APPENDIX H. AGRICULTURE

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Table H-1 Cropping Calendar

Crops	Variety	Nursery	Planting-Ripening	Harvesting
Tomato	E.V.	Aug. 1 - Sep.30	Oct. 1 - Nov.30	Dec. 1 - Jan.31
	M.V.	Sep. 1 - Oct.31	Nov. 1 - Dec.31	Jan. 1 - Feb.28
	L.V.	Oct. 1 - Nov.30	Dec. 1 - Jan.31	Feb. 1 - Mar.31
Eggplant	E.V.	Aug. 1 - Sep.30	Oct. 1 - Nov.10	Nov.11 - Jan.10
	M.V.	Sep. 1 - Oct.31	Nov. 1 - Dec.10	Dec.11 - Feb.10
	L.V.	Oct. 1 - Nov.30	Dec. 1 - Jan.10	Jan.11 - Mar.10
Redpepper	E.V.	Aug. 1 - Aug.31	Sep. 1 - Oct.31	Nov. 1 - Jan.31
	L.V.	Sep. 1 - Sep.30	Oct. 1 - Nov.30	Dec .1 - Feb.28
Cabbage	E.V.	Aug. 1 - Aug.31	Sep. 1 - Dec.31	Jan. 1 - Jan.31
	M.V.	Sep. 1 - Sep.30	Oct. 1 - Jan.31	Feb. 1 - Feb.28
	L.V.	Oct. 1 - Oct.31	Nov. 1 - Feb.28	Mar. 1 - Mar.31
Watermelon				
Winter	E.V.	-	Jan.15 - Mar.31	Apr. 1 - Apr.30
Season	M.V.	-	Feb. 1 - Apr.15	Apr.16 - May 15
	L.V.	-	Feb.16 - Apr.30	May 1 - May 31
Summer	E.V.	-	Jul. 1 - Sep.15	Sep.16 - Oct.15
Season	M.V.	-	Aug. 1 - Oct.15	Oct.16 - Nov.15
	L.V.	-	Sep. 1 - Nov.15	Nov.16 - Dec.15
Bean	E.V.	-	Sep. 1 - Nov.10	Nov.11 - Dec.31
	L.V.	-	Oct.11 - Dec.20	Dec.21 - Feb.10
Okra	E.V.	-	Feb. 1 - Mar.31	Apr. 1 - Jun.30
	M.V.	-	Mar. 1 - Apr.30	May 1 - Jul.31
	L.V.	-	Apr. 1 - May 31	Jun. 1 - Aug.31

E.V. ; Early Variety.
M.V. ; Medium Variety
L.V. ; Late Variety

Table H-2 Labor Requirements by Farming Practices

Crop: Tomato No.1 (Early Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Monthly Labor (hr/ha) Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Seed pot preparation		tiller, trailer or pick-up	2	160							(2) 160					
Seeding		by hand		55								55				
Nursery management	20days	by hand		90								45	45			
Transporting of manure		pick-up	10	20									(10) 20			
Ridging		ridger	5	5									(5) 5			
Fertilizing		tiller, trailer	2	10									(2) 10			
Manuring		tiller, trailer or pick-up	5	25									(5) 25			
Setting driphose		pick-up	5	29									(5) 29			
Transplanting		pick-up	30	400										(30) 400		
Setting supports		pick-up	30	440										(30) 440		
Weeding				90										20	40	30
Top dressing			6	30										(1) 5	(4) 20	(1) 5
Training Fruits thinning				200	10									30	80	80
Irrigating	120days			240	56									62	60	62
Crop protecting	4	pick-up sprayer	20	80	(3) 10									(3) 10	(7) 30	(7) 30
Harvesting Sorting		tiller, trailer	60	150	(30) 75											(30) 75
Farm cleaning		pick-up	9	34		(9) 34										
Total Machine			184		33	9					2		27	64	11	38
Man				2,058	151	34					160	100	134	967	230	282

Note: The figures within blackets are shown working hours for the machines and this Note can be referred to all tables in Appendix H-2.

Crop: Tomato No.2 (Middle Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
					Monthly Labour (hr/ha)											
Seed pot preparation		tiller, trailer or pick-up	2	160								(2) 160				
Seeding		by hand		55									55			
Nursery management	20days	by hand		90									45	45		
Transporting of manure		pick-up	10	20										(10) 20		
Ridging		ridger	5	5										(5) 5		
Fertilizing		tiller, trailer	2	10										(2) 10		
Manuring		tiller, trailer or pick-up	5	25										(5) 25		
Setting driphose		pick-up	5	29										(5) 29		
Transplanting		pick-up	30	400											(30) 400	
Setting supports		pick-up	30	440											(30) 440	
Weeding				90	30										30	30
Top dressing			6	30	(1) 5										(1) 5	(4) 20
Training Fruits thinning				200	70										60	70
Irrigating				234	62	50									60	62
Crop protecting	4	pick-up sprayer	20	80	(7) 30	(3) 10									(3) 10	(7) 30
Harvesting Sorting		tiller, trailer	60	150	(30) 75	(30) 75										
Farm cleaning		pick-up	9	34			(9) 34									
Total Machine			194		38	33	9					2		27	64	11
Man				2,052	272	135	34					160	100	134	1,005	212

Crop. Tomato No.3 (Late Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Monthly Labour (hr/ha) Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Seed pot preparation		tiller, trailer or pick-up	2	160									(2) 160			
Seeding		by hand		55										55		
Nursery management	20days	by hand		90										45	45	
Transporting of manure		pick-up	10	20											(10) 20	
Ridging		ridger	5	5											(5) 5	
Fertilizing		tiller, trailer	2	10											(2) 10	
Manuring		tiller, trailer or pick-up	5	25											(5) 25	
Setting driphose		pick-up	5	29											(5) 29	
Transplanting		pick-up	30	400												(30) 400
Setting supports		pick-up	30	440												(30) 440
Weeding				90	30	30										30
Top dressing			6	30	(4) 20	(1) 5										(1) 5
Training Fruits thinning				200	70	70										60
Irrigating				236	62	56	56									62
Crop protecting	4	pick-up strayer	20	80	(7) 30	(7) 30	(3) 10									(3) 10
Harvesting Sorting		tiller, trailer	60	150		(30) 75	(30) 75									
Farm cleaning		pick-up	9	34				(9) 34								
Total Machine			184		11	38	33	9					2		27	64
Man				2,054	212	266	141	34					160	100	134	1,007

Table H-3 Labour Requirements by Farming Practices

Crop: Eggplant No.1 (Early Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Seed pot preparation		tiller, trailer or pick-up	2	160							(2) 160					
Seeding				50								50				
Nursery management				90								45	45			
Manure transporting		pick-up	10	20									(10) 20			
Ridging Fertilizing		tiller, ridger, trailer	4	20									(4) 20			
Setting driphose		pick-up	2	26									(2) 26			
Transplanting		pick-up	30	375										(30) 375		
Setting supports		pick-up	30	440										(22) 330	(8) 110	
Weeding				90										20	40	30
Top dressing		pick-up or tiller trailer	6	33										(2) 11	(4) 22	
Training				100										20	50	30
Irrigating				198	14									62	60	62
Crop protecting		pick-up sprayer	10	40											(5) 20	(5) 20
Harvesting		pick-up or tiller trailer	60	200	(9) 30										(15) 50	(36) 120
Farm cleaning		pick-up or tiller trailer	9	34	(9) 34											
Total Machinery			163		18						2					
Man				1,876	78						160	95	111	818	352	262

Crop: Eggplant No.2 (Middle Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Seed pot preparation		tiller, trailer or pick-up	2	160								(2) 160				
Seeding				50									50			
Nursery management				90									45	45		
Manure transporting		pick-up	10	20										(10) 20		
Ridging Fertilizing		tiller, ridger, trailer	4	20										(4) 20		
Setting driphose		pick-up	2	26										(2) 26		
Transplanting		pick-up	30	375											(30) 375	
Setting supports		pick-up	30	440											(22) 330	(8) 110
Weeding				90	30										20	40
Top dressing		pick-up or tiller trailer	6	33											(2) 11	(4) 22
Training				100	30										20	50
Irrigating				198	62	14									60	62
Crop protecting		pick-up sprayer	10	40	(5) 20											(5) 20
Harvesting		pick-up or tiller trailer	60	200	(36) 120	(9) 30										(15) 50
Farm cleaning		pick-up or tiller trailer	9	34		(9) 34										
Total Machinery			163		41	18						2		16	54	32
Man				1,876	262	78						160	95	111	816	354

Crop: Eggplant No.3 (Late Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
					Monthly Labour (hr/ha)											
Seed pot preparation		tiller, trailer or pick-up	2	160									(2) 160			
Seeding				50										50		
Nursery management				90										45	45	
Manure transporting		pick-up	10	20											(10) 20	
Ridging Fertilizing		tiller, ridger, trailer	4	20											(4) 20	
Setting driphose		pick-up	2	26											(2) 26	
Transplanting		pick-up	30	375												(30) 375
Setting supports		pick-up	30	440	(8) 110											(22) 330
Weeding	3			90	40	30										20
Top dressing	2	pick-up or tiller trailer	6	33	(4) 22											(2) 11
Training				100	50	30										20
Irrigating	97days			194	62	56	14									62
Crop protecting	2	pick-up sprayer	10	40	(5) 20	(5) 20										
Harvesting		pick-up or tiller trailer	60	200	(15) 50	(36) 120	(9) 30									
Farm cleaning		pick-up or tiller trailer	9	34			(9) 34									
Total Machinery			163													
Man				1,872	354	256	78						160	95	111	818

Table H-4 Labor Requirements by Farming Practice

Crop: Redpepper No.1 (Early Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Seed pot preparation		tiller	3	300							(3) 300					
Seeding		by hand		90								90				
Nursery management		by hand		45								45				
Manure transporting		pick-up	10	20								(10) 20				
Ridging Fertilizing		tiller ridger	5	22								(5) 22				
Setting driphose		pick-up	2	30								(2) 30				
Transplanting		pick-up	20	320									(20) 320			
Weeding		by hand		30									10	10	10	
Top dressing		tiller cultivator ridger	6	36									(1) 6	(4) 24	(1) 6	
Irrigating				300	56								60	62	60	62
Crop protecting		pick-up	10	40										(7) 30	(3) 10	
Harvesting Sorting		pick-up	12	120	(4) 40										(3) 30	(5) 50
Farm cleaning		pick-up	5	20		(5) 20										
Total Machinery			73		4	5					3					
Man				1,373	96	20					300	207	396	126	116	112

Monthly Labour (hr/ha)

Crop: Redpepper No.2 (Late Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Monthly Labour (hr/ha) Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Seed pot preparation		tiller	3	300								(3) 300				
Seeding		by hand		90									90			
Nursery management		by hand		45									45			
Manure transporting		pick-up	10	20									(10) 20			
Ridging Fertilizing		tiller ridger	5	22									(5) 22			
Setting driphose		pick-up	2	30									(2) 30			
Transplanting		pick-up	20	320										(20) 320		
Weeding		by hand		30										10	10	10
Top dressing		tiller cultivator ridger	6	36										6	24	6
Irrigating				296	62	50								62	60	62
Crop protecting		pick-up	10	40											(7) 30	(3) 10
Harvesting Sorting		pick-up	12	120	(5) 50	(4) 40										(3) 30
Farm cleaning		pick-up	5	20			(5) 20									
Total Machinery			73													
Man				1,369	112	90	20					300	207	398	124	118

Table H-5 Labor Requirements by Farming Practice

Crop: Cabbage No.1 (Early Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Seed bed preparation		tiller ridger	2	5							(2) 5					
Seeding		by hand		3								3				
Nursery management		by hand		45								45				
Manure transporting		pick-up	10	40								(10) 40				
Ridging Fertilizing		tiller ridger	5	41								(5) 41				
Setting driphose		pick-up	6	28								(6) 28				
Irrigating	150day			300	56								60	62	60	62
Transplanting		tiller trailer or pick-up	20	320									(20) 320			
Weeding		by hand		90									20	40	30	
Top dressing		tiller cultivator trailer	4	18									(2) 9	(2) 9		
Crop protecting	4	pick-up sprayer	20	80									(5) 20	(5) 20	(5) 20	(5) 20
Harvesting Sorting		pick-up	30	270	(30) 270											
Farm cleaning		Pick-up	6	18		(6) 18										
Total Machinery			103		30	6					2	21	27	7	5	5
Man				1,258	326	18					5	157	429	131	110	82

Crop: Cabbage No.2 (Middle Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
					Monthly Labour (hr/ha)											
Seed bed preparation		tiller ridger	2	5								(2) 5				
Seeding		by hand		3									3			
Nursery management		by hand		45									45			
Manure transporting		pick-up	10	40									(10) 40			
Ridging Fertilizing		tiller ridger	5	41									(5) 41			
Setting driphose		pick-up	6	28									(6) 28			
Irrigating	148days			296	62	50								62	60	62
Transplanting		tiller trailer or pick-up	20	320										(20) 320		
Weeding		by hand		90										20	40	30
Top dressing		tiller cultivator trailer	4	18										(2) 9	(2) 9	
Crop protecting		pick-up sprayer	20	80	(5) 20									(5) 20	(5) 20	(5) 20
Harvesting Sorting		pick-up	30	270		(30) 270										
Farm cleaning		pick-up	6	18			(6) 18									
Total Machinery			103		5	30	6					2	21	27	7	5
Man				1,254	82	320	18					5	157	431	129	112

Crop: Cabbage No.3 (Late Variety)

Item	Freq.	Machinery	Working Hour Machine	Man	Monthly Labour (hr/ha) Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Seed bed preparation		tiller ridger	2	5									(2) 5			
Seeding		by hand		3										3		
Nursery management		by hand		45										45		
Manure transporting		pick-up	10	40										(10) 40		
Ridging Fertilizing		tiller ridger	5	41										(5) 41		
Setting driphose		pick-up	6	28										(6) 28		
Irrigating				296	62	56	56								60	62
Transplanting		tiller trailer or pick-up	20	320											(20) 320	
Weeding		by hand		90	30										20	40
Top dressing		tiller cultivator trailer	4	18											(2) 9	(2) 9
Crop protecting		pick-up sprayer	20	80	(5) 20	(5) 20									(5) 20	(5) 20
Harvesting Sorting		pick-up	30	270			(30) 270									
Farm cleaning		pick-up	6	18				(6) 18								
Total Machinery			103		5	5	30	6					2	16		
Man				1,254	112	76	326	18					5	157	429	131

Table H-6 *Labor Requirements by Farming Practice*

Crop: Watermelon (Winter Season), No.1 (Early Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Monthly Labour (hr/ha) Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Manure transporting		pick-up	10	20	(10) 20											
Ridging		ridger	1.5	2	(1.5) 2											
Seering Fertilizing		tiller, trailer	1.5	13	(1.5) 13											
Setting driphose		pick-up	2	11	(2) 11											
Irrigating				206	34	56	62	54								
Top dressing	3	tiller, trailer	3	9		(2) 6	(1) 3									
Training		by hand		160		90	70									
Weeding		by hand		60	10	30	20									
Harvesting Sorting		pick-up	30	300				(30) 300								
Farm cleaning		pick-up or tiller trailer	2	20					(2) 20							
Total Machinery			50		15	2	1	30	2							
Man				801	90	182	155	354	20							

Crop: Watermelon (Winter Season), No.2 (Middle Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Monthly Labour (hr/ha) Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Manure transporting		pick-up	10	20	(10) 20											
Ridging		ridger	1.5	2	(1.5) 2											
Seeding Fertilizing		tiller, trailer	1.5	13		(1.5) 13										
Setting driphose		pick-up	2	11	(2) 11											
Irrigating				202		56	62	60	24							
Top dressing	3	tiller, trailer	3	9		(1) 3	(1) 3	(1) 3								
Training		by hand		160		15	75	70								
Weeding		by hand		60		10	30	20								
Harvesting Sorting		pick-up	30	300				(15) 150	(15) 150							
Farm cleaning		pick-up or tiller trailer	2	20						(2) 20						
Total Machinery			50		13.5	2.5	1	16	15	2						
Man				797	33	97	170	303	174	20						

Crop: Watermelon (Winter Season), No.3 (Late Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
						Monthly Labour (hr/ha)										
Manure transporting		pick-up	10	20		(10) 20										
Ridging		ridger	1.5	2		(1.5) 2										
Seeding Fertilizing		tiller, trailer	1.5	13		(1.5) 13										
Setting driphose		pic-up	2	11		(2) 11										
Irrigating				204		26	62	60	56							
Top dressing	3	tiller, trailer	3	9			(1) 3	(2) 6								
Training		by hand		160			90	70								
Weeding		by hand		60		10	30	20								
Harvesting Sorting		pick-up	30	300					(15) 150	(15) 150						
Farm cleaning		pick-up or tiller trailer	2	20						(2) 20						
Total Machinery			50			15	1	2	15	17						
Man				799		82	185	156	206	170						

Table H-7 Labor Requirements by Farming Practice

Crop: Watermelon (Summer Season), No.1 (Early Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Monthly Labour (hr/ha) Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Manure transporting		pick-up	10	20						(10) 20						
Ridging		tiller, ridger	1.5	2						(1.5) 2						
Seeding Fertilizing		tiller, trailer	1.5	13							(1.5) 13					
Setting driphose		pick-up	2	11							(2) 11					
Irrigating	104days			208							62	62	60	24		
Top dressing	3	tiller, trailer	3	9							(1) 3	(1) 3	(1) 3			
Plant protecting	2	pick-up sprayer	10	20								(5) 10	(5) 10			
Training		by hand		160							30	90	40			
Weeding		by hand		60								30	30			
Harvesting Sorting		pick-up	30	300									(15) 150	(15) 150		
Farm cleaning		pick-up	2	20										(2) 20		
Total Machinery			60							11.5	4.5	6	21	17		
Man				823						22	119	195	293	194		

Crop: Watermelon (Summer Season), No.2 (Middle Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Manure transporting		pick-up	10	20							(10) 20					
Ridging		tiller, ridger	1.5	2							(1.5) 2					
Seeding Fertilizing		tiller, trailer	1.5	13								(1.5) 13				
Setting driphose		pick-up	2	11								(2) 11				
Irrigating	104days			208								62	60	62	24	
Top dressing	3	tiller, trailer	3	9								(1) 3	(1) 3	(1) 3		
Plant protecting	2	pick-up sprayer	10	20									(5) 10	(5) 10		
Training		by hand		160								30	90	40		
Weeding		by hand		60									30	30		
Harvesting Sorting		pick-up	30	300										(15) 150	(15) 150	
Farm cleaning		pick-up	2	20											(2) 20	
Total Machinery			60								11.5	4.5	6	21	17	
Man				823							22	119	193	295	194	

Monthly Labour (hr/ha)

Crop: Watermelon (Summer Season), No.3 (Late Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Monthly Labour (hr/ha) Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Manure transporting		pick-up	10	20								(10) 20				
Ridging		tiller, ridger	1.5	2								(1.5) 2				
Seeding Fertilizing		tiller, trailer	1.5	13									(1.5) 13			
Setting driphose		pick-up	2	11									(2) 11			
Irrigating	103days			206									60	62	60	24
Top dressing	3	tiller, trailer	3	9									(1) 3	(1) 3	(1) 3	
Plant protecting	2	pick-up sprayer	10	20										(5) 10	(5) 10	
Training		by hand		160									30	90	40	
Weeding		by hand		60										30	30	
Harvesting Sorting		pick-up	30	300											(15) 150	(15) 150
Farm cleaning		pick-up	2	20												(2) 20
Total Machinery			60									11.5	4.5	6	21	17
Man				821								22	117	195	293	194

Table H-8 Labor Requirements by Farming Practice

Crop: Dates

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Fertilizing	3	tiller, trailer	3	30	(1) 10	(1) 10	(1) 10									
Weeding	4	by hand		120		30			30			30			30	
Irrigating	365days			730	62 (3) 30	56 (3) 30	62 (2) 20	60	62	60	62	62	60	62	60	62 (3) 30
Leave thinning		pick-up	11	110						(13) 100	(14) 100	(13) 100				
Harvesting Sorting		pick-up	40	300												
Other		tiller, trailer	5	20	(2) 10	(3) 10										
Total Machinery			59		6	7	3			13	14	13				3
Man				1,310	112	136	92	60	92	160	162	192	60	62	90	92

Crop: Lime

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Pruning		tiller, trailer	10	100	(3) 35	(3) 30										(4) 35
Fertilizing		tiller, trailer	3	30	(1) 10		(1) 10		(1) 10							
Weeding		by hand		120	30		30			30			30			
Fruit thinning		by hand		100			50	50								
Crop Protecting		pick-up sprayer	20	60				(10) 30					(5) 15	(5) 15		
Irrigating				730	62	56	62	60	62	60	62	62	60	62	60	62
Harvesting Sorting		pick-up	50	400						(25) 200	(25) 200					
Total Machinery			83		4	3	1	10	1	25	25		5	5		4
Man				1,540	137	86	152	140	72	290	262	62	105	77	60	97

Crop: Banana

Item	Freq.	Machinery	Working Hour Machine	Man	Monthly Labour (hr/ha) Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Fertilizing		tiller, trailer	4	10			(1) 2.5					(1) 2.5		(1) 2.5	(1) 2.5	
Plant protecting	4	pick-up sprayer	154	194	(67) 67			(10) 30			(10) 30					(67) 67
Weeding		by hand		90			30				30			30		
Irrigating	365days			730	62	56	62	60	62	60	62	62	60	62	60	62
Harvesting Sorting		pick-up	17	204			(1) 12	(2) 24	(2) 24	(2) 24	(2) 24	(2) 24	(2) 24	(2) 24	(2) 24	
Total Machinery			175		67		2	12	2	2	12	3	2	3	3	67
Man				1,228	129	56	106.5	114	86	84	146	88.5	84	118.5	86.5	129

Table H-9 Labor Requirements by Farming Practices

Crop: Alfalfa (First Year)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Monthly Labour (hr/ha) Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Fertilizing Seeding		tiller, trailer	1	4		(1) 4										
Top dressing	3	tiller, trailer	3	9						(1) 3		(1) 3			(1) 3	
Plant protecting	9	pick-up sprayer	36	180				(4) 20	(4) 20	(4) 20	(4) 20	(4) 20	(4) 20	(4) 20	(4) 20	(4) 20
Harvesting Binding	8	hand mower	48	144					(6) 18	(6) 18	(6) 18	(6) 18	(6) 18	(6) 18	(6) 18	(6) 18
Irrigating				504		42	47	45	47	45	47	47	45	47	45	47
Total Machinery			88			1		4	10	11	10	11	10	10	11	10
Man				841		46	47	65	85	86	85	88	83	85	86	85

Crop: Alfalfa (2nd - 5th Year)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Monthly Labour (hr/ha) Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Top dressing	4	tiller, trailer	4	12			(1) 3			(1) 3			(1) 3			(1) 3
Plant protecting	12	pick-up sprayer	48	240	(4) 20	(4) 20	(4) 20	(4) 20	(4) 20	(4) 20	(4) 20	(4) 20	(4) 20	(4) 20	(4) 20	(4) 20
Irrigating	365days			551	47	42	47	45	47	45	47	47	45	47	45	47
Harvesting Binding	12	pick-up	72	216	(6) 18	(6) 18	(6) 18	(6) 18	(6) 18	(6) 18	(6) 18	(6) 18	(6) 18	(6) 18	(6) 18	(6) 18
Total Machinery			124		10	10	11	10	10	11	10	10	11	10	10	11
Man				1,019	85	80	88	83	85	86	85	85	86	85	83	88

Table H-10. Labor Requirements by Farming Practice

Crop: Bean, No.1 (Early Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Transporting of manure		pick-up	10	20								(10) 20				
Ridging		tiller, ridger	5	5								(5) 5				
Fertilizing		tiller, trailer	2	10								(2) 10				
Manuring		tiller, trailer	5	25								(5) 25				
Seeding				30									30			
Setting driphose		pick-up	5	29								(5) 29				
Setting supports		pick-up	30	160									(20) 110	(10) 50		
Weeding				90									20	35	35	
Top dressing		tiller, trailer	6	30									(1) 5	(4) 20	(1) 5	
Irrigating	119days			238									60	62	60	56
Crop protecting	3	pick-up sprayer	15	60									(5) 20	(5) 20	(5) 20	
Harvesting Sorting		pick-up	50	300											(20) 120	(30) 180
Farm cleaning		pick-up	9	50	(9) 50											
Total Machine			137		9							27	26	19	26	30
Man				1,047	50							89	245	187	240	236

