CHAPTER 5 MINERAL RESOURCES

5.1 Methodology

Location of mineral deposits and mining activities within the project or adjacent areas were examined in order to assess the effects of mineral resources on the project or impacts that result from construction in the project on future development of mineral resources. Data on mineral resource and related geological condition, status of mining activities and mineral production in the area of Chiang Rai, Payao, and Nan provinces were collected from geological and mineral resource maps, as well as from Mineral Resource Offices and field observation.

5.2 Results

5.2.1 Existing Mineral Resources

Data on mineral resources revealed that the project area is free from mineral deposit and past or present mining development. From mineral occurrence map of northern Thailand as shown in Figure 5.1, most mineral deposits are concentrated in the western mountain range of Chiang Rai and some in Payao. In Nan province, mineral deposits are found only in southeastern range. The major mineral resources found are the following.

a) **Tungsten:** Tungsten is the mineral found in the western mountain range of Thailand. Tungsten may occur as single mineral i.e. scheelite or wolframite or associated with other minerals such as tin and antimony. Potential areas for tungsten deposit are located in the western range of Chiang Rai and Payao. Chiang Rai formerly was the most famous producer of scheelite. Production, however, has been ceased.

b) **Tin and Antimony:** These two metallic minerals occur in the same geologic setting and may associate with tungsten. Both metals are also found along the western range of Chiang Rai and Payao but reserves are small. As the prices dropped, there is no production at present.

c) **Manganese:** Manganese deposits in Chiang Rai and Payao are small. Previous mineral production came from the abandoned mines north of Amphoe Thoeng (north of the project area). Mining concessions have now been granted for the development in Amphoe Phaya Mengrai, but still wait to be realized.

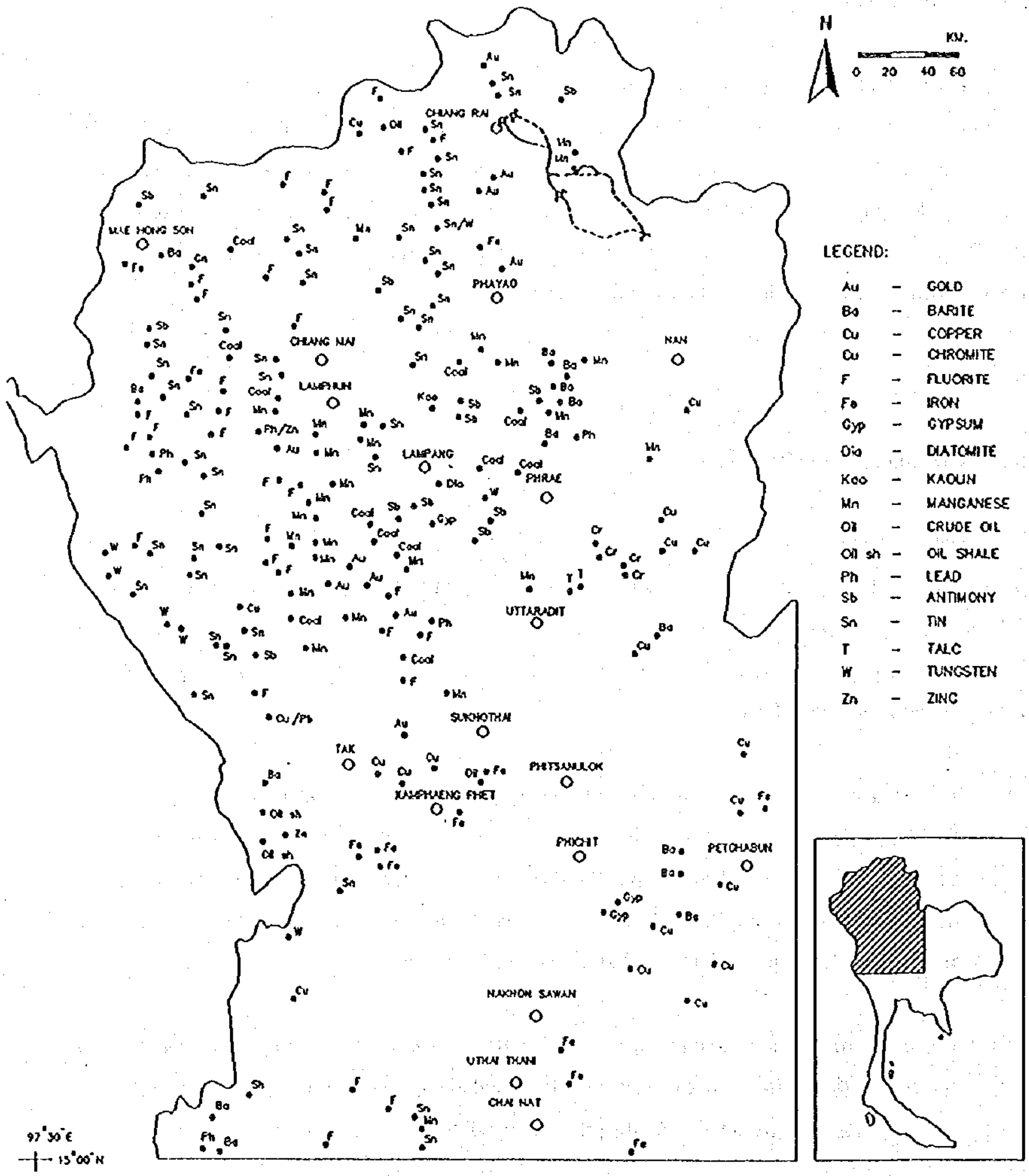

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Figure 5.1 Mineral Occurrence Map of Northern Thailand

d) **Pyrophyllite and Talc:** Both minerals are found in the mountain range between Amphoe Chiang Khong and Amphoe Thoeng. Reserves are marginal and production is still infeasible.

e) **Chromite and Magnesite:** These two minerals occur in the ultramafic belt outside the project area. The belt extends from Amphoe Na Noi, Nan province southwards into Uttaradit province.

f) **Kaolinite and Ball Clay:** The minerals scatterly occur as small deposits in Amphoe Wiang Papao, Chiang Rai province outside the project area.

For mineral resources development, data from Mineral Resource Offices of Chiang Rai, Payao and Nan reveal that there is mineral production in the area at present. Most mines are temporarily closed. The production trend is still going down especially for metallic minerals such as tungsten, tin, and manganese. Industrial minerals such as kaolin, ball clay, limestone for industrial and construction purposes, are increasing in demand. Limestone as construction material is produced by blasting and crushing at several quarries. Its production has been sharply increasing following the socio-economic development of the region.

5.2.2 Initial Environmental Evaluation

a) Impacts of the project on the mineral resources would mainly be a large consumption of construction materials. Requirement for crushed rocks, sand and cement for the project may result in the depletion of mineral resource in the nearby provinces.

b) No major mineral deposits are found in the project area except a small area covered with granite. The project, therefore, will not cause any adverse effect on mineral resources.

c) On the positive side, excavation work of the project might provide information on new mineral deposits.

d) Drilling and excavation of tunnels will encounter certain rocks such as limestone along tunnel alignment B. The rocks may have suitable property and can be used as construction material and might reduce the impacts caused by resource depletion and dumping of the wastes.

CHAPTER 6 GROUNDWATER

6.1 Methodology

A preliminary analysis on ground water system of the project areas covers hydrogeologic conditions, groundwater flow patterns, and groundwater quality. For a water diversion project, the groundwater flow pattern is an important factor due to hydraulic connection between surface water and groundwater. The existing groundwater conditions were preliminary studied based on available data and information gathered from various government and private agencies. The hydrogeological background of the project areas were reviewed, mainly based on the hydrogeological map of northern Thailand with a scale of 1: 500,000 and the hydrogeological map of Thailand with a scale of 1:1,000,000 published by the Department of Mineral Resources.

A field investigation and groundwater sampling were carried out in the project area on 6-7 April 1996. Eight wells were selected as sampling sites for the areas of Kok river basin, Ing River basin, Huai Yot and Nan River basin. The sampling sites are shown in Figure 6.1, while the descriptions are tabulated in Table 6.1.

During the field works, pH condition and electrical conductivity of all samples were measured on site. Other water quality parameters including total dissolved solids, total hardness, total alkalinity, bicarbonate alkalinity, carbonate alkalinity, sodium, potassium, calcium, magnesium, iron, manganese, chloride, phosphate, sulphate, nitrate, and organochlorine were analyzed at Chiang Mai University.

The level of organochlorine in groundwater was measured from four samples, each of which was selected to represent each area. All samples were located near agricultural areas.

Additionally, water level in each sampling well was measured so as to be used as supplementary data for an estimate of groundwater level and flow pattern.

6.2 Preliminary Results

6.2.1 Hydrogeological Background

With reference to the hydrogeological map of northern Thailand of a scale 1:500,000 compiled, the aquifers in the project area can be classified as follows and shown in Figure 6.2.

The Kok River Basin: The aquifers of the Kok river basin can be divided into two different groups, i.e., groundwater in porous rocks and that in jointed massive rocks. The groundwater in porous rocks is characterized as Chiang Rai aquifers and Chiang Mai aquifers. The groundwater in jointed massive rocks is characterized as Granite aquifers, Volcanic aquifers, and Lampang aquifers.

The Ing River Basin: The aquifers of the Ing river basin can be divided into two different groups, i.e., groundwater in porous rocks and that in jointed massive rocks. The groundwater in porous rocks is characterized as Chiang Rai aquifers. The groundwater in jointed massive rocks is characterized as Volcanic aquifers, and Lampang aquifers.

The Huai Yot Area: The aquifers of the Huai Yot area can be classified as the groundwater in jointed massive rocks which is characterized as Lampang aquifers and Metasediment aquifers.

The Nan River Basin: The aquifers of the Nan river basin can be divided into two different groups, i.e., the groundwater in porous rocks and that in jointed massive rocks. The groundwater in porous rocks is characterized as Chiang Rai aquifers and Chiang Mai aquifers. The groundwater in jointed massive rocks is characterized as Mae Sot aquifers, Lower Khorat aquifers, Middle Khorat aquifers, Lampang aquifers, and Volcanic aquifers.

The characteristics of each aquifer is as follows.

Chiang Rai Aquifers-Ocr: (Pleistocene) Consists of thick sequence of clay with minor sand and gravel beds. Generally forms low relatively flat-surfaced terraces. Yield ranges is 10-30 m^3/hr.

Chiang Mai Aquifers-Ocm: (Upper Tertiary to Pleistocene) Consists of unconsolidated and semi-consolidated sand, gravel, and clay beds. Generally forms high terrace and is concealed under younger sediments. Yields are normally 20-50 m^3/hr of potable water.

Mae Sot Aquifers-Tms: (Tertiary) Consists of semi-consolidated fluviatile sediments. The aquifers are generally not very productive due to semi-consolidated properties. Yields are lower at a range of 2-3 m^3/hr. Water quality is generally good.

Middle Khorat Aquifers-Jmk: (Jurassic) Consists of siltstones, sandstones, quatzose sandstones, and conglomerates of Phu Phan, Phra Wihan, and Sao Khua Formations. Groundwater occurs mainly in bedding planes and joints. Yields range from meager to about 5 m^3/hr. Water quality is generally excellent.

Lower Khorat Aquifer-Jlk: (Upper Triassic to Jurassic) Consists of dark brown shales, siltstones, micaceous shanstones, and conglomerates of Nam Phong and Phu Kradung Formations.

Groundwater occurs in complex fractured zones and bedding planes. Yields are 2-5 m^3/hr. Water quality is generally good for domestic purpose.

Lampang Aquifer-Tri: (Triassic) Consists of marine shales, fine grained sandstones, with limestones intercalated. Yields range from meager to about 5 m^3/hr of potable water from poorly interconnected jointing systems. Water quality is generally good.

Metasediment Aquifers-Pcms: (Permian to Carboniferous) Consists of clastic sedimentary rocks of Rat Buri and Kaeng Krachan Groups, of which quartzitic sandstones, feldspathic sandstones, phyllitic to slaty shales, and graywackes are predominant. Groundwater occurs only in joints and fractures. Average yield is 5 m^3/hr. Water quality is generally good, but in many places inferior due to high iron concentration.

Volcanic Aquifers-Vc: Consists of andesite, rhyolite, tuff, agglomerate and pyroclastic rocks. Yields generally range from none to about 5 m^3/hr.

Granitic Aquifers-Gr: A combination of granite, granodiorite, diorite and associated intrusive rocks. Groundwater yields mainly from jointed systems of decomposed zones at a rate of meager to about 5 m^3/hr.

6.2.2 Groundwater Quality

Groundwater quality of 8 samples are tabulated in Table 6.2, and the level of organochlorine of 4 samples are tabulated in Table 6.3. Taking the analyzed groundwater quality into consideration and compared to the groundwater quality standards for drinking purpose as shown in Table 6.4, it is apparent that the analyzed groundwater is generally of good quality and satisfactory for drinking and domestic purposes.

