PART II

TRANSPORTATION DEVELOPMENT

1. INTRODUCTION: TRANSPORT AND THE UPPER CENTRAL REGION

1.1 The Upper Central Region as a National Gateway

The Upper Central Region (UCR) is situated in central Thailand, directly north of Bangkok (See Fig. 1.1). It is roughly "Y" shaped, and serves as the gateway for Bangkok to the entire northern and northeastern portions of the nation.

Fig. 1.2 on the following page is based on road freight flows by commodity into and out of Bangkok for 1987 and obtained from the Ministry of Transport and Communication. Included in the transport data are the following categories:

1. Rice and rice products
2. Maize, cassava (or tapioca)
3. Sugar and molasses
4. Other agricultural products
5. Farm and fishery products
6. Forest products
7. Petroleum products
8. Earth, sand, and gravel products
9. Other mineral products
10. Cement
11. Other construction products
12. Fertilizer
13. Other manufactured goods
14. All other products
15. Unknown

Goods coming from or bound for either the UCR, the north, or northeast which pass though some portion of the study area are shown as "Inbound" or "Outbound Through UCR". Goods coming from or going to other areas are shown in the "Not Through UCR" bars.

It may be observed that over 33% of the tonnage of all goods travelling by road to Bangkok and over 52% of all material traveling from Bangkok must pass through the Upper Central Region, an area with just over 8% of the total land area of Thailand. Not only roads, but inland waterways and rail pass through

the UCR on their way to the north and northeast, as Figs. 1.3, 1.4, and 1.5 illustrate, increasing the role of the UCR as a gateway to upper portion the nation.

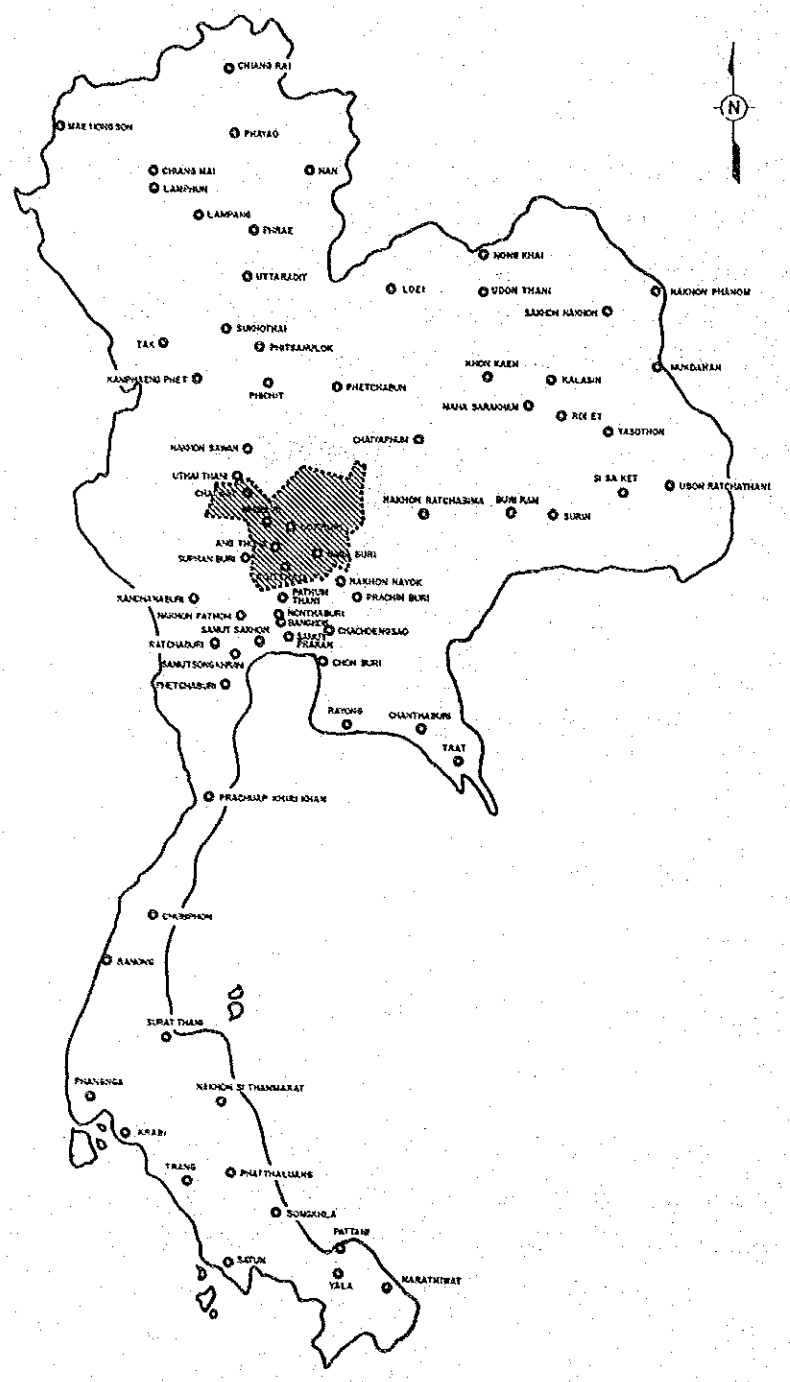
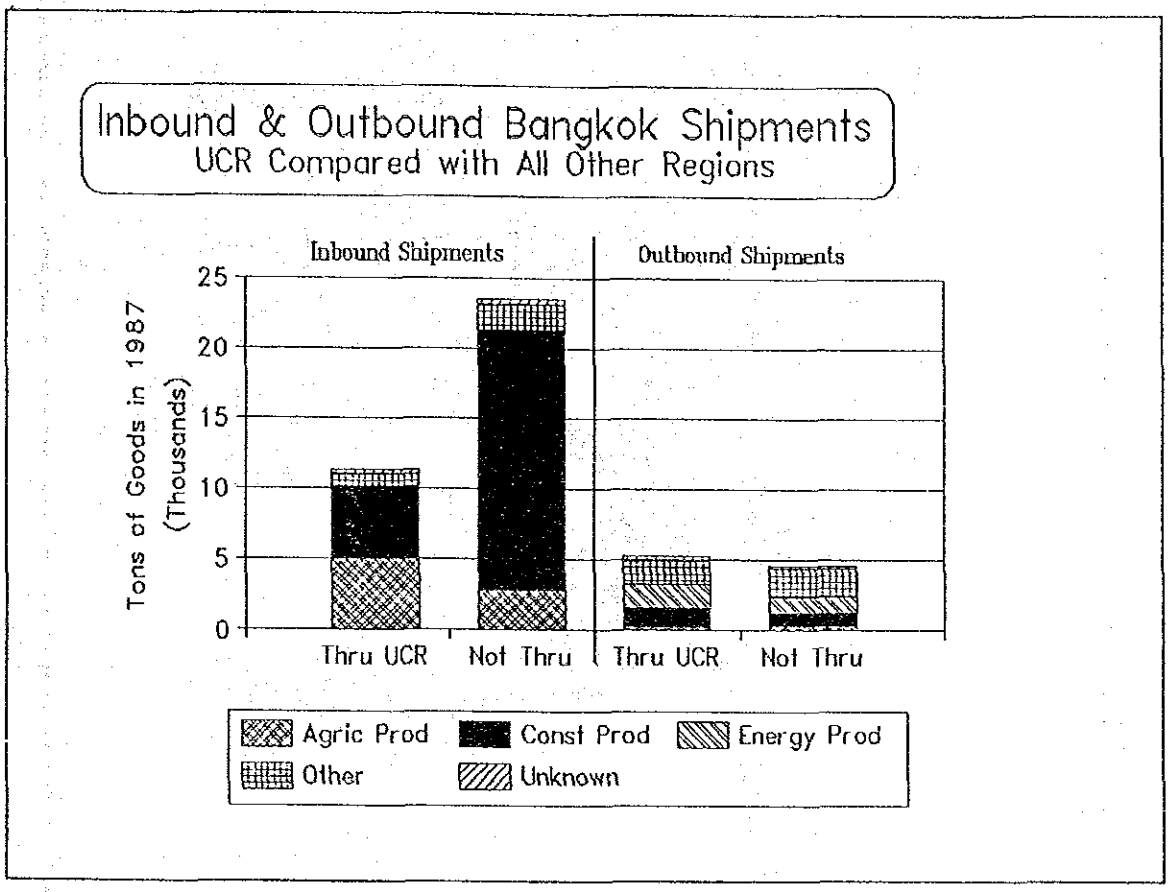


Fig. 1.1 The Upper Central Region of Thailand



Source : "Transport Statistics for 1987,"Ministry of Transport and Communications"
(Unit = Thousand Tons)

Fig. 1.2 The UCR as a National Gateway

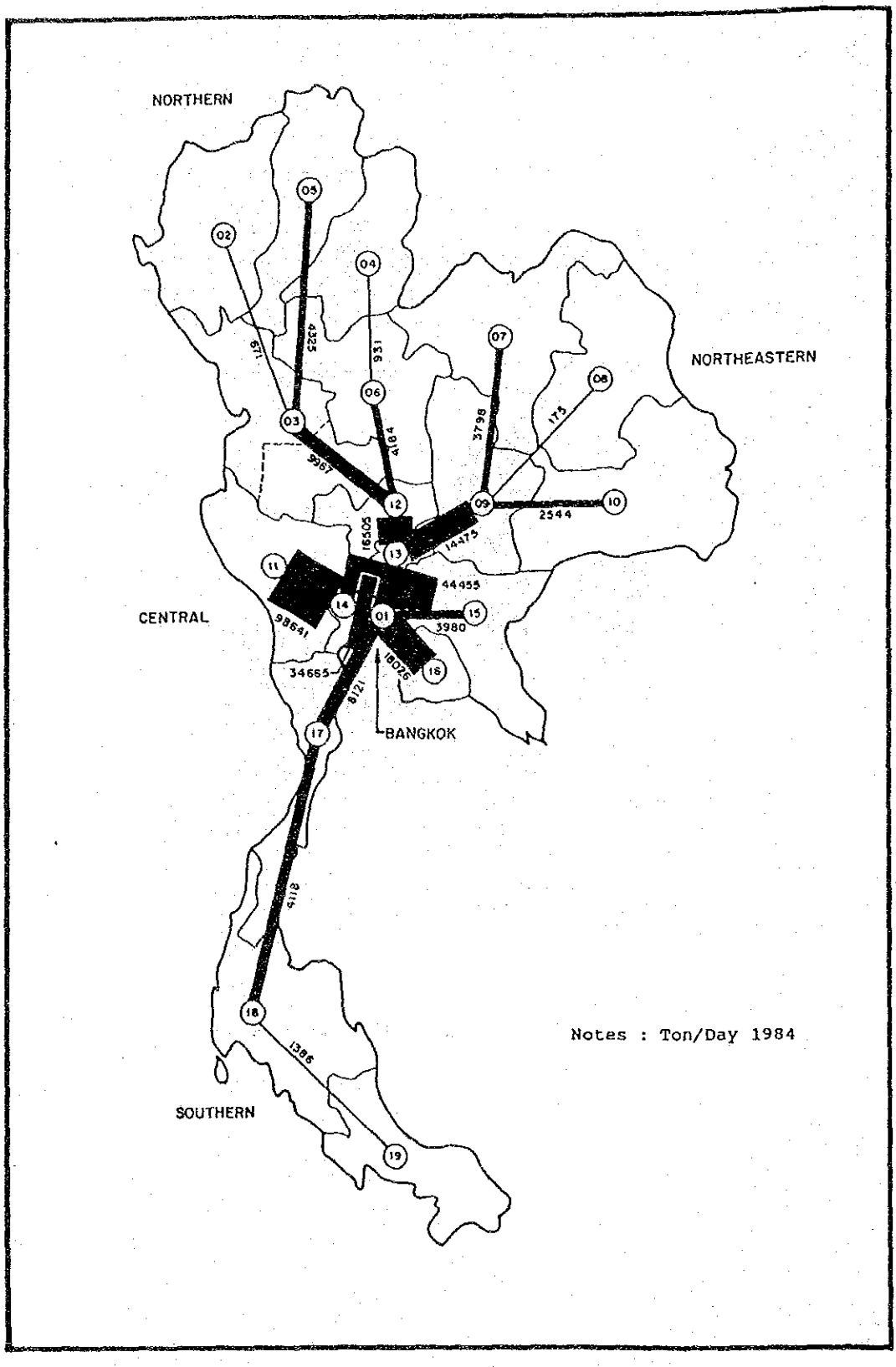


Fig. 1.3 Road Transport Commodity Flows In and Out of Bangkok

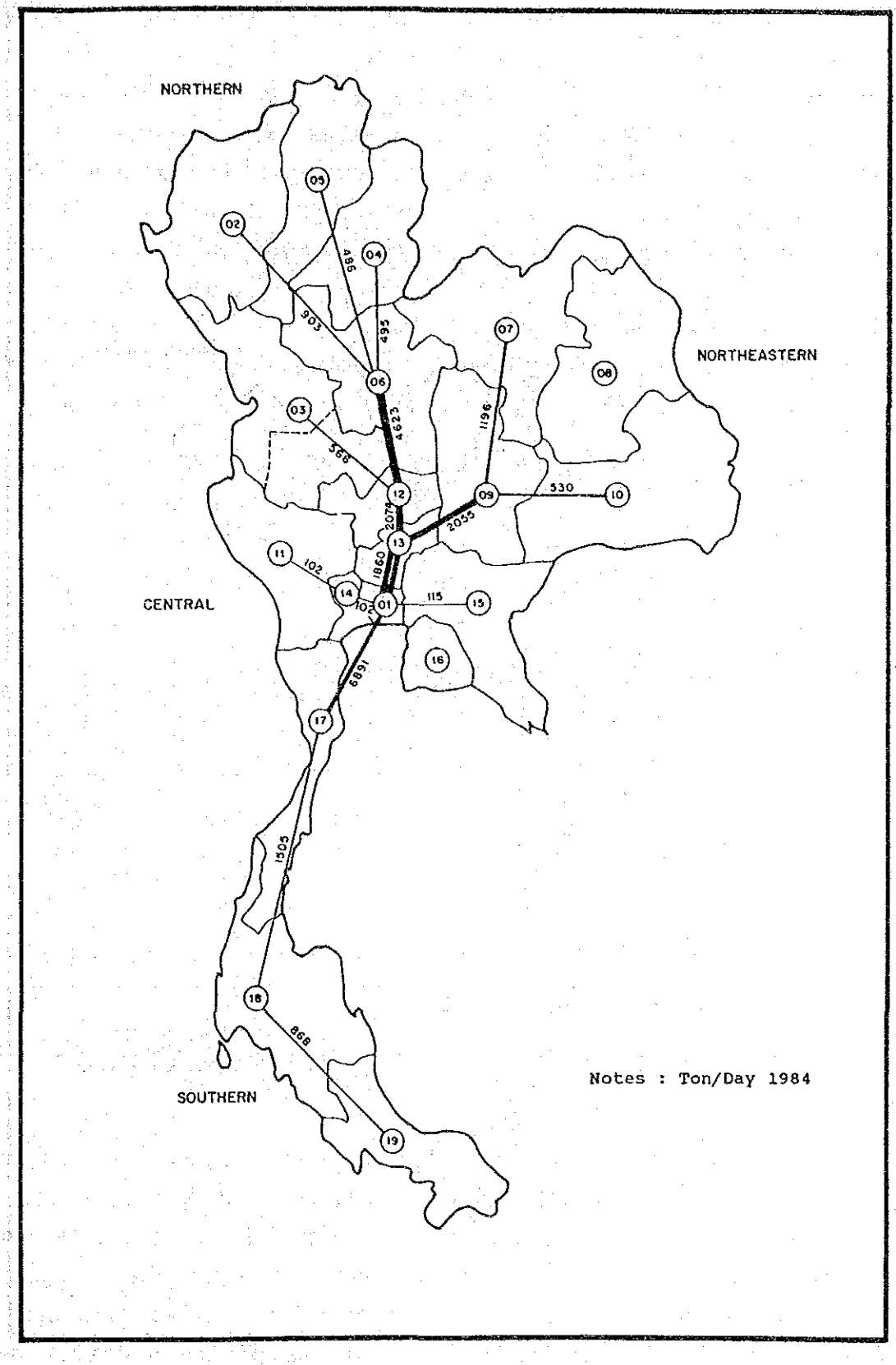


Fig. 1.4 Rail Transport Commodity Flows In and Out of Bangkok

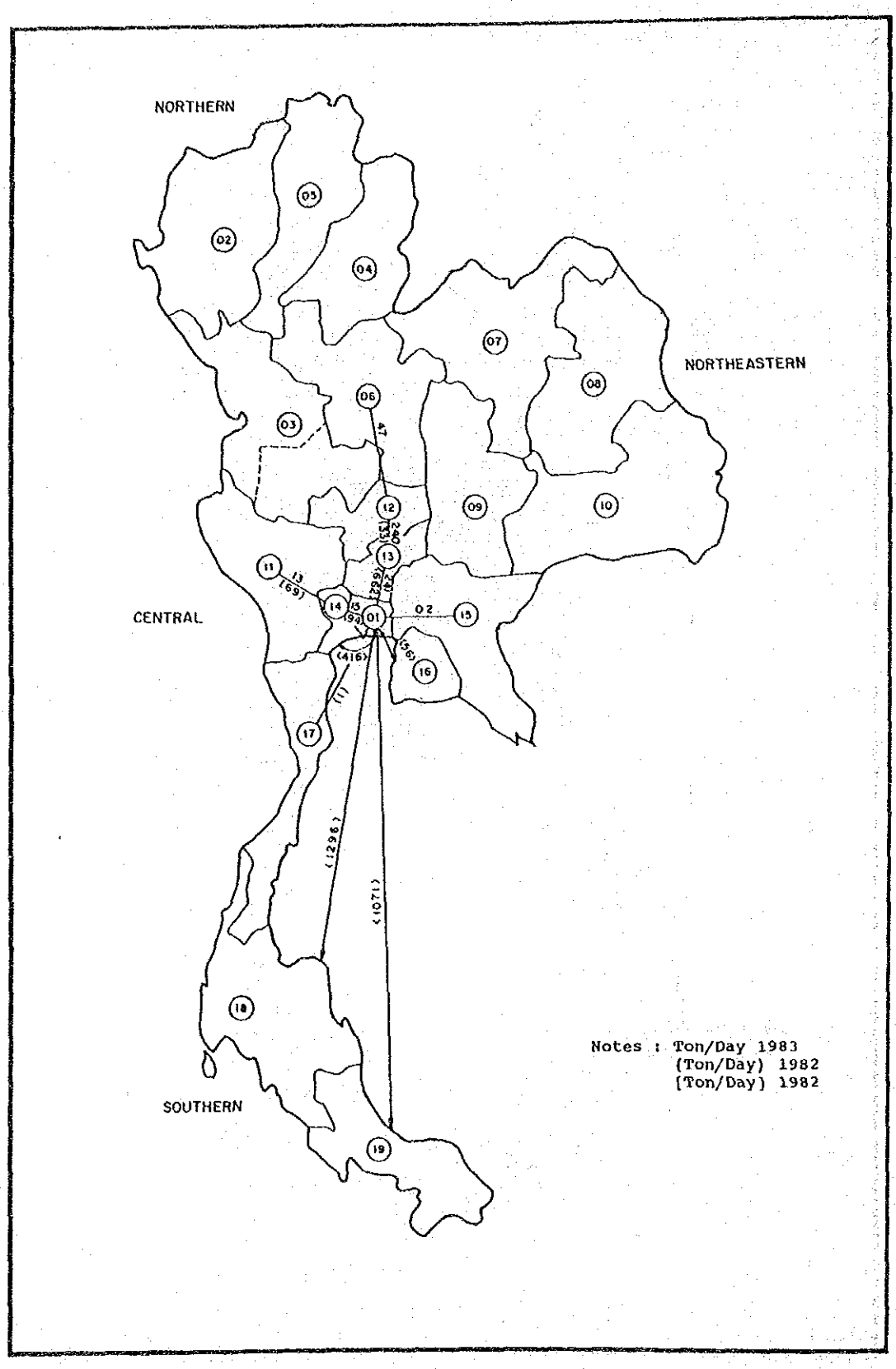


Fig. 1.5 Inland Water Transport Commodity Flows In and Out of Bangkok

1.2 Transport and Industries in the Upper Central Region

As part of the Upper Central Region Study, a survey of industrial managers was conducted both in the UCR and the BMR to gain insight into the problems which they face and their methods for making decisions. The survey covered 160 firms, 65 of which were located in the UCR, with the other 95 located in Bangkok Metropolitan Region (BMR). One question which was asked was "What infrastructures are the bottlenecks to your factory at present?" Each businessman could list two problems which his company faced, which resulted in a total of 320 possible responses. The results were grouped according to six overall categories as shown in Table 1.1 below.

