Table 8.2.7 Existing, Future and Poteatial Irrigation Development In Kok Basin

Irrigation Project	Drainage Area (sq km)	Average Runoff (MCM)			Runoff Yield (mm)	Reservoir Capacity (MCM)	Project Area (103 rai)	Irrigation Unit Demand (m3/rai)		Existing Irrigation Project (1996)						Proposed Irrigation Project (2016)						Potential Irrigation Project (Eventual)					
										Irrigation Area (103 rai)			Water Demand (MCM)			Irrigation Area (103 rai)			Water Demand (MCM)			Irrigation Area (103 rai)			Water Demand (MCM)		
		Wet	Dry	Total				Wet	Dry	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total
I. Myanmar Sub-basin																											
(1) Kok Hydropower Dam (L)	2980.0	1650.0	490.0	2140.0	718.0	4650.0																					
Sub-total	2980.0	1650.0	490.0	2140.0	718.0																						
(2) Mae Fang Sub-basin																											
2.1 Upper Fang Dam (M)	164.0	69.5	13.3	82.8	504.9	50.0	18.1	800	1,500							18.1	5.4	23.5	14.5	8.1	22.6	18.1	5.4	23.5	14.5	8.1	22.6
2.2 Mae Thalop Luang	85.0	22.0	6.0	28.0	329.4	13.0	9.3	800	1,500							9.3	2.8	12.1	7.4	4.2	11.6	9.3	2.8	12.1	7.4	4.2	11.6
2.3 Mae Ngon Noi Weir	15.0	6.0	2.0	8.0	533.0		4.0	800	1,500	4.0	0.4	4.4	3.2	0.6	3.8	4.0	0.4	4.4	3.2	0.6	3.8	4.0	0.4	4.4	3.2	0.6	3.8
2.4 Mae Mao Reservoir	128.0	62.0	17.0	79.0	617.0	60.0		800	1,500																		
2.5 Mae Chai Weir	60.0	29.0	8.0	37.0	617.0		37.5	800	1,500													37.5	15.0	52.5	30.0	22.5	52.5
2.6 Huai Khrai Reservoir	71.0	38.3	7.3	45.6	642.2	48.6	28.0	800	1,500							28.0	8.4	36.4	22.4	12.6	35.0	28.0	8.4	36.4	22.4	12.6	35.0
2.7 Mae Nawang Reservoir	85.0	43.0	7.6	50.6	595.3	36.2	13.0	800	1,500							13.0	3.9	16.9	10.4	5.9	16.3	13.0	3.9	16.9	10.4	5.9	16.3
2.8 Mae Sao Weir (M)	115.0	54.0	15.0	69.0	600.0		10.0	800	1,500	10.0	1.0	11.0	8.0	1.5	9.5	10.0	1.0	11.0	8.0	1.5	9.5	10.0	1.0	11.0	8.0	1.5	9.5
2.9 Mae Sao Reservoir	115.0	54.0	15.0	69.0	600.0	40.0	20.0	800	1,500													20.0	6.0	26.0	16.0	9.0	25.0
2.10 Mae Laeng Luang Weir	20.0	9.0	3.0	12.0	600.0		13.2	800	1,500	13.2	1.3	14.5	10.6	2.0	12.5	13.2	1.3	14.5	10.6	2.0	12.5	13.2	1.3	14.5	10.6	2.0	12.5
2.11 Mae Laeng Luang Reservoir	20.0	9.0	3.0	12.0	600.0	9.0	8.0	800	1,500													8.0	2.4	10.4	6.4	3.6	10.0
2.12 Mae Ai Reservoir	24.0	12.0	3.0	15.0	625.0	10.0	6.3	800	1,500													6.3	1.9	8.2	5.0	2.8	7.9
2.13 National Security Project						3.5	5.7	800	1,500	5.7	0.6	6.3	4.6	0.9	5.5	5.7	0.6	6.3	4.6	0.9	5.5	5.7	0.6	6.3	4.6	0.9	5.5
2.14 MSIP Package (17)							92.6	800	1,500	83.3	8.3	91.6	66.6	12.5	79.1	83.3	8.3	91.6	66.6	12.5	79.1	92.6	9.3	101.9	74.1	14.0	88.0
2.15 SSIP							169.4	800	1,500	73.1	7.3	80.4	58.5	11.0	69.4	109.7	11.0	120.7	87.8	16.5	104.2	169.4	16.9	186.3	135.5	25.4	160.9
2.16 Pump Irrigation							10.4	800	1,500	7.7	0.8	8.5	6.2	1.2	7.4	10.4	1.0	11.4	8.3	1.5	9.8	10.4	1.0	11.4	8.3	1.5	9.8
Sub-total	2160.0	920.0	160.0	1080.0	500.0		445.5			197.0	19.7	216.7	157.6	29.6	187.2	304.7	44.1	348.8	243.8	66.1	309.9	445.5	76.3	521.8	356.4	114.5	470.9
(3) Kok-Lao Sub-basin																											
3.1 Huai Pong Reservoir	14.0	3.0	1.0	4.0	286.0	4.0	4.4	800	1,500													4.4	1.3	5.7	3.5	2.0	5.5
3.2 Mae Chedi Reservoir (M)	165.0	30.9	10.6	41.5	251.5	35.0	21.9	800	1,500							21.9	6.6	28.5	17.5	9.9	27.4	21.9	6.6	28.5	17.5	9.9	27.4
							(14.1)	800	1,500							(14.1)	(4.2)	(18.3)	(11.3)	(6.3)	(17.6)	(14.1)	(4.2)	(18.3)	(11.3)	(6.3)	(17.6)
3.3 Mae Khao Reservoir	117.0	26.0	7.0	32.0	274.0	30.0	4.4	800	1,500													4.4	1.8	6.2	3.5	2.6	6.2
3.4 Mae Poon Luang Reservoir (M)	233.0	63.8	18.4	72.2	309.9	53.0	15.0	800	1,500							15.0	4.5	19.5	12.0	6.8	18.8	15.0	4.5	19.5	12.0	6.8	18.8
							(40.0)	800	1,500							(40.0)	(12.0)	(52.0)	(32.0)	(18.0)	(50.0)	(40.0)	(12.0)	(52.0)	(32.0)	(18.0)	(50.0)
3.5 Mae Tam Luang Reservoir	143.0	26.0	7.0	33.0	258.0	28.0	19.4	800	1,500													19.4	5.8	25.2	15.5	8.7	24.3
3.6 Huai Pong Phak Lao Reservoir	27.0	6.0	2.0	8.0	296.0	8.0	5.6	800	1,500													5.6	1.7	7.3	4.5	2.5	7.0
3.7 Mae Yang Min Reservoir (M)	146.0	35.1	12.0	47.1	322.6	32.0	(39.0)	800	1,500							(39.0)	(11.7)	(50.7)	(31.2)	(17.6)	(48.8)	(39.0)	(11.7)	(50.7)	(31.2)	(17.6)	(48.8)
3.8 Huai Hia Reservoir	22.0	5.0	1.0	6.0	273.0	5.0	1.6	800	1,500													1.6	0.6	2.2	1.3	1.0	2.2
							(1.7)	800	1,500													(1.7)	(0.5)	(2.2)	(1.4)	(0.8)	(2.1)
3.9 Huai Mae Kham Kaeng Reservoir	35.0	8.0	2.0	10.0	286.0	10.0	1.6	800	1,500													1.6	0.6	2.2	1.3	1.0	2.2
							(5.0)	800	1,500													(5.0)	(1.5)	(6.5)	(4.0)	(2.3)	(6.3)
3.10 Huai Mae Tha Chang Reservoir	100.0	23.0	7.0	30.0	300.0	15.0	10.6	800	1,500													10.6	3.2	13.8	8.5	4.8	13.3
3.11 Maae Phrik Reservoir	44.0	10.0	3.0	13.0	295.0	8.0	2.5	800	1,500													2.5	1.0	3.5	2.0	1.5	3.5
							(2.5)	800	1,500													(2.5)	(1.0)	(3.5)	(2.0)	(1.5)	(3.5)
3.12 Mae Suai Reservoir (M)	530.0	161.1	66.3	217.4	410.2	73.0	7.0	800	1,500							7.0	2.1	9.1	5.6	3.2	8.8	7.0	2.1	9.1	5.6	3.2	8.8
							(62.5)	800	1,500							(62.5)	(18.8)	(81.3)	(50.0)	(28.1)	(78.1)	(62.5)	(18.8)	(81.3)	(50.0)	(28.1)	(78.1)
3.13 Mae Lao Weir (L)	2723.0	648.1	204.4	862.5	313.1		43.3	800	1,500	43.3	4.3	47.6	34.6	6.5	41.1	43.3	4.3	47.6	34.6	6.5	41.1	43.3	4.3	47.6	34.6	6.5	41.1
							(122.7)	800	1,500	(122.7)	(12.3)	(135.0)	(98.2)	(18.5)	(116.6)	(122.7)	(12.3)	(135.0)	(98.2)	(18.5)	(116.6)	(122.7)	(12.3)	(135.0)	(98.2)	(18.5)	(116.6)
3.14 Tham Wok Weir	2944.0						8.0	800	1,500	8.0	0.8	8.8	6.4	1.2	7.6	8.0	0.8	8.8	6.4	1.2	7.6	8.0	0.8	8.8	6.4	1.2	7.6
3.15 Chai Sombat Weir (M)	3080.0	724.4	219.2	943.6	306.3		35.0	800	1,500	35.0	3.5	38.5	28.0	5.3	33.3	35.0	3.5	38.5	28.0	5.3	33.3	35.0	3.5	38.5	28.0	5.3	33.3
3.16 MSIP Package (4)							31.3	800	1,500	31.3	3.1	34.4	25.0	4.7	29.7	31.3	3.1	34.4	25.0	4.7	29.7	31.3	3.1	34.4	25.0	4.7	29.7
3.17 SSIP							67.2	800	1,500	52.4	5.2	57.6	41.9	7.8	49.7	67.2	6.7	73.9	53.8	10.1	63.8	67.2	6.7	73.9	53.8	10.1	63.8
3.18 Pump Irrigation							6.8	800	1,500	2.2	0.2	2.4	1.8	0.3	2.1	6.8	0.7	7.5	5.4	1.1	6.5	6.8	0.7	7.5	5.4	1.1	6.5
Sub-total	3570.0	760.0	190.0	950.0	266.0		285.6			172.2	17.1	189.3	137.8	25.7	163.4	235.5	32.3	267.8	188.4	48.5	236.9	285.6	48.4	334.0	228.5	72.5	301.0
							(287.5)			(122.7)	(12.3)	(135.0)	(98.2)	(18.5)	(116.6)	(278.3)	(59.0)	(337.3)	(222.6)	(88.5)	(311.1)	(287.5)	(62.0)	(349.5)	(230.0)	(93.0)	(323.0)
(4) Middle Kok Sub-basin																											
4.1 Chiang Rai Weir	6220.0	2895.0	695.0	3590.0	577.0		48.7	800	1,500							48.7	4.9	53.6	39.0	7.4	46.3	48.7	4.9	53.6	39.0	7.4	46.3
4.2 Kok-Ing Diversion							(34.8)	800	1,500							(34.8)	(17.4)	(52.2)	(27.8)	(26.1)	(53.9)	(34.8)	(17.4)	(52.2)	(27.8)	(26.1)	(53.9)
4.3 SSIP							6.1	800	1,500	4.1	0.4	4.5	3.3	0.6	3.9	6.1	0.6	6.7	4.9	0.9	5.8	6.1	0.6	6.7	4.9	0.9	5.8
4.5 Pump Irrigation							24.5	800	1,500	11.0	1.1	12.1	8.8	1.7	10.5	24.5	2.5	27.0	19.6	3.8	23.4	24.5	2.5	27.0	19.6	3.8	23.4
Sub-total	910.0	320.0	50.0	370.0	406.0		79.3			15.1	1.5	16.6	12.1	2.3	14.3	79.3	8.0	87.3	63.4	12.0	75.5	79.3	8.0	87.3	63.4	12.0	75.5
							(34.8)									(34.8)	(17.4)	(52.2)	(27.8)	(26.1)	(53.9)	(34.8)	(17.4)	(52.2)	(27.8)	(26.1)	(53.9)
(5) Lower Kok Sub-basin																											
5.1 Nong Luang	173.0				364.0	15.0	5.0	800	1,500							5.0	0.5	5.5	4.0	0.8	4.8	5.0	0.5	5.5	4.0	0.8	4.8
5.2 Wiang Nang							35.0	800	1,500													35.0	3.5	38.5	28.0	5.3	33.3
5.3 MSIP Package (8)							36.3	800	1,500	46.3	4.6	50.9	37.0	6.9	43.9	46.3	4.6	50.9	37.0	6.9	43.9	46.3	4.6	50.9	37.0	6.9	43.9
5.4 SSIP							30.2	800	1,500	30.2	3.0	33.2	24.2	4.5	28.7	30.2	3.2	33.4	24.2	4.8	29.0	30.2	3.0	33.2	24.2	4.5	28.7
5.5 Pump Irrigation							12.2	800	1,500	3.2	0.3	3.5	2.6	0.5	3.0	12.2	1.2	13.4	9.8	1.8	11.6	12.2	1.2	13.4	9.8	1.8	11.6
Sub-total	4080	555	95	650	159		118.7			79.7	7.9	87.6	63.8	11.9	75.6	93.7	9.5	103.2	75.0	14.3	89.2	128.7	12.8	141.5	103.0	19.2	122.2
Kok Basin Total	**13700.0**	**4205.0**	**985.0**	**5190.0**	**2849.0**	**0.0**	**929.1**			**464.0**	**46.2**	**510.2**	**371.2**	**69.3**	**440.5**	**713.2**	**93.9**	**807.1**	**570.6**	**140.9**	**711.4**	**939.1**	**145.5**	**1084.6**	**751.3**	**218.3**	**969.5**
							(322.3)			(122.7)	(12.3)	(135.0)	(98.2)	(18.5)	(116.6)	(313.1)	(76.4)	(389.5)	(250.5)	(114.6)	(365.1)	(322.3)	(79.4)	(401.7)	(257.8)	(119.1)	(376.9)

Note: Water Resources developed in Kok basin and shown in parentheses are used in Ing basin.

Table 8.2.8 Existing, Future and Potential Irrigation Development in Ing Basin

Irrigation Project	Drainage Area (sq.km)	Average Runoff (MCM)			Runoff Yield (mm)	Reservoir Capacity (MCM)	Project Area (103 rai)	Irrigation Unit Demand (m3/rai)		Existing Irrigation Project (1996)						Proposed Irrigation Project (2016)						Potential Irrigation Project (Eventual)					
										Irrigation Area (103 rai)			Water Demand (MCM)			Irrigation Area (103 rai)			Water Demand (MCM)			Irrigation Area (103 rai)			Water Demand (MCM)		
		Wet	Dry	Total				Wet	Dry	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	Total
1. Upper Ing Sub-basin																											
1.1 Mae Chai Reservoir						2.3	2.8	800	1,500							2.8	0.8	3.6	2.2	1.2	3.4	2.8	0.8	3.6	2.2	1.2	3.4
1.2 Nong Leng Sai Reservoir		120.0				6.5	10.0	800	1,500							10.0	1.0	11.0	8.0	1.5	9.5	10.0	1.0	11.0	8.0	1.5	9.5
1.3 Mae Phuem Reservoir		165.0					45.7	800	1,500	45.7	13.7	59.4	36.6	20.6	57.1	45.7	13.7	59.4	36.6	20.6	57.1	45.7	13.7	59.4	36.6	20.6	57.1
1.4 Mae Rong Sak Reservoir		27.0		8.0	296.0	4.0	12.5	800	1,500													12.5	2.5	15.0	10.0	3.8	13.8
1.5 Rong Chang Reservoir		14.0		4.0	286.0	0.3	1.9	800	1,500							1.9	0.6	2.5	1.5	0.9	2.4	1.9	0.6	2.5	1.5	0.9	2.4
1.6 Mae Tam Reservoir						13.0	40.3	800	1,500	40.3	12.1	52.4	32.2	18.1	50.4	40.3	12.1	52.4	32.2	18.1	50.4	40.3	12.1	52.4	32.2	18.1	50.4
1.7 Mae Tom Reservoir						5.2	8.0	800	1,500	8.0	2.4	10.4	6.4	3.6	10.0	8.0	2.4	10.4	6.4	3.6	10.0	8.0	2.4	10.4	6.4	3.6	10.0
1.8 Mae Lao Extension		Lao(Kok)					(164.8)	800	1,500													(164.8)	(49.4)	(214.2)	(131.8)	(74.2)	(206.0)
1.9 MSIP Package (4)							11.0	800	1,500	11.0	1.1	12.1	8.8	1.7	10.5	11.0	1.1	12.1	8.8	1.7	10.5	11.0	1.1	12.1	8.8	1.7	10.5
1.9 SSIP							48.1	800	1,500	37.1	3.7	40.8	29.7	5.6	35.2	48.1	4.8	52.9	38.5	7.2	45.7	48.1	4.8	52.9	38.5	7.2	45.7
1.10 Pump Irrigation							3.0	800	1,500	1.3	0.1	1.4	1.0	0.2	1.2	3.0	0.3	3.3	2.4	0.5	2.9	3.0	0.3	3.3	2.4	0.5	2.9
Sub-total					718.0	4650.0	183.3			143.4	33.1	176.5	114.7	49.7	164.4	170.8	36.8	207.6	136.6	55.2	191.8	183.3	39.3	222.6	146.6	58.9	205.6
							(164.8)															(164.8)	(49.4)	(214.2)	(131.8)	(74.2)	(206.0)
(2) Middle Ing Sub-basin																											
2.1 Lower Thoeng Weir	4380.0						37.0	800	1,500							37.0	3.7	40.7	29.6	5.6	35.2	37.0	3.7	40.7	29.6	5.6	35.2
2.2 Kin Diversion (1)							(23.0)	800	1,500							(23.0)	(11.5)	(34.5)	(18.4)	(17.3)	(35.7)	(23.0)	(11.5)	(34.5)	(18.4)	(17.3)	(35.7)
2.3 Phayao-Dok Kam Tai							12.0	800	1,500	12.0	1.2	13.2	9.6	1.8	11.4	12.0	1.2	13.2	9.6	1.8	11.4	12.0	1.2	13.2	9.6	1.8	11.4
2.4 MSIP Package (7)							98.9	800	1,500	98.9	9.9	108.8	79.1	14.8	94.0	98.9	9.9	108.8	79.1	14.8	94.0	98.9	9.9	108.8	79.1	14.8	94.0
2.5 SSIP							86.4	800	1,500	80.0	8.0	88.0	64.0	12.0	76.0	86.4	8.6	95.0	69.1	13.0	82.1	86.4	8.6	95.0	69.1	13.0	82.1
2.6 Pump Irrigation							41.4	800	1,500	7.2	0.7	7.9	5.8	1.1	6.8	41.4	4.1	45.5	33.1	6.2	39.3	41.4	4.1	45.5	33.1	6.2	39.3
Sub-total							275.7			198.1	19.8	217.9	158.5	29.7	188.2	275.7	27.6	303.3	220.6	41.4	261.9	275.7	27.6	303.3	220.6	41.4	261.9
							(23.0)									(23.0)	(11.5)	(34.5)	(18.4)	(17.3)	(35.7)	(23.0)	(11.5)	(34.5)	(18.4)	(17.3)	(35.7)
(3) Mae Nam Phung Sub-basin																											
3.1 Mae Lao Weir	Lao(Kok)						(122.7)	800	1,500	(122.7)	(24.5)	(147.2)	(98.2)	(36.8)	(135.0)	(122.7)	(24.5)	(147.2)	(98.2)	(36.8)	(135.0)	(122.7)	(24.5)	(147.2)	(98.2)	(36.8)	(135.0)
3.1 MSIP Package (8)							38.4	800	1,500	38.4	3.8	42.2	30.7	5.8	36.5	38.4	3.8	42.2	30.7	5.8	36.5	38.4	3.8	42.2	30.7	5.8	36.5
3.2 SSIP							57.6	800	1,500	10.4	1.0	11.4	8.3	1.6	9.9	57.6	5.8	63.4	46.1	8.6	54.7	57.6	5.8	63.4	46.1	8.6	54.7
3.3 Pump Irrigation							3.0	800	1,500	1.5	0.2	1.7	1.2	0.2	1.4	3.0	0.3	3.3	2.4	0.5	2.9	3.0	0.3	3.3	2.4	0.5	2.9
Sub-total							99.0			50.3	5.0	55.3	40.2	7.5	47.8	99.0	9.9	108.9	79.2	14.9	94.1	99.0	9.9	108.9	79.2	14.9	94.1
							(122.7)			(122.7)	(24.5)	(147.2)	(98.2)	(36.8)	(135.0)	(122.7)	(24.5)	(147.2)	(98.2)	(36.8)	(135.0)	(122.7)	(24.5)	(147.2)	(98.2)	(36.8)	(135.0)
(4) Mae Lao(Ing) Sub-basin																											
4.1 Nam Yuan Reservoir						24.0	20.0	800	1,500							20.0	6.0	26.0	16.0	9.0	25.0	20.0	6.0	26.0	16.0	9.0	25.0
4.2 MSIP Package (7)							42.0	800	1,500	42.0	4.2	46.2	33.6	6.3	39.9	42.0	4.2	46.2	33.6	6.3	39.9	42.0	4.2	46.2	33.6	6.3	39.9
4.3 SSIP							63.4	800	1,500	50.9	5.1	56.0	40.7	7.6	48.4	63.4	6.3	69.7	50.7	9.5	60.2	63.4	6.3	69.7	50.7	9.5	60.2
4.4 Pump Irrigation								800	1,500													0.0	0.0	0.0	0.0	0.0	0.0
Sub-total							125.4			92.9	9.3	102.2	74.3	13.9	88.3	125.4	16.5	141.9	100.3	24.8	125.1	125.4	16.5	141.9	100.3	24.8	125.1
(5) Lower Ing Sub-basin																											
5.1 Nam Ing Weir							48.0	800	1,500							48.0	4.8	52.8	38.4	7.2	45.6	48.0	4.8	52.8	38.4	7.2	45.6
5.2 Upper Thoeng Weir	6350.0					17.0	12.0	800	1,500							12.0	1.2	13.2	9.6	1.8	11.4	12.0	1.2	13.2	9.6	1.8	11.4
5.3 Mae Tak Reservoir							17.0	800	1,500	17.0	5.1	22.1	13.6	7.7	21.3	17.0	5.1	22.1	13.6	7.7	21.3	17.0	5.1	22.1	13.6	7.7	21.3
5.4 Huai Chang Reservoir							7.0	800	1,500	7.0	2.1	9.1	5.6	3.2	8.8	7.0	2.1	9.1	5.6	3.2	8.8	7.0	2.1	9.1	5.6	3.2	8.8
5.5 KIN Diversion (2)							(11.8)	800	1,500							(11.8)	(5.9)	(17.7)	(9.4)	(8.9)	(18.3)	(11.8)	(5.9)	(17.7)	(9.4)	(8.9)	(18.3)
5.2 MSIP Package (7)							33.9	800	1,500	33.9	3.4	37.3	27.1	5.1	32.2	33.9	3.4	37.3	27.1	5.1	32.2	33.9	3.4	37.3	27.1	5.1	32.2
5.3 SSIP							27.2	800	1,500	27.2	2.7	29.9	21.8	4.1	25.8	27.2	2.7	29.9	21.8	4.1	25.8	27.2	2.7	29.9	21.8	4.1	25.8
5.4 Pump Irrigation							36.5	800	1,500	20.1	2.0	22.1	16.1	3.0	19.1	36.5	3.7	40.2	29.2	5.5	34.7	36.5	3.7	40.2	29.2	5.5	34.7
Sub-total							181.6			105.2	15.3	120.5	84.2	23.0	107.1	181.6	23.0	204.6	145.3	34.4	179.7	181.6	23.0	204.6	145.3	34.4	179.7
							(11.8)									(11.8)	(5.9)	(17.7)	(9.4)	(8.9)	(18.3)	(11.8)	(5.9)	(17.7)	(9.4)	(8.9)	(18.3)
Ing Basin Total							**865.0**			**589.9**	**82.6**	**672.5**	**471.9**	**123.9**	**595.8**	**852.5**	**113.8**	**966.3**	**682.0**	**170.6**	**852.6**	**865.0**	**116.3**	**981.3**	**692.0**	**174.4**	**866.4**
							(322.3)			**(122.7)**	**(24.5)**	**(147.2)**	**(98.2)**	**(36.8)**	**(135.0)**	**(157.5)**	**(41.9)**	**(199.4)**	**(126.0)**	**(62.9)**	**(188.9)**	**(322.3)**	**(91.4)**	**(413.7)**	**(257.8)**	**(137.1)**	**(394.9)**

Note: Irrigation area and water demand in parentheses are covered by water resources to be developed in Loa (Kok) basin.

