Report to

TAIWAN AREA FREEWAY CONSTRUCTION BUREAU
MINISTRY OF COMMUNICATIONS
REPUBLIC OF CHINA

June 1972

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY
TAIWAN

DE LEUW, CATHER INTERNATIONAL-Consulting Engineers-Chicago

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CHANGES MADE SINCE THE DRAFT REPORT

During the preparation of this final edition of the report on the comprehensive toll road study, numerous changes were made from what had been presented in the draft edition. Most of these changes were small, and not worthy of mention. There were, however, just a few changes of greater importance, which might properly be mentioned here. These are listed below, with a brief discussion of each.

(1) Rescheduling of alternative highway improvements. This was done in the draft edition also, but was relegated to an appendix. As was explained in that draft appendix, the freeway investment had been rescheduled from the recommended schedule of the feasibility study, and, if the alternative investments would not be similarly rescheduled, the discounted incremental costs of the freeway investment alternative would fall markedly. This would be fine, if the benefits which would accrue with the alternative highway improvements in the years prior to freeway opening would also be calculated, thus, reducing the net benefits of the freeway investment alternative. Since these adjustments to net benefits would be difficult to accomplish without additional computer assignments, however, the alternative approach was to reschedule the alternative highway improvements so that additions to capacity would coincide with the years in which the various freeway sections would be scheduled to open. When this adjustment was made in the draft report, it reduced the rate of return estimate from 22.7 percent to 19.8 percent. The rate of return estimate of the final report is 20.9 percent, but, in addition to the rescheduling of alternative highway investments, this rate of return estimate was affected by the following two items.

(2) Rescheduling of the construction costs of freeway Section V. In the draft report, construction was erroneously shown as being completed in 1976; benefits did not begin to accrue until 1978, however, and this loss of a year (viz., 1977) resulted in an understatement by a few percentage points in the rate of return on the section. This adjustment raised the rate of return estimate for the entire freeway from 20.3 percent to 20.9 percent.

(3) Revision of Section VII construction costs. The draft report included in the estimates of costs of construction of the Tainan-Kaohsiung section, the costs of widening the freeway to six lanes between Kaohsiung and Tainan. According to the capacity analysis, however, only the section from Kaohsiung to Nantze should be widened by 1990, so that the costs of widening the Nantze-Tainan section are excluded from Section VII costs in this final report.

(4) Three appendices were added in answer to Government requests for additional analysis and information. These additional appendices are designed to give insight into the following: (a) the economic and financial effects of extending the period of freeway stage I construction; (b) the financial and traffic effects of adjustments to the recommended barrier toll network; and (c) rules and regulations for the operation of concessions along the freeway.

In addition to remarking on major changes which were made, it might properly be pointed out here that there was another notable change which might have been made in the analysis, but was not.

This concerns the costs and benefits in the Taipei area. The Taipei-Neihu section which is currently being designed is different from that assumed for cost estimates and traffic assignments in the toll study. The changes occurred after the toll analysis, however, and would affect both costs and benefits of the section (if the changes would only affect costs, as was true in the case of the revised Section VII costs, then the adjustment would have been made for the final report).

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June 15, 1972

CONSULTANTS TO:
MINISTRY OF COMMUNICATIONS
TAIWAN AREA FREEWAY
CONSTRUCTION BUREAU
NORTH-SOUTH FREEWAY PROJECT

Mr. M. H. Hu, Director
Taiwan Area Freeway Construction Bureau
Ministry of Communications

Dear Mr. Hu:

We are pleased to submit this final edition of the report on the Comprehensive Toll Road Study, which was prepared in accordance with the contract between the Freeway Construction Bureau and ourselves, dated March 6, 1971.

This study was broadly divided into three parts: the analysis of toll-collection networks and toll rates, and their economic and financial effects on the North-South Freeway project; the assessment of the organizational needs and the requirements of facilities and equipment for effective orderly operation of the freeway; and the analysis of freeway bus operations, and associated facilities to be provided along the freeway.

Our toll analysis indicated that a barrier toll-collection system would be preferable to a closed system; the former would be less costly to construct and to operate. Moreover, with our recommended toll rates of NT$15 on autos and light trucks, NT$20 on heavy trucks, and NT$40 on buses, the barrier system would produce both greater economic benefits and more toll revenue than the closed system. The rate of return estimate for the freeway with the barrier system and the recommended toll rates is 20.9 percent. The closed system would bring an estimated 19.5 percent rate of return. Toll revenue with the recommended barrier system would amount to an undiscounted total of approximately NT$48.4 billion (including revenue from induced traffic) over the 1975-1995 period.

We recommend that administration, maintenance and toll collection facilities be designed and built concurrently with the construction of the freeway. Training of highway patrol and other key maintenance personnel are important and should be started as soon as possible.

Thank you for the opportunity to continue our services on the North-South Freeway project.

Very truly yours
DE LEUW, CATHER INTERNATIONAL

Turan Ceran

Turan Ceran
Project Manager

Y. T. Lai

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ACKNOWLEDGEMENTS

We would like to thank Vice Minister C. C. Wang for his guidance and clarification of the government policies during the early stages of this study.

The assistance and cooperation extended by Mr. M. H. Hu, Director, Mr. C. T. Wang, Deputy Director, Mr. C. H. Leigh, Chief Engineer and the members of the Taiwan Area Freeway Construction Bureau assigned to the project are gratefully acknowledged.

We are also thankful for the valuable assistance of Mr. A. L. Anderson, Highway Advisor, CIECD, Mr. N. Baily, Railway Advisor, CIECD, and of the Taiwan Highway Bureau and Civil Aeronautical Administration.

We are greatly indebted to Mr. L. W. Newcomer, Chief Engineer-Manager of Kansas Turnpike who, as our special consultant, prepared the organization and facilities section of this report. His vast experience and knowledge on construction, operation and maintanance of toll roads was an invaluable assistance in the formulation of our recommendations.

PROJECT STAFF

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CHAPTER I

Introduction

Chapter I

INTRODUCTION

HISTORY OF THE FREEWAY PROJECT

A north-south freeway to serve the western coastal area of the Province of Taiwan was first considered by the Government of the Republic of China in 1965. The Government had previously studied a four-lane highway from Taipei to Taoyuan. In 1965, the Council for International Economic Cooperation and Development (CIECD) suggested that planning be initiated for a limited-access highway from Keelung on the northern coast to Kaohsiung on the southwestern coast – a distance of approximately 400 kilometers by existing roads. The proposed freeway would supplement or replace an existing arterial road, the North-South Highway, serving much of this corridor.

In August 1966, the Government assigned priority status to the planning of two sections of the freeway – from Taipei to Hsinchu, and from Tainan to Kaohsiung – and authorized the collection of data on traffic in the freeway corridor. By November 1966, it had been agreed by all Government agencies involved that the freeway should be an all-new facility, physically and financially independent of the existing North-South Highway.

The feasibility of the project was reviewed by various Government departments and funding agencies in April 1967. A Technical Assistance Agreement between the Taiwan Highway Bureau (THB) and the Asian Development Bank (ADB) was signed on November 30, 1968. On January 16, 1969, the THB retained De Leuw, Cather International Inc. (DCI), Consulting Engineers, to conduct a feasibility study of the entire proposed North-South Freeway, and prepare preliminary designs and cost estimates for the Erhchung-Chungli portion. Mobilization of the Consultant's project staff began immediately, and the initial group arrived in Taipei in early March 1969.

The feasibility study was submitted to THB on November 6, 1969. The study urged the immediate construction of all seven study sections and set forth construction completion priorities of these sections. The financial analyses of the study indicated that the proposed facility should be operated on a toll-free basis. The corresponding internal rate of return was estimated to be 22.3 percent.

After submittal of the feasibility report, work began on the preliminary design of the freeway from Erhchung to Chungli (later called Sanchung to Chungli). In December of 1969, the construction loan agreement was completed for this section.

The preliminary plans were submitted in February 1970. Final design work was completed in August. The contract documents were peprared thereafter and submitted in October 1970.

Construction planning of the Sanchung to Chungli section divided the facility into five construction projects. Details of the construction projects are given in the following table.

TABLE 1-1

SANCHUNG TO CHUNGLI SECTION OF NORTH-SOUTH FREEWAY
CONSTRUCTION PROJECTS

Project	City Limits	Cost NT$	Contractor
1	Sanchung to Taishan	294,800,000	Kuk Dong Construction Co.
2	(Flood Relief Structure)	166,908,000	Retired Servicemen Engineering Agency
3	Taishan to Linkou	287,347,620	BES Construction Co.
4	Linkou to Nankang	159,426,180	Retired Servicemen Engineering Agency
5	Nankan to Chungli	263,723,380	Aoki Construction Co.

The first bids were taken in May and construction work began in August 1971.

Additional design work for the freeway between the cities of Chungli and Yangmei, Taipei and Sanchung, and Neihu and Taipei was begun in July of 1970 by DCI. Design of the section from Neihu to Keelung, the northernmost segment of the freeway, is underway by another consultant.

Contracts covering the design of the southern 110 kilometers of the freeway were signed in July 1971, and work began in September. DCI is designing the section extending from Hsinshih (just north of Tainan) to Fengshan. A German consultant is designing the section from Chiayi to Hsinshih. The final design of the entire section is scheduled for completion within 15 months, and construction is scheduled to be completed by the end of 1976.

Recently, the Executive Yuan assigned top priority to construction of the North-South Freeway. The latest planning schedules completion, of the final sections to be constructed, in late 1977. The construction schedule for the entire freeway, from Keelung to Fengshan, is shown in the following table.

TABLE 1-2

NORTH-SOUTH FREEWAY CONSTRUCTION SCHEDULE

Section	City	Completion Date
I	Keelung – Neihu	Jun 1975
	Neihu – Taipei	Dec 1975
	Taipei – Sanchung	Jun 1975
II	Sanchung – Chungli	Jun 1974
	Chungli – Yangmei	Dec 1974
III	Yangmei – Hsinchu	Dec 1976
IV	Hsinchu – Taichung	Dec 1977
V	Taichung – Tounan	Jun 1977
VI	Tounan – Chiayi	Dec 1977
	Chiayi – Tainan	Dec 1976
VII	Tainan – Fengshan	Dec 1976

DEVELOPMENTS SINCE THE FEASIBILITY STUDY

The Economy

The freeway feasibility study was conducted during March-October 1969, so that the latest year for which data were available at the time was 1968. The study adopted, as its near-term economic growth forecasts, the Fifth Four-Year Development Plan projection of 7.0 percent average annual growth over the 1969-1972 period. On the basis of this predicted deceleration of economic growth, the study forecast that average annual growth over the 1969-1990 period would be 6.4 percent, rather than the higher rate of 6.7 percent per annum indicated by the historic trend.

Actual growth in 1969 was 8.8 percent (in real terms), and growth in 1970 rose to 10.0 percent; total expansion from 1968 was approximately 19.7 percent. Per capita income, in constant prices, grew by approximately 13.3 percent over the two-year period.

The growth in 1969 occurred despite a decline in agricultural production, which resulted from loss of crops caused by two typhoons during the September-October period of that year. Agricultural net domestic product, in 1970, was up by about 3.3 percent, in current prices, over 1968.

The production value of industry grew by approximately 40 percent over 1969-1970. Within the industrial sector, mining production grew by less than seven percent, but the production value of manufacturing, construction (private building construction), and public utilities increased by 39 percent, 74 percent, and 53 percent, respectively.

Within manufacturing, production value grew by more than 50 percent in the following major industries: basic metals; electrical machinery, apparatus, appliances and supplies; petroleum refining; furniture; and textiles and garments. Growth was nearly 50 percent in the paper and paper products industry, and in the beverage industry. Less rapid, but still impressive, growth was achieved in food processing (22 percent), wood and wood products (23 percent), chemicals (24 percent), metal products (27 percent), and non-electrical machinery (17 percent). The transportation equipment industry showed a slight drop in production value (less than one percent), despite the spectacular growth of the shipbuilding industry which increased its production from only 79,000 gross tons in 1968, to more than 205,000 gross tons in 1970.

In current value terms, the net domestic product of services rose from approximately NT$61.5 billion in 1968, to a level of NT$83.2 billion in 1970, an expansion of more than 35 percent. Within the services sector, transportation and communications grew by nearly 32 percent, money and banking expanded by 66 percent, and government services rose by about 35 percent.

Over 1969-1970, foreign trade continued its spectacular growth of the past several years. Exports of goods and services grew, in constant prices, by 19.7 percent in 1969, and by 28.8 percent in 1970. Imports of goods and services grew only slightly less rapidly, as they expanded by 14.6 percent and 26.9 percent, in 1969 and 1970, respectively. Over the first quarter of 1971, foreign trade (exclusive of services) showed a rise of 38.7 percent above the level of the corresponding period of the preceding year.

The foreign exchange reserves of the Republic of China increased by US$179 million, in 1970, to an end-year level of NT$656 million.

Traffic

Reported highway ton-kilometers rose by 18.3 percent in 1969, and by 15.8 percent in 1970, for a total two-year expansion of 36.9 percent above the level of 1968; in terms of freight tonnages, the total expansion was 32.2 percent. Heavy truck registrations increased by 32.1 percent from end-1968 to end-1970, to a total of more than 20,000.

Bus passenger-kilometers rose from 8,887 million in 1968, to approximately 11,206 million in 1970, an increase of 26.1 percent; bus passenger trips, over the same two-year period, rose by 28.0 percent. Bus registrations increased by 28.4 percent, rising from an end-1968 total of 6,193 to an end-1970 total of 7,954.

Taxi registrations continued their rapid growth in 1969, but slowed markedly in 1970; growth in 1969 was more than 29 percent, and was 12.0 percent the following year.

Private auto registrations and light truck registrations showed spectacular growth over the two years, as the former increased by a total 76.1 percent, while the latter registration total grew by 74.8 percent.

Motorcycles continued to replace bicycles during 1969-1970, as the number of motorcycles increased by 218,000, to a level of more than 701,000 by end-1970, while the number of bicycle registrations declined by about 302,000, to a level of 1.95 million.

The number of other slow-moving vehicles continued to fall. Pedicabs were reduced to only 4,159 by end-1970 (down from 10,492 at end-1968), and ox-carts declined from 57,321 end-1968 registrations, to 49,589 registrations by end-1970.

The provincial railway system experienced substantial growth of passenger traffic, but showed a decline in freight traffic, over 1969-1970. Growth of provincial railway passenger-kilometers was 8.2 percent in 1969 and 5.0 percent in 1970; the number of passenger trips, however, fell from more than 137 million in 1968 to about 129.3 million in 1970, a decline of approximately 5.6 percent. West Line Railway passenger-kilometers grew by 13.7 percent over the two-year period, while East Line passenger-kilometer growth was 9.8 percent. East Line passenger trips, however, declined by only 0.5 percent from 1968 to 1970, while West Line passenger trips fell by about 6.0 percent. The numbers of passenger trips declined primarily as a result of the program of localization of primary schooling and the resultant elimination of the need for large volumes of primary school students to travel to and from school via the railway. Despite the reduction in student traffic, the substantial rise in long-distance passenger volumes was sufficient to result in the increased levels of passenger-kilometers.

Total ton-kilometers of the provincial railway system fell from 2,544 million in 1968 (TRA's record year for freight traffic), to 2,477 million in 1970, a decline of 2.6 percent. The East Line Railway, however, had more than a twenty percent rise in ton-kilometers over the period because of the opening to the new pulp mill at Hualien. The West Line ton-kilometer total fell by 3.1 percent to 2,424 million; West Line freight tonnages declined by 2.2 percent.

Total international harbor traffic increased by about 34.4 percent, rising from a 1968 total of 18.6 million revenue tons, to a 1970 total of 25.0 million revenue tons. Keelung Harbor traffic rose by 33.5 percent to around 8.64 million tons; Kaohsiung Traffic increased by 35.7 percent to 16.0 million tons; and Hualien traffic advanced by only 6.7 percent to nearly 389,000 tons.

Both international and domestic air passenger traffic grew rapidly over 1969-1970. International passengers increased from 615,182 in 1968, to 997,403 in 1970, a rise of more than 62 percent. Domestic passenger traffic increased by 28 percent.

There was a 55.4 percent growth in passenger traffic at Taipei International Airport, and this was accompanied by a 39.7 percent expansion in the number of flights. Annual passengers numbered more than 1.5 million in 1970, while the number of flights grew to 41,662 (an average of 114 flights per day).

In 1970, Kaohsiung Airport had its first international passengers (but only 108). Domestic passenger volumes at Kaohsiung increased from 241,000 in 1968, to 356,000 in 1970, an increase of 47.7 percent. The number of flights rose by 34.4 percent to a total of 9,723.

At Hualien Airport, air passenger traffic rose by 42.9 percent to a total of more than 325,000 in 1970. The number of flights climbed by 82.1 percent to 8,066.

Developments in Transportation

The freeway feasibility study, together with the study for locating a planned new international seaport, was one of the first of a rush of major studies within the transportation sector. Before the feasibility study was completed, work had already begun on the study of a proposed elevated railway project for Taipei. In late 1969, work started on an island-wide transportation study; this study was completed in November 1970. Also completed during 1970, was the Taichung harbor study. In March 1971, a study was completed to determined the advisability of electrifying the trunk line of the West Line Railway. More recently, studies were completed on proposals for a new international airport, for equipping the railway to handle containers, and for constructing a railway link or an improved highway between Suao and Hualien, on the East Coast. Finally, a traffic cost study for the railway is currently underway.

Both the freeway feasibility study and the island-wide Transportation Economic Study indicated that the freeway should be constructed; the latter study recommending that the project be given the highest priority within the transportation sector.

The island-wide transportation study recommended that expansion of facilities at Keelung be given second priority among proposed transportation projects. The study also urged that a government transportation planning agency be established.

The Taichung harbor study advised that the port of Keelung would reach saturation in the near-term, and recommended that a port be developed on the coast of Taichung Hsien to relieve Keelung harbor of its future excess demand.

The various, completed railway studies recommended elevation (in Taipei only), electrification, and containerization.

The airport study indicated that the proposed international airport would be needed by 1975, and recommended a location near Taoyuan.

Partly as a result of these several studies, the Government has now:

1) Established the freeway as the infrastructure project with top priority;
2) Established expansion of facilities at Keelung harbor and at Kaohsiung as the infrastructure project having the next highest priority;
3) Determined to construct a new international seaport on the coast of Taichung Hsien, with a scheduled million tons of capacity in 1975, and twelve million tons in 1985;
4) Determined to electrify the trunk line of the West Line Railway; and
5) Established a new transportation agency, the Transportation Planning Board, within the Ministry of Communications.

The Government did not act according to the recommendations of the elevated railway study, and this proposed project has been shelved. Decisions have not yet been made regarding the recommendations of the railway containerization study, the new international airport study, and the East Coast (Suao-Hualien) study.

Projects which have not required major studies, and which are now underway, or have been approved, include:

1) Development of a second harbor entrance at Kaohsiung (an eight-year project, which was begun in 1968, and will be completed by 1976);
2) Construction of container and other facilities at the ports of Keelung and Kaohsiung;
3) Expansion of harbor facilities at Hualien;
4) Expansion of Taipei International Airport passenger terminal (recently completed);
5) Construction of a railway freight marshalling yard at Chi-Tu (to be completed in 1972);
6) Replacement of West Line Railway 37-kilogram (per meter) rail, with 50-kilogram rail;
7) Construction of an elevated highway to the port area at Keelung (to be completed in 1972);
8) Improvements to Kaohsiung International Airport (to be completed in early 1972);
9) Construction of a southern cross-island highway (to be finished by in 1972);
10) Widening of Highway 1 to four lanes between Taipei and Taoyuan, between Changhua and Yuanlin, and between Tainan and Kaohsiung;
11) Widening of Highway 3 to four lanes between Fengyuan and Taichung; and
12) Widening of Highway 12 to four lanes between Taichung and Nanwangtien.

The last three of these projects are of importance to this study since they all affect the capacity of the arterial highways in Taiwan's western corridor, and less diversion to the freeway might be expected, since the alternative routes would be capable of accommodating higher traffic volumes. In determining the incremental costs of the freeway investment alternative, these improvements were also taken into account, since they would occur with or without the freeway investment.

BACKGROUND AND SCOPE OF TOLL STUDY

The Government's decision to operate the North-South Freeway as a toll road, gave birth to the need for a study to determine the type of toll collection system and the levels of toll rates to be utilized. It was also necessary to know the effect of tolls on the rate of return of the project and on modal split between the railway and freeway in the same corridor.

A brief study was prepared in January 1970, by DCI covering toll analysis for the Sanchung to Chungli portion of the freeway. This study was requested by the ADB to determine the effects of charging tolls on traffic and revenues. This was an approximate evaluation and was done quickly, without computer assignment.

Recommendations covering administration, operations and maintenance of the freeway were also required, as the toll road is to be the first of its kind in Taiwan and maintenance facilities must be designed and built concurrently with the freeway. A bus operation study was included within the scope of work in order to establish the related facilities requirements.

During November 1970, TAFCB called for proposals for consulting engineering services related to toll road operations (excluding bus operation) covering the entire North-South Freeway corridor. In January 1971, TAFCB further called for studies related to bus operations along the freeway. DCI submitted a combined proposal covering all aspects and a contract was successfully negotiated in early March. Work on a comprehensive toll road study began on March 15, 1971.

The work involved in this study was grouped into three parts:

1) A complete toll study was prepared. This work involved analysis of alternative toll collection networks and various toll levels, and the effects which these would have on the patterns of traffic, and on the rate of return of the project.

2) Operations and maintenance studies were prepared, including the location of toll plazas, rest and service areas, maintenance stations, emergency facilities, highway patrol stations, and telecommunication facilities, and the determination of the required organization, equipment, and personnel to operate and maintain the toll road.

3) A brief study was conducted on freeway bus operation to establish the location and type of necessary facilities.

Exhibit 1 indicates a simplified flow diagram for this work, beginning with the previously prepared feasibility report.

ORGANIZATION OF STUDY

Study Design

The study was designed to be conducted over a five-month period. The toll analysis required the full period, whilst the conclusions and recommendations regarding toll road maintenance and operations were developed over two months, and the bus operation study required approximately one month.

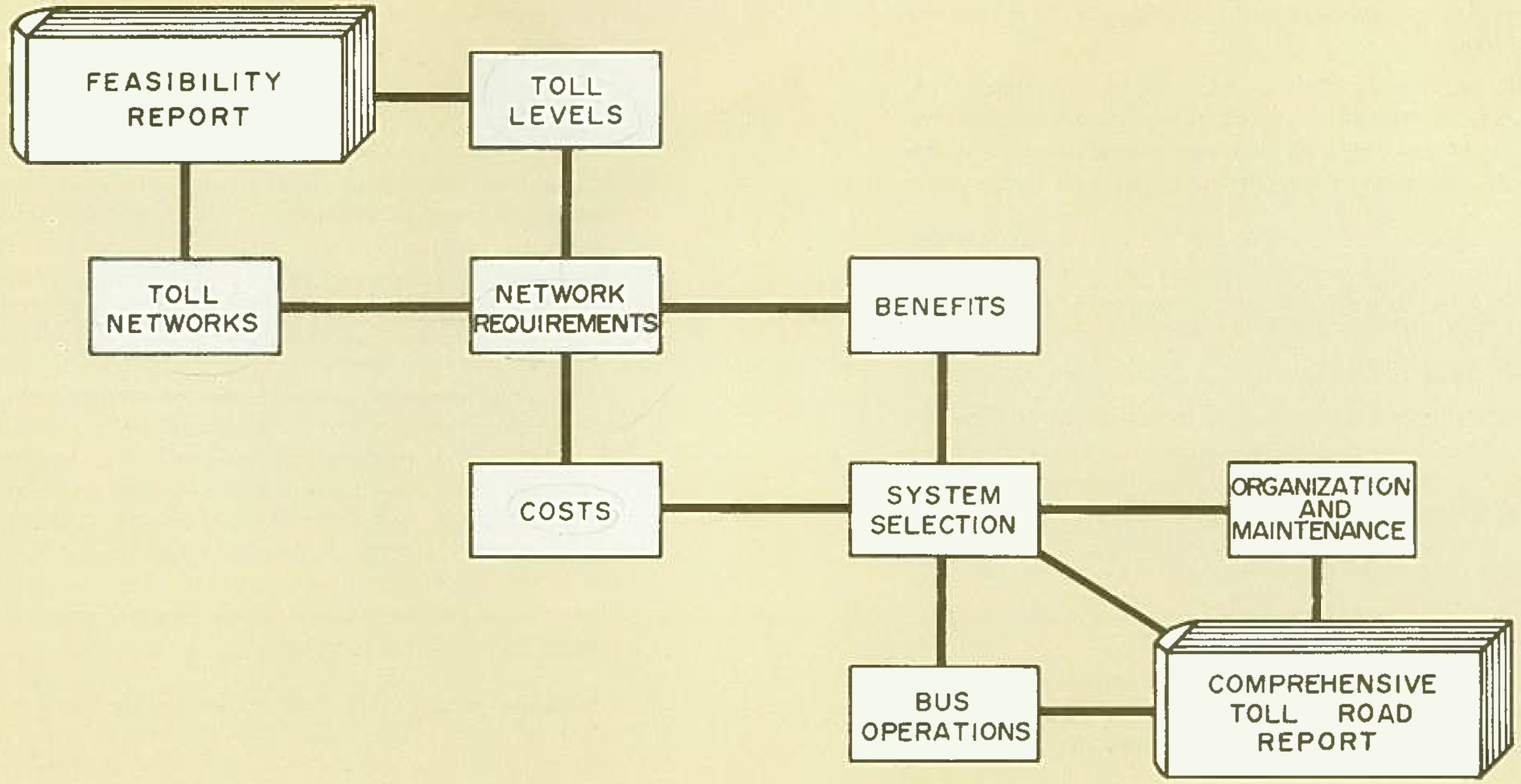
Exhibit 2 indicates the study plan. Both the plan and the personnel requirements were adjusted during the course of the study.

The principal adjustment in the study plan was to postpone the development of freeway maintenance and operation costs until the operations and maintenance consultant had completed much of his work; this delayed the final development of cost estimates by approximately one month. In order that the study as a whole world not fall behind schedule, much of the drafting, reviewing and editing of the final report was completed during the fourth month.

As far as personnel requirements were concerned, the need for local staff in the transportation planning section was considerably underestimated, but otherwise both local and expatriate staff requirements were close to what had initially been intended. It was originally expected that only one local staff man-month would be necessary to complete the work of the transportation planning section; actually, this had to be increased to approximately eight man-months over the full period of the study due to the numerous manual adjustments to the computer output. These adjustments were mainly required because of the capacity limitations of the parallel highways during 1990 traffic assignment.

At the study's start, the staff of the transportation planning section included the scheduled local transportation planning engineer, two trainees, and the expatriate transportation planning engineer. No other local staff were initially required, but other expatriate staff included the project manager, the business manager, and the project economist. During the first two weeks of the study, these expatriate staff members were responsible, inter alia, for more detailed planning of the conduct of the study.

The early burden of work was on the transportation planning section. During the first month, this section had first to develop alternative barrier and closed toll networks, and then, working jointly with the economic section, to develop the cost networks. To complete this latter step, it was necessary to select toll schedules to be tested, and to determine the increments to operating costs which would result from the making of toll stops.



COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
BASIC WORK DIAGRAM
DE LEUW, CATHER INTERNATIONAL CHICAGO

After the development of cost networks, one final step, the development of diversion curves for heavy trucks and for light vehicles, was accomplished by the transportation planning section, prior to using the computer for traffic assignment. Computer work began before the end of the second month, and required approximately three weeks for completion. The manual adjustments, by the staff of the transportation planning section (which, at the time that the computer output was received, consisted of the expatriate engineer, one trainee, and two estimators, who were originally scheduled to work only with the highway design section), required approximately an additional two weeks. At the conclusion of the first three months of the study, the work of the transportation planning section, including all analysis and drafting of text and exhibits, was completed as originally scheduled.

The economic section, which did not work on the study during the period from the end of the first month until midway through the third month, began working again as adjusted computer results became available from the transportation planning section. A second task of the economic section, which, from the middle of the third month included a local economist, as well as the expatriate economist, was the estimation of the extent of induced traffic which might be expected to arise as a result of the freeway.

Work also began during the third month on the development of toll road costs. Much of this work was postponed beyond the period for which it was originally scheduled, in order that all of the recommendations of the operations and maintenance consultant (who arrived at the end of the third month) could be taken into consideration.

During the third month, the highway design section, for all intents and purposes, consisted of only one local, and one expatriate, highway design engineer; the two estimators who were working on the study were assigned transportation planning work, and were only shifted to the highway design section at the end of the third month.

The fourth month of the study was, by far, the busiest. The economic section did all of its work on freeway benefits and toll revenue, and completed the drafting of most of its sections of the final report; the highway design section completed its work on cost estimating; the major portion of work of the operations and maintenance consultant was accomplished; drafting of two sections of the final report by the business manager was finished; much of the drafting of exhibits was done; the work of the bus operations specialist was started, and nearly completed; the architectural work was begun; and final review by the project manager of all report sections which had been drafted was made. By the end of the fourth month, the study was behind schedule only with regard to benefit-cost analysis, but was ahead of schedule insofar as the drafting of the final report was concerned.

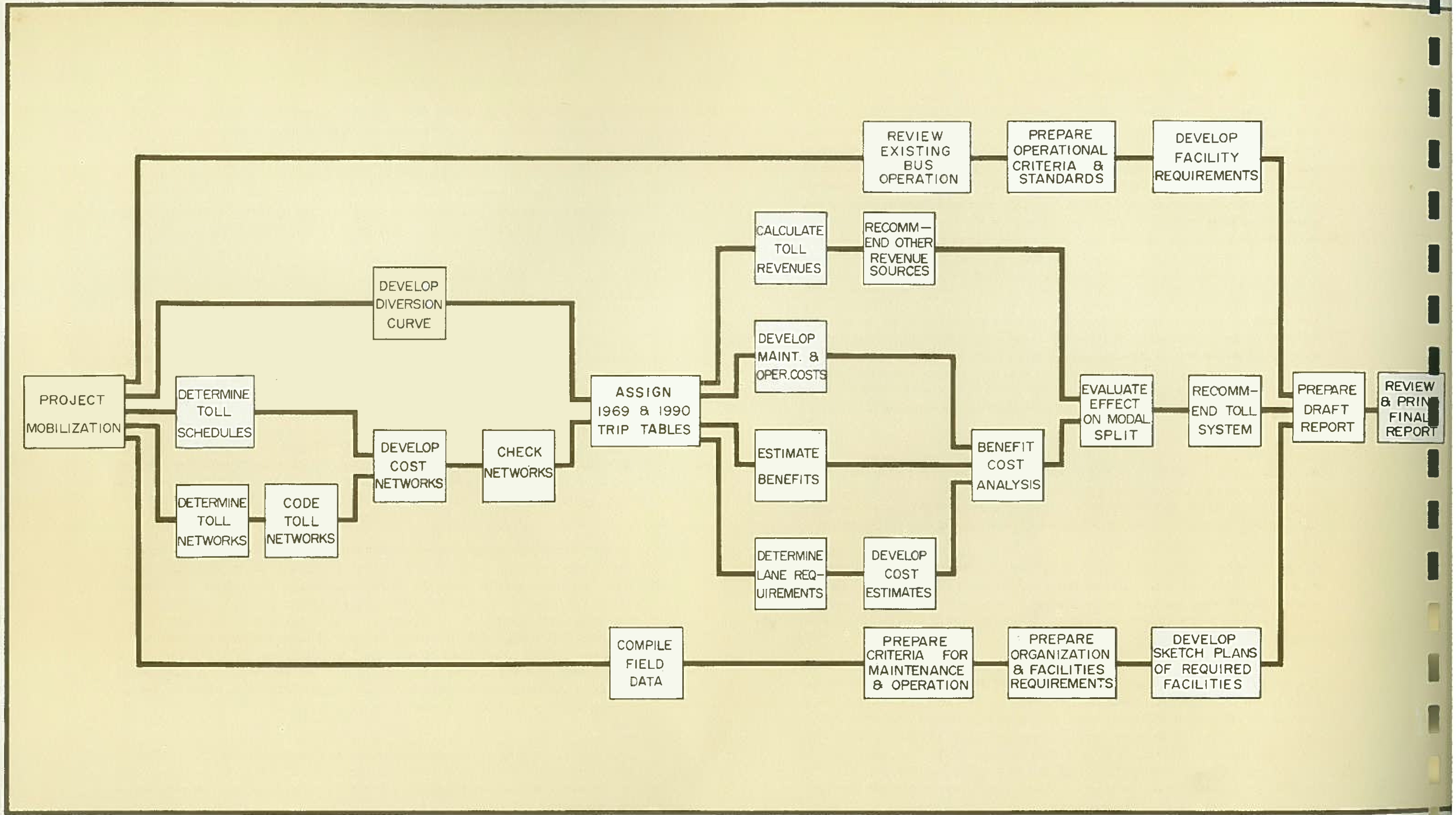
The economic section belatedly completed the benefit-cost analysis, and also completed a sensitivity analysis in the middle of the fifth month. The operations and maintenance consultant completed his work, and the architectural staff (consisting of two local, and one expatriate, architects) completed their work, near the end of the fifth month.

Methodology

It was only possible to complete this toll study in the short span of five months because a great deal of the basic data had already been developed in the freeway feasibility study. The 1969 trip tables were those obtained from the April 1969 O-D survey conducted as an integral part of the feasibility study. The vehicle operating and user costs used in the toll study were those developed during the feasibility study, and the traffic forecasts, used to expand the 1969 trip tables to 1990, were also taken from the earlier study. Finally, the highway construction and maintenance costs for the without-freeway alternative (i.e., for the "arterial system") were extracted from the feasibility report, as were most of the freeway construction costs.

Some thought was given to revision of a few of these basic data items, however. Nearly two years had passed since the traffic forecasts of the feasibility study were made and consideration was given to revising these in the light of actual growth which had occurred in that two-year period. Traffic growth was, therefore, re-examined (see Appendix A to Chapter I). The re-examination indicated that the feasibility study was either reasonably accurate, or was conservative, in most of its forecasts, so that those forecasts were deemed usable for the toll study. (Some adjustments were made in the traffic forecasts, at the time they were re-examined, however, and these adjusted forecasts are considered in the sensitivity analysis included in this study as Appendix E to Chapter III).

The vehicle operating costs were also re-examined (see Appendix B to Chapter I). Some minor adjustments were made, but these were all within the margin of error of the feasibility study calculations, and, therefore, operating costs were not altered for this study.



COMPREHENSIVE TOLL ROAD ST'D
NORTH-SOUTH FREEWAY TAIW N

PRECEDENCE DIAGRAM

DE LEUW, CATHER INTERNATIONAL-CHICAG

Where construction costs were concerned, consideration was given to using current unit costs, rather than those of 1969, but it was decided that this would add unfair weight to costs, since all benefits (user costs and alternative highway investments) would be based on 1969 prices. In any case, the recent bid prices received for various projects in the Sanchung-Chungli section support the accuracy of feasibility cost estimates.

The feasibility study had recommended a freeway facility with 56 interchange locations. Now that it has been determined to make the freeway a toll facility, 56 interchanges along an approximately 375-kilometer route would be too many, provided that most traffic should be required to pay a toll. Accordingly, a number of interchanges, which would not be expected to service large volumes of traffic were eliminated from the systems to be tested; in this manner, the number of freeway interchanges was reduced to 38.

Even this lower number of interchanges (approximately one for every ten kilometers) is high for a toll facility. It is high in this instance because the planned freeway must also serve urban traffic, which is usually not the case for a toll road, i.e., usually a toll road is located outside of urban areas, whilst the freeways which do serve urban traffic are normally free. There is a very good reason for this; urban freeways require a large number of interchanges. If urban traffic is then going to be charged tolls for use of the freeway, there will either have to be a large number of toll barriers (between every two adjacent interchanges), or there will have to be large, closed interchanges, which, because they require a large land area, are especially expensive in urban areas, and, which would cause considerable traffic congestion at all points of ingress and egress to and from the toll facility within the urban area.

When these problems of locating a toll facility within an urban area were discussed with concerned government officials, a government ruling was obtained to the effect that users of the freeway within the Taipei, Taichung-Changhua, and Kaohsiung urban areas would be permitted to use the freeway free of charge. This ruling, then, obviated the need, which otherwise would have existed, to reduce the numbers of interchanges in the aforementioned urban areas.

This ruling also meant, however, that no purely closed toll network could be developed, since freeway barriers would need to be used to separate these free travel zones from other areas of the freeway. Accordingly, the closed network developed in this study includes five barriers on the freeway. This number is increased to ten barriers with the selected barrier system.

The 1969 and 1990 trip tables of the feasibility report were to be assigned to the highway systems containing these freeway networks, as well as to the arterial system. First, however, additional operating costs had to be determined and a diversion curve had to be developed.

The additional operating costs included the toll charges, themselves, and the operating cost increments arising from the making of toll stops. In the determination of toll charges, another government ruling was basic. To wit: The toll schedule to be selected should be a partial cost-recovery schedule, rather than a full cost-recovery schedule.

Relative toll levels among the various vehicle types were determined by relating them to the relative benefits of using the freeway, e.g., express buses, because of their high passenger time value (viz., NT$350 per minute) would reap considerably more in the way of cost benefits per vehicle-kilometer than would other vehicle types, and it might therefore be considered equitable if express buses would be charged higher tolls. The absolute levels of tolls to be tested were initially selected on the basis of their depriving freeway users of certain percentage portions of benefits, and then were manually tested to obtain a preliminary indication of the amounts of toll revenue which they might be expected to produce.

The final cost item to be determined was the incremental operating cost arising from the making of toll stops. There were three different costs that had to be determined: stopping at freeway barriers with the barrier system; stopping at freeway barriers with the closed system; and the incremental cost of passing through a closed interchange compared with passing through an open interchange. The first two of these costs would be expected to differ only because of a longer average stopping time requirement at the point of toll payment with the closed system, since variable amounts of toll charges would be collected.

Although an all-or-nothing assignment technique had been used for the feasibility study, it was decided that a diversion assignment technique would be used for assigning some of the 1969 and 1990 trip tables in the toll study. The diversion technique is considered preferable in instances where: 1) a large number of trips would have two or more alternative routes with small cost differences; and 2) the small cost differences would not be expected to result in major shifts to the lower cost route. The diversion technique was used for assigning 1969 trip tables for autos, light trucks, and heavy trucks, because the cost differences between alternative routes were relatively small, generally, and the drivers of such vehicles were not expected to show strong preferences for lower cost routes, where the cost differences were small. For buses, however, the diversion assignment technique was not used, since the freeway operating cost advantages were sizable, and since, even with only small cost differences, the drivers (who would not normally make the route selection) would be expected to take the lowest cost route.

In order to use the diversion technique of assignment, diversion curves had to be developed. Separate curves were developed for light vehicles and for heavy trucks. These curves were based on absolute differences in the costs of two alternative routes, rather than on the relative costs of the various alternatives, i.e., the distribution of traffic between two routes was determined by the cost savings (expressed in NT dollars) of traveling on one route as compared to traveling on the other route. The point of even split between two routes (in this case, the freeway and the lowest cost alternative route) would occur where there would be no savings by using either route (i.e., the operating costs of traveling via the two routes would be the same). One hundred percent diversion to the freeway was estimated to occur when the cost saving, which would derive from use of the freeway, would be equivalent to one-half of the cost of using the arterials, over the average trip distance. The shapes of the curves between the even-split, and the one-hundred-percent diversion, points were established by referring to published diversion curves, and investigations conducted during the feasibility study.

Once all of the costs had been determined and the diversion curves had been developed, traffic assignments were made by the computer. After reviewing the traffic assignment computer output at each screenline, manual reassignments were made in those areas where traffic assignment overflow conditions had occurred. A traffic assignment flow diagram is shown in Exhibit 3.

Additionally, adjustments were made for 1990 traffic generated by the planned Taoyuan airport. At the time of the feasibility study, no in-depth analysis could be made of the traffic which might be generated by the planned new airport. Now, however, a comprehensive airport study has been completed, and the toll study made use of the airport study traffic forecasts; this necessitated upward adjustments of the airport traffic volumes which had been estimated in the feasibility study.

Time constraints and lack of agreement on estimates of the ultimate capacity of Keelung Harbor precluded any in-depth analysis, during the feasibility study, of the timing of Keelung Harbor saturation, and its effect on the growth of Keelung-Taipei heavy truck traffic, Since that time, various other studies have estimated the capacity of the port at Keelung, and although there is still wide disagreement on the harbor's ultimate capacity, one of these estimates was used in this study to make year-by-year forecasts of the future growth of truck traffic between Keelung and Neihu. These forecasts resulting in a downward adjustment of the 1990 heavy truck traffic forecast by the feasibility study.

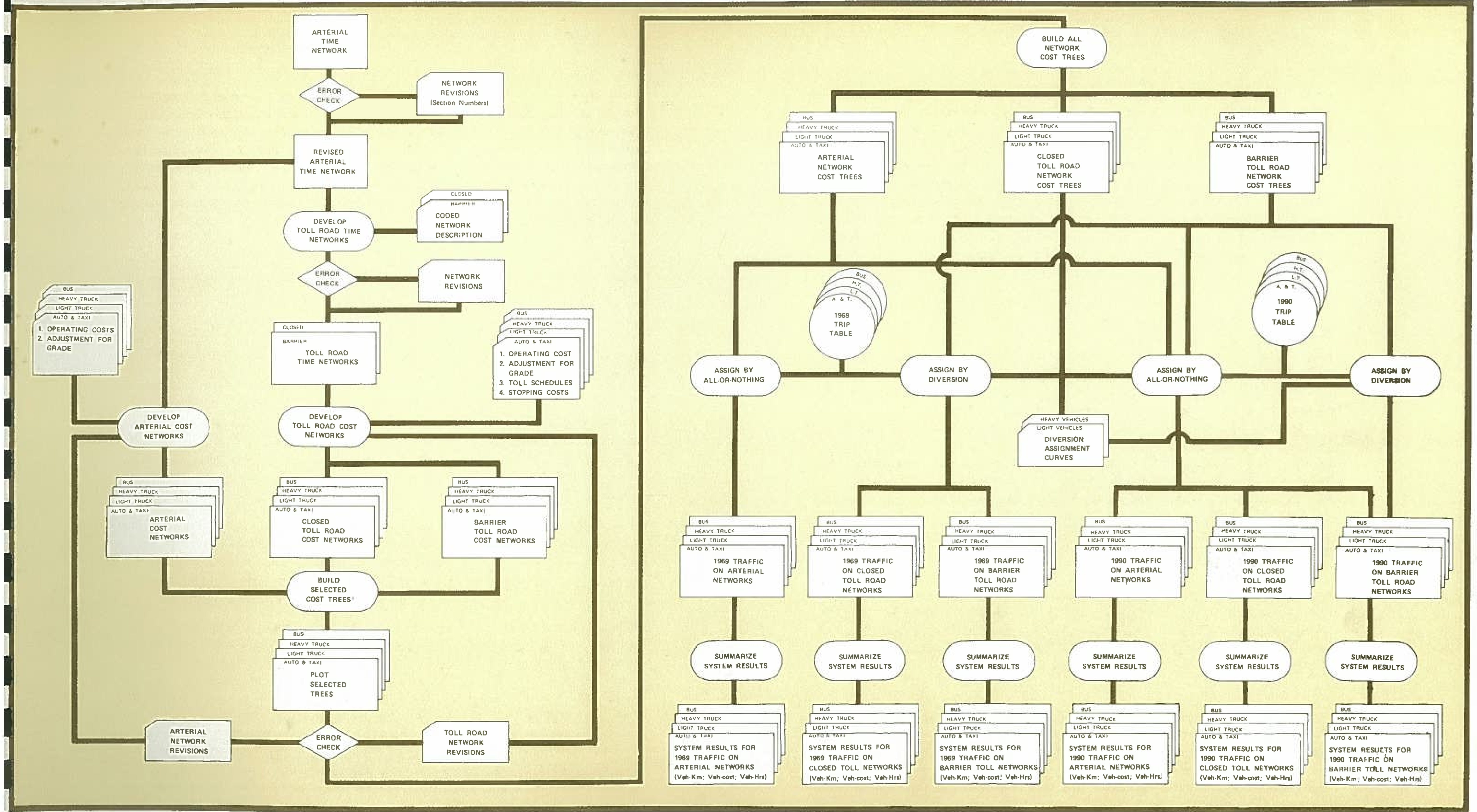
Traffic growth curves were prepared at each of fourteen screenlines showing the traffic growth between the present time and 1990. Also included on the growth curve diagrams are diversion curves showing the effect of diversion when the toll road is first opened, and the subsequent growth of traffic on both the toll road and parallel arterial highways. The traffic growth curves also indicate the toll road requirements in terms of the number of lanes required and the corresponding year of need.

The benefits indicated in this study as deriving from the freeway relate to the above-described adjusted traffic volumes, and do not include any benefits from induced traffic or traffic converted from the railway. These increments to freeway traffic are only considered in the aforementioned sensitivity analysis.

The benefits were calculated in this study by comparing the operating costs (including passenger time costs) of the arterial system, i.e., without the freeway, to the operating costs of the with-freeway alternatives with various toll systems. These costs were compared only after all taxes and tolls had been extracted.

Unlike as was done in the feasibility study, this study did not reduce the freeway user cost savings in section II after that segment of the freeway would be expected to reach capacity. The earlier study hypothesized that a second freeway would open in section II when the first freeway would reach the point of becoming congested, and that the newer freeway would act to divert large volumes of traffic from the initial freeway facility. The user savings which were then indicated for the first freeway were only those savings which would accrue to the traffic remaining on that freeway. Actually, the level of savings which the diverted traffic would have experienced by staying on the first freeway should still be credited to that facility, since the second freeway would have only improved vehicle operatings by their operating cost differentials between the two freeways.

EXHIBIT 3



COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN

TRAFFIC ASSIGNMENT FLOW DIAGRAM

DE LEUW, CATHER INTERNATIONAL-CHICAGO

In the feasibility study, the benefits deriving from the freeway included, in addition to user cost savings and some "lesser benefits", the estimated investment costs of the alternative highway (arterial) system. That is, the user savings with the freeway were not calculated by comparing the freeway alternative to a no-investment alternative, but were calculated instead by comparing the operating results with the freeway investment to the operating results with an alternative highway investment program, and did not include the benefits of this alternative investment program relative to the no-investment situation; in lieu of these latter benefits, the investment costs of this alternative highway system were included as freeway benefits. Provided that these alternative highway investments would have been economically feasible without the freeway, i.e., provided that the benefits of these investments would have exceeded their costs, the inclusion of their costs, rather than their benefits, as benefits of the freeway would tend to understate total freeway benefits.

This method of determining total freeway benefits was not understood by some of the reviewers of the feasibility study, however, so that it was felt that a slightly different approach might be preferable for the toll study. Accordingly, the benefit-cost analysis in this study compares the user cost savings (benefits) with the incremental cost of the freeway investment over the costs of the alternative highway investments. This is actually a very minor adjustment in methodology, and does not affect net present value or internal rate of return calculations at all. There is, however, some effect on benefit-cost ratios at discount rates other than the internal rate of return (i.e., an equal amount is deducted from both sides of benefit-cost ratios, so that the ratios would be altered in all instances other than a ratio of 1.0).

In determining the incremental freeway cost, adjustments were made in the related highway costs with the freeway, since additional highway improvements, over what had been indicated in the feasibility study, have now been scheduled. These additional improvements were also taken into consideration at the time of manual adjustment to computer output.

The construction of the freeway through from Keelung to Fengshan was scheduled, in the feasibility study, over the 1970-1974 period. It is no longer possible to complete construction over that period, and the revised schedule for construction calls for completion over the 1971-1977 period. The scheduling of construction over a seven-year period, rather than over a five-year period, would tend to lower discounted cost totals of the freeway investment at every given discount rate. If alternative highway improvements would not be similarly rescheduled to conform with the revised estimates of freeway opening rates, then the discounted incremental costs of the freeway investment would tend to be lowered. This would be permissable only if benefits for the highway improvements alternative would be calculated for the years prior to the scheduled freeway opening in the various sections. Since this would be difficult to accomplish without computer traffic assignments and operating cost summarys for every year, it was decided that the alternative highway improvements should also be rescheduled instead.

Because of the revised schedule for construction, the period over which freeway benefits were calculated was altered. The feasibility study calculated benefits for the 1972-1990 period. It was determined that, for the toll study, the 1975-1995 period would be used for the calculation of benefits. This adjustment in the analysis would tend to raise total benefits since: (1) two additional years of operation were added; and (2) the corridor traffic volumes would be higher in any given year of operations, e.g., the first year of operations of the entire freeway would be 1978, instead of 1975, and corridor volumes would be higher after three additional years of growth.

CHAPTER II

Toll System Alternatives

Chapter II

TOLL SYSTEM ALTERNATIVES

SELECTION AND DEVELOPMENT

Toll Networks

Functional Concepts of Toll–Free Freeways and Toll Roads

The primary function of both a toll-free freeway and a toll road is the movement of traffic. Both facilities exercise a high degree of access control to achieve their intended function. Relative to lower types of facilities, a toll-free freeway and a toll road exhibit many of the same characteristics. Comparing one directly with the other, however, their differences become more apparent. The most obvious difference is their approach to collecting funds necessary to repay their indebtedness. A more subtle differenciation is related to their access function. The toll-free freeway is generally characterized by more frequent access points than are normally provided on a toll road. Therefore, while providing a high standard of traffic operation, a toll-free freeway takes on the added function of land access more readily then does a toll road. That is, as a direct result of having more access points, a toll-free freeway provides a higher degree of accessibility to the adjacent land areas with an accompanying related rise in traffic demand. Conversely, a toll road continues to emphasize its primary function of traffic movement, generally providing a superior level of service to traffic over that offered by a similar toll-free freeway condition. The improved level of service however, is directly related to a lower degree of accessibility to the adjacent land area.

The toll-free freeway recommendation developed in the feasibility study recognized the desirability of striking a balance between the need for improving the movement of traffic and the need to maintain a high degree of accessibility to the adjacent land area. The decision to make the freeway into a toll road introduces additional constraints which tend to alter the balance between traffic service and accessibility.

In the consideration of the toll networks developed for this study, the problem was more complex than the simple translation of toll road concepts as they have evolved in countries where both toll roads and toll-free freeways have developed together. Because of the high population density along the freeway route in the present case, it was necessary to develop a toll road concept which provided for both the collection of tolls and good traffic movement, and maintained a relatively high level of accessibility.

Toll Collection Alternatives

There are two methods of toll collection presently in general use. One method is to locate toll collection stations on the toll road. This method is generally referred to as a barrier system. The second method is to locate toll collection stations within the interchange areas, and is generally referred to as a closed system.

The barrier system is characterized by the following general features:

> Toll plazas are located directly on the toll road, thereby requiring all vehicles to stop at each plaza, and disrupting the smooth flow of traffic.
>
> Toll rates are generally structured so as to facilitate the payment of the toll fee and minimize the delay to traffic.
>
> The number of times a vehicle is required to stop is dependent upon the vehicle trip length and the spacing of the toll plazas.
>
> The interchange configuration does not include provisions for toll collection and therefore can be designed to serve the traffic demand.
>
> Removal of toll collection at a later date requires some minor alterations to the main roadway through the toll plazas.
>
> Additional access points can be provided without increasing the number of toll plazas, provided some free travel over a short distance between adjacent access points is an acceptable policy.
>
> Depending upon the spacing of access points and toll plazas, some people using the toll road for a short distance may not be assessed a toll charge.

The closed concept for toll collection is characterized by the following general features:

Toll plazas are located within the interchange areas, off the main line of the toll road. A vehicle is required to make one stop before entering the toll road in order to collect an identifying card, and once when leaving the toll road to pay the toll charge.

Toll charges are based upon a specified toll rate per kilometer applied over the number of kilometers traveled. Therefore the toll charge is dependent upon the length of travel, as determined from the identifying card received prior to entry onto the toll road.

The number of times a vehicle is required to stop is limited to two (once when entering & once when leaving the toll road) and is not dependent on the vehicle trip length.

The interchange configurations must be designed in such a manner as to include provision for the collection of toll charges. Many of the design techniques available to facilitate the efficient movement of large volumes of traffic cannot be utilized to their maximum potential when toll collection facilities must also be included. While this is a minor problem in areas of low traffic volumes, the problem does become serious in areas of high traffic volumes.

Possible removal of toll collection at a later date would require major interchange alterations to adequately serve large traffic volumes.

All toll road access points must have a toll collection station. If not, trips of all lengths could leave the toll road at a free access point without paying for any portion of the trip.

Everyone using the toll road is assessed a toll charge.

In addition to the above comparative features, the closed system is more expensive to construct, operate and maintain. Comparative cost figures for the two systems developed and tested in this study are presented in a later section of this report.

General Alignment of Toll Road

During the feasibility study, alternative routes in several areas were evaluated. Two alternatives were investigated in the Kaohsiung area and two more were investigated in the area between Tounan and Taichung. Several alternatives were investigated in the Chungli to Keelung area.

Since the completion of the feasibility study, several important planning decisions have been made which have, in effect, fixed the roadway alignment. For example, final design for the entire section from Yangmei to Taipei following the west alternative is completed. Also, decisions relating to the expansion of an existing refinery site and the construction of a railroad marshalling yard in the area north of Kaohsiung have in effect eliminated the west alternative in this area from further consideration.

With these decisions as input, the final alignment of the toll road selected for analysis purposes for the comprehensive toll study was determined in conjunction with TAFCB personnel. The alignment from Keelung to Kangshan generally follows the west alternative freeway alignment developed during the feasibility study. From Kangshan to Kaohsiung the alignment follows the east alternative shown in the feasibility report. A change in alignment was also made for the section from Hsinchu to Yangmei to reflect the latest revision in route location for this section which is presently under design by TAFCB.

Selection of Barrier Toll Network

Following the toll road alignment previously established, and utilizing the interchange locations proposed in the feasibility study as a guide, a basic barrier toll network was developed, based on the criteria that each major city within the primary influence area of the toll road be provided with one access point. Barrier toll collection stations were then located between these initial access points at approximately equal spacing.

Additional access points were added to this basic network of interchanges and toll plazas to serve important new traffic generators such as the planned new port facilities at Kaohsiung and Taichung, the planned International Airport at Taoyuan, and the new community development planned in the Linkou area. A significant measure of the total effect that these developments will have upon the economy of Taiwan will be dependent upon the transportation facilities serving them. Therefore, inclusion of direct access from these traffic generators to the toll road was given primary importance.

Additional access points were also provided at the locations where Highway 1 crosses the toll road alignment. Highway 1 is presently the major north-south route and, because of the ribbon developments along most sections, the highway will continue to function as an important arterial highway after the toll road is completed. The intersection of these two important highway facilities will be characterized by large traffic volumes wishing to transfer to the other facility. Therefore, provision for the interchange of traffic between Highway 1 and the toll road is warranted on the basis of serving the travel desires of major volumes of traffic.

With these additional access points superimposed on the basic network, the number of toll plazas was no longer adequate to insure the collection of tolls from all users. Therefore some adjustment to the present concept was required. One alternative was to add additional toll plazas so that one plaza would exist between each two access points. The resultant frequency of stops required for all vehicles on the toll road rendered this approach unsatisfactory.

A second alternative was to alter basic toll road policy and not attempt to collect a toll from all the users of the facility. Since the Government has expressed the position that toll revenues would not have to recover all the costs of the toll road, this approach had added merit. Utilizing this concept, along with the preliminary toll plaza locations established for the basic network, alternate toll plaza locations were reviewed and analyzed in terms of the traffic demand crossing the station, the ease of bypassing the plaza via a parallel arterial route, and the relative cost differential between the toll road routing (including toll charges) and a parallel arterial routing. Trip tables, cost networks and traffic assignments developed during the feasibility study were utilized to evaluate the relative merits of alternative toll plaza locations.

Within the large urban areas of Taipei, Taichung-Changhua, and Kaohsiung special consideration was required since the toll road alignment passes in close proximity to these urban areas. Applying the original criteria of one access point for each major city to these three areas would concentrate traffic demand within the city, rather then disperse it, and severely reduce the benefits of the proposed facility for the areas which represent the major sources of traffic demand.

In order to provide a reasonable level of service to the urban areas, the number of access points required is such that a toll plaza between each pair would create extreme geometric, land use and operational difficulties. Therefore, a policy of free travel within these three urban areas was adopted. With the policy of no toll collection stations located within the urban areas, no adjustment in the access locations proposed in the feasibility study was required. Therefore the number and location of access points for the toll road within the urban area is identical to recommendations made in the feasibility study.

Having determined the general location and spacing of the toll plazas, preliminary dimensions for the toll plazas were developed and specific sites selected for the plazas to insure adequate topographic and geometric conditions. The proposed barrier toll network was reviewed by TAFCB personnel and appropriate adjustments were made to reflect their more intimate knowledge of local conditions and access requirements for both the present and future situations.

Exhibit 4 illustrates the resultant barrier toll network which was utilized in the traffic assignments and economic analysis. The barrier toll network includes ten barrier toll plazas between Keelung and Kaohsiung at an approximate spacing of thirty to forty kilometers. There are thirty-eight interchanges included in the barrier toll network, compared to fifty-six proposed for the freeway in the feasibility report.

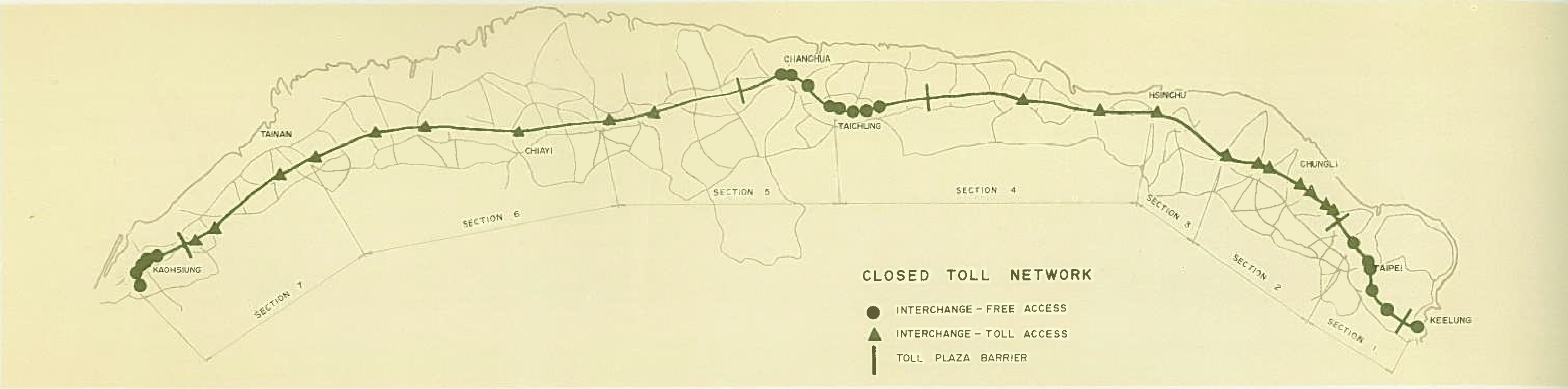
Selection of Closed Toll Network

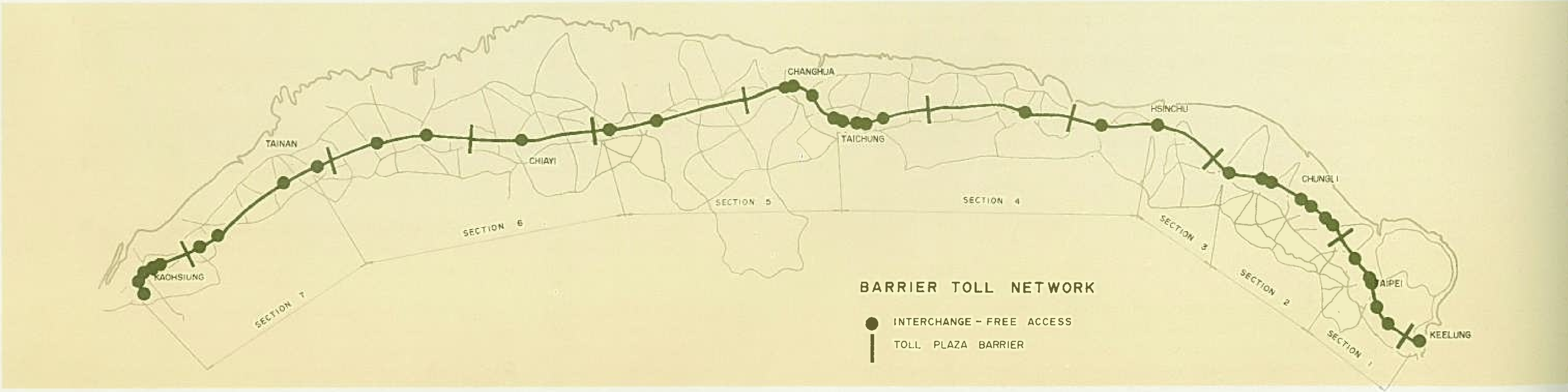
Whereas, for the barrier toll network all vehicles on the toll road are required to stop at each toll plaza, the toll collection function on a closed toll network is performed within the interchange areas, thereby requiring any given vehicle to stop once when entering the toll road and once again when leaving. The number of required stops is not dependent upon the length of trip or the number of access points provided along the toll road.

Therefore any reasonable number of access points can be included in a closed toll network without having an adverse effect upon the operational characteristics of the vehicles using it. For example, a closed toll network could include the same number of access points as proposed for the freeway in the feasibility report without causing a change in the operational characteristic of vehicles operating on the toll road.

Realistically, however, the inclusion of each access point in a closed toll network requires an additional investment (over the freeway investment) of sufficient magnitude as to render mandatory some control of the number of access points.

A typical toll plaza on a closed toll network will require, in addition to a normal interchange investment, additional investment in bridges, right-of-way, toll collection facilities and buildings, and continuing costs of operation, administration and maintenance. Therefore, in order to control the total investment required, it is necessary to exercise some control in the determination of the access points for a closed toll network.





SCALE IN KILOMETERS
0 10 20 30

COMPREHENSIVE TOLL ROAD STUD
NORTH-SOUTH FREEWAY TAIW N
TOLL ROAD NETWORKS
DE LEUW, CATHER INTERNATIONAL-CHICAG

Similar to the barrier toll network, the closed toll network was initially developed based upon the criteria that each major city within the primary influence area of the toll road be provided with one access point. Additional access points were again added to this basic network to serve important traffic generators as well as intersecting points with Highway 1.

Each of the proposed access points, as well as those which were eliminated from the original freeway proposal, were reviewed and analyzed as to their relative importance in terms of traffic demand and the ease of bypassing given sections of the toll road via a parallel arterial route. Trip tables, cost networks, and traffic assignments from the feasibility study were used to evaluate the relative merits and need for each access point. Within the large urban areas of Taipei, Taichung-Changhua, and Kaohsiung, special consideration was again required for reasons, similar to those explained in the previous section for the barrier toll network. Therefore, a policy of free travel within these three urban areas was also adopted for the closed toll network. Since a closed system must be controlled at both ends, barrier toll plazas on the toll road were added near the boundary of each of the three urban areas. The proposed closed toll network was reviewed by TAFCB personnel and appropriate adjustments were made to reflect their recommendations.

Exhibit 4 illustrates the resultant closed toll network which was utilized in the traffic assignment and economic analysis. The closed toll network includes five barrier toll plazas between Keelung and Kaohsiung. There are thirty-eight interchanges on the closed toll network of which nineteen are toll interchanges (i.e., interchanges which include toll plazas) and nineteen (in the urban areas) are free interchanges (i.e., there would be no toll collection at these interchanges).

Coding Toll Road Networks

Traffic assignment is the process whereby a specified set of trips between defined traffic analysis zones is assigned to a previously defined highway network. In order to utilize the computer in the traffic assignment, the highway network is defined by coding its pertinent characteristics. During the feasibility study, one arterial network and two freeway alternatives were coded and processed by computer for use in the traffic assignment phase. These networks were coded to include such information as link lengths, speeds, existing tolls, grades, jurisdiction (local, arterial, and freeway) and study sections.

The networks were divided into seven sections to facilitate separate evaluations of economic return, alternative routes and priorities. The sections are defined as follows:

Section 1 — Keelung - Erhchung
Section 2 — Erhchung - Yangmei
Section 3 — Yangmei - Hsinchu
Section 4 — Hsinchu - Taichung
Section 5 — Taichung - Tounan
Section 6 — Tounan - Tainan
Section 7 — Tainan - Fengshan

For the toll study, the arterial network from the feasibility study was reviewed and revised to reflect necessary changes in the section numbers of some links. The toll road links were then added to the revised arterial network to form barrier and closed toll networks. The coding of information for the toll road links was made to reflect all revisions in alignment which have occurred since completion of the feasibility study. The toll road networks are illustrated in a general form in Exhibit 5.

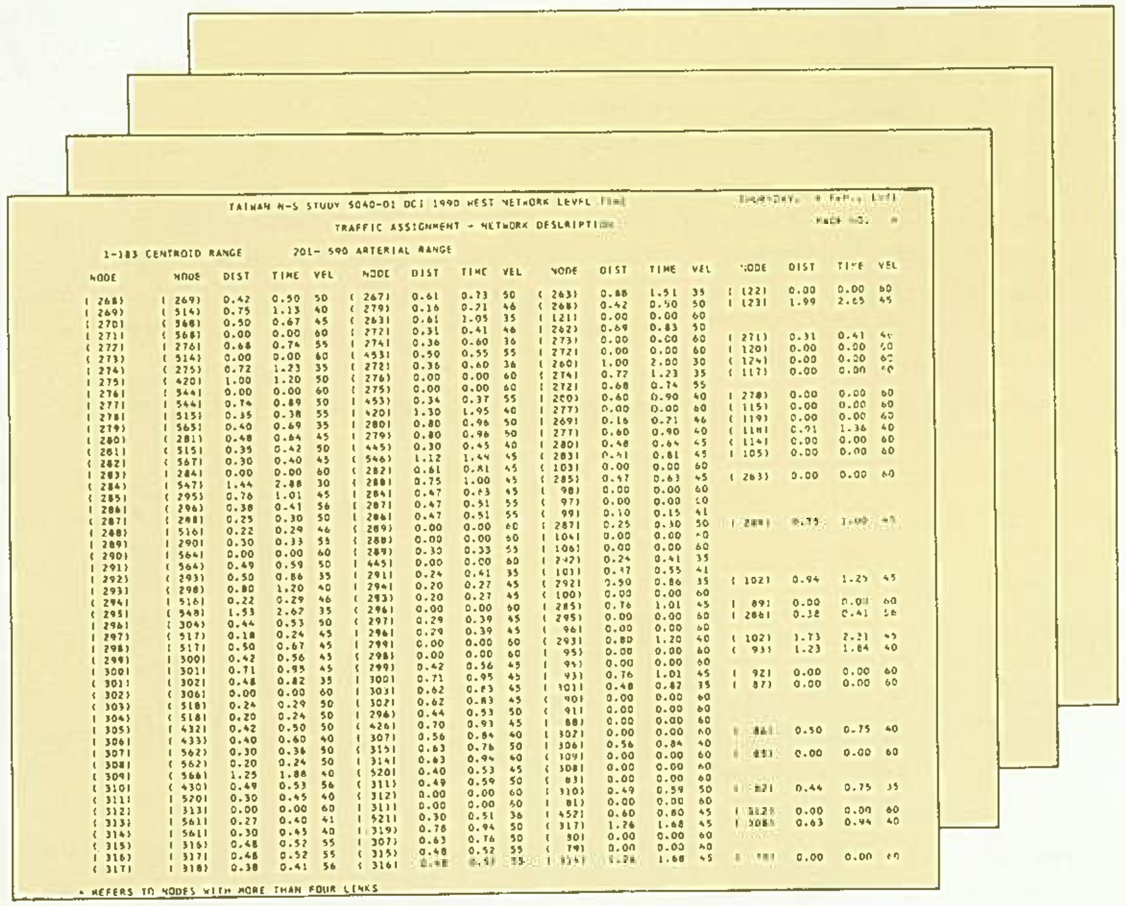
Toll Schedules

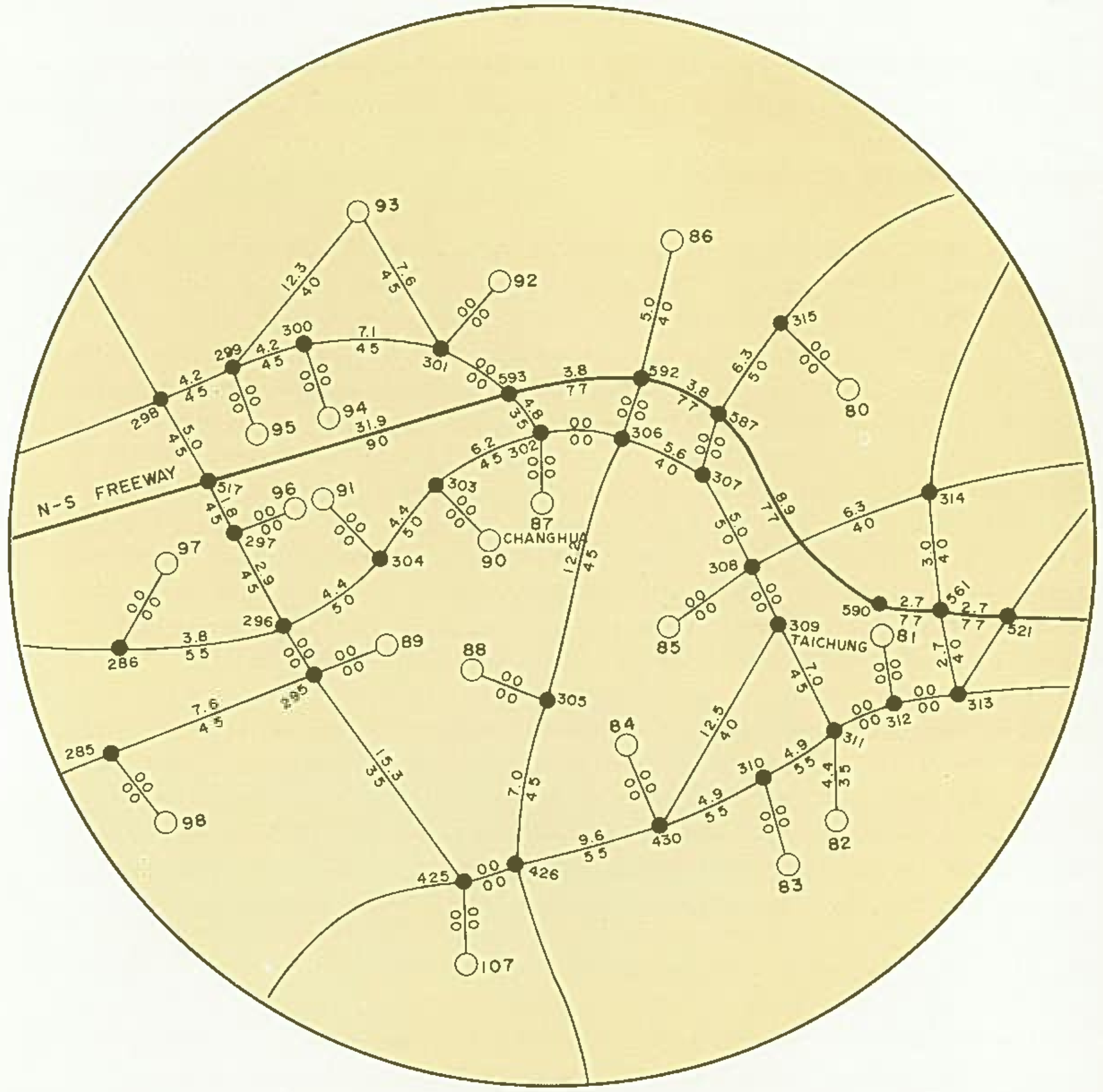
Considerations

Before the Government makes its decision on the levels of tolls to be imposed on the North-South Freeway, it is advisable that two or more toll schedules be selected for testing, to determine their effects on traffic patterns, transportation costs, the economic feasibility of the freeway, and the levels of toll revenues.

In making a selection of the toll schedules to be tested, there are several practical considerations, which when taken into account, greatly limit the number of possible toll level combinations. Several of these considerations are discussed in the following paragraphs.

> <u>The toll levels should not be so high as to eliminate all benefits of the freeway for any type of vehicle over any freeway section.</u> Despite the apparent logic in this qualification at first glance, it is nevertheless an arbitrary judgment, since it was arrived at without testing the effects of toll levels that would eliminate benefits of the freeway for some vehicle type, or types, over some area. The theory behind this qualification is that toll rates which would wipe out driver benefits would greatly retard the diversion of vehicles from alternative highway routes to the Freeway following the commencement of freeway operation. Thus, far fewer vehicles would be using the freeway than would be economically advantageous, and the freeway benefits and economic rate of return would be





LEGEND

○80 ZONE CENTROID

425 NODE NUMBER

7.1 / 4.5 = LENGTH OF LINK IN KMS / SPEED ON LINK IN KPH

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
TYPICAL NETWORK DESCRIPTION
DE LEUW, CATHER INTERNATIONAL-CHICAGO

reduced. (The freeway benefits arising from any vehicle which would use the freeway, however, would not be reduced at all; that is, the increased cost of freeway travel would arise solely from the toll charges, which are a form of tax, and, as such, do not constitute a cost to the economy, so that the economic benefits deriving from the vehicles which would use the freeway, despite high toll charges, would not be diminished.)

Toll rates which would eliminate driver benefits for some vehicle type would, moreover, nullify the possibility of induced traffic (theoretically, at least), since induced traffic should only arise when a new transportation service provides service superior to any theretofore obtainable, or provides a comparable service previously obtainable only at a higher cost. In other words, induced traffic arises only if a better transportation bargain becomes available; if driver freeway benefits would be eliminated through high toll rates, therefore, no improved transportation bargain would be presented to them, and induced traffic, including development traffic, would not be expected to arise.

The toll rates should, as nearly as possible, be equitable among vehicle types, and over all sections of the freeway. Actually, as will be discussed later, this qualification may be somewhat in conflict with some of the qualifications concerning toll collection operation and vehicle safety. There are both social and economic reasons, however, for attempting to make toll levels as equitable as possible. The social reason, with its political overtones, is, of course, concerned with avoidance of discrimination against any group of motorists. Equitable toll rates have an economic advantage, too, in that, for any given amount of total toll revenue, equitable rates might be counted upon to create the maximum diversion from other highways to the freeway after it would commence operations. (Actually, this isn't quite true; that is, the most equitable rates might not create maximum diversion to the freeway since the diversion curves for each of the vehicle types will not be identical, and since, for buses especially, drivers may not have the option to choose their own routes of travel.)

Two approaches are widely used for determining equitable rates for the several vehicle types and sizes. One of these, attempts to vary toll levels in accordance with the calculated variance in benefits among vehicle types and among the several sections of the toll facility. This approach was favored in this study, since it can be employed to maximize the diversion to the freeway from alternative highway routes. The following section of this chapter discusses the application of this approach to the North-South Freeway situation.

The other approach for determining equitable toll rates is to relate the relative toll rate magnitudes among vehicle types to the portions of freeway construction, maintenance, and operating costs which might legitimately be charged to the various vehicle types. At the time of the freeway feasibility study, it was determined that 15 percent of the paving costs, for example, should be charged to automobiles, while 20 percent should be charged to light trucks, 45 percent to heavy trucks, and 20 percent to buses. Some costs are not related to any vehicle type, but would be incurred for any four-lane freeway, regardless of the traffic mix; in such cases the costs are related to volumes of passenger car equivalents, which gave rise to the need for the freeway facility in the first place, and these costs should therefore be allocated among vehicle types according to their respective portions of total passenger car equivalent-kilometers over the lifetime of the toll facility.

When all of the costs would be allocated among vehicle types, the ratios of toll rates among the various vehicle types would then be found by adjusting the cost percentages by the respective percentages of discounted vehicle-kilometers (note: in this case, passenger-car equivalent-kilometers would not be used).

The toll levels should be such as to return a substantial portion of freeway costs to the Government. Since it has been decided that tolls will be collected on the freeway, and since the construction, maintenance, and operation of toll facilities will require considerable expenditure by the Government, it would seem only reasonable that a substantial portion of freeway costs should be recovered by the Government in the form of toll revenue in order to make the entire operation worthwhile from the Government's standpoint. The Government has indicated, however, that a full cost-recovery schedule is not desired, so that the schedules to be tested should only give promise of recovery of a portion of total freeway costs.

The toll schedules should not differ radically from historic precedent. Historically, heavy vehicles have been charged common toll rates, and these rates have always been double the rates for light vehicles. None of the toll schedules finally selected for testing exactly agreed with this historic precedent; nevertheless historic precedent was considered in attempting to appraise the political palatability of the various possible toll schedules.

Toll charges should be in multiples of NT$5. This qualification is solely for the purpose of fostering toll collection efficiency; it applies only to the barrier system.

There should be a common toll rate for heavy vehicles and a common rate for light vehicles. Completely aside from the question of historic precedent, it would be advantageous, in the case of the barrier system, if there would be only two rates common to light and heavy vehicles, respectively. In each lane there should only be one toll level charged, in order that a check can be maintained, by automatic traffic counts, on the amounts of toll revenues which should have been collected in any toll-collection lane. If then, there were four separate rates charged to the four vehicle types, each of the vehicle types would have its own lane or lanes to go to; such an arrangement would result in excessive weaving at approaches to toll barriers, and a resultant diminution of traffic safety.

Despite this preference for only two rates, however, the much higher benefits per vehicle-kilometer accruing to bus traffic compared with heavy truck per-kilometer benefits argued for examining one or more toll schedules wherein buses would be charged higher toll rates than would heavy trucks.

Where autos and light trucks were concerned, however, the freeway cost advantages for the two vehicle types were not so disparate, and, accordingly, common toll rates were indicated for each toll schedule selected for testing with the barrier system.

If other considerations would not seriously mitigate against it, it would be preferable, for reasons of toll collection efficiency, if the toll schedules with the barrier system would be identical at each barrier. This qualification was not given much weight, since it was expected to only make a slight difference in barrier system toll collection efficiency.

Procedures

As noted in the preceding section, an attempt was made to selected equitable relative toll rates, by relating toll charges to freeway operating cost advantages. In order to accomplish this, the first step was to determine what these cost advantages might be. The procedure by which this was done, and the subsequent analytical steps requisite to making the final selection of toll schedules to be tested, are discussed in detail in Appendix A to this chapter.

The cost advantages (benefits) of using the freeway depend on the cost of moving by freeway and the cost of moving by the best alternative route. The former of these is fairly uniform from section to section of the freeway, but the cost of moving by an alternative route is more variable, since the arterial highways are not uniformly congested along the full length of the western corridor. Hence, freeway cost advantages would be expected to vary from section to section. One possibility which ought to be given consideration, then (if it is desirable that toll charges be closely related to benefits), would be the charging of varying levels of tolls on the different freeway sections. In order to give this possibility due consideration, cost advantages had to be determined for each of the several freeway sections.

The per-kilometer user costs indicated in the feasibility study were used to do this, and were adjusted for the average distance differences of traveling by arterials, rather than by the freeway. The relative amounts of benefits, accruing to the various vehicle types per equivalent freeway vehicle-kilometer, determined the basic ratio of toll levels among these vehicle types.

This basic ratio was altered, however, for many of the considerations enumerated in the preceding section. Thus, for example, when toll schedules for the barrier system were being developed, only common charges for autos and light trucks were given consideration, despite the fact that autos would normally benefit more per kilometer of freeway travel than would light trucks. Adjustments of the basic ratio for reasons of historic precedent, inter alia, included the raising of charges on heavy trucks and the lowering of charges on buses.

Absolute toll levels were arrived at by calculating toll levels which deprived all vehicles of certain percentages of their benefits (20 percent, 30 percent, etc.), and then adjusting these "basic ratio" toll levels for the various considerations mentioned above.

The toll levels obtained in this fashion for the barrier and the closed systems were checked against each other to see that they did not differ too greatly (no effort was made to make them precisely equal, however, since small adjustments in rates could always be made manually at any time, if more precise comparisons would appear necessary). The range of charges for autos was also compared to that which recently existed in the United States for autos on toll facilities.

The final step, preparatory to testing the toll schedules by use of a computer, was to make a preliminary estimate of the toll revenue returns. Only the lowest schedule selected for further consideration was manually tested, since the preliminary indication of returns with this schedule appeared satisfactory (given the Government's ruling that the toll charges should only recover a portion of the costs of the toll road). According to this preliminary estimate of revenues, approximately 41 percent of all toll road construction, maintenance, and operating costs (discounted at eight percent) would be recovered by the end of 1990, and, by end-1994 (i.e., twenty years after the first section is scheduled to open), approximately 56 percent of the costs should be recovered.

Results

Eight toll schedules were selected for further consideration: four with the barrier network and four with the closed network. Six of these were processed by computer. These latter included two constant-rate schedules and one variable-rate schedule for each of the toll road networks (these six are indicated and discussed in the following section of this chapter).

The remaining two toll schedules are shown below.

Schedule B_1 (barrier): light vehicles - NT$10; heavy vehicles - NT$15

Schedule C_2 (closed):	Autos (NT$/km)	Light Trucks (NT$/km)	Heavy Trucks (NT$/km)	Buses (NT$/km)
Section I	0.35	0.26	0.43	0.86
Section II	0.22	0.26	0.43	0.86
Section III	0.25	0.19	0.41	0.82
Section IV	0.36	0.23	0.45	0.90
Section V	0.22	0.16	0.28	0.56
Section VI	0.22	0.16	0.28	0.56
Section VII	0.22	0.16	0.27	0.54

Development of Cost Networks

In the traffic assignment process the computer assigns the specified zonal trip matrix to a defined highway network either on the basis of travel time or travel cost. For the present study, as was done for the feasibility study, travel costs were used as the basis for making traffic assignments. This implies that drivers strive to minimize both travel distance and travel time. The process requires that all elements of travel distance and travel time be quantified for each link of all networks.

The distance cost (per kilometer) and time costs (per minute) developed during the feasibility study were reviewed for possible adjustments, and were subsequently utilized for the toll road study. These costs, however, were representative of toll-free freeway conditions, and the introduction of a toll road operation required that additional costs be added to the appropriate toll road network links.

Toll Schedules Selected For Testing

Since the route a driver selects is based upon an economic evaluation, the addition of toll charges on the toll road network links, with no concomitant change in operating costs on the arterial network links, is certain to affect his decision-making process.

A trip that originally was to be made via the freeway, because it was more economical than an alternative arterial routing, may find the arterial routing to be more economical once a toll charge is introduced. The toll charges, therefore, may be an important element of the total cost to the user.

From the toll schedules discussed in Appendix A to this chapter, three toll schedules for the barrier toll network and three toll schedules for the closed toll network were selected for computer processing.

The three toll schedules selected for the barrier toll network are shown in Table 11-1 and include two schedules (B-2 and B-3) having a fixed toll charge for all barrier plazas, and one schedule (B-4) having a toll charge which varies from section to section.

The three toll schedules selected for the closed toll network are shown in Table II-2 and include two schedules (C-1 and C-4) having a fixed toll charge per kilometer over the full length of the toll road and one schedule (C-3) having a toll charge per kilometer which varies from section to section.

The toll schedules for both the barrier and closed toll networks were chosen to test the following conditions:

a. Relatively low toll charges (Schedules B-2 and C-1).

b. Relatively high toll charges (Schedules B-3 and C-4).

c. Toll charges varying by section in relation to benefits received. (Schedules B-4 and C-3).

With the computer results from testing the above range in toll schedules as a base, it was possible to evaluate additional toll schedules, or variations of schedules using manual analysis procedures.

TABLE II-1

TOLL SCHEDULES FOR BARRIER TOLL NETWORK

Toll Schedule	Section No.	Toll Charge (NT$) Auto	Light truck	Heavy truck	Buses
B - 2		10	10	15	30
B - 3		15	15	20	40
B - 4	1	15	15	20	40
	2	15	15	20	40
	3	10	10	15	20
	4	15	15	20	40
	5	10	10	20	40
	6	10	10	15	20
	7	10	10	20	40

TABLE II-2

TOLL SCHEDULES FOR CLOSED TOLL NETWORK

Toll Schedule	Section No.	Toll Charge (NT$ per km) Auto	Light truck	Heavy truck	Buses
C - 1		0.32	0.23	0.40	0.80
C - 4		0.39	0.29	0.53	1.05
C - 3	1	0.53	0.39	0.66	1.32
	2	0.32	0.39	0.64	1.28
	3	0.38	0.28	0.61	1.22
	4	0.54	0.35	0.67	1.34
	5	0.32	0.23	0.42	0.84
	6	0.34	0.23	0.42	0.84
	7	0.32	0.23	0.40	0.80

Incremental Cost At Barrier Plazas

The placement of barrier toll plazas on the toll road requires that all vehicles stop at each station. Therefore, in addition to the actual toll charge, a driver will also experience an increase in time and distance costs attributable to the required stops.

To determine the cost of the barrier stops, the time and distance required for each of the following tasks were calculated.

a. Deceleration from a normal operating speed to a stop condition.

b. Delay at toll plaza due to traffic queuing.

c. Delay at toll plaza for processing of toll charge.

d. Acceleration from a stop condition to a normal operating speed.

This information was determined for both light and heavy vehicles using typical acceleration and deceleration rates characteristic of the vehicle types. The time required to traverse the same distance at a normal operating speed with no stopping was also determined. The per-second time costs for the various vehicle types were then applied to the differentials in time for the stop and no stop conditions to arrive at the incremental time cost per stop in terms of NT dollars.

Incremental distance costs arising from increased rates of fuel consumption, added wear on tires and brakes, and vehicle idling over the distance required to decelerate, stop and accelerate were also determined for each vehicle type.

The determination of incremental costs incurred by vehicles stopping at barrier toll plazas is discussed in detail in Appendix B to this chapter. The incremental costs for a barrier toll plaza on the closed network are greater then those on the barrier network, as a result of the longer processing time required for a closed system, where cards must be read and toll charges vary according to the distance traveled.

Incremental Costs At Toll Interchanges

The barrier toll network collects all toll charges at barrier plazas. The closed toll network developed for this study, however, utilizes both toll interchanges and barrier toll plazas. Therefore it was also necessary to assess the incremental time and distance cost required for a vehicle to traverse a toll interchange over that of a free interchange.

Unlike the previous case for stops at the barrier plazas, the incremental costs for toll interchanges was complicated by the fact that the geometric configuration of a toll interchange is distinct from that for a free interchange. Therefore, the distance a vehicle travels varies according to the interchange configuration, as well as the direction in which a vehicle proceeds after passing through the interchange.

The general approach, however, to calculating the incremental time and distance costs was similar to that used for the barrier plaza stops. The time required to move between two points common to both the toll and free interchange conditions were determined. Utilizing per-second time costs, the incremental time cost attributable to the toll collection features of the interchange were determined in terms of NT dollars. The net incremental distance costs were again added to arrive at a total incremental cost for toll interchanges. The incremental costs incurred by vehicles traversing a toll interchange are also discussed in Appendix B.

Development of Cost Trees

After all time and distance costs (operating costs, adjustments for grades, toll charges, and incremental costs for stopping at barrier toll plazas and toll interchanges) were determined and identification was made of the appropriate costs which should be applied on each of the many network links, the arterial and toll road time networks, discussed later in this chapter, were revised to form the arterial and toll road cost networks upon which traffic assignments were made.

For the three urban areas of Taipei, Taichung-Changhua, and Kaohsiung, barrier toll plazas were located near their boundaries with no toll collection facilities within the urban area. The toll charge to be assessed at each of the boundary stations would include a charge for travel through one-half of the urban area.

Through trips (trips passing through the urban area) will be assessed for the full use of the toll road in the urban area, since they will pass through both boundary stations. External trips (trips from within the urban area out and from outside the urban area in) will be assessed a toll charge representing travel through one-half of the urban area, since they will pass through only one boundary stations. Internal trips (trips originating and terminating within the urban area) will not cross a boundary station, and therefore will not be assessed a toll charge for usage of the toll road within the urban area.

In order to check the accuracy of the established cost networks, a computer process was used to identify, for any selected point, the preferred route to all other points. This allows the engineer to evaluate the logic of the routings selected by the computer. Adjustments to the network for any abnormalities can then be made before traffic is actually assigned to the network.

For the feasibility study, twelve trees were built in order to check the arterial network. For the toll study the only revisions made to the arterial network concerned section numbers and, therefore, there was no need for further testing of the arterial network.

Since several new cost factors were introduced into the toll road networks, eight trees were built for both the barrier and closed toll networks. These trees were plotted and checked with network revisions made as required.

After the cost networks were developed and tested, a computer process was used to determine the routing from each point to all other points, and store the information in coded form for use in the traffic assignment process.

EVALUATION

Trip Tables

The traffic assignment process requires two basic data inputs, a defined highway network in coded form, as discussed in earlier sections of this chapter, and a TRIP

TABLE. A trip table is a matrix of the number of trips from each centroid to all other centroids. It indicates the volume of desired trips between all centroids without specifying the method or routing required to make the trips.

The scope of the toll road study required that the trip tables developed during the feasibility study would also be utilized for the toll study. Therefore, no significant review of the accuracy of the trip tables, beyond that which was made during the feasibility study, was made for the present study. Adjustments for known variations, such as the traffic generated by the planned new Taipei international airport, which were not included in the trip table matrix, were made manually during the traffic assignment phase.

Trip tables for four vehicle types (auto-taxi, light truck, heavy truck, and express bus) were developed for the feasibility study for 1969 and 1990 conditions.

The 1969 trip tables are the result of an extensive origin-destination (O-D) survey conducted throughout the study corridor in April 1969. The O-D survey included 37 roadside stations, at which a total of 196,600 interviews were conducted. This information was coded, factored, checked, and sorted by the computer in developing the existing trip generation characteristics for each of the one hundred eight-three 183 traffic analysis zones representing the west coast corridor. The resultant computer output comprised 1969 trip tables for auto-taxi, light trucks, heavy trucks, and express buses.

The 1990 trip tables were determined by applying traffic growth factors to the 1969 trip generation by zones, using a FRATAR EXPANSION computer program. In this expansion procedure, zonal growth factors are developed for each traffic analysis zone. The number of present trips generated by each zone is then multiplied by both the origin and destination zonal growth factors. An iterative process adjusts the zone-to-zone trips until future trip production and attraction for each zone are balanced. The resultant computer output comprised the 1990 trip tables for auto-taxi, light trucks, heavy trucks, and express buses.

Traffic Assignments

Traffic assignment is the process by which the trips originating at each centroid and destined for all other centroids are assigned to a specific routing pattern between centroids, based upon specified route selection criteria. The most common traffic assignment techniques are ALL-OR-NOTHING ASSIGNMENT and DIVERSION ASSIGNMENT. Both assignment techniques have characteristic advantages and disadvantages such that the selection of the technique to be used is dependent upon the specific needs and controls of the situation under study.

With the all-or-nothing assignment technique, the minimum path between each pair of centroids is first determined. The minimum path may be in the form of minimum travel time or minimum travel cost. The latter was used in the feasibility and toll studies. Having established the minimum path between each pair of centroids, the total number of trips between pairs of centroids are assigned by direction to all network links making up the appropriate minimum path. In order words, from all the possible routes between any two centroids, all trips are assigned to the minimum path route and no trips are assigned to the other routes.

With the diversion assignment technique, the minimum path along an arterial network is first established. Next, the new highway (expressway, freeway, toll road, etc.) is added to the arterial network and another minimum path is determined, utilizing the new highway. The total number of trips between pairs of centroids are then assigned to the two routes in a proportion specified by a diversion curve. The diversion curve is an independent relationship which relates a comparative feature of the two alternative routes (usually travel time or cost) to the relative proportion of traffic using each route.

With both assignment techniques, the computer assigns the number of trips between each pair of centroids to the appropriate network links and accumulates the volumes on each link by direction until all interzonal trips have been assigned. The computer then prints out the accumulated volumes for each network link. A variety of additional information useful in the analysis and evaluation phases is also readily available from the computer.

Diversion Curve

The diversion assignment technique requires as input, a diversion curve relating a comparative feature of the two facilities with their relative traffic volumes. For the comprehensive toll study, the comparative feature used was travel cost.

Two diversion curves were developed for the toll study, one curve for use with both autos and light trucks and one curve for heavy trucks. No curve was required for express buses for reasons which will be explained later in this Chapter.

Previous experience in the development of diversion assignment curves for toll facilities has led to the conclusion that when travel cost on a new facility is one-half of the cost via the existing alternative, 100 percent of the trips can be expected to use the new facility. Conversely, if travel cost on a new facility would be twice the cost via the existing facility, none of the trips will use the new facility. When travel costs via the new facility and the existing alternative are equal, approximately 50 percent will use each one. These assumptions served as a basis for the development of the diversion assignment curves utilized in this study. Exhibit 6 illustrates the diversion assignment curves developed for autos and light trucks, and for heavy trucks.

The boundary conditions, at which zero percent and 100 percent diversion will occur, were quantified in terms of NT dollar savings utilizing trip summary information from the feasibility report. The average trip length of each vehicle type was multiplied by the average vehicle operating cost per kilometer on the arterial networks, and the boundary conditions for the diversion assignment curve are, therefore, defined as one-half of this cost and twice this cost.

