Table G.3.3.3. Comparative Study of Pumps and Pumping Station (1 / 6)

- Abstract of Facilities and Cost Comparison in Case Full (100%) Water of Regulating Ponds is Available (1)

		Case					
		I-1	I-2	I-3	I-4	II -1	
Pump Bore	mm	2,600	2,200	2,000	1,650	2,600	1,650
Capacity per Unit	m3/s	14.40	12.00	9.00	6.00	15.00	6.00
	m3/min	864.0	720.0	540.0	360.0	900.0	360.0
Number of Units	nos	5	6	8	12	4	2
Total Head of Pumps	m	22.7	22.7	22.7	22.7	22.7	22.7
Motor Power per Unit	kw	4,200	3,600	2,700	1,800	4,400	1,800
Size of Pump House (Width * Length)	m * m	70.0 * 32.5	72.0 * 32.5	80.0 * 32.5	96.0 * 32.5		72.0 * 32.5
Size of Settling Basin (Width * Length)	m * m	69.0 * 100.0	71.0 * 100.0	79.0 * 100.0	95.0 * 100.0		71.0 * 100.0
Annual Total Water Requirement	MCM	1,307.7	1,307.7	1,307.7	1,307.7		1,307.7
Annual Total Water Supply by Pumps	MCM	1,373.6	1,355.1	1,323.5	1,308.4		1,313.4
Annual Total Excess Water	MCM	65.9	47.4	15.8	0.8		5.7
Annual Total Operation Hours of Pumps	hr	26,496	31,368	40,848	60,576	21,432	8,472
Pump Equipments Cost	1,000Rs.	935,050	943,640	1,006,660	1,068,280		937,800
Pumps	1,000Rs.	313,000	337,200	360,800	361,200		310,600
Motors	1,000Rs.	207,500	214,200	224,800	235,200		212,000
Valves	1,000Rs.	153,150	125,040	130,160	135,480		145,100
Pipes	1,000Rs.	100,000	102,000	112,000	130,000		102,000
Others	1,000Rs.	161,400	165,200	178,900	206,400		168,100
Construction Cost of Pump House	1,000Rs.	27,300	28,080	31,200	37,050		27,690
Construction Cost of Settling Basin	1,000Rs.	6,540	6,690	7,310	8,530		6,690
Construction Cost of Suction Pit and Basement of Pump House	1,000Rs.	104,940	108,660	118,840	142,730		108,660
Concrete Work	1,000Rs.	87,350	90,710	99,670	120,490		90,710
Earthwork	1,000Rs.	4,130	4,190	4,410	4,940		4,190
In-situ RC Piling	1,000Rs.	13,460	13,760	14,760	17,300		13,760
Misccelaneous Works (5%)	1,000Rs.	53,690	54,350	58,200	62,830		54,040
Direct Cost	1,000Rs.	1,127,520	1,141,420	1,222,210	1,319,420		1,134,880
Indirect Cost (16 % of Direct Cost)	1,000Rs.	180,400	182,630	195,550	211,110		181,580
Contingencies (22 % of Direct Cost)	1,000Rs.	248,050	251,110	268,890	290,270		249,670
Total Construction Cost	1,000Rs.	1,555,970	1,575,160	1,686,650	1,820,800		1,566,130
Replacement Cost of Pump Equipments	1,000Rs.	929,640	933,490	987,750	1,009,990		921,430
Annual O & M Cost							
Electricity	1,000Rs.	171,365	174,031	170,210	168,394		168,948
Maintenance for Pump Equipments	1,000Rs.	18,701	18,873	20,133	21,366		18,756
Total O & M cost							
in the Early Stage of the Project Life (50%)	1,000Rs.	95,033	96,452	95,172	94,880		93,852
in the Late Stage of the Project Life	1,000Rs.	190,066	192,904	190,343	189,760		187,704
Net Present Value	1,000Rs.	3,425,500	3,462,600	3,615,600	3,769,200		3,415,800

Table G.3.3.3. Comparative Study of Pumps and Pumping Station

- Abstract of Facilities and Cost Comparison in Case Full (100%) Water of Regulating Ponds is Available (2)

		Case							
		II -2		II -3a		II -3b		II -3c	
Pump Bore	mm	2,200	1,650	2,000	1,650	2,000	1,350	2,000	1,650
Capacity per Unit	m3/s	12.00	6.00	10.00	6.00	10.00	4.00	10.00	5.50
	m3/min	720.0	360.0	600.0	360.0	600.0	240.0	600.0	330.0
Number of Units	nos	5	2	6	2	6	3	5	4
Total Head of Pumps	m	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7
Motor Power per Unit	kw	3,600	1,800	3,000	1,800	3,000	1,200	3,000	1,700
Size of Pump House (Width * Length)	m * m		76.0 * 32.5		76.0 * 32.5		81.0 * 32.5		82.0 * 32.5
Size of Settling Basin (Width * Length)	m * m		75.0 * 100.0		75.0 * 100.0		80.0 * 100.0		81.0 * 100.0
Annual Total Water Requirement	MCM		1,307.7		1,307.7		1,307.7		1,307.7
Annual Total Water Supply by Pumps	MCM		1,313.6		1,308.3		1,312.4		1,310.7
Annual Total Excess Water	MCM		6.0		0.6		4.7		3.0
Annual Total Operation Hours of Pumps	hr	28,704	3,408	31,416	8,208	30,888	13,920	29,544	12,480
Pump Equipments Cost	1,000Rs.		964,780		963,500		980,700		1,003,310
Pumps	1,000Rs.		341,200		330,800		332,400		345,900
Motors	1,000Rs.		217,700		227,000		230,700		231,300
Valves	1,000Rs.		126,780		120,200		119,100		126,510
Pipes	1,000Rs.		107,000		107,000		113,000		114,000
Others	1,000Rs.		172,100		178,500		185,500		185,600
Construction Cost of Pump House	1,000Rs.		29,640		29,640		31,590		31,980
Construction Cost of Settling Basin	1,000Rs.		7,000		7,000		7,380		7,460
Construction Cost of Suction Pit and Basement of Pump House	1,000Rs.		114,340		116,080		122,730		123,730
Concrete Work	1,000Rs.		95,670		97,410		103,180		103,990
Earthwork	1,000Rs.		4,320		4,320		4,470		4,510
In-situ RC Piling	1,000Rs.		14,350		14,350		15,080		15,230
Misccelaneous Works (5%)	1,000Rs.		55,790		55,810		57,120		58,320
Direct Cost	1,000Rs.		1,171,550		1,172,030		1,199,520		1,224,800
Indirect Cost (16 % of Direct Cost)	1,000Rs.		187,450		187,520		191,920		195,970
Contingencies (22 % of Direct Cost)	1,000Rs.		257,740		257,850		263,890		269,460
Total Construction Cost	1,000Rs.		1,616,740		1,617,400		1,655,330		1,690,230
Replacement Cost of Pump Equipments	1,000Rs.		946,240		935,640		941,440		971,120
Annual O & M Cost									
Electricity	1,000Rs.		169,020		168,373		168,874		169,665
Maintenance for Pump Equipments	1,000Rs.		19,296		19,270		19,614		20,066
Total O & M Cost									
in the Early Stage of the Project Life (50%)	1,000Rs.		94,158		93,822		94,244		94,866
in the Late Stage of the Project Life	1,000Rs.		188,316		187,643		188,488		189,731
Net Present Value	1,000Rs.		3,494,200		3,480,900		3,528,800		3,599,600

Table G.3.3.3. Comparative Study of Pumps and Pumping Station

- Abstract of Facilities and Cost Comparison in Case 50% Water of Regulating Ponds is Available (1)

		Case					
		I-1	I-2	I-3	I-4	II -1	
Pump Bore	mm	2,600	2,200	2,000	1,650	2,600	1,650
Capacity per Unit	m3/s	14.40	12.00	9.00	6.00	15.00	6.00
	m3/min	864.0	720.0	540.0	360.0	900.0	360.0
Number of Units	nos	5	6	8	12	4	2
Total Head of Pumps	m	22.7	22.7	22.7	22.7	22.7	22.7
Motor Power per Unit	kw	4,200	3,600	2,700	1,800	4,400	1,800
Size of Pump House (Width * Length)	m * m	70.0 * 32.5	72.0 * 32.5	80.0 * 32.5	96.0 * 32.5		72.0 * 32.5
Size of Settling Basin (Width * Length)	m * m	69.0 * 100.0	71.0 * 100.0	79.0 * 100.0	95.0 * 100.0		71.0 * 100.0
Annual Total Water Requirement	MCM	1,307.7	1,307.7	1,307.7	1,307.7		1,307.7
Annual Total Water Supply by Pumps	MCM	1,423.3	1,408.0	1,372.5	1,329.2		1,329.2
Annual Total Excess Water	MCM	115.6	100.3	64.8	21.5		21.5
Annual Total Operation Hours of Pumps	hr	27,456	32,592	42,360	61,536	21,936	7,680
Pump Equipments Cost	1,000Rs.	935,050	943,640	1,006,660	1,068,280		937,800
Pumps	1,000Rs.	313,000	337,200	360,800	361,200		310,600
Motors	1,000Rs.	207,500	214,200	224,800	235,200		212,000
Valves	1,000Rs.	153,150	125,040	130,160	135,480		145,100
Pipes	1,000Rs.	100,000	102,000	112,000	130,000		102,000
Others	1,000Rs.	161,400	165,200	178,900	206,400		168,100
Construction Cost of Pump House	1,000Rs.	27,300	28,080	31,200	37,050		27,690
Construction Cost of Settling Basin	1,000Rs.	6,540	6,690	7,310	8,530		6,690
Construction Cost of Suction Pit and Basement of Pump House	1,000Rs.	104,940	108,660	118,840	142,730		108,660
Concrete Work	1,000Rs.	87,350	90,710	99,670	120,490		90,710
Earthwork	1,000Rs.	4,130	4,190	4,410	4,940		4,190
In-situ RC Piling	1,000Rs.	13,460	13,760	14,760	17,300		13,760
Miscellaneous Works (5%)	1,000Rs.	53,690	54,350	58,200	62,830		54,040
Direct Cost	1,000Rs.	1,127,520	1,141,420	1,222,210	1,319,420		1,134,880
Indirect Cost (16 % of Direct Cost)	1,000Rs.	180,400	182,630	195,550	211,110		181,580
Contingencies (22 % of Direct Cost)	1,000Rs.	248,050	251,110	268,890	290,270		249,670
Total Construction Cost	1,000Rs.	1,555,970	1,575,160	1,686,650	1,820,800		1,566,130
Replacement Cost of Pump Equipments	1,000Rs.	929,640	933,490	987,750	1,009,990		921,430
Annual O & M Cost							
Electricity	1,000Rs.	177,211	180,420	176,130	170,899		170,096
Maintenance for Pump Equipments	1,000Rs.	18,701	18,873	20,133	21,366		18,756
Total O & M Cost							
in the Early Stage of the Project Life (50%)	1,000Rs.	97,956	99,647	98,132	96,133		94,426
in the Late Stage of the Project Life	1,000Rs.	195,912	199,293	196,263	192,265		188,852
Net Present Value	1,000Rs.	3,454,400	3,494,200	3,644,900	3,781,500		3,421,400

Table G.3.3.3. Comparative Study of Pumps and Pumping Station

- Abstract of Facilities and Cost Comparison in Case 50% Water of Regulating Ponds is Available (2)

		Case							
		II -2		II -3a		II -3b		II -3c	
Pump Bore	mm	2,200	1,650	2,000	1,650	2,000	1,350	2,000	1,650
Capacity per Unit	m3/s	12.00	6.00	10.00	6.00	10.00	4.00	10.00	5.50
	m3/min	720.0	360.0	600.0	360.0	600.0	240.0	600.0	330.0
Number of Units	nos	5	2	6	2	6	3	5	4
Total Head of Pumps	m	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7
Motor Power per Unit	kw	3,600	1,800	3,000	1,800	3,000	1,200	3,000	1,700
Size of Pump House (Width * Length)	m * m		76.0 * 32.5		76.0 * 32.5		81.0 * 32.5		82.0 * 32.5
Size of Settling Basin (Width * Length)	m * m		75.0 * 100.0		75.0 * 100.0		80.0 * 100.0		81.0 * 100.0
Annual Total Water Requirement	MCM		1,307.7		1,307.7		1,307.7		1,307.7
Annual Total Water Supply by Pumps	MCM		1,324.0		1,312.4		1,321.1		1,324.0
Annual Total Excess Water	MCM		16.3		4.7		13.4		16.4
Annual Total Operation Hours of Pumps	hr	28,704	4,128	31,704	7,920	31,656	12,600	30,984	10,536
Pump Equipments Cost	1,000Rs.		964,780		963,500		980,700		1,003,310
Pumps	1,000Rs.		341,200		330,800		332,400		345,900
Motors	1,000Rs.		217,700		227,000		230,700		231,300
Valves	1,000Rs.		126,780		120,200		119,100		126,510
Pipes	1,000Rs.		107,000		107,000		113,000		114,000
Others	1,000Rs.		172,100		178,500		185,500		185,600
Construction Cost of Pump House	1,000Rs.		29,640		29,640		31,590		31,980
Construction Cost of Settling Basin	1,000Rs.		7,000		7,000		7,380		7,460
Construction Cost of Suction Pit and Basement of Pump House	1,000Rs.		114,340		116,080		122,730		123,730
Concrete Work	1,000Rs.		95,670		97,410		103,180		103,990
Earthwork	1,000Rs.		4,320		4,320		4,470		4,510
In-situ RC Piling	1,000Rs.		14,350		14,350		15,080		15,230
Misceelaneous Works (5%)	1,000Rs.		55,790		55,810		57,120		58,320
Direct Cost	1,000Rs.		1,171,550		1,172,030		1,199,520		1,224,800
Indirect Cost (16 % of Direct Cost)	1,000Rs.		187,450		187,520		191,920		195,970
Contingencies (22 % of Direct Cost)	1,000Rs.		257,740		257,850		263,890		269,460
Total Construction Cost	1,000Rs.		1,616,740		1,617,400		1,655,330		1,690,230
Replacement Cost of Pump Equipments	1,000Rs.		946,240		935,640		941,440		971,120
Annual O & M Cost									
Electricity	1,000Rs.		170,899		168,874		169,918		171,137
Maintenance for Pump Equipments	1,000Rs.		19,296		19,270		19,614		20,066
Total O & M Cost									
in the Early Stage of the Project Life (50%)	1,000Rs.		95,098		94,072		94,766		95,602
in the Late Stage of the Project Life	1,000Rs.		190,195		188,144		189,532		191,203
Net Present Value	1,000Rs.		3,503,500		3,483,400		3,534,000		3,606,900

Table G.3.3.3. Comparative Study of Pumps and Pumping Station

- Abstract of Facilities and Cost Comparison in Case Less than 10% Water of Regulating Ponds is Available (1)

		Case					
		I-1	I-2	I-3	I-4	II -1a	
Pump Bore	mm	2,600	2,200	2,000	1,650	2,600	1,650
Capacity per Unit	m3/s	14.40	12.00	9.00	6.00	15.00	6.00
	m3/min	864.0	720.0	540.0	360.0	900.0	360.0
Number of Units	nos	5	6	8	12	4	2
Total Head of Pumps	m	22.7	22.7	22.7	22.7	22.7	22.7
Motor Power per Unit	kw	4,200	3,600	2,700	1,800	4,400	1,800
Size of Pump House (Width * Length)	m * m	70.0 * 32.5	72.0 * 32.5	80.0 * 32.5	96.0 * 32.5		72.0 * 32.5
Size of Settling Basin (Width * Length)	m * m	69.0 * 100.0	71.0 * 100.0	79.0 * 100.0	95.0 * 100.0		71.0 * 100.0
Annual Total Water Requirement	MCM	1,307.7	1,307.7	1,307.7	1,307.7		1,307.7
Annual Total Water Supply by Pumps	MCM	1,511.7	1,459.8	1,449.5	1,386.2		1,372.2
Annual Total Excess Water	MCM	204.0	152.1	141.8	78.5		64.5
Annual Total Operation Hours of Pumps	hr	29,160	33,792	44,736	64,176	22,656	8,136
Pump Equipments Cost	1,000Rs.	935,050	943,640	1,006,660	1,068,280		937,800
Pumps	1,000Rs.	313,000	337,200	360,800	361,200		310,600
Motors	1,000Rs.	207,500	214,200	224,800	235,200		212,000
Valves	1,000Rs.	153,150	125,040	130,160	135,480		145,100
Pipes	1,000Rs.	100,000	102,000	112,000	130,000		102,000
Others	1,000Rs.	161,400	165,200	178,900	206,400		168,100
Construction Cost of Pump House	1,000Rs.	27,300	28,080	31,200	37,050		27,690
Construction Cost of Settling Basin	1,000Rs.	6,540	6,690	7,310	8,530		6,690
Construction Cost of Suction Pit and Basement of Pump House	1,000Rs.	104,940	108,660	118,840	142,730		108,660
Concrete Work	1,000Rs.	87,350	90,710	99,670	120,490		90,710
Earthwork	1,000Rs.	4,130	4,190	4,410	4,940		4,190
In-situ RC Piling	1,000Rs.	13,460	13,760	14,760	17,300		13,760
Misccelaneous Works (5%)	1,000Rs.	53,690	54,350	58,200	62,830		54,040
Direct Cost	1,000Rs.	1,127,520	1,141,420	1,222,210	1,319,420		1,134,880
Indirect Cost (16 % of Direct Cost)	1,000Rs.	180,400	182,630	195,550	211,110		181,580
Contingencies (22 % of Direct Cost)	1,000Rs.	248,050	251,110	268,890	290,270		249,670
Total Construction Cost	1,000Rs.	1,555,970	1,575,160	1,686,650	1,820,800		1,566,130
Replacement Cost of Pump Equipments	1,000Rs.	929,640	933,490	987,750	1,009,990		921,430
Annual O & M Cost							
Electricity	1,000Rs.	187,589	186,684	185,432	177,790		175,880
Maintenance for Pump Equipments	1,000Rs.	18,701	18,873	20,133	21,366		18,756
Total O & M Cost							
in the Early Stage of the Project Life (50%)	1,000Rs.	103,145	102,779	102,783	99,578		97,318
in the Late Stage of the Project Life	1,000Rs.	206,290	205,557	205,565	199,156		194,636
Net Present Value	1,000Rs.	3,505,700	3,525,100	3,690,900	3,815,600		3,450,000

Table G.3.3.3. Comparative Study of Pumps and Pumping Station

- Abstract of Facilities and Cost Comparison in Case Less than 10% Water of Regulating Ponds is Available (2)

		Case							
		II -2		II -3a		II -3b		II -3c	
Pump Bore	mm	2,200	1,650	2,000	1,650	2,000	1,350	2,000	1,650
Capacity per Unit	m3/s	12.00	6.00	10.00	6.00	10.00	4.00	10.00	5.50
	m3/min	720.0	360.0	600.0	360.0	600.0	240.0	600.0	330.0
Number of Units	nos	5	2	6	2	6	3	5	4
Total Head of Pumps	m	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7
Motor Power per Unit	kw	3,600	1,800	3,000	1,800	3,000	1,200	3,000	1,700
Size of Pump House (Width * Length)	m * m		76.0 * 32.5		76.0 * 32.5		81.0 * 32.5		82.0 * 32.5
Size of Settling Basin (Width * Length)	m * m		75.0 * 100.0		75.0 * 100.0		80.0 * 100.0		81.0 * 100.0
Annual Total Water Requirement	MCM		1,307.7		1,307.7		1,307.7		1,307.7
Annual Total Water Supply by Pumps	MCM		1,386.2		1,345.9		1,351.5		1,348.1
Annual Total Excess Water	MCM		78.5		38.3		43.8		40.5
Annual Total Operation Hours of Pumps	hr	30,144	3,888	32,592	7,992	31,656	14,712	30,624	12,408
Pump Equipments Cost	1,000Rs.		964,780		963,500		980,700		1,003,310
Pumps	1,000Rs.		341,200		330,800		332,400		345,900
Motors	1,000Rs.		217,700		227,000		230,700		231,300
Valves	1,000Rs.		126,780		120,200		119,100		126,510
Pipes	1,000Rs.		107,000		107,000		113,000		114,000
Others	1,000Rs.		172,100		178,500		185,500		185,600
Construction Cost of Pump House	1,000Rs.		29,640		29,640		31,590		31,980
Construction Cost of Settling Basin	1,000Rs.		7,000		7,000		7,380		7,460
Construction Cost of Suction Pit and Basement of Pump House	1,000Rs.		114,340		116,080		122,730		123,730
Concrete Work	1,000Rs.		95,670		97,410		103,180		103,990
Earthwork	1,000Rs.		4,320		4,320		4,470		4,510
In-situ RC Piling	1,000Rs.		14,350		14,350		15,080		15,230
Misccelaneous Works (5%)	1,000Rs.		55,790		55,810		57,120		58,320
Direct Cost	1,000Rs.		1,171,550		1,172,030		1,199,520		1,224,800
Indirect Cost (16 % of Direct Cost)	1,000Rs.		187,450		187,520		191,920		195,970
Contingencies (22 % of Direct Cost)	1,000Rs.		257,740		257,850		263,890		269,460
Total Construction Cost	1,000Rs.		1,616,740		1,617,400		1,655,330		1,690,230
Replacement Cost of Pump Equipments	1,000Rs.		946,240		935,640		941,440		971,120
Annual O & M Cost									
Electricity	1,000Rs.		177,790		172,925		173,593		174,186
Maintenance for Pump Equipments	1,000Rs.		19,296		19,270		19,614		20,066
Total O & M Cost									
in the Early Stage of the Project Life (50%)	1,000Rs.		98,543		96,098		96,604		97,126
in the Late Stage of the Project Life	1,000Rs.		197,086		192,195		193,207		194,252
Net Present Value	1,000Rs.		3,537,600		3,503,400		3,552,200		3,621,900

Table G.3.3.4. Annual Operation Hours of Each Pump

- Case II-3a, 6 Units of 10.00m3/s Pump and 2 Units of 6.00m3/s Pump Installed

Month	Jan.			Feb.			Mar.			Apr.			May			Jun.			Jul.			Aug.			Sep.			Oct.			Nov.			Dec.		
10 Days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
No. of Days	10	10	11	10	10	8	10	10	11	10	10	10	10	10	11	10	10	10	10	10	11	10	10	11	10	10	10	10	10	11	10	10	10	10	10	11

▼ Pump Operation Pattern in Case Full (100%) Water of Regulating Ponds is Available

	Annual Operation Hours
10.00 m3/s Pump ①	365 days × 24 hr= 8,760 hr
10.00 m3/s Pump ②	345 days × 24 hr= 8,280 hr
10.00 m3/s Pump ③	292 days × 24 hr= 7,008 hr
10.00 m3/s Pump ④	173 days × 24 hr= 4,152 hr
10.00 m3/s Pump ⑤	93 days × 24 hr= 2,232 hr
10.00 m3/s Pump ⑥	41 days × 24 hr= 984 hr
	Total 31,416 hr
6.00 m3/s Pump ①	262 days × 24 hr= 6,288 hr
6.00 m3/s Pump ②	80 days × 24 hr= 1,920 hr
	Total 8,208 hr

▼ Pump Operation Pattern in Case 50% Water of Regulating Ponds is Available

10.00 m3/s Pump ①	365 days × 24 hr= 8,760 hr
10.00 m3/s Pump ②	345 days × 24 hr= 8,280 hr
10.00 m3/s Pump ③	313 days × 24 hr= 7,512 hr
10.00 m3/s Pump ④	153 days × 24 hr= 3,672 hr
10.00 m3/s Pump ⑤	93 days × 24 hr= 2,232 hr
10.00 m3/s Pump ⑥	52 days × 24 hr= 1,248 hr
	Total 31,704 hr
6.00 m3/s Pump ①	240 days × 24 hr= 5,760 hr
6.00 m3/s Pump ②	90 days × 24 hr= 2,160 hr
	Total 7,920 hr

▼ Pump Operation Pattern in Case Less than 10% Water of Regulating Ponds is Available

10.00 m3/s Pump ①	365 days × 24 hr= 8,760 hr
10.00 m3/s Pump ②	344 days × 24 hr= 8,256 hr
10.00 m3/s Pump ③	293 days × 24 hr= 7,032 hr
10.00 m3/s Pump ④	191 days × 24 hr= 4,584 hr
10.00 m3/s Pump ⑤	103 days × 24 hr= 2,472 hr
10.00 m3/s Pump ⑥	62 days × 24 hr= 1,488 hr
	Total 32,592 hr
6.00 m3/s Pump ①	252 days × 24 hr= 6,048 hr
6.00 m3/s Pump ②	81 days × 24 hr= 1,944 hr
	Total 7,992 hr

Table G.3.3.5. Comparative Study of Pipeline

Case		A-1	A-2	A-3	B-1	B-2	B-3	C-1	C-2	C-3
Velocity of pipeline	m/s		3.5			3.0			2.5	
Series of pipeline		1	2	3	1	2	3	1	2	3
Diameter of pipes	mm	5,200	3,600	3,000	5,600	4,000	3,200	6,000	4,200	3,400
Unit weight of pipes	t/m	4.00	2.22	1.75	4.42	2.59	1.90	4.98	2.75	2.03
Total head of pumps	m	22.7	23.3	23.5	22.4	22.7	23.0	22.3	22.5	22.7
Motor power per unit (for large pump)	kw	3,000	3,100	3,100	3,000	3,000	3,000	3,000	3,000	3,000
(for small pump)	kw	1,800	1,900	1,900	1,800	1,800	1,800	1,800	1,800	1,800
Pump equipments cost	1,000Rs.	785,000	789,400	789,400	785,000	785,000	785,000	785,000	785,000	785,000
Pumps	1,000Rs.	330,800	330,800	330,800	330,800	330,800	330,800	330,800	330,800	330,800
Motors	1,000Rs.	227,000	231,400	231,400	227,000	227,000	227,000	227,000	227,000	227,000
Valves	1,000Rs.	120,200	120,200	120,200	120,200	120,200	120,200	120,200	120,200	120,200
Pipes	1,000Rs.	107,000	107,000	107,000	107,000	107,000	107,000	107,000	107,000	107,000
Pipeline cost	1,000Rs.	165,260	180,890	212,710	182,760	211,030	230,980	205,850	224,170	246,920
Material	1,000Rs.	70,000	77,700	91,880	77,350	90,650	99,750	87,150	96,250	106,580
Manufacturing	1,000Rs.	61,600	68,380	80,850	68,070	79,770	87,780	76,690	84,700	93,790
Transportation	1,000Rs.	6,580	7,300	8,640	7,270	8,520	9,380	8,190	9,050	10,020
Installation	1,000Rs.	19,740	21,910	25,910	21,810	25,560	28,130	24,580	27,140	30,060
Earthwork	1,000Rs.	7,340	5,600	5,430	8,260	6,530	5,940	9,240	7,030	6,470
Misccelaneous Works (5%)	1,000Rs.	47,510	48,510	50,110	48,390	49,800	50,800	49,540	50,460	51,600
Direct cost	1,000Rs.	997,770	1,018,800	1,052,220	1,016,150	1,045,830	1,066,780	1,040,390	1,059,630	1,083,520
Indirect cost (16% of Direct Cost)	1,000Rs.	159,640	163,010	168,360	162,580	167,330	170,680	166,460	169,540	173,360
Contingencies (22% of Direct Cost)	1,000Rs.	219,510	224,140	231,490	223,550	230,080	234,690	228,890	233,120	238,370
Total Construction Cost	1,000Rs.	1,376,920	1,405,950	1,452,070	1,402,280	1,443,240	1,472,150	1,435,740	1,462,290	1,495,250
Replacement Cost of Pump Equipments	1,000Rs.	935,640	941,710	941,710	935,640	935,640	935,640	935,640	935,640	935,640
Annual O & M cost										
Electricity	1,000Rs.	172,932	178,817	178,817	172,932	172,932	172,932	172,932	172,932	172,932
Maintenance for pump equipments	1,000Rs.	15,700	15,788	15,788	15,700	15,700	15,700	15,700	15,700	15,700
Total O & M Cost										
in the Early Stage of the Project Life	1,000Rs.	94,316	97,303	97,303	94,316	94,316	94,316	94,316	94,316	94,316
in the Late Stage of the Project Life	1,000Rs.	188,632	194,605	194,605	188,632	188,632	188,632	188,632	188,632	188,632
Net Present Value	1,000Rs.	3,245,300	3,310,000	3,356,100	3,270,700	3,311,700	3,340,600	3,304,200	3,330,700	3,363,700

Table G.3.3.6. Diameter & Thickness of Delivery Pipes with Ribs in Each Case

Case	Velocity of Pipeline V (m/s)	Diameter of Pipes D (mm)	Height of Ribs h (cm)	Distance between Ribs l (cm)	Thickness of Pipes t (cm)	Thickness of Ribs t_1 (cm)	Unit Weight of Pipes w (t/m)
A-1	3.5	1 × φ5,200	40.0	100.0	1.9	2.8	4.00
A-2		2 × φ3,600	25.0	100.0	1.9	2.2	2.22
A-3		3 × φ3,000	20.0	100.0	1.9	2.1	1.75
B-1	3.0	1 × φ5,600	40.0	100.0	1.9	3.0	4.42
B-2		2 × φ4,000	30.0	100.0	1.9	2.2	2.59
B-3		3 × φ3,200	25.0	100.0	1.9	1.8	1.90
C-1	2.5	1 × φ6,000	40.0	100.0	1.9	3.4	4.98
C-2		2 × φ4,200	30.0	100.0	1.9	2.3	2.75
C-3		3 × φ3,400	25.0	100.0	1.9	1.9	2.03

Table G.4.1.1 Details of Main Canal Alignment

	TP-NO.	Inter Angle	Radius (m)	Curve Length (m)	STA of B.C.		STA of E.C.	
1	TP- 0	-	-	-	STA	0+000.00	STA	0+000.00
2	TP- 0'	3° 04′ 49″ L	1,000	53.76	STA	0+974.97	STA	1+ 28.73
3	TP- 1	43° 29′ 29″ L	1,000	759.07	STA	1+899.04	STA	2+658.11
4	TP- 2	54° 05′ 39″ R	500	472.06	STA	3+259.98	STA	3+732.04
5	TP- 3	22° 11′ 58″ L	1,000	387.45	STA	5+117.78	STA	5+505.24
6	TP- 4	41° 41′ 00″ R	800	582.01	STA	8+914.91	STA	9+496.92
7	TP- 5	19° 33′ 32″ L	1,000	341.37	STA	13+932.07	STA	14+273.44
8	TP- 6	60° 44′ 24″ L	500	530.06	STA	17+779.01	STA	18+309.07
9	TP- 7	00° 37′ 38″ R	1,000	10.95	STA	24+384.96	STA	24+395.91
10	TP- 8	14° 31′ 36″ L	1,000	253.54	STA	28+469.45	STA	28+722.98
11	TP- 9	39° 22′ 57″ R	500	343.68	STA	33+165.61	STA	33+509.28
12	TP-10	57° 23′ 28″ L	1,000	1001.66	STA	35+964.17	STA	36+965.83
13	TP-11	16° 10′ 42″ R	1,000	282.36	STA	45+746.86	STA	46+ 29.23
14	TP-12	37° 20′ 46″ R	500	325.91	STA	50+424.82	STA	50+750.73
15	TP-13	36° 16′ 40″ L	1,000	633.17	STA	53+840.07	STA	54+473.23
16	TP-14	12° 10′ 41″ L	800	170.04	STA	66+633.04	STA	66+803.08
17	TP-15	36° 07′ 18″ L	1,000	630.44	STA	68+414.05	STA	69+ 44.49
18	TP-16	15° 46′ 00″ R	1,000	275.18	STA	74+257.35	STA	74+532.52
19	TP-17	27° 51′ 53″ R	1,000	486.33	STA	80+921.08	STA	81+407.40
20	TP-18	32° 07′ 37″ L	1,000	560.72	STA	84+777.58	STA	85+338.29
21	TP-19	35° 13′ 18″ L	1,000	614.73	STA	87+893.03	STA	88+507.76
22	TP-20	49° 01′ 49″ R	1,000	855.74	STA	89+ 82.68	STA	89+938.43
23	TP-21	31° 51′ 56″ L	1,000	556.16	STA	93+279.47	STA	93+835.64
24	TP-22	56° 49′ 00″ L	500	495.82	STA	94+784.18	STA	95+280.00
25	TP-23	79° 42′ 03″ R	1,000	1391.04	STA	96+856.90	STA	98+247.94
26	TP-24	22° 27′ 15″ L	1,000	391.90	STA	106+148.80	STA	106+540.76
27	TP-25	26° 32′ 05″ R	1,000	463.12	STA	111+559.59	STA	112+ 22.71
28	EP	-	-	-	STA	113+250.00	STA	113+250.00
Total Length					113.250 Km			

Table G.4.1.2 Location of TP and BM in Main Canal

	Easting X	Northing Y	Elevation (m)
TP-0	3020135.00	876631.11	205.850
TP-0'	3019137.66	876726.19	208.600
TP-1	3017842.69	876779.68	208.430
TP-2	3016896.58	875953.57	207.710
TP-3	3015106.23	876365.86	208.470
TP-4	3011246.45	875738.55	207.200
TP-5	3007064.24	878398.01	208.600
BM	3004614.87	878957.34	210.548
TP-6	3003193.43	879284.07	208.356
BM	3000796.71	876548.15	205.150
BM	2999553.61	875262.53	206.545
TP-7	2998914.32	874557.14	206.881
BM	2997239.03	872579.18	207.956
TP-8	2996057.75	871470.24	206.916
BM	2995141.07	869806.45	205.946
BM	2994004.44	867631.88	203.435
TP-9	2993810.16	867287.98	203.093
TP-10	2990868.18	866077.53	205.992
BM	2990259.78	864404.81	207.494
BM	2989538.22	858719.94	206.632
TP-11	2989183.69	856758.00	205.152
BM	2988536.69	855432.50	203.424
BM	2987515.86	853603.09	204.566
TP-12	2987089.37	852543.41	203.107
TP-13	2983872.71	850958.51	206.740
BM	2982634.34	848596.74	210.670
BM	2981404.58	846216.02	205.260
TP-14	2978068.81	839805.47	203.530
BM	2977694.47	838439.19	206.852
TP-15	2977534.68	837854.87	207.745
TP-16	2979551.76	832547.05	204.346
BM	2979648.70	831701.77	204.300
BM	2979789.64	829789.05	204.392
BM	2979951.25	827932.55	203.953
TP-17	2980136.10	825797.21	200.115
BM	2979392.25	824037.76	200.322
TP-18	2978615.06	822199.35	200.846
BM	2978837.91	820824.77	199.989
TP-19	2979120.86	819079.94	200.104
TP-20	2980064.79	818117.10	200.356
TP-21	2979737.49	814047.67	200.803
TP-22	2980427.11	812709.67	201.376
TP-23	2983094.81	812433.23	197.839
TP-24	2983777.57	803525.33	197.942
TP-25	2986239.44	798659.49	194.428
EP	2986247.07	797213.31	195.500