Table 8.2.14 Runoff of Kok River at Diversion Site (Future Condition, W/O Mae Kok Dam)

(Unit: cu.m/sec)

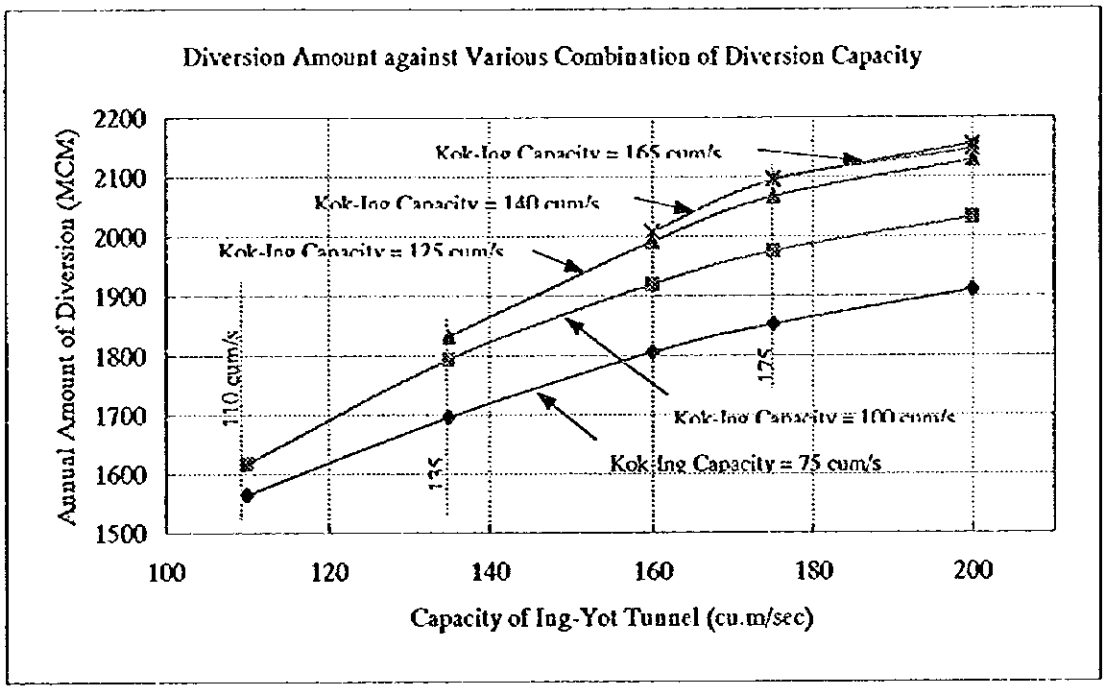
Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total (MCM)
1974	30.47	43.44	47.55	62.35	178.81	188.98	80.24	85.47	102.33	53.52	29.71	23.59	2,443.28
1975	19.41	30.38	57.97	119.90	230.57	313.79	192.11	115.23	73.26	48.28	37.86	26.92	3,336.43
1976	23.68	35.66	36.09	61.53	169.09	165.27	125.35	101.22	54.31	45.52	33.42	26.67	2,314.27
1977	29.89	46.78	30.54	113.44	122.26	231.63	166.74	123.36	73.39	66.05	40.47	30.70	2,833.57
1978	27.73	38.65	50.85	207.97	263.79	323.62	204.15	117.48	74.95	50.10	37.22	27.86	3,760.48
1979	22.34	30.29	51.08	56.63	156.09	169.96	106.12	50.94	41.14	31.33	24.66	16.34	1,995.51
1980	14.66	16.22	38.37	134.65	159.70	276.64	142.45	84.60	59.95	29.66	33.50	24.06	2,672.65
1981	22.09	64.95	76.50	182.68	315.02	256.66	176.15	159.84	91.10	59.81	43.98	33.60	3,914.50
1982	37.43	31.51	83.10	92.25	280.49	253.13	187.34	105.58	64.32	51.43	39.88	31.04	3,316.34
1983	23.61	25.50	37.35	84.41	226.13	259.27	195.22	197.84	132.64	64.78	47.78	34.11	3,501.48
1984	28.12	34.97	49.43	123.58	157.78	239.45	159.15	97.68	56.66	44.88	34.58	25.51	2,772.32
1985	23.58	39.87	52.06	109.44	215.77	267.31	126.07	187.00	95.30	58.60	43.96	32.88	3,295.75
1986	28.52	43.50	44.67	105.69	113.29	145.51	81.99	68.63	42.81	46.48	31.32	24.70	2,048.47
1987	19.66	18.53	34.76	56.65	168.59	135.72	79.56	88.96	49.96	34.83	27.56	20.45	1,937.98
1988	23.34	44.57	52.92	107.06	266.30	210.02	113.82	96.97	59.68	41.80	31.72	25.45	2,834.33
1989	19.35	27.90	57.15	134.68	177.32	228.64	215.66	116.47	67.80	48.09	37.59	30.63	3,064.20
1990	22.58	41.49	63.63	136.39	125.63	162.73	114.82	97.66	53.92	40.15	30.21	21.80	2,402.27
1991	24.23	28.48	73.75	89.52	203.31	224.06	125.68	108.51	64.18	46.81	38.78	27.38	2,777.63
1992	19.61	16.63	22.14	85.89	114.11	121.43	73.14	71.74	50.73	35.45	25.09	18.24	1,725.41
1993	13.19	22.36	33.49	114.46	147.18	178.71	118.39	81.18	49.38	46.48	35.95	27.46	2,289.66
1994	21.46	30.74	55.46	129.97	325.62	305.63	153.32	91.47	88.45	56.33	42.88	31.03	3,516.52
1995	25.32	32.67	39.69	103.00	401.71	387.76	107.33	96.46	55.65	43.03	39.40	27.47	3,583.59
1996	25.01	36.30	71.95	125.70	359.14	321.24	154.43	116.65	66.62	47.41	35.86	27.41	3,661.36
Average	23.71	33.97	50.46	110.34	212.07	233.35	139.10	107.00	68.20	47.43	35.80	26.75	2,869.48
Max.	37.43	64.95	83.10	207.97	401.71	387.76	215.66	197.84	132.64	66.05	47.78	34.11	3,914.50
Min.	13.19	16.22	22.14	56.63	113.29	121.43	73.14	50.94	41.14	29.66	24.66	16.34	1,725.41

Table 8.2.15 Runoff of Ing River at Diversion Site (Future Condition)

(Unit: cu.m/sec)

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total (MCM)
1974	3.31	4.05	1.41	6.52	130.57	147.52	43.10	41.28	7.31	15.21	2.36	1.41	1,064.88
1975	1.41	1.41	37.09	66.41	193.38	207.23	92.36	29.09	8.06	2.15	1.41	1.41	1,693.84
1976	1.41	3.89	0.00	4.42	52.27	60.64	105.28	59.14	4.77	6.67	0.19	0.00	789.46
1977	3.87	5.14	0.00	27.82	97.03	206.59	135.31	61.14	9.10	12.78	1.41	1.41	1,480.36
1978	1.41	6.76	0.37	134.51	153.19	194.66	59.27	18.58	4.41	1.41	1.21	0.00	1,523.28
1979	0.00	5.58	29.28	27.71	57.12	50.00	5.52	6.15	0.22	0.00	0.00	0.00	478.96
1980	0.00	0.24	0.22	78.01	172.44	286.38	87.69	11.07	9.01	1.41	0.00	0.00	1,705.79
1981	0.58	6.94	0.00	97.42	119.89	72.86	1.41	43.50	12.74	1.41	0.00	0.00	945.42
1982	5.44	3.55	0.00	7.63	36.87	64.25	50.27	13.76	1.39	0.00	0.00	0.00	483.37
1983	0.00	1.14	0.00	1.41	88.03	126.40	72.47	55.59	8.43	1.41	0.34	0.00	935.61
1984	0.01	6.21	10.47	36.57	114.73	172.30	31.29	33.31	1.59	1.41	0.00	0.00	1,073.82
1985	0.06	4.37	0.00	28.47	130.65	80.35	14.45	95.51	39.39	1.41	0.74	0.00	1,043.65
1986	1.14	14.56	0.00	24.56	72.68	86.53	21.30	25.60	3.12	3.42	0.14	0.00	667.95
1987	0.33	1.01	0.00	0.81	51.59	115.94	72.93	41.79	3.57	1.41	0.00	0.00	761.42
1988	0.00	46.36	39.86	42.30	107.14	66.68	10.80	19.08	1.41	0.42	0.00	0.00	883.87
1989	0.00	0.52	16.89	50.26	59.02	100.94	121.99	20.86	1.41	1.41	0.15	0.04	988.33
1990	0.02	1.72	0.00	40.38	109.68	62.62	13.26	37.79	2.51	0.50	0.00	0.00	710.42
1991	0.00	3.65	9.70	12.10	58.16	152.08	33.46	29.99	1.55	0.33	0.00	0.05	789.82
1992	0.00	0.00	0.00	1.41	23.00	44.76	17.05	26.84	8.85	11.84	1.41	3.02	363.55
1993	8.68	9.95	0.36	44.61	26.24	58.87	2.82	24.74	2.78	0.14	0.00	0.00	471.94
1994	12.57	22.49	35.62	96.51	356.04	371.67	43.51	6.25	11.78	1.82	0.00	2.37	2,536.14
1995	1.56	9.25	0.00	24.22	318.22	308.54	57.40	34.88	4.06	1.70	0.93	0.42	2,008.70
1996	2.72	12.14	4.11	34.53	111.18	118.18	28.42	32.81	2.79	1.41	1.09	0.26	922.56
Average	1.94	7.43	8.06	38.63	114.74	137.22	48.75	33.42	6.53	3.03	0.49	0.45	1,057.53
Max.	12.57	46.36	39.86	134.51	356.04	371.67	135.31	95.51	39.39	15.21	2.36	3.02	2,536.14
Min.	0.00	0.00	0.00	0.81	23.00	44.76	1.41	6.15	0.22	0.00	0.00	0.00	363.55

Figure 8.3.1 Diversion mount against Diversion Capacity



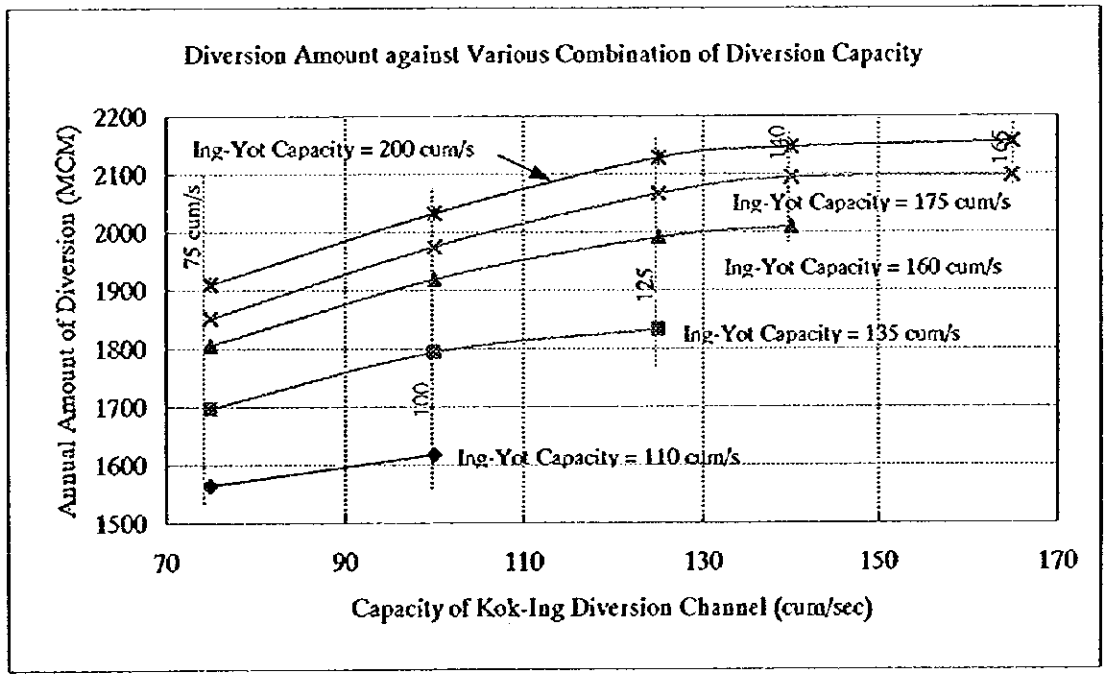


Table 8.3.2 Cost Comparison of Diversion Canal/Tunnel

Diversion Capacity		Diversion	Construction Cost			Water	Remark
Kok-Ing (m^3/sec)	Ing-Yot (m^3/sec)	Water (MCM)	Kok-Ing (10^6Baht)	Ing-Yot (10^6Baht)	Total (10^6Baht)	Cost Baht/m^3	
75	200	1,910	6,125	26,279	32,404	16.97	
100	200	2,032	6,558	26,279	32,837	16.16	
125	200	2,128	6,971	26,279	33,250	15.63	low
140	200	2,146	7,275	26,279	33,554	15.64	low
165	200	2,155	7,825	26,279	34,104	15.83	
75	175	1,852	6,125	24,945	31,070	16.78	
100	175	1,975	6,558	24,945	31,503	15.95	
125	175	2,066	6,971	24,945	31,916	15.45	low
140	175	2,094	7,275	24,945	32,220	15.39	lowest
165	175	2,097	7,825	24,945	32,770	15.63	low
75	160	1,805	6,125	24,129	30,254	16.76	
100	160	1,919	6,558	24,129	30,687	15.99	
125	160	1,991	6,971	24,129	31,100	15.62	low
140	160	2,009	7,275	24,129	31,404	15.63	low
75	135	1,696	6,125	23,106	29,231	17.24	
100	135	1,793	6,558	23,106	29,664	16.54	
125	135	1,832	6,971	23,106	30,077	16.42	
75	110	1,564	6,125	21,825	27,950	17.87	
100	110	1,617	6,558	21,825	28,383	17.55	

Figure 8.3.2 Cost Comparison

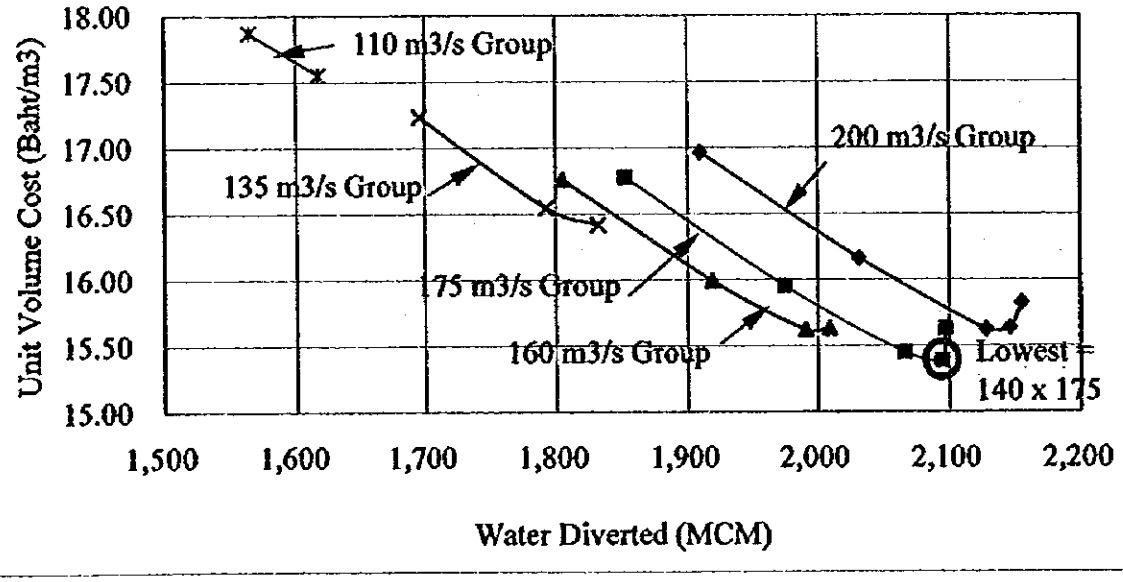


Table 8.3.3 Construction Cost of Alternative Diversion Capacity (10^6 Baht)

(1) Kok-Ing Diversion System

	Discharge Capacity m^3/sec				
	140	75	100	125	165
1. Kok-Ing Tunnel, Total	2,865	2,285	2,528	2,751	3,035
2. Other Construction Cost					
(1) Kok Intake	319	319	319	319	319
(2) Kok Open Canal	570	485	513	542	627
(3) Main O/M Office	288	288	288	288	288
(4) Tak Open Canal	294	250	265	279	323
(5) Tak Culvert Canal	1,757	1,493	1,581	1,669	1,933
(6) Ing Open Canal	867	737	780	824	954
(7) Ing Culvert Canal	315	268	284	299	347
Sub-total (1)~(7)	4,410	3,840	4,030	4,220	4,790
Total (1.+2.)	7,275	6,125	6,558	6,971	7,825

(2) Ing-Yot Diversion System

	Discharge Capacity m^3/sec				
	175	110	135	160	200
1. Ing-Yot Tunnel, Total	18,752	16,177	17,276	18,118	19,722
2. Other Construction Cost					
(1) Ing Weir	354	354	354	354	354
(2) Ing Intake	399	399	399	399	399
(3) Ing-Yot Open Canal	81	69	73	77	89
(4) Ing-Yot Culvert Canal	3,554	3,021	3,199	3,376	3,909
(5) Yao Dam & River Training	1,805	1,805	1,805	1,805	1,805
Sub-total (1)~(5)	6,193	5,648	5,830	6,011	6,557
Total (1.+2.)	24,945	21,825	23,106	24,129	26,279

Table 8.3.4 Tunnel Construction Cost by Alternative Discharge

(Unit; 10^3 Baht)

Discharge m^3/sec	Inner Section Area		Circuit Length		Excavation	Other Cost for Shot Crete, Rock Bolt Steel Support, Concrete, etc.	Cost for Tomporary & Adit Works	Total Construction Cost	Total Cost Including Overhead
	m^2	Rate (%)	m	Rate (%)					
	①		②		③ Ex.Cost×① rate	④ Other Cost×② rate	⑤ No Change	⑥=③+④+⑤	⑦=⑥×1.1
1. Kok-Ing Tunnel									
140	61.77	100	12.50	100	405,622	1,776,361	422,220	2,604,203	2,865,000
75	38.48	62	9.88	79	405,622×0.62= 251,486	1,776,361×0.79= 1,403,325	422,220	2,077,031	2,285,000
100	47.79	77	11.00	88	- do - ×0.77= 312,329	- do - ×0.88= 1,563,198	422,220	2,297,747	2,528,000
125	56.90	92	12.00	96	- do - ×0.92= 373,172	- do - ×0.96= 1,705,307	422,220	2,500,699	2,751,000
165	69.43	112	13.25	106	- do - ×1.12= 454,297	- do - ×1.06= 1,882,943	422,220	2,759,460	3,035,000
2. Ing-Yot Tunnel									
175	73.40	100	13.63	100	3,590,428	8,119,628	5,336,813	17,046,869	18,752,000
110	52.25	71	11.50	84	3,590,428×0.71= 2,549,204	8,119,628×0.84= 6,820,488	5,336,813	14,706,505	16,177,000
135	60.54	83	12.38	91	- do - ×0.83= 2,980,055	- do - ×0.91= 7,388,862	5,336,813	15,705,730	17,276,000
160	68.12	93	13.13	96	- do - ×0.93= 3,339,098	- do - ×0.96= 7,794,843	5,336,813	16,470,754	18,118,000
200	81.80	111	14.38	106	- do - ×1.11= 3,985,375	- do - ×1.06= 8,606,806	5,336,813	17,928,994	19,722,000

Remarks; (1) Excavation cost is changed based on the area rate of tunnel inner section.

(2) Other cost for shot crete, rock bolt, steel support, concrete living, etc is changed based on the circuit length rate of tunnel inner section.

(3) Cost for temporary and adit works is not changed and fixed in any alternative tunnel.

Table 8.3.5 Summary of Tunnel Construction Cost (140 m^3/sec for Kok-Ing and 175 m^3/sec for Ing-Yot)

(Unit; 10^3 Baht)

Tunnel Division	Excavation & Other Cost			Temporary and Adit Cost					Total Construction Cost	Tunnel Length km
	Excavation Cost ①	Other Cost ②	Total ③=①+②	Common Tomporary ④	Tunnel Inside Temporary ⑤	Sub-total ⑥=④+⑤	Adit Cost ⑦	Total ⑧=⑥+⑦	⑨=③+⑧	
1. Kok-Ing Tunnel										
(1) No. 1 Tunnel	142,277	650,118	792,395	39,620	133,410	173,030	0	173,030	965,425	3,047
(2) No. 2 Tunnel	263,345	1,126,243	1,389,588	69,479	179,711	249,190	0	249,190	1,638,778	5,415
Sub-total	405,622	1,776,361	2,181,983	109,099	313,121	422,220	0	422,220	2,604,203	8,462
2. Ing-Yot Tunnel										
(1) Ing-Yot No.1	107,204	459,685	566,889	28,345	93,848	122,193	0	122,193	689,082	2,008
(2) Ing-Yot No.2 Div. 1	291,844	949,576	1,241,420	62,071	177,645	239,716	0	239,716	1,481,136	4,910
(3) - do - Div. 2	314,812	661,730	976,542	66,905	216,321	283,226	361,574	644,800	1,621,342	4,550
(4) - do - Div. 3	369,397	855,762	1,225,159	77,260	230,205	307,465	320,049	627,514	1,852,673	5,435
(5) - do - Div. 4	491,983	1,072,569	1,564,552	93,996	248,360	342,356	315,365	657,721	2,222,273	7,215
(6) - do - Div. 5	460,197	852,202	1,312,399	86,467	245,112	331,579	416,947	748,526	2,060,925	6,440
(7) - do - Div. 6	434,760	969,514	1,404,274	89,132	236,350	325,482	378,370	703,852	2,108,126	6,400
(8) - do - Div. 7	452,370	753,722	1,206,092	81,109	247,563	328,672	416,083	744,755	1,950,847	6,060
(9) - do - Div. 8	367,304	611,210	978,514	63,964	233,841	297,805	300,762	598,567	1,577,081	4,950
(10) - do - Div. 9	300,557	933,658	1,234,215	61,711	187,458	249,169	0	249,169	1,483,384	4,915
Sub-total	3,590,428	8,119,628	11,710,056	710,960	2,116,703	2,827,663	2,509,150	5,336,813	17,046,869	52,883
Total	3,996,050	9,895,989	13,892,039	820,059	2,429,824	3,249,883	2,509,150	5,759,033	19,651,072	61,345

Remarks; The other cost in the above table consists of the works of shotcrete, rock bolt, steel support concrete living and drain pie.
The cost of those works is changed based on the circuit length of tunnel.

