APPENDIX F: IRRIGATION, DRAINAGE AND ROAD

I. PROPOSED ALTERNATIVE PLANS

1. Irrigation System

(1) The following four alternatives have been proposed for the establishment of the most feasible irrigation system.

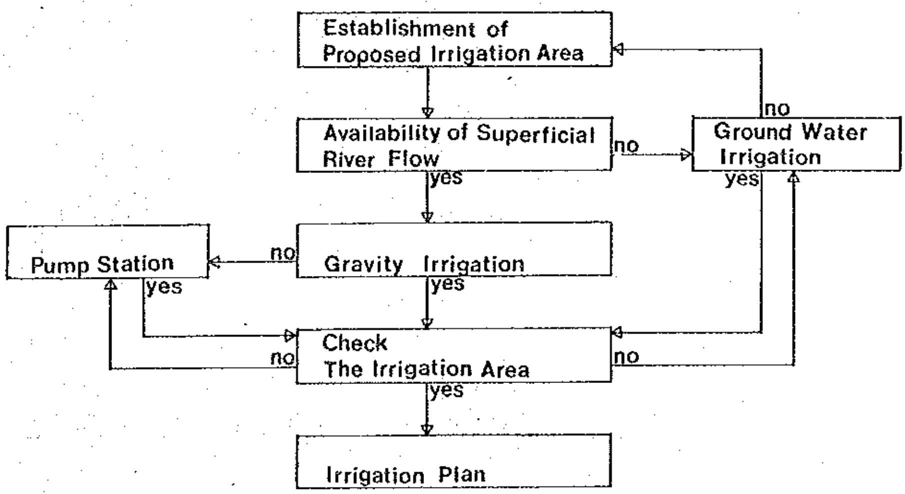
Alternative	Water Intake Volume (m^3/sec)	Irrigable Area (ha)	Intake Site		Intake Method	
			One	Several	Gravity	Pumping
Case 1	4,192	4,700	o		o	
Case 2	5,548	6,220		o	o	
Case 3	8,117	9,100		o	o	o
Case 4	8,920	10,000		o	o	o

Case 1: Given five years return period of drought, the discharge of the Aguan River at Pte. Olanchito will be 10.8 m^3/s. With this volume, approximately 12,000 ha can be irrigated. In this Case, a head works will be installed near Pte. Olanchito so as to divert river water for irrigation purpose.

Case 2: Within the project area, besides the Aguan River, river surface water will be available from the Mame and the Jaguaca Rivers even in the drought season. This Case deals with the proposal to divert the irrigation water from these two rivers.

Case 3: In Case 2, the irrigable area counts for only 40% of the total arable area. This Case proposes to extend the irrigable area by means of the installation of two pump station.

Case 4: The irrigable area will be extended to the middle plateau with increase in capacity of pump station.



(2) Comparison of Each Alternative

1) Project Cost

a. Project Cost

x 1,000 Lps.

Description	Case 1	Case 2	Case 3	Case 4
Head Works	4,500	8,700	8,700	8,700
Siphon	3,000	500	500	500
Pump Station	-	-	3,900	9,800
Main Canal	7,500	8,200	12,000	13,500
Secondary Canal	1,500	2,000	3,000	3,300
Drainage Canal	4,200	4,200	4,200	4,200
Road	29,200	29,200	29,200	29,200
Land Reclamation	17,400	17,400	17,400	17,400
Total Construction Cost	67,300	70,200	78,900	86,600
Project Cost (Construction Cost x 1.6)	107,700	112,300	126,200	138,600

The construction period will be 5 years and annual average amount of each case becomes as follows:

Case 1: Lps.107,700,000 x 1/5 = Lps. 21,500,000
Case 2: Lps.112,300,000 x 1/5 = Lps. 22,500,000
Case 3: Lps.126,200,000 x 1/5 = Lps. 25,200,000
Case 4: Lps.138,600,000 x 1/5 = Lps. 27,700,000

b. Annual Operation and Maintenance Cost

x 1,000 Lps.

Description	Case 1	Case 2	Case 3	Case 4
Maintenance Cost for Civil Work	190	200	220	240
O/M Cost of Equipment	1,020	1,020	1,020	1,020
Running Cost of Pump	-	-	170	560
Total	1,210	1,220	1,410	1,820

c. Replacement Cost

x 1,000 Lps.

Description	Case 1	Case 2	Case 3	Case 4
Pump (Annual Depreciation Cost)	- (-)	- (-)	2,572.1 (128.6)	6,440 (322)
Gate (Annual Depreciation Cost)	543.0 (18.1)	813.9 (27.1)	813.9 (27.1)	813.9 (27.1)
Total (Annual Depreciation Cost)	543.0 (18.1)	813.9 (27.1)	3,386 (155.7)	7,253.9 (349.1)

2) Benefit

Unit: Area - ha
Net Return - 1,000 Lps.

Description	Case 1		Case 2		Case 3		Case 4	
	Area	Net Return	Area	Net Return	Area	Net Return	Area	Net Return
Irrigable Area	4700	12600	6200	16600	9100	24400	10400	27900
Non-irrigable Area	11100	11900	9600	10300	6700	7200	5400	5800
Total Arable Area (A)	15800	24500	15800	26900	15800	31600	15800	33700
Actually Cultivated Area (B)	2671	1900	2671	1900	2671	1900	2671	1900
Benefit [(A)-(B)]	-	22600	-	25000	-	29700	-	31800

3) Cost-Benefit Analysis

(1,000 Lempira)

Description	Case 1	Case 2	Case 3	Case 4
Net Present Value (Cost)	92,800	96,838	109,735	122,325
Net Present Value (Benefit)	112,705	124,675	148,112	158,588
B/C	1.214	1.287	1.350	1.296
B-C	19,905	27,837	38,377	36,263

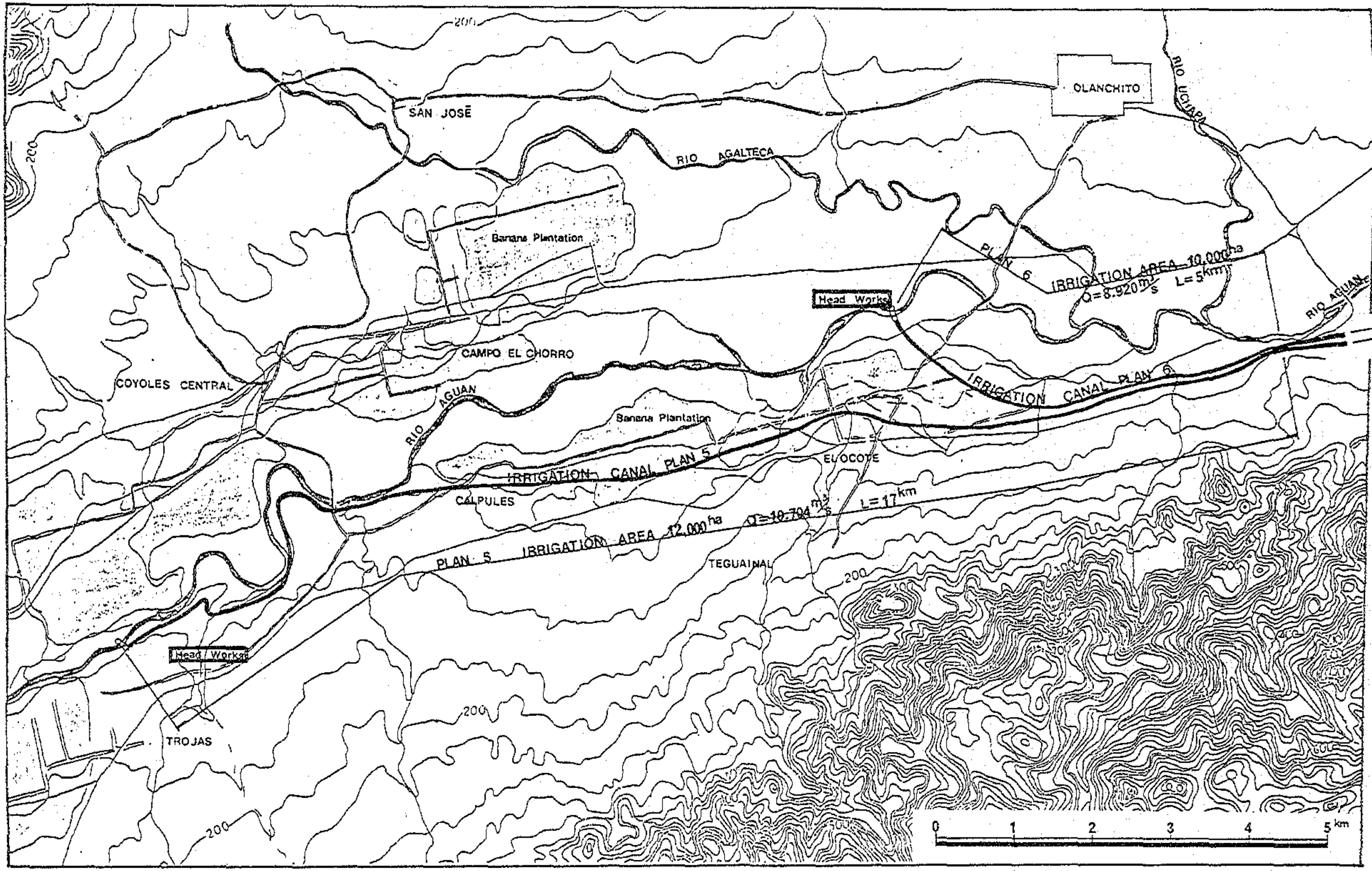
As shown in the above table, the B/C value becomes the highest figure in Case 3.

(3) Additional Alternative Plans

In addition to four cases (Case 1 - Case 4) set out before,the following two cases have been studied their technical and economic feasibility

Case 5: Proposes to locate head works in 17 km upper stream of Pte. Olanchito in view of increasing irrigable area up to 12,000 ha.

Case 6: Proposed to locate head work in 5 km upper stream, at the middle point between Case 1 and Case 5, in view of examining the profitability by the location of head works



Proposed Site for Head Works (Plan 5 & 6)

Cost/Benefit Analysis for Case 5 and Case 6

1) Project Cost

a. Project Cost

x 1000 Lps.

Description	Case 5	Case 6	
Head Works (Trojas)	5,500	5,000	
Siphon	9,000	7,000	Rio Mame, Rio Jaguaca, Banana Plant
Main canal	52,100	54,100	Stone Masonry 12 km Frame works 14 km
Secondary Canal	3,900	3,300	
Drainage canal	4,200	4,200	
Road	29,200	29,200	
Land Reclamation	17,400	17,400	
Total Construction Cost	121,300	120,200	
Project Cost (Construction Cost x 1.6)	194,080	192,300	

The construction period will be 5 years and annual average amount of each case becomes as follows:

Case 5

194,080,000 x 1/5 = 38,800,000

Case 6

192,300,000 x 1/5 = 38,500,000

b. Annual Operation and Maintenance Cost

x 100 Lps.

Description	Case 5	Case 6
Maintenance Cost for Civil Works	380	350
O/M Cost of Equipment	1,020	1,020
Total	1,400	1,370

c. Replacement Cost

x 1,000 Lps.

Description	Case 5	Case 6
Gate	813.9	813.9
(Annual Depreciation Cost)	27.1	27.1

2) Beneftit

Unit: Area - Ha
Net Return - 100 Lps.

Description	Case 5		Case 6	
	Area	Net Return	Area	Net Return
Irrigable Area	12,000	32,100	10,000	26,800
Non-irrigable Area	3,800	4,000	5,800	6,300
Total Arable Area (A)	15,800	1,900	2,671	1,900
Benefit ((A)-(B))	-	34,200		31,200

3) Cost-Benefit Analysis

x 1,000 Lps.

Description	Case 5	Case 6
Net Present Value (Cost)	163,777	162,566
Net Present Value (Benefit)	170,468	155,515
B/C	1.041	0.957
B-C	6,691	-7,051

Discount Rate = 12%

2. Intake Method for Block B

In respect to intake method to irrigate the Block B the following two technically feasible plans have been presented:

Plan A: With the head works in Block C the river water will be diverted and conveyed across the Mame River by means of syphon.

Facilities to be constructed:
- Diversion works 1
- Irrigation Canal .... 2,000 m (including driving canal in Block C)
- Syphon 1

Plan B: Independent head works will be constructed within the block area.

Facilities to be constructed:
- Head Works 1

Construction cost for each plan is as summarized below:

Lempira

Facilities	Plan A	Plan B	Remarks
Diversion Works	10,000	-	Direct Cost x 1.5
Irrigation Canal	23,500	-	The Difference Between Plan A and Plan B
Syphon	488,000	-	Refer to Breakdown of Cost Estimation
Head Works	-	971,000	Same feature of syphon to be constructed in Block C
Total	521,500	971,000	

3. Road Network

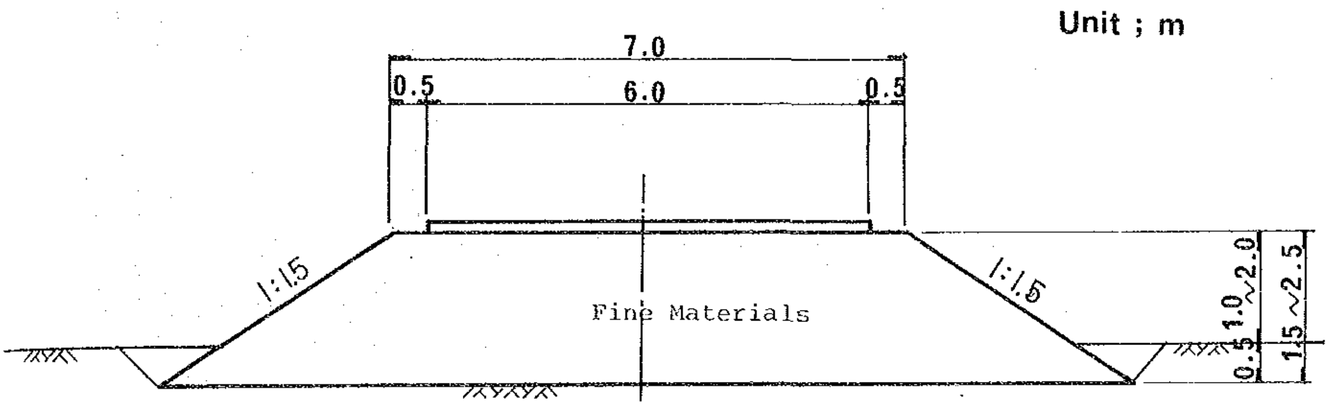
In planning road network for the Project the feasibility of two plans have been studied:

Plan A: To design the effective width B = 6 m for access road and B = 4 m for in-farm road

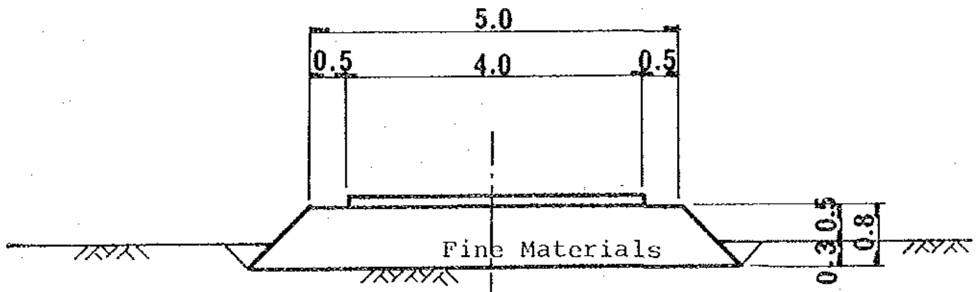
Plan B: To design the effective width B = 5 m to cover all roads proposed

Cross section for each plan is as shown below:

Plan A



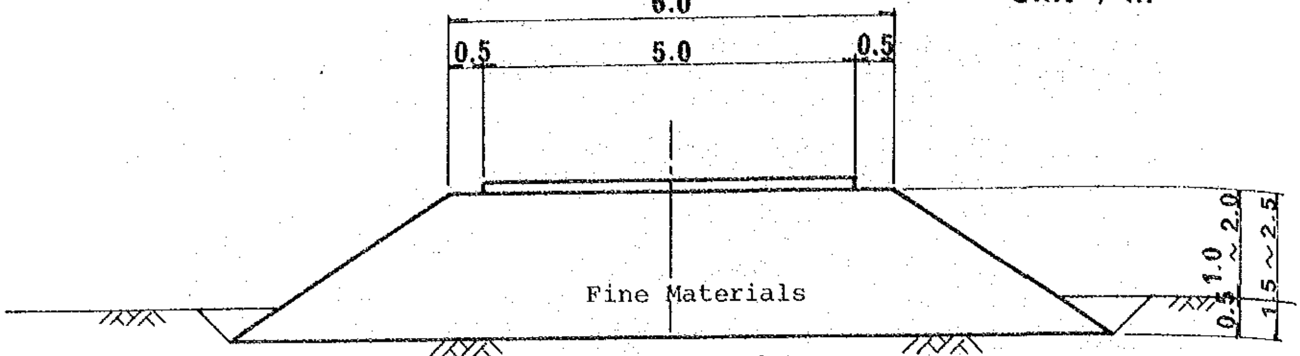
Access Road



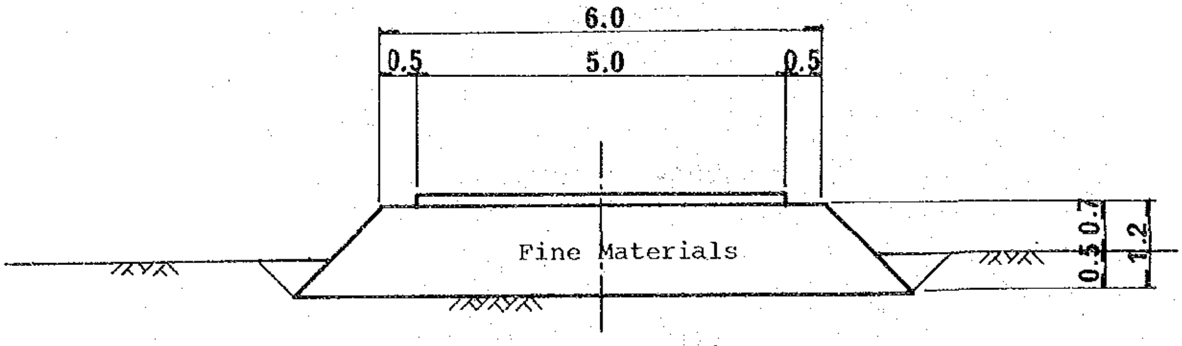
In-farm Road

Plan B

Unit ; m



Access Road



In-farm Road

Construction cost for each plan has been estimated as follows:

Unit: m

Description	Plan A	Plan B
Access Road (B = 6^{m})	37,150	-
" (B = 5)	-	37,150
Infarm Road (B = 5)	-	42,050
" (B = 4)	42,050	-
Total	79,200	79,200

Route layout: refer to Fig. S-1, Main Report

Cost x 1000 Lps

Description	Plan A	Plan B
Access Road (B = 6)	13,277	-
Stripping	(604)	(-)
Road Body	(9,213)	(-)
Gravel Surfacing	(1,895)	(-)
Bridge	(913)	(-)
Others	(632)	(-)
Access Road (B = 5)	-	11,766
Stripping	(-)	(538)
Road Body	(-)	(8,203)
Gravel Surfacing	(-)	(1,687)
Bridge	(-)	(778)
Others	(-)	(560)
In-farm Road (B = 5)	-	7,590
Stripping	(-)	(349)
Road Bed	(-)	(3,952)
Gravel Surfacing	(-)	(2,258)
Bridge	(-)	(670)
Others	(-)	(361)
In-farm Road (B = 4)	5,302	-
Stripping	(221)	(-)
Road Bed	(2,503)	(-)
Gravel Surfacing	(1,430)	(-)
Brdige	(536)	(-)
Others	(612)	(-)
Total	18,579	19,356

Maintenance x 1,000 Lps.

Description	Plan A	Plan B
Leveling	29.8	30.1

In view of cost saving both construction and maintenance phases the Plan A has been employed for this Project.

4. Comparison of Water Resources for Irrigation System - River Surface Water and Groundwater

The capitioned comparison is made as follows:

Given: 1. Groundwater reserves within the project area is enough to supply irrigation water

2. The available volume of water by pumping up is 2,000 m^3/day in alluvial plain and 500 m^3/day in diluvium terrace.

Based on the above given conditions, the following four alternative plans have been studied.

Case A : All irrigation system will be covered by gravity of river surface water except some terrace area where water will be supplied by pumping up. (Plan employed in our study)

Case B : All irrigation system will be covered by groundwater (irrigable area will be the same as the Case B)

Case C : All irrigation system will be covered by gravity of river surface water except some terrace area where will be irrigated by groundwater.

Case D : In addition to Case A, irrigable area will be increased by means of the utilization of goundwater.

Alternative Plan / Item	Case A	Case B	Case C	Case D	Remarks
Irrigation Facilities					
Irrigation Area	ha 9,100	ha 9,100	ha 9,100	*1/ ha 12,300	
Head Works	4	-	4	4	
Booster Pump	2	-	-	2	
Deep Well (Alluvium)	-	300 pcs	50 pcs	-	
Deep Well (Diluvium)	-	250 pcs	250 pcs	490 pcs	
Construction Cost					
Head Works	8,700	-	8,700	8,700	
Booster Pump Station	3,900	-	-	3,900	
Deep Well	-	40,100	23,100	38.700	Include pump
Main Canal	12,000	-	8,200*2	12,000	
Secondary Canal	3,000	3,000	3,000	3,800	
Drainage Canal	4,200	4,200	4,200	4,200	
Road	29,200	29,200	29,200	29,200	
Land Reclamation	17,900	93,900	93,800	123,500	
Sub Total	78,900	93,900	93,800	123,500	
Project Cost	126,200	150,200	150,100	197,600	Construction cost x 1.6
Annual Cost	25,200	30,040	30,020	39,520	Construction period = 5 years
Annual Operation and Maintenance Cost					
Maintenance Cost for					
Civil works	220	270	280	360	
O/M cost o Equipment	1,010	1,020	1,020	1,020	
Running Cost of Pumps	170	2,620	1,270	2,130	
Total	1,410	3,910	2,570	3,510	

Alternative Plan / Item	Case A	Case B	Case C	Case D	Remarks
Replacement Cost					
Pump	2,570	5,340	2,740	4,360	
(Annual Depreciation Cost)	(128)	(267)	(137)	(218)	20 years
Gates	814	-	*2/ 556		814
(Annual Depreciation Cost)	(27)	(-)	(19)	(27)	30 years
Total	155	267	156	244	
Benefit					
Net Return on Irrigation Area	24,400	24,400	24,400	33,000	2,680 Lps/ha
Net Return on Non-irrigation area	7,200	7,200	7,200	3,700	1,070 Lps/ha
A Total Net REturn	31,600	31,600	31,600	36,700	A=15,800 ha
B Present Net Return	1,900	1,900	1,900	1,900	A = 2,670 ha
Benefit	29,700	29,700	29,700	29,700	A - B
Cost-Benefit Analysis					
Net Present Value (Cost)	109,735	142,267	135,008	178,298	Project Life = 40 years
Net Present Value (Benefit)	148,112	148,038	148,038	173,958	
B/C	1,350	1,041	1,097	0,976	
B-C	38,377	5,772	13,030	-4,340	

*1/ Includes arable land on the right bank of the Aguan River
*2/ Excludes some 2,800 ha of pressed pumping area

Operation cost for pumping up groundwater is as estimated below:

	Alluvial Plain	Diluvial Terrace
Intake volume per well (m^3/day)	2,000	500
Irrigable area per well (ha)	25	6.5
Diameter of well (mm)	250	200
Depth of well (m)	20	50
Pump capacity (m^3/min.)	1.5	0.35
Motor capacity (KW)	15	11
Annual operation time *1)(hour)	2,070	2,070
Annual Consumption of electricity per well (KWH)	31,050	22,700
Annual Operation Cost *2) (Lempira)	5,400	4,000

*1) 23 hr x 30 days x 3 months

*2) Unit Price : 0.174/KWH

5 Comparative Analysis of Earth Canal and Concrete Canal

1) Fundamentals

The following factors have to be taken into account, when comparing the economical efficiency of earth canal and that of concrete canal.

(1) configuration of canal's cross-section acording to the type of material

(2) difference of the volume of water flow according to conveyance effieicncy

(3) area of cross-section acording to the coefficient to roughness.

(4) cost of canal construction works and appurtenant works according to the difference of canal's corss-section

(5) cost of maintenance

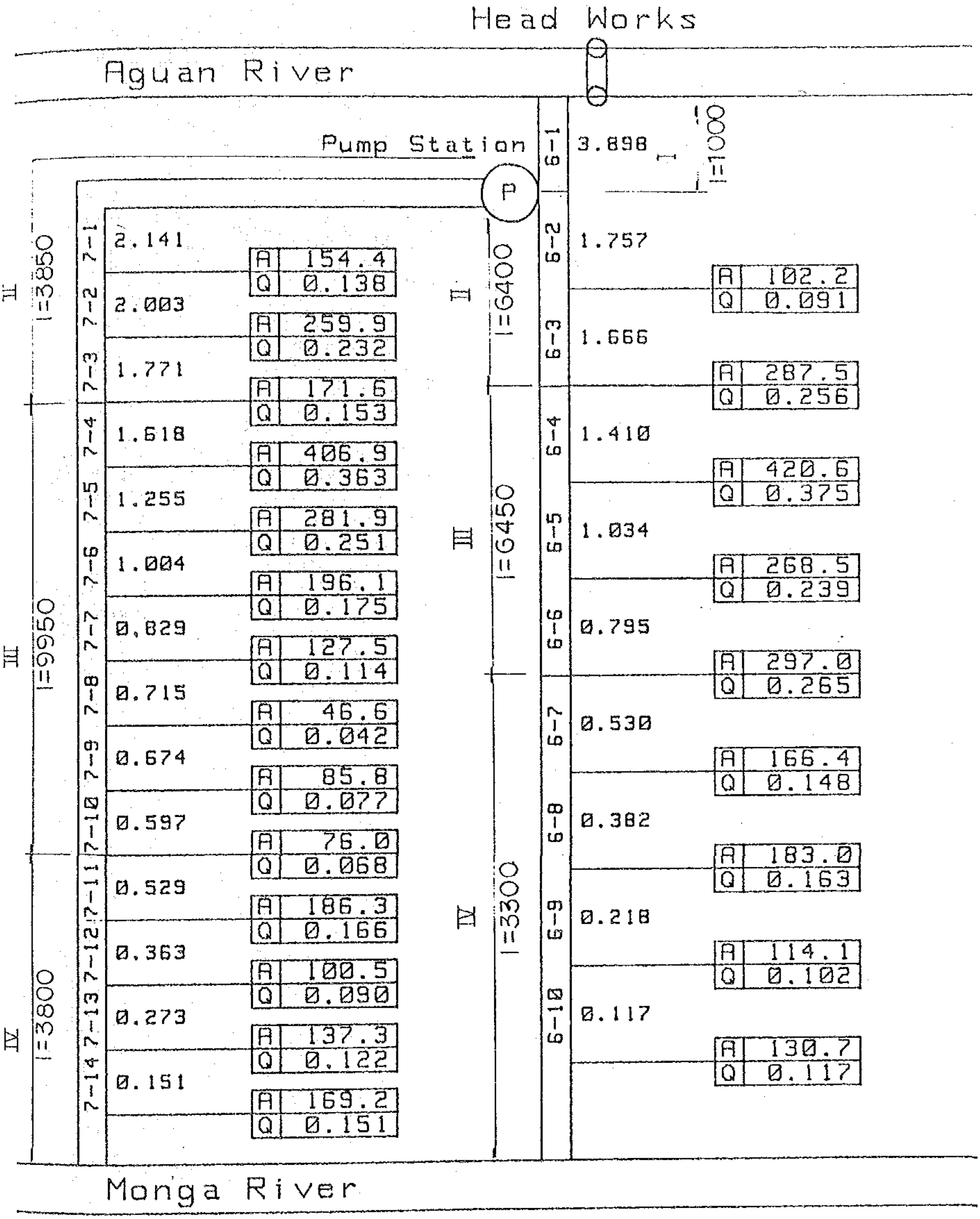
(6) the life of canal

Earth and concrete canals are then compared in terms of these basic factors, given the following conditions.

Item	Earth canal	Concrete canal
Conveyance efficiency	0.8	0.9
coeffiient of roughness	0.03	0.015
Canal slope gradient	1:2.0	1:2.0
Rate of maintenance cost	0.8%	0.5%
Durable period	10 years	15 years

2) Water Supply System

The irrigation area and a scheme of water supply system in Aguan Mid - Stream Block (D Block), which encompasses largest area in this project, are illustrated in next page.


Head Works
Aguan River
Pump Station
P
l=1000
6-1
3.898
6-2
1.757
A 102.2
Q 0.091
6-3
1.666
A 287.5
Q 0.256
6-4
1.410
A 420.6
Q 0.375
6-5
1.034
A 268.5
Q 0.239
6-6
0.795
A 297.0
Q 0.265
6-7
0.530
A 166.4
Q 0.148
6-8
0.382
A 183.0
Q 0.163
6-9
0.218
A 114.1
Q 0.102
6-10
0.117
A 130.7
Q 0.117
II l=6400
III l=6450
IV l=3300
II l=3850
III l=9950
IV l=3800
7-1
2.141
A 154.4
Q 0.138
7-2
2.003
A 259.9
Q 0.232
7-3
1.771
A 171.6
Q 0.153
7-4
1.618
A 406.9
Q 0.363
7-5
1.255
A 281.9
Q 0.251
7-6
1.004
A 196.1
Q 0.175
7-7
0.829
A 127.5
Q 0.114
7-8
0.715
A 46.6
Q 0.042
7-9
0.674
A 85.8
Q 0.077
7-10
0.597
A 76.0
Q 0.068
7-11
0.529
A 186.3
Q 0.166
7-12
0.363
A 100.5
Q 0.090
7-13
0.273
A 137.3
Q 0.122
7-14
0.151
A 169.2
Q 0.151
Monga River

3) Canal Dimensions

Earth Canal

Type	Canal slope	B	h	Q	V	H	Remarks
I	1,2,500	1.50	1.50	3.90	0.58	1.80	Slope gradient
II	1/2,000	1.00	1.20 - 1.06	2.20 - 1.65	0.55 - 0.52	1.40	1:20
III	"	0.75	1.00 - 0.65	1.65 - 0.55	0.48 - 0.38	1.20	Coefficient of roughness
IV	"	0.50	0.70 - 0.46	0.55 - 0.2	0.38 - 0.30	0.90	n : 0.03

Concrete Canal

Type	Canal slope	B	h	Q	V	H	Remarks
I	1/2,500	1.20	1.32	3.44	1.02	1.70	Slope gradient
II	1/2,000	1.00	1.20 - 0.87	2.80 - 1.45	1.06 - 0.90	1.40	1:1.0
III	"	0.75	0.95 - 0.40	1.45 - 0.2	0.90 - 0.55	1.15	Coefficient of roughness
IV	"	0.50	0.65 - 0.40	0.50 - 0.2	0.70 - 0.55	0.85	n = 0.015

4) Volume and Cost of Works

Type of Works	Earth Canal		Concrete Canal		Remarks
	Volume	Cost	Volume	Cost	
Excavation	405,570 m^3	932,811	279,372	642,556	
Embankment	63,072 "	145,066	63,072	145,066	
Disposal of Surplus Soil	342,501 "	822,002	216,299	519,118	
Concrete	-	-	37,792	4,126,886	
Form	-	-	115,810	4,053,350	
Appurtenant Works	*1 one set	1,478,402	*2 one set	887,041	
Total		3,378,281		10,374,017	
Other Related Works		184,719		517,933	about (5% of the total cost)
Grand Total		3,563,000		10,892,000	

*1 Calculated from the cost of appurtenant works involved in the Phase I works, in proportion to the length of canal.

*2 60% of earth canal (equal to the proportion of cross sectional area of flow.)

5) Maintenance Cost

Ratio of maintenance cost against construction cost is assumed below, according to the structure of canal, on the basis of which, the total annual cost required for canal maintenance is calculated.

Earth canal: 0.8 %/year of Construction Cost - 28,504 Lps./year

Concrete Canal: 0.5% year of Construction Cost - 54,460 Lps./year

6) Average Annual Amount of Reimbursement

Average annual amount of reimbursement is calculated in the following equation, with the life of earth canal and concrete canal fixed at 10 and 15 years respectively, and interest rate at 6%.

$$Dc = IC \times \quad i + \frac{i}{(1+i)^{n}-1}$$

where:
- Dc : Annual Amount of Reimbursement
- Ic : Construction Cost
- i : Interest Rate
- n : Length of Life

Earth Canal = 484,000 Lps./year

Concrete Canal = 1,121,000 Lps./year

7) Comparison of Economic Efficiency

Structure of canal	Construction cost	Maintenance cost	Annual cost of reimbursement	Total
Earth canal	3,563,000	29,000	484,000	513,000
Concrete Canal	10,892,000	54,000	1,121,000	1,175,000

8) Conclusion

We may thus conclude, from the above examinations, that the concrete canal would not be very profitable in every terms of construction cost, maintenance cost and annual amount of reimbursement, although the cross sectional area would be reduced by 60% compared with that of earth canal.

II. WATER REQUIREMENTS

1. Cropping Pattern Model

Maize, and beans are identified as proposed crops because they might be basic crops at the initial development stage as well as the future of this project area. And rice is also identified because it requires relatively large volume of water.

The share of area for each combination of crops is assumed as follows:.

60% .... Rice and maize

40% .... Rice and beans

The cropping stage has been decided after simulation for several cases had been made considering effective rainfall and river discharge. Fig. F-II-1 shows the most effective cropping pattern for water use.

2. Crop Water Requirements (ET crop)

(1) Potential Evapotranspiration (ETo)

For calculating the mean monthly ETo four methods:

Class A pan, Hargreaves and Samani, Blaney Criddle and Penman will be presented. The results of this calculation are shown in Table F-II-1 (see Fig. 4-10 of Main Report).

And the design ETo of 2, 3, 5 and 10 years return period has been analyzed probabilistically by Hergreaves method using 10 years data by month. (See Fig. F-II-2 and Tables F-II-2 and F-II-3.)

(2) Crop Coefficient (Kc)

In accordance with "Guidelines for Predicting Crop Water Requirements (FAO 1977)", the "Kc" of the development stage for each crop has been estimated as Fig. F-II-3 to Fig. F-II-5.

(3) Crop Water Requirements (Et crop)

The crop water requirements (ET crop) can be calculated by multiplying (ETo) by (Kc) on each stage. And the crop water requirement of the unit area, have been calculated by multiplying the share of cultivated area by ET crop of each crop.

The results are shown in Table F-II-4 to Table F-II-7.

3. Design Rainfall and Effective Rainfall

The design rainfall and the effective rainfall for 2, 3, 5 and 10 years return period's has been estimated using eleven years' data of the station in Olanchito. (See Fig. F-II-6 and F-II-7).

4. Irrigation Water Requirements

The net irrigation water requirements have been estimated by deducting effective rainfall from the crop water requirement. The results are shown in Table F-II-10.

The gross irrigation water requirements have been estimated by dividing the net irrigation water requirements by Project efficiency (Ep = 0.38). And the maximum total gross irrigation water requirements, which is required on March, of each block have been calculated by multiplying unit water requirement by area. The results are shown in Table 4-5 of Main Report.

5. River Discharge for Drought

The discharge of each intake point have been estimated based on discharge at Pte. Saba. The annual discharge pattern is shown in Fig. F-II-8 as an example for 2 years return period. And H-Q curve at Pte. Saba is shown in Fig. F-II-9. The river discharge for 2, 3, 5 and 10 years return period at each intake point are shown in Table 4-6 of Main Report.

6. Economical Water Supply

The basic data for estimation of analyzing for economical water supply are shown in Table F-II-11 to F-II-14.

7. Water Requirement for the Proposed Cropping Patterns

For calculating water requirement the following cases were set out.

Case - 0 : Cropping pattern model shown in Fig. F-II-1

Case - 1 : Case 1 presented in Land Use Plan of Main Report

Case - 2 : Case 2 presented in Land Use Plan of Main Report

Case - 3 : Case 3 presented in Land Use Plan of Main Report

Case - 4 : Case 4 presented in Land Use Plan of Main Report

Case - 5 : Case 5 shown in Table E-I-1 of Appendix E

Water requirements for each case are calculated based on 5 years return period and the results are as shown in Tables F-II-15 to F-II-20.