Table G.4.1.3 Comparison of Station Between Survey and Design

TP. No.	BC/EC	STA. of Survey	STA. of Design
0'	EC-0	0+515.10	1+028.74
1	BC-1	1+383.41	1+899.05
	EC-1	2+183.15	2+658.12
2	BC-2	2+785.02	3+259.98
	EC-2	3+295.58	3+732.05
3	BC-3	4+681.32	5+117.78
	EC-3	5+073.70	5+505.24
4	BC-4	8+483.37	8+914.92
	EC-4	9+092.49	9+496.93
5	BC-5	13+527.64	13+932.07
	EC-5	13+808.49	14+273.44
6	BC-6	17+312.33	17+779.01
	EC-6	17+898.33	18+309.07
7	BC-7	23+975.95	24+386.69
	EC-7	23+986.89	24+397.64
8	BC-8	28+060.43	28+470.54
	EC-8	28+315.33	28+724.08
9	BC-9	32+757.96	33+165.63
	EC-9	33+131.43	33+509.30
10	BC-10	35+586.33	35+964.25
	EC-10	36+681.07	36+965.90
11	BC-11	45+462.11	45+746.95
	EC-11	45+503.13	46+029.31
12	BC-12	49+898.72	50+424.47
	EC-12	50+236.68	50+750.38
13	BC-13	53+326.02	53+839.71
	EC-13	53+981.22	54+472.88
14	BC-14	66+141.03	66+632.75
	EC-14	66+311.71	66+802.79
15	BC-15	67+922.68	68+413.76
	EC-15	68+574.86	69+044.20
16	BC-16	73+786.88	74+256.98
	EC-16	74+065.48	74+533.79
17	BC-17	80+453.19	80+921.50
	EC-17	80+949.35	81+407.84
18	BC-18	84+319.50	84+777.99
	EC-18	84+895.42	85+338.74
19	BC-19	87+450.15	87+893.52
	EC-19	88+084.99	88+508.24
20	BC-20	88+659.93	89+083.14
	EC-20	89+572.01	89+938.87
21	BC-21	92+913.07	93+279.92
	EC-21	93+484.01	93+836.08
22	BC-22	94+432.56	94+785.43
	EC-22	94+973.44	95+281.25
23	BC-23	96+550.34	96+858.13
	EC-23	98+219.66	98+249.17
24	BC-24	106+120.52	106+150.04
	EC-24	106+517.52	106+541.94
25	BC-25	111+536.41	111+560.83
	EC-25	112+007.99	112+023.95

Table G.4.2.1 Design Capacity and Section of Main Canal

STA.	Distance (m)	Escape No.	Distributary No.	Distributary C.C.A (ha)	Distributary Discharge (m3)	Seepage Loss (m3)	Main Canal C.C.A (ha)	Main Canal Discharge (m3)	Main Canal Section No.	Main Canal Slope (1 :)
0+000										
	1,850					0.19	115,600	71.18	1	14,000
1+850			D - 1	1,700	1.72					
	6,000					0.26	113,900	69.27	1	14,000
7+850			D - 2	2,430	2.27					
	5,350					0.19	111,470	66.74	1	14,000
13+200			D - 3	2,390	1.76					
	6,350					0.08	109,080	64.79	1	14,000
19+550			D - 4	1,260	0.66					
	4,950					0.54	107,820	64.05	1	14,000
24+500			D - 5	9,280	4.87					
	5,897					0.59	98,540	58.64	1	14,000
30+397			D - 6	10,150	5.33					
	2,403						88,390	52.72	1	14,000
32+800		E - 1								
	1,900					0.14	88,390	52.72	2	14,000
34+700			D - 7	2,410	1.26					
	6,050					0.42	85,980	51.32	2	14,000
40+750			D - 8	7,060	3.70					
	4,700					0.66	78,920	47.20	2	14,000
45+450			D - 9	11,400	5.98					
	2,300					0.14	67,520	40.56	2	14,000
47+750			D - 10	2,380	1.25					
	2,350					0.15	65,140	39.17	2	14,000
50+100			D - 11	2,660	1.40					
	3,300					0.79	62,480	37.62	2	14,000
53+400			D - 12	13,620	7.15					
	3,150						48,860	29.68	2	14,000
56+550		E - 2								
	1,550					0.37	48,860	29.68	3	9,000
58+100			D - 13	6,240	3.27					
	5,100					0.22	42,620	26.04	3	9,000
63+200			D - 14	3,630	1.90					
	7,000					0.10	38,990	23.92	3	9,000
70+200			D - 15	1,860	0.98					
	3,650					0.35	37,130	22.84	3	9,000
73+850			D - 16	5,910	3.10					
	1,150						31,220	19.39	3	9,000
75+000		E - 3								
	3,150					0.53	31,220	19.39	4	7,000
78+150			D - 17	9,150	4.80					
	7,400					0.15	22,070	14.06	4	7,000
85+550			D - 18	2,560	1.34					
	4,550					0.16	19,510	12.57	4	7,000
90+100			D - 19	2,560	1.34					
	3,050					0.14	16,950	11.07	4	7,000
93+150			D - 20	2,440	1.28					
	1,150						14,510	9.65	4	7,000
94+300		E - 4								
	1,200					0.21	14,510	9.65	5	4,000
95+500			D - 21	3,650	1.92					
	7,400					0.21	10,860	7.52	5	4,000
102+900			D - 22	3,250	1.95					
	5,550					0.07	7,610	5.36	5	4,000
108+450			D - 23	1,180	0.62					
	3,750					0.19	6,430	4.67	5	4,000
112+200			D - 24	2,950	1.67					
	1,050						3,480	2.81	5	4,000
113+250		E - 5								
						0.28	3,480	2.81		
			D - 25	3,480	2.53					

Table G.4.3.1 Section Properties of Main Canal

Section No.	Design Discharge (m3/s)	Roughness Coefficient	Slope (1 :)	Area (m2)	Wetted Perimeter (m)	Water Depth (m)	Base Width (m)	Velocity (m/s)	Freeboard (m)
1	72	0.016	14,000	70.57	26.21	3.94	12.00	1.02	1.21
2	53	0.016	14,000	55.76	23.23	3.53	10.50	0.95	1.22
3	30	0.016	9,000	30.94	17.37	2.60	8.00	0.97	1.20
4	20	0.016	7,000	20.78	14.22	2.14	6.50	0.96	1.06
5	10	0.016	4,000	10.04	9.87	1.49	4.50	1.00	0.91

Note : Canal Side Slope 1 : 1.5

Table G.4.4.1 Head Loss and F.S.L. of Main Canal (1/3)

STA.	Discance (m)	Main Canal Q(m3/s)	X-Reg	X-Drainage No.	X-Drainage Type	Disty No.	Disty Q(m3/s)	Bridge Type	Escape No.	Head Loss Frict (m)	Head Loss Str (m)	Full Supply Level U/S (m)	Full Supply Level D/S (m)	Bed Level U/S (m)	Bed Level D/S (m)
(Section 1/Slope=1:14,000)															
0+000	0	72											209.00		205.06
1+850	1,850	72				D-1	1.72			0.13	0	208.87	208.87	204.93	204.93
3+350	1,500	72						VR-1		0.11	0.03	208.76	208.73	204.82	204.79
3+750	400	72						VR-2		0.03	0.03	208.70	208.67	204.76	204.73
7+850	4,100	72				D-2	2.27			0.29	0	208.38	208.38	204.44	204.44
7+888	38	72	CR-1							0	0.02	208.38	208.36	204.44	204.42
10+100	2,212	72		CD-1	SP					0.16	0.02	208.20	208.18	204.26	204.24
13+200	3,100	72				D-3	1.76			0.22	0	207.96	207.96	204.02	204.02
13+800	600	72						VR-3		0.05	0.03	207.91	208.88	203.97	203.94
15+165	1,365	72						VR-4		0.09	0.03	207.79	207.76	203.85	203.82
16+600	1,435	72						AR-1		0.11	0.05	207.65	207.60	203.71	203.66
19+550	2,950	72				D-4	0.66			0.21	0	207.39	207.39	203.45	203.45
19+588	38	72	CR-2							0	0.02	207.39	207.37	203.45	203.43
21+700	2,112	72		CD-2	C					0.15	0	207.22	207.22	203.28	203.28
23+450	1,750	72						VR-5		0.13	0.03	207.09	207.06	203.15	203.12
24+500	1,050	72				D-5	4.87			0.07	0	206.99	206.99	203.05	203.05
24+538	38	72	CR-3							0	0.02	206.99	206.97	203.05	203.03
30+397	5,859	72				D-6	5.33			0.42	0	207.55	207.55	203.61	202.61
32+800	2,403	72	CR-4						E-1	0.17	0.02	206.38	206.36	202.44	202.42
	32,800						16.61			2.34	0.30				
(Section 2/Slope=1:14,000)															
33+000	200	53		CD-3	C					0.01	0	206.35	206.35	202.82	202.82
34+700	1,700	53				D-7	1.26			0.13	0	206.22	206.22	202.69	202.69
38+100	3,400	53		CD-4	SP					0.24	0.02	205.98	205.96	202.45	202.43
38+465	365	53						DR-1		0.02	0.04	205.94	205.90	202.41	202.37
40+750	2,285	53				D-8	3.7			0.17	0	205.73	205.73	202.20	202.20
40+788	38	53	CR-5							0	0.02	205.73	205.71	202.20	202.18
42+500	1,712	53		CD-5	SP					0.12	0.03	205.59	205.56	202.06	202.03
44+650	2,150	53						VR-6		0.16	0.03	205.40	205.37	201.87	201.84
45+450	800	53				D-9	5.98			0.05	0	205.32	205.32	201.79	201.79
47+475	2,025	53		CD-6	C					0.15	0	205.17	205.17	201.64	201.64

Table G.4.4.1 Head Loss and F.S.L. of Main Canal (2/3)

STA.	Discance	Main Canal	X-Reg	X-Drainage		Disty		Bridge	Escape	Head Loss		Full Supply Level		Bed Level	
	(m)	Q(m3/s)		No.	Type	No.	Q(m3/s)	Type	No.	Frict (m)	Str (m)	U/S (m)	D/S (m)	U/S (m)	D/S (m)
47+750	275	53				D-10	1.25			0.02	0	205.15	205.15	201.62	201.62
47+788	38	53	CR-6							0	0.02	205.15	205.13	201.62	201.60
48+200	412	53						VR-7		0.03	0.03	205.10	205.07	201.57	205.54
49+620	1,420	53		CD-7	C					0.10	0	204.97	204.97	201.44	201.44
50+100	480	53				D-11	1.4			0.04	0	204.93	204.93	201.40	201.40
51+400	1,300	53		CD-8	C					0.09	0	204.84	204.84	201.31	201.31
51+600	200	53						VR-8		0.01	0.03	204.83	204.80	201.30	201.27
53+400	1,800	53				D-12	7.15			0.13	0	204.67	204.67	201.14	201.14
55+550	2,150	53						DR-2		0.16	0.04	204.51	204.47	200.98	200.94
56+550	1,000	53	CR-7						E-1	0.07	0.02	204.40	204.38	200.87	200.85
	23,750						20.74			1.70	0.28				
(Section 3/Slope=1:9,000)															
56+700	150	30		DC-9	SP					0.02	0.04	204.36	204.32	201.76	201.72
58+100	1,400	30				D-13	3.27			0.15	0	204.17	204.17	201.57	201.57
59+400	1,300	30		DC-10	SP					0.15	0.03	204.02	203.99	201.42	201.39
63+200	3,800	30				D-14	1.9			0.42	0	203.57	203.57	200.97	200.97
63+238	38	30	CR-8							0	0.02	203.57	203.55	200.97	200.95
65+710	2,472	30						DR-3		0.28	0.03	203.27	203.24	200.67	200.64
66+950	1,240	30		DC-11	SP					0.14	0.03	203.10	203.07	200.50	200.47
68+100	1,150	30		DC-12	SP					0.12	0.05	202.95	202.90	200.35	200.30
68+730	630	30						DR-4		0.07	0.03	202.83	202.80	200.23	200.20
70+200	1,470	30				D-15	0.98			0.17	0	202.63	203.63	200.03	200.03
70+238	38	30	CR-9							0	0.02	202.63	202.61	200.03	200.01
73+850	3,612	30				D-16	3.1			0.40	0	202.21	202.21	199.61	199.61
74+850	1,000	30						VR-9		0.11	0.03	202.10	202.07	199.50	199.47
75+000	150	30	CR-10						E-3	0.02	0.02	202.05	202.03	199.45	199.43
	18,450						9.25			2.05	0.30				
(Section 4/Slope=1:7,000)															
75+200	200	20		CD-13	SP					0.03	0.06	202.00	201.94	199.86	199.80
77+000	1,800	20						VR-10		0.26	0.03	201.68	201.65	199.54	199.51
78+150	1,150	20				D-17	4.8			0.16	0	201.49	201.49	199.35	199.35

Table G.4.4.1 Head Loss and F.S.L. of Main Canal (3/3)

STA.	Discance	Main Canal	X-Reg	X-Drainage		Disty		Bridge	Escape	Head Loss		Full Supply Level		Bed Level	
	(m)	Q(m3/s)		No.	Type	No.	Q(m3/s)	Type	No.	Frict (m)	Str (m)	U/S (m)	D/S (m)	U/S (m)	D/S (m)
78+188	38	20	CR-11							0.01	0.02	201.48	201.46	199.34	199.32
82+000	3,812	20						VR-11		0.54	0.03	200.92	200.89	198.78	198.75
82+350	350	20		CD-14	C					0.05	0	200.84	200.84	198.70	198.70
85+550	3,200	20				D-18	1.34			0.46	0	200.38	200.38	198.24	198.24
85+588	38	20	CR-12							0	0.02	200.38	200.36	198.24	198.22
88+600	3,012	20		CD-15	C					0.43	0	199.93	199.93	197.79	197.79
90+100	1,500	20				C-19	1.34			0.22	0	199.71	199.71	197.57	197.57
90+138	38	20	CR-13							0	0.02	199.71	199.69	197.57	197.55
90+500	362	20		CD-16	C					0.05	0	199.64	199.64	197.50	197.50
93+150	2,650	20				C-20	1.28			0.38	0	199.26	199.26	197.12	197.12
94+300	1,150	20	CR-14						E-4	0.17	0.02	199.09	199.07	196.95	196.93
	19,300						8.76			2.76	0.20				
(Section 5/Slope=1:4,000)															
94+550	250	10		CD-17	SP					0.06	0.03	199.01	199.98	197.52	197.49
95+500	950	10				D-21	1.92			0.24	0	198.74	198.74	197.25	197.25
95+532	32	10	CR-15							0.01	0.02	198.73	198.71	197.24	197.22
100+900	5,368	10						VR-12		1.32	0	197.37	197.37	195.88	195.88
102+900	2,000	10				D-22	1.95			0.50	0	196.87	196.87	195.38	195.38
102+932	32	10	CR-16							0.01	0.02	196.86	196.84	195.37	195.35
105+620	2,688	10		CD-18	C					0.67	0	196.17	196.17	194.68	194.68
108+450	2,830	10				D-23	0.62			0.71	0	195.46	195.46	193.97	193.97
108+482	32	10	CR-17							0.01	0.02	195.45	195.43	193.96	193.94
110+100	1,618	10		CD-19	C					0.40	0	195.03	195.03	193.54	193.54
112+200	2,100	10				D-24	1.67			0.53	0	194.50	194.50	193.01	193.01
113+250	1,050	10	CR-18						E-5	0.26	0.02	194.24	194.22	192.75	192.73
	18,950						6.16			4.72	0.11				
						25	2.53								

Table G.4.5.1 Location and Gate Size of Cross Regulator in Main Canal

CR-No.	STA.	Main Canal		Gate of Cross Regulator			
		Discharge (m3/s)	Section No.	Type	Span (m)	Height (m)	Nos.
CR-1	7+888						
CR-2	19+588	72	1	Roller Gate With Counter Weight	8	4.1	2
CR-3	24+538						
CR-4	32+800						
CR-5	40+788						
CR-6	47+788	53	2	Roller Gate With Counter Weight	7	3.7	2
CR-7	56+550						
CR-8	63+238						
CR-9	70+238	30	3	Roller Gate With Counter Weight	6	2.8	2
CR-10	75+000						
CR-11	78+188						
CR-12	85+588	20	4	Roller Gate With Counter Weight	5	2.3	2
CR-13	90+138						
CR-14	94+300						
CR-15	95+532						
CR-16	102+932	10	5	Roller Gate With Counter Weight	6	1.7	1
CR-17	108+482						
CR-18	113+250						

(Note) CR: Cross Regulator

Table G.4.5.2 Location and Discharge of Cross Drainage in Main Canal

CD-No.	STA.	Main Canal		Cross Drainage		
		Discharge (m3/s)	Section No.	Type	Nala	Discharge (m3/s)
CD-1	10+100	72	1	SP	Paniala	306
CD-2	21+700	72	1	C	Nose	1048
CD-3	33+000	53	2	C	Budh	722
CD-4	38+100	53	2	SP	Takawala	142
CD-5	42+500	53	2	SP	Gumal	558
CD-6	47+475	53	2	C	Shahid	198
CD-7	49+620	53	2	C	Rada	71
CD-8	51+400	53	2	C	Bhuar	156
CD-9	56+700	30	3	SP	Luni	912
CD-10	59+400	30	3	SP	Swan	538
CD-11	66+950	30	3	SP	Rod Kohi	487
CD-12	68+100	30	3	SP	Toe	977
CD-13	75+200	20	4	SP	Mochiwal	1243
CD-14	82+350	20	4	C	Ali Garah	82
CD-15	88+600	20	4	C	Bhcda	212
CD-16	90+500	20	4	C	Rod Kohi	161
CD-17	94+550	10	5	SP	Gajistan	295
CD-18	105+620	10	5	C	Sheranna	411
CD-19	110+100	10	5	C	Ramak Div.	49

(Note) CD: Cross Drainage
SP: Culvert Super Passage
C: Nala Culvert

Table G.4.5.3 Location and Discharge of Escape in Main Canal

E-No.	STA.	Main Canal		Escape Structure	
		Discharge (m3/s)	SectionNo.	Discharge (m3/s)	Connecting Nala
E-1	32+800	72	1	72	Budh
E-2	56+550	53	2	53	Luni
E-3	75+000	30	3	30	Mochiwal
E-4	94+300	20	4	20	Gajistan
E-5	113+250	10	5	10	Ramak

(Note) E: Escape Structure

Table G.4.5.4 Section and Head Loss of Head Regulator

	HEAD REGULATOR					Main Canal		Head Loss					Distributary				
	No. of Barrels	Unit Discharge (m3/s)	Width B (m)	Height H (m)	Bed Level (m)	F.S.L. (m)	C.W.L. (m)	Length (m)	Frict. (m)	Exit/En (m)	Transsi (m)	Total (m)	F.S.L. (m)	Bed Level (m)	Water Depth (m)	Slope (1:)	N.S.L. (m)
D- 1 (Q= 1.72 m3/s)	1	1.72	1.35	0.90	207.10	208.87	208.38	15	0.05	0.15	0.01	0.21	208.17	207.28	0.89	2,000	208.10
D- 2 (Q= 2.27 m3/s)	2	1.14	1.35	0.90	207.3	208.38	208.38	15	0.02	0.07	0.00	0.09	208.29	207.25	1.04	2,000	208.50
D- 3 (Q= 1.76 m3/s)	1	1.76	1.35	0.90	206.10	207.96	207.39	15	0.05	0.16	0.01	0.22	207.17	206.28	0.89	2,000	208.10
D- 4 (Q= 0.66 m3/s)	1	0.66	1.35	0.90	206.40	207.39	207.39	15	0.01	0.02	0.01	0.04	207.35	206.74	0.61	1,000	205.25
D- 5 (Q= 4.87 m3/s)	4	1.22	1.35	0.90	205.90	206.99	206.99	15	0.02	0.08	0.00	0.10	206.89	205.53	1.36	3,000	206.60
D- 6 (Q= 5.33 m3/s)	4	1.33	1.35	0.90	205.30	206.55	206.38	15	0.03	0.09	0.00	0.12	206.26	204.76	1.50	3,500	205.60
D- 7 (Q= 1.26 m3/s)	1	1.26	1.35	0.90	204.60	206.22	205.73	15	0.02	0.08	0.00	0.10	205.63	204.87	0.76	1,500	204.00
D- 8 (Q= 3.70 m3/s)	3	1.23	1.35	0.90	204.60	205.73	205.73	15	0.02	0.08	0.00	0.10	205.63	204.43	1.20	2,500	207.00
D- 9 (Q= 5.98 m3/s)	4	1.50	1.35	0.90	204.00	205.32	205.15	15	0.03	0.12	0.00	0.15	205.00	203.50	1.50	3,500	205.65
D-10 (Q= 1.25 m3/s)	1	1.25	1.35	0.90	204.10	205.15	205.15	15	0.02	0.08	0.01	0.11	205.04	204.28	0.76	1,500	203.00
D-11 (Q= 1.40 m3/s)	1	1.40	1.35	0.90	203.30	204.93	204.40	15	0.03	0.10	0.01	0.14	204.26	203.50	0.76	1,500	203.45
D-12 (Q= 7.15 m3/s)	5	1.43	1.35	0.90	203.20	204.67	204.40	15	0.03	0.11	0.00	0.14	204.26	202.55	1.71	4,000	205.24
D-13 (Q= 3.27 m3/s)	2	1.64	1.35	0.90	202.40	204.17	203.57	15	0.04	0.14	0.00	0.18	203.39	202.19	1.20	2,500	207.30
D-14 (Q= 1.90 m3/s)	2	0.95	1.35	0.90	202.50	203.57	203.57	15	0.01	0.05	0.00	0.06	203.51	202.62	0.89	2,000	204.10
D-15 (Q= 0.98 m3/s)	1	0.98	1.35	0.90	201.60	202.63	202.63	15	0.01	0.05	0.01	0.07	202.56	201.95	0.61	1,000	203.90
D-16 (Q= 3.10 m3/s)	2	1.55	1.35	0.90	200.90	202.21	202.05	15	0.04	0.12	0.00	0.16	201.89	200.69	1.20	2,500	204.70
D-17 (Q= 4.80 m3/s)	3	1.60	1.35	0.90	200.30	201.49	201.48	15	0.04	0.13	0.00	0.17	201.31	199.95	1.36	3,000	203.60
D-18 (Q= 1.34 m3/s)	1	1.34	1.35	0.90	200.30	201.38	201.38	15	0.03	0.09	0.01	0.13	201.25	200.49	0.76	1,500	200.80
D-19 (Q= 1.34 m3/s)	1	1.34	1.35	0.90	198.60	199.71	199.71	15	0.03	0.09	0.01	0.13	199.58	198.82	0.76	1,500	200.50
D-20 (Q= 1.28 m3/s)	1	1.28	1.35	0.90	198.00	199.26	199.09	15	0.03	0.08	0.00	0.11	198.98	198.22	0.76	1,500	200.10
D-21 (Q= 1.92 m3/s)	2	0.96	1.35	0.90	197.70	198.74	198.73	15	0.01	0.05	0.00	0.06	198.67	197.78	0.89	2,000	199.80
D-22 (Q= 1.95 m3/s)	2	0.98	1.35	0.90	195.80	196.87	196.86	15	0.01	0.05	0.00	0.06	196.80	195.91	0.89	2,000	196.70
D-23 (Q= 0.62 m3/s)	1	0.62	1.35	0.90	194.50	195.46	195.45	15	0.01	0.02	0.01	0.04	195.41	194.88	0.53	1,000	196.45
D-24 (Q= 1.67 m3/s)	1	1.67	1.35	0.90	193.00	194.50	194.24	15	0.04	0.14	0.01	0.19	194.05	193.16	0.89	2,000	194.60

Table G.4.5.5 Location and Type of Bridge in Main Canal

No.	STA.	Main Canal		Road Type	Remarks
		Discharge (m3/s)	Section No.		
VR-1	3+350	72	1	Village Road	
VR-2	3+750	72	1	Village Road	
VR-3	13+800	72	1	Village Road	
VR-4	15+165	72	1	Village Road	
AR-1	16+600	72	1	Arterial Road	Bannu Road
VR-5	23+450	72	1	Village Road	
FP-1	28+670	72	1	Foot Path	
FP-2	35+450	53	2	Foot Path	
DR-1	38+665	53	2	District Road	Tank Road
VR-6	44+650	53	2	Village Road	
VR-7	48+200	53	2	Village Road	
VR-8	51+600	53	2	Village Road	
DR-2	55+550	53	2	District Road	Kulachi Road
DR-3	65+610	30	3	District Road	Daraban Road
DR-4	68+730	30	3	District Road	Daraban Road
VR-9	74+850	30	3	Village Road	
VR-10	77+000	20	4	Village Road	
VR-11	82+000	20	4	Village Road	
FP-3	98+220	10	5	Foot Path	
VR-12	100+900	10	5	Village Road	
FP-4	105+710	10	5	Foot Path	

Table G.5.1.1 C.C.A and Discharge of Each Distributary

Disty No.	Name of Disty	G.C.A. (ha)	C.C.A. Good & Mod (ha)	C.C.A. Margi. (ha)	C.C.A. Total (ha)	Discharge (m3/s)
D- 1	SAKHI MARDAN	1,930	0	1,700	1,700	1.72
D- 2	UMAR KHAN WANDA	2,770	400	2,030	2,430	2.27
D- 3	YARIK (1)	2,740	1,350	1,040	2,390	1.76
D- 4	YARIK (2)	1,480	1,260	0	1,260	0.66
D- 5	RODI KHEL	10,470	9,280	0	9,280	4.87
D- 6	REHMAN DHERI	11,470	10,150	0	10,150	5.33
D- 7	BUDH	2,720	2,410	0	2,410	1.26
D- 8	KOT ISA KHAN	8,090	7,060	0	7,060	3.70
D- 9	POTAH	13,430	11,400	0	11,400	5.98
D-10	SHAHID	3,130	2,380	0	2,380	1.25
D-11	SIKANDAR	3,120	2,660	0	2,660	1.40
D-12	MADDI	15,510	13,620	0	13,620	7.15
D-13	KOT ZAFAR	7,500	6,240	0	6,240	3.27
D-14	SWAN	4,470	3,630	0	3,630	1.90
D-15	GANDI ASHIQ	2,300	1,860	0	1,860	0.98
D-16	MOCHIWAL	6,900	5,910	0	5,910	3.10
D-17	GARAH ISA KHAN	11,000	9,150	0	9,150	4.80
D-18	ALI GARAH	3,010	2,560	0	2,560	1.34
D-19	BABRAN	3,060	2,560	0	2,560	1.34
D-20	GAJISTAN	2,800	2,440	0	2,440	1.28
D-21	KAURI HOT	4,110	3,650	0	3,650	1.92
D-22	SHAH GHARBI	3,760	2,750	500	3,250	1.95
D-23	SHERANNA	1,440	1,180	0	1,180	0.62
D-24	CHIRRI BHUHAR	3,370	2,700	250	2,950	1.67
D-25	JHANGI	4,020	2,040	1,440	3,480	2.53

(Note) C.C.A.(1) : Good & Moderate irrigable land (Ordinary Land)
C.C.A.(2) : Marginal irrigable land (Sandy Land)

Table G.5.2.1 Sump Well Area of Each Distributary

(Unit : ha)

Disty No.	Gross Irrigable Area (G.I.A.) (1)	Cultivable Command Area (C.C.A.) (2)	Sump Well Area G.I.A. (3)	Sump Well Area C.C.A. (4)	Gravity Area G.I.A. (5)	Gravity Area C.C.A. (6)
D - 1	1,850	1,700	0	0	1,850	1,700
D - 2	2,640	2,430	0	0	2,640	2,430
D - 3	2,600	2,390	50	50	2,550	2,340
D - 4	1,370	1,260	0	0	1,370	1,260
D - 5	10,090	9,280	0	0	10,090	9,280
D - 6	11,030	10,150	150	140	10,880	10,010
D - 7	2,620	2,410	130	120	2,490	2,290
D - 8	7,680	7,060	270	250	7,410	6,810
D - 9	12,390	11,400	0	0	12,390	11,400
D - 10	2,590	2,380	0	0	2,590	2,380
D - 11	2,900	2,660	0	0	2,900	2,660
D - 12	14,800	13,620	630	580	14,170	13,040
D - 13	6,780	6,240	900	830	5,880	5,410
D - 14	3,950	3,630	280	260	3,670	3,370
D - 15	2,020	1,860	390	360	1,630	1,500
D - 16	6,430	5,910	280	260	6,150	5,650
D - 17	9,950	9,150	360	330	9,590	8,820
D - 18	2,790	2,560	0	0	2,790	2,560
D - 19	2,780	2,560	0	0	2,780	2,560
D - 20	2,650	2,440	50	50	2,600	2,390
D - 21	3,970	3,650	200	180	3,770	3,470
D - 22	3,530	3,250	0	0	3,530	3,250
D - 23	1,290	1,180	200	180	1,090	1,000
D - 24	3,210	2,950	80	70	3,130	2,880
D - 25	3,790	3,480	0	0	3,790	3,480
Total	125,700	115,600	3,970	3,660	121,730	111,940

(Note) : (1)=(3)+(5)
: (2)=(4)+(6)=(1)*0.92
: (4)=(3)*0.92
: (6)=(5)*0.92

Table G.5.3.1 Standard Section Properties for Distributary (1/3)

SLOPE OF 1 : 500

Distributary Range Q (m3/s)	Design Q (m3/s)	Area (m2)	Section Properties - Manning n=0.016 Wetted Perimeter (m)	Depth (m)	Base Width (m)	Velocity (m/s)	Freeboard (m)
0.00 - 0.25	0.250	0.29	1.57	0.31	0.45	0.91	0.49
0.25 - 0.50	0.500	0.48	2.02	0.41	0.55	1.07	0.49
0.50 - 0.75	0.750	0.65	2.36	0.47	0.65	1.18	0.53
0.75 - 1.00	1.000	0.80	2.62	0.53	0.70	1.27	0.52
1.00 - 1.50	1.500	1.08	3.05	0.61	0.85	1.40	0.54
1.50 - 2.00	2.000	1.34	3.39	0.69	0.90	1.51	0.56
2.00 - 3.00	3.000	1.81	3.95	0.80	1.05	1.66	0.60
3.00 - 4.00	4.000	2.25	4.40	0.89	1.20	1.79	0.61
4.00 - 5.00	5.000	2.66	4.78	0.97	1.30	1.89	0.63
5.00 - 6.00	6.000	3.04	5.11	1.04	1.35	1.98	0.66
6.00 - 7.00	7.000	3.42	5.42	1.10	1.45	2.06	0.70
7.00 - 8.00	8.000	3.78	5.70	1.15	1.55	2.13	0.70

(*)Canal Side Slope : 1 : 1.5

SLOPE OF 1 : 750

Distributary Range Q (m3/s)	Design Q (m3/s)	Area (m2)	Section Properties - Manning n=0.016 Wetted Perimeter (m)	Depth (m)	Base Width (m)	Velocity (m/s)	Freeboard (m)
0.00 - 0.25	0.250	0.33	1.68	0.34	0.45	0.77	0.46
0.25 - 0.50	0.500	0.55	2.19	0.44	0.60	0.91	0.46
0.50 - 0.75	0.750	0.75	2.54	0.51	0.70	1.01	0.49
0.75 - 1.00	1.000	0.93	2.82	0.58	0.75	1.09	0.52
1.00 - 1.50	1.500	1.25	3.28	0.66	0.90	1.20	0.54
1.50 - 2.00	2.000	1.56	3.66	0.74	1.00	1.29	0.56
2.00 - 3.00	3.000	2.11	4.26	0.86	1.15	1.43	0.59
3.00 - 4.00	4.000	2.61	4.74	0.95	1.30	1.53	0.60
4.00 - 5.00	5.000	3.09	5.16	1.04	1.40	1.62	0.61
5.00 - 6.00	6.000	3.54	5.52	1.12	1.50	1.70	0.63
6.00 - 7.00	7.000	3.97	5.84	1.19	1.55	1.76	0.66
7.00 - 8.00	8.000	4.39	6.15	1.25	1.65	1.82	0.65

(*)Canal Side Slope : 1 : 1.5

SLOPE OF 1 : 1,000

Distributary Range Q (m3/s)	Design Q (m3/s)	Area (m2)	Section Properties - Manning n=0.016 Wetted Perimeter (m)	Depth (m)	Base Width (m)	Velocity (m/s)	Freeboard (m)
0.00 - 0.25	0.250	0.37	1.78	0.36	0.50	0.69	0.44
0.25 - 0.50	0.500	0.62	2.31	0.46	0.65	0.82	0.49
0.50 - 0.75	0.750	0.83	2.67	0.53	0.75	0.91	0.47
0.75 - 1.00	1.000	1.03	2.98	0.61	0.80	0.97	0.49
1.00 - 1.50	1.500	1.40	3.47	0.70	0.95	1.08	0.50
1.50 - 2.00	2.000	1.73	3.86	0.78	1.05	1.16	0.52
2.00 - 3.00	3.000	2.35	4.49	0.91	1.20	1.28	0.54
3.00 - 4.00	4.000	2.91	5.00	1.01	1.35	1.38	0.59
4.00 - 5.00	5.000	3.44	5.44	1.11	1.45	1.46	0.59
5.00 - 6.00	6.000	3.94	5.82	1.18	1.55	1.52	0.62
6.00 - 7.00	7.000	4.42	6.16	1.25	1.65	1.58	0.60
7.00 - 8.00	8.000	4.89	6.49	1.31	1.75	1.64	0.64

(*)Canal Side Slope : 1 : 1.5

Table G.5.3.1 Standard Section Properties for Distributary (2/3)

SLOPE OF 1 : 1,500

Distributary Range Q (m3/s)	Design Q (m3/s)	Area (m2)	Section Properties - Manning n=0.016 Wetted Perimeter (m)	Depth (m)	Base Width (m)	Velocity (m/s)	Freeboard (m)
0.00 - 0.25	0.250	0.43	1.92	0.38	0.55	0.60	0.47
0.25 - 0.50	0.500	0.72	2.49	0.50	0.70	0.71	0.45
0.50 - 0.75	0.750	0.97	2.89	0.58	0.80	0.78	0.47
0.75 - 1.00	1.000	1.20	3.21	0.65	0.85	0.84	0.50
1.00 - 1.50	1.500	1.63	3.74	0.76	1.00	0.93	0.49
1.50 - 2.00	2.000	2.01	4.15	0.85	1.10	1.00	0.50
2.00 - 3.00	3.000	2.73	4.84	0.98	1.30	1.10	0.52
3.00 - 4.00	4.000	3.39	5.40	1.10	1.45	1.18	0.55
4.00 - 5.00	5.000	4.00	5.86	1.20	1.55	1.25	0.55
5.00 - 6.00	6.000	4.59	6.29	1.27	1.70	1.31	0.58
6.00 - 7.00	7.000	5.15	6.66	1.35	1.80	1.36	0.60
7.00 - 8.00	8.000	5.69	6.99	1.43	1.85	1.41	0.57

