KINGDOM OF THAILAND

PRE-FEASIBILITY REPORT

ON

RAILWAY CONSTRUCTION PROJECT

BANGKOK-MAE SOD

REPORT PREPARED IN CONNECTION
WITH THE TRANS-ASIAN
RAILWAY NETWORK PROJECT

DECEMBER 1972

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

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Preface

In response to the request made by ECAFE and the Government of Thailand, the Government of Japan decided to conduct the survey and study for the Railway Construction Project from Bangkok to Mae Sod, and entrusted the Overseas Technical Cooperation Agency (OTCA) with this task.

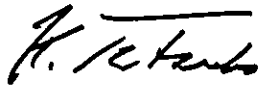
In view of the importance of the project, OTCA, expecting the cooperation of the Japan Railway Technical Service (JARTS), deputed its execution.

JARTS, thereupon, organized a survey team consisting of 8 members headed by Mr. Tokio Kondo, and sent them to Thailand for 30 days from November 1 to November 30, 1971 for the field survey chiefly of traffic demand, topography and existing railway facilities on the two proposed railway routes.

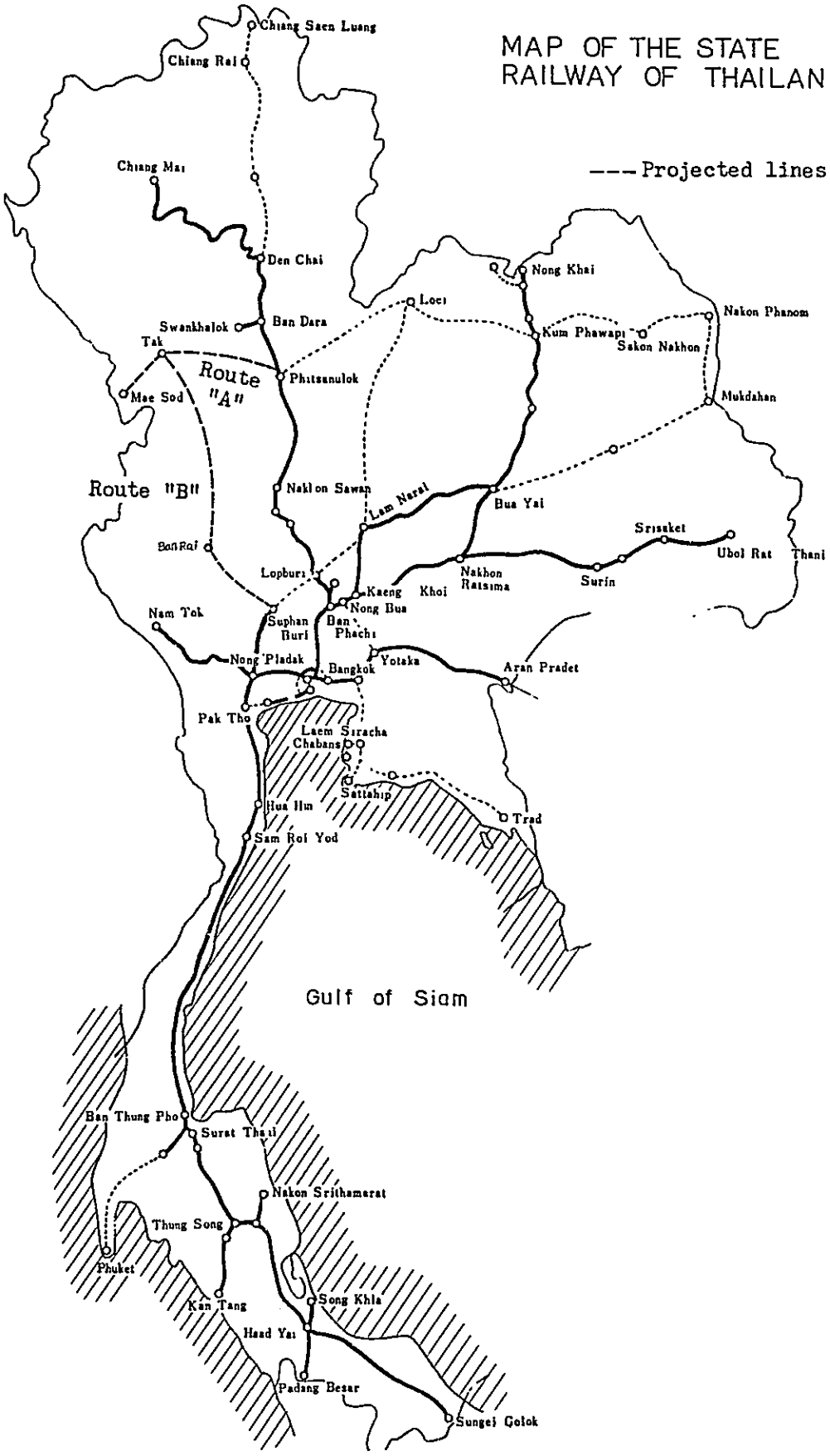
This report contains the results of the survey and study made by the team. We sincerely hope that it will contribute to the successful execution of the railway construction project of Thailand and serve to promote closer relationships between Thailand and Japan.

Finally, we would like to express our deep thanks to the ECAFE secretariat, the government agencies concerned to Thailand and the State Railway of Thailand for their kind assistance and cooperation extended to the survey team.

December 1972



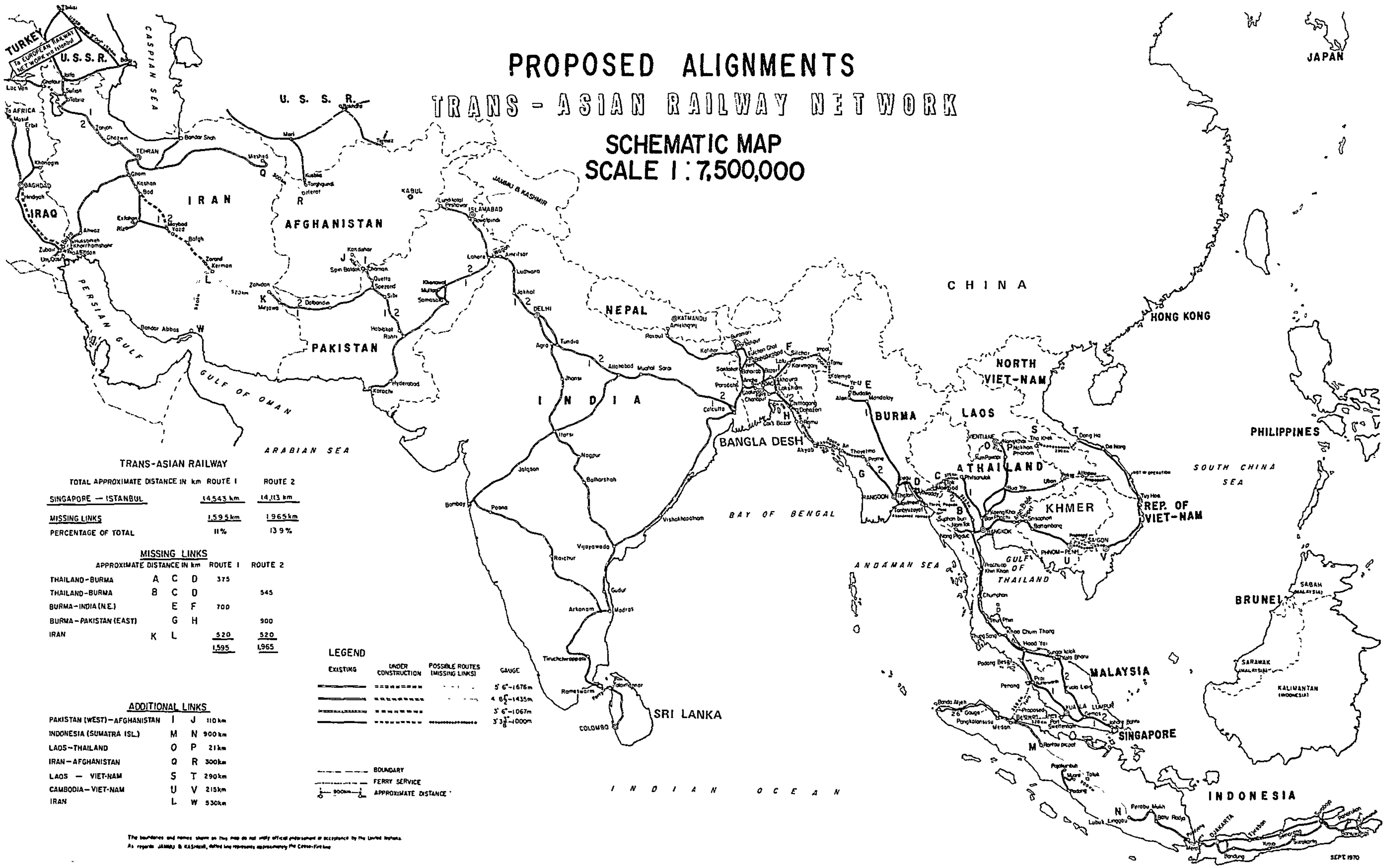
Keiichi Tatsuke,
Director General,
Overseas Technical Cooperation
Agency


MAP OF THE STATE
RAILWAY OF THAILAND
---Projected lines
Chiang Saen Luang
Chiang Rai
Chiang Mai
Den Chai
Swankhalok
Ban Dara
Tak
Route "A"
Phitsanulok
Mae Sod
Route "B"
Nakon Sawan
Lam Narai
Loei
Nong Khai
Nakon Phanom
Kum Phawapi
Sakon Nakhon
Mukdahan
Bua Yai
Srisaket
Ubol Rat Thani
Surin
Nakhon Ratsima
Khoi
Kaeng
Nong Bua
Ban Phachi
Lopburi
Ban Rai
Nam Tok
Suphan Buri
Nong Pladak
Bangkok
Yotaka
Aran Pradet
Pak Tho
Laem Sriracha
Chabans
Sattahip
Hua Hin
Trad
Sam Roi Yod
Gulf of Siam
Ban Thung Pho
Surat Thani
Nakon Srithamarat
Thung Song
Phuket
Kan Tang
Song Khla
Haad Yai
Padang Besar
Sungei Golok

PROPOSED ALIGNMENTS

TRANS - ASIAN RAILWAY NETWORK

SCHEMATIC MAP
SCALE 1 : 7,500,000



TRANS-ASIAN RAILWAY

TOTAL APPROXIMATE DISTANCE IN km	ROUTE 1	ROUTE 2
SINGAPORE — ISTANBUL	14,543 km	14,113 km
MISSING LINKS	1,595 km	1,965 km
PERCENTAGE OF TOTAL	11%	13.9%

MISSING LINKS

APPROXIMATE DISTANCE IN km				ROUTE 1	ROUTE 2
THAILAND-BURMA	A	C	D	375	
THAILAND-BURMA	B	C	D		545
BURMA-INDIA (N.E.)		E	F	700	
BURMA-PAKISTAN (EAST)		G	H		900
IRAN	K	L		520	520
				1,595	1,965

ADDITIONAL LINKS

PAKISTAN (WEST)—AFGHANISTAN	I	J	110 km
INDONESIA (SUMATRA ISL.)	M	N	900 km
LAOS—THAILAND	O	P	21 km
IRAN—AFGHANISTAN	Q	R	300 km
LAOS — VIET-NAM	S	T	290 km
CAMBODIA—VIET-NAM	U	V	215 km
IRAN	L	W	530 km

LEGEND

EXISTING	UNDER CONSTRUCTION	POSSIBLE ROUTES (MISSING LINKS)	GAUGE
			5' 6" - 1676 m
			4' 8½" - 1435 m
			3' 6" - 1067 m
			3' 3⅜" - 1000 m

BOUNDARY
FERRY SERVICE
APPROXIMATE DISTANCE

The boundaries and names shown on this map do not imply official endorsement or acceptance by the United Nations.
As regards JAMMU & KASHMIR, dotted line represents approximately the Cease-Fire line

Summary of Report

1. Purpose of Study and Its Outline

The purpose of the preliminary study for the railway construction project of Thailand is to select, from among the two proposed railway routes to be extended from an existing station on the State Railway of Thailand (RSR) toward the border line with Burma, namely, the Phitsanulok-Tak-Mae Sod route (Route "A") and the Suphanburi-Tak-Mae Sod route (Route "B"), the one more advantageous than the other technically and economically.

The Government of Thailand and ECAFE Secretariat requested the Japanese Embassy in Thailand (Bangkok), on April 22, 1971, to make this study. The Japanese Study Team stayed in Thailand from November 1 to November 30, 1971 and, meanwhile, made required studies and investigation for the selection of the proposed route, including field inspection trips in the areas along the proposed routes and collection of data, and, after making required study and discussions about the forecasted traffic demand, proposed train operation plans, proposed railway construction plans, economic advantageousness, etc. after returning to Japan, prepared this report.

2. Estimated Traffic Volume and Proposed Train Operation Plan

The volume of passenger traffic has been estimated, for each of the proposed routes, in the following manner:

The future population was estimated on the basis of populations of the respective provinces in 1970 by multiplying the national growth rate of 3.1% yearly. Then, the rate of population corresponding to the location, where the proposed route go through, was estimated, and the population presumed to be served by the proposed route was calculated considering the increase of 10% to be induced by this new route. And then, the number of passengers carried per year was calculated by multiplying the number of travels per capita during a year (1.36 times) by the population who is presumed to be served by the proposed route.

The volume of freight traffic has been estimated, for each of the pro-

Maximum track gradient:

Between stations	12 o/oo
Station yard	1.2 o/oo
Width of formation level:	4.75 m
Bearing capacity of bridge:	14 tons in axle weight
Weight of rail:	80 lb/yard
Construction gauge:	To be capable of letting International Container pass through.

4. Selection of Route

Route "A"

This proposed line is a single-track line for its whole section and branches off the Northern Line of RSR at a point near Phitsanulok (Kwae Noi Station), crosses Nan River into a wide paddy field area, runs toward west parallel to the Highway No.12, passes through the city of Sukhothai and, after going through another wide paddy field area for a while and crossing a hilly area, enters the city of Tak. Then, the line crosses Ping River, the longest river on the two proposed lines, and then enters a mountaineous area with a mean altitude of about 800 m, with two long tunnels, one 14.6 km long and the other 11.8 km long, both located on steep gradient with a maximum gradient of 12 o/oo. Then, Mae Sod is reached soon.

Its outline is as follows:

Route length:	196.0 km
– Roadbed:	166.1 km
– Bridges:	3.5 km
– Tunnels:	26.4 km (14.6 km and 11.8 km)
Stations:	23 stations
Block system:	Tokenless system

Route "B"

This proposed line is also a single-track railway, starting from Suphanburi Station on a local line branching from Nong Pladuk Junction of

posed routes, in the following manner:

First, all the figures for production obtained from data of the Provinces along and near the proposed routes, which we could collect, were converted to "ton". Then the future estimated tonnage of production of various commodities was calculated by multiplying, to above, 7% of annual increase, which is the annual rate of development of GDP planned in the 3rd Five-Year Plan of Thailand. Then, the ratio of share of railway (61%) was obtained from the freight traffic volumes of railway, road and waterway obtained at a representative check point near the proposed line. At the same time, the supposed ratio of freight which the proposed railway would share in each Province was determined. From the tonnage of annual production and ratios of share of railway freight transportation obtained in this way, the total annual volume of freight transportation has been calculated.

It may be noted that when the new line is extended into the Burman territory, the international transportation is expected via the new line. Therefore, an additional freight traffic volume based on the international freight traffic volume submitted by Mr. M. N. Bery at the Working Party of Experts on the Trans-Asian Railway held at Bangkok in October 1970 was added to above to obtain the total estimated freight traffic volume on the proposed routes. But, the international freight transportation should be further investigated.

The train operation plans have been made against the estimated passenger traffic volume and freight traffic volume calculated above, supposing 8-car passenger coach-trains would be used for passenger transportation (4-car trains between Tak and Mae Sod) and 50-freight car trains for freight transportation (40-freight car trains between Tak and Mae Sod), partly supplemented by mixed trains.

3. Construction Standards of New Line

In selecting the porposed route of the new railway and planning its construction, the following standards have been employed to let the new line have a character as the Trans-Asian Railway Network:

Track gauge:	1.00 m
Minimum radius of track curvature:	400 m

Maximum track gradient:	
Between stations	12 o/oo
Station yard	1.2 o/oo
Width of formation level:	4.75 m
Bearing capacity of bridge:	14 tons in axle weight
Weight of rail:	80 lb/yard
Construction gauge:	To be capable of letting International Container pass through.

4. Selection of Route

Route "A"

This proposed line is a single-track line for its whole section and branches off the Northern Line of RSR at a point near Phitsanulok (Kwae Noi Station), crosses Nan River into a wide paddy field area, runs toward west parallel to the Highway No.12, passes through the city of Sukhothai and, after going through another wide paddy field area for a while and crossing a hilly area, enters the city of Tak. Then, the line crosses Ping River, the longest river on the two proposed lines, and then enters a mountaineous area with a mean altitude of about 800 m, with two long tunnels, one 14.6 km long and the other 11.8 km long, both located on steep gradient with a maximum gradient of 12 o/oo. Then, Mae Sod is reached soon.

Its outline is as follows:

Route length:	196.0 km
– Roadbed:	166.1 km
– Bridges:	3.5 km
– Tunnels:	26.4 km (14.6 km and 11.8 km)
Stations:	23 stations
Block system:	Tokenless system

Route "B"

This proposed line is also a single-track railway, starting from Suphanburi Station on a local line branching from Nong Pladuk Junction of

the Southern Line of RSR. It advances toward north-west passing through a paddy field area and, after going through Don Chedi and a mixed upland plantation and hilly area, reaches Ban Rai. From there, the line turns its direction toward north, runs through or along the foot of hilly areas and table land, and reaches Tak on the right bank of Ping River. From Tak, the line advances to Mae Sod taking the same route as Route "A".

Its outline is as follows:

Route length:	377.0 km
– Roadbed:	346.1 km
– Bridges:	4.5 km
– Tunnels:	26.4 km (14.6 km and 11.8 km)
Stations:	32 stations
Block system:	Tokenless system

5. Cost and Period of Construction

The costs of construction have been calculated, on the time point of 1972, based on the standard cost of construction of the similar railways in Japan and adjusting them taking into consideration various situations and conditions in Thailand supposed to affect construction of the proposed line.

The periods of construction to be required, too, have been calculated mostly based on the data for construction of similar railways in Japan. Especially for the tunnels located between Tak and Mae Sod, whose period of construction governs the period of construction for the whole section of the proposed line, their period of construction has been estimated solely on the data in Japan, as there are no such long tunnels ever built in Thailand.

Estimated cost of construction:

Route "A"

Phitsanulok – Tak (134 km):	428.7 million Baht
Tak – Mae Sod (62 km):	751.7 million Baht
Total (196 km):	1,180.4 million Baht

Route "B"

Suphanburi – Tak (315 km):	722.9 million Baht

Tak – Mae Sod (62 km): 751.7 million Baht

Total (377 km): 1,474.6 million Baht

Estimated period of construction:

Route "A": 7 years

Route "B": 7 years

6. Economic Calculation

The economic calculation has been made based on the estimated traffic volume, construction cost and its period, rolling stock cost, additional investment, revenue, expenditure, interest rate, etc. by the Discounted Cash Flow Method.

7. Result of Study and Recommendation

(1) After making economic calculation for the two proposed routes, it has been determined that Route "B" is economically more advantageous than Route "A", because Route "B" passes through undeveloped areas rich in resources and is lower than Route "A" in the unit cost of construction.

(2) By the completion of the proposed new railway line, various national and people's interests such as regional development, social benefit and public peace are expected to be obtained.

(3) However, utmost attention should be directed to the fact that the construction of the proposed new railway line can be realized only when it is planned and constructed in close harmony with and in parallel to an overall areal economic and social development plan for the area concerned.

(4) As for that part of the proposed route between Tak and Mae Sod, route selecting study has been made for 2-3 routes, and, it has been determined that the straight line route passing two tunnels (14.6 km and 11.8 km) is the best route in terms of cost of construction, train operation expense, maintenance expense, etc. Its construction is fully technically possible judging from tunnel construction works experienced in Japan.

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1. Introduction

1.1 Outline of the Project

The State Railway of Thailand (RSR) has proposed two routes, one from Phitsanulok to Mae Sod via Tak and another from Suphanburi to Mae Sod via Tak, to extend its line to the border of Thailand and Burma. This survey was conducted as a preliminary investigation with the object of selecting more advantageous route, both technically and economically, from these routes based on the comparative study on the estimated demands for transportation of the both lines, the reconnaissance of the routes, and the examinations of the existing railway facilities and other transportation agencies.

By the letter dated April 22, 1971, addressed to the Japanese Embassy in Bangkok from the Secretariat of ECAFE, the Japanese Government was requested formally to conduct the survey of the said two routes which the Thai Government had required the advanced countries to undertake it through ECAFE.

In compliance with the request, Government of Japan demanded the Japan Overseas Technical Cooperation Agency to conduct the survey and the latter entrusted the Japan Railway Technical Service with the task en bloc.

This Railway Construction Project in Thailand contemplates to build a line to connect RSR to the Burmese railway as a part of the Trans-Asian Railway Network and the two routes have been proposed as follows:

Route "A": The line branches off a point near Phitsanulok, 389 km from Bangkok on the Northern Line, and extends westward for about 200 km via Tak to Mae Sod on the border of Thailand and Burma; the line is planned to be connected to Thaton in Burma.

Route "B": The line goes up north from Suphanburi (the terminal station of the local line of 78 km branching off Nong Pladuk on the Southern Line of RSR) approximately in parallel with the Northern Line to Tak from where the same line as Route "A" is followed to reach Mae Sod, with the total length of 380 km.

Though the length of Route "B" is longer than that of Route "A" by about 180 km, the areas along the route are rich in materials and the

construction of railway to serve them has been demanded as a part of the regional development.

Also, either route is expected to contribute to the exploitation of mineral resources in the vicinity of Mae Sod as well as to serve as a connecting line to the Burmese railway.

The section from Tak to Mae Sod common to Routes "A" and "B" runs through mountainous country, with the remaining section generally passing a flat land.

1.2 Sending of Survey Team

1.2.1 Organization of Survey Team

Tokio KONDO	Chief of team	Deputy Superintendent, Structure Design Office, Japanese National Railways
Hisao KOYAMA	Transportation economy	Deputy Director, Administration Division, Private Railways Dept., Railway Supervision Bureau, Ministry of Transport
Yoshio YAMAGUCHI	Transportation economy	Assistant Director, Planning Division, New Trunk Line Construction Dept., Japanese National Railways
Seiichi YUZAWA	Civil engineering	Assistant Director, Planning Division, Construction Dept., Japanese National Railways
Norio HANAZAWA	Train operation	Assistant Director, Planning Division, Train Operation Dept., Japanese National Railways
Kazuo YOSHIE	Civil engineering	Assistant Director, 1st Station & Yard Division, Construction Dept., Japanese National Railways
Takao TOTTORI	Civil engineering	Chief, SHIOHAMA Railway Construction Dept., Japan Railway Construction Public Corporation

Eiichi MUTSURO	Co-ordinator	Staff of Development Surveys Department, Overseas Technical Cooperation Agency

The Survey Team stayed in Thailand from 1st to 30th of November, 1971, to arrange with the Secretariat of ECAFE and the executives of RSR, to collect the necessary data and to survey the proposed routes.

1.2.2 Outline of Survey

(1) The items of survey to be conducted on the spot were determined as follows:

(a) Basic investigation of demand for transportation:
Population, industry, development plan, and land use plan.

(b) Investigation of various types of transportation:
Road, and waterway.

(c) Investigation of existing railway lines:
Specifications, Standards, rolling stock, and present state of and future plan for facilities.

(d) Survey of routes:
Geology, climate, and reconnaissance for route selection.

(e) Investigation of basic data relating to construction:
Wages, and investigation of construction materials.

(2) The items of work to be carried out in Japan after the survey on the spot having been completed were determined as follows:

(a) Presumption of demand for transportation.

(b) Formulation of transportation plan.

(c) Establishment of construction plan.

(d) Determination of standards for various facilities.

(e) Examination of economics and benefit of the two routes.

(f) Comparative study of the two routes.

1.2.3 Diary of Survey

Date	Time	Means of Travel	Activities	Stayed at
1971 Nov. 1 (Mon)	12.00	JAL 461	Left Tokyo.	
	17.50		Arrived in Bangkok	Bangkok
2 (Tue)	10.00-10.30		Had a talk with Chief of Transport & Communications Division, Chief of Railway Section and other persons, ECAFE.	
	11.00-11.40		Had a talk with Mr. Seki, 1st-class Secretary, Japanese Embassy, and other persons.	
	11.50-12.10		Had a talk with Mr. Miyamoto, Head of Overseas Office in Bangkok and other persons, OTCA.	
	14.00-16.30		Made an arrangement for the survey schedule and other matters at RSR Head Office.	Bangkok
3 (Wed)	9.30-10.00		Had a talk with General Manager, Deputy General Manager, and executives of RSR.	
	10.00-16.30		Made preparation and collected data for the field survey at RSR Head Office.	Bangkok
4 (Thu)	9.00-17.00		Made route selection on the map of scale, 1:50,000 and data collection at RSR Head Office.	Bangkok
5 (Fri)	9.00-17.00		The same as above.	
6 (Sat)	9.00-12.00		Made preparation for the field survey.	Bangkok
7 (Sun)		Train	Holiday. Left Bangkok at 17.05.	Train

Date	Time	Means of Travel	Activities	Stayed at
8 (Mon)		Train	Investigated the condition of track; arrived in Chiang Mai at 9.55.	Chiang Mai
9 (Tue)			Investigated the railway facilities, left Chiang Mai at 13.00.	
		Train	Arrived in Phitsanulok at 22.15.	Phitsanulok
10 (Wed)	8.00-10.30	Motor-car	Investigated the stations of Ban Teng-nam, Ban Tum, Kwae Noi, and Phrom Phiram on the Northern Line (50 km in distance).	
	12.30-17.20	Auto-mobile	Surveyed the proposed route of Phitsa-nulok - Sukhothai - Tak (194 km in distance).	Phumiphol Dam
11 (Thu)	8.40-16.30	Auto-mobile	Surveyed the proposed route from the city of Tak to Mae Sod (185 km in distance).	Mae Sod
12 (Fri)	9.00-16.00	Auto-mobile	Surveyed the proposed route from Mae Sod to Tak (213 km in distance).	Phumiphol Dam
13 (Sat)	8.50-17.00	Auto-mobile	Surveyed the section from 195 km point to 378 km point of the proposed route between Suphanburi and Tak (291 km in distance).	Nakhon Sawan
14 (Sun)			Holiday.	Nakhon Sawan
15 (Mon)	8.30-17.30	Auto-mobile	Surveyed the section from 96 km point to 195 km point of the proposed route between Suphanburi and Tak (291 km in distance).	Chao Phraya Dam
16 (Tue)	9.00-17.30	Auto-mobile	Surveyed the section from Suphanburi to 96 km point (237 km in distance).	Suphanburi
17 (Wed)			Investigated the station facilities of Suphanburi.	
		Train	Left Suphanburi at 10.30; investigated the track condition of the Suphanburi Line.	Bangkok

Date	Time	Means of Travel	Activities	Stayed at
18 (Thu)	9.00-17.00		Had a discussion on the results of field survey at RSR Head Office. Prepared route plan and route profile; collected data.	Bangkok
19 (Fri)	9.00-17.00		Prepared route plan and route profile; made construction work quantity calculation and construction cost estimate; collected data.	Bangkok
20 (Sat)	9.00-12.00		Made construction work quantity calculation and construction cost estimate.	Bangkok
21 (Sun)			Holiday.	Bangkok
22 (Mon)	9.00-17.00		Prepared primary report, collected data.	Bangkok
23 (Tue)	9.00-17.00		The same as above.	Bangkok
24 (Wed)	9.00-17.00		The same as above.	Bangkok
25 (Thu)	9.00-12.00		The same as above.	
	14.00 15.00		Explained about the primary report to the Japanese Embassy.	Bangkok
26 (Fri)	9.30-11.00		Explained about the primary report to Deputy General Manager and other executives of RSR.	Hua Hin
27 (Sat)			Holiday	Hua Hin
28 (Sun)			Holiday	Bangkok
29 (Mon)	10.20-11.20		Explained about the primary report to Chief of Transport & Communications Division, Chief of Railway Section and other persons, ECAFE.	

Date	Time	Means of Travel	Activities	Stayed at
29 (Mon)	11.40-12.00		Paid a visit of courtesy to the Japanese Embassy.	
	14.30-15.00		Paid a visit of courtesy to the executives of RSR.	Bangkok
30 (Tue)	12.15	JAL 714	Left Bangkok.	
	21.00		Arrived in Tokyo.	

1.2.4 Principal Persons Concerned

(1) ECAFE (Economic Commision for Asia and Far East)

Mr. S. M. Husain:	Chief, Transport and Communication. Division.
Mr. M. E. Saleh:	Chief, Railway Section.
U. Shwe Shane:	Regional Railway Network Adviser.
Mr. U. Warnemunde:	Railway Expert.
Mr. M. F. Lõhr:	Railway Expert.

(2) State Railway of Thailand

Mr. Ahna Ramyananda:	General Manager.
Dr. Chaovana Na Sylvanta:	Deputy General Manager (Engineering).
Mr. Charat Phaipradisht:	Chief Civil Engineer.
Mr. Prachoom Annavadhana:	Deputy Chief Civil Engineer.
Mr. Siri Fookiart:	Deputy Chief Civil Engineer.
Mr. Pojana Nagawajara:	Assistant Traffic Manager.
Mr. Yong Chantharangkun:	Construction Expert.
Mr. Chalit Siripak:	Superintending Engineer, Construction Division.
Mr. Siri Pipitsombat:	Civil Engineering, Planning Section.
Mr. Choti Rochanavipart:	District Engineer, Lampang (Northern Line).
Mr. Vanich Pansuwan:	Assistant Engineer, Planning Section.
Mr. Thavee Thongpan:	Assistant Engineer, Bridge Section.

2. Present Situation of the Areas along the Proposed Routes

2.1 Industry

The area between Phitsanulok and Tak abounds in paddy fields with rice cultivation being carried on and in mineral resources of which future exploitation is expected.

As the area between Tak and Mae Sod is a mountainous district, it produces only small amount of agricultural products. However, the area is rich in resources including forest products such as teak and minerals such as zinc, oil, barytes and gold which have not been developed as yet and their future exploitation is anticipated. Furthermore, as no through investigation of mineral resources having been conducted, there is a chance for the discovery of other rich mineral deposits.

The area near Suphanburi is a great granary where large amount of rice is produced. Forest products and mineral resources have been found in the skirts of mountains and the plateaus between Suphanburi and Tak, and their development is expected. At present, tin is produced near Ban Rai, and the investment procedure of mining by private company for zinc mine at Tambol Pha Daeng. Amphoe Mae Sod in Tak, is executing.

2.2 Climate

The climate is typical of tropical monsoon climate, having rainy season from May to October and dry season from December to April. The monthly average temperatures by districts are 26°C for the northern, 27°C for the middle and 28°C for the southern districts and the highest temperature which occurs in April rises to 40°C. Many areas have the annual precipitation ranging from 1,000 to 1,500 mm, while the mountain areas have about 2,000 mm and in some areas on the west coast of Malay Peninsula the precipitation exceeds 4,000 mm.

Annual precipitation and maximum daily precipitation of main points along the proposed routes are shown in Table 2.1.

2.3 River

The Chao Phraya River which is the principal river in Thailand flows traversing the center of the country; the Mun and Chi River flow through the north-eastern district and many waterways run through the whole country.

Table 2.1 Precipitation

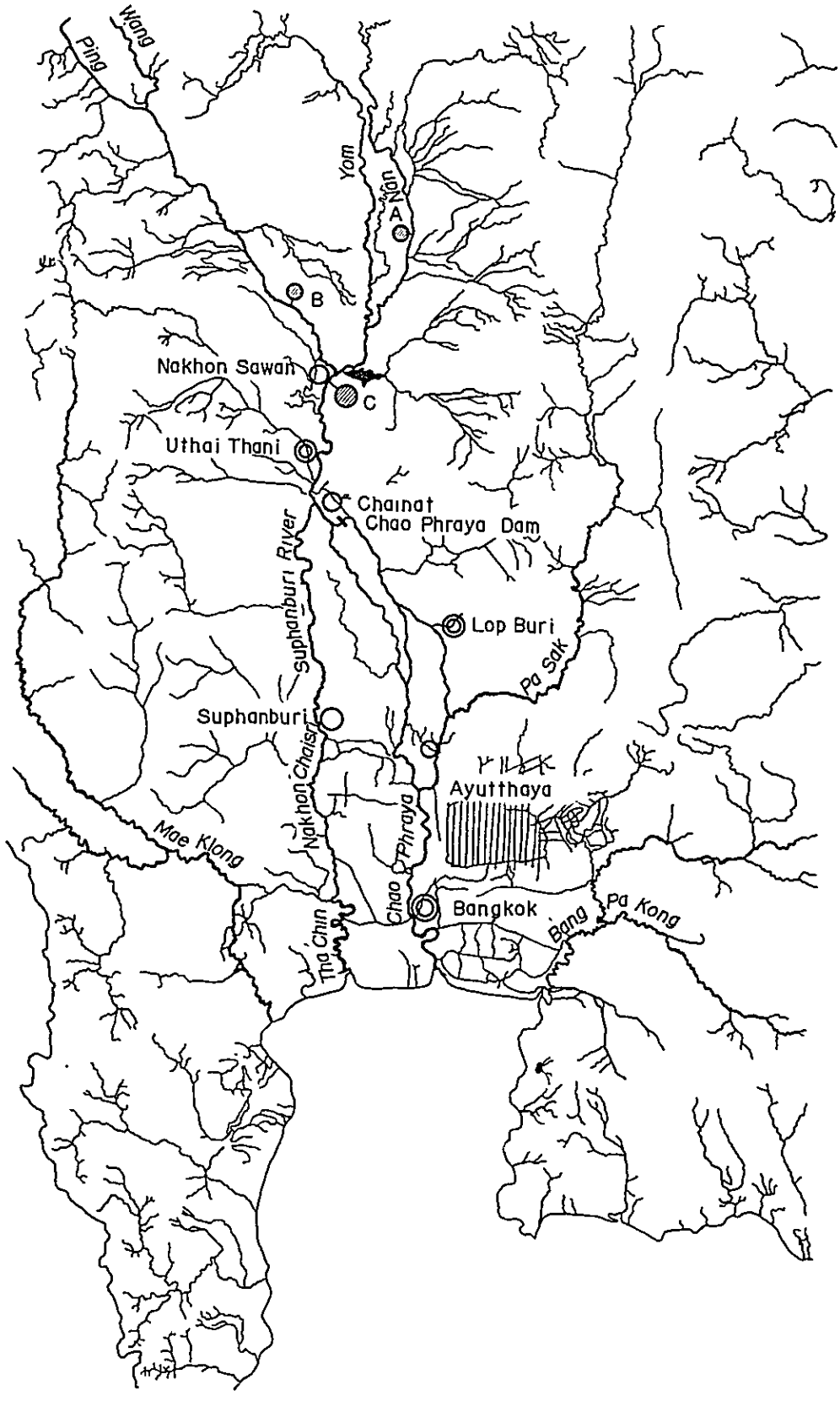
Month	Rainfall (mm)					
	Total		Max. in 24 hours		Days of rain	
	1966	1967	1966	1967	1966	1967
	Phra Nakhon Lat. 13° 44' N Long. 100° 30' E					
January ...	–	6.3	–	5.7	–	3
February	35.2	–	31.5	–	3	–
March	1.3	4.2	1.3	3.8	1	2
April	72 0	67.6	42.6	19.9	4	12
May	380.8	235.9	124.2	54.1	22	21
June	214.6	28.0	44.7	10.5	22	9
July	314.7	114.7	97.0	42.9	22	19
August	156.9	121.0	25.5	23.8	24	18
September... ...	257.4	165.1	101.2	33.2	20	20
October	191.3	96.6	51.9	22.6	15	13
November	4.2	36.2	2.6	17.4	3	5
December	39.2	–	17.1	–	5	–
	Nakhon Sawan Lat. 15° 48' N Long. 100° 10' E					
January	51.4	–	37.4	–	4	–
February	22.4	1.6	16.4	1.6	2	1
March	18.1	4.4	10.9	4.4	3	1
April	50.7	109.7	20.8	34.2	4	8
May	135.7	102.6	19.5	47.5	20	10
June	122.0	71.5	43.2	27.2	15	11
July	103.6	79.0	28.4	27.5	18	11
August	225.6	157.1	43.3	49.9	19	16
September... ...	181.3	345.6	40.2	85.4	17	25
October	335.3	113.8	99.9	27.0	14	11
November	132.2	90.9	121.6	72.2	3	5
December	60.6	–	45.6	–	2	–
	Chiang Mai Lat. 18° 47' N Long. 98° 59' E					
January	3.6	6.2	2.7	6.2	3	1
February	0.3	–	0.3	–	1	–
March	–	2.1	–	1.2	–	2
April	7.5	32.2	4.2	13.1	2	6
May	140.8	108.8	22.8	45.3	18	16
June	56.4	173.6	22.9	37.0	12	19
July	204.2	200.5	35.7	51.3	21	15
August	236.7	144.7	29.2	32.9	26	14
September... ...	131.4	529.6	27.6	131.6	18	27
October	77.7	54.9	34.3	29.0	8	10
November	5.8	97.8	2.0	44.9	5	8
December	0.5	3.7	0.5	3.7	1	1

Statistical Yearbook No. 28 (1967-1969)

The target areas of the present survey are the basins of relatively big rivers including Ping, Wang, Yom and Nan which are the tributaries of the Chao Phraya River. These rivers have great quantity of water and are maintained in good condition, but the smaller rivers are not so well controlled.