Table 8.3.7 Estimation of Agricultural Benefit

(a) Estimation of Available Water for Irrigation in Alternative Capacity

Unit MCM

Item \ Alternative Capacity m^3/sec	K = 140 I = 200	K = 140 I = 175	K = 125 I = 160	K = 125 I = 135	K = 75 I = 100
(1) Water Diversion Amount	2,146	2,094	1,991	1,832	1,617
(2) Additional Sirikit Outflow	800	800	800	800	800
(3) Municipal/Industrial Water Use	825	825	825	825	825
(4) Available Irrigation Water (1)+(2)-(3)	2,121	2,069	1,966	1,807	1,592

Remarks; (1) Additional Sirikit outflow means the additional dry season outflow produced by the improved reservoir operation based on the Kok-Ing water diversion project.

(2) Municipal and industrial water use means the water supply to Bangkok metropolitan and vicinity areas and its amount is constant at 825 MCM in any alternative capacity.

(b) Diversified Cropping Area in Dry Season by Alternative Capacity

Unit Area, 10^3 rai, Demand, MCM

Crops \ Alternative Capacity m^3/sec	Unit Irrigation Demand m^3/rai	K = 140 I = 200		K = 140 I = 175		K = 125 I = 160		K = 125 I = 135		K = 75 I = 100	
		Area	Water Demand	Area	Water Demand	Area	Water Demand	Area	Water Demand	Area	Water Demand
Sugar Cane	1,300	125	163	120	156	115	150	105	137	90	117
Fruit Tree	2,000	330	660	320	640	305	610	280	560	245	490
Fish Pond	1,450	80	116	80	116	75	109	70	102	60	87
Field Crops	1,300	250	325	240	312	230	299	210	273	185	241
Vegetable	550	145	80	140	77	130	72	120	66	110	61
Dry Paddy	1,850	420	777	415	768	390	722	360	666	320	592
Total	-	1,350	2,121	1,315	2,069	1,245	1,962	1,145	1,804	1,010	1,588

(c) Agricultural Benefit by Alternative Capacity

Unit Area, 10^3 rai, Amount 10^6 Baht

Crops \ Alternative Capacity m^3/sec	Unit Irrigation Per rai Baht	K = 140 I = 200		K = 140 I = 175		K = 125 I = 160		K = 125 I = 135		K = 75 I = 100	
		Area	Amount	Area	Amount	Area	Amount	Area	Amount	Area	Amount
Sugar Cane	8,152	125	1,019	120	978	115	937	105	856	90	734
Fruit Tree	15,000	330	4,950	320	4,800	305	4,575	280	4,200	245	3,675
Fish Pond	15,771	80	1,262	80	1,262	75	1,183	70	1,104	60	946
Field Crops	7,960	250	1,990	240	1,910	230	1,831	210	1,672	185	1,473
Vegetable	4,412	145	640	140	618	130	574	120	529	110	485
Dry Paddy	2,117	420	889	415	879	390	826	360	762	320	677
Total	-	1,350	10,750	1,315	10,447	1,245	9,926	1,145	9,123	1,010	7,990

Figure 8.3.3 Flow Condition of Kok River before/after Propoed Water Diversion

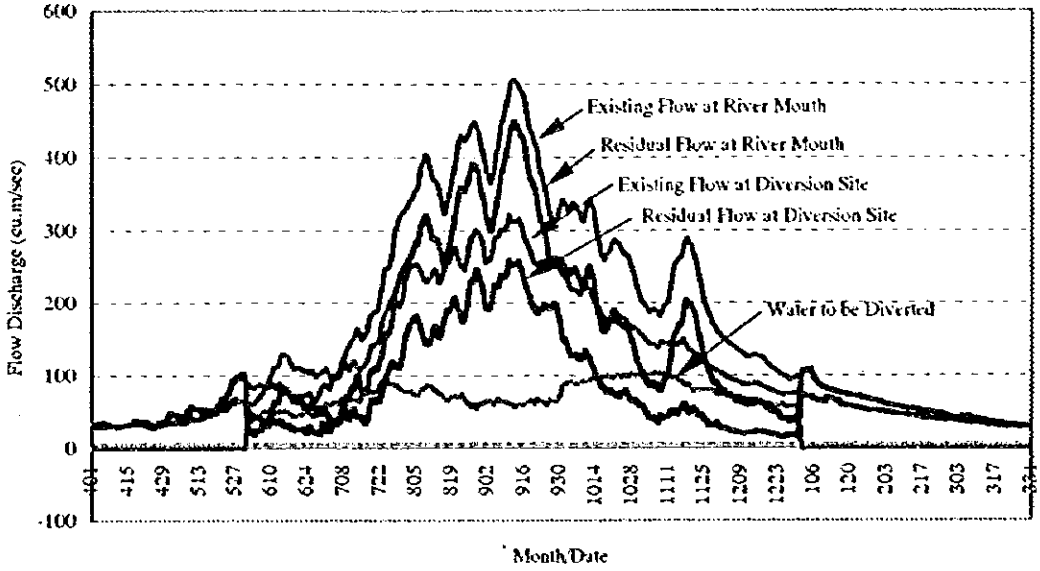


Figure 8.3.4 Flow Condition of Ing Riverefore/after Proposed Water Diversion

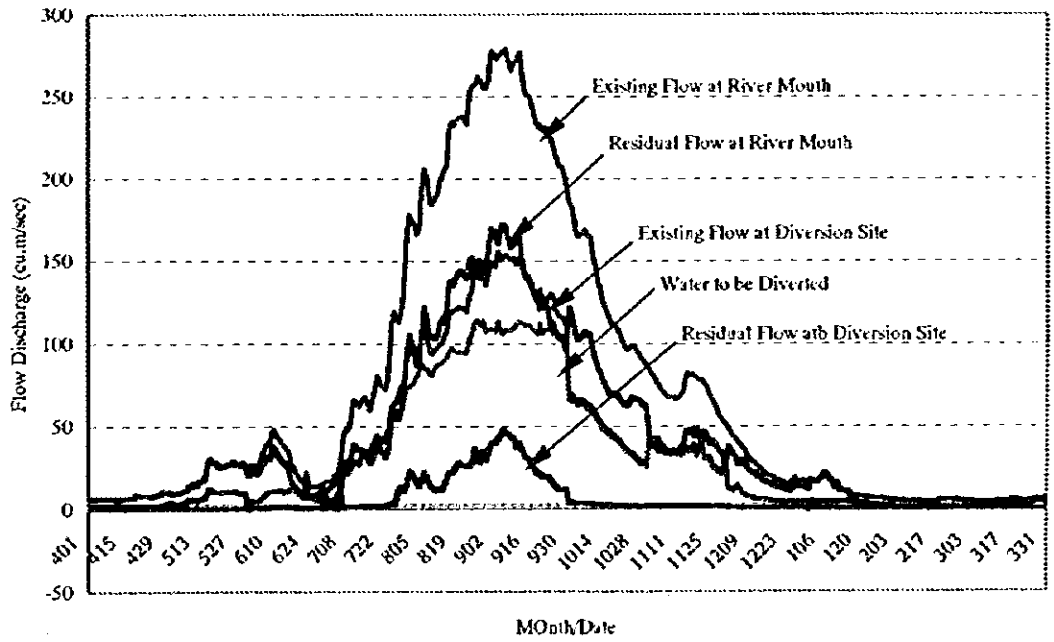
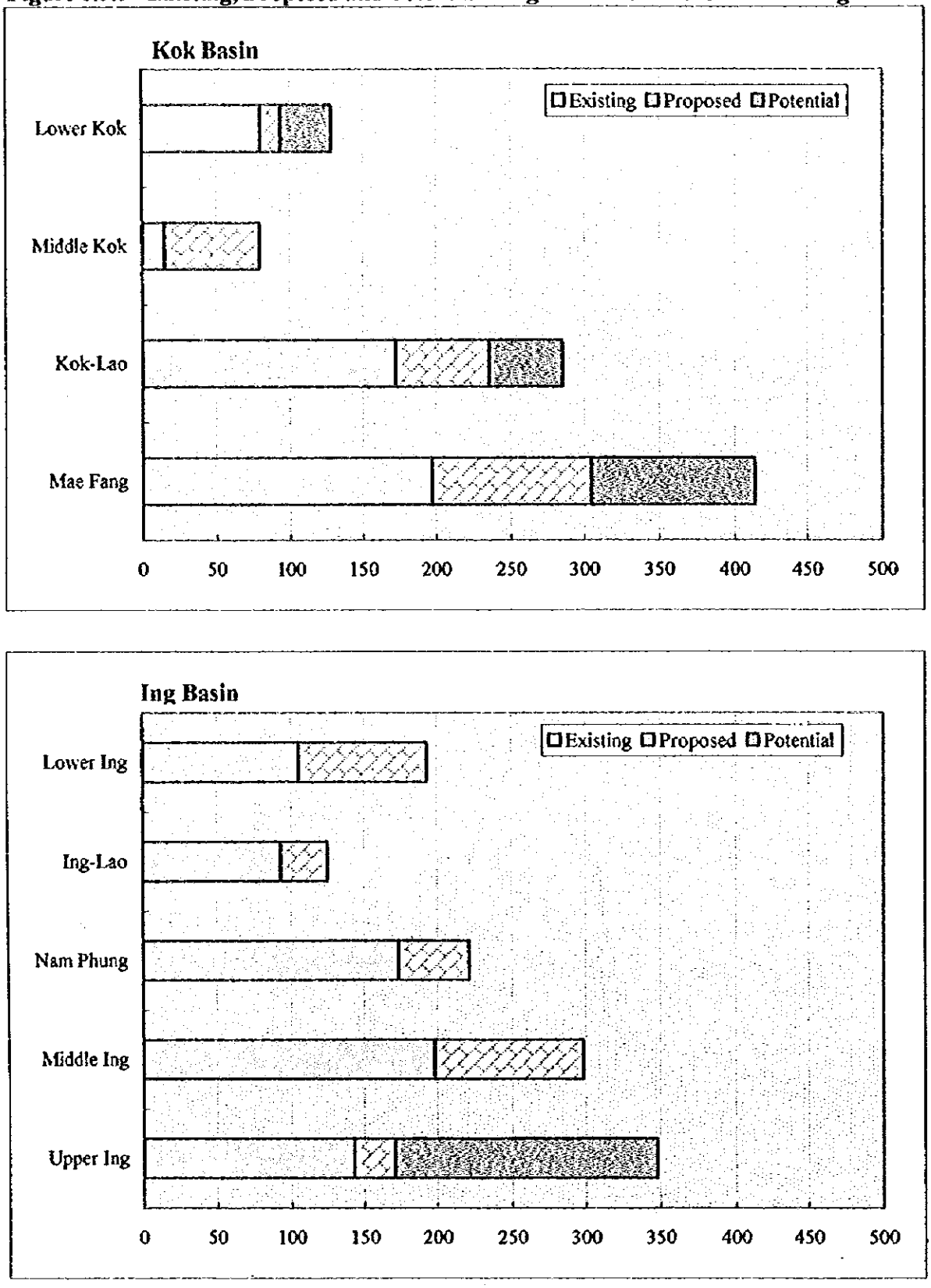
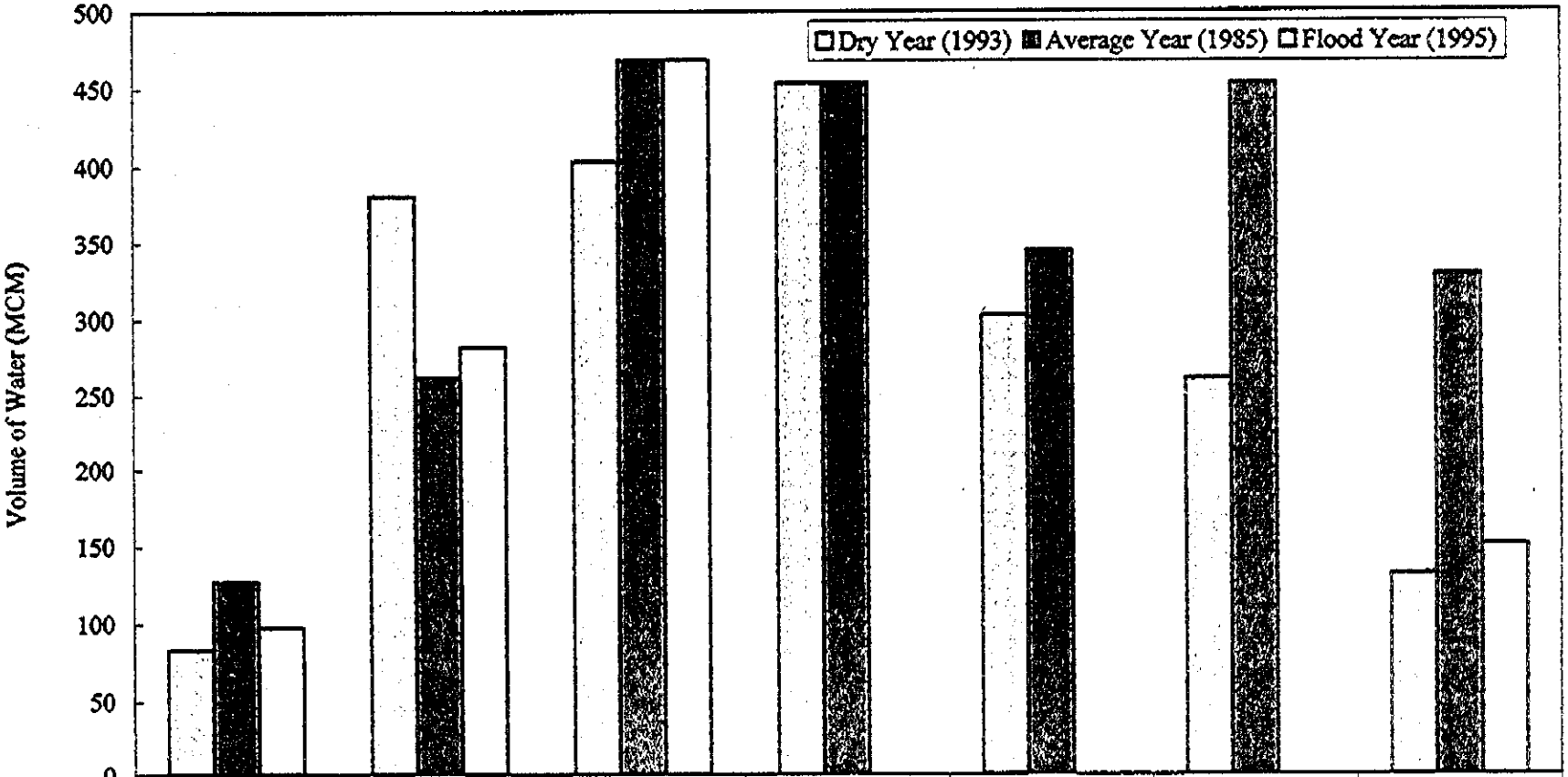


Figure 8.3.5 Existing, Proposed and Potential Irrigation Area in the Kok and Ing Basins



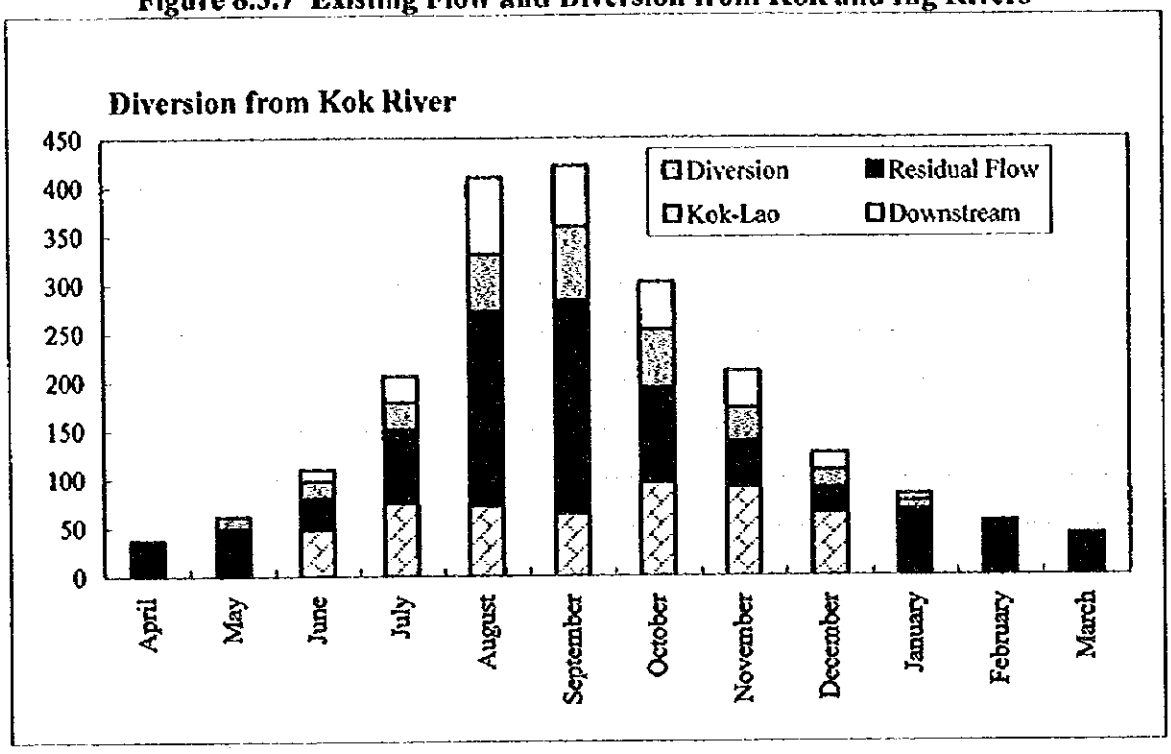
(Unit = 1,000 rai)

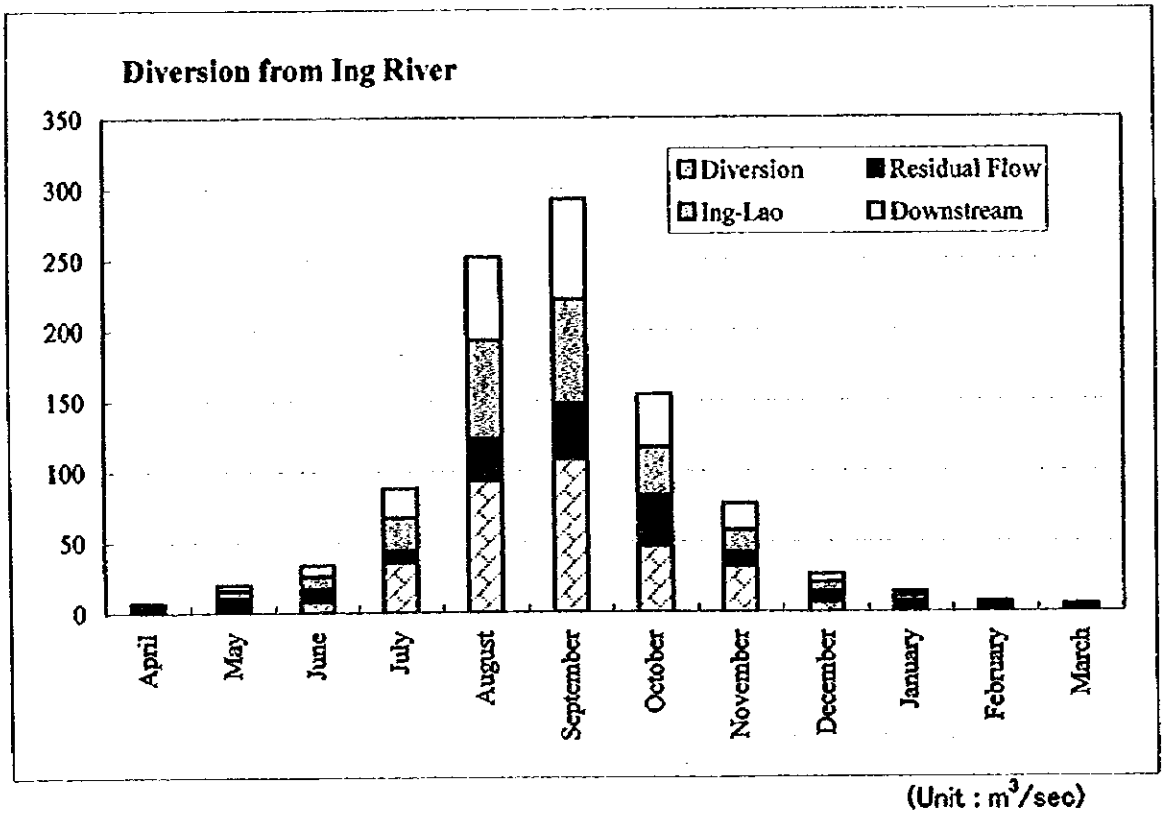
Figure 8.3.6 Monthly Volume of Water Diverted from Kok and Ing Rivers



	June	July	August	September	October	November	December
Dry Year (1993)	83.3	380.9	403.3	453.6	302.7	260.8	132.7
Average Year (1985)	127.9	262.4	468.7	453.6	344.9	453.3	329.3
Flood Year (1995)	97.7	282.3	468.7	0	0	0	151.9

Figure 8.3.7 Existing Flow and Diversion from Kok and Ing Rivers





(Unit : m^3/sec)

Figure 8.4.1 Sirikit Reservoir Operation (With KIN Project)

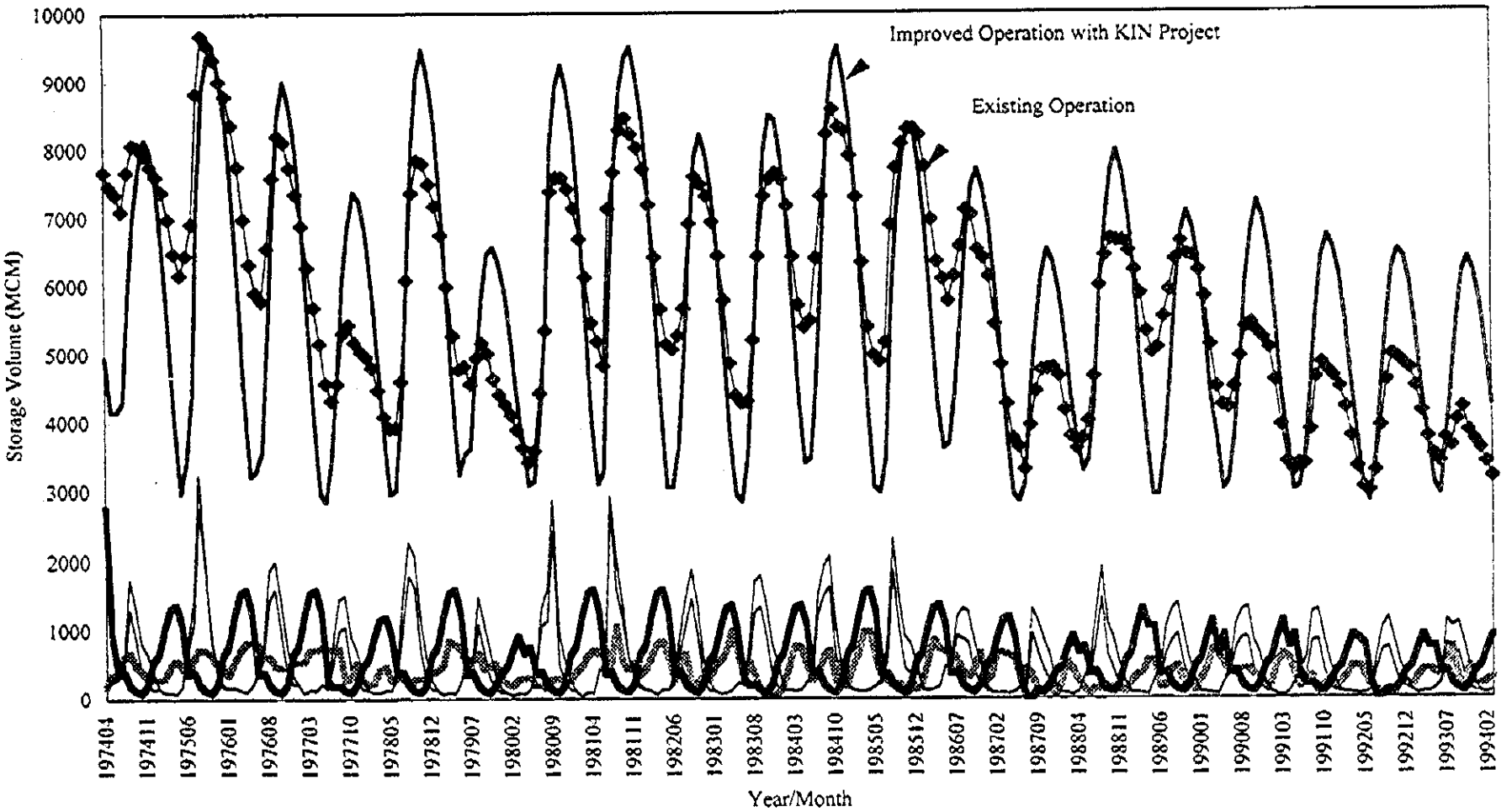


Figure 8.4.2 Sirikit Reservoir Operation (With KIN Project)