(*)Canal Side Slope : 1 : 1.5

SLOPE OF 1 : 2,000

Distributary Range Q (m3/s)	Design Q (m3/s)	Area (m2)	Section Properties - Manning n=0.016 Wetted Perimeter (m)	Depth (m)	Base Width (m)	Velocity (m/s)	Freeboard (m)
0.00 - 0.25	0.250	0.48	2.02	0.41	0.55	0.54	0.44
0.25 - 0.50	0.500	0.80	2.62	0.53	0.70	0.63	0.47
0.50 - 0.75	0.750	1.08	3.05	0.61	0.85	0.70	0.49
0.75 - 1.00	1.000	1.34	3.39	0.69	0.90	0.75	0.46
1.00 - 1.50	1.500	1.81	3.94	0.80	1.05	0.83	0.50
1.50 - 2.00	2.000	2.25	4.40	0.89	1.20	0.89	0.51
2.00 - 3.00	3.000	3.04	5.11	1.04	1.35	0.99	0.51
3.00 - 4.00	4.000	3.77	5.70	1.15	1.55	1.06	0.55
4.00 - 5.00	5.000	4.46	6.19	1.26	1.65	1.12	0.54
5.00 - 6.00	6.000	5.12	6.64	1.34	1.80	1.18	0.56
6.00 - 7.00	7.000	5.74	7.03	1.42	1.90	1.22	0.58
7.00 - 8.00	8.000	6.34	7.39	1.49	2.00	1.26	0.56

(*)Canal Side Slope : 1 : 1.5

SLOPE OF 1 : 2,500

Distributary Range Q (m3/s)	Design Q (m3/s)	Area (m2)	Section Properties - Manning n=0.016 Wetted Perimeter (m)	Depth (m)	Base Width (m)	Velocity (m/s)	Freeboard (m)
0.00 - 0.25	0.250	0.52	2.11	0.42	0.60	0.49	0.43
0.25 - 0.50	0.500	0.87	2.73	0.55	0.75	0.58	0.45
0.50 - 0.75	0.750	1.17	3.17	0.64	0.85	0.64	0.46
0.75 - 1.00	1.000	1.45	3.53	0.72	0.95	0.69	0.48
1.00 - 1.50	1.500	1.97	4.12	0.84	1.10	0.76	0.51
1.50 - 2.00	2.000	2.44	4.58	0.92	1.25	0.82	0.48
2.00 - 3.00	3.000	3.31	5.34	1.08	1.45	0.91	0.52
3.00 - 4.00	4.000	4.10	5.94	1.20	1.60	0.98	0.55
4.00 - 5.00	5.000	4.85	6.46	1.31	1.75	1.03	0.54
5.00 - 6.00	6.000	5.56	6.92	1.41	1.85	1.08	0.54
6.00 - 7.00	7.000	6.24	7.32	1.49	1.95	1.12	0.56
7.00 - 8.00	8.000	6.90	7.70	1.57	2.05	1.16	0.58

(*)Canal Side Slope : 1 : 1.5

Table G.5.3.1 Standard Section Properties for Distributary (3/3)

SLOPE OF 1 : 3,000

Distributary Range Q (m3/s)	Design Q (m3/s)	Area (m2)	Section Properties - Manning n=0.016 Wetted Perimeter (m)	Depth (m)	Base Width (m)	Velocity (m/s)	Freeboard (m)
0.00 - 0.25	0.250	0.55	2.19	0.44	0.60	0.45	0.46
0.25 - 0.50	0.500	0.93	2.82	0.58	0.75	0.54	0.47
0.50 - 0.75	0.750	1.25	3.28	0.66	0.90	0.60	0.49
0.75 - 1.00	1.000	1.56	3.66	0.74	1.00	0.65	0.46
1.00 - 1.50	1.500	2.11	4.26	0.86	1.15	0.71	0.49
1.50 - 2.00	2.000	2.61	4.74	0.95	1.30	0.77	0.50
2.00 - 3.00	3.000	3.54	5.52	1.12	1.50	0.85	0.53
3.00 - 4.00	4.000	4.39	6.15	1.25	1.65	0.91	0.50
4.00 - 5.00	5.000	5.19	6.69	1.36	1.80	0.96	0.54
5.00 - 6.00	6.000	5.95	7.15	1.46	1.90	1.01	0.54
6.00 - 7.00	7.000	6.68	7.58	1.54	2.05	1.05	0.56
7.00 - 8.00	8.000	7.38	7.97	1.62	2.15	1.08	0.58

(*)Canal Side Slope : 1 : 1.5

SLOPE OF 1 : 3,500

Distributary Range Q (m3/s)	Design Q (m3/s)	Area (m2)	Section Properties - Manning n=0.016 Wetted Perimeter (m)	Depth (m)	Base Width (m)	Velocity (m/s)	Freeboard (m)
0.00 - 0.25	0.250	0.58	2.23	0.45	0.60	0.43	0.45
0.25 - 0.50	0.500	0.98	2.90	0.58	0.80	0.51	0.47
0.50 - 0.75	0.750	1.33	3.38	0.69	0.90	0.57	0.46
0.75 - 1.00	1.000	1.65	3.76	0.77	1.00	0.61	0.48
1.00 - 1.50	1.500	2.23	4.38	0.88	1.20	0.67	0.47
1.50 - 2.00	2.000	2.77	4.88	0.99	1.30	0.72	0.51
2.00 - 3.00	3.000	3.75	5.69	1.15	1.55	0.80	0.50
3.00 - 4.00	4.000	4.66	6.33	1.28	1.70	0.86	0.52
4.00 - 5.00	5.000	5.50	6.88	1.40	1.85	0.91	0.55
5.00 - 6.00	6.000	6.30	7.36	1.50	1.95	0.95	0.55
6.00 - 7.00	7.000	7.08	7.80	1.58	2.10	0.99	0.57
7.00 - 8.00	8.000	7.82	8.20	1.67	2.20	1.02	0.58

(*)Canal Side Slope : 1 : 1.5

SLOPE OF 1 : 4,000

Distributary Range Q (m3/s)	Design Q (m3/s)	Area (m2)	Section Properties - Manning n=0.016 Wetted Perimeter (m)	Depth (m)	Base Width (m)	Velocity (m/s)	Freeboard (m)
0.00 - 0.25	0.250	0.62	2.31	0.46	0.65	0.41	0.44
0.25 - 0.50	0.500	1.03	2.97	0.60	0.80	0.49	0.45
0.50 - 0.75	0.750	1.40	3.47	0.70	0.95	0.54	0.45
0.75 - 1.00	1.000	1.73	3.86	0.78	1.05	0.58	0.47
1.00 - 1.50	1.500	2.35	4.49	0.91	1.20	0.64	0.49
1.50 - 2.00	2.000	2.91	5.00	1.01	1.35	0.69	0.49
2.00 - 3.00	3.000	3.94	5.82	1.18	1.55	0.76	0.52
3.00 - 4.00	4.000	4.89	6.49	1.31	1.75	0.82	0.54
4.00 - 5.00	5.000	5.79	7.06	1.43	1.90	0.87	0.52
5.00 - 6.00	6.000	6.63	7.55	1.54	2.00	0.91	0.56
6.00 - 7.00	7.000	7.44	8.00	1.62	2.15	0.94	0.53
7.00 - 8.00	8.000	8.22	8.41	1.71	2.25	0.97	0.54

(*)Canal Side Slope : 1 : 1.5

Table G.5.3.2 Hydraulic Design of Distributary No. 6 (1/2)

Name of Miner and Mogha	STA.	Gross Irrigable Area (G.I.A.) (ha)	Cultivable Command Area (C.C.A.) (ha)	Discharge		Remarks
				Mogha (m3/s)	Disty (m3/s)	
B.P.	0+000				5.330	
Sump Well		148	136	0.072	5.258	
1R	0+050	174	160	0.084	5.174	
M-1	0+720	504	464	0.244	4.930	1L-4L
2R	0+720	174	160	0.084	4.846	
3R	1+320	174	160	0.084	4.762	
5L	2+180	174	160	0.084	4.678	
M-2	2+180	870	800	0.420	4.258	4R-8R
6L	2+640	174	160	0.084	4.174	
7L	3+200	174	160	0.084	4.090	
8L	3+680	174	160	0.084	4.006	
9L	4+140	170	157	0.082	3.924	
9R	4+140	142	131	0.069	3.855	
10L	4+600	174	160	0.084	3.771	
11L	4+920	174	160	0.084	3.687	
12L	5+450	174	160	0.084	3.603	
10R	5+450	174	160	0.084	3.519	
11R	5+680	174	160	0.084	3.435	
13L	6+150	174	160	0.084	3.351	
12R	6+150	174	160	0.084	3.267	
14L	6+640	174	160	0.084	3.183	
13R	6+640	174	160	0.084	3.099	
14R	7+100	174	160	0.084	3.015	
15L	7+590	114	105	0.055	2.960	
15R	7+590	174	160	0.084	2.876	
16L	8+070	174	160	0.084	2.792	
16R	8+070	174	160	0.084	2.708	
17L	8+570	174	160	0.084	2.624	
17R	8+570	169	156	0.082	2.542	
18L	9+070	149	138	0.073	2.469	
18R	9+070	174	160	0.084	2.385	
19L	9+510	174	160	0.084	2.301	
19R	9+510	174	160	0.084	2.217	
20L	9+850	149	138	0.073	2.144	
20R	9+850	174	160	0.084	2.060	
21L	10+260	174	160	0.084	1.976	
21R	10+260	174	160	0.084	1.892	
22L	10+708	174	160	0.084	1.808	
22R	10+708	174	160	0.084	1.724	
M-3	10+708	3,005	2765	1.452	0.272	23L-30L,28R-37R
M-4	10+708	564	520	0.272	0	23R-27R
		11,030	10,150	5.330		

Table G.5.3.2 Hydraulic Design of Distributary No. 6 (2/2)

Name of Miner and Mogha	STA.	Gross Irrigable Area (G.I.A.) (ha)	Cultivable Command Area (C.C.A.) (ha)	Discharge Mogha (m3/s)	Discharge Disty (m3/s)	Remarks
(M-1)					0.244	
1L	0+020	126	116	0.061	0.183	
2L	1+550	126	116	0.061	0.122	
3L	2+770	126	116	0.061	0.061	
4L	3+800	126	116	0.061	0.000	
(M-2)					0.420	
4R	0+020	174	160	0.084	0.336	
5R	1+000	174	160	0.084	0.252	
6R	1+450	174	160	0.084	0.168	
7R	3+100	174	160	0.084	0.084	
8R	3+100	174	160	0.084	0.000	
(M-3)					1.452	
23L	0+600	174	160	0.084	1.368	
24L	1+200	140	129	0.068	1.300	
28R	1+200	174	160	0.084	1.216	
25L	1+700	153	141	0.074	1.142	
29R	1+700	174	160	0.084	1.058	
26L	2+260	174	160	0.084	0.974	
30R	2+260	174	160	0.084	0.890	
31R	2+780	174	160	0.084	0.806	
27L	3+270	149	138	0.073	0.733	
32R	3+270	174	160	0.084	0.649	
28L	4+030	174	160	0.084	0.565	
33R	4+030	174	160	0.084	0.481	
29L	4+800	174	160	0.084	0.397	
34R	4+800	174	160	0.084	0.313	
35R	5+620	174	160	0.084	0.229	
30L	6+540	127	117	0.061	0.168	
36R	6+540	174	160	0.084	0.084	
37R	7+360	174	160	0.084	0.000	
(M-4)					0.272	
23R	0+020	174	160	0.084	0.188	
24R	0+800	95	88	0.046	0.142	
25R	1+440	95	88	0.046	0.096	
26R	3+150	100	92	0.048	0.048	
27R	5+350	100	92	0.048	0.000	

Table G.5.3.3 Hydraulic Design of Distributary No. 18

Name of Miner and Mogha	STA.	Gross Irrigable Area (G.I.A.) (ha)	Cultivable Command Area (C.C.A.) (ha)	Discharge		Remarks
				Mogha (m3/s)	Disty (m3/s)	
B.P.	0+000				1.340	
1R	0+400	174	160	0.084	1.256	
1L	0+400	136	125	0.065	1.191	
2R	1+050	174	160	0.084	1.107	
2L	1+050	123	113	0.059	1.048	
3R	1+650	174	160	0.084	0.964	
3L	1+650	135	124	0.065	0.899	
4R	2+250	174	160	0.084	0.815	
4L	2+250	131	120	0.063	0.752	
5R	2+850	174	160	0.084	0.668	
5L	2+850	125	114	0.059	0.609	
6R	3+450	174	160	0.084	0.525	
6L	3+450	137	125	0.065	0.460	
7R	4+220	174	160	0.084	0.376	
7L	4+220	151	138	0.072	0.304	
8R	5+000	174	160	0.084	0.220	
8L	5+000	141	129	0.067	0.153	
9R	5+880	170	156	0.082	0.071	
9L	5+880	149	136	0.071	0.000	
		2,790	2,560	1.340		

Table G.5.3.4 Outline of Model Command Areas of Distributary No. 6 & No. 18 and Irrigation Facilities

Item		D-6	D-18
1. Gross Command Area (G.C.A).	(ha)	11,470	3,010
2. Gross Irrigable Area (G.I.A.)	(ha)	11,030	2,790
3. Cultivable Command Area (C.C.A)	(ha)	10,150	2,560
4. Discharge	(m^3/s)	5.33	1.34
5. Structures			
a. Length of Distributary	(km)	10.707	7.680
b. Length of Minor	(km)	20.85	-
c. Head Regulator for Minor	(nos.)	3	-
d. Mogha	(nos.)	37	18
e. Fall with V.R. Bridge (Drop Structures)			
Type - I	(nos.)	3	-
Type - II	(nos.)	4	-
Type - III	(nos.)	2	5
f. Side Spillway	(nos.)	3	-
g. Culvert Road Bridge	(nos.)	3	1
h. Village Road Bridge	(nos.)	1	-
i. Tail Cluster	(nos.)	4	1

Table G.6.2.1 Capacity and Size of Regulating Pond in Distributary

Distributary	Capacity			Size
	Dead (m3)	Effective (m3)	Total (m3)	(m)*(m)
D- 1	23,600	148,600	172,200	230*230
D- 2	33,100	206,800	239,900	270*270
D- 3	25,800	162,200	188,000	240*240
D- 4	9,400	61,000	70,400	150*150
D- 5	71,200	439,000	510,200	390*390
D- 6	75,000	462,200	537,200	400*400
D- 7	17,500	111,200	128,700	200*200
D- 8	53,500	331,700	385,200	340*340
D- 9	87,000	535,600	622,600	430*430
D-10	17,500	111,200	128,700	200*200
D-11	19,500	123,100	142,600	210*210
D-12	104,500	641,800	746,300	470*470
D-13	47,200	293,000	340,200	320*320
D-14	28,100	176,500	204,600	250*250
D-15	14,000	89,300	103,300	180*180
D-16	44,200	274,600	318,800	310*310
D-17	67,400	416,300	483,700	380*380
D-18	19,500	123,100	142,600	210*210
D-19	19,500	123,100	142,600	210*210
D-20	17,500	111,200	128,700	200*200
D-21	28,100	176,500	204,600	250*250
D-22	28,100	176,500	204,600	250*250
D-23	9,400	61,000	70,400	150*150
D-24	23,600	148,600	172,200	230*230
D-25	35,700	222,800	258,500	280*280

(*)Size : Length of Top Bank
Side Slope : 1:1.5

Table G.7.2.1 Hydraulic and Earthwork Calculation for Flood Carrier Channels

No.	Bed Width (m)	Berm Width (m)	Water Depth (m)	n	Area (m2)	Wetted Perimeter (m)	Velocity (m/s)	Discharge (m3/s)	Length of River (Km)	Height of Emb. (m)	Ex. (*10^6 m3)	Fill (*10^6 m3)
A 1	20.0	83.0	4.0	0.034	270.0	200.4	1.13	305	5.0	2.0	0.184	0.180
1-A	34.5	33.0	5.0	0.033	342.0	118.5	1.94	663	4.5	3.0	0.263	0.284
B 2	55.0	57.5	5.0	0.033	542.5	188.0	1.94	1048	12.0	3.0	1.071	0.757
2-A	36.0	34.5	5.0	0.033	355.5	123.0	1.94	690	4.0	3.0	0.243	0.252
C 3	38.0	35.5	5.0	0.033	369.5	127.0	1.95	722	10.5	3.0	0.669	0.662
3-A	45.5	45.0	5.0	0.033	445.0	153.5	1.95	864	10.5	3.0	0.788	0.662
D 4	7.0	38.0	4.0	0.034	128.0	97.4	1.12	142	12.5	2.0	0.216	0.450
E 5	29.0	26.0	5.0	0.033	286.5	99.0	1.95	558	24.5	3.0	1.232	1.544
F 6	10.0	60.0	4.0	0.034	184.0	144.4	1.09	198	18.0	2.0	0.392	0.648
G 7	8.5	10.0	3.5	0.033	58.1	41.1	1.21	71	17.0	1.5	0.332	0.421
H 8	7.0	46.0	4.0	0.034	144.0	113.4	1.09	156	16.5	2.0	0.285	0.594
I 9	48.0	48.0	5.0	0.033	469.5	162.0	1.95	912	22.0	3.0	1.732	1.386
9-A	22.0	52.0	4.5	0.034	285.4	142.2	1.48	425	5.0	2.5	0.199	0.244
9-B	26.0	60.0	4.5	0.034	327.4	162.2	1.49	487	7.0	2.5	0.320	0.341
J 10	28.0	69.5	4.5	0.034	364.9	183.2	1.47	538	14.0	2.5	0.683	0.683
K 11	26.0	60.0	4.5	0.034	327.4	162.2	1.49	487	5.0	2.5	0.228	0.243
L 12	52.0	51.0	5.0	0.033	501.5	172.0	1.96	977	6.0	3.0	0.508	0.378
12-A	78.0	81.5	5.0	0.033	753.5	259.0	1.95	1464	7.0	3.0	0.866	0.441
12-B	106.0	118.0	5.0	0.033	1039.5	360.0	1.94	2002	2.0	3.0	0.332	0.126
12-C	102.0	77.0	5.0	0.033	855.5	274.0	2.05	1750	5.0	3.0	0.730	0.315
12-D	12.0	60.0	4.0	0.033	192.0	146.4	1.15	220	6.5	2.0	0.221	0.234
12-E	89.0	66.0	5.0	0.033	746.5	239.0	2.05	1530	6.5	3.0	0.839	0.410
12-F	14.0	70.0	4.0	0.033	220.0	168.4	1.15	252	7.0	2.0	0.224	0.301
M 13	66.0	68.0	5.0	0.033	639.5	220.0	1.95	1243	5.0	3.0	0.529	0.315
13-A	36.0	21.0	5.0	0.033	301.5	96.0	2.05	618	10.5	3.0	0.578	0.662
13-B	41.0	26.0	5.0	0.033	346.5	111.0	2.05	708	4.0	3.0	0.249	0.252
13-C	36.0	23.0	5.0	0.033	309.5	100.0	2.03	625	13.0	3.0	0.715	0.819
N 14	10.0	42.0	3.5	0.034	95.4	106.6	0.86	82	8.0	1.5	0.174	0.198
14-A	14.5	34.0	4.5	0.034	197.6	98.7	1.48	294	4.0	2.5	0.100	0.171
0 15	18.0	32.0	4.0	0.034	160.0	96.4	1.30	212	8.0	2.0	0.270	0.288
P 16	12.0	28.0	4.0	0.034	128.0	82.4	1.25	161	9.5	2.0	0.235	0.342
Q 17	14.5	34.0	4.5	0.034	197.6	98.7	1.48	295	12.0	2.5	0.343	0.585
R 18	21.0	51.0	4.5	0.034	277.9	139.2	1.47	411	7.0	2.5	0.268	0.342
S 19	3.5	10.0	3.5	0.033	40.6	36.1	1.04	42	6.0	1.5	0.072	0.149
T 20	25.5	63.5	4.5	0.034	335.6	168.7	1.47	496	6.5	2.5	0.293	0.317
Total									321.5		16.383	15.996

Table G.7.3.1 List of Supplemental Drains

	No. of Drainage	Type	Length (Km)		No. of Drainage	Type	Length (Km)
1	SD-D 1-1	A	1.5	26	SD-D11-2	A	1.8
2	SD-D 1-2	A	4.4	27	SD-D12-1	A	8.8
3	SD-D 1-3	A	7.2	28	SD-D12-2	A	1.7
4	SD-D 2-1	A	3.3	29	SD-D12-3	A	11.4
5	SD-D 3-1	A	6.1	30	SD-D12-4	A	8.4
6	SD-D 3-2	A	0.7	31	SD-D12-5	A	3.5
7	SD-D 4-1	A	6.1	32	SD-D12-6	A	8.2
8	SD-D 5-1	A	10.1	33	SD-D12-7	A	5.0
9	SD-D 5-2	A	6.1	34	SD-D13-1	A	4.0
10	SD-D 5-3	A	4.7	35	SD-D14-1	A	6.7
11	SD-D 5-4	A	7.5	36	SD-D16-1	A	1.1
12	SD-D 5-5	A	4.5	37	SD-D17-1	A	6.2
13	SD-D 5-6	A	5.3	38	SD-D17-2	A	7.0
14	SD-D 6-1	A	4.5	39	SD-D17-3	B	1.7
15	SD-D 6-2	A	3.9	40	SD-D19-1	A	3.4
16	SD-D 6-3	A	1.5	41	SD-D20-1	A	5.7
17	SD-D 8-1	A	7.4	42	SD-D21-1	A	7.4
18	SD-D 8-2	A	6.4	43	SD-D21-2	A	4.3
19	SD-D 9-1	A	8.9	44	SD-D22-1	A	5.8
20	SD-D 9-2	A	12.7	45	SD-D24-1	A	7.8
21	SD-D 9-3	A	3.0	46	SD-D25-1	A	5.0
22	SD-D 9-4	B	5.5	47	SD-D25-2	A	5.5
23	SD-D 9-5	B	1.5	48	SD-D25-3	A	9.0
24	SD-D10-1	A	2.2				
25	SD-D11-1	A	3.6				

(*) Type A : Type A is provided to drains out the surplus irrigation water.

Total Length = 249.3 Km

Type B : Type B is provided to drains out the surplus irrigation water and flood discharge.

Total Length = 8.7 Km

FIGURES

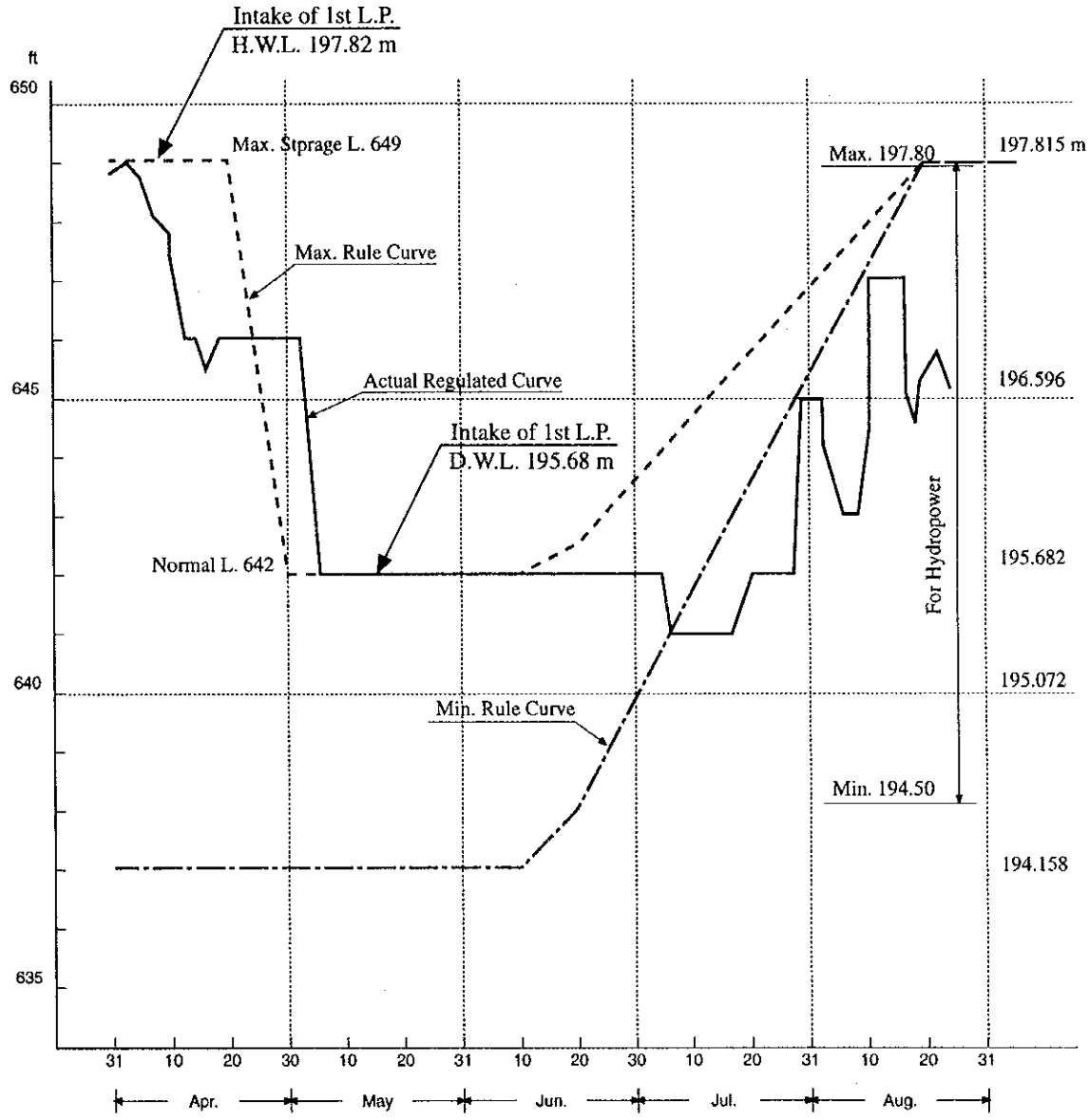
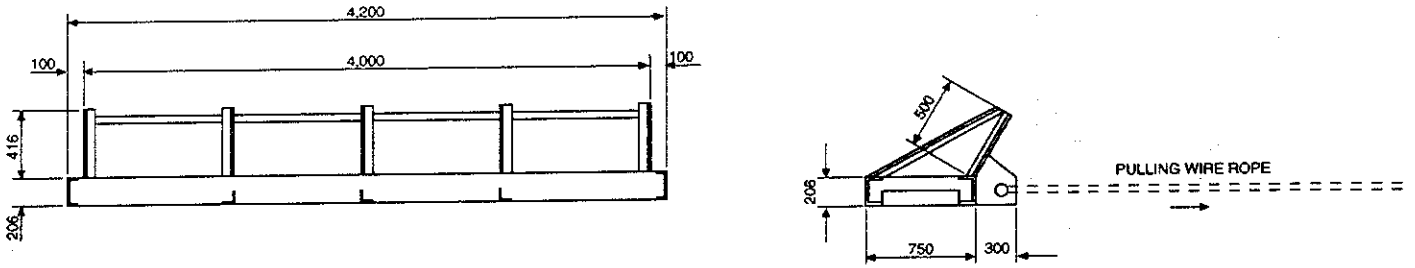


Fig. G.1.2.1 Water Level of Chashma Pond



DETAIL OF SLIP-FORM

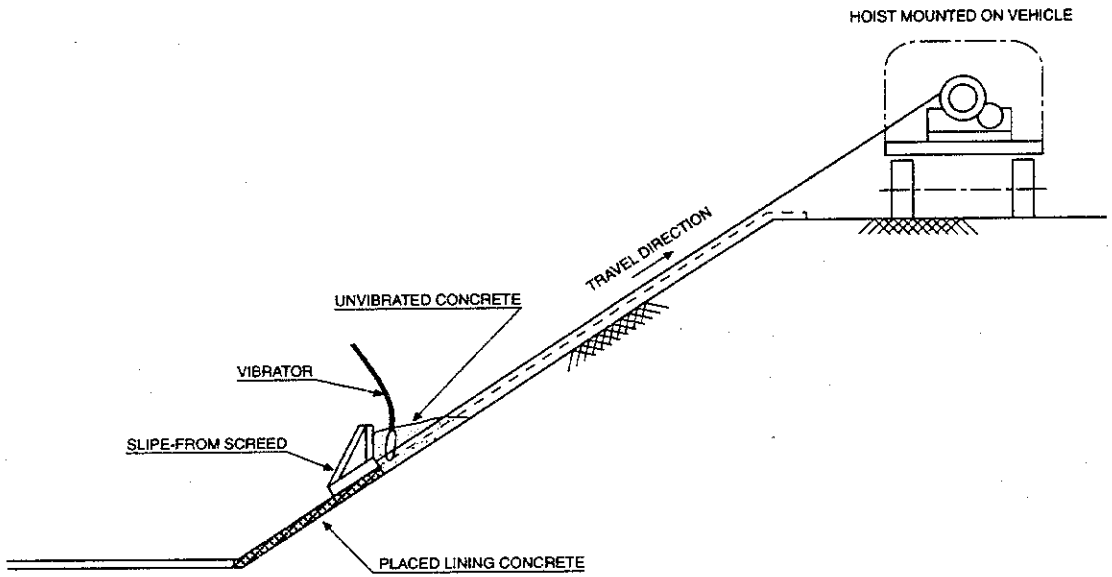


Fig. G.2.2.1 Canal Lining Method by Slipe-form Screed

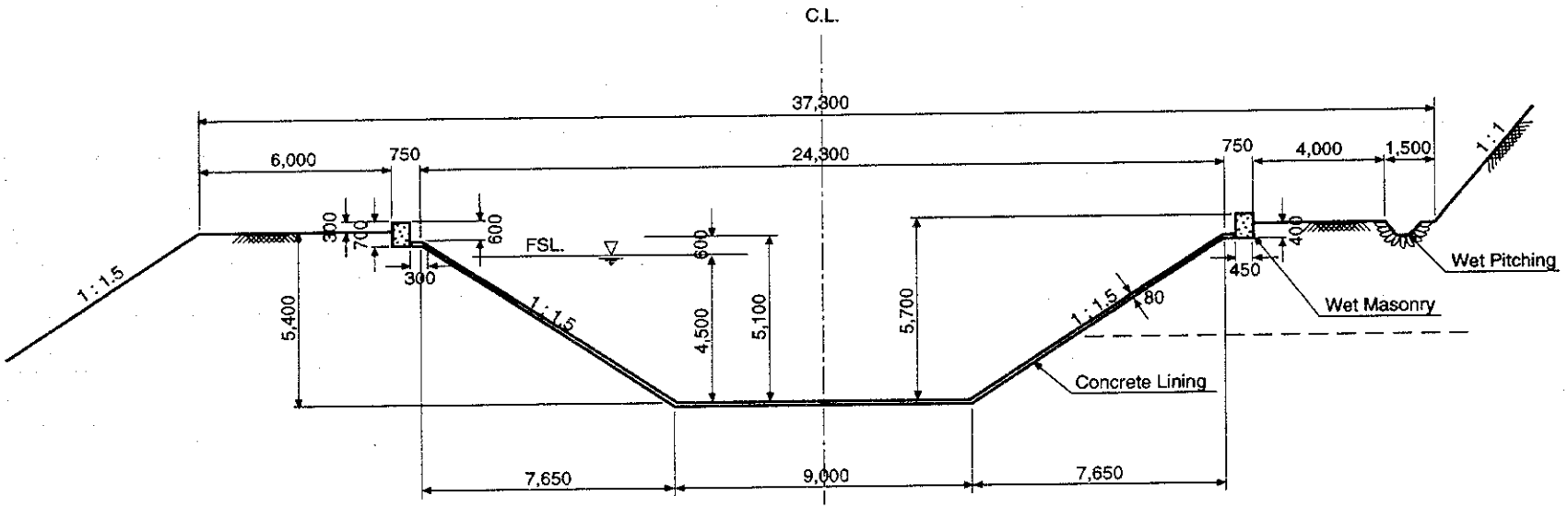
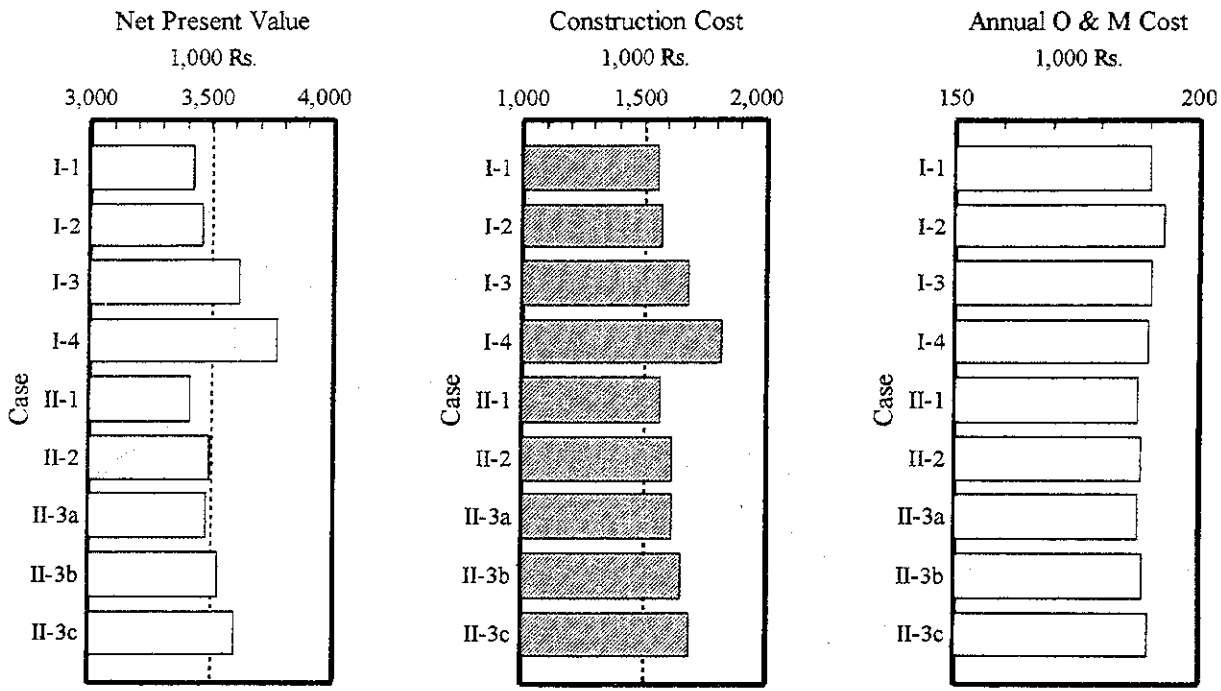