Question : "What infrastructures are the bottlenecks to your factory at present?"

Table 1.1 Answers to Survey Questions

Changwat	No Respnse	Elect Problem	Water Problem	TeleCom Problem	Transport Problem	Other Problem
Ang Thong	0	4	3	1	0	0
Ayutthaya	8	7	1	3	3	0
Bangkok	72	21	10	14	8	3
Chai Nat	11	2	0	1	0	0
Lop Buri	19	13	2	5	1	0
Nontha Buri	7	6	1	2	0	4
Pathum Thani	5	2	0	0	3	0
Samt Prakarn	19	7	1	3	2	0
Sara Buri	1	1	0	0	0	0
Sing Buri	21	15	3	4	1	0
All	163	78	21	33	18	7

Source: Japan International Cooperation Agency/Asian Engineering Consultants Corp., LTD; September, 1989

Breaking the responses down by region, a few differences become apparent. (Refer to Fig. 1.6) In the Bangkok Metropolitan Region, out of a total of 95 respondents, 33 did not identify any infrastructure bottlenecks. In the Upper Central Region, out of 65 respondents, only 19 felt that no infrastructure bottlenecks existed. Another contrast is found in the number of responses about problems with Electric Utilities. In the BMR, out of 95 respondents, there were 36 responses which identified either supply or cost problems. In contrast in the UCR, out of 65 respondents, there were 42 responses which

identified electric related bottlenecks. The primary concern in this technical paper, transport was not considered as a particularly serious problem in either area, although it was a bit more of a problem in the BMR. Thus, we must conclude that at present, industrial leaders do not generally consider the transport infrastructure to be a significant problem in the Upper Central Region.

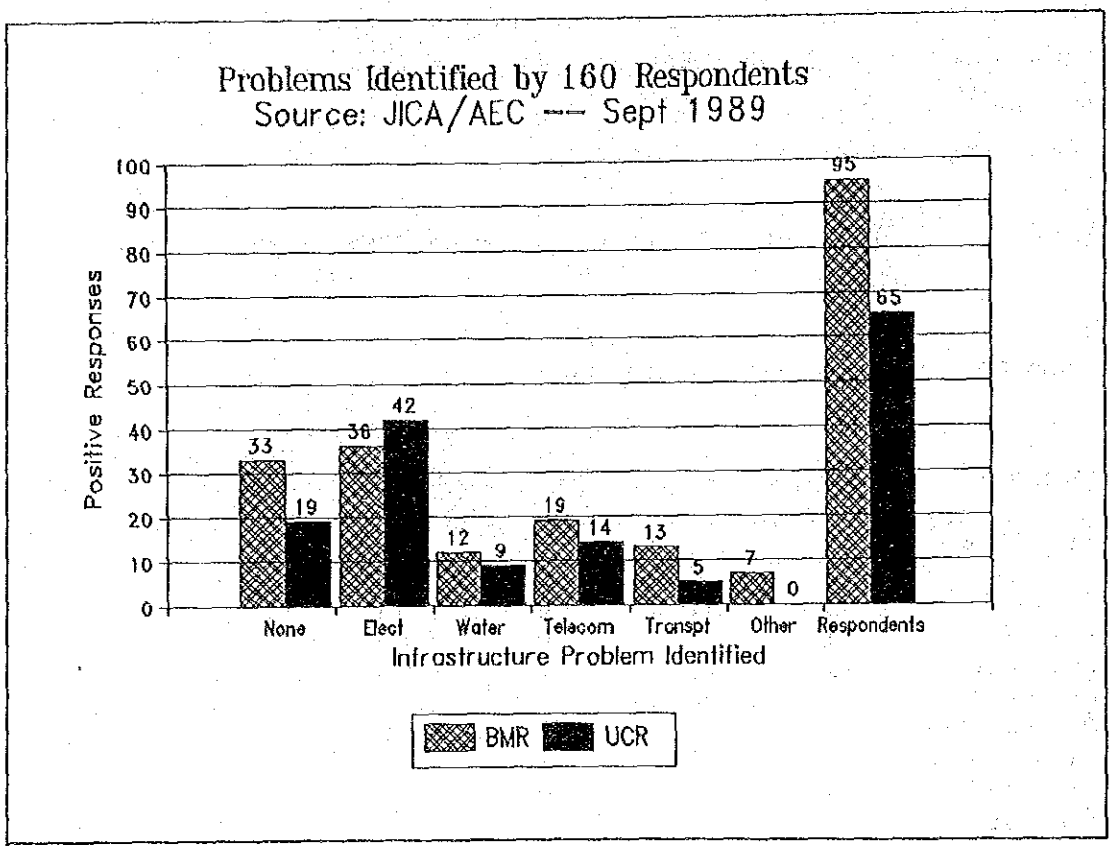


Fig. 1.6 Infrastructure Bottlenecks in the UCR and BMR

1.3 Transport and Local Residents

The concerns of transport to local residents is at the moment more difficult to quantify. Perhaps the best information at present is from the Provincial Information System Questionnaire which was conducted in 1986 by the Information Processing Institute for Education and Development at Thammasat University.

1.4 Emphasis in the Upper Central Region Study

The primary concern in the UCR transport study is with public, rather than private transport investment, thus this Final Report places emphasis on transport networks or ways rather than on modes of transport.

Also of importance is the focus of this study on physical projects rather than maintenance or other institutional reform programs. One reason for this is that numerous other more detailed sectoral studies have already been conducted covering each sub-sector of transportation, and the team has very little reason to disagree with the previous recommendations. Another reason is that institutional changes are by and large national issues, and it is a mistake to base national policy decision recommendations solely on information gleaned from a regional study.

This does not mean that institutional issues have been ignored, indeed needed institutional changes are mentioned throughout the report, it simply means that we feel that programs for major institutional reforms of the national agencies concerned with transport are subjects beyond the level of detail which should be covered under the aegis of a regional planning study.

A third and important point which should be remembered is that the emphasis in the final presentation of this Final Report and in other reports is on projects initiated in the UCR study. This by no means indicates that the study team feels that these are the only or even most important projects to be carried out, it simply means that other studies have already covered other subjects in detail and they need not be belabored here. Where other projects are felt to be particularly important, they are pointed out in this Final Report.

2. ROADS IN THE UPPER CENTRAL REGION

2.1 Introduction

Perhaps the most serious concerns pertaining to local roads in the UCR are administrative in nature, there being two issues of particular importance to the UCR. The first issue is that it there are so many agencies charged with the responsibility for planning, construction, and maintenance of local roads with very little apparent coordination between them. No fewer than eleven agencies are independently charged with such responsibilities within the UCR. A second, related issue is the perceived need for local residents to initiate the construction and maintenance of these local rural roads at a local level.

2.2 Definitions

Before beginning the detailed discussion of the present road conditions in the study area, it is useful to define a few terms which will be used in the discussion.

2.2.1 Rural versus Urban Roads

Basically, all of the roads (which are intended to include highways) which are addressed in the Upper Central Region Study are considered rural, as opposed to urban in nature. That is, they run between and connect cities and towns in the study area, instead of serving the strictly local travel within the cities or villages themselves.

2.2.2 Functional Classification

In order to clarify the discussion on roads in this report, the original division of roads into interregional and intra-regional categories as defined in the

Progress Report[1] has been changed. This change has been made due to the fact that the original terms are dependent upon the set of regional boundaries chosen. As boundaries shift, what was previously intra-regional will become interregional. A more important consideration is the fact that a new definition will make it easier to visualize the UCR as part of a larger national transport network.

The system chosen is the commonly used hierarchical system of classification by use or function "functional classification" as defined in the standard manual of the American Association of State Highway and Transportation Officials (AASHTO).[2]

The three types of roads which define the hierarchy are: arterials, collectors, and locals. Arterials and collectors may then be subdivided as primary or secondary arterials and primary and secondary collectors.[3]

A conceptual diagram of the functional classification of rural roads is shown above in Fig. 2.1. Arterials are generally highways which provide direct service between the changwat centers and the BMR or occasionally between the changwat centers themselves. Collector roads generally serve to connect changwat centers and amphur centers directly or connecting them to the arterial network. Roads of this category may be considered to both collect traffic from local roads, which serve individual farms or other rural land uses, and conversely to distribute traffic to these local roads from the arterials.

Another way of looking at the idea of functional classification is to consider the type of service which is provided by each class of road or highway. The major consideration in classifying roads \functionally is whether the road primarily serves to provide access to land or mobility. As is graphically illustrated in Fig. 2.2, arterials are primarily used for mobility, while locals are fundamentally for the access to land.

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1 "The Upper Central Region Study: Progress Report -- March 1989"; Japan International cooperation Agency.

2 A Policy on Geometric Design of Highways and Streets - - 1984; The American Association of State Highway and Transportation Officials.

3 For the sake of simplicity, the designations of primary and secondary arterials and collectors are not used in this report. There is also the issue of the precision of definitions which are currently in use.

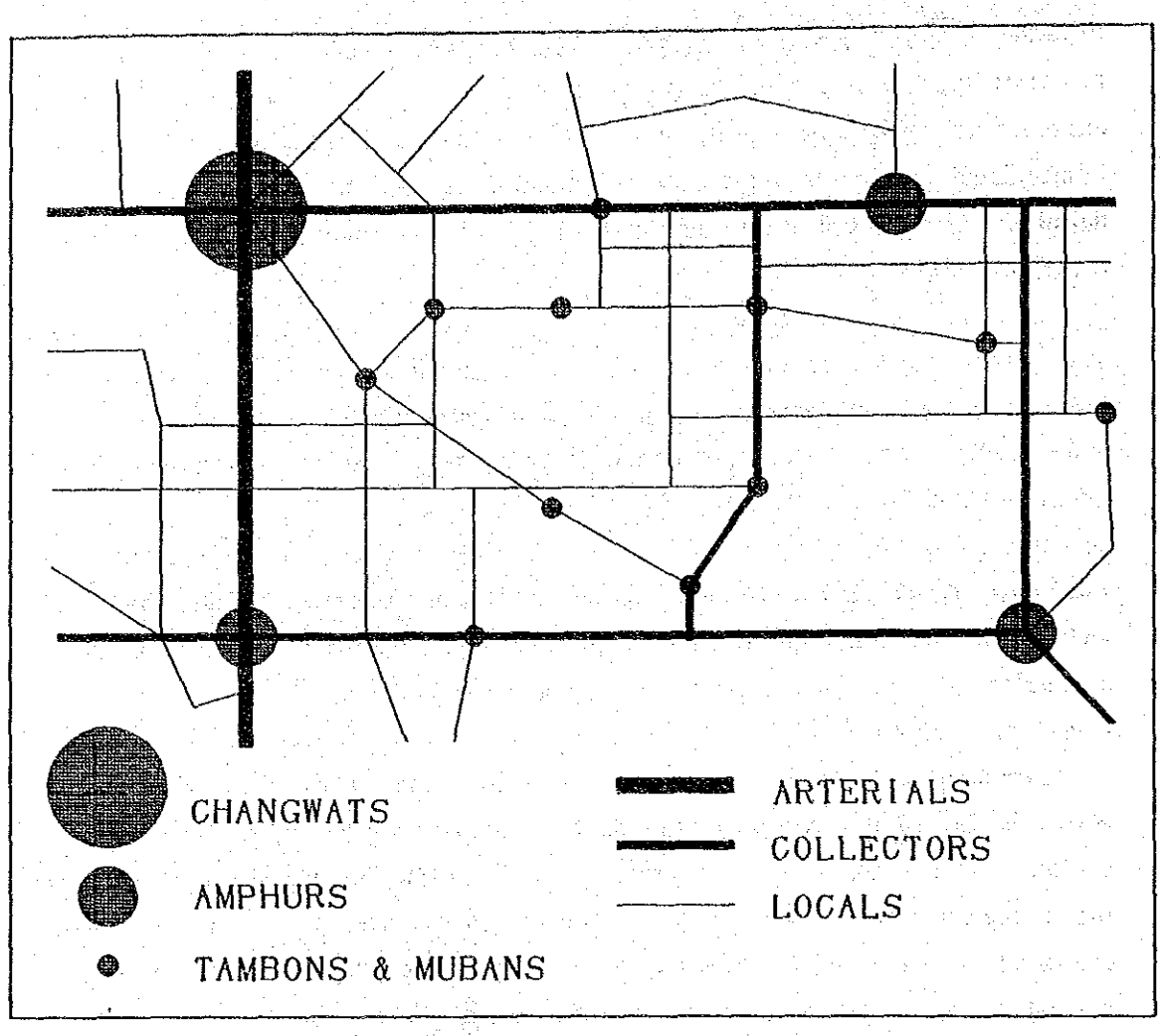

Fig. 2.1 Schematic of a Functionally Classified Rural Road Network

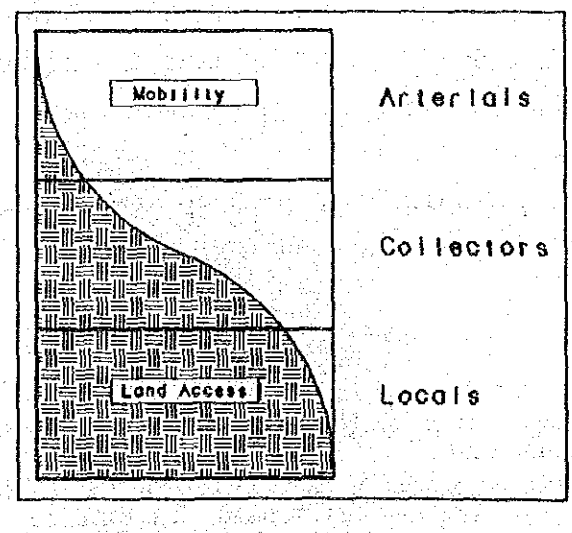

Fig. 2.2 Proportion of Service

This is important in that it sets different standards for of both design and evaluation for each type of road. Limitation of access in necessary on arterials to enhance their primary function of mobility, while the primary function of locals is to provide access. The need for arterials and improvement is defined in terms of trip demand, road capacity, design characteristics, level-of-service, and so forth.

Local roads are evaluated according to what extent that they provide for access to either the land itself or to features on the land such as houses, industries, utilities, and the like.

Yet another way to consider the different highway classifications is to compare the existing system of functional classification used by the Department of Highway (DOH) to the AASHTO functional classification scheme.

This comparison is shown below in Table 2.1. It should be mentioned that the comparisons are only approximate, as the two classification systems have some variation in the various parameters. In general, however, Department of Highways (DOH) roads tend to be somewhat under designed by AASHTO standards, both in terms of design speed and lane width.

Table 2.1 DOH Highway Classifications Compared To AASHTO Functional Classification

DOH Classification			AASHTO Class	Average Daily Traffic		Design Speed	Surface Type	C'way Width
P-D			Arterial	8,000	Above	100	High	14.00
	S-D	F-D	Arterial	8,000	Above	90	High	14.00
P-1			Arterial	4,000	8,000	100	High	7.00
	S-1	F-1	Arterial	4,000	8,000	90	High	7.00
P-2			Collector	2,000	4,000	100	Intrmdt	6.50
	S-2	F-2	Collector	2,000	4,000	90	Intrmdt	6.50
P-3			Collector	1,000	2,000	100	Intrmdt	6.00
	S-3	F-3	Collector	1,000	2,000	90	Intrmdt	6.00
	S-4		Local	300	1,000	90	Int-Low	5.50
		F-4	Local	300	1,000	80	Low	5.50
	S-5		Local	0	300	90	Soil	9.00
		F-5	Local	0	300	60	Soil	9.00
		F-6	Local	0	300	60	Soil	6.00

2.2.3 Level-of-Service

An additional concept is the "level-of-service" mentioned previously. The following quote is from the 1985 Highway Capacity Manual. [1]

"The concept of "levels of service" is defined as a qualitative measure describing operational conditions within a traffic stream, and their perception by motorists and/or passengers. A level-of-service definition generally describes these conditions in terms of such factors as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety.

Six levels of service are defined for each type of facility for which analysis procedures are available. They are given letter designations, from A to F, with level-of-service A representing the best operating conditions and level-of-service F the worst.

For two-lane rural roads, the various levels of service are defined as follows for uninterrupted flow facilities:

1) The highest quality of traffic service occurs when motorists are able to drive at their desired speed. Without strict enforcement, this highest quality, representative of **level-of-service** A, would result in average speeds approaching 95 km/hr on two-lane highways. The passing frequency required to maintain these speeds has not reached a demanding level. Passing demand is well below passing capacity, and almost no platoons of three or more vehicles are observed. Drivers would be delayed no more that 30 percent of the time by slow-moving vehicles. A maximum flow rate of 420 passenger cars per hour, total in both directions, may be achieved under ideal conditions.

2) **Level-of-service B** characterizes the region of traffic flow wherein speeds of 90 km/hr or slightly higher are expected on level terrain. Passing demand needed to maintain desired speeds becomes significant and approximately equals the passing capacity at the lower boundary of

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1 Highway Capacity Mannual. Special Report 209. Transportation Research Board, National Research Council, Washington D.C. 1985. pp. 8-5 through 8-6. (Modified slightly to reflect metric measurements)

level-of-service B. Drivers a delayed up to 45 percent of the time on the average. Service flow rates of 750 pcph, total in both directions, can be achieved under ideal conditions. Above this flow rate, the number of platoons forming in the traffic stream begins to increase dramatically.

3) Further increases in flow characterize **level-of-service** C, resulting in noticeable increases in platoon formation, platoon size, and frequency of passing impediment. Average speed still exceeds 83 km/hr on level terrain, even though unrestricted passing demand exceeds passing capacity. At higher volume levels, chaining of platoons and significant reductions in passing capacity begin to occur. While traffic flow is stable, it is becoming susceptible to congestion due to turning traffic and slow-moving vehicles. Percent time delays are up to 60 percent. A service flow rate of up to 1,200 pcph, total in both directions, can be accommodated under ideal conditions.

4) Unstable traffic flow is approached as traffic flows enter **level-of-service** D. The two opposing traffic streams essentially begin to operate separately at higher volume levels, as passing becomes extremely difficult. Passing demand is very high, while passing capacity approaches zero. Mean platoon sizes of 5 to 10 vehicles are common, although speeds of 80 km/hr can still be maintained under ideal conditions. The fraction of no passing zones along the roadway section usually has little influence on passing. Turning vehicles and/or roadside distractions cause major shock-waves in the traffic stream. The percentage of time motorists are delayed approaches 75 percent. maximum service flow rates of 1,800 pcph, total in both directions, can be maintained under ideal conditions. This is the highest flow rate that can be maintained for any length of time over an extended section of level terrain without a high probability of breakdown.

5) **Level-of-service** E is defined as traffic flow conditions on two-lane highways having a percent time delay of greater than 75 percent. Under ideal conditions, speeds will drop below 80 km/hr. Average travel speeds on highways with less than ideal conditions will be slower, as low as 40 km/hr on sustained upgrades. Passing is virtually

impossible under level-of-service E conditions, and platooning becomes intense when slower vehicles or other interruptions are encountered.

6) As with other highway types, **level-of-service** F represents heavily congested flow with traffic demand exceeding capacity. Volumes are lower than capacity, and speeds are below capacity speed. Level-of-service E is seldom attained over extended sections on level terrain as more than a transient condition; most often, perturbations in traffic flow as level E is approached cause a rapid transition to level-of-service F.

These definitions are general and conceptual in nature, and they apply primarily to uninterrupted flow. Levels of service for interrupted flow facilities vary widely in terms of both the user's perception of service quality and the operational variables used to describe them."

2.3 The Highway Network: Arterial and Collector Roads

2.3.1 Overview

The Upper Central Region is well served by its present arterial and collector road network. Indeed, when compared with the traffic problems of the Bangkok Metropolitan Region, the UCR is in excellent condition. This fact was reflected in the survey of local businessmen in a survey conducted during the UCR study and discussed in Section 1.2 of this Final Report.

Since the DOH is the sole responsible agency, administrative issues concerning the planning and construction of roads should be minimal. However problems do exist. At present, project ideas seem to originate from many different quarters, with the result that the default role of the DOH has been to react to planning by others. Although the existing arterial and collector network is adequate at present, this process in itself can easily tend to result in a poorly coordinated and ill conceived overall network. It also tends to exacerbate the other problems of the network such as excessive access to roads which are primarily needed for high speed travel, and to problems in land acquisition.

