high annual average growth rate of 9.4% in the industrial sector and 11.8% in the service sector over the past three years from 1993 to 1995.

Amphoe Bang Saphan is basically considered to be an agri-based area with approximately 87% of worker population of the Amphoe being engaged in the agricultural sector. The increase in the number of workers in the industrial and service sectors as stated above can be explained by the recent industrial development through the establishment of major steel factories in the Amphoe. However, since the population trend in the Amphoe shows a fairly low annual average growth rate of 0.6%, it can be assumed that most workers engaged in both sectors have been transferred internally from the agricultural sector within the Amphoe.

Local Economy

Local economy of Amphoe Bang Saphan is primarily based on agriculture, but it also involves the industrial and service sectors. As stated previously, approximately 87% of the total labor force of the Amphoe is engaged in the agricultural sector which covered a total area of 546.2 km^2 as of 1993. Major agricultural activities sector in the Amphoe are coconut plantation, fisheries, and stock farming.

Most farmers living inland acquire their income principally from coconut plantation with supplemental income from stock farming and local employment. Major crops are coconuts, para trees, rambutan, durian, mango, cashew, pineapple, corn, ginger, and chili. Rice is not grown in large amounts and therefore not considered as a major crop in the Amphoe. Fishermen living along the coastal area mainly gain their income (approximately 80% of the total) from local fishing. However, since fishermen also own some agricultural lands in the coastal area, they also earn supplemental income from coconut plantation. Like farmers, some fishermen obtain supplemental income through local employment as well. Major fish are pra too, tuna, shrimp, crab, and oyster. In addition to fishing, shrimp culture is also practiced but at a small scale. Fish processing factories are located near fishing villages to produce fish feeds for livestock. In terms of marketing, most farm and fishing products are sold locally and some are also sold at markets close to Bangkok and its surrounding area.

Besides the agricultural sector, the industrial sector has been playing an important role in Amphoe Bang Saphan in recent years, generating employment opportunities for the local communities. A steel-based industry is the largest one at present, employing about 1,000 workers.

Land Use and Land Ownership

According to Table F.1.9, 34.3% or 334.9 km2 of total fruit tree and crops lands in Changwat Prachuap Khiri Khan are located in the Amphoe. This is the largest share among the Amphoes in the changwat. Coconut plantations then represent the largest segment of fruit and crops in the Amphoe. According to interviews of local people, most farmers in Amphoe Bang Saphan have their own lands and are mostly engaged in coconut plantation. Since their lands are divided into small parcels, it is rather difficult to identify land ownership clearly and accurately.

Income Distribution

According to Table F.1.10, the majority of households in Amphoe Bang Saphan earn an annual income of approximately 20,000 bath or more. They account for 6,760 households or 53.6% of the total households in the Amphoe. Compared to other Amphoes, household income in the Amphoe is close to the changwat's average in each income class. The minimum wage for an unskilled worker as of 1995 was 118 bath per day in Changwat Prachuap Khiri Khan and 145 bath in Bangkok and other major cities.

General Education

In terms of quality and quantity of labor force available for future development in Amphoe Bang Saphan, the Amphoe has not been well developed yet. At present, the number of secondary school graduates in the Amphoe is estimated to be around 690 per year, and the number of graduates employed in the industry sector is anticipated to be at around 130 only, assuming that 15% of secondary school graduates are employed in the local industrial sector. According to some interviews of local government officers and industrial factory managers in the Amphoe, most workers employed locally are not educated well enough up to a high school diploma. In fact, there are no university level educational institutions in Amphoe Bang Saphan as well as in Changwat Prachuap Khiri Khan. However, there is a semi-higher educational institution called the Rajabhat Institute Petchaburi, which is a public institution offering bachelor degree in a relatively wide variety of subjects for students in the changwats of Petchaburi and Prachuap Khiri Khan.

In Amphoe Bang Saphan, the number of students in 1995 totaled 13,873, consisting of 2,093 (15.1%) in pre-schools, 7,052 (50.8%) in primary schools, 715 (5.2%) in extended primary schools, and 4,013 (28.9%) in secondary schools. In the past four years from 1992 to 1995, the number of schools has not increased significantly.

However, increase in the number of students has been observed in pre-schools and secondary schools with annual average growth rates of 10.1% and 18.5%, respectively, as illustrated in Table F.1.11. This trend reflects the latest national development policy in education that priority should be given to expand the number of pre-schools to further build up basic education as well as to expand the number of secondary schools to develop the trained workers needed for the further development of the country.

In terms of the ratio of primary school graduates going on to a secondary school in Amphoe Bang Saphan, the ratio for the Amphoe is 107.3%. This is higher than the average ratio of 91.9% of Changwat Prachuap Khiri Khan, according to Table F.1.12. It should be noted that the ratio of the Amphoe and Amphoe Pran Buri exceeded 100% in 1995, due mostly to the fact that some primary school graduates did not go on to secondary school but returned to school sometime later.

Vocational Education

The first vocational school in Amphoe Bang Saphan was established in May 1996 by the Department of Vocational Education under the Ministry of Education. The vocational school is then called Bang Saphan Industrial and Commercial College, which offers three kinds of formal vocational education programs: a 3-year vocational certificate program (upper secondary level), a 2-year technical certificate program (junior college level), and a 2-year diploma program (university level). For a 3-year vocational certificate program, 10 courses are available: auto mechanics, electrical engineering, welding, accounting, trading, electronics, mechanical engineering, dress making, food/nutrition science, and construction. For a 2-year technical certificate program: industrial engineering, commercial science, and domestic science. For a 2-year diploma program: auto mechanics, electrical engineering, welding, mechanical engineering, accounting, and secretary service.

Public Health

According to information obtained from Bang Saphan Community Hospital under the Ministry of Public Health as presented in Table F.1.13, there is only one hospital for the local community. The number of patients visiting the hospital has increased recently, particularly during construction of and after establishment of the steel factories, due mostly to the traffic accidents caused by commercial vehicles passing through the Amphoe. In addition to the hospital, public hygiene stations and public health centers are also located in the Amphoe. The public health personnel includes 4

physicians, 1 dentist, and 1 pharmacist. All these numbers are below the average of the changwat.

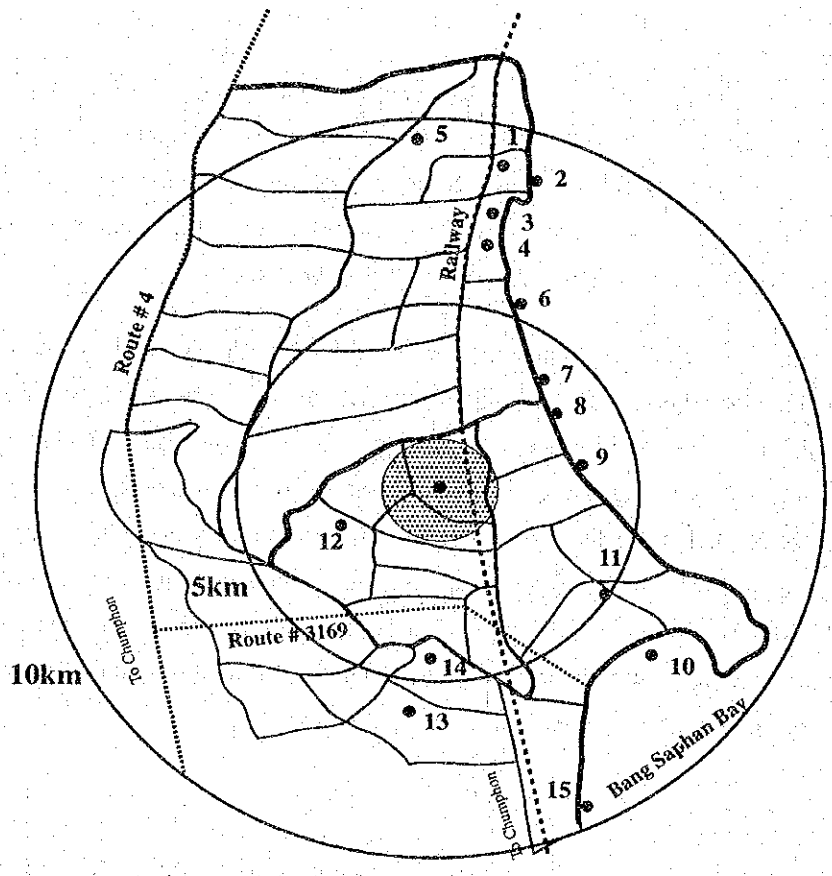
The most prevalent diseases observed in Amphoe Bang Saphan are the diseases of the respiratory system, digestive system and poisoning and violence, as presented in Table F.1.14. According to Bang Saphan Community Hospital, most cases of diseases of the digestive system have been reported to be diarrhea, since one of the main local foods in the Amphoe is fresh fish caught locally.

In Amphoe Bang Saphan, water sources locally available are mainly shallow wells, deep wells, and rivers. The water supply system uses combined water from both deep wells and rivers and distributes drinking water by pipe only to sanitary districts in the Amphoe. In other areas of the Amphoe, drinking water is supplied mainly in the form of bottled water for individual consumers and by water tank trucks for large consumers, both of which are provided by local private water venders. Water taken from shallow wells either individually or communally is used only for bathing and washing, since it is mostly undrinkable. Under these circumstances, water-born diseases are generally not observed in the Amphoe.

Tourism

In Amphoe Bang Saphan, a total of 15 major tourism points are identified, as presented in Table F.1.15. Of these, 5 tourism points are located near the proposed site of the industrial estate, namely Ban Nhong Mongkon Beach in the area of Tambon Thongchai, Ban Don Sam Ran Beach, Ban Thung Lang Beach and Klang Aow National Park in the area of Tambon Maeramperng, and Kao Boat Temple in the area of Tambon Kamnert Noppakhun. These tourism points are approximately 5 km away from the proposed site of the industrial estate. Their locations are presented in the figure below.

Major Tourism Points in Amphoe Bang Saphan



Legend

- Location of Proposed Site of Industrial Estate
- Location of Major Tourism Points

N

Note: The number of each tourism point is referred to the site number in Table F.1.15.

F.2 Environmental Impact Assessment

This section forecasts the environmental impact of the industrial activities on the air and water quality after operation of the industrial estate in the year 2011 in the Bang Saphan area. The impact on the air and water quality by pollution sources are evaluated by the use of environmental models. In the case of air quality, a so called diffusion model is normally adopted and the environmental impact is calculated using computer programs. And for estimating water pollution, a mixing model is adopted.

For forecasting the environmental impact caused by the industrial activities in the Bang Saphan area, the iron/steel making industry and the thermal power plant are assumed to exert large influence on the environmental quality in this area. Therefore in this study, in addition to the environmental impact caused by the activities of the industrial estate, those caused by the iron/steel making industry and the thermal power plant are also considered. Furthermore, the readily available data and information which characterize the emissions or effluents, meteorology and air/water chemistry of the project area were utilized for estimating the environmental impact.

F.2.1 Impact of Project Implementation

If the Bang Saphan I/E is not implemented in the proposed area, it is likely that the area will remain roughly as it is now. The implementation of the industrial estate will have both a direct and an indirect impact on the surrounding areas. The largest environmental impact of the project implementation is likely to occur during construction activities such as excavation, landfilling, construction of buildings and infrastructure. After the completion of the project, pollutants from factories such as air emissions, water effluent and disposal of solid and liquid wastes have potentially damaging environmental impacts. Furthermore, the new industrial estate will increase traffic, and it will enhance demand for housing and services in the area. Implementation of the industrial estate will also increase other activities and business in the area, and thus increase the number of workplaces in the service sector. The landscape will change totally from the existing coconut plantations to the factory buildings. Therefore, from the environmental conservation standpoint, it is necessary to pay careful attention to prevent pollution and changes during the construction and operation, and it is also necessary to consider how the landscape of the project will blend into the surrounding area.

During the construction phase, fugitive dust, sediments and erosion from construction activities will be the major pollutants which affect local air and water quality. And during the operation phase, stack emission gases and effluent waters from factories will have the

most important influence on the environment in and around the Bang Saphan area. Therefore, proper measures should be taken to mitigate and control these pollutants, such as proper construction techniques, flue gas desulfurization process, wastewater treatment facilities, etc. Table F. 2.5, Table 2.6 and Table F.2.7 indicate the estimated of significant indices of gaseous emission and water effluent loads by type of industry. And the environmental impact, mitigative measurse and monitoring plan in regard to the main items such as physical resource, biological resource, etc. in the Bang Saphan area are summarized in Table F.2.3 and Table F.2.4 for the construction phase and operation phase respectively.

F.2.2 Air Pollution

Stack effluent gas rises up and diffuses in the atmosphere due to the effects of exhaust velocity and buoyancy caused by high stack gas temperature. In order to know the impact of effluent gas from stack, it is necessary to calculate the ambient ground level concentration in the objective area. The ambient ground level concentration of effluent gas from stack can be calculated and predicted by using the smoke plume-puff formulae mentioned in Table F.2.3. And these calculations contain many assumptions which are shown below, such as meteorological conditions, emission gas volume, concentration of pollutants, etc. In this study the ambient concentration of stationary sources in the Bang Saphan area including the iron industry and the thermal power plant was forecast using computer programs with regard to significant air pollution indices of SO_2, NO_2 and TSP. The coal-fired thermal power plant of IPP to be built in the Bang Saphan area with a capacity of 1,400 MW will be the largest contributor to air pollution.

(1) Condition and assumption for calculation

Meteorological condition

Items	Data collected at	Year
Wind direction	Prachuap Khiri Khan station	1993 -1995
Wind speed	Prachuap Khiri Khan station	1993 -1995
Solar radiation	Bangkok	1993 -1995
Temperature	Prachuap Khiri Khan station	1986 -1995

Background concentration of SO_2, NO_x and TSP

Background concentration of SO_2, NO_x and TSP in the Bang Saphan area are shown in Table F.1.2.

Emission source

◆ Pollution loads

Pollution loads concerning SO_2, NO_x and TSP were estimated as shown in Table F.2.5 and F.2.6. The concentrations of pollutants discharged into the air are assumed as follows by type of industry and by pollutant.

	Industrial Estate	Iron/Steel Industry	Thermal Power Plant
SO_2 (ppm)	356	356	320 (*)
NO_x (ppm)	93	93	350 (*)
TSP (mg/m3)	300	300	120 (*)

(*) : Emission standards for a new power plant

◆ Stack height and effluent gas temperature

Type of Industry	Stack Height	Effluent Gas Temp.
Industrial Estate	20 m	230 ℃
Iron/Steel group	100 m	150 ℃
Thermal power plant	150 - 200 m	150 ℃

◆ Operating time

Industrial Estate : 12 hours/day (7:00 p.m. - 7:00 a.m.)
Iron/Steel group : 24 hours/day
Thermal power plant : 24 hours/day

Diffusion formula

In order to obtain the long-term average concentration of SO_2, NO_x and TSP, plume-puff formulae indicated in Table F.2.3 were used for the computer calculation according to the meteorological and emission conditions.