Fig. G.2.3.1 Standard Cross-section of Feeder Canal

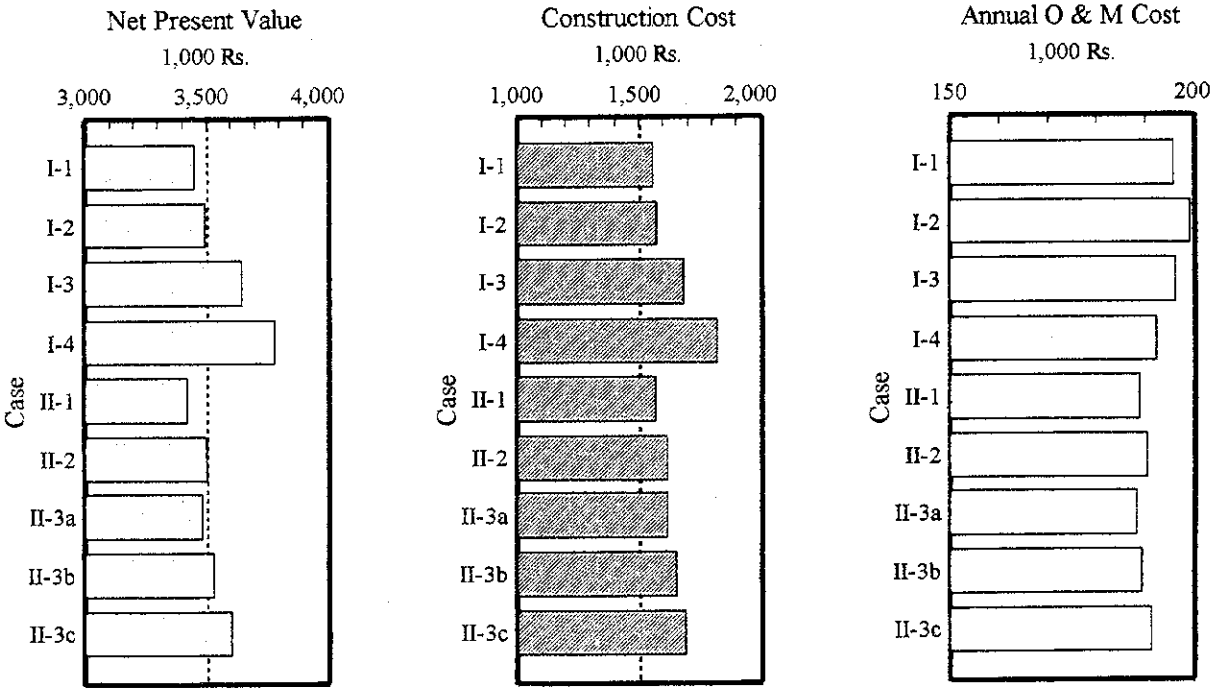
Case	Capacity per Unit (m^3/s)	No. of Units	Capacity per Unit (m^3/s)	No. of Units
I-1	14.40	5		
I-2	12.00	6		
I-3	9.00	8		
I-4	6.00	12		
II-1	15.00	4	6.00	2
II-2	12.00	5	6.00	2
II-3a	10.00	6	6.00	2
II-3b			4.00	3
II-3c		5	5.50	4



(1) Full (100%) Water of Regulating Ponds Assumed to be Available

Fig. G.3.3.1. Comparison of Net Present Value, Construction Cost and O&M Cost of Pumping Station (1/3)

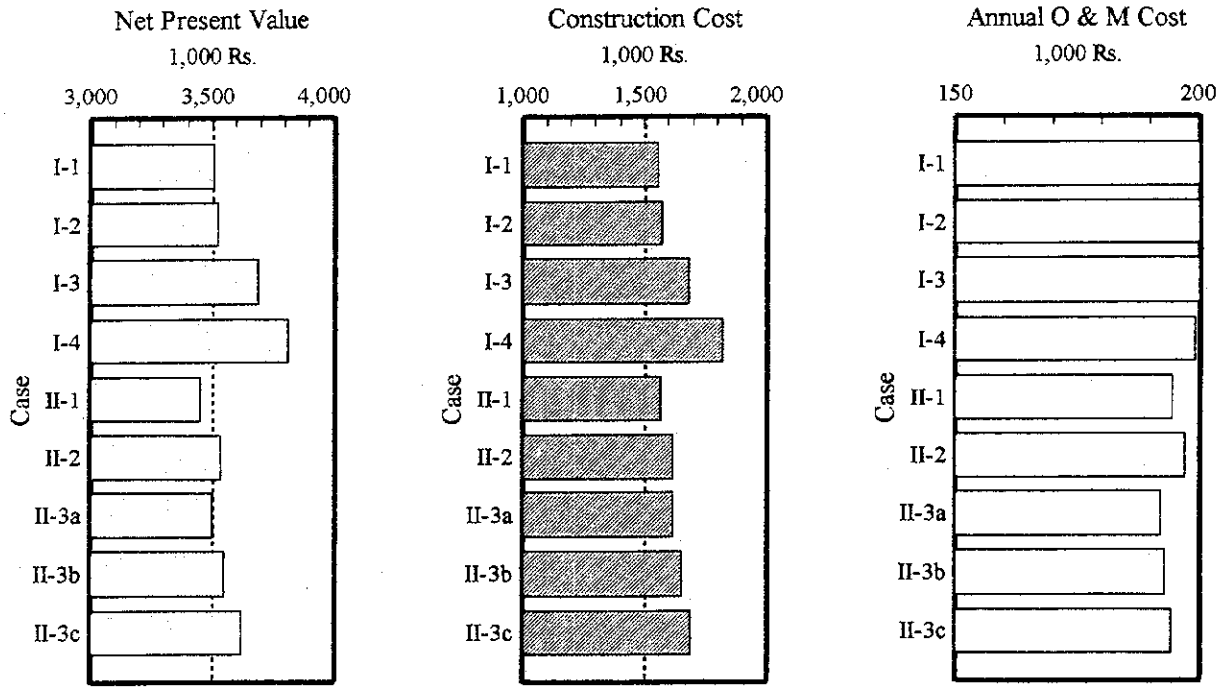
Case	Capacity per Unit (m^3/s)	No. of Units	Capacity per Unit (m^3/s)	No. of Units
I-1	14.40	5		
I-2	12.00	6		
I-3	9.00	8		
I-4	6.00	12		
II-1	15.00	4	6.00	2
II-2	12.00	5	6.00	2
II-3a	10.00	6	6.00	2
II-3b			4.00	3
II-3c		5	5.50	4



(2) 50% Water of Regulating Ponds Assumed to be Available

Fig. G.3.3.1. Comparison of Net Present Value, Construction Cost and O&M Cost of Pumping Station (2/3)

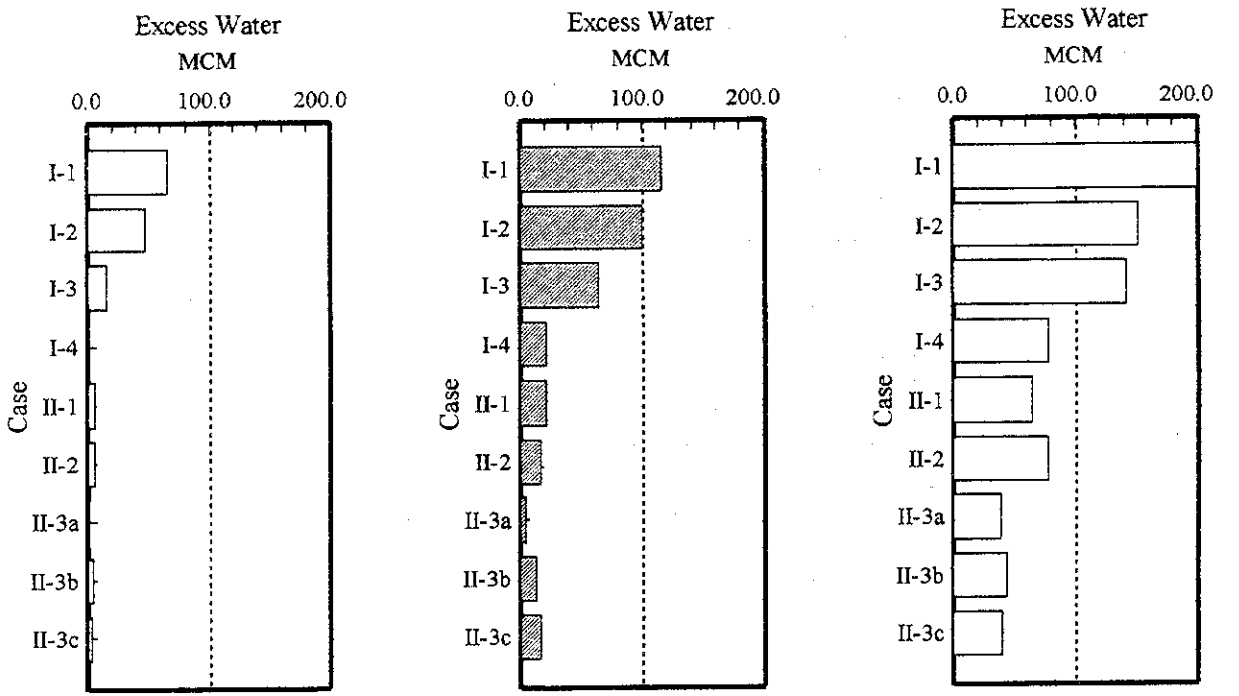
Case	Capacity per Unit (m^3/s)	No. of Units	Capacity per Unit (m^3/s)	No. of Units
I-1	14.40	5		
I-2	12.00	6		
I-3	9.00	8		
I-4	6.00	12		
II-1	15.00	4	6.00	2
II-2	12.00	5	6.00	2
II-3a	10.00	6	6.00	2
II-3b			4.00	3
II-3c		5	5.50	4



(3) Less than 10% Water of Regulating Ponds Assumed to be Available

Fig. G.3.3.1. Comparison of Net Present Value, Construction Cost and O&M Cost of Pumping Station(3/3)

Case	Capacity per Unit (m^3/s)	No. of Units	Capacity per Unit (m^3/s)	No. of Units
I-1	14.40	5		
I-2	12.00	6		
I-3	9.00	8		
I-4	6.00	12		
II-1	15.00	4	6.00	2
II-2	12.00	5	6.00	2
II-3a	10.00	6	6.00	2
II-3b			4.00	3
II-3c		5	5.50	4



(1) Full (100%) Water of Regulating Ponds Available

(2) 50% Water of Regulating Ponds Available

(3) Less than 10% Water of Regulating Ponds Available

Fig. G.3.3.2. Comparison of Excess Water Supply by Pumps in Each Case

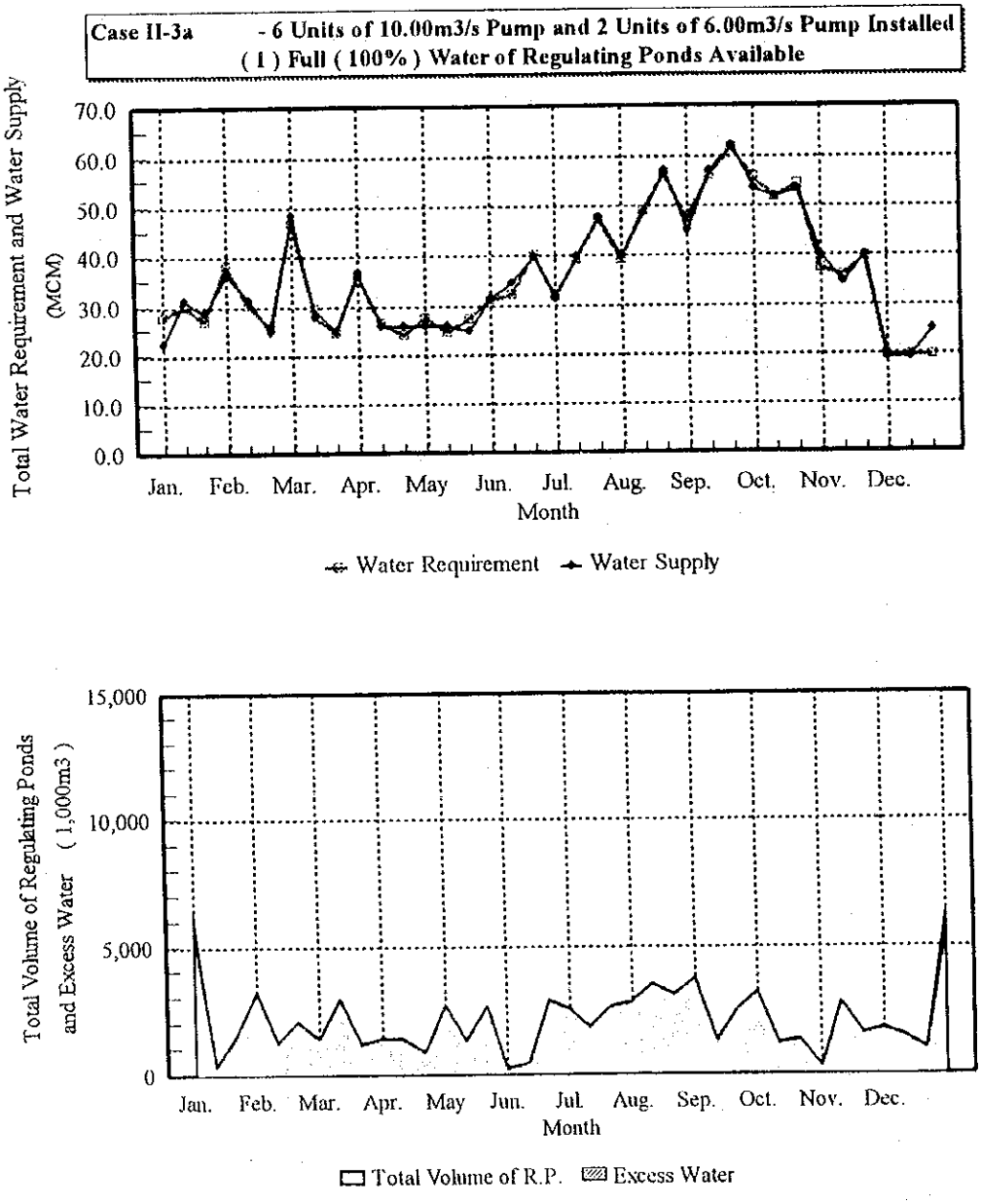


Fig.G.3.3.3. Results of Water Supply Simulatiom (1/3)

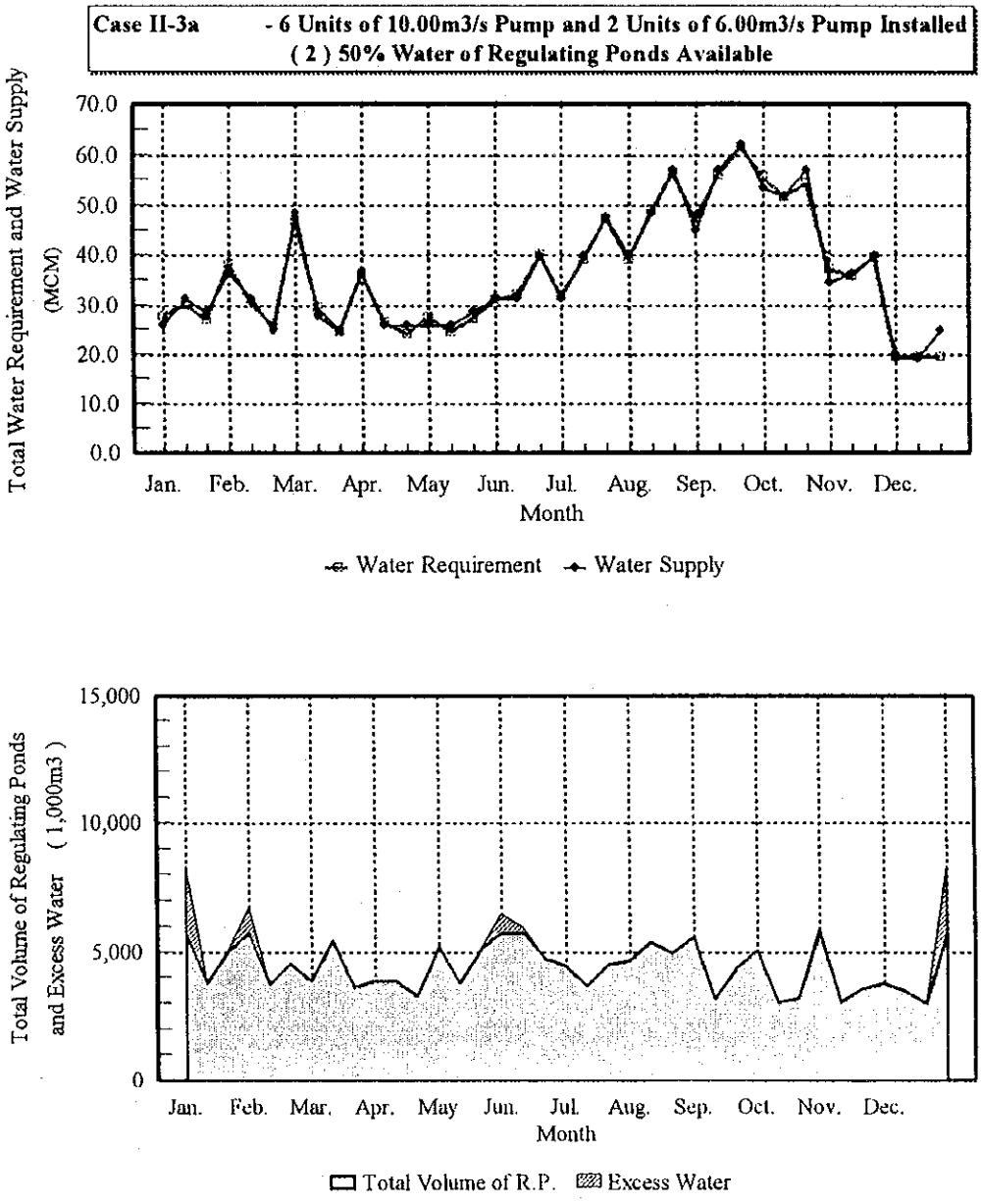


Fig.G.3.3.3. Results of Water Supply Simulatiom (2/3)

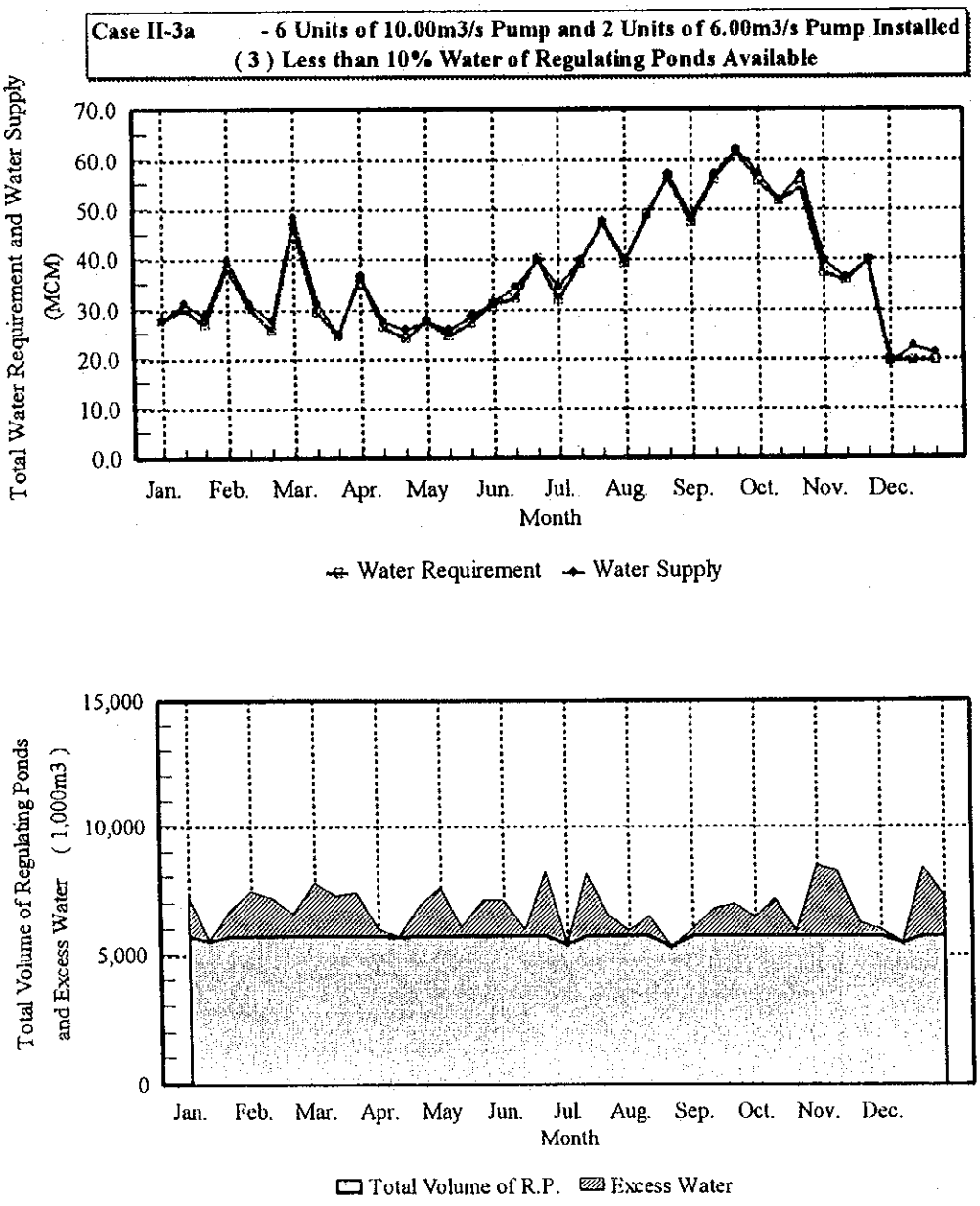


Fig.G.3.3.3. Results of Water Supply Simulatiom (3/3)

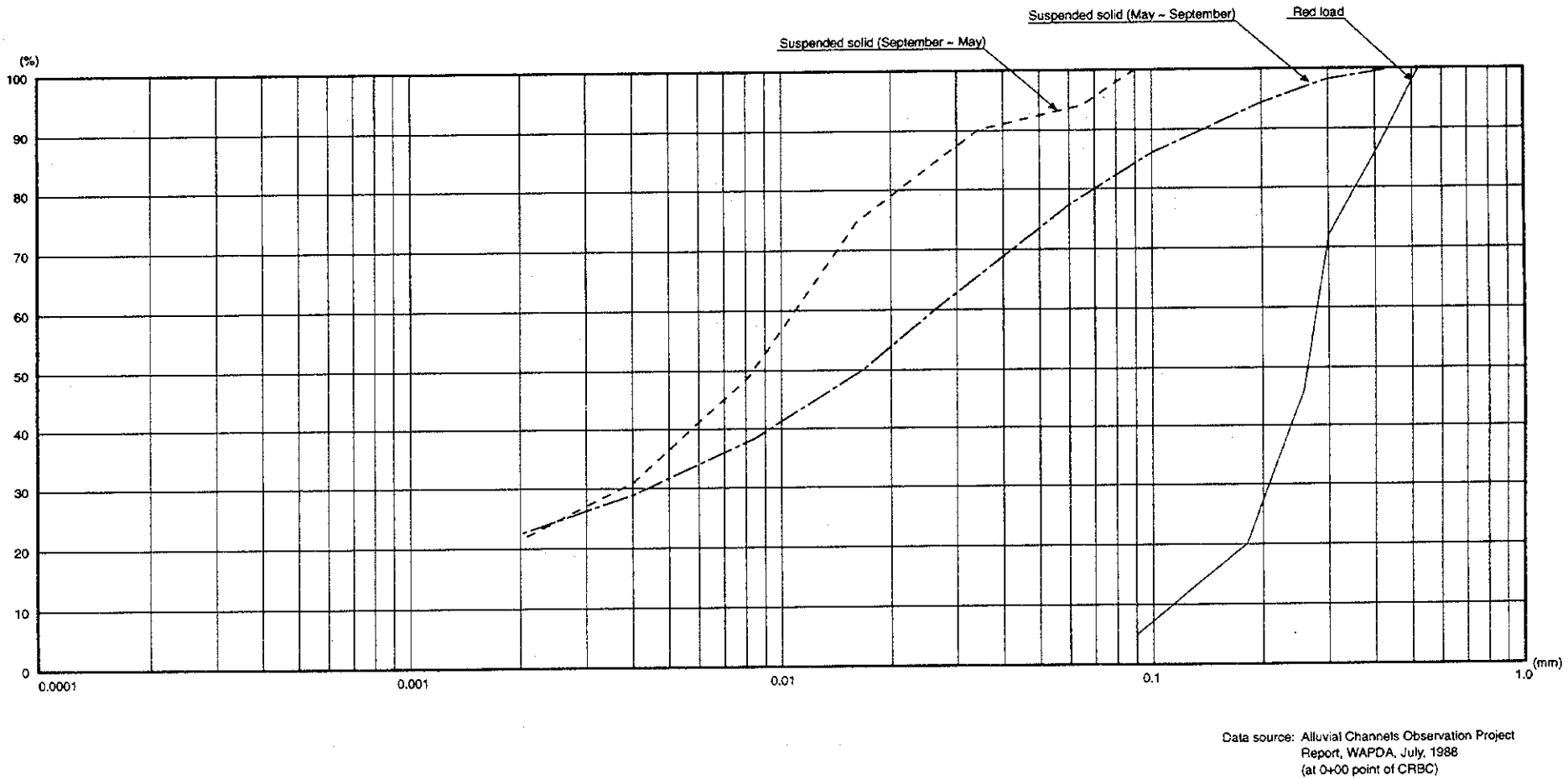


Fig. G.3.4.1 Gradation of Suspended and Bed Loads in CRBC at RD 0+00

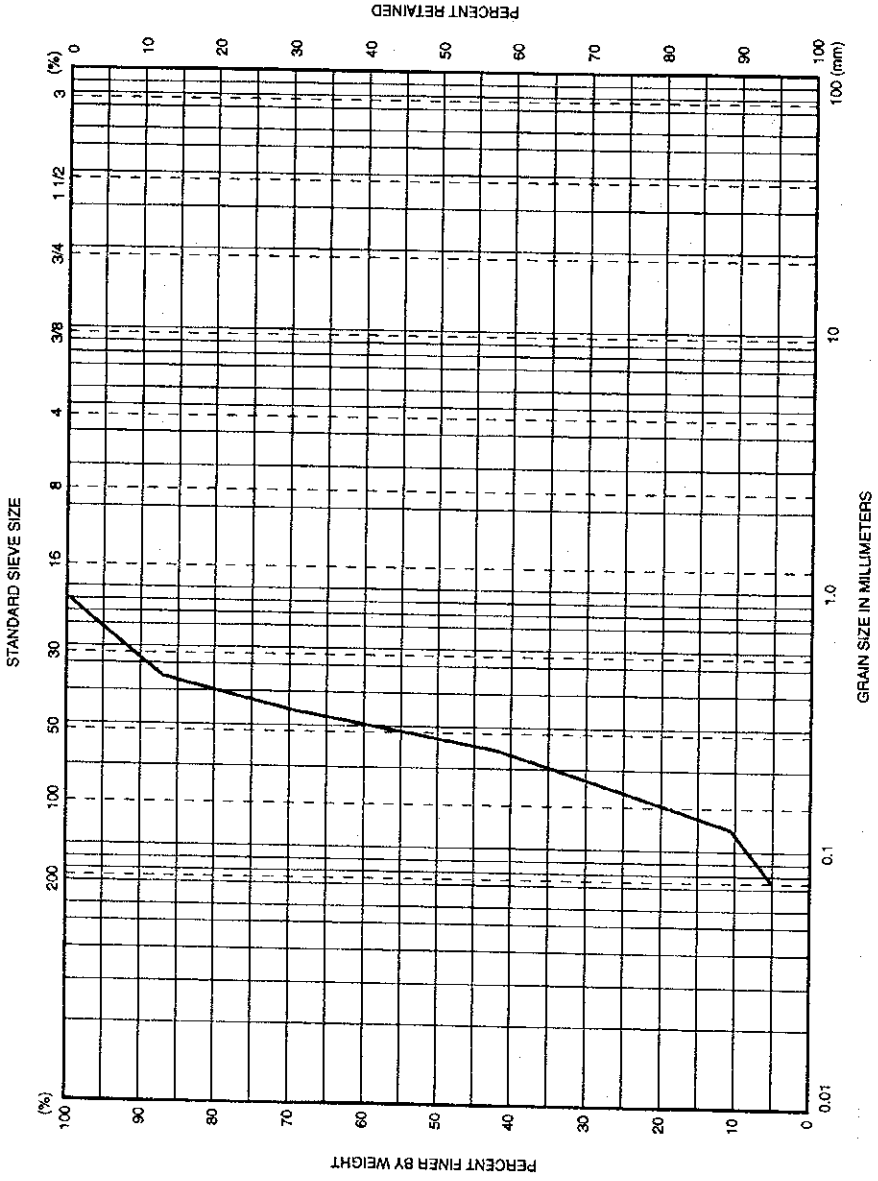
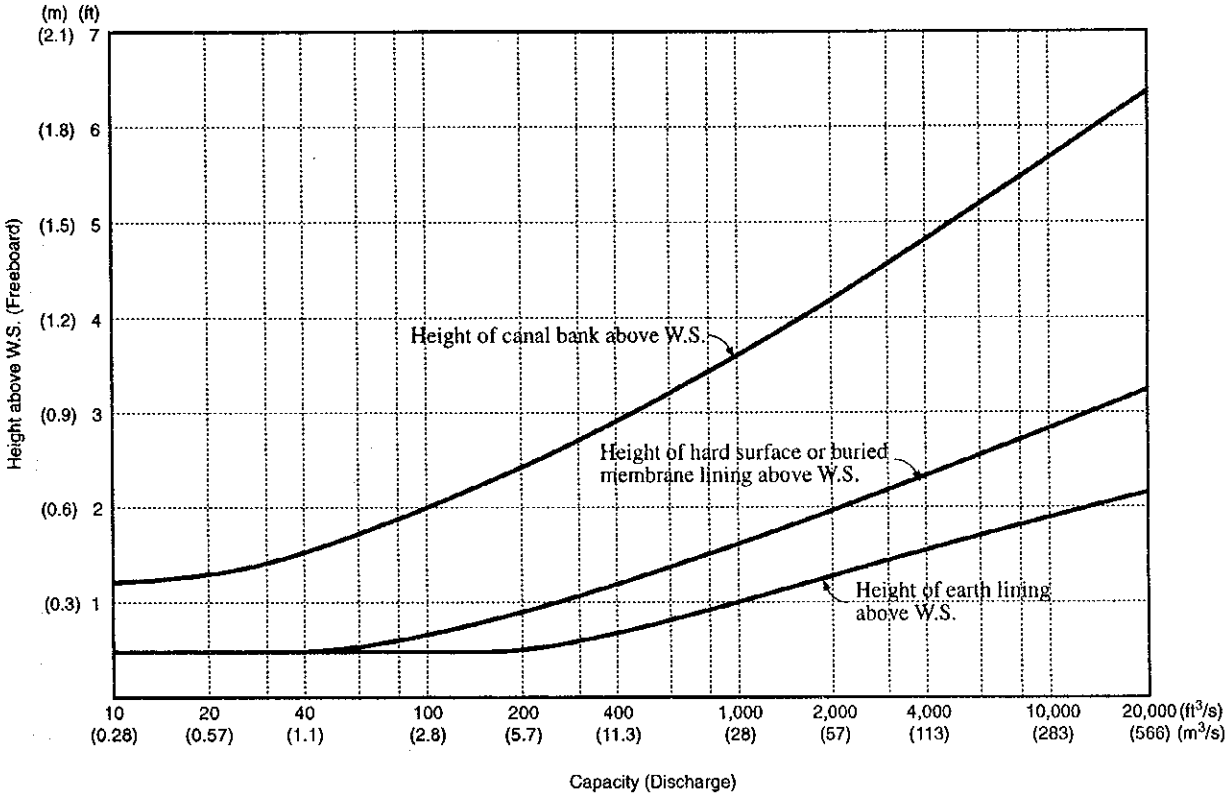


Fig. G.3.4.2 Gradation of Dune Sand in Pumping Site



(Note) Source: Design of Small Canal Structures
(United Stated Department of the Interior Bureau of Reclamation)

Fig. G.4.2.1 Freeboard for Main Canal

DIMENSION (Unit: mm)

	SECTION OF CANAL				
	1	2	3	4	5
B	12,000	10,500	8,000	6,500	4,500
D	3,940	3,530	2,600	2,140	1,490
Fb	1,200	1,200	1,200	1,050	900