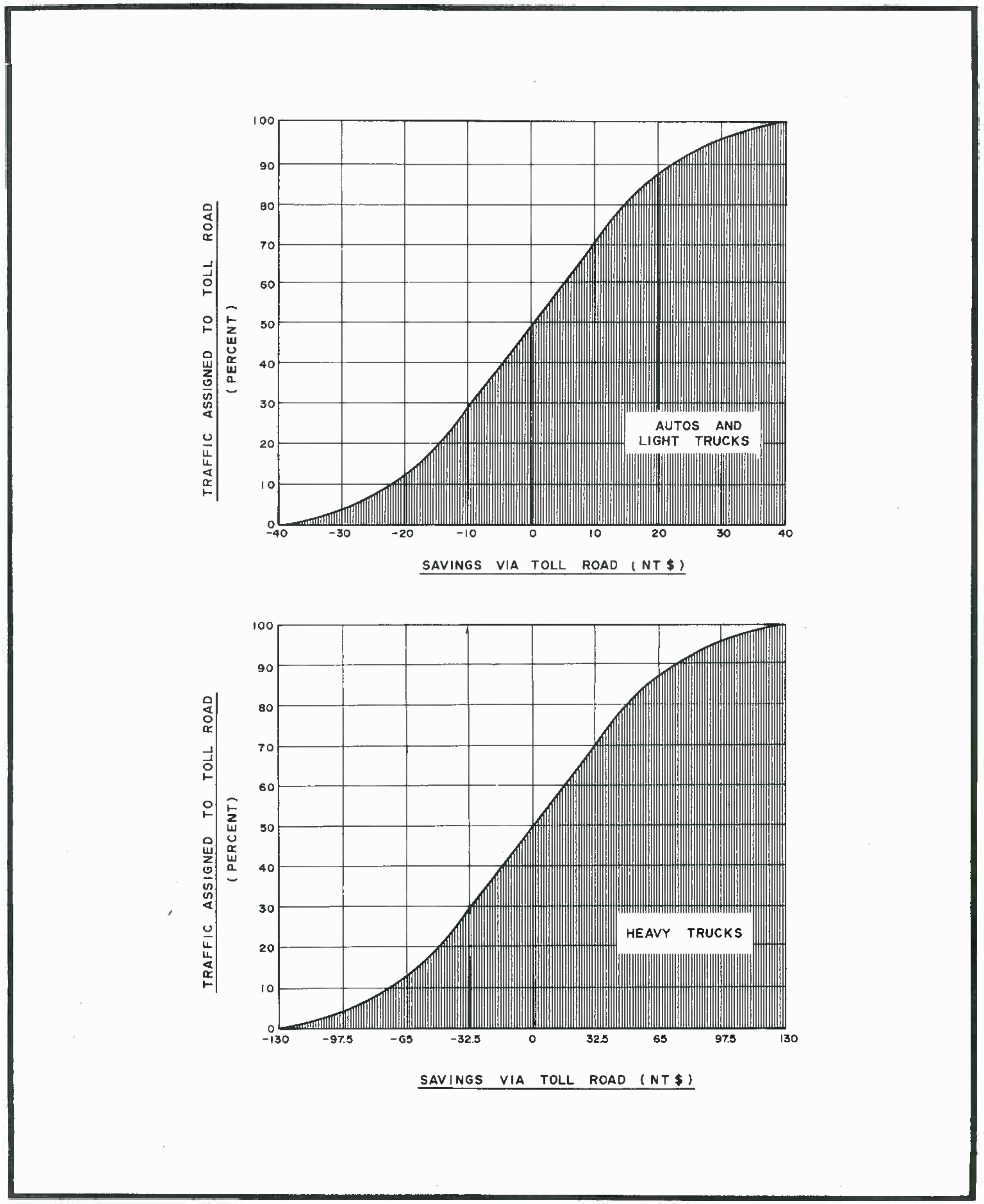
During the feasibility study, a special analysis was made of the O-D survey data and existing traffic conditions to develop a diversion relationship between the MacArthur Thruway and Highway 5. The boundary values developed for this curve closely agree with those of the present toll study diversion curve for autos and light trucks.

The shape of the curve between the established boundary conditions is based upon a general diversion relationship developed by Lionel Odier (see GRAPH IX-1 of feasibility study). The special analysis for the MacArthur Thruway established several intermediate points (between 50 percent and 100 percent diversion) which verified the validity of using the Odier relationship.

1969 Traffic Assignments

For comparative analysis and evaluation it is important to first test existing travel volumes on the existing and proposed networks, and then to test future travel volumes on the existing and proposed networks. For the comprehensive toll study, eighteen assignments were made using the diversion technique and six assignments were made by the all-or-nothing technique.

The results of the traffic assignments made for the feasibility study indicated that, if the freeway were provided immediately, the existing arterial network would have some reserve capacity. The freeway would cause a readjustment in travel patterns,



COMPREHENSIVE TOLL ROAD STUDY
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TRAFFIC DIVERSION CURVES
DE LEUW, CATHER INTERNATIONAL-CHICAGO

and thereby reduce the traffic volumes on the arterial network. The reserve capacity, however, would be only a temporary characteristic, since traffic growth would eventually cause the full utilization of the arterials sometime in the future.

In order to determine the effects of adding various toll charges to the cost networks, it was necessary to utilize the diversion assignment technique. Utilizing the diversion curves discussed earlier, assignments were made by vehicle type (auto, light truck and heavy truck) for three toll schedules on the barrier toll network and three toll schedules on the closed toll network.

The all-or-nothing technique, rather than the diversion technique, was used for the assignment of the bus trip table. The bus trip table represents express buses only, owned primarily by the Taiwan Highway Bureau, an agency of the provincial government. Since the owner, and not the driver will select the route to be followed, and since the toll road will continue to have some cost advantage over a parallel arterial routing, all buses are expected to utilize the toll road. Thus an all-or-nothing assignment provides a more realistic traffic flow pattern.

Assignment of the 1969 trip tables for all four vehicle types to the existing arterial network was also done by the all-or-nothing technique. Although similar assignments were made for the feasibility study, the changes required in the section numbers necessitated a reassignment of traffic to insure representative system results.

In summary, with the 1969 trip tables, four assignments were made on the arterial network, fourteen on the barrier toll network and ten on the closed toll network. Exhibits 7 and 8 identify each assignment, indicating the network, toll schedule and assignment technique utilized.

1990 Traffic Assignment

For comparative results with the 1969 traffic assignments, future conditions were determined by assigning the 1990 trip tables to the existing and proposed networks. For the comprehensive toll study, twelve assignments were made using the all-or-nothing technique and three assignments were made by using the diversion technique.

The results of the traffic assignments which were made for the feasibility study indicate that even with the provision of the freeway, the arterial network will be at, or above, full capacity by 1990. This implies that although the introduction of a toll charge would be expected to increase the arterial volumes and decrease the toll road volumes, this condition cannot realistically occur since the arterial network will already be loaded to capacity. Therefore, within reasonable bounds, the traffic volumes assigned to a freeway or a toll road will be the same for 1990. The validity of the above condition is based upon the assumption that (1) growth will occur and transportation will be provided, and (2) it will be government policy not to widen parallel arterial highways (beyond what has already been approved) to compete with the toll road.

Given the situation described above, the 1990 trip tables were assigned to the barrier and closed toll networks utilizing the all-or-nothing technique which gave a more realistic traffic assignment and required less manual adjustment than the diversion technique. For each toll network, the highest toll schedule was tested. Other toll schedules were easily evaluated by manual analysis.

Assignment of the 1990 trip tables for all four vehicle types to the existing arterial network was also done by the all-or-nothing technique.

In summary, with the 1990 trip tables, four assignments were made on the arterial network, eleven on the barrier toll network and four on the closed toll network. Exhibits 7 and 8 identify each assignment, indicating the network, toll schedule and assignment technique utilized.

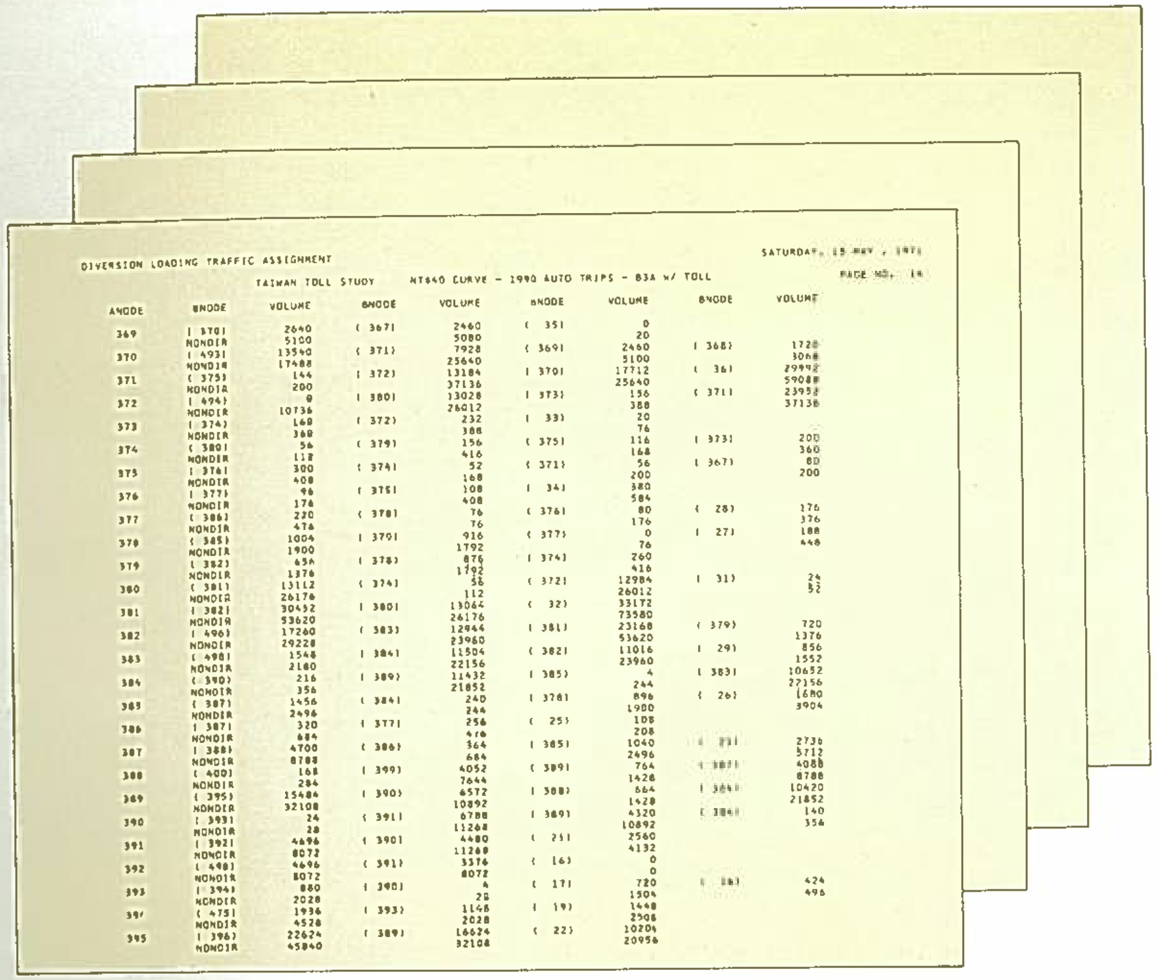
Traffic growth curves at each screenline for the preferred toll system are developed in a later section of this report. These curves represent the anticipated traffic growth between 1969 and 1990 indicating the initial level of diversion, the growth pattern while the arterial experiences some reserve capacity, the time when the arterial will be at full capacity, and the growth pattern beyond to 1990.

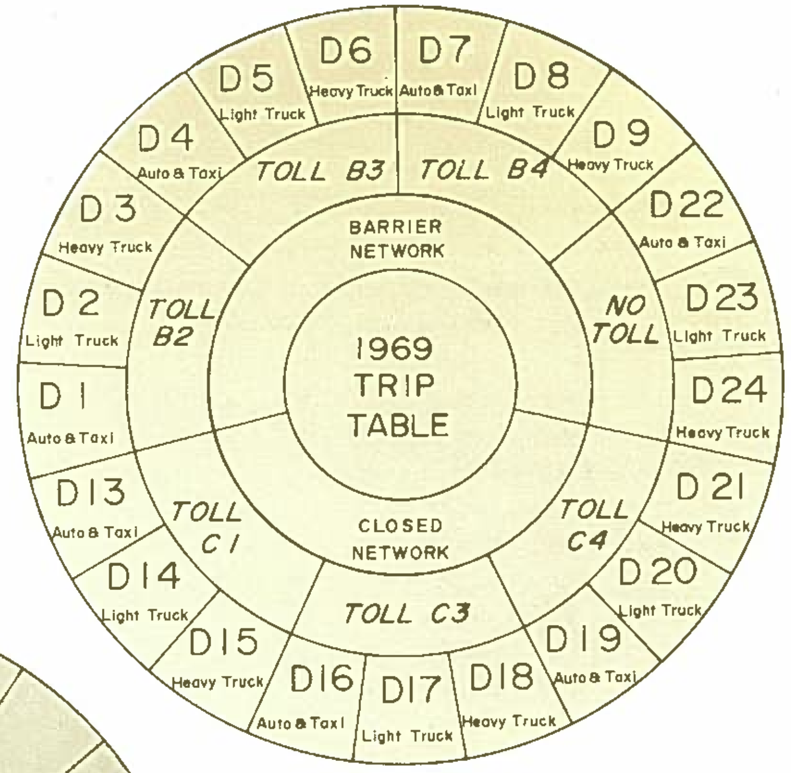
Manual Adjustments

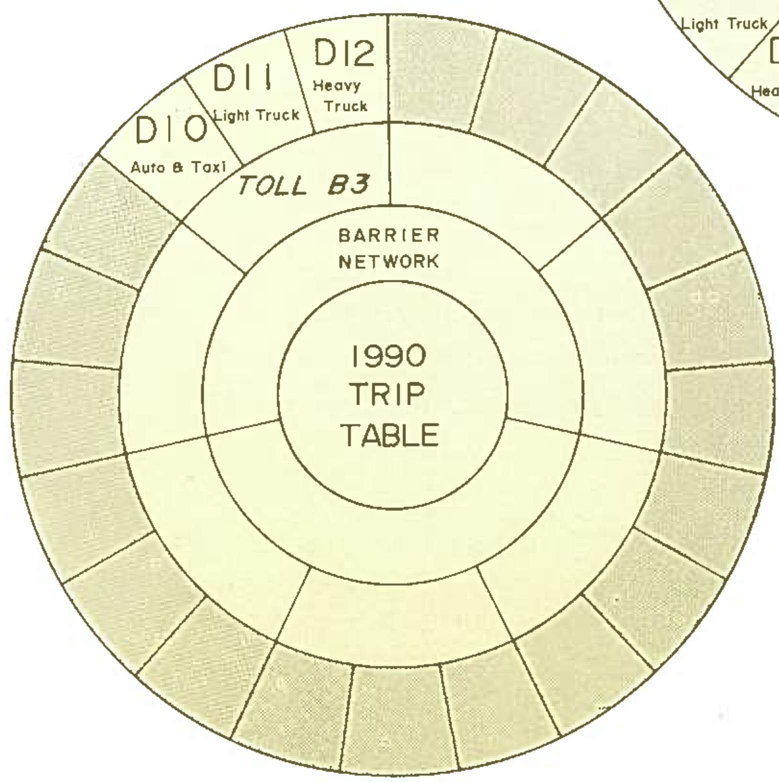
The traffic assignment process generally requires some manual adjustment to reflect changes which alter basic imput, or to correct situations where capacity overflows occur. Manual adjustments were made to the traffic assignments and system results to include consideration of (1) the new international airport at Taoyuan, (2) the effect of a reduction in the 1990 forecast volume of heavy trucks between Taipei and Keelung, and (3) capacity overflows on the arterial network links in the Taipei and Kaohsiung areas.

Planned New International Airport at Taoyuan

The planned international airport to be located near Taoyuan, when completed, will serve all international travel for the northern part of Taiwan. The present Sungshan International Airport will then serve domestic travel. The new airport



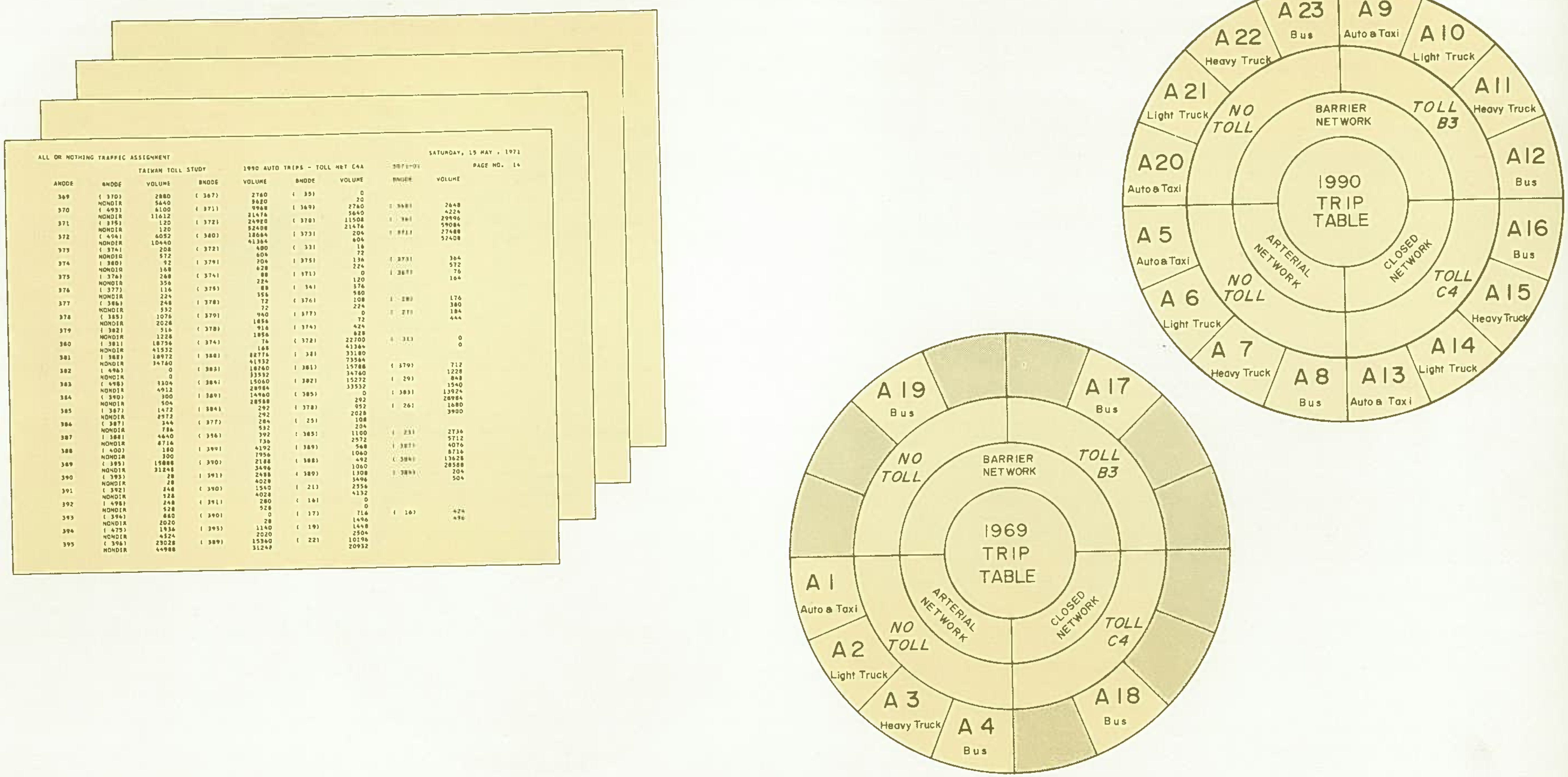




COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN

DIVERSION ASSIGNMENTS

DE LEUW, CATHER INTERNATIONAL-CHICAGO



COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
ALL OR NOTHING ASSIGNMENTS
DE LEUW, CATHER INTERNATIONAL-CHICAGO

will be a major traffic generator in the future and will be highly dependent upon the North-South Freeway as the major transportation link with Taipei and its environs. The trip tables utilized in the traffic assignment phase of the toll study do not include consideration of the new international airport, and therefore some manual adjustment to the computer assignments and system results were required.

Information concerning the forecast of traffic to be generated by the new airport was obtained from the airport planning study recently completed by another consultant. Additional information concerning passenger travel characteristics at the existing Sungshan International Airport were obtained from the Civil Aeronautics Administration and the Tourism Council.

From this information, the average daily traffic (ADT), in terms of passenger car equivalents (PCE), was determined for both 1975 (the year recommended for commencement of airport operations) and 1990. For 1990, an ADT of more than 38,000 PCE is forecast to be generated by the new international airport at Taoyuan. This traffic volume was manually incorporated into the traffic assignments and system results, and included in the subsequent economic analyses. A more detailed discussion of the airport generated traffic, for both 1975 and 1990, is included in Appendix C to this chapter.

Keelung—Taipei Heavy Truck Volumes

Due to several limitations, including disagreements as to what the ultimate capacity of Keelung Harbor really is, the feasibility study did not include a detailed evaluation of the effect of the saturation of the Keelung Harbor.

A separate analysis was subsequently made during the toll study with the resultant determination that the feasibility study forecast for 1990, of 22,600 heavy trucks per day, between Taipei and Keelung, was too high, and that a forecast volume of 10,500 heavy trucks for 1990 would be more reasonable. (The basis for adjusting downward this forecast truck traffic is detailed in Appendix D to this chapter.)

The trip tables utilized in the toll study included the heavy truck volumes forecast in the feasibility study. Therefore, the traffic assignments and systems results for Section I had to be manually adjusted to reflect this reduction in the forecast of heavy truck traffic between Taipei and Keelung.

Capacity Overflows

Both the all-or-nothing and diversion assignment techniques assign traffic volumes to the network according to certain defined network characteristics and assignment criteria. Neither technique is capable of limiting the assigned network link volumes to their respective capacities. Therefore, when the assigned 1990 traffic volumes were plotted on the network, the network link volumes on some links exceeded the capacity of the existing or planned facility, thereby creating what is referred to as a capacity overflow, and necessitating some reassignment of traffic to parallel highways.

If the traffic volumes assigned to the network links exceed their capacity, and if parallel highways are available with sufficient reserve capacity to adequately handle the excess volumes, the overflow volumes are manually reassigned to the alternative routes. This reassignment of traffic volumes required an accompanying revision in the appropriate system results, so the economic analysis would reflect the re-assignment condition, and not the overflow condition.

For the toll study, some manual reassignment of traffic volumes was required in Sections I and II in the Taipei area and in Section VII in the Kaohsiung area, since overflow conditions existed for some of the 1990 assignments.

Appendix F to this chapter presents the adjusted computer output, inter alia, for the entire freeway and its several sections. Adjusted output is shown for 1969 and 1990 for the arterial network, the freeway network without tolls, the freeway barrier toll network with toll schedules B-2, B-3, and B-4, and the freeway closed toll network with toll schedules C-1, C-3, and C-4.

Induced Traffic

Experience has shown that, when new highways which lower the total cost of transportation are made available, sizeable volumes of new traffic are generated over and above the traffic attributable to normal growth. When planning the capacity of a new facility, it is important to include an estimate of this additional traffic volume. This additional traffic is induced by the advantages afforded by the new facility in terms of lower operating costs, passenger time savings, and avoidence of congestion, with resultant increased comfort and convenience.

The amount of induced traffic which a new highway will generate is difficult to quantify. Since its magnitude is closely related to the before and after conditions of each specific case, historic relationships observed on other facilities can only be used where similar characteristics exist.

For the toll study, a method of estimating induced traffic was developed relating the amount of induced traffic to the cost ratio for the before and after freeway conditions. Numerical expressions were developed relating trip length to the estimated percentages of induced traffic for autos and buses. It was assumed that there would be no induced truck traffic. Table II-3 shows the relationships developed for autos and buses. A detailed discussion of these relationships is included in Appendix E to this chapter.

TABLE II-3 Decimal Proportions of Induced Traffic for Various Trip Lengths

Trip Length Range (kms)	Induced Traffic as Decimal Proportions of Base Traffic Volumes Autos	Buses
21 – 60	0.097	0.221
61 – 100	0.170	0.277
101 – 200	0.228	0.299*
201 – 400	0.277	0.266*

* See Appendix E

Having established the above relationship between induced traffic and trip length, the percentages of auto and bus trips falling within the specified ranges were determined for each screenline. These trip length frequency percentages were then applied to the decimal proportions shown in Table II-3 for corresponding trip length ranges. The resultant factors represent the measure of induced traffic as a percent of the normal growth traffic volume at each screenline. The induced traffic factors varied among screenlines depending upon the urban or rural characteristics of the area. For autos, the induced traffic factor ranged from eleven percent at urban screenlines to 19 percent at rural screenlines. For buses the range was from 24 percent at urban screenlines to 27 percent at rural screenlines.

Often in feasibility studies, no attempt is made to accurately estimate induced traffic; instead, a flat ten percent or twenty percent of the base traffic volumes might be used as reasonable estimates. The extent to which induced traffic might occur is directly related to the magnitude of the transportation improvement. Where the improvement might be considered major, an estimate of ten percent for induced traffic would normally be thought to be quite conservative, based on before and after traffic studies on various facilities in the United States.

The construction of the freeway will mean a major improvement in transportation in Taiwan's western corridor. The estimates of this study for induced auto traffic (viz., 11 to 19 percent) would fall within the ten to twenty percent range generally experienced. The estimates for induced bus travel are above this range, but, as indicated in Appendix E, actually represent both induced passenger volumes and some traffic converted from the railway. As combined totals of these two sources of highway traffic, even the 27 percent rise indicated for rural screenlines may be conservative.

Since no induced truck traffic is estimated, the total amount of forecast induced traffic (i.e., autos and buses only) would appear to be low.

The volumes of induced traffic in absolute terms were determined by applying the induced traffic factors to the appropriate vehicular volumes at the screenlines for 1969 and 1990.

Systems Analysis

The toll road systems, combining toll road networks and toll schedules, were evaluated from both economic and capacity standpoints. While the economic analysis uses the section as its basis of analysis and evaluation, the capacity analysis is centered around screenlines. The remainder of this chapter is concerned with traffic volume and capacity analyses, whilst a later chapter is devoted to the economic evaluation.

Capacity

The procedures for capacity calculations, as described in the 1965 "Highway Capacity Manual" and "A Policy on Geometric Design of Rural Highways", were used in determining capacities. For practical application, the same statistics and charts which were developed during the feasibility study, with regard to the special traffic composition in Taiwan, were also used for the toll study.

Traffic composition will change substantially, with a higher percentage of autos in the future. In order to use a set of capacity figures independent of the traffic mixture, passenger car equivalents are used to represent both capacity and traffic volumes. After testing the existing conditions, the passenger car equivalents (PCE), adopted in the feasibility study, were used. These are shown below.

Terrain	Auto	Light Truck	Heavy Truck	Bus
Level	1.0	1.0	2.0	2.0
Rolling	1.0	2.0	3.0	3.0
Mountainous	1.0	4.0	6.0	6.0

The level of service of a highway is determined by the prevailing traffic flow and speed. The levels, designated A through F, are described in the Highway Capacity Manual, with level A being applicable to higher speeds and low traffic volumes, and level F designating forced flow under continued traffic pressure. The following freeway capacities (PCE) were determined for level C, D and E corresponding to various roadway widths, and are same values which were used for the feasibility study.

	Level of Service		
Type of Freeway	C	D	E
4 lanes	50,000	60,000	66,000
6 lanes	75,000	90,000	100,000
8 lanes	100,000	120,000	133,000

Screenline Volumes

During the feasibility study screenlines were established to evaluate traffic forecast and assignment procedures. The same screenlines were subsequently used for the toll study to maintain continuity between the two studies. The locations of the screenlines are indicated in Exhibit 9. Utilizing the computer output from the forty-seven assignments made for the toll study, screenline volumes (total number of vehicles on network links intersecting a screenline) were determined for the various toll road systems that were tested. The screenline volumes were converted to passenger car equivalents (PCE) and compared with the capacity of the network links intersecting the screenline.

By comparing the traffic volume assigned by the computer on each screenline link with the actual capacity of the link, the necessary adjustments were identified. The screenline is used, however, only to identify necessary adjustments. When the need for an adjustment has been determined, a more detailed evaluation is made of all links between appropriate screenlines in order to define the magnitude and extent of the required adjustment. Once the limits of the adjustments are defined, the appropriate reassignment of traffic is made along with the corresponding change in the system results.

Since the actual number of trips between centroids is not affected by either the toll network or toll schedule, the screenline volumes for different toll systems are the same. Table II-4 shows the 1990 traffic volume at each of fourteen screenlines in terms of mixed vehicles and passenger car equivalents. Exhibit 10 illustrates the same information graphically.

Freeway Volumes

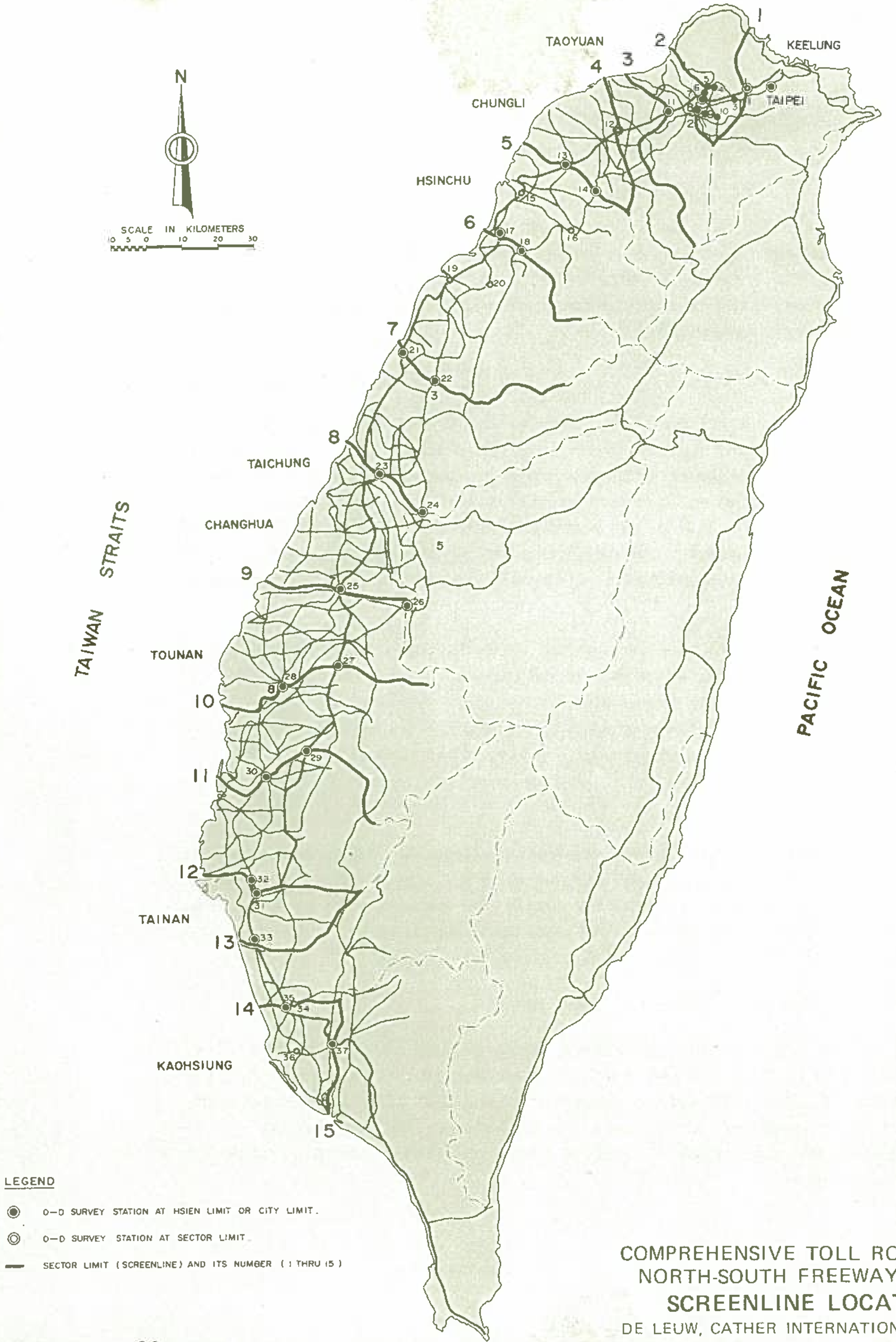
After manual adjustments correcting capacity overflows were made, the traffic volume on each freeway network line was obtained from the adjusted computer output. The freeway volumes, unlike the corridor volumes (which include volumes on arterials) are sensitive to variations in toll networks and toll schedules. While theorically correct, considering the practical limitations of the existing arterial capacities and the 1990 traffic volumes, the effect of varying toll systems on 1990 freeway traffic volumes is negligible in terms of capacity and lane requirements for 1990.

The time, when the effect of varying toll networks and toll schedules becomes apparent, is prior to 1990, when the arterial highway volume has not yet reached full capacity. As long as the arterial highway has some reserve capacity, the freeway volumes will be higher or lower depending on whether the toll schedule is raised or lowered. However, once the arterial volume reaches full capacity the effect of toll variations on the freeway traffic volumes disappears (except for the effect on induced traffic).

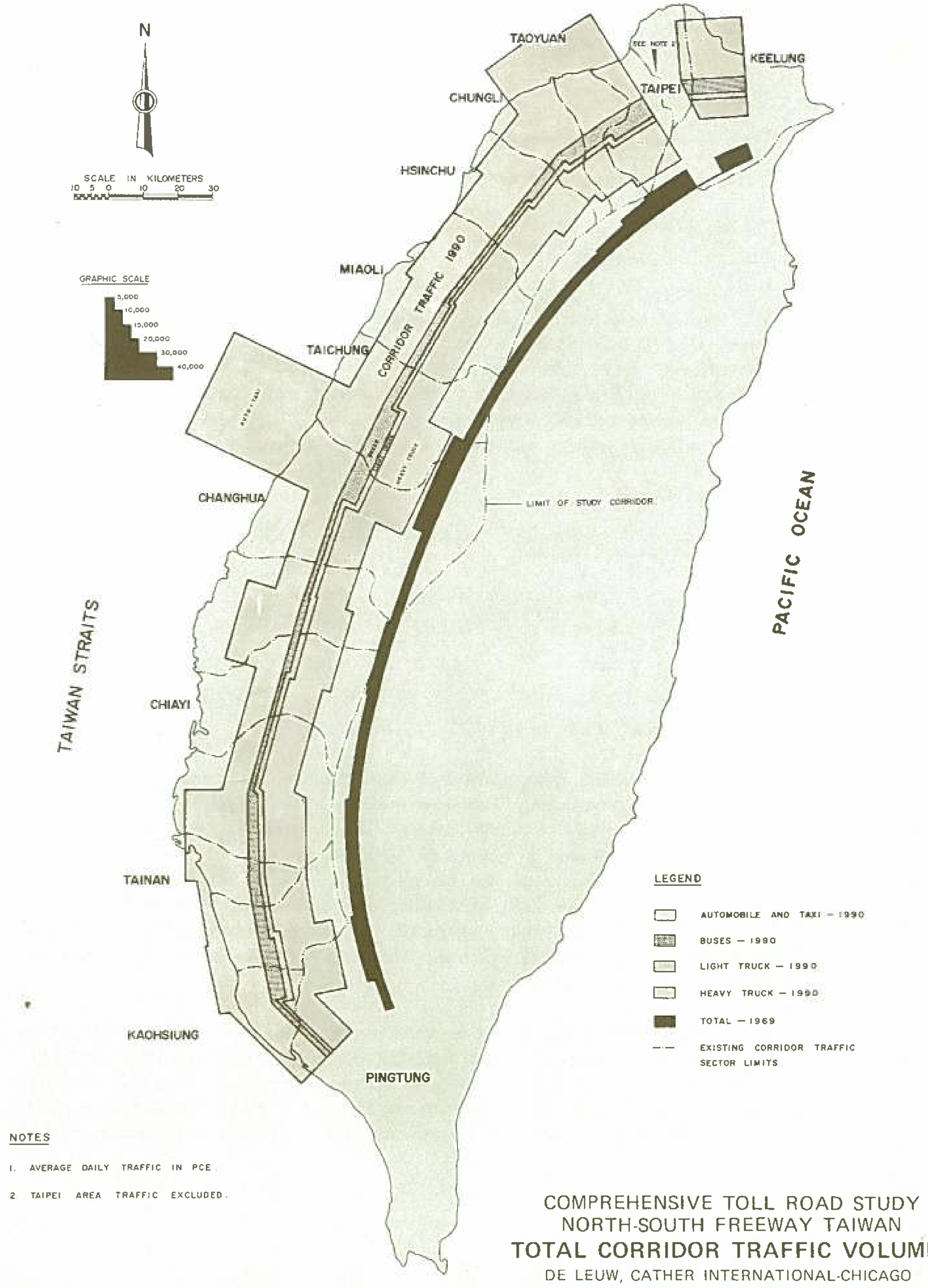
Therefore the assigned 1990 freeway volumes are similar for the three cases tested, which included the 1990 barrier toll network with toll schedule B3, the closed toll network with toll schedule C4, and the barrier toll network with no toll charge. Exhibit 11 illustrates the 1990 traffic volumes assigned to the toll road and is equally representative of either network and any toll schedule.

Traffic Growth Curves

Traffic growth curves showing anticipated traffic growth were developed for each screenline used in the toll study analysis. The traffic growth curves are illustrated in Exhibit 12. The 1969 vehicle screenline counts, and 1990 forecast screenline volumes, were converted to passenger car equivalents. The volumes for the intermediate years were based on growth curves previously developed during the feasibility study.

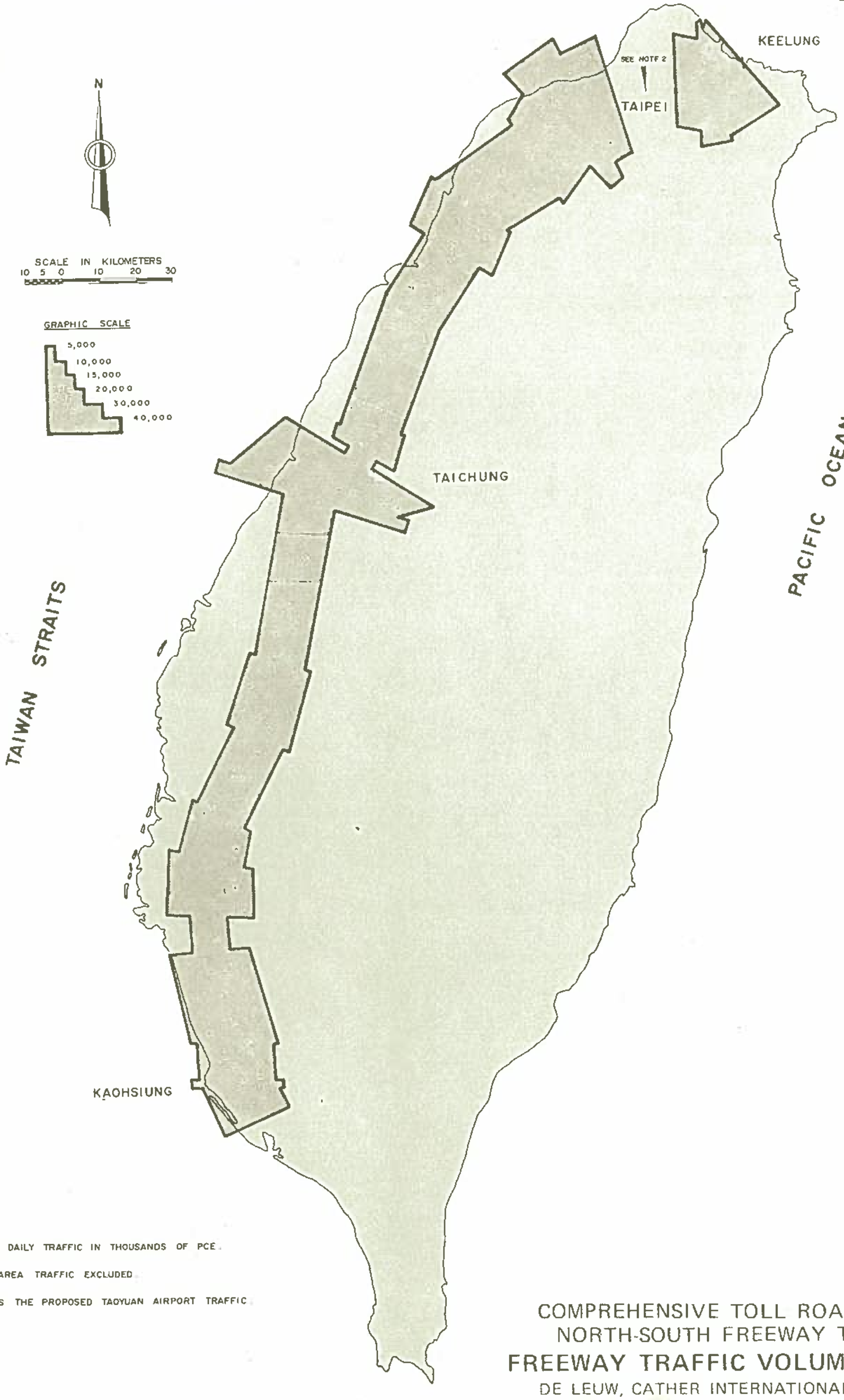


COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
SCREENLINE LOCATIONS
DE LEUW, CATHER INTERNATIONAL-CHICAGO



COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
TOTAL CORRIDOR TRAFFIC VOLUME
DE LEUW, CATHER INTERNATIONAL-CHICAGO

EXHIBIT 11



NOTES

AVERAGE DAILY TRAFFIC IN THOUSANDS OF PCE.

2 TAIPEI AREA TRAFFIC EXCLUDED.

INCLUDES THE PROPOSED TAOYUAN AIRPORT TRAFFIC.

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
FREEWAY TRAFFIC VOLUMES — 1990
DE LEUW, CATHER INTERNATIONAL-CHICAGO

After the basic growth curve was developed at each screenline, induced traffic was added as a dashed line from the time the freeway is opened until 1990. The induced traffic curve was established by applying the appropriate induced traffic factors (discussed earlier in this chapter) to the auto and bus volumes at each screenline.

When the freeway is opened, some traffic will be diverted from the arterial system to the freeway. Therefore, traffic growth will occur on both the arterial system and the freeway until such time that the arterial system is at full capacity. Once the arterial system is at full capacity all future traffic growth must occur on the freeway.

While the basic traffic growth curve is representative of total screenline growth (arterials & freeway) a secondary curve representing the anticipated effect of diversion was also included. The diversion growth curve was established from comparative traffic assignments which were made with and without the freeway. The diversion growth curve is discontinued when the full capacity of the arterial is reached. The shaded area below the diversion curve represents arterial traffic growth while the shaded area between the diversion and screenline growth curves represents the freeway traffic growth.

The latest construction schedule for each section was obtained from TAFCB (see section one of Chapter I) and is indicated by an inverted triangular symbol. At those screenlines where the traffic growth curve indicated the need for the freeway prior to the scheduled date, the freeway was shown according to its need. At certain locations where planned improvements to Highway 1 are scheduled to be completed before the freeway, the scheduling of the freeway included the assumption of the completed improvements. Should these improvements not proceed on schedule, the freeway would be required at an earlier date than indicated.

Certain of the growth curves have unique aspects not common to others. These characteristics are noted on the charts (Exhibit 12) for the appropriate screenlines.

For all screenlines, level of service C was initially used, and additional construction investment was only recommended after the assigned traffic volumes would become sufficient to lower the level of service to D.

TABLE II-4

1990 SCREENLINE VOLUMES AVERAGE DAILY TRAFFIC

Screenline	Vehicle Categories: Auto and Taxi	Bus	Light Truck	Heavy Truck	Total Vehicles: In Mixed Vehicles	In Passenger Car Equivalents
1	34,900	2,800	8,600	10,500	56,800	70,000
2	195,300	22,700	50,700	49,300	318,000	390,000
3	56,400	3,200	12,400	27,300	99,300	171,000
4	63,100	2,900	9,300	24,800	100,100	128,000
5	32,600	2,400	5,100	23,200	63,300	90,000
6	26,800	1,600	3,900	20,700	53,000	76,000
7	21,700	1,600	4,900	20,000	48,200	71,000
8	97,400	2,400	10,100	27,000	136,900	166,000
9	17,300	1,600	2,500	18,800	40,200	62,000
10	34,400	1,500	4,200	22,000	62,100	86,000
11	15,000	1,200	2,800	19,700	38,700	60,000
12	37,000	1,800	6,200	23,300	68,300	94,000
13	30,200	2,200	6,500	23,700	62,600	89,000
14	31,300	2,700	8,900	31,300	74,200	108,000
Percentage of Total	56.8	4.1	11.1	28.0	100.0	

Source: Computer Output

TABLE II-4

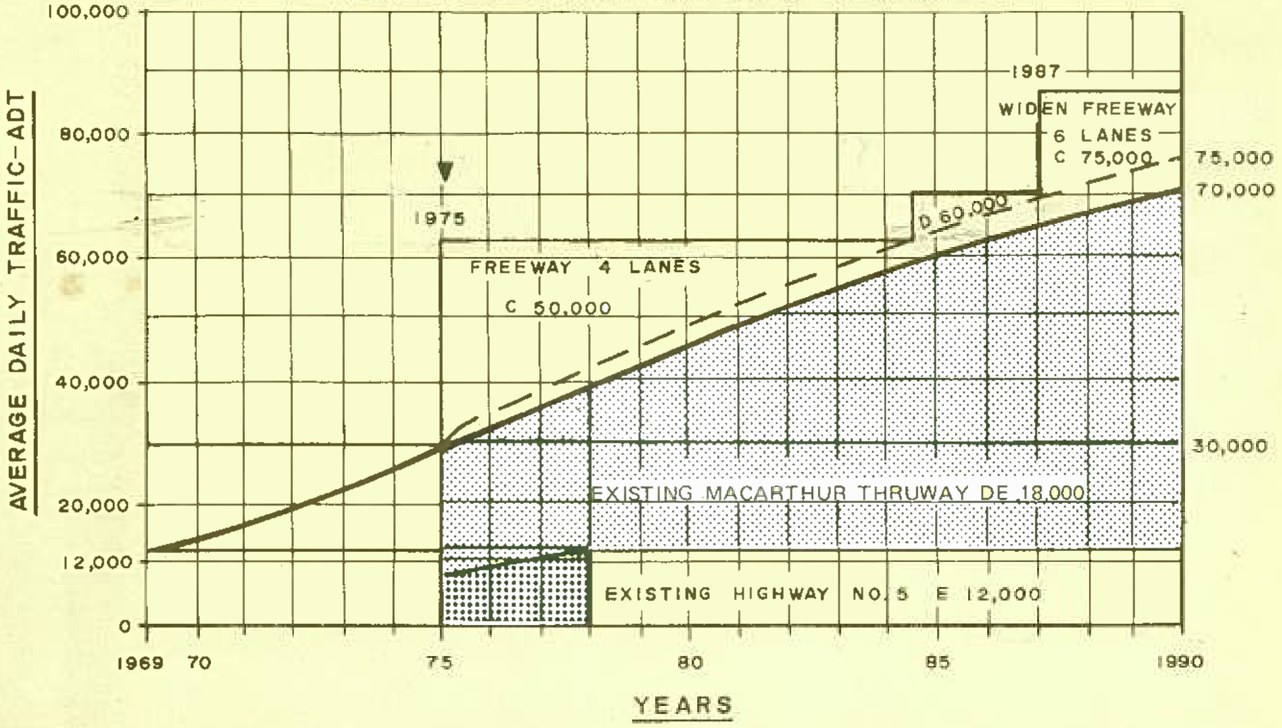
1990 SCREENLINE VOLUMES AVERAGE DAILY TRAFFIC

Screenline	Vehicle Categories				Total Vehicles	
	Auto and Taxi	Bus	Light Truck	Heavy Truck	In Mixed Vehicles	In Passenger Car Equivalents
1	34,900	2,800	8,600	10,500	56,800	70,000
2	195,300	22,700	50,700	49,300	318,000	390,000
3	56,400	3,200	12,400	27,300	99,300	171,000
4	63,100	2,900	9,300	24,800	100,100	128,000
5	32,600	2,400	5,100	23,200	63,300	90,000
6	26,800	1,600	3,900	20,700	53,000	76,000
7	21,700	1,600	4,900	20,000	48,200	71,000
8	97,400	2,400	10,100	27,000	136,900	166,000
9	17,300	1,600	2,500	18,800	40,200	62,000
10	34,400	1,500	4,200	22,000	62,100	86,000
11	15,000	1,200	2,800	19,700	38,700	60,000
12	37,000	1,800	6,200	23,300	68,300	94,000
13	30,200	2,200	6,500	23,700	62,600	89,000
14	31,300	2,700	8,900	31,300	74,200	108,000
Percentage of Total	56.8	4.1	11.1	28.0	100.0	

Source: Computer Output

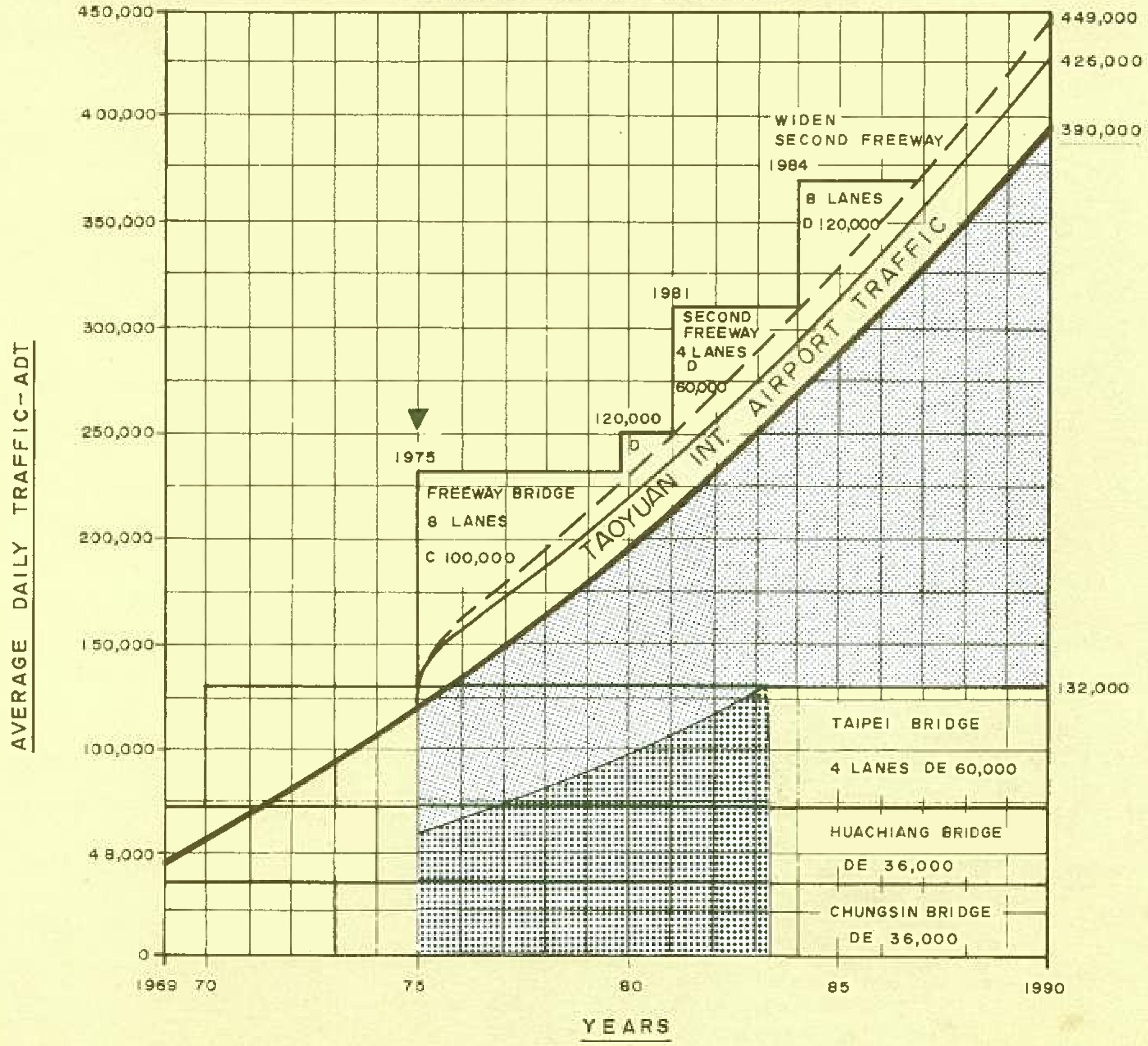
SCREENLINE 1

BETWEEN KEELUNG AND TAIPEI – SECTION 1



SCREENLINE 2

TAMSHUI RIVER – SECTION 1



NOTES:

1. SCREENLINE LOCATIONS ARE SHOWN ON EXHIBIT 9.
2. THE BASIC GROWTH CURVE WAS MADE TO REFLECT THE EFFECT OF THE SATURATION OF KEELUNG HARBOR.
3. THE DIVERSION GROWTH CURVE DOES NOT EXTEND TO INCLUDE THE MACARTHUR THROUGHWAY, SINCE IT WILL BE REPLACED BY THE FREEWAY.
4. TRAFFIC GENERATED BY THE NEW INTERNATIONAL AIRPORT AT TAOYUAN WAS ADDED TO SCREENLINE 2.

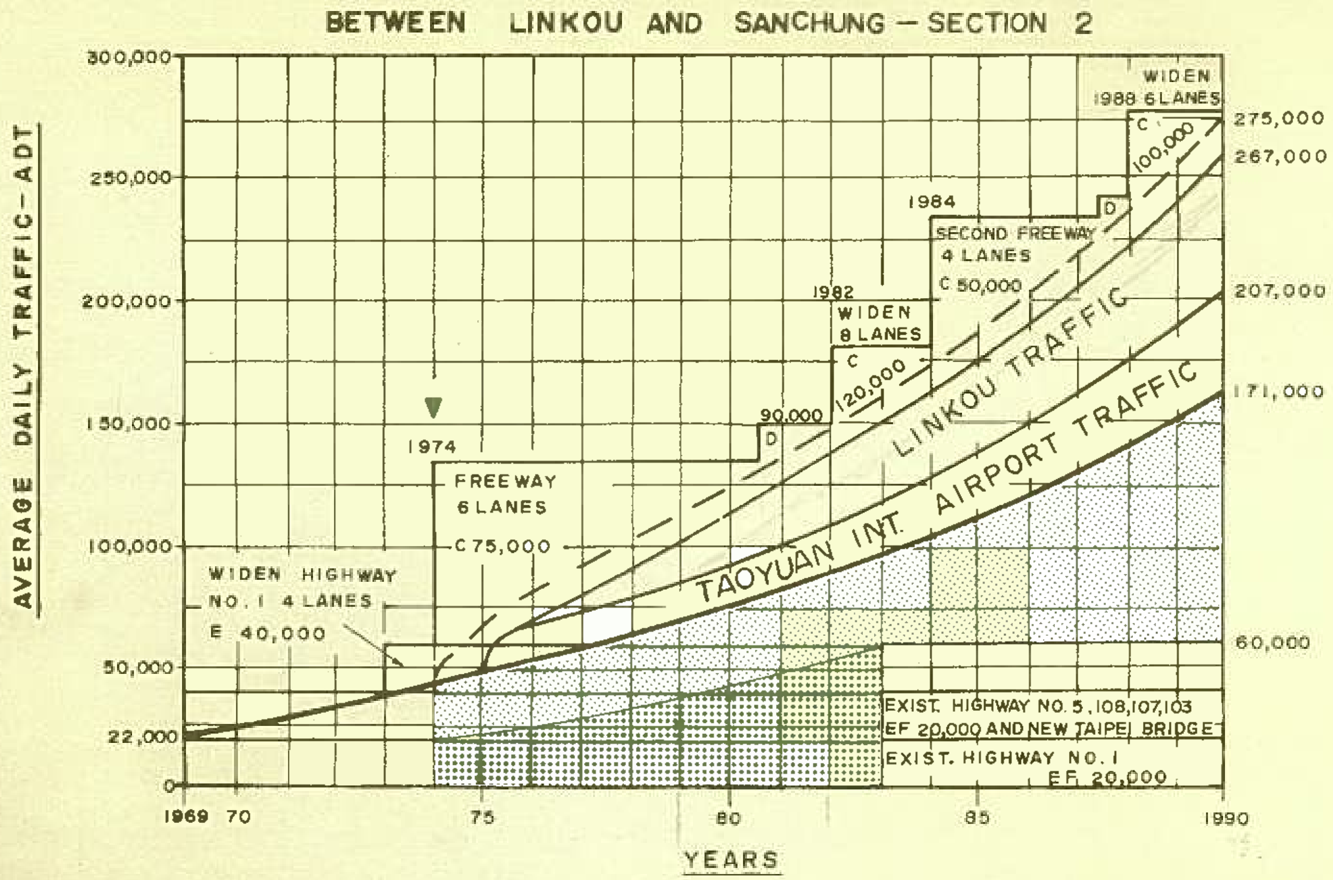
LEGEND:

- TOTAL SCREENLINE VOLUME
- TOTAL SCREENLINE TRAFFIC INCLUDING INDUCED TRAFFIC
- C 50,000 CAPACITY EQUALS 50,000 PCE AT LEVEL OF SERVICE C
- CORRIDOR TRAFFIC UTILIZING THE FREEWAY
- CORRIDOR TRAFFIC UTILIZING ARTERIAL HIGHWAYS
- ▼ SCHEDULED FREEWAY OPENING DATE

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
CAPACITY DIAGRAMS
DE LEUW, CATHER INTERNATIONAL-CHICAGO

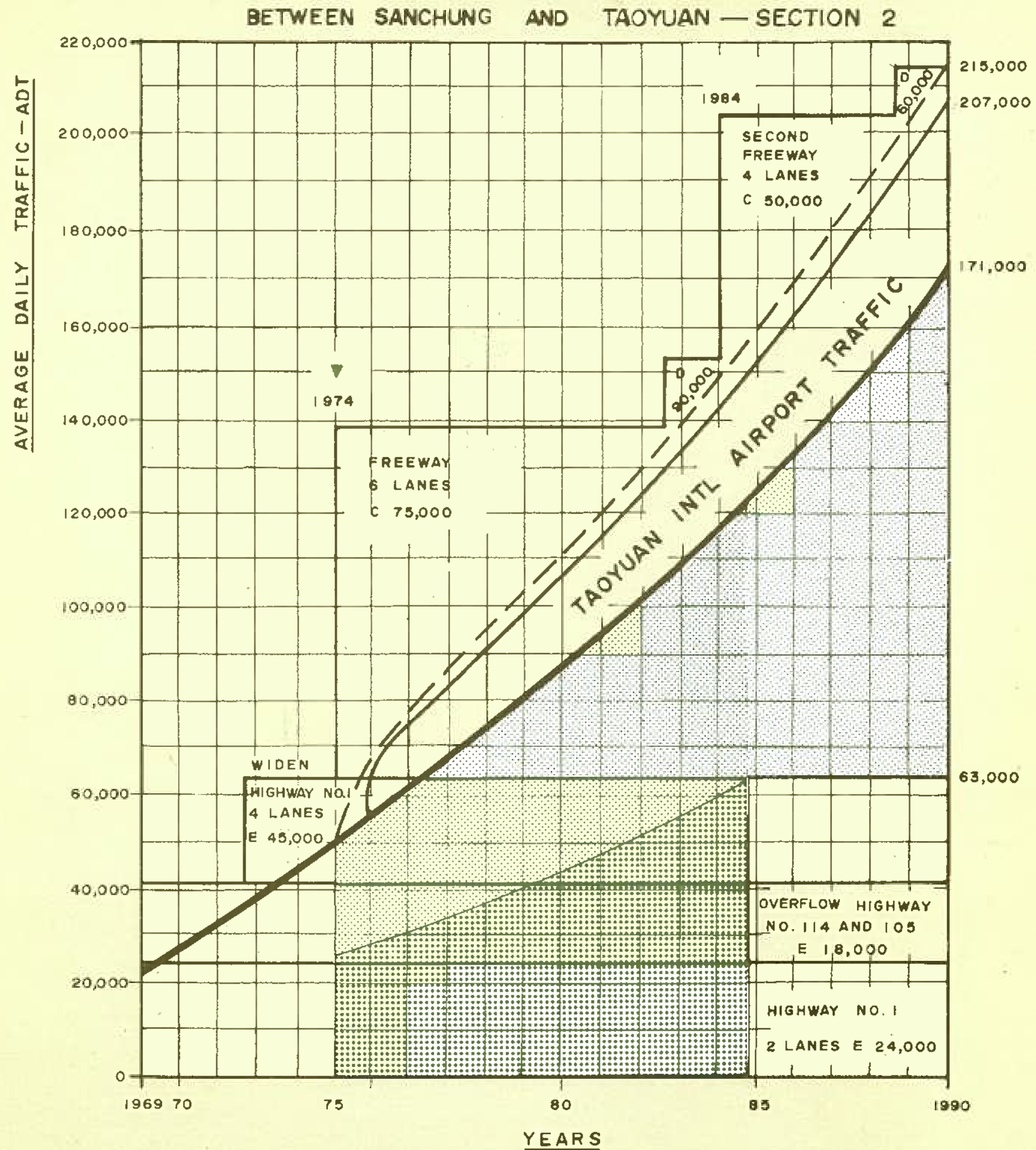
SCREENLINE 2 — 3

BETWEEN LINKOU AND SANCHUNG — SECTION 2



SCREENLINE 3

BETWEEN SANCHUNG AND TAOYUAN — SECTION 2



NOTES:

1. SCREENLINE LOCATIONS ARE SHOWN ON EXHIBIT 9.
2. AIRPORT TRAFFIC WAS ADDED.
3. EFFECT OF LINKOU COMMUNITY DEVELOPMENT IS SHOWN ON SCREENLINE 2–3.
4. ON SCREENLINE 2 – 3, THE WIDENING OF HIGHWAY NO. 1 BY 1973 IS ASSUMED.
5. ON SCREENLINE 3, THE NEED FOR WIDENING HIGHWAY NO. 1 IS SHOWN IN 1972, WHILE THE SCHEDULED WIDENING DATE IS 1974.

LEGEND:

- ——— TOTAL SCREENLINE VOLUME
- — — — TOTAL SCREENLINE TRAFFIC INCLUDING INDUCED TRAFFIC
- C 50,000 CAPACITY EQUALS 50,000 PCE AT LEVEL OF SERVICE C
- CORRIDOR TRAFFIC UTILIZING THE FREEWAY
- CORRIDOR TRAFFIC UTILIZING ARTERIAL HIGHWAYS
- ▼ SCHEDULED FREEWAY OPENING DATE

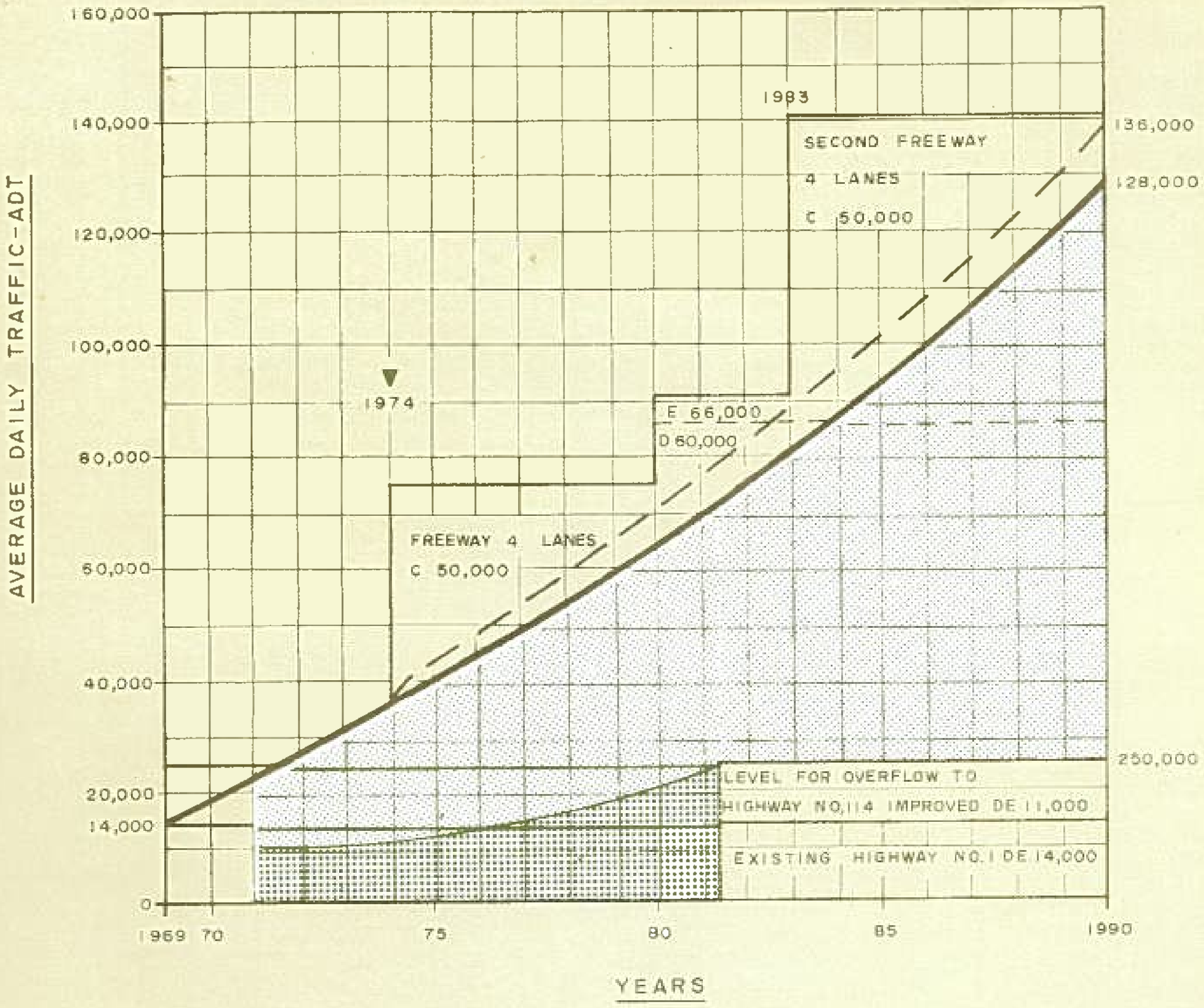
COMPREHENSIVE TOLL ROAD STUD
NORTH-SOUTH FREEWAY TAIWA

CAPACITY DIAGRAMS

DE LEUW, CATHER INTERNATIONAL CHICAG

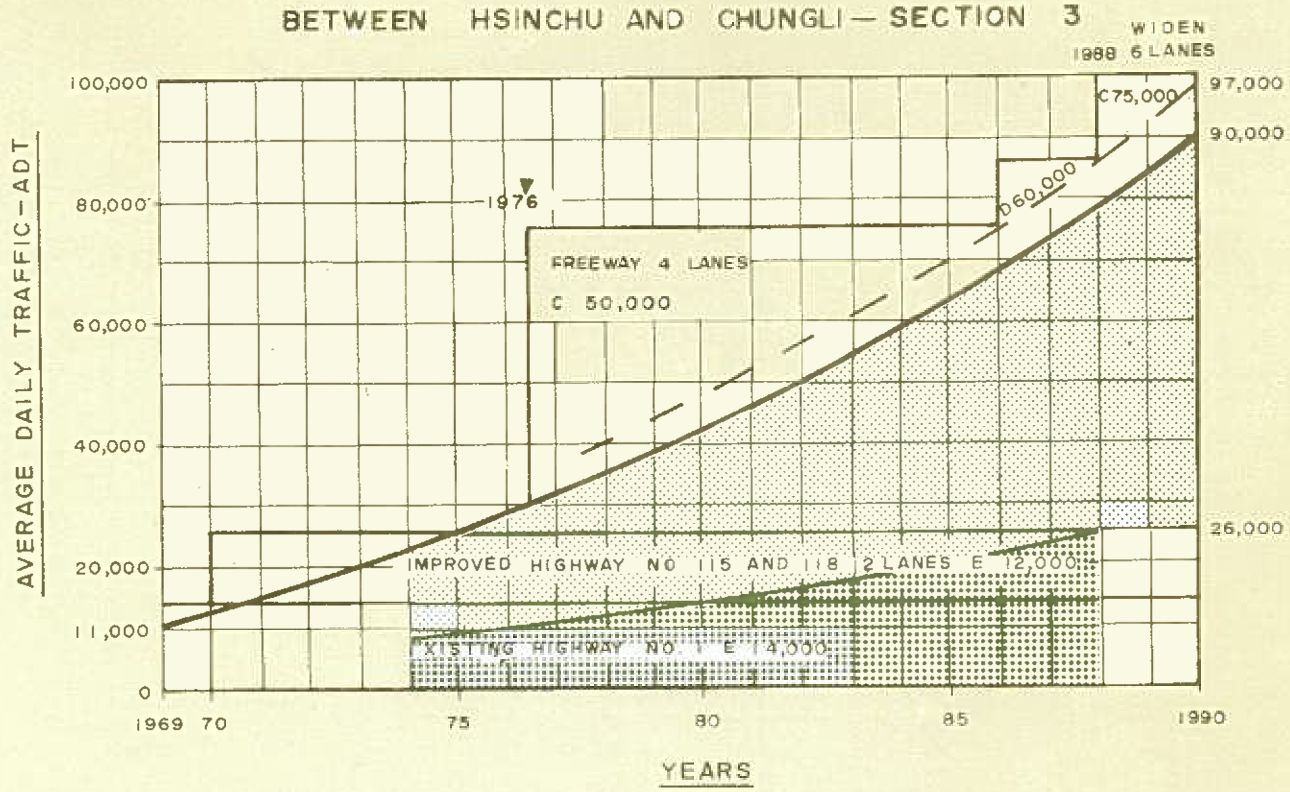
SCREENLINE 4

BETWEEN CHUNGLI AND TAOYUAN—SECTION 2



SCREENLINE 5

BETWEEN HSINCHU AND CHUNGLI — SECTION 3



NOTES:

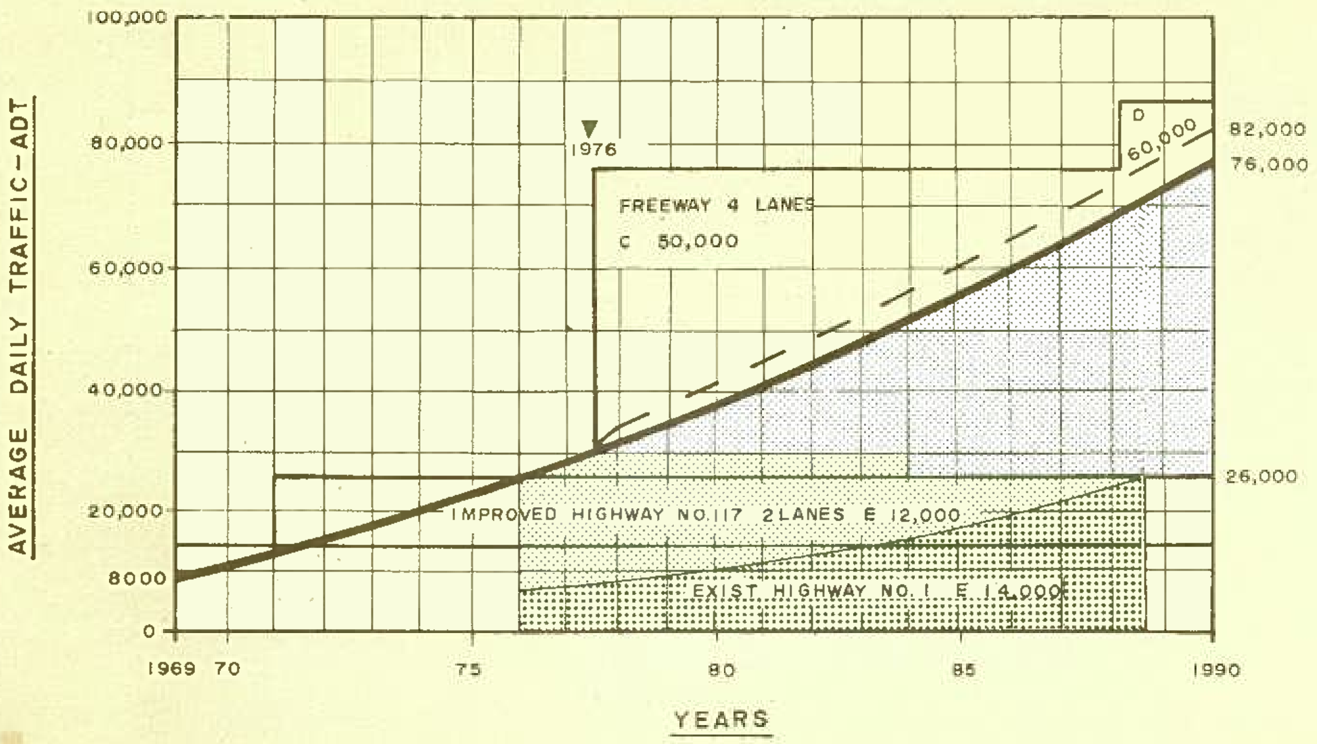
1. SCREENLINE LOCATIONS ARE SHOWN ON EXHIBIT 9.

LEGEND:

———	TOTAL SCREENLINE VOLUME
— — —	TOTAL SCREENLINE TRAFFIC INCLUDING INDUCED TRAFFIC
C 50,000	CAPACITY EQUALS 50,000 PCE AT LEVEL OF SERVICE C
(shading)	CORRIDOR TRAFFIC UTILIZING THE FREEWAY
(shading)	CORRIDOR TRAFFIC UTILIZING ARTERIAL HIGHWAYS
▼	SCHEDULED FREEWAY OPENING DATE

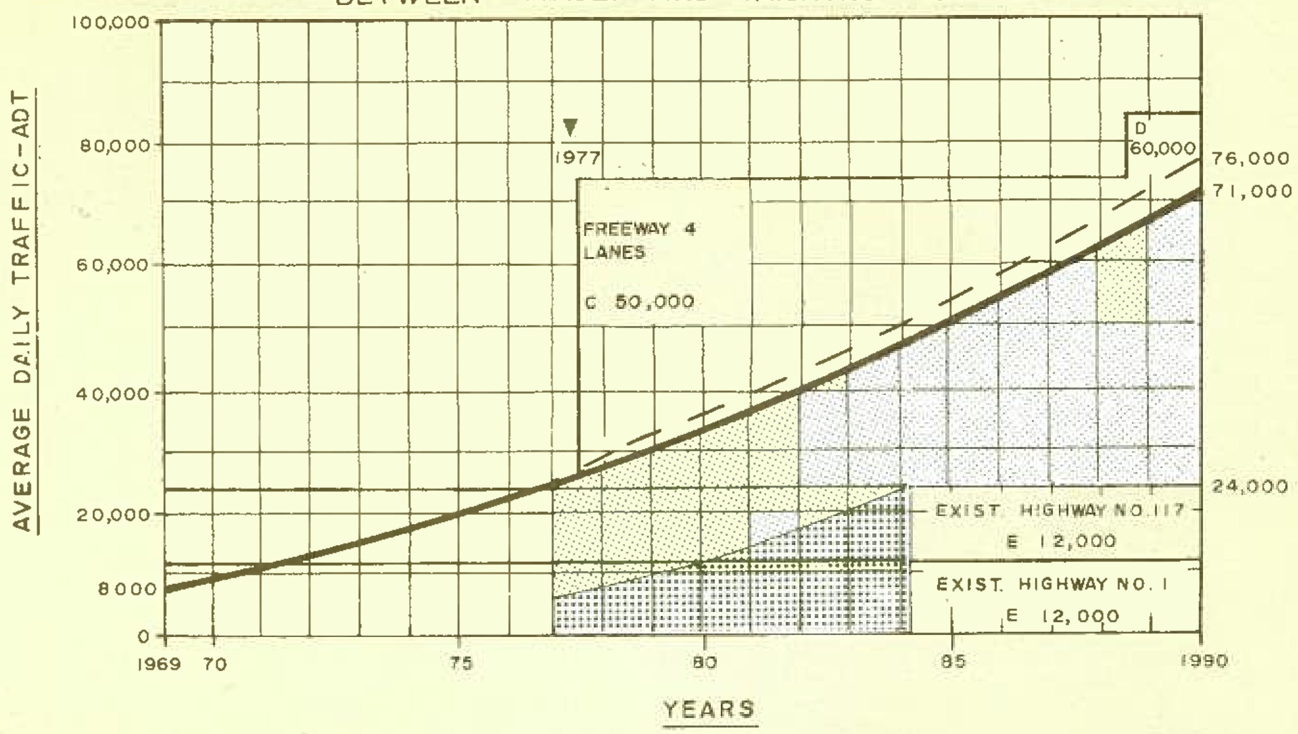
SCREENLINE 6

BETWEEN MIAOLI AND HSINCHU — SECTION 4



SCREENLINE 7

BETWEEN MIAOLI AND TAICHUNG — SECTION 4



NOTES:

1. SCREENLINE LOCATIONS ARE SHOWN ON EXHIBIT 9.

LEGEND:

———	TOTAL SCREENLINE VOLUME
— — —	TOTAL SCREENLINE TRAFFIC INCLUDING INDUCED TRAFFIC
C 50,000	CAPACITY EQUALS 50,000 PCE AT LEVEL OF SERVICE C
(dotted pattern)	CORRIDOR TRAFFIC UTILIZING THE FREEWAY
(dense pattern)	CORRIDOR TRAFFIC UTILIZING ARTERIAL HIGHWAYS
▼	SCHEDULED FREEWAY OPENING DATE

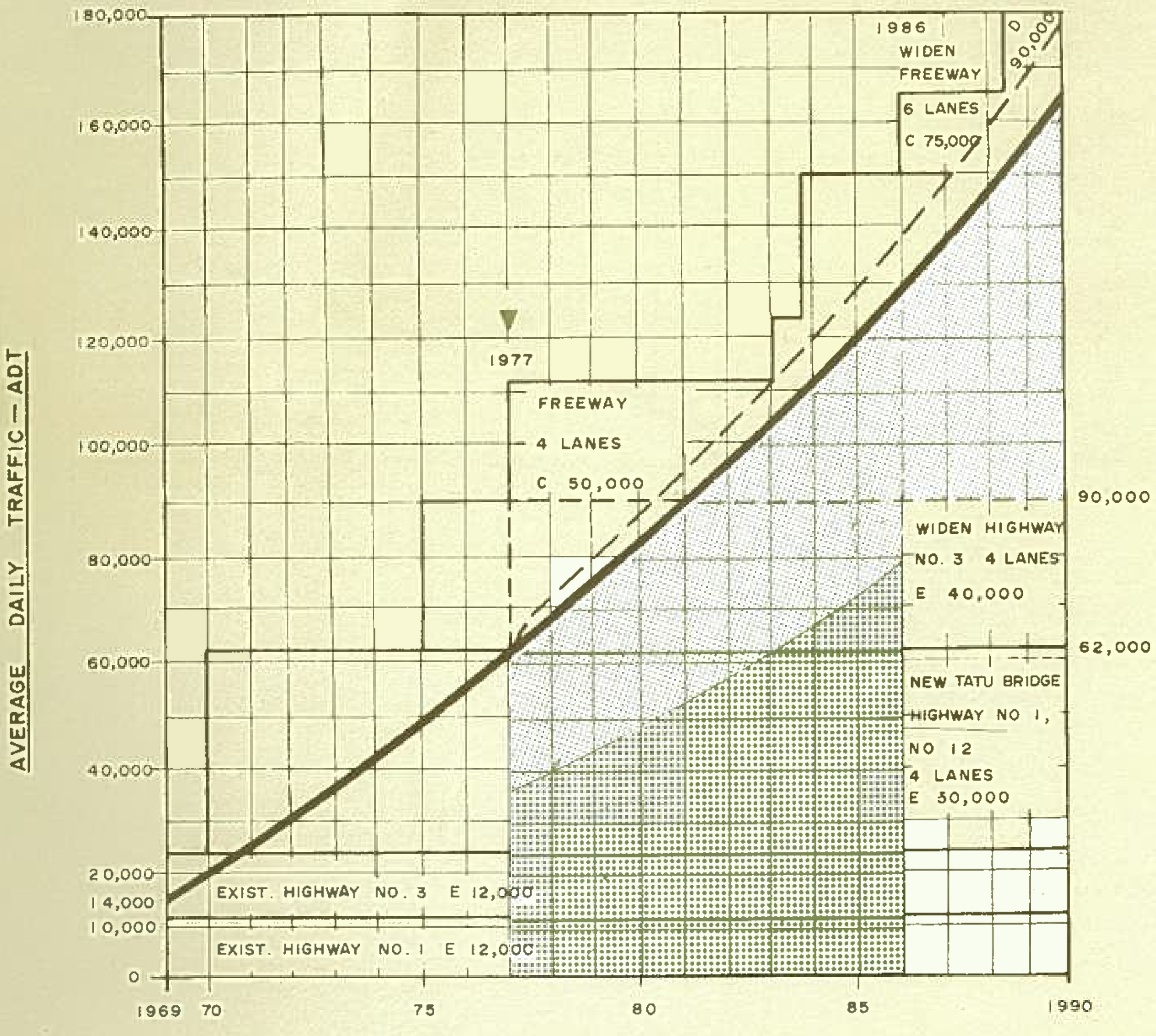
COMPREHENSIVE TOLL ROAD STUD
NORTH-SOUTH FREEWAY TAIWA

CAPACITY DIAGRAMS

DE LEUW, CATHER INTERNATIONAL-CHICAG

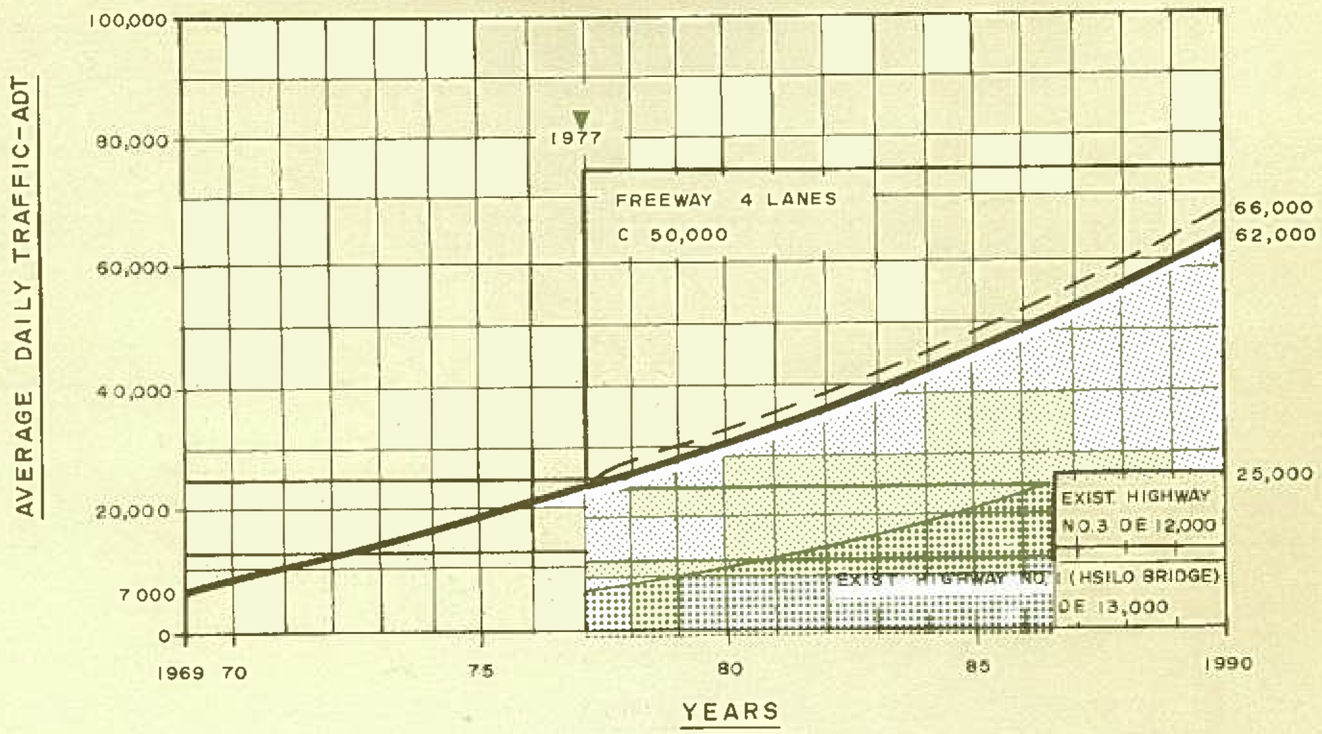
SCREENLINE 8

BETWEEN TAICHUNG AND CHUNGHUA — SECTION 5



SCREENLINE 9

BETWEEN HSILO BRIDGE AND CHUSAN — SECTION 5

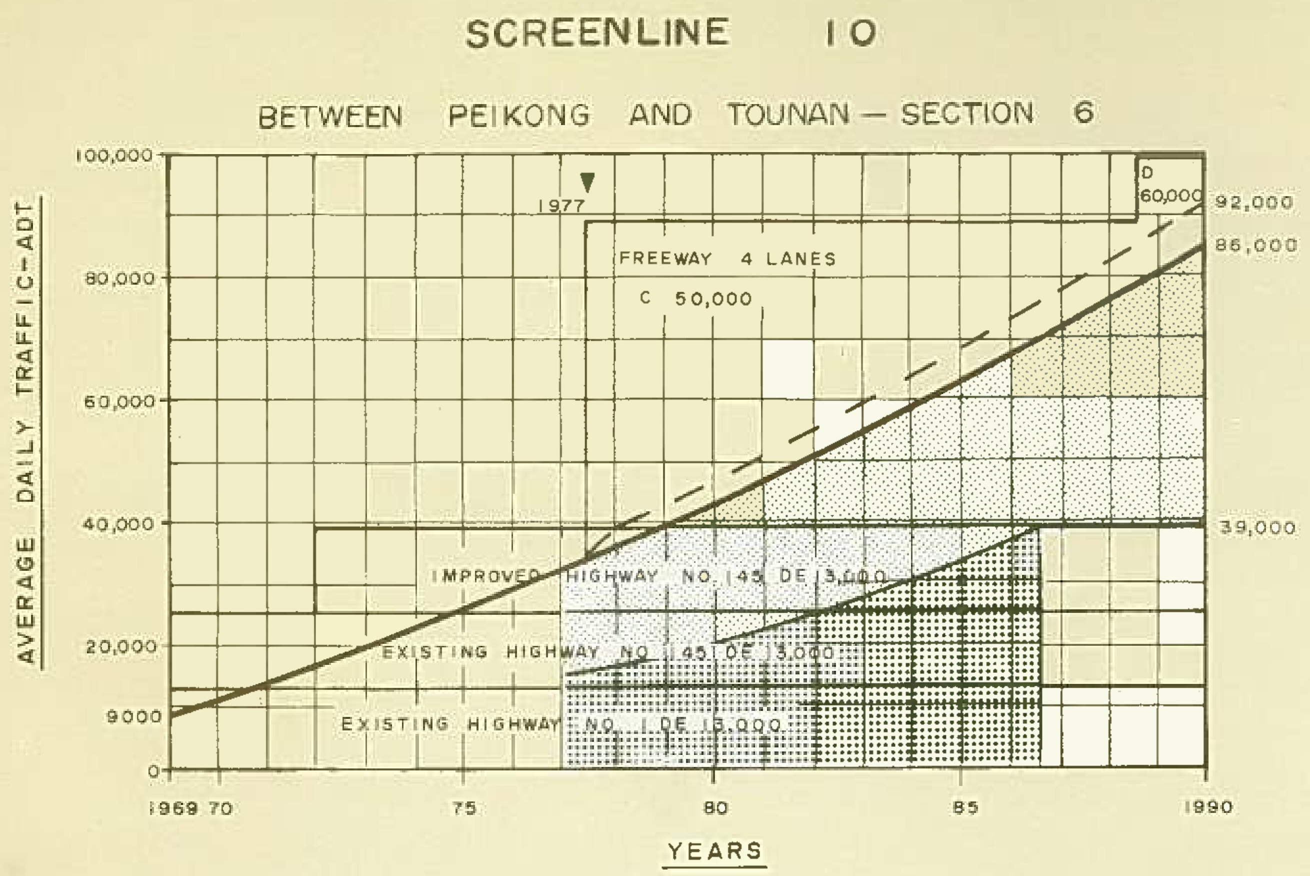


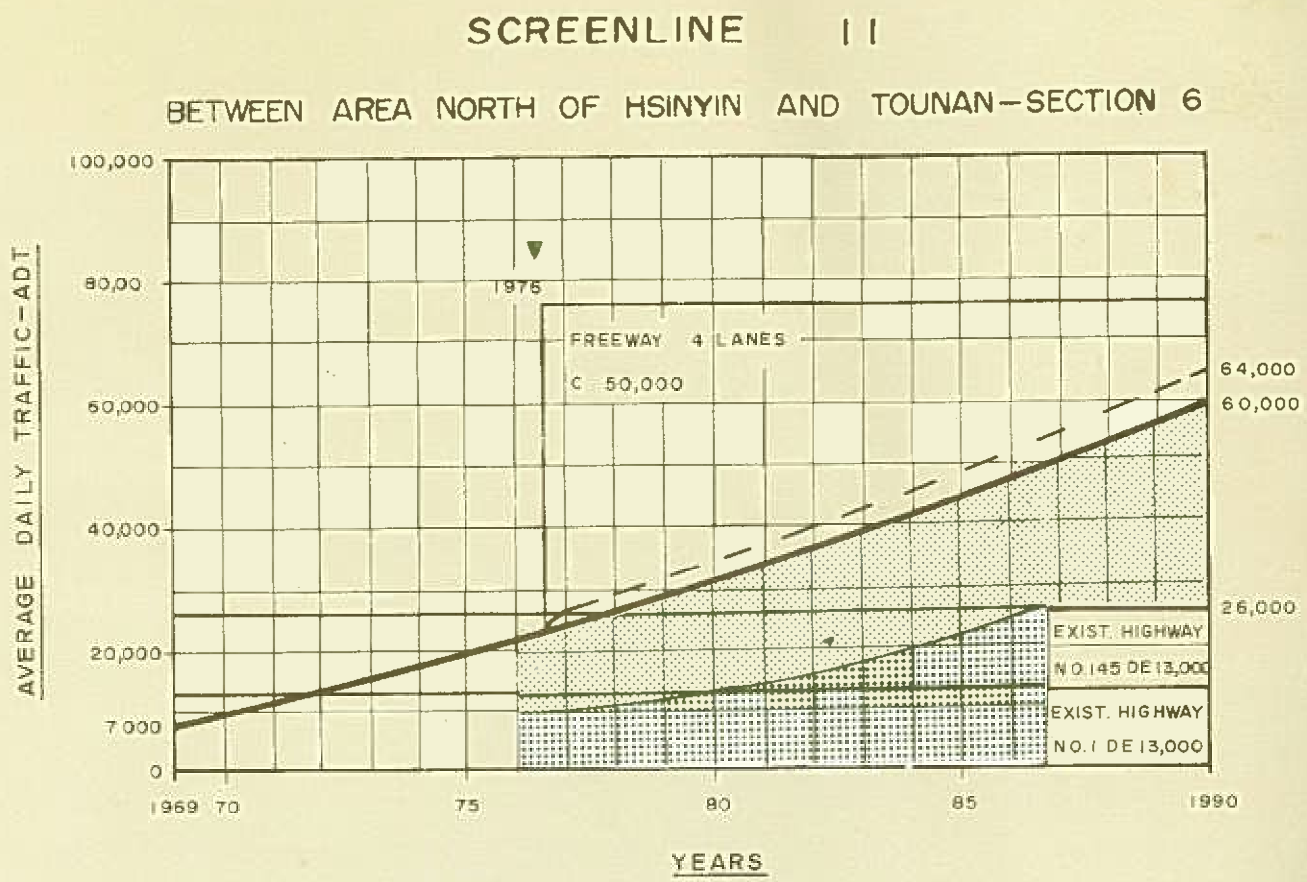
NOTES.

1. SCREENLINE LOCATIONS ARE SHOWN ON EXHIBIT 9.
2. FOR SCREENLINE 8, THE ARTERIAL TRAFFIC GROWTH CURVE DOES NOT CONTINUE TO THE FULL ARTERIAL CAPACITY SINCE THE USABLE CAPACITY IS REDUCED FOR THIS AREA.
3. FOR SCREENLINE 8, THE WIDENING OF HIGHWAY NO. 1 BY 1975 IS ASSUMED.

LEGEND:

——	TOTAL SCREENLINE VOLUME
— — —	TOTAL SCREENLINE TRAFFIC INCLUDING INDUCED TRAFFIC
C 50,000	CAPACITY EQUALS 50,000 PCE AT LEVEL OF SERVICE C
(stippled)	CORRIDOR TRAFFIC UTILIZING THE FREEWAY
(hatched)	CORRIDOR TRAFFIC UTILIZING ARTERIAL HIGHWAYS
▼	SCHEDULED FREEWAY OPENING DATE





NOTES:

SCREENLINE LOCATIONS ARE SHOWN ON EXHIBIT 9.

