2.8 Water Demand and Supply

(1) Water Demand and Supply in Thailand

Thailand is predominantly an agricultural country with rice as the main crop. Intensive investment has been made in agricultural development mainly for irrigation, with a steady growth of irrigable areas from 48,000 ha (100%) in 1910 to 4,435,000 ha (9,240%) in 1991. However, a rapid economic growth of Thailand in recent years has also brought a prompt increase of water demand in sectors other than agriculture.

(a) Agricultural Water Use

About 90% of annual withdrawals from available water resources is being utilized for agriculture. Though Thailand has a 6 to 9 month period of wet season with an average rainfall varying from 1,000 mm to 4,500 mm from place to place, the country's agricultural crops still suffer from drought periods as well as flood disaster. These varying hydrologic conditions create uncertainties in wet season rice production especially in non-irrigated areas. Based on the total country area of 51.3 million ha, the distribution of land use is comprising 26.3% for forestland, 32.5% for unclassified area and 41.2% or 21.1 million ha for cropland. Only 22% of the cropland is under irrigation.

The ESCAP predicted in 1991 the annual volume of water use for irrigation and annual irrigated areas for the future period 1990 to 2000 by a linear interpolation on the basis of actual data collected from RID, the main water user for irrigation, for the different regions of Thailand during the period 1980 to 1989 (Assessment of Water Resources and Water Demand by User Sectors in Thailand, ESCAP, 1991).

Predicted Annual Volume of Water Use for Irrigation and Annual Irrigated Area

Region	Annual Water Use for Irrigation (10^9 m^3/year)			Annual Irrigated Area (10^6 ha)		
	1990	1995	2000	1990	1995	2000
Northern	2.7	3.6	4.5	0.295	0.405	0.520
Central	22.25	24.25	26.40	2.16	2.20	2.25
Northeastern	3.0	3.6	4.3	0.310	0.380	0.405
Eastern	0.15	0.215	0.275	0.0101	0.0106	0.0112
Southern	2.0	2.5	3.0	0.128	0.156	0.183
Whole Country	30.00	34.25	38.50	2.92	3.16	3.40

From the above table, the annual volume of water use for irrigation will be 38,500 MCM in the year 2000 for the whole country, of which 68.5% or 26,400 MCM will be used in the central region. In the same year, the annual irrigated area will be 3.4 million ha for the whole country and 2.25 million ha or 66.2% for the central region. From the analysis of above prediction, the percentage increase in the annual volume of water use of the whole country for irrigation and the annual irrigated area during the period 1990 to 2000 will be 28.3% and 14.1%, respectively. The percentage increase in water use for irrigation is twice that of the annual irrigated area, meaning that the use of water for irrigation will be more restricted in future.

(b) Domestic Water Supply

The institutional arrangement for water supply in Thailand consists essentially of two major divisions, Bangkok and other than Bangkok. Water supply for Bangkok is the responsibility of the Metropolitan Waterworks Authority (MWA), a corporation under the Ministry of Interior. MWA is responsible for the production, supply and sale of water to a service area of Bangkok and neighboring provinces of Nonthaburi and Samut Prakan, with a total population of 7.2 million in 1994.

Outside the Bangkok area, the principal institution responsible for water supply is the Provincial Waterworks Authority (PWA) under the Ministry of Interior. In urban areas, PWA undertakes commercial operations while in the rural areas it undertakes the construction of small water supply systems that are financed largely from the governmental subsidies. Upon completion of the systems, these are turned

over to the community concerned to manage and operate themselves, and thereafter PWA furnishes technical guidance only.

Aside from the PWA managed waterworks, there are some concessional waterworks operated by municipalities, sanitary districts and other entities, to which the Department of Public Works (DPW) provides technical advice.

The main sources of urban water supply in Thailand is surface water from rivers and reservoirs. In some remote or isolated areas, however, urban water supply is obtained from groundwater resources. The forecast of urban water supply for the whole country was done by summing up the forecasted urban water supply by MWA, PWA and DPW. The MWA's forecast of annual water supply for the Bangkok Metropolitan area was obtained by interpolating based on the data provided by ADB in 1988. The nation-wide prediction of urban water supply excluding the Bangkok area responsible for PWA has been made by PWA in 1990 covering the period up to 2000. DPW's requirement was estimated by multiplying a factor of 0.23 to the forecast data of PWA.

The sources of rural water supply are shallow wells, deep wells, piped water supply system, surface water supply such as village ponds and rainwater. The use of rainwater jars is probably the most effective means of providing drinking water to the rural population over a wide geographical area, especially where piped water systems are not feasible. The forecast on annual volume of rural water supply was given by PWA in 1990, covering the period from 1991 to 2000.

Forecast Annual Urban and Rural Water Supply by Region in Thailand

Region	Forecast Annual Water Use for Urban and Rural Water Supply (MCM/year)					
	Urban Water Supply			Rural Water Supply		
	1990	1995	2000	1990	1995	2000
Northern	120	236	366	13.5	82.5	202.5
Central	1,031	1,322.5	1,638.5	10.5	65.5	161
Northeastern	129.5	254.5	394.5	26.5	161.5	396.5
Eastern	88	170	263	2	16	38
Southern	100	197	305	9.5	57.5	140
Whole Country	1,468.5	2,180	2,967	62	383	938

(c) Industrial Water Use

The sources of water supply for industries in Thailand are surface and groundwater. The major industries are located in Bangkok, Samut Prakan, Nonthaburi, Pathum Thani and Ayutthata provinces and in the eastern parts of the country, including Sattahip and Laem Chabang deep sea ports in Chonburi province, Bang Pakong industrial estate in Chachoengsao and Map Ta Put industrial estate in Rayong. Due to unreliable and insufficient pipe water supply and the lower cost and abundance of groundwater resources, groundwater is the main source for industrial water supply in these areas. In the eastern part of Thailand, the major source of water for industry is surface water from RID reservoir.

The forecast of annual volume of water supply for industrial uses from groundwater resources are made by TDRI for the period 1990 to 2000, while requirements from surface water resources mainly for industrial estate in the eastern part of the country are estimated by IEAT for the period 1990 to 2000.

Forecasted Annual Water Use for Industry by Region in Thailand

Region	Annual Water Use in MCM/year					
	1990			2000		
	Surface Water	Ground Water	Total	Surface Water	Ground Water	Total
Northern	-	-	-	N.A	N.A	50
Central	66	1,431	1,497	99	2,000	2,099
Northeastern	-	-	-	N.A	N.A	50
Eastern	50	-	-	90	N.A	90
Southern	-	-	-	N.A	N.A	50
Whole Country	116	1,431	1,547	N.A	N.A	2,339

Note: The term "N.A" denotes data not available.

(d) Water Demand and Supply in Thailand

The predicted annual volumes of water use by sectors are thus summarized as follows;

Water Demand in 1990 and 2000 (Whole Thailand : MCM)

Sector	1990	2000
Irrigation	30,030	38,480
Urban Water Supply	1,468	2,967
Rural Water Supply	62	938
Industry	1,547	2,339
Total	33,127	44,724

From the Thailand's average annual rainfall of about 1,485 mm or 761,700 MCM equivalent, the resulting surface runoff after subtracting losses such as evaporation, transpiration and infiltration is about 212,300 MCM or about 28% of rainfall. The above water demands account for only 15.6% and 21.1% of the annual runoff, respectively in 1990 and 2000. However, it is recognized commonly that the availability of surface water resources has come up to a limit because of the tropical characteristics of hydrology showing that about 80% of rainfall concentrates in wet season from June to November, mutually potentiated by the fact that construction of large scale dams and reservoirs are quite restricted from both topographic and social/environmental points of view. In addition, excessive concentration of about 65% of the said water demand has caused a rapid unbalance between supply and demand of water in the Chao Phraya river basin where the Bangkok Metropolitan areas are involved.

