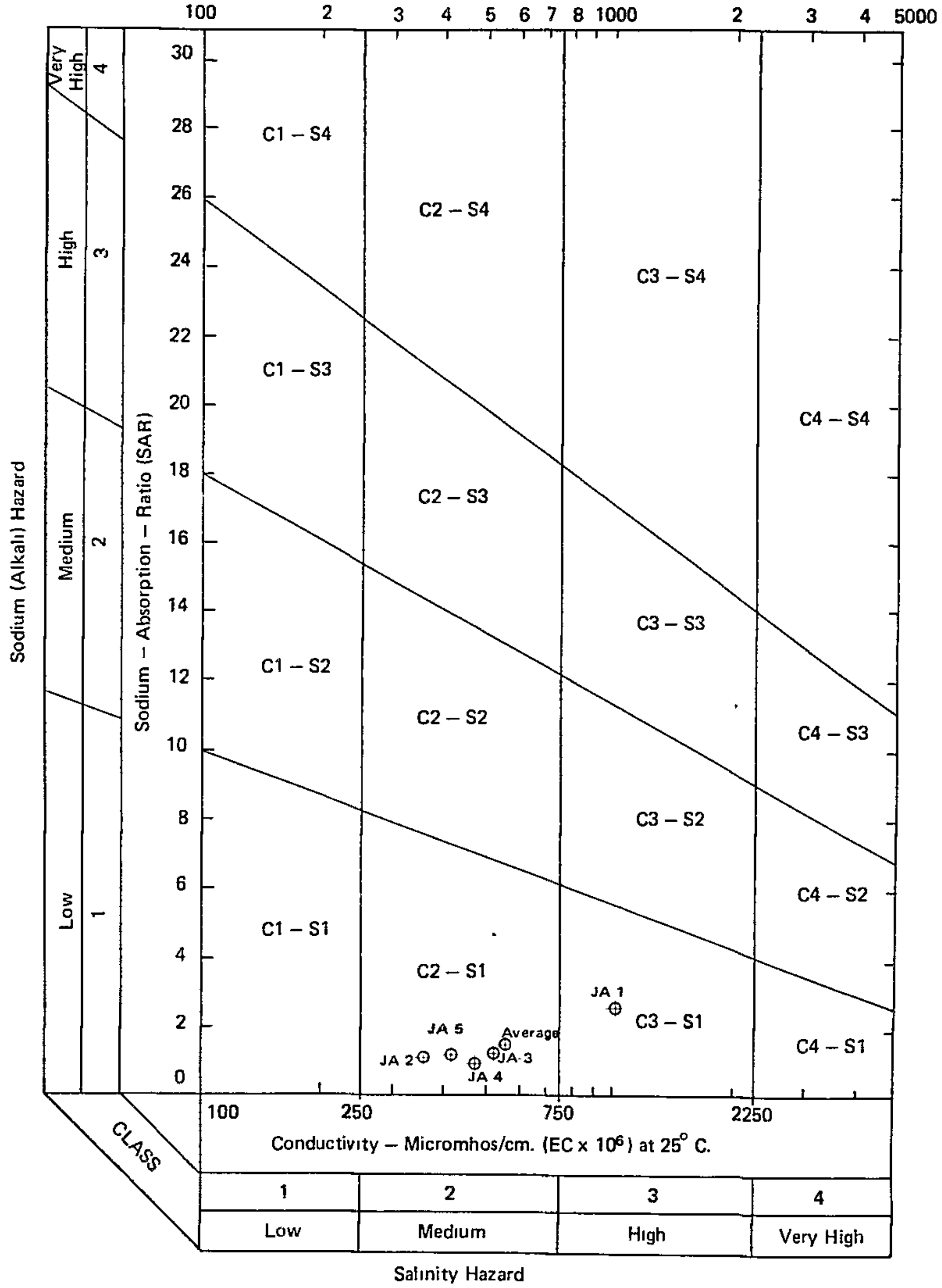
Table G-9 Results of Water Quality Analysis

Sampling site : Sohar
Laboratory : Rumais Agricultural Research Station
Analyzed date : 24/March, 1982

Sample	PH	EC µmhos/cm at 25°C	T.S.S.	Cations, me/ℓ					S.A.R.	Anions, me/ℓ				
				Na	K	Ca	Mg	Total		CO_3	HCO_3	Cl	SO_4	Total
JA-1	7.0	1,005.9	643.8	4.35	0.11	1.10	4.10	9.66	2.70	0.60	2.80	4.25	1.66	9.31
JA-2	7.4	367.0	234.9	1.17	0.06	-	2.50	3.73	1.05	0.60	1.45	1.10	0.16	3.31
JA-3	7.6	518.0	331.5	1.55	0.07	0.40	2.80	4.82	1.23	-	2.30	1.80	0.66	4.76
JA-4	7.7	489.4	313.2	1.30	0.07	0.20	3.45	5.02	0.97	0.60	2.30	1.30	0.42	4.62
JA-5	7.5	413.3	264.5	1.30	0.07	0.20	2.90	4.47	1.05	0.40	1.85	1.25	0.42	3.92
Average	7.4	558.7	357.6	1.93	0.08	0.38	3.15	5.54	1.40	0.55	2.14	1.94	0.66	5.18



Source: Agricultural Handbook 60, U S. Dept. of Agriculture



Source: Agricultural Handbook 60, U S. Dept. of Agriculture

Class	*Salinity or Conductivity*	*Sodium-Absorption Ratio*
Low 1	*Low-Salinity Water* (C1) can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.	*Low-Sodium Water* (S1) can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops such as stone-fruit trees and avocados may accumulate injurious concentrations of sodium
Medium 2	*Medium-Salinity Water* (C2) can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control	*Medium-Sodium Water* (S2) will present an appreciable sodium hazard in fine-textured soils having high cation-exchange capacity, especially under low-leaching conditions, unless gypsum is present in the soil. This water may be used on coarse-textured or organic soils with good permeability
High 3	*High-Salinity Water* (C3) cannot be used on soils with restricted drainage Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.	*High-Sodium* (S3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management–good drainage, high leaching, and organic matter additions. Gypsiferous soils may not develop harmful levels of exchangeable sodium from such waters. Chemical amendments may be required for replacement of exchangeable sodium. except that amendments may not be feasible with waters of very high salinity.
Very High 4	*Very High Salinity Water* (C4) is not suitable for irrigation under ordinary conditions, but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected	*Very High Sodium Water* (S4) is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity, where the solution of calcium from the soil or use of gypsum or other amendments may make the use of these waters feasible.

FIGURE G – 2 DIAGRAM FOR CLASSIFICATION OF IRRIGATION WATER

Estimation of Reference Crop Potential Evapo-transpiration(ETPc)

1. Modified Penman Method[1/]

Penman has made the most complete theoretical approach, showing that consumptive use is inseparably connected to incoming solar energy.

His formula representing the potential evapo-transpiration (consumptive use) is as follows in the modified form:

$$Etp = \frac{\Delta}{\Delta + \gamma} (Rn + G) + \frac{\gamma}{\Delta + \gamma} 15.36 (w_1 + w_2u_2) (es - ea) \qquad (7.1)$$

where Etp = reference crop potential evapo-transpiration, well-watered alfalfa in cal/cm^2 per day (langleys/day)

Δ = slope of saturation vapor pressure-temperature curve (de/dT) in mbar/°C

γ = psychrometric constant

Rn = net radiation in cal/cm^2 per day

G = soil heat flux in cal/cm^2 per day

u_2 = wind movement in km/day at 2 m

es = saturation vapor pressure, mean of values obtained at daily maximum and daily minimum temperatures in mbar (This is a modification of the original Penman equation.)

ea = mean actual vapor pressure in mbar

w_1, w_2 = wind term coefficients, some empirically determined values are:

w_1	w_2	Location	Reference Crop
1.10	0.0106	Mitchell, Nebraska	alfalfa
0.75	0.0115	Kimberly, Ibaho	alfalfa
1.00	0.0062	Penman	short grass

$$\gamma = cp \frac{P}{(0.622\lambda)} \qquad (7.2)$$

where cp = 0.240

P = 1013 - 0.1055 EL, mbar, (EL is elevation in meters) (7.3)

λ = latent heat of water in cal/g; estimated by $\lambda = 595.9 - 0.55\ T$, T in °C (7.4)

1/ quoted from the Book of "Irrigation Principals and Practices" written by O.W. Israelsen and V.E. Hansen

$$\Delta = 33.86\ [0.05904\ (0.00738T + 0.8072)^7 - 0.0000342] \quad (7.5)$$

for $T \geq 23°C$, Δ in mbar/°C

$$Rn = 0.77\ Rs - Rb \quad (7.6)$$

where Rs = incident solar radiation in cal/cm^2 per day.

The 0.77 value is obtained by assuming a reflectivity of 0.23 for a green growing crop.

$$Rb = Rbo\ [(aRs/Rso) + b] \quad (7.7)$$

where Rso = clear day solar radiation in langleys/day. If actual records are not available, Rso values may be estimated from Table G-12.

a,b = empirical constants, see table following equation 7.8.

$$Rbo = (a_1 + b_1 \sqrt{ea})\ 11.71 \times 10^{-8} (Ta^4 + Tb^4)/2 \quad (7.8)$$

where a_1, b_1 = empirical constants, see following table

ea = mean actual vapor pressure in mbar

Ta = maximum daily temperature in °K

Tb = minimum daily temperature in °K

Values of a, b, a_1 and b_1 have been determined for various locations as:

a	b	a_1	b_1	Location
0.90	0.10	0.37	-0.044	Mitchell, Nebraska1/
1.35	-0.35	0.35	-0.046	Davis, California
1.22	-0.18	0.33	-0.044	Kimberly, Idaho
1.20	-0.20			Arid regions (suggested)
1.10	-0.10			Semihumid (suggested)
1.00	0.00			humid (suggested)
		0.39	-0.05	general

1/ The reported w_1, w_2, a, b, a_1, and b_1, valued for Mitchell, Neb. are adapted from Scheduling Irrigations Using a Programmable Calculator, D. C. Kincaid and D. F. Heerman, U.S.D.A., ARS-NC-12, February 1974. Reported values for other locations are adapted from the A.S.C.E. report.

An empirical equation for estimating the soil heat flux is:

$$G = [\overline{T}pr - \overline{T}]\ 9.1 \qquad (7.9)$$

where $\overline{T}pr$ = mean air temperature for a previous time period, usually the previous three days when daily estimates of Etp are required

$\overline{T}$ = mean air temperature for the current time period, i.e. mean air temperature of the particular day for which Etp is required.

Estimation of ETPc

Reference crop potential evapo-transpiration (ETPc) is estimated by applying the above mentioned method, based upon the observed meteorological data at Sohar and Rustaq Meteorological Stations, and the results are tabulated in Table G-10.

2. Modified Blaney - Criddle Method

Blaney - Criddle developed a simplified formula using temperature and daytime hours for the arid region as shown belows;

$$U = 25.4\ K \cdot f \qquad (7.10)$$

where; U = Consumptive use of crop, in mm
K = Monthly crop coefficient
= Kc x Kt
Kc = Monthly crop coefficient
Kt = Climatic coefficient
= 0.0173t - 0.314
t = Mean air temperature, in °F
f = Monthly consumptive use factor
= (t x p)/100
p = Percentage of daytime hours of the year, see Table G-21.

Table G-21 shows the estimated consumptive use of crop by applying the Blaney - Criddle Method.

Table G-10 Estimation of Reference Crop Potential Evapo-transpiration (Modified Penman Method)

Elevation : 15.0 m MSL

	U_2 (km/day)	Rso (langleys/day)	Rs (cal/cm^2/day)	es (mbar)	ea (mbar)	$\overline{T}$ (°C)	Tmax (°C)	Tmin (°C)	ETPc (mm/day)	ETPc (mm/month)
Jan.	57.0	461	346	22.1	14.4	17.7	24.2	11.9	2.4	74.4
Feb.	61.8	600	375	23.0	15.4	18.8	24.7	12.9	3.2	89.6
Mar.	67.8	632	432	28.3	16.9	21.7	28.5	15.4	3.9	120.9
Apr.	72.1	720	535	35.6	17.0	25.9	33.1	18.4	4.9	147.0
May	76.5	740	576	46.2	24.0	30.3	37.9	22.0	5.7	176.7
Jun.	78.8	777	588	50.8	30.0	32.1	38.7	25.6	6.3	189.0
Jul.	90.1	743	533	50.7	37.4	32.2	37.6	27.4	6.0	186.0
Aug.	88.8	702	521	47.6	30.8	31.2	36.3	26.6	5.5	170.5
Sep.	75.6	663	505	43.5	27.3	28.4	35.6	23.4	5.1	153.0
Oct.	60.1	566	455	37.2	22.8	26.2	33.8	18.8	4.1	127.1
Nov.	51.3	493	341	29.4	19.3	21.9	29.6	15.2	2.7	81.0
Dec.	45.8	430	345	24.6	17.3	19.6	26.1	13.4	2.4	74.4
Average	68.8	627	463	35.6	22.7	25.5	32.2	19.3	4.35	1,589.6

Note;
- U_2 : Wind velocity at 2 m above ground (Sohar Station, 1974 - 1980), see Table G-11.
- Rso : Clear day solar radiation, see Table G-12
- Rs : Solar radiation (Rustaq Station, 1974 - 1981), see Table G-13.
- es : Saturation Vapor Pressure, see Table G-15.
- ea : Actual Vapor Pressure, see Table G-16.
- $\overline{T}$: Mean temperature (Sohar Station, 1974 - 1980), see Table G-18.
- Tmax : Mean maximum temperature (Sohar Station, 1974 - 1980), see G-19.
- Tmin : Mean minimum temperature (Sohar Station, 1974 - 1980), see G-20.