Calculation of Long-term average concentration

Long-term average concentration, in other words annual average concentration, is obtained by averaging over 8,760 hr (one year) of one-hour average concentrations which can be calculated on the basis of emission and meteorological data for one year

by using the above mentioned equations. Actual calculation is carried out by dividing meteorological conditions into a few classes. Thus long-term average concentration can be obtained by multiplying the corresponding concentration by the probability of occurrence of the class. Namely,

$$C = \sum_{k,i,j} C_1 (D_i, V_j, ak) \cdot f_1(D_i, V_j, ak) + \sum_{k} C_2 (ak) \cdot f_2(ak)$$

where C: annual average concentration; C_1 (D_i, V_j, ak): 1 hr concentration at wind direction D_i, wind speed V_j and stability ak (windy condition, calm 1 condition); $f_1(D_i, V_j, ak)$: probability of occurrence of wind direction D_i, wind speed V_j and stability ak (windy condition, calm 1 condition); C_2 (ak): 1 hr concentration at stability ak (calm 2 condition); f_2(ak): probability of occurrence of stability ak (calm 2 condition).

Calculation of effective stack height

Following two formulae were used for the calculation of effective stack height.

Windy condition	CONCAWE formula
Calm condition	CONCAWE formula and Briggs formula

— CONCAWE formula

$$\Delta H = 0.175\ Q_H^{1/2} / u^{3/4}$$

— Briggs formula

$$\Delta H = 1.4\ Q_H^{1/4} (d\theta / dz)^{-3/8}$$

where, ΔH: raising height (above stack, m); u: wind speed (m/sec); $d\theta/dz$: vertical gradient of potential temperature (℃/m); Q_H: heat emission of stack gas (cal/sec).

The emission rate of heat Q_H can be given by

$$Q_H = \rho\ Q_G C_p \Delta T$$

where, ρ, C_p: density (1.293×10^3 g/Nm^3) and specific heat at constant pressure (0.24 cal/deg. g) of stack gas, respectively; ΔT: temperature difference between air and stack gas (℃); Q_G: stack gas emission rate (Nm^3/sec)

(2) Result of calculation

Equal-concentration contours with regard to SO_2, NO_x and TSP are illustrated in Figures F.2.1 ~ F.2.3 respectively and the following table indicates maximum ground level concentrations. The result of calculation shows that the concentrations of SO_2, NO_x and TSP are all within the ambient air quality standard of Thailand as shown in Table F.2.12 as of the year 2011 when the factories in the Bang Saphan area, which are factories in the industrial estate, the iron/steel making mills and thermal power plant, are into operation. It is assumed that the concentrations of NO_x and TSP will not change remarkably as compared with those of present concentrations. However, the concentration of SO_2 is forecast to become relatively high compared with the present concentration in a near range of the industrial zone.

Maximum Ground level Concentration in Bang Saphan Area

	Maximum Ground Level Concentration	Ambient Concentration (Reference)*	Air Quality Standards		
			1-hr average value	24-hr average value	1-yr average value
SO_2 (mg/m^3)	0.034	0.003	-	0.30	0.10
NO_2 (mg/m^3)	0.012	0.017	0.32	-	-
TSP (mg/m^3)	0.008	0.096	-	0.33	0.10

*Note: * Data measured during March 12 to 15, 1995, in Bang Saphan area.*

F.2.3 Water Pollution

Wastewater generated from the industrial estate is to be treated by a central wastewater treatment facility to be installed in the I/E. The central wastewater treatment facility receives wastewater from factories in the I/E. Each factory should pre-treat the wastewater previously before discharging it to the central facility. This pre-treated wastewater in each factory, which is discharged to the central treatment facility, should conform with IEAT's standard shown in Table F.2.15. Treated wastewater in the central treatment facility should meet the industrial effluent standards provided by the Ministry of Industry. With regard to the wastewater generated from iron/steel making industry, it is also treated by the treatment facility installed in the site.

(1) Characteristics of wastewater by type of industry

The composition of industrial wastewater is complex and it varies largely according to the difference in the manufacturing process even among the same types of

manufacturing factories. However, it is necessary to understand the characteristics of the wastewater to be generated for formulating appropriate mitigation measures. Furthermore, each factory should make every effort to minimize generation of wastewater by adopting water saving techniques such as recycling and reuse of wastewater. Table F.2.4 shows characteristics of wastewater according to the type of manufacturing industry.

(2) Estimate of quantity of wastewater generated

In accordance with the IEAT criteria for wastewater treatment in the I/E, total wastewater to be treated can be estimated at 80% of water consumption. Table F.2.7 summarizes the quantity of wastewater by type of industry. This table also indicates the effluent loads of wastewater in connection with the major pollution indices of BOD and suspended solid (SS) when the wastewater is discharged to the receiving water with a value of industrial water effluent standards.

(3) Influence of effluent water on the receiving water

Wastewater is discharged into a receiving water after being treated at the central wastewater treatment facility. In this study, the receiving water is assumed to be the Mae Ramphung river. Pollutants discharged into the river are mixed with water and diluted. The factors influencing the dilution are : (a) the Brownian movement of the pollutant particles in water, (b) the density current caused by differences in water density and in pollutant concentrations, and (c) the turbulent flow resulting from disorder of water flow. Of these, the contribution of molecular migration due to the Brownian movement is very small, and the effect of turbulent diffusion caused by wind, changes of water flow rate and water depth, and water bottom conditions is generally very important.

In rivers, dilution and advection of pollutants proceed with the linear flow of water downstream. In this study, it is assumed that the treated wastewater is discharged into the Mae Ramphung river and mixed completely. Hence, concentrations of pollutants are determined by the flow rate of river water, and can be simply expressed by the following equation:

$$\text{Pollutant Concentration } C = \frac{C_0q_0 + C_1q_1 + C_2q_2}{q_0 + q_1 + q_2}$$

where, C_0 : Average concentration of a given pollutant in river water (mg/l); q_0 : Flow rate of river water (Mae Ramphung river = 135 MCM/year); C_1 , C_2: Concentration of the pollutant in wastewater flowing into the river (mg/l) [BOD = 20 mg/l, SS = 30mg/l] ; q_1, q_2 : Flow rate of wastewater (m^3/day).

The flow rate of wastewater and the concentration of pollutants in wastewater which were used for the calculations are summarized in Table F. 2.7. The following table shows the forecast of pollutants concentration in the Mae Ramphung river in connection with BOD and SS when the treated wastewater from the industrial estate and the iron/steel making industry is discharged into the river. A BOD value of 8 ppm is still admissible considering the fact that toxic waste will be removed in the wastewater treatment facility, however further degradation of the river water should be avoided and more high grade treatment of wastewater should be considered after 2011.

Forecast of Pollutants Concentration in Mae Ramphung River

	Concentration to be Forecast	Background Concentration *
BOD_5 (mg/l)	8.2	2 - 6
SS (mg/l)	17.5	3 - 22

* : *Data at Klong Maerampung, 1994 - 1996.*
Average is used for the forecast.

F.2.4 Solid Waste Disposal

(1) Load of Solid Waste

Solid wastes generated as a result of human activities are divided into two categories. One is municipal solid waste and the other is industrial solid waste. Furthermore, industrial solid wastes are classified into two types of waste, those that present a hazard to the environment as a result of improper disposal or handling, and those that do not.

1) Municipal Solid Waste

Municipal wastes generated in the Bang Saphan area are disposed now by dumping to the ground and burning. IEAT indicates that the waste generation rate in residential and commercial zone is 0.8 kg per person per day. Table

F.2.8 shows the conditions of existing municipal solid disposal in the Bang Saphan area.

When the Bang Saphan I/E is implemented in the proposed area, the total residential population in the year of 2011 is estimated to be 127,000 - 160,000 including current residents and natural growth of the population of Bang Saphan District. This means that the municipal waste generated from residential and commercial zone in the Bang Saphan area in 2011 will increase three or four times in quantity and this demands the establishment of appropriate waste collection systems and disposal methods such as sanitary landfill and incineration. The volume of municipal waste to be generated in the Bang Saphan area in 2011 is estimated at 37,000 to 47,000 tonnes per year.

2) Industrial Solid Waste

Industrial wastes are generally divided into two categories, general waste and hazardous waste. General waste does not present a hazard to the environment. Hazardous waste has physical, chemical, or biological characteristics which require special handling and disposal procedures to avoid risks to health and/or adverse environmental effects. As described in the Interim Report, the Department of Industrial Works (DIW) gave a definition of industrial hazardous wastes in the Notification No. 25 in 1988.

Wastes, both general and hazardous ones, generated in the Bang Saphan I/E include coal ash from the thermal power plant, refractories from the steel industry, organic sludge, wastewater treatment sludge, sludge and slurries containing chemicals, and off-specification products. Some of these wastes may contain heavy metals, chlorinated hydrocarbons and other chemicals, and require special care in disposal. Table F.2.9 indicates an example of existing waste management practice in Thailand.

IEAT has presented the design criteria for solid wastes disposal. According to the IEAT's criteria, solid waste generation rate in industrial estates is 18 kg per rai per day and the quantitative ratio of hazardous waste to total wastes generated is 10% to 15 %. Table F.2.10 summarizes the estimated general wastes and hazardous wastes which would be generated in the Bang Saphan area. In this table, the ratio of hazardous wastes generated from general manufacture is assumed to be 15 %.

(2) Treatment and Disposal of Solid Wastes

1) General Wastes

For the treatment and disposal of general wastes, there are two methods. One is by landfill and the other is by incineration. IEAT recommends to use incinerator or sanitary landfill for the treatment and disposal of general wastes. The table above indicates that the amount of general wastes to be treated in the industrial estate by these two methods is about 10,000 tonnes per year, and 150,000 tonnes and 480,000 tonnes per year in the iron/steel industry and the thermal power plant respectively. Refractories generated from the iron/steel industry will be reclaimed, and more than half of remaining wastes will be treated by landfill. IEAT will charge factories a treatment fee depending on the quantity and quality of wastes for incineration. Facilities to be equipped in the disposal site and incinerator are indicated in Table F.2.11 in accordance with the IEAT's design criteria.

2) Hazardous Wastes

A hazardous waste treatment facility should be constructed in the I/E area or adjacent to the I/E area for treatment and disposal of hazardous wastes generated from the Bang Saphan industrial estate. The table listed above shows that the total amount of hazardous wastes to be treated is about 1,800 tonnes per year. The Ministry of Industry (MOI) has the responsibility for treatment and disposal of hazardous wastes and has the guideline to implement an industrial waste treatment center. MOI has already established a new company, the General Environmental Conservation (GENCO), by a joint investment with G.C.N. Holding Co., Ltd., for constructing treatment centers. Considering these precedent examples, the facilities for treatment and disposal of hazardous wastes generated from the Bang Saphan I/E will be constructed and managed by a joint venture between the government and private sectors.

MOI will set up the standards for treatment and disposal of wastes. Operation of the facilities will be sub-contracted to a private firm. Treatment and disposal of hazardous wastes, after they are sorted by each factory, are entrusted to the private firm. This private firm is responsible for all waste collection, treatment and disposal activities, but its operations (including service fees and treatment specifications) are regulated by the DIW. In the case of the Samae Dam hazardous waste treatment center, which is Thailand's first hazardous treatment center, DIW has issued tender documents to select thae private company to

operate the center and provide the service to all factories. The bidder who offers the lowest price for waste disposal would be considered to operate the center. Considering the facilities and functions of the Samae Dam treatment center and GENCO's facilities, the waste treatment facility to be constructed in the Bang Saphan area should have the following features:

a) Capacity

Sufficient capacity to collect, treat, and dispose off the total quantity of hazardous wastes generated from the Bang Saphan I/E.

b) Treatment and disposal system

i) Securing landfill

ii) Physical-chemical treatment facility (to treat acidic and alkaline wastes together with heavy metals)

iii) Solidification facility (Cd, Hg)

iv) Stabilization facility (other heavy metals)

v) Wastewater treatment facility

vi) Incinerator (including air emission control equipment)

c) Collection and transportation system,

d) Sample analyzing function.

F.2.5 Social Environment Impacts

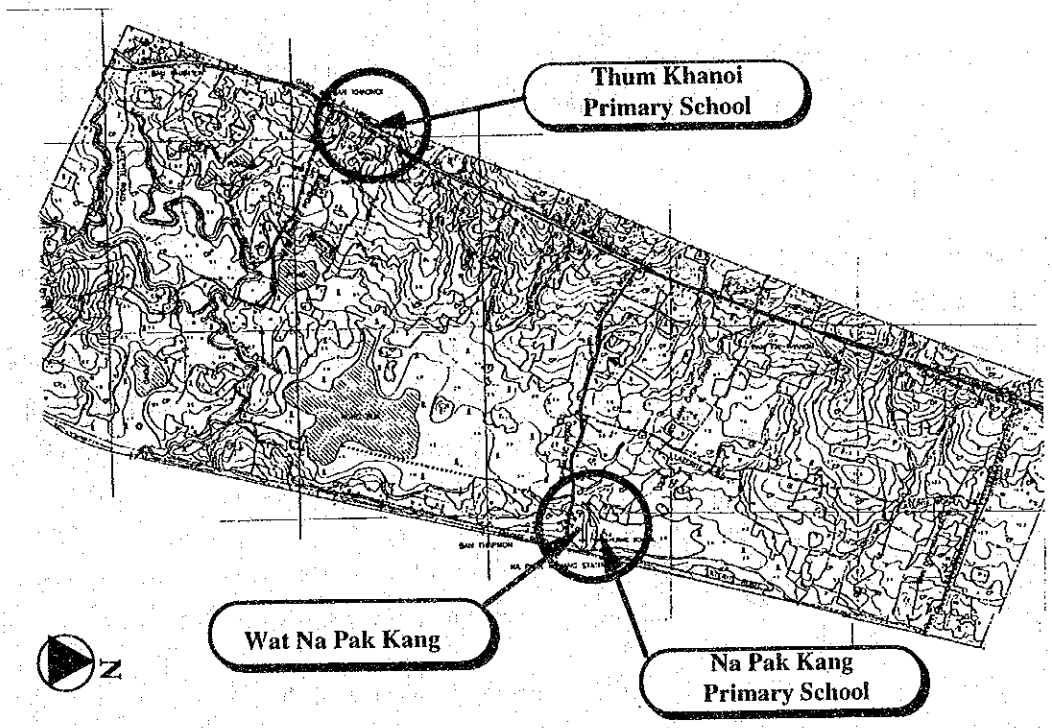
The following are the major social environment impacts in the Bang Saphan area prior to implementing the project.