Crop: Bean, No.2 (Middle Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
					Monthly Labour (hr/ha)											
Transporting of manure			10	20										(10) 20		
Ridging			5	5										(5) 5		
Fertilizing			2	10										(2) 10		
Manuring			5	25										(5) 25		
Seeding				30										30		
Setting driphose		pick-up	5	29										(5) 29		
Setting supports		pick-up	30	160										(30) 160		
Weeding				90	35										20	35
Top dressing			6	30	(1) 5										(1) 5	(4) 20
Irrigating				240	62	14								42	60	62
Crop protecting	3		15	60	(5) 20										(5) 20	(5) 20
Harvesting Sorting			50	300	(30) 180	(10) 60										(10) 60
Farm cleaning			9	50		(9) 50										
Total Machine			137		36	19								57	6	19
Man				1,049	302	124								321	105	197

Table H-11 Labor Requirements by Farming Practice

Crop: Okra, No.1 (Early Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Monthly Labour (hr/ha) Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Transporting of manure		pick-up	10	20	(10) 20											
Ridging		tiller, ridger	5	5	(5) 5											
Fertilizing		tiller, ridger	2	10	(2) 10											
Manuring		tiller, trailer	5	25	(5) 25											
Seeding				30		30										
Weeding				120			30	30	40	20						
Top dressing	3	tiller, trailer	6	30			(2) 10	(2) 10	(2) 10							
Irrigating				296		56	62	60	62	56						
Crop protecting		pick-up sprayer	10	40			(5) 20	(5) 20								
Harvesting Sorting		tiller, trailer	35	210				(10) 60	(13) 80	(12) 70						
Setting driphose		pick-up	5	29	(5) 29											
Farm cleaning		pick-up	9	34							(9) 34					
Total Machine			87		27		7	17	15	12	9					
Man				849	89	86	122	180	192	146	34					

Crop: Okra, No.2 (Middle Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Transporting of manure		pick-up	10	20		(10) 20										
Ridging		tiller, ridger	5	5		(5) 5										
Fertilizing		tiller, ridger	2	10		(2) 10										
Manuring		tiller, trailer	5	25		(5) 25										
Seeding				30			30									
Setting driphose		pick-up	5	29		(5) 29										
Weeding				120				30	30	40	20					
Top dressing		tiller, trailer	6	30				(2) 10	(2) 10	(2) 10						
Irrigating				300			62	60	62	60	56					
Crop protecting		pick-up sprayer	10	40				(5) 20	(5) 20							
Harvesting Sorting		pick-up	35	210					(10) 60	(13) 80	(12) 70					
Farm cleaning		pick-up	9	34								(9) 34				
Total Machine			87			27		7	17	15	12	9				
Man				853		89	92	120	182	190	146	34				

Crop: Okra, No.3 (Late Variety)

Item	Freq.	Machinery	Working Hour Machine	Working Hour Man	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
					Monthly Labour (hr/ha)											
Transporting of manure		pick-up	10	20			(10) 20									
Ridging		tiller, ridger	5	5			(5) 5									
Fertilizing		tiller, ridger	2	10			(2) 10									
Manuring		tiller, trailer	5	25			(5) 25									
Seeding				30				30								
Setting driphose		pick-up	5	29			(5) 29									
Weeding				120					30	30	40	20				
Top dressing		tiller, trailer	6	30					(2) 10	(2) 10	(2) 10					
Irrigating				300				60	62	60	62	56				
Crop protecting		pick-up sprayer	10	40					(5) 20	(5) 20						
Harvesting Sorting		pick-up	35	210						(10) 60	(13) 80	(12) 70				
Farm cleaning		pick-up	9	34									(9) 34			
Total Machine			87				27		7	17	15	12	9			
Man				853			89	90	122	180	192	146	34			

Table H-12 Labor Requirements by Farming Practice

Crop: Onion

Item	Machinery	Working Hour		Monthly Labour (hr/ha)											
		Machine	Man	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Nursery bed making	by hand		2								1	1			
Seeding	by hand		2									1	1		
Nursery management	by hand		100									30	30	30	10
Manure transporting	pick-up	10	20										(5) 10	(5) 10	
Ridging Fertilizing	tiller ridger	7	60										(3) 25	(3) 25	(1) 10
Setting driphose	pick-up	6	28									(2) 8	(2) 8	(2) 8	4
Irrigating			312	62	56	62	10							60	62
Transplanting	by hand		500									170	250	80	
Weeding	by hand		120									40	70	10	
Top dressing	tiller cultivator trailer	4	25									(1) 8	(2) 13	(1) 4	
Harvesting	by hand		450	150	200	100									
Farm cleaning	pick-up	6	15				(6) 15								
Total Machinery		33					6					3	12	11	1
Man			1,634	212	256	162	25				1	258	407	227	86

Table H-13 Labor Requirements by Farming Practice

Crop: Cauliflower

Item	Machinery	Machine	Man	Monthly Labour (hr/ha) Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Nursery bed making	by hand		4							2	2				
Seeding	by hand		2								1	1			
Thining	by hand		5								3	2			
Nursery management	by hand		100								30	50	20		
Manure transporting	pick-up	10	20									(5) 10	(5) 10		
Ridging Fertilizing	tiller ridger, trailer	5	40									(2) 16	(2) 16	(1) 8	
Setting driphose	pick-up	6	28									(2) 9	(3) 14	(1) 5	
Irrigating			348	62	58							44	62	60	62
Transplanting	tiller trailer or pick-up	20	320									(7) 107	(10) 160	(3) 53	
Weeding	by hand		90										30	30	30
Top dressing	tiller cultivator trailer	4	18										(2) 9	(2) 9	
Crop protecting	pick-up sprayer	20	80	(5) 20									(5) 20	(5) 20	(5) 20
Harvesting Sorting	pick-up	24	216	(10) 86	(10) 86	(4) 44									
Farm cleaning	pick-up	6	18			(6) 18									
Total Machinery		95		15	10	10						16	27	12	5
Man			1,289	168	144	62				2	36	239	341	185	112

FIGURE H-1 OPERATION SCHEDULE FOR PLOW AND SPRAYER

Crops		JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
Tomato,	E.V	O								—	O	O	O
	M.V	O									—	O	O
	L.V	O										—	O
Eggplant,	E.V									—		O	O
	M.V	O O									—		O
	L.V	O	O									—	
Red pepper,	E.V								—		O O		
	M.V									—		O O	
Cabbage,	E.V								—	O	O	O	O
	M.V	O								—	O	O	O
	L.V	O	O								—	O	O
Watermelon,	E.V					—			O	O			
	M.V						—			O	O		
	L.V							—			O	O	
Lime					O					O			
Alfalfa		O	O	O	O	O	O	O	O	O	O	O	O

Note: — Plowing
O Sprayering

Table H-14 Required Number of Plow and Sprayer

(Unit : ha)

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Plowing													
Tomato	-	-	-	-	-	-	-	-	1.67	1.67	1.66	-	5.0
Eggplant	-	-	-	-	-	-	-	-	2.00	2.00	2.00	-	6.0
Redpepper	-	-	-	-	-	-	-	-	3.00	3.00	-	-	6.0
Cabbage	-	-	-	-	-	-	-	1.67	1.67	1.66	-	-	5.0
W.Watermelon	3.44	1.66	-	-	-	-	-	-	-	-	-	-	5.0
S.Watermelon	-	-	-	-	-	1.67	1.67	1.66	-	-	-	-	5.0
Total	3.34	1.66	-	-	-	1.67	1.67	3.33	8.34	8.33	3.66	-	32.0
unit/day	1.6	0.8	-	-	-	0.8	0.8	1.6	4.0	4.0	1.7	-	
Sprayer													
Tomato	5.00	3.33	1.66	-	-	-	-	-	-	1.67	3.34	5.00	20.0
Eggplant	4.00	2.00	-	-	-	-	-	-	-	-	2.00	4.00	12.0
Redpepper	-	-	-	-	-	-	-	-	-	4.50	6.00	1.50	12.0
Cabbage	3.33	1.66	-	-	-	-	-	-	1.67	3.34	5.00	5.00	20.0
S.Watermelon	-	-	-	-	-	-	-	1.67	3.34	3.33	1.66	-	10.0
Alfalfa	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	240.0
Lime	-	-	-	20.00	-	-	-	-	10.00	10.00	-	-	40.0
Total	32.33	26.99	21.66	40.00	20.00	20.00	20.00	21.67	35.01	42.84	38.00	35.50	354.0
unit/day	12	10	8	15	7	7	7	8	13	16	14	13	130.0

Table H-15 Efficiency of Farm Operation

Machinery	(1) Operation width (m)	(2) Operation Speed (km/hr)	(3) (1)x(2)/10 Theoretic Operation Capacity (ha/hr)	(4) Efficiency in Field (%)	(5) (3)x(4) Operation Capacity in Field (ha/hr)	(6) Hours per ha (hr/ha)	Remark	
• Tractor 60 ps								
Diskplow 26 x 4	1.00	5	0.50	70	0.35	2.9		
Disk harrow 18 x 24	1.05	5.5	0.58	70	0.41	2.4		
• Tiller								
Ridzer								
Watermelon	2.5	3	0.75	85	0.64	1.5		
Eggplant	0.8	3	0.24	85	0.20	5.0		
Tomato	0.9	3	0.27	85	0.23	4.3		
Cabbage	0.75	3	0.23	85	0.20	5.0		
Redpepper	0.7	3	0.21	85	0.18	5.6		
Cultivater								
Cabbage	0.75	4	0.30	85	0.26	3.8		
Redpepper	0.7	4	0.28	85	0.24	4.2		
By Hand								
• Manuring								
Watermelon	2.5	1	0.25	55	0.14	7.1		
Eggplant	0.8	1	0.08	55	0.04	25.0		
Tomato	0.9	1	0.09	55	0.05	20.0		
Cabbage	0.75	1	0.08	55	0.04	25.0		
Redpepper	0.7	1	0.07	55	0.04	25.0		
Dates	9	1	0.90	55	0.50	2.0		
Lime	7	1	0.70	55	0.39	2.7	Only basic fertilizering	
• Fertilizing								
Watermelon	2.5	2	0.50	70	0.35	2.9	+1.5	4.4
Eggplant	0.8	2	0.16	70	0.11	9.1		11.0
Tomato	0.9	2	0.18	70	0.13	7.7	+1.9	9.6
Cabbage	0.75	2	0.15	70	0.11	9.1		11.0
Redpepper	0.7	2	0.14	70	0.10	10.0		11.9
Dates	9.0	2	0.18	70	0.13	7.7		
Lime	7.0	2	0.14	70	0.10	10.0		
Banana	3.0	2	0.60	70	0.42	2.4		
Alfalfa	3.0	2	0.60	70	0.42	2.4		
• Covering soil	2.0	3	0.60	90	0.54	1.9		
" watermelon	2.5	3	0.75	90	0.68	1.5		
• Mower	2.0	1	0.2	80	0.16	6.3		

Table H-16 Machinery Cost per Year

Item	No. (1) unit	Purchase Price (2) R.O.	Price (1)x(2) =(3) R.O.	Durable Period (4) Year	Depriciation Cost (3)x0.9 =(5) R.O.	Dep. Cost per Year (5)÷(4) =(6) R.O.	Repair Cost (3)x0.03 =(7) R.O.	Other Cost (3)x0.01 =(8) R.O.	Machinery Cost per Year (6)+(7)+(8) =(9) R.O.
Tractor	1	5,200	5,200	10	4,680	468	156	52	68 1/ (676)
Diskplow	1	1,000	1,000	15	900	60	30	10	10 2/ (100)
Sprayer	5	243	1,215	8	1,093	137	36	12	56 3/ (185)
Tiller	20	431	8,620	8	7,758	970	259	86	1,315
Redger	20	190	3,800	10	3,420	342	114	38	494
Cultivator	20	34	680	10	612	61	20	7	88
Handmower	20	154	3,060	8	2,754	344	92	31	467
Trailer	20	198	3.960	10	3,564	356	119	40	515
Pick-up	20	2,000	40,000	10	36,000	360	1,200	400	980 4/ (1,960)
Total			67,535		60,781	3,098	2,026	676	3,993

1/ : Share of Project farming 10% 676 x 0.1 = 68
2/ : Do 10 100 x 0.1 = 10
3/ : Do 30 185 x 0.3 = 56
4/ : Do 50 1,960 x 0.5 = 980

Table H-17 Agricultural Input Material

Crops	Area (ha)	Manure (t)	Fertilizer (t)	Seed (kg)	Dimethoate (ℓ)	Diathane (kg)	Kafil (ℓ)	Pirimor (ℓ)	Omit (ℓ)
Tomato	5	75	3.6	3	6	45	10	-	-
Watermelon (Winter S.)	5	75	3.6	18	-	-	-	-	-
Watermelon (Summer S.)	5	75	3.6	18	-	-	-	7	10
Cabbage	5	75	2.4	18	-	-	15	4	-
Eggplant	6	90	4.32	5	24	-	12	-	-
Redpepper	6	90	4.32	5	24	-	-	-	-
Dates	20	300	14.4	unit[1/] (2,960)	-	-	-	-	-
Lime	20	300	14.4	unit (4,900)	144	-	-	-	-
Banana	10	-	13.0	unit (16,000)	-	-	-	-	-
Alfalfa[2/]	20	300	9.52	720 kg	576	-	-	-	-
Sub-total[3/]	102	1,380	73.16	-	774	45	37	11	10
Cauliflower	6	90	2.9	11	-	-	18	5	-
Onion	6	90	3.0	60	-	-	-	-	-
Sub-total	12	180	5.9	-	-	-	18	5	-
Total[4/]	114	1,560	79.06	-	774	45	55	16	10

Note: 1/ Only fast year 2/ Lift time 6 years 3/ At full development stage
4/ Pre-full development stage (for 5 years)

Table H-18 Agricultural Input Material

Crops	Area	Furadan (kg)	Nogos (ℓ)	Nemacur (kg)	Pot (unit)	Support (unit)	Gasoline (ℓ)	Light Oil (ℓ)
Tomato	5	-	-	-	111,000	21,000	35,542	380
Watermelon (Winter S.)	5	-	-	-	-	-	11,180	130
Watermelon (Summer S.)	5	-	-	-	-	-	14,053	123
Cabbage	5	-	-	-	-	-	21,600	221
Eggplant	6	-	-	-	129,000	20,000	30,566	405
Redpepper	6	-	-	-	-	-	16,552	257
Dates	20	-	74	-	-	-	53,040	129
Lime	20	-	-	-	-	-	72,852	-
Banana	10	400	-	680	-	-	88,946	-
Alfalfa	20	-	-	-	-	-	125,415	-
Sub-total 1/	102	400	74	680	240,000	41,000	469,746	1,645
Cauliflower	6	-	-	-	-	-	25,920	265
Onion	6	-	-	-	-	-	30,566	405
Sub-total	12	-	-	-	-	-	56,486	670
Total 2/	114	400	74	680	240,000	41,000	526,232	2,315

Note: 1/ At full development stage 2/ Pre-full development stage (for 5 years)

Table H-19 Crop Production

Crops	Area (ha)	Yield	1st Year	2nd Year	3rd Year	3 ~ 5 Year	6 ~ 10 Year	11 ~ 20 Year	21 ~ Year
Dates	20	t/ha	0	0	0	0	4	6	6
		p.t 1/	0	0	0	0	80	120	120
Lime	20	t/ha	0	0	0	4	10	20	20
		p.t	0	0	0	80	200	400	400
Banana	10	t/ha	0	10	13	13	13	-	-
		p.t	0	100	130	130	130	-	-
Tomato	5	t/ha	20	30	40	40	40	40	40
		p.t	100	150	200	200	200	200	200
Cabbage	5	t/ha	13	19	25	25	25	25	25
		p.t	65	95	125	125	125	125	125
W.Watermelon	5	t/ha	8	12	15	15	15	15	15
		p.t	40	60	75	75	75	75	75
S.Watermelon	5	t/ha	5	8	10	10	10	10	10
		p.t	25	40	50	50	50	50	50
Eggplant	6	t/ha	13	19	25	25	25	25	25
		p.t	78	114	150	150	150	150	150
Redpepper	6	t/ha	8	12	15	15	15	15	15
		p.t	48	72	90	90	90	90	90
Alfalfa	20	t/ha	30	45	60	60	60	-	-
		p.t	600	900	1,200	1,200	1,200	-	-
Cauliflower	6	t/ha	10	15	18	18	-	-	-
		p.t	60	90	108	108	-	-	-
Onion	6	t/ha	8	12	15	15	-	-	-
		p.t	48	72	90	90	-	-	-

Note: 1/ p.t; Production (ton)

Table H-20 Labor Requirement per Farm

(Unit: hr)

Crops & Area	(ha)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Tomato	0.25	54	36	15	3	-	-	13	21	32	100	114	126	514
Watermelon														
Winter	0.25	10	30	42	67	33	16	-	-	-	-	-	-	198
Summer	0.25	-	-	-	-	-	2	12	28	50	57	40	16	205
Cabbage	0.25	43	35	29	2	-	-	1	14	50	60	56	27	317
Eggplant	0.30	59	28	7	-	-	-	13	21	30	85	106	120	469
Redpepper	0.30	26	14	3	-	-	-	38	64	76	66	31	29	347
Dates	1.00	112	136	92	60	92	160	162	192	60	62	90	92	1,310
Lime	1.00	137	86	152	140	72	290	262	62	105	77	60	97	1,540
Banana	0.50	65	28	53	57	43	42	73	44	42	59	43	65	614
Alfalfa	1.00	85	80	88	83	85	86	85	85	86	85	83	88	1,019
Sub-total 1/	5.10	591	473	481	412	325	596	659	531	531	651	623	660	6,533
Onion	0.30	64	77	49	8	-	-	-	1	77	122	68	26	492
Cauliflower	0.30	50	43	19	-	-	-	1	11	72	102	56	34	388
Sub-total	0.60	114	120	68	8	-	-	1	12	149	224	124	60	880
Total 2/	5.70	705	593	549	420	325	596	660	543	680	875	747	720	7,413

Note: 1/ At full development stage 2/ Pre-full development stage (for 5 years)

Table H-21 Labor Requirement

(Unit: hr)

Crops	Area (ha)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Tomato	5	1,080	720	300	60	-	-	260	420	640	2,000	2,280	2,520	10,280
Watermelon														
Winter	5	200	600	840	1,340	660	320	-	-	-	-	-	-	3,960
Summer	5	-	-	-	-	-	40	240	560	1,000	1,140	800	320	4,100
Cabbage	5	860	700	580	40	-	-	20	280	1,000	1,200	1,120	540	6,340
Eggplant	6	1,180	560	140	-	-	-	260	420	600	1,700	2,120	2,400	9,380
Redpepper	6	520	280	60	-	-	-	760	1,280	1,520	1,320	620	580	6,940
Dates	20	2,240	2,720	1,840	1,200	1,840	3,200	3,240	3,840	1,200	2,240	1,800	1,840	26,200
Lime	20	2,740	1,720	3,040	2,800	1,440	5,800	5,240	1,240	2,100	1,540	1,200	1,940	30,800
Banana	10	1,300	560	1,060	1,140	860	840	1,460	880	840	1,180	860	1,300	12,280
Sub-total 1/	102	11,820	9,460	9,620	8,240	6,500	11,920	13,180	10,620	10,620	13,020	12,460	13,200	130,660
Onion	6	1,280	1,540	980	160	-	-	-	20	1,540	2,440	1,360	520	9,840
Cauliflower	6	1,000	860	380	-	-	-	20	220	1,440	2,040	1,120	680	7,760
Sub-total	12	2,280	2,400	1,360	160	-	-	20	240	2,980	4,480	2,480	1,200	17,600
Total 2/	114	14,100	11,860	10,980	8,400	6,500	11,920	13,200	10,860	13,600	17,500	14,940	14,400	148,260

Note: 1/ At full development stage 2/ Pre-full development stage (for 5 years)

Incremental Production of Existing Date Plam Orchards

The existing date plam orchards in the Project Area stretch in 3-4 km wide strip land along the sea shore.

The groundwater in the sea shore area, holding water table ranging from 1.5m to 0m, has a salinity concentration of 1,000 to 3,000 ppm. The recent rapid increase in groundwater consumption suggests that the salinity concentration of the groundwater in this area will grow higher. The higher salinity concentration in the groundwater will result in lower quality of dates and decrease in their production (refer to Figure C-28, -29 and -36, Appendix-I). The Project, however, will alow to recharge the groundwater and prevent the sea water from intrusion to result in saving date production from yield decrease as well as from degrade the quality. The estimation of the benefits to be generated there from will require a time-consuming work, and the current study, being short in survey period, has made an estimation as follows.

The date production was presumed at 1.5 ton/ha for the high class and 1.3 ton/ha for the low class in production, respectively.

Based on these assumptions, the future production of date with sea water intrusion has been computed at 1.3 ton/ha for the high class and much lower than 1.3 ton/ha for the low class.

The existing acreages of the date orchards developing in the Project related area were estimated at 1,100 ha by measurement on the map. And the incremental production by Project realization was estimated at 220 ton.

[(1.5 ton/ha - 1.3 ton/ha) x 1,100 ha = 220 ton]

APPENDIX I. STRUCTURES AND FACILITIES

APPENDIX I.   STRUCTURES AND FACILITIES

I-1. Detention Dam

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I-2. Alternative Study on Irrigation Networks

1. Alternative Plan

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3. Hydraulic Calculation

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I-1. Detention Dam

1. Dam Site and Dam Axis

1.1 Dam Site

Five potential detention dam sites have been picked up and the comparative study has been made for the Wadi Jizzi Agricultural Development Project during early stage of the feasibility study. They are site A, B, C, D and E located along the Wadi Jizzi as shown in Figure I-1.

Judging from the topographical map and site investigations, the dam sites of A, B and C have rather small catchment areas and comparatively thin river-bed deposits with less than 10 meters in thickness compared with the dam sites of D and E. Since the detention dam mainly aims to store temporarily flood discharge and to recharge groundwater through infiltration along the existing water routes at the wadi course into aquifers with the stored water by the dam, the detention dam site should be located in the downstream reaches in order to command the river basin as large as possible taking into account the full utilization of the water resources, and the infiltration capacity into aquifers at the reservoir area formed by the dam and along the wadi course on the adjacent downstream of the detention dam site.

Consequently, the dam sites of A, B and C have been rejected through the study. In order to obtain the basic data on the potential dam site E, a brief topographical survey was carried out and the result was made clear that the length of the dam may exceed five kilometers.

As a result of survey, this dam site is not suitable to construct the detention dam from the economic point of view.