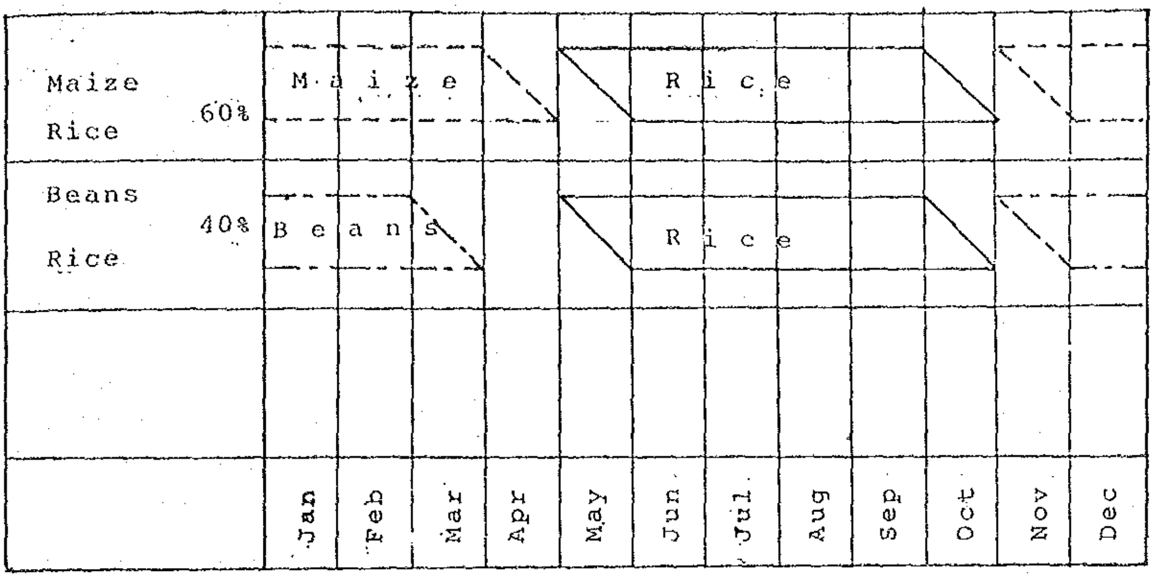


Fig. F-II-1 CROPPING PATTERN MODEL

Notes

1st crop	-	2nd crop		
Rice	-	Maize	----------	60%
Rice	-	Beans	----------	40%

Total

Rice	100%
Maize	60%
Beans	40%
	200%

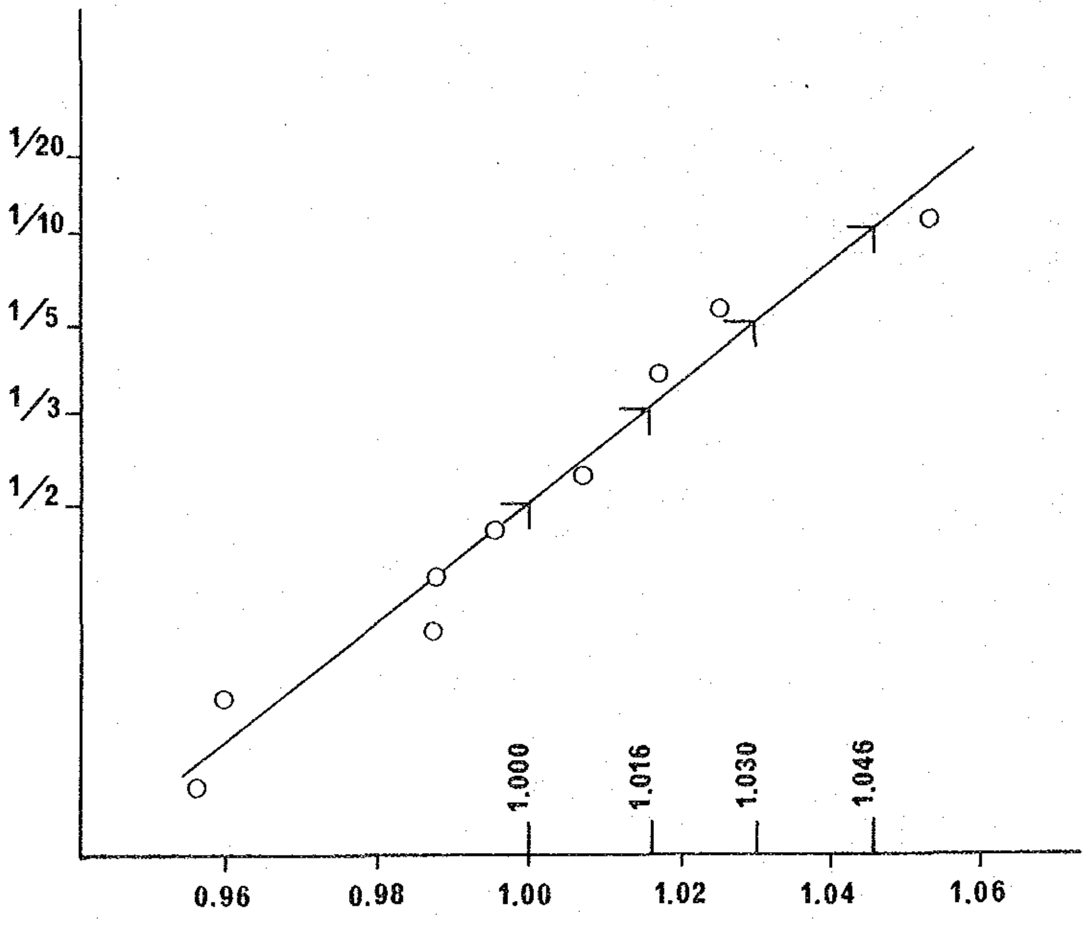


Fig. F-II-2 PROBABILITY FOR ET / ET mean

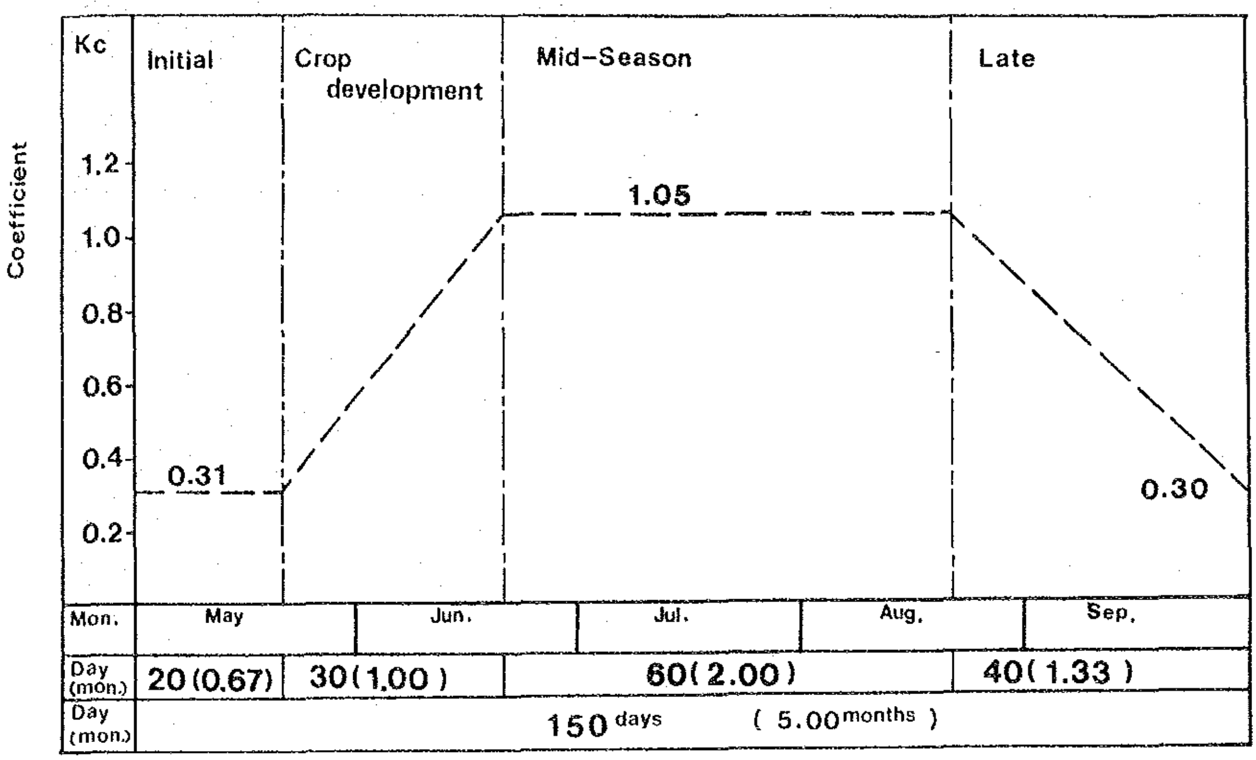
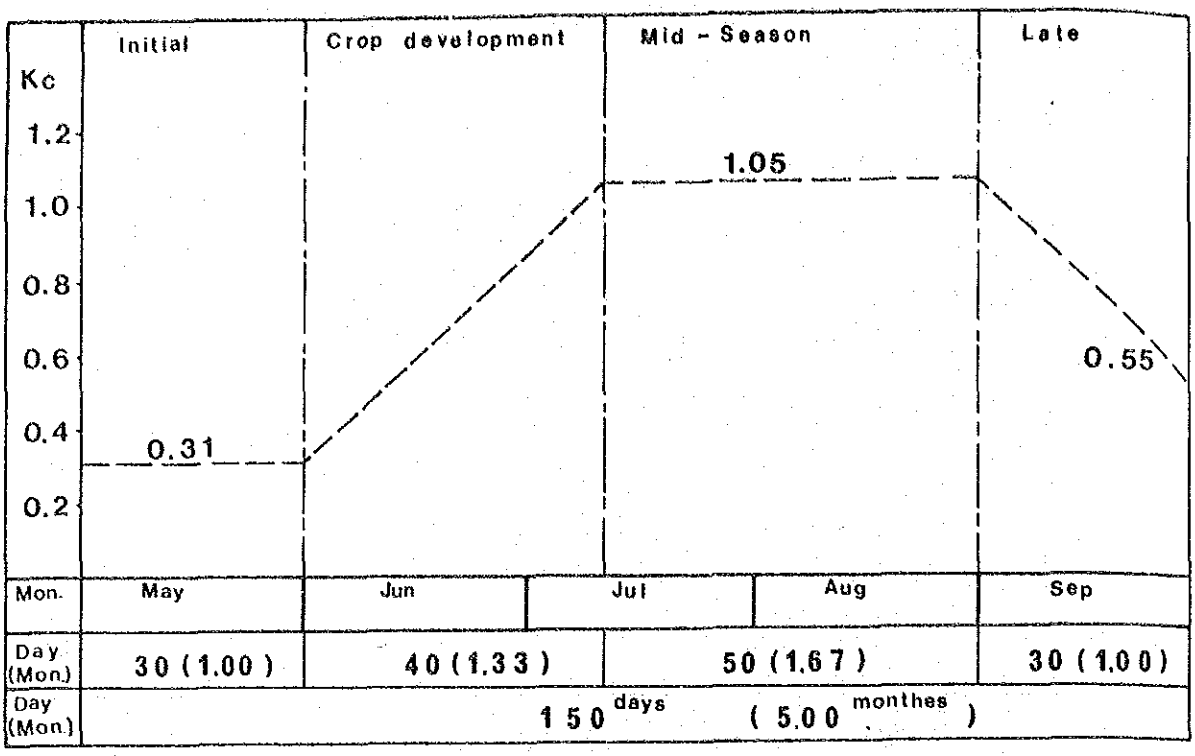


Fig. F-II-3 Crop Coefficient Curve (Rice)



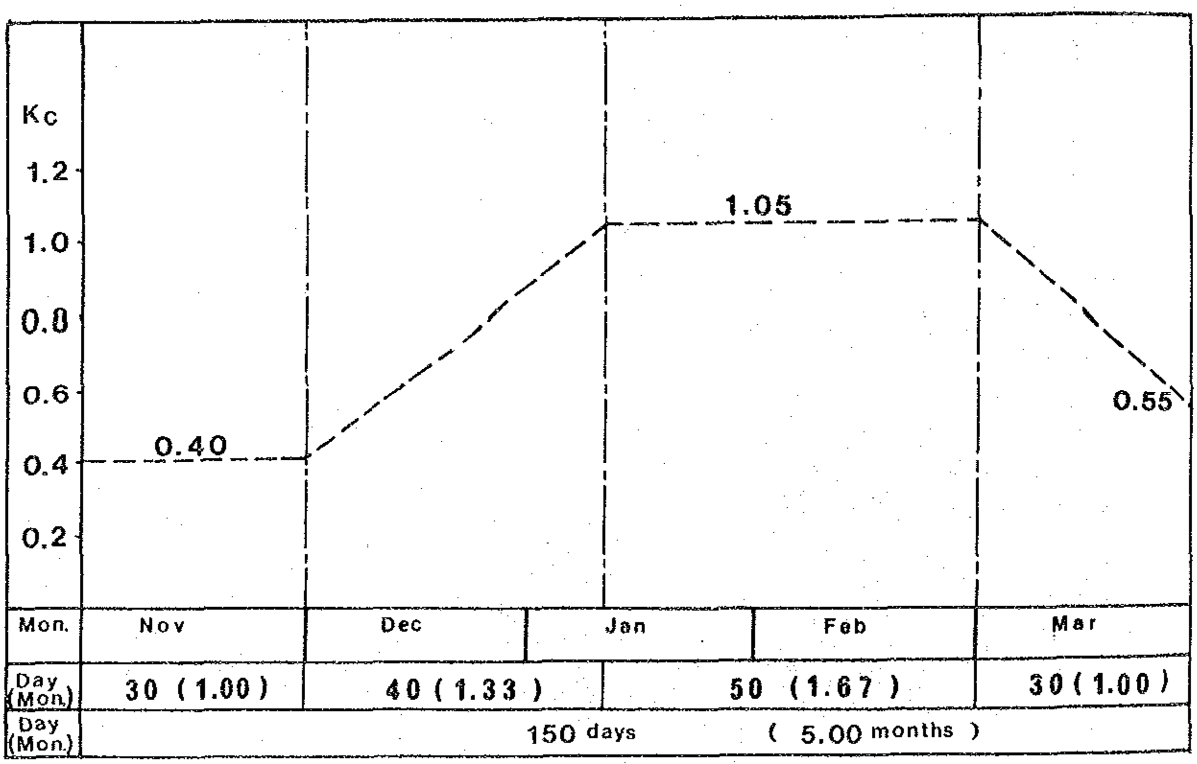
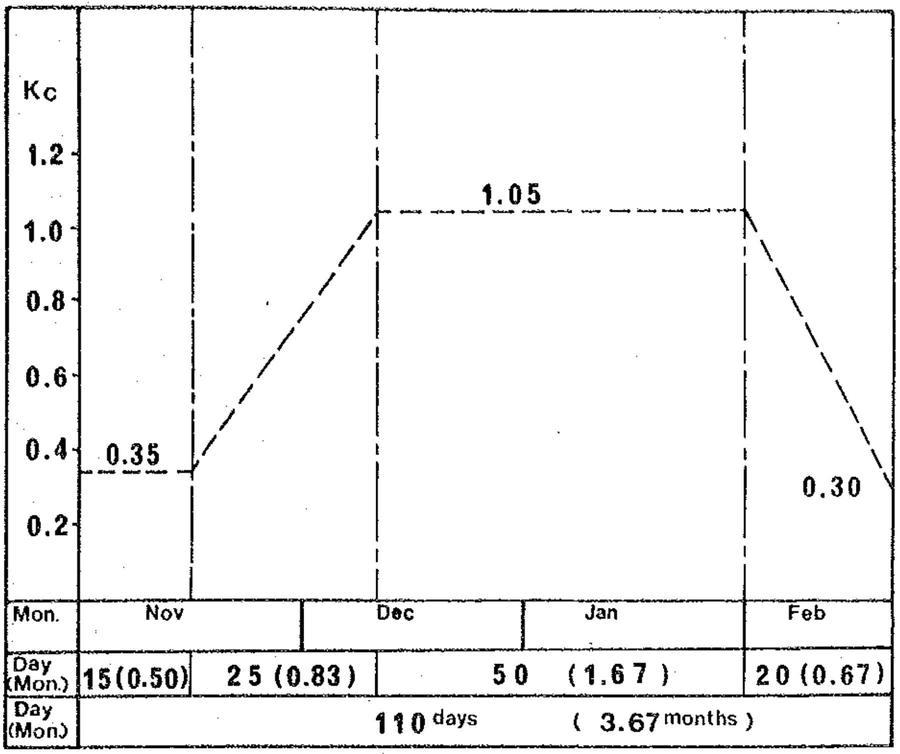


Fig. F-II-4 Crop Coefficient Curve (Maize)



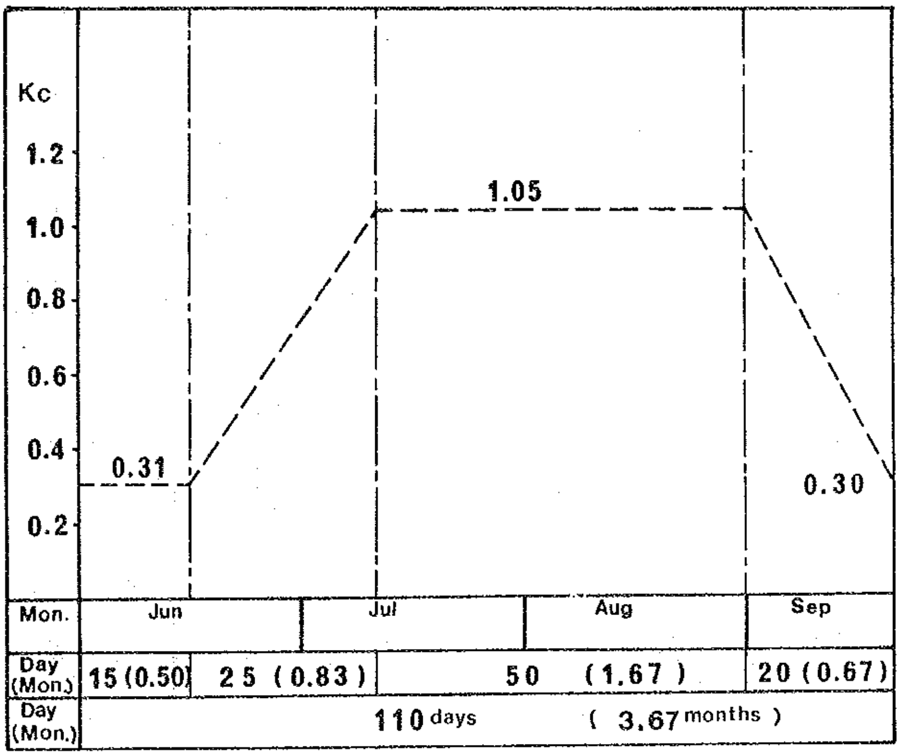


Fig. F-II-5 Crop Coefficient Curve (Beans)

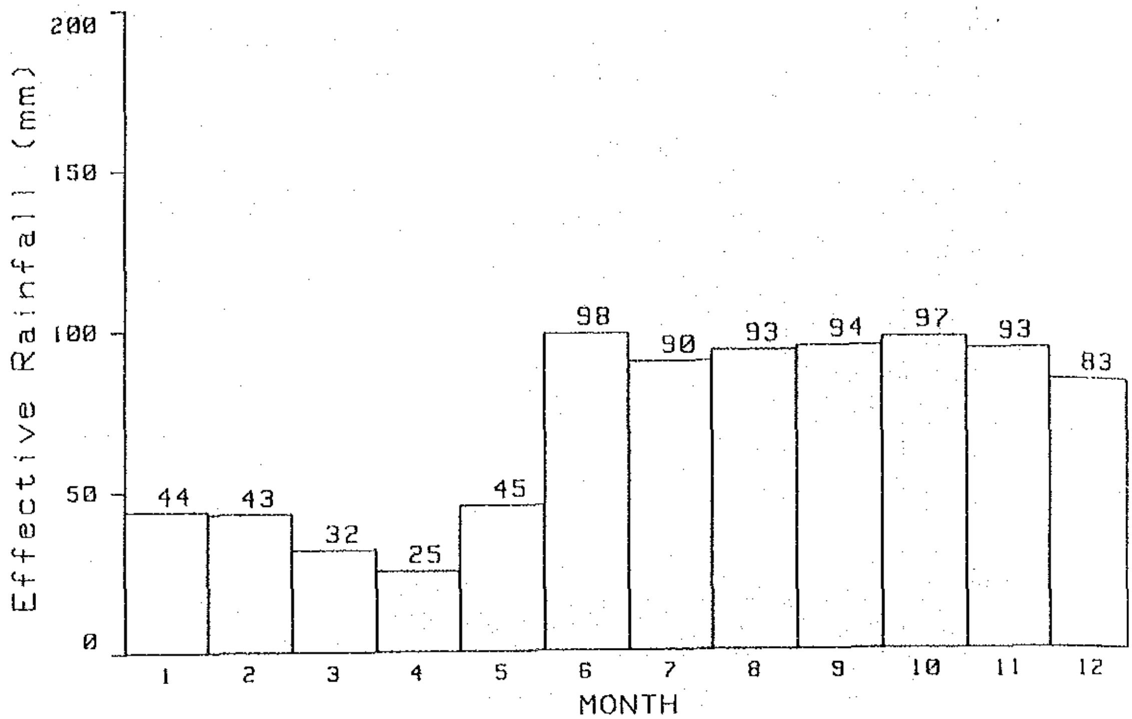


Fig. F-II-6 Effective Rainfall

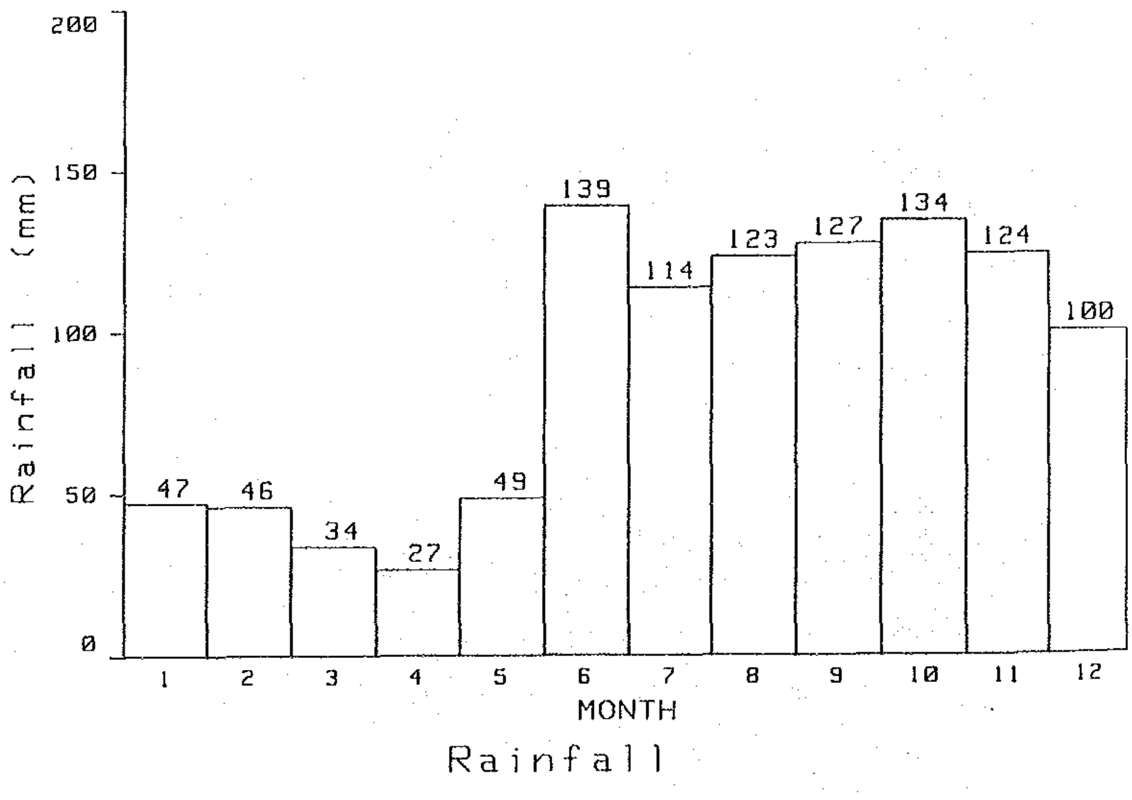


Fig. F-II-7 Design and Effective Rainfall (1:2 Return Period)

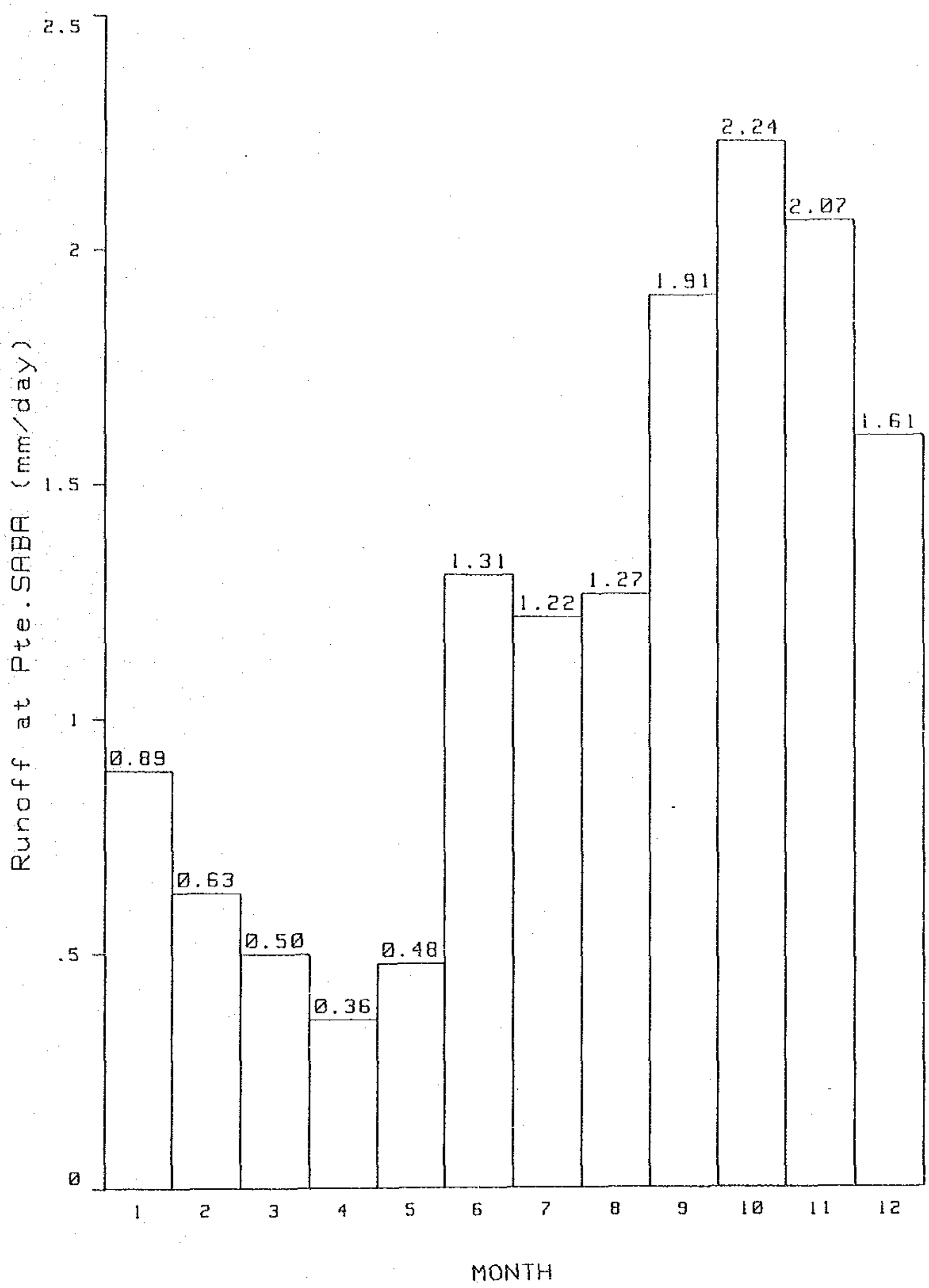
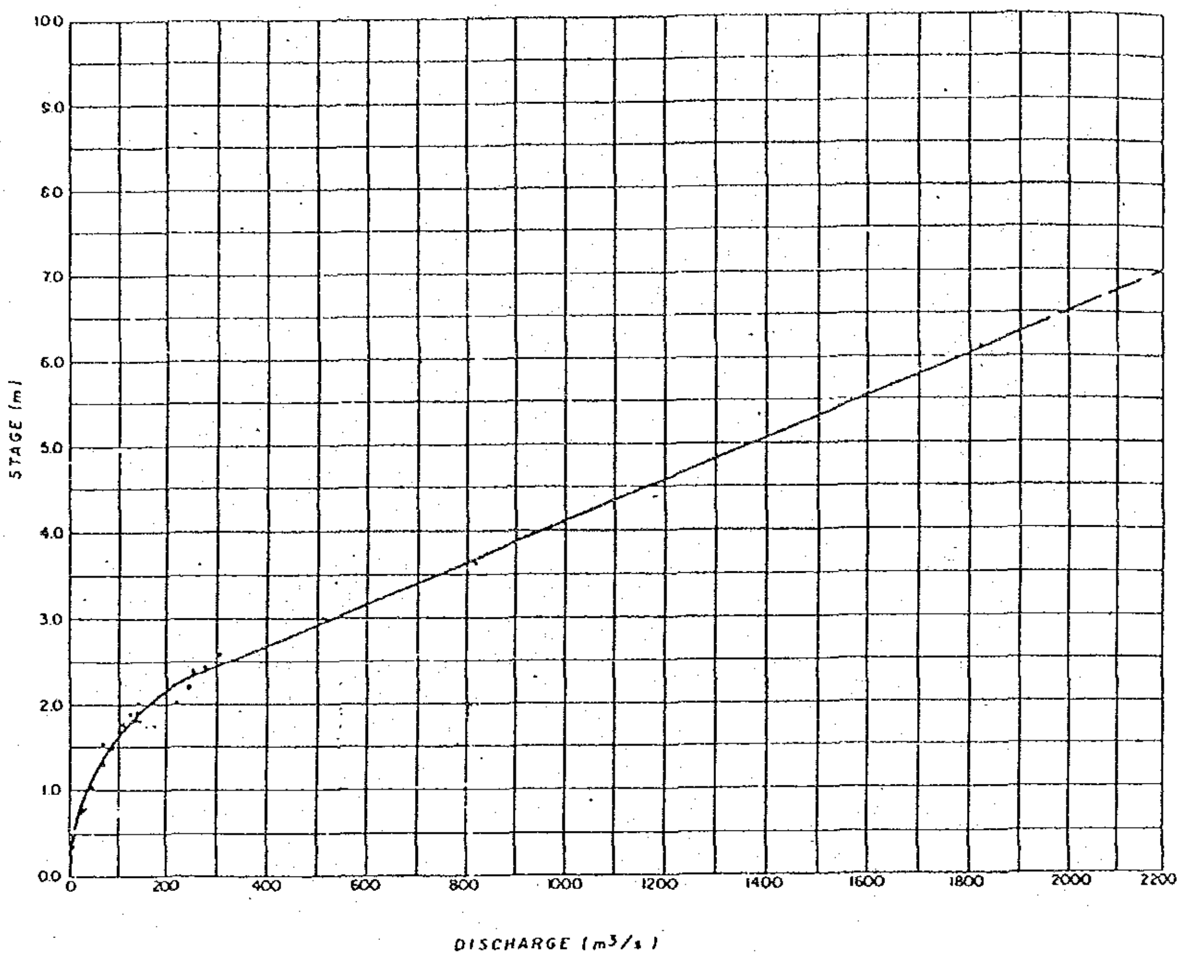


Fig. F-II-8 Mean Monthly Runoff at Pte. Saba (1:2 Return Period)



EQUATION OF CURVE

$Q = 25.96 (H + 0.125)^{2.63}$, $H < 3.64$

$Q = 399.67H - 617.64$, $H > 3.64$

Table F-II-9 Stage-Discharge Curve for the Aguan River at Pte. SABA

Source: The Hydrauric Master Plan for the Aguan River Basin

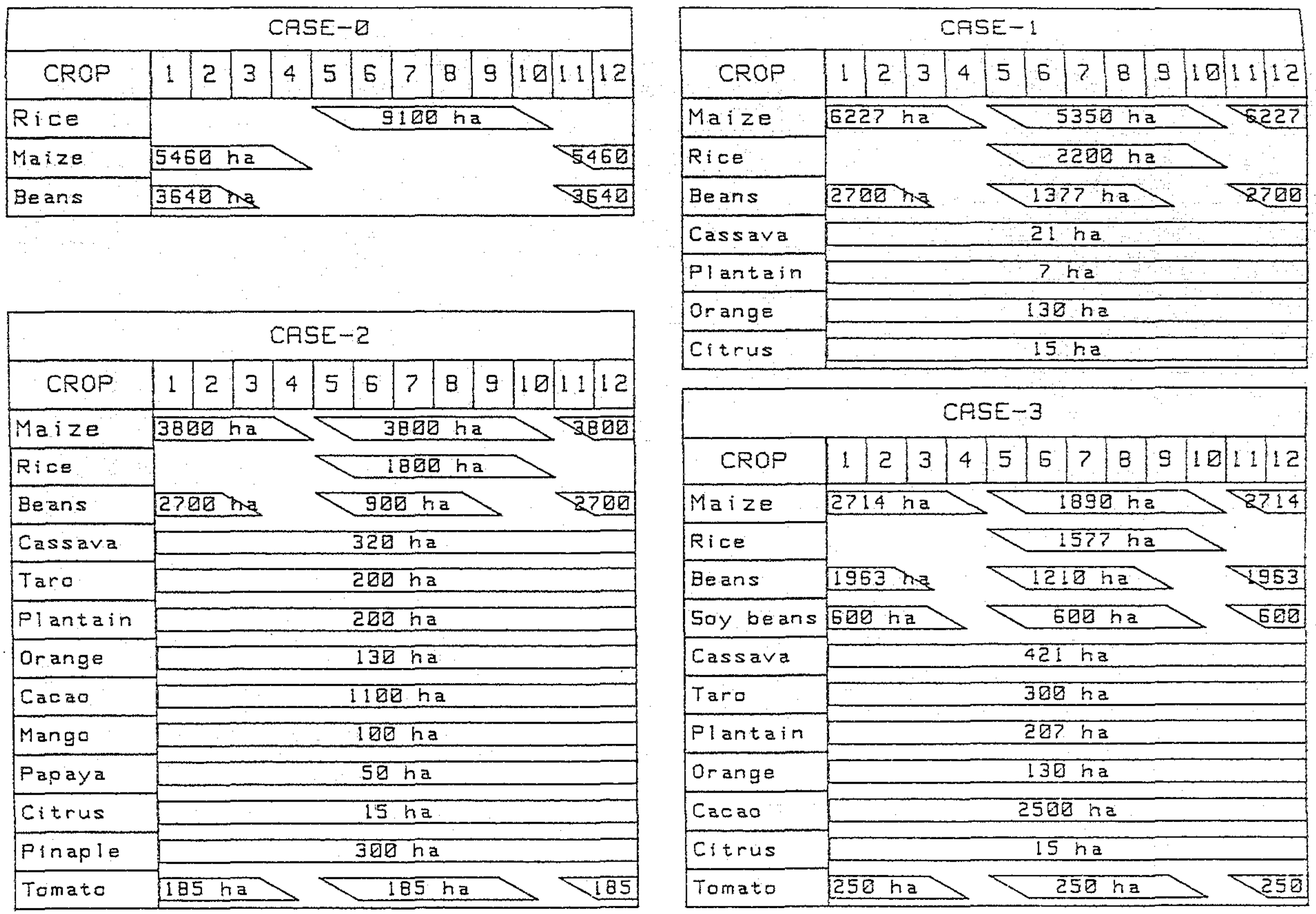


Fig. F-II-10 (i) Cropping Pattern

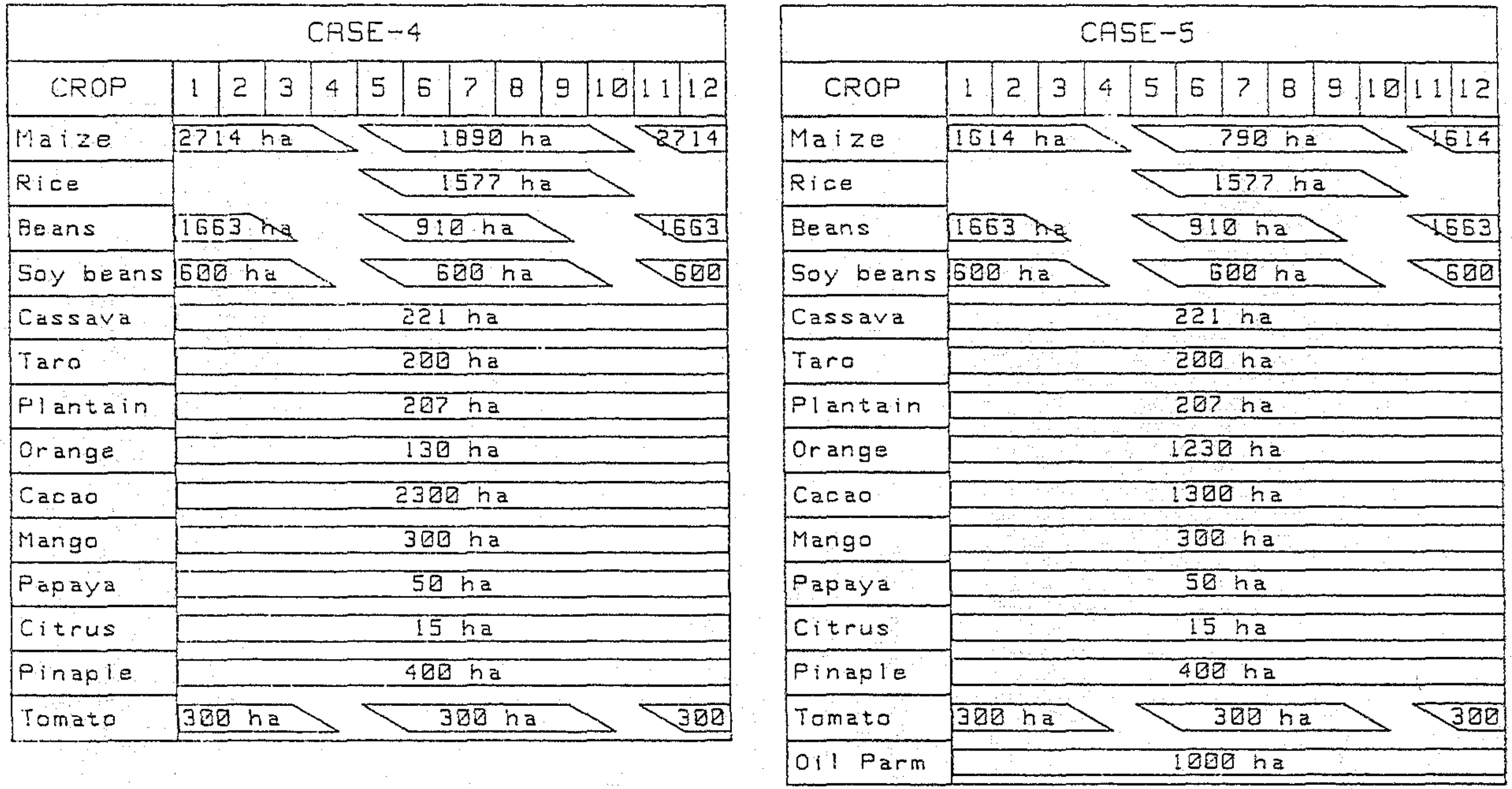


Fig. F-II-10 (ii) Cropping Pattern

Table F-II-1 Monthly Potential Evapotranspiration

Average of 1973 - 1983 (11 years)

