5. Pavement in Tunnel

It is recommended that cement concrete pavement be used in the tunnels as it has the following advantages over alternatives:

1) The pavement can be integrated with the foot of the concrete arch lining to provide additional resistance to earth pressure, especially in ground classified as "D" in Appendix 6.6-4. It behaves as a compressive strut against lateral earth pressure.

2) Concrete pavement requires less maintenance and is more durable compared to asphalt concrete pavement.

3) If a traffic accident occurs, the concrete pavement is resistant against fire and less liable to oil penetration compared to asphalt pavement.

4) The surface of the concrete pavement has a higher reflectivity and is a lighter color than asphalt pavement and thus has reduced artificial lighting requirements for a given level of illumination.

The thickness of concrete pavement in tunnel is 25 cm as shown in the drawing, DWG NO. LD. 5-3 of the DRAWINGS.

6.6.3 Portal

A tunnel portal can be considered as a type of retaining wall and is thus subject to the same design and construction methods. As the tunnel portals are frequently in steep unstable terrain extra care is needed to obtain sufficient site information on the geological conditions and material characteristics to enable a safe design to be made. The NATM system of support can also be applied to open cut slope stabilization. In some circumstances, the portal can be treated as an open extension of the tunnel body. Some examples of portal layout designs are presented in Figure 6.6-6 (a, b and c).

In consideration of the environmental requirements and economy of construction the portal types selected for the two tunnels are wing wall types and outstanding types. General views of the portal layouts for tunnel No. 1 and No. 3 are presented in DWG NO.'s LD 5-4 and LD 5-5 in the DRAWINGS.

FIGURE 6.6-6 (a) WING WALL TYPE PORTAL

FIGURE 6.6-6 (b) SEMI-OUTSTANDING TYPE PORTAL

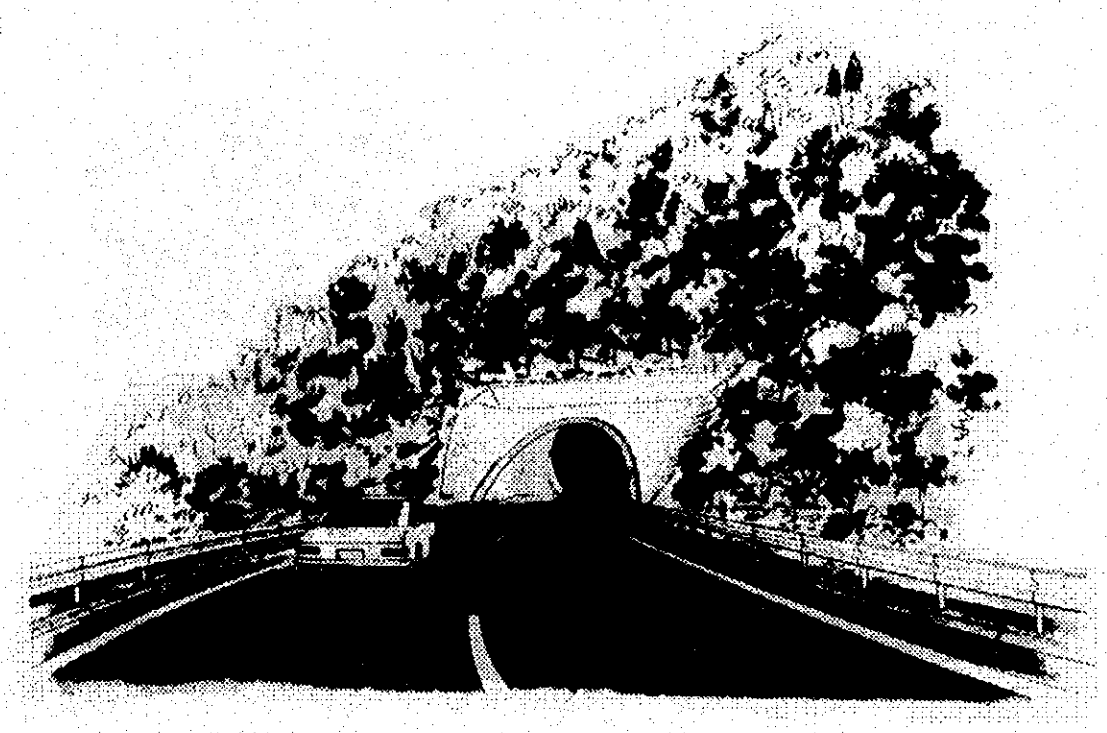


FIGURE 6.6-6 (c) OUTSTANDING TYPE PORTAL

6.6.4 Ventilation

The primary functions of the ventilation system is to remove noxious and toxic exhaust fumes and to enhance visibility by removing suspended particulate matter in the tunnel atmosphere. The detail design of the tunnel ventilation system depends on the traffic volume, types of vehicles, length of tunnel, slope gradient, cross sectional shape and area, meteorological conditions and permitted gas concentration standards. Detail procedures and summaries of practical methods of tunnel ventilation design are contained in Appendix 6.6-6 (Calculation for Jet Fan Requirement and Dust Collector).

1. Ventilation System

Ventilation systems are generally classified into three types depending on the mechanism of flow of air in the tunnel. These classes are summarized in Table 6.6-5 and described below:

1) Transverse Ventilation System

This system of ventilation uses one duct and fan for the intake of fresh air and another duct and fan for the removal of exhaust of foul air.

2) Semi-Transverse Ventilation System

This system uses a single duct and fan for both fresh air supply intake and exhaust expulsion.

3) Longitudinal Ventilation System

(3-1) Jet fan type

Ventilation is effected by axial flow fans suspended from the tunnel crown that move air by creating a longitudinal pressure gradient.

(3-2) Saccardo Type

A longitudinal pressure gradient is created by using Saccardo jet nozzles at the tunnel potals.

(3-3) Centralized Exhaust System

Ventilation is effected by using a central vertical duct with a fan to create a region of low pressure in the middle of the tunnel. The exhaust is drawn up the duct and fresh air enters at the portals.

(3-4) Combined Central Intake and Exhaust System

Ventilation fan driven intake and exhaust duct systems installed in a common central shaft.

(3-5) Jet Fan Type with Electric Dust Collectors

A combination of the Jet Fan type with ancillary electric dust collectors.

2. Selection of Ventilation Systems for Tunnel NO.1

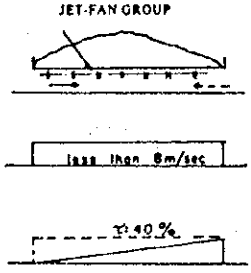
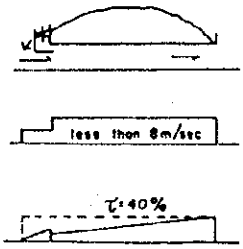
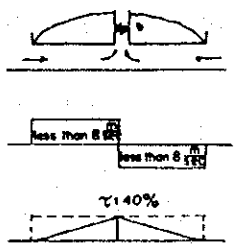
The use of longitudinal air ventilation systems using only jet fans or the Saccardo method are not suitable for this tunnel as the length is 3,800 m. The alternatives of using transverse methods or vertical central shafts would provide the required ventilation but involve very high construction costs.

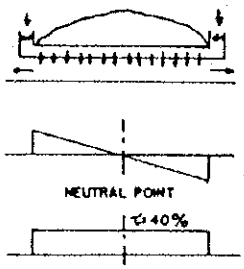
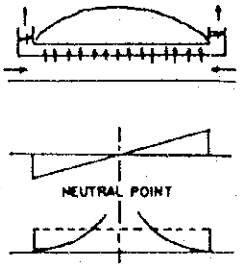
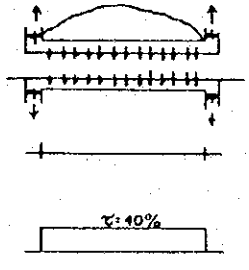
With due consideration of the economic constraints and the air quality standards the recommended system of ventilation for Tunnel No. 1 is the combination of Jet Fans with electric dust collectors. The preliminary design utilizes 14 jet fans (ϕ= 1500 mm) and 2 electric dust collector systems. Appendix 6.6-6 contains the calculations substantiating the number of fans required and the specifications for the capacity of the electric dust collectors. Figure 6.6-7 contains an illustration of a typical jet fan and Figure 6.6-8 presents the layout of the electric dust collector system. Detail drawings of the dust collector chamber are shown in DWG NO. LD. 5-3 in the DRAWINGS.

3. Selection of Ventilation Systems for Tunnel NO.3

Trial calculations (presented in Appendix 6.6-6) indicate that the length of the No. 3 tunnel is such that it does not require any artificial ventilation system. The natural flow of air will be sufficient in normal circumstances it is proposed that two jet fan units be installed for emergency use.

TABLE 6.6-5 CHARACTERISTICS OF VARIOUS VENTILATION SYSTEMS

VENTILATION SYSTEM	LONGITUDINAL VENTILATION		
TYPE	JET-FAN GROUP TYPE	SACCARD SYSTEM	SHAFT TYPE (EXHAUST TYPE)
FEATURE	BY BOOSTING PRESSURE OF JET-FAN GROUP	BY BOOSTING OF INJECTED AIR	TAKEN IN FROM BOTH PORTAL EXHAUST FROM CENTER SHAFT
SCHEMATIC DIAGRAM OF VENTILATION SYSTEM WIND VELOCITY IN TUNNEL CONCENTRATION OF GAS			
GENERAL FEATURES	1. The standard maximum tunnel length applicable is less than 1,000m. When traffic volume is small, it is applicable also for tunnel of more than 1,000 meters. 2. Installation of fans is possible even after construction is completed. 3. Installation cost is inexpensive. 4. When the tunnel is long and traffic volume is large, the maintenance cost will be high. 5. Reversing the circulation of fan, blowing to both directions is possible. 6. Since the duct is not necessary, the cross section area of the tunnel is small. 7. Studies on noise originated by the fan is necessary.	1. The length applicable is the same as jet-fan type. 2. Since the fan is installed at the ventilating facilities at portal, maintenance is easy. 3. The effect of boosting pressure affecting passing vehicles must be investigated. 4. The blowing direction is limited to one side.	1. Applicable length is less than 3000 meters as standard. 2. Since exhaust is not blown from the portal, the environmental problems at portal area is not seen. 3. By the natural wind and the difference of traffic volumes in both directions, ventilating conditions of both the right and left sides of the shaft will be uneven. 4. Roadway is utilized as duct and cross sectional area of tunnel will be small.

VENTILATION SYSTEM	SEMITRANSVERSE VENTILATION		TRANSVERSE VENTILATION
TYPE	BLOWING SEMI-TRANSVERSE TYPE	EXHAUST SEMI-TRANSVERSE TYPE	
FEATURE	BLOWING BY BLOW DUCT IN TUNNEL	EXHAUST BY EXHAUST DUCT IN TUNNEL	BLOW-EXHAUST DUCTS IN TUNNEL AFFECTS EQUAL AMOUNT OF BLOW AND EXHAUST
SCHEMATIC DIAGRAM OF VENTILATION SYSTEM WIND VELOCITY IN TUNNEL CONCENTRATION OF GAS			
GENERAL FEATURES	1. Applicable length is less than 3000 meters as standard. 2. Concentration of harmfull gases in the tunnel is even. 3. Effect of natural wind is small.	1. The concentration of carbon monoxide of neutral point will be tremendously increased. 2. No environmental problems at portal area will be seen.	1. Application length is more than 2,000 meters. 2. Due to the absence of longitudinal windflow in the tunnel, the concentration of harmfull gases will be even. 3. Since two ducts for blowing and exhaust, and also facilities for blowing and exhaust fans are necessary, installation and maintenance cost will be high.

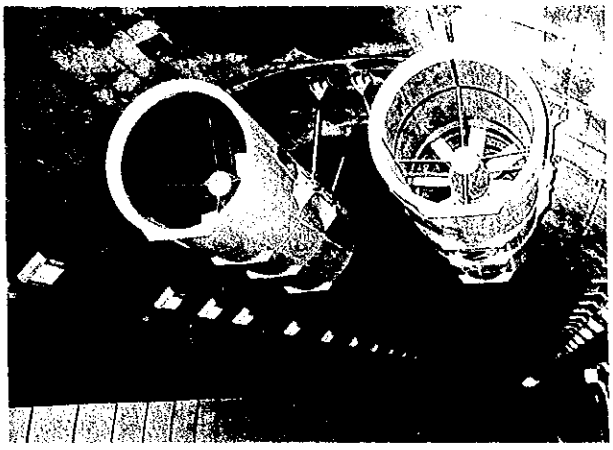


FIGURE 6.6-7 JET FAN

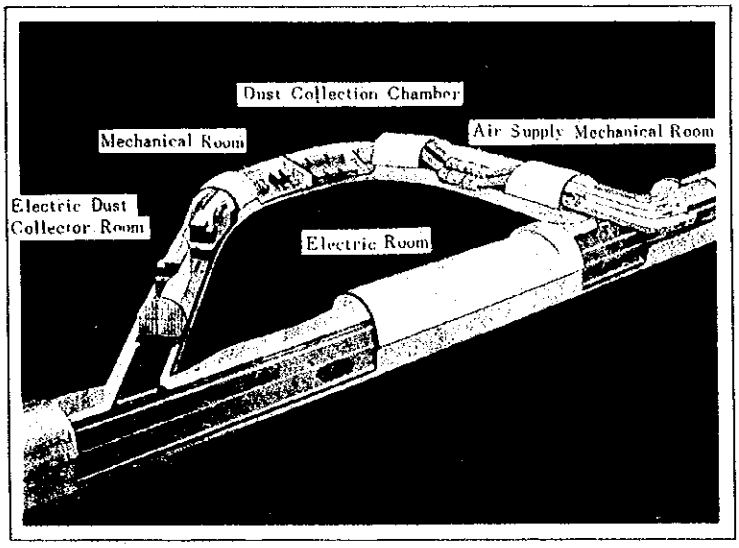


FIGURE 6.6-8 OUTLINE OF DUST COLLECTOR SYSTEM

6.6.5 Lighting

The fundamental specifications of the lighting systems adopted for the two tunnels conform to the Japanese Standard based on the "International Recommendations for Tunnel Lighting" as detailed by the International Commission on Illumination (CIE) publication No.26, 1974.

In general, the illumination systems consist of two parts as below:

1) Basic Lighting: Illumination in the main body of the tunnel to provide sufficient light to see obstacles, and obstructions etc.

2) Entrance Lighting: Bright illumination designed to limit the "Black Hole" effect and to permit the sufficient time for drivers eyes to adjust to the basic lighting during day time.

1. Basic Lighting

The specifications for the basic lighting are as below:

- Average luminance of the road surface : 9.0 cd/m² (sufficient for maintaining a transmission rate of 50 % per 100 m at 100 km/h).
- Lighting Fixtures : Opposed array type mounted 5.0 m above the PH.
- Luminance Source : Low Pressure Sodium Lamps.

2. Entrance Lighting

The tunnel entrance zone consists of three parts. These are: 1) boundary sector, 2) transition sector and 3) relaxing section as illustrated in Figure 6.6-9. The minimum road luminance (cd/m²) and the lengths for each component are specified in this figure. These specifications apply for a tunnel in excess of 400 m in length and with a design speed of 100 km/h.

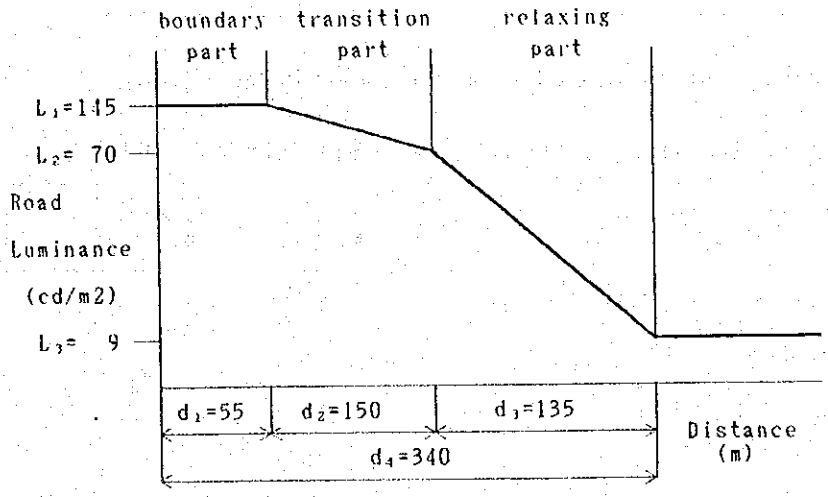


FIGURE 6.6-9 ENTRANCE LIGHTING

3. Disposition of Lighting Points

The recommended disposition of lighting points from the entrance through to the main body of the tunnel is illustrated in Figure 6.6-10.

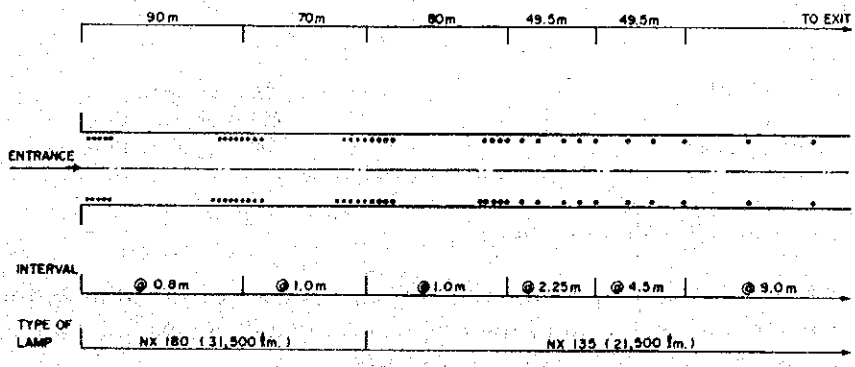


FIGURE 6.6-10 DISPOSITION OF LIGHT

6.6.6 Emergency Facilities

The procedures and standards for the planning and designing the emergency facilities for the two tunnels are based on those established in "Criteria for Installing Emergency Facilities in Tunnels" (Japan Road Association).

The relative levels of the installation of emergency facilities has been divided into five basic classes based on the tunnel length, and traffic volume. The classifications of the two tunnels considered in this study are as follows:

	Traffic volume (veh/day)	Length of Tunnel (m)	Class
No.1 tunnel (A-line)	25,200	3,830	AA
NO.1 tunnel (B-line)	25,200	3,810	AA
NO.3 tunnel (A-line)	23,700	750	A
No.3 tunnel (B-line)	23,700	720	A

The facilities required for each class are shown in Table 6.6-6.

TABLE 6.6-6 CRITERIA FOR INSTALLING EMERGENCY FACILITIES

Emergency facilities	Class				
	AA	A	B	C	D
Communication and alarm system					
Emergency Telephone	o	o	o	o	o
Manual Alarm Bell	o	o	o	o	
Automatic Fire Detector	o	o			
Emergency Warning System	o	o	o	o	o
Fire Extinguishing Facilities					
Fire Extinguisher	o	o	o	o	o
Fire Hydrant	o	o	▲		
Evacuation and Guide Facilities					
Evacuation Route Sign					
Emergency Exit Lamp	-- If evacuation pass is provided --				
Guide Board	o	o	o		
Evacuation Passage	------	3,000 m or more long			------
Other Facilities					
Hydrant	o	o	▲		
Radio Communication Aid	o	▲			
Radio Rebroadcast Relay System	o	▲			
Loud-speaker	o	▲			
Sprinkler	o	▲			
Monitor System	o	▲			
Emergency Parking Bay	--------	750 m or more long			-------
Emergency Lighting	--------	200 m or more long			-------
Emergency Power Source	--------	200 m or more long			-------

Notes: o = Required as a rule
▲ = Required depending on situation

Figure 6.6-11 illustrates a sample sketch of a layout of facilities within a tunnel,. The preliminary design layout of the proposed emergency systems for each tunnel are presented in DWG NO. 5-6 in the DRAWINGS.