The discharges by months observed at the principal points on the Chao Phraya River are shown in Fig. 2.1 – 2.4. These data indicate the characteristics of the river.

Fig. 2.1 Waterways in Thailand



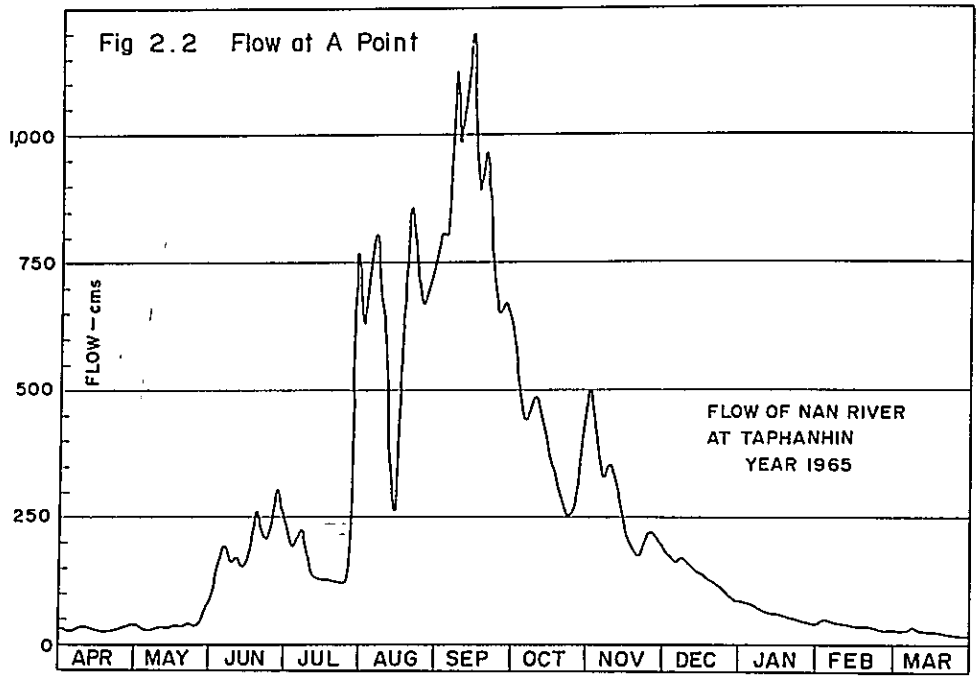


Fig 2.2 Flow at A Point
1,000
750
500
250
0
FLOW – cms
FLOW OF NAN RIVER
AT TAPHANHIN
YEAR 1965
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR

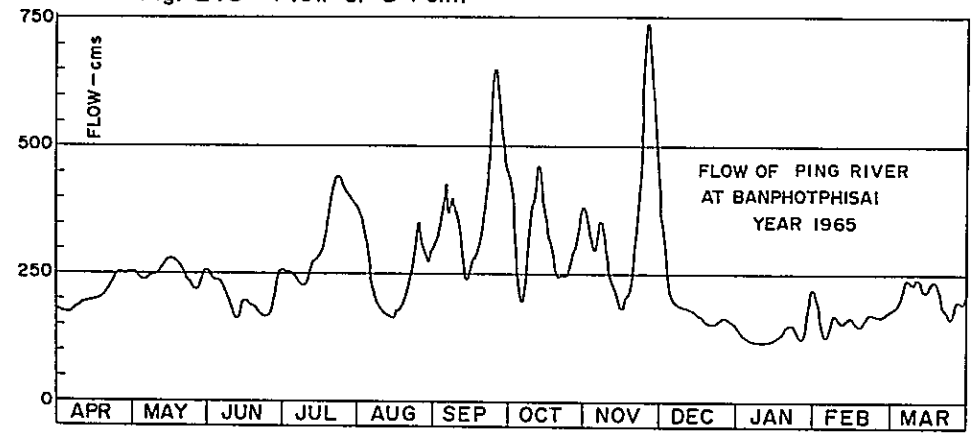


Fig. 2.3 Flow at B Point
750
500
250
0
FLOW – cms
FLOW OF PING RIVER
AT BANPHOTPHISAI
YEAR 1965
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR

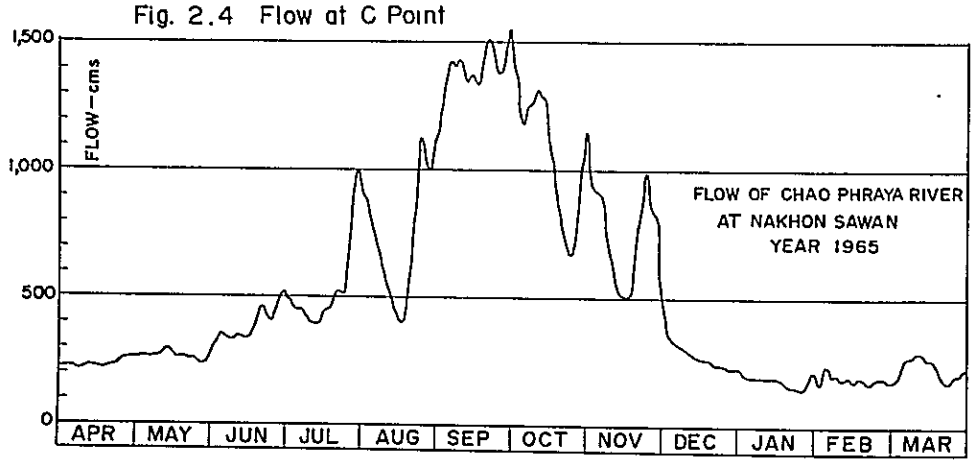


Fig. 2.4 Flow at C Point
1,500
1,000
500
0
FLOW – cms
FLOW OF CHAO PHRAYA RIVER
AT NAKHON SAWAN
YEAR 1965
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR

3. Outline of Traffic in the Areas along the Proposed Routes

3.1 Road Transportation

The long-term plan for economic development in Thailand had placed the greatest emphasis on the provision of highway facilities and the length at present of the national and provincial highways is 17,100 km in total, approximately 9,700km of the national highways and 1,900km of provisional highways are surfaced with concrete or asphalt.

In the areas along Route "A" railway line to be constructed between Phitsanulok and Mae Sod, the Highways No. 12 and No. 105 (both paved permanently) run respectively from Phitsanulok to Tak and from Tak to Mae Sod approximately in parallel with the proposed route. Also in the areas between Suphanburi and Tak on Route "B", the Highways No. 32 and No. 1 (both paved permanently) run respectively from Ayuthaya to Chainat and from Chainat to Tak approximately in parallel with and at a maximum distance of 60 km from the proposed route.

As for the topography along the proposed routes, the areas along Phitsanulok-Tak section of Route "A" and Suphanburi-Tak section of Route "B" are flat lands; only the section between Tak and Mae Sod runs through the mountain district where many steep grades and curves exist.

The data on the volume of traffic on the road between Bangkok and Thonburi compiled for each check point are shown in Table 3.1.

Table 3.1 Number of Trucks Passing Check Point (in 1971)

Check point		Incoming		Outgoing	
		No.	Net tonnage(t)	No.	Net tonnage(t)
Srisamran at Samut Sakhon (Highway No. 4)	Loaded	23,723	617,000	12,894	335,000
	Empty	11,940	0	17,937	0
	Total	35,663	617,000	30,831	335,000
Hinkong at Saraburi (Highway No. 1)	Loaded	36,599	952,000	28,675	746,000
	Empty	13,661	0	22,943	0
	Total	50,260	952,000	51,618	746,000
Chainat (Highway No.32)	Loaded	6,825	177,000	17,099	445,000
	Empty	1,929	0	9,073	0
	Total	8,754	177,000	26,172	445,000
Kamphaeng Phet (Highway No. 1)	Loaded	12,641	329,000	11,735	305,000
	Empty	2,606	0	3,911	0
	Total	15,247	329,000	15,646	305,000

Note: The tonnage was obtained by multiplying the number of trucks by the average loaded weight of 26 tons after considering all prevailing conditions.

3.2 River Transportation

In the northwestern district of Thailand where the proposed railway line is to pass through, the inland waterway transportation is highly developed using the river system of the Chao Phraya as its principal traffic route and it has played the leading part in the domestic transportation from the ancient time. About 80% of rice produced in the central plain has been carried to Bangkok by boats. Boats having the width of 8 meters can navigate the river for 250 km (to Chainat) upstream from Bangkok, but the boats which can go further upstream are limited to those having the width of 2 meters or less. Also, the river becomes unnavigable due to lowered water level in April and May at the end of dry season and, in general, the speed of water transportation is very slow. Thus the river traffic should be regarded as an unsatisfactory means of transportation to meet the requirements of rapidity and reliability.

The number of trips of boats navigating the rivers counted at each check point is shown in Table 3.2.

Table 3.2 Number of Trips of Boats at Check Point (in 1970)

Check point		No. of trips	Net tonnage(t)
Chainat	For the year	38,445	577,000
	Daily average	105	1,575
Suphanburi	For the year	22,396	336,000
	Daily average	61	915

Note: The tonnage was obtained by multiplying the number of trips by the average loaded tonnage of 15 tons.

3.3 Air Transportation

There are more than 40 airports in Thailand, many of which become unusable during the rainy season and the number of passengers carried is very small. Four scheduled flights are operated between Bangkok and Chiang Mai with about 30 passengers carried by one flight.

3.4 Railway Transportation

The existing railway lines to be involved in the present project for the construction of new railway line are the Northern Line, 751 km in length, between Bangkok and Chiang Mai and a local line between Nong Pladuk and Suphanburi.

The Northern Line, together with the Southern Line, constitutes the main trunk lines of RSR; one express and two rapid service passenger trains are operating in each direction a day, with 17 local and 7 freight trains scheduled in each direction over the entire line. The section of 90 km from Bangkok to Ban Phachi which is used jointly with the Eastern and Northeastern Lines is double tracked and the lock and block system is applied to it with semaphore signal. The line north of Ban Phachi is signle tracked, to which tokenless and tablet block systems are applied with semaphore signal.

If the Route "B" is adopted, the through train operating this route will use the local line between Nong Pladuk and Suphanburi. At present, two trains, one mixed and one rail car, are through operating in each direction from Bangkok, but the track is in poor condition and the safety devices are insufficient.

4. Estimation of Traffic Volume

4.1 Summary

As no data were available for the detailed distribution of population, products by industries and future plans in the areas along the proposed routes, the volume of traffic was estimated on the basis of the data obtainable for respective Provinces; that is, for passenger traffic, the future number of passengers carried was estimated using the growth rate of 3.1% per year based on the population in 1970 in each Province. For freight traffic, the future number of tons carried was estimated using the growth rate of GDP determined on the basis of the productions by industries in each Province.

4.2 Passenger Traffic

The number of passengers carried was estimated on the basis of population of respective Provinces (see Fig. 4.1) which could be obtained for 1970, according to the following processes.

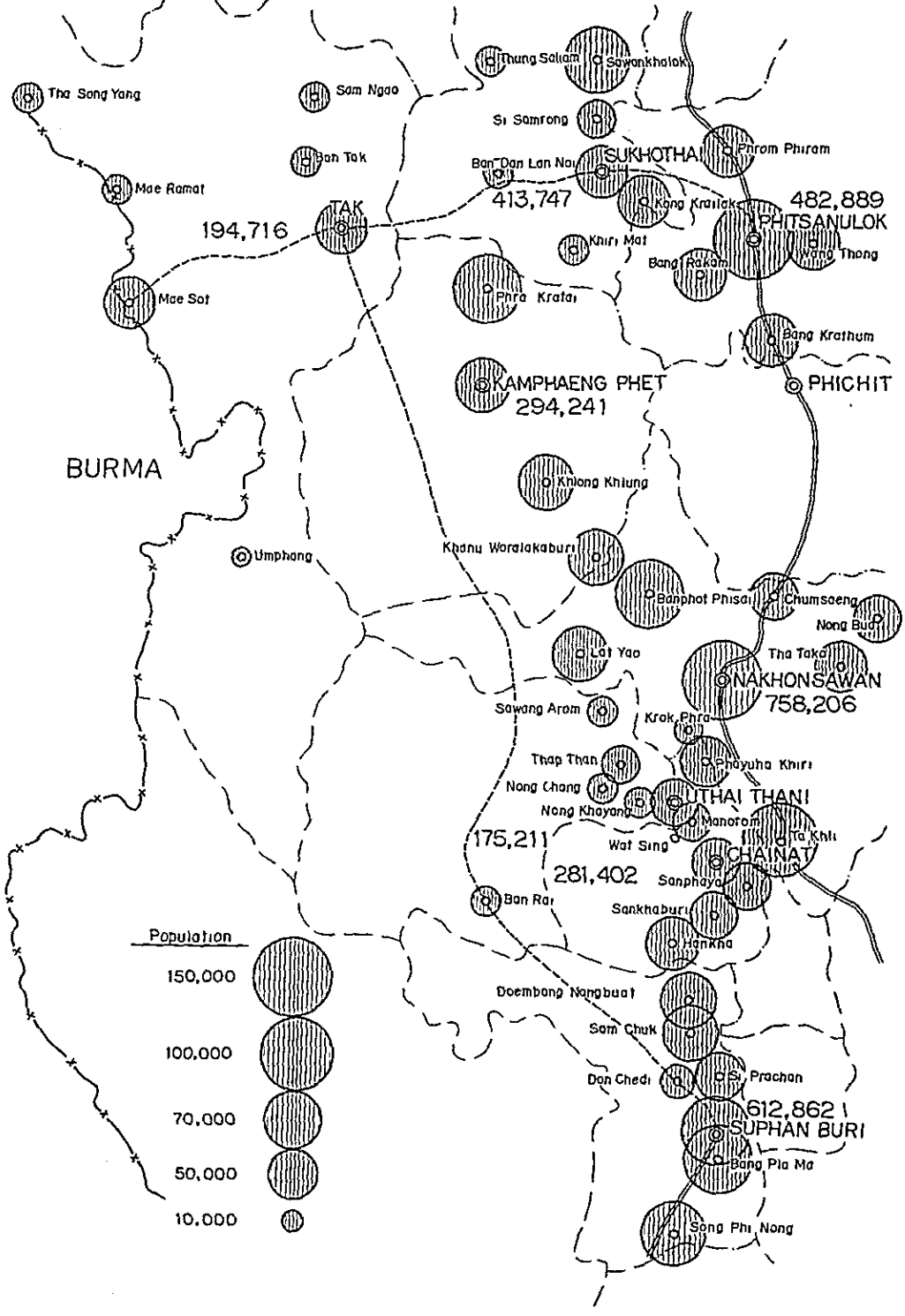
Process 1 : The population of each Province for 1947, 1960 and 1970 is shown in Table 4.1.

Process 2 : The future population was estimated on the basis of populations of the respective Provinces shown in 1970 by multiplying the national growth rate of 3.1% yearly. (see Table 4.2)

Process 3 : From the figure of population of each Province, the rate of population corresponding to the location, where the proposed route go through, was estimated, and the population presumed to be served by the proposed railway line was calculated considering the increase of 10% to be induced by this new route. (see Table 4.3)

Process 4 : The number of travels by rail per capita of population during a year (1.36 times) was obtained from the average of whole RSR, and the number of passengers carried per year was calculated by multiplying it by the population who is presumed to be served by the pro-

Fig. 4.1 Distribution of Population along the Proposed Routes



posed route. (see Table 4.4)

The formula to obtain the number of rail travels per capita of population per year is as follows:

$$t = \frac{N}{P} = \frac{47,326,000}{34,738,000} = 1.36$$

where t = number of rail travels per capita of population per year

P = total population of Thailand = 34,738,000 (Statistic Yearbook,1969)

N = number of passengers carried per year = 47,326,000 (RSR Information Booklet, 1969)

Table 4.1 Actual Population by Provinces

(1,000 persons)

Province	Actual population		
	1947	1960	1970
Suphanburi	341	491	652
Chainat	171	245	303
Uthaithani	105	146	193
Nakhon Sawan	379	648	830
Kamphaeng Phet	68	173	329
Tak	106	168	209
Phitsanulok	202	352	558
Sukhothai	189	316	443

Table 4.2 Estimated Total Population by Provinces

Province	Population in 1970 (1,000)	Magnification to 1970 as a basic year (3.1% per annum)					Estimated population (1,000 persons)				
		1980	1990	2000	2010	2020	1980	1990	2000	2010	2020
Suphanburi	652	1.357	1.842	2.499	3.391	4.602	885	1,201	1,629	2,211	3,001
Chainat	303	"	"	"	"	"	411	558	757	1,027	1,394
Uthaithani	193	"	"	"	"	"	262	356	482	654	888
Nakhon Sawan	830	"	"	"	"	"	1,126	1,529	2,074	2,815	3,820
Kamphaeng Phet	329	"	"	"	"	"	446	606	822	1,116	1,514
Tak	209	"	"	"	"	"	284	385	522	709	962
Phitsanulok	558	"	"	"	"	"	757	1,028	1,394	1,892	2,568
Sukhothai	443	"	"	"	"	"	601	816	1,107	1,502	2,039

Table 4.3 Population to be Expected to Travel by Rail

Route "A" (1,000 persons)

Province	Estimated population					Ratio to be served by rail A	*Magnification B	Integrated ratio C=AxB	Population expected to travel by rail				
	1980	1990	2000	2010	2020				1980	1990	2000	2010	2020
Phitsanulok	757	1,028	1,394	1,892	2,568	0.25	1.1	0.275	208	283	383	520	706
Sukhothai	601	816	1,107	1,502	2,039	0.50	"	0.550	331	449	609	826	1,121
Tak	284	385	522	709	962	0.50	"	0.550	156	212	287	390	529
Total									695	944	1,279	1,736	2,356

Route "B" (1,000 persons)

Province	Estimated population					Ratio to be served by rail A	* Magnification B	Integrated ratio C=AxB	Population expected to travel by rail				
	1980	1990	2000	2010	2020				1980	1990	2000	2010	2020
Suphanburi	885	1,201	1,629	2,211	3,001	0.50	1.1	0.550	487	661	896	1,216	1,651
Chainat	411	558	757	1,027	1,394	0.25	"	0.275	113	153	208	282	383
Uthaithani	262	356	482	654	888	0.50	"	0.550	144	196	265	360	488
Nakhon Sawan	1,126	1,529	2,074	2,815	3,820	0.25	"	0.275	310	420	570	774	1,051
Kamphaeng Phet	446	606	822	1,116	1,514	0.50	"	0.550	245	333	452	614	833
Tak	284	385	522	709	962	0.50	"	0.550	156	212	287	390	529
Total									1,455	1,975	2,678	3,636	4,935

* Magnification B contains the increasing rate of population (10%) considering the population to be induced by opening for service of the new railway line.

Table 4.4 Number of Passengers Carried by Rail for Each Year

Route "A" (1,000 persons)

Year	1980	1990	2000	2010	2020
Population expected to travel by rail	695	944	1,279	1,736	2,356
No. of passengers carried per year	695x1.36 = 945 ≒ 900	944x1.36 = 1,284 ≒ 1,300	1,279x1.36 = 1,739 ≒ 1,700	1,736x1.36 = 2,361 ≒ 2,400	2,356x1.36 = 3,204 ≒ 3,200

Route "B" (1,000 persons)

Year	1980	1990	2000	2010	2020
Population expected to travel by rail	1,455	1,975	2,678	3,636	4,935
No. of passengers carried per year	1,455x1.36 = 1,979 ≒ 2,000	1,975x1.36 = 2,686 ≒ 2,700	2,678x1.36 = 3,642 ≒ 3,600	3,636x1.36 = 4,945 ≒ 4,900	4,936x1.36 = 6,713 ≒ 6,700

4.3 Freight Traffic

The number of tons carried in railway freight was estimated on the products by industries (some of which were determined by presumption) which were obtainable for each Province, according to the following process.

Process 1 : The products by articles for each Province were converted into tonnage. (see Table 4.5)

Process 2 : The future products were estimated by means of the growth rate (7% per year) of GDP determined in the 3rd Five-Year Plan in Thailand. (see Table 4.6)

Process 3 : The total freight traffic by railway, road and waterway was obtained from the count made at the typical check points near the railway line to be constructed, and the ratio of railway freight was calculated based on it. (see Table 4.7) Then, the ratio of the products which are expected to be carried by the proposed railway line was estimated for each Province. This rate was made by adapting it to the location through which the line passes that Province and the volume of freight traffic was calculated for selected year in accordance with this ratio. (see Table 4.8)

Table 4.5 Products of Areas along the Proposed Railway Line (in 1971)

Province / Articles	Suphanburi	Chainat	Uthaithani	Nakhon Sawan	Kamphaeng Phet	Tak	Phitsanulok	Sukhothai
Paddy (unhulled rice)	536,805 t	250,630 t	111,895 t	355,926 t	289,110 t	59,416 t	553,875 t	135,927 t
Rice	214,722 t			213,555 t				
Corn	10,030 t	1,440 t	25,620 t	34,045 t	58,450 t		51,130 t	
Green pea			408 t		8,100 t			
Cotton			381 t		2,400 t			
Kapok			700 t					
Peanut			240 t		2,800 t			
Banana					78,252 t		38,341 t	
Raw sugar					33,000 t			
Tapioca					36,000 t			
Yellow pea					8,660 t			
Cabbage								
Carrot, others								
Coconut								
Sub-total of agricultural products	761,557 t	252,070 t	139,244 t	603,526 t	516,772 t	59,416 t	643,346 t	135,927 t

Province / Articles	Suphanburi	Chainat	Uthaithani	Nakhon Sawan	Kamphaeng Phet	Tak	Phitsanulok	Sukhothai
Pig				176,198 head			4,983 head	780,000 head
Buffalo & Cow	26,459 head		3,205 head	276,198 head		100,000 head	203,294 head	152,550 head
Hen Fowl				1,761,980 fowl			1,081,282 fowl	
Fish	8,277 t		344 t	3,555 t		1,435 t	1,224 t	2,000 t
Duck							12,663 fowl	214,000 fowl
Sub-total of cattle	13,569 t		985 t	96,677 t		21,435 t	44,521 t	188,831 t
Forest products	26,000 t	8,000 t	83,000 t	31,000 t	100,000 t	225,000 t		66,000 t
Mineral products			141 t	62,081 t		4,179 t		345 t
Total	801,126 ≒ 801,000t	260,070 ≒ 260,000t	223,370 ≒ 223,000t	793,284 ≒ 793,000t	616,772 ≒ 617,000t	310,030 ≒ 310,000t	687,867 ≒ 688,000t	391,103 ≒ 391,000t

Note: 1. Cattle was converted into tons by a rate of 200 kg per head and birds by a rate of 1.5 kg per fowl.

2. Source of data.
   (1) Agricultural products and cattle – investigation of products of Provinces furnished from RSR.
   (2) Forest products – the production volume of the respective Province along the proposed route for 1971 was estimated from "Statistical Yearbook No. 28 1967-1969".
   (3) Mineral products – data prepared by the Dept. of Mineral Resources, Ministry of National Development (1971).

Table 4.6 Estimation of Future Products by Provinces

Province	Production in 1971 (1,000 tons)	Magnification to 1971 as a basic year (7% per annum)					Estimated products (1,000 tons)				
		1980	1990	2000	2010	2020	1980	1990	2000	2010	2020
Suphanburi	801	1.84	3.62	7.11	13.99	27.53	1,474	2,900	5,695	11,206	22,052
Chainat	260	"	"	"	"	"	478	941	1,849	3,637	7,158
Uthaithani	223	"	"	"	"	"	410	807	1,586	3,120	6,139
Nakhon Sawan	793	"	"	"	"	"	1,459	2,871	5,638	11,094	21,831
Kamphaeng Phet	617	"	"	"	"	"	1,135	2,234	4,387	8,632	16,986
Tak	310	"	"	"	"	"	570	1,122	2,204	4,337	8,534
Phitsanulok	688	"	"	"	"	"	1,266	2,491	4,892	9,625	18,941
Sukhothai	391	"	"	"	"	"	719	1,415	2,780	5,470	10,764

Table 4.7 Freight Tons Carried and Ratios by Types of Transportation

Type of transportation	Check point	Number of tons carried (1,000 tons)	Ratio	Remarks
Railway	Ban Takli	1,883	0.61	Ban Takli is the station nearest to Chainat
Road	Chainat	622	0.20	
Waterway	Chainat	577	0.19	
Total		3,082	1.00	

Note: The number of tons carried by the freight trains passing Ban Takli (193 km from Bangkok) was obtained as follows.

6 southbound freight trains (for Bangkok) per day consist of 50 cars are operated, and 3/4 of each train is composed of 15 t and 12.5 t in half.

Thus, the number of tons carried per year is

$$6 \times (15 \times 25 + 12.5 \times 25) \times \frac{3}{4} \times 365 = 1,130,000 \text{ t}$$

6 northbound freight trains (from Bangkok) per day consist of 50 cars are operated, each train is composed of 1/2 of loaded and 1/2 of empty cars, and those loaded cars are of 15 t and 12.5 t in half.

Thus, the number of tons carried per year is

$$6 \times (15 \times 25 + 12.5 \times 25) \times \frac{1}{2} \times 365 = 753,000 \text{ t}$$

Total $1,130,000 + 753,000 = 1,883,000$ t

Table 4.8 Number of Freight Tons Carried for Each Year

Route "A"

Province	Total productions (1,000 tons)					Ratio to be served by rail A	Share of railway transportation B	Integrated ratio C=AxB	Tons carried by railway (1,000 tons)				
	1980	1990	2000	2010	2020				1980	1990	2000	2010	2020
Phitsanulok	1,266	2,491	4,892	9,625	18,941	0.25	0.61	0.153	194	381	748	1,473	2,898
Sukhothai	719	1,415	2,780	5,470	10,764	0.50	0.61	0.305	219	432	848	1,668	3,283
Tak	570	1,122	2,204	4,337	8,534	0.50	0.61	0.305	174	342	672	1,323	2,603
Total									587 ≒ 600	1,155 ≒ 1,200	2,268 ≒ 2,300	4,464 ≒ 4,500	8,784 ≒ 8,800

Route "B"

Province	Total productions (1,000 tons)					Ratio to be served by rail A	Share of railway transportation B	Integrated ratio C=AxB	Tons carried by railway (1,000 tons)				
	1980	1990	2000	2010	2020				1980	1990	2000	2010	2020
Suphanburi	1,474	2,900	5,695	11,206	22,052	0.50	0.61	0.305	450	885	1,737	3,418	6,726
Chainat	478	941	1,849	3,637	7,158	0.25	0.61	0.153	73	144	283	556	1,095
Uthaithani	410	807	1,586	3,120	6,139	0.50	0.61	0.305	125	246	484	952	1,872
Nakhon Sawan	1,459	2,871	5,638	11,094	21,831	0.25	0.61	0.153	223	439	863	1,697	3,340
Kamphaeng Phet	1,135	2,234	4,387	8,632	16,986	0.50	0.61	0.305	346	681	1,338	2,633	5 181
Tak	570	1,122	2,204	4,337	8,534	0.50	0.61	0.305	174	342	672	1,323	2,603
Total									1,391 ≒ 1,400	2,737 ≒ 2,700	5,377 ≒ 5,400	10,579 ≒ 10,600	20,817 ≒ 20.800

4.4 International Traffic

The completion of extension line from Mae Sod in Thailand to Thaton in Burma will enable to operate international transportation. The length of this extension line being about 170 km, the route length between Bangkok and Rangoon will be about 850 km.

The international traffic is classified into passenger and freight transportations. As the passenger transportation will need certain period of time until its regular service is implemented, it is difficult to estimate any volume of traffic.

In the field of freight transportation, the geographical conditions are favorable and a substantial volume of freight traffic is expected between Thailand and Burma.

At the Working Party of Experts on the Trans-Asian Railway Network Project held at Bangkok in October, 1970, Mr. M. N. Bery submitted the volume of traffic in the international freight transportation as shown in Table 4.9.

Table 4.9 Volume of Traffic in International Freight Transportation

Year	No. of trains operating	Tons carried per year (tons)
0 - 5	1 train in each direction per 2 days	600,000
6 - 10	2 up- and 3 down-trains or 5 trains per day	1,500,000
10 - 17	3 up- and 4 down-trains or 7 trains per day	2,100,000
18 - 30	3 up- and 5 down-trains or 8 trains per day	2,400,000

Based on the volume of freight traffic shown in Table 4.9, such volumes for selected years are estimated as shown in Table 4.10, assuming that they will increase lineally.

Table 4.10 Estimated Volume of Traffic in International Freight

(1,000 tons)

Year	1980	1990	2000	2010	2020
Volume of traffic	600	1,500	2,800	4,100	5,400

But, the international freight transportation should be further investigated.

5. Train Operation Plan

5.1 Route "A" (Phitsanulok - Tak - Mae Sod, 196 km in length)

5.1.1 Passenger Transportation

The number of passengers carried in case where Route "A" is assumed to be opened to traffic in 1980 is 900 thousand according to Table 4.4 and the number of trains needed to carry this traffic is calculated as follows:

(1) Number of departed and arrived passengers per year;

A = 900,000 persons

(2) Number of departed and arrived passengers per day;

$$B = \frac{A}{365} = 2,466 \text{ persons}$$

(3) Average trip kilometer per passenger;

C = 85.3 km

(actual kilometer of RSR for 1970)

(4) Average number of passengers passed through the line;

$$D = \frac{B \times 85.3}{196} = 1,073 \text{ persons}$$

(5) Transportation capacity needed in one direction;

$$E = \frac{D}{2} \times 1.25 = 671 \text{ persons}$$

(wave rate = 25 %)

(6) Carrying capacity of one train;

F = 60 passengers x 8 cars x 0.7

= 336 passengers

(utilization efficiency of passenger car = 70 %)

(7) Number of trains needed in one direction;

$$G = \frac{E}{F} = \frac{671}{336} = 2.0$$

Therefore, 2 passenger trains made up of 8 cars will be scheduled in each direction on the section between Phitsanulok and Tak where much demand is forecasted and 2 trains of 4 cars scheduled in each way on the section between Tak and Mae Sod where the future demand is less than half of that of between Phitsanulok and Tak.

In order to raise the efficiency of the utilization, one mixed train will be scheduled in each way between Phitsanulok and Tak.

5.1.2 Freight Transportation

A unit of freight train will be made up of 50 cars on a four-wheel basis, taking into account the restrictions from the effective length of station, brake system etc. The transportation capacity per unit of freight train per year is calculated as follows on the basis of loading capacity of 12.5 tons per car.

$$12.5\ t \times 50 \times 365 = 228{,}000\ t$$

However, on the grade section of 12 °/oo between Tak and Mae Sod, the limit of hauling is 40 freight cars in terms of four-wheel in view of the tractive load at the time of train starting and of running at balancing speed on the grade.

As for the locomotive, the present estimation was made based on the use of large locomotive of 1,800 h.p. or 1,500 h.p. series being arranged under the 3rd Five-Year Plan.

According to Table 4.8 and Table 4.10, the volume of freight traffic at the time when Route "A" is opened for service is estimated at 1,200 thousand tons in all, consisting of 600 thousand tons in the domestic and 600 thousand tons in the international transportation.

The number of freight trains needed to carry this traffic is calculated as follows.

(1) Volume of freight traffic per year;

$A = 1{,}200{,}000$ tons

(2) Average loading efficiency;

$B = 0.8$

(3) Carrying capacity per one freight train per year;

$C = 228{,}000$ tons

(4) Number of trains needed in one direction;

$$D = \frac{A}{2} \times \frac{1}{C \times 0.8} = 3.3$$

Based on the above calculation and taking into account the difference in the demands for freight transportation by areas along the proposed line,

3 freight trains will be scheduled in each direction between Phitsanulok and Mae Sod and one mixed train consisting of 2 passenger and 20 freight cars between Phitsanulok and Tak.

5.1.3 Planning of Train Operation

For Route "A", Phitsanulok Station at 390 km from Bangkok through the Northern Line seems to become a main railhead.

Phitsanulok Station is one of the principal railheads on the Northern Line; about 30 trains are now operating in both directions to and from there and it has a car depot and a freight yard capable to handle about 500 cars per day.

As Route "A" runs in parallel with the highway, it is necessary to shorten the running time of trains as much as possible by operating rapid service trains with station stops minimized to compete, in particular, with road transportation.

The standard running times between stations on Route "A" are shown in Table 5.1. The stopping-time of a passenger train will be from 5 to 10 minutes at large stations of class A and from 1 to 2 minutes at small stations of class B.

The train diagram at the time when the proposed line is opened for service is shown in Fig. 5.1, which is established taking into account the above factors.

The train kilometers per year computed based on this train diagram are shown in Table 5.2.

Fig. 5.1 Train Diagram on Route "A"

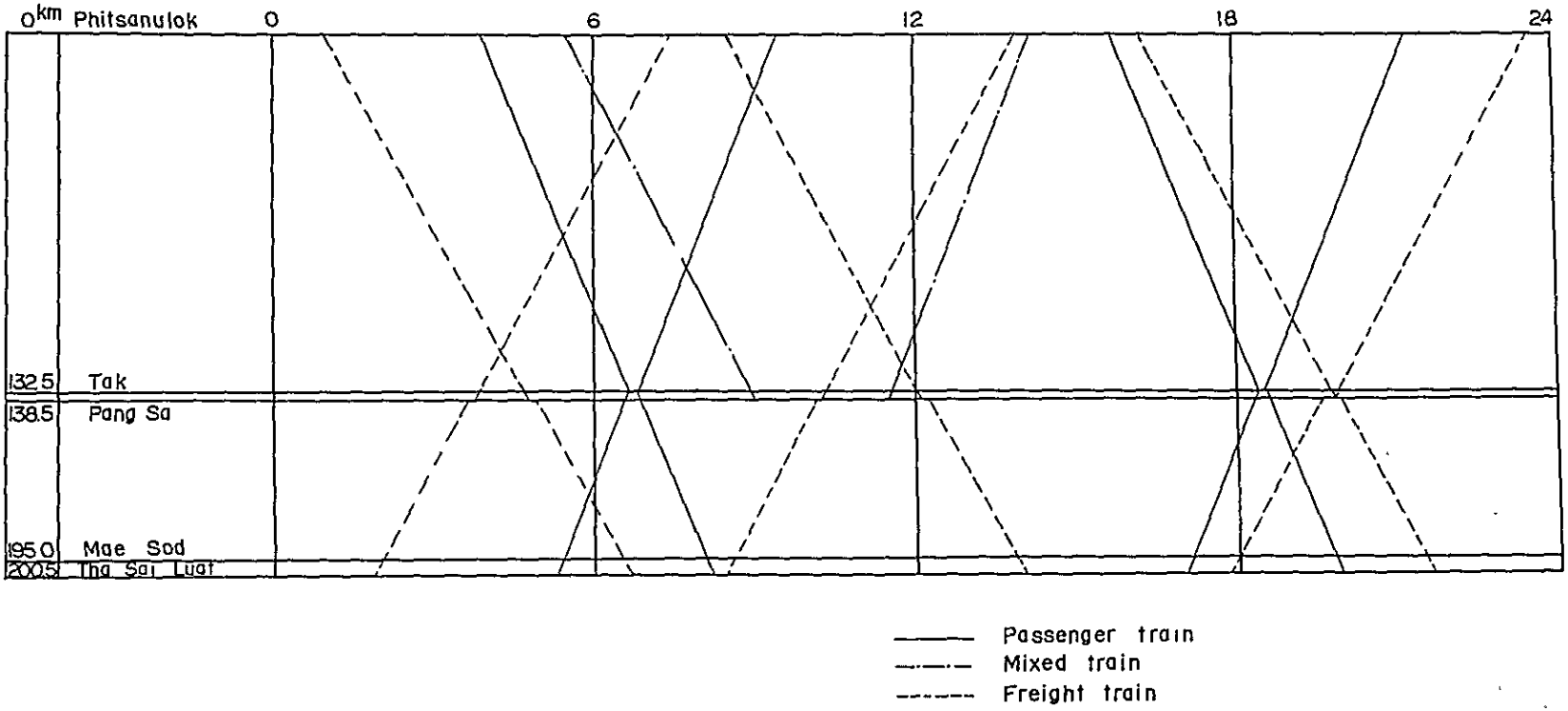


Table 5.1 Standard Running Time on Route "A"

Name of station (Provisional)	Distance between stations	Passenger train	Freight train		Remarks
	(km)	(min)	(min)		
Phitsanulok					Existing Sta.
Kwae Noi	(4.5)	6	8		- " -
Tha Chang	5.0	7	9		
Na Khum	5.0	7	9		
Kok Raet	8.0	10	12		
Prak Thong	8.0	10	12		
Khlong Khae	12.4	14	16		
Sukhothai	6.6	9	11		Class A Sta.
Hang Khlong	5.5	8	10		
Chedi Sung	5.5	8	10		
Wang Won	8.0	10	12		
Wang Dad	7.0	9	11		
Khao Un	10.0	12	14		
Chalad	12.5	15	17		
Taluk Chai	12.5	15	17		
Khao Khayang	10.0	12	14		
Tak	12.0	14	16		Class A Sta.
Pang Sa	6.0	8	10		Class A Sta.
Tha Chang Ta	5.0	8	13	9	
Doi Ruak	5.2	8	14	10	
Huai Pu	16.3	18	40	23	
Mae Lamao	8.9	11	13	23	
Huai Hin Tang	13.6	15	28	26	
Mae Sod	7.5	10	12	20	
Tha Sai Luat	5.5	8	9	10	
Total	196.0 (200.5)	252	(from Phitsanulok) 337	(to Phitsanulok) 329	

Table 5.2 Train Kilometer for Route "A"

(km)

Passenger train	Freight train	Mixed train	Total
196 x (2 x 2) x 365	196 x (3 x 2) x 365	134 x (1 x 2) x 365	
286,160	429,240	97,820	813,220

5.1.4 Number and Cost of Needed Rolling Stock

The making-up of trains at the time when the proposed line is opened for service, stated already, is as shown in Table 5.3 for Route "A".