LEGEND:

- TOTAL SCREENLINE VOLUME
- TOTAL SCREENLINE TRAFFIC INCLUDING INDUCED TRAFFIC
- C 50,000 — CAPACITY EQUALS 50,000 PCE AT LEVEL OF SERVICE C
- CORRIDOR TRAFFIC UTILIZING THE FREEWAY
- CORRIDOR TRAFFIC UTILIZING ARTERIAL HIGHWAYS
- ▼ SCHEDULED FREEWAY OPENING DATE

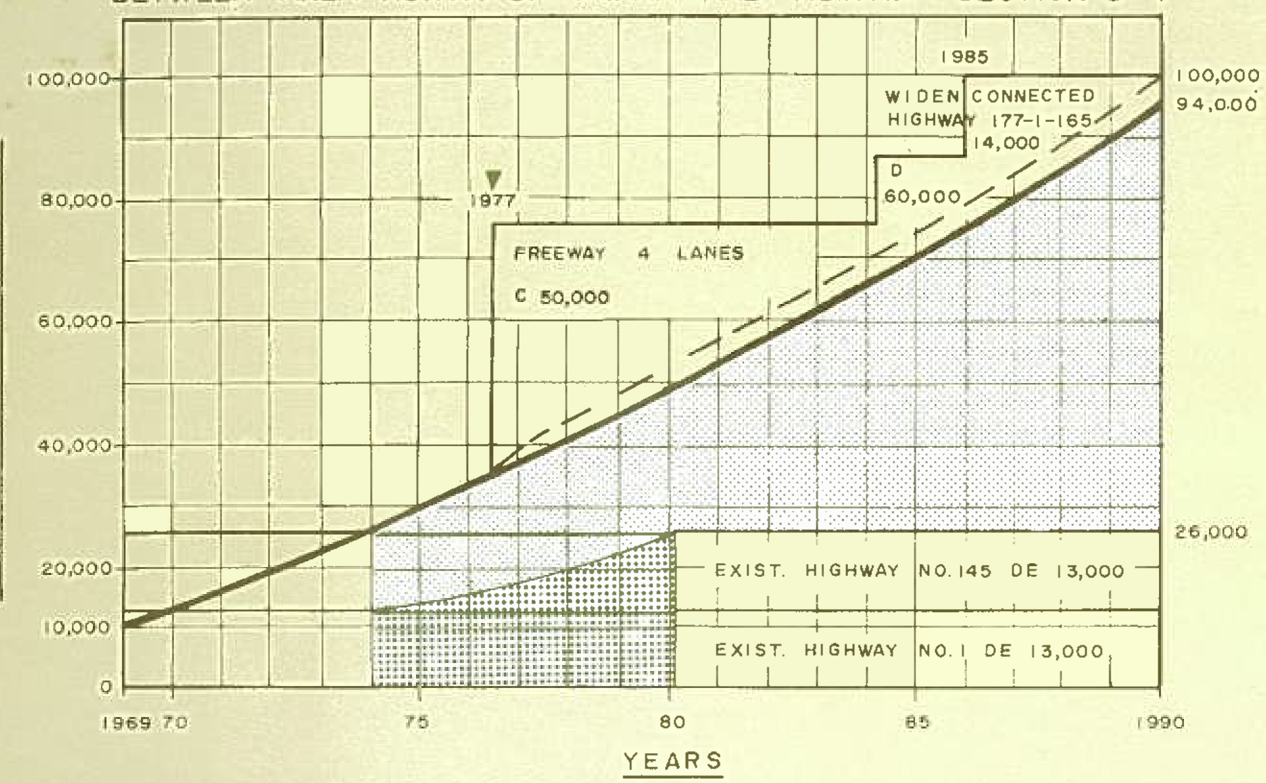
COMPREHENSIVE TOLL ROAD STU
NORTH-SOUTH FREEWAY TAIWA

CAPACITY DIAGRAMS

DE LEUW, CATHER INTERNATIONAL-CHICA

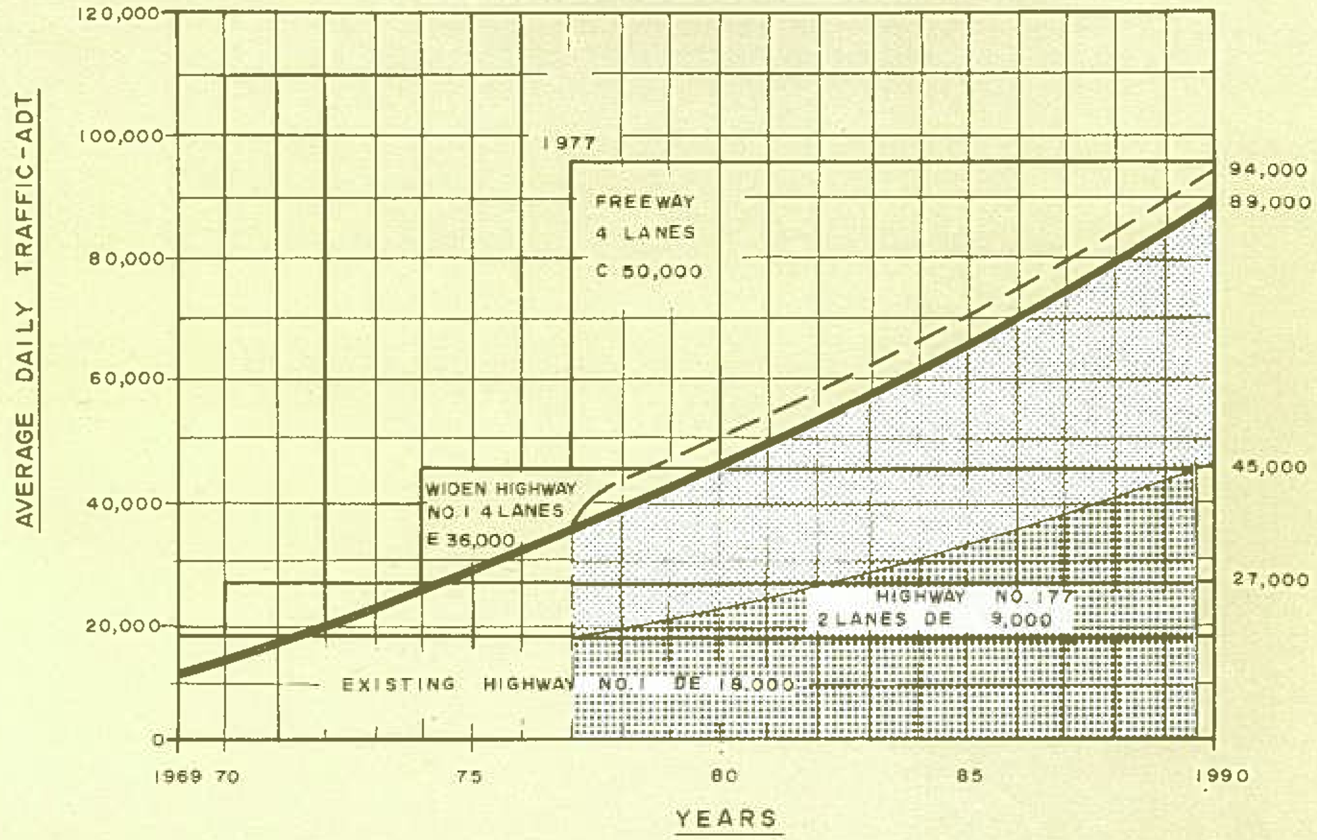
SCREENLINE 12

BETWEEN AREA NORTH OF TAINAN AND HSINYIN—SECTION 6–7



SCREENLINE 13

SOUTH OF TAINAN—SECTION 7



NOTES:

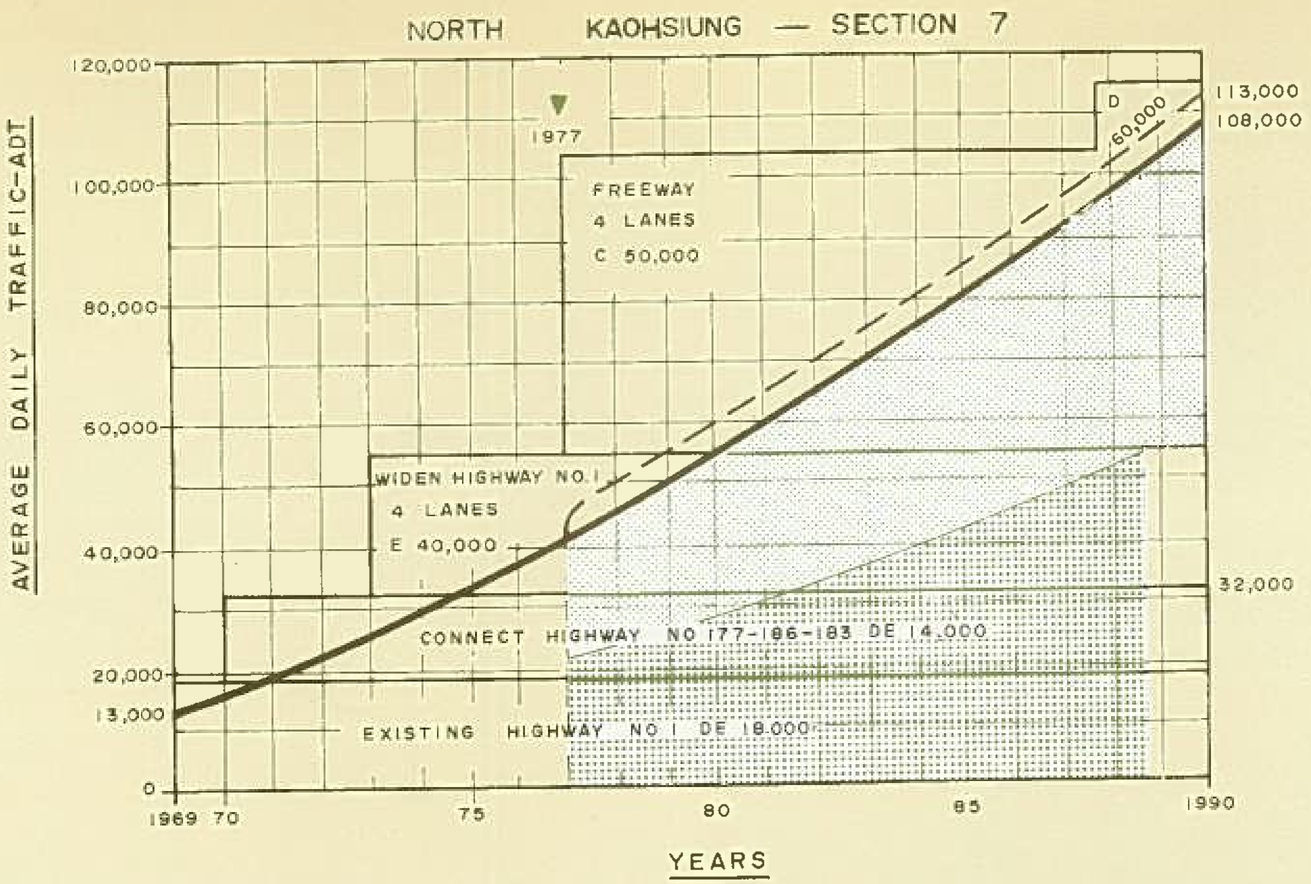
1. SCREENLINE LOCATIONS ARE SHOWN ON EXHIBIT 9.
2. FOR SCREENLINE 13, THE WIDENING OF HIGHWAY NO. 1 BY 1974 IS ASSUMED.

LEGEND:

———	TOTAL SCREENLINE VOLUME
— — —	TOTAL SCREENLINE TRAFFIC INCLUDING INDUCED TRAFFIC
C 50,000	CAPACITY EQUALS 50,000 PCE AT LEVEL OF SERVICE C
(dotted pattern)	CORRIDOR TRAFFIC UTILIZING THE FREEWAY
(dense pattern)	CORRIDOR TRAFFIC UTILIZING ARTERIAL HIGHWAYS
▼	SCHEDULED FREEWAY OPENING DATE

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
CAPACITY DIAGRAMS
DE LEUW, CATHER INTERNATIONAL-CHICAGO

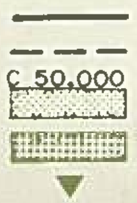
SCREENLINE 14



NOTES:

1. SCREENLINE LOCATION IS SHOWN ON EXHIBIT 9.
2. WIDENING OF HIGHWAY NO. I BY 1973 IS ASSUMED.

LEGEND:



TOTAL SCREENLINE VOLUME
TOTAL SCREENLINE TRAFFIC INCLUDING INDUCED TRAFFIC
C 50,000 CAPACITY EQUALS 50,000 PCE AT LEVEL OF SERVICE C
CORRIDOR TRAFFIC UTILIZING THE FREEWAY
CORRIDOR TRAFFIC UTILIZING ARTERIAL HIGHWAYS
SCHEDULED FREEWAY OPENING DATE

CHAPTER III

Economic and Financial Analysis of Alternative Systems

Chapter III

ECONOMIC AND FINANCIAL ANALYSES OF ALTERNATIVE SYSTEMS

BENEFIT-COST ANALYSIS

Incremental Investment Costs

As was done at the time of the feasibility study, the freeway investment is being compared in this study to an alternative highway investment. Unlike the feasibility study, however, this study does not consider the benefits and costs of the gross investment in the freeway and related highways; instead the benefit-cost analysis concerns only the incremental cost of the freeway and related highways investment compared to the alternative highway investment, which would represent the minimum investment cost (in present value terms) necessary to provide sufficient capacity to accommodate forecast normal growth traffic volumes (i.e., exclusive of volumes of converted or induced traffic which would be brought about by the freeway).

The feasibility study compared the gross freeway investment, as costs, to the combined total of user cost savings and the alternative highway investments, as benefits. The user cost savings would be those realized by highway users with the freeway network as compared to the network with the alternative highway investments; the savings would not include those which would result with the alternative highway investments relative to the no-investment situation. In lieu of these latter savings, the feasibility study included the costs of the alternative highway investments as benefits (investment savings) of the freeway; the implicit assumption in this method of evaluation is that the benefits of these alternative highway investments would be at least equal to their costs. Since these alternative investments represented the minimum cost required to prevent the highway system from degenerating to a transportation bottleneck, and thus restraining further economic growth, the benefits of these alternative investments would almost certainly outweigh their costs, and, if so, the total benefits to be derived from the freeway would have tended to be understated in the feasibility study.

Since this approach was not well understood by all of the reviewers of the feasibility study, however, it was decided that the toll study should take the approach mentioned above, viz., to determine the worth of only the incremental investment cost with the freeway.

This adjustment in approach has more apparent, than real, significance. Either approach would result in exactly the same internal rate of return, and the same levels of net present value of benefits at various discount rates; only the benefit-cost ratios, at values other than 1.0, would differ with the two approaches.

The incremental cost of the freeway investment, which is indicated in this study, differs from the incremental cost which would result from the cost estimates of the feasibility study. This difference results from the following cost adjustments:

(1) Freeway costs were altered as a consequence of the toll decision, since, with tolls, the number of interchanges would be reduced, thus tending to reduce investment costs, whilst, on the other hand, construction, maintenance, and operation costs would all tend to increase as a result of the toll plazas;

(2) Related highway costs with the freeway investment would rise over the costs that were indicated in the feasibility study, since additional investments have been approved since that time, and, thus, the freeway investment could no longer be construed as a substitute to these investments;

(3) Construction costs in the Taipei area are now estimated to be considerably higher than the cost estimates of the feasibility study (as explained in Appendix A to this chapter these cost increases would have occurred with either the freeway or the alternative highway improvements);

(4) Costs were determined through the year, 1995, rather than only through 1990, as was done in the feasibility study;

(5) The costs for the entire freeway include the costs for the freeway east alternative in Section VII, rather than the costs of the west alternative which was favored in the feasibility study, and these costs, moreover, have been revised since the time of the feasibility study; and

(6) Revised scheduling of construction of both the freeway and the alternative improvements, although not affecting undiscounted cost increments, had some effect on the discounted cost totals.

The development of all highway costs, including those of the freeway, and those of related, and alternative, highway improvements is discussed in detail in Appendix A to this chapter; all of the year-by-year costs are shown in appendix tables both inclusive and exclusive of taxes.

The incremental costs (excluding all taxes) are shown calculated in Table III-1. The freeway costs, including costs of maintenance and operations through 1995, would total NT$22,418 million with the barrier toll collection network, and NT$23,329 million with the closed toll-collection network; thus, the costs of the latter would be approximately 4.1 percent above the costs with the barrier network. The undiscounted, without-tax freeway cost total estimated in the feasibility study was NT$20,939 million, so that barrier network costs would be about 7.1 percent higher than the previously-estimated costs of the toll-free facility; the costs of the closed network would be nearly 11.5 percent higher.

The costs of related highway investments which would be needed with the freeway are indicated in Table III-1 at NT$6,049 million; this total represents a substantial rise of nearly 73 percent over the NT$3,500 million figure of the feasibility study. The reason for this marked increase is the inclusion in the former total of the costs of government-approved improvements to Highways 1, 3, and 12; these improvements were not regarded in the feasibility study as being necessary with the freeway, and thus were not included with the freeway investment alternative at that time.

The total without-tax costs of the freeway alternative (i.e., freeway plus related highway costs) is estimated at NT$28,467 million with the barrier network, and at NT$29,378 million with the closed network; the former total would represent a 16.5 percent rise over the NT$24,439 million total indicated in the feasibility study, whilst the closed system total would be more than 20.2 percent above the feasibility study estimate.

Alternative highway improvements are estimated to cost NT$25,804 million over the 1971-1995 period, or approximately 10 percent above the NT$23,477 million total of the feasibility study. This rise in costs results primarily from adding four additional years of maintenance, i.e., the years, 1991 through 1995, were added, and the year, 1970, was eliminated from the study period. If the maintenance costs, totalling NT$1,537 million, estimated for the 1992-1995 period could then be considered as constituting the net addition to maintenance costs, other costs of the alternative highway investments would have risen by only slightly more than four percent over feasibility study estimates (and most of this rise would pertain to increased construction costs in the Taipei area).

The incremental costs of the freeway alternative are shown in Table III-1 to be NT$2,663 million with the barrier toll-collection network, and NT$3,574 million with the closed network. The undiscounted, without-tax cost increment of the feasibility study was only NT$962 million.

Economic Benefits

The benefits of the incremental cost of the freeway alternative, as measured in this study consist solely of user cost savings which would accrue to forecast highway traffic with the freeway system as compared to the lower level of service which would be provided with the alternative highway system. As with costs, these benefits are incremental benefits since they do not include the benefits of the alternative highway system relative to the no-investment situation. It is left to the sensitivity analysis presented in Appendix E to this chapter to take into consideration the benefits which would derive from the forecast induced traffic volumes, and the benefits resulting from improved safety conditions. There would also be benefits accruing to traffic which would be converted from the railway, but no attempt is made in this study to quantify such benefits (see Appendix D to this Chapter for a discussion of modal split analysis).

As indicated in Chapter II and its appendices, the computer provided data on 1969 and 1990 daily vehicle-kilometers, vehicle-hours, and vehicle operating costs for each of four vehicle types in every freeway section with the arterial network and with every freeway system. The data from the computer were adjusted for reasons of overassignment to arterials (i.e., assignment to arterial highways of volumes in excess of arterial capacity); adjustments were also made to take into account the shift of air traffic to a new international airport near Taoyuan, and the effects of capacity constraints in Keelung Port.

In order to determine the economic cost savings with the freeway, tolls and taxes had to be deducted from the adjusted vehicle operating cost totals. The operating costs, without taxes or tolls, were then compared to the without-tax operating costs of the arterial network to determine the cost savings. (The processes by which tolls were calculated are described in a later section of this chapter, whilst the process of extracting taxes is discussed in Appendix B to this chapter.)

The without-tax savings with the barrier system and toll schedule B_3 are shown in Tables III-2 and III-3 for the entire freeway and for each freeway section. As indicated in the footnotes to Table III-3, the totals shown were neither adjusted for a revised forecast of heavy truck traffic in Section I, nor adjusted for airport traffic or capacity constraints in Section II.

The Table III-2 figure of NT$524 million represents the vehicle user savings which would have been expected to derive from the freeway in 1969, had the entire facility been open to traffic throughout that year. This figure compares to a feasibility study estimate of NT$676 million (with the east alternative freeway alignment in Section VII) in 1969. Thus, the increased operating costs with freeway toll collection would be expected to result in an approximately 22.5 percent decline in 1969 user savings.

For 1990, the Table III-3 forecast of nearly NT$4,651 million should be compared to a feasibility study total of NT$5,788 million (with Section II unadjusted for capacity constraints and airport traffic, and with the east freeway alternative in Section VII). The drop from the feasibility study user savings total would be nearly 20 percent.

With the closed network (and schedule C_4), the 1969 and 1990 user costs and cost savings for the entire freeway would be as shown below.

	Autos	Light Trucks	Heavy Trucks	Buses	Total Vehicles
1969					
Costs (NT$ mil.)	706	203	1,284	477	2,670
Cost savings (NT$ mil)	111	23	202	166	502
1990					
Costs (NT$ mil.)	10,604	1,977	9,631	1,898	24,110
Costs savings (NT$ mil)	2,095	229	1,607	598	4,529

The closed system operating costs would be only slightly higher (0.8 percent in 1969, and 0.5 percent in 1990) than the costs with the barrier system, but these slight differences would result in 4.2 percent lower cost savings in 1969, and 2.6 percent lower savings in 1990, or an average shortfall over the entire 1969-1990 period of around 3.4 percent.

Hypothetical 1970 user savings were estimated by assuming that savings would grow at rates equal to certain known expansions during the year; thus, auto registration grew by 25.0 percent over 1970, and hypothetical 1969 savings were therefore multiplied by a factor of 1.25 to estimate 1970 auto savings. In like manner, light truck savings were expanded at the rate of registration growth (27.1 percent), whilst heavy truck and bus user savings were estimated to expand by the same rates as commercial trucking ton-kilometers (15.8 percent) and bus passenger-kilometers (11.9 percent), respectively. Overall potential savings growth was estimated at 17.4 percent for 1970.

A quadratic curve was developed which would have gradually descending rates of growth from the estimated 1970 traffic growth to growth of less than six percent in 1995. The estimated 1969-1990 expansions of user savings for each freeway section with the barrier system were then compared to the quadratic curve which had been developed to obtain savings totals for the years, 1971-1989 and 1991-1995.

Adjustments were made to estimated savings totals in some sections because the volume of traffic on the freeway would be expected to reach capacity prior to 1995; adjustments were also made for airport traffic in Section II (see Appendix C to Chapter II) and for heavy truck traffic in Section I (see Appendix D to Chapter II).

The feasibility study indicated that the freeway in Section II should be filled to capacity by 1981; that estimate assumed, however, that no other major highway improvements would be made in the area. Now, however, the government has determined that Highway 1 should be widened in the area of Section II. This additional highway capacity would permit the freeway to maintain some excess capacity until 1984.

The feasibility study went on to assume that a second freeway would be opened in 1982, with the result that there would be considerable diversion from the North-South Freeway. Although the feasibility study lowered the user savings, deriving from the North-South Freeway, due to this expected diversion of traffic to a hypothetical second freeway, this reduction of benefits was not necessary. The first freeway would be capable of producing a certain user cost reduction in the corridor; if, then, a second freeway would be opened, it could only be credited with the incremental cost reduction in the corridor. Thus the estimate of annual savings of the first freeway should be maintained, whether or not diversion from it would occur.

Table III-4 indicates the adjusted year-by-year user cost saving for each of seven freeway sections over the 1969-1995 period. As indicated by footnote 4 to the table, in addition to Section II, five other freeway sections would be expected to accommodate capacity volumes of traffic by 1995. These estimates of the years in which the various freeway sections would be filled to capacity disregard the possibility that traffic might be converted from the railway; if volumes of such converted traffic would be significant, the various freeway sections would be expected to reach capacity in earlier years than are indicated.

The final column in Table III-4 disregards all hypothetical savings which might have accrued to users had the freeway actually opened to traffic in the earlier years of the study period. The undiscounted total of user savings foreseen to derive from the freeway over the study period is NT$70,398 million; this compares to an adjusted freeway total (adjusting for the inclusion of freeway east results in Section VII) of NT$54,221 million found at the time of the feasibility study. The difference in favor of the present study results entirely, however, from the inclusion of the years, 1991-1995, in the study period. In 1990 and in every prior year, the feasibility study estimated user savings total was higher than the respective total found in the present study.

Economic Analysis of Alternative Solutions

As indicated in the earlier sections of this chapter, the undiscounted incremental costs of the freeway investmant alternative would be NT$2,663 million with the barrier toll network, and NT$3,574 million with the closed toll network. Undiscounted barrier system (with toll schedule B_3) incremental benefits would be NT$70,398 million; closed system incremental benefits would be approximately NT$68,004 million (i.e., 3.4 percent below barrier system benefits).

Benefits would accrue in later years than the major portion of toll road costs, however, and in order to take into account the reduced value (in terms of present value) of these later-year benefits, both costs and benefits must be discounted.

Table III-5 shows the results of discounting freeway incremental costs and incremental benefits at rates of 10, 15, 20, and 25 percent. Despite the inclusion of the years, 1991-1995, in the study period, when benefits are discounted at a rate even as low as ten percent, the user savings totals found in this study are lower than the savings totals found in the feasibility study. The discounted total of NT$16,193 million found for the barrier system at a discount rate of ten percent, compares to an adjusted (for freeway east in Section VII) total of NT$16,719 million. At higher discount rates the difference widens: at a discount rate of 25 percent, the present study found a discounted savings total of NT$3,359 million with the barrier system, whereas the comparable feasibility study total was NT$4,856 million, or about 44.6 percent higher.

While these lower discounted savings totals would tend to lower the internal rate of return of the incremental cost of the freeway alternative, however, this tendancy was counterbalanced to some extent by the reduction of discounted costs of the freeway alternative. The undiscounted cost increment with the barrier system is nearly three times the cost increment found in the feasibility study (i.e., NT$2,663 million compared to NT$962 million), but the revised scheduling of construction results in lower discounted cost increments.

Discounted at ten percent, incremental costs of the barrier system would be NTS5,293 million; in the feasibility study, the comparable figure was NT$5,859 million. Discounted at 25 percent, the barrier system incremental costs decline to NT$4,687 million, whereas feasibility study incremental costs rose to NT$6,681 million, or more than 42 percent higher than the discounted barrier system incremental costs.

In spite of the fact, then, that estimates of user savings are significantly reduced in the present study from the discounted totals of the feasibility study, and, further, despite the fact that the present study ignores the "lesser benefits"* of the freeway which were calculated in the earlier study, the rate of return found for the freeway with the barrier system is 20.9 percent, which is only slightly lower than the rate of return found at the time of the feasibility study (22.3 percent). The internal rate of return found for the closed system, is 19.5 percent.

A few words might be in order here regarding the precision of these estimates. The estimates might be high or low, of course, depending upon the accuracy of the traffic forecasts (see this study's discussions with regard to the accuracy of traffic forecasts used herein and the effects of altering the forecasts — Appendix A to Chapter I and Appendix E to this chapter). Additionally, incremental benefits of the freeway were understated since benefits were not calculated for the forecast induced traffic, nor for possible traffic volumes which would be converted to highway transport. A major advantage of the freeway alternative compared to the alternative highway improvements would be a significant improvement in highway safety; however, no benefits for this safety improvement were included in the preceding analysis. Further, incremental benefits tended to be understated to the extent that no time savings were estimated for a reduction in stopping time; a highway trip between Taipei and Kaohsiung without the freeway, for example, would normally require two or three stops (primarily to alleviate driver fatigue), whereas, with the freeway, only one stop should normally be required. Finally, the above analysis tended to understate highway improvement costs by calculating only the direct costs of construction, while ignoring the indirect costs related to disruption of normal traffic flows.

Counterbalancing to some extent these various factors, which would tend to understate the rate of return on the incremental cost of the freeway, would be the disregard in the foregoing analysis of operating improvements on arterials immediately after a highway improvement. This factor was discussed at the time of the feasibility study, and when it was allowed for in isolation (i.e., without also allowing for factors

* Made up of the value of cargo time savings, and savings accuring to traffic converted from the railway.

which would tend to increase the rate of return), it was estimated to reduce the rate of return by about three percent.

(See Appendix E to this chapter for further discussion of some of the above factors which might alter the rate of return of the freeway cost increment. See Appendix C for a discussion of the rates of return for the various freeway sections. Appendix F indicates the change in the estimated rate of return which might be expected if the time table for completing the freeway would be extended for various periods.)

FINANCIAL ANALYSIS

Toll Revenue

Revenue was calculated for each diversion assignment with tolls, as well as for the bus all-or-nothing assignments with tolls. With the barrier system, the procedure for calculating daily toll revenue was quite simple, as it merely required that the daily volumes of three vehicle categories, viz., light vehicles, heavy trucks, and buses, on each freeway link with a barrier would be multiplied by their respective toll rates. The free-travel zones complicated slightly the procedure for determining closed system revenue. These zones would actually only be free for trips which would be wholly within the zone; any vehicle which would pass through one of the barriers forming a border for one of these zones of free travel would pay for traveling one-half of the free-travel zone distance. The amounts of payments for traveling within these zones, then, were found by multiplying one-half the zone distances by the per-kilometer toll rates for four vehicle types, and then multiplying these charges per vehicle by the daily volumes of the respective vehicle types at the freeway toll barriers.

Other closed system daily revenues (i.e., outside the zones of free travel) were calculated merely by multiplying the vehicle-kilometers for each type of vehicle by their respective toll rates per kilometer.

Adjustments were made for airport traffic in Section II, and for a revised heavy truck traffic forecast in Section I. Daily toll revenues were then converted to annual totals for 1969 and 1990 by using a factor of 365 for autos, light trucks, and buses, and a factor of 354 for heavy trucks; these factors were determined as appropriate at the time of the April 1969 O-D survey.

After the annual totals for 1969 and 1990 were determined, the 1970 totals were estimated by relating toll revenue directly to other indicators of traffic growth, as was done with user savings. Later-year totals were estimated by using the quadratic curve developed for that purpose (see the earlier discussion on estimating future year user savings).

Table III-6 indicates the expected toll revenue with toll schedule B_3; year-by-year revenue totals are shown for each freeway section, as well as for the entire freeway. The high total shown for Section VI of the freeway results from three out of ten proposed toll barriers being located in that section. As noted in a footnote to the table, growth of toll revenues was discontinued in any section after the year in which the freeway in that section would accommodate its capacity level volume of traffic.

Table III-7 indicates the toll revenue which would be expected with other toll schedules which were tested. The annual totals shown in this table, too, were adjusted for capacity constraints, airport traffic, and a revised heavy truck forecast in Section I.

These two tables complete the comparison between the barrier system with toll schedule B_3 and the closed system with toll schedule C_4. It was indicated in earlier sections of the chapter that the freeway cost with a closed toll collection system would be about 4.1 percent higher than with a barrier toll collection system, and it was shown that barrier system benefits (with toll schedule B_3) would be about 3.5 percent higher than benefits with a closed system. Thus, from both the standpoint of costs and the standpoint of benefits, the barrier system would be preferable to the closed system. Now, Tables III-6 and III-7 indicate that from a financial standpoint, as well, the barrier system with schedule B_3 should be favored over the closed system with schedule C_4.

Of course, there might well be some closed system toll schedule which would produce higher economic benefits or toll revenue than the barrier system with schedule B_3. Toll schedule C_3 provides more revenue than schedule C_4, and nearly as much as schedule B_3; closed system rates could be raised above those of schedule C_3, and, if additional diversion from the freeway were not excessive, total revenue might equal or exceed those produced with schedule B_3. This could only be done, however, by further reducing the economic benefits which would obtain with the closed system. Alternatively, closed system benefits might be raised to the level expected with schedule B_3, only by sacrificing some portion of closed system toll revenue.

The toll revenue shown calculated in Tables III-6 and III-7 constitutes only that revenue which is foreseen to be collected from normal growth traffic volumes, and thus does not include revenue which might be collected from possible highway traffic converted from the railway; nor does it include revenue from forecast induced traffic volumes.

In the years, 1969, 1970, and 1990, toll revenue with schedule B_3 would be collected from the various vehicle types as shown following (all figures in NT$ million).

Years	Autos	Light Trucks	Heavy Trucks	Buses	Total Vehicles
1969	65	16	154	69	304
1970	81	20	178	77	356
1990	1,483	199	1,375	342	3,399

The forecasts of induced traffic were for an average increase of approximately 15 percent in auto traffic, and an average 25 percent rise in bus traffic. In 1970, this would have meant an NT$12 million rise in revenue from autos and an NT$19 million increase in revenue from buses; total 1970 revenue would have been NT$387 million, or about 8.7 percent above the NT$356 million total shown above. In 1990, forecast induced traffic volumes would mean a NT$308 million increase in revenue, which would represent about a 9.1 percent rise from the above-indicated total for that year. Thus, on the average over the study period, revenue from induced traffic would be expected to be equivalent to nearly nine percent of revenue from normal growth traffic volumes.

(Appendix F indicates how total toll receipts might be altered if construction of some freeway sections would be deferred until later years than currently scheduled. Appendix G indicates how revenue totals might be altered with various adjustments to the recommended barrier toll system.)

Revenue Sufficiency

Prior to testing any toll schedules, the Government's view on the portion of toll road costs which should be recovered from toll revenue was ascertained. The Government indicated that, in order that highway users might be encouraged to use the freeway, only partial-cost-recovery toll schedules should be given consideration. Accordingly, toll schedules, which were not expected to provide sufficient revenue to cover all costs, were selected for testing.

As was done in the feasibility study, both projected toll revenue (with toll schedule B_3) and toll road costs were discounted at eight percent (the estimated average cost of money for the project) to determine the portion of total costs, including interest, which would be covered by tolls. The discounted revenue would total NT$13,076 million over the period, as shown in the last column of Table III-6. If an additional nine percent were added, as being received from induced traffic volumes, then discounted revenue over the study period would total NT$14,250 million.

The freeway costs for the 1971-1995 period (excluding the costs of related highways) are shown below undiscounted and discounted at eight percent, with and without taxes.

With-tax Costs (NT$ million)		W/O tax Costs (NT$ million)	
Undiscounted	Disc. @ 8%	Undiscounted	Disc. @ 8%
26,241	18,591	22,416	15,840

Excluding revenue from induced traffic, tolls would cover 70.3 percent of with-tax costs over the 1971-1995 period, and 82.5 percent of without-tax costs. With induced traffic revenue, tolls would cover 76.6 percent of with-tax costs, and 90.0 percent of costs without taxes.

If the period considered is extended to determine when the freeway costs might be fully recovered, the results are as shown below.

Cumulative Freeway Costs and Toll Revenues (Disc. @ 8%)

	Freeway Toll Revenue (NT$ Million)		Freeway Costs (NT$ Million)	
Year	W/O Induced Traffic	Incl. Induced Traffic	With Taxes	W/O Taxes
2000	15,390	16,780	18,740	15,970
2005	16,970	18,500	18,890	16,100
2010	18,050	19,670	19,040	16,230

The above method of determining the sufficiency of revenue is not entirely adequate, however, since it disregards the possibilities that: (1) not all construction period costs can be financed from credit, and thus other sources of revenue might be required prior to the opening of the freeway; and (2) the debt service may not grow exactly in accordance with toll revenue so that early year shortfalls of toll revenue compared to debt service might be considerably in excess of the average over the entire period, whilst later year revenue totals might be able to meet all debt service, or even to provide a surplus of funds.

In order that these possibilities be taken into account, revenue sufficiency might be considered on a year-by-year basis. Since much of the financing of the freeway project has not yet been arranged, a precise indication of the revenue needs in each year of the study period is not now possible. Nevertheless reasonable approximations might be made on the basis of information currently available.

The sources of financing the Neihu-Yangmei freeway section are listed below.

Financial source	NT$ Million	Percent of Total
ADB Loans	1,020	20.2
Yen Credit	300	5.9
Bonds	1,720	34.1
Total Debt	3,040	60.2
ADB Grant	4	0.1
Toll Revenue	36	0.7
Budget Allocation	1,440	28.5
Fuel Tax Revenue	530	10.5
Total Other Financing	2,010	39.8
Total	5,050	100.0

The first of two ADB loans is to be repaid in 33 semiannual installments, with the first installment scheduled for December 1973. The second loan is assumed to be repaid over a similar period, beginning one year later. The bonds are to be paid off over seven years, with the first payment coming at the end of the third year. Repayment terms on the yen credit have apparently not yet been settled; ten years repayment after a three-year grace period will be assumed here. Interest on the ADB loan is at 6.875 percent; interest on the bonds is at 9.4 percent; and interest on the yen credit is only 3.5 percent. The estimated service on this debt is indicated in Table III-8.

The last column of the referenced table indicates the expected toll revenue. In 1980 and thereafter, toll revenue would be far in excess of the combined total of debt service and maintenance and operation costs (maintenance and operating costs would only amount to around NT$11.0 million, including taxes, in the Neihu-Yangmei section in 1980).

In 1981, the surplus revenue would be nearly sufficient (NT$177 million) to meet the estimated NT$208 million cost of widening the freeway (in Section II) in that year. Prior to 1980, however, toll revenue would not be sufficient in any year, and the cumulative total (for the 1971-1979 period) of debt service and maintenance and operating costs which would need to be met with revenue from other sources would be NT$1,855 million (of which maintenance and operating cost would represent only about NT$47 million).

Since financing for other freeway sections is, as yet, indefinite, any estimate of debt service on those sections must be based on several assumptions. The first assumption made here is that debt financing will continue to represent approximately 60 percent of total resources. This would mean that, with the remaining freeway sections requiring an additional NT$18,194 million over the 1973-1977 period, additional debt requirements would amount to approximately NT$10,916 million. If debt service would bear the same relationship to debt as was true for the Neihu-Yangmei section, viz., about 1.55 to one, then service on this debt would total NT$16,920 million. Finally, if it were assumed that the percentage distribution of this debt service over a twenty-year period would be identical to the distribution found for the Neihu-Yangmei section, but that the twenty-year period would be 1973-1992, instead of 1971-1990, then the debt service would be as shown in Table III-9.

The table indicates that annual revenue from toll collection should be adequate in 1982 and every year thereafter to meet all freeway financial needs. Prior to 1982, however, toll revenue would be insufficient to meet all financial requirements in each year, and the cumulative net deficit over the 1971-1981 period is estimated at NT$9,074 million. Toll revenue, in fact, would have only amounted to NT$6,824 million, or about 42.9 percent of financial needs during the 1971-1981 period.

After 1981, however, freeway toll revenue should be far in excess of freeway funds requirements for debt service, maintenance and operations, and new construction, so that large portions of toll revenue could be diverted to other projects.

(Adjustments which might be made to improve annual debt service coverage are considered in appendices to this Chapter. Appendix F considers the effect of extending the period of construction, and Appendix G indicates the effects of making various adjustments to the recommended barrier toll system.)

Alternative Sources of Funds

It was already assumed in the preceding section that debt financing would constitute only about 60 percent of the total financial resources required for acquisition and clearing of right-of-way and for freeway construction during 1971-1977. The preponderance of other funds was expected to be supplied from development budget allocations and from fuel commodity taxes; the combined total from these sources, over 1971-1977, would need to be approximately NT$9.3 billion. This amount would more than cover the estimated NT$3,453 million of taxes which the freeway project would have to pay over 1971-1977, so that the project would be a net recipient of approximately NT$5.85 billion of tax revenue.

If the total of NT$9.3 billion would be divided between budget allocation and fuel commodity taxes in the same proportions as is true for the Neihu-Yangmei section, then funds made available from the former source would total around NT$6.8 billion, whilst fuel commodity taxes would furnish about NT$2.5 billion. If funds allocations from the development budget would be discontinued after 1977 (i.e., after the entire freeway would be opened to traffic), but funds from fuel commodity taxes would continue to be supplied over the next four years, i.e., 1978-1981, at about the NT$350 million per annum rate estimated for the 1971-1977 period, then approximately NT$7,680 million of projected 1971-1981 debt service would remain uncovered.

Table III-10 presents one possible scheme, out of innumerable possible schemes, for meeting this uncovered debt service over the 1972-1981 period (the estimated approximately NT$10 million of 1971 debt service is assumed to be met through other means). The scheme presented in the table is simple in that it would require a flat NT$4,000 annual vehicle license fee increment to be levied on all vehicles each year over a ten-year period.

An alternative to the above scheme, would be to defer most, or all, other highway new construction over a several-year period prior to 1982, and to divert the funds, which might otherwise have been used for new construction, to cover freeway debt service; then, in 1982 and thereafter, freeway toll revenue should be sufficient to finance an extensive program of other highway improvements.

TABLE III-1

INCREMENTAL COSTS (EXCLUDING TAXES) OF THE FREEWAY ALTERNATIVE
(NT$ Million)

Year	Freeway Costs		Related Highway Costs	Costs of Freeway Alternative		Alter-native Highway Costs	Incremental Costs Freeway Alternative	
	Barrier System	Closed System		Barrier System	Closed System		Barrier System	Closed System
1971	345	361	2,321	2,666	2,682	2,315	351	367
1972	1,822	1,903	1,001	2,823	2,904	1,876	947	1,028
1973	2,745	2,921	501	3,246	3,422	1,652	1,594	1,770
1974	3,588	3,771	28	3,616	3,799	1,402	2,214	2,397
1975	4,443	4,620	686	5,129	5,306	1,621	3,508	3,685
1976	4,051	4,039	38	4,089	4,077	2,398	1,691	1,679
1977	2,862	2,975	40	2,902	3,015	2,436	466	579
1978	54	59	41	95	100	938	- 843	- 838
1979	57	62	42	99	104	1,141	-1,042	-1,037
1980	60	65	45	105	110	527	- 422	- 417
1981	250	263	45	295	308	227	68	81
1982	66	71	47	113	118	769	- 656	- 651
1983	69	75	49	118	124	1,110	- 992	- 986
1984	73	80	224	297	304	2,056	-1,759	-1,752
1985	226	239	316	542	555	1,389	- 847	- 834
1986	402	408	57	459	465	605	- 146	- 140
1987	220	234	58	278	292	412	- 134	- 120
1988	105	115	60	165	175	329	- 164	- 154
1989	114	124	60	174	184	332	- 158	- 148
1990	122	134	62	184	196	366	- 182	- 170
1991	132	143	63	195	206	369	- 174	- 163
1992	140	153	65	205	218	369	- 164	- 151
1993	149	162	65	214	227	372	- 158	- 145
1994	157	171	67	224	238	375	- 151	- 137
1995	166	181	68	234	249	418	- 184	- 169
Totals	22,418	23,329	6,049	28,467	29,378	25,804	2,663	3,574

TABLE III-2

HYPOTHETICAL 1969 USER SAVINGS WITH BARRIER NETWORK AND TOLL SCHEDULE B_3

(NT$ 000)

Vehicle Type & User cost item*	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Entire Freeway
Autos & Taxis								
Without-Freeway costs	165,446	212,815	38,975	68,127	106,734	74,111	151,233	817,441
With-Freeway costs	157,305	168,992	29,381	55,715	97,375	60,006	137,679	706,453
Savings	8,141	43,823	9,594	12,412	9,359	14,105	13,554	110,988
Light Trucks								
Without-Freeway costs	42,847	52,897	12,759	25,757	23,371	23,528	44,436	225,595
With-Freeway costs	41,158	48,753	10,490	21,334	20,969	19,064	41,577	203,345
Savings	1,689	4,144	2,269	4,423	2,402	4,464	2,859	22,250
Heavy Trucks								
Without-Freeway costs	129,080	200,229	117,777	251,646	210,309	262,077	314,768	1,485,886
With-Freeway costs	120,621	184,439	87,740	213,779	188,199	206,229	286,078	1,287,085
Savings	8,459	15,790	30,037	37,867	22,110	55,848	28,690	198,801
Buses								
Without-Freeway costs	70,813	123,549	48,681	88,517	98,809	88,032	125,004	643,405
With-Freeway costs	57,572	75,301	30,170	63,177	62,074	58,919	104,208	451,421
Savings	13,241	48,248	18,511	25,340	36,735	29,113	20,796	191,984
Total Vehicles								
Without-Freeway costs	408,186	589,490	218,192	434,047	439,223	447,748	635,441	3,172,325
With-Freeway costs	376,656	477,485	157,781	354,005	368,617	344,218	569,542	2,648,304
Savings	31,530	112,005	60,411	80,042	70,606	103,530	65,899	524,023

* Exclusive of all taxes and tolls.

TABLE III-3

PROJECTED 1990 USER SAVINGS WITH BARRIER NETWORK AND TOLL SCHEDULE B_3

(NT$ 000)

Vehicle Type & User cost item*	Section I	Section II**	Section III	Section IV	Section V	Section VI	Section VII	Entire Freeway
Autos & Taxis								
Without-Freeway costs	1,700,881	2,991,017	609,139	1,600,154	2,103,000	1,619,800	2,075,122	12,699,113
With-Freeway Costs	1,436,016	2,262,494	525,598	1,264,119	1,994,736	1,267,854	1,738,081	10,488,898
Savings	264,865	728,523	83,541	336,035	108,264	351,946	337,041	2,210,215
Light Trucks								
Without-Freeway costs	363,622	530,581	100,579	297,107	276,144	248,595	389,556	2,206,184
With-Freeway costs	355,053	450,227	83,742	250,814	271,583	210.419	367,517	1,989,355
Savings	8,569	80,354	16,837	46,293	4,561	38,176	22,039	216,829
Heavy Trucks								
Without-Freeway costs	962,924	1,713,507	744,372	1,982,214	1,570,865	1,944,256	2,319,454	11,237,592
With-Freeway costs	903,565	1,472,623	537,831	1,694,694	1,440,238	1,501,200	2,141,222	9,691,373
Savings	59,359***	240,884	206,541	287,520	130,627	443,056	178,232	1,546,219
Buses								
Without-Freeway costs	269,159	491,375	183,054	370,693	359,031	344,504	478,524	2,496,340
With-Freeway costs	223,042	332,529	112,562	266,890	296,226	227,966	359,658	1,818,873
Savings	46,117	158,846	70,492	103,803	62,805	116,538	118,866	677,467
Total Vehicles								
Without-Freeway costs	3,296,586	5,726,480	1,637,144	4,250,168	4,309,040	4,157,155	5,262,656	28,639,229
With-Freeway costs	2,917,676	4,517,873	1,259,733	3,476,517	4,002,783	3,207,439	4,606,478	23,988,499
Savings	378,910	1,208,607	377,411	773,651	306,257	949,716	656,178	4,650,730

* Exclusive of all taxes and tolls.

** Figures shown are unadjusted for airport traffic and the freeway capacity constraint.

*** Unadjusted for a revised truck traffic forecast in Section I.

TABLE III-4

FORECAST USER SAVINGS WITH THE BARRIER TOLL NETWORK AND TOLL SCHEDULE B_3

(NT$ Millions)

Year	Section I	Section II 2/	Section III	Section IV	Section V	Section VI	Section VII	Undiscounted Total For Entire Freeway 1/
1969	32	112	60	80	71	104	66	–
1970	37	132	70	93	81	121	77	–
1971	43	154	76	107	86	138	89	–
1972	50	178	83	122	91	156	102	–
1973	58	205	91	139	96	178	116	–
1974	67	236	100	159	103	201	133	–
1975	77	269	109	180	110	227	151	269
1976	87	532	120	203	117	255	171	619
1977	99	594	131	229	126	287	193	1,017
1978	112	663	144	257	135	321	217	1,849
1979	126	737	158	288	145	358	243	2,055
1980	141	818	173	321	156	399	271	2,279
1981	157	906	189	356	168	442	301	2,519
1982	175	1,001	206	394	181	488	333	2,778
1983	193	1,103	224	434	194	537	367	3,052
1984	212	1,211 4/	243	476	208	588	403	3,341
1985	232	1,211	263	521	222	642	441	3,532
1986	254	1,211	284	568	238	699	481	3,735
1987	276	1,211	306	616	254	759	522	3,944
1988	299	1,211	329	667	271	820	566	4,163
1989	323	1,211	353	719	288	884	610	4,388
1990	348	1,211	377	774	306	950	656	4,622
1991	373	1,211	402	828	324	1,016	702	4,856
1992	398	1,211	427	833 4/	342	1,084	750	5,095
1993	423	1,211	452	883	361 4/	1,152	797	5,279
1994	449	1,211	477	883	361	1,220	844 4/	5,445
1995	474	1,211	502 4/	883	361	1,286 4/	844	5,561
Totals 3/	5,151	21,155	5,640	10,751	4,515	13,645	9,541	70,398

1/ From scheduled first full year of operations.
2/ Including airport traffic from 1976 onward.
3/ Exclusive of hypothetical user savings.
4/ Year in which the respective freeway sections are expected to reach capacity traffic volumes.

TABLE III-5

FREEWAY DISCOUNTED COSTS AND BENEFITS, NET PRESENT VALUE, & BENEFIT-COST RATIOS

Freeway Toll System	Discount Rates 10%	15%	20%	25%
Barrier System*				
Incremental costs	5,293	5,279	5,026	4,687
Benefits	16,193	8,919	5,308	3,359
Net present value	10,900	3,640	282	- 1,328
Benefit-cost ratio	3.06	1.69	1.06	0.72
Closed System**				
Incremental costs	5,882	5,784	5,461	5,086
Benefits	15,641	8,615	5,127	3,244
Net present value	9,759	2,831	- 334	-1,842
Benefit-cost ratio	2.66	1.49	0.94	0.64

* With toll schedule B_3

** With toll schedule C_4

Rates of return

Barrier system: 20.9 percent

Closed system: 19.5 percent

TABLE III-6

FORECAST TOLL REVENUES WITH THE BARRIER NETWORK AND TOLL SCHEDULE B_3

(NT$ Millions)

Year	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Entire Freeway * Undiscounted	Entire Freeway * Disc. @ 8% (from 1971)
1969	33	54	35	53	21	70	36	–	–
1970	39	64	42	62	25	82	43	–	–
1971	44	84	47	70	28	96	47	–	–
1972	50	106	53	79	33	111	53	–	–
1973	57	132	60	90	37	128	59	–	–
1974	64	160	68	101	42	147	66	–	–
1975	72	191	77	114	48	168	74	191	140
1976	82	225	86	128	55	191	82	307	209
1977	92	263	96	144	62	216	91	542	341
1978	102	304	108	161	69	244	101	1,089	635
1979	114	349	120	180	77	274	112	1,226	662
1980	127	397	133	200	86	307	124	1,374	687
1981	141	448	147	221	96	342	136	1,531	709
1982	156	503	163	244	106	379	150	1,701	730
1983	171	562	179	269	117	419	164	1,881	747
1984	188	623***	196	294	128	460	179	2,068	761
1985	205	623	213	321	141	504	195	2,202	749
1986	223	623	232	350	153	550	212	2,343	738
1987	243	623	252	379	166	598	229	2,490	727
1988	262	623	272	410	180	648	248	2,643	714
1989	283	623	293	442	194	700	266	2,801	700
1990	305	623	315	474	209	753	285	2,964	688
1991	325	623	337	508	224	807	304	3,128	673
1992	347	623	359	541***	239	862	324	3,295	656
1993	368	623	382	541	254***	917	344	3,429	631
1994	390	623	404	541	254	971	364***	3,547	603
1995	411	623	426***	541	254	1,026***	364	3,645	576
Totals**	4,535	10,718	4,627	6,617	2,947	10,761	4,192	44,397	13,076

* Exclusive of hypothetical revenues.
** From scheduled first full year of operations.
*** Freeway section reaches capacity.

TABLE III-7

FORECAST TOLL REVENUES WITH THE BARRIER NETWORK AND CLOSED NETWORK

(NT$ MILLIONS)

TOLL SCHEDULES

	Schedule B_2		Schedule B_4		Schedule C_1		Schedule C_3		Schedule C_4	
Years	Hypothetical*	Projected	Hypothetical*	Projected	Hypothetical*	Projected	Hypothetical*	Projected	Hypothetical*	Projected
1969	235	–	276	–	217	–	276	–	272	–
1970	275	–	324	–	255	–	323	–	319	–
1971	312	–	369	–	287	–	375	–	365	–
1972	353	–	419	–	324	–	434	–	416	–
1973	400	–	476	–	366	–	500	–	474	–
1974	452	–	540	–	412	–	574	–	539	–
1975	509	55	610	192	463	113	656	143	610	141
1976	572	197	687	308	520	189	745	261	689	238
1977	642	362	772	498	581	335	844	436	775	421
1978	–	717	–	864	–	649	–	952	–	869
1979	–	800	–	965	–	722	–	1,069	–	971
1980	–	888	–	1,074	–	802	–	1,195	–	1,082
1981	–	984	–	1,190	–	887	–	1,331	–	1,201
1982	–	1,085	–	1,314	–	977	–	1,476	–	1,327
1983	–	1,193	–	1,446	–	1,074	–	1,629	–	1,461
1984	–	1,306	–	1,585	–	1,175	–	1,790	–	1,602
1985	–	1,426	–	1,731	–	1,282	–	1,961	–	1,751
1986	–	1,552	–	1,885	–	1,394	–	2,140	–	1,907
1987	–	1,683	–	2,046	–	1,511	–	2,327	–	2,071
1988	–	1,819	–	2,213	–	1,633	–	2,521	–	2,241
1989	–	1,960	–	2,385	–	1,758	–	2,721	–	2,416
1990	–	2,105	–	2,564	–	1,888	–	2,929	–	2,596
1991	–	2,252	–	2,742	–	2,019	–	3,136	–	2,779
1992	–	2,401	–	2,924	–	2,152	–	3,348	–	2,964
1993	–	2,526	–	3,074	–	2,255	–	3,508	–	3,110
1994	–	2,640	–	3,211	–	2,329	–	3,644	–	3,232
1995	–	2,751	–	3,331	–	2,388	–	3,762	–	3,333
Totals	–	30,702	–	37,542	–	27,532	–	42,279	–	37,713

* Revenue which would be expected if all freeway sections were open.

TABLE III-8

ESTIMATED DEBT SERVICE ON CREDIT EXTENDED FOR NEIHU-YANGMEI SECTION*

(NT$ MILLION)

Years	ADB Loans			Yen Credit			Bonds			Total Debt Service	Toll revenue in Neihu-Yangmei Sec.**
	Prin-cipal	Inter-est	Total	Prin.	Int.	Total	Prin.	Int.	Total		
1971	–	9	9	–	–	–	–	9	9	18	–
1972	–	17	17	–	–	–	–	66	66	83	–
1973	12	35	47	–	1	1	–	131	131	179	–
1974	30	45	75	–	4	4	38	155	193	272	–
1975	38	47	85	–	7	7	242	158	400	492	208
1976	40	65	105	–	10	10	316	135	451	566	245
1977	43	62	105	30	11	41	344	106	450	596	287
1978	46	59	105	30	10	40	344	73	417	562	331
1979	50	56	106	30	8	38	306	41	347	491	380
1980	53	52	105	30	7	37	102	12	114	256	433
1981	57	49	106	30	6	36	28	3	31	173	488
1982	61	44	105	30	5	35	–	–	–	140	548
1983	65	40	105	30	4	34	–	–	–	139	613
1984	69	36	105	30	3	33	–	–	–	138	679
1985	74	31	105	30	2	32	–	–	–	137	679
1986	80	26	106	30	1	31	–	–	–	137	679
1987	85	20	105	–	–	–	–	–	–	105	679
1988	91	14	105	–	–	–	–	–	–	105	679
1989	97	8	105	–	–	–	–	–	–	105	679
1990	29	2	31	–	–	–	–	–	–	31	679
Totals	1,020	717	1,737	300	79	379	1,720	889	2,069	4,725	8,286

* Principal repayments and interest rounded to the nearest NT$1 million.
** Including estimated collection from induced traffic.

TABLE III-9

ESTIMATED FREEWAY PROJECT DEBT SERVICE AND COVERAGE BY TOLL REVENUE

(NT$ MILLION)

Years	Debt Service Sections other than Neihu-Yangmei	Debt Service Entire Free-way	Main tenance and opera-tions costs	New capital expen-diture (after 1977)	Total finan-cial needs	Estimated toll revenue (incl. from induced traffic)	Cumulative surplus or deficit (-) of toll revenue to required financial resources
1971	–	18	–	–	18	–	-18
1972	–	83	–	–	83	–	-101
1973	64	243	–	–	243	–	-344
1974	298	570	–	–	570	–	-914
1975	641	1,133	7	–	1,140	208	-1,846
1976	975	1,541	20	–	1,561	335	-3,072
1977	1,761	2,357	36	–	2,393	591	-4,874
1978	2,027	2,589	62	–	2,651	1,187	-6,338
1979	2,135	2,626	65	–	2,691	1,336	-7,693
1980	2,012	2,268	69	–	2,337	1,498	-8,532
1981	1,758	1,931	72	208	2,211	1,669	-9,074
1982	917	1,057	76	–	1,133	1,854	-8,353
1983	619	758	80	–	838	2,050	-7,141
1984	501	639	84	–	723	2,254	-5,610
1985	497	634	91	177	902	2,400	-4,112
1986	494	631	101	352	1,084	2,554	-2,642
1987	491	596	111	138	845	2,714	- 773
1988	491	596	121	–	717	2,881	1,391
1989	376	481	131	–	612	3,053	3,832
1990	376	407	141	–	548	3,231	6,515
1991	376	376	151	–	527	3,410	9,398
1992	111	111	161	–	272	3,592	12,718
1993	–	–	171	–	171	3,738	16,285
1994	–	–	181	–	181	3,866	19,970
1995	–	–	191	–	191	3,973	23,752
Totals	16,920	21,645	2,122	875	24,642	48,394	–

TABLE III-10

TEN-YEAR VEHICLE LICENSE FEE*

Years	Alternative revenue for meeting 1972-1981 Debt Service left uncovered by tolls: Vehicle license fee incremental receipts*: Vehicle Registrations**	Receipts (NT$ mil.)	Fuel Commodity taxes (NT$ mil.)	Total Alternative revenue (NT$ mil.)	Debt Service left uncovered by toll revenue (NT$ mil.)	Revenue Surplus or Deficit (-) (NT$ Million): Annual	Cumulative
1972***	120,000	480	—	480	83	397	397
1973	140,000	560	—	560	243	317	714
1974	160,000	640	—	640	570	70	784
1975	180,000	720	—	720	932	- 212	572
1976	200,000	800	—	800	1,226	- 426	146
1977	220,000	880	—	880	1,802	- 922	-776
1978	240,000	960	350****	1,310	1,464	- 154	-930
1979	260,000	1,040	350	1,390	1,355	35	-895
1980	280,000	1,120	350	1,470	839	631	-264
1981	300,000	1,200	350	1,550	542	1,008	744
Totals	—	8,400	1,400	9,800	9,056	744	—

* An average license fee increment of NT$4,000/annum/vehicle.

** The forecast included in this table is meant to be conservative rather than precise.

*** NT$18 million of debt service in 1971 is assumed to be met through other means.

**** Prior to 1978, fuel commodity taxes would be used to finance construction.

CHAPTER IV

Toll Road Organization and Facility Requirements

Chapter IV

TOLL ROAD ORGANIZATION AND FACILITY REQUIREMENTS

In order for a toll road to function properly it must have organization and facilities capable of accomplishing the following main objectives:

Traffic must be handled efficiently and tolls collected from the patrons without causing undue delay and inconvenience.

The traffic must be policed and methods established to assist patrons who have emergency trouble from accident, illness, or other causes.

Organization and facilities must be set up to take care of the maintenance of the roadway, buildings, lights, communications, water, and sewage facilities.

Rest and service areas are necessary with provision of fuel for vehicles at filling stations and food made available for patrons at restaurants.

A communications system must be set up to keep in touch between administrative heads, police troopers and maintenance personnel as well as headquarters, toll and maintenance offices.

The money from tolls must be efficiently handled and accounted for and records kept of all transactions from collection to banking.

In order to coordinate the operations of the several departments, management must designate specific duties, channel instructions to department heads, and devise operation manuals with instructions of duties to prevent duplication and loss of efficiency.

This chapter briefly describes the organization, facilities and equipment needed for the toll road authority to successfully operate the North-South Freeway in accordance with the basic objectives set forth above. All detailed information on procedures, job descriptions and equipment are covered in the appendices to this chapter.

ORGANIZATION

Two toll road organization charts have been developed. Exhibit 13 shows the ultimate toll road organization needed to operate and maintain the North-South Freeway after construction of all sections of the freeway is completed. Exhibit 14 shows the interim toll road organization needed for operation and maintenance of the northern and southern sections, while design and construction of other sections are underway.

Ultimate Toll Road Organization

Under the direction and guidance of the Toll Road Director, the operation and maintenance of the toll road would be handled by three departments: operations, administration and engineering. Fifteen sections would perform various functions under these three departments. This report briefly describes the duties and responsibilities of the Director, the department heads and the section chiefs. The job descriptions for other personnel are provided in Appendix F to this chapter.

Director

The Director would be responsible for the operation and maintenance of the toll road, and would perform the following functions:

Plan, direct, and evaluate operations and programs of the three departments.

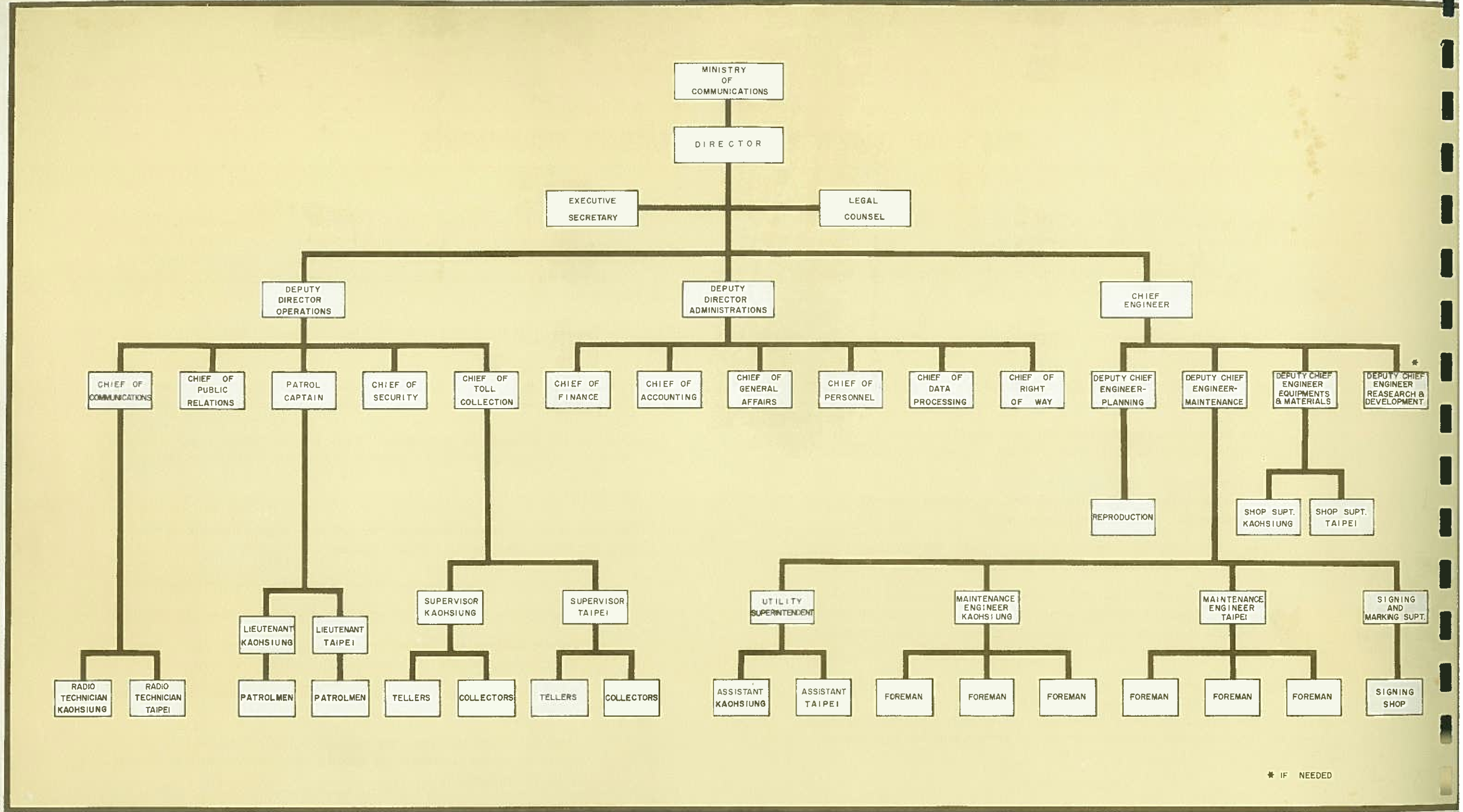
Participate in the formulation of agency objectives, policies and programs.

Provide direction and guidance to department heads and section chiefs in the interpretation and implementation of policies and programs.

Evaluate effectiveness of engineering programs and policies and periodic reports, and determine requirements.

Meet and correspond with other agencies, public officials, and the general public to resolve problems and provide information related to assigned areas of responsibility.

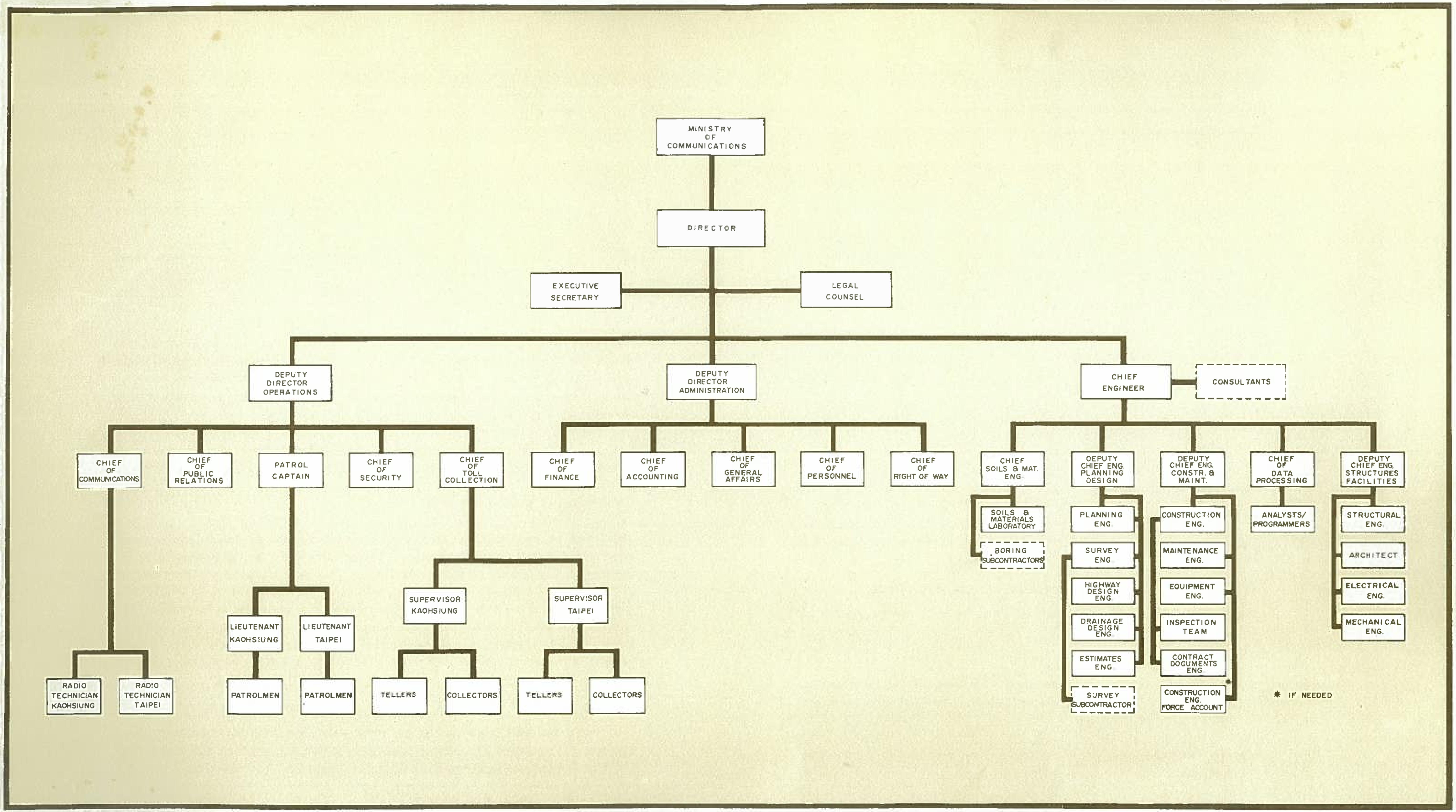
The Director would have three main assistants to help him in performing his duties.



COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN

ULTIMATE TOLL ROAD ORGANIZATI[N]

DE LEUW, CATHER INTERNATIONAL-CHICAGO



COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN

INTERIM TOLL ROAD ORGANIZATION

DE LEUW, CATHER INTERNATIONAL CHICAGO

These would be the Deputy Director of Operations, the Deputy Director of Administration and the Chief Engineer. In addition, the Director's top assistants would include a Legal Counsel who would attend to all legal matters concerning the toll road authority and an Executive Secretary who would handle all detail work for the Director and act as a liaison man directly reporting to him.

Deputy Director-Operations

This office under the Director would be responsible for communications, public relations, patrol, security and toll collection operations. The Deputy Director-Operations would perform the following major functions:

Act as liaison between the Director and chiefs of operations.

Give instructions and guidelines for cooperative efforts among operations chiefs and their departments.

Attend conferences, representing the Director when he would be unable to attend.

Deputy Director-Administration

This office under the Director would be responsible for the administration of finance, accounting, general affairs, personnel, data processing and right-of-way. The Deputy Director-Administration would perform the following major functions:

Act as liaison between the Director and the chiefs of administrative offices.

Give guidelines of coordination between administrative offices.

Represent the Director at conferences when he is unable to attend.

Chief Engineer

The office of the Chief Engineer would be responsible for planning, maintenance, equipment and materials, and research and development. The Chief Engineer would perform the following major functions:

Direct all highway and bridge construction, and maintenance activities on the toll road.

Direct major engineering functions of highway programs, such as the development of plans, all materials testing, special highway studies and planning, and other engineering functions of comparable scope and complexity.

Serve as a principal assistant to the Director by coordinating internal department operations and providing professional guidance and direction.

Establish and direct the maintenance of a system to schedule and monitor all highway preconstruction activities.

Coordinate assigned activities and professional guidance to meet established deadlines and priorities.

Legal Counsel

The Legal Counsel for the toll road would report directly to the Director. He should be versed in law, have legal education and experience in civic and municipal work, and be familiar with common highway problems. He must be versed in property condemnation proceedings, property line disputes and descriptions processes. He must also be familiar with motor vehicle and traffic laws.

Counsel would, at the request of the Director, bring suit for the toll road when necessary, and prepare the defense when the toll road authority is being sued.

Executive Secretary

The office of the Executive Secretary would handle complex secretarial work involving the performance of delegated administrative duties and the relieving of the Director of important administrative details. The work would require the exercise of considerable initiative, independent judgment, and discretion in screening calls, visitors and mail, and answering and disposing of requests for information. The work would involve responsible supervisory and office management responsibilities. He would attend meetings and conferences, take minutes, compose drafts of proceeding, and prepare agendas and materials in accordance with established practices.

Chief of Communications

This would be highly technical and supervisory work involving the installation, maintenance, and operation of a radio broadcasting station and receiving equipment. The Chief of Communications would perform the following major functions:

Plan, assign, and review the work of employees repairing and maintaining radio broadcasting and receiving equipment

Inspect new equipment and construction to determine compliance with specifications, and direct and participate in major repair or other complex work.

Conduct technical tests of radio broadcasting equipment to determine compliance with rules and regulations of the Ministry of Communications governing operation of licensed radio stations.

Design new facilities.

Recommend purchase of and prepare specifications for, broadcasting equipment, parts and supplies.

See that dispatches comply with Ministry of Communications regulations.

Chief of Public Relations

The Chief of Public Relations would perform the following major functions:

Plan, organize, and direct a comprehensive public relations and information program.

Supervise a staff of technical and clerical employees engaged in public relations and informational activities.

Formulate and direct the release of news to the press.

Assist administrative officials in policy planning and employee relations.

Direct the development of publications, including regular reports and special comprehensive books of an educational or related nature.

Organize and direct the assembly of speech material for departmental and other officials.

Organize and direct public relations activities.

Plan lay-outs and arrange for photographic illustrations.

Patrol Captain

The Captain of the Highway Patrol would be in charge of all law enforcement on the toll road.

This would be administrative and supervisory work in law enforcement and traffic supervision on the toll road. The work would involve technical police supervision of law enforcement personnel, and the directing, advising and organizing of training seminars for troopers, periodically.

The work would be performed under the direct supervision of the Deputy Director of Operations and include the conferring on budgeting requirements for highway patrol operations, and the review of policies desired by the Director, for operating the toll road.

The Patrol Captain would hold staff meetings. He would also hold marksman contests, for training and preparing troopers to be disciplined and efficient, and contests to improve physical and mental alertness of his troopers. He would grade his men on their operation under strict rules of conduct.

He would train his troopers to take charge of a section of the toll road, and to render service to patrons, as well as, to police the traffic properly.

It is recommended that he have two lieutenants under him, one based in Taipei and one in Kaohsiung, each of whom would be in charge of a division.

Chief of Security

The Chief of Security should have both legal and political experience, and be given proper government authority to represent the toll road authority on all matters of law.

He must be versed in techniques of operation which would make him the proper guardian of security on the toll road. He would be responsible for setting up procedures for checking necessary operations to insure proper security in the organization, and for establishing rapport with the proper toll road officers to insure cooperation among departments. The Patrol Captain would be apprised of all situations, on which the security officers felt the need of cooperation with his department. Tape recordings of communications should be made available to the Chief of Security by dispatchers in the communications office at his request.

Chief of Toll Collection

The work would involve the overall responsibility for the organization, administration, and supervision of the collection section. The Chief of Toll Collection would perform the following major functions:

Supervise all toll plaza supervisors, tellers, toll collection maintenance personnel and the traveling custodians for the entire toll road.

Be responsible for the proper maintenance, servicing, and upkeep of the toll road equipment and vehicles assigned to the toll collection department.

Requisition an adequate supply of all items for the collection of tolls, such as: report forms, office supplies, janitorial supplies, and all other items necessary for proper operation of the toll collection department.

Maintain close harmony and cooperation between the toll collection department and all other departments of the toll road organization.

Be responsible for recommending the employment of new collectors and the termination of incompetent personnel, and for marking periodic reviews of the performance of toll collectors to insure that their accounts are properly maintained.

Conduct meetings of supervisory personnel when needed for the purpose of discussing toll collection procedures and other matters pertaining to the toll collection department.

Approve vacation schedules for all employees assigned to the toll collection department.

Be responsible for all the toll collection facilities and for the assignment of collectors to each plaza.

Chief of Finance

This would be advanced administrative work, dealing with the financial planning, management and fiscal operations required for a toll road operation. The Chief of Finance would perform the following major functions:

Direct financial planning and programming for the agency.

Administer fiscal operations for the agency, check contracts, pass on all fiscal payments by the agency and income for the agency.

Act as representative for the toll road authority in dealing and negotiating financial matters with other agencies.

Chief of Accounting and Auditing

This would be advanced administrative and professional accounting and related financial work. The Chief of Accounting and Auditing would perform the following major functions:

Administer the accounting and fiscal operations of the toll road authority.

Perform the more complicated and complex accounting, auditing, and fiscal operations.

Train professional employees and help develop their capabilities.

Prepare and develop systems and procedures for agency fiscal operations and enforce compliance with them.

Consult with agency heads and other responsible officials, including those concerned with overall accounting procedures.

Supervise the review of financial data submitted, and verify employee and employer contributions toward retirement benefits.

Provide technical knowledge on accounting and fiscal procedures.

Prepare periodic reports showing all receipts and disbursements.

Chief of General Affairs

This would be general administrative support work. The Chief of General Affairs would perform the following major functions:

Supervise maintenance of properties owned by the agency and the cleaning of administration offices.

Keep adequate office supplies and distribute them on request from other sections.

Keep central filing system for documents and transactions.

Provide and schedule bus transportation for employees.

Supervise document processing, typing, clerical work and the handling of all incoming and outgoing mail.

Handle and check complaints involving administration offices of the agency.

Chief of Personnel

This would be advanced administrative work, dealing with records of, and rules for, individuals who would be on the payroll of the toll road. The Chief of Personnel would perform the following major functions:

Receive and pass on all personnel who apply for positions with the agency.

Keep records of vital statistics on all individuals who are employed.

Keep records of qualifications of personnel and confer with department heads on job requirements and the classifying of abilities and qualifications of personnel.

Chief of Data Processing

This would be highly responsible administrative and technical work in planning, organizing, and directing the activities of an electronic data processing section. The Chief of Data Processing would perform the following major functions:

Plan, organize, and direct the programming, system analysis, and operational activities of the electronic data processing section.

Confer with administrative officials, engineers, and other concerned persons to determine specific management and information needs.

Supervise directly, or through subordinate supervisors, a staff of programmers, systems analysts, and other technical and clerical employees engaged in activities of the section.

Confer with, and advise, subordinate personnel on administrative policies and procedures, and technical problems, priorities, and methods.

Analyze and evaluate current and new data processing equipment, determine ways and means by which further automation may be economically and efficiently effected, and make recommendations to administrative officials concerning the replacement of obsolete equipment with more advanced and efficient machines of greater capacity and versatility.

Determine and select problems and projects for application of electronic data processing, plan and devise the scope and objectives of studies, and supervise the development, evaluation, and analysis of subject matter under consideration.

Plan, direct, and administer training programs for both technical and non-technical employees, review and revise on-the-job training methods and techniques, and schedule and assign personnel to formal training classes.

Direct the preparation and maintenance of necessary records and reports.

Chief of Right-of-Way

This would be highly responsible work in the field of ownership of real estate. The Chief of Right-of-Way would perform the following major functions:

Review and analyze plans drawn up for describing requirements of toll road right-of-way.

Write legal descriptions of right-of-way requirements.

Keep records of all right-of-way transactions.

Handle acquisition of property as needed.

Inspect and take necessary actions on encroachments to the toll road right-of-way.

With the assistance of Legal Counsel, prepare contracts, including rules and regulations for concessions.

Inspect operations of concessionaires.

Deputy Chief Engineer-Planning

This would be work involving the planning for additions, improvements, and widenings to the roadway and facilities. The Deputy Chief Engineer-Planning would perform the following functions:

Conduct traffic surveys and review the traffic growth.

Determine needs and priorities for new construction and improvements.

Prepare long-range and annual programs and budgets for improvement and construction.

Supervise the operation of reproduction facilities.

Deputy Chief Engineer-Maintenance

The Deputy Chief Engineer-Maintenance would be responsible for the proper maintenance of all roadway, structures, buildings and utilities of the toll road. He would also supervise any new construction and major improvement projects. The Deputy Chief Engineer-Maintenance would perform the following major functions:

Control the activities of project engineers supervising the inspection of all construction materials and workmanship on assigned projects.

Direct all highway, bridge, building and utility maintenance, and all materials testing, control, and sampling.

Supervise all testing and analysis work.

Assist in the preparation of specifications, and the devising of new or modified techniques.

Provide professional advice in resolving unusual material or soils control problems, and in improving testing and sampling techniques.

Provide direction and guidance in the construction, maintenance, and operation of roads and bridges.

Recommend maintenance practices.

Interpret applicable engineering and administrative directives, policies, and standards.

Deputy Chief Engineer-Equipment and Materials

This would be administrative work in directing the highway equipment maintenance, repair, and replacement program. The Deputy Chief Engineer-Equipment and Materials would perform the following major functions:

Direct the maintenance, repair, and replacement of all highway automotive and related mechanical equipment.

Prepare recommendations and specifications for new equipment budgets.

Establish procedures and guidelines for the maintenance, repair, and operation of highway equipment.

Supervise and conduct inspection of highway equipment repair shops.

Provide guidance and direction on major repair problems.

Inspect and approve newly purchased equipment.

Approve the design, construction, and modification of equipment in highway shops.

Supervise the processing of equipment purchase requests, the preparation of equipment cost records and summaries of equipment and repair shop inspection, and the keeping of related records.

Supervise a staff of employees in obtaining prices and bids, preparing tabulations of prices, and placing orders for materials, supplies, and equipment.

Interim Toll Road Organization

The operations and administration departments would be the same as shown for the ultimate organization, with the exception of the data processing section. This section, because of the heavy use of its equipment in designing bridges and highways, would be under the Chief Engineer during the interim period, and then would be transferred to the administration department.

Under the Chief Engineer there would be five sections, basically oriented to perform the functions of planning, design and construction. Maintenance and equipment engineers would report to the Deputy Chief Engineer-Construction and Maintenance.

During the transition from the interim organization to the ultimate organization, the Deputy Chief Engineer-Planning and Design would become the Deputy Chief Engineer-Planning. The Deputy Chief Engineer-Construction and Maintenance would become the Deputy Chief Engineer-Maintenance. The Equipment Engineer would be elevated to the position of Deputy Chief Engineer-Equipment and Materials. The Deputy Chief Engineer-Structures and Facilities would become the Deputy

Chief Engineer-Research and Development, and the soils and materials engineers would be assigned to his section.

TOLL ROAD FACILITIES AND EQUIPMENT

Proper operation and maintenance of the toll road requires that certain facilities and equipment be provided for the staff described in the preceding section. Other facilities and equipment are necessary to provide service to the traveling public using the toll road. These facilities include administration buildings, equipment repair shops, maintenance yards, toll plazas, toll collection equipment, vehicle weighing facilities, communications facilities, public fuel and repair service stations, restaurants, and rest and recreation areas.

We have established various design parameters and concepts for these facilities which reflect the specific and unique requirements of the toll road authority. These design concepts are not intended to establish final criteria, but rather to define and illustrate the typical facilities which are needed. The architectural concepts provide for modern styling, give consideration to cultural aspects, and maximize the use of domestic materials and construction techniques. Integrated systems and forms inter-relate all facilities and unify the overall plan.

Exhibit 15 presents approximate locations of administration buildings, maintenance yards, toll plazas, service stations, and rest and recreational areas. Exact locations should be determined only after the toll road alignment and interchanges have been fixed. These locations should be discussed with local and regional planning agencies, and coordinated with existing and future land use plans.

Facilities for Headquarters Administration, Equipment Repair, and Maintenance

The headquarters administration building, and equipment repair and maintenance facilities should be located in the vicinity of Taipei, the primary seat of the national and provincial governments. Exhibit 16 illustrates typical site arrangements for these facilities. The administration, repair, and maintenance facilities are located adjacent to each other for convenience and to promote efficiency.

Exhibits 17, 18 and 19 provide details of the Taipei administration building. This facility would house the main administrative functions and is sized to accommodate the initial organization, with allowances for future expansion.

Movable partitions are proposed, to permit maximum flexibility in interior arrangements and to accommodate future changing conditions. The basement would house all mechanical functions. An electric generator is recommended for emergency power supply to assure continued service in the event a typhoon or tropical storm would cause a main power failure.

Exhibits 20 and 21 present details of the repair, maintenance and storage areas at the headquarters site. Major equipment repairs and toll road facility maintenance functions for the northern one-half of the toll road would be provided at the Taipei facility. Space would be allocated for maintenance vehicles and materials storage, as well as, painting and sign shops. These rather hazardous work areas would be separated from the main activities within the maintenance complex. Storage requirements for maintenance materials, such as asphaltic patching material, sand and gravel, cement, fencing guardrail replacement parts, signs, lighting lamps and standards, equipment repair parts and other materials, would be determined by the maintenance engineer. Appendix G describes the equipment which would be assigned to this headquarters maintenance yard.

Division Administration and Maintenance Facilities

A division headquarters is recommended to be located at Kaohsiung, to handle the major equipment repairs and maintenance functions for the southern one-half of the toll road. Exhibit 16 illustrates the possible site arrangements for administration and maintenance buildings. Details of the division administration building are shown in Exhibits 22 and 23. Maintenance and storage buildings would be identical to the ones proposed for Taipei, as shown in Exhibits 20 and 21.

The maintenance engineer for the southern one-half of the toll road would be in charge of the Kaohsiung division. The maintenance equipment required for his division would be identical to that assigned to the Taipei yard and described in Appendix G.

Section Maintenance Building

Six smaller section maintenance buildings are recommended to be constructed at the approximate locations shown on Exhibit 15. Final locations should only be established during the design phase. These buildings should be located close to interchanges for easy access to the freeway. Exhibit 24 shows details of a section maintenance building.

Together with the two main facilities in Taipei and Kaohsiung, there would be a total of eight maintenance yards along the freeway, for an average length of 50 freeway kilometers in each maintenance section. These maintenance stations would be equipped to provide service for minor equipment repairs.

Where electricity, water and sewage disposal would not be readily available from city supplies, small plants of adequate size to serve their requirements would need to be constructed.

The equipment which would need to be assigned to each maintenance section are described in Appendix G.

Toll Plazas

Ten barrier type toll plazas are recommended to be located along the toll road. Exhibit 15 shows the approximate locations. Exact locations can only be established during the design phase. Toll plazas should be located on long straight tangents to allow maximum sight distance and efficient traffic operations. Exhibit 25 illustrates a typical toll plaza for a four-lane roadway. Separate lanes are provided for automobiles (light trucks and taxis will use the same lane with the autos), heavy trucks and buses. Three toll booths are specified to serve each freeway lane during peak hours.

The reversible lane concept, using manually placed rubber cones, is recommended at all barrier type toll plazas. A common traffic distribution between two directions of flow is 60-40. However, in certain instances, a 70-30 or even an 80-20 traffic split may be experienced due to recreational or industrial areas near the freeway. In the illustrated design for a four-lane roadway, a total of nine toll booths are proposed, using two reversible lanes during peak periods. This would allow for six lanes in the peak direction and four lanes in the opposite direction for a 60-40 percent traffic distribution.

A six-lane freeway would require a total of fourteen lanes with nine lanes in the direction of peak hour flow and five lanes in the opposite direction for a 60-40 percent traffic distribution. An eight-lane freeway would require a total of twenty lanes for a twelve and eight lane peak hour distribution for the desired traffic split.

The general criteria provide for a minimum of a 1 to 10 taper, but preferrably 1 to 12 for the transitional approaches from the freeway lanes to the toll booth lanes. The vertical alignment is indicated in the lower part of Exhibit 25 with a flat gradient through the toll booths and a desirable gradient of 0.5 percent and a maximum of 1.0 percent sloping away from the toll booths. This would facilitate vehicle deceleration while approaching the toll facility and acceleration when leaving the toll plaza. It would also allow for a possible future concrete tunnel to be built under the toll booths which might be used to assist in removing money from the toll booths.

Drainage away from the plaza and booths is accommodated with this profile arrangement. Drainage across the lanes is best achieved with a 1½ percent cross slope away from the centerline followed by a 2 percent cross slope. A 1½ percent cross slope at the center would require only a three percent crossover for the reversible lanes.

Lanes widths through the toll booths provide for the minimum clearance requirements for cars, trucks and buses.

Ease of operation and safety is an important consideration in the design of the barrier type toll plaza. The consequences of forcing a compulsory stop for the motorist on a high-speed freeway have to be seriously considered. Many accidents have taken place at barrier type plazas because motorists failed to comprehend the situation.

Adequate advance warning signs should be posted. Striping for lane transitions from one lane on the freeway to three lanes through the booths can be accomplished as indicated with allowance for reversible lanes. Two methods of striping, which will alert the inattentive driver of the stop condition ahead, are indicated in Exhibit 25. The wiggly lines on the approach lanes usually have a profound impact on the driver. Another method using a series of horizontal strips, as shown on the left side approaches, would present a continuous warning to stop. The construction of two "rumble strips" as indicated for each approach would give a physical and positive warning of impending danger ahead.

Curbing, as indicated in Exhibit 25, should be provided to control traffic movements and to give access to and from the freeway for police and toll road personnel.

The location of the toll facility near a local road with a connection to it is desirable but not essential. Adequate parking should be provided for toll road personnel with additional space for police and visiting headquarters officials. Parking spaces should be proportionally allocated as to personnel requirements for four-lane, six-lane and eight-lane facilities.

Truck parking, as shown in dashed lines in Exhibit 25 should be provided when a truck weight station is incorporated with the toll collection facilities.

Manual toll collection is recommended in this report, with no tickets being issued by the attendant. Alternative toll collection systems have been considered. The cost of installation and maintenance of automatic equipment is much higher in comparison with the manual requirements. Also, highly trained technicians, who are capable of providing quick repairs, would be needed. In almost every case the automatic equipment has proven to be much slower and less convenient because most motorists are generally not ready with the correct sum of money needed.

Each booth would be provided with an automatic counter and time clock. The attendant, when he begins and leaves his shift, would punch his card, which would show the hours and the number of vehicles passing the booth. He must account for the money, which would be computed by multiplying the number of vehicles during his shift by the toll charge for each vehicle. A master counter, which would be installed in the supervisor's room, would show the traffic volumes on all toll lanes.

Some of the toll plazas would have electronic weighing scales for control of axle loads. Exhibit 15 shows the location of toll plazas with such scales. Special equipment installed in the truck lanes would be able to differentiate single and tandem axles, and indicators installed in toll booths would warn the attendants of overloaded trucks. These trucks would be directed by the attendant to the truck parking space for the highway patrol to issue citations.

Toll Plaza Administation Building

Exhibits 26, 27 and 28 illustrate an administration building required for a typical toll plaza. The building would be linked with a canopy to toll booths to permit covered access during inclement weather. It would be elevated to provide better visual control of toll plaza activities. Space would be provided for the supervisor, the highway patrol, toll collectors and tellers.

Communication Facilities

A modern, comprehensive and technically proficient and reliable communications system is essential for proper operation and maintenance of the toll road. Some portions of the system must be immediately and exclusively available to the toll road staff. Other portions could be provided within the commercial service of the national system.

The following communications services are essential:

Telephone connections between administrative and maintenance buildings and the national system.

Telephone connections between all administrative, maintenance, toll plazas, service stations and rest and recreational areas within the toll road.

Radio communications between all fixed installations and mobile units of the toll road patrol, maintenance forces and management personnel.

These essential services should be integrated through switching equipment so that complete communications would be possible between mobile stations, fixed stations and service connections within the national system.

The following communications services are desirable:

Emergency telephones at selected intervals along the toll road for use by motorists in distress. These emergency telephones should be connected to the nearest communications center on the toll road.

Public telephones at service, rest and recreational, and other areas on the toll road. These telephones should be connected with the national system.

Other features, which might be integrated with the communications facilities, would be traffic warning or control devices at various places along the toll road.

Facilities Which Must Be Exclusively and Immediately Available To The Toll Road Staff

Telecommunications between all fixed installations and radio communications with all mobile units of the toll road patrol and maintenance vehicles must be immediately, continuously and exclusively available to the toll road staff. This requirement is justifiable so that immediate action can be taken in law enforcement and for public safety in cases of accidents or development of hazards to motorists.

Discussion of Possible Systems

Each fixed installation on the toll road should have one or more line connections to the national telecommunications system. These lines should be connected through a switchboard to cables, which may be owned or leased, and which would interconnect all fixed installations directly. The switchboard should be connected manually with all fixed and mobile radio receivers and transmitters.

Instead of a cable connected system for all fixed installations on the toll road, a microwave system could be provided. The microwave system has some advantages:

It could be the independent, exclusive system needed for immediate use by the toll road staff.

It would remain operable if the national system were to have communications traffic demands during certain periods which exceeded its capacity.

Since radio antennae are needed at all base transmitters (usually at all major administrative and maintenance centers), they could also act as towers for the microwave system. Very few extra towers for the microwave system would be likely to be needed. This would offer some cost and maintenance advantages.

Integrated radio-microwave systems are available which would place all fixed and mobile stations within instant contact with each other by a simple switch on the hand piece.

The selection of a system of telecommunications (owned or leased, cable or microwave) could be influenced by the decision on the frequency of emergency telephones along the toll road. Intervals as frequent as one kilometer, on each side of the toll road, have been considered in Japan and elsewhere. Installations of this sort in the United States have suffered from vandalism, high maintenance expense and relatively low rates of usage.

The highway patrol operation, which should provide coverage of any point on the toll road at 30-minute intervals, plus maintenance traffic reduce the need for closely spaced emergency telephones. If emergency telephones were to be placed at one-kilometer intervals on both sides of the toll road, the desirability of a cable system relative to a microwave system would be enhanced.

We believe, however, that the mobile radio system which would be available on every patrol and maintenance vehicle, and the frequent patrolling of the toll road, negates the benefits of a closely spaced emergency telephone system. These benefits appear to be slight, so that it would seem advisable that no decision be reached on whether or not to incorporate an emergency telephone system within the toll road communications system, until after an experimental section would have given better insight into its advantages.

We believe that the two-way radio-microwave system used on the Kansas Turnpike has advantages which would be beneficial to efficient operation of the North-South Freeway.

Recommended Two-Way Radio-Microwave

Two-way mobile radio units should be installed in selected vehicles (highway patrol cars, maintenance trucks, and cars of the toll road officials).

Two-way fixed-station radio units should be installed at all toll plaza administration and maintenance centers and at service areas.

Microwave stations, with a service channel, an alarm system, multiplex equipment, audio amplifiers with speakers, battery charges, dial desk sets with two-way audio and push-to-talk facilities, and monitor units should be installed in all administration, maintenance and service areas along the toll road.

The headquarters control center should include a console desk with mounted equipment and a two-channel, two-deck recorder.

Microwave towers would be required at about 40-kilometer intervals. These towers might also serve as radio antennae.

Radio facilities should include two channels. One would be for the toll road patrol, and the other would be for maintenance and general service.

Technicians would establish microwave towers and radio antennae at proper intervals. These must be watched over by communication personnel to assure they remain undamaged. The dispatchers must be familiar with indicators and devices on the installed system which would point out all problems that affect the proper functioning of the communication equipment. They should equip their office with travel and other information in order to be useful whenever inquiries might be made. Appendix D describes the details of communication procedures.

The Chief of Communications should organize training courses for all road staff on the proper methods of giving or receiving messages on the radio equipment or microwave. A manual, indicating the standard rules and procedures, should be given to each toll road radio or microwave user. Each radio technician should receive special instructions for installing equipment in the cars and trucks, and for the placing of aerials. Each should be adept at checking local interference problems and correcting same. The Chief of Communications should establish a rapport with the Patrol Captain, and, together they should establish rules of conduct to fit all emergency situations.

Supplemental Facilities

Supplemental facilities are defined as service, recreational, and rest areas. Six service and recreational areas, and three rest areas are indicated on Exhibit 15.

Basically, service areas would supply fuel and oil for vehicles, and food for motorists, and should be located in open or isolated areas, removed from interchanges and built up areas, for maximum utilization.

Recreational areas would normally contain hotel or tourist accommodations for an overnight stay, as well as service stations for fuel, oil and minor repairs. Scenic lookout points and natural beauty spots should be chosen for recreational areas.

It may be desirable to make use of one, or all, of the six designated areas for combined service and recreational areas, depending on governmental policy.

Recommended locations for rest areas are shown in Exhibit 15. Rest area sites should be selected at scenic locations to remove the possibility of motorists stopping on the shoulders and walking along the edge of the freeway. They should also encourage the weary motorist to pull off the road, instead of continuing on as a potential accident hazard, and should serve as a convenience for the motorists to stop and look at maps for orientation.

Sites that appear to offer promising panoramic views include: (1) between Keelung and Taipei, overlooking the Keelung River; (2) just south of Linkou Plateau; (3) along the gently curving slopes just north of Hsinchu; and (4) between Taichung and Changhua, along the curving, hilly section, overlooking the Tatu River. Other areas should be investigated during the preliminary design stages of the freeway sections between Changhua and Kaohsiung, in order to exploit the various scenic vistas over rice paddy fields and the views of the sea.

All the supplemental facilities should be located at least one kilometer, and preferrably further, away from interchange ramps and toll facilities to avoid undesirable weaving maneuvers and signing problems.

Service Areas

Each service area would be a completely self-sufficient development, and may need to maintain its own water, sewage disposal, drainage utilities and power supply. Advantage should be taken of nearby municipal utilities whenever possible. Emergency water supply and electric power generating units should be constructed so that service areas would not have to be completely dependent on local utilities. The water tower, 30 meters or so in height, would also serve as a reference point for driver orientation regarding the service area. Service stations and truck parking areas should be located so they are out of sight and inaudible, to the maximum extent possible, to persons in the restaurant, and to those driving along the freeway.

Car parking should be removed also from the entrance to the restaurant, which would not only provide a more tranquil atmosphere around the restaurant, but would also remove a potential source of litter from its immediate environs.

Landscaping should be used to obtain a screening effect, both within the service area and between it and the freeway. Only shrubbery and small trees should be used between the freeway and the service area, to serve as an audio-visual, as well as, a safety, barrier and to cushion the collision of impact if an occasional vehicle would lose control along the freeway.

Wherever feasible, service and recreational facilities should be located so that adequate water, sewage disposal, drainage and electric power can be made available at low cost.

Gasoline stations in service areas must supply automobile and truck accessories, such as tires, fan belts, auto water hoses, and batteries, as well as gasoline and oil. These stations should be equipped with service trucks (with winches) which could be called to take a stranded vehicle from a ditch, or to fill a car or truck with fuel. If a car or truck would be stranded because of motor or other trouble it should be brought to the station and stored until the patrol decides what action to take. The station should also have a light pickup truck in service for delivering gas to, or for repairing, distressed vehicles. Exhibit 29 shows a typical, layout of a service station.

The restaurant in the service area should be equipped to feed all patrons who require food and drink during their travel on the toll road. It should be kept clean, and should furnish good food at standard prices.

These facilities may be leased by contract to concessionaires with satisfactory experience, stability, and integrity, to assure the correct kind of service to the traveling public. All required small equipment should be furnished by the conces-

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
FACILITY LOCATIONS
DE LEUW, CATHER INTERNATIONAL CHICAGO

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
FACILITY LOCATIONS
DE LEUW, CATHER INTERNATIONAL-CHICAGO

sionaire and be kept in sufficiently good condition, as to be acceptable to the authority inspector. The contract between the toll road authority and each concessionaire should be spelled out in detail, so as to remove all doubt as to which would be the responsible party in all service requirements. Special note should be taken of maintenance requirements for service area buildings and utilities. (See Appendix H for sample contracts for the operation of concessions on a toll road.)