Relocation of Social Facilities

In the proposed site of the industrial estate, two primary schools and one temple are identified as shown in the figure below. The two primary schools, namely Wat Na Pak Kang Primary School and Thum Khaonoi Primary School, reportedly had 122 and 106 students respectively in 1995. The temple is called Wat Na Pak Kang. The Wat Na Pak Kang Primary School is sited in the grounds of the Wat Na Pak Kang temple which is located in the middle of the eastern part of the site. The Thum Khaonoi Primary School is

located along the road near the southwestern corner of the site.

Existing Social Facilities in the Proposed Site



A preliminary relocation plan of each social facility has been examined and suggested in the study. The plan should be further examined and finalized in detail prior to implementation of the project. The following are taken into consideration in the plan:

(1) Considering that a temple is to be respected as a religious asset of local people and community, the Wat Na Pak Kang temple is suggested to be preserved as it is.

(2) To maximize utilization of the site, the existing two primary schools are proposed to be relocated outside in the following manner.

1) The Thum Khaonoi Primary School is located in the site of Phase I, and a certain number of students who are living outside the site are expected to remain there. The school is advised to be preserved until construction of new school buildings is completed in a relocating site and then be relocated as soon as possible before construction of Phase I starts. The relocating site should be selected nearby the project site, considering the commuting distance of the remaining students.

2) The Na Pak Kang Primary School is located in the site of Phase II, and a certain number of students who are living outside the site are expected to remain there. However, since the commuting routes of the students are occupied by the industrial estate and also by the expansion area of Sahaviria's factories, the school is presumed to be closed after construction of Phase II and start of Sahaviria's upstream factories. The school is suggested to be preserved for the time being and then be closed later on.

Relocation of Local Residents

In the site, approximately 170 establishments have been identified as of 1995. However, since some establishments are not in use at present, it is assumed that approximately 120 establishmentsor 70% are being occupied by local residents. Since the local residents currently living in the site are planned to be relocated to the outside area, the following are possible alternative measures for compensation and livelihood support to be carried out prior to the project implementation:

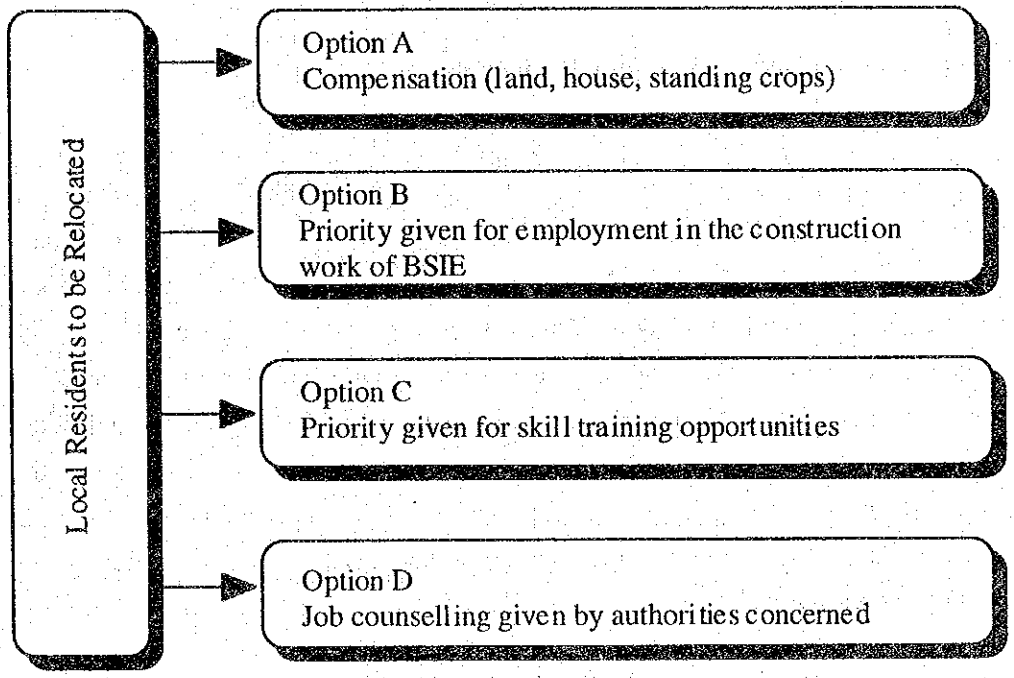
(1) Option A is basically to provide individual compensation for private lands, houses, and standing crops which most of the local residents in the site seem to posses.

(2) Option B is to give priority to the local residents who wish to get employed in the construction work of the Bang Saphan industrial estate.

(3) Option C is to give priority to the local residents who wish to get trained in order to obtain basic skills to be employed locally. In this case, the recently opened Bang Saphan Industrial and Commercial College could be the one to provide training opportunities for both full time courses and part time courses.

(4) Option D is to give priority to the local residents who wish to get a job counseling to for local employment. In this case, the Department of Employment in the Ministry of Interior could be the key government agency.

Possible Optional Measures for Compensation and Livelihood Support



F.3 Monitoring Plan

F.3.1 Monitoring of Air Pollution

(1) Location and Number of Monitoring Stations

A monitoring station must be able to grasp the level of air pollution and the pattern of its changes over the entire area its covers. Its covering range must be determined in the light of meteorological conditions, topographical features, and the distribution of pollution sources in the area. Upon determining the location of monitoring stations in areas crowded with pollution sources, such as industrial zones, it is considered that one monitoring station should cover an area of about 3 km in radius. And a broader area of about 5 to 10 km in radius should be covered for residential and other less polluted areas in general. Therefore, one monitoring station can cover entire the Bang Saphan area which includes the area of the iron/steel industry and the thermal power plant. For selecting the location of a monitoring station, the following factors must be considered:

1. The station must be located in a densely polluted area and in the area that represents the characteristic air pollution pattern.
2. Additional stations must be set on the periphery of the area to monitor the amount of pollutants coming into the area from the neighboring province.
3. The monitoring station must be arranged taking future land utilization plans into consideration.
4. The monitoring station must be arranged in a proper manner to effectively evaluate the air pollution control measures being planned.

(2) Measurement Items at Monitoring Stations

Generally, for the purpose of investigating pollution caused by industrial activities, the main items to be monitored are SO_2, NO_x, and SPM. Other particular pollutants (such as hydrocarbons, HCl, CO, etc.) will be added as occasional demands. The major artificial sources of each pollutant are presented in Table F. 3.1.

(3) Structure and Instruments of Monitoring Stations

An integrated air pollution monitoring station must be equipped with the following analyzers and instruments: SO_2, NO_x, CO, hydrocarbon and oxidant analyzers, high

and low-volume air samplers, and meteorological instruments to monitor wind velocity, wind direction, atmospheric temperature, solar radiation intensity, etc.

A part of an existing building is often utilized as a fixed station. A fixed station is usually unmanned, and should preferably be made of ferro-concrete instead of wood for fire prevention. In case of a prefabricated building, the use of heat insulating materials and an air conditioning system is essential and windows should be made as small as possible.

F.3.2 Monitoring of Water Pollution

(1) Monitoring Station

In the same manner as the monitoring of air pollution, a monitoring station of water pollution should be installed in the Bang Saphan area. Wastewaters generated by factories, which are discharged into rivers after being treated, will have an effect on the receiving environment. Therefore, monitoring of water quality should be executed with regard to both the effluent water and the receiving environment. Monitoring of effluent water, this means in-factory sampling, should be undertaken both before and after the wastewater treatment process. Measuring items and frequency are different depending on the characteristics of the water quality between effluent waters and the receiving environment. General measuring items and frequency ranges are mentioned below.

(2) Measuring Items and Frequency

Significant items that must be monitored are those that are contained in any of the following categories:

1. Primary pollutants arising from the process or site.
2. Heavy metals or chlorinated hydrocarbons which are known to bio-accumulate.
3. Nutrients (compounds of phosphorus or nitrogen) .

Examples of the above are given in Table F. 3.1.

Monitoring of effluent waters should be carried out continuously, daily, monthly, and sporadically according to necessity. However, it is not necessary to monitor the water quality of the receiving environment as frequently as in-factory monitoring because of its long time average influence. Table F. 3.2 shows measuring frequency ranges by pollutant and by sampling location.

Table F.1.1 Summary of Meteorological and Topographical feature in Bang Saphan Area

1) Monsoon	Under the influence of ; the northeast monsoon which brings dry and cool air from China, the southwest monsoon which brings moist and warm air from the Indian Ocean.	
2) Wind speed	3.7 - 6.0 knots (1.9 - 3.1 m/s) : monthly average. 44 knots (22.65 m/s) : maximum (May).	
3) Wind direction	February - April	: South
	May - September	: West
	October - January	: North
4) Temperature	Mean	: 27.0 ℃
	Mean max.	: 33.1 ℃ (April)
	Mean min.	: 19.6 ℃ (January)
5) Rainfall	1,153 mm per year	
6) Sea water quality	General	: Sea water quality in the district is generally good and within standards conditions.
	Temperature	: 29.6 ℃ (May), 28.7 (October)
	pH	: 8.1 (May), 7.8 (October)
	BOD	: 0.6 mg/l (May), 1.8 mg/l (October)

Source: Climatology Division, Meteorological Department, Ministry of Communications (Period 1961 - 1990), Station : Prachuap Khiri Khan

Table F.1.2 Ambient Air Quality in Bang Saphan area

STATION	Ban Tah Kham Stn.-1		Ban Tah Kham Stn.-2		Ban Tah Kham Stn.-3		Average value of 3 Stns.	Standard
	Detected range	Average Value(※1)	Detected range	Average Value(※1)	Detected range	Average Value(※1)		
TSP (mg/m³)	0.045 - 0.084	0.062	0.101 - 0.126	0.117	0.095 - 0.120	0.110	0.096	0.330 (※2)
SO_2 (mg/m³)	0 - 0.007	0.004	0 - 0.003	0.002	0 - 0.003	0.002	0.003	0.300(※2)
NO_2 (mg/m³)	0 - 0.058	0.036	0 - 0.044	0.015	ND	ND	0.017	0.320(※3)

(※1) : Average value in 3 days. (※2) : Average in 24 hours. (※3) : Average in 1 hour.

Source : SSI Hot Steel monitoring Project Report

Table F.1.3 Summary Result of Main Water Pollution Indices in Klong Maerampung

	Measured Point-1	Measured Point-2	Standard (*1)
BOD_5 (mg/l)	2 - 6	2 - 6	20 - 60
SS (mg/l)	6 - 22	3 - 20	30 - 150 (*2)
Oil & Grease (mg/l)	ND - 0.8	ND - 0.8	5.0
pH (-)	7.0 - 7.6	7.1 - 7.6	5 - 9

Note: Average value fromDec. 1994 to Apr. 1996.

*(*1) ; Effluent standards by MOI.*

*(*2) ; Depend on dilution ratio of wastewater and receiving water.*

Table F.1.4 The Average Results of Coastal Water Quality in 1995

Parameters	Average	NEB Standard (1)
Water Temperature (℃)	29.7	≦ 33 ℃
pH	8.1	** (2)
Salinity (ppt.)	31.1	**
Dissolved Oxygen (ppm.)	7.2	**
BOD (ppm.)	3.5	-
NO_2 (ppm.)	0.0019	**
NH_3 (ppm.)	0.015	**
PO_4 (ppm.)	0.006	**
SS (ppm.)	16.36	-
Chlorophyll A (mg/m3)	4.58	-
Total Bacteria (cfu/ml)	18,917	-
Total Coliform (MPN/100 ml.)	412.9	* (3)
Fecal Coliform (MPN/100 ml.)	384.9	*

Remarks : (1) NEB Standard for Class 7 Industrial Zone where water is used for industrial activities such as receiving water for industrial effluent. After effluent discharge, the water quality must be within the standards.

*(2)** = may be established as necessary.*

(3) = not include natural floatable solids.*

Source : Notification of the Ministry of Science Technology and Energy, dated June 7, B.E.2534 (1991)

Table F.1.5 Population Change and Annual Average Growth Rate in Amphoe Bang Saphan by Tambon from 1987 - 1995

Amphoe & Tambon	Population									Ann. Ave. Growth
	1987	1988	1989	1990	1991	1992	1993	1994	1995	1987 - 95
Bang Saphan	**61,639**	**62,496**	**63,219**	**63,668**	**64,377**	**64,669**	**64,146**	**64,748**	**65,503**	**0.76%**
Tongchai	11,812	11,837	11,925	11,963	11,974	9,981	9,740	9,721	10,138	-1.89%
Chaikasem	9,757	9,997	10,002	10,089	10,212	10,811	10,595	10,680	10,528	0.96%
Thong Mongkon	8,709	8,881	9,074	9,205	9,376	9,014	9,027	9,139	9,042	0.47%
Ron Thong	9,714	9,992	10,354	10,523	10,785	13,020	12,955	13,095	14,228	4.89%
Kamnert Noppakhun	9,248	9,186	9,070	8,926	8,810	8,160	8,149	8,303	7,873	-1.99%
Pong Prasart	7,020	7,080	7,206	7,301	7,414	7,554	7,520	7,609	7,515	0.86%
Maeramperng	5,379	5,523	5,588	5,661	5,806	6,129	6,160	6,201	6,179	1.75%

Sources:
1) For 1987 - 1994, Prachuap Khiri Khan Provincial Administration Office
2) For 1995, Bang Saphan District Administration Office