Table G-11 Monthly Average Wind Velocity 1/

(unit : Km/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1973	-	-	-	-	-	-	-	-	-	60.6	54.0	54.7	
1974	69.5	75.5	60.6	85.6	87.3	93.4	81.6	92.5	79.9	57.6	48.3	42.8	72.9
1975	58.4	62.0	80.1	69.6	78.8	71.2	106.3	86.1	65.8	59.6	52.3	45.0	69.6
1976	46.5	60.8	61.8	57.3	57.7	62.0	71.7	84.5	80.8	55.4	46.0	40.5	60.4
1977	49.9	47.8	44.0	61.1	79.1	94.0	96.3	91.7	65.1	60.0	50.5	46.8	65.5
1978	56.7	61.7	68.7	78.6	76.5	75.2	92.1	87.1	81.6	61.8	60.5	46.3	70.6
1979	63.2	69.5	86.1	78.3	76.5	90.0	95.0	85.5	79.6	65.9	49.9	53.5	74.4
1980	54.1	55.2	73.5	74.2	79.3	65.9	87.9	94.0	76.4				
Average	57.0	61.8	67.8	72.1	76.5	78.8	90.1	88.8	75.6	60.1	51.3	45.8	68.8

Source : Sohar Meteorological Station

1/: 2m height about ground

Table G-12 Clear Day Solar Radiation (Rso)

Latitude : 24°20'

(Unit: langleys/day)

Month	R_{20} (N20)	R_{25} (N25)	Rso (N24°20')	Month	R_{20} (N20)	R_{25} (N25)	Rso (N24°20')
Jan.	500	455	461	Jul.	729	745	743
Feb.	634	595	600	Aug.	697	703	702
Mar.	652	629	632	Sep.	680	660	663
Apr.	720	720	720	Oct.	597	561	566
May	726	742	740	Nov.	537	486	493
Jun.	760	780	777	Dec.	474	423	430

Note; R_{20} and R_{25} are referred to Table G-14.

Table G-13 Solar Radiation (Rs)

(Unit: cal/cm^2/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1974	-	-	-	-	-	-	-	-	-	469	396	325
1975	323	410	526	531	595	577	543	507	505	(440)	371	337
1976	359	-	-	554	-	-	523	535	-	-	389	328
1977	349	417	496	521	557	598	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	314	-
1979	354	353.9	345.3	-	-	-	-	-	-	-	235.5	388.5
1980	-	-	-	-	-	-	-	-	-	-	-	-
1981	-	320	361.5	-	-	-	-	-	-	-	-	-
Average	346	375	432	535	576	588	533	521	505	455	341	345

Source; Rustaq Meteorological Station

Table G-14 Total Daily Solar Radiation at the Top of the Atmosphere

(Unit: langlays/day)

Latitude °N	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
60	58	152	319	533	671	763	690	539	377	197	87	35
55	100	219	377	558	690	780	706	577	430	252	133	74
50	155	290	429	617	716	790	729	616	480	313	193	126
45	216	365	477	650	729	797	748	648	527	371	260	190
40	284	432	529	677	742	800	755	674	567	426	323	248
35	345	496	568	700	742	800	761	697	603	474	380	313
30	403	549	600	713	742	793	755	703	637	519	437	371
25	455	595	629	720	742	780	745	703	660	561	486	423
20	500	634	652	720	726	760	729	697	680	597	537	474
15	545	673	671	713	706	733	706	684	697	623	580	519
10	584	701	681	707	684	700	681	665	707	648	617	565
5	623	722	690	700	652	663	645	645	710	665	650	606
0	652	740	694	680	623	627	616	623	707	684	680	619
-5	648	758	690	663	590	587	577	590	693	690	727	677
-10	710	772	681	640	571	543	526	558	680	690	727	710
-15	729	779	665	610	516	497	497	519	657	687	747	739
-20	748	779	645	573	474	447	445	481	630	677	753	761
-25	761	779	626	533	419	400	406	439	600	665	767	777
-30	771	772	600	497	384	353	358	390	567	648	767	793
-35	774	754	568	453	335	300	310	342	530	629	767	806
-40	774	729	529	407	281	243	261	290	477	603	760	813
-45	774	704	490	357	229	183	203	235	447	571	747	813
-50	761	669	445	307	174	127	148	177	400	535	727	806
-55	748	630	397	250	123	77	97	123	343	497	707	794
-60	729	588	348	187	77	33	52	74	283	455	700	787

Table G-15 Vapor Pressure

Month	ea: Mean Actual Vapor Pressure 1/	es: Saturation Vapor Pressure, mean values obtained at daily maxmum and daily minimum temperature in mbar					(cs - ea)
		Max. 2/ Tem.	Min. 2/ Tem.	emax.	emin.	$es = \frac{emax. + emin.}{2}$	
	(mbar)	(°C)	(°C)	(mbar)	(mbar)	(mbar)	(mbar)
Jan.	14.4	24.2	11.9	30.2	13.9	22.1	7.7
Feb.	15.4	24.7	12.9	31.1	14.9	23.0	7.6
Mar.	16.9	28.5	15.4	39.0	17.5	28.3	11.4
Apr.	17.0	33.1	18.4	50.6	21.2	35.6	18.6
May	24.0	37.9	22.0	65.9	26.4	46.2	22.2
Jun.	30.0	38.7	25.6	68.8	32.8	50.8	20.8
Jul.	37.4	37.6	27.4	64.9	36.5	50.7	13.3
Aug.	30.8	36.3	26.6	60.4	34.9	47.6	16.8
Sep.	27.3	35.6	23.4	58.1	28.8	43.5	16.2
Oct.	22.8	33.8	18.8	52.6	21.7	37.2	14.4
Nov.	19.3	29.6	15.2	41.5	17.2	29.4	10.1
Dec.	17.3	26.1	13.4	33.8	15.4	24.6	7.3

Note: 1/: Observed at Rustaq Station (1974-1981), see Table G-16.
2/: Observed at Sohar Station (1974-1980), see Table G-19.
emax. and emin. are computed with using Table G-17.

Table G-16 Actual Vapor Pressure (ea)

(Unit: mbar)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1974	-	-	12.5	11.5	14.3	13.6	-	-	-	15.3	17.7	16.0
1975	13.7	14.4	16.6	20.8	24.7	22.8	33.7	28.5	22.6	-	16.8	18.0
1976	-	-	-	-	-	44.5	-	26.7	31.0	32.0	24.0	20.0
1977	15.0	13.6	16.0	17.6	22.7	28.6	35.6	33.2	32.8	31.8	25.9	18.7
1978	16.2	19.1	20.3	25.6	41.1	36.2	37.9	29.0	32.0	23.9	19.4	-
1979	14.1	13.9	16.4	14.0	17.2	34.5	47.1	41.2	19.7	16.0	14.7	15.7
1980	13.1	16.2	18.8	12.9	-	-	32.8	25.9	25.9	18.0	16.4	15.6
1981	14.0	15.1	17.8	-	-	-	-	-	-	-	-	-
Average	14.4	15.4	16.9	17.0	24.0	30.0	37.4	30.8	27.3	22.8	19.3	17.3

Source ; Rustaq Meteorological Station

Table G-17 Saturation Vapor Pressure

(Unit: mbar)

Temperature (°C)	Saturation Vapour Pressure (mbar)	Temperature (°C)	Saturation Vapur Pressure (mbar)
0	6.1	20	23.4
1	6.6	21	24.9
2	7.1	22	26.4
3	7.6	23	28.1
4	8.1	24	29.8
5	8.7	25	31.7
6	9.3	26	33.6
7	10.0	27	35.7
8	10.7	28	37.8
9	11.5	29	40.1
10	12.3	30	42.4
11	13.1	31	44.9
12	14.0	32	47.6
13	15.0	33	50.3
14	16.1	34	53.2
15	17.0	35	56.2
16	18.2	36	59.4
17	19.4	37	62.8
18	20.6	38	66.3
19	22.0	39	69.9

Table G-18 Monthly Average Air Temperature

(Unit: °C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1974	17.0	17.3	23.1	25.4	30.3	33.3	33.1	31.7	30.4	24.5	20.9	18.7	25.5
1975	17.3	18.3	21.4	25.4	31.5	33.2	31.2	31.1	23.2	26.3	22.1	19.2	25.0
1976	17.6	19.4	20.9	23.8	30.6	31.6	32.7	31.9	29.6	27.6	21.1	18.8	25.5
1977	17.6	18.0	22.2	25.2	30.4	31.6	31.7	30.6	28.9	26.1	23.0	21.0	25.5
1978	18.4	18.7	20.5	26.7	29.4	31.8	32.6	31.3	28.5	25.2	23.4	19.8	25.5
1979	18.2	19.7	21.7	26.8	28.3	30.6	30.8	31.1	29.3	27.3	20.9	20.0	25.4
1980	18.0	19.9	22.3	28.3	31.5	32.3	33.2	30.9	29.4	-	-	-	
Average	17.7	18.8	21.7	25.9	30.3	32.1	32.2	31.2	28.4	26.2	21.9	19.6	

Table G-19 Monthly Maximum Mean Air Temperature

(Unit: °C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1974	24.4	23.9	30.0	33.1	38.1	40.4	41.2	37.1	36.4	33.8	29.6	25.6	32.8
1975	23.9	24.0	28.1	32.2	38.8	39.2	35.1	35.2	36.2	33.5	28.9	26.2	32.6
1976	24.3	23.2	25.8	30.2	36.0	38.4	37.0	37.4	35.8	33.8	28.4	25.5	31.3
1977	22.7	24.6	30.0	30.5	38.0	37.4	35.6	35.1	34.8	32.8	29.1	27.9	31.5
1978	25.3	24.5	28.9	33.9	37.2	38.4	37.9	36.0	34.1	34.0	30.7	27.0	32.3
1979	24.7	27.5	28.1	34.7	37.6	38.0	37.4	37.1	36.3	35.0	30.6	24.2	32.6
1980	24.4	25.4	28.7	37.1	39.6	38.8	38.9	36.2	35.5	-	-	-	
Average	24.2	24.7	28.5	33.1	37.9	38.7	37.6	36.3	35.6	33.8	29.6	26.1	

Table G-20 Monthly Minimum Mean Air Temperature

(Unit: °C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1974	12.1	12.8	17.3	18.0	23.0	25.2	26.2	26.9	24.6	16.8	14.0	12.9	19.2
1975	12.2	13.8	14.5	18.0	23.3	25.7	28.1	27.4	23.2	18.7	15.2	12.9	19.4
1976	10.8	13.6	16.4	16.9	20.9	24.7	24.7	27.1	23.9	20.8	14.6	12.8	18.9
1977	12.9	11.1	14.8	18.6	23.3	25.6	31.0	26.1	23.0	19.4	16.9	14.1	19.7
1978	11.4	12.9	13.3	20.4	20.5	25.1	28.1	26.8	22.5	16.8	16.8	13.4	19.0
1979	12.1	11.7	15.2	17.2	20.5	27.6	26.4	25.2	23.0	20.1	13.9	14.2	18.9
1980	11.8	14.3	16.1	19.4	22.4	25.7	27.5	26.4	23.5	-	-	-	
Average	11.9	12.9	15.4	18.4	22.0	25.6	27.4	26.6	23.4	18.8	15.2	13.4	

Source ; Sohar Meteorological Station

Table G-21 Estimation of Evapo-transpiration (Modified Blaney - Criddle Method)

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1. Climate Element													
Mean Temperature, T(°C) 1/	17.7	18.8	21.7	25.9	30.3	32.1	32.2	31.2	28.4	26.2	21.9	19.9	25.5
Percentage of daytime hour (%) 2/	7.56	7.15	8.39	8.60	9.31	9.20	9.42	8.99	8.32	8.10	7.42	7.45	8.16
2. Consumptive Use of Crop ETcrop (mm/month) 3/	97.0	98.7	138.6	179.7	242.1	260.0	267.4	243.8	197.4	171.9	124.0	110.3	2,130.9

Note; 1/ : Monthly average for the periods of January 1974 ~ September 1980

2/ : Percentage of daytime hour : N 24° 20'