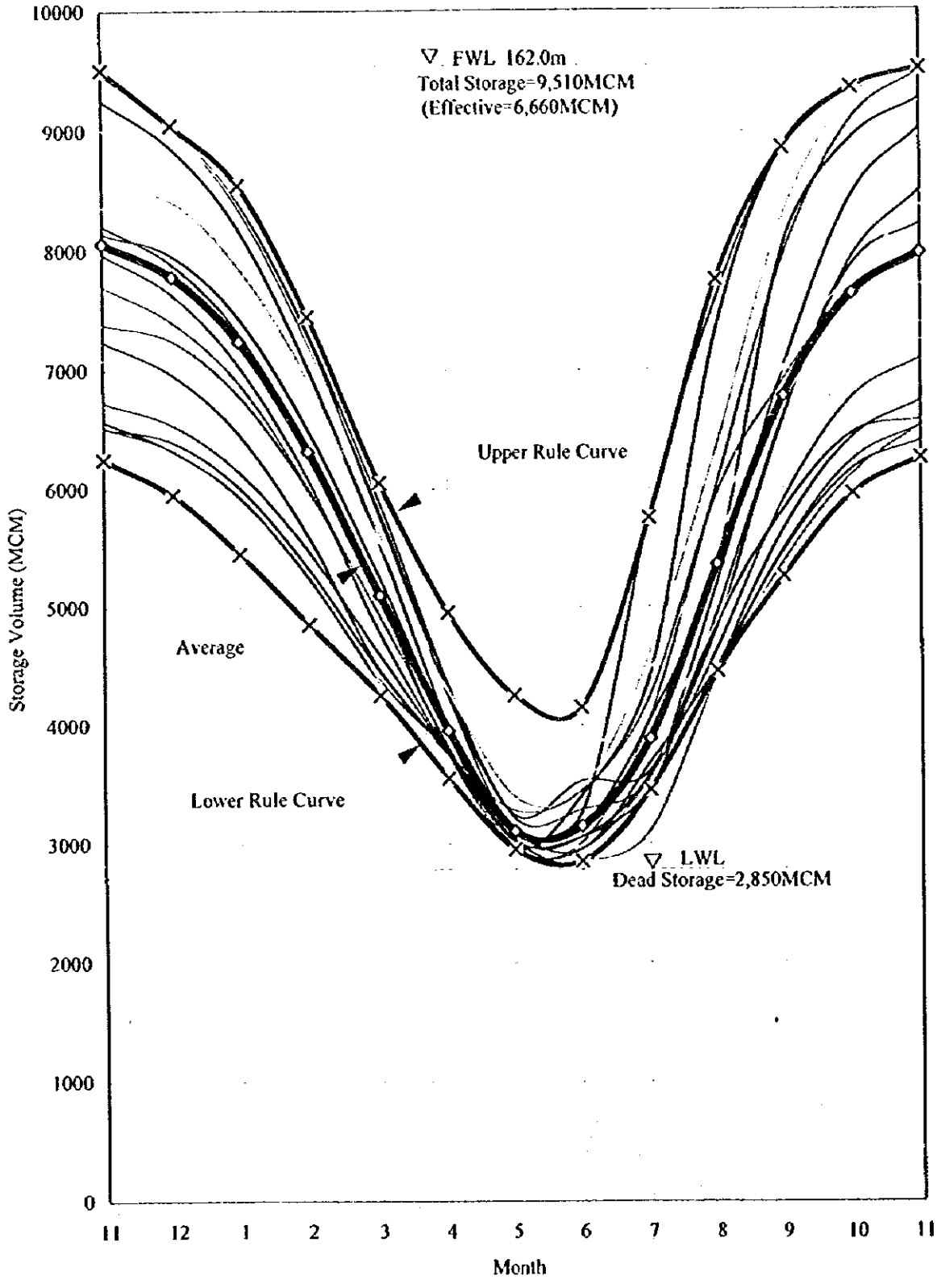


Figure 8.4.3 Flood Control Capacity

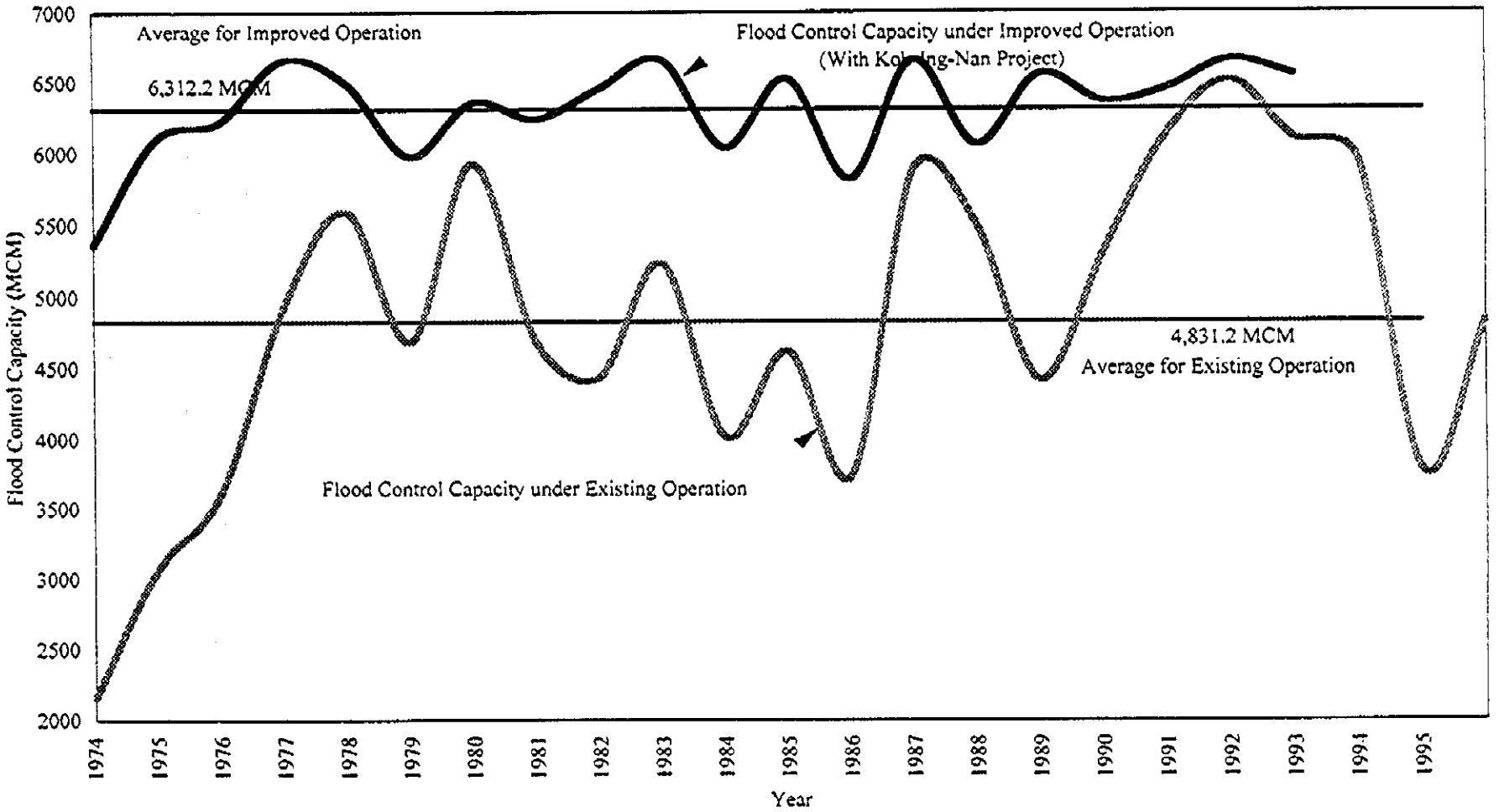


Figure 8.4.4 Frequency of Discharge Diverted from Kok River

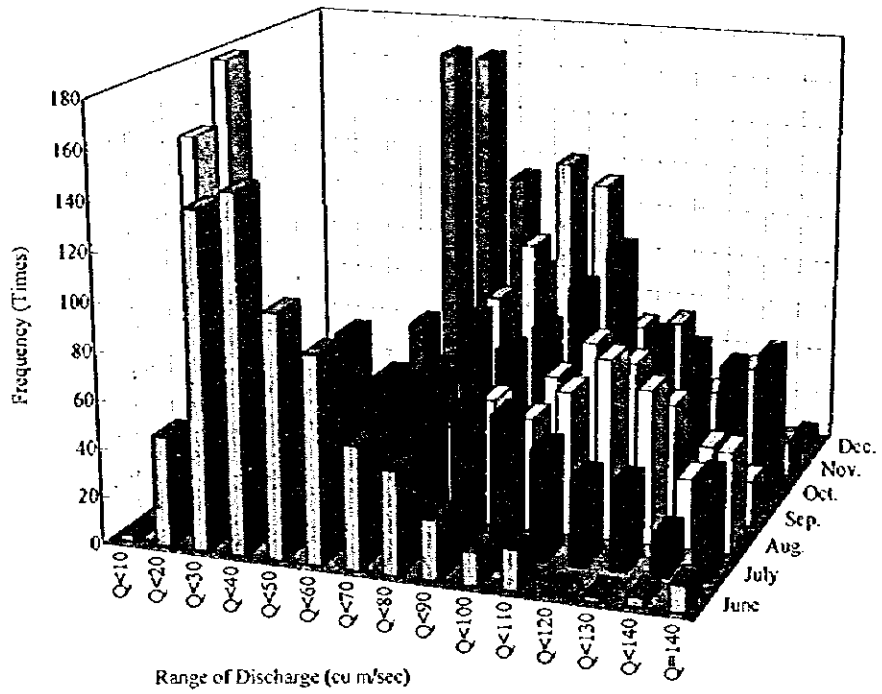


Figure 8.4.5 Frequency of Discharge Divertwd from Ing River

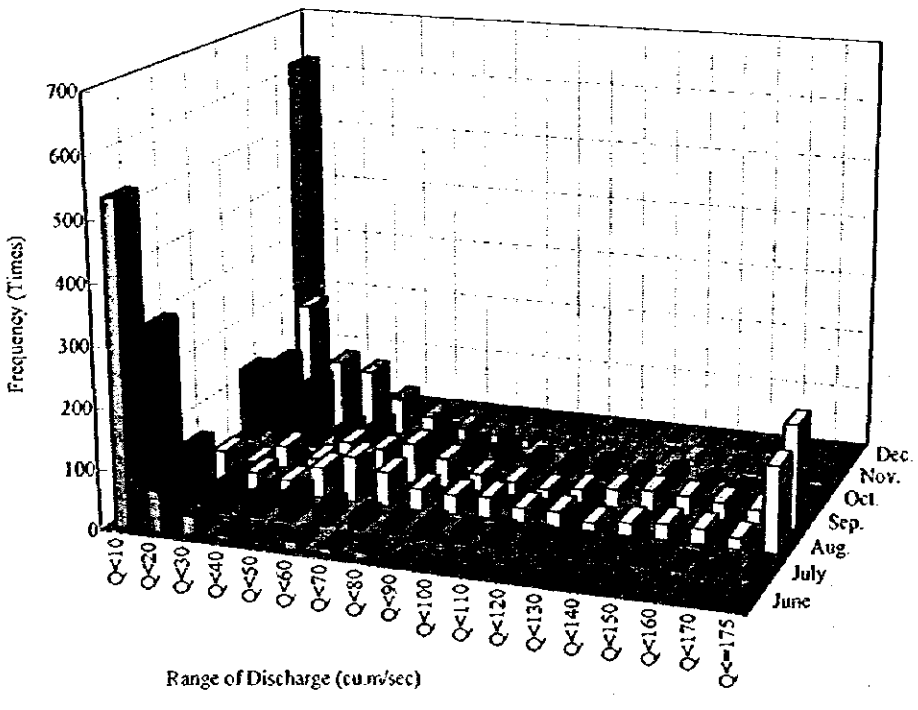


Figure 8.4.6 Average Monthly Discharge Diverted from Kok River

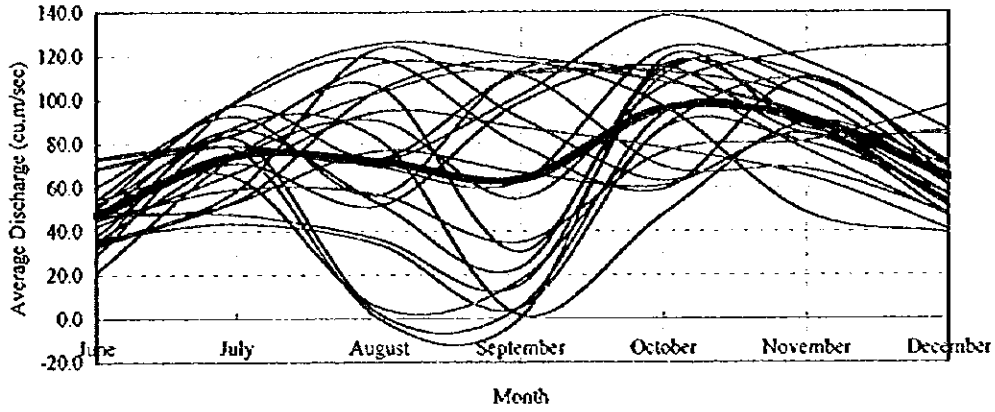


Figure 8.4.7 Average Monthly Discharge Diverted from Ing River

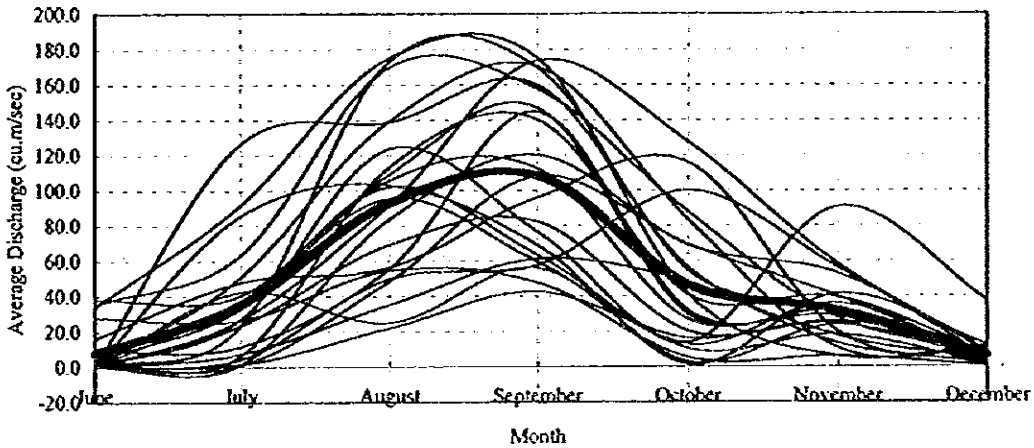


Figure 8.4.8 Average Monthly Discharge Passing through Ing-Yot Tunnel

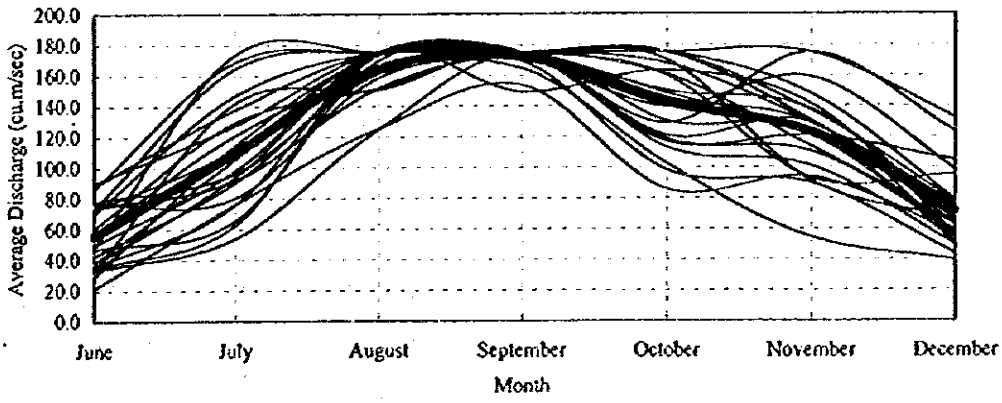


Table 8.4.5(1) Frequency of Discharge Diverted from Kok River

Month	Q<10	Q<20	Q<30	Q<40	Q<50	Q<60	Q<70	Q<80	Q<90	Q<100	Q<110	Q<120	Q<130	Q<140	Q=140
June	3	46	139	147	101	86	51	43	25	14	17	1	2	4	11
July	17	4	27	73	72	85	69	71	60	58	46	36	36	17	42
Aug.	152	16	30	21	23	26	35	40	53	47	60	75	64	29	42
Sep.	178	34	25	33	35	27	12	23	34	55	71	64	48	32	19
Oct.	7	5	11	17	13	42	66	54	65	84	102	66	62	56	63
Nov.	0	0	1	6	29	27	67	92	129	121	60	63	34	46	15
Dec.	0	0	0	42	167	166	113	74	60	42	22	7	7	6	7
Total	357	105	233	339	440	459	413	397	426	421	378	312	253	190	199
%	7.3	2.1	4.7	6.9	8.9	9.3	8.4	8.1	8.7	8.6	7.7	6.3	5.1	3.9	4.0

Table 8.4.5(2) Frequency of Discharge Diverted from Ing River

Month	Q<10	Q<20	Q<30	Q<40	Q<50	Q<60	Q<70	Q<80	Q<90	Q<100	Q<110	Q<120	Q<130	Q<140	Q<150	Q<160	Q<170	Q<=175
June	533	69	35	10	7	14	10	12	0	0	0	0	0	0	0	0	0	0
July	299	104	48	36	44	28	20	14	20	17	19	17	12	8	5	4	2	16
Aug.	27	59	29	22	50	75	56	35	32	35	24	25	14	21	26	25	17	141
Sep.	0	4	37	21	56	51	67	48	28	22	16	23	30	34	32	28	23	170
Oct.	124	144	111	37	46	21	44	32	32	20	18	22	14	21	12	5	6	4
Nov.	84	212	116	104	61	36	21	16	13	7	0	6	3	10	0	1	0	0
Dec.	619	67	13	2	1	2	0	2	3	3	1	0	0	0	0	0	0	0
Total	1686	659	389	232	265	227	218	159	128	104	78	93	73	94	75	63	48	331
%	34.3	13.4	7.9	4.7	5.4	4.6	4.4	3.2	2.6	2.1	1.6	1.9	1.5	1.9	1.5	1.3	1.0	6.7

Table 8.4.5(3) Frequency of Discharge Passing through the Ing-Yot Tunnel

Month	Q<10	Q<20	Q<30	Q<40	Q<50	Q<60	Q<70	Q<80	Q<90	Q<100	Q<110	Q<120	Q<130	Q<140	Q<150	Q<160	Q<170	Q<=175
June	3	34	133	110	94	89	58	45	27	24	16	11	9	6	19	5	3	4
July	0	0	16	55	50	50	49	39	39	42	31	21	24	28	38	21	27	183
Aug.	0	0	0	0	0	4	5	4	11	9	9	8	19	14	23	35	24	548
Sep.	0	0	0	0	0	0	0	0	0	0	3	8	6	9	9	20	23	612
Oct.	0	0	0	0	0	1	11	21	35	43	46	41	52	52	71	30	36	274
Nov.	0	0	0	0	10	14	7	29	55	88	92	65	47	63	40	46	10	124
Dec.	0	0	0	25	127	173	114	75	52	56	25	26	11	6	6	8	0	9
Total	3	34	149	190	281	331	244	213	219	262	222	180	168	178	206	165	123	1754
%	0.1	0.7	3.0	3.9	5.7	6.7	5.0	4.3	4.4	5.3	4.5	3.7	3.4	3.6	4.2	3.4	2.5	35.6

CHAPTER 9.

PROJECT WATER ALLOCATION PLAN

CHAPTER 9. PROJECT WATER ALLOCATION PLAN

9.1 Water Demand and Supply Scenarios

Projection of water demands for various water users including irrigation, domestic and industrial water supply and livestock was conducted with various cropping intensities covering from 20% to 90%, together with three degrees of development in promotion of crop diversification program for irrigation, namely 1) highly promoted, 2) normally promoted and 3) moderately promoted cases, and three growing cases for water demand other than irrigation, namely 1) high growth, 2) normal growth and 3) low growth cases. In estimating the total water demand, demands for irrigation and non-irrigation were combined in order of the volume of water consumption. Consequently, deficit of water in future at the project target year of 2016 was evaluated for the direct beneficiary areas, the lower Nan and lower Chao Phraya basins, as shown in Table 9.1.1.

Table 9.1.1 Dry Season Deficit of Water in the Direct Beneficiary Areas

Dry Season Minimum Cropping Intensity (%)	Water Deficit in MCM			Total Deficit under Increased Case of Water Use in Upper Chao Phraya Basins		
	Irrigation	Non-Irrigation	Total			
	Moderate Normal High	High Normal Low	(1) 0% =0 MCM	(2) 30% =570MCM	(3) 50% =950MCM	(4) 100% =1,900MCM
20%	136 40 -22	1,113 825 578	1,249 865 556	1,819 1,435 1,126	2,199 1,815 1,506	3,149 2,765 2,456
30%	499 447 386	1,113 825 578	1,612 1,272 964	2,182 1,842 1,534	2,562 2,222 1,914	3,512 3,172 2,864
40%	1,118 1,067 1,004	1,113 825 578	2,231 1,892 1,582	2,910 2,462 2,152	3,181 2,842 2,532	4,131 3,792 3,482
50%	1,935 1,883 1,761	1,113 825 578	3,048 2,708 2,339	3,618 3,278 2,909	3,998 3,658 3,289	4,948 4,608 4,239
60%	2,989 2,937 2,873	1,113 825 578	4,102 3,762 3,451	4,672 4,332 4,021	5,052 4,712 4,401	6,002 5,662 5,351
70%	4,152 4,100 4,035	1,113 825 578	5,265 4,925 4,613	5,835 5,495 5,183	6,215 5,875 5,563	7,165 6,825 6,513
80%	5,415 5,363 5,298	1,113 825 578	6,528 6,188 5,876	7,098 6,758 6,446	7,478 7,138 6,826	8,428 8,088 7,776
90%	6,739 6,689 6,634	1,113 825 578	7,852 7,514 7,212	8,422 8,084 7,782	8,802 8,464 8,162	9,752 9,414 9,112

Note: Increasing water demand in the upper Chao Phraya basins is projected as 1,900 MCM at 2016 if all of irrigation development projects proposed have been implemented.