During field trips to the UCR, it was discovered that numerous roads are under construction that were not mentioned in any set of plans given to us by the Department of Highways. Another indicator was the discovery that roads both

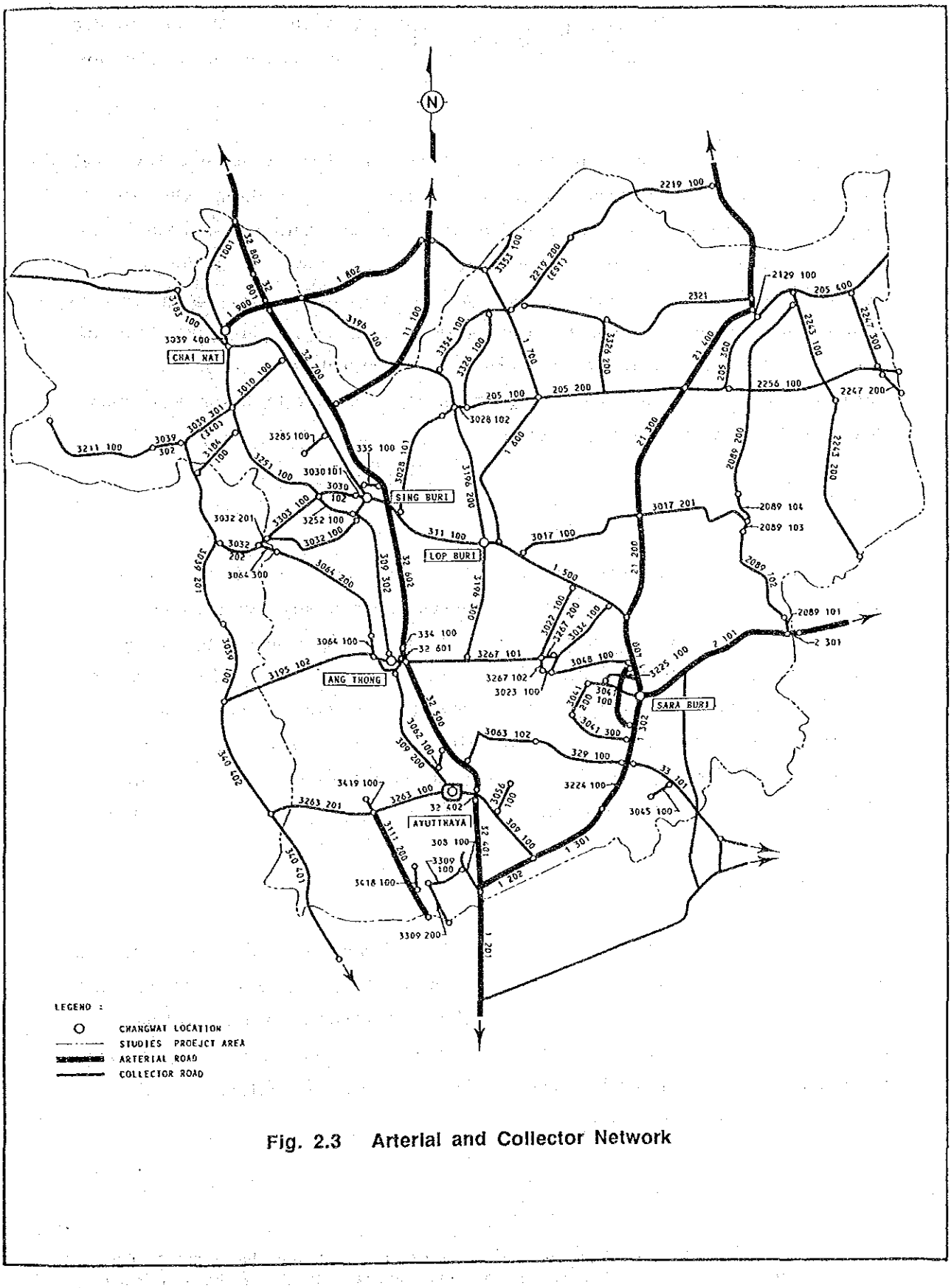

Fig. 2.3 Arterial and Collector Network

under construction and roads planned for construction that were not initiated by the DOH, and thus could not have been part of any general master plan for highway construction.

An example of the problems of land acquisition was observed on two new road construction projects, the bypasses of Suphan Buri and Sara Buri. On these projects, road construction began before the land acquisition had been completed, and construction has halted in several locations until the problems can be solved. It is felt that this process may in fact exacerbate the problem of land speculation, as a land owner can easily demand a very high price for his land when he knows that the government is committed to a particular corridor. It also does not allow the corridor to be shifted to lower acquisition costs while retaining design integrity.

2.3.2 The Existing Network

The present arterial and collector network in the Upper Central Region is illustrated in Fig. 2.3. The network as shown is essentially the existing network including two new bypass links around Lop Buri and Ang Thong which are currently under construction. The bold lines in the fig. illustrate arterial roads while the narrower ones show the collectors. The network consists of the network which is currently under the jurisdiction of the Department of Highways (DOH), and alignments are from numerous sources[1]. Classification of the roads as either arterial or collector is as used by the DOH.

2.3.3 The Approved Network

Table 2.2 on the following pages is a list of DOH highway projects for which the budget has been secured. These projects are the ones which were be included in the Sixth National Plan, and are therefore the changes to the existing network which should be included in the future network. These projects are incorporated into the following map in Fig. 2.4 where the future network, of Sixth Plan Network is shown.

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1 Alighnments were field checked for various roads, and it is felt that some of the alignments are considerably more accurate than others. It should be mentioned that accurate maps of roads in the UCR are extremely difficult to obtain, and most of the alignments are based on military maps created in 1969.

Table 2.2 Approved DOH Highway Projects (Projects in the Sixth National Plan for which the Budget is Secured)

Route No	Project	Length (km)	Std	Begn	End
	Primary and Secondary Highways				
1	Chai Nat to Ban Hang Nam	26.0	P1	1990	1992
205	Chai Badan to Ban Lam Son Thi	31.3	S2	1989	1991
	IBRD Loans				
1	Khok Samrong to Tha Klee	67.0	P1	1990	1992
309	Wang Noi to Ayutthaya	16.4	S2	1989	1991
	ADB Loans				
311	Sing Buri to Chai Nat	50.0	S2	1989	1992
	Provincial Highways				
3039	Junction 340 to Hankha	65.1	F1	1988	1990
3063	Phachi to Junction 32	23.0	F2	1989	1991
3195	Pho Phraya to Viset Chai Chan	26.0	F1	1989	1991
3196	Lop Buri to Junction 3267	33.0	F2	1990	1992
3039	Hankha to Chai Nat	12.0	F1	1990	1992
	IBRD Loans				
3041	Sara Buri to Sao Hai	8.0	F2	1989	1991
	OECF Loans				
3267	Junction 32 to Tha Rua	27.0	F1	1990	1992
	Not Begun, but in Sixth Plan To be presented to Cabinet about 1991				
308	Junction 32 to Bang Pa-in	9.0	S1		
309	Ang Thong to Sing Buri	39.0	S3		
3048	Huebong to Thalan	15.0	F2		
3020	Phra Phuttabat to Nong Don	10.0	F3		
3030	Sing Buri to Bang Rachan	10.0	F3		
3196	Ban Mi to Lop Buri	30.0	F3		
	Secondary Highways				
309	Pasak and RR Brdg @ Ayutthaya	0.6		1990	1992
	Provincial Highways				
3441	Brdg over C.Phraya @ Po Mok (Incl link to Hwy 309)	1.0	F3	1989	1991

Source: DOH

Table 2.2 Approved DOH Highway Projects (Projects in the Sixth National Plan for which the Budget is Secured) (Cont)

Route No	Project	Length (km)	Std	Begn	End
	Provincial Hwy Const Program				
2089	Bng Muang to Wang Kanlueng Wfall	24.9	F4	1989	1990
3442	Jct 1 (Bang Pa-in) to Jct 3309	10.8	F4	1988	1991
2089	Chai Badan to Wang Kanlueng Wfall	19.2	F4	1989	1990
3333	Khok Thum to Pasak River	34.0	F4	1989	1991
3056	Uthai to Phachi	11.0	F4	1990	1992
3056	Phachi to Tha Rua	14.0	F4	1990	1992
3056	Jct 32 to Hua Lan to Jct 329	25.0	F4	1990	1992
3056	Khok Ko Tao to Pa Mok	25.0	F3	1990	1992
2272	Nong Yai Toh to Jct 2089	11.0	F4	1990	1992
3184	Jct 3039 to Pak Nam	14.0	F4	1990	1992
3224	Kaeng Khoi to Salaeng Phan	31.0	F4	1990	1992
3224	Bang Pahan to Nakhon Luang	7.0	F4	1990	1992
3224	Jct 309 to Jct 32	6.0	F4	1990	1992
3224	Bang Pahan to Maha Rat to Jct 3267	15.0	F2	1989	1992
3224	Jct 3263 to Bang Pa-in	18.0	F4	1990	1992
	ADB Loans				
2247	Lam Som Phung to Jct 2256	17.0	F4	1990	1992
	IBRD Loans				
2243	Ban Bua Chum to Pak Chong	73.0	F4	1990	1992
	OECF Loans				
2243	Chan Na Sut to Sena to Pho Thong	41.0	F2	1990	1992
2243	Bang Pa-in to Ayutthaya	18.0	F2	1990	1992
	Not Begun, but in Sixth Plan To be presented to Cabinet about 1991				
3326	Ban Mi to Nong Muang	22.0	F4		
3354	Nong Ra Bien to Nong Muang	17.0	F4		
	Loan Project				
1	Rang Sit to Sara Buri	73.0	PD	1990	1992
2	Sara Buri to Nakhon Ratchasima	141.0	PD	1989	1992
32	Bang Pa-in to Nakhon Sawan	183.0	PD	1989	1992
	Secondary Hwy Construction				
309	Jct 32 to Ayutthaya	4.3	SD	1987	1989
	National Hwy Construction Plan				
1	Sara Buri By-pass	9.6	P1	1988	1990
	Secondary Hwy Construction Work				
334	Ang Thong By-pass	4.9	S3	1987	1990
	Provincial Hwy Const Plan				
347	Jct 3186 to BMA Outer Ring Road	32.5	F1	1988	1991
3309	Jct 3186 to BMA Outer Ring Road	32.5	F1	1988	1991
3214	Jct 3186 to BMA Outer Ring Road	32.5	F1	1988	1991

Source: DOH

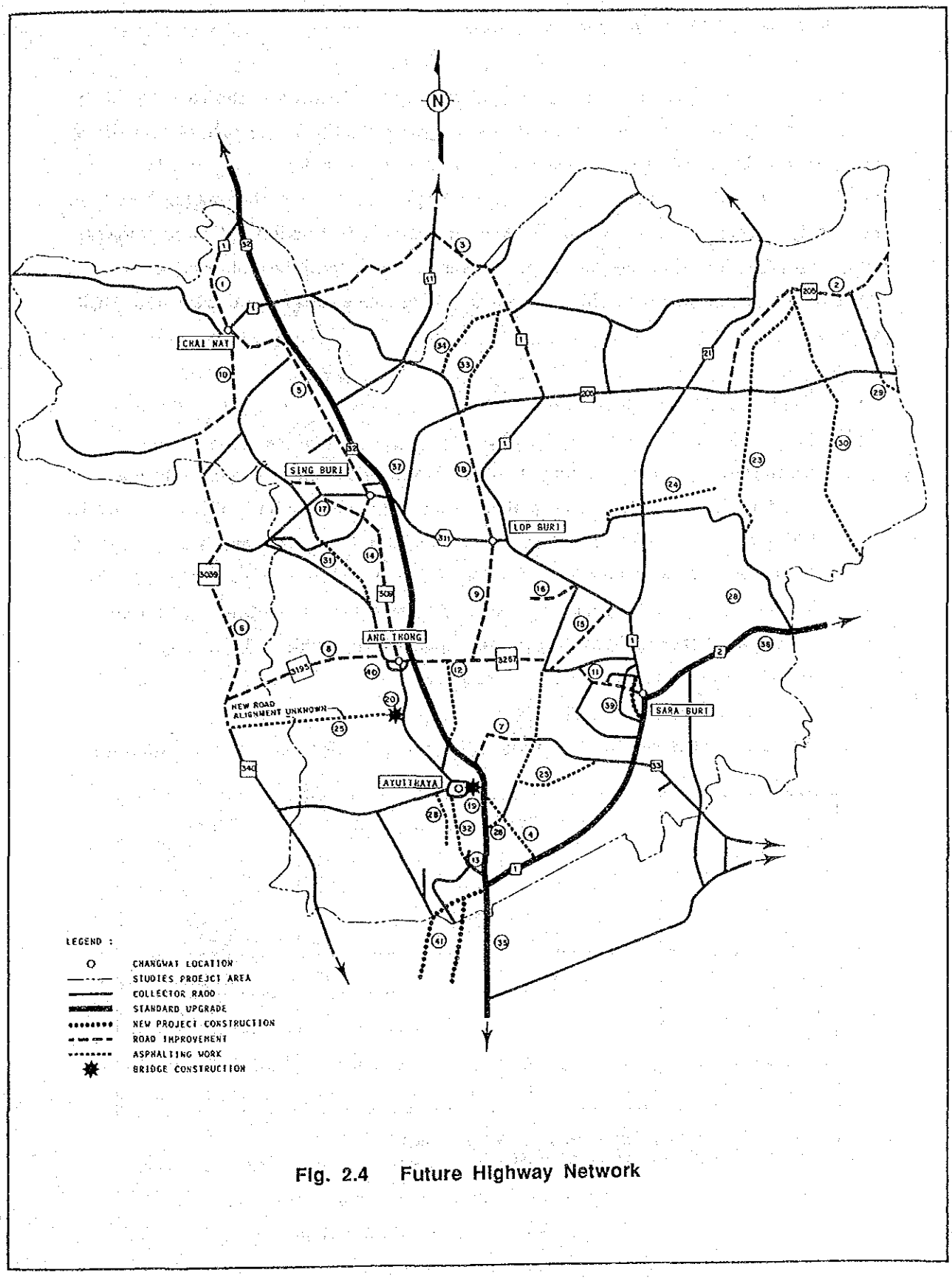


Fig. 2.4 Future Highway Network

2.3.4 Basis for Proposed Network Changes

Although the arterial and collector highway network serves the region fairly well at the present, a number of deficiencies exist which have been identified by various highway officials and other concerned individuals. It is the opinion of the Study Team that numerous improvements can be made, based on the study team's system for the evaluation and identification of improvements which will be described in the following pages. This will be followed by a discussion of the proposed improvements which have originated with the UCR study.

1) Based on Design Standards

Conformity of the existing road network with international "design standards" is the first and perhaps most obvious method of road analysis. This set of standards has been established by the DOH, and was compared to the AASHTO standards in Section 2.2. Overall, the distribution of road kilometers by functional classification is squarely within the normal range for those in the US as is shown below in Table 2.3.

Table 2.3 Distribution of Road-Kilometers by Functional Classification

Road Class	Upper Central Region		AASHTO Standard
	Road-km	Percent	
Local	4,861	69%	65-75%
Collector	1,636	23%	20-25%
Arterial	587	8%	6-12%
Total	7,084		

Source: *"Road Development in the Central Region", JICA;* and "Study of Rural Roads", DOH

As mentioned previously, roads in Thailand are under designed for high speed travel when evaluated by American (AASHTO) standards. More to the point, it is opinion of the study team that although the proper roads are designated as arterials, there is at present too much accessibility along them, thus impeding their primary function to enhance traffic mobility.

However, the arterials with the greatest problems of access are already part of the DOH plans for improvement. These problems were primarily observed along Route 32, the Asia highway between Bang Pa-in and Sing Buri. This road is already planned for improvement and will be developed as a four-lane divided highway with grade separated interchanges at Bang Pa-in, Ayutthaya, Ang Thong, Sing Buri, and Chai Nat.

This plan is strongly endorsed by the UCR team. It is understood that problems may exist with the grade separated interchanges due to expense. If this construction is impossible, then we feel that the intersections should be properly signalize and channelized to minimize traffic conflicts. Another important consideration is to avoid direct access by other roads crossing Route 32. Roads should cross by means of a fly-over intersection as is stated in the UCR proposed Suphan Buri to Tha Rua highway.

It is felt by the study team that other planned improvements to Route 1 between Bang Pa-in and Sara Buri are decidedly overkill, as the plans call for a ten-lane highway comprising a six-lane tollway flanked by two two-lane service roads. Based on the existing level-of-service and any conceivable increase in traffic, this presently four-lane road has no perceptible need of such drastic and expensive "improvement". In order to test the sensitivity of the level-of-service on this road, a test was made by increasing the average daily traffic by 50 percent, and then by 100 percent and calculating the changes in the level-of-service. Although the level-of-service does decline with such drastic changes in travel volume, the changes can be most likely alleviated by increasing the thoroughfare to six lanes or so.

Table 2.4 Sensitivity of LOS on Route 1 Between Bang Pa-in and Sara Buri to Changes in Traffic

Route	Sect	At Present		50% Increase		100% Increase	
		ADT	LOS	ADT	LOS	ADT	LOS
1	202	37,866	LOS-B	56,799	LOS-C	75,732	LOS-D
1	301	24,263	LOS-A	36,395	LOS-B	48,526	LOS-C
1	302	19,122	LOS-A	28,683	LOS-A	38,244	LOS-B

This situation concerning planned improvements to Route 1 relates to the earlier mentioned issue of administrative responsibilities as it has been reported that this road has been proposed, approved, and budgeted, although it was not initiated by the DOH as part of the national master plan.

Although general network improvement can be recommended concerning access control and lane width improvements, it is felt by the UCR team that no new UCR initiated projects should be based on the design standards criterion alone.

2) Based on Level-of-service

A second method for the evaluation of the network and the determination of network improvements is the level-of-service (LOS) criterion. This method includes both road geometry and the traffic volume as variables. For the existing network, this is not a particularly difficult addition, and it is also simple to interpret as the result is a letter designation of LOS A through LOS F.

In the UCR, the existing levels of service for two-lane roads the LOS is normally in the A to C category, and very few link improvements need to be made based on this criterion. The links which generally do need to be improved are almost without exception in the areas where improvements are either underway or in the approved future network.

Thus by the LOS criterion alone, only one of the UCR recommended proposals are based on the traffic volumes.

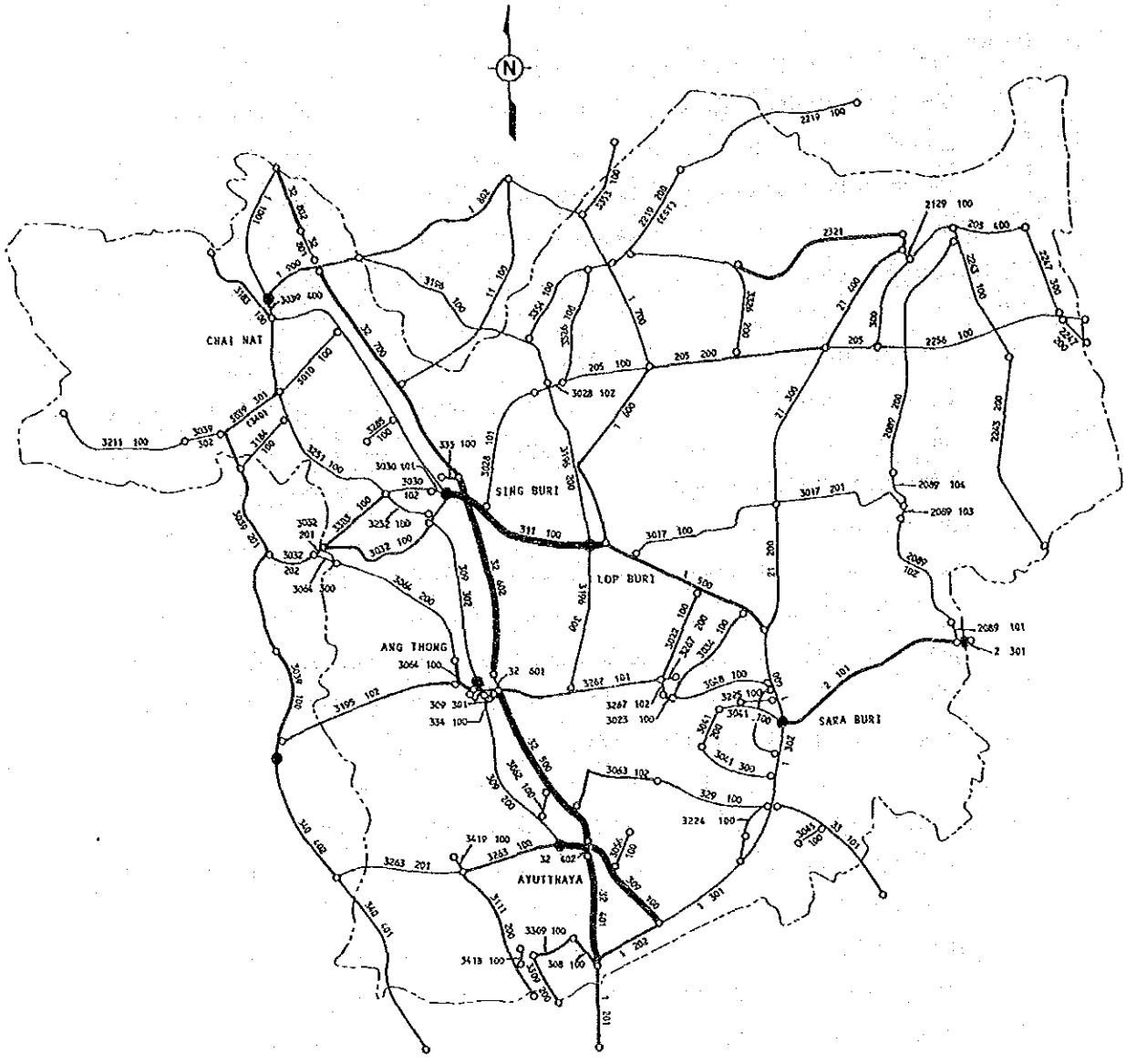
The obvious question at this point is what will be the traffic volumes on the road in the future. Especially by the target year 2010. Although the theory exists for reasonably sophisticated prediction of traffic volumes in an urban setting for daily commuters and the like, the theoretical basis for intercity traffic prediction is much weaker. There is also a considerable need for accurate and verifiable data in any such analysis.