On the other hand, the potential dam site D has an enough water storage capacity more than 3.0 MCM and the river-bed consists of thick layer of the sand and gravel deposits, however, the right bank

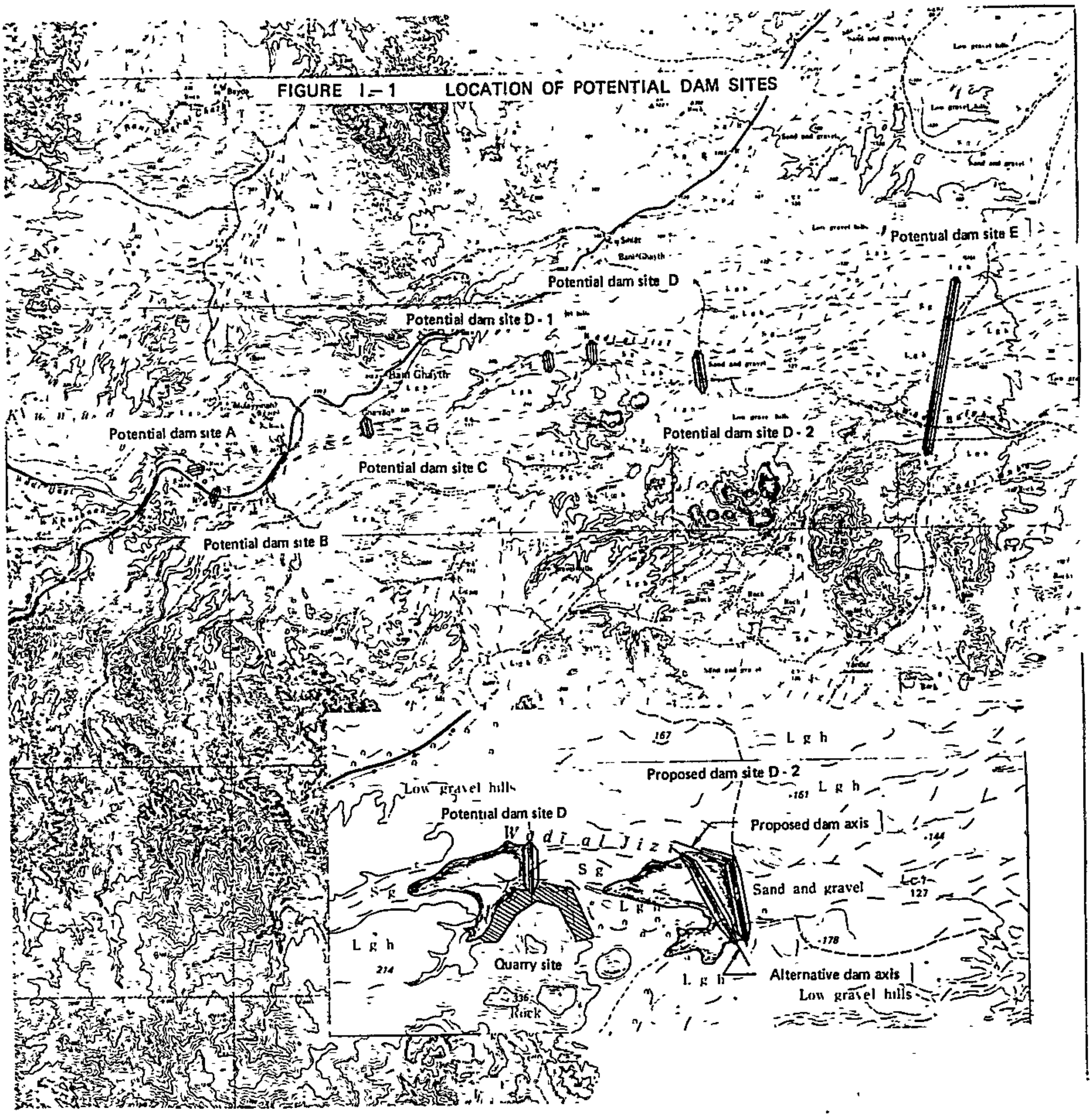


FIGURE I-1 LOCATION OF POTENTIAL DAM SITES
Potential dam site E
Potential dam site D
Potential dam site D - 1
Bani Ghayth
Potential dam site A
Potential dam site D - 2
Potential dam site C
Potential dam site B
L g h
Proposed dam site D - 2
Low gravel hills
Potential dam site D
Proposed dam axis
Wadi al Jiz
S g
Sand and gravel
Quarry site
Rock
Alternative dam axis
Low gravel hills

abutment is covered with thick talus deposits originated from siliceous limestones which are disunited with many block joints and disrupted materials.

According to the careful site investigations which were made around the potential dam site D, two alternative dam sites of D-1 and D-2 are examined as the detention dam site. The D-1 dam site is located at about 1.0 km upstream from the potential dam site D and the D-2 is about 2.5 km downstream from the dam site D.

The relations between the water surface elevation and area, and the sotrage capacity in the reservoir for two alternative dam sites (D-1 and D-2) are shown in Figure I-2 and I-3, respectively.

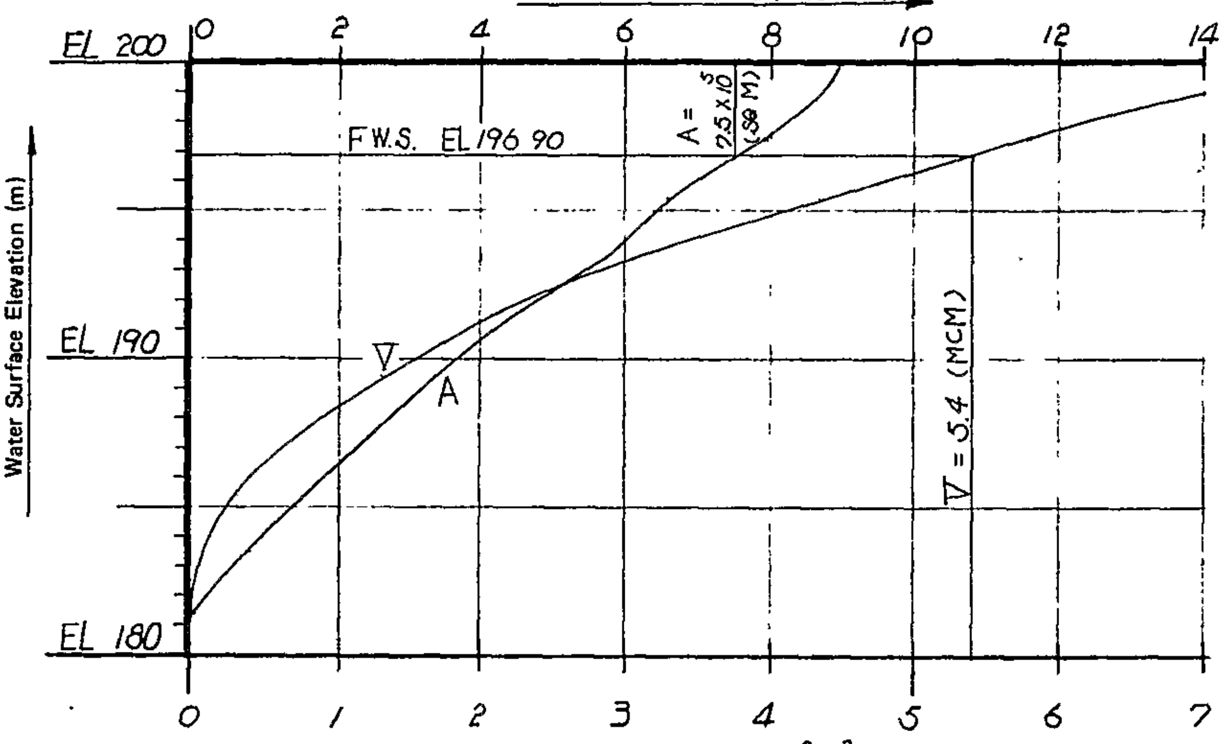
For each alternative dam site, the comparative study has been made on the dam height, embankment volume, direct construction cost1/ and corresponding rate to water cost. The results are tabulated below.

Items	D-1 dam site	D-2 dam site
Catchment area (sq.km)	665.0	812.0
Detention capacity (MCM)	5.4	5.4
Full water surface area (MSM)	0.75	1.25
Design flood discharge (cu.m/sec)	1,550.0	1,890.0
Dam height (m)	23.7	17.0
Crest length (m)	510.0	1,005.0
Corde-height ratio	22.0	59.0
Dam volume ('000 cu.m)	545.7	491.6
Direct construction cost (million R.O.)	2.059	2.013
Corresponding rate to water cost (R.O./cu.m)	0.3814	0.3728

1/ Direct construction cost consists of the costs for dam body, spillway and outlet facilities.

FIGURE I – 2 WATER SURFACE AREA AND STORAGE CAPACITY CURVE OF RESERVOIRS

POTENTIAL DAM SITE (D – 1)



ALTERNATIVE DAM AXIS

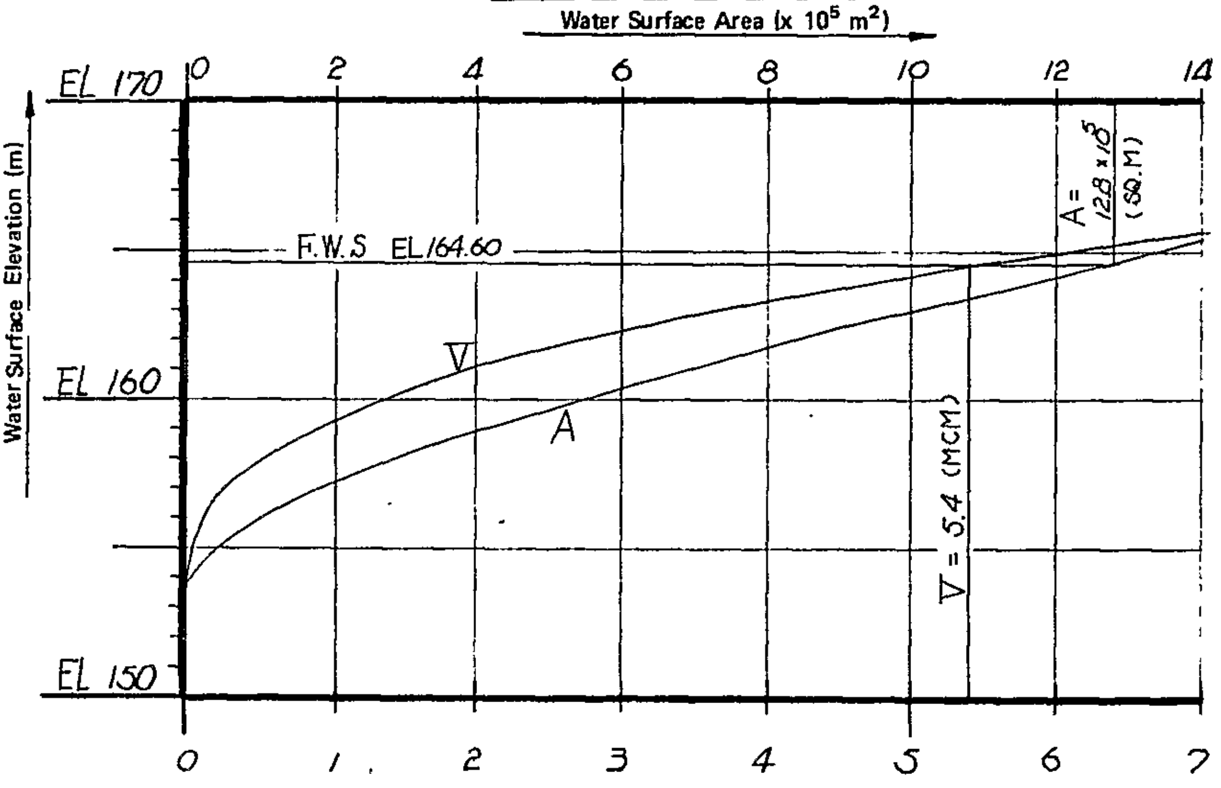
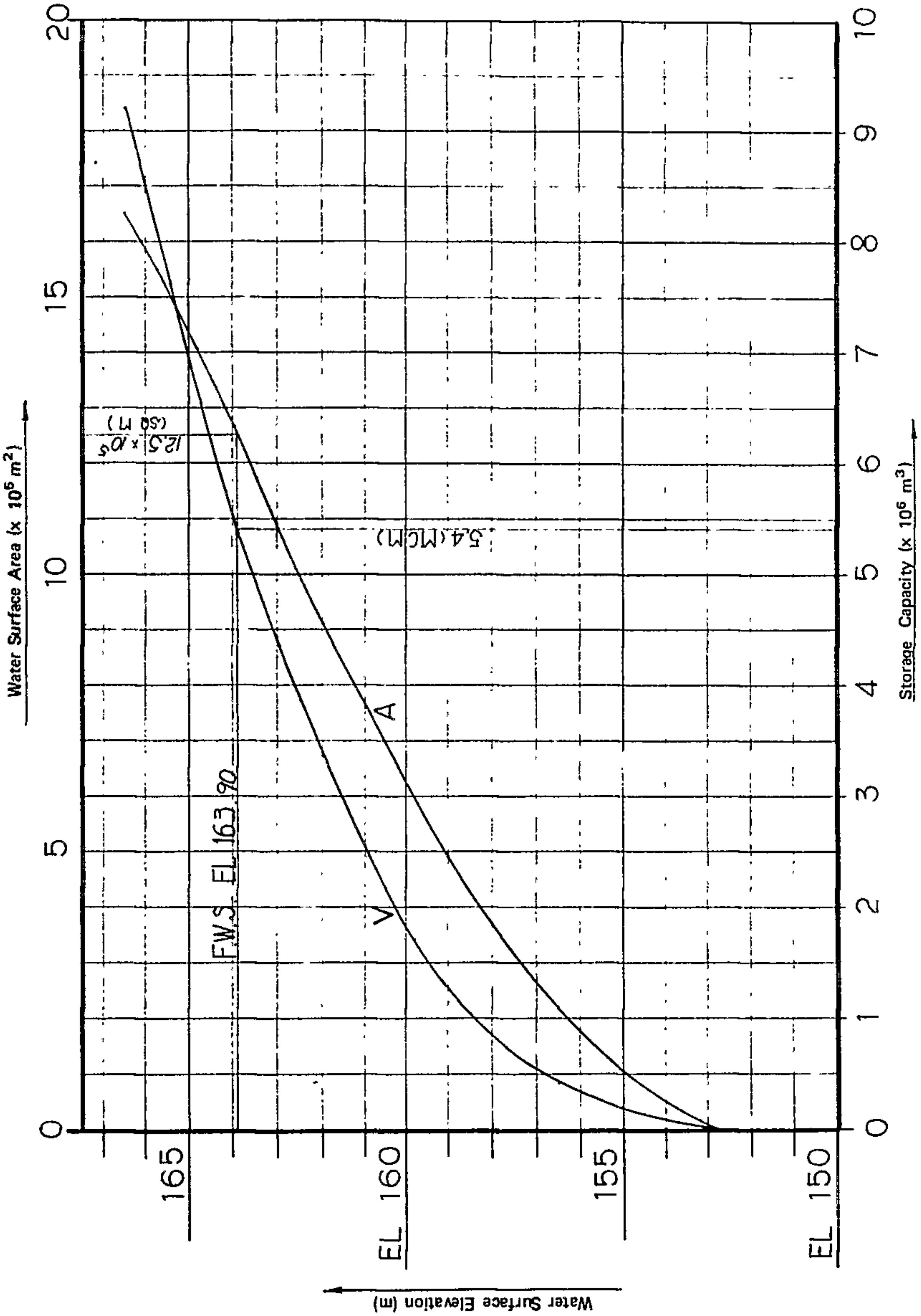


FIGURE I-3 WATER SURFACE AREA AND STORAGE CURVE OF PROPOSED DAMSITE (D-2)



As is indicated in the above table, the D-2 dam site is more economical than the D-1 dam site, consequently, the D-2 dam site is finally selected as the proposed dam site after due consideration on the following technical points.

- The capacity of reservoir at the D-2 dam site to aim flood control is larger than that of D-1 dam site.

- Since the D-2 dam site is located at about 3.5 km downstream from the D-1 dam site, the effective utilization of the water resources can be expected due to the commanded area of the river basin.

- The embankment materials to be used for sand and gravel fill can be easily obtained from any places and the borrowing conditions are more suitable than that of D-1 dam site.

- The height of detention dam to be constructed on the riverbed deposits is desirable as lower as possible due to the safety of the dam body against sliding and piping failures.

1.2 Dam Axis

Two dam axes shown in Figure I-1 were examined at the proposed dam site (D-2) and the comparative study has been made based on the major dimentions and required dam body costs. The results are summarized as follows:

Items	Proposed dam axis	Alternative dam axis
Detention capacity (MCM)	5.4	5.4
Full water surface area (MSM)	1.25	1.28 1/
Dam height (m)	17.0	17.7
Crest length (m)	1,005.0	915.0
Corde-height ratio ·	59.0	52.0
Dam volume ('000 cu.m)	491.6	518.0
Direct construction costs of dam body (million R.O.)	766.8	808.0

1/ Refer to Figure I-2.

Resulting from the comparative studies, the downstream axis is selected as the final dam axis for the detention dam from the economic point of view.

2. Dam Site Geology

According to the results of geological investigations executed around the proposed dam site, both the abutments are mainly composed of roundish gravel and sand, and they have the facies with variety of the horizons prevailing in well-sorted sand and pelitic materials. The gravel and sand have been well developed in conglomeration: particulary, conglomerates with calcareous matrix can be found in the lower part of this horizon. The gravels mainly composed of basic rocks, however, some rocks of diabase and gabbro are very much weathered and soft.

The Quaternary deposits existing in the river-bed can be classified into the recent wadi deposits and higher terrace deposits. The recent wadi deposits are formed with unconglomerated layers containing many roundish and subangular gravels, and these layers are developed evidently independent from the conglomerated lower formation which abounds in calcareous matrix.

The higher terrace deposits below the recent wadi deposits are composed mainly of the roundish to angular gravels, and the same as horizons of both abutments, although they have the facies with variety of the horizons prevailing in well-sorted sand and pelitic materials.

The permeability test conducted within an extent of the horizon shows ranging from n x 10^{-1} to n x 10^{-2} cm/sec. The horizons have been well developed in conglomeration in the whole extent.

The bed rocks are observed 10 to 30 m below the recent deposits and the facies seems to be composed of limestone and chart of Hawasina group. These rocks are hard and siliceous, and have many crucks, however, shear zone and fault are not expected around the dam site.

The geological map around the dam site and geological profiles along the dam axis are shown in Drawing D-1002 and the detail descriptions of geological investigations refer to Appendix D.

3. Embankment Materials

Embankment materials of the detention dam will mainly be obtained from terrace deposits composed of sand and gravel material on the spillway site and from the quarry site consisting of talus rock as described below:

3.1 Terrace Deposits (Sand and Gravel Materials, for Semi-pervious zone)

Terrace deposits are widely distributed all over the dam site, however these materials are deemed usuable as semi-pervious materials for the embankment of dam body. Therefore, the sampling of totally 10 materials have been executed at the dam site as shown in Figure I-4.

As to embankment materials of semi-pervious zone, the spillway site is selected as the borrow area taking into account the excavation volume at the spillway, physical properties of these materials and the borrowing condition.

Terrace deposits at the spillway site mainly consist of sand and gravel materials belonging to the well consolidated upper terrace deposits with a small quantity of cobble, and these materials can be easily borrowed from any places nearby the spillway site; moreover, the borrow area can be enlarged to any extent and to any depth, if required.

An outline of soil mechanical properties of the coarse materials such as sand and gravel can be assumed from the gradation analysis curve. Table I-1 and Figure I-5 show the results of soil tests of the samples of terrace deposits obtained around the dam site.