(2) Water Demand and Supply in Chao Phraya Basin

According to the NESDB's 25 Basin Study, water demand for irrigation at present and in future in the Chao Phraya basin is estimated as in the following table;

Present and Future Irrigation Water Demand in Chao Phraya Basin

	Nan	Yom	Wang	Ping	Sakae Krung	Pasak	Delta	Total
1.Existing Irrigation Area								
(1)Water Demand (MCM)	2,871	859	487	2,428	1,161	835	11,620	20,261
(2)Irrigable Area (1,000 ha)	278	132	68	260	92	121	1,281	2,232
(3)Unit Demand (cum/ha)	10,300	6,500	7,200	9,300	12,600	6,900	9,100	9,100
2.Future Irrigation Area								
(1)Water Demand (MCM)	4,360	2,066	813	4,344	1,161	1,114	13,500	27,358
(2)Irrigable Area (1,000 ha)	437	285	138	482	126	179	1,315	2,962
(3)Unit Demand (cum/ha)	10,000	7,200	5,900	9,000	9,200	6,200	10,300	9,200

The total irrigation water demand of the Chao Phraya basin in future increases to 27,360 MCM from the present demand of 20,260 MCM. The increased demand of about 7,100 MCM will be used mainly in tributary sub-basins. The JICA Study evaluated the unit irrigation water demand based on the available operation records as follows;

(a) Unit Irrigation Demand in Sub-Basins

As previously shown in a table, the unit irrigation demand per ha in sub-basins, Nan, Ping, Sakae Krung and delta, is relatively high at 9,000 to 10,000 cu.m/ha with the irrigation intensity of about 120%, while that for other sub-basins is slightly low because of the following reasons;

- In the former sub-basins, the cropping pattern consisting of 100% of wet season paddy, 20% of dry season paddy and 10% of dry season upland crops requires a larger amount of irrigation water.
- In the latter sub-basins, the typical cropping pattern consists about 90% of paddy and 20% of upland crops in dry season, requiring a smaller amount of irrigation water.

The unit irrigation water demand is evaluated approximately with the following assumption;

	Former Pattern	Latter Pattern
Wet Paddy	6,500 x 100%=6,500 cu.m/ha	6,500 x 90%=5,850 cu.m/ha
Dry Paddy	10,000 x 20%=2,000 cu.m/ha	-
Dry Upland Crops	6,000 x 10%=600 cu.m/ha	6,000 x 20%=1,200 cu.m/ha
Total	≈ 9,000 cu.m/ha	≈ 7,000 cu.m/ha

(b) Unit Irrigation Demand in Existing Project Area

The unit irrigation water demand in the existing large scale irrigation project area, the Phitsanulok area and Chao Phraya delta area, was also evaluated on the basis of the actual record of diverted water from the Naresuan and Chainat barrages and

irrigated paddy areas collected from O/M Division of RID, as tabulated in Table 2.8. The study result shows that the unit irrigation demands in both project areas are 6,000 to 7,000 cu.m/ha in wet season and 9,000 to 10,000 cu.m/ha in dry season.

(c) Standard Unit Irrigation Water Demand

The following values are considered to be suitable for the unit irrigation water demand in wet and dry season crops;

-	Wet season paddy	:	6,000 to 7,000 cu.m/ha
-	Dry season paddy	:	10,000 to 11,000 cu.m/ha
-	Dry season upland crops	:	4,000 to 5,000 cu.m/ha
-	Orchard throughout a year	:	11,000 cu.m/ha

(3) Domestic, Municipal and Industrial Water Demand in Chao Phraya Basin

In accordance with the NESDB's 25 Basin Study, the domestic, municipal and industrial and other water demands are estimated as summarized in Tables 2.9 and 2.10. The total domestic, municipal and industrial water demand in the whole Chao Phraya basin will increase from 2,180 MCM in 1993 to 3,570 MCM in 2016. The Chao Phraya delta area shows the largest amount of annual water demand with 1,750 MCM in 1993 and 2,960 MCM in 2016.

Characteristics of water demand for domestic, municipal and industrial uses are briefly described as follows;

(a) Nan Basin

The domestic water of 66 MCM at present and 76 MCM in future is to be supplied to the rural area in tributary basins irrelevant to the proposed Kok-Ing-Nan project. The municipal water demand of 37 MCM at present and 57 MCM in future for provincial capital cities of Uttaradit, Phitsanulok and Phichit is however lifted by pumps from the Nan river, and therefore a part of increasing water demand is to be supplied by the proposed project.

Table 2.8 Evaluation of Irrigation Water Demand in Phitsanulok Project and Delta Area

Year	Phitsanulok Project						Delta Area					
	Diverted Water (MCM)		Irrigated Area (10^3ha)		Unit Irrigation Demand (m^3/ha)		Diverted Water (MCM)		Irrigated Area (10^3ha)		Unit Irrigation Water (m^3/ha)	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
1985	354.0	247.5	87.8	19.6	4,000	12,600	8,268	4,578	1,005.8	434.2	8,200	10,500
1986	730.9	333.7	101.6	20.6	7,200	16,200	8,045	4,952	961.5	395.6	8,400	12,500
1987	686.7	231.1	101.8	27.7	6,700	8,300	6,451	3,891	973.5	399.8	6,600	9,700
1988	717.7	541.1	104.6	58.2	6,900	9,300	6,189	4,725	934.6	443.1	6,600	10,700
1989	681.8	436.1	102.8	51.5	6,600	8,500	7,180	4,302	947.3	469.9	7,600	9,200
1990	723.4	360.1	96.3	34.2	7,500	10,500	6,368	3,528	938.2	284.1	6,800	12,400
1991	551.2	476.4	102.2	48.4	5,400	9,800	5,613	2,608	905.7	330.7	6,200	7,900
1992	378.7	32.2	95.5	22.3	4,000	1,400	4,960	2,754	905.0	299.5	5,500	9,200
1993	550.7	25.9	107.0	18.1	5,100	1,400	4,435	1,502	913.4	266.0	4,900	5,600
1994	413.1	420.2	106.9	53.9	3,900	7,800	7,755	4,670	859.3	393.6	9,000	11,900
Mean	578.8	310.4	100.7	35.5	5,700	8,700	6,526	3,751	934.4	371.7	6,200	10,100

Table 2.9 Water Demand for Domestic and Industrial Uses in Chao Phraya Basin in 1993

	Nan	Yom	Wang	Ping	Sakae Krung	Pasak	Delta	Total
(1)Population	2,310	1,960	670	2,430	430	1,670	12,570	22,040
(2)Water Demand								
Domestic Water	66	54	20	76	8	72	-	296
Municipal Water	37	15	-	53	-	-	1,200	1,305
Industry/Tourism Water	-	-	1	-	-	24	550	575
Total	103	69	21	129	8	96	1,750	2,176

Remarks: (1)Domestic water in delta area is included in the irrigation demand as mentioned in 2.8 (2).
(2)Domestic water demand is for the rural area while municipal water is for Bangkok metropolitan area and the provincial capital area.

Table 2.10 Water Demand for Domestic and Industrial Uses in 2016

	Nan	Yom	Wang	Ping	Sakae Krung	Pasak	Delta	Total
(1)Population	3,110	2,066	850	3,980	690	2,210	13,420	26,670
(2)Water Demand								
Domestic Water	76	64	23	94	16	114	-	387
Municipal Water	57	28	-	90	-	-	1,860	2,035
Industry/Tourism Water	6	1	3	6	-	34	1,100	1,150
Total	139	93	26	190	16	148	2,960	3,572

(b) Delta Area

In Table 2.10, the municipal water of 1,860 MCM for the delta area is the amount to be diverted from the Chao Phraya river at Sam Lae. Accordingly in future condition in the year of 2016, 2,960 MCM of water is to be diverted from the Chao Phraya river with the increase of 1,210 MCM as compared to the present demand of 1,750 MCM. About 600 MCM in dry season, 50% of 1,210 MCM, should be supplied by the proposed Kok-Ing-Nan water diversion project.

2.9 Current Status of Water Operation

(1) Operation of Sirikit and Bhumibol Reservoirs

(a) Operation Data of Reservoirs

Operation data of the Sirikit and Bhumibol reservoirs including inflow, storage

and outflow are collected from EGAT and processed for evaluation purpose as given in the Supporting Report and Database Map. Major data collected are as follows;

- Monthly record of inflow into reservoirs for 22 years from 1974 to 1995
- Monthly record of outflow from reservoirs for 22 years from 1974 to 1995
- Monthly record of reservoir storage for 22 years from 1974 to 1995
- Monthly record of hydro-power generated for 22 years from 1974 to 1995

The above raw data of reservoir operation are then processed in order to summarize the current status of the Sirikit and Bhumibol reservoir operation as shown in Tables 2.11 and 2.12.