It is noted that the deficits of water to be possibly caused by the reduced flow of the Chao Phraya river when the development of water resources in the upper Chao Phraya basin has been progressed as scheduled are also added in the above figures. On the other hand, the Chapter 8 of the Main report concludes that the possible increase of water to be released in dry season from the Sirikit reservoir would be some 2,800 MCM at maximum in due consideration of combined effects of the availability of water in the Kok and Ing basins, regulating capacity of the Sirikit reservoir and the construction costs of the diversion facilities. The followings may be extracted from above considerations;

- At present, available runoff of the Chao Phraya river at Chainat is 6,000 MCM in dry season, of which 2,000 MCM is released downstream for the purposes of water supply, salt water exclusion, navigation and river channel maintenance. The remaining 4,000 MCM is diverted for irrigation to the lower Chao Phraya basin mainly to delta. In the dry year, however, the dry season flow decreases to 3,400 MCM of which 1,500 MCM id released downstream and 1,900 MCM is used for irrigation.
- In the "Conservation Area" of the lower delta, priority is given in utilization of water supplied from the Chainat diversion dam in dry season because that it is absolutely needed to protect the area from salt water intrusion even in a critically dry year. For example, even in successive dry years of 1991 to 1993, about 1.3 million rai of dry season rice had been cultivated consuming 1,300 MCM of water in the lower delta.
- The crop diversification program promoted by the Thai government under the present agricultural policy is premised in preparation of the above table, and it is also recognized that water is to be supplies without interruption to the diversified crops. Accordingly, supply of 1,300 MCM of water to the paddy fields of 1.3 million rai in the lower delta for saline water exclusion and 1,760 MCM of water for diversified crops in the entire delta should be guaranteed even in a dry year. Availability of water is not so sufficient in the Chao Phraya river even in an average year and even when it is assumed that the flow would continue in future at the current level. It is not possible to secure the minimum requirement of water in dry season in a dry year.
- Table 9.1.1 explains that the current order of the Chao Phraya flow at Chainat together with 2,800 MCM of water additionally released from the Sirikit reservoir in dry season under the proposed water diversion project would meet 50% at most of the minimum cropping intensity in the direct beneficiary area. The minimum cropping intensities to be secured by the proposed water diversion project would be some 40% if 30% of the proposed water resources development projects in the upper Chao Phraya basins have been implemented, and some 35% if 50% of the proposed

projects have been implemented.

- Only 20% of the minimum cropping intensity can be guaranteed under the average year condition in the direct beneficiary area if 100% of the proposed water resources development projects in the upper Chao Phraya basins have been implemented. In this case, about 865 MCM of water to be available additionally under the project will be allocated only to the growing demand of water supply sector providing no contribution to irrigation in the delta. The Chao Phraya flow at Chainat in a dry season in an average year will decrease to 3,900 MCM which is almost equivalent to the present dry year condition. In a dry year, the flow will decrease to about 1,500 MCM resulting a crucial water shortage over the delta area.
- To cope with water shortage problems in dry season at present and more crucial in future, in addition to the proposed Kok-Ing-Nan Water Diversion Project, a transbasin water diversion project from the Salawin river and its tributaries to the Bhumibol dam is planned to be studied by the MOSTE. The project would divert more or less 1,000 MCM of water in wet season when the case that water is diverted directly from the main stream of the Salawin is excluded. Moreover the Bhumibol dam seems to have no room to increase outflow in dry season by means of improvement of operation rules as is intended for the Sirikit reservoir. Accordingly, even if the Kok-Ing-Nan and Salawin-Bhumibol have been both implemented, the minimum cropping intensity in dry season in the delta would be no more than 60% in the case where development of the upper Chao Phraya basins is restricted or 40% if development has been progressed as scheduled.
- The study has been made focusing on the water shortage problems in dry season, however, the study also shows possible deficit of water even in wet season in near future. In due consideration of hydrological characteristics that more than 80% of annual rainfall and river runoff concentrate during wet season, water resources development in the Chao Phraya basins follows unavoidably the type where excess water is stored in storage reservoirs in wet season and stored water is released from reservoirs in dry season. As a result, wet season flow of the Chao Phraya river will decrease remarkably, causing frequent and serious water shortage problems throughout a year.

The above consideration suggests a strong possibility that water shortage problems would prevail over the whole Chao Phraya basins providing hopeless damages in the social and economic development. At present, water allocation and operation in the Chao Phraya delta seem to be done well making the best use of its scale merit, however, even greater efforts may be required in effective irrigation water use especially in wet season. The current tendency of increase in per capita demand for water supply sector may be one of the important target for saving. The risk of water shortage even in wet season in future

should be fully recognized by all of water users. The disordered and unlimited development in the upper Chao Phraya basin will result the serious water crisis in future in the delta, and therefore a proper rule of water operation and management should be established at the National level inclusive of restriction of development activities.

A series of water balance scenarios within a possible range have been studied for further consideration of appropriate actions by the Thai government. However, a possible scenario can be explained as a sample which is selected among various alternatives focusing on the current policy of the agricultural development in Thailand;

A Sample Scenario of Water Demand and Supply

Already 40.2% of dry season cropping has been achieved in the Chao Phraya delta area as an average from 1991 to 1996, as previously explained in Table 5.4.11 of Chapter 5, and if several irrigation sub-projects with lower intensities are excluded, the average cropping intensity in the dry season would be improved to 47.0%. As regards the present situation of water demand and supply for irrigation in the delta, it is evaluated that about 1,800 MCM is in short supply when the minimum cropping intensity is set up at 50%. It is also judged that there exists no shortage of water for domestic/industrial water supply sectors since priority in water use is given to these sectors.

Demand projection for irrigation was made based on the estimates of appropriate limit of crop diversification which are determined through discussions made with the MOAC taking into account limitation from topography, land use, water availability and domestic and export market demands. In addition, stable supply of water throughout a year is absolutely necessary to maintain perennial crops such as fruit trees, sugarcane and fish ponds. Important figures are extracted from Table 5.3.4 as follows, and figures given for the case with "highly promoted crop diversification program" are therefore considered to set an upper limit of land use for crop diversification.

Table 9.1.2 Proposed Areas for Diversified Crops in the Delta

Crop Diversification Program	Sugar Cane	Fruit Trees	Fish Pond	Field Crops	Vege-table	Total	Remarks
Highly Promoted	348.5	637.6	229.1	217.2	102.2	1,534.6	120%
Normally Promoted	290.4	531.3	190.9	181.0	85.2	1,278.8	100%
Moderately Promoted	232.3	425.0	152.7	144.8	68.2	1,023.0	80%

On the other hand, promotion of crop diversification also envisages to save water for

dry season irrigation, because that most of the diversified crops consume less water than rice. Even so, the government intends in the 8th 5-year plan to maintain 3.0 million rai of dry season rice cropping from view points of export demand and necessity of water supply in the conservation area (lower delta). Cropping of dry season rice needs irrigation, and 70% to 75% of the national products were harvested actually in the delta in the past. Out of 3.0 million rai, therefore, some 75% or 2.25 million rai may be allocated to the delta where a large extension of irrigated farmland exists. From the above consideration, appropriate limit of crop diversification plus some 2.1 million rai of rice would form the upper limit of dry season cropping in the delta.

Table 9.1.3 Upper Limit of Dry Season Cropping in the Delta in Future

Crop Diversification Program	Irrigable Area (1,000 rai)	Diversified Crops (1,000 rai)	Rice (1,000 rai)	Total (1,000 rai)	Cropping Intensity (%)
Highly Promoted	6,800	1,534.6	2,250.0	3,784.6	55.7

The above 2.25 million rai of dry season rice cropping corresponds to the total area of 1.3 million rai in the lower delta which has been maintained even in a critical dry year to protect the area from saline water intrusion and 0.9 to 1.2 million rai in the upper delta where water supply for dry season irrigation is always restricted depending on the availability of water. About 45% of dry season cropping is necessary in the delta even when the national target of dry season rice cropping is lowered to 80% and normal promotion case of crop diversification program is adopted, showing a lower limit in a practical meanings.

Table 9.1.4 Lower Limit of Dry Season Cropping in the Delta in Future

Crop Diversification Program	Irrigable Area (1,000 rai)	Diversified Crops (1,000 rai)	Rice (1,000 rai)	Total (1,000 rai)	Cropping Intensity (%)
Normally Promoted	6,800	1,278.8	1,800.0	3,078.8	45.3

Accordingly, realistic range of the minimum cropping intensity in dry season in the delta will be between 45% and 55%, and adoption of 50% of the minimum cropping intensity to be secured is, therefore, reasonable since it produces the mean intensity of some 54% over the delta. On the other hand from the water supply side, about 2,800 MCM of water, comprised of 2,000 MCM diverted from the Kok and Ing rivers and 800 MCM generated by improvement of the Sirikit reservoir operation, will be the maximum taking

the availability of water in the Kok and Ing basins, regulating capacity of the Sirikit reservoir and construction cost of diversion facilities into consideration. The cropping intensity of 54% over the delta can be achieved with 1,985 MCM of additional water supply for irrigation in dry season, after taking 825 MCM of water from 2,800 MCM for water supply uses in advance.

9.2 Scenarios of Water Allocation

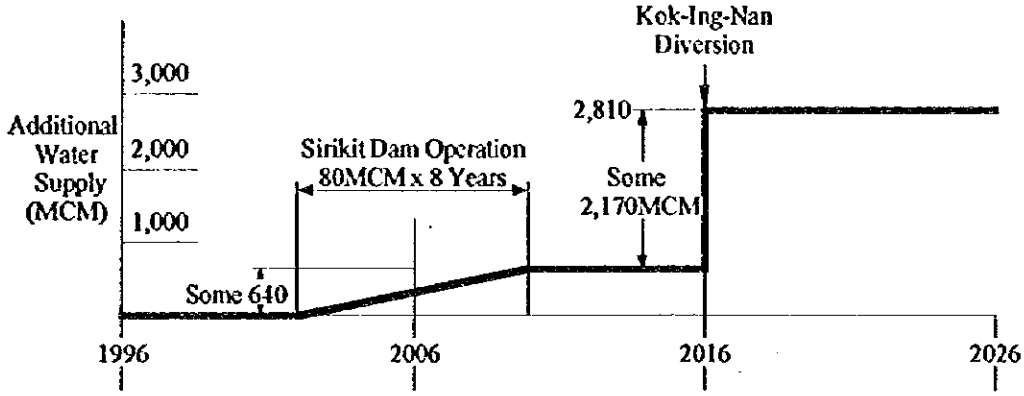
Diagrams to explain water balance between demand and supply are shown in Figures 9.2.1 and 9.2.2 respectively for cases 1) where development in the upper Chao Phraya basins is restricted to keep the availability of the Chao Phraya flow as it is and 2) where about 1,900 MCM of water is consumed in the upper basins for water resources development.

Projection of water demand for various water user sectors with various parameters given above was made without any relation to additional water supply or without any limitation of additional water supply. It may correspond to the needs and identification of the proposed water diversion project showing the current and future water shortage problems during the period of dry season particularly in the Chao Phraya delta. The water allocation plan on the contrary, works out the water demand allocation under the proposed water diversion where additional water supply capability in the dry season is preliminarily scheduled at about 640 MCM at around the year 2006, produced from the Sirikit reservoir by means of improvement of its operation, and at 2,810 MCM in 2016 due to water diversion from the donor basins.

Figure 9.2.3 shows a water supply curve in terms of additional supply of water brought from the proposed water diversion project.

In order to evaluate water supply and demand balance, water demands including irrigation and non-irrigation uses as projected in the Chapter 5 for various scenarios on crop diversification promotion and water consumption growth are plotted against the water supply curve, as shown in Figures 9.2.4 and 9.2.5.

Figure 9.2.3 Water Supply Scenario



The analysis given in Figure 9.2.4 and 9.2.5 indicates that at the target year 2016, water demands exceed the potential water supply when the minimum cropping intensity is taken at more than 50% for the case when expansion of new irrigation system in the lower Nan basin is included and 60% for the case if system expansion is excluded, both for the normal case of promotion of crop diversification program. Consideration given in the previous paragraph explains that about 52% of the minimum intensity for dry season cropping would be maximum even when requirement from crop diversification program as well as necessity of rice cropping especially in the conservation area is fully taken into account. More water would promote more cropping to rice, however, tightness of supply and demand of water would not allow such an extravagant plan to be implemented. A plan lowering the present achievement of dry season cropping is also meaningless, and therefore a plan with a minimum intensity of 50% would be the best selection under the current policy of irrigated agriculture development. The base-case of water allocation for dry season uses of water has been planned as given in Table 9.2.1.

Since the water use for non-irrigation sectors keeps a priority over the irrigation, available water is first allocated to non-irrigation sectors where three cases of growth in water use are considered. Residual water after withdrawn by these sectors is usable for irrigation. For irrigation purpose, two alternative cases of water allocation; namely allocation to the existing irrigable area in the direct beneficial area only (Case B) and allocation to the areas including new system expansion along the left bank of the Nan river (Phitsanulok Stage II Area)(Case B), can be considered. Six cases in total of scenarios of water allocation are thus produced as seen in the following table.

Table 9.2.2 Six Scenarios of Water Allocation Plan for Dry Season Use

Growing Scenario of Non-Irrigation Water Use	Agricultural Development	
	System Expansion Included	System Expansion Excluded
High Growth Case	A-1	B-1
Normal Growth Case	A-2	B-2
Low Growth Case	A-3	B-3

Allocation of water for nine cases of scenarios is tabulated in Table 9.2.3.

Table 9.2.3 Allocation of Water by Scenarios

Scenario of Water Allocation	Water Availability (MCM)	Power Generation (MCM)	Non-Irrigation Sectors (MCM)	Irrigation	
				Irrigable Area (1,000 rai)	Water Demand (MCM)
A-1	2,810	2,810	1,103	1,032.5	1,707
A-2	2,810	2,810	825	1,182.8	1,985
A-3	2,810	2,810	578	1,316.3	2,232
B-1	2,810	2,810	1,103	1,098.4	1,707
B-2	2,810	2,810	825	1,018.0	1,985
B-3	2,810	2,810	578	1,382.2	2,232

Table 9.2.1 Base Case of Dry Season Water Allocation Plan

Beneficial Area and Crops	Unit Irrigation Demand	Irrigation Area (10³ rai)		Water Demand (MCM)		Incremental	
		Existing	Future	Existing	Future	Area (10^3 rai)	Demand (MCM)
1. Chao Phraya Delta (Irrigable Area 3,956,000 at Present to 3,750,000 rai in Future)							
(1) Upper Zone							
Sugarcane	1,300.0	173.0	285.0	224.9	370.5	112.0	145.6
Fruit Trees	2,000.0	67.6	260.1	135.2	520.2	192.5	385.0
Fish Pond	1,450.0	15.7	62.1	22.8	90.0	46.4	67.3
Field Crops	1,300.0	64.4	178.8	83.7	232.4	114.4	148.7
Vegetable	1,100.0	7.7	49.7	8.5	54.7	42.0	46.2
Dry Paddy	1,850.0	905.8	1,129.2	1,675.7	2,089.0	223.4	413.3
Sub-total		1,234.2	1,964.9	2,150.8	3,356.9	730.7	1,206.1
(2) Lower Zone (Irrigable Area 3,836,000 at Present to 3,050,000 rai in Future)							
Sugarcane	875.0	2.3	5.4	2.0	4.7	3.1	2.7
Fruit Trees	1,250.0	255.6	271.2	319.5	339.0	15.6	19.5
Fish Pond	925.0	121.4	128.8	112.3	119.1	7.4	6.8
Field Crops	900.0	2.5	2.2	2.3	2.0	-0.3	-0.3
Vegetable	800.0	34.0	35.5	27.2	28.4	1.5	1.2
Dry Paddy	1,000.0	1,303.0	1,258.9	1,303.0	1,258.9	-44.1	-44.1
Sub-total		1,718.8	1,702.0	1,766.3	1,752.1	-16.8	-14.1
Total (1)+(2)		2,953.0	3,666.9	3,917.0	5,109.0	713.9	1,192.0
2. Lower Nan Basin							
(1) Existing Irrigation System (Phitsanulok Stage1 + DEDP Pump) (Irrigable Area 1,059,000 to 1,119,600 rai)							
Fruit Trees	2,000.0	0.0	78.4	0.0	156.8	78.4	156.8
Fish Pond	1,450.0	0.4	16.8	0.6	24.4	16.4	23.8
Field Crops	1,300.0	25.3	89.5	32.9	116.4	64.2	83.5
Vegetable	1,100.0	5.1	16.8	5.6	18.5	11.7	12.9
Dry Paddy	1,850.0	491.4	439.6	909.1	813.3	-51.8	-95.8
Sub-total		522.2	641.1	948.2	1,129.3	118.9	181.1
(2) System Expansion (Phitsanulok Stage2 + DEDP Pump) (Irrigable Area 700,000 rai in Future)							
Fruit Trees	2,000.0	0.0	49.0	0.0	98.0	49.0	98.0
Fish Pond	1,450.0	0.0	10.5	0.0	15.2	10.5	15.2
Field Crops	1,300.0	0.0	56.0	0.0	72.8	56.0	72.8
Vegetable	1,100.0	0.0	10.5	0.0	11.6	10.5	11.6
Dry Paddy	1,850.0	0.0	224.0	0.0	414.4	224.0	414.4
Sub-total		0.0	350.0	0.0	612.0	350.0	612.0
Total (1)+(2)		522.2	991.1	948.2	1,741.2	468.9	793.1
Grand Total		3,475.2	4,658.0	4,865.2	6,850.2	1,182.8	1,985.0

Figure 9.2.1 Structure of Water Demand and Supply

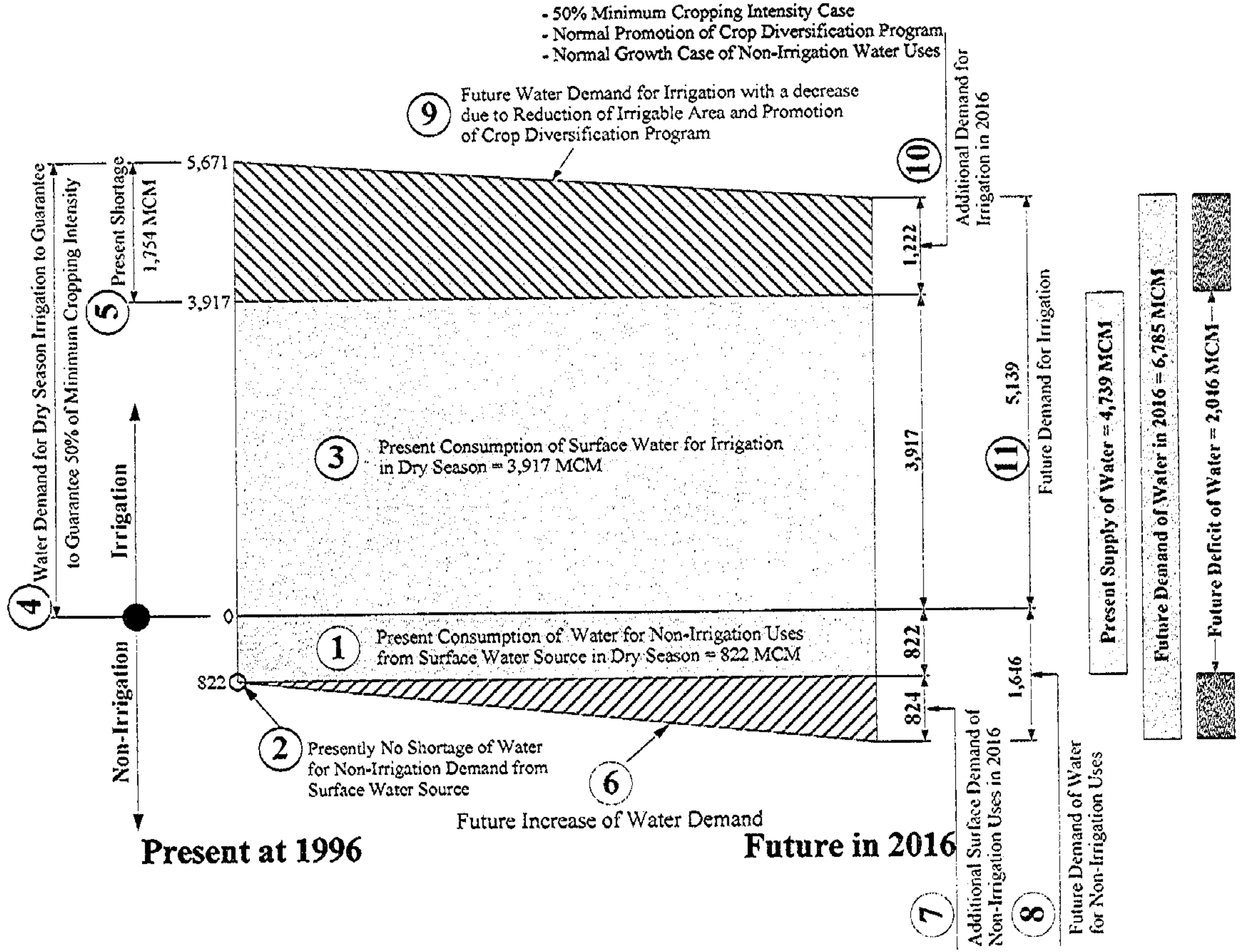


Figure 9.2.2 Structure of Water Demand and Supply

- 50% Minimum Cropping Intensity Case
- Normal Promotion of Crop Diversification Program
- Normal Growth Case of Non-Irrigation Water Uses