Table 5.3 Making-up of Trains for Route "A"

Section	Passenger train	Freight train	Mixed train
Kwae Noi – Pang Sa St.	8 passenger cars	50 freight cars	2 passenger cars 20 freight cars
Pang Sa – Tha Sai Luat St.	4 passenger cars	40 freight cars	–

The car kilometers in terms of 10 ton load computed from Fig. 5.1, Train Diagram, is shown in Table 5.4.

Table 5.4 Car Kilometer in terms of 10 ton Load for Route "A"

(km)

Section	Passenger train	Freight train	Mixed train	Total
Kwae Noi – Pang Sa St.	16 x 134 x (2 x 2) x 365	50 x 134 x (3 x 2) x 365	24 x 134 x (1 x 2) x 365	
(134 km)	3,130,240	14,673,000	2,347,680	20,150,920
Pang Sa – Tha Sai Luat St.	8 x 62 x (2 x 2) x 365	40 x 62 x (3 x 2) x 365		
(62 km)	724,160	5,431,200	–	6,155,360
Total	3,854,400	20,104,200	2,347,680	26,306,280

The engine kilometers computed by total train kilometers plus 10% are 894,542 km.

Prospected estimation of number and cost of the needed rolling stock to attain the above car kilometers is shown in Table 5. 5.

Table 5.5 Number and Cost of Needed Rolling Stock for Route "A"

	Number of Needed Rolling Stock (car)	Cost (million Baht)
Diesel locomotive	5	34.15
Passenger car	12	11.16
Freight car	about 550	about 121

Note: 1. Not including reserve rolling stock.

2. Unit cost is estimated as follows; DL 6.83 million Baht, PC 0.93 million Baht, FC 0.22 million Baht.

5.2 Route "B" (Suphanburi – Tak – Mae Sod, 377 km in length)

5.2.1 Passenger Transportation

The number of passengers carried in case where Route "B" is assumed to be opened to traffic in 1980 is 2,000 thousand according to Table 4.4. The number of trains needed to transport this traffic is calculated in the same way as Route "A" as follows:

(1) Number of departed and arrived passengers per year;

A = 2,000,000 persons

(2) Number of departed and arrived passengers per day;

B = 5,479 persons

(3) Average trip kilometer per passenger;

C = 85.3 km

(4) Average number of passengers passed through the line;

D = 1,240 persons

(5) Transportation capacity needed in one direction;

E = 775 persons

(6) Carrying capacity of one train;

F = 336 persons

(7) Number of trains needed in one direction;

G = 2.3

Based on the above calculation, 2 passenger trains made up of 8 cars

will be scheduled in each direction between Suphanburi and Tak with 2 others made up of 4 cars scheduled in each direction between Tak and Mae Sod. In addition, a mixed train is to be scheduled to cover the shortage in the capacity of transportation.

5.2.2 Freight Transportation

According to Table 4.8 and Table 4.10, the volume of freight traffic at the time when Route "B" is opened for service is estimated at 2,000 thousand tons in all, consisting of 1,400 thousand tons in the domestic and 600 thousand tons in the international transportation.

The number of freight trains needed to carry this traffic is calculated in the same way as Route "A" as follows.

(1) Volume of freight traffic per year;

A = 2,000,000 tons

(2) Average loading efficiency;

B = 0.8

(3) Carrying capacity per one freight train per year;

C = 228,000 tons

(4) Number of trains needed in one direction;

D = 5.5

Based on the above calculation and taking into account the difference in the demands for freight transportation by areas along the proposed line, 5 freight trains will be scheduled in each direction between Suphanburi and Ban Rai; 4 trains scheduled in each direction between Ban Rai and Tak; and 3 trains scheduled in each direction between Tak and Mae Sod; and addition, one mixed train consisting of 3 passenger and 25 freight cars will be scheduled in each direction between Suphanburi and Tak.

5.2.3 Planning of Train Operation

In the case of Route "B", Nong Pladuk Junction on the Southern Line constitutes a railhead and one mixed train and one passenger rail car train are now operating in each direction between the said junction and Suphanburi.

The standard running times between stations on Route "B" are shown

in Table 5.6. The train diagram at the time when the proposed line is opened for service is shown in Fig. 5.2.

The train kilometers per year computed based on this train diagram are shown in Table 5.7.

Table 5.6 Standard Running Time on Route "B"

Name of station (Provisional)	Distance between stations	Passenger train	Freight train	Remarks
	(km)	(min)	(min)	
Suphanburi				Existing Sta.
Talat Daeng	8.0	10	12	
Bang Ngam	8.0	10	12	
Nong Sarai Noi	13.3	15	17	
Nong Ratchawat	11.2	13	15	
Pa Phai	11.0	13	15	
Na Ta Pin	13.9	16	18	
Kok Tern	15.3	17	19	
Ban Rai	15.3	17	19	Class A Sta.
Khao Tamyae	12.3	14	16	
Bung Bang	15.9	18	20	
Thap Salao	12.9	15	17	
Huai Rang	15.9	18	20	
Nong Chik	13.3	15	17	
Ban Bung	13.1	15	17	
Ban Noi	9.1	11	13	
Huai Map Sanuan	12.5	15	17	
Pang Tha Som	15.8	18	20	
Thung Na Khwan	17.6	19	22	
Pong Nam Ron	13.9	16	18	
Khlong Phrai	17.7	19	22	
Khlong Hin	12.0	14	16	
Tongteng	18.0	19	22	
Tha Ta Kho	6.6	9	11	

Table 5.6 (Cont'd)

Name of station	Distance between stations	Passenger train	Freight train		Remarks
	(km)	(min)	(min)		
Den Tan (Tak)	6.7	9	11		Class A Sta.
Pang Sa	5.7	8	10		Class A Sta.
Tha Chang Ta	5.0	8	13	9	
Doi Ruak	5.2	8	14	10	
Huai Pu	16.3	18	40	23	
Mae Lamao	8.9	11	13	23	
Huai Hin Tang	13.6	15	28	26	
Mae Sod	7.5	10	12	20	
Tha Sai Luat	5.5	8	9	10	
			(from Suphanburi)	(to Suphanburi)	
Total	377.0	441	545	537	

Table 5.7 Train Kilometer for Route "B"

(km)

Passenger train	Freight train	Mixed train	Total
377 x (2x2) x 365	377 x (3x2) x 365 +315 x (1x2) x 365 + 96 x (1x2) x 365	315 x (1x2) x 365	
550,420	1,125,660	229,950	1,906,030

5.2.4 Number and Cost of Needed Rolling Stock

The making-up of trains at the time when the proposed line is opened for service is shown in Table 5.8 for Route "B"

Fig. 5.2 Train Diagram on Route "B"

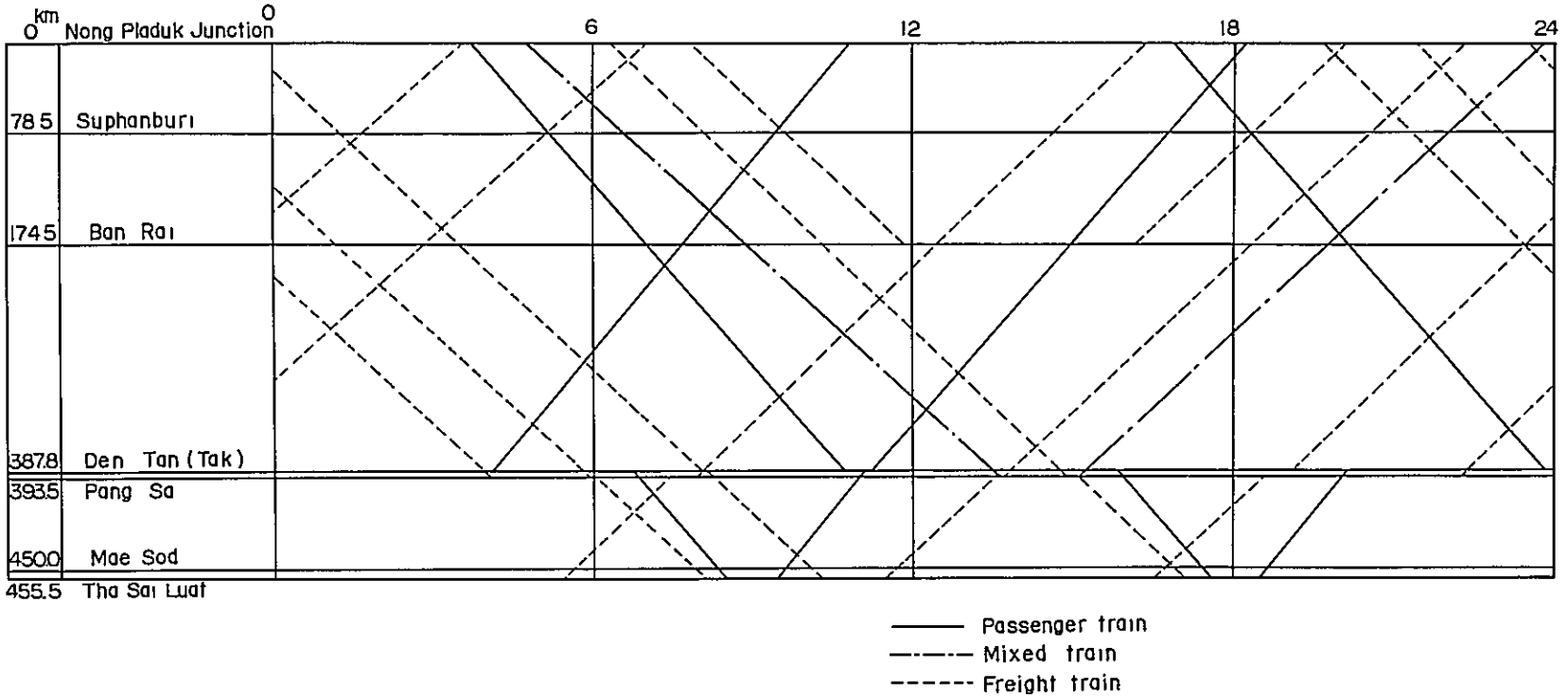


Table 5.8 Making-up of trains for Route "B"

Section	Passenger train	Freight train	Mixed train
Suphanburi – Pang Sa St.	8 passenger cars	50 freight cars	3 passenger cars 25 freight cars
Pang Sa – Tha Sai Luat St.	4 passenger cars	40 freight cars	–

The car kilometers in terms of 10 ton load computed from Fig.5.2, Train Diagram, is shown in Table 5.9.

Table 5.9 Car Kilometer in terms of 10 ton Load for Route "B"

(km)

Section	Passenger train	Freight train	Mixed train	Total
Suphanburi – Pang Sa St.	16x315x(2x2) x 365	50x315x(4x2) x365+50x96 x(1x2)x365	31x315x(1x2) x 365	
(315 km)	7,358,400	49,494,000	7,128,450	63,980,850
Pang Sa – Tha Sai Luat St.	8x62x(2x2) x 365	40x62x(3x2) x 365		
(62 km)	724,160	5,431,200	–	6,155,360
Total	8,082,560	54,925,200	7,128,450	70,136,210

The engine kilometers computed by total train kilometers plus 10% are 2,096,633 km.

Prospected estimation of number and cost of the needed rolling stock to attain the above car kilometers is shown in Table 5. 10.

Table 5.10 Number and Cost of Needed Rolling Stock for Route "B"

	Number of Needed Rolling Stock (car)	Cost (million Baht)
Diesel locomotive	14	95.62
Passenger car	27	25.11
Freight car	about 1,600	about 352

Note: 1. Not including reserve rolling stock.

2. Unit cost is estimated as follows; DL 6.83 million Baht, PC 0.93 million Baht, FC 0.22 million Baht.

6. Construction Plan

6.1 Route Selection

6.1.1 Section between Phitsanulok and Tak (Route "A")

The proposed route which branches off the point (Kwae Noi Station) near Phitsanulok lying about midway of the Northern Line running between Bangkok and Chiang Mai crosses the Nan River and extends westward through a vast paddy field area approximately in parallel with the Highway No. 12, to pass through the city of Sukhothai; where the line is located nearer to the city center so far as it does not interfere with the city planning. Leaving the city of Sukhothai, the line runs the paddy field area for some distance and then traverses a hilly land to enter the city of Tak to cross the Ping River by the longest bridge in this route. The route is of single track and 134 km in length.

In selecting the route the followings have been taken into consideration in particular.

(1) Examination of Branching-off Point

The branching-off station may be selected from the three stations of Phitsanulok, Kwae Noi and Phrom Phiram.

In view of the future plan for train operation and assignment of rolling stock, Phitsanulok Station may be preferable. However, the proposal to select the Phitsanulok as branching-off point is not suitable because of the facts that the line runs across the city; that some problems are involved in the method to cross the Nan River; and that it needs rather higher cost of construction.

The comparison of branching-off at the stations of Phrom Phiram and Kwae Noi reveals that the former needs less construction cost by about 20 million Baht while requiring longer running distance by about 4.6 km. Thus, when the through service from Bangkok in future is taken into account the plan for branching off at Kwae Noi nearer to Phitsanulok than Phrom Phiram is more preferable.

(2) Course of Route

One suggestion is that the existing line may be used for the section from Kwae Noi Station to the point just across the Kwae Noi River.

However, in view of the track arrangement in the station, the relation of main track to station building and the degree of superannuation of the existing truss bridge over the Kwae Noi River, the best plan is to build newly a double-track bridge for a separate line on the downstream side of the present bridge.

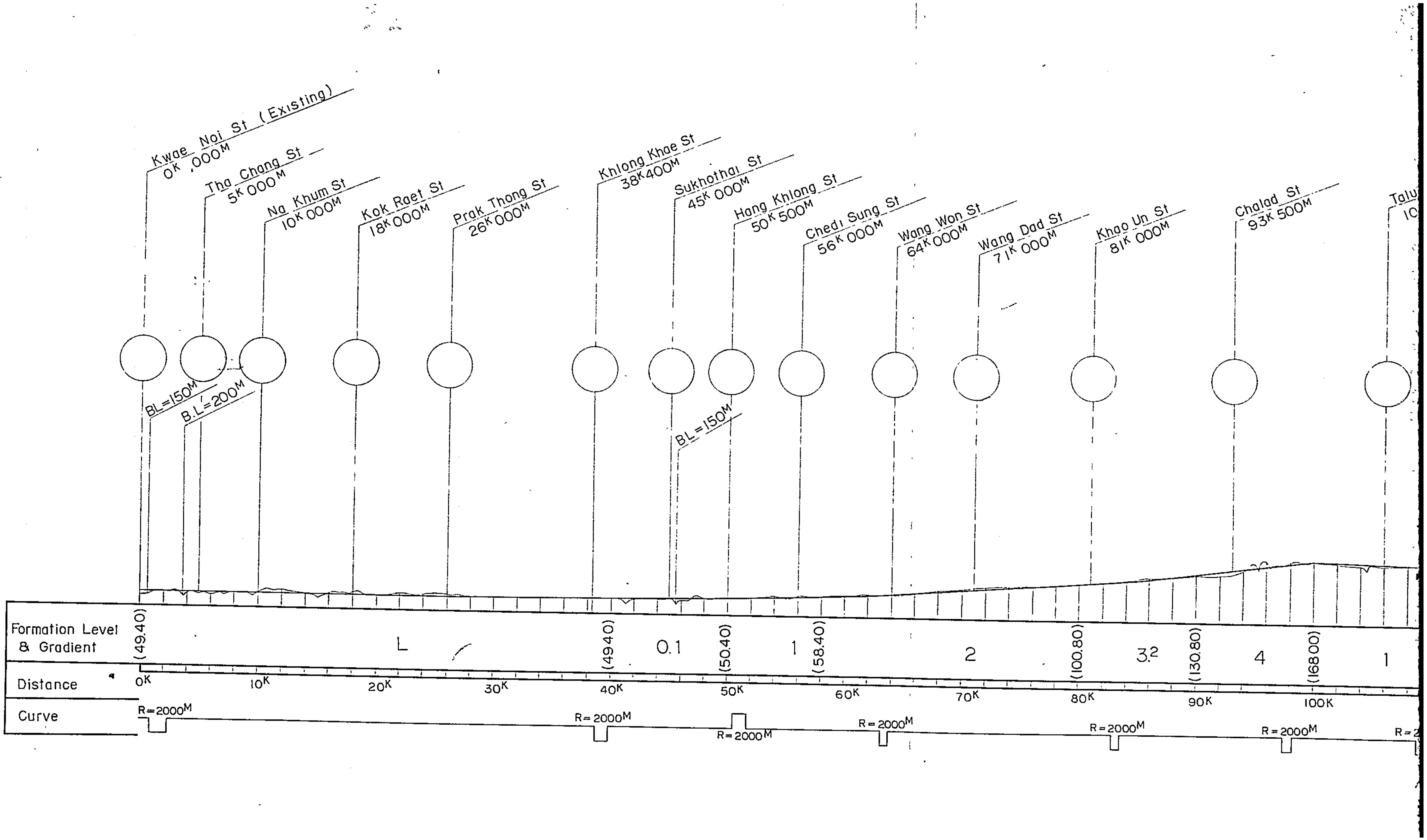
The urbanization of the area near Sukhothai is progressing, and in selecting the route a consideration was given not to interfere with city planning in future. Also for other cities and villages, a care has been taken not to impede the development of communities taking into account the conveniences of travellers.

In general, there are many temples and historic sites in Thailand which pose a problem in selecting the route for new railway; in this connection, the fundamental principle is not to disturb such sites.

(3) Locating of Station

The basic policy in establishing stations is to locate them near to communities, with stations for crossing of trains provided in a long section of more than 10 km in distance between stations.

The plan for locating stations and the route profile are shown in Table 6.1 and Fig. 6.1.



Kwae Noi St (Existing) 0K 000M
Tha Chang St 5K 000M
Na Khum St 10K 000M
Kok Raet St 18K 000M
Prak Thong St 26K 000M
Khlong Khae St 38K 400M
Sukhothai St 45K 000M
Hang Khlong St 50K 500M
Chedi Sung St 56K 000M
Wang Won St 64K 000M
Wang Dad St 71K 000M
Khao Un St 81K 000M
Chalad St 93K 500M
BL=150M
B.L=200M
BL=150M
Formation Level & Gradient
(49.40)
L
(4940)
0.1
(50.40)
1
(58.40)
2
(100.80)
3.2
(130.80)
4
(16800)
1
Distance
0K
10K
20K
30K
40K
50K
60K
70K
80K
90K
100K
Curve
R=2000M
R=2000M
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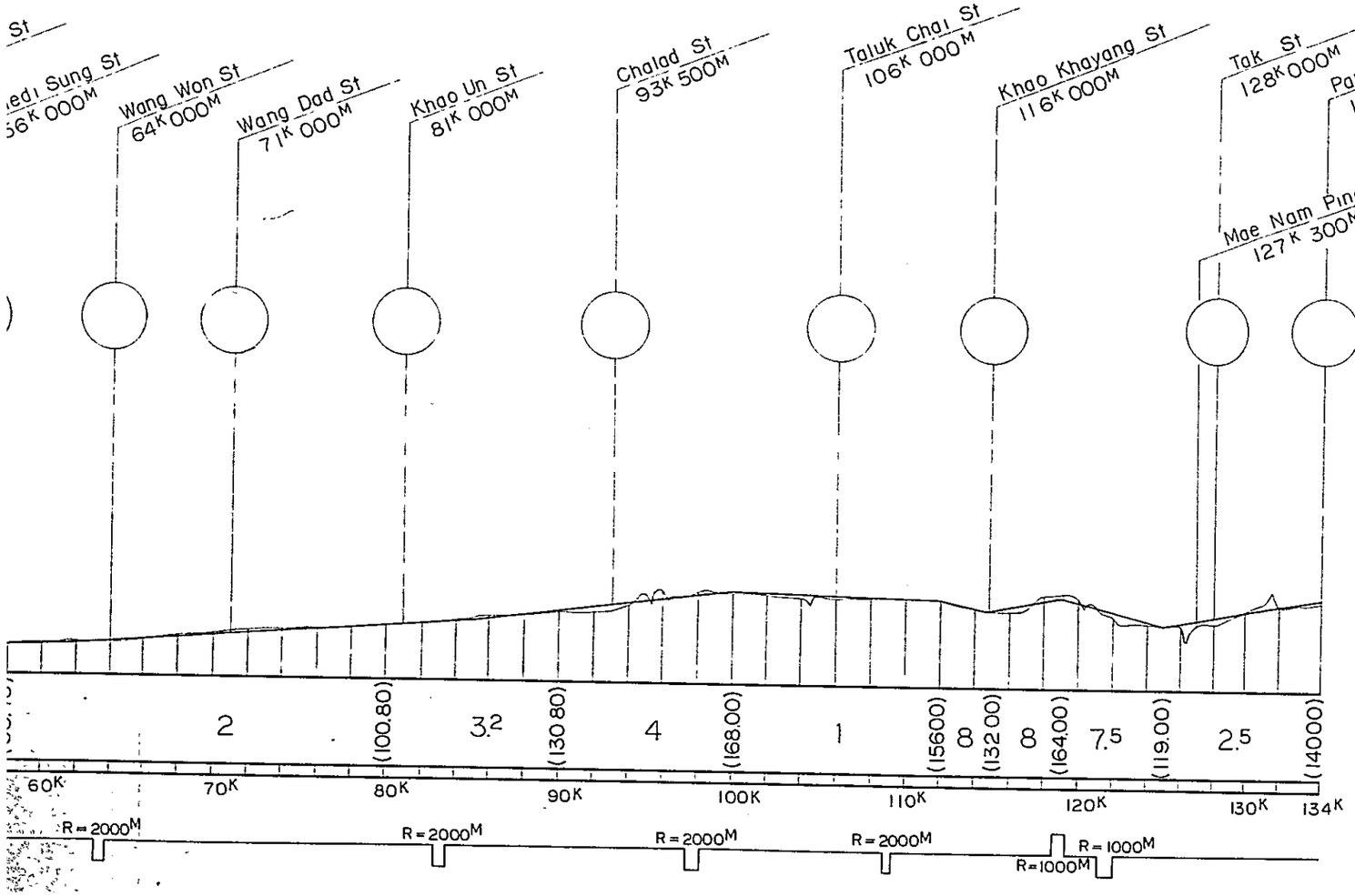


Fig. 6.1 Route Profile between Phitsanulok and Tak

Scale Breadth 1 : 250,000
Length 1 : 8,000

Table 6.1 Location of Stations for the Section between Phitsanulok and Tak

No.	Kilometerage	Name of station (provisional)	Distance between stations (km)	Class
	0.0	Kwae Noi		(existing station)
1	5.0	Tha Chang	5.0	B
2	10.0	Na Khum	5.0	B
3	18.0	Kok Raet	8.0	B
4	26.0	Prak Thong	8.0	B
5	38.4	Khlong Khae	12.4	B
6	45.0	Sukhothai	6.6	A
7	50.5	Hang Khlong	5.5	B
8	56.0	Chedi Sung	5.5	B
9	64.0	Wang Won	8.0	B
10	71.0	Wang Dad	7.0	B
11	81.0	Khao Un	10.0	B
12	93.5	Chalad	12.5	B
13	106.0	Taluk Chai	12.5	B
14	116.0	Khao Khayang	10.0	B
15	128.0	Tak	12.0	A
16	134.0	Pang Sa	6.0	A

6.1.2 Section between Suphanburi and Tak (Route "B")

Broadly, two routes may be suggested for the section between Suphanburi and Tak as follows:

Plan "1" - Suphanburi to Tak via Chainat, Uthai Thani, and Kamphaeng Phet

Plan "2" - Suphanburi to Tak via Ban Rai

The route under Plan "1" connects the communities in the western part of paddy field area and is expected to carry passengers and freight traffic (agricultural products in the main). Rich paddy field districts

have developed along the route with relatively large population and the cities are formed at the collecting centers of agricultural products.

The traffic is carried by road principally using the Highway No. 1 and by waterways through the Ping River, and it seems that the transportation demand is almost met by them.

When the railway line newly constructed is opened for service, it can be anticipated that some traffic is transferred from the existing agencies as well as induced by the new service. However, judging from the present state of things along the route and the character of regional industry, much may not be expected for any further development of the area and increase in the volume of traffic.

The route under Plan "2" runs from Suphanburi to Tak via Ban Rai, a town at the foot of mountainous area to the northwest of Suphanburi and most of it extends through the mountain foots or hilly lands that are almost undeveloped as yet. Though, for the present, much volume cannot be expected in freight not to speak of passenger traffic, the area along the route is rich in resources such as minerals and forestal products, and much can be expected from the vast unexploited land for its agricultural development. Therefore, this route can be expected to have significant effect on the regional development as compared with Plan "1" route

Since most part of the route under Plan "1" is in the paddy field, its roadbed needs to provide embankment from 2 to 3 m in height; while in Plan "2" it is possible to select a route which is constructed at a lowest cost with a minimum amount of earthwork, with remarkably lower construction cost than that for Plan "1".

It should be added that it is particularly important to establish the planning of the route in conjunction with the overall developing plan for this area.

Though the comparison of these route plans will need more detailed examination in future, the survey for the present plan was made with its focus centered on Plan "2" route which seems to have much effect on the development and to be advantageous technically and economically.

The route under Plan "2" is described in the following paragraphs.

(1) Course of Route

Starting from the station of Suphanburi, the route takes the course gradually making a detour to the left in order to avoid as far as possible to intersect with rivers and canals abounding in this area and crosses the Duan River at about right angle to run to the northwest to Ban Rai. As the area around Suphanburi is consisted of paddy field and abounds in rivers, canals and swamps which frequently overflow in the rainy season, a special care should be taken for the height of embankment, and location and length of bridges.

In the paddy field area there are many communities developed mainly along the rivers with magnificent temple situated in their middle which constitutes the religious center for the inhabitants in the region; thus the route has been always located so as to detour around it.

The paddy field which begin to decrease in the vicinity of 30 km point starting from the station of Suphanburi is replaced gradually by farm or hilly lands. At the same time the foundation becomes more favorable without any possibility of inundation and this makes it possible to construct economical roadbed with earthwork volume reduced to the minimum.

From the vicinity of Ban Na Ta Pin at 65 km point, the line detours to the right between hills to reach the east side of Ban Rai at about 96 km point, from where it detours again to the right. Though the line from about 110 km point passes through rather undulating section, the formation level can be determined in compliance with the topography.

At about 124 km point the line crosses a paddy field area along the Huai Thap Salao River and makes a slight turn to the left to cross the river at about right angle and runs straight forward.

For the section between 127 km and 190 km points, two routes, one straight and another detouring, may be suggested.

One of them which connects the both points by a straight line needs less construction cost with less route length.

Another route is located as near as possible to the paddy field area in the east, taking into account the service for the communities at the western edge of the above area and the transportation of agricultural

products. It is longer by about 2.2 km in route length with inevitable increases in the construction cost and the operation time.

Though a comparative study of the two routes will be necessary when a detailed survey is conducted in future, the plan for the present purpose has been made on the basis of a straight line taking into account the fact that the proposed railway line is a part of the Trans-Asian Railway Network.

The section between 159 km and 169 km points passes through rather low land abounding in medium and small rivers. In this section, the height of embankment is increased to some extent and the length of span of each bridge is made longer than the width of the river, with a considerable number of flood openings provided where necessary.

The line curves slightly to the left at the point near a community, or 190 km point and detours to the right between the mountains at about 233 km point; on coming to about 242 km point, it turns to the left with a curve radius of about 1,500 m.

The section passing through the hilly land between 250 km and 265 km points is rather rugged and the route is selected so as to minimize the earthwork volume. At about 296 km point the line comes to the bank of the Ping River.

The proposed route reaches Tak by running in parallel with and the west side of the Highway No. 1 which extends on the right bank of the Ping River to connect Tak and Nakhon Sawan. The total length of this route of single track is 315 km.

(2) Locating of Stations

The location of stations has been determined on the basis of the standard distance of from 6 km to 8 km between stations, taking into account the convenience of communities as much as possible. For the section of line running through a remote place in the mountains, the standard distance of about 15 km has been applied for stations with siding provided mainly for crossing of trains.

The plan for locating stations is shown in Table 6.2.

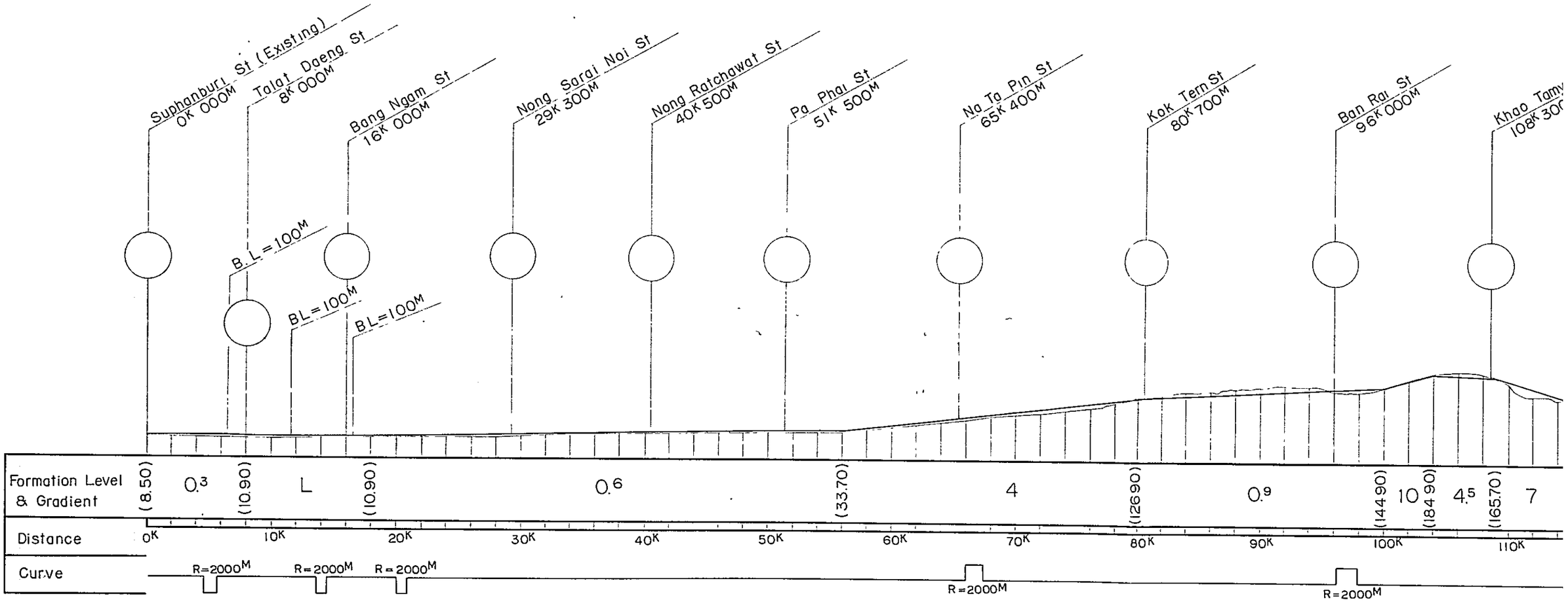
The reason why a small number of stations is proposed for the present plan is that it is more advisable to increase the stations gradu-

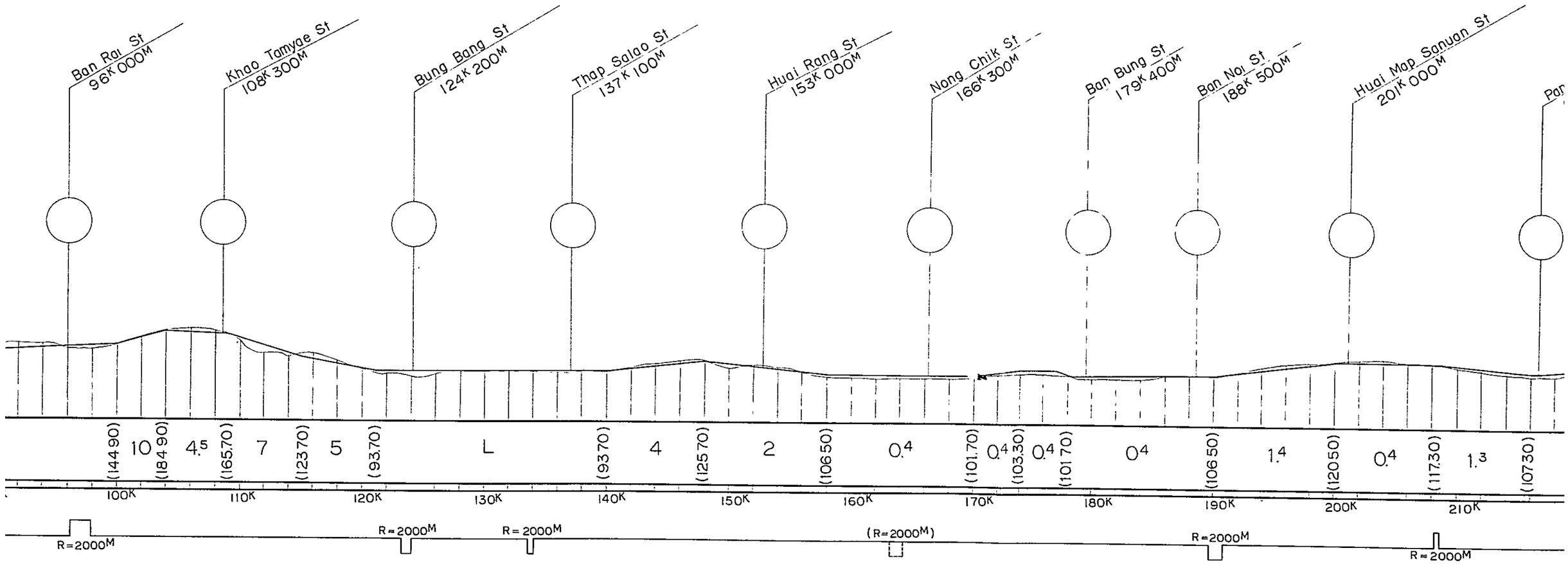
ally with the augmentation of trains operated after the line is opened for service.

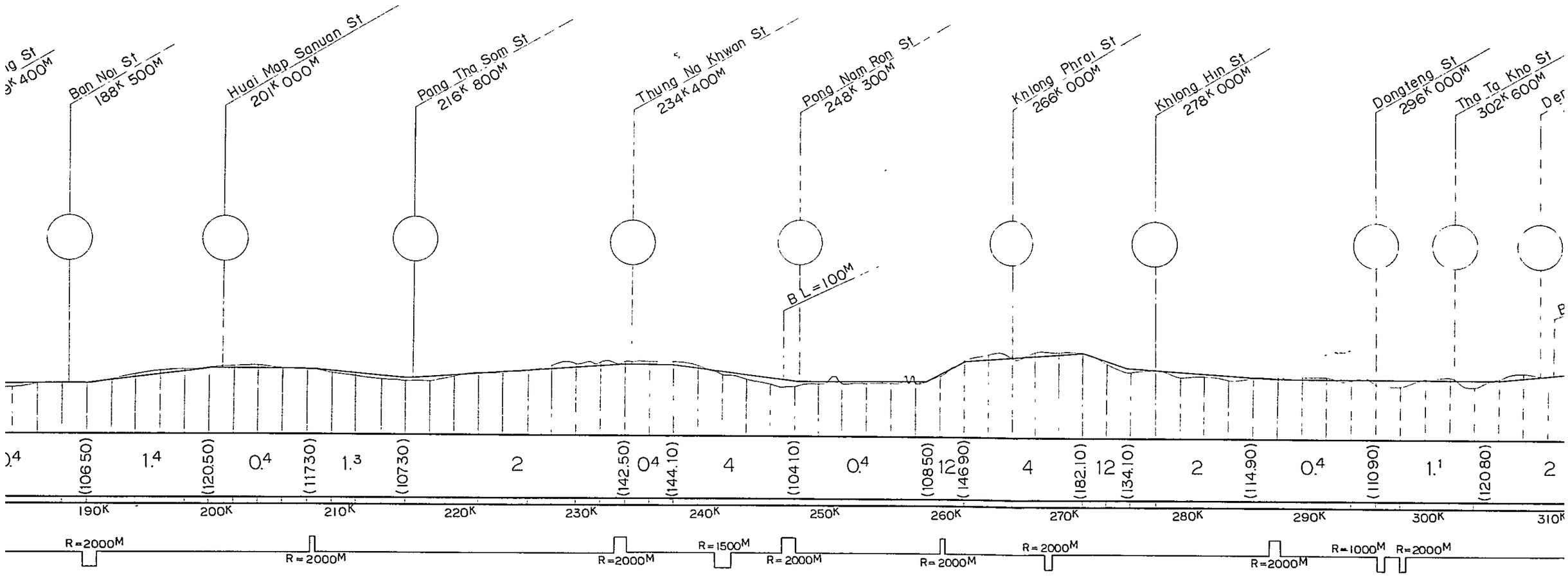
The route profile is shown in Fig. 6.2.

