(Lop Buri), Kok Cha Sit (Sara Buri), Muak Luk (Sara Buri), Tha Lan (Sara Buri), and In Buri (Sing Buri).

11.4 Development Concepts, Policies and Projects

1) Urban Development Concepts

Principles of urban development in the UCR are threefold: (1) urban activities should be strengthened as a whole; (2) the existing growth potential of urban economies should be reinforced; and (3) the lower order centers, which are endowed with strategic advantages or will be capable of playing specific roles in serving their hinterland activities, should be strengthened with provision of necessary urban infrastructure.

2)

Stimulation of potential urban cores are necessary for promoting regional development. Urban centers for the two following specific purposes are to be developed:

(1) For industrial supporting purposes of :

- Accommodation of industrial location
- Strengthening of local industries
- Creating urban services employments
- Tourism development

(2) For new regional core development purposes of :

- Encouragement of urban functions to be relocated from the BMR
- Promotion of R&D and new technologies
- Human resource development

Regarding the magnitude of urban economies, only Ayutthaya and Sara Buri Cities are noted : Ayutthaya City has a population of 63 thousand and its direct influence has 118 thousand population; and Sara Buri City has 57 thousand population, and its direct

hinterland has 119 thousand population. The population growth rates in these two cities in current years are over 3.0% per annum.

Another notable center is Lop Buri, although it has only 37 thousand urban population and its urban population growth rate indicates a negative figure of -0.1%. Though it is not much dense as a city, urbanization is stretching out the vicinities of the city, and its direct influence area holds 246 thousand population.

Development policies of the three potential cities are proposed based on these characteristics and endowments. Sara Buri should be developed to function as a strategic regional center to support all the hinterland economies of agriculture and industry. Ayutthaya should be developed to function as a sub-regional service center for both traditional and modern industrial activities in the surrounding areas, as well as to function as a tourism center in the UCR. Lop Buri, being another major sub-regional center, should be developed with emphasis on its administrative, educational and tourism functions.

(3) A New Industrial Core in Greater Sara Buri Area

The Greater Sara Buri Industrial Core (GSIC) is recommended to be organized as a focal area of the UCR's industrialization program. The GSIC will consist of four sub-cores as shown in Fig. 11.5. Kaeng Khoi, Sara Buri, Tha Rua - Tha Luang, and Nong Khae Sub-cores. These are to function as follows :

Kaeng Khoi Sub-core : The existing large scale cement industry and its related industries are seeds for further industrial development in this core. Mineral resource-based industries including ceramics and other advanced technology-based industries are to be promoted. Inter-modal transport facilities related to highways and a new rail link with the ESB will trigger the development of this industrial sub-core. Kaeng Khoi City will be an industrial service center.

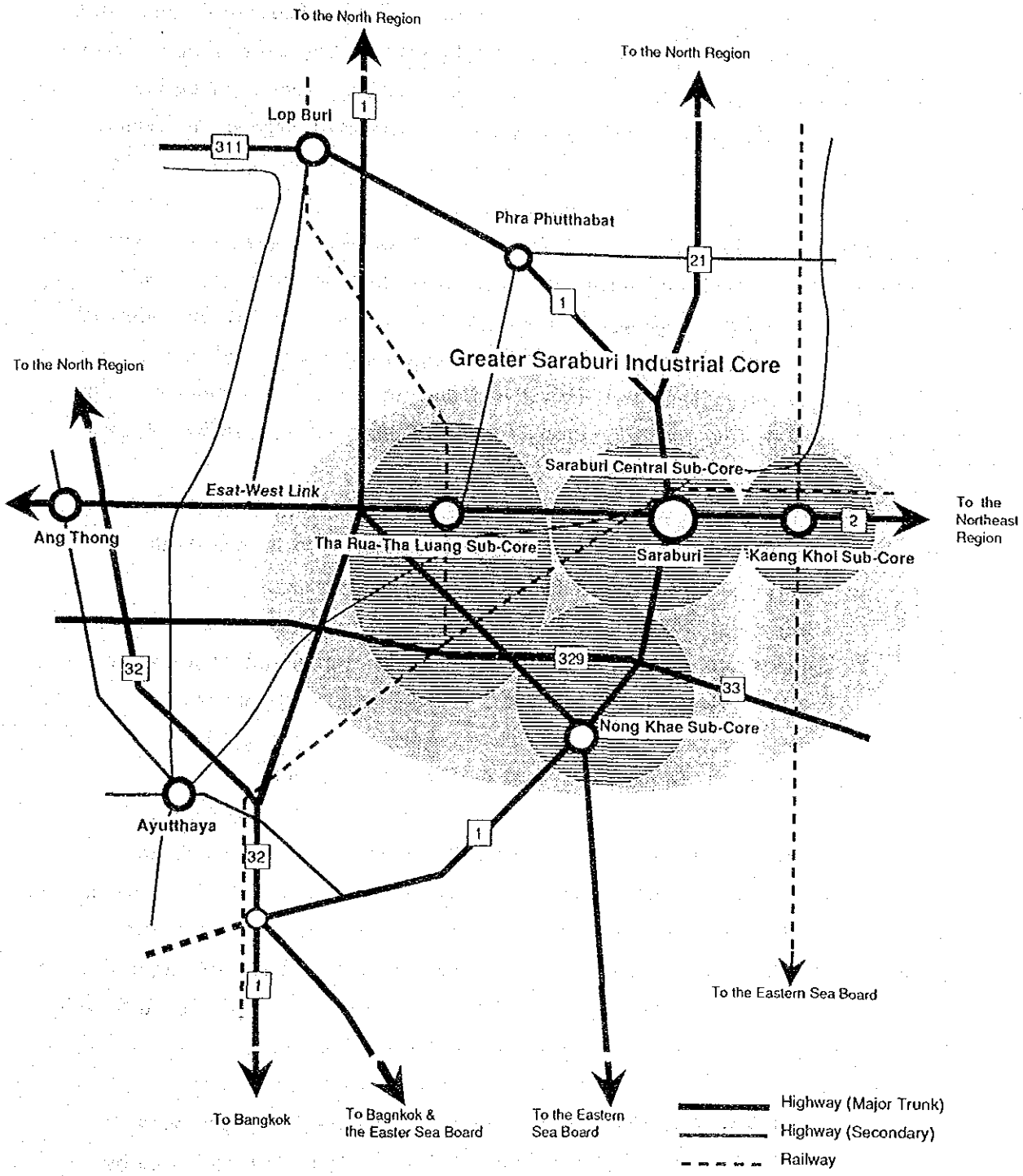


Fig. 11.5 Conceptual Structure of Greater Saraburi Industrial Core (GSIC)

Sara Buri Sub-core : The industries supported mainly by urban functions such as goods and information collecting, marketing, distributing, and human resources and technologies generating, are to be promoted in this sub-core. Technology-oriented, agro-processing, urban supporting, assembling and distribution services industries are acceptable. Sara Buri City is its center.

Tha Rua - Tha Luang Sub-core : The existing large scale cement and steel mill industries and distribution facilities (silos and warehouse) of maize, tapioca and rice are seeds of the industrial development in this sub-core. Agro-processing and agro-products and steel derivative industries are to be promoted. Tha Rua City and Tha Luang Town will function as service centers.

Nong Khae Sub-core : With an intersection of National Highway Routes No. 1 and No. 33, this area is assessed to be one of the potential areas for industrial development because of its advantageous location in road transport. A number of ceramic industries and small-and medium-scale garment industries are already located in this area.

(4) Regional Urban and Tourism Centers in Ayutthaya

Ayutthaya City is a significant regional center to serve the industrialization taking place in the surrounding areas, and at the same time, it is endowed with a large potential of tourism development based on invaluable historical assets. Combining these two characteristics, Ayutthaya City should be fostered with attention to the need to avoid over- urbanization.

In line with this concept, two master plans have been made : "Tourism Development Master Plan of Ayutthaya and Nearby Provinces" prepared by TAT (1988), and "Conservation and Development Project of Ayutthaya Historical City" prepared by Department of Fine Arts (1989). The two master plans have depicted an appropriate picture of Ayutthaya, and proposed a number of programs and projects to make the city more

attractive and functional. These may be guidelines for future city development.

In association with the increase in industrial facilities in surrounding areas, a rapid increase in the illegal settlers mainly of factory workers and venders have become social as well as urban problems in Ayutthaya City. Because of the limited available land within the municipal area (a large portion of the land is owned by the public), these squatters are likely to occupy the public land. Since a more increase in urban population will take place continuously, the proper management of land use is urgent not only in the municipal area but in its vicinities.

(5) Specific Urban Functions Development in Lop Buri

Lop Buri City has potential to become a regional center with a wide variety of cultural and higher educational functions. These functions with higher quality for not only Changwat but also the UCR may be encouraged in this city. The research and development institutions for new applied agricultural technologies are recommended to be promoted as well. Tourism is also a seed to develop this city.

3) Sub-Regional Centers Development

(1) Basic Urban Needs Development in Sub-Regional Centers

Ang Thong, Sing Buri, and Chai Nat are all Changwat centers and have important roles to serve the hinterland agricultural activities in the Chao Phraya Delta. Their commercial and marketing functions have historically been accumulated, and need to further be emphasized in the future as well.

Other than Changwat centers, there are two important centers which have comparatively great potentials as sub-regional centers : Phra Phutthabat and Lam Na Rai. Both centers will be service centers for upland agricultural activities. Phra Phutthabat is endowed with domestic tourism resources as well.

Lam Na Rai, although it is a sanitary district at present, will be the fourth largest urban center to serve upland agriculture to be encouraged by the Pasak River Basin Development.

All the centers have to be equipped with the basic urban infrastructures at certain standard levels such as water supply, drainage, solid waste treatment, waste treatment, electricity supply, telecommunication, public transport systems, and the road accesses to the hinterland.

(2) Agro-products Market and Goods Distribution Centers Development

The major commodities being generated from the UCR are agro-products. According to the results of our local market survey in 1989, it can be identified that there are three major markets with the function of wholesaling agro-products for extensive markets of Sara Buri, Sing Buri and Ang Thong.

Along with the expansion of domestic market, a local wholesaling market system associated with the central markets (in Bangkok) especially for fruits, vegetables, and other perishables, where the prices are determined through a well-functioning market mechanism, will be required, instead of traditional marketing system. This modernized marketing system will stimulate the agricultural diversification among farmers. It is recommended that such local wholesaling markets for agro-products will be developed or renovated in the three cities : Sara Buri, Ang Thong and Sing Buri. As for Ang Thong, its market service area will complete with that of Suphan Buri. However, taking into account its locational advantage and the present potentials, the Ang Thong Wholesale Market would still be feasible, if more interactions are to be maintained with Suphan Buri's economy.

Meanwhile, the locational advantage of the UCR as a gateway to the BMR and the north and northeast regions will potentially make goods distribution centers viable. Ang Thong with the northern hinterland and Sara Buri with the northeastern

hinterland are potential locations of the regional goods distribution centers. However, market areas of these two distribution centers will be limited only to the areas lower than Nakhon Sawan and Nakhon Ratchasima respectively. These primary regional growth centers are also capable of attracting the interregional goods distribution centers with stronger functions and wider service areas.

4) Secondary Order Center Development

In order to support a wide variety of agricultural activities, lower order centers should be developed with the following functions:

- Agro-products distribution
- Agricultural services and support
- Agro-processing
- Agro-technologies development

There are 80 human settlement centers in the forms of municipalities and sanitary districts in the UCR. Fig. 11.6 shows a distribution pattern of urban population on these centers and their population changes between 1981 and 1987. Most of the centers suffered from a minus growth or quite a low growth.

Out of these 80 human settlement centers, the notable 20 centers with service functions for agriculture are identified (see Fig.11.6). These are recommended to be developed as follows :

(1) Agricultural Support in the Chao Phraya Delta

The western bank areas of Chao Phraya River, especially the areas between two north-south corridors of National Highways of Route 32 and Route 340, are advanced paddy production areas. There are three significant centers capable of supporting the agricultural activities and agro-products distribution related to Suphan Buri in these areas, they are Sena-Chao Chet, San Chao Rong Thong, and Sing.

Sena and Chao Chet (Changwat Ayutthaya) : This center comprises of Sena (Tambon Municipality) and Chao Chet (sanitary district) with a population of about 14,800 in 1987 is located on Provincial Highways Route 3263 and Route 3111 which provide access to Ayutthaya, Suphan Buri and Bangkok. Because of this location advantage, a large scale factory (shoes maker) exists and another one (medical) is under construction in the vicinities. Commercial activities in this center are active and now changing a historical river side logistic center to the service center based on highway transport.