Method / Month	Master Plan (Irrigation) Class A Pan (mm)	Master Plan (Irrigation) Hargreaves (mm)	Master Plan (Irrigation) Blaney Criddle (mm)	Penman (mm)	Mean Estimate ETo (mm)
Jan.	97	105	105	111	105
Feb.	113	126	105	126	118
Mar.	168	162	168	182	170
Apr.	174	183	180	192	182
May	180	195	195	198	192
Jun.	143	159	141	161	151
Jul.	141	150	138	157	147
Aug.	149	150	132	161	148
Sep.	134	141	132	145	138
Oct.	112	123	123	126	121
Nov.	91	105	121	96	103
Dec.	87	96	105	94	96
Annual	1,589	1,695	1,645	1,749	1,671

Table F-II-2 Design Evapotranspiration

(mm/month)

Month \ Return Period	1/2 * (1.000)	1/3 (1.016)	1/5 (1.030)	1/10 (1.046)
Jan.	105	107	108	110
Feb.	118	120	122	123
Mar.	170	173	175	178
Apr.	182	185	187	190
May	192	195	198	201
Jun.	151	153	156	158
Jul.	147	149	151	154
Aug.	148	150	152	155
Sep.	138	140	142	144
Oct.	121	123	125	127
Nov.	103	105	106	108
Dec.	96	98	99	100

* ( ) : Ratio against mean ET°

Table F-II-3 Probability for Potential Evapotranspiration

(mm/Month) (Hargreaves)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1973	128.2	136.1	167.4	197.2	210.3	189.7	188.0	184.7	166.8	155.0	114.9	118.4	1,956.7
74	131.3	140.5	184.1	167.7	214.8	196.8	178.7	172.9	162.3	135.4	120.6	117.5	1,922.5
75	127.3	139.8	186.0	204.6	222.2	206.2	203.4	182.7	157.8	149.1	119.7	112.5	2,011.3
76	112.9	124.3	179.2	194.7	216.6	175.3	178.2	187.8	168.8	160.1	125.8	118.6	1,942.3
77	-	-	188.4	180.5	196.9	167.7	166.3	182.2	170.7	-	-	124.1	-
78	123.3	128.6	164.1	192.4	214.3	180.0	167.9	175.2	159.5	150.0	124.1	120.0	1,899.4
79	127.6	128.6	172.6	187.9	213.1	168.0	179.3	171.2	157.2	149.1	117.5	112.0	1,884.1
80	126.5	131.0	180.7	182.1	209.9	171.3	173.2	176.4	168.0	145.3	117.2	104.0	1,886.2
81	114.4	117.3	171.1	179.1	205.4	176.0	169.4	167.4	154.3	147.1	112.0	115.0	1,825.0
82	122.9	134.4	173.5	198.2	194.8	165.3	158.6	161.4	150.5	139.3	118.0	113.2	1,830.5
83	119.8	135.0	185.2	193.9	214.9	190.7	164.4	162.4	159.3	151.7	130.4	128.1	1,936.3
Mean	123.4	131.9	180.2	188.9	210.3	180.6	175.2	175.0	161.4	148.2	120.0	116.4	1,909.4

No.	ETo	$\frac{ETo}{ETo_m}$	$1-\frac{i}{n-1}$ (%)
1	2,011.3	1.053	90.9
2	1,956.7	1.025	81.8
3	1,942.3	1.017	72.7
4	1,936.3	1.014	63.6
5	1,922.5	1.007	54.5
6	1,899.4	0.995	45.5
7	1,886.2	0.988	36.4
8	1,884.1	0.987	27.3
9	1,830.5	0.959	18.2
10	1,825.0	0.956	9.1

1/T	(%)	ET/ET m
1/2	50	1.000
1/3	67	1.016
1/5	20	1.030
1/10	10	1.046

Table F-II-4 Crop Water Requirement

(mm/month)

Retern Period / Month	1/2			
	Rice-Maize (60 %)	Rice-Beans (40 %)	Total	
Jan.	52.534	43.136	95.670	
Feb.	73.398	35.453	108.851	
Mar.	94.350	15.376	109.726	
Apr.	43.680	0.0	43.680	
May	20.177	13.451	33.624	
Jun.	55.909	37.273	93.182	
Jul.	85.285	56.857	142.142	
Aug.	91.877	61.251	153.128	
Sep.	66.292	44.194	110.486	
Oct.	21.125	14.083	35.208	
Nov.	12.360	9.382	21.742	
Dec.	30.077	28.022	58.099	
Anual			1005.543	

Table F-II-5 Crop Water Requirement

(mm/month)

Retern Period / Month	1/3			
	Rice-Maize (60 %)	Rice-Beans (40 %)	Total	
Jan.	53.375	43.826	97.201	
Feb.	74.572	36.020	110.592	
Mar.	95.860	15.622	111.482	
Apr.	44.379	0.0	44.379	
May	20.500	13.666	34.166	
Jun.	56.804	37.869	94.673	
Jul.	86.650	57.766	144.416	
Aug.	93.347	62.231	155.578	
Sep.	67.352	44.902	112.254	
Oct.	21.463	14.309	35.772	
Nov.	12.558	9.532	22.090	
Dec.	30.559	28.471	59.030	
Anual			1021.633	

Table F-II-6 Crop Water Requirement

(mm/month)

Retern Period / Month	1/ 5			
	Rice-Maize (60 %)	Rice-Beans (40 %)	Total	
Jan.	54.110	44.430	98.540	
Feb.	75.600	36.517	112.117	
Mar.	97.181	15.838	113.019	
Apr.	44.990	0.0	44.990	
May	20.782	13.855	34.637	
Jun.	57.587	38.391	95.978	
Jul.	87.844	58.562	146.406	
Aug.	94.633	63.089	157.722	
Sep.	68.281	45.520	113.801	
Oct.	21.759	14.506	36.265	
Nov.	12.731	9.663	22.394	
Dec.	30.980	28.863	59.843	
Anual			1035.712	

Table F-II-7 Crop Water Requirement

(mm/month)

Retern Period / Month	1/ 10			
	Rice-Maize (60 %)	Rice-Beans (40 %)	Total	
Jan.	54.951	45.120	100.071	
Feb.	76.774	37.084	113.858	
Mar.	98.690	16.084	114.774	
Apr.	45.689	0.0	45.689	
May	21.105	14.070	35.175	
Jun.	58.481	38.987	97.468	
Jul.	89.389	59.472	148.861	
Aug.	96.103	64.069	160.172	
Sep.	69.341	46.228	115.569	
Oct.	22.097	14.731	36.828	
Nov.	12.929	9.813	22.742	
Dec.	31.461	29.321	60.773	
Anual			1051.881	

Table F-II-8 Design Rainfall (Drought)

(mm/month)

Retern Period / Month	1/2	1/3	1/5	1/10
Jan.	47.2	41.3	37.0	32.6
Feb.	46.2	40.5	36.2	31.9
Mar.	33.8	29.7	26.5	23.4
Apr.	26.6	23.3	20.8	18.4
May	48.7	42.7	38.1	33.6
Jun.	139.0	121.8	108.9	96.0
Jul.	113.7	99.6	89.1	78.5
Aug.	123.2	108.0	96.5	85.1
Sep.	127.1	111.4	99.6	87.8
Oct.	134.3	117.6	105.2	92.7
Nov.	124.0	108.6	97.1	85.6
Dec.	100.2	87.8	78.5	69.2
Anual	1064.0	932.3	833.5	734.8

Table F-II-9 Design Effective Rainfall

(mm/month)

Retern Period / Month	1/2	1/3	1/5	1/10
Jan.	44.0	38.7	34.8	30.8
Feb.	43.1	38.0	34.1	30.2
Mar.	31.9	28.1	25.2	22.3
Apr.	25.2	22.2	20.0	17.7
May	45.4	39.9	35.9	31.7
Jun.	98.3	92.4	87.6	80.9
Jul.	89.5	83.1	76.6	69.4
Aug.	92.8	87.2	81.3	73.9
Sep.	94.0	88.6	83.1	75.7
Oct.	96.7	91.0	86.0	78.9
Nov.	93.1	87.5	81.6	74.3
Dec.	83.5	75.8	69.5	62.4
Anual	837.5	772.5	715.7	648.2

Table F-II-10 Net Water Requirement

(mm/Month)

Return Period / Month	1/2	1/3	1/5	1/10
Jan.	51.667	57.451	63.765	69.305
Feb.	65.702	72.599	78.023	83.698
Mar.	77.807	83.413	87.855	92.480
Apr.	18.439	22.142	25.006	27.984
May	-	-	-	3.454
Jun.	-	2.299	8.407	16.523
Jul.	52.661	61.278	69.851	79.242
Aug.	60.303	68.407	76.449	86.232
Sep.	16.471	23.672	30.675	39.848
Oct.	-	-	-	-
Nov.	-	-	-	-
Dec.	-	-	-	-
Annual (mm/year)	343.0	391.3	440.0	498.8
Annual (m^3/ha/year)	3,430	3,913	4,400	4,988

Cropping pattern　　Rice - Maize　60%

Rice - Beans　40%

Table F-II-11 Assumption of Construction Cost for the Establishment of Design Year

A = 9,105 ha

Unit Lps

	Return Period			
	1/2	1/3	1/5	1/10
Canal	18,100,000	18,900,000	19,260,000	19,840,000
Pump	4,930,000	4,930,000	4,930,000	4,930,000
Head Work	3,530,000	3,530,000	3,530,000	3,530,000
Total	26,560,000	27,360,000	27,720,000	28,300,000
Unit Cost Per ha	2,920	3,000	3,040	3,110

Table F-II-12 Assumption of Crop Yield for the Establishment of Design Year

(ton/year/ha)

Item \ Return Period		1/2	1/3	1/5	1/10	Target Yield
Percentage of Damage	Mar.	4.85%	2.27	1.03	0.35	-
	Aug.	2.07	1.21	0.67	0.36	-
Rice (Aug.)		4.90	4.94	4.97	4.98	5.00
Maize (Mar.)		2.85	2.93	2.97	2.99	3.00
Beans (Mar.)		0.57	0.59	0.59	0.60	0.60
Total		8.32	8.46	8.53	8.57	8.60

		1st Crop	2nd Crop
Planting rate (Pr)	Rice :	100%	-
	Maize:	-	60%
	Beans:	-	40%
Target Yield (Ty)	Rice :	5 ton/ha	
	Maize:	5 ton/ha	
	Beans:	1.5 ton/ha	

Product output = Pt x Ty x (1-Percentage of Damage)

Table F-II-13 Assumption of Market Price for the Establishment of Design Year

Yield	Rice	5 ton/ha x (0.6 + 0.4)	= 5.0	ton/year
	Maize	5 ton/ha x (0.6)	= 3.0	
	Beans	1.5 ton/ha x (0.4)	= 0.6	
	Total		8.6	ton/ha/year
Production Cost	Rice	5.0 ton/ha x 484 Lps/ton	= 2,420	Lps/ha/year
	Maize	3.0 x 352	= 1,056	
	Beans	0.6 x 990	= 549	
	Total		4,025	Lps/ha/year
Unit Cost (a)		4,025 Lps/ha/year ÷ 8.6 Ton/ha/year = 468 Lps/ton		

Expenses for Product (e)

(According to Product output: that is carting, removing sheath & shelling, transpotation etc.)

Assumed as 5% of Unit Cost (a)

e = 468 x 0.05 = 23 Lps/ton

Table F-II-14 Water Cost

(Lps/m³)

Return Period / Item	1/2	1/3	1/5	1/10
Construction Cost (Initial Const.) (Lps/ha)	2,920	3,000	3,040	3,110
*Depreciation Cost (Lps/ha/year)	234	241	244	250
Running Cost (Lps/ha/year)	52	59	66	75
Total (Lps/ha/year)	286	300	310	325
Total Water Supply (m^3/ha/year)	3,430	3,913	4,400	4,988
Unit Water Cost (Lps/m^3)	0.083	0.077	0.070	0.065

* Depreciation Cost

$$Dc = Ic \times \left(i + \frac{i}{(1+i)^n - 1} \right)$$

Where: Dc: Depreciation Cost (Lps/year)

Ic: Initial Cost (Lps)

i: Interest (Assumed 5 %)

n: Durable period (Assumed as 20 years)

Table F-II-15 Water Requirement

WATER REQUIRMENT

Case		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CASE-0	(mm/month)	63.765	78.023	87.855	25.006	0.000	8.407	69.851	76.449	30.675	0.000	0.000	0.000
UNIT Q	(l/sec/ha)	.647	.792	.892	.254	0.000	.085	.709	.776	.311	0.000	0.000	0.000
CASE-1	(mm/month)	64.537	79.101	87.282	27.681	20.341	15.356	63.995	69.550	27.637	0.000	0.000	0.000
UNIT Q	(l/sec/ha)	.655	.803	.886	.281	.207	.156	.650	.706	.281	0.000	0.000	0.000
CASE-2	(mm/month)	58.284	70.429	87.239	45.073	36.919	15.687	58.314	68.424	39.381	0.000	0.000	0.000
UNIT Q	(l/sec/ha)	.592	.715	.886	.458	.375	.159	.592	.695	.400	0.000	0.000	0.000
CASE-3	(mm/month)	57.430	65.737	78.939	50.507	56.321	28.416	63.246	60.569	23.768	0.000	0.000	.041
UNIT Q	(l/sec/ha)	.583	.667	.801	.513	.572	.289	.642	.615	.241	0.000	0.000	0.000
CASE-4	(mm/month)	59.885	69.886	87.805	60.830	64.828	31.411	63.286	61.075	26.422	0.000	0.000	2.144
UNIT Q	(l/sec/ha)	.608	.710	.891	.618	.658	.319	.643	.620	.268	0.000	0.000	.022
CASE-5	(mm/month)	59.782	67.338	87.531	71.683	80.611	38.159	63.629	57.909	26.199	0.000	0.000	5.622
UNIT Q	(l/sec/ha)	.607	.684	.889	.728	.818	.387	.646	.588	.266	0.000	0.000	.057

NOTE. Unit Q=(Water Requirment)/(30 days)/(86400 sec)*10/(Irrigation Efficiency .38)

WATER REQUIRMENT (CASE-0)

(Unit : mm/month)

Crop	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rice	9100	0.00	0.00	0.00	0.00	34.64	95.98	146.41	157.72	113.80	36.26	0.00	0.00
Maize	5460	54.11	75.60	97.18	44.99	0.00	0.00	0.00	0.00	0.00	0.00	12.73	30.98
Beans	3640	44.43	36.52	15.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.66	28.86
CASE-0 GROSS		98.54	112.12	113.02	44.99	34.64	95.98	146.41	157.72	113.80	36.26	22.39	59.84
Effectiv Rain		34.78	34.09	25.16	19.98	35.90	87.57	76.56	81.27	83.13	86.00	81.60	69.50
NET		63.76	78.02	87.86	25.01	-1.26	8.41	69.85	76.45	30.67	-49.74	-59.21	-9.66

WATER REQUIRMENT (CASE-1)

(Unit : mm/month)

Crop	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maize (*)	11577	64.72	84.36	98.20	45.00	26.01	48.65	76.37	90.44	67.05	25.88	19.21	39.57
Rice	2200	0.00	0.00	0.00	0.00	21.04	35.16	38.25	40.54	36.51	15.44	0.00	0.00
Beans (*)	4077	33.01	27.09	11.75	0.00	6.31	16.74	23.50	17.33	4.86	0.00	7.84	22.08
Cassava	21	.02	.01	0.00	.01	.08	.15	.25	.33	.32	.28	.22	.11
Plantain	7	.09	.10	.12	.12	.13	.12	.13	.12	.10	.08	.07	.08
Orange	130	1.31	1.48	2.13	2.28	2.40	1.89	1.84	1.85	1.73	1.51	1.29	1.20
Citrus	15	.15	.17	.25	.26	.28	.22	.21	.21	.20	.17	.15	.14
CASE-1 GROSS		99.31	113.20	112.44	47.67	56.24	102.93	140.55	150.82	110.76	43.37	28.78	63.17
Effectiv Rain		34.78	34.09	25.16	19.98	35.90	87.57	76.56	81.27	83.13	86.00	81.60	69.50
NET		64.54	79.10	87.28	27.68	20.34	15.36	64.00	69.55	27.64	-42.63	-52.82	-6.33

NOTE. (*) Inclused Postrera

WATER REQUIRMENT (CASE-2)

(Unit : mm/month)

Crop	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maize (*)	7600	37.90	52.47	66.62	30.81	13.44	29.77	51.21	65.69	54.08	20.54	9.24	21.90
Rice	1800	0.00	0.00	0.00	0.00	17.21	28.76	31.30	33.17	29.87	12.63	0.00	0.00
Beans (*)	3600	33.01	27.09	11.75	0.00	4.12	10.94	15.36	11.32	3.18	0.00	7.84	22.08
Cassava	320	.26	.13	.02	.06	1.09	2.30	3.89	5.08	4.91	4.31	3.42	1.63
Taro	200	.06	.03	.01	.05	.73	1.55	2.62	3.33	2.87	1.17	.05	.06
Plantain	200	2.61	2.74	3.37	3.30	3.80	3.50	3.66	3.43	2.73	2.19	2.04	2.23
Orange	130	1.31	1.48	2.13	2.28	2.40	1.89	1.84	1.85	1.73	1.51	1.29	1.20
Cacao	1100	11.11	12.49	17.99	19.26	20.32	15.98	15.56	15.66	14.60	12.81	10.90	10.15
Mango	100	1.01	1.14	1.64	1.75	1.85	1.45	1.41	1.42	1.33	1.16	.99	.92
Papaya	50	.59	.67	.96	1.03	1.09	.85	.83	.84	.78	.68	.58	.54
Citrus	15	.15	.17	.25	.26	.28	.22	.21	.21	.20	.17	.15	.14
Pinaple	300	3.21	3.61	5.20	5.56	5.87	4.61	4.49	4.52	4.22	3.70	3.15	2.93
Tomato (*)	370	1.83	2.53	2.47	.70	.62	1.42	2.47	3.16	2.01	.47	.43	1.05
CASE-2 GROSS		93.06	104.52	112.40	65.06	72.82	103.26	134.87	149.70	122.51	61.35	40.07	64.84
Effectiv Rain		34.78	34.09	25.16	19.98	35.90	87.57	76.56	81.27	83.13	86.00	81.60	69.50
NET		58.28	70.43	87.24	45.07	36.92	15.69	58.31	68.42	39.38	-24.65	-41.53	-4.66

NOTE. (*) Inclused Postrera

WATER REQUIRMENT (CASE-3)

(Unit : mm/month)

Crop	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maize (*)	4604	29.11	36.21	39.01	17.72	12.25	20.09	28.82	31.07	19.76	7.83	9.78	18.52
Rice	1577	0.00	0.00	0.00	0.00	15.08	25.20	27.42	29.06	26.17	11.07	0.00	0.00
Beans (*)	3173	24.00	19.69	8.54	0.00	5.54	14.71	20.65	15.22	4.27	0.00	5.70	16.05
Soy beans	1200	6.71	7.41	6.41	1.94	3.18	6.67	9.31	9.29	5.21	1.35	2.02	4.54
Cassava	426	.39	.20	.03	.09	1.45	3.03	5.14	6.72	6.52	5.73	4.55	2.19
Taro	300	.09	.05	.02	.06	1.08	2.31	3.92	4.99	4.30	1.76	.07	.09
Plantain	207	2.71	2.83	3.49	3.41	3.94	3.63	3.79	3.55	2.83	2.27	2.11	2.31
Orange	130	1.31	1.48	2.13	2.28	2.40	1.89	1.84	1.85	1.73	1.51	1.29	1.20
Cacao	2500	25.25	28.38	40.89	43.78	46.18	36.32	35.35	35.60	33.19	29.10	24.77	23.09
Citrus	15	.15	.17	.25	.26	.28	.22	.21	.21	.20	.17	.15	.14
Tomato (*)	500	2.48	3.41	3.34	.95	.84	1.92	3.34	4.27	2.71	.63	.58	1.42
CASE-3 GROSS		92.20	99.83	104.10	70.49	92.22	115.99	139.80	141.84	106.89	61.43	51.03	69.54
Effectiv Rain		34.78	34.09	25.16	19.98	35.90	87.57	76.56	81.27	83.13	86.00	81.60	69.50
NET		57.43	65.74	78.94	50.51	56.32	28.42	63.25	60.57	23.77	-24.57	-30.57	.04

NOTE. (*) Inclused Postrera

WATER REQUIRMENT (CASE-4)

(Unit : mm/month)

Crop	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maize (*)	4604	29.11	36.21	39.01	17.72	12.25	20.09	28.82	31.07	19.76	7.83	9.78	18.52
Rice	1577	0.00	0.00	0.00	0.00	15.08	25.20	27.42	29.06	26.17	11.07	0.00	0.00
Beans (*)	2573	20.33	16.68	7.24	0.00	4.17	11.07	15.53	11.45	3.21	0.00	4.83	13.60
Soy beans	1200	6.71	7.41	6.41	1.94	3.18	6.67	9.31	9.29	5.21	1.35	2.02	4.54
Cassava	221	.17	.09	.01	.05	.76	1.59	2.70	3.51	3.39	2.97	2.36	1.12
Taro	200	.06	.03	.01	.05	.73	1.55	2.62	3.33	2.87	1.17	.05	.06
Plantain	207	2.71	2.83	3.49	3.41	3.94	3.63	3.79	3.55	2.83	2.27	2.11	2.31
Orange	130	1.31	1.48	2.13	2.28	2.40	1.89	1.84	1.85	1.73	1.51	1.29	1.20
Cacao	2300	23.23	26.11	37.62	40.27	42.49	33.41	32.53	32.75	30.54	26.77	22.79	21.24
Mango	300	3.03	3.41	4.91	5.25	5.54	4.36	4.24	4.27	3.98	3.49	2.97	2.77
Papaya	50	.59	.67	.96	1.03	1.09	.85	.83	.84	.78	.58	.58	.54
Citrus	15	.15	.17	.25	.26	.28	.22	.21	.21	.20	.17	.15	.14
Pinaple	400	4.28	4.81	6.93	7.42	7.82	6.15	5.99	6.03	5.62	4.93	4.20	3.91
Tomato (*)	600	2.97	4.09	4.01	1.14	1.01	2.30	4.01	5.13	3.25	.76	.70	1.70
CASE-4 GROSS		94.66	103.98	112.97	80.81	100.73	118.98	139.84	142.35	109.55	64.99	53.83	71.64
Effectiv Rain		34.78	34.09	25.16	19.98	35.90	87.57	76.56	81.27	83.13	86.00	81.60	69.50
NET		59.88	69.89	87.81	60.83	64.83	31.41	63.29	61.08	26.42	-21.01	-27.77	2.14

NOTE. (*) Inclused Postrera

WATER REQUIRMENT (CASE-5)

(Unit : mm/month)

Crop	Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maize (*)	2404	17.90	21.17	20.75	9.31	7.71	10.85	13.60	12.24	4.94	2.15	6.73	11.83
Rice	1577	0.00	0.00	0.00	0.00	15.08	25.20	27.42	29.06	26.17	11.07	0.00	0.00
Beans (*)	2573	20.33	16.68	7.24	0.00	4.17	11.07	15.53	11.45	3.21	0.00	4.83	13.60
Soy beans	1200	6.71	7.41	6.41	1.94	3.18	6.67	9.31	9.29	5.21	1.35	2.02	4.54
Cassava	221	.17	.09	.01	.05	.76	1.59	2.70	3.51	3.39	2.97	2.36	1.12
Taro	200	.06	.03	.01	.05	.73	1.55	2.62	3.33	2.87	1.17	.05	.06
Plantain	207	2.71	2.83	3.49	3.41	3.94	3.63	3.79	3.55	2.83	2.27	2.11	2.31
Orange	1230	12.43	13.96	20.12	21.54	22.72	17.87	17.40	17.51	16.33	14.32	12.19	11.36
Cacao	1300	13.13	14.76	21.26	22.76	24.01	18.89	18.39	18.51	17.26	15.13	12.88	12.01
Mango	300	3.03	3.41	4.91	5.25	5.54	4.36	4.24	4.27	3.98	3.49	2.97	2.77
Papaya	50	.59	.67	.96	1.03	1.09	.85	.83	.84	.78	.68	.58	.54
Citrus	15	.15	.17	.25	.26	.28	.22	.21	.21	.20	.17	.15	.14
Pinaple	400	4.28	4.81	6.93	7.42	7.82	6.15	5.99	6.03	5.62	4.93	4.20	3.91
Tomato (*)	600	2.97	4.09	4.01	1.14	1.01	2.30	4.01	5.13	3.25	.76	.70	1.70
Oil Parm	1000	10.10	11.35	16.36	17.51	18.47	14.53	14.14	14.24	13.28	11.64	9.91	9.24
CASE-5 GROSS		94.56	101.43	112.69	91.67	116.51	125.73	140.18	139.18	109.33	72.13	51.68	75.12
Effectiv Rain		34.78	34.09	25.16	19.98	35.90	87.57	76.56	81.27	83.13	86.00	81.60	69.50
NET		59.78	67.34	87.53	71.68	80.61	38.16	63.63	57.91	26.20	-13.87	-19.92	5.62

NOTE. (*) Inclused Postrera

III. FIELD IRRIGATION SCHEDULES AND APPLICATION EFFICIENCY

1. Field Irrigation Schedules

Field irrigation schedules are based on the field water balance and are expressed in depth of irrigation application (D in mm) and interval of irrigation (i in days). The flow chart of the method for the determination of field irrigation schedules is shown in Fig. F-III-1.

(1) The Relation between soil-water and irrigation constants

The Relation between soil-water and irrigation constants is shown Fig. F-III-2. For the optimum growth of crops, the hygroscopic water is not available and the gravitational water is harmful and only the capillary water is available for crop.

(2) Field Capacity (F.C)

Field capacity is defined to be the soil moisture after subtracting gravitational water from saturational water. However, in general, the soil moisture after 24 hours from full irrigation is adopted as the field capacity for irrigation schedules. The 24 hours' field capacity was investigated regarding soil textures classified into 3 types. The result is as shown in Table F-III-1.

(3) Wilting Point (W.P)

Wilting point is expressed in moisture ratio which is approximately pF 4.2 or atmosphere 15 of soil water tension. The wilting points in general of each soil texture is shown in Table F-III-2.

(4) Available moisture

Available moisture is estimated by following formula:

$$AM = (F.C - W.P) \times Gd$$

Where:

AM = available moisture in percent

F.C = field capacity in moisture ratio (%)

W.P = wilting point in moisture ratio (%)

Gd = dry density

The results are shown in Table F-III-1 and the relation between soil texture and available moisture in general is shown in Table F-III-3.

(5) Depletion of moisture content for optimum growth

Considering the optimum moisture content for crops, the minimum soil moisture is not wilting point but the soil moisture of approximately pF 3.0. This minimum soil moisture is called the depletion of moisture content for optimum growth and approximately 70% of moisture equivalent. The relation between moisture equivalent and wilting point is expressed as follows:

$$W.P = \frac{Me}{1.84}$$

Where:

W.P = wilting point in moisture ratio

Me = moisture equivalent in moisture ratio

Therefore the depletion of moisture content for optimum growth will be calculated by the following formula:

$$M1 = 1.84 \times W.P \times 0.7$$

Where:

M1 = depletion of moisture content for optimum growth in percent

The depletion of moisture content for optimum growth of each soil texture is shown in Table F-III-1.

(6) Readily available moisture (R.A.M)

Readily available moistures are estimated by the following formula:

$$R.A.M = (F.C - M1) \times Gd$$

Where:

R.A.M = readily available moisture in percent

The R.A.M for each soil texture is shown in Table F-III-1.

(7) Effective Soil Layer and Soil Moisture Extraction Pattern

Effective soil layer is also called effective rooting zoon (See Table F-III-4). This soil layer is which soil water is consumed by crop and is slightly different from rooting depth (See Table F-III-5 and F-III-6).

Within the effective rooting zoon consisting of several soil layers, in general the soil water is not consumed equally in each layer, which is called soil moisture extraction pattern (S.M.E.P) (See Fig. F-III-3). As shown in Fig. F-III-3, S.M.E.P depends upon crops and in most cases the share of each layer becomes 4:3:2:1 from top to bottom (See Fig. F-III-4).

The layer which consume the soil water the most within S.M.E.P is called important soil layer for growth and when all of R.A.M at this layer is consumed the operation of irrigation will be started.

(8) Total Readily Available Moisture

Total readily available moisture (T.R.A.M.) is whole the consumptive water in the effective soil layer when all of R.A.M in the important soil layer is consumed and is the depth of irrigation application (D) in general.

T.R.A.M is calculated by following formula:

$$T.R.A.M = \frac{R.A.M}{y} \times H$$

Where:

T.R.A.M	= total readily available moisture	(mm)
R.A.M	= readily available moisture	(%)
H	= effective soil layer	(mm)
y	= total consumptive water use in S.M.E.P	(%)

Example for Fig. F-III-4:

Given: S.M.E.P = 4:3:2:1

Calculation: y = 62.5%

(9) Irrigation Interval

Irrigation Interval is calculated by following formula;

$$i = \frac{D}{C.U}$$

Where:

i	= irrigation interval	(day)
D	= depth of irrigation application	(mm)
C.U	= consumptive water use	(mm/day)

(10) Field Water Management

The method for the field irrigation schedules mentioned before will be determined only taking into account of soil water balance.

Considering the cultivation environment of crops and the effective rain for each year, the result from this method might be sometimes different from the actual optimum field water management. Therefore the field irrigation schedules must be established by farmer within the extent of the total water balance and the order for irrigation system. For this purpose, farmer must study the optimum field water management considering conditions of crops' soils and climate.

(11) Field Investigation

After cylinder intake rate test had been carried out, the soils had been kept as they are for 24 hours, the soils which at 10 cm, 20 cm and 30 cm from surface were sampled, and the water content measured at the MRN laboratory in Tegucigalpa. The result is shown Table F-III-1.

The comparison of available moisture for each soil type with the total available soil water from Table F-III-6 is as follows;

		A.M	Sa (Table F-III-6)	R.A.M.
Fine	Point I	18.94%	20.0%	15.42%
	Point II	20.55%		16.88%
Medium	Point I	14.62%	14.0%	12.38%
	Point II	13.42		11.10%
Course	Point I	7.91%	6.0%	6.68%
	Point II	7.77%		6.38%

T.R.A.M is calculated for each soil type as shown in Table F-III-7, using this R.A.M and S.M.E.P in Fig. F-III-4.

2. Application Efficiency

(1) Intake Rate Test

Intake rate is described as following formula;

$$D = Ct^n$$

$$I = KT^m = 60\ CnT^{n-1}$$

Where:

D = Cylinder accumulated intake (mm)

I = Cylinder intake rate (mm/hr)

T = Time (min)

C, n, K, m = Constants

K = 60 Cn,

m = n-1

Basic intake rate is estimated by following formula;

$$Ib = 60\ Cn \quad 600\ (1-n)^{\ n-1}$$

Where:

Ib = Basic intake rate (mn/hr)

In accordance with the value for Ib, the following irrigation method can be proposed.

Ib Value (mm/hr.)	Irrigation Method
50 mm/hr	Furrow and Other Surface Irrigation
50 - 75 mm/hr	Furrow and Sprinkler
75 mm/hr	Sprinkler

The result of cylinder intake rate test is shown in Table F-III-8 and Fig. F-III-5 - F-III-8. The summary of this result is as follows:

Soil Classification	C	n	K	m	T.b
Fine	16.24	0.58	528.92	-0.42	46.97
Medium	21.40	0.56	716.86	-0.44	61.15
Coarse	21.65	0.58	733.44	-0.42	68.48

For furrow irrigation, field intake rate is estimated by following formula;

$$Df = \frac{b}{B} CT^n = Cf\ T^n$$

$$If = \frac{60\ b}{B}\ Cn\ T^{n-1} = Kf\ T^m$$

Where:

Df = Accumulated furrow intake (mn)

If = Furrow intake rate (mn/hr)

B = width of furrow (cm)

b = Width of water surface (cm)

(2) Slope of Furrow

Depending upon field conditions, the slope of furrow varies between 0.15% to 3%. The slope of furrow can be adjusted using contour ridge under the condition up to 27% of ground slope.

(3) Maximum Allowable Flow for Furrow

The maximum allowable flow for furrow has to be determined considering soil erosion. In general, the maximum flow is estimated by the following formula;

$$Q = 37.9/S \quad (l/min)$$

$$= 0.632/S \quad (l/sec)$$

Where:

Q = Maximum flow (l/min, l/sec)

S = Slope of Furrow (%)

(4) Width of Furrow

The width of furrow depends upon crops and soil conditions. Nevertheless, considering operation efficiency of farms, the width of furrow can be adjusted between 60 cm and 80 cm in general (See Fig. F-III-9).

(5) Length of Furrow

The length of furrow is determined by the application efficiency in accordance with the condition of soil, slope and flow of furrow and depth of irrigation application. The example of the length of furrow is shown in Table F-III-9.

(6) Time Required to Irrigate

Time required to irrigate is estimated by the following formula;

$$T_{max} = T + t$$

Where:

Tmax	= Time required to irrigate	(min)
T	= Time required to refill the soil moisture reservoir	(min)
t	= Time required running water from upper to lower ends of furrow	(min)

T and t is estimated by following formula:

$$T = \left(\frac{Df}{Cf}\right)^{\frac{1}{n}}$$

$$t = L' \quad \text{or} \quad t = \left(\frac{0.5hbL}{q - ibL}\right) \mu$$

Where:

L'	= Length of furrow	(m)
,	= Constants	
h	= Depth of water at upper of furrow	(m)
b	= Width of water surface	(cm)
i	= Mean intake rate for t minutes	(cm/sec)
L	= Length of furrow	(cm)
	= Constants	

is known as shown in Table F-III-10 in accordance with slope of furrow and soil characteristics.

(7) Application Efficiency of Furrow

Application Efficiency of furrow is estimated by following formula (See Fig. F-III-10):

$$Ea = \frac{De \times L}{\frac{Du + De}{2} \times L} \times 100$$

$$= \left(\frac{Cf\ T^n \times L}{\frac{Cf\ Tmax^n + Cf\ T^n}{2}}\right)_{\times L} \times 100$$

$$= \frac{2 \times T^n}{(T + t)^n + T^n} \times 100$$

Where;

Ea	= Application Efficiency	(%)
Du	= Accumulated intake at upper of furrow $Du = Cf\ Tmax^n$	(mm)
De	= Accumulated intake an end of furrow $De = Cf\ T^n$	(mm)

The above formula can be revised substituting N for T/t as follows:

$$Ea = \frac{2\ N^n}{(N+1)^n + N^n} \times 100$$

Where:

N = Rate of Time T/t

The relations between Ea, n and N is shown in Fig. F-III-11.