(b) Limited Reservoir Inflow and Outflow

From the Tables 2.11 and 2.12, inflow and outflow of both dams in wet and dry seasons can be summarized as under;

Reservoir Inflow and Outflow (Unit: MCM)

	Bhumibol Reservoir			Sirikit Reservoir		
	Wet	Dry	Total	Wet	Dry	Total
Inflow						
Average Year	4,560	690	5,250	4,420	700	5,120
Dry Year	3,200	500	3,700	2,720	520	3,240
Outflow						
Average Year	1,920	3,020	4,940	2,130	2,720	4,850
Dry Year	1,080	2,180	3,260	1,390	1,640	3,030

Note:Three years records 1991 to 1993 were averaged to produce dry year values.

From the above table, the followings can be pointed out;

- Inflow into the Bhumibol reservoir is almost same as that of the Sirikit reservoir, despite that the catchment area is about twice as much compared to the Sirikit. This is due to less rainfall and more intensive water use in the catchment.

- Inflow into reservoir in wet season, which is to be used to restore storage,

Table 2.11 Summary of Sirikit Reservoir Operation in Wet and Dry Season

Year	Inflow into Reservoir			Outflow from Reservoir			Balance (Inflow-Outflow)		Storage at End of		Storage Space at End of	
	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	June	November	June	November
1974	3505.2	723.6	4228.8	2861.8	2328.8	5190.6	643.4	-1605.2	7352	7928	2158	1582
1975	7649.4	924.7	8574.1	3522.1	3697.4	7219.5	4127.3	-2772.7	6442	9345	3068	165
1976	5347.3	976.2	6323.5	3432.4	3789.7	7222.1	1914.9	-2813.5	5902	8113	3608	1397
1977	3434.1	706.2	4140.3	3290.3	1850.4	5140.7	143.8	-1144.2	4577	5189	4933	4321
1978	5792.9	727.6	6520.5	1675.0	3660.0	5335.0	4117.9	-2932.4	3919	7803	5591	1707
1979	3068.0	508.4	3576.4	3092.6	1579.6	4672.2	-24.6	-1071.2	4828	4635	4682	4875
1980	5734.8	882.3	6617.1	1317.2	3094.2	4411.4	4417.6	-2211.9	3578	7588	5952	1922
1981	6858.3	717.2	7575.5	3711.6	3572.9	7284.5	3146.7	-2855.7	4830	8216	4680	1294
1982	4614.5	694.6	5309.1	2147.5	3612.0	5759.5	2467.0	-2917.4	5073	7488	4437	2022
1983	4592.2	857.9	5450.1	1353.7	2734.7	4088.4	3238.5	-1876.8	4273	7562	5237	1948
1984	5640.8	770.9	6411.7	2666.3	3815.0	6481.3	2974.5	-3044.1	5494	8310	4016	1200
1985	4517.3	1169.9	5687.2	1164.2	3120.3	4284.5	3353.1	-1950.4	4891	8274	4619	1236
1986	3593.0	485.4	4078.4	3028.3	3102.2	6130.5	564.7	-2616.8	5777	6519	3733	2991
1987	2552.0	684.6	3236.6	1402.5	1570.4	2972.9	1149.5	-885.8	3629	4776	5881	4734
1988	3843.0	643.4	4486.4	822.1	2100.1	2922.2	3020.9	-1456.7	4012	6648	5498	2862
1989	3315.6	605.3	3920.9	1761.8	2644.2	4406.0	1553.8	-2038.9	5092	6448	4418	3062
1990	3476.1	552.1	4028.2	2271.7	2446.4	4718.1	1204.4	-1894.3	4202	5320	5308	4190
1991	2862.1	401.5	3263.6	1297.1	1966.5	3263.6	1565.0	-1565.0	3376	4746	6134	4764
1992	2555.4	563.2	3118.6	569.1	1835.9	2405.0	1986.3	-1272.7	2997	4927	6513	4583
1993	2743.2	583.0	3326.2	2301.2	1122.7	3423.9	442.0	-539.7	3402	3853	6108	5657
1994	7112.1	623.5	7735.6	1055.0	3504.4	4559.4	6057.1	-2880.9	3549	9108	5961	402
1995	8401.0			4021.7			4379.3		5739	9397	3771	113
Mean	4419.4	704.8	5124.2	2130.6	2721.3	4852.0	2288.8	-2016.5	4629	6800	4881	2710
Max	7649.4	1169.9	8574.1	3711.6	3815.0	7284.5	6057.1	-539.7	7352	9345	6513	5657
Min	2552.0	401.5	3118.6	569.1	1122.7	2405.0	-24.6	-3044.1	2997	3853	2158	113

Note: (1) Wet season from June to November and dry season from December to next May. (2) The year 1995 was excluded from calculation of mean, maximum and minimum values. (3) Drainage area is 13,100 sqkm and gross capacity is 9,510 MCM.

Table 2.12 Summary of Bhumibol Reservoir Operation in Wet and Dry Season

Year	Inflow into Reservoir			Outflow from Reservoir			Balance (Inflow-Outflow)		Storage at End of		Storage Space at End of	
	Wet	Dry	Total	Wet	Dry	Total	Wet	Dry	June	November	June	November
1974	5427	1167	6594	2391	3123	5514	3036	-1956	8435	11687	5027	1775
1975	7654	1150	8804	3712	3908	7620	3942	-2758	9462	13366	4000	96
1976	4038	893	4931	3423	3874	7297	615	-2981	9610	10965	3852	2497
1977	4681	837	5518	3607	2966	6573	1074	-2129	7108	8806	6354	4656
1978	6379	470	6849	2055	3551	5606	4324	-3081	5955	10732	7507	2730
1979	2849	325	3174	3682	2020	5702	-833	-1695	7224	6480	6238	6982
1980	5596	652	6248	659	2995	3654	4937	-2343	4845	9475	8617	3987
1981	4599	878	5477	1578	3085	4663	3021	-2207	6773	10051	6689	3411
1982	4725	409	5134	2691	3582	6273	2034	-3173	7778	9588	5684	3874
1983	4538	675	5213	1063	2920	3983	3475	-2245	5808	9413	7654	4049
1984	3656	444	4100	1407	2494	3901	2249	-2050	7055	9040	6407	4422
1985	5124	1209	6333	874	2939	3813	4250	-1730	6801	10776	6661	2686
1986	3072	418	3490	2723	3321	6044	349	-2903	8415	8970	5047	4492
1987	4159	783	4942	1923	2854	4777	2236	-2071	5678	7933	7784	5529
1988	5429	740	6169	258	4323	4581	5171	-3583	6235	10611	7227	2851
1989	3803	622	4425	1921	3382	5303	1882	-2760	6812	8414	6650	5048
1990	3360	296	3656	2210	2277	4487	1150	-1981	5191	6404	8271	7058
1991	3948	312	4260	1003	2935	3938	2945	-2623	4254	6980	9208	6482
1992	3651	616	4267	429	2604	3033	3222	-1988	3902	7136	9560	6326
1993	2017	545	2562	1802	988	2790	215	-443	4507	5011	8955	8451
1994	7035	961	7996	848	3294	4142	6187	-2333	4822	10486	8640	2976
1995	5737			1360			4377		7415	12138	6047	1324
Mean	4559	686	5245	1917	3021	4938	2642	-2335	6508	9158	6954	4304
Max.	7654	1209	8804	3712	4323	7620	6187	-443	9610	13366	9560	8451
Min.	2017	296	2562	258	988	2790	-833	-3583	3902	5011	3852	96

Note: (1) Wet season from June to November and dry season from December to next May. (2) The year 1995 was excluded from calculation of mean, maximum and minimum values.
(3) Unit is given in MCM.

is 4,560 MCM and 4,420 MCM in the average year respectively for the Bhumibol and Sirikit reservoir. Out of these inflows, 1,920 MCM and 2,130 MCM of water are released from the Bhumibol and Sirikit reservoirs for the purposes of supplemental irrigation, hydro-power generation and river maintenance. Accordingly average inflows utilized to restore storage are 2,640 MCM for the Bhumibol reservoir (4,560-1,920=2,640) and 2,290 MCM for the Sirikit reservoir (4,420-2,130=2,290), which is quite insufficient to recover the active capacities of 9,660 MCM and 6,660 MCM for the Bhumibol and Sirikit reservoirs.