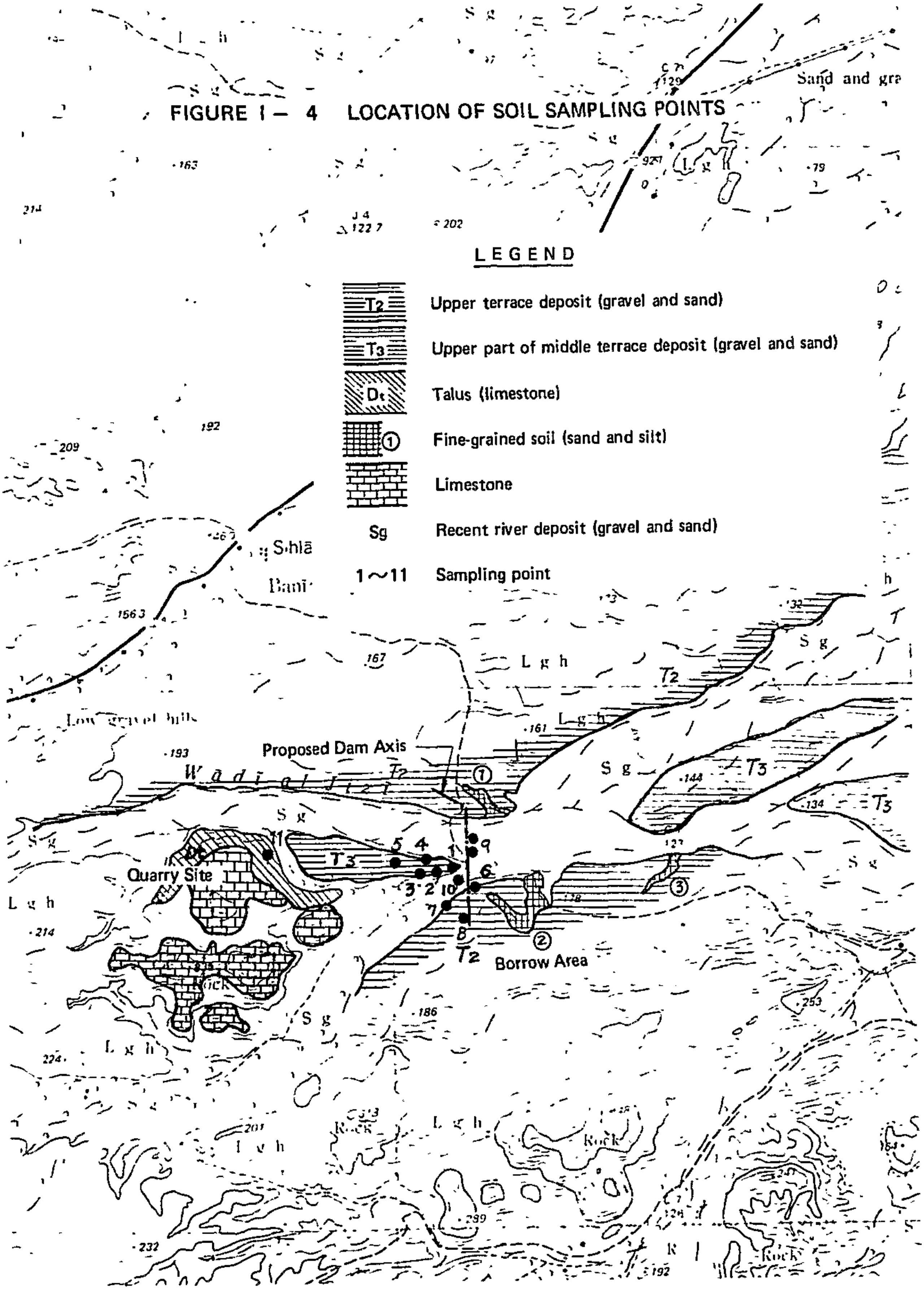


FIGURE I – 4 LOCATION OF SOIL SAMPLING POINTS

Table I - 1 Summary of Soil Tests

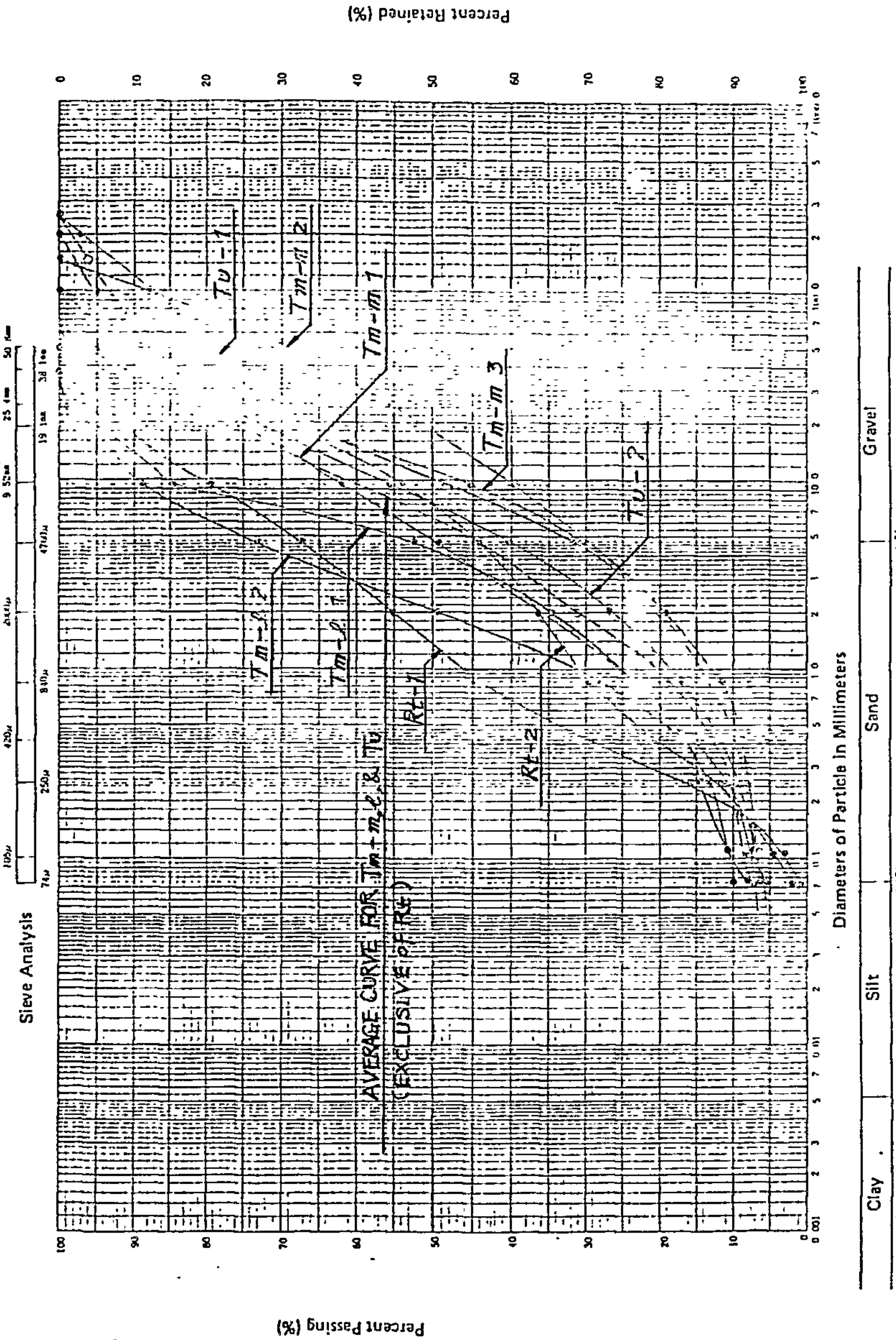
Group Symbols	Geological Formation & Lithology	Unified Soil Classification System	Apparent Specific Gravity (+4.76mm)	Water absorption (%)	Grain Size Distribution mm -0.074 (%)	Grain Size Distribution mm -4.76 (%)	Grain Size Distribution mm -50.8 (%)	Uc	Uc'	Classification
Tm - u	Upper part of middle terrace deposit Gravel and sand. Well consolidated. Gravel partially weathered. Assumed thickness 4.0 m.	GW	2.80 ~ 2.90 (2.85)	2.4 (2.4)	0.5 ~ 4.0 (1.5)	20.2 ~ 36.9 (28.0)	47.3 ~ 73.9 (62.6)	57.1 ~ 87.2 (78.2)	1.35 ~ 3.84 (1.52)	Semi-pervious
Tm - m	Middle part of middle terrace deposit Gravel and sand. Consolidated. Assumed thickness 3.0 m.	GW - GM	2.74 ~ 2.91 (2.92)	1.4 ~ 3.1 (2.2)	6.9 ~ 7.4 (7.1)	30.1 ~ 49.5 (36.6)	67.8 ~ 90.2 (80.1)	42.5 ~ 53.3 (56.7)	0.69 ~ 3.53 (1.04)	- do -
Tm - 1	Lower part of middle terrace deposit Gravel and sand. Consolidated. Assumed thickness 1.0 m and lenticular.	SW - SM	2.44 (2.44)	7.3 (7.3)	8.1 ~ 10.1 (9.1)	52.1 ~ 73.0 (62.6)	100.0 (100.0)	30.0 ~ 78.6 (50.0)	3.0 ~ 6.6 (4.8)	- do -
Tu - 1.2	Upper terrace deposit Gravel and sand. Well consolidated. Gravel partially weathered. Assumed thickness 20.0 m.	GW - GM	2.54 ~ 2.61 (2.58)	5.0 ~ 5.7 (5.4)	5.8 ~ 5.9 (5.9)	31.9 ~ 40.2 (36.1)	79.1 ~ 92.6 (85.9)	28.6 ~ 50.0 (29.2)	1.2 ~ 3.4 (1.3)	- do -
Rm	Recent wadi bed deposit of main stream Gravel and sand. Loose. Grain size distribution poorly sorted.	GP	2.79 ~ 3.00 (2.92)	-	1.8 ~ 2.1 (2.0)	17.1 ~ 47.6 (32.4)	66.0 ~ 100.0 (83.0)	19.0 ~ 136.7 (44.0)	1.0 ~ 18.3 (1.5)	- do -
Rt	Recent wadi bed deposit of tributary stream Gravel and sand. Loose. Grain size distribution poorly sorted.	SP	2.69 ~ 3.00 (2.85)	-	1.0 ~ 2.1 (1.6)	44.1 ~ 67.1 (55.6)	94.2 ~ 98.8 (96.5)	17.6 ~ 73.7 (29.5)	0.34 ~ 0.40 (0.25)	- do -
Lm	Talus deposit Gravel with sand and clay. Subangular to angular. Limestone.	GW	2.72 ~ 2.74 (2.73)	0	-	-	-	-	-	Rock Rip-rap
Fine Grained Soil	Talus and recent wadi bed deposit Sand, silt and clay. Distributed in small area and then deposit.	CL	-	-	60<	-	-	-	-	

Uc : Coefficient of Uniformity

Uc': Coefficient of Curvature

Figures in parentheses show an average value.

FIGURE I-5 GRAIN-SIZE ANALYSIS OF TERRACE DEPOSITS



Judging from results of the gradation analyses of terrace deposits at the spillway site (Tu-1 and Tu-2), the coefficient of uniformity of these materials is about 29, which indicates that they are well-graded semi-pervious materials and, (classified into GW-GM under the Unified Soil Classification System), although they contain about six percent of fine materials.

The data of the similar soil tests conducted in the past suggest that these materials are suitable for embankment because of a dense compacted weight, a high shearing strength and an enough workability.

From the above-mentioned soil mechanical properties of the terrace deposits at the spillway site, it is desirable that these materials would be used as embankment materials of detention dam in maximum from the view-points of abundant distribution, borrowing condition, physical and dynamic properties, purpose of dam construction and economical embankment.

Since the detention dam aims to store temporarily flood discharge and to recharge groundwater through infiltration along the existing water routes at the wadi course into aquifers with the stored water by the dam, a relatively large quantity of seepage water can be permitted to flow-out through the dam body. However, the inner shell of sand and gravel fill should be constructed as a semi-pervious zone of less than 1×10^{-4} cm/sec in permeability coefficient in order to ensure the temporary storage of flood discharge and the stability of the dam body.

3.2 Talus Deposits (Rockfill Materials, Riprap and Rock Zone)

Talus deposit materials located about 2.0 km away from the dam site will be mainly used for the rock zone embankment and the riprap fill. Such materials consist of mainly siliceous limestone which are disunited with many block joints and disrupted materials, however, the rock pieces have good lithologic characteristics such as hardness, soundness and durability.

The results of rock tests for the quarry rock and boulder materials are shown in the following table.

Specimen	Specific gravity	Absorption (%)	Durability by sodium sulfate (%)	Compressive strength (kg/cm^2)
Quarry rock (Limestone)	2.705	0.38	1.14	895
River-bed boulder (Diabase)	3.047	0.40	0.31	809
Terrace boulder (Diabase)	2.960	0.27	0.26	1,346

Judging on the above-mentioned table, these materials can be utilized in the rock zone and for the riprap fill from the view point of geotechnical properties. Moreover, these materials will be easily quarried by heavy dozzer without using of explosive, and the quarry site can be enlarged, if required.

3.3 Filter and Concrete Aggregate Materials

The materials to be used for the filter zone and concrete aggregates are obtainable in the sand and gravel deposit at the river-bed by using the screening plant to be installed near the dam site for the arrangement of grading.

4. Dam Type

In general, the dam type is classified into two types, concrete and fill. At the detention dam site, the most recommendable dam type is a zone type of fill dam taking into account the following items.

° A relatively large quantity of seepage water is allowed to flow-out through the dam body since the detention dam only functions to store temporarily flood discharge by means of cutting the peak of floods which flows down uselessly into the sea in a short time and to recharge ground water through infiltration along the existing water routes at the wadi course into aquifers with the stored water by the dam.

° The embankment materials are easily obtained from terrace deposits (for sandy and gravelly materials) and talus deposits (for rocky materials) around the dam site.

° The whole dam foundation consists of sandy and gravelly terrace deposits where no construction of the barrier structure is required.

° The corde-height ratio (dam length/dam height ≑ 59) at the dam axis is extremely large.

° The required bearing capacity and shearing strength of the dam foundation are not good enough, if concrete dam is adopted, and which shall be safe against normal and tangential component forces transmitted by the dam body.

° The construction of fill dam is economical in comparison with the concrete dam in this project.

A zone type dam with sand and gravel, rock and riprap fills is planned in taking the resistance against piping, erosion, protection, structural stability and economical execution of the embankment works into consideration. The sand and gravel to be obtained from terrace deposit will be used to construct the semi-pervious zone of which the permeability coefficient is less-than 1×10^{-4} cm/sec.

The upstream outer shell will be constructed with the rock materials to be obtained from the quarry.

Between the rock zone and sand and gravel zone, the filter zone should be constructed in order to prevent the fines contained in the sand and gravel zone from movement. And also, in the downstream of sand and gravel zone, the intersepter with horizontal drain is planned in order to reduce the seepage water pressure and to allow the seepage water to flow safely out of the zone.

The surfaces of both the slopes should be protected by the hand-placed riprap in order to prevent the fine materials in the sand and gravel zone from movement and suction by wave action at upstream slope and from erosion by rainy water at downstream slope.

Along the axis of dam, a trench should be provided in order to obtain a good bond between the embankment material and the dam foundation, to reduce the hydraulic gradient of seepage water through the foundation, and thereby to increase the safety against piping. The typical section of the detention dam is shown in Drawing D-1003.

At the toe of the dam body and both abutment at downstream side, the counter-weight fill is planned for stabilizing the dam against the seepage water pressure through its foundation and both abutments.

And also, the slope in front of approach channel of the spillway should be protected by a counter-weight fill for stabilizing the slope against the residual pressure of seepage water through the mountain mass, it may occur when the reserved water will be hastily drawn down.

5. Dam Dimensions

5.1 Dimension of Reservoir

According to the results of Alternative Studies as shown in Appendix F, the relevant dimensions of reservoir are determined as follows:

Catchment area	812 sq.km
Detention capacity	5.40 MCM
Specific sediment volume	100 cu.m/sq.km/year
Full water surface (F.W.S.)	EL 163.90 m
Reservoir water surface area at full water level	1.25 MSM
Design flood discharge	1,890 cu.m/sec
Water level at design flood discharge (H.W.S.)	EL 167.20 m

5.2 Dam Crest Elevation

The crest elevation of non-overflow section of the detention dam is determined by adding a height of wave due to the wind to the maximum water surface level of a reservoir.

5.2.1 Height of wave caused by wind

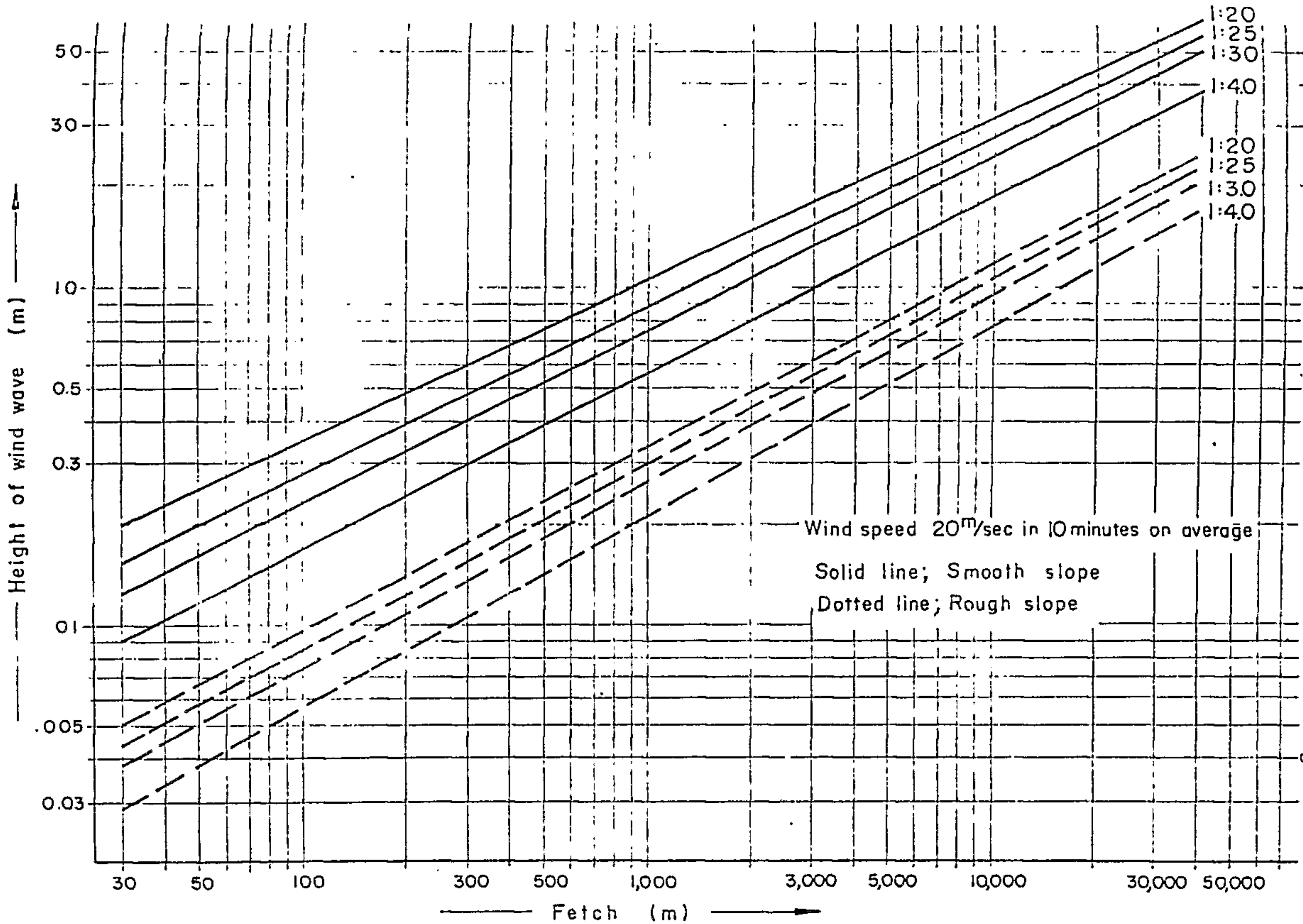
The height of wave caused by wind is considered to be deep-water wave. The height of significant wave is related to the factors such as fetch and wind speed and can be estimated with S.M.B. (Sherdrup-Munk-Breschneider) method.

On the other hand, since uprushing height varies in accordance with the gradient and roughness of embankment slope, height of significant wave should be corrected adequately with Saville method to obtain height of wave due to the wind.

The estimates under the different conditions of slope and fetch are shown in Figure I-6.

In order to obtain the height of wave caused by wind in the detention dam site, the wind speed of 20 meter per second in 10 minutes on an average is to be assumed taking into account the observed data of maximum wind movement in Sohar meteorological station (observed maximum value is 238.2 km per day).

FIGURE I – 6 HEIGHT OF WIND WAVE(S.M.B. and SAVILLE METHOD)



The upstream surface of the detention dam is formed with hand-placed riprap using the materials mainly obtained from quarry. Therefore, an intermediate value of 0.80 meter at the smooth slope and rough slope in the above-mentioned figure was adopted as the height of wave caused by wind.

5.2.2 Dam crest elevation

According to the hydraulic study of spillway, a rise of water from the full water surface level is estimated at 3.3 m when the design flood discharge is released through the spillway.

The crest elevation of detention dam without extra banking can be obtained by adding the height of wave due to wind to the maximum water surface level in the reservoir as follows:

Dam crest elevation, EL 167.20 + 0.80 = EL 168.00 m

5.3 Extra Banking

The settlement of dam body which may be caused by the weight of embankment materials and the storage water pressure should be considered in the design of a fill dam. The settlement of dam body is presumed by the following experimental formula

$$\Delta H = 0.001 \cdot H^{3/2}$$

Where, ΔH; settlement of the dam body
H; height of the dam adopted by 17.0 m

The settlement after construction of the dam is computed to be about 0.1 m from the above equation, and another 0.2 m is added to this value taking the settlement of dam foundation and the sightly condition into consideration.

The total presumed settlement, therefore, reaches 0.3 m, and it corresponds to about 1.8 percent of the dam height. The height of extra banking is determined at zero mater on both abutments and

0.3 m on riverbed portion, and the profile of dam crest forms in trapesoidal shape.

6. Stability Analysis

In general, the stability of detention dam will be studied from their structural and hydraulic viewpoints as shown below:

Structural stability:	Stability of dam slopes by the slip circle method
Hydraulic stability:	Study on the seepage water through the dam body and piping in the dam body

6.1 Design Values

Design values of the sandy, gravelly and rockfill materials to be used for the stability analysis of a dam body should be usually decided according to the results of soil test. However, since effective tests of these materials have not been conducted, the estimations are made refering to the data which have been obtained through various past soil test in the similar nature.

6.1.1 Sandy and gravelly materials

Soil test of sandy and gravelly materials of terrace deposits have been conducted regarding those auxiliary items of gradation analysis, specific gravity and absorption, and the respective results are shown in Figure I-5 and Table I-1.

Generally, the soil mechanism of those coarse materials is comparatively well correlated with the grain-size distribution.

The results[1/] of soil test for sandy and gravelly materials in various grain-size distribution are tabulated as follows:

1/ Data obtained through past soil tests in Japan

Max.size (mm)	D_{10} (mm)	D_{60} (mm)	Uc	Gs	γt (t/m³)	e	φ (°-')	K (cm/sec)
120	0.25	36.7	146.8	2.64	2.07	0.354	36°-52'	1×10^{-4}
150	0.56	42.0	75.0	2.60	2.17	0.275	39°-00'	5×10^{-4}
150	1.70	22.0	12.9	2.64	2.04	0.320	40°-00'	$10^{-1} \sim 10^{-2}$
200	0.28	10.5	37.5	2.70	2.25	0.250	35°-00'	-
200	0.80	38.0	47.5	2.66	1.94	0.400	39°-00'	1×10^{-3}
200	1.30	34.6	26.6	2.70	2.35	0.227	35°-00'	-
250	0.70	33.0	47.1	2.90	2.25	0.330	37°-00'	1×10^{-4}
300	0.16	2.5	15.6	2.64	2.25	0.257	40°-00'	6×10^{-4}
300	0.25	8.6	34.4	2.64	2.08	0.320	40°-00'	3×10^{-4}
350	0.70	75.0	107.1	2.45	1.95	0.289	36°-00'	-

Uc; coefficient of uniformity, $Uc = D_{60}/D_{10}$

Where, D_{10}, D_{60}; grain-size of materials finer than respective percentage by weight of total volume of materials

Gs; specific gravity

γt; wet density

e; porocity

φ; angle of internal friction

K; coefficient of permeability

Sandy and gravelly materials of terrace deposits around the spillway site are of good mixture with large and small particles with the coefficient of uniformity of about 29 which indicates that they are the well-graded semi-pervious materials for the fill type dam.

The shearing strength of sandy and gravelly materials is well correlated with the degree of compaction which represents by the relative density1/ as shown in the following table.

1/ Relative density = $\frac{\gamma max.\ (\gamma - \gamma min)}{\gamma(\gamma max - \gamma min)} \times 100$ (%)

Where, γmax.; density in the most compact state

γmin.; density in the loosest state

γ ; density in-situ

Grain-size and gradation distribution	Relative density		
	>70% (dense)	70∿50%	<50% (loose)
Uniform mixture of fine and coarse size materials	35° ∿ 38°	32° ∿ 34°	28° ∿ 30°
Well-graded coarse sand and poor-graded mixed materials of sand and gravel	37° ∿ 45°	33° ∿ 36°	30° ∿ 33°
Well-graded mixed materials of sand and gravel	40° ∿ 45°	36° ∿ 41°	33° ∿ 36°

In general, the value of relative density of sandy and gravelly materials will be obtained easily more than 70 percent in compacted fill and it corresponds to about 93 percent of the maximum dry density in dry weight of the materials.

Judging by the above data, the design values of sandy and gravelly materials to be used for the detention dam are presumed as follows:

Gs	e	Dr (%)	γt (t/m³)	γsat (t/m³)	Shearing strength φ (°-')	Shearing strength C (t/m²)
2.78	0.35	70	2.11	2.32	35°-00'	0

Where, Gs; specific gravity, adopted by 2.78 obtained from data
e; porocity, assumed to be 0.35
Dr; relative density, assumed to be more than 70%
γt; wet density
γsat; saturated density, $\gamma sat = (Gs+e)/(1+e)$
φ; angle of internal friction, assumed to be 35°00'
C; cohesion

In order to ensure the permeability coefficient of sand and gravel fill to be less than 1×10^{-4} cm/sec, those materials should contain more than seven percent of finer particles by weight passing through the No.200 sieve.

6.1.2 Rockfill materials

The geotechnical test for quarried rock has not been specially conducted except for the rock tests for the limestone and diabase rocks at the dam site as tabulated below:

	Quarry rock (Limestone)	River-bed boulder (Diabase)	Terrace boulder (Diabase)
Apparent specific gravity	2.705	3.047	2.960
Absorption (%)	0.38	0.40	0.27
Durability by sodium sulfate (%)	1.14	0.31	0.26
Compressive strength (kg/cm^2)	895	809	1,346

As to the design values of rockfill materials, the presumption is made based on the data obtained from the past geotechnical tests in Japan taking the results of rock tests into consideration. The result is shown in the following table.

Gs	e	Density		Shearing strength	
		γt (t/m^3)	γsat (t/m^3)	ϕ (°-')	C (t/m^2)
2.71	0.40	1.96	2.22	37°-00'	0

Where, the notes in the table are the same as is in the former paragraph for sandy and gravelly materials.

6.1.3 Filter materials

The materials to be used for the filter zone are obtained from the excavated river-bed deposits with arrangement of grading. Since the procedure of the embankment of filter materials is mostly same as the procedures of the sand and gravel fill, the design values of filter materials can be quoted completely from that of sand and gravel materials.

Design values of the above-mentioned sand and gravel fill rock fill and filter materials are summarized as follows:

Materials	Density		Shearing strength	
	γt (t/m³)	γsat (t/m³)	φ (°-')	C (t/m²)
Sand and gravel	2.11	2.32	35°-00'	0
Rock	1.96	2.22	37°-00'	0
Filter	2.11	2.32	35°-00'	0

Where, the notes in the table are same that in the former paragraph of sandy and gravelly materials.

6.2 Stability Analysis

6.2.1 Stability analysis against sliding failure

Fill dam has a sufficient resistivity against the sliding failures through the dam body itself and the foundation in consideration of the properties of embankment materials and the condition of the foundation of dam.