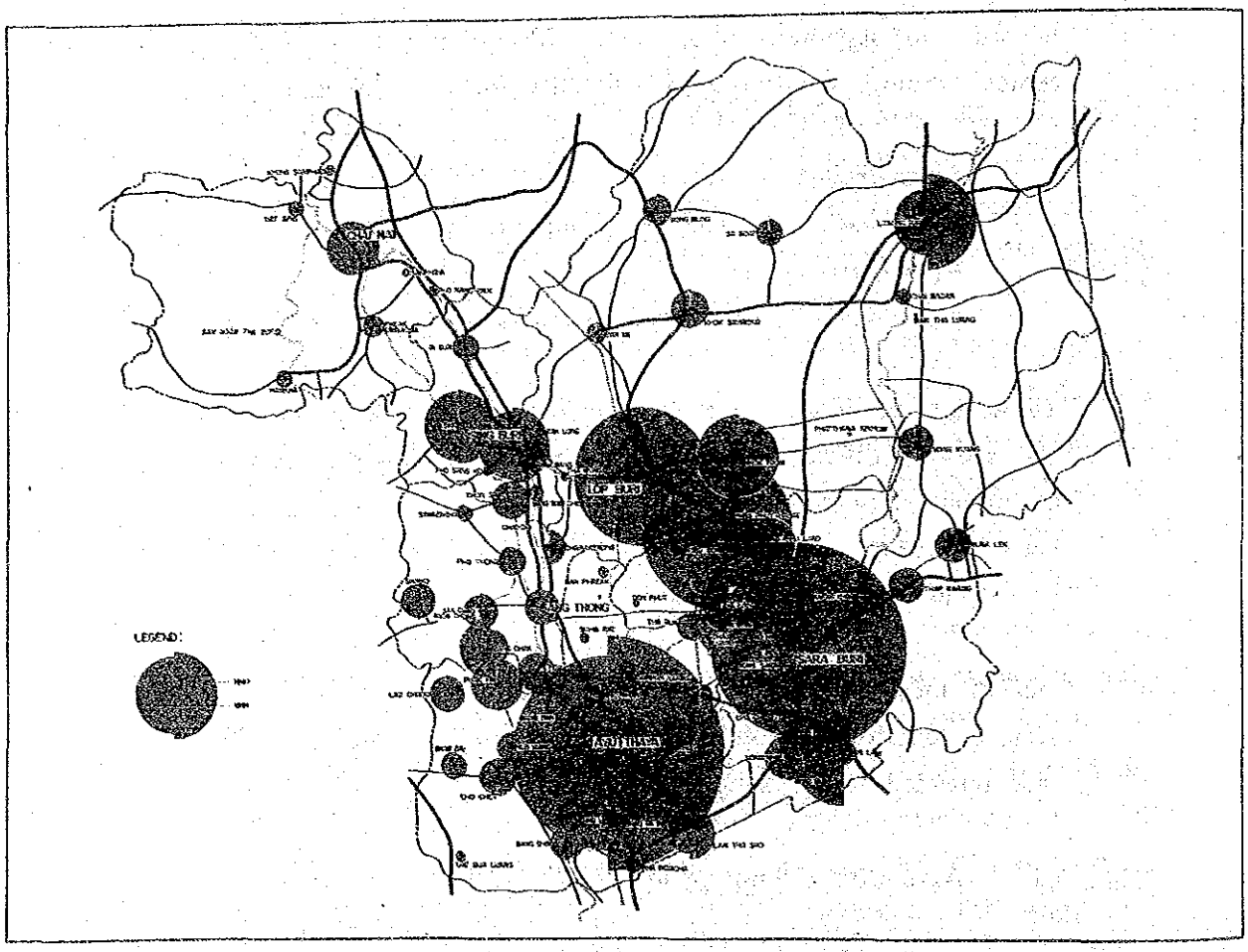


Fig. 11.6 Population Distribution of Human Settlement Centers : Municipalities and Sanitary Districts

San Chao Rong Thong (Changwat Ang Thong) : This sanitary district with a population of about 9,600, on Provincial Highway No. 3195, is located just at an intermediate place between Ang Thong and Suphan Buri, and functioning as a rice distribution center. This center is important in combining the economics of Ang Thong and Suphan Buri.

Sing (Changwat Sing Buri) : This sanitary district with a population of about 20 thousand is functioning as a significant agro-service center, located on the Provincial Highway No. 3303 which links this sanitary district linking with Sing Buri and the western region. This old settlement center as a river transport center, however, needs another stimulus to encourage this centers activities.

(2) Agricultural Diversification in the Upland Area

In order to support the agricultural diversification in the upland area, a number of centers should be noted and encouraged. Those are :

Lam Na Rai (Changwat Lop Buri) and Wang Muang (Changwat Sara Buri) : These two sanitary districts will be the service center for the Integrated Pasak River Basin Development. The former is a center with a population of about 26 thousand, and the latter, that of about 10 thousand. In 2010, the urban population of Lam Na Rai will be more than 70,000 capable enough to be a municipality.

Khok Samrong and Nong Mung (Changwat Lop Buri) : These two centers are located on National Highway No. 1. Reflected by a shift of major inter-regional traffic flows from National Highway No. 1 to No. 32, these centers' commercial activities have somewhat been depressed. However, these two centers are still important in supporting the diversified agriculture in the vast Upland Area in Lop Buri. The former is a municipality with a population of about 9,700 and the latter is a sanitary district with 8,500 population.

Phra Phutthabat (Changwat Sara Buri) : This considerably large municipality with about 34 thousand population is a local service center as well as a nation-wide domestic tourism center with religious assets. However, it shows a significantly negative population growth of - 5.4% between 1981 and 1987. An economic stimulus is necessary so as for this center to become a center for agricultural diversification. In this connection, a development concept of "Agro-Polis" may be employed in this center.

(3) Railway Transport Centers

A drastic shift in transportation systems from road to rail may come into reality in Bangkok Metropolis. Supposing this shift in Bangkok, the significance of the railway's functions would increase in the UCR as well. Based on this perspective, Ban Mi (Lop Buri), Tha Rua (Ayutthaya), Phachi (Ayutthaya), Bang Pa In (Ayutthaya) and Kaeng Khoi (Sara Buri) should be noted as potential rail transport centers.

5) Proposed Projects/Programs

Proposed projects/programs are summarized in Table 11.5.

Table 11.5 Projects/Programs for the Urban and Human Settlement Development

Package	Projects/Programs Component
A.	**Strategic Regional Center Development (Greater Saraburi Industrial Core Development)**
	(1) Short-Term Projects/Programs
	A1 Implementation of Development Master Plan Study for the Greater Saraburi Industrial Core Project (Investment Program and Feasibility Study)
	A2 Preparation of "Guidelines for Industrial Locations and Urban and Housing Development in both Ayutthaya and Saraburi Sub-Regions
	(2) Medium-Term Projects/Programs
	A3 Implementation of Urban Utilities and Infrastructure Projects including:
	A31 Expansion of Water Supply Capacity and Facilities in the GSIC
	A32 Sewerage System Development in Saraburi Urban Area
	A33 Acceleration of Urban Streets Network Development in Saraburi Urban Area, Tha Rua-Tha Luang and Kaeng Khoi Sub-Cores.
	A34 Solid Waste Collection and Treatment System in the whole GSIC
	A35 Inducement of Urban Gas Supply System in Saraburi Urban Area
	A36 Expansion of Telecommunication Capacity in the GSIC
	A37 Improvement of Inter-regional Bus Terminal in the Saraburi City
	A4 Development of a Housing Complex (Saraburi New Town) by the Public Initiation, with the Private Sector Involvement.
	A5 Promotion of Redevelopment Projects in the Saraburi Central Business District
	A6 Development of Goods Distribution Terminal and Improvement of Food Wholesale Market in Saraburi City
	A7 Preparation of Guidelines for Relocation of Bangkok-Based Facilities to the GSIC.
	(3) Long-Term Projects/Programs
	A8 Inducement of Higher Metropolitan Functions (Higher Educational and Medical Facilities)
	A9 Preparatory Work for A Rapid Transit System Development between Bangkok and Saraburi.

(Cont'd)

Package	Projects/Programs Component

B. Sub-Regional Center Basic Urban Needs Projects

(Ayutthaya, Lop Buri, Sing Buri, Ang Thong, and Chai Nat Urban Areas)

(1) Short-Term Projects/Programs

- B1 Implementation of Flood Mitigation Projects in Sing Buri, Ang Thong, Chai Nat
- B2 Preparation of an Overall Investment Guideline/Policies (Long-Term) for Basic Urban Needs Development Covering All Sub-Regional Urban Centers
- B3 Implementation of Ayutthaya Tourism Promotion Projects and Embarkment of "Historical City Ayutthaya" Development
- B4 Implementation of Sewerage System Project and Solid Collection and Treatment System development in Ayutthaya Urban Area

(2) Medium-Term Projects/Programs

- B5 Preparation of Long-Term Public Investment Master Plan by the Local Auhtorities
- B5 Improvement of Inter-Regional Bus Terminals in All Centers.
- B6 Implementation of Basic Urban Needs Projects in All Centers, based on the Investment Master Plan (with Emphasis on Solid Waste, Waste Water Disposal, Water, Telecommunication Systems Projects)
- B7 Development/Improvement of Food Wholesale Markets in Ang Thong and Sing Buri
- B8 Development of Goods Distribution Center in Ang Thong
- B9 Development of "Agro Technologies and Diffusion Center (ATDC)" in Lop Buri
- B10 Tourism Promotion Projects for "Historical City : Lop Buri", and "River-Side Explore Tourism Center" in Chai Nat

(3) Long-Term Projects/Programs

- B11 Acceleration of Implementation of the Basic Urban Needs Projects in All Centers

(Cont'd)

Package	Projects/Programs Component

C. Secondary Order center Development Projects/Programs

(1) Short-Term Projects/Programs

C1 Preparation of Guidelines for Secondary Order Center Development with Emphasis on Agricultural ad Community Service Functions

C2 Implementation of Critical Projects in Accordance with the Guidelines (Proposed by the Local Authorities)

(2) Medium- and Long-Term Projects/Programs

C3 Preparation of Long-Term Public Investment Plans by Local Auhtorities

C4 Implementation of the Planned Projects/Programs.

12. WATER RESOURCES

12.1 Water Resources in the UCR

1) Water Resources in the Chao Phraya River Basin

The UCR is located in the Chao Phraya River Basin. Area of the basin is 161,700 km^2, which is 32% of the national territory. The basin may be divided into upper, middle and lower basins.

Total annual run-off volume of the Chao Phraya River Basin is 30,300 million cubic meter (MCM) on the average. Fluctuations of the run-off is large and it varies from 14,500 MCM to 47,500 MCM.

A number of water resources development projects have been implemented in the basin. The locations of those projects are shown in the Fig. 12.1. The total volume of gross storages developed to date is 787 MCM in upper basin, 22,5500 MCM in middle basin, and 445 MCM in lower basin. Major storages are Bumipol and Sirikit Dams located near the boundary of the upper and middle basins; and the volume of two dams together is 22,462 MCM in gross storage.

2) Characteristics of Water Resources in the UCR

An upper part of the lower Chao Phraya River Basin and upland areas including a part of Pasak River Basin consist the UCR.

The Chao Phraya River and its tributaries, Lop Buri River, Noi River and Suphan River, flow through the region. Since the whole Chao Phraya Basin has the similar seasonal rainfall pattern, seasonal river flow pattern in the basin agrees with the rainfall pattern. The volume of run off from the upper basin is one of the most important factors for the

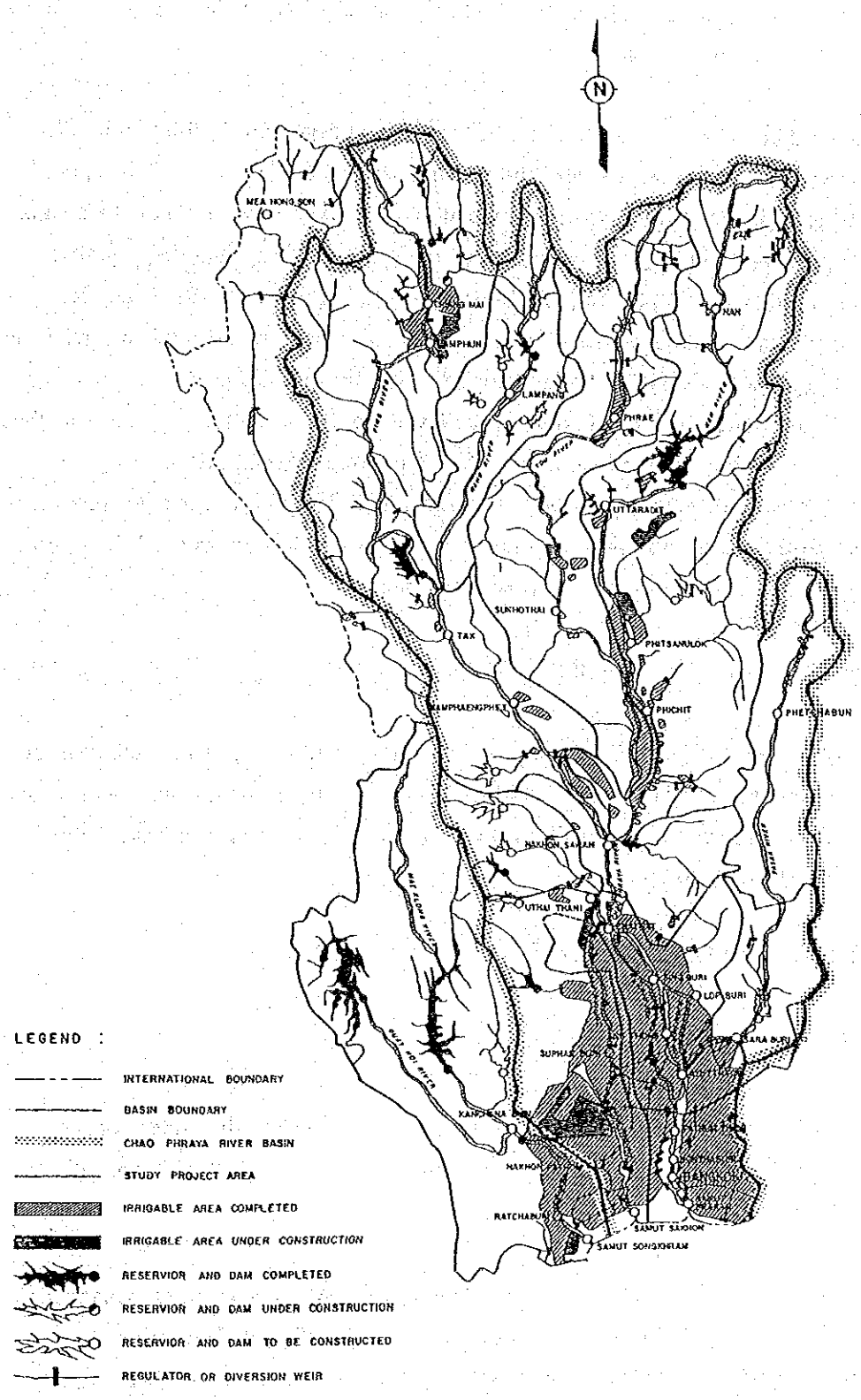


Fig. 12.1 Water Resource Projects in Chao Phraya River Basin

region's water resource, since the delta is largely dependent on it particularly in dry season.