Exhibit 30 shows various types of service areas. Type A would be constructed at the intended location with the entire facility located within the median. This design has been used with safety and efficiency in the United States. It is economical in that a single unit can serve traffic in both directions along the freeway. This would result in large savings in initial construction costs, right-of-way and personnel requirements. It should be noted that cars would not be able to cross from one side to the other, except through a gate, to preclude a motorist going in the wrong direction on the freeway after he has stopped and resumed his journey. The main disadvantage of this scheme is that traffic would have to enter and leave the freeway on the left, and enter and exit via ramps. However, this detrimental feature could be overcome by adequate signing, along with selecting locations that would provide sufficient advance observability.

Type B would be constructed as a dual facility on both sides of the freeway. The costs of a Type B area would be double those for Type A. But Type B would have the conventional ramp approach, and departure lanes along the right side of the freeway driving lanes.

A third type of service area is shown in Exhibit 31. In order to minimize the right-of-way requirement, the restaurant would be placed over the freeway. Exhibits 32 and 33 illustrate such a restaurant building. This design concept conserves land and avoids duplication. A modified bridge structure would be used for the structural system. Voids in the box girders would accommodate mechanical and electrical systems. The restaurant facility shown would accommodate approximately 200 persons under peak conditions.

Recreational Areas

Two proposals are shown for recreational areas in Exhibit 34. Recreational areas would differ from service areas in that they would cater to freeway users desiring a longer stay such as overnight or for a weekend. They would be developed, centering on a hotel in a park-like setting, with fountains, statues, park benches and such recreational facilities as swimming pools and tennis courts. A service station, inconspicuously located, would be contained within the area.

Type A would allow access to both directions along the freeway via a trumpet interchange. It would have a circumferential two-lane highway to minimize vehicular activity in the area. This proposal illustrates possible recreational facilities such as a rowing pond, a fish pond, a miniature golf course, and a park pavilion for band concerts. A toll plaza may or may not be included at the entrance, but might be desirable if the area is to be operated by a government agency, and vehicle entry records kept, as well as the collection fees.

Type B shows a recreational area contained within a rotary interchange. The principal feature of this proposal is its division into two sections. The upper section would consist of a recreational area only, with all the requirements for the pleasure and diversion of the average tourist. The lower section would have a service station, a truck parking area, and camping facilities for the economy-minded tourist. The freeway would act as a land use barrier, completely segregating the two different facilities, but at the same time providing both functional utilities and recreational activities within one accessible area.

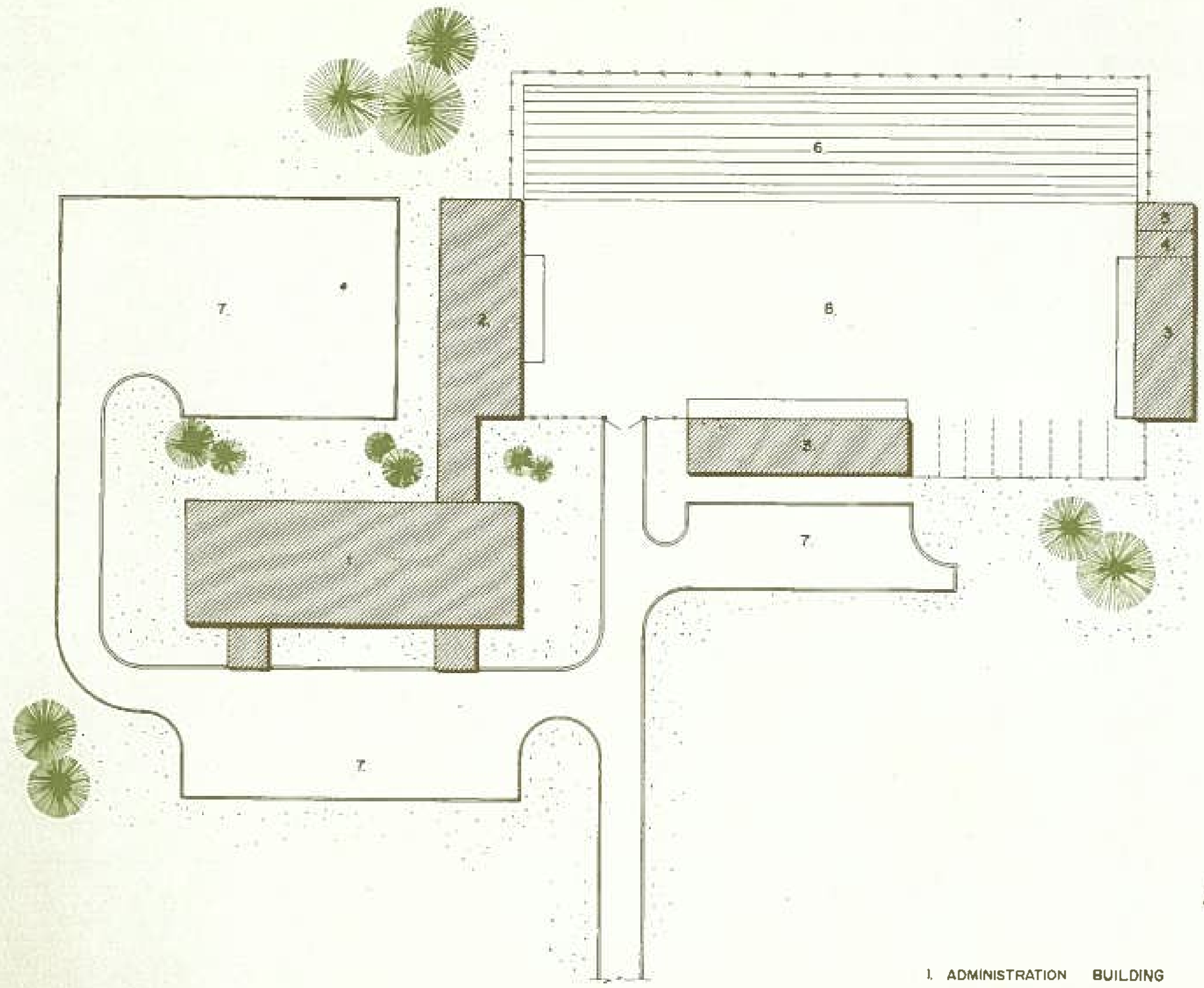
Rest Areas

Three types of rest areas are shown in Exhibit 35. (Only one facility is shown, serving traffic in one direction only, so that an identical rest area facility would have to be constructed on the other side of the freeway to serve traffic in both directions.) Rest areas are used only for temporary stops, and as picnic areas. Sufficient waste disposal units and adequate toilet and drinking water facilities (comfort stations) should be provided. These utility services are desirable to eliminate litter and wastedisposal. Nevertheless, a considerable amount of maintenance would be required by freeway personnel to maintain a high standard of cleanliness.

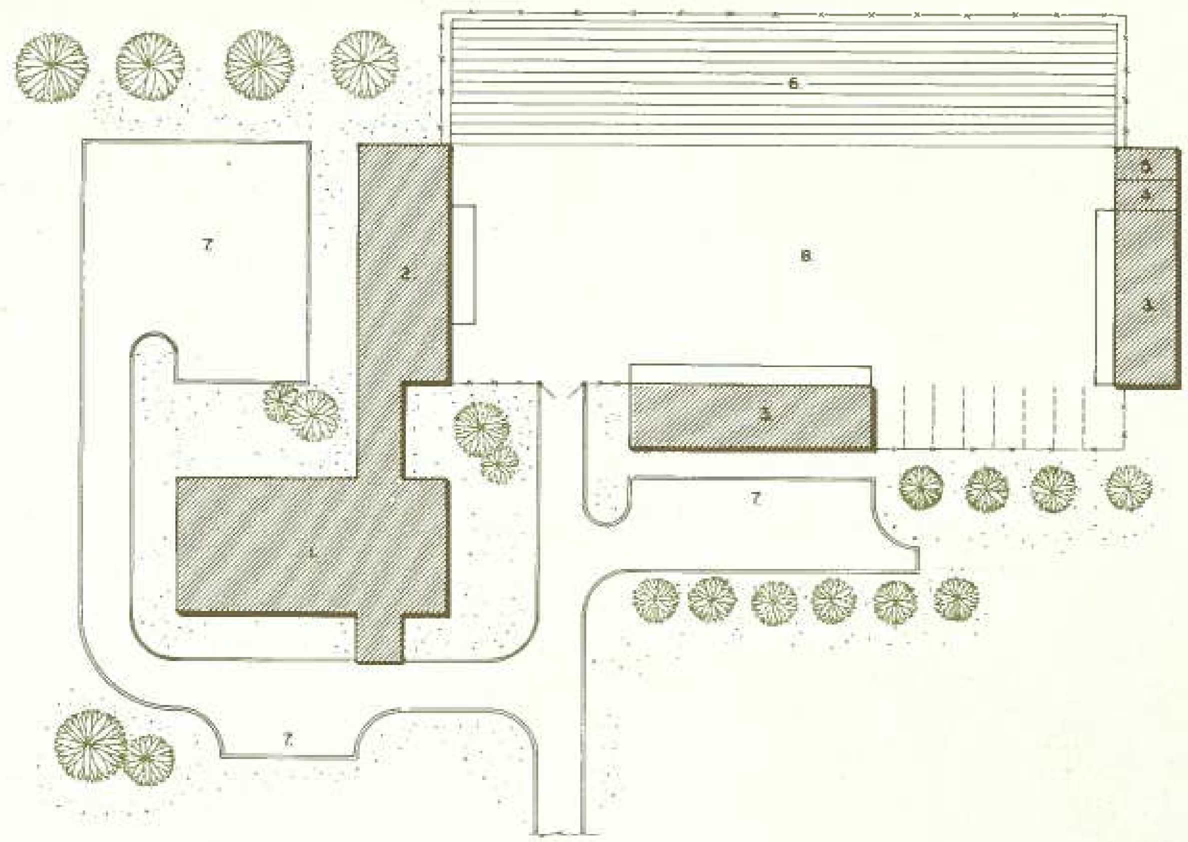
Types A and B are typical North American designs with standard acceleration and deceleration lanes and provision for the parking of cars, buses and trucks, and differ only in the parking arrangements of various vehicle types.

Type C varies from A and B in the arrangement of the acceleration and deceleration lanes. Minor weaving would occur, but this arrangement would offer the advantage of confining the acceleration and deceleration lanes within the length of the facility which may be useful in restricted areas, such as near an interchange.

It should be noted that, although two facilities are required for the designs shown, only one would be needed with the type of design shown for the service area, Type A, Exhibit 30.



TAIPEI



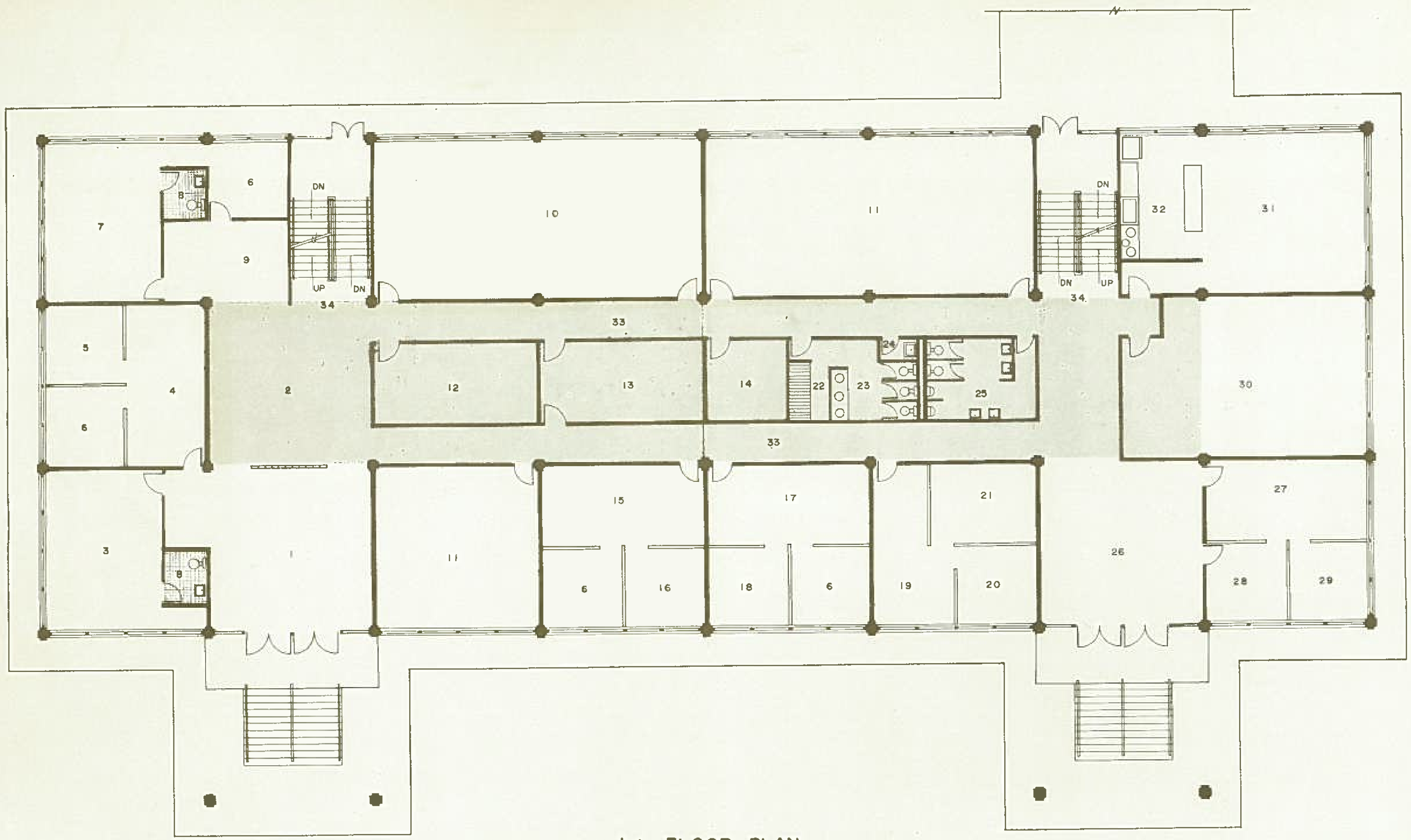
KAOHSIUNG

LEGEND

1. ADMINISTRATION BUILDING
2. MAINTENANCE BUILDING
3. STORAGE BUILDING
4. SIGN SHOP
5. PAINT SHOP
6. MATERIAL STORAGE
7. PARKING
8. PAVED AREA

SCALE IN METERS
0 10 20 30 40 50

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
HEADQUARTERS SITE PLANS
DE LEUW, CATHER INTERNATIONAL-CHICAGO



1st FLOOR PLAN

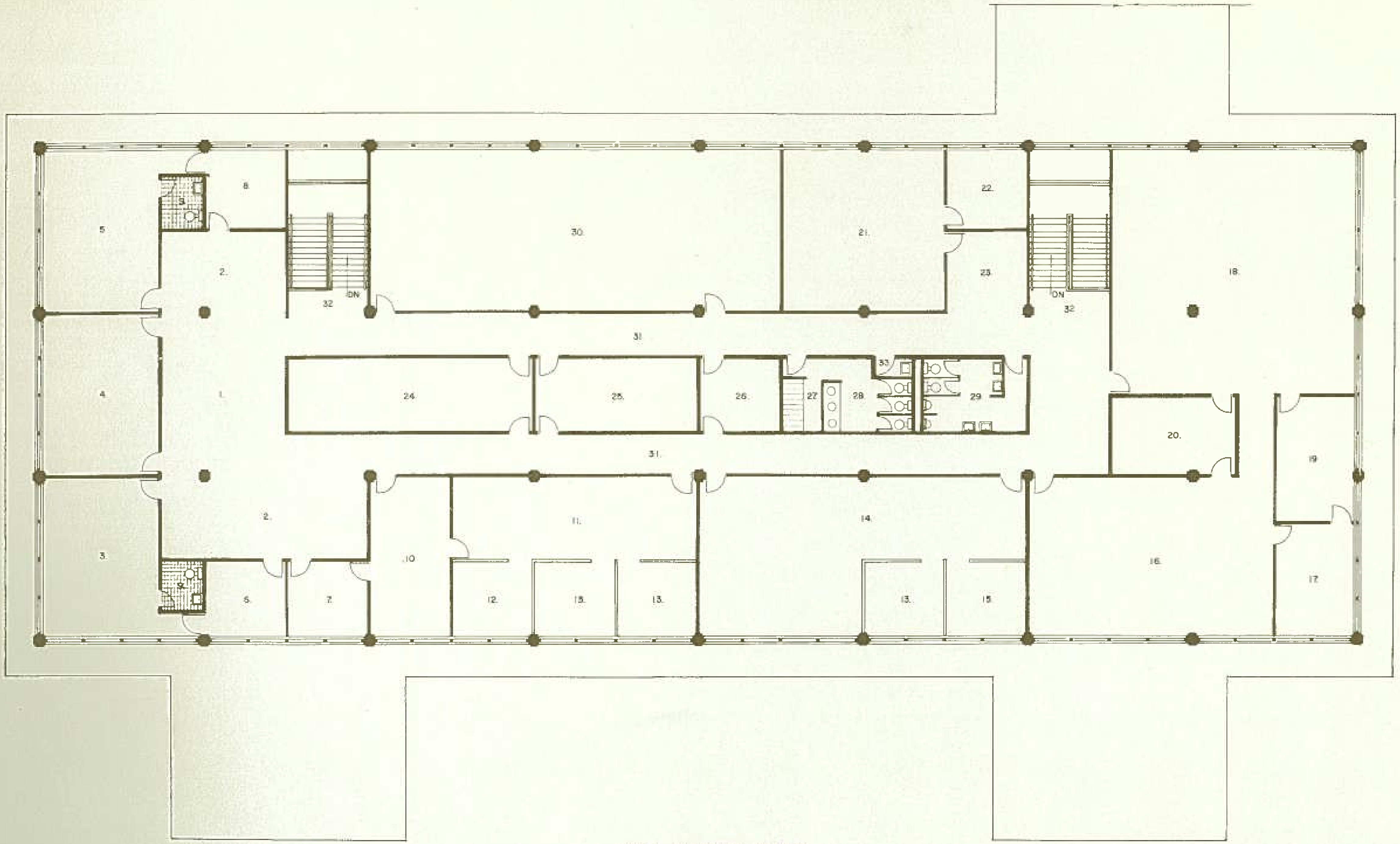
LEGEND

1. MAIN ENTRANCE LOBBY
2. WAITING AREA
3. DEPUTY DIRECTOR-OPERATIONS
4. PUBLIC RELATIONS DEPARTMENT
5. CHIEF OF PUBLIC RELATIONS
6. PRIVATE OFFICE
7. CHIEF ENGINEER
8. PRIVATE TOILET
9. SECRETARIES
10. ENGINEERING DEPARTMENT
11. UNASSIGNED SPACE (FUTURE EXPANSION)
12. REPRODUCTION ROOM
13. MECH.-ELEC. ROOM
14. FIRST AID ROOM
15. TOLL COLLECTION DEPARTMENT
16. CHIEF OF TOLL COLLECTION
17. SECURITY DEPARTMENT
18. CHIEF OF SECURITY
19. COMMUNICATION DEPARTMENT
20. CHIEF OF COMMUNICATION
21. RADIO ROOM
22. WOMEN'S REST ROOM
23. WOMEN'S TOILET
24. JANITORS' CLOSET
25. MEN'S TOILET
26. LOBBY
27. POLICE DEPARTMENT
28. LIEUTENANT
29. PATROL CAPTAIN
30. LIBRARY
31. LUNCHROOM
32. FOOD PREPARATION
33. CORRIDOR
34. STAIR

LOCATION OF BASEMENT

SCALE IN METERS
0 2 4 6 8 10

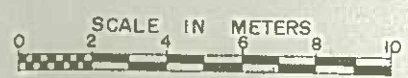
COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
TAIPEI ADMINISTRATION BUILDI[NG]
DE LEUW, CATHER INTERNATIONAL-CHICAGO



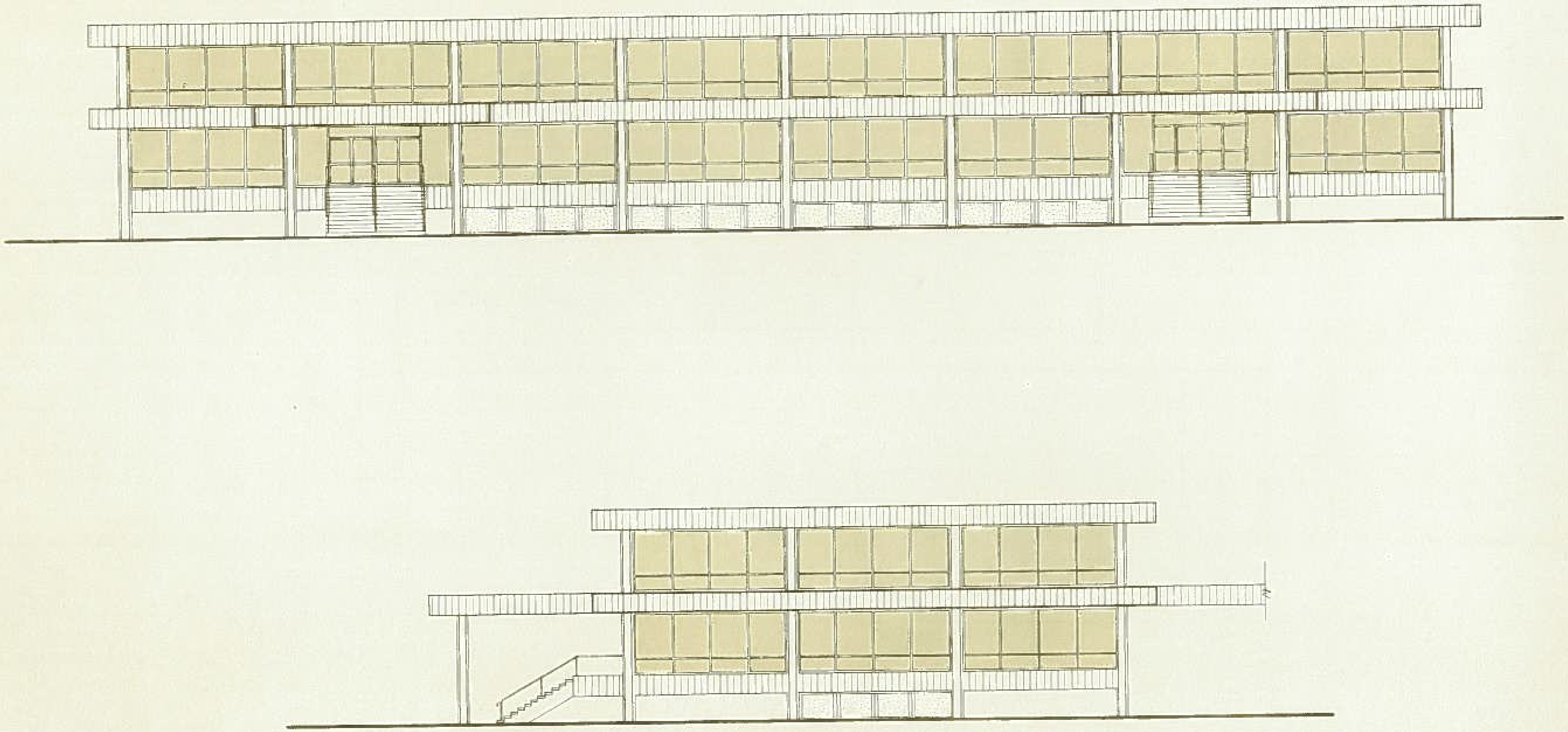
LEGEND

1. LOBBY AND WAITING AREA
2. SECRETARIES
3. DIRECTOR
4. CONFERENCE ROOM
5. DEPUTY DIRECTOR–ADMINISTRATION
6. EXECUTIVE SECRETARY
7. LEGAL COUNSEL
8. PRIVATE OFFICE
9. PRIVATE TOILET
10. LEGAL GENERAL OFFICE
11. R.O.W. GENERAL OFFICE
12. CHIEF OF R.O.W.
13. PRIVATE OFFICE
14. DATA PROCESSING DEPARTMENT–GENERAL OFFICE
15. CHIEF OF DATA PROCESSING
16. FINANCE DEPARTMENT–GENERAL OFFICE
17. CHIEF OF FINANCE
18. ACCOUNTING DEPARTMENT–GENERAL OFFICE
19. CHIEF OF ACCOUNTING
20. FILE ROOM
21. PERSONNEL DEPARTMENT–GENERAL OFFICE
22. CHIEF OF PERSONNEL
23. WAITING AREA
24. INACTIVE FILE ROOM
25. MECH.-ELEC. ROOM
26. OFFICE SUPPLIES
27. WOMEN'S REST ROOM
28. WOMEN'S TOILET
29. MEN'S TOILET
30. UNASSIGNED SPACE (FUTURE EXPANSION)
31. CORRIDOR
32. STAIR
33. JANITORIAL SERVICE

2nd FLOOR PLAN



COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
TAIPEI ADMINISTRATION BUILDING
DE LEUW, CATHER INTERNATIONAL-CHICAGO



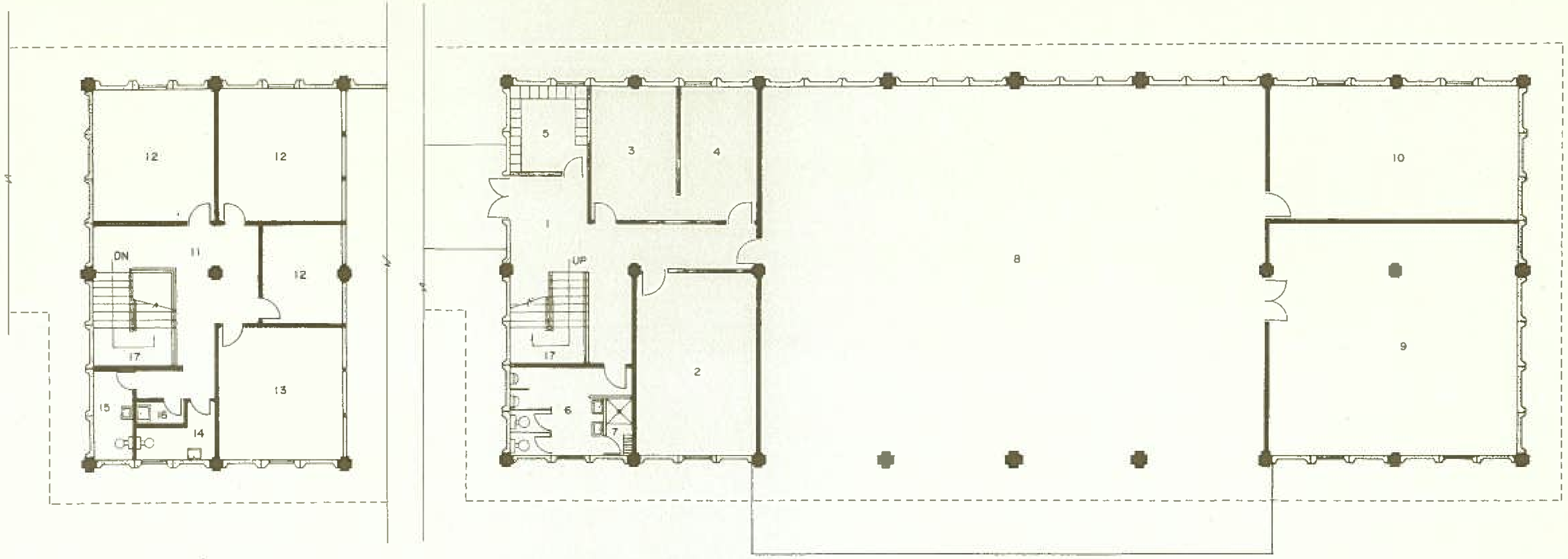
ELEVATIONS

SCALE IN METERS
0 2 4 6 8 10

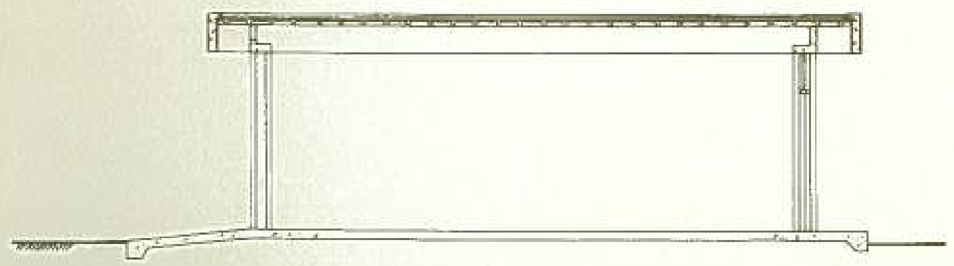
COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
TAIPEI ADMINISTRATION BUILDING
DE LEUW, CATHER INTERNATIONAL-CHICAGO

LEGEND

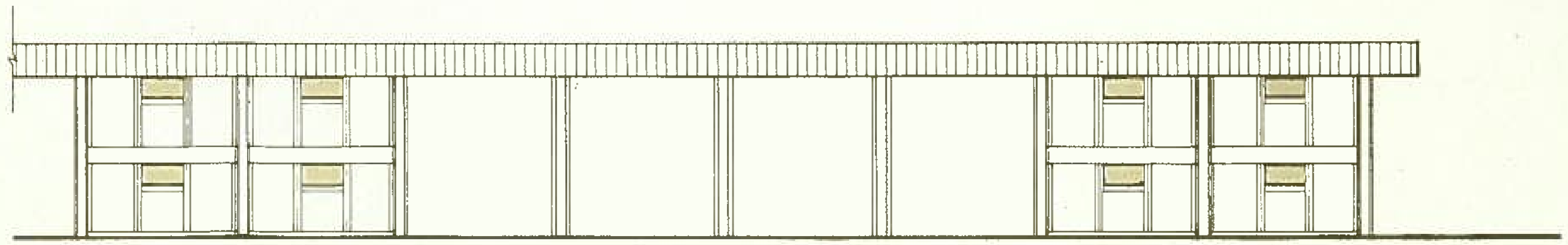
1. HALL
2. OFFICE
3. RADIO STORAGE AND REPAIR
4. RADIO EQUIPMENT
5. LOCKER ROOM
6. TOILET
7. SHOWER ROOM
8. SHOPS
9. TOOL ROOM
10. ENGINEERING EQUIPMENT STORAGE
11. LOBBY
12. OFFICE
13. DRAFTING ROOM
14. MEN'S TOILET
15. WOMEN'S TOILET
16. JANITORS' CLOSET
17. STAIR



PLAN



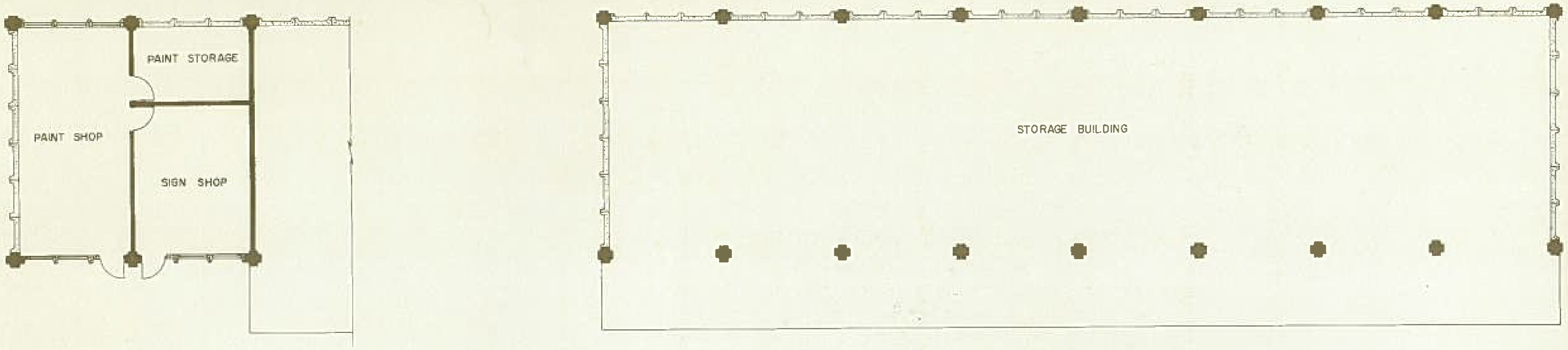
SECTION



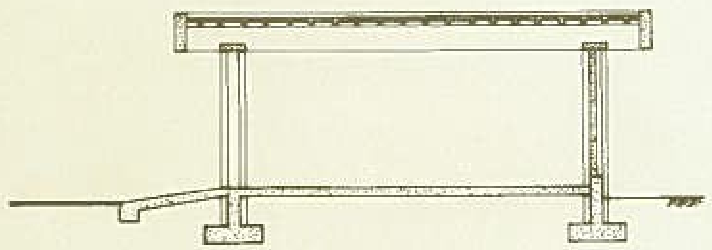
ELEVATION

SCALE IN METERS
0 2 4 6 8 10

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
TAIPEI MAINTENANCE BUILDING
DE LEUW, CATHER INTERNATIONAL-CHICAGO



PLAN



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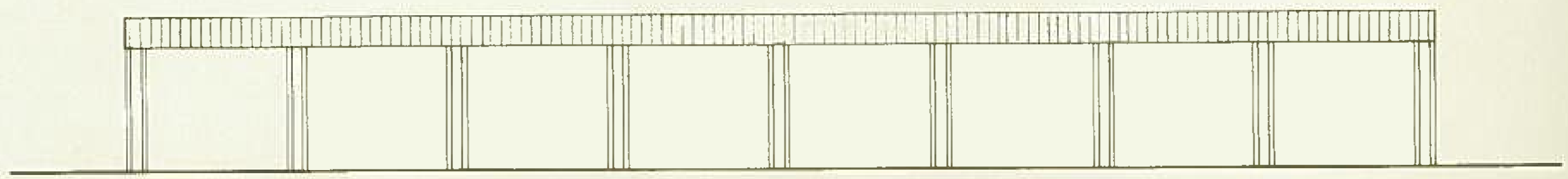
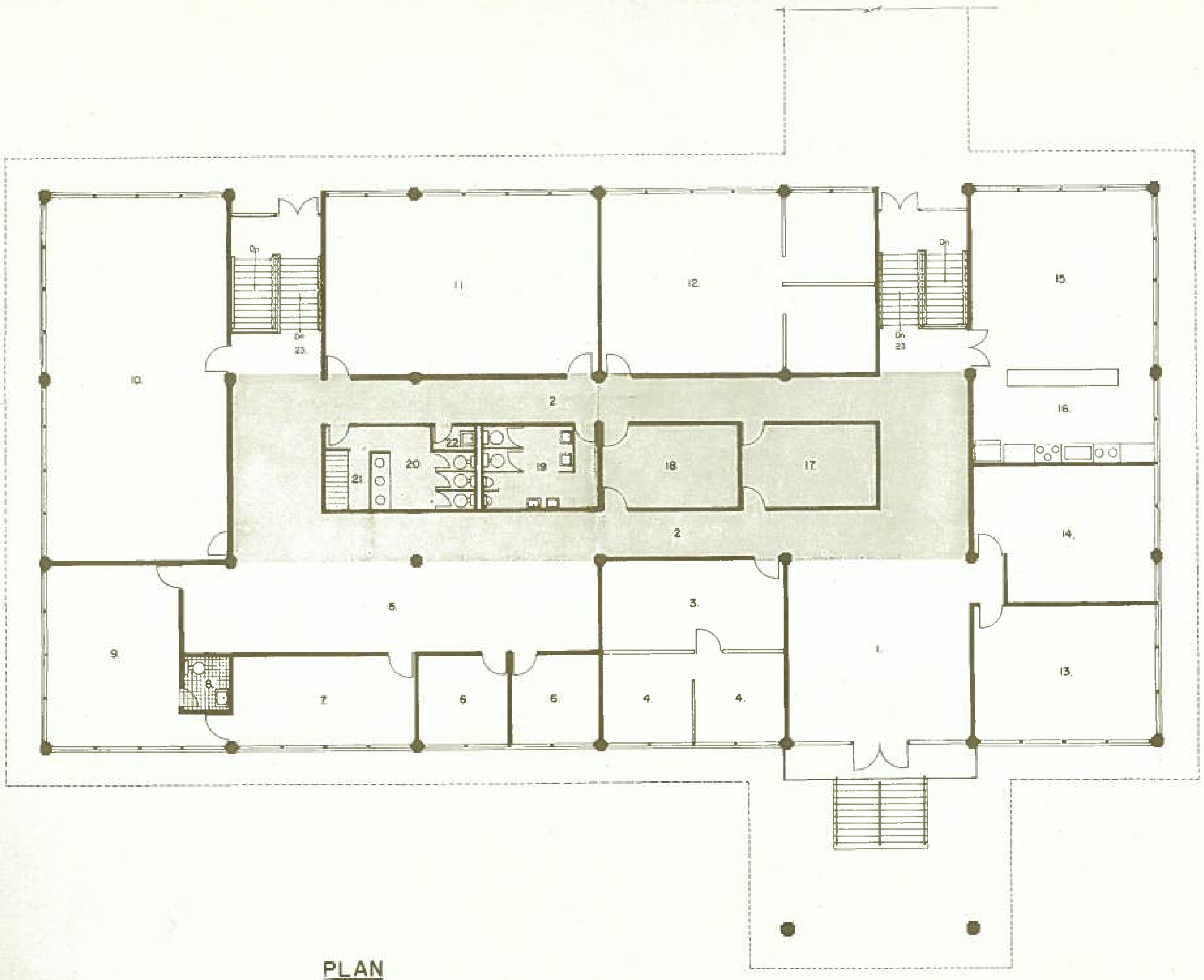


ELEVATION

SCALE IN METERS
0 2 4 6 8 10

COMPREHENSIVE TOLL ROAD STUD
NORTH-SOUTH FREEWAY TAIWA
TAIPEI STORAGE BUILDING
DE LEUW, CATHER INTERNATIONAL-CHICAG



PLAN

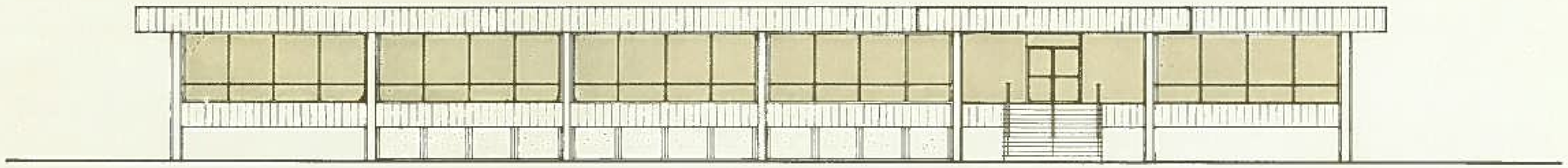
LEGEND

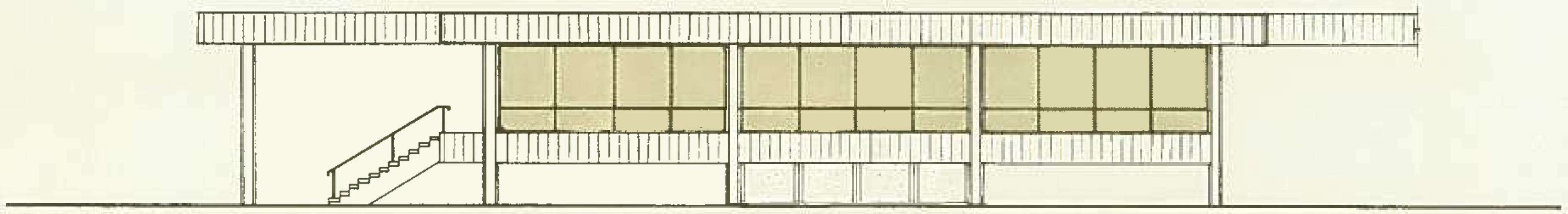
1. LOBBY
2. CORRIDOR
3. WAITING ROOM
4. PERSONNEL OFFICE
5. SECRETARIES
6. PRIVATE OFFICE
7. CONFERENCE ROOM
8. TOILET
9. DIVISION ENGINEER
10. GENERAL OFFICE
11. ACCOUNTING OFFICE
12. ENGINEERING OFFICE
13. POLICE OFFICE
14. RADIO ROOM
15. LUNCH ROOM
16. FOOD PREPARATION
17. OFFICE STORAGE
18. REPRODUCTION ROOM
19. MEN'S TOILET
20. WOMEN'S TOILET
21. WOMEN'S REST ROOM
22. JANITORS' CLOSET
23. STAIR

LOCATION OF BASEMENT

SCALE IN METERS
0 2 4 6 8 10

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
DIVISION ADMINISTRATION BUILDING-KAOHSIUNG
DE LEUW, CATHER INTERNATIONAL-CHICAGO

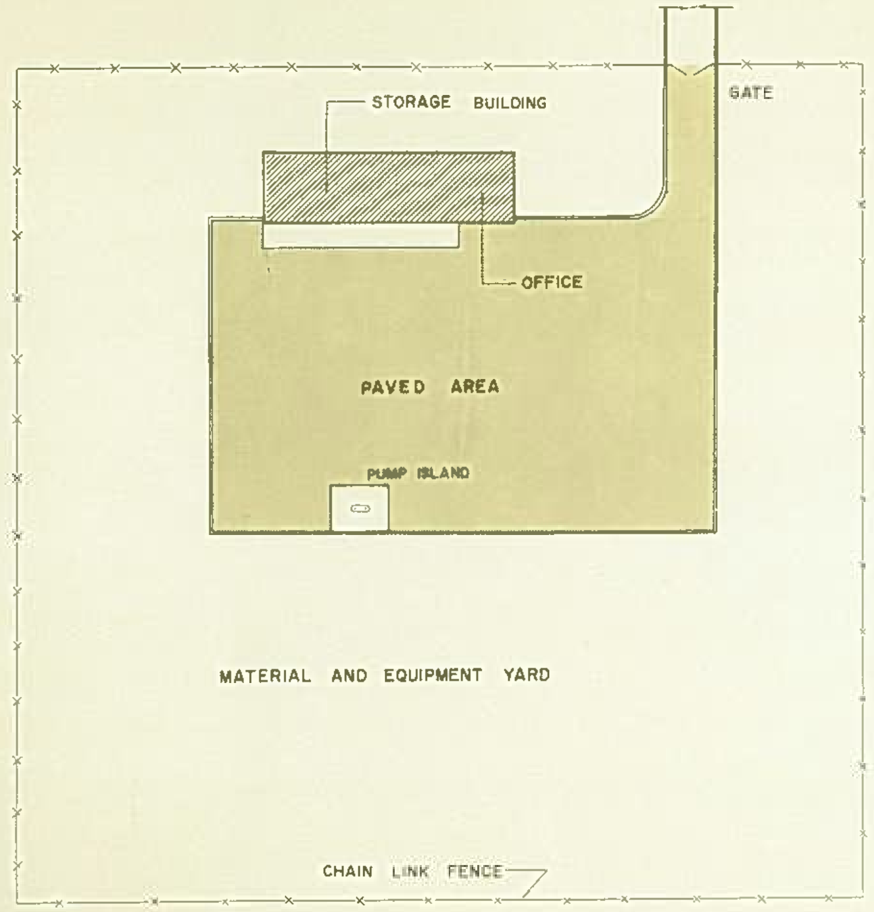




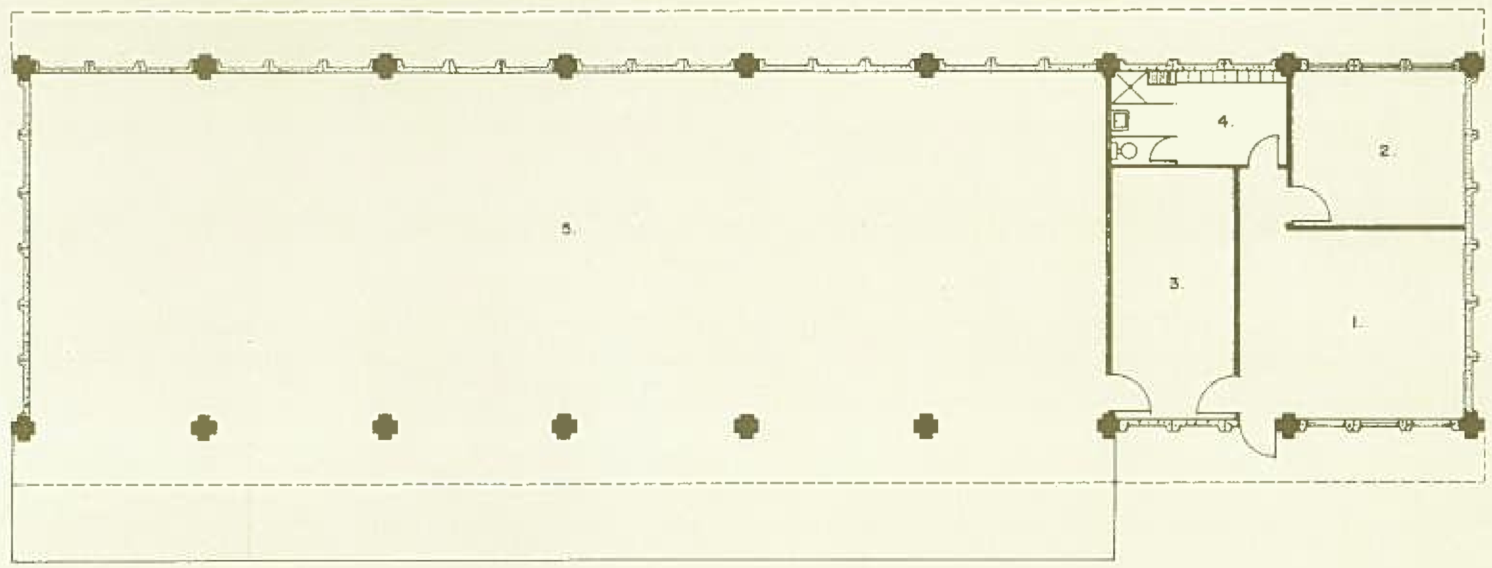
ELEVATIONS

SCALE IN METERS
0 2 4 6 8 10

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
DIVISION ADMINISTRATION BUILDING-KAOHSIU
DE LEUW, CATHER INTERNATIONAL-CHICAGO



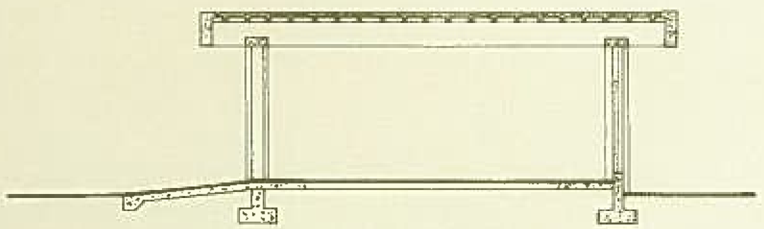
SITE PLAN



PLAN

LEGEND

1. OFFICE
2. COMMUNICATIONS EQUIPMENT ROOM
3. STORAGE
4. LOCKER, TOILET & SHOWER ROOM
5. SHED



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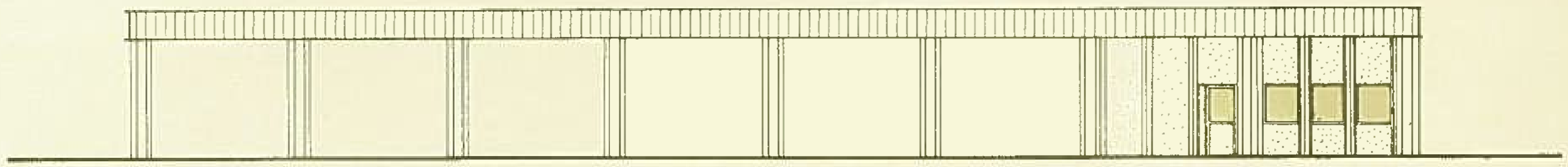
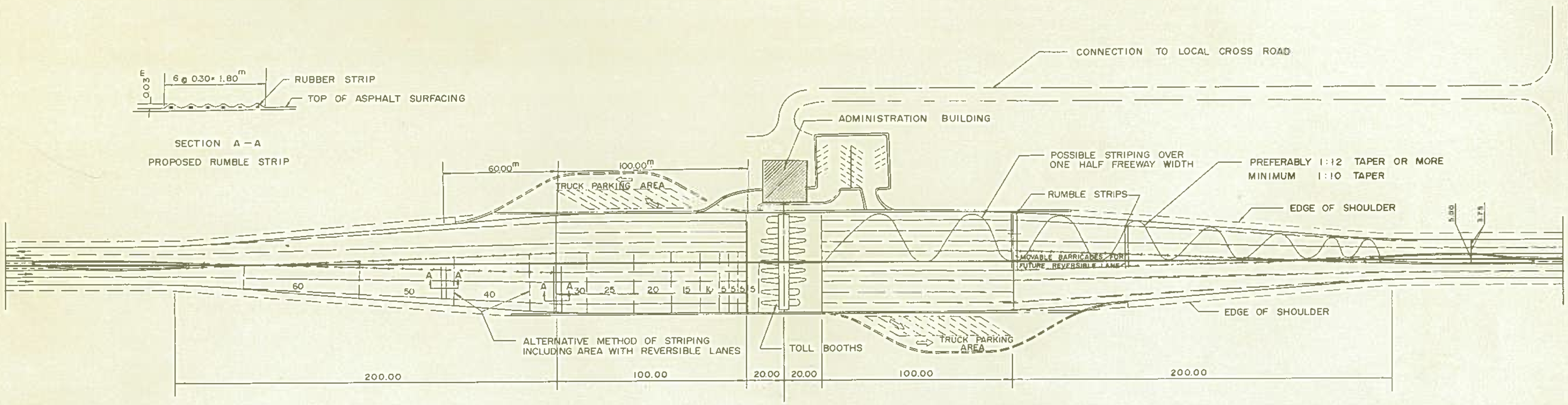
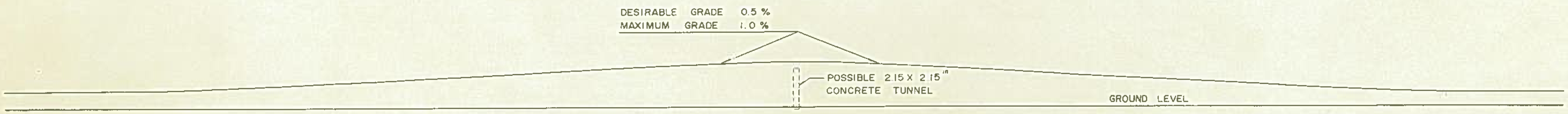


ELEVATION

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
MAINTENANCE SECTION BUILDING
DE LEUW, CATHER INTERNATIONAL-CHICAGO



PLAN



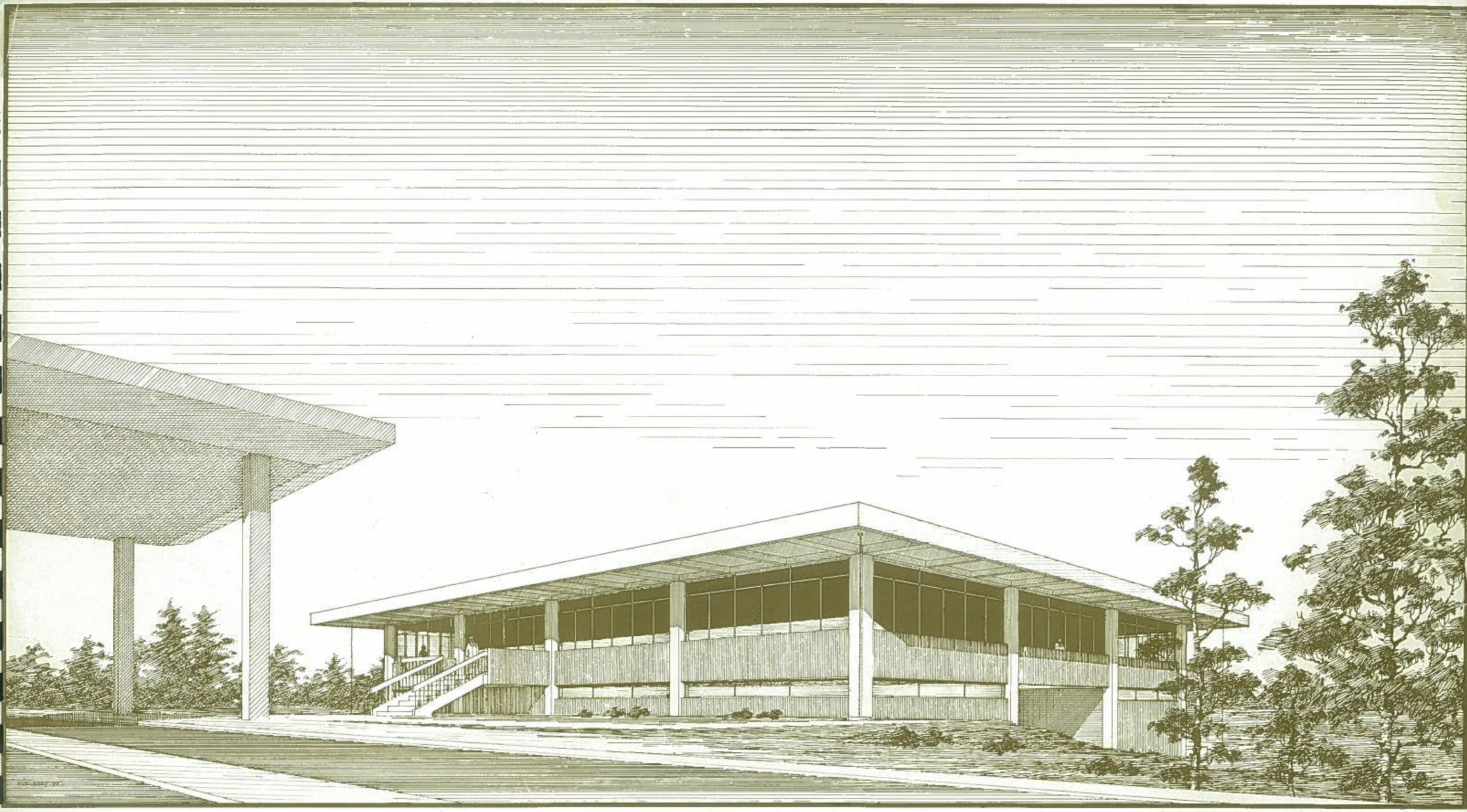
PROFILE

NOTES :

1. PLAZA SHOWN IS FOR 4 LANE FREEWAY.
2. TWO CENTER TOLL LANES WILL BE OPERATED REVERSIBLE WHEN TRAFFIC VOLUME APPROACHES CAPACITY OF THE FREEWAY.
3. TRUCK PARKING AREA IS NEEDED ONLY WHEN TRUCK WEIGHING FACILITIES ARE INCLUDED IN TOLL PLAZA.
4. ACCESS TO A LOCAL CROSS ROAD FROM ADMINISTRATION BUILDING IS DESIRABLE.

SCALE IN METERS
0 25 50 75 100

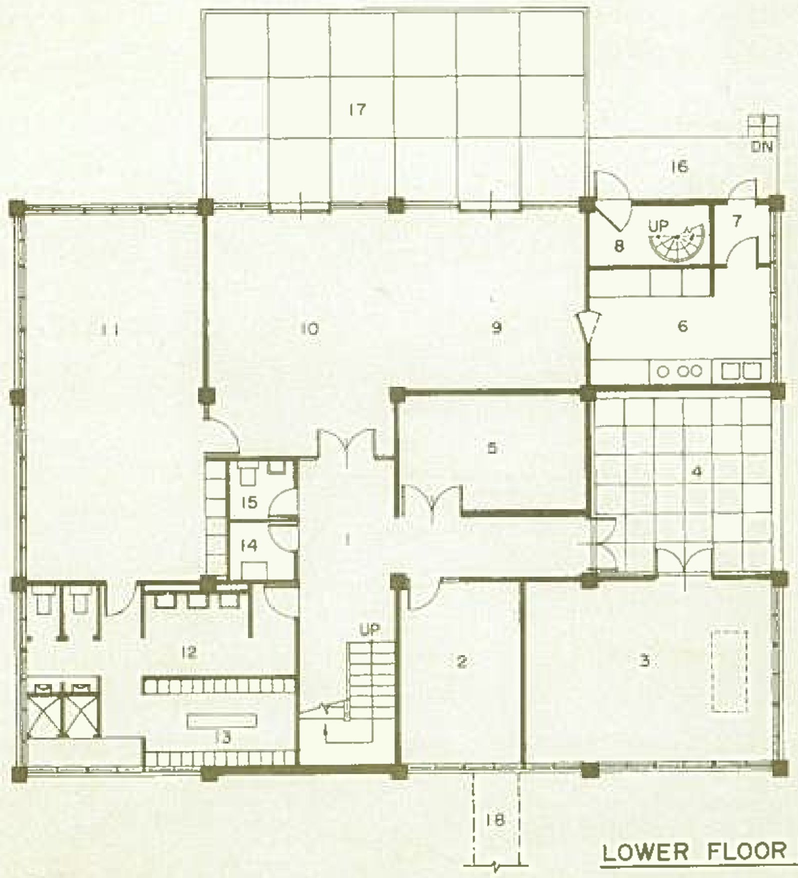
COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
TOLL PLAZA-BARRIER TYPE
DE LEUW, CATHER INTERNATIONAL-CHICAGO



COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN

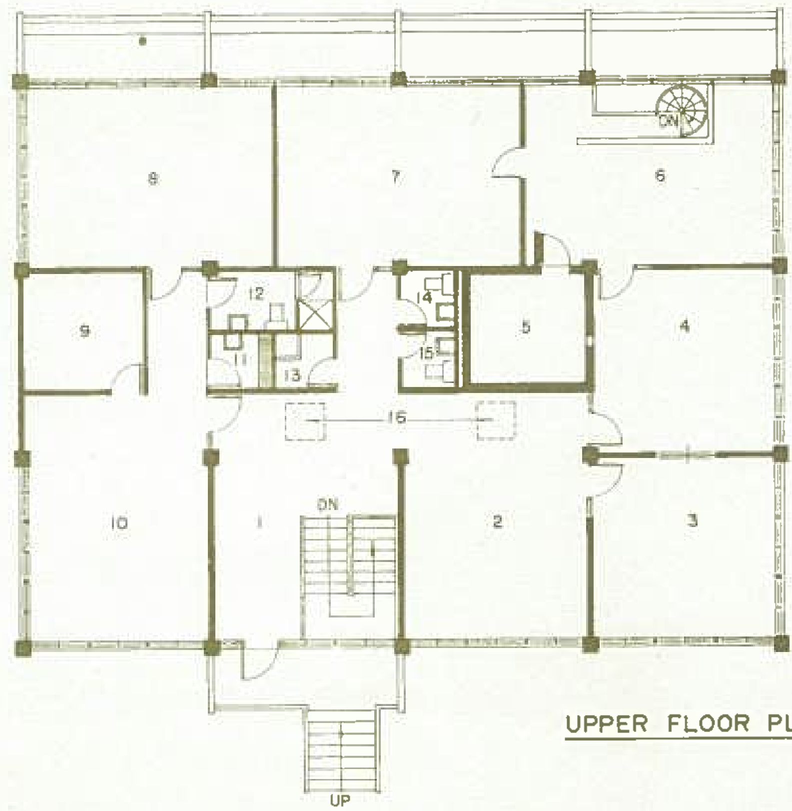
TOLL PLAZA ADMINISTRATION BUILDING

DE LEUW, CATHER INTERNATIONAL-CHICAGO



LOWER FLOOR PLAN

1. CORRIDOR
2. COMPUTER ROOM
3. MECH. & ELECT. UTILITIES
4. MOTORCYCLE & BICYCLE PARKING
5. STORAGE
6. KITCHEN
7. VESTIBULE
8. MONEY TRANSFER ROOM
9. DINING ROOM
10. DAY ROOM
11. TOLL COLLECTORS' REST ROOM
12. TOLL COLLECTORS' TOILET
13. TOLL COLLECTORS' LOCKERS & SHOWER
14. JANITOR'S CLOSET
15. WOMEN'S TOILET
16. LOADING DOCK
17. PATIO
18. CABLE TRENCH TO TOLL BOOTHS

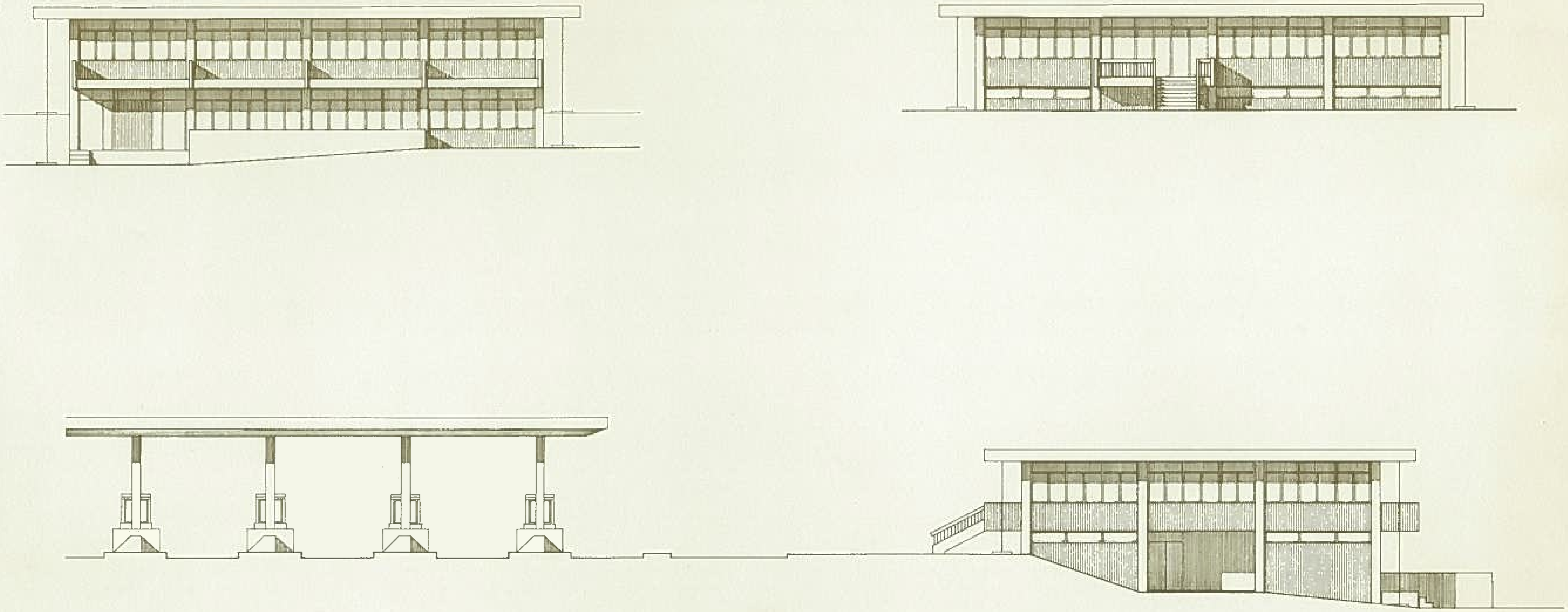


UPPER FLOOR PLAN

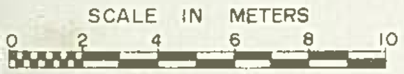
1. ENTRANCE & LOBBY
2. SECRETARY & RECEPTION
3. SUPERVISOR'S OFFICE
4. MONEY COUNTING ROOM
5. VAULT
6. TELLERS' OFFICE
7. GENERAL OFFICE
8. POLICE OFFICERS' DAY ROOM
9. COMMUNICATIONS ROOM
10. POLICE OFFICE
11. FIRST AID ROOM
12. POLICE OFFICERS' TOILET
13. JANITOR'S CLOSET
14. WOMEN'S TOILET
15. MEN'S TOILET
16. SKYLIGHT

SCALE IN METERS
0 2 4 6 8 10

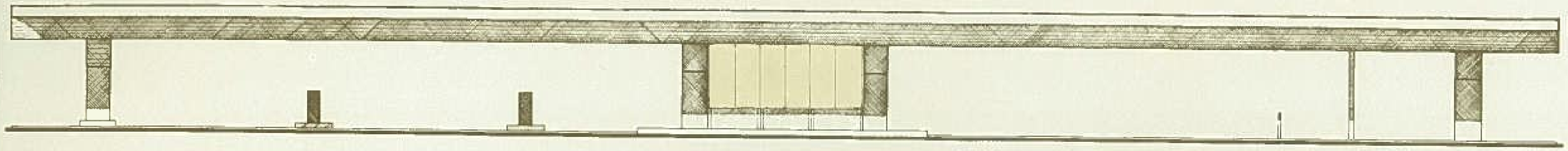
COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
TOLL PLAZA ADMINISTRATION BUILD
DE LEUW, CATHER INTERNATIONAL-CHICAGO



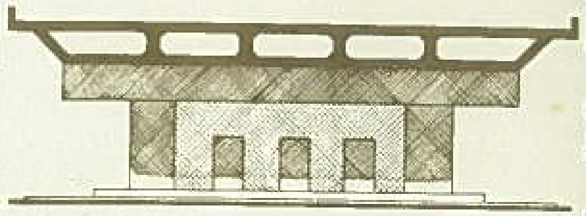
ELEVATIONS



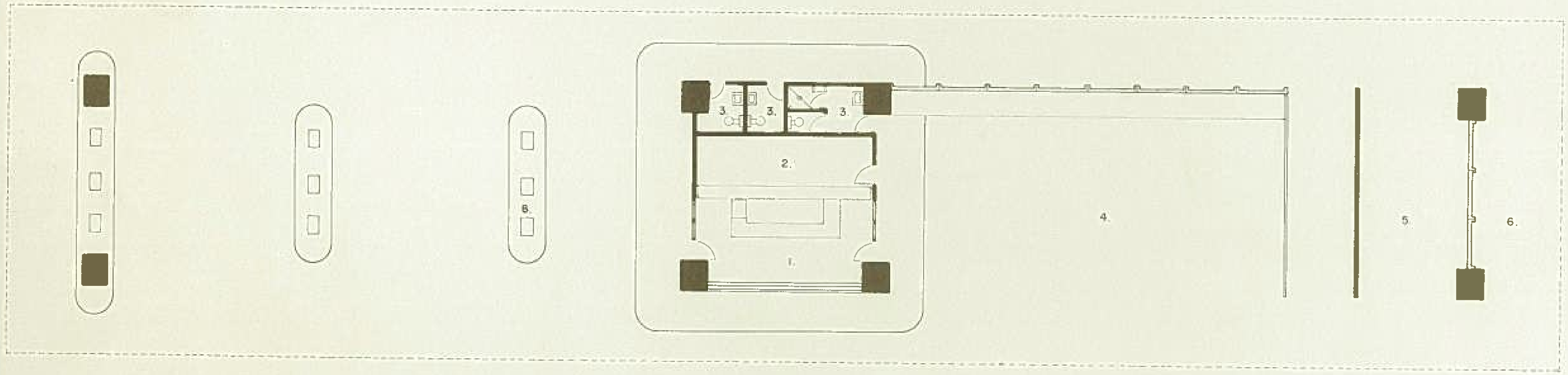
COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
TOLL PLAZA ADMINISTRATION BUILDING
DE LEUW, CATHER INTERNATIONAL-CHICAGO



ELEVATION



SECTION



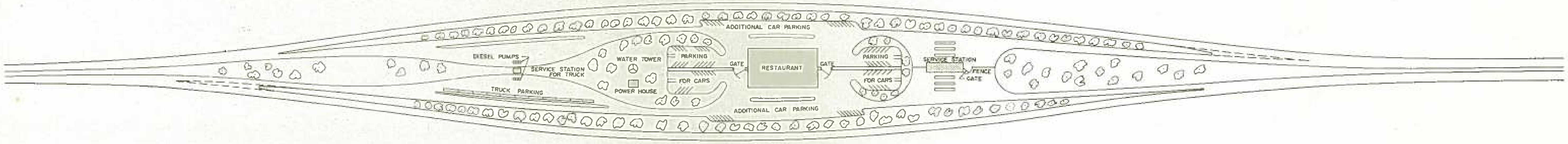
PLAN

LEGEND

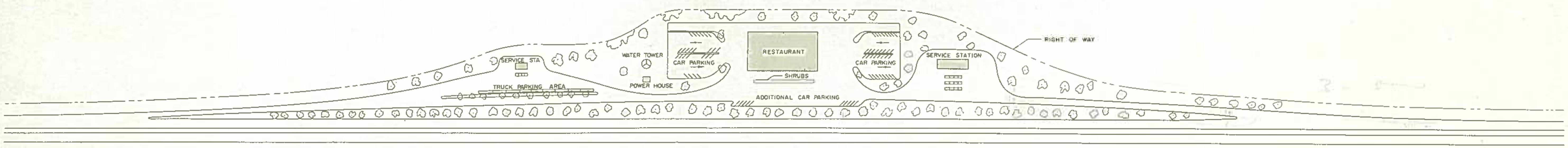
1. OFFICE
2. STORAGE
3. TOILET
4. GARAGE
5. WASHING LANE
6. TOW TRUCK
7. CAR LANE
8. ISLAND

SCALE IN METERS
0 2 4 6 8 10

COMPREHENSIVE TOLL ROAD STUD
NORTH-SOUTH FREEWAY TAIWAN
SERVICE AREA GAS STATIO
DE LEUW, CATHER INTERNATIONAL



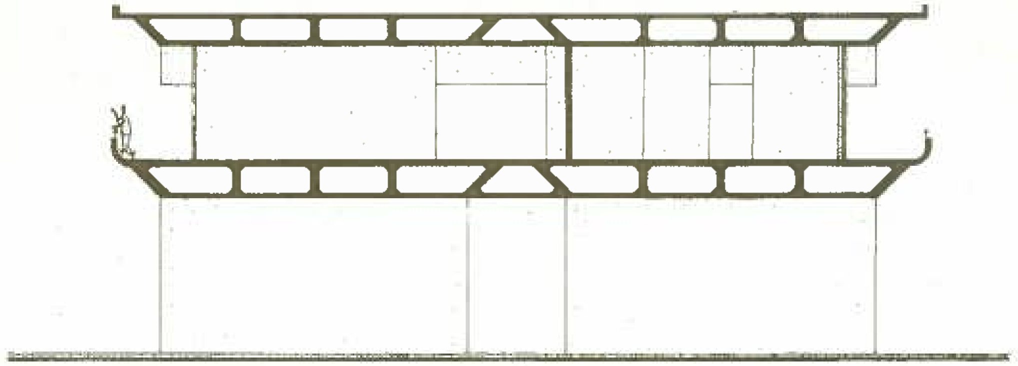
TYPE A – IN MEDIAN



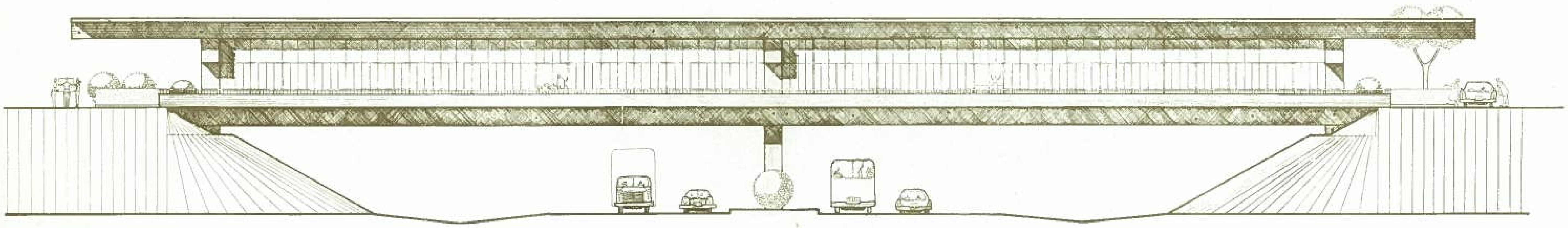
TYPE B – ON EACH SIDE OF FREEWAY

SCALE IN METERS
0 50 100 150 200

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
SERVICE AREAS
DE LEUW, CATHER INTERNATIONAL-CHICAGO



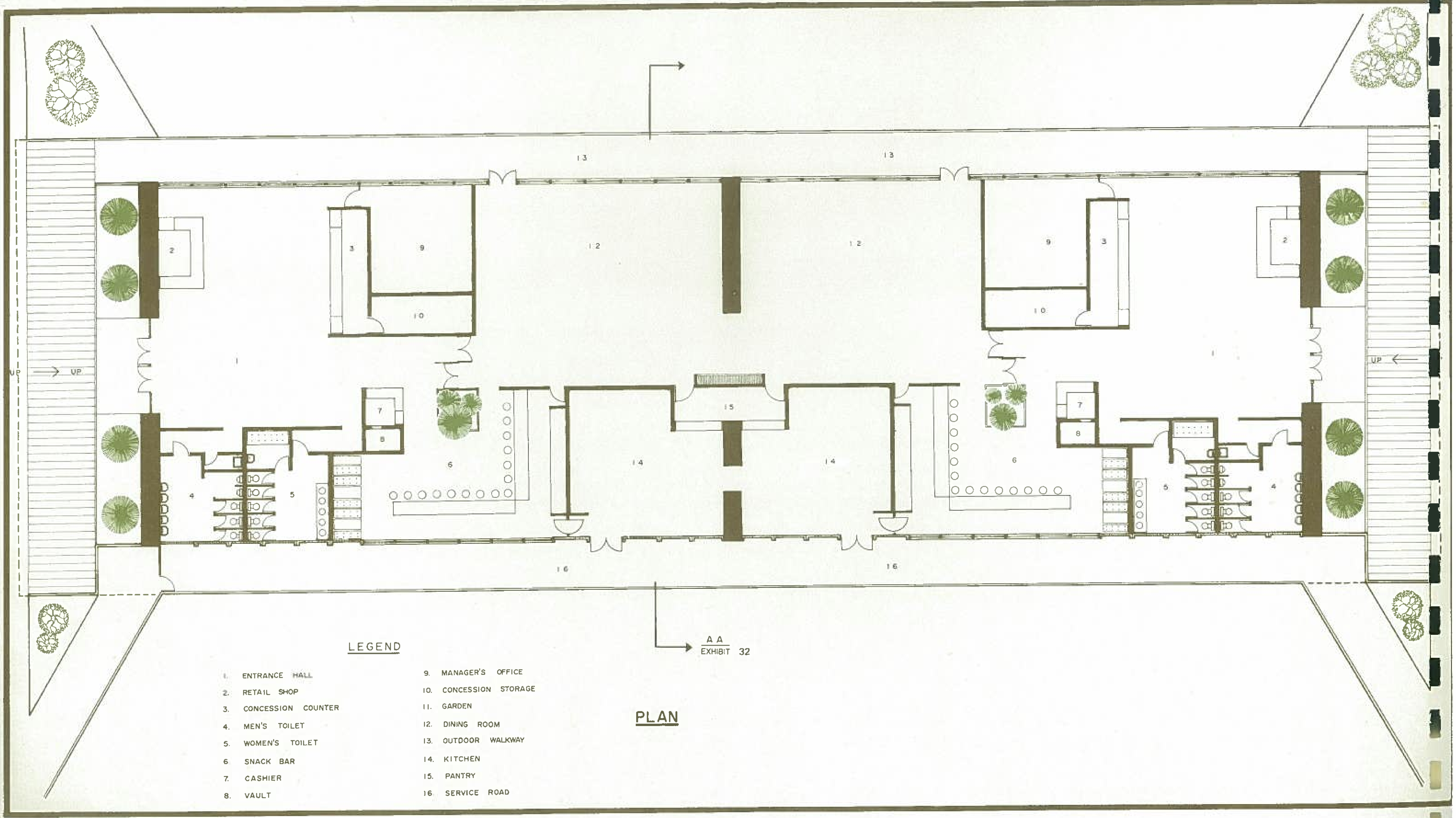
SECTION A A



ELEVATION

CALE IN METERS
4 6 8 10

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
SERVICE AREA RESTAURANT
DE LEUW, CATHER INTERNATIONAL-CHICAGO



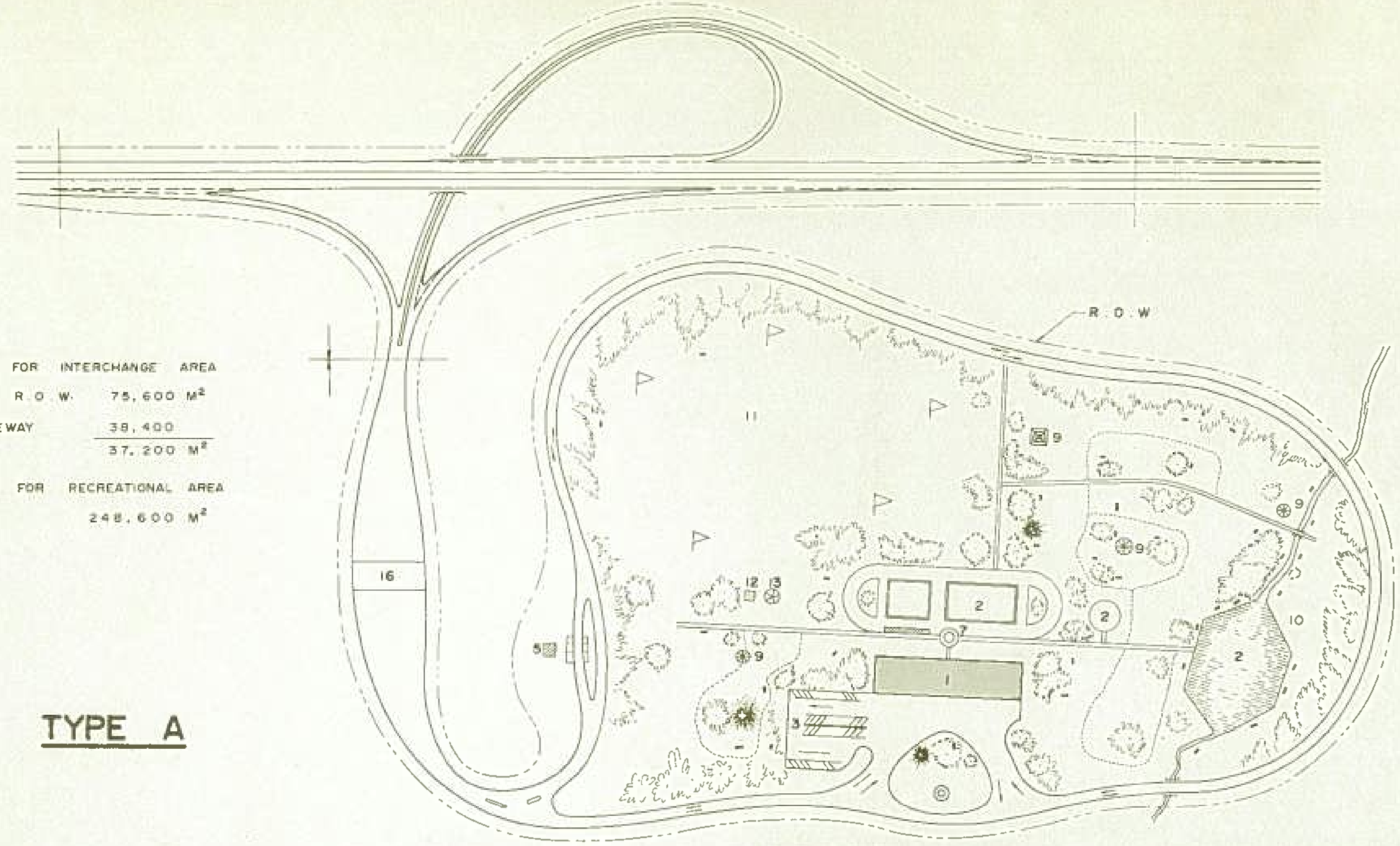
SCALE IN METERS
0 2 4 6 8 10

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
SERVICE AREA RESTAURANT
DE LEUW, CATHER INTERNATIONAL-CHICAGO

R.O.W. REQUIRED FOR INTERCHANGE AREA

TOTAL AREA OF R.O.W.	75,600 M^2	
R.O.W. OF FREEWAY	38,400	
	37,200 M^2	

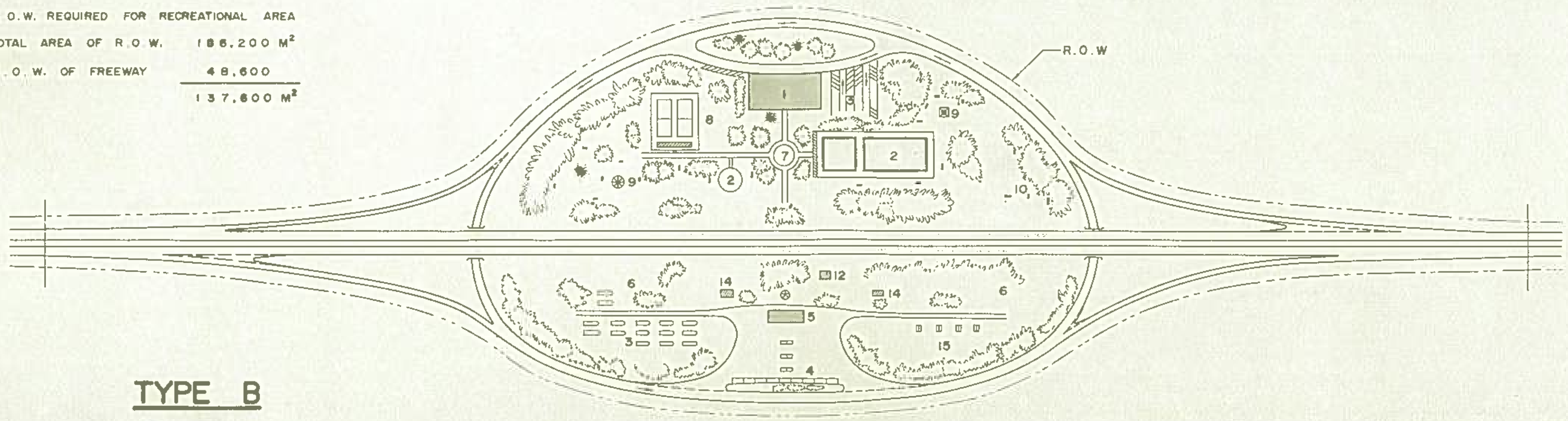
R.O.W. REQUIRED FOR RECREATIONAL AREA 246,600 M^2



TYPE A

R.O.W. REQUIRED FOR RECREATIONAL AREA

TOTAL AREA OF R.O.W.	186,200 M^2	
R.O.W. OF FREEWAY	48,600	
	137,600 M^2	



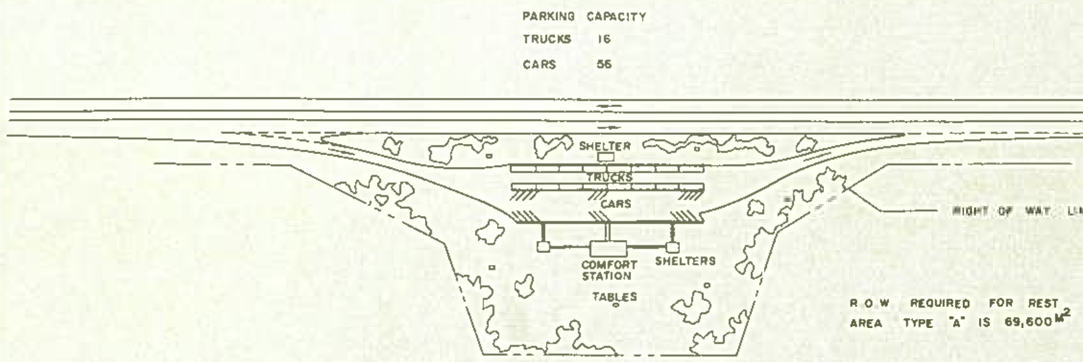
TYPE B

LEGEND

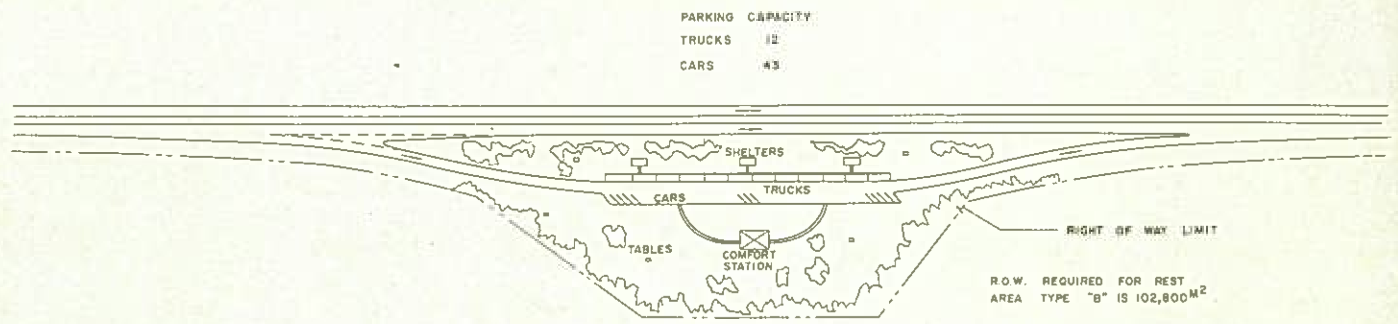
1. HOTEL
2. POOL
3. PARKING AREA
4. TRUCK PARKING AREA
5. SERVICE STATION
6. CAMPING AREA
7. FOUNTAIN
8. TENNIS COURSE
9. PAVILION
10. BENCHES
11. GOLF COURSE
12. POWER
13. WATER TOWER
14. TOILET
15. TENTS
16. TOLL BOOTHS

SCALE IN METERS
0 50 100 150 200

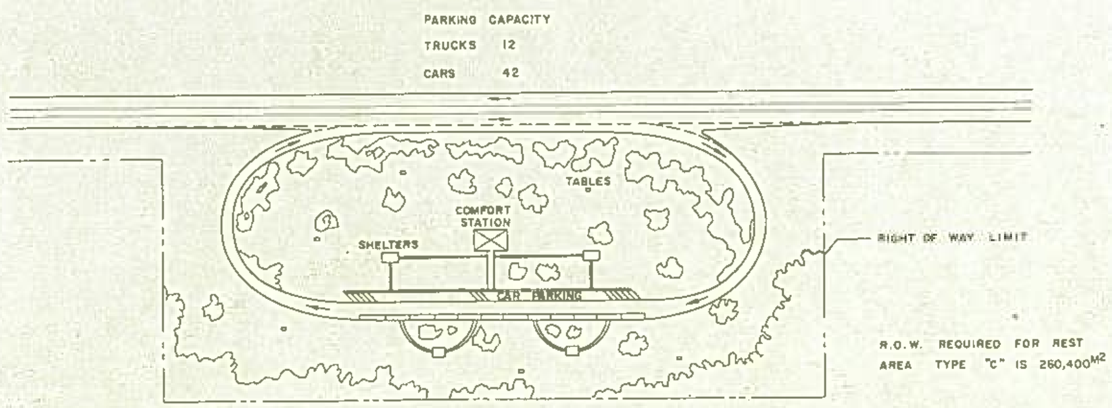
COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
RECREATIONAL AREAS
DE LEUW, CATHER INTERNATIONAL-CHICAGO



TYPE A



TYPE B



TYPE C

NOTE :
1. REST AREAS SHOWN ON ONE SIDE OF THE FREEWAY ONLY. ANOTHER SIMILAR FACILITY SHOULD BE CONSIDERED ON THE OTHER SIDE FOR TRAFFIC IN THE REVERSE DIRECTION.
2. AREAS GIVEN ARE EXCLUSIVE OF FREEWAY AND FOR ONE SIDE OF FREEWAY ONLY.

SCALE IN METERS
0 50 100 150 200

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
REST AREAS
DE LEUW, CATHER INTERNATIONAL-CHICAGO

CHAPTER V

Bus Operations on Toll Road

Chapter V
BUS OPERATIONS ON TOLL ROAD

Introduction

Bus travel has already established itself as the most important means of passenger transport in Taiwan. (Exhibit 36 shows the vast network of existing bus routes along the study corridor). In 1970, bus travel accounted for approximately 64 percent of reported passenger-kilometers (whilst railways accounted for 35 percent and domestic air flights handled one percent of the total). Moreover, bus services are growing rapidly; 1970 bus passenger-kilometers were up by 11.9 percent over the 1969 total.

Despite the importance of bus travel, however, it is largely restricted to short-distance trips. In 1970, there were a reported 1,213 million bus passenger trips; total bus passenger-kilometers amounted to 11,206 million, and the average trip distance was, therefore, only 9.24 kilometers. The Taiwan Highway Bureau (THB), which provides most longer-distance bus travel showed an average trip length of 15.2 kilometers in 1970, whilst city bus companies had an average trip length of 6.65 kilometers and private companies experienced an average of 9.62 kilometers.

Even the longer average distance of the THB contrasts sharply with an average passenger trip on the railway of more than forty kilometers. The primary reason for this difference is that long-distance bus travel is far less attractive at present than travel by the competing modes of railway and air; this is so because the congested highways of Taiwan do not permit high-speed, free-flow bus operation.

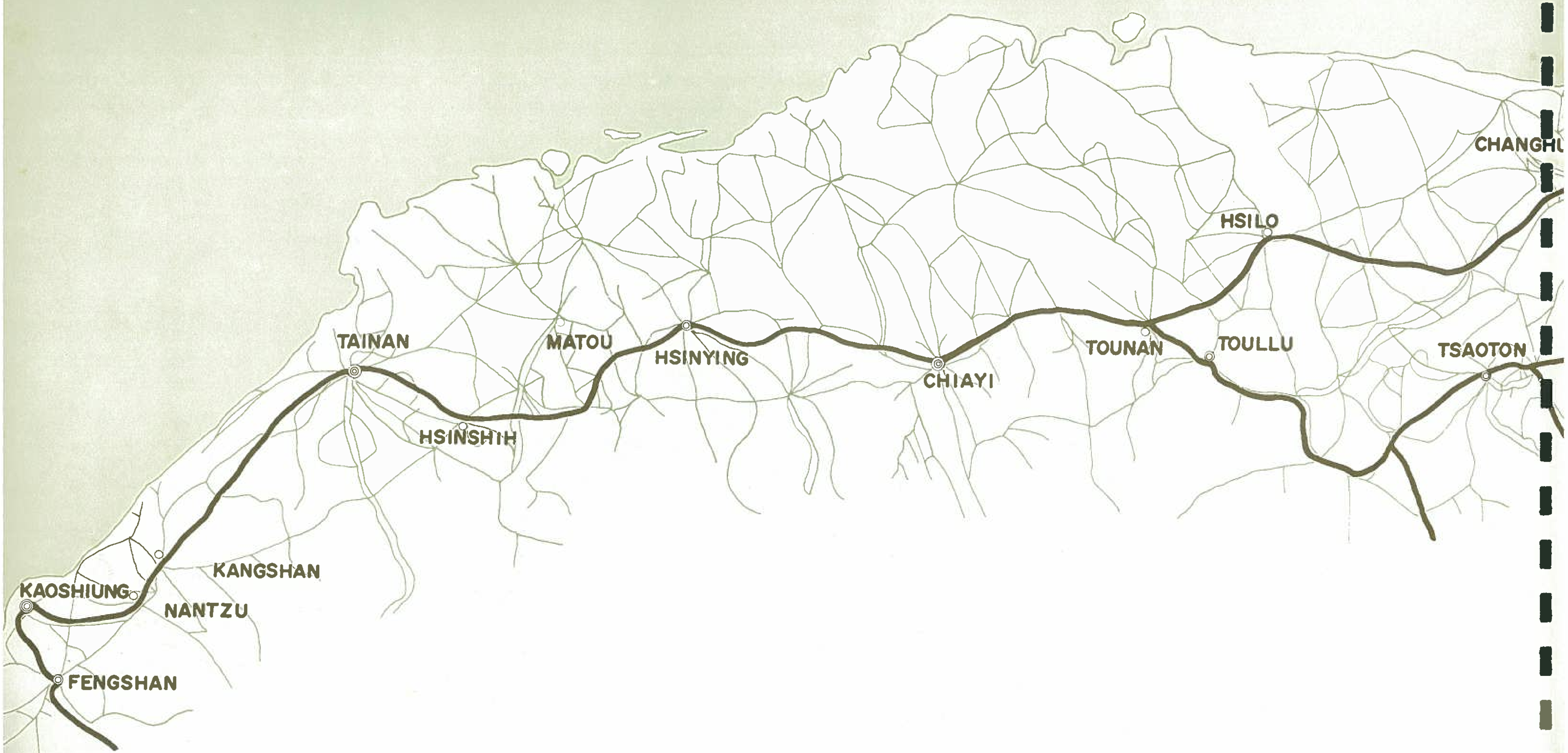
According to this study's computer data, express buses, in 1969, travelled at an average speed of about 44 kilometers per hour; in some of the more congested areas of the corridor, such as Section II (Taipei-Yangmei), average speed diminished to 36 kilometers per hour.

When the freeway opens, there should be a marked improvement in average bus speeds. Computer data indicate that on the freeway itself (with the barrier system), the average speed in 1969 would have been 87 kilometers per hour; including arterial highway and local road operation with the freeway, the average 1969 total network speed for buses would have been more than 66 kilometers per hour, if the freeway had been open in that year.

With such speed improvements, plus the comfort of being freed from congested conditions, the freeway should enable bus operators to compete in a travel market from which they have heretofore been virtually excluded, viz., the long-distance passenger market.

From the point of view of Taiwan as a whole, maximum development of the potential for provision of bus services on the freeway would enhance the economic return on the freeway facility. From the point of view of the freeway operating agency, maximum development of bus operations would mean higher toll collections. But, perhaps, most importantly, from the point of view of the prospective traveler, development of freeway express bus operations would offer a more varied choice of long-distance transportation. Moreover, it could be a choice with a great deal more flexibility than the passenger services provided by other modes. Depending upon the final decision with regard to choice of design of freeway bus operations, buses might have a great deal more flexibility where points of embarkation and debarkation are concerned. Perhaps, a more important aspect of flexibility would be with regard to timing of arrivals and departures. At the present time, there are 18 express trains daily operating between Taipei and Kaohsiung. Where domestic air travel is concerned, there are a total of seven Taipei-Kaohsiung round-trip flights, two Taipei-Tainan round-trips, and one round-trip between Taipei and Taichung each day; there are no night flights.