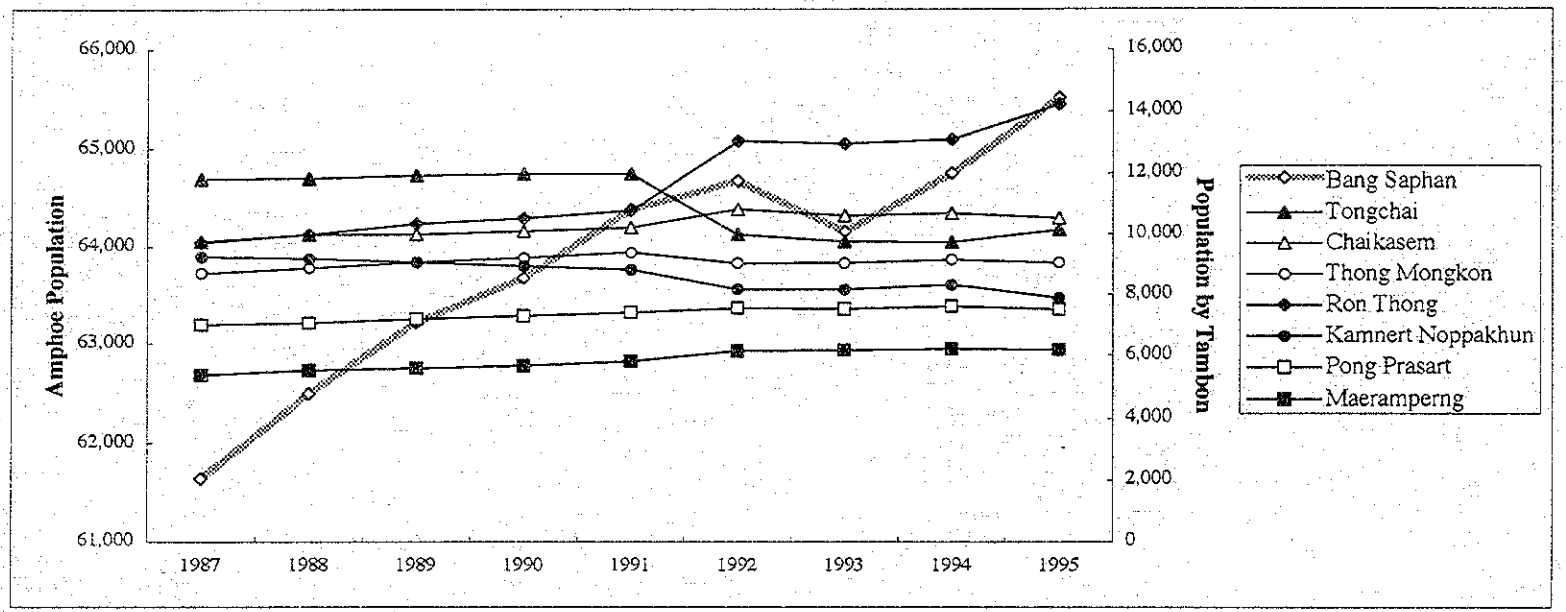


Table F.1.6 Present Population and Household in Amphoe Bang Saphan by Tambon and Muban in 1995

	Local Community		Area	Population					Household	
	Tambon Name	Muban Name	km2	Male	Female	Total	%	Density	Number	Size
A	1 **Tongchai**	1 Ban Tamkiriwong	-	349	323	672	-	-	131	5.1
	2	2 Ban Pakklong	-	635	648	1,283	-	-	252	5.1
	3	3 Ban Krut	-	758	697	1,455	-	-	316	4.6
	4	4 Ban Tung Rua Yao	-	568	553	1,121	-	-	231	4.9
	5	5 Ban Nong Rawang	-	699	698	1,397	-	-	280	5.0
	6	6 Ban Tamuang	-	638	679	1,317	-	-	253	5.2
	7	7 Ban Mongkon	-	456	409	865	-	-	184	4.7
	8	8 Ban Takien Song Pinong	-	309	378	687	-	-	132	5.2
	9	9 Ban Tang Sai	-	231	205	436	-	-	88	5.0
	10	10 Ban Chai Mongkon	-	360	332	692	-	-	149	4.6
	11	11 Ban Don Sung	-	102	111	213	-	-	43	5.0
		Sub-Total	**94**	**5,105**	**5,033**	**10,138**	**15.5**	**108**	**2,059**	**4.9**
B	12 **Chaikasem**	1 Ban Nong Yaphong	-	736	690	1,426	-	-	277	5.1
	13	2 Ban Nong Chan	-	379	362	741	-	-	150	4.9
	14	3 Ban Dong Maingam	-	473	488	961	-	-	165	5.8
	15	4 Ban Morasuab	-	454	432	886	-	-	165	5.4
	16	5 Ban Si Yaek Bankrut	-	621	588	1,209	-	-	240	5.0
	17	6 Ban Huay Kai Tor	-	363	348	711	-	-	140	5.1
	18	7 Ban Nong Mai Kaen	-	519	496	1,015	-	-	174	5.8
	19	8 Ban Hin Tang	-	313	348	661	-	-	139	4.8
	20	9 Ban Nong Phong	-	472	478	950	-	-	196	4.8
	21	10 Ban Sarm Kum	-	282	261	543	-	-	117	4.6
	22	11 Ban Kao Mun	-	326	344	670	-	-	147	4.6
	23	12 Ban Huay Takien	-	395	360	755	-	-	177	4.3
		Sub-Total	**162**	**5,333**	**5,195**	**10,528**	**16.1**	**65**	**2,087**	**5.0**
C	24 **Thongmongkon**	1 Ban Wang Yao	-	240	266	506	-	-	93	5.4
	25	2 Ban Pong Ko	-	1,037	915	1,952	-	-	409	4.8
	26	3 Ban Rat Prasong	-	809	727	1,536	-	-	321	4.8
	27	4 Ban Huay Kaeb	-	518	508	1,026	-	-	218	4.7
	28	5 Ban Tammarat	-	593	581	1,174	-	-	258	4.6
	29	6 Ban Kao Kaen	-	668	724	1,392	-	-	299	4.7
	30	7 Ban Sab Sombuan	-	432	413	845	-	-	186	4.5
	31	8 Ban Nai Lock	-	321	290	611	-	-	128	4.8
		Sub-Total	**223**	**4,618**	**4,424**	**9,042**	**13.8**	**40**	**1,912**	**4.7**
D	32 **Ron Thong**	1 Ban Don Samnak	-	1,276	1,220	2,496	-	-	527	4.7
	33	2 Ban Sai Ku	-	235	266	501	-	-	103	4.9
	34	3 Ban Kao Din	-	674	653	1,327	-	-	145	9.2
	35	4 Ban Samyaek	-	867	800	1,667	-	-	373	4.5
	36	5 Ban Ko yai Chim	-	1,517	1,562	3,079	-	-	716	4.3
	37	6 Ban Pa Ron	-	460	416	876	-	-	182	4.8
	38	7 Ban Wang Ngam Kaen	-	670	671	1,341	-	-	325	4.1
	39	8 Ban Klong Roi	-	456	341	797	-	-	199	4.0
	40	9 Ban Klong Ploen	-	504	467	971	-	-	241	4.0
	41	10 Ban Tung Chuek	-	537	319	856	-	-	152	5.6
	42	11 Ban Huay Plu	-	168	149	317	-	-	71	4.5
		Sub-Total	**228**	**7,364**	**6,864**	**14,228**	**21.7**	**62**	**3,034**	**4.7**

Source: Bang Saphan District Administration Office

Table F.1.6 Present Population and Household in Amphoe Bang Saphan by Tambon and Muban in 1995 (continued)

	Local Community		Area	Population					Household	
	Tambon Name	Muban Name	km2	Male	Female	Total	%	Density	Number	Size
E	43 **Kamnert Noppakhun**	1 Ban Tarad Bang Saphan Yai	-	1,102	843	1,945	-	-	460	4.2
	44	2 Ban Na Pak Kang	-	424	416	840	-	-	170	4.9
	45	3 Ban Por Dang	-	440	379	819	-	-	160	5.1
	46	4 Ban La Harn	-	533	483	1,016	-	-	185	5.5
	47	5 Ban Huay Sai Kao	-	591	561	1,152	-	-	261	4.4
	48	6 Ban Don Thong	-	453	496	949	-	-	199	4.8
	49	7 Ban Nong Ta Ja	-	303	308	611	-	-	122	5.0
	50	8 Ban Don Sanoa	-	281	260	541	-	-	115	4.7
		Sub-Total	**55**	**4,127**	**3,746**	**7,873**	**12.0**	**144**	**1,672**	**4.7**
F	51 **Pongprasart**	1 Ban Fai Tah	-	688	715	1,403	-	-	279	5.0
	52	2 Ban Hin Kong	-	551	497	1,048	-	-	190	5.5
	53	3 Ban Cha Muang	-	425	399	824	-	-	161	5.1
	54	4 Ban Tam Mah Rong	-	451	445	896	-	-	170	5.3
	55	5 Ban Rak Muang	-	305	293	598	-	-	116	5.2
	56	6 Ban Huay Kaen	-	308	286	594	-	-	114	5.2
	57	7 Ban Tung Pao	-	210	222	432	-	-	92	4.7
	58	8 Ban Tung Kitai	-	331	324	655	-	-	137	4.8
	59	9 Ban Ton Throng Lang	-	307	259	566	-	-	122	4.6
	60	10 Ban Tung Nun	-	243	256	499	-	-	96	5.2
		Sub-Total	**79**	**3,819**	**3,696**	**7,515**	**11.5**	**95**	**1,477**	**5.1**
G	61 **Maeramperng**	1 Ban Don Samlarn	-	351	373	724	-	-	150	4.8
	62	2 Ban Tah Manao	-	439	447	886	-	-	185	4.8
	63	3 Ban Ao Yang	-	238	239	477	-	-	99	4.8
	64	4 Ban Tah Kam	-	223	227	450	-	-	93	4.8
	65	5 Ban Pak Klong	-	881	749	1,630	-	-	305	5.3
	66	6 Ban Lang	-	819	836	1,655	-	-	348	4.8
	67	7 Ban Tung Larn Kuay	-	183	174	357	-	-	55	6.5
		Sub-Total	**35**	**3,134**	**3,045**	**6,179**	**9.4**	**174**	**1,235**	**5.0**
	Grand Total		**876**	**33,500**	**32,003**	**65,503**	**100.0**	**75**	**13,476**	**4.9**

Source: Bang Saphan District Administration Office

Table F.1.7 Characteristics of Sanitary Districts in Amphoe Bang Saphan in 1995

Character	Sanitary District							
	Kamnert Noppakhun		Ban Krut		Ron Thong		Total	
Population	3,097	(4.7%)	6,573	(10.0%)	9,070	(13.8%)	18,740	(28.6%)
Household Number	721	(5.4%)	1,332	(9.9%)	1,864	(13.8%)	3,917	(29.1%)
Average Household Size	4.3	-	4.9	-	4.9	-	-	-
Area (km2)	2.8	-	10.5	-	39.5	-	-	-
Density	1,106	-	626	-	230	-	-	-

Source: Bang Saphan District Administration Office

Note:
Since each sanitary district covers a couple of mubans partially and therefore can be hardly defined population and area with a limited information available at this moment, it is then assumed that all the population and area of the concerned mubans are fully taken into account as sanitary district in order to raoughly picture the characteristics of each sanitary district in Amphoe Bang Saphan.

Table F.1.8 Number of Labor Force in Amphoe Bang Saphan by Sector from 1993 - 1995

Sector	Type	Labor Force			Ann. Ave. Growth
		1993	1994	1995	1993 - 1995
Industry Sector	Skilled Labor	713	862	1,025	12.9%
	Unskilled Labor	1,782	1,973	2,243	8.0%
	Sub-Total	**2,495**	**2,835**	**3,268**	**9.4%**
Service Sector	Skilled Labor	524	634	712	10.8%
	Unskilled Labor	392	423	568	13.2%
	Sub-Total	**916**	**1,057**	**1,280**	**11.8%**
Agriculture Sector	Skilled Labor	-	-	-	-
	Unskilled Labor	-	-	-	-
	Sub-Total	**-**	**-**	**-**	**-**
Grand Total		**3,411**	**3,892**	**4,548**	**10.1%**

Source:

Prachuap Khiri Khan Provincial Office, Ministry of Labor Force and Welfare

Note:

1) Definition of skilled labor is bacically more than high school graduate by educational level and also white color position by job status.
2) Information on labor force in agricultural sector was not able get during the first field survey in December

Table F.1.9 Utilization of Farm Holding Land by Type of Farm Land and by Amphoe in 1993

Muang & Amphoe	Total Area	Farm Holding Land (km2)											
		Housing Area		Paddy Area		Field Crops Area		Fruit Tree & Crops Area		Vegetable Area		Other Area	
Prachuap Khiri Khan	2,930.6	101.1	(100.0%)	190.6	(100.0%)	1,602.4	(100.0%)	977.8	(100.0%)	57.5	(100.0%)	17.4	(100.0%)
Muang Prachuap Khiri Khan	472.5	11.5	(11.4%)	11.8	(6.2%)	311.1	(19.4%)	113.1	(11.6%)	9.0	(15.6%)	16.0	(91.8%)
Kui Buri	290.5	11.3	(11.1%)	43.4	(22.8%)	197.1	(12.3%)	33.5	(3.4%)	5.1	(8.9%)	0.1	(0.7%)
Thap Sakae	345.8	10.1	(10.0%)	19.8	(10.4%)	75.4	(4.7%)	239.0	(24.4%)	1.4	(2.4%)	0.1	(0.3%)
Bang Saphan	**546.2**	**15.3**	**(15.1%)**	**22.9**	**(12.0%)**	**151.1**	**(9.4%)**	**334.9**	**(34.3%)**	**22.0**	**(38.3%)**	-	-
Bang Saphan Noi	573.6	17.7	(17.5%)	64.2	(33.7%)	431.6	(26.9%)	56.0	(5.7%)	4.2	(7.3%)	-	-
Pran Buri	283.0	25.4	(25.1%)	26.8	(14.1%)	61.0	(3.8%)	174.2	(17.8%)	11.6	(20.2%)	-	-
Hua Hin	419.1	9.8	(9.7%)	1.6	(0.9%)	375.0	(23.4%)	27.2	(2.8%)	4.2	(7.3%)	1.2	(7.2%)

Source:
Prachuap Khiri Khan Provincial Administration Office

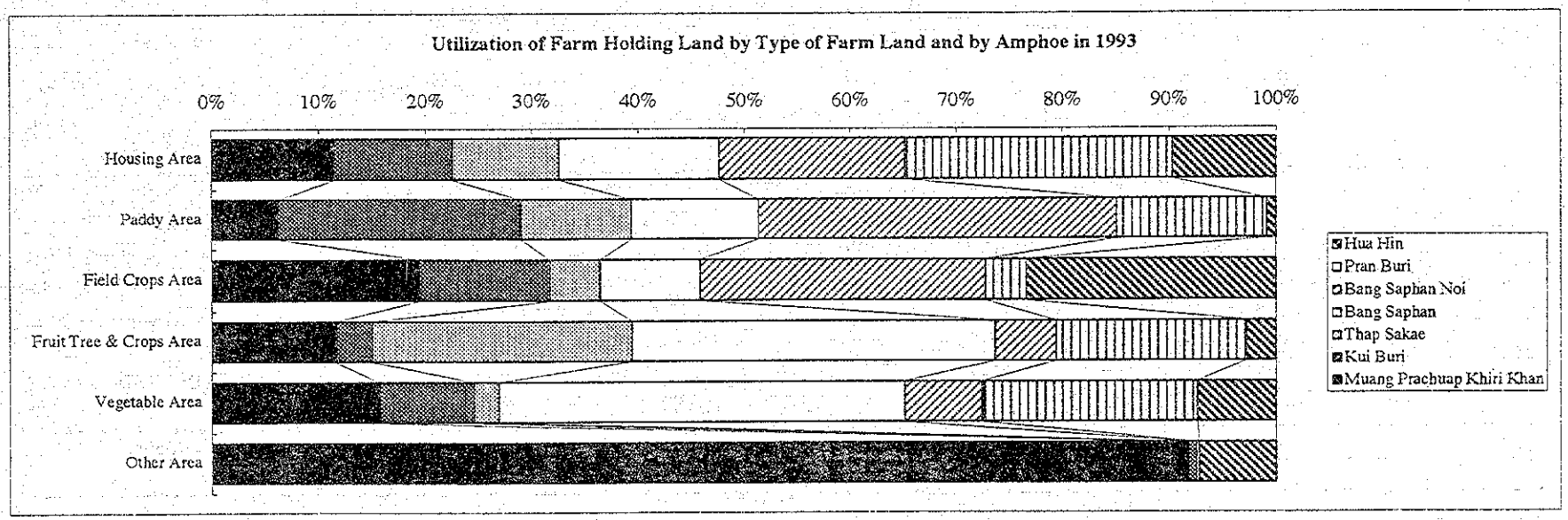


Table F.1.10 Number of Households in Non-Municipal Area by Income Class Per Annum and by Amphoe in 1994