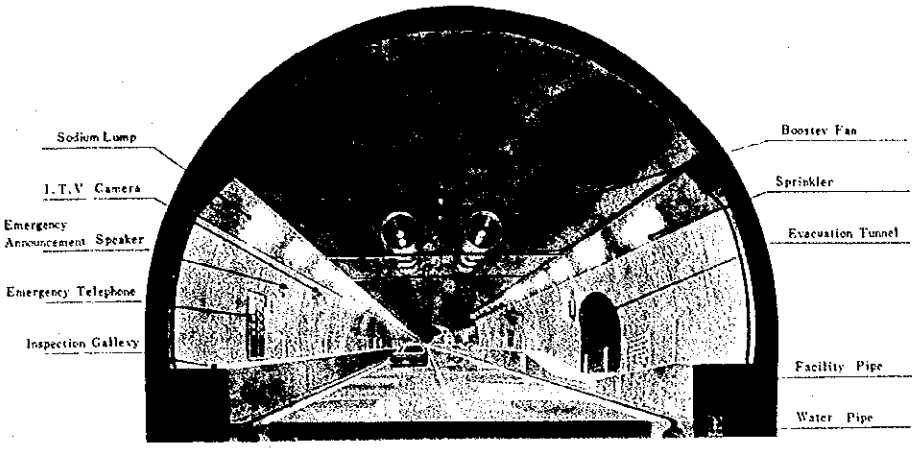


FIGURE 6.6-11 IMAGINARY SKETCH OF TUNNEL FACILITIES

6.6.7 Construction Planning

1. Excavation Method

Tunnel excavation in rock is carried out by a repeating cycle of work which includes drilling, blasting, mucking and support placement. The excavation methods are classified into three basic types depending on the sequence and content of the work cycles. These are described as follows:

1) Full-Face Excavation Method

This method is used in stable ground with rock conditions classified as A or B (refer to Figure 6.6.5) or when the total cross sectional area is less than 30 m^2 and the face is stable. the full height and width of the tunnel is excavated in a single step.

2) Bench Method

This method uses a cycle that involves the initial cutting of the top portion of the tunnel cross section and the installation of support prior to the final excavation down to the invert level. The actual cross sectional area of the initial crown cut is varied according to the ground conditions. The basic principles of three variations on this method are illustrated in Figure 6.6-12.

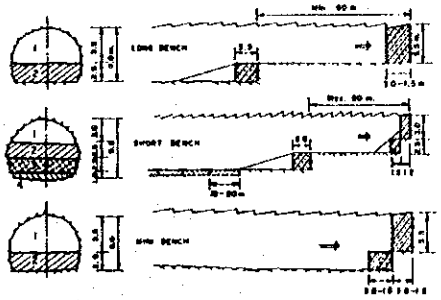


FIGURE 6.6-12 THREE TYPES OF BENCH METHOD

3) Side Drift Method

This method is normally used in poor ground conditions such as in heavily fractured or deeply weathered rock, stiff soil or near the portal areas. A small diameter pilot tunnel is driven ahead of the main body at the side of the invert level. It is expanded to provide the final cross sectional area as support is applied. It also serves as a source of advance information of the rock conditions and permits drainage along the line of the drive.

To permit preliminary estimates and costing of the tunnels under study the long bench method has been adopted for rock class B conditions and the short bench method for rock classes CI, CII and D.

For each cutting face using the bench method a minimum set of equipment will be needed as listed in Table 6.6-7. The disposition of the tunneling machine and auxiliary equipment is presented in Figure 6.6-13.

TABLE 6.6-7 MACHINE AND EQUIPMENT FOR 1 CUTTING FACE

Item	Description	Number	Remarks
Rock drill	110 kg	6	Hydraulic type
Drill jumbo	2-boom, 1-cage	3	Hydraulic wheel
Tractor shovel	2.0 m3	1	Side dump type
Back-hoe	0.4 m3	1	
Bulldozer	16 ton	1	for mucking
Dump truck	11 ton	4	
Shotcrete machine	19 m3/hr	1	
Concrete sprayer	14 ton	1	Hydraulic type
Concrete mobile	25 m3/hr	1	Truck mounted
Rock bolt setter	19 t W/drill	1	Hydraulic type
Slide form	for Full-face	1	Tunneling lining
Concrete pump car	15 m3/hr	1	
Agitator	6 m3	2	
Staging on truck	4 ton truck	1	
Dust collector	300 m3/min.	1	
Air compressor	125 kw	2	
Generator	50 kw	2	
Contra-fan	1000 m3/min.	1	
Blasting dust	900 mm	1800 m	
Aggregate plant		1	
Concrete mixing plant		1	
Turbid water treatment plant		1	
Hydraulic crane	20 ton	1	Material supply

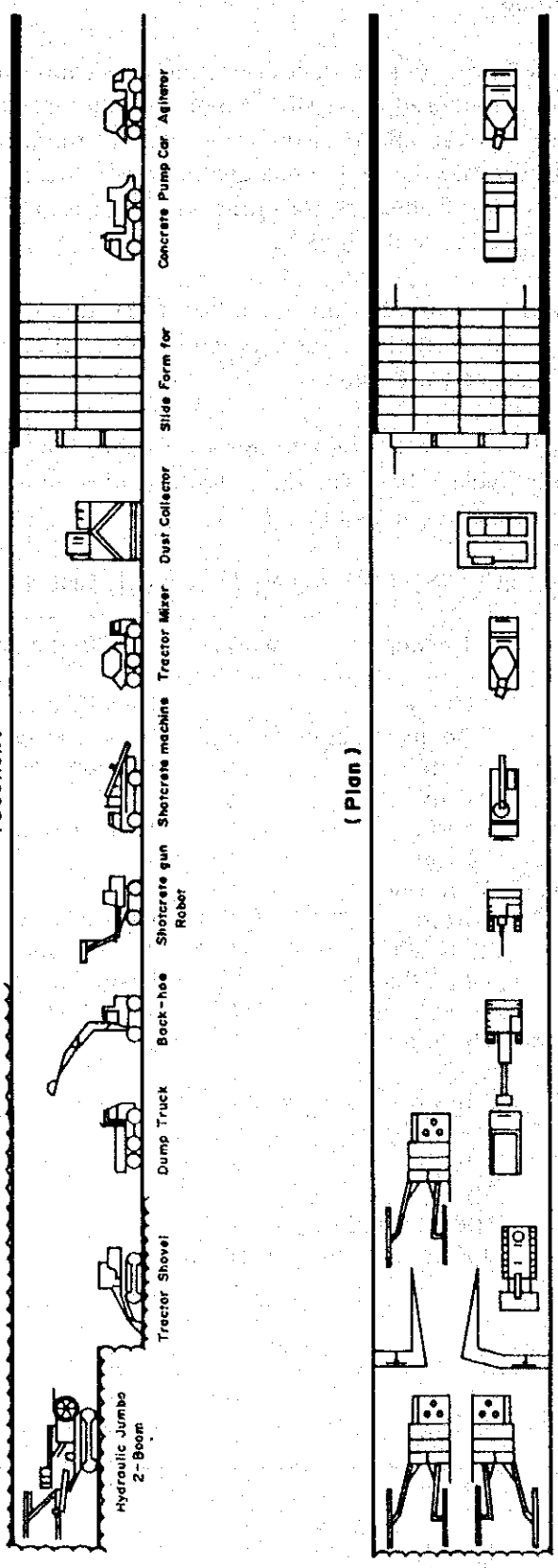


FIGURE 6.6-13 ARRANGEMENT OF TUNNELING MACHINE AND EQUIPMENT

2. Construction Period

The durations of the construction periods for tunnels No's. 1 & 3 are summarized below:

Work Item	Period (month)
No. 1 Tunnel (2 cutting faces for each line)	
Preparation	2.5
Protection of portal excavation	1.0
Tunneling	24.0
Dust collection chamber	1.5
Portal	1.5
Lining	1.5
Drainage	1.0
Pavement	1.5
Installation of facilities	9.0
Interior finishing	5.0
Total	48.5
No. 3 Tunnel (1 cutting face for each line)	
Preparation	3.0
Protection of portal excavation	1.0
Tunneling	11.0
Portal	2.0
Lining	1.0
Drainage	0.5
Pavement	1.5
Installation of facilities	6.0
Interior finishing	4.0
Total	30.0

6.7 DESIGN OF INTERCHANGE

6.7.1 Locational Planning

The efficient locational arrangement of the interchanges along the inter-city motorway is made by the traffic economy aspect so as to maximize the cost-benefit ratio throughout the motorway. For example, if excessive number of interchanges are provided, traffic volume using each interchange will not be enough for recovering construction and maintenance costs, or if a few number of interchanges are provided, they cannot play their functions as an important facilities along the motorways.

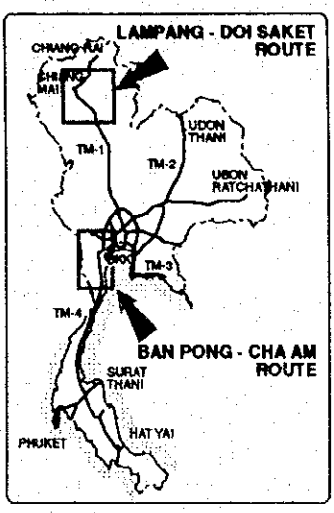
The locational planning should also consider with regional or city planning along motorways so that the interchanges should not badly affect to traffic volume and traffic operations of existing highway network.

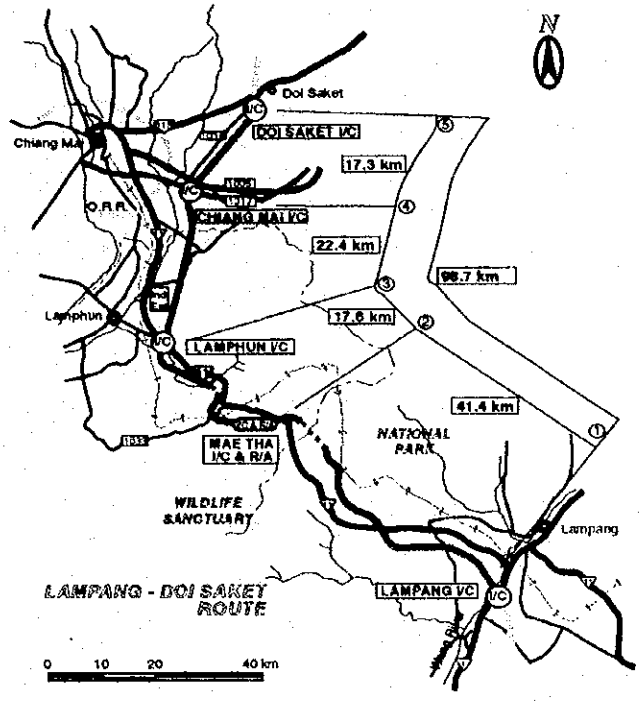
As a consequent, interchanges should be located at strategic points in a present and future highway network, such as suburbs of major cities, sightseeing spots, adjacencies of industrial areas, intersecting points with main highways, etc., where a large traffic is expected to be generated or attracted.

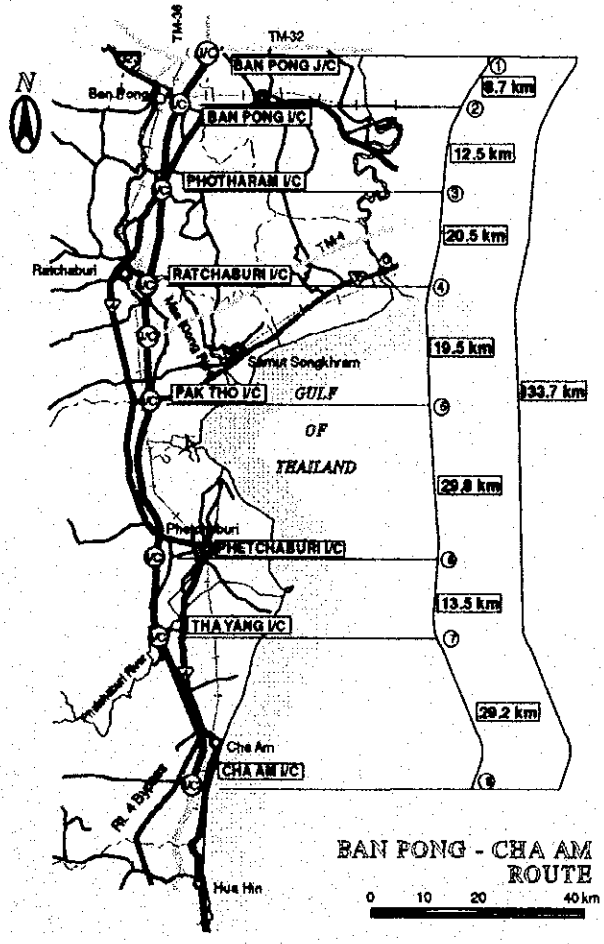
The main items to be considered for locational planning of interchange are as follows:

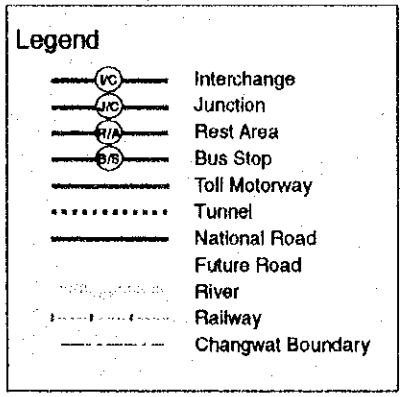
- The interchange shall be located where on-off traffic will be properly attracted and assigned into the existing road network without over loading.
- The best location of interchange is the nearest place to the origin of generated traffic.
- As for an interval between interchanges, 4.0 km is the minimum distance necessary to traffic control such as handling of waving and installment of sign plates. On the other hands, the efficient maintenance and operation of motorway requires 30 - 40 km distance between interchanges.
- Since a very wide area will be needed for construction of an interchange, the land acquisition cost of the interchange greatly influences on the total construction cost. The interchange location shall be avoided from high cost area.
- As the cost of interchange is greatly affected by topographic and geological conditions, the location shall be selected avoiding the area of steep topographic features, the soft ground area, the area with wide river or railway, etc.

Figure 6.7-1 shows the results of locational design of interchange along Lampang - Doi Saket Route and Ban Pong - Cha Am Route.









FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS	FIGURE 6.7-1 LOCATION OF INTERCHANGES

6.7.2 Type of Interchange

Interchanges are classified into two categories. First category of interchanges is interchange between two roads of which at least one is not a motorway, usually a motorway and a highway. The other category of interchanges is interchange between two motorways, which is called as a junction in this study.

The detail or general explanation and discussion on types of interchanges are found in the MOTORWAY DESIGN STANDARD.

1. Suitable type of interchange along toll motorway

The type of interchange along toll motorway in which toll is collected by using closed system should be suitable to toll collection system, so that toll gates are centered as much as possible and well alinment can be designed for the users to stop at toll gates.

Three-leg type, which is characterized by trumpet-type interchange, is generally used to center all on- and off-toll gate. Semi-direct connection type such as Y-type also is adoptable especially at hilly or mountainous terrain.

Trumpet-type has two sub-types, depending on that connecting type to highway is grade separation or at-grade crossing, i.e. double trumpet-type with 4 legs and single trumpet-type with 3 legs as shown in Figure 6.7-2. Selection of them should be in accordance with traffic volume of both motorway and highway.

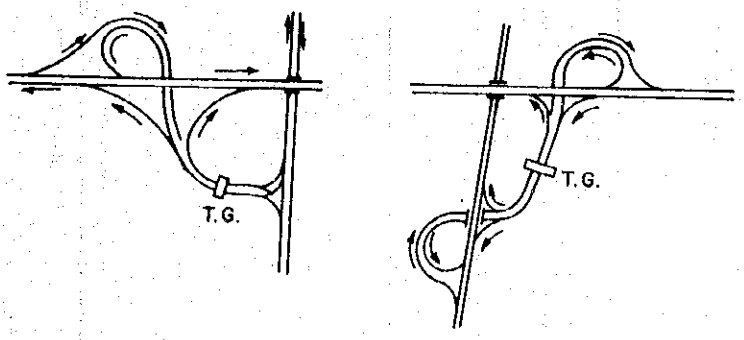


FIGURE 6.7-2 DOUBLE- AND SINGLE-TRUMPET INTERCHANGES

Type of each proposed interchange are summarized in Table 6.7-7.

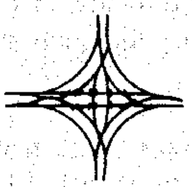
2. Type for Ban Pong Junction

Ban Pong junction is planned at the crossing point where Ban Pong - Cha Am Route intersects TM-32 (Toll Motorway No. 32 proposed in master plan study, routing between Bang Yai and Kanchanaburi) at the suburbs of Ban Pong city.

This junction to be located in flat terrain must carry high traffic which will require 2-lane ramp in one direction and less number of merging or diverging points in order to provide high level of services to users. Higher level of service can be realized on

direct connections, and in some instances on semidirect ramps, than on loops because of relatively high speed and the likelihood of more adequate ramp terminal design. Table 6.7-1 shows comparison study on the types of junction including semidirectional ramp, directional ramp and loop ramp and results that turbine-type is recommended for Ban Pong Junction.

TABLE 6.7-1 COMPARISON FOR TYPES OF JUNCTION

Illustration				
Ramp Type & Connection pattern	(Turbine Type) Semidirectional ramps Outer Connection	— Semidirectional ramps inner Connection	— Directional ramps inner Connection	(Cloverleaf) Loop ramps
Existing example	in U.S.A. in Japan	in U.S.A.	in U.S.A.	in U.S.A. in Germany in Japan
Traffic capacity	higher	higher	rather high	low
Extra traveled distance	rather long	short	short	long
merging or diverging	1 point	1 point	3-direction at a point	2 points
alignment	good	excellent	excellent	bad
number of layer	2 (Max. hight 7^m)	4 (Max. hight 21^m)	3 (Max. hight 14^m)	2 (Max. hight 7^m)
Site area	wide	extremely wide	wide	extremely wide
Construction cost	Costly	extremely costly	extremely costly	rather costly
adaptable condition	• High traffic volume • rural and urban area • Flat terain • intersecting at almost right angle	• High traffic volume • rural area • necessity for fitting	• High traffic volume • urban area	• Low traffic volume • rural area • not adaptable for more than 40 km/h
Conclusion	○	×	×	×

6.7.3 Traffic volume

Directional hour volume (DHV) and interchange hour volume (IHV) at 2020, which are basic traffic volume for determination of ramp lane number and toll lane number respectively, are calculated by using ADT of each interchange and direction discussed in Chapter 3. Table 6.7-2 summarizes them.