Studies in the past such as a study on highway improvements for the Central Region have indeed attempted such modelling efforts, but due to the lack of theory and data, results have been somewhat questionable. For example, in the previously mentioned JICA study, the only disaggregated independent variable used for trip generation was the number of registered vehicles in a zone. Although the model was able to make predictions for a future date, the ability of the model to predict present flows (or the model calibration) was not strong, especially when a link by link comparison needs to be made between predicted flows and existing traffic counts.

For the reasons of lack of data, lack of theory, and lack of resources, a traditional demand analysis by the four-step traffic modeling process was not attempted in the UCR study. What has been done is to calculate the level-of-service on links based on existing traffic counts. These level-of-service figures were then combined with road condition information and JICA 2006 predictions to derive numbers showing a poor level-of-service or "circuity" problems within the UCR. This subject is discussed in more detail later in this section.

In order to make the LOS calculations, the existing DOH inventory for all roads in the UCR was combined with the most recent traffic counts available (1987). The results of the calculatons are shown in Fig. 2.5.

As expected, problems were concentrated along Route 1 south of Bang Pa-in, Route 32 all the way through the UCR, and Route 2 east of Sara Buri. Other significant problem areas were Route 311 between Lop Buri and Sing Buri and Route 1 between Lop Buri and Sara Buri. The link on



LEGEND:

- LOS A
- LOS B
- LOS C
- LOS D
- LOS E OR F

Figure 2.5 Level of Service (LOS) Map

SOURCES : ANNUAL AVERAGE DAILY TRAFFIC COUNTS
PROVINCIAL & NATIONAL HIGHWAYS
DEPARTMENT OF HIGHWAYS, 1987
"ROAD DEVELOPMENT IN THE CENTRAL REGION" -- JICA, 1989

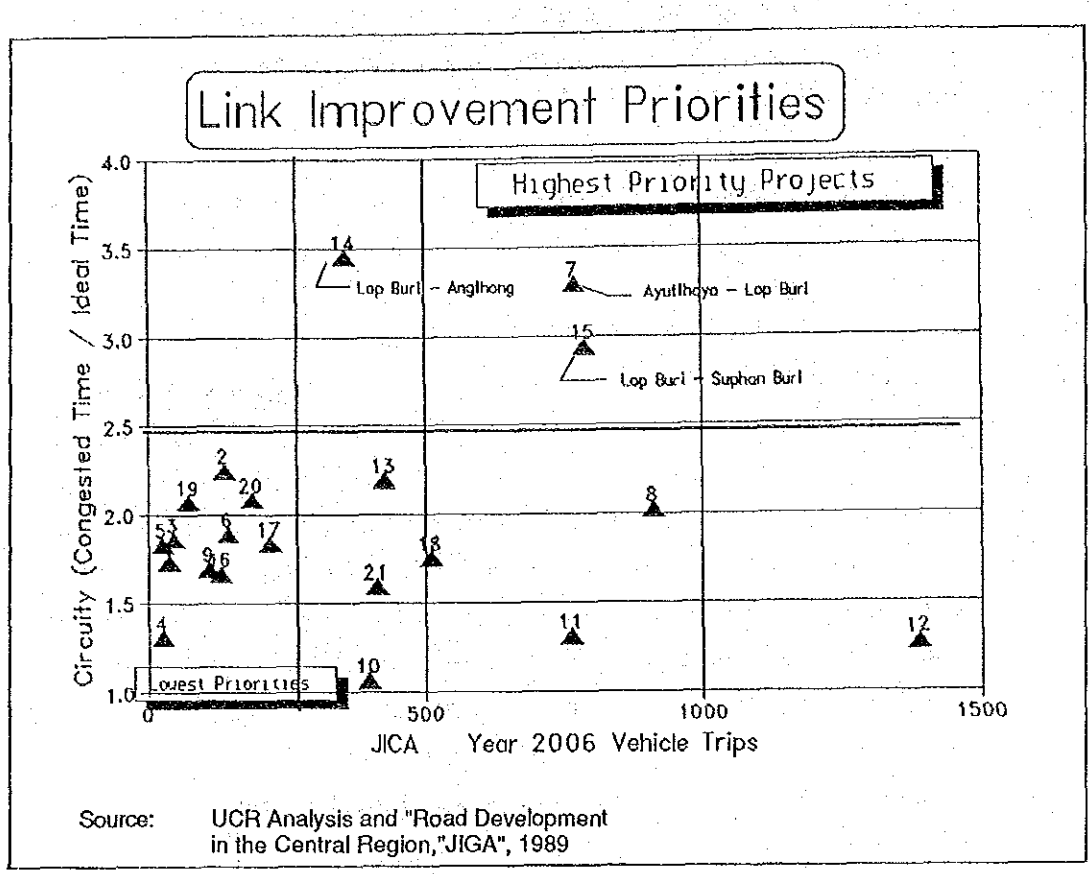
Route 311 was the single most congested link in the network, and remained so even after correcting the data base to reflect recent road improvement.

All of the problems except Route 311 and Route 1 leading to Lop Buri are scheduled for major improvements by the Department of Highways. Route 1 improvements are currently under construction, and planned to be continued all the way to Sara Buri. Route 2 is planned to become four-lane all the way from Sara Buri to Nakhon Ratchasima, and Route 32 is planned to become four-lane from Bang Pa-in to Nakhon Sawan.

After the LOS calculations were made on all arterial and collector roads, the information was combined with DOH road condition evaluations and field studies to calculate congested link travel times which included a factor for road condition. These standardized link travel times were then used to calculate congested travel times for the shortest possible path between all cells of an O-D matrix comprising trips between Ayutthaya, Ang Thong, Sara Buri, Sing Buri, Lop Buri, Suphan Buri, and Chai Nat.

In addition to the standardized travel times between the Changwat centers, a method of comparing these travel times to the shortest possible travel time was needed in order to determine a "need" for further action. This method of comparison was to compare the congested travel time (based at 80 km/hr design speed) with the theoretical shortest possible travel time between Changwat centers based on the same speed along a straight line. Dividing the congested travel time by the theoretical "minimum possible" time gave a number greater than 1.0 that has been coined the "circuity factor."

When this circuity factor was plotted against the number of daily trips in the year 2006 from a previous JICA study for highways in the same region between the same set of O-D pairs, an interesting pattern emerged, as is shown in Fig. 2.6. Although the scale was only a relative one, O-D pairs where the number of daily trips was high and the circuity factor was high were considered as higher priorities for improvement than O-D pairs where the number of daily trips was low and the circuity was low.



Source: UCR Analysis and "Road Development in the Central Region,"JIGA", 1989

Fig. 2.6 Circuity versus Demand Predictions: Priorities for Improvement

Using this new circuity analysis, the most significant problems to emerge were concentrated around Lop Buri, with the problems worst between Lop Buri and Ayutthaya, Lop Buri and Ang Thong, and Lop Buri and Suphan Buri. In every case Route 311 was part of the path.

Thus, the level-of-service problems around Route 1 and Route 311 on both sides of Lop Buri are the basis for a UCR project proposal. The proposal is for a new two-lane high standard arterial (P-1) road between Lop Buri and Ayutthaya which will not only serve the problem zone pairs mentioned, but also as an additional Bangkok radial route. It is believed that this road will not only relieve some of the congestion on the other two links, but also take up some of the future traffic on Route 32. Since Lop Buri is expected by the UCR team to grow rapidly in the next ten to twenty years, the right of way for this road should be wide enough to allow for widening to four lanes in the future.

3) Based on Spatial Considerations

The third method for the determination of new links in the UCR is to apply the "macro-spatial" considerations discussed in the section on land use and human settlements. In essence, this set of normative statements emphasizes the following issues which are relevant to transportation:

(1) Bangkok urbanization tends to expand radially along transport corridors, particularly highways. This tendency should be countered by the creation of a transport network which integrates regional cities in and around the UCR, rather than is simply Bangkok oriented.

(2) Regional growth centers such as Khon Kaen, Nakhon Ratchasima, and the Eastern Seaboard call for interregional connections which are considerably more complex than the historically radial system of the UCR.

(3) Structural changes currently underway in the BMR such as the creation of the new outer ring road and the rail link between Kaeng Khoi and Khlong 19 are intended to divert traffic and activity around and away from the already highly congested Bangkok area. These changes call for complementary adjustments of the road transport network in the UCR to take advantage of the new emphasis on regional cities.

Although considerably less quantitative in nature, this method of identifying network deficiencies is of considerable use in the analysis of transport systems in the UCR. In fact, most of the proposed changes are the result of its application. Although discussed in detail later in the specific project proposals, a set of these normative statements are listed below:

(4) In order to take advantage of its function as "national gateway" and to mitigate the associated problems of traffic congestion and deterioration of the environment in heavily traveled areas, heavily travelled arterials which pass through the region should be improved, strengthened, and made more direct.

(5) Interregional links other than the Bangkok centered ones should be strengthened to aid in the development of regional cities both within and outside of the UCR.

(6) All changwats within the UCR should be connected by reasonably direct links at an appropriate level-of-service.

With these policies in mind, a significant weakness of the road network in the UCR became apparent. Although the north to south links in the network are quite strong, east to west connections through the region in most cases seem almost incidental. It was strongly felt by the UCR team that a more effective Suphan Buri - Ang Thong - Sara Buri - Friendship Highway (Route 2) link should be created. The straightest path connecting all of these points was considered optimal, but a number of on-going and planned development projects for the network and some other observations altered the basic concept somewhat.

The first change in the concept was based on the Sara Buri western bypass of Route 1 which is currently under construction (and negotiation -- see Section 2.3.A. Combined with this is the current level of truck traffic congestion in Sara Buri, which is beginning to rival that of Bangkok. Although much of the traffic is north or southbound and will be routed around Sara Buri by the new bypass, a significant part of it is going to or from Highway 2 headed to the northeast. This traffic will not be affected by the bypass construction.

A second consideration in the proposed route is based on DOH plans for improvements to Route 3267 between Ang Thong and Tha Rua. This straight road is very close to the alignment that was originally considered by the UCR team, and also connects into Tha Rua, which will be an important part of the Greater Sara Buri Industrial Core (GSIC) and also serves the Pasak River inland water route.

The original plans called for a new road between Suphan Buri and Ang Thong which would parallel Route 3195 and connect into the new Ang Thong bypass which is very near completion. This idea was altered when the discovery was made of a new road between Suphan Buri and

Pa Mok, complete with a bridge over the Chao Phraya River which is already under construction (although not observed by the study team).

The combined plans call for a pair of project proposals. The first proposal is for an extension of the Suphan Buri to Pa Mok, to allow the road to cross over Route 32 and join to the new UCR proposed Ayutthaya to Lop Buri highway. This would allow for a pair of east west connections rather than the original concept of a single one.

The first would be from Suphan Buri to the new UCR north to south highway and then south across the Pasak River to Highway 3063 to Ban Phachi which is currently being improved and on to Route 329 which connects to National Highway 33 and eventually to Nakhon Nayok.

The second east route would be to go north to Highway 3267 which is scheduled for improvement and east to Tha Rua. There it would be joined by another new UCR proposed route. This route is to be a P-1 class road connecting from Tha Rua to a grade-separated interchange over Route 1 north of Sara Buri near the point where the new western bypass is scheduled to rejoin the main road. The UCR proposal calls for the western bypass to be rerouted to join the UCR east to west route. The east to west route would then continue eastward from the interchange to swing around Sara Buri and join Route 2 at another interchange east of the existing military base.

This new pair of proposals would not only strengthen the east to west connections through the UCR, it would also serve the western portion of the GSIC and enable through traffic on Route 1 and Route 2 to avoid downtown traffic in Sara Buri. It gains additional significance in light of the believed growth of the inland water transport along the Pasak River based largely on agricultural cargo from the northeast and the proposed inland oil depot west of Sara Buri.

1) Based on a need to serve other UCR project proposals

A fourth criterion for road construction which was not mentioned in the Interim Report is to serve other UCR project proposals. Two of the road projects are based on this criterion.

The first is a proposal for the creation of collector service roads along both sides of the Pasak River. These roads would allow for the development of warehouses and other water related industries. They would also serve the proposed agro-processing center and provide for important links in the area around Nakhon Luang which was one of the local road problem areas. These roads need not be high standard in terms of design speed and limit of access, but do need to be designed for the heavy truck traffic which they will support.

A second proposal is for the creation of direct connection between the UCR and the eastern seaboard to serve the GSIC. The proposed route would follow the existing Rapiphat canal alignment for most of its length. This alignment is potentially advantageous, in that it may be possible to improve the existing RID service roads which are in quite good condition. Since there is apparently very little room for improvement, the route might have to be altered somewhat.

There is also a problem at Nong Khae, where a rather large interchange would be necessary, especially after the ten-lane road is constructed. An intersection of this magnitude would be in serious conflict with the existing land use of the city, and alterations for the route in this area will no doubt be necessary.

2.4 Local Roads

2.4.1 Evaluation Criterion

Local roads were analyzed on a basis of access, rather than on the basis of speed, coverage, design standards, and the like, because of their primary function as conduits between local areas and the arterial and collector network. One obvious way to address the effectiveness of the rural road network is to look at network density in terms of the number of road kilometers per square kilometer in the UCR and then to compare it with other regions of Thailand. This has been done and is shown in Fig. 2.7. A look at this figure will tend to convince the reader that the UCR is relatively well served by rural roads when compared to other areas of Thailand.

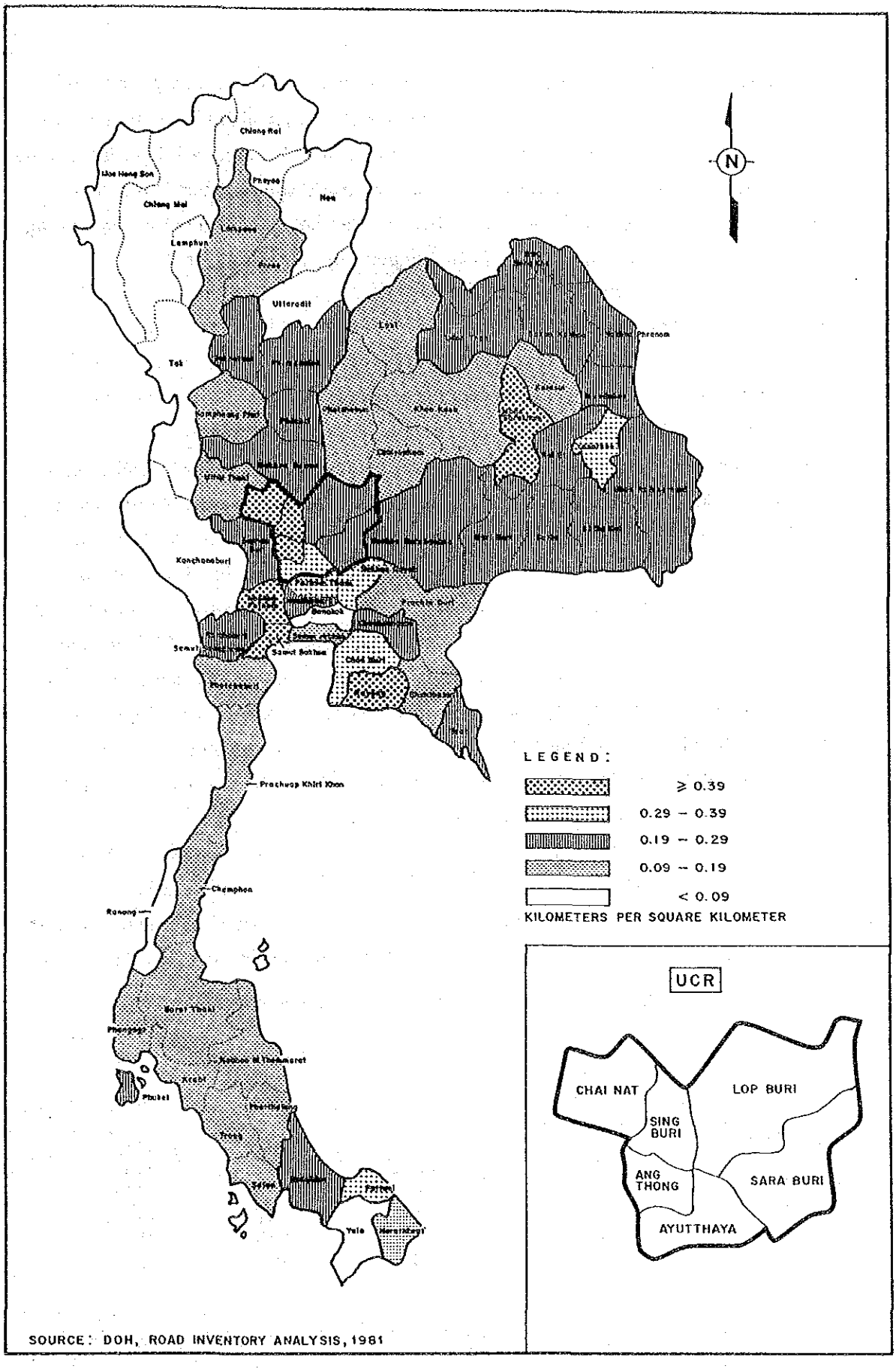


Fig. 2.7 Rural Road Network Density

A limitation of the use of such descriptive statistics is that it really does not directly address the issue of access to land, and the actual sufficiency of the network will depend on such variables as the size of the plots of land owned by individuals, the number of villages in a given area, the number of people living in an area, and so forth. For this reason, another method of evaluating the sufficiency of rural roads has been adopted by the study team.

2.4.2 Problem Identification

1) The NRDCC Provincial Information System Survey

As part of an effort to direct rural development programs where they could be most effective, the National Rural Development Cooperation Center (NRDCC) was established under the supervision of NESDB and charged with the responsibility of the establishment of a system of information management. Under this agency, a survey was conducted in 1986 with assistance from Thammasat University in which muban chiefs were interviewed concerning a large number of subjects. Included in the survey was information on transport for approximately 54,000 villages in Thailand. This is the most comprehensive set of information which is currently available which can be used for the evaluation of local transport throughout the UCR.

Among the many questions on the survey was one which asked, "Is there any through road from the village to the district?" Answers to the question were grouped according to changwat and appear in Table 2.5.

Table 2.5 Answers to the Question : "Is there a road to the district?"

Changwat	No Answer	No	Yes	All
Ang Thong	1	18	409	428
Ayutthaya	4	203	1007	1214
Chai Nat	12	1	398	411
Lop Buri	2	3	969	974
Sara Buri	6	13	839	858
Sing Buri	46	13	227	286

When the information shown in Table 2.5 is segregated by amphoe, the number of villages or mubans can be compared to the total number of villages reporting in the survey to show a percentage of the villages not connected to the district center by road. This has been done and is shown on the map in Fig. 2.8.