B : BED WIDTH
D : WATER DEPTH
Fb : FREE BOARD

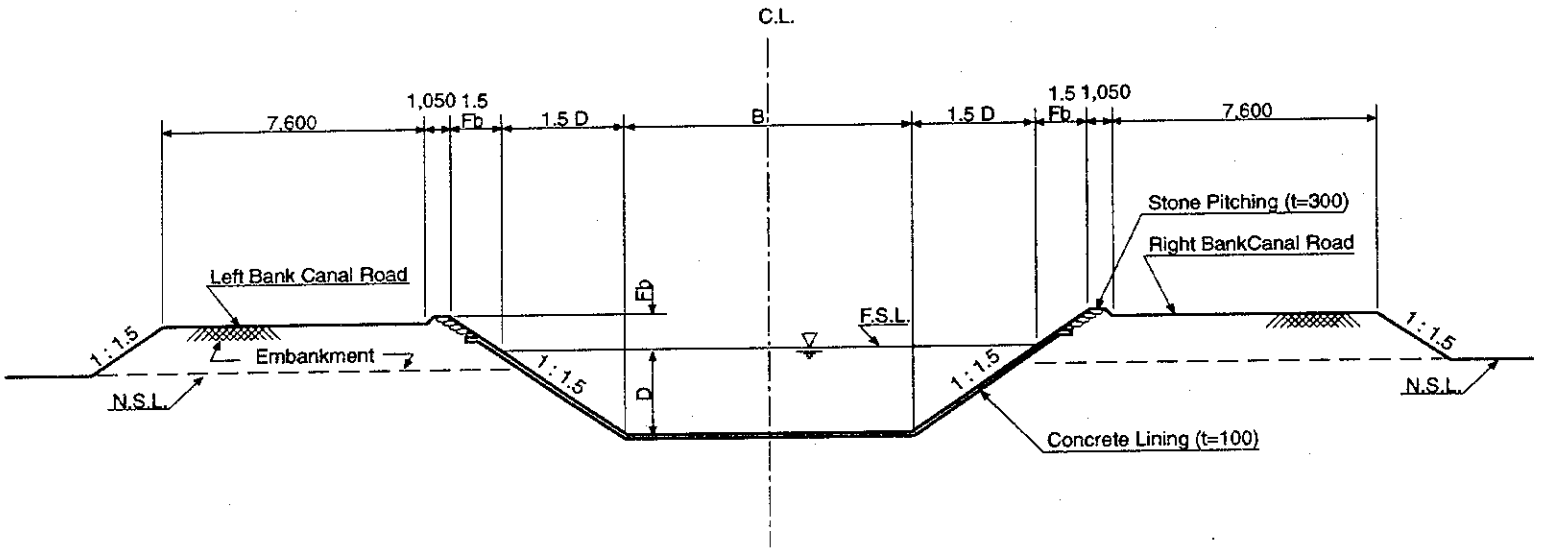


Fig. G.4.3.1 Standard Cross-section of Main Canal

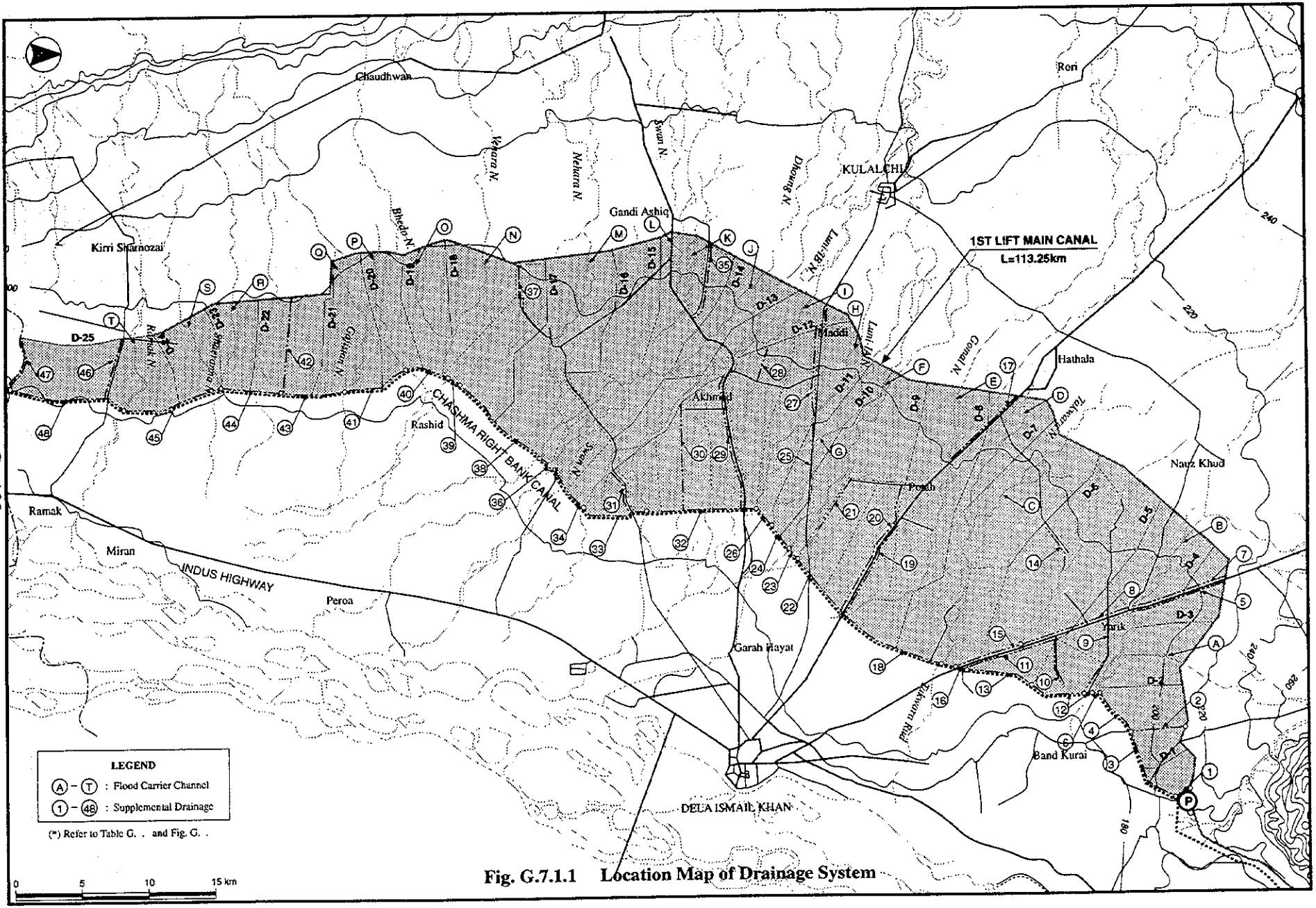


Fig. G.7.1.1 Location Map of Drainage System

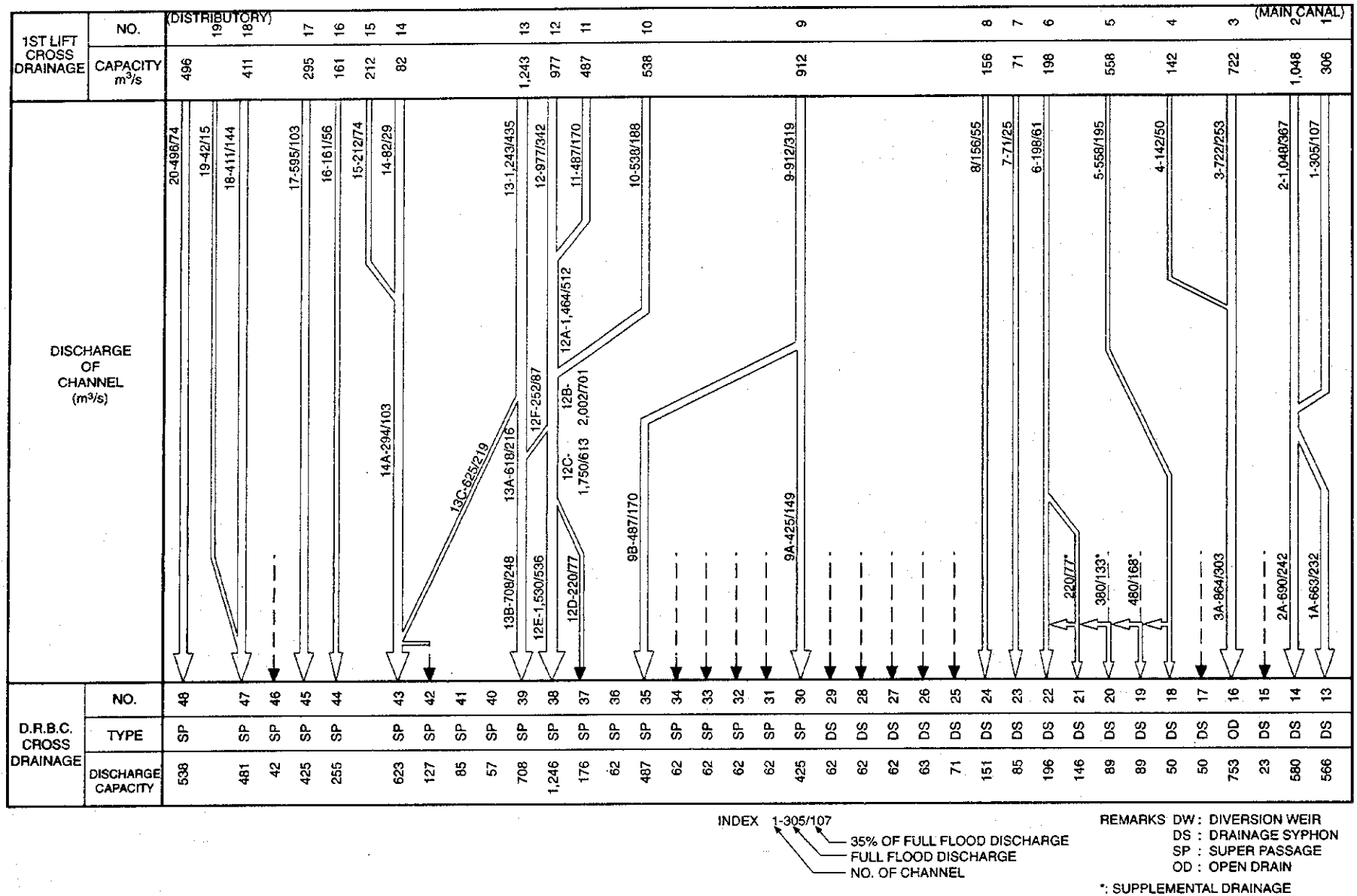


Fig. 7.2.1 Network of Flood Carrier Channel

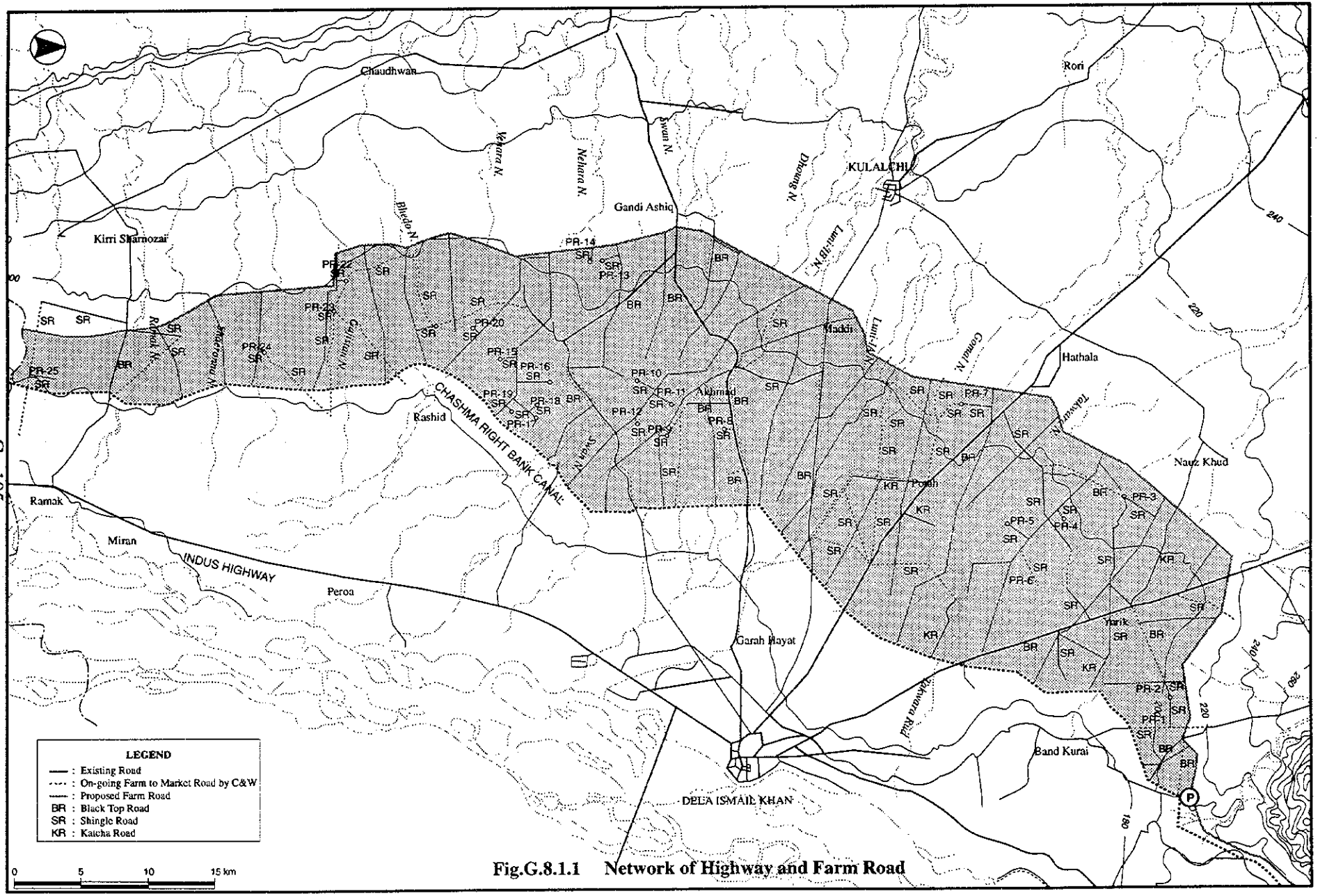
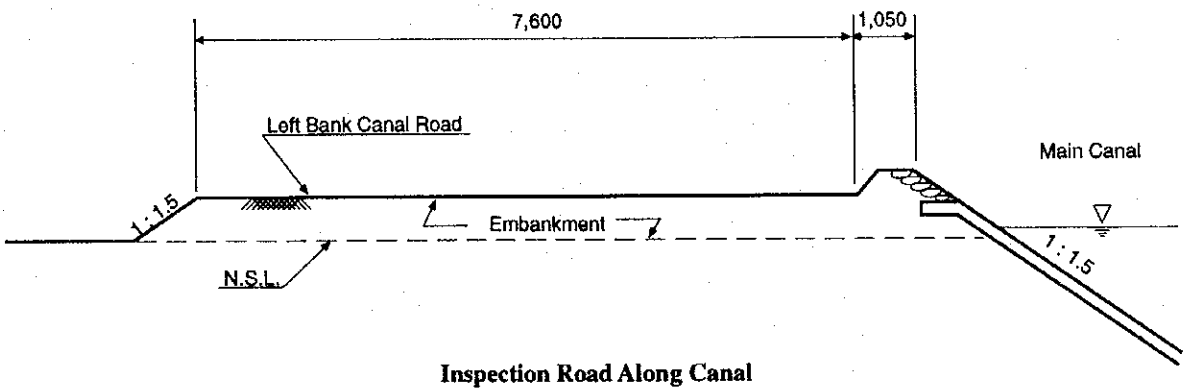
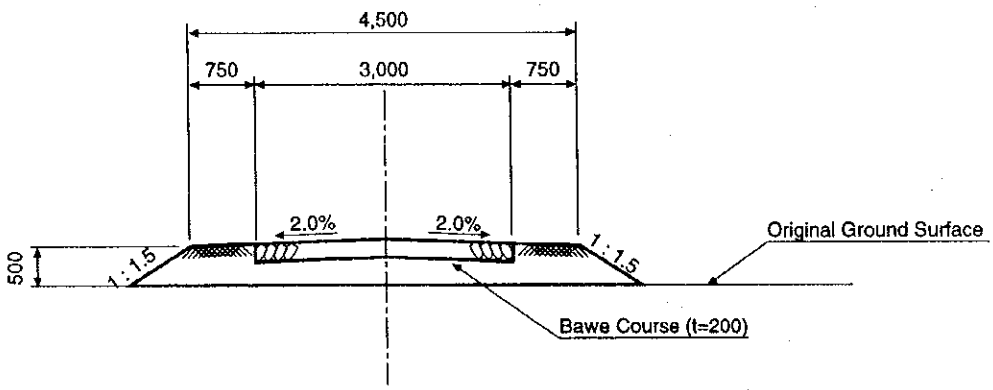


Fig.G.8.1.1 Network of Highway and Farm Road



Inspection Road Along Canal



Farm Road

(Proposed Additional Farm Road: Total length 32.5 km)

Fig. G.8.3.1 Standard Cross-section of Proposed Road

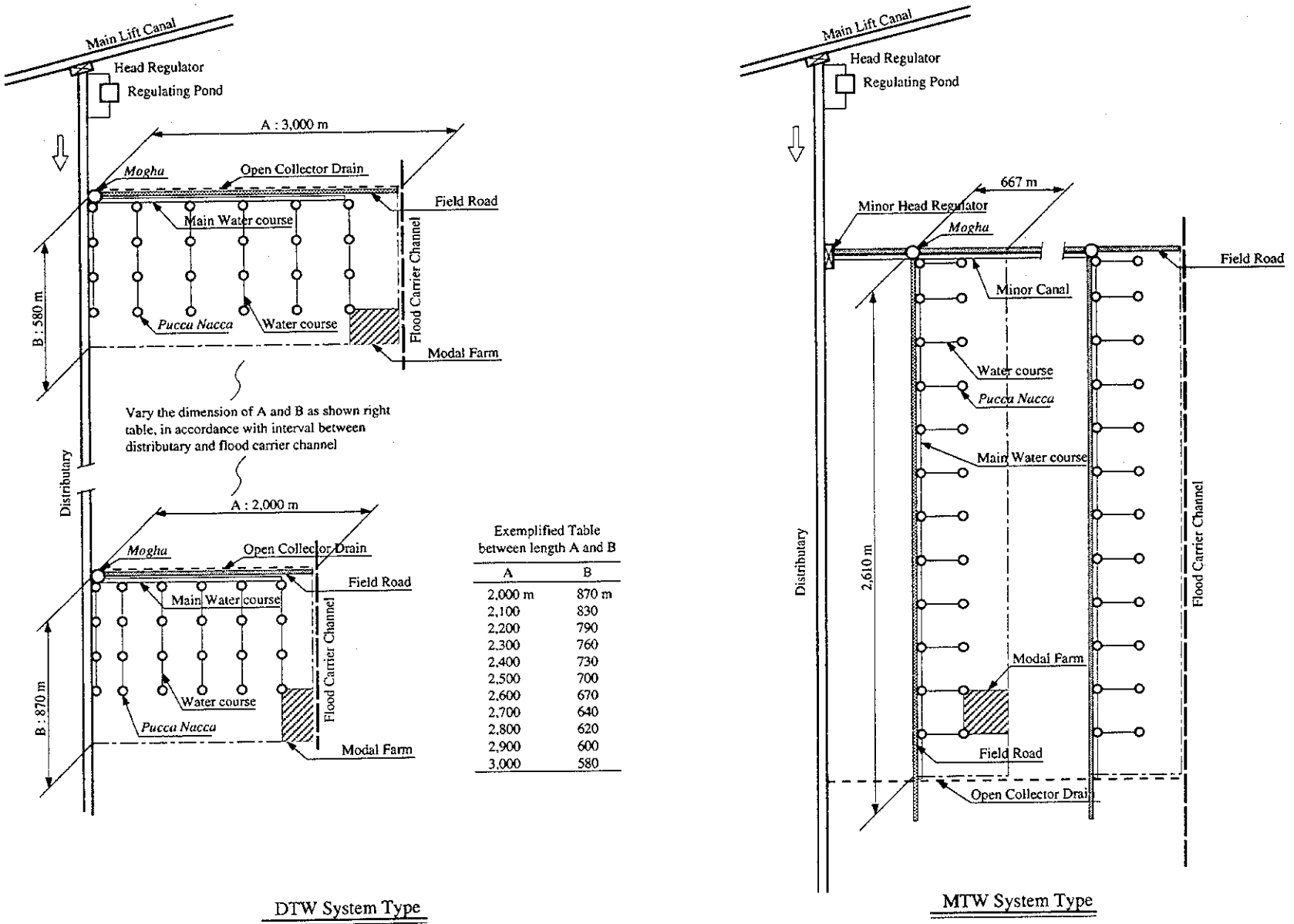


Fig. G.9.1.1 Typical Layout of Command Area Development System

ANNEX H

CONSTRUCTION PLAN AND COST ESTIMATE

ANNEX H

CONSTRUCTION PLAN AND COST ESTIMATE

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ANNEX H CONSTRUCTION PLAN AND COST ESTIMATE

H.1 Introduction

This ANNEX presents all the results of field and home studies for the construction plan and cost estimate of the Project comprising the project components of a feeder canal, a main canal, river treatments and drainage canals, distributory canals, on-farm development, additional farm roads, regulating ponds and other related facilities, based on the results of the comparative study discussed in ANNEX G. Some parts referring to the project organization and implementation arrangement are based on the study results discussed in ANNEX F.

H.2 Construction Plan

H.2.1 General

The construction works of the project are divided into two phases cost wise evenly considering work volume and role of each components so that the project will be benefiting right after completion of Phase I. Phase I consists of the feeder canal including a intake facility, the pump station with pump equipments for Phase I, section 1 of the main canal and other works in Phase I area. Phase II consists of remaining part of the main canal and the pump station and other works in Phase II. Each Phases are planned to be implemented partly in parallel for eighteen (18) months for acceleration of the project. Construction procedures for each components are stated in Chapter H.2.3 later. Major construction works having big earthwork volume are basically planned to be executed by the heavy duty construction machinery and equipment and minor construction works would be executed by combination of heavy equipment and manpower.

H.2.2 Basic Assumption of Construction Plan

H.2.2.1 Workable Days

Earth works are mostly affected by rainfall. Since embankment of canal band is controlled by moisture contents, special attention must be paid to execute the construction woks during rainy days. Flooding period is also to be considered for scheduling. Suspension days of these earth works caused by rainfall are assumed as following criteria according to the daily rainfall intensity.

Daily Rainfall Intensity (mm/day)	Suspension of Work (day)
0 - 10	0
10 - 30	1
30 - 50	2
50 - 100	3
more than 100	4

Annual mean workable days were estimated based on the above criteria and the rainfall records in D. I. Khan region for recent 10 years, and the computed result is shown in Table H.2.1 and its summary is as follows:

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
W. Days	31.0	27.5	29.8	29.5	30.6	29.9	28.4	29.0	28.8	30.9	30.0	30.4

The result shows that the above workable days of all months are more than 25 days of standard workable days of civil works. Therefore, workable days for the construction works , are decided to be 25 days throughout a year, and total workable days are 280 days in a year, taking public holidays into account.

H.2.2.2 Conversion Rate of Earth Volume

Earth volumes are changeable according to the natural conditions as they are. Earth materials naturally placed would increase in volume after excavation and decrease after compaction. These changes of volume should be considered for estimate of produced volumes by construction equipment and machinery or earth moving plan. The conversion rates of earth volumes are assumed as follows:

Abbreviation	Class of Earth	Conversion Rate		
		Natural Condition	Loose Condition	Compacted Condition
E	Earth material	1.00	1.15	0.90
R	Rock	1.00	1.60	1.30
S	Sand	1.00	1.10	0.95

H.2.2.3 Basic Method of Earth Works

Earth works consist of excavating, loading, hauling, spreading and compacting. Since there are various methods for these earth works, due consideration must be given to the choice of the suitable combination of a heavy duty equipment. Suitable thickness of spreading and compaction, way of mixing and water content should be

studied again according to mechanical and physical testing of actual earth material at the detailed design stage.

Following equipment would be basically introduced on these earth works of the project.

Earth-works	Earth Materials	Proposed Equipment
Excavation	Common Soil	Bulldozer (11-21t), back-hoe shovel (0.6/1.2m^3)
	Rock	Blasting and Bulldozer with ripper (21t)
Loading	Any kind of Materials	Wheel loader (2.2m^3)
		Back-hoe shovel (0.6/1.2m^3)
Hauling	Any kind of Materials	Dump truck (11/20t)
	Sod, Wood etc.	Tractor trailer (5t)
Spreading	Any kind of Materials	Bulldozer and Grader
Compacting	Common Soil	Tamping and Sheep foot Roller
	Road Paving Material	Vibration Roller and Tire Roller

H.2.3 Construction Procedure and Method

H.2.3.1 General

According to the optimization study for project implementation described in ANNEX G, introduction of phase wise implementation into Phase I and II and construction schedule of each components are decided as described in the sub-chapter H.2.4 and as shown in Fig. H.2.2. Principal feature of each components are described in ANNEX G.

H.2.3.2 Earth Moving Plan

From the results of earth moving investigations, earth material of each section/component would be obtained from the following places. Re-usage of excavated material is planned to be maximized unless affecting for degradation of embankment to reduce construction cost. Aggregate material are partly obtained from excavated rock in the feeder canal reach and partly from market supply. Spoiling work within short range are basically included within excavation work.

Taking into account available materials, most economical construction method, combination of suitable construction machinery, etc., the earth moving plan for Feeder canal and pump station is illustrated in Fig. H.2.1 (1/2) and for Main canal, regulating ponds, river treatments and drainage canals and distributory canals in Fig. H.2.1 (2/2). Earth borrow areas are planned at three (3) spots, one of which, borrow area 1, is at hilly area along the feeder canal, one of which, borrow area 2, is

at hilly area near from the pump station and another one, borrow area 3 is to be arranged at about 5 km apart from the main canal section 1 (B) towards to north-west along Bannu road as shown in the aforementioned Figures.

Component	Section	Borrow Area (Hauling Distance)
Feeder Canal	Entire reach	Borrow Area 1 (10 km)
Pump Station	Settling basin	Borrow Area 2 (5 km)
Main Canal	Section 1 (A)	Borrow Area 3 (10 km) and Section 1 (B) as well as Regulating Ponds (16 km)
Distributory Canal	Entire reach	Side Borrow (0.5 km)
Drainage Dikes	Entire reach	Side Borrow (0.3 km)

H.2.3.3 Construction Procedure and Method for Phase I

Construction procedure and method of major works and work volumes in each components for Phase I are as described below. Work volume at borrow area and haulage are not included. Required area of land acquisition would be about 1,000 ha.

(1) Intake Structure

The intake structure is planned to be completed within Phase I and its operation will start from middle of the fifth year. Prior to construction work of the intake facility, temporary coffer dike is to be filled up at about 100 m upstream connecting from Spur 1 to the embankment of the low-hydro power station to have been completed and land draining work will follow by pumps. Temporary road will be arranged at downstream till completion of Chashma dike crossing work.

Foundation excavation by bulldozer and back hoe and sheet piling works using vibro hammer while draining and concrete placing will start after complete draining of the site. Gate installation and back filling work will be done carefully for function and durability of the intake facility. Dredging work along the approach canal towards to the intake will be continuously conducted by sand pumps on deck of dredging ships. Major item and volume of construction works for the intake facility are tabulated below.

Work Item	Unit	Work Volume
Embankment	1,000 m^3	30.0
Dredging Work	1,000 m^3	184.0
Dry Masonry	1,000 m^3	5.6
Concrete Work	1,000 m^3	8.3
Sheet Piling	1,000 m^2	1.6
Radial Gate	nos	4

(2) Feeder Canal

The feeder canal is planned to be completed within Phase I and its operation will starts from middle of the fifth year. Construction works will be initiated by land clearing and stripping works along canal stretch and followed by excavation works. Weathered rock excavation would be done by bulldozer with ripper and blasting would be done for hard rock. Stepwise excavation like about 5 m gap stairs shall be applied for huge or mountainous section for safety execution. Replacement of foundation of embankment would be requested in case embankment would be partly saddle on right bank of CRBC or foundation soil would not be suitable. Embankment work should be done carefully observing water contents and soil properties of material.

Construction of cross drain structures (11 nos of super passages and 1 no of drainage culvert) are tightly scheduled within possible shortest period excluding flooding season and temporary closing dike should be arranged even in dry season for protection of construction sites.

Prior to placing of lining concrete of 80 mm thick, surface of slope and bottom should be smoothened, compacted well and pre-wetted and sand drain be completed. Concrete lining work will be conducted by about 4 m-width panel using motor driven steel slip form. Consolidation by vibrator and finishing by manual surfacing will be carefully done. Timely water supply to the surface shall be arranged while curing stage.

Temporary road will be pre-arranged for a part of Chashma road of about 4.0 km which is running on the canal stretch while construction and replacement will be done according to the design criteria of district road along the feeder canal.

Work Item	Unit	Work Volume
Embankment	1,000 m^3	7,250.3
Excavation common	1,000 m^3	4,103.8
Excavation Rock	1,000 m^3	3,329.0
Base Coarse	1,000 m^3	146.1
Dry Masonry	1,000 m^3	132.0
Concrete lining	1,000 m^2	1,611.5
Blasting Work	1,000 m^2	499.4
Structure*	nos	42

*: excluding intake and berm drains

(3) Pump Station

Pump house, settling basin with gates and spillway, outlet pond and necessary amount of excavation and back-filling for installation of a delivery pipeline are scheduled to be completed within Phase I. Pump equipment as listed below and other auxiliary equipments including all electric items are accordingly installed at the ending stage. Detailed construction scheduling is required at the design stage for arrangement of machinery, equipment and materials within limited construction period of about one (1) and half year and limited construction site. Concrete lining is proposed for the settling basin and connecting channels.

Excavation of foundation of pump station and construction of settling basin will be commenced at first and followed by foundation work of in situ concrete piles and building works of the station. Outlet pond can be executed independently. Pre-arrangement of procurement, production, transportation and fabrication of necessary equipment installed are necessary for timely completion of the pump station. Pump equipments, pipes and valves delivered to the site by several packages considering transportation convenience are to be installed using ceiling crane in the pump house.

Careful treatment of delivery pipes and casings while traveling are proposed for protection by arrangement of supporting bars or equivalent material inside. The delivery pipe is to be buried after installation temporarily for protection until completion of Phase II works.

Work Item	Unit	Work Volume
Embankment	1,000 m^3	84.4
Excavation Common	1,000 m^3	491.2
Back-filling	1,000 m^3	46.6
Concrete Lining	1,000 m^2	103.5
Concrete Work	1,000 m^3	35.5
RC Piling	m	5,414
Pump House	nos	1
Pump (d=2000)	nos	2
Pump (d=1650)	nos	1
Delivery Pipe (d=3200)	nos	1

(4) Main Canal

Section 1 of 32.8 km of the main canal is scheduled within Phase I. Major work items and procedures are as same as the feeder canal. Section 1 is divided into two (2) sub-section as mentioned in the sub-chapter of earth moving plan, upstream section of which is section 1 (A) of 16.6 km and running through sand dune area and

downstream section of which is section 1 (B) of 16.2 km in normal soil area. Procedure and method for concrete lining is as same as the feeder canal.

In the section 1 (A), embankment material is in short much and borrow from section 1 (B), regulating pond sites and borrow area 3 and quality control of embankment material is especially required. Work volume for each major items are listed below.

Work Item	Unit	Work Volume
Embankment	1,000 m^3	1,735.4
Excavation common	1,000 m^3	2,058.7
Base Coarse	1,000 m^3	79.9
Dry Masonry	1,000 m^3	53.1
Concrete lining	1,000 m^2	930.5
Structure*	nos	18

*: excluding intake and berm drains

(5) Distributory Canals

Construction of distributory canals of D-1 to D-6 and their minor canals (81.5 km) are included within Phase I. Major work items and volumes estimated using sample area method as described in Chapter 6 of the main report are listed below. Survey, mapping and design works are required for estimate of actual work volume and cost in the design stage.

Main work is embankment of canal band and structures using smaller machinery and equipment and more manual procedures comparing the feeder and main canal. After clearing and stripping, embankment work will be commenced using borrow material nearby within 500 m. Pre-fabricated steel forms are proposed for placing of concrete for the related structures to reduce construction period.

Prior to placing of lining concrete of 50 mm thick, surface of slope and bottom should be smoothened, compacted well and pre-wetted and sand drain be completed. Concrete lining work will be conducted by about 4 m-width panel using motor driven or manual steel slip form. Consolidation by vibrator and finishing by manual surfacing will be carefully done. Timely water supply to the surface shall be arranged while curing stage.

Work Item	Unit	Work Volume
Embankment	1,000 m^3	911.6
Excavation common	1,000 m^3	28.6
Base Coarse	1,000 m^3	41.7
Concrete lining	1,000 m^2	361.6
Regulating Pond	nos	6
Structure	nos	251

(6) Flood Carrier Channel and Supplemental Drainage

Major work items and volumes of flood carrier channels and supplemental drainages within Phase I are as listed below. Flood carrier channels have flood protection dikes at both side filled using excavation material from riverain expansion works. Excavation of riverain and compaction of the dikes are proposed to be done mainly by bulldozer. Supplemental drainages are planned to drain excess water in the project area and flow sections are much smaller than the flood carrier channels, therefore protection dikes are not proposed except few large drainages and drainage excavation mainly using bulldozer is main item of the construction work.

Work Item	Unit	Work Volume
Embankment	1,000 m^3	3,993.5
Excavation	1,000 m^3	5,057.1
Bridge	nos	4

(7) On-farm Development, Additional Farm Roads

On-farm development of 27,210 ha and additional farm roads in the area are scheduled within Phase I. Construction procedures are based on farmer's participation for major work except excavation work for collector drains by back hoe. All materials such as cement, bricks, pre-casted structures are given to them on project account and their manual execution of the rest of all works including compaction of canal band will be following.

Unit area (1.0 ha) work volumes are estimated as listed below.

Work Item	Unit	Work Volume
Excavation	1,000 m^3	11.2
Brick Work	1,000 nos	144
Cement	ton	30
Aggregate	m3	115
Structure (Pacca)	nos	60

H.2.3.4 Construction Procedure and Method for Phase II

Construction procedure and method of major works and work volumes in each components for Phase II are as described below. Work volume at borrow area and haulage are not included. Required area of land acquisition would be about 2,200 ha.

(1) Pump Station

Excavation, installation of two (2) delivery pipelines, back-filling and installation of remaining pump equipment as listed below are Phase II work for the pump station. Pre-arrangement of procurement, production, transportation and fabrication of necessary equipment installed are necessary for timely completion of the pump station also in Phase II

Work Item	Unit	Work Volume
Excavation Common	1,000 m^3	56.1
Back-filling	1,000 m^3	45.1
Pump (d=2000)	nos	4
Pump (d=1650)	nos	1
Delivery Pipe (d=3200)	nos	2

(2) Main Canal

Section 2 to 5 of 80.5 km of the main canal is scheduled within Phase II. Major work items and procedures are as same as the feeder canal. Procedure and method for concrete lining is as same as the feeder canal. Remaining work items and volumes are as listed below.

Work Item	Unit	Work Volume
Embankment	1,000 m^3	2,547.6
Excavation common	1,000 m^3	4,215.6
Base Coarse	1,000 m^3	196.6
Dry Masonry	1,000 m^3	130.7
Concrete lining	1,000 m^2	1,604.8
Structure	nos	68

(3) Distributory Canals

Construction of distributory canals of D-7 to D-25 and their minor canals (361.1 km) are included within Phase II. Major work items and volumes are as listed below. Procedures and methods are as same as Phase I.

Work Item	Unit	Work Volume
Embankment	1,000 m^3	2,961.4
Excavation common	1,000 m^3	92.8
Base Coarse	1,000 m^3	135.5
Concrete lining	1,000 m^2	1,174.5
Regulating Pond	nos	19
Structure	nos	816

(4) Flood Carrier Channel and Supplemental Drainage

Major work items and volumes of flood carrier channels and supplemental drainages within Phase I are as listed below. Procedures and methods are as same as Phase I.

Work Item	Unit	Work Volume
Embankment	1,000 m^3	12,972.5
Excavation	1,000 m^3	16,427.8
Bridge	nos	12

(5) On-farm Development, Additional Farm Roads

On-farm development of 88,390 ha and additional farm roads in the area are scheduled within Phase II. Procedures and methods are as same as Phase I.

H.2.3.5 Major Construction Equipment and Machinery Required

Major works required for the project are excavation works of about 45 x 10^6 m^3 including common excavation, excavation at borrow area and drainage excavation, rock blasting or excavation of about 3 x 10^6 m^3, common embankment, drainage dike embankment and back-filling works of about 40 x 10^6 m^3, concrete lining works of 6 x 10^6 m^2, stone works such as stone pitching and gabion works of about 690 x 10^3 m^3, base course works of about 630 x 10^3 m^3 for roads and other concrete works of 190 x 10^3 m^3.

The major construction equipment and machinery required for timely completion of the construction work volume above are shown in Table H.2.2 based on the implementation schedule of Fig. H.2.2.