Compared to this service, freeway bus operation could offer the public a departure every ten minutes, or even every two minutes when traffic would demand it. Moreover, while other modes might continue to require the reservation of seats in advance, this practice should be unnecessary with a fully-developed bus service. This would



COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
EXISTING BUS ROUTES
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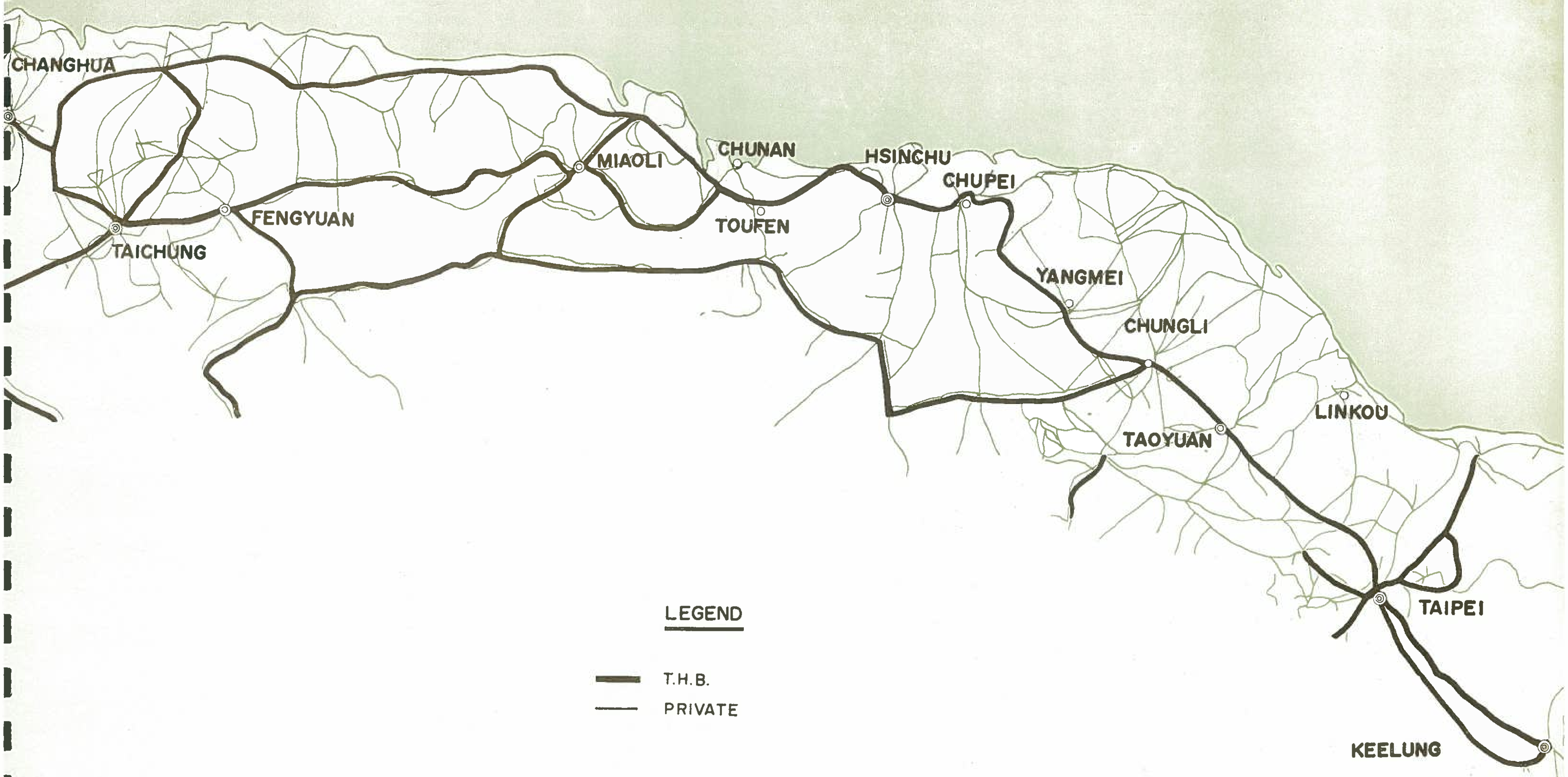

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
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mean that a prospective passenger need not make definite plans for the trip ahead of time; his time of departure would flexible; and he need not be anxious about "missing" his train (or flight). If, when he arrived at the bus terminal or at a bus stop, one bus had just left, he need only wait for a few minutes to catch the next one, or, if demand at a terminal for his desired trip were especially heavy, i.e., if a large number of prospective passengers were already waiting, another bus, not previously scheduled, might be dispatched immediately.

From the foregoing discussion, it might be concluded that large volumes of railway passenger traffic, and perhaps even domestic air traffic, might be expected to be converted to freeway bus travel in the future. This is regarded as likely, but even without such converted traffic volumes, bus traffic on the freeway can be expected to be heavy. The large volume of bus vehicle-kilometers, indicated by computer data to be on the freeway in 1990, results from the feasibility study's conservative estimate of normal growth traffic (see Appendix A to Chapter I for a revised forecast of normal growth bus volumes); the forecast bus-kilometer total is even further understated by the total exclusion of both induced, and converted, traffic volumes. Exhibit 37 shows the feasibility study forecast of 1990 express bus trips in the western corridor. These trips are exclusive of the induced volumes estimated in this study.

Subsequent sections of this chapter examine the applicability to the situation in Taiwan of three commonly-adopted designs for bus operations on highway systems dominated by a freeway facility. Also examined are the types and locations of bus operation facilities which would be required in order to fully develop bus operation on the North-South Freeway. The facilities suggested for bus operations in this final section are deemed to be needed, even without large volumes of induced, or converted, bus traffic; thus, they might be regarded as minimum facilities requirements.

Possible Designs for Future Freeway Bus Operations

Three possible designs recommended by the Institute of Traffic Engineers, U.S.A. were considered in this study for future bus operation on the freeway. Each of these is described in a separate paragraph below. Exhibit 39 schematically illustrates these three designs for operations.

"Throat Operation"

With this type of operation, buses would be loaded in the Central Business District (CBD) of a city or town. Whether or not they would acquire a full load of passengers, they would proceed immediately after loading to the freeway. They would enter onto the freeway and proceed to the interchange which best served their final destination. At that interchange, they would leave the freeway and continue to their final destination, which would be the CBD of another city or town. Along the way from the freeway to the final destination (perhaps, an average distance of 5 to 10 kilometers), the bus might make from one to several stops, depending upon the preferences of the passengers as to where they would disembark. The bus would make no stops on the freeway, and no special facilities (ramps, lanes, platforms, etc.) would need to be provided with this type of operation.

"Freeway and Parallel Street Distribution Operation"

This method of operation is well suited to a situation where at-grade highways, with substantial development along them, would parallel a freeway facility. Since this would be the case in Taiwan, where Highway 1, especially, has considerable development along it and would usually be located within one to five kilometers distance from the freeway, much of the freeway bus operations might be conducted in this manner.

As Exhibit 39 shows, a bus would begin to operate along a road facility parallel to the freeway. In the example shown, if a bus starting at the airport would pick up a full load of passengers, then it would proceed immediately to the freeway. If it did not take on a full passenger load at the airport, then it would be necessary to obtain a full load by making other stops along the parallel road. Because buses would normally obtain full loads before proceeding to the freeway, this method of operating would tend to maximize equipment utilization.

A modification of this method would be to schedule each bus to make certain specified stops to pick up passengers along the parallel arterial highway. This would have the advantage of giving greater assurance that passengers at each and every stop would be served within a certain specified number of minutes. The disadvantage would be that there would then be less assurance of maximum equipment utilization since, after making its specified stops, a bus would proceed directly to the toll road, whether or not it had taken on a full passenger land.

Regardless of which method of scheduling for picking up passengers is used, this type of operation would also tend to minimize the need for passenger transfers, since passengers would be picked up (and delivered) at a series of stops.

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   ORIGIN CENTROID =   1          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =      8.

( 15)    4 ( 16)    0 ( 17)    0 ( 18)    0 ( 19)    0 ( 20)    0 ( 21)    0 ( 22)    0 ( 23)    0 ( 24)    0
( 25)    0 ( 26)    0 ( 27)    0 ( 28)    0 ( 29)    0 ( 30)    0 ( 31)    0 ( 32)    0 ( 33)    0 ( 34)    0
( 35)    0 ( 36)    0 ( 37)    0 ( 38)    0 ( 39)    0 ( 40)    0 ( 41)    0 ( 42)    0 ( 43)    0 ( 44)    0
( 45)    0 ( 46)    0 ( 47)    0 ( 48)    0 ( 49)    0 ( 50)    0 ( 51)    0 ( 52)    0 ( 53)    0 ( 54)    0
( 55)    0 ( 56)    0 ( 57)    0 ( 58)    0 ( 59)    0 ( 60)    0 ( 61)    0 ( 62)    0 ( 63)    0 ( 64)    0
( 65)    0 ( 66)    0 ( 67)    0 ( 68)    0 ( 69)    0 ( 70)    0 ( 71)    0 ( 72)    0 ( 73)    0 ( 74)    0
( 75)    0 ( 76)    0 ( 77)    0 ( 78)    0 ( 79)    0 ( 80)    0 ( 81)    4

   ORIGIN CENTROID =   2          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =   1126.

( 15) 1091 ( 16)    0 ( 17)    0 ( 18)    0 ( 19)    0 ( 20)    4 ( 21)    0 ( 22)    0 ( 23)    0 ( 24)    4
( 25)    0 ( 26)    0 ( 27)    0 ( 28)    0 ( 29)    0 ( 30)    0 ( 31)    0 ( 32)    0 ( 33)    0 ( 34)    0
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( 45)    0 ( 46)    0 ( 47)    0 ( 48)    4 ( 49)    3 ( 50)    0 ( 51)    0 ( 52)    3 ( 53)    0 ( 54)    0
( 55)    0 ( 56)    0 ( 57)    0 ( 58)    0 ( 59)    0 ( 60)    0 ( 61)    0 ( 62)    0 ( 63)    0 ( 64)    0
( 65)    0 ( 66)    4 ( 67)    0 ( 68)    0 ( 69)    0 ( 70)    0 ( 71)    0 ( 72)    0 ( 73)    0 ( 74)    0
( 75)    0 ( 76)    0 ( 77)    0 ( 78)    0 ( 79)    0 ( 80)    0 ( 81)    4 ( 82)    0 ( 83)    0 ( 84)    0
( 85)    0 ( 86)    0 ( 87)    0 ( 88)    0 ( 89)    0 ( 90)    0 ( 91)    0 ( 92)    0 ( 93)    0 ( 94)    0
( 95)    0 ( 96)    0 ( 97)    0 ( 98)    0 ( 99)    0 (100)    0 (101)    0 (102)    0 (103)    0 (104)    0
(105)    0 (106)    0 (107)    0 (108)    0 (109)    0 (110)    0 (111)    0 (112)    0 (113)    0 (114)    0
(115)    0 (116)    0 (117)    0 (118)    0 (119)    0 (120)    0 (121)    0 (122)    0 (123)    0 (124)    0
(125)    0 (126)    0 (127)    2 (128)    0 (129)    0 (130)    0 (131)    0 (132)    0 (133)    0 (134)    0
(135)    0 (136)    0 (137)    0 (138)    0 (139)    0 (140)    0 (141)    0 (142)    0 (143)    0 (144)    0
(145)    0 (146)    0 (147)    0 (148)    0 (149)    0 (150)    0 (151)    0 (152)    0 (153)    0 (154)    0
(155)    0 (156)    0 (157)    0 (158)    0 (159)    0 (160)    0 (161)    0 (162)    0 (163)    0 (164)    0
(165)    0 (166)    0 (167)    0 (168)    0 (169)    0 (170)    0 (171)    0 (172)    0 (173)    0 (174)    0
(175)    0 (176)    0 (177)    0 (178)    0 (179)    0 (180)    0 (181)    0 (182)    4

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( 25)    0 ( 26)    0 ( 27)    0 ( 28)    4

   ORIGIN CENTROID =   7          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =      7.

( 15)    7

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( 15)    5 ( 16)    0 ( 17)    0 ( 18)    0 ( 19)    0 ( 20)    0 ( 21)    0 ( 22)    0 ( 23)    0 ( 24)    0
( 25)    0 ( 26)    0 ( 27)    0 ( 28)    0 ( 29)    0 ( 30)    0 ( 31)    0 ( 32)    0 ( 33)    0 ( 34)    0
( 35)    0 ( 36)    0 ( 37)    0 ( 38)    0 ( 39)    0 ( 40)    0 ( 41)    0 ( 42)    0 ( 43)    0 ( 44)    0
( 45)    0 ( 46)    0 ( 47)    0 ( 48)    0 ( 49)    0 ( 50)    0 ( 51)    0 ( 52)    0 ( 53)    0 ( 54)    0
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( 65)    0 ( 66)    0 ( 67)    0 ( 68)    0 ( 69)    0 ( 70)    0 ( 71)    0 ( 72)    0 ( 73)    0 ( 74)    0
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( 15)   12

   ORIGIN CENTROID =  13          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =     11.

(  6)   11
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   ORIGIN CENTROID =  14          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =     14.

( 20)   14

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(  1)   19 (  2)  996 (  3)    4 (  4)    0 (  5)    0 (  6)    0 (  7)    0 (  8)    0 (  9)    0 ( 10)    0
( 11)    0 ( 12)    0 ( 13)    0 ( 14)    0 ( 15)    0 ( 16)    0 ( 17)    4 ( 18)  443 ( 19)    4 ( 20)  168
( 21)   34 ( 22)  137 ( 23)  111 ( 24)    0 ( 25)    8 ( 26)   34 ( 27)    0 ( 28)    0 ( 29)   25 ( 30)    0
( 31)    0 ( 32)  160 ( 33)    0 ( 34)   16 ( 35)    0 ( 36)  194 ( 37)    4 ( 38)   53 ( 39)   21 ( 40)    8
( 41)    0 ( 42)    0 ( 43)    0 ( 44)    4 ( 45)    0 ( 46)    0 ( 47)    0 ( 48)    0 ( 49)  322 ( 50)   14
( 51)    0 ( 52)   21 ( 53)    3 ( 54)    0 ( 55)    0 ( 56)    0 ( 57)    0 ( 58)    0 ( 59)    0 ( 60)    0
( 61)    0 ( 62)    0 ( 63)    0 ( 64)    0 ( 65)    0 ( 66)    0 ( 67)    0 ( 68)    0 ( 69)    0 ( 70)    4
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(101)    0 (102)    0 (103)    0 (104)    0 (105)    0 (106)    0 (107)    3 (108)    0 (109)    2 (110)   20
(111)    2 (112)    0 (113)    0 (114)    4 (115)    0 (116)    0 (117)    3 (118)    0 (119)    0 (120)    0
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(131)    0 (132)    0 (133)    0 (134)    0 (135)    0 (136)    0 (137)   42 (138)    0 (139)    0 (140)    0
(141)    0 (142)    0 (143)    0 (144)    0 (145)    0 (146)    0 (147)    7 (148)    0 (149)    0 (150)    0
(151)    0 (152)    4 (153)    0 (154)    0 (155)    0 (156)    0 (157)    0 (158)    0 (159)    0 (160)    0
(161)    0 (162)    0 (163)    0 (164)    0 (165)   27 (166)    0 (167)    0 (168)    0 (169)    0 (170)    0
(171)    0 (172)    0 (173)    0 (174)    0 (175)    0 (176)    0 (177)    0 (178)    0 (179)    0 (180)    0
(181)    0 (182)  142 (183)    5

   ORIGIN CENTROID =  17          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =      8.

( 15)    8

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( 25)    0 ( 26)    0 ( 27)    0 ( 28)    0 ( 29)    0 ( 30)    0 ( 31)    0 ( 32)   69

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( 14)    9 ( 15)   24

   ORIGIN CENTROID =  20          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =    256.

(  8)    4 (  9)    0 ( 10)    0 ( 11)    0 ( 12)    0 ( 13)    0 ( 14)   56 ( 15)  196

   ORIGIN CENTROID =  21          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =     12.

( 15)   12

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( 12)    0 ( 13)    0 ( 14)   10 ( 15)  102 ( 16)    0 ( 17)    0 ( 18)    0 ( 19)    0 ( 20)    0 ( 21)    0
( 22)    0 ( 23)    0 ( 24)    0 ( 25)    0 ( 26)    0 ( 27)    0 ( 28)    0 ( 29)    0 ( 30)    0 ( 31)    0
( 32)   10
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   ORIGIN CENTROID =  23          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =    198.

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( 12)    0 ( 13)    0 ( 14)    5 ( 15)  189

   ORIGIN CENTROID =  24          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =      9.

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( 12)    0 ( 13)    0 ( 14)    0 ( 15)    5

   ORIGIN CENTROID =  25          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =      8.

( 15)    8

   ORIGIN CENTROID =  26          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =      8.

( 15)    8

   ORIGIN CENTROID =  29          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =     20.

(  2)    2 (  3)    0 (  4)    0 (  5)    0 (  6)    0 (  7)    0 (  8)    0 (  9)    0 ( 10)    0 ( 11)    0
( 12)    0 ( 13)    0 ( 14)    0 ( 15)    7 ( 16)    0 ( 17)    0 ( 18)    0 ( 19)    0 ( 20)    0 ( 21)    0
( 22)    0 ( 23)    0 ( 24)    0 ( 25)    0 ( 26)   11

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( 15)    7

   ORIGIN CENTROID =  32          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =    430.

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( 12)    0 ( 13)   10 ( 14)    4 ( 15)  187 ( 16)    0 ( 17)    0 ( 18)    0 ( 19)    0 ( 20)    7 ( 21)    0
( 22)   26 ( 23)   18 ( 24)    0 ( 25)    0 ( 26)   15 ( 27)    7 ( 28)    0 ( 29)    0 ( 30)    0 ( 31)    0
( 32)    0 ( 33)    0 ( 34)    0 ( 35)    0 ( 36)  113 ( 37)    0 ( 38)    9 ( 39)    0 ( 40)    0 ( 41)    0
( 42)    4 ( 43)    0 ( 44)    0 ( 45)    0 ( 46)    0 ( 47)    0 ( 48)    0 ( 49)    3 ( 50)    0 ( 51)    0
( 52)    0 ( 53)    3 ( 54)    0 ( 55)    0 ( 56)    0 ( 57)    0 ( 58)    0 ( 59)    0 ( 60)    0 ( 61)    0
( 62)    0 ( 63)    0 ( 64)    0 ( 65)    0 ( 66)    0 ( 67)    0 ( 68)    0 ( 69)    0 ( 70)    0 ( 71)    0
( 72)    0 ( 73)    0 ( 74)    0 ( 75)    0 ( 76)    0 ( 77)    0 ( 78)    0 ( 79)    0 ( 80)    0 ( 81)    4
( 82)    0 ( 83)    0 ( 84)    0 ( 85)    0 ( 86)    0 ( 87)    0 ( 88)    0 ( 89)    0 ( 90)    0 ( 91)    0
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(112)    0 (113)    0 (114)    0 (115)    0 (116)    0 (117)    0 (118)    0 (119)    0 (120)    0 (121)    0
(122)    0 (123)    0 (124)    0 (125)    0 (126)    0 (127)    0 (128)    0 (129)    0 (130)    0 (131)    0
(132)    0 (133)    0 (134)    0 (135)    0 (136)    0 (137)    0 (138)    0 (139)    0 (140)    0 (141)    0
(142)    0 (143)    0 (144)    0 (145)    0 (146)    0 (147)    0 (148)    0 (149)    0 (150)    0 (151)    0
(152)    0 (153)    0 (154)    0 (155)    0 (156)    0 (157)    0 (158)    0 (159)    0 (160)    0 (161)    0
(162)    0 (163)    0 (164)    0 (165)    2 (166)    0 (167)    0 (168)    0 (169)    0 (170)    0 (171)    0
(172)    0 (173)    0 (174)    0 (175)    0 (176)    0 (177)    0 (178)    0 (179)    0 (180)    0 (181)    0
(182)    8

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   ORIGIN CENTROID =  35          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =      7.

( 18)    7

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( 12)    0 ( 13)    0 ( 14)    0 ( 15)  183 ( 16)    0 ( 17)    0 ( 18)  142 ( 19)    0 ( 20)    0 ( 21)   16
( 22)    3 ( 23)    0 ( 24)    0 ( 25)    0 ( 26)    0 ( 27)    0 ( 28)    0 ( 29)    8 ( 30)    0 ( 31)    0
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( 42)   62 ( 43)    0 ( 44)    0 ( 45)    0 ( 46)    0 ( 47)   25 ( 48)    0 ( 49)   94

   ORIGIN CENTROID =  37          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =      3.

( 22)    3

   ORIGIN CENTROID =  38          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =     24.

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( 12)    0 ( 13)    0 ( 14)    0 ( 15)    4 ( 16)    0 ( 17)    0 ( 18)    0 ( 19)    0 ( 20)    4 ( 21)    0
( 22)    0 ( 23)    0 ( 24)    0 ( 25)    0 ( 26)    0 ( 27)    0 ( 28)    0 ( 29)    0 ( 30)    0 ( 31)    0
( 32)    9

   ORIGIN CENTROID =  39          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =     23.

( 15)    3 ( 16)    0 ( 17)    0 ( 18)   18 ( 19)    0 ( 20)    0 ( 21)    0 ( 22)    0 ( 23)    0 ( 24)    0
( 25)    0 ( 26)    0 ( 27)    0 ( 28)    0 ( 29)    0 ( 30)    0 ( 31)    0 ( 32)    0 ( 33)    0 ( 34)    0
( 35)    0 ( 36)    0 ( 37)    0 ( 38)    0 ( 39)    0 ( 40)    0 ( 41)    0 ( 42)    0 ( 43)    0 ( 44)    0
( 45)    0 ( 46)    0 ( 47)    0 ( 48)    0 ( 49)    1 ( 50)    0 ( 51)    0 ( 52)    0 ( 53)    0 ( 54)    0
( 55)    0 ( 56)    0 ( 57)    0 ( 58)    0 ( 59)    0 ( 60)    0 ( 61)    0 ( 62)    0 ( 63)    0 ( 64)    0
( 65)    0 ( 66)    0 ( 67)    0 ( 68)    0 ( 69)    0 ( 70)    0 ( 71)    0 ( 72)    0 ( 73)    0 ( 74)    0
( 75)    0 ( 76)    0 ( 77)    0 ( 78)    0 ( 79)    0 ( 80)    0 ( 81)    1

   ORIGIN CENTROID =  40          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =     18.

( 32)   14 ( 33)    0 ( 34)    0 ( 35)    0 ( 36)    4

   ORIGIN CENTROID =  42          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =     79.

( 24)    4 ( 25)    0 ( 26)    0 ( 27)    0 ( 28)    0 ( 29)    0 ( 30)    0 ( 31)    0 ( 32)    0 ( 33)    0
( 34)    0 ( 35)    0 ( 36)   65 ( 37)    0 ( 38)    0 ( 39)    7 ( 40)    0 ( 41)    0 ( 42)    0 ( 43)    0
( 44)    0 ( 45)    0 ( 46)    0 ( 47)    0 ( 48)    0 ( 49)    0 ( 50)    0 ( 51)    0 ( 52)    0 ( 53)    0
( 54)    0 ( 55)    0 ( 56)    0 ( 57)    0 ( 58)    0 ( 59)    0 ( 60)    0 ( 61)    0 ( 62)    0 ( 63)    0
( 64)    0 ( 65)    0 ( 66)    0 ( 67)    0 ( 68)    0 ( 69)    0 ( 70)    0 ( 71)    0 ( 72)    0 ( 73)    0
( 74)    0 ( 75)    0 ( 76)    0 ( 77)    0 ( 78)    0 ( 79)    0 ( 80)    0 ( 81)    0 ( 82)    0 ( 83)    0
( 84)    0 ( 85)    0 ( 86)    0 ( 87)    3

   ORIGIN CENTROID =  43          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =      4.

( 36)    4

   ORIGIN CENTROID =  44          DESTINATION CENTROIDS AND VOLUMES          TOTAL TRIPS =      7.

(  2)    3 (  3)    0 (  4)    0 (  5)    0 (  6)    0 (  7)    0 (  8)    0 (  9)    0 ( 10)    0 ( 11)    0
( 12)    0 ( 13)    0 ( 14)    0 ( 15)    4
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LISTING OF ZONE TO ZONE VOLUMES PAGE NO. 5

ORIGIN CENTROID = 47 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 54.

(15)	8 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	0 (33)	0 (34)	0
(35)	0 (36)	40 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	0 (50)	0 (51)	0 (52)	0 (53)	0 (54)	0
(55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	6	

ORIGIN CENTROID = 49 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 619.

(15)	317 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	12 (33)	0 (34)	3
(35)	0 (36)	91 (37)	0 (38)	3 (39)	6 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	0 (50)	0 (51)	0 (52)	38 (53)	6 (54)	0
(55)	0 (56)	10 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	0 (64)	0
(65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0 (72)	0 (73)	3 (74)	0
(75)	0 (76)	0 (77)	0 (78)	11 (79)	0 (80)	0 (81)	100 (82)	0 (83)	0 (84)	0
(85)	0 (86)	0 (87)	5 (88)	0 (89)	0 (90)	0 (91)	0 (92)	0 (93)	0 (94)	0
(95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0 (102)	0 (103)	0 (104)	0
(105)	0 (106)	0 (107)	0 (108)	0 (109)	0 (110)	0 (111)	0 (112)	0 (113)	0 (114)	0
(115)	0 (116)	0 (117)	0 (118)	0 (119)	0 (120)	0 (121)	0 (122)	0 (123)	0 (124)	0
(125)	0 (126)	0 (127)	0 (128)	0 (129)	0 (130)	0 (131)	0 (132)	0 (133)	0 (134)	0
(135)	0 (136)	0 (137)	0 (138)	0 (139)	0 (140)	0 (141)	0 (142)	0 (143)	0 (144)	0
(145)	0 (146)	0 (147)	0 (148)	0 (149)	0 (150)	0 (151)	0 (152)	0 (153)	0 (154)	0
(155)	0 (156)	0 (157)	0 (158)	0 (159)	0 (160)	0 (161)	0 (162)	0 (163)	0 (164)	0
(165)	3 (166)	0 (167)	0 (168)	0 (169)	0 (170)	0 (171)	0 (172)	0 (173)	0 (174)	0
(175)	0 (176)	0 (177)	0 (178)	0 (179)	0 (180)	0 (181)	0 (182)	9 (183)	2	

ORIGIN CENTROID = 52 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 50.

(15)	15 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	0 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	22 (50)	0 (51)	0 (52)	0 (53)	0 (54)	0
(55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	0 (64)	0
(65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0 (72)	0 (73)	11 (74)	0
(75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	0 (82)	0 (83)	0 (84)	0
(85)	0 (86)	0 (87)	0 (88)	0 (89)	0 (90)	0 (91)	0 (92)	0 (93)	0 (94)	0
(95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0 (102)	0 (103)	0 (104)	0
(105)	0 (106)	0 (107)	0 (108)	0 (109)	0 (110)	0 (111)	0 (112)	0 (113)	0 (114)	0
(115)	0 (116)	0 (117)	0 (118)	0 (119)	0 (120)	0 (121)	0 (122)	0 (123)	0 (124)	0
(125)	0 (126)	0 (127)	2							

ORIGIN CENTROID = 53 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 10.

(15)	4 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	3 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	0 (50)	0 (51)	0 (52)	0 (53)	0 (54)	0
(55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	0 (64)	0
(65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	3			

ORIGIN CENTROID = 55 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 4.

(36) 4

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ORIGIN CENTROID = 73 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 20.

(49)	4 (50)	0 (51)	0 (52)	8 (53)	0 (54)	0 (55)	0 (56)	0 (57)	0 (58)	0
(59)	0 (60)	0 (61)	0 (62)	0 (63)	0 (64)	0 (65)	0 (66)	0 (67)	0 (68)	0
(69)	0 (70)	0 (71)	0 (72)	0 (73)	0 (74)	0 (75)	0 (76)	0 (77)	0 (78)	0
(79)	0 (80)	0 (81)	0 (82)	0 (83)	0 (84)	0 (85)	0 (86)	0 (87)	0 (88)	0
(89)	0 (90)	0 (91)	0 (92)	0 (93)	0 (94)	0 (95)	0 (96)	0 (97)	0 (98)	0
(99)	0 (100)	0 (101)	0 (102)	0 (103)	0 (104)	0 (105)	0 (106)	0 (107)	0 (108)	0
(109)	0 (110)	0 (111)	0 (112)	0 (113)	0 (114)	0 (115)	0 (116)	0 (117)	0 (118)	0
(119)	0 (120)	0 (121)	0 (122)	0 (123)	0 (124)	0 (125)	0 (126)	0 (127)	3 (128)	0
(129)	0 (130)	0 (131)	0 (132)	0 (133)	0 (134)	0 (135)	0 (136)	0 (137)	0 (138)	0
(139)	0 (140)	0 (141)	0 (142)	0 (143)	0 (144)	0 (145)	0 (146)	0 (147)	0 (148)	0
(149)	0 (150)	0 (151)	0 (152)	0 (153)	0 (154)	0 (155)	0 (156)	0 (157)	0 (158)	0
(159)	0 (160)	0 (161)	0 (162)	0 (163)	0 (164)	0 (165)	0 (166)	0 (167)	0 (168)	0
(169)	0 (170)	0 (171)	0 (172)	0 (173)	0 (174)	0 (175)	0 (176)	0 (177)	0 (178)	0
(179)	0 (180)	0 (181)	0 (182)	5						

ORIGIN CENTROID = 77 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 4.

(182) 4

ORIGIN CENTROID = 78 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 10.

(64) 10

ORIGIN CENTROID = 79 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 4.

(49) 4

ORIGIN CENTROID = 80 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 26.

(86) 3 (87) 23

ORIGIN CENTROID = 81 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 1119.

(2)	4 (3)	0 (4)	0 (5)	0 (6)	0 (7)	0 (8)	0 (9)	0 (10)	0 (11)	0
(12)	0 (13)	0 (14)	0 (15)	217 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0
(22)	0 (23)	0 (24)	0 (25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0
(32)	8 (33)	0 (34)	0 (35)	0 (36)	0 (37)	0 (38)	0 (39)	12 (40)	0 (41)	0
(42)	0 (43)	0 (44)	0 (45)	0 (46)	0 (47)	6 (48)	0 (49)	131 (50)	0 (51)	0
(52)	0 (53)	0 (54)	0 (55)	0 (56)	9 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0
(62)	0 (63)	0 (64)	0 (65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0
(72)	0 (73)	0 (74)	0 (75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	0
(82)	0 (83)	0 (84)	0 (85)	0 (86)	0 (87)	98 (88)	0 (89)	85 (90)	0 (91)	0
(92)	0 (93)	0 (94)	0 (95)	4 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0
(102)	0 (103)	0 (104)	7 (105)	0 (106)	0 (107)	58 (108)	45 (109)	59 (110)	39 (111)	28
(112)	0 (113)	4 (114)	5 (115)	0 (116)	0 (117)	3 (118)	0 (119)	5 (120)	0 (121)	0
(122)	0 (123)	0 (124)	0 (125)	0 (126)	0 (127)	19 (128)	0 (129)	0 (130)	0 (131)	0
(132)	4 (133)	0 (134)	0 (135)	0 (136)	0 (137)	192 (138)	0 (139)	0 (140)	0 (141)	0
(142)	0 (143)	0 (144)	0 (145)	0 (146)	0 (147)	5 (148)	0 (149)	0 (150)	0 (151)	0
(152)	0 (153)	0 (154)	0 (155)	0 (156)	0 (157)	0 (158)	0 (159)	0 (160)	0 (161)	0
(162)	0 (163)	0 (164)	0 (165)	18 (166)	0 (167)	0 (168)	0 (169)	0 (170)	0 (171)	0
(172)	0 (173)	0 (174)	0 (175)	0 (176)	0 (177)	0 (178)	0 (179)	0 (180)	0 (181)	0
(182)	52 (183)	2								

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ORIGIN CENTROID = 56 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 40.

(15)	15 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	0 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	4 (50)	0 (51)	0 (52)	0 (53)	0 (54)	0
(55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	0 (64)	0
(65)	0 (66)	0 (67)	0 (68)	0 (69)	11 (70)	0 (71)	0 (72)	0 (73)	7 (74)	0
(75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	0 (82)	0 (83)	0 (84)	0
(85)	0 (86)	0 (87)	3							

ORIGIN CENTROID = 59 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 4.

(71) 4

ORIGIN CENTROID = 63 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 11.

(71)	4 (72)	0 (73)	0 (74)	0 (75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0
(81)	0 (82)	0 (83)	0 (84)	0 (85)	0 (86)	0 (87)	0 (88)	0 (89)	7	

ORIGIN CENTROID = 64 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 10.

(71)	7 (72)	0 (73)	0 (74)	0 (75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0
(81)	0 (82)	0 (83)	0 (84)	0 (85)	0 (86)	0 (87)	3			

ORIGIN CENTROID = 65 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 4.

(110) 4

ORIGIN CENTROID = 68 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 15.

(15)	5 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	0 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	0 (50)	0 (51)	0 (52)	0 (53)	0 (54)	0
(55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	0 (64)	0
(65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0 (72)	0 (73)	0 (74)	0
(75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	0 (82)	0 (83)	0 (84)	0
(85)	0 (86)	0 (87)	0 (88)	0 (89)	0 (90)	0 (91)	0 (92)	0 (93)	0 (94)	0
(95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0 (102)	0 (103)	0 (104)	0
(105)	0 (106)	0 (107)	0 (108)	0 (109)	0 (110)	7 (111)	0 (112)	0 (113)	0 (114)	0
(115)	0 (116)	0 (117)	0 (118)	0 (119)	0 (120)	0 (121)	0 (122)	0 (123)	0 (124)	0
(125)	0 (126)	0 (127)	3							

ORIGIN CENTROID = 69 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 18.

(15)	4 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	0 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	0 (50)	0 (51)	0 (52)	4 (53)	0 (54)	0
(55)	0 (56)	7 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	3	

ORIGIN CENTROID = 71 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 38.

(53)	5 (54)	0 (55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0
(63)	17 (64)	4 (65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0 (72)	0
(73)	0 (74)	0 (75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	0 (82)	0
(83)	0 (84)	0 (85)	0 (86)	0 (87)	12					

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ORIGIN CENTROID = 84 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 4.

(127) 4

ORIGIN CENTROID = 87 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 157.

(15)	20 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	0 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	3 (50)	0 (51)	0 (52)	3 (53)	0 (54)	0
(55)	0 (56)	0 (57)	0 (58)	0 (59)	4 (60)	0 (61)	0 (62)	0 (63)	0 (64)	1
(65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0 (72)	0 (73)	0 (74)	0
(75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	11 (81)	86 (82)	0 (83)	0 (84)	0
(85)	0 (86)	0 (87)	0 (88)	0 (89)	0 (90)	0 (91)	0 (92)	0 (93)	0 (94)	0
(95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0 (102)	0 (103)	0 (104)	0
(105)	0 (106)	0 (107)	0 (108)	0 (109)	0 (110)	0 (111)	0 (112)	0 (113)	0 (114)	0
(115)	0 (116)	0 (117)	0 (118)	0 (119)	0 (120)	0 (121)	0 (122)	0 (123)	0 (124)	0
(125)	0 (126)	0 (127)	10 (128)	0 (129)	0 (130)	0 (131)	0 (132)	0 (133)	0 (134)	0
(135)	0 (136)	0 (137)	2 (138)	0 (139)	0 (140)	0 (141)	0 (142)	0 (143)	0 (144)	0
(145)	0 (146)	0 (147)	0 (148)	0 (149)	0 (150)	0 (151)	3 (152)	0 (153)	0 (154)	0
(155)	0 (156)	0 (157)	0 (158)	0 (159)	0 (160)	0 (161)	0 (162)	0 (163)	0 (164)	0
(165)	10 (166)	0 (167)	0 (168)	0 (169)	0 (170)	0 (171)	0 (172)	0 (173)	0 (174)	0
(175)	0 (176)	0 (177)	0 (178)	0 (179)	0 (180)	0 (181)	0 (182)	4		

ORIGIN CENTROID = 89 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 83.

(15)	11 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	0 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	0 (50)	0 (51)	0 (52)	0 (53)	0 (54)	0
(55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	2 (64)	0
(65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0 (72)	0 (73)	0 (74)	0
(75)	0 (76)	0 (77)	0 (78)	8 (79)	0 (80)	0 (81)	62			

ORIGIN CENTROID = 93 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 3.

(127) 3

ORIGIN CENTROID = 95 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 13.

(114)	3 (115)	0 (116)	0 (117)	0 (118)	0 (119)	3 (120)	0 (121)	0 (122)	0 (123)	0
(124)	0 (125)	0 (126)	0 (127)	3 (128)	0 (129)	0 (130)	0 (131)	0 (132)	0 (133)	0
(134)	0 (135)	0 (136)	0 (137)	0 (138)	0 (139)	0 (140)	0 (141)	0 (142)	0 (143)	0
(144)	0 (145)	0 (146)	0 (147)	0 (148)	0 (149)	0 (150)	0 (151)	0 (152)	0 (153)	0
(154)	0 (155)	0 (156)	0 (157)	0 (158)	0 (159)	0 (160)	0 (161)	0 (162)	0 (163)	0
(164)	0 (165)	4								

ORIGIN CENTROID = 97 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 3.

(165) 3

ORIGIN CENTROID = 98 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 3.

(182) 3

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ORIGIN CENTROID = 103 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 3.

(56) 3

ORIGIN CENTROID = 106 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 3.

(81) 3

ORIGIN CENTROID = 107 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 93.

(81)	57 (82)	0 (83)	0 (84)	7 (85)	0 (86)	0 (87)	0 (88)	0 (89)	0 (90)	0
(91)	0 (92)	0 (93)	0 (94)	0 (95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0
(101)	0 (102)	0 (103)	0 (104)	0 (105)	0 (106)	0 (107)	0 (108)	0 (109)	0 (110)	0
(111)	0 (112)	0 (113)	0 (114)	0 (115)	0 (116)	0 (117)	20 (118)	0 (119)	0 (120)	0
(121)	0 (122)	0 (123)	0 (124)	0 (125)	0 (126)	0 (127)	0 (128)	0 (129)	0 (130)	0
(131)	0 (132)	0 (133)	0 (134)	0 (135)	0 (136)	0 (137)	9			

ORIGIN CENTROID = 108 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 66.

(81)	62 (82)	0 (83)	0 (84)	0 (85)	0 (86)	0 (87)	0 (88)	0 (89)	0 (90)	0
(91)	0 (92)	0 (93)	0 (94)	0 (95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0
(101)	0 (102)	0 (103)	0 (104)	0 (105)	0 (106)	0 (107)	0 (108)	0 (109)	0 (110)	0
(111)	0 (112)	0 (113)	0 (114)	0 (115)	0 (116)	0 (117)	0 (118)	0 (119)	0 (120)	0
(121)	0 (122)	0 (123)	0 (124)	0 (125)	0 (126)	0 (127)	2 (128)	0 (129)	0 (130)	0
(131)	0 (132)	0 (133)	0 (134)	0 (135)	0 (136)	0 (137)	0 (138)	0 (139)	0 (140)	0
(141)	0 (142)	0 (143)	0 (144)	0 (145)	0 (146)	0 (147)	0 (148)	0 (149)	0 (150)	0
(151)	0 (152)	0 (153)	0 (154)	0 (155)	0 (156)	0 (157)	0 (158)	0 (159)	0 (160)	0
(161)	0 (162)	0 (163)	0 (164)	0 (165)	2					

ORIGIN CENTROID = 109 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 54.

(81) 54

ORIGIN CENTROID = 110 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 57.

(15)	3 (16)	0 (17)	0 (18)	0 (19)	0 (70)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	0 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	0 (50)	0 (51)	0 (52)	0 (53)	0 (54)	0
(55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	0 (64)	0
(65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0 (72)	0 (73)	0 (74)	0
(75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	48 (82)	0 (83)	0 (84)	0
(85)	0 (86)	0 (87)	0 (88)	0 (89)	0 (90)	0 (91)	0 (92)	0 (93)	0 (94)	0
(95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0 (102)	0 (103)	0 (104)	0
(105)	0 (106)	0 (107)	0 (108)	0 (109)	0 (110)	0 (111)	0 (112)	0 (113)	0 (114)	0
(115)	0 (116)	0 (117)	0 (118)	0 (119)	0 (120)	0 (121)	0 (122)	0 (123)	0 (124)	0
(125)	0 (126)	0 (127)	0 (128)	0 (129)	0 (130)	0 (131)	0 (132)	0 (133)	0 (134)	0
(135)	0 (136)	0 (137)	2 (138)	0 (139)	0 (140)	0 (141)	0 (142)	U (143)	0 (144)	0
(145)	0 (146)	0 (147)	3 (148)	0 (149)	0 (150)	0 (151)	0 (152)	0 (153)	0 (154)	0
(155)	0 (156)	0 (157)	0 (158)	0 (159)	0 (160)	0 (161)	0 (162)	0 (163)	0 (164)	0
(165)	0 (166)	0 (167)	0 (168)	0 (169)	0 (170)	0 (171)	0 (172)	0 (173)	0 (174)	0
(175)	0 (176)	0 (177)	0 (178)	0 (179)	0 (180)	0 (181)	0 (182)	0 (183)	1	

ORIGIN CENTROID = 111 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 33.

(81)	31 (82)	0 (83)	0 (84)	0 (85)	0 (86)	0 (87)	0 (88)	0 (89)	0 (90)	0
(91)	0 (92)	0 (93)	0 (94)	0 (95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0
(101)	0 (102)	0 (103)	0 (104)	0 (105)	0 (106)	0 (107)	0 (108)	0 (109)	0 (110)	0
(111)	0 (112)	0 (113)	0 (114)	0 (115)	0 (116)	0 (117)	0 (118)	0 (119)	2	

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ORIGIN CENTROID = 112 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 9.

(117) 9

ORIGIN CENTROID = 113 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 27.

(81)	18 (82)	0 (83)	0 (84)	0 (85)	0 (86)	0 (87)	0 (88)	0 (89)	0 (90)	0
(91)	0 (92)	0 (93)	0 (94)	0 (95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0
(101)	0 (102)	0 (103)	0 (104)	0 (105)	0 (106)	0 (107)	0 (108)	0 (109)	0 (110)	0
(111)	0 (112)	0 (113)	0 (114)	0 (115)	0 (116)	0 (117)	9			

ORIGIN CENTROID = 114 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 23.

(15)	3 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	0 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	0 (50)	0 (51)	0 (52)	0 (53)	0 (54)	0
(55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	0 (64)	0
(65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0 (72)	0 (73)	0 (74)	0
(75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	12 (82)	0 (83)	0 (84)	0
(85)	0 (86)	0 (87)	2 (88)	0 (89)	2 (90)	0 (91)	0 (92)	0 (93)	0 (94)	0
(95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0 (102)	0 (103)	0 (104)	0
(105)	0 (106)	0 (107)	0 (108)	0 (109)	0 (110)	0 (111)	0 (112)	0 (113)	0 (114)	0
(115)	0 (116)	0 (117)	0 (118)	0 (119)	0 (120)	0 (121)	0 (122)	0 (123)	0 (124)	0
(125)	0 (126)	0 (127)	0 (128)	0 (129)	0 (130)	0 (131)	0 (132)	0 (133)	0 (134)	0
(135)	0 (136)	0 (137)	2 (138)	0 (139)	0 (140)	0 (141)	0 (142)	0 (143)	0 (144)	0
(145)	0 (146)	0 (147)	0 (148)	0 (149)	0 (150)	0 (151)	0 (152)	0 (153)	0 (154)	0
(155)	0 (156)	0 (157)	0 (158)	0 (159)	0 (160)	0 (161)	0 (162)	0 (163)	0 (164)	0
(165)	2									

ORIGIN CENTROID = 116 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 2.

(151) 2

ORIGIN CENTROID = 117 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 74.

(15)	3 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	0 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	0 (50)	0 (51)	0 (52)	0 (53)	0 (54)	0
(55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	0 (64)	0
(65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0 (72)	0 (73)	0 (74)	0
(75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	3 (82)	0 (83)	0 (84)	0
(85)	0 (86)	0 (87)	0 (88)	0 (89)	0 (90)	0 (91)	0 (92)	0 (93)	0 (94)	0
(95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0 (102)	0 (103)	3 (104)	0
(105)	0 (106)	0 (107)	26 (108)	0 (109)	0 (110)	0 (111)	0 (112)	0 (113)	5 (114)	0
(115)	0 (116)	0 (117)	0 (118)	0 (119)	0 (120)	0 (121)	0 (122)	0 (123)	0 (124)	0
(125)	0 (126)	0 (127)	0 (128)	0 (129)	3 (130)	5 (131)	0 (132)	0 (133)	0 (134)	0
(135)	0 (136)	0 (137)	19 (138)	0 (139)	3 (140)	0 (141)	0 (142)	0 (143)	0 (144)	0
(145)	0 (146)	0 (147)	0 (148)	0 (149)	0 (150)	0 (151)	0 (152)	0 (153)	0 (154)	0
(155)	0 (156)	0 (157)	0 (158)	0 (159)	3					

ORIGIN CENTROID = 118 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 5.

(15)	3 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	0 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	0 (50)	0 (51)	0 (52)	0 (53)	0 (54)	0
(55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	0 (64)	0

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ORIGIN CENTROID = 118 DESTINATION CENTROIDS AND VOLUMES CONTINUED

(65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0 (72)	0 (73)	0 (74)	0
(75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	0 (82)	0 (83)	0 (84)	0
(85)	0 (86)	0 (87)	0 (88)	0 (89)	0 (90)	0 (91)	0 (92)	0 (93)	0 (94)	0
(95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0 (102)	0 (103)	0 (104)	0
(105)	0 (106)	0 (107)	0 (108)	0 (109)	0 (110)	0 (111)	0 (112)	0 (113)	2	

ORIGIN CENTROID = 119 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 26.

(15)	3 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	0 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	0 (50)	0 (51)	0 (52)	0 (53)	0 (54)	0
(55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	0 (64)	0
(65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0 (72)	0 (73)	0 (74)	0
(75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	6 (82)	0 (83)	0 (84)	0
(85)	0 (86)	0 (87)	2 (88)	0 (89)	0 (90)	0 (91)	0 (92)	0 (93)	0 (94)	0
(95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0 (102)	0 (103)	0 (104)	0
(105)	0 (106)	0 (107)	0 (108)	0 (109)	0 (110)	0 (111)	2 (112)	0 (113)	0 (114)	0
(115)	0 (116)	0 (117)	0 (118)	0 (119)	0 (120)	0 (121)	0 (122)	0 (123)	0 (124)	0
(125)	0 (126)	0 (127)	0 (128)	0 (129)	3 (130)	0 (131)	0 (132)	0 (133)	0 (134)	0
(135)	0 (136)	0 (137)	4 (138)	0 (139)	0 (140)	0 (141)	0 (142)	0 (143)	0 (144)	0
(145)	0 (146)	0 (147)	0 (148)	0 (149)	0 (150)	0 (151)	3 (152)	0 (153)	0 (154)	0
(155)	0 (156)	0 (157)	0 (158)	0 (159)	0 (160)	0 (161)	0 (162)	0 (163)	0 (164)	0
(165)	0 (166)	0 (167)	0 (168)	0 (169)	0 (170)	0 (171)	0 (172)	0 (173)	0 (174)	0
(175)	0 (176)	0 (177)	0 (178)	0 (179)	0 (180)	0 (181)	0 (182)	3		

ORIGIN CENTROID = 120 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 13.

(129)	8 (130)	0 (131)	0 (132)	0 (133)	0 (134)	0 (135)	0 (136)	0 (137)	2 (138)	0
(139)	0 (140)	0 (141)	0 (142)	0 (143)	0 (144)	0 (145)	0 (146)	0 (147)	0 (148)	0
(149)	0 (150)	0 (151)	0 (152)	0 (153)	0 (154)	0 (155)	0 (156)	0 (157)	0 (158)	0
(159)	3									

ORIGIN CENTROID = 121 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 3.

(81) 3

ORIGIN CENTROID = 122 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 20.

(151)	3 (152)	0 (153)	0 (154)	0 (155)	0 (156)	0 (157)	0 (158)	0 (159)	0 (160)	0
(161)	0 (167)	0 (163)	0 (164)	0 (165)	17					

ORIGIN CENTROID = 123 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 5.

(15) 5

ORIGIN CENTROID = 127 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 119.

(15)	15 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	5 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	3 (50)	0 (51)	0 (52)	3 (53)	0 (54)	0
(55)	0 (56)	3 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	0 (64)	0
(65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0 (72)	0 (73)	0 (74)	0
(75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	19 (82)	0 (83)	0 (84)	3
(85)	0 (86)	0 (87)	10 (88)	0 (89)	4 (90)	0 (91)	0 (92)	0 (93)	0 (94)	0
(95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0 (102)	0 (103)	0 (104)	0

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ORIGIN CENTROID = 127 DESTINATION CENTROIDS AND VOLUMES CONTINUED

(105)	0 (106)	0 (107)	2 (108)	0 (109)	0 (110)	0 (111)	0 (112)	0 (113)	0 (114)	0
(115)	0 (116)	0 (117)	0 (118)	0 (119)	0 (120)	0 (121)	0 (122)	0 (123)	0 (124)	0
(125)	0 (126)	0 (127)	0 (128)	0 (129)	0 (130)	3 (131)	0 (132)	2 (133)	0 (134)	0
(135)	12 (136)	0 (137)	25 (138)	0 (139)	0 (140)	0 (141)	0 (142)	0 (143)	0 (144)	0
(145)	0 (146)	0 (147)	0 (148)	0 (149)	0 (150)	0 (151)	3 (152)	0 (153)	3 (154)	0
(155)	0 (156)	0 (157)	0 (158)	0 (159)	0 (160)	0 (161)	0 (162)	0 (163)	0 (164)	0
(165)	4									

ORIGIN CENTROID = 129 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 21.

(106)	4 (107)	0 (108)	0 (109)	0 (110)	0 (111)	0 (112)	0 (113)	0 (114)	0 (115)	0
(116)	0 (117)	0 (118)	0 (119)	7 (120)	10					

ORIGIN CENTROID = 135 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 6.

(127)	3 (128)	0 (129)	0 (130)	0 (131)	0 (132)	0 (133)	0 (134)	0 (135)	0 (136)	0
(137)	0 (138)	0 (139)	0 (140)	0 (141)	0 (142)	0 (143)	0 (144)	0 (145)	0 (146)	0
(147)	0 (148)	0 (149)	0 (150)	0 (151)	0 (152)	0 (153)	0 (154)	0 (155)	0 (156)	0
(157)	0 (158)	0 (159)	0 (160)	0 (161)	0 (162)	0 (163)	0 (164)	0 (165)	3	

ORIGIN CENTROID = 137 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 462.

(15)	46 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	0 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	0 (50)	0 (51)	0 (52)	0 (53)	0 (54)	0
(55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	0 (64)	0
(65)	0 (66)	0 (67)	0 (68)	4 (69)	0 (70)	0 (71)	0 (72)	0 (73)	6 (74)	0
(75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	170 (82)	0 (83)	0 (84)	0
(85)	0 (86)	0 (87)	2 (88)	0 (89)	0 (90)	0 (91)	0 (92)	0 (93)	0 (94)	0
(95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0 (102)	0 (103)	0 (104)	0
(105)	0 (106)	0 (107)	18 (108)	2 (109)	0 (110)	4 (111)	0 (112)	0 (113)	0 (114)	0
(115)	0 (116)	0 (117)	4 (118)	0 (119)	5 (120)	0 (121)	0 (122)	0 (123)	0 (124)	0
(125)	0 (176)	0 (127)	31 (128)	0 (129)	0 (130)	0 (131)	0 (132)	0 (133)	0 (134)	0
(135)	0 (136)	0 (137)	0 (138)	0 (139)	0 (140)	0 (141)	0 (142)	0 (143)	0 (144)	0
(145)	0 (146)	0 (147)	3 (148)	0 (149)	0 (150)	0 (151)	0 (152)	0 (153)	0 (154)	0
(155)	0 (156)	0 (157)	0 (158)	0 (159)	0 (160)	0 (161)	0 (162)	0 (163)	0 (164)	0
(165)	23 (166)	0 (167)	0 (168)	0 (169)	0 (170)	0 (171)	0 (172)	0 (173)	0 (174)	0
(175)	5 (176)	0 (177)	0 (178)	0 (179)	0 (180)	0 (181)	0 (182)	135 (183)	4	

ORIGIN CENTROID = 138 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 3.

(117) 3

ORIGIN CENTROID = 139 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 6.

(120)	2 (121)	0 (122)	0 (123)	0 (124)	0 (125)	0 (126)	0 (127)	0 (128)	0 (129)	0
(130)	0 (131)	0 (132)	0 (133)	0 (134)	0 (135)	0 (136)	0 (137)	0 (138)	0 (139)	0
(140)	0 (141)	0 (142)	0 (143)	0 (144)	0 (145)	0 (146)	0 (147)	0 (148)	0 (149)	0
(150)	0 (151)	0 (152)	0 (153)	0 (154)	0 (155)	0 (156)	0 (157)	0 (158)	0 (159)	0
(160)	0 (161)	0 (162)	0 (163)	0 (164)	0 (165)	4				

TAIWAN N-S STUDY 5040-01 DCI 1990 - 1 TRIP TABLE - SPECIAL-EXP. BUS WEDNESDAY, 9 JULY, 1969

LISTING OF ZONE TO ZONE VOLUMES PAGE NO. 13

ORIGIN CENTROID = 144 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 33.

(137)	3 (138)	0 (139)	0 (140)	0 (141)	0 (142)	0 (143)	0 (144)	0 (145)	0 (146)	0
(147)	0 (148)	0 (149)	0 (150)	0 (151)	0 (152)	0 (153)	0 (154)	0 (155)	0 (156)	0
(157)	0 (158)	0 (159)	0 (160)	0 (161)	0 (162)	0 (163)	0 (164)	0 (165)	15 (166)	0
(167)	0 (168)	0 (169)	0 (170)	0 (171)	0 (172)	0 (173)	0 (174)	0 (175)	0 (176)	0
(177)	0 (178)	0 (179)	0 (180)	0 (181)	0 (182)	15				

ORIGIN CENTROID = 147 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 73.

(15)	5 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	0 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	0 (50)	0 (51)	0 (52)	0 (53)	0 (54)	0
(55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	0 (64)	0
(65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0 (72)	0 (73)	0 (74)	0
(75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	0 (82)	0 (83)	0 (84)	0
(85)	0 (86)	0 (87)	0 (88)	0 (89)	0 (90)	0 (91)	0 (92)	0 (93)	0 (94)	0
(95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0 (102)	0 (103)	0 (104)	0
(105)	0 (106)	0 (107)	0 (108)	0 (109)	0 (110)	0 (111)	0 (112)	0 (113)	0 (114)	0
(115)	0 (116)	0 (117)	0 (118)	0 (119)	0 (120)	0 (121)	0 (122)	0 (123)	0 (124)	0
(125)	0 (126)	0 (127)	0 (128)	0 (129)	0 (130)	0 (131)	0 (132)	0 (133)	0 (134)	0
(135)	0 (136)	0 (137)	3 (138)	0 (139)	0 (140)	0 (141)	0 (142)	0 (143)	0 (144)	0
(145)	0 (146)	0 (147)	0 (148)	0 (149)	0 (150)	0 (151)	0 (152)	0 (153)	0 (154)	0
(155)	0 (156)	0 (157)	0 (158)	0 (159)	0 (160)	0 (161)	0 (162)	0 (163)	0 (164)	0
(165)	59 (166)	0 (167)	0 (168)	0 (169)	0 (170)	0 (171)	0 (172)	0 (173)	0 (174)	0
(175)	0 (176)	0 (177)	0 (178)	0 (179)	0 (180)	0 (181)	0 (182)	6		

ORIGIN CENTROID = 149 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 4.

(165) 4

ORIGIN CENTROID = 151 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 22.

(127)	3 (128)	0 (129)	0 (130)	0 (131)	0 (132)	0 (133)	0 (134)	0 (135)	0 (136)	0
(137)	3 (138)	0 (139)	0 (140)	0 (141)	0 (142)	0 (143)	0 (144)	0 (145)	0 (146)	0
(147)	0 (148)	0 (149)	0 (150)	0 (151)	0 (152)	0 (153)	0 (154)	0 (155)	0 (156)	0
(157)	0 (158)	0 (159)	0 (160)	0 (161)	0 (162)	0 (163)	0 (164)	0 (165)	6 (166)	0
(167)	0 (168)	0 (169)	0 (170)	0 (171)	0 (172)	0 (173)	0 (174)	0 (175)	0 (176)	0
(177)	0 (178)	0 (179)	0 (180)	0 (181)	0 (182)	10				

ORIGIN CENTROID = 152 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 94.

(15)	5 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	0 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	0 (50)	0 (51)	0 (52)	0 (53)	0 (54)	0
(55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	0 (64)	7
(65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0 (72)	0 (73)	0 (74)	0
(75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	0 (82)	0 (83)	0 (84)	0
(85)	0 (86)	0 (87)	0 (88)	0 (89)	0 (90)	0 (91)	0 (92)	0 (93)	0 (94)	0
(95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0 (102)	0 (103)	0 (104)	0
(105)	0 (106)	0 (107)	0 (108)	0 (109)	0 (110)	0 (111)	0 (112)	0 (113)	0 (114)	0
(115)	0 (116)	0 (117)	0 (118)	0 (119)	0 (120)	0 (121)	0 (122)	0 (123)	0 (124)	0
(125)	0 (126)	0 (127)	3 (128)	0 (129)	0 (130)	0 (131)	0 (132)	0 (133)	0 (134)	0
(135)	0 (136)	0 (137)	0 (138)	0 (139)	0 (140)	0 (141)	0 (142)	0 (143)	0 (144)	0
(145)	0 (146)	0 (147)	0 (148)	0 (149)	0 (150)	0 (151)	0 (152)	0 (153)	0 (154)	0
(155)	0 (156)	0 (157)	0 (158)	0 (159)	0 (160)	0 (161)	0 (162)	0 (163)	0 (164)	4
(165)	82									

TAIWAN N-S STUDY 5040-01 DCI 1990 - 1 TRIP TABLE - SPECIAL-EXP. BUS WEDNESDAY, 9 JULY, 1969

LISTING OF ZONE TO ZONE VOLUMES PAGE NO. 14

ORIGIN CENTROID = 153 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 72.

(127)	3 (128)	0 (129)	0 (130)	0 (131)	0 (132)	0 (133)	0 (134)	0 (135)	0 (136)	0
(137)	0 (138)	0 (139)	0 (140)	0 (141)	0 (142)	0 (143)	0 (144)	0 (145)	0 (146)	0
(147)	0 (148)	0 (149)	0 (150)	0 (151)	0 (152)	0 (153)	0 (154)	0 (155)	0 (156)	0
(157)	0 (158)	0 (159)	0 (160)	0 (161)	0 (162)	0 (163)	0 (164)	0 (165)	69	

ORIGIN CENTROID = 155 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 36.

(165) 36

ORIGIN CENTROID = 156 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 4.

(165) 4

ORIGIN CENTROID = 157 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 26.

(165) 21 (166) 0 (167) 5

ORIGIN CENTROID = 158 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 4.

(165) 4

ORIGIN CENTROID = 159 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 36.

(165) 36

ORIGIN CENTROID = 160 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 4.

(170) 4

ORIGIN CENTROID = 165 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 1065.

(2)	3 (3)	0 (4)	0 (5)	0 (6)	0 (7)	0 (8)	0 (9)	0 (10)	0 (11)	0
(12)	0 (13)	0 (14)	0 (15)	34 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0
(22)	4 (23)	0 (24)	0 (25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0
(32)	0 (33)	0 (34)	0 (35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0
(42)	0 (43)	0 (44)	0 (45)	0 (46)	0 (47)	0 (48)	0 (49)	3 (50)	0 (51)	0
(52)	0 (53)	0 (54)	0 (55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0
(62)	0 (63)	0 (64)	0 (65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0
(72)	0 (73)	0 (74)	0 (75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	27
(82)	0 (83)	0 (84)	0 (85)	0 (86)	0 (87)	9 (88)	0 (89)	0 (90)	0 (91)	0
(92)	0 (93)	3 (94)	0 (95)	3 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0
(102)	0 (103)	0 (104)	0 (105)	0 (106)	0 (107)	0 (108)	2 (109)	0 (110)	2 (111)	0
(112)	0 (113)	0 (114)	0 (115)	0 (116)	0 (117)	0 (118)	0 (119)	2 (120)	0 (121)	0
(122)	14 (123)	0 (124)	0 (125)	0 (126)	0 (127)	4 (128)	0 (129)	3 (130)	0 (131)	0
(132)	0 (133)	0 (134)	0 (135)	0 (136)	0 (137)	38 (138)	0 (139)	0 (140)	0 (141)	0
(142)	0 (143)	0 (144)	2 (145)	0 (146)	0 (147)	65 (148)	0 (149)	0 (150)	0 (151)	21
(152)	34 (153)	49 (154)	0 (155)	4 (156)	4 (157)	14 (158)	4 (159)	7 (160)	0 (161)	0
(162)	0 (163)	0 (164)	0 (165)	0 (166)	5 (167)	0 (168)	31 (169)	0 (170)	18 (171)	0
(172)	4 (173)	0 (174)	0 (175)	0 (176)	8 (177)	0 (178)	0 (179)	5 (180)	0 (181)	0
(182)	623 (183)	21								

ORIGIN CENTROID = 167 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 5.

(165) 5

TAIWAN N-S STUDY 5040-01 DCI 1990 - 1 TRIP TABLE - SPECIAL-EXP. BUS WEDNESDAY, 9 JULY, 1969

LISTING OF ZONE TO ZONE VOLUMES PAGE NO. 15

ORIGIN CENTROID = 168 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 48.

(165) 48

ORIGIN CENTROID = 170 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 43.

(182) 38 (183) 5

ORIGIN CENTROID = 174 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 138.

(182) 138

ORIGIN CENTROID = 176 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 10.

(165) 4 (166) 0 (167) 0 (168) 0 (169) 0 (170) 0 (171) 0 (172) 6

ORIGIN CENTROID = 177 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 5.

(183) 5

ORIGIN CENTROID = 182 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 1669.

(2)	5 (3)	0 (4)	0 (5)	0 (6)	0 (7)	0 (8)	0 (9)	0 (10)	0 (11)	0
(12)	0 (13)	0 (14)	0 (15)	164 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0
(22)	0 (23)	0 (24)	0 (25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0
(32)	0 (33)	0 (34)	0 (35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0
(42)	0 (43)	0 (44)	0 (45)	0 (46)	0 (47)	0 (48)	0 (49)	10 (50)	0 (51)	0
(52)	0 (53)	0 (54)	0 (55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0
(62)	0 (63)	0 (64)	0 (65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0
(72)	0 (73)	5 (74)	0 (75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	60
(82)	0 (83)	0 (84)	0 (85)	0 (86)	0 (87)	4 (88)	0 (89)	4 (90)	0 (91)	0
(92)	0 (93)	0 (94)	0 (95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0
(102)	0 (103)	0 (104)	0 (105)	0 (106)	0 (107)	0 (108)	0 (109)	0 (110)	4 (111)	0
(112)	0 (113)	0 (114)	0 (115)	0 (116)	0 (117)	0 (118)	0 (119)	3 (120)	0 (121)	0
(122)	0 (123)	0 (124)	0 (125)	0 (126)	0 (127)	0 (128)	0 (129)	0 (130)	0 (131)	0
(132)	0 (133)	0 (134)	0 (135)	0 (136)	0 (137)	174 (138)	0 (139)	0 (140)	0 (141)	0
(142)	0 (143)	0 (144)	12 (145)	0 (146)	0 (147)	11 (148)	0 (149)	0 (150)	3 (151)	6
(152)	0 (153)	0 (154)	0 (155)	0 (156)	0 (157)	0 (158)	0 (159)	5 (160)	0 (161)	3
(162)	0 (163)	0 (164)	0 (165)	460 (166)	0 (167)	16 (168)	0 (169)	0 (170)	95 (171)	0
(172)	45 (173)	0 (174)	245 (175)	0 (176)	0 (177)	0 (178)	0 (179)	0 (180)	0 (181)	0
(182)	0 (183)	335								

ORIGIN CENTROID = 183 DESTINATION CENTROIDS AND VOLUMES TOTAL TRIPS = 368.

(15)	6 (16)	0 (17)	0 (18)	0 (19)	0 (20)	0 (21)	0 (22)	0 (23)	0 (24)	0
(25)	0 (26)	0 (27)	0 (28)	0 (29)	0 (30)	0 (31)	0 (32)	0 (33)	0 (34)	0
(35)	0 (36)	0 (37)	0 (38)	0 (39)	0 (40)	0 (41)	0 (42)	0 (43)	0 (44)	0
(45)	0 (46)	0 (47)	0 (48)	0 (49)	0 (50)	0 (51)	0 (52)	0 (53)	0 (54)	0
(55)	0 (56)	0 (57)	0 (58)	0 (59)	0 (60)	0 (61)	0 (62)	0 (63)	0 (64)	0
(65)	0 (66)	0 (67)	0 (68)	0 (69)	0 (70)	0 (71)	0 (72)	0 (73)	0 (74)	0
(75)	0 (76)	0 (77)	0 (78)	0 (79)	0 (80)	0 (81)	2 (82)	0 (83)	0 (84)	0
(85)	0 (86)	0 (87)	0 (88)	0 (89)	0 (90)	0 (91)	0 (92)	0 (93)	0 (94)	0
(95)	0 (96)	0 (97)	0 (98)	0 (99)	0 (100)	0 (101)	0 (102)	0 (103)	0 (104)	0
(105)	0 (106)	0 (107)	0 (108)	0 (109)	0 (110)	0 (111)	0 (112)	0 (113)	0 (114)	0
(115)	0 (116)	0 (117)	1 (118)	0 (119)	0 (120)	0 (121)	0 (122)	0 (123)	0 (124)	0
(125)	0 (126)	0 (127)	0 (128)	0 (129)	0 (130)	0 (131)	0 (132)	0 (133)	0 (134)	0
(135)	0 (136)	0 (137)	3 (138)	0 (139)	0 (140)	0 (141)	0 (142)	0 (143)	0 (144)	0
(145)	0 (146)	0 (147)	0 (148)	0 (149)	0 (150)	0 (151)	0 (152)	0 (153)	0 (154)	0
(155)	0 (156)	0 (157)	0 (158)	0 (159)	0 (160)	0 (161)	0 (162)	0 (163)	0 (164)	0

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ORIGIN CENTROID = 183 DESTINATION CENTROIDS AND VOLUMES CONTINUED

(165)	28 (166)	0 (167)	0 (168)	0 (169)	0 (170)	2 (171)	0 (172)	2 (173)	0 (174)	0
(175)	0 (176)	33 (177)	0 (178)	0 (179)	0 (180)	16 (181)	0 (182)	275		

COMPREHENSIVE TOLL ROAD STU

NORTH-SOUTH FREEWAY TAIWAN

EXPRESS BUS TRIP TABLES –19

DE LEUW, CATHER INTERNATIONAL-CHICA

As with the "Throat Operation", discussed above, no stops would be made on the freeway with "parallel road operation", and no special facilities would need to be provided on or along the freeway.

"Freeway Trunkline Operation"

As shown in Exhibit 39, this type of operation would require stops being made along the freeway. One disadvantage of this type of operation, then, would be the requirement to design and construct special facilities for bus operations on the freeway. Trunkline operation would also have another disadvantage, particularly vis-a-vis parallel road operation, in that a greater number of transfers would be involved (normally two transfers for each passenger trip, since the freeway bus would only move the passengers along the freeway itself, and not bring them to, or carry them away from, the freeway facility).

The great advantage of trunkline operation is that it would normally provide both faster and more time-convenient service than the alternative methods of operation. A passenger could move between any two points having bus stops along the freeway on any freeway bus; since buses in each direction would be frequent, prospective passengers would seldom have long to wait to be picked up. In order to make this method more efficient, unnecessary pull-offs and stops by the express bus in rural areas should be prevented by installation of a method of signaling the express bus on the toll road. Whenever a passenger stop would be necessary, a signal (either a light or a radio signal) would be activated by a passenger wishing to board. This signal would be clearly visible to the driver and would remain in the positive position for a time equal to the headway or until a bus would arrive (whichever time would be shorter). Passengers on the bus wishing to disembark would advise the driver or attendant. The stops would be very brief, so that, even for travellers going long distances, the intermediate stops between their points of embarkation and their destinations would not constitute any appreciable delays.

Trunkline operation would eliminate most bus scheduling problems, although it would still be necessary to vary the frequency of buses on the freeway according to hourly and seasonal demand. It would not be necessary, however, as it would be with "throat" or "parallel road" operation to know the passenger demand between any two points, or to make decisions regarding the number of intermediate stops which might be made on a bus run.

With trunkline operation, points of passenger transfer to and from the freeway would require such fixed facilities as are listed following:

- Bus terminals adjacent to the freeway near major trip-generating points;
- Bus loading and unloading platforms, capable of handling from one to five buses at a time, at all bus stops on the freeway;
- Acceleration and deceleration ramps to the freeway bus platforms in each direction;
- Stairs or ramps from the toll road bus platform level to the crossroad level; and
- Two bus pull-off lanes and platforms at each major crossroad.

The importance of terminal transfer stations immediately adjacent to the freeway at the major trip-generating points is critical to the efficiency of this operation. These terminal transfer facilities would reduce stop time for the through-service to a minimum, decrease transfer time on feeder buses into and out of terminals and provide auxiliary services such as parking, ticketing and passenger activities.

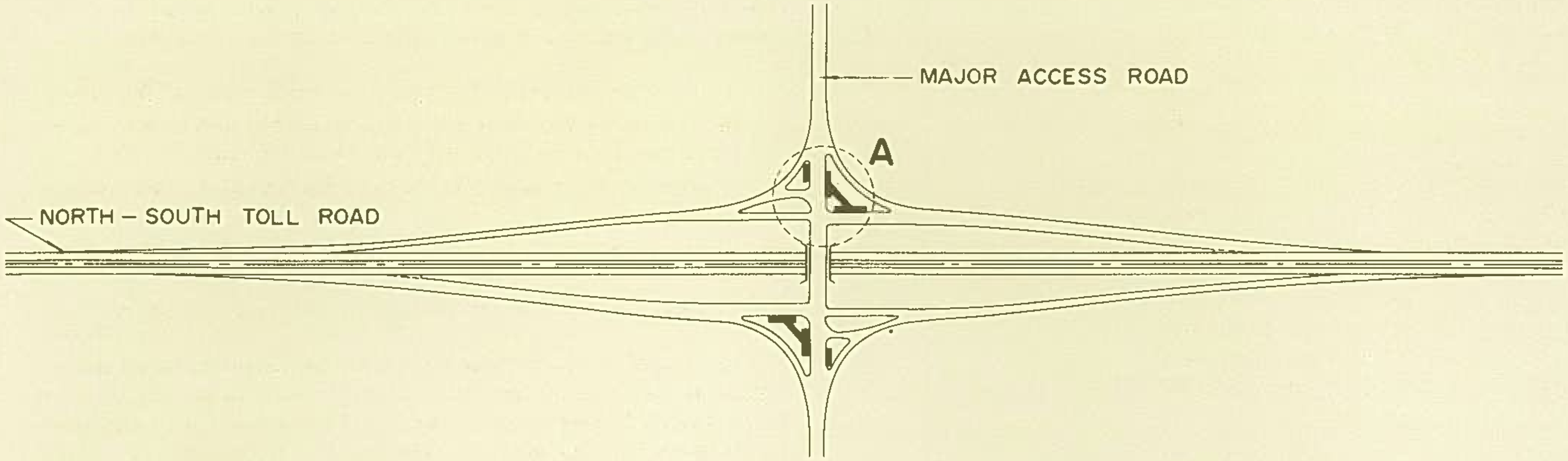
Exhibit 38 shows typical bus stops at a freeway interchange, and at a crossroad where no interchange would be provided.

Recommended Operations and Facilities

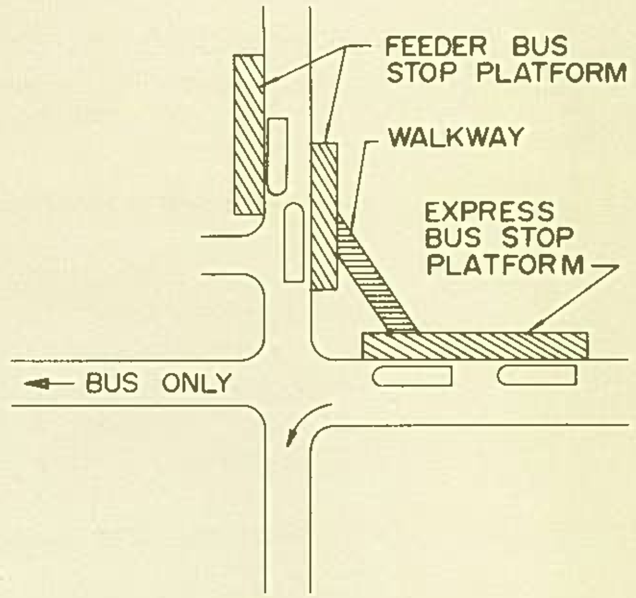
The three designs for bus operations discussed above are not necessarily mutually exclusive. In the particular case of the North-South Freeway, in fact, a hybrid design for operations would be preferred. To handle existing and normal growth bus traffic, the "toll road and parallel street distribution operation" would be the preferred plan of operation. This plan of operation would be especially well-suited to conditions in the northern and southern regions of the freeway because of the highly urbanized character of the highways which would parallel the freeway.

Not all passengers could easily be picked up and dropped off along these parallel highway routes, however, so that there would still need to be some centrally-located points where a portion of the bus trips would originate and terminate. With a preponderance of short-distance trips, these centrally-located points would logically be the central business districts of urban areas. Thus, the "toll road and parallel street distribution" plan of operation would have to be supplemented by "throat" operations.

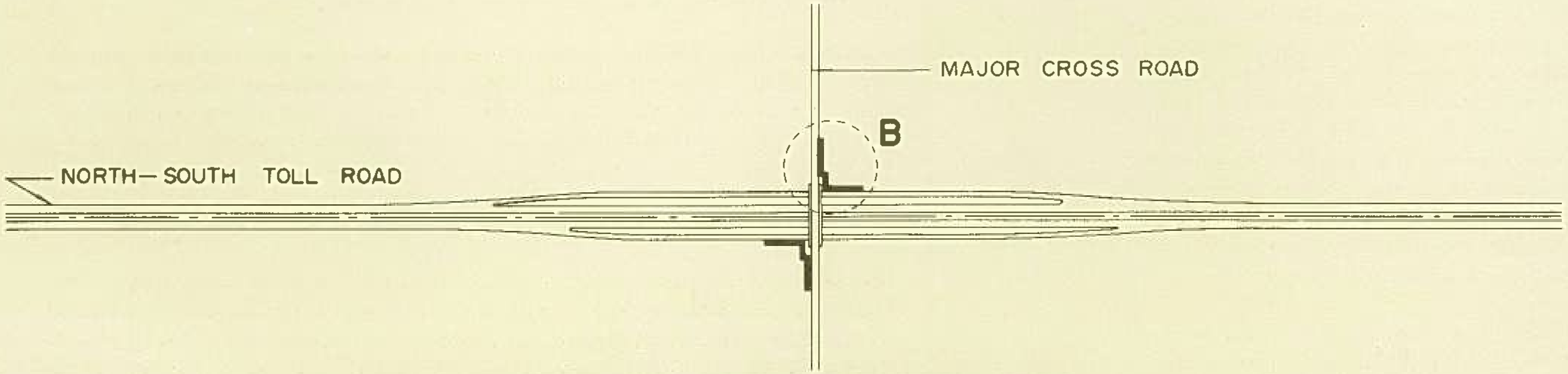
Such a design for operation would be sufficient to handle bus transport demand with present-day patterns.



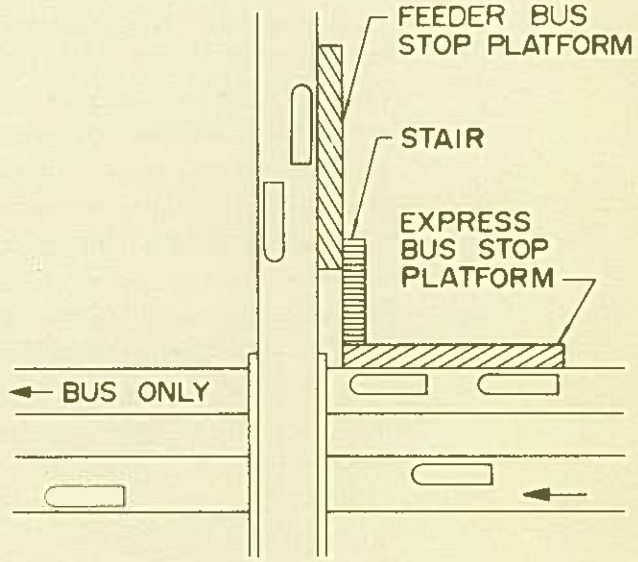
TYPICAL TOLL ROAD BUS STOP AT DIAMOND INTERCHANGE



DETAIL A



TYPICAL TOLL ROAD BUS STOP AT MAJOR CROSS ROAD



DETAIL B

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
TYPICAL BUS STOP LAYOUTS
DE LEUW, CATHER INTERNATIONAL-CHICAGO

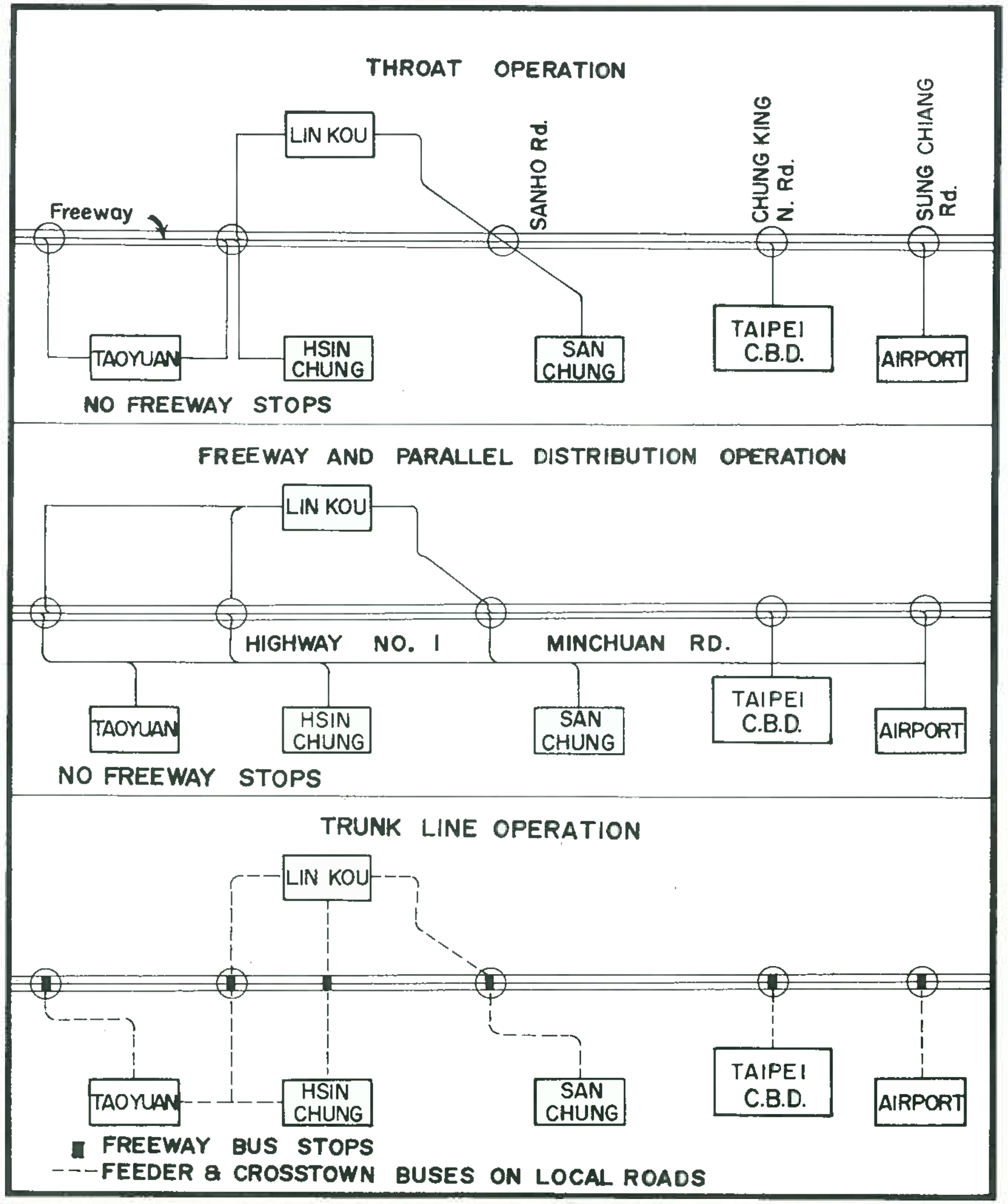
When the freeway is opened, however, the patterns of bus transport demand should be altered. Buses then should begin to transport large numbers of long-distance passengers. To handle high-volume, long-distance passenger traffic, trunkline operations would be preferred. Depending upon the extent to which such service would be developed, trunkline operation might wholly replace "throat" operations, since passengers would merely be congregating at a different location, i.e., they would gather at a terminal near the freeway, or at a bus stop along the freeway, rather than at a terminal in the central business district. The advent of trunkline operation would be expected to have a lesser effect on the "parallel road distribution" operations.

Whereas, when the freeway would first open, feeder buses and other means of transportation might carry passengers over considerable urban distances before reaching the freeway, future development along the freeway should assure that, eventually, a sizable portion of freeway bus passengers would only need to travel short distances to reach freeway bus stops. Thus, with the passage of time, trunkline operations should become more attractive relative to "throat" and "parallel road" operations.

Exhibits 40 and 41 through 44 indicate approximate locations and types of bus operating facilities being recommended in this study. A total of four terminals, eight interchange stops, and twenty bus stops on the freeway are shown in Exhibit 40, as recommended facilities.

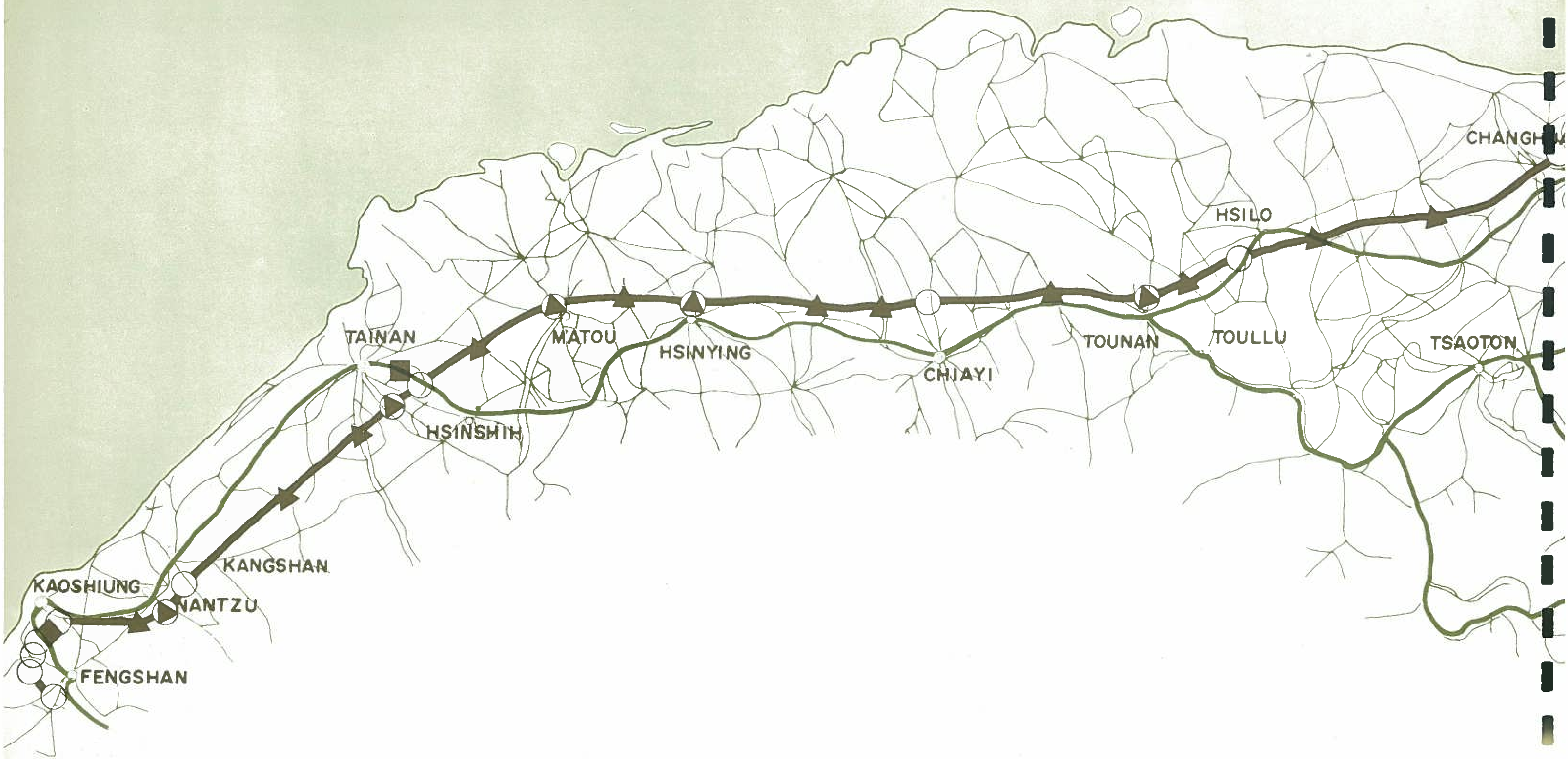
Exhibits 42 through 44 show a suggested layout of a typical bus transfer terminal under an elevated section of the freeway. The same concept could be modified to be applicable to a terminal located adjacent to the freeway, such as on an approach road. Location under the freeway would have two distinct advantages. Firstly, land acquisition would be minimized, inasmuch as space under the freeway would be utilized. Secondly, freeway buses would approach and leave the terminal directly from the freeway without involvement in local traffic. The terminal shown is designed to accommodate approximately 40 departing passengers per minute under peak conditions. Departing passengers would proceed directly from ticket counter to escalator, cross bus lanes on an elevated passageway, and walk down stairs to the designated bus platform. Arriving passengers would walk up stairs from the bus platform (individual escalators at some or all platforms could be provided), cross bus lanes on the elevated passageway, and proceed down stairs or escalators to the lobby level and depart. Public toilets, public telephones, concessionaire space, administrative offices, but dispatch offices, and bus driver areas are included in this concept. Additional elements such as a restaurants, public lounges, snack bars, etc. could be included, if conditions would warrant them, by expanding the lobby area.

EXHIBIT 39

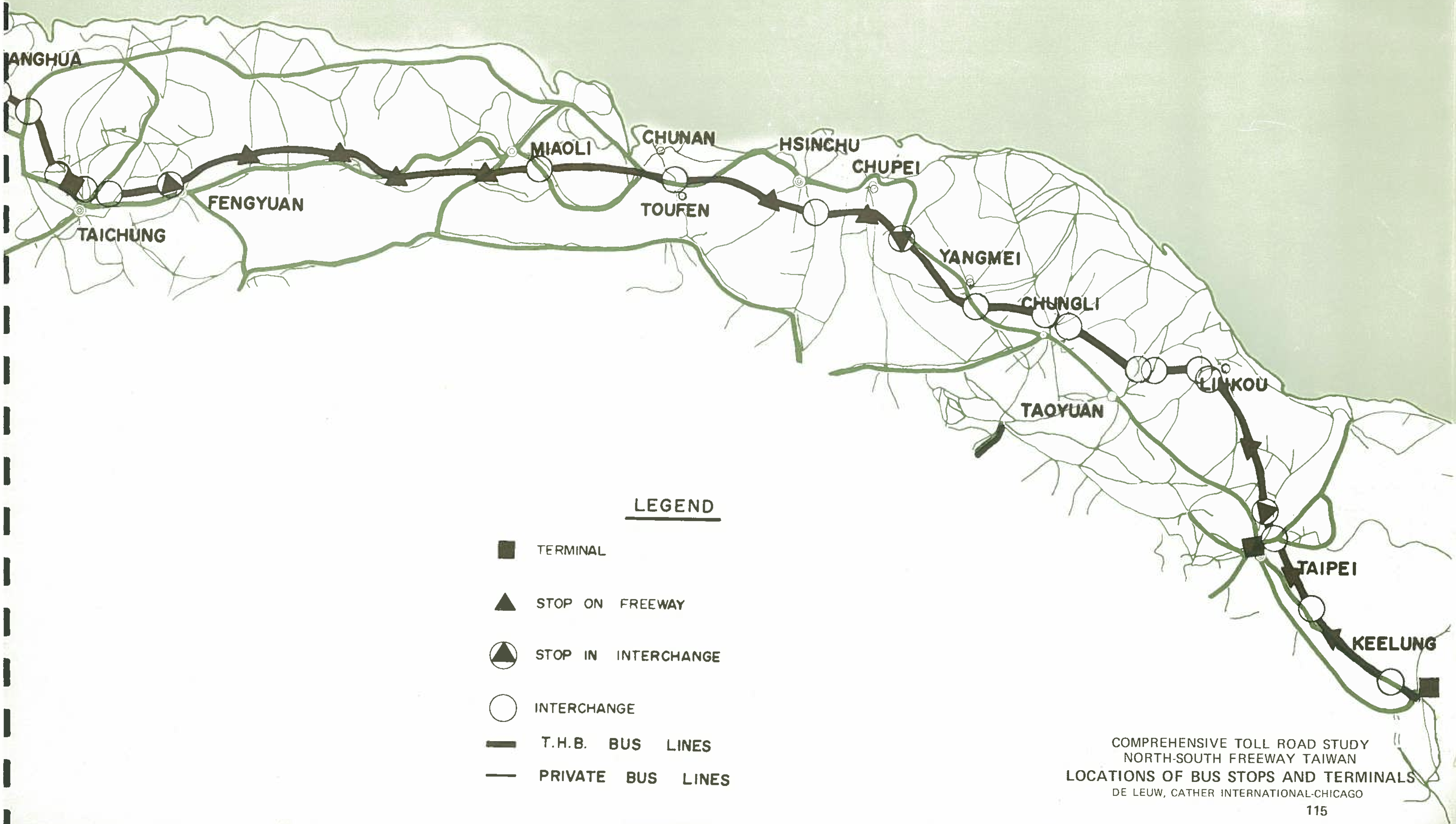


COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
ALTERNATIVE BUS OPERATION SCHEMATICS
DE LEUW, CATHER INTERNATIONAL-CHICAGO

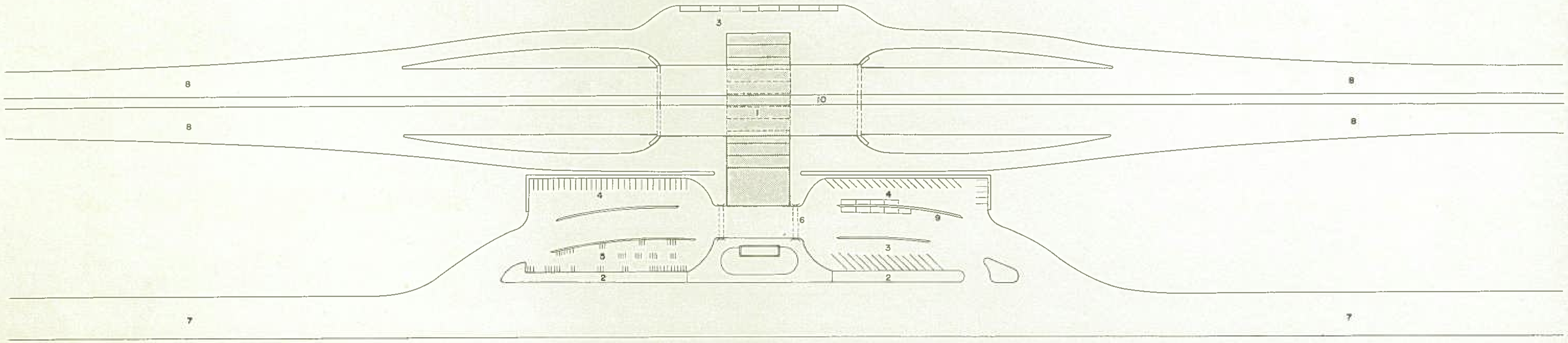
EXHIBIT



COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
LOCATIONS OF BUS STOPS AND TERMINAL
DE LEUW, CATHER INTERNATIONAL-CHICAGO



COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
LOCATIONS OF BUS STOPS AND TERMINALS
DE LEUW, CATHER INTERNATIONAL-CHICAGO



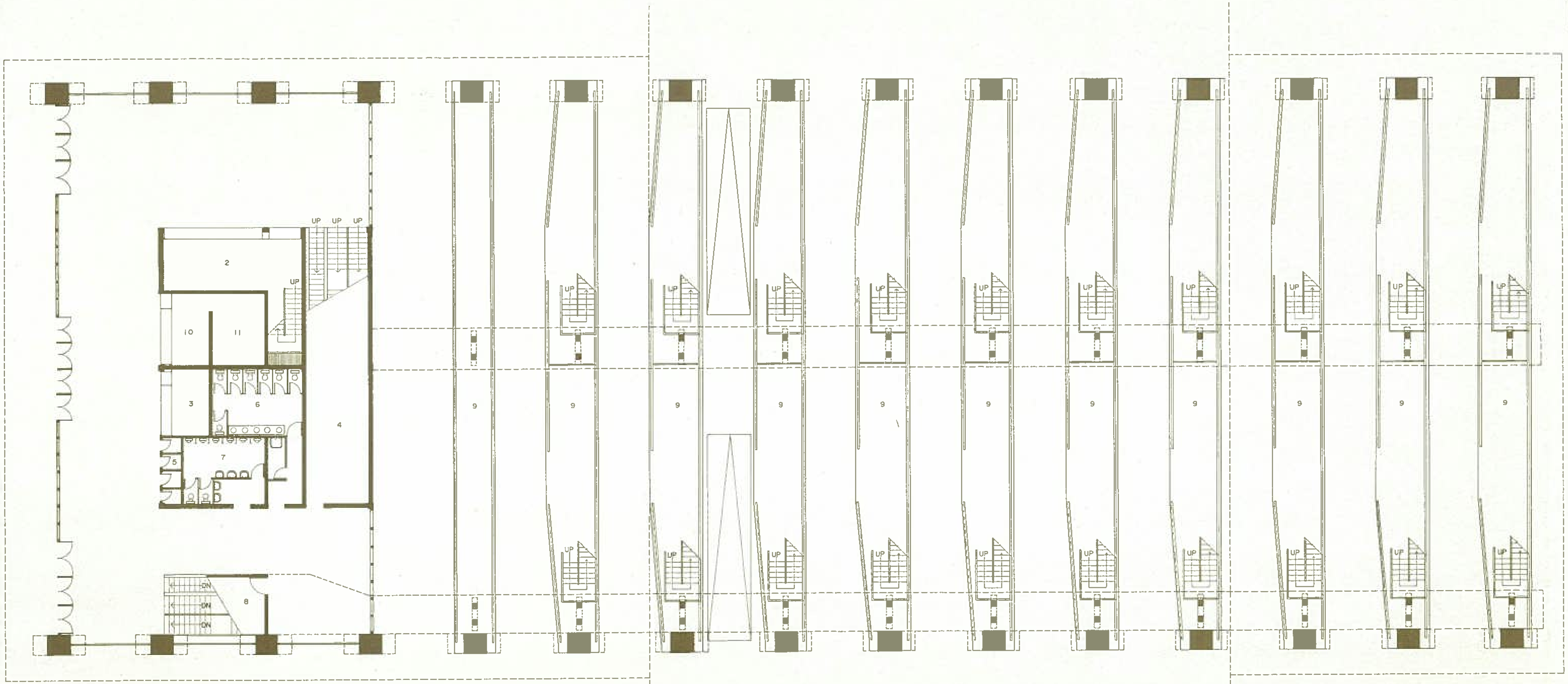
LEGEND

1. BUS TERMINAL
2. BUS STOPS
3. BUS PARKING
4. PARKING
5. BICYCLE PARKING
6. UNDERPASS
7. ARTERIAL ROAD
8. TOLL ROAD
9. TAXI STOP
10. BRIDGE

SITE PLAN

SCALE IN METERS
0 20 40 60 80 100

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
BUS TERMINAL
DE LEUW, CATHER INTERNATIONAL-CHICAGO



LEGEND

1. ENTRANCE HALL
2. TICKET COUNTER
3. CONCESSION COUNTER
4. MECHANICAL ROOM
5. TELEPHONE BOOTHS
6. WOMEN'S TOILET
7. MEN'S TOILET
8. STORAGE
9. PLATFORM
10. RETAIL SHOP
11. STORAGE

LOWER FLOOR PLAN

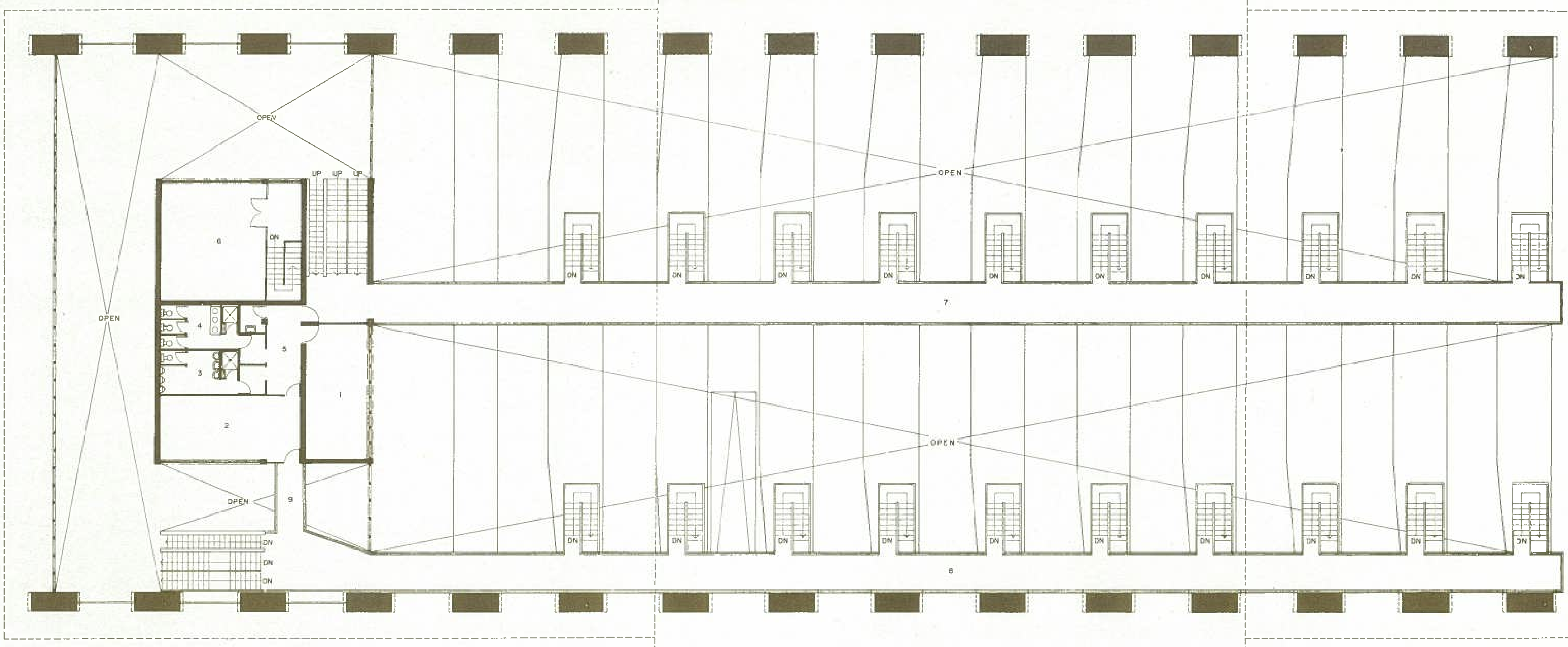
SCALE IN METERS
0 2 4 6 8 10

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN

BUS TERMINAL

DE LEUW, CATHER INTERNATIONAL-CHICAGO

EXHIBIT 3



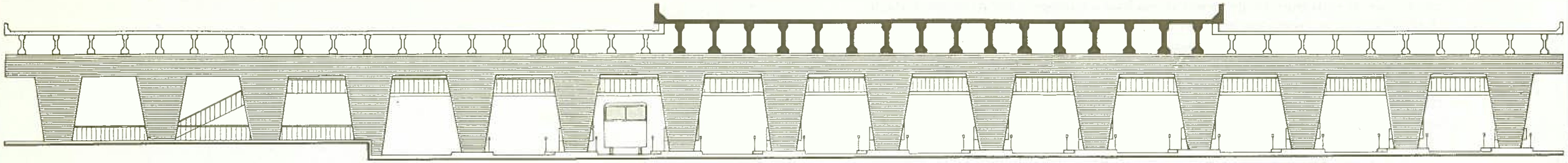
LEGEND

1. DISPATCHER'S OFFICE
2. DRIVER'S LOUNGE
3. MEN'S TOILET
4. WOMEN'S TOILET
5. LOBBY
6. TICKET OFFICE
7. PASSENGER BRIDGE
8. PASSENGER BRIDGE
9. BRIDGE

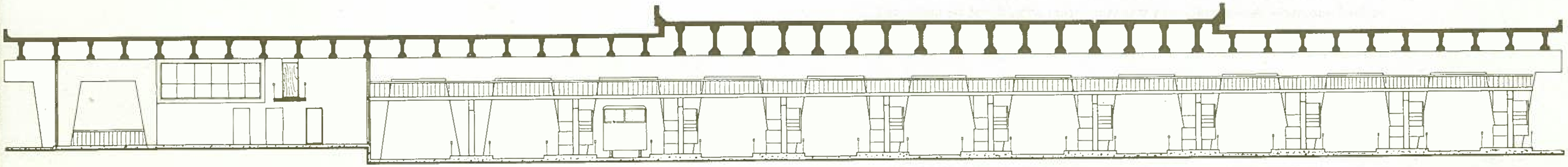
UPPER FLOOR PLAN

SCALE IN METERS
0 2 4 6 8 10

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
BUS TERMINAL
DE LEUW, CATHER INTERNATIONAL-CHICAGO



ELEVATION



SECTION

SCALE IN METERS
0 2 4 6 8 10

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
BUS TERMINAL
DE LEUW, CATHER INTERNATIONAL-CHICAGO

CHAPTER VI

Conclusions and Recommendations

Chapter VI

CONCLUSIONS AND RECOMMENDATIONS

SUMMARY OF CONCLUSIONS

Development and Comparison of Toll–Collection Networks and Toll Schedules

During the development of the two toll networks tested in this study, it was determined that it would be desirable if the freeway could be operated as a toll-free facility in urban areas. The alternatives to this plan would be: (1) to eliminate several interchanges in urban areas; or (2) to provide toll-collection facilities in the urban areas. The former of these two alternative proposals was not to be preferred, since a major benefit expected from the freeway would be the accommodation of those intra-urban area traffic volumes which would be effectively excluded from use of the freeway, if urban interchanges were eliminated. As for providing for toll collection from intra-urban area traffic, the costs of such a scheme would be prohibitive; moreover, there would be serious engineering difficulties with such a plan.