Table 6.1
Description of Sampling Sites
Kok-Ing-Nan Project

Area	Map Series	Sample No.	Location
The Kok river basin	4948I	1	Wat Pa Yang Mon, Tambon Rob Wiang, Amphoe Muang, Changwat Chiang Rai
		2	Ban Wiang Nua, Tambon Wiang Nua, Amphoe Wiang Chai, Changwat Chiang Rai
The Ing river basin	5048III	3	Ban Mae Loi Luang School, Tambon Si Don Chai, Amphoe Thoeng, Changwat Chiang Rai
		4	Wat Ammat, Tambon Wiang, Amphoe Thoeng, Changwat Chiang Rai
Huai Yod	5147IV	5	Ban Pha Lak, Tambon Yot, King Amphoe Song Khwae, Changwat Nan
		6	Ban Song Khwae, Tambon Na Rai Luang, King Amphoe Song Khwae, Changwat Nan
The Nan river basin	5147II	7	Ban Pu Kha, Tambon Rim, Amphoe Tha Wang Pha, Chagwat Nan
		8	Chum Chon Ban Don Tan School, Tambon Si Phum, Amphoe Tha Wang Pha, Changwat Nan

Table 6.2

Results of Groundwater Quality Analysis

(6-7 April 1996)

Parameters	Sampling Site							
	1	2	3	4	5	6	7	8
pH	5.85	6.72	7.20	6.62	6.80	6.95	6.05	6.20
Conductivity (ms/cm)	216	180	357	335	313	428	126	202
TDS (mg/l)	135	122	218	212	198	272	82	130
Total Hardness as $CaCO_3$ (mg/l)	54.7	51.0	123.3	114.4	106.7	167.3	31.6	70.8
Na (mg/l)	14.08	8.80	19.20	18.72	9.60	14.56	12.32	11.84
K (mg/l)	15.22	16.83	3.62	2.01	14.01	2.41	0.80	0.45
Ca (mg/l)	9.25	10.51	40.25	24.25	30.25	45.75	2.51	18.01
Mg (mg/l)	7.68	6.00	5.51	13.08	7.57	12.87	6.16	6.27
Fe (mg/l)	0.025	0.201	0.101	0.051	0.035	0.015	0.050	0.040
Mn (mg/l)	0.086	0.172	0.057	0.017	0.029	0.086	0.023	0.029
Cl (mg/l)	40.8	12.4	19.5	33.7	14.2	24.8	19.5	26.6
SO_4 (mg/l)	3.8	11.6	7.4	25.8	13.9	40.6	3.2	9.0
NO_3 (mg/l)	8.40	0.77	0.91	1.60	4.51	4.92	1.73	0.96
PO_4 (mg/l)	0.255	0.328	0.097	0.082	0.352	0.072	0.040	0.028

Table 6.3
Level of Organochlorine in Groundwater Samples
(6-7 April 1996)

Parameters	Sampling Site			
	1 (mg/L)	2 (mg/L)	6 (mg/L)	8 (mg/L)
HCB	<0.01	<0.01	<0.01	<0.01
gamma-BHC	<0.01	<0.01	<0.01	<0.01
Heptachlor	<0.01	<0.01	<0.01	<0.01
Aldrin	<0.01	<0.01	<0.01	<0.01
o,p-DDE	<0.01	<0.01	<0.01	<0.01
Dieldrin	<0.01	<0.01	<0.01	<0.01
Endrin	<0.01	<0.01	<0.01	<0.01
o,p-DDT	<0.01	<0.01	<0.01	<0.01
p,p-DDD	<0.01	<0.01	<0.01	<0.01
p,p-DDT	<0.01	<0.01	<0.01	<0.01
p,p-DDE	<0.01	<0.01	<0.01	<0.01

Table 6.4

Groundwater Quality Standards for Drinking Purpose

Propert ies	Parameters	Unit	Standard Values	
			Suitable Allowance	Max. Allowance
Physical	Colour	Platinum-Cobalt	5	50
	Turbidity	JTU, NTU	5	50
	pH		7.0-8.5	6.5-9.2
Chemical	Fe	mg/l	0.5	1.0
	Mn	mg/l	0.3	0.5
	Cu	mg/l	1.0	1.5
	Zn	mg/l	5.0	15.0
	SO_4	mg/l	200	250
	Cl	mg/l	200	600
	F	mg/l	1.0	1.5
	NO_3	mg/l	25.0	45
	Total hardness as $CaCO_3$	mg/l	300.0	500
	Non-carbonate hardnessas $CaCO_3$	mg/l	200.0	250
	Total solids	mg/l	750.0	1,500
Toxic	As	mg/l	none	0.05
	Cyanide	mg/l	none	0.2
	Pb	mg/l	none	0.05
	Hg	mg/l	none	0.001
	Ct	mg/l	none	0.001
	Se	mg/l	none	0.001
Bacterial	Standard plate count	colonics/ml	500	
	Coliform Bacteria	MPN/100 ml	2.2	
	E.coli	MPN/100 ml	none	

Note: Penalty : A lincesce who does not comply with this notification shall be punished by fine.

Source : Notification of Ministry of Industry No. 4 B.E. 2521 (1987) issued under the Groundwater Act B.E.2520 (1977), published in the Royal Government Gazette, Vol.95. Part 66. dated June, 27.

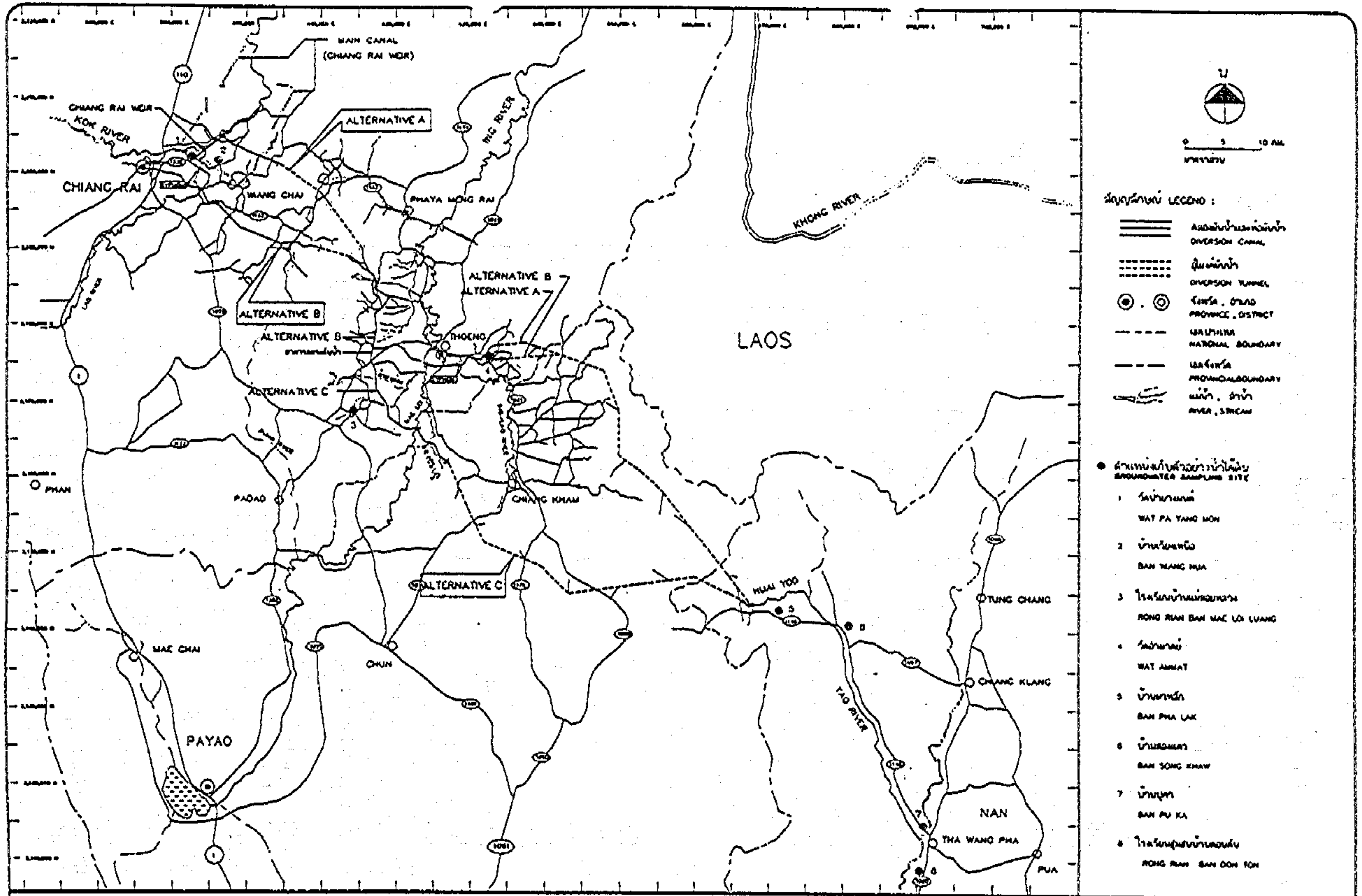

Figure 6.1 Map Showing Groundwater Sampling Site

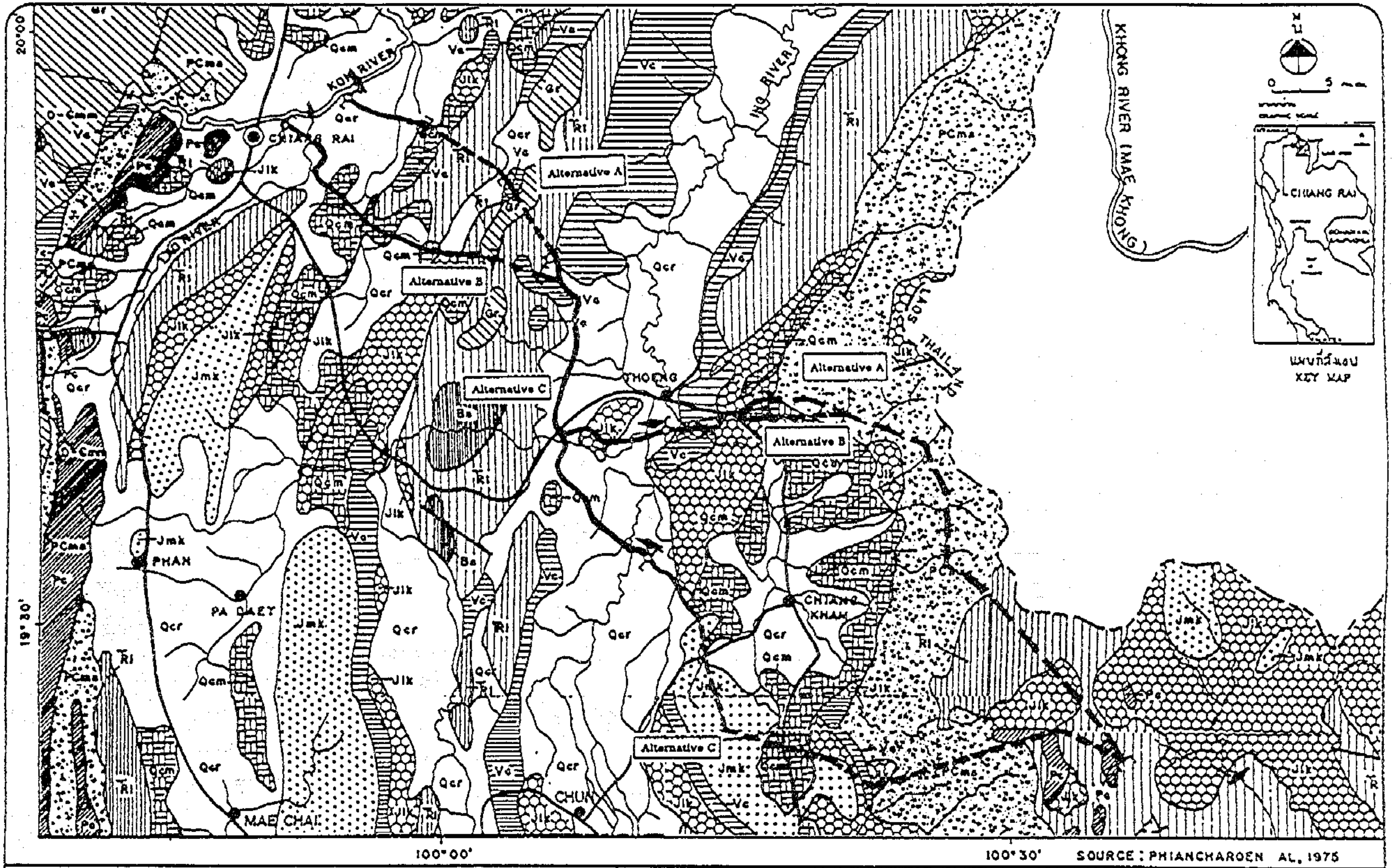

Figure 6.2 Hydrological Map for the Study Area (1/2)