The groundwater potential is high in the delta especially along the Chao Phraya River. Along the river, the groundwater yield is 45 - 200 gpm from Chai Nat to Ayutthaya and extending approximately 10 km from the river to the both sides. Although the yield is high in quantity, quality may be problematic depending on locations. In aquifers of 10 - 20 m depth from the ground surface, salt content is frequently found as well as iron. Groundwater has to be developed carefully to avoid over exploitation. The Central Region is believed to be a recharge area for the aquifers providing groundwater to the Bangkok Metropolitan Region (BMR). This indicates that negative effects will not be limited to the areas of over exploitation, possibly in the UCR, but extended to the BMR where, even now, groundwater is a scarce resource.

3) Surface Water Available in the UCR

Table 12.1 and Fig. 12.2 summarize the water availability and potential at Chao Phraya River Delta, Chao Phraya River itself, upland area, and Pasak River itself. In the table, wet season is from July to December and dry season is January to June.

12.2 PRESENT WATER RESOURCES UTILIZATION

1) Chao Phraya Irrigation Project in the Delta Area

The Greater Chao Phraya Irrigation Project is now in the stage of operation and maintenance. The total project area is 1,249,248 ha, of which 914,000 ha is in the UCR.

Many facilities were constructed as components of the Greater Chao Phraya Projects and they are being operated by Royal Irrigation Department (RID). Those facilities are: Chao Phraya Dam at Chai Nat, Rama VI Barrage, six head regulators (five at Chao Phraya River and one at Pasak River), main canals (Chai Nat - Pasak canal, Chai Nat - Ayutthaya canal, Noi River, Suphan River, and Makamthao - Uthong canal), canal system including lateral, tertiary and other canal networks, regulators in

Table 12.1 Present Water Resources Availability and Potential

(Unit : million cubic meter)

Surface water availability (1977-1986 avarage)	Wet Season	Dry Season
1. Chao Phraya delta		
Water release from Bumipol and Sirikit Dam	3,800	6,200
Water available at Nakhon Sawan and Rama VI	18,500	7,400
Water diverted to the whole delta at Chai Nat Dam	6,700	4,200
Water delivered to the UCR delta	3,790	1,450
2. Chao Phraya River : Water release at Chai Nat Dam		
Flow needs*	2,000	2,000
Flood spill**	10,760	1,060
3. Upland area water resources potential		
Chai Nat, Sara Buri and Lop Buri Provinces	1,176	785
4. Pasak River		
Water resources potential at Kaeng Khoi	2,146	206

Note : * Flow needs is the amount to satisfy downstream water demands.
** Flood spill is unavailable to downstream demands due to unstable flow of released floods

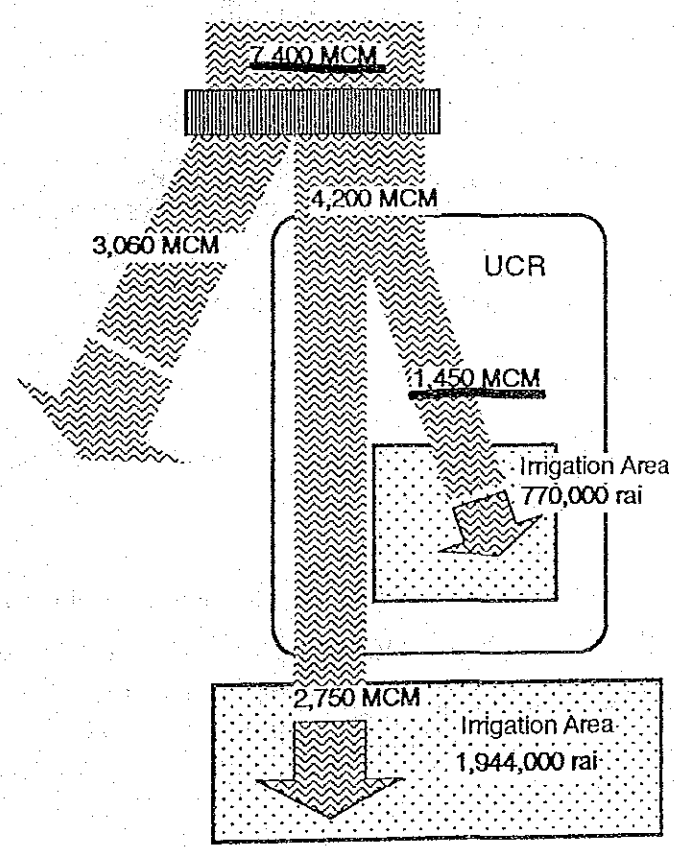


Fig. 12.2 Water Flow in Chao Phraya Delta in Dry Season

the main canals and the canal system, pumping stations and flood protection dikes along main rivers and canals. The Fig. 12.3 shows locations of the facilities constructed for the Greater Chao Phraya Project.

2) Water Allocation for Irrigated Agriculture

The Greater Chao Phraya Project was designed for supplementary water supply for wet season rice as well as flood drainage with the construction of large dams in the upper basin, however, dry season irrigation has become possible. Once dry-season water is made available, water demand for dry season crops emerged and it has been increasing. This situation has created difficulties in water allocation and problems in social or economic equity among farmers and regional economy, since water available at upstream dams cannot meet all of the dry-season water demands.

Irrigable area in the delta is 7,808,000 rai. The cultivated area within the delta varies especially in dry season, depending largely on water availability, as shown below;

	wet season	*dry season*
1974	6,241,000 rai	1,259,000 rai
1982	6,124,000 rai	3,326,000 rai
1987	6,068,000 rai	2,532,000 rai
Average (1976-86)	6,143,000 rai	2,714,000 rai

The average irrigated areas in the UCR are estimated at 3,238,000 rai in wet season and 770,000 rai in dry season.

A comparison between the water delivered to the delta during wet season versus that during dry season is shown in Fig. 12.4. It also shows the irrigated area in the whole delta versus that in the UCR.

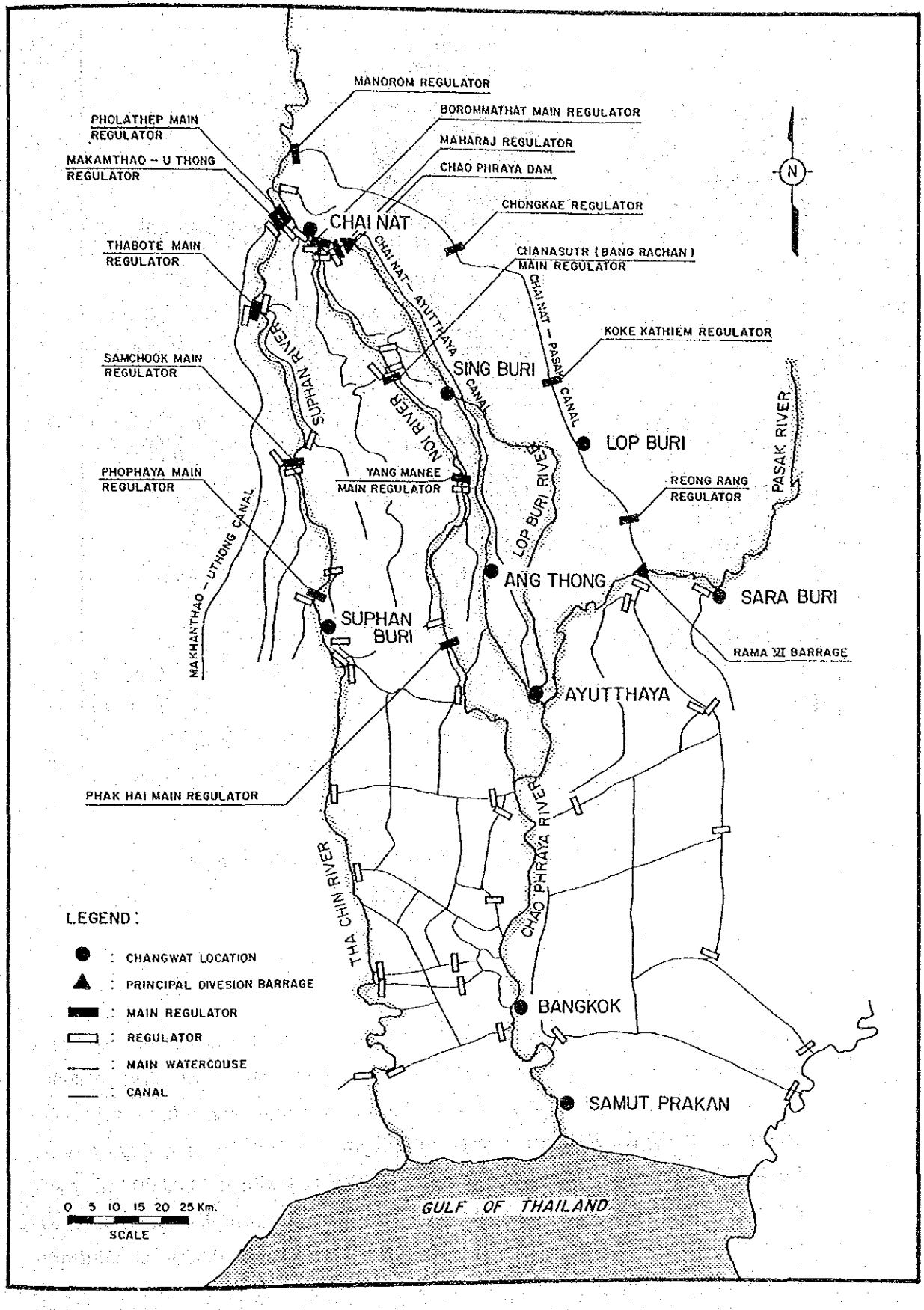


Fig. 12.3 Major Canals and Regulators in the Delta

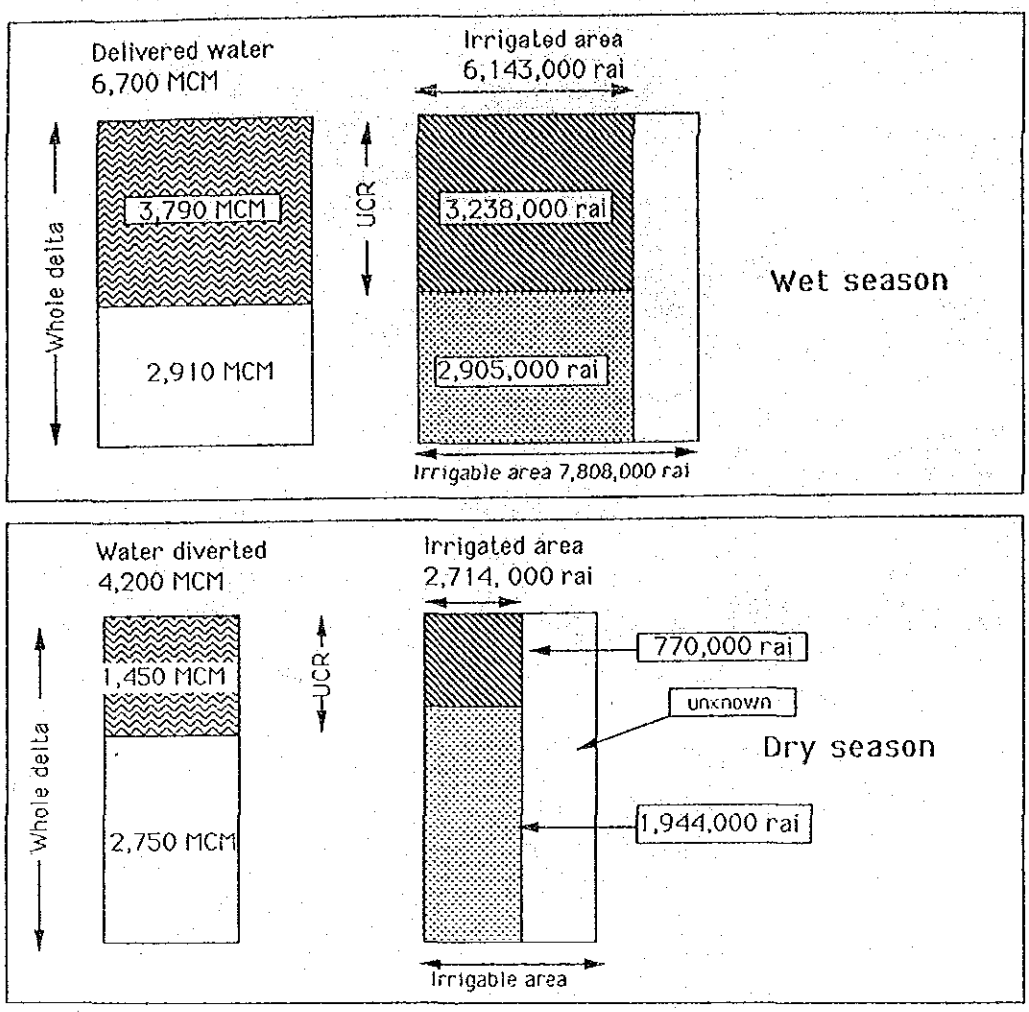
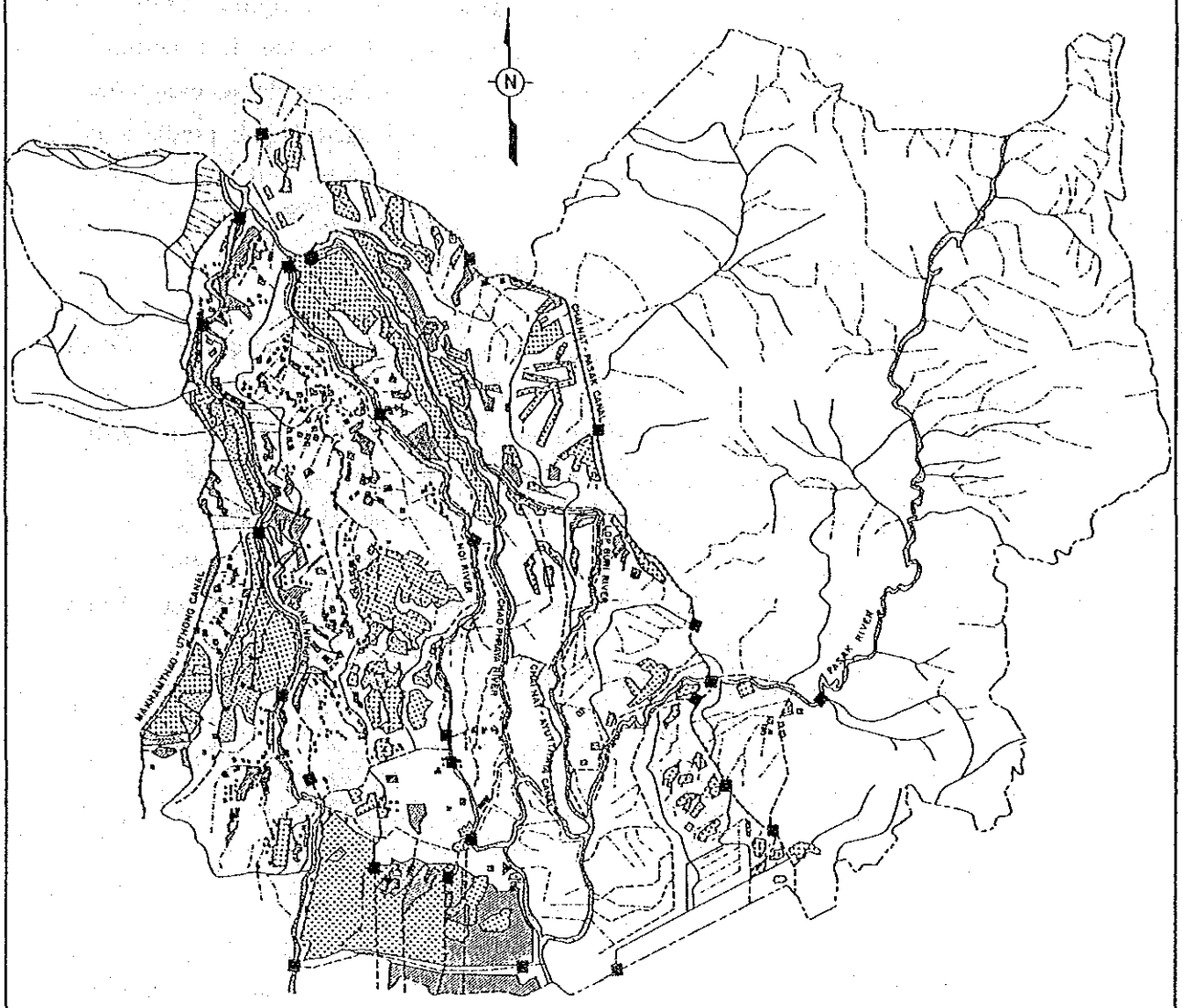