The only practical alternative, then, was to have zones of free travel in all the major urban areas. This conclusion meant that a purely closed toll-collection system could not be developed. Barriers would have to be located on the freeway, even with the closed system, in order to separate the freeway sections with closed interchanges from the sections having open interchanges (i.e., from the zones of free travel).

Accordingly a closed network was developed which would have five freeway toll barriers; one of these would be located between Keelung and Taipei, one southwest of Taipei, one on each side of a free-travel zone in the Taichung-Changhua area, and one north of Kaohsiung.

Only five additional freeway toll barriers were added to the barrier system; i.e., the barrier system which was tested in this study had a total of ten freeway toll barriers.

The additional barriers with the barrier system meant that long trips would be inconvenienced more often, by having to stop to pay tolls, than they would be with the closed system. For example, a trip between Taipei and Kaohsiung would require stopping at nine toll plazas with the barrier system, whilst there would be only four toll collection stops for the same trip with the closed system. Such long trips would not represent the average condition, however; computer data indicate that average trip lengths are far shorter, and these would only stop at one or two plazas.

The feasibility study estimate of the total right-of-way and construction cost of the freeway (including access roads) was NT$23,378 million; when this figure is adjusted for some engineering changes which have been made in Section I, and for the inclusion of the east alternative route, instead of the west alternative, in Section VII, the cost estimate for right-of-way and construction of the freeway becomes NT$24,847 million. The current study estimated the costs to be NT$24,119 million with the barrier system, and NT$25,980 million with the closed system. The barrier system cost would, thus, be about 2.9 percent lower than the adjusted feasibility study estimate for a toll-free facility. The closed system cost was estimated to be approximately 3.5 percent higher than the barrier system cost.

Where maintenance and operating costs were concerned, it was a different story. The annual cost of maintenance and operation for a middle year of the study period (viz., 1982) was estimated in the feasibility study to be NT$51 million for the entire freeway. In the present study, annual maintenance and operating costs for 1982 were estimated to be NT$76 million with the barrier system, and NT$82 million with the closed system.

The undiscounted cost increments of the freeway alternative, over the 1971-1995 period, were estimated to be NT$2,663 million with the barrier system and NT$-3,574 million with the closed system. Discounting of the cost increments resulted in lower discounted totals than were found at the time of the feasibility study, because of construction rescheduling.

The user savings benefits deriving from the freeway investment were found to be lower with toll collection than with a toll-free facility. The hypothetical 1969 user savings would be about 22.5 percent lower with the barrier system (and schedule B_3) than was previously estimated in the feasibility study for the freeway; with the closed system (and schedule C_4), savings would decline by 25.1 percent from the estimated total of the feasibility study, and would be 3.4 percent below the savings with the barrier system.

Thus, costs would be higher and benefits would be lower with the closed system compared to the barrier system. When both incremental costs and user savings were discounted for the two alternative systems, the internal rate of return with the barrier system was found to be 20.9 percent, compared to a 19.5 percent return for the freeway with the closed system.

From the financial standpoint, too, the barrier system with toll schedule B_3 was found to be preferable to the closed system and toll schedule C_4. With the former schedule a total of NT$44,397 million would be collected over the 1975-1995 period, whilst with the latter schedule, the 1975-1995 revenue total would be only NT$37,713 million, or approximately 15 percent lower. These totals would rise to NT$48,393 million and NT$41,107 million, respectively, when revenue from induced traffic is included in the totals. With higher closed system toll rates, perhaps as much revenue might be collected as with the barrier system and schedule B_3, but this could only be accomplished at the cost of further lowering the closed system rate of return. Thus, as the barrier system financial advantage would be narrowed, the economic advantage of the barrier system would be widened.

The results of this study's investigation into the comparative merits of a barrier versus a closed, toll collection system are confirmed by an examination of the recent trends in the United States. Several turnpikes, formerly with closed toll collection systems, have converted to using the barrier system. The main causes for this trend are the escalating costs of toll collection, and the expensive alterations needed at closed system interchanges in order to accommodate the growing traffic volumes. Also, construction of additional interchanges, which are quite often needed once the usage of land along a freeway intensifies, is easier with a barrier system, since right-of-way requirements are less, and interchange configurations can be adjusted to available right-of-way conditions.

As far as the toll schedules which were tested are concerned, schedule B_3 appears to give the best combination of economic and financial benefits, although toll rates might advantageously be lowered in Sections I and VII, where the schedule B_3 toll rates greatly reduced freeway usage.

Economic Return on The Freeway Investment

The estimate of the economic return on the incremental cost of the freeway with the barrier system was at 20.9 percent, only slightly lower than the feasibility study estimate of 22.3 percent for a toll-free facility. Whilst the imposition of tolls tended to reduce freeway benefits, other factors acted to counterbalance the effects on the toll decision, and to maintain the rate of return at a high level. Specifically, the rate of return was aided by the extension of the freeway construction period and the extension of the study period to 1995. The rate of return was also improved by higher forecast airport traffic.

Benefits from safely improvement were estimated. When these estimated benefits would be added to user savings, the rate of return on the incremental cost of the freeway would climb to 22.8 percent, or to 23.0 percent, depending upon which of the methods would be used to estimate safety benefits.

As far as the economic returns on the various sections of the freeway are concerned, only the two end sections suffered a significant diminution in their economic desirability. At the southern end (i.e., Section VII, extending from Tainan to Fengshan), especially, the estimate of the rate of return declined from that indicated by the feasibility study. In this instance the diminution was due largely to two factors: (1) the necessity of selecting the east alternative route, because other construction was approved along the economically-more-desirable west alternative route; and (2) the approval by the Government of a proposal to widen Highway 1 between Kaohsiung and Tainan (thus, the widening of this highway, which was not recommended in the feasibility study for the freeway investment alternative, would no longer be an investment saving of the freeway, but would become a related highway improvement cost).

Cost Coverage By Freeway Toll Revenue

When both freeway toll revenue (with schedule B_3) and total freeway costs, including maintenance and operations costs over 1975-1995, were discounted at eight percent (an approximation of the average cost of debt capital on the project), it was found that approximately 70.3 percent of the with-tax costs, and 82.5 percent of the without-tax costs, were covered. When revenue from forecast induced traffic volumes was also taken into consideration, the respective percentages of coverage of with-tax, and without-tax, costs were 76.6 percent and 90.0 percent.

When financial needs, in terms of debt service and maintenance and operating costs, were considered on a year-by-year basis, it was seen that toll revenue would not be sufficient to cover costs in any year prior to 1982, and a large deficit, estimated at NT$9,074 million, would accumulate over the 1971-1981 period. In 1981 however, and in every year thereafter, toll revenue would provide a large amount in excess of freeway needs. Thus, it would be desirable if projects with lower priority than the freeway could be deferred until 1982 or later, so that their prospective funding could be diverted to the freeway project. Then, in 1982, freeway toll revenue could begin to finance these other projects.

Traffic Forecasts

After review, the traffic forecasts of the feasibility study were adopted for use in the toll study. The review indicated that registrations of autos, light trucks, and buses had grown much more rapidly, over 1969-1970, than had been forecast by the feasibility study. Only heavy truck registrations were below the projected totals; these had been forecast in terms of 1969 truck equivalents (i.e., without assuming any rise in average capacity), however, so that it was not known to what extent actual truck capacity fell short of the forecasts.

In any case, trucking ton-kilometers continued to expand at very rapid rates during 1969 and 1970, so that the forecast expansion of trucking to 1990, did not appear high.

Although the feasibility study forecasts of 1990 traffic were used in this study, Appendix A to Chapter I, developed an alternative forecast, which considerably raised bus and light truck 1990 registrations, lowered the registration level for autos, and maintained the forecast for heavy trucks. When these revised forecasts were considered in the sensitivity analysis, it was found that they would produce nearly the same 1990 savings total as was found with the feasibility study forecasts.

Other adjustments to traffic forecasts were considered in the sensitivity analysis. When the 1990 forecasts for auto and heavy truck traffic would be lowered by 25 percent, the estimate of the freeway rate of return would be lowered to 18.7 percent (from 20.9 percent). When the 1990 forecasts for bus and light truck traffic would be raised by 33 percent, the estimated rate of return would climb to 21.5 percent.

Traffic Induced By The Opening of the Freeway

Computations of the induced traffic, which might be expected after the opening of the freeway, were based on ratios of user costs of traveling on the freeway and alternative highway routes over various trip lengths. Induced bus traffic was estimated to vary from 24 to 27 percent of normal growth bus volumes at 14 screenlines; induced auto volumes at the same screenlines were estimated to vary from 11 to 19 percent of normal growth volumes. No induced volumes were estimated for light or heavy trucks.

Induced auto and bus volumes were calculated to increase toll revenue by about nine percent, and to increase user savings by about 4.9 percent.

Airport Traffic

The average daily traffic to be generated by the proposed international airport at Taoyuan was estimated by the peak hour volume given by the airport consultants. The total volume of 38,350 PCE per day is higher than the 26,000 estimated during the feasibility study and has been used in the analysis of lane requirements and the computation of system results for this study.

Heavy Truck Traffic Between Taipei and Keelung

The forecast of volumes of heavy truck traffic between Taipei and Keelung was reduced from that of the feasibility study. The revision was primarily based on an estimate of the year in which traffic at Keelung port would reach the port's ultimate capacity. Based on an estimate of 13.3 million revenue tons as the ultimate port capacity, port-generated truck traffic was estimated to grow only until 1978, at which time port truck traffic would reach a level of 5,150 trucks (in terms of 1969 equivalents) per day. Projected 1990 Taipei-Keelung heavy truck volumes were adjusted downward by 12,100 trucks per day.

Freeway Lane Requirements

The capacity analysis of the present study took into account the forecast normal growth traffic volumes and forecast induced auto and bus traffic. No allowance was made for traffic which might be converted from the railway. Despite this disregard of possible converted traffic volumes, it was estimated that the capacity of every freeway section, except Section I, would be reached by 1995. In Section II (Taipei-Yangmei), it was estimated that the capacity traffic volume would be attained in 1984; the feasibility study had indicated that 1981 would be the year in which freeway traffic would reach capacity in this section, but the widening of Highway 1 in the section (now a government-approved project) should provide the section with sufficient highway capacity through 1984.

Freeway Bus Operation

To handle bus normal growth traffic, which would continue to be similar in nature to present day patterns, and, thus, would be primarily short-distance trips, a design for bus operations, designated as "toll road and parallel distribution", would be suitable. Under this operations plan, buses would travel for short distances along roads paralleling the freeway at both ends of each trip; there would be little need for transfers. These bus operations would need to be supplemented by operations which would start off and terminate in the central business districts of cities.

It is expected, however, that, with the opening of the freeway, bus operators will begin to vie with the railway and domestic air transport for long-distance passengers. If such is the case, then a premium will be placed on high-speed operations, and some bus trips might remain entirely on the freeway; i.e., transfers would be required to all points not in the immediate vicinity of the freeway.

Modal Split

As just stated above, the opening of the North-South Freeway should permit bus transport, for the first time, to become of significance in the transportation of long-distance passengers in the western corridor. In terms of travel time, fare levels, and comfort, there should be little difference between bus and railway transportation. The railway would maintain an advantage, where the ease with which it could enter the central business districts of cities was concerned. On the other hand, the passenger flexibility with regard to times of departure and arrival would be a large advantage for bus operation. If the two services would be roughly equally attractive, then buses might take about fifty percent of the surface long-distance passengers; this would be up from a very small percentage, and would constitute a large conversion of potential railway traffic.

Where freight is concerned, the railway should continue to carry what it carries best, viz., bulk cargo which can be loaded and unloaded in large volumes. Construction of private railway sidings should be encouraged whenever these would mean economic savings with railway haulage.

If any sizable amount of railway traffic would be converted to the freeway, the freeway capacity might be strained long before the years estimated in this study's capacity analysis. Of course, if substantial conversion to the freeway would create congestion prior to 1990, the congested freeway condition would be likely to reverse the trend, and create a reconversion to a less congested railway facility.

RECOMMENDATIONS

Preferred Toll System

A barrier toll-collection network is recommended. Exhibit 4 shows the barrier toll network which was developed and tested in this study. There are ten freeway toll plazas indicated, all of which would be outside of major urban areas. One change in this network is recommended. The southernmost barrier was located south of Nantzu for testing. This location, however, would result in substantial diversion from the freeway, and would adversely affect planned regional development. For these reasons, it is recommended that the plaza be located, instead, to the north of Kangshan, thus permitting free travel over the entire Kangshan-Fengshan section.

The B_3 toll schedule tested in this study is recommended. This toll schedule calls for rates of NT$15 on light vehicles (i.e., autos and light trucks), NT$20 on heavy trucks and NT$40 on buses. If, as estimated in this study, the heaviest debt service requirements would fall in the 1976-1981 period, then the recommended toll rates would provide revenue far in excess of freeway needs in 1982, and thereafter. Hence, there should be no need to escalate toll rates in the future, and they might even be reduced, depending upon what other highway improvements would need to be financed therefrom in the future.

Schedule for Completion of the Freeway

The various freeway sections should be completed in time to prevent the necessity of providing new capacity on other highways, when such capacity would only be required for a short period of, say, one to four years prior to a deferred opening of a freeway section. The delay in construction of the southern freeway section, for example, has necessitated the widening of Highway 1 from Kaohsiung to Tainan, although this highway improvement may not have been needed for many years, if the freeway section in that area could have been constructed according to the recommended schedule of the feasibility study. The present schedule of freeway construction (see Table I-2) should permit deferral of most other major north-south highway improvements not yet approved, nor indicated by this study as being necessary with the freeway alternative; it is, therefore, recommended that this schedule be adhered to, if at all possible.

Financing of The Freeway

If 60 percent or more of the scheduled 1971-1977 costs of freeway right-of-way and construction are to be financed through debt, and if the terms of debt financing are similar to those for financing the Neihu-Yangmei section, then freeway toll revenue cannot be expected to be sufficient to cover all service on debt through the year, 1981, and perhaps even later. Another form, or forms, of revenue for debt service coverage should therefore be developed; moreover, this should be done as soon as possible in order that revenue might begin to accumulate prior to the need to make debt service payments, which are foreseen to become significant as early as 1973. It is recommended that, wherever possible, other projects (especially, highway projects) should be deferred until after completion of the freeway; freeway toll revenue could then be used to finance such deferred projects as soon as annual revenue would be in excess of freeway needs.

Wide Median

As was done in the feasibility study, it is recommended here that a wide median be provided to allow construction of additional traffic lanes in the future. If there should be significant volumes of converted traffic from the railway, freeway widening would be necessary in earlier years than indicated in this study. Even if such traffic conversion should not occur, several freeway sections would require widening over the 1991-1995 period.

Additional Interchanges

Once development of the corridor served by the freeway accelerates, additional interchanges will be needed at various cross roads, special roads, and special development sites. In many cases it is possible to estimate the probable locations of these additional interchanges during the location and design phase. Some of them are the interchanges which were eliminated during conversion of the proposed toll-free facility to a toll road. We recommend that the required right-of-way for them either be acquired early, or be reserved for future use.

Manual Toll Collection

A simple manual toll collection system, without any issuing of tickets, is recommended. Electronic vehicle counters would allow proper checking of toll collection. Experience elsewhere indicates that manual collection is still the fastest way of collecting tolls. Automatic coin-collecting equipment needs the services of experienced maintenance repairmen, and, in spite of the provision of advance signing, quite often motorists without the required change take the automatic toll lanes, thus, creating traffic bottle-necks and increasing the processing time.

Locations of Facilities

The approximate locations of interchanges, toll plazas, headquarters and division buildings, maintenance sections, and service and rest areas were indicated in Exhibit 15. The final location of these facilities should be decided during the location study and design phase of each section of the freeway. Special consideration should be given to the usage of borrow areas already acquired for construction of the freeway.

One headquarters building and maintenance facility in Taipei, one division building and maintenance facility in Kaohsiung, and six small maintenance sections along the freeway are considered sufficient. Six service areas and three rest areas should be sufficient to attend to all the needs of the freeway users.

Bus operations facilities would include four terminals, eight interchange stops, and twenty other stops along the freeway. The recommended locations for these were shown on Exhibit 40.

Four of the proposed ten toll plazas are recommended to include truck weigh scales.

Timing of Construction of Maintenance and Operation Facilities

It is recommended that the facilities required for maintenance and operation of the freeway be designed and built simultaneously with the construction of the freeway, with special emphasis on the facilities for the northern and southern sections.

Organization of the Freeway Operating Agency

Under the Director of the toll road authority, two deputy directors and one chief engineer are recommended. One of the deputy directors would be in charge of operations, including highway patrol, communications, and toll collection, whilst the other deputy director would handle the administrative functions, such as personnel, accounting, and general affairs. The chief engineer would be responsible for the planning and maintenance of the facility, and should have several deputy chief engineers in charge of special functions.

Training of Maintenance, Operating, and Safety Personnel

Training of highway patrol, communication, and key maintenance personnel is vitally important to obtain the highest possible benefit from the freeway investment.

Highway patrol training should include high speed driving, public relations, techniques for apprehending violators, accident investigation, first aid methods, and general assistance to motorists

It is recommended that key patrol and maintenance people be sent abroad for actual experience and training on turnpikes under operation.

Communications

The communications facilities being recommended in this report are similar to those which have been successfully used on the Kansas Turnpike (U.S.A.) for more than 15 years. Provisions are made for:

> Two-way radio communications between major fixed stations and all mobile vehicles of the toll road patrol, maintenance forces and senior management personnel. One channel would be provided for the basic use of the patrol. A second channel would be provided for maintenance and general use.
>
> Microwave telecommunications between all fixed stations (including service, rest, and recreational area buildings). This system would be integrated with the radio system for immediate switching from one to the other.
>
> Lines from the national telecommunications system would be provided in all fixed stations including service, rest, and recreational buildings. This system would be integrated with the other systems through a manually-operated switchboard

This overall system approach provides for exclusive and immediate communications between all fixed and mobile stations on the toll road. The toll road system would be tied into the national system by normal switchboard and dialing techniques. This system has maximum versatility in providing alternative routes for communications for all but mobile units, which could drive to the nearest base station in case of radio failure.

This communications system should be supplemented by public telephone facilities in service areas (gasoline stations and restaurants) for private conversations. Provision of telephone booths at regular intervals along the freeway is not recommended, as the cost of installation and maintenance of these facilities is higher than the advantages obtained.

Coverage, every half hour, of all points on the freeway by the highway patrol, supplemented by radio-equipped maintenance vehicles, should be sufficient to assist distressed motorists, and to provide assistance in case of accidents.

Eventually, when the traffic gets very heavy, especially in urban areas, acquisition of a helicopter should be considered for traffic control and assistance in case of emergencies.

Operation of Service Facilities

Recommended service facilities should be operated by concessionaires, according to the rules and regulations to be established by the toll road authority. Regular inspection of these facilities by inspectors of the toll road authority is necessary to insure cleanliness and the satisfaction of patrons.

The concessionaires should be required to maintain a truck with winch for towing disabled vehicles, and a pick-up truck to provide gasoline and other emergency assistance to motorists. A two-way radio would also be needed in each of these service areas, as part of the toll road communication system.

Maintenance Operations

For efficient maintenance operation, all equipment should always be kept ready, and necessary materials should be stockpiled. On this high-speed highway, safety measures during the maintenance operation are extremely important. Safety rules and regulations should be established and maintenance personnel should be thoroughly trained in safety matters. Maintenance trucks and other equipment, and locations of maintenance activities, should be adequately designated in order to avoid serious traffic accidents.

Bus Operations

The recommended plan for bus operations is a hybrid of the three designs for operations which were studied. If freeway bus service is to be developed fully, as recommended, then trunkline operation should be adopted to at least handle long-distance passenger traffic. For handling those passenger trips which highway buses have normally handled, i.e., primarily short-distance volumes, however, operations designated as "toll road and parallel distribution" and "throat" would be preferable, since far fewer transfers would be involved.

CHAPTER I

APPENDICES

Appendix A Traffic Forecasts
Appendix B Vehicle Operating Costs And User Costs

Appendix A
TRAFFIC FORECASTS

INTRODUCTION

The freeway feasibility study was conducted over the March-October 1969 period, and all of the traffic forecasts were completed by about end-June of that year. The latest full-year traffic data available at that time were 1968 data, and the latest vehicle registration information available was for end-April 1969.

Two years have now passed since the feasibility study projections were made, and a re-examination of those projections might now be made in the light of the traffic growth which has occurred since then.

This toll study has adopted the traffic forecasts before modal split analysis of the feasibility study, except that adjustments were made for heavy truck volumes between Keelung and Neihu (a downward revision) and for airport traffic (an upward revision), and induced traffic volumes, not estimated in the feasibility study, were added to auto and bus traffic totals. Otherwise traffic forecasts before modal split analysis were not changed, and the possible adjustments to traffic forecasts which might be made on the basis of the re-examination in this appendix are only taken into account in the sensitivity analysis presented in a later appendix to this report. The net result of these proposed adjustments to traffic forecasts would be to improve slightly the freeway rate of return.

The following sections of this appendix discuss separately the feasibility study forecasts of highway freight ton-kilometers and heavy truck registrations, highway bus passenger-kilometers and bus registrations, light truck registrations, auto registrations, and total vehicle registrations.

HIGHWAY FREIGHT TRAFFIC & HEAVY TRUCK REGISTRATIONS

The feasibility study forecast that highway freight ton-kilometers would grow to 7.3 times the 1968 level by 1990, which would mean an average annual rate of growth of 9.5 percent over the 1969-1990 period. Actual growth in 1969 was 18.3 percent, whilst 1970 growth was 15.8 percent, for a total two-year expansion of 37 percent above the 1968 level. The required expansion from a 1970 total of approximately 1,354 million ton-kilometers to attain the forecast 1990 total of 7,243 million ton-kilometers would be 5.35 times, for an average annual compound growth rate of about 8.8 percent over the 1971-1990 period.

Using data on reported commercial trucking ton-kilometers over the 1956-1970 period, the following trend equation was derived:

$$Y_E = 451.6 + 79.6X + 6.07X^2$$

Where Y_E represents annual commercial trucking freight traffic, expressed in millions of ton-kilometers, and X represents the number of years removed from 1963.

This equation gives the following values for various years:

1970 – 1,306
1971 – 1,477
1972 – 1,660
1980 – 3,559
1990 – 7,026

The 1970 value is more than four percent below the actual 1970 level, and the 1971 value would require only an 8.3 percent growth from the actual 1970 level; these low values in the near term may indicate that longer-term values might also be somewhat on the low side. (If the trend-indicated expansion from 1970 to 1990, i.e., 7026 ÷ 1306, or 5.38 times would be applied to the actual 1970 total of 1,354 million, the 1990 total would become 7,284 million.) In any case, the indicated value for 1990 is 97.0 percent of the feasibility study forecast for that year (actually, the feasibility study forecast contains an adjustment for the expected effects of the opening of Taichung Harbor on highway freight traffic totals; when this adjustment is eliminated, the feasibility study forecast is for 7,131 million ton-kilometers in 1990, and the new trend value would become 98.5 percent of the feasibility study forecast).

The trend equation may tend to understate future growth since it is based on reported trucking company ton-kilometers only, and does not take into account (since no historic data are available) the growth of trucking by producing, or other, companies owning their own trucks. If the growth of registrations is an accurate indication, this latter trucking has been growing at a more rapid rate in recent years than has trucking service ton-kilometers. In 1968, trucking company heavy truck fleets grew by 27.3 percent, whilst the rise slowed to 15.3 percent, in 1969, and to only 5.2 percent, in 1970, for a total three-year rise of 54.3 percent above the end-1967 level. Meanwhile, other heavy truck registrations were expanding by 37.5, 47.5, and 7.6 percent in 1968, 1969, and 1970, respectively, for a total three-year growth of 118.3 percent. In absolute terms, trucking company heavy truck fleets increased by 4,653 vehicles, over the 1968-1970 period, whereas other heavy truck registrations increased by a lesser total of 3,808 vehicles over that period. (Number of registrations is actually not an accurate indicator of variations in freight traffic, since they do not precisely coincide with changes in total truck capacity, and they do not take into account changes in equipment utilization. In 1970, for example, while trucking company heavy truck fleets were expanding by only 5.2 percent, trucking company ton-kilometers grew by 15.8 percent. This wide divergence in growth was probably due in large part to the trend, which only began in 1969, to the use of larger trucks, of ten to fourteen tons capacity, and to the use of truck tractors for hauling containers.)

Another method (in addition to the historic trend) of estimating future growth of freight traffic is to relate it to expected economic growth. In a memorandum, prepared by DCI and dated January 15, 1971, to the Minister of Communications, it was pointed out that the GNP of the Republic of China grew by an average annual rate of 9.5 percent in real terms, over the 1960-1969 period, for a total ten-year growth of 147 percent, and that, over the same period, highway freight ton-kilometers grew at an average rate of 16.7 percent per annum, for a total growth of 367 percent over the ten years. The ratio of annual ton-kilometer growth to annual real growth of GNP was about 1.7 to one; the ratio of ten-year ton-kilometer growth to ten-year real growth of GNP was 2.5:1; and, if the growth rates were extended for twenty years, the growth ratio would become nearly 3.6:1.

As pointed out above, in order for highway freight service to attain the level forecast for it for 1990 in the freeway feasibility study, highway freight service ton-kilometers would need to grow by 435 percent above the 1970 level of 1,354 million, for an average annual growth rate of approximately 8.8 percent over the 1971-1990 period. If the above-calculated, twenty-year growth ratio of 3.6:1 for total highway freight service compared to real GNP were to obtain over the 1971-1990 period, then a total real GNP growth of only 121 percent (or 4.0 percent per annum) would be required in order for the forecast trucking growth to be attained.

The feasibility study forecast that GNP would grow by approximately 288 percent, or an average rate of about 6.4 percent, over the twenty-two year period, 1969-1990. The GNP actually grew by about 19.7 percent over the 1969-1970 period, so that it now would need to grow by approximately 225 percent, or 6.1 percent per annum, over the 1971-1990 period, in order to attain the growth forecast by the feasibility study.

The ratios of ton-kilometer growth, needed to attain the feasibility study forecast, to required real growth of GNP would be 1.44:1, on an annual basis (i.e., 8.8 percent ÷ 6.1 percent), and 1.93:1, over the entire 1971-1990 period (i.e., 435 percent ÷ 225 percent). These ratios are considerably below those experienced or indicated by the growth of the 1960-1969 period. Some diminution of these rates would be expected, however, since highway trucking continues to take a larger and larger share of total freight available, and, thus, its growth rate should gradually more closely approach the rate of economic growth.

On the other hand, the feasibility study forecast of future GNP growth is very likely conservative. A historic trend equation was derived from GNP data (in constant prices), covering the 1956-1970 period; this equation is given below.

$$Y_E = 110 + 9.07X + 0.39\,X^2$$

Where Y_E represents the GNP of the Republic of China, expressed in billions of constant 1964 NT dollars, and X represents the number of years removed from 1963.

This equation gives a value of NT$639 billion for 1990, which would require a total growth of 251 percent from the actual 1970 total of NT$182 billion (expressed in constant 1964 prices); the average annual growth rate over the 1971-1990 period would be 6.5 percent.

If this trend-indicated growth would be compared to the growth of highway ton-kilometers required to reach the forecast 1990 total of the freeway feasibility study, then the ratio of average annual growth would be lowered to 1.35:1 (i.e., 8.8 percent ÷ 6.5 percent), and the ratio of twenty-year growth would be lowered to 1.73:1 (i.e., 435 percent ÷ 251 percent).

From this analysis, it was determined that there would be no reason for adjusting the feasibility study 1990 heavy truck volumes (in terms of 1969 heavy truck equivalents) downward. They might, in fact, legitimately be adjusted upward if some induced traffic with the freeway would be allowed for.

In terms of 1990 trucks, however, there might need to be a downward adjustment. At the time of the feasibility O-D survey, the average truck load (including empty runs) was only 4.3 tons; this seems certain to rise substantially by 1990, especially since the trend to use of larger trucks and the containerization of freight only got started in 1969. The trend to larger-sized trucks will mean fewer vehicle-kilometers and vehicle-hours saved with the freeway; the amount of savings per heavy truck vehicle-kilometer or vehicle-hour would increase, however, so that the net effects on vehicle operating cost savings would be expected to be small.

Where heavy truck registrations are concerned, the feasibility study forecast these to grow to 99,240 equivalent 1969 trucks by 1990; if, by 1990, the average capacity of a heavy truck should double over the average which existed in 1969, then the registration level would be reduced to approximately 50,000 trucks. (The 1990 registration total would also tend to be reduced by the improved rate of utilization which would obtain from the freeway; on the other hand, haulage of induced freight shipments and traffic converted from the railway would tend to increase the number of heavy truck registrations.)

On the basis of the known January-April 1969 increment to heavy truck registrations, the feasibility report estimated there would be 20,803 heavy trucks by end-1969; the report then estimated that one more year of rapid growth would occur, so that, by end-1970, heavy truck registrations would have climbed to 26,000. Thereafter, according to the feasibility study, growth would level off, so that end-1971 registrations would only be 29,000, and end-1972 registrations would be 32,000.

Actually, growth of heavy truck registrations began leveling off during the second half of 1969. By end-1969, they totalled only 19,086, or more than eight percent below what had been forecast for that year. In 1970, heavy truck registrations increased by only a little more than six percent, so that end-1970 registrations were about 22 percent below the projected end-1970 total of the feasibility study. Heavy truck capacity expanded at a more rapid rate, over 1969-1970, than did the number of registrations. According to figures shown in the North Transportation Link Study, the number of trucks of more than ten tons capacity in Taiwan province (i.e. excluding Taipei city) grew from only 38 in 1968 to 3,009 in 1970.

Table 1 of this appendix indicates the changes in registration totals of heavy trucks (and other types of vehicles) in various cities and in all of the hsiens of Taiwan, over the period from end-March 1969 (just prior to the feasibility study O-D survey) to end-March 1971.

HIGHWAY BUS PASSENGER TRAFFIC & BUS REGISTRATIONS

The feasibility study projected highway bus passenger-kilometers to grow to 22,237 million in 1990, from an actual 1969 level of 6,279 million; the expansion would be to approximately 3.54 times the earlier year level, and would mean an average annual growth rate of slightly under 6.0 percent, over the 1969-1990 period.

The 1969 figure and the forecast 1990 level of highway passenger-kilometers, actually referred to the combined total of Taiwan Highway Bureau (THB) and private company passenger-kilometers, and excluded that passenger traffic classified as "City Bus". In late 1969 and during 1970, however, certain THB operations in urban areas were transferred to city bus operations. The combined total passenger-kilometers of THB and private companies, in 1969 and 1970, are therefore not comparable to earlier years. In order that all numbers in the bus traffic time series be comparable, then, combined totals of THB, private companies, and city bus traffic might be used. This includes all bus traffic on which published statistics are available.

Bus passenger-kilometers numbered 3,329 million in 1956, and reached 11,206 million in 1970, for an average annual growth of 9.1 percent per annum. Over the 1964-1970 period, the growth accelerated to an average annual rate of 12.2 percent. In 1969, total bus passenger-kilometers rose by 12.7 percent; growth in 1970 was 12.1 percent. The trend equation derived from passenger-kilometer totals for the period, 1956-1970, is given below.

$$Y_E = 5,420 + 530X + 37.26X^2$$

Where Y_E represents millions of bus passenger-kilometers per annum, and X represents the number of years removed from 1963.

This equation gives the following values for various years:

1970 – 10,956
1971 – 12,045
1972 – 13,208
1980 – 25,197
1990 – 46,891

The 1970 value from the equation is 98 percent of the actual value of 11,206 million passenger-kilometers, and the 1971 value would require only a 7.5 percent growth from the actual 1970 level. The expansion from 1970 to the trend value for 1990 would be about 4.26 times (7.5 percent per annum) from the trend-indicated value of 10,956 million, or 4.19 times (7.4 percent per annum) from the actual 1970 total of 11,206 million passenger-kilometers.

As stated above, the feasibility study forecast only a 3.54 expansion for the 1969-1990 period. Actual growth over 1969-1970 was to 1.263 times the level of 1968, so that remaining growth, required to attain the feasibility study forecast, would only be to 2.81 times the 1970 level (i.e., 3.54 ÷ 1.26 = 2.81).

The trend-indicated 1971-1990 expansion of approximately 4.2 times the 1970 level is almost exactly 50 percent higher (i.e., 4.2 ÷ 2.8) than the additional growth required to attain the forecast of the feasibility study. Thus, the forecast of the feasibility study appears to have been quite conservative; as stated in the introduction to this appendix, no adjustment was made for this higher traffic forecast in the data given to the computer, nor for the benefits or capacity analysis presented in the text. It is taken into consideration, however, in the sensitivity analysis presented in a subsequent appendix.

The forecasts of bus registrations in the feasibility study also are on the low side. The feasibility study estimated that bus registrations would total 6,700 by end-1969, and would climb to 7,200 by the end of 1970. Actual end-1969 registrations were 7,315 (9.2 percent above the forecast, and actual end-1970 registrations were 7,954 (10.5 percent above the forecast).

The feasibility projection for 1990 was for a total of 21,410 registered buses; for this total to be attained by that year, a total expansion of 2.69 times, or 5.1 percent per annum, would be required over the 1971-1990 period.

If bus registrations would expand by 4.2 times over the 1971-1990 period, as indicated by the trend equation for passenger-kilometers, then 1990 bus registrations would total approximately 33,400, or about 56 percent more than were forecast by the feasibility study for that year.

This forecast is before consideration of passenger traffic converted from the railway to highway buses after the freeway would open; nor does this forecast take into account the volumes of induced passenger traffic with the freeway.

LIGHT TRUCK REGISTRATIONS

On the basis of end-April 1969 light truck registrations, the feasibility study estimated that registrations would climb to 14,861 by the end of that year; registrations actually grew to 16,339 by the end of 1969, which was approximately ten percent above the estimate. The feasibility study forecast for end-1970 was for a light truck registration total of 18,000. This forecast was exceeded by more than 15 percent, as actual light truck registrations climbed to 20,764.

As of end-1956, light truck registrations numbered only 272; from that date to end-1970, registration growth averaged more than 36 percent per annum. Over the 1965-1970 period, average growth accelerated to approximately 46 percent per annum. Growth, in 1970, slowed to about 27 percent.

Using end-year registration data covering the 1956-1970 period (i.e., a 15-year period), the following trend equation for light truck registrations was derived:

$$Y_E = 1416 + 1192X + 197X^2$$

Where Y_E represents numbers of end-year light truck registrations, and X represents the number of years removed from 1963.

This equation gives the following levels of light truck registrations for various years:

1967 –	9,176
1968 –	12,051
1969 –	15,300
1970 –	18,923
1971 –	22,920
1972 –	27,291
1980 –	75,719
1990 –	169,911

These values from the trend equation indicate growth of 106 percent over the 1968-1970 period, whereas actual growth over this three-year period was 199 percent. The trend value for 1970, moreover, was approximately nine percent below actual end-year registrations. It appears evident, therefore, that the trend equation does not adequately account for recent, accelerated growth. A third or fourth-degree growth equation might be found which would give a curve, which would better fit recent growth; such equations, however, would give unrealistic values when used to make projections far into the future.

An alternative approach to obtaining more realistic forecast values is to shorten the period used to derive a second-degree equation. This solution is not ideal, since shortening of the basic data period upon which the trend is based, tends to overemphasize recent growth; despite this shortcoming, however, it was deemed advisable to make use of a shorter period in this instance. Accordingly nine and eleven-year periods were used to derive other trend equations in an attempt to more closely match historic growth. These trend equations were based on registrations data covering the 1962-1970 and 1960-1970 periods, respectively, and are shown below, together with their values (Y_E 9 and Y_E 11) for the 1967-1970 period, and for various future years. The actual past registration totals (Y) and an estimated end-1971 total are also shown. In the equations, T represents the number of years removed from 1966, while X represents the number of years removed from 1965.

$$Y_E\ 9 = 4937 + 2400T + 409.3\ T^2$$

$$Y_E\ 11 = 3261 + 1840X + 322.6\ X^2$$

Years	Y	Y_E 9	% Y_{E9} of Y	Y_E 11	% Y_{E11} of Y
1967	6,944	7,746	112	8,231	119
1968	11,876	11,374	96	11,684	98
1969	16,339	15,821	97	15,783	97
1970	20,764	21,086	102	20,526	99
1971	25,546*	27,170	106	25,915	101
1972	–	34,072		31,948	
1980	–	118,753	–	103,446	–
1990	–	298,285	–	250,886	–

* Estimated on the basis of the growth over January-October 1971

The total growth indicated for the 1968-1970 period by these trend equations based on nine and eleven-year periods would be, respectively, 172 percent and 149 percent, and, thus, would still be less than the growth which actually occurred over that period. The nine-year trend would mean an average annual compound growth of 14.3 percent over the 1971-1990 period, while growth would average 13.3 percent over that period, according to the eleven-year trend.

The feasibility study projected light truck registrations to grow to approximately 8.8 times the end-April 1969 volumes by end-1990; the registration level at end-1990 would be 113,550 light trucks, and the average annual growth rate over 1969-1990 would be 10.4 percent. The actual growth from end-April 1969 to end-1970 was 61.3 percent, as registrations grew from 12,871 to 20,764. In order to attain the 1990 forecast of the feasibility study, an expansion to 5.47 times the end-1970 total would need to occur, and the average growth rate would be 8.9 percent.

In comparison to the feasibility study forecast, the trend equations discussed in this section would all indicate much higher light truck registration totals. These comparisons are shown following.

Source of Projection	Projected 1990 light trucks	Index
Freeway feasibility study	113,550	100.0
Trend based on 1956-1970 period	169,910	149.6
Trend based on 1960-1970 period	250,890	221.0
Trend based on 1962-1970 period	298,290	262.7

It may come to pass that even the highest value indicated here for 1990 would be low. The freeway may induce a large number of prospective motorcycle purchasers to buy light trucks (very small sized-less than one ton) instead, since motorcycles will not be permitted to operate on the freeway, and light trucks will likely be the lowest cost vehicle which would be permitted to use the freeway.

Although the feasibility study forecast of light truck registrations for 1990 now appears to be quite low, in view of the much higher trend-indicated values, no adjustments were made for this low forecast in the analysis presented in the text of this study. A higher forecast (viz., to 2.0 times the forecast level of the feasibility study) is, however, taken into account in a subsequent appendix on sensitivity analysis.

AUTO REGISTRATIONS

The feasibility study forecast a total of 477,000 auto registrations by end-1990, of which 424,000 would be private autos, and the remaining 53,000 would be taxis. The expansion of private autos from end-April 1969 (when there were 17,066 registered private autos) would be 24.85 times, or an annual growth rate of 15.8 percent; the growth rate of taxi registrations would be only about 5.8 percent.

The lower rate of growth was forecast for taxis, despite the historic rapid growth of taxi registrations, because it was expected that this vehicle type was approaching the limit of the number that might usefully be used in Taiwan. Another study* delved into this forecast method further, and, on the basis of some unofficial guidelines for desirable numbers of inhabitants per taxi in various cities and regions of Taiwan, forecast that a useful number of taxis in 1980 would be 32,500. This figure should rise slightly faster than population growth, but somewhat slower than the growth of urban population, after 1980, so that, adopting a rate of 2.5 percent growth per annum over the 1981-1990 period, would give a 1990 taxi registration total of about 41,600. If allowance is made for some expansion of taxi registrations over what would be most desirable, these registrations might be forecast to grow to around 45,000 by end-1990.

Private auto registrations, on the basis of end-April 1969 data, were estimated to rise to 18,430 by end-1969; registrations actually rose to 21,137 by the end of the year, which was more than 14 percent above the estimate. The actual end-1969 registrations were, in fact, even slightly above (3.1 percent) the feasibility study's forecast for end-1970.

In 1970, the rapid growth continued; registrations climbed to 28,849, which was 40.7 percent above the study's forecast for end-1970, and 11.0 percent above the forecast for end-1971.

Some growth rates for private auto registrations, over the 1961-1970 period, are indicated below (where the period indicated comprises more than one year, the growth rate indicated is an average annual compound rate).

Time period	Growth rate for Private Auto Registrations
1961-1970	16.3%
1966-1968	22.3%
1969	29.0%
1970	36.5%

From these growth rates, it can be seen that private auto registration growth has been accelerating for a period of several years. Under such conditions a second-degree growth curve would not be expected to show a good fit for later years, and a third-or fourth-degree curve might prove to be the curve-of-best-fit.

A second-degree trend equation for private auto registrations was found from data covering the 1956-1970 period. The equation is given below.

* The Transportation Economic Study (November 1970)

$$Y_E = 6{,}947 + 1332X + 186.7X^2$$

Where Y_E represents the numbers of private auto registrations, and X represents the number of years removed from 1963.

This equation gives the following levels of private auto registrations for various years:

Year	Trend Values (Y_E)	Actual end-year Registrations (Y)	% Y_E of Y
1966	12,623	11,038	114
1967	15,262	14,245	107
1968	18,275	16,384	112
1969	22,660	21,137	107
1970	25,419	28,849	88
1971	29,552	–	–
1972	34,058	–	–
1980	83,553	–	–
1990	179,029	–	–

The trend-indicated growth over the 1967-1970 period would be 101 percent, whereas actual growth over that period was 162 percent. The actual end-1970 level of registrations was 13.5 percent above the trend-indicated value. According to the trend, the average annual growth of registrations over the 1971-1990 period would be 10.3 percent; if this growth rate would be applied to the actual end-1970 registration total, the end-1990 level of registrations would rise to 203,100.

As was done for light trucks, a trend based on end-year registrations over the 1962-1970 period was also derived, and this trend equation, together with its values for various years is shown below (in this equation, X represents the number of years removed from 1966).

$$Y_E = 10{,}800 + 2{,}542X + 419.6X^2$$

Year	Trend Values (Y_E)	Actual end-year Registrations (Y)	% Y_E of Y
1966	10,800	11,038	98
1967	13,762	14,245	97
1968	17,562	16,384	107
1969	22,202	21,137	105
1970	27,692	28,849	96
1971	34,000	–	–
1972	41,158	–	–
1980	128,634	–	–
1990	313,507	–	–

The trend-indicated growth over the four-year period, 1967-1970, would be 156 percent, or just slightly under the 162 percent growth which actually occurred during that period. The projected growth for the 1971-1990 period would be at an annual rate of 12.9 percent from the 1970 trend value, or 12.7 percent from the actual end-1970 registration level.

A total of 313,000 private autos, by the end of 1990, would be equal to approximately 74 percent of the 424,000 level forecast in the feasibility study. If a revised forecast of 45,000 taxis is added to the 313,000 private autos, then the combined forecast of auto registrations for end-1990 becomes 358,000, which would be equivalent to 75 percent of the feasibility study's projection of 477,000 end-1990 auto registrations. In the sensitivity analysis presented in a subsequent appendix, this estimate, that auto registrations may be equivalent to only about 75 percent of forecast totals of the feasibility study for 1990, is used to adjust downward the user savings, resulting from opening of the freeway, for auto traffic.

It should be noted, however, that this downward adjustment of projected 1990 auto registrations is made only for the purpose of sensitivity analysis, and the lower, adjusted total does not represent the consultants best estimate of the 1990 level of registrations. In the feasibility study, private auto registrations were forecast by relating auto ownership to per capita income, and then by projecting the 1990 level of per capita income. This method is still preferred by the consultants over reliance upon the extension of historic trends of auto registrations.

By relying on the forecasting method used in the feasibility study, and the new trend (based on the 1956-1970 period) forecast of GNP growth, the 1990 projected auto registrations would be even higher than the 477,000 forecast of the feasibility study.

The GNP trend equation shown earlier in this appendix would indicate an expansion to 4.2 times the 1968 GNP by 1990, whereas the feasibility study only foresaw a 3.9 times expansion. The new trend value would therefore be about 7.7 percent higher than the feasibility study forecast, and per capita income (in constant 1968 prices) would be expected to rise to US$629 by 1990, on the basis of the historic trend value, rather than to only US$584 as predicted by the study. This higher per capita income would tend to increase the number of autos per thousand population above the 22.6 forecast by the feasibility study.

Other factors which might tend to increase auto registrations above the 358,000 estimate for 1990, arrived at in this appendix would be: (1) a contemplated liberalization of import restrictions in Taiwan; (2) purchases induced by the freeway, as individuals would decline to purchase motorcycles, which will not be permitted to use the freeway, and would buy autos or light trucks instead; and (3) the possible participation of Taiwan in the manufacture of an inexpensive, Ford Company-developed "Asian Car".

TOTAL VEHICLE REGISTRATIONS

As of end-April 1969 i.e., approximately the time of the feasibility study O-D survey), there was a combined total of 69,758 private autos, taxis, heavy trucks, light trucks, and buses in Taiwan. Based on the growth which had occurred over the January-April 1969 period, the study estimated that these "total", vehicle registrations (i.e., excluding all motorcycles and slow-moving vehicles) would climb to a level of 80,594 by end-1969.

Actual registrations by end-1969 were 82,360, or about two percent above the estimate. The closeness of the estimate to actual registrations occurred, however, only as a result of counterbalancing errors. The study greatly underestimated the growth of private auto, light truck, and bus registrations,while it considerably overestimated the registration increases of taxis and heavy trucks.

The study predicted that registrations would grow by 20.0 percent, in 1970, to an end-year total of 96,700 vehicles. Once again, the study's prediction was exceeded by about two percent, as registrations actually grew to 98,500 vehicles, and, once again, private auto, light truck, and bus registration growth had been underestimated, while heavy truck and taxi registration growth failed to achieve the forecast levels.

The study's forecast for end-1990 was for a total of 711,200 vehicle registrations. The average annual growth rate for the 1971-1990 period, from the forecast end-1970 registrations, would be 10.5 percent; this rate would be reduced slightly to 10.4 percent per annum if measured from actual end-1970 registrations.

The earlier sections of this appendix made a few adjustments in vehicle registration forecasts for the purpose of the sensitivity analysis included in a subsequent appendix. These adjusted totals are summarized below.

Vehicle Type	Feasibility forecast (F)	Adjusted Forecast (A)	%(A) of (F)
Heavy trucks	99,240*	99,240*	100
Light trucks	113,550	227,100	200
Buses	21,410	32,120	150
Autos	477,000	358,000	75
of which:			
Private autos	(424,000)	(313,000)	(74)
Taxis	(53,000)	(45,000)	(85)
Total Vehicles	711,200	716,460	101

* In terms of equivalent 1969 trucks.

APPENDIX A – TABLE 1

NUMBER OF VEHICLES REGISTERED BY HSIEN & CITY

Hsien & City	Bus				Heavy trucks				Sedan				Light Truck			
	1969 March	1971 March	Total Increase	Annual Growth Rate (%)	1969 March	1971 March	Total Increase	Annual Growth Rate (%)	1969 March	1971 March	Total Increase	Annual Growth Rate (%)	1969 March	1971 March	Total Increase	Annual Growth Rate (%)
Taipei City	1,517	2,326	809	23.5	3,657	4,588	931	12.0	18,257	25,839	7,582	18.9	4,240	7,023	2,783	28.6
Keelung City	135	160	25	8.9	521	503	–18	– 1.8	656	1,055	399	26.5	168	300	132	33.5
Taipei Hsien	843	1,064	221	12.3	1,126	1,603	477	19.3	1,657	2,642	985	26.5	957	2,646	1,689	65.4
Yilan Hsien	168	192	24	6.9	460	542	82	8.5	179	326	147	34.8	161	329	168	42.8
Hualien Hsien	49	65	16	15.2	269	363	94	16.2	199	275	76	17.5	147	242	95	28.5
Hsinchu Hsien	214	246	32	7.2	880	1,005	125	6.9	601	935	334	24.8	371	696	325	37.0
Taoyuan Hsien	229	266	37	7.8	649	742	93	6.9	665	1,121	456	29.8	301	1,044	743	85.3
Miaoli Hsien	144	178	34	11.2	445	534	89	9.6	259	410	151	25.8	206	406	200	40.5
Taichung City	485	567	82	8.2	680	971	291	19.5	2,010	3,858	1,848	38.5	739	1,196	457	27.4
Taichung Hsien	181	224	43	11.2	657	855	198	14.1	579	1,065	486	35.5	554	1,052	498	37.5
Changhwa Hsien	382	447	65	8.2	525	789	264	22.5	684	1,192	508	32.0	399	870	471	47.8
Nantou Hsien	81	107	26	14.9	629	614	–15	– 1.2	577	558	– 19	– 1.7	249	395	146	25.8
Tainan City	329	365	36	5.3	628	753	125	9.5	1,551	2,307	756	21.8	528	988	460	36.8
Tainan Hsien	133	162	29	10.4	429	588	159	17.1	374	562	188	22.5	304	604	300	40.8
Chiayi Hsien	263	274	11	2.0	621	767	146	11.1	468	745	277	26.5	393	666	273	30.2
Yunlin Hsien	146	168	22	7.3	379	514	135	16.4	348	495	147	19.3	203	417	214	43.5
Kauhsiung City	640	706	66	5.0	2,052	2,509	457	10.6	2,928	4,498	1,570	23.8	1,000	1,545	545	24.5
Koahsiung Hsien	194	253	59	14.2	1,048	775	– 273	– 14.2	841	664	– 177	– 11.1	455	667	212	21.2
Pingtung Hsien	276	319	43	7.5	524	623	99	9.0	456	684	288	22.5	363	596	233	28.5
Taitung Hsien	10	32	22	78.0	197	283	86	19.8	127	177	50	18.1	79	173	94	47.8
Penghu Hsien	39	46	7	8.6	46	45	– 1	– 1.1	65	77	12	8.8	20	62	42	76.0
Totals	6,458	8,167	1,709	12.4	16,422	19,966	3,544	10.3	33,481	49,485	16,004	21.5	11,837	21,917	10,080	36.5

Appendix B
VEHICLE OPERATING COSTS AND USER COSTS

The vehicle operating costs used in the feasibility study were re-examined to determine whether they would be usable in the current study. Although some minor adjustments could be made, no major changes appeared necessary, and the net effects of the minor adjustments were well within the initial range of accuracy of operating costs, so that it was not considered necessary to make operating cost adjustments. The minor adjustments which could have been made (but were not) are discussed following.

At the time that they were calculated for the feasibility study, the operating costs did not include vehicle license fees or fuel consumption taxes (these latter, despite their name, are applied in the fashion of license fees). The addition of these taxes would tend to make time saving of greater value to vehicles, with the result that diversion to the freeway from other highways would tend to increase, and freeway benefits would likewise tend to rise (since the additional time costs are taxes, and thus would not be part of the economic cost savings, benefits per vehicle on the freeway would not tend to rise, but total benefits might be expected to increase only because the number of vehicles, deriving benefits from traveling on the freeway, would rise).

An adjustment to operating costs which would at least partially counterbalance this, however, would be a slight reduction in the interest rate. The rate used in the feasibility study was a cumulative total of the interest paid to purchase vehicles on time, an estimated minimum profit margin on invested capital, and a minimum rate for inflation. Upon reconsidering this interest rate, however, it was agreed that the inflation rate (2.2 percent/annum) was already in the time rate charged to vehicle purchasers, and, thus, should not be added in a second time.

The net effect of the tax and interest rate adjustments is to increase the with-tax operating costs slightly, and to reduce the without-tax operating costs by an even smaller amount. These adjustments are shown in Table B-1. In Table B-2, the adjusted time costs are compared with those time costs calculated in the feasibility study.

No changes were made in distance costs. Consideration was given to adjusting fuel costs, since it is generally considered that the retail prices in Taiwan reflect the monopoly position of the seller, and far exceed the actual economic cost (with a normal profit margin). One study*, completed during early 1971, indicated that the economic cost of diesel fuel might be NT$1.51 per liter; this is about 49 percent below the NT$2.94 without-tax cost indicated in the feasibility study. Since nearly all freeway cost savings are time savings, instead of distance savings, and thus do not involve fuel cost savings, an investigation into the true economic cost of fuel was not considered worthwhile. Moreover, during the course of the study, the prices of petroleum products were raised (with incremental prices ranging up to 19 percent), so that the two adjustments would tend to counterbalance one another. (As an indication of the possible effect of such a fuel cost adjustment, the adjusted computer results of this study indicated that distance savings for total vehicles would be about 5.5 percent with the freeway compared to an arterial highway network without the freeway, whereas time savings would be approximately 28.5 percent. If the economic cost of fuel would be about 60 percent of the average of the costs indicated in the feasibility study, then the economic costs of fuel per kilometer would be approximately NT$0.32, and the difference between this cost and the cost used to calculate savings would be approximately NT$0.21 per kilometer. If this latter figure would be applied to the approximately 153,000 vehicle-kilometers saved per day, then the total difference in distance cost savings would be approximately NT$32,000 per day; this would represent about 3.6 percent of the total user cost savings of NT$1,045,000 per day. This difference is well within the study's margin of error, and thus no adjustment is made for it elsewhere, especially since the true economic cost of fuel is not known, and might have been understated in the study referred to, in an attempt to be conservative in estimating the benefits for the project being evaluated.)

* The Taiwan Railway Electrification Study.

TABLE B-1

VEHICLE OPERATING COST ADJUSTMENTS

Auto & Taxi	With Taxes(NT$)	Without Taxes(NT$)
Unadjusted time cost/annum*	73,800	67,500
Add vehicle license fees	3,060	–
Add fuel consumption tax	3,600	–
Total addition	6,660	–
Deduct interest @2.2%	- 1,760	- 1,760
Net adjustments	4,900	- 1,760
Adjusted annual time cost	78,700	65,740
Operating cost/minute	0.42	0.35
User cost/minute	1.25	1.18
One-ton Truck		
Unadjusted time cost/annum*	93,000	86,300
Add vehicle license fees	1,740	–
Add fuel consumption tax	1,600	–
Total addition	3,340	–
Deduct interest @2.2%	- 1,760	- 1,760
Net adjustments	1,580	- 1,760
Adjusted annual time cost	94,580	84,540
Operating cost/minute	0.79	0.70
3.5-ton Truck		
Unadjusted time cost/annum*	117,100	108,600
Add vehicle license fees	2,340	–
Add fuel consumption tax	2,620	–
Total addition	4,960	–
Deduct interest @2.2%	- 2,640	- 2,640
Net adjustments	2,320	- 2,640
Adjusted annual time cost	119,420	105,960
Operating cost/minute	0.64	0.57
Six-ton Truck		
Unadjusted time cost/annum*	186,000	172,900
Add vehicle license fees	3,720	–
Add fuel consumption tax	8,520	–
Total addition	12,240	–
Deduct interest @2.2%	- 3,850	- 3,850
Net adjustments	8,390	- 3,850
Adjusted annual time cost	194,390	169,050
Operating cost/minute	1.04	0.90
Bus		
Unadjusted time cost/annum*	186,000	172,900
Add vehicle license fees	4,920	–
Add fuel consumption tax	17,940	–
Total addition	22,860	–
Deduct interest @2.2%	- 3,850	- 3,850
Net adjustments	19,010	- 3,850
Adjusted annual time costs	205,010	169,050
Operating cost/minute	1.10	0.90
User cost/minute	4.60	4.40

* Freeway feasibility study time cost estimate.

TABLE B-2

COMPARISON OF ADJUSTED TIME COSTS AND FEASIBILITY STUDY TIME COSTS

Vehicle Type	With Taxes: Feasibility Study (1) (NT$)	With Taxes: Adjusted Costs (2) (NT$)	With Taxes: Percent (1) of (2)	Without Taxes: Feasibility Study (1) (NT$)	Without Taxes: Adjusted Costs (2) (NT$)	Without Taxes: Percent (1) of (2)
Auto						
Operating cost	0.40	0.42	95.2	0.36	0.35	102.9
User cost	1.23	1.25	98.4	1.19	1.18	100.8
Light truck (1.0 ton)	0.78	0.79	98.7	0.72	0.70	102.9
Light truck (3.5 ton)	0.63	0.64	98.4	0.58	0.57	101.8
Heavy truck	1.00	1.04	96.2	0.92	0.90	102.2
Bus						
Operating cost	1.00	1.10	90.9	0.92	0.90	102.2
User cost	4.50	4.60	97.8	4.42	4.40	100.5

CHAPTER II
APPENDICES

Appendix A

SELECTION OF TOLL SCHEDULES FOR TESTING

THE BENEFITS APPROACH TO TOLL LEVEL DETERMINATION

An analysis of operating cost benefits on the freeway was employed primarily for the purpose of determining relative toll levels that might be justified as equitable among the different vehicle types, and over the several sections of the freeway. After relative levels were determined, the absolute levels which might be preferred would be selected by taking into account expected toll revenues, and the likely retarding effects on diversion of highway traffic to the freeway; benefits would be a consideration in the determination of the absolute toll rates to be examined only insofar as no rate would be considered which would entirely eliminate freeway cost savings for any vehicle type over any freeway section.

In order to determine freeway cost advantages relative to travel via the arterial highways, the computer output of the freeway feasibility study was used. Because of some adjustments which had been made in the freeway route, and other adjustments which were being made in this study, the feasibility study data were no longer entirely accurate with regard to freeway cost advantages per vehicle (even in the situation without tolls); nevertheless, only approximations of relative benefits were needed for the purpose of determining toll schedules, and the feasibility study data were therefore deemed adequate. The various adjustments which affected the reliability of the feasibility study computer output included:

Route adjustments in some freeway sections;

Elimination of some interchanges, as a result of the decision to impose tolls on the freeway; and

The imposition of tolls (which should affect the portions of corridor traffic that would use the freeway).

Of these various adjustments, only the last, viz., the imposition of tolls on the freeway might significantly affect the freeway with-tax cost advantages per vehicle-kilometer.

As a first step to determining freeway operating cost advantages, the freeway investment alternative totals of vehicle-kilometers and vehicle operating costs on the freeway and on the arterial highways in 1969 and 1990 were adjusted to include the East route alternative in Section VII (the West route alternative had been recommended for selection in the feasibility study, and the freeway totals included data pertaining to that route). These revised freeway totals are shown in Table A-1; totals for the individual sections are shown in Tables VI-22 and VI-25 of the feasibility study.

Vehicle operating costs in each case were divided by the appropriate vehicle-kilometer totals to produce the per-kilometer vehicle operating cost figures shown in Table A-2. The mean average (1969 and 1990) freeway per-kilometer cost advantages for the various vehicle types are: Auto-NT$1.03; light truck-NT$0.86; heavy truck-NT$1.05; and bus-NT$4.40. The cost advantage for autos is nearly as high as the advantage for heavy trucks because of the inclusion of passenger time value; the very high cost advantage of using the freeway to express buses also stems largely from the value of passenger time savings.

Although the preponderance of vehicle operating cost advantages are gained as a result of more rapid running speeds on the freeway compared to operating on arterial highways, there should also be some distance savings in a few sections (and distance dissavings in others). In order to find arterial highway operating costs for freeway equivalent kilometers, then, the arterial highway per-kilometer costs were adjusted for distance savings or dissavings, as shown in Tables A-3 to A-6.

The mean averages (1969 and 1990) of adjusted freeway cost advantages for the four vehicle types are as shown below.

Vehical Types	Mean Average Freeway Cost Advantages NT$	% of Arterial Hwy Oper. Cost
Autos	1.31	40.9
Light Trucks	1.05	31.9
Heavy Trucks	1.48	31.8
Buses	5.39	48.5

Using the light truck cost advantage of NT$1.05 per freeway equivalent kilometer as the base value to establish an index (i.e., 1.05=100), the index numbers for the other vehicle types are as follows: auto-125; heavy truck-141; and bus-513.

Two approaches to using freeway operating cost benefits for establishing relative toll levels were considered in this study. One approach would be to institute tolls which would take a common percentage of freeway benefits from the several vehicle types. Thus, if rates would not vary from section to section, and the average benefits over the entire freeway were used to establish relative toll levels, then the rates would vary among vehicle types approximately in accordance with the index calculated in the preceding paragraph. That is, the ratio of toll levels among the four vehicle types would be: 1.0(light trucks):1.25(autos):1.4(heavy trucks):5.0(buses).

The other approach (discussed in the feasibility report as a "minimum diversion" technique) would permit all vehicle types to operate on the freeway with about the same percentage of operating cost benefits; that is, the freeway operating costs, including toll charges and operating costs arising from toll collection stops, would be equivalent to a percentage of adjusted (for distance savings or dissavings with freeway travel) arterial highway operating costs, and this percentage would be common to all vehicle types.

Referring back to the mean average freeway cost advantages shown above, it may be noted that the per-freeway-equivalent-kilometer percentage cost advantages vary from 31.8 percent for heavy trucks to 48.5 percent for buses. Suppose now, it were considered that tolls should be instituted in such a manner as to maintain a 25 percent operating cost advantage for the freeway for all vehicle types. The cost advantages, in terms of NT dollars, would then be adjusted as shown following:

Autos	:	1.31 x (25.0 ÷ 40.9) = NT$0.80
Light Trucks	:	1.05 x (25.0 ÷ 31.9) = NT$0.82
Heavy Trucks	:	1.48 x (25.0 ÷ 31.8) = NT$1.16
Buses	:	5.39 x (25.0 ÷ 48.5) = NT$2.78

With freeway per-kilometer cost advantages of these magnitudes, the combined costs of toll charges and toll collection stops per kilometer would be as follows: autos-NT$0.51 (i.e., NT$1.31 less NT$0.80); light trucks-NT$0.23; heavy trucks-NT$0.32; and buses-NT$2.61.

The toll cost for autos would thus be more than twice the cost for light trucks, and more than one and one-half times the cost for heavy trucks. If the percentage operating cost advantage were altered, however, the relative magnitudes of toll costs among vehicle types would vary. Suppose, for example, that the percentage were changed to ten percent, that is, on the average every vehicle type would realize a ten percent cost advantage per kilometer by operating on the freeway rather than on the alternative arterial routes. Then the per-kilometer cost advantages, in terms of NT dollars, and the per-kilometer toll costs would be as shown below.

Vehicle Type	Fwy Cost Advantage/km. NT$	Toll costs/km. NT$
Autos	0.32	0.99
Light trucks	0.33	0.72
Heavy trucks	0.46	1.02
Buses	1.11	4.28

When only a ten percent benefit level would be permitted on the freeway, then, the auto toll cost would drop slightly below that of heavy trucks. These toll rates however, are quite high, and were deemed to be unrealistic for Taiwan. At the more realistic rates of, perhaps, twenty percent or more cost advantage on the freeway, auto toll costs would be greater than the costs for heavy trucks. To charge higher rates for autos than for heavy trucks would present several difficulties, most notably the following: (1) such an arrangement would clash with historic precedent: (2) light vehicles could then not be charged a common rate, since, to do that, would mean that light trucks would pay higher toll costs than heavy trucks, and the rate would, thus, be all out of proportion to light truck benefits; and (3) the proposal would be strongly at variance with the conclusion of the cost approach of determining equitable relative rates among vehicle types, which would indicate that higher rates should be imposed upon heavy trucks than upon autos.

For these several reasons, the common percentage of cost advantage approach was deemed to be unusable and was discarded in favor of common percentage of cost benefit reduction approach. That is, it was decided to select toll rates which would reduce freeway per-kilometer cost advantages by an approximately equal percentage for all vehicle types. If, then, there were no other considerations, and it would be deemed acceptable to use the average benefits for the entire freeway, and not to differentiate among sections, then the ratio of toll levels among vehicle types would be that calculated earlier, viz., 1.0 (light trucks): 1.25(autos): 1.4(heavy trucks): 5.0(buses).

Referring back to Tables A-3 through A-6, however, it can be noted that there might exist some reason for differentiating among freeway sections. The adjusted auto per-kilometer cost advantage ranges from a low of NT$0.38 in Section V, to a high of NT$2.08 in Section IV (this high cost advantage in Section IV will be somewhat reduced, however, since five of an original number of 12 interchanges in the section are being proposed to be eliminated, now that the decision has been made to impose tolls on the freeway).

Using the auto cost benefit in Section V (which was the lowest cost advantage for any vehicle type in any section) as the base figure, an index of relative magnitude of freeway adjusted cost advantage was established; these index numbers are shown in Table A-7. (Note: the index numbers are based only on 1969 cost advantages, and the ratio for the total freeway, thus, differs from the 1.0:1.25:1.4:5.0 ratio shown above.)

At this point in the discussion it might be worthwhile to refer to the sixth toll level consideration discussed in Chapter II. Although auto and light truck benefits, as indicated by the Table A-7 index numbers, differ considerably in every freeway section, it was determined that, for traffic safety reasons (avoidance of excessive weaving at approaches to toll barriers), light vehicles would have common toll levels with the barrier system, (but need not have common rates with the closed system). With, at least, the barrier system, then, either light trucks or autos would bear the toll level established for the other vehicle type. Use of average cost advantages for light trucks and autos was considered, but was discarded because the wide divergences of light truck and auto cost advantages would mean that the vehicle type with the lower advantages might lose all, or nearly all, of its cost advantage if toll charges were equivalent to a significant portion of the two vehicle types average cost advantage. Hence, it was decided to base barrier system toll rates for the two vehicle types on the lower cost advantages of the two vehicle types. Referring back to Table A-7, this decision would mean that the light truck index number of 339 would be used for the two light vehicle types in Section I, and the heavy truck rate would be approximately 1.35 times (i.e., 458 ÷ 339) the light vehicle rate.

Table A-8 indicates what the per-kilometer toll costs (i.e., toll charges plus stopping costs) would be for the various vehicle types on the several freeway sections, if costs would be equivalent to 10, 20, 30, or 40 percent of freeway cost advantages. It may be noted that, in three of the seven freeway sections (Sections II, III, and VII), the ratio of truck toll costs to light vehicle costs is approximately two to one; in only two sections (Sections I and IV) is the ratio of heavy truck toll costs to light vehicle toll costs significantly below a two to one ratio. It should be kept in mind, however, that these two to one ratios occur with some frequency only when heavy truck cost advantages are compared with the lower cost advantages of either autos or light trucks in the several sections, and that, when heavy truck cost advantages are compared to light truck advantages per kilometer over the entire freeway, the ratio is only 1.46, and when compared to auto advantages the heavy truck cost advantages sink (in relative terms) to only 1.06 times as high. Thus, a two to one ratio of heavy truck toll costs to light vehicle costs cannot actually be justified as equitable from the standpoint of benefits, and, lower ratios should also be considered. Especially with the closed, or hybrid system, in which case it would not be necessary to impose common toll rates on autos and light trucks, the heavy trucks should not be made to bear toll rates which approach twice the rates of the light vehicles.

In Table A-9, the per-kilometer toll costs, indicated in the preceding table, were multiplied by the route lengths of the various freeway sections to obtain total toll cost figures for three vehicle categories in each of the seven freeway sections. The final toll cost figures selected for testing, however, were the result of a number of adjustments from the toll costs shown in this table.

FINAL SELECTION OF BARRIER SYSTEM TOLL RATES

After the Government decision in late 1969, that tolls should be imposed on the freeway, a limited study was done to determine the effects of the institution of tolls on Section II of the freeway, and on the freeway bridge leading into Taipei, and crossing the Tamshui River. The toll levels used for this limited study were those initially indicated by the Government, viz., NT$10 and NT$15 on light and heavy vehicles, respectively, on the Section II freeway segment, and NT$5 and NT$10 on light and heavy vehicles at the freeway bridge. With these toll levels, the study determined, a high percentage (78 percent excluding the bridge section, and more than 100 percent with the bridge section) of freeway construction, maintenance, and operating costs would be returned in toll revenues (in this analysis, toll revenues were maintained in present value by discounting at a rate of eight percent).

It was decided that because of the qualification (discussed in Chapter II) requiring that a fairly sizable portion of freeway costs be recovered from tolls, the toll levels of NT$10 and NT$15 for light and heavy vehicles, respectively, would be considered as minimum tolls at each toll barrier. These toll rates should not be expected to return as high a portion of costs to be recovered as was found in the December 1969 limited study for the following reasons: (1) this study is recommending that traffic confined to the three major urban areas not be required to pay tolls; (2) because highways in the Section II area are already congested, considerable diversion to the freeway was indicated by the limited study even with the imposition of tolls, but arterial highways in other sections are not so congested, and diversion to the freeway would be expected to be less; and (3) the tolls considered, at the time of the limited study, were actually being imposed on only a 30-kilometer stretch of Section II (viz., Sanchung-Chungli), and so constituted rates of NT$0.33 and NT$0.50 per kilometer on light and heavy vehicles, respectively, whereas, if the rates of NT$10 and NT$15 would be imposed at each of a proposed ten barriers with the barrier system, the per-kilometer charges would drop slightly to NT$0.27 and NT$0.40 for light and heavy vehicles, respectively.

The rates of NT$10 and NT$15 would agree with historic precedent in Taiwan to the extent that both light vehicles and heavy vehicles would be charged common rates; this toll schedule would differ from historic precedent, however, in that heavy vehicles would only be charged fifty percent more than light vehicles, rather than double the light vehicle rate. As far as heavy trucks are concerned, this adjustment would agree with the conclusion of the benefits analysis of the last section; buses, however, would be paying a much lower portion of their benefits than would other vehicle types.

For this toll schedule, it was proposed that the toll charges not be varied from barrier to barrier. The table below indicates what this would mean in terms of cost advantage reductions of the several freeway sections. In a number of the barrier locations, the toll payments from traffic moving in one of the two directions would constitute payments for benefits derived in both the section where the barrier was located and the adjacent section; thus, the benefit portions, indicated in the table as being reduced by toll charges, are only approximations. Moreover, it should be remembered that toll charges do not constitute total toll costs, and the operating costs increments, arising from the making of toll-collection stops, would have to be added to determine total freeway cost advantage reductions. Despite these qualifications, the reductions indicated in Table A-10, below, should be fairly close approximations of what might be expected with this toll schedule.

TABLE A-10

FREEWAY COST ADVANTAGE REDUCTIONS WITH TOLLS OF NT$10 AND NT$15 ON LIGHT AND HEAVY VEHICLES RESPECTIVELY

Section & No. of Barriers	Autos & Lt. Trucks: Toll Charges (NT$)	Autos & Lt. Trucks: % of Fwy. Cost Advantage	Heavy Trucks: Toll Charges (NT$)	Heavy Trucks: % of Fwy. Cost Advantage	Buses: Toll Charges (NT$)	Buses: % of Fwy. Cost Advantage
I-1 barrier	10	27	15	30	15	8
II-1 barrier	10	22	15	17	15	6
III-1 barrier	10	50	15	35	15	17
IV-2 barriers	20	20	30	23	30	6
V-1 barrier	10	40	15	17	15	6
VI-3 barriers	30	52	45	47	45	15
VII-1 barrier	10	44	15	28	15	6

As may be noted from the above table, buses would be paying the equivalent of only a very small portion of their freeway cost advantages. From the standpoint of making toll rates more equitable, then, it would be preferable to charge buses higher rates. Referring back to Table A-7, it may be noted that the toll costs indicated for buses at any given percentage of freeway cost advantage were at least two times the costs for heavy trucks in every freeway section, and, indeed, it was only in Section III that the ratio of bus toll costs to heavy truck toll costs approached as low a ratio as two to one. Accordingly, it was decided that a second toll schedule to be tested would only differ from the first by the charges imposed on buses, which would be double those imposed on heavy trucks, or NT$30 per barrier.

A higher rate on buses can be justified on the basis of the much higher benefits per vehicle-kilometer accruing to buses, since there would be time savings for an average of 35 passengers (the average, found during the O-D survey of the feasibility study, for tourist and express buses); it can be supported also from the standpoint of the desirability of maximum diversion of vehicles from existing highways to the freeway. That is, buses are very likely to use the freeway for all north-south express trips; bus drivers, unlike the drivers of most other vehicles, will normally not have the option to choose any route other than the freeway. Moreover, as indicated in Appendix B to Chapter I, the passenger time value included in express bus user costs is actually a minimum value for present express bus passengers, and, as such, greatly understates the benefits for buses of using the freeway. In the future, express buses should be competitive with the railway for long-distance passengers, and the passengers traveling by express rail today apparently have higher time value (since they pay higher fares for the same distances) than today's express bus passengers.

There is a problem, however, in charging heavy trucks and buses different toll rates. To wit: these two vehicle types may have to be required to use separate lanes at the toll barriers.

Both of the toll schedules discussed thus far would be uniform throughout the barrier toll network. As indicated in the section on benefits, however, the benefits per kilometer for any vehicle type would not be uniform among the several freeway sections, but would instead vary to a considerable extent.

When consideration was given to imposing higher toll levels, than have heretofore been discussed, in order that all, or nearly all, of freeway costs might be collected in toll revenues, it was decided that toll rates which would be variable from barrier to barrier, and would bear a closer relation to relative cost advantages, ought to constitute one toll rate network option, in order that no vehicle type in any section would be deprived of the preponderance of the cost advantages of the freeway.

The rates chosen for recovery of a large proportion of total cost are as follows: light vehicles-NT$15; heavy trucks-NT$20; and buses-NT$40. Table A-11, below, indicates what these tolls would mean in terms of cost advantage percentage reductions for the various vehicle types over the seven freeway sections, if the rates were applied uniformly at all barriers.

TABLE A-11

FREEWAY COST ADVANTAGE REDUCTIONS WITH TOLLS OF NT$15, NT$20 AND NT$40 IMPOSED ON LIGHT VEHICLES, HEAVY TRUCKS, AND BUSES, RESPECTIVELY

Section & No. of Barriers	Autos & Lt. Trucks		Heavy Trucks		Buses	
	Toll Charges (NT$)	% of Fwy. Cost Advantage	Toll Charges (NT$)	% of Fwy. Cost Advantage	Toll Charges (NT$)	% of Fwy. Cost Advantage
I-1 barrier	15	40	20	40	40	22
II-1 barrier	15	35	20	22	40	16
III-1 barrier	15	75	20	47	40	43
IV-2 barrier	30	30	40	31	80	15
V-1 barrier	15	60	20	21	40	16
VI-3 barrier	45	78	60	63	120	40
VII-1 barrier	15	64	20	38	40	15

The toll charges for light vehicles appear excessively high in Sections III, VI, V, and VII; heavy truck charges may be somewhat high in Sections II and VI; and bus charges are high (relative to other sections for buses, though not relative to other vehicle types) in Sections III and VI. Even though the costs may not be entirely equitable among freeway sections, however, the vehicles using the freeway would maintain at least twenty percent of freeway operating cost advantages in every section (although this is before calculation of costs of toll-collection stops), and thus considerable diversion to the freeway would be expected even at these rates.

These constant-rate schedules, however do not take into account the varying amounts of operating cost benefits per vehicle-kilometer; nor do they take into account the varying distances between barriers (although, with the proposed barrier network, these distances do not vary greatly). Variable-rate schedules would take both of these factors into account, since they would vary according to operating cost benefits derived from freeway use over the various sections (and these cost benefits, in turn, vary with benefits per kilometer and total distance of each section); thus, the variable-rate schedules might be considered more equitable. A variable-rate schedule, proposed for testing, is shown in Table A-12.

TABLE A-12

FREEWAY COST ADVANTAGE REDUCTIONS WITH VARIABLE TOLLS OF NT$10 & NT$15 ON LIGHT VEHICLES, NT$15 & NT$20 ON HEAVY TRUCKS, AND NT$20 & NT$40 ON EXPRESS BUSES

Section & No. of Barriers	Autos & Lt. Trucks		Heavy Trucks		Buses	
	Toll Charges (NT$)	% of Fwy. Cost Advantage	Toll Charges (NT$)	% of Fwy. Cost Advantage	Toll Charges (NT$)	% of Fwy. Cost Advantage
I-1 barrier	15	40	20	40	40	22
II-1 barrier	15	35	20	22	40	16
III-1 barrier	10	50	15	35	20	22
IV-2 barriers	30	30	40	31	80	15
V-1 barrier	10	40	20	21	40	16
VI-3 barriers	30	52	45	47	60	20
VII-1 barrier	10	44	20	38	40	15

Four toll schedules have now been suggested for testing. To summarize, these are as shown below.

Toll networks with schedules common to all barriers:

(B_1) Light vehicles-NT$10; heavy vehicle-NT$15
(B_2) Light vehicles-NT$10; heavy trucks-NT$15; buses-NT$30
(B_3) Light vehicles-NT$15; heavy trucks-NT$20; buses-NT$40

Toll network with schedules variable among barriers:

(B_4) Section I barrier – light vehicles-NT$15; heavy trucks-NT$20; buses-NT$40.

Section II barrier — light vehicles-NT$15; heavy trucks-NT$20; buses-NT$40.

Section III barrier — light vehicles-NT$10; heavy trucks-NT$15; buses-NT$20.

Section IV barriers(2) — light vehicle-NT$15; heavy trucks-NT$20; buses-NT$40.

Section V barrier — light vehicles-NT$10; heavy trucks-NT$20; buses-NT$40.

Section VI barriers(3) — light vehicle-NT$10; heavy trucks-NT$15; buses-NT$20.

Section VII barrier — light vehicles-NT$10; heavy trucks-NT$20; buses-NT$40.

The total toll charge costs for vehicles traveling along the entire length of the freeway with each of the four proposed toll rate networks (the variable schedule network is designated as network B_4) are as shown below in Table A-13. The freeway distance is approximately 375 kilometers, and this distance is divided into the toll charge totals to determine the per-kilometer charges over the entire freeway length.

TABLE A-13

TOTAL TOLL CHARGES AND CHARGES PER KILOMETER WITH FOUR TOLL RATE NETWORKS
(NT$)

Toll Rate	Light Vehicles		Heavy Trucks		Buses	
Networks	Total Charges	Charge/ km.	Total Charges	Charge/ km.	Total Charges	Charge/ km.
B_1	100	0.27	150	0.40	150	0.40
B_2	100	0.27	150	0.40	300	0.80
B_3	150	0.40	200	0.53	400	1.07
B_4	120	0.32	180	0.48	320	0.85

The toll charges per kilometer for light vehicles are very much in line with those which were imposed on autos in the United States until recently; autos there have normally been charged between US$0.01 and US$0.015 per mile, which converted to NT dollars and kilometers, is a range of NT$0.24-NT$0.36 per kilometer (Actually, the average charge in the United States, has now risen to US$0.017 per mile.)

FINAL SELECTION OF CLOSED SYSTEM TOLL RATES

With the closed system, there is no operational advantage to charging light or heavy vehicles common rates, and, thus, relative toll levels among vehicle types may be more closely tied to the respective freeway cost advantages. It is not only easier to vary toll rates among vehicle types, but also to vary them among sections for each category of vehicle. Nevertheless, of the four closed system toll schedules finally selected for consideration, two do not vary toll rates per kilometer from section to section.

One schedule which does not vary from section to section was based upon the ratio of average per-kilometer benefits among the various vehicle types over the entire freeway in 1969, but was adjusted upward for heavy trucks and downward for express buses. This ratio was as follows: 1.0 (light trucks) : 1.375 (autos) : 1.46 (heavy trucks) : 5.15 (buses). In order to set toll rates with this ratio, the NT$0.32 per kilometer average toll charge for autos, from schedule B_4 with the barrier system, was selected as a base value; the per-kilometer toll charges for the other vehicle types would then be as follows: light trucks-NT$0.23; heavy trucks-NT$0.34; and buses-NT$1.20. Two adjustments were made in these indicated per-kilometer toll charges to bring them more in line with historic precedent. First of all, the differential between autos and heavy trucks was too slight, and the heavy truck per-kilometer charge was therefore raised to NT$0.40. Secondly, the high toll charge multiple for buses would differ radically from the historic precedent, and was therefore lowered to twice the rate for heavy trucks, i.e., to a level of NT$0.80 per kilometer. This toll schedule with rates of NT$0.32 for autos, NT$0.23 for light trucks, NT$0.40 for heavy trucks, and NT$0.80 for buses, is designated hereafter as Schedule C_1. These rates would mean that trips along the entire length of the freeway would cost the four vehicle types the following amounts in tolls: Autos-NT$120; light trucks-NT$86; heavy trucks-NT$150; and buses-NT$300.

In order to establish toll networks with variable rates among sections, the toll costs per kilometer shown in Table A-8 for heavy trucks and buses were used. The costs shown in the table for light trucks and autos, jointly, were no longer usable in the case where those two vehicle types could (and should — from the standpoint of equitable benefits) be charged different rates. Accordingly, these costs were determined for autos and light trucks separately, and are shown following in Table A-14. Only the costs at 20 percent and 30 percent are shown, however, since it was determined that the two variable toll rate networks to be tested should have rates which would approximate 20 percent and 30 percent of freeway cost advantages (although, in deference to historic precedent, rates slightly higher than these for heavy trucks and considerably lower than these for buses were chosen). The rates 20 percent and 30 percent were chosen as desirable since, at these rates, the average charge per kilometer on autos would be NT$0.29 and NT$0.43, respectively, or nearly equal to the NT$0.27-NT$0.40 range determined for the barrier system toll schedules.

Several adjustments were made in the auto and light truck per-kilometer costs shown in Table A-14, and in the heavy truck and bus per-kilometer toll costs shown in Table A-8, to obtain the final variable rates used for the two closed system variable toll schedules selected for testing. These adjustments are discussed following.

> The rate variations for light trucks and autos were deemed to be too great from section to section, so that a deviation of 25 percent from the average figures for the entire freeway was arbitrarily set as the upper and lower limits for rates. This means that for autos the rates might vary from NT$0.22 to NT$0.36 for the schedule based on 20 percent of freeway cost advantages, and from NT$0.32 to NT$0.54 for the network based on 30 percent. For light trucks, the respective rote ranges would be NT$0.16-NT$0.26 and NT$0.23-NT$0.39.
>
> Heavy truck rates were adjusted to bear a relation to auto rates of at least 1.25:1 in every section.
>
> Bus rates were lowered to bear a two to one relation to heavy truck rates in every section.

Table A-15 shows the variable-rate toll schedules selected for testing for the closed system. Table A-16 indicates the total toll charges that would be paid in the various sections with these variable rates by vehicles traveling the entire length of the sections. At the bottom of this last table, the average per-kilometer toll charges over the entire freeway with these variable rate schedules are shown. The average rates of the higher variable-rate toll schedule were used as the rates for a second constant-rate toll schedule (designated as schedule C_4). Schedule C_1, which was calculated earlier, has, in the case of each vehicle type, rates which fall in between the high and low averages of the variable-rate schedules; thus, the range of charges selected for further consideration with the closed system is indicated by the two sets of variable-rate averages. The range of NT$0.26-NT$0.39 for autos is nearly the same as the barrier system range for autos of NT$0.27-NT$0.40.

TABLE A-1

WITH-FREEWAY VEHICLE OPERATING TOTALS: WEST ALTERNATIVES IN SECTIONS II AND V & EAST ALTERNATIVE IN SECTION VII

Year & Item	Vehicle Categories				
	Auto & Taxi	Light Trucks	Heavy Trucks	Express Buses	Total Vehicles
1969 Traffic					
Vehicle-kms					
Arterials	402,700	126,240	320,280	52,430	901,650
Freeway	506,650	161,440	945,470	160,380	1,773,940
Total	909,350	287,680	1,265,750	212,810	2,675,590
Vehicle operating cost(NT$)					
Arterials	1,208,120	391,560	1,361,810	526,890	3,488,380
Freeway	952,250	359,170	2,998,210	907,650	5,217,280
Total	2,160,370	750,730	4,360,020	1,434,540	8,705,660
1990 Traffic					
Vehicle-kms					
Arterials	6,329,700	1,123,020	2,620,950	180,060	10,253,730
Freeway	8,411,240	1,536,200	6,727,390	638,210	17,313,140
Total	14,741,040	2,659,220	9,348,340	818,270	27,566,870
Vehicle operating cost(NT$)					
Arterials	18,028,030	3,469,340	11,008,580	1,824,530	34,330,480
Freeway	16,018,010	3,436,540	21,361,130	3,673,490	44,489,170
Total	34,046,040	6,905,880	32,369,710	5,498,020	78,819,650

TABLE A-2

VEHICLE OPERATING COSTS PER KILOMETER (NT$)

Year & Freeway Section	Auto: Arte-rial Hwy.	Auto: Free-way	Auto: Fwy. Advan-tage*	Light Truck: Arte-rial Hwy.	Light Truck: Free-way	Light Truck: Fwy. Advan-tage*	Heavy Truck: Arte-rial Hwy.	Heavy Truck: Free-way	Heavy Truck: Fwy. advan-tage*	Bus: Arte-rial Hwy.	Bus: Free-way	Bus: Fwy. Advan-tage**
1969												
I	3.51	2.01	1.50	3.27	2.28	0.99	4.61	3.22	1.39	11.51	5.95	5.56
II	3.09	1.84	1.25	4.16	2.25	1.91	5.65	3.30	2.35	12.02	5.80	6.22
III	2.75	1.82	0.93	2.78	2.18	0.60	4.33	3.09	1.24	9.15	5.46	3.69
IV	2.67	1.86	0.81	2.65	2.22	0.43	3.84	3.22	0.62	9.12	5.68	3.44
V	2.58	1.94	0.64	2.67	2.21	0.46	3.95	3.13	0.82	8.83	5.65	3.18
VI	2.70	1.82	0.88	2.70	2.18	0.52	3.88	3.10	0.78	8.43	5.42	3.01
VII**	3.00	1.89	1.11	2.84	2.21	0.63	4.10	3.13	0.97	10.47	5.70	4.77
Average: all sections**	3.00	1.88	1.12	3.10	2.22	0.88	4.25	3.17	1.08	10.05	5.66	4.39
1990												
I	3.47	1.99	1.48	3.27	2.28	0.99	4.61	3.22	1.39	11.50	5.98	5.52
II	3.05	1.92	1.13	3.91	2.31	1.60	5.64	3.33	2.31	12.09	6.14	5.95
III	2.75	1.82	0.93	2.80	2.18	0.62	4.29	3.09	1.20	9.11	5.46	3.65
IV	2.63	1.86	0.77	2.65	2.22	0.43	3.74	3.22	0.52	8.98	5.68	3.30
V	2.62	1.94	0.63	2.66	2.21	0.45	3.89	3.12	0.77	8.82	5.66	3.16
VI	2.63	1.81	0.82	2.72	2.18	0.54	3.76	3.09	0.67	8.45	5.42	3.03
VII**	2.94	1.88	1.06	2.83	2.21	0.62	4.10	3.13	0.97	10.29	5.70	4.59
Average: all sections**	2.85	1.90	0.95	3.09	2.24	0.85	4.20	3.18	1.02	10.13	5.76	4.42

* Unadjusted for distance savings or dissavings

** Freeway east alternative; the average for all sections is adjusted to include the freeway east alternative in Section VII.