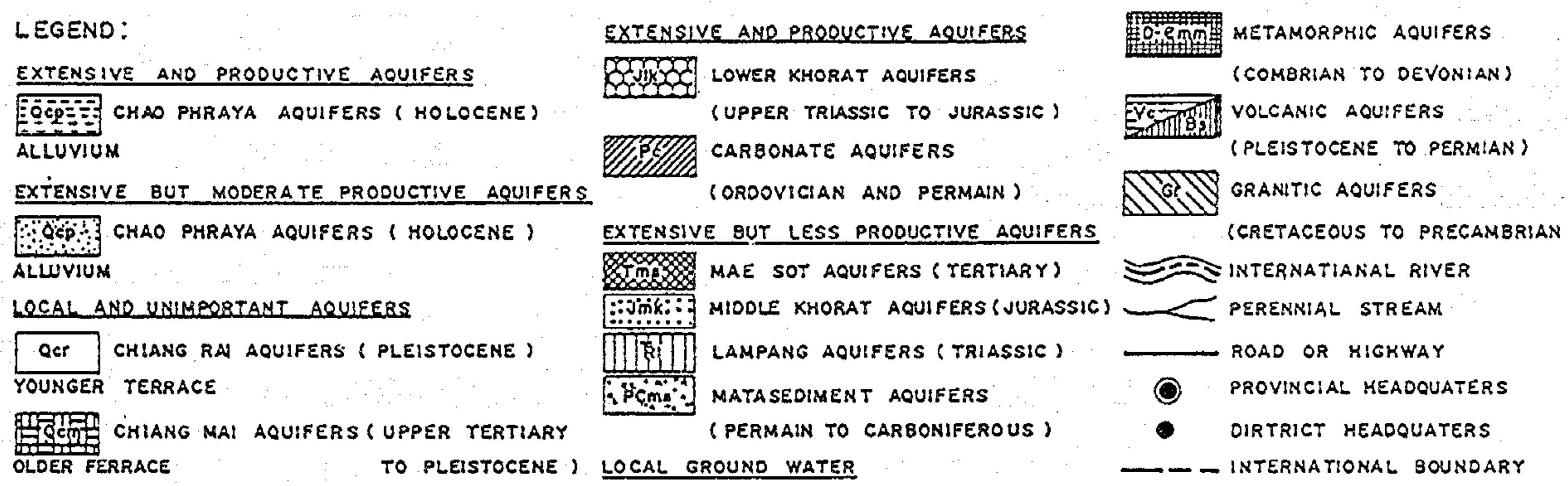

Figure 6.2 Hydrological Map for the Study Area (2/2)

CHAPTER 7 SURFACE WATER HYDROLOGY

7.1 Methodology

The planned diversion canals and tunnels will pass through the natural waterways in Kok-Ing and Nan river basins. The project activities may impose impact on these waterways during construction and operation period. It would be important to select best alignments of diversion canals and culverts based on an analysis of the impact on the existing waterways and incorporate necessary mitigation measures in the event that any adverse impacts are envisaged.

A preliminary analysis on surface water hydrology was carried out based on the existing hydrological data collected and field surveys.

7.2 Data Collected

Meteorological data are collected for 3 meteorological stations in the vicinity of the proposed diversion routes as shown in Table 7.1 through Table7.3. The data present similar levels of the three locations in temperature, pressure, relative humidity, evaporation and cloudiness.

Table 7.4 and 7.5 show rainfall and runoff data at selected points in the three basins. Relatively higher levels of rainfall are recorded in Chieng Rai Province. Generally main waterways have higher runoff and floods in some years, while high runoff is found only in some years and in branch waterways.

7.3 Impact on Surface Water Hydrology

The diversion dam of Alternative B would impose almost no impact since the existing facility will be utilized. Alternative A would impose a higher impact due to the construction of new diversion facilities.

The basic concept of the project is to divert excess water to the Nan river. Excess water during rainy season, therefore, will be diverted resulting in the prevention of floods. No change in surface water condition is envisaged during dry season since no water will be diverted.

Normal flow of waterways will be secured during the construction period due to careful construction planning of various facilities.

Table 7.1

Meteorological Data for the 44 Year Period (1951-1994) at Chiang Rai Station

Months	Pressure (Hectopascal)			Temperature (°C)			Relative Humidity (%)			Visibility (km.)		Cloudiness (0-10)	Sunshine Duration (hr)	Evaporation (mw.)	Dewpoint (°C)	Wind (knots)		
	Mean	Ext. Max	Ext. Min	Mean	Mean Max	Mean Min	Mean	Mean Max	Mean Min	700 L.ST.	Mean	Mean	Mean	Mean	Mean	Mean Wind Speed	Prevailing Wind	Max Wind Speed
January	1014.54	1029.73	1001.06	19.4	27.7	11.9	76	95	47	4.5	7.7	3.2	225.9	93.5	14.5	1.5	E	30
February	1011.71	1024.86	998.02	21.6	30.9	12.7	68	93	36	5.2	6.7	2.5	254.2	129.4	14.4	1.9	S	64
March	1009.39	1026.46	996.65	24.6	33.5	15.9	63	89	33	3.1	4.0	2.9	238.2	164.6	15.9	2.0	S	47
April	1007.26	1021.14	994.36	27.4	35.1	19.7	64	88	38	5.3	6.3	4.3	245.4	185.4	18.9	2.7	S	55
May	1005.79	1017.02	994.28	27.4	33.4	22.1	74	92	53	10.6	11.1	6.6	224.8	148.4	21.9	2.8	S	63
June	1004.16	1012.91	992.91	27.1	31.8	23.0	80	93	62	10.9	11.3	7.9	151.8	113.7	23.1	2.6	S	40
July	1004.30	1014.62	994.02	26.6	31.0	22.9	82	94	66	10.1	10.7	8.3	137.9	99.5	23.1	2.4	S	50
August	1004.59	1014.82	994.00	26.3	30.6	22.7	84	95	68	9.2	10.2	8.1	142.4	88.2	23.2	2.1	S	50
September	1007.36	1018.08	996.38	26.1	30.7	22.2	83	95	66	8.2	10.4	7.3	167.4	93.4	22.9	2.1	S	35
October	1011.33	1022.85	999.25	24.9	29.9	20.4	82	96	62	6.8	10.0	5.9	199.6	97.7	21.4	2.0	NE	30
November	1014.20	1028.42	1002.55	22.4	28.4	17.0	80	96	57	5.7	9.8	4.6	209.6	87.7	18.4	1.7	NE	24
December	1015.88	1028.06	1002.52	19.3	26.5	12.8	79	96	52	4.1	8.5	3.8	225.8	84.6	15.0	1.6	NE	33
Annual	1009.21	1029.73	992.91	24.4	30.8	18.6	76	94	53	7.0	8.9	5.5	2453.0	1386.1	19.4	2.1	-	64

Remark : 1 Knots = 0.5 m/s

Source : Meteorological Department

ENV1010/X2X2/T710-1.XLS

Table 7.2

Meteorological Data for the 44 Year Period (1951-1994) at Payao Station

Months	Pressure (Hectopascal)			Temperature (°C)			Relative Humidity (%)			Visibility (km.)		Cloudiness (0-10)	Sunshine Duration (hr)	Evaporation (mw.)	Dewpoint (°C)	Wind (knots)		
	Mean	Ext. Max	Ext. Min	Mean	Mean Max	Mean Min	Mean	Mean Max	Mean Min	700 L.ST.	Mean	Mean	Mean	Mean	Mean	Mean Wind Speed	Prevailing Wind	Max Wind Speed
January	1013.24	1024.59	1002.66	20.7	28.8	13.4	72.0	93.0	42.0	5.7	7.3	2.6	N.O.	96.1	14.6	0.9	S,NW	27.0
February	1010.32	1024.28	999.60	23.6	32.2	15.3	60.0	87.0	30.0	6.0	6.8	2.1	N.O.	120.3	14.0	1.2	SE,S	29.0
March	1007.96	1026.48	996.26	27.4	35.1	19.6	51.0	76.0	28.0	5.6	6.2	2.5	N.O.	171.2	14.9	1.7	SE	33.0
April	1006.19	1020.36	995.12	29.4	36.2	22.9	55.0	78.0	34.0	7.7	7.9	4.0	N.O.	192.0	18.1	1.7	SE	64.0
May	1005.40	1014.54	995.50	28.2	33.6	23.7	71.0	88.0	52.0	11.4	11.3	6.2	N.O.	164.7	21.8	1.7	SE	40.0
June	1003.68	1011.08	994.98	27.5	31.9	24.0	76.0	89.0	61.0	12.1	12.0	7.6	N.O.	138.1	22.6	2.3	SE	30.0
July	1004.22	1011.81	995.54	27.0	31.2	23.5	79.0	91.0	63.0	11.3	11.3	8.2	N.O.	126.6	22.6	2.0	SE	25.0
August	1004.25	1012.18	994.19	26.7	31.1	23.4	81.0	94.0	65.0	10.6	11.1	7.5	N.O.	121.2	23.0	1.6	SE	40.0
September	1007.19	1015.94	998.44	26.4	31.1	23.0	83.0	95.0	65.0	8.0	10.0	7.1	N.O.	110.1	23.1	1.1	SE	25.0
Octerber	1010.55	1021.73	998.69	25.2	30.0	21.6	83.0	96.0	63.0	5.9	8.7	5.8	N.O.	101.2	21.8	0.9	NW	19.0
November	1013.80	1027.28	1001.49	22.8	28.6	18.0	81.0	96.0	56.0	5.6	8.3	4.4	N.O.	87.6	18.8	0.9	NW	32.0
December	1015.41	1027.56	1004.36	19.5	27.0	13.1	77.0	95.0	48.0	4.9	7.4	2.9	N.O.	84.8	14.9	0.9	NW	20.0
Annual	1008.52	1027.56	994.19	25.4	31.4	20.1	72.0	90.0	51.0	7.9	9.0	5.1	N.O.	1513.9	19.2	-	-	64.0

Remark : 1 Knots = 0.5 m/s. N.O. = Non Observation

Source : Meteorological Department

ENV1010/X2X2/T710-2.XLS

Table 7.3

Meteorological Data for the 44 Year Period (1951-1994) at Nan Station

Months	Pressure (Hectopascal)			Temperature (°C)			Relative Humidity (%)			Visibility (km.)		Cloudiness (0-10)	Sunshine Duration (hr)	Evaporation (mw.)	Dewpoint (°C)	Wind (knots)		
	Mean	Ext. Max	Ext. Min	Mean	Mean Max	Mean Min	Mean	Mean Max	Mean Min	700 L.ST.	Mean	Mean	Mean	Mean	Mean	Mean Wind Speed	Prevailing Wind	Max Wind Speed
January	1014.48	1028.86	1003.10	21.1	30.0	13.5	76.0	97.0	46.0	2.0	5.6	3.3	N.O.	81.0	15.8	0.9	SE	16.0
February	1011.79	1025.48	1000.42	23.5	32.8	15.0	69.0	95.0	39.0	2.6	4.6	2.6	N.O.	90.8	16.5	1.2	S	33.0
March	1009.55	1026.18	998.66	26.7	35.4	18.4	65.0	92.0	37.0	2.5	3.6	2.7	N.O.	118.5	18.4	1.3	S	47.0
April	1007.48	1021.00	995.75	29.2	36.7	22.0	66.0	90.0	41.0	3.6	4.9	3.8	N.O.	142.5	21.3	1.5	S	40.0
May	1006.14	1021.74	997.38	28.9	34.8	23.7	75.0	93.0	55.0	6.3	8.5	6.7	N.O.	138.5	23.6	1.4	S	63.0
June	1004.82	1012.68	995.80	28.3	33.0	24.2	80.0	94.0	63.0	7.5	9.0	8.0	N.O.	109.4	24.1	1.5	S	35.0
July	1005.00	1016.50	995.88	27.6	32.0	23.9	82.0	95.0	67.0	7.2	8.8	8.4	N.O.	100.5	24.0	1.4	S	33.0
August	1005.12	1013.89	995.18	27.2	31.6	23.7	85.0	96.0	70.0	6.8	8.5	8.4	N.O.	96.9	24.2	1.3	S	33.0
September	1007.43	1016.19	996.60	27.1	32.2	23.4	85.0	97.0	67.0	5.9	8.5	7.6	N.O.	99.5	24.1	1.0	S	40.0
Octerber	1011.04	1021.10	1000.04	26.3	32.0	21.8	82.0	96.0	62.0	4.1	8.1	5.9	N.O.	101.0	22.7	0.8	S	33.0
November	1013.83	1025.52	1002.58	24.3	30.8	18.5	80.0	97.0	56.0	2.3	7.4	4.6	N.O.	86.2	19.9	0.8	E	33.0
December	1015.58	1028.27	1004.12	20.9	29.2	14.3	78.0	97.0	51.0	1.6	6.7	3.8	N.O.	77.3	16.4	0.8	E	21.0
Annual	1009.36	1028.86	995.18	25.9	32.5	20.2	77.0	95.0	55.0	4.4	7.0	5.5	N.O.	1242.1	20.9	1.1	-	63.0

Remark : 1 Knots = 0.5 m/s, N.O. = Non Observation

Source : Meteorological Department

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Table 7.4
Rainfall Data at Stations in the Study Area