Fig. 12.4 Diverted Water and Irrigated Area in Wet and Dry Season

Water allocation practice by the RID is a kind of land use control by the government. Fig. 12.5 shows such a government practice in dry season. The RID is finding difficulty in such control over farmers. In a dry season of 1988, the RID set a target to irrigate 744,000 rai of paddy in the Region 7. However, unplaned area for rice of additional 988,000 rai was planted with rice due to high market price of rice. Similar situation was observed in the Region 8, i.e., actual planted area of 680,000 rai contrary to the government plan of 200,000 rai.



LEGEND :

- STUDY PROJECT AREA
- RIVER
- MAIN IRRIGATION CANAL
- IRRIGATION CANAL
- DRAINAGE CANAL
- LATERAL CANAL
- DAM
- REGULATOR
- TARGET AREA FOR THE SECOND RICE BUT NOT PLANTED
- SECOND RICE CULTIVATED IN THE TARGET AREA
- SECOND RICE CULTIVATED OUT OF THE TARGET AREA
- SHRIMP PONDS – FISH PONDS

Fig. 12.5 Dry Season Irrigation in the Delta (1987)

Another problem is increasing complication of land use in the delta. Although the Great Chao Phraya Project was designed for wet season paddy, other agricultural production activities which require water supply are increasing, such as cash crops, vegetables, and fish culture. Timing and the amount of water supply to these agricultural production are different each others. The diversification of agricultural produce is now imposing difficulties to the RID.

3) Small and Medium Scale Water Resources Development

The upland areas is dependent mainly on the rain-fed agriculture. Small and medium scale water resources projects have been implemented by the RID as well as by other government agencies. Location of the small and medium scale projects completed by the year 1986 and a few small scale projects under construction in 1987 are shown in the Fig. 12.6. Irrigable areas by the small and medium water resources development projects of RID, which were completed by the year 1987, are shown below:

Changwat	Medium Scale	Small Scale
Chai Nat	23,000 rai	157,000 rai
Lop Buri	47,000 rai	108,000 rai
Sara Buri	97,000 rai	25,000 rai
Total	167,000 rai	290,000 rai

It should be noted, however, the total irrigable area is not necessarily irrigated every year owing to the rain and a lack of facility maintenance.

4) Urban and Industrial Water Uses

Sources of urban water supply in the UCR are natural rivers, irrigation canals and groundwater. The total urban water supply in the UCR is 54,800 m^3/day, which is 20 MCM in total annual volume. Assuming daily use of 130 liter per capita, this amount of water supply is estimated to cover 57% of the present urban population

Rural settlements utilize water at natural rivers, irrigation canals and rain water. The total amount of domestic water consumption by rural

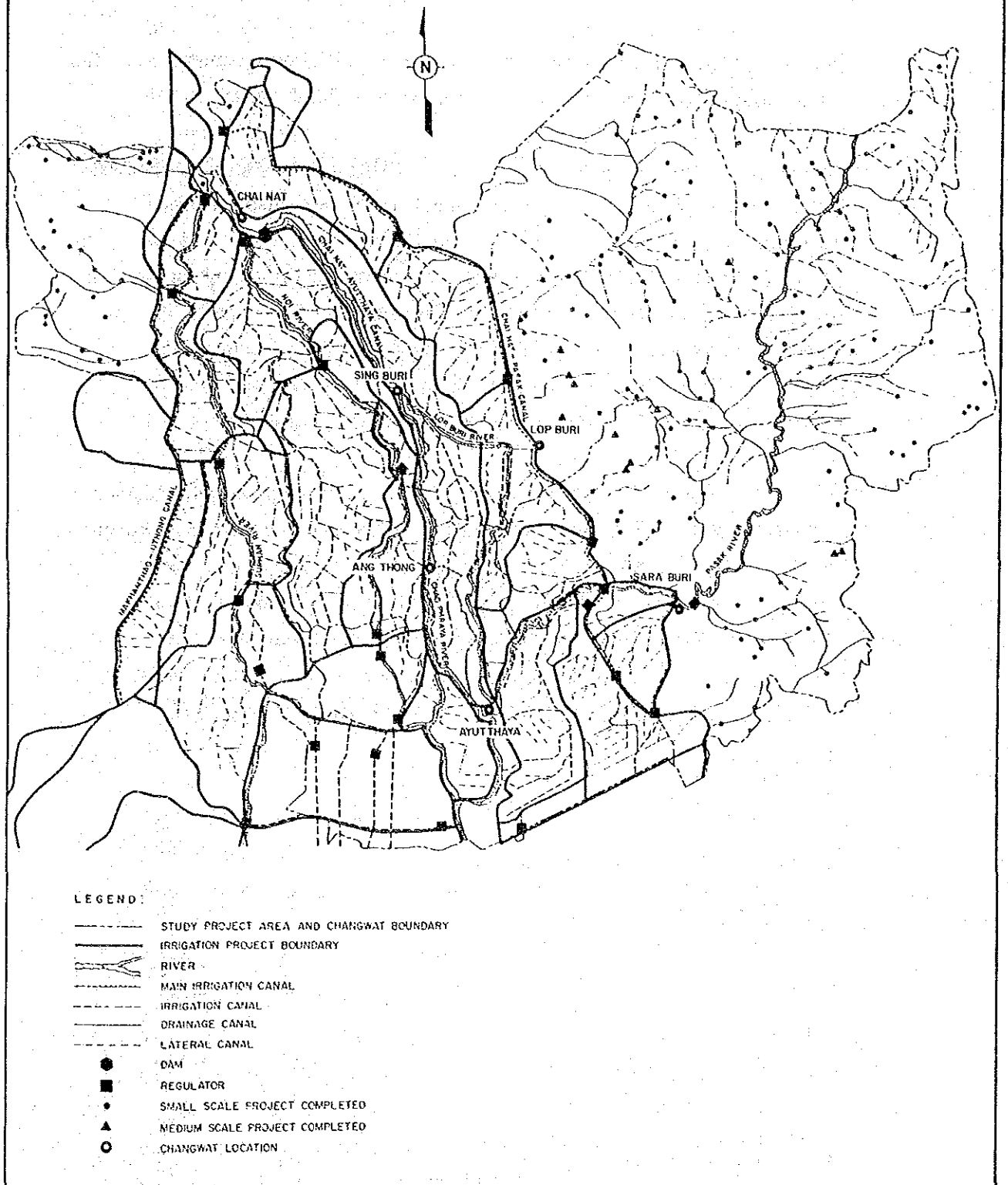


Fig. 12.6 Small and Medium Scale Irrigation Project

settlements may be estimated at 36 MCM/year by assuming 50 liter per capita per day.

Bangkok Metropolitan Waterworks Authority withdraws water from the Chao Phraya River and its volume amounts to 778 MCM.

Sources of industrial water supply, in the UCR, are mainly groundwater, but Chao Phraya River and other natural rivers are also utilized. According to our industrial survey, high dependency is found on river water in Changwat Ayutthaya and on groundwater in Changwat Lop Buri and Sara Buri. The total amount of industrial water, at present, is estimated at 50 MCM/year in the UCR.

5) Balance of Water Availability and Utilization

Table 12.2 shows the present water availability and potential together with water uses in the UCR. It is clear that available water is sufficient to satisfy water use demand.

Table 12.2 Present Water Resources Availability/Potential and Uses

(Unit : million cubic meter)

Surface water availability (1977-1986 avarage	Wet Season	Dry Season
1. Chao Phraya delta		
Water delivered to the UCR delta	3,790	1,450
2. Chao Phraya River : Water release at Chai Nat Dam		
Flow needs*	2,000	2,000
Flood spill**	10,760	1,060
3. Upland area water resources potential		
Chai Nat, Sara Buri and Lop Buri Province	1,176	785
Upland (available storage)	78	78
4. Pasak River		
Water resources potential at Kaeng Khoi	2,146	206

Water uses	Wet Season	Dry Season
5. Irrigation water		
UCR delta	3,790	1,450
6. Domestic water		
Urban settlement	10	10
Rural settlement	18	18
7 Industrial water	25	25
8.Total volume of 6. and 7.	53	53

Balance :Volume of 8. is met by the available water of 1, 2, 3, 4 and groundwater.

Note : * Flow needs is the amount to satisfy downstream water demands.
** Flood spill is unavailable to downstream demands due to unstable flow of released floods

However, water availability in the delta (no. 1 in the table) is not sufficient for potential dry season irrigation demand. Chao Phraya River release (no. 2 in the table) is not sufficient for the river navigation where the navigation demand is 300 m^3/second, which is equivalent to 47,000 MCM in each season.

12.3 Water Resources Balance of 2010

1) Irrigation Water

After the major project "improvement in communication and data management system." is completed, water use efficiency will rise by 5 to 10% in the whole delta. Ten percent increase is equivalent to additional 145 MCM available for the UCR in dry season.

Water conservation in the upper delta of the UCR would yield additional water at the on-farm level. This amount, which is available in dry season, may be assumed with the target of 50 MCM in the gravity irrigation area of the UCR. In the upland area, the target of small and medium scale water resources development is set to create the storages for the 10% of total annual run-off, which is equivalent to 200 MCM. The present level of storage, under the category of small and medium scale projects, is 4% of the annual run-off.

Pasak Dam may be constructed at Pattana Nikhom of Changwat Lop Buri. The amount of availed water may, then, be assumed at 7 m^3/second or 100 MCM in dry season.

2) Domestic Water

The total amount of domestic water supply for the UCR, in 2010, is estimated at 142 MCM/year. Metropolitan Waterworks Authority will continue to withdraw water from Chao Phraya River, and it plans to intake water from Maeklong River. The intake from Chao Phraya River will reach 1700 MCM/year in 2010.

3) Industrial Water

The total amount of industrial water supply, in 2010, is estimated at 166 MCM/year. This volume is at the similar level of domestic water supply.

4) Water Resource Balance

Table 12.3 presents the water resources balance in 2010. The projected volume of water demand for domestic and industrial consumption is 154 MCM per year for each wet and dry seasons. The annual total is 308 MCM per year. This amount is 10% and 4% of water to be delivered to the delta area in the UCR in wet and dry seasons, respectively. This share of 10% in dry season is rather significant.