3/ : Monthly crop coefficient is assumed to be Kc = 1.0

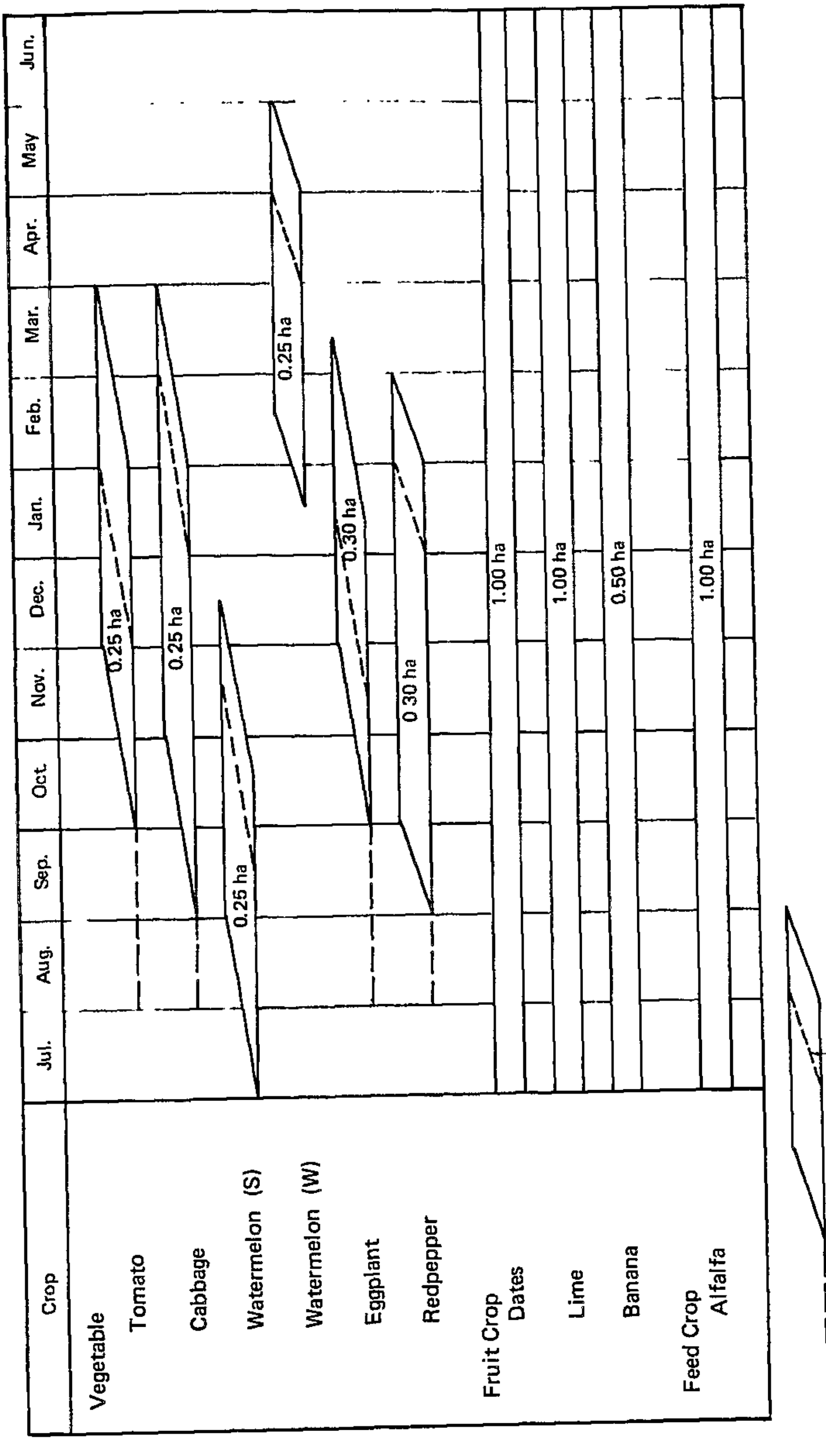


FIGURE G – 3 PROPOSED CROPPING PATTERN

Table G-22 Estimation of Effective Rainfall (1)

(Unit: mm)

Month	Rainfall	Tomato Early Variety ET(C)	R(E)	RER	Tomato Medium Variety ET(C)	R(E)	RER	Tomato Late Variety ET(C)	R(E)	RER	Cabbage Early Variety ET(C)	R(E)	RER	Cabbage Medium Variety ET(C)	R(E)	RER	Cabbage Late Variety ET(C)	R(E)	RER
Jan	12.7	71.1	8.9	9.3	87.4	9.0	9.4	61.7	8.3	8.6	49.7	8.0	8.3	67.7	8.5	8.8	69.4	8.8	9.2
Feb	37.1	-	-	-	78.2	26.2	27.2	96.1	27.9	29.0	-	-	-	54.6	25.1	26.1	74.4	26.1	27.1
Mar.	8.8	-	-	-	-	-	-	107.9	6.1	6.3	-	-	-	-	-	-	75.4	6.1	6.3
Apr.	14.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jun.	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jul.	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aug.	0.8	207.2	0	0	-	-	-	-	-	-	207.2	0	0	-	-	-	-	-	-
Sep.	0	175.2	0	0	175.2	0	0	-	-	-	70.1	0	0	175.2	0	0	-	-	-
Oct.	5.6	68.8	0	0	149.5	0	0	149.5	0	0	104.7	0	0	59.8	0	0	149.5	0	0
Nov.	2.4	73.8	0	0	47.2	0	0	102.5	0	0	83.0	0	0	71.8	0	0	41.0	0	0
Dec.	9.8	94.2	6.6	6.9	66.5	6.7	7.0	42.5	5.9	6.1	73.0	6.7	7.0	74.8	6.7	7.0	64.7	6.7	7.0
Total	95.4	690.3	15.5	16.2	604.0	41.9	43.6	560.2	48.2	50.0	587.7	14.7	15.3	503.9	40.3	41.9	474.4	47.7	49.6

Month	Rainfall	Water Melon (Summer) Early Variety ET(C)	R(E)	RER	Water Melon (Summer) Medium Variety ET(C)	R(E)	RER	Water Melon (Summer) Late Variety ET(C)	R(E)	RER	Water Melon (Winter) Early Variety ET(C)	R(E)	RER	Water Melon (Winter) Late Variety ET(C)	R(E)	RER
Jan.	12.7	-	-	-	-	-	-	-	-	-	20.2	8.0	8.3	-	-	-
Feb.	37.1	-	-	-	-	-	-	-	-	-	60.3	25.4	26.4	22.1	23.0	23.9
Mar.	8.8	-	-	-	-	-	-	-	-	-	106.6	6.1	6.3	83.2	6.2	6.4
Apr.	14.8	-	-	-	-	-	-	-	-	-	117.7	11.3	11.8	134.0	12.8	13.3
May	2.9	-	-	-	-	-	-	-	-	-	-	-	-	150.8	0	0
Jun.	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jul.	0.5	117.9	0	0	-	-	-	-	-	-	-	-	-	-	-	-
Aug.	0.8	161.6	0	0	107.7	0	0	-	-	-	-	-	-	-	-	-
Sep.	0	136.7	0	0	136.7	0	0	91.1	0	0	-	-	-	-	-	-
Oct.	5.6	52.4	0	0	116.6	0	0	116.6	0	0	-	-	-	-	-	-
Nov.	2.4	-	-	-	35.8	0	0	80.0	0	0	-	-	-	-	-	-
Dec.	9.8	-	-	-	-	-	-	32.3	6.7	6.0	-	-	-	-	-	-
Total	95.4	468.6	0	0	396.8	0	0	320.0	6.7	6.0	304.8	50.8	52.8	390.1	42.0	43.6

Remarks:

ET(C): Reference Crop Evapo-transpiration (mm/month)

R(E): Effective Rainfall (mm/month)

RER: Revised Effective Rainfall (mm/month) = R(E) x 1.04

1.04: Correction factor = Porosity (50%) x soil moisture (35%) x cultivation depth (400mm) = 130mm, so, correction factor is 1.04

Note: Effective rainfall, R(E) is derived from Figure G-4.
Rainfall less than 8mm is decided to be no effective rainfall (zero).

Table G-25 Estimation of Effective Rainfall (2)

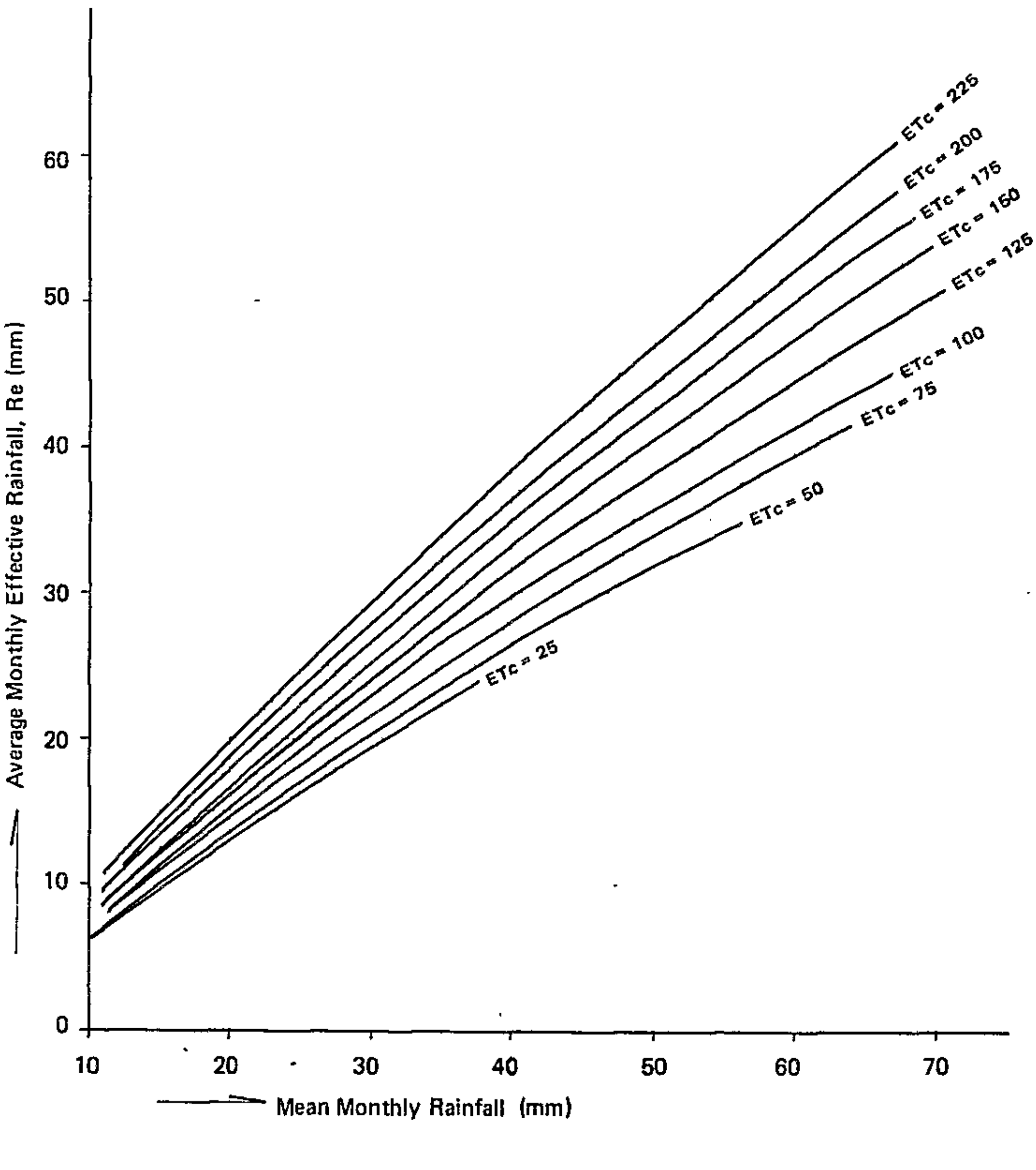
(Unit: mm)

Month	Rainfall	Eggplant Early Variety ET(C)	R(E)	RER	Eggplant Medium Variety ET(C)	R(E)	RER	Eggplant Late Variety ET(C)	R(E)	RER	Redpepper Early Variety ET(C)	R(E)	RER	Redpepper Late Variety ET(C)	R(E)	RER
Jan.	12.7	41.1	7.9	8.2	65.1	8.4	8.7	68.6	8.7	9.0	49.7	8.0	8.3	67.7	8.5	8.8
Feb.	37.1	-	-	-	[illegible]	24.4	25.6	[illegible]	26.0	27.0	-	-	-	[illegible]	[illegible]	26.1
Mar.	8.8	-	-	-	-	-	-	62.4	5.1	5.3	-	-	-	-	-	-
Apr.	14.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
May	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jun.	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Jul.	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aug.	0.8	207.2	0	0	-	-	-	-	-	-	207.2	0	0	-	-	-
Sep.	0	175.2	0	0	175.2	0	0	-	-	-	70.1	0	0	175.2	0	0
Oct.	5.6	71.8	0	0	149.5	0	0	149.5	0	0	104.7	0	0	59.8	0	0
Nov.	2,4	82.0	0	0	49.2	0	0	102.5	0	0	83.0	0	0	71.8	0	0
Dec.	9.8	70.2	6.7	7.0	73.9	6.7	7.0	44.35	6.6	6.9	73.0	6.7	7.0	74.8	6.7	7.0
Total	95.4	647.5	14.6	15,2	558.1	39.5	41.3	498.9	46.4	48.2	587.7	14.7	15.3	503.9	40.3	41.9

