CHAPTER 11. BASIC DESIGN OF ELECTRIC FACILITIES

The electric facilities are composed of an incoming 22 KV distribution line, substations and cabling to electric facilities, and include protective equipment and emergency generators.

11.1 Incoming 22 KV Distribution Line

There are two main distribution lines of 22 KV near the construction sites of the project facilities. These lines are come from Chachoengsao switch yard under the control of PEA and their electric source is two 40 MVA transformers in Chachoengsao substation belonging to EGAT.

One main distribution line is F-6 on the left bank of Bang Pakong River and the other one is F-7 on the right bank. 22 KV branch distribution lines connected to two main distribution lines supply electric power to villages near the sites of the diversion dam and pumping station. Electric power for the Project will be supplied from these distribution lines.

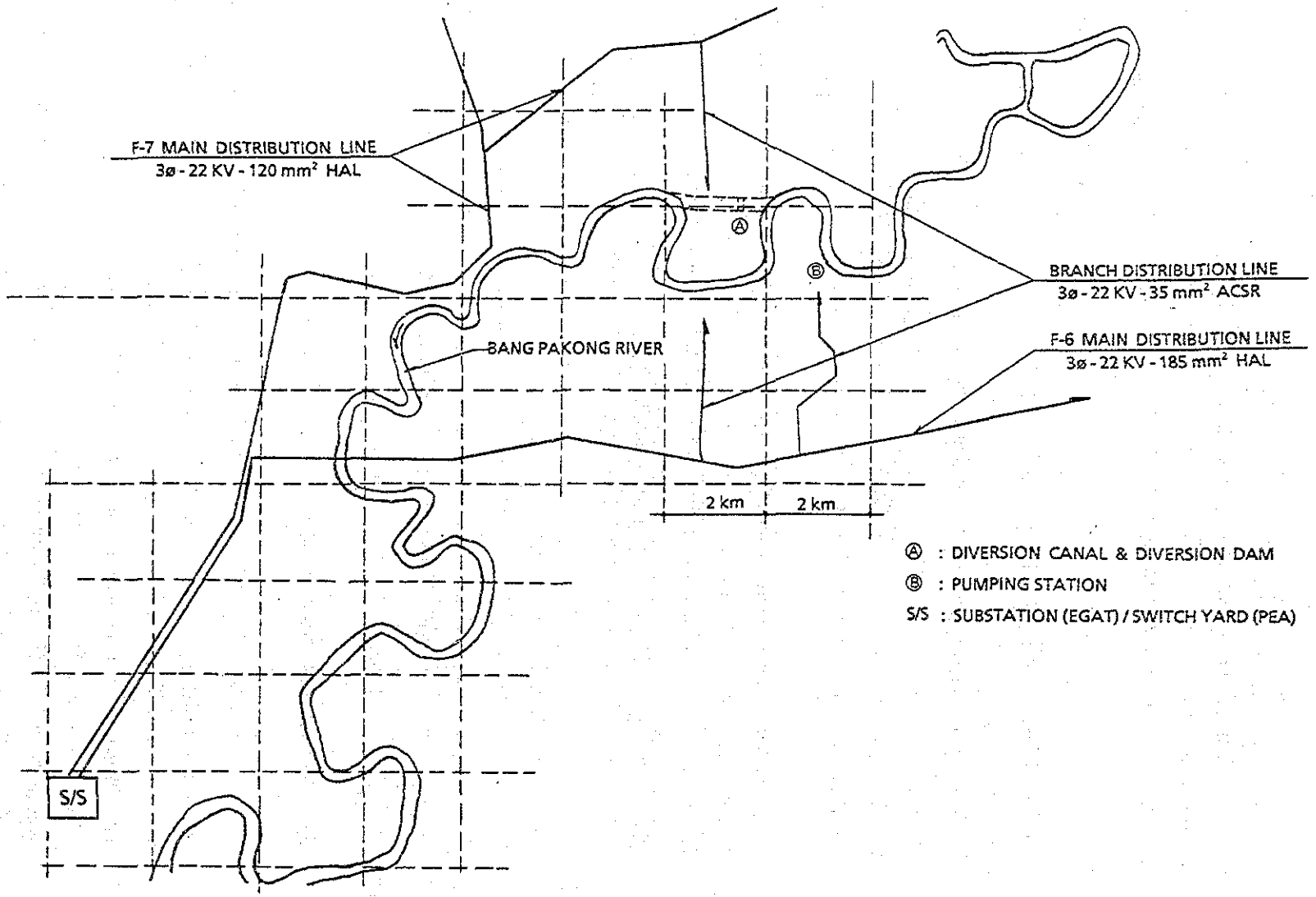
1) Main Distribution Line

As a result of a meeting with PEA, it is decided that electric power required for the Project should be supplied from the F-6 main distribution line on the left bank of Bang Pakong river.

2) Branch Distribution Line

The existing main distribution line has an HAL 185 mm^2 conductor which can supply electric power of 20 MVA in the condition of 22 KV. The branch distribution line capacity is 6.3 MVA for an existing ACSR 35 mm^2 conductor. This conductor is not big enough to add the electric power of 4.2 MVA required for the Project, to the present demand of electric power. PEA suggested that it would be possible to change the conductor from the existing ACSR 35 mm^2 to ACSR 120 mm^2. This will be decided after the final decision on the capacity of electric power required for the Project.

FIGURE 11-1 LOCATION MAP OF DISTRIBUTION LINES



3) Route of Branch Distribution Line

The routes of branch distribution lines for electric power supplies to the diversion dam and pumping station will be fixed after negotiation with PEA. Incoming electrical works will be done by PEA and the cost of works will be paid as a part of the construction cost of the Project.

11.2 Substations

Four substations, one for the diversion dam, control house and training center building, one for the pumping station and two for the residential area on the O/M building site, will be necessary. The two substations for the residential area will be investigated by RID.

1) Kind of Load and Required Electric Power

The major load is the motors of the tide protection gates and the pumps. The required capacities of transformers and the emergency diesel generator are affected by the capacities of these motors and the operation rules for the gates and the pumps as shown below.

a) Motor Capacity and Operation Rule of Tide Protection Gates

TABLE 11-1 MOTOR CAPACITY AND OPERATION RULE OF TIDE PROTECTION GATES

Gate		No. of Gate	Motor Capacity Per One Gate	Total Capacity
Flood Gate		3	18.5 KW × 2 = 37kw	37 kw × 3 = 111 kw
Regulating :	Upper	2	11 kw × 2 = 22 kw	22 kw × 2 = 44 kw
Gate :	Lower	2	22 kw × 2 = 44 kw	44 kw × 2 = 88 kw

Operation Rule of Tide Protection Gate

i) Flood gate : One gate operation at one time
ii) Regulating gate : One gate (upper gate or lower gate) operation at one time.
iii) Flood gate and regulating gate are not operated at same time.

Notes : i) Regardless of the operation rule, the capacity of a transformer is decided according to the electric power required to operate one flood gate and one regulating gate.
ii) Emergency diesel generator capacity is decided according to the motor capacity of 44 kw for the lower gate of the regulating gate.

b) Motor Capacity and Operation Rule of Pumps

TABLE 11-2 MOTOR CAPACITY AND OPERATION RULE OF PUMPS

Pump No.	Prime Mover	Type of Motor
No 1	350 KW motor	Cage Rotor
No 2	350 KW motor	Cage Rotor
No 3	350 KW motor	Cage Rotor
No 4	500 PS Diesel Engine	-

Operation Rule of Pumps

i) No.4 pump will be operated when four pumps are required or when there is a power failure.
ii) Starting of No.1 to No.3 pumps should be done one by one.
iii) Starting current for motor is estimated at 3.9 times for rating current.

c) Required Electric Power and the Installation Capacity

Required electric power under the conditions shown in clause a) and b) is computed as shown in Table 11-3. These figures will be revised in future because required electric power for the control house, training center building and residential houses, which are designed by RID, is only roughly estimated.

TABLE 11-3 REQUIRED CAPACITY AND INSTALLATION CAPACITY OF TRANSFORMER

Area	Required Capacity	Installation Capacity
Diversion Dam Area	1.095 KVA	1.500 KVA
Pumping Station Area	2.650 KVA	3.000 KVA
Residential Houses Area	463 KVA	300 KVA × 2 = 600 KVA
Total	4.208 KVA	5.100 KVA

2) No.1 Substation (Diversion Dam Area)

a) Supply Area

No.1 substation transforms incoming 22 KV to 400 V/230 V 3 wire and supplies electric power for the tide protection gate motors, auxiliary electric facilities, air conditioning and lighting for the control house and training center building, road lighting and other electric facilities.

b) Location of Substation

Since 22 KV incoming cubicle and transformer can be installed outside or inside the control house. The location will be decided after discussion with RID who will design the control house. Low voltage equipment will be installed in the control house.

c) Structure of Equipment

All equipment including charging equipment will be enclosed in an iron metal case. Secondary power from a transformer will be supplied to each electric facility by cable or bus duct.

d) Equipment List

Outside Installation

i) 22 KV incoming cubicle ..... 2 Sets
ii) 22 KV 1.500 KVA transformer ..... 1 Set
iii) Bus duct ..... 1 Set

Inside Installation

i)	Incoming low voltage cubicle	1	Set
ii)	Low voltage feeder cubicle	3	Sets
iii)	Relay cubicle	1	Set
iv)	DG, ACB, OCR cubicle	1	Set
v)	Condenser cubicle	3	Sets
vi)	Battery cubicle	2	Sets
vii)	Motor operation cubicle	2	Sets

3) No.2 Substation (Pumping Station Area)

a) Supply Area

No.2 substation is provided for electric power supply of 350 kw each to three pump motors and for auxiliary electric facilities and lighting facilities inside and outside the pump house. Outside lighting should only be in the area around the pump house and substation equipment installed outside.

b) Location of Substation

The 22 KV incoming cubicle and transformer will be installed outside will be the pump house and other equipment not including the condenser cubicle will be installed inside. Outside equipment should be installed near the pump house and electric power of 3 KV will be supplied by cable to the pump house. The condenser cubicle will be installed outside.

c) Structure of Equipment

As in the case for No.1 substation, charging equipment will be enclosed in an iron metal case so it is not exposed.

d) Equipment List

Outside Installation

i)	22 KV incoming cubicle	2	Sets
ii)	22 KV 3,000 KVA transformer	1	Set
iii)	3 KV condenser	4	Sets
v)	Bus duct	1	Set

Inside Installation

i)	Incoming low voltage cubicle	1	Set
ii)	Low voltage feeder cubicle	1	Set
iii)	In station power supply cubicle	1	Set
iv)	Motor operation cubicle	3	Sets
v)	Battery cubicle	2	Sets
vi)	Engine control cubicle	1	Set
vii)	OCR cubicle	1	Set

4) Substation for Residential Houses

Two transformers of 3 ø-50 HZ-300 KVA-22KV-380-220V-Δ- $\curlywedge$ will be installed in the residential area for about 460 families.

11.3 Electric Power Cabling to Facilities

i) The electric power cable should generally be polyethylene cable, but steel-tape armored cable will be used in special cases. Remote control from the control center will be done through the control cable for the tide protection gates and the private telephone circuit for the irrigation pumps.

ii) Cable pits, cable ducts and wiring tubes will be used to lay cables, and cable should not be buried directly in the ground, if possible.

11.4 Protective Equipment

i) Lightning rods will be installed to protect major facilities against lightning and electric facilities will be protected by a lightning arrester.

ii) At the time of electric circuit failure, the electric facilities will be protected by over current relay, direction ground relay, lack phase, reverse phase relay (2E relay) and thermal relay installed in low voltage motors. These relays will be set in a relay cubicle.

iii) A supervisory cubicle will be installed in No.1 and No.2 substations for indication of electric circuit failure and buzzer alarm.

iv) When a rapid increase of river flow or other emergency occurs, necessary information will be transmitted to inhabitants via the paging system and existing information system.

11.5 Emergency Diesel Generator

An emergency diesel generator will be installed in both in the area of the diversion dam and the pumping station.

1) Capacity of Emergency Generator

a) Diversion Dam Area ..... 3 ø-50HZ-270 KVA-400/230 V

This capacity is enough for operation of two motors of 22 kw each for the lower gate of the regulating gate and electric power supply of 34 KVA for lighting and air-conditioning in the control center at the same time.

b) Pumping Station Area ..... 3 ø-50HZ-60 KVA-380/230 V

Irrigation pumps consist of three sets of 350 kw motor driven pump and one set of diesel engine driven pump. At the time of electric power failure, one diesel engine driven pump only will be operated. Therefore, an emergency diesel generator is planned with sufficient capacity to supply electric power for auxiliary electric facilities of 30 KVA and lighting facilities of 30 KVA.

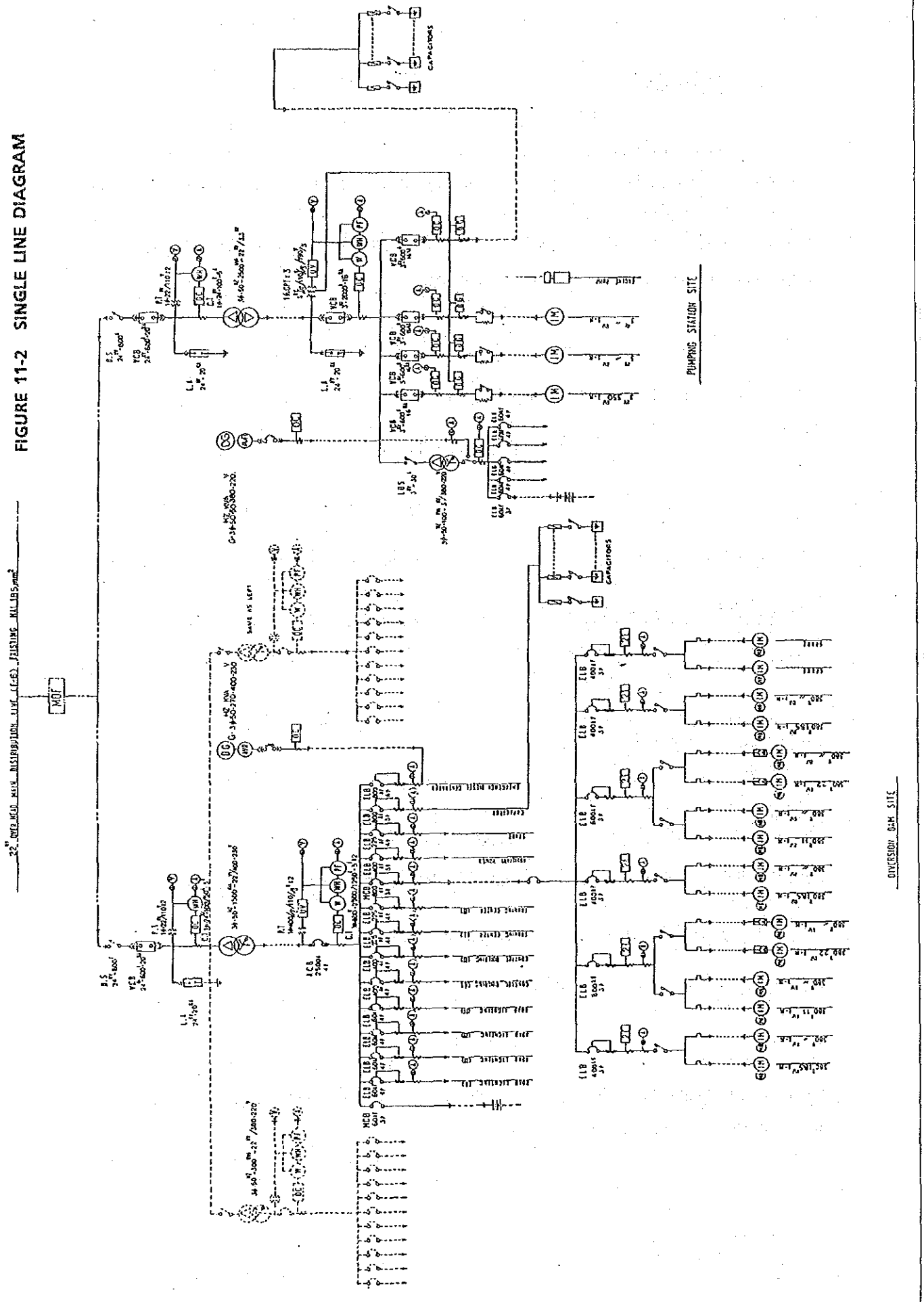
2) Type of Emergency Generator

The cooling method of the generator should be the air cooling type. The emergency generator for the diversion dam area will be installed in a noise protection cover because the generator capacity is large and the occurrence of a high noise level is assumed.