TABLE 6.7-2 INTERCHANGE TRAFFIC VOLUME IN 2020

Interchange	Direction	ADT	DHV	IHV
Lampang - Doi Saket Route				
1. Lampang I/C	South ↔ Rt. 1	19,100	945	
	Rt. 1 ↔ Mae Tha	15,500	767	1,415
2. Mae Tha I/C	Lampang ↔ Ac. Rd.	6,700	332	
	Ac. Rd. ↔ Lamphum	3,600	178	421
3. Lamphum I/C	Mae Tha ↔ Rt. 11	12,600	624	
	Rt. 11 ↔ Chiang Mai	14,400	713	1,104
4. Chiang Mai I/C	Lamphum ↔ Rt.1317	40,600	2,010	
	Rt.1317 ↔ Doi Saket	21,600	1,069	2,544
5. Doi Saket I/C	Chiang Mai ↔ Ac. Rd.	9,300	460	
	Ac. Rd. ↔ North	7,700	381	695
Ban Pong - Cha Am Route				
1. Ban Pong J/C	TM-32(East)↔Ban Pong	30,900	1,505	
	TM-32(West)↔Ban Pong	34,500	1,680	
2. Ban Pong I/C	Ban Pong J/C↔Rt.323	25,000	1,218	
	Rt.323 ↔ Photharam	25,600	1,246	1,804
3. Photharam I/C	Ban Pong ↔ Rt. 4	17,500	852	
	Rt. 4 ↔ Ratchaburi	7,500	365	891
4. Ratchaburi I/C	Photharam ↔ Ct.Rd.	24,300	1,184	
	Ct. Rd. ↔ Pak Tho	24,400	1,188	1,736
5. Pak Tho I/C	Ratchaburi ↔ Rt. 35	32,400	1,578	
	Rt. 35 ↔ Phetchaburi	5,500	268	1,351
6. Phetchaburi I/C	Pak Tho ↔ Rt.3171	8,300	404	
	Rt.3171 ↔ Tha Yang	11,400	555	702
7. Tha Yang I/C	Phetchaburi↔Rt.3187	9,200	448	
	Rt.3187 ↔ Cha Am	10,400	507	699
8. Cha Am I/C	Tha Yang ↔ Ac. Rd.	29,700	1,447	
	Ac. Rd. ↔ South	8,100	395	1,348

Note: 1. Ac. Rd. = Access Road
2. Ct. Rd. = City-plan Road

The relations between ADT and DHV or IHV are as follows:

$$DHV = ADT \times K \times D \times E$$
$$IHV = ADT \times K \times D$$

where; K = percent of ADT occurring in peak hour,
0.0818 for L-D, 0.0713 for B-C
D = percent of peak hour traffic in the heaviest direction and
0.5 for both L-D and B-C
E = passenger car equivalent.
1.211 for L-D, 1.366 for B-C

Number of lanes for ramp and toll gate are according to relevant standards and guidelines such as AASHTO, JHPC and HCM.

1. Number of lanes for ramp

AASHTO and JHPC provide the maximum acceptable DDHV for single-lane ramps as follows:

AASHTO	1,000 pcphpl at entrance, 1,050 pcphpl at exit
JHPC	1,200 pcphpl for design speed $\leq$ 50 km/h,
	1,500 pcphpl for design speed $\geq$ 60 km/h

Preliminary design provides single-lane ramp for all interchanges except Ban Pong junction, as shown in "SUMMARY OF PROPOSED INTERCHANGES" of Table 6.7-7. In such case, level of service based on HCM ranges D to E for several interchanges with over 1,100 pcphpl of DHV (except Lamphum ↔ Rt.1317 direction at Chiang Mai I/C), while single-lane ramps of all other interchanges are sufficient from the capacity point of view.

2. Number of lanes for toll gate

JHPC provides Table 6.7-3 for selecting number of toll gate lane from the affected elements of time for service (sec), average queue and IHV (vph).

TABLE 6.7-3 NUMBER OF LANES FOR TOLL GATE

Unit:vph

Number of Lanes	Time of Service (sec)							
	6.0		8.0		10.0		14.0	
	Average Queue							
	1.0	3.0	1.0	3.0	1.0	3.0	1.0	3.0
1	300	450	230	340	180	270	130	190
2	850	1,040	640	780	510	620	360	440
3	1,420	1,630	1,070	1,230	850	980	610	700
4	2,000	2,230	1,500	1,670	1,200	1,340	860	960
5	2,590	2,830	1,940	2,210	1,550	1,700	1,110	1,210
6	3,180	3,430	2,380	2,570	1,910	2,060	1,360	1,470
7	3,770	4,020	2,830	3,020	2,260	2,410	1,620	1,720
8	4,360	4,630	3,270	3,470	2,260	2,780	1,870	1,980
9	4,960	5,220	3,720	3,920	2,980	3,310	2,130	2,240
10	5,560	5,820	4,170	4,370	3,330	3,490	2,380	2,490
11	6,150	6,420	4,610	4,820	3,690	3,850	2,640	2,750

Service time of 6 seconds for on-traffic and 14 seconds for off-traffic, and 1.0 average queue are recommended for the interchanges with closed type toll system. Number of toll lane for the proposed interchanges are summarized in Table 6.7-7.

6.7.4 Design Standard for Ramp

1. Design speed

Ramp design speeds shall be determined in consideration of safety and comfortableness of users and economical investment. Ramp design speeds are usually lower than carriageway design speed and a driver who intends to turn his direction and change running speed on a ramp can take transition movements smoothly along alinement of a ramp if turning movements are reasonable.

In this study, ramp design speeds are standardized through studying various standards of AASHTO, MOC (Ministry of Construction in Japan) and JHPC (Japan Highway Public Cooperation). Introduction and study of these standards are found in Appendix 6.7-1.

As a result of the study, ramp design speeds shown in Tables 6.7-4 and 6.7-5 are introduced in this study.

TABLE 6.7-4 PROPOSED RAMP DESIGN SPEEDS FOR MOTORWAY - MOTORWAY (JUNCTION)

Unit:km/h

Motorway Design Speed	120	100
120	80,60	80,60,50
100		60,50

TABLE 6.7-5 PROPOSED RAMP DESIGN SPEEDS FOR MOTORWAY - HIGHWAY (INTERCHANGE)

Unit:km/h

	Motorway side		Highway side		
Design Speed	120	100	100	80	60
Upper range	60	50	50	40	40
Lower range	50	40	40	--	--

2. Geometric design standard

Table 6.7-6 provides minimum curve radius and maximum grade to be applied in this preliminary design. The following equation is used for calculation of minimum curve radius and design standards of AASHTO, MOC and JHPC are referred to specify maximum grade.

$$R = D^2/127(S + F)$$

Where R : Curve radius (m)
D : Design speed (km/h)
S : Superelevation ratio
F : Side-sliding friction factor

TABLE 6.7-6 MINIMUM CURVE RADIUS AND MAXIMUM GRADES

Design Speed	S	F	R m	R (round)	Grade %
60	0.06	0.15	134	140	5
50	0.06	0.17	86	96	6
40	0.06	0.19	50	50	6

3. Typical Cross Section

Typical cross sections of ramp illustrated in Figure 6.7-3.

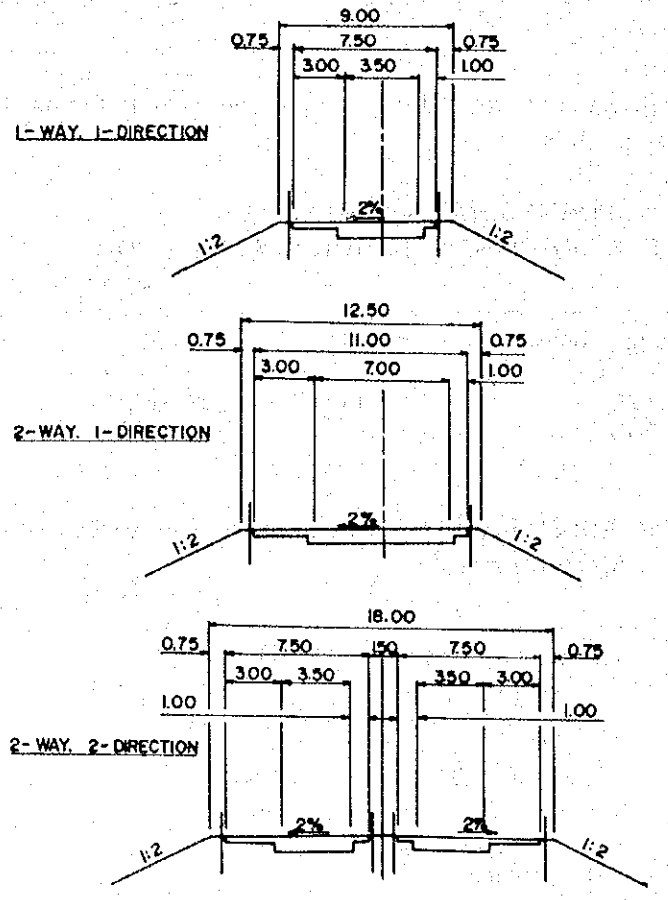


FIGURE 6.7-3 TYPICAL CROSS SECTION OF RAMP

6.7.5 Summary of Interchange Design

All information of interchanges designed and proposed in Figure 6.7-1, including classification of interchanges, drawing numbers in separate volume VOLUME IV DRAWINGS for each interchange, ramp design speed applied, etc. are summarized in Table 6.7-7.

TABLE 6.7-7 SUMMARY OF PROPOSED INTERCHANGES

Location	Type	DWG NO	Motorway side			Highway side		
			Design Speed	Number of Lane	Number of Toll Lane	Intersec-ting Road	Design Speed	Number of Lane
Lampang - Doi Saket Route								
1. Lampang	Double Trumpet	LD.6-1/-2	50	1	3/7	Rt. 1	40	4
2. Mae Tha	With Rest Area	LD.6-3/-4	40	1	2/3	Access road	--	2
3. Lamphun	Double Trumpet	LD.6-5/-6	50	1	3/5	Rt.11	40	4
4. Chian Mai	Double Trumpet	LD.6-7/-8	60	1	5/11	Rt.1317	50	4
5. Doi Saket	Single Trumpet	LD.6-9/-10	50	1	2/4	Access road	--	2
Ban Pong - Cha Am Route								
1. Ban Pong J/C	Junction Turbine	BC.5-1/-2	60	2	--	TM-32	60	6
2. Ban Pong	Double Trumpet	BC.5-3/-4	60	1	4/8	Rt.323	40	4
3. Photharam	Double Trumpet	BC.5-5/-6	60	1	3/5	Rt. 4	40	4
4. Ratchaburi	Single Trumpet	BC.5-7/-8	60	1	4/8	City-plan road	--	4
5. Pak Tho	Double Trumpet	BC.5-9/-10	60	1	3/6	Rt.35	50	6
6. Phetchaburi	Single Trumpet	BC.5-11/-12	60	1	2/4	Rt.3171	--	2
7. Tha Yang	Single Trumpet	BC.5-13/-14	50	1	2/4	Rt.3187	--	2
8. Cha Am	Single Trumpet	BC.5-15/-16	60	1	3/6	Access road	--	4

Note: 1. Unit of Design Speed = km/h.
2. Number of Toll Lane = for on-traffic/for off-traffic
3. DWG NO. = drawing number in VOLUME IV DRAWINGS

6.8 DESIGN OF REST AREA AND BUS STOP

6.8.1 Rest Area

1. Locational Planning

The function of Rest Area is to provide all service that the users and their vehicles can receive during travel on the motorway.

The location and interval of the rest area should be discussed at the first stage of rest area planning, so as to provide effective and appropriate utility services. Locational planning of the rest area should be made by comprehensive considerations of; the location and size of cities along the route, traffic volume and characteristics landscape, locational relationship between other facilities including interchanges and bus stops, route alinement, geometric conditions along the route, maintenance and construction cost, etc.

A large rest area is desirably located at the suburbs of a large city because of its heavy traffic demand, and also between two interchanges connecting a large city to another city being one-day-trip zone or a famous tourist place. A relatively large rest area locating at a scenic spot is convenience for the users of private cars or tourist buses who often use the facilities for the purposes of their meal and sightseeing. A route having high heavy-vehicles ratio requires the rest areas regularly spacing and convenience for the drivers' rest rather than the large rest areas.

The spacing between a rest area and an other facility should be long enough to clearly recognize each traffic sign and to avoid users' puzzling. A small spacing between the rest areas is required when the shortage in number of parking lots is expected due to heavy traffic.

Locational planning should made through careful consideration of locational conditions in aspects of natural environment, construction and operation including maintenance, and traffic engineering. Main items are as follows :

- Landscape resources; A good landscape provides a suitable location to the rest area. At a beautiful spot, it is better to prepare the rest area also in order to prevent irregular parking on main road.

- Facilities recognized during travel; Visibility on the road facilities during travel is the most effective guide sign.

- Difficulty of construction including land acquisition; A rest area should be planed basically where its construction activities will be easily made. Land acquisition cost of the rest area, which usually requires a large space, also affects significantly to the total construction cost. Therefore, practical planning for their locations should be carried out with comprehensive study on the aspects of construction cost and benefit.

- An interval between large-scale rest areas (Type A) is 50 km in standard and 100

km in maximum.

- An interval between facilities including interchanges, junctions, rest areas and bus stop is 5 km preferably and 3 km absolutely.

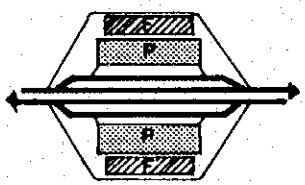
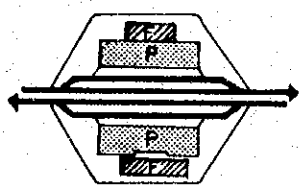
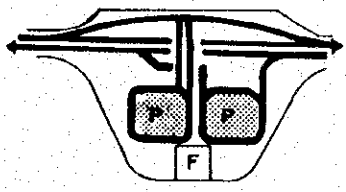
Figure 6.8-1 shows the results of locational design of rest areas along Lampang - Doi Saket Route and Ban Pong - Cha Am Route.

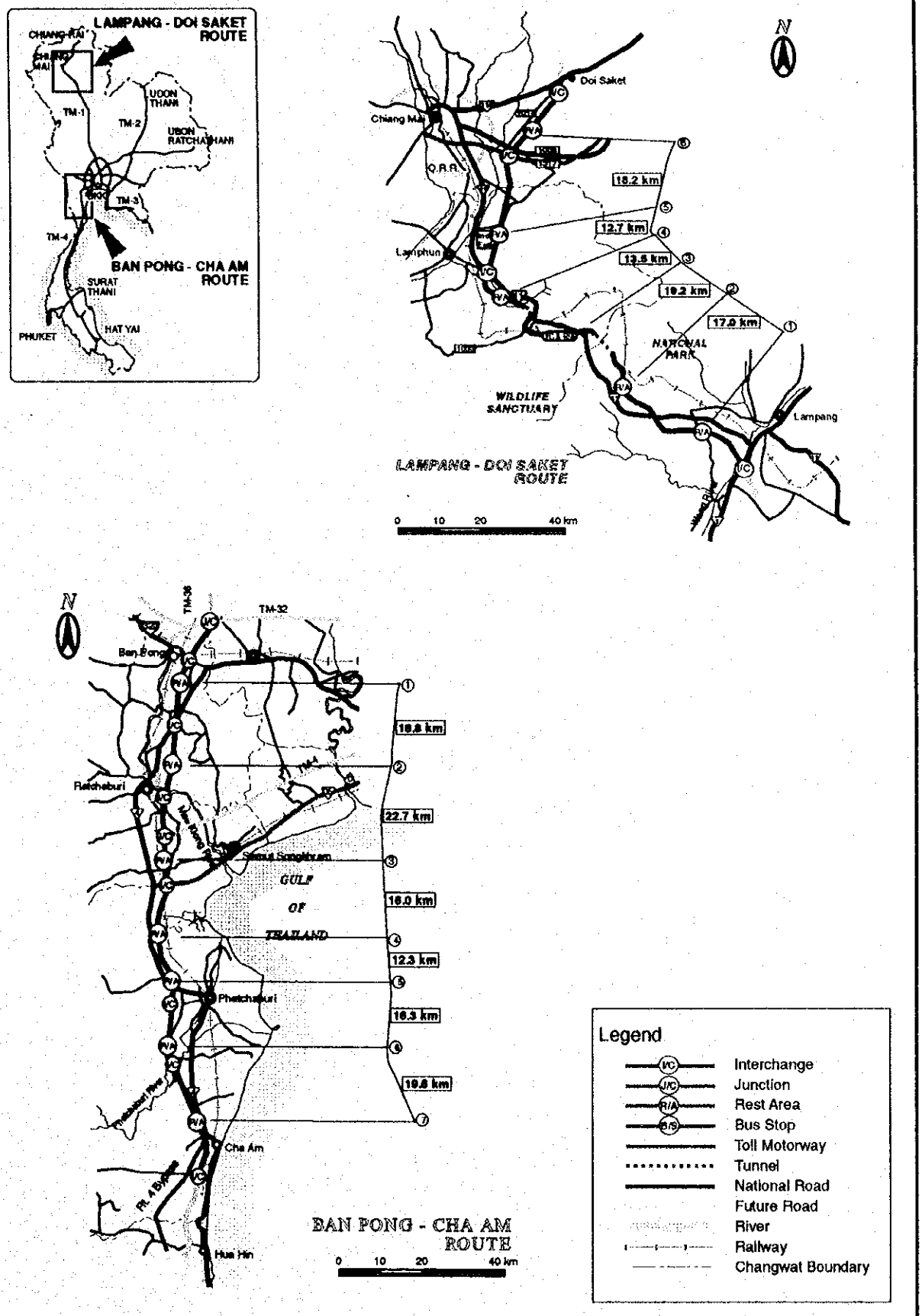
2. Type of Rest Area

There are three types of rest area categorized by the number of parking lots to be facilitated, as mentioned below and shown in Table 6.8-1:

Type A : number of parking lots 70 - 250 (one side) with full facilities
Type B : number of parking lots 25 - 70 (one side) with partial facilities
Type C : number of parking lots 15 - 25 (one side) with partial facilities

TABLE 6.8-1 TYPES OF REST AREA

TYPE	ILLUSTRATION	POSITION OF PROVISION	FACILITES
A		BOTH SIDES OF ROADWAY	• TOILET • SHOP • RESTAURANT • RESTING ROOM • ELECTRIC POWER ROOM • MACHINE ROOM FOR WATER SUPPLY& SEWAGE
B		BOTH SIDES OF ROADWAY	• TOILET • SHOP • ELECTRIC POWER ROOM • MACHINE ROOM FOR WATER SUPPLY & SEWAGE
C		EITHER SIDES OF ROADWAY	• TOILET • SHOP • ELECTRIC POWER ROOM • MACHING ROOM FOR WATER SUPPLY & SEWAGE



FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS	FIGURE 6.8-1 LOCATION OF REST AREAS

3. Summary of Rest Area Design

Design of proposed rest areas are summarized in Table 6.8-2.

TABLE 6.8-2 SUMMARY OF PROPOSED REST AREAS

Location	Distance between rest areas km	Type	Remarks
Lampang - Doi Saket Route			
1. Lampang	0	B	
2. Hang Chat	17.0	C	
3. Mae Tha	19.2	A	70 Parking lots
4. Lamphun South	13.5	B	
5. Lamphun North	12.7	B	
6. Chian Mai	18.2	B	
Ban Pong - Cha Am Route			
1. Ban Pong	0	B	
2. Ratchaburi	18.8	B	
3. Pak Tho	22.7	B	
4. Khao Yoi	16.0	A	190 Parking lots
5. Phetchaburi	12.3	B	
6. Tha Yang	16.3	B	
7. Cha Am	19.6	B	

6.8.2 Bus Stop

1. Locational Planning

Locational planning of bus stop should be made in full consideration of traffic safety, users' convenience and economic aspects.