Muang & Amphoe	Household Number		Income Per Annum (Baht) Under 6,000		6,000 - 10,000		10,000 - 20,000		Over 20,000		Unknown	
Prachuap Khiri Khan	74,333	(100.0%)	6,383	(8.6%)	9,009	(12.1%)	13,942	(18.8%)	40,096	(53.9%)	4,903	(6.6%)
Muang Prachuap Khiri Khan	10,511	(100.0%)	329	(3.1%)	1,156	(11.0%)	2,179	(20.7%)	6,015	(57.2%)	832	(7.9%)
Kui Buri	10,397	(100.0%)	439	(4.2%)	1,268	(12.2%)	1,774	(17.1%)	6,612	(63.6%)	304	(2.9%)
Thap Sakae	9,177	(100.0%)	358	(3.9%)	859	(9.4%)	1,904	(20.7%)	5,728	(62.4%)	328	(3.6%)
Bang Saphan	**12,613**	**(100.0%)**	**902**	**(7.2%)**	**1,470**	**(11.7%)**	**2,568**	**(20.4%)**	**6,760**	**(53.6%)**	**913**	**(7.2%)**
Bang Saphan Noi	7,032	(100.0%)	547	(7.8%)	1,010	(14.4%)	1,858	(26.4%)	3,385	(48.1%)	232	(3.3%)
Pran Buri	18,022	(100.0%)	2,784	(15.4%)	2,214	(12.3%)	2,321	(12.9%)	8,603	(47.7%)	2,100	(11.7%)
Hua Hin	6,581	(100.0%)	1,024	(15.6%)	1,032	(15.7%)	1,338	(20.3%)	2,993	(45.5%)	194	(2.9%)

Source:
Prachuap Khiri Khan Provincial Administration Office

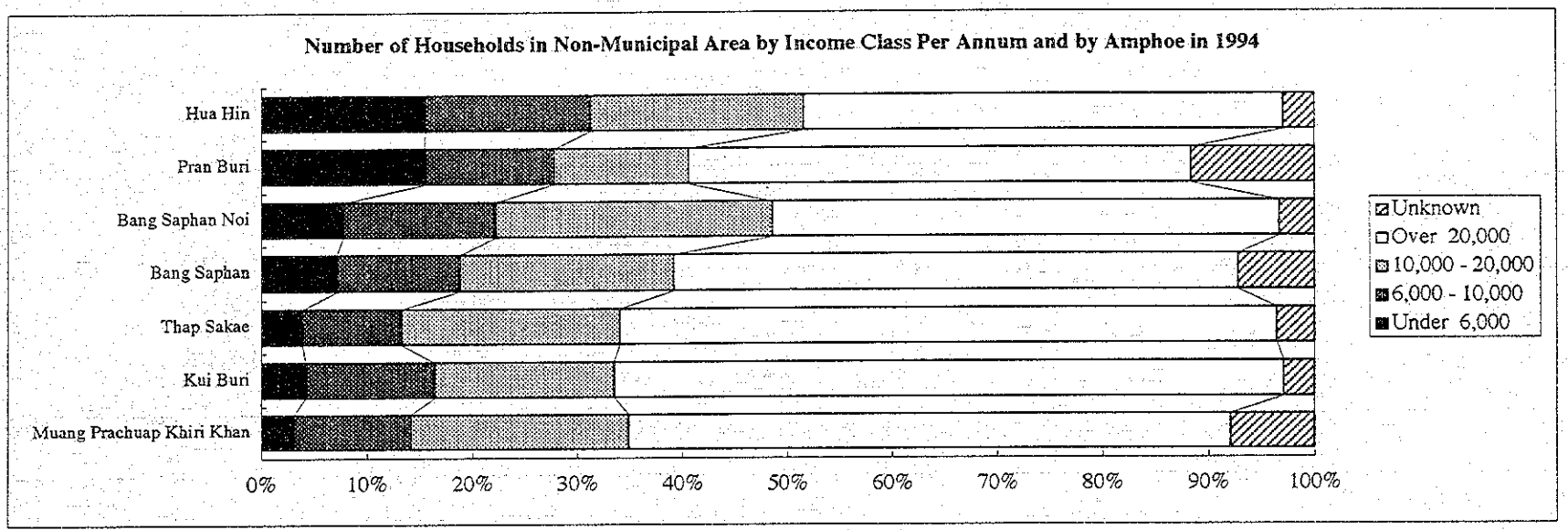


Table F.1.11 Number of Students and Schools in Amphoe Bang Saphan by Educational Level and by Type of School from 1992 - 1995

Level	Type	1992 Student		1992 School	1993 Student		1993 School	1994 Student		1994 School	1995 Student		1995 School	Ann. Ave. Growth 1992 - 1995
Pre-School	Public	1,085	-	-	1,364	-	-	1,799		-	-		-	-
	Private	339	-	-	333	-	-	291		-	-		-	-
	Sub-Total	**1,424**	**12.8%**	-	**1,697**	**14.3%**	-	**2,090**	**16.6%**	-	**2,093**	**15.1%**	-	**10.1%**
Primary School	Public	7,187	-	34	7,320	-	34	6,992		34	6,702		34	-
	Private	298	-	1	350		1	349		1	350		1	-
	Sub-Total	**7,485**	**67.5%**	**35**	**7,670**	**64.5%**	**35**	**7,341**	**58.3%**	**35**	**7,052**	**50.8%**	**35**	**-1.5%**
Extended Primary School	Public	153	-	8	269	-	8	509		8	715		8	-
	Private	0	-	0	0	-	0	0		0	0		0	-
	Sub-Total	**153**	**1.4%**	**8**	**269**	**2.3%**	**8**	**509**	**4.0%**	**8**	**715**	**5.2%**	**8**	**47.0%**
Secondary	Public	2,034	-	3	2,250	-	3	2,647		4	3,336		4	-
	Private	0	-	0	0	-	0	0		0	677		1	-
	Sub-Total	**2,034**	**18.3%**	**3**	**2,250**	**18.9%**	**3**	**2,647**	**21.0%**	**4**	**4,013**	**28.9%**	**5**	**18.5%**
Grand Total		**11,096**	**100.0%**	**46**	**11,886**	**100.0%**	**46**	**12,587**	**100.0%**	**47**	**13,873**	**100.0%**	**48**	**5.7%**

Source:
Prachuap Khiri Khan Provincial Office, Ministry of Education

Table F.1.12 Number and Ratio of Primary School Graduates Going on to Secondary School from 1992 - 1995 in Changwat Prachuap Khiri Khan by Amphoe

	1992			1993			1994			1995		
Muang & Amphoe	Primary Graduates	Secondary Enters	Ratio 1992	Primary Graduates	Secondary Enters	Ratio 1993	Primary Graduates	Secondary Enters	Ratio 1994	Primary Graduates	Secondary Enters	Ratio 1995
Prachuap Khiri Khan	7,665	5,124	66.8%	7,746	5,642	72.8%	8,092	6,848	84.6%	7,470	6,867	91.9%
Muang Prachuap Khiri Khan	1,421	850	59.8%	1,386	941	67.9%	1,381	1,153	83.5%	1,410	1,291	91.6%
Kui Buri	791	364	46.0%	846	413	48.8%	896	676	75.4%	889	587	66.0%
Thap Sakae	951	656	69.0%	904	646	71.5%	911	804	88.3%	959	788	82.2%
Bang Saphan	**873**	**672**	**77.0%**	**965**	**822**	**85.2%**	**1,305**	**1,129**	**86.5%**	**1,211**	**1,300**	**107.3%**
Bang Saphan Noi	558	261	46.8%	582	250	43.0%	512	399	77.9%	553	492	89.0%
Pran Buri	1,696	1,233	72.7%	1,681	1,340	79.7%	1,696	1,439	84.8%	1,072	1,079	100.7%
Hua Hin	1,375	1,088	79.1%	1,382	1,230	89.0%	1,391	1,248	89.7%	1,376	1,330	96.7%

Source:
Prachuap Khiri Khan Provincial Office, Ministry of Education

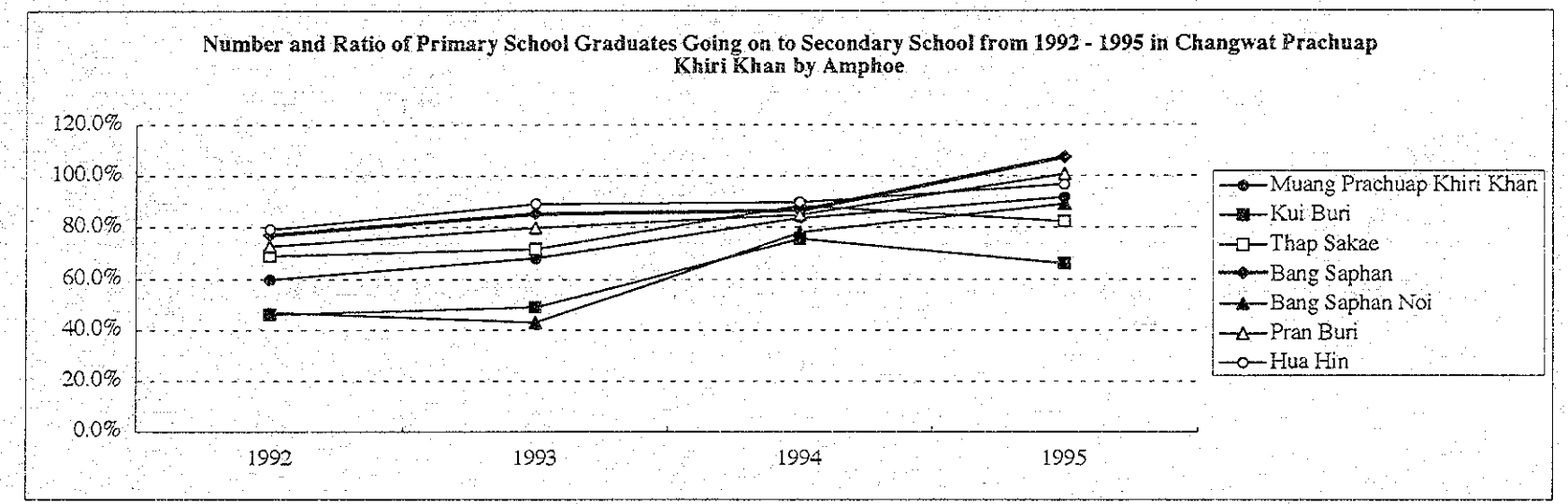


Table F.1.13 Number of Public Health Facilities and Personnel in Amphoe Bang Saphan in 1995

(1) Public Health Facilities

Ownership	Facility Type	Total Number	Ratio of Population to Facility		Remarks
			Bang Saphan	Provincial Average	
Government Owned Institution	Community Hospital	1	65,503	65,859	60 Beds at Present, additional 30 Beds on Plan
	Health Center	13	5,039	6,147	-
	Public Health Station	1	65,503	-	-
	Public Health Education Center	1	65,503	-	-
Private Owned Institution	Medical Clinic	4	16,376	12,460	-
	Nursery	2	32,752	-	-
	Drug Store	13	5,039	5,622	-

(2) Public Health Personnel

Status	Personnel Type	Total Number	Ratio of Population to Personnel		Remarks
			Bang Saphan	Provincial Average	
Government Public Health Personnel	Physician	4	16,376	7,318	-
	Dentist	1	65,503	27,119	-
	Phamacist	1	65,503	25,612	-
	Professional Nurse	33	1,985	1,787	-
	Technical Nurse	22	2,977	2,414	-

Source:
Bang Saphan Community Hospital, Ministry of Public Health

Table F.1.14 Top Ten Cause Group of Illness by Number of Out-Patient in Amphoe Bang Saphan from 1993 - 1995

	1993	
	Type of Disease	Number
1	Diseases of Respiratory System	17,283
2	Accidents, Poisoning and Violence	9,783
3	Unclear Causes	8,155
4	Infectious and Parastic Diseases	6,627
5	Diseases of Digestive System	6,171
6	Diseases of Skin and Subbcutaneous Tissue	5,910
7	Diseases of Musculoskeletal System and Connective Tissue	4,435
8	Disease of Circulatory System	3,530
9	Disease of Genito-Urinary System	3,390
10	Disease of Nervous System and Sense Organs	3,301

	1994	
	Type of Disease	Number
1	Diseases of Respiratory System	9,692
2	Diseases of Digestive System	7,568
3	Poisoning and Violence	4,160
4	Accidents	3,860
5	Disease of Circulatory System	3,822
6	Diseases of Gland and Metabolism	3,213
7	Other Causes of Illness	2,909
8	Diseases of Skin and Subbcutaneous Tissue	2,669
9	Disease of Genito-Urinary System	2,226
10	Diseases of Musculoskeletal System and Connective Tissue	2,074

	1995	
	Type of Disease	Number
1	Diseases of Respiratory System	9,132
2	Poisoning and Violence	5,760
3	Diseases of Digestive System	5,115
4	Other Causes of Illness	4,564
5	Diseases of Gland and Metabolism	4,151
6	Disease of Circulatory System	3,245
7	Accidents	3,096
8	Disease of Genito-Urinary System	2,615
9	Complications during Pregnant, Prenatal, and Postnatal Periods	2,284
10	Diseases of Skin and Subbcutaneous Tissue	1,836