Table 12.3 Water Resources Balance in 2010

(Unit : million cubic meter)

Surface water availability (2010)	Wet Season	Dry Season
1. Chao Phraya delta		
Water delivered to the UCR delta	3,790	1,595
Availed water storage by water conserva	50	50
2. Chao Phraya River : Water release at Chai Nat Dam		
Flow needs*	2,000	2,000
Flood spill**	10,760	915
3. Upland area water resources potential/availability		
Upland (potential)	1,176	785
Upland (available storage)	200	200
4. Pasak Dam		
Availed water resource	100	100
5. Pasak River		
Water resources potential at Kaeng Khoi	1,946	206
Water uses	**Wet Season**	**Dry Season**
6. Irrigation water		
UCR delta	3,790	>1,595
7. Domestic water		
Urban settlement	35	35
Rural settlement	36	36
8. Industrial water	83	83
9. Total volume of 7 and 8	154	154

Balance :Volume of 9. is met by the available water of 1. 2. 3. 4. 5 and groundwater.

Note : * Flow needs is the amount to satisfy downstream water demands.
** Flood spill is unavailable to downstream demands due to unstable flow of released floods

Assuming 30% of 154 MCM may be met by groundwater, 108 MCM is to be met by (1) delivered water to the delta area of the UCR, (2) Chao Phraya River flow needs, (3) upland storages, (4) availed water by Pasak Dam, and (5) Pasak River itself. A total of (1), (3), and (4) together with 10% of (2) and (5) amounts to 2,166 MCM. This total should be sufficient to satisfy the increased water demand of domestic and industrial sectors, which is 5% of the available total. Local water shortage may ,however, be foreseen at Sara Buri area since urban and industrial growth is expected to take place around Sara Buri.

12.4 Proposed Projects

1) Chao Phraya Delta Irrigation Redevelopment

(1) Chao Phraya Irrigation Operation Improvement Project

This project aims at enhancing overall efficiency in the utilization of irrigation water by improving communication and data management systems as well as by improving operation of major structures of RID.

This project consists of: (A) installation of equipment such as telemeters and radios at water level observation stations and (B) civil works such as improvement of on-farm facilities and gate structures, and canals. The gate structures can be automated by replacing present manual operation. This project should be implemented by the RID after the completion of feasibility study.

(2) Chao Phraya Feeder Canal Rehabilitation Project

The RID's maintenance activities are limited with the resources to properly maintain all of its facilities from the main to sub-lateral canals. The maintenance of lateral and sub-lateral canals can be made by farmers without any technical difficulties. Although maintenance activities by farmers should be made by their own resources as they are the beneficiaries, a government's financial source may be utilized as a part of the resources.

2) Pasak River Basin Development

(1) Pasak Small and Medium Water Resources Project

This project is intended to make more water available for various farming activities such as paddy, upland crops, orchard, livestock, and fish culture in the Pasak Basin. The upland areas are traditionally dependent on rain-fed agriculture and are subject to unstable production; however, the upland areas have received less water resources investment in the past. By implementing medium and small scale projects, storage may be increased from the present level of 4% to 10% of total run-off in the upland area.

It is recommended to conduct a study for identifying potential sites of medium scale projects in the upland areas. Small scale projects are to be requested by the local people and submitted to the central government through local level agencies, and then the National Water Resources Committee makes coordination for their implementations by various agencies. Since the implementation of large scale Pasak Dam project is recommended, the coordination of medium and small scale projects with the Pasak Dam project will be necessary in terms of water resources development and beneficiaries. It is important to avoid possible overlaps among medium and small projects. Coordinating role of the National Water Resources Committee will be very important.

(2) Pasak On-farm Water Storage Project

This project is intended to make more water available for farming activities and at the same time to improve environment by increasing vegetation on the upland areas. Water conservation may be made by creating water storages in various forms such as a farm pond and raised-bed cultivation. This activity should be performed either by individual farmers at on-farm level or by farmers' groups collectively. Technical advices may be provided by the government agencies.

The water stored in the rainy season may not be sufficient for the whole dry season if catchment area and storage size are small. After water conservation storages are created, the need of more stable water supply will become high among farmers since they have the measure of water storage and they are accustomed with using water for agricultural activities. Then, the need and preparedness of farmers to implement the medium or large scale reservoir projects will increase. With its implementation, the medium or large scale reservoirs may be connected with the farmers storages; and this arrange will result in high efficiency in the government investment of medium and large scale project.

(3) Pasak Dam Project

This project is intended to increase water availability in the upper east delta and particularly at Sara Buri area. The original project objectives were to increase water availability in the lower east delta and to mitigate flood at the downstream of Rama VI Barrage and in the lower east delta. It is recommended to shift the major beneficial areas of water supply from the lower east delta to Pasak Basin and upper east delta. Pasak River Basin deserves to receive the benefits from the project since a part of the basin has to sacrifice the area to be inundated by the reservoir.

There are two proposed sites for Pasak Dam: at Phattana Nikhom as upstream site and Kaeng Khoi as downstream site. We recommend the upstream site. This is because the scale of inundation would be closer to a socially acceptable level at the upstream site than the downstream site. Upland areas of Changwat Lop Buri and Sara Buri have a chance of utilizing the reservoir by both reservoir releases and pumping from the reservoir.

This project will increase the flexibility of water management in both the upper and lower east delta. Such flexibility will be gained by the following manner. After the completion of Pasak Dam, the upper east delta can utilize more water from the Chai Nat-Pasak Canal and this increased amount may be substituted by Pasak Dam

release for the lower east delta. By having two sources of water, the east delta will gain flexible water management.

Benefits of the dam are not only for the agriculture. It has multi-purpose benefits. The project's implementation will augment water available for the GSIC, where urban and industrial development is planned. This will allow more flexible water resource management with the existing water sources at Chai Nat-Pasak Canal.

3) Groundwater Potentials Study Project

This project is intended to facilitate and to the control groundwater use by industries in the GSIC. As described above, industrial water used are expected to increase in Changwat Sara Buri. It is always beneficial to have alternative sources of water supply and surface water and groundwater can be used conjunctively, which is safe for industry and for resource conservation as well. By evaluating groundwater potentials in terms of locations and safe yield, it will facilitate industries to secure a source of water supply and, more importantly, it will restrict the industries from over-exploitation of groundwater. This study should be conducted by the Department of Mineral Resources.

13. TRANSPORTATION

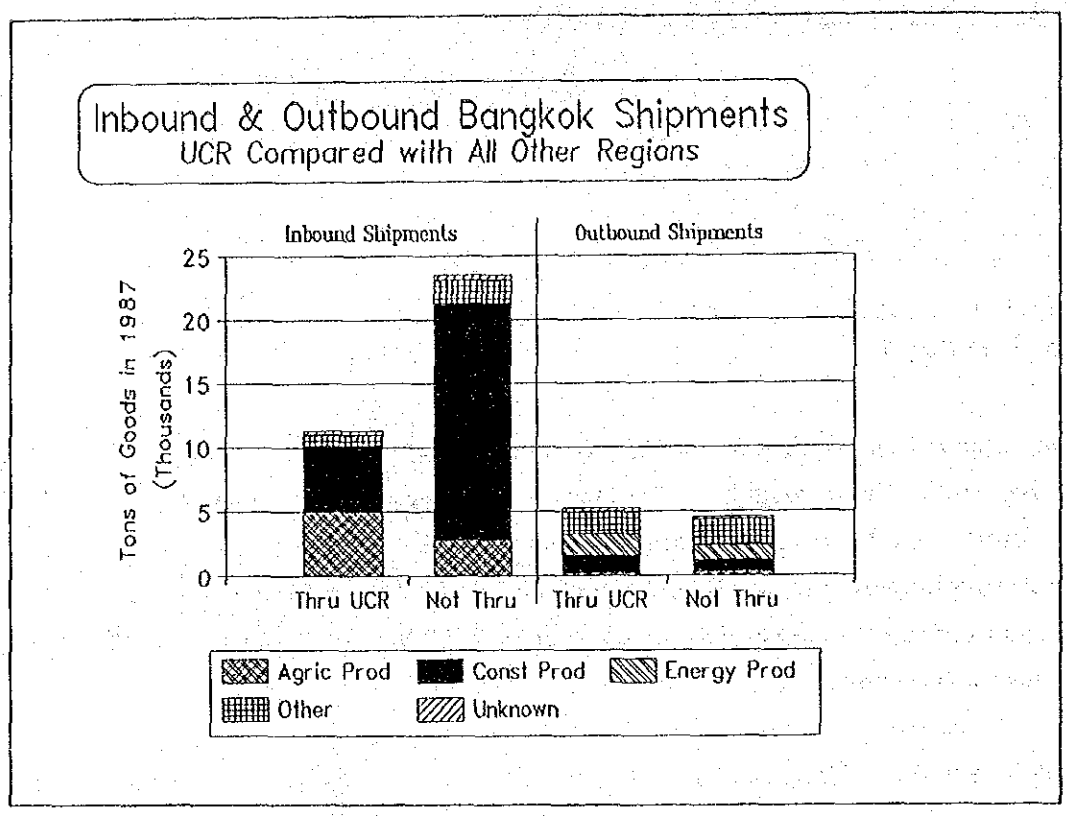
13.1 Issues

The Upper Central Region (UCR) is situated in Central Thailand, directly north of Bangkok. It is roughly "Y" shaped, and serves as the gateway for Bangkok to the entire northern and northeastern portions of the nation (see Fig. 13.1). The determination of transportation development is to apply the macro-spatial considerations of spatial development of the UCR. In essence, the following issues are important:

- 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. Thus, is 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.

  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 also be improved, strengthened, and made more direct.

- Industrialization of the Eastern Seaboard (ESB) of the Gulf of Thailand calls for direct connections between regional cities, and the industries and ports along the ESB. Continuous expansion of the national economy will warrant the diversified modes of transport which include highway, railway, petroleum pipeline and inland water way between the BMR and other parts of the country including the UCR.



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

Fig. 13.1 The UCR as a National Gateway

- For the intraregional road network, all Changwats within the UCR should be connected by reasonably direct links at an appropriate level of service.

- The UCR is a major corridor for the export of rice, maize and tapioca. As an economical means of transport, inland waterway transport plays a special role in the export of these commodities as well as in the transport of low unit value balk cargoes. Due attention should be paid to this means of transport especially for agricultural export in light of cargo-specific intermodel coordination.

13.2 Transport in the Upper Central Region

13.2.1 The Highway Network : Arterial and Collector Roads

1) The Existing Network

The present arterial and collector network in the Upper Central Region is illustrated in Fig. 13.2. 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 figure 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.

2) The Approved Network

The are 50 DOH highway projects for which the budget has been secured. There projects are the ones which were 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 map in Fig. 13.3. Total length of highways under these projects reach 1467 Km^2 (30 Km per project on average), and most of them are improvement and asphalting work on existing roads with exception of Sara Buri and Ang Thong by-passes, which are new construction.

We have analyzed the present network from the three viewpoints of (A) design standard, (B) the level of service (LOS) for present traffic demand and (C) the circuity factor in view of future traffic demand.

