

6. SPOIL UTILISATION

6 SPOIL UTILISATION

This section presents supporting information on the following topics:

- Current Land Use;
- Community Consultation (agenda and meetings);
- Spoil Data (excavation rates, stratigraphy and igneous rocks, spoil volumes);
- Construction Aggregate Demand;
- Transport Rates;
- Quarry Areas;
- Stone Crushing Plant; and
- Spoil Use Plan Data.

6.1 Current Land Use

Table 6.1. Present Land Use of the Proposed Spoil Heap Areas (Source: Tesco Co. Ltd., 1998).

Spoil source	Spoil heap location	Present land use of the proposed area and the suitable area for quarried rock storage
Kok-Ing Tunnel No.1 entrance		<p>The entrance of the BJT-1 tunnel is located at the West of Doi Ong in zone E forest (map sheet 4948I, location 601500, 2198000). The height of elevation is about 400-420 m. SL. The topography is hill slope of Doi Ong. The area is used for growing fruit trees and upland crops such as corn, soil bean etc. The plain adjacent to the West in used for growing rice and vegetables.</p> <p>The suitable area for quarried rock storage is nearby the tunnel entrance in zone E forest at the foot hill slope which is deteriorated forest area.</p>
Kok-Ing Tunnel No.1 exit		<p>The exit of the BJT-1 tunnel is located at the East of Doi Ong in zone C forest (map sheet 4948I, location 604300, 2196700). The topography is Undulating slope area. The height of elevation is approximately 420-440 M. MSL. The zone C forest of this area has been destroyed and planted high land crops.</p> <p>The suitable area for quarried rock storage can be selected from deteriorated forest land of the zone C forest or unsuitable for planting crop area in zone A forest about 1.5 km. from the exit in the south direction.</p>
Kok-Ing Tunnel No.2 entrance		<p>The entrance of the BJT-2 tunnel is located behind Dong Sila Withayakhom school nearby a small hill (map sheet 5048IV, location 609200, 2194400).</p> <p>The flat plain area around the entrance is used for paddy while the hill and mountain are forest land.</p> <p>The suitable area for quarried rock storage is the area in zone E forest next to zone C forest back ward from the entrance about 800 m.</p>
Kok-Ing Tunnel No.2 exit		<p>The exit of the BJT-2 tunnel is located in zone A forest which has been transferred to agricultural land reform (map sheet 5048IV, location 614300, 2189400). The topography of the area is foot slope of the mountain and the height of elevation is about 400 m. MSL. Present land use is orchard and high land crop.</p> <p>The suitable area for quarried rock storage is the area in zone A forest nearby the tunnel exit. To avoid high compensation, the storage site should be selected from the area for growing crops rather than fruit-trees.</p>
Ing-Yot Tunnel entrance	5048II; 636400, 2174300	<p>The proposed spoil heap location is 60% out of the Pa Doi Ta and Pa Doi Bo Som national reserved forest and 40% in zone C forest. The topography of the area is a small flat plain valley. The height of elevation is about 400 m. MSL. The present land use is for paddy in flood plain area and fruit-tree in higher area.</p> <p>Due to the proposed spoil heap area is in the valley which is used for paddy and fruit-tree plantation, it is suggested that the heap area should be transferred to the East of the proposed area which is less used for agriculture and the forest has been destroyed or to zone E forest about 2 km. To the North-East of the entrance to avoid using of zone C forest and private land.</p>

Spoil source	Spoil heap location	Present land use of the proposed area and the suitable area for quarried rock storage
Adit No.1	5048II; 639700, 2174400	The proposed heap area is located in the zone E and zone A forest of the Pa Doi Ta and Pa Doi Bo Som national reserved forest. The zone A forest has been transferred to agricultural land reform area. The topography of the area is undulating terrace. The height of elevation is about 480 m. MSL. Land use types are deteriorated forest and agricultural land for crops and fruit-trees. The proposed dumping area is suitable.
Adit No.2	5048II; 646000, 2173200	The proposed heap area is located in the zone E forest near Phu Sang National Park to the East of Phra That Phu Sang. The topography of the area is undulating terrace. The height of elevation is about 460 m. MSL. Land use types are deteriorated forest and agricultural land for crops and fruit-trees. The proposed storage site is suitable, however, the Adit No.2 and its spoil heap area is very near to Phra That Phu Sang any operation should be done carefully.
Adit No.3	5048II; 648000, 2169800	The proposed heap area is located in zone E forest to the East of Ban Hua Na. The topography is foot slope of mountainous range of the Phu Sang National Park. Elevation is about 460-480 m. MSL. Present land uses are orchard and crop land. The proposed dumping area is suitable.
Adit No.4	5048II; 650500, 2160700	The proposed spoil heap area is located in zone C forest and surrounding by the Phu Sang National Park and Class 1A and 1B watershed area. The topography of the area is a valley in very steep slope mountain with a large stream. Present land uses are high land crops and upland rice cultivation. Generally, the proposed muck storage site is unsuitable because severe impacts might be occurred from erosion and muck transportation. It is suggested that the Adit No.4 should be transferred to open in zone E forest at location 646800, 2161500 and the quarried rock storage site can be selected from the area nearby.
Adit No.5	5047I; 654500, 2156500	The proposed spoil heap area is located in zone C forest of the Pa Nam Pui Pa Nam Yuan and Pa Nam Lao national reserved forest near the Phu Sang National Park. The topography of the area is a valley which a tributary stream of Nam Yuan pass trough. The height of elevation is about 520-600 m. MSL. Present land uses are high land crops and up land rice cultivation. Even the zone C forest which is selected to be used for quarried rock storage has been destroyed and changed to be agricultural land. The excavated material dumping area of the Adit No.5 should be transferred to zone E forest next to the East of the Adit.
Adit No.6	5047I; 656000, 2156200	The proposed spoil heap area is located in zone C forest and class 2-3 watershed. The topography of the area is a valley in mountainous range. The height of elevation is about 540-620 m. MSL. Although the site found in the map is only 1.5 km. to the East of the proposed area of the Adit No.5 but the topography between these two sites is high mountain. The transportation route from the Adit No.5 to the Adit No.6 is about 12-13 km. Poor dirt road on the mountain and has no access road to the heap area. This spoil heap site is unavoidable to use zone C forest.
Adit No.7	5147IV; 665100, 2146000	The proposed spoil heap area is located in zone C forest and class 3 watershed. The topography of the area is undulating terrace of a large valley. Elevation is about 360-400 m. MSL. Land use pattern are deteriorated forest and high land crops. Due to the whole area of the valley is zone C forest, the spoil heap location of this Adit is unavoidable to use the area of zone C forest. The proposed area for quarried rock storage is suitable.
Ing-Yot Tunnel exit	5147IV; 670000 2144800	The proposed spoil heap area is located in zone C forest and class 4 watershed. The topography is undulating slope. Elevation is about 360-400 m. MSL. The original forest has been destroyed totally for cultivation Especially corn & soil bean and Ma Khawn tree (leaf and fruit used as food spice). Due to the whole area nearly the tunnel exit is zone C forest, the spoil heap area of the tunnel exit is unavoidable to locate in the zone C forest. The proposed area for quarried rock storage is suitable.

6.2 Community Consultation

Issues discussed at each meeting:

- I. Disposal site management plan
 - I.1 Compensation plan
 - I.2 Environmental protection plan
 - I.3 Reclamation plan
 - I.4 Other
- II. Muck utilisation plan
 - II.1 Usable case: RID hires contractor to crush muck for K-I-N project construction and to allocate to the community for public use
 - II.2 Unusable case: RID performs permanent piling with environmental safeguards

Those present: Nick Bonvoisin (JICA study team), and Mr Pongthep, Mr Mongkol, Aea, Orapin (TESCO consultants).

The results of the meetings are presented in the following Tables 6.2 to 6.5.

Table 6.2. First Meeting : Ban Pha Lak, Tambon Yod, Amphoe Song Khwae

When	15/11/98 2pm
With	village representative on Aboto of Ban Pha Sing, village heads of Ban Yod and Ban Pha Lak
Where	office of Yod Local Administrative Organisation
Subject	adit no. 7, tunnel exit, Yao reservoir
Notes	already visited once by TEAM/JV
Issues raised	<ul style="list-style-type: none"> • like idea of public use of disposal site, e.g. community forest • interested in separation of different materials • keep as resource, especially for concrete roads in the village • some people anti-project, others resigned to it - "no" if a choice • reps mentioned fears over sediment in rivers, loss of trees, loss of land, flooding, deforestation leading to soil erosion, landslide, explosion (blasting) (shock to livestock, human danger), loss of fishery, sediment from disposal site and during construction running into paddy fields • generally happy if compensation payments high enough • "makwaen" (spice) trees on disposal site - these earn 1000B/tree/year for years 4-5, rising to 4000-5000B/tree/year; tamarind trees earn 500B/tree/year • access roads must be repaired • would want limestone for concrete village roads • do not want noise and dust of disposal site • separate useful materials and keep these accessible • make disposal site available to the community, e.g. as community forest • would want RID to crush the limestone • also interested in making concrete blocks as an industry

Table 6.3. Second Meeting : Ban Phu Sang, Tambon Phu Sang

When	16/11/98 11am
Whom	Head of Pha Lat Luang village (proposed spoil heap site of Adit No.1), Head of That Phu Sang village (proposed spoil heap site of Adit No.2), Assistant Head of That Phu Sang village, and a representative of Pha Lat Luang village in Phu Sang Local Administrative Organisation Committee.
Where	house of Assistant Head of That Phu Sang Village
Subject	adits 1 & 2
Issues raised	<ul style="list-style-type: none"> • leaching to the river • much of the land is held by people in Amphoe Toeng, who cross a few km to get there • land-slide risk to paddy • dust and noise of trucks passing through village unacceptable - people transport is acceptable • can owner have land back? • compensation? • land used for maize and orchard • loss of water because of infiltration to tunnel • would want other land as compensation - not much/no land available • would want community forest • proposed disposal site may be suitable for paddy, so prefer it further up the mountain • would like spoil used for irrigation "check" dam (dry season water), & for benefit of village, e.g. roads & irrigation canals • Pha Lat Luang quite positive about it (perhaps because it's not their land) • would like job opportunities

Table 6.4. Third Meeting : Ban Cho Ko, Tambon Rom Yen

When:	16/11/98 2pm
Whom:	Chairman of Rom Yen Local Administrative Organisation Committee, Chairman of Rom Yen Local Administrative Organisation Executive Committee, Head of Pracha Phuk Dee village (proposed spoil heap site of Adit No.4), Head of Pha Daeng Lang Village (proposed spoil heap site of Adit No.5) and permanent secretariat for local authority (an Amphoe official working at local administrative organisation)
Where:	office of Rom Yen Local Administrative Organisation
Subject:	for adits 4, 5, 6
Notes:	aboto of 13 villages, population 5001+4898 in 2110 households, total income 889,484B of which 202,697 cigarette tax & 635,867 alcohol tax; mu 9 is Pang Tham, mu 16 is Ton Phung
Issues raised:	<ul style="list-style-type: none"> • worried about surface water disappearing into tunnel • rocks blocking river • no land title (i.e. concern over compensation) • loss of trees and wildlife • water resources downstream • land used for maize, paddy, red bean (really?) • will drive people to slash and burn if they're not being compensated • no other land available • spoil sites inaccessible so difficult for them to imagine using the spoil - expensive to transport • want to use water in the tunnel! • leaching - discoloration of water • complain that in Chao Phraya they have 2 crops whereas here it's only one • could use spoil if had a factory • want good roads to spoil sites • interested in community forest, or ownership by aboto for it to rent out • want more RID input, plus meeting of RID, NGOs, consultants and community together

Table 6.5. Summary of Comments of Local Administrative Authority and Village Leaders on Muck Material Disposal and Utilisation (Source: Tesco Co. Ltd., 1998).

Agenda	Detail of comments	Meeting 1	Meeting 2	Meeting 3
1	Tunnel muck disposal management			
1.1	Compensation for cultivation land and plants			
	a) Farmers have no land titles in proposed areas for muck disposal but they have possessed for cultivation.	✓		✓
	b) Farmers hold agricultural land in very small area and it is unable to possess a new land because the whole village boundary is located in zone C forest.	✓		✓
	c) Compensation rate should be fair to the affected farmers e.g. the income from Makhwuan tree is 1,000-4,000 Baht/year depended on age (3-5 years » 1,000 Baht/ year, more than 20 years » 3,000-4,000 Baht/year), the compensation should be high enough to buy a equal piece of land at nearby location etc.	✓		✓
	d) Cultivation lands in the proposed muck storage site belong to the Ban Don Chai villagers although it is in Ban Pha Lat Laung administrative boundary (muck storage site of Adit No.1) cultivation at the same size and quality to them.		✓	
	f) In order to avoid the use of villager possessed land the muck storage site should be transferred to use the hill foot area which is deteriorated forest land and less productive. (muck storage site of Adit No.1 and 2)		✓	
	g) The RID should inform the local administrative organisation and villages about the designated area for muck storage, compensation rate and payment procedure as soon as possible.	✓	✓	
1.2	Environmental impact protection and mitigation measures			
	a) Muck stock pile can cause serious siltation and sedimentation into nearby water courses and paddy field.	✓	✓	✓
	b) Muck material stock piling over stream may reduce downstream water flow, deteriorate aquatic ecosystem and reduce aquatic animals.			✓
	c) The entrance of Adit No.1 and its proposed muck material storage site is located between 2 streams. This can change quality and quantity of the stream water because of toxic mineral contamination and siltation.		✓	
	d) Loss of valuable agricultural and forest land by muck material stock piling	✓		✓
	e) Loss of wildlife animals because their habitats are damaged are the impacts from human and working of heavy machines during construction.	✓		✓
	f) Unconsolidated muck material stock pile can slide into cultivation areas and villager houses and causes damage to lands, plants, animals and even human life.	✓		✓
	g) Muck material transportation can cause road damage and accident and reduce human health efficiency by dust, noise and vibration. The RID should its own road for muck material transportation in order to avoid aforesaid impacts.	✓	✓	
	h) Site selection, design and construction of spoil heap bank and muck material piling operation should take environmental impacts and safety factors in to account.	✓	✓	✓
1.3	Muck material disposal site reclamation			
	a) Different usable muck materials should be stored up separately in muck material disposal site for future use. The usable muck material stock piles should be temporary reclaimed to protect erosion.	✓	✓	✓
	b) Low quality and useless muck material disposal site should be reclaimed to be community forest.	✓	✓	✓
	c) due to available land for agriculture in the village is a scarce resource the villagers who will be recall their land for muck disposal, should have right to return to use that land after the usable muck materials have been taken out.		✓	✓
	d) Muck material disposal site of Adit No.3 should be reclaimed to recreation area because it is located next to Phra That Phu Sang and the Phu Sang National Park Head Office.			✓

Agenda	Detail of comments	Meeting 1	Meeting 2	Meeting 3
	e) Useable muck materials should be brought out and given to Rom Yen local administrative organisation in order to reduce disposal areas and reclamation cost.			✓
2	Muck Material Utilisation			
2.1	Useable muck materials			
	a) Government agencies in consulting with the local administrative organisation should make use of the useable muck materials by creating small infrastructure project e.g. check dam, village connection road etc. for rural development.	✓	✓	✓
	b) The remained useable muck materials should be given to the local administrative organisation for future uses. Any income from the muck material utilisation by any means should belong to the authority for using in community development.	✓	✓	✓
	c) The relevant government agencies should support loan, equipment and training courses for high quality muck material utilisation such as lime and brick for construction. This will be another source of income for the villagers.	✓	✓	
	d) The government should support the local administrative organisation for using of muck materials if appropriate e.g. a loan for establishing a stone crushing plant if the quarried rock quantity is high enough to make profit.			✓
2.2	Useless muck materials			
	a) The community and villagers should have right to use low quality muck materials for land levelling or other purposes unless the reclamation has been done already.	✓		
	b) Unuseable muck materials should be piled up in the disposal areas and the reclamation of the sites should be done properly to prevent environmental impacts and to provide some benefit to the villagers for example, to reclaim to a community forest.	✓	✓	✓
3	Other issues			
	a) The following environmental impact issues have not been made clear to the rural community;			
	• Can subsidence occur along the tunnel route?	✓		✓
	• Is the surface and underground water able to flow or penetrate into the tunnel and Adits and is drought problem occur?	✓	✓	✓
	• Are there any adverse Impacts from tunnel construction and water diversion to agricultural land use?	✓	✓	✓
	• What will be happen to aquatic animals from trans-basin water diversion, will fishes lose or reduce?	✓		
	• Will flood events be increased in upstream areas during rainy season after Nam Yao dam had been built and what is the maximum height of the flood?	✓		
	• How serious of tunnel blasting impacts to the villagers animal and other property?	✓		
	b) The local people should be employed to work in this project.		✓	
	c) The RID should develop small irrigation system for the affected communities in return such as Nam Sa and Nan Yuan irrigation system development.			✓
	d) Many environmental groups came and gave different information to the villagers. This makes the rural people confuse and most of the villagers feel against this project. The RID should provide more information about the project both advantage and disadvantage of each activities to the villagers. Questions and doubtful issues should have clear answers. In addition, the local administrative authorities requested the RID to keep the Local communities fully informed of the progress of the project.	✓	✓	✓

6.3 Spoil Data

(1) Excavation Rates

Table 6.6. Excavation rates for tunnel types (m³/m), with approximations.

Type	Kok-Ing tunnels	approximation	Ing-Yot tunnels	approximation	Ing-Yot adits	approximation
B	-	-	92.20	92	approx. 45	45
C1	77.20	77	92.70	92	approx. 45	45
C2	77.20	77	92.20	92	approx. 45	45
D1	81.50	82	95.70	96	approx. 47	47
D2	82.60	82	96.90	96	approx. 47	47
E1	85.90	86	100.50	101	-	-
E2	87.00	86	101.70	101	approx. 47	47

(2) Stratigraphy and Igneous Rocks

Table 6.7. Stratigraphical Classification.

Geological age	Formation	Acronym	Rock facies
Holocene	Alluvial deposit	Qa	Unconsolidated sand, silt, gravel
Pleistocene	Terrace deposit	Qt	Unconsolidated red soil, sand, silt, gravel
Jurassic	ms3	ms3	Conglomerate sandstone
	ms5-3	ms5-3	Tuff, shale and sandstone
Middle-Upper Triassic	Doi Pong Nok	TRpn	Sandstone, shale, tuff, lapilly tuff
	Pa Lae	TRpl	Limestone
	Huai Fak	TRhf	Sandstone, tuff, interbedded with shale
Triassic-Permian	PTR	PTR	Sandstone, shale, tuff
Permian	P3	P3	Sandstone, shale, tuff, limestone
	P2	P2	Limestone
Permian-Carboniferous	Huai Krai	CPhk	Meta-sandstone interbedded with slate
	Nam Bong	CPnb	Slate, quartzite, interbedded with sandstone foliated
	Doi Mun	CPdm	Schist, phyllite, slate, meta-sandstone

Table 6.8. Igneous Rocks

Geological age	Formation	Acronym	Rock facies
Tertiary	Basalt	Bs	Basalt
Jurassic	Tuff	Jv	Rhyolite, tuff
Jurassic	Andesite	an	Andesite
Triassic-Permian	Granite	PTRgr	Granite, granidiorite, porphyry
	ms2	ms2	Conglomerate, andesite, rhyolitic tuff
	PTRv	PTRv	Andesite, rhyolite, dacite, tuff, agglomerate

(3) Spoil from Kok-Ing Tunnels

Table 6.9. Kok-Ing tunnel no. 1 - lengths per stretch of tunnel type.

Rock facies, weathering	Map unit	Type	Length (m)
Talus, loose sand, clay	Top soil, talus, alluvium	E	205
Shale (slate), sandstone, tuff alternation, highly weathered, intensely fractured	PTR formation	E	394
		D	154
Rhyolite & tuff, medium hard to soft, moderately to slightly weathered, intensely fractured	Rhyolite, tuff (Jv)	D	103
		C	188
		D	120
		E	171
		D	188
		C	86
		D	60
Shale (slate), sandstone, tuff alternation, highly to slightly weathered, moderately to intensely fractured, tuff, hard, massive	PTR formation	D	111
		C	154
		D	68
		E	171
		D	111
		C	68
		D	111
		E	368
Talus, loose sand, clay	Top soil, talus, alluvium	E	214
Total			3,047

Table 6.10. Kok-Ing tunnel no. 1 - lengths totalled for each tunnel type

Rock facies, weathering	Map unit	Type	Total length (m)	Area (m ² /m)	Volume (1000 m ³)
Talus, loose sand, clay	Top soil, talus, alluvium	E	205	86	18
Shale (slate), sandstone, tuff alternation, highly weathered, intensely fractured	PTR formation	E	394	86	34
		D	154	82	13
Rhyolite & tuff, medium hard to soft, moderately to slightly weathered, intensely fractured	Rhyolite, tuff (Jv)	D	471	82	39
		C	274	77	21
		E	171	86	15
Shale (slate), sandstone, tuff alternation, highly to slightly weathered, moderately to intensely fractured, tuff, hard, massive	PTR formation	D	401	82	33
		C	222	77	17
		E	539	86	46
Talus, loose sand, clay	Top soil, talus, alluvium	E	214	86	18
Totals			3,045		253

Table 6.11. Kok-Ing tunnel no. 1 - volumes totalled for each rock type

Rock facies, weathering	Map unit	Total volume (1000 m ³)
Talus, loose sand, clay	Top soil, talus, alluvium	36
Shale (slate), sandstone, tuff alternation, highly weathered, intensely fractured	PTR formation	47
Rhyolite & tuff, medium hard to soft, moderately to slightly weathered, intensely fractured	Rhyolite, tuff (Jv)	75
Shale (slate), sandstone, tuff alternation, highly to slightly weathered, moderately to intensely fractured, tuff, hard, massive	PTR formation	96
Total		254

Table 6.12. Kok-Ing tunnel no. 2 - lengths per stretch of tunnel type

Rock facies, weathering	Map unit	Type	Length (m)
from entrance			
Weathered shale/sandstone	P3 formation, slate interbedded with sandstone	E	676
Faults, limestone, diameter 0.4m cave	P2 formation, limestone	E	317
Shale (slate) interbedded with thin sandstone layer, frequently dark grey, fresh, partly quartzite and limestone, foliated and slaty cleavage formed, break along bedding and slaty cleavage. Overlain by basalt (Qv).	P3 formation, slate interbedded with sandstone	E	215
		D	113
		C	235
		D	113
		E	174
		D	113
		C	61
		D	317
		E	205
		D	113
		C	51
from exit			
Shale (slate) interbedded with thin sandstone layer, frequently dark grey, fresh, partly quartzite and limestone, foliated and slaty cleavage formed, break along bedding and slaty cleavage. Overlain by basalt (Qv).	P3 formation, slate interbedded with sandstone	D	113
		E	194
		C	532
Basalt, black-dark grey, hard, intensely fractured	Basalt	C	92
Black shale/partly sandstone interbedded, easily broken along bedding plane	PTR formation	C	430
		D	256
		E	266
Highly weathered black shale, soft cracky, partly upper half could find loose sand of talus	PTR formation	E	829
Total distance			5,415

Table 6.13. Kok-Ing tunnel no. 2 - lengths totalled for each tunnel type.