- Particularly in dry year, amounts of wet season inflow to be used for storage restoration are as small as 2,120 MCM (3,200-1,080) and 1,330 MCM (2,720-1,390) respectively for the Bhumibol and Sirikit reservoirs, causing decrease of outflow in successive dry season.

- The dry season cropping in the lower Chao Phraya delta depends mostly on outflow from the Bhumibol and Sirikit reservoirs. However, average dry season outflows from the both reservoirs are 3,020 MCM and 2,720 MCM only, which are too small as compared with the active storage capacities of 9,660 MCM and 6,660 MCM.

(c) Improper Reservoir Operation

The both Bhumibol and Sirikit reservoirs are not always operated following the rule curves, as shown in Figures 2.2 and 2.3. The actual operations were made within the range below the lower rule curve for more than 10 years during the past 20 years in the case of Sirikit reservoir. This is inevitably due to lack of inflow into the reservoir, however, a particular rule of operation should be established in future linking together with the effect of the proposed transbasin water diversion plan.

(d) Large Empty Storage Space in Reservoirs

The reservoir is to be operated in principle in such a way to restore storage during wet season toward the full storage level at the end of wet season (October to

Figure 2.4 Bhumibol Reservoir Operation Curve

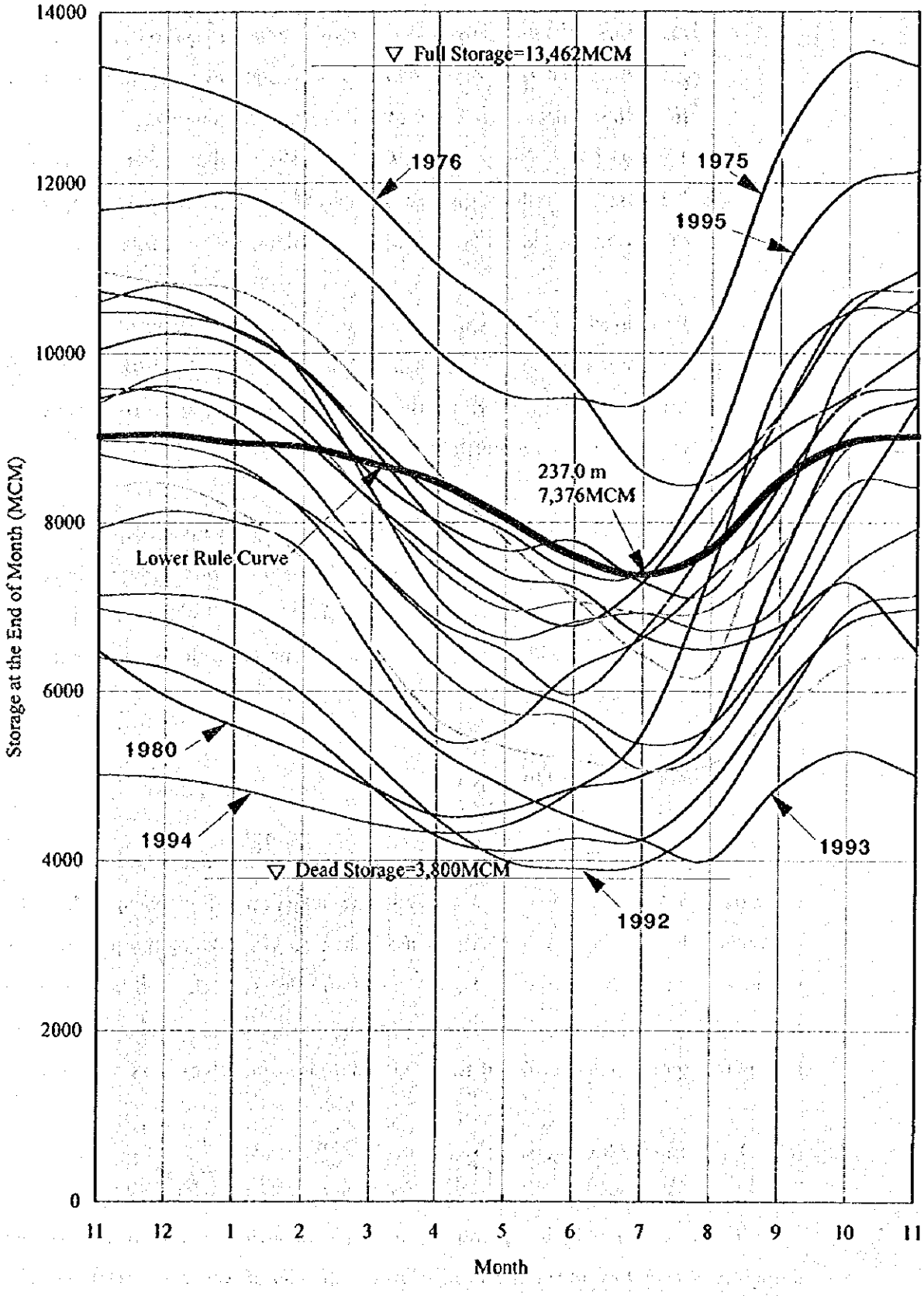
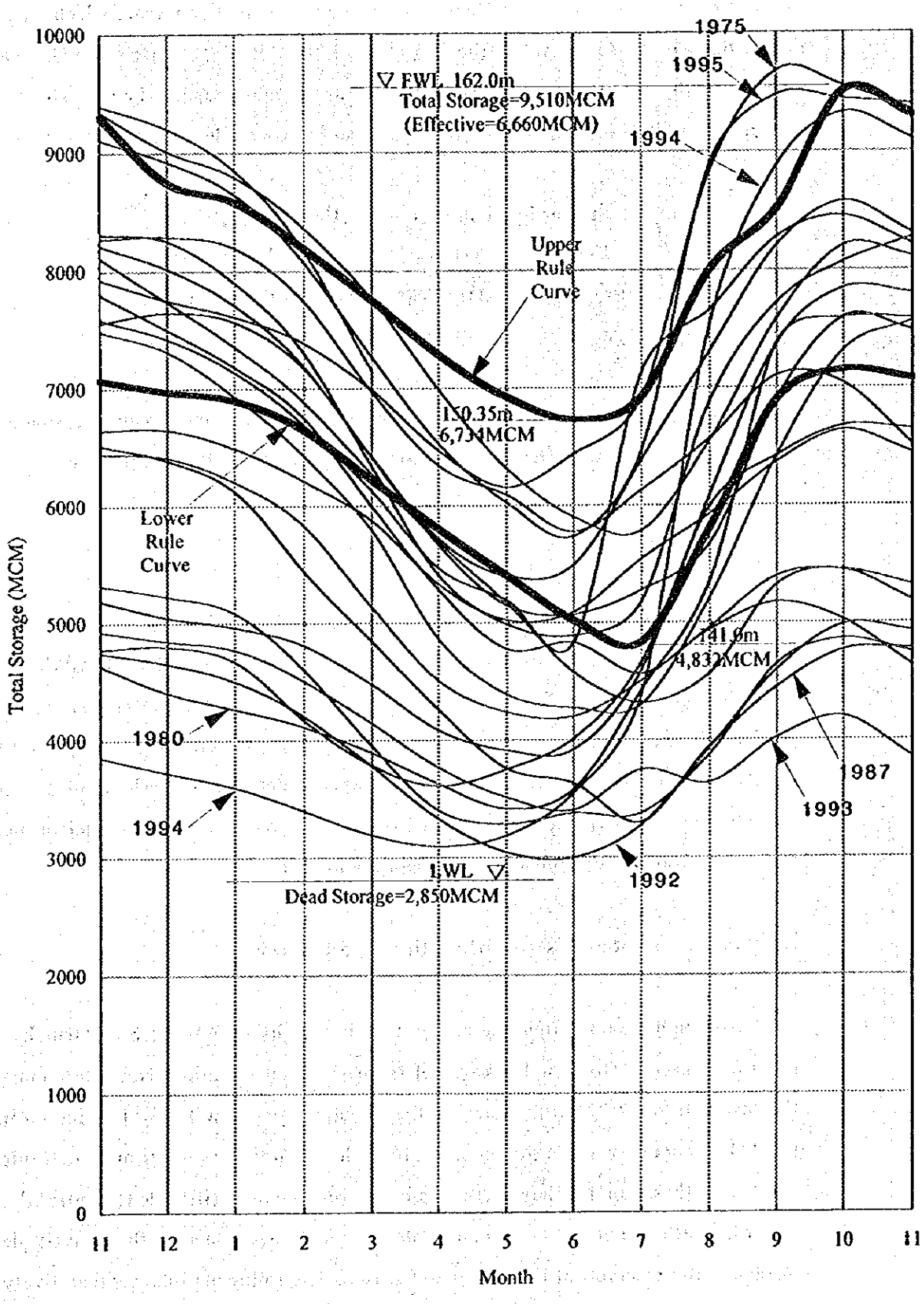


Figure 2.5 Sirikit Reservoir Operation Curve



November). The operational record in the past reveals that there are still great rooms for additional storage in the both reservoirs, due mainly to the lack of inflows into reservoirs. In case of the Bhumibol reservoir, except flood years which would occur once in 10 to 20 years, there is about 4,300 MCM of space for additional storage at the end of November when the storage should properly be full. There is about 2,700 MCM of room at the end of October in case of the Sirikit reservoir.