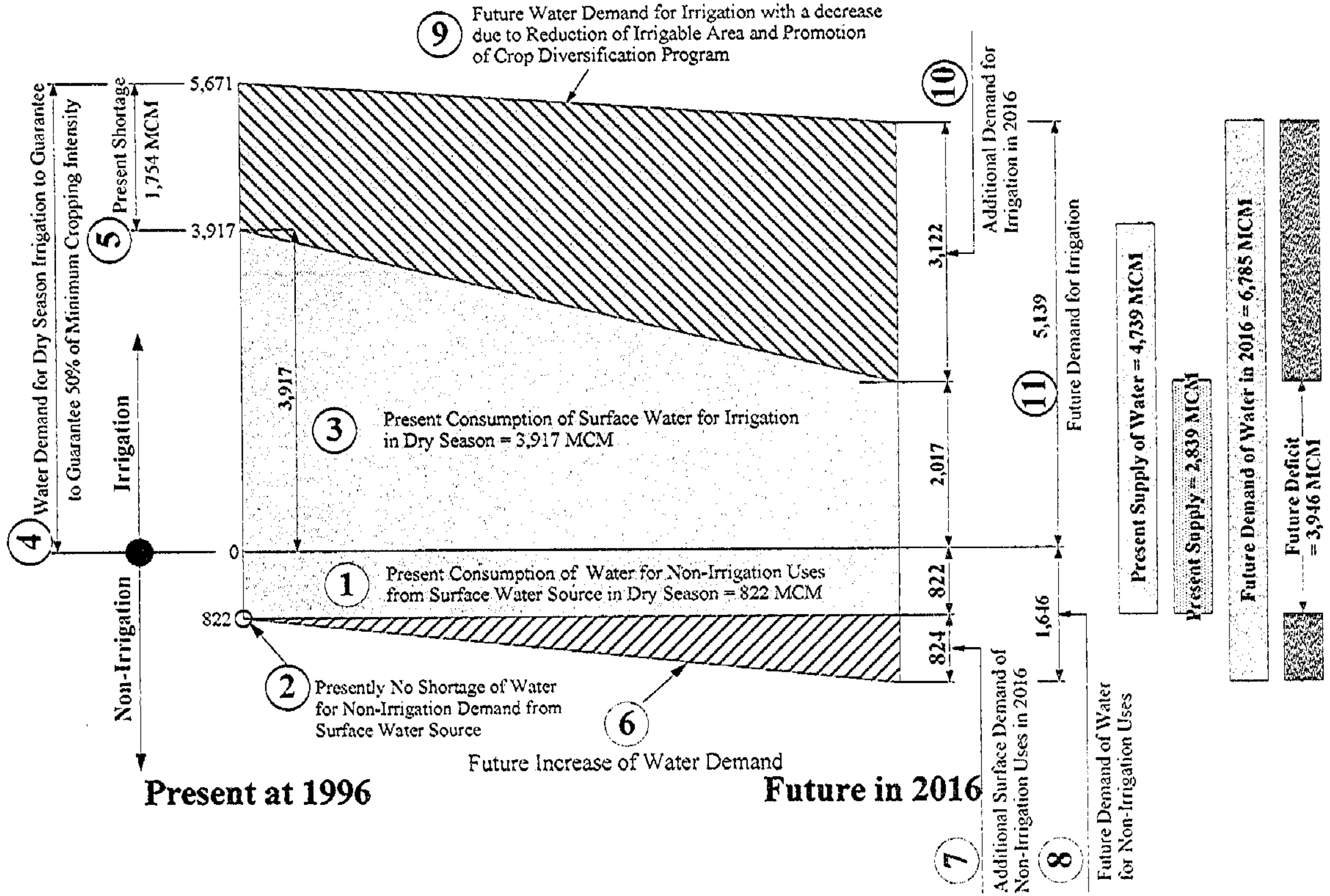


Figure 9.2.4 **Additional Dry Season Demand and Supply of Water**
(System Expansion Excluded)

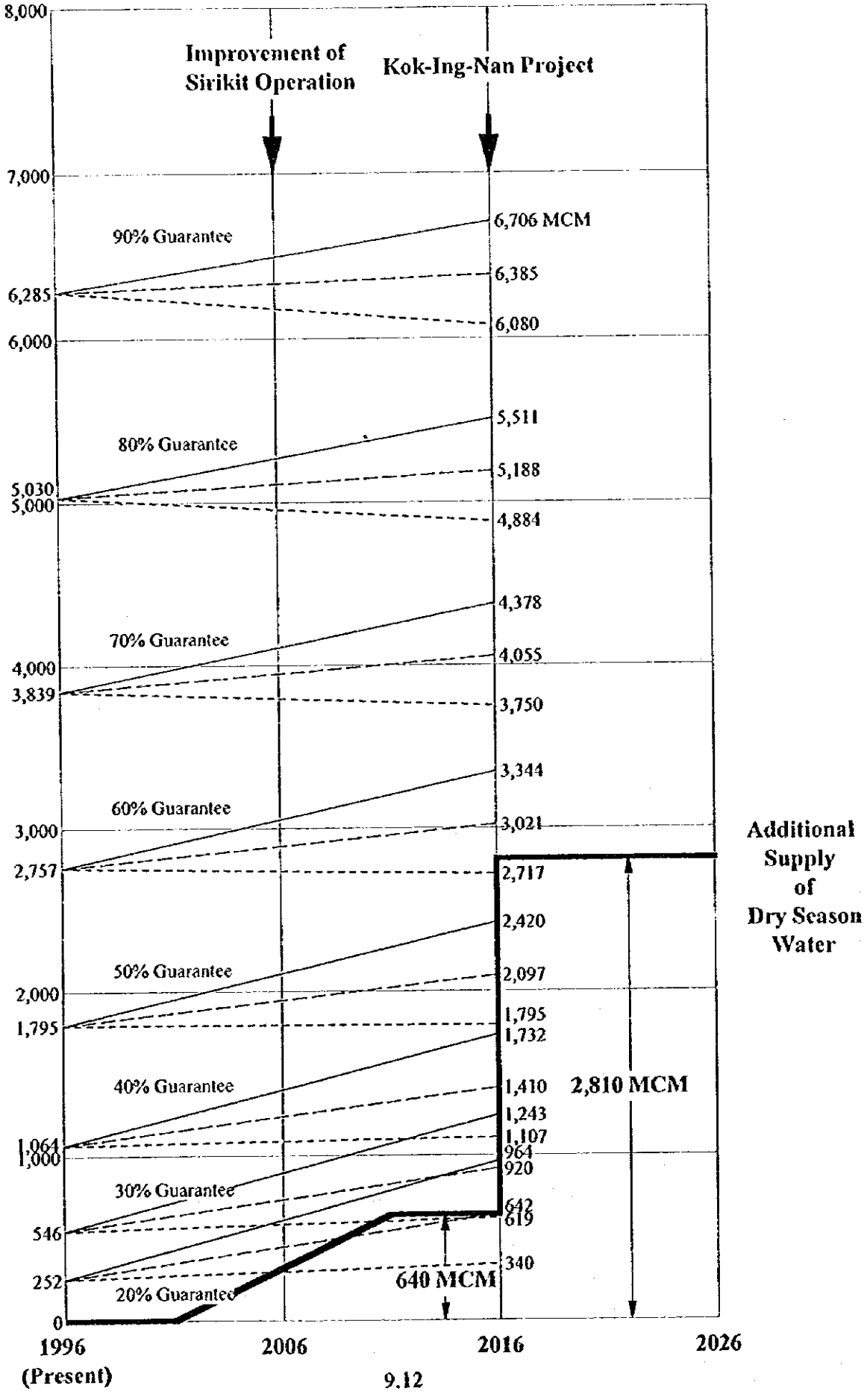
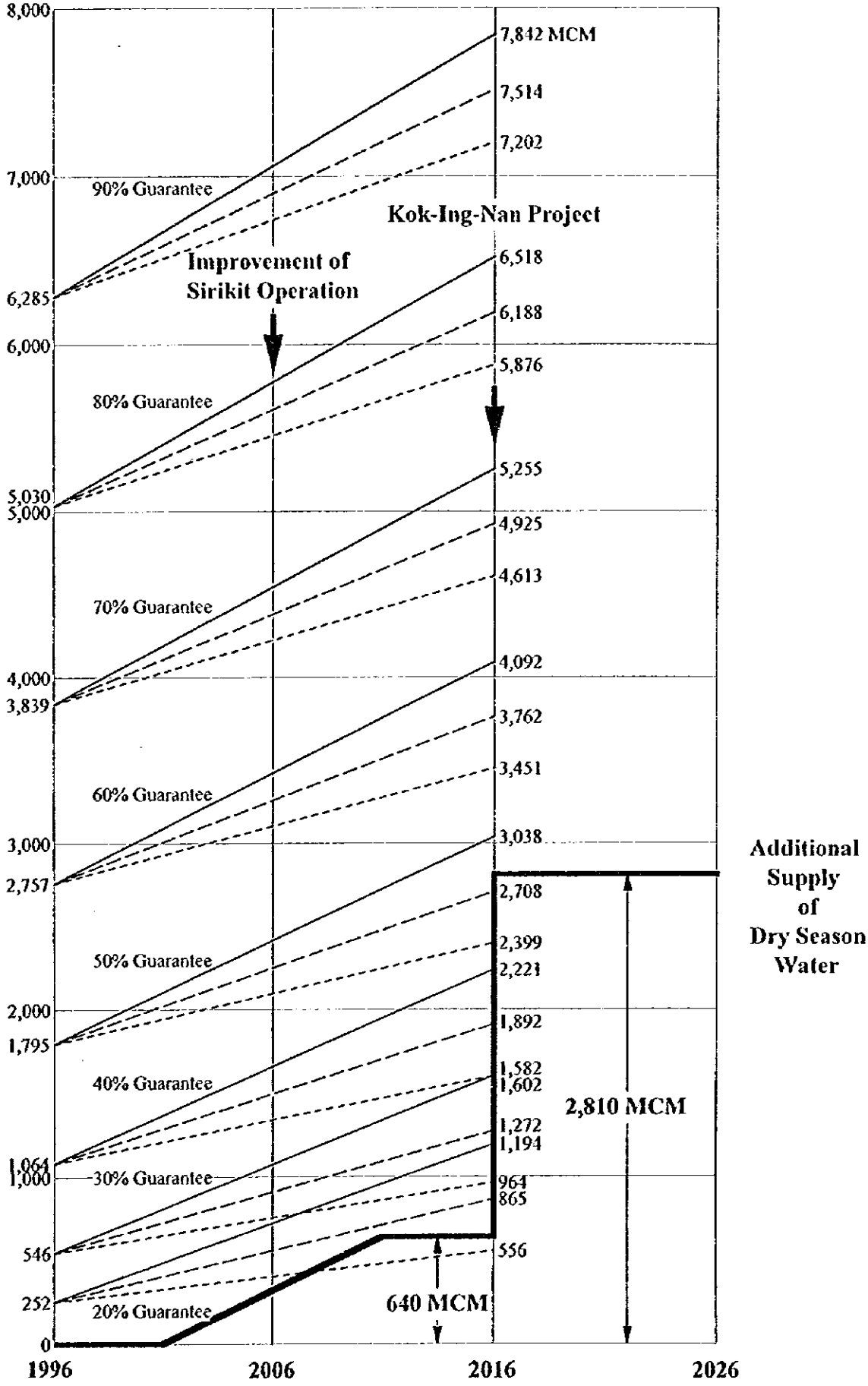


Figure 9.2.5 **Additional Dry Season Demand and Supply of Water**
(System Expansion Included)



CHAPTER 10.

IRRIGATED AGRICULTURE PROJECT IN KOK, ING AND UPPER NAN BASIN

CHAPTER 10 IRRIGATED AGRICULTURE DEVELOPMENT IN KOK, ING AND UPPER NAN BASINS

10.1 Existing and Future Potential Irrigation Area

The Kok-Ing-Nan Water Diversion Project is the transbasin project to divert the wet season surplus water from the Kok and Ing rivers to the Sirikit reservoir through the Nan river. The diverted water will be controlled by the Sirikit reservoir and used for the Chao Phraya basin, where has been suffering from the chronic water shortage in the dry season and expected to face more severe water shortage in the coming 21st century.

In case of the transbasin water diversion project, it shall be noted that the Kok and Ing basins are the donor basin to supply the water to the Chao Phraya basin and have a sufficient available water in the wet season for the transbasin even if the water is fully used by the future water resources development in both basins. While the upper Nan basin will be considered to be incommoded basin to convey a bulk diversion water in the wet season to the Sirikit reservoir.

It is necessary accordingly in the transbasin project to formulate and implement the rural development to provide benefits for rural peoples who have used the existing water and land resources in the basins.

In accordance with the socio economic and impact study which have been continuously carried out by the Community Development Department in three provinces of Chiang Rai, Payao and Nan and agencies of provincial RID, ARD, PWA, etc. in charging water resources development and management, many peoples in three basins have requested the irrigated agricultural development to use the existing water resources and to stabilize their job opportunity and income.

The RID and ARD therefore have identified, planned and implemented various irrigated agricultural development since 1980s in the basins. JICA Team carried out the inventory survey for the existing and future potential irrigation projects promoted by RID and ARD or newly identified by JICA Team in cooperation with Thai Consultant J.V. The survey result is shown in the Supporting Report 8.2 and in Table 8.2.7 and 8.2.8 in the Main Report. The irrigation area and irrigation intensity by those irrigation projects are summarized in Table 10.1.1.

Those irrigation development projects will be planned and implemented in advance or in parallel with the water diversion Project in order to respond to people's request and obtain people's participation and cooperation for the Project.

10.1.1 Irrigation Project Area in Kok Basin

(1) Whole Kok Basin

The Kok basin has a catchment area of 10,880 km^2 including the Myanmer territory and rich annual runoff of about 5,500 MCM. The basin is divided into four sub-basins of Mae Fang, Kok-Lao, Middle Kok and Lower Kok.

Total potential farm area is about 1.3 million rai, of which the irrigation area is estimated at 464,000 rai (36%) in the existing projects and 939,000 rai (73%) in the future potential projects. It is expected that the future potential irrigation area will reach twice of the existing area.

Table 10.1.1 Existing and Future Potential Irrigation Area and Irrigatin Intensity

(1) Irrigation Area (10^3rai)

Basin & Sub-Basin	Existing				Future Potential			
	Large & Medium	Small	Pump	Total	Large & Medium	Small	Pump	Total
1. Kok Basin								
(1) Mae Fang Sub-Basin	116.2	73.1	7.7	197.0	265.6	169.4	10.4	445.4
(2) Kok-Lao Sub-Basin	117.6	52.4	2.2	172.2	211.6	67.2	6.8	285.6
(3) Middle Kok Sub-Basin	0.0	4.1	11.0	15.1	48.7	6.1	24.5	79.3
(4) Lower Kok Sub-Basin	46.3	30.2	3.2	79.7	86.3	30.2	12.2	128.7
Sub-total	280.1	159.8	24.1	464.0	612.2	272.9	53.9	939.0
2. Ing Basin								
(1) Upper Ing Sub-Basin	105.0	37.1	1.3	143.4	297.0	48.1	3.0	348.1
(2) Middle Ing Sub-Basin	110.9	80.0	7.2	198.1	170.9	86.4	41.4	298.7
(3) Mae Nam Phung Sub-Basin	161.1	10.4	1.5	173.0	161.1	57.6	3.0	221.7
(4) Mae Lao (Ing) Sub-Basin	42.0	50.9	0.0	92.9	62.0	63.4	0.0	125.4
(5) Lower Ing Sub-Basin	57.9	27.2	20.1	105.2	129.7	27.2	36.5	193.4
Sub-total	476.9	205.6	30.1	712.6	820.7	282.7	83.9	1,187.3
Total	757.0	365.4	54.2	1,176.6	1,432.9	555.6	137.8	2,126.3
3. Upper Nan Basin								
(1) Upper Nan Sub-Basin	23.2	28.5	9.2	60.9	58.7	42.5	15.2	116.4
(2) Nam Yao I Sub-Basin	0.0	3.9	1.0	4.9	36.0	3.9	7.7	47.6
(3) Nan Part II Sub-Basin	15.2	96.6	35.5	147.3	66.4	96.6	41.5	204.5
(4) Nam Yao II Sub-Basin	3.6	10.8	0.0	14.4	3.6	24.3	2.7	30.6
(5) Nam Samun Sub-Basin	21.0	2.5	1.3	24.8	78.4	4.6	4.5	87.5
(6) Nam Haeng Sub-Basin	0.0	19.4	15.5	34.9	0.0	27.4	24.5	51.9
(7) Nam Haeng Sub-Basin	6.0	8.0	1.5	15.5	6.0	15.0	16.5	37.5
(8) Nan Part III Sub-Basin	0.0	0.4	2.0	2.4	7.0	15.0	19.0	41.0
Total	69.0	170.1	66.0	305.1	256.1	229.3	131.6	617.0
Grand Total	826.0	535.5	120.2	1,481.7	1,689.0	784.9	269.4	2,743.3

(2) Irrigation Intensity (%)

	Farm Area 10^3rai	Existing Irrigation		Future Potential Irrigation	
		Area (10^3rai)	Intensity (%)	Area (10^3rai)	Intensity (%)
1. Kok Basin	1,288	464	36	939	73
2. Ing Basin	1,761	713	40	1,187	67
Total	3,049	1,177	39	2,126	70
3. Upper Nan Basin	1,120	305	27	617	55

The irrigation areas developed by the large/medium scale reach 280,000 rai in the existing projects and 612,000 rai in the future potential projects, which occupy a large portion of 60% and 65% respectively for total irrigation areas in the basin. The small scale projects also covers relatively large areas as shown in 160,000 rai (34%) in the existing and 273,000 rai (30%) in the future potential. Pumping irrigation area is as small as only 24,000 rai and 54,000 rai respectively.

Since runoff in tributaries of the Kok river is rich in the wet season but scarce in the dry season, many irrigation projects are developed with the large, medium and small scale reservoirs to store the wet season runoff and use it in the dry season. Pumping irrigation is limited to tributary with sufficient runoff even in the dry season.

(2) Mae Fang Sub-Basin

The Mae Fang river is one of the large tributaries of the Kok river and flows into the Kok river near the border of Myanmer. The Mae Fang sub-basin holds a catchment area of 2,160 km^2 and average annual runoff of 1,300 MCM (Yield of 600 mm).

The basin has the largest irrigation area of 197,000 rai in the existing and 445,000 rai in the future potential in the Kok basin. The increased irrigation area in future is 248,000 rai, which is mostly developed with the large/medium scale projects. The medium scale dam and weir such as Upper Fang, Mae Ngon Noi, Mae Mao, Huai Khrai, Mae Sao, etc. will be implemented in future and its irrigation area will reach 150,000 rai. Small scale irrigation area of 96,000 rai also will be developed in future.

The basin locates at the most upstream basin of the Kok river and has no direct relation with the water diversion Project. However, the existing available runoff for the water diversion at the existing Chiang Rai weir site will be decreased slightly due to the water use in the future irrigation projects.

(3) Kok-Lao Sub-Basin

The Kok-Lao sub-basin is adjoing the Mae Fang sub-basin and has a catchment area of 3,580 km^2 and average annual runoff of 780 MCM (Yield of 220 mm). The basin also has a large irrigation area of 172,000 rai in the existing and 286,000 rai in the future potential. The existing Mae Lao weir project, the famous large irrigation project in the Kok basin, covers the area of 43,300 rai in the Lao own basin and 122,700 rai in the upper Ing basin by transbasin. In the basin, the medium scale projects of more than 10 units such as Huai Pong, Mae Chedi, Mae Khao, Mae Poon Luang, Mae Yang Min, Mae Suai, etc. are proposed newly in future. The existing famous Chai Sombat weir which locates at the downstream of the Lao river and has been used for the large people irrigation system covering the area of 43,000 rai, will be rehabilitated in future by request of people irrigation group. The small scale and pumping irrigation areas in the basin in future are limited to less than 20,000 rai.

The irrigation development in the Kok-Lao sub-basin has no influence at all to the water diversion in the Project, because the Kok-Lao river joins the Kok main river at the downstream of the existing Chiang Rai weir to be used for the water diversion in the Project and its water can't be used for the water diversion in the Project and will be released to the Mekong river.

(4) Middle Kok and Lower Kok Sub-Basins

The middle Kok basin lies on the area between the Mae Fang sub-basin and the existing Chiang Rai weir and is formed with mountain and deep valley areas, while the lower Kok sub-basin locates at the area between the existing Chiang Rai weir and the Kok river mouth. Both basins have a catchment area of 2,160 km^2 and average annual runoff of about 1,100 MCM (Yield of 510 mm). Since the middle Kok and lower Kok sub-basins have not a large irrigation area because of the middle Kok basin consisting of mountains and the lower Kok basin being suffered from inundation in the wet season by backwater of the Mekong river. The irrigation area in both basins is estimated at 95,000 rai in the existing and 208,000 rai in the future potential.

The existing area of 46,000 rai is developed by the medium scale and 49,000 rai by the small and pumping irrigation. The middle Kok sub-basin has the existing area of only 15,000 rai developed by small scale and pumping irrigation. The future potential area developed by the medium scale projects will increase to 135,000 rai from the existing area of 46,000 rai. Major medium scale projects proposed in future are as follows;

- Chiang Rai weir project constructed by DEDP to supply irrigation water to the existing people irrigation area of 48,700 rai. Although this irrigation area has received the irrigation water from the Chai Sombat weir in the Kok-Lao river, the irrigation water taken in the weir has decreased in the recent year due to the irrigation development in the upper basin of the Kok-Lao. Accordingly the area will be irrigated by the Kok water diverted from the existing Chiang Rai weir and canal system under construction by DEDP instead of the Lao water.
- Mae Lao rehabilitation project to improve the existing irrigation canal system. The Mae Lao irrigation project is the large scale project completed in 1963 and consisting of Mae Lao weir of 2.5 m high and 30.5 m long, the intake capacity of 13.4 cu.m/sec for the left canal and 5.2 cu.m/sec for the right canal and the beneficial area of 166,000 rai.
- Upgrading project of the Nong Luang swamp to increase the storage volume of the existing swamp for fish culture and irrigation at the downstream area. Feasibility study of this project was conducted by the local consultant J.V in parallel with the Kok-Ing-Nan Project. In accordance with study result, the farmland of 12,000 rai could be irrigated by increasing swamp capacity.
- Irrigation water supply project to the lower Ing basin of 35,000 rai by transbasin of Kok-Ing diversion canal in the Project. This project supplies a part of diverted water from the Kok river by the Kok-Ing open canal to the lower Ing basin suffered from water shortage in dry season.
- New irrigation area of 46,000 rai at the Wiang district near the Kok river mouth by providing a polder dike to prevent inundation caused by the Kok flood and backwater of the Mekong river.
- The future small scale and pumping irrigation area in both basins is as small as only 73,000 rai.

Since the middle Kok and lower Kok sub-basins have not a large irrigation area which could be irrigated sufficiently by tributary water at the middle and lower Kok sub-basins, it is not necessary to release much water to the downstream river at the existing Chiang Rai weir site. Namely, the water diversion in the Project could be easily carried out without a particular attention to the water supply for the downstream area, because the downstream of the Kok river is covered with surplus water of the Kok river and backwater of the Mekong river in wet season.

10.1.2 Irrigation Project Area in Ing Basin

(1) Whole Ing Basin

The Ing basin has a catchment area of 7,120 km^2 and average annual runoff of about 2,500 MCM (Yield of 350 mm). The potential water resources in the Ing basin are about 50% of those in the Kok basin because of Low rainfall and large farmlands to use rain water in the Ing basin.

The basin is divided into five sub-basins of the upper Ing, Mae Nam Phung, middle Ing, Ing-Lao and lower Ing. The basin is formed mostly with hilly area and vast alluvial plain and holds a large farm area of 1.76 million rai which is about 1.4 times of that in the Kok basin. The irrigation area is estimated at 713,000 rai (40% intensity) in the existing projects and 1,187,000 rai (67%) in the future potential projects.

Out of the total irrigation area in the Ing basin, the irrigation area developed by the transbasin of the Kok-Lao and Kok rivers is 123,000 rai in the existing and 322,000 rai in the future potential. The irrigation area developed by the large/medium scale is estimated at 477,000 rai (67% of total irrigation area) and 1,187,000 rai (69%) in the future potential. The small scale irrigation area is 206,000 rai (29%) and 283,000 rai (24%) respectively. Though the existing pumping irrigation area is small as 30,000 rai, its future area will increase to 84000 rai, which will be distributed mostly at the area along the lower Ing river and served by the diversion water of the Kok-Ing canal.

Since many irrigated agricultural projects have been developed in the upper Ing and Mae Phung and middle Ing basins, the available water in the dry season for irrigation in the lower Ing basin has been decreased. It will be necessary accordingly to convey the Kok water in the dry season to the lower Ing basin by the water diversion in the Project.

(2) Upper Ing Sub-Basin

The Ing river originates at the plateau where the Nong Leng Sai large swamp locates and empties into the Payao lake in the upper Ing basin. The basin has a catchment area of 1,100 km^2 and average runoff of 270 MCM (Yield of 245 mm). The potential water resources in the basin are small as compared with the Kok upper basin because of less rainfall and many farm areas to consume water in the upper Ing basin.