Rock facies, weathering	Map unit	Type	Total length (m)	Area (m ² /m)	Volume (1000 m ³)
from entrance					
Weathered shale/sandstone	P3 formation, slate interbedded with sandstone	E	676	86	58
Faults, limestone, diameter 0.4m cave	P2 formation, limestone	E	317	86	27
Shale (slate) interbedded with thin sandstone layer, frequently dark grey, fresh, partly quartzite and limestone, foliated and slaty cleavage formed, break along bedding and slaty cleavage. Overlain by basalt (Qv).	P3 formation, slate interbedded with sandstone	E	594	86	51
		D	769	82	63
		C	347	77	27
from exit					
Shale (slate) interbedded with thin sandstone layer, frequently dark grey, fresh, partly quartzite and limestone, foliated and slaty cleavage formed, break along bedding and slaty cleavage. Overlain by basalt (Qv).	P3 formation, slate interbedded with sandstone	D	113	82	9
		E	194	86	17
		C	532	77	41
Basalt, black-dark grey, hard, intensely fractured	Basalt	C	92	77	7
Black shale/partly sandstone interbedded, easily broken along bedding plane	PTR formation	C	430	77	33
		D	256	82	21
		E	266	86	23
Highly weathered black shale, soft cracky, partly upper half could find loose sand of talus	PTR formation	E	829	86	71
Totals			5,415		449

Table 6.14. Kok-Ing tunnel no. 2 - volumes totalled for each rock type.

Rock facies, weathering	Map unit	Total volume (1000 m ³)
from entrance		
Weathered shale/sandstone	P3 formation, slate interbedded with sandstone	58
Faults, limestone, diameter 0.4m cave	P2 formation, limestone	27
Shale (slate) interbedded with thin sandstone layer, frequently dark grey, fresh, partly quartzite and limestone, foliated and slaty cleavage formed, break along bedding and slaty cleavage. Overlain by basalt (Qv).	P3 formation, slate interbedded with sandstone	141
from exit		
Shale (slate) interbedded with thin sandstone layer, frequently dark grey, fresh, partly quartzite and limestone, foliated and slaty cleavage formed, break along bedding and slaty cleavage. Overlain by basalt (Qv).	P3 formation, slate interbedded with sandstone	67
Basalt, black-dark grey, hard, intensely fractured	Basalt	7
Black shale/partly sandstone interbedded, easily broken along bedding plane	PTR formation	77
Highly weathered black shale, soft cracky, partly upper half could find loose sand of talus	PTR formation	71
Total		448

(4) Spoil from Ing-Yot Tunnels

Table 6.15. Ing-Yot tunnel no. 1 - lengths per stretch of tunnel type.

Rock facies, weathering	Map unit	Tunnel type	Length (m)
Conglomerate sandstone. Greenish-grey to purple, moderately to highly weathered, medium hard to hard, intensely fractured. Iron oxide stained.	ms3 formation	E	137
		D	223
		E	51
		D	429
		E	43
		D	146
		C	103
		D	446
		E	240
		4-BOX	189
Total			2,008

Table 6.16. Ing-Yot tunnel no. 1 - lengths totalled for each tunnel type.

Rock facies, weathering	Map unit	Type	Total length (m)	Area (m ³ /m)	Volume (1000 m ³)
Conglomerate sandstone. Greenish-grey to purple, moderately to highly weathered, medium hard to hard, intensely fractured. Iron oxide stained.	ms3 formation	E	471	101	48
		D	1244	96	119
		C	103	92	9
		4-BOX	189	64	12
Totals			2,007		189

Table 6.17. Ing-Yot tunnel no. 1 - volumes totalled for each rock type.

Rock facies, weathering	Map unit	Total volume (1000 m ³)
Conglomerate sandstone. Greenish-grey to purple, moderately to highly weathered, medium hard to hard, intensely fractured. Iron oxide stained.	ms3 formation	189

Table 6.18. Ing-Yot tunnel no. 2 construction divisions.

Construction division	length (m)	from	to	Access point	access at
1	4,910	0	4,910	entrance	-
2	4,550	4,910	9,460	adit 1	5,727
3	5,435	9,460	14,895	adit 2	10,919
4	7,215	14,895	22,110	adit 3	18,521
5	6,440	22,110	28,550	adit 4	25,509
6	6,440	28,550	34,990	adit 5	31,958
7	6,060	34,990	41,050	adit 6	38,156
8	4,950	41,050	46,000	adit 7	44,869
9	4,915	46,000	50,915	exit	50,875

Note 1:

Parallel alignment of fine-grained muscovite, chlorite and clay minerals marks strong foliation (slaty cleavage) in the rock. Sandstone consists mainly of quartz, fine-very fine grain, shows elastic (semi-schistose) texture. Fresh, hard to moderately hard, broken with ordinary to light hammer blow along latent slaty cleavage (bedding).

Note 2:

Faults along Yuan River interpreted by topographical feature and relatively low resistivity zone is interpreted by TDEM, and which will be not so fractured at tunnel level considering with borehole data and TDEM resistivity.

Table 6.19. Ing-Yot tunnel no. 2 - lengths per stretch of tunnel type.

Map unit	Rock facies, weathering	Type	Length (m)
From entrance			
TRpn (Doi Pong Nok) formation	Reddish-brown to reddish-purple shale, sandstone, tuff alternation. Easily breakable along bedding planes. Weathered.	E	840
PTRv formation	Greenish-grey, tuff, lapilly tuff, hard, intruded with porphyrite.	E	117
		D	175
		C	408
TRhf (Huai Fak) formation	Greenish-greyish-brown shale, interbedded with sandstone and tuffaceous sandstone.	C	945
		D	82
		E	35
		D	373
		E	152
CPhk (Huai Krai) formation	Very intensely fractured, altered and moderately to highly weathered.	E	117
	Dark grey to grey slate interbedded with thin layer of meta-sandstone, some limestone, calcareous shale, quartzite, quartz vein. Foliated texture, fresh, medium hard, break along latent crack along bedding and slaty cleavage.	E	82
		D	642
		C	58
		D	245
		C	583
		D	58
From adit 1			
CPhk (Huai Krai) formation	Dark grey to grey slate interbedded with thin layer of meta-sandstone, some limestone, calcareous shale, quartzite, quartz vein. Foliated texture, fresh, medium hard, break along latent crack along bedding and slaty cleavage.	D	257
		C	152
		D	47
		C	245
		D	47
		C	245
		D	58
		C	35
	Brownish-grey to dark grey slate interbedded with sandstone	C	315
		D	245
		E	58
		D	175
		C	210
		C	93
CPnb (Nam Bong) formation	Fault sheared zone, soft, very intensely fractured slate altered to clay thrust fault?	C	105

Map unit	Rock facies, weathering	Type	Length (m)
	Dark grey-black slate interbed with thin layer of sandstone, some quartzite & quartz vein. Fresh, medium hard (slate), hard (sandstone), foliated slate structure, breakable along bedding plane, sometimes slicken side along bedding plane. Slight metamorph.	C	12
		D	82
		E	105
		D	408
		C	1,608
		D	47
From adit 2			
CPnb (Nam Bong) formation	Dark grey-black slate interbed with thin layer of sandstone, some quartzite & quartz vein. Fresh, medium hard (slate), hard (sandstone), foliated slate structure, breakable along bedding plane, sometimes slicken side along bedding plane. Slight metamorph.	D	1,142
		E	140
	Porphyrite? High resistivity by TEM.	E	93
		D	163
		E	140
	Dark grey interbedded with sandstone	E	70
		D	93
		C	47
		D	23
		C	617
	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1.	C	338
		D	117
		C	280
		D	35
		C	82
		D	35
		C	128
		C	82
		D	151
		C	489
		B	291
		C	303
		D	128
		E	58
		D	151
		C	221
		D	23
From adit 3			
CPnb (Nam Bong) formation	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1.	D	70
		C	431
		D	571
		E	35
		D	524
		C	396
		D	93
		C	70
		D	583
		C	816
		B	396
		C	117
		C	233

Map unit	Rock facies, weathering	Type	Length (m)
		D	327
		C	677
		D	128
		C	222
		D	140
		E	93
		D	280
		C	233
		D	163
		C	280
		D	82
		C	245
From adit 4			
CPnb (Nam Bong) formation	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1.	C	222
		B	304
		C	222
		D	58
		C	969
		B	128
	Dark grey to black slate interbedded with thin sandstone layer. Foliate texture. Consists of quartz muscovite.	B	222
		C	642
		D	128
		D	422
		C	433
PTRv formation	Greyish-green tuff, fine grain, contains lapilly. Some Dacite interbedded. Tuff consists of quartz, plagioclase, volcanic lithic fragment. Hard, massive, rock blocks are separated by firm hammer blow along latent cleavage.	C	258
		D	59
		C	562
		D	152
		C	105
		D	152
		C	398
		D	304
		C	82
		D	59
		C	176
		D	47
		C	199
		D	129
		C	12
TRpl (Pa Lae) formation	Limestone, greyish to greyish-black, dense, hard.		
From adit 5			
TRpl (Pa Lae) formation	Limestone, greyish to greyish-black, dense, hard.	C	164
		D	117
		E	59
		D	70
		E	105
		D	141
		E	23
		D	47
		C	82
		D	35
		E	23

Map unit	Rock facies, weathering	Type	Length (m)
		D	47
		C	35
		D	82
		C	23
		D	23
		C	117
		D	35
		E	23
		D	47
		C	152
		D	47
		E	47
		D	502
TRhf (Huai Fak) formation	Light grey to dark grey, tuff, tuffaceous sandstone, interbedded with thin shale layer, partly intensely silicified, hard, fresh, massive without fault sheared zone.		
		C	455
		D	58
		C	152
		D	140
		C	362
		D	58
		C	339
		D	198
		C	128
		D	140
		C	374
		C	209
		D	233
		E	116
		D	267
		C	640
		B	93
	Dark grey sandstone, sandy tuff, fine to medium-grained interbedded with thin layer of shale very frequently, fresh, hard, massive, up to 100m iron oxide stained along cracks. See Note 2.	B	314
		C	116
From adit 6			
TRhf (Huai Fak) formation	Dark grey sandstone, sandy tuff, fine to medium-grained interbedded with thin layer of shale very frequently, fresh, hard, massive, up to 100m iron oxide stained along cracks. See Note 2.	C	756
		D	535
		C	1,070
		D	395
		C	256
	Sandstone, sandy tuff, fine to medium grained, interbedded with thin layer of shale. Fresh, hard, massive.	C	349
		B	198
		C	198
		B	198
		C	58
		C	186
		D	163
		D	279
	Top of mountain is underlain by ms5-3 formation which consists of tuff, shale and sandstone referring to published geological map, but exact distribution and rock facies have not yet been confirmed.	C	1,267
		B	163

Map unit	Rock facies, weathering	Type	Length (m)
From adit 7			
TRhf (Huai Fak) formation	Top of mountain is underlain by ms5-3 formation which consists of tuff, shale and sandstone referring to published geological map, but exact distribution and rock facies have not yet been confirmed.	C	1,547
		D	116
		C	221
		D	58
		D	186
		C	233
		D	302
		C	837
	Sandstone, sandy tuff interbedded with shale.	B	500
		C	942
From exit			
TRhf (Huai Fak) formation	Sandstone, sandy tuff interbedded with shale.	C	105
TRpl (Pa Lae) formation	Limestone dark grey to grey, fresh, medium hard to hard, interbedded with thin shale layer. Separated along slicken side formed in shale layer by soft to medium hammer blow.	C	140
		D	209
		E	430
		D	116
		D	70
		C	58
TRhf (Huai Fak) formation	Sandy tuff and tuffaceous sandstone interbedded with shale and tuffaceous shale, dark grey, fresh to slightly weathered, hard, along fault sheared zone very intensely fractured and soft.	C	301
		D	186
		E	58
		D	267
		C	1,507
		D	255
		E	174
TRpl (Pa Lae) formation	Limestone, dark grey, hard, fresh	E	116
		D	267
		E	209
TRhf (Huai Fak) formation	Sandy tuff, shale	D	151
	Highly weathered sandy tuff, tuffaceous shale alternation, reddish brown, clay soft.	C	70
		D	139
		E	46

Table 6.20. Ing-Yot tunnel no. 2 - lengths totalled for each tunnel type.

Map unit	Rock facies, weathering	Type	Length (m)	Area (m ² /m)	Volume (1000 m ³)
From entrance: Construction division 1					
TRpn (Doi Pong Nok) formation	Reddish-brown to reddish-purple shale, sandstone, tuff alternation. Easily breakable along bedding planes. Weathered.	E	840	101	85
PTRv formation	Greenish-grey, tuff, lapilly tuff, hard, intruded with porphyrite.	E	117	101	12
		D	175	96	17
		B,C	408	92	38
TRhf (Huai Fak) formation	Greenish-greyish-brown shale, interbedded with sandstone and tuffaceous sandstone.	B,C	945	92	87
		D	455	96	44
		E	187	101	19
CPhk (Huai Krai) formation	Very intensely fractured, altered and moderately to highly weathered. Dark grey to grey slate interbedded with thin layer of meta-sandstone, some limestone, calcareous shale, quartzite, quartz vein. Foliated texture, fresh, medium hard, break along latent crack along bedding and slaty cleavage.	E	117	101	12
		E	82	101	8
		D	945	96	91
		B,C	641	92	59
			4,911		470
From adit 1: Construction division 2					
CPhk (Huai Krai) formation	Dark grey to grey slate interbedded with thin layer of meta-sandstone, some limestone, calcareous shale, quartzite, quartz vein. Foliated texture, fresh, medium hard, break along latent crack along bedding and slaty cleavage. Brownish-grey to dark grey slate interbedded with sandstone	D	409	96	39
		B,C	677	92	62
		B,C	618	92	57
		D	420	96	40
		E	58	101	6
CPnb (Nam Bong) formation	Fault sheared zone, soft, very intensely fractured slate altered to clay thrust fault? Dark grey-black slate interbed with thin layer of sandstone, some quartzite & quartz vein. Fresh, medium hard (slate), hard (sandstone), foliated slate structure, breakable along bedding plane, sometimes slicken side along bedding plane. Slight metamorph.	B,C	105	92	10
		B,C	1,620	92	149
		D	537	96	52
		E	105	101	11
			4,549		425
From adit 2: Construction division 3					
CPnb (Nam Bong) formation	Dark grey-black slate interbed with thin layer of sandstone, some quartzite & quartz vein. Fresh, medium hard (slate), hard (sandstone), foliated slate structure, breakable along bedding plane, sometimes slicken side along bedding plane. Slight metamorph. Porphyrite? High resistivity by TEM. Dark grey interbedded with sandstone	D	1,142	96	110
		E	140	101	14
		E	233	101	24
		D	163	96	16
		E	70	101	7
		D	116	96	11
		B,C	664	92	61

Map unit	Rock facies, weathering	Type	Length (m)	Area (m ² /m)	Volume (1000 m ³)
	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1.	B,C	2,214	92	204
		D	640	96	61
		E	58	101	6
			5,440		513
From adit 3:	Construction division 4				
CPnb (Nam Bong) formation	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1.	D	2,961	96	284
		B,C	4,116	92	379
		E	128	101	13
			7,205		676
From adit 4:	Construction division 5				
CPnb (Nam Bong) formation	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1.	B,C	1,845	92	170
		D	58	96	6
		B,C	1,297	92	119
	Dark grey to black slate interbedded with thin sandstone layer. Foliate texture. Consists of quartz muscovite.	D	550	96	53
PTRv formation	Greyish-green tuff, fine grain, contains lapilly. Some Dacite interbedded. Tuff consists of quartz, plagioclase, volcanic lithic fragment. Hard, massive, rock blocks are separated by firm hammer blow along latent cleavage.	B,C	1,780	92	164
		D	902	96	87
		B,C	12	92	1
			6,444		599
TRpl (Pa Lae) formation	Limestone, greyish to greyish-black, dense, hard.				
From adit 5:	Construction division 6				
TRpl (Pa Lae) formation	Limestone, greyish to greyish-black, dense, hard.	B,C	573	92	53
		D	691	96	66
		E	280	101	28
		D	1,596	96	153
TRhf (Huai Fak) formation	Light grey to dark grey, tuff, tuffaceous sandstone, interbedded with thin shale layer, partly intensely silicified, hard, fresh, massive without fault sheared zone.	B,C	2,752	92	253
		E	116	101	12
		B,C	430	92	40
	Dark grey sandstone, sandy tuff, fine to medium-grained interbedded with thin layer of shale very frequently, fresh, hard, massive, up to 100m iron oxide stained along cracks. See Note 2.		6,438		605
From adit 6:	Construction division 7				
TRhf (Huai Fak) formation	Dark grey sandstone, sandy tuff, fine to medium-grained interbedded with thin layer of shale very frequently, fresh, hard, massive, up to 100m iron oxide stained along cracks. See Note 2.	B,C	2,082	92	192
		D	930	96	89
		B,C	1,187	92	109
	Sandstone, sandy tuff, fine to medium grained, interbedded with thin layer of shale. Fresh, hard, massive.	D	163	96	16

Map unit	Rock facies, weathering	Type	Length (m)	Area (m ² /m)	Volume (1000 m ³)
	Top of mountain is underlain by ms5-3 formation which consists of tuff, shale and sandstone referring to published geological map, but exact distribution and rock facies have not yet been confirmed.	D	279	96	27
		B,C	1,430	92	132
			6,071		564
From adit 7: Construction division 8					
TRhf (Huai Fak) formation	Top of mountain is underlain by ms5-3 formation which consists of tuff, shale and sandstone referring to published geological map, but exact distribution and rock facies have not yet been confirmed.	B,C	2,838	92	261
	Sandstone, sandy tuff interbedded with shale.	D	662	96	64
		B,C	1,442	92	133
			4,942		457
From exit: Construction division 9					
TRhf (Huai Fak) formation	Sandstone, sandy tuff interbedded with shale.	B,C	105	92	10
TRpl (Pa Lae) formation	Limestone dark grey to grey, fresh, medium hard to hard, interbedded with thin shale layer. Separated along slicken side formed in shale layer by soft to medium hammer blow.	B,C	198	92	18
		D	395	96	38
		E	430	101	43
TRhf (Huai Fak) formation	Sandy tuff and tuffaceous sandstone interbedded with shale and tuffaceous shale, dark grey, fresh to slightly weathered, hard, along fault sheared zone very intensely fractured and soft.	B,C	1,808	92	166
		D	708	96	68
		E	232	101	23
TRpl (Pa Lae) formation	Limestone, dark grey, hard, fresh	E	325	101	33
		D	267	96	26
TRhf (Huai Fak) formation	Sandy tuff, shale	D	151	96	14
	Highly weathered sandy tuff, tuffaceous shale alternation, reddish brown, clay soft.	B,C	70	92	6
		D	139	96	13
		E	46	101	5
			4,873		464

Table 6.21. Ing-Yot tunnel no. 2 - volumes totalled for each rock type.