(A) Design Standard

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 13.1

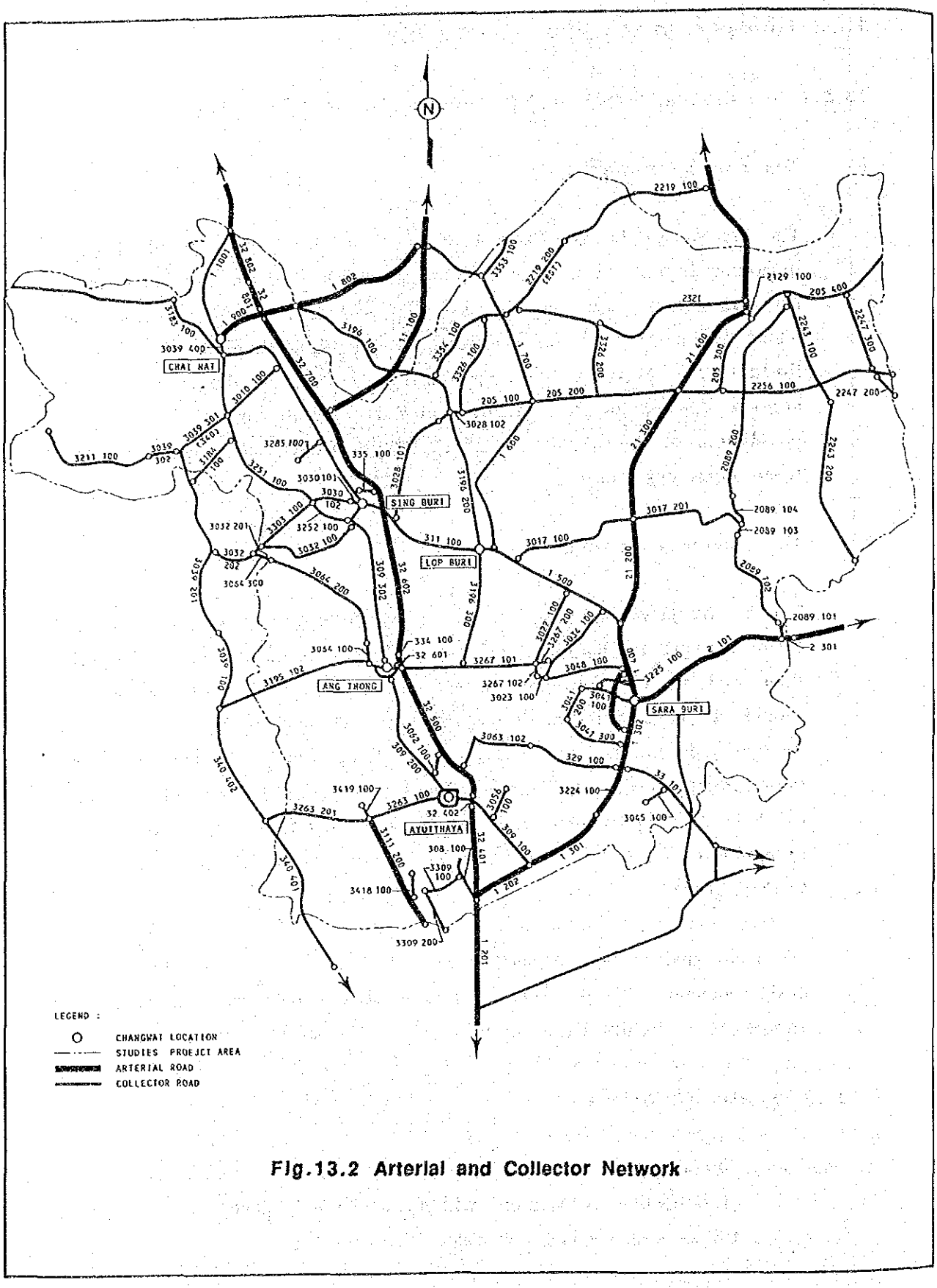


Fig.13.2 Arterial and Collector Network

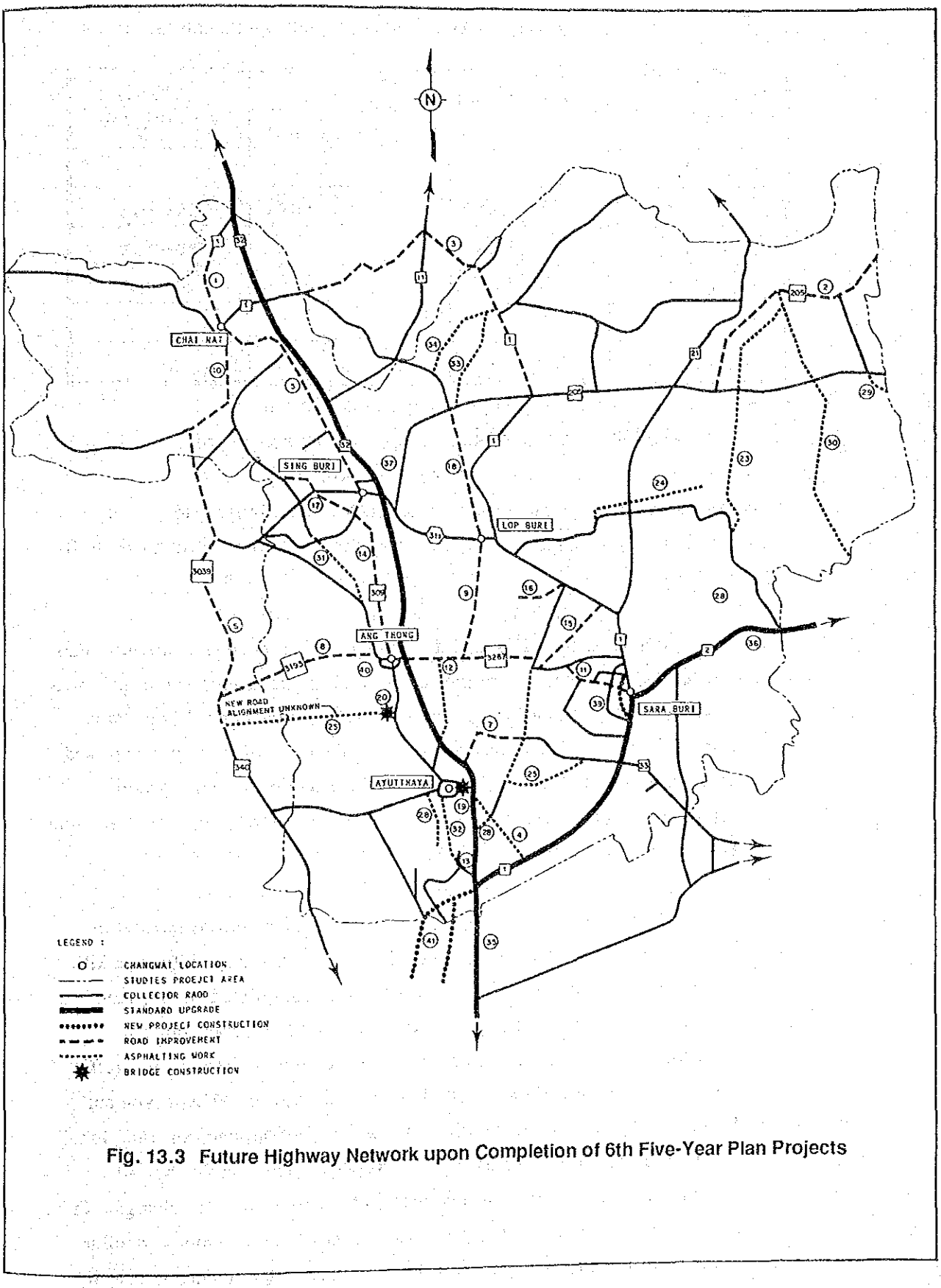


Fig. 13.3 Future Highway Network upon Completion of 6th Five-Year Plan Projects

Table 13.1 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 Department in the Central Region", JICA; and
"Study of Rural Roads" DOH

However, there is at present too much accessibility along the arterials, thus impeding their primary function to enhance traffic mobility.

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.

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-land 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 "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.

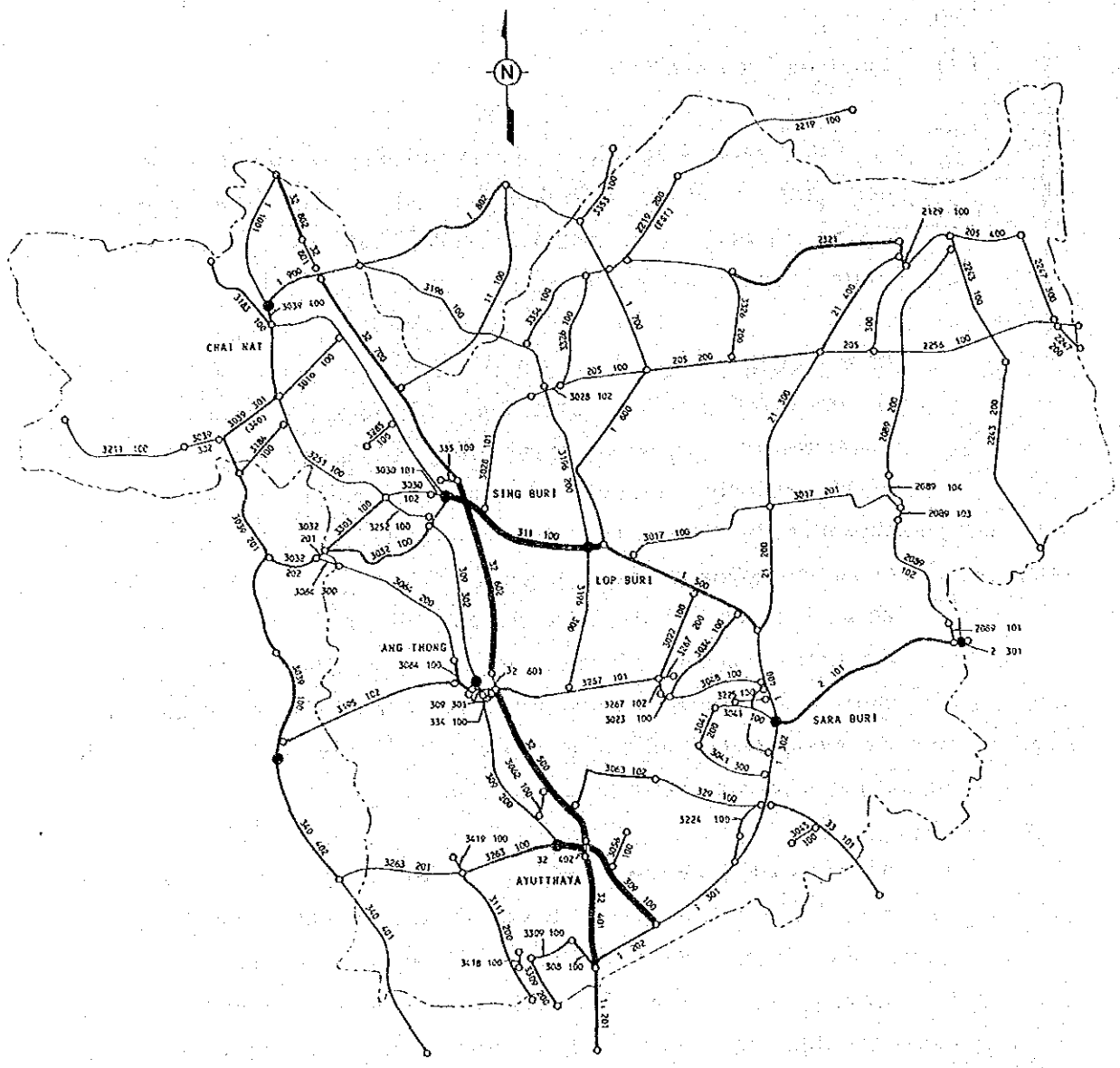
(B) Level of Service (LOS)

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.

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. 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 calculations are shown in Fig. 13.4.

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 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.



LEGEND:

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

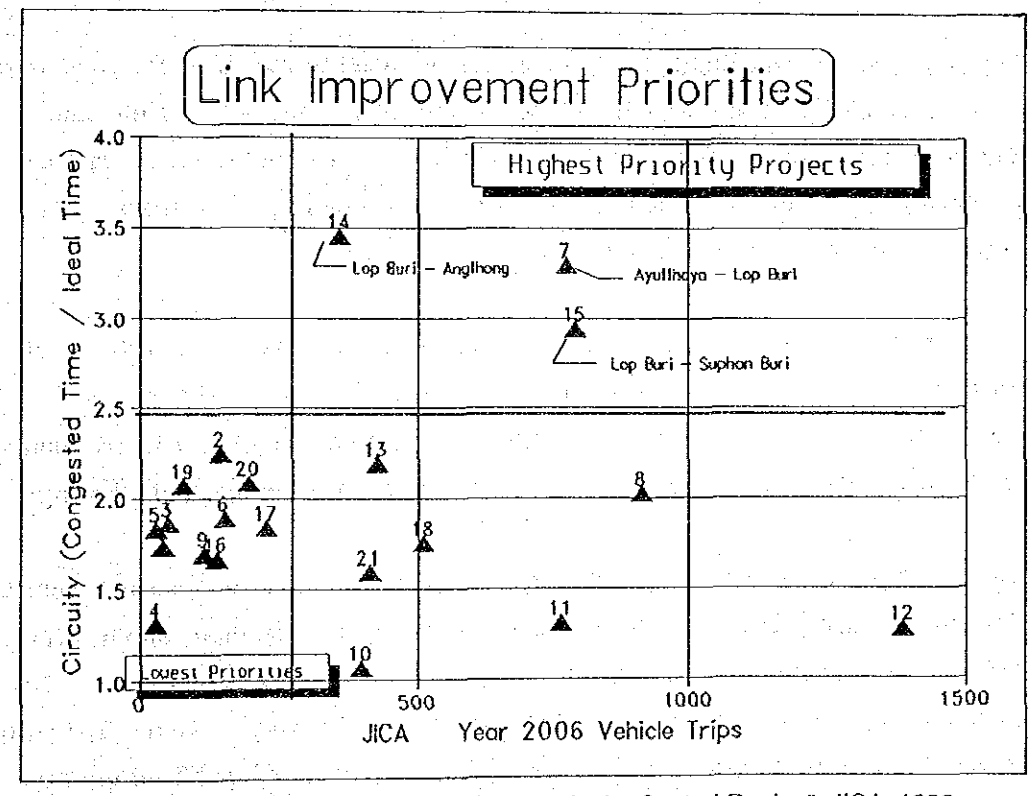
Fig. 13.4 Level of Service (LOS) Map

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

(C) Circuity Factor

Circuity factor is to compare the congested travel time (based to 80 km/hr design speed) with the theoretical shortest possible travel time between Changwat centers based on the same speed along a straight line.

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. 13.5.O-D pairs where the number of daily trips was high and the circuity factor was high were considered as higher priorities for improvement. 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.



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

Fig. 13.5 Circuity versus Demand Predictions : Priorities for Improvement

13.2.2 Local Roads

The UCR appears to be relatively well served with local roads when their density in terms of the number of road kilometers per square kilometer is compared to the density in other regions. However, road service is generally poor in selected areas of the UCR, notably in Ayutthaya and parts of Ang Thong provinces which suffer from chronic floods (see Fig. 13.6.).

The simple fact that road service is generally poor in parts of Ayutthaya and Ang Thong province does not, in the opinion of the study team constitute a significant problem which requires immediate action by the Thai government.

It was observed that during the dry season, a large number of people are able to travel by *song thao* along roads maintained by the Royal Irrigation Department. During the rainy season, even though the buses still run, 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.

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 quit 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.

Local roads have been constructed and maintained by a number of central government agencies as well as local governments and their subdivisions. The central government agencies involved are Public Works Department, Office of Accelerated Rural Development, Department of Highways, Royal Irrigation Department, Agricultural Land Reform Office, Community Development Department and National Security Command. There is a great need to coordinate planning of local roads at the Changwat level and strengthen planning and coordinating capability of local authorities and Changwat administration.