The juxtaposed bus stop with interchange is convenience for users and economical for construction, since the interchange is located at a strategic point for traffic where it is convenience to change motorway bus to local bus or other transportation. A bus stop and a rest area can be juxtaposed where their functions do not interfere each other.

Main items to be considered for locational planning of bus stop are as follows :

- Number of local buses operated in the influence area.
- Population density in the influence area.
- An interval between bus stops - minimum 5 km.
- Convenience for transferring mutually between motorway bus system and local bus system.
- An interval between other facilities - absolutely 3 km preferably 5 km.

Figure 6.8-2 shows the proposed locations of bus stop along Lampang - Doi Saket Route and Ban Pong - Cha Am Route.

2. Type of bus stop

Figure 6.8-3 illustrates three types of bus stop, i.e. A. Independent, B. Between ramps on a single trumpet type and, C. Between ramps on a double trumpet type (arterial side).

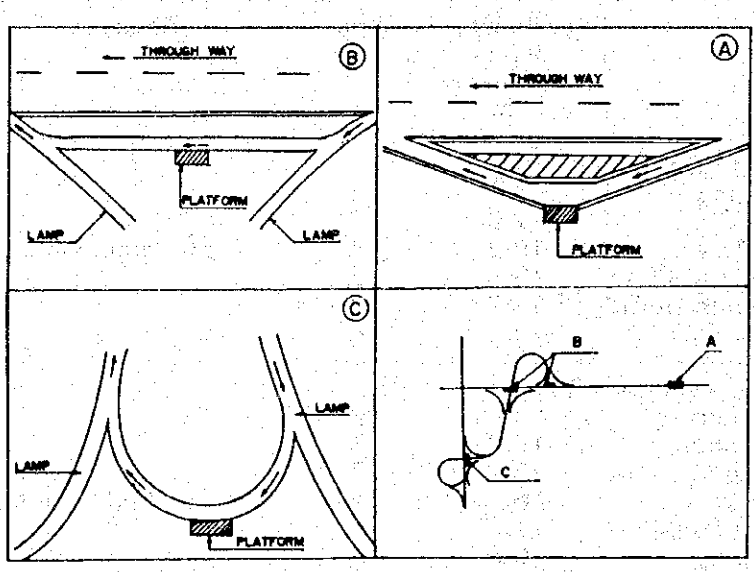


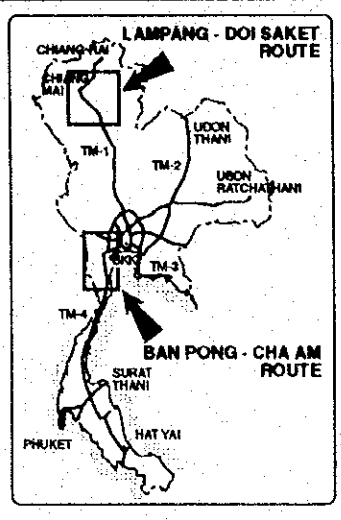
FIGURE 6.8-2 TYPES OF BUS STOP

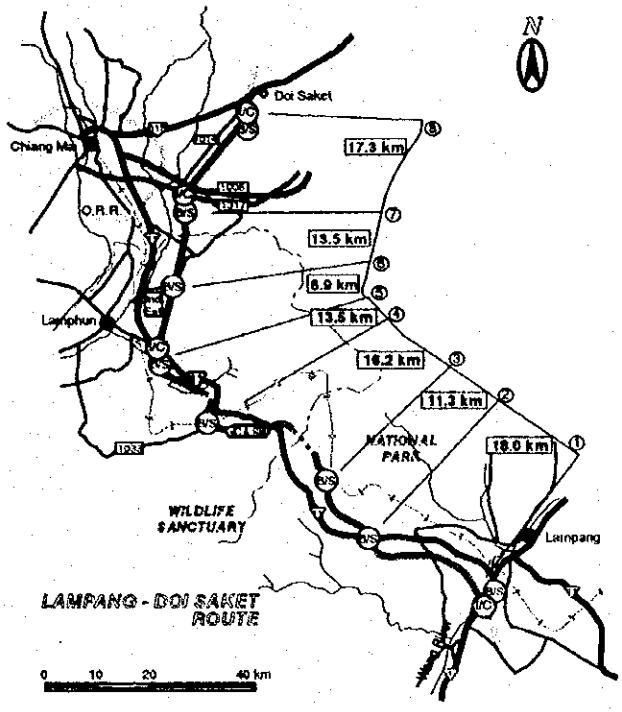
3. Summary of Bus Stop Design

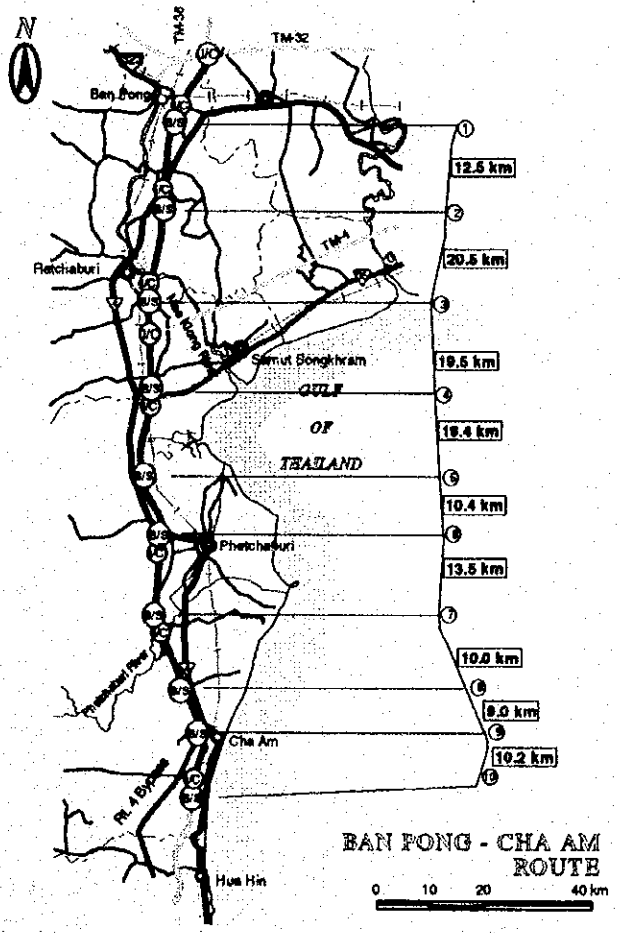
All bus stops proposed in Figure 6.8-2 are summarized in Table 6.8-3.

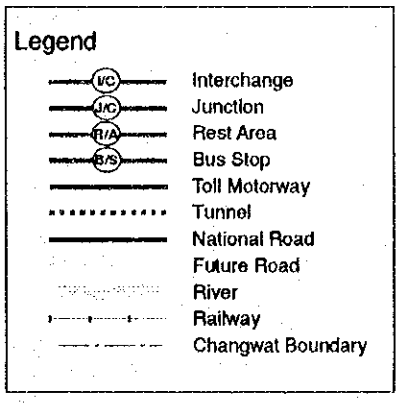
TABLE 6.8-3 SUMMARY OF PROPOSED BUS STOPS

Location	Distance between bus stops km	Type	Connecting Road
Lampang - Doi Saket Route			
1. Lampang	0	C	Rt.1
2. Hang Chat South	18.0	A	Rt.11
3. Hang Chat North	11.3	A	
4. Mae Tha	16.2	A	
5. Lamphun South	13.5	C	Rt.11
6. Lamphun North	8.9	A	
7. Chian Mai	13.5	C	Rt.1317
8. Doi Saket	17.3	B	
Ban Pong - Cha Am Route			
1. Ban Pong	0	C	Rt.323
2. Photharam	12.5	C	Rt.4
3. Ratchaburi	20.5	B	City-plann road
4. Pak Tho	19.5	C	Rt.35
5. Khao Yoi	19.4	A	
6. Phetchaburi	10.4	B	Rt.3171
7. Tha Yang North	13.5	B	Rt.3187
8. Tha Yang South	10.0	A	
9. Cha Am North	9.0	A	
10.Cha Am South	10.2	B	









FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS	FIGURE 6.8-3 LOCATION OF BUS STOPS

CHAPTER 7

ENVIRONMENTAL EXAMINATION

CHAPTER 7

ENVIRONMENTAL EXAMINATION

Environmental examination is conducted in three phases. They are; i) initial environmental examination carried out in initial stage of this study including optimum route selection, ii) environmental examination phase I carried out before and early stage of preliminary design study to give design engineers effective recommendations on mitigation measures for all field of motorway preliminary design and iii) environmental examination phase II carried out just before finalization of preliminary design to review and assess design results in environmental aspects. Main structures of this chapter come from and summarize a report of ENVIRONMENTAL IMPACT ASSESSMENT OF THE INTER-CITY TOLL MOTORWAY PROJECTS IN THE KINGDOM OF THAILAND, FINAL REPORT, MARCH 1994, conducted by Thorani Tech Ltd., Bangkok, Thailand under JICA Study Team supervision, which should be referred to for finding more details.

7.1 ENVIRONMENTAL LAW AND AGENCY

7.1.1 Related Laws

The Enhancement and Conservation of National Environmental Quality Act (The Environmental Act) was drastically revised in 1992. After the completion of all legislative procedures, the new Environmental Act (the Act) was enacted in March 1992 and took effect in June 1992. Unlike the former version of the Environment Act of 1979, under which the former Office of the National Environment Board (ONEB) served only as an advisory function. In contrast with the former Act, the Act provides, a comprehensive set of instruments and facilities to effectively manage the environmental issues. Under the Act, unprecedented authority has been given to three department level environmental management agencies, i.e., the Office of Environmental Policy and Planning (OEPP), the Department of Pollution Control (DPC), and the Department of Environmental Quality Promotion (DEQP); all of which are entrusted by a newly-setup ministerial level organization, the National Environment Board (NEB).

The Act is efficiently implemented by the use of two new mechanisms, which are the establishment of the NEB, chaired by the premier and consisting of the cabinet members, and a financial support from the Environmental Fund which is supervised by the Board. The Act also adopts the new concepts of the environmental conservation and pollution control, namely "Environmentally Conservation Area" (national parks and wildlife sanctuaries are included in this area) and "Pollution Control Area". In addition to declaring the environmentally protected areas, the environmental impact assessment (EIA) is required for specific size and type of projects; a large scale road construction is fallen into this category. Under the Act, an EIA report should be prepared by registered consultants (about 30 consultants are registered to the Office of Environmental Policy and Planning), and prepared report is reviewed by the EIA Division of OEPP and must have a final approval from the NEB. The report should include the analysis of potential adverse impacts on the environment and

also propose mitigation measures.

Laws regulating forest and wildlife resources are the Forest Act of 1960, the National Forest Reserve Act of 1964, the National Park Act of 1961, and the Wildlife Protection and Reservation Act of 1960. Among these four acts, forest protection measures are generally provided by the Forest Act and the National Forest Reserve Act. The other two acts, the National Park Act and the Wildlife Protection and Reservation Act, aim to maintain the natural features of forests by setting conservation boundaries.

Forest areas are divided into two parts for the purpose of the policy, namely, "Conservation Forest" and "Commercial/Productive Forest". Conservation forests are areas away from any activities that may be harmful or may adversely affect or change the pristine state of the ecosystems of such areas. This kind of forest includes national parks and wildlife sanctuaries, both of which are completely protected by the National Park Act and the Wildlife Protection and Reservation Act, respectively.

In addition to these two legally protected areas, class 1-A watersheds, non-hunting areas, reserved parks, arboretums, botanical gardens, and reserved areas for specific projects fall into this category, while there is no solid law concerning these areas. According to the classification based on the physical characteristics of landscape units, class 1-A includes conservation forests and headwater source areas, usually at higher elevations with very steep slopes. These areas still remain under permanent forest cover, resulting in a high probability of natural disasters occurring. Any kind of activity disturbing this class of watershed is restricted by law. Class 1-B watersheds are areas having similar physical features as class 1-A, but where portions of the area have already been cleared for agricultural use or occupied for other types of human use. Unlike class 1-A, this class of watershed can be disturbed, although proper soil protection measures are required. On the other hand, commercial/productive forests, in which economic activities are allowed, include forest reserves, plantation areas, community forests, private tree farms, and timber concession areas. The total target area for forest cover is divided between these two forest types.

7.1.2 Major Governmental Agencies

For natural resource conservation, the supervising ministry-level bodies are the Ministry of Agriculture and Cooperatives (MOAC) and the Ministry of Science, Technology, and Environment (MOSTE). Under MOAC, the Department of Forestry exclusively controls matters by using the National Park Division and the Wildlife Sanctuary Division as major control agencies. Under MOSTE, the Environmental and Natural Resources Coordination Division and the Environmental Impact Assessment Division under the Office of Environmental Policy and Planning (OEPP) act as major division-level controlling bodies to supervise natural resources conservation. It should be noted that the Environmental Impact Assessment Division has the right to give approval to any kind of megaproject implementation by examining an EIA report which has been prepared by a private registered consulting firm and submitted by an implementing agency.

7.2 ENVIRONMENTAL EXAMINATION

7.2.1 Air Quality

The assessment of air quality impacts caused by the project implementation involves monitoring existing air quality (12 locations in L-D Route and 6 location in B-C Route) to obtain baseline information, and air quality modeling to predict future pollutant levels. The modeling results are then compared to the ambient air quality standards set by OEPP.

1. Existing Ambient Air Quality

The pollutants monitored are carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), total suspended particles (TSP), and lead (Pb). The results of the monitoring reveale that the levels of CO, NO_2, SO_2, and Pb are well below the set standards, while levels of TSP are relatively high, and in one case exceeded the set standards of 330 micrograms per cubic meter (ug/m^3) on each of the three days.

2. Modeling and Impact Assessment

In summary, the modeling results indicate that there are relatively low pollutant levels at the edge of the right-of-way for all the cross sections except for tunnels and high cuts (only in the case of assumed worst scenario). Predicted CO concentrations for typical cross sections are generally below 3 mg/m^3, which is much lower than set standards of 50 mg/m^3. Similarly, predicted NOx levels at the right-of-way are also low enough to meet the set standards of NO_2 with 320 micrograms per cubic meter.

Pollutant levels in deep cuts may be higher due to the potential of a canyon effect, but nonetheless are predicted to be well below the standards.

Pollutant concentrations in a long tunnel would be high and then will be controlled by installing ventilation systems to reduce CO levels to less than 100 mg/m^3, which is generally considered an acceptable level of CO in a road tunnel.

7.2.2 Noise

The assessment of noise impacts caused by the project implementation involves monitoring existing noise level (8 locations each in L-D Route and B-C Route) to obtain baseline information, and noise level modeling to predict future noise levels. The modeling results are then compared to the noise level standards set by OEPP of Thailand and USEPA.

1. Existing Noise Level

The results of the monitoring revealed that the noise levels generally fall into the range between 50 and 75 decibels (dBA), depending on proximity of existing highways and types of land uses. The noise levels regarding the land uses can be generally classified as 70-75 dBA for highways and commercial, 55-60 for rural

residential and educational, and 50-55 for agricultural and forest not near residential.

2. Modeling and Impact Assessment

In summary, the modeling results indicate that ther are relatively high noise levels at the edge of the right-of-way on the ground level for all the cross sections except for a viaduct or bridge. Predicted noise level for the at-grade road is about 75 dBA which is equivalent to lower embankment case. The cut structure has some noise reduction effects, but not significant enough to satisfy the noise standards. The noise revel reducing measures need to be taken for these two types of road structures if it is found that inhabitants reside close enough to be exposed to the excessive noise.

On contrary, a likely-applied 8-meter viaduct/bridge will significantly reduce the noise level for the receptors on the ground; the reduced level is estimated as low as 63 dBA.

In the tunnels, peak noise levels may be as high as 90 to 100 dBA. No counter measures to reduce the levels is considered necessary, due to no receptors residing in the tunnels.

It may also need to be mentioned about the noise generated during construction stage. Noise disturbance during construction is shorter than one during operation; however, its magnitude is considered much higher than one caused during operation. The following table shows the previously studied noise ranges of constructions equipment (Rupert, 1979) and the adequate noise levels required by the FHWA.

Equipment	Noise Level at 15 meters (dBA)	Required Noise Level (dBA)
Concrete Mixers	71-90	75
Pile Drivers	90-104	95
Rock Blaster	82-98	80
Backholes	72-93	75
Tractors	73-96	75
Trucks	70-96	75
Generators	70-82	75

7.2.3 Vibration

The vibration monitoring was conducted in the selected monitoring locations (8 locations in each L-D Route and B-C Route) to obtain baseline vibration levels as well as information on characteristics of surface vibration movement and attenuation, and predicted vibration levels caused by the project implementation were then evaluated based on the main findings.

1. Existing Vibration Level

The results of the monitoring indicates that the existing vibration levels are very low

along the two study routes. Maximum peak particle velocity measured are generally below 1 mm/s, and in only one case relatively high numbers are at Pak Tho monitoring station, where average peak particle velocity were about 1 mm/s, with a maximum of 2.09 mm/s mainly caused by heavy trucks.

2. Modeling and Impact Assessment

On the Lampang-Doi Saket Route, a large portion of the motorway will be on rock bed, but the construction calls for a layer above the rock, which can be considered a sand and gravel bed. Since the buffer zone for each side of the motorway is designed for about 16 meters for the Lampang-Doi Saket Route, it can be estimated that likely vibration level at the edge of the right-of-way is about 65 dB. Considering the construction of the frontage roads for the convenience of the roadside residents and, in the same manner, for alleviating the problems of the split of communities, an actual buffer zone would be well over 24 meters. Based on the predicted model, the vibration level at 24 meters from the source is estimated at 57 dB.

On the Ban Pong-Cha Am Route, the vibration level to affected receptors should be lower, because the route has soils of clay loam to sand with a similar type of construction and longer buffer zone of 18.5 meters. Consequently, the vibration level will be under 60 dB, which is equiavalent to 0.16 mm/s at 10 Hz and low enough to damaging humans, and it can be concluded that no receptors will be significantly disturbed by the vibration caused by the motorway operations.

The viaduct/bridge sections will have less impacts due to the rigid and massive concrete structure which has a damping effect on vibration. The cut sections will also have less impacts because of the added mass above the horizontal wave propagated at the level of the road beds.

Concerning the vibration impacts during construction phase, pile driving and rock blasting are major potential vibration producing sources. Since rock blasting is only needed for tunnel construction, mainly at the entrance of the tunnels, and the areas will be far from any major residential areas (although some impacts on wildlife are likely), vibration impacts from the blasting are not expected to be a concern. Another potential vibration producing source, pile driving, will be required in various construction sites. Although there are several types of pile driving methods, having different magnitudes of vibration, it is not likely that the levels exceed 2 mm/s at a distance of 30 meters from the vibration source. This level is equivalent to 80 dB and also barely to clearly perceptible to persons.

7.2.4 Water Resources and Aquatic Ecology

Water quarity monitoring is conducted at selected 12 sampling locations, 6 for each route. Aquatic life sampling also is conducted at a total 16 selected locations, 8 for each route.

1. Existing Conditions

Water Quarity

The testing results of water quarity indicates that water bodies along Ban Pong - Cha Am Route are generally more polluted regarding BOD concentrations than those along Lampang - Doi Saket Route.