Map unit	Rock facies, weathering	Volume (1000 m ³)
From entrance:		
Construction division 1		
TRpn (Doi Pong Nok) formation	Reddish-brown to reddish-purple shale, sandstone, tuff alternation. Easily breakable along bedding planes. Weathered.	85
PTRv formation	Greenish-grey, tuff, lapilly tuff, hard, intruded with porphyrite.	67
TRhf (Huai Fak) formation	Greenish-greyish-brown shale, interbedded with sandstone and tuffaceous sandstone.	150
CPhk (Huai Krai) formation	Very intensely fractured, altered and moderately to highly weathered.	12
	Dark grey to grey slate interbedded with thin layer of meta-sandstone, some limestone, calcareous shale, quartzite, quartz vein. Foliated texture, fresh, medium hard, break along latent crack along bedding and slaty cleavage.	158
		<u>472</u>
From adit 1:		
Construction division 2		
CPhk (Huai Krai) formation	Dark grey to grey slate interbedded with thin layer of meta-sandstone, some limestone, calcareous shale, quartzite, quartz vein. Foliated texture, fresh, medium hard, break along latent crack along bedding and slaty cleavage.	101
	Brownish-grey to dark grey slate interbedded with sandstone	103
CPnb (Nam Bong) formation	Fault sheared zone, soft, very intensely fractured slate altered to clay thrust fault?	10
	Dark grey-black slate interbed with thin layer of sandstone, some quartzite & quartz vein. Fresh, medium hard (slate), hard (sandstone), foliated slate structure, breakable along bedding plane, sometimes slicken side along bedding plane. Slight metamorph.	212
		<u>426</u>
From adit 2:		
Construction division 3		
CPnb (Nam Bong) formation	Dark grey-black slate interbed with thin layer of sandstone, some quartzite & quartz vein. Fresh, medium hard (slate), hard (sandstone), foliated slate structure, breakable along bedding plane, sometimes slicken side along bedding plane. Slight metamorph.	124
	Porphyrite? High resistivity by TEM.	40
	Dark grey interbedded with sandstone	79
	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1.	271
		<u>514</u>
From adit 3:		
Construction division 4		
CPnb (Nam Bong) formation	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1.	676
		<u>676</u>
From adit 4:		
Construction division 5		
CPnb (Nam Bong) formation	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1.	176
	Dark grey to black slate interbedded with thin sandstone layer. Foliate texture. Consists of quartz muscovite.	172
PTRv formation	Greyish-green tuff, fine grain, contains lapilly. Some Dacite interbedded. Tuff consists of quartz, plagioclase, volcanic lithic fragment. Hard, massive, rock blocks are separated by firm hammer blow along latent cleavage.	251
TRpl (Pa Lae) formation	Limestone, greyish to greyish-black, dense, hard.	1
		<u>600</u>

Map unit	Rock facies, weathering	Volume (1000 m ³)
From adit 5:	Construction division 6	
TRpl (Pa Lae) formation	Limestone, greyish to greyish-black, dense, hard.	147
TRhf (Huai Fak) formation	Light grey to dark grey, tuff, tuffaceous sandstone, interbedded with thin shale layer, partly intensely silicified, hard, fresh, massive without fault sheared zone.	418
	Dark grey sandstone, sandy tuff, fine to medium-grained interbedded with thin layer of shale very frequently, fresh, hard, massive, up to 100m iron oxide stained along cracks. See Note 2.	40
		<hr/> 605
From adit 6:	Construction division 7	
TRhf (Huai Fak) formation	Dark grey sandstone, sandy tuff, fine to medium-grained interbedded with thin layer of shale very frequently, fresh, hard, massive, up to 100m iron oxide stained along cracks. See Note 2.	281
	Sandstone, sandy tuff, fine to medium grained, interbedded with thin layer of shale. Fresh, hard, massive.	125
	Top of mountain is underlain by ms5-3 formation which consists of tuff, shale and sandstone referring to published geological map, but exact distribution and rock facies have not yet been confirmed.	159
		<hr/> 565
From adit 7:	Construction division 8	
TRhf (Huai Fak) formation	Top of mountain is underlain by ms5-3 formation which consists of tuff, shale and sandstone referring to published geological map, but exact distribution and rock facies have not yet been confirmed.	325
	Sandstone, sandy tuff interbedded with shale.	133
		<hr/> 458
From exit:	Construction division 9	
TRhf (Huai Fak) formation	Sandstone, sandy tuff interbedded with shale.	10
TRpl (Pa Lae) formation	Limestone dark grey to grey, fresh, medium hard to hard, interbedded with thin shale layer. Separated along sliken side formed in shale layer by soft to medium hammer blow.	99
TRhf (Huai Fak) formation	Sandy tuff and tuffaceous sandstone interbedded with shale and tuffaceous shale, dark grey, fresh to slightly weathered, hard, along fault sheared zone very intensely fractured and soft.	257
TRpl (Pa Lae) formation	Limestone, dark grey, hard, fresh	59
TRhf (Huai Fak) formation	Sandy tuff, shale	14
	Highly weathered sandy tuff, tuffaceous shale alternation, reddish brown, clay soft.	24
		<hr/> 463

Table 6.22. Ing-Yot tunnel no. 2 adits - length per stretch of tunnel type.

Adit	Rock facies, weathering	Map unit	Tunnel type	Length (m)
1	Slate, grey-dark grey, interbedded with thin layer of sandstone, calcareous shale, quartzite, fresh, hard, moderately to intensely fractured. From ground level down 43.1m highly weathered shale yellowish brown; 43.1 to 65 m calcareous shale.	CPhk (Huai Krai) formation	E	741
			D	217
			C	108
			D	452
			C	488
				2,005
2	Shale, tuff, grey to dark grey, medium hard in fresh rock, highly to moderately weathered, intensely fractured. Highly weathered and altered to reddish brown clay and white tuffaceous clay.	CPhk (Huai Krai) formation	E	368
			D	621
			C	665
			D	88
			E	79
				1,820
3	Highly weathered shale Slate interbedded with thin layer of sandstone, frequently light grey to dark grey. Slightly to highly weathered, intensely fractured.	CPhk formation	E	269
			CPnb (Nam Bong) formation	E
			D	346
			C	962
			B	625
				2,270
4	Sandstone interbedded with shale, light grey to dark grey, nearby inlet, highly weathered, intensely fractured, soft to hard, silicified.	CPhk (Huai Krai) formation	E	278
			D	258
			C	913
			B	546
			C	585
	Slate interbedded with thin sandstone layer, frequently hard, foliated, slaty	CPnb formation	C	575
				3,155
5	Sandstone, highly weathered tuff, sandstone Sandstone, slightly to moderately weathered, intensely to moderately fractured Sandstone, tuff (sandy) interbedded with shale. Light green to greenish grey, hard to very hard, fresh, slightly fractured.	TRhf formation	E	159
			D	308
			C	804
	Fault zone, intensely altered, intensely fractured, soft to medium hard.		B	347
			C	308
			E	119
			E	99
			D	109
			C	248
			D	69
				2,570
6	Highly weathered Slightly to moderately weathered, tuff interbedded with shale, hard to very hard, slightly fractured.	TRhf formation	E	117
			E	70
	Sandstone, tuff (sandy), fine to medium grained, interbedded thin layer of shale very frequently fresh, hard to very hard massive, up to 100m depth. Iron oxide stained along crack.		D	164
			C	1,240
			B	749

Adit	Rock facies, weathering	Map unit	Tunnel type	Length (m)
			C	562
			B	386
			C	152
				<u>3,440</u>
7	Highly weathered shale, sandstone	TRhf formation	E	63
	Sandstone, interbedded with thin shale layer frequently, hard to very hard, massive, fresh.	ditto	D	135
			C	719
			D	99
			C	692
			B	710
			C	81
				<u>2,500</u>

Table 6.23. Ing-Yot tunnel no. 2 adits - totalling lengths per tunnel type.

Adit	Rock facies, weathering	Map unit	Tunnel type	Total length (m)	Area (m ² /m)	Volume (1000 m ³)
1	Slate, grey-dark grey, interbedded with thin layer of sandstone, calcareous shale, quartzite, fresh, hard, moderately to intensely fractured. From ground level down 43.1m highly weathered shale yellowish brown; 43.1 to 65 m calcareous shale.	CPhk (Huai Krai) formation	D, E	1410	47	66
			B, C	596	45	27
				<u>2,006</u>		<u>93</u>
2	Shale, tuff, grey to dark grey, medium hard in fresh rock, highly to moderately weathered, intensely fractured. Highly weathered and altered to reddish brown clay and white tuffaceous clay.	CPhk (Huai Krai) formation	D, E	1,156	47	54
			B, C	665	45	30
				<u>1,821</u>		<u>84</u>
3	Highly weathered shale	CPhk formation	D, E	269	47	13
	Slate interbedded with thin layer of sandstone, frequently light grey to dark grey. Slightly to highly weathered, intensely fractured.	CPnb (Nam Bong) formation	D, E	413	47	19
			B, C	1,587	45	71
				<u>2,269</u>		<u>103</u>
4	Sandstone interbedded with shale, light grey to dark grey, nearby inlet; highly weathered, intensely fractured, soft to hard, silicified.	CPhk (Huai Krai) formation	D, E	536	47	25
			B, C	2,044	45	92
	Slate interbedded with thin sandstone layer, frequently hard, foliated, slaty	CPnb formation	B, C	575	45	26
				<u>3,155</u>		<u>143</u>
5	Sandstone, highly weathered tuff, sandstone	TRhf formation	D, E	159	47	7
	Sandstone, slightly to moderately weathered, intensely to moderately fractured		D, E	308	47	14
	Sandstone, tuff (sandy) interbedded with shale. Light green to greenish grey, hard to very hard, fresh, slightly fractured.		B, C	1,459	45	66
			D, E	119	47	6

Adit	Rock facies, weathering	Map unit	Tunnel type	Total length (m)	Area (m ² /m)	Volume (1000 m ³)
	Fault zone, intensely altered, intensely fractured, soft to medium hard.		D, E	277	47	13
			B, C	248	45	11
					2,570	
6	Highly weathered	TRhf formation	D, E	117	47	5
	Slightly to moderately weathered, tuff interbedded with shale, hard to very hard, slightly fractured. Sandstone, tuff (sandy), fine to medium grained, interbedded thin layer of shale very frequently fresh, hard to very hard massive, up to 100m depth. Iron oxide stained along crack.		D, E	234	47	11
			B, C	3,089	45	139
					3,440	
7	Highly weathered shale, sandstone	TRhf formation	D, E	63	47	3
	Sandstone, interbedded with thin shale layer frequently, hard to very hard, massive, fresh.		D, E	234	47	11
			B, C	2,202	45	99
					2,499	

Table 6.24. Ing-Yot tunnel no. 2 adits - volumes totalled for each rock type.

Adit	Rock facies, weathering	Map unit	Total volume (1000 m ³)
1	Slate, grey-dark grey, interbedded with thin layer of sandstone, calcareous shale, quartzite, fresh, hard, moderately to intensely fractured. From ground level down 43.1m highly weathered shale yellowish brown, 43.1 to 65 m calcareous shale.	CPhk (Huai Krai) formation	93
2	Shale, tuff, grey to dark grey, medium hard in fresh rock, highly to moderately weathered, intensely fractured. Highly weathered and altered to reddish brown clay and white tuffaceous clay.	CPhk (Huai Krai) formation	84
3	Highly weathered shale	CPhk formation	13
	Slate interbedded with thin layer of sandstone, frequently light grey to dark grey. Slightly to highly weathered, intensely fractured.	CPnb (Nam Bong) formation	90
			103
4	Sandstone interbedded with shale, light grey to dark grey, nearby inlet; highly weathered, intensely fractured, soft to hard, silicified.	CPhk (Huai Krai) formation	117
	Slate interbedded with thin sandstone layer, frequently hard, foliated, slaty	CPnb formation	26
			143
5	Sandstone, highly weathered tuff, sandstone	TRhf formation	7
	Sandstone, slightly to moderately weathered, intensely to moderately fractured	ditto	14
	Sandstone, tuff (sandy) interbedded with shale. Light green to greenish grey, hard to very hard, fresh, slightly fractured.	ditto	71
	Fault zone, intensely altered, intensely fractured, soft to medium hard.	ditto	24
			116
6	Highly weathered	TRhf formation	5
	Slightly to moderately weathered, tuff interbedded with shale, hard to very hard, slightly fractured.	ditto	11
	Sandstone, tuff (sandy), fine to medium grained, interbedded thin layer of shale very frequently fresh, hard to very hard massive, up to 100m depth. Iron oxide stained along crack.	ditto	139

			155
7	Highly weathered shale, sandstone	TRhf formation	3
	Sandstone, interbedded with thin shale layer frequently, hard to very hard, massive, fresh.	ditto	110
			113

Table 6.25. Ing-Yot tunnel no. 2 - Adding in adits.

Map unit	Rock facies, weathering	Volume (1000 m ³)
From entrance: Construction division 1		
TRpn (Doi Pong Nok) formation	Reddish-brown to reddish-purple shale, sandstone, tuff alternation. Easily breakable along bedding planes. Weathered.	85
PTRv formation	Greenish-grey, tuff, lapilly tuff, hard, intruded with porphyrite.	67
TRhf (Huai Fak) formation	Greenish-greyish-brown shale, interbedded with sandstone and tuffaceous sandstone.	150
CPhk (Huai Krai) formation	Very intensely fractured, altered and moderately to highly weathered.	12
	Dark grey to grey slate interbedded with thin layer of meta-sandstone, some limestone, calcareous shale, quartzite, quartz vein. Foliated texture, fresh, medium hard, break along latent crack along bedding and slaty cleavage.	158
472		
From adit 1: Construction division 2		
CPhk (Huai Krai) formation	Dark grey to grey slate interbedded with thin layer of meta-sandstone, some limestone, calcareous shale, quartzite, quartz vein. Foliated texture, fresh, medium hard, break along latent crack along bedding and slaty cleavage.	101
	Slate, grey-dark grey, interbedded with thin layer of sandstone, calcareous shale, quartzite, fresh, hard, moderately to intensely fractured. From ground level down 43.1m highly weathered shale yellowish brown; 43.1 to 65 m calcareous shale.	93
	Brownish-grey to dark grey slate interbedded with sandstone	103
CPnb (Nam Bong) formation	Fault sheared zone, soft, very intensely fractured slate altered to clay thrust fault?	10
	Dark grey-black slate interbed with thin layer of sandstone, some quartzite & quartz vein. Fresh, medium hard (slate), hard (sandstone), foliated slate structure, breakable along bedding plane, sometimes slicken side along bedding plane. Slight metamorph.	212
519		
From adit 2: Construction division 3		
CPnb (Nam Bong) formation	Dark grey-black slate interbed with thin layer of sandstone, some quartzite & quartz vein. Fresh, medium hard (slate), hard (sandstone), foliated slate structure, breakable along bedding plane, sometimes slicken side along bedding plane. Slight metamorph.	124
	Porphyrite? High resistivity by TEM.	40
	Dark grey interbedded with sandstone	79
	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1.	271
CPhk (Huai Krai) formation	Shale, tuff, grey to dark grey, medium hard in fresh rock, highly to moderately weathered, intensely fractured. Highly weathered and altered to reddish brown clay and white tuffaceous clay.	84
598		
From adit 3: Construction division 4		
CPnb (Nam Bong) formation	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1.	676
	Slate interbedded with thin layer of sandstone, frequently light grey to dark grey.	90
	Slightly to highly weathered, intensely fractured.	
CPhk formation	Highly weathered shale	13

		779
From adit 4:	Construction division 5	
CPnb (Nam Bong) formation	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1.	176
	Dark grey to black slate interbedded with thin sandstone layer. Foliate texture. Consists of quartz muscovite.	172
	Slate interbedded with thin sandstone layer, frequently hard, foliated, slaty	26
CPnk (Huai Krai) formation	Sandstone interbedded with shale, light grey to dark grey, nearby inlet; highly weathered, intensely fractured, soft to hard, silicified.	117
PTRv formation	Greyish-green tuff, fine grain, contains lapilly. Some Dacite interbedded. Tuff consists of quartz, plagioclase, volcanic lithic fragment. Hard, massive, rock blocks are separated by firm hammer blow along latent cleavage.	251
TRpl (Pa Lae) formation	Limestone, greyish to greyish-black, dense, hard.	1
		743
From adit 5:	Construction division 6	
TRpl (Pa Lae) formation	Limestone, greyish to greyish-black, dense, hard.	147
TRhf (Huai Fak) formation	Light grey to dark grey, tuff, tuffaceous sandstone, interbedded with thin shale layer, partly intensely silicified, hard, fresh, massive without fault sheared zone.	418
	Dark grey sandstone, sandy tuff, fine to medium-grained interbedded with thin layer of shale very frequently, fresh, hard, massive, up to 100m iron oxide stained along cracks. See Note 2.	40
	Sandstone, highly weathered tuff, sandstone	7
	Sandstone, slightly to moderately weathered, intensely to moderately fractured	14
	Sandstone, tuff (sandy) interbedded with shale. Light green to greenish grey, hard to very hard, fresh, slightly fractured.	71
	Fault zone, intensely altered, intensely fractured, soft to medium hard.	24
		721
From adit 6:	Construction division 7	
TRhf (Huai Fak) formation	Dark grey sandstone, sandy tuff, fine to medium-grained interbedded with thin layer of shale very frequently, fresh, hard, massive, up to 100m iron oxide stained along cracks. See Note 2.	281
	Sandstone, sandy tuff, fine to medium grained, interbedded with thin layer of shale. Fresh, hard, massive.	125
	Top of mountain is underlain by ms5-3 formation which consists of tuff, shale and sandstone referring to published geological map, but exact distribution and rock facies have not yet been confirmed.	159
	Highly weathered	5
	Slightly to moderately weathered, tuff interbedded with shale, hard to very hard, slightly fractured.	11
	Sandstone, tuff (sandy), fine to medium grained, interbedded thin layer of shale very frequently fresh, hard to very hard massive, up to 100m depth. Iron oxide stained along crack.	139
		720
From adit 7:	Construction division 8	
TRhf (Huai Fak) formation	Top of mountain is underlain by ms5-3 formation which consists of tuff, shale and sandstone referring to published geological map, but exact distribution and rock facies have not yet been confirmed.	325
	Sandstone, sandy tuff interbedded with shale.	133
	Highly weathered shale, sandstone	3
	Sandstone, interbedded with thin shale layer frequently, hard to very hard, massive, fresh.	110
		571
From exit:	Construction division 9	
TRhf (Huai Fak) formation	Sandstone, sandy tuff interbedded with shale.	10

TRpl (Pa Lae) formation	Limestone dark grey to grey, fresh, medium hard to hard, interbedded with thin shale layer. Separated along sliken side formed in shale layer by soft to medium hammer blow.	99
TRhf (Huai Fak) formation	Sandy tuff and tuffaceous sandstone interbedded with shale and tuffaceous shale, dark grey, fresh to slightly weathered, hard, along fault sheared zone very intensely fractured and soft.	257
TRpl (Pa Lae) formation	Limestone, dark grey, hard, fresh	59
TRhf (Huai Fak) formation	Sandy tuff, shale	14
	Highly weathered sandy tuff, tuffaceous shale alternation, reddish brown, clay soft.	24
		463

(5) Review of Spoil from Route

Table 6.26. Lengths of different structures, including assumed cross-section of non-tunnel stretches.

Section	Open (m)	Culvert (m)	Siphon (m)	Tunnel (m)	Total (m)	Length (m)	Internal area (m ² /m)	Volume (1000 m ³)
Kok-Ing								
Intake	465	-	-	-	465	465	314	146
Reach-1	10,968	-	724	-	11,692			
canal						10,968	80	877
siphon						724	52	38
No.1 Tunnel	-	-	-	3,039	3,039			
Reach-2	5,360	5,459	-	-	10,819			
canal						5,360	80	429
culvert						5,459	54	295
No.2 Tunnel	-	-	-	5,417	5,417			
Reach-3	22,289	1,345	-	-	23,634			
canal						22,289	80	1,783
culvert						1,345	54	73
Ing-Yot								
Intake	332	-	-	-	332	332	312	104
Reach-1	1,827	360	-	-	2,187			
canal						1,827	98	179
culvert						360	64	23
No.1 Tunnel	-	-	-	2,008	2,008			
Reach-2	-	9,092	185	-	9,277			
culvert						9,092	64	582
siphon						185	53	10
No.2 Tunnel	-	-	-	50,875	50,875			
Total	41,241	16,256	909	61,339	119,745			

Table 6.27. Spoil volumes and possibly useful volume (by material as geological condition).

Section	Geology (map unit)	Geological condition	Section	per	useable
				material	
Kok-Ing					
Intake		Sand, silt, gravel (& red soil)	146	146	146
Reach-1			38		
Canal	will be spread along canal route			0	0
Siphon		Sand, silt, gravel (& red soil)		38	38
No.1 Tunnel			254		
	Top soil, talus, alluvium	Talus, loose sand, clay		36	36
	Rhyolite, tuff (Jv)	Rhyolite & tuff, medium hard to soft, moderately to slightly weathered, intensely fractured		75	0
	Sandstone, shale, tuff (PTR formation)	Shale (slate), sandstone, tuff alternation, highly weathered, intensely fractured		47	0
	ditto	Shale (slate), sandstone, tuff alternation, highly to slightly weathered, moderately to intensely fractured, tuff, hard, massive		96	0
Reach-2			295		
canal	will be spread along canal route			0	0
culvert		Sand, silt, gravel (& red soil)		295	295
No.2 Tunnel			226		
from entrance					
	Sandstone, shale, tuff, limestone (P3 formation, slate interbedded with sandstone)	Weathered shale/sandstone		58	0
	ditto	Shale (slate) interbedded with thin sandstone layer, frequently dark grey, fresh, partly quartzite and limestone, foliated and slaty cleavage formed, break along bedding and slaty cleavage. Overlain by basalt (Qv).		141	0
	Limestone (P2 formation)	Faults, limestone, diameter 0.4m cave		27	27
from exit			222		
	Sandstone, shale, tuff, limestone (P3 formation, slate interbedded with sandstone)	Shale (slate) interbedded with thin sandstone layer, frequently dark grey, fresh, partly quartzite and limestone, foliated and slaty cleavage formed, break along bedding and slaty cleavage. Overlain by basalt (Qv).		67	0
	Basalt	Basalt, black-dark grey, hard, intensely fractured		7	7
	Sandstone, shale, tuff (PTR formation)	Black shale/partly sandstone interbedded, easily broken along bedding plane		77	0
	ditto	Highly weathered black shale, soft cracky, partly upper half could find loose sand of talus		71	0
Reach-3			73		
canal	will be spread along canal route			0	0
culvert		Sand, silt, gravel (& red soil)		73	73
Total			1253	1253	
Ing-Yot					
Intake	-	Sand, silt, gravel (& red soil)	104	104	104

Section	Geology (map unit)	Geological condition	Section	per	useable
				material	
Reach-1 canal	will be spread along canal route		23	0	0
culvert	-	Sand, silt, gravel (& red soil)		23	23
No.1 Tunnel	Congolmerate sandstone (ms3 formation)	Conglomerate sandstone. Greenish-grey to purple, moderately to highly weathered, medium hard to hard, intensely fractured. Iron oxide stained.	189	189	0
Reach-2 culvert	-	Sand, silt, gravel (& red soil); Sandstone & shale (ms1)	592	582	582
siphon	-	Sand, silt, gravel (& red soil); Sandstone & shale (ms1)		10	10
No.2 Tunnel from entrance (construction division 1)			472		
	Sandstone, shale, tuff, lapilly tuff (TRpn (Doi Pong Nok) formation)	Reddish-brown to reddish-purple shale, sandstone, tuff alternation. Easily breakable along bedding planes. Weathered.		85	0
	Andesite, rhyolite, dacite, tuff, agglomerate (PTRv formation)	Greenish-grey, tuff, lapilly tuff, hard, intruded with porphyrite.		67	67
	Sandstone, tuff, interbedded with shale (TRhf (Huai Fak) formation)	Greenish-greyish-brown shale, interbedded with sandstone and tuffaceous sandstone.		150	0
	Meta-sandstone interbedded with slate (CPhk (Huai Krai) formation)	Very intensely fractured, altered and moderately to highly weathered.		12	0
	ditto	Dark grey to grey slate interbedded with thin layer of meta-sandstone, some limestone, calcareous shale, quartzite, quartz vein. Foliated texture, fresh, medium hard, break along latent crack along bedding and slaty cleavage.		158	0
from adit 1 (construction division 2)			519		
	Meta-sandstone interbedded with slate (CPhk (Huai Krai) formation)	Dark grey to grey slate interbedded with thin layer of meta-sandstone, some limestone, calcareous shale, quartzite, quartz vein. Foliated texture, fresh, medium hard, break along latent crack along bedding and slaty cleavage.		101	0
	ditto	Slate, grey-dark grey, interbedded with thin layer of sandstone, calcareous shale, quartzite, fresh, hard, moderately to intensely fractured. From ground level down 43.1m highly weathered shale yellowish brown; 43.1 to 65 m calcareous shale.		93	0
	ditto	Brownish-grey to dark grey slate interbedded with sandstone		103	0