Ea in this case is larger than actual application efficiency. Therefore, Ea is generally adjusted to the actual field operation subtracting 10% from the result of the above estimation.

Ea varies depending upon soil conditions, depth of irrigation application and crops. Consequently, considering the operation efficiency, time for irrigation, length of furrow, slope and flow of furrow, should be adjusted to comply with the required Ea.

The relations between application efficiency, length of furrow and slope of furrow for each soil type and depth of irrigation application are shown in Table F-III-11 and Fig. F-III-12 - F-III-14.

As a result of these considerations, the condition of furrow is adjusted so that the application efficiency becomes over 70%.

Nevertheless considering the farmer's technics for irrigation, the application efficiency of irrigation system is adopted to be 60%.

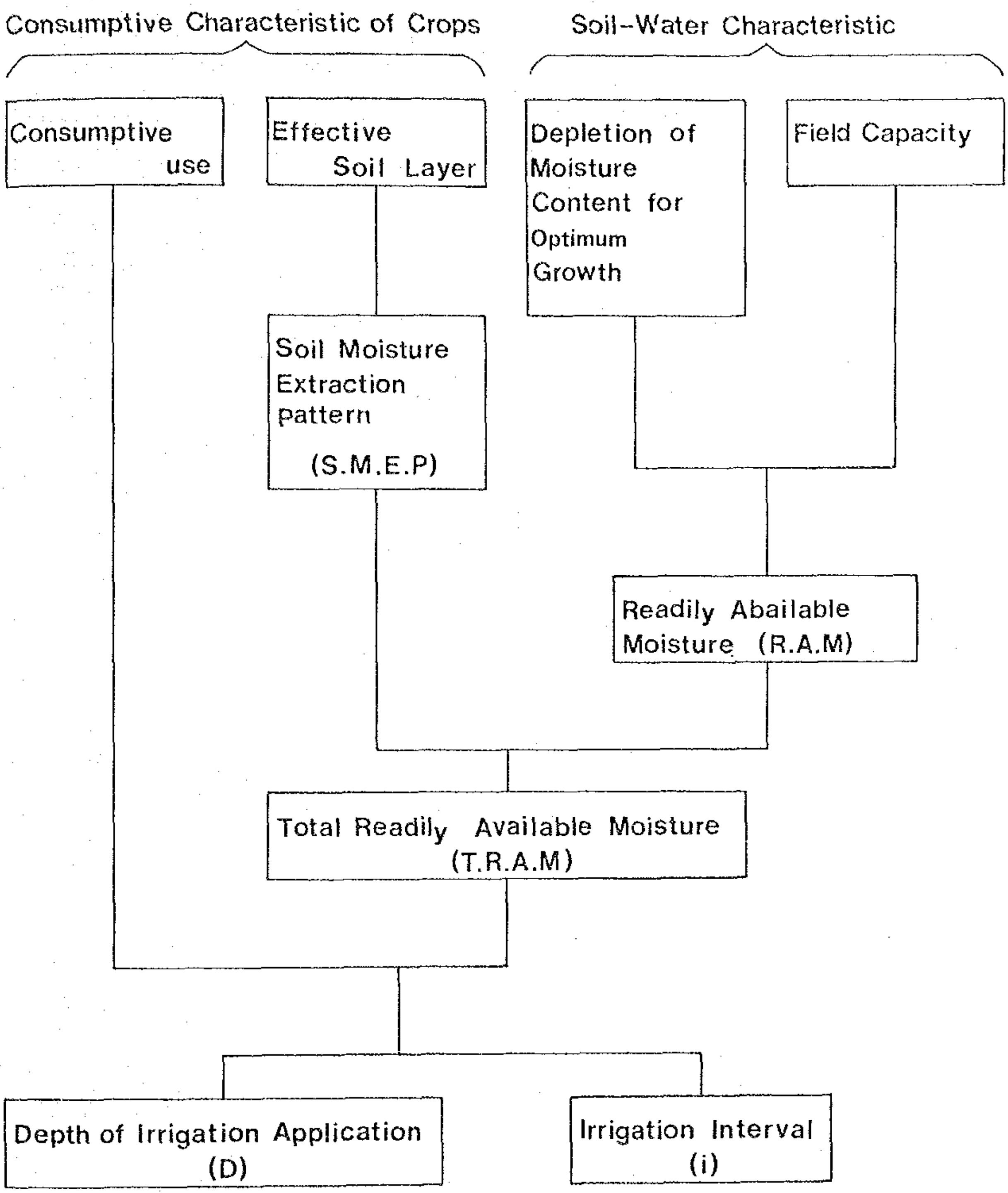


Fig. F-III-1 The Flowchart for Determination of Irrigation Schedules

Condition	Soil Moisture Suction: pF	Soil Moisture Suction: Water head (cm)	Soil Moisture Suction: Atomos-pheres	Soil Water Constants	Remark
	7	10^7	10000		
Dry	6	10^6	1000		Higroscopic Water
	5	10^5	100		
	4.5		31	Hygroscopic Coefficient	
	4.2		15	Wilting Point	
	4	10^4	10	Available moisture	
Moist	3	10^3	1	Moisture Equivalent	Capillary Water
	2.7		0.5		
	2	10^2	0.1		
	1.5	31	0.031	Field Capacity	
Wet	1	10	0.01		Gravitational Water
	0	1	0.001	Saturation	

Fig. F-III-2 The Relation of Between Soil Water and Irrigation Constants

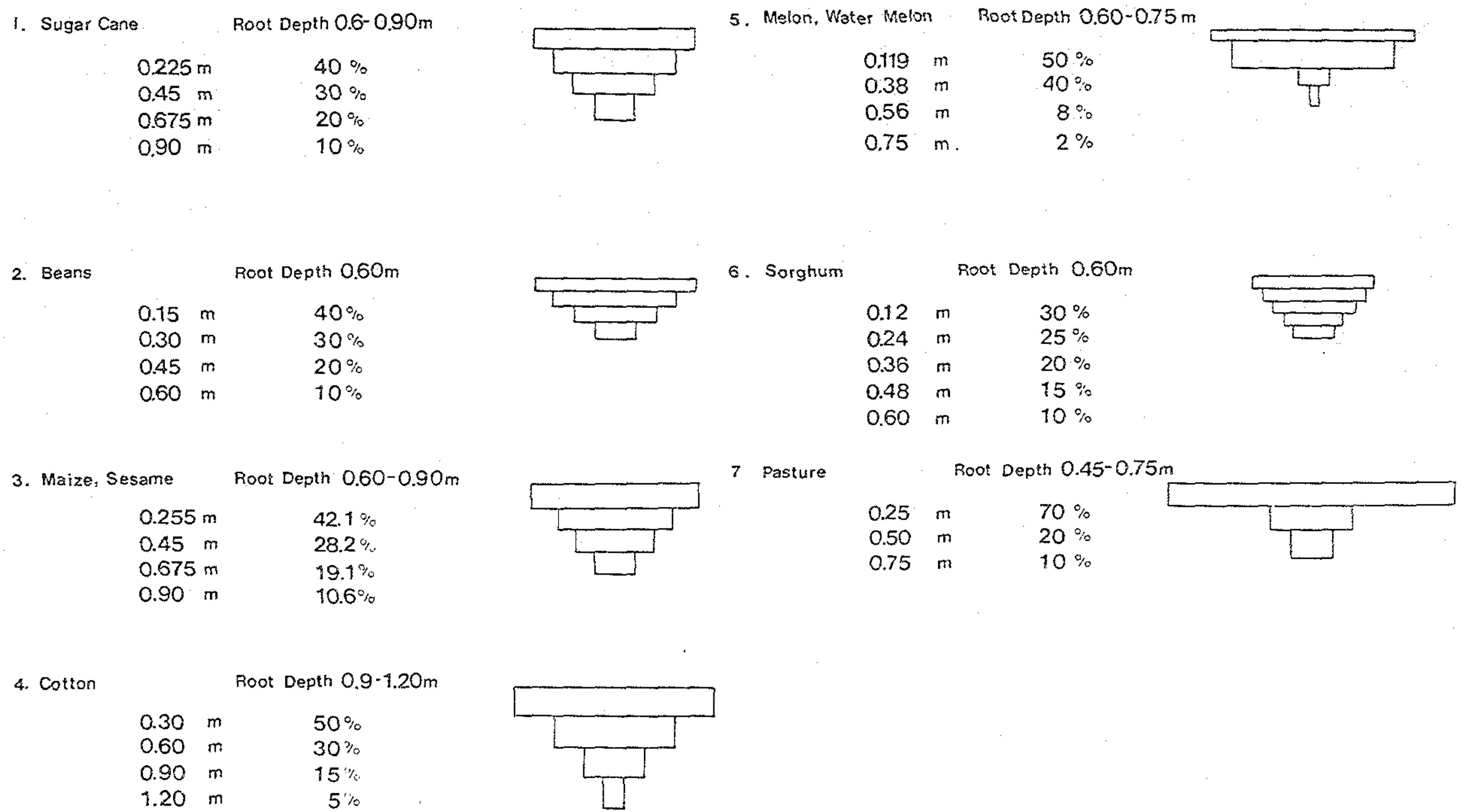
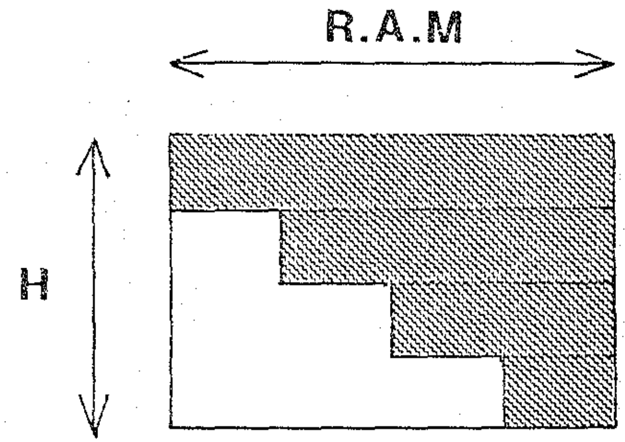


Fig. F-III-3 Soil Moisture Extraction Pattern



S.M.E.P.

4	25.	%
3	18.75	%
2	12.5	%
1	6.25	%
Total	62.5	%

Fig. F-III-4 Total Readly Available Moisture and Soil Moisture Extraction Pattern

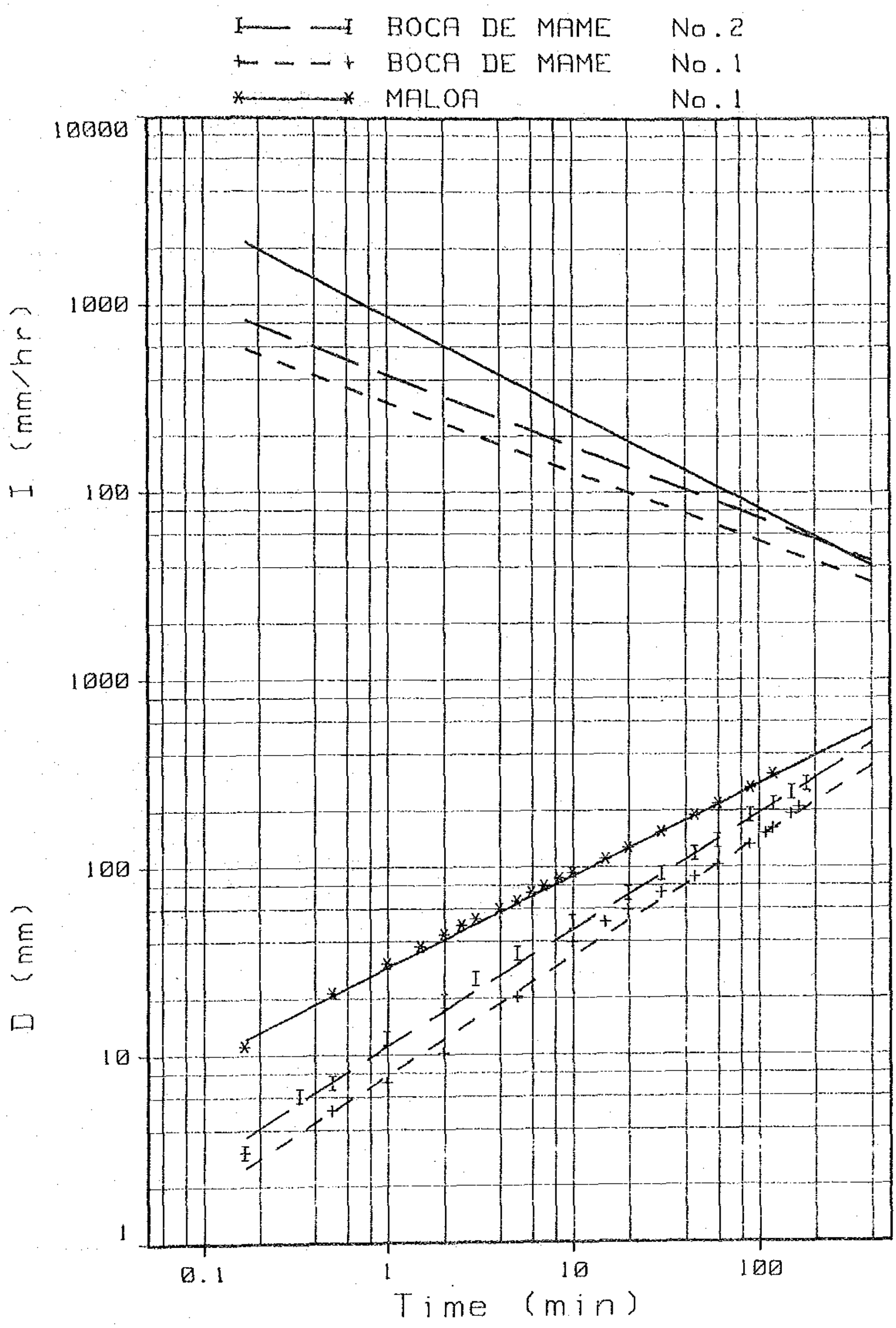


Fig. F-III-5 Intake Rate of Fine

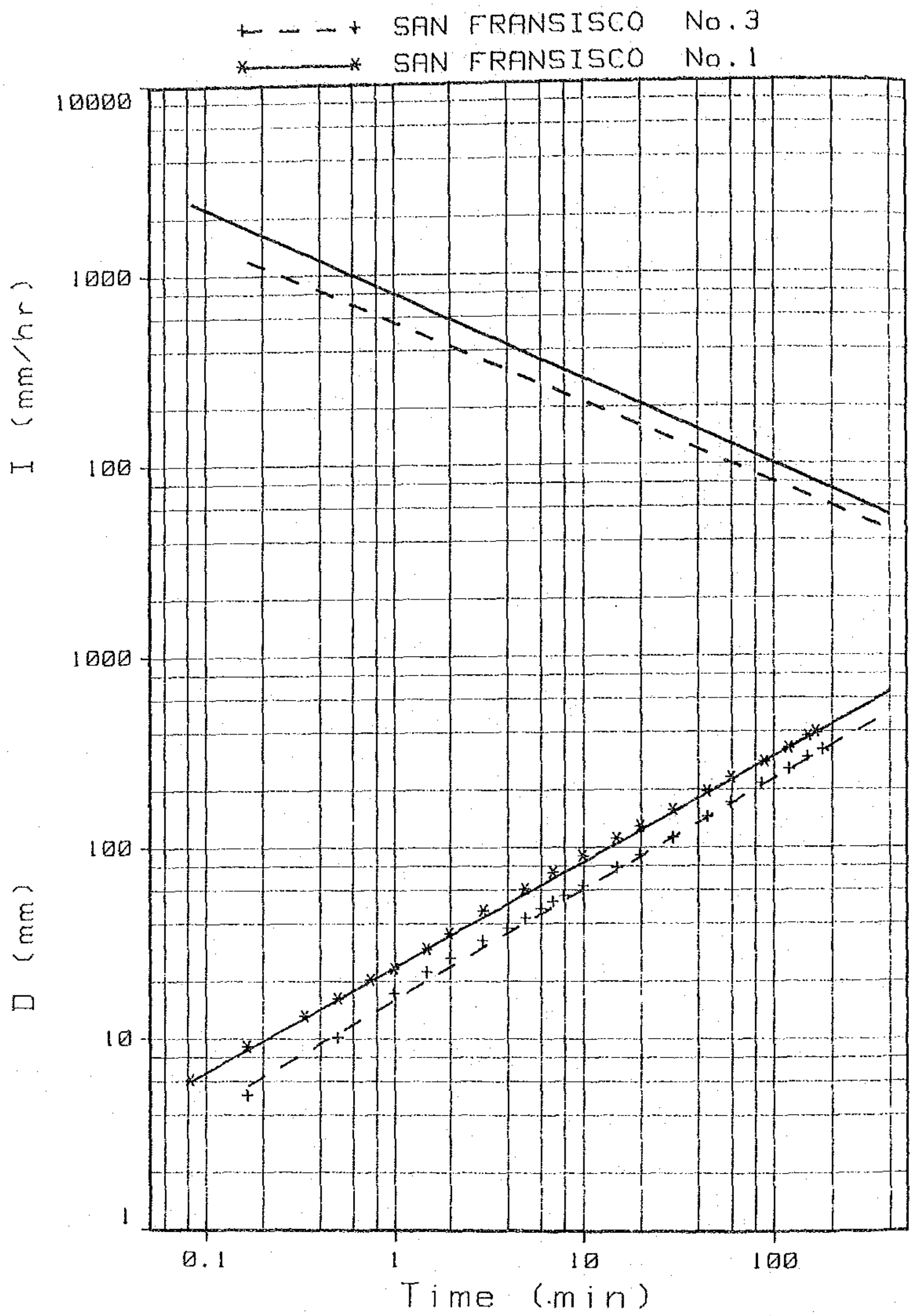


Fig. F-III-6 Intake Rate of Medium (1)

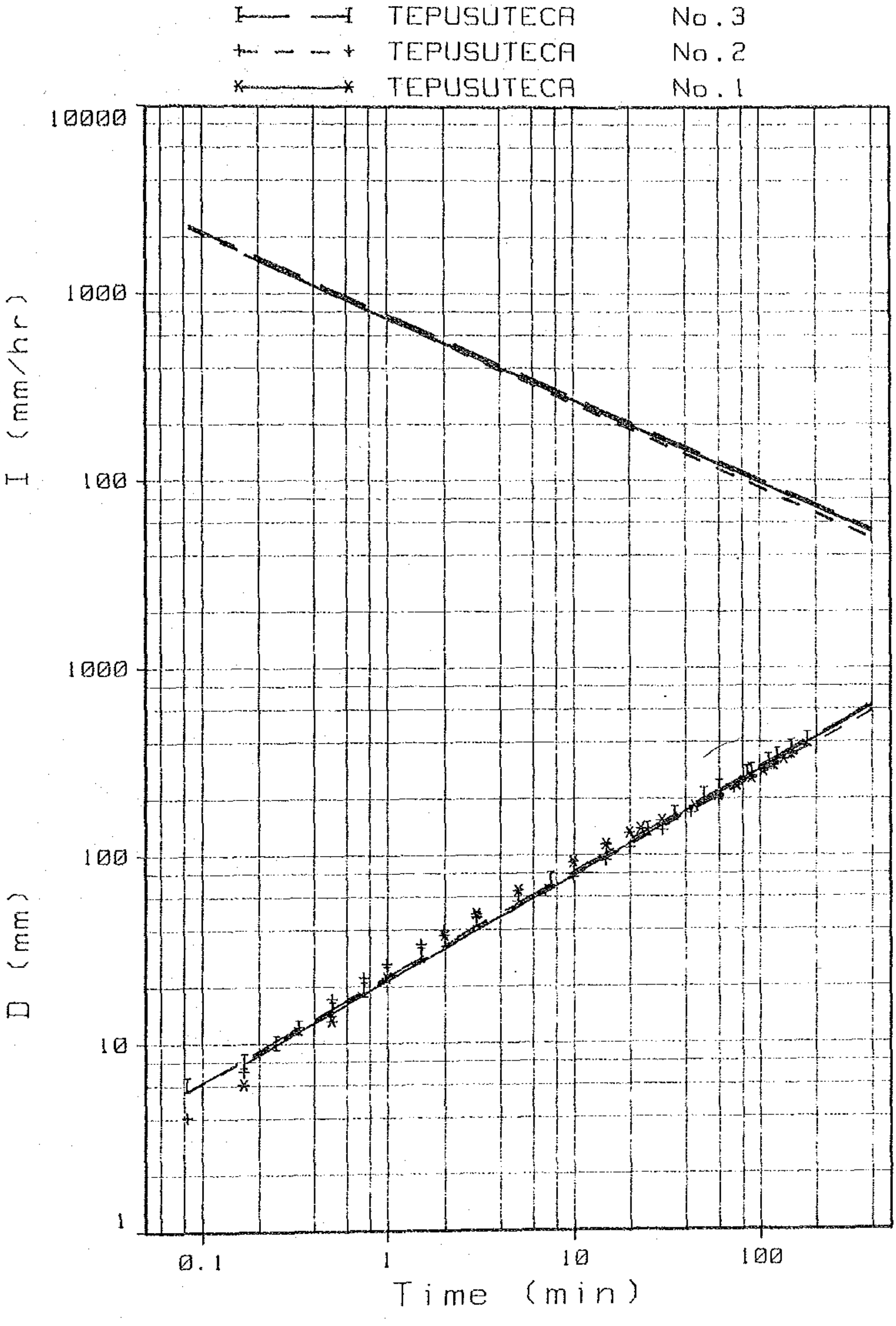


Fig. F-III-7 Intake Rate of Medium (2)

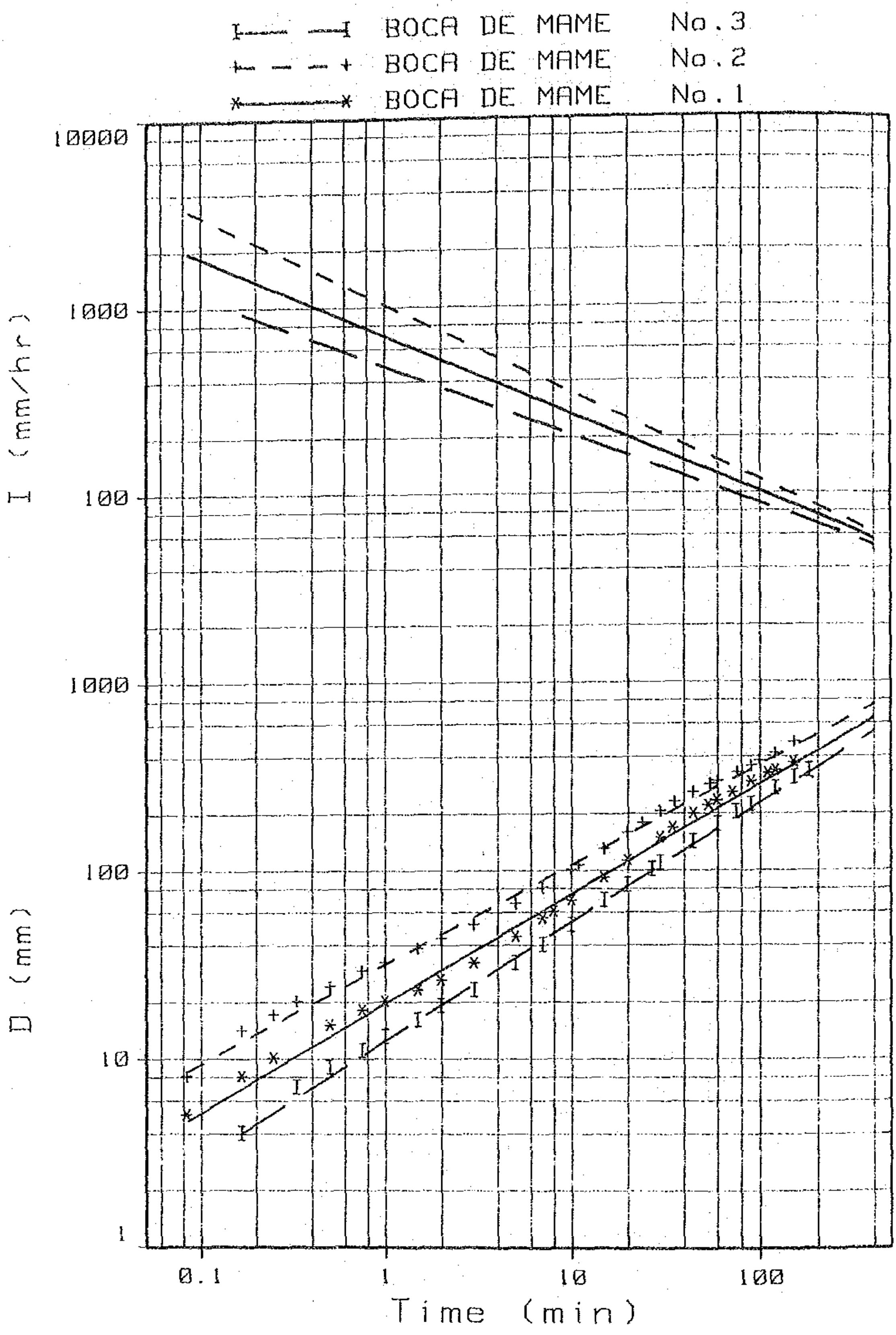


Fig. F-III-8 Intake Rate of Coarse

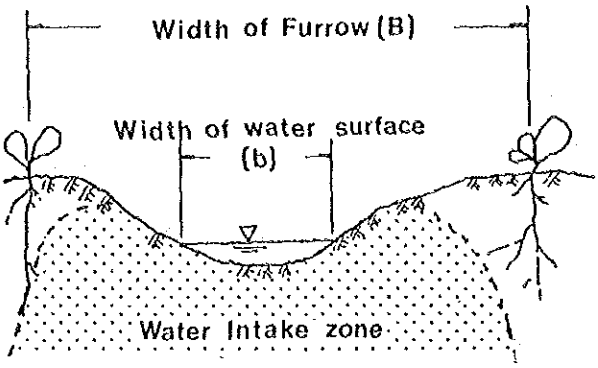


Fig. F-III-9 Section of Furrow

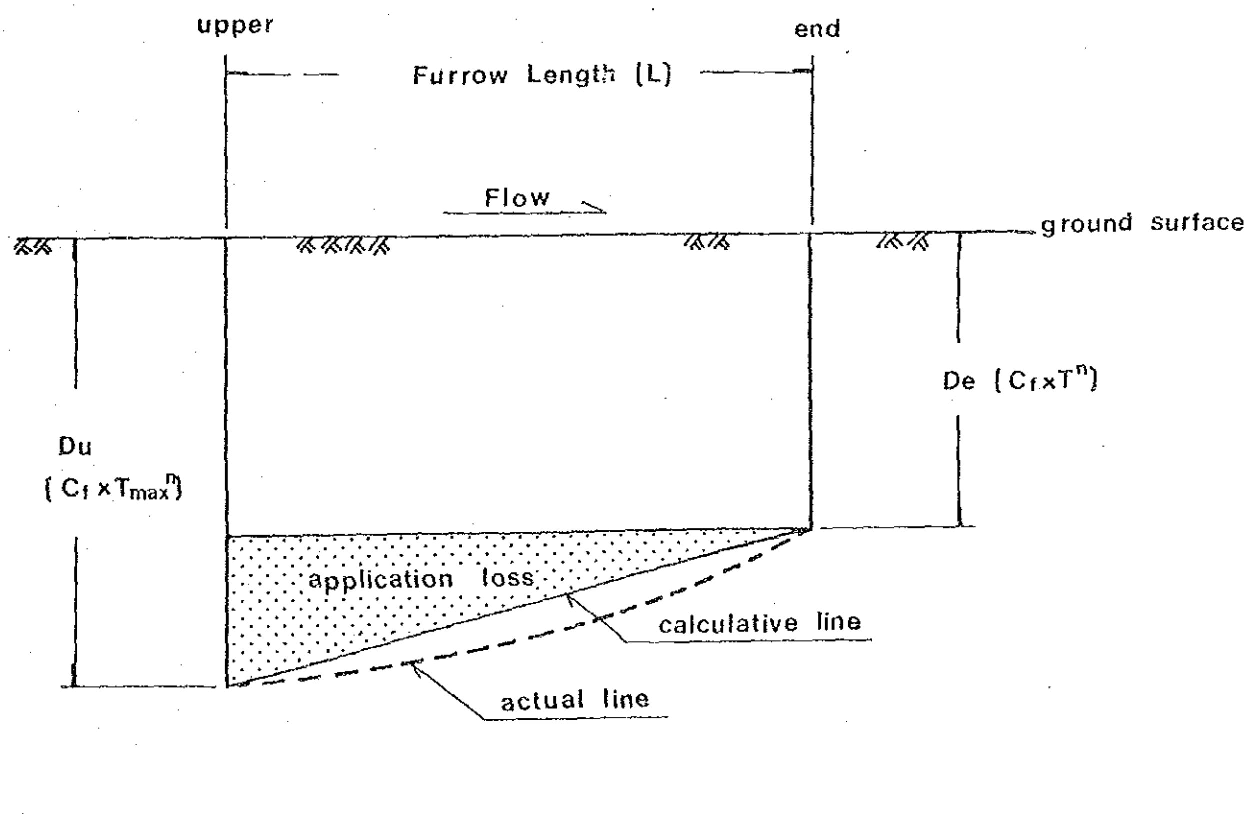


Fig. F-III-10 Model Picture of Intake

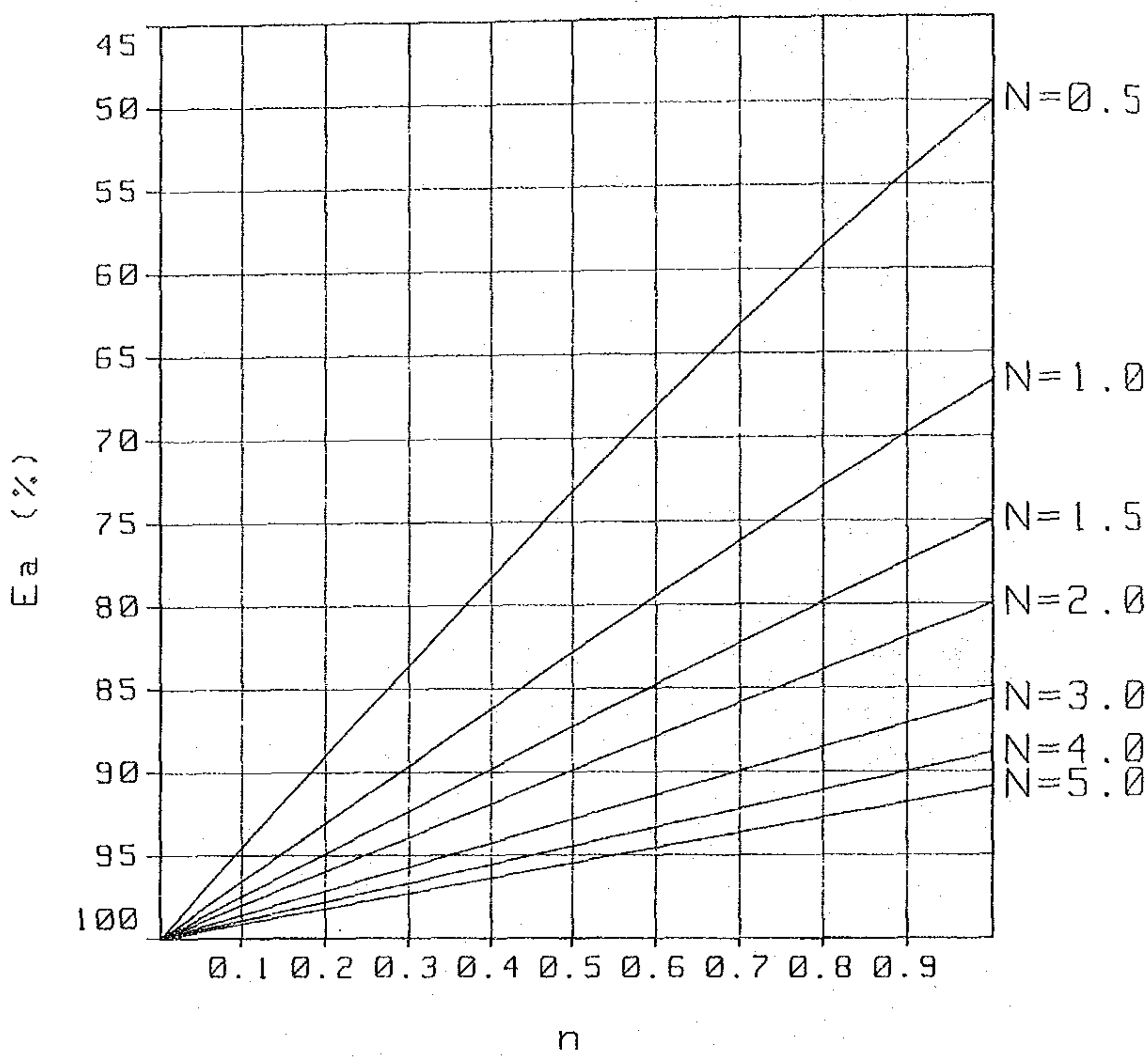


Fig. F-III-11 Relation Between Ea, n and N

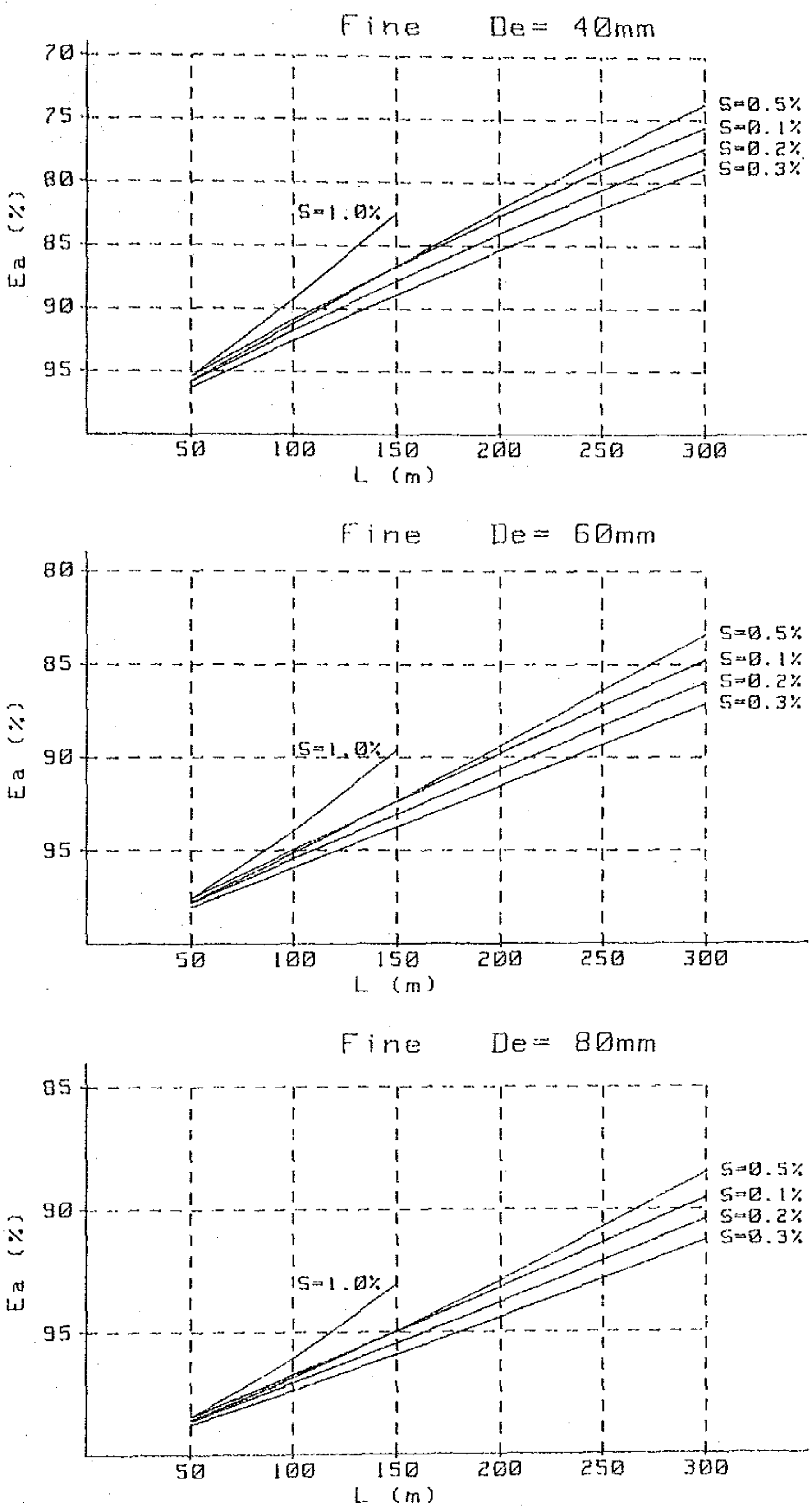
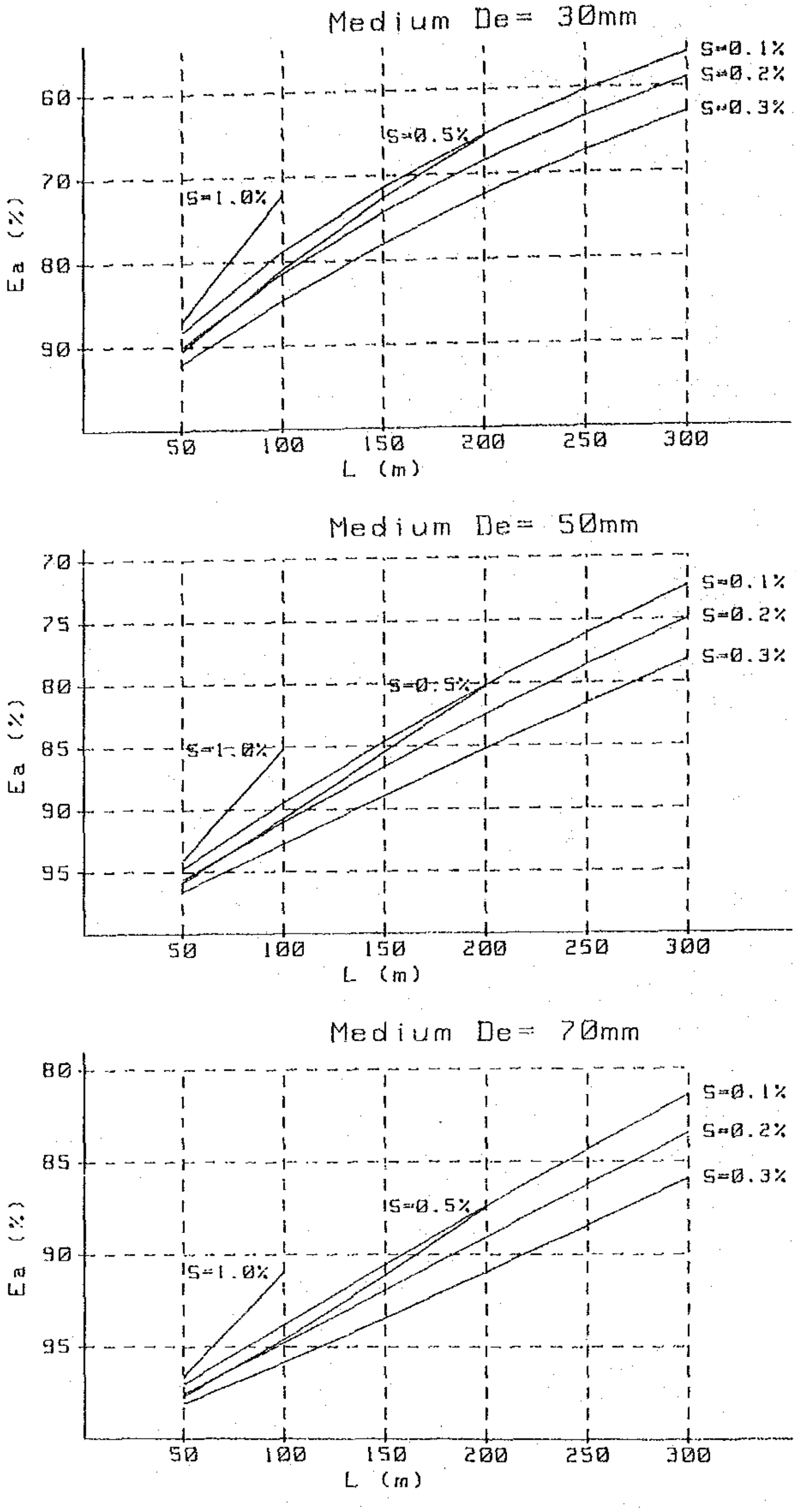