H.2.4 Implementation Schedule

The project implementation schedule for the project is shown in Fig. H.2.2. Phase wise implementation schedule are as described below.

Phase I, for five (5) and half years, will be started by detailed design, construction of camp facilities and procurement of vehicles and office equipment for approximately one (1) year. Procurement of O&M equipment is scheduled within the third year prior to the completion of components. Arrangement and setting-up of the farmer's associations and construction works of other facilities will also start from the first year and continue through to the end of Phase I.

Civil works for the feeder canal and the pump station will be commenced at the middle of the second year while the intake structure starts from the fourth year. Works for the main canal and distributory canals will start from the third year and be followed by commencement of the on-farm development including construction of additional farm roads and drainage works from middle of the fourth year and from the fifth year respectively.

Installation of radial gate for the intake and pump equipment are scheduled from middle of the fourth year to middle of the fifth year. Whole works for the feeder canal and intake facility as well as Phase I part of the main canal (section 1), pump station and distributory canals (D1 to D6) are planned to be completed by middle of the fifth year and the rest of all works for Phase I are to be completed by middle of the sixth year.

Phase II, for four (4) and half years, will be commenced by detailed design and arrangement for farmer's associations for approximately one (1) year. Phase II part of the main canal and distributory canals and other facilities will be commenced from the fifth year and followed by Phase II part of the pump station, drainage works and on-farm development including additional farm roads from middle of the fifth year. Installation of pump equipment is scheduled within the sixth year. Whole works are planned to be completed by the end of the seventh year.

H.3 Cost Estimate

H.3.1 Basic Conditions and Assumption for the Cost Estimate

The project cost comprises direct construction cost including project components, compensation cost for the land acquisition and Miscellaneous works, indirect construction cost including consultancy services, procurement of Office and O&M equipment and administration cost, physical and price contingency and interest and service charge. Following basic conditions and assumption are made for the estimate of the project cost.

(1) The unit prices are analyzed on current price basis at the time of March, 1994 for the cost estimate.

(2) The exchange rate used in the cost estimate is shown as follows.
US$ 1.0 = Rs. 30.0 = ¥ 107.1 as average during the period from July, 1993 to March, 1994.

(3) Construction works would be executed by full contract basis through international competitive bidding. The machinery and equipment required for construction works would be provided by the contractors themselves. Therefore, depreciation costs of machinery and equipment are considered in the estimate of the construction unit cost.

(4) Taxes on the construction materials, machinery and equipment to be imported from abroad are excluded from the cost estimate but taxation for machinery and equipment are separately listed up in Table H.2.2 based on current Excise and Taxation condition in Pakistan.

(5) The construction cost integrated by construction unit costs is divided into both foreign and local currency portions. Local currency portion is estimated on the basis of the current price as at March, 1994 and of the data collected from the on-going projects and markets around the project area. Foreign currency portion is estimated based on the CIF prices at Karachi.

(6) The physical contingency estimated at 10 % of the direct construction cost is included in the construction cost of both foreign and local currency portions.

H.3.2 Estimate of the Project Cost

Based on the conditions and assumption mentioned above, the construction cost for the project is summarized below. Details of each items are shown in Table H.3.1.

Cost Component	Foreign Currency (1,000Rs.)	Local Currency (1,000Rs.)	Total (1,000Rs.)
1. Direct Construction Cost	6,251,158	3,869,243	10,120,402
2. Indirect Construction Cost	1,000,185	619,079	1,619,264
3. Physical Contingency	625,116	386,924	1,012,040
Base Construction Cost	7,876,459	4,875,247	12,751,706
4. Price Contingency	2,281,202	1,779,755	4,060,957
5. Interest and Service Charge	218,907	134,183	353,090
Project Cost	10,376,568	6,789,185	17,165,753

Phase wise cost are summarized below and details are shown in Table H.3.2.

Phase wise Cost	Foreign Currency (1,000Rs.)	Local Currency (1,000Rs.)	Total (1,000Rs.)
1. Phase I	5,343,524	3,498,414	8,841,938
2. Phase II	5,033,045	3,290,771	1,619,264
Project Cost	10,376,568	6,789,185	17,165,753

H.3.3 Breakdown of Project Cost

(1) Land Acquisition and Compensation Cost

Cost for land acquisition is and compensation for the project is estimated based on the land price data from Excise and Taxation office and construction cost for normal house. Land acquisition cost and compensation cost are 97.9 million Rs. and 75.0 million Rs. respectively and shown in Table H.3.3. The cost is figured as a component of the direct construction cost for the project.

(2) Direct Construction Cost

Direct construction cost was estimated for the individual components by unit cost basis as discussed in the following Subsection H.3.5. Cost breakdown for major components such as Feeder canal, pump station, Main canal and river treatment and drainage canals are described in Table H.3.4, H.3.5, H.3.6 and H.3.7 respectively. List of pump equipment proposed are shown in Table H.3.8.

(3) Consultancy Service Costs

Consultancy services by foreign Consultants is required for the detailed design and construction supervision stages. Total required man-month of the engineers

including local consultant is 193 M/M for the detailed design and 964 M/M for the construction supervision for Phase I and 193 M/M for the detailed design and 864 M/M for the construction supervision for Phase II. The breakdown of the consultancy service costs and required man-month are shown in Tables H.3.10 and H.3.11.

(4) O&M Equipment

All the construction equipment and materials necessary for the construction of the Project would be provided by the contractors. While, vehicles, O&M equipment and office equipment are planned to be procured within the implementation cost by the Government for the smooth operation and maintenance of the Project facilities after the completion of the construction works.

The number of the vehicles, O&M equipment and office equipment and their procurement costs are estimated as listed in Table H.3.9.

(5) Administration Cost

Organization of the project office for implementation are as described in ANNEX F. Administration costs during implementation stage comprise staff salary, and direct costs such as office equipment, operation and maintenance costs for the vehicles and office operation costs.

H.3.4 Annual Disbursement Schedule

The annual disbursement schedule for the project is worked out as shown in Table H.3.12 based on the project implementation schedule illustrated in Fig. H.2.2 and the summary is as follows.

Unit: Rs. 10^6

Financial Year	Total	Foreign Currency	Local Currency
year 1	638.0	458.9	179.1
year 2	932.2	539.8	392.4
year 3	1,655.2	1,002.5	652.7
year 4	2,918.7	1,711.0	1,207.7
year 5	4,374.1	2,602.2	1,771.9
year 6	4,000.5	2,497.0	1,503.5
year 7	2,647.0	1,565.1	1,081.9
Total	17,165.8	10,376.6	6,789.2

H.3.5 Unit Cost Analysis

Construction cost was calculated by use of detailed unit cost. Each unit cost is composed of the basic unit cost and working rate of labor and/or construction machinery. Basic costs of and materials surveyed and those classifications of foreign and local portions are shown in Table H.3.13.

Summary of CIF prices of the major construction machinery and equipment, and their hourly costs including the depreciation costs, operation and maintenance costs are shown in Table H.3.14. Unit cost was calculated by each, according to the proposed work items which were designed by construction method. Analyzed unit cost is summarized in Table H.3.15.

H.3.6 Annual Operation and Maintenance Cost

Annual operation and maintenance cost comprise of the salaries for administrative and technical staff, the materials and costs for replace and maintenance of the project facilities , and the costs for operation and maintenance of O&M equipment. The summary of the annual operation and maintenance cost is shown in Table H.3.16.

H.3.7 Replacement Cost

Some of the facilities installed or constructed in the Project have some shorter useful life than the Project life and will require replacement at a certain time within the project useful life. The replacement costs and the useful lives of these facilities are listed in Table H.3.20 .

TABLES

Table H.2.1 Monthly Workable Days

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1984	31	28	31	30	31	30	28	30	29	31	30	31
1985	31	28	31	30	31	30	28	31	30	31	30	30
1986	31	28	29	28	28	30	26	28	30	30	30	31
1987	31	26	29	30	31	30	30	31	30	31	30	31
1988	31	28	30	30	31	30	26	31	30	31	30	30
1989	31	28	31	30	31	30	29	27	30	31	30	29
1990	31	29	30	30	30	29	29	28	26	31	30	30
1991	31	27	30	29	31	30	31	26	30	31	30	31
1992	31	26	29	29	31	30	29	29	24	31	30	31
1993	31	27	28	29	31	30	-	-	-	-	-	-
Total	310	275	298	295	306	299	256	261	259	278	270	274
Workable Days	31.0	27.5	29.8	29.5	30.6	29.9	28.4	29.0	28.8	30.9	30.0	30.4

Note; Hyphone shows lack of data

Table H.2.2 List of Major Construction Equipment and Machinery and Taxation

Unit: 1,000 Rs.

No.	Equipment	Specifications Spec.	PS	Tax Ratio	CIF Price for each Machine	Nos of Machine Required	Amount of Tax and Duty
A	**Earth Moving & Excavation**						
1.	Bulldozer ,D6 with Ripper	11t	160	90%	3,300	50	148,500
2.	Bulldozer ,D7 with Ripper	17 t	220	90%	4,950	60	267,300
3.	Bulldozer ,D8 with Ripper	21 t	290	90%	6,600	50	297,000
4.	Tractor shovel	1.2m3	100	70%	2,000	20	28,000
5.	Excavator	0.6m3	140	90%	3,500	125	393,750
6.	Excavator	1.2m3	210	90%	5,250	125	590,625
9.	Wheel loader	2.2m3	160	90%	2,500	50	112,500
10.	Dump truck	11 t	210	90%	1,000	60	54,000
11.	Dump truck	20 t	290	90%	1,500	50	67,500
B.	**Compaction**						
12.	Tire roller	11-17t	100	90%	1,000	30	27,000
13.	Tire roller	21-31t	150	90%	1,250	10	11,250
16.	Vibration roller	3t	25	90%	1,000	10	9,000
17.	Vibration roller	15t	160	90%	1,100	10	9,900
18.	Sheet-Foot Roller	11-17t	100	90%	1,000	5	4,500
19.	Pneumatic Vibrater	-	-	90%	20	50	900
20.	Tractor Water Bowser,4m3	5 t	60	90%	500	50	22,500
21.	Water tank rolly, 10m3	11 t	210	90%	1,000	50	45,000
22.	Moter Grader of 3.7m brade	17 t	150	90%	1,500	40	54,000
C.	**Other Equipment**		L.S.			100	35,000
	sub-total					**945**	**2,178,225**
	Additional Tax(Sales and other)						501,953
	TOTAL AMOUNT OF TAX AND DUTY						**2,680,178**

Note: in addition to above, 21% of sales or other kind of tax would be charged

CIF Karachi price is estimated as same as domestic price in Japan. US$1.00 = Rs. 30.0 = Yen 107.1

Table H.3.1 Project Cost

Project Cost Component	Working Volume	unit	Foreign Currency (1,000 Rs.)	Local Currency (1,000 Rs.)	Total Cost (1,000 Rs.)
I. Direct Construction Cost					
a) Land Acquisition, Compensation & Preliminary			35,604.8	226,407.2	262,012.0
Land Acquisition	3,200.0	ha	0.0	97,850.0	97,850.0
Compensation(House)	130	nos	0.0	75,000.0	75,000.0
Preliminary(Construction Camp)		L.S.	35,604.8	53,557.2	89,162.0
b) Feeder Canal			1,479,685.8	808,072.7	2,287,758.4
Earthwork	58.6	km	1,080,540.4	281,637.3	1,362,177.7
Structure	241	nos	399,145.3	526,435.4	925,580.7
c) Pump Station	1	sta.	1,193,602.8	395,015.2	1,588,618.0
Pump Equipment		set	909,964.7	162,494.9	1,072,459.5
Other Works*1		set	283,638.1	232,520.3	516,158.5
d) Main Canal			1,084,801.2	1,044,497.6	2,129,298.8
Earthwork	113.3	km	453,934.3	219,631.6	673,565.9
Structure	463	nos	630,866.9	824,866.0	1,455,732.9
e) Distributory Canals			413,238.5	402,778.4	816,016.8
Earthwork	442.6	km	272,449.2	179,933.3	452,382.5
Structure	1,093	nos	140,789.3	222,845.1	363,634.4
f) Regulation Pond	25	nos	330,307.0	265,176.4	595,483.5
h) River Treatment & Drainage Canals	579.5	km	1,247,968.5	273,147.7	1,521,116.2
i) Commercial Roads	32.5	km	11,014.5	7,045.6	18,060.1
j) On-farm Development Cost	115,600.0	ha	346,915.6	292,202.0	639,117.6
k) Sump Well & Domestic Water Supply		nos	10,915.6	9,244.5	20,160.2
l) Other and Miscellaneous Works		L.S.	97,104.0	145,656.0	242,760.0
Sub-total			**6,251,158.3**	**3,869,243.3**	**10,120,401.6**
II. Indirect Construction Cost					
a) Consultancy Service Cost(10% to D.Cost)		L.S.	625,115.8	386,924.3	1,012,040.2
b) Implementation Cost(6% to D.Cost)		L.S.	375,069.5	232,154.6	607,224.1
- Procurement of Office and O&M Equipment			208,500.0		208,500.0
- Administration Cost			166,569.5	232,154.6	398,724.1
Sub-total			**1,000,185.3**	**619,078.9**	**1,619,264.3**
III. Physical Contingency	10%		**625,115.8**	**386,924.3**	**1,012,040.2**
Total Base Construction Cost			**7,876,459.4**	**4,875,246.6**	**12,751,706.0**
IV. Price Contingency*2	29%	F.C.	**2,281,201.8**	**1,779,755.1**	**4,060,956.9**
	37%	L.C.			
V. Interest and Service Charge			**218,907.1**	**134,183.2**	**353,090.3**
a) Interest During Construction Period (No interest for GOP is proposed)					
b) Bank Service Charge(1 %)	3%		218,907.1	134,183.2	353,090.3
GRAND TOTAL COST			**10,376,568.4**	**6,789,184.9**	**17,165,753.3**

Note; *1: Construction cost of the substation is counted within the Other Works.

However counteraction work of transmission line is not considered because installation of transmission line for the Project should be done by the GOP in consideration of nationwide facilitating plan of national grid of electricity supply.

*2:with annual escalating of 4.5% for F.C. and 5.5 % for L.C.

Table H.3.2 Phasewise Construction Cost

Project Cost Component	Project Total			Phase I			Phase II		
	Foreign Currency (1,000 Rs.)	Local Currency (1,000 Rs.)	Total Cost (1,000 Rs.)	Foreign Currency	Local Currency	Total Cost	Foreign Currency	Local Currency	Total Cost
I. Direct Construction Cost									
a) Land Acquisition, Compensation & Preliminary (3200ha) (I:Camp, 1,000ha and 72 houses II: 2,200ha and 58 houses)	35,604.8	226,407.2	262,012.0	35,604.8	119,407.2	155,012.0	0.0	107,000.0	107,000.0
b) Feeder Canal (58.6km)	1,479,685.8	808,072.7	2,287,758.4	1,479,685.8	808,072.7	2,287,758.4	0.0	0.0	0.0
c) Pump Station (1 station) (I: Major part of Pump equipment and Delivery Pipe)	1,193,602.8	395,015.2	1,588,618.0	679,383.4	282,032.4	961,415.8	514,219.3	112,982.8	627,202.1
d) Main Canal (113.3km) (I: Sta.0-Sta.32+800 II: Further to the End)	1,084,801.2	1,044,497.6	2,129,298.8	471,888.5	454,356.4	926,245.0	612,912.7	590,141.1	1,203,053.8
e) Distributory Canals (442.6km) (I: D-1 to D-6 II: D-7 to D-25)	413,238.5	402,778.4	816,016.8	97,111.0	94,652.9	191,764.0	316,127.4	308,125.4	624,252.9
f) Regulation Pond (25 nos) (Same as above)	330,307.0	265,176.4	595,483.5	77,622.2	62,316.5	139,938.6	252,684.9	202,860.0	455,544.9
h)Drainage Canals (579.5km) (Same as above)	1,247,968.5	273,147.7	1,521,116.2	293,272.6	64,189.7	357,462.3	954,695.9	208,958.0	1,163,653.9
i) Commercial Roads (32.5km) (Same as above)	11,014.5	7,045.6	18,060.1	2,588.4	1,655.7	4,244.1	8,426.1	5,389.9	13,816.0
j) On-farm Development Cost (32.5km) (Same as above)	346,915.6	292,202.0	639,117.6	81,525.2	68,667.5	150,192.6	265,390.4	223,534.5	488,925.0
k) Sump Well & Domestic Water Supply (L.S.) (Same as above)	10,915.6	9,244.5	20,160.2	2,565.2	2,172.5	4,737.6	8,350.5	7,072.1	15,422.5
l) Other and Miscellaneous Works (L.S.) (Same as above)	97,104.0	145,656.0	242,760.0	38,841.6	58,262.4	97,104.0	58,262.4	87,393.6	145,656.0
Sub-total of Direct Construction Cost	**6,251,158.3**	**3,869,243.3**	**10,120,401.6**	**3,260,088.7**	**2,015,785.8**	**5,275,874.5**	**2,991,069.6**	**1,853,457.5**	**4,844,527.1**
II. Indirect Construction Cost									
a) Consultancy Service Cost(10% to D.Cost)	625,115.8	386,924.3	1,012,040.2	326,008.9	201,578.6	527,587.5	299,107.0	185,345.7	484,452.7
b) Implementation Cost(6% of D. Cost)	375,069.5	232,154.6	607,224.1	195,605.3	120,947.2	316,552.5	179,464.2	111,207.4	290,671.6
Sub-total	**1,000,185.3**	**619,078.9**	**1,619,264.3**	**521,614.2**	**322,525.7**	**844,139.9**	**478,571.1**	**296,553.2**	**775,124.3**
III. Physical Contingency (10%)	**625,115.8**	**386,924.3**	**1,012,040.2**	**326,008.9**	**201,578.6**	**527,587.5**	**299,107.0**	**185,345.7**	**484,452.7**
Total Base Construction Cost	**7,876,459.4**	**4,875,246.6**	**12,751,706.0**	**4,107,711.7**	**2,539,890.2**	**6,647,601.9**	**3,768,747.7**	**2,335,356.4**	**6,104,104.1**
IV. Price Contingency*1	**2,281,201.8**	**1,779,755.1**	**4,060,956.9**	**1,148,159.6**	**905,819.8**	**2,053,979.4**	**1,133,042.2**	**873,935.3**	**2,006,977.5**
V. Interest and Service Charge	**218,907.1**	**134,183.2**	**353,090.3**	**87,652.2**	**52,704.1**	**140,356.3**	**131,254.9**	**81,479.2**	**212,734.1**
GRAND TOTAL COST	**10,376,568.4**	**6,789,184.9**	**17,165,753.3**	**5,343,523.5**	**3,498,414.1**	**8,841,937.6**	**5,033,044.8**	**3,290,770.9**	**8,323,815.7**

Note; *1: with annual escalation of 4.5% for F.C. and 5.5 % for L.C.

Table H.3.3 Cost of Land Aquisition and Compensation

Item	Unit	Unit Rate (1,000Rs.)	Q'ty	Amount (1,000Rs.)
I. Land Acquisition				
a) Rod kohi Area	ha	3,000	3,200	95,850
- Feeder canal	- do -	- do -	322	9,660
- Main canal	- do -	- do -	574	17,220
- Distributory canals	- do -	- do -	709	21,270
- Drainage canals	- do -	- do -	1,248	37,440
- Quarry and other area	- do -	- do -	347	10,260
b) Village Area	ha	400,000	5	2,000
- Feeder canal	- do -	- do -	2	800
- Main canal	- do -	- do -	2	800
- Distributory canals & and other area	- do -	- do -	1	400
sub-total				97,850
II. Compensation				
a) Residence	nos	440,000	130	57,200
- Feeder canal area	- do -	- do -	54	23,760
- Main canal area	- do -	- do -	54	23,760
- Distributory canals & other area	- do -	- do -	22	9,680
b) Miscellaneous expense	L.S.			17,800
sub-total				75,000
Total				172,850

Table H.3.4 Breakdown of Construction Cost for Feeder Canal Including Intake Structure

Unit: Pakistan Rs.

Description	Unit	Unit Price		Work	Construction Cost		
		F.C.	L.C.	Volume	F.C.	L.C.	Total
A. Earthwork & Stonework							
Stripping of Top Soil	m2	2.5	0.5	785,640	1,964,100	400,676	2,364,776
Excavation Common(Backhoe),Type 1	m3	37.2	6.4	4,103,799	152,661,306	26,264,311	178,925,617
Excavation Common(Backhoe),type 2	m3	38.8	8.6		0	0	0
Excavation Common(Composite),Type 1	m3	31.7	6.3	3,556,875	112,752,947	22,408,314	135,161,262
Excavation Common(Composite),Type 2	m3	26.6	6.8		0	0	0
Excavation Manual	m3	0.0	25.2		0	0	0
Excavation of Common Rock(ripper-dozer)	m3	92.8	14.3	3,328,997	308,930,922	47,604,657	356,535,579
Excavation for Structure(Small Backhoe)	m3	36.1	11.4		0	0	0
Excavation for Drain	m3	33.8	4.2		0	0	0
Haulage of Earth Material,type1	m3*km	4.9	0.9	35,568,753	174,286,890	32,011,878	206,298,768
Haulage of Earth Material,type 2	m3*km	3.8	2.3		0	0	0
Embankment and Compaction,type 1	m3	33.9	5.7	7,250,294	245,784,967	41,326,676	287,111,642
Embankment and Compaction, type 2	m3	33.6	8.0	13,200	443,520	105,600	549,120
Embankment and Compaction,Manual	m3	0.0	23.0		0	0	0
Embankment for Drain	m3	19.3	4.5		0	0	0
Backfill&Compaction ,type 1	m3	43.3	7.4		0	0	0
Backfill&Compaction,Type 2	m3	42.6	9.9		0	0	0
Sod Facing(turfing)	m2	0.0	11.0	225,000	0	2,475,000	2,475,000
Dredging Work	m3	55.7	6.2		0	0	0
Sand Filter	m3	36.6	226.5		0	0	0
Loading or Unloading of Earth Material,1	m3	14.6	4.0	3,556,875	51,930,379	14,227,501	66,157,881
Loading or Unloading of Earth Material,2	m3	0.0	20.3		0	0	0
Gravelling & Compaction of sub-base	m2	7.5	13.0	19,200	143,232	250,176	393,408
Base Coarse filling and Compaction	m3	110.8	219.5	146,076	16,185,190	32,063,621	48,248,810
Metalling and Tarring	m2	142.3	106.4	19,200	2,732,160	2,042,880	4,775,040
Wet Masonry	m3	557.8	1,093.6		0	0	0
Dry Masonry	m3	96.4	458.0	132,000	12,724,800	60,456,000	73,180,800
Gabbion Mattress	m3	259.1	473.1		0	0	0
Blick Masonry	m3	250.0	1,100.0		0	0	0
Riprap	m3	26.0	196.0		0	0	0
SUB-TOTAL					1,080,540,413	281,637,290	1,362,177,703
B. Structure and Other Work							
a) Lining Work					191,768,500	275,566,500	467,335,000
Reinforced Concrete Lining at Structure	m2	611.6	630.0		0	0	0
Concrete Lining Type 1	m2	119.0	171.0	1,611,500	191,768,500	275,566,500	467,335,000
Concrete Lining Type 2	m2	72.7	120.5		0	0	0
b) Other Work					15,661,497	48,334,688	63,996,185
Building	m2	1,400.0	3,000.0	200	280,000	600,000	880,000
Reforestation	1,000nos	7,160.9	5,294.3	56	401,010	296,481	697,491
Blasting of Rock	m3	30.0	95.0	499,350	14,980,487	47,438,207	62,418,694
In-situ RC Piling(0.75m in dia) by Auger	m	1,485.0	1,215.0		0	0	0
c) Related Structures					191,715,347	202,534,208	394,249,555
Intake Structure	nos	42,006,426.6	37,054,158.1	1	42,006,426.6	37,054,158.1	79,060,585
Berm Drain	nos	3,934.3	4,791.7	197	775,062.6	943,960.4	1,719,023
Cross Drain(Nala Culvert)	nos	7,831,106.4	8,785,013.1	1	7,831,106.4	8,785,013.1	16,616,119
Cross Drain(Super Passage)	nos	11,490,148.1	12,766,764.7	11	126,391,628.7	140,434,412.0	266,826,041
Escape with Silt Ejecter	nos	3,639,342.9	3,732,001.4	1	3,639,342.9	3,732,001.4	7,371,344
D.R. Bridge	nos	1,045,762.9	1,001,772.6	1	2,091,525.9	2,003,545.2	4,095,071
V.R. Bridge	nos	401,638.0	419,376.4	17	6,827,846.6	7,129,398.7	13,957,245
Footpath Bridge	nos	195,673.4	222,883.6	11	2,152,407.1	2,451,719.3	4,604,126
SUB-TOTAL					399,145,344	526,435,396	925,580,740
GRAND TOTAL					**1,479,685,756**	**808,072,686**	**2,287,758,442**

Table H.3.5 Brakedown of Construction Cost for Pump Station

Unit: Pakistan Rs.

Description	Unit	Unit Price		Work	Construction Cost		
		F.C.	L.C.	Volume	F.C.	L.C.	Total
A. Earthwork & Stonework							
Stripping of Top Soil	m2	2.5	0.5		0	0	0
Excavation Common(Backhoe),Type 1	m3	37.2	6.4	289,659	10,775,315	1,853,818	12,629,132
Excavation Common(Backhoe),type 2	m3	38.8	8.6		0	0	0
Excavation Common(Composite),Type 1	m3	31.7	6.3	160,959	5,102,400	1,014,042	6,116,442
Excavation Common(Composite),Type 2	m3	26.6	6.8		0	0	0
Excavation Manual	m3	0.0	25.2		0	0	0
Excavation of Common Rock(ripper-dozer)	m3	92.8	14.3		0	0	0
Excavation for Structure(Small Backhoe)	m3	36.1	11.4		0	0	0
Excavation for Drain	m3	33.8	4.2		0	0	0
Haulage of Earth Material,type1	m3*km	4.9	0.9	358,140	1,754,886	322,326	2,077,212
Haulage of Earth Material,type 2	m3*km	3.8	2.3		0	0	0
Embankment and Compaction,type 1	m3	33.9	5.7	71,628	2,428,189	408,280	2,836,469
Embankment and Compaction, type 2	m3	33.6	8.0		0	0	0
Embankment and Compaction,Manual	m3	0.0	23.0		0	0	0
Embankment for Drain	m3	19.3	4.5		0	0	0
Backfill&Compaction ,type 1	m3	43.3	7.4	27,359	1,184,645	202,457	1,387,101
Backfill&Compaction,Type 2	m3	42.6	9.9		0	0	0
Sod Facing(turfing)	m2	0.0	11.0		0	0	0
Dredging Work	m3	55.7	6.2		0	0	0
Sand Filter	m3	36.6	226.5		0	0	0
Loading or Unloading of Earth Material,1	m3	14.6	4.0	71,628	1,045,769	286,512	1,332,281
Loading or Unloading of Earth Material,2	m3	0.0	20.3		0	0	0
Gravelling & Compaction of sub-base	m2	7.5	13.0		0	0	0
Base Coarse filling and Compaction	m3	110.8	219.5		0	0	0
Metalling and Tarring	m2	142.3	106.4		0	0	0
Wet Masonry	m3	557.8	1,093.6		0	0	0
Dry Masonry	m3	96.4	458.0		0	0	0
Gabbion Mattress	m3	259.1	473.1	94	24,381	44,519	68,900
Blick Masonry	m3	250.0	1,100.0		0	0	0
Riprap	m3	26.0	196.0		0	0	0
SUB-TOTAL					22,315,585	4,131,952	26,447,537
B. Structure and Other Work							
a) Concrete and other					29,082,003	39,603,965	68,685,968
Concrete A (140kgf/cm2,1:4:8)	m3	610.4	706.2	258.0	157,483.2	182,199.6	339,682.8
Concrete B (170kgf/cm2,1:3:6)	m3	761.8	965.4		0.0	0.0	0.0
Concrete C (210kgf/cm2 ,1:2:4)	m3	858.9	1,110.9	7,497.9	6,439,946.3	8,329,417.1	14,769,363.4
Wooden Form	m2	16.4	93.4	10,680.8	175,165.1	997,586.7	1,172,751.8
Reinforcement Bar	kg	12.2	10.8	599,800.0	7,311,562.0	6,480,839.0	13,792,401.0
Reinforced Concrete Lining at Structure	m2	611.6	630.0	1,164.5	712,208.2	733,635.0	1,445,843.2
Concrete Lining Type 1	m2	119.0	171.0	100,603.0	11,971,757.0	17,203,113.0	29,174,870.0
Concrete Lining Type 2	m2	72.7	120.5		0.0	0.0	0.0
Steel Slip Form	m2	7.2	25.5	1,039.0	7,480.8	26,494.5	33,975.3
Fixed Wheel Gate Installation(W/O C/W)	m2	26,100.0	63,945.0	84.0	2,192,400.0	5,371,380.0	7,563,780.0
Slide Gate Installation	m2	22,800.0	55,860.0	5	114,000.0	279,300.0	393,300.0
b) Related Structures					1,142,999,952	350,776,242	1,493,776,194
Suction Pit and Pump House	nos	80,037,946.8	87,060,471.3	1	80,037,946.8	87,060,471.3	167,098,418
Pump and Auxiliary Equipment	nos	909,964,650.0	162,494,850.0	1	909,964,650.0	162,494,850.0	1,072,459,500
Delivery Pipeline	nos	148,043,087.4	97,346,234.8	1	148,043,087.4	97,346,234.8	245,389,322
Outlet Pond	nos	4,954,268.0	3,874,685.8	1	4,954,268.0	3,874,685.8	8,828,954
SUB-TOTAL					1,172,081,955	390,380,207	1,562,462,162
GRAND TOTAL					**1,193,603**	**395,015**	**1,588,618**

Table H.3.6 Breakdown of Construction for Main Canal

Unit: Pakistan Rs.

Description	Unit	Unit Price		Work	Construction Cost		
		F.C.	L.C.	Volume	F.C.	L.C.	Total
A. Earthwork & Stonework							
Stripping of Top Soil	m2	2.5	0.5	1,467,700	3,669,250	748,527	4,417,777
Excavation Common(Backhoe),Type 1	m3	37.2	6.4	6,274,318	233,404,630	40,155,635	273,560,265
Excavation Common(Backhoe),type 2	m3	38.8	8.6		0	0	0
Excavation Common(Composite),Type 1	m3	31.7	6.3		0	0	0
Excavation Common(Composite),Type 2	m3	26.6	6.8		0	0	0
Excavation Manual	m3	0.0	25.2		0	0	0
Excavation of Common Rock(ripper-dozer)	m3	92.8	14.3		0	0	0
Excavation for Structure(Small Backhoe)	m3	36.1	11.4		0	0	0
Excavation for Drain	m3	33.8	4.2		0	0	0
Haulage of Earth Material,type1	m3*km	4.9	0.9	8,000,000	39,200,000	7,200,000	46,400,000
Haulage of Earth Material,type 2	m3*km	3.8	2.3		0	0	0
Embankment and Compaction,type 1	m3	33.9	5.7	2,694,932	91,358,195	15,361,112	106,719,307
Embankment and Compaction, type 2	m3	33.6	8.0		0	0	0
Embankment and Compaction,Manual	m3	0.0	23.0		0	0	0
Embankment for Drain	m3	19.3	4.5	1,588,094	30,650,217	7,146,424	37,796,640
Backfill&Compaction ,type 1	m3	43.3	7.4		0	0	0
Backfill&Compaction,Type 2	m3	42.6	9.9		0	0	0
Sod Facing(turfing)	m2	0.0	11.0	195,000	0	2,145,000	2,145,000
Dredging Work	m3	55.7	6.2		0	0	0
Sand Filter	m3	36.6	226.5		0	0	0
Loading or Unloading of Earth Material,1	m3	14.6	4.0	500,000	7,300,000	2,000,000	9,300,000
Loading or Unloading of Earth Material,2	m3	0.0	20.3		0	0	0
Gravelling & Compaction of sub-base	m2	7.5	13.0		0	0	0
Base Coarse filling and Compaction	m3	110.8	219.5	276,452	30,630,882	60,681,214	91,312,096
Metalling and Tarring	m2	142.3	106.4		0	0	0
Wet Masonry	m3	557.8	1,093.6		0	0	0
Dry Masonry	m3	96.4	458.0	183,829	17,721,118	84,193,691	101,914,809
Gabbion Mattress	m3	259.1	473.1		0	0	0
Blick Masonry	m3	250.0	1,100.0		0	0	0
Riprap	m3	26.0	196.0		0	0	0
SUB-TOTAL					453,934,290	219,631,603	673,565,894
B. Structure and Other Work							
a) Lining Work					301,703,080	433,539,720	735,242,800
Reinforced Concrete Lining at Structure	m2	611.6	630.0		0	0	0
Concrete Lining Type 1	m2	119.0	171.0	2,535,320	301,703,080	433,539,720	735,242,800
Concrete Lining Type 2	m2	72.7	120.5		0	0	0
b) Other Work					811,330	599,844	1,411,174
Building	m2	1,400.0	3,000.0		0	0	0
Reforestation	1,000nos	7,160.9	5,294.3	113	811,330	599,844	1,411,174
Blasting of Rock	m3	30.0	95.0		0	0	0
In-situ RC Piling(0.75m in dia) by Auger	m	1,485.0	1,215.0		0	0	0
c) Related Structures					328,352,483	390,726,419	719,078,901
Drainage Culvert	nos	9,574,021.6	9,560,608.5	10	95,740,216	95,606,085	191,346,301
Super Passage(Canal Culvert)	nos	16,626,141.9	19,082,572.0	9	149,635,277	171,743,148	321,378,425
Cross Regulator	nos	2,549,845.8	4,558,419.0	18	45,897,224	82,051,542	127,948,766
Escape	nos	4,053,182.3	4,131,665.7	5	20,265,912	20,658,329	40,924,240
Berm Drain	nos	3,934.3	4,791.7	377	1,483,242	1,806,462	3,289,704
Head Regulator to Distributory	nos	237,327.1	384,381.1	24	5,695,852	9,225,148	14,920,999
A.R. Bridge	nos	1,292,899.2	1,237,247.0	1	1,292,899	1,237,247	2,530,146
D.R. Bridge	nos	944,333.6	904,609.9	4	3,777,334	3,618,440	7,395,774
V.R. Bridge	nos	358,792.9	372,228.3	11	3,946,722	4,094,511	8,041,233
Footpath Bridge	nos	154,451.4	171,376.9	4	617,805	685,507	1,303,313
SUB-TOTAL					630,866,893	824,865,983	1,455,732,876
GRAND TOTAL					**1,084,801,183**	**1,044,497,586**	**2,129,298,769**

Table H.3.7 Breakdown of Construction Cost for River Treatment and Drainage Canals

Unit: Pakistan Rs.