Table 6.2 Location of Stations for the Section between Suphanburi and Tak

No.	Kilometerage	Name of Station (provisional)	Distance between stations (km)	Class
	0.0	Suphanburi		(existing station)
1	8.0	Talat Daeng	8.0	B
2	16.0	Bang Ngam	8 0	B
3	29.3	Nong Sarai Noi	13.3	B
4	40.5	Nong Ratchawat	11.2	B
5	51.5	Pa Phai	11.0	B
6	65.4	Na Ta Pin	13.9	B
7	80.7	Kok Tern	15.3	B
8	96.0	Ban Rai	15.3	A
9	108.3	Khao Tamyae	12.3	B
10	124.2	Bung Bang	15.9	B
11	137.1	Thap Salao	12.9	B
12	153.0	Huai Rang	15.9	B
13	166.3	Nong Chik	13.3	B
14	179.4	Ban Bung	13.1	B
15	188.5	Ban Noi	9.1	B
16	201.0	Huai Map Sanuan	12.5	B
17	216.8	Pan Tha Som	15.8	B
18	234.4	Thung Na Khwan	17.6	B
19	248.3	Pong Nam Ron	13.9	B
20	266.0	Khlong Phrai	17.7	B
21	278.0	Khlong Hin	12.0	B
22	296.0	Dongteng	18.0	B
23	302.6	Tha Ta Kho	6.6	B
24	309.3	Den Tan (Tak)	6.7	A
25	315.0	Pang Sa	5.7	A


Suphanburi St (Existing)
0K 000M
Talat Daeng St
8K 000M
Bang Ngam St
16K 000M
Nong Sarai Noi St
29K 300M
Nong Ratchawat St
40K 500M
Pa Phai St
51K 500M
Na Ta Pin St
65K 400M
Kok Tern St
80K 700M
Ban Rai St
96K 000M
Khao Tamy
108K 30
B.L=100M
BL=100M
BL=100M
Formation Level & Gradient
(8.50)
0.3
(10.90)
L
(10.90)
0.6
(33.70)
4
(126.90)
0.9
(144.90)
10
(184.90)
4.5
(165.70)
7
Distance
0K
10K
20K
30K
40K
50K
60K
70K
80K
90K
100K
110K
Curve
R=2000M
R=2000M
R=2000M
R=2000M
R=2000M


Ban Rai St
96K 000M
Khao Tamyae St
108K 300M
Bung Bang St
124K 200M
Thap Salao St
137K 100M
Huai Rang St
153K 000M
Nong Chik St
166K 300M
Ban Bung St
179K 400M
Ban Noi St
188K 500M
Huai Map Sanuan St
201K 000M
(144.90)
10
(184.90)
4.5
(165.70)
7
(123.70)
5
(93.70)
L
(93.70)
4
(125.70)
2
(106.50)
0.4
(101.70)
0.4
(103.30)
0.4
(101.70)
0.4
(106.50)
1.4
(120.50)
0.4
(117.30)
1.3
(107.30)
100K
110K
120K
130K
140K
150K
160K
170K
180K
190K
200K
210K
R=2000M
R=2000M
R=2000M
(R=2000M)
R=2000M
R=2000M


ıg St
ɔK 400M
Ban Noi St
188K 500M
Huai Map Sanuan St
201K 000M
Pang Tha Som St
216K 800M
Thung Na Khwan St
234K 400M
Pong Nam Ron St
248K 300M
B L = 100M
Khlong Phrai St
266K 000M
Khlong Hin St
278K 000M
Dongteng St
296K 000M
Tha Ta Kho St
302K 600M
Der
P
)4
(106 50)
1.4
(120.50)
0.4
(117.30)
1.3
(107.30)
2
(142.50)
0.4
(144.10)
4
(104 10)
0.4
(108.50)
12
(146.90)
4
(182.10)
12
(134.10)
2
(114.90)
0.4
(110.90)
1.1
(120.80)
2
190K
200K
210K
220K
230K
240K
250K
260K
270K
280K
290K
300K
310K
R=2000M
R=2000M
R=2000M
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R=2000M
R=2000M
R=2000M
R=1000M
R=2000M

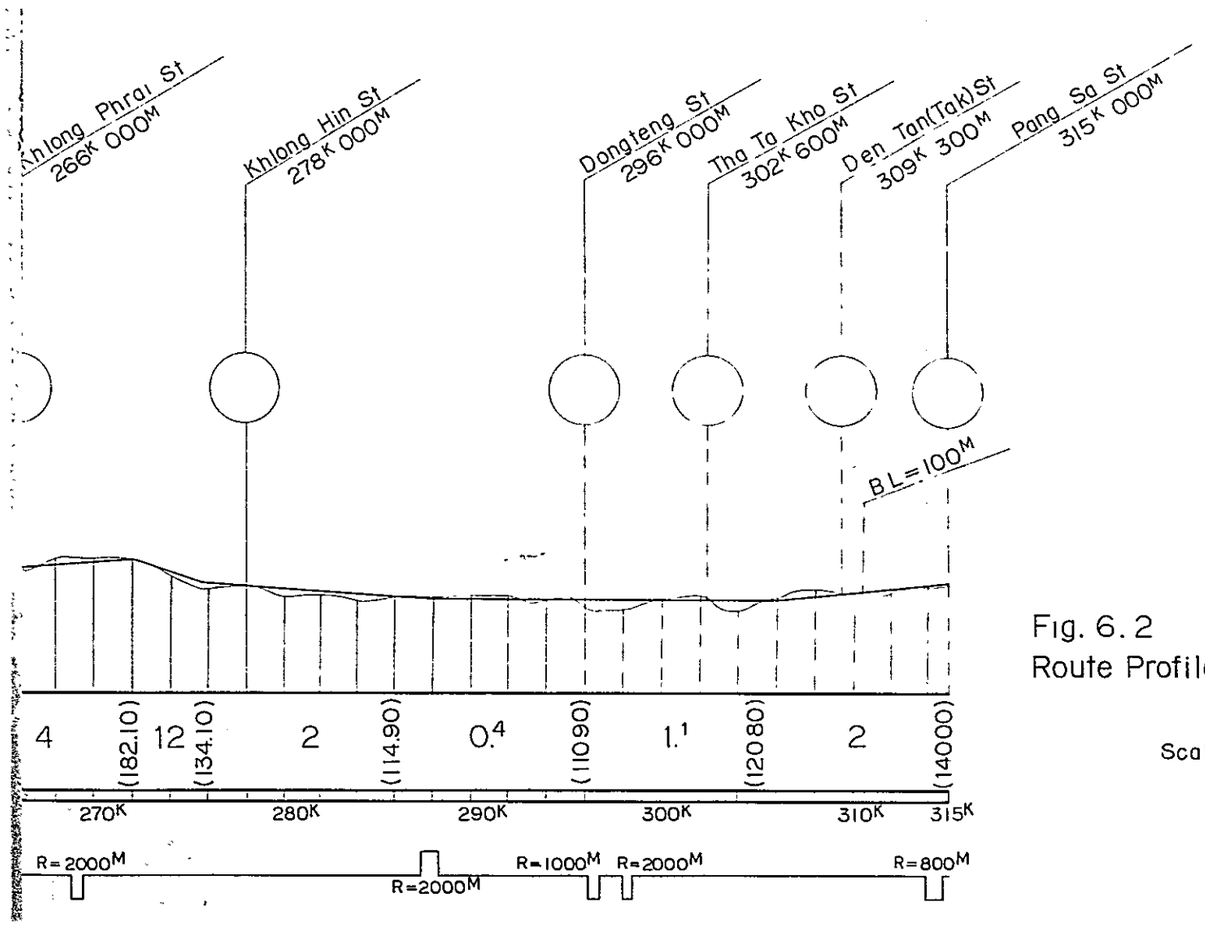


Fig. 6.2
Route Profile between Suphanburi and Tak

Scale Breadth 1 : 250,000
Length 1 : 8,000

6.1.3 Section between Tak and Mae Sod (Section Common to Route "A" and "B")

The western mountain district ranges between Tak and Mae Sod; the elevation around Tak is about 120 m and that around Mae Sod about 200 m, with that of mountain district between them being about 900 m.

Since the construction standard for the route selection requires the maximum track grade of 12 °/oo, it is technically impossible to avoid any long tunnel.

For the section between Tak and Mae Lamao, a route passing a long tunnel (named the Doi Montha Tunnel provisionally) of 14.6 km is comparatively good alignment and the execution of tunneling work is not so difficult as it is near to the Highway No. 105.

Mountains with elevation of about 800 m stand between Mae Lamao and Mae Sod, where a straight route has been selected by means of a tunnel (named the Khao Pawor Tunnel provisonally) of 11.8 km. As the alternative, a route detouring to the north along a valley is conceivable but in this case the length of the route is longer by about 70% and the construction cost increases by about 10%. In addition, as the line runs along a deep valley, the operating and maintenance expenses in future are so high that this route may not be preferred apart from the fact that tunnels of 1 km in total are to be constructed.

The comparison of the straight route and its alternative is shown in Table 6.3 in terms of their construction costs.

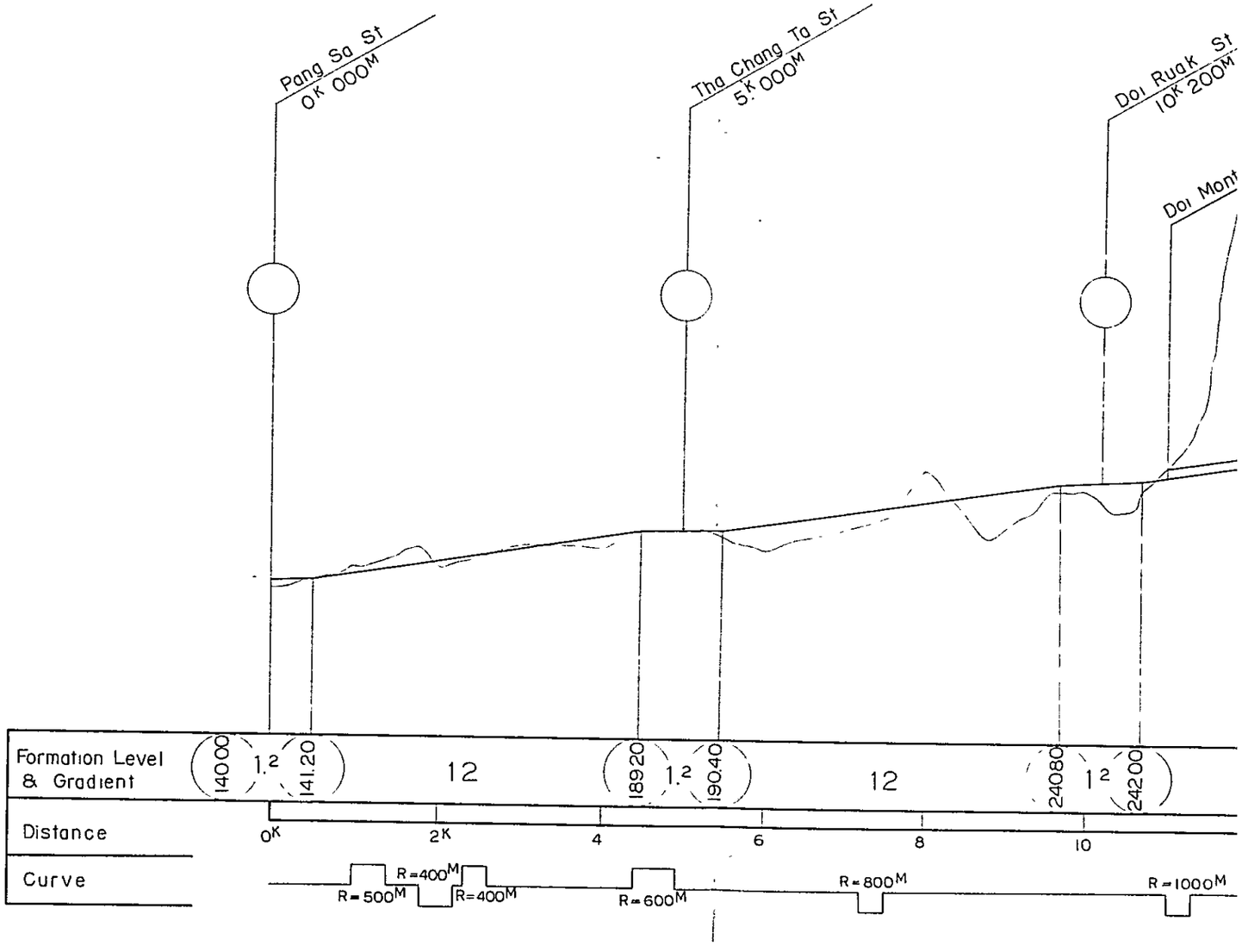
Table 6.3 Comparison of Construction Cost by Routes between Tak and Mae Sod

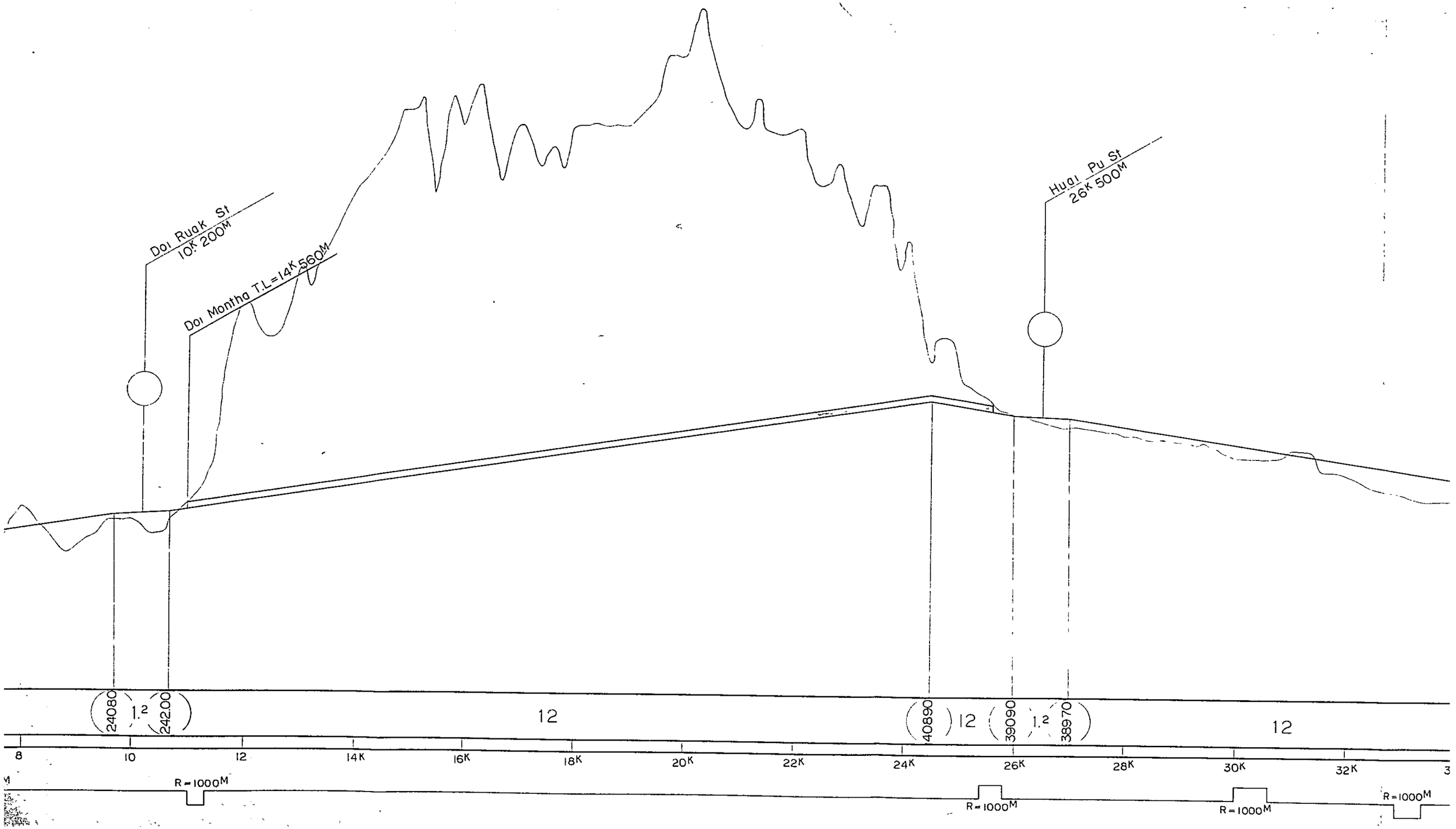
	Straight route (28 km in length)			Route to be compared (48 km in length)		
	Quantity	Unit price (1,000 Baht)	Construction cost (1,000 Baht)	Quantity	Unit price (1,000 Baht)	Construction cost (1,000 Baht)
Right of way	8 km	100	800	18 km	100	1,800
Cutting	1.5 km	1,150	1,725	10 km	2,300	23,000
Embankment	14.2 km	1,100	15,620	30.8 km	2,750	84,700
Bridge	0.5 km	16,700	8,350	6.2 km	28,000	173,600
Tunnel	11.8 km	22,200	261,960	1.0 km	16,700	16,700
Station	4 stns.	550	2,200	7 stns.	275	1,925
Track	28 km	900	25,200	48 km	900	43,200
Signal & telecommunication	28 km	150	4,200	48 km	150	7,200
Others	5 %		16,003	5 %		17,606
Total			336,058			369,731

The proposed route based on the above examination extends through the hilly land; the Doi Montha Tunnel of 14.6 km; the vicinity of Mae Lamao in the basin; the Khao Pawor Tunnel of 11.8 km; and then it runs approximately in parallel with the Highway No. 105 to reach Mae Sod. It consists of single track section of 62 km in length. The route will be extended to Thaton in Burma across the Moei River flowing along the border between Thailand and Burma to form the Trans-Asian Railway in future.

The locating of stations has been planned on the same policy as that for the section between Suphanburi and Tak. (see Table 6.4)

The route profile is shown in Fig. 6.3.


Pang Sa St
0K 000M
Tha Chang Ta St
5K 000M
Doi Ruak St
10K 200M
Doi Mont
Formation Level
& Gradient
14000
1.2
141.20
12
189.20
1.2
190.40
12
24080
1.2
24200
Distance
0K
2K
4
6
8
10
Curve
R=500M
R=400M
R=400M
R=600M
R=800M
R=1000M

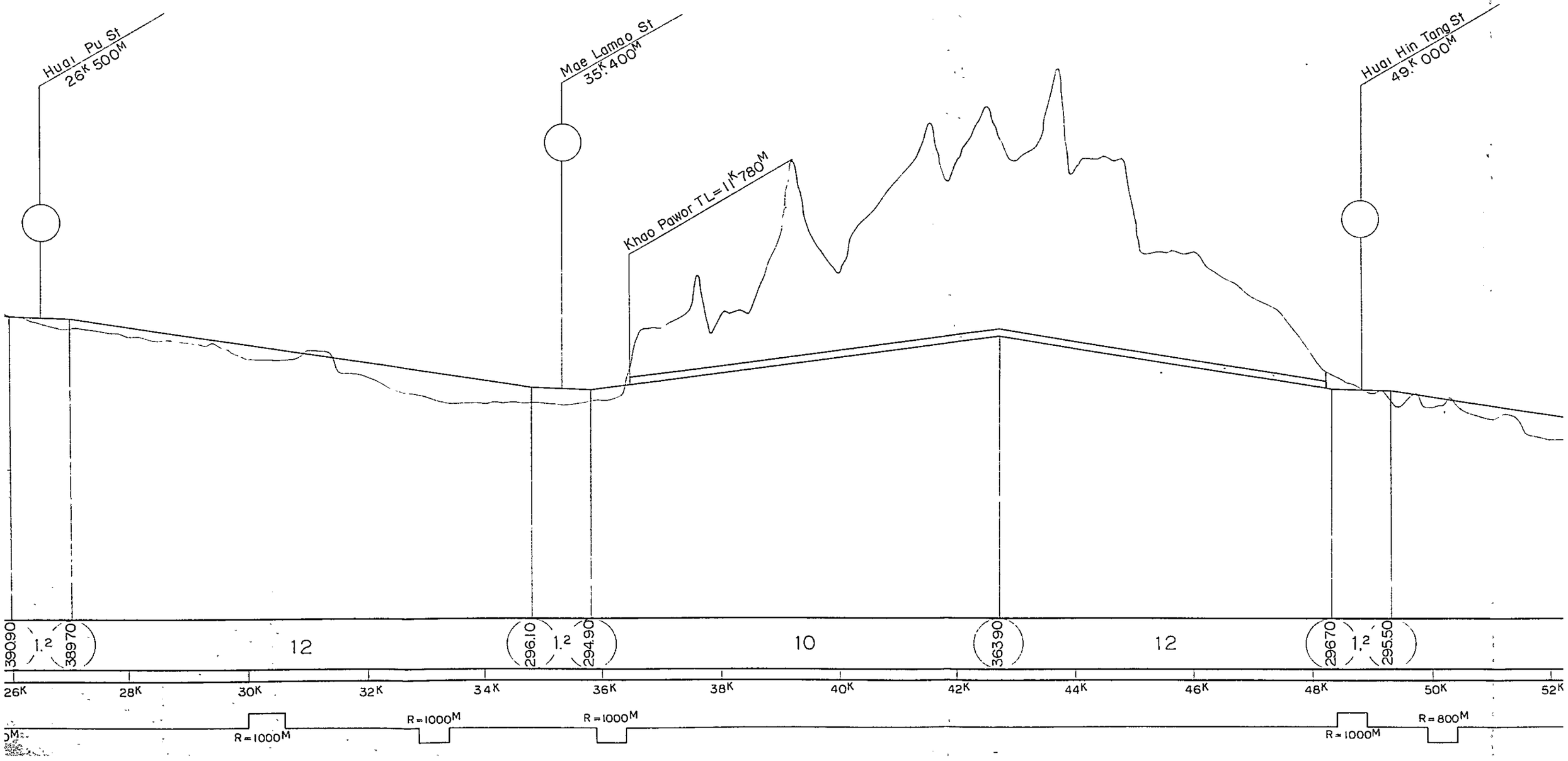

Doi Ruak St
10K 200M
Doi Montha T.L=14K 560M
Huai Pu St
26K 500M
24080
1.2
242.00
12
40890
12
39090
1.2
389 70
12
8
10
12
14K
16K
18K
20K
22K
24K
26K
28K
30K
32K
R=1000M
R=1000M
R=1000M
R=1000M

Huai Pu St
26K 500M

Mae Lamao St
35K 400M

Khao Pawor TL=11K780M

Huai Hin Tang St
49K 000M



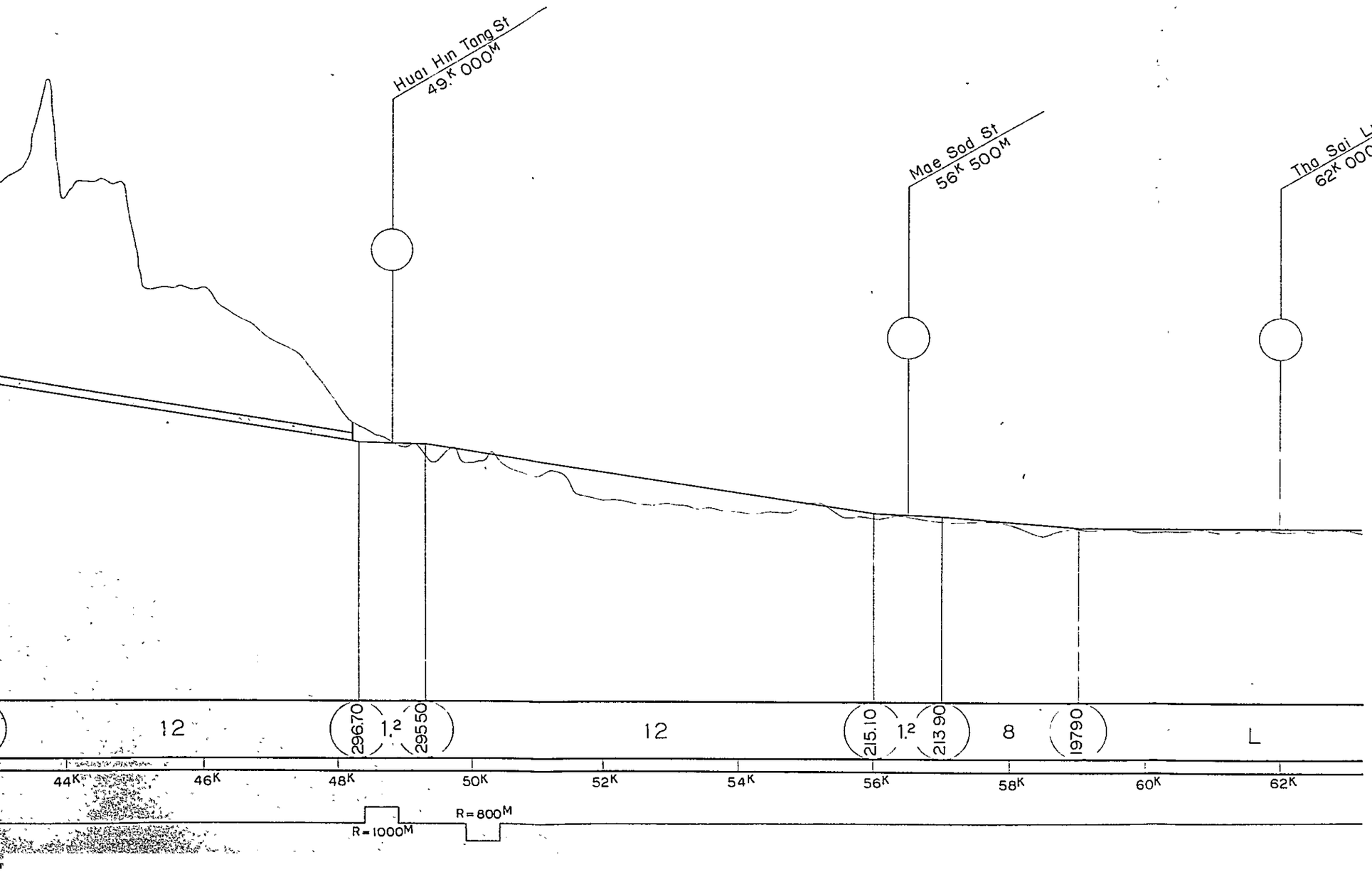


Fig. 6.3 Route Profile between Tak

Scale Breadth 1: 50,000
Length 1: 4,000

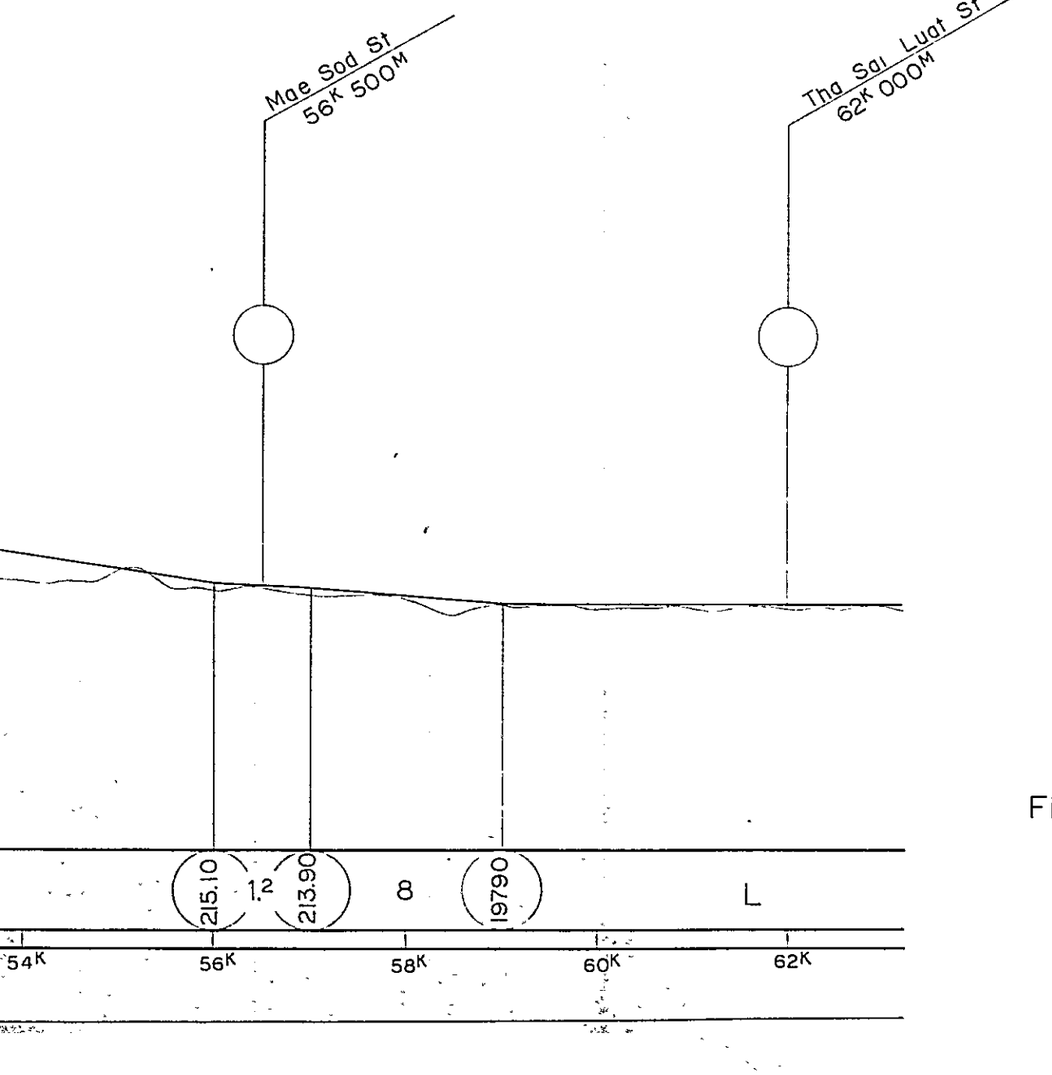


Fig. 6.3 Route Profile between Tak and Mae Sod

Scale Breadth 1. 50,000
Length 1. 4,000

Table 6.4 Location of Stations for the Section between Tak and Mae Sod

No.	Kilometerage	Name of Station (provisional)	Distance between stations (km)	Class
	0.0	Pang Sa		
1	5.0	Tha Chang Ta	5.0	B
2	10.2	Doi Ruak	5.2	B
3	26.5	Huai Pu	16.3	B
4	35.4	Mae Lamao	8.9	B
5	49.0	Huai Hin Tang	13.6	B
6	56.5	Mae Sod	7.5	B
7	62.0	Tha Sai Luat	5.5	B

6.2 Construction Standards

The construction standards have been determined by referring to the standards for the RSR modernization plan which is under way and as a result of arrangement between RSR and the officers concerned of ECAFE. They are as follows:

(1) Track gauge: 1.00 m

(2) Minimum radius of curve: R = 400 m

(3) Maximum grade:

Between stations 12 o/oo

Station yard 1.2 o/oo

(4) Width of formation level: 4.75 m

(5) Bearing capacity of bridge: 14 tons in axle weight

(6) Track structure:

Weight of rail – 80 lbs/yard

No. of sleepers – 1,500/km

Ballast – crushed stone, 200 mm in thickness

(7) Others:

Construction gauge - see Fig. 6.4

to be capable of letting International Container (Standard 8' x 8' x 20') pass through

Roadway diagram - see Fig. 6.5.

Fig. 6.4 Vehicle Gauge & Structure Gauge

S = 1/30

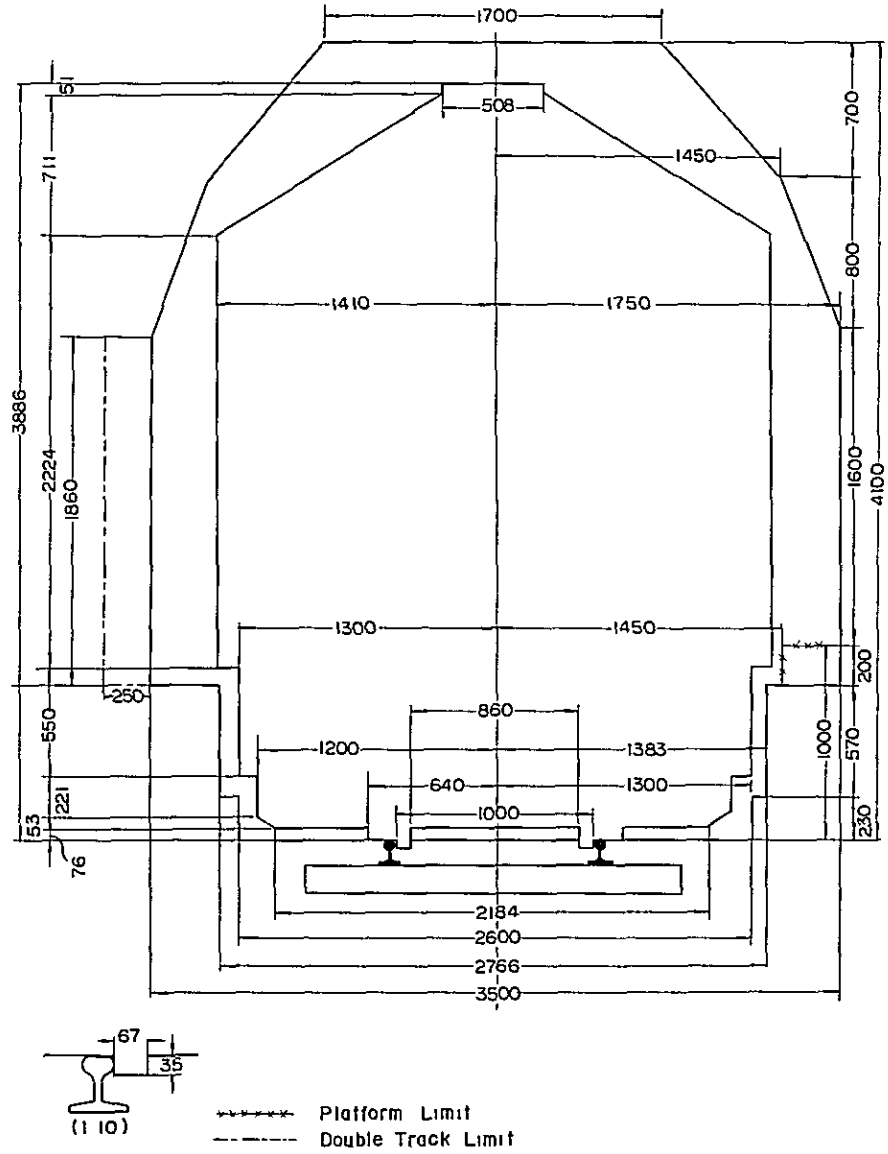
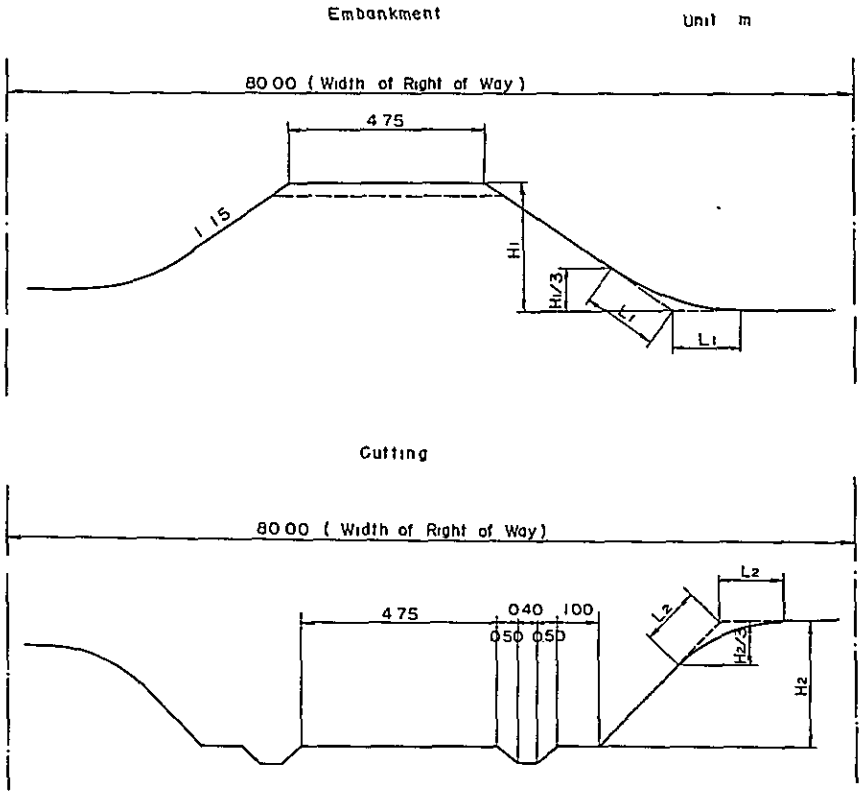


Fig. 6.5 Roadway Diagram



Though the items as described below have been considered in the present planning, they will need to be examined further in detail prior to the actual execution of works.

(1) Radius of Curve

Except in the mountain district lying between Tak and Mae Sod, most part of the line runs through the flat lands. Therefore, it is possible to set the radius of curve without restriction and the curves have been designed with a large radius of more than 2,000 m whenever possible.