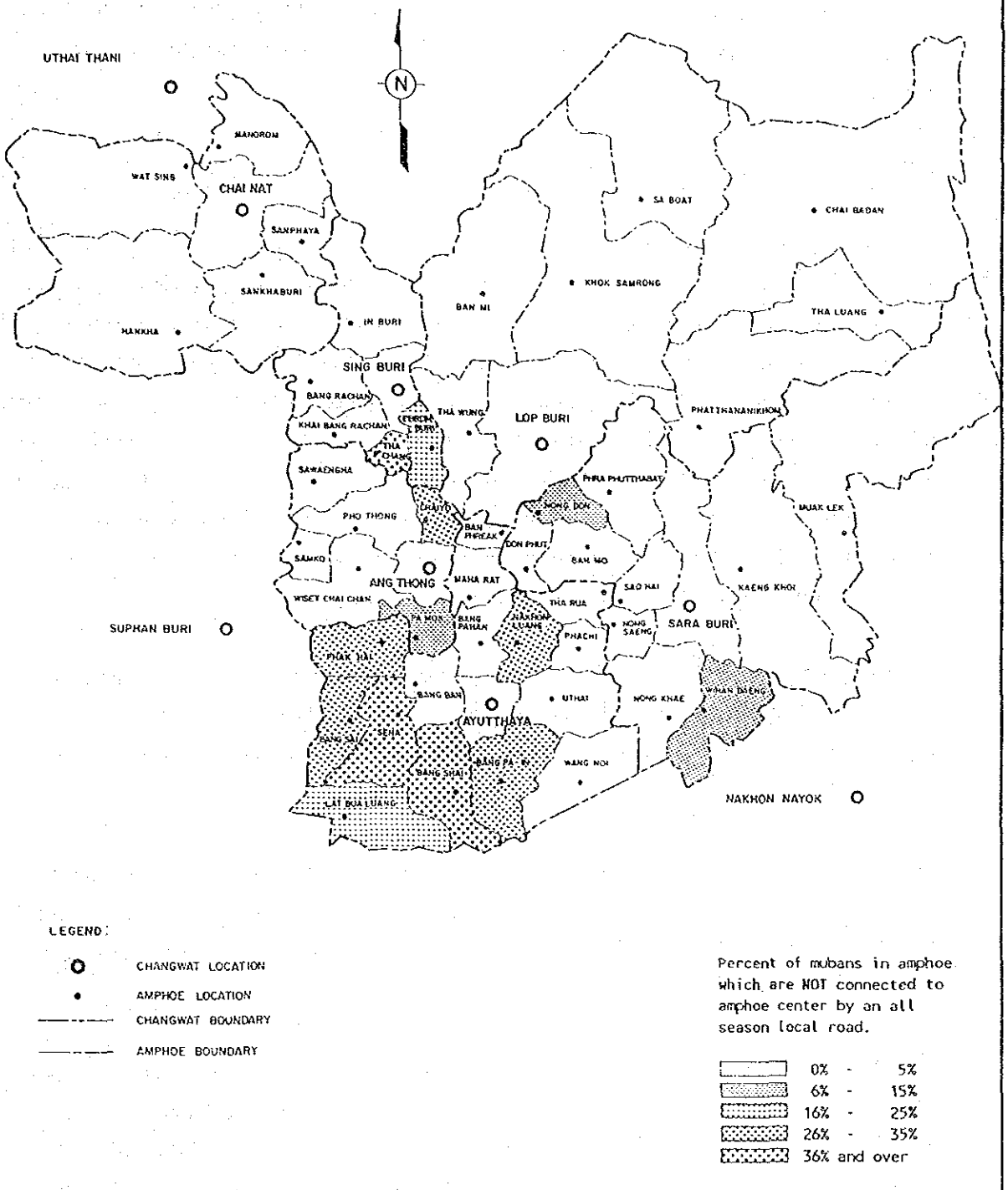


Fig. 13.6 Mubans Not Connected to Amphoe Center

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, this most likely should be done through existing agencies.

13.2.3 Railways

In 1987/88, about 1.55 million tons were shipped out of the UCR. This represents 25.0% of the national total. Three types of bulk shipments: petroleum products, rice and cement comprise 65% of all rail freight, and the use of unit trains (entire trains dedicated to a single product) has become the most common type of freight shipment. In 1987, over 99% of all freight tonnage was by unit train. Due to the fact that a significant portion of rail transport costs are involved in loading, unloading, and shunting operations, line haul distances have gradually been increasing and cargo traffic is almost exclusively full container load (FCL). In spite of such economizing measures, the annual deficit due to rail freight hauling has increased over time.

As for passenger traffic, in 1987, there were just under 6.5 million passenger trips by rail which originated in the UCR. The number represents approximately 8.3% of the total passenger trips of the national total of all rail operations.

The average number of UCR-Bangkok based passengers on each train passing through the UCR was over 450. This clearly shows that the demand for travel by rail is inherently quite high in spite of numerous operational problems that State Railway of Thailand (SRT) is 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. Ban Mo and Ban Chong Tai in the UCR are two of the larger freight stations in the nation (see Fig. 13.7).

As shown in Fig. 13.8, the operational problem of the SRT results in train delays especially in the north and northeast of Bangkok. Problems exist in the UCR between Ban Phachi and Lop Buri (the northeast line) because of the single

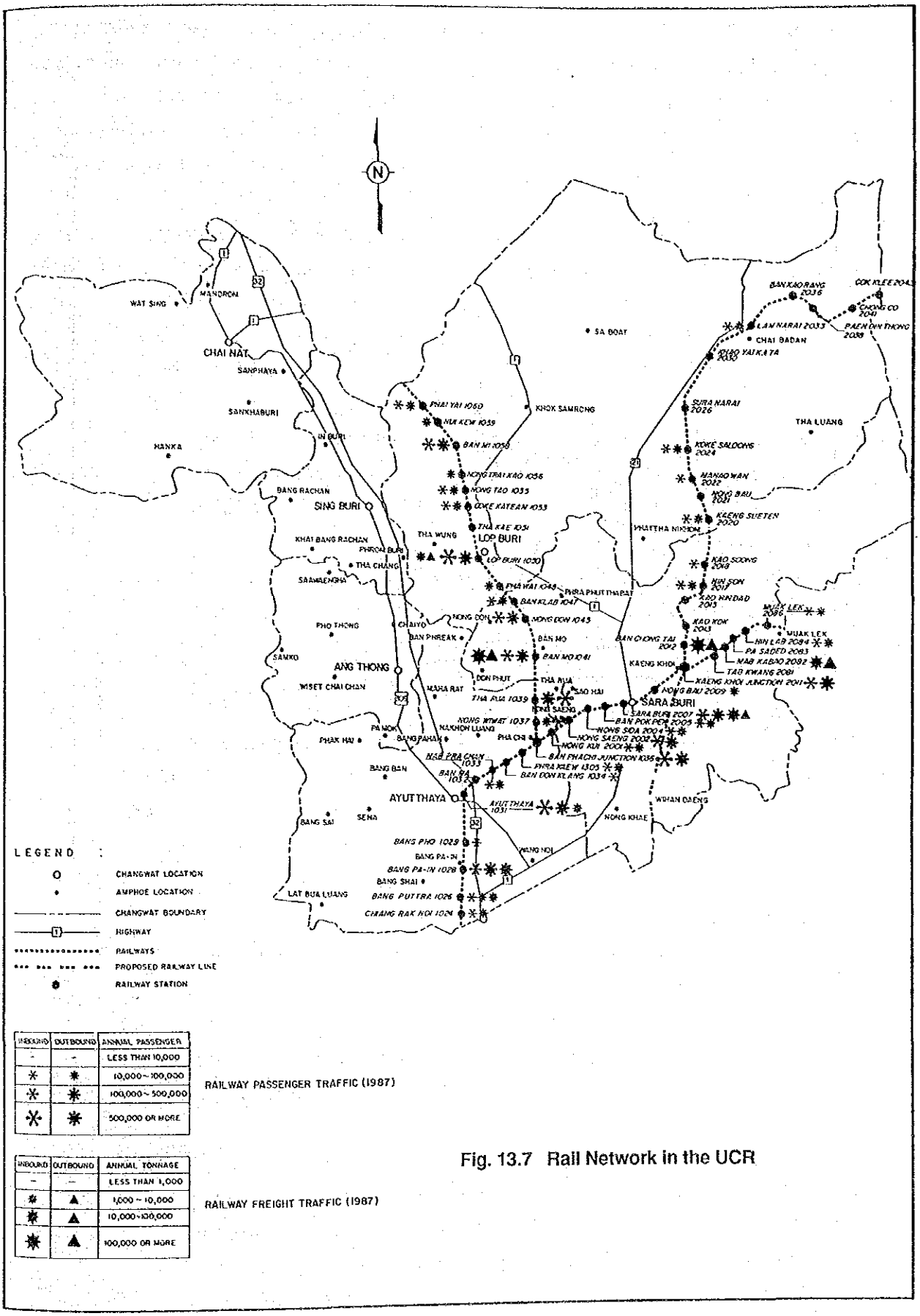


Fig. 13.7 Rail Network in the UCR

tracking north of Ban Phachi. From Bangkok to Bang Sue, of grade crossing greatly hinder operations.

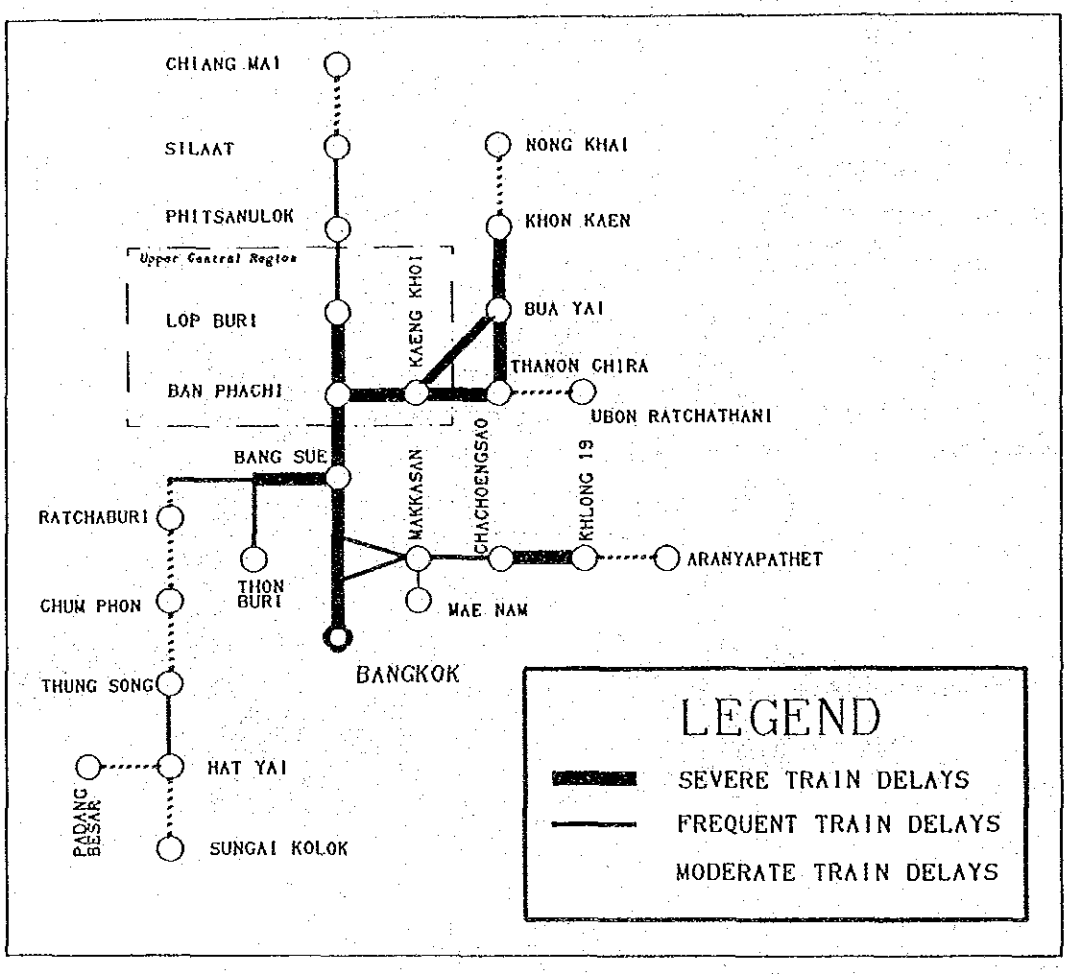


Fig. 13.8 Rail Transport Operation Bottlenecks

The northeastern 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 an effort to solve these problems and increase the use of the existing railway network, SRT plans to implement a number of projects. Of them, those which will directly benefit the UCR are the following :

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 Klong 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.

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.

Intensifying traffic congestion in Bangkok will eventually warrant the introduction of high capacity inter-city rail as a major means of passenger transport in and around the BMR. The proposed sky train must efficiently be utilized by linking it with the inter-city rail. On the part of regions surrounding the BMR, the efficient absorption of the activities decentralize from in core cities will be made possible by making use of the rail and its stations. A vicious cycle of ribbon-type urban sprawl and intensified and expanding traffic congestion would continue to an extent that the national economic growth is obstackled by deteriorating urban service efficiency in Bangkok, unless such basic solution is made for the transport problem of Bangkok.

The inter-city rail should be considered not only toward the northern direction, at which the UCR is situated, but toward the south eastern and western directions within a long-term framework of infrastructure network development in the central region. The inter-city rail could be laid out on either the existing SRT network or a totally new network depending on the prospects of mobilizing investment capital, especially from the private sector.

13.2.4 Inland Waterway

Transport of bulky, non-perishable goods by inland water has been, and is expected to continue to be an important form of commerce in the UCR. This is especially true in the case of cargo for export, as it is possible to bypass Bangkok land transportation problems, and proceed directly to the port at Ko Sichang or at Laem Chabang in the future.

Inland waterway transport has been plagued with problems of water depth, meandering and bank erosion, dredging, and lock width and depth in Chao Phraya River and Noi River. The problems are much less serious in Pasak River.

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. As shown in Fig. 13.9, most of the maize and tapioca slipped out from the UCR are collected by trucks and transferred to barges. Intermodal coordination between inland waterway and highway network is quit important in this regard. There is potential, it is believed not only for bulk cargo, but for containerized cargo barges similar to those which are used down stream in the UCR.