Since the foundation of detention dam consists of sandy and gravelly materials having a sufficient resistivity, the stability of dam body will be herein studied assuming the following conditions:

Reservoir condition	Slope	K[1/]	Water surface elevation	Pore pressure
Full water level	Upstream Downstream	0.10	EL 163.90m	Steady flow
Immediately after completion of fill	Upstream Downstream	0.05	Nil	Nil
Middle water level	Upstream	0.10	EL 159.0m	Steady flow
Rapid drawdown	Upstream	0.10	F.W.L. to L.W.L.[2/]	Unsteady flow
Flood water level	Upstream Downstream	Nil	EL 167.20m	Steady flow

Stability analysis against sliding failure has been carried out by applying the slice method to the slip circle surface shown in Figure I-7 and the safety factor is obtained by the following formula:

$$S.F. = \frac{\Sigma\{C \cdot \ell + (N-Ne-U+Np+Wn) \times \tan\phi\}}{\Sigma\,(T+Te-Tp+Wt)}$$

Where, S.F.; safety factor

C; cohesion of materials on slip circle of each slice

ℓ; arc length of slip circle of each slice

N; normal force acting on slip circle of each slice

Ne; normal force of earthquake load acting on slip circle of each slice

U; pore pressure acting on slip circle of each slice

Np; normal force of hydrostatic pressure acting on slip circle of each slice

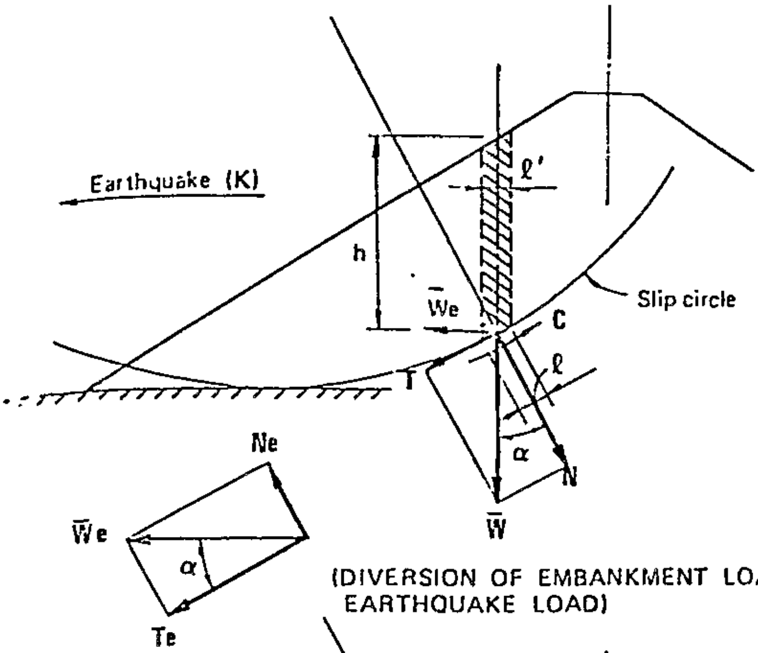
Wn; normal force surcharge water acting on slip circle of each slice

ϕ; angle of internal friction of materials on slip circle of each slice

1/ From the observed data of earthquake around the Arabian peninsula, there were no epicenters in Oman. However, in the southern part of neighbouring Iran approx. 250 km away from the Sohar, a number of big earthquakes have occurred in the past. In this case, it seems to be reasonable that the intensity of 0.10 is to be adopted as horizontal seismicity to design the dam body owing to the attenuation of the shock wave over those distance from the epicenters.

2/ Low water level EL 154.0m.

FIGURE I – 7 STABILITY ANALYSIS WITH SLIP CIRCLE METHOD

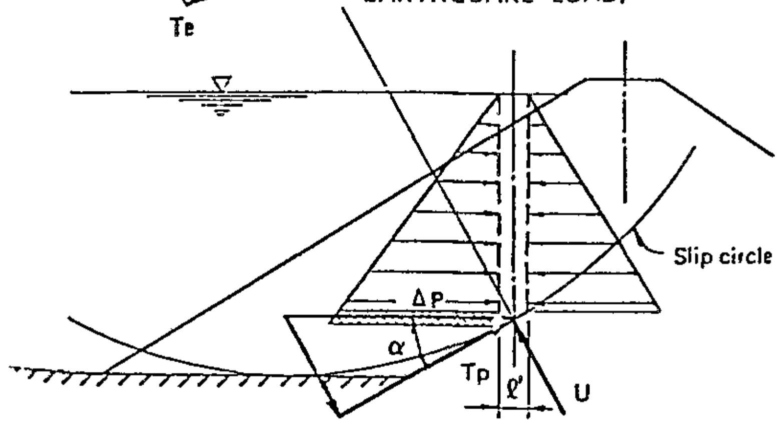


(DIVERSION OF EMBANKMENT LOAD AND EARTHQUAKE LOAD)

$\bar{W} = h \times \ell' \times \gamma$
- ℓ': width of slice
- γ : unit weight

$N = \bar{W} \times \cos\alpha$
$T = \bar{W} \times \sin\alpha$
$\ell = \ell'/\cos\alpha$
$\bar{W}e = \bar{W} \times K$
- K: seismic coefficient

$Ne = \bar{W}e \times \sin\alpha$
$Te = \bar{W}e \times \cos\alpha$

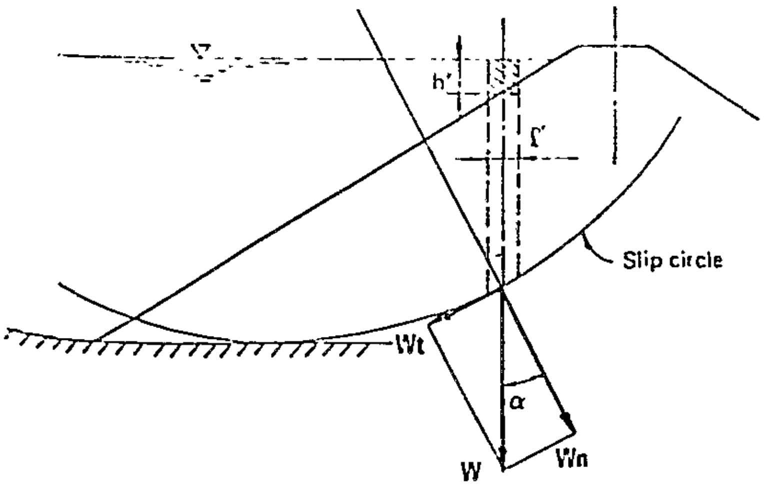


(DIVERSION OF HYDROSTATIC PRESSURE)

$Np = \Delta P \times \sin\alpha$

$Tp = \Delta P \times \cos\alpha$

- ΔP: difference of hydrostatic pressure between both side of slice
- ℓ': width of slice
- U : pore pressure



(DIVERSION OF SURCHARGE WATER)

$W = h' \times \ell' \times \gamma'$
- ℓ': width of slice
- γ': unit weight of storage water

$Wn = W \times \cos\alpha$

$Wt = W \times \sin\alpha$

T; tangential force acting on slip circle of each slice

Te; tangential force of earthquake load acting on slip circle of each slice

Tp; tangential force of hydrostatic pressure acting on slip circle of each slice

Wt; tangential force of surcharge water acting on slip circle of each slice

Allowable minimum safety factor is decided in conformity with the Design Criteria For Dams authorized by Japanese Government, that is to say, it must not be less than 1.2 in any case. The repeat computation should be made by using the above equation to seek the minimum value of the safety factor for a different sliding surfaces. The computation procedures, the so-called trial and error, can be advantageously carried out by an electronic computer operation according to the flow chart shown in Figure I-8.

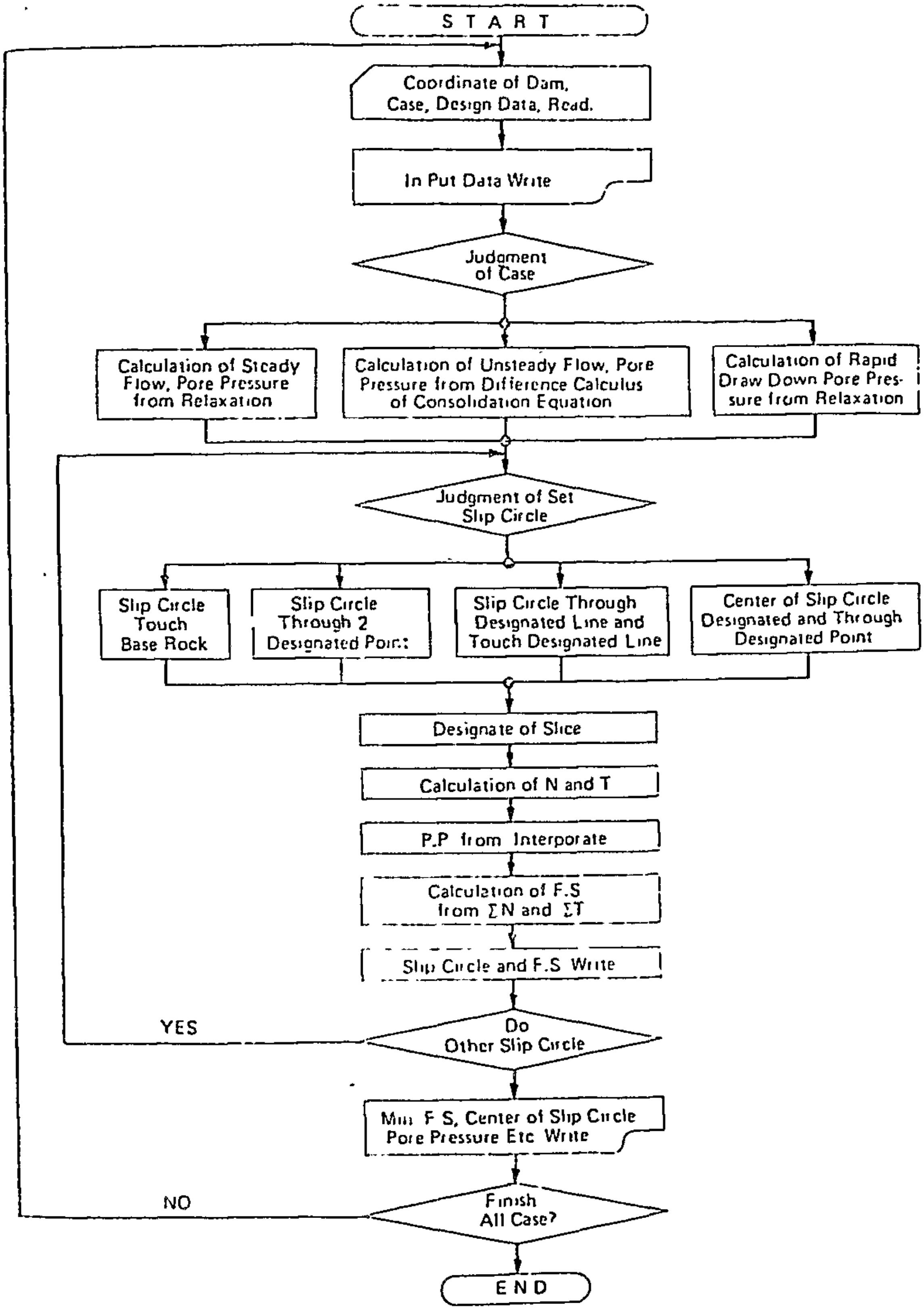
The following table shows the results of the stability analyses under the above-mentioned conditions.

Case	Reservoir condition	Water surface elevation	K	Slope	Safety factor
1-1	Full water level	EL 163.90m	0.10	Upstream	1.331
1-2				Downstream	1.329
2-1	Immediately after completion of fill	Nil	0.05	Upstream	1.883
2-2				Downstream	1.531
3	Middle water level	EL 159.0m	0.10	Upstream	1.343
4	Rapid drawdown	F.W.L. to L.W.L.1/	0.10	Upstream	1.448
5	Flood water level	EL 167.20m	Nil	Upstream	2.115
				Downstream	1.759

The dam body will have a sufficient stability since the safety factor is more than the allowable minimum safety factor of 1.2 under the various conditions as mentioned above. Besides, the value of the above-mentioned safety factor in each case will be increased taking the counter-weight fill at the toe of the dam into account.

1/ Low water level EL 154.0m

FIGURE I-8 FLOW CHART OF STABILITY ANALYSIS



The contour of safety factors for the critical case of upstream and downstream slopes, and distributions of pore pressure are shown in Figure I-9.

6.2.2 Surface slope stability

It may sometimes happen that critical slip circle approaches to the surface of dam body in case that dam body is constructed with cohesionless materials. In this case, the safety factor can be obtained with the following formula.

For upstream slope: $$S.F = \frac{(1-k\,\frac{\gamma sat}{\gamma sub} \cdot \tan\alpha)}{K \cdot \frac{\gamma sat}{\gamma sub} + \tan\alpha} \times \tan\phi$$

For downstream slope: $$S.F = \frac{1 - K \cdot \tan\alpha}{K + \tan\alpha} \times \tan\phi$$

Where, S.F; safety factor
K; seismic coefficient, adopted by 0.10
γsat; saturated density of outer shell material
γsub; submerged density of outer shell material ($\gamma sub = \gamma sat - 1$)
α; tangential value of slope
ϕ; angle of internal friction of outer shell material

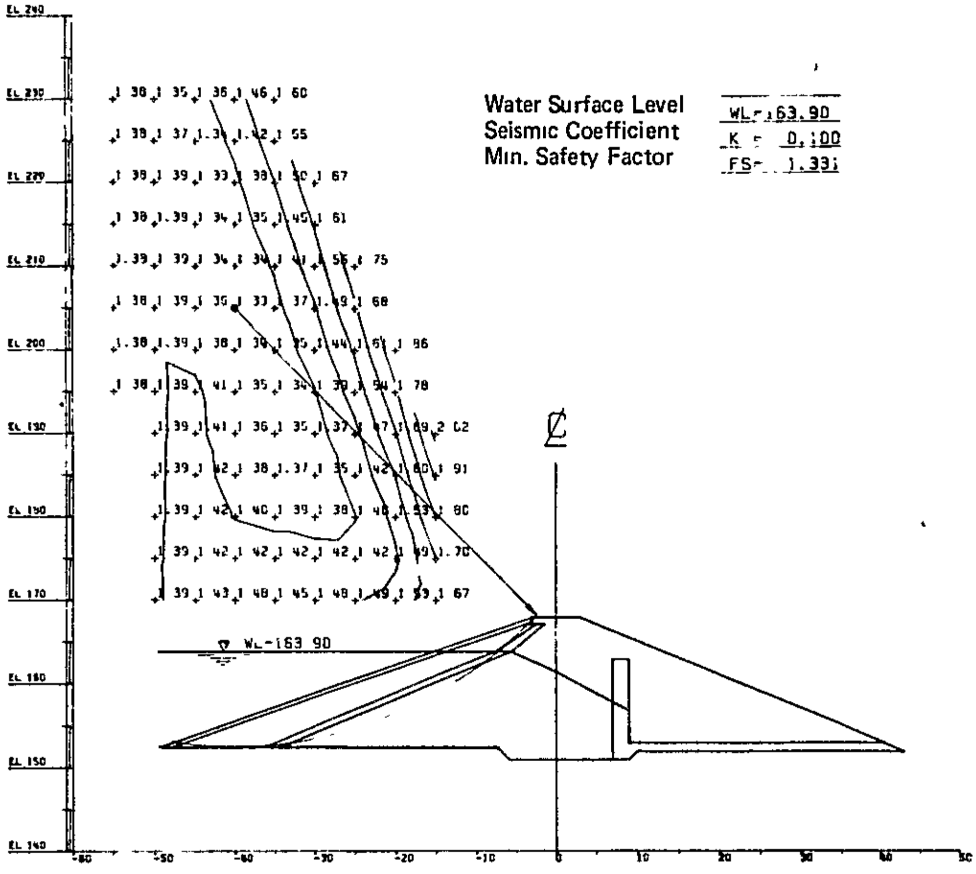
Safety factor for the surface sliding is 1.375 in upstream with slope of one vertical to 3.0 horizontal and 1.344 in downsrream with slope of one vertical to 2.5 horizontal.

6.3 Seepage Analysis

6.3.1 Seepage through dam body

The permeability in horizontal and vertical directions of embanked sand and gravel zone is quite different. In this case the embankment should be considered as an anisotropic medium with the permeability depending on the direction of flow. The raio of vertical coefficient of permeability (Kv) to horizontal one (Kh) at the compacted sandy and gravelly materials varies depending on

FIGURE I – 9 CONTOUR MA



Upstream slope

Distributio
(Full

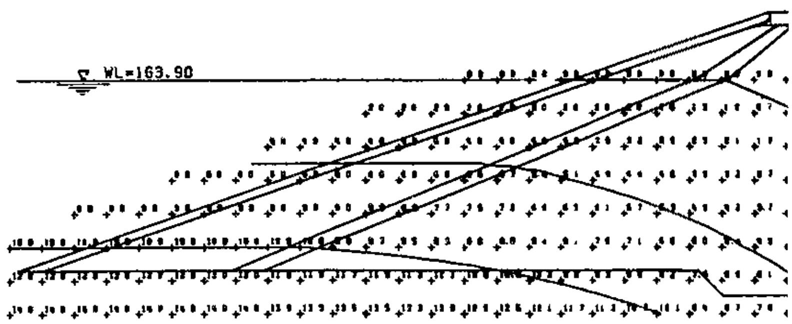
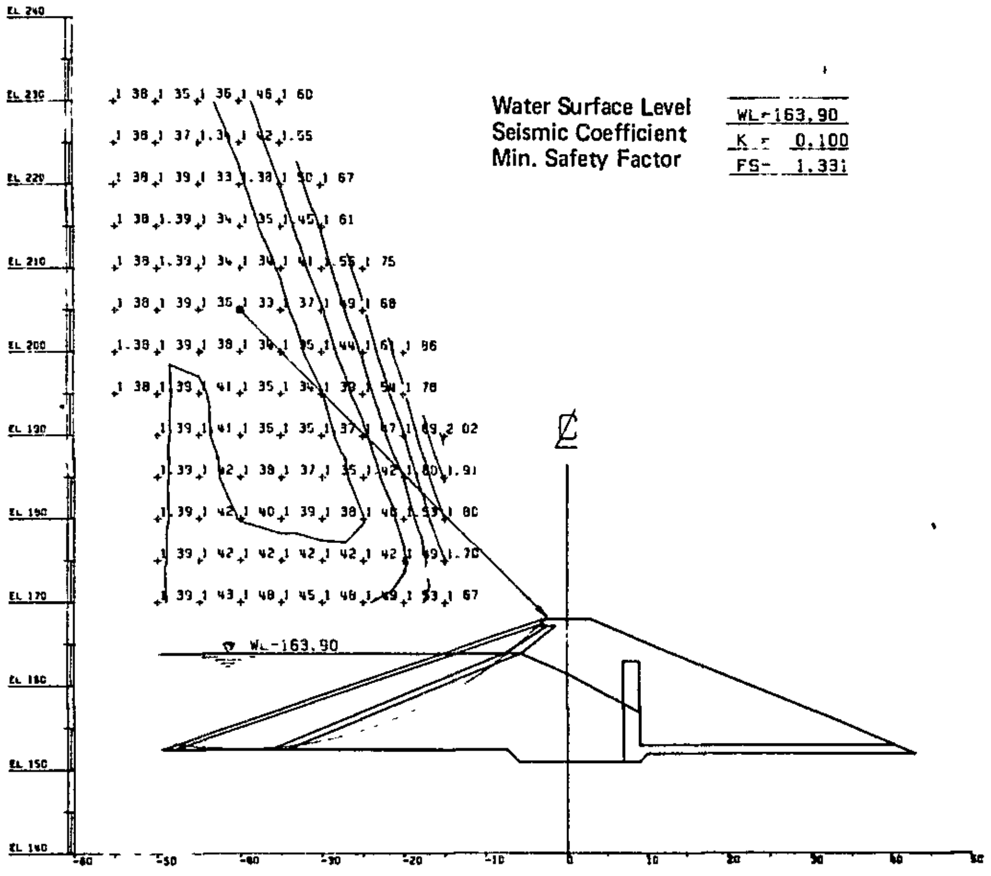
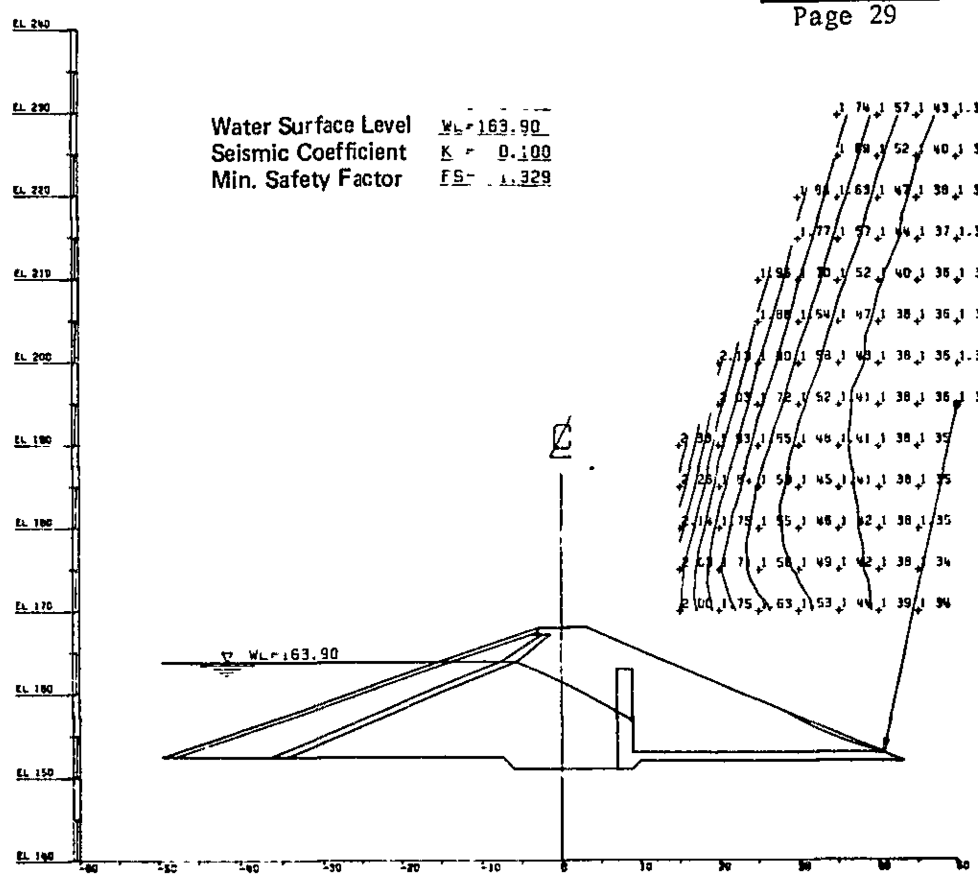


FIGURE I – 9 CONTOUR MAP OF SAFETY FACTOR

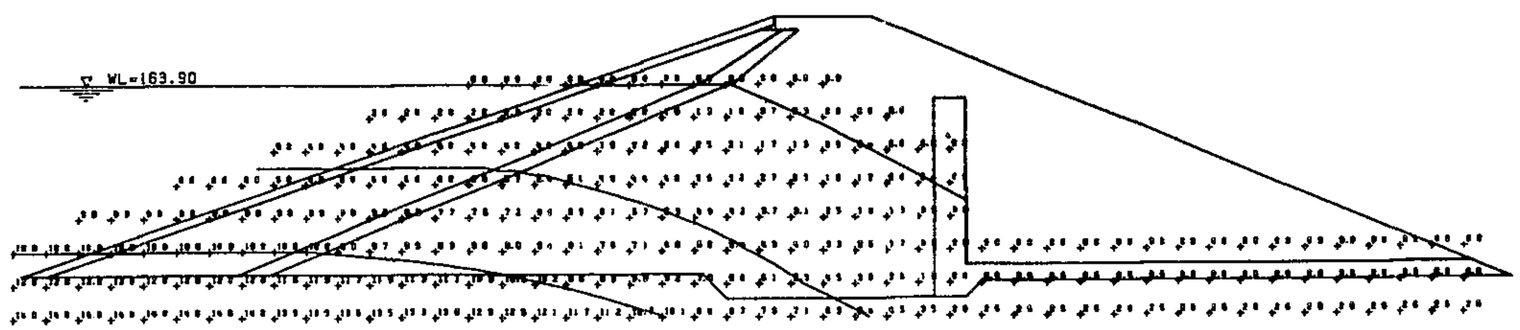


Upstream slope



Downstream slope

Distribution of Pore Pressure
(Full Water Condition)



the method of compaction. Generally, in case that compaction is made by flat type vibrating rollers, Kh may nearly be equal to 25 times of Kv.