3) Maintenance

The emergency diesel generator is equipped with many incidental devices such as a circulating system of cooling water and lubricant oil, compressor, etc.. These devices should be maintained in good condition at all times. In order to check and confirm the condition of the devices, the generator should be operated at least twice a month.

FIGURE 11-2 SINGLE LINE DIAGRAM



CHAPTER 12. CONSTRUCTION PLAN

12. 1 Construction Materials and Equipment

1) Construction Materials

Of the construction materials and equipment required for the Bang Pakong Diversion Dam Project, the tide protection gates and the pumps will be supplied by foreign manufactures. The other materials and equipment are procurable domestically. The market conditions for major construction materials are as follows:-

a) Cement

Portland blast furnace slag cement is not found on the market so locally produced ordinary Portland cement, which is anti-sulfate cement prescribed as Type V in TIS 15 (Thai Industrial Standard), will be used. In Thailand, this type of cement has been widely used for seashore structures. Therefore, there are no problems with the quality and production capacity.

b) Rock Materials

Aggregate for concrete and rock for rip-rap will be procured from quarries in Chonburi about 60 km away form the construction site. The rock materials obtained from the quarries are mainly hard sandstone without any problem of quality and quantity.

c) P.C. Pile

A P.C. pile maker in Thailand will be contracted to manufacture piles using type V cement in TIS 15. There being several P.C. pile makers in Thailand, there should be no problem with the manufacturing of the P.C. piles.

d) Reinforcing Bars and Shaped Steel

Round bars and deformed bars of ø12~28mm dia. can be procured from the market easily. Shaped steel is also generally available unless it is specialized one.

2) Construction Machinery

The major construction machinery to be required for the Bang Pakong Diversion Dam Project is roughly estimated as shown in Table 12-1.

TABLE 12-1 CONSTRUCTION MACHINERY LIST

Name of Construction Machinery	Specification	Required Number
Dragline	$2m^3$	4 sets
Backhoe	$1m^3$	6 sets
Dump Truck	11t	17 sets
Bulldozer	21t	4 sets
Swamp Bulldozer	15t	5 sets
Pile Driver	Tower-type	2 sets
Concrete Plant	$0.75m^3 \times 2$	1 plant
Concrete Pump	$45m^3/hr$	2 sets
Agitator	$3m^3$	5 sets
Crawler Crane	150t	2 sets
Crawler Crane	50t	2 sets
Truck Crane	35t	1 set
Grader	12ft	1 set
Tire Roller	15t	1 set
Tamping Roller	2drams	2 sets
Pump Dredger	1,200PS	2 ships
Tug Boat	250PS	1 boat
Bottom Open type Barge	$200m^3$	2 ships

12. 2 Temporary Facilities Plan

1) Access Road

As illustrated in Figure 12-1, there is one existing route on the right bank and two existing routes on the left bank, as access to the construction site.

Route No. 1 This is the road to the diversion dam and the diversion canal. Since the existing road condition is bad, rehabilitation will be completed by RID, by the time of the commencement of the Bang Pakong Diversion Dam Project.

Route No. 2 This is the road to the closure dam. It is paved with laterite, in good condition and about 9 m in width.

Route No. 3 This is the road to the pumping station. It is paved with concrete and is about 4 m in width.

2) Electric Power for Construction Works

Since branch distribution lines with 22 KV have been set up along the roads mentioned above, they will be able to supply electric power for the construction work. The capacity of the main distribution line being estimated to be enough for the construction work, no problem with electric power supply is foreseen.

3) Water Supply for Construction Works

For stable water supply for concrete mixing and curing, and for other purposes, facilities for storing water with sufficient capacity, such as a water tank or a reservoir, will be required.

Water pumped from the Bang Pakong River in the wet season will be stored in the facilities. Drinking water purchased at Chachoengsao or water taken from appropriate water sources in the dry season will be conveyed by tank lorries and also stored in the facilities.

The capacity of the facilities storing water for construction works should be determined taking into account sedimentation as well as the quantity required to ensure a stable water supply.

FIGURE 12-1 LOCATION MAP OF ACCESS ROAD

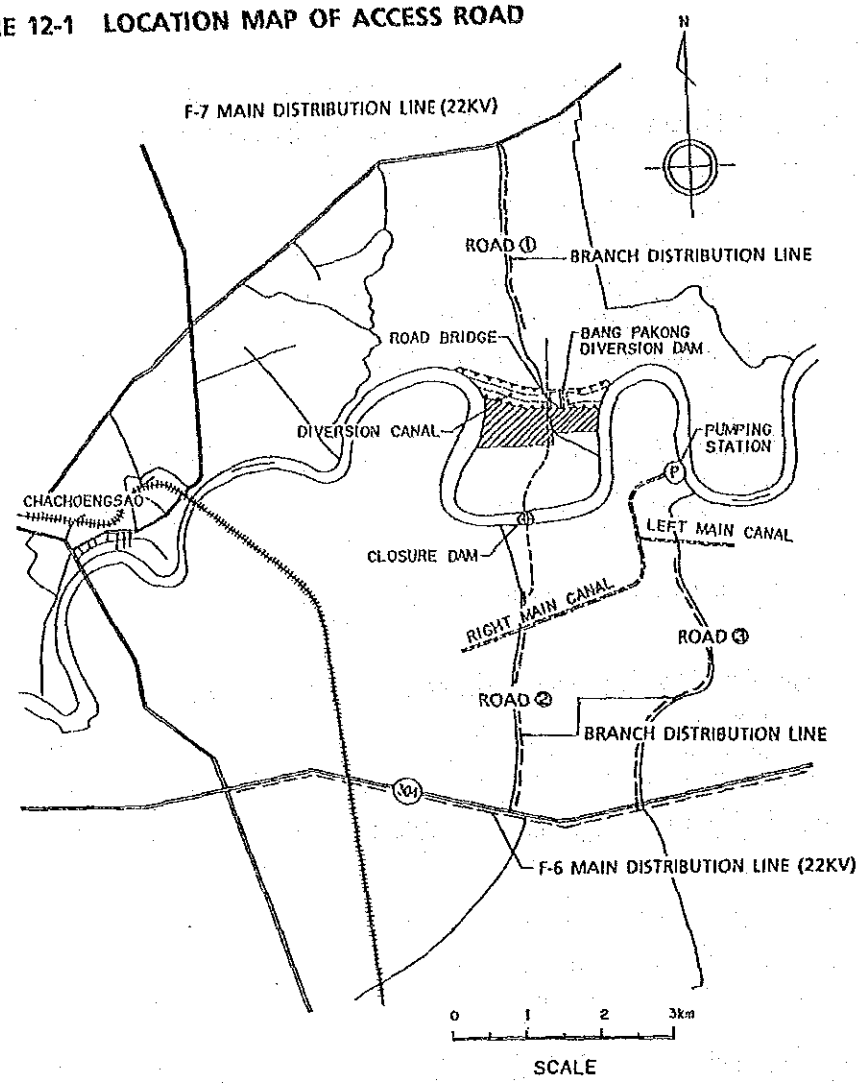
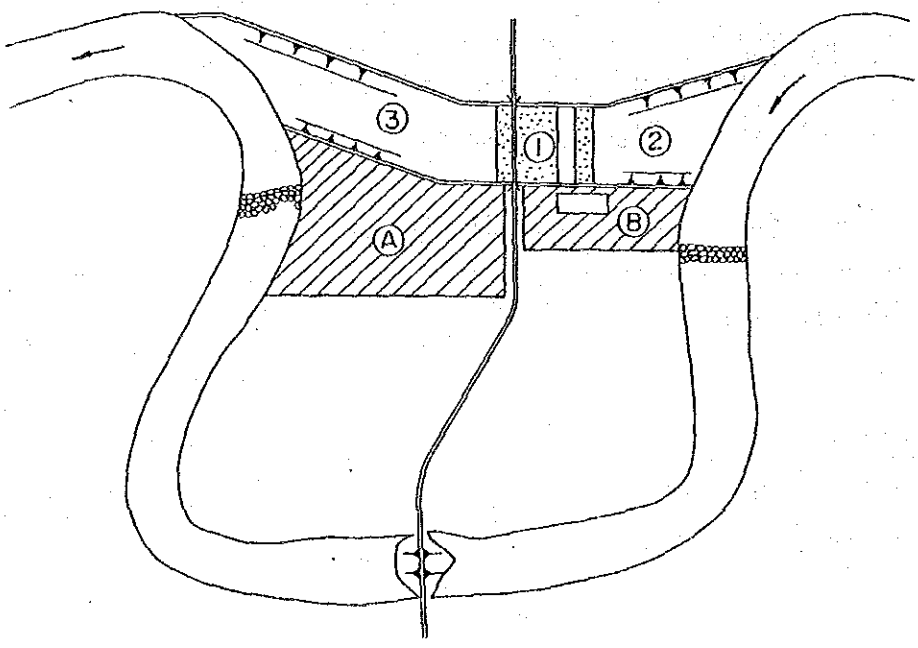


FIGURE 12-2 EXPLANATION MAP OF EXCAVATION PLAN



12. 3 Construction of Diversion Canal and Diversion Dam

1) Excavation Plan

Concerning the excavation of the diversion canal and the diversion dam, firstly the of 530 m section from the diversion dam to the road bridge (① in Figure 12-2) will be excavated under dry conditions, and then the remaining part of the diversion canal (② and ③ in Figure 12-2) will be excavated by pump dredgers.

The total amount to be excavated from ① is about 950,000 cu.m. In the first stage, the section for the diversion dam amounting to 500,000 cu.m will be excavated taking about 7 months. In the second stage, the sections at the road bridge and the downstream riverbed protection with rip-rap, amounting to 450,000 cu.m will be excavated.

The excavated materials will temporarily be banked on the site for the O/M building (Ⓐ400,000 sq.m + Ⓑ150,000 sq.m = 550,000 sq.m in Figure 12-2). The height of the stockpile will be 1.5m~2.0m. The ground surface of the site will be covered with crushed rock to form a horizontal drainage blanket. then, the excavated material will be dumped to form small parallel valleys running down to the river at intervals of 30~40m, providing for the discharge of existing water and rain from the materials. The excavated materials should remain in this condition for 12 months and then be removed before construction of the O/M building. Part of the material will be used for embankments on the O/M building site.

Based on the results of geological investigations and soil test, it has been assessed that the use of well points would be ineffective in removing ground water from the construction site. Light weight, steel sheet pilings which effectively prevent seepage, are planned in order to establish cutoffs along each slope of the trench (① Figure 12-2). In order to remove rainwater rapidly, drains will be constructed in a lattice formation in the foundation grade. Water will be removed by sump pumps installed at the end of each drain.

The amount to be excavated at ② and ③ in the diversion canal is estimated at about 2.2 million cu.m. As a result of an examination of the

construction schedule, it is planned that the excavation of this part should be carried out intensively by two pump dredgers of 1,200 ps each over a period of 12 months towards the end of the construction schedule, allowing for the gate installation and testing period. The gate test will be carried out after excavation of the first 200,000 cu.m for the construction of waterway from upstream end to downstream end of the diversion canal.

According to RID, the paddy field area proposed as a spoil bank is not located within 5 km of the site. It will, in fact, be very hard to secure it as a spoil bank and its distance from the diversion canal will be very uneconomical.

Therefore, excavated materials will be dumped into the old river course, keeping the end of the discharge pipe not in the air but in the river water, 2-3 m above the riverbed, so as to accelerate the deposit of dredged materials and prevent river water pollution as much as possible. Also to prevent out flow of dredged materials dumped into the old river course, a rock embankment with a crest elevation of EL.(-) 3.0~(-)4.0 m will be constructed at 2 spots shown in Figure 12-2.

Incidentally, in case a spoil bank is established on land, an area of 120~150 ha will be necessary.

2) Concrete Work

Although several ready-mixed concrete plants are found around Chachoengsao city, a concrete plant will be set up at the site to ensure a secure supply of concrete. The concrete plant is planned to be equipped with 2 sets of mixers with a capacity of 0.75 cu.m. Concrete placing will be performed by concrete pump with a capacity of 45 cu.m/hr.

12. 4 Construction of Closure Dam

1) Excavation Plan

The soft surface layer of 5 m in thickness in the river-bed will be dredged by pump dredgers of 1,200 ps.

2) Embankment Plan

Rock materials required for the rock zone and rip-rap will be purchased from a quarry at Chonburi city 60 km from the site. Coarse grained soil material required for the earthfill zone will be taken from a borrow area 20km from the site. The embankment of the rock zone and earthfill zone in the portion lower than the crest elevation of (-)5.0 m will be made using a bottom-open type barge.

The embankment of the upper part of the earthfill zone will be carried out by pushing the embankment materials from the river bank towards the river with bulldozers.

The rip-rap will be built using the above-mentioned barge.

12. 5 Construction of Pumping Station

1) Excavation Plan

In front of the intake canal of the pumping station, a temporary cofferdam with a double row of steel sheet piles will be constructed. The excavation required for the structure's construction will be done mainly by using draglines with a capacity of $2m^3$.

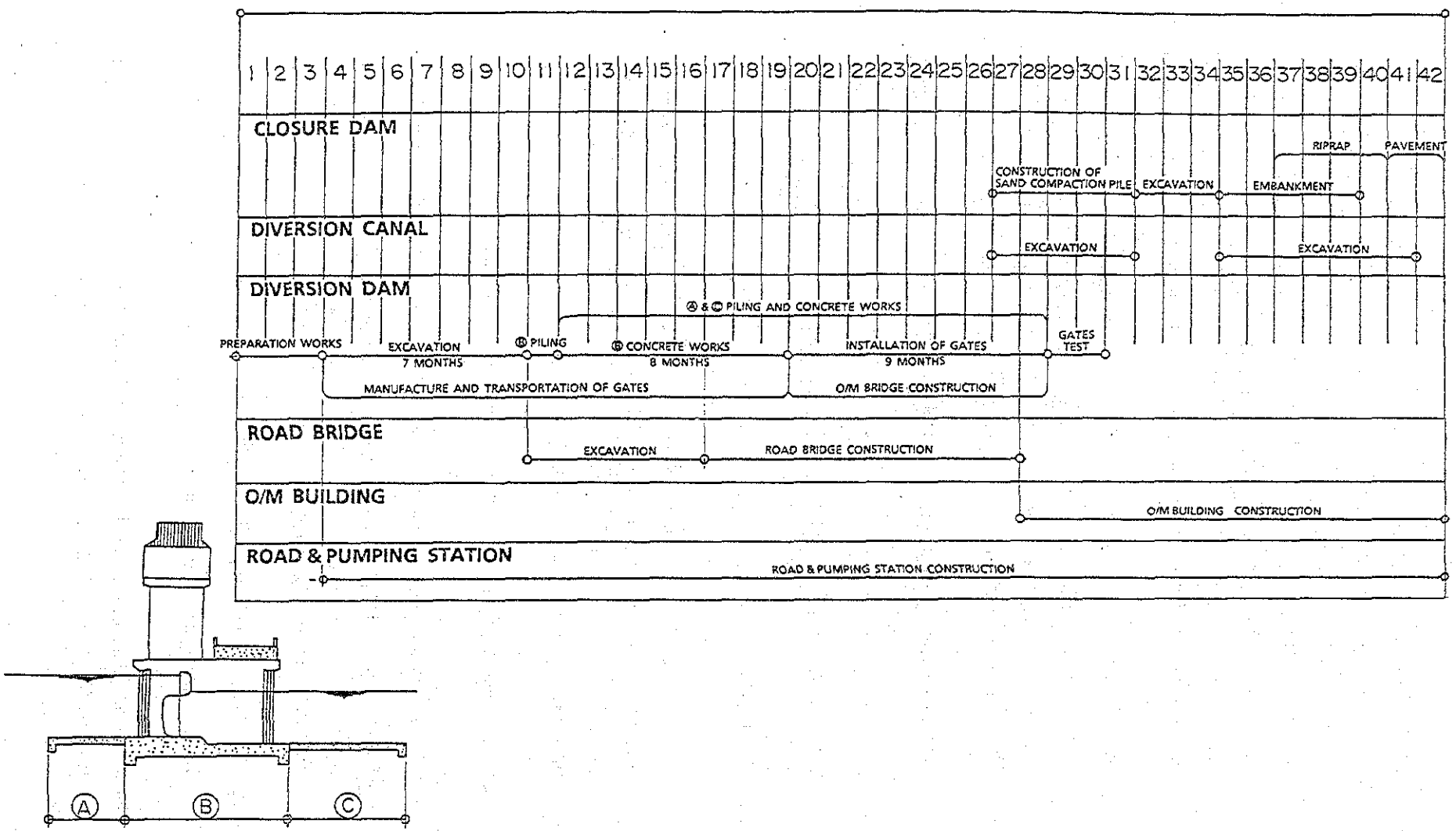
2) Concrete Works

Transportation of concrete from the concrete plant near the diversion dam to the pumping station site will be difficult so a portable concrete plant with a mixing capacity of 0.4 cu.m will be set up at the site. Concrete will be placed by concrete pump.