Aquatic Ecology

Lampang - Doi Saket Route: A total of 45 species of plankton are identified at the 8 sampling locations. Plankton counts averaged 442 individuals per liter, and varied from 105 to 957 individuals per liter. The number of benethic organisms per location varied considerably, with the smallest number of only two individuals per square meter, the largest number of 185 individuals, and the average number of 53. Concerning fish species, 16 kinds are found, none of which are endangered. In addition, 10 species of aquatic plants are identified.

Ban Pong - Cha Am Route: A total of 59 species of plankton are identified at the 8 sampling locations. Plankton counts averaged 15,209 individuals per liter, and varied from 26 to 92,567 individuals per liter. For samples taken at sampling stations 1, 2, and 5, the plankton count appears to have increased. This is due to the effects of nearby pig farms which discharge high nutrient content organic waste into adjacent water bodies. The number of benethic organisms per location varied considerably, with the smallest number of only four individuals per square meter, the largest number of 98 individuals, and the average number of 38. Large numbers of Chironomides are found in the Petchaburi River sampling station, indicating low water quality, since Chironomides thrive in oxygen poor conditions. Concerning fish species, 28 kinds are found, none of which are endangered. In addition, 11 species of aquatic plants are identified. The dominant spices found are family of carp, including Cyclocheilichthys sp., Hampala sp., Osteocheilus sp., and Puntius sp.. Some of the fish species are considered of economic importance to local fishermen, but none are endangered.

2. Impact Assessment

The impact assessments common to above-mentioned water-related resources, i.e., surface water hydrology, ground water hydrology, water quality, and aquatic ecology, are presented.

During construction, most of water bodies crossed by the motorway will need to be temporarily diverted and in some cases temporarily dammed, and existing useful water drainage patterns may be altered. This could result in irregular and interrupted down stream flow and drainage, affecting local water users. Bridge construction, particularly if a new bridge were constructed over the major rivers, would have some impact on aquatic ecology; the principal sources of water quality deterioration affecting aquatic ecology are water stream alteration and sedimentation changes from earthworks associated with the bridge piers and approaches, grease and oil discharges from machinery maintenance, and fecal contamination from construction camps.

During operation, the major impacts on water resources arising from soil runoff of fill material used to construct the embankment of the road, water runoff from the

road surface, waste water discharge from rest areas. These adverse impacts, combined together, would result in the deterioration of the water quality caused by the increased levels of suspended solids, chemical contaminants in the form of heavy metal, pesticide, grease, and rubber residues accumulated on road surfaces, waste water discharge from the facilities in service areas. The mechanism of these pollutants affecting the water quality is that such pollutant can be built up during the rainfall, and subsequently be washed by rain into water bodies. In the case of affecting groundwater quality, the mechanism is performed through soils into the ground water aquifer. The speeds of contamination vary from short-term to long-term, and either cumulative or non-cumulative. For example, buoyant pollutants such as hydrocarbons move rapidly downstream so that resultant degradation of water quality is short-term and non-cumulative. On the other hand, more persistent polluntants such as heavy metals can accumulate in sediments, resulting in long-term and cumulative degradation of water quality.

7.2.5 Soil Conditions

Soil conditions have been examined in consideration of soil erosion or loss for both routes, particularly in mountainous areas on the Lampang - Doi Saket Route which may be subject to landslides, and ground subsidence in soft ground area on the Ban Pong - Cha Am Route. The results of detailed geological survey along the two routes are also presented in Chapter 6 in this report.

1. Existing Conditions

Lampang - Doi Saket Route: It is found that the section between Amphoe Hang Chat and Amphoe Mae Tha on this route may have a high potential for soil erosion. A soil survey has revealed that soil characteristics in the above mentioned portion are deeply and highly weathered schist and granite from the Silurian-Devonian periods. The typical soil type is sandy gravel, which is relatively vulnerable to soil erosion typically caused by massive rainfall. The soil condition in the section between the north side of the planned 4.5 kilometer tunnel and the Mae Tha Interchange/Service Area is better, having lower potential of soil erosion. On the other hand, soil conditions in the other planned tunnels just north of the Mae Tha Interchange/Service Area were found unstable, containing mostly weathered sandstone and shale.

Ban Pong - Cha Am Route: Soil conditions in this route are different from those in Lampang-Doi Saket Route. Salient features of soil conditions in the Ban Pong-Cha Am Route are found soft ground areas along the route. A soil survey has revealed that soft or medium alluvial silty clay deposits from the Holocene period are widely found on the ground surface in the section between the Photharam Interchange and Phetchaburi Interchange. The ground water level in the section is relatively shallow, observed 1.5 meters from the ground surface. This implies that a portion of thiss segment is suffering from a high water table, having potential drainage problems.

2. Impact Assessment

The results of soil loss estimation reveal that one kilometer of motorway on an

averaged 2.3 m hight embankment will contain about 0.99 hectare of embankment draining to both sides, amounting to 209.1 tons and 198.6 tons per kilometer per year for the Lampang - Doi Saket Route and the Ban Pong - Cha Am Route, respectively. Similarly, a 7 m hight slope of cut, which occur only on the Lampang - Doi Saket Route, will lose 32.6 tons per 100 linear meters per side of each tier of a cut. In case of rolling and mountainous sections, having both cut and embankment structures in different degrees, the amount of soil loss primarily depends on a total slope area of cut, because the magnitude of soil loss on slope of cut is much greater than that of embankment and, in some section in mountainous area, a total length of cut will be as deep as 30 m. Particular attention should be made to prevent soil loss as small as possible in these areas.

Ground subsidence is only anticipated on the Ban Pong-Cha Am Route. The results of natural condition survey and the analysis of the results show that the problems of the ground subsidence is not serious as anticipated at the early stage of the study. The detailed analysis and mitigation measures are presented in Section 6.5 in this report. In sum, no serious ground subsidence problems are expected if proposed counter measures are properly taken at the stage of the motorway construction.

7.2.6 Terrestrial Ecology

Terrestrial ecology in the section between Amphoe Hang Chat and Amphoe Mae Tha on Lampang - Doi Saket Route is examined in this section.

1. Existing Conditions

Vegetation Cover along the Motorway Route: The region is dominated by two mountains, namely Doi Khun Tan and Doi Pha Muang, in which the wildlife sanctuary and the national park are gazetted. Classification of forest cover has been made for these two protected areas located on either side of the route. Doi Khun Tan National Park, which covers 255 square kilometers, is predominantly composed of dry dipterocarp forest amounting to 165 square kilometers. The site also contains 5 square kilometers of endangered evergreen forest, as well as 55 square kilometers of evergreen forest and 23 square kilometers of hill evergreen. Submontane/scrub forest, another threatened habitat, covers 7 square kilometers. Doi Pha Muang Wildlife Sanctuary covers 591 square kilometers. Dry dipterocarp is dominant, amounting to 478 square kilometers. Lowland evergreen forest covers 5 square kilometers, while evergreen forest cover 83 square kilometers and hill evergreen covers 20 kilometers. Submontane/scrub forest covers 5 square kilometers.

Wildlife Habitats in the Neighboring Protected Areas: Some indication of the faunal composition found along both sides of route can be gained from data on the fauna present in the adjacent protected areas, Doi Khun Tan National Park and Doi Pha Muang Wildlife Sanctuary. Unfortunately, data regarding these two protected areas is limited, as both the national park and the wildlife sanctuary have received large survey coverage.

2. Impact Assessment

The planned motorway route will pass through an intact forested area, which mainly comprises dry dipterocarp and mixed deciduous forests. Based on the assumption that the motorway has its right-of-way width of 60 meters, the amount of forested land to be cleared can be estimated. The estimated areas of cleared land in terms of the types of forests are 48 hectares of teak plantation, 17 hectares of dry dipterocarp, 6 hectares of transitional dry dipterocarp forest with mixed deciduous, and 3 hectares of mixed deciduous forest. Clearance of forested land and plantation trees would generate about Baht 34.1 million. The forested land to be cleared and estimated valued of these tree types are summarized in the table below.

Forest Type	Affected Area(ha)	Wood Price (Baht/ha)	Total Price(Baht)
Teak Plantation	48	575,988	27,647,424
Dry Dipterocarp	17	216,043	3,872,731
/Mixed Deciduous	6	187,799	1,126,794
Mixed Deciduous	3	549,983	1,649,949
Total	74		34,096,898

The clearance of vegetation would also affect faunal habitats, possibly destroying some of the habitats. Species most vulnerable to the changes of habitual conditions will include rodents and insectivores. In addition, there are a number of large and medium-sized mammals whose territories, used mainly for food sources, will be disrupted by the motorway construction. During operation, terrestrial species could stray onto the motorway and be killed, although boundary fence is planned to be installed in both sides of motorway.

7.2.7 Transportation Network

The analysis of impacts on transportation network in affected areas is based on the conducted traffic study, which is presented in Chapter 3 in this report. The focus of the analysis is given to severance caused by the motorway construction and operation.

1. Existing Transportation Network

The traffic along the Lampang - Doi Saket Route is currently carried by two primary highways, Rt. 11 and Rt. 118, and a secondary highway Rt. 106. Rt. 11 connects Lampang to Lamphun and Chiang Mai. Rt. 118 connects Doi Saket with Chiang Mai and Rt. 106 does Chiang Mai with Lamphun. The linkage between Chiang Mai, a regional growth center, and Lampang, a second-generation regional growth center, is considered particularly important for the future development in north and north-eastern regions.

The traffic along the Ban Pong - Cha Am Route is currently carried by one of prime national highway, Rt. 4. All the major cities, Ban Pong, Rachaburi, Pak Tho, Pecha-

buri, and Cha Am, are connected by Rt. 4. Major portion of Rt. 4 is four lanes except for a two lane section between Pak Tho and Rachaburi.

2. Impacts on Existing Transportation Network

The planned motorway route will intersect with a number of existing roads, 17 for the Lampang - Doi Saket Route and 36 for the Ban Pong - Cha Am Route. Among these number of intersected existing roads, the motorway is designed to overpass national highways numbered with single and double digit, such as Rt. 4 and Rt. 11. Other national highways, provincial roads, and roads for a specific purpose will be either supplied with bridges overpassing the motorway or be cut off by the motorway. The former case should not create any problems since communications between the communities over the motorway stay same, while the latter case would cause split of community and communication inconvenience problems. Severance, the interruption between two locations, of communication includes foot and vehicular traffic, movement of agricultural workers, equipment, and livestock. The results of this feasibility study shows that the numbers of roads which will be cut off by the motorway were counted to be xxx for the Lampang - Doi Saket Route and xxx for the Ban Pong - Cha Am Route. Although these numbers of interfered roads are not significantly high, some mitigation measures should be taken.

7.2.8 Land Use Pattern

Potential impacts on existing land use are analyzed based on various types of maps, land use maps, topographic maps and aerial photographs, and extensive field surveys. Land value information was collected as part of socioeconomic study, which is also presented in this chapter, and from government land assessment figures.

1. Existing Land Use

The areas along the both planned motorway routes are located in mostly rural land,and land use is primarily agriculture, with considerable area of forested land along the Lampang-Doi Saket Route. Ratios of seven land use types for both routes are summarized in the table below.

Land Use	Lampang-Doi Saket Route Area (Rai)	Ratio (%)	Ban Pong-Cha Am Route Area (Rai)	Ratio (%)
Agriculture	3,370	56	6,921	80
Residential	305	5	776	9
Commercial	39	0.6	45	0.5
Forest	2,113	35	0	0
Plantation	117	2	335	4
Water body	12	0.2	94	1
Others	73	1.2	477	5.5
Total	6,029	100	8,648	100

Note: The affected land areas are defined as 0.5 km on either side of the motorway from center line.

The numbers of rural communities would be affected are 49 for the Lampang - Doi Saket Route, along which some industrial areas are located, and 86 for the Ban

Pong - Cha Am Route.

Land values along the motorway routes are assessed. Survey data indicates that farm land and non-farm land range in value from Baht 50,000 to Baht 500,000 per rai for both routes, unless it is located near a special feature. Land close to an important roadway may be worth as much as Baht 4 million per rai. Prices also increase near an industrial estate (Baht 1.5 million) and near housing development (Baht 1.5-3.0 million) along the Lampang - Doi Saket Route.

2. Impacts on Existing Land Use

Due to the introduction of the motorway, land use pattern and land value changes are expected for those areas close to on-ramps and off-ramps. These areas will experience land use changes from agricultural to a higher level of economic activities, i.e., commercial and industrial. This increased productivity and anticipated speculation on land will increase land prices. Although increased productivity is positive change to communities, unmanaged growth will result in inefficient land use, through ribbon development and associated infrastructure and environmental problems. Ribbon development along improved transportation routes and pocket development at important intersection are well-observed features in Thailand.

The predominant effect on land values is expected to be an increase in land prices. This will certainly true in the areas mentioned above. The socioeconomic survey conducted as part of this study shows that most of the villages along the motorway routes believe the future increase in land prices induced by the introduction of the motorway. This belief is primarily based on improved transportation system for agricultural products and higher opportunities for commercial and industrial development.

In summary, the impacts of the project implementation on land use are mixed, but with proper planning an overall impact could be positive. Well-planned growth and increasing land prices would be movements in a positive economic direction.

7.2.9 Socio-Economic Conditions

Socio-Economic study, regarding environmental aspects, concerns two major impacts, the induced regional impacts and the expropriation of residential and agricultural land, necessitating relocation of affected inhabitants.

1. Existing Socio-Economic Conditions

Existing socio-economic conditions are examined by a series of interviews conducted at selected villages and available secondary data. Collected data is utilized as a basic information on the analysis.

A total of 20 regional communities are selected along the Lampang - Doi Saket Route (10 villages) and the Ban Pong - Cha Am Route (10 villages) for conducting socio-economic surveys. Ten households are randomly selected to be interviewed in each village, making a total number of interview to be 200. The interview is con-

ducted based on a prepared questionnaire, asking for household structure, occupation, employment status, household income, education background, land ownership, value of property they own, and attitudes towards the project. The results of the surveys are summarized below.

Item	Lampang-Doi Saket Route	Ban Pong-Cha Am Route
Average number of household	259 households	140 households
Average size of household	3.3-4.4 persons (1.5-3.8 children)	4.1-6.8 persons (2.5-5.0 children)
Income ratio from farm work	37 %	36 %
Average household income	Baht 64,800/Year	Baht 74,300/Year
Average land price	Baht 250,000/Rai	Baht 210,000/Rai
Average land holding size	6.2 Rai	8.0 Rai
Education background	70 % (4-year)	56 % (4-year)
Attitude towards project	94 % in favor	85 % in favor

It is interesting to know from the results of the interview that relatively small portion of income comes from farm work, accounting 37 per cent for average income along the Lampang - Doi Saket Route and 36 per cent for one along the Ban Pong - Cha Am Route. The steady shift from farm work to non-farm work can be observed on several socio-economic data. Some villages, such as Ban Klang and Ban Fon along the Lampang - Doi Saket Route, are predominantly dependent on income from non-farm work, accounting more than 90 per cent.

The results of surveys also indicate that villages along both routes are well-established, having been settled for a hundred years or more. Migration is not common; more than 80 per cent of the inhabitants were born in their villages. In addition, more than 98 per cent of those surveyed had relatives in their own and neighboring villages.

2. Impacts Assessment

Induced socio-economic impacts typically include population increase, changes in employment opportunity, and land price changes. Population changes along the motorway routes are expected to be minimal due to its nature of full-control access. Only exceptional cases are areas near interchanges, where pocket development would like occur. Motorway construction may affect employment opportunity of villagers, due to reduced agricultural land and increased chances to have non-farm work induced by better traffic communications. This would be particularly true in case of some areas along Ban Pong - Cha Am Route near Bangkok, because access to these areas from and to Bangkok becomes much easier, inducing potential residential, commercial and industrial development. As already discussed, land price would be changed only in areas near interchanges.

Concerning impacts on land expropriation, the planned motorway routes, both the Lampang - Doi Saket Route and the Ban Pong - Cha Am Route, will generally pass through farm land, mostly paddy fields, and in some cases through the residential

areas. Land expropriation matter should be discussed separately in agricultural fields and residential land, because of different amplitude of impacts on the quality of life.

Based on the analysis of various types of information sources in-hand and a series of field surveys, a preliminary design for a motorway structure, as well as exact route alignments, are determined. The determination of the route alignments make possible to describe the condition of the affected residential and farm land.

In order to estimate the magnitude of impact, concerned areas are categorized into farmland and built-up areas for both routes. Estimated size of farmland and built-up areas are 2,483 rai and 593 rai for the Lampang - Doi Saket Route, and 4,086 rai and 1,916 rai for the Ban Pong - Cha Am Route. Based on estimated affected land areas and assessed land values, compensation prices are calculated to be Baht 649.25 million for the Lampang - Doi Saket Route and Baht 1,471 million for the Ban Pong - Cha Am Route. It should be noted that land values of farmland and built-up areas are not assessed separately; even land values from surveys also do not show significant difference between the values. It is normal practice that assessed values are generally lower than reported or market values. Moreover, increased demand for land for acquisition of new farmland or resettlement land might push up actual land prices further. Therefore, assessed valued should be used with caution, regarding as minimums, although the values can be used as initial estimator of land acquisition. Based on analysis of all the collected data, it is estimated that approximately 600 households in the Lampang - Doi Saket Route and 490 households in the Ban Pong - Cha Am Route will be affected, in terms of significant reduction of farmland. On the other hand, direct impact of motorway construction on living, i.e., human displacement, would be expected to be 33 in the Lampang - Doi Saket Route and 89 in the Ban Pong - Cha Am Route. As is already reviewed, dependency on agriculture, regarding income, has been gradually decreased in both project affected areas, impacts on farmland are not as great as those on inhabitants.

7.2.10 Cultural/Aesthetics/Archaeological Values

1. Existing Conditions and Concept of Aesthetic

There are believed to be no important archeological resources in the project affected areas. Some cultural properties, in this case Buddhist temples, would be adversely affected, in terms of exposure to excessive noise and visual impairment caused by the introduction of the motorway.

Aesthetics value is generally considered to be disturbed by the appearance of new structures, which may destroy the harmony of the existing scenery or simply shut it out. Areas to be considered typically include near temples and bridges, and areas with great land form changes, e.g., deep cut sections and tunnels in mountainous. Differing from the environmental parameters previously described, this parameter cannot be numerically evaluated because evaluation is made in a subjective manner, image presentation methods. This pictorial presentations have been produced for two typically affected locations, the bridge over the Mae Klong River and the motorway toward Wat Phra Non.

2. Impact Assessment

To assess the impact on likely affected areas mentioned above, temples close to the motorway (less than 100 meters from the right-of-way), proposed bridge over the Mae Klong River, and mountainous areas with deep cut sections and tunnels are examined.

As discussed in noise impact section, general noise level at 100 meters from the right-of-way of the motorway is 69 dBA, which satisfy the OEPP standard; however, not suitable for noise sensitive receptors. Temples fall within this impact zone are: Wat Ban Khek Wua and Wat Duang Dee along the Lampang - Doi Saket Route; and Wat Welu Wararam and Wat Nong Phao Than along the Ban Pong - Cha Am Route. These four temples would also suffer visual impairment. In addition to four temples, some other temples, including Wat Ban Mo Saom, Wat Ban Pa Tan, Wat Phra Non, Wat Ban Phae Nua, and Wat Mae Chong along the Lampang - Doi Saket Route; and Wat Nong Hu Chang, Wat Amphawan, Wat Tham Wirot, and Wat Bo Bun along the Ban Pong - Cha Am Route, may suffer visual impairment, although these temples are located far enough not to suffer noise impact from the motorway. In mountainousd areas with deep cut sections and tunnels, improper manner on slope and tunnel portal protection will disrupt visual beauty (This is mostly from drivers' view points).