No.	Code	Stations	Data Period	Monthly Rainfall (mm.)												Annual Rainfall (mm.)		
				Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Average	Maximum	Minimum
		Kok River Basin																
1	08013	Muang, Chiang Rai	1952-1994	84.9	201.0	208.3	305.1	396.5	271.3	130.6	50.4	20.9	11.7	7.0	21.2	1,708.9	2,184.5	1,006.3
2	08042	Toeng, Chiang Rai	1956-1994	74.4	193.6	185.5	295.3	368.4	229.0	91.6	46.1	15.0	10.2	9.7	22.2	1,541.0	2,144.3	711.6
3	08242	Wiangchai, Chiang Rai	1971-1994	35.9	102.0	142.7	270.6	262.1	191.5	116.3	29.6	13.3	0.2	7.8	28.3	1,200.3	1,580.9	781.5
4	08261	Mae Kok (G2A), Muang, Chiang Rai	1993-1994	34.8	215.8	220.9	252.2	437.2	269.9	128.1	12.2	6.0	0.0	0.0	108.2	1,685.3		
		Ing River Basin																
1	08042	Toeng, Chiang Rai	1956-1994	74.4	193.6	185.5	295.3	368.4	229.0	91.6	46.1	15.0	10.2	9.7	22.2	1,541.0	2,144.3	711.6
2	73022	Chiangkham, Phayao	1952-1994	80.7	175.2	159.8	247.9	306.1	211.7	84.6	33.7	13.7	9.4	10.4	21.3	1,354.5	2,003.6	802.3
3	73032	Pong, Phayao	1952-1994	92.0	181.0	116.0	179.6	245.6	197.4	98.0	20.4	9.9	8.0	6.5	21.9	1,176.3	1,620.9	770.9
		Nan River Basin																
1	28073	Tha Wang Pha, Nan	1968-1994	95.3	197.8	197.4	256.1	297.1	170.3	77.2	19.7	10.2	10.0	11.9	35.9	1,378.9	1,857.1	956.9
2	28102	Chiangklang, Nan	1970-1994	88.7	146.9	151.2	275.1	306.0	138.5	55.3	13.2	6.0	8.6	5.6	27.3	1,222.4	1,724.0	322.5

Table 7.5
Average Annual Runoff at Stations in the Study Area

No.	Rivers	Stations	District	Province	Location		Code	Responsible Office	Watershed (km^2)	Record Period	Data	Average Annual Runoff		Average Runoff per Watershed ($l/s/km^2$)
					Latitude	Longtitude						mcm.	cms.	
	Kok River Basin													
1	Kok River	Mae Kok Bridge	Muang	Chiang Rai	19°55'18"N	99°50'54"E	G2A	RID	6,063	2501-2524	24	3593.64	113.95	18.79
	Ing River Basin													
1	Ing River	Thoeng	Thoeng	Chiang Rai	19°41'12"N	100°11'30"E	IN1	DEDP	5,700	2510-2536	27	1818.60	57.67	10.12
	Nan River Basin													
1	Yao River	Ban Wat Hit	Tha Wang Pha	Nan	19°09'31"N	100°46'56"E	N51	RID	774	2522-2534	13	384.20	12.18	15.74
2	Ing River	Ban Nam Ing	King Amphoe Phraya Meng Rai	Chiang Rai	19°05'08"N	100°55'51"E	N4	RID	6,155	2537	1	4233.00	134.23	21.81

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CHAPTER 8 WATER USES AND IRRIGATION

Data on water demand for industrial, domestic and irrigation uses are collected from the existing reports and plans as follows.

Table 8.1 Existing Estimates of Water Demand

River	Industrial & Domestic Water (MCM / year)				Irrigation Water (m^3 / Rai)		
Kok River	(a)	1993	:	417	Rainy season	:	848
		1996	:	471	Dry season	:	4,090
		2006	:	574			
	(b)	Present	:	583			
		Future	:	787			
Ing River	(c)	1993	:	283	Rainy season	:	834
	(d)	Present	:	360	Dry season	:	3,894
		Future	:	477			
Nan River	(e)	Present	:	866	Upper Nan		
	(f)	Upper Nan			Rainy season	:	1,611
		Present	:	135	Dry season	:	4,289
		Future	:	293	Lower Nan		
					Rainy season	:	1,302
					Dry season	:	4,373

Source:

(a) Study of Development Potential for Kok River Basin, Chiang Mai University (1994)

(b), (d), (e) engineering estimate

(c) Study of Principal Plan and Action Plans for Environmental Management and Water Resources Rehabilitation in Mae Ing Watershed Area, OEPP (1995)

(d) Study by NESDB (1994)

The impact of the project on water uses and irrigation is on the positive side in terms of increased water supply. No negative impact is envisaged.

CHAPTER 9 FLOOD CONTROL

The Kok and Ing River Basins experience severe flood every 20 years. In 1994 substantial damages were caused by heavy rain and four depressions. Short-period floods occur occasionally in the Nan River Basin. Drainage condition is better in the Nan Basin.

The Alternative A route passes through plains, while Alternative B route runs through mountainous areas. Measures for flood control would be needed more for the Alternative B and C routes, since a larger number of natural streams cross the routes as shown in Table 9.1.

Table 9.1
Summary of the Natural Stream and Road Crossed by Diversion Canals/Culverts and Tunnels

(Unit:Line)

Item	Kok-Ing		Ing-Nan		
	Alternative A	Alternative B	Alternative A	Alternative B	Alternative C
Natural Strream					
- Small	22	28	3	1	3
- Medium	6	6	4	2	1
- Large	3	3	4	3	1
Road					
- Rural road	15	18	2	2	1
- Main road	6	10	-	-	-

Source : Field Survey, 1996

CHAPTER 10 TRANSPORTATION

10.1 Methodology

The implementation of the Kok-Ing-Nan project would induce many activities during construction period which would increase traffic volume on roads in and around the project area, such as material transportation, workers transportation and tunnel construction residue transportation.

The study on transportation comprises land transportation and navigation. A field survey was conducted during 27-29 May 1996 including investigation on condition of existing roads, waterways within the 3 alternative areas, collection of data on type and numbers of vehicles from related government offices. An impact assessment of the 3 alternatives of water diversion schemes was made based on the collected information.

10.2 Results

10.2.1 Data and Information Collected

Land transportation network in the project area in Chiang Rai Province and Payao Province consists of the national highway No. 1 from Payao to Chiang Rai as the main route linking with provincial highway No. 101 (Sukhothai - Phrae - Nan) by highway No. 103 (Ngao - Rong Kwang) as shown in Figure 10.1. Other highways include highway No. 1126 (Phan - Pa Daed), highway No. 1202 (Payao - Pa Daed), highway No. 1021 (Payao - Chun - Toeng) and highway No. 1020 (Chiang Rai - Toeng).

Table 10.1 and 10.2 show highways crossing the proposed canal and culvert routes under three alternative cases.

In the area of diversion dam area in Nam Kok and Nam Ing, there are 2 main asphaltic roads with 2 traffic lanes connected by 2-lane minor lateritic roads in generally rather good condition.

Diversion canals and diversion tunnels in each alternative run mainly through agricultural area and in pararel with roads except at the crossings with the existing highways mentioned in Tabale 10.1 and 10.2. The tunnel entrance is located far from the traffic route. The tunnel alignment would be at a depth of 500-1,000 meters from soil surface.

Data on traffic volume on highways within the project area are shown in Table 10.3. It is found that the traffic volumes are low. The most vehicles were motorcycles, four-wheel trucks and private cars.

10.2.2 Initial Environmental Impacts

Same characteristics were found in the network of the transportation routes near diversion canal of the alternative A, B and C of the Kok-Ing section and diversion canals and tunnels of the Ing-Nan section i.e., there are main roads and minor roads linking together, some part of the roads are rough, inconvenient for traveling, especially the access road to diversion dam in Nam Kok of the alternative A and the access road to tunnel entrance of the alternative C of the Ing-Nam portion. These access roads are very rough with high slope. During the construction period, construction material transportation may cause some damage to surface of roads, thus, the material transportation issue should be well taken care of.

Table 10.1

The Main Road Near or Crossing with the Diversion Canals

Kok-Ing		Ing-Nan		
Alternative A	**Alternative B**	**Alternative A**	**Alternative B**	**Alternative C**
Highway number 1173, 1152, 1174 and 1020	Highway number 1232, 1152, 1174 and 1020	Highway number 1021, 1155 and 1222	Highway number 1021, 1155 and 1222	Highway number 1179

Source : Field Survey, 1996

Table 10.2

The Main Road Which The Diversion Tunnels will Pass Beneath

Kok-Ing		Ing-Nan		
Alternative A	**Alternative B**	**Alternative A**	**Alternative B**	**Alternative C**
Highway number 1152	–	Highway number 1155, 1222, 1903, 1210, 1148 and 1160	Highway number 1021, 1155, 1222, 109, 1210, 1148 and 1160	Highway number 1021, 1179, 1148 and 1160

Source : Field Survey, 1996

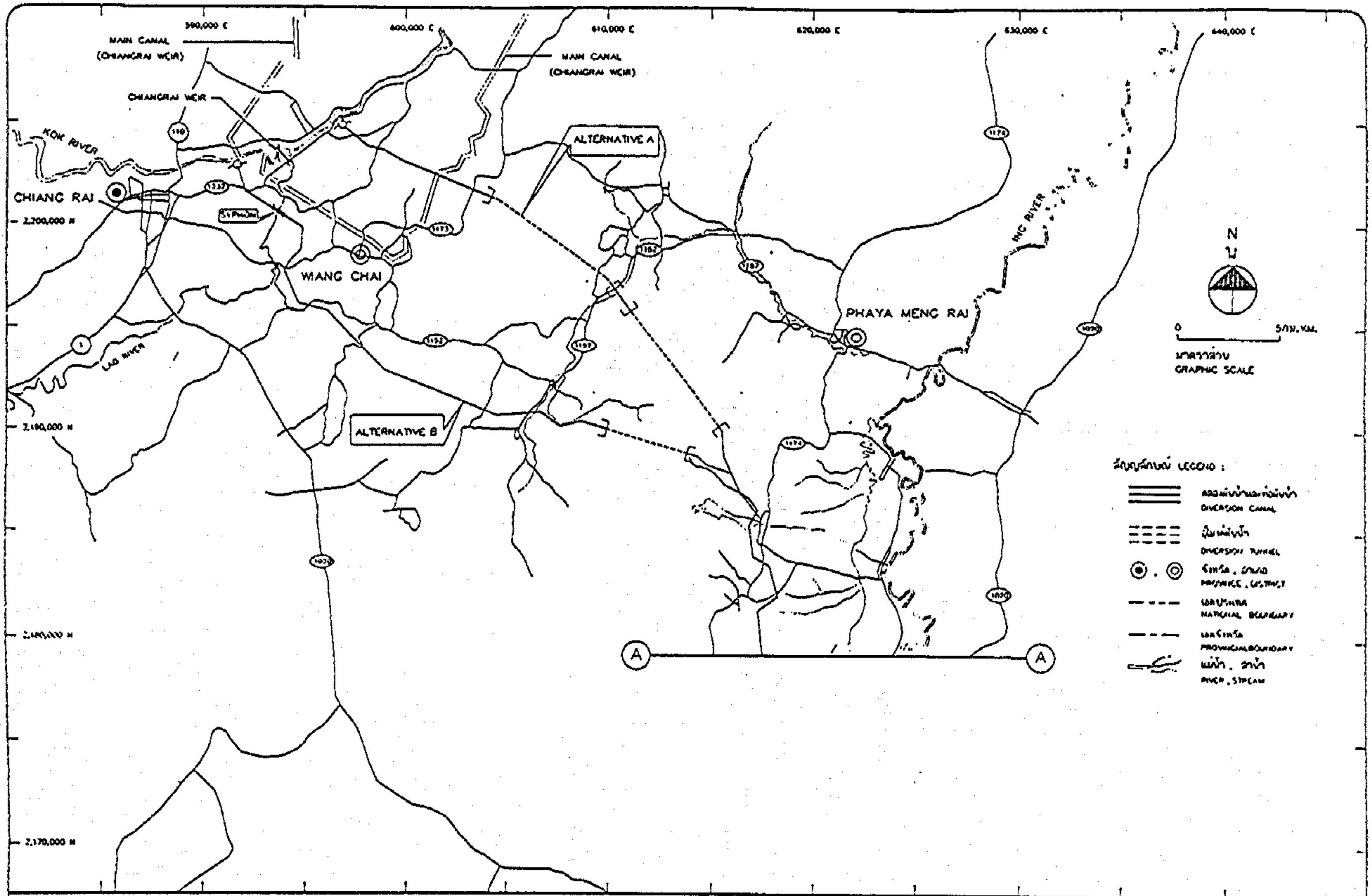
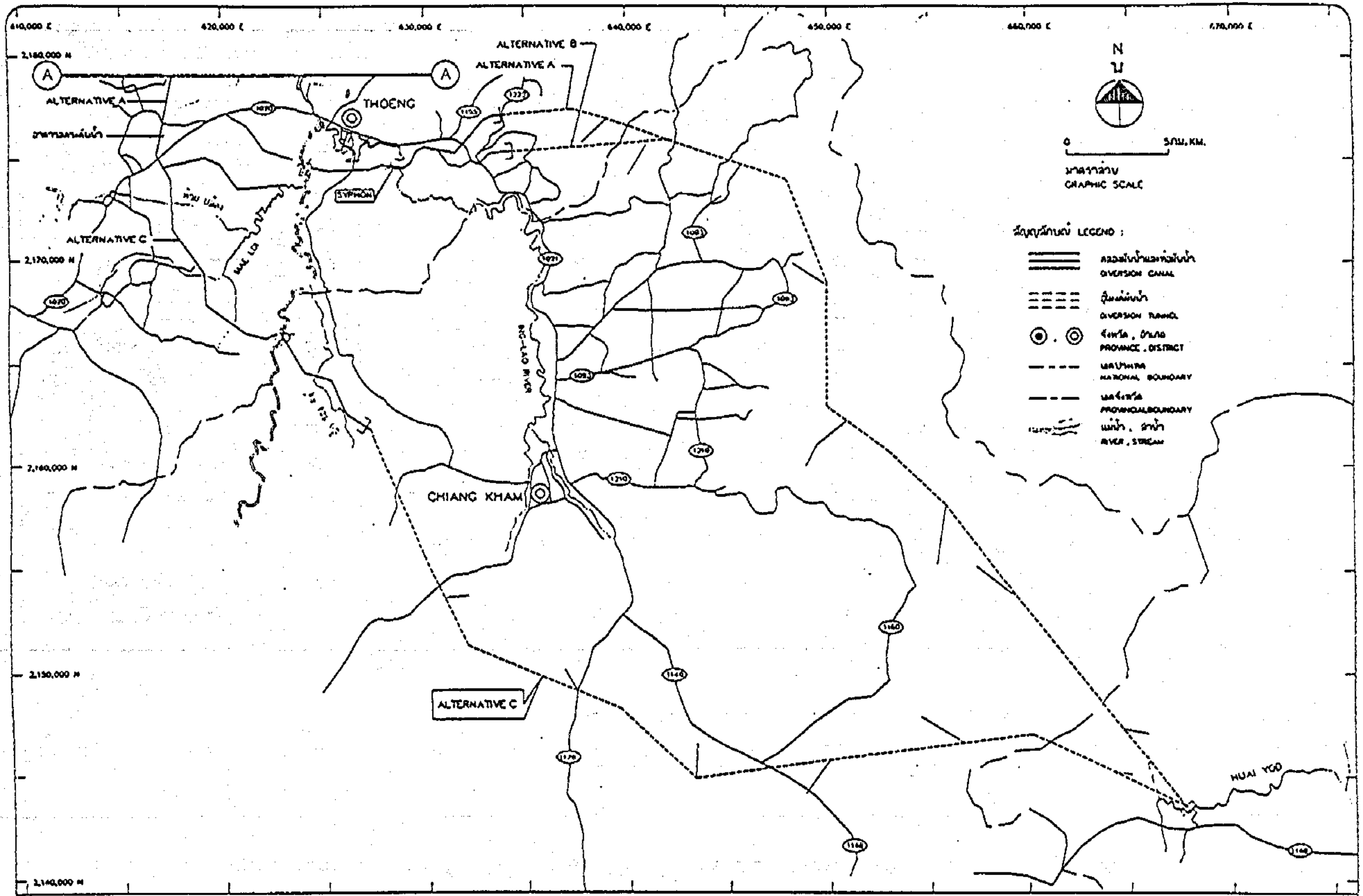