Description	Unit	Unit Price		Work	Construction Cost		
		F.C.	L.C.	Volume	F.C.	L.C.	Total
A. Earthwork & Stonework							
Stripping of Top Soil	m2	2.5	0.5		0.0	0.0	0.0
Excavation Common(Backhoe),Type 1	m3	37.2	6.4		0.0	0.0	0.0
Excavation Common(Backhoe),type 2	m3	38.8	8.6		0.0	0.0	0.0
Excavation Common(Composite),Type 1	m3	31.7	6.3	1,234,900	39,146,330.0	7,779,870.0	46,926,200.0
Excavation Common(Composite),Type 2	m3	26.6	6.8		0.0	0.0	0.0
Excavation Manual	m3	0.0	25.2		0.0	0.0	0.0
Excavation of Common Rock(ripper-dozer)	m3	92.8	14.3		0.0	0.0	0.0
Excavation for Structure(Small Backhoe)	m3	36.1	11.4		0.0	0.0	0.0
Excavation for Drain	m3	33.8	4.2	20,250,000	684,450,000.0	85,050,000.0	769,500,000.0
Haulage of Earth Material,type1	m3*km	4.9	0.9	370,470	1,815,303.0	333,423.0	2,148,726.0
Haulage of Earth Material,type 2	m3*km	3.8	2.3		0.0	0.0	0.0
Embankment and Compaction,type 1	m3	33.9	5.7	970,000	32,883,000.0	5,529,000.0	38,412,000.0
Embankment and Compaction, type 2	m3	33.6	8.0		0.0	0.0	0.0
Embankment and Compaction,Manual	m3	0.0	23.0		0.0	0.0	0.0
Embankment for Drain	m3	19.3	4.5	15,996,000	308,722,800.0	71,982,000.0	380,704,800.0
Backfill&Compaction ,Type 1	m3	43.3	7.4		0.0	0.0	0.0
Backfill&Compaction,Type 2	m3	42.6	9.9		0.0	0.0	0.0
Sod Facing(turfing)	m2	0.0	11.0		0.0	0.0	0.0
Dredging Work	m3	55.7	6.2		0.0	0.0	0.0
Sand Filter	m3	36.6	226.5		0.0	0.0	0.0
Loading or Unloading of Earth Material,1	m3	14.6	4.0	1,234,900	18,029,540.0	4,939,600.0	22,969,140.0
Loading or Unloading of Earth Material,2	m3	0.0	20.3		0.0	0.0	0.0
Gravelling & Compaction of sub-base	m2	7.5	13.0		0.0	0.0	0.0
Base Coarse filling and Compaction	m3	110.8	219.5		0.0	0.0	0.0
Metalling and Tarring	m2	142.3	106.4		0.0	0.0	0.0
Wet Masonry	m3	557.8	1,093.6		0.0	0.0	0.0
Dry Masonry	m3	96.4	458.0		0.0	0.0	0.0
Gabbion Mattress	m3	259.1	473.1		0.0	0.0	0.0
Blick Masonry	m3	250.0	1,100.0		0.0	0.0	0.0
Riprap	m3	26.0	196.0		0.0	0.0	0.0
SUB-TOTAL					1,085,046,973.0	175,613,893.0	1,260,660,866.0
B. Concrete Work							
Concrete A (140kgf/cm2,1:4:8)	m3	610.4	706.2		0.0	0.0	0.0
Concrete B (170kgf/cm2,1:3:6)	m3	761.8	965.4		0.0	0.0	0.0
Concrete C (210kgf/cm2 ,1:2:4)	m3	858.9	1,110.9		0.0	0.0	0.0
Wooden Form	m2	16.4	93.4		0.0	0.0	0.0
Reinforcement Bar	kg	12.2	10.8		0.0	0.0	0.0
Reinforced Concrete Lining at Structure	m2	611.6	630.0		0.0	0.0	0.0
Concrete Lining Type 1	m2	119.0	171.0		0.0	0.0	0.0
Concrete Lining Type 2	m2	72.7	120.5		0.0	0.0	0.0
Steel Slip Form	m2	7.2	25.5		0.0	0.0	0.0
Mortar	m3	839.1	1,138.9		0.0	0.0	0.0
SUB-TOTAL					0.0	0.0	0.0
C. Other Work							
A.R. Bridge (76.5m length ave.)	nos	3,878,697.7	3,878,697.7	2	7,757,395.3	7,757,395.3	15,514,790.7
D.R. Bridge (195.4m length ave.)	nos	8,366,103.5	8,366,103.5	7	58,562,724.3	58,562,724.3	117,125,448.6
V.R. Bridge (32.8m length ave.)	nos	594,190.9	1,568,644.4	7	4,159,336.3	10,980,510.8	15,139,847.1
Causeway	nos			0	0.0	0.0	0.0
Divider of Flood	nos			0	0.0	0.0	0.0
SUB-TOTAL					70,479,455.9	77,300,630.5	147,780,086.4
D. Additional Item(Protection)	%			5%	57,776,321.4	12,645,726.2	70,422,047.6
E. Misccelaneous Works	%			3%	34,665,792.9	7,587,435.7	42,253,228.6
GRAND TOTAL					**1,247,968,543.2**	**273,147,685.3**	**1,521,116,228.6**

Table H.3.8 List of Pump Equipment

Unit: Pakistan Rs.

Description	Unit	Unit Price		Work	Construction Cost		
		F.C.	L.C.	Volume	F.C.	L.C.	Total
A. Pump Equipment							
Large Pump, Vertical Volute Mixed Flow	nos	40,590,000.0	4,510,000.0	6	243,540,000.0	27,060,000.0	270,600,000.0
Small Pump, Vertical Volute Mixed Flow	nos	27,090,000.0	3,010,000.0	2	54,180,000.0	6,020,000.0	60,200,000.0
Main Motor for Large Pump	nos	28,170,000.0	3,130,000.0	6	169,020,000.0	18,780,000.0	187,800,000.0
Main Motor for Small Pump	nos	16,650,000.0	1,850,000.0	2	33,300,000.0	3,700,000.0	37,000,000.0
Check Valve (1800mm in dia)	nos	11,070,000.0	1,230,000.0	6	66,420,000.0	7,380,000.0	73,800,000.0
Check Valve(1200mm in dia)	nos	7,299,000.0	811,000.0	2	14,598,000.0	1,622,000.0	16,220,000.0
Motor Operated Butterfly Valve,4000mm	nos	19,260,000.0	2,140,000.0	2	38,520,000.0	4,280,000.0	42,800,000.0
Motor Operated Butterfly Valve,1800mm	nos	3,573,000.0	397,000.0	6	21,438,000.0	2,382,000.0	23,820,000.0
Motor Operated Butterfly Valve,1200mm	nos	2,637,000.0	293,000.0	2	5,274,000.0	586,000.0	5,860,000.0
Discharge Pipe	lot	16,520,000.0	7,080,000.0	1	16,520,000.0	7,080,000.0	23,600,000.0
Auxiliary Equipments	lot	9,100,000.0	3,900,000.0	1	9,100,000.0	3,900,000.0	13,000,000.0
Emergency Generator (150KVA)	nos	3,857,000.0	1,653,000.0	1	3,857,000.0	1,653,000.0	5,510,000.0
Electlic Equipments	lot	88,200,000.0	37,800,000.0	1	88,200,000.0	37,800,000.0	126,000,000.0
Motor Operated Butterfly Valve,3200mm	nos	12,060,000.0	1,340,000.0	3	36,180,000.0	4,020,000.0	40,200,000.0
SUB-TOTAL					800,147,000.0	126,263,000.0	926,410,000.0
B. Bar Screen and Stop Log							
Bar Screen, 4.0mW-5.5mH	lot	4,739,000.0	2,031,000.0	1	4,739,000.0	2,031,000.0	6,770,000.0
Bar Screen, 3.8m & 2.2mW-5.5mH	lot	11,620,000.0	4,980,000.0	1	11,620,000.0	4,980,000.0	16,600,000.0
Stop Log	lot	3,857,000.0	1,653,000.0	1	3,857,000.0	1,653,000.0	5,510,000.0
SUB-TOTAL					20,216,000.0	8,664,000.0	28,880,000.0
C. Substation							
Sub-station	lot	46,270,000.0	19,830,000.0	1	46,270,000.0	19,830,000.0	66,100,000.0
SUB-TOTAL					46,270,000.0	19,830,000.0	66,100,000.0
D. Additional Item(than above)	%			2.5%	21,665,825.0	3,868,925.0	25,534,750.0
E. Misccelaneous Works	%			2.5%	21,665,825.0	3,868,925.0	25,534,750.0
GRAND TOTAL					**909,964,650.0**	**162,494,850.0**	**1,072,459,500.0**

Table H.3.9 List of Vehicle, O&M Equipment and Office Equipment

No.	Name of Equipment	Price (1,000Rs.)	nos	Total (1,000Rs.)
I.	OFFICE USE			
I-1	Utility Vehich(4WD)	2,000	10	20,000
I-2	Light Geep(4WD)	600	78	46,800
I-3	Pickup Truck(4WD)	1,200	25	30,000
	Sub total		113	96,800
II.	General			
II-1	Vibration Roller (3ton)	1,000	2	2,000
II-2	Back hone(0.6m3)	3,500	4	14,000
II-3	Bull Dozer (11ton)	3,000	4	12,000
II-4	Pickup Truck (4WD)	1,200	4	4,800
II-5	Wheel Loader (1m3)	2,500	3	7,500
II-6	Dump Truck	1,000	6	6,000
II-7	Tructor	350	6	2,100
	Sub total		29	48,400
III.	Intake			
III-1	Pump-ship for Dredging	4,000	2	8,000
IV.	Pump Station			
IV-1	Jet Pump for Cleaning	300	3	900
V.	On-farm Development (for construction also)			
V-1	Tructor with Trenching Attachment	500	50	25,000
VI.	OFFICE & Communication EQUIPMENT	L.S.		29,400
IV.	Spare Parts other Eqwpment(30%)	L.S.		62,550
	Total			208,500

Table H.3.10 Cost of Consultancy Services

Unit: 1,000Rs

Item	Foreign Currency	Local Currency	Total
(Phase I)			
I. Detailed Design stage	47,800	39,240	87,040
1 Remuneration (Foreign 65 M/M)	39,000	-	39,000
2 " (Local 128 M/M)	-	10,240	10,240
3 Direct Cost	5,000	9,000	14,000
4 Other Study Cost & Special Equipment	3,800	20,000	23,800
II. Construction Supervision Stage	278,209	162,339	440,548
1 Remuneration (Foreign 316 M/M)	189,600	-	189,600
2 " (Local 648 M/M)	-	51,840	51,840
3 Other Study Cost & Special Equipment	38,609	30,499	69,108
4 Direct Cost	50,000	80,000	130,000
Phase I Total	326,009	201,579	527,588
(Phase II)			
I. Detailed Design stage	47,800	39,240	87,040
1 Remuneration (Foreign 65 M/M)	39,000	-	39,000
2 " (Local 128 M/M)	-	10,240	10,240
3 Direct Cost	5,000	9,000	14,000
4 Other Study Cost & Special Equipment	3,800	20,000	23,800
II. Construction Supervision stage	251,307	146,105	397,412
1 Remuneration (Foreign 258 M/M)	154,800	-	154,800
2 " (Local 606 M/M)	-	48,480	48,480
3 Other Study Cost & Special Equipment	56,507	37,625	94,132
4 Direct Cost	40,000	60,000	100,000
Phase II Total	299,107	185,345	484,452
Total Cost	**625,116**	**386,924**	**1,012,040**

Table H.3.11 Required Man-months of Consultant Engineers

Unit: Man-Month

Specialist	Phase I			Phase II			Total		
	Foreign Staff	Local Staff	Total	Foreign Staff	Local Staff	Total	Foreign Staff	Local Staff	Total
I. Detailed Design stage									
1 Project Director	1	-	1	1	-	1	2	-	2
2 Team Leader	12	-	12	12	-	12	24	-	24
3 Senior Design Engineer	12	-	12	12	-	12	24	-	24
4 Structure Engineer	12	48	60	12	48	60	24	96	120
5 Soil Mechanical Engineer	4	12	16	4	12	16	8	24	32
6 Engineering Geologist	4	12	16	4	12	16	8	24	32
7 Drainage & Hydrological Engineer	4	12	16	4	12	16	8	24	32
8 On-farm Design Engineer	4	8	12	4	8	12	8	16	24
9 Mechanical Engineer	4	8	12	4	8	12	8	16	24
10 Institutional Coodinator	4	12	16	4	12	16	8	24	32
11 Specialist as required	4	16	20	4	16	20	8	32	40
Sub Total	65	128	193	65	128	193	130	256	386
II. Construction Supervision Stage									
1 Project Director	4	-	4	3	-	3	7	-	7
2 Resident Project Engineer	54	-	54	36	-	36	90	-	90
3 Senior Construction Engineer	54	-	54	36	-	36	90	-	90
4 Construction Supervisor	108	432	540	108	432	540	216	864	1,080
5 Engineering Geologist	12	24	36	6	12	18	18	36	54
6 Mechanical Engineer	12	24	36	9	18	27	21	42	63
7 Institutional Coodinator	24	72	96	24	72	96	48	144	192
8 Specialist as required	48	96	144	36	72	108	84	168	252
Sub Total	316	648	964	258	606	864	574	1,254	1,828
Total Man-Month	**381**	**776**	**1,157**	**323**	**734**	**1,057**	**704**	**1,510**	**2,214**

Table H.3.12 Disbursement Schedule

Unit; 1,000 Rs.

Project Cost Compone	Project Total Cost			Annual Disbursement Schedule													
				1st(1996)		2nd(1997)		3rd(1998)		4th(1999)		5th(2000)		6th(2001)		7th(2002)	
	FC	LC	Total Cost	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC	FC	LC
I. Direct Cost																	
a) Land Acquisition	35,604.8	226,407.2	262,012.0	35605	20582	0	41165	0	41165	0	41165	0	41165	0	41165	0	0
b) Feeder Canal	1,479,685.8	808,072.7	2,287,758.4	0	0	246614	134679	493229	269358	493229	269358	246614	134679	0	0	0	0
c) Pump Station	1,193,602.8	395,015.2	1,588,618.0	0	0	67938	28203	135877	56406	271753	112813	306659	107206	411375	90386		
d) Main Canal	1,084,801.2	1,044,497.6	2,129,298.8							188755	181743	393060	378456	298682	287585	204304	196714
e) Distributory Canals	413,238.5	402,778.4	816,016.8							38844	37861	144220	140570	124798	121639	105376	102708
f) Regulation Pond	330,307.0	265,176.4	595,483.5							31049	24927	115277	92547	99753	80083	84228	67620
h)Drainage Canals	1,247,968.5	273,147.7	1,521,116.2									386454	84585	479636	104980	381878	83583
i) Farm Roads	11,014.5	7,045.6	18,060.1							647	414	2979	1906	4018	2570	3370	2156
j) On-farm Development	346,915.6	292,202.0	639,117.6							20381	17167	93841	79041	126537	106581	106156	89414
k) Sump Well	10,915.6	9,244.5	20,160.2							1026	869	3810	3226	3297	2792	2783	2357
l) Miscellaneous	97,104.0	145,656.0	242,760.0	13872	20808	13872	20808	13872	20808	13872	20808	13872	20808	13872	20808	13872	20808
Sub-total	**6,251,158.3**	**3,869,243.3**	**10,120,401.6**	49477	41390	328425	224855	642977	387737	1059557	707124	1706786	1084188	1561968	858589	901969	565361
II. Indirect Cost																	
a) Consultancy Service	625,115.8	386,924.3	1,012,040.2	131603	81458	82252	50911	98702	61093	164504	101822	65802	40729	49351	30547	32901	20364
b) Implementation	375,069.5	232,154.6	607,224.1	232296	33165	23796	33165	23796	33165	23796	33165	23796	33165	23796	33165	23796	33165
Sub-total	**1,000,185.3**	**619,078.9**	**1,619,264.3**	363899	114623	106048	84076	122498	94258	188300	134987	89597	73894	73147	63712	56696	53529
III. Phisical Contingency	**625,115.8**	**386,924.3**	**1,012,040.2**	4948	4139	32842	22485	64298	38774	105956	70712	170679	108419	156197	85859	90197	56536
Base Cost	**7,876,459.4**	**4,875,246.6**	**12,751,706.0**	418323	160152	467315	331416	829773	520769	1353813	912823	1967062	1266501	1791311	1008159	1048862	675426
IV. Price Contingency	**2,281,201.8**	**1,779,755.1**	**4,060,956.9**	38496	18101	65969	57746	159747	124372	333284	280200	594564	479805	646416	458389	442725	361141
V. Service Charge	**218,907.1**	**134,183.2**	**353,090.3**	2092	801	6520	3259	13005	7520	23923	14687	40528	25584	59319	36957	73520	45375
TOTAL COST	**10,376,568.4**	**6,789,184.9**	**17,165,753.3**	**458911**	**179054**	**539804**	**392422**	**1002525**	**652661**	**1711020**	**1207711**	**2602154**	**1771890**	**2497046**	**1503506**	**1565108**	**1081942**
VI. Annual O&M	0.0	229,721.6	229,721.6	0	0	0	0	0	0	0	0	0	33210	0	49710	0	146802
TOTAL	**10,376,568.4**	**7,018,906.5**	**17,395,474.9**	**458911**	**179054**	**539804**	**392422**	**1002525**	**652661**	**1711020**	**1207711**	**2602154**	**1805100**	**2497046**	**1553215**	**1565108**	**1228744**
FC ; Foreign Currency, LC ; Local Currency																	
Development Area(ha)			115,600.0	0		0		0		6,800		38,100		80,300		115,600	
Area Under Irrigation(ha)			115,600.0	0		0		0		0		18,140		27,210		80,210	

Table H.3.13 Unit Cost of Labour and Construction Materials

No.	Item	Unit	Cost (Rs.)	Component F (%)	Component L (%)	Unit Costs F (Rs.)	Unit Costs L (Rs.)	Remarks
A. Labour								
1	Forman	man-day	150.0	0%	100%	0	150	(Normal Market)
2	Assist. forman/Semi-skilled	man-day	90.0	0%	100%	0	90	(unless otherwise)
3	Heavy equi. ope	man-day	200.0	0%	100%	0	200	(stated hereinafter)
4	Assist. heavy equi. ope	man-day	80.0	0%	100%	0	80	
5	Dump truck driver	man-day	150.0	0%	100%	0	150	
6	Assist. dump driver	man-day	70.0	0%	100%	0	70	
7	Common driver	man-day	120.0	0%	100%	0	120	
8	Carpenter/Mason	man-day	130.0	0%	100%	0	130	
9	Bar bender(cut and bind)	ton	1050.0	0%	100%	0	1050	Local Style
10	Common labour(unskilled)	man-day	60.0	0%	100%	0	60	
B. Construction Materials								
1	Aggregates and rock							
	a) Sand(normal)	m3	60.0	20%	80%	12	48	Indus Riverbed
	b) Sand(coarse)	m3	160.0	20%	80%	32	128	Panyala sand
	c) Coarse Aggregate/Gravel	m3	250.0	30%	70%	75	175	6-20mmdia
	d) Rock, Gabion/Mason	m3	210.0	20%	80%	42	168	
	e) Rock, Riprap	m3	120.0	20%	80%	24	96	
2	Lumber							
	a) Plywood ,5mm	m2	165.0	30%	70%	49.5	115.5	WAPDA rate
	b) Timber (Plank,1"*12")	m	25.0	20%	80%	5	20	
	c) Timer(Scaffolding,4")	m	35.0	20%	80%	7	28	
3	Rainforced iron bar	ton	16500.0	60%	40%	9900	6600	
4	Portrand cement	ton	3300.0	40%	60%	1320	1980	
5	Fuel and Oil Product							
	a) Gasoline	lit	14.4	50%	50%	7.2	7.2	
	b) Diesel	lit	6.2	50%	50%	3.1	3.1	
	c) Engine oil	lit	58.3	50%	50%	29.15	29.15	
	d Bitumen 80/100	kg	11.0	50%	50%	5.5	5.5	
6	RC Pipe							
	a) Dia. 6"	m	65.6	40%	60%	26.24	39.36	
	b) Dia. 12"	m	164.1	40%	60%	65.64	98.46	
	c) Dia. 18"	m	240.0	40%	60%	96	144	WAPDA rate
	d) Dia. 24"	m	390.0	40%	60%	156	234	WAPDA rate
	e) Dia. 30"	m	610.0	40%	60%	244	366	WAPDA rate
7	Steel							
	a) Steel Plate/products	ton	17500.0	70%	30%	12250	5250	
	b) Hand Rail	ton	20000.0	70%	30%	14000	6000	
	c) Steel Pipe(600mm)	m	75000.0	70%	30%	52500	22500	
	d) Steel Pipe(4,000mm)	m	1500000.0	70%	30%	1050000	450000	
8	Blasting							
	a) TNT,Dynamite	kg	76.0	50%	50%	38	38	WAH Nobel(Pvt)
	b) Detonator	pc	37.0	50%	50%	18.5	18.5	WAH Nobel(Pvt)
	c) Fuse/Detonator Code	m	11.0	50%	50%	5.5	5.5	WAH Nobel(Pvt)
	d) Drilling Rod	pc	3400.0	50%	50%	1700	1700	Foreign Market
	e) Drilling Bit	pc	4600.0	50%	50%	2300	2300	Foreign Market
9	Other							
	a) Brick	1,000pc	1000.0	0%	100%	0	1000	
	b) Neoplene Bearing Pad	m2(t=30mm)	16500.0	40%	60%	6600	9900	
	c) G.I. Pipe 1" dia	m	62.0	50%	50%	31	31	WAPDA rate
	d) G.I. Pipe 2" dia	m	121.0	50%	50%	60.5	60.5	WAPDA rate
	e) Roof Tile	1,000pc	1500.0	0%	100%	0	1500	
	f) Sod Glass	m2	6.0	0%	100%	0	6	
	g) Tree for Planting	1,000nos	1000.0	0%	100%	0	1000	Official Nursery
10	Gate, Fixed Wheel Type(Counterweight Type) with Electric Motor							
	Set of Gate	m2	87000.0	30%	70%	26100	60900	Mech. Circle.Irrig.
11	Gate, Normal Slide Type & Manual Operation							
	Set of Gate	m2	76000.0	30%	70%	22800	53200	Mech. Circle.Irrig.

Table H.3.14 Operation Cost of Construction Equipment

No.	Equipment	Specifications		Operation Cost			Remarks
		Spec.	PS	FC (Rs./hr)	LC (Rs./hr)	Total (Rs./hr)	
A	**Earth Moving & Excavation**						
1.	Bulldozer ,D6	11t	160	733	78	811	
2.	Bulldozer ;D7	17 t	220	917	112	1,029	
3.	Bulldozer ,D8 with Ripper	21 t	290	1,653	154	1,808	
4.	Tractor shovel	1.2m3	100	569	109	678	E/Market
5.	Excavator	0.6m3	140	954	81	1,035	WAPDA
6.	Excavator	1.2m3	210	1,804	112	1,916	E/WAPDA
7.	Dredger of 1.2m3 backet	21 t	230	1,804	112	1,916	E/WAPDA
8.	Tractor Trailer	5 t	60	140	30	170	Market
9.	Wheel loader	2.2m3	160	914	94	1,008	WAPDA
10.	Dump truck	11 t	210	660	130	790	WAPDA
11.	Dump truck	20 t	290	1,265	178	1,443	
B.	**Compaction**						
12.	Tyre roller	11-17t	100	290	60	350	WAPDA
13.	Tyre roller	21-31t	150	505	75	580	E/WAPDA
14.	Tamping roller (C. dozer)	17t	150	1,070	104	1,174	
15.	Tamping roller (C. dozer)	21t	230	1,675	177	1,852	
16.	Vibration roller	3t	25	339	43	382	
17.	Vibration roller	15t	160	1,359	109	1,468	
18.	Sheep-Foot Roller	11-17t	100	400	85	485	E/WAPDA
19.	Pneumatic Vibrater	-	-	45	5	50	Market
20.	Tractor Water Bowser,4m3	5 t	60	150	30	180	Market
21.	Water tank rolly, 10m3	11 t	210	600	75	675	WAPDA
22.	Motor Grader of 3.7m brade	17 t	150	1,070	104	1,174	WAPDA
C.	**Other Equipment**						
23.	Normal Truck	10t	160	300	45	345	Market
24.	Normal Truck	2 t	100	200	30	230	Market
25.	Jeep,4-wheel drive	2 t	120	275	40	315	Market
26.	Truck w/ 2t crane	10 t	160	350	45	395	E/Market
27.	Tractor w/ 1t crane	5t	60	180	30	210	E/Market
28.	Compressor	11m3	110	373	87	460	
29.	Compressor	17m3	190	549	130	678	
30.	Concrete mixer,1bag	0.16m3	-	330	30	360	Market
31.	Concrete mixer ,3bag	0.5m3	-	600	50	650	E/Market
32.	Truck Mixer(4m3)	11t	210	600	75	675	E/WAPDA
33.	Batching Plant,0.6m3	41kw	-	1,118	38	1,156	
34.	Generator	10kVA	-	150	50	200	Market
35.	Generator	35kVA	-	320	75	395	Market
36.	Crusher Plant,dia=600mm	45kw	-	465	38	503	
37.	Secondary Crusher	0.5m3	-	110	15	125	Market
38.	Fuel Bowser, 10m3	11t	210	600	75	675	WAPDA
39.	Low-bed Trailer	35t	320	1,200	150	1,350	E/WAPDA
40.	Bitumen Sprayer,Truck Mountec	11 t	210	600	75	675	E/WAPDA
D.	**Boring, Blasting & Piling**						
41.	Boring Machine	3.7kW	-	81	31	112	
42.	Augar Machine	45kw	-	465	38	503	
43.	Pile Driver	-	210	600	75	675	
44.	Pneumatic Jack Hammer	2" bit		190	20	210	
45.	Rock Drill			190	20	210	

Note: 1. Blank Remarks means etimated cost according to international price
2. WAPDA: Price Listed from WAPDA 3. Market: Price quated or checked from Local Market
3. E/Market(WAPDA): estimated from Local Market(WAPDA) Price of Equivalent or similar item

Table H.3.15 Summary of Unit Construction Cost (1/2)

(Unit : Pakistan Rs.)

No.	Description	Unit	Unit Price			Remarks
			Total	F.C.	L.C.	
A.	**Earthwork & Stonework**					
A1	Stripping of Top Soil	m2	3.0	2.5	0.5	General
A2	Excavation Common(Backhoe),Type 1	m3	43.6	37.2	6.4	Main/Feeder
A3	Excavation Common(Backhoe),type 2	m3	47.4	38.8	8.6	Dist/Minor
A4	Excavation Common(Composite),Type 1	m3	38.0	31.7	6.3	Borrow/Wide
A5	Excavation Common(Composite),Type 2	m3	33.4	26.6	6.8	Borrow/Narrow
A6	Excavation Manual	m3	25.2	0.0	25.2	General
A7	Excavation of Common Rock(ripper-dozer)	m3	107.1	92.8	14.3	
A8	Excavation for Structure(Small Backhoe)	m3	47.5	36.1	11.4	
A9	Excavation for Drain	m3	38.0	33.8	4.2	
A10	Haulage of Earth Material,type1	m3*km	5.8	4.9	0.9	by Dump-truck
A11	Haulage of Earth Material,type 2	m3*km	6.1	3.8	2.3	by Tractor trailer
A12	Embankment and Compaction,type 1	m3	39.6	33.9	5.7	Main/Feeder
A13	Embankment and Compaction, type 2	m3	41.6	33.6	8.0	Dist/Minor
A14	Embankment and Compaction,Manual	m3	23.0	0.0	23.0	General
A15	Embankment for Drain	m3	23.8	19.3	4.5	
A16	Backfill&Compaction ,type 1	m3	50.7	43.3	7.4	Main/Feeder
A17	Backfill&Compaction,Type 2	m3	52.5	42.6	9.9	Dist/Minor
A18	Sod Facing(turfing)	m2	11.0	0.0	11.0	
A19	Dredging Work	m3	61.9	55.7	6.2	by dredger
A20	Sand Filter	m3	263.1	36.6	226.5	Lining
A21	Loading or Unloading of Earth Material,1	m3	18.6	14.6	4.0	Dump Truck
A22	Loading or Unloading of Earth Material,2	m3	20.3	0.0	20.3	Tractor
A23	Gravelling & Compaction of sub-base	m2	20.5	7.5	13.0	Road
A24	Base Coarse filling and Compaction	m3	330.3	110.8	219.5	Road
A25	Metalling and Tarring	m2	248.8	142.3	106.4	Road
A26	Wet Masonry	m3	1,651.4	557.8	1,093.6	with mortar
A27	Dry Masonry	m3	554.4	96.4	458.0	Stone-pitching
A28	Gabbion Mattress	m3	732.2	259.1	473.1	slope protection
A29	Blick Masonry	m3	1,350.0	250.0	1,100.0	Transition, wall
A30	Riprap	m3	222.0	26.0	196.0	slope protection
B	**Concrete Work**					
B1	Concrete A (140kgf/cm2,1:4:8)	m3	1,316.7	610.4	706.2	Foundation
B2	Concrete B (170kgf/cm2,1:3:6)	m3	1,727.2	761.8	965.4	Lining,structure
B3	Concrete C (210kgf/cm2 ,1:2:4)	m3	1,969.8	858.9	1,110.9	Structure
B4	Wooden Form	m2	109.8	16.4	93.4	non-standard
B5	Reinforcement Bar	kg	23.0	12.2	10.8	deformed bar
B6	Reinforced Concrete Lining at Structure	m2	1,241.6	611.6	630.0	at Structure

F.C. : Foreign Currency Portion L.C. : Local Currency Portion

Table H.3.15 Summary of Unit Construction Cost (2/2)

(Unit : Pakistan Rs.)

No.	Description	Unit	Unit Price			Remarks
			Total	F.C.	L.C.	
B7	Concrete Lining,type 1	m2	290.0	119.0	171.0	Main/Feeder
B8	Lining for Distributory	m2	193.2	72.7	120.5	Dist/Minor
B9	Steel Slip Form	m2	32.7	7.2	25.5	for Lining
B10	Mortar	m3	1,978.0	839.1	1,138.9	supplemental
B11	Steel Form	m2	85.1	27.6	57.5	standard structure
B12	RC Pipe, 300mm in dia.	m	284.1	125.6	158.5	mogha, causeway
B13	RC Pipe, 200/150mm in dia.	m	170.0	76.0	94.0	Sump Well
C	**Other Work**					
C1	Hand Rail/Safty Ladder	m	120.0	63.0	57.0	Bridge/Ope. deck
C2	Trush Rack	m2	1,050.0	600.0	450.0	
C3	Building (Normal office or House)	m2	4,400.0	1,400.0	3,000.0	general
C4	Building (Upgraded Office or House)	m2	6,000.0	2,000.0	4,000.0	for const. camp
C5	Building (Pomp House)	m2	15,000.0	5,000.0	10,000.0	
C6	Reforestation	1,000nos	12,455.2	7,160.9	5,294.3	Along Canal
C7	Steel Piling(dia=400 or H-350mm)	m	19,000.0	15,000.0	4,000.0	
C8	Sheet Piling	m2	4,300.0	2,900.0	1,400.0	
C9	Blasting of Rock	m3	125.0	30.0	95.0	Blasting Only
C10	In-situ RC Piling(0.8m dia)	m	2,700.0	1,485.0	1,215.0	
C11	Neoprene Bearing Pad	m2	18,900.0	7,000.0	11,900.0	Bridge
C12	Mild Steel Plate (t=10mm)	m2	1,932.0	1,176.0	756.0	operation deck
C13	Overhead Crane	set	12,100,000.0	8,470,000.0	3,630,000.0	for pump house
C14	Steel Pipe for Pump (4000mm in dia.)	m	162,400.0	96,520.0	65,880.0	delivery pipe
C15	Installation of motor-operate-Roller Gate	m2	90,045.0	26,100.0	63,945.0	
C16	Installation of manual-operate-Slide Gate	m2	78,660.0	22,800.0	55,860.0	

F.C. : Foreign Currency Portion L.C. : Local Currency Portion

Table H.3.16 Annual O&M Cost

Unit: 1,000Rs.

