Major commodities transported from Metro Manila to Bicol or Batangas are 977 tons of food stuff for animals, 682 tons of groceries and daily products and 498 tons of milled rice. From Bicol to Metro Manila or Batangas are 1,011 tons of vegetable oils and fats. From Batangas to Manila or Bicol are 641 tons of gasoline and diesel, 588 tons of palay and 532 tons of coals.

Figure 4.3-8 showsOD patterns of three major commodities; unprocessed agricultural cash crops (copra), mineral oil products (gasoline and diesel) and processed agricultural products (milled rice and coconut oil).

4.3.4 Other Traffic Characteristics

Other traffic characteristics on the Pan-Philippine Highway are summarized hereunder. Details of various traffic characteristics are presented in Volume V "Guide for Road Function Improvement Planning".

1) Hourly Traffic Volume Variation

Generally, hourly traffic volume variation during day time from 6:00 a.m. to 6:00 p.m. is small and hourly traffic volumes are more or less evenly distributed. Therefore, there is no predominant peak hour. Peak hour ratio (ratio of peak hour traffic volume to daily traffic volume) ranges from 5.2% to 8.2% in rural sections and from 6.6% to 8.7% in urban sections.

2) Directional Distribution

Directional variation of traffic volume at the peak hour is small. Share (in %) of traffic volume of each direction ranges from 50:50 to 60:40 and mostly 55:45.

3) Travel Speed

Travel speeds in rural sections are, in general, high over 60 kms. per hour, except the following four (4) sections:

- Sta. Rita-Plaridel Sections — Travel speed ranges 40 to 45 kms. per hour due to heavy traffic volume.
- Dalton Pass Section — travel speed is about 40 kms. per hour due to sharp grades and successive sharp horizontal curves.
- Calamba-Sto. Tomas Section — travel speed ranges from 35 to 40 kms. per hour due to heavy volume of traffic.
- Pagbilao-Atimonan Section (km. 158 to km 175) — travel speed is about 40 kms. per hour due mainly to very bad pavement surface condition.

Travel speeds are drastically reduced to low speeds in major urban sections due mainly to heavy volume of traffic, high composition of slow moving vehicles like tricycle, frequent stops of public utility vehicles and on-street parkings. Travel speeds in the following major urban sections are:

Plaridel Urban Section. . . . . .20-30 kms. per hour
Gapan Urban Secion . . . . .35-40 kms. per hour
Cabanatuan Urban Section. . . . . .25-35 kms. per hour
San Jose Urban Section. . . . . .30-40 kms. per hour

In other urban sections, travel speed of about 40 kms. per hour is maintained.

4) Average Number of Passengers

Average number of passengers by vehicle type is shown is Table 4.3-3.

TABLE 4.3-3 AVERAGE NUMBER OF PASSENGERS

Survey Station (Section)	Direction	Car	Jeepney	Bus
N-02 (Sta. Rita – Plaridel)	Cagayan Bound	2.8	7.2	35.9
	Manila Bound	2.8	6.7	36.0
N-08 (San Miguel – Gapan)	Cagayan Bound	3.1	10.3	28.0
	Manila Bound	3.7	8.1	30.5
N-24 (Gapan – Sta. Rosa)	Cagayan Bound	2.9	12.5	24.8
	Manila Bound	2.9	10.9	25.8
S-05 (At Sto. Tomas)	From Batangas to Bicol	3.4	7.8	34.8
	From Manila to Batangas	2.9	10.5	45.8
	From Bicol to Manila	3.2	8.0	53.6
S-12 (Sariaya-Lucena)	Bicol Bound	2.8	11.7	32.9
	Manila Bound	3.1	12.9	29.6

SOURCE: This Study

5) Passenger's Trip Purpose

Passenger's trip purpose compositions at selected survey-stations (N-02 and S-05) are shown in Figures 4.3-9 and 10.

Survey Station N-02 (Sta-Rita-Plaridel Section)

There are about 57,560 passengers per day on this section, of which 29,670 passengers (or 52%) are transported by bus, 13,230 passengers (23%) by jeepney and 14,660 passengers (25%) by car. Bus passenger's trip is predominantly "Visit Relative", followed by "To/From Work". Jeepney passengers have various trip purposes of which major ones are "To/From Work" and "Visit Relatives". "Business" is the predominant trip purpose of car passengers.

Survey Station S-05 (at Sto. Tomas)

About 99,600 passengers pass through Sto. Tomas. Bus passengers account for about 49% (49,470 passengers), followed by 29% (28,900 passengers) of car and 12% (12,230 passengers) of jeepney. Car passenger's trip purpose is predominantly "Business". Jeepney passengers have various trip purposes of which major ones are "To/From Work", "Shopping" and "Business". Bus passenger's trip purpose composition has directional variations. Major trip purpose of passengers to/from Manila/Batangas and Bicol/Manila is "To/From Work", whereas to/from Batangas/Bicol is "Visit Relatives".

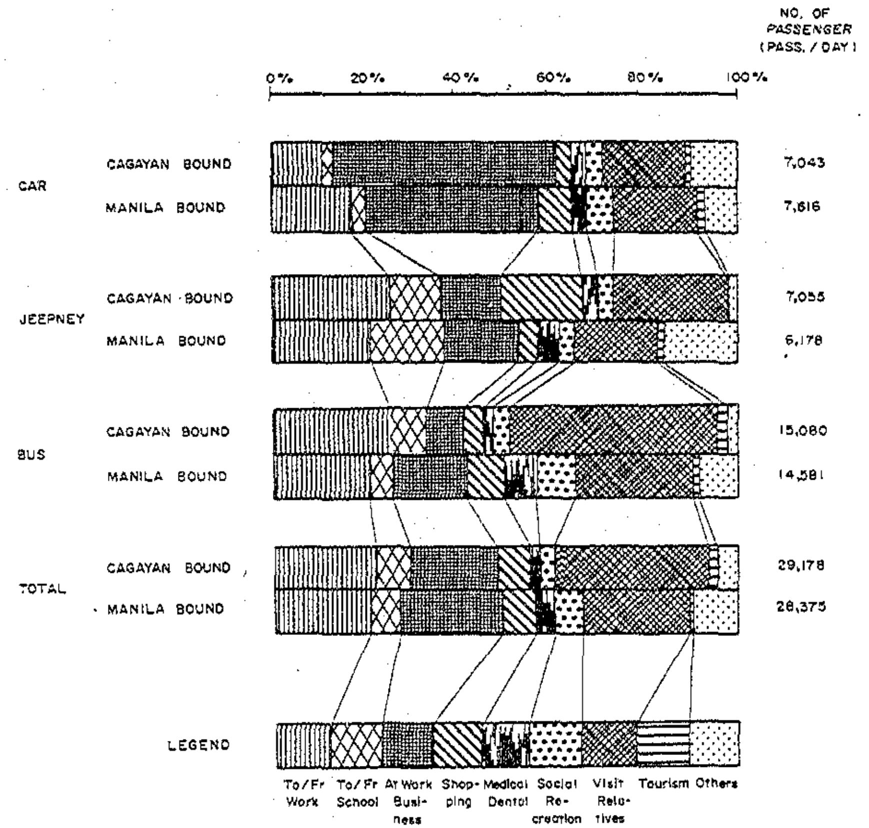


FIGURE 4.3-9

PASSENGERS' TRIP PURPOSE COMPOSITION SURVEY STATION: N-02

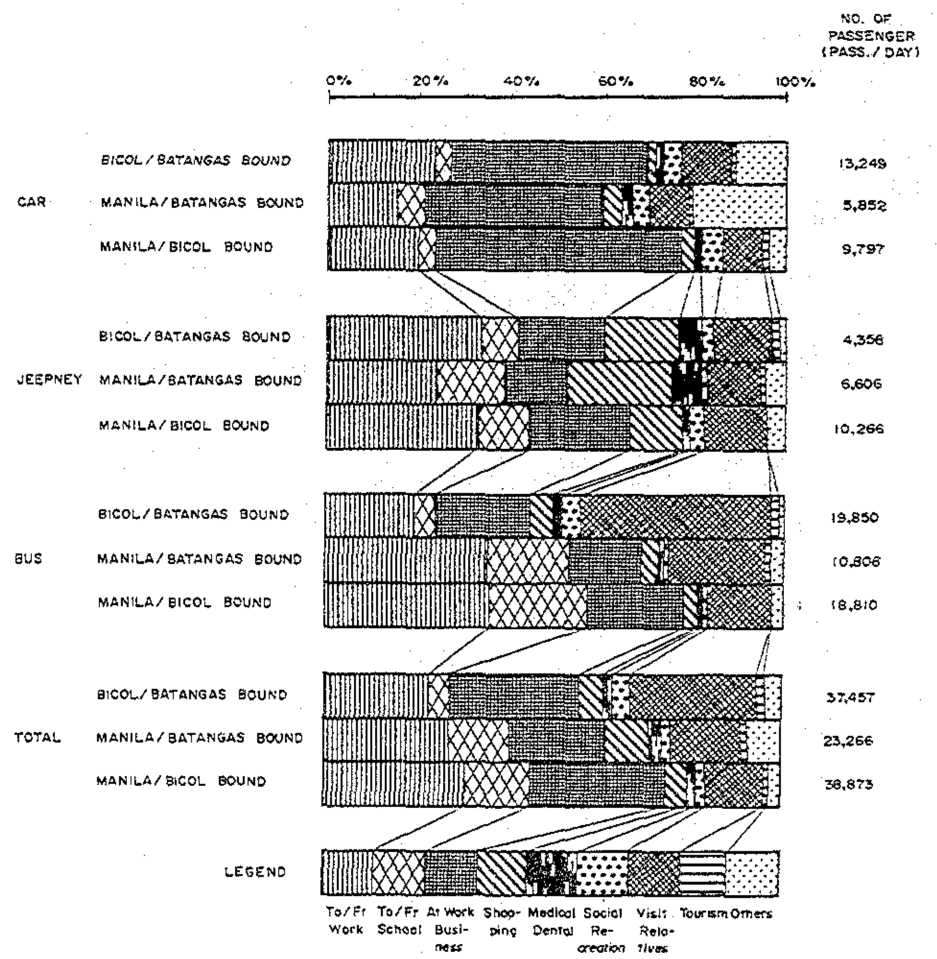


FIGURE 4.3-10

PASSENGERS' TRIP PURPOSE COMPOSITION SURVEY STATION: S-05

CHAPTER 5

TRAFFIC DEMAND FORECAST

5.1 APPROACH

5.1.1 Procedure of Traffic Demand Forecast

An analysis of current traffic behaviors in the Study Section indicates the following points:

- Traffic in the Study Section is divided into "inter-zonal traffic" and "local traffic". There are differences in the trip purpose composition between those two types of traffic. The inter-zonal traffic has various features about trip purpose composition in each vehicle types. Whereas, the local traffic has the high share of private purpose trips as represented by "shopping" and "to/from school" in all vehicle types.

- Of the inter-zonal traffic, business purpose accounts for a high share of trip purposes of car passengers, whereas private purpose accounts for a high share of public transportation passengers.

- Of the public transportation, jeepneys and buses show different trip length patterns. The average trip length of buses is longer than that of jeepneys.

- Tricycles are operated only in the urban areas, and their trip length is very short.

- There are large differences in volumes and items of commodity transported depending on sections of the Study Section.

From the above, making separate traffic forecasts for the inter-zonal traffic and for the local traffic is judged to be approriate. For the inter-zonal traffic, cars, jeepneys and buses are forecasted separately. In the case of the inter-zonal truck traffic, it is judged appropriate to first forecast volume of commodity by item and then convert these into truck trips using the loading factors. The traffic demand forecast procedures are shown in Figure 5.1-1.

5.1.2 Target Years

The target years for traffic demand forecast are established by taking into account the opening year of the project and the project life. With 1990, 2000 and 2010 as target years, future traffic volumes are forecasted based on current origin-destination data, existing traffic volumes, traffic characteristics and future socio-economic frameworks.

5.1.3 Forecast Models

The future traffic volume is estimated by growth rate model which is recommended by the "Highway Planning Manual" prepared by the then Ministry of Public Works

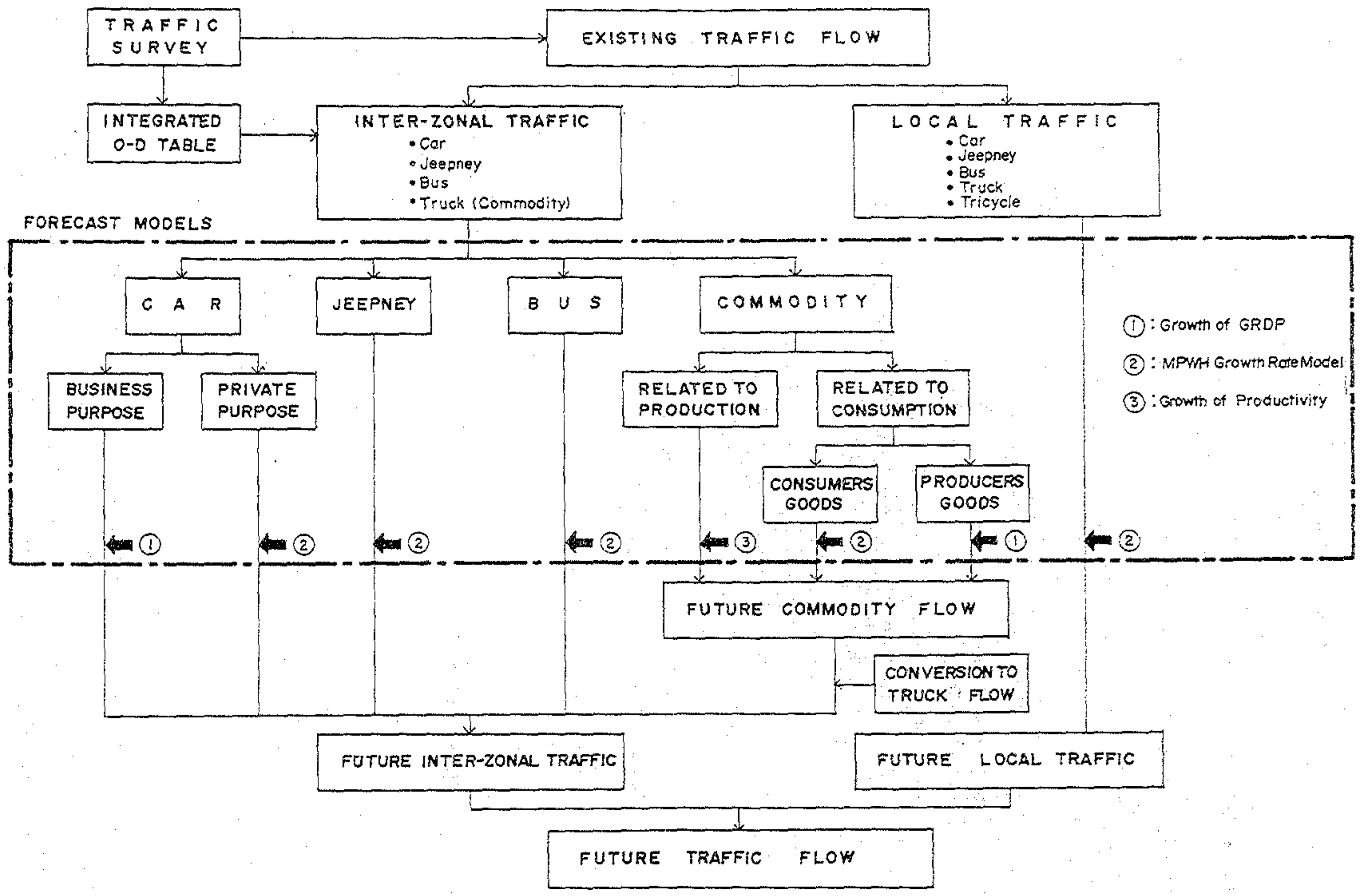


FIGURE 5.1-1 TRAFFIC DEMAND FORECAST PROCEDURE

and Highways. Application of growth rate model to local traffic forecast and inter-zonal traffic forecast is as follows:

a) Local Traffic

Predominant trip purpose of local traffic is "private purpose". Most of commodities locally transported by cargo trucks are basic consumption commodities for daily use such as foodstuff and groceries. Therefore, the volume of local traffic will increase in proportion to the personal income growth and population growth. The forecast model recommended in "Highway Planning Manual" uses those factors as independent variables. The model is expressed by the following formula:

$$TGR = \left(\left(\frac{I \times E}{100} + 1 \right) \cdot CP - 1 \right) \times 100$$

Where:

TGR = is the traffic (or commodity) growth rate in percent per annum.

E = is the transport demand (or goods consumption) income elasticity.

I = is the growth rate (in percent) for per capita income in constant prices, and

CP = is the compound population growth rate per annum.

After having examined the transport demand (or goods consumption) income elasticity values recommended in the manual as well as used in other highway projects, the following values are used in the Study.

Car	:	1.5
Jeepney	:	1.1
Bus	:	1.1
Tricycle	:	1.1
Basic Commodity	:	0.8

b) Inter-zonal Traffic

- Car

Business purpose trips and private purpose trips are forecasted separately. The former are assumed to increase in proportion to the region's economic growth as measured by GRDP. The latter, meanwhile, reflects the trip-maker's intentions, and the trip frequency will increase in proportion to the trip-maker's ability to pay traffic costs. Hence, above-mentioned DPWH's growth rate model is used to forecast future private purpose trips.

- Jeepney and Bus

Most of passenger trips transported by jeepneys and buses are private purpose trips. For the same reason as given for private purpose car trips above, DPWH's growth rate model is used for forecasting the jeepney and bus trips.

- Cargo Truck

Commodities carried by cargo trucks are divided into those produced in the area and those to be consumed in the area. Future volume of produced commodities is forecasted on the basis of the growth of productivity targeted in the Medium Term Development Plan (1987-1992) and Regional Development Plan. Consumption commodities can be divided into consumers goods (mainly processed foods) and producer's goods (such as construction materials and gasoline). The former is assumed to correspond to personal income growth and latter to GRDP which is the indicator of regional economic vitality.

Future volumes of commodity flow are converted into truck traffic volume using the loading factor established by commodity types on the basis of the traffic surveys. Empty truck volume is assumed to increase in proportion to the average growth rate of all loaded trucks.

Major commodities carried through the North and the South Study Sections are shown in Figure 5.1-2.

5.1.4 Forecast of Intersection Traffic

Although traffic flow pattern at the intersection will be greatly affected by the development plan in the influence area, there are no large scale development plans near the major intersections. It is assumed that the present traffic flow pattern will continue even in the future. Future traffic volume of each flows are forecasted to increase in proportion to traffic volume growths in the adjacent sections.

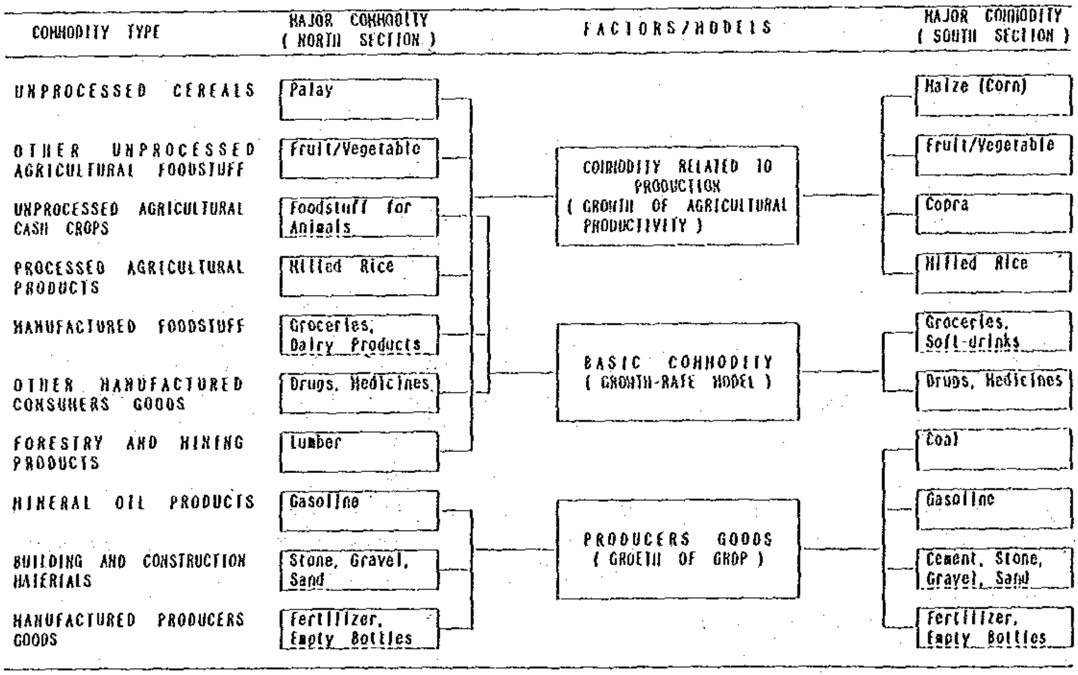


FIGURE 5.2-1 FACTORS TO FORECAST FUTURE COMMODITY VOLUME

5.2 FUTURE SOCIO-ECONOMIC FRAMEWORK

5.2.1 Population

National Census and Statistics Office (NCSO) made population projections which forecasted national, regional, provincial and municipal population, which were used as the most basic framework for formulating "The Medium Term Philippine Development Plan, 1987-1992". This Study also adopted NCSO's projected population.

Total population of the Philippines is estimated to be 56 million in 1986 and will reach to as high as 75 million by the year 2000 and 87 million by the year 2010. Family planning measures initiated by the Government seems to have contributed a lot to lower population growth rate in the past. Hence, it is expected that the declining rates of population growth will continue in the future. From an annual growth rate of 2.7 percent in the past ten-year period (1970-1980), it is expected to decline to 2.0 percent in the period 1990-2000 and to 1.5 percent in the period 2000-2010.

Population growth trend of Regions in the influence area of the Project will generally follow that of the Philippines. Population of NCR will be 9.9 million in 2000 and 11.5 million in 2010 with population growth rate of 2.2 percent for the period 2000-2010. Population growth rate for the period 1990-2010 of Regions II, III, IV and V will be 2.1, 2.1, 2.3 and 2.0 percent, and will decrease to 1.6, 1.5, 1.7 and 1.5 percents for the period 2000-2010, respectively. (See Table 5.2-1).

Projected population of related provinces and municipalities are presented in Appendix 5-1.

TABLE 5.2-1 PROJECTED POPULATION, NATIONAL, REGIONAL AND PROVINCIAL LEVEL

Region	Province	Projected Population				Annual Growth (%)		
		1986	1990	2000	2010	1986-1990	1990-2000	2000-2010
(Philippines)		55,980,372	61,480,180	75,223,853	87,206,449	2.4	2.0	1.5
NCR	All	7,136,586	7,974,002	9,894,837	11,481,317	2.8	2.2	1.5
I	All	3,976,736	4,291,931	5,072,984	5,720,643	1.9	1.7	1.2
II	All	2,581,477	2,844,695	3,517,966	4,116,473	2.5	2.1	1.6
III		5,687,087	6,141,618	7,528,875	8,713,203	2.4	2.1	1.5
	Bataan	397,814	462,120	589,032	711,894	3.3	2.7	1.9
	Bulacan	1,306,038	1,441,261	1,798,183	2,113,626	2.5	2.2	1.6
	Nueva Ecija	1,219,493	1,325,281	1,588,606	1,807,393	2.1	1.8	1.3
	Pampanga	1,379,999	1,522,709	1,889,381	2,207,035	2.5	2.2	1.6
	Tarlac	771,010	827,678	964,254	1,071,030	1.8	1.5	1.1
	Zambales	519,658	572,569	699,421	802,225	2.3	2.0	1.4
IV		7,323,317	8,104,632	10,188,021	12,031,459	2.6	2.3	1.7
	Aurora	132,448	162,049	208,482	263,145	3.5	3.2	2.4
	Batangas	1,341,167	1,461,993	1,750,073	1,987,215	2.2	1.8	1.3
	Cavite	967,161	1,113,454	1,488,029	1,836,822	3.6	2.9	2.1
	Laguna	1,177,196	1,325,941	1,692,593	2,012,974	3.0	2.5	1.7
	Mindoro Occ.	262,166	289,867	358,195	418,626	2.5	2.1	1.6
	Mindoro Or.	632,099	688,959	738,427	874,926	2.6	2.3	1.7
	Quezon	1,316,387	1,439,679	1,751,955	2,022,494	2.3	2.0	1.4
	Rizal	695,277	792,048	1,043,748	1,271,006	3.3	2.8	2.0
	Others	899,426	940,642	1,156,519	1,344,251	1.1	2.1	1.5
V	All	4,011,746	4,388,134	5,354,815	6,211,605	2.3	2.0	1.5
VIII	All	3,128,268	3,360,434	3,972,997	4,518,309	1.8	1.7	1.3

SOURCE: NCSO

5.2.2 Economy

The positive growth in 1986 shows a gradual recovery of the Country's economy. With the presence of various programs and thrusts of the government in order to alleviate poverty, generate more productive employment, promote equity and social justice and achieve sustainable economic growth as given in the Medium-Term Development Plan 1987-1992, a rapid growth starting 1987 to 1992 will be expected. From 1.0 in 1986, the Philippine economy is expected to grow from 6.0 percent in 1987 to 7.0 percent in 1992. The Medium-Term Development Plan also indicates that real per capita GNP, which has been set back by 10 years in 1985 when it fell down to 1975 level at ₱1,663, is expected to attain the highest level ever reached in the past, sometime in 1991 at ₱1,928.

TABLE 5.2-2 FUTURE GNP AND PER CAPITA GNP TARGETS (AT CONSTANT 1972 PRICES)

Year	GNP (Million ₱)	Growth Rate (₱)	Per Capita GNP	Growth Rate
1986	88,432	1.0	1,595	-4.3
1987	93,738	6.0	1,651	3.5
1988	99,362	6.0	1,709	3.5
1989	105,820	6.5	1,779	4.1
1990	112,699	6.5	1,852	4.1
1991	120,024	6.5	1,928	4.1
1992	128,426	7.0	2,020	4.8
Average Growth Rate (1987-1992)	–	6.4	–	4.0

SOURCE: Medium Term Philippine Development Plan (1987-1992)

Table 5.2-3 shows Gross Regional Domestic Product (GRDP) by Region. It shows that different levels of growth are expected among the regions of the country. This apparently conforms with the government objective to achieve a more balanced spatial development through the acceleration of the growth of less developed regions.

For traffic demand forecast, it is assumed that the same economic growth rates at 1992 will be attained even thereafter.

5.2.3 Major Products

Under the Medium-Term Philippine Development Plan 1987-1992, government aims to increase productivity through employment oriented rural-based development strategies. Under the strategy, policies that will promote rural development, remove the bias against the agricultural sector and improve the access of the people to land, natural resources and other productive assets, will be implemented. These shall be

TABLE 5.2-3 GRDP BY REGION: 1987-1992
(IN MILLION PESOS AT 1972 PRICES)

	1987	1992	Average Growth Rate (1987-1992)
Philippines	96,402	131,390	6.3
N C R	28,670	36,441	4.9
I	4,280	5,899	7.8
II	2,805	4,076	7.3
III	8,522	12,021	7.2
IV	13,111	18,329	7.3
V	3,191	4,467	7.3
VI	7,712	10,485	6.7
VII	6,835	9,263	6.6
VIII	2,294	3,330	7.8
IX	3,490	4,848	7.2
X	4,897	7,213	8.4
XI	6,623	9,421	7.7
XII	3,972	5,597	7.5

SOURCE: Medium Term Philippine Development Plan (1987-1992)

complemented by programs and projects that will bring about increased agricultural productivity that will all lead to higher rural incomes, increased demand for agricultural and non-agricultural good, increase savings and stimulate more investments.

Particularly, the government thrusts to increase agricultural productivity and rural employment includes the following:

- Promotion of the efficient use of land;
- *Promotion of crop diversification;*
- Improvement of farm technology;
- Provision of rural infrastructure;
- Maintenance of effective price support for palay and corn;
- Provision of greater access to credit and other farm inputs;
- Improvement of research, extention, and information services;
- Development of new markets for non-traditional agriculturai exports;
- Strengthening of farmers' organizations;
- Minimization of risks in agriculture; and
- Expansion of the scope of agrarian reform program.