The existing irrigation area is estimated at 143,000 rai, of which 94,000 rai is developed by the medium scale dams of Mae Phuem, Mae Tam and Mao Tom.

In order to supply an additional water at the farm area surrounding the Payao lake in the upper Ing basin, JICA Team proposed the Mae Lao extension project which is the transbasin

project from the Kok-Lao river by using the existing Mae Lao weir and right bank canals. The irrigable area developed by the Mae Lao extension project is estimated at 165,000 rai. However the feasibility study will be required for this project.

The small scale irrigation area in the basin is small as 37,000 rai in the existing and 48,000 rai in the future potential. Those area is mostly scattered in small tributaries surrounding the Payao lake. The pumping area is very limited to 1,300rai in the existing and 3,000 rai in the future potential.

(3) Mae Nam Phung Sub-Basin

The Mae Nam Phung Sub-basin locates at the plateau where the Nong Hong swamp is existing and has a catchment area of 1,130 km^2 and average annual runoff of 280 MCM (Yield of 250 mm). The irrigation area is estimated at 173,000 rai in the existing and 222,000 rai in the future potential.

The existing irrigation area developed by the medium scale projects is 161,000 rai, of which 123,000 rai is developed by the transbasin from the Kok-Lao river by using the existing Lao weir and right bank canal. There is no more medium scale projects in future in the basin due to no suitable dam and weir sites with sufficient water. The future irrigation project will be developed by the small scale and its area will increase to 58,000 rai from the existing of 10,000 rai. The pumping irrigation area is quite limited to 1,500 rai in the existing and 3,000 rai in the future potential.

(4) Middle Ing Sub-Basin

The middle Ing sub-basin lies on the area between the Khao-Ing Rod weir site where the Mae Nam Phung river joins to the Ing main river and the Thoeng weir site, where the Ing diversion weir is proposed in the Project. A catchment area and average annual runoff in the basin is 2,210 km^2 and 670 MCM (Yield of 300 mm) respectively. The irrigation area is estimated at 198,000 rai in the existing and 299,000 rai in the future potential.

The existing irrigation area developed by the medium scale dams is 111,000 rai, which distribute mostly at the tributaries in the left bank of the Ing river. The future area by the medium scale will reach 171,000 rai and the increased area of 60,000 rai is developed with the diversion water of the Kok-Ing canal and reservoir water of the Ing weir. Though the area by the small scale is 80,000 rai in the existing and 86,000 rai in the future potential and does not increase so much in future, the pumping irrigation area will increase largely to 41,000 rai in the future potential from the existing area of 7,000 rai. The increased pumping irrigation area of 34,000 rai will be expanding at the both bank areas in the reservoir which will be provided by the Ing weir and receive the diversion water from the Kok-Ing canal in the Project.

(5) Mae Ing-Lao Sub-Basin

The Ing-Lao river flows down collecting runoff of many tributaries in the high mountain areas between Ing and Nan basin and joins to the Ing main river at Ampho Thoeng. The basin has a catchment area of 1,260 km^2 and rich annual runoff of 640 MCM (yield of 510 mm). Since the basin is mostly formed with high mountains, its farm area is limited to the alluvial

plain being formed with the Lao main stream.

The irrigation area in the basin is small as 93,000 rai in the existing and 125,000 rai in the future potential. The irrigation area is mostly developed by the medium and small scale dams in tributaries, while no pumping irrigation area is existing at present and in future because of the Lao river being formed with deep valley and very scarce water in the dry season.

Since the Ing-Lao river has a rich runoff as compared with the irrigation water demand in the limited farm area in the basin, much surplus runoff is flowing down and joining to the Ing river at Amphoe Thoeng site. This surplus water, however, will not be diverted to the Chao Phraya basin but use for the farmland along the lower Ing river.

(6) Lower Ing Sub-Basin

The lower Ing sub-basin locates at the basin between the Ing weir site and the Ing river mouth and has a catchment area of 1,420 km^2 and average annual runoff of 410 MCM (Yield of 240 mm). Though large farm areas are expanding at alluvial plain along the lower Ing river, they have been suffered from inundation in the wet season caused by the Ing river flood and backwater of the Mekong river and faced the critical water shortage in the dry season due to no or scarce runoff in the river.

The existing irrigation area in the basin is 105,000 rai and will increase to 193,000 rai in the future. The irrigation area developed by the medium scale is estimated at 58,000 rai in the existing and 130,000 rai in the future potential. The irrigation water for the increased area of 78,000 rai in future will be mostly supplied by irrigation canals branched off from the proposed Kok-Ing open canal in the Project.

The irrigation area developed by the small scale is small as 27,000 rai in the existing and also in the future potential. There is no additional irrigation area developed by the small scale in future. However the pumping irrigation area in the future will increase slightly to 36,500 rai from the existing area of 20,100 rai. The increasing pumping area is expanding in the lower land along the Ing river.

10.1.3 Irrigation Project Area in Upper Nan Basin

(1) Whole Upper Nan Basin

The upper Nan basin occupies the upstream basin of the Sirikit reservoir and has a catchment area of 13,140 km^2 and average annual runoff of 5,600 MCM (Yield of 430 mm). The basin consists of eight sub-basins as shown in Table 10.1.1 and is mostly formed with high mountain and hilly areas. The farmland is small as 1,120,000 rai, which is scattering at the alluvial plain with slender shape along the Nan river.

The irrigation area is 305,000 rai in the existing and 617,000 rai in the future potential. The medium scale projects are developed mainly in the sub-basins of upper Nan, Nan Part II and Nam Samun and their irrigation area is 131,000 rai in the existing projects and 318,000 rai in the future potential.

The small scale irrigation area is 108,000 rai in the existing, which will increase largely to 318,000 rai in the future potential. Pumping irrigation area is 30,000 rai and 84,000 rai

respectively, which is scattered along the Nan river and withdraws the river water by floating pumping system.

(2) Nam Yao Ⅰ Sub-Basin

The Nam Yao Ⅰ sub-Basin locates at the northwest corner of the upper Nan basin and has a catchment area of 780 km^2 and average annual runoff of 310 MCM. The Mae Yao river is one of the important Project area to release the diversion water to the Nan main river, so that a flood control dam and river training works are planned in the river.

Since the river basin is formed with steep mountains and deep valleys, farmland is very limited and the existing irrigation area is only 5,000 rai consisting of mostly the small scale and pumping projects. Though farmlands of about 6,000 rai are existing at the area where the Yao river joins to the Nan main river, the area has been suffering from flood backwater of the Nan river during August and September in wet season. However, this farmland could be irrigated in the dry season in future by the dry season water release from the Yao dam.

(3) Upper Nan Sub-Basin

The upper Nan Sub-basin locates at the most upstream of the upper Nan basin and is formed with high mountains and deep valley, so that farmland is limited. Accordingly the existing irrigation area is as small as 61,000 rai, of which the 25,000 rai is developed by the medium scale weirs of Nam Pua, Nam Kon, Chao, Huai Nam Bue, etc. and the other area by the small scale and pumping project.

Since peak flood of more than 1,500 cu.m/sec takes place often at the conjunction point of the Yao river and the Nan main river and brings about the inundation damage at farmlands along the Nan river, the upper Nan flood control dam will be required in future. In accordance with the preliminary survey of JICA Team, a damsite suitable for flood control is identified at Amphoe Thung Chang in the upper Nan sub-basin. The proposed dam will have the reservoir capacity of about 100 MCM for flood control during August and September and could supply the dry season irrigation water to the farmland of 30,000 rai along the upper Nan river.

(4) Nan Part 2 Sub-Basin

The Nan Part 2 sub-basin locates at the central area along the upper Nan river and includes Nan city and a large alluvial plain lying on the downstream of Nan city, where rainfed agriculture is dominant. The basin area is 1,570 km^2 and its average annual runoff is as small as 570 MCM (Yield of 360 mm). However a rich runoff flows down from the upstream basin and its average annual runoff at N1 station located at Nan city reach 2,650 MCM (Yield of 580 mm).

This sub-basin has the largest irrigation area in the upper Nan basin as shown in 147,000 rai (50% of total irrigation area) in the existing projects and 205,000 rai (33%) in the future potential projects. The existing area developed by the medium scale is small as 15,000 rai by three dams of Huai Head, Nam Kaen and Nam Pa Klang, while the existing area by the small scale and pumping projects occupies the large area of 132,000 rai.

Though there is no more irrigation area developed by the small scale in future, the medium scale projects covering 51,000 rai are newly developed in future by weirs of Thong Noi and Nong Kok constructed crossing the Nan main river and Nam Rim dam at tributary. The pumping irrigation area in future will reach 42,000 rai from the existing area of 36,000 rai.

The area newly developed by two weirs and pumping systems is estimated at 53,000 rai, which could use the dry season irrigation water supplied by the Yao dam in the project.

(5) Nam Yao 2 and Nam Wa Sub-Basin

The Nam Yao 2 and Nam Wa sub-basins located at the east side of the Nan Part 2 sub-basin and is formed mostly with high mountain areas. The basin area is 2,780 km^2 and its average annual runoff shows the high value of 2,150 MCM (Yield of 770 mm). The irrigation area is small as 49,000 rai in the existing and 83,000 rai in the future potential due to small farmlands in the basin.

(6) Nam Samun and Nam Sa Sub-Basins

The Nam Samun and Nam Sa sub-Basins locates at the central west side of the upper Nan basin and both rivers of Nam Samun and Nam Sa empties into the upper Nan river at the downstream of Nan city. The basin area and its annual runoff are 1,350 km^2 and 110 MCM (Yield of 80 mm) respectively.

(7) Nam Haeng and Nan Part 3 Sub-Basins

The Nam Haeng and Nam Part 3 sub-basins locate at the downstream of the upper Nan basin adjoing the Sirikit reservoir area. The basin area and its average annual runoff are 4,420 km^2 and 1,210 MCM (Yield of 270 mm).

The irrigation area in the basins is as small as 18,000 rai in the existing and 78,000 rai in the future potential. The irrigation area developed by the medium scale is 6,000 rai by Nam Haeng dam in the existing and 7,000 rai by dams of Huai Lod and Nam Muab in the future. Other areas of 12,000 rai in the existing and 66,000 rai in the future are developed by the small scale and pumping projects.

10.1.4 Proposed Medium Scale Projects for Implementation

The proposed medium scale projects to be implemented in advance or in parallel with the water diversion Project are listed up as shown in Table 10.2.1.

The proposed irrigation area and construction cost in each basin is summarized as follows;

Basin	Irrigation Area (10^3 rai)	Construction Cost (10^3 Baht)	Project Cost Per rai (Baht/rai)
Kok	230	5,857	25,500
Ing	147	3,218	21,900
Upper Nan	107	3,805	35,600
Total	484	12,880	26,600

Table 10.1.2 Proposed Medium Scale Projects to be Implemented in Kok, Ing and Upper Nan Basin

No	Project Name	Location			Reservoir Capacity (MCM)	Irrigation Area (10^3rai)	Project Cost (10^6Baht)	F/S&EIA	Detailed Design	Construction
		Sub-Basin	Province	Muang or Amphoe						
1. Kok Basin										
(1)	Upper Fang Dam	Mae Fang	Chiang Mai	Chai Prakan	50.0	18.1	758	2006~07	2008~09	2010~14
(2)	Mae Thalop Luang	Mae Fang	Chiang Mai	Chai Prakan	15.3	9.3	475	Completed	Completed	2002~06
(3)	Huai Khrai Dam	Mae Fang	Chiang Mai	Chai Prakan	48.5	28.0	767	2005~06	2007~08	2009~2013
(4)	Mae Nawang Dam	Mae Fang	Chiang Mai	Fang	36.2	13.0	615	2004~05	2006~07	2008~12
(5)	Mae Chedi Dam	Mae Lao	Chiang Rai	Wiang Pa Pao	35.0	36.0	676	2003~06	2005~06	2007~11
(6)	Mae Poon Luang Dam	Mae Lao	Chiang Rai	Wiang Chai	53.0	55.0	856	2001~02	2003~04	2005~09
(7)	Mae Yang Min Dam	Mae Lao	Chiang Rai	Mae Suai	32.0	39.0	690	2002~03	2004~05	2006~10
(8)	Mae Suai Dam	Mae Lao	Chiang Rai	Mae Suai	73.0	7.0	906	Completed	Completed	1999~2003
(9)	Chai Sombat Weir	Mae Lao	Chiang Rai	Chiang Rai	-	13.0	25	Completed	2002~03	2004~07
(10)	Nong Luang Swamp	Middle Kok	Chang Rai	Chiang Rai	15.0	12.0	89	Completed	2001~02	2003~06
Total		-	-	-	358.0	230.4	5,857	-	-	-
2. Ing Basin										
(1)	Mae Chai Dam	Upper Ing	Payao	Mae Jai	3.0	2.7	78	Completed	Completed	1999~2001
(2)	Nong Leng Sai Dam	Upper Ing	Payao	Mae Jai	6.5	10.0	125	2000~01	2002~03	2004~07
(3)	Lower Thoeng Weir	Middle Ing	Chiang Rai	Thoeng	-	37.0	804	2003~04	2005~06	2007~11
(4)	Nam Yuan Dam	Mae Lao	Payao	Chiang Kam	36.0	20.0	675	2006~07	2008~09	2010~14
(5)	Pak Ing Weir	Lower Ing	Chiang Rai	Chiang Kong	-	48.0	996	2004~05	2006~07	2008~12
(6)	Upper Thoeng Weir	Lower Ing	Chiang Rai	Thoeng	-	12.0	445	2005~06	2007~08	2009~13
(7)	Mae Tak Dam	Lower Ing	Chiang Rai	Wang Chai	9.0	17.0	95	Completed	Completed	1999~2001
Total		-	-	-	54.5	146.7	3,218	-	-	-
3. Nan Basin										
(1)	Nam Khwang Dam	Upper Nan	Nan	Pur	7.1	5.5	289	2007~08	2009~10	2011~15
(2)	Tha Wang Pha Weir	Yao 1	Nan	Tha Wang Pha	-	20.0	312	2008~09	2010~11	2012~16
(3)	Thong Nai Weir	Nan Part 2	Nan	Wiang Sa	9.6	22.8	312	Completed	Completed	2004~07
(4)	Nong Nok Weir	Nan Part 2	Nan	Wiang Sa	6.9	23.9	325	2000~01	2002~03	2004~07
(5)	Nam Samun Dam	Nam Samun	Nan	Muang Nan	13.5	12.0	646	Completed	2001~02	2003~06
(6)	Mae Khaning Dam	Nam Samun	Nan	Wiang Sa	62.0	13.5	756	2004~05	2006~07	2008~12
(7)	Mae Hi Dam	Nam Samun	Nan	Wiang Sa	15.0	2.1	549	2006~07	2008~09	2010~14
(8)	Huai Lod Dam	Nan Part 3	Nan	Wiang Sa	12.0	1.6	422	2005~06	2007~08	2009~13
(9)	Nam Muab Dam	Nan Part 3	Nan	Wiang Sa	6.0	5.8	194	2006~07	2008~09	2010~14
Total		-	-	-	132.1	107.2	3,805	-	-	-

The medium scale project in the Ing basin shows the low investment cost per rai as compared with that of the Kok and upper Nan, because the medium scale projects in the Kok and upper Nan are mostly composed of dams, while those in the Ing includes weir projects.

The annual schedule for feasibility study, detailed design and construction works of the medium scale projects is proposed as shown in Table 10.1.2.

In accordance with RID information, the budget for the medium scale projects is already provided by the Thai government.

10.2 Associate Irrigation Project

10.2.1 Proposed Associate Irrigation Project Area

Out of the future potential irrigation area in the Kok, Ing and upper Nan basin as mentioned in 10.1, the irrigation area to be served by the Kok-Ing diversion canal and the Yao dam is denominated as the associate irrigation project area and will be implemented together with the diversion canal and Yao dam works in the Project.

The associate irrigation project area will be estimated at about 200,000 rai in the Kok and Ing basin and about 50,000 rai in the upper Nan basin as mentioned below.

(1) Kok Basin (3,000 rai)

The proposed associated irrigation areas locate at the area between the existing DEDP's main canal and the Kok diversion canal and at the area along the diversion open canal. Those area is situated nearby the Chiang Rai urban district and will be improved to suitable farm for orchard, vegetable and flower plantation taking into account the urban agriculture and agro-tourism to sell agricultural products to the consumers in Chiang Rai district and/or tourists visiting Chiang Rai province. The public parks, cycling and walking course, outdoor recreation area, etc, will be provided in the above irrigation area. The dry season irrigation water also is diverted from the Kok river and used for the proposed irrigation area. The total area along the canal is estimated at 3,500 rai of which 3,000 rai could be used for the net irrigation area to produce crops and flowers.

(2) Tak Basin (7,000 rai)

The existing farmland in the Tak basin, a large tributary of the Ing river and the water sources for farmland in the Amphoe Phaya Meng Rai, has been partially irrigated by the Tak river water in the wet season. However the Tak river and tributaries are mostly dried up in the dry season and no crop plantation is found at the existing farmland except the area developed by the small scale reservoirs.

In order to divert the supplemental irrigation water in wet season and full dry season water for paddy and diversified crops, a regulator and turnout structure is to be provided at the open canal reach in the outlet of Kok-Ing No.1 tunnel in the Tak basin.

The farmland expanding along the Tak river and surrounding Amphoe Phaya Mong Rai could be irrigated by gravity or pumping system using a part of diversion water in the Kok-Ing canal.

In addition, some excess diversion water and return flow in the irrigation area will be conveyed to the proposed irrigation area in the lower Ing basin by the irrigation canal newly constructed between the Tak downstream and the lower Ing basin.

The total irrigation area in the Tak basin is estimated at about 7,000 rai.

(3) South Thoeng Area in Middle Ing Basin (52,000 rai)

The south Thoeng area locates at the upstream basin of the proposed Ing diversion canal route and Ing weir site.

The vast farmland expanding at the upstream of the Ing open canal in the Project has been suffering from water shortage in the dry season, while the low farmland along the Ing river at the upstream of the Ing weir has been inundated in the wet season by the Ing flood and suffered from water shortage in the dry season.

The former farmland could receive a part of diversion water by the proposed new irrigation canal which will be branched off from the Ing open canal and run through the hilly foot area at the left bank of the Ing basin. In the latter farmland, the inundation problem in the wet season could be solved by diverting the water of 175 cu.m/sec in the flood season to the Nan basin and dry season water could be supplied by the reservoir provided along the upstream river channel by the Ing weir. In addition several secondary and tertiary irrigation canals branched off from the Ing open canal will be constructed to serve the existing rainfed farmland along the proposed Ing diversion canal route.

Surplus water from the Kok-Ing canal and return flow from the irrigation area will flow into the Ing river and stored in the Ing regulating reservoir with the full water level of 363.5 m and the capacity of 10 MCM. The reservoir water will be used for irrigation at the right bank area of the Ing river by pumping system.

Although there are existing a large farmland in the middle Ing basin, the irrigable area by the Kok-Ing diversion canal system and Ing weir will be about 52,000 rai consisting of 38,000 rai in the left bank of and 14,000 rai in the right bank of the Ing river.

(4) North Thoeng Area in the Lower Ing (46,000 rai)

The north Thoeng area locates on the both banks of the Ing river downstream between the proposed Ing weir site and the site where the Tak river joins to the Ing river. The farm area being located at the high land at the left bank of the Ing river could be irrigated by the gravity irrigation canal which is branched off at the downstream of the Tak river and passes through the high land area of the elevation 390 to 360 m. While the lower farmland lying on the left and right bank along the downstream of the river will be irrigated with the a number of small pumping stations to be installed by DEDP in future. In order to rise up the water level in the Ing river and store the dry season water in the river channel, a concrete weir with gate with a length of about 50 m will be in stalled crossing the Ing river at the conjunction point of the Tak and Ing river. The flood during August to September will flows down to the downstream with the full open of spillway gate in order to prevent inundation problems at the low land area along the river. In the dry season, the surplus water coming from the Ing-Lao river, the Kok-Ing canal and the return flow will be regulated by the reservoir provided by the weir at the upstream

river channel. The reservoir outline is as follows;

- Reservoir water level; 356 m
- Reservoir width and length; 100 m and 30 km
- Average depth of reservoir; 3~4 m
- Reservoir Capacity; 5 MCM

The proposed irrigation area in the north Thoeng area is estimated at 46,000 rai consisting of 35,000 rai in the left bank and 11,000 rai in the right bank.

(5) South Pak and Pak Ing Area (92,000 rai)

The south Pak and Pak Ing area is located at the lower reaches of 75 km in the Ing river from the proposed weir site for the North Thoeng irrigation to the site near the Ing river mouth. The farmland area along the Ing river will be irrigated by the similar method mentioned in the above North Thoeng Area such as storing the surplus water in the river channel by weir and pumping up the reservoir water to the irrigation areas of both river banks. The following two weirs will be planned in the river reaches of 95 km taking into account the flood and reservoir water level, possible reservoir capacity, elevation of farmland area, etc.

Items	South Pak Ing	Pak Ing
Weir Location	44 km upstream from River Mouth	33 km upstream from River Mouth
Reservoir Water Level	350 m	346 m
Reservoir Length	30 km	30 km
Average depth of reservoir	4 m	4 m
Reservoir capacity	10 MCM	10 MCM
Total Irrigation Area	49,000 rai	43,000 rai
Left Bank	38,000 rai	37,000 rai
Right Bank	11,000 rai	6,000 rai

(6) Upper Nan Area (50,000 rai)

Many farmlands are scattered with slender shape along the upper Nan main river and some farm areas has irrigated by the floating pumps. However, the existing farmlands including irrigation area have been suffering from water shortage in the dry season. In accordance with the inventory survey result for the future potential irrigation area, the area to be developed by weirs and pumping stations to use the Nan river water will reach more than 150,000 rai. However, this proposed irrigation is mainly for the supplemental water supply for the wet season paddy but limited to the dry season water supply for diversified crops due to scarce runoff in the river in the dry season.

The Yao dam proposed in the Project is used not only for the flood control purpose but irrigation water supply in dry season. Namely, the dam could store the water of 30 MCM by the Kok and Ing diversion water in October and November after ending the flood season from

August to September. This storaged water could be used for the dry season irrigation at the farmland along the Yao river and the upper Nan river. The dry season area of about 20,000 rai will be newly irrigated by the reservoir water of 30 MCM.

10.2.2 Cropping Pattern and Irrigation Demand in Associate Project

(1) Cropping Pattern

The above mentioned associate project areas could be cultivated with 95% cropping intensity in the wet season because of sufficient rainfall and river follow available for irrigation. During the dry season, however the cropping intensity of 40% could be proposed taking into account available dry season water in the river and stored water in the river channel reservoirs in the Ing and the Yao dam in the Yao river.

The proposed Cropping Pattern is as shown in the following Table 10.2.1.

Table 10.2.1 Proposed Cropping Pattern in Associated Irrigation Projects

Crops	Wet Season						Dry Season					
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1. Kok-Ing Basin (Total Area of 200,000 rai)												
Paddy	160,000 rai (80%)						25,000 rai (12.5%)					
Fruit	20,000 rai (10%)						20,000 rai (10%)					
Field Crops	-						20,000 rai (10%)					
Vegetables	5,000 rai (2.5%)		-				5,000 rai (2.5%)			5,000 rai (2.5%)		
Fish Culture	5,000 rai (2.5%)						5,000 rai (2.5%)					
Total	190,000 rai (95%)						80,000 rai (40%)					
2. Upper Nan Basin (Total Area of 50,000 rai)												
Paddy	40,000 rai (80%)						6,500 rai (15%)					
Fruit	5,000 rai (10%)						5,000 rai (10%)					
Field Crops	-						5,000 rai (15%)					
Vegetables	1,000 rai (2%)		-				1,000 rai (2%)			1,000 rai (2%)		
Fish Culture	1,500 rai (3%)						1,500 rai (3%)					
Total	47,500 rai (95%)						20,000 rai (40%)					

(2) Monthly Irrigation Demand in Dry Season

The irrigation water will be sufficiently available at the Kok, Ing and upper Nan river. However dry season irrigation water is not existing in the Ing and upper Nan river and could be supplied by the Kok-Ing diversion canal and the Yao dam in the Project.