Figure 10.1 Transportation Network in the Project Area (1/2)



CODE : POZC.DWG

Figure 10.1 Transportation Network in the Project Area (2/2)

Table 10.3 (1/3)

Average Annual Daily Traffic Volumes on Highway No. 1020, 1721, and 1152, during 1993-1995

Route No.	Control Section	Terminal	Year	Type Code	Station km.	Car and Taxi	Light Bus	Heavy Bus	Light Truck	Medium Truck	Heavy Truck	Total	% Heavy Vehicle	Bi + Tri Cycles	Motor Cycle
1020	100	SCT.R.No.1 (Chiang Rai -	2536	C	6+000	1296	236	133	2716	630	315	5326	20.24	23	2155
		Pong Klua)	2537			2018	517	118	1331	438	530	4952	21.93	21	2181
			2538			3314	281	145.	1681	400	217	6038	12.62	18	2548
	201	Pong Klua - Ban Phlong	2536	C	36+000	558	41	115	992	212	111	2032	21.70	11	446
		(Chiang Kam Dist.)	2537			426	41	129	1311	219	132	2258	21.25	63	568
			2538			1118	40	119	1076	210	143	2706	17.44	8	594
	202	km. 52+550	2536	C	60+000	395	170	117	2267	315	130	3394	16.55	66	2516
		(Chiang Rai Dist.) - Thoeng	2537			596	279	212	2477	441	214	4219	20.54	169	3114
			2538			1734	998	338	4001	854	384	8309	18.96	345	4620
	300	Thoeng - Nam Phrae Bridge	2536	C	74+000	414	127	118	1760	299	169	2887	20.29	74	1964
			2537			783	219	173	2288	601	290	4354	24.43	188	2890
			2538			1046	228	181	2953	589	315	5312	20.42	264	3919
	400	Nam Phrae Bridge -	2536	C	106+000	212	43	79	833	87	36	1290	15.65	135	1436
		Chiang Khong	2537			206	36	77	853	96	40	1308	16.28	77	1806
			2538			167	38	56	914	115	38	1328	15.73	5	978

Table 10.3 (2/3)

Average Annual Daily Traffic Volumes on Highway No. 1020, 1721, and 1152, during 1993-1995

Route No.	Control Section	Terminal	Year	Type Code	Station km.	Car and Taxi	Light Bus	Heavy Bus	Light Truck	Medium Truck	Heavy Truck	Total	% Heavy Vehicle	Bi + Tri Cycles	Motor Cycle
1021	100	JCT.R.No.1 (Mae Dam) -	2536	C	7+800	2546	304	173	3278	451	155	6907	11.27	112	3510
		Chun	2537			3134	384	261	2880	462	349	7470	14.95	248	2767
			2538			3566	287	173	2687	728	407	7848	16.66	142	2886
	201	Chun - km.59+100	2536	C	46+455	722	79	80	935	275	74	2165	19.81	67	1113
		(Chiang Kham Dist.)	2537			1103	40	85	496	187	77	1988	17.55	35	1119
			2538			1168	65	99	920	253	206	2711	20.58	38	1244
	202	km.59+100 (Phayao Dist.) -	2536	C	70+000	848	169	156	2222	310	111	3816	1512.00	66	3584
		by pass Chaing Kham	2537			885	156	149	1228	202	118	2738	17.12	159	2796
			2538			716	75	99	2590	322	143	3945	14.29	33	3806
	203	Bypass Chiang Kham	2536	C	73+000	239	44	21	1059	263	112	1738	22.78	70	1558
			2537			301	32	23	1175	296	122	1949	22.62	61	1846
			2538			504	58	41	1260	539	179	2581	29.40	120	2397
	300	Bypass Chaing Kham -	2536	C	87+000	321	115	117	1195	161	103	2012	18.93	89	1055
		Thoeng	2537			217	62	114	1247	135	102	1877	18.70	30	722
			2538			325	82	105	1755	210	131	2608	17.10	102	1292

Table 10.3 (3/3)

Average Annual Daily Traffic Volumes on Highway No. 1020, 1721, and 1152, during 1993-1995

Route No.	Control Section	Terminal	Year	Type Code	Station km.	Car and Taxi	Light Bus	Heavy Bus	Light Truck	Medium Truck	Heavy Truck	Total	% Heavy Vehicle	Bi + Tri Cycles	Motor Cycle
1152	100	JCT.R.No.1020	2536	C	3+500	-	-	-	-	-	-	-	-	-	-
		(Hua Doi) - Sop Pao	2537			401	143	22	1427	182	123	2298	14.22	67	1330
			2538			427	132	21	1635	172	133	2520	12.93	62	1432
	201	Sop Pao - R. No. 1020	2536	C	35+500	-	-	-	-	-	-	-	-	-	-
			2537			448	77	23	1293	232	45	2118	14.16	97	1090
			2538			310	75	24	1553	217	74	2253	13.98	13	1275
	202	To Tung Chao	2536	C	36+000	-	-	-	-	-	-	-	-	-	-
			2537			100	76	0	395	19	1	531	3.76	663	950
			2538			178	74	0	527	6	0	785	0.76	774	1163

Source :

CHAPTER 11 SOCIO-ECONOMY

11.1 Present Condition

The implementation of the Kok-Ing-Nan Project will affect 140 to 160 villages in the project area as shown in Table 11.1.

The population in the project area are mostly engaged in agriculture activities growing rice, upland crops and fruits. Livestock and fishery activities are also conducted. The total value of agriculture production in the project area is estimated to be about 9,354 million bahts.

Due to the lack of water, the lands that can be cultivated are limited to 61%, 59% and 57% respectively of the agriculture lands in the areas of Alternative A, B and C. The present cropping intensity is 152%. Average households incomes are 34,366 Bahts, 52,788 Bahts and 47,536 Bahts per household per year in alternative A, B and C area respectively.

The laborforce in respective alternative case accounts for 69%, 69% and 71% of all the population in A, B and C cases. The proportions of out-migrants to the total laborforce are 26%, 28% and 28% for A, B and C cases, indicating low income level of the region and the resultant necessity for out-migration to other areas for earning additional income.

Low income level of the region hinders most primary school graduates to continue their study and many drop-outs before completing the primary level education.

11.2 Expected Socio-economic Changes by the Project Implementation

Changes, both positive and negataive, expected to take place due to the project implementation are summarized as follows.

<u>Construction Phase</u>

a) No increase in agriculture production is envisaged.

b) There will be an increase in construction-related job opportunities, bringing back out-migrants to the project area.

c) As a result, income level of the local population will rise.

d) Increased job opportunities will attract laborforce from other regions resulting in increased commercial activities.

e) On the negative side, the agriculture lands to become uncultivable will reach 8,462 rai, 10,424 rai and 10,745 rai respectively in Alternative A, B and C. The need for compensation is estimated to be 803, 1,308 and 1,283 million baht respectively.

f) The number of households that will have to resettle is 20 for Alternative A, while no houssehould will have to resettle under Alternative B and C.

g) Some social problems might arise such as arguing and theft as a result of increased population and inflow of workers from other regions.

h) Traffic congestion might result in an increase in noise and air pollution.

Operation Phase

a) As a result of increased water supply for agriculture use, the cropping intensity will rise to 165%, equivalent to a cultivation area of 808,000 rai.

b) Gradual increase of farmers household income is expected due to changes in cropping pattern and an increase in yield and price. The income increase will be gradual as adaptation to new farming technologies will take time.

c) Outflow of labor force will decline as a result of dry season farming made possible. Family unity will be strengthened and educational attainment improve in paralel with increasing income level.

Table 11.1

Number of Province, District, Sub-District and Village in Water Diversion Alternatives of Kok-Ing-Nan Project

Diversion Line	Province	Alternative								
		A			B			C		
		District	Sub-district	Village	District	Sub-district	Village	District	Sub-district	Village
Kok-Ing	Chiang Rai	4	9	49	4	8	39	4	7	35
Ing-Nan	Chiang Rai	1	1	6	1	1	7	0	0	0
	Payao	1	1	5	1	5	18	1	7	6
	Sub-Total	2	2	11	2	6	25	1	7	6
Nan-Sirikitti	Nan	8	26	101	8	26	101	8	26	101
Total		14	37	161	14	40	165	13	40	142

CHAPTER 12 COMPENSATION AND RESETTLEMENT

12.1 Conditions

Basic standard for estimating the area to be affected and compensation cost in alternative diversion routes are as follows:

(1) Area to be affected in diversion canal is 300 metre of right of way.
(2) Area to be affected in conduit is 200 metre of right of way.
(3) Area to be affected in river redredging is 100 metre of right of way.
(4) Tunnel has no area to be affected.

12.2 Result

Table 12.1 shows an estimate of the area to be affected and land compensation costs in the three alternative diversion routes. Table 12.2 is a cost estimate for buildings and tree crops compensation. The estimated compensation costs in each diversion route are summarized as follows.