When the question was answered about what alternative means of transport was used if roads did not connect the villages with the district, the information as shown in Table 2.6 [1] was given. Table 2.6 indicates that in the villages where no district roads exist, the predominant modes are walking or by boat. If it may be assumed that "walk plus other" may include boat and that "boat plus other" may include walking, then these two modes overpower any other form of alternative transport. Indeed, the way in which the questions were worded, and the correlation between the areas of poor road service and flood prone land lead us to believe that roads are in short supply wherever seasonal flooding and associated rice farming makes land transport more difficult.

It should also be mentioned that in interviews with local officials in Changwat Ayutthaya by the study team, numerous remarks were made about the lack of and poor condition of roads in that province.

Table 2.6 Replies to the Question : "If there is no road, to the district, what mode do you use to travel there?"

District	Walk	Boat	Rail	Other	Walk Plus Other	Boat Plus Other	Rail Plus Other	All
Angthong	0	4	0	14	0	0	1	19
Ayutthaya	42	74	0	76	117	0	2	311
Chai Nat	5	4	2	10	2	1	1	25
Lop Buri	1	0	0	4	1	0	0	6
Sara Buri	3	0	0	19	0	0	0	22
Sing Buri	2	1	0	9	3	0	44	59
All	53	83	2	132	123	1	48	442

[1] It will be apparent that there are more answers to the question of alternate modes than there are negative answers to the question of whether roads exist. since the categories overlap, such as "walk and "walk plus other," this is to be expected.

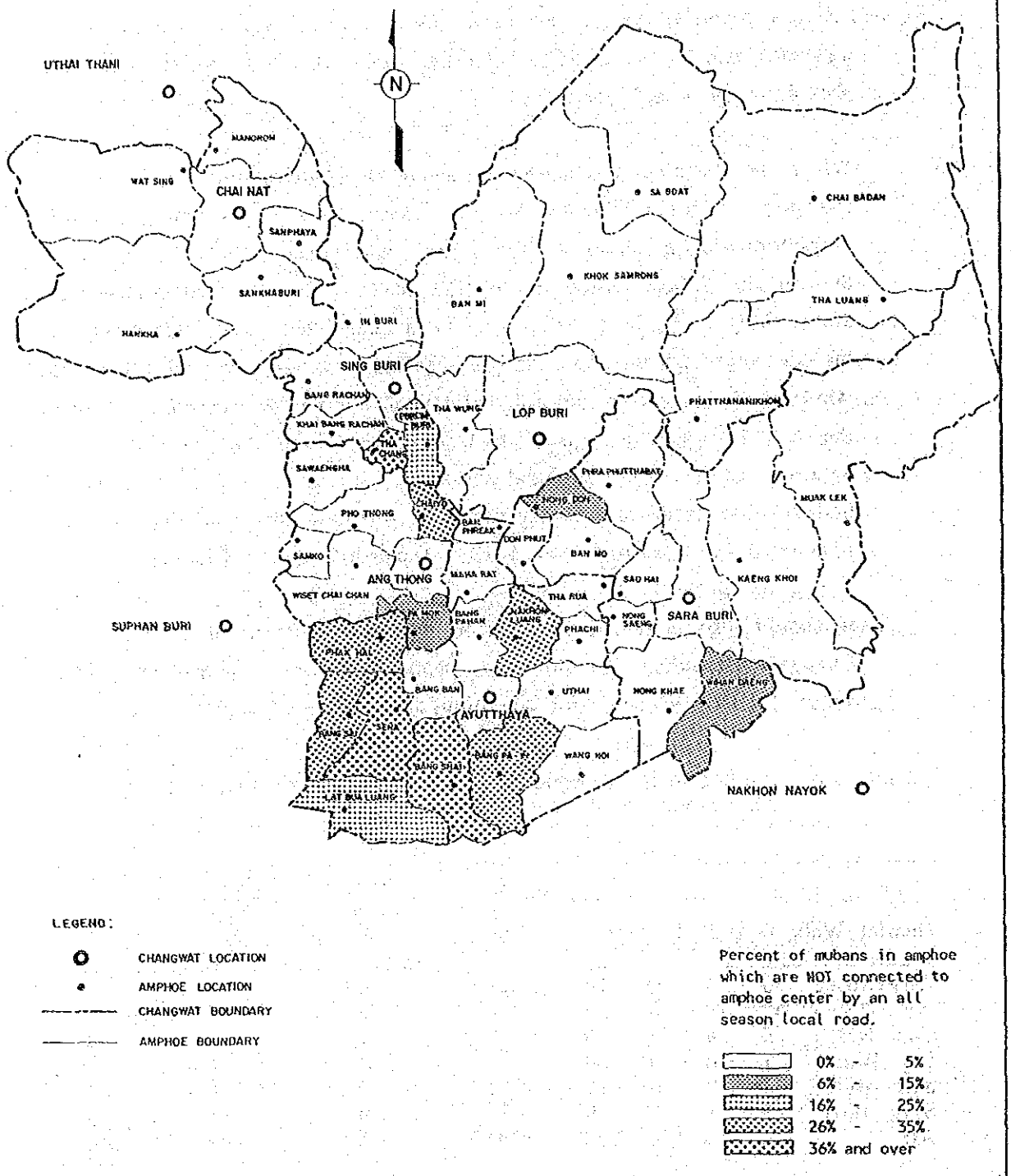


Fig. 2.8 Amphurs not Connected by Roads

2) Ayutthaya Changwat Administrative Office

In order to further confirm the information from the Provincial Information System Survey by the NRDCC, a second set of data was obtained with the help of the Ayutthaya Chamber of Commerce. This data set which was gathered by the Ayutthaya Changwat Administrative Office in 1989 addresses the issue of transport service to numerous tambons or villages. Specifically addressed are whether or not there is service by road, service by bus, and bus service during the rainy season.

When this new information is compared with the 1986 NRDCC data for road service, as is shown in Fig. 2.9, it will be seen that the service by road is indeed limited in numerous amphurs throughout Changwat Ayutthaya. Although the number of mubans without road service in each amphur vary somewhat from the NRDCC study, there is basic agreement with the earlier data. Indeed, as will be noticed in Amphur Bang Shai, the number of mubans which do not have roads may be higher than the previous estimates led us to believe.

2.4.3 Recommended Action

The simple fact that road service is generally poor in parts of Ayutthaya and Ang Thong provinces does not, in the opinion of the study team, constitute a significant problem which requires immediate action by the Thai government. This opinion is based on a recent visit to the areas which were identified as having a "shortage" of rural roads.

1) Social Considerations

A visit by the study team to Amphur Sena, Bang Sai, Bang Shai, Ayutthaya, Bang Ban, and Bang Pa-in in Changwat Ayutthaya revealed a number of interesting features of the local communities that led us to believe that large scale local road construction not only would not benefit local residents, but might in fact act to their disadvantage. Although the field observations were informal and the following discussion thus anecdotal, it is felt that a sufficient amount is known to act as a basis for policy concerning rural roads.

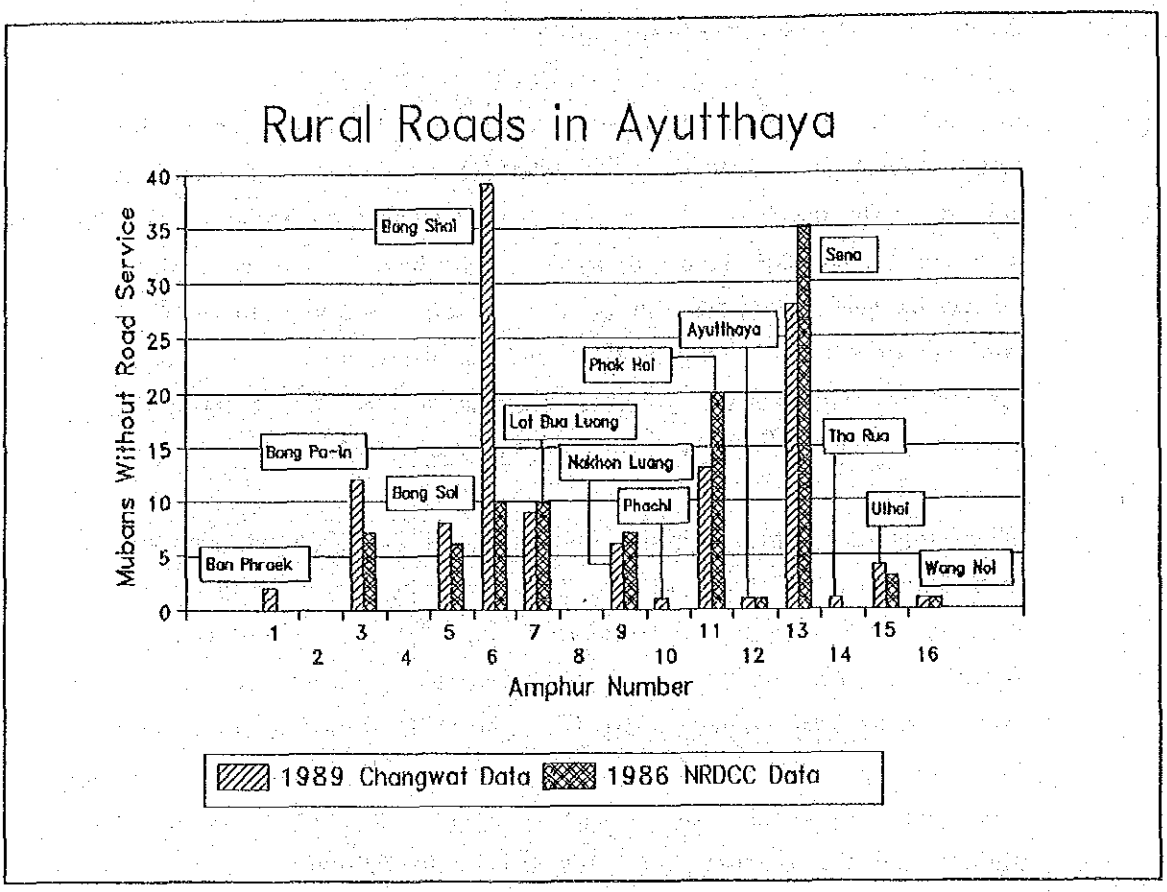


Fig. 2.9 Comparison of NRDCC and Changwat Ayutthaya Data

Amphur Number	Amphur
1	Ban Phraek
2	Bang Ban
3	Bang Pa-in
4	Bang Pahan
5	Bang Sai
6	Bang Shai
7	Lat Bua Luang
8	Maha Rat
9	Nakhon Luang
10	Phachi
11	Phak Hai
12	Phra Nakhon Si Ayutthaya
13	Sena
14	Tha Rua
15	Uthai
16	Wang Noi

It was observed that during the dry season, a large number of people are able to travel by song thao[1] along roads maintained by the Royal Irrigation Department. During the rainy season, even though the buses still run, they are considered less comfortable and people often take one of the rua hang yao or passenger boats which serve as a sort of "water-bus" and are ubiquitous in the area. A number of areas which are not served at all by bus are still served by boat, and apparently with what is considered to be relatively little inconvenience to the user.

The price of a song thao ride in Amphur Sena is four baht; the price the rua hang yao is five baht. The operation of the two is essentially the same: a person who wishes to travel from a village to the amphur center may either walk or ride a bicycle or motorcycle to either the bus stop or a pier at a local wat or other public place and waits for the next vehicle. It is believed that the frequency of the bus may be considerably higher, and thus the wait may be less onerous. As will be discussed in the later section on inter-city buses and rail transit, most trips are discretionary in nature, and punctuality may not be critical at present.

2) Environmental Considerations

As previously mentioned, the area under consideration is basically a flood-prone rice farming region which has clearly been established as ecologically sensitive. With this in mind, any new road construction should considered quite carefully, as it can easily lead to changes in land use, particularly the construction of industries which could quite easily harm the natural environment.

Another environmental concern is the fact that in order to build an all-weather road, particularly in these areas, the road must be constructed on an embankment to raise it above the rainy season flood level. This embankment, in turn causes damming problems that exacerbates the flooding of the region. Therefore, roads through this low-lying region must be considered very carefully to avoid creating more problems than they solve.

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1 "Two seat" local bus

3) The Need for Consultation

A previous study, the Study of Rural Roads [1] recommended the formation of a single entity, the Department of Rural Roads, to coordinate all planning, construction, and maintenance of rural roads in the kingdom. Although it is beyond the scope of this UCR study to address this issue, it is felt that whatever organizational form is used, the key to the success of any agency is the degree to which it communicates with the local administrators and users of the roads. It is the opinion of the study team that the issue of rural road construction and maintenance is basically one which must be solved on a local level, by the people who know the problem best.

An anecdotal example of how the system currently fails to perform is the example of an island in Changwat Ayutthaya just northeast of Amphur Sena which used to be served by a rural road and a bridge to the amphur center. The bridge was destroyed by a storm a few years ago, and the residents have had no luck in having it rebuilt, although we are told they really want it. An effective system of administration must have at least have effective paths of communication from local residents, if not decentralized decision making.

If decisions are to be made or at least influenced by local residents, the question remains about institutional capabilities to foster needed communication between local residents and government agencies with implementation capabilities. At any rate, since this most likely should be done through existing agencies, a list of the various agencies involved in local rural road construction in Thailand and a description of each follows. This list may be useful by pointing out what programs exist, and how they could be used considering the current problems in the Thai economy

- to maximize the share of the UCR in road construction program benefits by satisfying eligibility requirements

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1 Study of Rural Roads; Kingdom of Thailand; Ministry of Communications; Department of Highways; BCEOM, LBII, AEC, and UECC; 1982.

- to have good coordination of the road construction programs with other rural development programs available.

2.4.4 Institutions which Construct Rural Roads

1) Ministry of the Interior

(1) Public Works Department

The Public Works Department (PWD) is a department within the Ministry of the Interior (MOI), which is responsible for the planning and construction of public works, and has the following objectives:

- To relieve the central budget since the Changwat Administration Organizations (CAOs) must support 20% of the budget
- To distribute project implementation with the CAOs
- To achieve a national balance in the construction, rehabilitation, and maintenance of rural roads, national highways, and provincial highways
- For political, economic, and strategic advantages

Three PWD programs for rural road development:

(2) Rural Road Construction Project (RRCP)

Developed to improve accessibility from rural areas in 38 changwats only. The approximate budget is 250-300 million baht per year from the Department of Local Administration (DOLA). Program implementation is carried out by the PWD. The projects are carried out in conjunction with the Changwat Administrative Organizations (CAOs) in the construction of roads which are limited to laterite road construction only.

All six changwats of the UCR are in the area under the jurisdiction of the RRCP, which has been relatively active in the area in part due to the active financial involvement of DOLA. In

order to attract more of the budget for RRCP projects, the UCR needs to increase agricultural production, population density, and resource exploitation.

(3) Public Utilities Project (PUP)

This program started in 1981 to construct roads in rural areas which are more developed than areas eligible for RRCP programs. All changwats in the country are eligible to receive the approximately 600-800 million baht per year which are allocated with 80% to roads and bridges, with 20% reserved for flood control. Constructors are hired for the actual construction, which are generally laterite, but may be bitumen where the traffic is greater than 200 ADT.

The PUP program is important to the UCR, largely due to the size of its budget, and because of the relatively high standard roads and bridges in relatively developed rural areas that it tends to construct. It will become more important for the UCR as the PUP budget increases in the region due to economic development. It could be of special significance in Ayutthaya due to the need for bridges, higher standard roads, and the fact that of all provinces, Ayutthaya seems most likely to have rapid economic growth in the near future.

Both RRCP and the PUP administration need to be coordinated with ARD projects (which are described below) in the UCR, as the overall result will affect economic growth, particularly for the rural poor to share in its benefits. This coordination should not only be limited to requests for funds, but should carry through to construction and maintenance of roads.

(4) Labor Based Construction Project

This program was established in 1984 and is intended for the construction of roads but emphasizes employment creation. The program is designed only for designated "poverty areas" which are in north and northeast Thailand. In the UCR, the only

changwat which is eligible for the program is Chai Nat. The program has an approximate budget of 150 million baht per year, about 60% of which is used to hire local workers who work with relatively primitive equipment in the construction of low standard rural roads under the supervision of PWD engineers.

This program has not been too active in the UCR in the past, and due to its anticipated development, it is expected to be even less active in the future.

2) Office of Accelerated Rural Development (ARD)

(1) History of ARD

The ARD office started operations in 1964, and was officially organized in 1966 under the Office of the Prime Minister. It was later transferred to the Ministry of the Interior in 1972. The primary emphasis of ARD's activities is on infrastructure development such as rural roads and water supply. Until 1977, it offered medical service by mobile units, but transferred this function to the Ministry of Public Health.

ARD started operations in six changwats in the northeastern region, and by 1974 expanded to include 38 changwats considered to be politically sensitive. In 1988, ARD expanded its operations to 57 changwats which were designated as "poverty areas." Between 1975 and 1988, however, the major emphasis remained with the 38 original changwats for which the operation systems of ARD had been well established.

In view of the strong needs for rural road development in the entire country, ARD was authorized to operate in all 72 changwats starting in 1989. Although ARD has been consistently contributing to rural road development, the historical changes in its activities reflect social, political, and financial development in the country. Although ARD may be categorized as a general purpose rural road development agency, its programs have had a

significant effect in the development of special purpose rural road development.

In 1989, ARD is becoming a general purpose rural road development agency for the first time, but its contributions will not be distributed equally over the nation for a while due to its primary emphasis in only 38 changwats.

(2) ARD Operations and the UCR

ARD road construction and maintenance operations are based in the ARD Operation Centers located in:

Changwat	Area of Thailand
Lampang	Northeast
Suphan Buri	West
Hat Yai	South
Prachuap	West
Nakhon Ratchasima	Northeast
Khon Kaen	Northeast

Each ARD operation center is staffed by 600-700 workers and approximately 50 engineers. In the UCR, Chai Nat is covered by the ARD Operation Center in Suphan Buri. The other 5 changwats which are only recently included in the ARD operation coverage in 1989. In the past, only Chai Nat has had a small share in benefits from ARD activities since 1977, mostly due to the fact that it is a relatively poor changwat in the UCR.

(3) ARD Rural Development Achievements

- A total of 27,270 km of roads have been constructed by ARD 19,270 km of roads still maintained by the ARD 3,500 km transferred to the DOH to be upgraded to highway status

- 4,500 km transferred to tambon councils for maintenance (sections of rural roads within tambons and mubans)

- New road construction comprises less than 10% of all ARD road work. Most of the construction is for road improvement, widening, rehabilitation, and so forth.

ARD Budget Allocation

Administration	32%
Water Resource Development	5-25%
Rural Roads Development	43-53%

- In 1988, just over 1,000,000,000 baht was spent for rural roads. In 1989, the large increase of the budget is because operations expanded to all 72 changwats. After 1989, the concept of ARD budget allocation over the 72 changwats is will be:

  Allocation of the maintenance budget in a manner proportional to changwats' ARD road inventory

  Allocation of the road development budget based on terms of population, economic development potential, traffic volume, and so forth. Details not known until the FY 1989 budget is organized. This is a key point in order for the UCR to enjoy the new programs of ARD.

3) Local Governments and Their Subdivisions

Local governments which may be involved in rural local road development are the Changwat Administrative Organizations (CAOs), amphurs, tambons, and mubans. In all cases it is the CAOs which implement programs. Municipalities and sanitary districts are responsible for urban local roads.

A fund from the national budget is allocated to the changwats for the changwat development projects which may include projects such as provision and maintenance of water works, roads, and other small scale public facilities. Each CAO allocates its portion of this fund over different projects in the Changwat Development Committee which is

chaired by the Governor[1]. There appear to be few engineers or specialists with the proper background to carry out these works, so engineers dispatched to the changwat from the PWD work as advisors to changwat officers. Amphurs, tambons, and mubans participate in the planning stage by offering information or requests. Amphur governments implement some of these projects at the construction stage.

The CAOs and the subsidiary governments are also charged with maintaining rural roads which were developed by other rural road development agencies but turned over to them. For example, a CAO may have to maintain rural roads constructed by the PWD; a tambon may maintain some of the roads constructed by the ARD. In all, a total of 4,500 km of the roads developed by ARD between 1964 and 1988 have been transferred to various tambons nationwide.

The CAO subsidiary governments participate in the planning of the rural development programs implemented by the other rural road development agencies by making proposals and supplying information. Among the programs are the ones implemented by PWD, ARD, and the Royal Irrigation Department (RID).