Fig. F-III-12 Application Efficiency and Furrow Length (Soil Type Fine)



Fig, F-III-13 Application Efficiency and Furrow Length (Soil Type Medium)

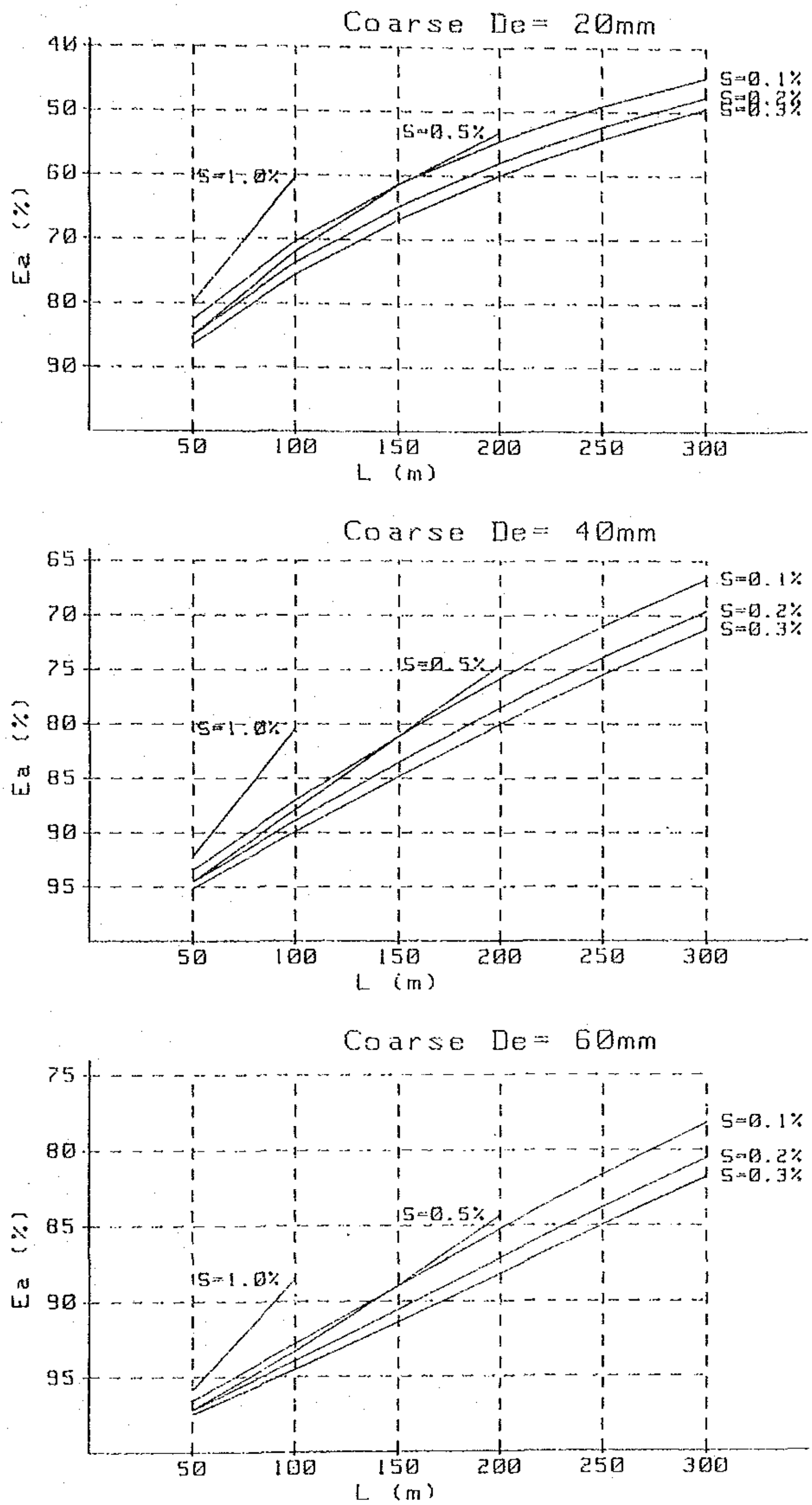


Fig. F-III-14 Application Efficiency and Furrow Length (Soil Type Coarse)

Table F-III-1 Field Capacity and Available Moisture

Sampl		No.	FCW	SDW	WFC	FCWP	WP	AM	GD	AMM	DP	RAM
Fine	Point I	1	151.8	121.6	30.2	24.84	10.00	14.84	1.24	18.38	12.88	14.81
		2	147.6	119.8	27.8	23.21	10.00	13.21	1.22	16.11	12.88	12.60
		3	152.6	118.8	33.8	28.45	10.00	18.45	1.21	22.33	12.88	18.84
Average			150.7	120.1	30.6	25.50	10.00	15.50	1.22	18.94	12.88	15.42
Fine	Point II	1	143.6	110.7	32.9	29.72	10.00	19.72	1.13	22.24	12.88	18.99
		2	158.4	125.6	32.8	26.11	10.00	16.11	1.28	20.62	12.88	16.93
		3	171.8	139.4	32.4	23.24	10.00	13.24	1.42	18.80	12.88	14.71
Average			157.9	125.2	32.7	26.36	10.00	16.36	1.28	20.55	12.88	16.88
Medium	Point I	1	143.7	122.3	21.4	17.50	6.00	11.50	1.25	14.32	7.73	12.17
		2	137.4	117.3	20.1	17.14	6.00	11.14	1.19	13.30	7.73	11.24
		3	167.0	142.5	24.5	17.19	6.00	11.19	1.45	16.25	7.73	13.74
Average			149.4	127.4	22.0	17.28	6.00	11.28	1.30	14.62	7.73	12.38
Medium	Point II	1	140.7	121.3	19.4	15.99	6.00	9.99	1.24	12.35	7.73	10.21
		2	144.0	122.7	21.3	17.36	6.00	11.36	1.25	14.20	7.73	12.04
		3	173.1	150.6	22.5	14.94	6.00	8.94	1.53	13.71	7.73	11.06
Average			152.6	131.5	21.1	16.10	6.00	10.10	1.34	13.42	7.73	11.10
Coarse	Point I	1	125.2	114.3	10.9	9.54	3.00	6.54	1.16	7.61	3.86	6.60
		2	163.5	149.3	14.2	9.51	3.00	6.51	1.52	9.90	3.86	8.59
		3	167.3	156.5	10.8	6.90	3.00	3.90	1.59	6.22	3.86	4.84
Average			152.0	140.0	12.0	8.65	3.00	5.65	1.43	7.91	3.86	6.68
Coarse	Point II	1	149.3	136.4	12.9	9.46	3.00	6.46	1.39	8.97	3.86	7.77
		2	182.4	170.5	11.9	6.98	3.00	3.98	1.74	6.91	3.86	5.41
		3	179.3	167.0	12.3	7.37	3.00	4.37	1.70	7.43	3.86	5.96
Average			170.3	158.0	12.4	7.93	3.00	4.93	1.61	7.77	3.86	6.38

NOTE

FCW	:	Weight of Wet Soil of Field Capacity	(g)	
SDW	:	Weight of Dry Soil	(g)	
WFC	:	Weight of Soil Water of Field Capacity	(g)	
FCWP	:	Water Content of Field Capacity	(%)	
WP	:	Water Content of Wilting Point	(%)	
AM	:	Water Content of Available Moisture	(%)	[FCWP-WP]
GD	:	Apparent Specify Gravity		
AMM	:	Available Moisture	(%)	[AM*GD]
DP	:	Depletion of Water Content for Optimum Growth	(%)	[1.84*WP*70%]

Table F-III-2 Wilting point (Briggs and Shantz, 1914)

Soil Characteristics Crops	Coarse	Medium	Fine
Maize	3.1	6.5	9.9
Wheat	3.3	6.3	10.3
Beans	3.3	6.9	12.4
Tomatoes	3.3	6.9	11.7
Rices	2.7	5.6	10.7

Source: Field Irrigation Handbook

Table F-III-3 Relation between Soil Water Tension in bars (atmospheres) and Available Soil Water in mm/m soil depth

(after Rijtema, 1969)

Soil water tension (atmospheres)	0.2	0.5	2.5	15
	Available soil water in mm/m (Sa)			
Heavy clay	180	150	80	0
Silty clay	190	170	100	0
Loam	200	150	70	0
Silt loam	250	190	50	0
Silty clay loam	160	120	70	0
Fine textured soils	200	150	70	0
Sandy clay loam	140	110	60	0
Sandy loam	130	80	30	0
Lamy fine sand	140	110	50	0
Medium textured soils	140	100	50	0
Medium fine sand	60	30	20	0
Coarse textured soils	60	30	20	0

Source: Crop water requirement, FAO, 1977

Table F-III-4 Effective Rooting Depth (m)
(East of U.S.A.)

Crop	Depth	Crop	Depth	Crop	Depth
Alfalfa	0.9 ∿ 1.0	Wheat	0.6 ∿ 0.75	Floots (Tree)	0.75
Beans	0.6	Grapes	0.9 ∿ 0.20	Soybeans	0.6
Beets	0.6 ∿ 0.9	Melons	0.75 ∿ 0.90	Sweet potatoes	0.9
Olives	0.45 ∿ 0.6	Onions	0.45	Tomatoes	0.9
Carrots	0.45 ∿ 0.6	Grass	0.45		
Maize	0.75	Clover	0.60		
Cotton	1.2	Peanuts	0.45		

Source: Field Irrigation Handbook

Table F-III-5 Rooting Zone (Japan)

Crop	Maximum depths (cm)	0 ∿ 20cm	20∿40cm	40∿60cm	60∿80cm
Rice (without irrigation)	55.0	63.5%	30.7%	10.1%	
Rice (with irrigation)	71.8	54.0%	31.9%	12.9%	1.1%
Sweet Potatoes	114.0	54.9%	24.3%	16.0%	4.8%
Soybeans	76.0	66.3%	19.5%	11.7%	2.5%
Egg plant	74.0	72.5%	17.2%	7.6%	0.8%

Source: Field Irrigation Handbook

Table F-III-6 Generalized Data on Rooting Depth of Full Grown Crops, Fraction of Available Soil Water (p) and Readily Available Soil Water (p.Sa) for Different Soil Types (in mm/m soil depth) when ET crop is 5 - 6 mm/day

Crop		Rooting depth (D) m	Fraction (p) of available soil water 1/	Readily available soil water (p.Sa) mm/m 1/ Fine	Medium	Coarse
Alfalfa		1.0 - 2.0	0.55	110	75	35
Banana	2/	0.5 - 0.9	0.35	70	50	20
Barley	2/	1.0 - 1.5	0.55	110	75	35
Beans		0.5 - 1.0	0.45	90	65	30
Beets		0.6 - 1.0	0.5	100	70	35
Cabbage		0.4 - 0.5	0.45	90	65	30
Carrots		0.5 - 1.0	0.35	70	50	20
Celery		0.3 - 0.5	0.2	40	25	10
Citrus		1.2 - 1.5	0.5	100	70	30
Clover		0.6 - 0.9	0.35	70	50	20
Cocoa			0.2	40	30	15
Cotton		1.0 - 1.7	0.65	130	90	40
Cucumber		0.7 - 1.2	0.5	100	70	30
Dates		1.5 - 2.5	0.5	100	70	30
Dec. orchards		1.0 - 2.0	0.5	100	70	30
Flax	2/	1.0 - 1.5	0.5	100	70	30
Grains small	2/	0.9 - 1.5	0.6	120	80	40
winter		1.5 - 2.0	0.6	120	80	40
Grapes		1.0 - 2.0	0.35	70	50	20
Grass		0.5 - 1.5	0.5	100	70	30
Groundnuts		0.5 - 1.0	0.4	80	55	25
Lettuce		0.3 - 1.5	0.3	60	40	20
Maize	2/	1.0 - 1.7	0.6	120	80	40
silage			0.5	100	70	30
Melons		1.0 - 1.5	0.35	70	50	25
Olives		1.2 - 1.7	0.65	130	95	45
Onions		0.3 - 0.5	0.25	50	35	15
Palm trees		0.7 - 1.1	0.65	130	90	40
Peas		0.6 - 1.0	0.35	70	50	25
Peppers		0.5 - 1.0	0.25	50	35	15
Pineapple		0.3 - 0.6	0.5	100	65	30
Potetoes		0.4 - 0.6	0.25	50	30	15
Safflower	2/	1.0 - 2.0	0.6	120	80	40
Sisal		0.5 - 1.0	0.8	155	110	50
Sorghum	2/	1.0 - 2.0	0.55	110	75	35
Soybeans		0.6 - 1.3	0.5	100	75	35
Spinach		0.3 - 0.5	0.2	40	30	15
Strawberries		0.5 - 0.3	0.15	30	20	10
Sugarbeet		0.7 - 1.2	0.5	100	70	30
Sugarcane	2/	1.2 - 2.0	0.65	130	90	40
Sunflower	2/	0.8 - 1.5	0.45	90	60	30
Sweetpotetoes		1.0 - 1.5	0.65	130	90	40
Tobacco early		0.5 - 1.0	0.35	70	50	25
Tobacco late			0.65	130	90	40
Tomatoes		0.7 - 1.5	0.4	180	60	25
Vegetables		0.3 - 0.6	0.2	40	30	15
Wheat		1.0 - 1.5	0.55	105	70	35
ripening			0.9	180	130	55
Total available soil water (Sa)				200	140	60

1/ When ET crop is 3 mm/day or smaller increase values by some 30% when ET crop is 8 mm/day or more reduce values by some 30%, assuming non-saline conditions (ECe < 2 mmhos/cm).

2/ High values than those shown apply during ripening.

Sources: Taylor (1965), Stuart and Hagan (1972), Salter and Goode (1967), Rijtema (1965) and others.

Table F-III-7 Effective Soil Layer and Total Readily Available Moisture

	Fine				Medium				Coarse			
	Point I AMM=18.9 RAM=15.4		Point II AMM=20.6 RAM=16.9		Point I AMM=14.6 RAM=12.4		Point II AMM=13.4 RAM=11.1		Point I AMM= 7.9 RAM= 6.7		Point II AMM= 7.8 RAM= 6.4	
H (cm)	TRAM 1	TRAM 2	TRAM 1	TRAM 2	TRAM 1	TRAM 2	TRAM 1	TRAM 2	TRAM 1	TRAM 2	TRAM 1	TRAM 2
45	53.27	43.36	57.80	47.47	41.13	34.83	37.74	31.23	22.25	18.78	21.85	17.94
50	59.18	48.18	64.22	52.74	45.70	38.70	41.94	34.70	24.72	20.87	24.28	19.94
60	71.02	57.81	77.07	63.29	54.84	46.44	50.32	41.64	29.66	25.04	29.14	23.92
75	88.78	72.27	96.34	79.12	68.55	58.05	62.90	52.05	37.08	31.30	36.42	29.90
90	106.53	86.72	115.60	94.94	82.27	69.66	75.49	62.46	44.49	37.56	43.70	35.88
100	118.37	96.36	128.45	105.49	91.41	77.39	83.87	69.40	49.44	41.74	48.56	39.87
120	142.04	115.63	154.14	126.59	109.69	92.87	100.65	83.28	59.33	50.08	58.27	47.84
150	177.55	144.53	192.67	158.23	137.11	116.09	125.81	104.10	74.16	62.60	72.84	59.81
200	236.74	192.71	256.90	210.98	182.81	154.79	167.75	138.81	98.88	83.47	97.12	79.74

NOTE

H	: Effective Soil Layer	(cm)	
FCWP	: Water Content of Field Capacity	(%)	
WP	: Water Content of Wilting Point	(%)	
AM	: Water Content of Available Moisture	(%)	[FCWP-WP]
GD	: Apparent Specify Gravity		
AMM	: Available Moisture	(%)	[AM*GD]
DP	: Depletion of Water Content for Optimum Growth	(%)	[1.84*WP*70%]
RAM	: Readily Available Moisture	(%)	[(FCWP-DP)*GD]
SMEP	: Soil Moisture Extraction Pattern	(%)	[4:3:2:1 62.5%]
TRAM 1	: Total Readily Available Moisture	(mm)	[from FCWP to WP (TRAM=AMM*H/SMEP)]
TRAM 2	: Total Readily Available Moisture	(mm)	[from FCWP to DP (TRAM=RAM*H/SMEP)]

Table F-III-8 CONSTANTS of INTAKE RATE

D=C*T^n : Df=Cf*T^n
I=K*T^m : If=Kf*T^m

Name of Point			C	n	K	m	Ib	Cf	Kf
MALDA	Fine	No.1	29.49	.49	865.84	-.51	46.56	8.42	247.38
BOCA DE MAME	Fine	No.1	7.93	.63	300.46	-.37	41.10	2.27	85.85
BOCA DE MAME	Fine	No.2	11.31	.62	420.46	-.38	53.25	3.23	120.13
MEAN			16.24	.58	528.92	-.42	46.97	4.64	151.12
SAN FRANSISCO	Medium	No.1	23.92	.55	790.61	-.45	64.02	6.83	225.89
SAN FRANSISCO	Medium	No.3	16.18	.58	560.34	-.42	53.99	4.62	160.10
TEPUSUTECA	Medium	No.1	21.84	.56	736.05	-.44	64.04	6.24	210.30
TEPUSUTECA	Medium	No.2	22.18	.55	729.98	-.45	58.23	6.34	208.57
TEPUSUTECA	Medium	No.3	22.88	.56	767.34	-.44	65.49	6.54	219.24
MEAN			21.40	.56	716.86	-.44	61.15	6.11	204.82
BOCA DE MAME	Coarse	No.1	20.03	.58	698.01	-.42	68.79	5.72	199.43
BOCA DE MAME	Coarse	No.2	32.24	.53	1022.44	-.47	71.46	9.21	292.13
BOCA DE MAME	Coarse	No.3	12.69	.63	479.87	-.37	65.19	3.62	137.11
MEAN			21.65	.58	733.44	-.42	68.48	6.19	209.55

NOTE

D	: Cylinder Accumlated Intake	(mm)
Df	: Furrow Accumlated Intake	(mm)
T	: Time	(min)
I	: Cylinder Intake Rate	(mm/hr)
If	: Furrow Intake Rate	(mm/hr)
Ib	: Basic Intake Rate	(mm/hr)
C,Cf,n	: Constants of Accumlated Intake	
K,Kf,m	: Constants of Intake Rate	

Table F-III-9 Length of Furrows and Stream Size for Different Soil Type, Land Slope and Depth of Water Application

Slope (%)	Length of furrow (m)												Average flow (1/sec).
	heavy texture				medium texture				light texture				
0.05	300	400	400	400	120	270	400	400	60	90	150	190	12
0.1	340	440	470	500	180	340	440	470	90	120	190	220	6
0.2	370	470	530	620	220	370	470	530	120	190	250	300	3
0.3	400	500	620	800	280	400	500	600	150	220	280	400	2
0.5	400	500	560	750	280	370	470	530	120	190	250	300	1.25
1.0	280	400	500	600	250	300	370	470	90	150	220	250	0.6
1.5	250	340	430	500	220	280	340	400	80	120	190	220	0.4
2.0	220	270	340	400	180	250	300	340	60	90	150	190	0.3
Application depth (mm)	75	150	225	300	50	100	150	200	50	75	100	125	

Source: Crop water requirement, FAO, 1977

Table F-III-10 Value of μ

Slope	Soil Classification		
	Fine	Medium	Coarse
1.0%	0.8 ∿ 1.0	0.5 ∿ 0.8	0.4 ∿ 0.7
0.5%	0.9 ∿ 1.2	0.5 ∿ 0.9	0.4 ∿ 0.8
0.3%	0.9 ∿ 1.3	0.5 ∿ 1.0	0.5 ∿ 0.9
0.2%	1.0 ∿ 1.5	0.8 ∿ 1.2	0.6 ∿ 1.0
0.1%	1.3 ∿ 1.5	1.0 ∿ 1.5	0.8 ∿ 1.2

Source: Field Irrigation Handbook

Table F-III-11 Application Efficiency and Length of Furrow (Sheet 1)

Fine C=11.31 Cf= 3.23 n= .62 D=C*t^n , Df=Cf*t^n S=1.00 (%) Q= .632 (l/sec)

Bw= 70 (cm) Bn= 20 (cm) h= 5 (cm)

L, Mu, T	De	t	Tmax	N	Ea
L= 150 (m) Mu=0.8 T= 41.62 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 99.48 (min)	N= 1.39	Ea= 83.35 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 152.90 (min)	N= 2.67	Ea= 90.18 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 218.59 (min)	N= 4.25	Ea= 93.46 (%)
L= 150 (m) Mu=1.0 T= 47.94 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 105.80 (min)	N= 1.21	Ea= 81.50 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 159.21 (min)	N= 2.32	Ea= 88.94 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 224.91 (min)	N= 3.69	Ea= 92.58 (%)
L= 100 (m) Mu=0.8 T= 22.20 (min)					
	De=40 mm	t= 57.85 (min)	Tmax= 80.05 (min)	N= 2.61	Ea= 89.97 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 133.47 (min)	N= 5.01	Ea= 94.37 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 199.16 (min)	N= 7.97	Ea= 96.34 (%)
L= 100 (m) Mu=1.0 T= 26.05 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 83.91 (min)	N= 2.22	Ea= 88.53 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 137.32 (min)	N= 4.27	Ea= 93.49 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 203.02 (min)	N= 6.79	Ea= 95.75 (%)
L= 50 (m) Mu=0.8 T= 8.48 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 66.34 (min)	N= 6.82	Ea= 95.76 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 119.75 (min)	N= 13.12	Ea= 97.72 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 185.45 (min)	N= 20.86	Ea= 98.55 (%)
L= 50 (m) Mu=1.0 T= 10.19 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 68.04 (min)	N= 5.68	Ea= 94.98 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 121.46 (min)	N= 10.92	Ea= 97.29 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 187.16 (min)	N= 17.37	Ea= 98.27 (%)

NOTE

- C,Cf,n : Constants of Intake
- Q : Flow of Furrow
- L : Length of Furrow
- Tmax : Time Riquired to Irrigate
- T : Time Riquired to Refill the Soil Moisture Reservoir
- t : Time Riquired to Running Water from Upper to Lower End of Furrow
- D,Df : Accumulated Intake
- Bw : Width of Furrow
- Mu : Consutant for t
- N : Rate of Time T/t
- S : Slope of Furrow
- Bn : Width of Water Surface
- h : Depth of Water at Upper Furrow
- Ea : Application Efficiency
- De : Depth of Irrigation Application

Table F-III-11 Application Efficiency and Length of Furrow (Sheet 2)

Fine C=11.31 Cf= 3.23 n= .62 D=C*t^n , Df=Cf*t^n S=0.50 (%) Q= 1.264 (l/sec)

Bw= 70 (cm) Bn= 20 (cm) h= 10 (cm)

L (m)	Mu	T (min)	De (mm)	t (min)	Tmax (min)	N	Ea (%)
300	0.9	71.77	40	57.86	129.63	.81	75.50
			60	111.27	183.04	1.55	84.69
			80	176.97	248.74	2.47	89.49
300	1.2	88.72	40	57.86	146.58	.65	71.96
			60	111.27	199.99	1.25	82.02
			80	176.97	265.69	1.99	87.47
250	0.9	55.31	40	57.86	113.17	1.05	79.50
			60	111.27	166.59	2.01	87.56
			80	176.97	232.28	3.20	91.59
250	1.2	68.96	40	57.86	126.82	.84	76.14
			60	111.27	180.23	1.61	85.16
			80	176.97	245.93	2.57	89.83
200	0.9	40.70	40	57.86	98.55	1.42	83.64
			60	111.27	151.97	2.73	90.37
			80	176.97	217.66	4.35	93.59
200	1.2	51.20	40	57.86	109.06	1.13	80.60
			60	111.27	162.47	2.17	88.32
			80	176.97	228.17	3.46	92.14
150	0.9	27.86	40	57.86	85.72	2.08	87.88
			60	111.27	139.13	3.99	93.08
			80	176.97	204.83	6.35	95.47
150	1.2	35.40	40	57.86	93.26	1.63	85.31
			60	111.27	146.67	3.14	91.46
			80	176.97	212.37	5.00	94.35
100	0.9	16.76	40	57.86	74.62	3.45	92.13
			60	111.27	128.03	6.64	95.65
			80	176.97	193.73	10.56	97.20
100	1.2	21.54	40	57.86	79.40	2.69	90.22
			60	111.27	132.81	5.17	94.52
			80	176.97	198.51	8.22	96.44
50	0.9	7.41	40	57.86	65.27	7.81	96.27
			60	111.27	118.68	15.02	98.00
			80	176.97	184.38	23.89	98.73
50	1.2	9.65	40	57.86	67.51	6.00	95.22
			60	111.27	120.92	11.53	97.42
			80	176.97	186.62	18.34	98.35

Table F-III-11 Application Efficiency and Length of Furrow (Sheet 3)

Fine C=11.31 Cf= 3.23 n= .62 D=C*t^n , Df=Cf*t^n S=0.30 (%) Q= 2.107 (l/sec)
Bw= 70 (cm) Bn= 20 (cm) h= 15 (cm)

L= 300 (m) Mu=0.9 T= 49.22 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 107.07 (min)	N= 1.18	Ea= 81.15 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 160.49 (min)	N= 2.26	Ea= 88.69 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 226.18 (min)	N= 3.60	Ea= 92.41 (%)
L= 300 (m) Mu=1.3 T= 67.09 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 124.95 (min)	N= .86	Ea= 76.57 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 178.37 (min)	N= 1.66	Ea= 85.48 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 244.06 (min)	N= 2.64	Ea= 90.07 (%)
L= 250 (m) Mu=0.9 T= 39.11 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 96.97 (min)	N= 1.48	Ea= 84.13 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 150.38 (min)	N= 2.84	Ea= 90.69 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 216.08 (min)	N= 4.52	Ea= 93.82 (%)
L= 250 (m) Mu=1.3 T= 53.67 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 111.53 (min)	N= 1.08	Ea= 79.93 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 164.94 (min)	N= 2.07	Ea= 87.86 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 230.64 (min)	N= 3.30	Ea= 91.81 (%)
L= 200 (m) Mu=0.9 T= 29.74 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 87.60 (min)	N= 1.95	Ea= 87.21 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 141.01 (min)	N= 3.74	Ea= 92.67 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 206.71 (min)	N= 5.95	Ea= 95.19 (%)
L= 200 (m) Mu=1.3 T= 41.09 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 98.95 (min)	N= 1.41	Ea= 83.52 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 152.36 (min)	N= 2.71	Ea= 90.29 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 218.06 (min)	N= 4.31	Ea= 93.54 (%)
L= 150 (m) Mu=0.9 T= 21.10 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 78.96 (min)	N= 2.74	Ea= 90.39 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 132.37 (min)	N= 5.27	Ea= 94.62 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 198.07 (min)	N= 8.39	Ea= 96.51 (%)
L= 150 (m) Mu=1.3 T= 29.38 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 87.23 (min)	N= 1.97	Ea= 87.34 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 140.65 (min)	N= 3.79	Ea= 92.75 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 206.35 (min)	N= 6.02	Ea= 95.24 (%)
L= 100 (m) Mu=0.9 T= 13.21 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 71.07 (min)	N= 4.38	Ea= 93.63 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 124.49 (min)	N= 8.42	Ea= 96.52 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 190.18 (min)	N= 13.39	Ea= 97.77 (%)
L= 100 (m) Mu=1.3 T= 18.55 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 76.41 (min)	N= 3.12	Ea= 91.40 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 129.83 (min)	N= 6.00	Ea= 95.22 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 195.52 (min)	N= 9.54	Ea= 96.91 (%)
L= 50 (m) Mu=0.9 T= 6.13 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 63.99 (min)	N= 9.44	Ea= 96.88 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 117.40 (min)	N= 18.16	Ea= 98.34 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 183.10 (min)	N= 28.88	Ea= 98.94 (%)
L= 50 (m) Mu=1.3 T= 8.69 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 66.55 (min)	N= 6.66	Ea= 95.66 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 119.96 (min)	N= 12.80	Ea= 97.67 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 185.66 (min)	N= 20.36	Ea= 98.51 (%)

Table F-III-11 Application Efficiency and Length of Furrow (Sheer 4)

Fine C=11.31 Cf= 3.23 n= .62 D=C*t^n , Df=Cf*t^n S=0.20 (%) Q= 2.107 (l/sec)
Bv= 70 (cm) Bn= 20 (cm) h= 15 (cm)

Condition	De	t	Tmax	N	Ea
L= 300 (m) Mu=1.0 T= 53.74 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 111.60 (min)	N= 1.08	Ea= 79.91 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 165.01 (min)	N= 2.07	Ea= 87.85 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 230.71 (min)	N= 3.29	Ea= 91.80 (%)
L= 300 (m) Mu=1.5 T= 75.86 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 133.72 (min)	N= .76	Ea= 74.60 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 187.13 (min)	N= 1.47	Ea= 84.02 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 252.83 (min)	N= 2.33	Ea= 88.99 (%)
L= 250 (m) Mu=1.0 T= 42.79 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 100.65 (min)	N= 1.35	Ea= 83.00 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 154.06 (min)	N= 2.60	Ea= 89.95 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 219.76 (min)	N= 4.14	Ea= 93.30 (%)
L= 250 (m) Mu=1.5 T= 60.82 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 118.68 (min)	N= .95	Ea= 78.09 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 172.09 (min)	N= 1.83	Ea= 86.56 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 237.79 (min)	N= 2.91	Ea= 90.87 (%)
L= 200 (m) Mu=1.0 T= 32.60 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 90.46 (min)	N= 1.77	Ea= 86.23 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 143.88 (min)	N= 3.41	Ea= 92.05 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 209.57 (min)	N= 5.43	Ea= 94.76 (%)
L= 200 (m) Mu=1.5 T= 46.68 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 104.54 (min)	N= 1.24	Ea= 81.86 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 157.95 (min)	N= 2.38	Ea= 89.18 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 223.65 (min)	N= 3.79	Ea= 92.76 (%)
L= 150 (m) Mu=1.0 T= 23.19 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 81.04 (min)	N= 2.50	Ea= 89.59 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 134.46 (min)	N= 4.80	Ea= 94.14 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 200.15 (min)	N= 7.63	Ea= 96.19 (%)
L= 150 (m) Mu=1.5 T= 33.46 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 91.32 (min)	N= 1.73	Ea= 85.95 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 144.73 (min)	N= 3.33	Ea= 91.87 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 210.43 (min)	N= 5.29	Ea= 94.64 (%)
L= 100 (m) Mu=1.0 T= 14.56 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 72.42 (min)	N= 3.97	Ea= 93.05 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 125.83 (min)	N= 7.64	Ea= 96.19 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 191.53 (min)	N= 12.16	Ea= 97.55 (%)
L= 100 (m) Mu=1.5 T= 21.20 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 79.05 (min)	N= 2.73	Ea= 90.35 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 132.47 (min)	N= 5.25	Ea= 94.60 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 198.16 (min)	N= 8.35	Ea= 96.49 (%)
L= 50 (m) Mu=1.0 T= 6.77 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 64.63 (min)	N= 8.55	Ea= 96.57 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 118.04 (min)	N= 16.43	Ea= 98.17 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 183.74 (min)	N= 26.14	Ea= 98.84 (%)
L= 50 (m) Mu=1.5 T= 9.96 (min)					
	De=40 mm	t= 57.86 (min)	Tmax= 67.82 (min)	N= 5.81	Ea= 95.08 (%)
	De=60 mm	t= 111.27 (min)	Tmax= 121.24 (min)	N= 11.17	Ea= 97.34 (%)
	De=80 mm	t= 176.97 (min)	Tmax= 186.93 (min)	N= 17.76	Ea= 98.50 (%)

Table F-III-11 Application Efficiency and Length of Furrow (Sheet 5)

Fine C=11.31 Cf= 3.23 n= .62 D=C*t^n , Df=Cf*t^n S=0.10 (%) Q= 2.107 (l/sec)

Bw= 70 (cm) Bn= 20 (cm) h= 15 (cm)