Month	Rainfall	Date ET(C)	R(E)	RER	Lime ET(C)	R(E)	RER	Banana ET(C)	R(E)	RER	Alfalfa ET(C)	R(E)	RER
Jan.	12.7	60.0	8.3	8.6	42.9	7.9	8.2	77.1	9.0	9.4	72.8	8.9	9.3
Feb.	37.1	65.9	25.7	26.7	47.1	24.5	25.5	84.8	27.2	28.3	80.1	26.7	27.8
Mar.	8.8	91.0	6.1	6.3	65.0	5.2	5.4	117.0	6.1	6.3	110.5	6.1	6.3
Apr.	14.8	114.4	11.3	11.8	81.7	10.7	11.1	147.1	11.8	12.3	138.9	11.7	12.2
May	2.9	146.6	0	0	104.7	0	0	188.5	0	0	178.0	0	0
Jun.	0	157.2	0	0	112.3	0	0	202.1	0	0	190.8	0	0
Jul.	0.5	158.7	0	0	113.4	0	0	204.0	0	0	192.7	0	0
Aug.	0.8	145.0	0	0	103.6	0	0	186.5	0	0	176.1	0	0
Sep.	0	122.6	0	0	87.6	0	0	157.7	0	0	148.9	0	0
Oct.	5.6	104.7	0	0	74.8	0	0	134.6	0	0	127.1	0	0
Nov.	2.4	71.8	0	0	51.3	0	0	92.3	0	0	87.1	0	0
Dec.	9.8	64.7	6.7	7.0	46.2	5.9	6.1	83.2	6.6	6.9	78.5	6.6	6.9
Total	95.4	1,302.6	58.1	60.4	930.6	54.2	56.3	1,674.9	60.7	63.2	1,581.5	60.0	62.5

FIGURE G – 4

AVERAGE MONTHLY EFFECTIVE RAINFALL AS RELATED TO AVERAGE MONTHLY ET CROP AND MEAN MONTHLY RAINFALL



Source: Crop Water Requirement, FAO Irrigation and Drainage paper, No.24, Table 34

Table G-24 Estimation of Water Supply Requirement per Hectare

Crop : Tomato (Early Variety)
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan.	85.7	0.83	0.56	13	0.8	0.81	1.00	9.3	71.1	0.027	784.5
Feb											
Mar.											
Apr.											
May.											
Jun.											
Jul.											
Aug	207.2	1.00	0.56	13	0.8	0.81	0.10	0	207.2	0.027	262.9
Sep.	175.2	1.00	0.56	13	0.8	0.81	0.10	0	175.2	0.027	222.3
Oct.	149.5	0.46	0.56	13	0.8	0.81	1.00	0	68.8	0.027	872.5
Nov.	102.5	0.72	0.56	13	0.8	0.81	1.00	0	73.8	0.027	936.3
Dec.	92.4	1.02	0.56	13	0.8	0.81	1.00	6.9	94.2	0.027	1,108.2
Total	812.5							16.2	690.3		4,186.7

Crop : Tomato (Medium Variety)
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan	85.7	1.02	0.56	13	0.8	0.81	1.00	9.4	87.4	0.027	989.8
Feb	91.2	0.83	0.56	13	0.8	0.81	1.00	27.2	78.2	0.027	646.9
Mar											
Apr.											
May											
Jun											
Jul											
Aug.											
Sep.	175.2	1.00	0.56	13	0.8	0.81	0.10	0	175.2	0.027	222.3
Oct.	149.5	1.00	0.56	13	0.8	0.81	0.10	0	149.5	0.027	189.7
Nov	102.5	0.46	0.56	13	0.8	0.81	1.00	0	47.2	0.027	598.2
Dec.	92.4	0.72	0.56	13	0.8	0.81	1.00	7.0	66.5	0.027	755.2
Total	69[illegible].5							43.6	604.0		3,402.1

Crop : Tomato (Late Variety)
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan.	85.7	0.72	0.56	13	0.8	0.81	1.00	8.6	61.7	0.027	673.7
Feb.	91.2	1.02	0.56	13	0.8	0.81	1.00	29.0	96.1	0.027	851.1
Mar.	13[illegible].0	0.83	0.56	13	0.8	0.81	1.00	6.3	107.9	0.027	1,289.0
Apr.											
May											
Jun.											
Jul.											
Aug.											
Sep.											
Oct.	149.5	1.00	0.56	13	0.8	0.81	0.10	0	149.5	0.027	189.7
Nov.	102.5	1.00	0.56	13	0.8	0.81	0.10	0	102.5	0.027	130.0
Dec.	92.4	0.46	0.56	13	0.8	0.81	1.00	6.1	42.5	0.027	461.9
Total	651.3							50.0	560.2		3,595.4

$$V = \frac{10}{EP}\left[\frac{A(ETcrop - RE)}{1 - LR}\right] \quad (m^3/month)$$

LR : Leaching requirement

V : Water supply requirement (m^3/month)

ET : Evapo-transpiration (mm/month)

KC : Crop coefficient

EC(W) : Electric conductivity of irrigation water (mmhos/cm)

MEC(E) : Maximum tolerable electrical conductivity of soil saturation extract (mmhos/cm)

LE : Leaching efficiency

EP : Protect irrigation efficiency

A : Area (ha)

R(E) : Effective rainfall (mm/month)

ET(C) Reference crop evapo-transpiration (mm/month)

Table G-25 Estimation of Water Supply Requirement per Hectare

Crop : Cabbage (Early Variety)
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan.	85.7	0.58	0.56	12	0.8	0.81	1.00	8.3	49.7	0.029	526.5
Feb.											
Mar.											
Apr.											
May											
Jun.											
Jul.											
Aug.	207.2	1.00	0.56	12	0.8	0.81	0.10	0	207.2	0.029	263.5
Sep.	175.2	0.40	0.56	12	0.8	0.81	1.00	0	70.1	0.029	891.2
Oct.	149.5	0.70	0.56	12	0.8	0.81	1.00	0	104.7	0.029	1,330.8
Nov.	102.5	0.81	0.56	12	0.8	0.81	1.00	0	83.0	0.029	1,055.8
Dec.	92.4	0.79	0.56	12	0.8	0.81	1.00	7.0	73.0	0.029	839.2
Total	812.5							15.3	587.7		4,907.0

Crop : Cabbage (Medium Variety)
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan.	85.7	0.79	0.56	12	0.8	0.81	1.00	8.8	67.7	0.029	749.0
Feb.	94.2	0.58	0.56	12	0.8	0.81	1.00	26.1	54.6	0.029	362.9
Mar.											
Apr.											
May											
Jun.											
Jul.											
Aug.											
Sep.	175.2	1.00	0.56	12	0.8	0.81	0.10	0	175.2	0.029	222.8
Oct.	149.5	0.40	0.56	12	0.8	0.81	1.00	0	59.8	0.029	760.5
Nov.	102.5	0.70	0.56	12	0.8	0.81	1.00	0	71.8	0.029	912.4
Dec.	92.4	0.81	0.56	12	0.8	0.81	1.00	7.0	74.8	0.029	862.7
Total	699.5							41.9	503.9		3,870.7

Crop : Cabbage (Late Variety)
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan.	85.7	0.81	0.56	12	0.8	0.81	1.00	9.2	69.4	0.029	765.8
Feb.	94.2	0.79	0.56	12	0.8	0.81	1.00	27.1	74.4	0.029	601.7
Mar.	130.0	0.58	0.56	12	0.8	0.81	1.00	6.3	75.4	0.029	878.7
Apr.											
May											
Jun.											
Jul.											
Aug.											
Sep.											
Oct.	149.5	1.00	0.56	12	0.8	0.81	0.10	0	149.5	0.029	190.1
Nov.	102.5	0.40	0.56	12	0.8	0.81	1.00	0	41.0	0.029	521.4
Dec.	92.4	0.70	0.56	12	0.8	0.81	1.00	7.0	64.7	0.029	733.5
Total	654.3							49.6	474.4		3,691.2

$$V = \frac{10}{EP} \left[\frac{A(ETcrop - RE)}{1 - LR} \right] \quad (m^3/month)$$

ET : Evapo-transpiration (mm/month)

KC : Crop coefficient

EC(W) : Electric conductivity of irrigation water (mmhos/cm)

MEC(E) : Maximum tolerable electrical conductivity of soil saturation extract (mmhos/cm)

LE : Leaching efficiency

EP : Protect irrigation efficiency

A : Area (ha)

R(E) : Effective rainfall (mm/month)

ET(C) : Reference crop evapo-transpiration (mm/month)

LR : Leaching requirement

V : Water supply requirement (m^3/month)

Table G-26 Estimation of Water Supply Requirement per Hectare

Crop : Water Melon -- Summer (Early Variety)
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan.											
Feb.											
Mar.											
Apr.											
May											
Jun.											
Jul.	226.7	0.52	0.56	10	0.8	0.81	1.00	0	117.9	0.035	1,508.1
Aug	207.2	0.78	0.56	10	0.8	0.81	1.00	0	161.6	0.035	2,067.6
Sep.	175.2	0.78	0.56	10	0.8	0.81	1.00	0	136.7	0.035	1,748.3
Oct.	74.8	0.70	0.56	10	0.8	0.81	1.00	0	52.4	0.035	669.9
Nov											
Dec.											
Total	683.9							0	468.6		5,993.6

Crop : Water Melon -- Summer (Medium Variety)
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan.											
Feb.											
Mar											
Apr											
May											
Jun											
Jul											
Aug	207.2	0.52	0.56	10	0.8	0.81	1.00	0	107.7	0.035	1,378.4
Sep	175.2	0.78	0.56	10	0.8	0.81	1.00	0	136.7	0.035	1,748.3
Oct	149.5	0.78	0.56	10	0.8	0.81	1.00	0	116.6	0.035	1,491.8
Nov	51.2	0.70	0.50	10	0.8	0.81	1.00	0	35.8	0.035	456.7
Dec.											
Total	583.1							0	396.8		5,075.2

Crop : Water Melon -- Summer (Late Variety)
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan											
Feb											
Mar											
Apr											
May											
Jun											
Jul											
Aug											
Sep	175.2	0.52	0.56	10	0.8	0.81	1.00	0	91.1	0.035	1,165.5
Oct	149.5	0.78	0.56	10	0.8	0.81	1.00	0	116.6	0.035	1,491.8
Nov.	102.5	0.78	0.56	10	0.8	0.81	1.00	0	80.0	0.035	1,022.8
Dec	46.2	0.70	0.56	10	0.8	0.81	1.00	6.0	32.3	0.035	337.0
Total	473.4							6.0	320.0		4,017.1

$$V = \frac{10}{EP}\left[\frac{A(ETcrop - RE)}{1-LR}\right] \quad (m^3/month)$$

ET : Evapo-transpiration (mm/month)

KC : Crop coefficient

EC(W) : Electric conductivity of irrigation water (mmhos/cm)

MEC(E) : Maximum tolerable electrical conductivity of soil saturation extract (mmhos/cm)

LE : Leaching efficiency

EP : Protect irrigation efficiency

A : Area (ha)

R(E) : Effective rainfall (mm/month)

ET(C) : Reference crop evapo-transpiration (mm/month)

LR : Leaching requirement

V : Water supply requirement (m^3/month)

Table G-27 Estimation of Water Supply Requirement per Hectare

Crop : Water Melon -- Winter (Early Variety)
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan	42.9	0.47	0.56	10	0.8	0.81	1.00	8.3	20.2	0.035	151.8
Feb	94.2	0.64	0.56	10	0.8	0.81	1.00	26.4	60.3	0.035	433.5
Mar	130.0	0.82	0.56	10	0.8	0.81	1.00	6.3	106.6	0.035	1,283.2
Apr	163.4	0.72	0.56	10	0.8	0.81	1.00	11.8	117.7	0.035	1,354.2
May											
Jun.											
Jul											
Aug											
Sep											
Oct.											
Nov.											
Dec.											
Total	430.5							52.8	304.8		3,222.7

Crop : Water Melon -- Winter (Late Variety)
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan.											
Feb.	47.1	0.47	0.56	10	0.8	0.81	1.00	23.9	22.1	0.035	0(-22.6)
Mar.	130.0	0.64	0.56	10	0.8	0.81	1.00	6.4	83.2	0.035	982.5
Apr.	163.4	0.82	0.56	10	0.8	0.81	1.00	13.3	134.0	0.035	1,544.0
May	209.4	0.72	0.56	10	0.8	0.81	1.00	0	150.8	0.035	1,928.8
Jun.											
Jul.											
Aug.											
Sep.											
Oct.											
Nov.											
Dec.											
Total	549.9							43.6	390.1		4,455.3

$$V = \frac{10}{LP}\left[\frac{A(ETcrop - RE)}{1 - LR}\right] \quad (m^3/month)$$

ET : Evapo-transpiration (mm/month)

KC : Crop coefficient

EC(W) : Electric conductivity of irrigation water (mmhos/cm)

MEC(E) : Maximum tolerable electrical conductivity of soil saturation extract (mmhos/cm)

LE : Leaching effeciency

EP : Protect irrigation efficiency

A : Area (ha)

R(E) : Effective rainfall (mm/month)

ET(C) : Reference crop evapo-transpiration (mm/month)

LR : Leaching requirement

V : Water supply requirement (m^3/month)

Table G-28 Estimation of Water Supply Requirement per Hectare

Crop : Eggplant (Early Variety)
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m³)
Jan	85.7	0.48	0.56	9	0.8	0.81	1.00	8.2	41.1	0.039	423.1
Feb.											
Mar.											
Apr											
May											
Jun.											
Jul.											
Aug	207.2	1.00	0.56	9	0.8	0.81	0.10	0	207.2	0.039	266.2
Sep.	175.2	1.00	0.56	9	0.8	0.81	0.10	0	175.2	0.039	225.0
Oct.	149.5	0.48	0.56	9	0.8	0.81	1.00	0	71.8	0.039	921.8
Nov.	102.5	0.80	0.56	9	0.8	0.81	1.00	0	82.0	0.039	1,053.3
Dec.	92.4	0.76	0.56	9	0.8	0.81	1.00	7.0	70.2	0.039	812.1
Total	726.8							15.2	647.5		3,701.5