Alternative Routes	Compensation Cost (Million Baht)			
	Land	Buildings	Tree Crops	Total
Kok-Ing				
Route A	732.40	7.20	20.47	760.07
Route B	1,234.10	-	26.22	1,260.32
Route C	1,253.33	-	28.58	1,281.91
Ing-Yod				
Route A	66.25	-	4.62	70.87
Route B	68.92	-	4.75	73.67
Route C	29.25	-	3.66	32.91
Kok-Ing-Yod				
Route A	798.65	7.20	25.09	830.94
Route B	1,303.02	-	30.97	1,333.99
Route C	1,282.58	-	32.24	1,314.82

Table 12.1
Cost Estimate of Land Compensation

Area	Official Land Cost	Route A				Route B				Route C			
	(M Baht/rai)	Diversion System	Length (km)	Affected Area [1] (rai) [2]	Land Compensation Cost (Million Baht)	Diversion System	Length (km)	Affected Area [1] (rai)	Land Compensation Cost (Million Baht)	Diversion System	Length (km)	Affected Area [1] (rai)	Land Compensation Cost (Million Baht)
Kok-Ing													
C. Chiangrai													
A. Muang													
T. Robwiang	0.3-3.0	-	-	-	-	Earth canal	0.215	40	72.00	Earth canal	0.215	40	72.00
						Concrete canal	3.525	661	173.70	Concrete canal	3.525	661	173.70
A. Wiangchai													
T. Wiangnua	0.1-0.5	Kok diversion dam	0.10	300	150.00	-	-	-	-	-	-	-	-
		concrete canal	3.95	741	78.60	-	-	-	-	-	-	-	-
T. Muangchum	0.1-0.4	Concrete canal	4.40	825	87.00	-	-	-	-	-	-	-	-
		Tunnel	1.50	-	-	-	-	-	-	-	-	-	-
T. Pha-ngam	0.04-0.32	Tunnel	9.90	-	-	-	-	-	-	-	-	-	-
	-	Concrete canal	1.56	293	13.92	-	-	-	-	-	-	-	-
T. Wiangchai	0.16-1.8	-	-	-	-	Concrete canal	9.96	1,863	396.85	Concrete canal	9.96	1,863	396.85
						Conduit	1.14	143	22.88	Conduit	1.14	143	22.88
T. Donsila	0.06-0.12	-	-	-	-	Conduit	11.81	1,476	90.06	Conduit	11.81	1,476	90.06
						Tunnel	3.5	-		Tunnel	3.5	-	
A. Phayamengrai													
T. Maiya	0.08-0.3	Tunnel	3.2	-	-	Tunnel	1.5	-	-	Tunnel	1.5	-	-
		Concrete canal	11.84	2,220	182.10	Conduit	1.75	219	17.53	Conduit	1.75	219	17.52
						Concrete canal	10.00	1,890	155.70	Concrete canal	10.00	1,890	155.70
A. Thoeng													
T. Ngio	0.04-0.35	Concrete canal	3.992	749	30.26	Concrete canal	3.992	749	30.26	Concrete canal	5.82	1,091	45.59
		Earth canal	0.572	1,609	65.93	Earth canal	0.572	1,609	65.93	Earth canal	-	-	-
		River redredging	1.40	88	3.52	River redredging	1.40	88	3.52	-	-	-	-
T. Pong	0.04	-	-	-	-	-	-	-	-	Concrete canal	3.20	600	24.00
T. Nongraet	0.03	-	-	-	-	-	-	-	-	Concrete canal	8.20	1,538	46.14
Subtotal, Kok-Ing			30.41	6,823	732.45 [3]		56.444	8,741	1,234.10 [3]		59.700	9,526	1,253.33 [3]
Ing-Yom													
A. Thoeng													
T. Wiang	0.04-0.3	Concrete canal	2.43	456	19.14	Concrete canal	2.43	456	19.14	-	-	-	-
		Conduit	2.02	10	10.12	Conduit	2.02	10	10.12	-	-	-	-
T. Ngao	0.03-0.3	Conduit	6.64	26	25.95	Conduit	6.64	26	25.95	-	-	-	-
From T. Ngao to Huai Yot		Tunnel	51.80	-	-	Tunnel	53.80	-	-	-	-	-	-
C. Phayao													
A. Chiangkham													
T. Angthong	0.07	-	-	-	-	-	-	-	-	Concrete canal	6.50	1,219	24.38
From T. Angthong to Huai Yot		-	-	-	-	-	-	-	-	Tunnel	50.70	-	-
Subtotal, Ing-Yom			63.59	1,539	66.25 [3]		11.440	1,583	68.92 [3]		57.20	1,219	29.25 [3]
Total			114.3	8,362	798.65 [3]		119.884	10,324	1303.02 [3]		116.90	10,745	1282.58 [3]

Remark : 1/ Affected area in diversion route

- Right of way of diversion canal is 300 metre
- Right of way of conduit is 200 metre
- Right of way of river redredging is 100 metre
- Tunnel has no affected area

2/ 1 rai = 1,600 square metre

3/ Contingency 20%

CHAPTER 13 ARCHAEOLOGICAL AND HISTORICAL ASPECTS

13.1 Methodology

In order to assess impacts of the Kok-Ing-Nan Project on archaeological and historical assets, a preliminary survey was made to identify those assets that might be affected by the project. The following method and assumptions were applied.

a) A survey was carried out using 1:50,000 scale map, analyzing existing documents and conducting field checks.

b) The target area of the survey was set to be areas within 1,000 meters from the planned structures and diversion canals and culverts.

13.2 Results

Only archaeological and historical assets identified within a 1,000m distance from the project facilities are temples. No other assets were formed. Table 13.1 lists the temples identified for each alternative case. Figure 13.1 shows locations of these temples.

The number of temples located within 1,000m from division canals and culverts are the following.

The Number of Temples located within 1,000 m from Diversion Canals and Culverts

Position	A	B	C
Kok-Ing			
within 500m	5	9	10
501 – 1,000m	7	10	12
sub total	12	19	22
Ing-Nan			
within 500m	4	3	0
501 – 1,000m	3	1	2
sub total	7	4	2
Total	19	23	24

Table 13.1

Temples and Archaeological Sites in the Vicinity of Alternative Diversion Canals

(Within 1,000 metre)

Environmental Resources	Name of Temples / Archaeological Site		
	Alternative A	Alternative B	Alternative C
Kok-Ing 1. Wat/Archaeological site within 500 m	- Wat San Salit (150 m) - Wat Rong Bot (300 m) - Wat Ban Rong Kok (400 m) - Wat Huay Tom Tai (500 m) - Wat Ban Pa Phai (500 m)	- Wat Si Wiang (100 m) - Wat Phra That Wiang Thong (200 m) - Wat Nong Lom (200 m) - Wat Ban Rong Kok (400 m) - Wat Pa Yang Mon (500 m) - Wat Pho Chai (500 m) - Wat Thung Khong (500 m) - Wat Huai Tom Tai (500 m) - Wat Ban Pa Phai (500 m)	- Wat Si Wiang (100 m) - Wat Phra That Wiang Thong (200 m) - Wat Nong Lom (200 m) - Wat Ban Rong Kok (400 m) - Wat Pa Yang Mon (500 m) - Wat Pho Chai (500 m) - Wat Thung Khong (500 m) - Wat Huai Tom Tai (500 m) - Wat Ban Pa Phai (500 m) - Wat Nong Rat Tai (200 m)
Subtotal	5	9	10
2. Wat/Archaeological site within 501-1,000 m	- Wat Boran (900 m) - Wat Wang Chang (1,000 m) - Wat Phra That Pulan (1,000 m) - Wat San Sa-at (900 m) - Wat Ban Mai Ya Khu Wiang (900 m) - Wat Huai Kang (800 m) - Wat Suan Dok (900 m) - Wat Bun Yuen (900 m)	- Wat Chai Narai (700 m) - Wat Cho Charoen (800 m) - Wat Si Don Chai (600 m) - Wat Chai Sawat (600 m) - Wat Phrathat Pulan (1,000 m) - Wat San Sa-at (900 m) - Wat Ban Mai Ya Khu Wiang (900 m) - Wat Huai Kang (800 m) - Wat Suan Dok (900 m) - Wat Bun Yuen (900 m)	- Wat Chai Narai (700 m) - Wat Cho Charoen (800 m) - Wat Si Don chai (600 m) - Wat Chai Sawat (600 m) - Wat Phrathat Pulan (1,000 m) - Wat San Sa-at (900 m) - Wat Ban Mai Ya Khu Wiang (900 m) - Wat Huai Kang (800 m) - Wat Suan Dok (900 m) - Wat Bun Yuen (900 m) - Wat Nong Rat Nua (900 m) - Wat Ban Plong San (1,000 m)
Subtotal	7	10	12
Total	12	19	22
Ing-Nan 1. Wat/Archaeological site withinn 500 m	- Wat Thung Khan Chai (<100 m) - Wat Pra Bong (100 m) - Wat Pa Pao (500 m) - Wat Pa Chi (500 m)	- Wat Thung Khan Chai (<100 m) - Wat Sala Wat (200 m) - Wat Pa Chi (<100 m)	—
Subtotal	4	3	-
2. Wat/Archaeological site within 501-1,000 m	- Wat Ban Phi (600 m) - Wat Bun Nak (800 m) - Wat Sala Wat (900 m)	- Wat Ban Phi (600 m)	- Wat Lai Pattana (900 m) - Wat Bo Noi (900 m)
Subtotal	3	1	2
Total	7	4	2
Grand Total	19	23	24

Remark: Number in ( ) - distance from the alignments.

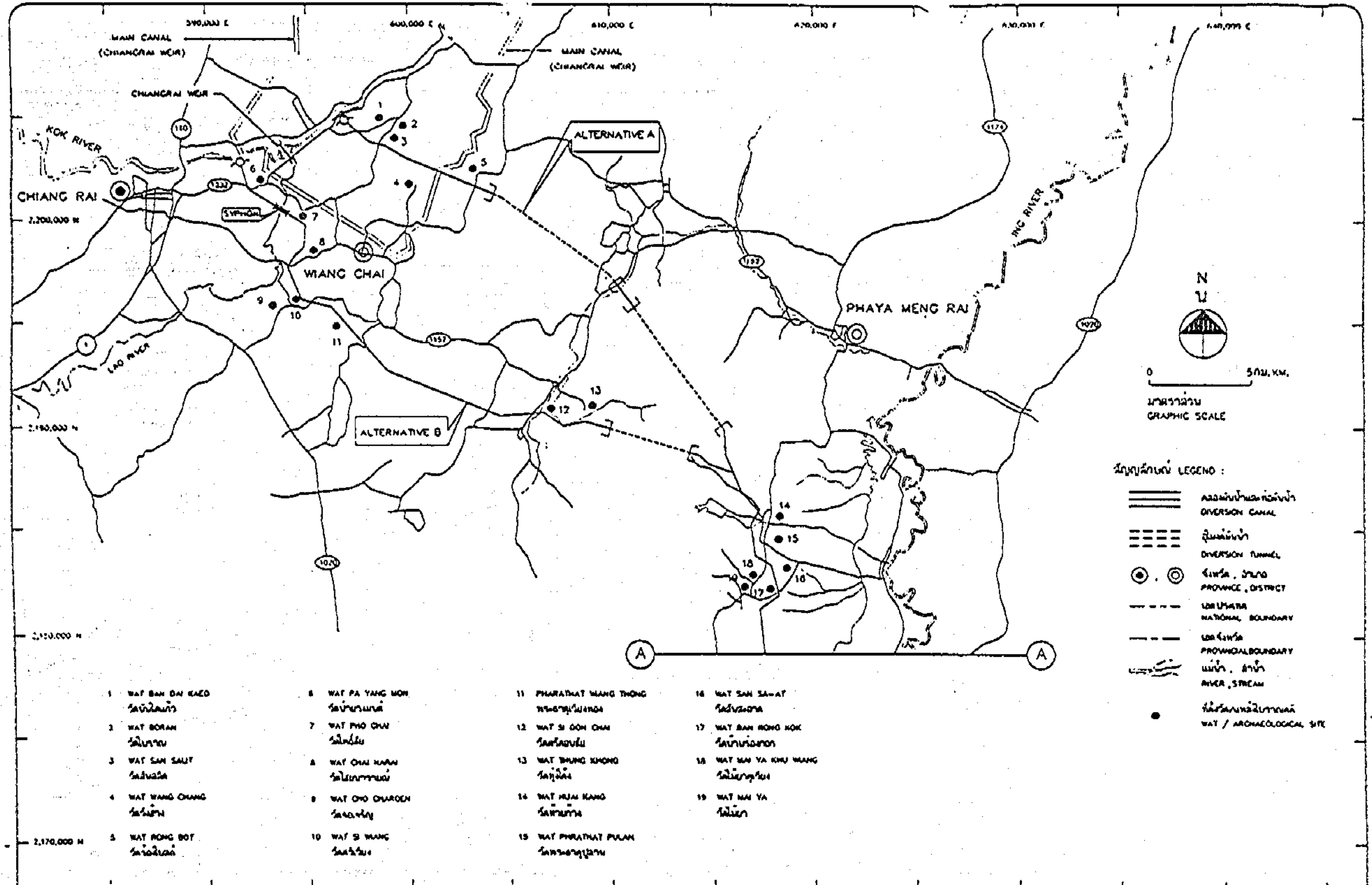


Figure 13.1 Temples and Archaeological Sites Along the Alternative Route of Diversion Canals and Tunnels of Kok-Ing-Nan Project (1/2)