Source:
Bang Saphan Community Hospital, Ministry of Public Health

Table F.1.15 Major Tourism Points in Amphoe Bang Saphan

Site Number	Tourism Point	Site Location		Remarks
		in Muban	in Tambon	
1	Lamlar Island	Ban Tang Sai	Thongchai	
2	Saikaew Beach	Ban Tamkiriwong	Thongchai	
3	Saikaew Cave	Ban Tamkiriwong	Thongchai	
4	Kiriwong Cave	Ban Tamkiriwong	Thongchai	
5	Tongchai Mountain	Ban Tung Rua Yao	Thongchai	
6	Ban Krud Beach	Ban Pakklong	Thongchai	
7	Ban Nhong Mongkon Beach	Ban Mongkon	Thongchai	
8	Ban Don Sam Ran Beach	Ban Don Samlarn	Maeramperng	
9	Ban Thong Lang Beach	Ban Tah Manao	Maeramperng	
10	Gulf of Mae Ram Pung		Maeramperng	
11	Klang Aow National Park		Maeramperng	
12	Kao Boat Temple		Kamnert Noppakhun	
13	Kao Ma Rong Cave		Pongprasart	
14	Pole of Amphoe Bang Saphan		Pongprasart	Religious Monument of Buddhist
15	Suan Luang Beach		Pongprasart	

Source:
Annual Operation Report 1995, Bang Saphan Community Hospital, Ministry of Public Health

Tourism points located within 5km from the proposed site of an industrial estate

Table F.2.1 Environmental Impact, Mitigating Measure, and Monitoring Plan During Construction Phase of Bang Saphan I/E

Item	Environmental Impact	Level of Impact *			Mitigative Measure	Monitoring Plan
		MA	ME	MI		
1	Physical Resource					
1.1	Air Quality					
	- The major construction activity will naturally generate fugitive dust which affect local air quality.	√			- Control of fugitive dust emission by spraying with water.	- Check ambient air quality.
	- Traffic around the site is another source of fugitive dust, especially traffic on unpaved roads around the site.		√		- Vehicle speed limit and water spraying on roads is required.	
1.2	Surface Water Quality					
	- Sediments and soil erosion from construction activities will be the major pollutants which will increase turbidity in sea water.	√			- Proper construction techniques must be employed to prevent sediment or soil erosion into surface water.	- Check surface water quality
	- Domestic wastewater from construction workers and staff, if not properly treated, will contaminate groundwater or surface water.		√		- A conventional wastewater treatment system must be constructed to handle all wastewater from construction activities.	
1.3	Groundwater Hydrology and Quality					
	- Effluent from cesspools of construction workers camps, when seeping into the ground, would bacterially contaminate the aquifer and groundwater locally. This can be serious if the cesspool is near the domestic water wells.		√		- Cesspools and solid waste collection areas must be located far apart from groundwater sources to prevent contamination of leachate.	
1.4	Soils					
	- A large amount of soil will be excavated from the site during the site preparation for construction.		√		- Cut and fill operation is recommended.	
	- Most of excavated soil is subsoil which possesses unfavourable chemical and physical properties for plant growth. Thus, disposal of this soil in surrounding areas which are used for economic crop plantation would cause damage.		√		- Sell the soil to local private construction companies in the area. Select idle lands far away from agricultural land to be used as a disposal site.	

Lebel of Impact : MA = Major, ME = Medium, MI = Minor

Table F.2.1 Environmental Impact, Mitigating Measure, and Monitoring Plan During Construction Phase of Bang Saphan I/E

(During construction phase, 2/3)

Item	Environmental Impact	Level of Impact *			Mitigative Measure	Monitoring Plan
		MA	ME	MI		
2	**Biological Resource**					
2.1	Aquatic Ecology and Fisheries					
	- The input of sediments and untreated effluent into the sea will stimulate the growth of certain marine species. This situation may lead to the increasing of the eutrophication in the marine environment.		√		- The mitigative measures specified for surface water quality must be taken into consideration since any effects on water quality will also affect aquatic lifes.	
3	**Human Use Values.**					
3.1	Land Use					
	- Owing to a relatively large number of worker's families effects on land use in both rural and urban areas would be considerable.		√		- Establish workers communities and control development such that it is strictly within the land use development frame work and regulations of local authorities concerned.	
3.2	Agriculture					
	- Fugitive dust created from construction activities may cause low impacts on crops.		√		- Control the fugitive dust emission by spraying with water.	
	- Disposal of soil excavated from the construction site may affect agricultural land.		√		- Use idle land as soil disposal sites or practice cut and fill operation.	
3.3	Transportation					
	- Heavier volume of traffic may cause damages to the roads resulting in inconvenience to residents.		√		- The access road must be well maintained. Pavement of the access road must be considered.	
	- Sudden increase in traffic volume will give rise to more potential of accidents		√		- Warning signs and stop signs must be put up to warn motorists at every junction. - Truck drivers must be instructed to drive within speed limit.	

Lebel of Impact : MA = Major, ME = Medium, MI = Minor.

Table F.2.1 Environmental Impact, Mitigating Measure, and Monitoring Plan During Construction Phase of Bang Saphan I/E

(During construction phase, 3/3)

Item	Environmental Impact	Level of Impact *			Mitigative Measure	Monitoring Plan
		MA	ME	MI		
4	Quality of Life Values					
4.1	Socio-Economics.					
	- There will be a lot of people who move to live and work in the area. A large number of people living together may cause the following problems: 1. Crowded and disorderly living space. 2. Disputes and crimes. 3. Overuse of existing infrastructure. 4. Abuse of child and woman labor.		√		- Housing units must be properly planned to avoid slum problems. - Proper sanitary systems including water supply, waste treatment and health care must be provided to prevent poor quality of life - Improve the access roads, schools, hospitals, health centers and some public infrastructures..	
4.2	Public Health					
	- Construction activities will create mostly dust which will settle on floor, roof, things or even food. Some respiratory related and gastrointestinal diseases may spread.		√		- Provision of medical services at the site should be implemented for primary care to give prompt treatment and to minimize sick leave.	
4.3	Archaeology and Historical Values.					
	- There will be more labourers migrating into the area. The migrators may introduce some new culture into the area.			√	- No ancient places and objects near the site therefore no mitigative meassure is required.	
4.4	Aesthetics and Tourism					
	- Some beachfront areas may be dirty or damaged due to invasion of construction workers. This will affect local tourism.		√		- An access to the beachfront must be provided for local tourists with a proper safety measure.	

Lebel of Impact : MA = Major, ME = Medium, MI = Minor.

Table F .2.2 Environmental Impact, Mitigating Measure, and Monitoring Plan During Operation Phase of Bang Saphan I/E

Item	Environmental Impact	Level of Impact *			Mitigative Measure	Monitoring Plan
		MA	ME	MI		
1	**Physical Resource**					
1.1	Air Quality					
	- Stack emission gas from the thermal power plant, the iron/steel industry, and the industrial estate is the main source of particulates and gaseous emissions and expected to have high impact to ambient air quality. The impact of air quality on human health and environment are caused preliminary by three main air pollutants, namely SO_2, NO_x and TSP.	√			- The adverse effects can be minimized by using relatively clean fuels, good engineering practice, proper stack height and state-of-the-art air pollution control systems such as Electrostatic Precipitator(EP), Flue Gas Desulfurization(FGD), Low NO_x Burner, etc.	- Emission and ambient air quality monitoring programs must be established to ensure efficiency of the control system.
1.2	Surface Water Quality					
	- Sea water is expected to be affected by thermal pollution of cooling water since the power plant uses sea water for cooling.	√			- Cooling water must be cooled down by means of properly designed cooling system before disposal to reduce thermal effects.	- Check sea water temperature at the discharge point of cooling water pipe.
	- Wastewaters from equipment cleaning, cooling, dust collecting, and other process from the thermal power plant, iron/steel industry and the industrial estate are expected to contain several pollutants such as heavy metals, acidic & alkaline waste, oily discharge, and suspended solids. It can adversely affect quality of receiving water stream.	√			- Each factory should pre-treat the wastewater before discharging to the central facility. The pre-treated wastewater should be treated in the central treatment facility - Minimize a generation of waste water by adopting water saving technique such as recycling and reuse of wastewater.	- Treated effluent from central treatment facility should be monitored to check the compositions before discharging to receiving water stream.
1.3	Groundwater Hydrology and Quality					
	- The impacts on groundwater quality are from contamination by leachate from ash dumping, chemical storage, oil spills and process wastewater. This leachate may contain toxic heavy metals and high suspended solids which easily contaminate the shallow aquifer.	√			- The wastewater treatment plant units, ash dumping areas, etc. with seepage and leakage potentially to contaminate groundwater sources must be lined with cement or other proper lining materials.	- The observation wells should be constructed to monitor the effects.

Lebel of Impact : MA= Major, ME = Medium, MI = Minor.

Table F.2.2 Environmental Impact, Mitigating Measure, and Monitoring Plan During Operation Phase of Bang Saphan I/E

(Operation phase, 2/4)

Item	Environmental Impact	Level of Impact *			Mitigative Measure	Monitoring Plan
		MA	ME	MI		
1.4	Soils					
	- Gaseous emission and fly ash from the power plant, if present in considerable amount, may fall on the ground and can change soil property and quality.	√			- The mitigative measures recommended for air quality will alleviate the adverse impacts.	
	- Soil may receive acid rain attributed by SO_2 and NO_2 released from the power plant and other industrial plants.	√				
	- The leakage and seepage containing heavy metals and other toxic substances from the wastewater treatment plant, ash storage area, coal storage yard, may pollute groundwater aquifer	√			- Covering the floor/basin of wastewater treatment plant, ash storage area, coal storage yard with cement or other lining materials is recommended.	
2	**Biological Resources**					
2.1	Aquatic Ecology and Fisheries.					
	- The oil leakage from barges may cause visual pollution to the sea. The oil spill may cause serious effects to marine organisms and also nearby environment.	√			- The wastewater treatment facility for ballast water should be provided.	
	- Thermal pollution impacts may cause some problems to fishes and economic species.	√			- Cooling water must be cooled down before disposal to reduce thermal effects.	
3	**Human Use Values.**					
3.1	Land Use					
	- Land use and housing development attributed construction workers will slow down. Some portions of the growth will remain to serve the personnel at the factory.			√		
3.2	Agriculture					
	- Fly ash emission of the power plant containing heavy metal elements will affect economic crops since some of them are toxic to plant biological activity.	√			- Adverse effects of the emission fly ash on economic crops are alleviated by the measures applied for soil pollution.	- Quality and quantity of metals in tress and soil adjacent to the plant should be monitored.

Lebel of Impact : MA= Major, ME =Medium, MI =Minor.

Table F.2.2 Environmental Impact, Mitigating Measure, and Monitoring Plan During Operation Phase of Bang Saphan I/E

(Operation phase, 3/4)

Item	Environmental Impact	Level of Impact *			Mitigative Measure	Monitoring Plan
		MA	ME	MI		
3.3	Transportation					
	- Traffic on the access road leading to the site will be delayed due to more congestion particularly during the peak hours.			√	- A four-lane road should be provided for the access road.	
	- Traffic accidents will be increased.			√	- Installation of adequate lighting system and warning lights is recommended.	
4	**Quality of Life Values**					
4.1	Socio-Economics.					
	- The industrial estate will benefit the residents in two aspects i.e. increase of land price and more employment opportunities.		√		- Priority for employment in the factory must be given to local people.	
	- A lot of people migrating to settle in the area may cause many problems i.e. crimes, disputes, crowded areas, abouse of child and woman, etc.		√		- Public relation programs must be set up to inform local people of industrial estate activities. - Co-ordinate with the community committee.	
4.2	Public Health					
	- Air emissions from the power plant are mainly SO_2 , No_x and TSP. Prolonged and chronic exposure to these air pollutants may be harmful to human respiratory system.	√			- A medical center must be set up in the industrial estate to provide primary medical care and basic nursing care services. - Blood level of certain heavy metals must be assessed for those who work in the areas of excessive exposure.	

Lebel of Impact : MA= Major, ME =Medium, MI =Minor.

Table F.2.2 Environmental Impact, Mitigating Measure, and Monitoring Plan During Operation Phase of Bang Saphan I/E

(Operation phase, 4/4)

Item	Environmental Impact	Level of Impact *			Mitigative Measure	Monitoring Plan
		MA	ME	MI		
4.3	Archaeology and Historical Values.					
	- Rural society will change to more consumer and materialistic urban society.			√		
	- The way of living will change from the accustomed simple and peaceful rural society to more complicated, rushing, noisy and crowded conditions.			√		
4.4	Aesthetics and Tourism					
	- More tourists will be expected and this will result in many types of extended local industries for local people.			√	- An access road must be improved and maintained in good conditions. Signs must be provided to indicate restricted areas.	
	- There will be more entertaining places to serve plant's staff.			√	- Some donation to communities should be made by industrial estate.	

Lebel of Impact : MA= Major, ME =Medium, MI =Minor.