	De (mm)	t (min)	Tmax (min)	N	Ea (%)
L= 300 (m) Mu=1.3 T= 67.09 (min)					
	De=40 mm	57.86	124.95	.86	76.57
	De=60 mm	111.27	178.37	1.66	85.48
	De=80 mm	176.97	244.06	2.64	90.07
L= 300 (m) Mu=1.5 T= 75.86 (min)					
	De=40 mm	57.86	133.72	.76	74.50
	De=60 mm	111.27	187.13	1.47	84.02
	De=80 mm	176.97	252.83	2.33	88.93
L= 250 (m) Mu=1.3 T= 53.67 (min)					
	De=40 mm	57.86	111.53	1.08	79.93
	De=60 mm	111.27	164.94	2.07	87.86
	De=80 mm	176.97	230.64	3.30	91.81
L= 250 (m) Mu=1.5 T= 60.82 (min)					
	De=40 mm	57.86	118.68	.95	78.09
	De=60 mm	111.27	172.09	1.83	86.56
	De=80 mm	176.97	237.79	2.91	90.87
L= 200 (m) Mu=1.3 T= 41.09 (min)					
	De=40 mm	57.86	98.95	1.41	83.52
	De=60 mm	111.27	152.36	2.71	90.29
	De=80 mm	176.97	218.06	4.31	93.54
L= 200 (m) Mu=1.5 T= 46.68 (min)					
	De=40 mm	57.86	104.54	1.24	81.86
	De=60 mm	111.27	157.95	2.38	89.18
	De=80 mm	176.97	223.65	3.79	92.76
L= 150 (m) Mu=1.3 T= 29.38 (min)					
	De=40 mm	57.86	87.23	1.97	87.34
	De=60 mm	111.27	140.65	3.79	92.75
	De=80 mm	176.97	206.35	6.02	95.24
L= 150 (m) Mu=1.5 T= 33.46 (min)					
	De=40 mm	57.86	91.32	1.73	85.95
	De=60 mm	111.27	144.73	3.33	91.87
	De=80 mm	176.97	210.43	5.29	94.64
L= 100 (m) Mu=1.3 T= 18.55 (min)					
	De=40 mm	57.86	76.41	3.12	91.40
	De=60 mm	111.27	129.83	6.00	95.22
	De=80 mm	176.97	195.52	9.54	96.91
L= 100 (m) Mu=1.5 T= 21.20 (min)					
	De=40 mm	57.86	79.05	2.73	90.35
	De=60 mm	111.27	132.47	5.25	94.60
	De=80 mm	176.97	198.16	8.35	96.49
L= 50 (m) Mu=1.3 T= 8.69 (min)					
	De=40 mm	57.86	66.55	6.66	95.56
	De=60 mm	111.27	119.96	12.80	97.67
	De=80 mm	176.97	185.66	20.36	98.51
L= 50 (m) Mu=1.5 T= 9.96 (min)					
	De=40 mm	57.86	67.82	5.81	95.08
	De=60 mm	111.27	121.24	11.17	97.34
	De=80 mm	176.97	186.93	17.76	98.30

Table F-III-11 Application Efficiency and Length of Furrow (Sheet 6)

Medium C=22.28 Cf= 6.37 n= .55 D=C*t^n , Df=Cf*t^n S=1.00 (%) Q= .632 (l/sec)
Bw= 70 (cm) Bn= 20 (cm) h= 5 (cm)

L (m)	Mu	T (min)	De (mm)	t (min)	Tmax (min)	N	Ea (%)
100	0.5	27.28	30	16.75	44.04	.61	74.03
			50	42.41	69.69	1.55	86.43
			70	78.20	105.48	2.87	91.79
100	0.8	33.84	30	16.75	50.59	.50	70.51
			50	42.41	76.25	1.25	84.01
			70	78.20	112.04	2.31	90.14
50	0.5	8.87	30	16.75	25.63	1.89	88.36
			50	42.41	51.29	4.78	94.78
			70	78.20	87.07	8.81	97.04
50	0.8	11.80	30	16.75	28.55	1.42	85.44
			50	42.41	54.21	3.60	93.26
			70	78.20	89.99	6.63	96.14

NOTE
C,Cf,n : Constants of Intake
Q : Flow of Furrow
L : Length of Furrow
Tmax : Time Riquired to Irrigate
T : Time Riquired to Refill the Soil Moisture Reservoir
t : Time Riquired to Running Water from Upper to Lower End of Furrow
D,Df : Accumulated Intake
Bw : Width of Furrow
Mu : Consutant for t
N : Rate of Time T/t
S : Slope of Furrow
Bn : Width of Water Surface
h : Depth of Water at Upper Furrow
Ea : Application Efficiency
De : Depth of Irrigation Application

Table F-III-11 Application Efficiency and Length of Furrow (Sheet 7)

Medium C=22.28 Cf= 6.37 n= .55 D=C*t^n , Df=Cf*t^n S=0.50 (%) Q= 1.264 (l/sec)
Bw= 70 (cm) Bn= 20 (cm) h= 10 (cm)

L= 200 (m) Mu=0.5 T= 38.02 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 54.77 (min)	N= .44	Ea= 68.53 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 80.43 (min)	N= 1.12	Ea= 82.58 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 116.21 (min)	N= 2.06	Ea= 89.15 (%)
L= 200 (m) Mu=0.9 T= 53.79 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 70.54 (min)	N= .31	Ea= 62.41 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 96.20 (min)	N= .79	Ea= 77.85 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 131.98 (min)	N= 1.45	Ea= 85.70 (%)
L= 150 (m) Mu=0.5 T= 24.52 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 41.28 (min)	N= .68	Ea= 75.70 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 66.93 (min)	N= 1.73	Ea= 87.52 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 102.72 (min)	N= 3.19	Ea= 92.51 (%)
L= 150 (m) Mu=0.9 T= 35.83 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 52.58 (min)	N= .47	Ea= 69.55 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 78.24 (min)	N= 1.18	Ea= 83.32 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 114.02 (min)	N= 2.18	Ea= 89.66 (%)
L= 100 (m) Mu=0.5 T= 13.67 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 30.42 (min)	N= 1.23	Ea= 83.74 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 56.08 (min)	N= 3.10	Ea= 92.33 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 91.86 (min)	N= 5.72	Ea= 95.57 (%)
L= 100 (m) Mu=0.9 T= 20.77 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 37.53 (min)	N= .81	Ea= 78.18 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 63.18 (min)	N= 2.04	Ea= 89.08 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 98.97 (min)	N= 3.76	Ea= 93.53 (%)
L= 50 (m) Mu=0.5 T= 5.42 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 22.18 (min)	N= 3.09	Ea= 92.30 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 47.84 (min)	N= 7.82	Ea= 96.69 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 83.62 (min)	N= 14.42	Ea= 98.16 (%)
L= 50 (m) Mu=0.9 T= 8.69 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 25.45 (min)	N= 1.93	Ea= 88.56 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 51.10 (min)	N= 4.88	Ea= 94.88 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 86.89 (min)	N= 9.00	Ea= 97.10 (%)

Table F-III-11 Application Efficiency and Length of Furrow (Sheet 8)

Medium   C=22.28   Cf= 6.37   n= .55   D=C*t^n , Df=Cf*t^n   S=0.30 (%)   Q= 2.107 (l/sec)
Bw= 70 (cm)   Bn= 20 (cm)   h= 15 (cm)

L= 300 (m) Mu=0.5 T= 41.14 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 57.90 (min)	N= .41	Ea= 67.16 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 83.55 (min)	N= 1.03	Ea= 81.57 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 119.34 (min)	N= 1.90	Ea= 88.43 (%)
L= 300 (m) Mu=1.0 T= 65.83 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 82.58 (min)	N= .25	Ea= 58.75 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 108.24 (min)	N= .64	Ea= 74.79 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 144.02 (min)	N= 1.19	Ea= 83.36 (%)
L= 250 (m) Mu=0.5 T= 31.68 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 48.43 (min)	N= .53	Ea= 71.61 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 74.09 (min)	N= 1.34	Ea= 84.78 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 109.88 (min)	N= 2.47	Ea= 90.67 (%)
L= 250 (m) Mu=1.0 T= 51.73 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 68.48 (min)	N= .32	Ea= 63.11 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 94.14 (min)	N= .82	Ea= 78.42 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 129.92 (min)	N= 1.51	Ea= 86.13 (%)
L= 200 (m) Mu=0.5 T= 23.23 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 39.98 (min)	N= .72	Ea= 76.53 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 65.64 (min)	N= 1.83	Ea= 88.05 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 101.43 (min)	N= 3.37	Ea= 92.86 (%)
L= 200 (m) Mu=1.0 T= 38.80 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 55.56 (min)	N= .43	Ea= 68.18 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 81.21 (min)	N= 1.09	Ea= 82.32 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 117.00 (min)	N= 2.02	Ea= 88.96 (%)
L= 150 (m) Mu=0.5 T= 15.79 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 32.55 (min)	N= 1.06	Ea= 81.94 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 58.21 (min)	N= 2.69	Ea= 91.32 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 93.99 (min)	N= 4.95	Ea= 94.95 (%)
L= 150 (m) Mu=1.0 T= 27.07 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 43.83 (min)	N= .62	Ea= 74.16 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 69.48 (min)	N= 1.57	Ea= 86.51 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 105.27 (min)	N= 2.89	Ea= 91.84 (%)
L= 100 (m) Mu=0.5 T= 9.38 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 26.14 (min)	N= 1.79	Ea= 87.83 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 51.80 (min)	N= 4.52	Ea= 94.51 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 87.58 (min)	N= 8.33	Ea= 96.88 (%)
L= 100 (m) Mu=1.0 T= 16.59 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 33.34 (min)	N= 1.01	Ea= 81.30 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 59.00 (min)	N= 2.56	Ea= 90.95 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 94.78 (min)	N= 4.71	Ea= 94.71 (%)
L= 50 (m) Mu=0.5 T= 4.05 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 20.81 (min)	N= 4.13	Ea= 94.05 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 46.47 (min)	N= 10.46	Ea= 97.49 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 82.25 (min)	N= 19.29	Ea= 99.61 (%)
L= 50 (m) Mu=1.0 T= 7.45 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 24.21 (min)	N= 2.25	Ea= 89.91 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 49.87 (min)	N= 5.69	Ea= 95.55 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 85.65 (min)	N= 10.49	Ea= 97.50 (%)

Table F-III-11 Application Efficiency and Length of Furrow (Sheet 9)

Medium C=22.28 Cf= 6.37 n= .55 D=C*t^n , Df=Cf*t^n S=0.20 (%) Q= 2.107 (l/sec)
Bv= 70 (cm) Bn= 20 (cm) h= 15 (cm)

L (m)	Mu	T (min)	De (mm)	t (min)	Tmax (min)	N	Ea (%)
300	0.8	56.19	30	16.75	72.94	.30	61.62
			50	42.41	98.60	.75	77.21
			70	78.20	134.38	1.39	85.22
300	1.2	75.26	30	16.75	92.01	.22	56.31
			50	42.41	117.67	.56	72.65
			70	78.20	153.45	1.04	81.67
250	0.8	43.89	30	16.75	60.64	.38	66.03
			50	42.41	86.30	.97	80.71
			70	78.20	122.08	1.78	87.81
250	1.2	59.41	30	16.75	76.16	.28	60.61
			50	42.41	101.82	.71	76.37
			70	78.20	137.60	1.32	84.58
200	0.8	32.70	30	16.75	49.46	.51	71.08
			50	42.41	75.11	1.30	84.41
			70	78.20	110.90	2.39	90.42
200	1.2	44.78	30	16.75	61.54	.37	65.67
			50	42.41	87.20	.95	80.44
			70	78.20	122.98	1.75	87.61
150	0.8	22.64	30	16.75	39.40	.74	76.91
			50	42.41	65.06	1.87	88.29
			70	78.20	100.84	3.45	93.02
150	1.2	31.42	30	16.75	48.18	.53	71.74
			50	42.41	73.84	1.35	84.87
			70	78.20	109.62	2.49	90.74
100	0.8	13.75	30	16.75	30.51	1.22	83.67
			50	42.41	56.16	3.08	92.29
			70	78.20	91.95	5.69	95.55
100	1.2	19.38	30	16.75	36.14	.86	79.17
			50	42.41	61.80	2.19	89.69
			70	78.20	97.58	4.03	93.92
50	0.8	6.11	30	16.75	22.86	2.74	91.47
			50	42.41	48.52	6.94	96.30
			70	78.20	84.31	12.80	97.93
50	1.2	8.78	30	16.75	25.54	1.91	88.46
			50	42.41	51.20	4.83	94.83
			70	78.20	86.98	8.90	97.07

Table F-III-11 Application Efficiency and Length of Furrow (Sheet 10)

Medium C=22.28 Cf= 6.37 n= .55 D=C*t^n , Df=Cf*t^n S=0.10 (%) Q= 2.107 (l/sec)
Bw= 70 (cm) Bn= 20 (cm) h= 15 (cm)

L= 300 (m) Mu=1.0 T= 65.83 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 82.58 (min)	N= .25	Ea= 58.75 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 108.24 (min)	N= .64	Ea= 74.79 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 144.02 (min)	N= 1.19	Ea= 83.36 (%)
L= 300 (m) Mu=1.5 T= 89.10 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 105.86 (min)	N= .19	Ea= 53.24 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 131.52 (min)	N= .48	Ea= 69.85 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 167.30 (min)	N= .88	Ea= 79.38 (%)
L= 250 (m) Mu=1.0 T= 51.73 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 68.48 (min)	N= .32	Ea= 63.11 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 94.14 (min)	N= .82	Ea= 78.42 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 129.92 (min)	N= 1.51	Ea= 86.13 (%)
L= 250 (m) Mu=1.5 T= 70.70 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 87.45 (min)	N= .24	Ea= 57.45 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 113.11 (min)	N= .60	Ea= 73.65 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 148.89 (min)	N= 1.11	Ea= 82.47 (%)
L= 200 (m) Mu=1.0 T= 38.80 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 55.56 (min)	N= .43	Ea= 68.18 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 81.21 (min)	N= 1.09	Ea= 82.32 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 117.00 (min)	N= 2.02	Ea= 88.96 (%)
L= 200 (m) Mu=1.5 T= 53.60 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 70.35 (min)	N= .31	Ea= 62.47 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 96.01 (min)	N= .79	Ea= 77.90 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 131.79 (min)	N= 1.46	Ea= 85.74 (%)
L= 150 (m) Mu=1.0 T= 27.07 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 43.83 (min)	N= .62	Ea= 74.16 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 69.48 (min)	N= 1.57	Ea= 86.51 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 105.27 (min)	N= 2.89	Ea= 91.84 (%)
L= 150 (m) Mu=1.5 T= 37.85 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 54.60 (min)	N= .44	Ea= 68.61 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 80.26 (min)	N= 1.12	Ea= 82.64 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 116.04 (min)	N= 2.07	Ea= 89.19 (%)
L= 100 (m) Mu=1.0 T= 16.59 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 33.34 (min)	N= 1.01	Ea= 81.30 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 59.00 (min)	N= 2.56	Ea= 90.95 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 94.78 (min)	N= 4.71	Ea= 94.71 (%)
L= 100 (m) Mu=1.5 T= 23.52 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 40.28 (min)	N= .71	Ea= 75.34 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 65.93 (min)	N= 1.80	Ea= 87.93 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 101.72 (min)	N= 3.32	Ea= 92.78 (%)
L= 50 (m) Mu=1.0 T= 7.45 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 24.21 (min)	N= 2.25	Ea= 89.91 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 49.87 (min)	N= 5.69	Ea= 95.55 (%)
	De=70 mm	t= 78.20 (min)	Tmax= 85.65 (min)	N= 10.49	Ea= 97.50 (%)
L= 50 (m) Mu=1.5 T= 10.76 (min)					
	De=30 mm	t= 16.75 (min)	Tmax= 27.52 (min)	N= 1.56	Ea= 86.44 (%)
	De=50 mm	t= 42.41 (min)	Tmax= 53.17 (min)	N= 3.94	Ea= 93.79 (%)
	De=70 mm	t= 78.20 (min)	Tmax= [illegible] (min)	N= 7.27	Ea= [illegible] (%)

Table F-III-11 Application Efficiency and Length of Furrow (Sheet 11)

Coarse C=20.03 Cf= 5.72 n= .58 D=C*t^n , Df=Cf*t^n S=1.00 (%) Q= .632 (l/sec)
Bw= 70 (cm) Bn= 20 (cm) h= 5 (cm)

L= 100 (m) Mu=0.4 T= 24.63 (min)					
	De=20 mm	t= 8.65 (min)	Tmax= 33.28 (min)	N= .35	Ea= 62.80 (%)
	De=40 mm	t= 28.57 (min)	Tmax= 53.20 (min)	N= 1.16	Ea= 82.16 (%)
	De=60 mm	t= 57.48 (min)	Tmax= 82.12 (min)	N= 2.33	Ea= 89.69 (%)
L= 100 (m) Mu=0.7 T= 31.59 (min)					
	De=20 mm	t= 8.65 (min)	Tmax= 40.24 (min)	N= .27	Ea= 58.15 (%)
	De=40 mm	t= 28.57 (min)	Tmax= 60.17 (min)	N= .90	Ea= 78.73 (%)
	De=60 mm	t= 57.48 (min)	Tmax= 89.08 (min)	N= 1.82	Ea= 87.37 (%)
L= 50 (m) Mu=0.4 T= 7.49 (min)					
	De=20 mm	t= 8.65 (min)	Tmax= 16.14 (min)	N= 1.15	Ea= 82.11 (%)
	De=40 mm	t= 28.57 (min)	Tmax= 36.06 (min)	N= 3.82	Ea= 93.26 (%)
	De=60 mm	t= 57.48 (min)	Tmax= 64.97 (min)	N= 7.68	Ea= 96.45 (%)
L= 50 (m) Mu=0.7 T= 10.53 (min)					
	De=20 mm	t= 8.65 (min)	Tmax= 19.17 (min)	N= .82	Ea= 77.31 (%)
	De=40 mm	t= 28.57 (min)	Tmax= 39.10 (min)	N= 2.71	Ea= 90.93 (%)
	De=60 mm	t= 57.48 (min)	Tmax= 68.01 (min)	N= 5.46	Ea= 95.13 (%)

NOTE
C,Cf,n : Constants of Intake
Q : Flow of Furrow
L : Length of Furrow
Tmax : Time Riquired to Irrigate
T : Time Riquired to Refill the Soil Moisture Reservoir
t : Time Riquired to Running Water from Upper to Lower End of Furrow
D,Df : Accumulated Intake
Bw : Width of Furrow
Mu : Consutant for t
N : Rate of Time T/t
S : Slope of Furrow
Bn : Width of Water Surface
h : Depth of Water at Upper Furrow
Ea : Application Efficiency
De : Depth of Irrigation Application

Table F-III-11 Application Efficiency and Length of Furrow (Sheet 12)

Coarse C=20.03 Cf= 5.72 n= .58 D=C*t^n , Df=Cf*t^n S=0.50 (%) Q= 1.264 (l/sec)
Bw= 70 (cm) Bn= 20 (cm) h= 10 (cm)

L= 200 (m) Mu=0.4 T= 33.81 (min)				
De=20 mm	t= 8.65 (min)	Tmax= 42.46 (min)	N= .26	Ea= 56.88 (%)
De=40 mm	t= 28.57 (min)	Tmax= 62.38 (min)	N= .85	Ea= 77.74 (%)
De=60 mm	t= 57.48 (min)	Tmax= 91.29 (min)	N= 1.70	Ea= 86.67 (%)
L= 200 (m) Mu=0.8 T= 50.43 (min)				
De=20 mm	t= 8.65 (min)	Tmax= 59.08 (min)	N= .17	Ea= 49.41 (%)
De=40 mm	t= 28.57 (min)	Tmax= 79.00 (min)	N= .57	Ea= 71.33 (%)
De=60 mm	t= 57.48 (min)	Tmax= 107.91 (min)	N= 1.14	Ea= 81.94 (%)
L= 150 (m) Mu=0.4 T= 21.23 (min)				
De=20 mm	t= 8.65 (min)	Tmax= 29.88 (min)	N= .41	Ea= 65.52 (%)
De=40 mm	t= 28.57 (min)	Tmax= 49.80 (min)	N= 1.35	Ea= 84.02 (%)
De=60 mm	t= 57.48 (min)	Tmax= 78.71 (min)	N= 2.71	Ea= 90.91 (%)
L= 150 (m) Mu=0.8 T= 33.04 (min)				
De=20 mm	t= 8.65 (min)	Tmax= 41.68 (min)	N= .26	Ea= 57.31 (%)
De=40 mm	t= 28.57 (min)	Tmax= 61.61 (min)	N= .86	Ea= 78.08 (%)
De=60 mm	t= 57.48 (min)	Tmax= 90.52 (min)	N= 1.74	Ea= 86.91 (%)
L= 100 (m) Mu=0.4 T= 11.50 (min)				
De=20 mm	t= 8.65 (min)	Tmax= 20.14 (min)	N= .75	Ea= 75.96 (%)
De=40 mm	t= 28.57 (min)	Tmax= 40.07 (min)	N= 2.49	Ea= 90.23 (%)
De=60 mm	t= 57.48 (min)	Tmax= 68.98 (min)	N= 5.00	Ea= 94.72 (%)
L= 100 (m) Mu=0.8 T= 18.83 (min)				
De=20 mm	t= 8.65 (min)	Tmax= 27.48 (min)	N= .46	Ea= 67.68 (%)
De=40 mm	t= 28.57 (min)	Tmax= 47.40 (min)	N= 1.52	Ea= 85.42 (%)
De=60 mm	t= 57.48 (min)	Tmax= 76.32 (min)	N= 3.05	Ea= 91.80 (%)
L= 50 (m) Mu=0.4 T= 4.43 (min)				
De=20 mm	t= 8.65 (min)	Tmax= 13.07 (min)	N= 1.95	Ea= 88.07 (%)
De=40 mm	t= 28.57 (min)	Tmax= 33.00 (min)	N= 6.46	Ea= 95.83 (%)
De=60 mm	t= 57.48 (min)	Tmax= 61.91 (min)	N= 12.99	Ea= 97.85 (%)
L= 50 (m) Mu=0.8 T= 7.75 (min)				
De=20 mm	t= 8.65 (min)	Tmax= 16.40 (min)	N= 1.12	Ea= 81.66 (%)
De=40 mm	t= 28.57 (min)	Tmax= 36.32 (min)	N= 3.69	Ea= 93.05 (%)
De=60 mm	t= 57.48 (min)	Tmax= 65.23 (min)	N= 7.42	Ea= 96.33 (%)

Table F-III-11 Application Efficiency and Length of Furrow (Sheet 13)

Coarse C=20.03 Cf= 5.72 n= .58 D=C*t^n , Df=Cf*t^n S=0.30 (%) Q= 2.107 (l/sec)
Bw= 70 (cm) Bn= 20 (cm) h= 15 (cm)

L= 300 (m) Mu=0.5 T= 41.32 (min)					
	De=20 mm	t= 8.65 (min)	Tmax= 49.97 (min)	N= .21	Ea= 53.11 (%)
	De=40 mm	t= 28.57 (min)	Tmax= 69.89 (min)	N= .69	Ea= 74.63 (%)
	De=60 mm	t= 57.48 (min)	Tmax= 98.80 (min)	N= 1.39	Ea= 84.42 (%)
L= 300 (m) Mu=0.9 T= 61.72 (min)					
	De=20 mm	t= 8.65 (min)	Tmax= 70.37 (min)	N= .14	Ea= 45.73 (%)
	De=40 mm	t= 28.57 (min)	Tmax= 90.29 (min)	N= .46	Ea= 67.82 (%)
	De=60 mm	t= 57.48 (min)	Tmax= 119.21 (min)	N= .93	Ea= 79.16 (%)
L= 250 (m) Mu=0.5 T= 31.61 (min)					
	De=20 mm	t= 8.65 (min)	Tmax= 40.26 (min)	N= .27	Ea= 58.14 (%)
	De=40 mm	t= 28.57 (min)	Tmax= 60.18 (min)	N= .90	Ea= 78.73 (%)
	De=60 mm	t= 57.48 (min)	Tmax= 89.10 (min)	N= 1.82	Ea= 87.36 (%)
L= 250 (m) Mu=0.9 T= 48.11 (min)					
	De=20 mm	t= 8.65 (min)	Tmax= 56.75 (min)	N= .18	Ea= 50.28 (%)
	De=40 mm	t= 28.57 (min)	Tmax= 76.68 (min)	N= .59	Ea= 72.13 (%)
	De=60 mm	t= 57.48 (min)	Tmax= 105.59 (min)	N= 1.19	Ea= 82.55 (%)
L= 200 (m) Mu=0.5 T= 23.04 (min)					
	De=20 mm	t= 8.65 (min)	Tmax= 31.69 (min)	N= .38	Ea= 64.03 (%)
	De=40 mm	t= 28.57 (min)	Tmax= 51.61 (min)	N= 1.24	Ea= 83.02 (%)
	De=60 mm	t= 57.48 (min)	Tmax= 80.52 (min)	N= 2.49	Ea= 90.26 (%)
L= 200 (m) Mu=0.9 T= 35.78 (min)					
	De=20 mm	t= 8.65 (min)	Tmax= 44.43 (min)	N= .24	Ea= 55.81 (%)
	De=40 mm	t= 28.57 (min)	Tmax= 64.36 (min)	N= .80	Ea= 76.88 (%)
	De=60 mm	t= 57.48 (min)	Tmax= 93.27 (min)	N= 1.61	Ea= 86.06 (%)
L= 150 (m) Mu=0.5 T= 15.58 (min)					
	De=20 mm	t= 8.65 (min)	Tmax= 24.23 (min)	N= .56	Ea= 70.98 (%)
	De=40 mm	t= 28.57 (min)	Tmax= 44.15 (min)	N= 1.83	Ea= 87.45 (%)
	De=60 mm	t= 57.48 (min)	Tmax= 73.06 (min)	N= 3.69	Ea= 93.06 (%)
L= 150 (m) Mu=0.9 T= 24.76 (min)					
	De=20 mm	t= 8.65 (min)	Tmax= 33.40 (min)	N= .35	Ea= 62.70 (%)
	De=40 mm	t= 28.57 (min)	Tmax= 53.33 (min)	N= 1.15	Ea= 82.10 (%)
	De=60 mm	t= 57.48 (min)	Tmax= 82.24 (min)	N= 2.32	Ea= 89.65 (%)
L= 100 (m) Mu=0.5 T= 9.22 (min)					
	De=20 mm	t= 8.65 (min)	Tmax= 17.87 (min)	N= .94	Ea= 79.26 (%)
	De=40 mm	t= 28.57 (min)	Tmax= 37.79 (min)	N= 3.10	Ea= 91.91 (%)
	De=60 mm	t= 57.48 (min)	Tmax= 66.70 (min)	N= 6.24	Ea= 95.69 (%)
L= 100 (m) Mu=0.9 T= 15.04 (min)					
	De=20 mm	t= 8.65 (min)	Tmax= 23.69 (min)	N= .57	Ea= 71.58 (%)
	De=40 mm	t= 28.57 (min)	Tmax= 43.62 (min)	N= 1.90	Ea= 87.79 (%)
	De=60 mm	t= 57.48 (min)	Tmax= 72.53 (min)	N= 3.82	Ea= 93.27 (%)
L= 50 (m) Mu=0.5 T= 3.98 (min)					
	De=20 mm	t= 8.65 (min)	Tmax= 12.62 (min)	N= 2.18	Ea= 89.08 (%)
	De=40 mm	t= 28.57 (min)	Tmax= 32.55 (min)	N= 7.19	Ea= 96.22 (%)
	De=60 mm	t= 57.48 (min)	Tmax= 61.46 (min)	N= 14.46	Ea= 98.06 (%)
L= 50 (m) Mu=0.9 T= 6.71 (min)					
	De=20 mm	t= 8.65 (min)	Tmax= 15.35 (min)	N= 1.29	Ea= 83.51 (%)
	De=40 mm	t= 28.57 (min)	Tmax= 35.28 (min)	N= 4.26	Ea= 93.89 (%)
	De=60 mm	t= 57.48 (min)	Tmax= 64.19 (min)	N= 8.57	Ea= 96.80 (%)

Table F-III-11 Application Efficiency and Length of Furrow (Sheet 14)

Coarse C=20.03 Cf= 5.72 n= .58 D=C*t^n , Df=Cf*t^n S=0.20 (%) Bw= 70 (cm) Q= 2.107 (l/sec) Bn= 20 (cm) h= 15 (cm)

L (m)	Mu	T (min)	De (mm)	t (min)	Tmax (min)	N	Ea (%)
300	0.6	46.57	20	8.65	55.21	.19	50.88
			40	28.57	75.14	.61	72.67
			60	57.48	104.05	1.23	92.96
300	1.0	66.63	20	8.65	75.28	.13	44.37
			40	28.57	95.20	.43	66.45
			60	57.48	124.11	.86	78.04
250	0.6	35.85	20	8.65	44.50	.24	55.77
			40	28.57	64.42	.80	76.85
			60	57.48	93.33	1.60	86.04
250	1.0	52.08	20	8.65	60.73	.17	48.82
			40	28.57	80.65	.55	70.78
			60	57.48	109.57	1.10	81.51
200	0.6	26.31	20	8.65	34.95	.33	61.57
			40	28.57	54.88	1.09	81.29
			60	57.48	83.79	2.19	89.12
200	1.0	38.87	20	8.65	47.51	.22	54.25
			40	28.57	67.44	.74	75.60
			60	57.48	96.35	1.48	85.13
150	0.6	17.92	20	8.65	26.57	.48	68.55
			40	28.57	46.50	1.59	85.97
			60	57.48	75.41	3.21	92.15
150	1.0	26.98	20	8.65	35.63	.32	61.10
			40	28.57	55.56	1.06	80.95
			60	57.48	84.47	2.13	88.88
100	0.6	10.70	20	8.65	19.35	.81	77.06
			40	28.57	39.27	2.67	90.80
			60	57.48	68.19	5.37	95.05
100	1.0	16.46	20	8.65	25.11	.53	70.03
			40	28.57	45.04	1.74	86.88
			60	57.48	73.95	3.49	92.71
50	0.6	4.67	20	8.65	13.32	1.85	87.55
			40	28.57	33.24	6.12	95.62
			60	57.48	62.15	12.32	97.74
50	1.0	7.38	20	8.65	16.05	1.17	82.30
			40	28.57	35.95	3.87	92.55
			60	57.48	54.86	7.79	96.50

Table F-III-11 Application Efficiency and Length of Furrow (Sheet 15)

Coarse C=20.03 Cf= 5.72 n= .58 D=C*t^n , Df=Cf*t^n S=0.10 (%) Q= 2.107 (l/sec)
Bw= 70 (cm) Bn= 20 (cm) h= 15 (cm)

L	Mu	T	De	t	Tmax	N	Ea
L= 300 (m)	Mu=0.8	T= 56.75 (min)	De=20 mm	t= 8.65 (min)	Tmax= 65.40 (min)	N= .15	Ea= 47.25 (%)
			De=40 mm	t= 28.57 (min)	Tmax= 85.32 (min)	N= .50	Ea= 69.30 (%)
			De=60 mm	t= 57.48 (min)	Tmax= 114.24 (min)	N= 1.01	Ea= 80.34 (%)
L= 300 (m)	Mu=1.2	T= 76.28 (min)	De=20 mm	t= 8.65 (min)	Tmax= 84.93 (min)	N= .11	Ea= 42.00 (%)
			De=40 mm	t= 28.57 (min)	Tmax= 104.85 (min)	N= .37	Ea= 63.99 (%)
			De=60 mm	t= 57.48 (min)	Tmax= 133.77 (min)	N= .75	Ea= 75.99 (%)
L= 250 (m)	Mu=0.8	T= 44.08 (min)	De=20 mm	t= 8.65 (min)	Tmax= 52.73 (min)	N= .20	Ea= 51.90 (%)
			De=40 mm	t= 28.57 (min)	Tmax= 72.65 (min)	N= .65	Ea= 73.58 (%)
			De=60 mm	t= 57.48 (min)	Tmax= 101.57 (min)	N= 1.30	Ea= 83.64 (%)
L= 250 (m)	Mu=1.2	T= 59.91 (min)	De=20 mm	t= 8.65 (min)	Tmax= 68.56 (min)	N= .14	Ea= 45.27 (%)
			De=40 mm	t= 28.57 (min)	Tmax= 88.48 (min)	N= .48	Ea= 68.34 (%)
			De=60 mm	t= 57.48 (min)	Tmax= 117.40 (min)	N= .96	Ea= 79.58 (%)
L= 200 (m)	Mu=0.8	T= 32.67 (min)	De=20 mm	t= 8.65 (min)	Tmax= 41.32 (min)	N= .26	Ea= 57.52 (%)
			De=40 mm	t= 28.57 (min)	Tmax= 61.24 (min)	N= .87	Ea= 78.24 (%)
			De=60 mm	t= 57.48 (min)	Tmax= 90.15 (min)	N= 1.76	Ea= 87.02 (%)
L= 200 (m)	Mu=1.2	T= 44.94 (min)	De=20 mm	t= 8.65 (min)	Tmax= 53.59 (min)	N= .19	Ea= 51.54 (%)
			De=40 mm	t= 28.57 (min)	Tmax= 73.51 (min)	N= .64	Ea= 73.26 (%)
			De=60 mm	t= 57.48 (min)	Tmax= 102.43 (min)	N= 1.28	Ea= 83.40 (%)
L= 150 (m)	Mu=0.8	T= 22.51 (min)	De=20 mm	t= 8.65 (min)	Tmax= 31.16 (min)	N= .38	Ea= 64.45 (%)
			De=40 mm	t= 28.57 (min)	Tmax= 51.08 (min)	N= 1.27	Ea= 83.31 (%)
			De=60 mm	t= 57.48 (min)	Tmax= 79.99 (min)	N= 2.55	Ea= 90.45 (%)
L= 150 (m)	Mu=1.2	T= 31.39 (min)	De=20 mm	t= 8.65 (min)	Tmax= 40.03 (min)	N= .28	Ea= 58.27 (%)
			De=40 mm	t= 28.57 (min)	Tmax= 59.96 (min)	N= .91	Ea= 78.83 (%)
			De=60 mm	t= 57.48 (min)	Tmax= 88.87 (min)	N= 1.83	Ea= 87.43 (%)
L= 100 (m)	Mu=0.8	T= 13.61 (min)	De=20 mm	t= 8.65 (min)	Tmax= 22.26 (min)	N= .64	Ea= 73.25 (%)
			De=40 mm	t= 28.57 (min)	Tmax= 42.18 (min)	N= 2.10	Ea= 88.75 (%)
			De=60 mm	t= 57.48 (min)	Tmax= 71.09 (min)	N= 4.22	Ea= 93.85 (%)
L= 100 (m)	Mu=1.2	T= 19.28 (min)	De=20 mm	t= 8.65 (min)	Tmax= 27.93 (min)	N= .45	Ea= 67.26 (%)
			De=40 mm	t= 28.57 (min)	Tmax= 47.85 (min)	N= 1.48	Ea= 85.16 (%)
			De=60 mm	t= 57.48 (min)	Tmax= 76.76 (min)	N= 2.98	Ea= 91.53 (%)
L= 50 (m)	Mu=0.8	T= 6.03 (min)	De=20 mm	t= 8.65 (min)	Tmax= 14.68 (min)	N= 1.43	Ea= 84.78 (%)
			De=40 mm	t= 28.57 (min)	Tmax= 34.60 (min)	N= 4.74	Ea= 94.45 (%)
			De=60 mm	t= 57.48 (min)	Tmax= 63.52 (min)	N= 9.53	Ea= 97.11 (%)
L= 50 (m)	Mu=1.2	T= 8.71 (min)	De=20 mm	t= 8.65 (min)	Tmax= 17.36 (min)	N= .99	Ea= 80.07 (%)
			De=40 mm	t= 28.57 (min)	Tmax= 37.28 (min)	N= 3.28	Ea= 92.30 (%)
			De=60 mm	t= 57.48 (min)	Tmax= 66.19 (min)	N= 6.60	Ea= 95.91 (%)

IV. MAIN STRUCTURES

1. Head Works

The source for the irrigation water will depend only on the surface river water. In this context, river water will be diverted by means of four head works to be constructed in the Aguan (two), in the Mame and in the Jaguaca rivers. Being natural rivers, the high water level of these rivers should not be elevated after being constructed weirs. This means that the cross-sectional area of flow should not be changed. In order to keep the cross-sectional area of flow stable, the broadening of the river course and the protection works of its both side will be required for the Aguan River. In case of other two rivers, because the construction of weir will not influence the upper stream of these rivers, only protection works should be carried out. Considering to the damage by driftwood and others, gates should not be constructed in the low flow course. In order to keep the stable intake of the river water, the top of the weir on the intake side should be lowered 3-5 m in width and 0.5-1.2 m in depth.

The specification of the head works is as shown in table below.

SPECIFICATION OF THE HEAD WORKS

Description	Middle Aguan	Jaguaca	Mame	Upper Aguan
Location	1.5km down stream from the conflu- ence of Jaguaca River	1.0km down stream from Pte. Jaguaca	2.0km upper stream from Pte. Mame	1.5km upper stream from Pte. Olanchito
Amount of Intake Water (m^3/s)	3.9	0.5	2.1	1.5
Head Water Level (m)	84.0	111.0	120.0	112.0
E.L. of the Top of Weir (m)	83.70	111.1	120.2	112.0
Height of the Weir (m)	1.20	0.50	1.20	1.00
Length of the Weir (m)	210.0	35.0	59.0	124.0

2. Pump Station

Two pump stations will be constructed in this project. The location of these pump station is Campo Nuevo (No. 1) and near El Puento (No. 2).

In order to minimize the flood damage, river water will be diverted to irrigation canal by gravity.

Both pump stations will be equipped with mixed flow pump (vertical type). Main features of these pumps are as described below.

	No. 1	No. 2
Capacity (m^3/s)	2.141 (128.46 m /min)	0.446 (26.76 m /min)
Suction Water Surface (m)	EL = 83.5	EL = 111.5
Discharge Water Surface (m)	EL = 101.4	EL = 117.4
Head (m)	H = 17.9	H = 5.9
Total Head (m)	H = 22	H = 7

Type and capacity of motor are as follows:

	No. 1	No. 2
Type	ϕ700 mm x 2 595 rpm	ϕ350 mm x 2 1,020 rpm
Capacity	480 ps/1,500 rpm	40 ps/1,500 rpm

3. Irrigation Canal

(1) Canal Type

Besides the topographic and soil conditions, construction cost saving and the efficiency of construction works have been taken into account; as a result, the earth type canal has been proposed as the most suitable one to be applied for this project. The side slope of this canal has been designed to be 1:2.0 except such specific portion as neiboring areas of intake and siphon installation sites.