Empty Storage Space in Reservoirs (Unit: MCM)

	Bhumibol Reservoir		Sirikit Reservoir	
	Average Year	Dry Year	Average Year	Dry Year
Empty Space	4,300	7,090	2,700	5,000

The above evidence would permit of no doubt that the transbasin diversion of water would be the most effective when combined with these storage functions.

(e) Lower Energy Output

The average annual output of energy produced during the past 20 years from 1974 to 1994 was 820 GWh, much lower than the planned output of 1,200 GWh, due to insufficient amount of outflow and low effective head for power generation. Particularly in dry years such as 1988 and 1992, the energy produced was only 350 to 360 GWh. This situation would be improved when waters from transbasin diversion are introduced into the reservoirs. More operational records of the Bhumibol and Sirikit reservoirs are compiled in the Supporting Report.

(f) Improvement of Reservoir Operation for Sirikit Dam

Although the operation rule has been established by EGAT, the Sirikit dam has not always been operated well because of frequent deficit of inflow. Notwithstanding the reservoir was filled with water by the abnormal flood in 1995. The reservoir should be operated with its storage at a proper level within the upper and lower rule curves already set up. It is however necessary to provide a specific rule to control the reservoir outflow more especially during dry season, in accordance with the available storage in the reservoir at the end of wet season. The following rule was tentatively

set up to control the reservoir outflow during dry season;

Tentative Outflow Control of Sirikit Reservoir During Dry Season

Active reservoir Storage at the End of Wet Season	Rate of Release	Volume of Outflow during the Next Dry Season
More than 6,000 MCM	105%	6,300 MCM
5,000 to 6,000 MCM	85%	5,100 MCM
4,000 to 5,000 MCM	70%	4,200 MCM
3,000 to 4,000 MCM	60%	3,600 MCM
Less than 3,000 MCM	50%	3,000 MCM

(2) Naresuan Barrage

The Chao Phraya irrigation project is the largest water user in the Chao Phraya basin while the Phitsanulok project is the largest water user in tributary basins, located along the Nan river downstream of the Sirikit dam. In the proposed water diversion project the Sirikit reservoir performs an important part in receiving and storing the water diverted in wet season and releasing it during dry season for downstream utilization mainly in Uttaradit and Pitsanulok area in the Nan basin and the Chao Phraya delta area.

(a) Operation Data

Operation data of the Naresuan barrage including inflow, storage and outflow are collected from RID and processed for evaluation purpose as given in the Supporting Report and Database Map. Major data collected are as follows;

- Monthly record of inflow at the barrage for 13 years from 1982 to 1994
- Monthly record of diversion from the barrage for 13 years from 1982 to 1994
- Monthly record of downstream release at the barrage for 13 years from 1982 to 1994
- Paddy planted area in the Phitsanulok project area

The above raw data of reservoir operation are then processed in order to summarize the current status of the Naresuan barrage operation as shown in Table 2.13.

Table 2.13 Summary of Naresuan Operation in Wet and Dry Season

Year	Inflow at the Diversion Dam			Diversion from the Dam			Downstream Release at Diversion Dam		
	Wet Season	Dry Season	Total	Wet Season	Dry Season	Total	Wet Season	Dry Season	Total
1982	3187.6	3592.4	6780.0	357.6	145.4	503.0	2830.0	3447.0	6277.0
1983	2065.4	2499.9	4565.3	386.4	254.9	641.3	1679.0	2245.0	3924.0
1984	3090.0	3610.5	6700.5	489.0	256.5	745.5	2601.0	3354.0	5955.0
1985	1918.0	2829.5	4747.5	354.0	247.5	601.5	1564.0	2582.0	4146.0
1986	3202.9	2709.7	5912.6	730.9	333.7	1064.6	2472.0	2376.0	4848.0
1987	1913.7	1538.1	3451.8	686.7	231.1	917.8	1227.0	1307.0	2534.0
1988	1838.7	2756.1	4594.8	717.7	541.1	1258.8	1121.0	2215.0	3336.0
1989	1672.8	2624.1	4296.9	681.8	436.1	1117.9	991.0	2188.0	3179.0
1990	2843.4	2407.1	5250.5	723.4	360.1	1083.5	2120.0	2047.0	4167.0
1991	1572.2	1486.4	3058.6	551.2	476.4	1027.6	1021.0	1010.0	2031.0
1992	1044.7	1461.2	2505.9	378.7	32.2	410.9	666.0	1429.0	2095.0
1993	2139.7	910.9	3050.6	550.7	25.9	576.6	1589.0	885.0	2474.0
1994	2567.1	2935.2	5502.3	413.1	420.2	833.3	2154.0	2515.0	4669.0
Mean	2235.1	2412.4	4647.5	540.1	289.3	829.4	1695.0	2123.1	3818.1
Max.	3202.9	3610.5	6780.0	730.9	541.1	1258.8	2830.0	3447.0	6277.0
Min.	1044.7	910.9	2505.9	354.0	25.9	410.9	666.0	885.0	2031.0

Note: Wet season from June to November and dry season from December to next May.
Unit is given in MCM.

(b) Water Shortage Status and Necessity of Dry Season Water

The Pitsanulok irrigation area of 108,000 ha has been receiving water from the Nan river at the Naresuan barrage. From the operation record collected, water balance at the Naresuan barrage since 1982 is summarized as follows;

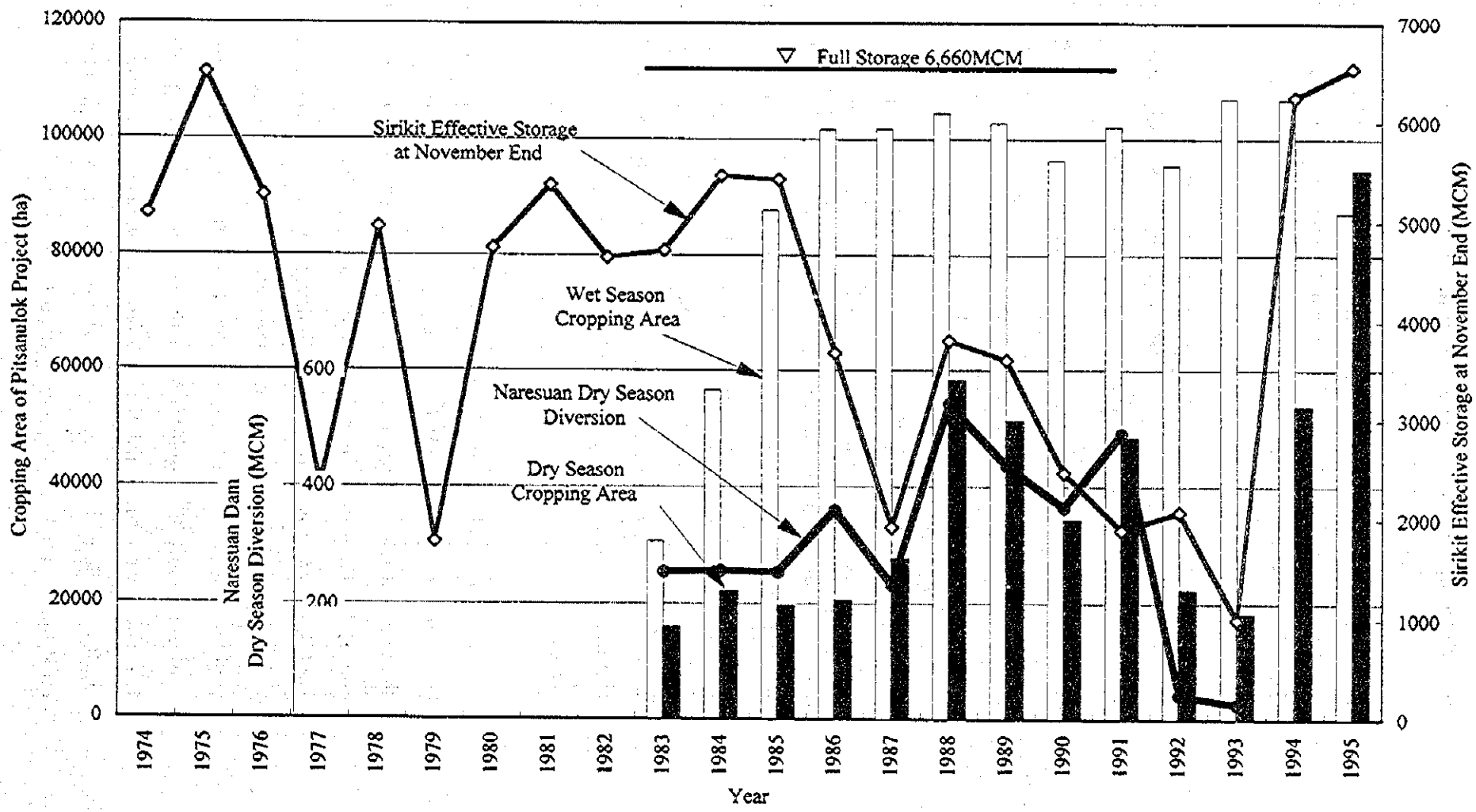
Water Balance at Naresuan Barrage (Unit: MCM)