Based on the above mentioned strategies and program thrusts, future production growth targets on major products are estimated as shown in Table 5.2-4. Palay production is expected to increase at an average annual growth of 3.7 percent during the period 1987-1992; corn production at 6.4 percent; sugar production at 1.4 percent; coconut production at 0.5 percent; fishery production at 3.4 percent, and lumber, plywood and veneer production at 9.8, 13.6 and 5.0 percent, respectively.

TABLE 5.2-4 PRODUCTION OF SELECTED AGRICULTURAL, FORESTRY AND MINING PRODUCTS (CALENDAR YEAR BASIS, IN THOUSAND METRIC TONS) 1987-1992

	Actual	Estimates	Projections						Annual
	1985	1986	1987	1988	1989	1990	1991	1992	Growth Rate
Food Crops									
Palay	8,806	9,113	9,431	9,774	10,141	10,510	10,905	11,315	3.7
Corn	3,863	4,016	4,255	4,510	4,781	5,068	5,422	5,802	6.4
Vegetables	342	345	355	359	369	372	383	386	1.7
Fruits	5,576	5,639	6,222	6,359	6,506	6,683	6,835	7,014	
Commercial Crops									
Tobacco	60	68	70	74	78	81	86	91	5.5
Sugar	1,664	1,503	1,330	1,342	1,349	1,357	1,391	1,426	1.4
Coconut (Copra)	3,113	2,972	9,940	1,900	1,890	1,920	1,954	1,987	0.5
Abaca	59	69	72	72	73	74	77	80	2.1
Fish	2,135	2,206	2,282	2,359	2,438	2,521	2,607	2,696	3.4
Meat	819	800	817	929	848	860	877	898	1.9
Forestry a/									
Logs		7,710	8,580	9,400	10,210	11,020	11,840	12,660	8.1
Lumber		1,260	2,300	2,610	2,900	3,200	3,430	3,680	9.8
Plywood		1,220	1,600	1,920	2,210	2,500	2,780	3,020	13.6
Veneer		180	180	190	200	210	220	230	5.0
Mining b/									
Gold		33	44	48	52	56	61	66	8.4
Silver		60	56	58	60	63	65	68	3.9
Copper (Metal)		223	178	183	189	194	200	206	3.0
Nickel (Metal)		19	29	30	30	31	31	32	2.0
Zinc (Metal)		2	2	2	2	2	2	2	1.0
Chronite		–	281	289	297	305	314	323	2.8
Manganese		.3	.3	.3	.4	.4	.4	.5	9.0
Cement		84,679	69,454	70,843	72,260	73,705	75,179	76,683	2.0
Sand and Gravel		10,842	17,229	17,729	18,243	18,772	19,316	19,876	2.9
Silicon Sand		390	418	426	435	444	452	462	2.0
Marble		6	5	6	7	8	10	12	19.0
White Clay		–	9	9	9	10	10	10	2.2
Coal		1,337	2,212	2,699	3,292	4,017	4,900	5,978	22.0
Guano		–	.6	.75	.94	1.2	1.5	1.8	25.0
Adobe		–	1	1	1	1	1	1	1.3
Limestone		–	13	13	13	14	14	14	2.0
Perlite		–	16	16	16	17	17	17	1.3
Phosphate Rock		–	7	7	7	7	8	8	1.9

SOURCE: Bureau of Agricultural Economics, DAG

NOTE: a/ Forestry product's are expressed in terms of cubic meters.

b/ Mineral commodities like gold and silver are expressed in kg; cement in bags; Sand and Gravel, Marble and Adobe in cubic meter and the rest are in metric tons.

5.3 FUTURE TRAFFIC VOLUME

5.3.1 North Study Section

Future traffic volumes on the North Study Section are shown in Figure 5.3-1. In the year 2000, traffic volume (without tricycle) will be over 20,000 vehicle per day on the urban sections of Plaridel and Cabanatuan and on the rural section of Sta. Rita-Plaridel, the nearest section to Metro Manila. Traffic volume (without tricycle) on the most rural sections between Plaridel and Cabanatuan will be more than 10,000 vehicle per day. Sections north of San Jose City will be about 5,000 vehicle per day.

Although there is a slight difference in the average annual traffic growth rates among sections, the average annual traffic growth rate will be around 5.0 percent during the period of 1986-1990, and around 5.5 percent after 1990. Reflecting high rate of economic growth, car traffic has the highest growth rate, especially in urban sections of Cabanatuan and Gapan. Cargo truck traffic has the second highest growth rate. The average annual growth of truck in the rural sections are higher than in the urban sections, which is due to projected high production of forestry products in Region II and palay production in Regions II and III. Of the public transportation traffic, jeepney has high growth rates in the urban sections such as Plaridel, Gapan and Cabanatuan. Bus traffic, on the other hand, has high growth rates in the rural sections.

Traffic volume and average annual traffic growth rates by vehicle type are presented in Appendix 5-2.

5.3.2 South Study Section

Figure 5.3-2 shows future traffic volumes on the South Study Section. The future traffic volumes in the Calamba-Sto. Tomas section which has the current traffic volume of 12,000 vehicle/day will be 15,000 vehicle/day in the year 1990 and will reach 26,000 vehicle/day in the year 2000. In the sections between Sto. Tomas and Lucena, traffic volume is expected to be about 10,000 vehicle/day by the year 2000. In the sections located south of Pagbilao (excluding Gumaca urban section), traffic volume in the year 2000 will not exceed 4,000 vehicle/day and that in the year 2010 will still be about 6,000 vehicle/day.

Annual average growth of traffic in the South Study Section are slightly lower than that in the North Study Section. In the sections located south of Lucena, growth rates are especially low. Annual average growth of traffic during 1986 to 1990 is around 4.5 percent in the sections between Calamba and Lucena, on the other hand, around 4.0 percent in the sections located south of Lucena. For the period of 1990 to 2000, the traffic growth rate of the former sections is around 5.5 percent and the latter sections around 5.0 percent.

Of all the vehicle types, car has the highest annual average growth rate of about 6.0 percent (1986-2000). Cargo truck has low growth rate which will be less than 4.0 percent in the sections located south of Lucena. Jeepney traffic operated between Candelaria and Lucena has higher growth of 5.0 percent than that of the other section. In the case of bus traffic, there is slight difference on the growth rate between sections north of Lucena and sections south of Lucena.

Traffic volume and average annual traffic growth rates by vehicle type are presented in Appendix 5-2.

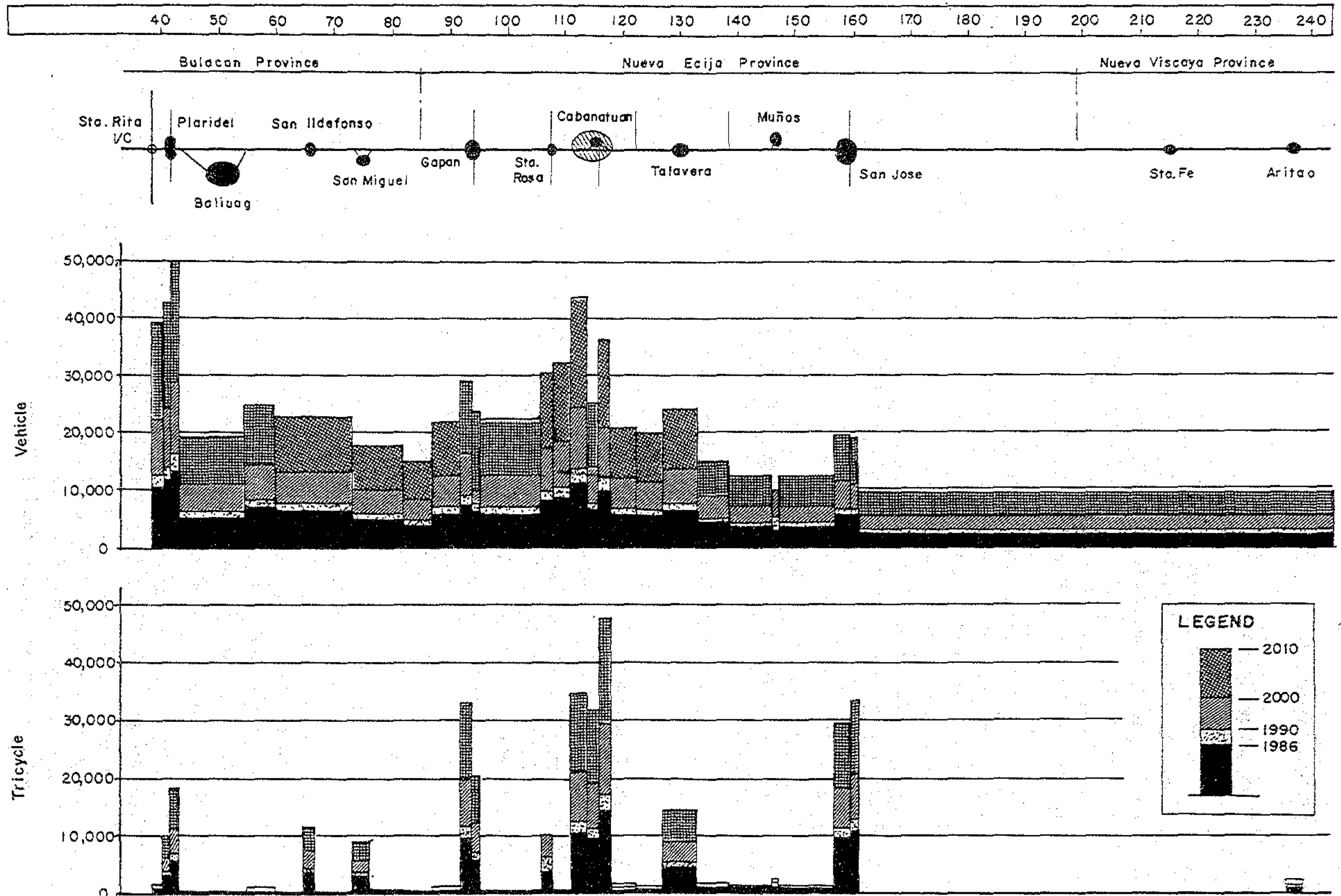


FIGURE 5.3-1 PROJECTED TRAFFIC VOLUME ON NORTH SECTION

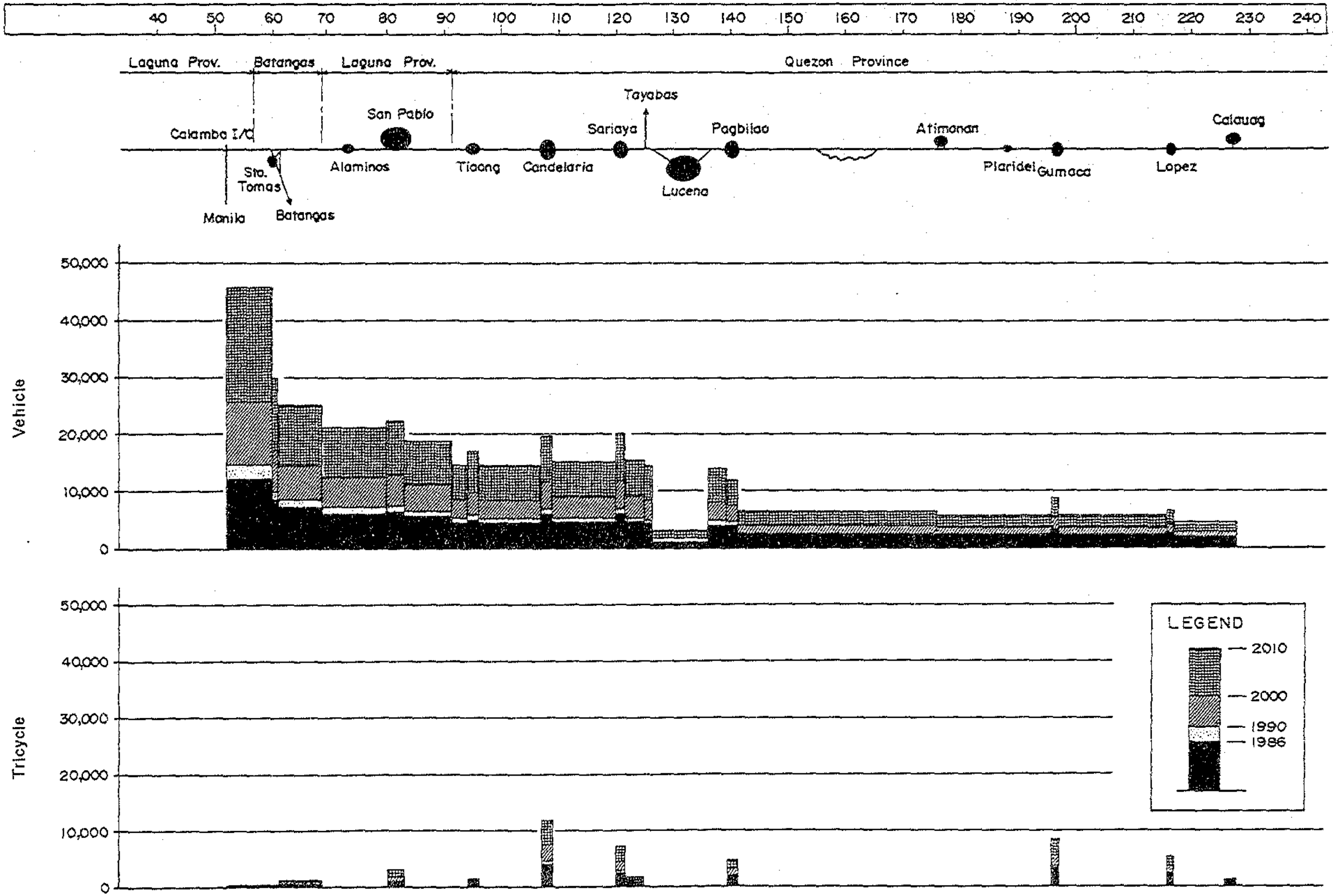


FIGURE 5.3-2 PROJECTED TRAFFIC VOLUME ON SOUTH SECTION

CHAPTER 6

TRAFFIC LOADING

6.1 APPROACH

Procedure to determine the axle load distribution pattern is shown in Figure 6.1-1. Based on the axle load data, axle load distribution pattern by type of axle (single and tandem axles) was established, then the axle load distribution pattern for all types of trucks was developed based on percentage shares of empty and loaded trucks as well as truck types. This chapter discussed up to axle load distribution pattern by type of axle.

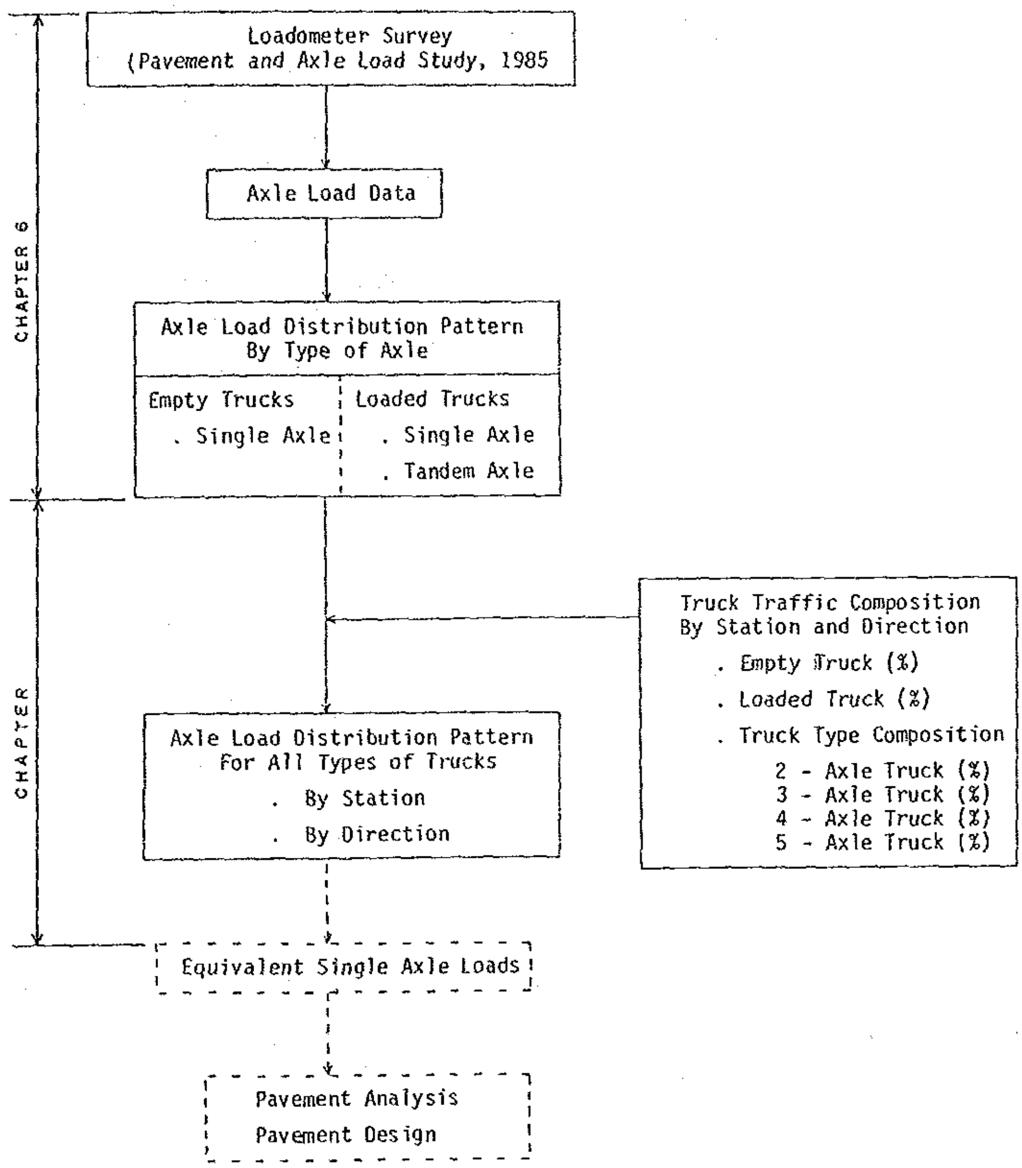


FIGURE 6.1-1 PROCEDURE TO DETERMINE AXLE LOAD DISTRIBUTION PATTERN

6.2 AXLE LOAD DATA

An intensive loadmeter survey was conducted in 1985 at 29 survey stations all over the country by the Pavement and Axle Load Study, of which four (4) survey stations are located within the Study Section of this Study, two (2) in the North Study Section and two (2) in the South Study Section. Axle load data obtained at the said four (4) survey stations were used for this Study. Table 6.2-1 shows number of trucks weighed at each survey station.

TABLE 6.2-1 NUMBER OF TRUCKS WEIGHED

urvey tation	Location	Hours of Survey	Daily Truck Volume		No. of Trucks Weighed					
					Direction 1			Direction 2		
			Direction 1	Direction 2	Loaded	Empty	Total	Loaded	Empty	Total
01	San Jose-Sta. Fe. (3 Km. North of San Jose)	2 x 16 hours 1 x 24 hours	346	369	259	22	281	450	17	467
02	Plaridel-Gapan (1 Km. North of Bulacan/Nueva Ecija Boundary)	2 x 16 hours 1 x 24 hours	722	707	353	6	359	695	-	695
07	Calamba-Sto. Tomas (DPWH Weighbridge)	2 x 16 hours 1 x 24 hours	1,178	1,308	684	66	750	429	72	501
29	Lucena-Lopez (1 Km. West of Pagbilao)	2 x 12 hours	379	443	142	-	142	136	-	136

SOURCE: Pavement and Axle Load Study, 1985

NOTE: For Survey Stations 01 and 02

Direction 1: Cagayan Bound
Direction 2: Manila Bound

For Survey Stations 07 and 29

Direction 1: Manila Bound
Direction 2: Bicol Bound

6.3 AXLE LOAD DISTRIBUTION PATTERN BY TYPE OF AXLE

As shown in Table 6.3-1, the following four (4) types of axle load distribution pattern by type of axle were developed.

1.) Loaded Trucks

- Single axle load distribution pattern for 2-axle load
- Single axle load distribution pattern for trucks with 3 or more axles
- Tandem axle load distribution pattern

2.) Empty Trucks

- Single axle load distribution pattern

These patterns were prepared for each direction of the Station except for empty trucks. As number of empty trucks weighed was small, and axle load distribution pattern of empty trucks is judged to be more or less the same at any station, one pattern common to all survey stations was prepared.

Table 6.3-2 shows the axle load distribution patterns of Manila bound direction at the survey station 01 (San Jose – Sta. Fe Section). The rest of axle load distribution patterns are presented in Appendix 6-1.

TABLE 6.3-1 AXLE LOAD DISTRIBUTION PATTERN BY TYPE OF AXLE

Truck Type	Axle Composition of Truck	Axle Load Distribution Pattern By Type of Axle
Loaded Trucks		
2 - Axle Truck	2 Single-Axles	Single Axle Load Distribution Pattern for 2-axle Trucks (2 single-axle loads combined)
3 - Axle Truck	1 Single-Axle 1 Tandem-Axle	
		Single Axle Load Distribution Pattern for Trucks with 3 or more axles (All single axle loads of 3, 4 & 5 axle trucks combined)
4 - Axle Truck	2 Single-Axles 1 Tandem-Axle	
		Tandem Axle Load Distribution Pattern (All tandem axle loads of 3,4 and 5 axle trucks combined)
5 - Axle Truck	1 Single-Axle 2 Tandem-Axles	
Empty Trucks		
All Type	———	. Single Axle Load Distribution Pattern for Empty Trucks (All axles are treated as single axle)

TABLE 6.3-2 AXLE LOAD DISTRIBUTION PATTERN BY TYPE OF AXLE MANILA BOUND: SAN JOSE-STA. FE SECTION

Axle Load (Metric Tons)	Loaded, Trucks: 2-Axle Trucks Single Axle Load Distribution Pattern	Loaded, Trucks: 3 or More Axle Trucks Single Axle Load Distribution Pattern	Loaded, Trucks: 3 or More Axle Trucks Tandem Axle Load Distribution Pattern	Empty Trucks: Single Axle Load Distribution Pattern
1	0.4	–	–	0.45
2	5.3	–	–	6.02
3	21.2	1.67	–	28.35
4	11.1	10.46	0.42	38.62
5	7.1	20.50	–	22.99
6	7.7	32.22	–	3.57
7	4.4	27.20	0.42	–
8	3.5	7.95	1.26	–
9	4.0	–	0.42	–
10	4.2	–	–	–
11	4.0	–	1.26	–
12	5.5	–	–	–
13	5.8	–	0.84	–
14	4.4	–	–	–
15	6.6	–	1.67	–
16	1.8	–	1.67	–
17	2.4	–	–	–
18	0.4	–	0.84	–
19	–	–	1.67	–
20	–	–	0.84	–
21	–	–	4.18	
22	–	–	6.69	
23	–	–	10.88	
24	–	–	10.46	–
25	–	–	12.97	–
26	–	–	10.46	–
27	–	–	10.88	–
28	–	–	7.53	–
29	–	–	5.43	–
30	–	–	3.35	–
31	–	–	3.35	–
32	–	–	1.67	–
33	–	–	0.42	–
34	–	–	0.42	–

PART III ROAD FUNCTION

CHAPTER 7

GENERAL INFORMATION ON ROAD FUNCTION

7.1 ROAD SYSTEM

The road system in the Philippines consists of the following five (5) groups which is basically classified by administrative jurisdiction:

Classification	Length (in 1985)	% Share
National Road	26,259 kms.	16.2
Provincial Road	28,424 kms.	17.6
City Road	3,987 kms.	2.5
Municipal Road	12,825 kms.	7.9
Barangay Road	90,214 kms.	55.6
TOTAL	161,709 kms.	100%

National roads form the trunkline system of the country. Roads leading to major terminals of other transport modes such as national airports and seaports and some coast-to-coast roads are also included in national roads. Provincial roads connect national roads as well as municipalities with each other. Roads leading to minor transport terminals are also included in this classification. Municipal roads branches off from the national or the provincial roads and connect barangays. Barangay roads are, in principle, farm-to-market roads.

Inter-provincial trips are served by national roads. Provincial roads serves inter-municipal trips and also function as collector-distributors of national roads. Municipal roads serve short trips within the municipality. Barangay roads provide accesses to farm lands.

National and barangay roads fall under the jurisdiction of the Department of Public Works and Highways. Provincial, city and municipal roads under the jurisdiction of the respective local governments under the supervision of the Department of Local Governments.

7.2 HIGHWAY TECHNOLOGY

7.2.1 Highway Planning Manual

The Highway Planning Manual (hereinafter referred to as the Manual) consisting of eight (8) volumes was prepared in 1982 based on findings and methods developed from previous feasibility studies. Most of ordinary road feasibility studies are being carried out in line with the Manual. Of the subjects dealt with in the Manual, level of service concept and road capacity analysis are most related with this Study, both of which basically follow "Highway Capacity Manual, Highway Research Board, Washington D.C. 1965" (hereinafter referred to as "HCM, 1965").

1) Level of Service

The level of service and corresponding traffic volume/capacity ratio (v/c ratio) in the Manual are as follows:

Level A	:	Free flow traffic, v/c less than 0.20
Level B	:	Free flow traffic, v/c 0.21-0.50
Level C	:	Moderate traffic, v/c 0.51-0.70
Level D	:	Moderate/heavy traffic, v/c 0.71-0.85
Level E	:	Heavy traffic, v/c 0.86-1.00
Level F	:	Saturation volume, stop and go

2) Two-lane Highway Capacity

The Manual concluded to use the formula recommended by HCM, 1965 for two-lane highway capacity analysis with modifications of the two factors.

Basic Traffic Capacity

Based on various traffic surveys in the Philippines, the Manual concluded that "the capacities under Philippine conditions are about 20% higher than those reported in HCM, 1965, which is related to a USA data base. This could be due to fact that the average passenger car unit in the Philippine roads is smaller than its USA average counterpart and it could also be due to different driver behavior. In the Philippines, it is common to drive quite close to the vehicle in front."

The Manual recommend 2,400 passenger car units (PCU) per hour for both directions of a 2-lane flat 7.3 meters highway without roadside friction, instead of 2,000 pcu which is recommended by HCM, 1965. Table 7.2-1 show recommended basic hourly capacity in pcu in both directions for various carriageway widths.

TABLE 7.2-1 BASIC HOURLY CAPACITY RECOMMENDED BY THE MANUAL

Road Type	Carriageway Width (M)	Roadside Friction	Basic Hourly Capacity in PCU in Both Directions
Highway	4.0	None or Light	600
Highway	4.1-5.0	None or Light	1200
Highway	5.1-5.5	None or Light	1800
Highway	5.6-6.1	None or Light	1900
Highway	6.2-6.5	None or Light	2000
Highway	6.6-7.3	None or Light	2400
Highway	2 x 7.0	None or Light	7200 Expressway
Urban Street	-6.0	Heavy	1200
Urban Street	6.1-6.5	Heavy	1600
Urban Street	6.6-7.3	Heavy	1800
Urban Street	2 x 7.0	Heavy	6700

Passenger Car Equivalent Factors (PCEF)

The Manual recommended PCEF as shown in Table 7.2-2 for a road section with no roadside friction in flat terrain.

TABLE 7.2-2 PASSENGER CAR EQUIVALENT FACTOR IN FLAT TERRAIN RECOMMENDED BY THE MANUAL

Vehicle Type	P C E F
Car, Van, Jeep	1.0
Jeepney	1.5
Bus	2.0
Truck	2.0
Motor-tricycle	2.5
Motorcycle	0.5

A motor-tricycle is given higher PCEF than buses and trucks.

3) Intersection Capacity

The Manual did not deal with intersection capacity analysis. The intersection capacity analysis method currently used in Metro Manila is the one recommended by Metro Manila Traffic Engineering and Management Project (TEAM Project) in 1981.