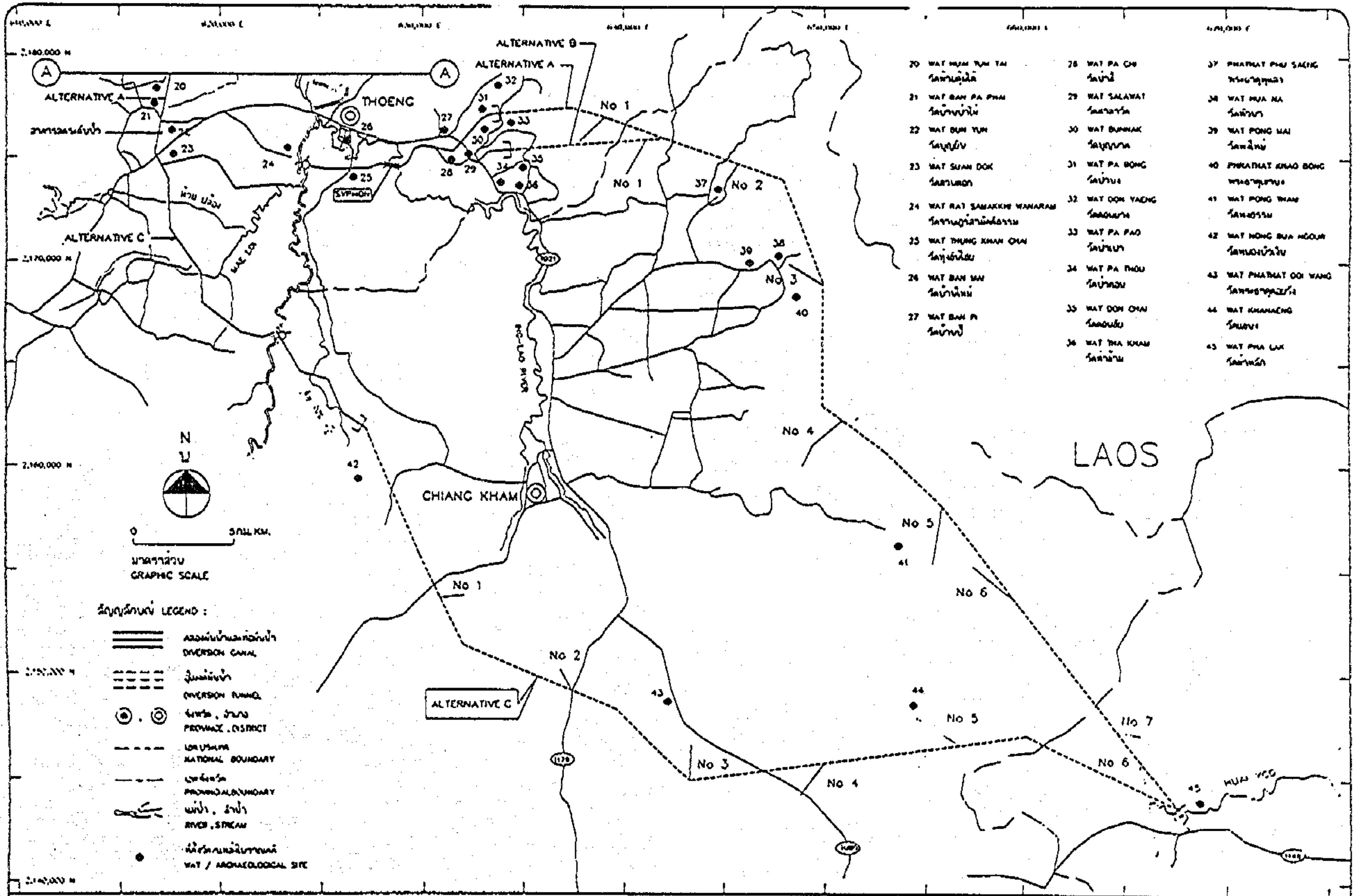


Figure 13.1 Temples and Archaeological Sites Along the Alternative Route of Diversion Canals and Tunnels of Kok-Ing-Nan Project (2/2)

CHAPTER 14 PUBLIC HEALTH AND NUTRITION

14.1 Methodology

The following works were made.

a) Collection of health data/information and relevant diseases in the project area with emphasis on locations of canals and shafts of wiers.

b) Community health survey including physical examination, clinical nutritional assessment and stool examination in areas mentioned in (1).

c) Mosquito, snail and fish surveys in the project area (1). A mosquito survey was conducted in rainy season, whilst snail survey was made in rainy and dry seasons. Cyprinoid fish was examined for metacercaria of liver fluke.

The locations of the surveys performed are as follows.

a) Community health data / information was collected from Tambon Yod and Tambon Chondan Song Kwae Subdistrict (King Amphoe), Nan Province.

b) Physical examination, clinical nutritional assessment and stool examination were conducted for villagaers of Ban Yod, Tambon Yod and Ban Pang Kom, Tambon Chondan, Song Kwae Sub district, Nan Province.

c) Snail surveys were conducted in dry season and collection at the following stations:

- Ban Pang Kom from Kom river, pond and rice field
- Yod river and Yao river (Ban Yod, Tambon Yod)
- Nam Tom stream (Tambon Pha Changnoi, Pong District, Payao Province)
- Yao river at Ban Hae, Tambon Mae Lao, Chiang Kham District
- Lao river at Ban Pee, Tambon Ngao, Thoeng District, Chiang Rai Province
- Ing river at Ban Tung Khao, Thoeng District, and
- Kok river at Ban Payangmon, Tambon Rob Vieng, Muang District, Chiang Rai Province.

14.2 Results

The following are the findings of the survey.

a) Areas selected for study are not far from local health centers which were adequately staffed.

Villagers received sufficient health services provided by health centers and a community hospital.

b) Water-borne disease found was malaria, whereas encephalitis and hemorrhagic fever were not recorded.

c) Common malnutrition problems were goitre and anemia.

d) Stool examination of 172 villagers revealed 53 were positive, 12 opisthorchiasis, 21 strongyloidiasis, 6 hook worms infection, 6 Giadiasis and 3 Entamoeba hystolutica infection.

e) There were 15 snail species collected. *Bithynia (Dignoniostoma) siamensis siamensis* was found at Ban Pong Kom, Ban Muang, and Ban Pee. *Lymnaea (Radix) auricularia rubiginosa* and *Filopaludina (Siamopaludina) martensi martensi* were found almost everywhere. Pila spp and Pomacea were also collected. No *Neotricula aperta* was found.

14.3 Preliminary Assessment

The following are the preliminary results of findings on the impact of the project on health conditions.

<u>Construction Phase</u>

The main problem would be outbreak of malaria among labors and communities in areas around the tunnel outlet and shaft construction sites. Spread of AIDS and diarrhea could also be possible among workers.

<u>Operation Phase</u>

Snail-borne diseases: The possibility of wider spread of opisthorchiasis is high due to wide distribution of Bithynia spp.

Mosquito-borne diseases: None or only slight changes of problem is envisaged in the magnitude of malaria and hemorrhagic fever, whereas encephalitis may be increased due to expanded irrigated areas.

Schistosomiasis: Though Neotricula aperta was not found in this survey, it was recorded at Khong-Ing confluence in Chiang Khong district, Chiang Rai province in the past survey. It is expected that the operation of this project will not result in the occurrence and distribution of this snail since its habitat is confined to Khong river.

It is considered that the Ministry of Public Health with the existing operation and measures will be able to appropriately cope with the foreseen changes in terms of mosquitoborne diseases and case finding, treatment, improvement of sanitation and change of food habit related with opisthorchiasis. No difference in health impact is foreseen among alternative routes of the diversion canals and culverts.

CHAPTER 15 AESTHETIC AND TOURISM ASSETS

15.1 Tourism Resources in Mae Kok Watershed Area

The Kok River Basin covers an area in Chiang Mai and Chiang Rai which is mostly covered with mountainous and forest areas. Most of tourist attractions, therefore, are of natural type such as Doi Ang Khang, Phang Hot Spring, Mae Kok raft tour, jungle tour, and Wiang Pa Pao Spa. There are also tourist attractions of cultural type such as hill tribe culture at Ban Kariang Ruam Mit. Main tourist attractions in Mae Kok watershed area are presented in Figure 15.1.

At present Chiang Rai is being developed into the tourist centre of the 4 Chiangs comprising Chiang Rai, Chiang Tung, Chiang Rung and Chiang Mai. The tourist sites outside Mae Kok watershed boundary are the golden triangle, Amphoe Chiang Saen, Mae Sai, Doi Mae Salong, Doi Tung palace, and jetty for Mae Khong tour in Chiang Saen. Tourism in Chiang Rai is growing and foreseen to accelerate economic growth of Chiang Rai.

15.2 Tourism Resources in Ing Watershed Area

Tourism resources in the Ing River Basin can be grouped into 2 types; natural and cultural types. The main natural tourist attraction is Kwan Phayao. Tourist attractions of cultural type are Wat Analayo and local weaving villages. The main tourist attractions in the Ing River Basin are presented in Figure 15.1.

15.3 Tourism Resources in Upper Nan River Basin

The Upper Nan River Basin area covers 2 provinces comprising Nan and Utaradit. The major tourism sites in the provinces are as follows.

<u>Nan comprise</u>

Phra That Chae Haeng, Phra That Khao Noi, Wat Phu Min, Nan National Museum, Wat Suan Tan, Phra Chao Thong Thip, Wat Chang Kham Woriwihan, Pha Toob National Park, Tham Pha Mong, Tham Pha Wiang, Sao Din (Hon Chom), Doi Pha Jik, Wat Nong Bua, Thung Chang, Pua Immigrant Camp, Sila Phet Waterfall, Doi Phukha National Park, Boat Racing Festival

<u>Utaradit</u>

Phraya Phichai Dab Huk Monument, Wat Phra Fang, Luang Pho Phet, Phra Thaen Sila At, Wat

Phra Yuen Phutthabat Yukhon, Phra boromthat Chedi, Muang Lublae, Mae Pool Waterfall, Sirikit Dam, Sak Yai National Park, Lang Sad Festival,

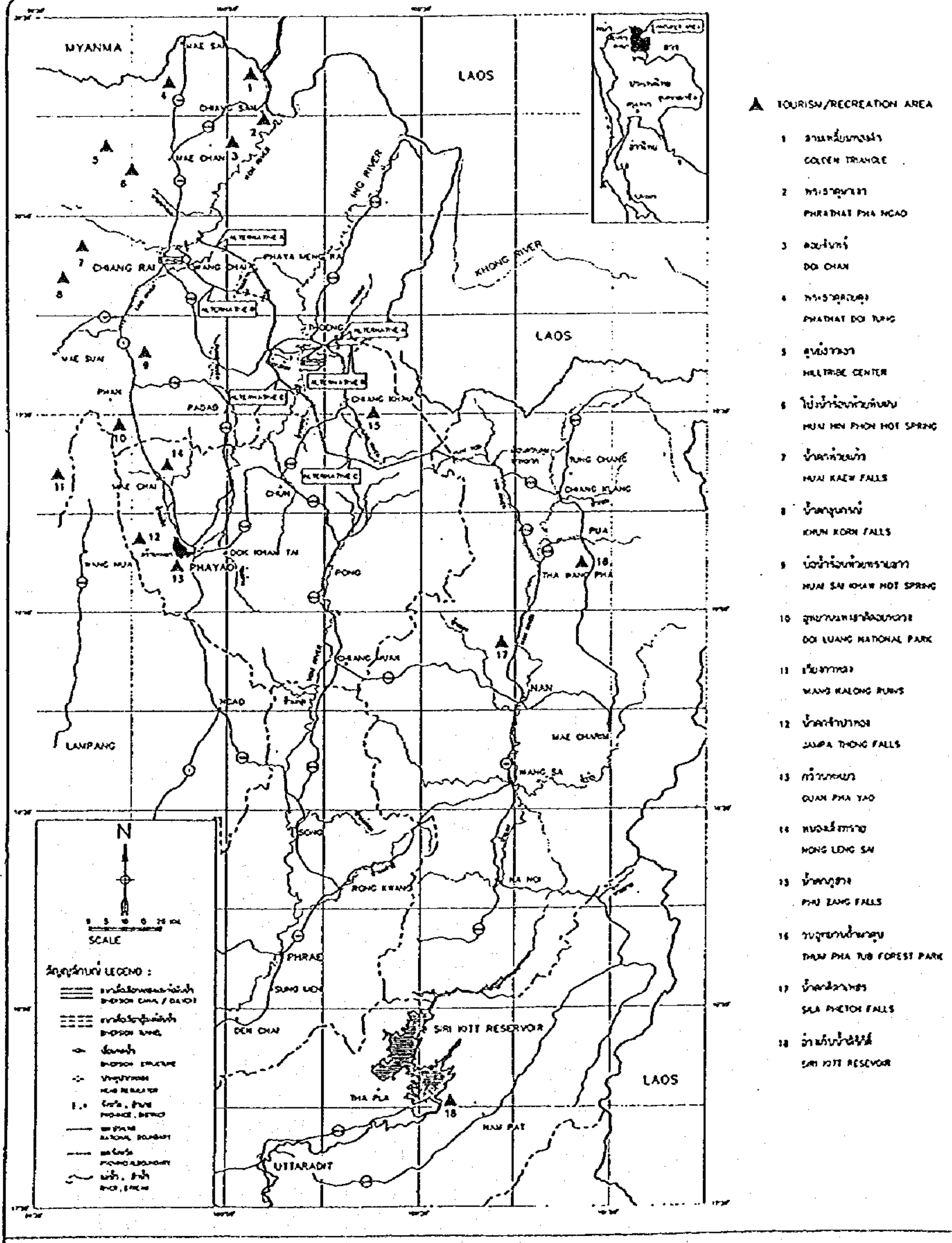


Figure 15.1 Important Tourism/Recreation Areas in Kok-Ing-Nan Basin

CHAPTER 16 GEOLOGY / SEISMOLOGY

16.1 Results of Preliminary Study

16.1.1 General

The Kok-Ing-Nan project area lies within the tectonic unit called Sukhothai Fold Belt. The basement rocks in this fold belt are low grade metamorphic and sedimentary rocks of Lower Paleozoic and sedimentary rocks of Upper Paleozoic to Mesozoic. The rocks are highly deformed and mostly metamorphosed. Fold axis is aligned in the N-S direction. Faults are striking NE to NNE, Uplift and faulting towards the end of Permian, resulting in the division of the cover rocks and formation of various basins such as Chiang Rai, Payao and Nan Basin in the Upper Triassic. These basins accumulated the Cenozoic sediments and recent fluvial deposits.

16.1.2 Stratigraphy

As results of uplift and fault, the Sukhothai Fold Belt was divided into three units according to their ages:

- The Upper Carboniferous to Upper Premian: composed of clastic sedimentary rocks.
- The Lower to Upper Triassic: comprises continental redbed series and volcanics overlain by limestone in Lampang Basin. In the Nan Basin, massive shale and sandstone prevail from Permian to Triassic.
- The Upper Triassic to Upper Jurassic: represented by deposition of redbeds, rhyolite and andesite in Payao-Nan Basin.