12. 6 Construction Schedule

The construction period of the Bang Pakong Diversion Dam Project will be three and half years (42 months) shown in Figure 12-3.

FIGURE 12-3 CONSTRUCTION SCHEDULE



CHAPTER 13. CONSTRUCTION COST ESTIMATION

13. 1 Basic Rate

The basic rate for labour and material is estimated on the basis of the prevailing rate in Chachoengsao Province on October 1992, as follows:

1) Labour Rate

The labour rate is considered totally in local currency and the following rates are adopted.

	L/C (฿)
- Foreman Class I	500
- Foreman Class II	350
- Operator of Equipment	350
- Assistant of Operator	150
- Driver	300
- Steel Worker	150
- Welder	250
- Carpenter	180
- Mechanics	250
- Electrician	250
- Mason	180
- Skilled Labour	130
- Common Labour	110

2) Material Rate

The following material rate is adopted dividing items into foreign and local currency for the construction cost estimation.

(unit: ฿)

Item Description	Unit	Total	F/C	L/C
Portland Cement Type I	Ton	1,400	840	560
Portland Cement Type V	〃	1,900	1,200	700
Sand for Aggregate	m^3	250	75	175
Crushed Stone for Aggregate	〃	270	80	190
Reinforcing Bar	Ton	13,000	9,000	4,000
Wood for Form	cu.ft	200	40	160
P.C. Pile ø 600 × 10 m	No.	10,300	6,200	4,100
P.C. Pile ø 500 × 10 m	〃	7,500	4,500	3,000
P.C. Pile ø 400 × 15 m	〃	8,100	4,900	3,200
Sheet Pile Type II	Ton	15,000	12,000	3,000
Gasoline	ℓ	9	7	2
Diesel Fuel	〃	8	6	2
Industrial Oil	〃	4	3	1
Electric Charge	KWH	2.6	-	2.6
Plywood 10 m/m × 4'× 8'	No.	420	80	340

13. 2 Construction Cost

The estimated construction cost for Bang Pakong Diversion Dam Project based on the basic design and collected data for labour rates, material rates, etc. is summarized in the following Table.

TABLE 13-1 CONSTRUCTION COST TABULATION

Description of Works	Unit	Quantity	Rate (Baht)			Amount (1,000 Baht)		
			F/C	L/C	Total	F/C	L/C	Total
1. Diversion Dam & Its Appurtenant Facilities								
a) Temporary Work	L.S.	1				100,000	40,000	140,000
b) Diversion Canal								
Stripping	m^3	220,000	28	14	42	6,160	3,080	9,240
Excavation	m^3	2,200,000	58	22	80	127,600	48,400	176,000
Embankment	m^3	50,000	50	20	70	2,500	1,000	3,500
Sub-Total						136,260	52,480	188,740
c) Diversion Dam								
Stripping	m^3	80,000	28	14	42	2,240	1,120	3,360
Excavation	m^3	850,000	68	26	94	57,800	22,100	79,900
Backfill	m^3	120,000	65	25	90	7,800	3,000	10,800
Embankment	m^3	22,000	50	20	70	1,100	440	1,540
P.C. Pile, ø600, ℓ = 10 m	pcs.	700	10,300	7,000	17,300	7,210	4,900	12,110
P.C. Pile, ø400, ℓ = 10~12 m	pcs.	1,500	5,400	3,700	9,100	8,100	5,550	13,650
Sheet Pile, type II, ℓ = 3 m	pcs.	1,400	3,400	800	4,200	4,760	1,120	5,880
Concrete	m^3	38,000	1,980	2,420	4,400	75,240	91,960	167,200
Riverbed Protection	m^2	18,000	560	690	1,250	10,080	12,420	22,500
Hoist House	L.S.					4,800	7,200	12,000
O/M Bridge	L.S.					5,100	3,400	8,500
Sub-Total						184,230	153,210	337,440
d) Tide Protection Gates			(1,000 Baht)	(1,000 Baht)	(1,000 Baht)			
Flood Gate	Nos.	3	108,000	27,000	135,000	324,000	81,000	405,000
Regulating Gate	Nos.	2	160,000	40,000	200,000	320,000	80,000	400,000
Stop Log	L.S.					40,600	17,400	58,000
Sub-Total						684,600	178,400	863,000
e) Closure Dam								
Excavation	m^3	200,000	58	22	80	11,600	4,400	16,000
Earthfill Zone Embankment	m^3	250,000	86	34	120	21,500	8,500	30,000
Rock Zone Embankment	m^3	40,000	210	490	700	8,400	19,600	28,000
Riprap	m^3	15,000	250	570	820	3,750	8,550	12,300
Sand Compaction Pile	L.S.					15,000	10,000	25,000
Sub-Total						60,250	51,050	111,300
f) Road & Road Bridge								
Road	m	2,600	3,000	2,000	5,000	7,800	5,200	13,000
Road Bridge	L.S.					31,000	23,000	54,000
Sub-Total						38,800	28,200	67,000
g) Miscellaneous Works	L.S.					60,160	25,360	85,520
Total						1,264,300	528,700	1,793,000
2. Pumping Station								
a) Temporary Work	L.S.					10,000	4,000	14,000
b) Pumping Station								
Stripping	m^3	1,000	14	7	21	14	7	21
Excavation	m^3	22,000	54	21	75	1,188	462	1,650
Backfill	m^3	10,000	36	14	50	360	140	500
Embankment	m^3	9,000	65	25	90	585	225	810
Sheet Pile, type II, ℓ = 2 m	pcs.	50	2,480	620	3,100	124	31	155
R.C. Pile, 400 mm × 400 mm ℓ=14m	pcs.	90	10,000	6,800	16,800	900	612	1,512
P.C. Pile, ø400, ℓ = 20 m	pcs.	40	11,800	7,800	19,600	472	312	784
P.C. Pile, ø500, ℓ = 16~23 m	pcs.	60	13,200	8,800	22,000	792	528	1,320
P.C. Pile, ø600, ℓ = 14 m	pcs.	50	14,400	9,600	24,000	720	480	1,200
Concrete	m^3	3,000	3,000	3,600	6,600	9,000	10,800	19,800
Stone Pitching	m^2	3,400	150	360	510	510	1,224	1,734
Pumps, including ø1,350 mm (motor) × 3 units and ø1,350 mm (diesel engine) × 1 unit	L.S.					160,000	40,000	200,000
Sub-Total						174,665	54,821	229,486
c) Miscellaneous Works	L.S.					9,235	3,279	12,514
Total						193,900	62,100	256,000
3. Control System & Electric Facilities	L.S.					112,000	48,000	160,000
4. O/M Building	L.S.					120,000	180,000	300,000
Grand Total						1,690,200	818,800	2,509,000

PART - IV. ENVIRONMENTAL CONSIDERATION

REVIEW ON THE ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF BANG PAKONG DIVERSION DAM PROJECT

CHAPTER 1. CONSIDERATION ON ENVIRONMENTAL IMPACT AND ITS MITIGATIVE MEASURES

The EIA draft report of Bang Pakong Diversion Dam Project was reviewed in order to draw consideration and conclusion on the impact and mitigative measures together with monitoring program. Such information is useful for the JICA study team in carrying out detailed design of the diversion dam. This review was made during the first field work and home office work periods from October 1992 to January 1993. At this time final EIA report has not yet been completed. Summary of existing environment and probable impacts during construction and operation phases was made under four environmental resources.

Each item of the review will cover brief conclusion on significant findings during the EIA study as well as impacts and mitigative measures as well as its comments on each study-item.

1. Physical Resources

1.1 Surface Water Hydrology

The EIA has pointed out the great advantage of the Bang Pakong Diversion Dam having an impoundment capacity for freshwater of 30 MCM. This amount of freshwater can be supplied to both existing irrigable area on the left bank and future expanded agricultural land in the total area of 14,300 ha (about 92,000 rai) during rainy and dry seasons, 18.9 MCM as domestic water and 69.7 MCM as industrial water.

A study was also made on the effects of back water. As a result, a dike on the left bank mat be required. When considering safety height of 0.50 m, the embankment of the dike should be constructed at the level of +2.64 m MSL for 10-year-return period or +2.80 m MSL for 20-year-return period. The dike should be located from the diversion dam up to Khlong The Luang in Amphoe Bang Khla which is about 13 km.

The present average range of maximum water level at the damsite in dry season is 1.10-1.20 m MSL. Therefore, when tide gates are closed up after future impoundment, water level in the lower stream may increase to 1.45-1.65 m MSL. Sea water protection dike should be provided along Bang Pakong left bank to protect future expanded irrigable area from high sea water level. The dike should start from damsite along the river bank down to Highway No. 304 for a total length of 15 km. This dike will also serve as flood protection dike during inundation period. Therefore, a suitable height of this dike should be considered to serve both purposes.

Comments

Since the EIA Report mentioned that the study results are only an estimation and recommended that hydraulic simulation be carried out as previously suggested also by JICA (1990), the existing dike height and river bank level upstream and downstream of the river should be surveyed. After the result of detailed hydraulic simulation is obtained, the decision will be made on the requirement of upstream and downstream dikes and dike height.

1.2 Surface Water Quality

Sampling of surface water in the Bang Pakong river was made monthly during August 1991 to January 1992 for a total of six times at 5 different locations (See Figure 1) including:-

Station 1 - Upstream of diversion dam, at Bang Khlong Lat to the south of Amphoe Bang Khla.

Station 2 - About 3 km upstream of the diversion dam at Wat Nai Bang Khla.

Station 3 - Downstream of diversion dam and upstream of Amphoe Muang Chachoengsao, at railroad bridge across the river.

Station 4 - Khlong Bang Phai in Amphoe Muang, which is a tributary acting as drainage canal carrying runoff from the left bank irrigable area into the downstream Bang Pakong river.

Station 5 - Khlong Don Si-Non in Amphoe Ban Pho which is a tributary serving as drainage canal carrying runoff from the left bank irrigable area into downstream of Bang Pakong river.

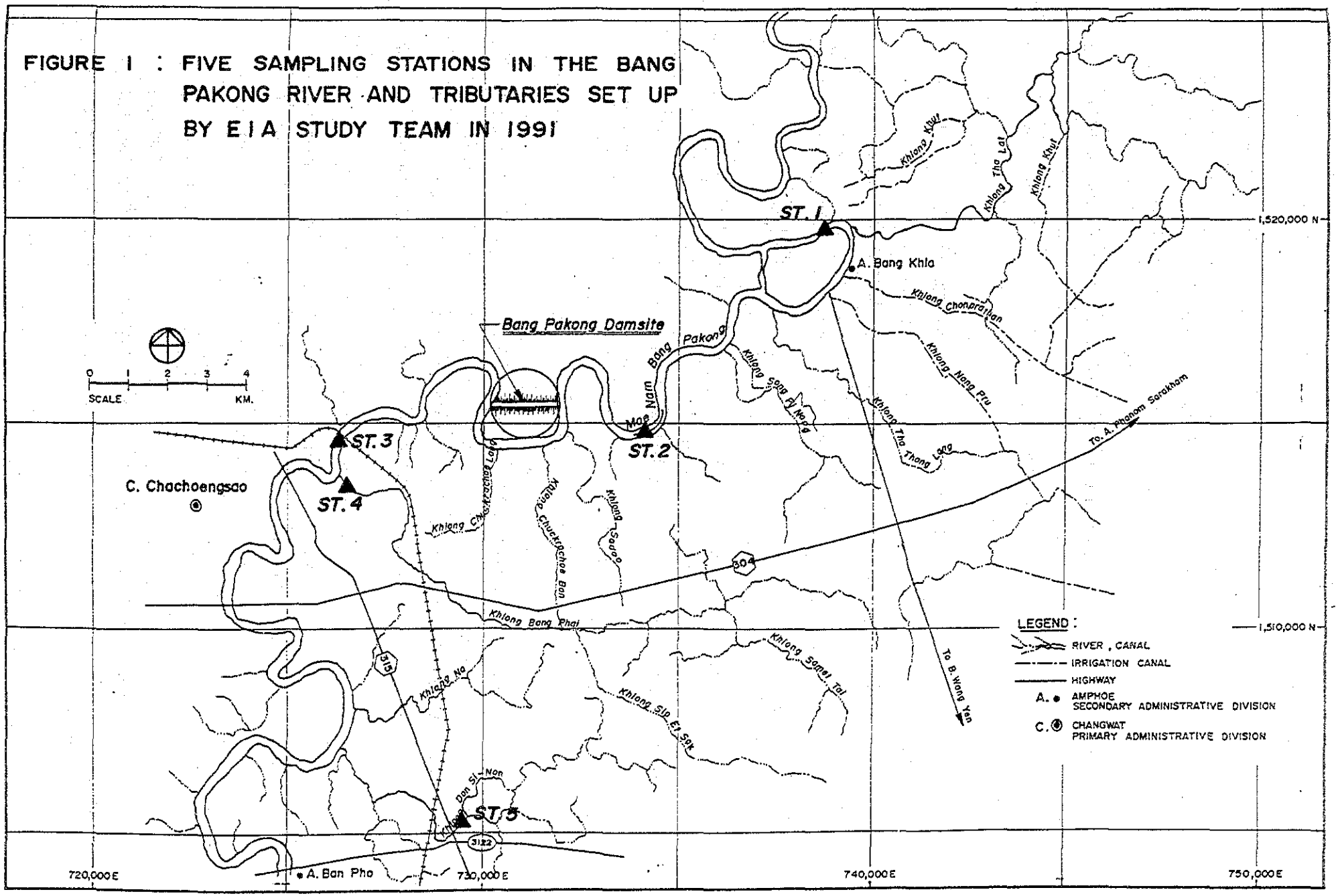


FIGURE 1 : FIVE SAMPLING STATIONS IN THE BANG PAKONG RIVER AND TRIBUTARIES SET UP BY E I A STUDY TEAM IN 1991

The analysis covers 43 parameters including the first group of temperature, pH, turbidity, salinity, conductivity, suspended solids (SS), total solids (TS), total dissolved solids (TDS) alkalinity, dissolved oxygen (DO), BOD, hardness, nitrate, phosphate, ammonia, fecal and total coliforms, and another group of trace elements including potassium, sodium, calcium, magnesium, bicarbonate, carbonate, sulphate, chloride, fluoride, arsenic, cyanide, iron, manganese, nickel, copper, zinc, lead, cadmium, chromium, mercury and pesticides (e.g. DDT, a-BHC, dieldrin, aldrin, heptachlor and endrin).

Sampling in the Bang Pakong river was made at 2 depths, i.e. mid-depth and surface level, while in its tributaries, sampling was made only at mid-depth level. First group parameters were analysed monthly while the second group parameters were analysed only twice, i.e. in the low and high flow seasons. Samples are integrated for analysis. Sampling was made during ebb tide by using Rigosha Sampler.

The results of survey showed no difference in most water quality at different depths of each sampling location excluding BOD and coliforms.

Bang Pakong River Water Quality

The pH of the Bang Pakong river water ranged from 6.9 - 7.6 (averagely 7.2). The upstream pH value reduced slightly in the end of rainy season, and in January pH value increased slightly. Salinity was not detectable throughout the survey period, i.e. during August to January river water flowing from upper reaches down to Amphoe Muang Chachoengsao was all freshwater.

The river water was found to be soft with moderate turbidity, conductivity, total dissolved solids (TDS), alkalinity and hardness. All above parameters decreased to minimum in September 1991 and reached maximum in January 1992 (dry period).

Turbidity at all stations was almost equal. In October and November, turbidity was lower than the other months because it was the end of rainy season, therefore, river flow was decelerating and resulted in more

sedimentation to the riverbed. Turbidity and suspended solids are found the highest in January.

Do was almost equal at all sampling stations, ranging from 4.3 to 5.4 mg/l at the beginning and in mid-rainy season (August to September). The minimum DO of 3.1 mg/l was found at station 1 in November and station 3 in December 1991.