Crop : Eggplant (Medium Variety)
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m³)
Jan.	85.7	0.76	0.56	9	0.8	0.81	1.00	8.7	65.1	0.039	724.9
Feb	94.2	0.48	0.56	9	0.8	0.81	1.00	25.6	45.2	0.039	252.0
Mar.											
Apr											
May											
Jun.											
Jul.											
Aug.											
Sep.	175.2	1.00	0.56	9	0.8	0.81	0.10	0	175.2	0.039	225.0
Oct.	149.5	1.00	0.56	9	0.8	0.81	0.10	0	149.5	0.039	192.0
Nov.	102.5	0.48	0.56	9	0.8	0.81	1.00	0	49.2	0.039	632.0
Dec.	92.4	0.80	0.56	9	0.8	0.81	1.00	7.0	73.9	0.039	859.6
Total	699.5							41.3	558.1		2,885.5

Crop : Eggplant (Late Variety)
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m³)
Jan.	85.7	0.80	0.56	9	0.8	0.81	1.00	9.0	68.6	0.039	765.1
Feb.	94.2	0.76	0.56	9	0.8	0.81	1.00	27.0	71.6	0.039	572.8
Mar.	130.0	0.48	0.56	9	0.8	0.81	1.00	5.3	62.4	0.039	733.5
Apr											
May											
Jun.											
Jul.											
Aug.											
Sep.											
Oct.	149.5	1.00	0.56	9	0.8	0.81	0.10	0	149.5	0.039	192.0
Nov.	102.5	1.00	0.56	9	0.8	0.81	0.10	0	102.5	0.039	131.7
Dec.	92.4	0.48	0.56	9	0.8	0.81	1.00	6.9	44.35	0.039	481.1
Total	654.3							48.2	498.9		2,876.2

$$V = \frac{10}{EP}\left[\frac{A(ETcrop - RE)}{1 - LR}\right] \quad (m^3/month)$$

ET : Evapo-transpiration (mm/month)

KC : Crop coefficient

EC(W) : Electric conductivity of irrigation water (mmhos/cm)

MEC(E) : Maximum tolerable electrical conductivity of soil saturation extract (mmhos/cm)

LE : Leaching efficiency

EP : Protect irrigation efficiency

A : Area (ha)

R(E) : Effective rainfall (mm/month)

ET(C) : Reference crop evapo-transpiration (mm/month)

LR : Leaching requirement

V : Water supply requirement (m^3/month)

Table G-29 Estimation of Water Supply Requirement per Hectare

Crop : Redpepper (Early Variety)
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m3)
Jan.	85.7	0.58	0.56	9	0.8	0.81	1.00	8.3	49.7	0.039	531.9
Feb.											
Mar.											
Apr.											
May											
Jun.											
Jul.											
Aug.	207.2	1.00	0.56	9	0.8	0.81	0.10	0	207.2	0.039	266.2
Sep.	175.2	0.40	0.56	9	0.8	0.81	1.00	0	70.1	0.039	900.2
Oct.	149.5	0.70	0.56	9	0.8	0.81	1.00	0	104.7	0.039	1,344.3
Nov.	102.5	0.81	0.56	9	0.8	0.81	1.00	0	83.0	0.039	1,066.5
Dec.	92.4	0.79	0.56	9	0.8	0.81	1.00	7.0	73.0	0.039	847.7
Total	812.5							15.3	587.7		4,956.8

Crop : Redpepper (Late Variety)
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m3)
Jan.	85.7	0.79	0.56	9	0.8	0.81	1.00	8.8	67.7	0.039	756.6
Feb.	94.2	0.58	0.56	9	0.8	0.81	1.00	26.1	54.6	0.039	366.6
Mar.											
Apr.											
May											
Jun.											
Jul.											
Aug.											
Sep.	175.2	1.00	0.56	9	0.8	0.81	0.10	0	175.2	0.039	225.0
Oct.	149.5	0.40	0.56	9	0.8	0.81	1.00	0	59.8	0.039	768.1
Nov.	102.5	0.70	0.56	9	0.8	0.81	1.00	0	71.8	0.039	921.6
Dec.	92.4	0.81	0.56	9	0.8	0.81	1.00	7.0	74.8	0.039	871.4
Total	699.5							41.9	503.9		3,909.3

$$V = \frac{10}{EP}\left[\frac{A(ETcrop - RE)}{1 - LR}\right] \quad (m^3/month)$$

ET · Evapo-transpiration (mm/month)

KC Crop coefficient

EC(W : Electric conductivity of irrigation water (mmhos/cm)

MEC( ) : Maximum tolerable electrical conductivity of soil saturation extract (mmhos/cm)

LE : Leaching effeciency

EP : Protect irrigation efficiency

A : Area (ha)

R(E) : Effective rainfall (mm/month)

ET(C) : Reference crop evapo-transpiration (mm/month)

LR : Leaching requirement

V : Water supply requirement (m^3/month)

Table G-30 Estimation of Water Supply Requirement per Hectare

Crop : Date
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m³)
Jan	85.7	0.70	0.56	32	0.8	0.81	1.00	8.6	60.0	0.011	641.5
Feb	94.2	0.70	0.56	32	0.8	0.81	1.00	26.7	65.9	0.011	489.8
Mar	130.0	0.70	0.56	32	0.8	0.81	1.00	6.3	91.0	0.011	1,057.2
Apr	163.4	0.70	0.56	32	0.8	0.81	1.00	11.8	114.4	0.011	1,280.4
May	209.4	0.70	0.56	32	0.8	0.81	1.00	0	146.6	0.011	1,829.6
Jun	224.5	0.70	0.56	32	0.8	0.81	1.00	0	157.2	0.011	1,961.6
Jul	226.7	0.70	0.56	32	0.8	0.81	1.00	0	158.7	0.011	1,980.8
Aug	207.2	0.70	0.56	32	0.8	0.81	1.00	0	145.0	0.011	1,810.4
Sep	175.2	0.70	0.56	32	0.8	0.81	1.00	0	122.6	0.011	1,530.8
Oct	149.5	0.70	0.56	32	0.8	0.81	1.00	0	104.7	0.011	1,306.3
Nov	102.5	0.70	0.56	32	0.8	0.81	1.00	0	71.8	0.011	895.6
Dec	92.4	0.70	0.56	32	0.8	0.81	1.00	6.7	64.7	0.011	723.7
Total	1,860.7							58.1	1,302.6		15,507.7

Crop : Lime
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m³)
Jan	85.7	0.50	0.56	8	0.8	0.81	1.00	8.2	42.9	0.044	447.3
Feb	94.2	0.50	0.56	8	0.8	0.81	1.00	25.5	47.1	0.044	278.9
Mar.	130.0	0.50	0.56	8	0.8	0.81	1.00	5.4	65.0	0.044	769.5
Apr	163.4	0.50	0.56	8	0.8	0.81	1.00	11.1	81.7	0.044	911.5
May	209.4	0.50	0.56	8	0.8	0.81	1.00	0	104.7	0.044	1,351.7
Jun	224.5	0.50	0.56	8	0.8	0.81	1.00	0	112.3	0.044	1,449.2
Jul.	226.7	0.50	0.56	8	0.8	0.81	1.00	0	113.4	0.044	1,463.4
Aug	207.2	0.50	0.56	8	0.8	0.81	1.00	0	103.6	0.044	1,337.5
Sep.	175.2	0.50	0.56	8	0.8	0.81	1.00	0	87.6	0.044	1,131.0
Oct	149.5	0.50	0.56	8	0.8	0.81	1.00	0	74.8	0.044	965.1
Nov.	102.5	0.50	0.56	8	0.8	0.81	1.00	0	51.3	0.044	661.7
Dec.	92.4	0.50	0.56	8	0.8	0.81	1.00	6.1	46.2	0.044	517.7
Total	1,860.7							56.3	930.6		11,284.5

Crop : Banana
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m³)
Jan.	85.7	0.90	0.56	8	0.8	0.81	1.00	9.4	77.1	0.044	874.4
Feb.	94.2	0.90	0.56	8	0.8	0.81	1.00	28.3	84.8	0.044	729.2
Mar.	130.0	0.90	0.56	8	0.8	0.81	1.00	6.3	117.0	0.044	1,429.2
Apr.	163.4	0.90	0.56	8	0.8	0.81	1.00	12.3	147.1	0.044	1,739.8
May	209.4	0.90	0.56	8	0.8	0.81	1.00	0	188.5	0.044	2,433.1
Jun.	224.5	0.90	0.56	8	0.8	0.81	1.00	0	202.1	0.044	2,608.6
Jul.	226.7	0.90	0.56	8	0.8	0.81	1.00	0	204.0	0.044	2,634.1
Aug.	207.2	0.90	0.56	8	0.8	0.81	1.00	0	186.5	0.044	2.407.6
Sep.	175.2	0.90	0.56	8	0.8	0.81	1.00	0	157.7	0.044	2,035.7
Oct.	149.5	0.90	0.56	8	0.8	0.81	1.00	0	134.6	0.044	1,737.1
Nov.	102.5	0.90	0.56	8	0.8	0.81	1.00	0	92.3	0.044	1,191.0
Dec.	92.4	0.90	0.56	8	0.8	0.81	1.00	6.9	83.2	0.044	984.6
Total	1,860.7							63.2	1,674.9		20,804.4

$$V = \frac{10}{EP}\left[\frac{A(ETcrop - RE)}{1 - LR}\right] \quad (m^3/month)$$

ET : Evapo-transpiration (mm/month)

KC : Crop coefficient

EC(W) : Electric conductivity of irrigation water (mmhos/cm)

MEC(E) : Maximum tolerable electrical conductivity of soil saturation extract (mmhos/cm)

LE : Leaching efficiency

EP : Protect irrigation efficiency

A : Area (ha)

R(E) : Effective rainfall (mm/month)

ET(C) : Reference crop evapo-transpiration (mm/month)

LR : Leaching requirement

V : Water supply requirement (m^3/month)

Table G-31 Estimation of Water Supply Requirement per Hectare

Crop : Alfalfa
Year :

Month	ET (mm)	KC	EC(W) (mmhos/cm)	MEC(E) (mmhos/cm)	LE	EP	A (ha)	R(E) (mm)	ET(C) (mm)	LR	V (m^3)
Jan.	85.7	0.85	0.56	16	0.8	0.67	1.00	9.3	72.8	0.022	969.6
Feb	94.2	0.85	0.56	16	0.8	0.67	1.00	27.8	80.1	0.022	797.6
Mar.	130.0	0.85	0.56	16	0.8	0.67	1.00	6.3	110.5	0.022	1,590.0
Apr.	163.4	0.85	0.56	16	0.8	0.67	1.00	12.2	138.9	0.022	1,933.2
May	209.4	0.85	0.56	16	0.8	0.67	1.00	0	178.0	0.022	2,716.0
Jun	224.5	0.85	0.56	16	0.8	0.67	1.00	0	190.8	0.022	2,911.8
Jul	226.7	0.85	0.56	16	0.8	0.67	1.00	0	192.7	0.022	2,940.4
Aug	207.2	0.85	0.56	16	0.8	0.67	1.00	0	176.1	0.022	2,687.4
Sep.	175.2	0.85	0.56	16	0.8	0.67	1.00	0	148.9	0.022	2,272.4
Oct.	149.5	0.85	0.56	16	0.8	0.67	1.00	0	127.1	0.022	1,939.1
Nov.	102.5	0.85	0.56	16	0.8	0.67	1.00	0	87.1	0.022	1,329.5
Dec.	92.4	0.85	0.56	16	0.8	0.67	1.00	6.9	78.5	0.022	1,093.2
Total	1,860.7							62.5	1,581.5		23,180.2

$$V = \frac{10}{EP} \left[\frac{A(ETcrop - RE)}{1 - LR} \right] \quad (m^3/month)$$

ET : Evapo-transpiration (mm/month)

KC : Crop coefficient

EC(W) : Electric conductivity of irrigation water (mmhos/cm)

MEC(E) : Maximum tolerable electrical conductivity of soil saturation extract (mmhos/cm)

LE : Leaching efficiency

EP : Protect irrigation efficiency

A : Area (ha)

R(E) : Effective rainfall (mm/month)

ET(C) : Reference crop evapo-transpiration (mm/month)

LR : Leaching requirement

V : Water supply requirement (m^3/month)

Hydraulic Calculation
for Terminal Irrigation Facilities (Manifold) in Irrigation Unit

a) Calculation Conditions

1) Size of Farm

Irrigation unit : 4.25 ha (45.2m x 235m x 4)

Area covered by one manifold : 2.125 ha

2) Cropping Area and Intensity

Vegetable

Tomato	:	0.25 ha
Cabbage	:	0.25
Watermelon (s)	:	0.25
Watermelon (w)	:	0.25
Eggplant	:	0.30
Redpepper	:	0.30

Fruit Crop

Dates	:	1.00
Lime	:	1.00
Banana	:	0.50

Feed Crop

Alfalfa	:	1.00

Total 5.10 (Cropping Intensity = 120%)

3) Irrigation

Irrigation method:

Vegetable, Fruit Crop	:	Drip irrigation (1-day interval)
Feed Crop	:	Sprinkler irrigation (3-day interval)

Max. crop evap-transpiration (ETC):

Vegetable (Tomato)	:	3.58 mm/day (4.42 mm/day) 1/
Dates	:	5.30 mm/day (6.54 mm/day)
Lime	:	3.91 mm/day (4.83 mm/day)
Banana	:	7.05 mm/day
Alfalfa	:	6.51 mm/day (9.71 mm/day)
Windbreak	:	5.30 mm/day (6.54 mm/day)