Saturation Flow

For calculating saturation flows (si), the following formula was adopted by TEAM Project:

- For approach width of more than 5 meters

  Si = 530 x (Approach width)

- For approach width between 5 and 3 meters

W	=	5	Si	=	2,700
W	=	4.5 m	Si	=	2,300
W	=	4 m	Si	=	2,050
W	=	3.5 m	Si	=	1,950
W	=	3.0	Si	=	1,850

Si in through car units (TCU) per hour of effective green time

Through Car Units (TCUs) Equivalents

Table 7.2-3 shows through car units equivalents by vehicle type and by movement adopted by TEAM Project.

TABLE 7.2-3 TCU EQUIVALENTS ADOPTED BY TEAM PROJECT

Vehicle Movement	Vehicle Type		
	Car	Jeepney	Bus and Commercial Vehicle
Through	1.0	1.2	2.0
Right Turn	1.25	1.3	2.5
Unopposed Left Turn	1.0	1.2	2.0

7.2.2 Design Standards

In 1984, the Bureau of Design, then MPWH developed "Highway Design Guidelines". The guidelines were prepared using various references, of which most pertinent was "A Policy on Geometric Design of Rural Highway, 1965 AASHTO". The guidelines provided for 2-lane, 4-lane and divided highways. The lane width varies from 3.00 to 3.65 meters depending upon the importance of the road and traffic volume. Minimum design standards set by highway Design Guidelines are shown in Table 7.2-4.

TABLE 7.2-4 MINIMUM DESIGN STANDARD PHILIPPINE HIGHWAYS

ADT - AVERAGE DAILY TRAFFIC ON OPENING	UNDER 200	200 – 400	400 - 1000		1000 - 2000		MORE THAN 2000	
			MINIMUM	DESIRABLE	MINIMUM	DESIRABLE	MINIMUM	DESIRABLE
DESIGN SPEED (km/hr)								
FLAT TOPOGRAPHY	60	70	70	90	80	95	90	100
ROLLING "	40	50	60	80	60	80	70	90
MOUNTAINOUS "	30	40	40	50	50	60	60	70
RADIUS (metre)								
FLAT TOPOGRAPHY	120	160	160	280	220	320	280	350
ROLLING "	55	85	120	220	120	220	160	280
MOUNTAINOUS "	30	50	50	80	80	120	180	160
GRADE (PERCENT)								
FLAT TOPOGRAPHY	6.0	6.0	5.0	3.0	4.0	3.0	4.0	3.0
ROLLING "	8.0	7.0	6.0	5.0	5.0	5.0	5.0	4.0
MOUNTAINOUS "	10.0	9.0	8.0	6.0	7.0	6.0	7.0	5.0
PAVEMENT WIDTH (m)	4.0	5.5 ; 6.0	6.10		6.70		6.70	7.30
SHOULDER WIDTH (m)	0.50	1.00	1.50	2.00	2.50	3.00	3.00	
RIGHT OF WAY WIDTH (m)	20	30	30		30	30	60	
SUPERELEVATION (m/m)	0.10 (MAX.)		0.10 (MAX.)		0.10 (MAX.)		0.10 (MAX.)	
NON PASSING SIGHT DISTANCE (metre)								
FLAT TOPOGRAPHY	70	90	90	135	115	150	135	160
ROLLING "	40	60	70	115	70	115	90	135
MOUNTAINOUS "	40	40	40	60	60	70	70	90
PASSING SIGHT DISTANCE (metre)								
FLAT TOPOGRAPHY	420	490	490	615	560	645	615	675
ROLLING "	270	350	420	560	420	560	490	615
MOUNTAINOUS "	190	270	270	350	360	420	420	490
TYPE OF SURFACING	GRAVEL, CRUSHED GRAVEL OR CRUSHED STONE; BIT. PRESERVATIVE TREATMENT; SINGLE OR DOUBLE BIT. SURFACE TREATMENT; BITUMINOUS MACADAM PAVEMENT.		BITUMINOUS MACADAM PAVEMENT, DENSE OR OPEN GRADED PLANT MIX SURFACE COURSE, BITUMINOUS CONCRETE SURFACE COURSE		BITUMINOUS CONCRETE SURFACE COURSE		BITUMINOUS CONCRETE SURFACE COURSE; PORTLAND CEMENT CONCRETE PAVEMENT	

SOURCE : HIGHWAY DESIGN GUIDELINES, MPWH, 1984

CHAPTER 8

ROAD FUNCTION SURVEY AND ANALYSIS

8.1 APPROACH

The study flow for the road function survey and analysis is shown in Figure 8.1-1. The road function survey which consists of the roadway condition surveys use the control condition survey and the road environmental survey were conducted.

Criteria to evaluate road function were studied and level of service was selected for evaluation criterion. Methodology of level of service analysis was studied, specifically applying the "Highway Capacity Manual, Highway Research Board, Washington, D.C., 1985" (hereinafter referred to as "HCM, 1985") to Philippine roads.

Present level of service of each road section and intersection was assessed based on road and traffic data obtained and the methodology developed.

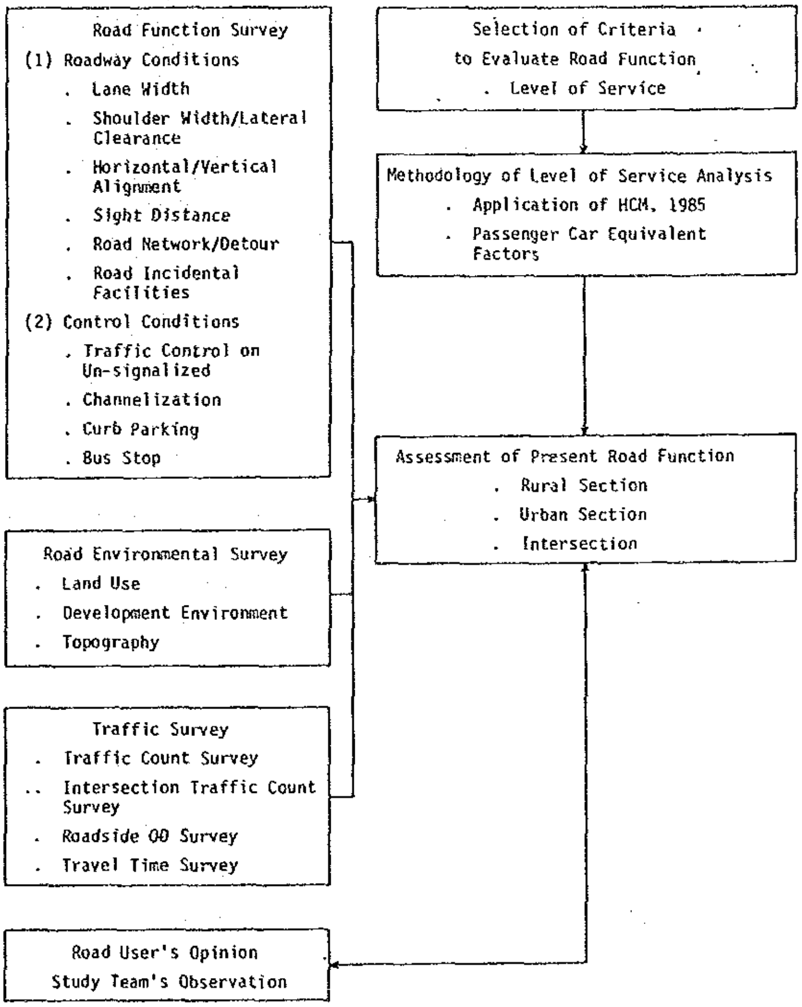


FIGURE 8.1-1 STUDY FLOW FOR ROAD FUNCTION SURVEY AND ANALYSIS

8.2 ROAD FUNCTION/ENVIRONMENTAL SURVEY

The road inventory format as shown in Appendix 8-1 was prepared to undertake the road function and the environment surveys. Items surveyed in accordance with the road inventory format were as follows:

1) Cross-section element

- pavement type and width
- shoulder type and width
- side ditches (approximate dimensions, locations of beginning and outlet and direction of water flow)
- sidewalk width
- fences or houses for identification of approximate location of right-of-way boundary
- physical features (cut or embankment and approximate defficiencies in elevation between road surface and original ground level)

Cross-section drawings were prepared at an interval of about 500 meters.

2) Horizontal and Vertical Alignment

Such elements as the radius of curvature, superelavation and horizontal sight distance for the horizontal alignment and the gradient vertical sight distance for the vertical alignment were measured and entered in the format. The topographic map of scale 1:10,000 prepared by the feasibility study of the Dalton Pass Tunnel was used for the Dalton Pass section to determine horizontal and vertical alignment elements.

3) Intersecting Roads and Bridges

Roads and railways intersecting the Pan-Philippine Highway and bridges in the Study Section were recorded.

4) Terrain

Terrain was classified into three (3), flat, rolling and mountainous, and entered in the format.

5) Roadside and Land Use

Roadside land uses were classified into five (5), i.e. residential, commercial, industrial, agricultural and others. Others include schools, hospitals, churches, etc., which were individually indicated in the format.

Examples of the road inventory format in which data were entered are shown in Appendix 8-1.

8.3 LEVEL OF SERVICE ANALYSIS

8.3.1 Selection of Criteria for Road Function Evaluation

"Level of Service" was selected as a measure to evaluate road function. It describes traffic operational conditions in terms of such factors as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety. Three (3) parameters are commonly used to describe service quality for two-lane highways: 1) average travel speed, 2) percent time delay and 3) v/c ratio (the ratio of the demand flow rate to the capacity).

8.3.2 Methodology of Level of Service Analysis

Methodologies presented in "Highway Capacity Manual, Highway Research Board, 1985" (HCM, 1985) were adopted with modification to suit Philippine road and traffic conditions for level of service analysis in consideration that the Highway Planning Manual prepared by then MPWH basically followed HCM, 1965.

Detail Methodologies are presented in Volume V "Guide for Road Function Improvement Planning". In this Chapter, modifications made are discussed.

1) Two-lane Highway

Jeepneys and tricycles are unique vehicle types and observed only in the Philippines. HCM, 1985 which is developed based on USA data base, is judged applicable with modification of passenger car equivalent factors (PCEF) of these two vehicle types. The Highway Planning Manual recommends PCEF of 1.5 for jeepneys and 2.5 for tricycles in flat terrain with no roadside friction. Tricycles are given high PCEF due mainly to their slow moving and frequent-stopping operations. However, contrary to these movements having an adverse effect on road capacity, the following movements which eventually have an effect to increase road capacity, are observed in the Study Section:

- double driving on one lane of one direction
- utilization of shoulder for stopping (loading/unloading) and sometimes even for driving

To fine appropriate PCEFs, two analyses were conducted:

- Headway analysis by utilizing video tape recording
- *Comparison of v/c ratios for various PCEFs with road user's opinions* on traffic congestion degree

Flows of vehicles in several urban sections were recorded in video tapes and headways were computed. Results are shown in Table 8.3-1.

TABLE 8.3-1 HEADWAYS IN URBAN SECTIONS

Type of Vehicle		Mean Value of Headway (sec.)	Ratio to Headway of Car	PCEF Based on Headway
Preceding	Following			
Car	Car	2.00	1.00	1.00
Car	Jeepney	3.10	1.55	
Jeepney	Car	2.20	1.10	Jeepney = 1.5
Jeepney	Jeepney	2.90	1.45	
Car	Tricycle	2.06	1.03	
Tricycle	Car	1.94	0.97	Tricycle = 1.0
Tricycle	Tricycle	1.49	0.75	

Jeepney

PCEF of a jeepney in the urban section based on headway characteristics is found to be 1.5 which is the same value recommended by the Highway Planning Manual for flat terrain with no roadside friction. PCEFs for a jeepney recommended by the Highway Planning Manual are adopted by this Study.

Tricycle

PCEF for a tricycle in the urban section based on headway characteristics is found to be 1.0 which is much lower than the one recommended by the Highway Planning Manual which is 2.5 for flat terrain with no roadside friction. It is the fact that about 23,900 vehicles are accomodated by the Cabanatuan Urban Section, of which more than one half or about 14,200 are tricycles.

The changes of v/c ratios against various PCEFs for a tricycle were plotted as shown in Figure 8.3-1 and compared with opinions of road users and the Study Team regarding congestion degree.

It was found that PCEF of 1.0 for a tricycle is a best fit and reflecting a tricycle's movement characteristics. This factor of 1.0 should be understood as a nominal value, and if there is no double driving and/or frequent utilization of shoulder space is not possible, PCEF for a tricycle could be higher than this as recommended by the Highway Planning Manual.

Table 8.3-2 shows adopted PCEFs for each type of vehicle in the Study.

TABLE 8.3-2 PCEF FOR 2-LANE HIGHWAY IN FLAT TERRAIN ADOPTED BY THE STUDY

Vehicle Type	Passenger Car Equivalent Factor
Jeepney	1.5 1/
Tricycle	1.0
Truck	2.0 – 2.2 2/ (depending on level of service)
Bus	1.6 – 2.0 2/ (depending on level of service)

1/ Highway Planning Manual, MPWH

2/ HCM, 1985

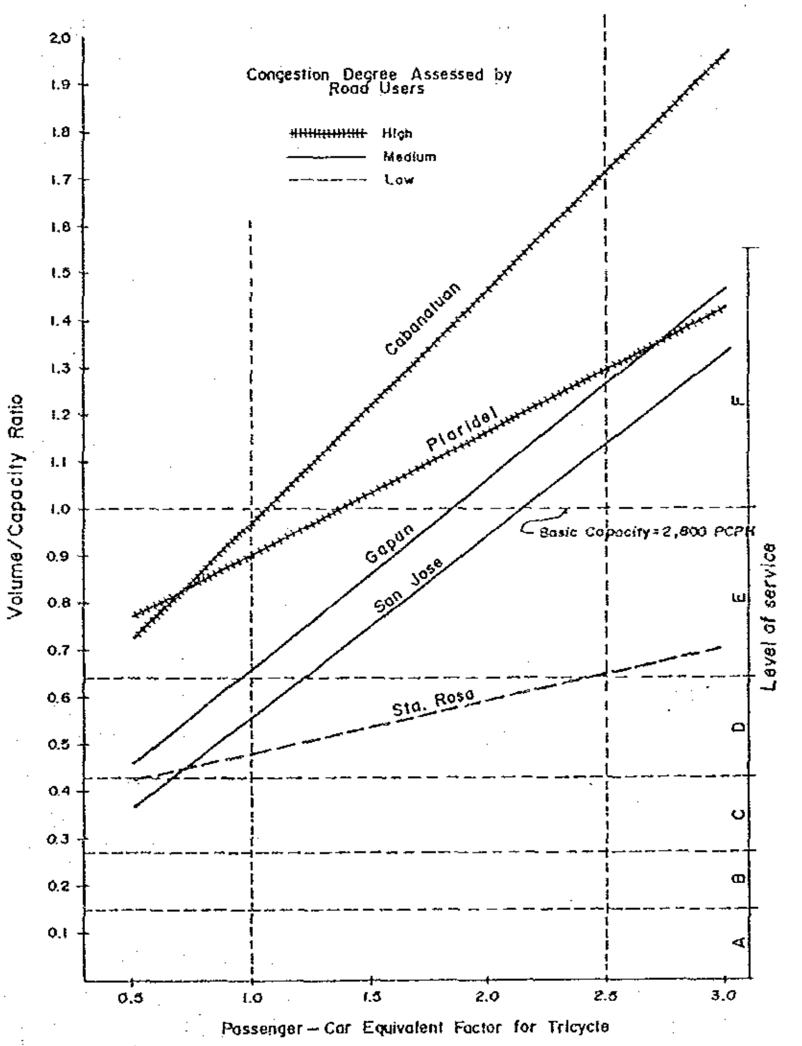


FIGURE 8.3-1 VOLUME/CAPACITY RATIO BY THE CHANGE OF PASSENGER – CAR EQUIVALENT FACTOR FOR TRICYCLE (TWO-LANE HIGHWAY)

2) Intersection in Urban Area

All intersections in the Study Section are uncontrolled intersections (no traffic signal is installed and no right-of-way is assigned at an intersection). No method for the capacity analysis of uncontrolled intersection discussed either in the Highway Planning Manual nor in HCM, 1985. The following three (3) cases were studied:

a) Analyze as if it were a signalized intersection
b) Analyze as a two-way yield controlled intersection
c) Analyze as a four-way stop-controlled intersection

It was concluded that case a) gives an enough approximation to evaluate the uncontrolled intersection under the following assumptions/modifications of HCM, 1985;

- Ideal saturation flow rate is reduced to 1,600 pcphgpl. 1/
- Two-phase signal with signal split prorated on the basis of the flow ratio in the critical flow of each phase is assumed.
- Right-turn traffic is disregarded in the analysis because the field observation shows that right-turn is made mostly using shoulder, therefore, right-turn movement is considered to have little effect on intersection capacity in the Study Section.
- Passenger car equivalent factors are as shown in Table 8.3-3.

TABLE 8.3-3 PCEF FOR INTERSECTION

Vehicle Type	P C E F
Heavy Vehicle	1.5
Jeepney	1.0
Tricycle	0.6

1/ Passenger car per hour green per lane.

PCEF for heavy vehicles is based on HCM, 1985. The movement of jeepney at an intersection is considered to be basically the same as that of a car except for stopping for loading/unloading, effect of which is, however, adjusted separately. Headway analysis is also suggested PCEF of 1.0 for a jeepney at an intersection (See Table 8.3-4).

Tricycles are flowing quite flexibly, fully utilizing gaps in a major traffic stream at an intersection. Similar analyses made for PCEF of a 2-lane highway were conducted. Table 8.3-4 shows headway characteristics of tricycles and Figure 8.3-2 shows v/c ratios against various PCEFs for a tricycle. PCEF of 0.6 was adopted for a tricycle in the urban intersection.

TABLE 8.3-4 HEADWAYS AT URBAN INTERSECTION

Type of Vehicle: Preceding	Type of Vehicle: Following	Mean Value of Headway (sec.)	Ratio to Headway Time of Car	PCEF Based on Headway
Car	Car	2.18	1.00	1.0
Car	Jeepney	2.30	1.06	Jeepney
Jeepney	Car	2.30	1.06	= 1.0
Jeepney	Jeepney	2.30	1.06	
Car	Tricycle	1.74	0.80	
Tricycle	Car	1.36	0.62	Tricycle
Tricycle	Tricycle	1.32	0.61	= .6

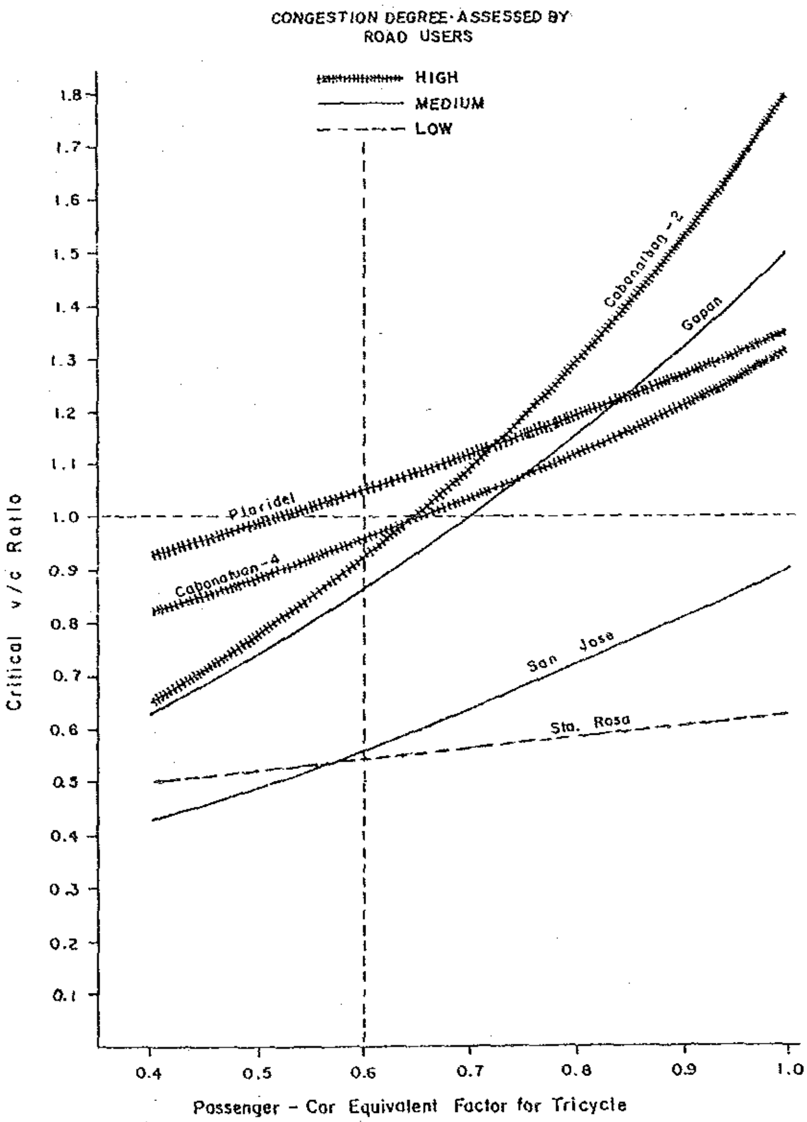


FIGURE 8.3-2 CRITICAL V/C RATIO BY THE CHANGE OF PASSENGER – CAR EQUIVALENT FACTOR FOR TRICYCLE (INTERSECTION)

3) Intersection in Rural Area

Service volumes and capacities were estimated by the criteria for two-way yield-controlled intersections, assuming that the right-of-way is assigned to the through-traffic on the Pan-Philippine Highway, for the following reasons:

- According to field observation, traffic movement is mostly in conformity with the above assumption.
- In addition to relatively low traffic volume, the major intersections are channelized, therefore, the conflicting flows are limited. Thus, it is quite easy for the traffic on an intersecting road to find gaps in the conflicting flow.

8.4 ASSESSMENT OF PRESENT ROAD FUNCTION

Figures 8.4-1 and 2 summarize assessment of present road function conditions. Level of service of each section and intersection is presented in Appendix 8-2.

FIGURE 8.4-1 SUMMARY OF ROAD FUNCTION ASSESSMENT NORTH SECTION

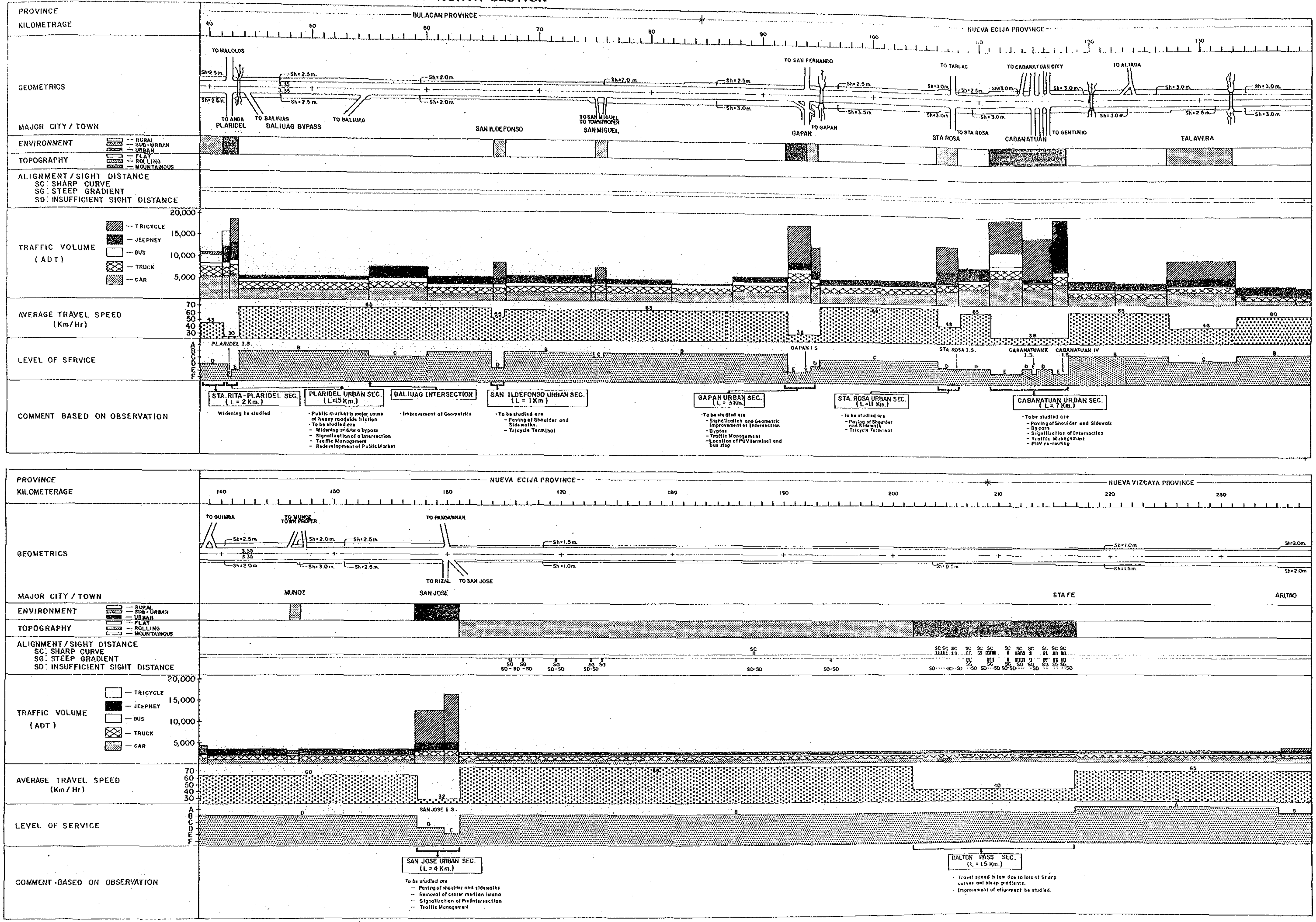
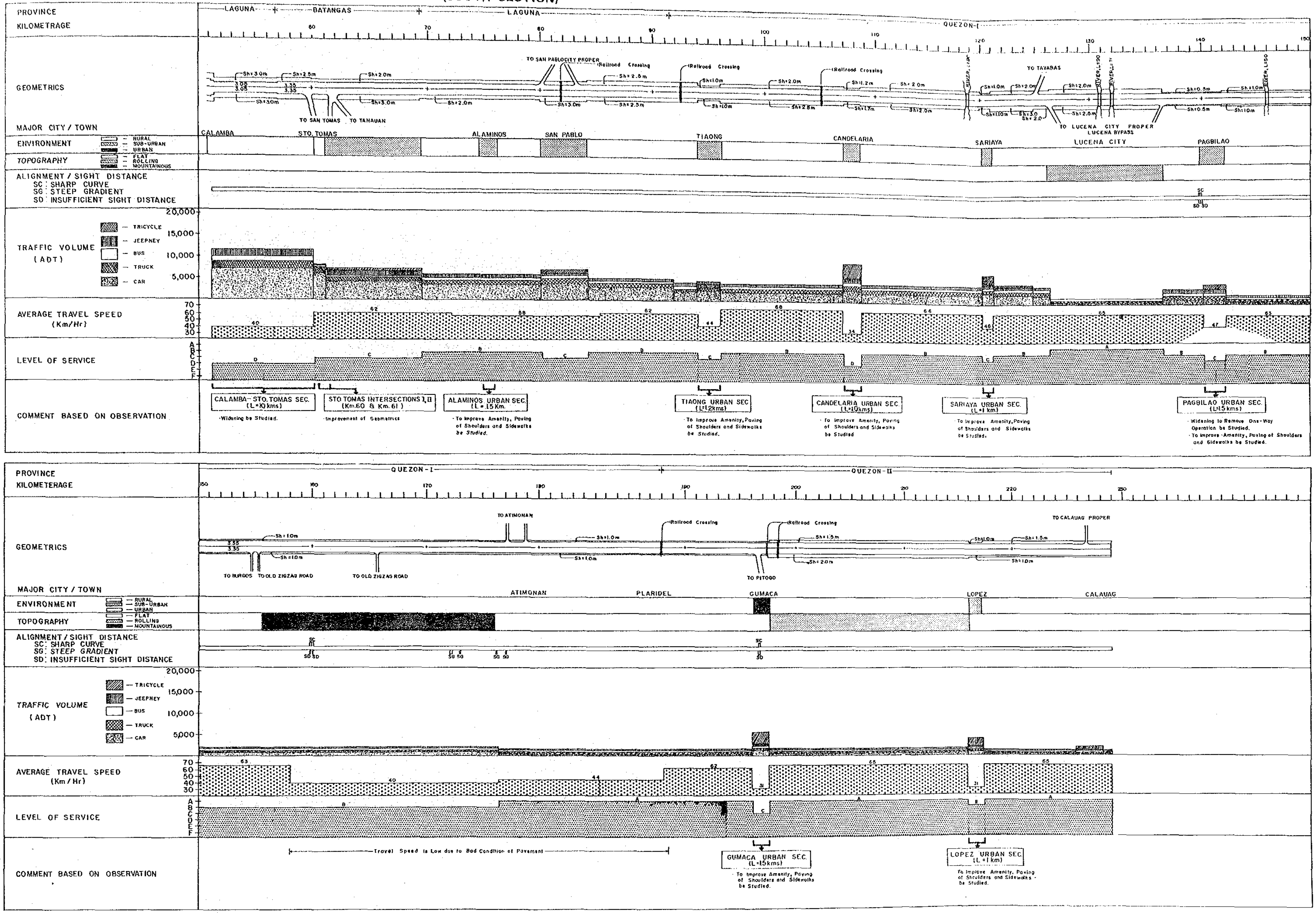


FIGURE 8.4-2 SUMMARY OF ROAD FUNCTION ASSESSMENT (SOUTH SECTION)



CHAPTER 9

IMPROVEMENT LEVEL FOR ROAD FUNCTION AND IDENTIFICATION OF PROBLEM SECTIONS

9.1 APPROACH

One of the major issues of the Study is to establish appropriate improvement levels for road function. *"Improvement Level" in the Study is defined as:*

"the minimum allowable level of traffic operational conditions to be maintained by the Pan-Philippine Highway in order to fully fulfill its roles and functions as the most important trunk road in the country. When a certain section approaches to the minimum allowable level, improvement or remedial measures of the said section should be implemented, therefore, the improvement level specifies optimum timing for implementation of improvement."