Section	Geology (map unit)	Geological condition	Section per useable material	
	Slate, quartzite, interbedded with sandstone foliated (CPnb (Nam Bong) formation)	Fault sheared zone, soft, very intensely fractured slate altered to clay thrust fault?	10	0
	ditto	Dark grey-black slate interbed with thin layer of sandstone, some quartzite & quartz vein. Fresh, medium hard (slate), hard (sandstone), foliated slate structure, breakable along bedding plane, sometimes slicken side along bedding plane. Slight metamorph.	212	0
from adit 2 (construction division 3)			598	
	Slate, quartzite, interbedded with sandstone foliated (CPnb (Nam Bong) formation)	Dark grey-black slate interbed with thin layer of sandstone, some quartzite & quartz vein. Fresh, medium hard (slate), hard (sandstone), foliated slate structure, breakable along bedding plane, sometimes slicken side along bedding plane. Slight metamorph.	124	0
	ditto	Porphyrite? High resistivity by TEM.	40	0
	ditto	Dark grey interbedded with sandstone	79	0
	ditto	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1.	271	0
	Meta-sandstone interbedded with slate (CPhk (Huai Krai) formation)	Shale, tuff, grey to dark grey, medium hard in fresh rock, highly to moderately weathered, intensely fractured. Highly weathered and altered to reddish brown clay and white tuffaceous clay.	84	0
from adit 3 (construction division 4)			779	
	Slate, quartzite, interbedded with sandstone foliated (CPnb (Nam Bong) formation)	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1.	676	0
	ditto	Slate interbedded with thin layer of sandstone, frequently light grey to dark grey. Slightly to highly weathered, intensely fractured.	90	0
	Meta-sandstone interbedded with slate (CPhk (Huai Krai) formation)	Highly weathered shale	13	0
from adit 4 (construction division 5)			743	
	Slate, quartzite, interbedded with sandstone foliated (CPnb (Nam Bong) formation)	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1.	176	0
	ditto	Dark grey to black slate interbedded with thin sandstone layer. Foliate texture. Consists of quartz muscovite.	172	0

Section	Geology (map unit)	Geological condition	Section per useable material	
	ditto	Slate interbedded with thin sandstone layer, frequently hard, foliated, slaty	26	0
	Meta-sandstone interbedded with slate (CPhk (Huai Krai) formation)	Sandstone interbedded with shale, light grey to dark grey, nearby inlet; highly weathered, intensely fractured, soft to hard, silicified.	117	0
	Andesite, rhyolite, dacite, tuff, agglomerate (PTRv formation)	Greyish-green tuff, fine grain, contains lapilly. Some Dacite interbedded. Tuff consists of quartz, plagioclase, volcanic lithic fragment. Hard, massive, rock blocks are separated by firm hammer blow along latent cleavage.	251	251
	Limestone (TRpl (Pa Lae) formation)	Limestone, greyish to greyish-black, dense, hard.	1	1
from adit 5 (construction division 6)			721	
	Limestone (TRpl (Pa Lae) formation)	Limestone, greyish to greyish-black, dense, hard.	147	147
	Sandstone, tuff, interbedded with shale (TRhf (Huai Fak) formation)	Light grey to dark grey, tuff, tuffaceous sandstone, interbedded with thin shale layer, partly intensely silicified, hard, fresh, massive without fault sheared zone.	418	0
	ditto	Dark grey sandstone, sandy tuff, fine to medium-grained interbedded with thin layer of shale very frequently, fresh, hard, massive, up to 100m iron oxide stained along cracks. See Note 2.	40	0
	ditto	Sandstone, highly weathered tuff, sandstone	7	0
	ditto	Sandstone, slightly to moderately weathered, intensely to moderately fractured	14	14
	ditto	Sandstone, tuff (sandy) interbedded with shale. Light green to greenish grey, hard to very hard, fresh, slightly fractured.	71	0
	ditto	Fault zone, intensely altered, intensely fractured, soft to medium hard.	24	0
from adit 6 (construction division 7)			720	
	Sandstone, tuff, interbedded with shale (TRhf (Huai Fak) formation)	Dark grey sandstone, sandy tuff, fine to medium-grained interbedded with thin layer of shale very frequently, fresh, hard, massive, up to 100m iron oxide stained along cracks. See Note 2.	281	0
	ditto	Sandstone, sandy tuff, fine to medium grained, interbedded with thin layer of shale. Fresh, hard, massive.	125	0
	ditto	Top of mountain is underlain by ms5-3 formation which consists of tuff, shale and sandstone referring to published geological map, but exact distribution and rock facies have not yet been confirmed.	159	159
	ditto	Highly weathered	5	0
	ditto	Slightly to moderately weathered, tuff interbedded with shale, hard to very hard, slightly fractured.	11	0
	ditto	Sandstone, tuff (sandy), fine to medium grained, interbedded thin layer of shale very frequently fresh, hard to very hard massive, up to 100m depth. Iron oxide stained along crack.	139	0

Section	Geology (map unit)	Geological condition	Section	per	useable
			571	material	
from adit 7 (construction division 8)					
	Sandstone, tuff, interbedded with shale (TRhf (Huai Fak) formation)	Top of mountain is underlain by ms5-3 formation which consists of tuff, shale and sandstone referring to published geological map, but exact distribution and rock facies have not yet been confirmed.		325	325
	ditto	Sandstone, sandy tuff interbedded with shale.		133	0
	ditto	Highly weathered shale, sandstone		3	0
	ditto	Sandstone, interbedded with thin shale layer frequently, hard to very hard, massive, fresh.		110	0
from exit (construction division 9)			463		
	Sandstone, tuff, interbedded with shale (TRhf (Huai Fak) formation)	Sandstone, sandy tuff interbedded with shale.		10	0
	ditto	Sandy tuff and tuffaceous sandstone interbedded with shale and tuffaceous shale, dark grey, fresh to slightly weathered, hard, along fault sheared zone very intensely fractured and soft.		257	0
	ditto	Sandy tuff, shale		14	0
	ditto	Highly weathered sandy tuff, tuffaceous shale alternation, reddish brown, clay soft.		24	0
	Limestone (TRpl (Pa Lae) formation)	Limestone dark grey to grey, fresh, medium hard to hard, interbedded with thin shale layer. Separated along slicken side formed in shale layer by soft to medium hammer blow.		99	99
	ditto	Limestone, dark grey, hard, fresh		59	59
Total			6,493	6,493	2,463

(6) Simplified Summary of Spoil from Route

Table 6.28. Spoil volumes (summed by geology).

Section	Geology (map unit)	Geological condition	Volume (1000m ³)	Section per material
Kok-Ing				
Intake	-	Sand, silt, gravel (& red soil)	146	146
Reach-1 (siphon)	-	Sand, silt, gravel (& red soil)	38	38
No.1 Tunnel			254	
	Top soil, talus, alluvium	Talus, loose sand, clay		36
	Rhyolite, tuff (Jv)	Rhyolite & tuff, medium hard to soft, moderately to slightly weathered, intensely fractured		75
	Sandstone, shale, tuff (PTR formation)	Shale (slate), sandstone, tuff alternation, highly weathered, intensely fractured; highly to slightly weathered, moderately to intensely fractured, tuff, hard, massive.		143

Section	Geology (map unit)	Geological condition	Volume (1000m ³)	
			Section	per material
Reach-2 (culvert)	-	Sand, silt, gravel (& red soil)	295	295
No.2 Tunnel:				
	from entrance		226	
	Sandstone, shale, tuff, limestone (P3 formation, slate interbedded with sandstone)	Weathered shale/sandstone; Shale (slate) interbedded with thin sandstone layer, frequently dark grey, fresh, partly quartzite and limestone, foliated and slaty cleavage formed, break along bedding and slaty cleavage. Overlain by basalt (Qv).		199
	Limestone (P2 formation)	Faults, limestone, diameter 0.4m cave		27
	from exit		222	
	Sandstone, shale, tuff, limestone (P3 formation, slate interbedded with sandstone)	Shale (slate) interbedded with thin sandstone layer, frequently dark grey, fresh, partly quartzite and limestone, foliated and slaty cleavage formed, break along bedding and slaty cleavage. Overlain by basalt (Qv).		67
	Basalt	Basalt, black-dark grey, hard, intensely fractured		7
	Sandstone, shale, tuff (PTR formation)	Black shale/partly sandstone interbedded, easily broken along bedding plane; Highly weathered black shale, soft cracky, partly upper half could find loose sand of talus		148
Reach-3 (culvert)	-	Sand, silt, gravel (& red soil)	73	73
Total			1,254	1,254
Ing-Yot				
Intake	-	Sand, silt, gravel (& red soil)	104	104
Reach-1 (culvert)	-	Sand, silt, gravel (& red soil)	23	23
No.1 Tunnel	Conglomerate sandstone (ms3 formation)	Conglomerate sandstone. Greenish-grey to purple, moderately to highly weathered, medium hard to hard, intensely fractured Iron oxide stained.	189	189
Reach-2 (culvert & siphon)	-	Sand, silt, gravel (& red soil); Sandstone & shale (ms1)	592	592
No.2 Tunnel:				
	from entrance (construction division 1)		472	
	Sandstone, shale, tuff, lapilly tuff (TRpn (Doi Pong Nok) formation)	Reddish-brown to reddish-purple shale, sandstone, tuff alternation. Easily breakable along bedding planes. Weathered.		85
	Andesite, rhyolite, dacite, tuff, agglomerate (PTRv formation)	Greenish-grey, tuff, lapilly tuff, hard, intruded with porphyrite.		67
	Sandstone, tuff, interbedded with shale (TRhf (Huai Fak) formation)	Greenish-greyish-brown shale, interbedded with sandstone and tuffaceous sandstone.		150
	Meta-sandstone interbedded with slate (CPhk (Huai Krai) formation)	Very intensely fractured, altered and moderately to highly weathered;		170

Section	Geology (map unit)	Geological condition	Volume
			(1000m ³) Section per material
from adit 1 (construction division 2)		Dark grey to grey slate interbedded with thin layer of meta-sandstone, some limestone, calcareous shale, quartzite, quartz vein. Foliated texture, fresh, medium hard, break along latent crack along bedding and slaty cleavage.	519
	Meta-sandstone interbedded with slate (CPhk (Huai Krai) formation)	Dark grey to grey slate interbedded with thin layer of meta-sandstone, some limestone, calcareous shale, quartzite, quartz vein. Foliated texture, fresh, medium hard, break along latent crack along bedding and slaty cleavage.	297
	Slate, quartzite, interbedded with sandstone foliated (CPnb (Nam Bong) formation)	Slate, grey-dark grey, interbedded with thin layer of sandstone, calcareous shale, quartzite, fresh, hard, moderately to intensely fractured. From ground level down 43.1m highly weathered shale yellowish brown; 43.1 to 65 m calcareous shale. Brownish-grey to dark grey slate interbedded with sandstone Fault sheared zone, soft, very intensely fractured slate altered to clay thrust fault?	222
from adit 2 (construction division 3)		Dark grey-black slate interbed with thin layer of sandstone, some quartzite & quartz vein. Fresh, medium hard (slate), hard (sandstone), foliated slate structure, breakable along bedding plane, sometimes slicken side along bedding plane. Slight metamorph.	598
	Slate, quartzite, interbedded with sandstone foliated (CPnb (Nam Bong) formation)	Dark grey-black slate interbed with thin layer of sandstone, some quartzite & quartz vein. Fresh, medium hard (slate), hard (sandstone), foliated slate structure, breakable along bedding plane, sometimes slicken side along bedding plane. Slight metamorph.	514
	Meta-sandstone interbedded with slate (CPhk (Huai Krai) formation)	Dark grey interbedded with sandstone Porphyrite? High resistivity by TEM; Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1. Shale, tuff, grey to dark grey, medium hard in fresh rock, highly to moderately weathered, intensely fractured. Highly weathered and altered to reddish brown clay and white tuffaceous clay.	84

Section	Geology (map unit)	Geological condition	Volume (1000m ³)
			Section per material
from adit 3 (construction division 4)			779
	Slate, quartzite, interbedded with sandstone foliated (CPnb (Nam Bong) formation)	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1. Slate interbedded with thin layer of sandstone, frequently light grey to dark grey. Slightly to highly weathered, intensely fractured.	766
	Meta-sandstone interbedded with slate (CPhk (Huai Krai) formation)	Highly weathered shale	13
from adit 4 (construction division 5)			743
	Slate, quartzite, interbedded with sandstone foliated (CPnb (Nam Bong) formation)	Dark grey to black slate interbedded with thin sandstone layer, some quartzite and quartz vein. Foliated (slaty) texture. Consists mainly of muscovite and quartz. See Note 1.	374
	Meta-sandstone interbedded with slate (CPhk (Huai Krai) formation)	Dark grey to black slate interbedded with thin sandstone layer. Foliate texture. Consists of quartz muscovite; Slate interbedded with thin sandstone layer, frequently hard, foliated, slaty.	117
	PTRv formation	Sandstone interbedded with shale, light grey to dark grey, nearby inlet; highly weathered, intensely fractured, soft to hard, silicified.	251
	Limestone (TRpl (Pa Lae) formation)	Greyish-green tuff, fine grain, contains lapilly. Some Dacite interbedded. Tuff consists of quartz, plagioclase, volcanic lithic fragment. Hard, massive, rock blocks are separated by firm hammer blow along latent cleavage.	1
from adit 5 (construction division 6)			721
	Limestone (TRpl (Pa Lae) formation)	Limestone, greyish to greyish-black, dense, hard.	147
	Sandstone, tuff, interbedded with shale (TRhf (Huai Fak) formation)	Light grey to dark grey, tuff, tuffaceous sandstone, interbedded with thin shale layer, partly intensely silicified, hard, fresh, massive without fault sheared zone. Dark grey sandstone, sandy tuff, fine to medium- grained interbedded with thin layer of shale very frequently, fresh, hard, massive, up to 100m iron oxide stained along cracks. See Note 2. Sandstone, highly weathered tuff, sandstone; Sandstone, slightly to moderately weathered, intensely to moderately fractured	574

Section	Geology (map unit)	Geological condition	Volume (1000m ³)	
			Section	per material
		Sandstone, tuff (sandy) interbedded with shale. Light green to greenish grey, hard to very hard, fresh, slightly fractured; Fault zone, intensely altered, intensely fractured, soft to medium hard.	720	
from adit 6 (construction division 7)	Sandstone, tuff, interbedded with shale (TRhf (Huai Fak) formation)	Dark grey sandstone, sandy tuff, fine to medium-grained interbedded with thin layer of shale very frequently, fresh, hard, massive, up to 100m iron oxide stained along cracks. See Note 2. Sandstone, sandy tuff, fine to medium grained, interbedded with thin layer of shale. Fresh, hard, massive; Highly weathered. Top of mountain is underlain by ms5-3 formation which consists of tuff, shale and sandstone referring to published geological map, but exact distribution and rock facies have not yet been confirmed. Slightly to moderately weathered, tuff interbedded with shale, hard to very hard, slightly fractured. Sandstone, tuff (sandy), fine to medium grained, interbedded thin layer of shale very frequently fresh, hard to very hard massive, up to 100m depth. Iron oxide stained along crack.	720	
from adit 7 (construction division 8)	Sandstone, tuff, interbedded with shale (TRhf (Huai Fak) formation)	Top of mountain is underlain by ms5-3 formation which consists of tuff, shale and sandstone referring to published geological map, but exact distribution and rock facies have not yet been confirmed. Sandstone, sandy tuff interbedded with shale; Highly weathered shale, sandstone; Sandstone, interbedded with thin shale layer frequently, hard to very hard, massive, fresh.	571	571
from exit (construction division 9)	Sandstone, tuff, interbedded with shale (TRhf (Huai Fak) formation)	Sandstone, sandy tuff interbedded with shale; Sandy tuff, shale; Highly weathered sandy tuff, tuffaceous shale alternation, reddish brown, clay soft. Sandy tuff and tuffaceous sandstone interbedded with shale and tuffaceous shale, dark grey, fresh to slightly weathered, hard, along fault sheared zone very intensely fractured and soft.	463	305
	Limestone (TRpl (Pa Lae) formation)	Limestone dark grey to grey, fresh, medium hard to hard, interbedded with thin shale layer. Separated along slicken side formed in shale layer by soft to medium hammer blow; Limestone, dark grey, hard, fresh.		158
Total			6,494	6,494

6.4 Construction Aggregate Demand

Table 6.29. Prediction of Construction Aggregate Demand of Chiang Rai Phayao and Nan Provinces for 1995-2014 (Source: Mining Technology Division, Department of Mineral Resources, 1995).

Year	Prediction of construction aggregate demand (million/tons)	
	Chiang Rai & Phayao	Nan
1995	5.3	1.6
1996	5.8	1.7
1997	6.5	2.0
1998	7.2	2.2
1999	8.0	2.4
2000	8.6	2.6
2001	9.3	2.8
2002	10.0	3.0
2003	10.8	3.3
2004	11.4	3.5
2005	12.0	3.6
2006	12.6	3.8
2007	13.3	4.0
2008	13.9	4.2
2009	14.6	4.4
2010	15.3	4.6
2011	16.1	4.9
2012	16.9	5.1
2013	17.8	5.4
2014	18.7	5.6
Total	234.1	70.8

6.5 Transport Rates

Table 6.30. Indicative commercial transport rates (Source: ChiangRailLand Associates Co. Ltd., Pha Mae Ok Ru quarry and rock-crushing plant).

Category (ref.)	Description	Transport cost, 1-50km (baht/tonne/km)	Transport cost, more than 50km (baht/tonne/km)
1	rock (limestone)		
1.1	1-inch gravel	1.25	1.10
1.2	¼-inch gravel	1.25	1.10
1.3	½-inch gravel	1.25	1.10
1.4	¾-inch gravel	1.25	1.10
1.5	hard core	1.20	1.00
1.6	fine	1.20	1.00
1.7	coarse	1.30	1.20
2	sand		
2.1	coarse	1.60	1.50
2.2	fine	1.60	1.50

6.6 Quarry Areas

Table 6.31. Designated Areas for Quarry Operation of Chiang Rai, Phayao and Nan Provinces
(Source: Mine Technology Division, Department of Mineral Resources, 1998).

(Ref. No.) District*	(Ref. No.) Site*	Map Position	Area Size (rai)	Rock Type	Rock reserve (million tonnes)	No. quarries (crushing plants)	MOI Notification No. and Date	Accessibility
(1) A. Pa Dad, C. Chiang Rai	Mu 8, T. Sri Khan	4949II; 583900, 2234800	100	Lime- stone	12.5	- (-)	No.2, 26 Sep.1996	10 km. from Amphoe Mae Chum; 750 m. from Mae Chun- Mae Salong Nai Highway
(2) A. Wieng Chai, C. Chiang Rai	(2.1) Doi Pha Muan	5048IV; 511200, 2200300	220	Lime- stone	26.3	1 (1)	No.1, 7 Aug. 1996	45 km, from Chiang Rai,
	(2.2) Doi Mae Ok Ru	5048IV; 610700, 2198800	240	Lime- stone	62.5	1 (1)	No.8, 1 Oct. 1997	1 km. from Wieng Chai- Phya
	(2.3) Doi Pha Hin Tak	5048IV; 611600, 2200700	70	Lime- stone	5.3	- (-)	No.2, 26 Sep. 1996	Meng Rai highway
(3) A. Pa Dad, C. Chiang Rai	Doi Pha Charui	4948II; 604000, 2165000	75	Lime- stone	6.6	1 (1)	No.1, 7 Aug. 1996	50 km. from Chiang Rai, 500 m from 1128 (Pa Dad- Ban Chiang Khian) highway
(4) A. Muang, C. Phayao	Doi Ton	4947II; 602900, 2108200	1000	Lime- stone	72	17 (4)	No.1, 7 Aug. 1996	17 km from Phayao; 2 km from Phayao- Dok Kham Tai highway
(5) A. Muang; C. Nan	T. Sing	5146I, 683100, 2082100	60	Lime- stone	4	1 (1)	No.3, 26 Mar. 1997	12 km from Nan; 1.5 km from 1080 highway
(6) A. Wieng Sa, C. Nan	(6.1) T. San (1)	5145IV, 683000, 2042000	1025	Lime- stone	65	4 (2)	No.3, 26 Mar. 1997	~ 16 km from Amphoe Wieng Sa
	(6.2) T. San (2)	5145IV; 678500, 2041100	200	Lime- stone	3	1 (1)	No.4, 23 Apr. 1997	~ 16 km. From Amphoe Wieng Sa
	(6.3) T. San (3)	5145IV; 682300, 2040700	550	Lime- stone	32	- (-)	No.10, 8 Apr. 1998	~ 16 km. From Amphoe Wieng Sa

*district/site: T. - tambon, A. - amphoe, C. - changwat

6.7 Stone Crushing Plant

Table 6.32. Stone Crushing Plant in Chiang Rai, Phayao and Nan Provinces (Source: Mineral Technology Division, Department of Mineral Resources, and Mineral Resource Provincial Offices).