BOD fluctuated with sampling times and sampling locations ranging between 0.1 - 2.5 mg/l. Surface BOD was found higher than the mid-depths. During heavy runoff (in September), upstream BOD was high with the maximum value of 2.05 mg/l at Station 1.

Ammonia (NG_3), NITRATE (NO_3) and phosphate (PO_4) in Bang Pakong river were about moderate. Most nitrogen presented in form of NO_3. NH_3 content was influenced by biological degradation of organic matter ranging from non-detectable level up to 0.06 mg/l with the higher content at stations 1, 3 than at station 2. NO_3 and PO_4 were ranging between 0.042 - 0.456 mg/l and non-detectable to 0.084 mg/l, respectively. Both increased with distance from upstream to downstream and became maximum in January.

Fecal and total coliforms were very high with the range between 460 - 54,000 MPN/100 ml and 700 - 92,000 MPN/100 ml, respectively. More coliforms were observed at surface rather than the mid-depth, and also at stations 1 and 3 close to large communities than station 2 (damsite). The highest content of total coliforms (92,000 MPN/100ml) was found as often as three sampling times, i.e. in September, November and December.

Toxic substances and heavy metals, cationic and anionic elements presented at low level in August, i.e. inundation period. Sulphate (SO_4) and chloride (Cl) were also very low. However, in the low flow month of December, sodium (14-20 mg/l) and chloride (27 - 40 mg/l) became doubled when compared to the detectable level in the flooding season. The SAR value in the dry season was still low and the river water from Bang Khla down to Amphoe Muang had SAR lower than 10 and conductivity less than 250 microsiemens/cm in August till December. This means Bang Pakong river in that section has suitable quality for irrigation.

Cyanide was the only toxic element found in the river at the concentration between 0.002 - 0.003 mg/l which is still lower than standard limit of surface water. Iron in the river water has its origin of the natural mineral resources. Simple coagulation is expected to remove iron to the safe level of domestic consumption. For heavy metals, only nickel and mercury exceeded the surface water standard at all stations in inundation period for nickel and only at stations 1 and 2 in dry season for mercury.

Residual herbicides e.g. o, p-DDT, a-BHC, dieldrin and heptachlor epoxide were detectable during high flow season but at very low concentrations. Only dieldrin could be detected in the dry period at all stations (0.10 ppb.).

Compared to records of Bang Pakong water quality surveyed by the National Environment Board (NEB) during 1986 - 1987, the river water between Amphoe Bang Khla and Amphoe Muang Chachoengsao showed much increasing trend of deterioration especially in terms of organic matter. As a result, BOD and coliforms bacteria thus sharply increased. This is also the same for mercury, lead and cadmium. Especially mercury has increased many times more, which is expected to be due to the generation of waste water from metal and electronic factories, which also results in increasing of nickel and cadmium in the river. On the other hand, copper, chromium and organochlorine and herbicides reduced. The reduction of such herbicide is related to the prohibition of using these substances in agriculture since 1984.

NEB (1988) summarized that main pollution sources of the Bang Pakong river are livestock farming, communities and factories. In 1987 pig farms generated as much as 12,560 kg BOD/d while community wastewater contributed about 5,760 kg BOD/d. In 1989 industrial wastewater discharged about 140 kg BOD/d into this river (Industrial Works Department, 1989). In this study BOD loading from pig farms was estimated at 15,504 kg/d.

Water Quality in Tributaries of Bang Pakong River

As previously mentioned, water quality in Khlong Bang Phai and Khlong Don Si Non which are tributaries of the Bang Pakong river was also surveyed. Both are drainage canal receiving discharge from left bank

irrigable area. Water in both canals were even more deteriorated as compared with that in the Bang Pakong river. No salinity could be detected at both places. BOD was between 0.5 - 6.8 mg/l (average, 3.5 mg/l) in Khlong Bang Phai and between 0.7 - 2.9 mg/l (average, 1.8 mg/l) in Khlong don Si Non. Consequently, DO in both canals were very low (average, 0.8 and 1.4 mg/l, respectively). Much higher NH_3 (1.82 mg/l) was observed in Khlong Bang Phai in January than that in the Bang Pakong river. However, fecal and total coliforms were less in the tributaries than in the river water. Concerning concentration of herbicides, organochlorine at very low level could still be detected but much less than the previous survey result (1984 - 1985). High organic contamination in both tributaries is expected to come from factories and pig farms.

Water quality in the Nakhon Nayok river, Prachinburi river, Bang Pakong River and Tributaries Surveyed by RID

Since water quality survey in the EIA was conducted during August 1991 to January 1992 due to the very limited study period, some additional surveyed data obtained from RID were taken into consideration to cover all three weather seasons in a year. The data included the survey results only in May 1991 and March 1992 at 6 different locations as follows (See Figure 2).

Station 1 - Nakhon Nayok river at Hog Wa canal
Station 2 - Prachinburi river at Amphoe Bang Sang
Station 3 - Bang Pakong river in front of Wat So Thorn in Amphoe Muang Chachoengsao
Station 4 - Bang Pakong river at Bang Pakong bridge
Station 5 - The Lat canal before joining Bang Pakong river
Station 6 - Radom canal before joining Tha Lat canal

The results showed that in dry season of 1992 and 1992, water in Nakhon Nayok river (station 1), lower Bang Pakong river (stations 3 and 4) and at the mouth of Tha Lat canal (station 5) was turbid and much affected by salt water intrusion resulting in high electrical conductivity beyond 5,000 micromhos/cm. Less effect of saline water was observed in Prachinburi river (less than 500 micromhos/cm). Radom canal in dry season still had soft water with only 81-110 micromhos/cm of electrical conductivity.

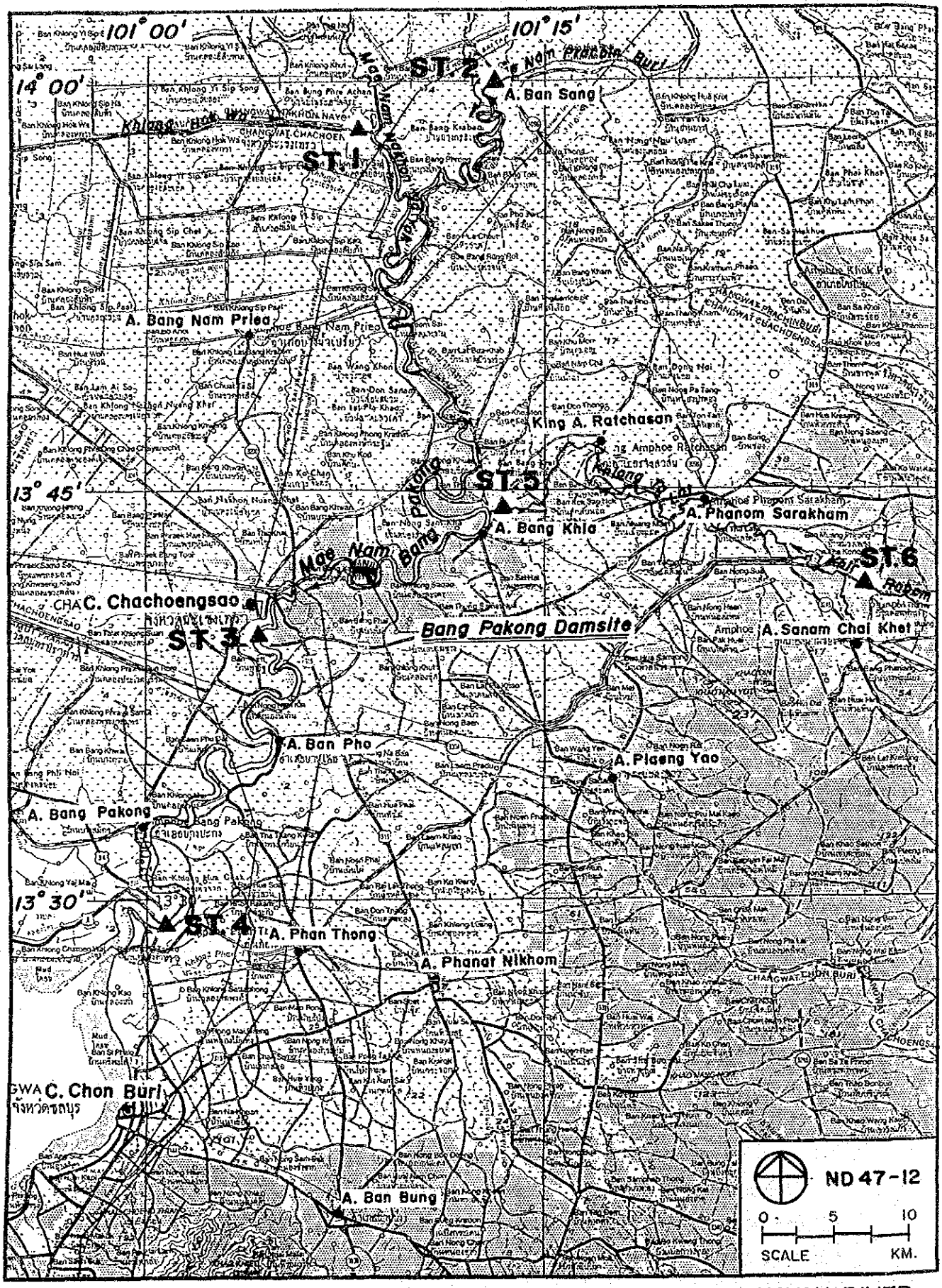


FIGURE 2 : SIX SAMPLING STATIONS IN THE NAKHON NAYOK RIVER, PRACHINBURI RIVER, BANG PAKONG RIVER AND TRIBUTARIES SURVEYED BY RID. IN 1991-1992

DO level in the lower Bang Pakong in May 1991 was lower (3.4 - 3.6 mg/l) than at other locations. In March 1992 BOD in the lower Bang Pakong river was high (1.4 - 1.6 mg/l) and much higher (4.1 mg/l) at the mouth of Tha Lat canal that received wastewater from communities in Amphoe Tha Lat and Phanomsarakham. However, DO at all stations was still high (5.2 - 8.3 mg/l).

As regards plant nutrients, all stations showed high concentration of nitrate and phosphate in the dry period of 1991 and 1992 especially in the lower Bang Pakong and at the mouth of Tha Lat canal. Nitrate (0.9 - 9.3 mg/l) and phosphate (0.1 - 0.4 mg/l) were many times higher than those observed in the flooding season. Very high content of total iron (3.7 - 11.6 mg/l) was detectable in Nakhon Nayok river, Bang Pakong river and at the mouth of Tha Lat canal especially in 1992. Dissolved iron at all locations in May 1991 was low except in Rabom canal where dissolved iron (1.27 mg/l) was higher than the drinking water standard.

Heavy metals and all toxic substances in dry period of the years 1991 and 1992 at all locations were still within the surface water standard.

Salt intrusion in dry season has caused very high concentrations of cations and anions in Nakhon Nayok river, Bang Pakong river and Tha Lat canal. Particularly when considering sodium iron content, electrical conductivity, Soluble Sodium Percentage (SSP) and Sodium Adsorption Ratio (SAR) as well as high content of chloride and sulphate, all the results pointed out that water quality at three above-mentioned sources were not suitable for irrigation in the dry season. This intensifies the necessity of prohibition of salt water intrusion in the Bang Pakong river basin. However, after in Prachinburi river and Rabom canal was still usable for irrigation purpose even for the dry period.

Regarding impacts on water quality, the EIA pointed out that increase of turbidity during construction period will cause deterioration of river water quality both up-and downstream and subsequently reduces beneficial uses of the river water. However, the impact will be moderate in mid-and end of rainy season during when turbidity is generally low. In dry season Bang Pakong river is normally highly turbid, and the degree of impact is less due to construction.

When the diversion dam is completed, accumulation of organic matter is likely to occur in the upstream water. The biodegradation of this accumulated organic matter will result in reduction of dissolved oxygen (DO) especially for dry period when river flow diminishes and absorption of oxygen gas from atmosphere is less. In a severe case, anaerobic condition may occur and generates hydrogen sulphide gas. Degradation of organic matter will also result in increase of plant nutrients and subsequently causes eutrophication or phytoplakton bloom. In such event, the upstream river water will no longer be suitable for any beneficial uses. Therefore, it is strongly recommended that wastewater discharged from all pollution sources upstream of the diversion dam including livestock farming, local communities and factories be strictly controlled.

The Lower Bang Pakong River was also expected to have higher accumulation of pollutants after the diversion dam and closure dam are constructed. This is because of less river flow flushing from the upper reaches and extensive expansion of industrial activity in Chachoengsao province. Deterioration of downstream river water will adversely affect aquatic lives and aquiculture. Therefore, pollution control should not be implemented only to upstream sources but also along the lower reaches of the Bang Pakong river down to the river mouth.

Increased availability of freshwater due to the upstream impoundment of the Bang Pakong Diversion Dam will result in increase of fresh water distribution into the left bank irrigable area. It is thus likely that flushing of pollutants out of the drainage canals of that irrigable area, including Bang Phai and Don Si-Non canals as surveyed in this study, would become more efficient. This will greatly improve water quality in drainage canals that receive discharge from irrigable area. However, if agricultural pattern on the left bank is changing from paddy fields to livestock farming or aquiculture, these drainage canals can become even more polluted. Therefore, monitoring of water quality in the canals when the dam is completed is recommended.

Comments

Concerning the increase of turbidity during construction, it shall be emphasized that sediment-generating activity should not be carried out during October to November, i.e. during mid and end of rainy season. In other months and also in dry season, Bang Pakong river is usually highly turbid, and the degree of impact is less due to construction.

The EIA Report pointed out that impact on water quality during impoundment due to accumulation of pollutants both upstream and downstream of the dam will become serious, if no control at sources is implemented. Therefore, effluent standard for livestock wastewater especially pig farm waste should be set up by the responsible environmental agency, such as the Ministry of Science, Technology and Environment (MOSTE).

This mitigative measure is expected to be able to effectively reduce BOD loading into the receiving water.

Another measure of providing drainage canal to divert pig farm wastewater to lower reaches has been extensively discussed about its direction, sizing and requirement of downstream treatment plant. Since pig farms are located in many places, the direction of this canal and their branches for efficient collection of all discharged wastewater has to be carefully determined. Survey on locations of all the pig farms in the vicinity has to be primarily carried out. At this stage it seems that the proposed measure of setting up standard for livestock wastewater by responsible implementing agency would be the key solution for effective control of discharged wastewater from pig farms.

Wastewater from RID office at damsite, where not more than 500 staff and their families will be staying, should also be properly treated to avoid discharging of polluted wastewater into the Bang Pakong river.

Instead of drainage canal construction, simple drainage treatment facilities (oxidization ponds) are sought to be built by farmers themselves, keeping more than 1000 pigs under the guidance of the Livestock Department the Ministry of Agriculture and Cooperations (MOAC). If a

prevention of pollutant from pig farms from flowing into the river is possible by strengthing and developing this idea, it will be extremely realistic means of solution.

1.3 Soil Property

Soil property in most part of the whole study area is suitable for sustainable agriculture. The only problem found at some locations on the right and left bank irrigable areas is related to saline soil condition and high acidity. Soil property at the project site also shows high potential for sustainable agriculture, i.e. suitable for rice and fruit tree cultivation.

Development of Bang Pakong Diversion Dam will need to clear certain part of fertile orchards covering about 126.4 ha (793 rai) for dam structure, diversion canal, office building, staff housing, etc. However, great benefit will be offered to agricultural land area on both right and left banks of the Bang Pakong river. Systematic water regulation will be able to reduce saline and acid soil problems. No additional comment is needed.

1.4 Groundwater Hydrology and Quality

There are 79 deep wells in total in the study area. Most of them were dug by Department of Mineral Resources and Public Works Department and located far from the proposed damsite. Most wells have diameters between 4-6 inches with depth ranging from 27 - 146 m or 50 - 80 m on an average. Water yield is generally low between 2 - 4 cu.m/hr with the maximum yield of 18 cu.m/hr. Almost all of deep wells are operated with hand pumps and many of them are no longer in use due to poor water quality regarding too high chloride content.

It is not expected that Bang Pakong Diversion Dam will cause any impact on groundwater hydrology and quality in the study area. No other comments are made on this regard.

1.5 Erosion and Sedimentation

Erosion and sedimentation along the Bang Pakong river banks are caused by:-

(1) river currents
(2) land use pattern
(3) waves induced by water transport and wind

Erosion and sedimentation caused by river currents

The Bang Pakong river has long been eroded until now reaching the equilibrium condition, i.e. no more erosion on the river banks (with erodibility index of 0.44 - 0.49) and at the river bed (with erodibility index of 0.35 - 0.38) at the straight river portion.