Shown in Figure 9.1-1 is the procedure to establish improvement levels. Alternatives for improvement levels will be developed based on road user's requirements and from the viewpoint of highway planning. Problem sections will be identified based on improvement level alternatives. All possible solutions will be studied and improvement measures alternatives will be developed in combination with improvement level alternatives, of which economic viability will be evaluated. Then, appropriate improvement levels will be recommended.

A level of traffic operational conditions is measured by a "level of service," Figure 9.1-2 shows characteristics of each level of service and corresponding daily traffic volume of the Pan-Philippine Highway.

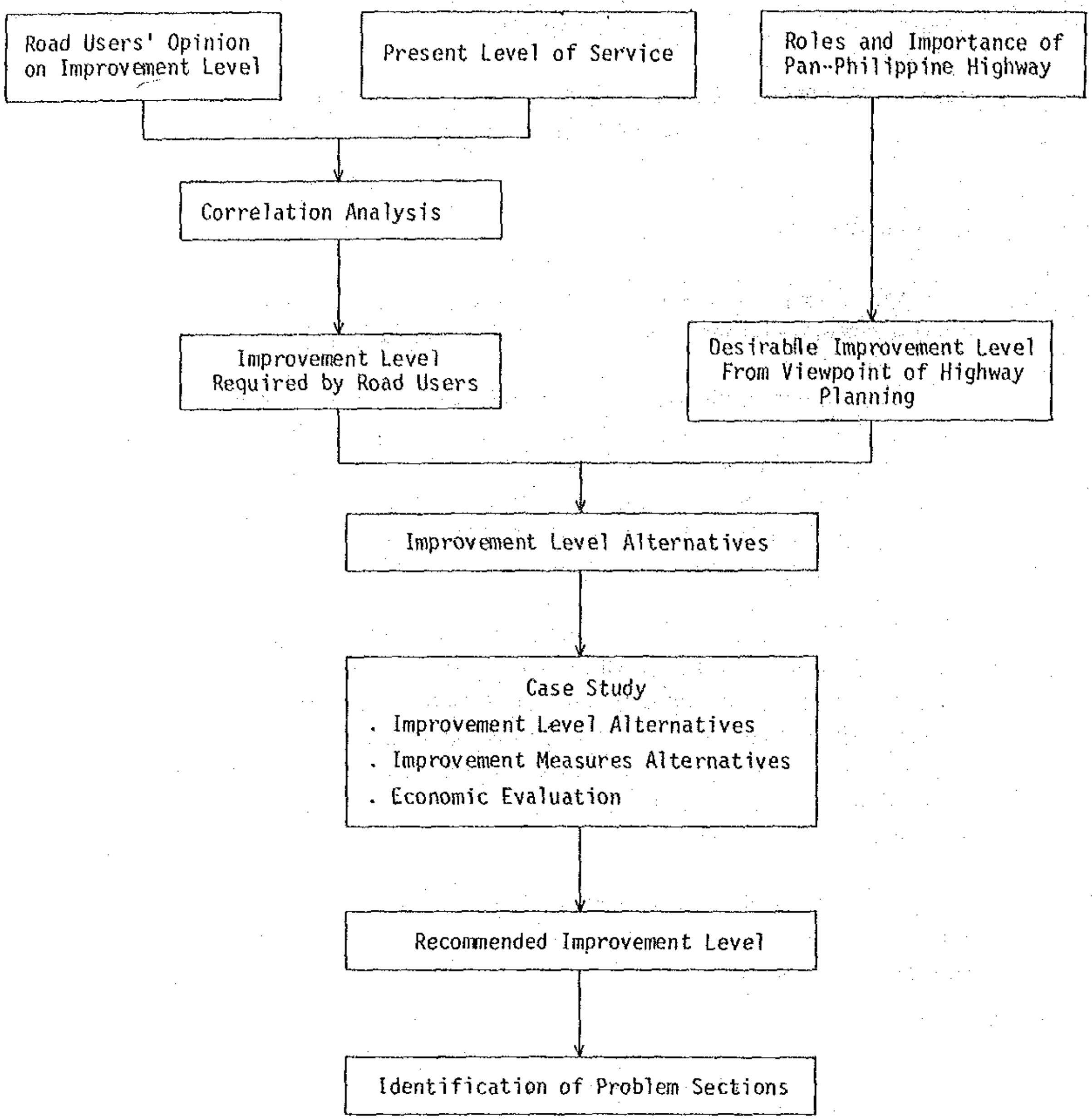


FIGURE 9.1-1 PROCEDURE FOR ESTABLISHMENT OF IMPROVEMENT LEVEL

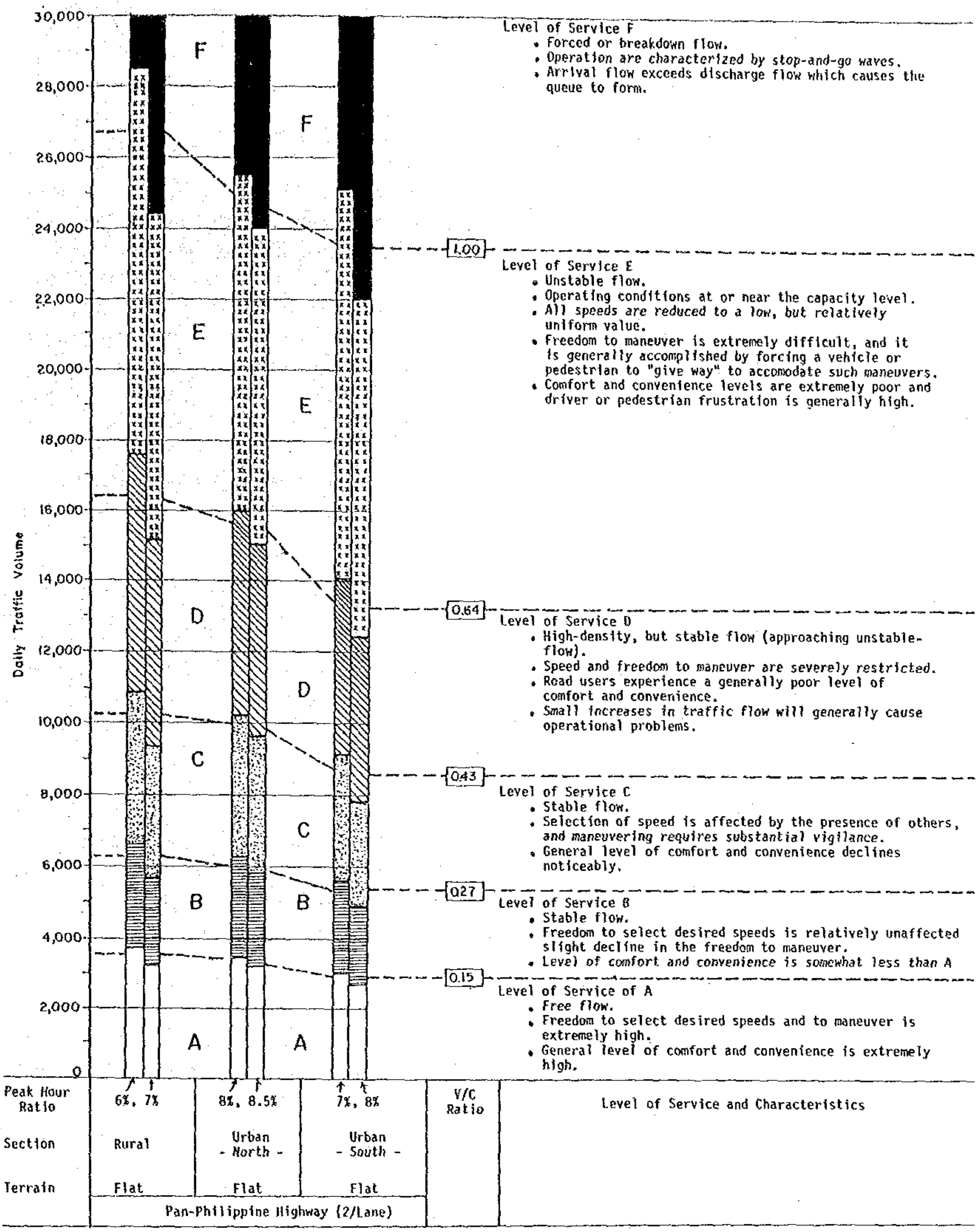


FIGURE 9.1-2 LEVEL OF SERVICE VS. DAILY TRAFFIC VOLUME

9.2 ESTABLISHMENT OF IMPROVEMENT LEVEL

9.2.1 Road User's Opinion on Improvement Level

1) Correlation between Road User's Opinion and Level of Service

Two (2) kinds of surveys were conducted to obtain road user's tolerable limit to traffic congestion and opinions on improvement needs. One was the interview survey, in which car, bus and truck drivers were interviewed to identify five (5) most congested sections along the Study Section and to assess degree of congestion and needs of improvement of each section which they identified. The other survey was conducted by traffic and highway engineers. While they were travelling along the Study Section, they were required to assess degree of congestion, needs of improvement and type of improvement needed, without having been given any information on traffic volumes prior to their travel.

Results of two surveys and levels of service of corresponding sections are correlated and presented in Figures 9.2-1 and 2. Survey results are interpreted hereunder.

a) Rural Sections

- No rural sections were included among 5 most congested sections which drivers were requested to identify.
- Engineers assessed as follows:

Section of LOS D

- About 20% of engineers assessed congestion of sections is approaching untolerable level. Another 50% feel sections are congested, but congestion is still tolerable. About 60% of them suggested improvement is needed but not urgent.

Sections of LOS C and B

- Majority of engineers (about 80%) assessed congestion of sections is still tolerable and improvement is not needed yet.

b) Urban Section

Section LOS E

- About 80% of drivers and about 70% of engineers feel either sections of LOS E (Plaridel and Cabanatuan) are very congested and congestion is not tolerable or sections are congested and congestion is approaching to untolerable level. About 50% of drivers and 40% of engineers suggested improvement be made urgently.

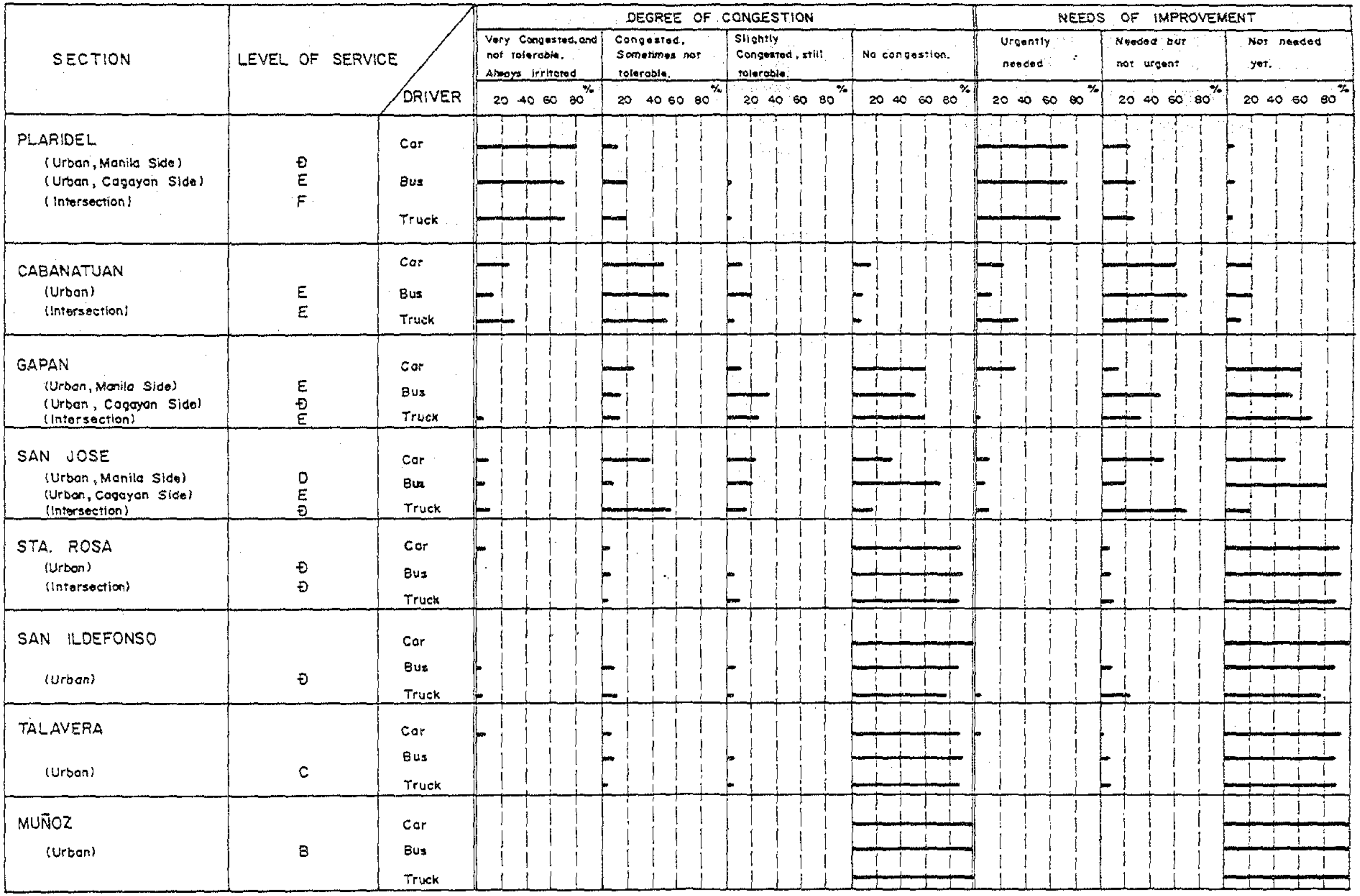


FIGURE 9.2-1 DRIVERS' OPINION ON IMPROVEMENT NEEDS AND LEVEL OF SERVICE

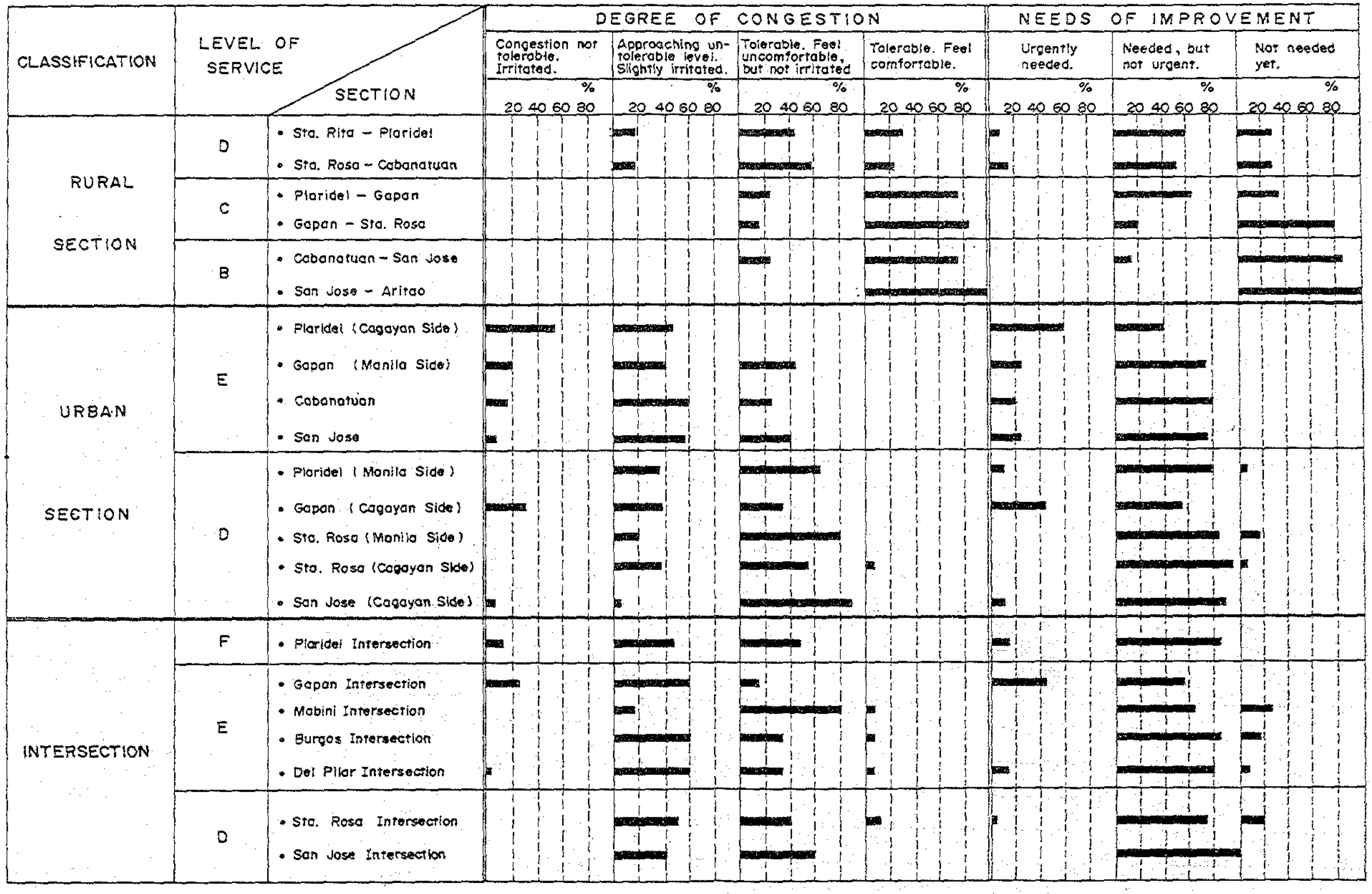


FIGURE 9.2-2 ENGINEERS' OCULAR ASSESSMENT ON IMPROVEMENT NEEDS AND LEVEL OF SERVICE

Sections of LOS D

- Sections of LOS D could be categorized into two: sections at the early and middle stages of LOS D and sections at the latter stage of LOS D or the stage approaching to LOS E.

- For sections at the latter stage of LOS D or the stage approaching to LOS E (Gapan and San Jose), about 30% of drivers feel sections are very congested or slightly congested and congestion is sometimes untolerable. About 40% of them feel improvement is needed but not urgent. About 20% to 50% of engineers assessed congestion of sections is approaching untolerable level and improvement is needed but not urgent.

- For sections at the early and middle stages of LOS D (Sta. Rosa and San Ildefonso), about 10% of drivers feel sections are congested but the rest (about 90%) do not feel sections are congested and suggested no improvement is needed yet. Engineers assessed slightly different that about 30% of them assessed congestion is approaching to untolerable level. About 85% suggested improvement is needed but not urgent.

Sections of LOS C and B

- More than 95% of drivers do not feel sections are congested and suggested no improvement is needed yet.

c) Intersection

Intersection of LOS F

- About 15% engineers feel congestion is not tolerable. About 45% of them feel congestion is approaching to untolerable level.

- Urgent improvement was suggested by about 15% of engineers. About 85% of engineers assessed improvement is needed but not urgent.

Intersection of LOS E

- About 60% of engineers feel congestion is approaching to untolerable level and improvement is needed but not urgent.

Intersection of LOS D

- About 40% of engineers feel congestion is approaching to untolerable level. About 80% of them assessed improvement is needed but not urgent.

2) Improvement Level Required by Road Users

When degree of congestion reaches to a level that "congestion is approaching to untolerable condition", it could be interpreted that the condition is unacceptable to road users and they desire improvement. Based on discussions in section 9.2.1, percent of drivers and engineers stating unacceptable is summarized in Table 9.2-1.

TABLE 9.2-1 LEVEL OF SERVICE AND % OF UNACCEPTANCE

	Level of Service	Percent of Drivers/Engineers Stating Unacceptable		
		Rural Section	Urban Section	Intersection
F		______ 1/	______ 1/	60%
E	(mostly middle stage of E)	______ 1/	70 – 80%	60%
D	Approaching to E	20%	20 – 40%	40%
	early and middle stages of D		10 – 30%	
	C & B	0%	0 – 5%	–––––

NOTE: 1/ At present, no section falls in this level of service.

When a level of service of an urban section or an intersection becomes the middle stage of E, more than 50% of road users feel unacceptable. Therefore, the middle stage of LOS E of urban sections and intersection seems to be a critical level for establishing improvement levels required by road users.

Whereas, the middle stage of LOS D is presently the lowest level of the rural sections, the lowest accptable level of service required by road users for rural sections could not be identified by the surveys. However, road users generally require higher level of service in rural sections than in urban sections, therefore, the early stage of level of service E would be a critical level for rural sections.

Improvement levels required by road users are estimated as shown in Table 9.2-2.

TABLE 9.2-2 IMPROVEMENT LEVEL REQUIRED BY ROAD USERS

Section	Improvement Level Required by Road Users
Rural Section	early stage of LOS E
Urban Section	middle stage of LOS E
Intersection	middle stage of LOS E

9.2.2 Desirable Improvement Level

Improvement levels required by road users would be the lowest allowable levels. From the viewpoint of highway planning, highways should be planned to provide higher quality of service as much as possible to provide faster, safer and more comfortable means of transport, in due consideration of roles and function of each highway, if such plans are economically and financially feasible.

Taking into account the importance of roles to be fulfilled by the Pan-Philippine Highway, which were discussed in Chapter 2, desirable improvement levels are discussed hereunder.

1) Principal Function

Among various functions, traffic function is principal one for roads. Traffic function consists of two functions: mobility and land access. These functions are incompatible. For mobility, consistent high speeds and infrequent passing delays are desirable and low speeds undesirable. For land access, low speeds are desirable and high speeds undesirable.

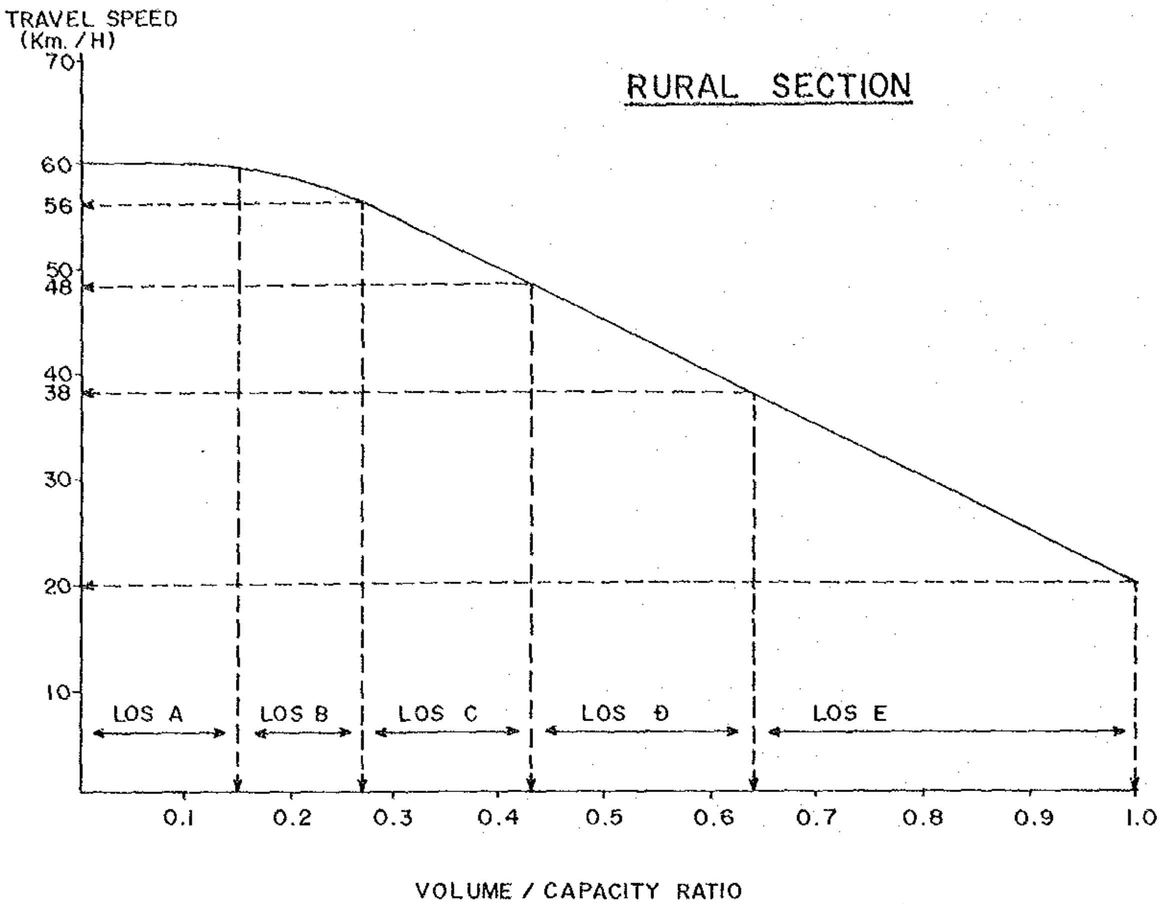
The Pan-Philippine Highway is the major trunk road serving for long-distance trips and connecting major urban centers in the regions with Metro Manila, mobility should be given high priority. Land accessibility should be, as much as possible, restricted to minimum. Therefore, travel speeds at reasonable level should be maintained all the time on the Pan-Philippine Highway.

2) Travel Speed and Level of Service

Relationship between travel speeds and levels of service which developed by the Study Team is shown in Figure 9.2-3 and summarized in Table 9.2-3.