An anisotropics in permeability shall be converted to an isotropics by the reduction of the horizontal dimensions of the coordinates. Namely, transformed section can be obtained by reduction of horizontal dimensions of coordinates by the rate of $1/\sqrt{Kh/Kv} = 1/5.0$. In the transformed section, the phreatic line can be obtained by using Casagrande method in the respective cases of EL 167.20 m, EL 163.90 m, EL 159.0 m and EL 154.0 m of reservoir surface levels. The phreatic lines in original section are shown in Figure I-10.

Since the embanked sand and gravel zone is an anisotropic media, the computation of a quantity of seepage water is made on the isotropic media in using transformed coordinate system mentioned above. It is also required that the coefficient of permeability in anisotropic media should be converted to modified permeability coefficient of $\sqrt{Kv \cdot Kh}$. On the assumption that the flat type vibrating rollers are used for compaction of sand and gravel zone and the permeability coefficient of these materials are controlled at 1×10^{-4} cm/sec, the modified permeability coefficient is computed as follows:

$$\overline{K} = \sqrt{25} \times (1 \times 10^{-4}) \times 864 = 4.32 \times 10^{-1} \text{ m/day}$$

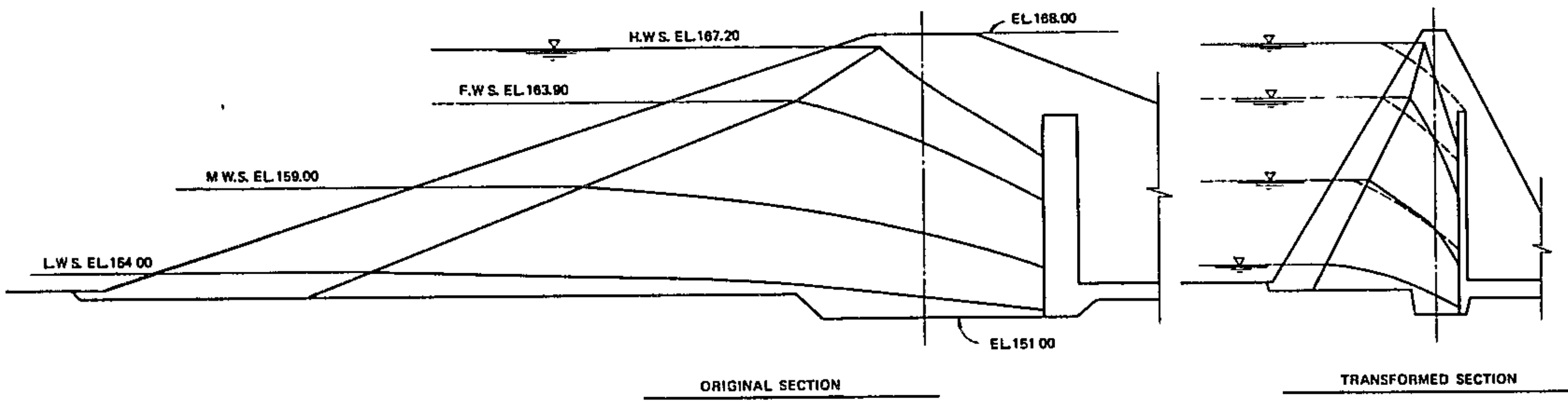
A quantity of seepage water through the dam body is calculated in the following equation.

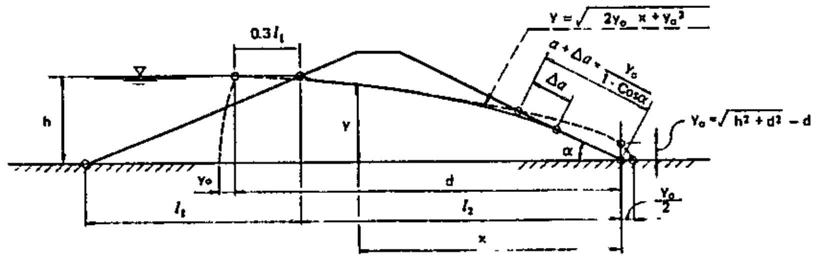
$$Q = \overline{K} \cdot Y_0 \cdot L = 4.32 \times 10^{-1} \times 9.14\text{m} \times 1{,}005\text{m}$$
$$= 3{,}968.2 \text{ cu.m/day} = 0.046 \text{ cu.m/sec}$$

Where, Q; quantity of seepage water through the dam body
$\overline{K}$; modified coefficient of permeability
Y_0; height of discharge face, $Y_0 = \sqrt{h^2+d^2} - d = 9.14$m
L; crest length of dam, adopted by 1,005m

FIGURE I - 10 PHREATIC LINE

Note: Kh = 25 Kv,
Shrinkage ratio of coordinates $\sqrt{Kh/Kv} = 5.0$





	h	l_1	l_2	d	Y_0	$Y = \sqrt{2Y_0 \cdot x + Y_0^2}$	$a + \Delta a$
N W.S. EL.167.20	16.2	6.7	1.9	3.91	12.76	$Y = \sqrt{25.25x + 162.82}$	2.76
F W.S. EL.163.90	12.9	5.8	2.8	4.54	9.14	$Y = \sqrt{18.28x + 83.54}$	9.14
M.W.S. EL.159.00	8.0	3.3	6.3	6.29	3.89	$Y = \sqrt{7.78x + 15.13}$	3.89
L.W.S. EL.154.00	3.0	0.8	7.9	8.14	0.54	$Y = \sqrt{1.08x + 0.29}$	0.54

$d = 0.3 l_1 + l_2$, $Y_0 = \sqrt{h^2 + d^2} - d$, $a + \Delta a = \frac{Y_0}{1 - \cos\alpha}$, $\alpha = 90^\circ$

$\Delta a = c(a + \Delta a)$, $c = 0.25$ $(\alpha = 90^\circ)$

6.3.2 Piping in dam body

The detention dam body mainly consists of the sand and gravel zone with a permeability coefficient of 1 x 10^{-4} cm/sec, and the zone will be affected by the seepage water pressure. When the seepage water pressure exceeds a certain limit, it causes to collapse the dam through the piping phenomenon, etc. In general, the following formula for computing the critical hydraulic gradient is employed to study the stability against piping.

$$ic^{1/} = \frac{H}{L} \leq \frac{Gs - 1}{1 + e}$$

Where, ic; critical hydraulic gradient
H; difference of water head within the creep length
L; creep length
Gs; specific gravity of embankment materials
e; porocity of embankment materials

Computation of the critical hydraulic gradient is made for the contact face of the sand and gravel zone and the foundation assuming the full water level of the reservoir.

$$ic = \frac{H}{L} = \frac{14.7}{60} = 0.245, \quad \frac{GS - 1}{1 + e} = \frac{2.78 - 1}{1 + 0.35} = 1.319$$

$$ic = 0.245 < \frac{Gs - 1}{1 + e} = 1.319$$

The computation result suggests that the sand and gravel zone has a sufficient resistivity against piping.

1/ In general, critical hydraulic gradient (ic) of 0.5 to 0.8 is employed in case of sand and gravel materials having no cohesion.

7. Foundation Treatment

The detention dam aims to store temporarily the flood discharge that appears once or twice a year and to recharge groundwater through infiltration along the existing water routes at the Wadi course into aquifers with the stored water by the dam as well as aims for flood control in the downstream area by means of cutting the peak of flood.

Being different from ordinary storage dam, the detention dam will require no barrier structures in its foundation. In other wards, the detention dam will require the foundation treatment to secure a sufficient bearing capacity to free the dam body itself from unsuitable settlement caused by a weight of the embankment and the stored water as well as to secure the stability against the collapse due to piping failure.

Excavation of the dam foundation is classified into two parts, one is for the whole of dam body base and the other for the trench base along the dam axis. In the former excavation objectionable materials such as top-soil, loose deposits, mud, organic materials, plants and roots shall be removed. The excavation depth of the dam base is different in places; however, is assumed to reach 0.5 m on an average. A trench along the dam axis shall be excavated to obtain a good bond between the materials embanked and the dam foundation. The excavation shall be performed not to create an extremely irregular surface and very steep slope.

For the trench base, the excavation depth is assumed to reach two meters on an average; however, the maximum depth may be less than four meters in consideration of the deposit condition at the river course and both the abutments.

8. Spillway

8.1 Type and Alignment

In general, open-type spillway should be adopted to the fill dam from viewpoints of nonresistance against over topping caused by unexpected flood and hydraulic characteristics of itself.

The non-control type spillway, i.e. the overflow type spillway having no gate, is selected compared with the other type of spillway taking into account the design flood discharge, topography and surrounding environment of the spillway site and possible dangerousness in gate operation if provided.

As for the alignment of spillway, the site at terrace plain with a tributary of the wadi at the right bank is more advantageous than the left abutment because of the applicability of topographical feature and connection with existing wadi course at the downstrdam of spillway through a tributary of the wadi. The spillway is composed of four main elements such as approach channel, control weir, chute and tailrace.

8.2 Design Flood Discharge

For the spillway design purpose, a 10,000 year probability flood discharge of 1,890 cu.m/sec[1/] is employed taking into account the lack of hydrological data and the precedent in Gulf Countries.

A peak discharge to be released through the spillway may be less than the design flood discharge by the effect of extra storage above full water surface level in reservoir, however, decreasing from the design flood discharge is negligible taking into account the unavailability in observe flood hydrograph, shortness in arrival time of peak flood and comparative smallness in flood water surface area. Such neglect of decrease is in safety side in designing spillway.

1/ Refer to Appendix B Surface Water

8.3 Overflow Head

The following table shows the relationship between varying overflow head[1/] on the crest and excavation volume of the spillway, embankment volume of the dam body and direct construction costs.[2/]

	Overflow head (m)		
	2.30	3.30	4.30
Water surface elevation in reservoir (EL m)	166.20	167.2	168.2
Dam crest elevation (EL m)	167.00	168.00	169.00
Crest length of spillway (m)	298.70	169.20	112.00
Excavation volume of spillway ('000 cu.m)	663.5	490.6	391.3
Embankment volume of dam body ('000 cu.m)	429.7	491.6	552.5
Direct construction cost ('000 R.O.)	3,060	2,700	2,800

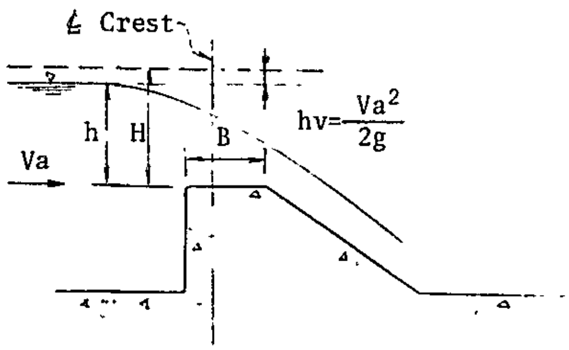
The above table suggests that the figure of 3.3 m is reasonable as the most suitable overflow head of the spillway with the crest length of 169.2 m in consideration of the construction costs, appropriation of excavated materials to embankment and topographic restriction of the spillway and dam sites.

8.4 Hydraulic Design

The dimensions of a weir under the complete overflow condition have a close relation with a shape of the weir. Provided that a board crested weir type shown in the following figure is employed for the overflow crest, the coefficient of discharge and length of crest can be obtained from the following Beresinski's formula:

1/ Overflow head = Water surface elevation in reservoir - EL 163.90(m)

2/ Direct construction costs of spillway and dambody.



$C = 1.973 - 0.222\ (B/h) = 1.864$

$L = Q/CH^{3/2} = 169.14m \doteqdot 169.20m$

Where, C; coefficient of discharge
B; width of crest, adopted by 1.5m
h; overflow depth (H - hv), assumed to be 3.05m
L; effective crest length
Q; design flood discharge, adopted by 1,890 cu.m/sec
H; overflow head, adopted by 3.3m

The water depth at chute and tailrace is estimated by applying the following Bernoulli's theorems setting up the two control points at the crest and 288.513 m downstream from the crest along the center of spillway.

$$D_1 \cos\theta + \frac{V_1^2}{2g} + \Delta X \cdot \tan\theta = D_2 \cos\theta + \frac{V_2^2}{2g} + \frac{n^2 \cdot Vm^2 \cdot \Delta \ell}{Rm^{4/3}}$$

Where, D_1, V_1; depth and velocity at the previous section
D_2, V_2; depth and velocity at a section under consideration
θ; angle of bottom slope at the chute and tailrace
g; gravitational acceleration
ΔX; increment of distance
n; coefficient of roughness, adopted by 0.03
Vm; mean velocity of flow, $Vm = 1/2\ (V_1+V_2)$
Δℓ; increment of distance measured along the bottom of chute and tailrace
Rm; mean hydraulic radius, $Rm = 1/2\ (R_1+R_2)$

The results of estimation of water depth at the chute and tail-race are shown below;

Distance[1/] (m)	Bottom elevation (EL m)	Bottom width (m)	Water surface elevation (EL m)	Water depth (m)	Velocity (m/sec)	Fr[2/]
0.0	163.90	169.20	166.22	2.32	4.72	1.00 (0.99)
4.0	161.90	163.20	163.21	1.31	8.75	2.44
44.0	161.90	163.20	163.63	1.73	6.60	1.60
94.0	160.20	131.60	162.13	1.93	7.27	1.67
119.0	159.35	115.80	161.47	2.12	7.48	1.64
144.0	158.50	100.00	160.89	2.39	7.64	1.58
183.513	158.50	100.00	162.80	4.30	4.13	0.64
218.513	158.50	100.00	162.63	4.13	4.31	0.68
253.513	158.50	100.00	162.39	3.89	4.59	0.74
288.513	158.50	100.00	161.75	3.25	5.55	1.00(0.98)

Judging from velocity and Froude number in the above table, there is no possibility of definite hydraulic jump occurring in the spillway, except disorder of water vein accompanied by surface turblance at the end of chute. However, the running water through the spillway possesses some energy to bring about erosion and scouring.

Since the spillway is constructed on the terrace deposit which has no sufficient resistivity against erosion and scouring, the protection works with gabion should be executed at the chute and tail-race of the spillway.

8.5 Ultimate Outflow Capacity

Supposing the occurrance of an unexpected flood discharge more larger than the design flood discharge of the spillway, a flow-out capacity is roughly estimated by using the following formula in

---

1/ Distance is measured from the crest along center of spillway

2/ Froude number, $Fr = V/\sqrt{g \cdot d}$

consideration of a storage effect of the reservoir.

$$\Delta H = \frac{2}{3} \cdot \alpha \cdot \frac{H}{1 + \frac{A \cdot H}{Qd \cdot T}}$$

Where, ΔH; height of the reservoir water surface raised by an unexpected flood discharge

α; increased rate of an unexpected flood discharge in comparison with the design flood discharge

H; design overflow head, adopted by 3.30m

A; reservoir water surface area with the design flood discharge, adopted by 1.74 MSM

Qd; design flood discharge, adopted by 1890.0 cu.m/sec

T; continuation hours of an unexpected flood of more than the designed flood discharge, adopted by 2 hours

From results of the calculation, the relationship between an increase in water surface and flow-out peak discharge is shown below:

	α(Increase rate an unexpected flood discharge)				
	0.1	0.2	0.3	0.4	0.5
(1+α)Qd (cu.m/sec)	2,079	2,268	2,457	2,646	2,835
ΔH (m)	0.15	0.31	0.46	0.62	0.77

If it is defined that the ultimate outflow capacity of the spillway is equivalent to the discharge to be released through the spillway when the reservoir water surface reaches the dam crest elevation, the said capacity counts about 2,850 cu.m/sec. Judging from the above-mentioned fact, the reservoir formed by the detention dam will play a great role in flood control.

9. Outlet Facility

Temporary storage water by the detention dam which will be released through the outlet facility flows into the downstream of existing Wadi. Moverover coping with the requirement of quick lowering of the reservoir water level in case of emergency after completion of the dam, the emergency outlet with slide gate is considered at the left bank of the dam site.

9.1 Outlet Conduit

An outlet conduit is to be embedded beneath the dam body in consideration of the existing condition of the water route, effective recharging of groundwater in the downstream river deposits, and necessity to flush-out the fine sediments around the entrance of the outlet conduit.

A circular shape reinforced concrete conduit with the inner diameter of 1,400 mm is planned for the outlet facilities of the detention dam. At the entrance of outlet conduit, trush-rake is equipped in order to prevent the objectionable materials flowing into the conduit.

On outlet discharge of this conduit at the varying reservoir water levels can be obtained as a pipeline flow by the following equation.

$$Q = \frac{\sqrt{2g} \cdot A}{\sqrt{fv + fe + fr}} \cdot \sqrt{H} \text{ , } A \approx 0.7854D^2$$

Where, Q; outlet discharge of conduit as a pipeline flow
g; gravitational acceleration
A; flow area
D; inner diameter of outlet conduit pipe, adopted by 1.40m
fv; coefficient of changing velocity loss, adopted by 1.0
fe; coefficient of the entrance loss adopted by 0.5
fr; coefficient of friction loss, $fr = 124.5xn^2/D^{4/3}xL$
n; coefficient of roughness, adopted by 0.015
L; length of conduit, adopted by 115.0 m
H; total head, measured from top surface at the end of conduit

Based on the results of the above-mentioned computation, the relationship between an outlet discharge and a reservoir water level can be estimated as follows:

	Reservoir water surface level (EL m)				
	155.0	158.0	161.0	163.9	167.2
Outlet discharge (cu.m/sec)	5.60	8.40	10.47	12.15 1/	13.81

The running water flowing out of the outlet conduit has a relatively high velocity, therefore, the protection work with stone pitchings should be executed at adjacent downstream of the dam body in order to prevent the toe of dam from excessive erosion and scouring.

Around the entrance of outlet conduit, the preventive gabion dike with about two meters in height is provided in order to prevent the blockade of the outlet conduit caused by flowing into the objectionable materials such as plants, trunks and roots in case of the lowest water in the reservoir.

9.2 Emergency Outlet

Provided as the emergency outlet are a tower structure of intake equipped with trush-rack, slide gate and operation bridge, and a conveyance conduit with the inner diameter of 1,400 mm which are to be at the left abutment of dam. In case of blockade at the outlet conduit caused by unexpected accident, the slide gate will be operated by manpower and the stored water will be released through the emergency outlet.

The intake sill is set at elevation of 158 m to keep the facilities free from the sediment trouble.

Flow-out discharge of the emergency outlet at the relevant reservoir water levels is calculated as follows:

	Reservoir water surface level (EL m)				
	160.0	162.0	163.0	165.5	167.2
Flow-out discharge (cu.m/sec)	3.45	7.18	9.45	11.00	12.44

1/ The figure corresponds to the allowable maximum flow-out capacity of 13.6 cu.m/sec quoted from Appendix C.

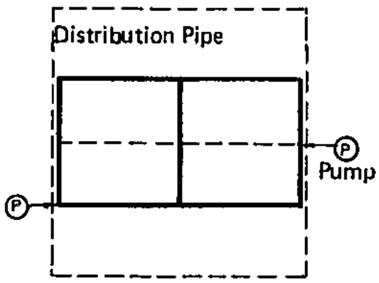
The stone pitching is provided at downstream of the conduit in order to protect adjacent toe of the dam from excessive erosion and scouring.

Alternative Study on Irrigation Networks

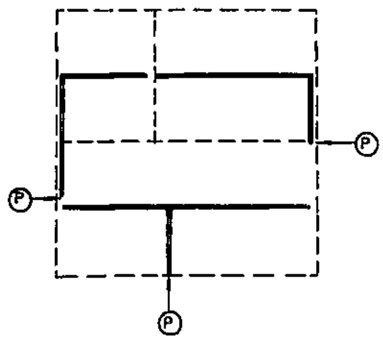
1. Alternative Plan

The following two alternative irrigation networks in the new extension farm land have been formulated taking into account the location of the proposed wells, in order to determine the most optimum pipeline networks.

Case - 1 (Link System)



Case - 2 (Open System)



Details are given in Figure I-11.

2. Hydraulic Calculation Method and Criteria

The hydraulic calculation in pipeline networks was made by applying the modified Hardy-Cross Method, and the calculation criteria are shown below;

° Velocity formula:

Harzen-Williams Formula: $V = 0.84935 \cdot C \cdot R^{0.63} \cdot I^{0.54}$ (m/sec)

C: Velocity coefficient, 140 - 150 (VP)
R: Hydraulic radius (m)
I: Hydraulic gradient

° Design velocity:

D = 75 - 150mm : 0.7 - 1.0 m/sec
D = 200 - 400mm : 0.9 - 1.6 m/sec

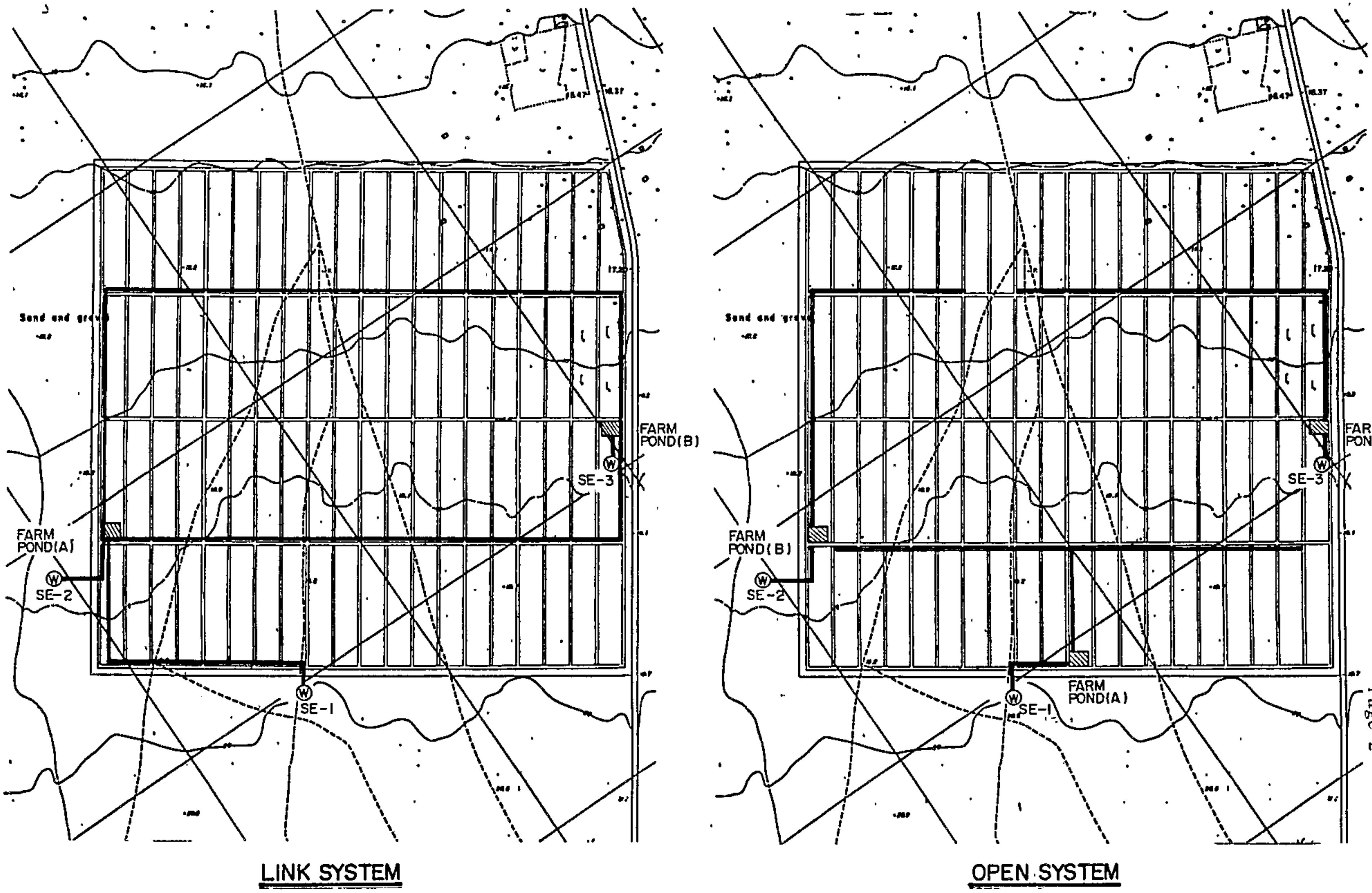


FIGURE I-11 ALTERNATIVE PIPELINE SYSTEM

° Maximum manifold capacity and presure

Capacity : q_1 = 8.1 ℓ/sec
q_2 = 6.6 ℓ/sec

Presure : h_1 = 40m
h_2 = 24m

° Type of Pipe : Vinyl chloride pipe (VP)

3. Hydraulic Calculation

Based upon the above mentioned criteria, the hydraulic calculation of pipeline networks has been made in the both cases of link and Open systems, and the results are indicated in Figure I - 12 and Figure I - 13. The following shows the estimated maximum discharge and required water head at pump station.