Table F. 2.3 Diffusion Formulae for the Calculation of Air Pollution Simulation

	Diffusion Formula
Plume formula (Windy condition, u ≧1.0 m/sec)	$c(x,y,z) = \frac{Q}{(2\pi)^{1/2}\ \pi/8\ R\ \sigma_z u} \{\exp\{-\frac{(z-He)^2}{2\sigma_z^2}\} + \exp\{-\frac{(z+He)^2}{2\sigma_z^2}\}\}$
Puff formula (Calm 1 condition, 0.5 m/sec ≦ u < 1.0 m/sec)	$c(x,y,z) = \frac{Q}{(2\pi)^{1/2}\ \pi/8\ \gamma} \{\frac{1}{\eta_-^2} \exp\{-\frac{u^2(z+He)^2}{2\gamma^2\eta_-^2}\} + \frac{1}{\eta_+^2} \exp\{-\frac{u^2(z+He)^2}{2\gamma^2\eta_+^2}\}\}$
Puff formula (Calm 2 condition, u≦0.4 m/sec)	$c(x,y,z) = \frac{Q}{(2\pi)^{3/2}\ \gamma} (\frac{1}{\eta_-^2} + \frac{1}{\eta_+^2})$
Notations	$R: R^2 = X^2 + Y^2$
	$\eta_-: \eta_-^2 = X^2 + Y^2 + \alpha^2/\gamma^2 (Z-He)^2$
	$\eta_+: \eta_+^2 = X^2 + Y^2 + \alpha^2/\gamma^2 (Z+He)^2$
	C : Concentration (m^3/m^3 or kg/m^3)
	X : Leeward distance (m)
	Y : Horizontal distance (m)
	Z : Vertical distance (m)
	He : Effective stack height (m)
	σ_z : Diffusion parameter along with Z direction (windy condition) (m)
	u : Wind speed (m/sec)
	Q: Emission rate (Nm^3/sec or kg/sec)
	α : Diffusion parameter along with horizontal direction (Calm condition) (m/sec)
	γ : Diffusion parameter along with vertical direction (Calm condition) (m/sec)

Table F.2.4 Characteristics of Wastewater of Main Industries

Type of Industry	Characteristics of Wastewater
Industrial Estate	
Food Industry	Waste water varies greatly with material, the kind and degree of processing, etc. It is commonly characterized by : (1) high concentrations of organic matters ; (2) high concentrations of semi-solid wastes and floating substances ; and (3) big seasonal fluctuations. For a hygienic reason, washing water (sometimes, high-temperature water) is often discharged in a large volume. Since in principle no harmful substances such as heavy metals are mixed in waste water, excess sludge generated at treatment of the waste water can be dehydrated and dried, and be recovered as the resource for manure, livestock feed, etc. It is broadly classified as a protein group, a fat and oil group and a carbohydrate group. The contents of oil, nitrogen and phosphorus are generally high.
Textile Industry	There is much difference in the content of waste water between natural and chemical textile industries. Wastewater from the wool industry contains high concentrations of BOD, fat and alkali. Wastewater from dyeing discharges various pollutants such as dyes, auxiliary additives and other chemicals. Quality and quantity much vary day to day, in seasons or according to changes of fashion.
Paper & pulp Industry	Generally speaking, the pulp and paper making industries are typical water-using industries and the pollution load of waste water is high. The wastewater is characterized by its particularly high COD and coloration as well. However, the type of factory to be introduced in Bang Saphan I/E are manufacturing factories of office paper, paper containers and boxes, etc. These kind of factories generate not so much wastewater and the pollutant load of wastewater is also not so high.
Chemical Industry	There is the possibility that those substances of a wide range from inorganic to organic may be mixed in wastewater in correspondence with the production process, and the chemical industry generally discharges complicatedly polluted waste water. It often contains harmful substances, foul-smelling ingredients, is strongly acidic or alkaline and has high-COD ingredients.
Ceramics Industry	Waste water contains plenty of inorganic suspended ingredients and is alkaline. The ceramic industry may give birth to coloring ingredients and harmful substances.
Iron/ Steel making	This industry is also a water-consuming industry. Wastewater from the cooling and cleaning processes for coke furnace contains ammonia, cyanide, phenols, etc. Besides, there is wastewater from the dust collecting process of each furnace which contains suspended solids (coke dust and ore), and that from the pickling process which contains acid, iron and oil. Majority of the wastewater is cooling water. Recycling of the waste water is very much developing in this industry and newly built steel mill recycles more than 90% of industrial water.
Thermal Power Plant (Fossil-Fuel)	Thermal power plants discharge large quantities of effluent water from the cooling process. In this project, the thermal power plant is planned to locate close to the sea. In this case, the plant uses sea water for cooling. The temperature of wasted cooling water in normally high, and such waste water can cause thermal pollution or the elevation of temperature to the vicinity of discharging outlet possibly resulting the destruction of marine ecosystem.

Table F.2.5 Estimation of Gaseous Emission Loads in Bang Saphan I/E by Type of Industry

Type of Industry	SO_2 [1]		NOx [2]		TSP	Emission Volume [3]
	(Nm^3/hr)	(kg/hr)	(Nm^3/hr)	(kg/hr)	(kg/hr)	(Nm^3/hr)
Food	11.8	33.8	3.1	6.4	10.0	33,215
Textile	2.0	5.8	0.5	1.1	1.7	5,729
Wooden and furniture	1.3	3.7	0.3	0.7	1.1	3,684
Paper and pulp	1.0	2.9	0.3	0.5	0.9	2,835
Chemicals	31.0	88.6	8.1	16.7	26.1	87,159
Ceramics	32.8	93.7	8.6	17.6	27.6	92,146
Steel processing	13.0	37.1	3.4	7.0	11.0	36,528
Machinery	8.6	24.7	2.3	4.6	7.3	24,283
Ship building	0.2	0.5	0.0	0.1	0.1	446
General manufacture total	101.8	290.8	26.6	54.7	85.8	286,026

1), 2), 3): Calculated based on the units by Nomura Research Institute Ltd.

Estimation of Gaseous Emission Loads in Bang Saphan I/E by Type of Industry

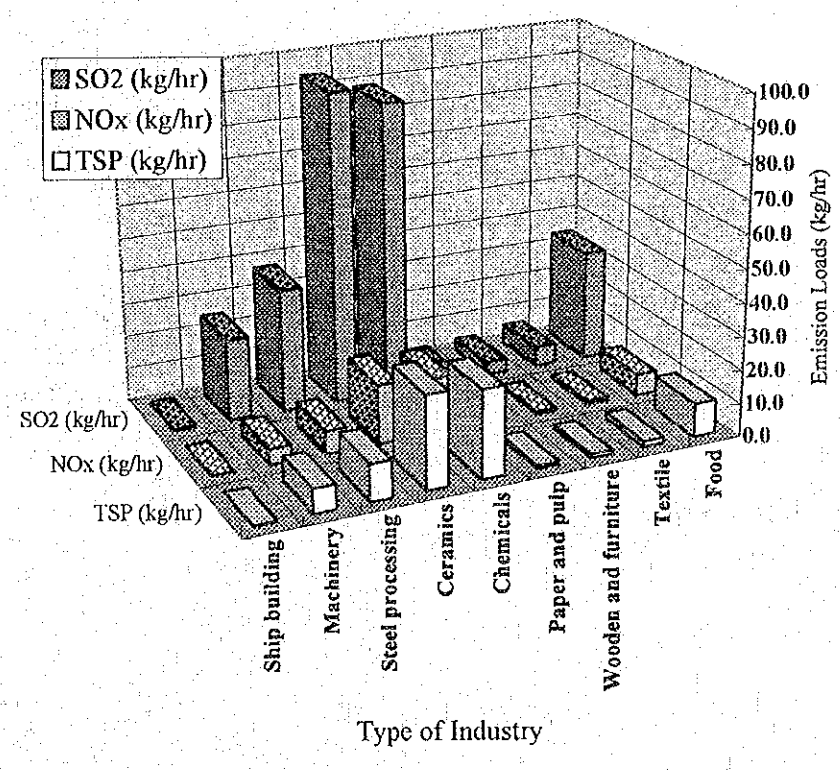


Table F. 2.6 Estimation of Gaseous Emission Loads in Bang Saphan Area by Type of Source

	Type of Source	SO_2 (tons/yr)	SO_2 (%)	NOx (tons/yr)	NOx (%)	TSP (tons/yr)	TSP (%)
(1)	**General manufacture total**	907	2.4	171	0.6	268	4.8
(2)	**Iron/ Steel group**	1,642	4.3	309	1.1	484	8.7
(3)	**Thermal power plant**	35,840	93.3	28,175	96.6	4,704	84.7
	Stationary Sources Total (1)+(2)+(3)	(38,389)	(99.9)	(28,654)	(98.2)	(5,456)	(98.2)
(4)	**Road transport vehicle**	27	0.1	514	1.8	100	1.8
	Grand Total (1)+(2)+(3)+(4)	38,416	100.0	29,168	100.0	5,556	100.0

Note: ton/yr = 12 hr x 260 days x ton/hr

Estimation of Gaseous Emission Loads by Type of Source

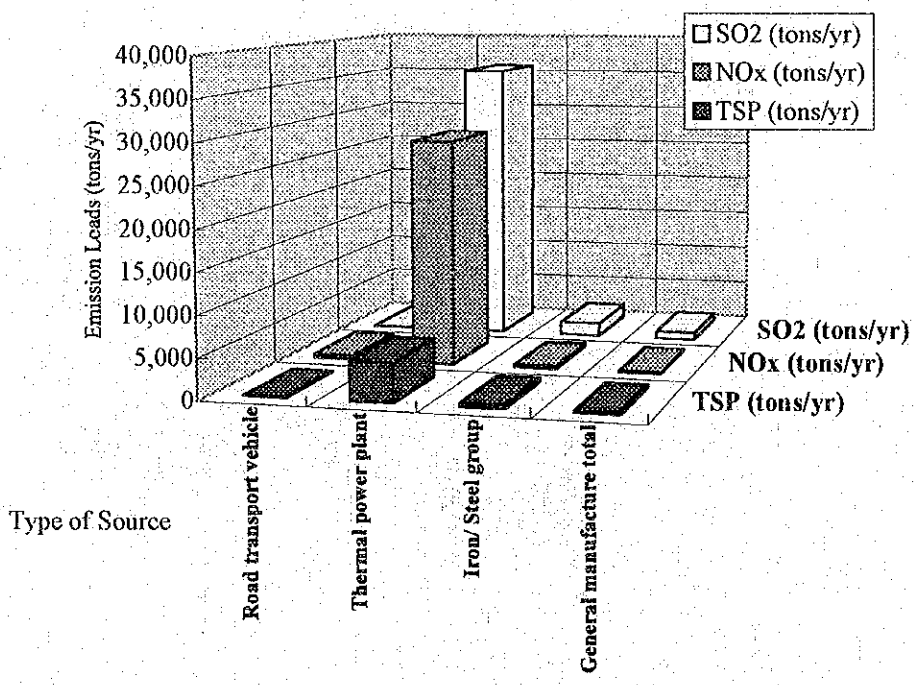


Table F.2.7 Estimation of Wastewater to be Treated by Type of Industry

Type of Industry	Wastewater to be Treated (m^3/day)	BOD Load (kg/day)	SS Load (kg/day)
Food	8,664	173	260
Textile	4,840	97	145
Wooden & furniture	352	7	11
Paper & pulp	56	1	2
Chemicals	20,672	413	620
Ceramics	5,920	118	178
Steel processing	6,000	120	180
Machinery	4,956	99	149
Ship building	152	3	5
General manufacture total	51,612	1,032	1,548
Iron/Steel group	79,840	1,597	2,395

Table F. 2.8 Existing Municipal Solid Disposal Sanitation in Bang Saphan Area

Sanitation Name	The place for solid waste disposal (year : 1995)	Dumping Area(Rai) Capacity	Starting year	Methodology of Solid Waste Disposal
Kamnoed Noppakhun Sanitation	Plain area around with rice field, Moo 5, Kamnoed Nappakhun Sub-District, outside sanitation area 3 kms.	8 Rai, 2 -3 tonnes/day	No record	Dumping to the ground and burning.
Ronthong Sanitation	Plain area, Moo 4, Ronthong Sun-District, public area, outside sanitation area 1.5 kms.	9 Rai, 2 -3 tonnes/day	No record	Dumping to the ground and burning.
Ban Krud Sanitation	Plain area, outside sanitation area.	3.06 Rai, 2 -3 tonnes/day	No record	Dumping to the ground and temporary burning.

Source : Information from Questionnaires of Environmental Management in Sanitation and Municipal Area of Prachuap Khirikhan Province, Survey by Southeast Asia Technology Co., Ltd., January 1996.

Table F. 2.9 Existing Waste Management Practice

Waste Management Practice	Type of Waste
On-site landfill	Bio-sludge, Activated carbon, Ash, Wastewater treatment sludge, etc.
On-site burial	Activated carbon, Spent charcol, Spent catalyst, Mud, etc.
On-site land farming	Oil & sludge, Slop tank drain, Bio-sludge, etc.
Incineration on-site	Waste oil, Tank bottom, Bio-sludge, Waste from Filter Press, Reactor skimmings, Wastewater, etc.
On-site pavement	Bituminous waste
Collected by sanitary district	Factory and office debris, etc.
Stored on-site	Waste polymer, Spent catalyst, Brine mud, Spent solvent, Skimmer and mud, Resins, etc.
Sold outside	Waste oil, Waste polymer, Off spec. product, etc.
Regenerated by supplier	Spent catalyst
Fixed with cement	Waste contaminated with heavy metals

Source : The Monitoring and Control of Industrial Hazardous Waste: Hazardous Waste Management in Thailand, TDRI, 1995.

Table F. 2.10 Estimation of Industrial Solid Wastes Generated in Bang Saphan Area

(Unit : tons/yr)

Type of Industry	General Waste	Hazardous Waste (*)	Total
Food	1,377	243	1,620
Textile	387	68	456
Wooden & furniture	316	56	371
Paper & pulp	57	10	68
Chemicals	1,836	324	2,160
Ceramics	1,865	329	2,194
Steel processing	2,235	394	2,629
Machinery	2,080	367	2,447
Ship building	29	5	34
General manufacture total	10,181	1,797	11,978
Iron/Steel group	90,000		150,000
	** 60,000 ** Sludge from polishing and plating		
Thermal power plant	480,000 (Ash)		480,000
	Ash, Dust, Others	*(400,000) (Reuse/Sale)*	

(*) :Hazardous waste is assumed to be 15 % of total solid wastes.

(**):Although the sludge generated from the pickling and plating process will contain Ferrite, Zinc, etc., heavy metal will not be contained. Therefore, the sludge will be recycled efficiently.

Estimation of Industrial Solid Wastes Generated from Bang Saphan I/E

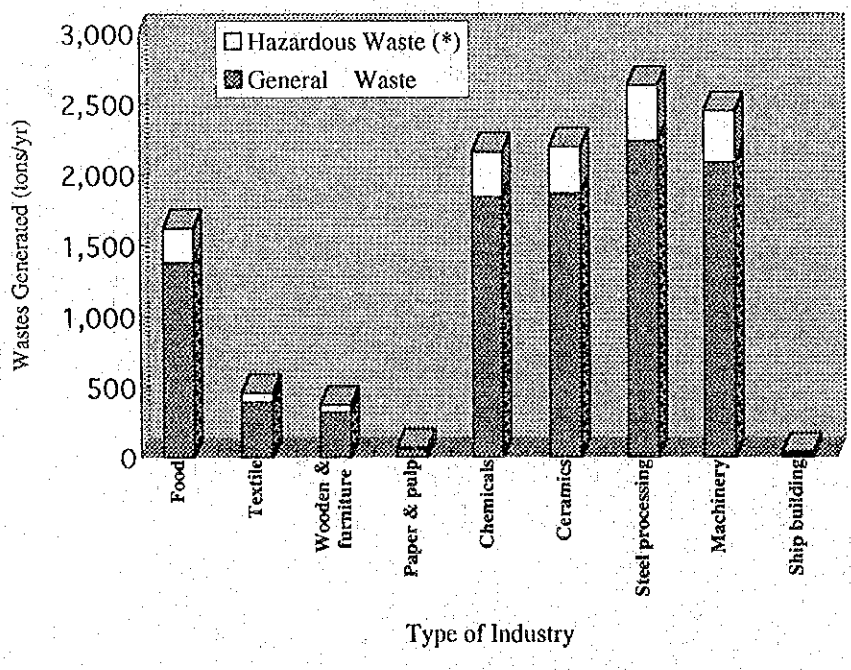


Table F. 2.11 Site and Incinerator for Treatment and Disposal of General Wastes

1. Disposal site:
must be composed of a) Incinerator building b) Car parking and car washing area c) Ash removal pond
2. Incinerator building:
must be composed of a) Storage room b) Waste separation room c) Incinerator area d) Rest room
3. Incinerator:
a) To be installed sufficient amounts of incinerators b) Working hour = 8 hours or 12 hours c) Emission must meet the air emission standards of MOI d) Incinerator must be composed of : - Automatic feeder - Temperature controller and other significant parameters - Stack height ≧ 15 m - Secondary chamber (dust burning) can control temperature to 1,000 ℃ and retention time is 0.5 seconds or higher e) Ash removal - Amount of ash from incinerator can be estimated from 20 % of total solid wastes

Source : IEAT

Table F. 2. 12 Ambient Air Quality Standards (Thailand)

Pollutants	1 h average mg/m³	8 h average mg/m³	24 h average mg/m³	1 year average mg/m³	Methods of measurement
Carbon monoxide (CO)	50	20			Non - dispersive infrared detection
Nitrogen dioxide (NO_2)	0.32				Gas phase chemi-luminescence
Sulfur dioxide (SO_2)			0.30	0.10*	Pararosaniline
Suspended particulate matter (SPM)			0.33	0.10*	Gravimetric-high volume
Photochemical Oxidant (O_3)	0.20				Chemi-luminescence
Lead (Pb)			0.01		Wet ashing

* Geometric mean value

Note : (1) Standards-Notification of Office of the National Environment Board No.2 dated November 6. B.E. 2524, published in the Royal Government Gazette, Vol. 98, part 197, dated December 1, B.E. 2524 (1981) 4322 - 4323.