TABLE 9.2-3 TRAVEL SPEED AND LEVEL OF SERVICE ON THE PAN-PHILIPPINE HIGHWAY

Level of Service	Travel Speed (Kms. per hour)	
	Rural Section	Urban Section
A	60	40
B	56 – 60	37 – 40
C	48 – 56	31 – 37
D	38 – 48	23 – 31
E	20 – 38	10 – 23
F	20	10



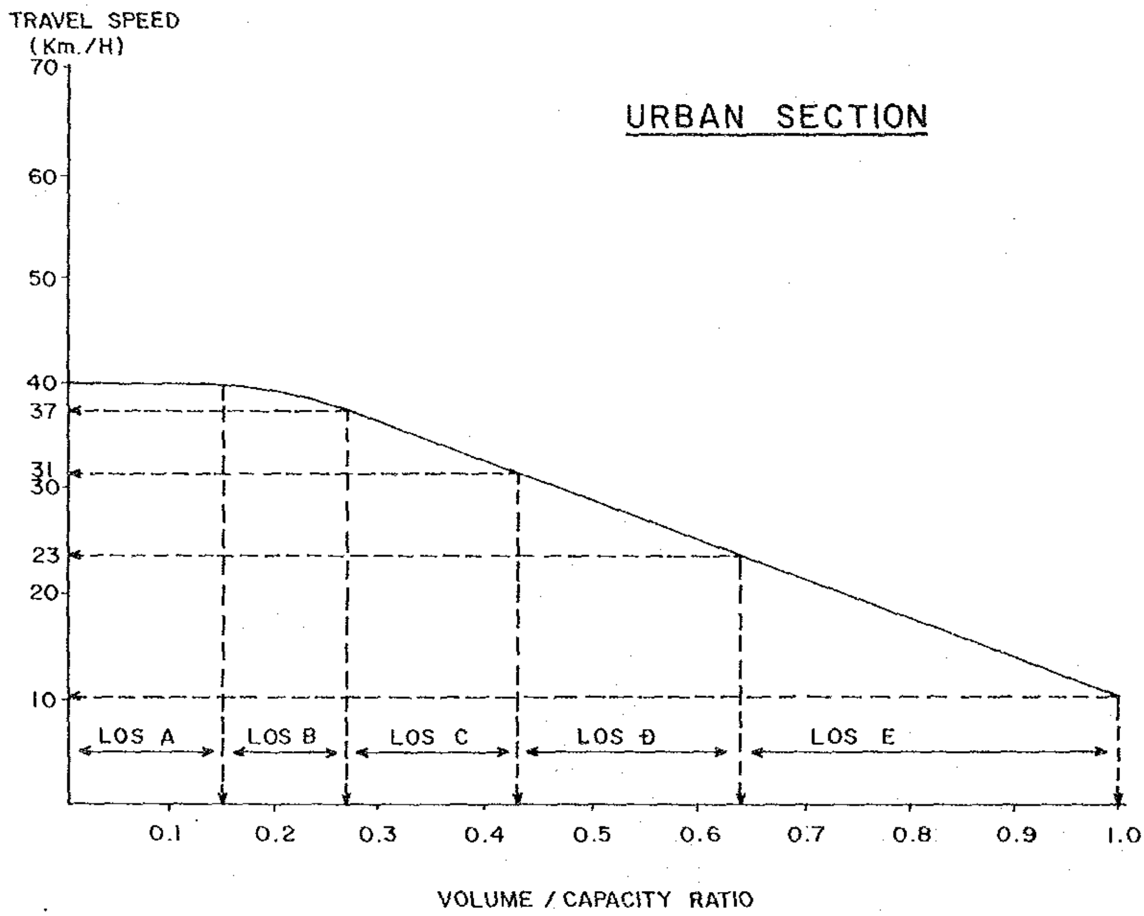


FIGURE 9.2-3 TRAVEL SPEED AND LEVEL OF SERVICE

In rural sections, travel speeds at a level of service D will become 38 to 48 kms per hour. Traffic stream will be approaching unstable flow, freedom to maneuver will be severely restricted and small increase in traffic flow will generally cause operational problems. The Pan-Philippine Highway mostly passes through rural areas, therefore, rural sections should be planned to provide high quality of service, which will produce overall efficiency of mobility. Travel speed of more than 40 kms. per hour in rural sections would be an appropriate target. From the viewpoint of highway planning, it would be appropriate that the improvement level for rural sections be set at the latter stage of level of Service D (approaching E).

In urban sections, travel speeds are lower by about 10 to 15 kms. per hour than rural sections. Urban sections of the Pan-Philippine Highway continue only for a short stretch, mostly 1.0 to 2.0 kms and maximum, 4.5 kms at Cabanatuan City, therefore, even though a lower quality of service is planned in urban sections, overall efficiency of mobility will not be affected considerably. It would be acceptable that improvement level for urban sections be set at the early stage of level of service E.

Problem intersections are usually located in urban sections, therefore, the improvement level for intersections should be the same as that of urban sections.

Desirable improvement levels proposed from the viewpoint of highway planning are summarized in Table 9.2-4.

TABLE 9.2-4 DESIRABLE IMPROVEMENT LEVEL

Section	Desirable Improvement Level
Rural Section	the latter stage of level of service D (approaching E)
Urban Section	the early stage of level of service E
Intersection	the early stage of level of service E

9.2.3 Alternatives of Improvement level

Based on the above discussions, alternatives of improvement levels were developed as follows:

TABLE 9.2-5 IMPROVEMENT LEVEL ALTERNATIVES

	Improvement Level	
	Alternative A	Alternative B
Rural Section	early stage of LOS E	latter stage of LOS D (Approaching E)
Urban Section	middle stage of LOS E	early stage of LOS E
Intersection	middle stage of LOS E	early stage of LOS E
Basis of Alternative	required by Road users	Desirable from the viewpoint of highway planning

9.2.4 Recommended Improvement Level

Two (2) improvement level alternatives were economically evaluated by developing improvement measures alternatives. Economic evaluation shows that "Improvement Level Alternative B" which requires higher level of service than Alternative A, is economically feasible (Refer to Chapter 21).

Recommended improvement levels are shown in Table 9.2-6.

TABLE 9.2-6 RECOMMENDED IMPROVEMENT LEVEL

Section Type	Recommended Improvement Level	Type of Improvement Measures
Rural Section	Latter Stage of LOS D	• Widening to a 4-lane road
Urban Section	Early Stage of LOS E	• Bypass 1/ • Paving of shoulders and construction of sidewalks
Intersection	Early Stage of LOS E	• Signalization

NOTE: 1/ In case that a project requires bigger investment than usual projects due to construction of a long bridge or such, improvement level at the middle stage of LOS E is recommended.

9.3 IDENTIFICATION OF PROBLEM SECTIONS

9.3.1 Approach

Present problem sections were identified based mainly on requirement of improvement level, traffic characteristics, roadside environment and traffic safety considerations. Future problem sections were predicted based solely on requirement of improvement level, and classified into three (3) time spans as follows:

Short Term 1987-1992
Medium Term 1993-1998
Long Term 1999-2010

On the assumption that no improvement measures would be implemented in the Study Section (Do Nothing Case), levels of service of the Study Section were estimated based on traffic volume forecasted for years 1990, 1995, 2000 and 2010, which are graphically shown in Figures 9.3-1 and 2 (also refer to Appendix 9-1).

9.3.2 Short Term Problem Sections (1987-1992)

1) General Problems

The Pan-Philippine Highway in the Study Section runs mostly through rural areas. Regional urban centers are developed along the Study Section at intervals of about 10 kilometers. At present, built-up urban areas extend only a short stretch ranging from 1.0 kilometer to 2 kilometers, and maximum 4.5 kilometers at Cabanatuan City.

Travellers still enjoy high travel speeds of more than 55 kms per hour in the rural sections, except two (2) sections nearest to Metro Manila: the Sta. Rita-Plaridel Sections in North Section and the Calamba-Sto. Tomas Section in the South Section. However, travel speeds on the major urban sections such as Plaridel, Gapan, Cabanatuan and San Jose (all in the North Section) are drastically reduced to low at about 20 to 35 kms. per hour, and about 15 to 20 kms per hour at intersections.

On major urban sections, share of long-distance trip traffic to total traffic becomes quite low, instead local traffic increases drastically, as shown in Figure 9.3-3. About 60% of total traffic on the Plaridel urban section are local traffic, and about 80% on the Cabanatuan, Gapan and San Jose urban sections. On these sections, mobility which is principal function to be pursued by the major trunk road, is severely affected by the existence of large volume of local traffic.

Urban road network in most urban centers is not developed well yet, and is generally formed by only two (2) major roads, i.e. the Pan-Philippine Highway and a major road intersecting the former. Urbanization has progressed centered at the intersection of said two major roads, public and private commercial facilities are concentrated along the urban sections of the Pan-Philippine Highway. Therefore, land access is quite important function to be provided by urban sections of the Highway.

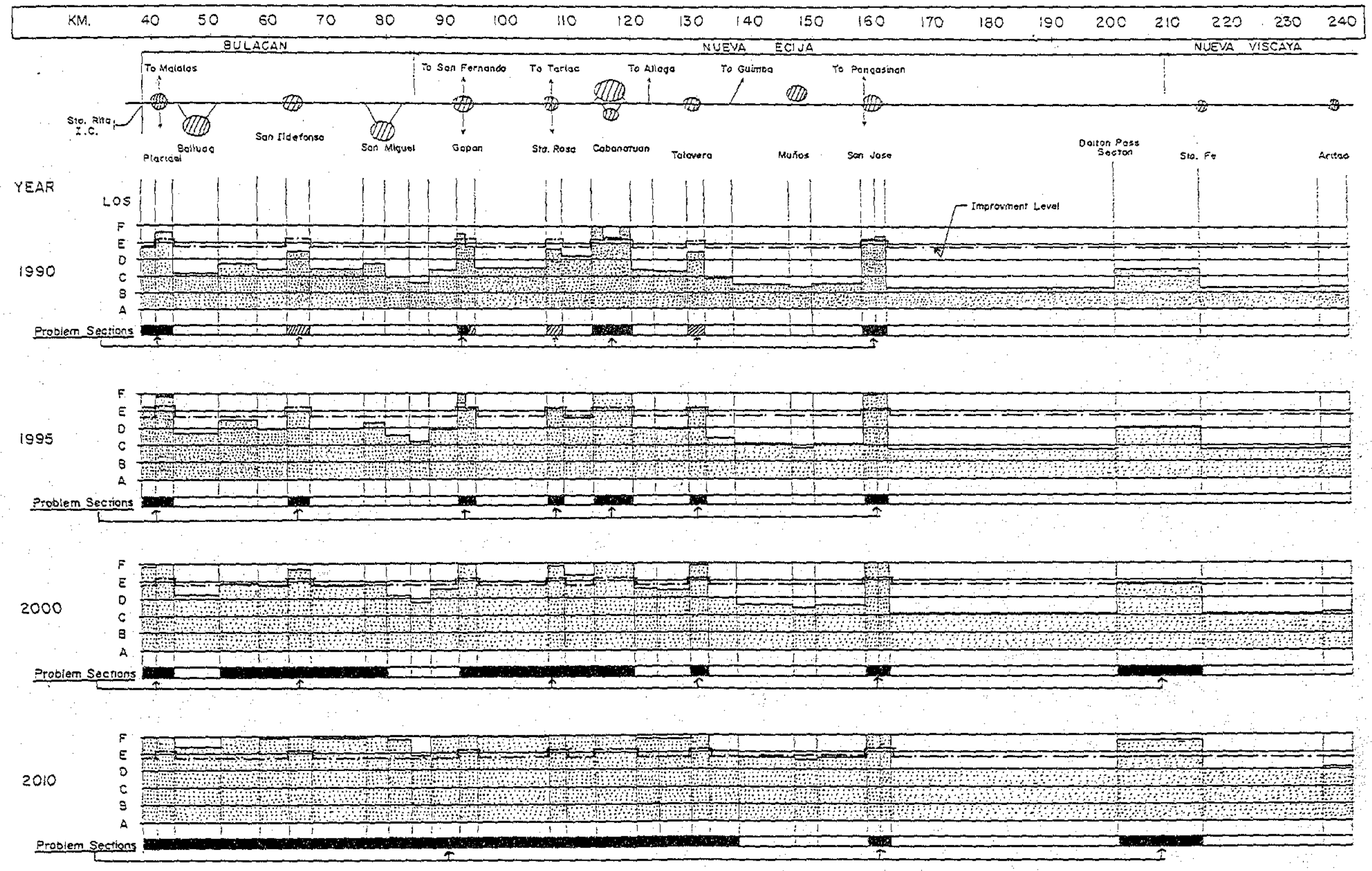


FIGURE 9.3-1 FUTURE LEVEL OF SERVICE – NORTH SECTION – (DO NOTHING CASE)

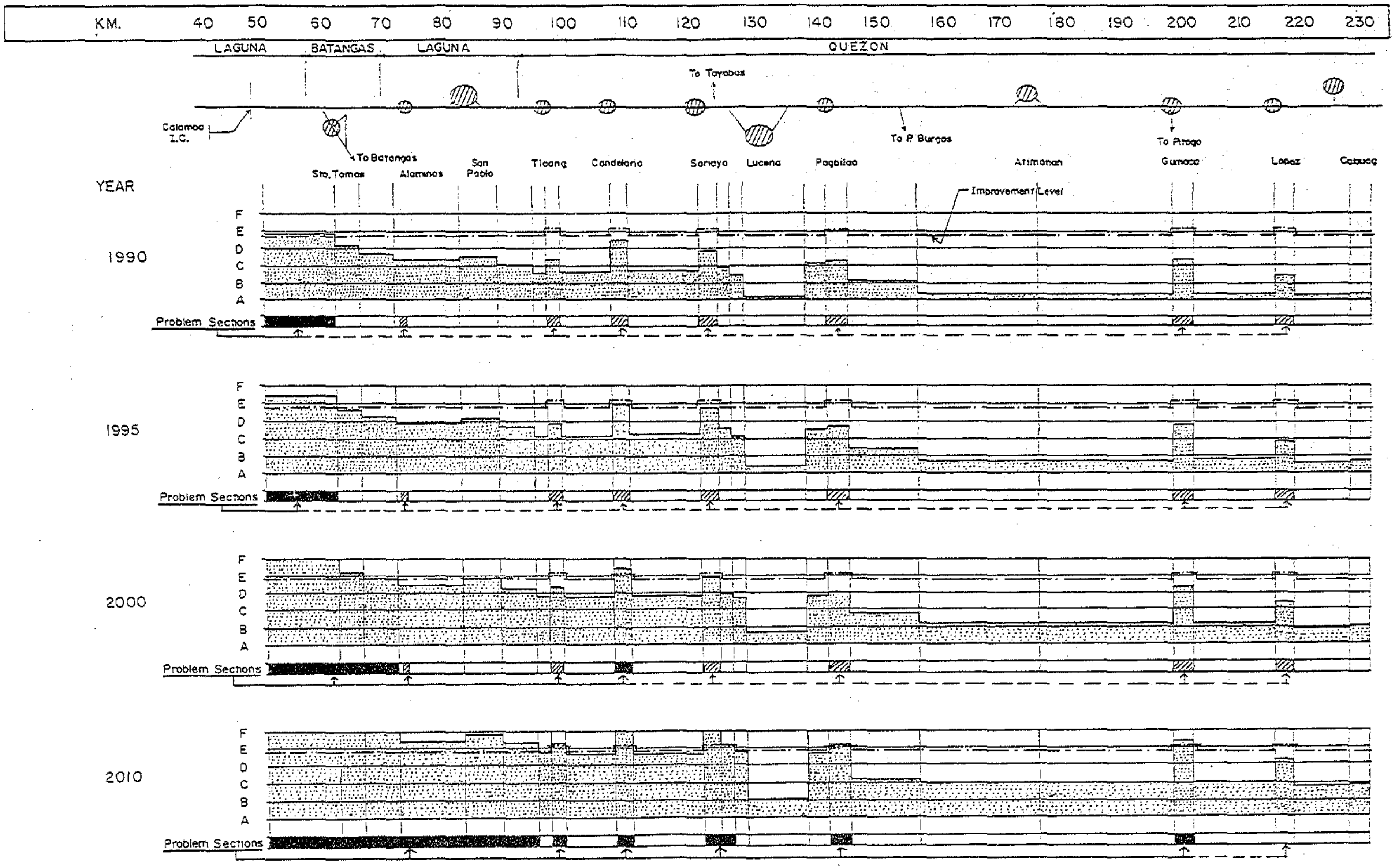


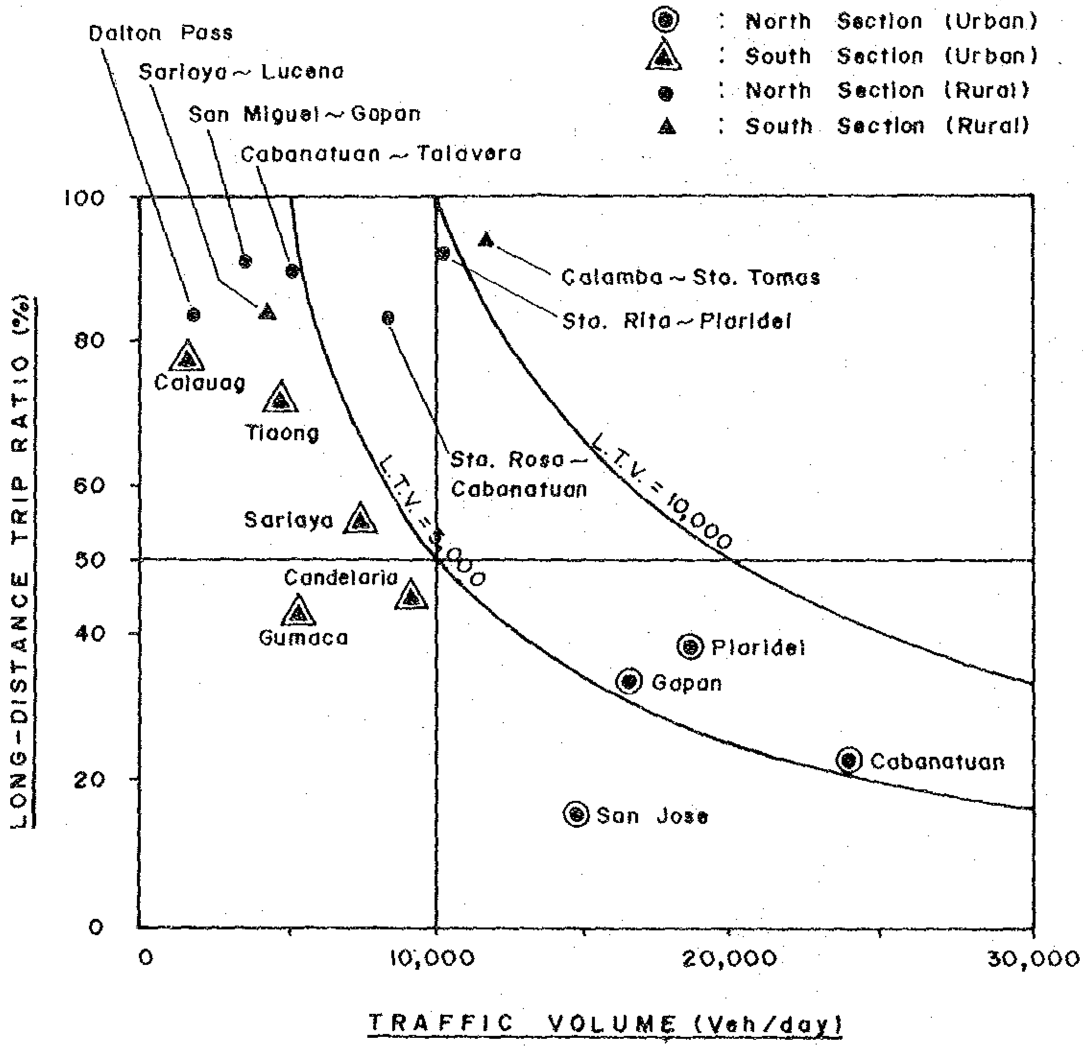
FIGURE 9.3-2 FUTURE LEVEL OF SERVICE – SOUTH SECTION – (DO NOTHING CASE)

Two (2) incompatible functions, mobility and land access, are required to be provided at the same degree of importance by urban sections of the Pan-Philippine Highway. Therefore, how and when to split these two (2) functions is one of the major issues to be solved.

The South Section has less problems than the North Section. Unlike the North Section, Urban Sections in the South Section have less local traffic, therefore less problems than the North Section.

2) Identified Problem Sections

Identified problem sections are summarized in Table 9.3-1, and problems will be discussed in detail together with possible solutions in Chapter 10.



Notes: Long-distance Trip Ratio = $\frac{\text{Long-distance Trip Traffic Volume}}{\text{Total Traffic Volume}}$

L.T.V. : Long-distance Trip Traffic Volume (Veh/day)

FIGURE 9.3-3 LONG-DISTANCE TRIP RATIO ON THE PAN-PHILIPPINE HIGHWAY

TABLE 9.3-1 SHORT TERM PROBLEM SECTIONS

Period	General Assessment	Type of Section	Major Problems	Identified Problem Sections: North Study Section (L = 200 kms.)	Identified Problem Sections: South Study Section (L = 181 kms.)
Short Term (1987-1992)	. Most of rural sections maintain high level of service, except 2 sections nearest to Metro Manila.	a) Rural Section	i) LOS is less than Improvement Level	. Sta. Rita-Plaridel Section (Km. 39 - Km 41 L = 2 kms.)	. Cajamba-Sto. Tomas Section (Km. 52 - Km. 61 L = 10 kms.)
			ii) Sub-standard aligmment	. Dalton Pass Section (Km. 201 - Km. 216, L=15.0 km.)	(None)
	. Most of urban sections also provide relatively good quality of service, except 4 major urban sections. . In 4 major urban sections, mobility of long-distance trips are severely interfered due to large volume of local traffic, especially tricycles.	b) Urban Section	i) Type 1 . LOS is less than Improvement Level . ADT more than 10,000 vpd. . Long-distance trip traffic volume more than 5,000 vpd.	. Plaridel (Km. 41 - Km. 42.5, L = 1.5 Kms.) . Gapan (Km. 92 - Km. 95, L=3.0 kms) . Cabanatuan (Km. 111 - Km. 118, L = 7.0 kms.)	(None)
			ii) Type 2 . LOS is less than Improvement Level . ADT more than 10,000 vpd. . Long-distance trip traffic volume less than 5,000 vpd.	. San Jose (Km. 154 - Km. 161, L = 4.0 kms.)	(None)
			iii) Type 3 . no problem in terms of LOS, but improvement needed due to rural type of cross section and traffic safety consideration.	. San Ildefonso (Km. 65.7 - Km. 66.7 L = 1.0 km.) . Sta. Rosa (Km. 106.8 - Km. 107.9, L = 1.1 kms.) . Talavera (Km. 130 - Km. 131, L = 1.0 km.)	. Alaminos (Km. 73.2 - Km. 74.4, L = 1.2 kms.) . Tiaong (Km. 94.6 - Km. 95.8, L = 1.2 kms.) . Candelaria (Km. 107 - Km. 108, L = 1.0 km.) . Sariaya (Km. 120 - Km. 121, L = 1.0 km.) . Pagbilao (Km. 140 - Km. 140.5, L = 1.5 kms.) . Gumaca (Km. 196 - Km. 197.5, L = 1.5 kms.) . Lopez (Km. 216 - Km. 217, L = 1.0 kms.)
		c) Inter-Section	i) LOS is less than Improvement Level	. Plaridel Intersection (Km. 41.7) . Gapan Intersection (Km. 93.9) . Cabanatuan Intersection II (Junction with Mabini, Km. 115.7) . Cabanatuan Intersection IV (Junction with Del Pilar, Km. 116.6) . San Jose Intersection (Km. 159.4)	(None)
			ii) Inadequate geometric design	. Baliuag Bypass Intersection (Km. 54.4)	. Sto. Tomas Intersection I (Km. 60) . Sto. Tomas Intersection II (Km. 61)

9.3.3 Medium Term Problem Sections (1993-1998)

In this period, rural sections will still maintain higher level of service than improvement level, however, problems will be observed in most of major urban sections. In the North Study Section, all urban sections will experience low quality of service. In the South Study Section, all urban sections north of Lucena City will be problem sections. (See Table 9.3-2).

9.3.4 Long Term Problem Sections (1999-2010)

In the early stage of this period (in the year about 2000), rural sections will begin to suffer traffic problems. In the North Study Section, the 22.2 kms sections between end of Baliwag Bypass (Km 54 + 800) and San Miguel (Km 77), the 26.0 kms section between Gapan (km 92) and Cabanatuan (Km 118) and the Dalton Pass Section (Km 200-Km 216) will be additional problem sections. In the South Study Section, one short rural section (9.3 kms) between Sto. Tomas (Km 60) and Batangas/Laguna boundary (Km 69 + 300) will experience lower level of service than improvement level.

In the latter stage of this period, more than 50% of sections in the North Study Section and about 25% of sections in the South Study Section will suffer insufficient quality of service. (See Table 9.3-2).

TABLE 9.3-2 MEDIUM AND LONG TERM PROBLEM SECTIONS

Period	Gereral Assessment	Type of Section	Urban Problems	Identified Problem Sections	
				North Study Section (L = 200 kms.)	South Study Section (L = 181 kms)
Medium Term (1993-1998)	. Most of rural sections will still maintain higher level of service than Improvement Level.	a) Rural Section	Additional sections of which LOS will be less than Improvement Level.	(None)	(None)
	. All urban sections in North Study Section and those north of Lucena in South Study Section will suffer lower level of service than Improvement Level.	b) Urban Section	Additional sections of which LOS will be less than Improvement Level.	. San Ildefonso (Km. 65.7 - Km. 66.7, L = 1.0 km.) . Sta. Rosa (Km. 106.8 - Km. 107.9, L = 1.1 kms.) . Talavera (Km. 130 - Km. 131, L = 1.0 km.)	. Tiaong (Km. 94.6 - Km. 95.8, L = 1.2 kms.) . Candelaria (Km. 107 - Km. 108, L = 1.0 km.) . Sariaya (Km. 120 - Km. 121, L = 1.0 km.)
Long Term (1999-2010)	. In the year about 2000 Problems of low service quality will be suffered not only in urban sections but also in rural sections.			. End of Baliuag Bypass - San Miguel Section (Km. 54.8 - Km. 77, L = 22.2 kms.) . Gapan-Cabanatuan Section (Km. 92 - Km. 118, L = 26.0 kms.) . Dalton Pass Section (Km. 201 - Km. 216, L = 15.0 kms.)	. Sto. Tomas - Batangas/Laguna Boundary (Km. 61 - Km. 69.3, L = 8.3 kms.)
	. In the year about 2010 More than 50% of sections in the North Study Section will suffer lower level of service than Improvement Level. About 25% of sections in the South Study Sections will suffer insufficient quality of service.			. Full stretch from Sta. Rita to junction to Guimba (Km. 39 - Km. 138.5, L = 99.5 kms.)	. Full stretch from Calamba to Laguna/Quezon Boundary (Km. 52 - Km. 91.4, L = 39.4 km

CHAPTER 10

PROPOSED IMPROVEMENT MEASURES AND EVALUATION

10.1 APPROACH

The following procedure was adopted to find out the most appropriate improvement measures to cope with problems:

1) Possible improvement measures

All possible improvement measures were studied for each short term problem section identified, and sections were classified into groups in accordance with similarity of problems.

2) Selection of Case Study Sections

From each group, one or two sections were selected for case studies. Alternative improvement measures for each selected section were studied. The most appropriate improvement measures was selected.

3) Evaluation of Improvement Measures

Improvement measures selected were economically evaluated.

4) Recommendation

Based on above studies, the most appropriate improvement measures were recommended for each group of sections.

10.2 POSSIBLE IMPROVEMENT MEASURES

10.2.1 Short Term Problem Sections

Problems and all possible improvement measures for short term problem sections are summarized and shown in Table 10.2-1.

Sections/intersections which were identified as short term problem sections are classified into following groups based on similarity of nature of problems:

Group	Classification Criteria	No. of Section/Intersection North Study Section	South Study Section
Rural: Type 1	LOS is less than improvement level	1	1
Rural: Type 2	Sub-standard alignment	1	0
Urban: Type 1	• LOS is less than improvement level • ADT more than 10,000 vpd. • Long-distance trip more than 5,000 vpd.	3	0
Urban: Type 2	• LOS is less than improvement level • ADT more than 10,000 vpd. • Long-distance trip less than 5,000 vpd.	1	0
Urban: Type 3	• No problem in LOS, but improvement needed due to rural type of cross section and traffic safety consideration f	3	7
Intersection: Type 1	• LOS is less than improvement level	5	0
Intersection: Type 2	• Inadequate geometric design	1	2

10.2.2 Medium and Long-Term Problem Sections

1) Medium Term Problem Sections (1993-1998)

In this period, no rural sections will be newly problem sections, but most of urban sections will have lower level of service than required by improvement level. Nature of problems of urban sections in this period will be the same as that in the short terms period, recommended improvement measures for short term period will be applicable. All urban sections which will become problem sections in this period, extend only for a short stretch and widening beyond the existing right-of-way is not practical due to heavy roadside development, construction of a bypass will be the most practical solution.