Pumps	Link System Discharge (ℓ/sec)	Link System Water Head (m)	Open System Discharge (ℓ/sec)	Open System Water Head (m)
Pupm No.1	190.6	64.0	140.7	63.3
Pump No.2	95.3	62.5	42.6	62.6
Pump No.3	-	-	96.3	62.6

Detailed hydraulic calculation is given in Table I-2 to I-4.

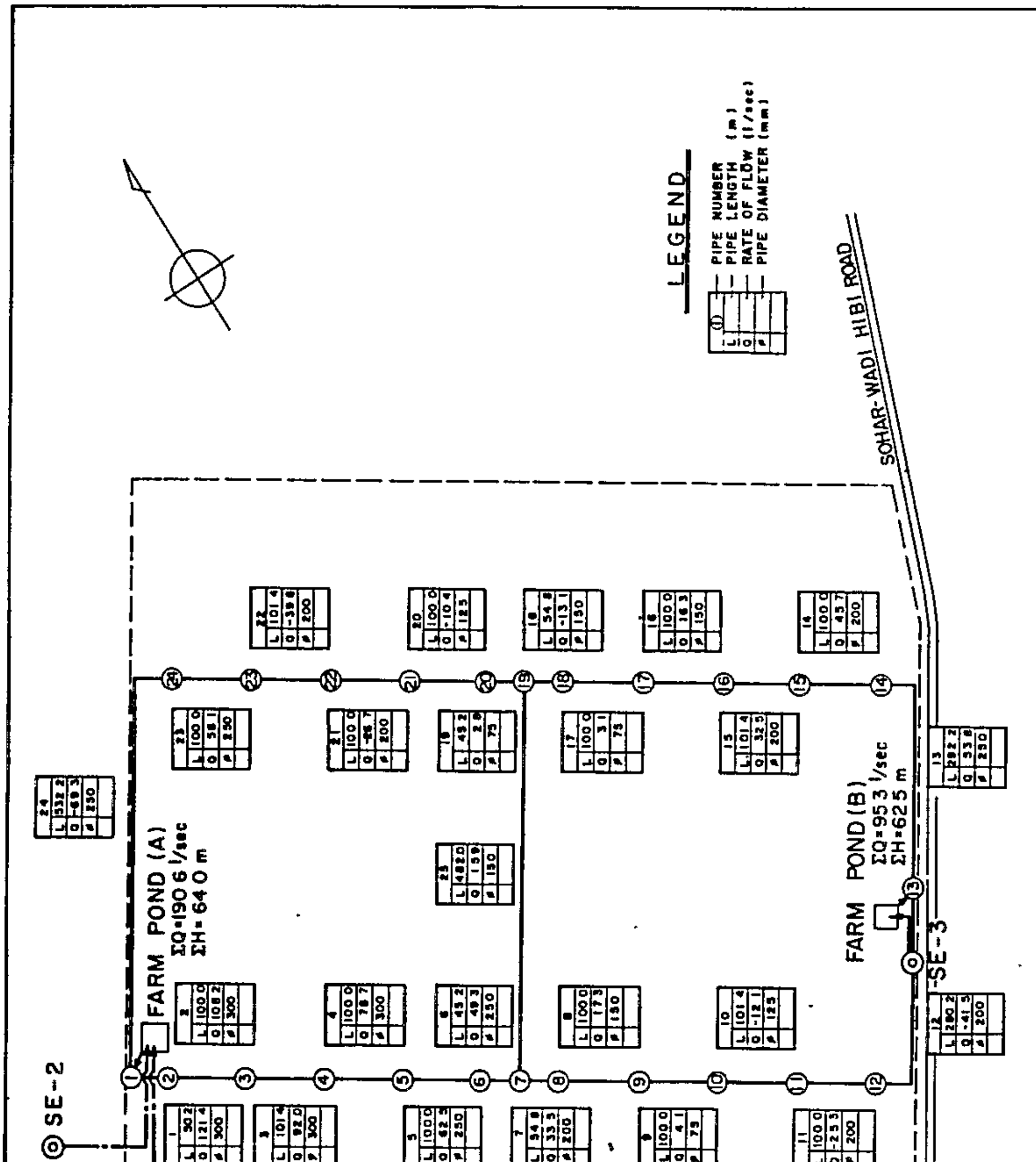


FIGURE I-12 DIAGRAM OF IRRIGATION NETWORK (LINK SYSTEM)

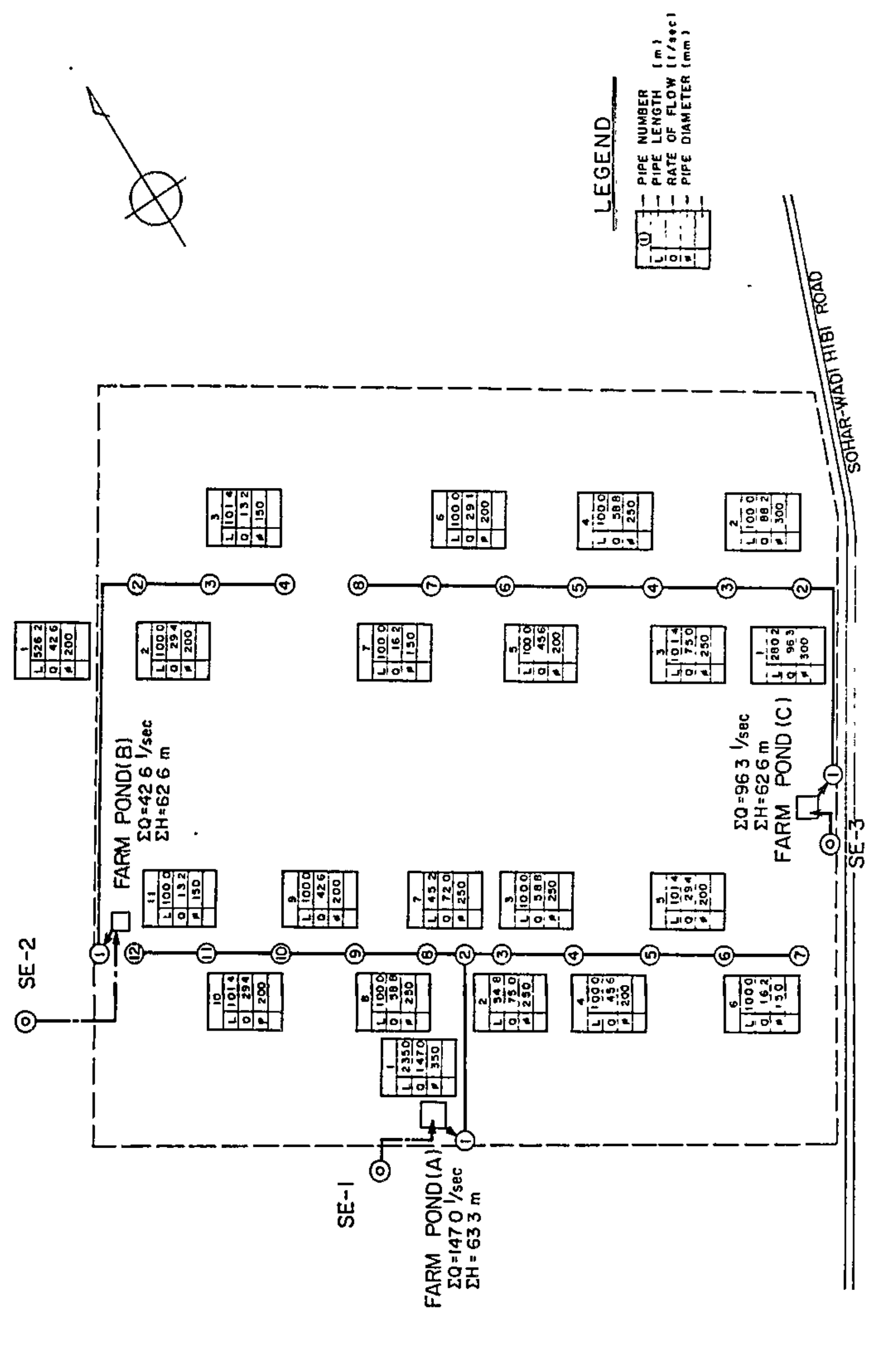


FIGURE I-13 DIAGRAM OF IRRIGATION NETWORK (OPEN SYSTEM)

Table I-2 Estimated Maximum Capacity and Pressure (Link System)

Point No.	Total Water Head (EL.m)	Elevation (EL.m)	Actual Pressure (m)	Area (ha)	Discharge (ℓ/sec)	
1	64.000	18.600	45.400	0.0	-190.6	(pump No.1)
2	63.628	18.700	44.928	4.3	13.2	
3	63.029	18.900	44.129	4.3	16.2	
4	62.579	19.050	43.529	4.3	13.2	
5	62.247	19.100	43.147	4.3	16.2	
6	61.719	19.100	42.619	4.3	13.2	
7	61.565	19.150	42.415	0.0	0.0	
8	61.296	19.200	42.096	4.3	16.2	
9	60.631	19.100	41.531	4.3	13.2	
10	59.298	19.050	40.248	4.3	16.2	
11	60.152	19.050	41.102	4.3	13.2	
12	60.446	19.100	41.346	4.3	16.2	
13	62.500	18.500	44.000	0.0	-95.3	(pump No.2)
14	61.335	17.400	43.935	2.1	8.1	
15	60.461	17.700	42.761	4.3	13.2	
16	59.990	17.800	42.190	4.3	16.2	
17	59.394	17.700	41.694	4.3	13.2	
18	58.602	17.500	41.102	4.3	16.2	
19	58.822	17.400	41.422	0.0	0.0	
20	58.528	17.300	41.228	4.3	13.2	
21	59.166	17.400	41.766	4.3	16.2	
22	59.488	17.400	42.088	4.3	13.2	
23	60.177	17.400	42.777	4.3	16.2	
24	60.608	17.500	43.108	4.3	13.2	

Note; The figures with minus symbol indicate the flows from right to left, while the other figures without minus indicate the flows from left to right.

Table I.3 Hydraulic Calculation of Pipeline Networks (Link System)

Pipe No.	Point No. From	Point No. To	Pipe Dia. (mm)	Pipe Length (m)	C	Discharge (l/sec)	Velocity (m/sec)	Loss Head (m)	Hydraulic Gradient (m/1,000m)	Friction Coefficient	Hydraulic Pressure(1) (kg/sq.cm)	Water Hammer Pressure(2) (kg/sq.cm)	(1)+(2)
1	1	2	300	50.20	150	121.4	1.717	0.372	7.062	0.01478	4.62	4.50	9.12
2	2	3	300	100.00	150	108.2	1.530	0.599	5.703	0.01504	4.61	4.50	9.11
3	3	4	300	101.40	150	92.0	1.301	0.450	4.222	0.01540	4.59	4.50	9.09
4	4	5	300	100.00	150	78.7	1.114	0.333	3.168	0.01576	4.58	4.50	9.08
5	5	6	250	100.00	150	62.5	1.274	0.528	5.025	0.01593	4.57	4.50	9.07
6	6	7	250	45.20	150	49.3	1.005	0.154	3.239	0.01650	4.57	4.50	9.07
7	7	8	200	54.80	150	33.5	1.065	0.269	4.680	0.01697	4.56	4.50	9.06
8	8	9	150	100.00	140	17.3	0.977	0.665	6.335	0.02050	4.57	4.50	9.07
9	9	10	75	100.00	140	4.1	0.919	1.333	12.698	0.02322	4.57	4.50	9.07
10	10	11	125	101.40	140	-12.1	-0.989	-0.854	-8.026	-0.02109	4.57	4.50	9.07
11	11	12	200	100.00	150	-25.3	-0.807	-0.294	-2.797	-0.01769	4.57	4.50	9.07
12	12	13	200	280.20	150	-41.5	-1.322	-2.054	-6.983	-0.01644	4.63	4.50	9.13
13	13	14	250	292.20	150	53.8	1.095	1.165	3.798	0.01629	4.74	4.50	9.24
14	14	15	200	100.00	150	45.7	1.454	0.874	8.322	0.01621	4.74	4.50	9.24
15	15	16	200	101.40	150	32.5	1.034	0.471	4.425	0.01705	4.71	4.50	9.21
16	16	17	150	100.00	140	16.3	0.921	0.596	5.676	0.02068	4.71	4.50	9.21
17	17	18	75	100.00	140	3.1	0.694	0.792	7.546	0.02420	4.72	4.50	9.22
18	18	19	150	54.80	140	-13.1	-0.743	-0.220	-3.822	-0.02134	4.74	4.50	9.24
19	19	20	75	45.20	140	2.8	0.623	0.294	6.187	0.02459	4.74	4.50	9.24
20	20	21	125	100.00	140	-10.4	-0.851	-0.638	-6.077	-0.02156	4.75	4.50	9.25
21	21	22	200	100.00	150	-26.7	-0.848	-0.322	-3.070	-0.01756	4.74	4.50	9.24
22	22	23	200	101.40	150	-39.8	-1.268	-0.688	-6.466	-0.01654	4.74	4.50	9.24
23	23	24	250	100.00	150	-56.1	-1.142	-0.431	-4.103	-0.01619	4.74	4.50	9.24
24	24	1	250	532.20	150	-69.3	-1.411	-3.392	-6.071	-0.01569	4.73	4.50	9.23
25	7	19	150	482.00	140	15.9	0.898	2.744	5.421	0.02075	4.74	4.50	9.24

Note; The figures with minus symbol indicate the flows from right to left, while the other figures without minus indicate the flows from left to right.

Table I-4 Hydraulic Calculation of Pipeline Networks (Open System)

Point No.3	Elevation (EL.m)	Pipe Length (m)	Difference of Elevation (m)	Pipe Diameter (mm)	Discharge (ℓ/sec)	Velocity (m/s)	Hydraulic Gradient (m/1,000m)	Loss Head (m)	Total Water Head (EL.m)	Actual Pressure (m)	
No.1 Block											
1	19.85	-	-	-	-	-	-	-	63.300	43.450	(pump No.1)
2	19.15	235.00	-0.70	350	147.00	1.538	4.810	1.187	62.113	42.963	
3	19.20	54.80	0.05	250	75.00	1.539	7.131	0.410	61.703	42.503	
4	19.10	100.00	-0.10	250	58.80	1.207	4.546	0.477	61.225	42.125	
5	19.05	100.00	-0.05	200	45.60	1.463	8.420	0.884	60.341	41.291	
6	19.05	101.40	0.0	200	29.40	0.944	3.738	0.398	59.943	40.893	
7	19.10	100.00	0.05	150	16.20	0.925	5.724	0.601	59.342	40.242	
2	19.15	-	-	-	-	-	-	-	62.113	42.963	
8	19.10	45.20	-0.05	250	72.00	1.478	6.612	0.314	61.799	42.699	
9	19.10	100.00	0.0	250	58.80	1.207	4.546	0.477	61.322	42.222	
10	19.05	100.00	-0.05	200	42.60	1.367	7.424	0.779	60.542	41.492	
11	18.90	101.40	-0.15	200	29.40	0.944	3.738	0.398	60.144	41.244	
12	18.70	100.00	-0.20	150	13.20	0.754	3.919	0.411	59.733	41.033	
No.2 Block											
1	18.60	-	-	-	-	-	-	-	62.600	44.000	(pump No.2)
2	17.50	526.20	-1.10	200	42.60	1.367	7.424	4.102	58.498	40.998	
3	17.40	100.00	-0.10	200	29.40	0.944	3.737	0.393	58.106	40.706	
4	17.40	101.40	0.0	150	13.20	0.754	3.919	0.417	57.689	40.289	
No.3 Block											
1	18.50	-	-	-	-	-	-	-	62.600	44.100	(pump No.3)
2	17.40	280.20	-1.10	300	96.30	1.372	4.660	1.371	61.229	43.829	
3	17.70	100.00	0.30	300	88.20	1.257	3.961	0.416	60.813	43.113	
4	17.80	101.40	0.10	250	75.00	1.539	7.131	0.759	60.054	42.254	
5	17.70	100.00	-0.10	250	58.80	1.207	4.546	0.477	59.577	41.877	
6	17.50	100.00	-0.20	200	45.60	1.463	8.420	0.884	58.693	41.193	
7	17.30	100.00	-0.20	200	29.40	0.944	3.738	0.393	58.300	41.000	
8	17.40	100.00	0.10	150	16.20	0.925	5.724	0.601	57.699	40.299	

4. Required Pipe and Pump Facilities

The major features of required pipe and delivery pumps are summarized as shown below;

Pipeline:

Pipe (m)	Pipe Length: Link System (m)	Pipe Length: Open System (m)	Remarks
ϕ 350	-	240	Dip
ϕ 300	360	390	VP
ϕ 250	1,070	510	VP
ϕ 200	840	1,230	VP
ϕ 150	740	410	VP
ϕ 125	210	-	VP
ϕ 100	-	-	VP
ϕ 75	250	-	VP
Total	3,470	2,780	VP

Dip : Ductile iron pipe
VP : Vinyl chloride pipe

Delivery Pumps:

Calculation of Total Head

Item	Link System Pump No.1	Link System Pump No.2	Open System Pump No.1	Open System Pump No.2	Open System Pump No.3
Suction Water Level (m)	EL.15.5	EL.15.5	EL.16.9	EL.15.6	EL.15.5
Delivery Water Level (m) 1/	EL.64.0	EL.62.5	EL.63.3	EL.62.6	EL.62.6
Actual Head (m)	48.5	47.0	46.4	47.0	47.1
Pump Loss (m)	2.0	2.0	2.0	2.0	2.0
Total Head (m)	50.5	49.0	48.4	49.0	49.1

1/ : Equivalent to total water head (see Table I-2 to I-4)

Calculation of Motor Capacity

Item	Link System Pump No 1	Link System Pump No.2	Open System Pump No.1	Open System Pump No.2	Open System Pump No.3
Peak Discharge (ℓ/sec)	190.6	95.3	147.0	42.6	96.3
Peak Discharge per Unit (cu.m/min)	2.859	2.859	2.940	2.556	2.889
Pump Diameter (mm)	150	150	150	150	150
Pump Efficiency (%)	65	65	65	65	65
Total Head (m)	50.5	49.0	48.4	49.0	49.1
Motor Capacity (Kw) 1/	41.6(45)	40.4(45)	41.0(45)	36.1(45)	40.9(45)
Pump Units	4	2	3	1	2
Pump Type	Horizontal Volute Pump		Holizontal Volute Pump		

1/ : Pump Capacity (P) ;

$$P = \frac{0.163 \cdot Q \cdot Ht}{\eta p} (1+R)$$

Q : Peak discharge per unit (cu.m/min)
Ht: Total head (m)
R : Allowance, R = 15 %
ηp: Pump efficiency, ηp = 65 %

5. Selection of Optimum Pipeline Network

Comparison of the both plans in the terms of the annual costs for pumps as well as the operation of facilities has been made as shown in Table I - 5 and I - 6, and as the results the link system was selected as the most optimum pipeline networks in the project.

Table I-5 Comparison of Annual Cost in Alternatives

Items	Link System	Open System
1. Construction Cost (R.O)		
Pipeline System	54,500	54,800
Delivery Pumps		
No.1	54,000	40,500
No.2	31,000	17,800
No.3	-	31,500
Lifting pump	30,000	30,000
Total	169,500	174,600
2. Annual Cost (R.O)		
Depreciation cost 1/	19,746	20,340
Replacement cost of pumps 2/	6,532	6,804
Operation and maintenance cost		
Maintenance cost 3/	5,080	5,238
Pump operation cost 4/	10.342	10.347
Total	41,700 (100)	42,729 (102)

Note: 1/ : Initial cost (IC) x $1/\sum_{n=1}^{n=40} \frac{1}{(1+i)^{40}}$ = 0.1165 IC (i = 11.5%)

2/ : Cost (C) x $1/(1+i)^n$ x $1/\sum_{n=1}^{n=40} \frac{1}{(1+i)^{40}}$ (i = 11.5%)

Useful lives of pump : n=10 : 0.0392
n=20 : 0.0132
n=30 : 0.0044

3/ : Initial cost (IC) x 3 %

4/ : Consumed electric power (P) x 0.02 R.O. Kwh.

Table I-6 Merit and Demerit between Link and Open System

Item	Link System	Open System
1. Formation of farm	Favorable for wide area	Favorable for long strip area
2. Topography	Favorable for areas with flat topography or with gentle slope in one direction	Favorable for areas with undulation and large difference in elevation.
3. Pipe length	Long	Short
4. Pipe diameter	Small	Big
5. Correspondence to accident	Easy with limited area under influence	Difficult with the influence to whole area
6. Increase of discharge	Relatively easy	Difficult
7. Operation	Easy to obtain constant water pressure	Easy to control water distribution.