Season	Outflow from Sirikit Reservoir	Water Operation at Naresuan Barrage		
		Inflow	Diversion	Downstream Release
Wet Season	2,100	2,200	540	1,700
Dry Season	2,700	2,400	290	2,100
Total	4,800	4,600	830	3,800

At present, about 100,000 ha out of 108,000 ha are irrigated in wet season. However in dry season mainly due to lack of inflow, irrigable area is limited to 20,000 to 40,000 ha as shown in Figure 2.4. Bulk water of 1,700 MCM in wet season and 2,100 MCM in dry season is released downstream mainly for use in Chao Phraya delta. According to the past operation record of the Naresuan barrage, dry season irrigation of about 50,000 ha could be achieved with 500 MCM of water diversion, and some 210 MCM of water diversion in addition to the present amount of 290 MCM seems necessary to be secured in dry season to stabilize irrigated agriculture in this area.

Feasibility study for the Uttaradit irrigation project prepared by RID in 1970 intended to irrigate about 140,000 ha by use of the Nan river water supplemented with the Sirikit release. In spite that the area is most suitable for upland cultivation, however, development has been suspended except the Nam Rid project with irrigable area of 6,800 ha, because that irrigation development would reduce available flow in the Nan river and in turn would exert a bad influence for water use in the downstream Chao Phraya delta. Presently about 60,000 ha of DEDP's pumping irrigation projects are diverting more than 400 MCM of the Nan water involving sideflow from the catchment between the Sirikit dam and Naresuan barrage in dry season, and additional 300 MCM would be necessary in future to stabilize irrigated agriculture in this area. More detail is given in the Supporting Report.

Figure 2.6 Cropping Area of Pitsanulok Project vs Naresuan Diversion/Sirikit Storage



(3) Chao Phraya Diversion Dam (Chainat Barrage)

(a) Operation Data

Operation data of the Chainat barrage including inflow, storage and outflow are collected from RID and processed for evaluation purpose as given in the Supporting Report and Database Map. Major data collected are as follows;

- Monthly record of inflow at the barrage for 21 years from 1974 to 1994
- Monthly record of diversion from the barrage for 21 years from 1974 to 1994
- Monthly record of downstream release at the barrage for 21 years from 1974 to 1994
- Paddy planted area in Chao Phraya delta area

The above raw data of reservoir operation are then processed in order to summarize the current status of the Chainat barrage operation as shown in Table 2.14.

(b) Water Shortage Status and Necessity of Dry Season Water

As shown in Figure 2.1, in total 25 irrigation projects (Greater Chao Phraya project) with projected area of 1,370,000 ha and irrigable area of 1,190,000 ha have been receiving water from the Chao Phraya river at the Chao Phraya diversion dam. From the operation record collected, about 957,000 ha and 391,000 ha are cropped under wet and dry season irrigation as an average during the recent 20 years. Water balance at the Chainat diversion dam since 1974 is summarized below;

Water Balance at Chainat Diversion Dam (Unit: MCM)

Season	Inflow	Diversion	Downstream Release
Wet Season	16,000	7,400	8,600
Dry Season	6,400	4,200	2,200
Total	22,400	11,600	10,800

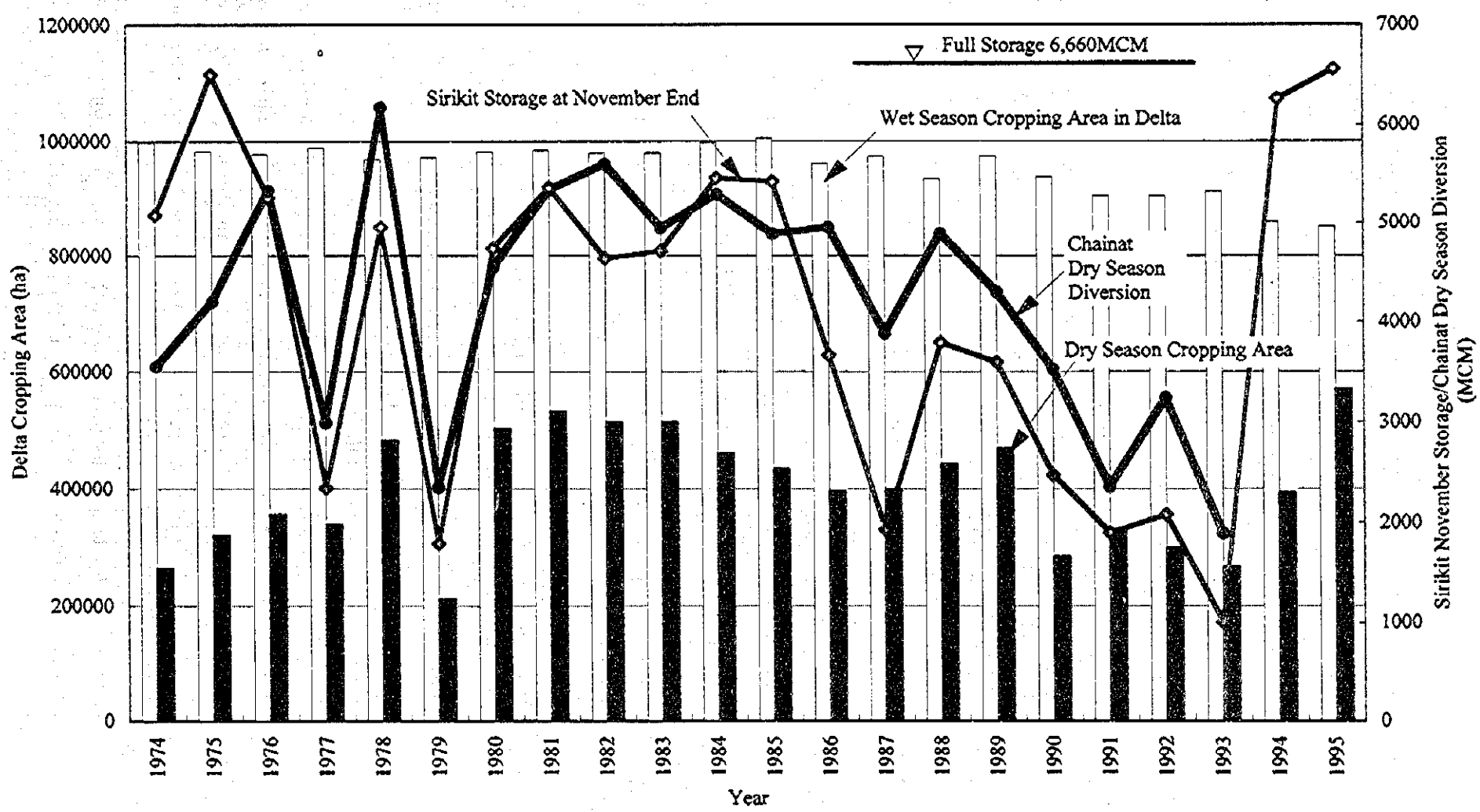
As is seen in Figure 2.5, irrigated area in dry season in delta has a close correlation with the amount of water diverted from the Chao Phraya diversion dam.