Some sedimentation is evident along the river banks. This is because some plants growing on both the banks caused deceleration of river flow during high tide resulting in higher sedimentation rather than erosion. These sediments will be traveling along with the current during low tide to the Gulf of Thailand. Therefore, silty clay is found remaining along the river banks and became good bases for water plants resulting in formation of natural river bank protection strip.

The meandering of the river was noted to have deeper erosion at the river bed, about 1 m deeper than the straight portion. The outer meandering shows very steep bank while inner meandering has about 8 - 15% sloping.

Erosion and sedimentation caused by land use pattern

Land use pattern along the left bank irrigable area mostly consists of orchards, shrimp and fish ponds and paddy fields. Nypa palm, avicennia and sonneratia that are found along the river banks can protect the banks from the river flow. Discharge from orchards containing some sediment generally flows into the river and the sediments settle along the river bank.

Erosion and sedimentation caused by water transport and wind

Driving boats along the Bank Pakong river has caused erosion at all the meandering portions of the river. On the other parts with thick vegetation or with stone barrier, the river banks do not get eroded by such water transport. Waves induced by driving boats have amplitudes ranging

between 30 - 40 cm for large passenger boat (about for 30 passengers) and between 20 - 30 cm for small long-tailed boat. Amplitude of waves by wind action is much lower with the maximum range of only 15 - 20 cm.

During the construction period some sediments mainly of soft clay will be generated. It is expected that these sediments will flocculate well for a period of about 15 - 30 days and results in insignificant impact on water quality.

To predict effects of erosion and sedimentation during impoundment of the Bang Pakong Diversion Dam, quantity of sediment was estimated in the EIA using mathematical modeling. Monthly runoff and sedimentation at the damsite are as follows:-

	Runoff (MCM)	Sedimentation (Ton)
April	31.9	2,705.7
May	124.1	12,800.4
June	472.3	59,054.8
July	843.6	114,670.1
August	1,406.7	205,822.2
September	1,954.6	299,861.0
October	1,547	229,470.4
November	298.9	34,996.6
December	103.4	10,388.7
Manuary	30.1	2,531.8
February	12.5	926.4
March	13.5	1,011.7
Total	6,838.6	974,233.8

The sum of above monthly sedimentation can be compared for different period of opening/closing tide gates for further determination on tide gates operation as follows:-

Tide Gates Operation	Sum of Sediments	
	Ton	%
a) Tide Gates Opening Period		
May - November	956,670	98
June - November	897,615	94
May - December	967,058	99
b) Tide Gates Closing Period		
December - April	17,564	2
December - May	52,555	6
January - April	7,176	0.7

Based on the above figures, the EIA concluded that impacts due to sedimentation when tide gates are closing in dry season will be insignificant, compared with the effects of accumulated pollutants which seem to be much more serious.

Closing of tide gates in dry season is expected to cause stagnation from Ban Laem Sai up to the confluence of Nakhon Nayok and Prachin rivers at Ban Pan, Amphoe Ban Sang in Prachinburi Province. This would result in sedimentation along the Bang Pakong river up to Ban Pan. Highest degree of sedimentation will occur at the location where the stagnant water joining with the flowing river water. However, all the sediments will be flushed out during in undation period when tide gates are open.

Erosion by wave action during impoundment is expected to be more serious especially at all the meandering portions of the river. The upstream vegetation will change from brackish type to fresh water ecosystem. No erosion will occur on the straight portion of the river because of existing thick vegetation. No other comment is needed on this subject.

2. BIOLOGICAL RESOURCES

2.1 Aquatic Ecology, Fisheries and Aquiculture

The EIA Report indicated that fish found in the Bang Pakong river during the study are of general types. No rare species were observed. Marine fish usually migrate from the Bang Pakong river mouth far up to Amphoe Bang Khla during dry season. Only 5 species of brackish water fish and freshwater fish that can live in brackish water are reported migrating up to Amphoe Muang Nakhon Nayok and Amphoe Ban Sang in Prachinburi. Freshwater fish will travel down to Amphoe Bang Pakong only for short period during rainy season along with the high river flow and travel back quickly. Usually freshwater fish does not travel down beyond Amphoe Bang Khla.

Bang Pakong river mouth is abundant with nutrients for aquatic lives. Therefore, aquiculture is extensively practiced in Amphoe Bang Pakong close to the river mouth. In 1989 Amphoe Bang Pakong was reported to have fish ponds covering about 5,500 ha (34,269 rai) and shrimp farm about 2,650 ha (16,565 rai). Later shrimp farming for Penaeus monodon has become popular especially in Amphoe Bang Pakong where there are over 1,000 P. monodon farms. Stronger effect of salt-water intrusion and must drop of rice price are main reasons why farmers in Chacheongsao tend to change their paddy fields into shrimp farming.

In 1991, aquiculture was performed in 5 Amphoes, i.e. Bang Nam Priew, Bang Khla, Muang Chachoengsao, Ban Pho and Bang Pakong. P. monodon culture covered area of 3,344 ha (20,900 rai) with production yield of about 44 million kg/year or economic value of 3,156 million Baht. Cuture of fresh water and brackish water fish covered total area of 5,870 ha (36,685 rai) resulting in production yield of about 27 million kg/year which cost about 23 million Baht.

Shrimp farms usually obtain saline water from Bang Pakong river and branch canals. Extensive culture will be performed during 8-month period (November - June) when salt water is available. Most hatchery farms purchase concentrated brine water with salinity 60 - 110 ppt. from salt farm to save cost on transportation and storage. Freshwater is obtained from

underground water, tap water or river water/tributaries located in the northern area.

Aquiculture of freshwater fish obtains freshwater from upstream of the Bang Pakong river. Dikes are erected in some canals for holding of freshwater. The EIA estimated that aquaculture requires about 0.86 MCM/year of freshwater and about one MCM/year of brine water for the whole Chachoengsao province. Supply of fresh water from other sources for aquiculture is extensively required from October to June which covers the dry months of February to May. During July to September rain water is sufficiently available, therefore, requirement of freshwater from other sources is minimum.

Concerning impact during construction phase, it is not expected that turbidity in the river will increase tremendously, therefore, impact on aquatic lives and aquiaulture will not be significant. However, technical approach to minimize sediment dispersion must be applied such as bundling of the sediment disposal site, etc.

After the dam is completed, fish productivity is expected to increase in the upstream impoundment area, as it generally occurs in other impoundment dams. The dam will clearly separate freshwater and salt water, therefore causing separation of freshwater fish in the upstream and brackish water or marine fish in the lower reaches. Being completely different in their nature of living, fish ladder is then not recommended to transfer fresh water fish to downstream area and brackish water/marine fish to upstream fresh water because fish will die when changing to unfavorable habitat abruptly.

Freshwater aquaculture will no longer be possible in the downstream area except there is fresh water distribution system to low income agriculturist who cannot afford P. monodon farming.

With less river runoff to the lower reaches when the dam is constructed, water quality downstream may become worse due to more accumulation of pollutants discharged from various downstream activities. Such poor water quality will adversely affect the aquaculture in the river lower reaches.

Comments

The EIA recommended to conduct at least five-year investigation of egg-laying and hatching places of some upstream freshwater fish that are likely to have reduced productivity. This point needs to be clarified because in impact assessment, the EIA mentioned that impoundment by the dam is expected to cause increased productivity of freshwater fish. Therefore, it should then be recommended that records of fish catch (usually performed by Dept. of Fisheries) in the upstream impoundment be kept and determined whether there is reduction of any fish species. This will be brought into further consideration on management of fish propagation plan.

2.2 Forestry

Mangrove forest along shoreline has higher density than at the Bang Pakong river mouth due to less degree of development of aquaculture and other activities and being far away from large communities. However, the remaining mangrove forest both along shoreline and river mouth is not so productive.

The proposed project site of about 127 ha (793 rai) is at present occupied by orchards, e.g. areca palm (Areca catch), coconut (Cocos nucifera), and mang (Mangifera indica). Mangrove forest can also be observed on a narrow strip along the river banks and along the canals in the orchards. Main species in the mangrove forest are nypa palm (Nypa fruticans) and Bruguiera sp.

To construct diversion dam and canal, a total of 60,017 trees will have to be cut off, most of which are planted orchards rather than mangrove forest.

After starting impoundment, the upstream water will be fresh water all year-round. Thus, the remaining of a little mangrove forest along upstream river bank may disappear.

Comments

The EIA Report suggested that mangrove forest strip of width not less than 20 m be planted along both the banks of diversion canals to

maintain the mangrove ecosystem existed before the dam is constructed. It should be added that such strip plantation of mangrove species can only be made along the downstream side. On the upstream side, large trees can be planted to protect the canal banks.

The EIA Report suggested that illegal invasion in the mangrove forest at the river mouth and shoreline be prohibited. Since the location of damsite is about 70 km from the river mouth, it seems that such existing invasion and prohibition is absolutely not related to the Bang Pakong Diversion Dam project.

2.3 Wildlife

Four groups of animals are found in the study area including amphibians, reptiles, birds and mammals. There are a total of 167 species reported, the details of which are as follows:-

Type	Damsite	Mangrove Forest (at the river mouth)	Total No. of Species Found
Amphibians	9	2	10
Reptiles	32	9	36
Birds	53	95	112
Mammals	6	8	9
Total	100	114	167

A great number of amphibian and reptile species are found at damsite, while a lage number of birds are also observed at mangrove forest around the river mouth. Number of mammal species are not much different in both the areas.

During construction of the diversion dam and canal there will be only little effects to wildlife species in the project site, because they can migrate to the nearby vicinity of the same ecological system. No impact on wildlife will occur during operation period.

Comments

The EIA Report suggested that RID cooperate with Division of Wildlife Conservation, Department of Forestry in conserving the small island (70 rai), located about 2 km before reaching the river mouth and nearby vicinity for Pteropus lylei. Since that island is about 70 km away from project site, this suggestion is considered out of the scope of this project.

3. Human Use Value

3.1 Water Supply

During the recent years, Bang Pakong River is no longer considered as good source of water supply mainly due to too high salinity, low DO value and presence of trace elements, e.g. heavy metals and pesticides. "Degradation of the river water quality also causes reduction of productivity of brackish water shrimp farms in Amphoe Muang Chachoengsao, Amphoe Bang Pakong and Amphoe Ban Pho close to the river mouth. In addition, rapid expansion of industrial sector has also resulted in freshwater shortage and wastewater pollution.

At present, in spite of poor water quality, river water not only from Bang Pakong river but also from tributaries mostly downstream of the proposed damsite is taken up as water supply source. The water is treated and supplied for domestic uses.

The EIA Report presented the demand of water supply for different activities in 1990 and also forecast of the future demand as shown in Table 1.

TABLE 1

ANNUAL DEMAND OF WATER SUPPLY FOR DIFFERENT ACTIVITIES IN 1990 AND FORECAST OF INCREASING DEMAND FOR FUTURE YEARS

Activities	Year 1990		Year 1995		Year 2000		Year 2005	
	MCM	%	MCM	%	MCM	%	MCM	%
1. Domestic water supply	4.913	27	6.266	22	7.896	21	9.757	19
2. Industrial use								
- For industrial estates	0.365	2	6.023	20	9.692	25	18.050	35
- For factories outside industrial estate	5.842	33	8.531	30	12.374	32	14.260	30
Sub-total	6.207	35	14.554	50	22.066	57	32.310	63
3. Livestock farming	6.014	33	7.177	25	7.625	20	8.102	16
4. Aquaculture	0.822	5	0.822	3	0.822	2	0.822	2
Grand total	17.956	100	28.819	100	38.409	100	50.991	100

Ref.: Draft Final EIA of Bang Pakong Diversion Dam Prepared by Kasetsart University, April 1992.

Regarding impact during construction of the proposed Bang Pakong Diversion Dam project, turbidity of river water might increase but it is not expected to cause adverse impact on water supply because locations of raw water intake locations are much far away from the project site. Positive impact on water supply can be predicted due to the increase of availability of freshwater for nearby Provincial Waterworks Authority (PWA). Therefore, the EIA Report strongly recommended that mitigative measures to preserve good water quality at the upstream of the damsite be strictly undertaken.

Comments

The distribution system to transfer freshwater from upstream impoundment to downstream waterworks should be completed when the dam starts operating, otherwise the downstream waterworks will have serious problems of increased salinity in the raw water almost throughout the year. The problem will be generated to most downstream communities that rely on tap water supplied from those waterworks.

3.2 Land and Water Transportation

The EIA Report has summarized that no problems is expected on both land and water transportation in Chachoengsao province after the dam is constructed. Road transport between both the banks would become even more convenient due to new connecting road, connecting bridge and extension road across the closure dam. Small passenger boats which are at present the only water transport means along Bang Pakong river will not be able to go through the diversion dam in the future.

Comments

Passenger transfer stations should be located at closure dam instead of at upstream/downstream of diversion dam as suggested in the EIA Report.

3.3 Livestock Farming and Industry

3.3.1 Livestock Farming

The EIA Report concluded the data on livestock farming in the study area in the year 1991, as follows:-

Province	Location	No of Individuals		
		Pig	Chicken	Duck
1. Chachoengsao				
- Amphoe Bang Khla	Upstream		84,574	45,009
- Amphoe Muang	Downstream		286,702	275,324
- Amphoe Ban Pho	Downstream		30,009	71,000
- Amphoe Bang Pakong	Downstream		10,718	160,000
Sub-total	Upstream	84,574	1,097,609	45,009
	Downstream		11,368,754	506,324
Total (1)		412,003	12,466,363	551,333
2. Chonburi				
- Amphoe Phan Thong	Downstream		1,572,789	278,000
Total (2)	Upstream	84,574	1,097,609	45,009
	Downstream		12,941,543	784,324
Grand Total in study area		443,427	14,039,152	829,333

Ref: Provincial Livestock Development Office (1991)

Water supply sources for livestock farming are from Bang Pakong river and its branch canals, tap water and also underground water. Livestock water demand in the study area in 1992 is concluded in the EIA Report as follows:-

Pig farming	6.06	MCM/year
Chicken farming	0.56	MCM/year
Duck farming	0.02	MCM/year
Total	6.64	MCM/year

Most livestock farming is considered to be on large scale. Since wet and dry pig manure are salable, remaining waste generated from all pig farms are farm wash water mixing with pig urines and left-over pig feed.

This mixed waste stream is generally retained in a small holding sump before seeping into the soil or flowing over into nearby swamp. However, most small-scaled pit farms generally do not have such holding sumps. For chicken and duck farms, their manure can also be sold and the farms do not require washing. Thus, wastewater generation from chicken and duck farms is very limited. It can, therefore, be concluded that pig farming is the prime wastewater source among livestock development in the study area. Size of pig farms and estimation of BOD loading into the Bang Pakong river in the study area covering 2 provinces, i.e. Chachoengsao and Chonburi can be summarized as follows:-

Size of Pig Farm	Upstream		Downstream		Total	
	No. of farm	BOD loading (kg/d)	No. of farm	BOD loading (kg/d)	No. of farm	BOD loading (kg/d)
Less than 100 pigs	336	299	1,428	1,272	1,764	1,571
More than 100 pigs	375	6,759	398	7,174	773	13,933
Total	711	7,058	1,826	8,446	2,537	15,504

The above BOD loading estimation is based on the survey data of Department of Livestock Development that each pig farm of less than 100 pigs generates the average waste flow of 1.8 cu.m/day with BOD concentration of 495 mg/l. In addition, large pig farm of more than 100 pigs generally discharges 10.8 cu.m/day of waste with BOD concentration of 1,669 mg/l.

It can be noted that livestock farming in the study area is expanding at the decreasing rate of expansion due to increasing land price caused by the development of Eastern Seaboard Project. With approximately 3 percent expansion of livestock farming according to Chachoengsao Provincial Development Plan, the number of livestock farming in the years 1992 and 1996 which is the year end of the this development plan can be concluded below:-

Livestock	Livestock	
	Year 1992	Year 1996
Pig	424,363	477,623
Chicken	12,840,354	14,451,932
Duck	567,873	621,146

Note: The above mentioned figures are for Chachoengsao province only not including Amphoe Phan Thong of Chonburi province.

As a result, BOD loading into the upstream and downstream of diversion dam will increase to 8,188 kg/day and 8,973 kg/day, respectively.

It can be noted that survey on locations of existing farms has not been conducted in the EIA study and such location map is not available at the Provincial Livestock Development Office.