(2) Grade

The maximum grade has been set at 12 °/oo taking into account the performance of the existing rolling stock, and economic comparison between the above grade and the grade set at from 20 to 25 °/oo between Tak and Mae Sod does not show any appreciable difference in cost.

(3) Right of Way

The width of the right of way has been determined in accordance with the present standards of RSR of 40 m on each side of track between stations and 80 m for station premises with a length of 700 m.

(4) Types of Rail

The standard rail is of 80 lbs per yard. However, in the execution of actual construction, the rails of 70 lbs per yard should be laid initially to reduce the construction cost, taking into account the expected volume of traffic and number of trains so that they can be replaced with those of 80 lbs per yard when the volume of traffic increases in future.

6.3 Roadbed Construction

The method of roadbed construction varies in accordance with the work to be done in paddy field area, farm or hilly land, or mountain district.

6.3.1 Paddy Field Area

In General, there are many rivers, canals and swamps in the paddy field area, most of which remain in the natural conditions and often overflow in the rainy season. In many places the depth of water is from about 1 to 1.5 m but differs considerably by places. Therefore, it is necessary to make a detailed survey when the actual measurement is performed.

In the present plan, the standard for the height of embankment has been set at about 1 m above the flood level and the embankment in the paddy field areas designed with the height of from 2 to 4 m.

The low and swampy land is generally weak and some consolidation settlement seems to occur to the embankment, though it will not need, any special method for filling as the embankment is low. A thorough survey of the ground is necessary by the use of penetrometer and others when a detailed investigation is made in future.

One of the filling method applied so far is to form the roadbed with the filling materials obtained by excavating on the both sides of permanent way. In the present plan, in addition to these filling materials obtained from the both sides of the way, the materials of good quality to be placed on the surface course are obtained from borrow pits at a distance of about 5 km for carrying them to the site. Any special consideration is not given to the slope protection and side drain at toe of slope which are to be in accordance with the usual practice.

For the section between Phitsanulok and Tak, the proposed line branching off the station of Kwae Noi runs for some distance through the paddy field where the weak ground is forecasted partially and the rise of water level is forecasted in the rainy season. The existing track is laid on the embankment of from 3 to 4 m high, and it is necessary to set the standard height of embankment at about 4 m on the basis of the roadway diagram. The protection of face of slope is necessary by means of slope protection piling or wall at some portions (near the Kwae Noi Bridge and Nan River) taking into account the flood during the rainy season in particular.

6.3.2 Hilly Land

The ground of farm or hilly land is generally good without any fear for flood. Therefore, the construction of roadbed has been planned to lower the formation level as near as possible to the ground level so that the earthwork volume can be reduced as well as to make a mutual use of materials obtained from cutting for filling. As a result, the construction cost of roadbed is the lowest compared with other sections. However, though it runs through the hilly land, the section in a lower land where the rivers are concentrating is provided with rather higher embankment and the length of bridge over the river portion is made somewhat longer than the width of such portion with considerable number of flood openings provided.

6.3.3 Mountain District

The roadbed is not surveyed at many places in the mountain section from Tak to Mae Sod and further study of it is necessary in the future survey.

When the route to be compared which makes a detour along a valley is examined, special attention should be given to the following facts

As the route run through the mountainside with a slope as steep as 1 5-to-1 both the cutting and embankment require a longer length of slope and this poses many problems in stabilizing the surface of slope.

The cutting will be constructed with a slope between 0.5-to-1 and 1-to-1 and the slope protection provided at need. However, judging from the cuttings on the Highway No. 105, the cuttings at many places will be compelled to make with a slope 1-to-1 and it is necessary to determine the cutting slope based on the further detailed survey.

For the embankment on the mountainside with steep slope it is topographically impossible to construct it with a ratio of slope steeper than 1.5-to-1. Therefore, the masonry with slope of from 0.5-to-1 to 1-to-1 must be provided using the stones produced from the materials from the cutting or tunnel excavation or the concrete retaining wall must be constructed.

As described above, the route to be compared has the problem in stabilizing the surface of slope both for cutting and embankment, and a thorough examination is needed by making the actual measurement.

6.4 Bridge Construction

The great rivers in the entire section are the Ping River having width of 400 m, and the Kwae Noi, Nan, and Yom Rivers having the width of from 100 to 150 m, and others are medium or small rivers having with less than 100 m.

Except some rivers which are relatively well improved, most rivers are left in their natural conditions to meander very much. Also the river changes its width as it flows, and in an extreme case the width of the same river varies from about 50 to 400 m. In addition, many ponds and swamps which seem to be the former riverbeds are found in the paddy field area.

These properties of river should be fully taken into account in determining the bridge site. It is necessary to make the length of bridge somewhat longer than the width of the river to deal with the movement of river course or concentric flow and the increase in the width of river which are expected for these rivers.

It seems no special restriction is imposed on the span of bridge for the river administration purpose. As the current is slow in general the size of span does not present any serious problem and it is advisable to plan the spans so as to be technically profitable.

The technically profitable span which depends on the type and depth of the substructure of bridge is to be determined based on a thorough survey made on individual bridge; in this connection a span of 20 to 30 m is conceivable in general.

In the present plan the standard types of bridges over the medium and small rivers have been determined on the basis of the condition of foundation tentatively as follows:

Condition of foundation	Type of structure
Weak foundation and deep bearing stratum	Deck plate girder, span of 30 m
Weak foundation and not so deep bearing stratum	Deck plate girder, span of 25 m
Relatively good foundation	Deck plate girder, span of 20 m

Actually, only few rivers have very weak foundation and the bridges have been planned principally with spans of 25 m and 20 m; however, a thorough survey is necessary prior to the designing of bridge.

Besides the river bridges, the construction of a considerable number of flood openings has been planned at the places where the overflow of river is forecasted, with greater number provided especially for the section running the hilly land between Ban Rai and Tak, where the ground is relatively low and the rivers concentrate.

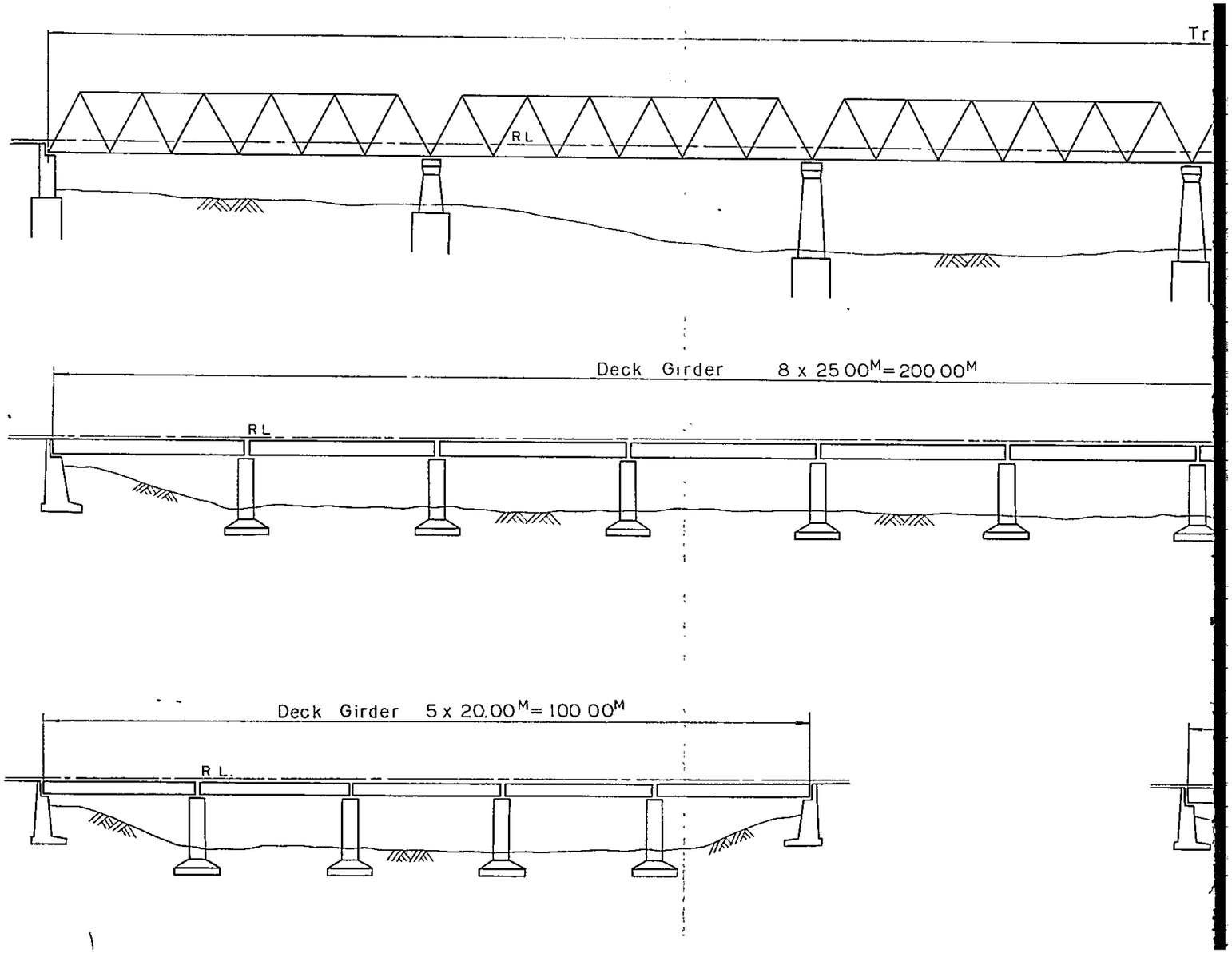
On the other hand, the filling-up and embankment have been planned to pass the ponds and swamps lying frequently in the paddy field area, where any special need is recognized to construct a bridge.

The bearing capacity of bridge for the line to be constructed has been planned with the axle load of 14 t, in order to accord with the improvement of the existing line which is now under way to provide it with the axle load of 13.75 t by RSR and the adoption of 14 t being examined under the Trans-Asian Railway Network Project.

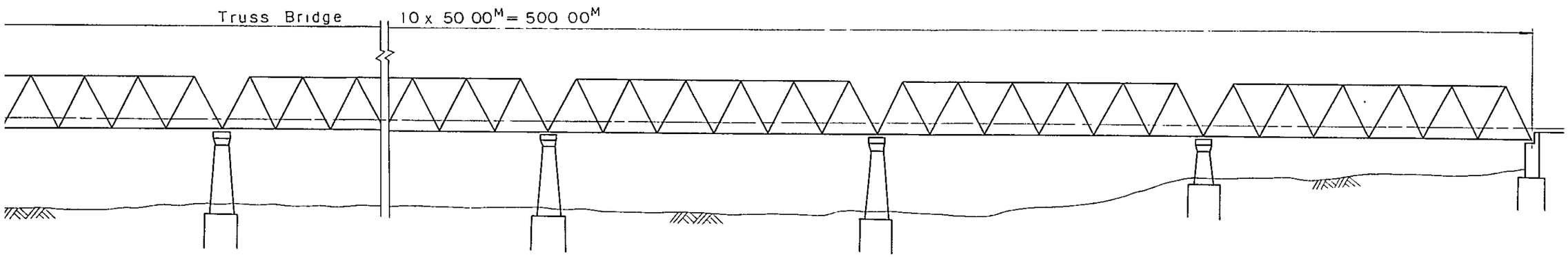
The railway bridge to be built over the Ping River which is the only great river in the section under the present survey has been planned with 10 spans x 50 m, referring to 12 spans x 40 m of the road bridge at about 600 m downstream from the projected site of bridging. (see Fig. 6.6)

Though the continuous deck plate girder is regarded as the desirable type of girder, the steel truss structure has been adopted which permits the easy transportation from abroad.

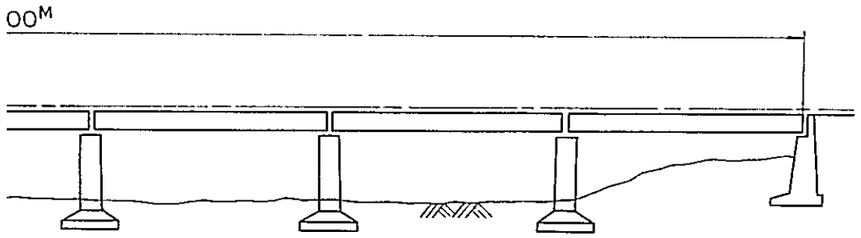
The river-crossing spots which have been actually confirmed by the present survey includes three sites respectively for the Ping, Kwae Noi and Yom Rivers and a few sites for medium and small rivers, while it was almost impossible to make the actual investigation or the collection of data

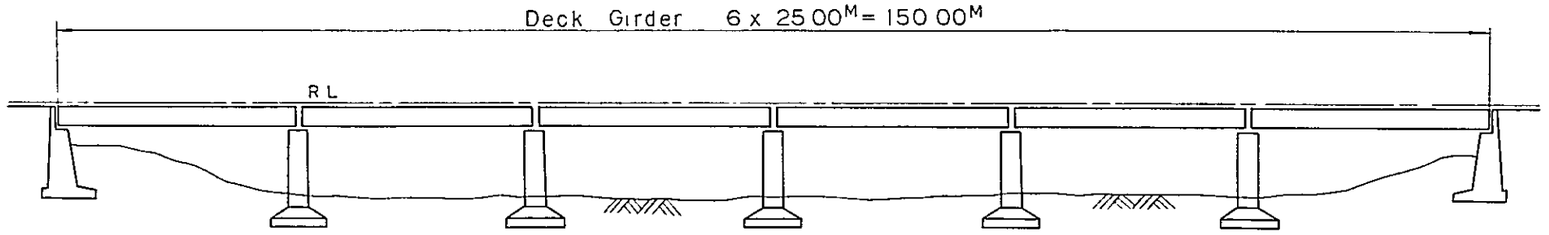

Tr
RL
Deck Girder 8 x 25.00M = 200.00M
RL
Deck Girder 5 x 20.00M = 100.00M
RL

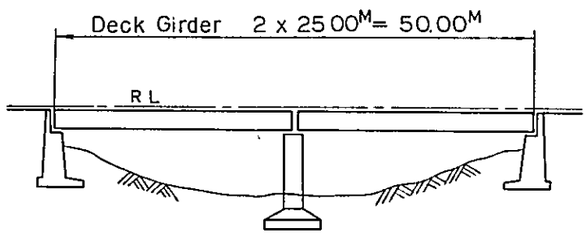
Mae Nam Ping Bridge

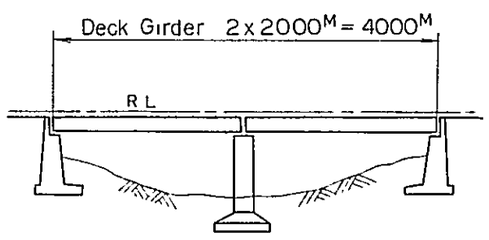


Standard – type of Bridges









S = 1/500

Fig. 6.6 Design of Bridges

in order to have the details of geological survey, water depth and flood water level. Therefore, the basic designs have been prepared for the five bridges of 200 m, 150 m, 100 m, 50 m and 40 m long as the standards and the actual designings are to be made referring to them after the survey having been completed in future. (see Fig. 6.6)

The number of bridges presumedly need to construct is shown in Table 6.5.

Table 6.5 Number of Bridges

Overall length of bridge (in m) / Section	10	20	40	50	100	150	200	500	Total
Phitsanulok-Tak	11	53	2	5		2	1	1	75
Suphanburi-Tak	10	99	23		5				137
Tak-Mae Sod	2	14	15	2					33

6.5 Tunnel Construction

Based on the results of field investigation and the route selection on the map, two long tunnels have been planned for the section between Tak and Mae Sod, and the designs of these tunnels are outlined in the below. However, until the field survey and geological survey have been completed, it is impossible to prepare the detailed designs.

Given in the following are the general items to be examined in constructing a tunnel.

In order to excavate a tunnel safely, it is necessary to conduct the investigation and planning thoroughly and to select the route taking into account the topography and geology so as to avoid any bad geology such as fault and shuttered zone. If such bad geology cannot be avoided by all means, a thorough examination should be made into the earth pressure anticipated to act to the tunnel and the excavation method to prevent any collaspe to devise a safety construction method.

The geological conditions which affect the excavation of tunnel are

shown in the following and these should be examined thoroughly.

(1) Topography ..... depth, and topography;

(2) Geological structure ..... state of stratification, fault, fold, landslide, and talus;

(3) Character and condition of rock ..... joint, crack, weathering, poor stratum, geology, clay, and expansile stratum;

(4) Groundwater ..... artesian, and water leak.

The principal items of the construction planning for a tunnel are given in the following;

(1) Determination of cross section of tunnel;

(2) Determination of thickness of concrete lining;

(3) Calculation of volume of excavation;

(4) Calculation of volume of concrete lining;

(5) Determination of excavating method (including subsidiary shaft such as inclined and vertical shafts);

(6) Determination of method of concrete lining work;

(7) Division of working section;

(8) Preparation of progress schedule;

(9) Planning of plant and equipment.

The construction of the two long tunnel, respectively 14.6 km and 11.8 km in length, in the section between Tak and Mae Sod is outlined below using the data obtained from the present survey.

The route plan and profiles are shown in Figs. 6.7, 6.8 and 6.9.

(1) Cross Section of Tunnel

The cross section of the tunnel which permits to pass through the Standard container (8" x 8' x 20') (see Fig. 6.10) (Fig. 6.11 shows the cross section of tunnel considering electrification) has been designed referring to the construction gauges of various countries participating in the Trans-Asian Railway Network Project. (see Fig. 6.12). This standard cross section is designed so as to be most profitable, taking into account the construction gauge submitted to the Working Party of Experts on the Trans-Asian Railway Network in November, 1970, and

Fig. 6.7 Plan of Tunnels
S=1/250.000

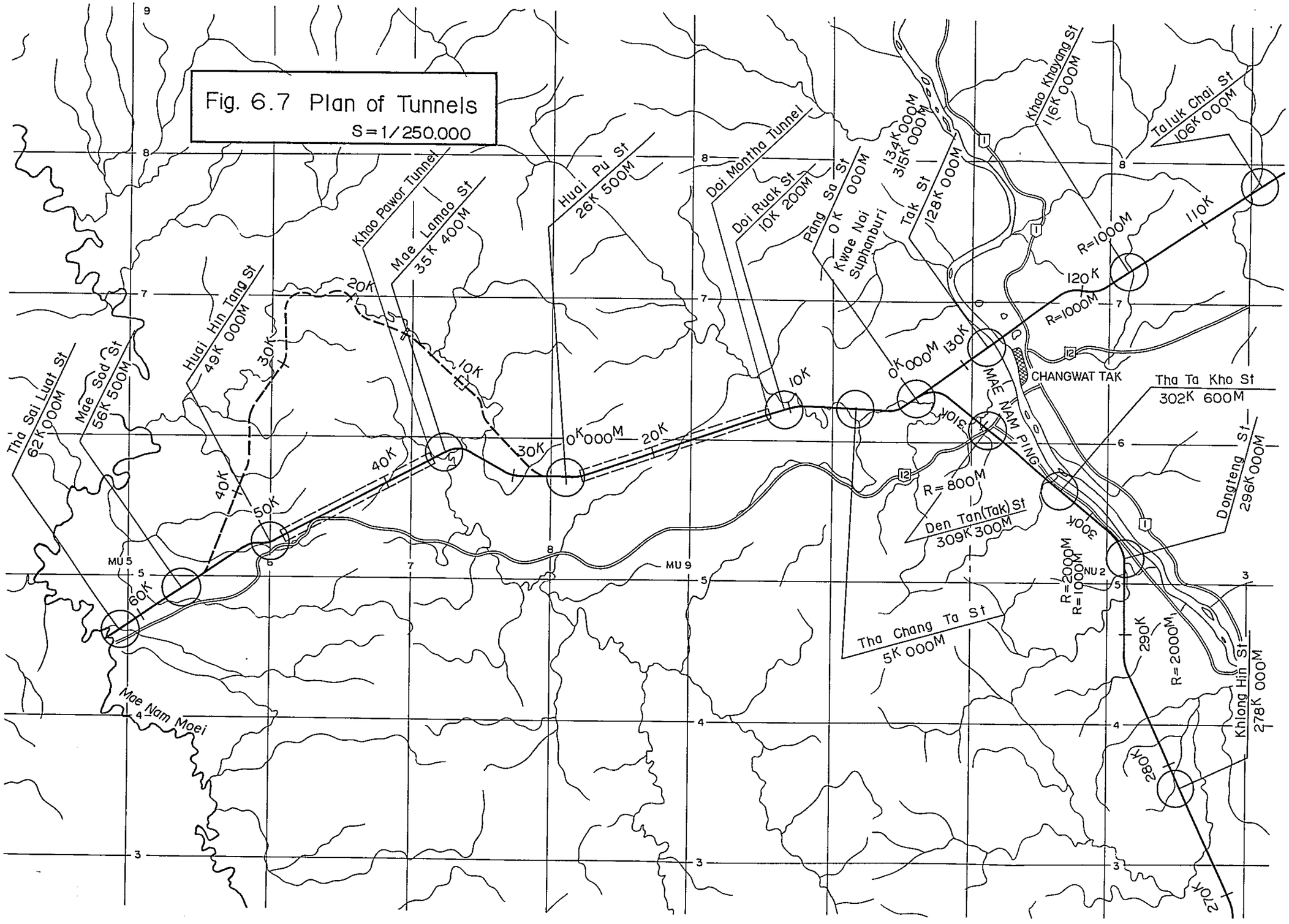


Fig. 6.8 Profile of Doi Montha Tunnel

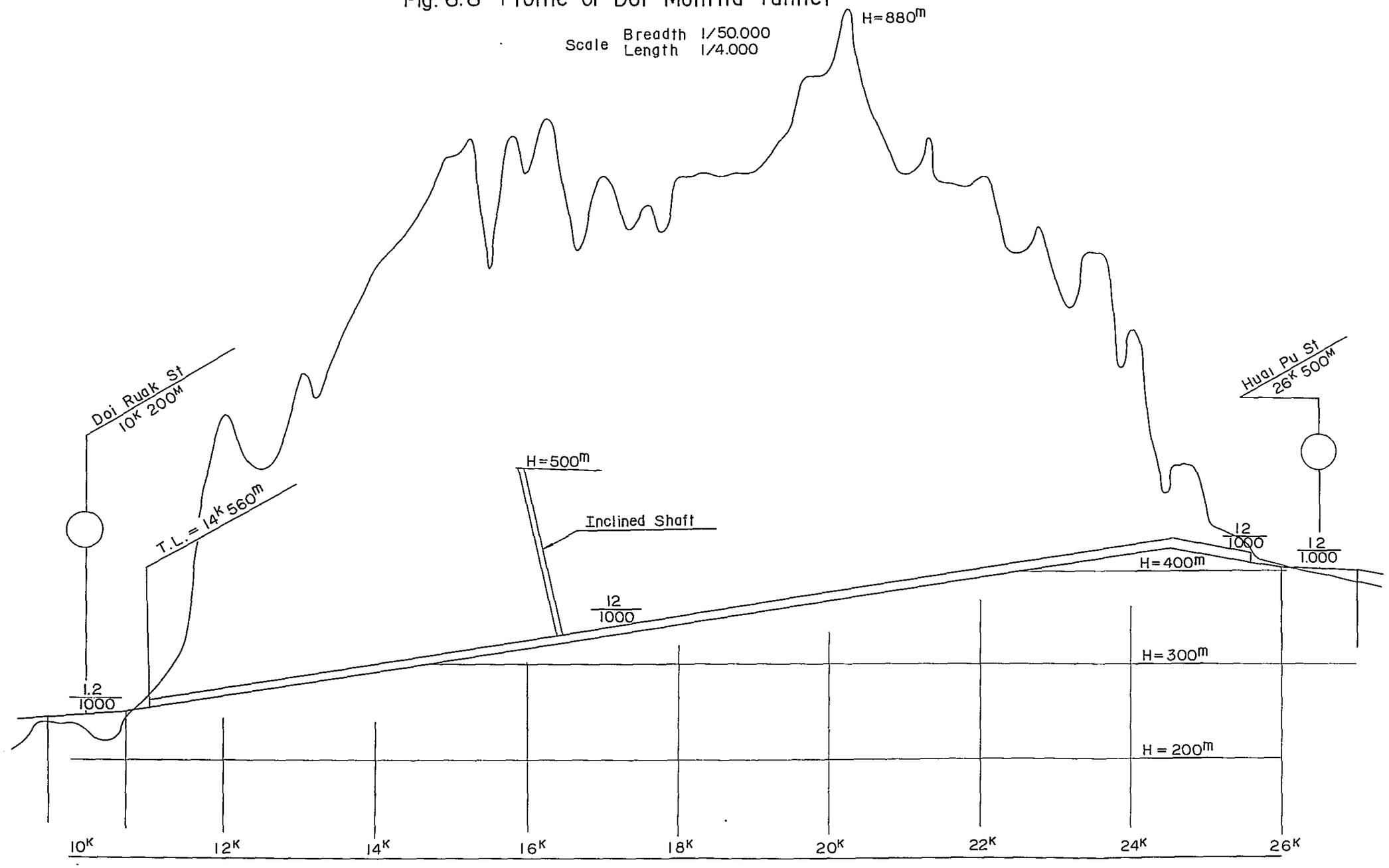


Fig. 6.9 Profile of Khao Pawor Tunnel

Scale Breadth 1/50 000
Length 1/4.000

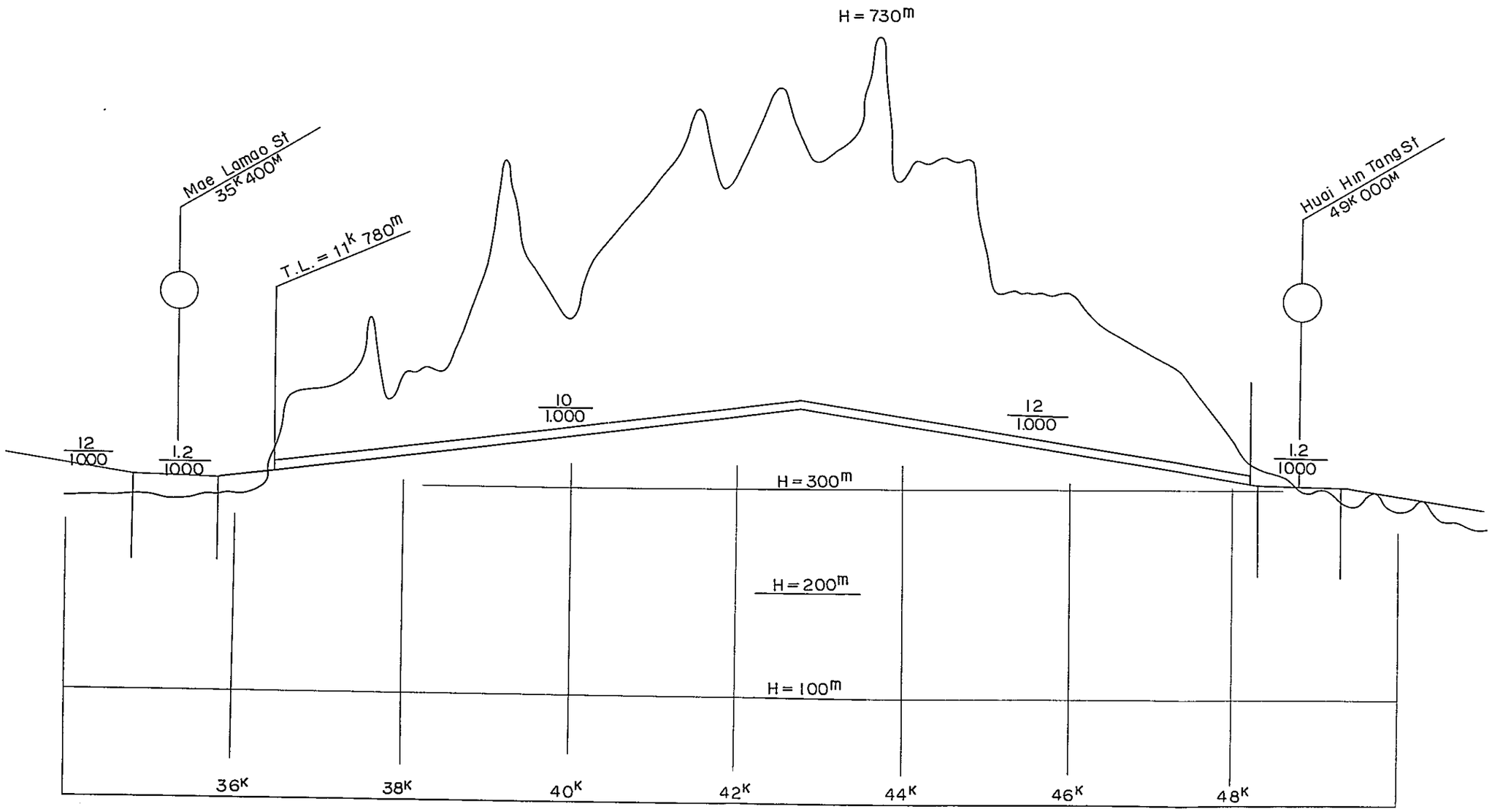


Fig. 6.10 Section of Tunnel

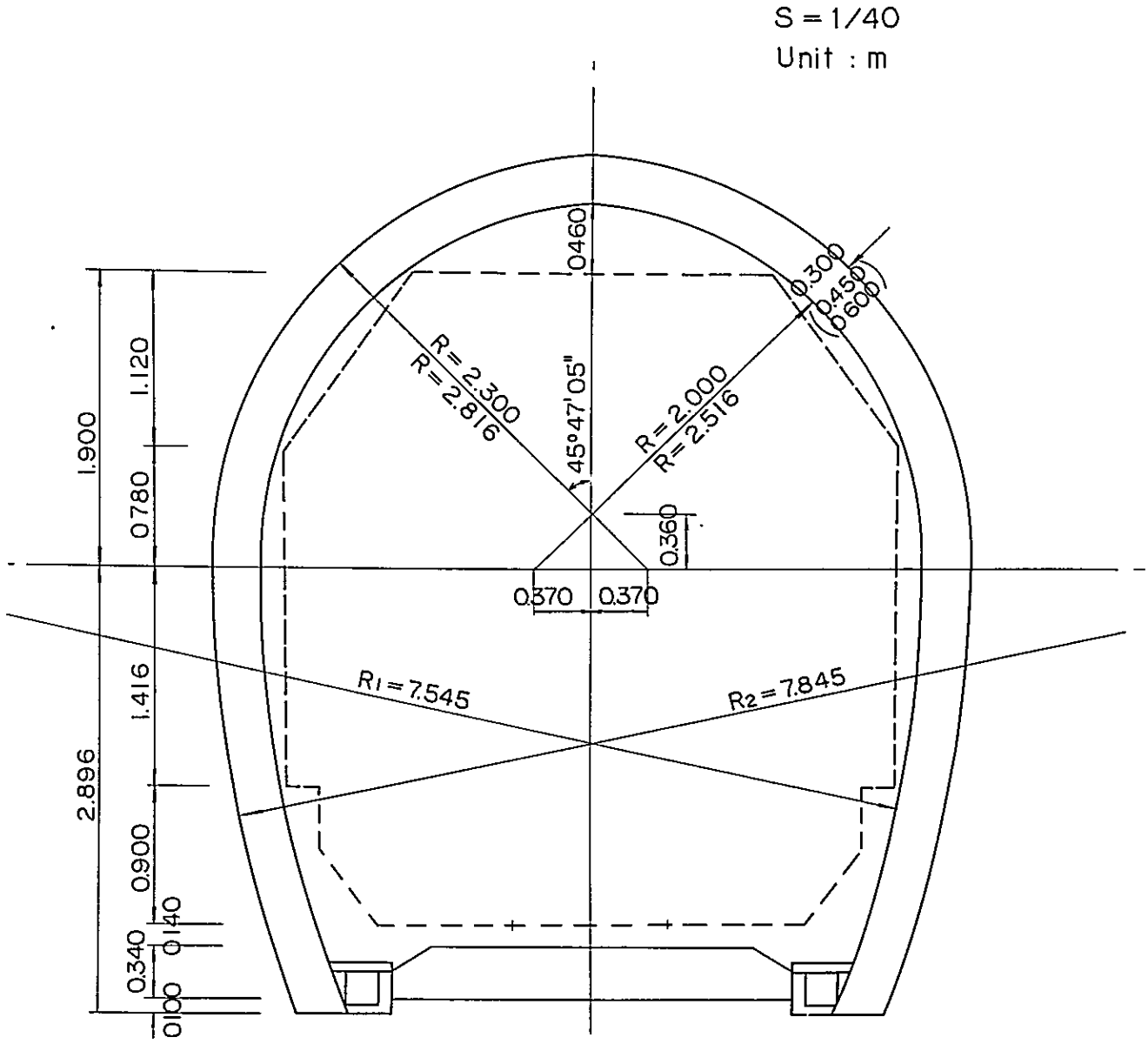


Fig. 6.11 Section of Tunnel
(Considering Electrification)

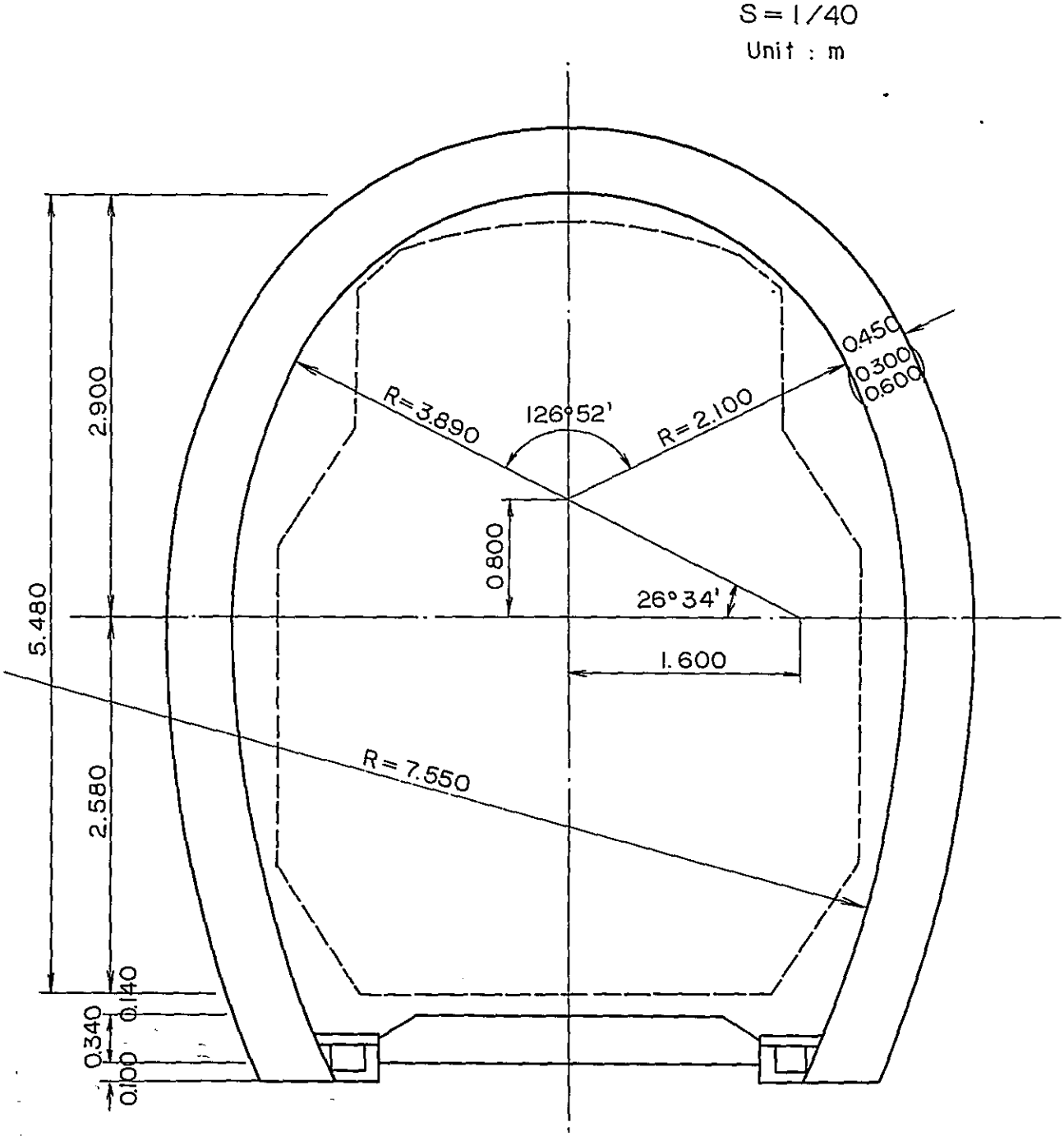
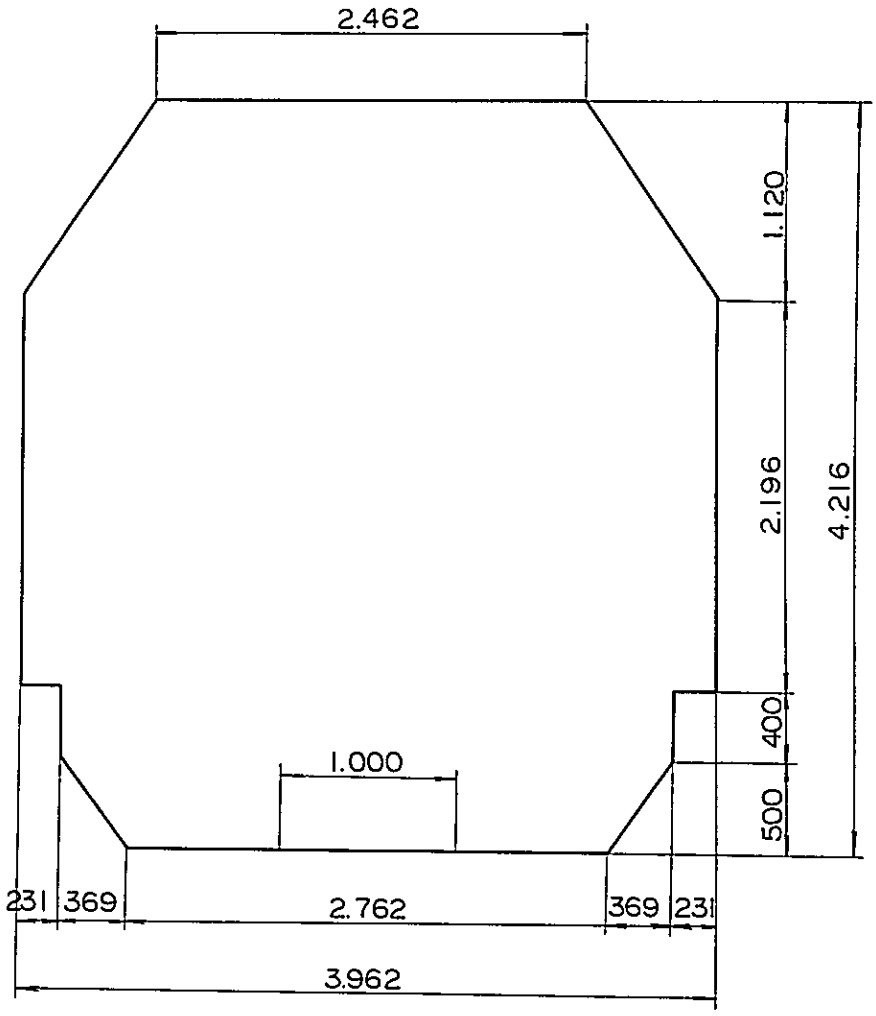


Fig. 6.12 Structure Gauge

(Considering International Container)

S = 1/40
unit : mm



that in planning by RSR. The sectional areas are shown by thickness of lining in Table 6.6.