7.3 CONSIDERATION OF THE TARGETS OF ENVIRONMENTAL CONSERVATION

7.3.1 Introduction

Environmental conservation targets are desired to be established quantitatively from scientic aspects; however, some environmental parameters are difficult to be evaluated quantitatively. In the case, qualitative way of evaluation targets are considered. Among several environmental parameters discussed, air quality, noise and vibration levels, and water quality can be evaluated quantitatively and target standards are already set up, while other parameters are two-fold; can be evaluated quantitatively but standards are diffcult to be set, and can not be evaluated quantitatively but only qualitatively. The former case includes soil condition, aquatic and terrestrial ecology, land use pattern, transportation network, and socio-economic conditions, and latter case is cultural/aesthetics properties. For example, the number of households to be relocated and the volume of trees to be cut down could be estimated, but specific targeting figures are difficult to be determined.

7.3.2 Air Quarity, Noise Level, Water Quarity and Vibration Level

At present, Thailand has standards of air quality, noise level, and water quality. Environmental conservation targets for these environmental parameters should abide with these set standards. Since there are no vibration standards in Thailand, standards currently being applied in other countries, e.g., Japan and the United States, could be considerable targets. Details of set standards being applied in Thailand, air quality, surface water quality, ground water quality, motor vehicle noise (other than general noise standards of 70 dBA), are presented in Appendices 7.3-1, 7.3-2, 7.3-3, and 7.3-4, respectively.

7.3.3 Other Parameters

Conservation targets for other environmental parameters can not be set up explicitly; considerable conservation targets/guidelines for these parameters are discussed below.

1. Aquqtic and Terrestrial Ecology

Conservation targets of aquatic and terrestrial ecological resources could depend on the scarcity and the importance of these resources on local communities. For example, if endangered species are found in the project affected areas, massive conservation efforts should be made in such a way that replanting or appropriate habitants provision, and if certain species are found to be important resources for inhabitants, these resources should be conserved in same state.

2. Land Use Pattern and Transportation Network

Changes in land use pattern, including land price increase, should not be drastic, and inconvenience of transportation network should be tolerable level for people in local communities. Specific numericaal targeting figures for these parameters can not be set explicitly. Consideration should be made based on the previous statistics

and case studies if any of these are available.

3. Socio-economic Conditions

The targets of land expropriation, causing reduction on agricultural land and human relocation, could be considered in line with compensation measures. In case of farm land matter, maintaining current income levels, either by providing alternative farm land or opportunity to have other occupation, could be considerable targets. In case of human relocation, only considerable target can be the provision of alternative resettlement sites and production systems, which has to be studied in depth and clearly stated into the development plan.

4. Cultural/aesthetic Properties

Cultural/aesthetic properties should be conserved depending on the importance of these values. Since Buddhist temples are so important in Thailand that these properties should not be disturbed in any case. In numerous cases, areas with aesthetic values coincide with culturally and naturally important sites. Thailand has a juridical system to conserve natural conditions by setting up protected areas, e.g., national parks and wildlife sanctuaries. However, no juridical system to conserve cultural properties themselves. Therefore, it is suggested that cultural properties be conserved regarding the level of jurisdiction, national, provincial, city, and village. In general, the higher the level of jurisdiction, the heavier the properties would be conserved.

7.4 MITIGATION MEASURES

7.4.1 Introduction

Based on the planned preliminary design of the motorway structures, appropriate mitigation measures to alleviate negative impacts of the project implementation on both social and natural environment are concerned. Some proper mitigation measures are designed and incorporated into the preliminary structure design. For example, protective design measures for soil erosion and siltation, ground subsidence, and split of communities are applied, while others are considered as future design, i.e., waste water treatment facilities in rest areas and passageways for wildlife, and other means. Environmental parameters typically affected by new road construction include: (1) air quality, (2) noise, (3) vibration, (4) water resources and aquatic ecology, (5) soil conditions, (6) terrestrial ecology, (7) transportation network, (8) land use pattern, (9) socio-economic conditions, and (10) cultural/aesthetics/archaeological values. Mitigation measures on specific environmental parameters are examined in terms of four environmental parameter groups, physical resources, ecological resources, human use values, and quality of life values.[1] Relations of each environmental parameter and four groups are presented in the table below.

Environmental Parameter Group	Specific Environmental Parameter
Physical Resources	(1) Air Quality (2) Noise (3) Vibration (4) Water Resources and Aquatic Ecology (5) Soil Conditions
Ecological Resources	(6) Terrestrial Ecology
Human Use Values	(7) Transportation Network
Quality of Life Values	(8) Land Use Pattern (9) Socio-Economic Conditions (10) Cultural/Aesthetics/Archaeological Values

Applied and concerned feasible mitigation measures on the project implementation with respect to each category of environmental parameters are described in following sections. Expected adverse impacts, areas to be affected, and applied and concerned mitigation measures on specific environmental parameters are summarized in Table 7.4-1.

7.4.2 Physical Resources

1. Air Quality

During the construction stage, water and chemical sprinkling would be an efficient means to alleviate dust impacts on roadside residents. Additional proposed measures to minimize air quality decline include; storage of bulk construction materials in closed silos with appropriate dust preventing filters, shrouding the aperture for dry

mix batching, and confining working vehicles to designated routes only.

The long tunnel must be equipped with an appropriate ventilation system to keep the pollutant concentration, particularly CO, at an acceptable level. The details of the ventilation system designed in this study are presented in Section 6.6.4.

Regarding a potential relatively high pollutant levels in *deep cut sections*, it is recommended that the slope of the cut be as flat as possible in order to make natural ventilation effective.

2. Noise

The areas affected by excessive noise are most likely near the motorway with *viaduct*. In the case, wall noise barriers would be an appropriate noise reduction structure, which can be installed adjacent to the traffic lanes. Noise reduction effect of wall barriers is expected to be 10 to 12 dBA. Wall barriers designed in this study are made with concrete foundations, having typical height of 2 to 3 meters.

In the section of *low embankment*, tree planting in the buffer zone of the motorway is designed as shown in cross section drawings in separate volume. Since it was found from the field survey, residential and sensitive areas are not likely located within the motorway noise affected area. Trees have relatively low noises reduction effect, providing about 2 dBA attenuation for every 10 meters of dense-leaf trees.

If the affected areas are along the motorway with *cut section*, earth berms designed in this study are considered appropriate noise reduction structure. The berms can be built with a 45 degree slope covered with glass. Earth berms have similar effectiveness of noise barriers, i.e., 10 to 12 dBA reduction.

3. Vibration

During construction stage, low vibration generating pile driving machines and methods, e.g., hydraulic pressure and vibratory pile drivers, and bore piling, are recommended in the areas relatively close to the receptors.

Vibration mitigation *during the operation stage* is not considered necessary if the designed buffer zone is maintained and roads are kept in good conditions. As part of regular maintenance procedure, potholes should be promptly repaired, and connecting junctions between sections maintained to provide a smooth interface. Overweight heavy vehicles should not be allowed because road surface damage is mainly caused by these vehicle operation.

4. Water Resources and Aquatic Ecology

During construction, locating machinery maintenance areas and construction camps away from water bodies are an efficient means of preventing water quality deterioration caused by motorway, particularly bridge construction. In order to reduce the chance of oil spills from construction equipment and fecal contamination from construction camps, it is recommended that the supervising agency be designated

the sites for these areas and provide adequate facilities to deal with the activities.

For preventing water contamination at *the operation stage*, effectively maintaining designed dranage system results to prevent pollutants runoff from the road surface, and properly designed facilities to treat waste water discharged from rest areas are installed in this study.

5. Soil Conditions

Besides *construction stage* to prevent soil erosion, a major eathwork in concerned areas should be avoided during heavy rainy season. This might be particularly important in mountainous areas.

Among slope protection measures to prevent soil errosion, sodding and seeding are applied for all *the slope of embankments* on both outer sides and on the median side, in which planting tree is also designed in order to reduce blinding from oncoming headlights during the nighttime. Other preventive measures are applied in areas with *long and steep slope* in rolling and mountainous areas; of which slope protection with sack is designed for slopes with about 45 degrees, while leaning type retaining wall and concrete block masonry are applied for steep slopes with more than 60 degrees. All slope protection structures designed in this study are found in the relevant drawings in separate volume.

In addition to the slope preventive measures on *the cut and embankment sections*, the provision of proper drainage system is also very effective means to reduce soil loss. The drainage systems designed include berm drain (concrete ditch) designed on a gap between slopes of deep cut with 45 degrees and the bottom end of embankments in cut and embankment sections in mountainous and rolling areas, side drain (concrete ditch) designed in the outer edge of all cut sections, and side drain (non concrete ditch) on the outer sides of embankments and center drain (mortar rip-rap) in both median of embankment and cut sections in flat areas.

In some *soft ground areas* along Ban Pong - Cha Am Route, it is determined that three types of mitigation measures, embedding cement stabilizer into soft top soils, installing bearing unit piles in the areas with high embankment of bridge approch section, and gradual embankment work with monitoring soil behavior during construction, are applied. The details of these measures are presented in Section 6.4.1 and relevant drawings in separate volume.

7.4.3 Ecological Resources

6. Terrestrial Ecology

No significant impacts on terrestrial ecology are expected due to careful alignment selection. Selection of the planned motorway route greatly reduces the amount of mixed deciduous trees to be cut if the route is compared to the alternative route which was originally planned and removed based on the careful consideration on environmental-friendly route selection.

The impacts on *watershed areas* are also considered to determine the planned route; the adverse impacts on watershed areas were greatly reduced. However, minor adverse impacts caused by the form of tree cutting in mountainous area are still anticipated. If these negative impacts are apparently expected at the further study or project implementation stage, appropriate mitigation measures, e.g., replanting precise vegetation, providing passageways for wildlife, should be made.

Impacts caused by the implementation of the project would be two-fold; short-term and long-term. In the short-term, the actual impact on terrestrial ecology is derived from tree cutting and earth moving. It is recommended that a supervising agency require a contractor to dispatch an inspector who examines the changes in terrestrial ecology as construction progreses and sends reports the agency. Regarding long-term monitoring, it is recommended that the Royal Forest Department's possessing infrastructure and manpower for forest protection utilize efficiently. This will be effective means to prevent illegal logging. It is also desired that the long-term monitoring include floral and faunal changes near the motorway.

7.4.4 Human Use Values

7. Transportation Conditions

To maintain *inter-community traffic and access* between farmers and their fields, mitigation measures on constructing frontage roads along the motorway will be taken. The frontage roads are designed to connect with overbridges, which overpass the motorway, and existing minor roads, which are to be cut off by the motorway. The combination of overbridges and frontage roads provides detour routes for motor vehicles, farm-carts, and pedestrians to reach the destination safely. In locations where the motorway bisect a village, separates two proximal villages, or creates any inconvenience to farmers, access should be provided at a distance of no more than two kilometers from impacted villagers.

7.4.5 Quality of Life Values

8. Land Use Pattern

It is recommended that government-mandated land use plans be developed for these concerned areas to create appropriate zones for induced commercial and industrial development. Particular attention should made for *newly developed industrial estates*, which will be potential sources of environmental degradation, regarding air quality from excessive industrial emission and water quality from improperly-treated effluent discharges.

9. Socio-economic Conditions

Viable mitigation measures to minimize *negative induced socio-economic impacts* include the control on changes in land use, particularly near interchanges and the secondary roads serving them. In order to prevent unfavorable land value hike, new commercial and industrial development in likely affected areas must be strictly controlled. Therefore, it is recommended that relevant agencies prepare appropriate land

use planning, in line with motorway management program.

Realignment, bypassing the affected areas as much as possible, would be the first measure to be considered to alleviate land expropriation impact, related to *human relocation problem*. If this measure is not viable, appropriate compensation measures should be taken place; the measures should include provision of sufficient fund or substitution housing in proper locations to keep at least same level of living standards for relocated inhabitants. Resettlement plans should be prepared in order to ready at the time of appraisal; the plan have to be the operating-size specific.

It is also recommended that a *public hearing* be held at proper timing. The hearing is desired to be organized by relevant agencies and to be based on integrity and goodwill. The purpose of the hearing is to solve conflicts between an executing agency and inhabitants. Hence, the hearing has to provide a whole picture of the project, both pros and cons, with inhabitants, and the agency acquires better understand of inhabitants' concern. A successful public hearing is considered important step for smooth implementation of the project.

10. Cultural/Aesthetics/Archaeological Values

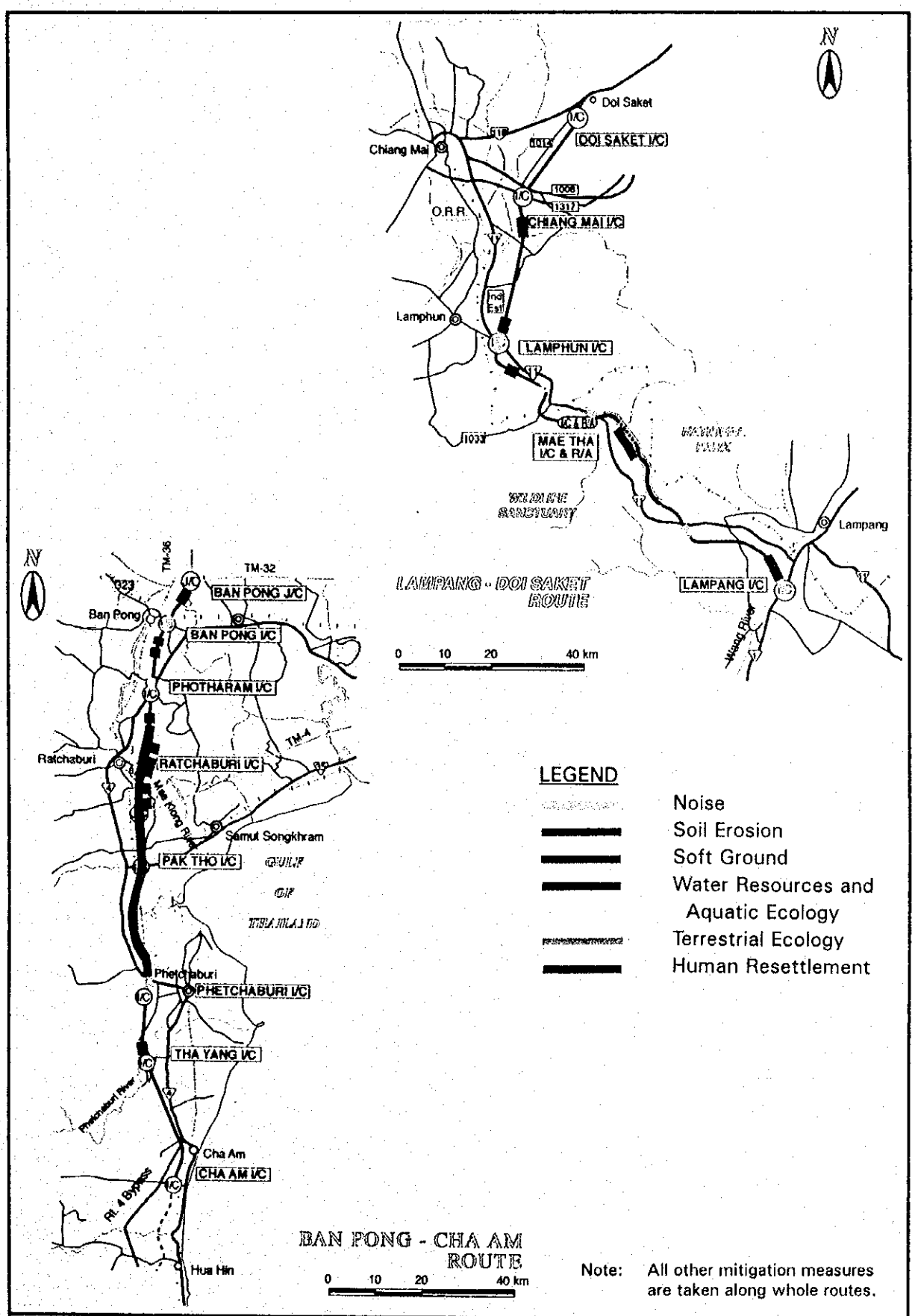
To mitigate visual impairment on *temples nearby*, tree planting to create natural buffer between temples and the motorway is recommended. The planted trees are desired to be indigenous species with fast growing nature; evergreens are preferable.

Since the impact at *the bridge construction area* would be caused by a combination of obstruction of the natural scenic view of the river and the unattractive image of the bridge itself. Mitigation measures for the bridge focus on improving its attractiveness. It is generally recognized that there is a limit to the degree the size of the bridge can be reduced to mitigate its obstructiveness without reducing the carrying capacity or structual integrity. Therefore, it is recommended that the design of bridge make use of surface detailing, color and other artistic efforts to enhance the appearance of the structure.

In order to mitigate large land development impacts on *natural harmony in mountainous areas*, appropriate mitigation measures, i.e., applying wing wall and outstanding type portals and nature-oriented slope protection, are planned in this study. These tunnel portal type and proper slope protection methods, i.e., sodding seeding, are considered to fit the natural environment, providing comfortable driving atmosphere for drivers. These measures are presented in Chater 6, Preliminary Design and relevant drawings in separate volume.

TABLE 7.4-1 ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

Environmental Parameters Affected by the Project Implementation	Areas to be Affected	Impacts on the Environment	Feasible Mitigation Measures
1. Air Pollution	1. Populated areas, particularly near temples, schools and hospitals.	1. Nuisance and health hazards to neighbors, travelers and wildlife.	1. Sprinkling water/chemicals during construction; control of motor vehicle emissions during operation.
2. Noise and Vibration	2. Populated areas, particularly near temples, schools and hospitals.	2. Nuisances to neighbors, travelers and wildlife.	2. Installing noise barriers; using low noise and vibration construction equipment; and selecting proper time for construction.
3. Water Quality	3. Near planned rest areas.	3. Water contamination caused by discharge from restaurants and rest rooms in rest areas.	3. Installing waste water treatment facilities.
4. Soil Erosion and Siltation	4. Mountainous areas with steep slope, in which high cut is required.	4. Negative impacts on terrestrial ecology and impairment of downstream water quality caused by top soil runoff.	4. Careful resurfacing or replanting of exposed areas; the provision of slope protection frame with sack, leaning type retaining wall, concrete block masonry, and sodding.
5. Ground Subsidence	5. Wide area along the motorway on Bang Pong-Cha Am route.	5. Sinking of ground level.	5. Providing cement stabilization, bearing units, and gradual embankment work.
6. Terrestrial Ecology	6. Forested mountainous areas.	6. Alteration of wildlife habitats and loss of biodiversity from tree cutting.	6. Replanting precious vegetation; providing passageways for wildlife.
7. Aquatic Ecology	7. Planned bridge construction areas.	7. Water pollution and river bed condition changes caused by earthworks, fecal contamination and machine operation (oil and grease spills) related to new bridge construction.	7. Setting up machinery maintenance areas and construction camps away from the river; providing measures to prevent river bank erosion.
8. Split of Community	8. Near major cities and some villages.	8. Inconvenience of transport.	8. Constructing frontage roads and overbridges along the motorway with appropriate intervals.
9. Historical/Cultural Properties	9. Near temples and other cultural properties.	9. Loss of cultural properties and increased possibility of these properties being stolen.	9. Rerouting; relocation of properties, if applicable.
10. Human Resettlement and Land Use Changes	10. Populated areas, particularly near major cities.	10. Relocation of roadside residents.	10. Rerouting; adequate compensation affected inhabitants.