The monthly irrigation demand in dry season is estimated as shown in Table 10.2.2.

Table 10.2.2 Estimated Monthly Irrigation Demand in Dry Season for Associate Projects

Item		Dec	Jan	Feb	Mar	Apr	May	Total
1. Kok-Ing Basin								
(1) Dry Season Paddy,	Unit Demand	(600)	(360)	(360)	(360)	(170)	-	(1,850)
25,000 rai (12.5%)	Total Demand	15.0	9.0	9.0	9.0	4.3	-	46.3
(2) Fruit	Unit Demand	(320)	(320)	(320)	(360)	(360)	(320)	(2,000)
20,000 rai (10%)	Total Demand	6.4	6.4	6.4	7.2	7.2	6.4	40.0
(3) Field Crops	Unit Demand	(280)	(280)	(280)	(300)	(160)	-	(1,300)
20,000 rai (10%)	Total Demand	5.6	5.6	5.6	6.0	3.2	-	26.0
(4) Vegetables	Unit Demand	(200)	(200)	(200)	(220)	(220)	(210)	(1,250)
5,000 rai×2 (5%)	Total Demand	1.0	1.0	1.0	1.1	1.1	1.1	6.3
(5) Fish Culture	Unit Demand	(220)	(240)	(240)	(270)	(270)	(210)	(1,450)
5,000 rai	Total Demand	1.1	1.2	1.2	1.4	1.4	1.1	7.4
Total Water Demand	(MCM)	29.1	23.2	23.2	24.7	17.2	8.6	126.0
80,000 rai	(cu.m/sec)	10.9	8.7	9.6	9.2	6.6	3.2	8.0
2. Upper Nan Basin								
(1) Dry Season Paddy,	Unit Demand	(600)	(360)	(360)	(360)	(170)	-	(1,850)
6,500 rai (13%)	Total Demand	3.9	2.3	2.3	2.3	1.1	-	11.9
(2) Fruit	Unit Demand	(320)	(320)	(320)	(360)	(360)	(320)	(2,000)
5,000 rai (10%)	Total Demand	1.6	1.6	1.6	1.8	1.8	1.6	10.0
(3) Field Crops	Unit Demand	(280)	(280)	(280)	(300)	(160)	-	(1,300)
5,000 rai (10%)	Total Demand	1.4	1.4	1.4	1.5	0.8	-	6.5
(4) Vegetables	Unit Demand	(200)	(200)	(200)	(220)	(220)	(210)	(1,250)
1,000 rai×2 (4%)	Total Demand	0.2	0.2	0.2	0.2	0.2	0.2	1.2
(5) Fish Culture	Unit Demand	(240)	(240)	(240)	(270)	(270)	(240)	(1,500)
1,500 rai	Total Demand	0.4	0.4	0.4	0.4	0.4	0.4	2.0
Total Water Demand	(MCM)	7.5	5.9	5.9	6.2	4.3	2.2	32.0
20,000 rai	(cu.m/sec)	2.8	2.2	2.4	2.3	1.7	0.8	2.0

The water demand of about 130 MCM will be required for the dry season crops in the Kok-Ing basin, while the demand of 32 MCM in the upper Nan basin.

(3) Available Water for the Proposed Water Demand

The available water for the proposed water demand of 130 MCM for the Kok-Ing irrigation area of 80,000 rai in the dry season could be obtained sufficiently from the Kok river, which has a rich runoff even in the dry season and flows into the Mekong river without use at present.

Table 10.2.3 Available Monthly Discharge in Dry Season in Kok River

		Dec	Jan	Feb	Mar	Apr	May	Total
Monthly Runoff	Average (MCM)	183	126	91	83	61	9.1	635
	Minimum (MCM)	110	79	61	44	34	43	371
Discharge	Average (m^3/sec)	68.3	47.0	37.6	31.0	23.5	34.0	40.4
	Minimum (m^3/sec)	41.1	29.5	25.2	16.4	10.1	16.1	23.6
Irrigation Demand in Kok & Ing Area	(m^3/sec)	11.9	9.5	10.5	10.1	7.3	3.5	8.7

As shown in the above table, the available water in the Kok river can cover sufficiently the proposed irrigation demand even in the dry year with the minimum discharge. Although the daily discharge will be slightly fluctuated, it can be controlled by the reservoir provided in the river channel in the lower Ing river.

The water demand at the upper Nan basin in the dry season can be supplied by the reservoir water of the Yao dam which has the irrigation outflow facility of 3.0 cu.m/sec.

(4) Fish Culture Area in Reservoir

The reservoir area of 44,000 rai is created in the river channel by weirs in the lower Ing basin, while the area of 13,000 rai by the Yao dam in the upper Yao river. Those reservoir will be used for fish culture in future.

10.2.3 Project Cost and Agricultural Benefit of Associate Irrigation Project

(1) Project Cost

The project cost for the medium scale irrigation projects is estimated at 25,000 to 35,000 Baht/rai as shown in table in 10.1.4. However this cost includes the cost for water sources such as dams and the cost for irrigation canal system and pumping facilities for the beneficial area will be 15,000 Baht/rai.

Since the associate projects do not include the water source works and are composed of irrigation canal and pumping system in the beneficial area, the project cost is estimated as follows based on the 15,000 Baht/rai.

Project Cost for Kok-Ing Basin;	15,000 Baht/rai × 200,000 rai =	3,000 million Baht
Project Cost for upper Nan Basin;	15,000 Baht/rai × 50,000 rai =	750 million Baht
Total		3,750 million Baht

In addition in the above, the project cost will require the following land consolidation cost for orchard gardens and fish culture ponds.

Cost for Kok-Ing Basin;	2,000 Baht/rai × 25,000 rai =	50 million Baht
Cost for upper Nan Basin;	2,000 Baht/rai × 6,5000 rai =	13 million Baht
Total		63 million Baht

Total Cost for the associate projects are 3,813 million Baht

(2) Agricultural Benefit

The agricultural benefit in the economic term for the Kok, Ing and upper Nan basin is estimated at 948 million Baht as shown in the following Table.

Table 10.2.4 Agricultural Benefit (Financial and Economic Terms) in Associate Projects

Crop	Unit Net Value		Kok-Ing Basin			Upper Nan Basin			Total		
	Financial	Economic	Area	Benefit		Area	Benefit		Area	Benefit	
				Financial	Economic		Financial	Economic		Financial	Economic
	(Baht/rai)	(Baht/rai)	(10^3 rai)	(10^3 Baht)	(10^3 Baht)	(10^3 rai)	(10^3 Baht)	(10^3 Baht)	(10^3 rai)	(10^3 Baht)	(10^3 Baht)
Dry Paddy	1,243	2,027	25.0	31,075.0	50,675.0	6.5	8,079.5	13,175.5	31.5	39,154.5	63,850.5
Orchard	11,839	15,000	20.0	236,780.0	300,000.0	5.0	59,195.0	75,000.0	25.0	295,975.0	375,000.0
Field Crops	1,878	2,324	20.0	37,560.0	46,480.0	5.0	9,390.0	11,620.0	25.0	46,950.0	58,100.0
Vegetable	2,573	4,100	10.0	25,730.0	41,000.0	2.0	5,146.0	8,200.0	12.0	30,876.0	49,200.0
Fish Culture in Ponds	13,536	15,771	5.0	67,680.0	78,855.0	1.5	20,304.0	23,656.5	6.5	87,984.0	102,511.5
Fish Culture in Reservoirs	6,768	7,885	44.0	297,792.0	346,940.0	13.0	87,984.0	102,505.0	57.0	385,776.0	449,445.0
Total	-	-	124.0	696,617.0	863,950.0	33.0	190,098.5	234,157.0	157.0	886,715.5	1,098,107.0

Note: Unit value of fish culture in the natural reservoir is estimated at about 7,885 Baht/rai, which is about 50% for the value in the village ponds, because of production of 1.3 ton/rai in the pond, while 0.65 ton/rai in the reservoir.

Figure 10.1 Existing, Proposed and Potential Water Resources Development Project

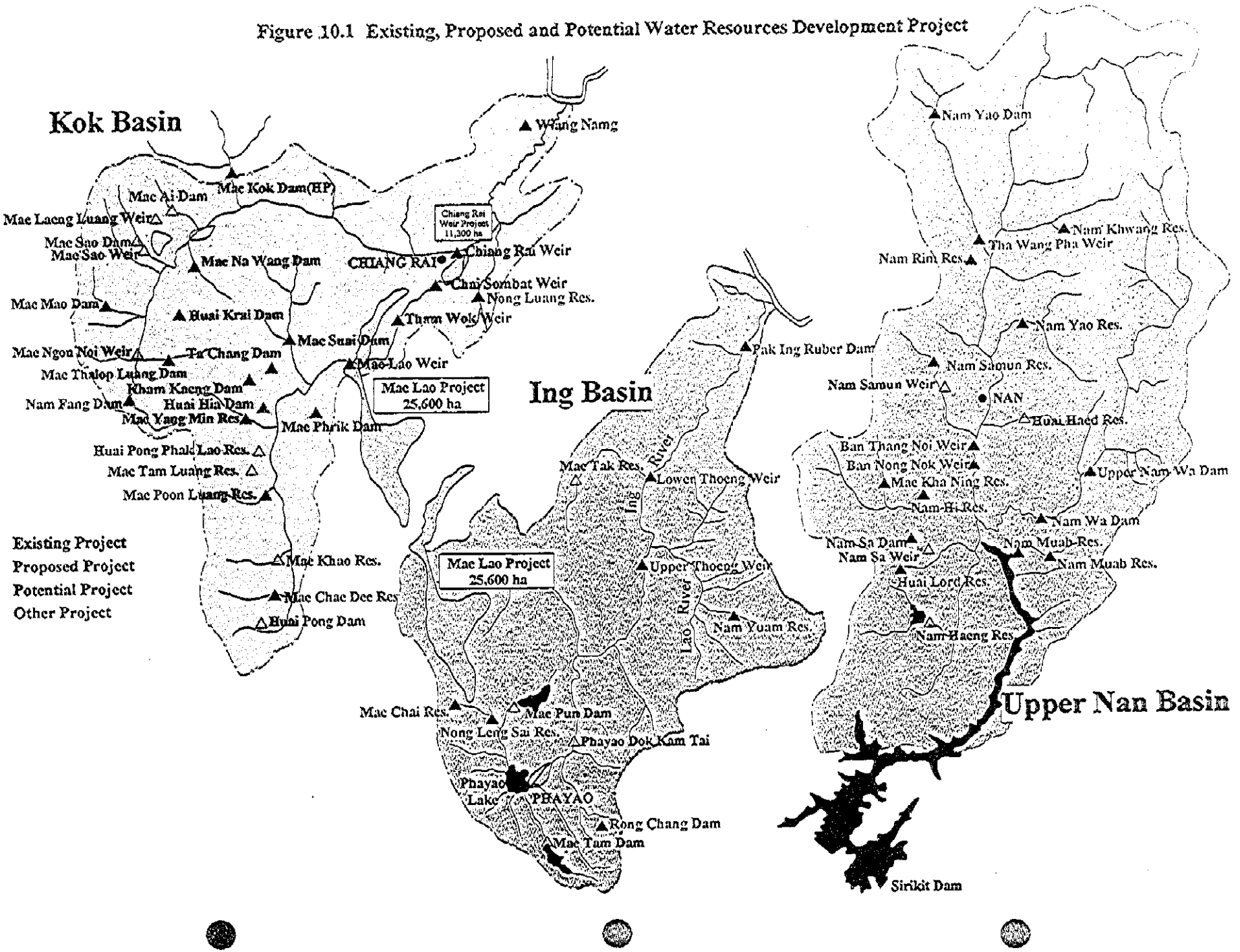


Figure 10.2 Associated Irrigation Projects in the Ing Basin

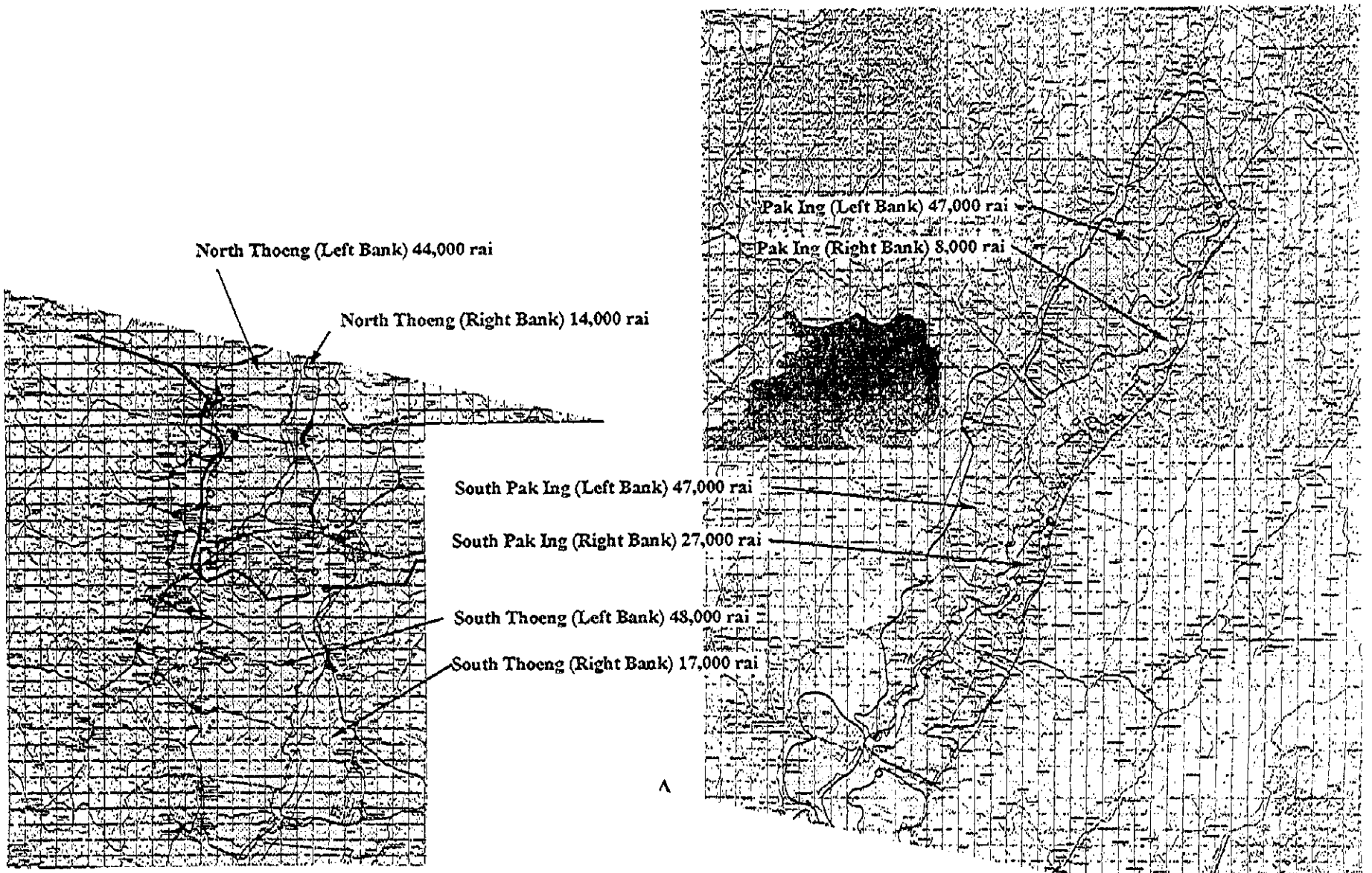
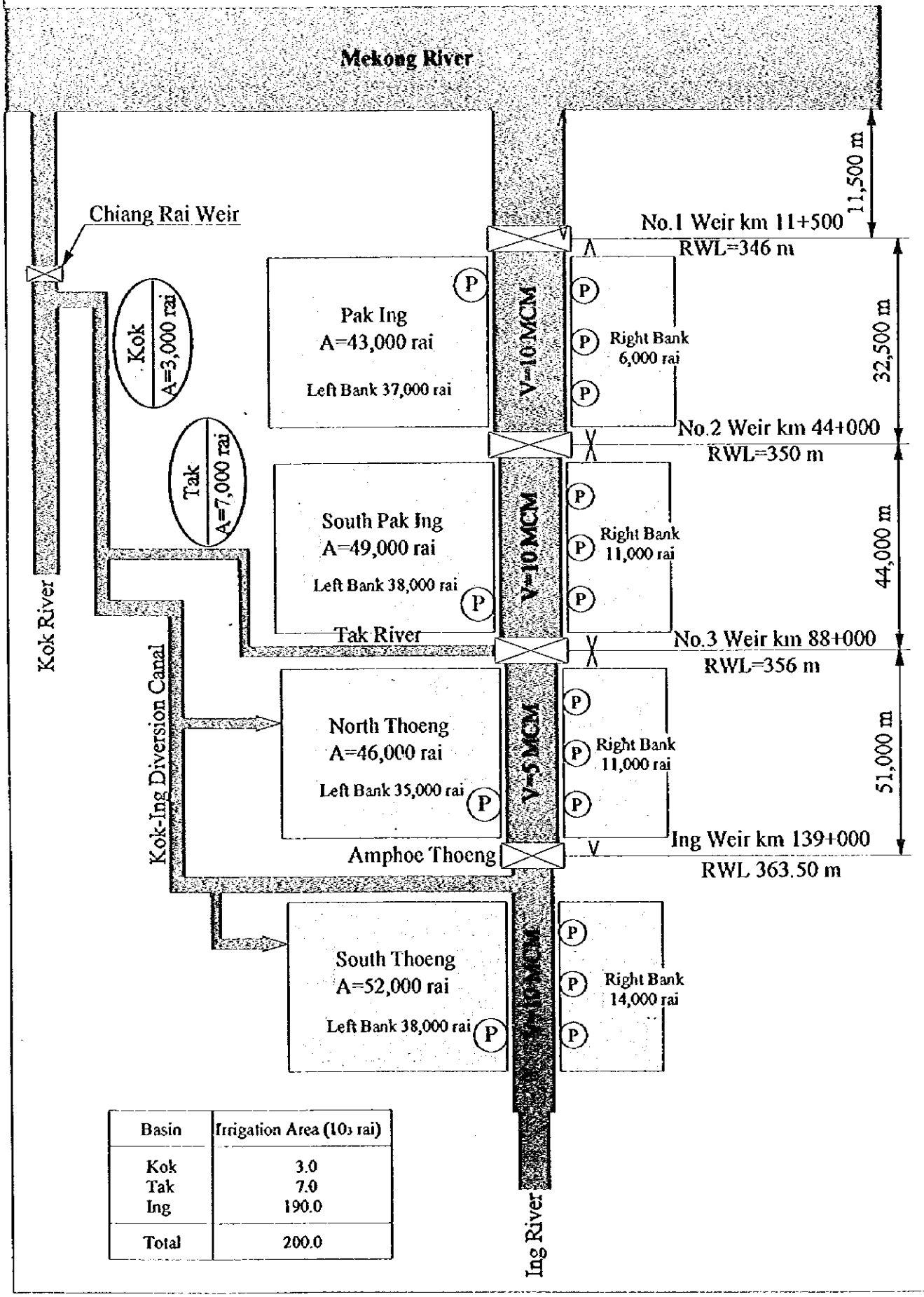
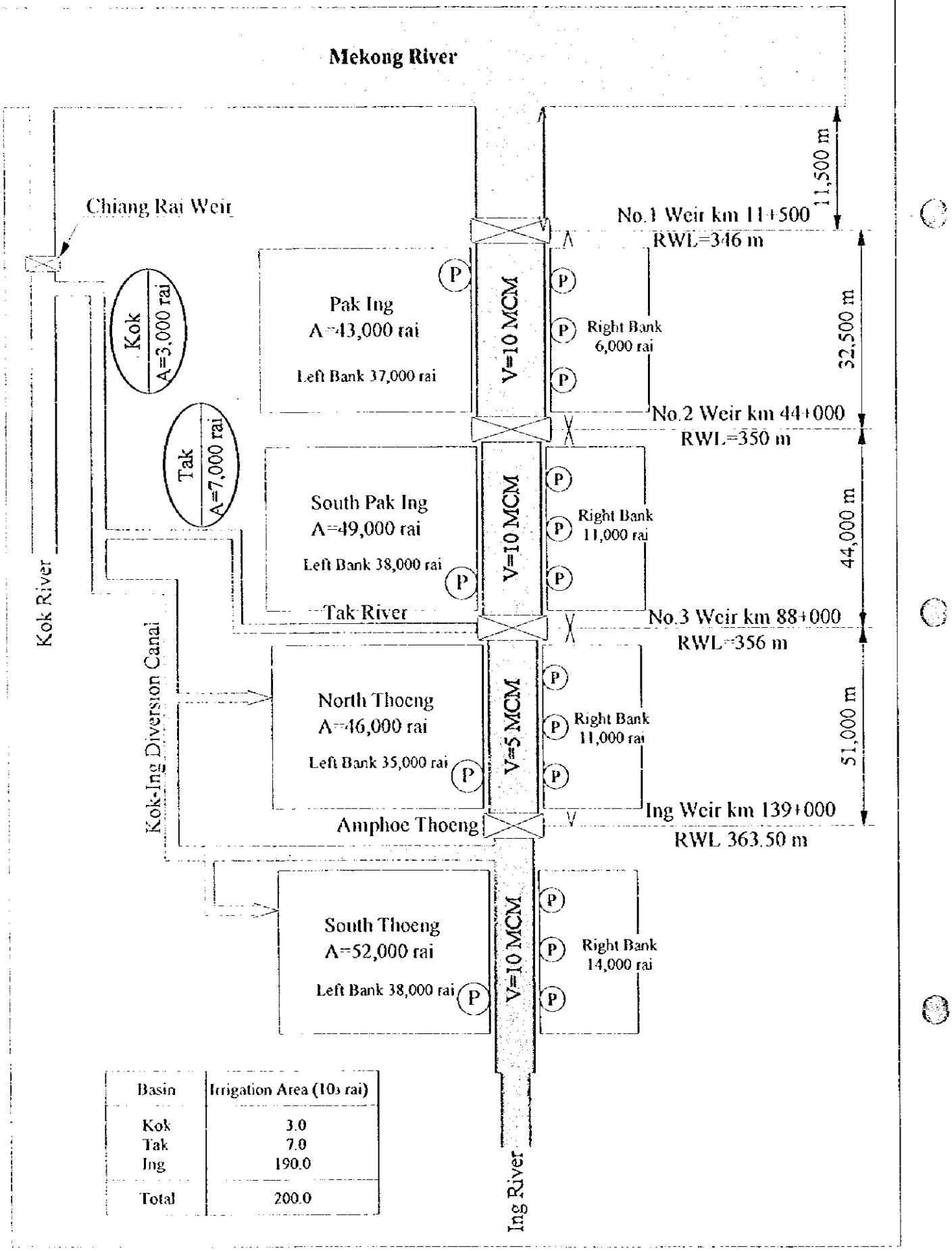


Figure 10.3 Schematic Diagram for Associate Projects



Basin	Irrigation Area (10^3 rai)
Kok	3.0
Tak	7.0
Ing	190.0
Total	200.0

Figure 10.3 Schematic Diagram for Associate Projects



Basin	Irrigation Area (10³ rai)
Kok	3.0
Tak	7.0
Ing	190.0
Total	200.0