Province	Name of Licensee	Crushing Plant Location	Primary crusher size (inches)	Maximum capacity (million tonnes/year)	Production 1997 (tonnes)	Production Jan.-Aug, 1998 (tonnes)
Chiang Rai	Chiang Rai Pattananun Part Ltd	204 Mu.6 T. Pa Nga, A. Pa Dad.	40x30	0.30	109,510	55,600
	Chiang Rai Thanawong Co Ltd	Mu.6 Chiang Khian-Pa Nga Rd, T. Pa Nga, A. Pa Dad	40x30	0.30	58,310	14,173
	Kitichai Construction Co Ltd	Mu.5 Sri Wieng-Pha Ngam Rd, T. Pha Ngam, A. Wieng Chai	40x30	0.54	79,780	-
	Chiang Rai Land Associate Co Ltd	49 Mu.9 1152 Highway T. Pha Ngam, A. Wieng Chai	2 (40x30)	1.08	678,784	154,850
	Harn Chareong Enterprise Chiang Rai Co Ltd	Mu.9 T. Pa Or Don Chai, A. Mueng	40x30	0.54	414,020	204,000
	Kiriphunt Co Ltd	Mu.9 T. Pa Or Don Chai, A. Mueng	40x30	0.54		No Quarry
Phayao	Mae Sai Sifa Part Ltd	96 Mu.5 T. Wieng Phang Kham, A. Mae Sai.	40x30, 36x24	0.54		No Quarry
	Charal Rattana Part Ltd	727/119 Mu.8 Phaholyothin Rd., T. Mae Ka, A. Mueng	40x30	0.30	131,650	53,900
	Phayao Business Co Ltd	464 Mu.6 Phaholyothin Rd., T. Mae Ka, A. Mueng	40x30	0.54	144,360	79,000
	Pisit Business Co Ltd	63/1 Mu.3 Phaholyothin Rd., T. Mae Ka, A. Mueng	54x42	1.20	108,412	59,270
	Phayao Silaphant Co Ltd	Mu.3 T. Mae Ka, A. Mueng	54x42	1.20	83,042	47,000
Nan	Srinakaranukul Anusorn Co Ltd	Mu.11 Phayao-Wang Nua Rd., T. Mae Na Rua, A. Mueng	42x30	0.60		Under Construction
	Phayao Pattana Silathong Part. Ltd.	Phayao-Chiang Kham Rd., T. Hui Lan A. Dokkham Tai	40x30	0.54	28,470	10,642
	S.Theng Trirattana (Nan) Co Ltd	Mu.1 Nan-Ta Wang Pha Rd., T. Pha Sing, A. Mueng	36x20	0.10	N.A.	N.A.
	S.Theng Trirattana (Nan) Co Ltd	268 Mu.1 Nan-Ta Wang Pha Rd., T. Pha Sing, A. Mueng	30x40	0.10	N.A.	N.A.
	S.Theng Trirattana (Nan) Co Ltd	Mu.1 Ban Pha Tub, T. Pha Sing, A. Mueng	40x30	0.54	N.A.	N.A.
	S.Theng Trirattana (Nan) Co Ltd	T. Aynalai, A. Wieng Sa.	36x20	0.10	N.A.	N.A.
	T.S. Sila Part. Ltd.	2305 Mu.4, Sa-Na Noi Rd., T. San, A. Wieng Sa	40x30	0.54	N.A.	N.A.
	Phae Thamrong Wit Prt. Ltd.	Mu.5 Ban Pha Tub, T. San, A. Wieng Sa	54x42	1.20	N.A.	N.A.
	S.Theng Trirattana (Nan) Co Ltd	Mu.6 T. Pon, A. Thung Chang	36x20	0.10		No Quarry
	Boon Chai Phanit (1979) Co Ltd	T. Bo Klau Tai K.A. Bo Klau	N.A.	N.A.		No Quarry

N.A. = data not available

6.8 Spoil Use Plan Data

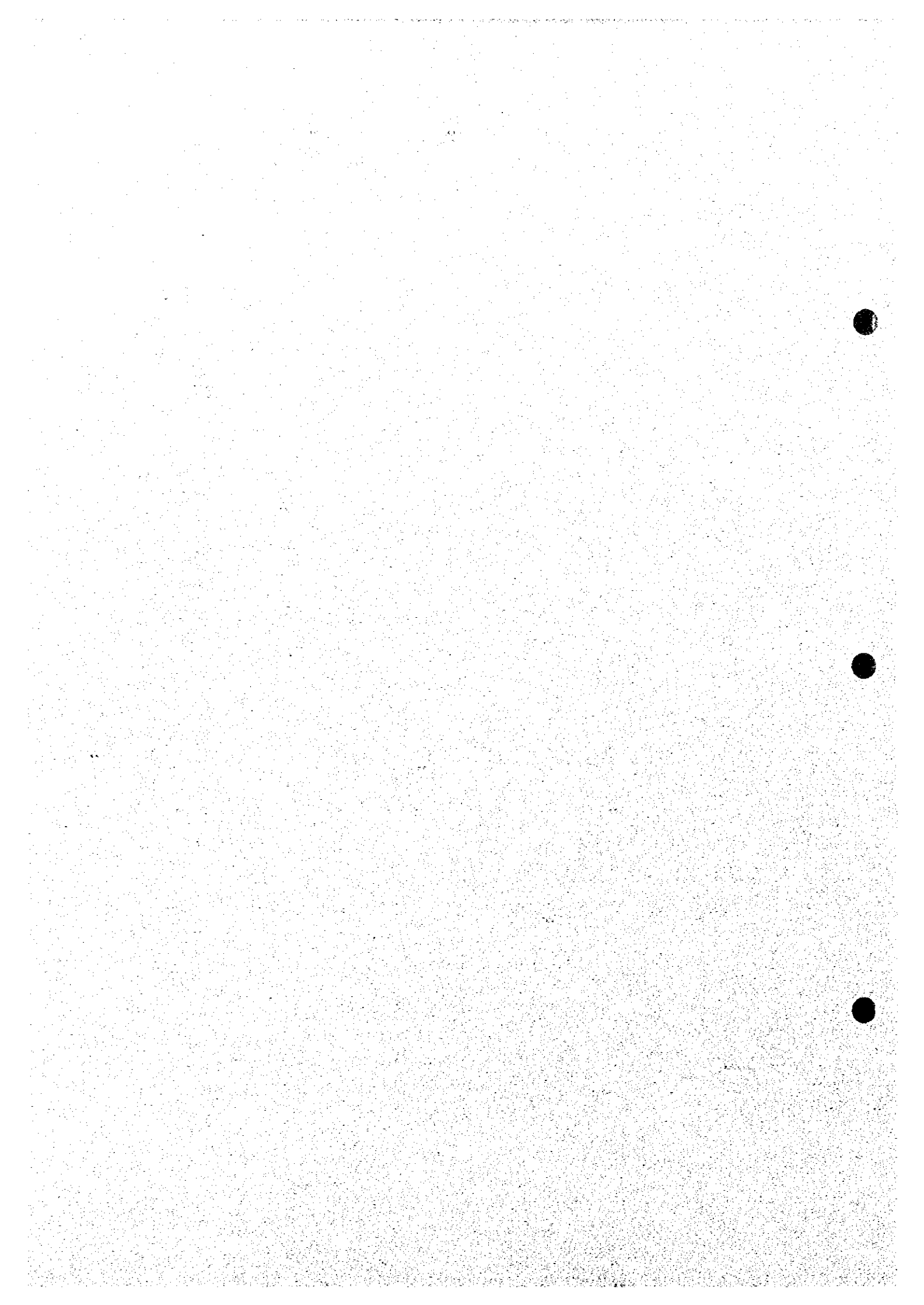
Table 6.33. Spoil Use Plan Economic Calculations.

Section	Volume (1000 m ³)	Geology (map unit)	Soil volume (1000 m ³)	Weight (1000 tonne)	Distance (km)	Transport (b/tonne)	Processing (baht/tonne)	Price (baht/tonne)	No disposal savings		With disposal savings			
									Net price (baht/tonne)	Profit (1000 baht)	Net price (baht/tonne)	Profit (1000 baht/year)		
Kok-Ing Intake	146	Sand, silt, gravel (& red soil)	146	262.8	10	15	0	20	2.2	578	96	22.2	5,834	972
Reach-1 (siphon) No.1	38	Sand, silt, gravel (& red soil)	38	68.4	15	23	0	20	-5.3	-	-	14.7	1,005	168
Tunnel Reach-2 (culvert)	36	Top soil, talus, alluvium	36	64.8	20	30	0	20	-13	-	-	7.2	467	78
Tunnel No. 2 entrance	295	Sand, silt, gravel (& red soil)	295	531	30	45	0	20	-28	-	-	-7.8	-	-
Tunnel No. 2 exit	27	Limestone		48.6	30	45	58	110	4.7	228	38	24.7	1,200	200
Reach-3 (culvert)	7	Basalt		12.6	15	23	58	110	27.2	343	57	47.2	595	99
Ing-Yot Intake	73	Sand, silt, gravel (& red soil)	73	131.4	10	15	0	20	2.2	289	48	22.2	2,917	486
Reach-1 (culvert)	104	Sand, silt, gravel (& red soil)	104	187.2	10	15	58	110	34.7	6,496	1,083	54.7	10,240	1,707
Reach-2 (culvert/siphon)	23	Sand, silt, gravel (& red soil)	23	41.4	10	15	58	110	34.7	1,437	239	54.7	2,265	377
Tunnel No.2 Entrance	592	Sand, silt, gravel (& red soil); Sandstone & shale	592	1066	15	23	58	110	27.2	28,985	4,831	47.2	50,297	8,383
Adit no.4	67	Andesite, rhyolite, dacite, tuff, agglomerate		120.6	15	23	58	110	27.2	3,280	547	47.2	5,692	949
Adit no.5	251	Andesite, rhyolite, dacite, tuff, ...		451.8	15	23	58	110	27.2	12,289	2,048	47.2	21,325	3,554
Tunnel No. 2 exit	147	Limestone		264.6	25	38	58	110	12.2	3,228	538	32.2	8,520	1,420
	14	Sandstone, tuff, ...		25.2	25	38	58	110	12.2	307	51	32.2	811	135
	158	Limestone		284.4	80	120	58	110	-70	-	-	-50	-	-
Total	1,978		1,307							57,460	9,577		111,168	18,528

Assumptions:

- 1.8 tonne/m³ density
- 1.5 baht/tonne/km transport
- 2.8 baht/tonne royalty
- 20 baht/tonne saved disposal cost

7. *POLICY, LEGISLATION AND INSTITUTIONS*



7 POLICY, LEGISLATION AND INSTITUTIONS

7.1 Policy

(1) National Economic and Social Development Plan

The Eighth National Economic and Social Development Plan B.E. 2540-2544 (1997-2001) recognises the inequity of development in Thailand, with Bangkok and the surrounding provinces benefiting far more than the more remote provinces. The plan sets the following relevant objectives:

- To [...] promote increasing community participation.
- To promote stable and sustainable growth, and empower people to play a greater role in the development process and receive a fair share of the benefits of growth.
- To utilise, preserve and rehabilitate the environment and natural resources [...].
- To reform the system of public administration so as to allow greater participation of non-governmental organisations, the private sector, communities and the general public in the process of national development.

The Plan also includes the following targets:

- Upgrade and expand infrastructure provision in the regions and rural areas.
- Reduce the incidence of poverty [...].
- Preserve and rehabilitate forest areas [...].
- Increase awareness of sustainable alternative agricultural methods, and increase opportunities for their application.
- Promote investment in the rehabilitation and protection of urban, regional and rural environments.

The Plan has a number of parts; the relevant ones are reproduced below.

Enhancing the development potential of the regions and rural areas to promote a better quality of life

Objectives include

- To enhance the development potentials of people and communities in regional and rural areas, so that they can participate in the process of local development.
- To encourage popular participation in the conservation [...] of natural resources and environments, and ensure natural resources are utilised economically and efficiently, with the minimum environmental impact.
- To increase the roles of people's organisations and local administrative and government units so that they can work together to achieve regional and rural development which is responsive to the needs of people living in those areas.

Targets include

- Provide rural people working in the agricultural sector with a wider range of non-agricultural employment options.
- Encourage communities to play a greater role in the conservation [...] of local natural resources and environments.
- Empower all local communities to deal effectively with their own problems. [...]

Strategies include

- Promote popular participation in local development and encourage communities to develop their own capabilities to that end.

Guidelines include

- Allocate government budget to support community organisations, to support the formation of all types of popular organisation.
- Make community organisations the principal recipients of government support in their areas, in order to promote participation by local people in the process of decision-making, implementation, monitoring and evaluation.

- Extend the scope of operations of the Rural Development Fund so as to encourage savings at the community level, and give wide-ranging support to local and community development activities.
- Promote the establishment of community funds and fund networks for various activities [...].
- Enhance public awareness and understanding of the conservation [...] of natural resources and the environment, and incorporate local wisdom into their administration.
- Encourage community organisations, such as women's groups and youth groups, to play a greater role in controlling, supervising and alleviating any environmental problems facing the community.
- Enhance the capabilities of local administrative organisations, particularly tambon administrative councils, so that they can more effectively implement the policy of decentralisation of prosperity.
- Upgrade the potentials of the relevant agencies in the development administration to safeguard, reorganise and develop rural communities in border and mountainous regions in order that they become permanent settlements, in line with those communities' economic potentials. Administrative organisations along with mechanisms and systems for planning co-ordination, [...] should be adjusted accordingly.

Natural resource and environmental management

"Local people and community organisations should be urged to play an increasingly active role in the management of natural resources and environments."

Objectives are

- To ensure utilisation of natural resources is counter-balanced by rehabilitation and protection programmes.
- To promote more effective management, involving collaboration of various different sectors of society, so as to achieve greater balance in ecosystems and environments. Opportunities will be provided for local people and organisations to play a greater role in natural resource and environmental conservation in their own communities, with support from the public sector, academic experts, NGOs and business enterprises.

Targets include

- Promote proper natural resource management systems for community forests so as to protect the environment and develop the quality of life of local people.

Strategies are

- Rehabilitation of natural resources and environments.
- Promotion of the participation of local people and communities.
- Proper management of natural resources and environments.

Guidelines include

- Providing opportunities for people and communities to participate in decision-making about, monitoring and evaluation of public development projects likely to have an impact on natural resources and the environment. The government should facilitate continual public discussion at every step of those projects: initiation, preparation and implementation.
- Enacting the Community Forest Legislation, in a form which is acceptable to all parties concerned, so that local people will have legal rights to protect and utilise community forests.
- Encouraging local communities and organisations to conduct eco-tourism within their localities for the benefit of community economies. [...]
- Establish systematic management of water resources, especially at river basin level, including the provision of clean drinking water and supervision of water quality, pollution control and drainage. This will include:
- With participation of all parties concerned, setting up appropriate systems at various levels for the allocation of water resources between the various types of water consumer, based on the principles of necessity, priority and fairness.
- Collecting fees for raw water from industrial and agricultural producers and from domestic consumers. The pricing structure for domestic consumption and industrial production will be adjusted to properly reflect the actual costs of procurement, production, distribution and wastewater treatment.
- Co-ordinate land use policy and management consistent with and appropriate for the development potential of each area, which will ensure fair distribution of benefits to all local people and communities.
- Adjust the administration of the current agricultural land reform system so as to resolve the problems of landless farmers, both by issuing land rights documents and establishing a system for monitoring and inspecting utilisation and reforms of public land.

Development of popular governance

"The public sector [...] is subject to a number of restraining factors, particularly those related to the very centralised power structure, administrative inefficiency, lax law enforcement, lack of popular participation, unethical and unfair use of administrative power, lack of administrative accountability and lack of continuity in policy and implementation to meet the demands of national development plans."

Objectives include

- To encourage all social sectors to participate in government activities, especially in managing national development.

Targets include

- Guarantee the people's right to play a greater role in state, social and community activities [...].

Strategies include

- Creating opportunities and an enabling environment to support the participation of all sectors in the development process.

Guidelines include

- Provide greater opportunities for participation in the development process for communities and other groups who are currently under-represented, such as small farmers, conventional [...] fishermen and the urban poor.
- Encourage people's organisations in local areas and communities to participate in local administration, and carry out development activities through local administrative units, such as tambon administrative organisations, tambon councils, municipal councils and sanitary district councils.
- Legislate the rights of local people and communities to participate in the management of natural resources and environments, and to participate in development activities and projects implemented in their communities. For example, those affected by government-initiated development projects should be entitled to participate in assessments of environmental impact and in monitoring and evaluating implementation of the project.
- Assign increasingly larger portions of the national budget to local organisations as general subsidies and while reducing the funds apportioned as specific subsidies. This budget approach will give local organisations the autonomy and flexibility to formulate action plans and manage development activities consistent with the specific conditions and needs in their areas.
- Promote the establishment of NGOs and people's organisations, both formal and non-formal.

Managing implementation of the eighth plan

Objectives include

- To enhance popular participation in development administration, and to increase the efficiency of development efforts on the basis of a people-centred holistic approach to development and the promotion of development partnerships.

Targets include

- Empower development partnerships and local communities in order that they can participate effectively in the implementation [...].

Strategies include

- Revising the development administration system in such a way as to facilitate implementation [...].
- Promoting popular participation in implementation.

Guidelines include

- Upgrade the capability of community organisations, NGOs, the general public and private businesses in order for them to participate more actively in the implementation of development projects [...].
-

(2) Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality

The OEPP's *Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality 1997-2016* contains a number of relevant objectives, goals and policies, as well as clearly identifying a number of the issues that have caused environmental degradation.

The three objectives of the Plan are

1. Protect and rehabilitate environmental quality for enhancement of quality of life and better health of human beings.
2. Conserve natural resources to be the resource base for sustainable development, by rehabilitating degraded natural resources for future development, by preserving and sustainably using non-renewable resources.
3. Boost institutional capacities to administrate and manage environmental quality, in addition to decentralising power to provincial and local authorities.

The main OEPP policy on natural resources includes the following elements:

- Increase efficiency in the use of natural resources; co-ordinate any utilisation of natural resources and reduce conflicts; and accelerate rehabilitation of degraded natural resources to be the basic inputs for sustainable development.
- Enhance administration and management of natural resources by systematic decentralisation of power and authority from central offices to regional offices, in addition to strengthening relationships among government agencies, the private sector, NGOs and local people.
- Support the application of resource economics for effective management of natural resources and establishment of social justice.
- Amend the legal and regulatory framework enabling support for more effective administration and management of natural resources, and recognition of rights and responsibilities of local people to demonstrate ownership of resources.

The key goals and policies relevant to this study, and the Plan's appreciation of past causes of environmental degradation, are presented below for water resources, forest resources, and soil and land use.

Water Resources

Water resource problems "have resulted from degradation of forest resources and watersheds; poor administration and management of water resources; no limitations on water consumption; ineffective water resource conservation; and poor measures for water conservation."

Goal : Systematically develop, conserve and rehabilitate water resources, both surface and ground water, in all watersheds in order to ensure sufficient quantity and acceptable quality, and for sustainable use.

Policy 1 : Systematically develop and conserve surface and ground water sources at the basin level, taking into consideration socio-economic factors and environmental impacts.

- Guideline 1.1 : Support development of surface and ground water sources at the basin level, both within and outside the country, by considering the suitability of hydrology, physical environment, environmental impacts, and good relationships with neighbouring countries.
- Guideline 1.2 : Conserve natural resources and the environment, specifically important watersheds, to main watershed ecosystems, with the participation of local people.

Policy 2 : Improve administration and management of surface water resources to have integrity and to be efficient.

- Guideline 2.1 : Upgrade the organisational structure of national agencies responsible for surface water development [...].
- Guideline 2.2 : Formulate and improve laws related to administration, management and control of water consumption [...].
- Guideline 2.3 : Administration and management of water resources must correspond to the potential of water budget; [...] and must undertake to prepare clear and fair water allocation plans [...].
- Guideline 2.4 : Collect fees for water consumption based on real costs and categories of users [...].

Policy 3 : Promote effective utilisation of surface water resources to maximise benefits and minimise environmental impacts.

- **Guideline 3.3 :** Support implementation of a cost policy as a mechanism to control water consumption based on the user pays principle, distributing responsibility fairly.

Policy 4 : Promote effective administration and management of ground water

Policy 5 : Promote effective utilisation of ground water while minimising environmental impacts.

Forest Resources

“The degradation and encroachment on forests occurred for many reasons including: land speculation; low agricultural production; ineffective implementation of government policies; [...] ineffective enforcement of natural resource management laws and regulations; conflict between national forest policy and national land policy; ineffective implementation of the water classification system [...]”

Goal 1 : Forests will cover 50% of the country [...].

Goal 2 : Utilise forest areas in a manner that will retain the natural balance of the ecosystem and environmental quality.

Goal 3 : Conserve and sustainably utilise biodiversity.

Policy 1 : Increase forest cover to 50% of the country [...].

- **Guideline 1.2 :** Accelerate reforestation and rehabilitation of degraded watersheds by re-establishing natural healthy forests using native species [...].
- **Guideline 1.4 :** Formulate a legal framework to protect watersheds. Decree that Class I watersheds are environmentally protected areas. Enforce this legal framework effectively.
- **Guideline 1.5 :** Promote economic incentives for reforestation on privately owned land and support participation of the private sector, NGOs, communities and local people in development of community forests, urban forestry and fast-growing tree plantations.

Policy 2 : Utilisation of forests must be in accordance with natural resources conservation practices.

- **Guideline 2.1 :** Clearly classify uses of forest lands including [...] formulating measures for sustainable utilisation [...].
- **Guideline 2.2 :** [...] limit the size of (illegal) land holdings in national reserve forests.
- **Guideline 2.3 :** Consideration of any request to use forest areas by the government or private sectors should be undertaken carefully and approval given only if necessary and only after considering the overall ecosystem of each area.

Policy 3 : Protect remaining natural forest areas from encroachment.

- **Guideline 3.1 :** Prepare individual management plans for each national reserve forest, including rehabilitation of degraded areas and protection against further degradation
- **Guideline 3.5 :** Accelerate enactment of the Community Forestry Act and support decentralisation of roles and power of government authorities by having local people and NGOs participate in forest resources management in the form of efficient community forestry; including supporting NGOs, local citizens' organisations and individuals in participating in forest stewardship.

Policy 4 : Reduce conflict over utilisation of forest resources and other resources in forest areas.

- **Guideline 4.2 :** Prepare a master plan for agricultural land reform and issue land certificates to poor farmers and farmers occupying state lands based on the letter of the law, as appropriate.
- **Guideline 4.3 :** Resolve the problem of people occupying protected areas. If necessary and unavoidable, they shall be allowed to stay in the same area under the condition that they may not expand occupied areas. They must rehabilitate and strictly protect forest areas. If relocation can be carried out, resettlement areas and basic infrastructure should be provided and fair compensation and job opportunities should be offered to ensure improved living conditions.