FEASIBILITY STUDY ON THE INTER-CITY TOLL MOTORWAY PROJECTS	FIGURE 7.4-1 ENVIRONMENTAL MITIGATION MAPS

7.5 OVERALL ENVIRONMENTAL INPACT EVALUATION

Existing conditions and predicted impacts on major environmental parameters are studied in depth, assessment of these impacts are made, and feasible mitigation measures and recommendations, as well as monitoring programs, are proposed.

It is studied from the entire analysis that the magnitude of adverse impact on the environment is mixed. Some environmental parameters will be severely affected, while others have minor impacts. For example, some areas on motorway routes need to be expropriated, causing severe human relocation problems, while impact on air quality has been found minimal. All the environmental parameters will be adversely affected in some degree by the project implementation. However, these negative impacts can be mitigated by the provision of appropriate counter measures. Unfortunately, it is an unavoidable fact that a total area of 75 hectares, 48 hectares of teak plantation and 26 hectares of natural forest, need to be cut down, although the density of the forests is not very high and total economic loss of these tree cutting is evaluated relatively low, about Baht 34.1 million. This is only environmental parameter which mitigation measures can not relieve the vanishing resources. Alteration of wildlife habitats caused by tree cutting is also anticipated; however, thanks to surronding huge protected areas, it is considered that wildlife could easily find shelters or alternative habitats in the surronding areas. Adverse impacts on any other environmental parameters can most likely be mitigated by the proposed counter measures and monitoring programs, and no serious environmental problems are expected in the future.

Consequently, overall environmental impact caused by the motorway project is evaluated to be minimal only if all the proposed mitigation measures and monitoring programs are properly implemented.

Apart from negative impact on the environment, on balance, it is expected that the motorway will actually enhance economic development through the provision of smooth and time-saving transport systems. Economic evaluation of the project is studied in Chapter 10 in this report, concluding that the motorway project is economically viable. The economic viability and overall environmental impact discussed above will promise vital outcome from the project implementation.
As a final remark, it is proposed that mitigation measures during construction be clearly stated in construction contract and qualified environmental inspectors be hired to oversee implementation of the mitigation measures during construction. Reports on the mitigation measures should be prepared by inspectors and submitted to relevant agencies regularly.

CHAPTER 8

STUDY ON OPERATION AND MAINTENANCE SYSTEM

CHAPTER 8

STUDY ON OPERATION AND MAINTENANCE SYSTEM

One of the most important factors for success of any of the project development lies in the effectiveness, productivity and efficiency of the executing body and its management systems. This chapter discusses the organization status and structure of the executing body of the motorway development and operations, together with reviews on source of funds, toll collection system, maintenance system, traffic control plan, and safety measures.

8.1 Management System

8.1.1 Executing Body

In general, the executing body of the proposed motorway system should have two major functions, one for effective management at time of construction and the other for operational efficiency at time of motorway operations.

Through reviews and discussions on the practical solution on the executing body for implementation of the motorway system, the study recommend that the construction and operations of some of the routes and sections of the system shall be executed by the Department of Highways (DOH), Ministry of Transport and Communications (MOTC), until such time as a new State Enterprise (tentatively named as the Inter-City Motorway Authority (ICMA)) is created with endorsement of establishment law being effected and is ready for taking over the complete functions of the motorways already constructed and being operated. There are following reasons why the DOH should be the executing agency of the motorway system:

1. The DOH is a government agency responsible for development, improvement and maintenance of most of the major highways throughout the Kingdom, and now constructing some portions of the motorway network. In other words, motorway construction, operation and maintenance are the jurisdiction of the DOH.

2. The DOH has been engaged in planning of the motorway network system through master plan study of whole network and feasibility study of the two routes of Lampang-Doi Saket and Ban Pong-Cha Am. Therefore, the DOH is well versed in the engineering and economic aspects of the motorway system.

3. Implementation of the motorway network system is needed immediately to cater for the rapidly increasing traffic demand, which will contribute to the development of the national economic activities, and it will take a considerable time to establish a state enterprise capable of effective management of the construction and operations of the motorways.

4. The DOH has abundant experience and expertise in management of the construction and maintenance of high-standard of highways with high level of service,

which can be applied and utilized to the proposed motorways.

5. The DOH has 8 construction offices under Chief Engineer and 85 district offices through supervision by Highway Division Offices which are under control of the Deputy Director for Maintenance. These local offices are spread out and located in most of the major cities in the country. Their main functions are either to construct or maintain the highways, and they can be ready for utilization to the motorway construction and maintenance until offices will be made for exclusive use for motorway construction and maintenance.

6. The initial stage of motorway development can be realized without delay, extra financial burden by the government for establishment of new organization with recruitment of personnel, equipment and extra fund, which is a great advantage for the government in saving of money, personnel and property, in terms of national economy.

8.1.2 Execution by the DOH

1. Motorway Organizing Committee

For implementation of the motorway network system, it is urgently required to establish a motorway organizing committee with the secretariat office at the DOH, which proposes recommendations to the central transport-related committees and other related agencies in connection with the policies and management of the inter-city toll motorways, and all concerned measures and preparatory procedures including coordination with the central government agencies and state enterprises which are relating or affecting the establishment and management of the motorways executing body. The Committee is to deal with the following issues:

- Development Policy and Strategy
  Formulation of policy and strategy for effective development and efficient operations of the motorways.

- Legal Issues
  Study and research on laws and regulations pertaining to toll motorways and establishment of a state enterprise.

- Economic Issues
  Study and research on financial resources and economics regarding toll motorways, including transport economics and toll rates.

- Engineering Issues
  Study and research on various engineering technologies such as civil, electric, electronic, mechanical, traffic and other fields, including materials.

2. Office of Toll Motorways

For actual implementation of the motorway network system, the existing Office of Toll Highway of the DOH shall be immediately restructured to cope with the re-

quired roles and functions. Major roles and functions needed for are somewhat similar to those of the DOH, and it is necessary to set up clear-cut definition of the missions and requirements of the toll motorways to avoid duplication and confusion. The organizational functions of the Office of Toll Motorways within the DOH are described below and its proposed organization is shown in Figure 8.1-1. Also, Figure 8.1-2 shows the functional relations of the Office of Motorways and other divisions within the DOH.

1) Head Office Function and Organization

The function and organizational structure of the head office of the Office of Toll Motorway is given below.

- Director of the Office of Toll Motorways
  The status of the director of this office shall be promoted to be the Deputy Director General, who will be responsible for administration and management of all the matters of this office.

- Legal Council
  As a staff function of the office, it is staffed with a few officials dealing with all the legal matters concerning the motorways.

- Auditing
  This staff function can be performed by the existing Office of Internal Audit to deal with all the auditing function of the Office of Toll Motorways

- ROW Acquisition
  This function shall have a division status dealing with ROW planning and drawing, actual activities for acquisition, squatter relocation and relocation sites, etc.

- Motorway Plannings
  This function covers all planning activities such as conceptual planning with conceptual design, feasibility study, detailed engineering, traffic engineering, environmental assessment, etc. This function shall have a division status.

- Motorway Construction
  This function deals with all the matters and procedures relating to motorway construction works which ranges from bidding for motorway construction, con tracting, construction supervision and certification, etc. This function shall have a division status and the local offices may be shared with either existing Offices of Highway Division or District Offices.

- Motorway Operations
  Motorway operations ranges from toll collection, toll accounting, motorway maintenance, traffic control and management, traffic safety and related facility management like rest areas, bus stop bays and various properties belonging to the motorways. This function shall have a division status.

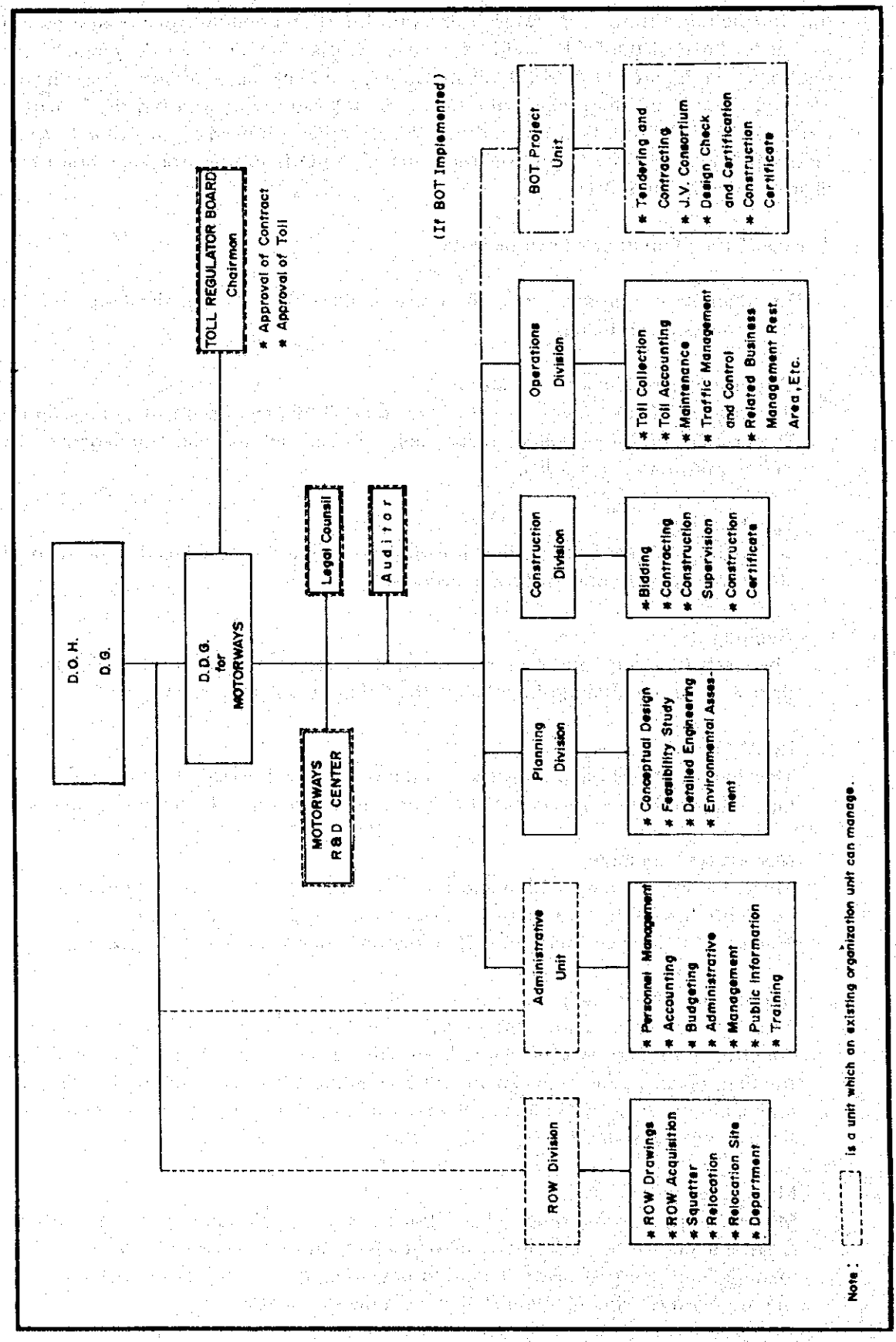


FIGURE 8.1-1 ORGANIZATION OF OFFICE OF TOLL MOTORWAYS

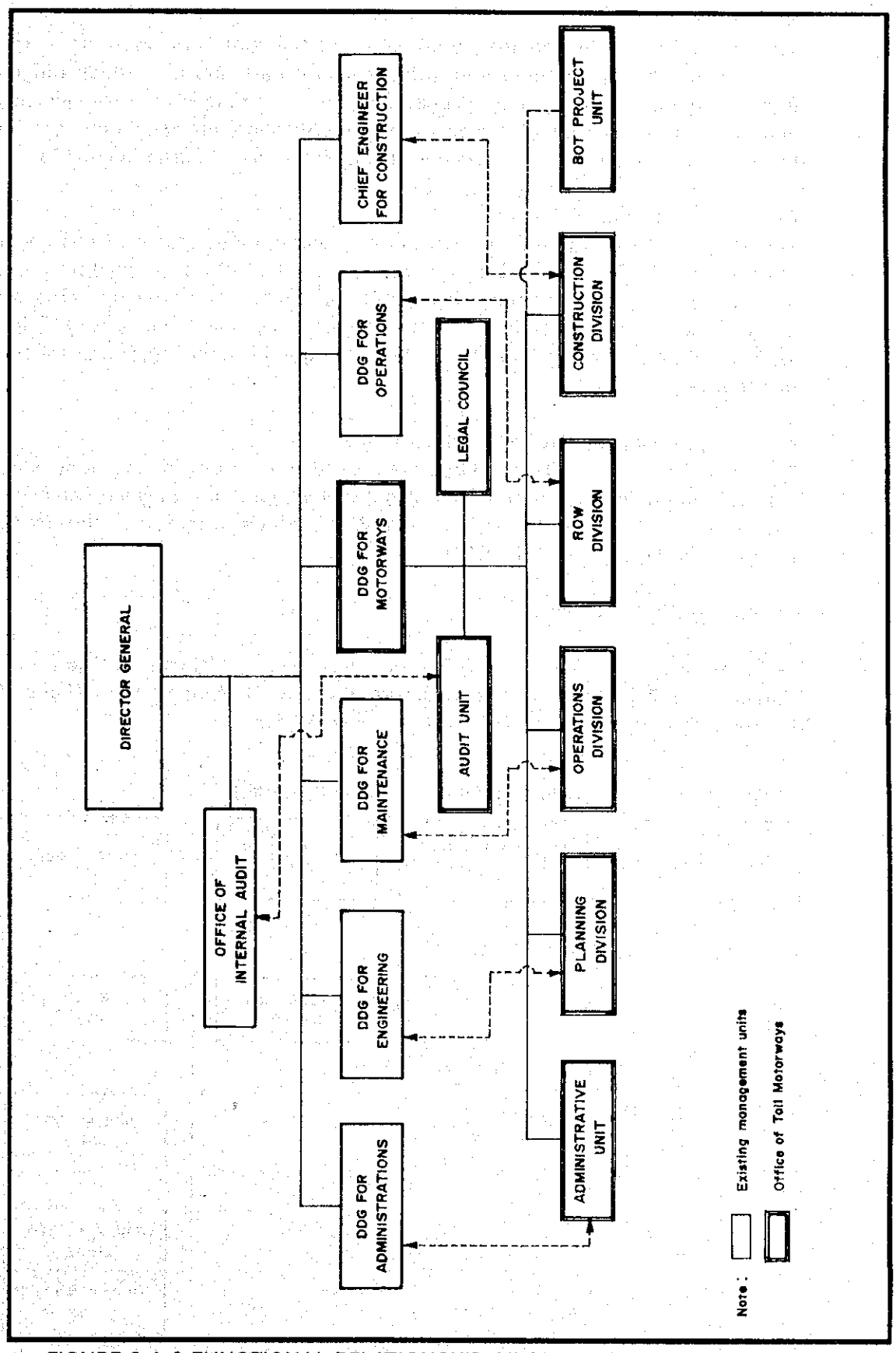


FIGURE 8.1-2 FUNCTIONAL RELATIONSHIP OF OFFICE OF TOLL MOTORWAYS

- BOT Project
  This function may be required when some of the routes or sections of the motorways are implemented with private sector participation, which ranges from tendering and contracting, concession and rate arrangement management, design check and certification, construction certification, etc. This function can be shared with the office of legal council and motorway construction division.

- Administrative General Affairs
  This staff function can be dealt with those executed by various divisions under supervision of the Deputy Director for Administration, such as personnel management, accounting, budgeting, public information and relations, procurement, training and secretariat. However, there should be a separate section with small unit of personnel exclusively engaged in these functions for the motorways.

- Motorways Research and Development Center
  This R & D Center shall be newly established to conduct all the necessary research and development activities of the motorways with qualified personnel assigned to the center. The results of R & D shall be reflected to the active training of all the staffs of the DOH.

2) Division and District Offices

The hierarchical structure of the Office of Toll Motorways (shown in Figure 8.1-3) shall be similar to the existing structure of the DOH, namely, the Offices of Motorway Divisions and the District Motorway Offices.

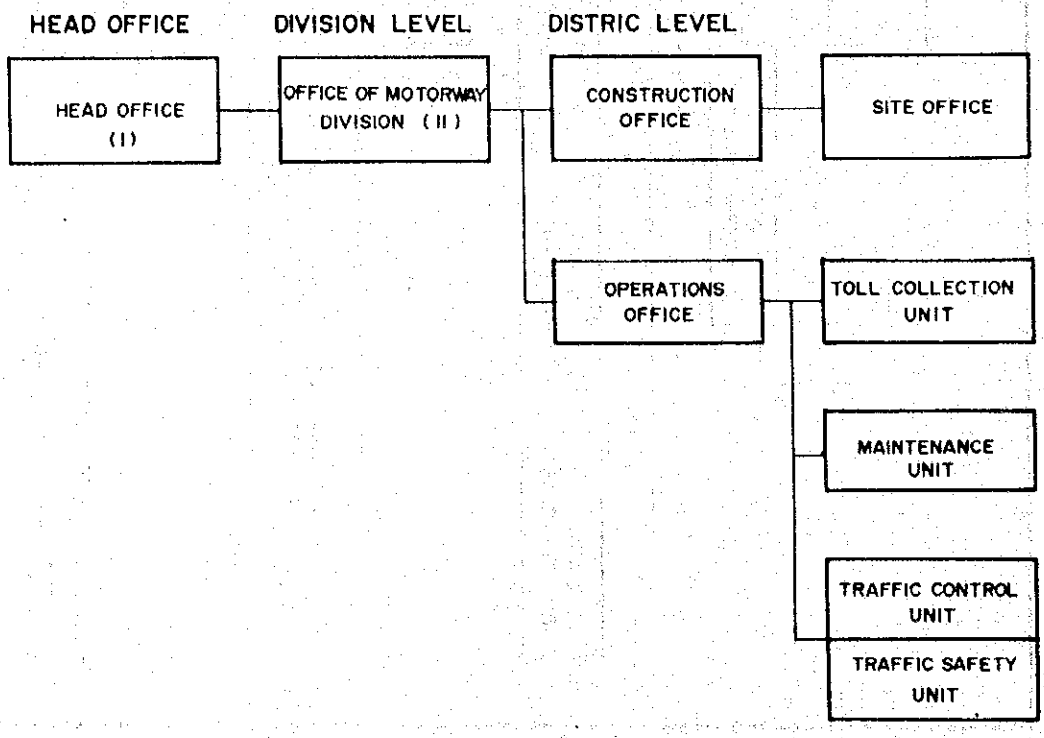


FIGURE 8.1-3 HIERARCHICAL STRUCTURE OF OFFICE OF TOLL MOTORWAYS

There would be 11 Offices of Motorways Division, which are to be strategically located in Chiang Mai, Phitsanulok, Khon Kaen, Surin, Chon Buri, Saraburi, Bangkok, Ratchaburi, Petchaburi, Surat Thani and Songkhla, and the details of coverage length of the motorway network are given in section 8.4.2 of this report.

The Offices of Motorway Division and the Motorway District Offices shall have five major functions required for the development and operations; the first is for construction, the second for maintenance operations, the third for toll collection operations, the fourth for traffic management and control operations and the fifth for traffic safety operations. However, at the initial stage of motorways implementation, functions for construction are expected to be activated. Operational functions are to be required after certain routes or sections of the motorways are opened to traffic, but the preparatory works are to begin since establishment of the Office of Toll Motorways.