Table 6.6 Sectional Areas by Thickness of Tunnel Lining

Thickness of lining	Inner section area (m^2)	Excavation section area (m^2)	Lining section area (m^2)
30 cm	19.0 (23.4)	23.0 (28.0)	4.0 (4.6)
45 cm	" (")	25.2 (30.4)	6.2 (7.0)
60 cm	" (")	27.4 (32.8)	8.4 (9.4)

Note: ( ) are for electrification

(2) Thickness of Lining

Three kinds of lining respectively of 30, 45 and 60 cm thick are to be applied successively with the change in the rock nature from good to poor. Assuming from the results of the field survey, the rock through which the Doi Montha Tunnel of 14.6 km is excavated consists principally of granite and mudstone, having a high solidification and relatively good nature. The rock for the Khao Pawor Tunnel of 11.8 km is also assumed to consist of the same type of rock except that a low solidification and many cracks are suspected. Therefore, the latter requires more thick lining to be applied.

(3) Quantity of Work

The estimated quantity of work for the tunnel construction is shown in Table 6.7.

Table 6.7 Estimated Quantity of Works for Tunnel Construction

Name of tunnel	Volume of excavation (m^3)	Volume of lining (m^3)	Remarks
Doi Montha Tunnel	345,000	68,000	Linings of 30, 45, and 60 cm thick account for respectively 80, 10, and 10%.
Khao Pawor Tunnel	289,000	66,000	Linings of 30, 45, and 60 cm thick account for respectively 50, 30 and 20%.

(4) Method of Excavation

Since a long tunnel requires a long period of time until completion, it is necessary to build a subsidiary inclined shaft for excavating the Doi Montha Tunnel of 14.6 km, in order to recover the invested fund in a short period. In this case, the construction is carried out by dividing into three working sections.

Many methods are available for excavating a tunnel and among them the working methods used generally at present are

(a) Bottom drift and half section tunneling method,

(b) Top heading half section tunneling method, and

(c) Full face tunneling method.

Various methods except the above are used to the poor geology such as falt and shuttered zone.

Judging from the geological condition, the geology for the Doi Montha Tunnel seems to be relatively good and the full face tunneling method having a high excavating efficiency may be suitable to it. On the other hand the bottom drift and half section tunneling method may be more suitable to the geology for the Khao Pawor Tunnel.

At present the tunnel boring machine is developed and used practically in various countries in the world, but as it costs high and its profitability is low in many cases, a thorough examination is necessary for adopting it.

The temporary support necessary for excavating should be of H-shape steel (150 x 150 mm and 125 x 125 mm in size) or of used rail

(50 kg/m in size). The steel support is easy to handle and as it is left burried the use of it increases the safety in tunneling.

The subsidiary inclined shaft is generally excavated with a section area of 8.0 m^2 and with a slope of 1/4 and it needs to provide the lifting and shaft bottom facilities. (see Fig. 6.13)

(5) Progress Schedule

Since the entire period of construction is determined depending on the completion of the long tunnels, the preparation of the progress schedules for such tunnels requires a thorough examination of the relevant conditions. The construction of these two long tunnels with require about 7 years from the start to the completion of work including the track construction. (see Fig. 6.14)

6.6 Station Facilities

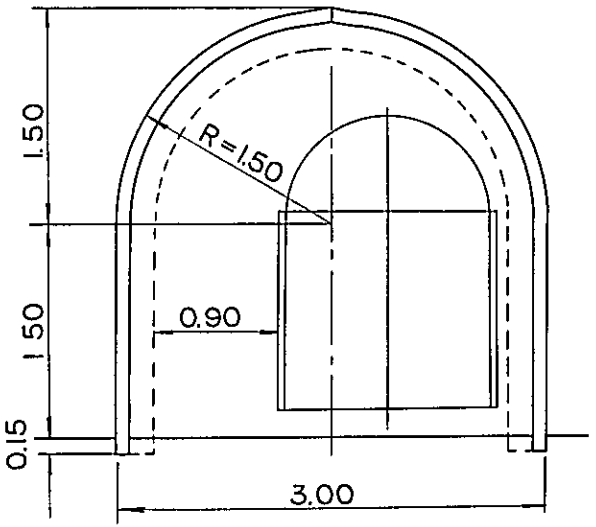
The track layout in the intermediate stations has been so arranged that the passing trains always run the main track on the straight side of turnouts. Accordingly, the local trains, either of up and down trains, run the track on turnout side to arrive and start from the track on the station building side, in spite of the rule of left side traffic. Though this method of train handling requires to establish a platform only on the side of the station building, another platform is provided on the main track at each station to enable the local passenger trains to pass each other. The freight handling stations are designated at every 3 to 5 stations taking into account the economic conditions of stations along the route, with freight siding provided to receive and dispatch the freight train.

The effective length of tracks is 500 m.

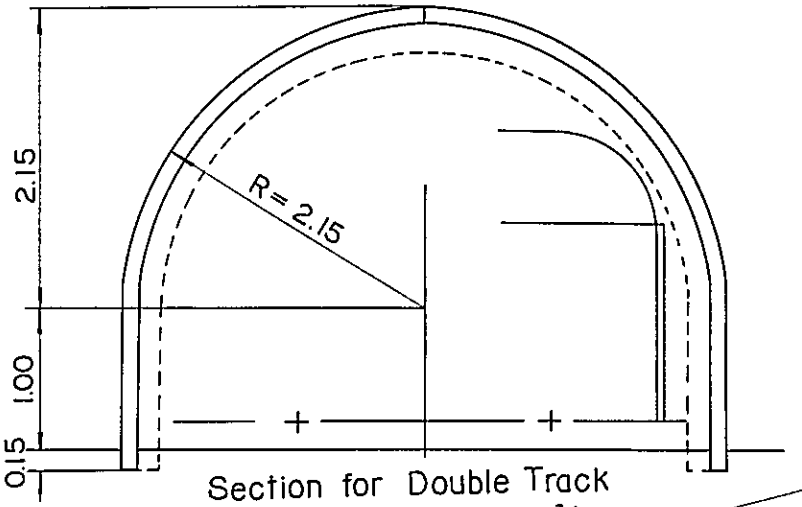
For Route "A", an engine shed is set up at Tha Sai Luat Station on the border between Thailand and Burma, and some storage tracks are provided at Pang Sa Station for regulating the nominal tractive capacity. For Route "B", engine sheds are set up at Tha Sai Luat and Ban Rai Stations and some storage tracks provided at Pang Sa Station for the same purpose.

The skeleton of track layout between Kwae Noi and Pang Sa Stations in Route "A" and that between Suphanburi and Pang Sa Stations in Route "B"

Fig. 6.13 Inclined Shaft S=1/50
unit : m



Section for Single Track
(Sectional Area 8.0m³)



Section for Double Track
(Sectional Area 11.6m³)

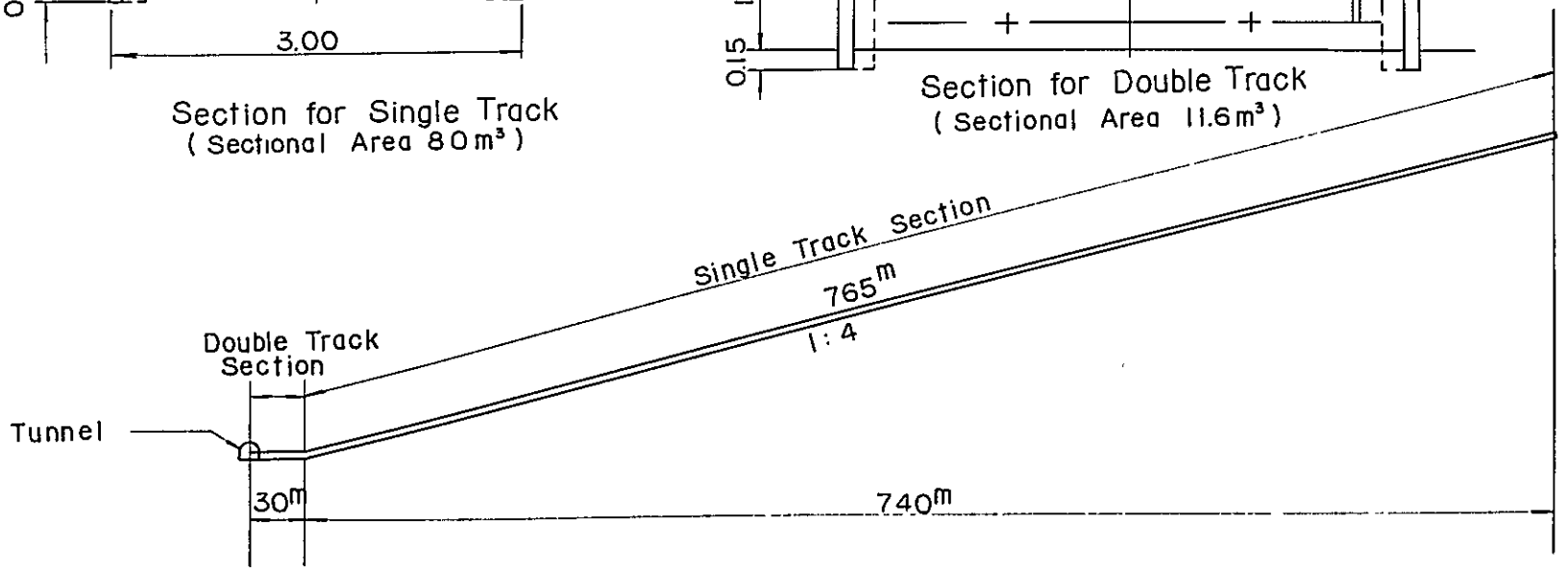
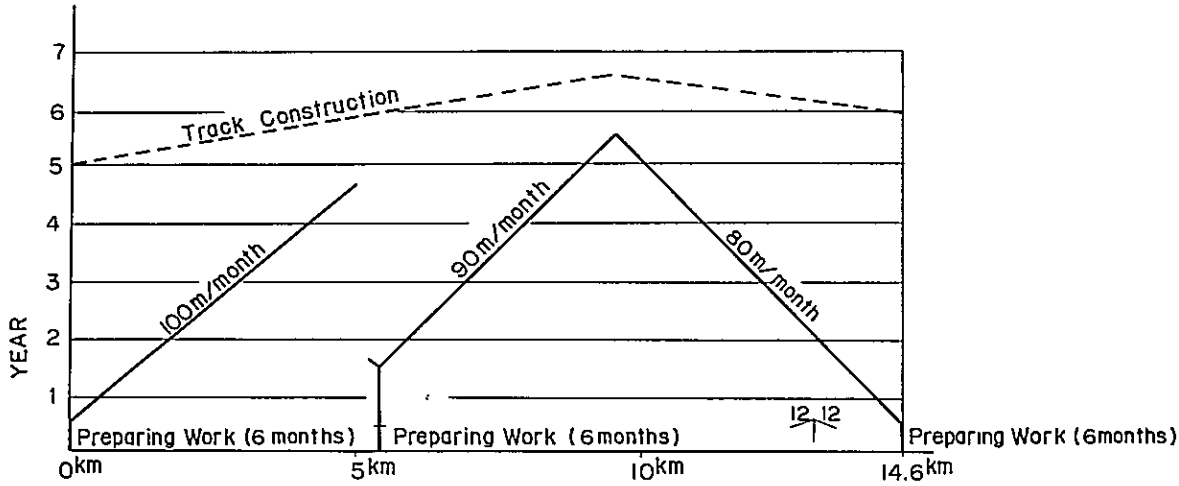
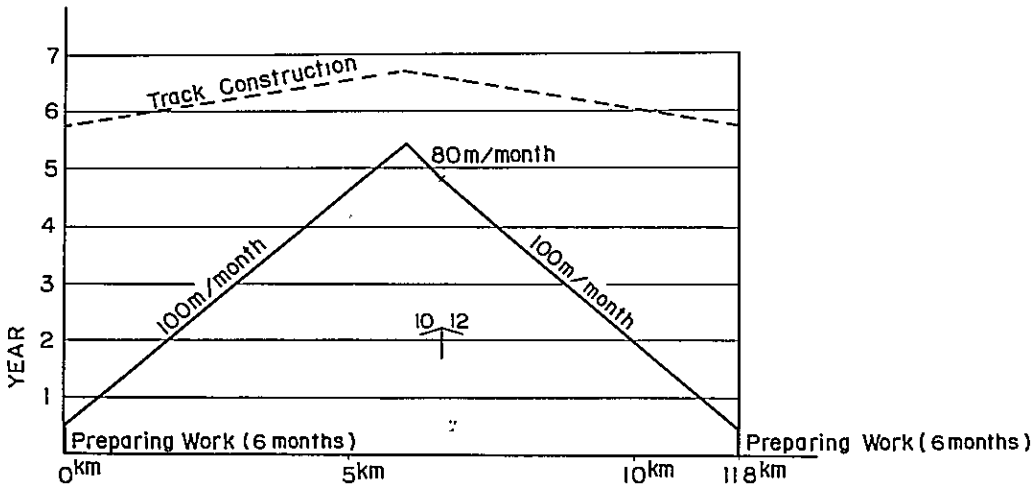


Fig. 6.14 Construction Term of Tunnels

Doi Montha Tunnel (L=14.6 km)



Khao Pawor Tunnel (L= 11 8 km)



are shown respectively in Fig. 6.15 and 6.16. Such skeleton between Tha Chang Ta and Tha Sai Luat Stations in the common section of Routes "A" and "B" is shown in Fig. 6.17.

6.7 Track Construction

The track structure has been planned as follows.

(1) The rails used at present for the main line of RSR include four kinds in weight designated by 50, 60, 70, and 80 lbs yard, respectively accounting for 13, 16, 63, and 8% in track length, with 70 lbs/yard rail predominating. However, the track replacement with rails of 80 lbs/yard is now under way for the existing lines of RSR, then, the same rails of 80 lbs/yard are to be used for the line to be constructed.

(2) The adoption of long welded tracks has not been examined for the line to be constructed, though it is progressing considerably on the important line such as the Northern Line.

(3) The wooden sleepers account for 95% of sleepers used on the existing tracks with 5% representing the RS type concrete sleepers. Though the adoption of concrete sleeper is progressing on the existing tracks, the wooden sleepers are used for the track to be constructed in view of the construction cost and the capacity of supply.

(4) The number of sleepers inserted on the existing tracks is 1,430, 1,500, or 1,540 pieces per km and the sleepers of 1,500 pieces per km are to be inserted on the new track.

(5) The tie plates are to be used only in the curve section of less than 500 m radius and none is used in the straight section.

(6) The ballast is to consist of crushed stones in conformity with that of the existing track.

(7) The thickness of ballast on the existing tracks is 150 mm or 200

Fig. 6.15 Skeleton of Track Layout between Kwae Noi and Pang Sa Stations in Route "A"

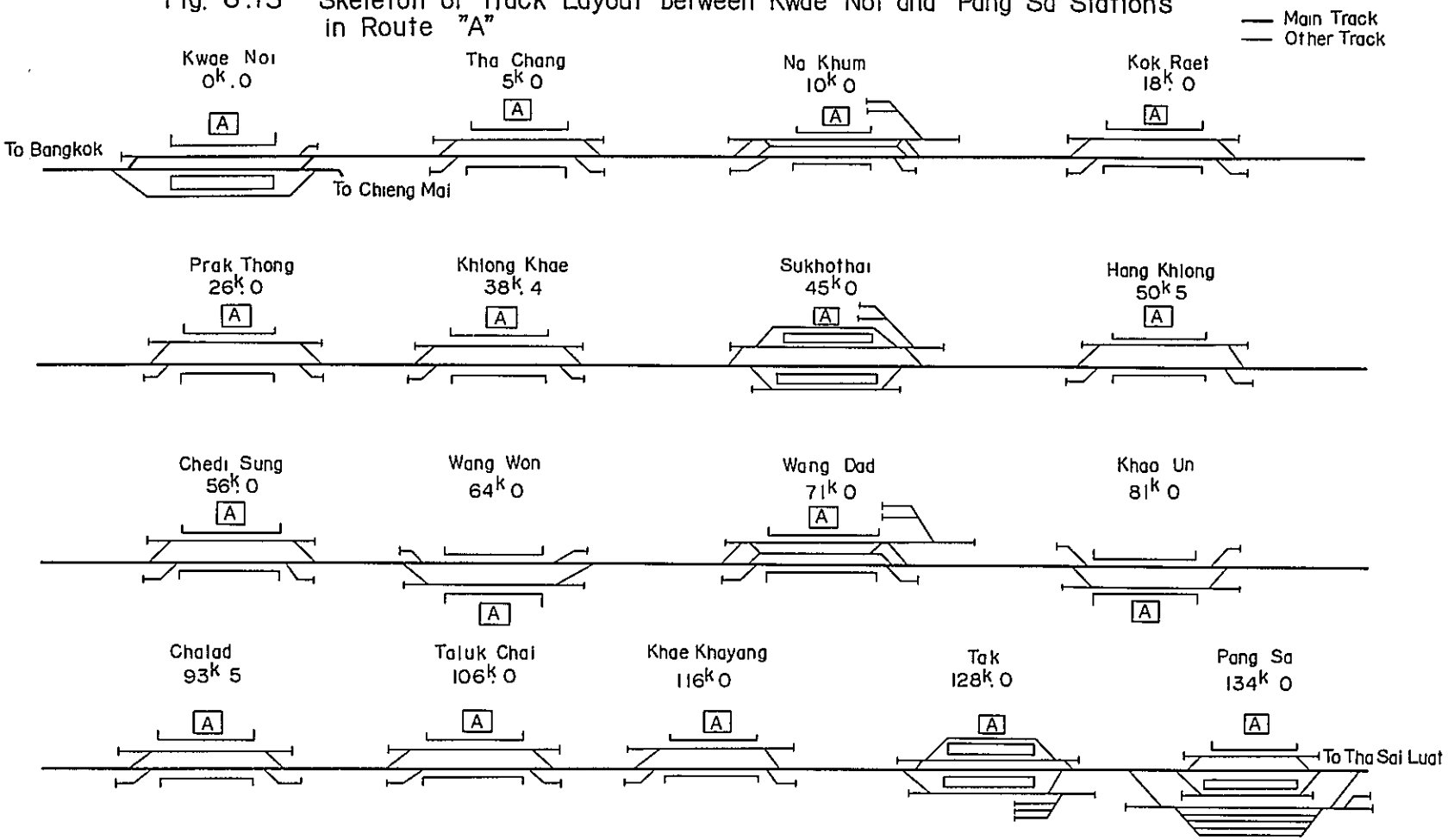
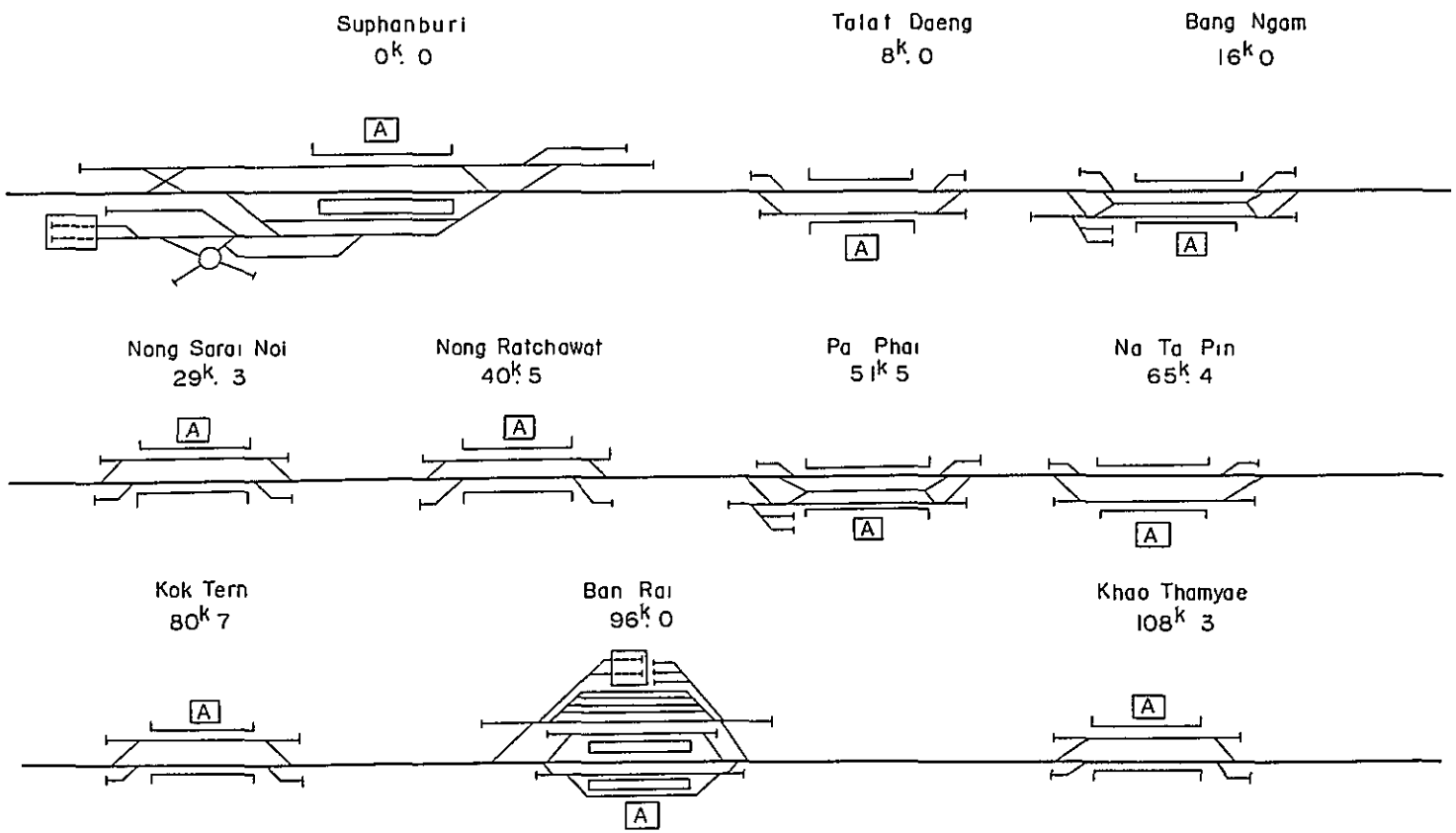


Fig. 6.16 Skeleton of Track Layout between Suphanburi and Pang Sa Stations in Route "B"



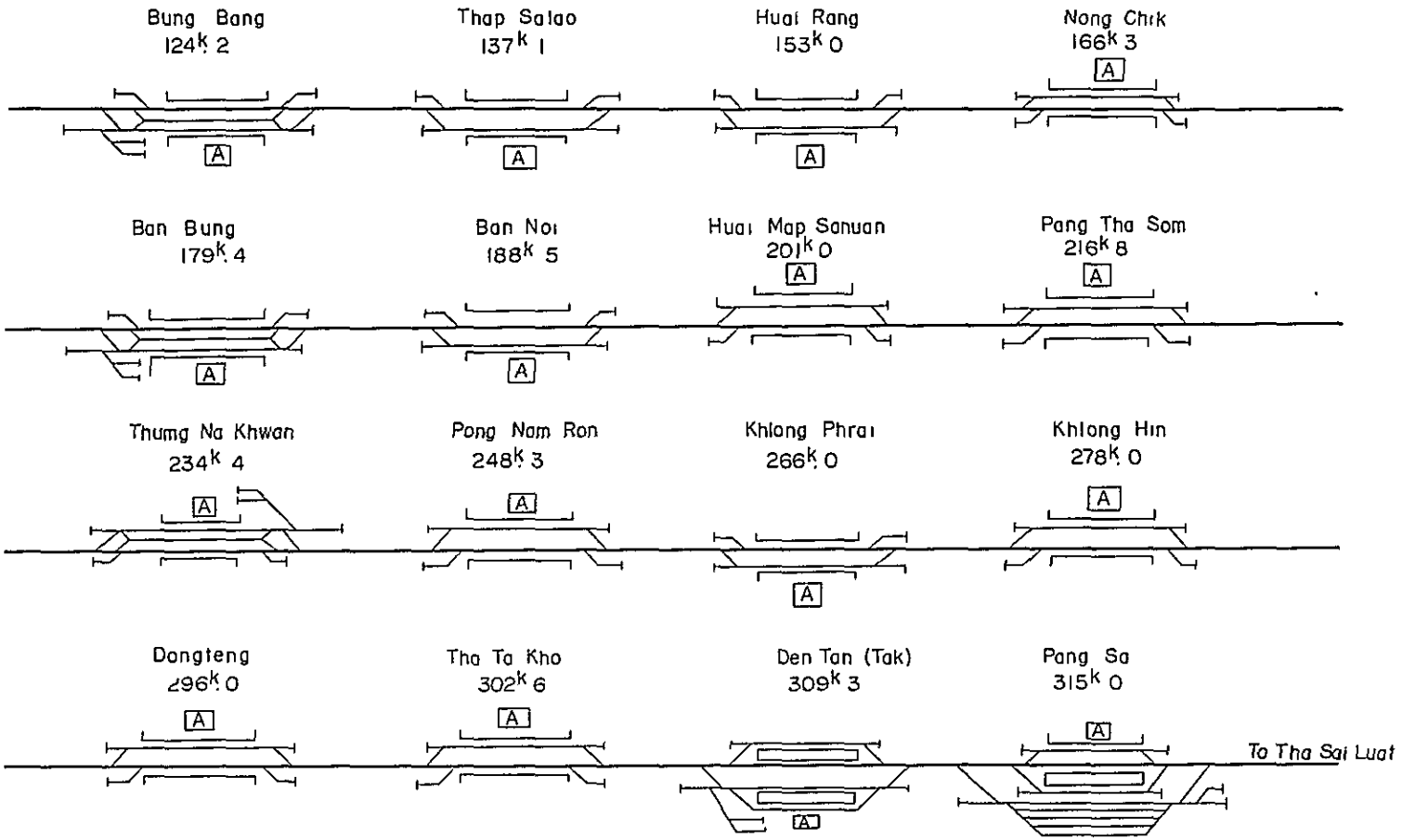
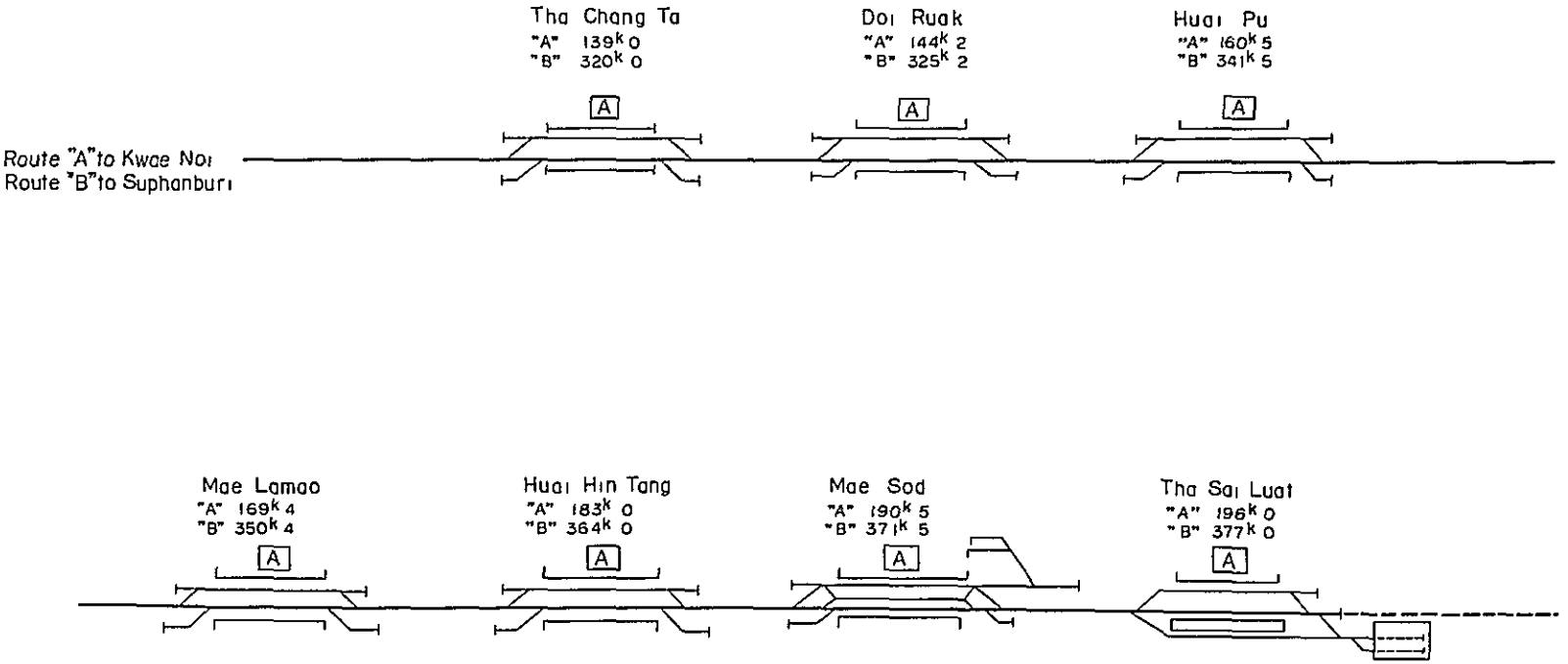

Bung Bang
124k 2
Thap Salao
137k 1
Huai Rang
153k 0
Nong Chik
166k 3
A
Ban Bung
179k 4
Ban Noi
188k 5
Huai Map Sanuan
201k 0
Pang Tha Som
216k 8
Thung Na Khwan
234k 4
Pong Nam Ron
248k 3
Khlong Phrai
266k 0
Khlong Hin
278k 0
Dongteng
296k 0
Tha Ta Kho
302k 6
Den Tan (Tak)
309k 3
Pang Sa
315k 0
To Tha Sai Luat

Fig. 6.17 Skeleton of Track Layout between Tha Chang Ta and Tha Sai Luat Stations in Route "A" , "B"



mm depending on the importance of the line and that of 200 mm is applied to the track to be constructed.

Though the railway line to be built should be considered as a part of Trans-Asian Railway, the standards described above are satisfactory for the construction of such line in view of the traffic volume at the time of opening for service. However, the strengthening of track structure should be carried out with the increase of frequency of train service and the speed up of international trains – all these must be taken up as the future problems.

6.8 Signalling and Telecommunication Facilities

The signalling and telecommunication facilities as planned below are those required for the line to be constructed as the Trans-Asian Railway.

6.8.1 Block System

Of the block system now operating on RSR, the tokenless system accounts for about 17%. The adoption of tokenless system is required for the high speed operation of passing trains through the line as the Trans-Asian Railway in future. Therefore, the present plan has been prepared on the basis of such system.

6.8.2 Signalling

The absolute signals such as home and departure signals are to be installed on the main tracks of each station.

6.8.3 Interlocking

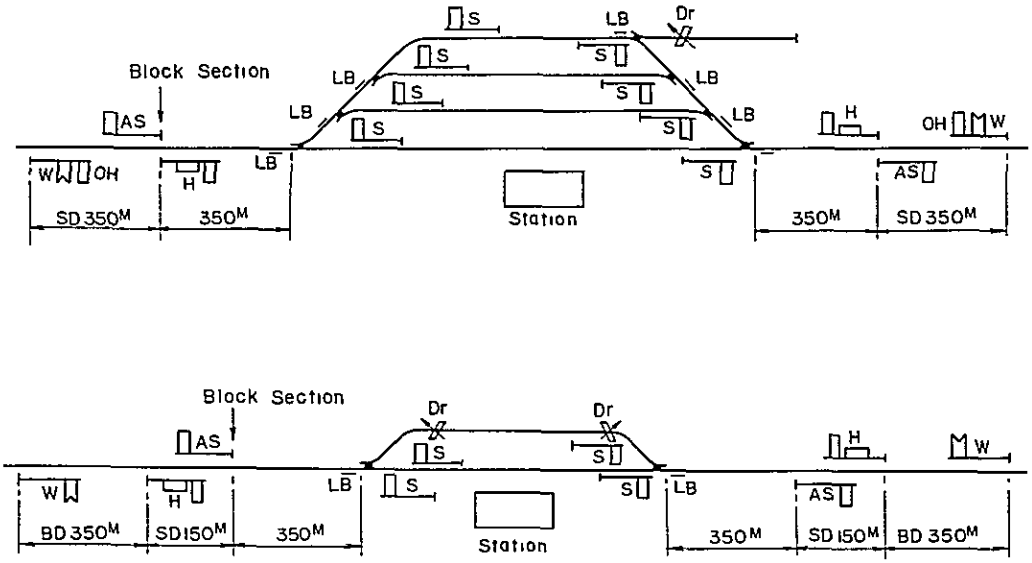
The interlocking is to be installed at all stations to interlock all switches, signals and block devices. A typical example of the interlocking for RSR is shown in Fig. 6.18.

6.8.4 Telecommunication

In either case of Routes "A" and "B", it is necessary to install a new circuit of intercall traffic control telephone. An exchange board is to be

Fig. 6.18 Sample of Interlocking Installation

"A3" Type



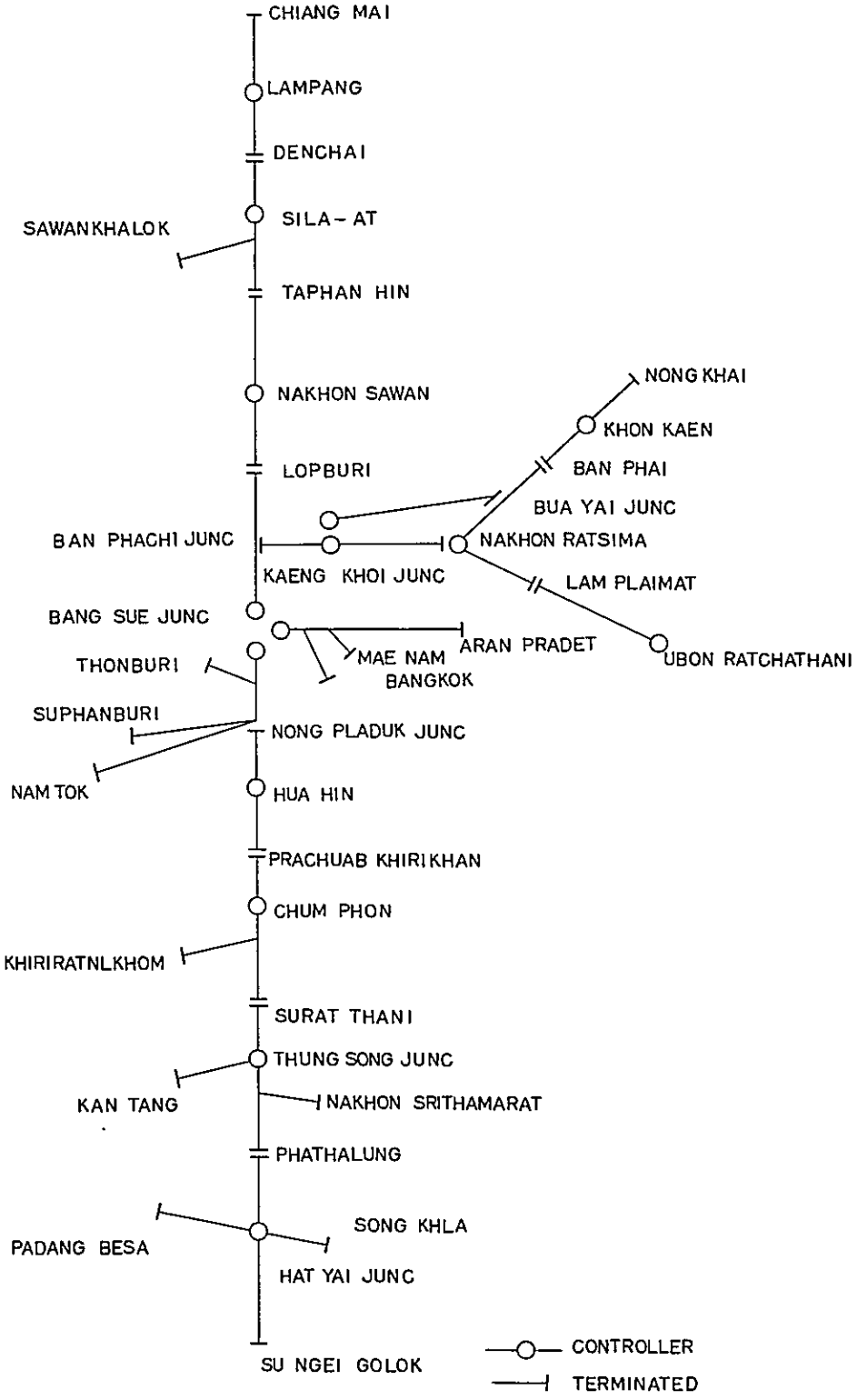
W	Warner Signal
OH	Outer Home Signal
H	Home Signal
AS	Advance Starter Signal
S	Starter Signal
Dr	Derailer
LB	Locking Bar
SD	Safety Distance
BD	Breaking Distance

installed at Sila-At which control the section north of Taphan Hin for Route "A" or at Thonburi for Route "B".