Policy [5] : Protect, preserve and conserve flora, fauna, aquatic life and other living organisms in forest areas

Soil and Land Use

"Soil and land resource problems have arisen for many reasons including lack of co-ordination in the implementation of land-use policy; lack of effective administration and management; improper enforcement of land-use plans; uncontrolled expansion of settlement; and lack of appropriate urban-development planning. In addition, previous land policies did not ensure security of land holdings nor justly allocate land occupation rights."

Goal 2 : Conserve, rehabilitate and develop degraded soils and land to be a resource base for sustainable development [...].

7.2 International Treaties

Below are listed international treaties in force 1 March 1997 (Table 7.1). More recently, the (Ramsar) Convention of Wetlands of International Importance Especially as Waterfowl Habitat was signed by Thailand 13 September 1998; Kuan Ki Sian of the Thale Noi Non-Hunting Area (in Songkhla) was designated a Ramsar site 13 May 1998.

Three biosphere reserves have been established since June 1976 under the Unesco Man and the Biosphere programme. There are also ASEAN Heritage Sites.

Of the treaties listed below, the following have some relevance to the project:

- The Convention on Biological Diversity (not yet in force)
- ASEAN Agreement on the Conservation of Nature and Natural Resources (not yet in force)
- Convention on Biological Diversity
- International Covenant on Civil and Political Rights
- Convention and Statute on the Regime of Navigable Waterways of International Importance
- Agreement on the Co-operation for the Sustainable Development of the Mekong River Basin
- Agenda 21 : Action Plan for Sustainable Development

Table 7.1. International treaties in force in Thailand as at 1 March 1997 (Source: IUCN).

Title	date entered into force	date of signature
International Plant Protection Convention	16/8/78	6/12/51
Plant Protection Agreement for the Asia and Pacific Region	26/2/56	
Convention on Fishing and Conservation of the Living Resources of the High Seas	1/8/68	29/4/58
Convention on the Territorial Sea and the Contiguous Zone	1/8/68	29/4/58
Convention on the High Seas	1/8/68	29/4/58
Convention on the Continental Shelf	1/8/68	29/4/58
Treaty Banning Nuclear Weapon Test in the Atmosphere, in Outer Space and under Water	15/11/63	8/8/63
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	21/4/83	3/3/73
Convention concerning the Protection of the World Cultural and Natural Heritage	17/12/87	
United Nations Convention on the Law of the Sea		10/12/82
International Tropical Timber Agreement	9/10/85	
ASEAN Agreement on the Conservation of Nature and Natural Resources		9/7/85
Convention for the Protection of the Ozone Layer	5/10/89	
Protocol on Substances that Deplete the Ozone Layer	5/10/89	15/9/88
Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal		22/3/90
Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer	23/9/92	
Agreement on the Establishment of the Network of Aquaculture Centres in Asia and the	28/3/94	

Title	date entered into force	date of signature
Pacific		
Framework Convention on Climate Change	28/3/95	12/6/92
Convention on Biological Diversity		12/6/92
Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer	29/2/96	
Convention on the International Regulations for Preventing Collisions at Sea	6/8/79	
International Convention for the Safety of Life at Sea (SOLAS)	18/3/85	
International Covenant on Civil and Political Rights	28/1/97	
Convention and Statute on the Regime of Navigable Waterways of International Importance	27/2/23	
Convention on Recognition and Enforcement of Foreign Arbitral Awards	30/3/60	
Convention on Road Traffic	14/9/62	
International Agreement for the Creation of an International Office for dealing with Contagious Diseases of Animals at Paris	6/5/27	
Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or other Gases, and of Bacteriological Methods of Warfare	6/6/31	
Agreement of the International Bank for Reconstruction and Development	3/5/49	3/5/49
Treaty on Principles Governing the Activities of States in Exploration and Use of Outer Space, including the Moon and other Celestial Bodies	5/9/68	27/1/67
Treaty on the Non-proliferation of Nuclear Weapons	7/12/72	
Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects launched into Outer Space	26/5/69	
Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction	28/5/75	17/1/73
Constitution of the United Nations Educational, Scientific & Cultural Organisation	1/1/49	29/12/48
Statute of the International Atomic Energy Agency	15/10/57	
Convention on International Civil Aviation Annex 16 Aircraft Noise	4/5/47	7/12/44
Convention of the World Meteorological Organisation	23/3/50	
Charter of the United Nations	16/12/46	
Convention of the International Maritime Organisation	20/9/73	
Agreement establishing the Asian Development Bank	22/8/66	4/12/65
Constitution of the World Health Organisation	7/4/48	22/7/46
Constitution of the Food and Agriculture Organisation of the United Nations	27/8/47	
Articles of Agreement of the International Development Association	24/9/60	
Agreement for the Establishment of the Asia Pacific Fishery Commission	9/11/48	
Agreement of the International Monetary Fund	3/5/49	3/5/49
Amendment of the Plant Protection Agreement for the Asia and Pacific Region	16/8/69	
General Agreement on Tariffs and Trade	30/6/82	
Agreement Establishing the South-east Asian Fisheries Development Centre	28/12/67	
Statutes of the International Centre for the Study of the Preservation and Restoration of Cultural Property	8/2/67	
Convention on Early Notification of a Nuclear Accident	21/4/89	25/10/87
Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	21/4/89	25/9/87
Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and their Destruction		14/1/93
Constitution of the United Nations Industrial Development Organisation	21/6/85	8/4/79
International Tropical Timber Agreement	1/1/97	10/4/96
Agreement on the Co-operation for the Sustainable Development of the Mekong River Basin	5/4/95	5/4/95
Treaty on the South-east Asia Nuclear Weapon Free Zone		12/12/95
Protocol to the Treaty on the South-east Asia Nuclear Weapon Free Zone		12/12/95

7.3 Village Rules

Table 7.2. Example Village Rules from in Yot Tambon, Nan province (adit no. 7 and tunnel exit) (Source: first draft of *Upper Nan Watershed Management Project : Village Rules and Regulations*, December 1997).

Yot Village (no. 2 in Tambon)	Pha Lak Village (no. 3 in Tambon)
1. Whosoever shoots in the village will be fined 500 baht.	1. Whosoever shoots in the village will be fined 500 baht.
2. Whosoever steals will be fined 2,000 baht.	2. Whosoever steals in the village will be fined 1,500 baht.
3. Whosoever fishes with explosives, by electric shock or with poison will be fined 1,500 baht.	3. Whosoever misses a village meeting will be fined 50 baht.
4. Whosoever cuts down forest in the village conservation zone will be fined between 5,000 and 10,000 baht.	4. Whosoever fishes with explosives, by electric shock or with poison will be fined 1,500 baht.
5. Whosoever abandons cows or buffaloes, allows them to defecate in the village and does not clean up will be fined 50 baht.	5. Whosoever has a brawl will be fined 500 baht.
6. Whosoever is a paramour will be fined 2,000 baht.	6. Whosoever burns forest will be fined 5,000 baht.
7. Whosoever has a brawl or quarrel will be fined 1,500 baht.	7. Whosoever creates a disturbance will be fined 1,500 baht.
8. Whosoever misses a village meeting will be fined 20 baht.	8. Whosoever does not co-operate in the development of the village will be fined 50 baht.
9. Whosoever transgresses someone's rights, such as to land or assets, will be fined 2,500 baht.	9. Whosoever steals and cuts the palm lok dtoi/dtaw or rattan will be fined 10 baht (for rattan), or 50 baht (for lok dtoi/dtaw).
	10. Whosoever cuts down trees or forest will be fined 1,500 baht and be taken to the police.

7.4 Government Irrigation Act

Further relevant provisions of the Government Irrigation Act B.E. 2485 (1942), as amended:

Section 13 bis. When it is deemed appropriate to transfer the government irrigation in any locality or in any area of government irrigation project to be the people's irrigation, it shall be made by issuing a Royal Decree prescribing the are of government irrigation to be transferred. The government irrigation so transferred shall, upon issuing the Royal Decree announcing the said transfer, be deemed to be the people's irrigation under the law on people's irrigation as from the date the Royal Decree comes into force.

Section 17. Kamnan, Village headman or Councillor of the locality situated in the irrigation zone has the duty to maintain the embankment and irrigation waterway within the boundaries of that locality or municipality.

Section 18. The Director-General shall have the power to exempt Kamnan, Village headman or Councillor from irrigation fees under the preceding section, or to exempt the persons named by Kamnan, Village headman or Councillor to be entirely or partially exempted therefrom for and on his behalf, at the following rates:

- a. Kamnan and Councillor at fifty rai each;
- b. Village headman at twenty-five rai each.

Section 19. In the excavation and repair of irrigation waterway, if there is no place for discarding the earth mould, it shall, as deemed necessary, be discarded in the adjoining land; but in case of any damages caused to crops or structures existing at that time, the compensation therefor must be paid.

Section 36. Whoever fails to pay the irrigation fee as prescribed in Ministerial Regulations issued under section 8(3) or (4) shall be liable to a fine not exceeding ten times the amount in arrears.

When the offender under paragraph one has, within the period as specified by the official, paid him the irrigation fee in arrears together with a surcharge of time the said amount, the offender shall not be punished in that case.

7.5 Mekong River Agreement

In the Agreement on the Co-operation for the Sustainable Development of the Mekong River Basin, Article 5 for Reasonable and Equitable Utilisation and Article 6 for Maintenance of Flows on the Mainstream declare that parties agree:

Article 5:

To utilise the waters of the Mekong River system in a reasonable and equitable manner in their respective territories, pursuant to all relevant factors and circumstances, the Rules for Water Utilisation and Inter-basin Diversion provided under Article 26 and the provisions of A and B below:

- A. On tributaries of the Mekong River, including Tonle Sap, intra-basin uses and inter basin diversions shall be subject to notification to the Joint Committee.
- B. On the mainstream of the Mekong River:
 - 1. During the wet season:
 - a) Intra-basin use shall be subject to notification to the Joint Committee.
 - b) Inter-basin diversion shall be subject to prior consultation which aims at arriving at an agreement by the Joint Committee.
 - 2. During the dry season:
 - a) Intra-basin use shall be subject to prior consultation which aims at arriving at an agreement by the Joint Committee.
 - b) Any inter-basin diversion project shall be agreed upon by the Joint Committee through a specific agreement for each project prior to any proposed diversion. However, should there be a surplus quantity of water available in excess of the proposed uses of all parties in any dry season, verified and unanimously confirmed as such by the Joint Committee, an inter-basin diversion of the surplus could be made subject to prior consultation.

Article 6:

To co-operate in the maintenance of the flows on the mainstream from diversions, storage releases, or other actions of a permanent nature; except in the cases of historically severe droughts and/or floods:

- A. Of not less than the acceptable minimum monthly natural flow during each month of the dry season;
- B. To enable the acceptable natural reverse flow of the Tonle Sap to take place during the wet season; and
- C. To prevent average daily peak flows greater than what naturally occur on the average during the flood season.

The Joint Committee shall adopt guidelines for the locations and levels of the flows, and monitor and take action necessary for their maintenance as provided in Article 26.

Article 26:

In addition, the Article 26 for Rules for Water Utilisation and Inter-Basin Diversions states that: The Joint Committee shall prepare and propose for approval of the Council, inter alia, Rules for Water Utilisation and Inter-Basin Diversion pursuant to Articles 5 and 6, including but not limited to: 1) establishing the time frame for the wet and dry seasons; 2) establishing the location of hydrological stations, and determining and maintaining the flow level requirements at each station; 3) setting out criteria for determining surplus quantities of water during the dry season on the mainstream; 4) improving upon the mechanism to monitor intra-basin use; and 5) setting up a mechanism to monitor inter-basin diversions from the mainstream.

Definition of Terms

For the purpose of this Agreement, it shall be understood that the following meanings to the underlined terms shall apply except where otherwise inconsistent with the context:

Agreement under Article 5: A decision of the Joint Committee resulting from prior consultation and evaluation on any proposed use for inter-basin diversions during the wet season from the mainstream as well as for intra-basin use and inter-basin diversions of these waters during dry season. The objective of this agreement is to achieve an optimum use and prevention of waste of the waters through a dynamic and practical consensus in conformity with the Rules for Water Utilisation and Inter-Basin Diversions set forth in Article 26.

Acceptable minimum monthly natural flow: The acceptable minimum monthly natural flow during each month of the dry season.

Acceptable natural reverse flow: The wet season flow level in the Mekong River at Kratie that allows the reverse flow of the Tonle Sap to an agreed upon optimum level of the Great Lake.

Basin Development Plan: The general planning tool and process that the Joint Committee would use as a blueprint to identify, categorise and prioritise the projects and programmes to seek assistance for and to implement the plan at the basin level.

Environment: The conditions of water and land resources, air, flora, and fauna that exists in a particular region.

Notification: Timely providing information by a riparian to the Joint Committee on its proposed use of water according to the format, content and procedures set forth in the Rules for Water Utilisation and Inter-Basin Diversions under Article 26.

Prior Consultation: Timely notification plus additional data and information to the Joint Committee as provided in the Rules for Water Utilisation and Inter-Basin Diversions under Article 26, that would allow the other member riparians to discuss and evaluate the impact of the proposed use upon their uses of water and any other effects, which is the basis for arriving at agreement. Prior consultation is neither a right to veto the use nor unilateral right to use water by any riparian without taking into account other riparians' rights.

Proposed use: Any proposal for definite use of waters of the Mekong River system by any riparian, excluding domestic and minor uses of water not having a significant impact on mainstream flows.

7.6 Environmental Standards

Table 7.3. Environmental Standards (Source: Laws and Standards on Pollution Control in Thailand, 4th edition, PCD, 1997).

	Standard	Range	Legislation
I	Air Quality		
I.1	Ambient Air Standards of Thailand (1995)	7 pollutants	
I.2	Emission		
I.2a	Industrial Emission	1 parameter (emission blackness)	Notification of MOInd No. 4, B.E. 2514 (1971) Notification of MOInd No. 2, B.E. 2536 (1993) Factory Act B.E. 2512 (1969) Factory Act No. 2 B.E. 2518 (1975) Factory Act B.E. 2535 (1992)
		15 substances	Notification of MOInd No. 2, B.E. 2536 (1993) Notification of MOInd No. 9, B.E. 2538 (1995)
		1 substance	Notification of MOI No. 3, B.E. 2540 (1997)
I.2b	Motor Vehicle Emission		
I.2b.1	In-use vehicle		
I.2b.1.1	present standard	4 parameters (3 substances) 2 parameters	Notifications of MOSTE B.E. 2535, 2536, 2537 (1992, 1993, 1994) Notification of the Police Department issued under the Announcement of Revolutionary Party No. 16, B.E. 2527 (1984)
		3 parameters	Notification of Department of Land Transport, B.E. 2531 (1988) Land Transport Act, B.E. 2522 (1979)
I.2b.2	proposed standard	3 pollutants	MOSTE
I.2b.2.1	New motor vehicle Gasoline Engine Vehicle	TIS. 1365-1996	EEC standard 93/59/EC from 1 January 1997
I.2b.2.2	Light Duty Diesel Engine Vehicles	TIS. 1370-1996	EEC standard 93/59/EC from 1 January 1997
I.2b.2.3	Heavy Duty Diesel Engine Vehicles	TIS. 1295-1995	EURO II from 1 January 1999
I.2b.2.4	Motorcycle	TIS. 1305-1995	Thai standard
I.2c	Boat/ship/vessel emissions	1 parameter (black smoke)	Notification of the Harbour Department No. 177, B.E. 2527 (1984)
II	Noise		
II.1	Ambient Noise	2 parameters	
II.2	Motor Vehicle Noise		
II.2a	MOSTE	2 standards	Notification of MOSTE, B.E. 2535 (1992)
II.2b	Royal Thai Police Department	1 standard	Notification of the Royal Thai Police Department B.E. 2527 (1984)
II.2c	Department of Land Transport	2 standards	Notification of the Department of Land Transport No. 78, B.E. 2527 (1984)
II.3	Motor Boat Noise	1 standard	Notification of MOSTE, B.E. 2535 (1992)
II.4	Noise Standards in Workplace		
II.4a	Ministry of Interior	4 levels	Notification of MOI issued under the Announcement of the Revolutionary Party No. 103, B.E. 2519 (1976)
II.4b	Ministry of Industry		Notification of Ministry of Industry No. 4, B.E. 2514 (1971) Factory Act B.E. 2512 (1969) Factory Act No. 2 B.E. 2518 (1975)

	Standard	Range	Legislation
III	Water Quality		
III.1	Drinking Water		
III.1a	Drinking Water Quality	30 parameters	Notification of MOInd No. 332, B.E. 2521 (1978) Industrial Products Standards Act B.E. 2511 (1968)
III.1b	Bottled Drinking Water Quality	26 parameters	Notification of MOPH No. 61, B.E. 2524 (1981) Food Act B.E. 2522 (1979)
III.1c	Ground Water Standards for Drinking Purposes	23 parameters	Notification of MOInd No. 4, B.E. 2521 (1978) Ground Water Act B.E. 2520 (1977)
III.2	Effluent		
III.2a	Industrial Effluent	27 parameters	Notification of MOSTE, B.E. 2539 (1996)
III.2b	Water Characteristics Discharged into Deep Wells	16 parameters	Notification of MOInd No. 5, B.E. 2521 (1978) Ground Water Act B.E. 2520 (1977)
III.2c	Building Effluent	8 parameters, 5 levels, 10 types	Notification of MOSTE, B.E. 2537 (1994)
III.2d	Housing Estate	8 parameters, & methods	Notifications of MOSTE Nos. 5 & 6, B.E. 2539 (1996) USA methods
III.2e	(draft) gas station effluent and oil terminal effluent	4 parameters, & methods	to be issued by notification by MOSTE USA methods
III.2f	Regulation of channelisation in respect of waste dumping in water courses		Navigation of Thai Waters Act B.E. 2456 (1913) as amended under the Announcement of the Revolutionary Party No. 50, B.E. 2515 (1972)
III.3	Coastal Water Quality		
III.3a	Classification of coastal water	7 classes	
III.3b	Coastal water quality	31 parameters for 7 classes	Notification of NEB No. 7, B.E. 2537 (1994)
III.3c	Area classification for the west coast of Phuket Island	7 classes	draft of Notification of PCD, B.E. 2537 (1995) (?)
III.3d	Methods of examination	22 parameters	USA methods
III.4	Surface Water		
III.4a	Surface Water Quality Standards : Classification and Objectives	27 parameters for 5 classes, & methods	Notification of NEB No. 8, B.E. 2537 (1994) USA methods
III.4b	Chao Phraya River Water Quality	3 control areas	Notification of PCD, B.E. 2537 (1994)
III.4c	Thachin River Water Quality	3 control areas	Notification of PCD, B.E. 2537 (1994)
III.4d	Bangpakong, Nakornnayak, Prachinburi River Water Quality	3 control areas	Notification of PCD, B.E. 2537 (1994)
III.4e	Maeklong River Water Quality	1 control area	Notification of PCD, B.E. 2537 (1994)
III.4f	Restricted zone for protecting the source of water supply in BMR		NEB Cabinet Resolutions, B.E. 2522, 2531 & 2535 (1979, 1988 & 1992)

	Standard	Range	Legislation
IV	Solid Waste, Night Soil and Hazardous Waste Legislation		
IV.1	General Management		Public Health Act B.E. 2535 (1992)
IV.2	for Multi-storey or Large Buildings		Regulation of the Ministry of Interior Vol. 33, B.E. 2535 (1992) Control of Building Act, B.E. 2522 (1979)
IV.3	Management in Factories	4 substance types, 20 expired or unusable solvents, 10 wastes or unusable material, 9 ground-water sampling parameters	Ministerial Regulation No. 2, B.E. 2535 (1992) Notification of MOInd No. 25, B.E. 2531 (1988) Factory Act B.E. 2512 (1969) Factory Act B.E. 2535 (1992)
IV.4	Other acts and regulations		Public Cleansing and Orderliness Act B.E. 2535 (1992) Royal Thai Irrigation Act B.E. 2485 (1942) Maintenance of Canals Act B.E. 2446 (1903) Royal Highway Act B.E. 2535 (1992) National Park Act B.E. 2504 (1961) Penal Code Notification of Customs Department, repeated by Notification of the Revolutionary Party No. 329, B.E. 2515 (1972) Navigation in Thai Waterways (Vol. 14) Act B.E. 2535 (1992) Ministerial Regulation No. 2, B.E. 2535 (1992) Atomic Energy for Peace Act B.E. 2504 (1961) Minerals Acts B.E. 2510 (1967), as amended by Minerals Act No. 2 B.E. 2516 (1973) Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (1992)
V	Toxic Substances Legislation		
V.1	Toxic Substance Limits in Food		
V.1.1	Extraneous residue limit	5 pesticides for 12 foods	Notification of MOPH No. 163 B.E. 2538 (1995)
V.1.2	Maximum residue limit	11 substances for 55 foods	Notification of MOPH No. 163 B.E. 2538 (1995)
V.2	Hazardous Substance Controlled under the Hazardous Substances Act	approx. 600 substances, types, authorities & conditions	
VI	Nuisance Abatement		
VI.1	Sources of Nuisance		
VI.2	Industrial Nuisance		Factory Act B.E. 2535 (1992)
VI.3	Business Detrimental to Health		Public Health Act B.E. 2535 (1992)

7.7 Protected Area Classifications

(1) National Parks

Any land or natural feature which is of interest to be maintained with a view to preserving it for the benefit of public education and pleasure, with the provision that such land is not owned or legally possessed by any person other than a public body.

Prohibited activities are defined in Chapter 3 of the National Parks Act to provide comprehensive habitat and wildlife protection, but with provision for recreation.

Administrative authority: Ministry of Agriculture and Co-operatives (Director, National Park Division, Royal Forest Department)

Source: National Parks Act, 3 October 1961 (B.E. 2504)

(2) Other wildlife preservation areas

- *Wild animal preserved area* (Wildlife sanctuary is the commonly used terminology): Any area deemed appropriate for the preservation of the breed of animal and on land not owned or legally possessed by any person other than a public body.
- *Non-hunting area*: Any place used for official service or public interest or place for common use of the public in which hunting of any wild animal of any kind or category is prohibited.
- *Monastic precincts*: Within the precinct of a monastery or place provided for religious observance of the public, hunting, collecting or endangering any wild animal is prohibited.

Source: Wild Animals Reservation and Protection Act, 26 December 1960 (B.E. 2503), now superseded by the 1992 (B.E. 2535) Act.