Volcanic rocks are characteristic of the basement in the Sukhothai Fold Belt. They are intercalated in sedimentary rocks of various ages. Andesitic to rhyolitic volcanic rocks are found in Late Carboniferous to early Permian, at Permian/Triassic boundary and Late Triassic.

In Quaternary, the surface covered with basalts are found between Chiang Rai and Payao, one of the center of effusion in northern Thailand. The rocks appear as rolling hills in the project area.

16.1.3 Geologic Setting of the Project Area

(1) Alternative Routes

Geomorphology of the Upper Kok drainage basin is represented by high terrane, narrow valley and high velocity stream flow. The river is wider and terrane is flat where it enters the Chiang Rai Basin. The Kok-Ing diversion canals and tunnels will align along the plains and the divide of the two river basins. The rocks are highly weathered sedimentary rocks and granite. The routes are also located along the foothills of sedimentary rocks intercalated with volcanics and young basalts.

The diversion tunnels between the Ing and Nan river basins will pass under the high mountain range between Payao and Nan with the highest point at an elevation of more than 1,600 m MSL. The length of the tunnels are about 50 km. Three alternative routes are proposed:

Tunnel alignment A and B will pass through high mountain with an elevation between <400 m to 1,600 m MSL. and parallel to the Thai-Laos border. The total length of both alignments is about 52 km.

Alignment C, with the inlet located west of Amphoe Chiang Kham, will align along low hills of less than 460 m MSL. and mountain heights of 600 m to 1,600 m MSL. The tunnel will be 50 km long and the outlet is located at the same place as alignment A and B.

(2) Geologic Conditions Along the Tunnel Route

From geologic maps of scale 1:250,000 published by Federal Institute for Geoscience and Natural Resources, F.R.G., in 1975 and 1976, the geologic conditions along the canal and tunnel routes can be summarized as follows:

(a) Geologic conditions between Nam Mae Kok and Nam Mae Ing

The diversion canals of alignment A and B will run across the plains of Quaternary alluvium (q), consisting of gravel, sand, and clay.

Rocks that will be found along the tunnel alignments include:

- Permo-Triassic sedimentary rocks (t-p) This unit found along alignment A comprises conglomerate, sandstone, shale, limestone and chert. The rocks are mostly aligned in NE-SW direction and dip to the west.

- Volcanic rocks Volcanic rocks, exposing along tunnel route A, consist of andesite, rhyolite, and tuff of Late Triassic and Early Jurassic (L-ms2). Late Permian and Early Triassic (L t-p) andesite, tuff, and thyolite are also found. Tunnel of alignment B will pass through the Quaternary basalts (B-ng).
- Plutonic rocks Tunnel of alignment A will be driven across Middle Triassic granite (G-t)

Geologic structures in this area are composed of small scale faults and fractures in granite and volcanic rocks. Attitudes of all strata are more or less the same.

(b) Geologic conditions between Nam Mae Ing and Mae Nam Nan

The canal and tunnel alignment A and B possess similar geologic conditions throughout the routes. Differences are found in the setting at the inlets located east of Amphoe Thoeng. The alternative C, running further south in Amphoe Chiang Kham along the first 30 km, has a distinctly different geology from alignment A and B. Rock units encountered along the canal and tunnel routes include:

- Quaternary Sediments (q) Sediments comprising gravel, sand, and clay will be found along the canal of alternative C and at the end of all tunnels.
- Jurassic to Cretaceous sedimentary rocks (ms 5-3) The unit is represented by sandstone and shale, found at the end of all tunnels.
- Late Triassic sedimentary rocks (ms-1) Sandstone, shale, and volcaniclastics found at the inlets of alignment A and B.
- Permo-Carboniferous sedimentary rocks (p-h) Sandstone, graywacke, shale or phylite, and limestone will be encountered at the mid-way of all tunnels.
- Carboniferous sedimentary rocks (h) On high mountainous area, at the middle of alignment A and B, sandstone and shale of this unit will be found.
- Volcanic rocks Late Triassic to Early Jurassic (L-ms2) rhyolite and andesite expose at beginning of alignment C.

Important geologic structures appearing along the routes of all the alternatives are faults, especially a fault zone crossed by tunnel of alignment C. The rocks are generally aligned in a NE-SW direction, folded and metamorphosed. Rocks in all units are distinctly foliated and cleaved.

16.1.4 Seismology

The area of Chiang Rai, Payao, and Nan provinces is in the region where earthquakes are frequently felt. Seismicity in the area is, however, low and damages on objects or buildings would be low. In Myanmar and the People Republic of China, there is a major seismic zone where seismicity is very high, activating ground shaking in Thailand. Since the project area lies close to the mentioned earthquake zone, earthquake activities and potentials have to be further studied and assessed.

From geographic point of view, Thailand is not situated in the earthquake-prone area. Major earthquakes normally occur along the plate boundaries, for instance along the major seismic belt that passes through China, Myanmar, and Andaman Sea which is the boundary of Eurasia and Indo-Australian plates. Frictions and collisions may cause sudden movement of faults and earthquakes. Seismic waves travel in all directions and vibrations can be felt over a long distance. Major faults can be traced in southern China, Myanmar, Laos, Andaman Sea and Upper Sumatra. In Thailand, earthquake can also occur along faults, but is less frequent and smaller in magnitude.

The proposed project area is located in the eastern part of the "Shan-Thai Terrane", a tectonic subdivision between Indochina Terrane on the east and West Burma Terrane on the west. The Shan-Thai Terrane is separated from the West Burma Terrane by a large scale strike-slip fault known as the "Sagaing fault" located only 100 km west of the Thai border. The Sagaing fault has a total length of 1,500 km, running from south China, across central Myanmar, Andaman Sea, extends southwards and probably links with Sumatra fault in Samatra Island of Indonesia. This fault has been activated since the Late Mesozoic time. In the past, major earthquakes have caused enormous damages along this fault.

The seismicity of the Northern Thailand seismic source region including the proposed project area is not high (Nutalaya and others, 1985). Earthquakes that occurred in the region is generally of low magnitude (less than 4.0 on Richter scale). Magnitude of over 5.0 is scarce. The seismicity map of the region covering Myanmar, Thailand, Indochina, and Andaman-Nichobar shown in Figure 16.1 reveals that earthquake of high magnitude (over 7.0 on Richter scale) are restricted to the vicinities along large-scale faults i.e. Red River fault in southern China, the Sagaing fault in Myanmar and the Sumatra fault in Indonesia.

Earthquakes which occur in Myanmar and Laos and are felt in northern Thailand are generally less than 6.0 on Richter scale. From earthquake data of the past 84 years (1913-1995), there were only 6 events with magnitude over 7.0 with the eqiecenters all in Myanmar. There was only one event with a magnitude exceeding 6.0,: the earthquake of magnitude 6.5 on 13 May 1935 with the center in Laos.

Earthquake of magnitude 5.0 or more, within a distance of 100 km around the project area occurred only once in Thailand. The earthquake of magnitude 5.1 on 11 September 1994, occurred in the mountain range between Amphoe Mae Suai and Amphoe Phan, Chiang Rai province, 15 km from Amphoe Phan. The quake caused damages to governmental and public buildings including: more than 20 school buildings, 30 monasteries and Phan Hospital. Amphoe Muang Chiang Rai, 60 km away from the epicenter, was not affected.

16.2 Initial Environmental Evaluation

(1) Diversion canal and tunnel routes between Nam Mae Kok and Nam Mae Ing

(a) The following items should be clarified with regard to the impact of geology on the construction of diversion canals.

- the canal routes are covered by sediments of bedrock and how the rocks weathered.
- If the canal bed reaches the fresh rock.
- If there is any geologic structure such as fracture of fault.

Both canal alignment A and B will pass through area with similar geologic condition. Impacts should, therefore, be the same. Since alignment A is shorter, it is more economical.

(b) The following items should be clarified with regard to the impacts of geology on the construction of diversion tunnels.

- the tunnel routes would pass through sediments of hard rocks. If driven in rocks, how the soundness and weathering are.
- the attitude of strata and changing of rock types through the route
- spacing and attitude of joints and faults
- vugs or caves in limestone
- amount of rocks to be excavated and availability of dumping areas

Alignment A is longer than alignment B and tunnel has to be driven in granite where joint and fault are expected. The Alternative B tunnel will pass through young volcanic rocks and only one joint is envisaged. Alignment B would create lower level of effects.
In conclusion, the alignment B is judged to generate effects of lower level than A.

(2) Diversion canal and tunnel routes between Nam Mae Ing and Mae Nam Nan

- Impacts of geology on the construction of diversion canals: Same effects as mentioned are expected in the impacts of geology on the construction of diversion canal. The alignment A and B are expected to have the same level of impacts as both routes are almost parallel. Deference would be found only in the relief along the routes. Alignment A and B are considered to have less impact than the longer route of alignment C.
- Impacts of geology on the construction of diversion tunnels: Since the maximum depth of tunnel under present surface is more than 1,200 m in certain part of the route, the impacts in addition to those already mentioned will include bursting of rock and occurrence of unwanted gas during excavation. The fault zone with broken rocks in alignment C is the major problem in construction.

In terms of geotechnics, alignment A and B are more suitable than alignment C. From economic point of view, alignment B is better than alignment A with respect to its shorter route.

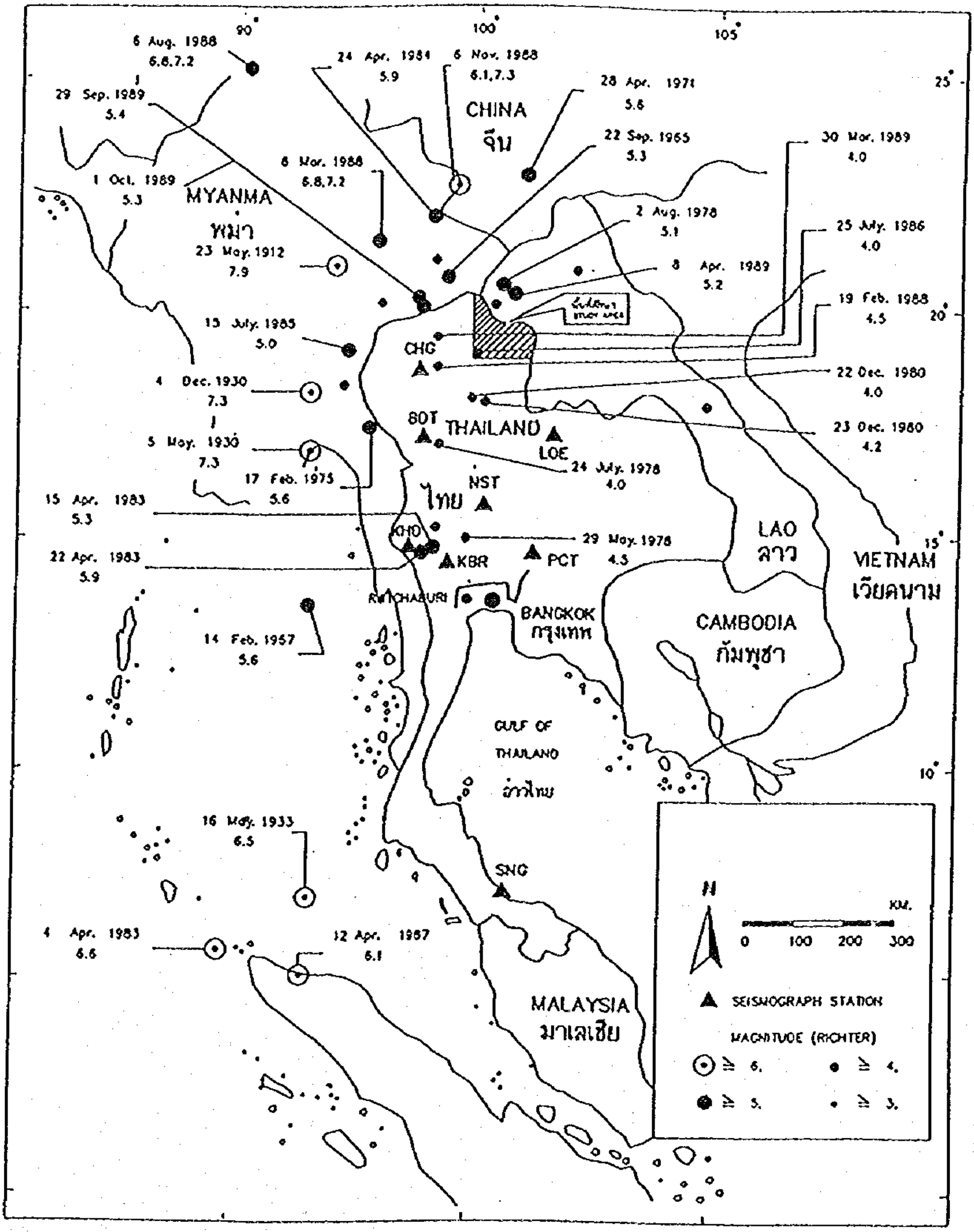


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Figure 16.1 Earthquake in Thailand and Other Countries in Indochina Region