When the Trans-Asian Railway is extended to Burma, a through circuit will be necessary between adjacent countries to operate the international transportation.

The present traffic control system of RSR is shown in Fig. 6.19.

Fig. 6.19 Traffic Control System



7. Construction Period and Cost

7.1 Construction Period

As no construction of new railway line has been carried out in Thailand since 1967, the estimation of the construction period has been made referring to the example of new line construction in Japan as well as taking into account the actual circumstances about the construction work in Thailand. In particular, for the section between Tak and Mae Sod where there are two long tunnels, the total construction period depends on the completion time of these tunnels; however, as there is no precedent of the construction of such long tunnel, the construction period has been estimated based on the examples in Japan.

It is desirable that the earthwork in the paddy field area is executed as far as possible avoiding the rainy season during which such work is difficult to perform.

Though the problem of procuring the fund will also have a great influence on the construction period it is not taken into account for the present plan. The progress schedule prepared from the above estimations is as shown in Table 7.1.

Table 7.1 Progress Schedule

Section	Kinds of work \ Period in years	1	2	3	4	5	6	7
Phitsanulok – Tak	Acquisition of right-of-way							
	Roadbed construction							
	Bridge construction							
	Track construction							
	Station facilities							
	Electrical facilities							
Suphanburi – Tak	Acquisition of right-of-way							
	Roadbed construction							
	Bridge construction							
	Track construction							
	Station facilities							
	Electrical facilities							
Tak – Mae Sod	Acquisition of right-of-way							
	Roadbed construction							
	Bridge construction							
	Tunnel construction							
	Track construction							
	Station facilities							
	Electrical facilities							

7.2 Construction Cost

7.2.1 Principles in Estimating Construction Cost

(1) The construction cost has been estimated on the basis of the results of investigation made on the prices of principal construction materials and the wages of workers in Thailand.

(2) The unit prices have been calculated by types of works from the various prices obtained from the above investigation referring to the construction costs of various railway lines in Japan.

(3) All unit prices have been computed on the basis of prices as of

1972.

(4) The amount of foreign currency to be reserved has been calculated with the cost of steel girder estimated at 13,300 Baht per ton and the costs of H-shape steel and rail at 4,700 Baht.

7.2.2 Cost of Construction Work

The construction cost estimated in accordance with the above principles is 1,181 million Baht for Route "A" of 196 km from Kwae Noi St. to Tha Sai Luat St. via Tak, or 1,475 million Baht for Route "B" of 377 km from Suphanburi St. to Tha Sai Luat St. via Tak, as shown in Table 7.2. The costs of construction works by types of works are shown in Table 7.3, the breakdown of costs of construction works by sections in Table 7.4, and the amount of reserve in foreign currency of principal material of steel for construction is shown in Table 7.5.

Table 7.2 Overall Construction Cost

Section	Length (km)	Cost (million Baht)
Kwae Noi - Pang Sa St.	134	428.7
Pang Sa - Tha Sai Luat St.	62	751.7
Total	196	1,180.4
Suphanburi - Pang Sa St.	315	722.9
Pang Sa - Tha Sai Luat St.	62	751.7
Total	377	1,474.6

Table 7.3 Costs of Construction Works by Types of Works

(1,000 Baht)

Types of works	Kwae Noi - Pang Sa St.	Suphanburi - Pang Sa St.	Pang Sa - Tha Sai Luat St.
Right-of-way	24,610	47,750	2,470
Roadbed	173,740	225,445	38,560
Bridge	47,250	61,200	16,700
Tunnel	-	-	586,080
Track*	132,840	300,060	59,400
Station facilities	10,250	14,650	3,850
Electrical facilities	19,620	39,400	8,810
Miscellaneous	20,415	34,425	35,793
Total	428,725	722,930	751,663

* If 60 or 70 lbs second handed rails are used, this cost will be reduced by app. 40%.

Table 7.4 Breakdown of Costs of Construction Works by Sections

(1) Section between Kwae Noi and Pang Sa Stations

Type of work \ Item	Quantity	Unit price (1,000 Baht)	Work cost (1,000 Baht)	Remarks
Right-of-way			24,610	Acquisition of land in mountain district assumed to be without cost.
Main track	65.0 km	250	16,250	Paddy field area
- " -	50.0 km	100	5,000	Hilly land
Station	16 stns.	210	3,360	
Roadbed			173,740	
Cutting	13.0 km	1,150	14,950	5.0 m in average depth
Embankment	118.5 km	1,340	158,790	4.0 m in average height

Type of work \ Item	Quantity	Unit price (1,000 Baht)	Work cost (1,000 Baht)	Remarks
Bridge			47,250	
Long bridge	1.0 km	22,200	22,200	500m x 1, 200m x 1, etc.
Short bridge	1.5 km	16,700	25,050	
Track			132,840	
Main track	134 km	900	120,600	
Siding	17 km	720	12,240	Passing track included
Station facilities			10,250	
A class	3 stns.	850	2,550	
B class	14 stns.	550	7,700	
Electrical facilities			19,620	
Signalling	17 stns.	300	5,100	
Communication line	134 km	80	10,720	
Carrier facilities	1 set	500	500	
Exchange board	1 set	1,600	1,600	
Lighting equipment	17 stns.	100	1,700	
Miscellaneous			20,415	
Incidental expenses		3%	12,249	
Building and others		2%	8,166	
Total			428,725	

(2) Section between Suphanburi and Pang Sa Stations

Type of work \ Item	Quantity	Unit price (1,000 Baht)	Work cost (1,000 Baht)	Remarks
Right-of-way			47,750	Acquisition of land in mountain district assumed to be without cost.
Main track	110 km	250	27,500	Paddy field area
- " -	150 km	100	15,000	Hilly land
Station	25 stns.	210	5,250	
Roadbed			225,445	
Cutting	93 km	850	79,050	4.0m in average depth
Embankment	218.5km	670	146,395	2.5m in average height
Bridge			61,200	
Long bridge	0.5 km	22,200	11,100	100 m x 5
Small bridge	3.0 km	16,700	50,100	
Track			300,060	
Main track	315 km	900	283,500	
Siding	23 km	720	16,560	Passing track included
Station facilities			14,650	
A class	3 stns.	850	2,550	
B class	22 stns.	550	12,100	
Electrical facilities			39,400	
Signalling	25 stns.	300	7,500	
Communication line	315 km	80	25,200	
Carrier facilities	1 set	1,000	1,000	
Exchange board	1 set	3,200	3,200	
Lighting equipment	25 stns.	100	2,500	
Miscellaneous			34,425	
Incidental expenses		3%	20,655	
Building and others		2%	13,770	
Total			722,930	

(3) Section between Pang Sa and Tha Sai Luat Stations

Type of work \ Item	Quantity	Unit price (1,000 Baht)	Work cost (1,000 Baht)	Remarks
Right-of-way			2,470	Acquisition of land in mountain district assumed to be without cost.
Main track	10 km	100	1,000	Hilly land
Station	7 stns.	210	1,470	
Roadbed			38,560	
Cutting	10 km	1,150	11,500	5.0m in average depth
Embankment	24.6km	1,100	27,060	3.5m in average height
Bridge			16,700	
Small bridge	1 km	16,700	16,700	
Tunnel			586,080	
Long tunnel	26.4km	22,200	586,080	
Track			59,400	
Main track	62 km	900	55,800	
Siding	5 km	720	3,600	Passing track included
Station facilities			3,850	
B class	7 stns.	550	3,850	
Electrical facilities			8,810	
Signalling	7 stns.	300	2,100	
Communication line	62 km	80	4,960	
Carrier facilities	1 set	250	250	
Exchange board	1 set	800	800	
Lighting equipment	7 stns.	100	700	
Miscellaneous			35,793	
Incidental expenses		3%	21,476	
Building and others		2%	14,317	
Total			751,663	

Table 7.5 Reserve in Foreign Currency of Principal Material of Steel for Construction

Section	Weight of principal steel materials (1,000 tons)	Reserve in foreign currency (million Baht)
Kwae Noi - Pang Sa St.	15.7	96
Suphanburi - Pang Sa St.	31.2	171
Pang Sa - Tha Sai Luat St.	10.5	56

8. Appraisal of Investment

8.1 Outline of Cost/Benefit Calculation

An ordinary commercial enterprice will never make any investment unless some internal return is expected from it; whereas a public enterprise such as railway contemplating to invest in the construction of new line is often required to do so for the sake of national interest though no return is insured for that enterprise. It is necessary that the appraisal of public investment is made in the context of the system of social economy as differed from that of private investment. Needless to say, the system of social economy is compatible with the system of enterprise by comprising the latter as a component.

The total benefit to be calculated in planning an investment may be expressed by the following equation.

Total benefit (B) = consumers' surplus (CS) + producers' surplus (PS) + cost (C)

This means that the investment of cost, (C), produces a revenue, (PS + C), for the enterprise at the same time it offers a net benefit, CS (consumers' surplus), to the nation in general.

The appraisal of the investment by a public enterprise as in the case of the present plan is often made on the negative profit basis and, therefore, following factors.

(1) The present plan has been studied from a long term view consider-

ing the fact that it relates closely to the economic development, the implementation of which is expected under a separate plan.

(2) In addition to the secondary and indirect benefits and economic effects of the plan, the social and physical effects should be appraised, but their examination has been made only in general because of the difficulties involved in their measuring.

(3) The present plan has many uncertain elements due to the uncertainty in other relating plans for carrying out the economic development plan.

(4) Though the discount rate should be determined from the market interest rate it has been fixed from the interest rate applied to the assisting funds offered to the developing countries.

In the present report, the assessment of investment efficiency has been made within a limit of economic calculation with the omission of social benefits as the calculation of the benefits has many difficult problems.

8.2 Methos for Calculating Cost and Benefit

8.2.1 Criteria of Investment Appraisal

The methods used generally to appraise the investment may be classified as follows according to what criteria are employed basically.

(1) Net present value method.

(2) Method of feasible investment amount.

(3) Payout period method.

(4) Internal rate of return method.

(5) Method of simple interest.

All of these methods are those based on the present value method and there are other method including the final value of annuity and present value of annuity methods. For the purpose of the present plan the effects of investment have been computed by the net present value method using in combination with the payout period method.

The net present value (NPV) can be obtained from the following equation.

$$NPV = -I_o + \sum_{t=1}^{T} \frac{V_t}{(1+r)^t}$$

where,

NPV ; net present value

I_o ; amount of initial investment

T ; project life

V_t ; difference between income and expenditure for t year

r ; discount rate

The payout period may be obtained by calculating T from the above equation putting NPV = 0.

$$I_o = \sum_{t=1}^{T^*} \frac{V_t}{(1+r)^t}$$

where,

T^* = payout period

8.2.2 Discount Rate

It is expected that the fund for the present plan is provided through the economic assistance from the advance countries. Therefore, it has been considered appropriate to calculate the interest rate of investment applying the interest rate of economic aid fund, not that of the general commercial fund.

At present the rate of interest on the economic assistance funds varies greatly, and the average rate of interest for sixteen member countries of Development Assistance Committee, Organization for Economic Cooperation and Development, was 2.7% for the term of loan of 30 years (with term of deferment of 7-1/2 years) as of 1970 (investigated by the Ministry of Foreign Affairs of Japan).

DAC recommended already in 1969 that such variance in the interest rates should be eliminated and the assistance should be given on a more generous condition such as, for example, 2% for the term of loan of 25 years (with term of deferment of 7 years). Thus, though the interest rate on the development assistance fund will decrease to about 2% in average in future a discount rate of 2.5% has been used for the purpose of the present plan as it is considered a reasonable one in the present state of things.

8.3 Economic Comparison

The economic prospects have been established by the Discount Cash Flow Method using the equation shown in paragraph 8.2.1. on the basis of construction cost and its period, rolling stock cost, additional investment to meet the increasing requirement, traffic volume, revenue, expense, interest, period of fund amortization and other factors for respective routes on the assumption that the operation will start in 1980.

(1) Calculation was made in the term of additional investment for those of diesel locomotives, passenger cars and freight cars needed to meet the requirement of traffic volume to be increased, as well as for the new construction of stations with siding (waiting track) required according to the increased train operation.

(2) Although the average transport distance on passenger and freight of RSR in 1970 show 85.3 km/pasgr and 470.2 km/ton respectively (Table 8.1, 8.2), 85.3 km/pasgr for passenger and actual route length for freight are used on the course of calculation. Also the tariff of 0.11 Baht/pasgr -km and 0.15 Baht/ton-km are used.

(3) Operating cost was calculated on the basis of Table 8.3 presented by RSR.

(4) The interest for construction cost of 2.5% per year and equal amortization of 30 years are used.

(5) Life of rolling stock is decided referring that of JNR is using 20 years for diesel locomotive, passenger car and freight car with 10% of scrap value. Also, 2.5% interest of rolling stock cost for the ones when the line open for operation and 8% interest for the additional rolling stock cost are adopted.

8.3.1 Economic Comparison between Route "A" and "B"

Calculation was made as shown in Table 8.4, 8.5 and 8.6.

According to the result of calculation, the balance of Route "A" will not go into the black figure even after 50 years from the start of operation while Route "B" will be in black figure biginning from the 37th year after the line opened for traffic. The economical advantage of Route "B" over Route "A" is due to the facts that it runs underdeveloping area rich in

resources and construction cost of line is less than that of Route "A" in 65% per kilometer.

By this construction of new line, it is expected to contribute largely to the national and people's interests such as regional development, social benefit and public peace. Also, it is clear that these benefit, if added on the economic prospects, would make this construction line to be more advantageous. However, it should be emphasized that the plan for the construction of new railway line can be justified only when it is carried out in line with the overall implementation of regional economic and social development.

8.3.2 Economic Comparison for the Section other than between Tak and Mae Sod

This survey was made for the purpose to select advantageous route on technical and economical aspects between Route "A" and "B".

The result of economical comparison is shown in paragraph 8.3.1 however, both routes require to build two long tunnels of 14.6 km and 11.8 km in length between Tak and Mae Sod and it requires more investment and longer construction work period. Therefore, economical prospect was tried only presuming the case of sections between Phitsanlok and Tak (Route "A'") or Suphanburi and Tak (Route "B'") beside the section between Tak and Mae Sod is to be scheduled as the second separate construction.

The way of thinking and method on calculation are of similar to that of for Route "A" and Route "B". The result of calculation is shown in Table 8.7, 8.8 and 8.9.

Table 8.1 Average Passenger Travelling Distance

Fiscal year	Number of passengers Carried (1,000 persons)	Passenger-km (million p.-km)	Average distance per passenger
1966	46,024	3,173	68.9
1967	48,108	3,614	75.1
1968	48,729	3,884	79.7
1969	47,326	3,962	83.7
1970	48,190	4,113	85.3

Table 8.2 Average Freight Hauling Distance

Fiscal year	Volume (Carload) (1,000 t)	Net ton-km (million t-km)	Average hauling distance per ton (km)
1966	4,172	1,607	385.22
1967	4,699	1,941	413.04
1968	4,952	2,083	420.60
1967	4,364	1,979	453.44
1970	4,699	2,209	470.23

Table 8.3 Unit Cost of Operating Expense

1.	Terminal Services	(Baht)
	Personel and other expenses cost per year:	
	Class 4 - 5 station	101,427.-
	Maintenance of fixed installation	8,200.-
2.	Train Formation and Shunting	
	– per passenger car km.	0.034
	– per one carload shipment of freight :	
	at dispatching and receiving terminal	
	– per 4 wheeled wagon	24.889
	at station en route	
	– per wagon km.	0.031
	– per one shipment of LCL freight	1.483
3.	Line Haulage (using diesel locomotives)	
	– per passenger train km.	9.389
	– per freight train km.	8.996
	– per mixed train km.	8.828
4.	Maintenance of Rolling Stock	
	– per passenger car km.	0.239
	– per freight car km.	0.091
5.	Roadway Maintenance	
	Track and roadway	
	Building and other structure	
	Miscellaneous	
	– per km. year	34,000.-
6.	General Administration	
	about 8.78% of 1 ~ 5 expenditures	

Note : all expenditures are excluding of depreciation

Table 8.4 Economic Comparison between Routes "A" and "B"

	Route "A" (Phitsanulok - Tak - Mae Sod)					Route "B" (Suphanburi - Tak - Mae Sod)				
Route length	196.0 km					377.0 km				
Construction cost	1,180.4 million Baht					1,474.6 million Baht (excluding the improvement cost of 75 million Baht for Suphanburi Line)				
Period of construction	7 years					7 years				
Traffic volume	1980	1990	2000	2010	2020	1980	1990	2000	2010	2020
Passenger (1,000 p.)	900	1,300	1,700	2,400	3,200	2,000	2,700	3,600	4,900	6,700
Freight (1,000 t.)	1,200	2,700	5,100	3,600	14,200	2,000	4,200	8,200	14,700	26,200
-Inland	600	1,200	2,300	4,500	8,800	1,400	2,700	5,400	10,600	20,800
-International	600	1,500	2,800	4,100	5,400	600	1,500	2,800	4,100	5,400
Average transporting kilometer										
Passenger	85.3 km/capita					85.3 km/capita				
Freight	196.0 km/ton					377.0 km/ton				
Unit of tariff										
Passenger	0.11 Baht/psgr.-km					0.11 Baht/psgr.-km				
Freight	0.15 Baht/t-km					0.15 Baht/t-km				
Life of rolling stock										
Diesel locomotive	20 years					20 years				
Passenger car	20 years					20 years				
Freight	20 years					20 years				
Unit cost of rolling stock										
Diesel locomotive	6.83 million Baht/car					6.83 million Baht/car				
Passenger car	0.93 million Baht/car					0.93 million Baht/car				
Freight car	0.22 million Baht/car					0.22 million Baht/car				
For the construction cost										
Interest	2.5% per year (8% per year for additional construction cost)					2.5% per year (8% per year for additional construction cost)				
Period of amortization	30 years					30 years				
For the rolling stock cost										
Interest	2.5% per year (8% per year for additional rolling stock cost)					2.5% per year (8% per year for additional rolling stock cost)				
Period of amortization	20 years					20 years				
Economic prospect	The balance will not go into the black figure within 50 years after traffic is opened.					The balance will go into the black figure beginning from the 37th year after traffic is opened.				

Table 8.5 Prospective Profit and Loss Statement on Route "A"

No. of year	Passenger traffic (1,000 p.)	Freight traffic (1,000 t.)	Revenue (million Baht)	Operating expense (million Baht)	Amortization of rolling stock cost (million Baht)	Amortization of construction cost (million Baht)	Interest on loan (million Baht)	Total expense (million Baht)	Profit and loss (million Baht)	Accumulated loss and profit (million Baht)
1	900	1,200	44	24	9	60	0	93	-49	-49
2	940	1,350	49	27	11	60	1	99	-50	-99
3	980	1,500	53	29	12	60	2	103	-50	-149
4	1,020	1,650	58	32	13	60	4	109	-51	-200
5	1,060	1,800	63	35	15	60	5	115	-52	-252
6	1,100	1,950	68	37	17	60	6	120	-52	-304
7	1,140	2,100	72	40	19	60	8	127	-55	-359
8	1,180	2,250	77	42	20	60	9	131	-54	-413
9	1,220	2,400	82	45	22	60	10	137	-55	-468
10	1,260	2,550	87	48	23	60	12	143	-56	-524
11	1,300	2,700	92	51	25	60	13	149	-57	-581
12	1,340	2,940	99	54	28	60	15	157	-58	-639
13	1,380	3,180	106	58	30	60	16	164	-58	-697
14	1,420	3,420	114	63	33	60	17	173	-59	-756
15	1,460	3,660	121	67	35	60	19	181	-60	-816
16	1,500	3,900	129	71	38	60	20	189	-60	-876
17	1,540	4,140	136	75	40	60	22	197	-61	-937
18	1,580	4,380	144	79	43	60	23	205	-61	-998
19	1,620	4,620	151	83	45	60	25	213	-62	-1,060
20	1,660	4,860	158	87	48	60	27	222	-64	-1,124
21	1,700	5,100	166	91	51	60	28	230	-64	-1,188
22	1,770	5,450	177	97	54	60	30	241	-64	-1,252
23	1,840	5,800	188	103	58	60	31	252	-64	-1,316
24	1,910	6,150	199	109	61	60	33	263	-64	-1,380
25	1,980	6,500	210	115	65	60	34	274	-64	-1,444
26	2,050	6,850	221	122	68	60	36	286	-65	-1,509
27	2,120	7,200	232	128	72	60	38	298	-66	-1,575
28	2,190	7,550	243	134	76	60	39	309	-66	-1,641
29	2,260	7,900	253	139	80	60	41	320	-67	-1,708
30	2,330	8,250	264	145	83	60	43	331	-67	-1,775
31	2,400	8,600	275	151	87	0	44	282	-7	-1,782
32	2,480	9,160	293	161	93	0	45	299	-6	-1,788
33	2,560	9,720	310	171	99	0	45	315	-5	-1,793
34	2,640	10,280	327	180	105	0	45	330	-3	-1,796
35	2,720	10,840	344	189	111	0	45	345	-1	-1,797
36	2,800	11,400	361	199	116	0	45	360	1	-1,796
37	2,880	11,960	379	208	122	0	45	375	4	-1,792
38	2,960	12,520	396	218	127	0	45	390	6	-1,786
39	3,040	13,080	413	227	133	0	45	405	8	-1,778
40	3,120	13,640	430	236	139	0	44	419	11	-1,767
41	3,200	14,200	448	246	144	0	44	434	14	-1,753
42	3,310	15,180	478	263	154	0	44	461	17	-1,736
43	3,420	16,160	508	279	165	0	43	487	21	-1,715
44	3,530	17,140	537	295	175	0	43	513	24	-1,691
45	3,640	18,120	567	312	185	0	42	539	28	-1,663
46	3,750	19,100	597	328	196	8	42	574	23	-1,640
47	3,860	20,080	627	345	206	8	41	600	27	-1,613
48	3,970	21,060	657	361	216	8	40	625	32	-1,581
49	4,080	22,040	686	377	226	8	40	651	35	-1,546
50	4,190	23,020	716	394	237	8	39	678	38	-1,508
51	4,300	24,000	746	410	247	8	38	703	43	-1,465

Table 8.6 Prospective Profit and Loss Statement on Route "B"

No. of year	Passenger traffice (1,000 p.)	Freight traffic (1,000 t.)	Revenue (million Baht)	Operating expense (million Baht)	Amortization of rolling stock cost (million Baht)	Amortization of construction cost (million Baht)	Interest on loan (million Baht)	Total expense (million Baht)	Profit and loss (million Baht)	Accumulated loss and profit (million Baht)
1	2,000	2,000	132	73	27	75	0	175	-43	-43
2	2,070	2,220	145	80	31	75	1	187	-42	-85
3	2,140	2,440	158	87	36	75	2	200	-42	-127
4	2,210	2,660	171	94	41	75	3	213	-42	-169
5	2,280	2,880	184	101	45	75	4	225	-41	-210
6	2,350	3,100	197	108	49	75	5	237	-40	-250
7	2,420	3,320	210	116	53	75	6	250	-40	-290
8	2,490	3,540	224	123	58	75	7	263	-39	-329
9	2,560	3,760	237	130	62	75	8	275	-38	-367
10	2,630	3,980	250	138	67	75	9	289	-39	-406
11	2,700	4,200	263	145	72	75	10	302	-39	-445
12	2,790	4,600	286	157	80	75	11	323	-37	-482
13	2,880	5,000	310	171	88	75	12	346	-36	-518
14	2,970	5,400	333	183	95	75	13	366	-33	-551
15	3,050	5,800	357	196	103	75	14	388	-31	-582
16	3,150	6,200	380	209	111	75	15	410	-30	-612
17	3,240	6,600	404	222	119	75	15	431	-27	-639
18	3,330	7,000	427	235	127	75	16	453	-26	-665
19	3,420	7,400	451	248	135	75	17	475	-24	-689
20	3,510	7,800	474	261	143	75	17	496	-22	-711
21	3,600	8,200	497	273	150	75	18	516	-19	-730
22	3,730	8,850	535	294	163	75	18	550	-15	-745
23	3,860	9,500	573	315	176	75	19	585	-12	-757
24	3,990	10,150	611	336	190	75	19	620	-9	-766
25	4,120	10,800	649	357	202	75	19	653	-4	-770
26	4,250	11,450	687	378	215	75	19	687	0	-770
27	4,380	12,100	725	399	227	75	19	720	5	-765
28	4,510	12,750	763	420	240	75	19	754	9	-756
29	4,640	13,400	801	441	252	75	19	787	14	-742
30	4,770	14,050	839	461	267	75	19	822	17	-725
31	4,900	14,700	877	482	279	8	18	787	90	-635
32	5,080	15,850	944	519	301	8	16	844	100	-535
33	5,260	17,000	1,011	556	325	8	13	902	109	-426
34	5,440	18,150	1,077	592	347	8	11	958	119	-307
35	5,620	19,300	1,144	629	369	8	8	1,014	130	-177
36	5,800	20,450	1,211	666	392	34	4	1,096	115	-62
37	5,980	21,600	1,278	703	414	34	2	1,153	125	63

Table 8.7 Economic Comparison between Routes "A'" and "B'"

	Route "A'" (Phitsanulok - Tak)					Route "B'" (Suphanburi - Tak)				
Route length	134.0 km					315.0 km				
Construction cost	428.7 million Baht					722.9 million Baht (excluding the improvement cost of 75 million Baht for Suphanburi Line)				
Period of construction	5 years					5 years				
Traffic volume										
	1980	1990	2000	2010	2020	1980	1990	2000	2010	2020
Passenger (1,000 p.)	800	1,100	1,500	2,100	2,800	1,900	2,500	3,400	4,700	6,400
Freight (1,000 t)	500	1,000	1,900	3,800	7,500	1,300	2,600	5,000	9,900	19,500
-Inland	500	1,000	1,900	3,800	7,500	1,300	2,600	5,000	9,900	19,500
-International										
Average transporting kilometer										
Passenger	85.3 km/capita					85.3 km/capita				
Freight	134.0 km/ton					315.0 km/ton				
Unit of tariff										
Passenger	0.11 Baht/psgr.-km					0.11 Baht/psgr.-km				
Freight	0.15 Baht/t-km					0.15 Baht/t-km				
Life of rolling stock										
Diesel locomotive	20 years					20 years				
Passenger car	20 years					20 years				
Freight car	20 years					20 years				
Unit cost of rolling stock										
Diesel locomotive	6.83 million Baht/car					6.83 million Baht/car				
Passenger car	0.93 million Baht/car					0.93 million Baht/car				
Freight car	0.22 million Baht/car					0.22 million Baht/car				
For the construction cost										
Interest	2.5% per year (8% per year for additional construction cost)					2.5% per year (8% per year for additional construction cost)				
Period of amortization	30 years					30 years				
For the rolling stock cost										
Interest	2.5% per year (8% per year for additional rolling stock cost)					2.5% per year (8% per year for additional rolling stock cost)				
Period of amortization	20 years					20 years				
Economic prospect	The balance will not go into the black figure within 50 years after traffic is opened.					The balance will go into the black figure in 31 years after traffic is opened.				

Table 8.8 Prospective Profit and Loss Statement on Route "A'"

No. of year	Passenger traffic (1,000 p.)	Freight traffic (1,000 t.)	Revenue (million Baht)	Operating expense (million Baht)	Amortization of rolling stock cost (million Baht)	Amortization of construction cost (million Baht)	Interest on loan (million Baht)	Total expense (million Baht)	Profit and loss (million Baht)	Accumulated loss and profit (million Baht)
1	800	500	18	10	4	21	0	35	-17	-17
2	830	550	19	10	4	21	0	35	-16	-33
3	860	600	20	11	5	21	1	38	-18	-51
4	890	650	21	12	5	21	1	39	-18	-69
5	920	700	23	13	5	21	2	41	-18	-87
6	950	750	24	13	6	21	2	42	-18	-105
7	980	800	25	14	6	21	3	44	-19	-124
8	1,010	850	27	15	6	21	3	45	-18	-142
9	1,040	900	28	15	7	21	4	47	-19	-161
10	1,070	950	29	16	7	21	4	48	-19	-180
11	1,100	1,000	30	17	8	21	4	50	-20	-200
12	1,140	1,090	33	18	8	21	5	52	-19	-219
13	1,180	1,180	35	19	9	21	5	54	-19	-238
14	1,220	1,270	37	20	10	21	6	57	-20	-258
15	1,260	1,360	39	21	10	21	6	58	-19	-277
16	1,300	1,450	41	23	11	21	7	62	-21	-298
17	1,340	1,540	44	24	12	21	7	64	-20	-318
18	1,380	1,630	46	25	12	21	8	66	-20	-338
19	1,420	1,720	48	26	13	21	8	68	-20	-358
20	1,460	1,810	50	27	13	21	9	70	-20	-378
21	1,500	1,900	52	29	14	21	9	73	-21	-399
22	1,560	2,090	57	31	16	21	10	78	-21	-420
23	1,620	2,280	61	34	17	21	10	82	-21	-441
24	1,680	2,470	65	36	18	21	11	86	-21	-462
25	1,740	2,660	70	38	20	21	12	91	-21	-483
26	1,800	2,850	74	41	21	21	12	95	-21	-504
27	1,860	3,040	79	43	23	21	13	100	-21	-525
28	1,920	3,230	83	46	24	21	13	104	-21	-546
29	1,980	3,420	87	48	26	21	14	109	-22	-568
30	2,040	3,610	92	51	27	21	14	113	-21	-589
31	2,100	3,800	96	53	29	0	15	97	-1	-590
32	2,170	4,170	104	57	31	0	15	103	1	-589
33	2,240	4,540	112	62	34	0	15	111	1	-588
34	2,310	4,910	120	66	37	0	15	118	2	-586
35	2,380	5,280	128	70	39	0	15	124	4	-582
36	2,450	5,650	137	75	42	0	15	132	5	-577
37	2,520	6,020	145	80	45	0	14	139	6	-571
38	2,590	6,390	153	84	48	0	14	146	7	-564
39	2,660	6,760	161	89	50	0	14	153	8	-556
40	2,730	7,130	169	93	53	0	14	160	9	-547
41	2,800	7,500	177	97	56	0	14	167	10	-537
42	2,910	8,220	193	106	61	0	13	180	13	-524
43	3,020	8,940	208	114	66	0	13	193	15	-509
44	3,130	9,660	224	123	71	0	13	207	17	-492
45	3,240	10,380	239	131	76	0	12	219	20	-472
46	3,350	11,100	255	140	81	0	12	233	22	-450
47	3,460	11,820	270	148	86	0	11	245	25	-425
48	3,570	12,540	286	157	91	0	11	259	27	-398
49	3,680	13,260	301	166	96	0	10	272	29	-369
50	3,790	13,980	317	174	101	0	9	284	33	-336
51	3,900	14,700	332	183	106	0	8	297	35	-301

Table 8.9 Prospective Profit and Loss Statement on Route "B'"

No. of year	Passenger traffic (1,000 p.)	Freight traffic (1,000 t.)	Revenue (million Baht)	Operating expense (million Baht)	Amortization of rolling stock cost (million Baht)	Amortization of construction cost (million Baht)	Interest on loan (million Baht)	Total expense (million Baht)	Profit and loss (million Baht)	Accumulated loss and profit (million Baht)
1	1,900	1,300	79	43	16	36	0	95	-16	-16
2	1,960	1,430	86	47	18	36	0	101	-15	-31
3	2,020	1,560	93	51	20	36	1	108	-15	-46
4	2,080	1,690	99	54	22	36	1	113	-14	-60
5	2,140	1,820	106	58	24	36	1	119	-13	-73
6	2,200	1,950	113	62	26	36	2	126	-13	-86
7	2,260	2,080	119	65	29	36	2	132	-13	-99
8	2,320	2,210	126	69	31	36	2	138	-12	-111
9	2,380	2,340	133	73	33	36	3	145	-12	-123
10	2,440	2,470	140	77	35	36	3	151	-11	-134
11	2,500	2,600	146	80	37	36	3	156	-10	-144
12	2,590	2,840	158	87	42	36	4	169	-11	-155
13	2,680	3,080	171	94	47	36	4	181	-10	-165
14	2,770	3,320	183	101	50	36	4	191	-8	-173
15	2,860	3,560	195	107	54	36	4	201	-6	-179
16	2,950	3,800	207	114	58	36	4	212	-5	-184
17	3,040	4,040	219	120	62	36	5	222	-4	-188
18	3,130	4,280	232	128	67	36	5	236	-4	-192
19	3,220	4,520	244	134	70	36	5	245	-1	-193
20	3,310	4,760	256	141	75	36	5	257	-1	-194
21	3,400	5,000	268	147	78	36	5	266	2	-192
22	3,530	5,490	293	161	87	36	5	289	4	-188
23	3,660	5,980	317	174	95	36	5	310	7	-181
24	3,790	6,470	341	188	103	36	5	332	9	-172
25	3,920	6,960	366	201	111	36	4	352	14	-158
26	4,050	7,450	390	215	119	36	4	374	16	-142
27	4,180	7,940	414	228	128	36	4	396	18	-124
28	4,310	8,430	439	241	136	36	3	416	23	-101
29	4,440	8,920	463	255	144	36	3	438	25	-76
30	4,570	9,410	488	268	152	36	2	458	30	-46
31	4,700	9,900	512	282	161	0	1	444	68	22

9. Improvement of the Line between Nong Pladuk and Suphanburi Stations

9.1 Improvement Plan

As the through train service is expected between Bangkok and Mae Sod via Nong Pladuk, Suphanburi and Tak after the completion of new line from Suphanburi to Mae Sod via Tak, the track facilities between Bangkok and Suphanburi need to be improved to the same level as that of the new line.

The Southern Line between Bangkok and Nong Pladuk Stations needs no improvement of facilities. For the line of 78.5 km between Nong Pladuk and Suphanburi Stations, the track structure is inadequate and some bridges are still of rail beams; in particular, as about a half of the line on Suphanburi side run the soft roadbed area much sinking occurs with breaking of slope at many places.

Therefore, an all-out plan has been prepared as a separate plan for improving the subject line according to the standards of the new line to be constructed.

9.1.1 Track

The subject line is a light traffic line with two trains operated in each direction a day. The number of maintenance workers assigned per 1 km of track is about a half of that on the trunk line and the track structure is very inadequate. The various improvement programs prepared for the line include the replacement of rails with 80 lbs yard rails, and increase in the number of sleepers inserted (up to 1,500 pcs/km) and in the thickness of ballast (up to 200 mm). But it is desirable to give the last priority to the replacement of rails, for which it will be advisable to carry out gradually with the increase in the volume of traffic.

9.1.2 Roadbed

An extensive sinking presents in section of 38.5 km between 104.0 and 142.5 km points, where the raising by about 1 m at the maximum is necessary in view of the water level during the rainy season.