Administrative authority: Ministry of Agriculture and Co-operatives (Director, Wildlife Conservation Division, Royal Forest Department)

(3) National Forest Reserves

A forest designated as such under this or, preceding but repealed, acts on protection and reservation of forest (1938, 1953, 1954) for the purpose of preserving forest, timber, forest products or other natural resources, by recourse to a Ministerial Regulation. Within such a forest it is forbidden to hold or possess land, clear land, burn forest, work timber, gather forest products or do any act detrimental to the nature of the national reserved forest with the exception of:

- (1) working timber or gathering forest products under Section 15, utilising or dwelling under Section 16, acting under Section 17, putting to use under Section 18 or acting under Section 19 or 20;
- (2) working prohibited timber or gathering prohibited forest products under the laws on forest.

NB: Amended in 1989 to remove the right of exploitation.

Source: National Forest Reserves Act, 16 April 1964 (amended 1989)

Admin. authority: Minister of Agriculture & Co-operatives (Director General, Royal Forest Dept.)

Classes: C Conservation Forest Area
 E Economic Forest Area
 A Forest Land Suitable for Agriculture Area

(4) Classified watersheds

Approximately 27 km of the diversion tunnel under watershed class I area (Source: TEAM/JV interim EIA). A map of watershed classification is produced by the Natural Resources and Environmental Management and Co-ordination Division, OEPP.

Table 7.4. Watershed Classes.

1	primary headwaters	Protected or Conservation Forest
1A		Includes areas of protected forest and headwater source areas, usually at higher elevation with very steep slopes. These areas must be protected permanently and remain with permanent forest cover.
1B		Denotes similar physical and environmental features to class 1A, but portions of the area have been cleared for agricultural use or occupied by villages. These areas require special soil-conservation and protection measures and should be replanted to forest or maintained in permanent agro-forestry.
2	secondary headwaters	Protected or commercial forest (usually commercial forest), usually at higher elevations with steep to very steep slopes. Land-forms are less erosive than classes 1A or 1B. Areas may be used for grazing or certain crops with soil-protection measures.
3	commercial forestry, mining & agriculture (fruit trees)	Upland areas with steep slopes and less-erosive land-forms. These areas may be used for commercial forests, grazing, fruit trees, or certain agricultural crops with need for soil-conservation measures.
4	upland crops	Areas of gently-sloping lands suitable for row crops, fruit trees, and grazing with moderate need for soil-conservation measures. (Upland Farming)
5	agriculture, especially rice farming	Gently-sloping to flat areas used for paddy fields or other agricultural uses with few restrictions. (Lowland Farming)

7.8 Organisation Charts

Organisation charts for a number of relevant sections of the Government are provided on the following pages:

- Government Ministries
- Ministry of Agriculture and Co-operatives
- Ministry of Interior
- Ministry of Transport and Communications
- Office of Prime Minister
- Ministry of Science, Technology and Environment
- Ministry of Public Health
- Provincial Government Structure
- Provincial Administration

Figure 7.1. Government Ministries.

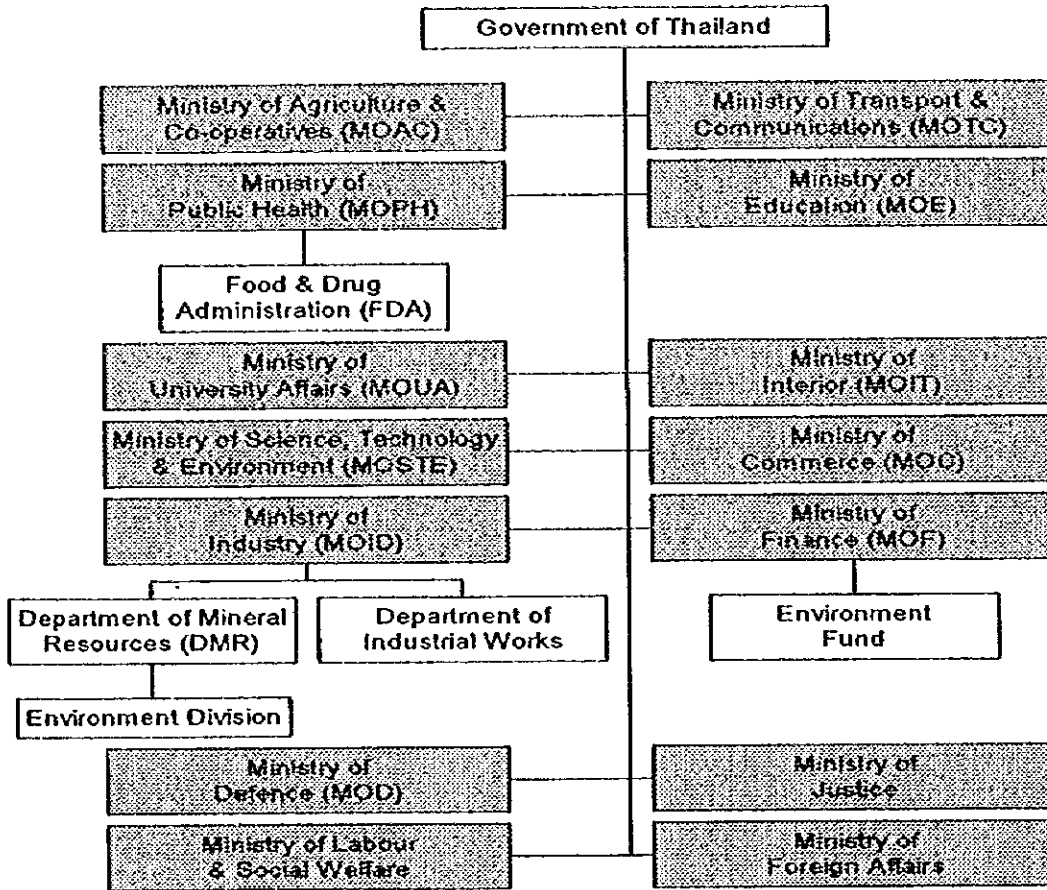


Figure 7.2. Ministry of Agriculture and Co-operatives (MOAC).

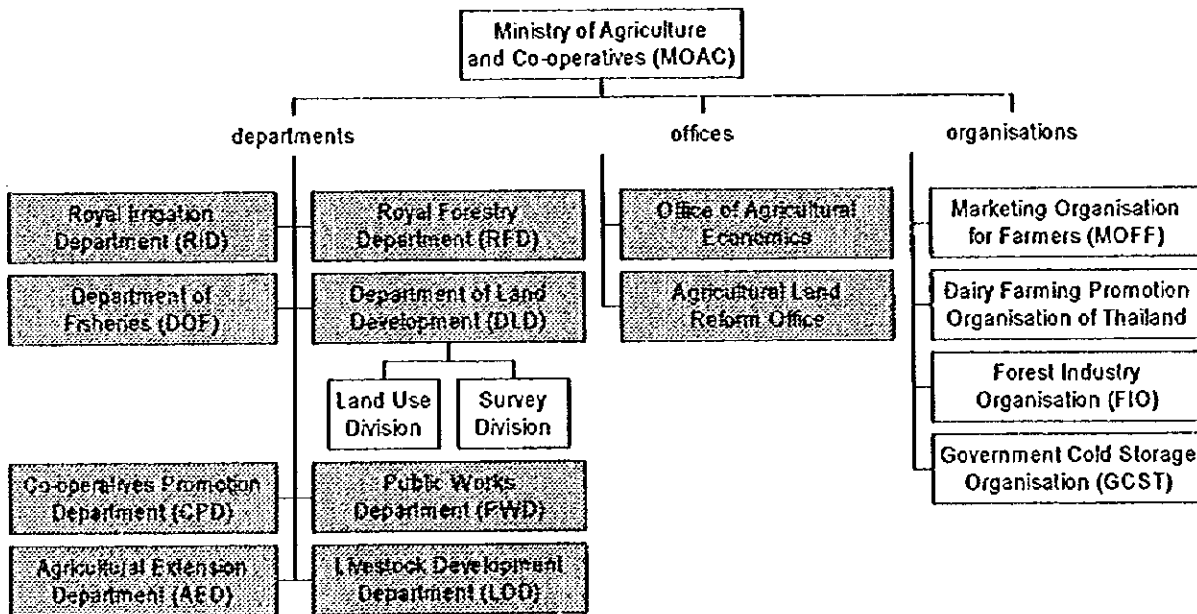


Figure 7.1. Government Ministries.

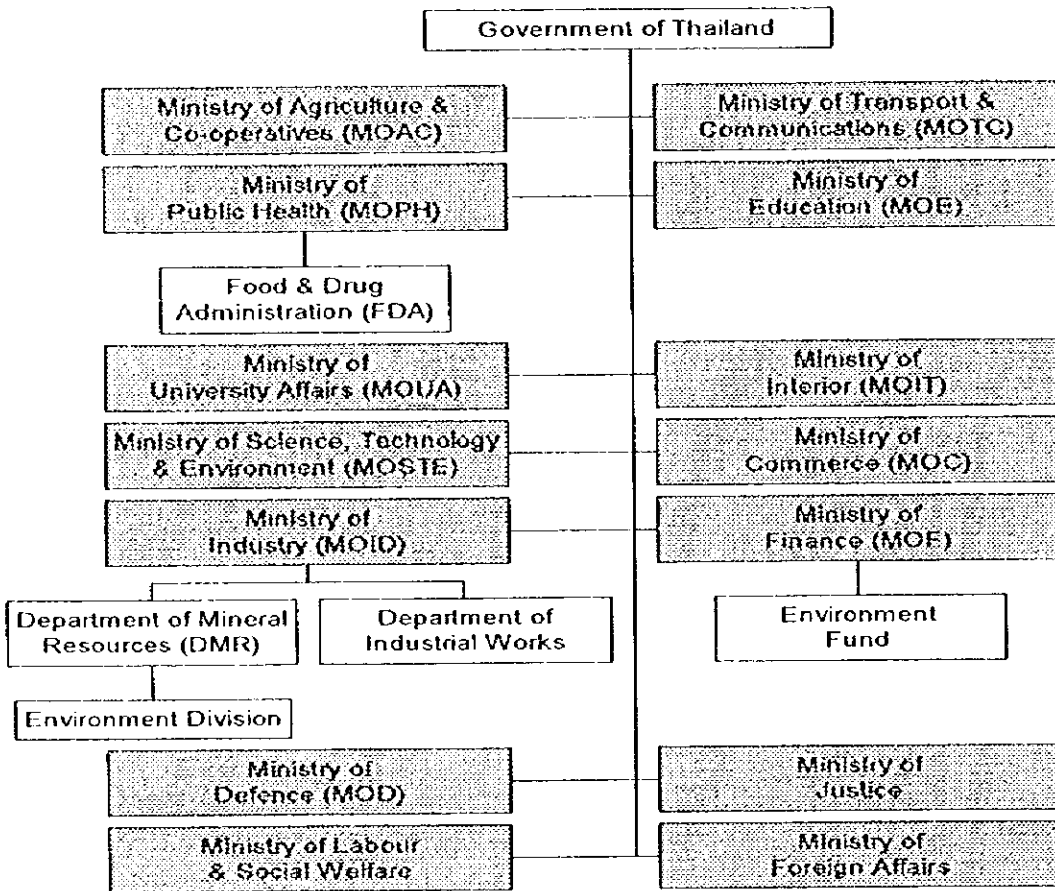


Figure 7.2. Ministry of Agriculture and Co-operatives (MOAC).

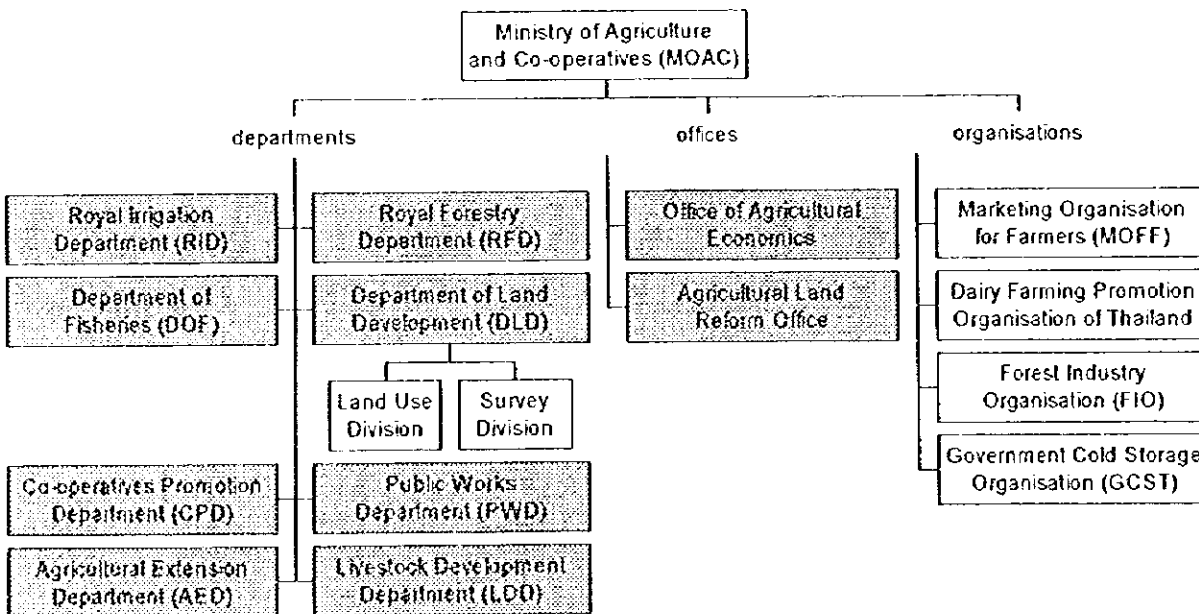


Figure 7.3. Ministry of Interior (MOI).

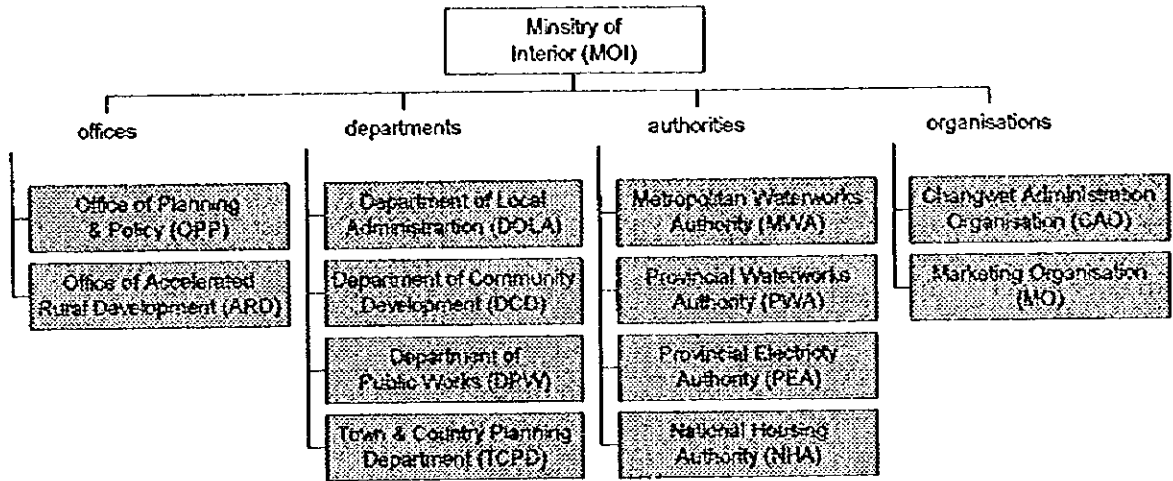


Figure 7.4. Ministry of Transport and Communications (MOTC).

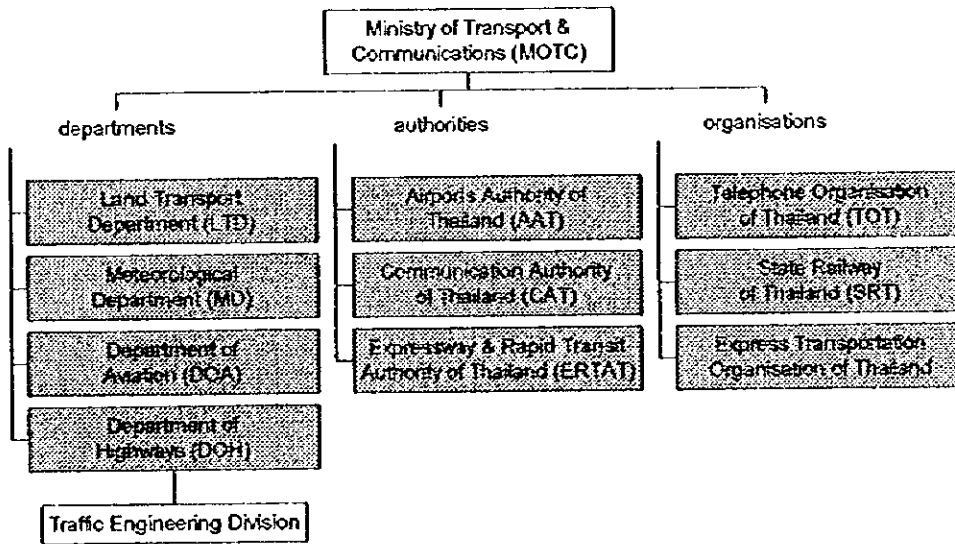


Figure 7.5. Office of Prime Minister.

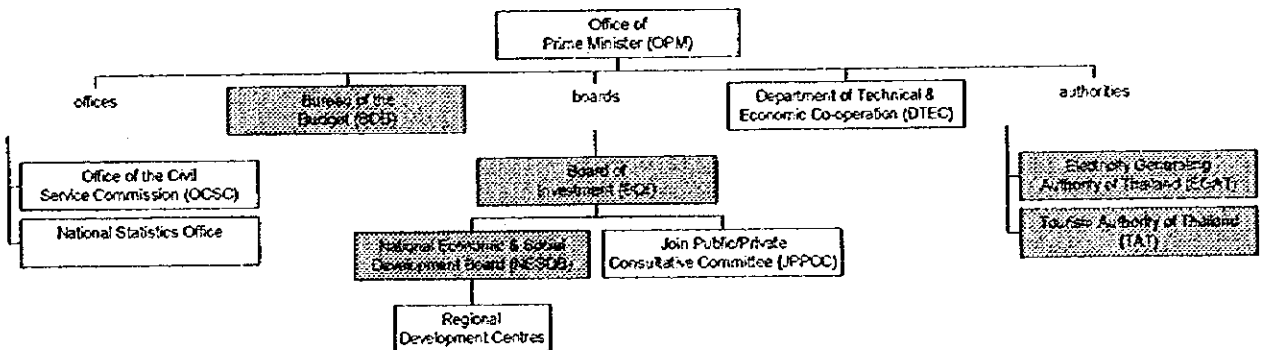


Figure 7.3. Ministry of Interior (MOI).

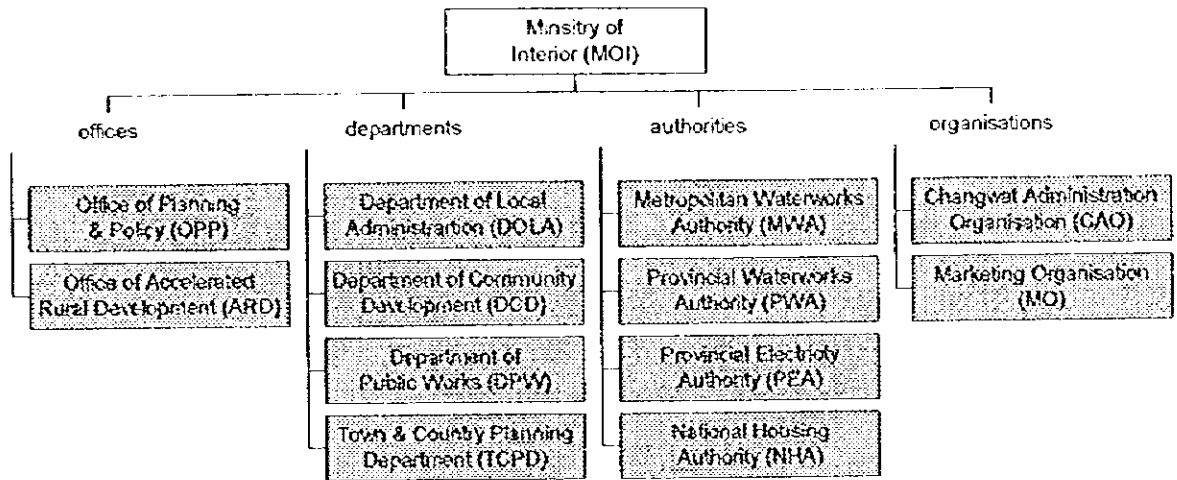


Figure 7.4. Ministry of Transport and Communications (MOTC).

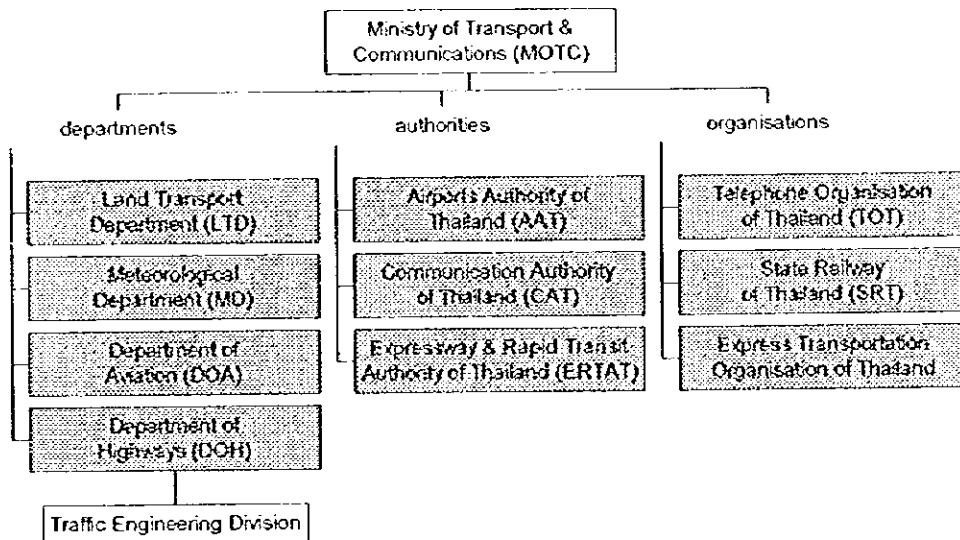


Figure 7.5. Office of Prime Minister.