1/ : Inclusive of losses (see Table G-32)

4) Pipe Materials

Manifold : Vinyl Pipe (VP)···· underground

Driphose : Polyethylene Pipe

b) Required Capacity and Pressure

Hydraulic calculations for each crop has been made based upon the above conditions, and their results are summarized in Figure G-5. As the results, the total capacity and required pressure at distribution point of each manifold are estimated as shown below:

Distribution point No.1 : q_1 = 8.1 ℓ/sec (P_1 = 39.9m)

Distribution point No.2 : q_2 = 6.6 ℓ/sec (P_2 = 24.8m)

Table G-32 Monthly Water Supply Requirement by Crops[1/]

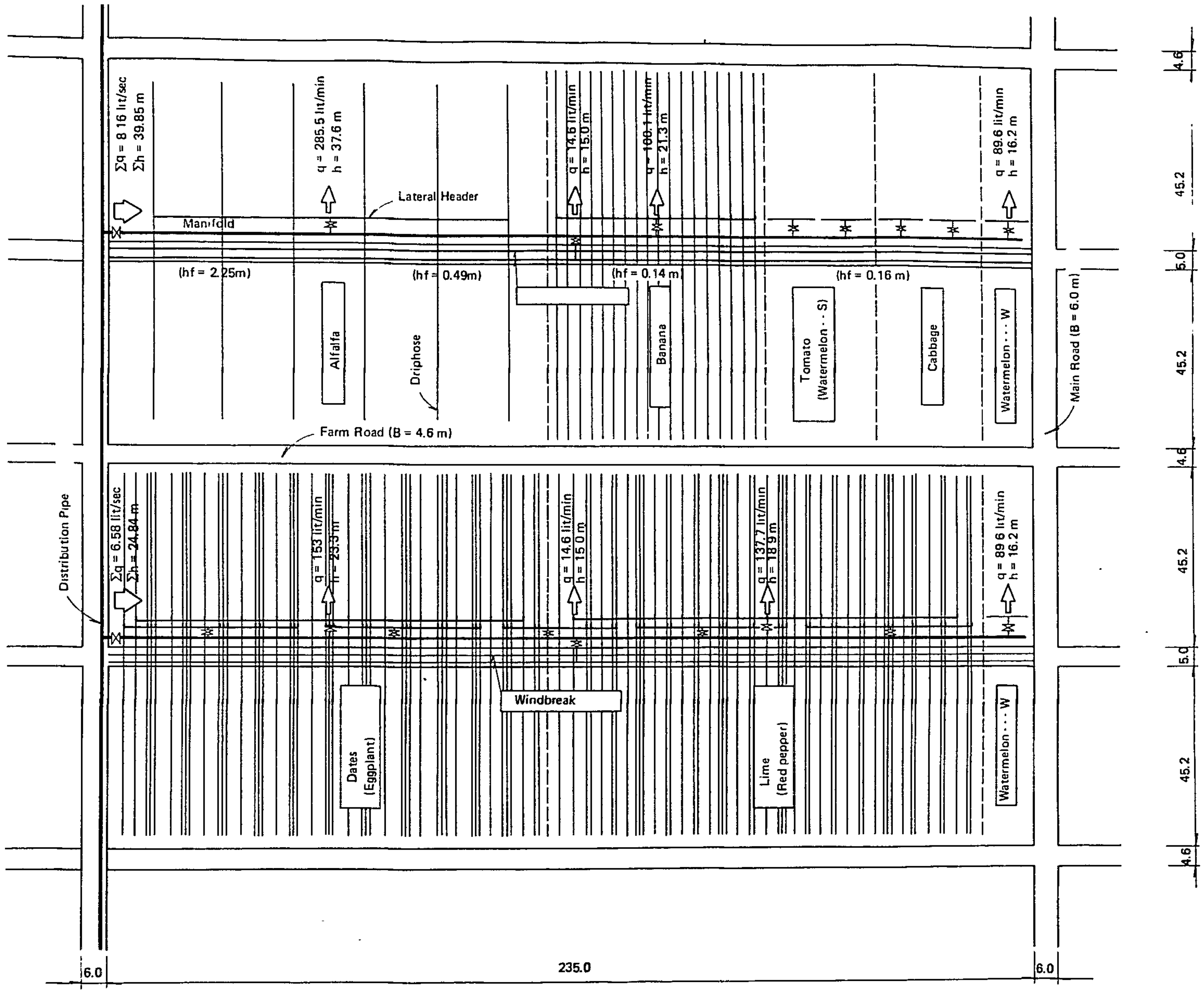
(Unit : mm/day)

Month	Vegetable: Tomato (5.88%) Early Variety	Medium Variety	Late Variety	Average	Cabbage (5.88%) Early Variety	Medium Variety	Late Variety	Average	Water melon (Summer) (5.88%) Early Variety	Medium Variety	Late Variety	Average	Water melon (Winter) (5.88%) Early Variety	Late Variety	Average
Jan.	2.91	3.58	2.53	3.01	2.04	2.78	2.85	2.56					0.83		0.42
Feb.		3.54	4.35	2.63		2.48	3.38	1.95					2.75	1.01	1.88
Mar.			4.42	1.47			3.09	1.03					4.40	3.43	3.92
Apr.													5.02	5.71	5.37
May														6.22	3.11
Jun.															
Jul.									4.86			1.62			
Aug.	0.85			0.28	0.84			0.28	6.67	4.45		3.71			
Sep.	0.74	0.74		0.49	2.92	0.73		1.22	5.82	5.83	3.89	5.18			
Oct.	2.82	0.61	0.61	1.34	4.22	2.41	0.60	2.41	2.16	4.81	4.81	3.93			
Nov.	3.12	1.99	0.43	1.85	3.45	2.98	1.71	2.71		1.52	3.41	1.64			
Dec.	3.86	2.72	1.74	2.77	2.99	3.07	2.65	2.90			1.33	0.44			

Month	Vegetable: Eggplant (7.06%) Early Variety	Medium Variety	Late Variety	Average	Red pepper (7.06%) Early Variety	Late Variety	Average	Fruit Crop: Dates (23.53%)	Lime (23.53%)	Banana (11.75%)	Feed Crop: Alfalfa (23.53%)	Average (120.0%)
Jan.	1.70	2.70	2.84	2.41	2.06	2.81	2.44	2.42	1.78	3.21	3.59	2.90
Feb.		2.07	3.28	1.78		2.51	1.26	2.94	2.17	3.91	4.36	3.28
Mar.			2.59	0.86				3.66	2.71	4.87	5.44	3.79
Apr.								4.76	3.52	6.33	7.06	4.67
May								5.90	4.36	7.85	8.76	5.58
Jun.								6.54	4.83	8.70	9.71	5.98
Jul.								6.39	4.72	8.50	9.49	5.94
Aug.	0.86			0.29	0.86		0.43	5.84	4.31	7.77	8.67	5.64
Sep.	0.75	0.75		0.50	3.00	0.75	1.88	5.10	3.77	6.79	7.57	5.24
Oct.	2.97	0.62	0.62	1.40	4.34	2.48	3.41	4.21	3.11	5.60	6.26	4.63
Nov.	3.51	2.11	0.44	2.02	3.56	3.07	3.32	2.99	2.21	3.97	4.43	3.47
Dec.	2.91	3.06	1.84	2.60	3.02	3.10	3.06	2.60	1.92	3.46	3.87	3.14
Average												4.52

Note : 1/: Inclusive of required water losses
Drip irrigation (vegetable and fruit crop) : 0.81
Sprinkler irrigation (feed crop) : 0.67
Underlined figures show the maximum water requirement of crops.

FIGURE G – 5. TYPICAL LAYOUT OF IRRIGATION UNIT AND TERMINAL IRRIGATION SYSTEM



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q = Distribution capacity
h = Required distrivution head
Irrigation Unit = 4.25 ha

Crop	:	Vegetable
Spacing	:	0.9m x 2m (Emitter)
Max ETcrop	:	3.58 mm/day (Tomato)
Irrigation Efficiency	:	81 %
Irrigation Interval	:	1 day
Water Application	:	3.58 mm/day ÷ 0.81 x 0.9m x 2m = 7.96 litres per day per emitter
Model Selection and Operating Condition	:	EMJ 10 3.98 lph at 15.1m head
Time per Irrigation	:	7.96 litres ÷ 3.98 lph = 2.0 hr/day
Nos of Irrigation Set	:	7 sets per day
Nos of Emitter per Set	:	1,350 emitters per set
Total Flow per Set	:	89.6 lpm
Required Pressure	:	16.2m head at section inlet

Crop	:	Dates
Spacing	:	9m x 9m (Tree)
Max ETcrop	:	5.30 mm/day
Irrigation Efficiency	:	81 %
Irrigation Interval	:	1 day
Water Application	:	5.30 mm/day ÷ 0.81 x 9m x 9m = 530 litres per day per tree
Model Selection and Operating Condition	:	2 x EMTB 6 76.5 lph at 14.5m head
Time per Irrigation	:	530 litres ÷ 76.5 lph = 6.9 hrs/day
Nos of Irrigation Set	:	1 set per day
Nos of Emitter per Set	:	120 emitters per set
Total Flow per Set	:	153 lpm
Required Pressure	:	23.3m head at section inlet

Crop	:	Lime
Spacing	:	7m x 7m (Tree)
Max ETcrop	:	3.91 mm/day
Irrigation Efficiency	:	81 %
Irrigation Interval	:	1 day
Water Application	:	3.91 mm/day ÷ 0.81 x 7m x 7m = 236.5 litres per day per tree
Model Selection and Operating Condition	:	EMTB 6 38.3 lph at 14.5m head
Time per Irrigation	:	236.5 litres ÷ 38.3 lph = 6.2 hrs/day
Nos of Irrigation Set	:	1 set per day
Nos of Emitter per Set	:	180 emitters per set
Total Flow per Set	:	137.7 lpm
Required Pressure	:	18.9m head at section inlet

Crop	:	Banana
Spacing	:	2.5m x 3m (Tree)
Max ETcrop	:	7.05 mm/day
Irrigation Efficiency	:	81 %
Irrigation Interval	:	1 day
Water Application	:	7.05 mm/day ÷ 0.81 x 2.5m x 3m = 65.3 litres per day per tree
Model Selection and Operating Condition	:	EMJ 20 9.27 lph at 18.9m head
Time per Irrigation	:	65.3 litres ÷ 9.27 lph = 7.0 hrs/day
Nos of Irrigation Set	:	1 set per day
Nos of Emitter per Set	:	648 emitters per set
Total Flow per Set	:	100.1 lpm
Required Pressure	:	21.3m head at section inlet

Crop	:	Alfalfa
Spacing	:	12m x 18m (Sprinkler)
Max ETcrop	:	6.51 mm/day
Irrigation Efficiency	:	67 %
Irrigation Interval	:	3 days
Water Application	:	6.51 mm/day ÷ 0.67 x 3 days x 12m x 18m = 6.296 litres per set per sprinkler
Model Selection and Operating Condition	:	Rain Bird 30H 35.7 lpm at 28m head
Time per Irrigation	:	6.296 litres ÷ (35.7 lpm x 60 min/hr) = 2.94 hrs per set
Nos of Irrigation Set	:	2 sets per day
Nos of Emitter per Set	:	8 sprinklers
Total Flow per Set	:	285.6 lpm
Required Pressure	:	37.6m head at section inlet.

Crop	:	Wind Breaks
Spacing	:	2m x 3m (Tree)
Max ETcrop	:	5.30 mm/day
Irrigation Efficiency	:	81 %
Irrigation Interval	:	1 day
Water Application	:	5.30 mm/day ÷ 0.81 x 2m x 3m = 39.3 litres per day per tree
Model Selection and Operating Condition	:	EMJ 15 5.61 lph at 13.6m head
Time per Irrigation	:	39.3 litres ÷ 5.61 lph = 7.0 hrs/day
Nos of Irrigation Set	:	1 set per day
Nos of Emitter per Set	:	156 emitters per set
Total Flow per Set	:	14.6 lpm
Required Pressure	:	15m head at section inlet

Depth and Interval of Irrigation Application for Crops

1. Measurement of Intake Rate

During the field survey, intake rate measurements were made at four sites in the Project Area (see Figure G-6), under wet conditions, in order to pursue an adequate irrigation method and water amounts to be applied to the crop. The wet conditions mean the field keeping the water holding capacity after 24 hours of soil saturation.

To measure the intake rate, a cylinder infiltrometer was used and the reading of the water depth within the cylinder was made at the interval of every five to 10 minutes at the initial stage and 30 minutes intervals from one hour later.