(2) Design Criteria

a. Mean Velocity Formula

Manning formula is employed to calculate the canal velocity as follows:

$$V = \frac{1}{n} \cdot R^{\frac{2}{3}} \cdot I \qquad (m/sec)$$

$$Q = A \cdot V \qquad (m^3/sec)$$

where:

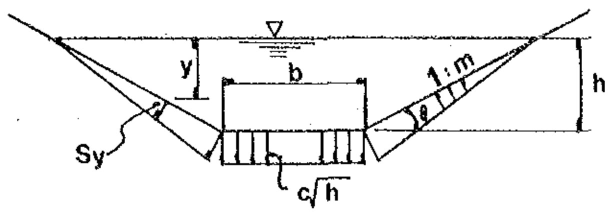
V = Mean velocity (m/sec)
n = Coefficient of roughness
(Assumed to be 0.03 for earth canal)
R = Hydraulic mean depth (m)
= A/P
A = Cross-sectional area of flow (m)
P = Wetted perimeter (m)
I = Hydraulic gradient (= Bed Slope)
Q = Discharge (m^3/sec)

b. Maximum Allowable Velocity

The maximum allowable velocity is set out to be 0.60 m/sec for earth canal considering the typical soil in the project area is sandy loam.

c. Canal Section

In the project area, sand and/or sandy loam are extended, so it should be reminded that the seepage would occur during the conveyance of the irrigation water. The amount of seepage can be calculated in the following formula:



$$Sy = C \cdot \sqrt{y}$$

$$\Sigma Sy = F\left(\frac{b}{h}\right) = C \cdot \sqrt{h}\ \left(b + \frac{4 \cdot h}{3 \cdot \sin\Theta}\right)$$

$$= C\ \{A/(\frac{b}{h} + \cot\theta)\}^{\frac{4}{3}} \cdot \left(\frac{b}{H} + \frac{4}{3 \cdot \sin\Theta}\right) \quad \ldots \text{ (i)}$$

And the minimum seepage amount (ΣSy) can be calculated by differentiating $F\left(\frac{b}{h}\right)$ with respect to $\left(\frac{b}{h}\right)$.

Given: $F\left(\frac{b}{h}\right) \cdot d\left(\frac{b}{h}\right) = 0$

$$\frac{b}{h} = 4\left(\frac{1 - \cos\Theta}{\sin\Theta}\right) = 4 \tan\frac{\theta}{2}$$

where:

- Sy = Seepage at depth y
- C = Coefficient of seepage
- h = Water depth
- b = Width of canal bed
- m, θ = Side slope
- A = Cross-sectional area of flow

When the side slope is set out to be 1:2.0 (= 26°34') the minimum amount of seepage becomes as represented in the equation below.

$$\frac{b}{h} = 0.94 \fallingdotseq 1.0.$$

Consequently, the ratio of b/h for the canal section should be designed 1.0.

d. Freeborad

The freeboad has been decided as follows:

$$Fb = 0.05\ h + hv + (fa + fb)$$

where:

h = Depth (m)
hv = Velocity head (m)
fa = Freeboard for wave (m) = 0.05 ∿ 0.15 m
fb = Height of extra banking (m) = 0.20 ∿ 0.60 m

Given the maximum allowable velocity to be 0.6 m/sec and the water depth to be almost the same as the width of canal bed, the calculation of the freeboard shall be as follows:

Width of Canal Bed (= Water Depth)	< 0.5 m	0.5∿1.0 m	1.0∿1.5 m	1.5 m <
Freeboard	0.4 m	0.5 m	0.6 m	0.7 m

(3) Hydraulic Analysis

The relation among canal section, water depth, longitudinal slope, velocity of water and discharge have been calculated. The results are shown in Fig. F-IV-1 to F-IV-7.

4. Drainage Canal

In establishing design discharge 5 years return period has been employed it being considered to be the most effective design year. The discharge has been calculated as follows:

(1) Time of Concentrate (T)

Time of Concentrate (T) is calculated by the following formula:

$$T = ta + tb \quad (min)$$

$$ta = [\frac{2}{3} \times 3.28 \times La \times (\frac{n}{S})]^{0.467} \qquad \text{(Kervey formula)}$$

$$tb = \frac{1}{60} \cdot \frac{Lb}{Vb}$$

where:

ta = inlet time (min)
tb = flow time (min)
La = Length of slope from the remotest point to water course (assumed as 500 m)
n = Coefficience of delay (assumed as 0.4)
S = Slope of field surface (assumed as 1/500)
Lb = Length of canal (assumed as 3,000 m)
Vb = Mean velocity in canal (assumed as 1.2 m/s)

$$\therefore \; ta = [2/3 \times 3.28 \times 500 \,(0.4/\sqrt{1/500})]^{0.467} = 73 \text{ min}$$

$$tb = \frac{1}{60} \times \frac{3,000}{1.2} = 50 \text{ min}$$

$$T = 73 + 50 = 123 \doteqdot 120 \text{ min}$$

(2) Rainfall Intensity

The design rainfall intensity has been calculated by the following formula: (See Appendix B)

$$I\frac{1}{5} = \frac{5,617}{t + 22.8} \qquad (mm/hr)$$

In here t = 120 min

$$I\frac{1}{5} = \frac{5,617}{120 + 22.8} = 39 \; (mm/hr)$$

(3) The Unit Runoff Discharge (Specific Discharge)

The unit runoff per 1 km^2 has been calculated as follows:

$$q = \frac{1}{3.6} f \cdot A \cdot I$$

where:

f = Runoff coefficient (assumed as 0.35)
A = Catchment area (1 km^2)
I = Rainfall intensity during the time of concentrate
(assumed as 39 mm/hr)

$$\therefore q = \frac{1}{3.6} \times 0.35 \times 1.0 \times 39 = 3.8 \ (m^3/sec/km^2)$$

(4) Standard of Drainage Canal

Considering topographic and soil conditions, the canal type should be designed as earth canal with side slope of 1:1.5.

The four types of canal side are considered according to catchment area, as shown below.

Canal Type	Catchment Area (km)	Design Dis-Discharge Q (m /sec)	Velosity V (m/sec)	Water Depth H (m)	Canal Bed Width B (m)	Longitudinal Slope I
I	4.0	15.2	1.5	2.0	2.0	1/550
II	3.0	11.4	1.5	1.7	2.0	1/450
III	2.0	7.6	1.5	1.4	1.5	1/340
IV	1.0	3.8	1.5	1.0	1.0	1/200

5. Study of Canal Conveyance Loss According to Soil Mechanics

In the feasibility study, a conveyance efficiency (Ec) of 0.8 (water conveyance loss : 20%) was applied. The value was employed based on FAO's guideline and its appropriateness was confirmed in the following manner.

A. E.A. Moritz Formura

$$S = 0.0619 \cdot C \cdot \sqrt{Q/V}$$

where
- S: Permeability Loss(m^3/sec/km)
- Q: Water Discharge (m^3/sec)
- V: Water Velocity (m/sec.)
- C: Conveyance Loss Coefficient (m/day/km)

Soil Mechanics	C
Sandy Ash	0.19
Sandy Ash or Sandy Clay	0.23
Gravel	0.32

B. Observation Value by Etcheverry

	m^3/m^2/hr
Sandy Loam	0.305 - 0.457
Coarse Sand	0.457 - 0.609
Gravel Sand	0.609 - 0.762

Calculation of Water Conveyance Loss for Canals No. 6 and No. 7

A. E.A.Moritz' Formula

Main Canal	Length (m)	Q (m^3/sec.)	V (m/sec.)	Sandy Ash C=0.19	Sandy Ash or Sandy Clay C=0.23	Gravel C=0.32
6-I	1,000	3.90	0.58	0.030	0.036	0.051
6-II 7-II	10,250	1.95	0.54	0.229	0.277	0.385
6-III 7-III	16,400	1.10	0.43	0.308	0.373	0.519
6-IV 7-IV	7,100	0.35	0.34	0.084	0.102	0.142
Total	34,750			0.651	0.788	1.097

B. Observation Value By Etcheverry

Main Canal	Length (m)	Sandy Loam		Coarse Sand
6-I	1,000	0.028 -	0.0043 -	0.0057
6-II 7-II	10,250	0.219 -	0.328 -	0.437
6-III 7-III	16,400	0.257 -	0.385 -	0.513
6-IV 7-IV	7,100	0.077 -	0.116 -	0.154
Total	34,750	0.581	0.872	1.161

Not that about 85% of the total length for No.6 and No. 7 Canals passes through the sandy loam and the remainder through sand, the water conveyance loss in these canals is estimated to be no more than 0.75 m^3/s; this volume, corresponding 19% for the water intake volume of 3.90 m^3/sec, is an appropriate one for the irrigation planning.

6. Cost Estimation of Lining Works for Main Canals

The breakdown of main canals categorized in each type and soil series is as shown below.

Unit: m

Soil Series / Type of Canal	A_b	Oℓ	Tℓ	T_g	A_g	Ja	Te	Am	Total
I	400	-	-	-	600	(600) -	-	-	(600) 1,000
II	(750) 3,400	-	2,050	1,250	750	12,100	1,600	600	(750) 22,500
III	-	2,000	-	-	3,500	16,150	2,900	200	24,750
IV	3,600	-	-	-	9,350	11,850	-	-	24,800
Total	(750) 7,400	2,000	2,050	1,250	14,200	(600) 40,100	4,500	800	(1,350) 72,300

Note: 1) Figure in parenthesis is estimated as other works. (pipe or stone canals)

2) Soil series: refer to section 3.5.2 of the Main Report.

Of total canal length of 72,300 meter, soil series corresponding to Ab and Oℓ will be required lining works. Therefore, the canal length to be lined will be 9,400 meters.

Cost Estimation for Canal Lining Works
(Soil Series Ab and Oℓ)

Canal Type	Canal to be lined		Cost	
	Length (m)	Area (m^2)	Unit Price (Lps/m)	Amount (Lps)
I	400	8.66	40.27	16,108
II	3,400	6.37	29.62	100,708
III	2,000	5.22	24.27	48,540
IV	3,600	3.63	16.88	60,768
Total	9,400	-		226,124

Note: 1) Lining Area (A) = $(B + 2\sqrt{5} \times H)$ (m^2/m)
Where B: Width of Canal Bed (m)
H: Design Excavation Depth (m)

2) Unit Price = $4.65^{*} \times A$
Where A: Area to be lined (m^2/m)

3) * Refer to Appendix G-III-36

Length of Main Canals According to Soil Series (m)

Soil Series / Canal	Ab	Oℓ	Iℓ	Tg	Ag	Ta	Te	Am	Total
No.1 Canal									
II	(750) –	–	–	–	500	–	–	–	(750) 500
III	–	2,000	–	–	3,500	1,850	–	–	7,350
IV	–	–	–	–	2,150	–	–	–	2,150
Sub total	(750) –	2,000	–	–	6,150	1,850	–	–	(750) 10,000
No.2 Canal									
IV	–	–	–	–	3,750	–	–	–	3,750
No.3 Canal									
II	3,400	–	2,050	1,250	250	3,450	–	600	11,000
III	–	–	–	–	–	800	–	200	1,000
IV	600	–	–	–	1,300	950	–	–	2,850
Sub total	4,000	–	2,050	1,250	1,550	5,200	–	800	14,850
No.4 Canal									
IV	2,400	–	–	–	2,150	–	–	–	4,550
No.5 Canal									
IV	600	–	–	–	–	3,800	–	–	4,400
No.6 Canal									
I	400	–	–	–	600	–	–	–	1,000
II	–	–	–	–	–	6,400	–	–	6,400
III	–	–	–	–	–	6,450	–	–	6,450
IV	–	–	–	–	–	3,300	–	–	3,300
Sub total	400	–	–	–	600	16,150	–	–	17,150
No.7 Canal									
II	–	–	–	–	–	(600) 2,250	– 1,600	–	(600) 3,850
III	–	–	–	–	–	7,050	2,900	–	9,950
IV	–	–	–	–	–	3,800	–	–	3,800
Sub total	–	–	–	–	–	(600) 13,100	4,500	–	(600) 17,600
Total	(750) 7,400	2,000	2,050	1,250	14,200	(600) 40,100	4,500	300	(1,350) 72,300