4) Department of Highways (DOH)

The main responsibility of the DOH is the construction and maintenance of national and provincial highways, which are not defined as rural roads, as discussed earlier in this report. DOH involvement in rural road development takes place through what is called "minimum maintenance" roads.

Some of the rural local roads developed by the rural road development agencies listed in this report are transferred to DOH. They are the roads with a significantly large traffic volume which are considered to be necessary to be upgraded to national or provincial highway standards and maintained by DOH. For example, ARD has transferred a total of

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1 In FY 1980, 900 million baht was allocated to all the changwats in the nation, about 10% of which seemed to be spent for rural roads.

3,500 km of roads which it originally constructed between 1964 and 1988.

When DOH takes over these important roads, it cannot upgrade all of them to its standards promptly due to budget and other constraints such as right-of-way width. In fact, due to the problems associated with the width of the right-of-way, DOH is now refusing to accept ARD roads unless the more stringent DOH standards are met. In the past, it has accepted the roads anyway, and has had serious legal and construction problems as a result.

Roads transferred to DOH but awaiting upgrading are called "minimum maintenance" roads, and DOH is responsible for their maintenance. DOH receives approximately 25% of normal maintenance expenditures as a part of their budget. The Provincial Construction Division of the Operations Branch of DOH carries out the maintenance work of these roads in place of the Maintenance Division, which is responsible for all other DOH highways.

5) Special Categories

(1) Royal Irrigation Department (RID)

Since 1955, RID has had the policy that all canal construction should be associated with road construction alongside. There are exceptions which have been observed, such as cases in which new canal construction is along existing roads. Based on this policy, rural road construction is carried out three sections within the RID:

Large Scale Irrigation Construction Subdivision of the Large Scale Construction Division

- Construction of rural roads along the canals to be constructed as a part of large scale irrigation projects.

Medium Scale Irrigation Construction Subdivision of the Medium Scale Construction Division

- Construction of rural roads along the canals to be constructed as a part of medium scale irrigation projects.

Roadway Construction Subdivision of the Medium Scale Construction Division

- Construction of roads only along existing canals which are without parallel roads. Often, these are the canals which were constructed prior to 1954.

It should be remembered that RID road construction is based on needs of irrigation systems, and not on the needs for local roads. Nevertheless, it's 5-year master plan indicates that the budget for the system as a whole is to increase at a rate of 7 to 10% per year. The UCR is likely to receive more benefit from RID road construction only as new canals are built in the region.

(2) Agricultural Land Reform Office (ALRO)

ALRO was established in 1977 to administer land reform according to the Agricultural Land Reform Act of 2518 B.E.[1] It makes improvements in connection with its reform activities including the procurement of housing for small and landless farmers as well as the creation of agricultural institutions to rent, lease-purchase, or cultivate land. The agency assists in agricultural land occupation and the development and improvement of resources, inputs, production, and marketing.

ALRO can use three programs through which rural roads are developed as a part of its land reform programs. These are the Basic Infrastructure Development (BID) program established in 1983, the Rural Infrastructure Development (RID) program established in 1984, and the Land Consolidation Works (LCW) established in 1981.

RID and LCW are package programs designed to develop a set of public facilities including local rural roads. RID is a program to

1 1975 A.D.

develop individual facilities in land reform areas. Major components of RID are schools, health clinics, and small water wells. LCW is often applied to construct irrigation ditches and rural roads.

More significant rural road development takes place under BID. Three types of roads developed by BID are main roads (6 m wide), secondary roads (4 m wide), and service roads. Only 1.9% of all main roads and 5.7% of secondary roads are located in the UCR.

Projects under these programs are proposed by the Provincial Land Reform Office (PLRO), sometimes on the request of villages within land reform areas. There are 34 PLROs in Thailand including areas in Chai Nat, Lop Buri, Sara Buri, and Ayutthaya. The implementation of land reform programs themselves is based on the national master plan which itself is based on the needs of land reform.

To date, the UCR has not benefitted much from these programs. However, significant land reform programs for the UCR are included in the master plan awaiting implementation. To this extent, ALRO rural road construction is expected to increase in the UCR.

(3) Community Development Department (CDD)[1]

The CDD is the government's most direct and widespread link with the rural population. It operates with the executive part of government at the national, changwat, and amphur levels where it is part of the local administration. It is also part of the more democratic local government at the tambon and village levels, where it participates as secretary of the tambon and village planning objective is to change in both the physical conditions and the customary practices in the rural communities in order to increase the general well-being. It sees itself as a catalyst for self-induced change in rural areas, where it provides a minimum of physical resources, concentrating on training, technical

1 From DOH: Study on Rural Roads: Institutional Analysis, 1981, 99. 57-60.

assistance, and guidance in selecting the most desirable and feasible avenues for change. It can furnish limited resources, usually as an addition to internally generated resources of money, time, and local materials.

Its role in road building and maintenance il limited to helping villagers build relatively small, low quality roads, including many of the so-called tambon roads. However, it has a more direct role in administering a large part of the New Village Development Program (NVDP), where a more planned road-building effort replaces the usual ad hoc construction projects. After the changwats and amphurs in which the program will work are selected on a national level, the CDD selects the villages for program implementation.

(4) National Security Command (NSC)[1]

The National Security Command, which was established in 1962, operates two agencies that build roads, its Engineering Division, and the Mobile Development Units.

- Engineering Division
  The Engineering Division builds roads normally in sensitive areas, although it may build roads for civil purposes. As of 1981, it has built 2181 km of rural roads, most of which were turned over to DOH or the changwats for maintenance.

- Mobile Development Units
  These units are designed to project a positive governmental presence in remote and isolated villages that are susceptible to communist guerilla attack or influence. Consisting of both military and civilian personnel, their firs priority is to provide a road link between the village and the road network.

1 From DOH: Study on Rural Roads: Institutional Analysis, 1981, 99. 60-66.

Twenty eight MDUs operate in 29 changwats and are grouped into five regions:

North	7 changwats
Upper Northeast	6 changwats
Lower Northeast	4 changwats
Center	5 changwats
South	7 changwats

(5) Self Help Land Settlement Division (SHLSD)

This agency is part of the PWD, and is the oldest of the land settlement agencies, as it was established in 1941. There are 51 settlements in 38 changwats across the country that are operating under this agency's program. Road building has been a major contribution of the SHLSD, and as of 1980, nearly 10,000 km of soil and soil aggregate roads have been constructed through its operations.

These roads do not take the geographic shape of typical villages, as they are evenly spaced in a grid form, usually a kilometer apart over a relatively large area. The total number of kilometers is larger than a normal village would be expected to maintain. This is exacerbated by the fact that funds for road maintenance are about one-tenth the amount deemed necessary. It is expected that local cooperatives will assume the responsibility for maintenance.

3. RAILWAYS

3.1 Overview

All intercity trains in the country are operated by the State Railways of Thailand (SRT) which is a wholly government owned enterprise. It came into being as a government department in 1890, but was made an autonomous organization in 1951. The first line from Bangkok to Nakhon Ratchasima was opened in 1900.

Railway lines all radiate from Bangkok; the ones which pass through the UCR are shown in Fig. 3.1. The trunk lines consist of the Northern Line to Chiang Mai (751 km), the Northeastern Line to Nong Khai near the border with Laos (624 km) and to Ubon Ratchathani near the Cambodian border (575 km), the Eastern Line to Aranyapathet near Cambodia (255 km), and the Southern Line to Sungai Kolok with connections to the Malaysian Railway (1,159 km). The total route length in service is 3,735 km with a new railway from Chachoengsao to Sattahip on which construction began in 1987. The number of stations in 1984 was 445 and the number of stopping places was 150.

The density of railway routes is 7.3 line-km per every 1,000 km2 at present. being far below that of highway density, which is 93.4 km per 1,000 km2. Railways pass through only 41 of the 73 changwats in Thailand.

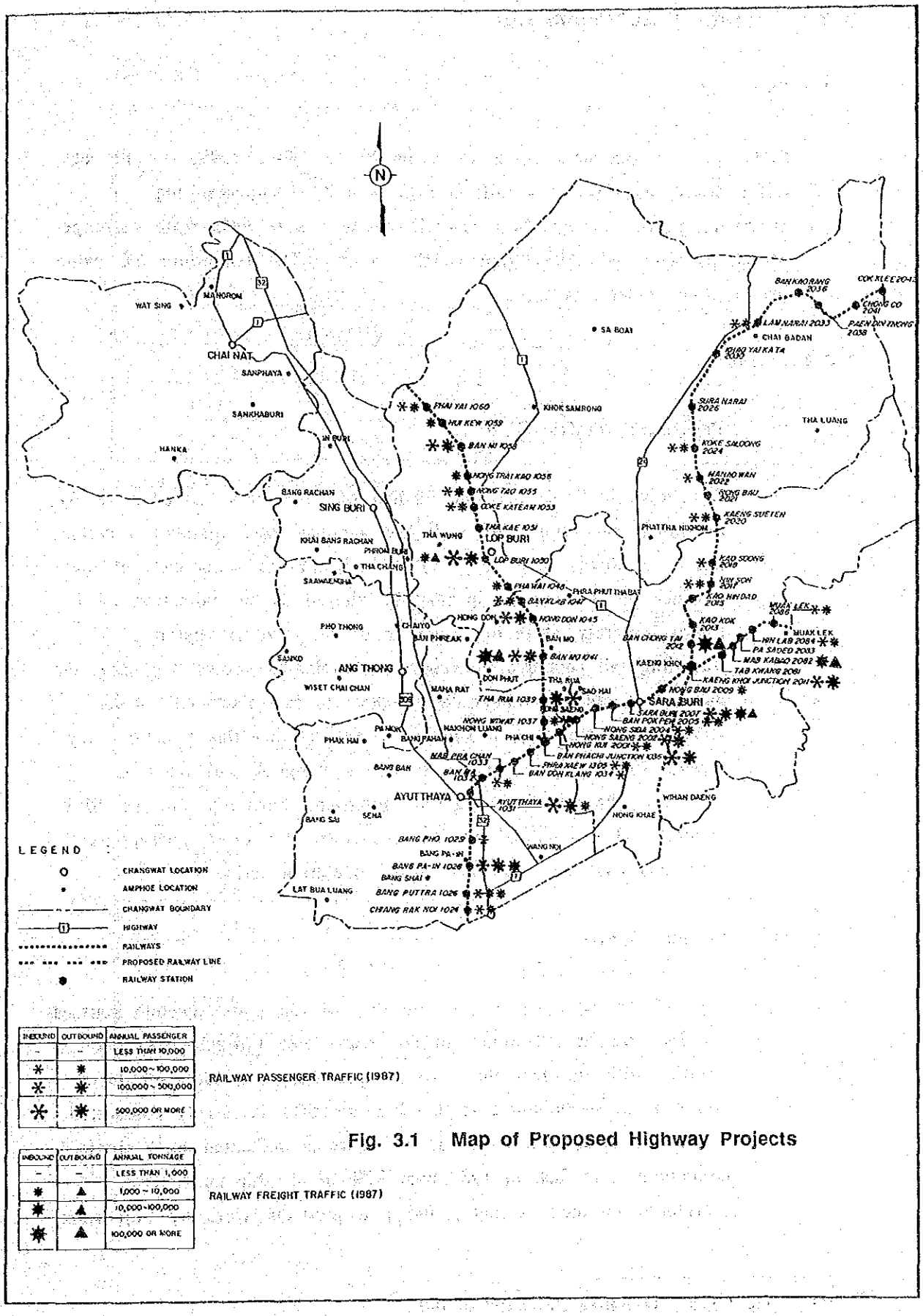

Fig. 3.1 Map of Proposed Highway Projects

3.2 Operating Achievements

3.2.1 Financial

SRT has been operating continuously in the red since 1979, and the net rail operating loss was 569 million baht in 1987. The resulting operating ratio[1] was 117.84. Overall revenues were 64% from passenger operations with only 30% from freight traffic. The remaining 6% came from other revenue sources.

3.2.2 Traffic

1) Passenger Traffic

As shown in Table 3.1, the number of passengers has been slowly declining over time, although the average total distance traveled has been slowly increasing. This indication of a increase of the distance per passenger trip may be viewed as an indication of a rather severely shrinking number of very short distance travelling rail commuters. Indeed as Table 3.2 shows, by 1987, the number of rail commuters had dropped to less than half of its 1982 level. However, it should be realized that this situation may change for the better in the future as Bangkok rail lines are improved through the numerous programs currently on the SRT agenda. The potential revenue generated by these passengers may also ease the problems of the operating ratio.

2) Freight Traffic

Fig. 3.2 below shows the relationship of the main revenue sources for SRT freight operations for the years 1985 through 1987. In parallel with the fact that two commodities, petroleum products and cement, so dominate is the fact that SRT is largely committed to shipments by unit train, or entire trains dedicated to a single commodity. In fact, in 1987 over 99% of all shipments of petroleum products, cement, and rice products were by unit train.

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1 (Operating Costs / Operating Revenues) x 100

Table 3.1 Trends in Passenger Transport

Year	Passengers (thous)	Passenger-km (million)	Average Trip Length (km)
1982	80,306	9,231	114.9
1983	81,404	9,699	119.1
1984	81,498	9,643	118.3
1985	78,013	9,140	117.2
1986	76,702	9,274	120.9
1987	77,931	9,583	123.0

Source : SRT Information Booklets

Table 3.2 Passenger Traffic by Category

Fiscal Year	One-way (thousand)	Round-trip (thousand)	Commuter (thousand)
1982	60,629	8,811	10,866
1983	62,844	8,143	10,417
1984	66,293	7,976	7,229
1985	64,992	6,737	6,284
1986	65,309	5,877	5,516
1987	67,305	5,170	5,386

Source : SRT Information Booklets

This is important in that it indicates that a fairly high level of efficiency has been attained by SRT in its freight operations.

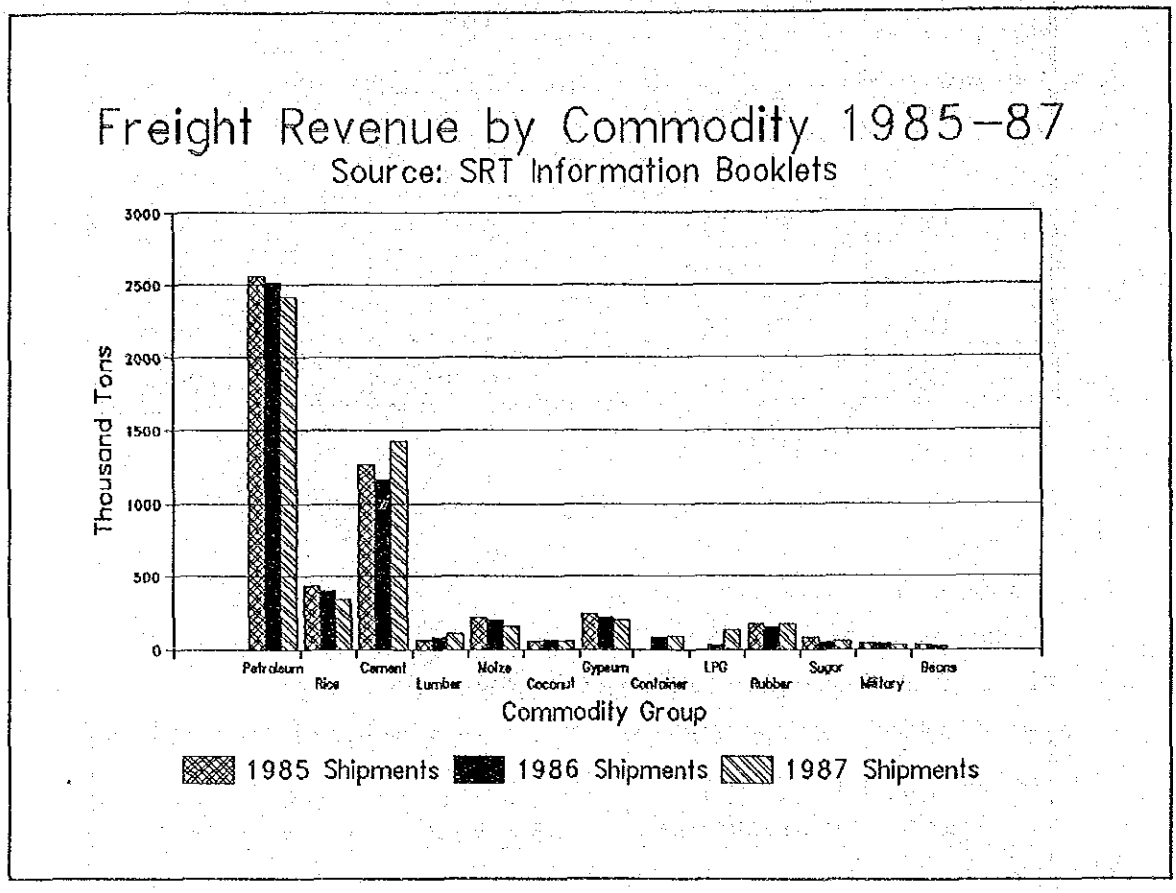

Fig. 3.2 Rail Commodity Shipments

As Table 3.3 shows, almost all freight traffic that is carried by SRT is full carload (FCL) with less than one percent carried by less than carload (LCL). Overall, freight tonnage carried by rail has remained fairly constant over the six year period.

Table 3.3 Tonnage Transported

Fiscal Year	FCL Freight		LCL Freight		Total
	(tons)	(percent)	(tons)	(percent)	
1982	5,518	101.7%	96	1.7%	5,614
1983	5,177	101.6%	82	1.6%	5,259
1984	5,506	101.2%	67	1.2%	5,573
1985	5,616	100.6%	32	0.6%	5,648
1986	5,265	100.4%	23	0.4%	5,288
1987	5,570	100.4%	20	0.4%	5,590

Source : SRT Information Booklets

3.3 Rail Operations

Passenger trains are grouped into three separate categories based on distance of travel:

Express or Rapid	Long distance trains
Ordinary	Medium to long distance trains
Commuter	hort distance trains

Freight trains are grouped into operational categories based on operating characteristics:

Conventional	Mixed cars carrying varying cargo
Unit trains	Train dedicated to one commodity

For an understanding of the existing operational bottlenecks, refer to Fig. 3.3 which shows the existing operational bottlenecks in the rail network operated by SRT.

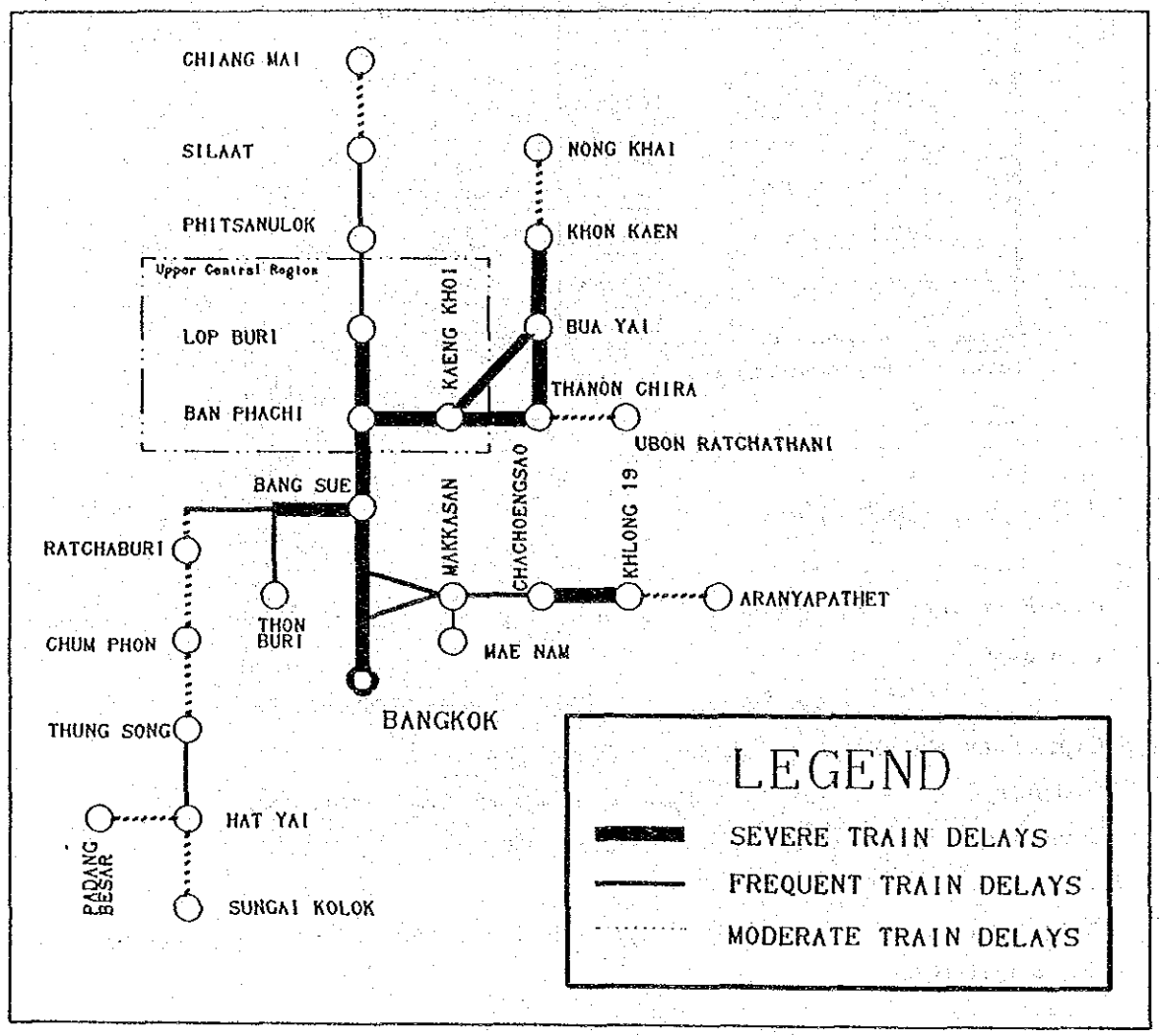

Fig. 3.3 Rail Transport Operation Bottlenecks

3.3.1 The Northern Line

The link between Silaat and Chiang Mai is currently limited by sections with severe gradient and curvature restrictions. Although some curvature improvement projects are under way, more are necessary. Other problems are evident in the existing signalling blocks which are too long and of a low grade. This set of operating limitations results in train delays that are difficult to recover from.