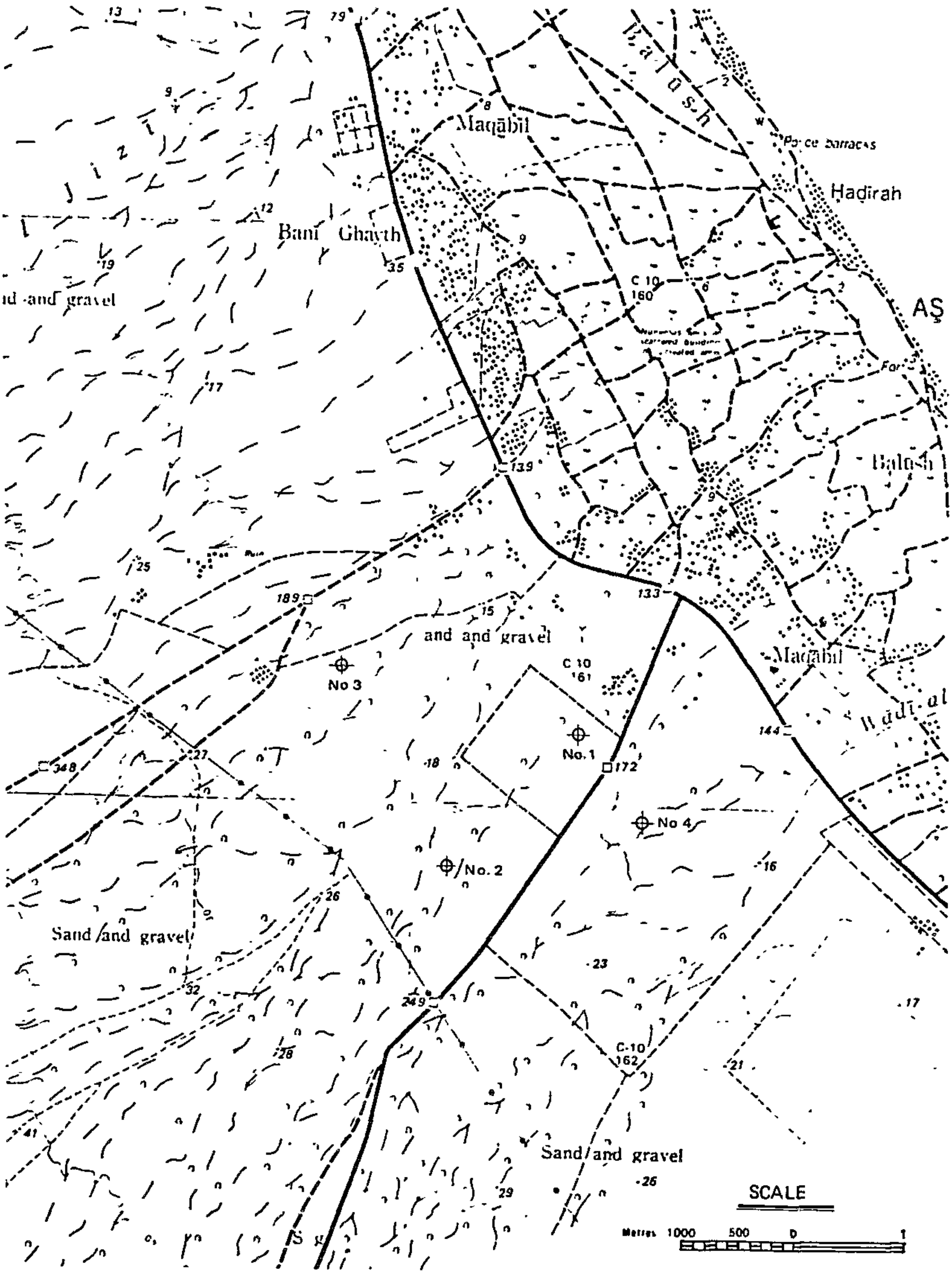
Results of intake rate measurements are plotted on a logarithmic paper (see Figure G-7 to Figure G-10). Usually, the intake rate plotted against time on logarithmic scale shows a straight line, and therefore, can be presented by the equation of $D = CT^n$. When the observation of intake rate extends over long time, a better representation of the data can usually be obtained by using the equation of $D = CT^n + b$. Since n is negative, an accumulative intake rate (ΣD) decreases with an increase in time of T. Therefore, the intake rate (D) will approach a constant value of b as time increase. Generally, the intake does approach a constant rate, which will be referred to as basic intake rate (Ibi). Caution should be observed in using the basic intake rate for irrigation design such as irrigation method.

The following table gives the obtained basic intake rate, based upon each observation of the intake rate.

Obtained Basic Intake Rate (Wet Conditions)

Site	Ibi (mm/hr)
No.1	59.9
No.2	43.3
No.3	128.5
No.4	105.6
Average	84.3

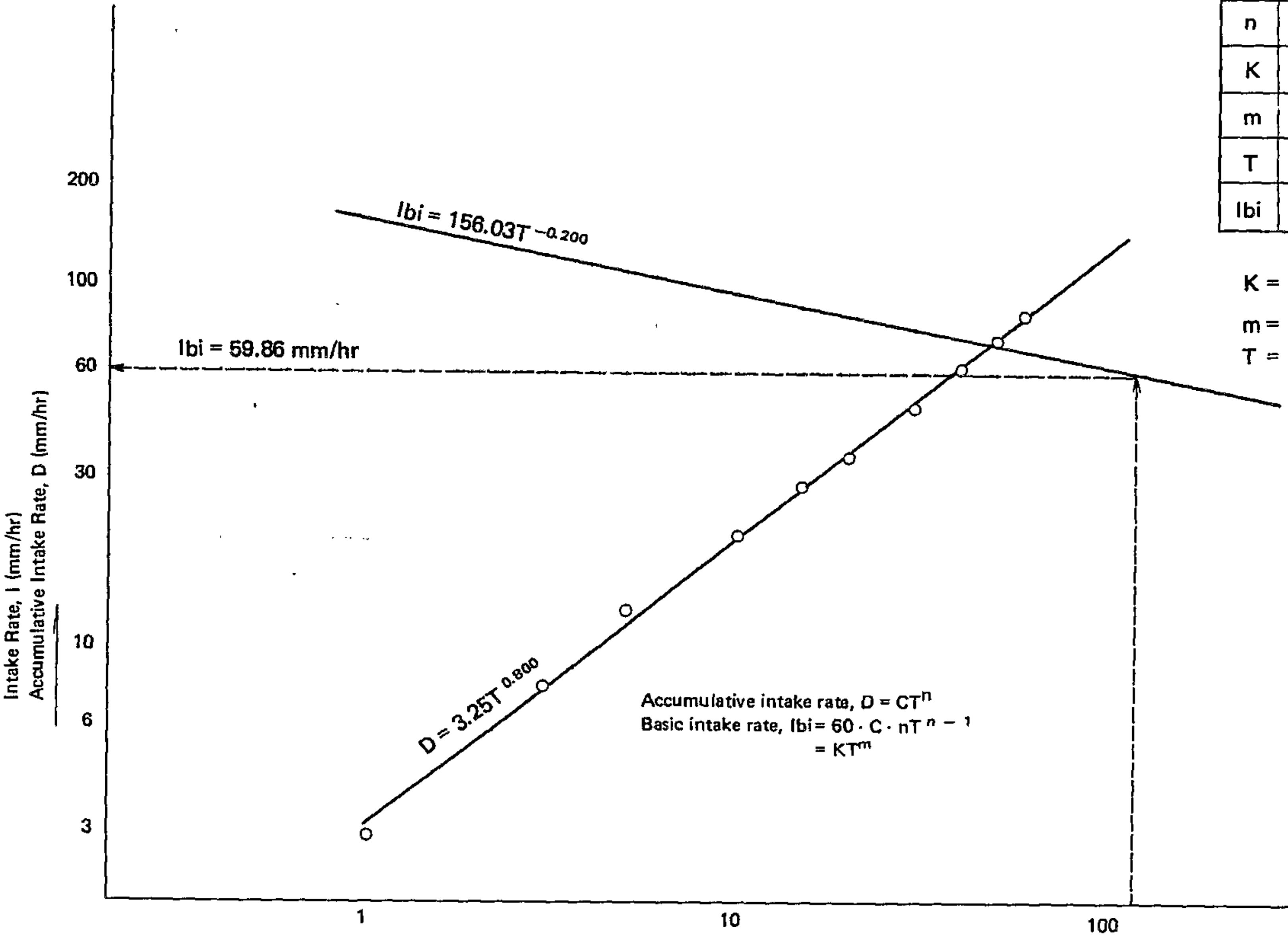
FIGURE G – 6 LOCATION OF INTAKE RATE MEASUREMENT AND SOIL SAMPLING



LEGEND

-⊕- MEASUREMENT AND SAMPLING SITES

[ ] PROPOSED FARM LAND AREA



C	3.25
n	0.800
K	156.03
m	- 0.200
T	120.06
Ibi	59.86

$K = 60 \cdot C \cdot n$

$m = n - 1$

$T = 600\,(n - 1)$

FIGURE G – 7 RESULT OF CYLINDER INTAKE RATE (NO..1)

C	5.17
n	0.693
K	214.75
m	– 0.307
T	184.32
Ibi	43.25

K = 60 · C · n
m = n – 1
T = 600 (n – 1)

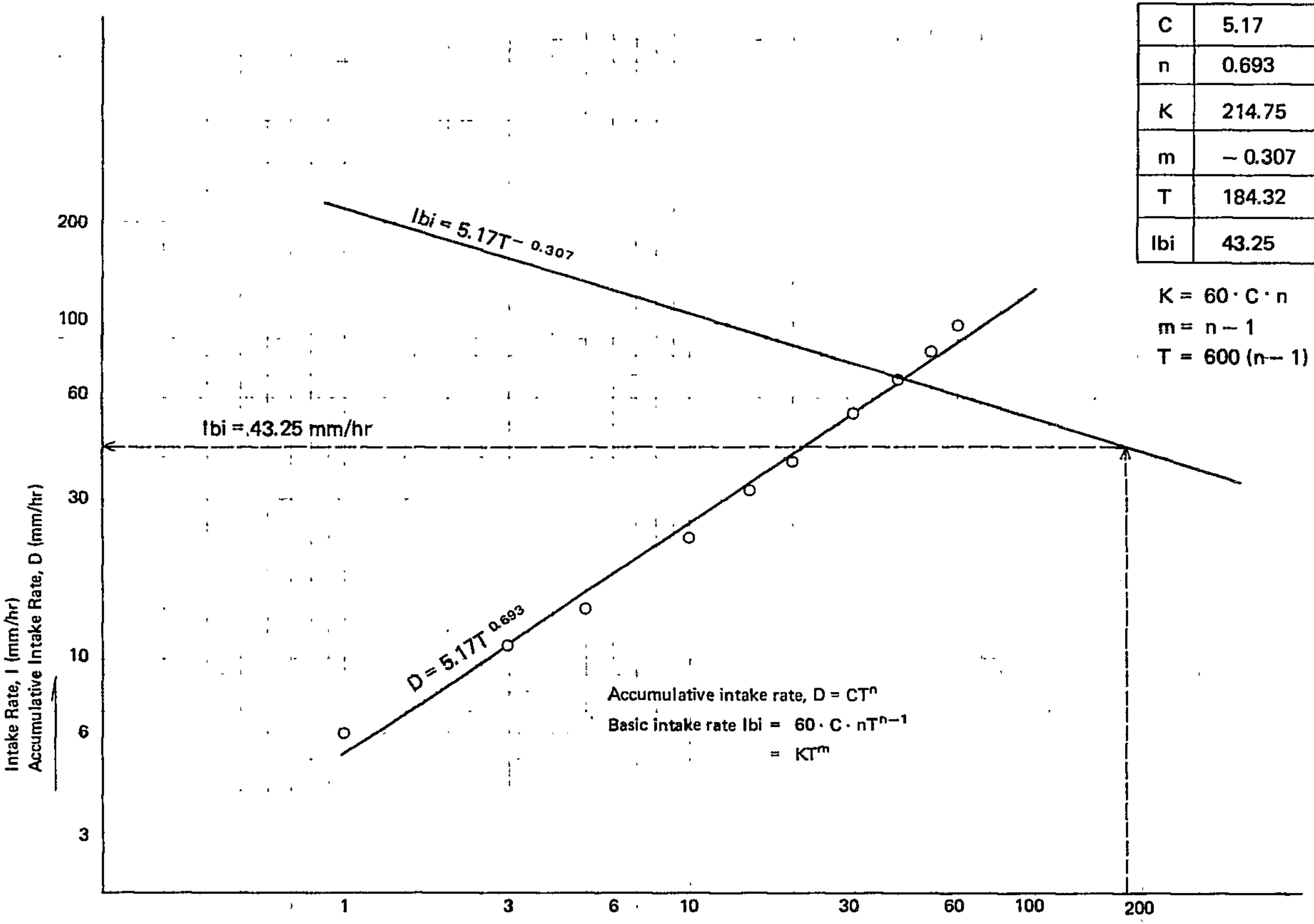


FIGURE G – 8 RESULT OF CYLINDER INTAKE RATE (NO. 2)