APPENDIX J. COST ESTIMATE

APPENDIX J. COST ESTIMATE

Table J-1 Investment Cost of the Project

Description	Total R.O.'000	Total (US$'000)	Foreign Currency R.O.'000	Foreign Currency (US$'000)	Local Currency R.O.'000	Local Currency (US$'000)
1. Construction Works						
1-1 Preparation	505	1,477	420	1,228	85	249
1-2 Dam	3,159	9,237	2,744	8,024	415	1,213
1-3 Water Supply Facilities	67	196	62	181	5	15
1-4 Farm and Related Facilities	1,383	4,044	1,183	3,459	200	585
1-5 Overhead	1,023	2,991	882	2,579	141	412
Sub-total	6,137	17,945	5,291	15,471	846	2,474
2. Pre-engineering works	146	427	125	365	21	62
3. Administration Cost	26	76	0	0	26	76
4. Consulting Services	910	2,661	725	2,120	185	541
Sub-total (1 - 4)	7,219	21,109	6,141	17,956	1,078	3,153
5. Contingency	1,083	3,166	921	2,693	162	473
Sub-total (1 - 5)	8,302	24,275	7,062	20,649	1,240	3,626
6. Price Escalation	1,688	4,936	1,406	4,111	282	825
Total (1 - 6)	9,990	29,211	8,468	24,760	1,522	4,451

Table J-2 Breakdown of Investment Cost

Item No.	Description	Quantity	Unit	Rate (R.O)	Total Cost (R.O'000)	Foreign Currency Equipment (R.O'000)	Foreign Currency Material (R.O'000)	Foreign Currency Labor (R.O'000)	Foreign Currency Total (R.O'000)	Local Currency Material (R.O'000)	Local Currency Labor (R.O'000)	Local Currency Total (R.O'000)
1-1.	Preparation											
	Access Road	5,000	m	14	70.0	50.4	2.1	7.0	59.5	9.1	1.4	10.5
	Mobilization of Equipment and Plant	L.S			15.0	9.5	0.5	2.5	12.5	2.0	0.5	2.5
	Contractor's Facilities Camp,' Office, Wearhouse, etc.	1,300	sq.m	130	169.0	1.7	42.3	84.5	128.5	23.7	16.8	40.5
	Water and Power Supply	L.S			50.0	3.5	37.5	7.5	48.5	0	1.5	1.5
	Safety Precautious	L.S			72.0	0	0	57.6	57.6	0	14.4	14.4
	Facilities for Site Operation Furniture, Equipment, etc.	L.S			20.0	0	20.0	0	20.0	0	0	0
	Setting Out and Shop Drawings	L.S			10.0	0	0	9.0	9.0	0	1.0	1.0
	Site Test Equipment and Testing Services	L.S			15.0	0	5.0	9.0	14.0	0	1.0	1.0
	Miscellaneous	L.S			84.0	13.0	21.5	35.4	69.9	[illegible]	7.1	11.1
	Total				505.0	78.1	128.9	212.5	419.5	11.8	15.7	85.5
					(505.0)	(78.0)	(129.0)	(213.0)	(420.0)	(12.0)	(15.0)	(85.0)

Item No.	Description	Quantity	Unit	Rate (R.O.)	Total Cost (R.O.'000)	Foreign Currency: Equipment (R.O.'000)	Foreign Currency: Material (R.O.'000)	Foreign Currency: Labor (R.O.'000)	Foreign Currency: Total (R.O.'000)	Local Currency: Material (R.O.'000)	Local Currency: Labor (R.O.'000)	Local Currency: Total (R.O.'000)
1-2.	Dam											
1-2-1.	Dam Body				937.5	516.3	27.9	242.5	786.7	106.8	44.0	150.8
1-2-2.	Spillway				1,783.1	536.2	632.5	414.2	1,582.9	118.8	81.4	200.2
1-2-3.	Conduit				151.6	27.4	70.0	29.6	127.0	19.1	5.5	24.6
1-2-4.	Emergency Outlet				96.0	16.6	48.6	15.7	80.9	11.7	3.4	15.1
1-2-5.	Dispersion Facilities				40.3	17.7	10.2	7.6	35.5	3.3	1.5	4.8
1-2-6.	Miscellaneous Works (5%)				150.4	55.7	39.5	35.5	130.7	13.0	6.7	19.7
	Total				3,158.9	1,169.9	828.7	745.1	2,743.7	272.7	142.5	415.2
					(3,159.0)	(1,170.0)	(829.0)	(745.0)	(2,744.0)	(273.0)	(142.0)	(415.0)

Item No.	Description	Quantity	Unit	Rate (R.O)	Total Cost (R.O'000)	Foreign Currency Equipment (R.O'000)	Foreign Currency Material (R.O'000)	Foreign Currency Labor (R.O'000)	Foreign Currency Total (R.O'000)	Local Currency Material (R.O'000)	Local Currency Labor (R.O'000)	Local Currency Total (R.O'000)
1-2-1.	Dam Body											
	Stripping	33,100	cu.m	1.34	44.4	31.8	1.3	4.6	37.7	6.0	0.7	6.7
	Excavation of Sand and Gravel	34,800	cu.m	0.94	32.7	23.3	1.4	3.5	28.2	4.2	0.3	4.5
	Excavation of Terrace	24,800	cu.m	1.25	31.0	24.2	0.6	2.6	27.4	3.3	0.3	3.6
	Embankment of Sand and Gravel	347,400	cu.m	1.00	347.4	216.2	13.0	52.5	281.7	59.1	6.6	65.7
	Embankment of Rock	69,800	cu.m	1.85	129.1	94.9	3.5	13.3	111.7	15.4	2.0	17.4
	Embankment of Filter	52,400	cu.m	2.15	112.7	83.3	3.1	12.6	99.0	11.5	2.2	13.7
	Riprap	21,000	cu.m	9.66	202.9	22.9	0.8	146.2	169.9	2.7	30.3	33.0
	Stabilizing Fill	74,000	cu.m	0.31	22.9	16.3	0.7	2.2	19.2	3.0	0.7	3.7
	Plain Concrete	200	cu.m	28.45	5.7	2.0	1.2	0.8	4.0	1.5	0.2	1.7
	Formworks	1,200	sq.m	5.7	6.8	0	2.2	4.0	6.2	0	0.6	0.6
	Gravel Paving	1,000	cu.m	1.85	1.9	1.4	0.1	0.2	1.7	0.1	0.1	0.2
	Sub-total				937.5	516.3	27.9	242.5	786.7	106.8	44.0	150.8
1-2-2.	Spillway											
	Stripping	44,100	cu.m	0.89	39.2	30.4	0.9	3.5	34.8	4.0	0.4	4.4
	Excavation of Sand and Gravel	446,500	cu.m	0.95	424.2	330.4	8.9	35.7	375.0	44.7	4.5	49.2
	Embankment of Sand and Gravel	34,600	cu.m	1.00	34.6	21.5	1.3	5.3	28.1	5.9	0.6	6.5
	Stabilizing Fill	13,700	cu.m	0.31	4.2	3.0	0.1	0.4	3.5	0.5	0.2	0.7
	Riprap	14,400	cu.m	9.66	139.1	15.7	0.6	100.2	116.5	1.9	20.7	22.6
	Gabion	37,500	cu.m	25.0	937.5	77.0	567.6	234.4	879.0	9.2	49.3	38.5
	Masonry	100	cu.m	26.30	10.5	2.3	3.3	2.8	8.1	1.5	0.6	2.1
	Boulder Concrete	800	cu.m	31.78	25.4	9.2	4.9	4.1	18.2	6.5	0.7	7.2
	Reinforced Concrete	1,900	cu.m	80.0	152.0	46.7	36.5	21.0	104.2	11.6	5.2	47.8
	Formworks	1,500	sq.m	5.7	8.6	0	2.7	5.0	7.7	0	0.9	0.9
	Reinforcing Bar	20,500	kg	0.38	7.8	0	5.7	1.8	7.5	0	0.3	0.3
	Sub-total				1,783.1	536.2	632.5	414.2	1,582.9	118.8	81.1	200.2

Item No.	Description	Quantity	Unit	Rate (R.O)	Total Cost (R.O'000)	Foreign Currency Equipment (R.O'000)	Foreign Currency Material (R.O'000)	Foreign Currency Labor (R.O'000)	Foreign Currency Total (R.O'000)	Local Currency Material (R.O'000)	Local Currency Labor (R.O'000)	Local Currency Total (R.O'000)
1-2-3.	Conduit											
	Stripping	1,600	cu.m	1.34	2.1	1.5	0.1	0.2	1.8	0.2	0.1	0.3
	Excavation of Sand and Gravel	2,000	cu.m	1.38	2.8	1.9	0.1	0.4	2.4	0.3	0.1	0.4
	Embankment of Sand and Gravel	400	cu.m	1.00	0.4	0.2	0	0	0.2	0.2	0	0.2
	Riprap	200	cu.m	9.66	1.9	0.2	0	1.4	1.6	0	0.3	0.3
	Gabion	2,000	cu.m	25.0	50.0	4.1	30.3	12.5	46.9	0.6	2.5	3.1
	Masonry	300	cu.m	26.30	7.9	1.7	2.5	2.1	6.3	1.1	0.5	1.6
	Reinforced Concrete	700	cu.m	80.0	56.0	17.1	13.5	7.7	38.3	16.5	1.2	17.7
	Formworks	700	sq.m	5.7	4.0	0	1.3	2.3	3.6	0	0.4	0.4
	Reinforcing Bar	25,900	kg	0.38	9.8	0	7.3	2.3	[illegible]	0	0.2	0.2
	R.C.Pipe, ϕ = 1,400mm	120	m	139.4	16.7	0.7	14.9	0.7	16.3	0.2	0.2	0.4
	Sub-total				151.6	27.4	70.0	29.6	127.0	19.1	5.5	24.6
1-2-4.	Emergency Outlet											
	Excavation of Sand and Gravel	3,300	cu.m	1.38	4.6	3.1	0.1	0.7	3.9	0.5	0.2	0.7
	Embankment of Sand and Gravel	300	cu.m	1.0	0.3	0.2	0	0	0.2	0.1	0	0.1
	Masonry	900	cu.m	26.30	23.7	5.2	7.5	6.2	18.9	3.4	1.4	4.8
	Reinforced Concrete	300	cu.m	80.0	24.0	7.3	5.8	3.4	16.5	7.1	0.4	7.5
	Formworks	300	sq.m	5.7	1.7	0	0.5	1.0	1.5	0	0.2	0.2
	Reinforcing Bar	12,400	kg	0.38	4.7	0	3.5	1.1	4.6	0	0.1	0.1
	R.C.Pipe, ϕ = 1,400mm	50	m	139.4	7.0	0.3	6.2	0.3	6.8	0.1	0.1	0.2
	Gate, Screen, Bridge		L.S		30.0	0.5	25.0	3.0	28.5	0.5	1.0	1.5
	Sub-total				96.0	16.6	48.6	15.7	80.9	11.7	3.4	15.1

Item No.	Description	Quantity	Unit	Rate (R.O)	Total Cost (R.O'000)	Foreign Currency Equipment (R.O'000)	Foreign Currency Material (R.O'000)	Foreign Currency Labor (R.O'000)	Foreign Currency Total (R.O'000)	Local Currency Material (R.O'000)	Local Currency Labor (R.O'000)	Local Currency Total (R.O'000)
1-2-5.	Dispersion Facilities											
	Stripping	700	cu.m	1.34	0.9	0.7	0	0.1	0.8	0.1	0	0.1
	Excavation of Sand and Gravel	13,300	cu.m	0.94	12.5	8.9	0.5	1.3	10.7	1.6	0.2	1.8
	Excavation of Trench	5,900	cu.m	1.38	8.1	5.6	0.2	1.2	7.0	0.9	0.2	1.1
	Embank~ent of Sand and Gravel	1,000	cu.m	1.26	1.3	1.0	0.1	0.1	1.2	0.1	0	0.1
	Riprap	300	cu.m	9.66	2.9	0.3	0	2.1	2.4	0.1	0.4	0.5
	Gabion	400	cu.m	25.0	10.0	0.8	6.0	2.4	9.2	0.2	0.6	0.8
	Masonry	50	cu.m	26.30	1.3	0.3	0.4	0.3	1.0	0.2	0.1	0.3
	R.C.Pipe, ϕ1,000mm	40	m	83.64	3.3	0.1	3.0	0.1	3.2	0.1	0	0.1
	Sub-total				40.3	17.7	10.2	7.6	35.5	3.3	1.5	4.8

Item No.	Description	Quantity	Unit	Rate (R.O)	Total Cost (R.O'000)	Foreign Currency Equipment (R.O'000)	Foreign Currency Material (R.O'000)	Foreign Currency Labor (R.O'000)	Foreign Currency Total (R.O'000)	Local Currency Material (R.O'000)	Local Currency Labor (R.O'000)	Local Currency Total (R.O'000)
1-3.	Water Supply Facilities											
	Rehabilitation of Well	3	Set	5,000	15.0	8.8	0.7	4.0	13.5	0.7	0.8	1.5
	Pump Facilities φ100 - φ125mm, 7.5 - 18.5 kw	3	Set	10,000	30.0	0	21.0	7.5	28.5	0	1.5	1.5
	Pipeline φ200mmVP	850	m	15.0	12.8	3.1	6.8	2.0	11.9	0.3	0.6	0.9
	φ150mmVP	240	m	12.0	2.9	0.7	1.5	0.5	2.7	0.1	0.1	0.2
	Miscellaneous (10%)	L.S			6.1	1.3	3.0	1.4	5.7	0.1	0.3	0.4
	Total				66.8	13.9	33.0	15.4	62.3	1.2	3.3	4.5
					(67.0)	(14.0)	(33.0)	(15.0)	(62.0)	(1.0)	(4.0)	(5.0)

Item No.	Description	Quantity	Unit	Rate (R.0)	Total Cost (R.0'000)	Foreign Currency Equipment (R.0'000)	Foreign Currency Material (R.0'000)	Foreign Currency Labor (R.0'000)	Foreign Currency Total (R.0'000)	Local Currency Material (R.0'000)	Local Currency Labor (R.0'000)	Local Currency Total (R.0'000)
1-4.	Farm and Related Facilities											
1-4-1.	New Extension Farm				155.1	96.7	23.2	13.8	133.7	19.0	2.4	21.4
1-4-2.	Irrigation System				618.9	53.0	399.7	107.6	560.3	41.4	17.2	58.6
1-4-3.	Buildings				609.5	12.4	217.9	258.9	489.2	69.7	50.6	120.3
	Total				1,383.5	162.1	640.8	380.3	1,183.2	130.1	70.2	200.3
					(1,383.0)	(162.0)	(641.0)	(380.0)	(1,183.0)	(130.0)	(70.0)	(200.0)

Item No.	Description	Quantity	Unit	Rate (R.O)	Total Cost (R.O'000)	Foreign Currency Equipment (R.O'000)	Foreign Currency Material (R.O'000)	Foreign Currency Labor (R.O'000)	Foreign Currency Total (R.O'000)	Local Currency Material (R.O'000)	Local Currency Labor (R.O'000)	Local Currency Total (R.O'000)
1-4-1.	New Extension Farm											
	Land Cleaning and Leveling	85	ha	20.0	1.7	1.2	0.1	0.2	1.5	0.2	0	0.2
	Main Road (w=5.0m)	7,000	m	8.0	56.0	40.3	1.7	5.6	47.6	7.3	1.1	8.4
	Farm Road (w=4.0m)	8,500	m	3.0	25.5	18.4	0.8	2.6	21.8	3.3	0.4	3.7
	Flood Protection Works and Fence	4,000	m	14.0	56.0	28.0	18.5	3.9	50.4	5.0	0.6	5.6
	Wind Break	6,100	trees	0.3	1.8	0	0	0.2	0.2	1.5	0.1	1.6
	Miscellaneous (10%)	L.S			14.1	8.8	2.1	1.3	12.2	1.7	0.2	1.9
	Sub-total				155.1	36.7	23.2	13.8	133.7	19.0	2.4	21.4
1-4-2.	Irrigation System											
	Farm Pond (1)	3,100	cu.m	44.0	136.4	21.8	54.6	35.5	111.9	20.5	4.0	24.5
	Farm Pond (2)	1,600	cu.m	52.0	83.2	13.3	33.3	21.6	68.2	12.5	2.5	15.0
	Pump Facilities (1) ϕ150mm, 45kw x 4 units	L.S			54.0	0	37.8	11.9	49.7	2.2	2.1	4.3
	Pump Facilities (2) ϕ150mm, 45kw x 2 units	L.S			31.0	0	21.7	6.8	28.5	1.2	1.3	2.5
	Pipeline ϕ300mmVP	360	m	25.0	9.0	2.2	4.8	1.4	8.4	0.2	0.4	0.6
	ϕ250mmVP	1,070	m	19.0	20.3	4.9	10.8	3.2	18.9	0.4	1.0	1.4
	ϕ200mmVP	840	m	15.0	12.6	3.0	6.7	2.0	11.7	0.3	0.6	0.9
	ϕ150mmVP	740	m	12.0	8.9	2.1	4.7	1.4	8.2	0.2	0.5	0.7
	ϕ125mmVP	210	m	10.0	2.1	0.5	1.1	0.3	1.9	0.1	0.1	0.2
	ϕ75mmVP	250	m	6.5	1.6	0.4	0.8	0.3	1.5	0	0.1	0.1
	Terminal Facilities Sprinkler, Drip	85	ha	1,530	130.1	0	117.1	10.4	127.5	0	2.6	2.6
	Operation System of Water Supply	L.S			73.4	0	70.0	3.0	73.0	0	0.4	0.4
	Miscellaneous (10%)				56.3	4.8	36.3	9.8	50.9	5.8	1.6	5.4
	Sub-total				618.9	53.0	399.7	107.6	560.3	41.4	17.2	58.6

Item No.	Description	Quantity	Unit	Rate (R.O)	Total Cost (R.O'000)	Foreign Currency Equipment (R.O'000)	Foreign Currency Material (R.O'000)	Foreign Currency Labor (R.O'000)	Foreign Currency Total (R.O'000)	Local Currency Material (R.O'000)	Local Currency Labor (R.O'000)	Local Currency Total (R.O'000)
1-4-3.	Buildings											
	Settler's house 150m² x 20	3,000	sq.m	140.0	420	4.2	105.0	210.0	319.2	58.8	42.0	100.8
	Sorting and Packing Center	200	sq.m	100.0	20	0.4	8.0	7.0	15.4	3.6	1.0	4.6
	Water Supply Well, Water Tank, etc.	L.S			50	5.0	35.2	8.0	48.2	1.0	0.8	1.8
	Power Transmission Line	5	km	10,000	50	1.7	40.0	6.6	48.3	0	1.7	1.7
	Power Connecting Line	L.S			14.1	0	9.9	3.7	13.6	0	0.5	0.5
	Miscellaneous (10%)				55.4	1.1	19.8	23.5	44.5	6.3	4.6	10.9
	Sub-total				609.5	12.4	217.9	258.9	489.2	69.7	50.6	120.3

Item No.	Description	Quantity	Unit	Rate (R.O)	Total Cost (R.O'000)	Foreign Currency Equipment (R.O'000)	Foreign Currency Material (R.O'000)	Foreign Currency Labor (R.O'000)	Foreign Currency Total (R.O'000)	Local Currency Material (R.O'000)	Local Currency Labor (R.O'000)	Local Currency Total (R.O'000)
2.	Pre-engineering Works											
	Longitudinal and Cross Section Survey	21	km	1,300	27.3	0	1.4	22.0	23.4	0	3.9	3.9
	Topographic Survey for Reservoir Area, 1/2,000	250	ha	100	25.0	0	1.3	20.1	21.4	0	3.6	3.6
	Geological Investigation Bore-hole Drilling and Test	L.S			50.0	19.5	4.5	19.0	43.0	3.5	3.5	7.0
	Embankment Material Test	L.S			10.0	0	0.5	8.1	8.6	0	1.4	1.4
	Topographic Survey for New Extension Farm Land, 1/1,000	200	ha	100	20.0	0	1.0	16.1	17.1	0	2.9	2.9
	Miscellaneous (10%)				13.2	2.0	0.9	8.5	11.4	0.4	1.4	1.8
	Total				145.5	21.5	9.6	93.8	124.9	3.9	16.7	20.6
					(146.0)	(22.0)	(10.0)	(93.0)	(125.0)	(4.0)	(17.0)	(21.0)

4. Consulting Services

Item	Description	Quantity	Unit	Rate (R.O)	Total Cost: Foreign Currency (R.O)	Total Cost: Local Currency (R.O)
4-1.	Consulting Services					
4-1-1.	Pre-engineering Stage					
	a) Foreign Currency					
	Consultants Remuneration	6	month	2,700	16,200	
	Out-of-pocket Expenses					
	International travel expense	3	trip	1,200	3,600	
	Reimbursable cost item and other		L.S.(10%)		1,980	
	Vehicles	2	unit	4,500	9,000	
	Miscellaneous		L.S.(10%)		3,080	
	Sub-total				33,860	
	b) Local Currency					
	Consultants per Diem	180	day	12		2,160
	Living Allowance and Quarters	6	month	1,000		6,000
	Local Communication		L.S.			340
	Printing of Report		L.S.			600
	Miscellaneous		L.S.(10%)			910
	Sub-total					10,010

Item	Description	Quantity	Unit	Rate (R.O)	Total Cost: Foreign Currency (R.O)	Total Cost: Local Currency (R.O)
4-1-2.	Detailed Design Stage					
	a) Foreign Currency					
	Consultants Remuneration	80	month	2,700	216,000	
	Out-of-pocket Expenses					
	International travel expense	17	trip	1,200	20,400	
	Reimbursable cost item and other		L.S.(10%)		23,640	
	Vehicles	5	unit	4,500	22,500	
	Miscellaneous		L.S.(10%)		25,890	
	Sub-total				308,430	
	b) Local Currency					
	Consultants per Diem	750	day	12		9,000
	Living Allowance and Quarter	25	month	1,000		25,000
	Local Communication		L.S.			3,100
	Printing of Report		L.S.			10,000
	Office	8	month	3,000		24,000
	Miscellaneous		L.S.(10%)			7,110
	Sub-total					78,210

Item	Description	Quantity	Unit	Rate (R.O)	Total Cost Foreign Currency (R.O)	Total Cost Local Currency (R.O)
4-1-3.	Tendering Stage					
	a) Foreign Currency					
	Consultants Remuneration	6	month	2,700	16,200	
	Out-of-pocket Expenses					
	International travel expense	3	trip	1,200	3,600	
	Reimbursable cost item and other		L.S.(10%)		1,980	
	Miscellaneous		L.S.(10%)		2,180	
	Sub-total				23,960	
	b) Local Currency					
	Consultants per Diem	150	day	12		1,800
	Living Allowance and Quarter	4	month	1,000		4,000
	Local Communication		L.S.			580
	Office	4	month	1,000		4,000
	Miscellaneous		L.S.(10%)			990
	Sub-total					10,840
4-1-4.	Construction Supervision					
	a) Foreign Currency					
	Consultants Remuneration	91	month	2,700	245,700	

Item	Description	Quantity	Unit	Rate (R.O)	Total Cost: Foreign Currency (R.O)	Total Cost: Local Currency (R.O)
	Out-of-pocket Expenses					
	International travel expense	14	trip	1,200	16,800	
	Reimbursable cost item and other		L.S.(10%)		26,250	
	Miscellaneous		L.S.(10%)		40,880	
	Sub-total				329,630	
	b) Local Currency					
	Consultants per Diem	2,730	day	12		32,760
	Living Allowance and Quarter	91	month	100		9,100
	Local Communication		L.S			2,910
	Printing Report		L.S.			10,000
	Office	20	month	1,000		20,000
	Miscellaneous		L.S.(10%)			7,480
	Sub-total					82,250
4-1-5.	Operation and Maintenance					
	a) Foreign Currency					
	Consultants Remuneration	8	month	2,700	21,600	
	Out-of-pocket Expences					
	International travel expense	2	trip	1,200	2,400	
	Reimbursable cost item and other		L.S.(10%)		2,400	

Item	Description	Quantity	Unit	Rate (R.O.)	Total Cost Foreign Currency (R.O.)	Total Cost Local Currency (R.O.)
	Miscellaneous		L.S.(10%)		2,640	
	Sub-total				29,040	
	Total				712,920	184,510
	b). Local Currency					
	Consultant per diem	240	day	12		2,880
	Living Allowance and Quarter	8	month	100		800
	Local communication		L.S.			440
	Miscellaneous		L.S.			200
	Sub-total					4,320
	Total				724,920	185,630

Table J-3 List of Required Construction Equipment

Equipment	Specification	Number
Bulldozer	21 ton	11
Ripper	32 ton	3
Vibrating Roller	11 ton	4
Tractor-Shovel	4 m^3	6
Dump Truck	32 ton	13
Bakhoe Shovel	1.2 m^3	1
Water Truck	6 ton	10
Truck Crane	13 ton	1
Screening Plant	1.8 m x 4.8 m	1
Concrete Mixing Plant	0.5 m^3	1
Agitator Truck	3 m^3	3
Generator	75 KVA	1

Table J-4 Disbursement Schedule of Investment Cost

(Unit: R.O.'000)

Description	Total			1983			1984			1985		
	Total	F.C.[1/]	L.C.[2/]	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.
1. Construction Works												
1-1 Preparation	505	420	85				505	420	85			
1-2 Dam	3,159	2,744	415				790	686	104	2,369	2,058	311
1-3 Water Supply Facilities	67	62	5							67	62	5
1-4 Farm and Related Facilities	1,383	1,183	200				609	489	120	774	694	80
1-5 Overhead	1,023	882	141				381	319	62	642	563	79
Sub-total	6,137	5,291	846				2,285	1,914	371	3,852	3,377	475
2. Pre-engineering Works	146	125	21	146	125	21						
3. Administration Cost	26	0	26	2	0	2	12	0	12	12	0	12
4. Consulting Services	910	725	185	455	363	92	145	116	29	310	246	64
Sub-total (1 - 4)	7,219	6,141	1,078	603	488	115	2,442	2,030	412	4,174	3,623	551
5. Contingency	1,083	921	162	90	73	17	367	305	62	626	543	83
Sub-total (1 - 5)	8,302	7,062	1,240	693	561	132	2,809	2,335	474	4,800	4,166	634
6. Price Escalayion	1,688	1,406	282	28	22	6	465	376	89	1,195	1,008	187
Total (1 - 6)	9,990	8,468	1,522	721	583	138	3,274	2,711	563	5,995	5,174	821

Note: 1/ F.C.: Foreign Currency
2/ L.C.: Local Currency