The EIA Report already mentioned that pig farms located upstream of the Bang Pakong Diversion Dam discharge not less than 7,058 kg GOD/day into branch canals e.g. Chuckrachoe Bon canal, Sadao canal, Song Phi-Nong canal and Thong Lang canal. All of these canals will transfer pig farm wastewater into the Bang Pakong river. When the diversion dam is constructed, accumulation of organic matter in the upstream of the dam may be resulted and consequently causes extensive deterioration of river water quality.

Comments

The assumption that all the wastewater generated flows into the river, is not correct, as already mentioned in Chapter 1. (Even if water taken from the river, wastewater is hardly discharged into the river.)

Accordingly, it can be said that the figures shown into EIA Report are tremendously large. The respectable mitigative measures such as construction of oxidization ponds, prohibition of new factories establishment in the area, are, of course, indispensable.

3.3.2 Industry

Most factories in Chachoengsao province are related to agro-industrial type such as rice mill, noodle mill, tapioca mill, animal feed plant, etc. Industrial sector has expanded sharply during the past years. Industrial types and number of factories are summarized in Table 2.

Most factories are located along main roads, i.e. highway nos. 3, 34 and 304. Exact number and location of factories require to be surveyed because such information is not available at both Provincial Industrial Office and Industrial Works Department in Bangkok.

It was mentioned in section "3.1 Water Supply" that the industrial water demand in the year 1990 was about 6.2 MCM/year, and by the years 1995 and 2005 it will increase to 14.6 and 32.3 MCM/year, respectively. The source is mainly from the Bang Pakong river, of which the quality is deteriorated especially during dry period.

The Industrial Environment Division, Industrial Works Department, Ministry of Industry surveyed some industries in Chachoengsao province during 1978-1979 and the following conclusions can be made:-

(1) Most agro-industrial factories are rice mills having waste flow rate of 30-200 cu.m/day with BOD content in the raw waste between 20-3,200 mg/l. All rice mills have waste treatment system, most of which are collection sump or ponding system. Most mills do not discharge the waste stream to the surrounding canals. Only some mills discharged BOD of about 4-60 mg/l into nearby canals. The effluent standard is set up as the limiting value for BOD of 20 mg/l with the maximum allowable limit of 60 mg/l.

(2) For food mills such as noodle plant, beam thread mill, chinese cake plant, etc., the waste discharge was about 3-300 cu.m/day with BOD in the raw wastewater between 100-1,000 mg/l. Collection sump and ponding system are applied for wastewater treatment. All the generated wastewater is recycled without discharge to the nearby canals.

(3) BOD loading from various factories into the Bang Pakong river can be summarized as follows:-

TABLE 2

INDUSTRIAL TYPES AND NUMBER OF FACTORIES IN CHACHOENGSAO PROVINCE

Industrial Type	Amphoe				Total
	Muang	Ban Pho	Bang Pakong	Bang Khla	
1. Agro-industrial related or food preservation	21	20	25	20	86
2. Food production	10	1	2	11	24
3. Textile and spinning mill	-	-	1	-	1
4. Construction material and equipment production	9	1	6	3	19
5. Animal feed production	1	-	4	1	6
6. Leather/Shoes manufacturing	-	-	4	-	4
7. Furniture manufacturing	2	1	4	3	10
8. Machine/tool production or repair shop	45	-	1	6	52
9. Printing shop	4	-	-	1	5
10. Plastic pellet production	1	-	5	-	6
11. Electronic plant	-	-	5	-	5
12. Sport utility production	1	-	2	-	3
13. Medical equipment production	1	-	-	-	1
14. Decorative articles production	2	-	1	-	3
15. Cooking gas filling plant	1	-	-	1	2
16. Container manufacturing	-	1	-	-	1
17. Chemical plant	-	-	1	-	1
Total	98	24	61	46	229

Source: Industrial Works Department (1989).

Source	BOD loading (kg/d)
Amphoe Bang Khla Amphoe Muang Amphoe Ban Pho Amphoe Bang Pakong	17 112 7 3
Total	139

Main source of BOD loading is from agro-industry and food production plants, most of which are provided only with primary treatment system.

It is expected that in the near future industrial sector will still be expanding in Chachoengsao province. However, the limiting factors for industrial expansion are related to insufficient availability of freshwater and tap water, insufficient power supply, insufficient telephone connection system as well as environmental problems.

The BOD loading from industry in the upstream area of only 17 kg/day is considered to be minor when compared to that discharged from pig farms (7,058 kg/day). Therefore, pig farm will be considered as the main source of BOD contamination in the upstream of the Bang Pakong Diversion Dam.

Comments

Industrial discharge from factories in the vicinity of Bang Pakong river must comply with the effluent standard. And to control pig farm wastewater, effluent standard has to be set up for livestock discharge by responsible government agency.

However, the estimation of BOD loading of wastewater from pig farms are too large, as mentioned above.

3.4 Land Use and Agriculture

Total project area for construction of diversion dam, diversion canal, office building, housing, etc. will cover about 126.4 ha. (793 rai). The existing land use pattern of this area is potential agricultural land, most of which are for mango and coconut plantation. All areas will be expropriated.

Construction of diversion dam will give great benefit to irrigation area along both banks of the Bang Pakong river especially the left bank irrigable area of about 20,000 ha consisting mainly of paddy fields (about 13,500 ha) and orchards (about 6,000 ha). Sufficient availability of freshwater as a result of the construction of Bang Pakong Diversion Dam is expected to increase the agricultural productivity of the irrigation area. Additionally, regulation of water level by the diversion dam is also believed to reduce problems of acid/salty solid in some areas which, in turn, will give more favorable condition for agricultural production. No other suggestion is added on this aspect.

Comments

In order to improve acid/salty soils in some area, there is no case that the water level is purposely controlled by tidal gates. As a result of water level rise due to impoundment in a dry season, they may be improved in some cases.

4. Quality of Life Values

4.1 Socio-economics

Bang Pakong Diversion Dam is one component of the Bang Pakong River Basin Development Project. The dam is expected to provide freshwater to the existing 12,300 ha (76,900 rai) irrigable area on the left bank and future expanded zone of 2,000 ha (12,500 rai) located in Amphoe Bang Khla, Amphoe Muang, Amphoe Ban Pho and Amphoe Bang Pakong of Chachoengsao province and also Amphoe Phan Thong of Chonburi province.

In 1991, Chachoengsao province had 124,020 households, each with average number of 4.8 persons. Amphoe Phan Thong in Chonburi had 7,227

households with average number of 6.2 persons per household. Number and characters of households in the study area can be summarized as follows:-

Description	Damsite	Upstream irrigable area		Upstream irrigable area		Total
		Existing	Future expanded	Existing	Future expanded	
No. of household	52	106	33	175	29	395
Av. members	4.6	4.7	5.5	4.9	5.2	4.9
Family member,	1-9	1-11	1-11	1-11	2-9	1-11
person	2.8	2.9	3.5	2.9	3.0	49.1
Av. workforce, person	45.4	49.1	48.0	50.4	48.3	50.9
% of male	54.6	50.9	52.0	49.6	51.7	
% of female						

Office of Agricultural Economics (1991) predicted that agricultural workforce in Chachoengsao province would have tendency to reduce. It was predicted that out of total workforce of 310,125 in 1992, the agricultural workforce would be only 137,617 or about 44 percent. And in 1996, the agricultural workforce would become only 126,879 or about 38 percent of total workforce of 331,175. The survey in this EIA study revealed the distribution of workforce as detailed in Table 3.

Thus, about 40 percent of population in the study area are agricultural workforce and about 23 percent are non-agriculturist while unemployed is as low as 1.8 percent. It can be noted that the upstream and downstream irrigable areas to be expanded in the future exhibited quite high percentage of non-agricultural workforce of about 18 and 41 percent, respectively.

Agricultural areas in Chachoengsao and Chonburi occupy about 62 and 67 percent of total area of the provinces as shown in detailed below:-

TABLE 3

DISTRIBUTION OF WORKFORCE IN STUDY AREA

Description	Damsite		Upstream Irrigable Area				Downstream Irrigable Area				Total	
			Existing		Future Expanded		Existing		Future Expanded			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Agricultural workforce	132	55	185	38	90	49	330	39	38	25	775	40
Non-agri. workforce	18	8	130	26	33	18	197	23	62	41	440	23
Unemployed	3	1	4	1	3	2	19	2	5	4	34	2
Younger than 15 yrs. old	62	26	101	20	35	19	189	22	23	15	410	21
Others (houseworker, handicapped and old aged)	25	10	73	15	21	12	121	14	23	15	263	14
Total	240	100	493	100	182	100	856	100	151	100	1,922	100

Land Use	Chachoengsao		Chonburi	
	ha	%	ha	%
Forest	126,400	24	25,600	6
Agricultural land	331,200	62	292,800	67
Unclassified	76,800	14	118,400	27
Total	534,400	100	436,800	100

In Chachoengsao, about half of the agricultural area is paddy field with about 27 percent of the remaining agricultural area as orchard. Agricultural products in Chachoengsao in 1991 can be listed as follows:-

	M ton	M Baht
Rice	0.8	2,652
Tapioca	1.3	884
Mango	0.06	1,468

Considering only the districts related to the Bang Pakong Diversion Dam, i.e. Amphoes Bang Khla, Muang, Ban Pho and Bang Pakong, rice and mango are two main products from these districts resulting in income of total 1,357 and 907 million Baht, respectively.

Regarding the construction of Bang Pakong Diversion Dam, the study revealed that about 73 percent of surveyed population is aware of this project. About 43 percent do not know the real purposes of the dam, while about 14 percent perceived that it is aimed at irrigation, and about 12 percent thought that the dam will serve the water consumption demand. Details of surveyed on this regard is summarized in Table 4.

Most of people in the study area are aware of this project from local officers such as district or village heads. Only few percentages learned about this project from mass media.

About 60 percent of surveyed population perceived that this project will bring good benefit to them while the negative perception is that the dam

TABLE 4

SURVEYED RESULT ON ATTITUDE TOWARDS BANG PAKONG DIVERSION DAM

Description of Dam Purpose	Damsite		In the Vicinity of Damsite		Upstream Irrigable Area				Downstream Irrigable Area				Total	
					Existing		Future Expanded		Existing		Future Expanded			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Perception of this project														
Never heard about this project before	0	0	2	11	42	40	2	6	63	36	3	10	112	27
Already knew	52	100	17	89	64	60	31	94	112	64	26	90	302	73
Total	52	100	19	100	106	100	33	100	175	100	29	100	414	100
Perception of purpose of project														
No idea	2	4	6	35	27	42	16	52	68	61	10	39	129	43
Irrigation	10	19	3	17	8	12	3	10	13	12	5	19	42	14
Consumption	13	25	2	12	5	8	4	13	11	10	1	4	36	12
Prevention of brine intrusion	5	10	1	6	10	16	1	3	6	5	3	11	26	9
Flood protection	4	8	1	6	5	8	1	3	2	2	1	4	14	4
Distribution of water to eastern region	8	15	1	6	4	6	1	3	6	5	4	15	24	8
Irrigation and prevention of brine intrusion	2	4	2	12	3	5	1	3	4	3	2	8	14	4
Irrigation and consumption	8	15	1	6	2	3	4	13	2	2	0	0	17	6
Total	52	100	17	100	64	100	31	100	112	100	26	100	302	100

will cause flooding, water pollution and retardation of water drainage. The details on this aspect are summarized in Table 5.

About 41 percent of surveyed population agreed with this project, 30 percent have no idea while 29 percent disagreed. Most people who disagreed have their households at the damsite where they have to be relocated. And those who live at the upstream area disagreed with this project because they are afraid of inundation, wastewater caused by stagnant impoundment and loss of living households and vegetative land. The reason for disagreement expressed by downstream people is because the dam will result in salt water intrusion for a longer period.

Regarding land expropriation and compensation, about 36 percent of surveyed population are willing to cooperate, 22 percent are not willing and 42 percent of people have no idea. The reasons for their willingness to cooperate are mainly because of the perception that the dam will bring great benefit to public and that opposition against the government requirement is considered not possible. Those who are not willing to cooperate gave the reason that they have to lose their agricultural land and believed that the dam is rather disadvantageous. It is worth noted that there seems to be fewer well-cooperated people in the upstream area as presented in detail in Table 6.

The EIA Report emphasized that 65 households at the damsite have to be relocated. Almost all of them (96 percent) are satisfied with existing environment, e.g. neighbourhood, vegetative land, etc. Strong feeling of loving and clinging to present living places makes most of people at the damsite area disagree with this project. About 75 percent of these people still have no plan to relocate. This implies that it would be quite difficult for the government to find new relocation site as suitable as the present living places. Therefore, definite advice and planning for relocation is needed to avoid escalating the unsatisfaction to strong opposition among inhabitants to be relocated. In addition, expropriation and compensation must be completed quickly at one time with reasonable price.

TABLE 5

SURVEYED ATTITUDE TOWARDS WILLINGNESS TO COOPERATE IN LAND EXPROPRIATION/COMPENSATION

Attitude	Damsite		In the Vicinity of Damsite		Upstream Irrigable Area				Downstream Irrigable Area				Total	
					Existing		Future Expanded		Existing		Future Expanded			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
- Willing to cooperate	25	48	6	32	31	29	8	24	67	38	12	41	149	36
- Not willing to cooperate	22	42	4	21	17	16	9	27	33	19	7	24	92	22
- Not decided yet	5	10	9	47	58	55	16	49	75	43	10	35	173	42
Total	52	100	19	100	106	100	33	100	175	100	29	100	414	100
Reasons to cooperate														
- Public benefit	8	32	1	16.7	10	32	3	38	24	36	4	33	50	34
- Reasonable expropriation/ compensation	4	16	1	16.7	1	3	1	12	4	6	1	8	12	8
- More availability of water	0	0	1	16.7	5	16	1	12	6	9	1	8	14	9
- Cannot be opposable against government	13	52	1	16.7	8	26	3	38	18	27	4	33	47	32
- No reason	0	0	2	33.2	7	23	0	0	15	22	2	17	26	17
Total	25	100	6	100	31	100	8	100	67	100	12	99	149	100
Reasons not to cooperate														
- Loss of agricultural land property	13	59	1	25	4	23	4	45	22	67	3	43	47	51
- The dam would bring more disadvantages	4	18	2	50	2	12	2	22	5	15	2	29	17	19
- More serious flooding	0	0	1	25	1	6	1	11	2	6	1	14	6	6
- Severe water pollution due to stagnant impoundment	0	0	0	0	1	6	1	11	1	3	0	0	3	3
- Existing agricultural land is already fertile	5	23	0	0	2	12	0	0	1	3	0	0	8	9
- No reason	0	0	0	0	7	41	1	11	2	6	1	14	11	12
Total	22	100	4	100	17	100	9	100	33	100	7	100	92	100

TABLE 6

ATTITUDE TOWARDS IMPACT DUE TO CONSTRUCTION OF BANG PAKONG DIVERSION DAM

Nature of Impact	Damsite		In the Vicinity of Damsite		Upstream Irrigable Area				Downstream Irrigable Area				Total	
					Existing		Future Expanded		Existing		Future Expanded			
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Positive impacts:-														
a) Irrigation improvement	5	27	4	25	27	44	5	29	71	66	4	24	116	49
b) Water consumption	1	6	2	13	2	3	2	12	5	4	3	17	15	6
c) Flood protection	0	0	1	6	2	3	1	6	4	4	1	6	9	4
d) Prevention of brine intrusion	4	22	1	6	10	16	3	18	9	8	2	12	29	12
e) Flushing of wastewater	1	6	1	6	4	7	1	6	3	3	1	6	11	5
f) Provision of new professions	1	6	2	13	3	5	0	0	4	4	2	12	12	5
g) Provision of benefits to other development	2	11	1	6	4	7	4	23	2	2	3	17	16	7
h) a)/c)/d) above	2	11	3	19	8	13	0	0	7	6	0	0	20	8
i) No supporting reasons	2	11	1	6	1	2	1	6	3	3	1	6	9	4
Total	18	100	16	100	61	100	17	100	108	100	17	100	237	100
Negative impacts:-														
a) Reduction of irrigation water	1	2	1	10	2	4	2	7	4	7	1	11	11	6
b) Flooding	20	50	2	20	28	55	7	26	28	53	3	34	88	46
c) More wastewater	5	13	2	20	4	8	2	7	5	9	1	11	19	10
d) Longer period of salt intrusion	3	8	1	10	1	2	2	7	2	4	1	11	10	5
e) Poorer drainage	7	18	1	10	5	10	1	5	3	6	2	22	19	10
f) Inconvenient water transport	1	2	0	0	3	6	2	7	1	2	0	0	7	4
g) b)/c)/e) above	2	5	2	20	7	13	8	30	10	19	1	11	30	16
h) No supporting reasons	1	2	1	10	1	2	3	11	0	0	0	0	6	3
Total	40	100	10	100	51	100	27	100	53	100	9	100	190	100

Comments

The EIA Report has predicted different aspects of positive and negative impacts to be generated during construction and after impoundment. It proposed that 2.4 km flood protection dike be constructed along the river bank at Ban Bang Hua Lane (Moo 4), Tambon Sao Cha-Ngok in Amphoe Bang Khla. This village has ground level at +0.4 to _0.8 m MSL. The village area is about 300 rai with about 30 households. The requirement of flood protection dike should be definitely determined after hydraulic simulation is carried out in order to identify location of flooding, and if the dike is needed, the length and height of the dike will be considered.