Problems exist in the UCR as well between Ban Phachi and Lop Buri because of the single tracking north of Ban Phachi. From Bangkok to Bang Sue, at grade crossings greatly hinder operations. The result of these problems is numerous delays for passenger trains, especially on long distance service. Freight operations are also hindered by yard operations.

3.3.2 The Northeastern Line

This line is plagued with gradient and curvature problems between Kaeng Khoi and Pak Chong which causes both low hauling capacity and line capacity problems. Between Bua Yai and Nong Khae, there are also problems of curvature, and excessively long blocks of low grade. Between Ban Phachi and Kaeng Khoi are additional line capacity problems. In short, the Northeastern line suffers from the same problems on long distance passenger trains and with freight trains, and for the same problems.

3.3.3 Rail Transport in the Upper Central Region

In 1987, there were just under 6.5 million passenger trips by rail which originated in the UCR. This number represents approximately 8.3% of the total passenger trips of the national total of all rail operations. Table 3.4 below is based on answers to a questionnaire sent to the SRT by the UCR team. It shows the number of trains per day operating on each line in the country along with the total number of passengers either boarding or alighting in UCR stations during 1989. Numbers are calculated for the number of UCR based passengers on trains either bound to or coming from Bangkok. As the numbers show, the average inbound train on the trunk line south of Ban Phachi junction carries 467 UCR based passengers, while the average outbound train carries 478. This clearly shows that the demand for passenger service in the UCR is quite high,

Table 3.4 Passenger Rail Use in the UCR

Lines	Northern	North Eastern	Eastern	North Northeast	Below Phachi
Outbnd Pax	2,171,478	50,833	272,740	1,607,256	2,356,974
Inbnd Pax	2,066,843	57,595	222,076	1,528,004	2,427,591
Trains/Day	13	12	12	24	37
Trains/Year	4,745	4,380	4,380	8,760	13,505
InBnd Px/T	436	13	51	174	467
OutBnd Px/T	458	12	62	183	478

Source : SRT 1989 Passenger Counts and Answers to UCR Survey

in spite of the numerous operational problems that the SRT is currently experiencing.

The major rail stations in the UCR, or stations more than 2,700 passengers per day are Ayutthaya, Ban Phachi, Tha Rua, Lop Buri, and Kaeng Khoi. Stations with between 500 and 2,700 passengers per day are: Bang Pa-in, Ban Mo, Nong Don, Ban Mi, Nong Saeng, and Sara Buri. All were shown in Fig. 3.1.

Much of the passenger traffic is to and from the BMR, and many of the through passengers transfer between lines at Ban Phachi junction. Traffic to and from the UCR, like the rest of the nation is gradually decreasing, with the primary causes being train delays and competition with intercity bus.

UCR rail freight shipments are almost exclusively by unit train with the *following corridors predominating:*

From	To	Product
Ban Mo	Bang Sue	Cement
Taphan Hin	Ban Mo	Gypsum
Ban Chong Tai	Bang Sue	Cement
Mae Nam	Ban Chong Tai	Bunker Oil
Mab Ka Bao	Bang Sue	Cement

Ban Mo and Ban Chong Tai in the UCR are two of the larger freight stations in the nation.

3.4 Competition

3.4.1 Competition for Capital Investment

Like all other agencies in the government, the SRT must compete on the most basic level with other agencies for funds. This is particularly a problem when it comes to the issue of competing with the Department of Highways. Due to political and other reasons, it is felt by many SRT officials that the railroads do not receive sufficient funding. A look at the number of construction projects involving road combined with the lack of investment in rail tends to convince the study team that there may be a rather strong bias in favor of investment in roads.

3.4.2 Highways

Not only does the SRT have to compete within the government for funding, it has to compete with trucking and bus companies for both passengers and cargo. Since highway and road costs are paid for by the government, the truck and bus companies in effect enjoy a subsidy which the railroad does not enjoy. Not only due to operating problems, but largely since the road network is so much more extensive, SRT is at a considerable disadvantage in the UCR in serving passengers and the freight which tends to be largely agricultural, and thus scattered at a low density over a large area.

3.4.3 Inland Waterways

Railroads at present not only compete with highways for the more moveable and higher value freight, but they must also compete with inland water transport for the bulkier low value cargo which they might be able to carry otherwise. Inland water transport has the advantage that it is cheaper than rail, but since it is quite slow, it cannot compete with rail for higher value freight or for passenger service. Inland water also suffers from a much less extensive network than rail.

3.5 Existing Problems of Rail Transport

3.5.1 Fares

One possible solution to the dilemma of low revenue by SRT would be to increase fares, as is usually done in a market where the demand is high. Although passenger trains tend to operate at or near capacity, fares cannot be raised by the SRT without a recommendation from the Minister of Communication and confirmation by the cabinet. For obvious political reasons, this is quite difficult, even if it should be done.

In the past, SRT has offered special service such as first class, air-conditioned cars, and so forth to try to capture a more affluent passenger market and an alternative method of increasing fares. However, faster trains arriving on schedule are really the service improvements that are needed to attract the wealthier and more time sensitive traveller.

3.5.2 Schedule Adherence Problems

Nationally, the SRT achieved a 43% on time performance of its trains in 1989. For the northern and northeastern lines which pass through the UCR, the performance was slightly lower at 39%. These schedule adherence problems are largely the result of single tracking for passing trains, poor signalling, long operating blocks, and conservative operating practices. In order to improve the level-of-service for passenger transport, a number of projects are on going, are approved for execution, or are proposed.

3.6 Improvement of Rail Transport

3.6.1 Approved Projects

1) Signalling improvements are currently under way within the UCR which should improve on time performance in the very near future.

2) Construction of a new line between Khlong 19 and Kaeng Khoi should increase freight traffic to and from the UCR to the ESB. This line may be used to the advantage of the GSIC. Much of its advantage may lie in the

fact that it frees the existing track below Kaeng Khoi to some extent to allow for more passenger trains to be run to Bangkok.

3) Double tracking on southern line is scheduled in the near future, but will not effect the UCR.

3.6.2 Planned Projects

1) Elevation of rail tracks in Bangkok may help somewhat to ease the extremely conservative operating practices of trains passing through Bangkok.

2) Double tracking between Ban Phachi and Nakhon Sawan could greatly improve northern line operations, and is highly recommended by the study team.

3) Double tracking between Ban Phachi and Kaeng Khoi is also proposed, and will take on special urgency with the construction of the proposed Sara Buri oil pipeline terminal. Although SRT will lose much of the petroleum unit train operation it currently enjoys from Bangkok, it will likely continue to serve from Sara Buri and beyond if the terminal is built there. In fact double tracking not only to Kaeng Khoi, but on to Nakhon Ratchasima is encouraged by the study team.

3.6.3 Ideas

1) In order to change the passenger fares that SRT currently charges, special consideration should be given to encourage the more affluent rider. In order to help develop a "rail habit" and for short term gains, a weekend tourist train between Bangkok and Ayutthaya or possibly on to Lop Buri like the current train from Hua Lum Phong to Kanchanaburi could be run.

2) Integration with Sky Train at least at the station level will be a necessity in the future, and is a must if SRT is to be able to capture a future BMR northern daily commuter market.

4. INLAND WATERWAYS

4.1 Overview

In the "Study for the Improvement of Inland Waterways" conducted for the Harbour Department in 1988[1] the statement was made that "the Thai waterways system should be considered as an integrated transport system". It is agreed that this is certainly the case. Even though it is far beyond the scope of the UCR study to examine any of the various transport networks or modes as integrated systems, in the numerous trips by the study team to the UCR a number of observations were made of inland water transport which reflect on the results of the study by the Harbour Department.

Transport by inland waterways in the Upper Central Region is an important part of the total amount of goods flowing within and through the region and provides a means of support for many of its residents. It is especially important for the transport of bulky and low unit value agricultural products which are not easily damaged and for which time of transport is not such an important issue. Moreover, inland water transport it critical as it is the preferred means of transport for these bulky products which are primarily bound for export.

In numerous areas in the UCR, inland water transport has been plagued with water depth problems, which are usually blamed on upstream dams controlled by either RID or the Electricity Generation Authority of Thailand (EGAT) and their conflicts of interest with the Harbour Department. The logic of the explanation says that the Harbour Department wants to increase the water released by the dams in order to supply the rivers with water for transport. RID and EGAT, on the other hand, want to retain sufficient water for electricity generation and irrigation. It is the opinion of the study team that the conflict

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1 "Study for the Improvement of Inland Waterways" -- Final Report; Kingdom of Thailand, Ministry of Communications, Harbour Department; May 1988. Study conducted by BCEOM, DECONS, DEC, and CNR consultants.

of interest may be overstated. Many areas visited had little or no depth problems during the field observations in both the rainy and dry season, while others had severe limitations during both. In the Chao Phraya River north of Ayutthaya, where the bureaucratic conflict is usually blamed for navigation problems, it is difficult to believe that any amount of water released by RID would be sufficient for sustainable transport. Explanations follow.

4.2 Problems

One of the most significant findings from field observations is that the problems associated with inland water transport were limited to the upstream reaches of the various rivers. Problems on the Chao Phraya generally began between Ayutthaya and Ang Thong, problems on the Noi River began upstream from about Sena, and problems on the Pasak River began upstream from Tha Rua. The Lop Buri River is generally not navigable by the lighters currently in use in river transport.

4.2.1 Water Depth

On a field trip to survey the conditions of inland water transport in the UCR during the rainy season in early September of 1989[1] , one of the most obvious problems to large scale shipping is the problem of an insufficient depth of the water. Even the smaller wooden barges were seen stuck in the middle of the Noi River, barges were seen stuck in locks on the Noi River just north of Ayutthaya, and numerous barges and boats were observed waiting for high tide to pass at the locks at the Chao Chet canal west of Ayutthaya.

Also observed was the fact that even during the rainy season, the water in the Chao Phraya river between Sing Buri and Chai Nat is not deep enough for loaded barges to pass, as they require water depths in excess of 3.5 meters. In fact, even the boat owned by RID with a draft of about 2.5 meters hit bottom in the Chao Phraya numerous times in spite of careful navigation by the boat captain.

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1 It should be mentioned that the rainy season of 1989 was a part what has so far been a three year drought in Thailand, so that even the rainy season was quite dry by Thai standards.

4.2.2 Meandering and Bank Erosion

Also observed in the Chao Phraya River between Sing Buri and Chai Nat was the problem of bank erosion. The problem in essence is that the river from bank to bank is extremely wide considering the volume of water in the river, and the depth is correspondingly shallow. This is apparently connected with the problem of the river meandering, as numerous inlets which appeared to be old branches were observed. On the Chao Phraya south of Ang Thong and on the Noi and Pasak Rivers, this did not appear to be a problem.

The problem of bank erosion is a significant problem in the Chao Phraya, as the wide banks create a very large cross sectional area of the river. It has often been stated that the Chao Phraya could be used regularly as a navigable river if the dam controlled by RID at Chai Nat would only release enough water to the river. A look at the existing banks and at the water depth, would leave one to wonder if any enough water for a sustainable transport corridor is even possible.

4.2.3 Dredging

Sand dredging from the river is done primarily for the purpose of obtaining sand for sale for the construction trade, rather than for the maintenance of the channel. It is thus not so tightly controlled, and can be quite detrimental to navigation in the river, as it is closely related to the problem of bank erosion. This dredging was observed being done both by companies with large "basket dredgers" and large steel barges near Ayutthaya and even by one industrious individual with a bucket and a wooden barge in the Noi River.

Although beneficial when conducted by the Harbour Department to increase water depth, unrestricted sand dredging has caused severe bank erosion in some sections such as one area observed in the Noi River near Bang Shai. This bank erosion and the resulting widening of the river causes a reduction in the flow rate allowing sand and silt to settle out, thus increasing the number of sand bars in the section. Although the process is potentially beneficial to the dredging companies, the effect can be devastating on water transport through the rivers. For this reason, private dredging has been prohibited in numerous areas in the Chao Phraya River, especially upstream from Ayutthaya.

4.2.4 Lock Width and Depth

The width of locks is a restriction on travel in some locations. For example the locks seen on the Noi River and its canals as well as the lock on the Pasak River at Rama VI dam were six meters wide, making them too narrow for the 7.2 to 9.1 meter wide steel barges which are used in the unregulated portions of the Chao Phraya and Pasak Rivers. Depth was also a problem in that barges were often observed stuck inside the locks themselves or as in the case of the Chao Chet lock, waiting on high tide to go through.

4.3 Overall Summary of Problems

4.3.1 To Bangkok from Northern Thailand

To travel by river from Nakhon Sawan to the Gulf of Thailand, one must take one of two primary routes: either the Tha Chin River route, or the Chao Phraya River route. If the Tha Chin route is selected, the traveller will travel entirely outside the boundary of the UCR, so it is not addressed here. If the Chao Phraya route is selected, a choice of three routes is still possible: the Noi River on the west side which branches away from the Chao Phraya north of Chai Nat and rejoins it south of Ayutthaya, the Chao Phraya itself, and the Lop Buri river on the east which branches from the main stream between Sing Buri and Chai Nat, to rejoin the Pasak River just upstream from Ayutthaya. The Lop Buri River was not traversed by the study team, and thus will not be discussed here, it can be said, however, that it is not a good alternative due to water depth, width, and curvature constraints.

1) Noi River

To northern Thailand, the Noi River is by far the best of the two alternate routes observed by the study team in that it was deep enough during the observations for fully loaded wooden barges to travel from the north to the mainstream of the Chao Phraya, where no problems exist for large or small barges. There were intermittent problems observed in the river itself with depth and in the two locks observed. The first lock north of the confluence with the Chao Phraya on the Noi was observed to have depth limitations. A possible solution could be to

dredge the lock itself, or it might be possible to release more water from the upstream dam north of Chai Nat. This is one case in which there might be a solution by resolving conflicts of interest between the Harbour Department and other agencies. The lock itself was only six meters wide, however, making it still impossible for larger barges to use the Noi alternative. Considering the depth problems for even the small barges, widening is not recommended anyway. This part of the overall system has difficulties, but during the rainy season at least, it works for the smaller barges as is.

2) Chao Phraya River

As mentioned previously, the banks of the Chao Phraya were very wide and severely eroded, and the water depth was so low that navigation by even small loaded barges was impossible[1]. It is not believed that during the time of the observation that any amount of water released from the Chai Nat Dam would have been sufficient to cure the navigation problem due to the width of the banks and the apparent limited size of the dam reservoir. It was obvious that navigation is at times possible in the channel since many wrecked barges and boats were observed in the well-marked portion of the river between Chai Nat and Sing Buri. It should also be mentioned here that the dam at Chai Nat was equipped with fourteen meter wide lock gates, but this was irrelevant at the time since the river itself was not navigable below the dam.

4.3.2 To Bangkok from Northeastern Thailand

To come from northeastern Thailand by river, essentially only one route exists, and that is by way of the Pasak River which joins the main body of the Chao Phraya at Ayutthaya. On observation trips by the study team during both the rainy and dry seasons, although the river did have numerous bends and double backs, no operational problems were encountered, nor were any observed for the barges in route, which were travelling both upstream and

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1 It should be noted however, that two barge trains were observed headed upstream, which was made possible by the fact that they were empty.

down; both empty and fully laden.[1] Along the river, there were numerous warehouses, grain silos, and factories with docking facilities, and many of them were in use by barges loading for the trip downstream. Also, although the problem of bank erosion was observed, it is clearly less significant than that along the Chao Phraya.

4.4 The Vessels

The barges used for water transport within the UCR are of two general types, wooden and steel. The report for the Harbour Department lists the following range of characteristics for the mid-range of barges generally in use in the UCR:

Type	Length (m)	Width (m)	Draft (m)	DWT[2]
Wood	18.0 - 24.0	3.0 - 5.3	0.8 - 2.1	10 - 60t
Steel	19.0 -4 2.6	3.5 - 9.1	1.5 - 3.8	20 -4 00t

4.4.1 Operations

The conventional method of barge towing presently used in Thailand is towing by tug boat. The lighters are tied together by ropes and are towed in a convoy of 4-10. Convoy size is restricted by channel alignment, water depth, and tug horsepower. On long distances in the north, there are many convoys of eight to twelve 60-80 ton capacity barges and some convoys of up to 20 barges. Where transport demand is large, as between Tha Rua and Bangkok, and where sand dredged out of the river, trains of three to four 200-400 ton barges are used. Sometimes, two tug boats are used for towing the largest barges. The same towing technique is used on the Gulf of Thailand, in which 3-4 steel barges are towed by a 350 hp tugboat.

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1 It was observed that during the dry season, a few of the lighters carrying cement which were observed did not appear to be fully loaded. It is not known if this was for navigational or other reasons.

2 GRT Gross Registered Tonnage (Barge + Payload)
DWT Dead Weight Tons (Carrying Capacity)

A distinguishing characteristic of the pull towing technique is that a steering crew is required on each barge. On wood barges, the crew may consist of the owner's family living on board, but many new steel barges are operated by transport companies, who hire crews of 2 to 3 persons per barge. Another disadvantage is that long barge convoys are not very maneuverable, especially when traveling downstream fully loaded. Maneuvers for entering navigation locks, for stopping to convoy, and handling the barges at ports of destination are difficult and time consuming. In addition, night navigation of long barge convoys is difficult and dangerous. So far, push towing has hardly been used in Thailand, as it involves a higher capital cost, and only transport companies can afford it. The lower operating costs and better maneuverability may make push towing the mode of choice for the future. It is at present the preferred method for most other countries (like the United States) that have highly developed inland waterway systems.

An experiment based on a 1979 study for the Harbour Department[1], a 2800 DWT push boat was built. At its test navigation from Bangkok to Nakhon Sawan, operational control difficulties were observed. The model now stays in Nakhon Sawan port and is not used downstream for practical purposes. Due to the operational difficulties and the low cost of labor, investment in push-towing barges has not proved to worthwhile as yet, and traditional towing techniques are used exclusively.

4.4.2 Operating Speeds

The navigation speeds in the Chao Phraya River are about 4 knots (7 km per hour) downstream of Ayutthaya. Upstream, operating speeds are lower because of narrow channels, shallow water, and river curvature.

4.5 Comparison of Pasak and Chao Phraya/Noi Systems

The 1985 traffic is shown in Fig. 4.1 above, which compares the Chao Phraya / Noi River system with the Pasak River system in terms of tonnage of traffic carried. Immediately apparent is the fact that the overall tonnage of material carried through the Pasak River is far greater than that carried in the Chao Phraya River. The difference is even more significant considering the fact that by far the most significant commodity carried in the Chao Phraya is sand

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1 Find this reference.

dredged up from the river bottom. It is for this reason that the study team feels that the Harbour Department should coordinate its efforts so that the Pasak River is maintained as a clear path for barge transport. It is felt that river transport will increase in the future due to rising fuel costs especially if there is the study team predicted increase in food exports from the UCR, and that development in the area between Ayutthaya and Sara Buri combined with good access will cause further increases in the concentration of water transport along the Pasak River.