* Figure in parenthesis is estimated as the length for other works

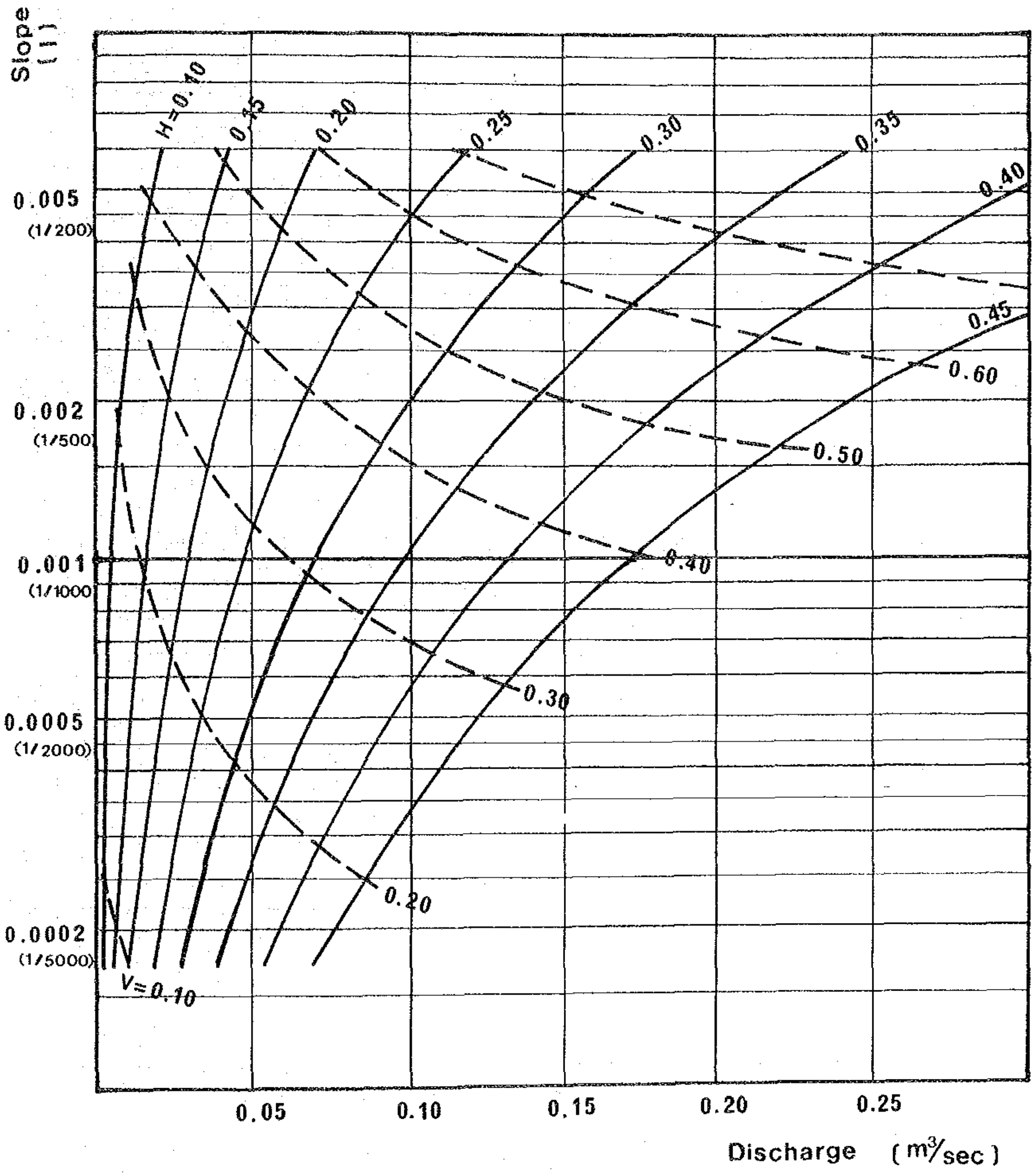


Fig. F-IV-1 Q-I-H-V Curve B=0.3 m=1.5 n=0.03

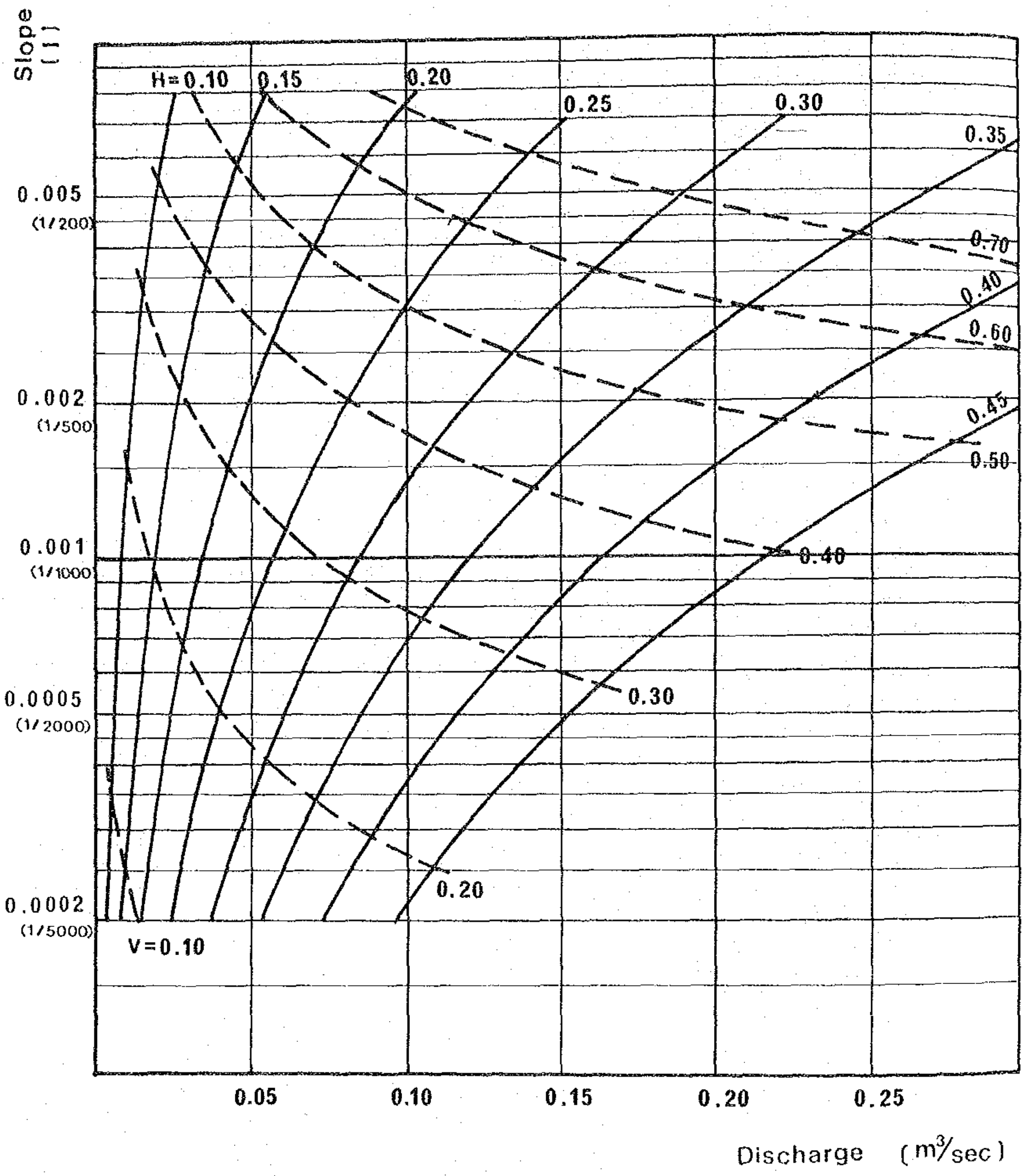


Fig. F-IV-2 Q-I-H-V Curve B=0.3 m=2.0 n=0.03

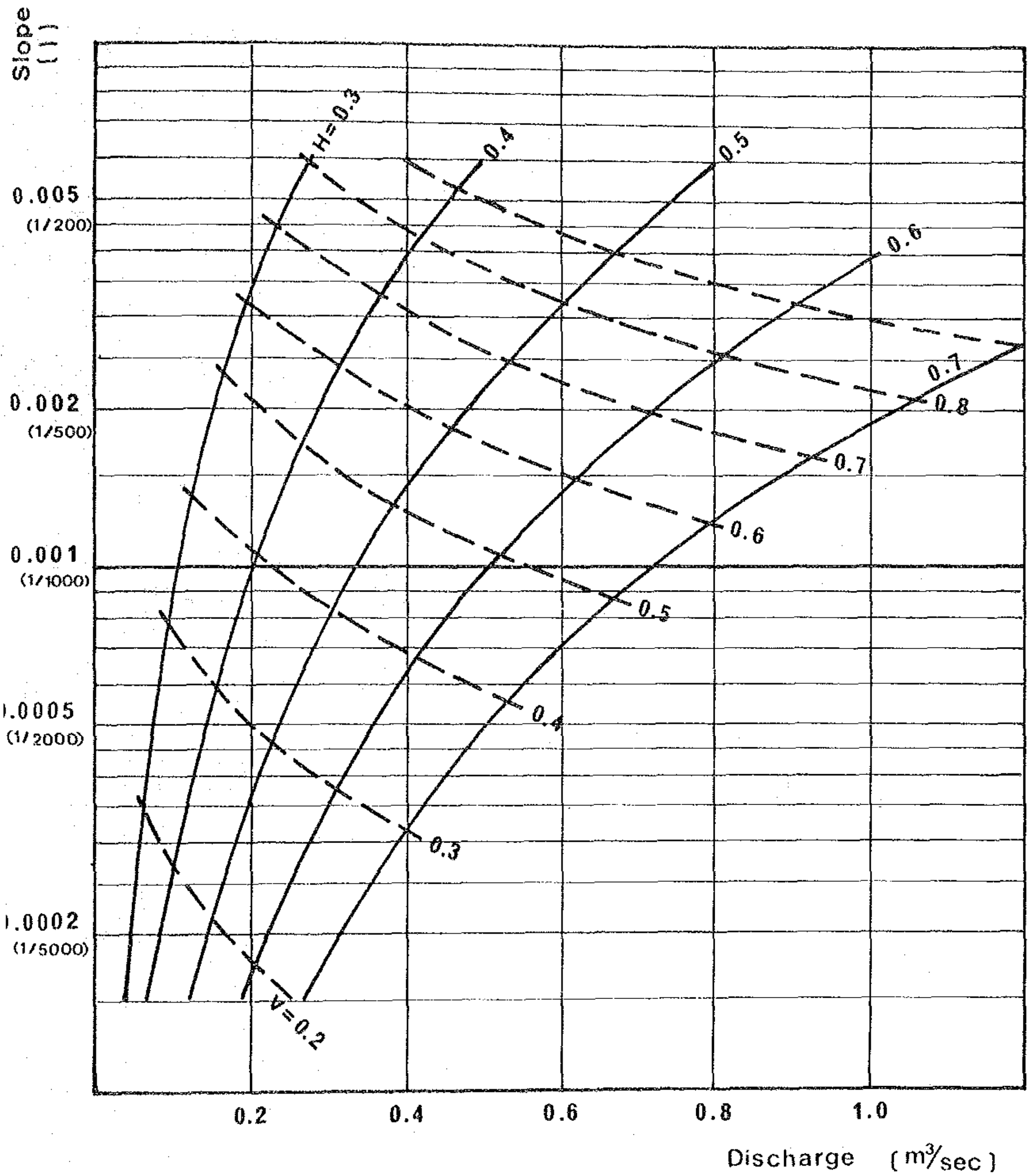


Fig. F-IV-3 Q-I-H-V Curve B=0.5 m=2.0 n=0.03

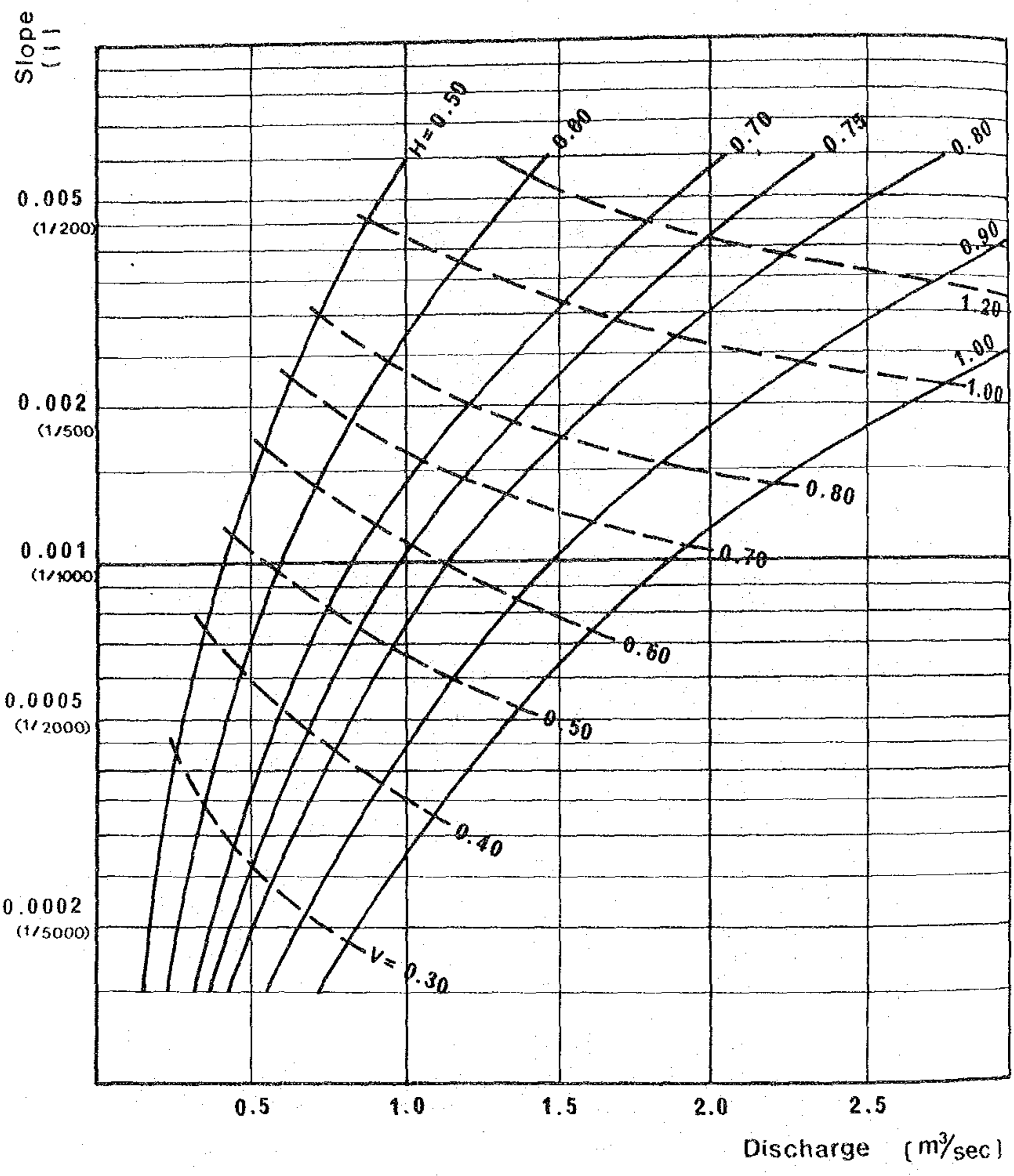


Fig. F-IV-4 Q-I-H-V Curve B=0.75 m=2.0 n=0.03

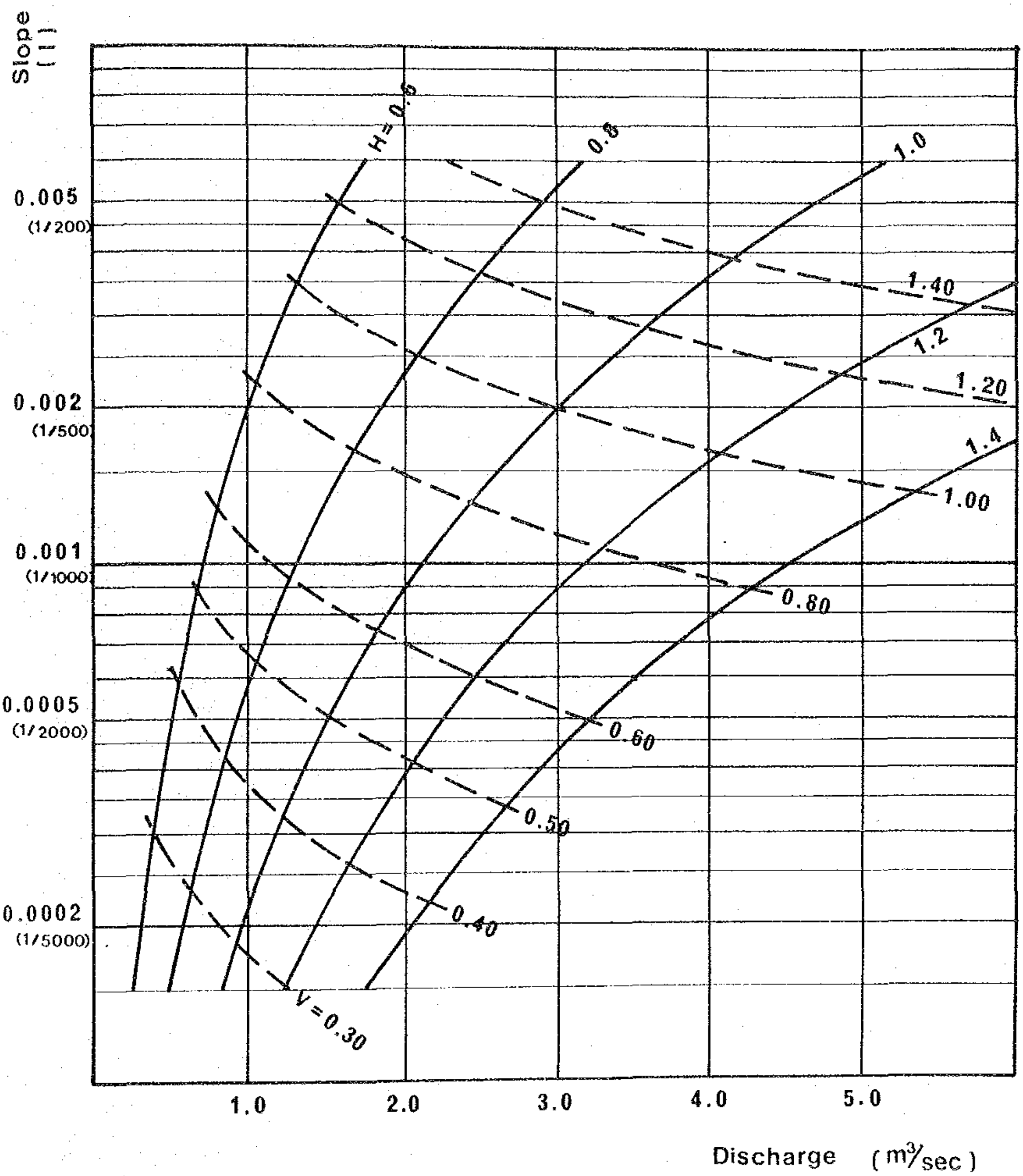


Fig. F-IV-5 Q-I-H-V Curve B-1.0 m=2.0 n=0.03

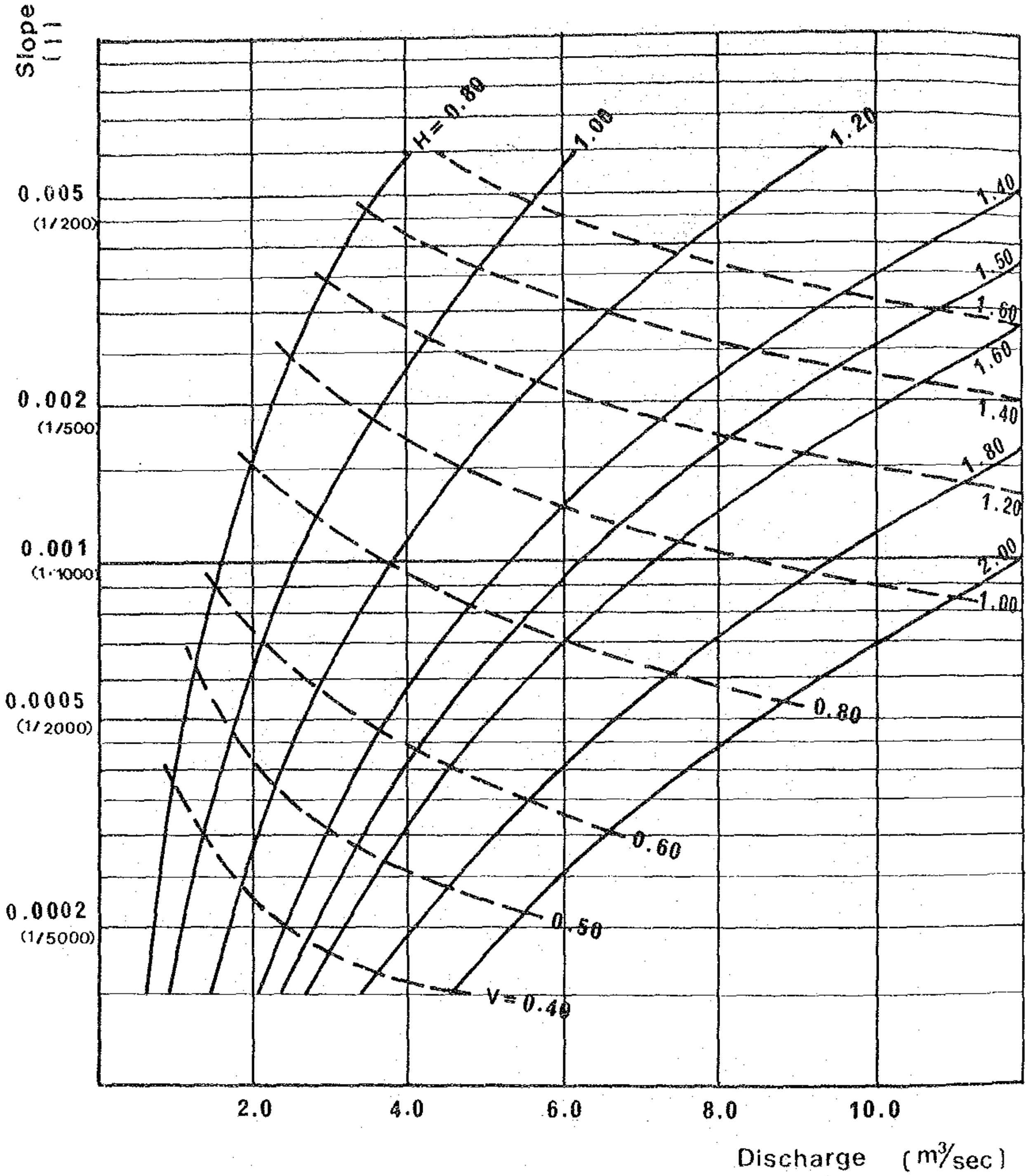


Fig. F-IV-6 Q-I-H-V Curve B=1.5 m=2.0 n=0.03

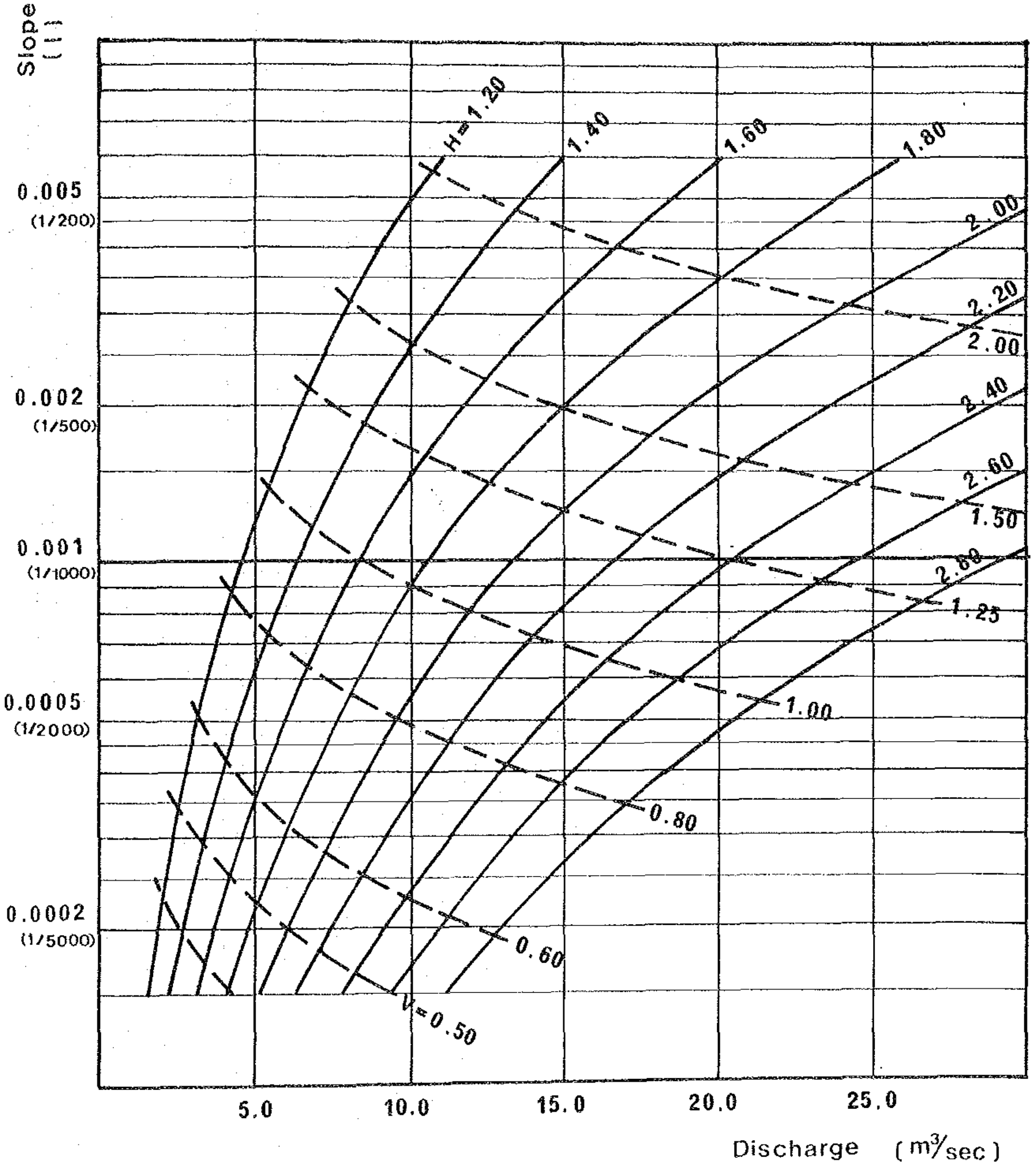


Fig. F-IV-7 Q-I-H-V Curve B=2.0 m=2.0 n=0.03

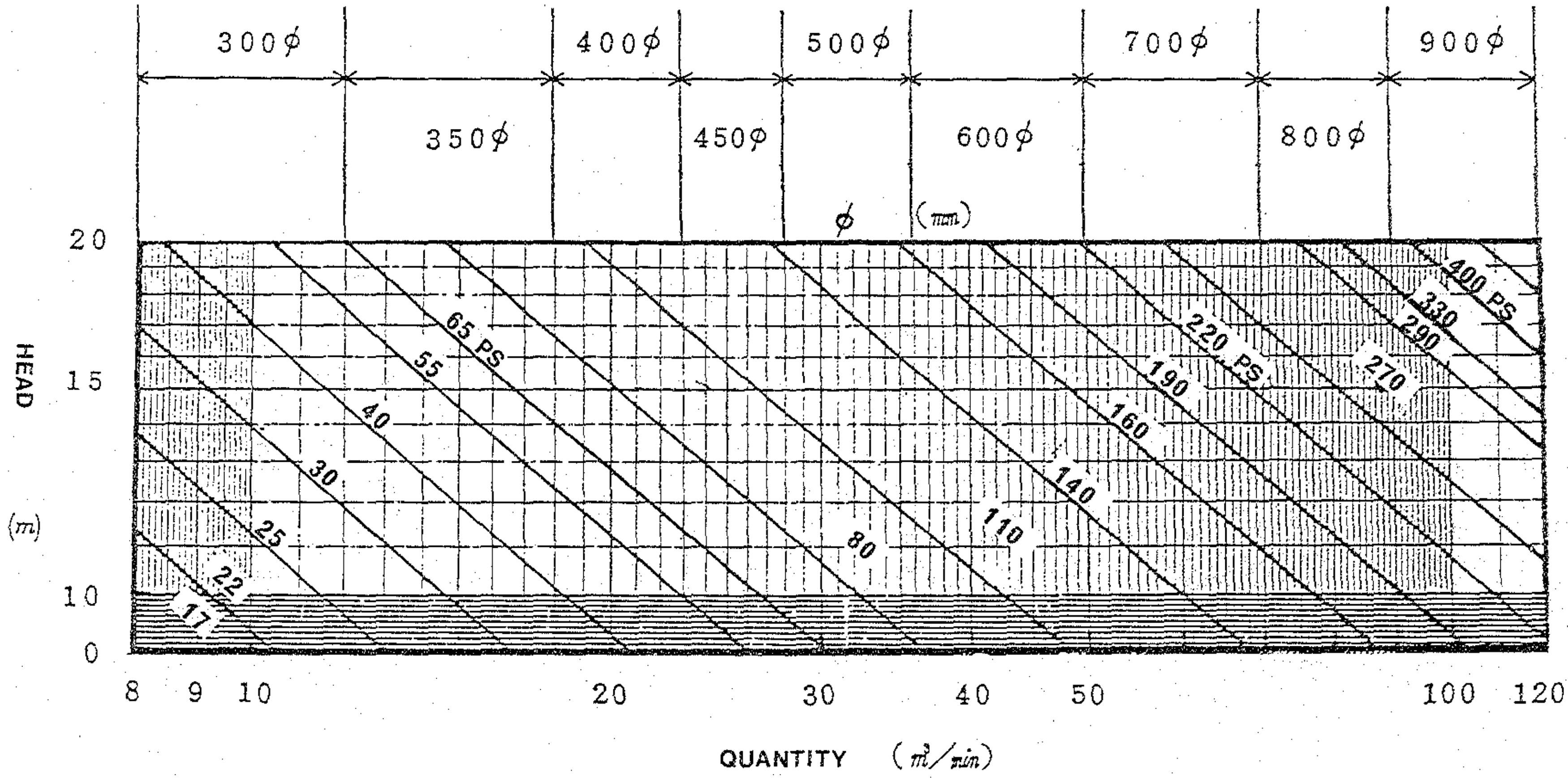


Fig. F-IV-8 Mixed Flow Pump Motor Capacity Selection Chart

V. Operation Plan for Irrigation System

The system operation plans to be applied for main canals No. 6 and No. 7 are shown in Tables F-V-1 to F-V-7 and the maximum water supply plans for five years return period are as set out in Fig. F-V-1 to F-V-4, which are slightly different from those for normal year.

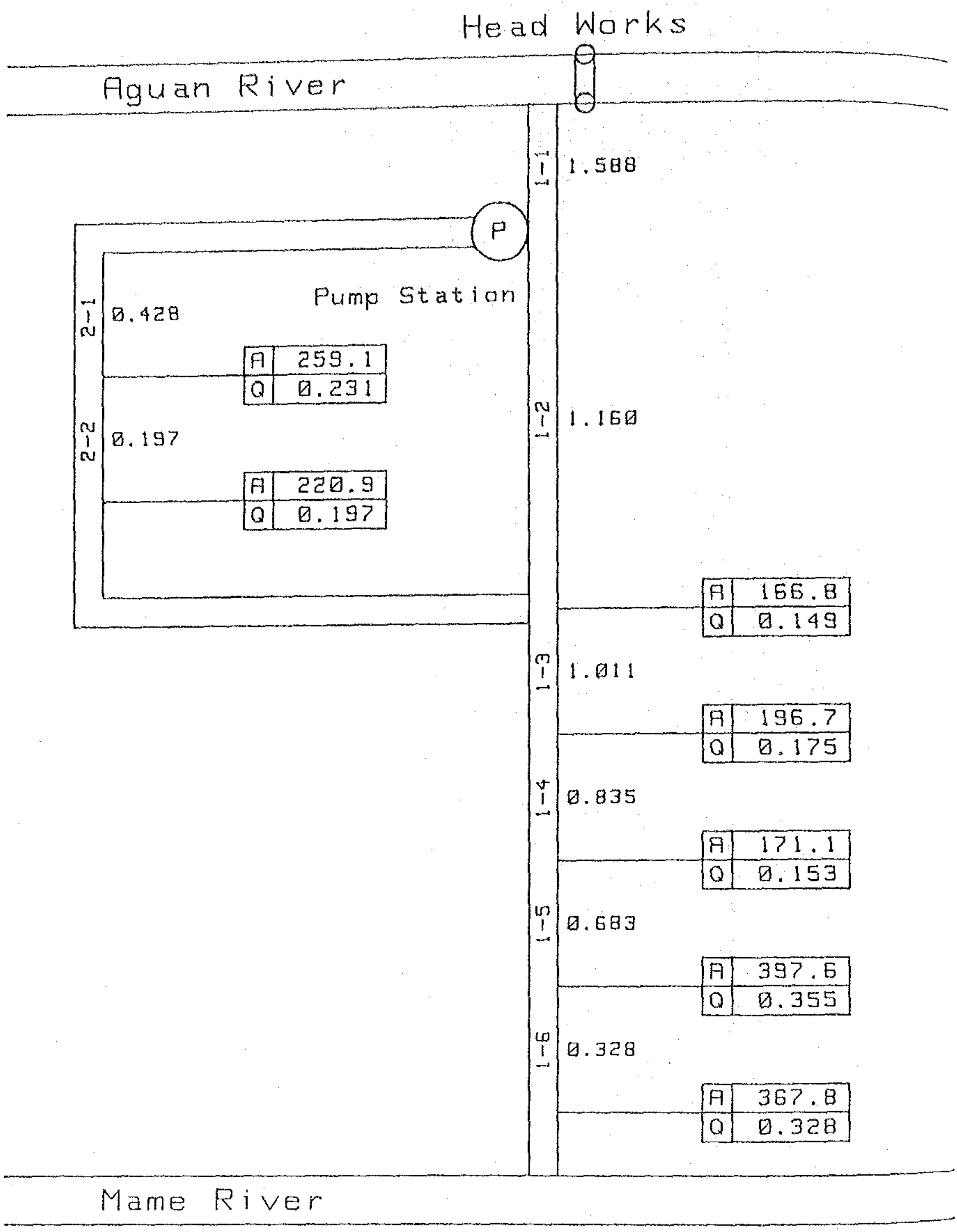


Fig. F-V-1 System Model (No.1 and No.2)

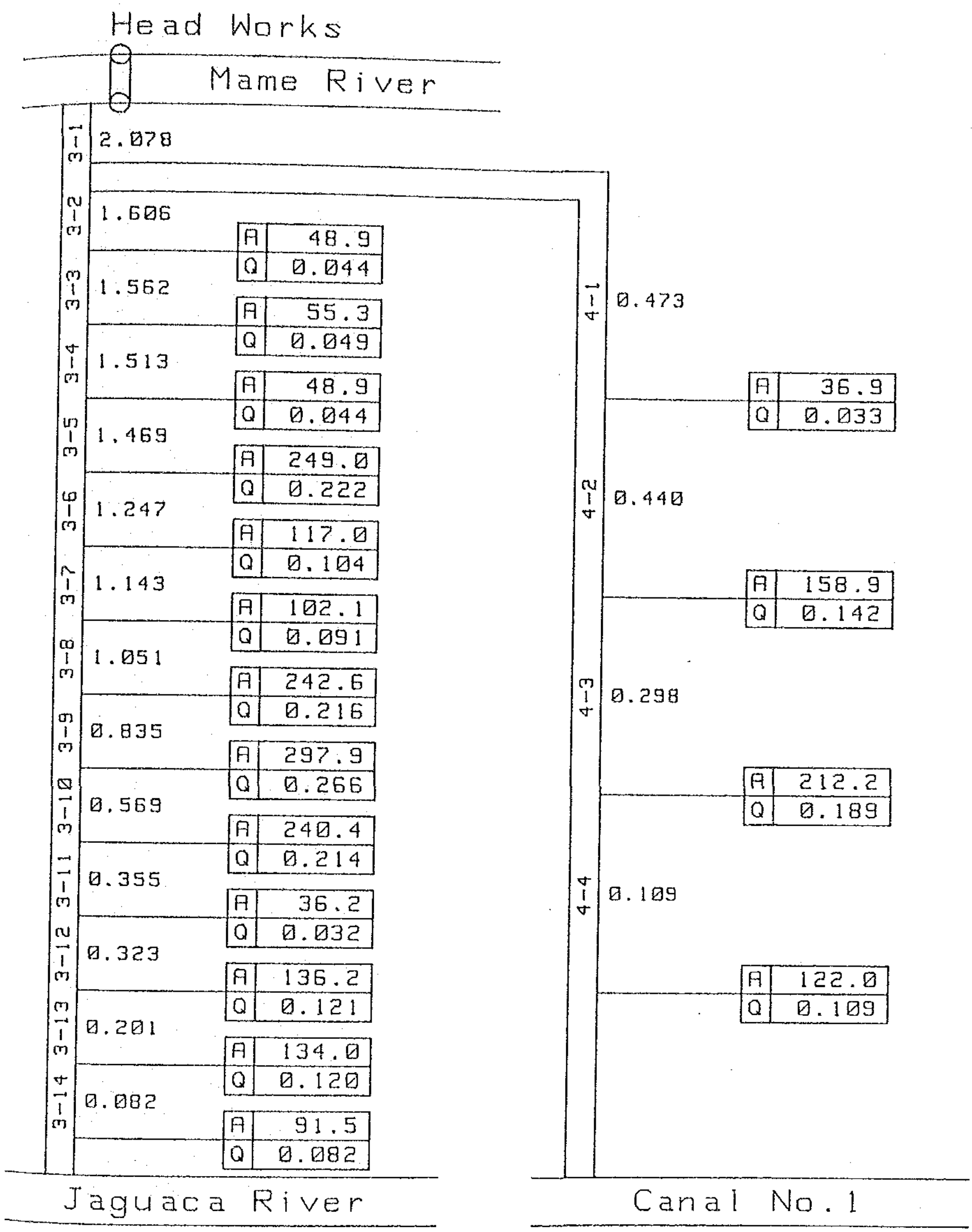


Fig. F-V-2 System Model (No.3 and No.4)

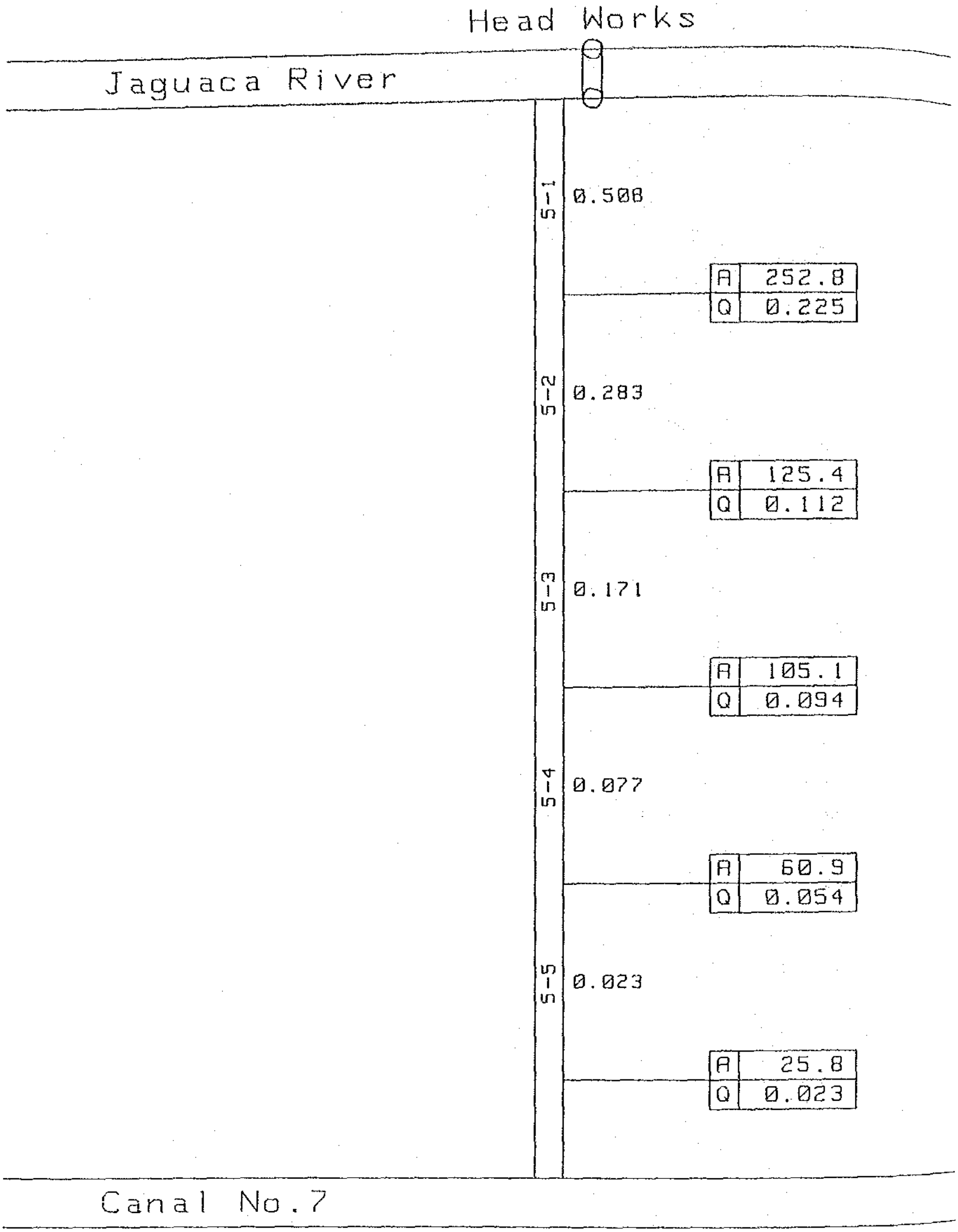


Fig. F-V-3 System Model (No.5)

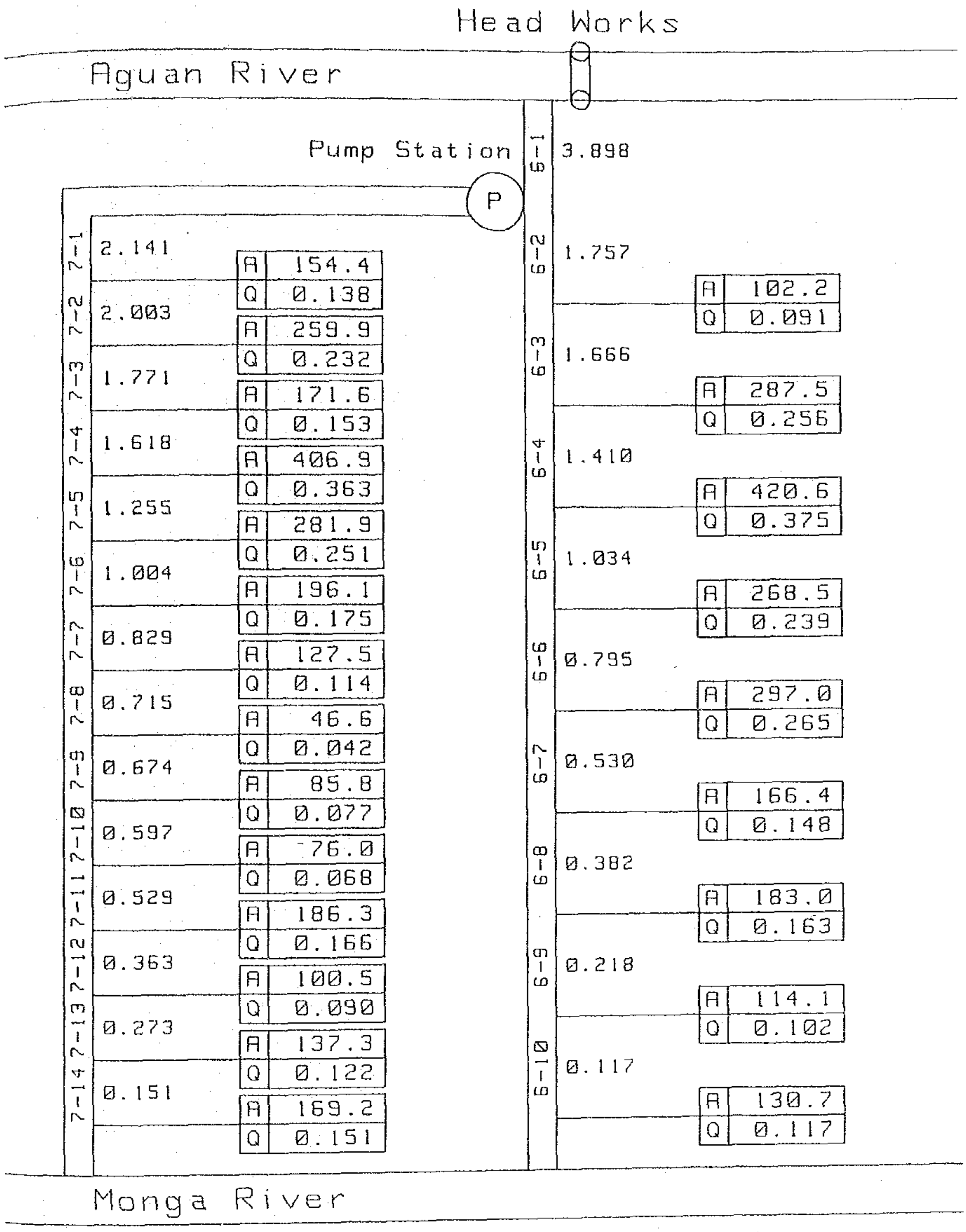


Fig. F-V-4 System Model (No.6 and No.7)

Table F-V-1 Operation Program

(MAIN CANAL No.1)

(Unit : m3/sec)

Canal No.		Irrigation Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAIN	1- 1	1780.0	1.152	1.410	1.588	.452	0.000	.152	1.262	1.382	.554	0.000	0.000	0.000
DIVERSION	1- 1	480.0	.311	.380	.428	.122	0.000	.041	.340	.373	.149	0.000	0.000	0.000
MAIN	1- 2	1300.0	.842	1.030	1.160	.330	0.000	.111	.922	1.009	.405	0.000	0.000	0.000
DIVERSION	1- 2	166.8	.108	.132	.149	.042	0.000	.014	.118	.129	.052	0.000	0.000	0.000
MAIN	1- 3	1133.2	.734	.898	1.011	.288	0.000	.097	.804	.880	.353	0.000	0.000	0.000
DIVERSION	1- 3	196.7	.127	.156	.175	.050	0.000	.017	.139	.153	.061	0.000	0.000	0.000
MAIN	1- 4	936.5	.606	.742	.835	.238	0.000	.080	.664	.727	.292	0.000	0.000	0.000
DIVERSION	1- 4	171.1	.111	.136	.153	.043	0.000	.015	.121	.133	.053	0.000	0.000	0.000
MAIN	1- 5	765.4	.496	.606	.683	.194	0.000	.065	.543	.594	.238	0.000	0.000	0.000
DIVERSION	1- 5	397.6	.257	.315	.355	.101	0.000	.034	.282	.309	.124	0.000	0.000	0.000
MAIN	1- 6	367.8	.238	.291	.328	.093	0.000	.031	.261	.285	.115	0.000	0.000	0.000
DIVERSION	1- 6	367.8	.238	.291	.328	.093	0.000	.031	.261	.285	.115	0.000	0.000	0.000

(MAIN CANAL No.2)

(Unit : m3/sec)

Canal No.		Irrigation Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAIN	2- 1	480.0	.311	.380	.428	.122	0.000	.041	.340	.373	.149	0.000	0.000	0.000
DIVERSION	2- 1	259.1	.168	.205	.231	.066	0.000	.022	.184	.201	.081	0.000	0.000	0.000
MAIN	2- 2	220.9	.143	.175	.197	.056	0.000	.019	.157	.171	.069	0.000	0.000	0.000
DIVERSION	2- 2	220.9	.143	.175	.197	.056	0.000	.019	.157	.171	.069	0.000	0.000	0.000

(MAIN CANAL No.3)

(Unit : m3/sec)

Canal No.		Irrigation Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAIN	3- 1	2330.0	1.508	1.846	2.078	.592	0.000	.199	1.652	1.808	.726	0.000	0.000	0.000
DIVERSION	3- 1	530.0	.343	.420	.473	.135	0.000	.045	.376	.411	.165	0.000	0.000	0.000
MAIN	3- 2	1800.0	1.165	1.426	1.606	.457	0.000	.154	1.277	1.397	.561	0.000	0.000	0.000
DIVERSION	3- 2	48.9	.032	.039	.044	.012	0.000	.004	.035	.038	.015	0.000	0.000	0.000
MAIN	3- 3	1751.1	1.134	1.387	1.562	.445	0.000	.149	1.242	1.359	.545	0.000	0.000	0.000
DIVERSION	3- 3	55.3	.036	.044	.049	.014	0.000	.005	.039	.043	.017	0.000	0.000	0.000
MAIN	3- 4	1695.8	1.098	1.343	1.513	.431	0.000	.145	1.203	1.316	.528	0.000	0.000	0.000
DIVERSION	3- 4	48.9	.032	.039	.044	.012	0.000	.004	.035	.038	.015	0.000	0.000	0.000
MAIN	3- 5	1646.9	1.066	1.305	1.469	.418	0.000	.141	1.168	1.278	.513	0.000	0.000	0.000
DIVERSION	3- 5	249.0	.161	.197	.222	.063	0.000	.021	.177	.193	.078	0.000	0.000	0.000
MAIN	3- 6	1397.9	.905	1.107	1.247	.355	0.000	.119	.991	1.085	.435	0.000	0.000	0.000
DIVERSION	3- 6	117.0	.076	.093	.104	.030	0.000	.010	.083	.091	.036	0.000	0.000	0.000
MAIN	3- 7	1280.9	.829	1.015	1.143	.325	0.000	.109	.908	.994	.399	0.000	0.000	0.000
DIVERSION	3- 7	102.1	.066	.081	.091	.026	0.000	.009	.072	.079	.032	0.000	0.000	0.000
MAIN	3- 8	1178.8	.763	.934	1.051	.299	0.000	.101	.836	.915	.367	0.000	0.000	0.000
DIVERSION	3- 8	242.6	.157	.192	.216	.062	0.000	.021	.172	.188	.076	0.000	0.000	0.000
MAIN	3- 9	936.2	.606	.742	.835	.238	0.000	.090	.664	.727	.292	0.000	0.000	0.000
DIVERSION	3- 9	297.9	.193	.236	.266	.076	0.000	.025	.211	.231	.093	0.000	0.000	0.000
MAIN	3-10	638.3	.413	.506	.569	.162	0.000	.054	.453	.495	.199	0.000	0.000	0.000
DIVERSION	3-10	240.4	.156	.190	.214	.061	0.000	.021	.170	.187	.075	0.000	0.000	0.000
MAIN	3-11	397.9	.258	.315	.355	.101	0.000	.034	.282	.309	.124	0.000	0.000	0.000
DIVERSION	3-11	36.2	.023	.029	.032	.009	0.000	.003	.026	.028	.011	0.000	0.000	0.000
MAIN	3-12	361.7	.234	.287	.323	.092	0.000	.031	.257	.281	.113	0.000	0.000	0.000
DIVERSION	3-12	136.2	.088	.108	.121	.035	0.000	.012	.097	.106	.042	0.000	0.000	0.000
MAIN	3-13	225.5	.146	.179	.201	.057	0.000	.019	.160	.175	.070	0.000	0.000	0.000
DIVERSION	3-13	134.0	.087	.106	.120	.034	0.000	.011	.095	.104	.042	0.000	0.000	0.000
MAIN	3-14	91.5	.059	.072	.082	.023	0.000	.008	.065	.071	.028	0.000	0.000	0.000
DIVERSION	3-14	91.5	.059	.072	.082	.023	0.000	.008	.065	.071	.028	0.000	0.000	0.000

(MAIN CANAL No.4)

(Unit : m3/sec)

Canal No.	Irrigation Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAIN 4- 1	530.0	.343	.420	.473	.135	0.000	.045	.376	.411	.165	0.000	0.000	0.000
DIVERSION 4- 1	36.9	.024	.029	.033	.009	0.000	.003	.026	.029	.011	0.000	0.000	0.000
MAIN 4- 2	493.1	.319	.391	.440	.125	0.000	.042	.350	.383	.154	0.000	0.000	0.000
DIVERSION 4- 2	158.9	.103	.126	.142	.040	0.000	.014	.113	.123	.049	0.000	0.000	0.000
MAIN 4- 3	334.2	.216	.265	.298	.085	0.000	.029	.237	.259	.104	0.000	0.000	0.000
DIVERSION 4- 3	212.2	.137	.168	.189	.054	0.000	.018	.150	.165	.066	0.000	0.000	0.000
MAIN 4- 4	122.0	.079	.097	.109	.031	0.000	.010	.087	.095	.038	0.000	0.000	0.000
DIVERSION 4- 4	122.0	.079	.097	.109	.031	0.000	.010	.087	.095	.038	0.000	0.000	0.000

(MAIN CANAL No.5)

(Unit : m3/sec)

Canal No.	Irrigation Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAIN 5- 1	570.0	.369	.452	.508	.145	0.000	.049	.404	.442	.178	0.000	0.000	0.000
DIVERSION 5- 1	252.8	.164	.200	.225	.064	0.000	.022	.179	.196	.079	0.000	0.000	0.000
MAIN 5- 2	317.2	.205	.251	.283	.081	0.000	.027	.225	.246	.099	0.000	0.000	0.000
DIVERSION 5- 2	125.4	.081	.099	.112	.032	0.000	.011	.089	.097	.039	0.000	0.000	0.000
MAIN 5- 3	191.8	.124	.152	.171	.049	0.000	.016	.136	.149	.060	0.000	0.000	0.000
DIVERSION 5- 3	105.1	.068	.083	.094	.027	0.000	.009	.075	.082	.033	0.000	0.000	0.000
MAIN 5- 4	86.7	.056	.069	.077	.022	0.000	.007	.061	.067	.027	0.000	0.000	0.000
DIVERSION 5- 4	60.9	.039	.048	.054	.015	0.000	.005	.043	.047	.019	0.000	0.000	0.000
MAIN 5- 5	25.8	.017	.020	.023	.007	0.000	.002	.018	.020	.008	0.000	0.000	0.000
DIVERSION 5- 5	25.0	.017	.020	.023	.007	0.000	.002	.018	.020	.008	0.000	0.000	0.000

(MAIN CANAL No.6)

(Unit : m3/sec)

Canal No.		Irrigation Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAIN	6- 1	4370.0	2.829	3.462	3.898	1.109	0.000	.373	3.099	3.392	1.361	0.000	0.000	0.000
DIVERSION	6- 1	2400.0	1.554	1.901	2.141	.609	0.000	.205	1.702	1.863	.747	0.000	0.000	0.000
MAIN	6- 2	1970.0	1.275	1.561	1.757	.500	0.000	.168	1.397	1.529	.614	0.000	0.000	0.000
DIVERSION	6- 2	102.2	.066	.081	.091	.026	0.000	.009	.072	.079	.032	0.000	0.000	0.000
MAIN	6- 3	1857.8	1.209	1.480	1.666	.474	0.000	.159	1.325	1.450	.582	0.000	0.000	0.000
DIVERSION	6- 3	287.5	.186	.228	.256	.073	0.000	.025	.204	.223	.090	0.000	0.000	0.000
MAIN	6- 4	1580.3	1.023	1.252	1.410	.401	0.000	.135	1.121	1.227	.492	0.000	0.000	0.000
DIVERSION	6- 4	420.6	.272	.333	.375	.107	0.000	.036	.298	.326	.131	0.000	0.000	0.000
MAIN	6- 5	1159.7	.751	.919	1.034	.294	0.000	.099	.822	.900	.361	0.000	0.000	0.000
DIVERSION	6- 5	268.5	.174	.213	.239	.068	0.000	.023	.190	.208	.084	0.000	0.000	0.000
MAIN	6- 6	891.2	.577	.706	.795	.226	0.000	.076	.632	.692	.278	0.000	0.000	0.000
DIVERSION	6- 6	297.0	.192	.235	.265	.075	0.000	.025	.211	.231	.092	0.000	0.000	0.000
MAIN	6- 7	594.2	.385	.471	.530	.151	0.000	.051	.421	.461	.185	0.000	0.000	0.000
DIVERSION	6- 7	166.4	.108	.132	.148	.042	0.000	.014	.118	.129	.052	0.000	0.000	0.000
MAIN	6- 8	427.8	.277	.339	.382	.109	0.000	.037	.303	.332	.133	0.000	0.000	0.000
DIVERSION	6- 8	183.0	.118	.145	.163	.046	0.000	.016	.130	.142	.057	0.000	0.000	0.000
MAIN	6- 9	244.8	.158	.194	.218	.062	0.000	.021	.174	.190	.076	0.000	0.000	0.000
DIVERSION	6- 9	114.1	.074	.090	.102	.029	0.000	.010	.081	.089	.036	0.000	0.000	0.000
MAIN	6-10	130.7	.085	.104	.117	.033	0.000	.011	.093	.101	.041	0.000	0.000	0.000
DIVERSION	6-10	130.7	.085	.104	.117	.033	0.000	.011	.093	.101	.041	0.000	0.000	0.000

(MAIN CANAL No.7)

(Unit : m3/sec)

Canal No.		Irrigation Area (ha)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MAIN	7- 1	2400.0	1.554	1.901	2.141	.609	0.000	.205	1.702	1.863	.747	0.000	0.000	0.000
DIVERSION	7- 1	154.4	.100	.122	.138	.039	0.000	.013	.109	.120	.048	0.000	0.000	0.000
MAIN	7- 2	2245.6	1.454	1.779	2.003	.570	0.000	.192	1.593	1.743	.699	0.000	0.000	0.000
DIVERSION	7- 2	259.9	.168	.206	.232	.066	0.000	.022	.184	.202	.081	0.000	0.000	0.000
MAIN	7- 3	1985.7	1.286	1.573	1.771	.504	0.000	.169	1.408	1.541	.618	0.000	0.000	0.000
DIVERSION	7- 3	171.6	.111	.136	.153	.044	0.000	.015	.122	.133	.053	0.000	0.000	0.000
MAIN	7- 4	1814.1	1.174	1.437	1.618	.461	0.000	.155	1.287	1.408	.565	0.000	0.000	0.000
DIVERSION	7- 4	406.9	.263	.322	.363	.103	0.000	.035	.289	.316	.127	0.000	0.000	0.000
MAIN	7- 5	1407.2	.911	1.115	1.255	.357	0.000	.120	.998	1.092	.438	0.000	0.000	0.000
DIVERSION	7- 5	281.9	.182	.223	.251	.072	0.000	.024	.200	.219	.088	0.000	0.000	0.000
MAIN	7- 6	1125.3	.729	.891	1.004	.286	0.000	.096	.798	.873	.350	0.000	0.000	0.000
DIVERSION	7- 6	196.1	.127	.155	.175	.050	0.000	.017	.139	.152	.061	0.000	0.000	0.000
MAIN	7- 7	929.2	.602	.736	.829	.236	0.000	.079	.659	.721	.289	0.000	0.000	0.000
DIVERSION	7- 7	127.5	.083	.101	.114	.032	0.000	.011	.090	.099	.040	0.000	0.000	0.000
MAIN	7- 8	801.7	.519	.635	.715	.204	0.000	.068	.569	.622	.250	0.000	0.000	0.000
DIVERSION	7- 8	46.6	.030	.037	.042	.012	0.000	.004	.033	.036	.015	0.000	0.000	0.000
MAIN	7- 9	755.1	.489	.598	.674	.192	0.000	.064	.536	.586	.235	0.000	0.000	0.000
DIVERSION	7- 9	85.8	.056	.068	.077	.022	0.000	.007	.061	.067	.027	0.000	0.000	0.000
MAIN	7-10	669.3	.433	.530	.597	.170	0.000	.057	.475	.519	.208	0.000	0.000	0.000
DIVERSION	7-10	76.0	.049	.060	.068	.019	0.000	.006	.054	.059	.024	0.000	0.000	0.000
MAIN	7-11	593.3	.384	.470	.529	.151	0.000	.051	.421	.460	.185	0.000	0.000	0.000
DIVERSION	7-11	186.3	.121	.148	.166	.047	0.000	.016	.132	.145	.058	0.000	0.000	0.000
MAIN	7-12	407.0	.263	.322	.363	.103	0.000	.035	.289	.316	.127	0.000	0.000	0.000
DIVERSION	7-12	100.5	.065	.080	.090	.026	0.000	.009	.071	.078	.031	0.000	0.000	0.000
MAIN	7-13	306.5	.198	.243	.273	.078	0.000	.026	.217	.238	.095	0.000	0.000	0.000
DIVERSION	7-13	137.3	.089	.109	.122	.035	0.000	.012	.097	.107	.043	0.000	0.000	0.000
MAIN	7-14	169.2	.110	.134	.151	.043	0.000	.014	.120	.131	.053	0.000	0.000	0.000
DIVERSION	7-14	169.2	.110	.134	.151	.043	0.000	.014	.120	.131	.053	0.000	0.000	0.000