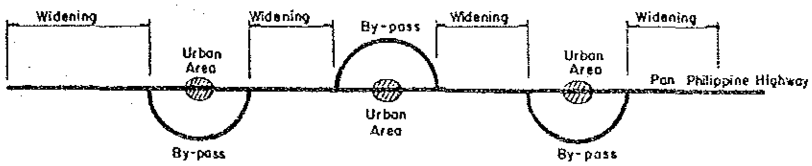
2) Long-Term Sections (1999-2010)

In the early stage of this period, rural sections will begin to suffer traffic problems. This tendency will be expanded further and more than 50% of the North Study Section and about 25% of the South Study Section will be problem section by the latter stage of this period.

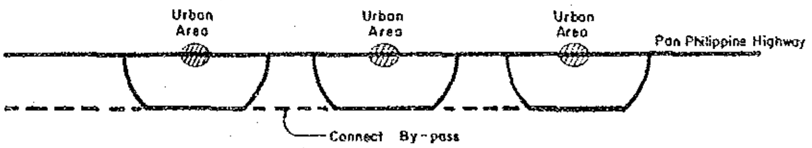
The most serious problem expected in the implementation is that the existing right-of-way width of the Pan-Philippine Highway is only 15 to 18 meters, therefore, 4 lanes cannot be accomodated within the existing right-of-way. Urbanization along the Pan-Philippine Highway will progress further, therefore right-of-way acquisition will be a major obstraction for implementation.

The three (3) schemes and/or combination of these should be studied at the early stage of this period, are as follows:

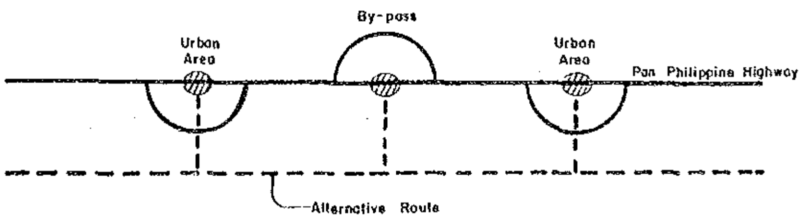
Scheme A	:	Bypass + widening of existing section
Scheme B	:	Bypass + construction of roadside to link bypasses
Scheme C	:	Construction of an alternative route



(Scheme A) By-pass + Widening of Existing Section



(Scheme B) By-pass + Construction of Roads to Link By-pass



(Scheme C) Construction of an Alternative Route

FIGURE 10.2-1 POSSIBLE SOLUTIONS (1999-2010)

TABLE 10.2-1 PROBLEMS AND POSSIBLE MEASURES OF SHORT TERM PROBLEM SECTIONS

Section Classification		Identified Problem Section	Problems	Possible Improvement Measures
Rural Section	North	a) Sta. Rita-Plaridel Sect. (Km 39-Km 41: L=2 kms)	. ADT .... 10,750 . LOS .... latter stage of D . Travel Speed .... 40-45 kph.	. Widening to 3-lanes . Widening to 4-lanes . Construction of an alternative route
	South	b) Calamba-Sto. Tomas Sect. (Km. 52-Km. 61: L=10 kms)	. ADT .... 12,085 . LOS .... latter stage of D . Travel Speed .... 35-40 kph.	
	North	c) Dalton Pass Section (Km 201-Km 216: L=15 km)	. Sharp curves and steep grade	. Improvement of alignment . Construction of new route
Urban Section	North Section	Type 1 a) Plaridel Urban Section (Km 41-Km 42 + 500, L = 1.5 kms)	. ADT .... 14,681-18,901 . LOS .... latter stage of D Middle of Stage of E . Travel Speed .... 20-30 kph . Long-distance trip.. 40% . Local trip .... 60% . Heavy roadside friction due to public market and loading/unloading of PUV passengers . On-street parking of private/public vehicles especially near the public market . Jeepney/tricycle terminals near the intersection . U-turn of jeepneys assigned to Plaridel-Monumento/Meycauayan route . Irregular and slow movement of tricycles (tricycle traffic 3,070-5,590) . Frequent crossings of pedestrians at any place of the section	. Improvement of existing section with traffic management - paving of shoulders and sidewalks - selection of proper location of PUV loading/unloading zones and terminals - regulation and/or re-routing of tricycle/jeepney route - on-street parking ban - re-development of public market area . Construction of a bypass
		Type 1 b) Gapan Urban Section (Km 92-Km 95, L = 3 km)	. ADT .... 16,718-11,896 . LOS .... Middle Stage of E-latter Stage of D . Travel Speed .... 35-40 kph . Long-distance trip.. 34% . Local trip .... 66% . High share of tricycles of which movement is irregular and slow (tricycle traffic 9,350-5,755) . Heavy roadside friction due to loading/unloading of PUV passengers . Bus stops and jeepney/tricycle terminals near intersection . Frequent crossing of pedestrians at any place of the section	. Improvement of existing section with traffic management - paving of shoulders and sidewalks - regulation of tricycle routes - selection of proper location of bus stops and jeepney/tricycle loading/unloading zones . Construction of bypass
		Type 1 c) Cabanatuan Urban Section (Km 111-Km 118, L = 7 kms)	. ADT................ 21,311 - 15,610 - 23,931 . LOS .... latter Stage of E and D . Travel Speed .... 25 - 35 kph . Long-distance trip . 20% . Local Trip.......... 80% . Heavy roadside friction due to many intersecting roads and loading/unloading of PUV passengers . Concentration of PUV routes to certain roads going to city center . High share of tricycles of which movement is irregular and slow (tricycle traffic 10,290-9,340-14,220) . Frequent crossings of pedestrians at any place of the section . Urban road network is insufficient and is not coincide with urban expansion trend, resulting in concentration of traffic on the Pan-Philippine Highway	. Improvement of existing section with traffic management - paving of shoulders and sidewalks - re-routing of PUV routes - selection of proper location of bus stops and jeepney/tricycle loading/unloading zones . Construction of a bypass or an alternative route parallel to the Pan-Philippine Highway

Section Classification		Identified Problem Section	Problems	Possible Improvement Measures
Urban Section	North Section	Type 2 d) San Jose Urban Section (Km 157-Km 161, L = 4 kms)	. ADT .... 14,851 - 16,012 . LOS .... latter stage of D and early stage of E . Travel Speed .... 30-40 kph . Long-distance trip . 18% . *Local trip* .... *82%* . No overtakings due to center median island . High share of tricycles of which movement is irregular and slow (tricycle traffic: 9,480 - 16,012) . Heavy roadside frictions due to loading/unloading of PUV passengers . Frequent crossings of pedestrians at any place of the section	. *Improvement of existing* section with traffic management - removal of center median island or widening to allow overtakings - paving of shoulders and sidewalks - selection of proper location of bus stops *and jeepney/tricycle* loading/unloading zones
Urban Section	North Section	Type 3 e) Urban section of - San Ildefonso (Km 65+700-Km 66+700, L = 1.0 km) - Sta. Rosa (Km 106+800-Km 107+900 L = 1.1 kms) - Talavera (Km 130-Km 131, L = 1.0 km)	. In terms of levels of service, no problem yet . Sections have either gravel shoulder or severely deteriorated AC pavement shoulders . Sections have either no sidewalks nor deteriorated sidewalks . *Loading/unloading of PUV passengers* disturbing flow of traffic . Pedestrians walking on a roadway are one of potential causes of traffic accidents	. Improvement of existing section - paving of shoulders and sidewalks
Urban Section	South Section	- Alaminos (Km 73+200-Km 74+400, L = 1.2 kms) - Tiaong (Km 94+600-Km 95+800, L = 1.2 kms) - Candelaria (Km 107-Km 108, L = 1.0 km) - Sariaya (Km 120-Km 121, L = 1.0 km) - Pagbilao (Km 140-Km 141+500, L = 1.5 kms) - Gumaca (Km 196-Km 197+500, L = 1.5 kms) - Lopez (Km 216-Km 217, L = 1.0 kms)	. In terms of levels of service, no problem yet . Sections have either gravel shoulder or severely deteriorated AC pavement shoulders . Sections have either no sidewalks nor deteriorated sidewalks . *Loading/unloading of PUV passengers* disturbing flow of traffic . Pedestrians walking on a roadway are one of potential causes of traffic accidents	. Improvement of existing section - paving of shoulders and sidewalks
Intersection	*North* Section	a) Plaridel Intersection (Km 41+700) b) Gapan Intersection (Km 93+900) c) Cabanatuan Intersection (Junction with Mabini St. Km 115+700) d) *Cabanatuan Intersection IV* (Junction with Del Pilar St., Km 116+600) e) San Jose Intersection (Km 159+400)	. Level of Service a) ....F b) ....E c) ....E d) ....E e) ....E . Loading/Unloading of PUV passengers within the intersection area . Pedestrians are potential causes of traffic accidents	. Signalization . Channelization . Pedestrian crossings
Intersection	*North* Section	*f) Baliuag Bypass Intersection* (Km 54 + 400)	. In terms of level of service, no problem, yet . Priority is not given to traffic on the Pan-Philippine Highway . Improper guide signs	: Improvement of geometrics
Intersection	*South* Section	g) Sto. Tomas Intersection I (*Km. 60*) h) Sto. Tomas Intersection II (Km 61)	. In terms of level of service, no problem, yet . Priority is not given to traffic on the Pan-Philippine Highway . Improper guide signs	: Improvement of geometrics

10.3 CASE STUDY

10.3.1 Rural Section: Type 1

1) Problems

Due to large volume of traffic, level of service is deteriorated lower than required level by improvement level. Travel speed is reduced to 35 to 40 km. per hour.

2) Sections Under This Group

Two (2) sections are classified in this group.

- Sta. Rita – Plaridel Section (Km. 39-Km 41)
- Calamba – Sto Tomas Section (Km 52-Km. 61)

3) Possible Improvement Measures

Three (3) alternative improvement measures are possible solutions.

- Widening to a 3-lane road
- Widening to a 4-lane road
- Construction of an alternative route

4) Screening of Alternatives

Two (2) alternatives, i.e. widening to a 3-lane road and construction of an alternative route, were not recommended and widening to a 4-lane road was recommended due to the following reasons:

Widening to a 3-lane road

A 3-lane road could be an intermediate solution to a 4-lane expansion, however, utilization of a center lane has operational defects or is not applicable. A center lane is usually utilized in one of the following ways:

- passing lane for vehicles in either direction

  .... the first vehicle to occupy the center lane has the right-of-way. This operation is hazardous and causing serious traffic accidents.

- passing lane for vehicles in one direction

  .... the center lane is assigned to one direction for a short distance, then alternates the assignment of the passing lane to the other direction. This method will not be practical considering that the section length is too short to apply this method.

- Left-turn lane .... a few intersection exist within the section, therefore, this method is not effective.

- Reversible lane .... difference of directional distribution is quite small throughout a day, therefore not applicable.

In view of the above, widening to a 3-lane road was not recommended.

Widening to a 4-lane road

Key to this solution is whether new right-of-way to accomodate a 4-lane road can be acquired or not. Straight road diagrams indicating existing houses and stores for both problem sections were prepared. Houses and stores along the sections are mostly one-storey wooden building with hollow block walls. It was concluded that acquisition of an average 2.5 meters of land on each side (total right-of-way width of 20 meters) is practically possible. This solutionwas subjected to a case study.

Construction of an alternative road

In principle, this solution should be considered when widening of the existing route is practically difficult.

In case of the Sta. Rita-Plaridel Section which is connected with the Manila North Expressway, this solution requires construction of one additional interchange in between existing two interchanges which are located about 5.6 kms apart. Addition of one interchange may result in too close interchanges to handle traffic on the expressway smoothly. In addition to that, high construction cost is expected.

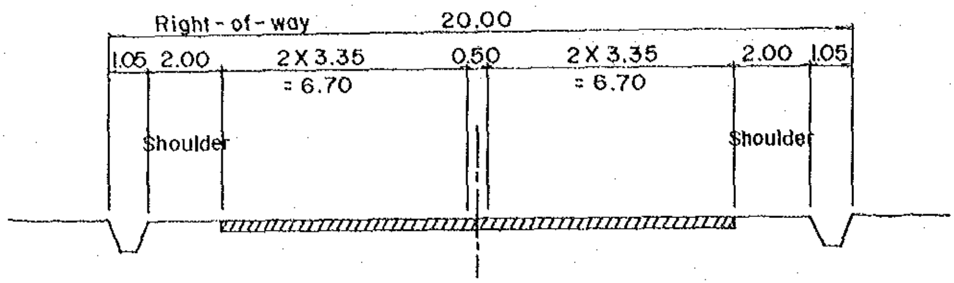
In case of the Calamba-Sto. Tomas Section, there is a plan to extend the Manila South Expressway to Batangas City via Sto. Tomas. However, the feasibility study on Luzon Expressway System Study, conducted by NTPP in 1985, recommended to defer extension of the Expressway instead widening of the existing road was recommended.

In view of the above, this solution was not recommended.

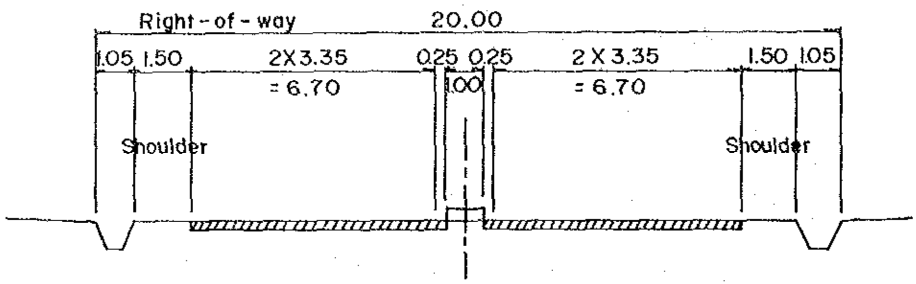
5) Case Study

The Calamba-Sto. Tomas Section was selected for a case study section. (Details are discussed in Chapter 21).

The existing right-of-way ranges from 15 to 19 meters. Based on the straight road diagram which indicate locations of houses and stores, right-of-way width of 20 meters was found most feasible. Two (2) types of a cross section; a 4-lane undivided road and a 4-lane divided road as shown below were compared.



4 – lane Undivided



4 – lane Divided

From the viewpoint of traffic safety, mobility to be assured and the class of road as the Pan-Philippine Highway, a 4-lane divided road is desirable, however, in this particular case, a 4-lane undivided road was recommended in consideration that frequent stops of buses and jeepneys for loading/unloading purposes will be expected as urbanization of the roadside progressed, wider shoulders are desirable to assure smooth flow of traffic stream.

Table 10.3-1 shows traffic volumes and level of service for with and without project cases. Upon completion of the project, level of service of the section will greatly improved.

TABLE 10.3-1 TRAFFIC VOLUME AND LEVEL OF SERVICE
– CALAMBA–STO. TOMAS SECTION –

	Year			
	1986	1990	2000	2010
Traffic Volume (vpd)	12,085	14,671	25,958	46,003
Level of Service				
Without Project	D	D	F	F
With Project	–	A	B	D

Construction cost and right-of-way acquisition cost for widening of the 10-km section were estimated at 57.06 million pesos and 4.28 million pesos, respectively.

Two (2) alternatives were economically evaluated as shown below.

	Implementation	IRR (%)
Case 1	At the early stage of LOS E (Opening year 1995)	48.9
Case 2	At the latter stage of LOS D (Opening year 1991)	35.9

Both cases were evaluated economically feasible. Project implementation at the latter stage of level of service D, which is recommended improvement level, was also economically justified.

10.3.2 Rural Section: Type 2

The Dalton Pass Section (Km 201 – Km. 216) in the North Study Section is the only section identified under this type. The section is located in the mountainous area of the Caraballo Mountain which borders the Cagayan Valley and the Luzon Central Plain. Due to severe topographical conditions, existing alignment is very substandard as shown below.

	Design Requirement – Design Speed 50 km. p.h. –	No. of Curves/Sections Which Do Not Satisfy Design Requirement
• Minimum Horizontal Radius	80 meters	98
• Minimum Non-Passing Sight Distance	60 meters	66
• Maximum Grade	7%	——1/

1/ *Existing maximum grade is 6% for a 1-km section between km 209 and km 210.* Average grade for a 6 km section between km 209 and 215 is 4.9%.

Possible improvement measures are;

1) improvement of existing alignment

This solution is not practical due to severe topographical conditions.

2) construction of a new route

The Dalton Pass Tunnel Project was planned and will be implemented in future.

The most practical solution will maintain the existing alignment with sufficient provisions of traffic safety devices, until such time that the Dalton Pass Tunnel Project is implemented.

10.3.3 Urban Section: Type 1

1) Problems

Urban sections under this type have the most serious problems in the Study Section. Problem are summarized below:

a) Low quality of service (LOS D to E)

b) Section are loaded two incompatible functions, i.e. mobility and land access, at the same degree of importance

- Long-distance trip traffic exceeds 5,000 vehicle per day.
- High share of local traffic (60 to 80% of total traffic)

c) Large volume of tricycle traffic (3,100 to 14,200 tricycles per day)

d) Heavy roadside frictions

2) Sections Under This Group

Three (3) sections in the North Study Section are classified in this group.

- Plaridel Urban Section
- Gapan Urban Section
- Cabanatuan Urban Section

3) Possible Improvement Measures

Possible improvement measures are as follows:

- Improvement of the existing section with traffic management for problems a), c) and d)

- Construction of a bypass for problems a) and b)

4) Case Study

The Plaridel and the Cabanatuan Urban Sections were selected for case study sections. (Details are discussed in Chapter 21).

a) Plaridel Urban Section

As the existing section has been developed as an urban type, i.e. roadway is fully paved and sidewalks are provided. Widening of the section beyond the existing right-of-way is not practical due to heavy roadside development. There is no room for improvement of the existing section. Traffic management on the existing section and construction of a bypass are recommended.

Of a total of 18,900 vehicles per day, 7,065 vehicles (37%) are through traffic, therefore, the primary solution is construction of a bypass.

Construction cost and right-of-way acquisition cost for construction of a bypass were estimated at 76.3 million pesos and 5.5 million pesos, respectively. High construction cost was required due to construction of a 335-meter bridge over Angat River.

Economic evaluation results for bypass project are summarized below.

	Implementation	IRR (%)
Case 1	At the middle stage of LOS E (opening year 1995)	16.4
Case 2	At the early stage of LOS E (opening year 1990)	13.2

Implementation at the early stage of LOS E (opening year 1990) was not justified economically. The project is recommended to be implemented in the medium term period.

b) Cabanatuan Urban Section

Improvement of the Existing Section

Existing right-of-way width ranges from 15 to 18 meters. Based on the survey conducted by the Study Team, the 16-meter right-of-way was proposed which requires minimal land acquisition.

The existing section is composed of 6.7 meter paved travelway with 2.5-meter gravel shoulder on both sides. The proposed cross section is composed of 6.7-meter paved travelway with 3.0-meter paved shoulder and 1.65-meter sidewalk on both sides. A 3-meter shoulder is intended to be utilized for the following purposes:

- Tricycle priority lane (tricycles should be guided to travel on the shoulder as much as possible).

- Loading/unloading zone for jeepneys, buses and tricycles.

- Loading/unloading zone for cargo trucks

- Temporary stopping for loading/unloading purposes is allowed, however, on-street parking should be strictly prohibited.

Construction of an alternative route (bypass)

In most of the long-distance traffic lane have their origins or destinations at Cabanatuan City, therefore, volume of through traffic is still light. In 1986, through traffic (Manila-Cagayan) is 1,551 vehicles, on the other hand, total volume on the section ranges from 15,600 to 23,900 vpd. Construction of a bypass intended only for through traffic will not solve the problems on the Pan-Philippine Highway. Considering the present and future direction of urbanization, an alternative route parallel to the Pan-Philippine Highway was proposed.

Construction costs were estimated as follows:

	Construction Cost (Million ₱)	Land Acquisition Cost (Million ₱)	Total (Million ₱)
Improvement of Existing Section	25.5	1.1	26.6
Construction of an alternative route	59.4	12.6	72.0

Economic evaluation results were as follows:

Project	Implementation	IRR (%)
a) Improvement of the existing section	At the early stage of LOS E (opening year 1990)	36.4
b) Construction of an alternative route	At the early stage of LOS E (opening year 1990)	35.6
c) a) + b)	a) .... 1990 b) 1995	38.0

Implementation of both projects at the early stage of LOS E (opening year 1990) were economically justified. However, stage construction, i.e. improvement of the existing section by 1990 and construction of an alternative route by 1995, was recommended.

10.3.4 Urban Section: Type 2

1) Problems

Due to large volume of local traffic, especially tricycle traffic, level of service is deteriorated lower than improvement level. Long-distance traffic volume is still light.

2) Sections Under This Type

One section: the San Jose Urban Section is classified under this type.

3) Possible Improvement Measures

Of a total traffic volume of 16,000 vpd in 1986, through traffic accounts for only 5% (or 743 vpd), instead tricycle traffic shares 67% (or 10,720 tricycles).

Improvement of the existing section by paving shoulders and sidewalks was recommended. Paved shoulders will be utilized for tricycle travelway and loading/unloading zone for public utility vehicles and trucks.

4) Case Study

Construction cost for improvement of the San Jose Urban Section was estimated at 18.9 million pesos.

When the project is implemented at the early Stage of LOS E (by 1990), it was evaluated economically feasible at internal rate of return (IRR) of 15.0%.

10.3.5 Urban Section: Type 3

1) Problems

In terms of level of service, there is no problem yet, however, sections have still rural type cross sections. Shoulders are either gravel or deteriorated AC pavement. Sections have either no sidewalks nor deteriorated sidewalks.

2) Sections Under This Type

Three (3) minor urban sections in the North Study Section and all seven (7) urban sections in the South Study Section were classified under this type.

3) Improvement Measures

Improvement of the existing section by paving of shoulders and sidewalk was the recommended solutions.

4) Case Study

Estimated construction cost and economic evaluation results are shown below.

Urban Section	Construction Cost (Million ₱)	IRR (%)
San Ildefonso	4.16	14.9
Sta. Rosa	6.24	26.8
Talavera	5.38	24.6

10.3.6 Intersection

Five (5) intersections in the urban sections were found to have lower level of service than improvement level. As the vicinities of urban intersections are already heavily built-up, widening is not a practical solution. Improvement measures should be planned within the existing right-of-way. To attain maximum utilization of the existing roadway space as well as to attain orderly stream of traffic and traffic safety, signalization of an intersection was recommended.

Signalization costs and results of economic evaluation are presented below.

Intersection	LOS	Signalization Cost (Million ₱)	Economic Evaluation	
			B/C	IRR (%)
Plaridel	F	1.57	5.2	81.1
Cabanatuan	E	1.53	17.4	215.7
Cabanatuan IV	E	1.69	18.4	236.8
San Jose	E	1.72	1.5	25.5
Sta. Rosa	D	1.62	0.9	12.6

CHAPTER 11
RECOMMENDED IMPROVEMENT WORKS

11.1 RECOMMENDED IMPROVEMENT MEASURES

Based on the case studies, improvement measures were recommended as shown in Table 11.1-1.

11.2 RECOMMENDED IMPROVEMENT WORKS BY SHORT, MEDIUM AND LONG TERMS

1) Short Term Improvement Works (1987-1992)

Improvement measures for short term problem sections were economically evaluated by case studies. Two (2) major issues revealed are as follows:

Plaridel Bypass

Implementation of the Plaridel Bypass project in the short term period was not justified economically due to high construction cost. Economic evaluation suggested that the Plaridel Bypass project be implemented in the medium term period. Accordingly, widening to a 4-lane road between Sta. Rita and Plaridel be implemented in the medium term period. However, right-of-way acquisition for both projects should be implemented within the short term period before further urbanization develops along the roadside.

11

Construction of an alternative route at Cabanatuan

In case of the Cabanatuan Urban Section, both of the following alternatives were found economically feasible:

- Improvement of the existing section in the short term period, then construction of an alternative route (bypass) in the medium term period, and

- Construction of an alternative route (bypass) in the short term period.

The former alternative was recommended, thus construction of an alternative route be implemented in the medium term period, however, in view of the urbanizatin trend, right-of-way acquisition should be implemented in the short term period.

TABLE 11.1-1 RECOMMENDED IMPROVEMENT MEASURES

Section	Type	Major Problems	Identified Sections	Recommended Improvement Measures
Rural	Type 1	. LOS is less than improvements level	. Sta. Rita-Plaridel . Calamba-Sto. Tomas	. Widening to a 4-lane road
	Type 2	. Sub-standard alignment	. Dalton Pass Section	. Maintain existing alignment with sufficient provisions of traffic safety until the tunnel project is implemented
Urban	Type 1	. LOS is less than improvement level . ADT more than 10,000 vpd . Long-distance trip traffic more than 5,000 vpd.	. Plaridel . Gapan . Cabanatuan	. Stage Construction First : Improvement of Existing Section with traffic management Second: Construction of a bypass
	Type 2	. LOS is less than improvement level . ADT more than 10,000 vpd . Long-distance trip traffic less than 5,000 vpd	. San Jose	. Improvement of existing section by paving shoulders and sidewalks
	Type 3	. No problem in terms of LOS, but improvement recommended due to . Rural type of cross section and traffic safety consideration	. San Ildefonso . Sta. Rosa . Talavera . Alaminos . Tiaong . Candelaria . Sariaya . Pagbilao . Gumaca . Lopez	. Improvement of existing section by paving shoulders and sidewalks
Intersection	Type 1	. LOS is less than improvement level	. Plaridel . Gapan . Cabanatuan II . Cabanatuan IV . San Jose	. Signalization
	Type 2	. Inadequate geometric design	. Baliaug bypass Intersection . Sto. Tomas I . Sto. Tomas II	. Improvement of geometrics

TABLE 11.2-1 RECOMMENDED IMPROVEMENT WORKS FOR SHORT TERM PERIOD (1987-1992)

November 1986 Prices

Section Type	Section	Section Length (Km)	Improvement Works	Estimated Cost (Million ₱) Construction	ROW	Total
North Study Section Urban Type 1	Gapan	1.2	Paving of shoulders/sidewalks	6.01	-	6.01
	Cabanatuan	4.5	Paving of shoulders/sidewalks	25.52	1.05	26.57
Urban Type 2	San Jose	3.5	Paving of shoulders/sidewalks	18.90	-	18.90
Urban Type 3	San Ildefonso	1.0	Paving of shoulders/sidewalks	4.16	-	4.16
	Sta. Rosa	1.1	Paving of shoulders/sidewalks	6.24	-	6.24
	Talavera	1.0	Paving of shoulders/sidewalks	5.38	-	5.38
Intersection	Plaridel	-	Signalization	1.57	-	1.57
	Gapan	-	Signalization	1.34	-	1.34
	Sta. Rosa	-	Signalization	1.59	-	1.59
	Cabanatuan II	-	Signalization	1.41	-	1.41
	Cabanatuan IV	-	Signalization	1.68	-	1.68
	San Jose	-	Signalization	1.69	-	1.69
	Baliuag Bypass	-	Improvement of Geometrics	0.53	-	0.53
(ROW Acquisition)	Sta. Rita-Plaridel	(1.5)	(Widening to a 4-lane)	-	1.61	1.61
	Plaridel Bypass	(4.6)	(Construction of a bypass)	-	5.50	5.50
	Cabanatuan Bypass	(7.1)	(Construction of an alternative route)	-	12.62	12.62
Sub-Total				76.02	20.78	96.80
South Study Section Rural	Calamba-Sto. Tomas	10.0	Widening to a 4-lane	57.06	4.28	61.34
Urban Type 3	Alaminos	1.2	Paving of shoulders/sidewalks	2.36	-	2.36
	Tiaong	1.2	Paving of shoulders/sidewalks	2.07	-	2.07
	Candelaria	1.0	Paving of shoulders/sidewalks	2.70	-	2.70
	Sariaya	1.0	Paving of shoulders/sidewalks	2.20	-	2.20
	Pagbilao	1.3	Paving of shoulders/sidewalks	2.07	-	2.07
	Gumaca	1.5	Paving of shoulders/sidewalks	3.45	-	3.45
	Lopez	1.0	Paving of shoulders/sidewalks	2.67	-	2.67
Intersection	Sto. Tomas I	-	Improvement of Geometrics	1.16	-	1.16
	Sto. Tomas II	-	Improvement of Geometrics	1.59	-	1.59
Sub-Total				77.33	4.28	81.61
Grand Total				153.35	25.06	178.41

2) Medium Term Improvement Works (1993-1998)

North Study Section

Three (3) urban sections of San Ildefonso, Sta. Rosa, and Talavera were identified as problem sections in the medium term period, however, with improvements implemented in the short term period, no improvement will be needed in this period.