Project Cost Component	Foreign Cost	Local Cost	Total
1 Public Expenses	174,260	96,070	270,330
Administration Staff	-	59,130	59,130 (*)
Office Operation Cost	700	700	1,400
O&M Cost for Pump Station	169,200	18,800	188,000
O&M Cost for Others	4,360	17,440	21,800
2 Associations' Expenses	4,990	18,000	22,990
Manpower(**)	-	23,760	23,760
Office operation	650	650	1,300
O&M Cost for facilities	4,340	17,350	21,690
Total Cost	179,250	114,070	293,320

* : Annual Salary; 47,304 + Additional allowances; 9,461 + Duty travel 2,365

** : Substituted by farmers' activity and not calculated for the total cost

Table H.3.17 Array for Operation and Maintenance

Name of Office	Building	Staff	Equipment					
			Vechicles	Wireless	Office equipment			
	(m2)	(persons)	(nos.)		Copy mch.	Computer	Fax	Phone
CRBDA Main Office	3150	210	30	[C.L.1]	4	8	9	30
Pump Operation Office	260	26		[C.L.2]				1
Intake Operation Office	30	3		[C.L.2]				1
Feeder canal O&M Office (F-1)	50	8		[C.L.2]				
Feeder canal O&M Office (F-2)	50	8		[C.L.2]				
Main canal O&M Office (M-1)	60	10	2	[C.L.2]				
Main canal O&M Office (M-2)	60	10	2	[C.L.2]				
Main canal O&M Office (M-3)	60	10	2	[C.L.2]				
Main canal O&M Office (M-4)	60	10	1	[C.L.2]				
Main canal O&M Office (M-5)	60	10	1	[C.L.2]				
Main canal O&M Office (M-6)	60	10	1	[C.L.2]				
Distributary O&M Office (D-1)	180	5	1	[C.L.3]		1		
Distributary O&M Office (D-2)	200	5	1	[C.L.3]		1		
Distributary O&M Office (D-3)	180	5	1	[C.L.3]		1		
Distributary O&M Office (D-4)	160	5	1	[C.L.3]		1		
Distributary O&M Office (D-5)	260	5	1	[C.L.3]		1		
Distributary O&M Office (D-6)	270	5	1	[C.L.3]		1		
Distributary O&M Office (D-7)	170	5	1	[C.L.3]		1		
Distributary O&M Office (D-8)	230	5	1	[C.L.3]		1		
Distributary O&M Office (D-9)	280	5	1	[C.L.3]		1		
Distributary O&M Office (D-10)	170	5	1	[C.L.3]		1		
Distributary O&M Office (D-11)	170	5	1	[C.L.3]		1		
Distributary O&M Office (D-12)	310	5	1	[C.L.3]		1		
Distributary O&M Office (D-13)	220	5	1	[C.L.3]		1		
Distributary O&M Office (D-14)	190	5	1	[C.L.3]		1		
Distributary O&M Office (D-15)	160	5	1	[C.L.3]		1		
Distributary O&M Office (D-16)	210	5	1	[C.L.3]		1		
Distributary O&M Office (D-17)	250	5	1	[C.L.3]		1		
Distributary O&M Office (D-18)	170	5	1	[C.L.3]		1		
Distributary O&M Office (D-19)	170	5	1	[C.L.3]		1		
Distributary O&M Office (D-20)	170	5	1	[C.L.3]		1		
Distributary O&M Office (D-21)	190	5	1	[C.L.3]		1		
Distributary O&M Office (D-22)	180	5	1	[C.L.3]		1		
Distributary O&M Office (D-23)	160	5	1	[C.L.3]		1		
Distributary O&M Office (D-24)	180	5	1	[C.L.3]		1		
Distributary O&M Office (D-25)	180	5	1	[C.L.3]		1		
	8,910	440	64		4	33	9	32

Communication Line (I) [C.L.1] : Pump Operation Office ~ Intake Operation Office

Communication Line (II) [C.L.2] : Pump Operation Office ~ CRBDA Main Office

Communication Lines (III-1~25) [C.L.3] : each Distributary O&M Office ~ CRBDA Main Office

Table H.3.18 Number of O&M Staff by Grade

Name of Office	Grade							
	1~16	17	18	19	20	21	22	Total
CRBDA Main Office	139	23	22	22	2	1	1	210
Pump Operation Office	21	5						26
Intake Operation Office	3							3
Feeder canal O&M Office (F-1)	8							8
Feeder canal O&M Office (F-2)	8							8
Main canal O&M Office (M-1)	9.5	0.5						10
Main canal O&M Office (M-2)	9.5	0.5						10
Main canal O&M Office (M-3)	9.5	0.5						10
Main canal O&M Office (M-4)	9.5	0.5						10
Main canal O&M Office (M-5)	9.5	0.5						10
Main canal O&M Office (M-6)	9.5	0.5						10
Distributary O&M Office (D-1)	5							5
Distributary O&M Office (D-2)	5							5
Distributary O&M Office (D-3)	5							5
Distributary O&M Office (D-4)	5							5
Distributary O&M Office (D-5)	5							5
Distributary O&M Office (D-6)	5							5
Distributary O&M Office (D-7)	5							5
Distributary O&M Office (D-8)	5							5
Distributary O&M Office (D-9)	5							5
Distributary O&M Office (D-10)	5							5
Distributary O&M Office (D-11)	5							5
Distributary O&M Office (D-12)	5							5
Distributary O&M Office (D-13)	5							5
Distributary O&M Office (D-14)	5							5
Distributary O&M Office (D-15)	5							5
Distributary O&M Office (D-16)	5							5
Distributary O&M Office (D-17)	5							5
Distributary O&M Office (D-18)	5							5
Distributary O&M Office (D-19)	5							5
Distributary O&M Office (D-20)	5							5
Distributary O&M Office (D-21)	5							5
Distributary O&M Office (D-22)	5							5
Distributary O&M Office (D-23)	5							5
Distributary O&M Office (D-24)	5							5
Distributary O&M Office (D-25)	5							5
Number of Staff	361	31	22	22	2	1	1	440
Unit Salary by Grade (Rs./month)	6,000	17,000	21,000	29,000	34,000	39,000	42,000	
Annual Salary (,000 Rs.)	25,992	6,324	5,544	7,656	816	468	504	47,304

Table H.3.19 Summary for Operation and Maintenance Office

Distributary O&M Office	Command Area (ha)	Length of Disty (m)	Length of Minor (m)	Head Regulator (Nos.)	Minor Regulator (Nos.)	Mogha (Nos.)	Gata keeper (Persons)	Ditch tender (Persons)	Driver (Persons)
D - 1	1,700	4,000	0	1	0	24	11	3	1
D - 2	2,430	5,600	0	1	0	32	14	4	1
D - 3	2,390	10,200	0	1	0	24	11	7	1
D - 4	1,260	3,700	0	1	0	9	6	3	1
D - 5	9,280	12,700	13,700	1	2	61	26	17	1
D - 6	10,150	10,700	20,850	1	3	67	29	20	1
D - 7	2,410	9,900	0	1	0	17	9	7	1
D - 8	7,060	22,000	4,000	1	1	47	20	17	1
D - 9	11,400	9,300	29,800	1	2	75	30	25	1
D - 10	2,380	16,700	0	1	0	17	9	11	1
D - 11	2,660	14,300	0	1	0	19	10	9	1
D - 12	13,620	22,500	57,700	1	6	90	39	50	1
D - 13	6,240	20,900	8,100	1	1	41	18	19	1
D - 14	3,630	9,800	5,000	1	1	26	13	10	1
D - 15	1,860	9,900	0	1	0	13	8	7	1
D - 16	5,910	11,800	14,800	1	2	39	18	17	1
D - 17	9,150	15,100	13,000	1	1	60	24	18	1
D - 18	2,560	7,600	0	1	0	18	9	5	1
D - 19	2,560	9,400	0	1	0	18	9	6	1
D - 20	2,440	10,600	0	1	0	17	9	7	1
D - 21	3,650	10,600	0	1	0	26	12	7	1
D - 22	3,250	7,000	0	1	0	23	11	5	1
D - 23	1,180	5,700	0	1	0	8	6	4	1
D - 24	2,950	6,000	0	1	0	21	10	4	1
D - 25	3,480	9,600	0	1	0	24	11	6	1
		275,600	166,950	25	19	816	(372)*	(288)*	25

*: These duties will be carried out by farmers.

Main Canal O&M Office	Length of Canal (m)	Head Regulator (Nos.)	Cross Regulator (Nos.)	Canal tender (Persons)	Gate Keeper (Persons)	Driver (Persons)
M - 1	15,000	3	1	-	-	1.5
M - 2	17,800	3	3	-	-	1.5
M - 3	23,750	6	3	-	-	1.5
M - 4	18,450	4	3	-	-	1.5
M - 5	19,300	4	4	-	-	1.5
M - 6	18,950	4	4	-	-	1.5
						9

Feeder Canal O&M Office	Length of Canal (m)	Canal tender (Persons)	Driver (Persons)
F - 1	27,360	-	-
F - 2	31,205	-	-

Table H.3.20 Replacement Cost

Item	NOS of Structure	Cost Required (1,000 Rs.) Foreign Currency	Local Currency	Total
I. Pump station (1 time at the middle of Project Life)				
Pump Equipment	1 set	910,000	170,000	1,080,000
II. Gates (1 times at the Middle)		31,500	74,000	105,500
II.-1 Radial Gate				
- In take	1	4,000	10,000	14,000
II.-2 Roller Gate with counter weight		17,000	39,500	56,500
- Feeder Canal	1	2,000	3,500	5,500
- Main Canal	23	15,000	36,000	51,000
II.-3 Slide Gate		10,500	24,500	35,000
- Main Canal	25	3,500	7,000	10,500
- Regulating Pond	25	5,000	10,500	15,500
- Distributory Canals	19	2,000	7,000	9,000
Total Cost		**941,500**	**244,000**	**1,185,500**

FIGURES

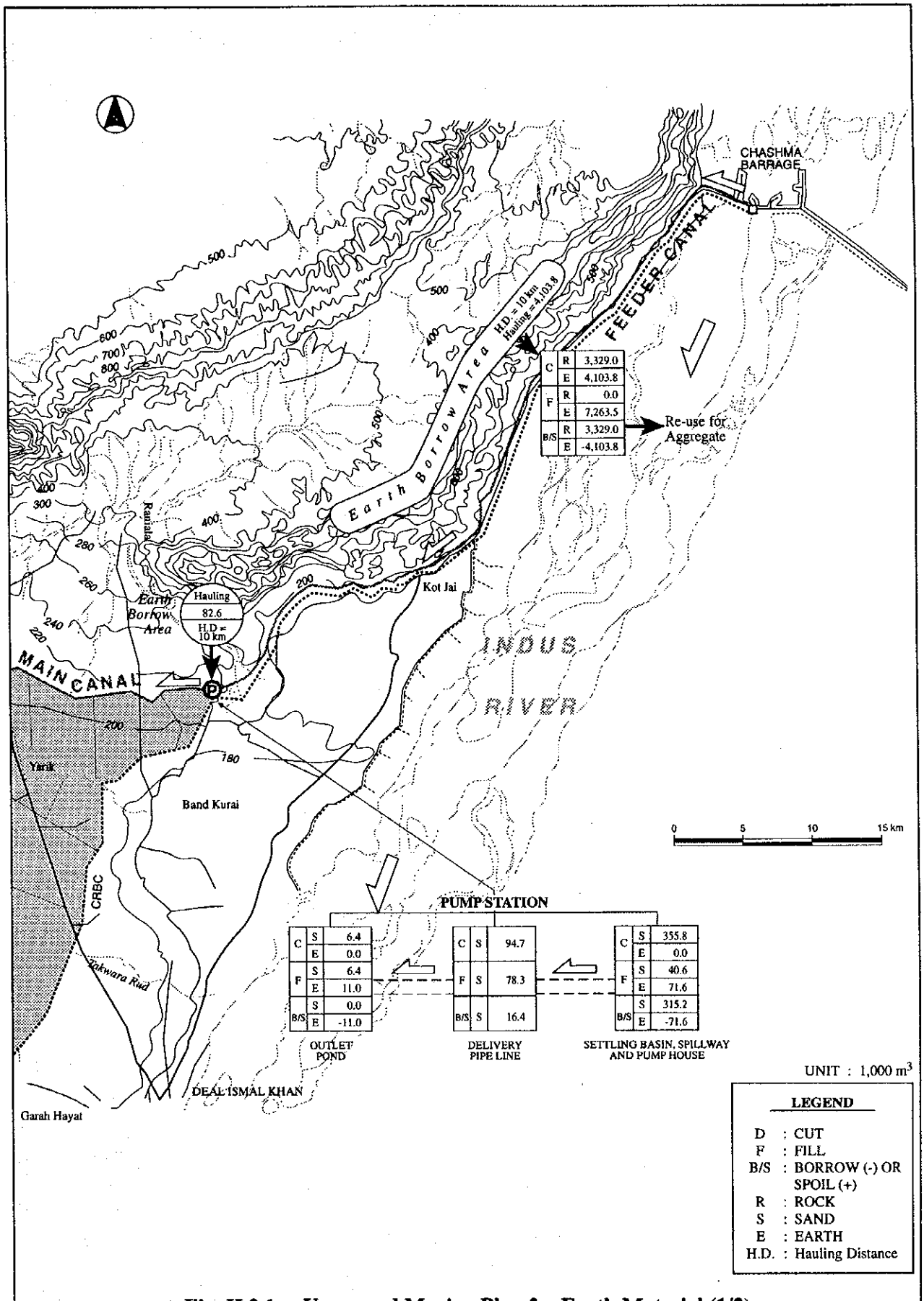


Fig. H.2.1 Usage and Moving Plan for Earth Material (1/2)

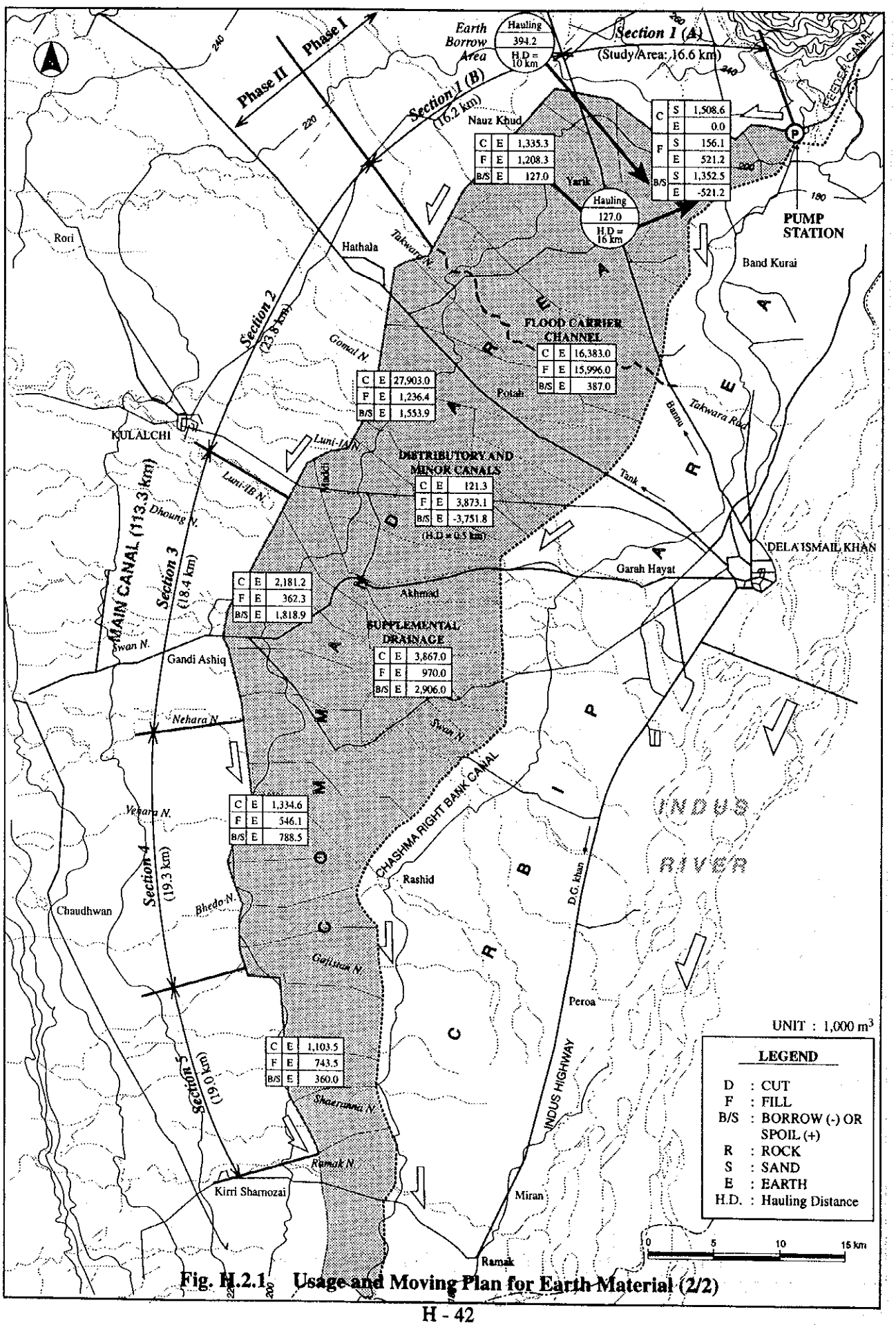
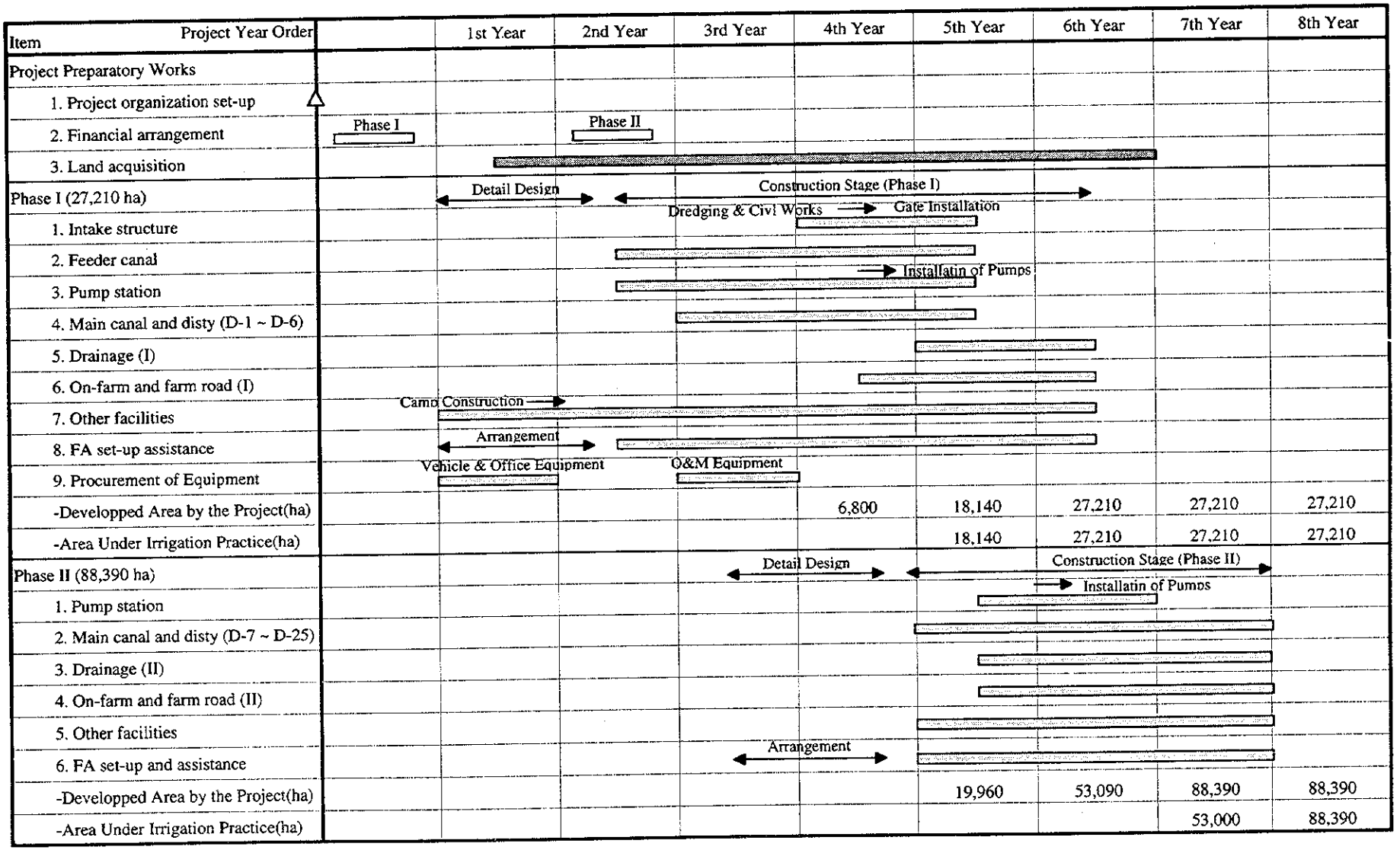


Fig. H.2.1 Usage and Moving Plan for Earth Material (2/2)

Fig. H.2.2 Implementation Schedule for the Project



Note: Other facilities comprise O&M, FA offices, support facilities, etc.

ANNEX I

PROJECT EVALUATION

ANNEX I

PROJECT EVALUATION

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ANNEX I PROJECT EVALUATION

I.1 Introduction

The results from the assessment of alternative pump irrigation and agricultural plans lead to the selection of proposed 60 feet lift irrigation plan covering canal command area of 115,600 ha with a cropping intensity of 160%. In this Annex-I, overall project evaluation is discussed in detail for this selected plan.

Chashma Right Bank 1st Lift Irrigation Project primarily aims at increasing agricultural productivity by irrigation and drainage development, organization of self-reliance farmer organizations, and provision of adequate agricultural support services provision, and re-organization of provincial government institutions. The Project has other significant impact on the rural community taking the present less development progress of the area into consideration. The rural village road is poor and hinterareas from rural road are hard to access after occasional rains. The villagers face difficulty to get municipal water throughout a year. Some villages become vacant in the dried and hot season due to lack of water. Evaluation of the Project, hence is required to count other development effects beside crop production benefit.

The project evaluation involves making an assessment of project feasibility in view of economic, financial and socio-economic aspects. The economic feasibility is firstly evaluated by calculating the economic internal rate of return (EIRR) and sensitivity analysis against possible adverse changes in the future. Financial evaluation is carried out by analyzing the effect to farm budgets and requirement of O&M and replacement costs according to the typical crop rotation systems. The social impact of the project is also briefly studied.

I.2 Economic Evaluation

I.2.1 Basic Assumption

The basic assumptions applied for economic evaluation of the Project are summarized as follows :

(1) The economic useful life of the Project is 50 years,
(2) All prices are expressed at March 1994 prices in Rupee,
(3) The exchange rate of US$ 1.00 = Rs. 30.0 = Yen 107.1 as of average during July to March, 1993/4 is applied,
(4) A standard conversion factor (SCF) with 0.9 is applied to domestic cost

elements such as transport, handling and processing for estimation of economic value, and

(5) The transfer payment such as tax, duty, subsidy and interest are excluded for the estimation of economic costs and prices,

I.2.2 Crop Production Benefit

(1) Economic Prices of Agricultural Outputs and Inputs

Economic prices of farm inputs (urea, triple super phosphate and muriate potash) and tradable farm produce (wheat, maize, sugar cane, cotton, cotton seed, and sunflower) are estimated on the basis of IBRD projection of world market prices for 2005 in constant 1994 terms. Economic prices of other non-tradable farm outputs (pulses, fodder, oilseeds, fruits, vegetables, by-products) and farm inputs (seed/seedling, machinery) are set at same financial prices.

Assuming an opportunity cost (shadow wage rate) for farm labor of 0.75 during the lean labor demand period of 6 months (June to August and November to January), the weighted economic farm labor price is estimated at Rs. 44/day against the financial price of Rs. 50/day. Economic prices of farm inputs and outputs are shown in Table I.2.2.1 to I.2.2.7 and summarized in Table I..2.2.8.

(2) Crop Production Benefit

Crop production benefit could accrue from the pumping irrigation water supply to rainfed and barani area, organized irrigation activities by farmer associations, and improvement of farming practices and productivity. Livestock production benefits are indirectly estimated through the value assessment of fodder crops and by-products of other crops.

Economic crop production budgets per ha both for irrigated and barani/rainfed conditions are prepared under Without (WO) and With (W) project conditions on the basis of farm input requirement, present and future yields, and economic farm gate prices of farm inputs and outputs. Economic net crop production value (ENCPV) per ha under (WO) and (W) project conditions is estimated on the basis of the present and proposed cropping patterns and cropping intensities as shown in Table I.2.2.9 and summarized as follows. Incremental crop production benefit will be expected to increase year by year after the completion of development according to the implementation schedule. It is assumed that the built-up period to achieve full benefit is seven (7) years after the completion of physical works (first year 50%, second

65%, third 75%, forth 85%, fifth 90%, sixth 95%) :

Item	Cropping Area (ha)	Economic Net Crop Production Total (Rs.'000)	Per Cropping Area (Rs./ha)	Per Project Area (Rs./ha)
1. Without Project Condition (WO)	20,470	86,540	4,228	749
2. With Project Condition (W)	170,500	2,592,619	15,206	22,428
3. Incremental (W) - (WO)	150,030	2,506,080	10,978	21,679

I.2.3 Other Development Benefits

(1) Farm road development benefit

Farm road of 555.9 km along the main, distributary and minor canals and 32.5 km connecting between canals and villages will be constructed under the Project. The road density will increase from the present 129m/km^2 to 702m/km^2. Traffic volume covering the future crop production, required farm inputs and consumer goods are estimated on the basis of the future crop production plan and crop budgets. Transport cost savings between the future (WO) and (W) project conditions are assessed by mode of transportation (vehicle and animal) and estimated at Rs. 92/ton per 6 km which is average distance from farm or farm gate to local markets. The farm road development benefit is estimated at Rs. 224, 154 thousand including cost saving for passenger traffic which is assumed at 10% of the commodity traffic as follows (Ref. Table I.2.3.1) :

1. Quantity of Commodity Traffic ('000)	2,461.1
Crop production	2,303.3
Farm inputs	143.5
Consumer goods	14.3
2. Financial Benefit (Rs.'000)	249,060
Commodity traffic	226,418
Passenger traffic	22,642
3. Economic Benefit / (2) x 0.9 (Rs.'000)	224,154

(2) Benefit from transfer of Rod Kohi water right to upper hill torrent

Rod Kohi is an unique system of irrigation in which the hill torrent (nullah) water is diverted and spread into the fields for cultivation. It is a form of water harvesting technique. Hill torrent water is diverted and spread into the fields for cultivation. There are 25 nullahs (hill torrents) in D. I. Khan division to irrigate the area. For

diverting water from these nullahs into the field, big dams called Sads are constructed in their beds. Then there is a distributary channel called Kinda from a dam. After that another channel called Khula, Munha or Kas takes the water to different fields which are embanked and called Bandra.

The general rule of rights is that known as the " Saroba Paina ". This means that the man at the head of the stream has the first right to use as much water as he requires for his cultivated land, and when he has taken this, it is his duty to clear the bed of the stream and allow the water to pass on to the village next below and so on to the tail of the stream. There are some cases where the area irrigable at the head of the stream is so large that if it is all irrigated, the lower villages will get no water. In such cases, limits of area have been fixed, beyond which the **Saroba** lands (areas at the head of a Nullah) are not allowed to irrigate until the **Paina** villages (areas at the tail of a Nullah) have irrigated an area similarly fixed. The Deputy Commissioner (Collector) has the powers on all " Rods " to cut a dam as soon as the land belonging to it have been irrigated or as soon as the water begins to run from it into the ravines.

After the commissioning of 1st lift irrigation canal, 27,100 ha of Rod Kohi area in the Project area will come under the irrigation. This area will no more require flood water irrigation. Therefore , the water rights in the CCA area will be transferred and reallocated to the non-command area. Re-allocation of water rights will be ordered by the Deputy Commissioner keeping in view the cultivated area of the villages above the command area of 1st Lift canal. The upstream dams will be further improved and strengthened to divert larger quantities of floods water to the increased area brought under cultivation according to re-allocation of the water rights.

Benefit accrued by the transfer of Rod Kohi water right to the upper stream is considered as the net production value in the present Rod Kohi area under the Project area. Out of the Rod Kohi area, 10,700 ha is harvested in a normal year and produces the economic net production value of Rs. 43,729 thousand. The transferable value is assumed at 60% of the total value, hence the annual water right benefit will be Rs. 26,237 thousand (Ref. Table I.2.3.2).

(3) Water resource development benefit for domestic water supply
(Domestic water supply benefit)

Domestic water supply facilities in the Project area are less developed and their water quality, especially shallow tube well (less than the depth of 91.4 m), is usually saline. Actual beneficiary population by the tube wells is limited at around 25% in 104

mouzas concerned the Project area. Utilization of irrigation canal water as domestic water is prevailing in the villages under the gravity irrigation system. This phenomena will accrue in the Project area after the commencement of lift canal irrigation. The water quality of canal water is more suitable than those saline tube well water if the water is properly treated, hence irrigation water supply is considered as water resource development for domestic water supply in the Project area.

The water resource development benefit for domestic water supply through the irrigation development accounts for alternative development cost for deep tube wells and their O&M cost including domestic water charges. It is assessed that another 66 deep tube wells will be required covering the rest of non-beneficiary population of around 92,100. Total economic domestic water supply benefit is estimated at Rs. 42,754 thousand (Ref. Table I.2.3.3).

(4) Benefit from reduction of seasonal migration mainly due to lack of water, no farming activities, and no feed for livestock

Based on the farm survey, around 18% of household in the Project area migrate to other area during March to June, when are most dried and hot season, mainly due to shortage of water and feed for livestock. Migrants spent additional livelihood and feed expenditures which were estimated at Rs. 9,902 thousand/year. After the Project completion, these cost will be never required for the villagers and be considered as the Project benefit.(Ref. Table I.2.3.4).

(5) Environmental improvement benefit

The survey on villagers' concerns on environmental conditions and residential land prices was implemented in the developed area (stage I area), newly developed area (stage II area) under the gravity irrigation system, and the Project area during July to August in 1994. The total sampling number became 126 households after excluding the samples with abnormal land prices. As for the environmental factors, five major items covering water supply, road/accessibility, medical care, education and communication, which were considered major elements for village livelihood improvement, were evaluated by the respondents' scoring from zero (0) to five (5). There was significant correlation between the sum of environmental scoring of the respective respondents and their residential prices as follows (Ref. Fig.-I.2.2.1 and 2.2.2) :

Polynomial Regression ; $Y = 989.7 - 229.6\ X + 20.8\ X^2$

X = Environmental Factor (sum of scoring for 5 items)

Y = Residential land price (Rs.'000)

R-squared = 0.958

The environmental improvement is hard to assess in terms of monetary value. The residential land prices were obviously reflected by the villagers' evaluation on the environmental factors covering the above five items. It is concluded that the difference of residential land prices between the Project area and the stage II area (Rs. 11,000/ha) is environmental improvement value by the Project. The environmental benefit is estimated at Rs. 44,000 thousand covering the future residential area of 4,000 ha as follows :

Area	Environmental Factors (Average Sum of Scoring Number)	Residential Land Price (Rs.'000)
Project Area	6.3	371
Gravity Irrigation Area		
Stage II Area (Newly developed)	6.6	382
Stage I Area (Developed)	14.2	1,932

I.2.4 Economic Cost

The financial costs for the construction components are grouped into two parts of local and foreign costs. The local cost comprises three (3) items such as transfer payment, unskilled labor cost, and other costs for material and skilled labor. Construction Conversion Factors (CCFs) that are the weighted average of the respective cost items by applying other conversion factors are estimated as the following procedure (Ref. Table I.2.4.1) :

(1) Financial foreign cost accounts for the economic cost,
(2) Transfer payment in the local cost at the rate of 10% is excluded from the financial cost,
(3) The rest 90% of financial cost is split into unskilled labor and other costs,
(4) The part of unskilled labor is converted to the economic value applying the conversion factor of 0.88,
(5) The standard conversion factor of 0.9 is applied for the conversion of other costs, and
(6) The CCFs by the project components are calculated as the sum of economic

shares by cost items after the conversion of those financial shares.

Conversion factor for O&M cost is estimated same as the above procedure. Replacement costs are converted applying the related CCFs to the financial costs. The economic project costs are estimated as follows (Ref. Table I.2.4.2) :

Item	Financial Cost (Rs.'000)	Economic Cost (Rs.'000)
1. Project Cost	12,751,706	11,727,250
Construction	10,120,402	9,292,282
Engineering/Administration	1,619,264	1,498,831
Physical contingency	1,012,040	936,137
2. Annual O&M Cost	317,080	266,664
3. Replacement Cost		
Pump	1,080,000	1,042,200
Gate	105,500	91,363
Others	4,655	4,747

I.2.5 Economic Evaluation

Economic evaluation is made through the estimation of (i) Economic Internal Rate of Return (EIRR), (ii) Net Present Value (NPV) and (iii) Benefit-Cost Ratio (B/C) both at the discount rate of 10% as shown in Table I.2.5.1. The project benefits on farm road development, water right transfer, domestic water, reduction of migration and environmental improvement are included in the crop production benefit one by one for the evaluation as follows :

Item	Crop Production =(A)	Farm Road +(A) =(B)	Water Right +(B) =(C)	Domestic Water +(C) =(D)	Migration +(D)	Total
1. EIRR	13.6	14.7	14.8	15.0	15.1	15.3
2. NPV(Rs. Million)						
- Benefit	12,505	13,624	13,755	13,969	14,018	14,238
- Cost	9,066	9,066	9,066	9,066	9,066	9,066
3. B / C	1.38	1.50	1.52	1.54	1.55	1.57

In order to evaluate soundness of the project against possible adverse changes in the future, sensitivity analysis is made for the following cases :

Item	Crop Production =(A)	Farm Road +(A) =(B)	Water Right +(B) =(C)	Domestic Water +(C) =(D)	Migration +(D)	Total
1. Project cost overrun by 20%	11.8	12.7	12.8	13.0	13.1	13.2
2. Benefit decrease by 20%	11.0	12.0	12.1	12.3	12.3	12.5
3. Delay in construction for 2 years	11.2	12.0	12.0	12.2	12.2	12.4
4. Case 1 and 2	9.5	10.3	10.4	10.6	10.6	10.8
5. Case 1 and 3	9.8	10.5	10.6	10.7	10.8	10.9
6. Case 2 and 3	9.2	9.9	10.0	10.1	10.2	10.3
7. Case 1, 2 and 3	7.9	8.6	8.7	8.8	8.9	9.0

I.3 Financial Evaluation

In order to evaluate the Project from the financial aspect of the farmers, the farm budget analysis on different sizes of farms are made under the representative crop rotation systems in the future (W) project condition as follows :

Years / Seasons	Type -I	Type-II	Type-III
Ist Year			
Rabi	-	Wheat	Fodder
Spring	Maize	-	-
Kharif	Fodder	Maize	Sugarcane (September)
2nd Year			
Rabi	Wheat	Oilseeds	Sugarcane (ratoon)
Spring	-	-	- do -
Kharif	Maize	Maize	- do -
3rd Year			
Rabi	Wheat	Wheat	-
Spring	-	-	Maize
Kharif	Cotton	Maize	-

For the assessment of farmers' capacity to pay by the respective farm budget surplus (balance of gross income and expenditure covering non-farm expenditures), water charges and replacement costs for the Project are estimated on the basis of crop water requirement to the total O&M costs from the intake to on-farm level and replacement facilities (pumps are excluded due to their heavy burden to the farmers) as shown in Table I.3.1.1. The replacement cost will be collected from the farmers according to the crop water requirement and amortized in 25 years by the interest rate of 10 %/year. The assessment results are shown in Table I.3.1.2 and summarized as follows :

Item	Small (2.31 ha)	Medium (4.70 ha)	Large (18.89 ha)	Average (12.94 ha)
I. Crop Rotation-I (Maize-Fodder-Wheat-Maize-Wheat-Cotton)				
a) Farm Budget Surplus	15,680	39,550	208,040	138,390
b) Water Charge	4,750	9,670	38,870	26,620
c) Replacement Charge	1,370	2,780	11,170	7,650
Share of (b+c) to (a)	(39%)	(31%)	(24%)	(25%)
II.Crop Rotation-II (Wheat-Maize-Oilseeds-Maize-Wheat-Maize)				
a) Farm Budget Surplus	24,580	57,650	280,810	188,240
b) Water Charge	5,250	10,670	42,890	29,380
c) Replacement Charge	1,510	3,070	12,320	8,440
Share of (b+c) to (a)	(28%)	(24%)	(20%)	(20%)
III.Crop Rotation-III (Fodder-Sugarcane-Sugarcane-Maize)				
a) Farm Budget Surplus	11,600	31,320	174,620	115,500
b) Water Charge	8,040	16,360	65,740	45,030
c) Replacement Charge	2,310	4,700	18,890	12,940
Share of (b+c) to (a)	(89%)	(67%)	(48%)	(50%)

Based on the assessment on the future farm budget surplus, water charges and replacement cost, the followings could be clarified :

(1) Crop rotation-II is most suitable for small scale farmers holding 2.3 ha and the water charges and replacement costs will be within 30% of the future farm budget surplus,

(2) Crop rotation-I and II are economical for medium scale farmers with 4.7 ha and the water charges and replacement costs will be around 30% of the future farm budget surplus,

(3) Crop rotation-III including sugarcane production is not economically suitable for any scale of farmers due to the high water consumption of sugarcane compared to its low profitability. Sugarcane production in the Project area could be manageable by the commercialized farming through reduction of crop production costs beside the water charges, and

(4) Appropriate crop rotation systems according to the scale of farms should be introduced and rational irrigation water allocation not only at the distributary and water course levels but also among the farmers be practised.