Although it was reported in the EIA study carried out in August to November 1991 that most inhabitants disagreed with relocation, agreement of all the inhabitants to be relocated by monetary land purchasing and compensation were made as a result of the governments efforts, getting the last two households' agreement in December 1991. As of October 1992 when JICA Study Team were executing the first field works, the pressing matters of land expropriation and compensation where the existing difference of land purchasing price and compensation cost between the government side and the related inhabitants should be lessened and ceased to exist for the final agreement of both the sides, and the necessary amount of money should be provided for early payment at once by the Provincial Government. The governor of the Province stressed to JICA Study Team to solve this problem in order that project implementation will not be delayed.

4.2 Land Expropriation and Compensation

The land requirement for the project is 126.4 ha (793 rai) as stated above.

Three alternative approaches were applied to estimate land price:-

Alt. 1 Estimation by provincial sub-committee (Provincial Land Office)

Alt. 2 Estimation by provincial working group on Bang Pakong Project

Alt. 3 Estimation by EIA study team

Land value recently evaluated since Jan 1, 1992 by provincial subcommittee (Provincial Land Office) is as follows:-(Alt. 1)

	Baht/rai
1. Land strip within 80 m along Bang Pakong river bank	600,000
2. Land strip within 40 m along irrigation canal	400,000
3. Land area below irrigation canal up to Bang Pakong river	
(a)Close to road or passage within 40 m	300,000
(b)Other than 3(a) above	200,000
4. Land area below irrigation canal up to boundary of Amphoe Bang Nam Priew	
(a)Close to road or passage of canal within 40 m	200,000
(b)Other than 4(a) above	120,000

Provincial working group on Bank Pakong Diversion Dam project has estimated land price as follows (Alt. 2):-

	Baht/rai
1. Land strip within 80 m along Bang Pakong river bank	1,000,000
2. Other areas	500,000

Land price estimated by EIA study team is based on Alt. 1 above and also sale price expected by landlord which is as follows:- (Alt. 3)

		Baht/rai
1.	Land strip within 80 m along Bang Pakong river bank	900,000
2.	Land close to street, road, public passage within 40 m	650,000
3.	Other areas	500,000

Comparison of land price at market value and expected price by landlord at the location of damsite is as follows:-

Damsite		Market value (Baht/rai)	Expected price by Landlord (Baht/rai)
Village no.1 - Ban Phai Saweg		557,241	766,667
Village no.11 -	Ban Laem Praya Chak	692,857	820,000
	Average price	625,049	793,334

The average investment cost for land development is estimated at 1,620 Baht/rai consisting of following items:-

		Baht/rai
1.	Land preparation for crop cultivation	340
2.	Dredging of fish/shrimp pond	145
3.	Annual dredging of 2x2 m ponding for fighting fish	600
4.	Annual construction of flood protection earth dike	535
	Total	1,620

Compensation cost consisting of land value and investment cost to develop land property can be summarized for each alternative approach as follows:-

Alternatives	Land Value (Million Baht)	Investment Cost (Million Baht)	Total (Million Baht)
1) By provincial sub-committee	197.6	1.3	198.9
2) By provincial working group	439.9	1.3	441.2
3) By EIA study team	437.6	1.3	438.9

Vegetative orchards of mangoes, areca palms and coconuts at damsite will be expropriated and compensated. compensation cost is about 53.7 million Baht.

Government properties and privately-owned buildings will be with total value of 20.3 million Baht. Total compensation cost for each alternative approach can be summarized as follows:-

	Alternative 1 (Baht)	Alternative 2 (Baht)	Alternative 3 (Baht)
1. Land value and investment for development	198,865,480	441,150,880	438,840,230
2. Orchard			
3. Privately-owned building	53,666,881	53,666,881	53,666,881
4. Government property	20,334,140	20,334,140	20,334,140
5. Expense of survey and management	1,090,112	1,090,112	1,090,112
6. Contingency (10%)	1,500,000	1,500,000	1,500,000
	27,395,660	51,624,200	51,393,130
Total	302,852,273	569,366,213	566,824,493

The third alternative estimated by the EIA study teamwas based on present market value and seems to be the most reasonable estimation.

4.3 Evacuation and Relocation

Two alternative evacuation plans were proposed in the EIA. The first plan involves zone-by-zone evacuation depending on development phasing, while the second plan is complete evacuation out of the project site

at one time. Advantages and disadvantages for each alternative can be summarized as follows:-

First alternative Advantage

(1) With less number of evacuees each year, less annual budget will be generated. Market price of construction material and requirement of land area will not much increase.
(2) Those evacuees who are relocated to new places in the former year can assist their relatives to be relocated thereafter.
(3) The remaining groups of evacuees will have longer time for better preparedness, thus having less troubles.

Disadvantages

(1) Longer evacuation period may affect the project schedule.

(2) The remaining villagers may be psychologically affected when their neighbouring friends are gradually relocated.

(3) The same neighbourhood may not be possible to get reunited due to evacuation at different period of time.

Second alternativeAdvantages

(1) Complete evacuation out of the whole project site will not affect the project schedule.

(2) No psychological effect because evacuation is made continuously and shortly finished.

(3) Formation of the same neighbourhood at the new resettlement site is more possible.

Disadvantages

(1) Higher cost for compensation will have to be paid at once for relocation of the whole group of people. This may result in great increase of

demand and market price of construction materials and new resettlement sites.

(2) The evacuees may not be able to assist their relative because all of them will have to be relocated together.

Comments

The EIA Report envisaged various impacts due to evacuation and relocation. Most of them are already mentioned in other study aspects. The most important impact is related to possible loss of agricultural profession among relocated population, if no reasonable compensation is made or new resettlement site and potential vegetative land not arranged for them.

At present the construction period of only about three years being likeliest, the second alternatives should be taken for the relocation, because it will be much time due to unexpected trouble in some cases for the related inhabitants to relocate even at the same time.

4.4 Public Health and Nutrition

Birth rate in Chachoengsao in 1990 of 13.35 per 1,000 is less than the previous year's. Death rate of the same year was 4.48 per 1,000 resulting in net growth rate of 8.8 per 1,000 while the previous year (1989) had net growth rate of 9.4 per 1,000.

Eminent endemic sickness/diseases are diarrhea, dysentery and food poisoning which are quite typical for coastal provinces. Poor environmental conditions favourable to diarrhea are as follows:-

(1) About 99 percent of surveyed population use rainwater for drinking, while 5 percent still have unsanitary water collection system.

(2) Only 26 percent of surveyed population have rainwater available all the year round.

(3) Domestic water comes from wells or canals without pretreatment as much as 99 percent.

(4) About 63 percent of surveyed population have fairly clean domestic water and only 28 percent have clean water.

(5) About 53 percent of surveyed population do not have garbage receptors while about 14 percent dispose of solid waste scatteringly on the ground. About 87 percent of the population burn garbage by themselves.

Diarrhea spreads in both dry and wet seasons, in dry season due to insufficient drinking/domestic water and in wet season due to extensive spreading of infectious germs along with water to those people who never treat their water before consumption. Such infection among children younger than 5 years old normally lasts long without correct medical treatment. It should be mentioned that in 1990 cholera infection occurred in Chachoengsao originally as Vibrio-cholera Inaba and finally as V. C. Ogawa. This infectious disease spread acutely among construction workers generally living in poor environment in the Municipality of Amphoe Muang, Amphoe Ban Pho and Amphoe Bang Pakong. The spreading stopped in March but few cases were still reported many months thereafter.

Dengue haemorrhagic fever transmitted by mosquito Aedes aegypty generally occurred in Chachoengsao every other year. The disease became highly prevalent in the vicinity of damsite in 1989 especially in Amphoe Ban Pho, Amphoe Bang Pakong, Bang Khla and Amphoe Muang. This disease occurred again in 1990 and being continuously prevalent even after rainy season. This means that the mosquito A. aegyti can be culturing well in clean water all the year-round not limited only in rainy season. This conclusion matches well with the survey on sanitation in 1990 which found that only 41 percent of surveyed households had proper covering lids for rain-water jars.

Another infections disease transmitted by mosquito-culex is Japanese B. Encephalitis (JE.). This kind of mosquito transmits the infections virus from livestock to human beings. Even though the infection is quite low in Chachoengsao at present, the tendency of prevalence may increase in the future because of large number of pig farms in the province. Besides, the existing moving currents along canals and rivers as well as brackish water type are not quite favourable to this mosquito-culex.

Malaria transmitted by mosquito-Anopheles generally occurs in July to November. Most malarial patients are found coming from dense forest area in Amphoe Sanamchaiket. It should be emphasized that prevalence rate of malaria in the vicinity of damsite is not high but never becomes reduced and it is still considered as endemic disease.

Even though Opisthorchiasis has never been reported in Chachoengsao, it may become prevalent in future because surveyed population in five amphoes in the vicinity of damsite have habit of eating raw preserved fish which are intermediate host for liver fluke worms. In addition, the habit of defecation in the paddy fields may probably cause transmission of this disease during rice cultivation.

The EIA Report has concluded about impacts possibly occurring after the dam impoundment that sufficient availability of fresh water will be able to reduce prevalence rate of cholera and malaria. However, stagnant water in the impounding area which is the preferable growing condition for mosquito-culex may result in increased prevalence of Japanese Encephalitis. Also, more availability of fresh water is expected to enhance industrialization in the province, which may cause immigration of Northeastern workforces who carry liver fluke worms with them. Thus, higher prevalence of opisthorchiasis is likely to occur after the dam is operated.

Comment

The EIA Report proposed that tidal gates be opened once in a while during dry season to flush away brackish water which is the favourable condition for the growth of vibrio cholera. This is expected to be able to reduce prevalence of cholera in Chachoengsao. However, this approach seems to be impossible because freshwater is very valuable, therefore, tidal gates will not be opened. Only little amount of water will be overflowed.

In the area upstream of the diversion dam, factories location will be planned to be limited even in the future as water quality special conservation area. Therefore, there will be no inflow of laborers from the Northeast Region.

4.5 Recreation and Aesthetics

The EIA study team made a survey at the damsite and concluded that the damsite has never been developed for tourism. Tourist attractive spots are located in Amphoe Muang Chachoengsao, most of which are religious or historic places. The natural scenery of the Bang Pakong river is also attractive to some tourists, therefore, there are boat trip services along the river offered to interested tourists.

Some service business owners at the vicinity of damsite expected that the dam may be attractive to some tourists. Tourists also gave an interview that they want to visit the dam. Most of them want to see beautiful scenery. If the place is developed for tourism, other facilities may have to be provided, e.g. garden/park, toilets, restaurants, fishing area, security guards, etc. The upstream impounded basin will have stagnant water, therefore, it can be developed for water sports such as boat touring, water-skiing, fishing, etc. Upstream land area may become attractive to some investors to develop the place for tourism. However, green scenery along the river bank has to be reserved. In addition, pollution control must be very stringent for these places, otherwise, they may become pollution sources discharging waste into the impounded water.

Conclusion on environmental impacts and mitigative measures of Bang Pakong Diversion Dam project will be summarized in the final detailed design report.

CHAPTER 2. CONSIDERATION ON ENVIRONMENTAL MONITORING PROGRAM

The EIA Report has proposed monitoring program for eight environmental aspects, surface water quality, erosion and sedimentation, aquatic ecology and fishery, forestry, quality of water supply and land use.

Relevant monitoring program under RID's responsibility seems to be related to surface water quality, erosion and sedimentation and aquatic ecology and fishery. The remaining subjects will be responsible for by other government offices.

1. Surface Water Quality Monitoring

1.1 During construction

The EIA Report did not suggest to have monitoring during construction. However, monitoring of suspended solids of the supernatant flowing from the sediment holding basin is considered important.

Location	:	Supernatant flowing out of the sediment holding basin before discharging into the river
Parameter	:	Suspended solids
Frequency	:	Once every day during dredging of both ending joints of diversion canals to the river course
Remark	:	If SS in the supernatant exceeds 500 mg/l, mitigation has to be immediately applied such as increasing height of bund wall surrounding the sediment holding basin or increasing number of sediment holding basins so as to lengthen the sediment retention period.

1.2 During operation

The EIA Report proposed 11 monitoring stations in the Bang Pakong river and its tributaries. However, only six of them seem to be relevant to this diversion dam project and worth for monitoring. Altogether 25 parameters are suggested and considered suitable.

Monitoring program for surface water quality can be summarized as follows:-

(1) Band Pakong river, upstream of Amphoe Bang Khla
(2) Bang Pakong river, upstream of damsite

(3) Bang Pakong river, downstream of Amphoe Muang in front of Wat Sothorn

(4) Bang Pakong river at river mouth

(5) Khlong Bang Phai tributary before joining Bang Pakong river

(6) Khlong Don Si-Non tributary before joining Bang Pakong river

Station No. 1-4 are aimed at monitoring the changing of water quality in the Bang Pakong river after the dam is operating. Especially station No. 4 will be able to point out accumulation of pollutants discharged from downstream factories. Stations No. 4 and No. 5 are tributaries receiving runoff from the left bank irrigable area and discharging it into the downstream river course. Water quality in these tributaries may improve or even become worse depending on whether there is changing of agricultural activity in the vicinity or not.

Sampling depths and sampling time	:	Mid depth sampling is recommended for all parameter except coliforms at surface level. Sampling should be made during low tide for stations located in the downstream river course, i.e. stations No. 3 and No. 4.
Parameters	:	25 parameters including temperature, pH, salinity, turbidity, SS, electrical conductivity, DD, BOD, alkalinity, hardness, ammonia, nitrate, phosphate, fecal coliforms, total coliforms, SAR, fluoride, cyanide, iron, nickel, Manganese , lead, mercury, chromium and cadmium.
Frequency	:	Three times per year in April, September and December. After the first three years of

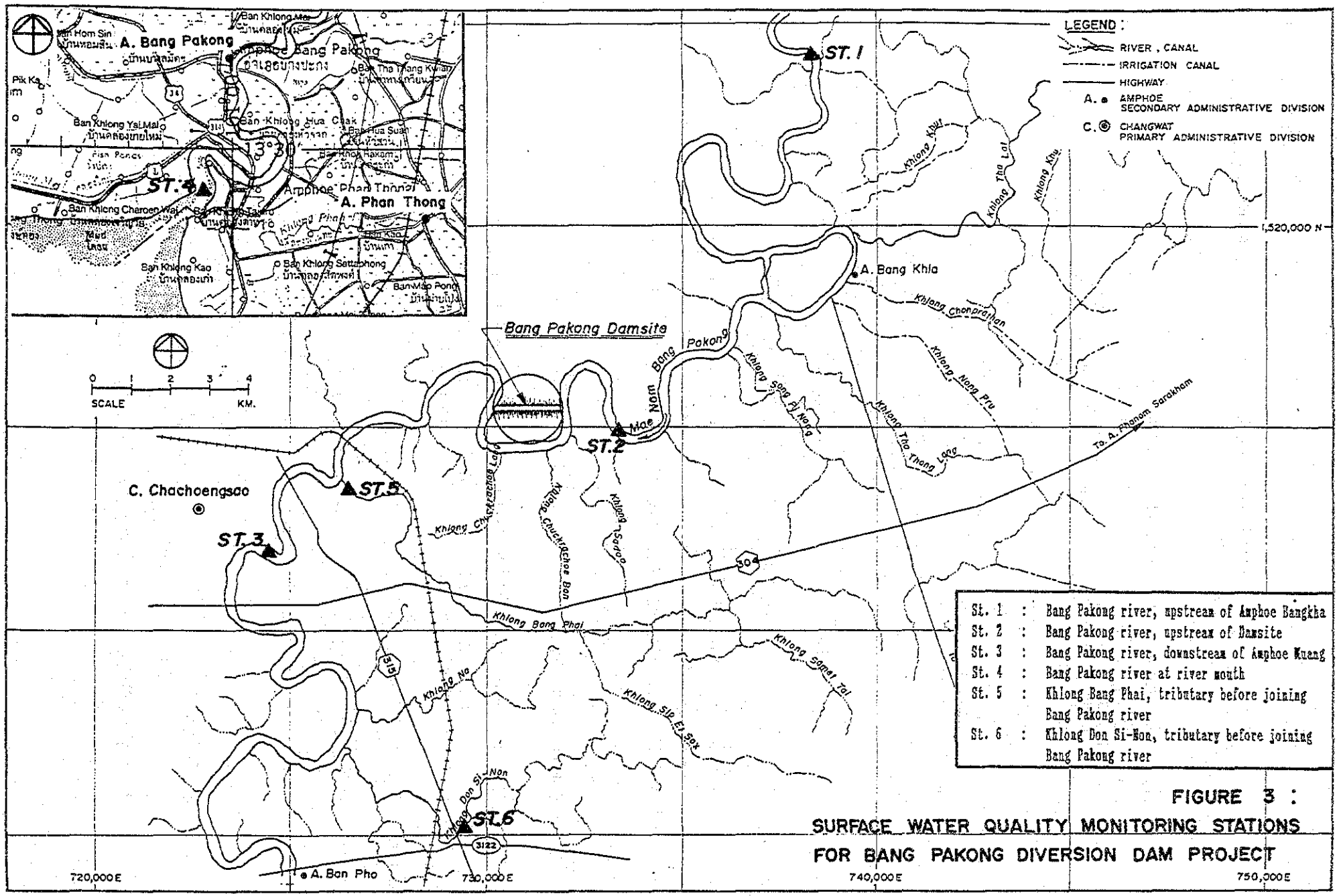


FIGURE 3 :
SURFACE WATER QUALITY MONITORING STATIONS
FOR BANG PAKONG DIVERSION DAM PROJECT

impoundment, all recorded data should be evaluated to identify impacts due to the diversion dam on water quality such that mitigative measures and monitoring program can be adjusted immediately. Comparison of surveyed data with those investigated by other government agencies should also be conducted. For example, if any of heavy metals is not detectable throughout the monitoring period, monitoring in the following years can be neglected.