Projects to be implemented in this period are as follows:

- Widening to a 4-lane road of the Sta. Rita-Plaridel Section
- Construction of a Plaridel Bypass
- Widening to a 4-lane road of the Gapan Urban Section
- Construction of an alternative route for the Cabanatuan Urban Section

South Study Section

Three (3) urban sections of Tiaong, Candelaria and Sariaya were identified as problem sections in the medium term period. Sections of these urban areas were also recommended to be improved by paving shoulders and sidewalk within the existing right-of-way in the short term period. Shoulder widths of these urban sections are narrow ranging from 0.5 to 1.0 meter, therefore, improvement effects in the short term period is minimal for increasing road capacity. To cope with growing traffic, construction of a bypass for urban sections of Tiaong, Candelaria and Sariaya was recommended.

TABLE 11.2-2 RECOMMENDED IMPROVEMENT WORKS FOR MEDIUM TERM PERIOD (1993-1998)

November 1986 Prices

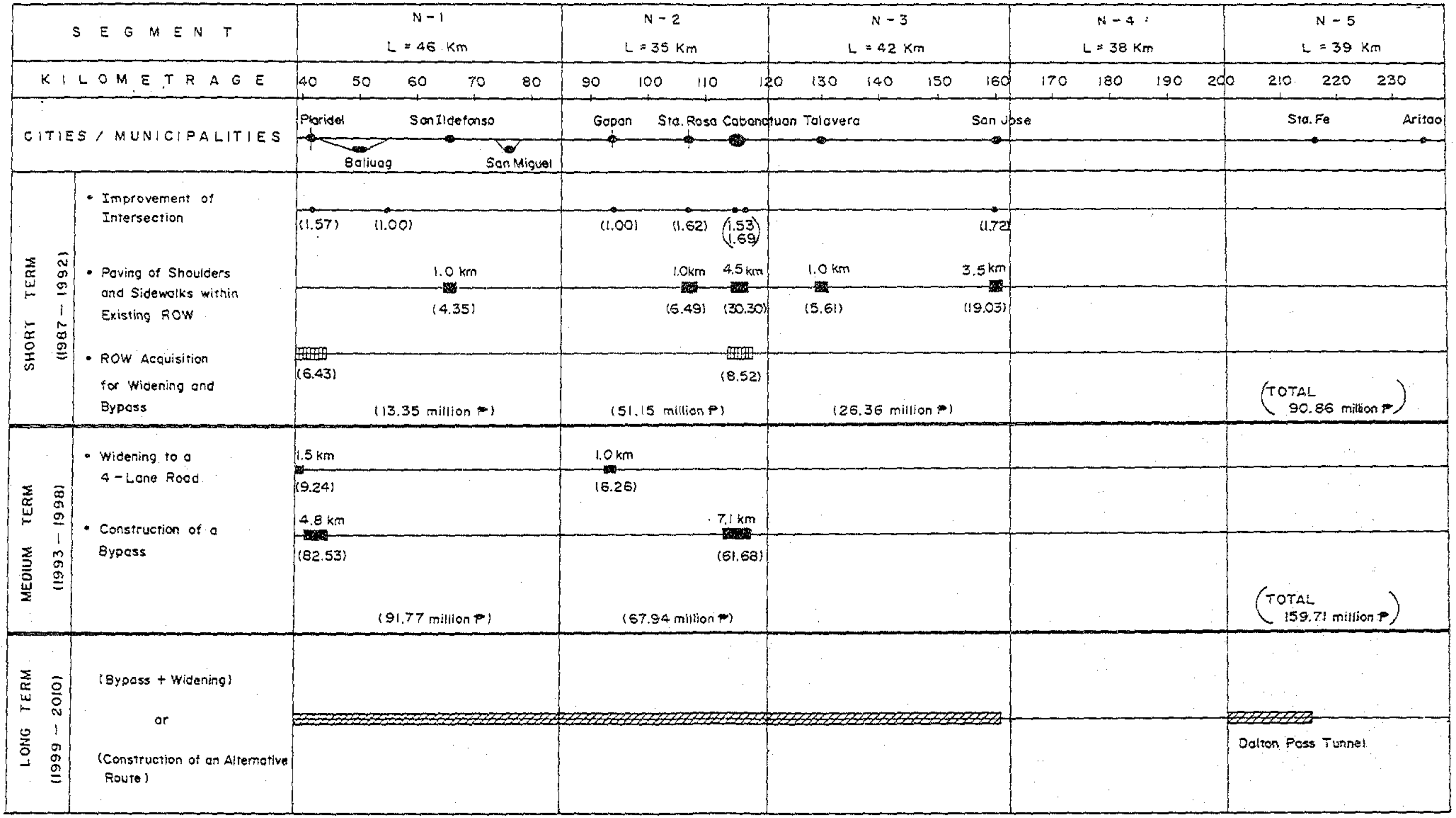
Section Type	Section	Section Length (Km)	Improvement Works	Estimated Cost (Million P) Construction	ROW	Total
North Study Section						
Rural	Sta. Rita – Plaridel	1.5	Widening to a 4-lane	9.20	–	9.20
Urban Type 1	Plaridel	4.6	Construction of a bypass	76.30	–	76.30
	Cabanatuan	7.1	Construction of an alternative route	59.43	–	59.43
Sub-Total				144.93	–	144.93
South Study Section						
Urban Type 3	Tiaong	3.0	Construction of a bypass	18.00	2.70	20.70
	Candelaria	4.0	Construction of a bypass	24.00	3.60	37.60
	Sariaya	4.0	Construction of a bypass	24.00	3.60	37.60
Sub-Total				66.00	9.90	95.90
Grand Total				210.93	9.90	240.83

3) Long-Term Improvement Works (1999-2010)

In this period, traffic volumes of most rural sections will approach to their capacities. Following schemes or combination of these should be studied and optimum solution should be out in the early Stage of this period:

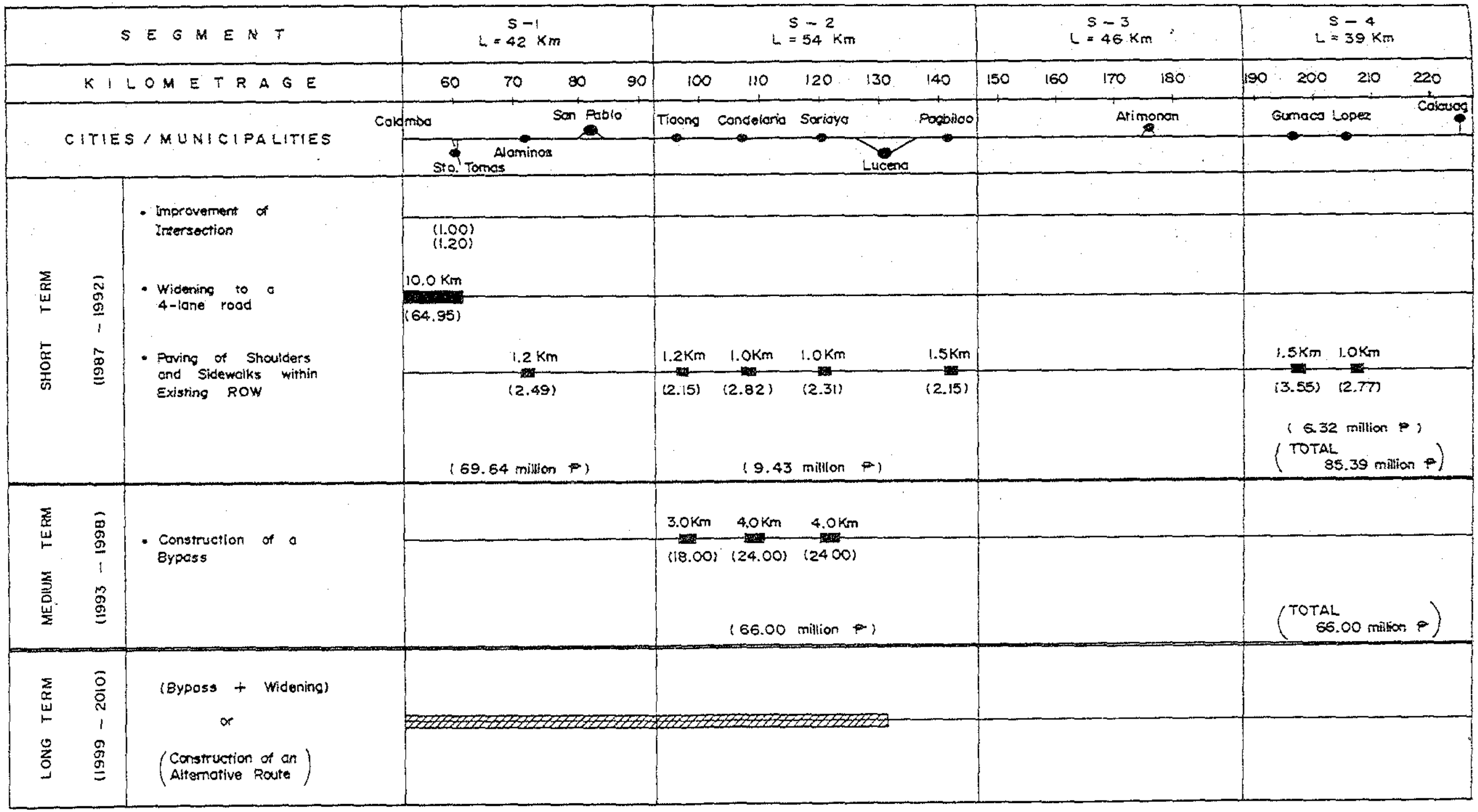
- Bypasses + Widening of Existing Sections
- Bypasses + Construction of roads to link bypasses
- Construction of an alternative route

Recommended improvement works are summarized and illustrated in Figures 11.2-1 and 2.



Note : Figure in ( ) Shows Roughly Estimated Construction Cost.

FIGURE 11.2-1 SUMMARY OF PROPOSED IMPROVEMENT WORKS (NORTH STUDY SECTION)
— ROAD FUNCTION IMPROVEMENT —



Note: *Figure in ( ) Shows Roughly Estimated Construction Cost.*

FIGURE 11.2-2 SUMMARY OF PROPOSED IMPROVEMENT WORKS (SOUTH STUDY SECTION)
— ROAD FUNCTION IMPROVEMENT —

PART IV PAVEMENT

CHAPTER 12
GENERAL INFORMATION ON CONCRETE PAVEMENT

12.1 PRESENT CONDITION OF PAVEMENT

12.1.1 General

Table 12.1-1 shows a paved ratio for the road networks of the Philippines. The ratio is of a considerable low level, only 14% to a total road length. Such a low level for the whole road network is led by an extremely low ratio of 1.6% of a barangay road. The barangay roads are important for socio-economic activities of local areas, but they are a mere peripheral penetration road in the fabrication of the road networks. However, even if barangay roads are excluded, the paved ratio is only 30%.

As shown in Table 12.1-1, there are almost the same number of kilometers of concrete as that of asphalt surfaced sections in the national highways and the municipal roads. Asphalt pavements are predominant over concrete pavement in other classes of roads, especially in the city roads where asphalt sections are about 3 times longer than that of concrete. The totals for the road networks as a whole are approximately 9,797 km or 6% for concrete; and 12,981 km or 8% for asphalt.

TABLE 12.1-1 PAVED RATIO OF ROAD NETWORKS IN THE PHILIPPINES

Road	Length by Pavement Type (km)					Paved Ratio (%)		
Class	Concrete	Asphalt	Gravel	Earth	Total	Concrete	Asphalt	Total
National Highways	6,133	5,715	13,601	810	26,259	23.0	22.0	45.0
Provincial Roads	712	2,739	19,449	5,525	28,425	2.0	10.0	12.0
City Road	637	2,017	1,167	166	3,987	16.0	50.0	66.0
Municipal Road	1,706	1,629	6,319	3,221	12,875	13.0	13.0	26.0
Sub.Total	9,188	12,100	40,536	9,722	71,546	13.0	17.0	30.0
Barangay Roads	609	881	47,165	41,559	90,214	0,6	1.0	1.6
Grand Total	9,797	12,981	87,701	51,281	161,760	6.0	8.0	14.0

Source: Department of Public Works and Highways

12.1.2 Present Condition of Pavement in the Study Section

The Pan-Philippine Highway is by standards a two-lane road with 6.7 meter pavement width, 95% of which is paved with portland cement concrete and the rest with asphalt concrete. The shoulders are of gravel varying from 2.0 m to 2.5 m on each side.

A whole length of the study section is of the portland cement concrete pavement whose slab thickness is 23.0 cm in standard. About 20 cm thick granular subbase is placed underneath the concrete slab. The concrete slab is unreinforced with sawn contraction joints at interval of 4.0 m to 5.0 m. The contraction joints are not dowelled, but end of day joints are provided with dowels. There are no expansion joints, because of the small seasonal variation of temperature. A central tongue and groove longitudinal joints are tied with steel bars.

The pavements in the study sections were mostly constructed during the 1970's, except only one section constructed in 1969. The newest sections were paved in 1978, only 8 years ago.

The North Study Section, approximately 200 km in length, was constructed under about 43 contract segments, and the South Study Section, approximately 180 km in length, was undertaken by about 33 contract segments. The average length of one contract segment was only 5 km. This may indicate that the construction of the pavement have been done mainly with man power, simple tools and small equipment.

These construction methods, however, have resulted in poor quality pavement as an inevitable consequence. Among 73 contract sections, about 20 sections have already been reconstructed or overlayed and moreover considerable lengths of remaining sections are now being deteriorated by progressive cracking.

12.2 CONCRETE PAVEMENT TECHNOLOGY

12.2.1 Standard Types of Pavement

Typical structural components of pavements in the Philippines are shown in Figure 12.2-1.

For major roads, either concrete or asphalt pavements are widely adopted, but the former is more preferred because of long performance period. Concrete pavement consists of 23 cm thick portland cement concrete slab (PCC slab) and 15 cm thick crushed aggregate base course. When the subgrade soils are of relatively poor quality, 20 cm thick aggregate base course is provided. Asphalt pavement is composed of 5 cm to 7.6 cm. thick bituminous asphalt concrete surface, 20 cm thick crushed aggregate base course and 20 cm to 30 cm thick aggregate subbase course.

For relatively important roads other than major roads, intermediate types of pavements are applied. For concrete pavements, the thickness of portland cement concrete slab ranges from 15 cm to 23 cm. As to an asphalt pavement, a double bituminous surface treatment as shown in Figure 12.2-1 is prominent.

Besides these roads mentioned above, most of the rural roads are surfaced by gravel as shown in Figure 12.2-1 or left along as an earth road.

Standard pavement structure of the Study Section is shown in Figure 12.2-2.

12.2.2 Design Method

The concrete pavements in the Study Sections were mostly constructed in the early 1970's. No information were confirmed on how the design thickness of 23 cm (9 in.) was selected in the Section. It was probably determined based on the empirical performance of concrete pavement in other countries.

In 1984, the Bureau of Design, Ministry of Public Works and Highways, issued "Highway Design Guidelines", covering the discussion on existing pavement evaluation and pavement design procedures. The Guidelines adopted two pavement design methods. These are:

- AASHTO Method:

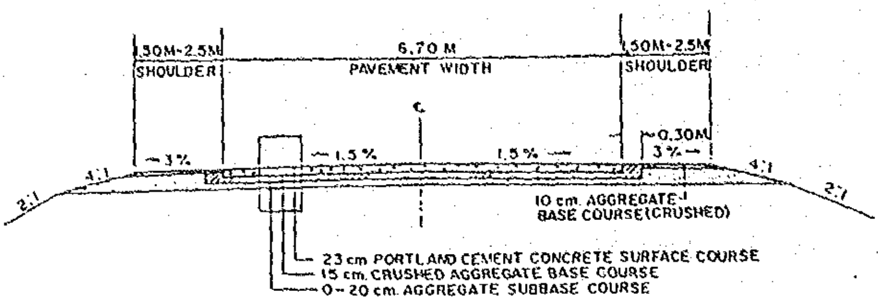
  AASHTO Interim Guide for Design of Pavement Structures – 1972, American Association of State Highway and Transportation Officials.

- TRRL Method:

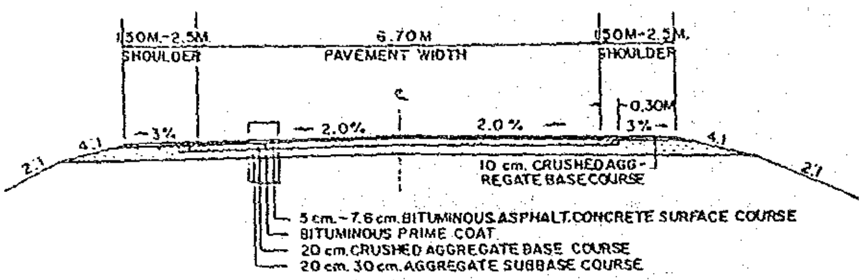
  A Guide to the Structural Design of Pavements for New Roads (Road Notes 29), 1970

  Department of Environment Road Research Laboratory.

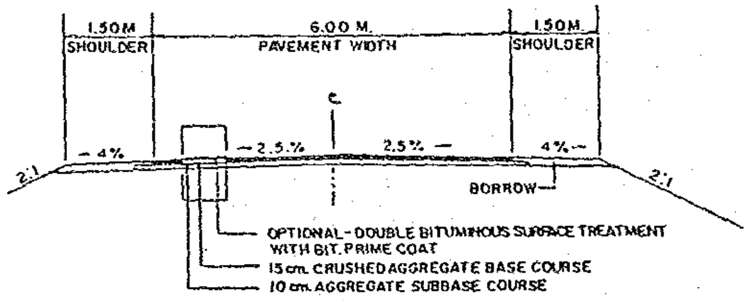
TYPICAL STRUCTURAL COMPONENT OF CONCRETE PAVEMENT FOR MAJOR ROAD



TYPICAL STRUCTURAL COMPONENT OF ASPHALT PAVEMENT FOR MAJOR ROAD



TYPICAL STRUCTURAL COMPONENT OF DOUBLE BITUMINOUS SURFACE TREATMENT



TYPICAL STRUCTURAL COMPONENT OF GRAVEL ROAD

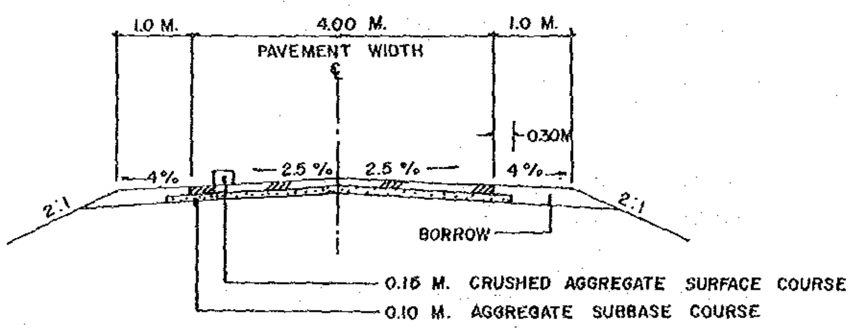


FIGURE 12.2-1 STANDARD TYPES OF PAVEMENT IN THE PHILIPPINES

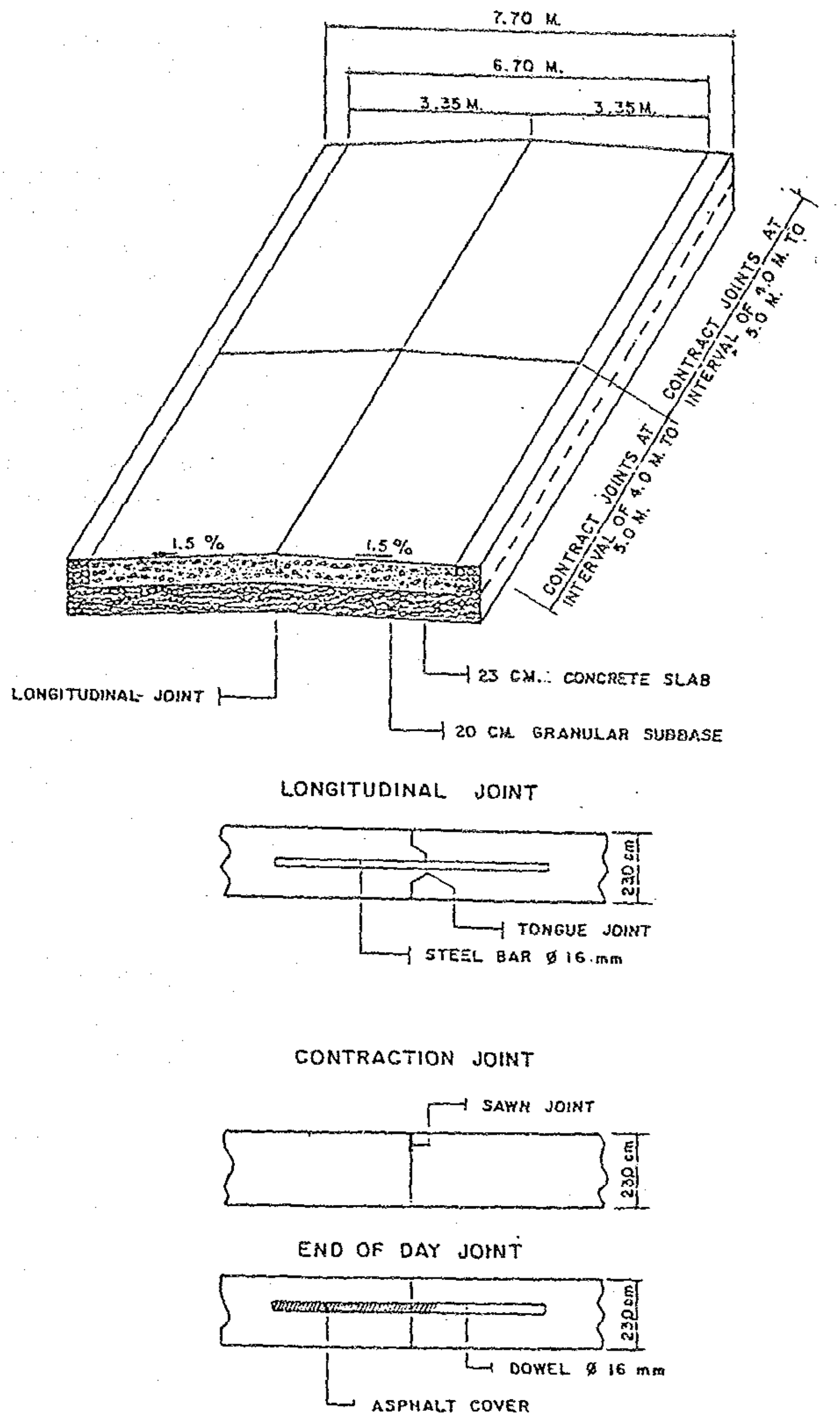


FIGURE 12.2-2 STANDARD PAVEMENT STRUCTURE OF THE STUDY SECTION

The Guidelines regulates rigid pavement design procedures as follows;

A rigid pavement structure may consist of two layers, designated as the pavement slab and the subbase course. When the roadbed soils are of subbase quality, the subbase course is often omitted. The design procedure includes the determination of the thickness of the portland cement concrete pavement slab, and the design of joints and of the steel reinforcement. Also included are recommendations as to the treatment of subbase soils and the type and thickness of subbase required.

The serviceability of pavement is defined as the ability to serve high speed, high volume automobile and truck traffic. Pavement may be designed for the level of serviceability desired at the end of the selected traffic analysis period or after exposure to a special total traffic volume. Selection of the terminal serviceability index (Pt) is based on the lowest index that will be tolerated before resurfacing or reconstruction become necessary. An index of 2.5 is suggested as a guide for design of major highways and 2.0 for highways with lesser traffic volumes.

12.2.3 Specification

The following three (3) specifications are presently used for the construction of concrete pavement.

- Standard Specifications for Highway and Bridges Revised 1972, Department of Public Works and Communications Bureau of Public Highways

- BPH Memo Circular
  The above standard specification was partly revised

- General Specification for Roads and Bridges 1976, Department of Public Highways
  This specification seems only to be used in the design of IBRD-assisted road

Flexural strength of concrete for cement concrete pavement is required to be more than 525 psi (37 kg/cm^2 at 14 days) under BPH Memo Circular and 43 kg/cm^2 under General Specification. Standard Specification does not specify any value.

Main requirements on the concrete pavement specified in the Specification mentioned above are summarized in Appendix 12-1.

Appendix 12-2 presents the present state of asphalt pavement in the Philippines.

12.2.4 Construction Method

The Pan-Philippine Highway built under the Philippine-Japan Highway Loan (PJHL) was constructed by piecemeal. The work was divided into small contracts, some only 2 km in length and others are longer than 10 km. The pavement was designed by the engineers of the Government and the constructions were done by the local contractors without supervision of foreign engineers.

The aggregate used in the construction were taken from the local river beds. This was done without careful attention being paid to the grading of the aggregate. Mixing was carried out in '2-bag' (½ cu.yd.) mixers, of which several would be employed on each contract. The concrete was tipped onto the compacted based, spread and compacted with poker vibrators before being screeded off, from the steel forms.

This method of work would produce concrete of considerable variability because of the lack of aggregate grading control and the small capacity of the mixing plant. About 100 m. of carriageway a day was the output.

Tongue and groove central joints were used on the early work and the two lanes were constructed separately. In the previous contracts, full width construction was used, the central joint being provided with a buried forming strip or by longitudinal sawing.

Beam samples were prepared each day and these were tested for flexural strength generally within 28 days. The size of the beam was 150 mm. x 150 mm x 450mm. The compressive strength was measured by the Bureau of Materials and Quality Control. They also prepared some coring in a number of the contracts in the previous years. However, some of the flexural tests are not available for all the contracts.

12.3 TRAFFIC LOADING REGULATION

12.3.1 *Present Regulations*

The present system of regulations which specify the weights and dimensions of vehicles which use the Public highway are derived in part from the clauses of Republic Act 4136 dated June 20, 1964.

It has been amended and changed by the following Letters of Instructions and Memoranda.

a) Letter of Instruction No. 112 dated August 8, 1973
b) Letter of Instructions No. 874 dated June 14, 1970
c) Department of Public Highways
 Memorandum Circular No. 98 dated July 25, 1977
d) Ministry of Public Highways
 Memorandum dated January 8, 1979
e) Ministry of Public Highways
 Memorandum dated December 18, 1979
f) Ministry of Public Works and Highways
 Memorandum dated November 11, 1981
g) Memorandum of Agreement dated May 31, 1983 between the Ministry of Public Works and Highways
 The Ministry of Transportation and Communication
 The Ministry of National Defense

The present regulations limits the weights of good vehicles in the Philippines to 8 tons (18 kip) for most heavily loaded axle and 14.5 tons (32 kip) for most heavily loaded axle group (the two axles being at least 1 m and less than 2 m apart).

Refer to Appendix 12-3; Traffic Regulations.

12.3.2 Proposed Regulation

Surveys and studies conducted by experts for the Department of Public Works and Highways, have established that because the laws on the control of truck loads have been frequently amended and changed by various memoranda, administrative orders and Letter of Instruction, there is some confusion and lack of understanding of the requirement of the law on vehicle operators, drivers and those employed on enforcement. As a result, excessively loaded trucks are using the country's roads causing considerable damage to the road network.

A complete new statute is proposed rather than amend the present regulations embodied in Sections 9 and 10 of Republic Act 4136 otherwise known as the Land Transportation and Traffic Code of the Philippines.