Table 2.14 Summary of Chainat Dam Operation in Wet and Dry Season

Year	Inflow at the Diversion Dam			Diversion from the Dam			Downstream Release at Diversion Dam		
	Wet Season	Dry Season	Total	Wet Season	Dry Season	Total	Wet Season	Dry Season	Total
1974	16971	6712	23683	7351	3640	10991	9620	3072	12692
1975	29763	9008	38771	8792	3924	12716	20971	5084	26055
1976	21901	8655	30556	8995	5227	14222	12906	3428	16334
1977	13301	5073	18374	8907	3443	12350	4394	1630	6024
1978	25503	7667	33170	7363	5806	13169	18140	1861	20001
1979	11615	4376	15991	8148	2597	10745	3467	1779	5246
1980	26985	6937	33922	8190	4550	12740	18795	2387	21182
1981	20541	8406	28947	9111	5344	14455	11430	3062	14492
1982	13301	7578	20879	8815	5621	14436	4486	1957	6443
1983	20306	7708	28014	6054	4750	10804	14252	2958	17210
1984	12258	7075	19333	9099	5478	14577	3159	1597	4756
1985	17121	9326	26447	8268	4578	12846	8853	4748	13601
1986	12042	6587	18629	8045	4952	12997	3997	1635	5632
1987	12025	5725	17750	6451	3891	10342	5574	1834	7408
1988	16817	6305	23122	6189	4725	10914	10628	1580	12208
1989	10331	5845	16176	7180	4302	11482	3151	1543	4694
1990	11333	4804	16137	6368	3528	9896	4965	1276	6241
1991	9234	3731	12965	5613	2608	8221	3621	1123	4744
1992	8504	4097	12601	4960	2754	7714	3544	1343	4887
1993	6255	2332	8587	4435	1502	5937	1820	830	2650
1994	20487	6058	26545	7755	4670	12425	12732	1388	14120
Mean	16028	6381	22409	7433	4185	11618	8595	2196	10791
Max	29763	9326	38771	9111	5806	14577	20971	5084	26055
Min	6255	2332	8587	4435	1502	5937	1820	830	2650

Note: Wet season from June to November and dry season from December to next May. (Unit: MCM)

Figure 2.7 Cropping Area of Delta vs Chao Phraya Diversion/Sirikit Storage



At present on the average from 1974 up to 1995, about 391,000 ha is under irrigation in dry season with 4,200 MCM of water diverted from the dam. In 1981, dry season irrigation amounted to 532,000 ha with the diversion water of 5,600 MCM, showing the cropping intensity of 56% against the wet season average of 957,000 ha, and therefore some 1,500 MCM of water diversion in addition to the present amount of 4,200 MCM seems necessary to be secured in dry season to stabilize irrigated agriculture in this area.

2.10 Present Status of Hydro-Power Generation

The present status of hydro-power generation at the Sirikit dam is described in detail in the Supporting Report as summarized below;

The total installed capacity of the Sirikit power plant is 500 MW consisting of 4 units of 125 MW each. The annual hydro-power energy to be produced by this capacity originally planned was 1,200 GWh with the average annual inflow of 6,000 MCM and the effective power head of 85 m. The annual energy actually produced during the period from 1974 to 1994 was however 820 GWh as shown in Table 2.15, due to scarce reservoir inflow and low water head.

The basic characteristics of the Sirikit hydro-power generation is outlined in accordance with the said table as follows;

- When relatively rich inflow is available as is seen in 1975, 1976 and 1981, the annual production of power reaches a high value of exceeding 1,300 GWh, while low production of less than 500 GWh was only achieved in a dry year such as 1988, 1991 and 1992. Accordingly the annual energy production presents a wide fluctuation depending on the available inflow into the reservoir.
- The average monthly production of energy varies between 45 to 60 GWh during June to January except August when large monthly inflow is available but outflow is restricted in order to restore the storage and 80 to 100 GWh in dry season from February to May when outflow from the reservoir is promoted in response to the demand in downstream beneficial area.
- In particular in the critical dry period occurred successively in 1992, 1993 and 1994, energy production decreased remarkably to the monthly value of less than 10 GWh.

It is rather difficult to use the produced power energy because of its large monthly and annual fluctuation as mentioned above. The proposed Kok-Ing-Nan water diversion project would contribute the Sirikit power generation to a great extent, since it would bring large amount of additional inflow together with increased power head in the reservoir. About 1,200 GWh of energy production as an annual average could be achieved with the water introduced by the proposed project.

2.11 Socio-Economic Conditions

(1) Population

(a) Present and Projected Population

The population in the past from 1989 to 1994 in the Chao Phraya basin and the project area was studied based on the population data on the provincial level in the Population Statistics of Ministry of Interior. The population in sub-basins such as the Nan, Yom, Pin, delta, etc. in the Chao Phraya basin and the Kok and Ing in the project area was estimated in proportion to the relating provincial area involved in each sub-basin. The projected population in 1996, 2006 and 2016 was estimated based on the average annual rate of population growth observed from 1989 to 1994. The study results are shown in the Supporting Report as well as summarized below;

Projected Population in Chao Phraya Basin and Project Area (Unit: 1,000 person)

Basin	1989	1996	2006	2016	Annual Growth Rate (%)
1. Chao Phraya					
Nan	2,160	2,370	2,720	3,110	1.37
Yom	1,870	2,000	2,200	2,410	0.94
Wang	630	680	760	850	1.13
Ping	2,170	2,540	3,180	3,980	2.27
Pasak	1,570	1,720	1,950	2,210	1.28
Sakae Krung	400	450	510	690	1.38
Delta	12,380	12,640	13,020	13,420	0.30
Total	21,180	22,400	24,340	26,670	0.79
2. Project Area					
Kok & Ing	1,190	1,480	2,010	2,730	3.12
3. Whole Country	55,890	60,520	67,650	75,620	1.12

Table 2.15 Monthly Hydro-Power Energy Generated at Sirikit Dam (Unit: MKWH)

Year	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Annual
1974	36.40	52.31	74.56	117.13	127.96	92.79	79.46	54.34	50.62	50.14	56.60	89.29	881.60
1975	106.07	77.12	61.89	111.75	143.12	150.34	137.51	104.92	96.77	69.03	111.68	139.91	1310.11
1976	161.76	152.81	142.64	104.48	108.36	85.86	86.96	86.73	103.61	102.18	101.82	126.16	1363.37
1977	120.31	121.81	112.82	106.85	111.45	41.53	47.81	83.50	40.73	27.46	35.31	61.75	911.33
1978	68.19	34.59	40.70	44.23	32.05	50.20	54.08	49.45	68.42	74.49	89.29	148.69	754.38
1979	130.57	114.53	69.48	83.40	101.93	64.81	73.80	78.85	44.49	29.85	24.09	38.99	854.79
1980	40.80	41.06	24.37	25.87	20.56	49.48	55.35	37.82	47.31	70.21	87.38	108.82	609.03
1981	119.64	103.06	114.14	75.45	202.96	103.85	82.01	103.87	62.27	79.97	115.67	144.66	1307.55
1982	143.03	95.14	42.25	75.43	105.65	32.72	39.21	62.61	47.91	84.07	98.27	115.35	941.64
1983	160.45	100.95	42.21	76.31	48.68	17.46	6.88	10.37	8.10	34.83	90.22	140.18	736.64
1984	128.49	80.49	43.14	58.48	111.65	138.57	44.05	102.84	32.18	89.66	127.95	176.45	1133.95
1985	165.28	92.31	46.82	42.50	33.14	41.95	12.03	21.96	24.65	37.41	104.15	157.20	779.40
1986	129.37	116.69	116.35	94.37	69.47	53.69	75.75	123.73	42.32	57.63	120.33	109.99	1109.69
1987	101.10	85.80	38.30	63.70	41.40	17.20	11.10	29.70	7.00	30.50	83.70	60.80	570.30
1988	34.40	20.00	9.10	22.00	19.20	31.60	24.40	30.50	13.40	36.50	59.20	60.70	361.00
1989	94.80	90.80	22.60	27.20	75.00	82.10	35.70	61.00	18.40	64.20	74.00	121.50	767.30
1990	101.30	72.30	55.40	61.60	64.20	69.40	52.80	54.10	27.60	33.50	80.90	99.40	772.50
1991	83.37	42.50	19.81	45.34	43.65	8.58	29.55	41.58	24.96	33.23	51.71	68.27	492.55
1992	64.96	43.13	15.18	15.14	3.44	8.14	5.92	31.5	32.47	22.78	45.34	62.33	350.33
1993	60.49	49.24	39.60	60.22	105.92	36.93	18.05	66.83	27.47	24.24	32.68	36.39	558.06
1994	17.77	13.15	3.99	1.98	17.13	58.91	32.58	93.56	69.75	74.06	127.55	161.90	672.33
MEAN	98.50	76.18	54.06	62.54	75.57	58.86	47.86	63.32	42.40	53.62	81.80	106.13	820.85
MAX.	165.28	152.81	142.64	117.13	202.96	150.34	137.51	123.73	103.61	102.18	127.95	176.45	1363.37
MIN.	17.77	13.15	3.99	1.98	3.44	8.14	5.92	10.37	7.00	22.78	24.09	36.39	350.33