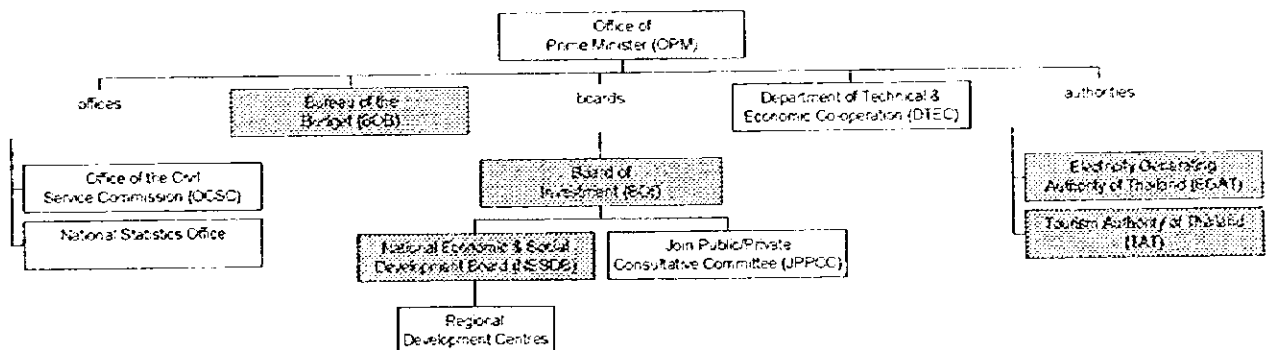


Figure 7.6. Ministry of Science, Technology and Environment (MOSTE).

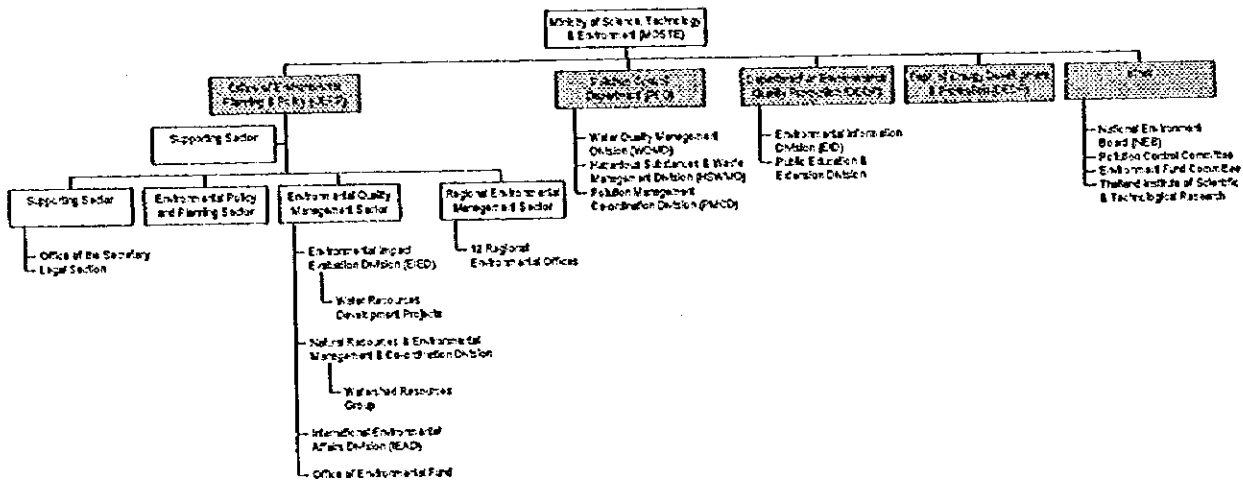


Figure 7.7. Ministry of Public Health (MOPH).

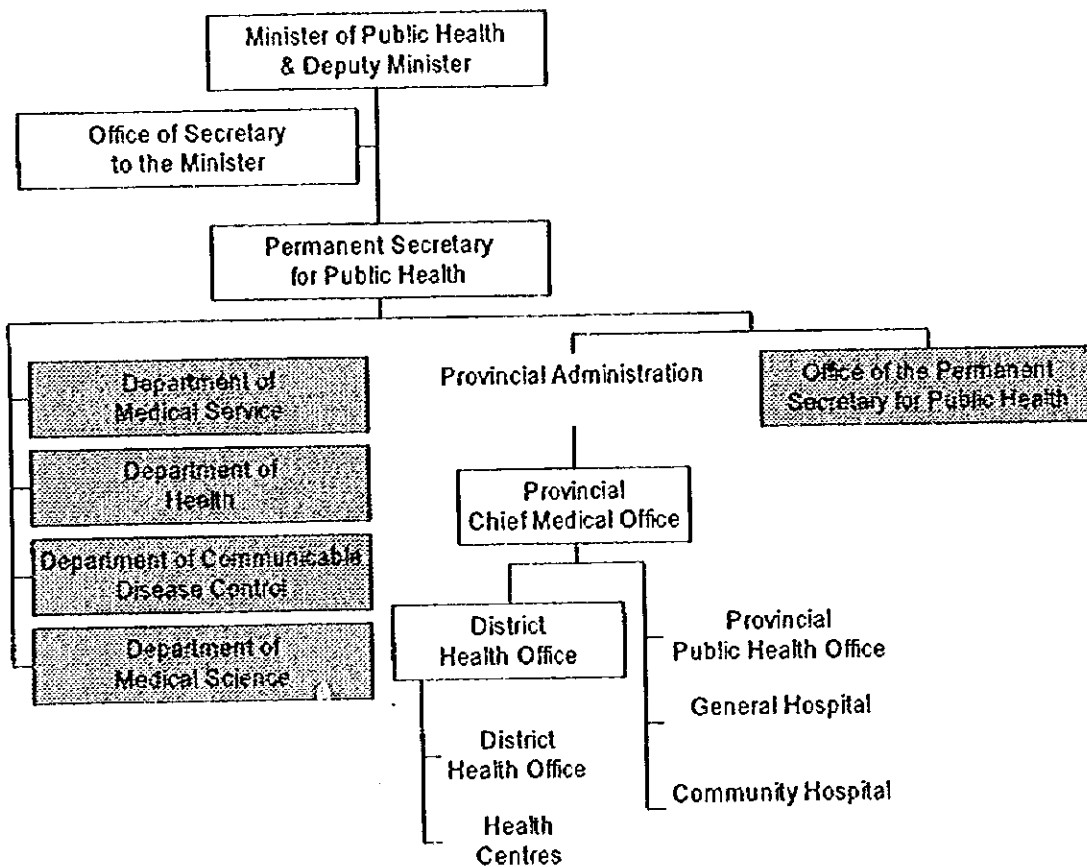


Figure 7.6. Ministry of Science, Technology and Environment (MOSTE).

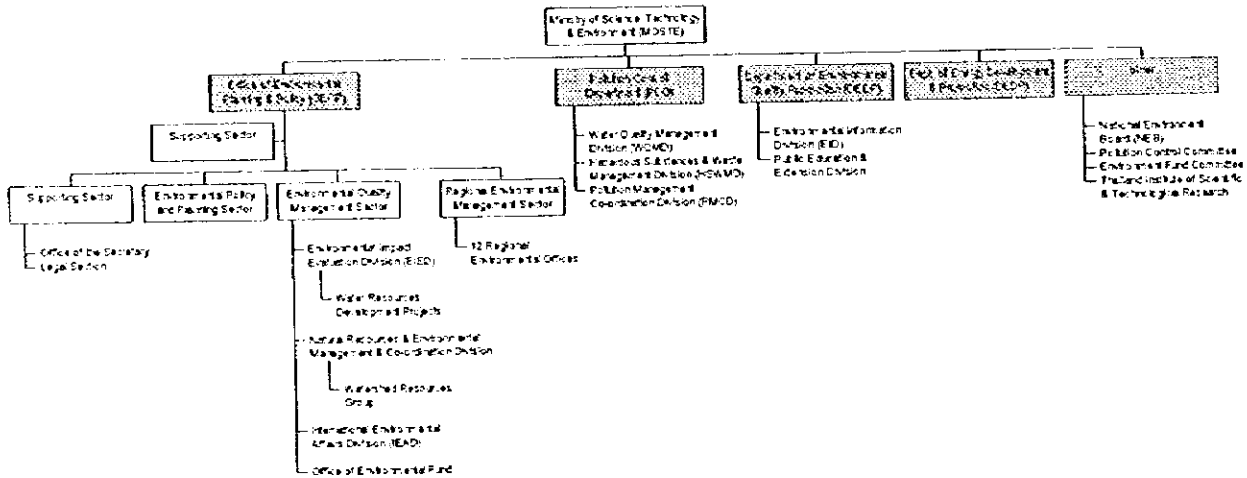


Figure 7.7. Ministry of Public Health (MOPH).

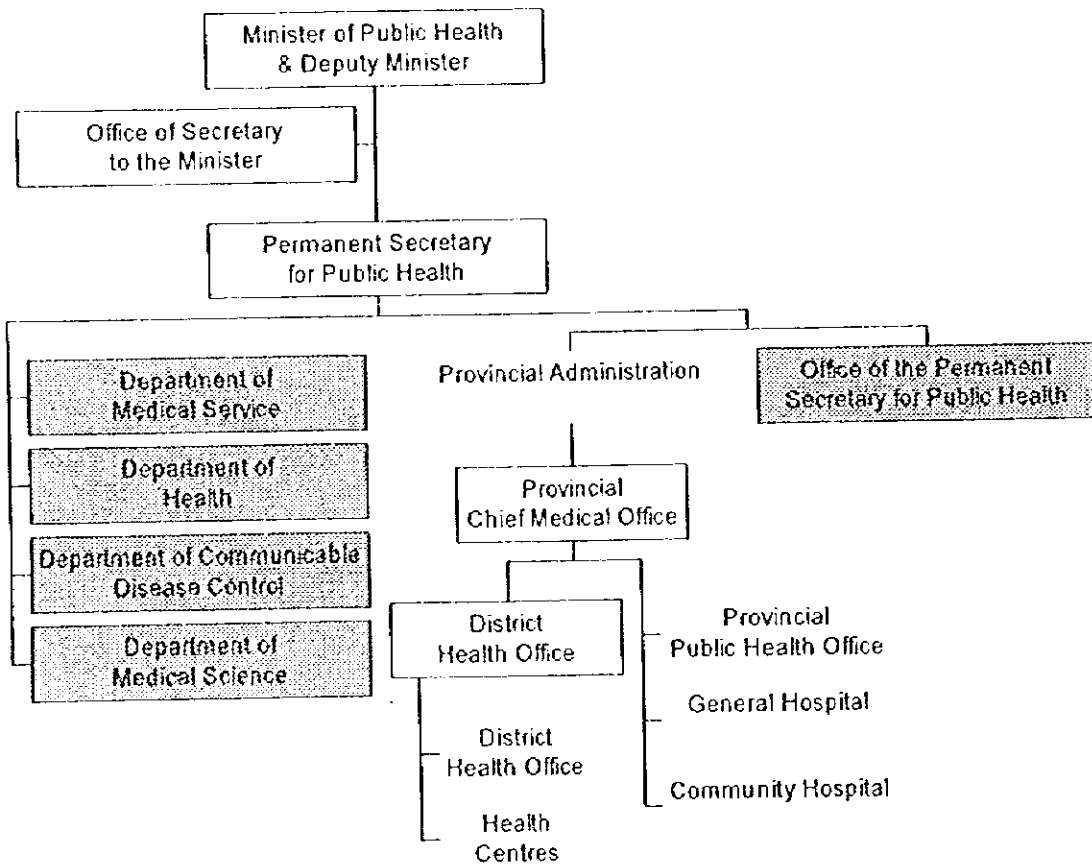


Figure 7.8. Provincial Government Structure (after Western Seaboard Regional Development Master Plan : Institutional Report, NK for JICA, June 1997, and Study on the Functions of Local Administration, OECF, March 1994).

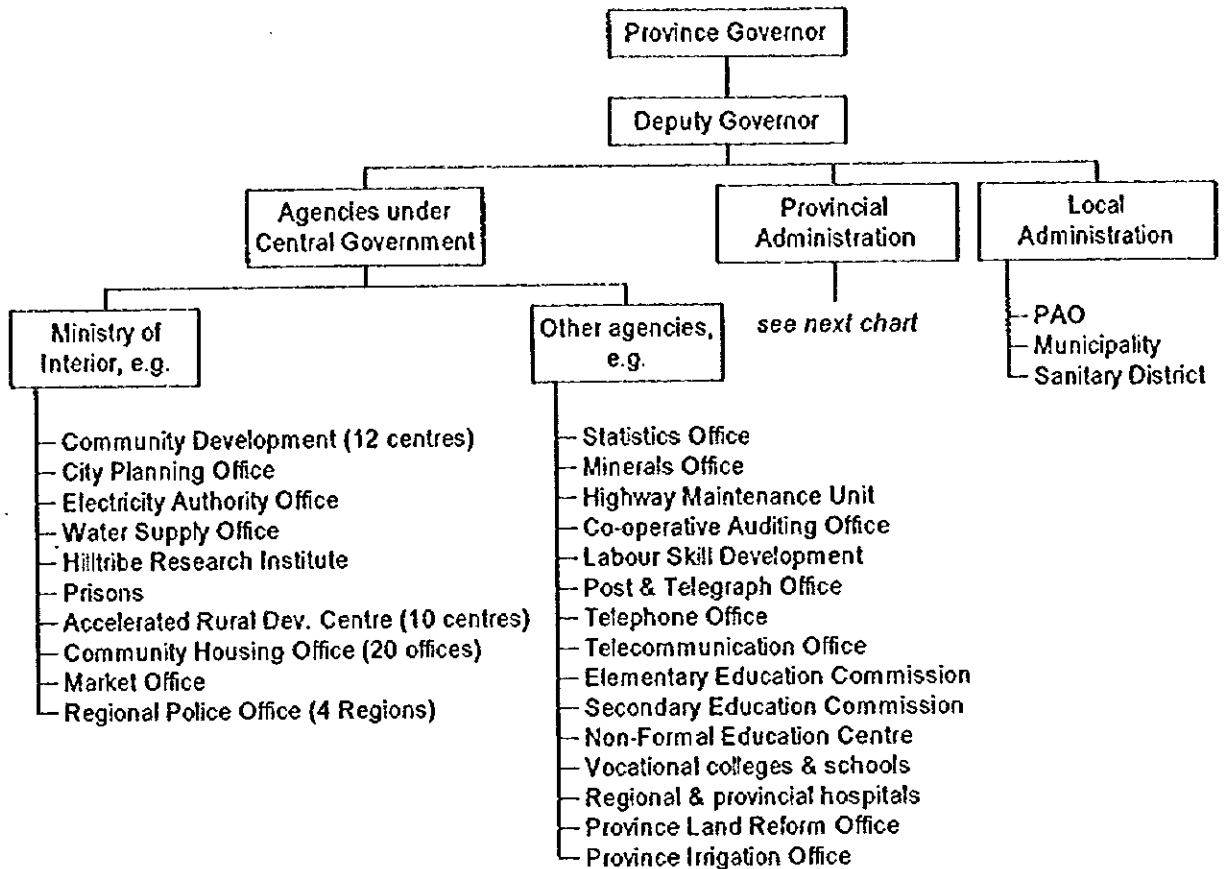
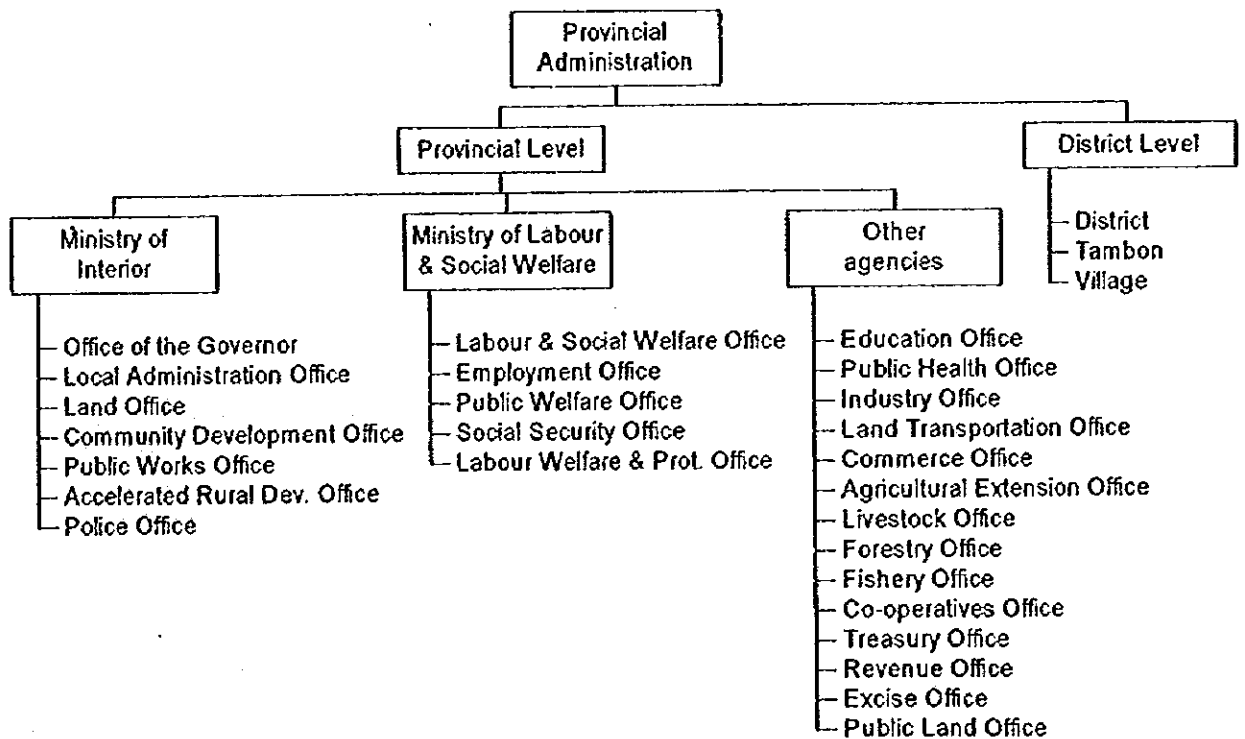


Figure 7.9. Provincial Administration.



7.9 Water User Organisations

Table 7.5. Comparison of the different types of water users organisation (Source: *A Guideline for WUO's Development* by Poolswat Duanduan, On-farm Water Management Branch, O&M Division, RID, 1992).

Characteristics	Water Users Group	Integrated Water Users Group	Water Users Association	Water Users Co-operative
Boundary	Command area of a single tertiary	Command area of a zone, a lateral (secondary canal) or the entire irrigation scheme	Command area of a zone, a lateral (secondary canal) or the entire irrigation scheme	Command area of a zone, a lateral (secondary canal) or the entire irrigation scheme
Area	16-160 ha	480 - 1,600 ha	480 - 1,600 ha	480 - 1,600 ha
Legal status	not legitimated	not legitimated	Civil & Commercial Code	Co-operatives Act, B.E. 2511 (1968)
Administrative structure	<ol style="list-style-type: none"> 1. Chairman with or without assistance. 2. Work under group agreements 	<ol style="list-style-type: none"> 1. Administrative board of 7-15 members plus a number of tertiary leaders. 2. Regulations not to be declared externally. 3. Group agreements are a subset of the regulations 	<ol style="list-style-type: none"> 1. Administrative board of 7-15 members plus a number of tertiary leaders. 2. Regulations to be declared to legitimation office (Governor) on request for registration. 3. Group agreements are a subset of the regulations. 	<ol style="list-style-type: none"> 1. Administrative board of 7-15 members plus a number of tertiary leaders. 2. Regulations drafted by the committee and concurred by the Co-operatives Promotion Department. 3. Group agreements are a subset of the regulations
Objectives	<ol style="list-style-type: none"> 1. On-farm water management within tertiary system. 2. Maintenance of on-farm irrigation systems including related structures 	<ol style="list-style-type: none"> 1. In conjunction with RID staff, allocate water up to secondary system. 2. Maintenance of tertiary systems, sometimes including secondary systems 	<ol style="list-style-type: none"> 1. In conjunction with RID staff, allocate water up to secondary system. 2. Maintenance of tertiary systems, sometimes including secondary systems 3. Agricultural inputs services provision, but not as a business 	<ol style="list-style-type: none"> 1. In conjunction with RID staff, allocate water up to secondary system. 2. Maintenance of tertiary systems, sometimes including secondary systems 3. Agricultural inputs provision business 4. Loan or credit provision 5. Other relevant activities for the benefit of the members

Characteristics	Water Users Group	Integrated Water Users Group	Water Users Association	Water Users Co-operative
Activities	<ol style="list-style-type: none"> 1. Crop scheduling (within tertiary) 2. Planning and control of water distribution. 3. Conducting maintenance activities 4. Message transfer 5. Issue of regulations 	<ol style="list-style-type: none"> 1. Crop scheduling up to secondary systems 2. Participation in planning of water allocation in secondary system 3. Plan and control water distribution in tertiary system 4. Maintenance of tertiary system 5. Issue of regulations 6. Conduct of elections of board members and group leaders 7. Prepare annual schedule of activities 8. Prepare meeting for committee and members 	<ol style="list-style-type: none"> 1. Crop scheduling up to secondary systems 2. Participation in planning of water allocation in secondary system 3. Plan and control water distribution in tertiary system 4. Maintenance of tertiary system 5. Issue of regulations 6. Conduct of elections of board members and group leaders 7. Prepare annual schedule of activities 8. Prepare meeting for committee and members 9. Agricultural inputs services provision but not as business 	<ol style="list-style-type: none"> 1. Crop scheduling up to secondary systems 2. Participation in planning of water allocation in secondary system 3. Plan and control water distribution in tertiary system 4. Maintenance of tertiary system 5. Issue of regulations 6. Conduct of elections of board members and group leaders 7. Prepare annual schedule of activities 8. Prepare meeting for committee and members 9. Agricultural inputs provision business 10. Loan, credit and deposit services business 11. Collect and distribute production of members to market 12. Farm machinery services 13. Agro-industrial services 14. Training of members