The toll collection offices having required number of booths located at the toll plazas are under the supervision of the Motorway District Offices in the specified routes with span of control given by the Office of Motorway Division which is responsible for operations of 250 km. to 600 km. of the motorways.

With regard to the detailed operations relating to maintenance, traffic control and traffic safety, together with measures and plans to be drawn up for respective operations are described and presented in Sections 8.4 for maintenance, 8.5 for traffic control and section 8.6 for traffic safety.

8.1.3 Execution by a State Enterprise

1. Status of Public Corporation

When the Motorway Organizing Committee formulated all the necessary plans and finalized the procedures required for establishment of a state enterprise, a tentatively named Inter-City Motorway Authority (ICMA) is to be created with the approval of the Cabinet and endorsement of a ICMA establishment law. This ICMA is to be under supervision of the MOTC with specific objectives of financing, constructing and operating of the inter-city toll motorway network system of about 4,350 km. The ICMA is also expected to be guided by concerned ministries and agencies like DOH, NESDB, Ministry of Finance, etc.

Because of the reason that the ICMA is a government-owned company, equity in vestment and loans required for the development and operations of the motorway network system can be expected from the central and local governments, local financial companies and international lending institutions.

The ICMA may implement sections of the motorway system in the form of joint venture or joint operation with private investors with the agreements in principle similar to "Build, Operate, Transfer (BOT)" or "Build, Transfer" scheme, which is discussed in Section 8.2.

2. Functions and Organization

1) Functions

The ICMA shall conduct the following business affairs in order to attain the objectives to develop and improve the motorway network system in the Kingdom.

- Construction, reconstruction, maintenance, repair, and other form of administration of the motorways for passage or use of which tolls may be collected.

- Execution of disaster rehabilitation works on the motorways.

- Construction and management of the rest areas and parking-places for use of which tolls may be collected.

- Construction and management of such rest-houses, gasoline service stations and other facilities necessary for securing smooth traffic on the motorways as may be prescribed by cabinet order.

- Conduct business affairs incidental to those specified in the preceding four items.

The head office of the ICMA shall be in charge of formulating basic plans, policies for execution, standards and so forth, raising funds, auditing works, and the others. They can be interpreted as "making synthetically" and effectively construction, reconstruction, maintenance, repair and other management of the motorways for which tolls may be collected with passing or use thereof, and of other similar projects promoting the motorway improvement and of contributing to the smooth transportation.

The capital of the ICMA shall be the amount which is deemed to have been invested by the Government in accordance with the laws and regulations set forth thereof. It may, if necessary, increase its capital by obtaining approval of the Minister of MOTC, in which the government may invest within the limits of the amount as may be fixed in the budget.

2) Responsibilities of Officers

The ICMA shall have, as its officers, one president, two vice-president, not more than 10 directors and not more than two auditors. The president shall represent the ICMA and presides over the business thereof. The vice-presidents shall, under the rules laid down by the president, represent the ICMA, assist the president in his management of the business of the ICMA, discharge the duties of the president in his place in case he is prevented from attending to this duties, and, in case the presidency is vacant, discharge the duties of the president.

The directors shall, under the rule laid down by the president, represent the ICMA, assist the president and the vice-presidents in their management of the business of the ICMA, discharge the duties of the president and of the vice-president in

their place in case they are prevented from attending to their duties, and, in case the presidency and the vice-presidency are vacant, discharge the duties of the president and the vice-presidents.

The auditors shall inspect the business of the ICMA.

With regard to the responsibilities of officers at middle and lower management levels, they are similar to those of the DOH and other state enterprises, but shall have an important duties to earn profits out of the motorway operations through operational activities at the fields.

3) Business Management

The ICMA shall, at the commencement of its business, prepare the specifications of business management and obtain approval of the Minister of MOTC. The same shall apply when it intends to alter the specifications. The matters to be stated in the specifications of business management shall be fixed by the applicable laws and regulations.

The ICMA shall, for each business year, prepare its budget, business plan and fi nance plan and obtain the approval of the Minister of MOTC prior to the commencement of the business year concerned. The same shall apply when it intends to alter these. It shall also complete the settlement of accounts of every business year.

In case there is any profit accruing from operation in any business year, it shall make up the loss carried over from the previous business year with such profit, and appropriate the surplus, if any, for reserves. In case there is any loss caused in operation in any business year, it shall settle the loss by reducing the amount of the reserve, and if there is any deficit still unsettled, by making it transferred deficiency.

There are other matters to determine for the management of the ICMA's business, such as loan and road bonds, government suretyship, redemption plan, subsidy, standards of payment of salaries and retirement allowances, in addition to the standards and specifications pertaining to engineering aspects. These are to be studies and determined by the Motorway Preparatory Committee.

4) Proposed Organization

Figure 8.1-4 shows the general and detailed organization structures of the head office of proposed state enterprise, the ICMA.

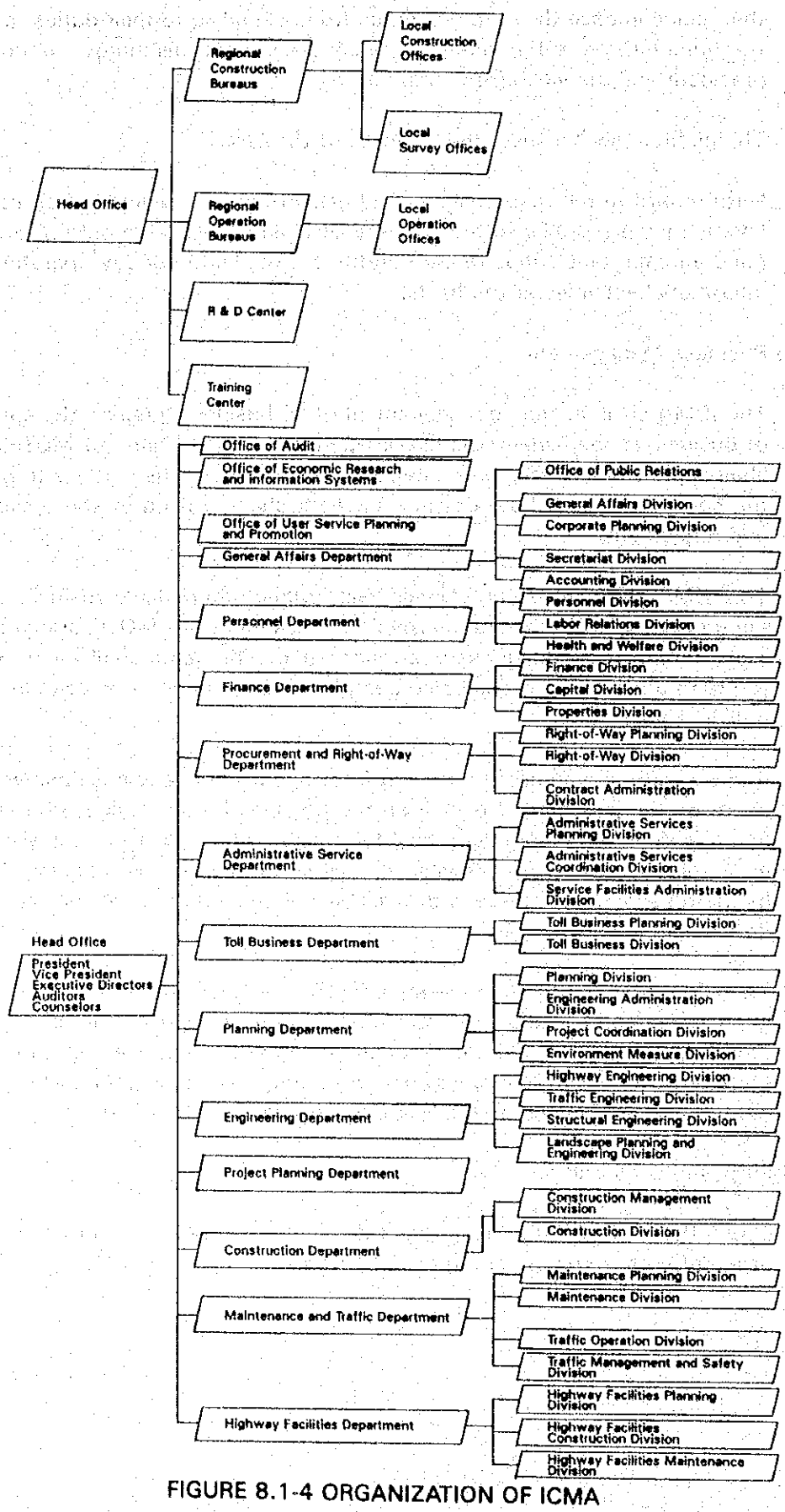


FIGURE 8.1-4 ORGANIZATION OF ICMA

8.1.4 Organization for Two Routes

The organization structure for implementation of the two routes of Lampang-Doi Saket and Ban Pong-Cha Am for which the feasibility study is being carried out, as discussed in the preceding section 8.1.2, the DOH is recommended to take the following measures, because it is responsible for actual implementation of the two routes.

At the initial stage two divisional construction offices are to be established in Chiang Mai for Lampang-Doi Saket Route and Petchaburi for Ban Pong-Cha Am Route with several field construction offices to be made depending on the number of motorway sections to be divided for construction purposes.

As to Lampang-Doi Saket Route, a divisional construction office is to be placed at Chiang Mai with field construction offices at Lampang, Hang Chat, Mae Tha, Lamphun and Doi Saket to coordinate with the divisional office.

For Ban Pong-Cha Am Route, a divisional construction office is to be established in Petchaburi with field construction offices at Ban Pong, Ratchaburi, Pak Tho and Cha Am to cover up the divisional office.

It is to be noted that construction of the tunnels with about 3.82 km. length between Hang Chat and Mae Tha, and 0.74 km. length between Mae Tha and Lamphun is the first attempt in Thailand for road tunnel construction and requires specific planning and construction technologies, for which enough preparation, staffing with qualified personnel and various equipment are to be provided for.

8.2 FUNDS FOR CONSTRUCTION AND OPERATIONS

8.2.1 Resources of Funds

The financial resources required for implementation of the motorway project can be categorized as government capital investment fund, subsidies, borrowed fund and proceeds of bond issuance. After certain routes or sections of the motorways are open to traffic, operating revenues can be expected which will increase in proportion to the operational length of and traffic volumes of the motorways.

1. Public Investment (Government Fund Financing)

Generally, the source of funds of the government in the category of public sector investment programs, in particular for development and improvement of infrastructure facilities is either financed mainly by the general taxes or by specified taxes like gasoline and automobile taxes. However, in recent years in the light of magnitude of the scale and diversity of social infrastructure facilities requiring huge amount of budget in each field, funds for public investment which yield operational revenues tend to be appropriated by special account of the national budgeting system either in the form of direct investment or subsidy to the government-owned state enterprises with their sources from specified taxes, proceeds of bond issuances and borrowings from various financial institutions, due to aforesaid financial constraints.

1) Funds by Earmarked Tax Revenues

The funds by earmarked tax revenues are based on the beneficiaries pay principle. In case of the motorway development project, specific taxes such as gasoline tax, oil tax, vehicle acquisition and ownership taxes, etc. shall be introduced in Thailand and levied to the road users in the similar systems as adopted in many countries like Japan, Germany, France, Korea, etc. It would be high time to commence planning for restructuring of the taxation system including introduction of the specific taxes applicable to the motorway and other infrastructure facilities development in this country.

2) Funds Borrowed from International Institutions

It is a general tendency that the financing of fixed social capital formation or public infrastructure facilities such as the motorways, sea ports and airports, etc. is becoming increasingly hard in most of the countries, even in the advanced industrial countries. The major cause of difficulty results from the increasing demand on the government for higher and greater social and public capital formation in limited financial resources.

In this connection, it would be inevitable for the implementing government agency to raise the funds for the proposed motorway project implementation by means of loans from such international financial institutions as the Overseas Economic Cooperation Fund of Japan (OECF), World Bank, Asian Development Bank (ADB), etc. Although this arrangement will induces increase of debt service ratio of the Government of Thailand, from the national economic viewpoint, it

would be advantageous because the borrowings from these institutions are in general soft loan being the official development aids to the developing countries with low interest rates and long repayment period including grace period.

Taking above discussions into consideration, it is expected that the implementation of the motorway project would proceed in accordance with the financial arrangements with these institutions. By this arrangement, direct constraint on raising financial resources can be eased, and at the same time realization of the social and economic requirements for the motorways as the public infrastructure can be pursued.

2. Government Subsidy

As in the case of many of the State Enterprises in the Kingdom, the government subsidy financing will be applicable to a government-owned public corporation to be newly established with the specific objectives of planning, financing, construction, operation and management of the proposed motorway network system. In this case, soft loans as the official development assistance (ODA) can be expected from international financial institutions, apart from the sources from general taxes. These loans from multilateral or bilateral resources may be converted into a corporate equity. When the state enterprise for this purpose is once established, in addition to ODA financing, investments from private sectors, foreign and domestic, may be expected in the form of equity and debts.

As proposed in the preceding section, establishment of a state enterprise tentatively called ICMA to be supervised by the DOH may encourage private sector participation in the forms of capital investment, purchase of motorway development bonds, BOT of certain routes or sections of the motorways, etc.

As the examples of this system, the Japan Highway Public Corporation (JHPC) and Indonesia Highway Corporation (P. T. Jasa Marga) and Expressway and Rapid Transit Authority of Thailand (ETA) are described in Appendix 8.2-1.

3. Private Financing

The huge and acute demands for development and improvement of the transport facilities are causing the government into increasing difficult position to construct and maintain road systems, especially those facilities like motorways which require quite a large amount of investment, because traditional public financing resources are insufficient to meet these demands. As one of the measures to solve the problems, funding from private sector through road pricing shall be carefully considered.

In the case of transport infrastructure development projects, a whole package of financial arrangements can be available, ranging from the financing of all the investment costs by the government to the funds entirely financed by the private sector. The principal development guidelines for economic growth set forth in the 7th National Economic and Social Development Plan emphasize that the investment in infrastructure services be expedited to ensure adequacy of supply at high quality with active involvement and increase of the role of private sector in investment and

management with clear criteria and operational procedures. In drawing up a financial package classification, the distribution of construction and operation costs as well as the contractual relationship between public and private sectors in development of the motorways shall be carefully taken into account.

There are four major types of financial packages for the private sector participation in the development of infrastructure facilities as described below.

1) Type 1 Involvement of Private Resources with Government Responsibility
Various types of private resources are to be involved in for financing the infrastructure facility development project, but construction, operation and risk guarantees are responsibility of the government.

2) Type 2 Private Finance with Government Involvement
The investment required for the infrastructure facility development project is financed with the private capital. Construction of the facility is to be executed by the private bodies, but in view of the nature of the facility to be of public service, the government may be fully or partly responsible for operation and management.

3) Type 3 Private Finance with Government Guarantee
Financing, construction, operation and management of the infrastructure facility shall be the responsibility of the private bodies. Guarantees may be provided by the government.

4) Type 4 All-Private Involvement
Financing, construction, operation including maintenance and management of the infrastructure facility and services shall be exclusively executed by the private sector. This type of solution is feasible under the conditions that the private investment project can earn enough profit and at the same time public service requirements are complied and warranted.

The typical practice where private sector is presently being participated in highway development projects is so-called "Build, Operate, Transfer (BOT)" scheme, which may fall into Type 3 or 4 depending on guarantees to be provided by the government. So-called "Build, Transfer (BT)" scheme may be categorized as Type 2 and Type 1 but has not yet been practiced so far.

8.2.2 Financing Implementation

1. Implementation by Government

For financing of the proposed motorways project the Government of Thailand may request the long-term soft loans as the official development aids from international financial institutions, in case the Government will implement the project. One of the probable sources may be Overseas Economic Cooperation Funds of Japan (OECF).

The procurement conditions of an OECF loan are to be determined by the Japanese

Government on a case by case basis. In recent years, the procurement conditions have been untied. "General Untied" means that the countries eligible for procurement under the loan are any developing country and any DAC member country. OECF is introducing its "Fixed-Percentage Financing Criteria", under which OECF can provide loans covering part of the local currency portion. The criteria to determine the upper limit for the amount of an OECF loan is by multiplying the total project cost by a certain percentage that will be determined depending on the per capita GNP of the borrower's country.

2. Implementation by State Enterprise

Because of the reason that state enterprise is a government-owned company, equity investment and loans required for motorway development projects can be expected from the central and local governments, local banking companies and foreign lending institutions. One of the possible sources as foreign lending institutions may be OECF.

One of the OECF's principal operations is to provide equity investment in corporations engaged in development projects in developing countries, apart from loans to government or government agencies discussed in the preceding paragraph. OECF considers projects in the following categories suitable for such equity investment.

- Project is expected to facilitate economic development in the country through foreign exchange earnings or savings, contributing to employment creation, promoting rural development, etc.

- Project is requested or expected to be implemented by the government or a government agency of the developing country concerned.

- Project is scheduled to be participated in by international organizations, such as IFC, ADB, etc. or a governmental financial institution(s) of an advanced country(ies).

- Equity investments are limited to a Japanese investment corporation, especially established for the project or in a local corporation with a business relationship with a Japanese corporation. Amount of equity investment, to be decided on a case by case basis, may not exceed 50 % of Japanese corporation's investment or 25 % of total investment.

A typical example of investment scheme where OECF makes equity investment is shown in Figure 8.2-1.

Equity investment can be, therefore, expected from the central and local governments, international lending institutions, foreign and local private sectors. Equity necessary for the motorway projects may be roughly estimated to be 20 % of the project cost. Even under this scheme, the Right-of-Way (R.O.W) acquisition shall be done by the government utilizing the government fund. The engineering service and civil work costs shall be shouldered by the state enterprise utilizing soft loans extended from international lending institutions.

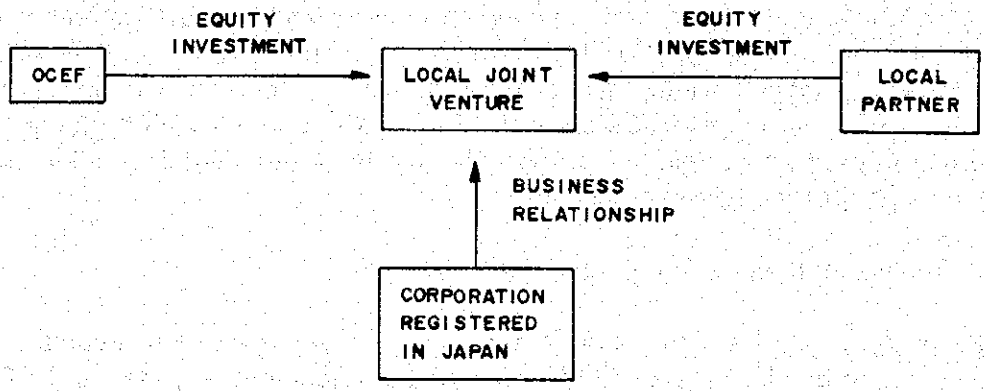


FIGURE 8.2-1 TYPICAL EXAMPLE OF OECF EQUITY INVESTMENT

3. Financial Implementation for Two Routes

Regarding the two routes of the proposed motorway system, they are recommended to be implemented by the DOH, which leads to indicates project implementation by utilization of the loans from international financial institutions. Detail discussion on financial implementation for proposed two routes is made in Chapter 10.