(2) Methods of Measurement : Notification of the Ministry of Science, Technology and Energy, issued under National Environmental Quality Act B.E. 2518, B.E. 2521, published in the Royal Government Gazette. Vol. 98, part 197, dated December 1, B.E. 2524(1981) p. 4299 - 4306.

Source : Laws and Standards on Pollution Control in Thailand, 3rd ed., PCD, Sept. 1994

Table F. 2.13 Emission Air Quality Standards (Thailand)

No.	Substances	Proposed standard values	Sources
1.	Particulate		·Boiler and furnace
		0.3 g/Nm^3	Heavy Oil as fuel
		0.5 g/Nm^3	Coal as fuel
		400 mg/Nm^3	·Steel manufacturing
		400 mg/Nm^3	·Cement plant and calcium carbide plant
		400 mg/Nm^3	·Rock and grave aggregate plants (production capacity more than 50,000 t/a)
		500 mg/Nm^3	·Other source
2.	Smoke opacity	not exceed 40% Ringelmann scale	Boiler or furnace
3.	Aluminium	(dust) 300 mg/Nm^3 (Al) 50 mg/Nm^3	Furnace or smelter
4.	Alcohol	0.05 lb/m	Any source
5.	Aldehyde	0.05 lb/m	Any source
6.	Ammonia	25 ppm	Gas plant
7.	Antimony	25 mg/Nm^3	Any source
8.	Aromatics	0.05 lb/min	Any source
9.	Asbestos	27 μ g/Nm^3	Any source
10.	Arsenic	20 mg/Nm^3	Any source
11.	Beryllium	10 μ g/Nm^3	Any source
12.	Carbonyls	25 ppm	Burning refuse
13.	Chlorine	20 mg/Nm^3	Any source
14.	Ethylene	0.03 lb/min	from production or by usage
15.	Ester	0.05 lb/min	Any source
16.	Fluorine	0.3 lb/t P_2O_5	Any source
17.	Hydrogen chloride	200 mg/Nm^3	Any source
18.	Hydrogen fluoride	10 mg/Nm^3	Any source
19.	Hydrogen sulphide	100 ppm	Any source
20.	Cadmium	1.0 mg/Nm^3	Any source
21.	Copper	dust 300 mg/Nm^3 (Cu) 20 mg/Nm^3	Any source
22.	Lead	dust 100 mg/Nm^3 (Pb) 30 mg/Nm^3	Any source
23.	Mercury	0.1 mg/Nm^3	Any source
24.	CO	1,000 mg/Nm^3	Any source
25.	SO_2	500 ppm	H_2SO_4 production, Other activities:
		400 ppm	·Bangkok and its vicinities
		700 ppm	·Other area
26.	NO_x	1,000 mg/Nm^3	Combustion source
		2,000 mg/Nm^3	HNO_3 production and others
27.	Nitric acid	70 mg/Nm^3	Any source
28.	Organic material	0.01 L/min	Any source
29.	Phosphoric acid	3 mg/Nm^3	Any source
30.	Sulphur trioxide	35 mg/Nm^3 as H_2SO_4	Any source also in combination with H_2SO_4
31.	Sulphuric acid	35 mg/Nm^3	Any source

Source : ONEB (1989)

Table F. 2. 14 Industrial Water Effluent Standards (Thailand) - Selected Indicators

Quality Indicator	Units	Standards	Remarks	
BOD (5 days, at 20°)	mg/l	20 - 60	Fishery canning	
	Max 100			
			Starch industry	
			Centrifugal	Max 60
			Sedimentation	Max 100
			Noodle industry	Max 100
			Tanning industry	Max 100
			Pulp industry	Max 100
			Frozen food industry	Max 100
Suspended solids (SS)	mg/l	Depend on dilution ratios of wastewater and receiving water	Ratio	
			1/8 to 1/150	Max 30
			1/151 to 1/300	Max 60
			1/301 to 1/500	Max 150
Dissolved solids (DS)	mg/l	Max 2,000 or under office's consideration but not more than 5,000	If salinity of receiving water is higher than 2,000 mg/l, DS in the effluent should not be higher than 5,000 mg/l of the DS in the receiving water	
pH	--	5 - 9		
Cyanide as HCN	mg/l	Max 0.2		
Oil & Grease	mg/l	Max 5.0	Refinery & Lubricant oil industry	Max 15.0
Free Chlorine	mg/l	Max 1.0		
Heavy Metals				
Zinc (Zn)	mg/l	Max 5.0	Zinc industry	Max 3.0
Mercury (Hg)	mg/l	Max 0.005	Zinc industry	Max 0.002
Lead (Pb)	mg/l	Max 0.2		
Manganese (Mn)	mg/l	Max 5.0		

Source : Laws and Standards on Pollution Control in Thailand, 3rd ed., PCD, Sept. 1994.

Table F. 2. 15 Standard for Wastewater Effluent from Factory that is allowed to discharge to I/E

1.	Average BOD_5	≦ 500	mg/l
2.	Average Suspended Solids	≦ 200	mg/l
3.	pH	5.0 - 9.0	
4.	Temperature	≦ 45	—
5.	Sulphide as hydrogen sulphide	≦ 5	mg/l
6.	Cyanide as hydrogen cyanide	≦ 2	mg/l
7.	Oil and grease	≦ 10	mg/l
8.	Tar	≦ 10	mg/l
9.	Formaldehyde	≦ 2	mg/l
10.	Phenol and Cresols	≦ 1	mg/l
11.	Free Chlorine	≦ 5	mg/l
12.	Insecticide	none	
13.	Radioactive compound	none	
14.	Fluoride (F)	≦ 5	mg/l
15.	Free Ammonia	≦ 5	mg/l
16.	Total Ammonia Nitrogen as N	≦ 50	mg/l
17.	Mercury and Mercury Compound	≦ 0.005	mg/l
18.	Soluble Iron and Manganese	≦ 10	mg/l
19.	Chromium, Arsenic, Silver, Selenium, Lead, Nickel, Barium, Copper, Cadmium, Total or Each	≦ 1	mg/l
20.	Other materials that should not discharge into the wastewater pipeline - High viscosity material - Settleable solids that cause pipe clogging - Calcium Carbide Sludge		
21.	Synthetic Detergent	≦ 30	mg/l
22.	Chloride (Cl) as Chlorine	≦ 2,000	mg/l

Source : IEAT

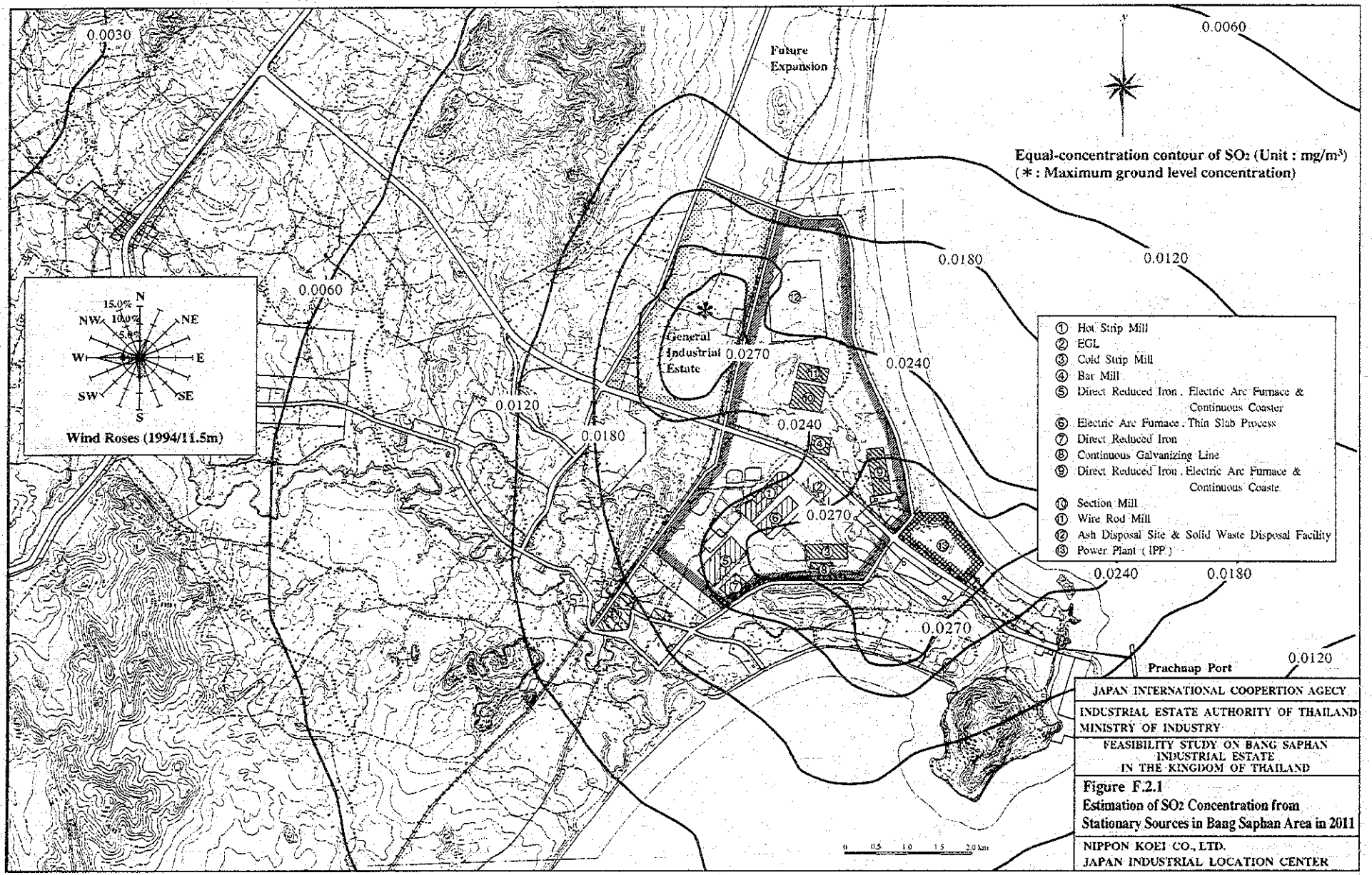
Table F. 3. 1 Significant Pollutants to be Monitored

Pollutant	Main Industrial Polluting Source
Air Pollutants	
Sulfur dioxide (SO_2)	Sulfuric acid production, industries using heavy oil as fuel, metal industry, pulp mill
Nitrogen Oxides (NO_x)	Nitric acid manufacture, various industries accompanying combustion
Particulate Matter (PM)	Various industries accompanying combustion (boiler, furnace, kiln, etc.)
Carbon Monoxide (CO)	Gas industry, metal refinery, internal combustion, motor vehicles
Hydrocarbon	Motor vehicles, oil storage, refining sites, painting facilities
Hydrogen Chloride (HCl)	Soda industry, plastic process
Others (heavy metals and thier compounds, asbestos, offensive odors, etc.)	
Water Pollutants	
Suspended Solid	Almost all industryies, especially ceramics, paper, pulp, food processing, stone quarryng, mining
BOD, COD	Almost all industries, especially food processing, pulp, petroleum, chemical, fermentation
Oil & Grease	1) Mineral oil (petrochemical, machinery, iron/steel) 2) Biological oil and fat (food, oil & fat industry
pH	Electroplating, inorganic industry, iron/steel mill, leather manufacture
Inorganic and Organic Toxic Substances 1) Heavy metal ion (Hg, Cd, Pb, Cr, Zn, Cu, As, etc.) 2)Non-metals (cyanide, fluorine,etc.) 3) Organic	1) Metal mining, electroplating, inorganic chem., glass, organic synthesis 2) Electroplating, synthetic chem., aluminum, glass, chemical fertilizer 3) Pesticide, industrial chemical, plasticizer, plastic monomer, organic solvents for electronic industry.
Others (Nutrients, color, offensive odor, heat, etc)	

Table F. 3. 2 Frequency of Water Monitoring by Parameter

Monitoring Item	Monitoring Frequency
In-Factory Monitoring (Effluent Water)	
Those primary pollutants which affect the performance of the wastewater treatment process or can have immediate effect on the receiving environment. BOD/COD, Temperature, Oil & Grease, pH	Continuous - daily
Other primary pollutants	Daily - weekly
Other pollutants relevant to the receiving waters.	Monthly - annual
Feedstock composition as required by delivery of raw materials.	Sporadic
Receiving Environment	
• Dissolved oxygen (to assess the effects of discharges containing BOD). • Chlorophyll - a (to assess the effects of discharges containing nutrients on alga growth). • Biological uptake for discharges containing bioaccumulative pollutants.	Basically a monthly or seasonal.

Source : Guideline for Environmental Impact Assessment and Management of Chemical and Petrochemical Industries, OEPP. 1993



JAPAN INTERNATIONAL COOPERTION AGECY

INDUSTRIAL ESTATE AUTHORITY OF THAILAND
MINISTRY OF INDUSTRY

FEASIBILITY STUDY ON BANG SAPHAN INDUSTRIAL ESTATE IN THE KINGDOM OF THAILAND

Figure F.2.1
Estimation of SO_2 Concentration from Stationary Sources in Bang Saphan Area in 2011

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