TABLE A-3

ADJUSTED PER-KILOMETER OPERATING COST ADVANTAGES* OF THE FREEWAY
AUTO & TAXI

Year & Section	Unadj. per-km. operating cost on arterials with fwy. NT$	Adjustment of arterial per-km. operating cost for distance savings or dissavings with the freeway. Derivation of adjustment factor: Art. hwy vehicle km. w/o Freeway**	Less art. hwy. veh-kms. with Freeway**	Net art. hwy. vehicle-kms.**	Freeway vehicle-kms.**	Ratio: net art. hwy. veh-kms/ fwy. veh-kms. (adj. factor)	Adjusted per-km cost on art. NT$	Per-km. operating cost on Freeway NT$	Adjusted Freeway cost advantages NT$	Adjusted Freeway cost advantages As % of art. operating cost
1969										
I	3.51	165.8	96.6	69.2	64.4	1.075	3.77	2.01	1.76	46.7
II	3.09	211.5	64.4	147.1	155.9	0.944	2.92	1.84	1.08	37.0
III	2.75	46.4	11.2	35.2	31.5	1.117	3.07	1.82	1.25	40.7
IV	2.67	104.3	11.5	92.8	62.9	1.475	3.94	1.86	2.08	52.8
V	2.58	139.4	89.9	49.5	55.1	0.898	2.32	1.94	0.38	16.4
VI	2.70	89.1	34.3	54.8	50.1	1.094	2.95	1.82	1.13	38.3
VII	3.00	171.6	94.8	76.8	86.7	0.886	2.66	1.89	0.77	28.9
All Sections	3.00	928.1	402.7	525.4	506.6	1.037	3.31	1.88	1.43	43.2
1990										
I	3.47	1859.3	426.4	1432.9	1305.8	1.097	3.81	1.99	1.82	47.8
II	3.05	3391.0	1201.1	2189.9	2067.2	1.059	3.23	1.92	1.31	40.6
III	2.75	791.8	275.2	516.6	476.8	1.083	2.98	1.82	1.16	38.9
IV	2.63	2421.8	456.3	1965.5	1220.2	1.611	4.24	1.86	2.38	56.1
V	2.62	2684.3	1417.5	1266.8	1536.6	0.824	2.16	1.94	0.22	10.2
VI	2.63	1925.4	959.9	965.5	891.4	1.083	2.85	1.81	1.04	36.5
VII	2.94	2383.6	1593.3	790.3	913.3	0.865	2.54	1.88	0.66	26.0
All Sections	2.85	15,457.2	6329.7	9127.5	8411.3	1.085	3.09	1.90	1.19	38.5

* Before calculation of operating cost increments arising from toll-collection stops.

** Thousands of vehicle-kilometers per day.

TABLE A-4

ADJUSTED PER-KILOMETER OPERATING COST ADVANTAGES* OF THE FREEWAY/ LIGHT TRUCKS

Year & Section	Unadj. per-km. operating cost on arterials with Fwy. NT$	Adjustment of arterial per-km. operating cost for distance savings or dissavings with the freeway. Derivation of adjustment factor: Art. hwy vehicle km. w/o Freeway**	Less art. hwy. veh-kms. with Freeway**	Net art. hwy vehicle-kms.**	Freeway vehicle-kms.**	Ratio: net art. hwy. veh-kms/ fwy veh-kms. (adj. factor)	Adjusted per-km cost on arterials NT$	Per-km. operating cost on Freeway NT$	Adjusted Freeway cost advantages NT$	Adjusted Freeway cost advantages as % of art. oper. cost
1969										
I	3.27	52.9	31.4	21.5	19.7	1.091	12.30	5.95	6.35	51.6
II	4.16	57.3	19.8	37.5	39.2	0.957	11.98	5.80	6.18	51.6
III	2.78	15.2	31.4	11.8	10.5	1.124	9.70	5.46	4.24	43.7
IV	2.65	39.8	6.1	33.7	26.5	1.272	11.83	5.68	6.15	52.0
V	2.67	38.6	19.3	19.3	19.1	1.010	9.58	5.65	3.93	41.0
VI	2.70	34.2	11.5	22.7	21.0	1.081	9.31	5.42	3.89	41.8
VII	2.84	58.4	34.8	23.6	25.5	0.925	10.51	5.70	4.81	45.8
All sections	3.10	296.4	126.3	170.1	161.5	1.053	11.02	5.66	5.36	48.6
1990										
I	3.27	455.4	266.6	188.8	170.2	1.109	14.00	5.98	8.02	57.3
II	3.91	562.0	213.0	349.0	352.8	0.989	12.03	6.14	5.89	49.0
III	2.80	129.0	30.5	98.5	88.2	1.117	10.29	5.46	4.83	46.9
IV	2.65	414.2	67.2	347.0	267.9	1.295	11.65	5.68	5.97	51.2
V	2.66	382.4	173.7	208.7	222.9	0.936	9.14	5.66	3.48	38.1
VI	2.72	309.1	106.7	202.4	188.0	1.077	9.39	5.42	3.97	42.3
VII	2.83	504.9	265.3	239.6	246.2	0.973	10.45	5.70	4.75	45.5
All sections	3.09	2757.0	1123.0	1634.0	1536.2	1.064	11.18	5.76	5.42	48.5

* Before calculation of operating cost increments arising from toll-collection stops.

** Thousands of vehicle-kilometers per day.

TABLE A-5

ADJUSTED PER-KILOMETER OPERATING COST ADVANTAGES* OF THE FREEWAY
HEAVY TRUCKS

Year & Section	Unadj. per-km. operating cost on arterial hwys. with freeway NT$	Adjustment of arterial per-km operating costs for distance savings or dissavings with the freeway — Derivation of adjustment factor: Daily art. hwy. veh-kms. w/o freeway (000)	Less daily art. hwy. veh-kms. with fwy. (000)	Net daily art. hwy. veh-kms. (000)	Freeway veh-kms. per day (000)	Ratio: net art. hwy. veh-kms/ fwy. veh-kms. (adj. factor)	Adjusted per-km. operating cost on arterials NT$	Per-km. operating cost on freeway NT$	Adjusted Freeway Cost Advantages NT$	Adjusted Freeway Cost Advantages As % of adjust. art. hwy operating cost
1969										
I	4.61	112.5	43.9	68.6	63.7	1.077	4.96	3.22	1.74	35.1
II	5.65	162.0	27.8	134.2	139.3	0.963	5.44	3.30	2.14	39.3
III	4.33	92.9	12.8	80.1	67.8	1.181	5.12	3.09	2.03	39.6
IV	3.84	262.7	17.2	245.5	200.2	1.226	4.71	3.22	1.49	31.6
V	3.95	214.9	56.3	158.6	138.6	1.144	4.52	3.13	1.39	30.8
VI	3.88	245.6	31.3	214.3	192.2	1.115	4.33	3.10	1.23	28.4
VII	4.10	273.1	130.9	142.2	143.7	0.990	4.06	3.13	0.93	22.9
All sections	4.25	1363.7	320.2	1043.5	945.5	1.104	4.69	3.17	1.52	32.4
1990										
I	4.61	834.4	337.6	496.8	456.7	1.088	5.01	3.22	1.79	35.7
II	5.64	1253.4	239.7	1013.7	1018.5	0.995	5.61	3.33	2.28	40.6
III	4.29	629.3	70.2	559.1	476.4	1.174	5.03	3.09	1.94	38.6
IV	3.74	2023.9	234.1	1789.8	1427.8	1.254	4.69	3.22	1.47	31.3
V	3.89	1535.4	376.9	1158.5	1100.2	1.053	4.10	3.12	0.98	23.9
VI	3.76	1748.1	361.3	1386.8	1253.9	1.106	4.16	3.09	1.07	25.7
VII	4.10	1991.4	1001.2	990.2	993.9	0.996	4.08	3.13	0.95	23.3
All sections	4.20	10015.9	2621.0	7394.9	6727.4	1.099	4.62	3.18	1.44	31.2

* Before calculation of operating cost increments arising from toll-collection stops.

TABLE A-6

ADJUSTED PER-KILOMETER OPERATING COST ADVANTAGES* OF THE FREEWAY BUSES

Year & Section	Unadj. per-km. operating cost on arterial hwy. with Freeway NT$	Adjustment of arterial per-km operating costs for distance savings or dissavings with the freeway — Derivation of adjustment factor: Daily art. hwy. veh-kms. w/o freeway (000)	Less daily art. hwy. veh-kms. with fwy. (000)	Net daily art. hwy. veh-kms. (000)	Freeway veh-kms. per day (000)	Ratio: net art. hwy. veh-kms/ freeway veh-kms. (adjust. factor)	Adjusted per-km. operating cost on arterials NT$	Per-km. operating cost on freeway NT$	Adjusted Freeway Cost Advantages NT$	As % of adjust. art. hwy operating cost
1969										
I	11.51	21.5	9.0	12.5	11.7	1.068	12.30	5.95	6.35	51.6
II	12.02	34.7	4.3	30.4	30.5	0.997	11.98	5.80	6.18	51.6
III	9.15	16.3	2.1	14.2	13.4	1.060	9.70	5.46	4.24	43.7
IV	9.12	41.2	1.9	39.3	30.3	1.297	11.83	5.68	6.15	52.0
V	8.83	39.6	12.8	26.8	24.7	1.085	9.58	5.65	3.93	41.0
VI	8.43	34.4	5.8	28.6	25.9	1.104	9.31	5.42	3.89	41.8
VII	10.47	40.5	16.6	23.9	23.8	1.004	10.51	5.70	4.81	45.8
All sections	10.05	228.2	52.5	175.7	160.3	1.096	11.02	5.66	5.36	48.6
1990										
I	11.50	92.4	35.2	57.2	47.0	1.217	14.00	5.98	8.02	57.3
II	12.09	164.5	19.6	144.9	145.6	0.995	12.03	6.14	5.89	49.0
III	9.11	62.0	7.2	54.8	48.5	1.130	10.29	5.46	4.83	46.9
IV	8.98	160.3	7.6	152.7	117.7	1.297	11.65	5.68	5.97	51.2
V	8.82	131.8	38.1	93.7	90.4	1.037	9.14	5.66	3.48	38.1
VI	8.45	121.1	17.1	104.0	93.6	1.111	9.39	5.42	3.97	42.3
VII	10.29	152.2	55.3	96.9	95.4	1.016	10.45	5.70	4.75	45.5
All sections	10.13	884.3	180.1	704.2	638.2	1.103	11.18	5.76	5.42	48.5

* Before calculation of operating cost increments arising from toll-collection stops.

TABLE A-7

INDEX OF ADJUSTED FREEWAY COST ADVANTAGES

(Auto 1969 per-kilometer Cost Advantage in Section V=100)

Sections	Vehicle Categories			
	Auto & Taxi	Light trucks	Heavy trucks	Express Buses
I	463	339	458	1671
II	284	455	563	1626
III	329	247	534	1116
IV	547	303	392	1618
V	100	129	366	1034
VI	297	195	324	1024
VII	203	111	245	1266
All Sections	376	274	400	1411

TABLE A-8

TOLL COSTS PER KILOMETER OVER THE SEVERAL FREEWAY SECTIONS FOR THREE VEHICLE CATEGORIES BASED ON VARYING PERCENTAGES OF HYPOTHETICAL 1969 FREEWAY COST ADVANTAGES BEFORE CONSIDERATION OF COSTS OF TOLL-COLLECTION STOPS

Sections & Percentages of Freeway Cost Advantages	Toll costs per kilometer		
	Autos & Light Trucks*	Heavy Trucks	Buses
Section I 10 percent	0.13	0.17	0.64
20 "	0.26	0.35	1.27
30 "	0.39	0.52	1.91
40 "	0.52	0.70	2.54
Section II 10 percent	0.11	0.21	0.62
20 "	0.22	0.43	1.24
30 "	0.32	0.64	1.85
40 "	0.43	0.86	2.47
Section III 10 percent	0.09	0.20	0.42
20 "	0.19	0.41	0.85
30 "	0.28	0.61	1.27
40 "	0.38	0.81	1.70
Section IV 10 percent	0.12	0.15	0.62
20 "	0.23	0.30	1.23
30 "	0.35	0.45	1.85
40 "	0.46	0.60	2.46
Section V 10 percent	0.04	0.14	0.39
20 "	0.08	0.28	0.79
30 "	0.11	0.42	1.18
40 "	0.15	0.56	1.57
Section VI 10 percent	0.07	0.12	0.39
20 "	0.15	0.25	0.78
30 "	0.22	0.37	1.17
40 "	0.30	0.49	1.56
Section VII 10 percent	0.04	0.09	0.48
20 "	0.08	0.19	0.96
30 "	0.13	0.28	1.44
40 "	0.17	0.37	1.92

* Since it has been determined that autos and light trucks should use the same toll-collection lanes and pay the same levels of toll charges in order to avoid problems of vehicle weaving at approaches to toll barriers, these vehicle types are grouped together and the toll costs indicated are based on the lower cost advantage of the two vehicle types in the several freeway sections.

TABLE A-9

TOTAL TOLL COSTS PER VEHICLE OVER THE SEVERAL FREEWAY SECTIONS FOR THREE VEHICLE CATEGORIES BASED ON VARYING PERCENTAGES OF HYPOTHETICAL 1969 FREEWAY COST ADVANTAGES BEFORE CONSIDERATION OF OPERATING COST INCREMENTS RESULTING FROM TOLL-COLLECTION STOPS

Section & Percentages of Freeway Cost Advantages		Toll costs per vehicle over freeway sec. (NT$-Rounded to the nearest whole dollar)		
		Auto & Light trucks	Heavy Trucks	Buses
Section I	10 percent	4	5	18
distance	20 "	7	10	37
=28.75 kms.	30 "	11	15	55
	40 "	15	20	73
Section II	10 percent	5	9	25
distance	20 "	9	18	51
=41.00 kms	30 "	13	26	76
	40 "	18	35	101
Section III	10 percent	2	4	9
distance	20 "	4	9	18
=21.58 kms	30 "	6	13	27
	40 "	8	17	37
Section IV	10 percent	10	13	53
distance	20 "	20	26	106
=85.92 kms	30 "	30	39	159
	40 "	40	52	211
Section V	10 percent	3	9	25
distance	20 "	5	18	51
=64.40 kms	30 "	7	27	76
	40 "	10	36	101
Section VI	10 percent	5	9	30
distance	20 "	12	19	60
=77.30 kms	30 "	17	29	90
	40 "	23	38	121
Section VII	10 percent	2	5	27
distance	20 "	4	11	54
=55.85 kms	30 "	7	16	80
	40	9	21	107

* Since it has been determined that autos and light trucks should use the same toll-collection lanes and pay the same levels of toll charges in order to avoid problems of vehicle weaving at approaches to toll barriers, these vehicle types are grouped together and the toll costs indicated are based on the lower cost advantage of the two vehicle types in the several freeway sections.

TABLE A-14

TOLL COSTS PER KILOMETER OVER THE SEVERAL FREEWAY SECTIONS FOR AUTOS AND LIGHT TRUCKS BASED ON 20 AND 30 PERCENT OF HYPOTHETICAL 1969 FREEWAY COST ADVANTAGES BEFORE CONSIDERATION OF COSTS OF TOLL-COLLECTION STOPS (NT$ PER KM.)

Fwy. sections & percentages of Fwy. cost advantages	Autos	Light Trucks
I – 20 percent	0.35	0.26
– 30 "	0.53	0.39
II – 20 percent	0.22	0.35
– 30 "	0.32	0.52
III – 20 percent	0.25	0.19
– 30 "	0.38	0.28
IV – 20 percent	0.42	0.23
– 30 "	0.62	0.35
V – 20 percent	0.08	0.10
– 30 "	0.11	0.15
VI – 20 percent	0.22	0.15
– 30 "	0.34	0.22
VII – 20 percent	0.15	0.08
– 30 "	0.23	0.13
Average: Entire Fwy.		
20 percent	0.29	0.21
30 "	0.43	0.31

TABLE A-15

VARIABLE-RATE TOLL SCHEDULES SELECTED FOR TESTING WITH THE CLOSED SYSTEM
(ALL FIGURES IN NT DOLLARS PER KILOMETER)

Toll Schedules and freeway sections	Autos	Vehicle Types: Light Trucks	Heavy Trucks	Buses
Schedule C_2 *				
Section I	0.35	0.26	0.43	0.86
Section II	0.22	0.26	0.43	0.86
Section III	0.25	0.19	0.41	0.82
Section IV	0.36	0.23	0.45	0.90
Section V	0.22	0.16	0.28	0.56
Section VI	0.22	0.16	0.28	0.56
Section VII	0.22	0.16	0.27	0.54
Schedule C_3 *				
Section I	0.53	0.39	0.66	1.32
Section II	0.32	0.39	0.64	1.28
Section III	0.38	0.28	0.61	1.22
Section IV	0.54	0.35	0.67	1.34
Section V	0.32	0.23	0.42	0.84
Section VI	0.34	0.23	0.42	0.84
Section VII	0.32	0.23	0.40	0.80

* Based on 20 percent reduction of freeway cost advantage.
** Based on 30 percent reduction of freeway cost advantage.

TABLE A-16

TOLL CHARGES PER VEHICLE WITH CLOSED SYSTEM VARIABLE-RATE TOLL SCHEDULES
(ALL FIGURES IN NT DOLLARS)

Toll Schedules and Freeway Section	Autos	Vehicle Types: Light Trucks	Heavy Trucks	Buses
Schedule C_2				
Section I-28.75 kms	10	7	12	25
Section II-41.00 kms	9	11	18	35
Section III-21.58 kms	5	4	9	18
Section IV-85.92 kms	31	20	39	77
Section V-64.40 kms	14	10	18	36
Section VI-77.30 kms	17	12	22	43
Section VII-55.85 kms	12	9	15	30
Total all sections: 374.8 kms.	98	73	133	264
Schedule C_3				
Section I	15	11	19	38
Section II	13	16	26	52
Section III	8	6	13	26
Section IV	46	30	58	115
Section V	21	15	27	54
Section VI	26	18	32	65
Section VII	18	13	22	45
Total all sections:	147	109	197	395

Average over all sections (NT$ per kilometer):

	Schedule C_2	Schedule C_3 (and C_4)
Autos	0.26	0.39
Lt. Trucks	0.19	0.29
Hvy. Trucks	0.35	0.53
Buses	0.70	1.05

Appendix B

DETERMINATION OF COSTS OF TOLL STOPS

INTRODUCTION

The final step in the development of cost networks was the determination of the costs of making toll-payment stops. Three different costs had to be determined, viz., the cost of stopping at a barrier on the freeway with the barrier system, the cost of stopping at a freeway barrier with the closed system, and the incremental cost of passing through a closed interchange compared with an open interchange. The first two of these three costs would differ only because it would require a longer time to process toll payments, since the amounts of toll payments would vary.

To determine the incremental costs of stopping at barriers on the freeway, the first step was to determine the distance and time required, from the point at which vehicles would need to begin deceleration from normal speeds to the point at which normal speeds would be reattained beyond the toll barrier; separate calculations of these data were made for light vehicles and for heavy vehicles.

The second step in the analysis was to calculate the time that would have been required to negotiate these same distances at normal speeds. With these two sets of time data, the time losses of stopping at a freeway barrier to pay tolls could be determined. The per-second user time costs for the various vehicle types were then applied to the numbers of lost seconds per stop, to arrive at the time costs per stop in terms of NT dollars.

To these time costs were added distance cost increments. These latter arise mainly from increased rates of fuel consumption during deceleration and acceleration, added wear on tires and brakes, and the costs of idling.

The determination of incremental costs with closed system interchanges was a much more complicated procedure. In this case, too, data was furnished on distances covered and time required. Unlike the case of the freeway barrier stops, though, the incremental interchange cost calculation was complicated by the fact that vehicles would be traveling different distances with the two types of interchanges, and the distances would differ, also, according to which direction a vehicle might care to proceed after passing through each interchange.

Essentially, however, the approach to calculating this incremental cost was the same as was used to find freeway barrier costs; that is, time losses were found by finding the time differences required to move between two points common to both the closed and open interchange cases, and then net incremental distance costs (including the costs of idling) were added to the time costs to arrive at total incremental costs.

Tables B-1 and B-2 show the results of these calculations. The detailed considerations and calculations which led up to these results are discussed in the following sections of this appendix.

Incremental Costs of Stopping at Toll Barriers on the Freeway

The introduction of a toll plaza on the main route requires vehicles to come to a complete stop. Such a stop results in an increase in both time and distance costs over what would normally be incurred over the same section without the imposed stop.

In order to compute the costs attributable to a toll plaza stop, the time and distance requirements for such a stop were determined for each toll plaza condition. The time and distance requirements which were developed for each of two vehicle classes are composed of the following elements:

(1) Deceleration from highway operating speed to stop condition.

(2) Processing at toll booth.

(3) Acceleration from stop condition to highway operating speed.

At the toll booth proper the following processing rates were used to determine the time element:

	Vehicles Per Hour Per Lane
Payment of fixed fee	
light vehicles	600
heavy vehicles	400
Payment based on card	
light vehicles	300
heavy vehicles	250
Passing out cards	
light vehicles	600
heavy vehicles	400

These rates were translated into delay time per vehicle (see Table B-3). This delay time however assumes a vehicle will immediately be able to proceed into a toll booth. While, during periods of light traffic, this condition will exist, during periods of heavy traffic, queues will form which will increase the delay time. Since the length of delay can vary from the minimum to an relatively high value, an average total time delay at the toll booth equal to twice the processing rate was utilized.

Forty meters was used as the distance element at the toll booth. In determining the time and distance requirements associated with the deceleration process, a deceleration rate of 9 feet per sec. per sec was used for light vehicles and 6 feet per sec. per sec for heavy vehicles.

For acceleration, rates of 6 feet per sec. per sec for light vehicles and 2 feet per sec. per sec for heavy vehicles were utilized.

The deceleration and acceleration processes actually do not occur at uniform rates of change, as observed in field studies. Vehicles actually alter their rate of change continuously.

In order to realistically quantify the costs attributed to a toll stop, a reasonable uniform rate of change was utilized to determine the time and distance requirements for the deceleration and acceleration processes.

Using the approximate freeway speed of 90 kilometers per hour (81 feet per sec.) for both light and heavy vehicles, the time required for stopping was equal to this normal operating speed divided by the rates of deceleration. Thus, for light vehicles it was 9 seconds (i.e., 81 feet per second ÷ 9 feet per second per second), and for heavy vehicles, the time was 13.5 seconds. The distances required to accomplish deceleration to a full stop were determined from the following formula:

$$d = \frac{1}{2} (r \times t^2)$$

Where d represents stopping distance, expressed in feet, r represents the rate of deceleration, and t represents stopping times, expressed in seconds.

The time and distance requirements for accelerating to normal speeds beyond the toll plazas were calculated in much the same fashion. All the time and distance requirements for stopping at barriers on the freeway are indicated in Table B-4.

To find the incremental costs of making the toll stops, the following procedure was used.

The seconds required to travel 319 meters (light vehicles) and 723 meters (heavy vehicles) at normal operating speeds on the freeway were determined.

The differences in the times required to travel these distances with and without a toll barrier were calculated.

The per-second vehicle time costs were applied to the time increments with the barrier, to obtain the time cost increments of the toll stop.

The incremental distance costs resulting from deceleration, idling, and acceleration were calculated.

The incremental operating costs of making toll stops equalled the sums of the time cost increments and the distance cost increments for the respective vehicle types.

The time which would be required to cover the toll stop distances at normal operating speeds on the freeway would be 14 seconds for light vehicles and 30 seconds for heavy vehicles. The time losses from making a toll stop on the freeway would, therefore, be as shown below.

Time Lost Per Vehicle Per Barrier Toll Stop

	Barrier System	Closed System
Light vehicles	21 seconds	27 seconds
Heavy vehicles	43 "	48 "

These time losses were converted to operating cost increments by using the feasibility study user time costs of NT$1.23 per minute for autos and taxis, NT$0.71 for light trucks, NT$1.00 for heavy trucks, and NT$4.50 per minute for buses. The resulting time cost increments are shown in Table B-1.

Distance cost increments were calculated by referring to an AASHO report* which established relationships between free flow operating costs and stopping costs. The costs, which this report indicated for a passenger car traveling at, and then stopping from, a free flow running speed of 52 miles per hour (i.e., approximately the average speed foreseen for the freeway), are shown below (costs are expressed in U.S. cents).

	Fuel Costs	Tire Costs	Other Operating Costs
(a) costs/mile	2.34	0.47	2.99
(b) costs/kilometer	1.45	0.29	1.85
(c) stopping costs[1]	0.44	0.61[2]	0.50
(c) as % of (b)	30	210	27

[1] Excluding costs of idling, but including incremental costs of deceleration and acceleration.

[2] Including costs of braking.

The percentages calculated above were then applied to the distance costs per kilometer calculated in the feasibility study. The incremental stopping costs which result are shown below.

	Fuel		Tires		Other Oper. costs		Distance cost increment (NT$)
	free flow cost/km	stopping cost	free flow cost/km	stopping cost	free flow cost/km	stopping cost	
Autos	0.440	0.13	0.046	0.10	0.514	0.14	0.37
Lt. Trucks	1.000	0.30	0.270	0.57	0.430	0.12	0.99
Hvy. Trucks	1.060	0.32	0.660	1.39	0.710	0.19	1.90
Buses	1.060	0.32	0.660	1.39	0.710	0.19	1.90

* Informational Report by Committee on Planning and Design Policies on Road User Benefit Analyses For Highway Improvements, American Association of State Highway Officials (AASHO), 1960

The costs of idling are not included in these incremental distance costs, however, so that these had to be determined separately.

The same AASHO report mentioned above estimates that an average idling auto consumes approximately 0.5 gallon (1.9 liters) of fuel per hour. The report also estimated that additional oil and maintenance costs resulting from idling are approximately equal to the cost of fuel.

If an auto consumes 1.9 liters of gasoline per hour, then its hourly fuel cost, with a price of NT$4.80 per liter, would be NT$9.12, and its cost per second would be NT$0.00253. If the incremental costs of oil and maintenance would be equal to this, then the total per-second cost of idling for autos would be NT$0.00506.

If the same ratios between free flow fuel and maintenance cost of autos and these same costs of other vehicles could be applied to idling costs, then additional costs of idling would be as shown following for other vehicle types.

	Fuel costs/ second	Oil & maintenance cost/sec.	Idling costs/ second
Light trucks	NT$0.00575	NT$0.00212	NT$0.00787
Heavy vehicles	0.00607	0.00349	0.00956

Applying these costs per second to the seconds of idling, results in the idling cost increments calculated below.

Autos:	Barrier system - 12 seconds x NT$0.00506/sec. = NT$0.06	
	Closed system - 18 seconds x NT$0.00506/sec. = NT$0.09	
Light trucks:	Barrier system - 12 seconds x NT$0.00787/sec. = NT$0.09	
	Closed system - 18 seconds x NT$0.00787/sec. = NT$0.14	
Heavy Vehicles:	Barrier system - 18 seconds x NT$0.00956/sec. = NT$0.17	
	Closed system - 23 seconds x NT$0.00956/sec. = NT$0.22	

When these costs of idling are added to the other distance cost increments of stopping, calculated earlier, the total distance cost increments shown in Table B-1 result. The distance costs and time costs are then summed to arrive at total incremental user costs resulting from the making of a toll stop on the freeway.

INCREMENTAL USER COSTS ARISING FROM PASSING THROUGH A CLOSED SYSTEM INTERCHANGE COMPARED TO PASSAGE THROUGH AN OPEN INTERCHANGE

This is a more complex situation than the one just discussed, since vehicles, in this comparison, would not be traveling the same distances. The design of a closed interchange is such that only one ramp is provided for exiting; this results in some distance saving in one direction, compared to a free interchange, but results in a large distance loss in the other direction.

The distances and times which have to be compared are those required from a point on the freeway where a vehicle would begin to decelerate to a point on the crossroad where vehicles would attain normal speed. These distances and times would differ somewhat, depending on the design of the interchanges, and the normal running speeds on both the freeway and the crossroad. The interchanges assumed for these calculations are fairly typical of their respective types; the speeds assumed were 90 kilometers per hour on the freeway and 60 kilometers per hour on the crossroad.

In the discussion which follows, the instance in which the toll plaza would be located in the direction that traffic would wish to move will be designated as the "first direction", whilst the instance where the traffic would be going out of its way (because it would wish to travel in the other direction) to pass through the toll area will be designated as the "second direction". For the free interchange, "first direction" will apply to the instance where traffic could exit by using a simple ramp, whilst "second direction" will refer to the instance where a loop must be used.

In either direction, the traffic exiting at the closed interchange would need to begin its deceleration earlier than would traffic exiting at an open interchange. Since the comparison of travel through closed and open interchanges must be between two points common to both, it would then be necessary to include some distance of normal freeway operations for the open interchange; this distance would be from the initial point of deceleration with the closed interchange to the point of beginning deceleration with the open interchange. The distance is estimated to be 457 meters for light vehicles and 427 meters for heavy vehicles. The calculation of time requirements for light and heavy vehicles in the first direction are shown below.

OPEN INTERCHANGES – TIME REQUIREMENTS – FIRST DIRECTION

Light Vehicles	– Total distance traveled = 1354 meters	
	of which 457 meters @ 90 kms/hour	- 18 seconds
	61 meters deceleration to 60 kilometers/hr.	- 5 seconds
	836 meters @ 60 kms/hr (ramp & crossroad)	- 50 seconds
	Total time requirement	- 73 seconds
Heavy Vehicles –	Total distance traveled = 1454 meters	
	of which 427 meters @ 90 kms/hr	- 17 seconds
	122 meters deceleration to 60 kms/hr	- 10 seconds
	905 meters @ 60 kms/hr	- 54 seconds
	Total time requirement	- 81 seconds

In the second direction with the open interchange, a loop of approximately 274 meters must also be negotiated. This loop increases the time requirements, not only because of the added distance, but also because the loop must be negotiated at a lower speed (40 kilometers per hour), with resultant increased distances and times for deceleration and acceleration (there was no need for acceleration in the first instance). The increased times are calculated as shown following.

OPEN INTERCHANGES – TIME REQUIREMENTS – SECOND DIRECTION

Light Vehicles		
Additional time requirements -	28 meters (decel. to 40 kms/hr)	- 2 seconds.
	274 meters @ 40 kms/hr	- 25 seconds
	42 meters (accel. to 60 kms/hr)	- 3 seconds
Total time to decel., negoitate loop, & accel. to 60 kms/hr		30 seconds
Less time required to travel 70 meters @ 60 kms/hr.		4 seconds
Total additional time required for loop		- 26 seconds
Total time requirement for second direction		- 99 seconds
Heavy Vehicles		
Additional time requirements -	42 meters (decel. to 40 kms/hr)	- 3 seconds
	274 meters @ 40 kms/hr	- 25 seconds
	139 meters (accel. to 60 kms/hr)	- 10 seconds
Total time to decel, negotiate loop, & accel. to 60 km/hr		- 38 seconds
Less time required to travel 181 meters @ 60 kms/hr		- 11 seconds
Total additional time required for loop		- 27 seconds
Total time requirement for second direction		-108 seconds

With a closed interchange, light vehicles would require only 988 meters from the point at which deceleration would begin, to the point where normal operating speed on the crossroad had been attained; this would represent a saving of 366 meters of travel between the same two points with the open interchange. Nevertheless, the time required to negotiate the closed interchange in the first direction would be greater than the open interchange time requirement, since the vehicles would need to make two stops, viz., one for toll payment, and one at the intersection with the crossroad. Heavy vehicles would require a total distance of 1088 meters in the first direction, for a distance saving, again, of 366 meters compared to the open interchange situation.

In the second direction, vehicles passing through a closed interchange would have to travel an additional 1280 meters at a speed of 60 kilometers per hour to reach the point at which vehicles passing through an open interchange would attain normal operating speed. This additional distance would be the same for both light and heavy vehicles, and would require 77 seconds to travel.

The calculations of time requirements for both light and heavy vehicles to pass through a closed interchange are shown below.

CLOSED INTERCHANGE – TIME REQUIREMENTS

Light Vehicles	
First direction (988 meters)	
of which 48 meters deceleration to 68 kms/hr	- 4 seconds
516 meters @ 68 kms/hr	- 27 seconds
122 meters (decel. to stop, stop, & accel. to 32 kms/hr)	- 29 seconds
229 meters travel to crossroad	- 25 seconds
stop at crossroad	- 10 seconds
73 meters acceleration to 60 kms/hr	- 7 seconds
Total time requirement	-102 seconds
Second direction (2268 meters)	
Additional time to travel 1280 meter @ 60 kms/hr	- 77 seconds
Total time requirement	-179 seconds
Heavy Vehicles	
First direction (1088 meters)	
of which 122 meters deceleration to 62 kms/hr	- 10 seconds
381 meters @ 62 kms/hr	- 22 seconds
244 meters (deceleration, stop, & accel. to 32 kms/hr	- 46 seconds
168 meters travel to crossroad	- 18 seconds
stop at crossroad	- 10 seconds
174 meters accelerate to 60 kms/hr	- 19 seconds
Total time requirement	-125 seconds
Second direction (2368 meters)	
Additional time to travel 1280 meters @ 60 kms/hr.	- 77 seconds
Total time requirement	-202 seconds

A summary of the time requirements for vehicles to pass through open and closed interchanges is shown below. The time savings with the open interchange are also shown; the per-second user time costs were applied to these time savings to arrive at the time cost savings indicated in Table B-2.

	First Direction	Second Direction	Average Direction
Light Vehicles			
(1) Closed interchange	102 seconds	179 seconds	140 seconds
(2) Open interchange	73 "	99 "	86 "
(1) less (2)	29 "	80 "	54 "
Heavy Vehicles			
(1) Closed interchange	125 seconds	202 seconds	163 seconds
(2) Open interchange	81 "	108 "	94 "
(1) less (2)	44 "	94 "	69 "

In addition to the time cost differences for the open and closed interchanges, there are also differences in distance costs. As noted earlier, in the first direction, vehicles (both light and heavy) would have to travel an additional 366 meters with the open interchange; the costs of traveling this distance are shown below for the various vehicle types.

Autos -	NT$0.37
Light trucks -	NT$0.62
Heavy vehicles -	NT$0.89

There are, of course, also additional distance costs to be calculated for the closed interchange, since this alternative would require that two stops be made (the first, from a speed of approximately 62 kilometers per hour, and the second, from a speed of about 32 kilometers per hour). The AASHO report, referred to earlier, was used again to find relationships between the distance costs of stopping and the distance costs of moving under normal flow conditions at the relevant speeds. The incremental cost percentages are indicated below for the two stops.

INCREMENTAL STOPPING COSTS AS PERCENTAGES OF NORMAL FLOW

DISTANCE COSTS

	Toll Stop	Crossroad Stop
Fuel	19	8
Tires & Brakes	114	24
Other distance costs	17	5

The distance costs which result from using these percentages, and the idling costs (calculated by using the per-second idling costs determined in the preceding section of this appendix), are shown below.

Distance Costs of Toll Stop (NT$)

	Fuel	Times & Brakes	Other distance Costs	Idling	Total
Autos	0.08	0.05	0.09	0.09	0.31
Lt. Trucks	0.19	0.31	0.07	0.14	0.71
Heavy Vehicles	0.20	0.75	0.12	0.22	1.29

Distance Costs of Crossroad Stop (NT$)

	Fuel	Times & Brakes	Other distance Costs	Idling	Total
Autos	0.04	0.01	0.03	0.05	0.13
Lt. Trucks	0.08	0.06	0.02	0.08	0.24
Heavy Vehicles	0.08	0.16	0.04	0.10	0.38

The net distance costs of the closed interchange in the first direction are shown calculated below.

	Autos	Light trucks	Heavy Vehicles
Closed interchange	NT$ 0.44	NT$0.95	NT$1.67
Open interchange	0.37	0.62	0.89
Net cost increment	0.07	0.33	0.78

In the second direction, the open interchange would have the additional costs associated with traveling the 274 meter loop, while for the closed interchange, there would be the extra costs of traveling 1280 meters at a speed of 60 kilometers per hour.

In order to calculate the distance cost of negotiating the open interchange loop, the relationships* between moving along a 30-degree horizontal curve and moving along a tangent highway were used. At a running speed of approximately 40 kilometers per hour, the distance running costs would be expected to rise by the following factors during negotiation of the loop; Autos - 1.50; light trucks - 1.48; and heavy vehicles 2.79. The normal distance costs associated with traveling 274 meters, and the increased costs because of curvature are shown below.

	Normal Distance cost	Curvature Factor	Adjusted Distance cost
Autos	NT$0.27	1.50	NT$0.40
Lt. trucks	0.47	1.48	0.70
Heavy vehicles	0.67	2.79	1.87

The added distance costs associated with the closed interchange in the second direction are equal to the average distance costs per kilometer times 1.28 kilometers; these costs are shown calculated below.

	Distance Cost/km.	Distance cost for 1280 meters
Autos	NT$1.00	NT$1.28
Light trucks	1.70	2.17
Heavy vehicles	2.43	3.11

The net distance costs in the second direction are calculated as shown below.

	Net in first Direction	plus	Closed Increment	less	Open Increment	= Net
Autos	NT$0.07		NT$1.28		NT$0.40	NT$0.95
Lt. trucks	0.33		2.17		0.70	1.80
Hvy. vehicles	0.78		3.11		1.87	2.02

A summary of the distance and time cost increments with the closed interchange as compared to the open interchange in both the first and the second direction are shown in Table B-5. The average total cost figures are also shown in Table B-2.

* See Economic Analysis For Highways, Robley Winfrey, 1969, pp.686-699.

TABLE B-1

VEHICLE USER COST INCREMENTS ARISING FROM STOPS AT TOLL BARRIERS ON FREEWAY

(NT DOLLARS PER STOP: INCLUDING ALL TAXES BUT EXCLUDING TOLL CHARGES)

Vehicle Types & Nature of Costs	Barrier System (NT$)	Closed System (NT$)
Autos		
Distance Cost	0.43	0.46
Time Cost	0.44	0.56
Total	0.87	1.02
Light Trucks		
Distance Cost	1.08	1.13
Time Cost	0.25	0.32
Total	1.33	1.45
Heavy Trucks		
Distance Costs	2.07	2.12
Time Cost	0.72	0.80
Total	2.79	2.92
Buses		
Distance Cost	2.07	2.12
Time Cost	3.24	3.44
Total	5.31	5.56

TABLE B-2

VEHICLE USER COST INCREMENTS AT CLOSED SYSTEM INTERCHANGES

Vehicle Types	User Cost Increments (NT Dollars Per Vehicle Per Interchange)		
	Distance Costs	Time Costs	Total Costs
Autos	0.51	1.11	1.62
Light Trucks	1.07	0.64	1.71
Heavy Trucks	1.40	1.15	2.55
Buses	1.40	5.17	6.57

TABLE B-3

TOLL STATION PROCESSING TIMES

Function	Time (Sec) Light Vehicles	Heavy Vehicles
Pay a fixed toll charge on barrier toll network	6	9
Pay a variable toll charge on closed toll network	12	14
Collect an entry identification card on closed toll network	6	9

TABLE B-4

DISTANCE AND TIME REQUIREMENTS
FOR STOPPING AT TOLL PLAZAS LOCATED ON THE FREEWAY

Vehicle Type & Toll System	Deceleration	Toll Booth	Acceleration	Totals
Barrier system				
Light vehicles				
Distance	375 feet	120 feet	550 feet	1045 feet (319 mtrs.)
Time	9 sec.	12 sec.	14 sec.	35 seconds
Heavy vehicles				
Distance	550 feet	120 feet	1700 feet	2370 feet (723 mtrs.)
Time	14 sec.	18 sec.	41 sec.	73 seconds
Closed System				
Light vehicles				
Distance	375 feet	120 feet	550 feet	1045 feet (319 mtrs.)
Time	9 sec.	18 sec.	14 sec.	41 seconds
Heavy vehicles				
Distance	550 feet	120 feet	1700 feet	2370 feet (723 mtrs.)
Time	14 sec.	23 sec.	41 sec.	78 seconds

TABLE B-5

TWO-DIRECTIONAL INCREMENTAL COSTS
OF A CLOSED INTERCHANGE
(NT$ PER VEHICLE PER INTERCHANGE)

Vehicle Types	First Direction			Second Direction			Average Total Cost (NT$)
	Distance Cost (NT$)	Time Cost (NT$)	Total Cost (NT$)	Distance Cost (NT$)	Time Cost (NT$)	Total Cost (NT$)	
Auto	0.07	0.59	0.66	0.95	1.64	2.59	1.62
Light Truck	0.33	0.34	0.67	1.80	0.95	2.75	1.71
Heavy Truck	0.78	0.73	1.51	2.02	1.57	3.59	2.55
Bus	0.78	3.30	4.08	2.02	7.05	9.07	6.57

Appendix C

TRAFFIC GENERATION FROM THE NEW INTERNATIONAL AIRPORT

The trip tables developed for the feasibility study and used for the toll study did not include consideration of the new international airport to be built near Taoyuan. Since the new airport will be a major traffic generator in the future, the traffic volumes must be manually added to the assignment results obtained from the computer.

In order to manually assign the airport generated traffic, it was necessary to first determine its magnitude and characteristics. Another consultant has recently completed a planning study for the new airport. Since the report was not finalized at the time that data were required for the toll study, DCI requested that TAFCB obtain certain information concerning the character and volume of ground traffic to and from the new airport. The information supplied by TAFCB included the peak hour volumes on the airport access road (by vehicle type) for domestic and international flight service.

The airport study projections of air travel indicate that the existing airport will be saturated by 1975. Therefore the new international airport should be completed by that date. When the new airport would be completed, all international service would use the new facility while domestic service would continue at the existing airport.

The airport consultant indicated that by 1985 the existing airport may be saturated by domestic service and the new airport will have to serve both domestic and international travel thereafter.

Based upon forecasts made in other studies and in view of the proposed improvements to other forms of transportation before 1985, it appears likely that the existing airport will be able to accommodate all domestic travel up to 1990 or later. The toll study, which uses 1990 as its horizon year for capacity analysis, did not, therefore, include consideration of domestic air travel at the proposed new international airport.

DETERMINATION OF K FACTOR

Since the traffic volumes on the airport access road, forecast by the airport consultants, were in the form of peak hour volumes, it was necessary to develop average daily traffic (ADT) for the toll study analysis.

Several sources were reviewed in establishing a representative K factor relating peak hour volume to ADT. Sources with applicable data are as follows:

ASCE Journal Vol. 96 No. TE3 August 1970

Data: 6.5 million passengers per year
1250 passengers during the peak hour.

K Factor: 14% (passenger movements)

ASCE Journal Vol. 95 No. TE2 1969

Data: 1200 plane movements per day
170 peak hour movements

K Factor: 14% (plane movements)

ASCE Journal Vol. 96 No. TE1 Feb. 1970

Data: 275,000 operations yearly
130 operations during peak hour

K Factor: 17% (plane movements)

Fisher Report On Existing Taipei Airport Development For CIECD May 1969

Data: Normal peak hour is 10% of daily value (passengers)

K Factor: 10%

Data: 125 daily operations (1975)
18 peak hour operations

K Factor: 14%

From an analysis of the above information relating peak hour volumes of passengers and plane operations to daily volumes, a K factor of 12 per cent was selected for the toll study.

1990 TRAFFIC GENERATION

Utilizing the peak hour volumes obtained from the airport consultants, and a K factor of 12 percent relating peak hour to ADT, the following table was prepared.

Vehicle Types	1990 ADT	P.C.E.
Auto & Taxi	27,350	27,350
Light Truck	1,000	1,000
Heavy Truck	2,000	4,000
Bus	3,000	6,000
	33,350	38,350

The 1990 ADT values are based upon the peak hour traffic related to international travel and does not include any domestic travel for reasons discussed earlier.

The peak hour volume is generally composed of a different vehicle mix then is the ADT. Peak hour volumes tend to have more automobiles and less trucks than normally representative of other hours of the day. Therefore, all the traffic is converted into passenger car equivalents (PCE) which is a more representative unit. As a result, the 1990 ADT values shown above are not meant to represent the indicated vehicle mix but rather the total ADT in terms of PCE's only.

1975 TRAFFIC GENERATION

When the new airport is opened, and all international travel is shifted to the new facility, a certain amount of accompanying highway traffic will also be shifted. This volume will not grow from zero when the new airport opens, but rather will appear as a lump sum on the freeway and thereafter grow according to the international travel growth.

For the traffic growth curves at screenlines it is necessary to determine the traffic generated when all international travel is transferred to the new airport (1975).

The fisher report shows an international passenger volume for 1975 at the existing airport of 1.8 million passengers per year. The more recent study by the airport consultant forecasts a 1975 international passenger volume of 2.1 million. A volume of 2.0 million passengers in 1975 was used in this study, as the number which would transfer to the new airport.

The airport consultants forecast a 1990 passenger arrival & departure volume of four times the 1975 passenger volume. It is assumed that freight will exhibit somewhat similar characteristics. The 1975 traffic volumes (ADT) shown below were then developed by factoring the 1990 traffic volumes in the same proportion as airport passenger volumes.

Vehicle Type	1975 ADT	P.C.E.
Auto & Taxi	6,837	6,837
L. Truck	250	250
H. Truck	500	1,000
Bus	750	1,500
	8,337	9,587

Again, it is the total ADT (9,587 PCE) that is significant and not the vehicie mix shown.

DISTRIBUTION OF TRAFFIC GENERATED BY THE NEW AIRPORT

It is not enough to know how much traffic will be generated by the new airport. The geographic distribution of the trips is also required in order to assign the traffic to the proper highway facilities.

Contact was made with the Civil Aviation Administration and the Tourism Council to obtain data which would be useful in the determination of the geographic orientation of the airport traffic.

Passengers arriving on international flights can be classified into two groups for the present needs. The first group is composed of foreigners and overseas Chinese who, when they arrive will go directly to Taipei, either to stay or in order to utilize other trasnportation facilities to other parts of the Island. The second group is composed of local Chinese on international travel. While these people may come from areas other than Taipei, Taipei will certainly account for a large portion of them, based upon its higher population density and higher income levels.

While many statistics concerning international travel were reviewed, no precise figure is readily available, relating the proportions of Group 1 and Group 2 to the total number of international passengers. A figure of 90% plus for Group 1 is generally felt to be reasonable.

Considering that a significant portion of the remaining 10% or less, representing Group 2, are also oriented toward Taipei, only a small portion (2-3%) of all international travelers would be oriented to areas other than Taipei.

Therefore it was assumed that nearly 100% of the traffic will be oriented toward Taipei.

It is estimated that 7,000 to 8,000 employees will work at the new airport by 1990. The CAA has indicated that living accommodations for most of these people are being planned in conjunction with the airport development and therefore should not contribute to the traffic demand on the freeway.

The remaining traffic element is trucks. While some of the truck traffic will also be oriented to Taipei, some portion will also be oriented to other areas where light weight, high cost elements such as electronic components are manufactured and shipped by air freight to other countries. Since the number of trucks not oriented to Taipei would not have a significant effect on the final lane requirements, the work involved in accurately estimating their volume was not warranted.

In conclusion, for the toll study, it is assumed that nearly 100% of the traffic generated by the new airport will be oriented to Taipei, at least within the study period of this study.

Appendix D

PROJECTED GROWTH OF HEAVY TRUCK TRAFFIC BETWEEN KEELUNG AND NEIHU

At the time of the O-D survey for the freeway feasibility report (April 1969), the truck traffic between Keelung and Neihu averaged 3,034 vehicles per day. The feasibility study predicted that heavy truck traffic would expand to seven (7.0) times this level, to a volume of 21,223 trucks per day in 1990. In making this forecast, no attempt was made to take into account possible capacity constraints at Keelung Harbor.

According to capacity estimates for Keelung Harbor, traffic cannot grow to seven times the volume handled in April 1969. In terms of revenue tonnages, Keelung Harbor was handling cargo at an approximate annual rate of 7.2 million tons per annum in April 1969. According to the Transportation Economic Study (TES, November 1970), the ultimate capacity of Keelung Harbor is 13.3 million revenue tons (actually, there are methods for increasing the capacity beyond this amount, but 13.3 million might be accepted as a practical limit). Harbor cargo tonnages, therefore, may only be able to expand by 1.85 times the April 1969 level.

Two factors, however, will permit heavy truck traffic (in terms of 1969 truck equivalents) to expand by more than 1.85 times. First of all, truck traffic between Keelung and Neihu is not restricted to harbor traffic, but includes other heavy truck volumes as well; and, secondly, the share of Keelung Harbor traffic which is handled by trucks may be expected to be increased. This latter circumstance should occur even without diversion of traffic from the railway.

This assertion undoubtedly requires further explanation. As the port of Keelung becomes congested, cargoes which would have otherwise been shipped through Keelung, will be shipped through Kaoshiung or the planned port near Taichung instead. These cargoes will generally be from the furthest parts of Keelung's hinterland, and would, therefore, be primarily tonnages which would have normally been hauled by the railway to Keelung. Even if the railway continues to handle all of these tonnages by hauling them to Kaohsiung or to Taichung Port, i.e., even if there is no diversion of these tonnages to the highway, the tonnages hauled by the railway to and from Keelung Port would be expected to decline, while the highway share of the total would be expected to increase.

In 1969, it is estimated that nearly 1.5 million metric tons of Keelung Harbor traffic was carried on the railway; this represented approximately one-third of total Keelung Harbor cargo in that year.

The freeway feasibility study and subsequent analyses indicate that nearly all Keelung Harbor traffic should be handled by trucks after construction of Taichung Harbor has proceeded to a stage where grain imports could be adequately accommodated. If trucking, then, might eventually handle all Keelung Harbor traffic, the ultimate expansion over April 1969 truck volumes of the 1969 truck equivalents hauling these cargoes would be 2.8 times (i.e., 1.5 x 1.85).

Using freight O-D information from the railway electrification study, it is estimated that trucks hauled in the neighborhood of 2.7 to 2.8 million metric tons of Keelung Harbor freight in 1969. Using the average size of load (including empty trucks) found in the O-D survey of April 1969, viz., 4.3 tons, the estimated 1969 harbor freight carried by trucks would have required approximately 650,000 trucks, or about 1840 trucks per day (using a factor of 354 days, which was also calculated at the time of the feasibility study). This number of trucks per day would have represented approximately 60 percent of the total of 3,034 trucks per day moving between Keelung and Neihu.

About 60 percent of the 1969 truck volumes, then, might eventually be expanded to 2.8 times their 1969 level. In order to determine the expansion, which might be expected over the 1969-1990 period, of total Neihu-Keelung heavy truck traffic, it is necessary to forecast the growth of the remaining 40 percent of 1969 truck volumes which were related to the production and consumption of the city of Keelung, itself.

The Transportation Economic study estimated that production tonnages of the Keelung area would grow only by about 31 percent over the 1970-1980 period, while the combined total of production and consumption tonnages would increase by roughly 50 percent. Beyond 1980, some decline in the output of the coal industry might be expected, so that the compound annual growth rate of production might be expected to slow. Population increase over that decade might also be slow, so that, in absolute terms, the growth of production and consumption tonnages might do no more than match the expansion of the previous 11-year period; that is, expansion over 1981-1990 might be 33 percent, so that the 1990 total would be double the numbers of 1969 tonnages.

The freeway feasibility study indicated that the ratio of trucking growth to growth of production tonnages over the 1969-1990 period should be about 3.5 to 1. If this ratio would be applied to forecast growth of Keelung production and consumption tonnages, then total trucking growth would be 350 percent (3.5 x 100%). Total expansion of this 40 percent portion of 1969 Neihu-Keelung trucking volumes would then be to 4.5 times the 1969 level by 1990, and the average annual growth rate would be 7.4 percent over 1969-1990. The expansion of all Neihu-Keelung trucking would then be calculated as shown below.

$$(0.6 \times 2.8) \div (0.4 \times 4.5) = 3.5$$

The average annual growth rate of total Neihu-Keelung trucking volumes, over the entire 1969-1990 period, would be 6.1 percent.

The growth would not be smooth, however. Following are estimates of how growth might be expected to proceed over the 1971-1990 period.

1971. Tonnages handled at Keelung over the period of January and February were up by approximately 30 percent over the same period of 1970. Assuming this rate would slow somewhat to about a 25 percent rise for the entire year, revenue tons handled at Keelung would be 10.8 million for the year. Additional night labor might be required to handle this amount, given the current stage of construction of new port facilities.

If other truck traffic would increase at about half that rate, i.e., around 13 percent, then total truck traffic growth would be as calculated following.

$$(0.6 \times 1.25) + (0.4 \times 1.13) = 1.20 \text{ (20 percent)}$$

In 1970, tonnages handled at Keelung increased by twenty percent; railway tonnages were up only marginally for the year, so that it is probable that trucking tonnages to and from Keelung grew by at least 25 percent in that year, too. Total expansion of heavy truck traffic between Keelung and Neihu will therefore probably be on the order of 45 percent over the two years 1970 and 1971. Remaining expansion to 1990, then, should only be 2.4 times (i.e., 3.5 ÷ 1.45), or an average annual rate of growth of only 4.7 percent over the 1972-1990 period.

1972. Port capacity should increase to about 12.2 million tons by the end of the year; average capacity may only be around 11.5 million tons over the year, however, so that expansion of tonnages handled at Keelung may be held down to about seven percent. Diversion will therefore start to Kaohsiung. Assuming that demand from Keelung's present hinterland would grow by at least 20 percent to a minimum total of 13.0 million tons, then approximately 1.5 million tons would have to be diverted to Kaohsiung. If nearly all of this diverted traffic would be tonnages handled by the railway (as would be likely), then railway tonnages which would have tended to increase by about 0.7 million tons (i.e., about one-third of the increase in demand) would, instead, decrease by 0.8 million tons, whilst highway tonnages to and from Keelung would rise by 1.5 million tons in 1972 (i.e., 0.7 million more tons handled at Keelung plus 0.8 million tons in replacement of railway cargoes diverted to Kaohsiung).

In terms of revenue tonnages, about 4.8 million were handled on the highway in 1969, and, after two years of 25 percent growth, about 7.5 million would be handled on the highways in 1971. The 1972 increase of around 1.5 million revenue tons would represent a 20 percent rise. The split of Keelung Harbor traffic between modes in 1972 would be about 9.0 million revenue tons to the highway and 2.5 million to the railway.

Assuming that growth of trucking in general would continue to slow, in percentage terms, other Keelung-Neihu trucking might only rise by about 12 percent in 1972. The total increase of 1972 Neihu-Keelung heavy truck traffic would therefore be as calculated following (no adjustment is yet made for the changing shares of harbor and other heavy truck traffic, since the original 60:40 split was only an approximation).

$$(0.6 \times 1.20) \div (0.4 \times 1.12) = 1.17 \text{ (17 percent)}$$

In 1972, harbor traffic would represent about 62 percent of the total Neihu-Keelung heavy truck traffic. Total expansion over 1970-1972 would be to nearly 1.7 times the 1969 level of heavy trucks, leaving a 2.08 times expansion to be realized by 1990 (4.1 percent per annum).

1973. Assuming that demand for harbor facilities from Keelung's present hinterland would continue to decline, a rate of around 15 percent would appear reasonable, and total demand would rise to about 14.9 million revenue tons. Capacity would only be 12.2 million tons, so that at least 2.7 million tons would have to be diverted to Kaohsiung (actually, more than this might usefully be diverted since congestion would set in at about 80 percent of capacity, but shippers normally seem unwilling to divert before it becomes essential – thus, at the present time, Keelung's capacity is being taxed, while Kaohsiung has excess capacity).

Railway Keelung Harbor tonnages would tend to rise by about 0.6 million tons (i.e., one-third of the 1.9 million ton rise in demand), but, with an additional 1.2 million tons being diverted to Kaohsiung, would actually decline by 0.6 million tons to a level of 1.9 million revenue tons. Highway cargoes to and from Keelung Harbor would rise by 1.3 million tons, comprising 0.7 million additional tons handled at the port, and 0.6 million tons to replace railway-hauled tonnages diverted to Kaohsiung.

The 1.3 million ton rise would represent about a 14.4 percent increase over 1972. If other trucking cargo would continue its gradually decelerating growth, and rise by 11 percent, then total Keelung-Neihu heavy truck volumes would grow as calculated following.

$$(0.62 \times 1.144) \div (0.38 \times 1.11) = 1.13 \text{ (13 percent)}$$

1974. Assuming continued slowdown in demand from Keelung's hinterland to a 12 percent growth in 1974, total demand would rise to 16.7 million revenue tons. Assuming, also, that capacity will have been increased to 13.3 million tons in that year, a minimum of 3.4 million tons would have to be diverted to Kaohsiung; this would represent an increase of 0.7 million tons diverted over the 1973 total of 2.7 million diverted tons. With sufficient capacity at Keelung, the railway might have expected an increase of 0.6 million tons going through that Harbor, but instead would experience a small diminution of 0.1 million tons, to a 1974 total of 1.8 million tons. The highway would have a total increase of 1.2 million tons, made up of 1.1 million tons of additional harbor traffic and 0.1 million tons replacing railway cargoes diverted to Kaohsiung.

The 1.2 million ton increase would represent around an 11.6 percent rise from the previous year. Total Keelung-Neihu heavy truck traffic would probably show about an 11 percent increase.

Over a five-year period, then, the total expansion from 1969 would be about 2.11 times (1.20 x 1.20 x 1.17 x 1.13 x 1.11), and the remaining expansion over the 1975-1990 period would be approximately 1.66 times (only 3.2 percent per annum).

1975. In 1975, the tonnages handled at Keelung Port might be expected to fall below capacity, and highway harbor tonnages would also be expected to decline. A new northern petroleum refinery is scheduled to open in that year, with the result that Keelung Harbor might be relieved of having to accommodate 2.3 million tons of oil product imports (estimate from the TES). Since it might require some period of time to convert wharfage for handling liquid bulk cargo to wharfage for handling dry bulk or general cargo, the Port would probably not be able to accommodate 13.3 million revenue tons as it would have done the year before.

From traffic information presented in the Railway Electrification Study, it is known that the highway currently hauls more than 95 percent of the petroleum product imports which are shipped out of the Keelung Port area. Thus, port-associated trucking traffic would be expected to lose 2.2 million tons of petroleum product imports in 1975 (but other trucking volumes, not associated with the port, would begin to supply the Keelung area with an estimated 200,000 tons of petroleum products in 1975).

An accurate assessment of the outlook for trucking of Keelung Harbor cargoes, in the year that the planned northern petroleum refinery is foreseen to commence operations, would require greater in-depth analysis than can be done here. It is perhaps sufficient for the purposes of the present analysis if the following assumptions are made for 1975:

(1) Demand from Keelung's present hinterland would tend to rise by 12 percent to a total of 18.7 million tons, except that, of this amount, 2.3 million tons would be petroleum products, and only about 0.1 million of these tons would be used for ship bunkering (estimate from the TES), so that the net effect on demand would be to reduce it by 2.2 million tons to 16.5 million revenue tons; and

(2) Keelung Harbor would have an effectively utilized capacity of about 12.0 million revenue tons in 1975, so that about 4.5 million tons would have to be diverted to Kaohsiung.

In 1974, the railway would have carried 1.8 million revenue tons of Keelung Harbor freight. This would have tended to rise to 2.5 million tons if there were no shift in the pattern of petroleum product distribution, and if Keelung Harbor capacity would be adequate to handle the increase. As calculated above, the railway would only lose about 0.1 million tons of petroleum product freight, so that total Keelung Harbor freight handled by the railway would tend to rise to 2.4 million tons, before considering additional diversion to Kaohsiung Harbor. Tonnages diverted to Kaohsiung would rise from the 1974 level of 3.4 million tons to a level of 4.5 million tons, so that the increment would be 1.1 million tons, and total railway-handled Keelung Harbor tonnages would therefore decline to 1.3 million in 1975.

The highways had accommodated 11.5 million revenue tons of Keelung Harbor traffic in 1974. Haulage by trucks would have tended to rise by about 1.3 million tons in 1975, except that the port-associated highway traffic would have had a gross decline of 2.2 million tons of petroleum products moving out of Keelung. Because fuel for ship bunkering in excess of 0.1 million tons would now have to be hauled to the port from the northern refinery, however, the net loss to the highway of petroleum product harbor freight might be only around 2.1 million tons. There would, then, be a net decline of 0.8 million tons of highway-carried Keelung Harbor freight, in 1975, to a total of 10.7 million revenue tons. That is, 1975 highway harbor cargoes would be equivalent to only 93.0 percent of the 1974 level.

Other highway traffic would show a marked rise, however, Whereas, in the absence of any shift in the pattern of petroleum product distribution, this traffic would have been foreseen to rise by only about nine percent, it would now be necessary for this other truck traffic to supply the Keelung area with its estimated 1975 demand for 0.2 million tons of petroleum products (excluding demand for ship bunkering). This annual total would require an average daily haulage of around 550 tons, and, assuming an average load of 4.0 tons (including empty trucks, which would represent 50 percent of the trips), would mean a truck traffic increment of about 140 trucks per day.

Keelung-Neihu truck traffic, other than that servicing the harbor, was an estimated 1194 trucks per day in 1969, and would be expected to grow to around 5,370 trucks per day by 1990. Over the 1970-1974 period, it has been projected to grow to 1.75 times (i.e., 1.13 x 1.13 x 1.12 x 1.11 x 1.1) its 1969 volume, or to approximately 2,090 trucks per day. This total would have increased to about 2,280 trucks per day in the absence of any shift in the pattern of distribution of petroleum products, but, taking this shift into account, the trucking total of non-Keelung Harbor traffic would rise to 2,420 trucks per day. The percentage increase from the 1974 level would be 15.8 percent.

By 1974, harbor traffic trucking volumes have been forecast to have risen to 4,420 trucks per day, which would be about 2.4 times (i.e., 1.25 x 1.25 x 1.20 x 1.144 x 1.116) the 1969 level of 1840 trucks per day. In 1975, this would fall to around 4,110 trucks per day. Total 1969 equivalent heavy trucks would rise from 6,510 trucks per day in 1974 to 6,530 trucks per day in 1975, an increase of only about 0.3 percent.

Expansion of total Keelung-Neihu trucking volumes over the 1970-1975 period would have been to 2.15 times (i.e., 6690 ÷ 3,034) the 1969 level. Since forecast 1990 volumes would be 10,520 equivalent 1969 trucks per day, a 1.61 expansion, or only 3.2 percent per annum, would be foreseen for the 1976-1990 period.

1976. Assuming that demand for harbor facilities from Keelung's present hinterland might rise by about ten percent, total demand would be 18.2 million tons in 1976. If the port would once again have an effective capacity of 13.3 million tons, then a total of 4.9 million tons would have to be diverted to Kaohsiung, or to the new Taichung Harbor, if it would commence to operate by this year. The increase in diverted tonnages over the previous year would be 0.4 million. The increment of diverted railway-hauled traffic would be more than counterbalanced, where railway Keelung Harbor traffic was concerned, by 0.6 million tons of new demand, however, so that railway haulage of cargoes to and from Keelung Harbor would rise slightly to 1.5 million.

Highway trucking Keelung Harbor cargoes would rise by 1.1 million, or 10.0 percent. Other trucking would probably rise by about eight percent (continuing its gradual deceleration), so that total Keelung-Neihu heavy truck volumes would increase to 7,130 trucks (4520 plus 2610) per day, representing about a 9.2 percent rise from 1975.

1977. Demand from Keelung's present hinterland would be expected to rise to around 20.0 million tons in 1977. This would mean that 6.7 million tons would have been diverted to other ports; the rise in diverted tonnages would be approximately 1.8 million, which would lower the total of railway-handled Keelung Harbor cargo to only 0.3 million revenue tons.

Highway haulage of Keelung Harbor tonnages would rise to 13.0 million. The percentage rise, in 1977, would be about 10.3 percent, so that the volume of 1969 equivalent trucks handling Keelung Harbor traffic would rise to 5,010 per day.

Other truck volumes could be expected to rise by about eight percent to a level of 2,820 per day. Total Neihu-Keelung trucks would, therefore, rise to 7,830 per day.

1978. With an additional rise in demand from Keelung's present hinterland for harbor facilities in 1978, railway handling of Keelung Harbor freight might be entirely eliminated in that year (under the simple assumptions used in this analysis - actually, when railway sidings and handling of containers are taken into account, some railway servicing of Keelung Harbor would be expected to be continued, but such freight tonnages should be small by 1978, even without considering the probable effects of the freeway).

In terms of 1969 heavy truck equivalents, Keelung Harbor traffic would be handled by a constant volume of 5,150 trucks per day from 1978 onward. Other truck traffic might rise by about seven percent, in 1978, to a level of 3,020 trucks per day. Total Neihu-Keelung trucks per day would be 8,170 in 1978, representing an increase of about 4.3 percent over the 1977 total.

After 1978, truck volumes would advance only very slowly. Harbor traffic would not grow at all, and other truck volumes would rise by only 78 percent, or an average of 4.9 percent per annum, over the 1979-1990 period.

1979-1990. The approximate numbers of 1969 heavy truck equivalents which might be expected per day between Keelung and Neihu, in each of the years over the 1979-1990 period, are shown below.

Years	Heavy Truck per day
1979	8,350
1980	8,510
1981	8,680
1982	8,860
1983	9,050
1984	9,250
1985	9,450
1986	9,660
1987	9,870
1988	10,080
1989	10,300
1990	10,520

Appendix E
INDUCED TRAFFIC

INTRODUCTION

When completed, the North-South Freeway will be a transportation facility far superior to any facilities currently in existence in Taiwan. It will combine the high capacity and comfort provided by the railway with the far greater transport flexibility (convenience) of highway travel. In terms of transport costs, it will provide Taiwan's western corridor with lower-cost transport than is currently available (except for the transport of bulk freight over long distances and/or with the use of private sidings, some of which may continue to be accommodated more cheaply by the railway).

Transportation is like most other goods and services, in that, lowering of the cost of transportation would be expected to increase the demand. The traffic forecasts of the feasibility study did not take this expected increase into account; that is, the forecasts indicate the traffic volumes which would be expected to occur in the future in the absence of anything which would markedly improve transport service and lower transport costs.

The North-South Freeway, however, will result in marked improvement of transport service and lowering of transport costs; thus, given the accuracy of the forecasts of traffic that would exist even without the freeway, transport demand increments should be added for the with-freeway situation. Theoretically, they should be added for each type of vehicle which would use the freeway. In this study, however, consideration is given to induced auto and bus traffic only, since: (1) these vehicle types will probably constitute the bulk of the induced traffic; and (2) induced trucking traffic, arising from expanded markets and extended raw materials hinterlands, would be difficult to estimate with any reliable degree of precision.

The induced passenger traffic with the freeway would result from lowered auto and bus operating costs and the value of passenger time savings, both of which would be reflected in the user cost savings, and from the improved comfort of travel (i.e., relief from congested traffic conditions), which would not be reflected in user cost savings. From this established relationship comes the first assumption of the induced traffic analysis.

Assumption I : Induced passenger traffic, expressed as proportions of the base traffic volumes, which would exist without an improved transport facility, are directly related to cost ratios which compare the total cost of movement with and without an improved facility for various trips, in terms of operating cost, passenger time value, and passenger discomfort.

Since the improvements in passenger comfort are not reflected in user costs, and yet must be included in the cost ratio, it is necessary to quantify the value of passenger discomfort under congested traffic conditions. In order to accomplish this, two other assumptions were necessary, as follows:

Assumption II : The passenger time cost of traveling 300 kilometers at an average speed of 48 kilometers per hour (i.e., E level of service on rural highways) is assumed equal to the passenger discomfort cost of traveling 300 kilometers under congested conditions.

Assumption III : Passenger discomfort cost is assumed to vary directly with distance, and this relationship is defined by the following equation:

$$C_D = K\,(d + (0.05d)^2)$$

Where C_D is the passenger discomfort cost per vehicle, K is a cost constant (separate for autos and for buses) derived from Assumption II, and d is the trip distance, expressed in kilometers.

Cost ratios are first calculated in the analysis which follows, on the basis of user costs; then the discomfort costs are determined, and are used to adjust the cost ratios. The adjusted cost ratios are then used to derive expected traffic increments, which are expressed as decimal proportions of the base forecast traffic volumes. These derivations are accomplished by using the equation given under Assumption IV, following.

Assumption IV : Induced traffic, as a decimal proportion of the base trip volumes, will be found to vary directly with the adjusted cost ratios according to the following relationship:

$$T_I = X^2 - (X - 0.1)^3$$

Where T_I represents the induced traffic, and X is equal to the difference of the cost ratio less 1.0.

Values of this equation are shown below for various cost ratios. These values are compared in the final column below to the values which would have been obtained with the square root method which was used in another recent study* to determine induced traffic (in that study the square roots of trip time ratios, rather than cost ratios, were used to estimate induced traffic).

Ratios	Calculations		T_I	Square roots method T'_I
1.1	(.1 x .1) - (.1 - .1)^3	=	0.010	0.049
1.2	(.2 x .2) - (.2 - .1)^3	=	0.039	0.095
1.3	(.3 x .3) - (.3 - .1)^3	=	0.082	0.140
1.4	(.4 x .4) - (.4 - .1)^3	=	0.133	0.183
1.5	(.5 x .5) - (.5 - .1)^3	=	0.186	0.225
1.6	(.6 x .6) - (.6 - .1)^3	=	0.235	0.265
1.7	(.7 x .7) - (.7 - .1)^3	=	0.274	0.304
1.8	(.8 x .8) - (.8 - .1)^3	=	0.297	0.342
1.9	(.9 x .9) - (.9 - .1)^3	=	0.298	0.378

The final assumptions relating to the calculation of induced traffic volumes are as follows:

Assumption V : With very small cost improvements (less than 9.1 percent, or, expressed otherwise, with cost ratios below 1.1) there will be only negligible induced traffic volumes, and the above equation will not apply.

Assumption VI : Since, even in the extreme instance that all transportation would be free, the number of trips which would be useful per person would be limited, and since the number of persons in the population is also limited, induced passenger trips would grow asymptotically, and would have an upper limit of 30 percent of the base traffic volumes.

Assumption VII: The cost ratios will vary with trip distances, since the proportion that arterial kilometers with the freeway system would represent of a total trip distance would tend to fall as the total trip distance would increase, but it is assumed that various trip-distance ranges may be adequately represented by the cost ratios of the mid-point distances of those ranges. These distance ranges and mid-points are listed below.

Distance Ranges		Mid-points	
0- 20 kilometers		No induced traffic estimated	
21- 60	"	40 kilometers	
61-100	"	80	"
101-200	"	150	"
201-400	"	300	"

Assumption VIII: The distance on arterials and local roads, of every trip for which the freeway would be used, is assumed to be equal to the quotient of local and arterial vehicle-kilometers with the freeway system divided by vehicle trips for buses and for autos.

Using these several assumptions as a basis for analysis, the analysis proceeded as described in the following two sections, which discuss induced auto and bus trips separately.

INDUCED AUTO TRAFFIC

As stated in the preceding section, the trip distances for which cost ratios were calculated were 40, 80, 150, and 300 kilometers. The average trip distance for autos would be slightly higher without the freeway, viz., 1.013 times the distance of the average freeway trip, so that, if this factor is applied to the freeway trip lengths, the costs of comparable arterial system trips would actually be for distances of 41, 81, 152, and 304 kilometers.

* Taiwan Railway Electrification Study

The average per-kilometer user cost for autos on the arterial system in 1969 was indicated by the computer output to be NT$2.80. Using this value, the costs for various trips are shown below.

Trip Distance	Trip Cost
41 kilometers	NT$115
81 "	227
152 "	426
304 "	851

With the freeway system, the average per-kilometer cost of operating on local roads and arterials, in 1969, would have been NT$2.92, while the average per-kilometer freeway user cost (including toll costs) would have been NT$2.32. The average distance of arterial travel with the freeway system would have been 14 kilometers. The cost totals for various trips are shown below.

	Trip Cost		
Trip Distance	Arterials	Freeway	Total
40 kilometers	NT$41	NT$ 60	NT$101
80 "	41	153	194
150 "	41	316	357
300 "	41	664	705

The unadjusted cost ratios that would obtain from these cost totals and the cost totals shown earlier for the comparable arterial system trips would be as follows:

Trip Distance	Cost Total (arterial system/freeway system)	Cost Ratios
40 kilometers	NT$115/101	1.14
80 "	NT$227/194	1.17
150 "	NT$426/357	1.19
300 "	NT$851/705	1.21

In order to adjust these ratios to take into account the relief from congested conditions with the freeway, this improved travel comfort must be quantified according to Assumptions II and III of the preceding section. Assumption II indicated that the discomfort cost of traveling under congested conditions might equal the time cost of traveling at an average speed of 48 kilometers per hour over a distance of 300 kilometers.

Using the average frequencies of taxis and private autos estimated by the freeway feasibility study for the 1969-1990 period, viz., 60 percent private autos and 40 percent taxis, the average passenger time value per auto per minute would be NT$1.07 (i.e, 0.4 x 1.26 plus 0.6 x 0.95).

At a rate of 48 kilometers per hour, it would require 375 minutes to travel 300 kilometers. The passenger time cost per auto would be NT$401, and this would also be the passenger discomfort cost. This particular passenger discomfort cost would be used to find the value of K in the equation given under Assumption III. These calculations would be as follows:

$$C_D = K\ (d + (0.5d)^2)$$
$$401 = K\ (300 + 15^2)$$
$$401 = 525\ K$$
$$K = \text{NT\$}0.764$$

The distances for which arterial travel discomfort cost have to be calculated are 14 kilometers for freeway trips, and 41, 81, 152, and 304 kilometers for arterial system auto trips. These discomfort costs, and the adjusted trip costs and cost ratios, are shown below.

Trip Distance	Calculation	Discomfort Cost	Adjusted Trip Cost	Adjusted Cost Ratio
14 kilometers	$0.764x(14+0.7^2)$	NT$ 11	NT$ 52*	–
41 "	$0.764x(41+2^2)$	34	149	1.33
81 "	$0.764x(81+4^2)$	74	301	1.47
152 "	$0.764x(152+7.6^2)$	160	586	1.59
304 "	$0.764x(304+15^2)$	405	1256	1.71

* Arterial-kilometers with freeway trips.

The adjusted cost ratios can now be used to derive induced traffic proportions by using the formula given in Assumption IV. These calculations are shown following.

Trip-distance Ranges	Calculations		Decimal Proportions of Induced Auto Traffic
21- 60 kilometers	$0.33^2 \cdot 0.23^3$	=	0.097
61-100 "	$0.47^2 \cdot 0.37^3$	=	0.170
101-200 "	$0.59^2 \cdot 0.49^3$	=	0.228
201-400 "	$0.71^2 \cdot 0.61^3$	=	0.277

INDUCED BUS TRAFFIC

As with autos, the average bus trip with the freeway system would include approximately 14 kilometers of arterial highway and local road travel. The average per-kilometer user cost, in 1969, on arterials (and local roads) with the arterial system would be NT$8.84, whereas the arterial user cost would be NT$9.79 with the freeway system. The cost of operating on the freeway would be NT$6.95 per kilometer.

The freeway trip lengths for the induced bus trip analysis are the same as were used for autos, viz., 40, 80, 150, and 300 kilometers. The comparable arterial trips will be slightly longer than were used for autos, however, since the average arterial system bus trip is 7.0 percent longer than the average freeway system bus trip, whereas the average auto trip was only 1.3 percent longer on the arterial system. The comparable bus trips with the arterial system will, therefore, be 43, 86, 160, and 321 kilometers.

The user costs for the various arterial system and freeway system trips are given below. Also shown are the cost ratios, unadjusted for discomfort costs.

Arterial System Trip Distance	Trip Cost
43 kilometers	NT$ 380
86 "	760
160 "	1,414
321 "	2,838

Freeway System Trip Distance	Arterials	Trip Cost Freeway	Total
40 kilometers	NT$137	NT$ 181	NT$ 318
80 "	137	459	596
150 "	137	945	1,082
300 "	137	1,988	2,125

Cost Ratios

Freeway System Trip Distance	Cost Ratios
40 kilometers	1.195
80 "	1.275
150 "	1.307
300 "	1.335

These cost ratios need to be adjusted to take into account the discomfort costs of arterial travel, arising from congested traffic conditions. As with autos, a value must first be found for the constant, K, in the equation under Assumption III.

Using the passenger time value arrived at in the freeway feasibility study for express bus passengers, viz., NT$0.10 per minute, and 35 passengers, as the average number per express bus, the per-vehicle-minute passenger time value would be NT$3.50. As was calculated earlier, 375 minutes would be required to travel 300 kilometers at an average speed of 48 kilometers per hour, so that the vehicle passenger time cost would total NT$1 313; according to Assumption II, this would also be equal to the passenger discomfort cost for the 300-kilometer trip. The value of the constant, K, would then be calculated as follows:

$$C_D = K\ (d + (0.05d)^2)$$
$$1313 = K\ (300 + 15^2)$$
$$1313 = 525\ K$$
$$K = NT\$2.50$$

The distances for which arterial travel discomfort costs have to be calculated for express bus traffic are 14 kilometers for freeway trips, and 43, 86, 160, and 321 kilometers for arterial system trips. These discomfort costs, and the adjusted trip costs and cost ratios, are shown below.

Trip Distance	Calculation	Discomfort Cost	Adjusted Trip cost	Adjusted Cost Ratios
14 kilometers	$2.5x(14+0.7^2)$	NT$ 36	NT$ 173*	–
43 "	$2.5x(43+2.2^2)$	120	500	1.57
86 "	$2.5x(86+4.3^2)$	261	1,021	1.71
160 "	$2.5x(160+8^2)$	560	1,974	1.82
321 "	$2.5x(321+16^2)$	1443	4,281	2.01

* Arterial-kilometers with average freeway trip.

As was done with autos, the adjusted cost ratios can be used to obtain proportions of induced traffic by applying the equation given in Assumption IV. These calculations are shown below.

Trip-Distance ranges	Calculations	Decimal proportions of induced bus traffic
21- 60 kilometers	$0.57^2 - 0.47^3$ =	0.221
61-100 "	$0.71^2 - 0.61^3$ =	0.277

101-200	"	$0.82^2 \cdot 0.72^3$	=	0.299*
201-400	"	$1.01^2 \cdot 0.91^3$	=	0.266*

* The equation is not usable outside of a cost-ratio range of 1.10 to approximately 1.83 (where induced traffic would become 30.0 percent of base traffic); induced bus traffic is assumed to be 30.0 percent for all trips of more than 100 kilometers.

In 1969 (and at the present time), long-distance passengers showed a decided preference for traveling by railway as opposed to traveling by highway bus. Some portion of the railway's long-distance passengers would travel by highway bus if the railway would suddenly cease to exist. Others, however, might forgo their trips entirely since the utility of the trips, while greater than the cost (in terms of fares, time costs, discomfort, and inconvenience) on the railway, would be less than the cost via highway. These latter volumes of passengers might be considered the passenger traffic induced by the existence of the railway. If the railway did not exist, but the freeway would be constructed, then these same passengers would make up part of the induced express bus passenger traffic of the freeway. Thus, with the railway in existence, the freeway induced traffic indicated in this analysis should be expected to be at least partly made up of passenger traffic converted from the railway.

DETERMINATION OF INDUCED TRAFFIC VOLUMES

For each of 14 screenlines, the approximate percentages of auto and bus trips within each trip-distance range were found. These percentages were then multiplied by the induced traffic percentages, indicated in the previous two sections of this appendix, for the respective trip-distance ranges. In this manner, induced auto and bus traffic, as percentages of base volumes, were found for every screenline. Table E-1 gives these percentages for screenlines 1-14.

These percentages were then applied to the actual 1969, and forecast 1990, average daily auto and bus volumes to arrive at the hypothetical 1969 volumes of induced traffic (shown in Table E-2), and the projected 1990 induced traffic volumes (Table E-3).

TABLE E-1

INDUCED TRAFFIC PERCENTAGES

Screenline No.	% Induced Auto	% Induced Bus
1	11	24
2	11	24
3	11	24
4	11	24
5	16	26
6	19	27
7	19	27
8	11	24
9	16	26
10	16	26
11	19	27
12	14	25
13	11	24
14	11	24

TABLE E-2

AVERAGE DAILY INDUCED TRAFFIC VOLUMES - 1969

Screenline No.	Induced Auto	Induced Bus	Total Mixed	Total PCE
1	396	216	612	828
2	1,980	1,488	3,468	4,956
3	594	240	834	1,074
4	462	216	678	894
5	304	182	486	668
6	228	135	363	498
7	190	135	325	460
8	495	336	831	1,167
9	128	130	258	388
10	240	208	448	656
11	133	135	268	403
12	280	225	505	730
13	231	168	399	567
14	297	216	513	729

TABLE E-3

AVERAGE DAILY INDUCED TRAFFIC VOLUMES - 1990

Screenline No.	Induced Auto	Induced Bus	Total Mixed	Total PCE
1	3,839	672	4,511	5,183
2	21,483	720	22,203	22,923
3	6,204	768	6,972	7,740
4	6,941	696	7,637	8,333
5	5,216	624	5,840	6,464
6	5,092	432	5,524	5,956
7	4,123	432	4,555	4,987
8	10,714	576	11,290	11,866
9	2,768	416	3,184	3,600
10	5,504	390	5,894	6,284
11	2,850	324	3,174	3,498
12	5,180	450	5,630	6,080
13	3,322	528	3,850	4,378
14	3,443	648	4,091	4,739

Appendix F
COMPUTER SUMMARY RESULTS

The computer output included summary results for each of 47 assignments. These summary results indicated daily totals of vehicle-kilometers, vehicle-hours, and vehicle operating costs in each freeway section, and the totals for all sections. Since the computer assigned traffic volumes without regard to consideration of capacity constraints, and, in so doing, overassigned 1990 traffic to arterials in some instances, it was necessary to adjust these totals to reflect the required shifting of additional traffic to the freeway.

The tables which follow show the section-by-section 1969 and 1990 traffic operating results for the arterial network (i.e., without the freeway), and for the freeway network with the preferred toll system. Results are also shown for the freeway network (but not on a section-by-section basis) with all of the other toll systems which were tested. The results shown do not include traffic converted from the railway or induced traffic. The heavy truck traffic operating results in Section I are only shown adjusted (as indicated in Appendix D to this chapter) in Table F-7. Airport traffic is shown in Table F-8.

The operating results with the freeway differ from those obtained at the time of the feasibility study, of course, for several reasons, most of which are related to the decision to impose tolls on the freeway. First of all, the toll charges themselves are now included in the operating costs which would result with the freeway network. Secondly, the payment of these charges requires vehicles to stop, and results, therefore, in additional stopping costs. Thirdly, there would be a smaller portion of total vehicle-kilometers which would be on the freeway, since the number of interchanges would be reduced with a toll facility, and since less traffic would be diverted to the freeway when it would open because of the higher freeway operating costs (i.e., with tolls and toll-stopping costs).

Operating results with the freeway system were also altered because of some freeway section distance changes. The results for 1990 also were affected by related highway improvements, which would be in addition to those indicated as necessary in the feasibility study.

The operating results with the arterial network also differ somewhat from the costs shown for the network in the feasibility study. Vehicle speeds were adjusted in some instances, and some distance adjustments were found to be necessary in Sections IV and VI.