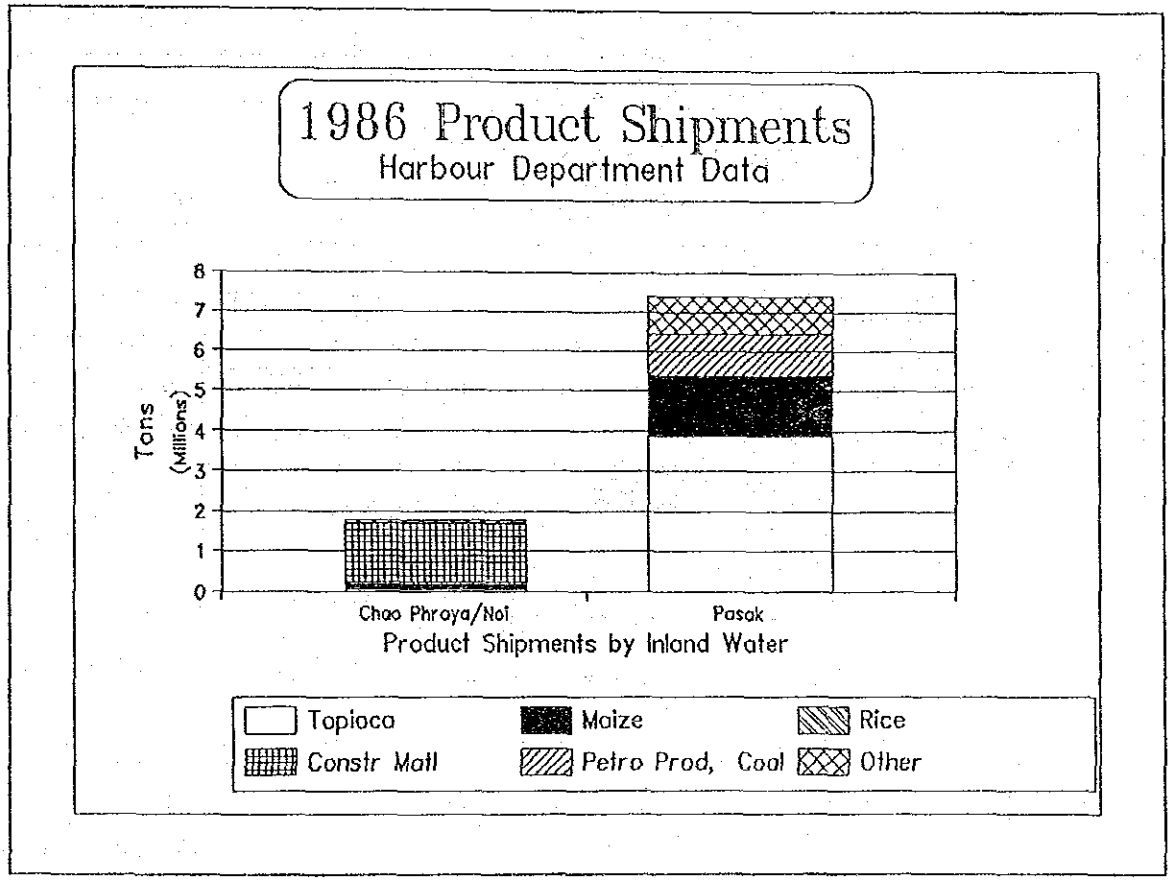

Fig. 4.1 Comparison of River Traffic North of Ayutthaya on Chao Phraya/Noi and Pasak River

4.6 Pasak Hinterland Traffic

Looking more specifically at the traffic from the Pasak River hinterland itself, which includes essentially all of northeastern Thailand, the same bulk commodity flows, broken down by mode are shown in Fig. 4.2. These bulk commodities which are currently shipped from Northeastern Thailand either to Bangkok or for export are either shipped by road, rail, inland water, or some combination such as road and inland water.

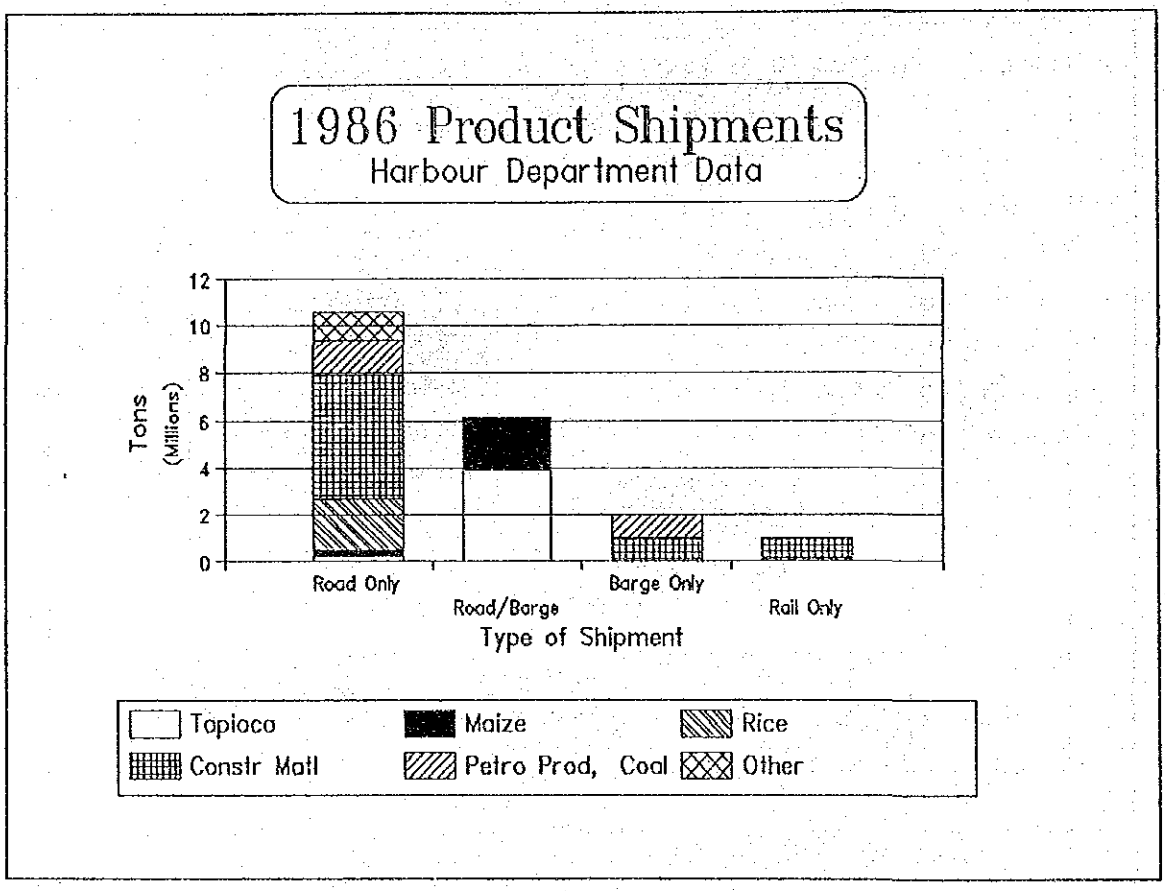

Fig. 4.2 Bulk Product Shipments in the Pasak River Hinterland

4.6.1 Tapioca Pellets

Since tapioca is a bulk product of the extensive cassava farming from the northeast and since it is a product primarily bound for export, it is particularly well suited for inland water transportation. It does not suffer from the need to be redistributed to trucks and shipped to numerous locations within Bangkok. Typically, tapioca pellets are shipped from inland processing plants by truck to storage warehouses many of which are located along the Pasak River. There they are held until international market price dictates that a sale should be made. They are then shipped by barge to Ko Sichang to be loaded alongside ocean going vessels for export.

4.6.2 Maize

Production of corn or maize in Thailand may either be used for domestic consumption or for export. In general, maize grown in the Pasak River hinterland is predominantly exported due to the ready availability of warehousing and shipment by water to be loaded on to ships. The maize may either be loaded directly from the barge alongside a ship in the mouth of the Chao Phraya River, or it may be towed to Ko Sichang to be loaded there.

4.6.3 Rice

At present, the only loading facilities for rice for international shipment are in Bangkok, so that rice shipping is done primarily by truck.

4.6.4 Construction Materials

1) Cement

Production of cement is concentrated in the Tha Rua and Kaeng Khoi areas. Since all of the cement is for the domestic market, primarily in Bangkok, it is not carried as efficiently by inland water as it might be if bound for a single point for export. Nevertheless, about 40% of the cement produced at the Tha Rua plant is carried by barge. The remaining cement is carried by either truck (40%) or rail (20%). At

Kaeng Khoi, about 60% is carried by road with the remaining 40% by rail.

2) Gravel

Although the amount of gravel has to be estimated, it is believed that the primary means of shipment is by road (93%) with about 7% by barge. It is believed that essentially all of the gravel is used domestically in Bangkok.

4.6.5 Petroleum Products and Coal

1) Petroleum Products

Petroleum products leaving Bangkok and bound for the hinterland are carried either by road (55%) or by rail (45%).

2) Coal

Coal bound for the Kaeng Khoi cement plant is carried to Thailand by ship, off-loaded onto barges at the mouth of the Chao Phraya River, and taken to Bang Pa-in where it is loaded onto trucks and driven to Kaeng Khoi.

4.6.6 Animal Feed and Fertilizer

Due to the widely dispersed nature of the consumers scattered throughout the Pasak River hinterland, the flow of animal feed and fertilizers is direct from Bangkok to the individual consumers by road.

4.7 The Pasak River Navigation Dam Not Recommended

The previously mentioned 1988 study for Harbour Department recommended the construction of a weir or navigation dam across the Pasak River just upstream from Ayutthaya. However, from field observations, it is the opinion of the study team that the dam, although it would have no harmful effects as mentioned in the Interim Report of the UCR study, is simply unnecessary.

During the dry season, the effect of ocean tides is seen in the Pasak River as far north as midway between Tha Rua and Nakhon Luang, where water hyacinth was observed moving upstream. Also barges were loaded at the Siam Cement plant north of Tha Rua and sent out with the rising tide bound for Bangkok during the dry season[1]. It is therefore felt that the dam is entirely unnecessary and would in fact be a hindrance, rather than an aid to transport by inland water in the Pasak River, since a toll would be necessarily charged and waiting time would make the trip more expensive as well.

4.8 Potential

Present traffic is rather heavy on the Chao Phraya River south of Ayutthaya and the Pasak River south of Tha Rua year round. It is felt that there is still room for additional traffic, and it is expected to grow in the near future along with the growth of the GSIC. Among the factors to encourage this growth are the proposed agro-processing center, and the opening of the new Pasak collector roads. There is potential, it is believed not only for bulk cargo, but for containerized cargo barges similar to those which are used downstream in the BMR.

Problems which are related to transport by inland water which relate to the UCR are relatively small when discussing the large scale product shipping which already occur. At present no large scale investment in the water transport system itself is recommended as it is felt that it would not be economically justified across the Chao Phraya or Noi, and is simply unnecessary across the Pasak. It is felt that current efforts by the Harbour Department to maintain the waterways should be continued, and indeed Harbour Department dredging barges were observed in operation. Although there has been some criticism that the number of dredging barges is too low, and the work inadequate, the information from this study is insufficient to either confirm or deny the criticism.

Probably the most important area for investment to encourage shipping by barge is to construct better access roads to the areas along the Pasak River between Sao Hai and Nakhon Luang on the north side and between Tha Rua

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1 In a later conversation with Harbour department officials, it was stated that the primary reason for the weir would be to help minimize bank erosion.

and Ayutthaya on the north side of the river. This is indeed proposed and is discussed in the chapter on road construction projects.

If there is to be future investment in the inland water system itself, it is believed that the next place to search is the possibility of building a wider lock at Rama VI to allow traffic further upstream toward Sara Buri. It is not felt that there is anything to justify such an investment at this time. Perhaps as the Greater Sara Buri Industrial Core (GSIC) grows, and if the cost of fuel grows sufficiently the demand for transport by inland water may increase with it.

Another potential area for investment is in the use of container carrying barges. These are already in use downstream and could be applied to the processed food shipments from the agro-processing center if built near the Pasak River. It should be obvious that the investment in this area is strictly an area for private investment, and that the only function of government is to ensure the safety of operations. This system already exists, as it is the primary responsibility of the Harbour Department to license all new barges which operate in Thailand.

5. PROJECT PROPOSALS

5.1 Ayutthaya to Lop Buri Highway (North-South Highway)

Should use a new alignment and serve Lop Buri, Nong Don, Don Phut, Nakhon Luang, and Ayutthaya

Should be a P-1 class road with a wide carriageway, wide shoulders, limited access control, and straight R-O-W.

May have at-grade intersections for arterials and collector roads, but they should be signalized for arterial roads and possibly channelized, with stop signs for collectors. Private access roads should be prohibited.

Should not pass directly through towns, but should pass nearby.

5.2 Pasak River Collector Roads

Should be class F-3 roads primarily to serve industrial development on both sides of the Pasak River.

Access to these roads by other roads and by private roads need not be discouraged.

The alignment should be close to the Pasak River, but not adjacent to it to allow for sufficient room for development. The precise alignment should minimize the demolition of existing structures.

5.3 Tha Rua to Sara Buri Highway and Northern By-pass

This should be a class S-1 or S-2 road between Tha Rua and Highway 1 and a P-D or P-1 road between Highway 1 and Highway 2.

The northern Sara Buri bypass should connect with both Highway 1 and Highway 2 at a grade-separated interchange. If this is not possible, the interchange should at least be signalized and channelized to minimize traffic congestion and for safety.

5.4 Suphan Buri to Tha Rua Highway

This road is currently under construction, although of an unknown design standard and along an unknown alignment. Ideally it should be a P-2 or P-3 road which would serve traffic now and allow for future improvement. It is not really the only east-west link, but is considered as a "network" of east to west links which would include the existing road between Suphan Buri and Ang Thong and Sara Buri.

The road itself also poses a set of east-west connections by allowing traffic from Suphan Buri to travel by a relatively direct route on the south side of the Pasak River to Nakhon Nayok by way of Phachi or on the north side to Tha Rua and Sara Buri.

5.5 Tha Rua to ESB Highway

This link to the ESB should begin near Tha Rua and proceed southward roughly along the existing RID Rapiphat canal in the direction of Nong Khae. At Nong Khae, the road should tie into Highway 1 by some means consistent with the DOH plans for Highway 1.

South of Nong Khae, the road should head in the direction of Nongchok, and tie into the planned expressway from Bangkok to Rayong.

These proposed new road network is illustrated in Fig. 5.1.

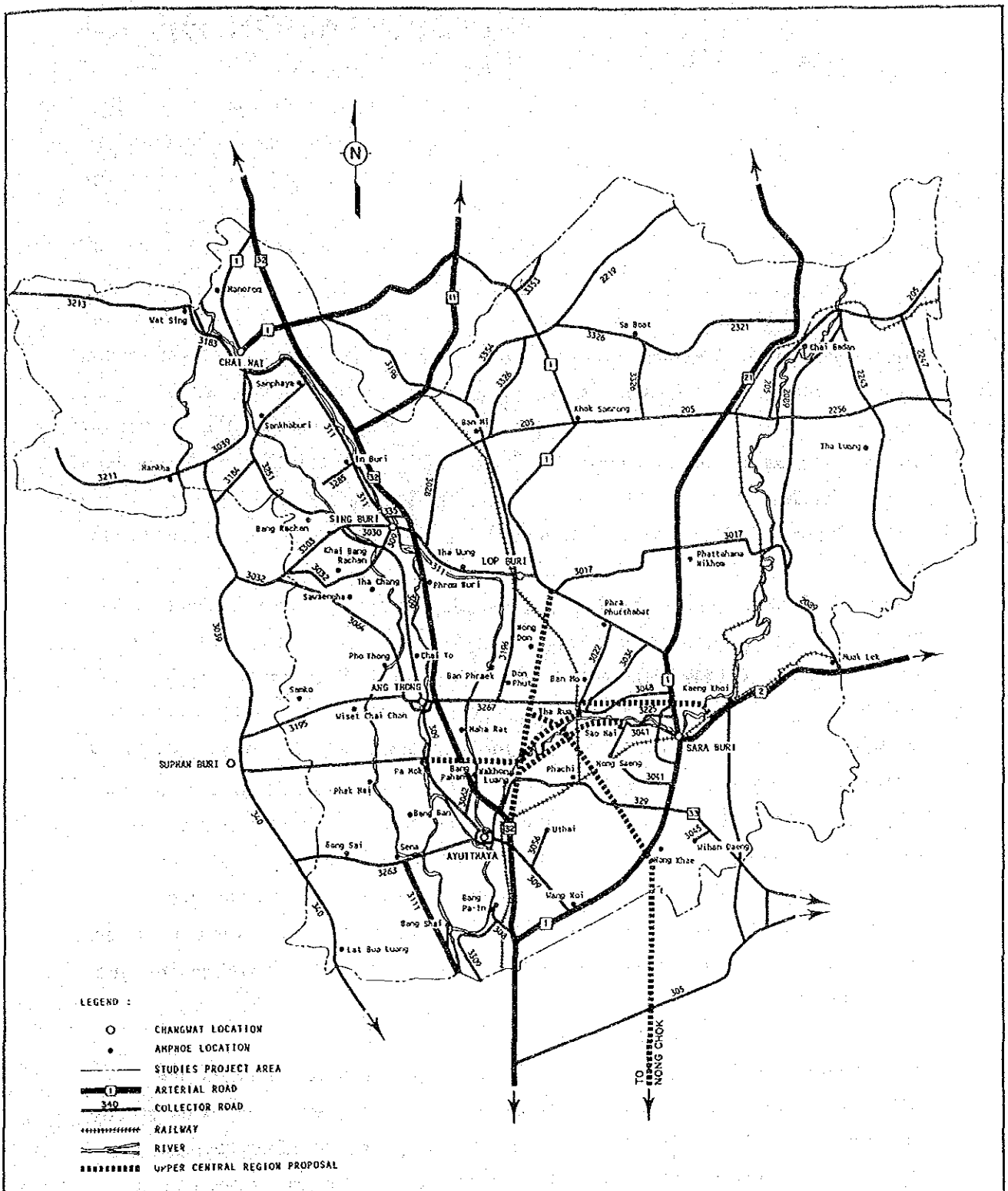

Fig. 5.1 Map of Proposed Highway Projects

6. PRIORITY FOR IMPLEMENTATION OF PROPOSED PROJECTS

Based on Level-of-service Considerations:

(1) Ayutthaya to Lop Buri Highway

Based on Spatial Considerations:

(2) Tha Rua to Sara Buri Hwy and Northern Bypass

(3) Suphan Buri to Tha Rua Highway

Based on Need to Serve UCR Project Proposals:

(4) Pasak River Collector Roads

(5) Tha Rua to ESB Highway

A number of factors must be taken into consideration in the determination of priorities for the UCR highway projects. One of the factors is to consider the projects in terms strictly related to transport issues. A second factor is to consider the timing of other UCR projects and the importance of the road projects to them. A third, and very important, factor is to consider the environment and presence of other components of the infrastructure before beginning construction which will likely lead to industrial development and urbanization.

The highest priority project in terms of transport issues is no doubt the Ayutthaya to Lop Buri highway. Indeed, it is only link which is based strictly in terms of transport demand. Although the Sara Buri northern bypass also fills a critical role in serving existing demand, it is based on more complex considerations, and must be considered in terms of UCR projects as well.

Roads designed to serve UCR projects need to take several things into account. First, the UCR to ESB road is considered somewhat speculative and should be built after more is known about the need to ship goods directly from or to the UCR from the ESB, and the success of the Bangkok outer ring road, to which this road is designed as an alternative.

The second set of roads to serve UCR projects, the Pasak River collectors, are considered as a much higher priority and must go in to allow for further industrialization. However, the opinion of the UCR team is that this industrialization should not be encouraged until the potential environmental danger to the Pasak River is alleviated. Sewage collection and treatment systems need to be built, pollution monitoring systems need to be in place, and institutional capabilities for control need to be functioning before industrialization begins. Therefore, road development of this region is recommended only as an integral part of a larger GSIC master plan.

Roads designed primarily for spatial considerations are of two levels of priority. The highest priority is obviously the Tha Rua to Route 1 and the Sara Buri northern bypass, as it serves the GSIC. It should be part of the GSIC master plan. The second connector route between Pa Mok and the UCR north-south highway is a lower priority.