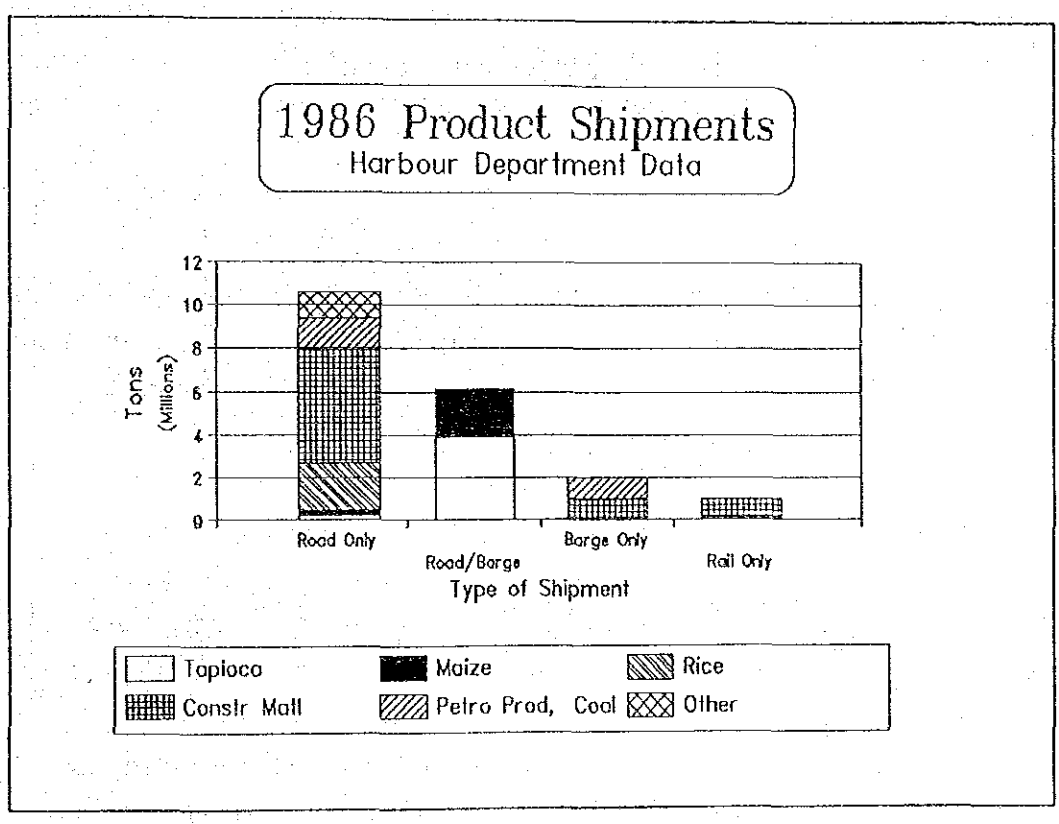


Fig. 13.9 Bulk Product Shipments in the Pasak River Hinterland

Existing traffic north of Ayutthaya is much higher in the Pasak River than in the Chao Phraya River, and is especially so when total value is considered (Fig. 13.10). The future development of the GSIC is expected to increase this disparity.

"Study for the Improvement of Inland Waterways" conducted for Harbor Department in 1988 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. is simply unnecessary.

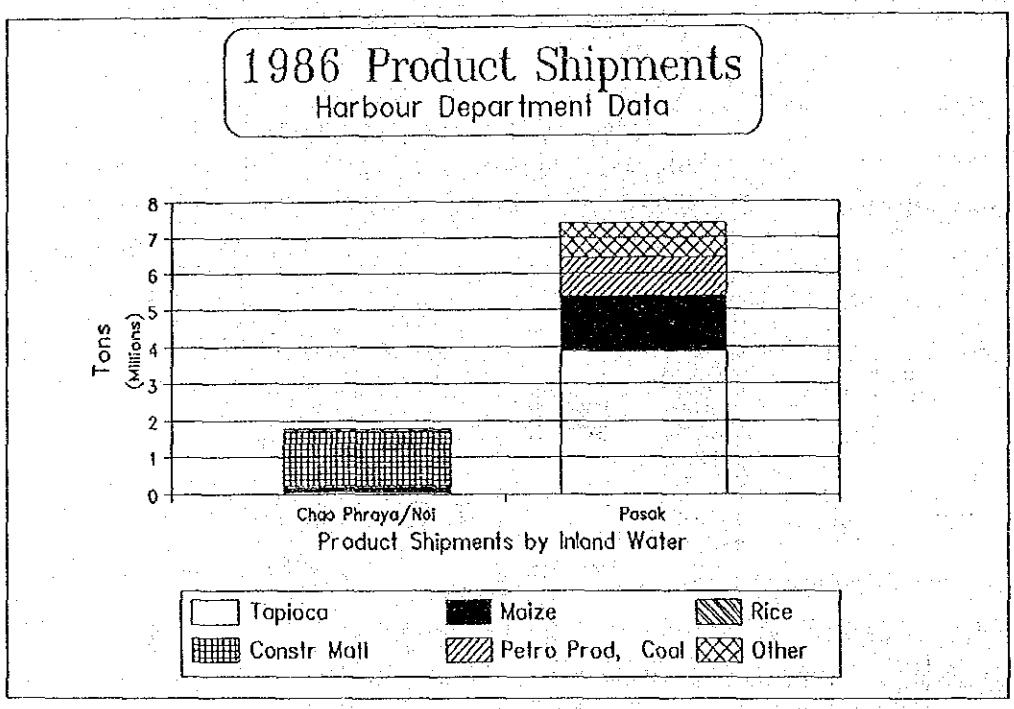


Fig. 13.10 Comparison of River Traffic North of Ayutthaya on Chao Phraya/Noi and Pasak River

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. 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. 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. Current efforts by the Harbor Department to maintain the waterways should be continued. Other necessary investments should also be made to fully utilize the existing system.

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 and Ayutthaya on the north side of the river. In the long-run, a possibility may be explored to substantially upgrade the existing inland waterway system to a modernized component integrated in the interregional transport networks.

13.3 Proposed Projects (see Fig. 13.11)

Five highway projects are proposed based on the analysis of present highway network from the viewpoint of design standard, level of service and circuity factor and based on the following planning considerations :

- Bangkok urbanization tends to expand radially along transport corridors, particularly highways. This tendency should be countered by the creation of a transport network which support the growth of development cores in the regions surrounding the BMR. It is the Greater Sara Buri Industrial core (GSIC) in the UCR.
- 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
- 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

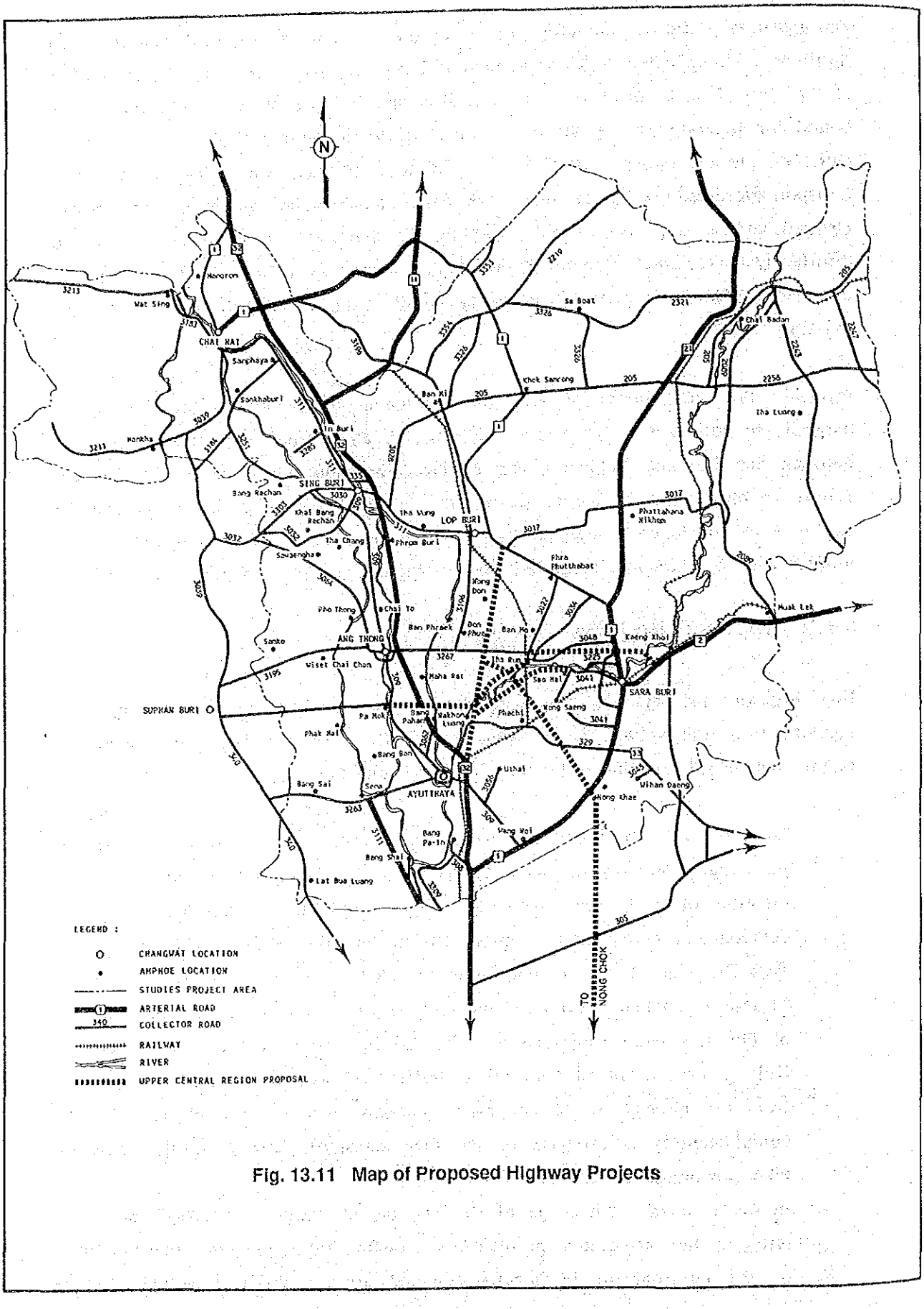


Fig. 13.11 Map of Proposed Highway Projects

which pass through the region should be improved, strengthened, and made more direct.

- 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.
- All Changwat within the UCR should be connected by reasonably direct links at an appropriate level-of-service.

In order to support agricultural and agro-processing activities an efficient integration should be made between highway network and inland waterway.

1) Ayutthaya to Lop Buri Highway Project

The highest priority project in terms of transport issues is no doubt the Ayutthaya to Lop Buri highway. The level-of-service problems around Route 311 on both sides of Lop Buri are the basis for this project. 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, which substantially reduces the travel time between Lop Buri and Bangkok. 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 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.

This highway should use a new alignment and serve Lop Buri, Nong Don, Don Phut, Nakhon Luang, and Ayutthaya.

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

It may have at-grade intersections for arterials and collector roads, but they should be signalized for arterial roads and possible channelized, with stop signs for collectors. Private access roads should be prohibited. It should not pass directly through towns, but should pass nearby.

2) Pasak River Collector Roads

This 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.

These 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.

Industrialization among the Pasak River should not be encouraged until the potential environmental danger to the Pasak River is alleviated. 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.

3) Tha Rua to Sara Buri Highway Project (East - West Link Highway)

The East-West Link aimed at connecting straight Suphan Buri and Sara Buri for the agro-processing industrial belt to be developed around the BMR is proposed to consist of this highway connecting Tha Rua and Sara Buri and the other one connecting Suphan Buri and Tha Rua, in order to adjust the original aim of the link with ongoing and already planned projects.

This project will support the development of the GSIC by connecting Tha Rua, a major agro-processing center with Sara Buri City. At present,

existing roads within this section involves numerous discontinuities. This is an extension of the planned DOH project to improve the Route 3257 between Ang Thong and Tha Rua. If two these projects are completed, Sara Buri-Ang Thong-Suphan Buri link will Substantially be reinforced.

This project also serves for alleviating the traffic congestion in Sara Buri City. The ongoing Sara Buri Western Bypass Project can take care mainly the north-south bound traffic but it is not so effective to divert the traffic between the northeastern region and Bangkok. This project will thus compliment the ongoing western bypass project.

4) Suphan Buri to Tha Rua Highway Project (East-West Link Highway)

This link is a part of the East-west Link and at the same time functions, together with the proposed Ayutthaya to Lop Buri Highway, as a short-cut between to major cities of Ayutthaya and Sara Buri. At present, there are no arterial or collector links which connect the two cities in a direct manner.

Part of this link 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.

The new UCR proposed road should cross over Route 32 by means of a grade-separated interchange, as traffic congestion is already a problem at intersections on that important national highway. Whether or not the road should actually connect to Route 32 is unresolved, but it is possible that it should not. North to south traffic could easily be taken up by the new Lop Buri to Ayutthaya highway.

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) Tha Rua to ESB Highway Project (UCR-ESB Link)

If the UCR is to enjoy an enhanced position in Thailand as an industrial and trade area, the road connection with the ESB must be improved. The UCR-ESB Link should be considered as one of a series of the links to be developed as bypass of the BMR.

Which are planned for the area related to the new Bangkok outer ring road, a more direct connection from the UCR to somewhere near Chachoengsao is in order.

This proposal is for the creation of a direct connection between the UCR and the ESB 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.

This link 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.

Though completely outside the UCR, a direct link between the northeast region and the ESB is recommended to be reinforced by streamlining the connection between the Route 3222 bound for Kaeng Khoi in the UCR and the Route 331 bound for Rayong.

It is recommended that Bangkok outer Ring Road should be completed first of all and it should be followed by the UCR-ESB Link and further by Kaeng Khoi-Rayong Link.

6) Early Completion and Accelerated Implementation of Major Planned and Ongoing Projects

The following projects are already proposed or ongoing. They should be completed at the earliest possible time, because they are expected to give great positive impact on UCR development, GSIC development in particular.

(1) Klong 19 Kaeng Khoi Railway,
(2) Bangkok Outer Ring Road, and
(3) Sara Buri By-pass