2. Erosion and Sedimentation

2.1 Monitoring of suspended solids (SS)

Location : 5 stations (See Figure 4)

(1) Ban Pan just downstream form the confluence of Nakhon Nayok and Prachinburi rivers.
(2) Ban Leam Sai about 10 km downstream from station 1.
(3) Ban Klauy about 10 km downstream from station 2.
(4) At Amphoe Bang Khla.
(5) At damsite in the upstream impoundment.

Parameter : Suspended solids

Frequency : Once every month in dry season during the first two years after the dam starts operating.

2.2 Monitoring of sedimentation along the river banks

This can be achieved by erecting scales to detect sedimentation at the inner concave meandering and straight river portion close to above five stations proposed for monitoring of SS. Detection should be made monthly continued for at least 5 years after impoundment.

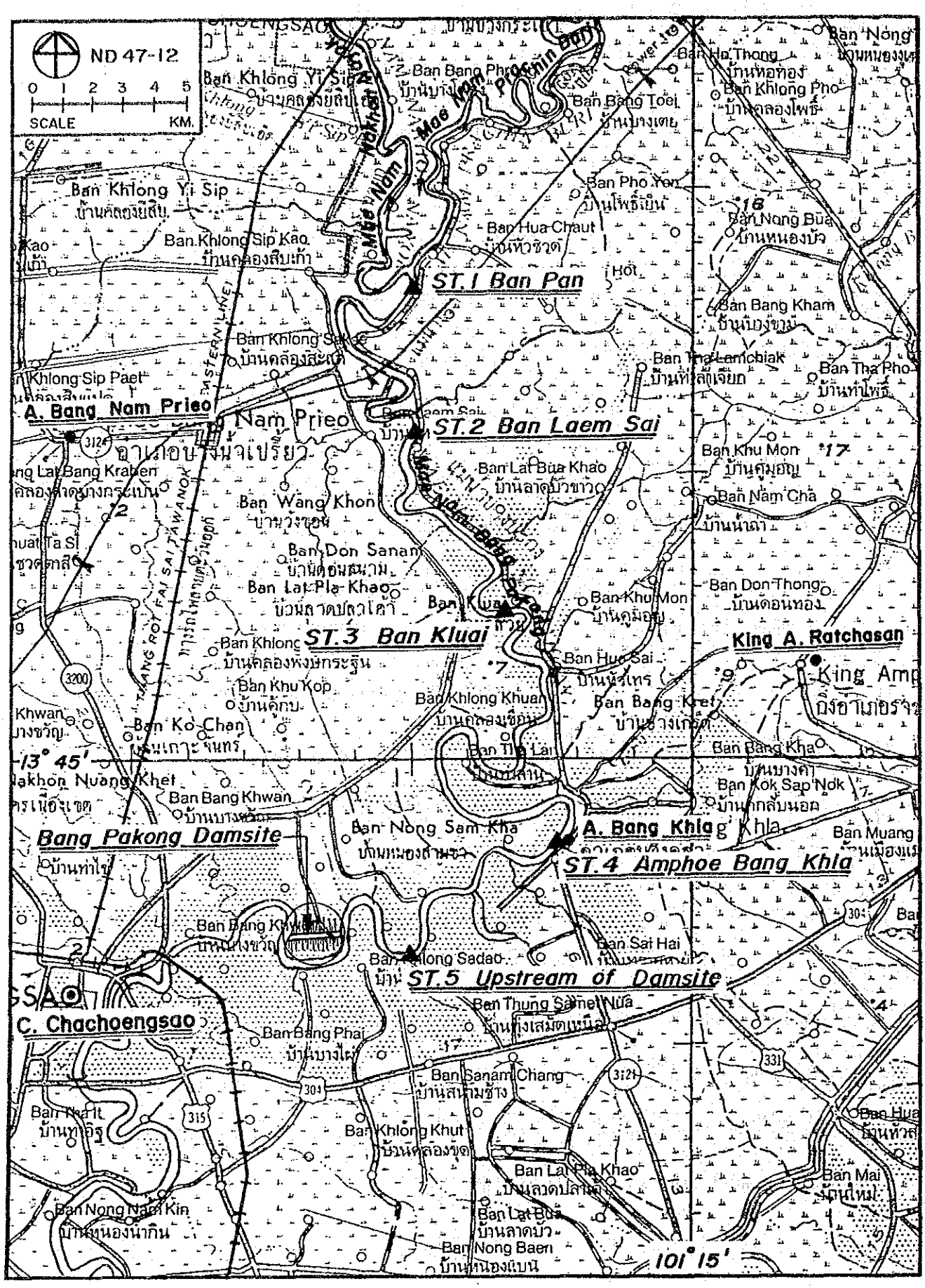


FIGURE 4 : MONITORING STATIONS OF SUSPENDED SOLID

2.3 Monitoring of river bank erosion

Ten locations of non-eroded river bank (outer concaved meandering) should be marked up starting at damsite up to Ban Pan and monthly checking should be made for 2 years after impoundment.

3. Aquatic Ecology and fishery

3.1 Planktons and benthos

Location : At 2 locations, e.e. stations No. 2 and No. 3 as designated for water quality monitoring which are:-
1) Bang Pakong river, upstream of damsite.
2) Bang Pakong river, downstream of Amphoe Muang in front of Wat Sothorn.

Parameters : Type, density and composition of:-
1) Planktons.
2) Benthos.

Frequency : Three times per year concurrently with water quality monitoring, i.e. in April, September and December. Post evaluation should be made after three year monitoring for further adjustment of mitigative and monitoring programs. Comparison of mitigative and monitoring programs. Comparison of RID data with investigation results by other government agencies is also recommended.

3.2 Aquatic plants

Location : Along upstream and downstream river course.

Parameters : type and density of aquatic plants.

Frequency : Three times per year concurrently with water quality monitoring. Post evaluation after 3-year investigation is recommended.

4. Fishery

Type and quantity of fish should be recorded by collecting data from existing fishing equipment available in the Bang Pakong river. Locations for collection of such data are recommended as follows:-

Location : Four stations:-

1) Upstream at Amphoe Ban Sang in Prachinburi province.
2) Upstream impoundment.
3) Downstream close to damsite.
4) Downstream at the river mouth, where there is push net.

Frequency : Once every year.

The monitoring programs in 5 other environmental aspects under the other governmental bodies' responsibilities than 3 aspects under RID's responsibility, which must be included in the EIA report, could not be collected this time. After receiving and reviewing them, a summary of the environmental impact monitoring program will be compiled in the final detailed design report.

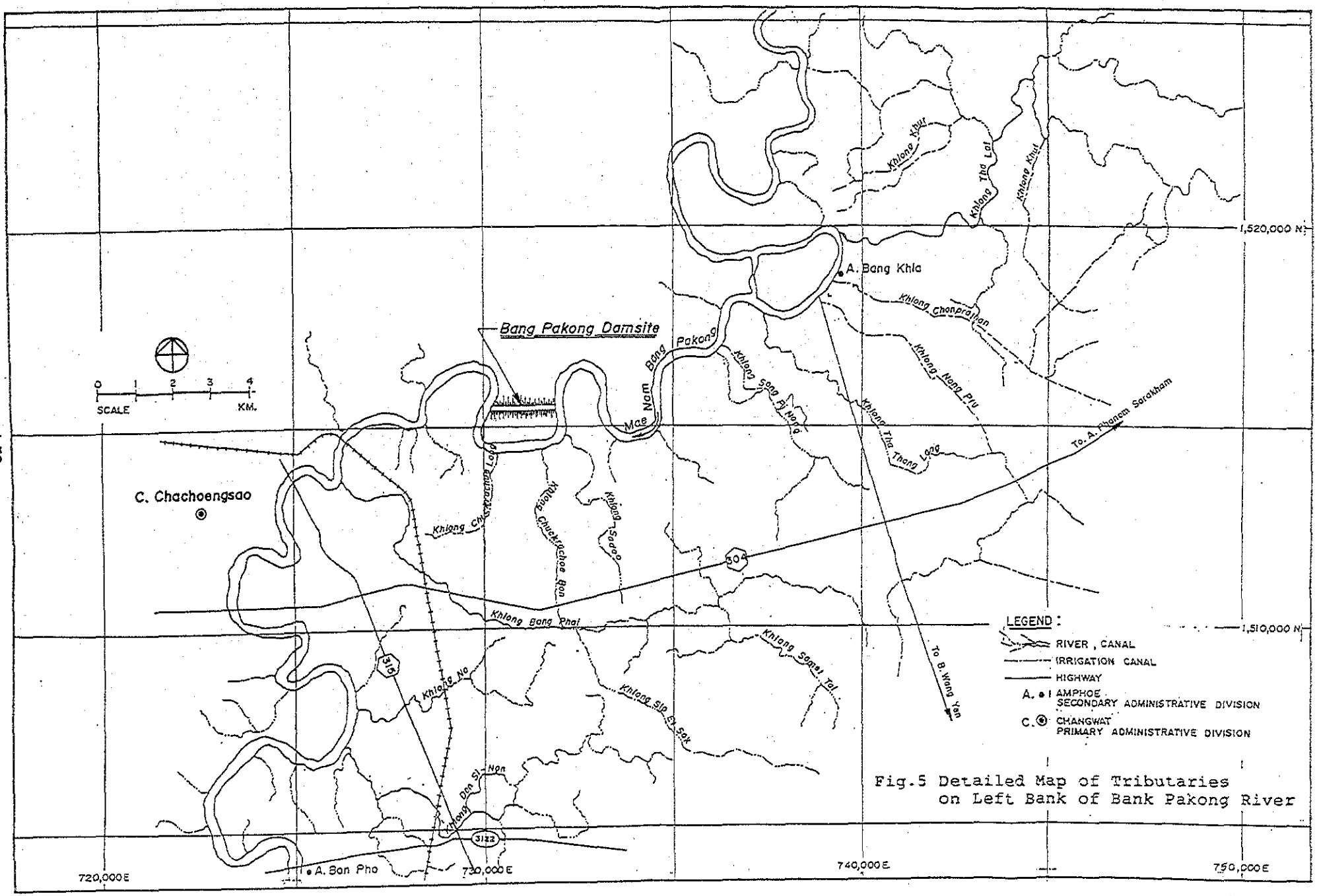


Fig.5 Detailed Map of Tributaries on Left Bank of Bank Pakong River

CHAPTER 3. ENVIRONMENTAL IMPACT ASSESSMENT

1. Recommendation under Environmental Impact Assessment (EIA) Report

In the EIA report compiled by Kasetsart University, there were five recommendations and environmental impact mitigative measures indicated namely:

Recommendation

1) Before the diversion dam can be designed in detail, it is recommended that the hydrological impact of the Bang Pakong river be reassessed. This could be carried out by the hydraulic simulation analysis as proposed by JICA in 1990.

2) It is imperative that a drainage canal be constructed to receive contaminated water from natural canals caused by waste water discharge from livestock farms, manufacturing plants, and the communities. This canal will divert the contaminated discharge into the Bang Pakong river downstream of the damsite.

3) Public relation campaigns should be organized to promote better understanding among the people in the project area and its vicinity concerning the nature, objectives, advantages and disadvantages of the project.

4) A working committee to help the potential evacuees should be set up as soon as possible.

5) A regulating gate or drainage pipe that can regulate or drain bottom layer water should be constructed at the closure dam. this regulating gate must be capable of draining waste water, organic matters, as well as sediments from the bottom layer during the rainy season.

Mitigative Measures

1) Land expropriation of 793 rai involving 65 households has already created tension among the potential evacuees. These people are under duress, and calling for timely social adjustment plan. Such plan should be carried out by the provincial agencies as soon as possible and must be done before the commencement of the project.

2) It is evident that livestock farming and manufacturing industry are the two major water polluters. To prevent waste water discharge into the Bang Pakong river upstream of the damsite, it is recommended that all canals now receiving waste water discharge from livestock farms and manufacturing plants be closed. A drainage canal should therefore be constructed to take natural stream flow to be discharged into the river downstream of the damsite with a total length of 20 km. A budget of 12 million baht will be needed for the construction of this drainage canal and necessary irrigation control building, excluding the land appropriation.

3) Higher water level resulting from water storage will create an overflow on the left bank of the river. It is, therefore, necessary to construct a dike upstream of the diversion damsite along the river bank to the district center of Amphoe Bank Khla, with a length of 13.0 km. A dike downstream of the diversion damsite should also be constructed from the damsite along the river bank to Highway 304 with a length of 15 km. The construction cost of these two dikes (28 km in total) is approximately 35 million baht including the construction of irrigation control building, but excluding land appropriation.

4) After completion of the diversion dam and diversion canal, it is expected that navigation will resume and moderately increase. It is, however, not expected that the number of the passengers will sharply rise. Therefore, the passenger transfer upstream and downstream could be effectively handled allowing them to pass across the dam crest. But to enounce greater security and to

facilitate effective control, it is recommended that jetties be constructed as landing sites both in the upstream and downstream of the damsite.

5) For better protection of brackish water animals, it is imperative to have mangrove forest reforestation along the banks of the river 20 k m in total length from the damsite down to the river mouth. Reforestation area must be at least 2.8 sq.km or 1,750 rai in total with a budget of 7 million baht.

6) One of the objectives of the proposed project is to supply irrigation water. Therefore, it is necessary to establish an agricultural development plan with emphasis on water user's organization and agricultural technology.

The JICA Study Team has made a different recommendation in respect to the item 2 of the recommendation and the item 2 of mitigative measures from the EIA report proposed by Kasetsart University. These two items require construction of drainage canals of 20 km. While the item 5 of recommendation setting up a regulating gate or a drain pipe through the closure dam is no longer needed, as a result of the change of construction design, the old river course upstream and downstream of the closure dam will be used for spoil-dumping upto a depth of 3 m.

The JICA Study Team also recognized that livestock and factory discharges were not regarded as main pollution sources. This fact was proven as a result of JICA study, including that of water quality analyses conducted by the Kasetsart University and the Study Team.

In EIA Report, livestock discharge data obtained was based on the result of the survey made by the Provincial Livestock Department, however, the data, particularly pollution data is lacking in reliability. Moreover, BOD load of factory discharge was recorded only as 17 kg/d due to lack of water supply for livestock and factories at present in the upstream of the proposed diversion damsite. It is unbelievable that the discharges influencing the river water quality flows down into the river. Also, taking into consideration the route of the drainage canal (20 km in length), and such flat