C	5.15
n	0.844
K	260.93
m	– 0.156
T	93.60
Ibi	128.53

$K = 60 \cdot C \cdot n$

$m = n - 1$

$T = 600 (n \cdot\cdot 1)$

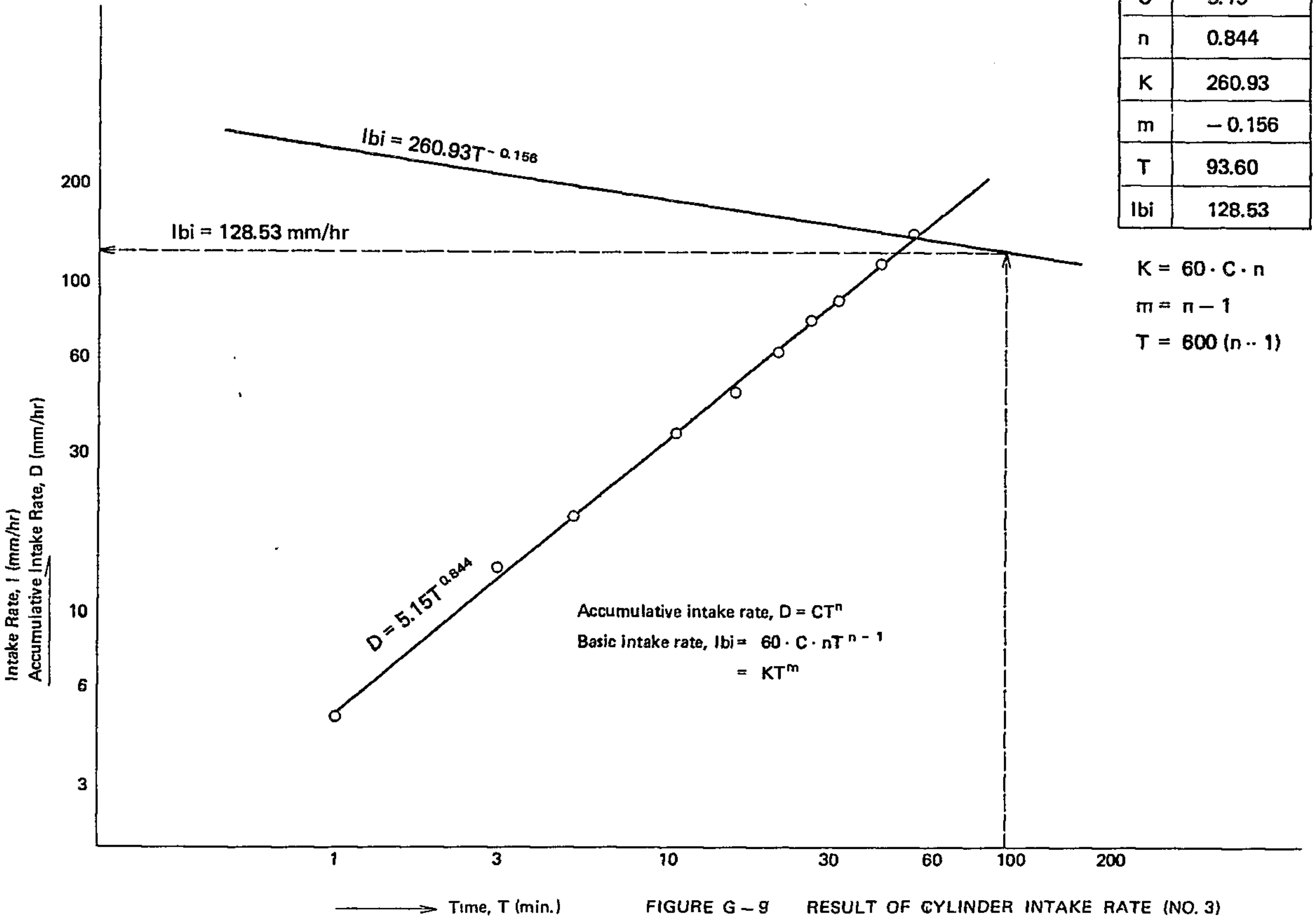
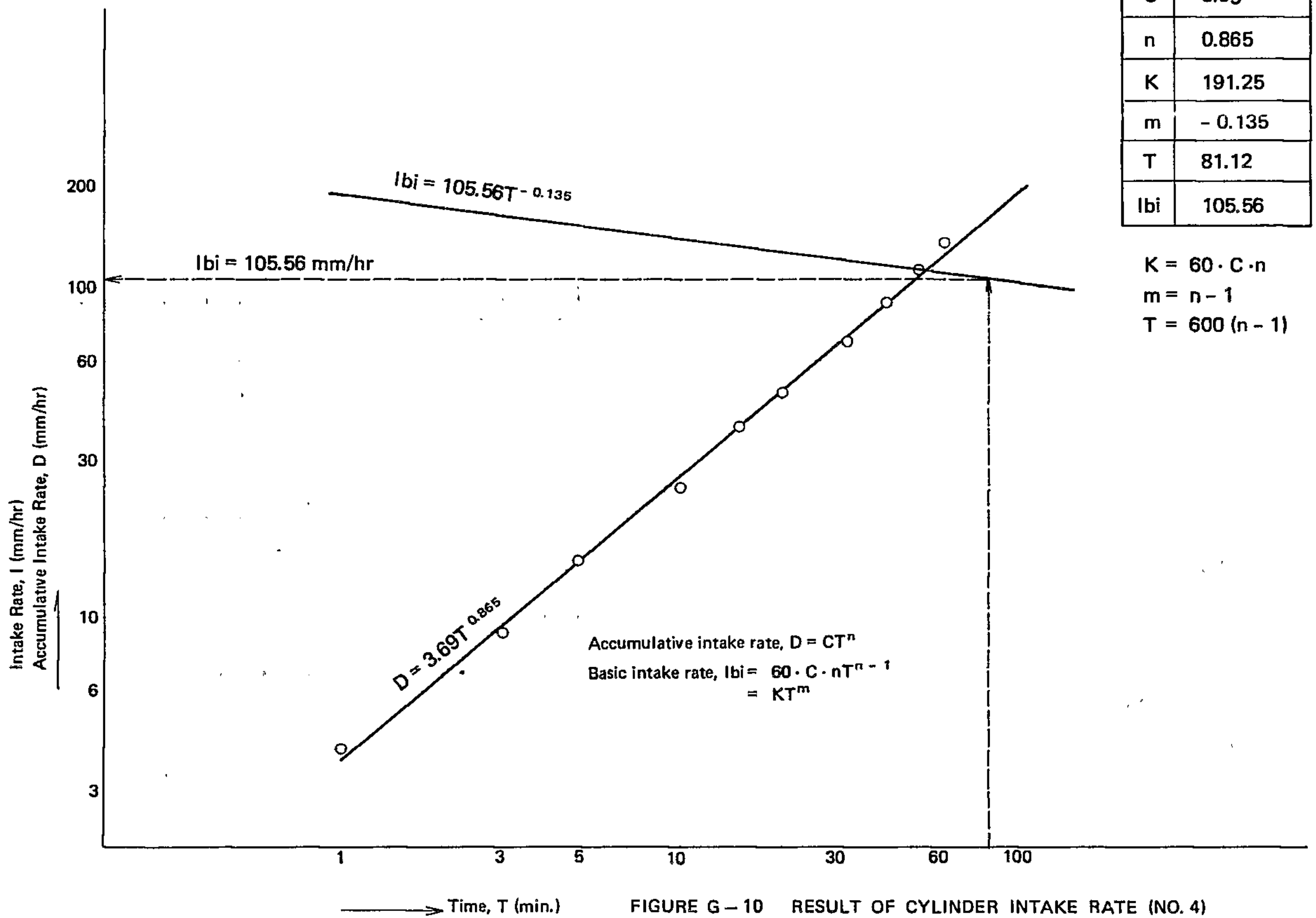


FIGURE G – 9 RESULT OF CYLINDER INTAKE RATE (NO. 3)



C	3.6g
n	0.865
K	191.25
m	- 0.135
T	81.12
Ibi	105.56

$K = 60 \cdot C \cdot n$

$m = n - 1$

$T = 600\ (n - 1)$

FIGURE G – 10 RESULT OF CYLINDER INTAKE RATE (NO. 4)

From the above figures, it could be considered that drip and sprinkler irrigation methods would be suitable for water supply to the crop.

In the parallel with such measurements of the intake rate, soil samples in the depth of 50 cm with an interval of 10 cm depth were taken to analyze the physical properties of the soils in the field, such as specific gravity, porosity, field capacity. and wilting point.

The analysis results of soils under the wet conditions are summarized as shown in Table G-33.

2. Depth and Interval of Irrigation Application

Depth and Interval of irrigation application are determined in accordance with the following procedure:

i) Determination of effective root zone

ii) Determination of moisture extraction pattern

iii) Calculation of available moisture of each soil layer within effective root zone

iv) Calculation of total readily available moisture (TRAM), and

v) Determination of depth and interval of irrigation application

i) Depth of Effective Root Zone

The depth of effective root zone (restricting layer) was on the basis of field survey and collected data as shown below:

Crops	Depth of Effective Root Zone (Restricting Layer) (cm)
Vegetable	30
Fruit Crop	80
Feed Crop	40

Table G-33 Physical Features of Soil (Wet Condition)

Location	Soil Depth (cm)	Real Specific Gravity(Sr) (g/cm^3)	Aparent Specific Gravity(Sa) (g/cm^3)	Porosity 1/ (P) (%)	Field 2/ Capacity (Fc) (%)	Wilting 2/ Point (Wp) (%)
No:1	10	2.65	1.37	48.3	26.7	7.9
	20	3.14	1.40	55.4	26.7	7.9
	30	2.43	1.37	43.6	26.7	7.9
	40	2.72	1.56	42.6	26.7	7.9
	50	2.81	1.64	41.6	26.7	7.9
No:2	10	2.85	1.61	43.5	26.7	7.9
	20	2.87	1.47	48.8	26.7	7.9
	30	2.94	1.67	43.2	26.7	7.9
	40	2.99	1.67	44.1	26.7	7.9
	50	2.78	1.54	44.6	26.7	7.9
No:3	10	2.67	1.69	40.1	26.7	7.9
	20	2.66	1.67	37.2	26.7	7.9
	30	2.71	1.63	40.2	26.7	7.9
	40	2.76	1.84	33.3	26.7	7.9
	50	2.70	1.78	34.0	26.7	7.9
No:4	10	2.85	1.64	42.5	26.7	7.9
	20	2.77	1.65	40.4	26.7	7.9
	30	2.44	1.75	28.3	26.7	7.9
	40	3.28	1.55	52.7	26.7	7.9
	50	2.67	1.42	46.8	26.7	7.9
Average		2.78	1.60	42.6	26.7	7.9

Note: 1/ P = (Sr - Sa) x 100 / Sr (%)

2/ Derived from soil analysis data described in the report of " Water Resources Development Project ", North Oman, Interim Report, Volume 2 prepared by ILACO, January 1975.

Field capacity : PF 2.0

Wilting point .: PF 4.2

Above soil tests are made at Rumais Agricultural Research Station.

ii) Moisture Extraction Pattern

Consumptive use of soil moisture by crop evapo-transpiration will vary depending on the depth of soil. This consumptive rate of soil moisture is the so-called "moisture extraction pattern" which will be determined based upon the field investigation.

Due to the lack of such data concerned, the following pattern was applied.

Percent of Depth (%)	Ratio of Moisture Extraction (%)
0 - 25	40
25 - 50	30
50 - 75	20
75 - 100	10

iii) Available Moisture in Each Soil Layer within Effective Root Zone

Available moisture (A.M.) is obtained from the following equation:

$$A.M. = \frac{1}{100} \cdot \Sigma(Fc - Wp) \cdot D \text{ (mm)}$$

Where:

Fc: water holding capacity after 24 hours of soil saturation (%)

Wp: moisture ratio at wilting point (%)

D : depth of soil in each soil layer (mm)

iv) Total Readily Available Moisture (TRAM)

$$\text{In the soil layer concerned, Consumed Moisture} = \frac{\text{Available Moisture}}{\text{Ratio of Moisture Extraction}}$$

The layer presenting the minimum value obtained from the above equation is the restricting layer of moisture and its value becomes Total Readily Available Moisture (TRAM), that is, net amount of water to be replaced is given in Table G-34.

v) Interval of Irrigation Application

The interval of irrigation application is obtained by dividing the TRAM by the maximum crop evapo-transpiration as shown below:

Estimation of Irrigation Interval

Crops	TRAM (mm)	Max. ETcrop (mm/day)	Irrigation Interval (day)
Vegetable			
Tomato	35.3	3.58	9
Cabbage	35.3	3.42	10
Watermelon (s)	35.3	5.40	6
Watermelon (w)	35.3	5.04	7
Eggplant	35.3	2.84	12
Redpepper	35.3	3.52	10
Fruit Crop			
Dates	94.0	5.30	17
Lime	94.0	3.91	24
Banana	94.0	7.05	13
Feed Crop			
Alfalfa	47.0	6.51	7

Note: Detailed estimation is given in Table G-34.

Table G-34 Net Amount of Water to be Replaced for Crops

Vegetable

(1) Depth (cm)	(2) Available[1/] Moisture (AM) (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 be Replaced (mm)
0-7.5	14.1	0.4	35.3	*	35.3	35.3
7.5-15.0	14.1	0.3	47.0			
15.0-22.5	14.1	0.2	70.5			
22.5-30.0	14.1	0.1	141.0			

Fruit Crop

(1) Depth (cm)	(2) Available[1/] Moisture (AM) (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 be Replaced (mm)
0-20	37.6	0.4	94.0	*	94.0	94.0
20-40	37.6	0.3	125.3			
40-60	37.6	0.2	188.0			
60-80	37.6	0.1	376.0			

Feed Crop

(1) Depth (cm)	(2) Available[1/] Moisture (AM) (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 be Replaced (mm)
0-10	18.8	0.4	47.0	*	47.0	47.0
10-20	18.8	0.3	62.7			
20-30	18.8	0.2	94.0			
30-40	18.8	0.1	188.0			

Note : 1/: $AM = \frac{1}{100}(Fc - Wp)\cdot D$

Fc: Field Capacity (%)
Wp: Wilting Capacity (%)
D : Depth (mm)

2/: TRAM: Total Readily Available Moisture