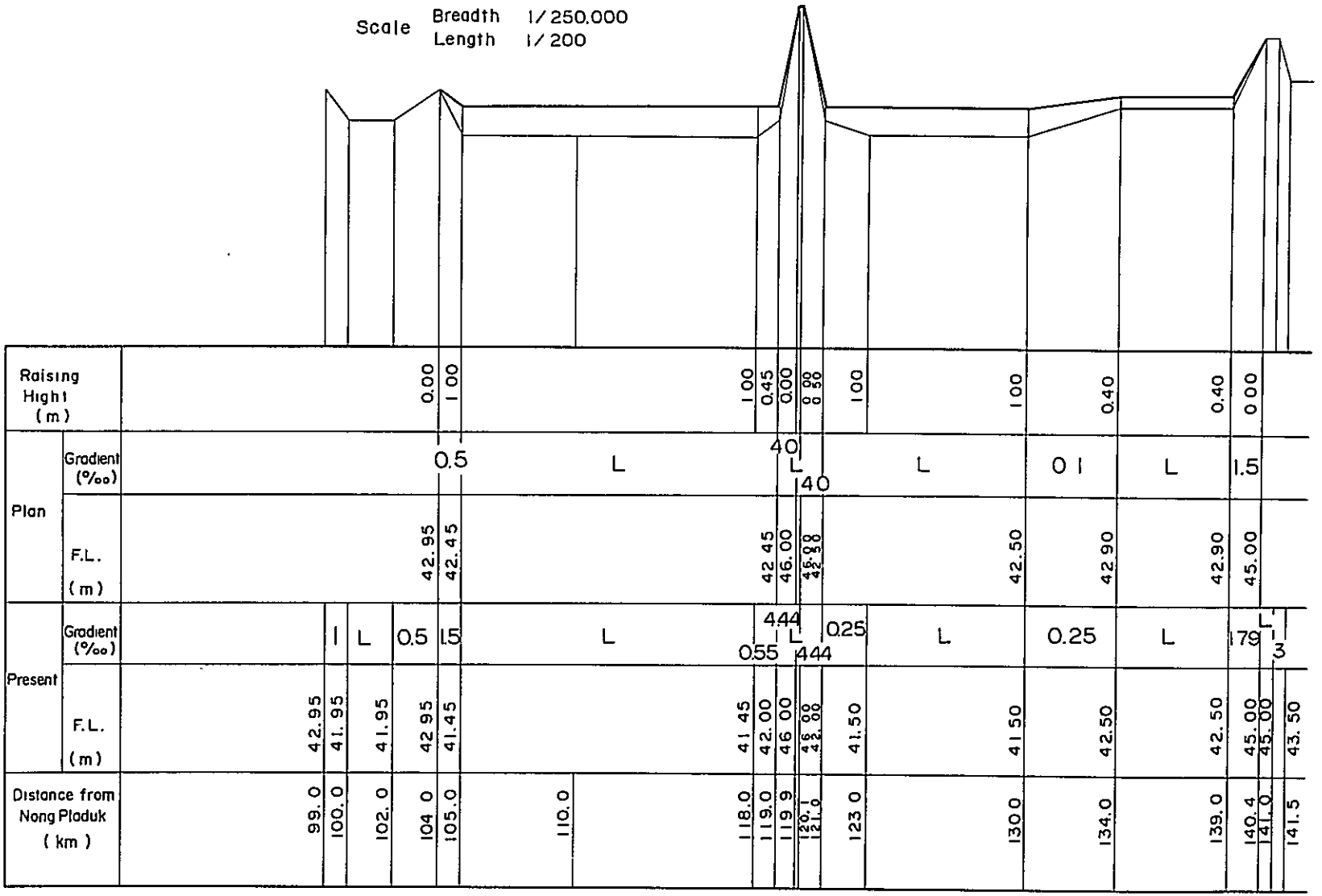
Various places of the slope are just before the breaking or eroded considerably though some places are strengthened after having broken. Thus overall strengthening works of the slope are required concurrently with the raising of roadbed. In this, slope protection pilings are to be carried out all over the section, with the slope protection concreting or sheathing applied where necessary.

The details of roadbed raising are shown in Table 9.1 and Fig. 9.1.

Table 9.1 Raising of Roadbed – Suphanburi Line

	Section	Length (km)	Amount of raising (m)
	104 km – 105 km	1.0	0 – 1.0
	105 " – 118 "	13.0	1.0
	118 " – 119 "	1.0	1.0 – 0.45
	119 " – 119.9 "	0.9	0.45 – 0
	120.1 " – 121 "	0.9	0 – 0.5
	121 " – 123 "	2.0	0.5 – 1.0
	123 " – 130 "	7.0	1.0
	130 " – 134 "	4.0	1.0 – 0.4
	134 " – 139 "	5.0	0.4
	139 " – 140.4 "	1.4	0.4 – 0
Total	104 " – 140.4 "	36.2	
	(except 119.9 " – 120.1 ")		

Fig. 9.1 Profile of Suphanburi Line



9.1.3 Bridge

Almost of the substructures of bridges are of concrete which need no immediate improvement, while some superstructures are still of rail beams and this is due to impossibility to secure the clearhead as required because of low formation level. In improving the bridges it is advisable to raise the girders as well as wholly replacing them with plate or through girders.

Some bridges must be raised in accordance with the raising of roadbed and in which case it is necessary to reinforce the bearing surfaces of girders along with the existing rail beams replaced as described above.

The bridges which need raising or replacing of their girders are as follows.

(1) Bridge of which Rail Girder to be Replaced with Plate Girder

Section where roadbed to be raised	12 bridges		137 m
Other section	2 "		30 m
Total	14 bridges		167 m
Breakdown:	1 x 5 m	1 bridge	5 m
	2 x 5 m	6 "	60 m
	3 x 5 m	2 "	30 m
	4 x 5 m	3 "	60 m
	1 x 6	2 "	12 m

(2) Bridge to be raised with the Raising of Roadbed

Steel bridge	7 bridges		192 m
Concrete slab bridge	1 "		8 m
Total	8 bridges		200 m
Breakdown:	3 x 5 m	1 bridge	15 m
	3 x 6 m	1 "	18 m
	4 x 6 m	1 "	24 m
	1 x 15m	2 "	30 m
	4 x 20m	1 "	80 m
	2 x 5 m + 1 x 15 m	1 "	25 m

	2 x 4 m	1 bridge	8 m (concrete slab)

9.1.4 Others

(1) Station Facilities

Of 11 stations existing in the whole section 5 stations need the raising of their station buildings and platforms in accordance with the raising of roadbed.

(2) Electrical Facilities

It is also necessary to improve the signalling, telecommunication and electric power facilities to the equal level as that of the line to be constructed.

9.2 Improvement Expenditure

The expenditures for the improvement plan are as shown in Table 9.2.

Table 9.2 Expenditures for Improvement of Suphanburi Line

Type of Work	Expenditure (million Baht)
Track	38.3
Roadbed	20.3
Bridge	1.7
Station facilities	1.7
Electrical facilities	13.0
Total	75.0

It is advisable to divide the various works into two groups respectively to be executed in the 1st period (when the construction of new line has been completed) and the 2nd period (when the traffic has increased substantially) as shown in Table 9.3.

Table 9.3 Improvement Expenditures by Periods of Work for Suphanburi Line

(million Baht)

Type of work		1st Period	2nd Period	Total
Track	Replacement of rail		26.5	26.5
	Increase of inserted sleepers	2.2		2.2
	Increase of chickness of ballast	9.6		9.6
Roadbed	Raising of roadbed	14.1		14.1
	Strengthening of slope	6.2		6.2
Bridge	Replacement of rail beam	1.2		1.2
	Raising of girder	0.5		0.5
Station facilities	Raising of station facilities	1.7		1.7
Electrical facilities	Signalling, telecommunication and electric power		13.0	13.0
Total		35.5	39.5	75.0

75
74
73
72
71
70
69
68
67
66
65
64

25K
20K
15K
10K
30K

Doi Mae Phaso
Ban Mae Phaso

55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 73

200

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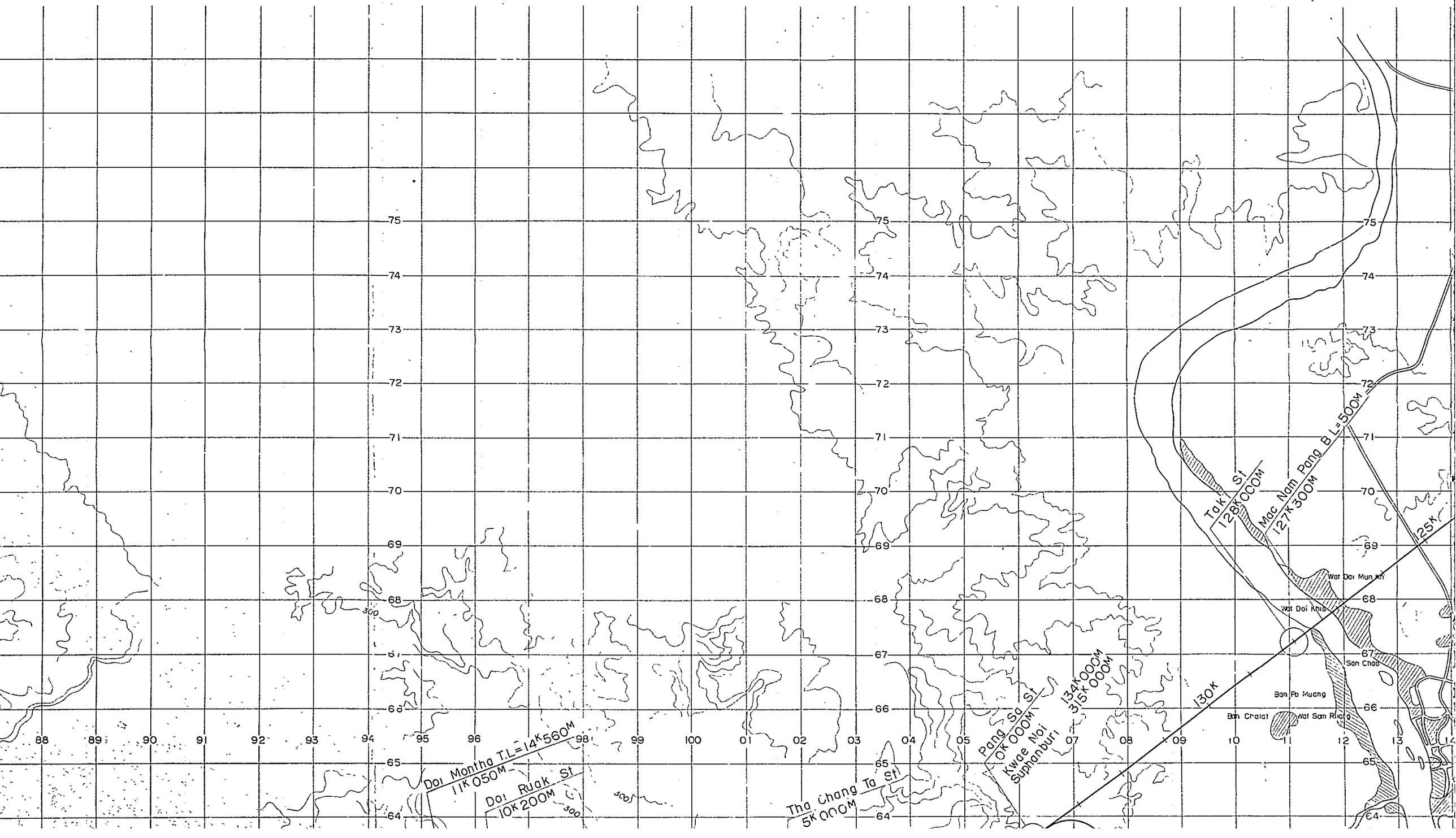
Dol Monthg 11k05OM
Dol Rudk St
10k200M
300
Dol Monthg
10k
300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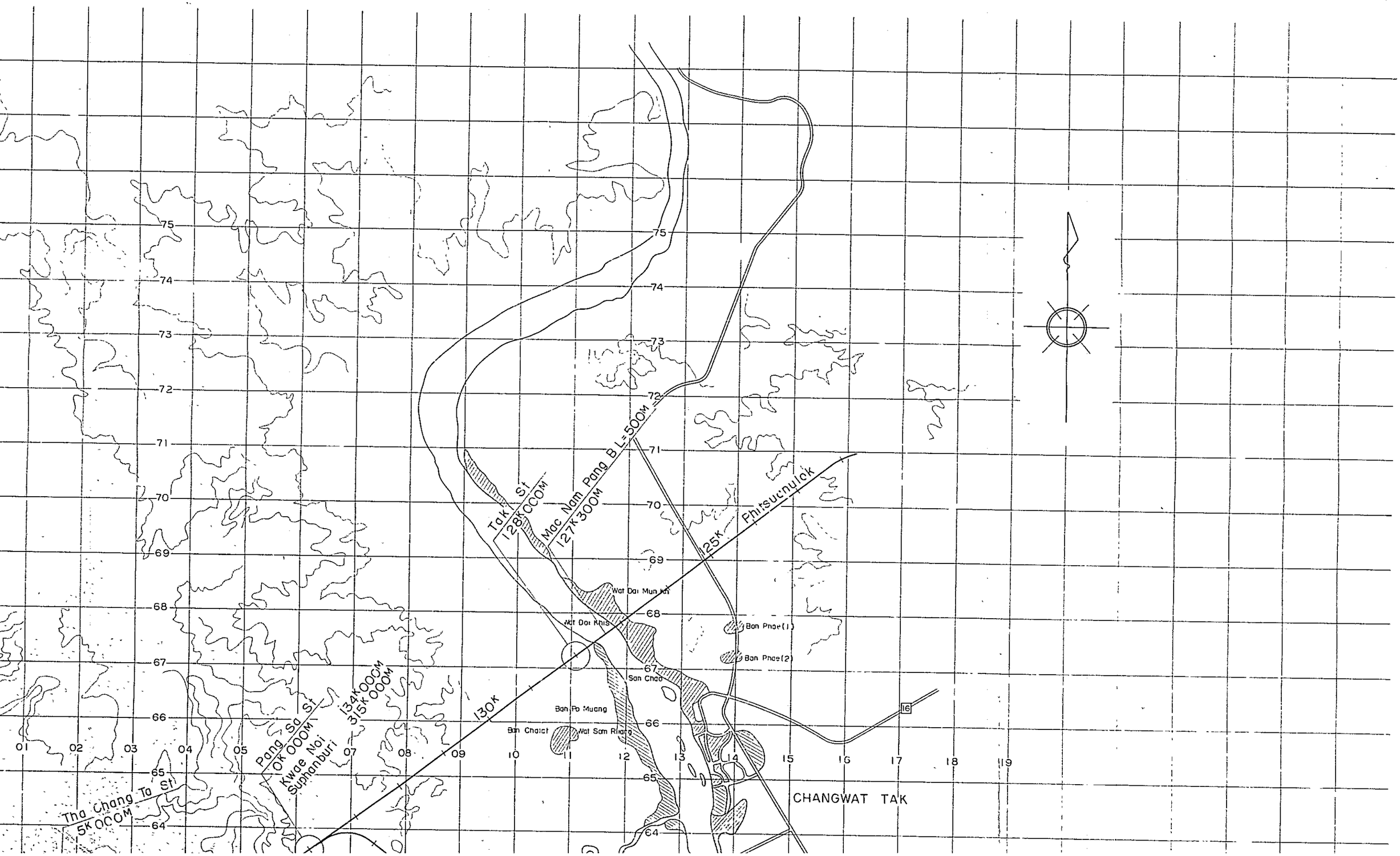
13
Doi Montha T.L=14K560M
11K050M
Doi Ruak St
10K200M
300
Tha Chang Ta St
5K000M
Pang Sa St
0K000M
Kwae Noi
Suphanburi
134K000M
315K000M
Tak St
128K000M
Mae Nam Pang B.L=500M
127K300M
125K
130K
Wat Doi Mun Kh
Wat Doi Khia
San Chao
Ban Po Muang
Ban Chalat
Wat San Rieng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Mae Nam Pang B L=500M
127K300M
125K
Phitsanulok
130K
Pang Sa St
0K000M
Kwae Noi
Suphanburi
134K000M
315K000M
Tha Chang Ta St
5K000M
Wat Dai Mun Kri
Wat Dai Khla
Ban Phae(1)
Ban Phae(2)
San Chao
Ban Po Muang
Ban Chalat
Wat Sam Riang
16
CHANGWAT TAK
75
74
73
72
71
70
69
68
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64
01
02
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17
18
19

Mae Nam Pang B L=500M

Tak St
128K000M

127K300M

25K Phitsanulok

Wat Dai Mun Kri

Wat Dai Khlo

Ban Phae(1)

Ban Phae(2)

San Chao

Ban Po Muang

Ban Chalat

Wat Sam Rieng

130K

134K000M

315K000M

Pang Sa St
0K000M

Kwae Noi
Suphanburi

Tha Chang Ta St
5K000M

16

CHANGWAT TAK

Ban Mae Phaso
30K
10K
Khao Pawor T L = 11K 780M
36K 450M
Mae Lamao
35K 400M
35K
Ban Mae Lamao
Wat Matanuson
40K
Huai Hin Tang St
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Ban Mae Pa
Ban Mae Pa Klang
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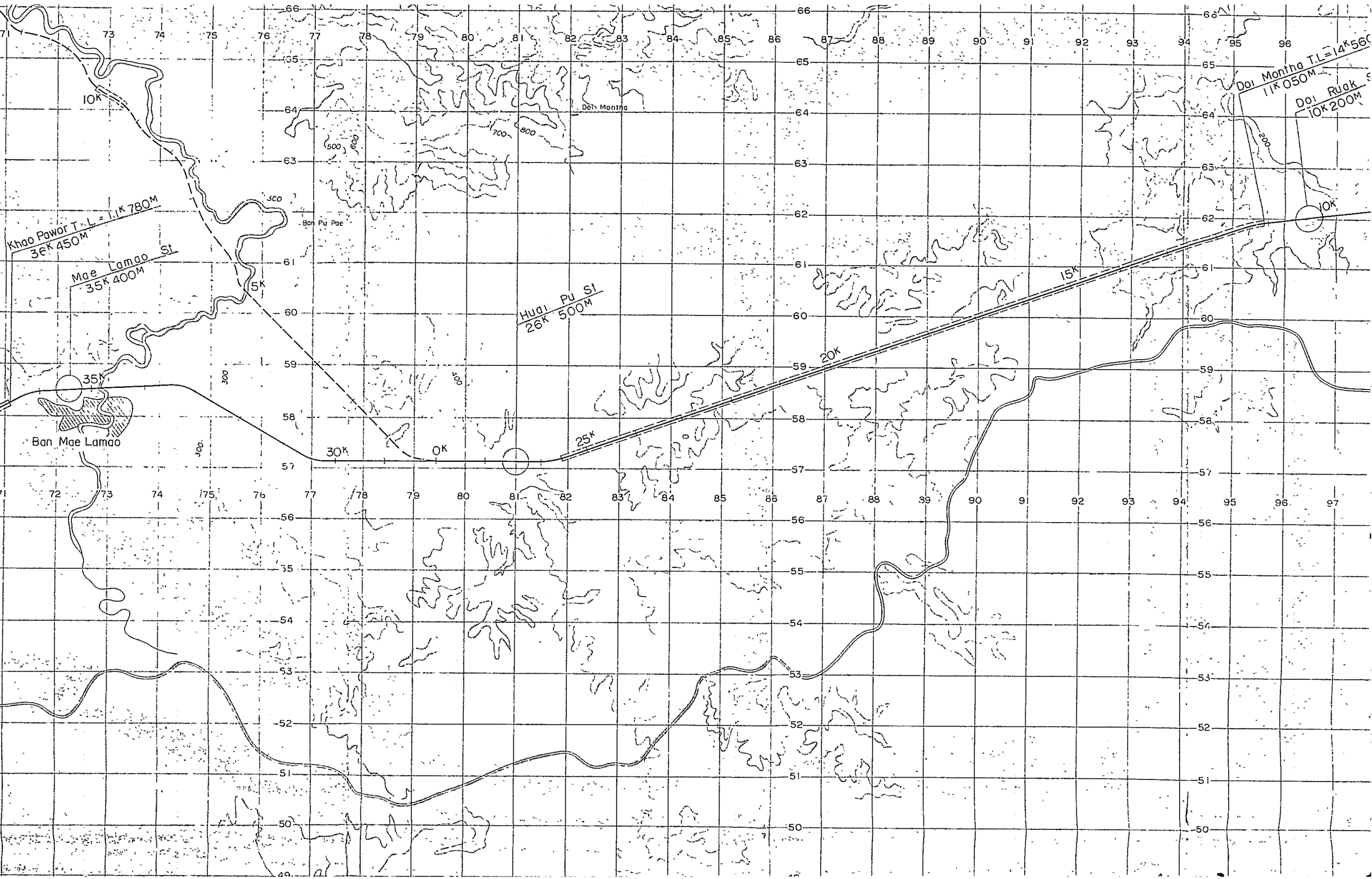
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Ban Pu Pae
Mae Lamao St
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5K
15K
Huai Pu St
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Ban Mae Lamao
30K
0K
25K
10K

Doi Montha TL=14K560M
11K050M
Doi Ruak St
10K200M
Tha Chang Ta St
5K000M
Pang Sa
10K000M
Kwae Noi
Suphanburi
Ban Chalat
Wat Sam Rieng
CHANGWAT TAK
Don Pang Sa
10K
5K
Police Patrol Rest Stop
Ban The Chang
310K
Den Tan(Tak) St
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Suphanburi
Mae Nam Ping

Route Map
between Tak and Mae Sod

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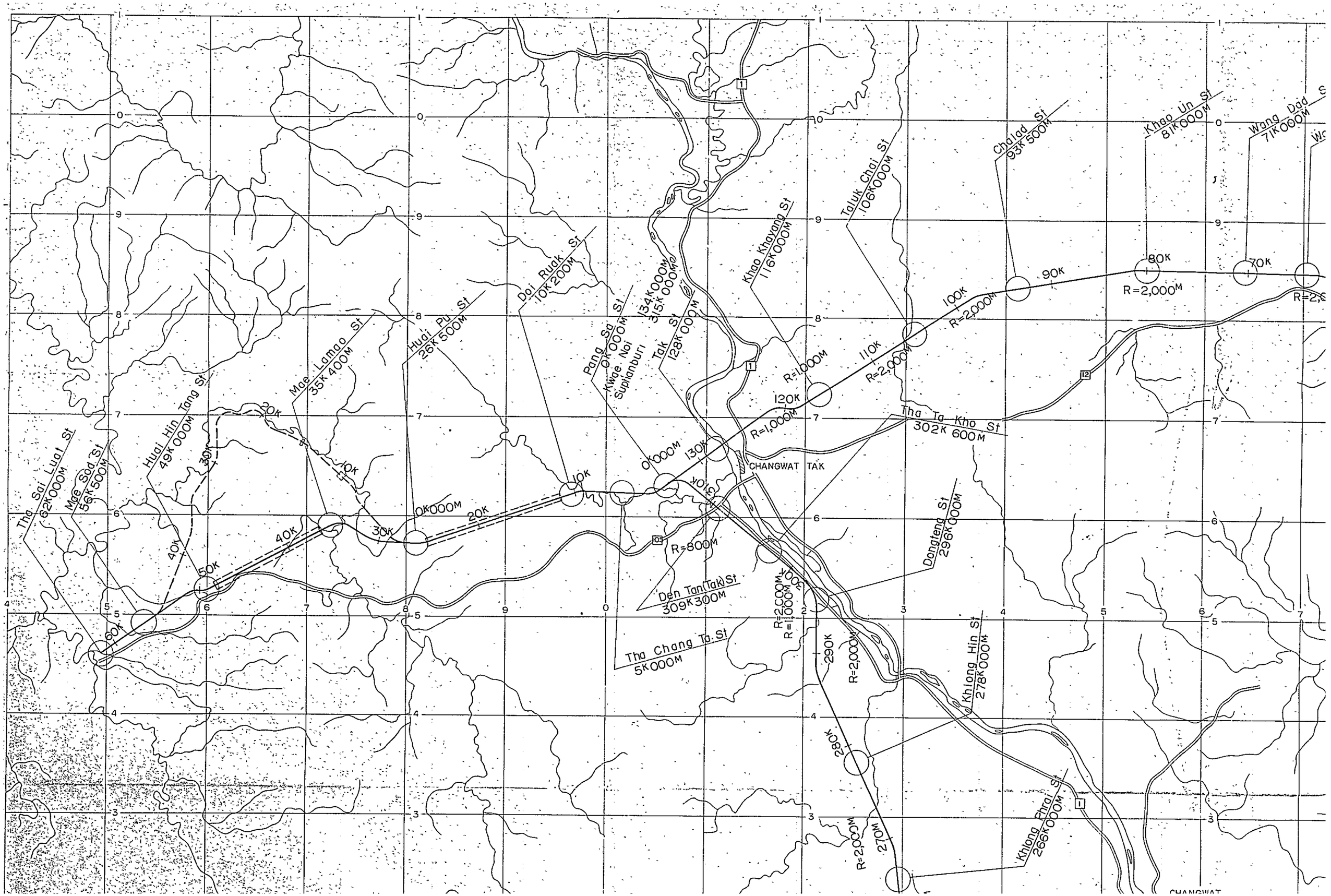
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Doi Ruak St
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Pang Sa
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Kwae Noi
Suphanburi
134K000M
315K000M
Tak St
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Khao Khayang St
116K000M
Taluk Chai St
106K000M
Chalad St
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Khao Un St
81K000M
Wang Dad
71K000M
80K
70K
90K
100K
R=2,000M
110K
R=2,000M
120K
R=1,000M
R=1,000M
130K
0K000M
CHANGWAT TAK
Tha Ta Kho St
302K 600M
Dongteng St
296K000M
Den Tan(Tak) St
309K300M
R=800M
R=2,000M
R=1,000M
Tha Chang Ta. St
5K000M
290K
R=2,000M
280K
R=2,000M
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CHANGWAT
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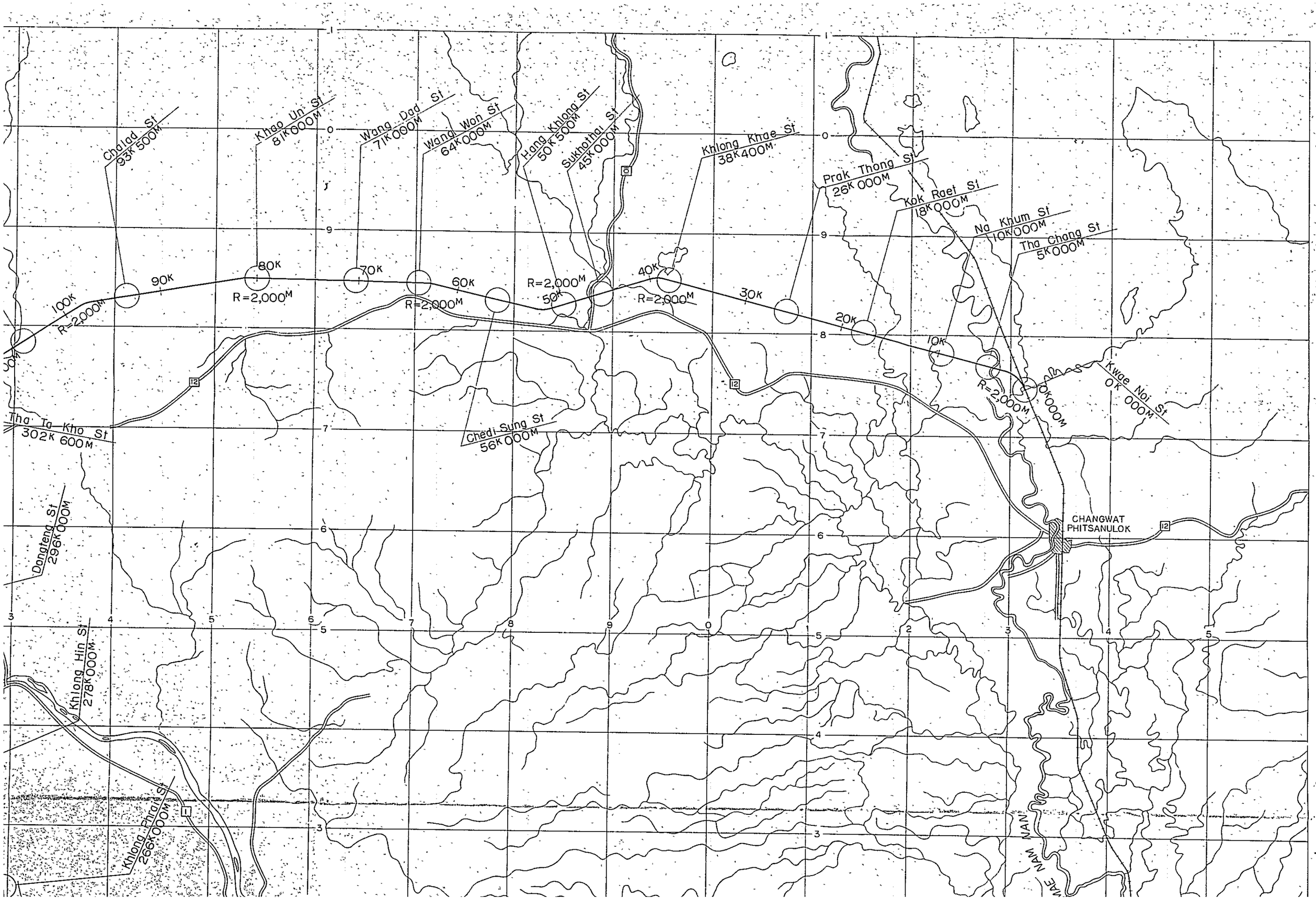
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Kwae Noi St
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Chedi Sung St
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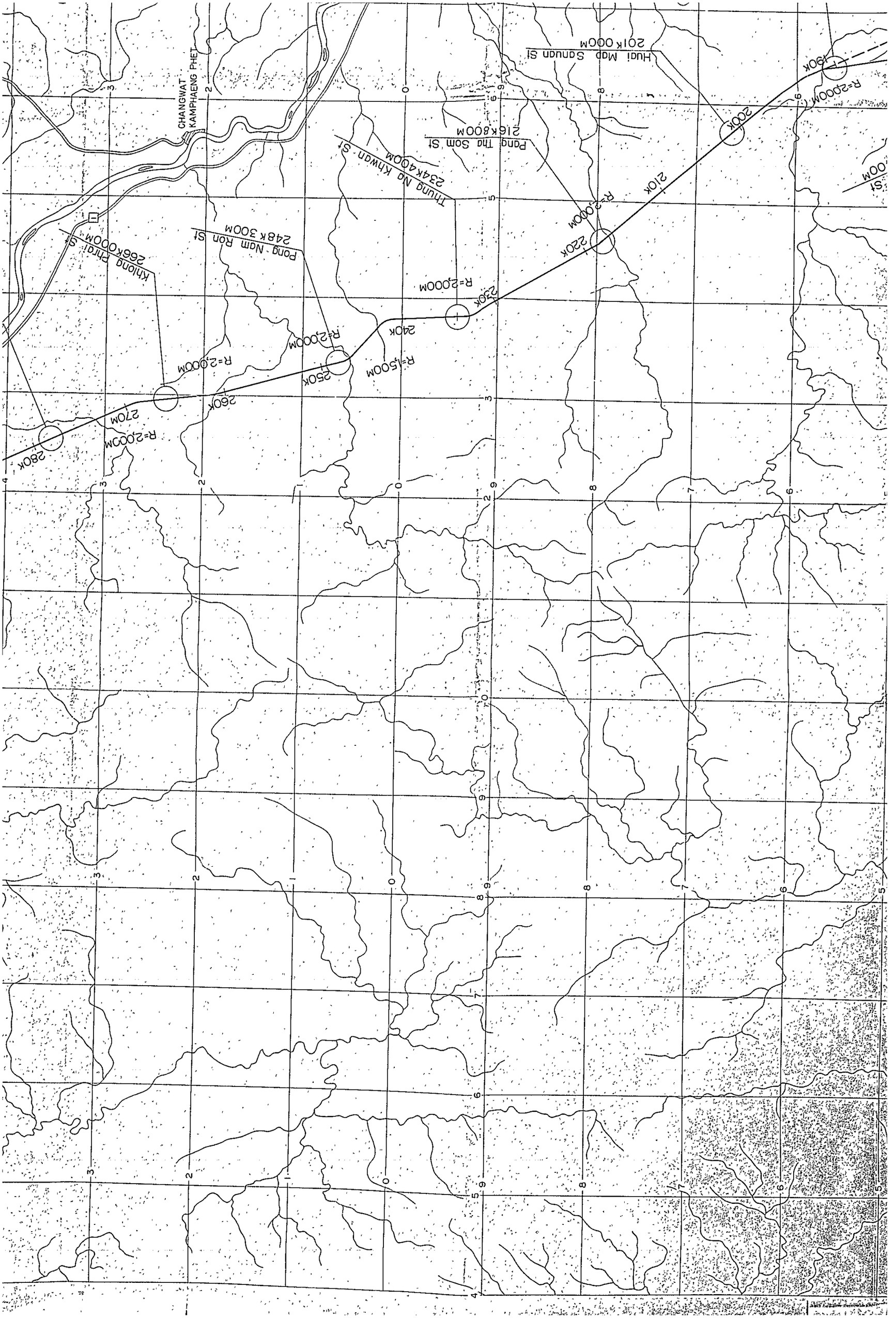
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Pang Tha Som St
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Thung Na Khwan St
234k 400M
210k
R=2,000M
220k
Pong Nam Ron St
248k 300M
Khlong Chroi St
266k 000M
R=2,000M
230k
240k
R=2,000M
R=1,500M
250k
R=2,000M
260k
270M
R=2,000M
280k

MAE NAM NAN

PHICHIT
CHANGWAT

CHANGWAT
KAMPHAENG PHET

MAE NAM PING

Khlong Phrai St
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Pong Nam Ron St
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Thung Na Khwan St
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Pong Tha Som St
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Huai Mae Sanuan St
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Ban Noi St
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Ban Bung St
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Ban Bung St
179K400M

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R=2,000M

R=2,000M

R=1,500M

R=2,000M

R=2,000M

270M

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240K

230K

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Khao Tamyae St
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170K
180K

Ban Bung St
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Nong Chik St
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150K
140K
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CHANGWAT NAKHON SAWAN
BUNG BORAPHET
CHANGWAT UTHAI THANI

Route Map

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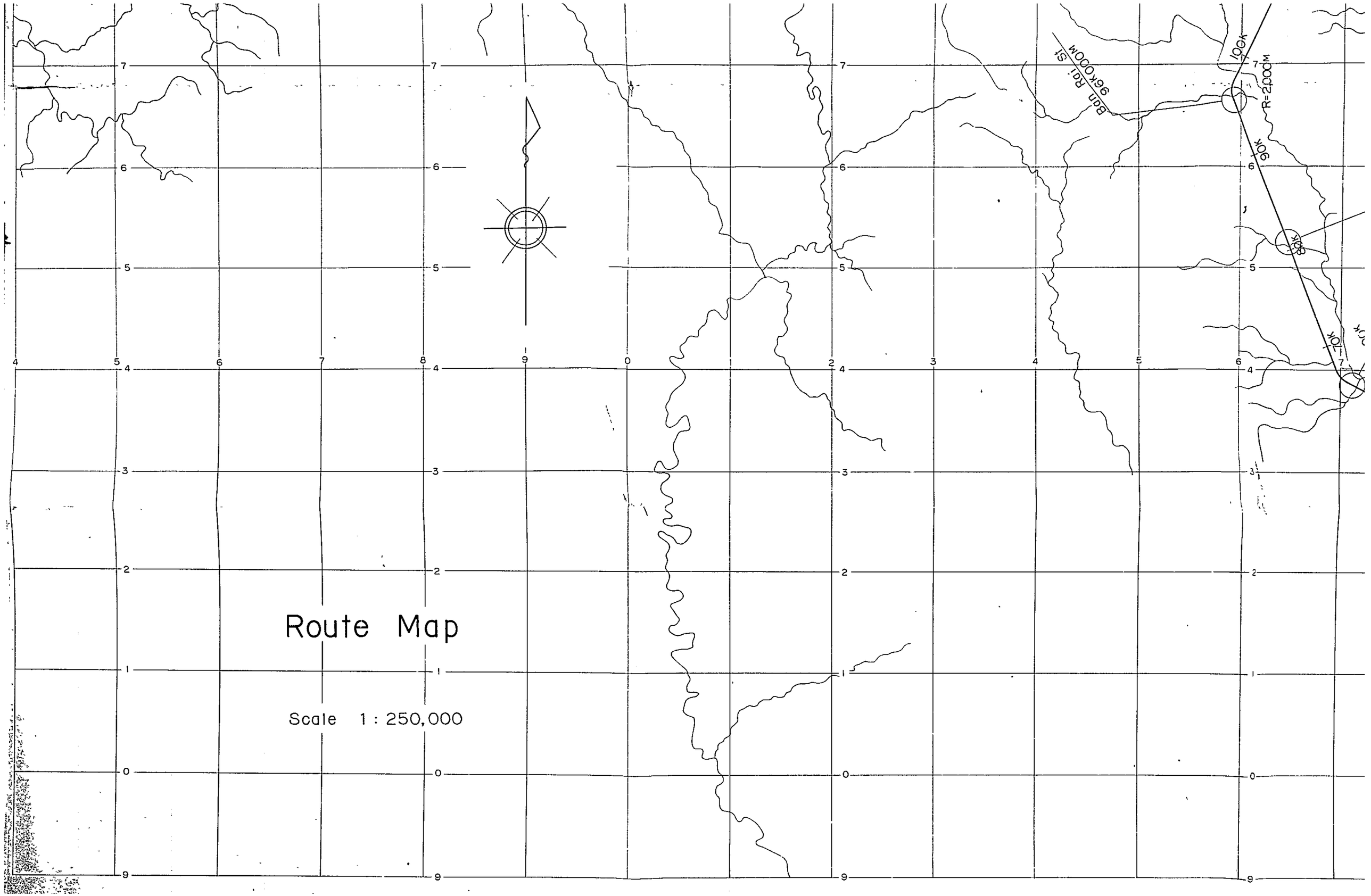

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Pa Phai St
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Nong Ratchawat St
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Bang Ngam St
16K 000M

Talat Daeng St
8K 000M

Suphanburi St
0K000M

CHANGWAT
SUPHAN BURI

Ban Rai St
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R=2000M

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90k

80k

70k

60k

50k

40k

30k

20k

10k

0k000M

305