The objectives of the proposed regulation is to eliminate, or at least minimize the factors which reduce the effectiveness of the existing laws which regulate, control and supervise the operation of motor trucks on the public highways.

The proposed legislation shall provide the authority for the Secretary of Public Works and Highways to control and enforce rules and regulations which specify the weights and dimensions of vehicles, which use the public highways.

Axle loads permitted under the proposed regulation are as follows:

The weight transmitted to the road surface by all wheel of:

a) Single axle, 2 tire axle shall not exceed 8,000 kg.
b) Single axle, 4 tire shall not exceed 13,000 kg.
c) Three axle, 4 tire axle (12) wheels shall not exceed 30,000 kg.
d) Three axle, 2 tire axle (6) wheels shall not exceed 23,000 kg.

Refer to Appendix 12-3; Traffic Regulations

CHAPTER 13
PAVEMENT SURFACE CONDITION SURVEY AND EVALUATION

13.1 APPROACH

(1) Basic Concept

The pavement condition survey was conducted to evaluate the present surface condition of pavements and identify the road sections where the pavement rehabilitation will be required. The factors mainly involved for evaluation were riding comfort and physical distress of pavements.

In evaluating pavement performance to identify the road sections for rehabilitation, the procedure adopted in the Study was the serviceability-performance concept established by American Association of State Highway and Transportation Officials (AASHTO). AASHTO terms that current concepts of pavement performance include some consideration of functional performance, structural performance and safety. Refer to Chapter 2, Volume VI of the Study.

The pavement rehabilitation concept adopted in the Study are those defined under Pavement Management System (PMS). Refer to Chapter 2, Volume VI of the Study.

The evaluation of pavement condition includes consideration of specific problems that exist in the pavement. This requires a determination of type and causes of pavement distress, as well as the extent of pavement deterioration. The Study follows the categorization of pavement distress proposed in AASHTO Guide for Design of pavement Structure, 1986. Refer to Chapter 5, Volume VI of the Study.

(2) Study Flow

The study flow on pavement condition survey and evaluation is shown in Figure 13.1-1.

The study is divided into four (4) steps:

Step 1: Pavement Surface Condition Survey . . . .

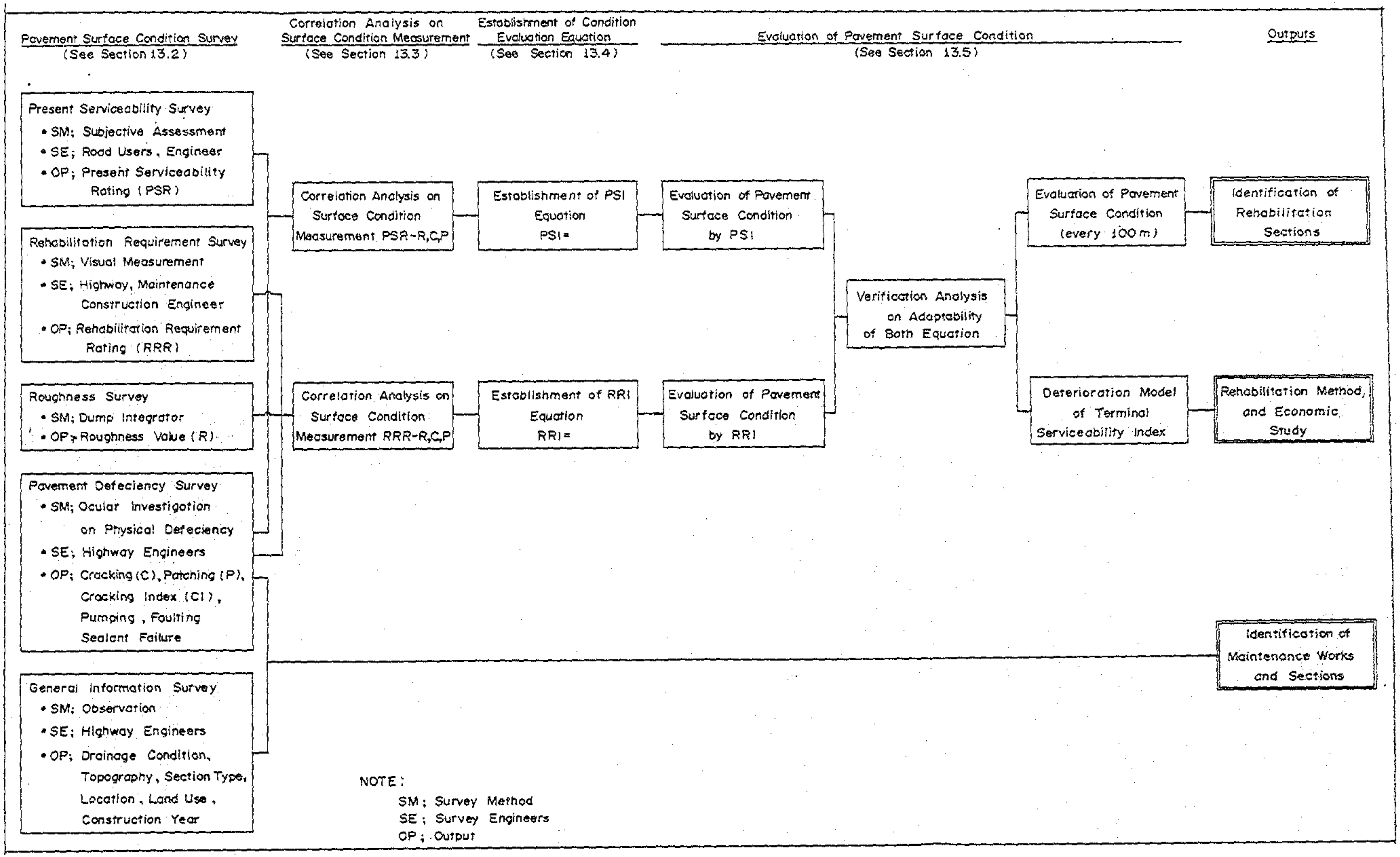
- Present Serviceability Survey
- Rehabilitation Requirement Study
- Roughness Survey
- Pavement Deficiency Survey
- General Information Survey

Step 2: Correlation Analysis on Surface Condition Measurements

- Present Serviceability Rating (PSR) . . . .

Roughness (R)
Cracking (C)
Patching (P)

FIGURE 13.1-1 STUDY FLOW ON PAVEMENT CONDITION SURVEY AND EVALUATION



- Rehabilitation Requirement Rating (RRR) . . .

  Roughness (R)
  Cracking (C)
  Patching (P)

Step 3: Establishment of Condition Evaluation Equation

- Present Serviceability Index (PSI)
- Rehabilitation Requirement Index (RRI)

Step 4: *Evaluation*

- Evaluation of Pavement Surface Condition by PSI
- Evaluation of Pavement Surface Condition by RRI
- Verification Analysis on Adaptability

13.2 PAVEMENT SURFACE CONDITION SURVEY

Pavement surface condition surveys conducted in the Study are:

- Present Serviceability Survey
- Rehabilitation Requirement Survey
- Roughness Survey
- *Pavement Deficiency Survey*
- General Information Survey

Those surveys were carried out for each direction of the roads along the whole length of the Study Sections – the North Study Section of about 200 km and the South Study Section of about 180 km. The unit length for evaluation was 100 m. The data surveyed are recorded in the separate volume of the Study.

13.2.1 Present Serviceability Survey

The present serviceability of a pavement is defined as the ability to serve high speed, high volume automobile and truck traffic. In the AASHTO Road Test, the present serviceability is expressed in terms of the mean value of individual rating by a selected panel including highway engineers and road users.

It is understood that the basis of judgement may be swayed by the tolerableness of road users, national characters as well as economic conditions of the country since comfort or riding quality is a matter of subjective response or the opinion of the users. Each country, therefore, may have their own rating.

In order to ascertain the basis for the Philippines, the assessment of ridability was conducted by the following procedures in August 1986 (the rainy season).

Rating Panel

Filipino: 2 – Highway Engineers
1 – Economic Researcher
1 – Accountant
1 – Statistician
2 – Driver
Japanese: 1 – Highway Engineer

Rating Method

Each member of the rating panel was asked to rate the serviceability/comfort using their own judgement on every 100 m of the road and recorded in the format as shown in Appendix 13-1, while the survey vehicles were travelling at 60 kph.

The rating states range 0 to 5, as follows:

4 – 5 Very Good
3 – 4 Good
2 – 3 Fair
1 – 2 Poor
0 – 1 Very Bad

Present Serviceability Rating (PSR)

The mean rating of the panel was calculated by the computer and used to define the Present Serviceability Rating (PSR) for every 100 m of the road surveyed.

Acceptability

Each member of the rating panel was further asked to say whether the sections were acceptable or not, and then the mean opinion on acceptability was calculated.

13.2.2 Rehabilitation Requirement Survey

Since the present serviceability rating is a subjective assessment by the road users using their own guideline and judgement, the rating does not necessarily identify the sections where the rehabilitation works are needed, when judged from the engineering point of view.

Cognizant with the fact mentioned above the survey team composed of only the experienced engineers conducted the ocular survey on the pavement condition, paving their attentions to the pavement deficiencies especially cracking and patching, among others. The survey was carried out on July 1986.

Rating Panel

Filipino: 3 – Highway Engineers
2 – Maintenance Engineers
1 – Construction Engineer
Japanese: 1 – Highway Engineer

The Filipino engineers were selected from the Bureau of Maintenance, Design and Construction and the Regional Offices of the DPWH.

Rating Method

Each engineer was asked to rate his engineering judgement on every 100 m of the road and recorded in the format as shown in Appendix 13-1, while survey vehicles were running at 20 kph.

The criteria for the judgement of surface conditions are as follows. Before the actual survey in the field, each survey engineer was trained to be familiar with the criteria of the judgement.

Point	Surface Condition	Pavement Status
5-4	No Deficiencies	No cracks
4-3	Little Deficiencies	A few and short cracks
3-2	Considerable Deficiencies but immediate treatment is not required	There exists cracks but not badly damaged
2-1	Considerable severe deficiencies, immediate treatment is required	Badly deteriorated
1-0	Reconstruction is immediately required	Severely deteriorated

R e m a r k s

1. Sealing — If sealing exists or required

2. Patching — If patching exists or required

Rehabilitation Requirement Rating (RRR)

The mean rating of the panel was calculated by the computer and used to define the Rehabilitation Requirement Rating (RRR) of every 100 m of the sections surveyed.

Acceptability

Each member of the rating panel was further asked to say whether the sections were acceptable or not, and then the mean opinion on acceptability was calculated.

13.2.3 Roughness Survey

The roughness of the road surface of each direction along the study section was surveyed by the Bump Integrator equipped to a Toyota Land Cruiser of the Department of Public Works and Highways on July 1986.

The bump integrator is a device which produces an electric impulse for a particular amount of movement of an axle relative to the frame of the test vehicles. The pulses are counted and expressed as a total amount of movement per length of road.

Survey Method

The survey engineer of DPWH with a long experience in roughness survey conducted this survey. The test vehicle was driven at the speed of 30 kph most suited to measurement. The intensity of the integrator was recorded at every 100 m with the reading of the odometer in the format shown in Appendix 13-1.

Roughness Index

The reading of the counter gave the number of inches of unidirectional movement of the rear axle of the test vehicle and converted to Roughness Value (RV).

$$RV\ (cm/km) = \frac{\text{Actual Reading} \times 25.4}{\text{Length of the section (Km)}}$$

13.2.4 Pavement Deficiency Survey

In order to establish a correlation between the ratings by the subjective assessment (PSR and RRR) and the measurement of the physical deficiencies of the pavement, pavement deficiency survey was conducted by the ocular investigation on July 1986.

Survey Members

Exprerienced Highway Engineers including One Japanese Engineer.

Pavement Deficiencies Surveyed

There are various types of pavement deficiencies, but only the following were investigated.

- Cracks
- Patching
- Faulting
- Sealant Failure
- Pumping

Crack Survey

The length of cracks was roughly estimated by each slab taking into account its proportion to a longitudinal or transversal length of a slab. While survey vehicles were running at 20 kph. The cracks were categorized into the following four (4) types.

- Longitudinal Cracks
- Transverse Cracks
- Corner Cracks
- Block/Random Cracks

The cracks length of each slab were recorded in seven ranks (0, 50, 100, 150, 200, 250 and 300 m) and the average crack length per 100 m of a lane was calculated.

Although no tape was used for the measurement, it could be estimated accurately enough for practical purpose. At the first stage of the survey, the surveyors were trained with the illustration of cracking levels.

The definition of cracks in the Study are as follows:

(a) Class of Cracks

Cracks were classified in accordance with AASHTO Road Test.

Class 1: Fine cracks not visible under day surface condition for a man with good vision standing at a distance of 15 ft.

Class 2: Cracks that can be seen at a distance of 15 ft. but exhibited only minor spalling such that the opening at the surface is less than ¼ inch.

Class 3: Any crack spalled at the surface to a width of ¼ inch. or more for at least one-half its length.

Class 4: Any crack which has been sealed.

In this Study, cracks under Class 1 and 2 were called as fine cracks and Class 3 and 4 as wide crack.

(b) Cracking

Cracking is termed as the amount of cracks in the pavement surface and express in linear meter of cracks under class 3 and 4 per 1000 sq. meter of surface area.

(c) Cracking Index

Cracking index is the total length of all cracks under Class 1, 2, 3 and 4 per 1000 sq. meter of surface area.

Patching

The area of patching was also estimated by the judgement of surveyors, and expressed in square meter of patching per 100 sq. meter of surface area.

Faulting

Faulting is the vertical displacement of the pavement surface at one side of a joint or crack relative to the slab surface on the other side of the joint or crack and was expressed in each.

Sealant Failure

Sealant failure is failure and damage of joint seal due to incompressive materials and/or infiltration of water. The infiltration can result in pumping, spalling and blow-ups. This was identified by its existence.

Pumping

Pumping is the ejection of the water and subbase material or embankment soil from beneath the pavement surface and counted in number.

The data surveyed were recorded in the format shown in Appendix 13-1 and were put into the computer for the analysis.

13.2.5 General Information

General informations required for the evaluation of pavement performance were also collected and recorded in the format shown in Appendix 13-1.

- Topography — Flat, Rolling, Mountainous
- Location — Rice Field, Plowed Field, Coconut Field, Forest, Wasteland
- Section Tape — Cut, Embankment, Cut/Embankment
- Land Use
- Drainage Condition — Good, Fair, Bad
- Construction Year

13.3 CORRELATION ANALYSIS ON SURFACE CONDITION MEASUREMENT

13.3.1 Correlation Between Measurement Variables

As the first step in derivation of RRI (Rehabilitation Requirement Index) and PSI (Present Serviceability Index) formulas, the correlations between RRR/PSR's and measurement variables i.e. roughness, cracks, patching, etc. should be analyzed. Such analyses make it possible to determine which of the measurement variables have the most predictable value and which are negligible.

Measurement variables are plotted in Figure 13.3-1 (a) and (b) against corresponding RRR/PSR values. Same figures contain the average and standard deviation of RRR/PSR values at each range of variables. Figures 13.3-2 show the mutual correlations of measurement variables. Detailed figures are presented in Appendix 13-2.

The coefficient of correlation in each combination of two variables are shown in Table 13.3-1.

13.3.2 Mutual Correlation

The following characteristics were found as to mutual correlation of variables based on the figures and table shown.

1) In degree of correlation with RRR, cracking is the highest (0.63) followed by faulting (0.55) pumping (0.52) and roughness (0.46). No other factors, e.g., patching, topography, road type, land use, drainage conditions etc. are correlated with RRR.

2) In degree of correlation with PSR, cracking and roughness show almost same coefficient (0.57 and 0.59). The correlations of other variables with PSR are almost in the same degree as those with RRR.

3) While AASHTO's PSI formula shows that the roughness is the most predominant factor to pavement serviceability, it is obsserved that in the Philippines, the highway users judge the quality of highway according to its surface deterioration rather than to roughness.

4) Little correlation is observed between roughness and surface deterioration. Roughness is widely scattered on road sections with any level of cracking.

5) Both faulting and pumping are closely correlated with cracking.

TABLE 13.3-1 COEFFICIENT OF CORRELATION BETWEEN TWO VARIABLES

	RRR	PSR	Roughness	Crack 1/ 6 mm	Crack 2/ All	Patching	Faulting	Pumping
RRR	1.00		–.46	–.63	–.66	–.25	–.55	–.52
PSR		1.00	–.59	–.57	–.58	–.22	–.52	–.50
Roughness			1.00	.43	.37	.13	.41	.38
Crack, 6 mm				1.00	.90	.06	.67	.65
Crack, all					1.00	.11	.65	.62
Patching						1.00	.07	.05
Faulting							1.00	.86
Pumping								1.00

NOTE: 1/ Cracking

2/ Cracking Index (Center)

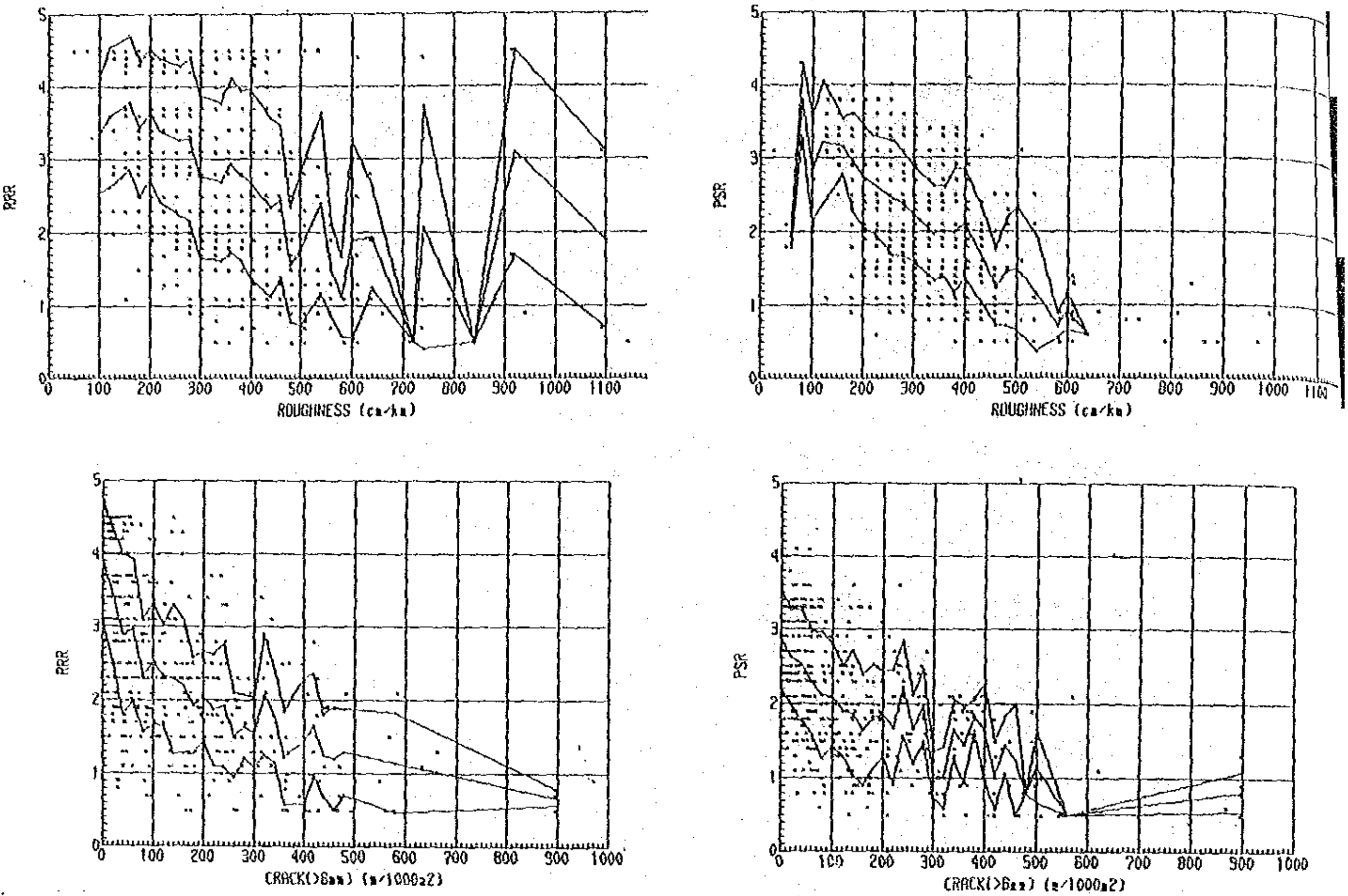


FIGURE 13.3-1 (a) RRR/PSR VS. MEASUREMENT VARIABLES (1)

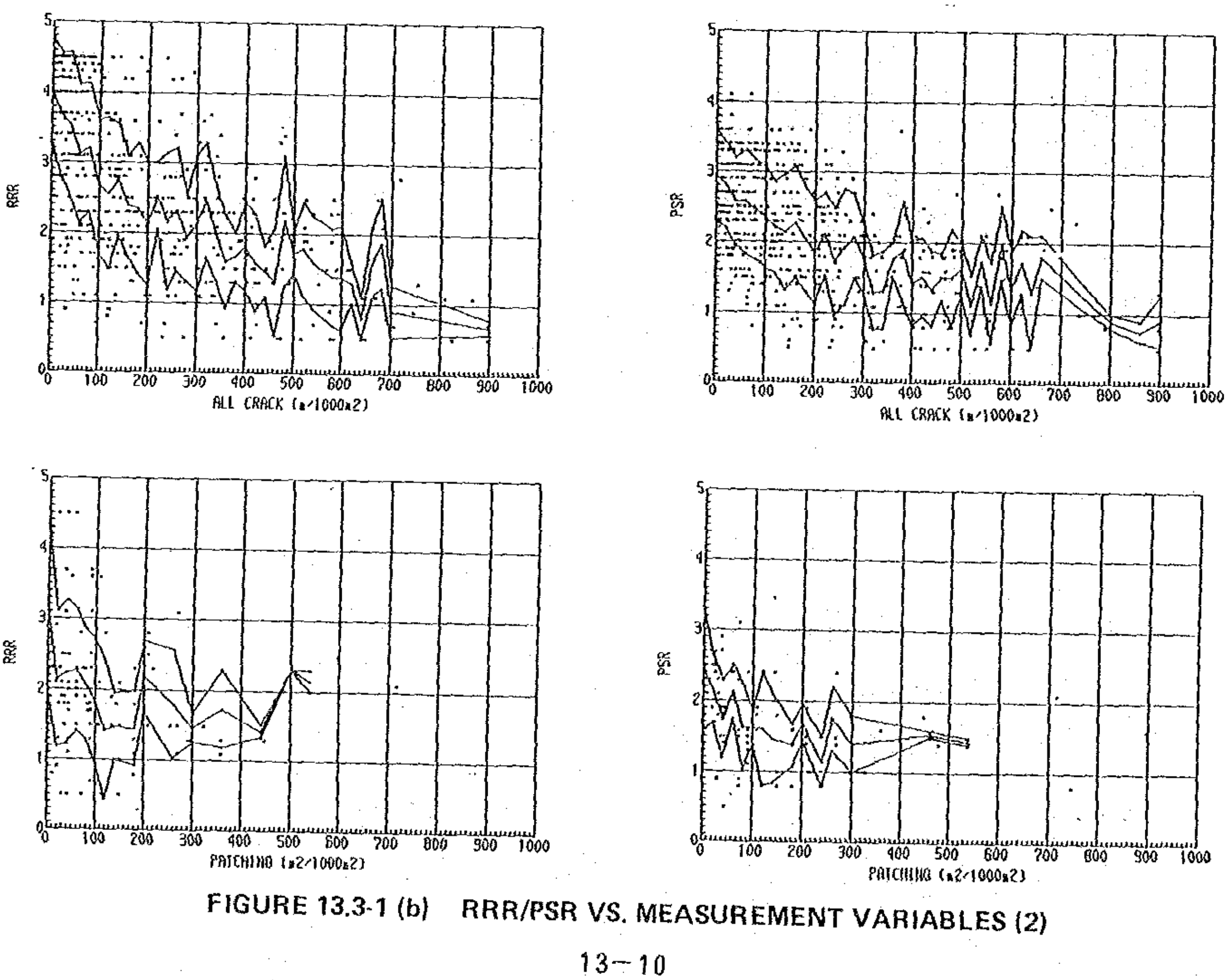


FIGURE 13.3-1 (b) RRR/PSR VS. MEASUREMENT VARIABLES (2)

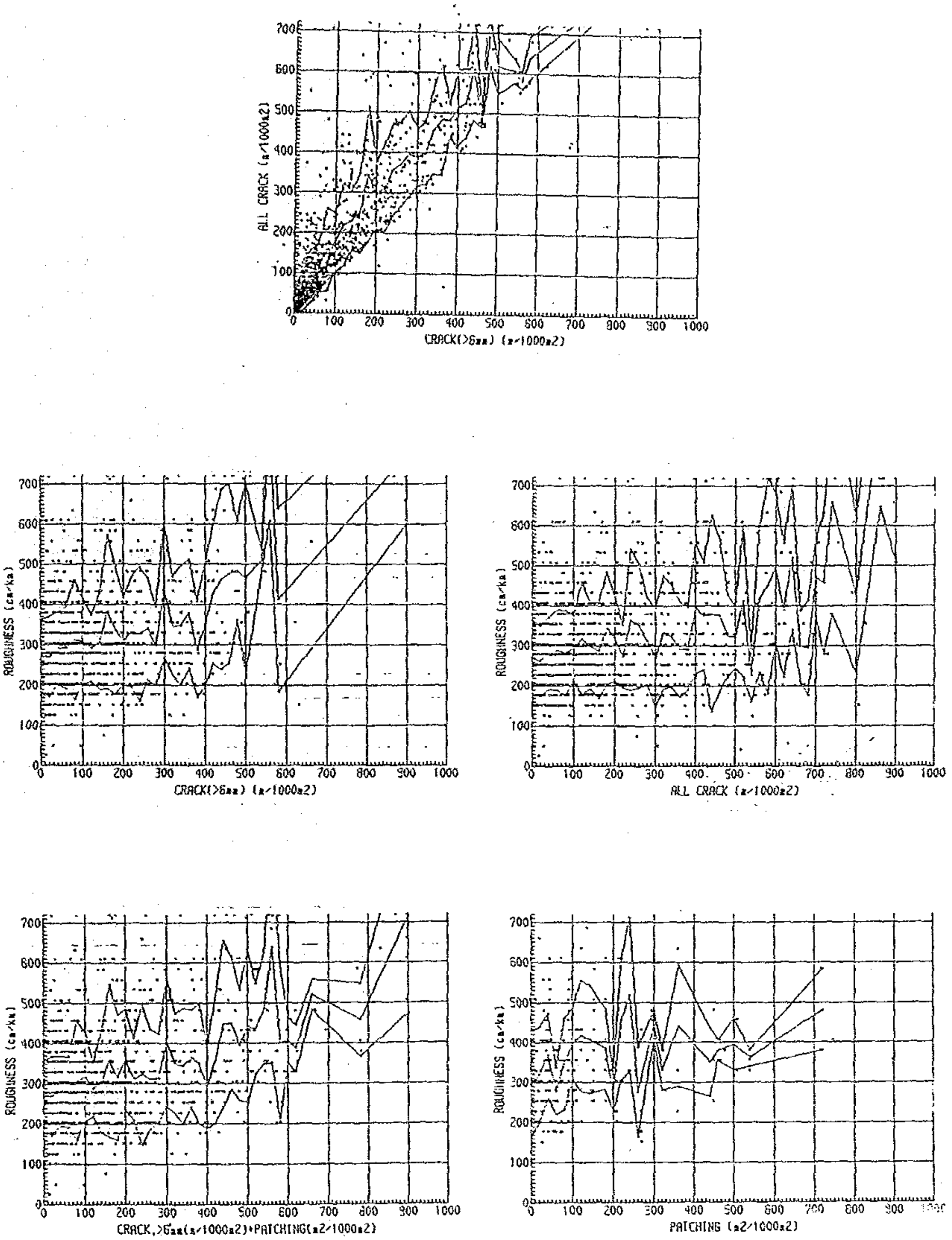


FIGURE 13.3-2 CORRELATION BETWEEN MEASUREMENT VARIABLES