Note: Unit=GWH

The characteristics of population in the Chao Phraya basin and the project area is described as follows;

- The population in the whole Chao Phraya basin will increase with a low annual growth rate of 0.79% and will reach 26.7 million in 2016 from 21.2 million in 1989.
- The annual growth rate of the Nan and Ping basins is relatively high as 1.37% and 2.27% respectively. The Nan basin consisting of provinces of Phitsanulok, Phichit and Phetchabun holds large and stabilized farm land which is high potential for irrigated agriculture with the water from the Sirikit reservoir, accordingly the basin population will increase toward 21 century. In the Ping basin, Chiang Mai, the famous agricultural and tourism province, and Khampaeng Phet, agricultural province, also present high growing rates of 2.59 and 2.91%, as a result the population in the Ping basin will increase remarkably to 3.98 million in 2016 from 2.17 million in 1989.
- The delta area shows the lowest annual growth rate of population at only 0.3%, because the population in the Bangkok Metropolis occupying about 50% of population tends to decrease with the negative growing rate of 0.87%, while surrounding provinces such as Pathum Thani, Nonthaburi, Samut Prakan and Samut Sakhon will increase at a high growth rate of 2.0 to 3.0% because of expansion of urban and industrial development in these provinces.
- The population in the Kok and Ing basin of the project area will increase rapidly to 3.1 million in 2016 from 1.48 million in 1996 with a high growing rate of 4.0%, because Chiang Rai province, which is the economic center of the basin, has been developed rapidly as the tourism center in the Northern region and also as the trade center with Myanmar and Chine.
- Population growth rates in other basins are 1.1% to 1.3% showing steady growth.

(b) Agricultural Population

It is rather difficult to grasp the agricultural population on a provincial level because of no available data. Agricultural population on a provincial and sub-basin level is assumed based on the number of farm household in provinces as shown in the

Supporting Report. From the said table, the agricultural population in basins is summarized as below;

Agricultural Population in Basins (Unit: 1,000 persons)

Basin	Agricultural Population		Annual Growth Rate (%)	Total Population In 1993	Agricultural Population Rate (%)
	1988	1993			
1. Chao Phraya					
Nan	945	1,075	2.62	2,288	47
Yom	899	1,029	2.72	1,950	53
Wang	308	346	2.38	660	53
Ping	902	1,087	3.81	2,407	45
Pasak	537	607	2.49	1,660	37
Sakae Krung	162	189	3.06	431	44
Delta	1,645	1,755	2.58	12,471	14
Total	5,398	6,088	2.43	21,867	28
2. Project Area					
Kok & Ing	596	704	3.39	1,380	51
3. Whole Country	19,509	22,589	2.97	58,336	38.7

- Agricultural population in the Chao Phraya basin is estimated at about 6 million in 1993 or 28% of the total population. Although the rates of agricultural population in sub-basins except the delta area are as high as 40 to 50%, that for the delta area is as low as 14% involving Bangkok Metropolitan area and satellite cities having the large urban population of 10.7 million in 1993.

(2) GDP

(a) Present GDP

GDP in the past from 1989 to 1994 in the Chao Phraya basin and the project area was studied as given in the Supporting Report. The present GDP in 1994 is summarized as under;

Present GDP in 1994

Basin	Population (1,000)	GDP		Per Capita GDP	
		(10^6Baht)	(10^6US$)	(Baht)	(US$)
1. Chao Phraya					
Nam	2,306	43,121	1,725	18,670	750
Yom	1,963	35,446	1,418	18,060	720
Wang	665	17,399	696	26,160	1,050
Ping	2,428	72,353	2,894	29,800	1,190
Sakae Krung	434	9,518	381	21,930	880
Pasak	1,672	55,681	2,227	33,300	1,330
Delta	12,565	1,515,453	60,618	120,610	4,820
Total	22,033	1,748,971	69,959	79,380	3,180
2. Project Area					
Kok & Ing	1,391	25,398	1,016	18,260	730
3. Whole Country	59,095	2,686,000	107,440	45,450	1,820

- GDP in the Chao Phraya basin reaches about 1,750 billion Baht (US$ 70 billion) in 1994 occupying the large portion of 65% of the national GDP of 2,686 billion Baht (US$ 107 billion). GDP per capita in the basin is accordingly as high as 79,000 Baht or US$ 3,200.
- GDP in the delta area shows the highest value of 1,515 billion Baht (US$ 60.6 billion) occupying the large portion of GDP in the whole Chao Phraya basin.
- GDP per capita in the Nan basin, the beneficial area of the project, is as low as 18,670 Baht (US$ 750) as compared with other sub-basins in the Chao Phraya basin.
- GDP per capita in the project area covering the Kok and Ing sub-basins is also as low as 18,260 Baht (US$ 730).
- GDP per capita in Bangkok Metropolis and surrounding provinces of Pathum Thani, Samut Prakan and Samut Sakhon presents the highest value of more than 180,000 Baht (US$ 7,000).

(b) Projected GDP

The projected GDP for the year 2006 and 2016 estimated based on the average annual growth rate of GDP from 1989 to 1994 is shown in the Supporting Report. Increasing GDP for the years 2006 and 2016 is estimated as follows;

Projected GDP in Years 2006 and 2016

	2006					2016				
	Popul.	GDP		GDP/Capita		Popul.	GDP		GDP/Capita	
	(10^6)	10^9B	10^9S	10^3B	US$	(10^6)	10^9B	10^9S	10^3B	US$
1. Chao Phraya										
Nan Basin	2.7	73	2.9	27	1,070	3.1	113	4.5	37	1,450
Delta Area	13.0	3,746	149.8	288	11,520	13.4	6,582	263.3	492	19,650
Other Basins	8.6	421	16.8	49	1,950	10.1	714	28.6	71	2,830
Total	24.3	4,240	169.5	174	6,980	26.6	7,409	296.4	278	11,140
2. Project Area	2.0	51	2.0	25	1,000	2.7	83	3.3	31	1,220
3. Whole Country	67.7	6,337	253.5	94	3,740	75.6	10,824	433.0	143	5,730

- Average annual growth rate of GDP is assumed at 4.5% for the Nan and Yom basins composed mostly with rural area, while 6.9% for the Ping, Pasak and delta area which are mainly consisted of urban and industrial districts.
- GDP per capita in the delta area is assumed to be very high at 492,000 Baht or US$ 19,650 in the year 2016, while that in the Nan, Kok and Ing sub-basins is placed at a low value of 30,000 to 37,000 Baht or US$ 1,200 to 1,500. In order to eradicate the large income disparity between the basins consisting mostly of rural area and the delta area which is holding many urban districts, the particular agricultural development to generate rural income such as the agro-industry, should be introduced and promoted in the Kok, Ing and Nan sub-basins.