TABLE F-1

TRAFFIC OPERATING RESULTS - ARTERIAL SYSTEM
DAILY TRAFFIC - 1969

Sections	Auto & Taxi	Light Truck	Heavy Truck	E-Bus	Total Vehicles
	Vehicle Categories				
Section 1					
Veh-km	167,392	50,115	108,716	21,612	347,835
Veh-hours	4,727	1,423	2,891	575	9,616
Oper. cost NT$	516,245	147,407	437,087	208,631	1,309,370
Section 2					
Veh-km	219,097	61,061	157,844	34,945	472,947
Veh-hours	6,154	1,749	4,444	972	13,319
Oper. cost NT$	664,324	182,096	678,461	366,217	1,891,098
Section 3					
Veh-km	48,094	16,231	97,056	16,445	177,826
Veh-hours	1,019	343	2,069	345	3,776
Oper. cost NT$	124,208	44,887	404,821	146,961	720,877
Section 4					
Veh-km	84,056	34,172	232,110	34,384	384,722
Veh-hours	1,799	731	4,660	664	7,854
Oper. cost NT$	216,927	90,137	862,565	264,515	1,434,144
Section 5					
Veh-km	134,969	31,548	194,340	36,302	397,159
Veh-hours	2,789	649	3,916	740	8,094
Oper. cost NT$	340,797	81,967	720,856	295,539	1,439,159
Section 6					
Veh-km	90,120	31,255	241,078	31,913	394,366
Veh-hours	1,971	682	5,136	680	8,469
Oper. cost NT$	235,599	82,168	895,484	261,814	1,475,065
Section 7					
Veh-km	166,162	55,257	269,245	40,660	531,333
Veh-hours	4,194	1,397	6,811	1,015	13,417
Oper. cost NT$	475,679	153,836	1,068,485	368,277	2,066,277
Total All Sections					
Veh-km	909,890	279,639	1,300,389	216,270	2,706,188
Veh-hours	22,653	6,974	29,927	4,991	64,545
Oper. cost NT$	2,573,779	782,498	5,067,759	1,911,954	10,335,990

TABLE F-2

TRAFFIC OPERATING RESULTS - ARTERIAL SYSTEM
DAILY TRAFFIC - 1990

Sections	Auto & Taxi	Light Truck	Heavy Truck	E-Bus	Total Vehicles
	Vehicle Categories				
Section 1					
Veh-km	1,712,617	424,578	799,451	81,737	3,018,383
Veh-hours	48,676	12,090	21,428	2,188	84,382
Oper. cost NT$	5,304,906	1,250,813	3,262,148	792,839	10,610,706
Section 2					
Veh-km	3,091,927	620,255	1,370,373	140,430	5,222,985
Veh-hours	84,822	17,616	38,551	3,897	144,886
Oper. cost NT$	9,351,793	1,825,439	5,800,335	1,454,332	18,431,899
Section 3					
Veh-km	747,542	127,906	618,046	61,906	1,555,400
Veh-hours	15,905	2,708	13,085	1,299	32,997
Oper. cost NT$	1,939,942	353,818	2,559,919	552,618	5,406,297
Section 4					
Veh-km	1,941,058	393,016	1,810,906	144,083	4,289,063
Veh-hours	42,607	8,473	37,127	2,780	90,987
Oper. cost NT$	5,085,491	1,039,364	6,793,038	1,108,488	14,026,381
Section 5					
Veh-km	2,639,551	373,287	1,455,502	132,192	4,600,532
Veh-hours	55,143	7,719	29,368	2,693	94,923
Oper. cost NT$	6,709,104	967,895	5,383,007	1,073,575	14,133,581
Section 6					
Veh-km	1,967,051	289,744	1,787,689	125,164	4,169,648
Veh-hours	43,110	7,220	38,112	2,659	91,101
Oper. cost NT$	5,148,603	868,006	6,643,192	1,024,848	13,684,649
Section 7					
Veh-km	2,260,065	488,089	1,979,092	155,403	4,882,649
Veh-hours	57,739	12,197	50,247	3,814	123,997
Oper. cost NT$	6,521,168	1,349,321	7,872,743	1,414,946	17,158,178
Total All Sections					
Veh-km	14,359,811	2,716,875	9,821,059	840,915	27,738,660
Veh-hours	348,002	68,023	227,918	19,330	663,273
Oper. cost NT$	40,061,007	7,654,656	38,314,382	7,421,646	93,451,691

TABLE F-3

TRAFFIC OPERATING RESULTS - FREEWAY SYSTEM
BARRIER SYSTEM - TOLL SCHEDULE B_3 - 1969

Sections	Vehicle Categories Auto & Taxi	Light Truck	Heavy Truck	E-Bus	Total Vehicles
Section I					
Veh-km					
Arterial	123,013	39,565	67,742	9,096	239,416
Freeway	50,077	10,524	40,043	10,968	111,612
Total	173,090	50,089	107,785	20,064	351,028
Veh-hrs.					
Arterial	3,695	1,166	1,919	302	7,082
Freeway	649	137	520	142	1,448
Total	4,344	1,303	2,439	444	8,530
Oper. cost (NT$)					
Arterial	395,704	118,482	278,276	103,636	896,098
Freeway	127,872	29,659	166,249	92,132	415,912
Total	523,576	148,141	444,525	195,768	1,312,010
Section 2					
Veh-km.					
Arterial	104,312	39,783	58,834	5,225	208,154
Freeway	120,463	21,792	109,123	29,338	280,716
Total	224,775	61,575	167,957	34,563	488,870
Veh-hrs.					
Arterial	2,942	1,152	1,718	143	5,955
Freeway	1,336	242	1,211	325	3,114
Total	4,278	1,394	2,929	468	9,069
Oper. cost (NT$)					
Arterial	321,432	119,186	259,051	53,712	753,381
Freeway	277,335	60,371	433,154	209,363	980,223
Total	598,767	179,557	692,205	263,075	1,733,604

CON'T TABLE F-3

TRAFFIC OPERATING RESULTS - FREEWAY SYSTEM
BARRIER SYSTEM - TOLL SCHEDULE B_3 - 1969

Sections	Vehicle Categories Auto & Taxi	Light Truck	Heavy Truck	E-Bus	Total Vehicles
Section 3					
Veh-km					
Arterial	15,148	7,005	29,863	2,356	54,372
Freeway	28,889	7,588	53,982	12,418	102,877
Total	44,037	14,593	83,845	14,774	157,249
Veh-hrs.					
Arterial	369	177	757	56	1,359
Freeway	321	85	600	138	1,144
Total	690	262	1,357	194	2,503
Oper. cost (NT$)					
Arterial	42,380	20,162	129,248	22,092	213,882
Freeway	73,845	22,269	224,605	93,454	414,173
Total	116,225	42,431	253,853	115,546	628,055
Section 4					
Veh-km.					
Arterial	23,985	8,836	35,820	2,286	70,927
Freeway	64,460	23,988	190,607	30,986	310,041
Total	88,445	32,824	226,427	33,272	380,968
Veh-hrs.					
Arterial	540	194	760	54	1,548
Freeway	729	272	2,158	351	3,510
Total	1,269	466	2,918	405	5,058
Oper. cost (NT$)					
Arterial	63,837	23,285	135,459	20,504	243,085
Freeway	141,340	61,316	697,221	202,095	1,101,972
Total	205,177	84,601	832,680	222,599	1,345,057

CON'T TABLE F-3

TRAFFIC OPERATING RESULTS - FREEWAY SYSTEM
BARRIER SYSTEM - TOLL SCHEDULE B_3 - 1969

Sections	Vehicle Categories				
	Auto & Taxi	Light Truck	Heavy Truck	E-Bus	Total Vehicles
Section 5					
Veh-km					
Arterial	89,447	18,453	67,006	12,317	187,223
Freeway	46,402	11,602	123,869	25,248	207,121
Total	135,849	30,055	190,875	37,565	394,344
Veh-hrs.					
Arterial	1,850	383	1,383	259	3,875
Freeway	568	141	1,456	298	2,463
Total	2,418	524	2,839	557	6,338
Oper. cost (NT$)					
Arterial	225,977	48,370	256,419	107,096	637,862
Freeway	95,239	27,690	432,032	158,769	713,730
Total	321,216	76,060	688,451	265,865	1,351,592
Section 6					
Veh-km.					
Arterial	45,337	14,720	64,107	5,058	129,222
Freeway	39,737	12,847	148,424	24,498	225,506
Total	85,074	27,567	212,531	29,556	354,728
Veh-hrs.					
Arterial	1,024	327	1,381	109	2,841
Freeway	441	143	1,648	272	2,504
Total	1,465	470	3,029	381	5,345
Oper. cost (NT$)					
Arterial	120,908	38,954	238,863	42,336	441,061
Freeway	99,072	36,620	599,545	178,968	914,205
Total	219,980	75,574	838,408	221,304	1,355,266

CON'T TABLE F-3

TRAFFIC OPERATING RESULTS - FREEWAY SYSTEM
BARRIER SYSTEM - TOLL SCHEDULE B_3 - 1969

Sections	Vehicle Categories				
	Auto & Taxi	Light Truck	Heavy Truck	E-Bus	Total Vehicles
Section 7					
Veh-km					
Arterial	113,434	41,005	154,741	15,694	324,874
Freeway	55,774	13,270	109,283	25,674	204,001
Total	169,208	54,275	264,024	41,368	528,875
Veh-hrs.					
Arterial	2,983	1,070	4,158	443	8,654
Freeway	650	156	1,279	299	2,384
Total	3,633	1,226	5,437	742	11,038
Oper. cost (NT$)					
Arterial	333,579	115,291	627,399	159,456	1,235,725
Freeway	126,089	34,692	402,037	171,189	734,007
Total	459,668	149,983	1,029,436	330,645	1,969,732
All Sections					
Veh-km,					
Arterial	514,676	169,367	478,113	52,032	1,214,188
Freeway	405,802	101,611	775,331	159,130	1,441,874
Total	920,478	270,978	1,253,444	211,162	2,656,062
Veh-hrs.					
Arterial	13,403	4,469	12,076	1,366	31,314
Freeway	4,694	1,176	8,872	1,825	16,567
Total	18,097	5,645	20,948	3,191	47,881
Oper. cost (NT$)					
Arterial	1,503,817	483,730	1,924,715	508,832	4,421,094
Freeway	940,792	272,617	2,954,843	1,105,970	5,274,222
Total	2,444,609	756,347	4,879,558	1,614,802	9,695,316

TABLE F-4

TRAFFIC OPERATING RESULTS - FREEWAY SYSTEM
BARRIER SYSTEM - TOLL SCHEDULE B_3 - 1990

Sections	Auto & Taxi	Light Truck	Heavy Truck	E-Bus	Total Vehicles
	Vehicle Categories				
Section 1					
Veh-km.					
Arterial	909,768	246,257	265,188	32,447	1,453,660
Freeway	771,361	177,750	521,059	49,581	1,519,751
Total	1,681,129	424,007	786,247	82,028	2,973,411
Veh-hrs.					
Arterial	28,522	5,888	6,729	973	42,112
Freeway	10,018	2,307	6,768	643	19,736
Total	38,540	8,195	13,497	1,616	61,848
Oper. cost (NT$)					
Arterial	3,014,692	851,284	1,165,418	367,578	5,398,972
Freeway	2,048,936	476,815	2,150,389	392,523	5,068,663
Total	5,063,628	1,328,099	3,315,807	760,101	10,467,635
Section 2					
Veh-km.					
Arterial	1,111,736	280,048	289,166	15,729	1,696,679
Freeway	2,155,078	312,504	1,052,153	151,562	3,671,297
Total	3,266,814	592,552	1,341,319	167,291	5,367,976
Veh-hrs.					
Arterial	30,739	8,242	8,606	440	48,027
Freeway	23,888	3,465	12,499	1,682	41,534
Total	54,627	11,707	21,105	2,122	89,561
Oper. cost (NT$)					
Arterial	3,380,233	843,645	1,261,082	164,142	5,649,102
Freeway	5,003,520	882,023	4,494,165	1,038,993	11,418,701
Total	8,383,753	1,725,668	5,755,247	1,203,135	17,067,803

CON'T TABLE F-4

TRAFFIC OPERATING RESULTS - FREEWAY SYSTEM
BARRIER SYSTEM - TOLL SCHEDULE B_3 - 1990

Sections	Auto & Taxi	Light Truck	Heavy Truck	E-Bus	Total Vehicles
	Vehicle Categories				
Section 3					
Veh-km.					
Arterial	317,135	40,991	95,829	8,618	462,573
Freeway	445,917	81,836	454,282	46,739	1,028,774
Total	763,052	122,827	550,111	55,357	1,491,347
Veh-hrs.					
Arterial	7,655	1,014	2,372	203	11,244
Freeway	4,955	909	5,047	519	11,430
Total	12,610	1,923	7,419	722	22,674
Oper. cost (NT$)					
Arterial	882,074	116,074	403,252	80,226	1,481,626
Freeway	1,139,851	239,527	1,890,131	351,753	3,621,262
Total	2,021,925	355,601	2,293,383	431,979	5,102,888
Section 4					
Veh-km.					
Arterial	564,461	117,817	289,820	11,541	983,639
Freeway	1,427,318	266,956	1,510,333	128,083	3,332,690
Total	1,991,779	384,773	1,800,153	139,624	4,316,320
Veh-hrs.					
Arterial	12,888	2,509	6,102	267	21,766
Freeway	16,094	3,022	17,092	1,448	37,656
Total	28,982	5,531	23,194	1,715	59,422
Oper. cost (NT$)					
Arterial	1,515,595	307,697	1,082,725	102,074	3,008,091
Freeway	3,081,189	673,945	5,492,938	835,533	10,083,605
Total	4,596,784	981,642	6,575,663	937,607	13,091,696

CON'T TABLE F-4

TRAFFIC OPERATING RESULTS - FREEWAY SYSTEM
BARRIER SYSTEM - TOLL SCHEDULE B_3 - 1990

Sections	Vehicle Categories: Auto & Taxi	Light Truck	Heavy Truck	E-Bus	Total Vehicles
Section 5					
Veh-km					
Arterial	1,271,023	185,563	422,828	41,484	1,920,898
Freeway	1,695,401	214,458	1,054,657	95,145	3,059,661
Total	2,966,424	400,021	1,477,485	136,629	4,980,559
Veh-hrs.					
Arterial	26,667	3,879	8,894	873	40,313
Freeway	21,070	2,607	12,374	1,121	37,172
Total	47,737	6,486	21,268	1,994	77,485
Oper. cost (NT$)					
Arterial	3,239,048	486,913	1,627,912	360,090	5,713,963
Freeway	3,436,808	512,020	3,685,291	598,175	8,232,294
Total	6,675,856	998,933	5,313,203	958,265	13,946,257
Section 6					
Veh-km.					
Arterial	797,805	138,252	295,340	17,296	1,248,693
Freeway	1,106,687	172,252	1,294,084	97,621	2,670,644
Total	1,904,492	310,504	1,589,424	114,917	3,919,337
Veh-hrs.					
Arterial	17,822	3,047	6,452	374	27,695
Freeway	12,004	1,913	14,369	1,084	29,370
Total	29,826	4,960	20,821	1,458	57,065
Oper. cost (NT$)					
Arterial	2,113,069	364,830	1,108,932	144,354	3,731,185
Freeway	2,737,996	493,629	5,239,340	713,663	9,184,628
Total	4,851,065	858,459	6,348,272	858,017	12,915,813

CON'T TABLE F-4

TRAFFIC OPERATING RESULTS - FREEWAY SYSTEM
BARRIER SYSTEM - TOLL SCHEDULE B_3 - 1990

Sections	Vehicle Categories: Auto & Taxi	Light Truck	Heavy Truck	E-Bus	Total Vehicles
Section 7					
Veh-km					
Arterial	1,113,144	295,564	1,065,075	46,766	2,520,549
Freeway	1,256,269	214,654	942,674	110,124	2,523,721
Total	2,369,413	510,218	2,007,749	156,890	5,044,270
Veh-hrs.					
Arterial	27,876	6,864	24,784	1,278	60,802
Freeway	15,612	2,607	9,177	1,312	28,708
Total	43,488	9,471	33,961	2,590	89,510
Oper. cost (NT$)					
Arterial	3,170,393	817,873	4,288,804	472,841	8,749,911
Freeway	2,922,623	527,410	3,241,279	736,249	7,427,561
Total	6,093,016	1,345,283	7,530,083	1,209,090	16,177,472
All Sections					
Veh-km.					
Arterial	6,085,072	1,304,492	2,723,246	173,881	10,286,691
Freeway	8,858,031	1,440,410	6,829,242	678,855	17,806,538
Total	14,943,103	2,744,902	9,552,488	852,736	28,093,229
Veh-hrs.					
Arterial	152,169	31,443	63,939	4,408	251,959
Freeway	103,641	16,830	77,326	7,809	205,606
Total	255,810	48,273	141,265	12,217	457,565
Oper. cost (NT$)					
Arterial	17,315,104	3,788,316	10,938,125	1,691,305	33,732,850
Freeway	20,370,923	3,805,369	26,193,533	4,666,889	55,036,714
Total	37,686,027	7,593,685	37,131,658	6,358,194	88,769,564

TABLE F-5

COMPUTER SUMMARY RESULTS FOR ENTIRE FREEWAY NETWORK

Toll Network, Toll Schedule, Year & Item	Daily Traffic Operating Results				
	Auto & Taxi	Light Truck	Heavy Truck	Express Bus	Total Vehicles
Barrier Network					
1969					
No Tolls					
Vehicle-kms					
Arterials	432,804	137,158	376,257	51,375	997,594
Freeway	498,830	135,716	889,834	160,093	1,684,473
Total	931,634	272,874	1,266,091	211,468	2,682,067
Vehicle-hours					
Arterials	11,377	3,677	9,747	1,349	26,150
Freeway	5,788	1,576	10,190	1,835	19,389
Total	17,165	5,253	19,937	3,184	45,539
Operating Cost (NT$)					
Arterials	1,273,848	394,110	1,526,593	502,467	3,697,018
Freeway	925,413	303,841	2,820,134	899,475	4,948,863
Total	2,199,261	697,951	4,346,727	1,401,942	8,645,881
Schedule B_2					
Vehicle-kms					
Arterials	486,039	115,669	434,085	52,033	1,087,826
Freeway	441,984	117,550	820,936	159,130	1,539,600
Total	928,023	233,219	1,255,021	211,163	2,627,426
Vehicle-hours					
Arterials	12,692	4,132	11,063	1,366	29,253
Freeway	5,113	1,362	9,397	1,825	17,697
Total	17,805	5,494	20,460	3,191	46,950
Operating Cost (NT$)					
Arterials	1,421,542	445,707	1,750,907	508,832	4,126,988
Freeway	963,045	300,363	3,019,608	1,059,130	5,342,146
Total	2,384,587	746,070	4,770,515	1,567,962	9,469,134

CON'T TABLE F-5

COMPUTER SUMMARY RESULTS FOR ENTIRE FREEWAY NETWORK

Toll Network, Toll Schedule, Year & Item	Daily Traffic Operating Results				
	Auto & Taxi	Light Truck	Heavy Truck	Express Bus	Total Vehicles
Schedule B_4					
Vehicle-kms					
Arterials	503,403	162,741	453,025	52,033	1,171,202
Freeway	419,876	110,244	798,801	159,130	1,488,051
Total	923,279	272,985	1,251,826	211,163	2,659,253
Vehicle-hours					
Arterials	13,147	4,315	11,508	1,366	30,336
Freeway	4,854	1,275	9,142	1,825	17,096
Total	18,001	5,590	20,650	3,191	47,432
Operating cost (NT$)					
Arterials	1,471,959	465,982	1,825,590	508,832	4,272,363
Freeway	948,271	288,323	3,001,257	1,084,370	5,322,221
Total	2,420,230	754,305	4,826,847	1,593,202	9,594,584
1990					
No Tolls					
Vehicle-kms					
Arterials	5,878,932	1,122,985	2,241,373	168,533	9,411,823
Freeway	9,257,924	1,625,488	7,304,734	705,960	18,894,106
Total	15,136,856	2,748,473	9,546,107	874,493	28,305,929
Vehicle-hours					
Arterials	150,897	29,952	57,247	4,225	242,321
Freeway	105,253	18,634	84,554	8,128	216,569
Total	256,150	48,586	141,801	12,353	458,890
Operating Cost (NT$)					
Arterials	16,495,695	3,215,668	9,129,112	1,648,280	30,488,755
Freeway	17,549,110	3,663,326	23,339,256	3,977,733	48,529,425
Total	34,044,805	6,878,994	32,468,368	5,626,013	79,018,180

CON'T TABLE F-5

COMPUTER SUMMARY RESULTS FOR ENTIRE FREEWAY NETWORK

Total Network, Toll Schedule, Year & Item	Daily Traffic Operating Results				
	Auto & Taxi	Light Truck	Heavy Truck	Express Bus	Total Vehicles
Closed Network					
1969					
Schedule C_1					
Vehicle-kms					
Arterials	490,855	154,551	432,261	58,597	1,136,264
Freeway	425,074	115,183	821,124	150,523	1,511,904
Total	915,929	269,734	1,253,385	209,120	2,648,168
Vehicle-hours					
Arterials	12,791	4,114	11,032	1,512	29,449
Freeway	4,934	1,337	9,403	1,728	17,402
Total	17,725	5,451	20,435	3,240	46,851
Operating Cost (NT$)					
Arterials	1,451,470	446,995	1,758,170	576,120	4,232,755
Freeway	935,373	289,325	2,981,478	994,801	5,200,977
Total	2,386,843	736,320	4,739,648	1,570,921	9,433,732
Schedule C_3					
Vehicle-kms					
Arterials	506,286	162,133	471,314	58,597	1,198,330
Freeway	406,535	108,205	787,029	150,523	1,452,292
Total	912,821	270,338	1,258,343	209,120	2,650,622
Vehicle-hours					
Arterials	13,191	4,306	11,954	1,512	30,963
Freeway	4,715	1,258	9,015	1,728	16,716
Total	17,906	5,564	20,969	3,240	47,679
Operating Cost (NT$)					
Arterials	1,494,666	468,302	1,914,007	576,120	4,453,095
Freeway	929,821	279,349	2,959,819	1,040,496	5,209,485
Total	2,424,487	747,651	4,873,826	1,616,616	9,662,580

CON'T TABLE F-5

COMPUTER SUMMARY RESULTS FOR ENTIRE FREEWAY NETWORK

Toll Network, Toll Schedule, Year & Item	Daily Traffic Operating Results				
	Auto & Taxi	Light Truck	Heavy Truck	Express Bus	Total Vehicles
Schedule C_4					
Vehicle-kms					
Arterials	506,196	157,688	464,739	58,597	1,187,220
Freeway	409,105	112,269	789,640	150,523	1,461,537
Total	915,301	269,957	1,254,379	209,120	2,648,757
Vehicle-hours					
Arterials	13,176	4,197	11,757	1,512	30,642
Freeway	4,754	1,340	9,046	1,728	16,868
Total	17,930	5,537	20,803	3,240	47,510
Operating Cost (NT$)					
Arterials	1,493,653	455,910	1,882,428	576,120	4,408,111
Freeway	927,075	287,944	2,968,247	1,031,261	5,214,527
Total	2,420,728	743,854	4,850,675	1,607,381	9,622,638
1990					
Schedule C_4					
Vehicle-kms					
Arterials	6,260,087	1,176,142	2,597,654	183,947	10,217,830
Freeway	8,516,671	1,560,068	6,938,849	681,525	17,697,113
Total	14,776,758	2,736,210	9,536,503	865,472	27,914,943
Vehicle-hours					
Arterials	159,452	30,815	65,624	4,676	260,567
Freeway	99,670	18,277	82,292	7,930	208,169
Total	259,122	49,092	147,916	12,606	468,736
Operating Costs (NT$)					
Arterials	17,988,986	3,318,485	10,277,358	1,724,865	33,309,694
Freeway	19,449,460	4,124,583	26,465,457	4,775,652	54,815,152
Total	37,438,446	7,443,068	36,742,815	6,500,517	88,124,846

TABLE F-6

DAILY 1969 VOLUMES OF VEHICLES AT TOLL BARRIERS WITH VARIOUS TOLL CHARGES

Vehicle Type & Level of Toll	Freeway Barriers									
	Section I	Section II	Section III	North Barrier Section IV	South Barrier Section IV	Section V	North Barrier Section VI	Middle Barrier Section VI	South Barrier section VI	Section VII
Autos & Taxis										
No Charge	2,944	4,908	1,412	780	720	456	616	540	972	2,156
NT$10*	2,148	4,156	1,368	752	708	452	556	500	800	1,692
NT$15**	1,884	3,672	1,340	744	704	436	512	456	720	1,408
Light Trucks										
No Charge	696	940	432	280	288	144	204	208	300	596
NT$10*	500	756	404	268	288	136	184	196	252	432
NT$15**	384	604	352	268	280	120	164	164	204	336
Heavy Trucks										
No Charge	3,108	3,256	2,856	2,432	2,360	2,020	2,392	2,384	2,484	3,072
NT$15*	1,776	2,872	2,620	2,344	2,276	1,912	2,208	2,184	2,220	2,700
NT$20**	1,660	2,724	2,504	2,248	2,180	1,804	2,076	2,012	2,044	2,504
Bus										
No Charge	612	796	576	360	368	372	352	296	384	628
NT$40**	612	776	576	360	360	372	352	292	380	620

* Schedule B_2

** Schedule B_3

TABLE F-7

REDUCTIONS IN SECTION I HEAVY TRUCK OPERATING RESULTS*

Arterial System	
Vehicle-kms	352,176
Vehicle-hours	8,865
Veh. oper. costs (NT$)	1,384,416
Barrier System (B_3)	
Vehicle-kms	
Arterials	54,648
Freeway	295,099
Total	349,747
Vehicle-hours	
Arterials	8,015
Freeway	3,801
Total	11,816
Veh. oper. costs (NT$)	
Arterials	242,880
Freeway	1,309,440
Total	1,552,320
Closed System (C_4)	
Vehicle-kms	
Arterials	54,648
Freeway	295,099
Total	349,747
Vehile-hours	
Arterials	8,015
Freeway	3,801
Total	11,816
Veh. oper. costs (NT$)	
Arterials	242,880
Freeway	1,226,544
Total	1,469,424

* Daily 1990 truck volumes reduced by 12,144.

TABLE F-8

SECTION II AIRPORT TRAFFIC – 1990*

	Vehicle Categories			
	Auto & Taxi	Light Truck	Heavy Truck	Express Bus
Arterial System				
Vehicle-kms	880,300	32,200	64,400	95,100
Vehicle-hrs	24,500	890	1,630	1,950
Veh. oper.cost (NT$)	2,893,000	116,000	319,000	1,128,000
Barrier System (B_3)				
Vehicle-kms**	661,870	24,200	48,400	72,600
Vehicle-hrs	7,302	267	534	646
Veh. oper. costs (NT$)	1,641,000	74,000	220,000	588,000
Closed System (C_4)				
Vehicle-kms**	661,870	24,200	48,400	72,600
Vehicle-hrs	7,302	267	534	646
Veh. oper. costs (NT$)	1,586,300	69,000	214,000	573,000

* Daily volumes: Autos & Taxis – 27,350
Light Trucks – 1,000
Heavy Trucks – 2,000
Buses – 3,000
Total mixed vehicles – 33,350

** Freeway only; no travel via arterials would be necessary.

CHAPTER III

APPENDICES

Appendix A
TOLL ROAD COSTS

CONSTRUCTION AND PROPERTY COSTS

Unit Costs

Unit costs for construction and property are shown in Table A-1. They are identical to those in the feasibility study, which were based on 1969 prices.

Barrier System

Construction and property costs for each of seven freeway sections and for the entire freeway are indicated in Tables A-2 through A-10 for barrier system.

Stage construction costs used the same concept as the feasibility study in that the additional lanes were considered to be added on the inside (in the median) for surfacing and structural widths.

Interchange types were considered to be the same as previously indicated in the feasibility study except that their locations would conform with those in Exhibit 15. The toll facilities were costed for four, six, and eight lanes based on the known estimated cost for the final design of the barrier toll plaza just south of Taipei with the cost of the freeway lanes through the toll plaza deducted.

Preliminary cost estimates for Section I-A, from Keelung to Neihu, were nearly the same as in the feasibility study, so that the feasibility study figures of construction and property costs were used, with the addition of one barrier toll plaza.

Section I-B was re-estimated using the latest preliminary cost figures. The construction costs have almost doubled due to the additional lengths of the Tamshui River Bridge and a single Keelung River crossing near Neihu. The change in concept required a change in alignment and a high steel bridge over the Keelung River near the Grand Hotel.

Other factors, contributing to the increase in costs, were the extra fill requirements, due to the holding of a rigid height and horizontal alignment for the combination of freeway and levee throughout Taipei and the necessity of obtaining this fill by dredging material from the Tamshui River or from "ripping" operations on nearby soft rock materials. All construction in this section will be completed in one stage. Property costs were reduced by about 24 percent, due to the realignment along a lengthy structure near the Grand Hotel in Taipei.

The contractors' bid prices were very close to the feasibility study estimates for the Sanchung to Chungli section, so that the feasibility costs were again used for Section II, with the addition of a barrier toll plaza, and with adjustments to interchange and property costs. Staging costs would still be close to those originally anticipated, as the future international airport, would offset the rescheduling of structural widening costs, which would actually be done during stage 1.

The costs for Sections III through VI were not altered from the estimates of the feasibility study, except for adjustments to construction and property costs, resulting from the elimination of some interchanges and structures, and the addition of barrier toll plazas.

Section VII cost estimates reflect the feasibility study estimate for the east alternative, with adjustments in the construction and property costs, due to a decrease in the number of interchanges and structures, and the addition of barrier toll plazas.

The total construction and property cost for the freeway with the barrier toll collection network is estimated at NT$24,119 million (this includes the costs of access roads); the comparable cost with the closed system would be NT$24,980 million, or about 3.5 percent higher than with the barrier system. If the cost estimated in the feasibility study for a toll-free facility were adjusted for Section I cost rises and for selection of the east alternative in Section VII, then the total right-of-way and construction cost would have been estimated at NT$24,847 million. Thus, the estimated cost of the freeway with the barrier system would be about 2.9 percent lower than the adjusted estimate for the toll-free facility, meaning that the cost reductions brought about by the necessary elimination of some interchanges, in converting the freeway to a toll facility, were slightly greater than the cost increases resulting from the addition of toll plazas.

Closed System

The ground rules for estimating costs were basically the same as for the barrier system, in that the feasibility costs were used, along with latest updated costs for Section I-A, adjustments to construction and property costs for interchanges and roadway structures, and the addition of toll plaza facilities.

Toll plaza facility costs included additional lanes, lighting, signing, drainage and toll booth buildings and interchange treatment as shown in Exhibits 45 and 46. An at-grade intersection with the crossroad was used at all crossroads designated as two-lane in the feasibility study. A small trumpet at the crossroad was used at all connections with four-lane crossroads.

Toll-free interchanges (indicated with a circle in Exhibit 4) were considered to be of the same type as used for the barrier system, and for the toll-free facility. Barrier toll plazas at locations shown in Exhibit 4 were also included in the toll facilities cost.

Total construction and property costs for the closed system are shown in Table A-11. The total cost for all sections for the closed system, excluding access roads, is NT$24,478 million which is 5 percent more than for the barrier system.

Alternative Highways

These are highways that would be required to be built to accommodate traffic to 1990 if the freeway were not constructed.

Alternative highway costs are shown in Tables A-12 through A-18 for Sections I through VII, respectively. Except for some of the opening dates which were rescheduled in line with the revised scheduling for completion of the freeway, these tables are the same as those used in the feasibility study with property, construction, and maintenance costs (for the year 1982) indicated. One exception, however, occurs in Section I. The expressway cost for Section I, which was considered as having an alignment, capacity and a design similar to, but of a lower standard than, the freeway from Sanchung to Neihu, was adjusted upwards for a more accurate comparison. Its cost was increased in proportion to the increase in cost of the freeway for relevant items, such as bridges and earthwork. Other modifications were made in Sections II, IV, V and VII as noted below in "Highways Under Construction".

Highways with the Freeway

These are highways that would be required along with the freeway to meet 1990 traffic requirements. Highways with the freeway are shown in Tables A-19 through A-23 for Sections III through VII respectively and are the same as those used in the feasibility study, except that adjustments were made in Sections II, IV, V and VII as noted below in "Highways Under Construction".

Highways Under Construction

Highways under construction or approved for construction, which are within the scope of this study, are shown in Table A-24 with construction and property costs and opening dates indicated. This information, supplied by the Taiwan Highway Bureau, and not known during the preparation of the feasibility study, was necessary for making cost adjustments to highways with and without the freeway.

Summary of Highway Costs

Total construction and property costs, with costs per kilometer, are shown in Table A-25.

MAINTENANCE AND OPERATING COSTS

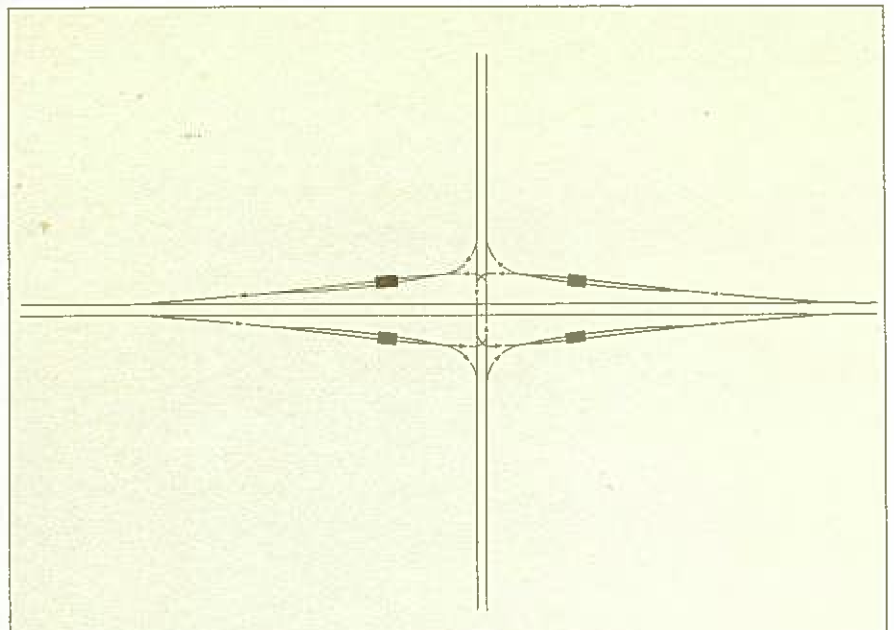
Development of Annual Costs

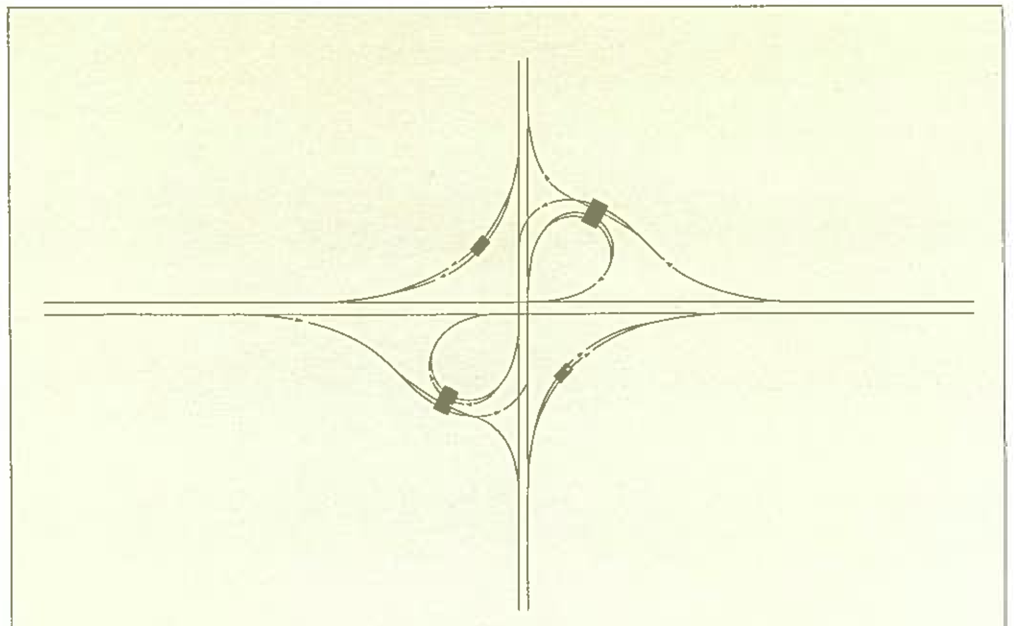
All maintenance costs were developed annually, using 1969 as a base year, and are comparable to toll roads in the United States of similar lengths and conditions.

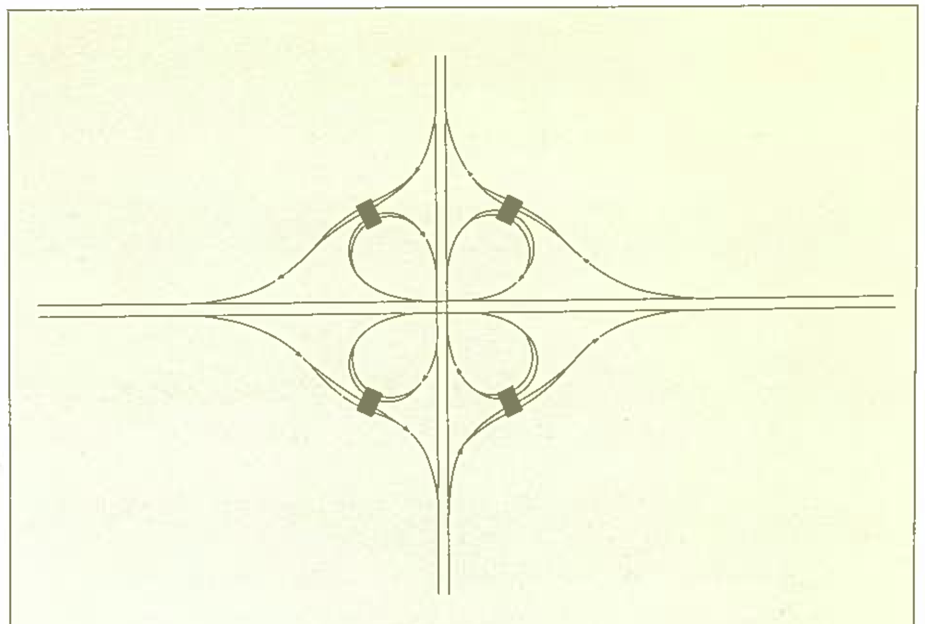
Personnel and Labor

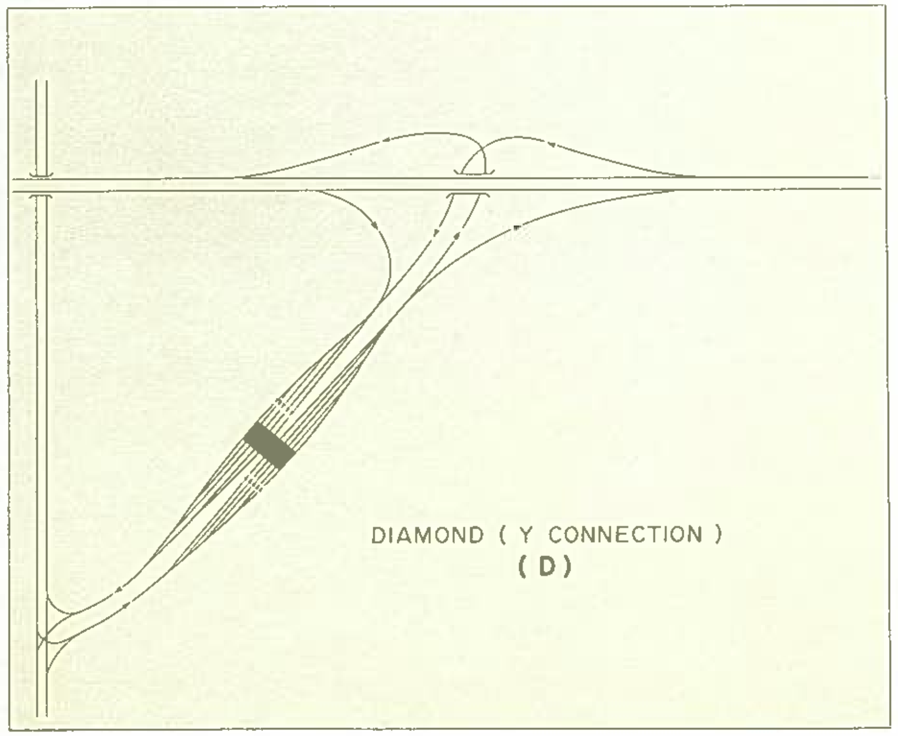
Annual personnel and labor costs required for administration and maintenance of the freeway amounted to NT$10,092,000. This cost would be the same for a barrier or closed system.

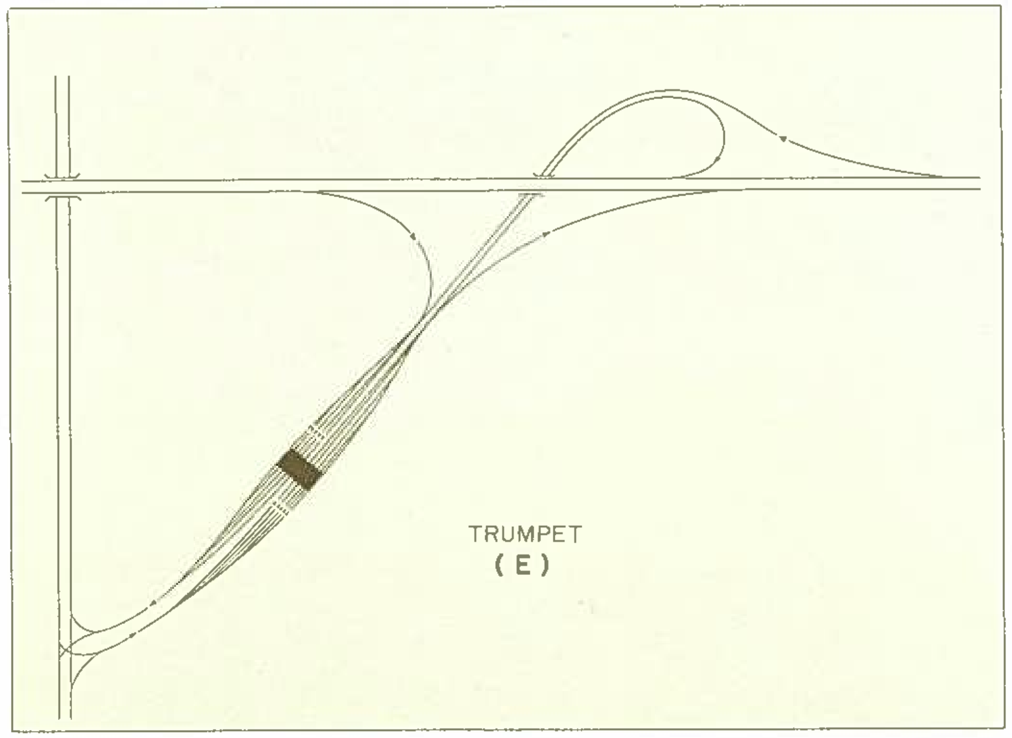
Toll collection personnel are listed for both the barrier and closed system in Table A-26. Toll collection costs for the barrier system amount to NT$10,096,000 or

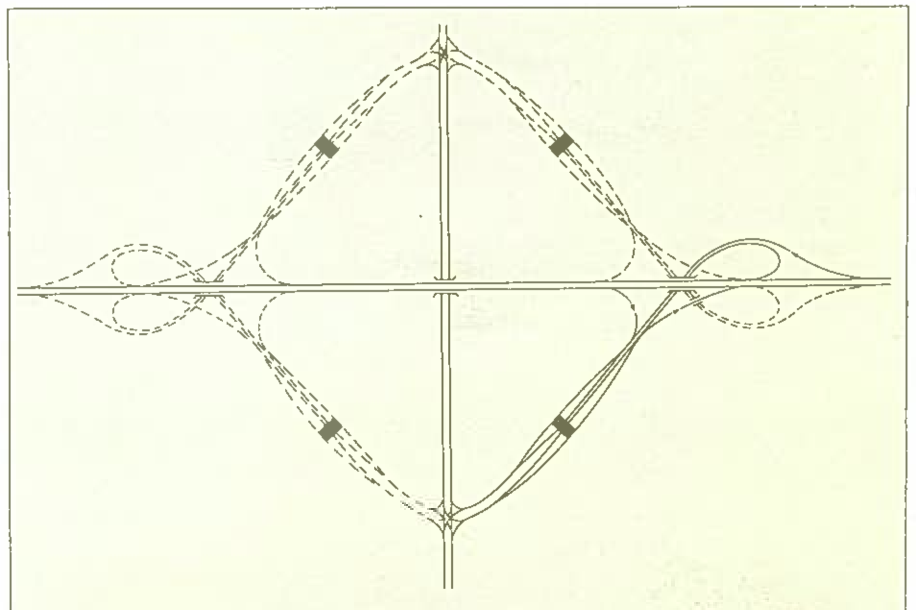

DIAMOND
(A)


PARCLO
(B)


CLOVERLEAF
(C)


DIAMOND (Y CONNECTION)
(D)

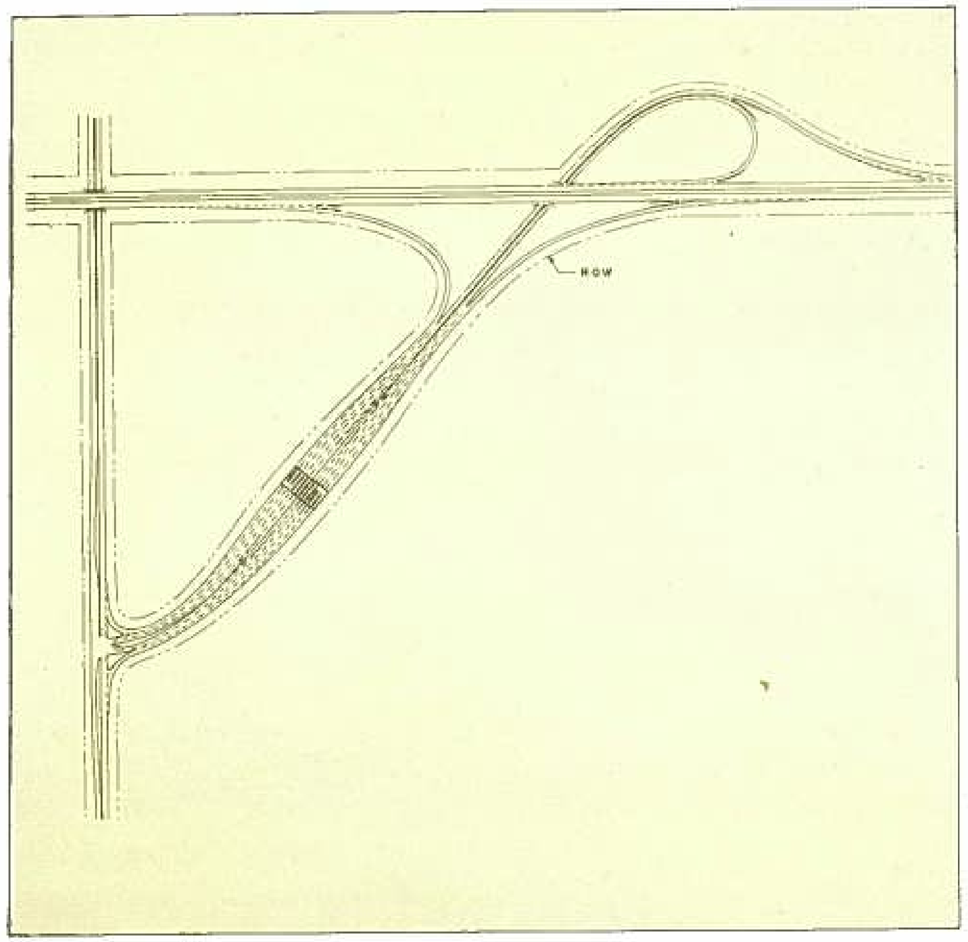

TRUMPET
(E)


TRUMPET (VARIOUS LOCATIONS)
(F)

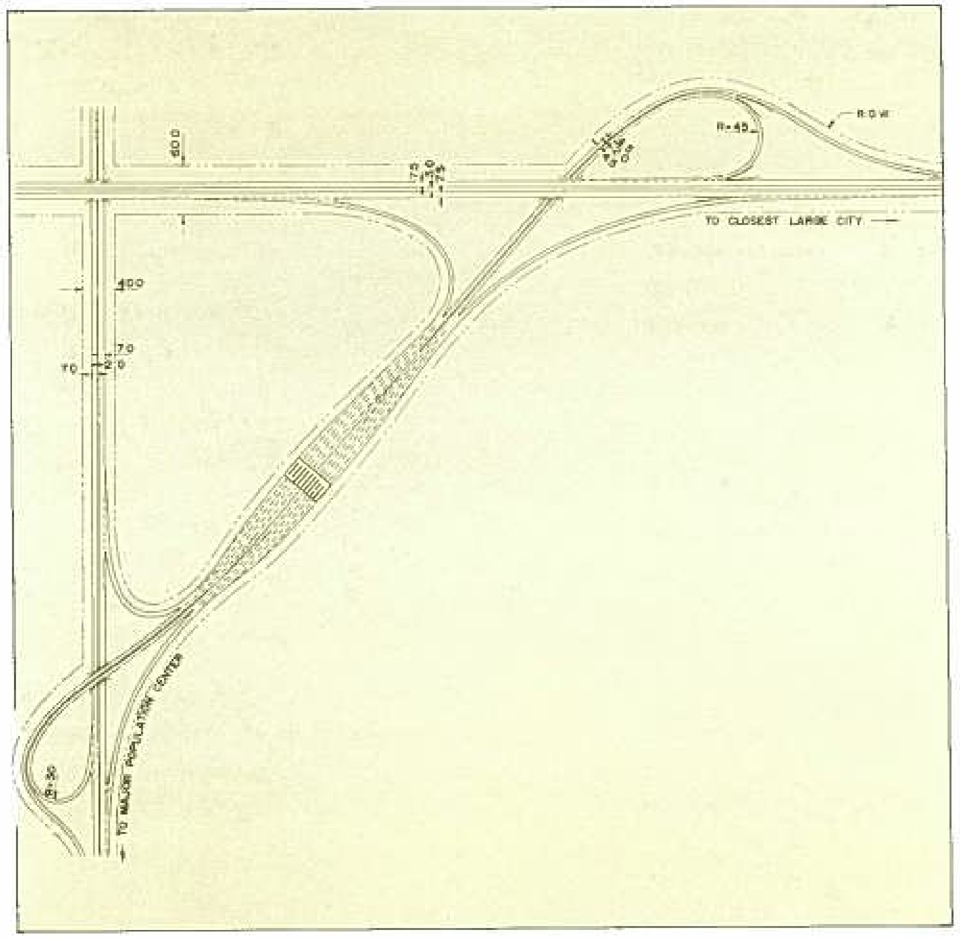
COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN

TYPICAL CLOSED SYSTEM INTERCHANGES

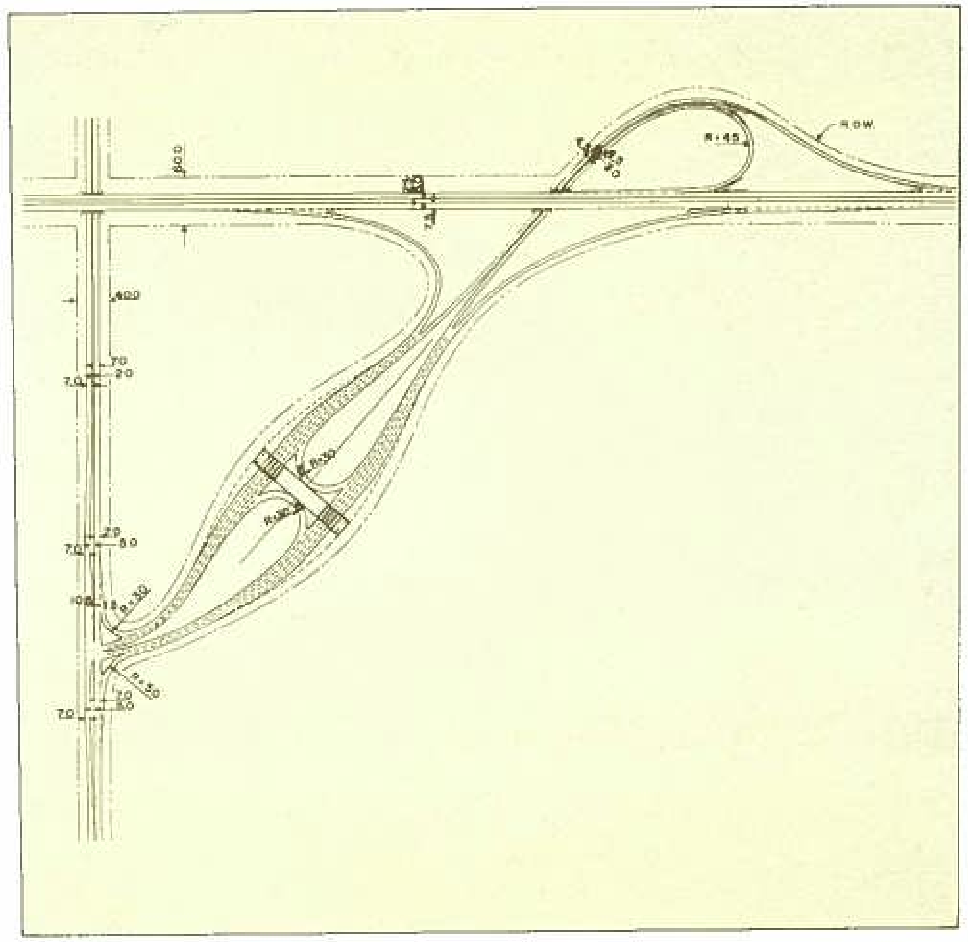
DE LEUW, CATHER INTERNATIONAL-CHICAGO



ALTERNATIVE 1



ALTERNATIVE 2



ALTERNATIVE 3

SCALE IN METERS
0 100 200 300 400

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
CLOSED SYSTEM TRUMPET INTERCHANGE
DE LEUW, CATHER INTERNATIONAL-CHICAGO

about NT$40,000 per kilometer. The toll collection costs for the closed system would be NT$15,158,000 or about 50 percent higher than for the barrier system. This increase occurs because about 390 toll collectors would be required for the closed system, as compared to only 240 for the barrier system, since there would be a greater number of toll booths with the closed system.

Equipment

Annual costs for equipment would be the same for both systems and are shown in Table A-27 to amount to NT$16,611,000. The items listed are used on similar facilities in the United States. Costs and taxes have been adjusted to 1969 Taiwan values.

Materials

Annual costs of materials, as shown in Table A-28, would amount to NT$19,102,000. Of interest, is the fact that patching and resurfacing (asphalt concrete) would amount to nearly 40 percent of the total cost. This cost may be reduced somewhat if concrete surfacing is used. Pavement striping, bridge repairs, utilities and utilities maintenance are other major items amounting to an additional 48 percent of the materials cost.

Summary

Total annual maintenance and operating costs and their relative proportions for both the barrier and closed systems are indicated in Table A-29. The closed system would cost about 9 percent more than the barrier system to operate and maintain. The barrier system costs are proportioned into equal thirds for personnel, equipment, and materials, whereas the closed system is weighted a little more heavily (40 percent) towards personnel and labor. Annual cost per kilometer would be NT$ 149,000 with the barrier system.

Table-graph A-30 shows the anticipated growth trend per year for 20 years based on experience on United States turnpikes. Growth rates for the 20-year period were superimposed on a base year of 1975. The sharp rise after eight years is attributed to asphalt resurfacing and might be modified slightly if concrete is used. However, toll collection costs have an even sharper rise than maintenance cost, because of the substantial effects of traffic growth.

CONSTRUCTION SCHEDULES

The proposed freeway construction schedule is shown in Table A-31. Opening dates have been adjusted backward from the feasibility study. Section lengths have been adjusted for the latest known information for Sections I, II and VII. The proposed highway improvement schedule for freeway and other highways is shown in Table A-32 and Exhibit 47 and the schedule for alternative highways is shown in Table A-33 and Exhibit 48. Highway Sections, dates and locations have been adjusted to include the information in Table A-31.

SUMMARY OF IMPROVEMENT COSTS FOR ALL HIGHWAYS

Tables summarizing the property, construction and maintenance costs for the barrier system from 1971 to 1995 are shown for the improvements with freeway for Sections I through VII in Tables A-34 through A-40. The time period was extended from 1990 to 1995 because the average completion time is 1975 and the life for freeway is taken as 20 years.

All property is assumed to be purchased prior to the construction of stage 1 with construction costs proportionally allocated for two or more years prior to construction completion. Costs for stage 2 are allocated to the year previous to construction completion and appear about midway down the table.

Taxes were included in all of the original cost estimates, and various tax factors had to be applied to arrive at the costs without (w/o) tax. Tax percentages were the same as those used in the feasibility study. They vary somewhat from section to section but they average approximately as follows:

- 33% on property costs
- 10% on costs of construction
- 10% on costs of maintenance and operations

Table A-41 summarizes all costs with and without taxes for all sections of the barrier system.

The summary of all costs with and without taxes for the closed system is shown in Table A-42.

Alternative highways costs, with and without taxes are summarized in Tables A-43 through A-49.

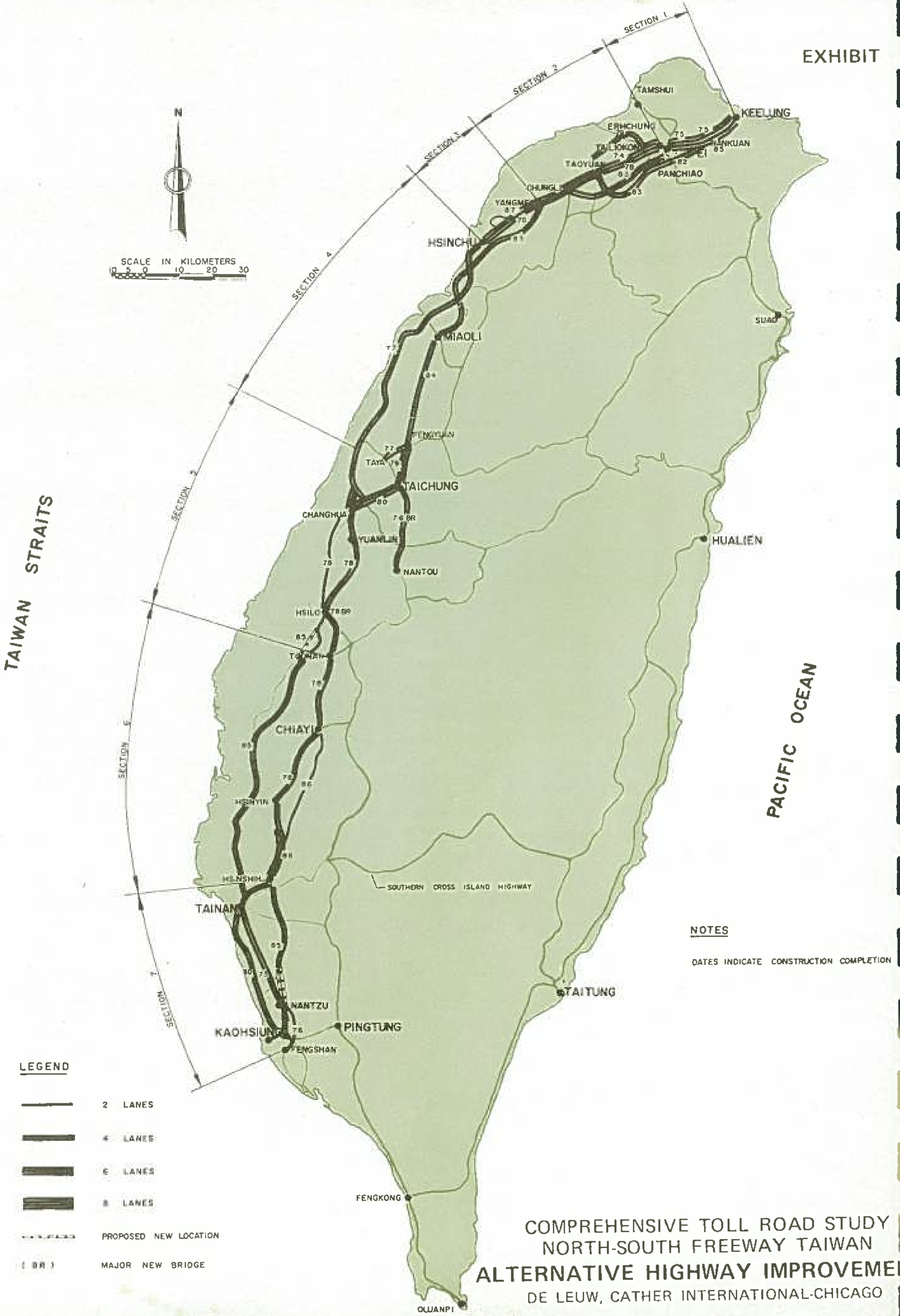
TOLL BOOTHS AT INTERCHANGES FOR THE CLOSED SYSTEM

Toll facility arrangements for the closed system for six different interchange types are shown in Exhibit 45 with suggested arrangements and locations for toll booths.

EXHIBIT 47

COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
FREEWAY AND HIGHWAY IMPROVEMENTS
DE LEUW, CATHER INTERNATIONAL-CHICAGO

EXHIBIT 48



COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN
ALTERNATIVE HIGHWAY IMPROVEMENTS
DE LEUW, CATHER INTERNATIONAL-CHICAGO

These toll booth arrangements could be added to presently proposed interchanges or included in future interchanges if the closed system were chosen. They include the full diamond, partial cloverleaf, full cloverleaf, partial diamond and trumpet.

Schemes A, B and C could have toll booths constructed at interchange ramps, requiring four separate toll plazas to intercept all traffic to and from the freeway.

Schemes D and E, the half-diamond, and trumpet, types, would intercept traffic at one location only.

Schemes D and E have the advantage of requiring only one large single intercepting toll booth area instead of four as in Schemes A, B and C, but they do, however, have the disadvantage of requiring an additional structure. The right-of-way requirements would be slightly more with schemes D or E than with Schemes A, B or C, but the areas between the connecting road and the crossroad could be utilized as a maintenance area or parking area.

The single toll booth area in Schemes D and E appears to be the preferable arrangement. Scheme E was chosen as the most desirable of all alternatives, because of its directness of access, and was subsequantly used for cost estimates.

Layout F shows the arrangement of the Scheme E interchange in the four quadrants for a crossroad and the freeway. The chosen quadrants would allow the interchange connection to conform with the major traffic flow. For example, in layout F, if the freeway were running east and west with the closest major city toward the east, and the largest population being served in the south, then the southeast quadrant should be chosen for location of the toll booths, as indicated with the solid lines.

TRUMPET INTERCHANGE DETAILS FOR THE CLOSED SYSTEM

Exhibit 46. Alternative 1 shows a connection with a four-lane crossroad. An at-grade intersection would be sufficient to accommodate traffic at minor or two-lane crossroads.

A connection with a four-lane or six-lane crossroad as shown in Exhibit 46. Alternative 2 was considered as a major connection and would be required to accommodate relatively heavy traffic volumes. Subsequently a small trumpet interchange was proposed and assumed for cost estimates.

Exhibit 46. Alternative 3 shows a bus terminal incorporated into the toll area. Express buses from both directions along the freeway could drop off and pick up passengers at the terminal while local buses could transfer them to local destinations. This bus terminal could also be constructed without the toll plaza.

TABLE A-1

UNIT CONSTRUCTION AND PROPERTY COSTS

Item No.	Description	Unit	Cost NT$	Cost US$
1	Asphalt Concrete	Ton	480	12.00
2	Granular Material "A"	M^3	190	4.75
3	Granular Material "B"	"	140	3.50
4	Curb	m	300	7.50
5	Top Soil	m	50	1.25
6	Clearing and Grubbing			
	Rice Paddies	m^2	3	0.075
	Urban Area	"	5	0.125
	Forested Area	"	7	0.175
7	Guard Rail	M	186	4.64
8	Fencing			
	Woven Wire	M	600	15.00
	Barbed Wire	M	100	2.50
9	Earthwork			
	Earthwork Excavation	M^3	14	0.35
	Soft Rock Excavation	"	24	0.60
	Sound Rock Excavation	"	66	1.65
	Compaction	"	7	0.175
10	Haul			
	3 km	M^3	13	0.325
	5 km	"	19	0.475
	10 km	"	35	0.875
	15 km	"	50	1.25
11	Bridges			
	Road	M^2	4,600	115.00
	Drainage - Low Structure	"	5,000	125.00
	- High Structure	"	6,000	150.00
12	Tunnels			
	3 lane - with ventilation	M	132,000	3,300
	- without ventilation	"	100,000	2,500
13	Utility Relocation	Each		
	Power Transmission Line	Tower	300,000	7,500
	Oil Pipe Line	M	2,400	60
	Main Water Line	"	3,600	90
	Telephone Line	"	400	10
	Sugar Refineries Railroad	"	640	16
14	Property Costs			
	R.C. Buildings - Residental	M^2	1200-3000	30-75
	- Commercial	"	3000-3200	75-80
	- Industrial	"	1000-1600	25-40
	Wooden Buildings		600-1200	15-30
	Lane - Urban	M^2	600-3600	15-90
	- Rural - Rice	"	80- 480	2-12
	- Forested	"	20- 100	0.5- 2.5

TABLE A-2

BARRIER SYSTEM
COST ESTIMATE OF SECTION I-A

(NT$ Thousands)

Item	Stage 1	Stage 2	Total
1. Clearing and Grubbing	3,440		3,440
2. Roadway Surfacing	105,700	21,140	126,840
3. Guard Rail	2,960		2,960
4. Fencing	3,040		3,040
5. Earthwork	64,880		64,880
6. Utility Relocation	24,960		24,960
7. Drainage	4,160	1,840	6,000
8. Stage Construction		1,056	1,056
9. Signing	2,732	548	3,280
10. Lighting	4,236	844	5,080
11. Landscaping	2,096	424	2,520
12. Interchanges	36,400		36,400
13. Frontage Roads and Road Relocation	31,320		31,320
14. Toll Plaza & Facilities	29,160		29,160
15. Miscellaneous — Includes Rest Areas, Service Areas, Weight Stations and Bus Stations	10,564	2,116	12,680
TOTAL ROADWAY COSTS	325,648	27,968	353,616
16. Bridges - Roadway	67,160	22,600	87,960
17. Bridges - Drainage	87,905	44,675	132,580
18. Retaining Walls Tunnels	45,000	44,000	89,000
TOTAL STRUCTURAL COSTS	200,065	111,275	311,340
19. Engineering Costs and Emergencies 20%	105,142	27,849	132,991
TOTAL CONSTRUCTION COST	630,855	167,092	797,947
20. Property Costs for Freeway and Interchanges	208,740		208,740
TOTAL HIGHWAY IMPROVEMENT COST	839,595	167,092	1,006,687
21. Access Road			
- Construction Costs			
- Property Costs			
TOTAL COSTS FOR ACCESS ROADS			

TABLE A-3

BARRIER SYSTEM
COST ESTIMATE OF SECTION I-B

(NT$ Thousands)

Item	Stage 1	Total
1. Clearing and Grubbing	5,900	5,900
2. Roadway Surfacing	80,188	80,188
3. Guard Rail	5,249	5,249
4. Fencing	12,244	12,244
5. Earthwork	251,020	251,020
6. Utility Relocation	26,701	26,701
7. Drainage	22,168	22,168
8. Stage Construction		
9. Signing	5,804	5,804
10. Lighting	6,134	6,134
11. Landscaping	1,700	1,700
12. Interchanges	173,262	173,262
13. Frontage Roads and Road Relocation	1,055	1,055
14. Toll Plaza & Facilities		
15. Miscellaneous — Includes Rest Areas, Service Areas, Weight Stations and Bus Stations	12,934	12,934
TOTAL ROADWAY COSTS	604,359	604,359
16. Bridges - Roadway	1,247,400	1,247,400
17. Bridges - Drainage	8,306	8,306
18. Retaining Walls Tunnels	18,600	18,600
TOTAL STRUCTURAL COSTS	1,274,306	1,274,306
19. Engineering Costs and Emergencies 20%	375,733	375,733
TOTAL CONSTRUCTION COST	2,254,398	2,254,398
20. Property Costs for Freeway and Interchanges	848,313	848,313
TOTAL HIGHWAY IMPROVEMENT COST	3,102,711	3,102,711
21. Access Road		
- Construction Costs		
- Property Costs		
TOTAL COSTS FOR ACCESS ROADS	5,300	5,300

TABLE A-4

BARRIER SYSTEM
COST ESTIMATE OF SECTION II

(NT$ Thousands)

Item	Stage 1	Stage 2	Total
1. Clearing and Grubbing	12,320	–	12,320
2. Roadway Surfacing	317,480	27,560	345,040
3. Guard Rail	11,680	–	11,680
4. Fencing	13,600	–	13,600
5. Earthwork	459,320	–	459,320
6. Utility Relocation	10,000	–	10,000
7. Drainage	23,800	–	23,800
8. Stage Construction	–	1,360	1,360
9. Signing	8,240	720	8,960
10. Lighting	12,680	1,120	13,800
11. Landscaping	6,360	560	6,920
12. Interchanges	130,270	–	130,270
13. Frontage Roads and Road Relocation	16,160	–	16,160
14. Toll Plaza & Facilities	40,130	–	40,130
15. Miscellaneous – Includes Rest Areas, Service Areas, Weight Stations and Bus Stations	31,760	2,760	34,520
16. TOTAL ROADWAY COSTS	1,093,800	34,080	1,127,880
16. Bridges - Roadway	83,000	8,000	91,000
17. Bridges - Drainage	383,000	131,440	514,440
18. Retaining Walls Tunnels	–	–	–
TOTAL STRUCTURAL COSTS	466,000	139,440	605,440
19. Engineering Costs and Emergencies 20%	311,960	34,704	346,664
TOTAL CONSTRUCTION COST	1,871,760	208,224	2,079,984
20. Property Costs for Freeway and Interchanges	949,360	–	949,360
TOTAL HIGHWAY IMPROVEMENT COST	2,821,120	208,224	3,029,344
21. Access Road			
- Construction Costs	116,280	–	116,280
- Property Costs	282,160	–	282,160
TOTAL COSTS FOR ACCESS ROADS	398,440	–	398,440

TABLE A-5

BARRIER SYSTEM
COST ESTIMATE OF SECTION III

(NT$ Thousands)

Item	Stage 1	Stage 2	Total
1. Clearing and Grubbing	4,612	–	4,612
2. Roadway Surfacing	151,060	30,212	181,272
3. Guard Rail	2,908	–	2,908
4. Fencing	5,516	–	5,516
5. Earthwork	208,348	–	208,348
6. Utility Relocation	4,380	–	4,380
7. Drainage	21,400	–	21,400
8. Stage Construction	–	1,512	1,512
9. Signing	3,928	784	4,712
10. Lighting	6,044	1,208	7,252
11. Landscaping	3,020	604	3,624
12. Interchanges	12,000	–	12,000
13. Frontage Roads and Road Relocation	11,880	–	11,880
14. Toll Plaza & Facilities	29,160	–	29,160
15. Miscellaneous – Includes Rest Areas, Service Areas, Weight Stations and Bus Stations	15,108	3,020	18,128
TOTAL ROADWAY COSTS	479,364	37,340	516,704
16. Bridges - Roadway	48,196	8,556	56,752
17. Bridges - Drainage	137,696	68,852	206,548
18. Retaining Walls Tunnels			
TOTAL STRUCTURAL COSTS	185,892	77,408	263,300
19. Engineering Costs and Emergencies 20%	133,051	22,950	156,001
TOTAL CONSTRUCTION COST	798,307	137,698	936,005
20. Property Costs for Freeway and Interchanges			
TOTAL HIGHWAY IMPROVEMENT COST	1,036,063	137,698	1,173,761
21. Access Road			
- Construction Costs	4,540	–	4,540
- Property Costs	3,200		3,200
TOTAL COSTS FOR ACCESS ROADS	7,740		7,740

TABLE A-6

BARRIER SYSTEM
COST ESTIMATE OF SECTION IV

(NT$ Thousands)

Item	Stage 1	Stage 2	Total
1. Clearing and Grubbing	17,912	–	17,912
2. Roadway Surfacing	524,940	7,280	532,220
3. Guard Rail	22,348	–	22,348
4. Fencing	22,344	–	22,344
5. Earthwork	822,400	–	822,400
6. Utility Relocation	32,200	–	32,200
7. Drainage	50,560	–	50,560
8. Stage Construction	–	364	364
9. Signing	13,648	–	13,648
10. Lighting	20,996	292	21,288
11. Landscaping	10,484	160	10,644
12. Interchanges	90,800	–	90,800
13. Frontage Roads and Road Relocation	16,632	–	16,632
14. Total Plaza & Facilities	34,384	–	34,384
15. Miscellaneous – Includes Rest Areas, Service Areas, Weight Stations and Bus Stations	52,504	720	53,224
TOTAL ROADWAY COSTS	1,732,152	8,816	1,740,968
16. Bridges - Roadway	154,688	8,400	163,088
17. Bridges - Drainage	850,480	680	851,160
18. Retaining Walls Tunnels	–	–	–
TOTAL STRUCTURAL COSTS	1,005,168	9,080	1,014,248
19. Engineering Costs and Emergencies 20%	547,464	3,579	551,043
TOTAL CONSTRUCTION COST	3,284,784	21,475	3,306,259
20. Property Costs for Freeway and Interchanges	586,984	–	586,984
TOTAL HIGHWAY IMPROVEMENT COST	3,871,768	21,475	3,893,243
21. Access Road			
- Construction Costs	248,008	–	248,008
- Property Costs	85,380	–	85,380
TOTAL COSTS FOR ACCESS ROADS	333,388	–	333,388

TABLE A-7

BARRIER SYSTEM
COST ESTIMATE OF SECTION V

(NT$ Thousands)

Item	Stage 1	Stage 2	Total
1. Clearing and Grubbing	12,360	–	12,360
2. Roadway Surfacing	405,800	27,800	433,600
3. Guard Rail	20,920	–	20,920
4. Fencing	18,200	–	18,200
5. Earthwork	708,200	–	708,200
6. Utility Relocation	27,040	–	27,040
7. Drainage	29,760	–	29,760
8. Stage Construction	–	1,400	1,400
9. Signing	10,560	720	11,280
10. Lighting	16,240	1,120	17,360
11. Landscaping	8,120	560	8,680
12. Interchanges	79,200	–	79,200
13. Frontage Roads and Road Relocation	18,160	–	18,160
14. Toll Plaza & Facilities	17,192	–	17,192
15. Miscellaneous – Includes Rest Areas, Service Areas, Weight Stations and Bus Stations	40,560	2,800	43,360
TOTAL ROADWAY COSTS	1,412,312	34,400	1,446,712
16. Bridges - Roadway	196,391	13,520	209,911
17. Bridges - Drainage	740,320	81,600	821,920
18. Retaining Walls Tunnels	–	–	–
TOTAL STRUCTURAL COSTS	936,711	95,120	1,031,831
19. Engineering Costs and Emergencies 20%	469,805	25,904	495,709
TOTAL CONSTRUCTION COST	2,818,828	155,424	2,974,252
20. Property Costs for Freeway and Interchanges	871,480	–	871,480
TOTAL HIGHWAY IMPROVEMENT COST	3,690,308	155,424	3,845,732
21. Access Road			
- Construction Costs	56,240	–	56,240
- Property Costs	106,560	–	106,560
TOTAL COSTS FOR ACCESS ROADS	162,800	–	162,800

TABLE A-8

BARRIER SYSTEM
COST ESTIMATE OF SECTION VI

(NT$ Thousands)

Item	Stage 1	Stage 2	Total
1. Clearing and Grubbing	13,155	–	13,155
2. Roadway Surfacing	497,812	–	497,812
3. Guard Rail	15,980	–	15,980
4. Fencing	20,400	–	20,400
5. Earthwork	1,212,300	–	1,212,300
6. Utility Relocation	26,044	–	26,044
7. Drainage	37,680	–	37,680
8. Stage Construction	–	–	–
9. Signing	12,944	–	12,944
10. Lighting	19,912	–	19,912
11. Landscaping	9,956	–	9,956
12. Interchanges	79,800	–	79,800
13. Frontage Roads and Road Relocation	50,560	–	50,560
14. Toll Plaza & Facilities	51,576	–	51,576
15. Miscellaneous – Includes Rest Areas, Service Areas, Weight Stations and Bus Stations	49,782	–	49,782
TOTAL ROADWAY COSTS	2,097,901	–	2,097,901
16. Bridges - Roadway	190,026	–	190,026
17. Bridges - Drainage	404,334	–	404,334
18. Retaining Walls Tunnels	–	–	–
TOTAL STRUCTURAL COSTS	594,360	–	594,360
19. Engineering Costs and Emergencies 20%	538,452	–	538,452
TOTAL CONSTRUCTION COST	3,230,713	–	3,230,713
20. Property Costs for Freeway and Interchanges	231,412	–	231,412
TOTAL HIGHWAY IMPROVEMENT COST	3,462,125	–	3,462,125
21. Access Road			
- Construction Costs	18,920	–	18,920
- Property Costs	2,464	–	2,464
TOTAL COSTS FOR ACCESS ROADS	21,384	–	21,384

TABLE A-9

BARRIER SYSTEM
COST ESTIMATE OF SECTION VII

(NT$ Thousands)

Item	Stage 1	Stage 2	Total
1. Clearing and Grubbing	10,200	–	10,200
2. Roadway Surfacing	249,000	51,000	300,000
3. Guard Rail	34,000	–	34,000
4. Fencing	33,000	–	33,000
5. Earthwork	660,000	–	660,000
6. Utility Relocation	28,200	–	28,200
7. Drainage	150,000	–	150,000
8. Stage Construction	–	3,900	3,900
9. Signing	6,720	1,280	8,000
10. Lighting	26,880	5,120	32,000
11. Landscaping	7,800	1,600	9,400
12. Interchanges	130,000	–	130,000
13. Frontage Roads and Road Relocation	10,000	–	10,000
14. Toll Plaza & Facilities	35,000	–	35,000
15. Miscellaneous – Includes Rest Areas, Service Areas, Weight Stations and Bus Stations	14,110	2,890	17,000
TOTAL ROADWAY COSTS	1,394,910	65,790	1,460,700
16. Bridges - Roadway	235,720	28,980	264,700
17. Bridges - Drainage	120,600	59,400	180,000
18. Retaining Walls Tunnels	–	–	–
TOTAL STRUCTURAL COSTS	356,320	88,380	444,700
19. Engineering Costs and Emergencies 20%	350,246	30,834	381,080
TOTAL CONSTRUCTION COST	2,101,476	185,004	2,286,480
20. Property Costs for Freeway and Interchanges	1,153,900	–	1,153,900
TOTAL HIGHWAY IMPROVEMENT COST	3,255,376	185,004	3,440,380
21. Access Road			
- Construction Costs	60,000	–	60,000
- Property Costs	176,300	–	176,300
TOTAL COSTS FOR ACCESS ROADS	236,300	–	236,300

TABLE A-10

BARRIER SYSTEM
CONSTRUCTION AND PROPERTY COSTS

(NT$ Thousands)

Item	IA 14.7	IB 13.6	II 41.7	III 21.56	IV 85.92	V 64.4	VI 77.3	VII 55.85	Total 375.05
1. Clearing and Grubbing	3,440	5,900	12,320	4,612	17,912	12,360	13,155	10,200	79,899
2. Roadway Surfacing	126,840	80,188	345,040	181,272	532,220	433,600	497,812	300,000	2,496,972
3. Guard Rail	2,960	5,249	11,680	2,908	22,348	20,920	15,980	34,000	116,045
4. Fencing	3,040	12,244	13,600	5,516	22,344	18,200	20,400	33,000	128,344
5. Earthwork	64,880	251,020	459,320	208,348	822,400	708,200	1,212,300	660,000	4,386,468
6. Utility Relocation	24,960	26,701	10,000	4,380	32,200	27,040	26,044	28,200	179,525
7. Drainage	6,000	22,168	23,800	21,400	50,560	29,760	37,680	150,000	341,368
8. Stage Construction	1.056	–	1,360	1,512	364	1,400	–	3,900	9,592
9. Signing	3,280	5,804	8,960	4,712	13,648	11,280	12,944	8,000	68,628
10. Lighting	5,080	6,134	13,800	7,252	21,288	17,360	19,912	32,000	122,826
11. Landscaping	2,520	1,700	6,920	3,624	10,644	8,680	9,956	9,400	53,444
12. Interchanges	36,400	173,262	130,270	12,000	90,800	79,200	79,800	130,000	731,732
13. Frontage Roads and Road Relocation	31,320	1,055	16,160	11,880	16,632	18,160	50,560	10,000	155,767
14. Toll Plaza and Facilities	29,160	–	40,130	29,160	34,384	17,192	51,576	35,000	236,602
15. Miscellaneous – Includes Rest Areas, Service Areas, Weight Stations and Bus Stations	12,680	12,934	34,520	18,128	53,224	43,360	49,782	17,000	241,628
TOTAL ROADWAY COSTS	353,616	604,359	1,127,880	516,704	1,740,968	1,446,712	2,097,901	1,460,700	9,348,840
16. Bridges - Roadway	89,760	1,247,400	91,000	56,752	163,088	209,911	190,026	264,700	1,312,637
17. Bridges - Drainage	132,580	8,306	514,440	206,548	851,160	821,920	404,334	180,000	3,119,288
18. Retaining Walls Tunnels	89,000	18,600	–	–	–	–	–	–	107,600
TOTAL STRUCTURAL COSTS	311,340	1,274,306	605,440	263,300	1,014,248	1,031,831	594,360	444,700	5,539,525
19. Engineering Costs and Emergencies 20%	132,991	375,733	346,664	156,001	551,043	495,709	538,452	381,280	2,977,673
TOTAL CONSTRUCTION COST	797,947	2,254,398	2,079,984	936,005	3,306,259	2,974,252	3,230,713	2,286,480	14,896,038
20. Property Costs for Freeway and Interchanges	208,740	848,313	949,360	237,756	586,984	871,480	231,412	1,153,900	5,087,945
TOTAL HIGHWAY IMPROVEMENT COST	1,006,687	3,102,711	3,029,344	1,173,761	3,893,243	3,845,732	3,462,125	3,440,380	22,953,983
21. Access Road									
- Construction Costs	–	5,300	116,280	4,540	248,008	56,240	18,920	60,000	509,288
- Property Costs	–	–	282,160	3,200	85,380	106,560	2,464	176,300	656,064
TOTAL COSTS FOR ACCESS ROAD	–	5,300	398,440	7,740	333,388	162,800	21,384	236,300	1,165,352

TABLE A-11

CLOSED SYSTEM
CONSTRUCTION AND PROPERTY COSTS

(NT$ Thousands)

Item	IA 14.7	IB 13.6	II 41.7	III 21.56	IV 85.92	V 64.6	VI 77.3	VII 55.85	Total 375.05
1. Clearing and Grubbing	3,400	5,900	12,320	4,162	17,912	12,360	13,155	10,200	79,899
2. Roadway Surfacing	126,840	80,188	345,040	181,272	532,220	433,600	497,812	300,000	2,496,972
3. Guard Rail	2,960	5,249	11,680	2,908	22,348	20,920	15,980	34,000	116,045
4. Fencing	3,040	12,244	13,600	5,516	22,344	18,200	20,400	33,000	128,344
5. Earthwork	64,880	251,020	459,320	208,348	822,400	708,200	1,212,300	660,000	4,386,468
6. Utility Relocation	24,960	26,701	10,000	4,380	32,200	27,040	26,044	28,200	179,525
7. Drainage	6,000	22,168	23,800	21,400	50,560	29,760	37,680	150,000	341,368
8. Stage Construction	1,056	–	1,360	1,512	364	1,400	–	3,900	9,592
9. Signing	3,280	5,804	8,960	4,712	13,648	11,280	12,944	8,000	68,628
10. Lighting	5,080	6,134	13,800	7,252	21,288	17,360	19,912	32,000	122,826
11. Landscaping	2,520	1,700	6,920	3,624	10,644	8,680	9,956	9,400	53,444
12. Interchanges	38,000	173,262	150,600	12,000	95,040	86,520	90,320	143,564	789,306
13. Frontage Roads and Road Relocation	31,320	1,655	16,160	11,880	16,632	18,160	50,560	10,000	155,767
14. Toll Plaza and Facilities	60,160	–	224,528	–	109,592	78,773	123,200	81,500	677,753
15. Miscellaneous – Includes Rest Areas, Service Areas, Weight Stations and Bus Stations	12,680	12,934	34,520	18,128	53,224	43,360	49,782	17,000	241,628
TOTAL ROADWAY COSTS	386,216	604,359	1,332,608	487,544	1,820,416	1,515,613	2,180,045	1,520,764	9,847,565
16. Bridges - Roadway	93,440	1,247,400	105,360	56,752	184,612	220,740	220,828	219,045	2,348,177
17. Bridges - Drainage	132,580	8,306	514,440	206,548	851,160	821,920	404,334	180,000	3,119,288
18. Retaining Walls Tunnels	89,000	18,600	–	–	–	–	–	–	107,600
TOTAL STRUCTURAL COSTS	315,020	1,274,306	619,800	263,300	1,035,772	1,042,660	625,162	456,745	5,575,065
19. Engineering Costs and Emergencies 20%	140,247	375,733	390,482	150,169	571,238	511,654	561,041	395,502	3,084,526
TOTAL CONSTRUCTION COST	841,483	2,254,398	2,342,890	901,013	3,427,426	3,069,927	3,366,248	2,373,011	18,507,156
20. Property Costs for Freeway and Interchanges	210,220	848,313	982,360	237,756	669,964	998,980	252,188	1,288,000	5,487,781
TOTAL HIGHWAY IMPROVEMENT COST	1,051,703	3,102,711	3,325,250	1,138,769	4,097,390	4,068,907	3,618,436	3,661,011	23,994,937
21. Access Road									
- Construction Costs	–	5,300	116,280	4,540	248,008	56,240	18,920	33,817	483,105
- Property Costs	–	–	282,160	3,200	85,380	106,560	2,464	52,600	532,364
TOTAL COSTS FOR ACCESS ROAD	–	5,300	398,440	7,740	333,388	162,800	21,384	86,417	1,015,469

TABLE A-12

COST ESTIMATE OF HIGHWAY IMPROVEMENTS IN SECTION I KEELUNG-ERHCHUNG, (WITHOUT FREEWAY)

(NT$ Thousands)

Item / Route No. / Opening Date	MacA. 1975	Exp. 1975	HWY 5 1985	Total
No. of Lanes	4	8	4	
Total Length of Section (Km)	16.7	13.00	20.43	50.13
Roadway (Surface, base and subbase)	74,720	150,000	96,000	320,720
Earthwork	26,600	80,000	21,280	127,880
Utilities (10% of land cost for Highway 1) (5% of land cost for all other highways)	4,960	47,000	76,000	127,960
Miscellaneous (10% of Roadway Cost)	7,480	15,000	9,600	32,080
Drainage	10,000	20,000	3,000	33,000
Tunnel	33,400	–	17,920	51,320
Bridges - Rebuild	–	900,000	47,360	947,360
- Widen	87,920	–	4,720	92,640
Engineering Costs and Contingencias - 20%	49,040	242,000	55,200	346,240
Total Construction Cost	294,120	1,454,000	331,080	2,079,200
Construction Cost Per km.	17,640	–	16,240	23,360
Property				
Land	98,880	466,500	762,000	1,327,400
Buildings	34,920	126,200	35,200	196,320
Total Property Costs	133,800	592,700	797,200	1,523,700
TOTAL HIGHWAY IMPROVEMENT COST	427,920	2,046,700	1,128,280	3,602,900
HIGHWAY MAINTENANCE COST/KM*	295.2	656	295.20	
TOTAL HIGHWAY MAINTENANCE COST*	4,928	8,528	6,032	

*(Average for base year 1982)

MacA: Neihu to Keelung
HWY 5: Neihu to Keelung
Exp.: Neihu to Erhchung

TABLE A-13

COST ESTIMATE OF HIGHWAY IMPROVEMENTS IN SECTION II ERHCHUNG-YANGMEI, (WITHOUT FREEWAY)

(NT$ Thousands)

Item / Route No. / Opening Date	HWY 1 1972-74	HWY1 (Ext) 1974	HWY 1 1978	106,105 6,109 1979	Total
No. of Lanes	4 Stage 1	4	6 Stage 2	4	
Total Length of Section (km)	38	4.2	38	27.9	70.10
Roadway (Surface, base and subbase)	143,200	20,000	126,160	132,800	422,160
Earthwork	80,200	6,520	25,440	29,160	141,320
Utilities (10% of land cost for Highway 1) (5% of land cost for all other highways)	81,840	3,600	22,080	12,400	119,920
Miscellaneous (10% of Roadway Cost)	14,320	2,000	12,600	13,280	42,200
Drainage	10,840	800	3,520	6,680	21,840
Tunnel					
Bridges - Rebuild	40,920	1,200	8,840	26,880	77,840
- Widen					
Engineering Costs and Contingencies - 20%	74,240	6,840	39,720	44,240	105,040
Total Construction Cost	445,560	40,960	238,360	265,440	990,320
Construction Cost Per km.	11,760	9,720	6,280	9,520	14,130
Property					
Land	818,400	74,400	220,760	248,560	1,362,120
Buildings	93,200	400	65,000	8,800	167,400
Total Property Costs	911,600	74,800	285,760	257,360	1,529,520
TOTAL HIGHWAY IMPROVEMENT COST	1,357,160	115,760	524,120	522,800	2,519,840
HIGHWAY MAINTENANCE COST/KM*	295.2	295.2	557.6	295.2	
TOTAL HIGHWAY MAINTENANCE COST*	11,200	1,240	21,188	8,236	

*(Average for base year 1982)

HWY 1: Erhchung - Taoyuan to Yangmei
HWY 1 (Ext.): Sanchung to Erhchung

TABLE A-14

COST ESTIMATE OF HIGHWAY IMPROVEMENTS IN SECTION III YANGMEI-HSINCHU, (WITHOUT FREEWAY)

(NT$ Thousands)

Item / Route No. / Opening Date	115-118 1972	1 1977	115-118 1983	1 1987	Total
No. of Lanes	2	4	4	6	
Total Length of Section (km)	26.94	25.45	26.94	25.45	52.39
Roadway (Surface, base and subbase)	72,200	78,240	82,200	84,600	317,240
Earthwork	51,000	64,520	35,760	29,920	181,200
Utilities (10% of land cost for Highway 1) (5% of land cost for all other highways)	4,800	21,560			26,360
Miscellaneous (10% of Roadway Cost)	7,240	7,840	8,240	8,480	31,800
Drainage	2,040	7,160	800	2,800	12,800
Structures					
Bridges - Rebuild	41,960				41,960
Tunnels - Widen	160	135,280	28,080	41,320	204,840
Engineering Costs and Contingencies - 20%	35,880	62,920	31,000	33,440	163,240
Total Construction Cost	215,280	377,520	186,080	200,560	79,440
Construction Cost Per Km.	7,960	14,834	6,907	7,881	18,700
Property					
Land	96,120	215,600	39,280	—	351,000
Buildings	9,920	8,400	2,840	—	21,160
Total Property Costs	106,040	224,000	42,120	—	372,160
TOTAL HIGHWAY IMPROVEMENT COST	321,320	601,520	228,200	200,560	1,351,600
HIGHWAY MAINTENANCE COST/KM.	164	295.2	295.2	557.6	
TOTAL HIGHWAY MAINTENANCE COST*	4,416	7,540	4,192	14,200	

*(Average for base year 1982)

HWY 115-118: Yangmei to Hsinchu
HWY 1 : Chungli to Hsinchu

TABLE A-15

COST ESTIMATE OF HIGHWAY IMPROVEMENTS IN SECTION IV HSINCHU-TAICHUNG,
(WITHOUT FREEWAY)

(NT$ Thousands)

Item / Route No. / Opening Date	117 1972	1 1978	125 1978	3 1980	117 1984	Total
No. of Lanes	2	4	4	6	2 to 4	
Total Length of Section (km)	40.11	88.12	7.69	11.38	77.76	184.95
Roadway (Surface, base and subbase)	104,000	274,200	36,600	87,360	301,200	803,360
Earthwork	80,800	119,280	9,680	35,840	117,840	363,440
Utilities						
(10% of land cost for Highway 1)	11,200	44,000	8,040	32,560	18,480	114,280
(5% of land cost for all other highways)						
Miscellaneous (10% of Roadway Cost)	10,400	27,440	3,680	8,720	30,120	80,360
Drainage	4,080	15,320	2,080	1,360	6,360	29,200
Structures						
Bridges - Rebuild	11,040	455,800	6,240	26,640	200,000	699,720
Widen		16,240			20,000	36,240
Engineering Costs and Contingencies - 20%	44,320	190,440	13,280	38,480	138,800	425,320
Total Construction Cost	265,840	1,142,720	79,600	230,960	832,800	2,551,920
Construction Cost Per Km.	6,627.6	12,967.6	10,350.8	20,295.2	10,709.6	13,800
Property						
Land	223,680	440,840	160,880	651,200	369,920	1,846,520
Buildings	56,760	48,280	33,680	70,360	50,440	259,520
Total Property Costs	280,440	489,120	194,560	721,560	420,360	2,106,040
TOTAL HIGHWAY IMPROVEMENT COST	546,280	1,631,840	274,160	952,520	1,253,160	4,657,960
HIGHWAY MAINTENANCE COST/KM*	164	295.2	295.2	557.6	295.2	
TOTAL HIGHWAY MAINTENANCE COST*	6,592	26,040	2,664	6,344	22,960	

*(Average for base year 1982)

HWY 117: Hsinchu to Miaoli
HWY 1 : Tatu Bridge to Hsinchu
HWY 125: Fengyuan to Wuzih
HWY 3 : Taichung to Fengshan

TABLE A-16

COST ESTIMATE OF HIGHWAY IMPROVEMENTS IN SECTION V TAICHUNG-TOUNAN, (WITHOUT FREEWAY)

(NT$ thousands)

Item / Route No. / Opening Date	12 1972	145 1978	3 1976	10 1978	1 1978	1 1978	12 1980	145 1985	Total
No. of Lanes	4	2	4	6	4	4	4-6	4	
Total Length of Section (km)	9.5	46.4	32.0	8.7	68.9		9.5	9.5	175.0
Roadway (Surface, base and subbase)	45,240	124,360	152,320	66,800	241,600	Hsilo Bridge Only	31,560	45,240	707,120
Earthwork	24,720	46,920	112,920	51,160	203,200		10,640	45,200	494,760
Utilities (10% of land cost for Highway 1) (5% of land cost for all other highways)	29,920	11,440	17,520	11,280	30,640		—	160	100,960
Miscellaneous (10% of Roadway Cost)	4,520	12,440	15,240	6,680	24,160		3,160	4,520	70,720
Drainage	2,920	6,120	5,120	3,800	15,080		1,120	800	34,960
Structures									
Bridges - Rebuild		16,920		186,000	98,800	204,000		8,480	514,200
Tunnels - Widen	29,480		28,080		30,120		14,760		102,440
Engineering Costs and Contingencies - 20%	27,360	43,640	66,240	65,160	128,720	40,800	12,240	20,880	405,040
Total Construction Cost	164,160	261,840	397,440	390,880	772,320	244,800	73,480	125,280	2,430,200
Construction Cost Per Km.	17,280	5,640	12,400	44,800	11,200		7,760	13,200	13,800
Property									
Land	299,400	228,720	349,960	225,320	613,040			3,800	1,720,240
Buildings	5,000	46,880	30,160	5,600	12,840			2,160	102,640
Total Property Costs	304,400	275,600	380,120	230,920	625,880			5,960	1,822,880
TOTAL HIGHWAY IMPROVEMENT COST	468,560	537,440	777,560	621,800	1,398,200	244,800	73,480	131,240	4,253,080
HIGHWAY MAINTENANCE COST/KM.*	295.20	164	295.20	556	295.2	2	556	295.20	
TOTAL HIGHWAY MAINTENANCE COST*	2,800	7,600	9,440	4,840	20,320		5,280	2,800	

* (Average for base year 1982)

TABLE A-17

COST ESTIMATE OF HIGHWAY IMPROVEMENTS IN SECTION VI TOUNAN-TAINAN.
(WITHOUT FREEWAY)

(NT$ thousands)

Item / Route No. / Opening Date	1 1977-78	145 1972	145 1985	165 1986	1 1986	Total
No. of Lanes	4	2	4	2	6	
Total Length of Section (km)	83.03	38.9	85.2	40.62	16.65	208.85
Roadway (Surface, base and subbase)	275,040	104,400	351,280	108,880	55,206	894,800
Earthwork	224,400	68,800	186,360	70,680	18,720	568,960
Utilities (10% of land cost for highway 1) (5% of land cost for all other highways)	44,760	4,880	16,680	8,360	–	74,680
Miscellaneous (10% of Roadway Cost)	27,520	10,440	35,120	10,880	5,520	89,480
Drainage	10,080	3,200	10,680	4,000	1,640	29,600
Structures						
Bridges - Rebuild	256,880	35,960	324,480	42,200	–	659,520
Widen	7,400	–	–	14,280	41,640	63,320
Engineering Costs and Contingencies - 20%	169,200	45,520	184,920	51,840	24,560	476,040
Total Construction Cost	1,015,280	273,200	1,109,520	311,120	147,280	2,856,400
Construction Cost Per km.	12,240	7,040	13,040	7,640	8,840	13,680
Property						
Land	447,400	97,600	333,880	167,000	–	1,045,880
Buildings	43,000	6,960	64,560	36,320	–	150,840
Total Property Costs	490,400	104,560	398,440	203,320	–	1,196,720
TOTAL HIGHWAY IMPROVEMENT COST	1,505,680	377,760	1,507,960	514,440	147,280	4,053,120
HIGHWAY MAINTENANCE COST/KM*	295.2	164	295.2	164	295.2	
TOTAL HIGHWAY MAINTENANCE COST*	24,520	6,360	25,160	6,680	4,920	

* (Average for base year 1982)

HWY 1 : Tainan to Chiayi to Tounan HWY 157-145 : Taku-Potzu (bypass) HWY 145 : Tainan to Potzu to Tounan HWY 1 : Hsinchen to Kuantien

TABLE A-18

COST ESTIMATE OF HIGHWAY IMPROVEMENTS IN SECTION VII TAINAN-KAOHSIUNG, (WITHOUT FREEWAY)

(NT$ thousands)

Item / Route No. / Opening Date	183-186 -177 1972-77	1 1973	181-175 1980	183,186 177 1985	Total
No. of Lanes	2	4	4	4	
Total Length of Section (Km)	65.5	56.96	51.75	65.5	174.21
Roadway (Surface, base and subbase)	175,920	204,400	246,320	136,560	763,200
Earthwork	150,400	217,520	238,760	94,440	701,120
Utilities (10% of land cost for highway 1) (5% of land cost for all other highways)	21,680	93,920	37,680	–	153,280
Miscellaneous (10% of Roadway Cost)	17,600	20,440	24,640	13,640	76,320
Drainage	13,320	5,360	8,040	–	26,720
Tunnel					
Bridges - Rebuild	55,800	56,200	–	–	112,000
- Widen	2,000	4,280	96,800	57,760	160,840
Engineering Costs and Contingencies - 20%	87,320	120,440	130,440	60,480	398,680
Total Construction Cost	524,040	722,560	782,680	362,880	2,392,160
Construction Cost Per Km.	8,000	12,720	15,120	5,520	13,730
Property					
Land					
Buildings					
Total Property Costs	471,240	961,920	442,360	–	1,875,520
TOTAL HIGHWAY IMPROVEMENT COST	995,280	1,684,480	1,225,040	362,880	4,267,680
HIGHWAY MAINTENANCE COST/KM.*	164	295.2	295.2	295.2	
TOTAL HIGHWAY MAINTENANCE COST*	10,720	16,800	15,280	19,320	

* (Average for base year 1982)
HWY 183-186-177 : Fengshan to Tainan
HWY 1 : Tainan to Fengshan
HWY 181-175 : Kaohsiung to Tainan

TABLE A-19

COST ESTIMATE OF HIGHWAY IMPROVEMENTS IN SECTION III YANGMEI-HSINCHU,
(WITH FREEWAY)

(NT$ thousands)

Item / Route No. / Opening Date	115-118 / 1972	Total
No. of Lanes	2	
Total Length of Section (Km)	26.94	26.94
Roadway (Surface, base and subbase)	72,200	72,200
Earthwork	51,000	51,000
Utilities (10% of land cost for Highway 1) (5% of land cost for all other highways)	4,800	4,800
Miscellaneous (10% of Roadway Cost)	7,240	7,240
Drainage	2,040	2,040
Bridges - Rebuild	41,960	41,960
Tunnels - Widen	160	160
Engineering Costs and Contingencies - 20%	35,880	35,880
Total Construction Cost	215,280	215,280
Construction Cost Per Km.	7,960	7,960
Property		
Land	96,120	96,120
Buildings	9,920	9,920
Total Property Costs	106,040	106,040
TOTAL HIGHWAY IMPROVEMENT COST	321,320	321,320
HIGHWAY MAINTENANCE COST/KM.*	164	
TOTAL HIGHWAY MAINTENANCE COST*	4,416	

* (Average for base year 1982)

TABLE A-20

COST ESTIMATE OF HIGHWAY IMPROVEMENTS IN SECTION IV HSINCHU-TAICHUNG, (WITH FREEWAY)

(NT$ thousands)

Item / Route / Opening Date	117 / 1972	Total
No. of Lanes	2	
Total Length of Section (Km)	40.11	40.11
Roadway (Surface, base and subbase)	104,000	104,000
Earthwork	80,800	80,800
Utilities (10% of land cost for highway 1) (5% of land cost for all other highways)	11,160	11,160
Miscellaneous (10% of Roadway Cost)	10,400	10,400
Drainage	4,080	4,080
Structures		
Bridges - Rebuild	11,040	11,040
- Widen		
Engineering Costs and Contingencies - 20%	44,280	44,280
Total Construction Cost	265,760	265,760
Construction Cost Per Km.	6,625.6	6,625.6
Property		
Land	222,960	222,960
Buildings	28,120	28,120
Total Property Costs	251,080	251,080
TOTAL HIGHWAY IMPROVEMENT COST	516,840	516,840
HIGHWAY MAINTENANCE COST/KM.*	164	
TOTAL HIGHWAY MAINTENANCE COST*	6,592	

* (Average for base year 1982)

TABLE A-21

COST ESTIMATE OF HIGHWAY IMPROVEMENTS IN SECTION V TAICHUNG-TOUNAN,
(WITH FREEWAY WEST)

(NT$ thousands)

Item / Route No. / Opening Date	12 1972	3 1976	Total
No. of Lanes	4	4	
Total Length of Section (km)	9.5	32.0	41.5
Roadway (Surface, base and subbase)	45,240	152,320	197,560
Earthwork	24,720	112,920	137,640
Utilities (10% of land cost for Highway 1) (5% of land cost for all other highways)	22,400	17,520	39,920
Miscellaneous (10% of Roadway Cost)	4,520	15,240	19,760
Drainage	2,920	5,120	8,040
Structures			
Bridges - Rebuild			
- Widen	29,480	28,080	57,560
Engineering Costs and Contingencies - 20%	25,880	66,240	92,120
Total Construction Cost	155,160	397,440	552,600
Construction Cost Per Km.	16,333	12,420	13,315
Property			
Land	224,160	349,960	574,120
Buildings	3,720	30,160	33,880
Total Property Costs	227,880	380,120	608,000
TOTAL HIGHWAY IMPROVEMENT COST	383,040	777,560	1,160,600
HIGHWAY MAINTENANCE COST/KM.*	295.20	295.20	
TOTAL HIGHWAY MAINTENANCE COST*	2,800	9,440	

* (Average for base year 1982)

TABLE A-22

COST ESTIMATE OF HIGHWAY IMPROVEMENTS IN SECTION VI TOUNAN-TAINAN, (WITH FREEWAY)

(NT$ thousands)

Item / Route No. / Opening Date	145 1972	165 1986	Total
No. of Lanes	2	2	
Total Length of Section (Km)	38.9	40.62	79.52
Roadway (Surface, base and subbase)	104,400	108,880	213,280
Earthwork	68,800	70,680	139,480
Utilities (10% of land cost for Highway 1) (5% of land cost for all other highways)	4,880	8,360	13,240
Miscellaneous (10% of Roadway Cost)	10,440	10,880	21,320
Drainage	3,200	4,000	7,200
Structures			
Bridges - Rebuild	35,960	42,200	78,160
- Widen	—	14,280	14,280
Engineering Costs and Contingencies - 20%	45,520	51,840	97,360
Total Construction Cost	273,200	311,120	584,320
Construction Cost Per Km.	7,040	7,640	7,350
Property			
Land	97,600	167,000	264,600
Buildings	6,960	36,320	43,280
Total Property Costs	104,560	203,320	307,880
TOTAL HIGHWAY IMPROVEMENT COST	377,760	514,440	892,200
HIGHWAY MAINTENANCE COST/KM*	164	164	
TOTAL HIGHWAY MAINTENANCE COST*	6,400	6,680	

* (Average for base year 1982)

TABLE A-23

COST ESTIMATE OF HIGHWAY IMPROVEMENTS IN SECTION VII TAINAN-KAOHSIUNG, (WITH FREEWAY)

(NT$ thousands)

Item / Route No. / Opening Date	183 1972	Total
No. of Lanes	2	
Total Length of Section (Km)	22.35	22.35
Roadway (Surface, base and subbase)	60,000	60,000
Earthwork	40,760	40,760
Utilities (10% of land cost for Highway 1) (5% of land cost for all other highways)	22,680	22,680
Miscellaneous (10% of Roadway Cost)	6,000	6,000
Drainage	1,560	1,560
Structures	13,920	13,920
Bridges - Rebuild		
- Widen		
Engineering Costs and Contingencies - 20%	29,000	29,000
Total Construction Cost	137,920	137,920
Construction Cost Per Km.	7,780	7,780
Property		
Lane	453,760	453,760
Buildings	57,480	57,480
Total Property Costs	511,240	511,240
TOTAL HIGHWAY IMPROVEMENT COST	658,160	658,160
HIGHWAY MAINTENANCE COST/KM.*	164	
TOTAL HIGHWAY MAINTENANCE COST*	3,660	

* (Average for base year 1982)

TABLE A-24

HIGHWAY IMPROVEMENTS UNDER CONSTRUCTION

Route No.	Section	Section Number	Length (km)	Number of Lanes	Costs (NT$ Thousands)		Construction Period
Highway 1	Taipei-Taliaokan	2	11.25	2 to 4	Const	100,000	1971 - 1972
					Prop	100,000	
					Total	200,000	
	Taliaokan-Taoyuan	2	10.75	2 to 4	Const	88,000	1971 - 1973
					Prop	90,000	
					Total	178,000	
	Changhwa-Yuanlin	5	14.50	2 to 4	Const	110,000	1971 - 1973
					Prop	160,000	
					Total	270,000	
	Tainan-Nantzu	7	30.00	2 to 4	Const	200,000	1971 - 1972
					Prop	150,000	
					Total	350,000	
Highway 3	Fengyuan-Taichung	4	7.00	2 to 4	Const	42,000	1971 - 1972
					Prop	80,000	
					Total	122,000	
Highway 12	Taichung-Nanwangtien	5	5.80	2 to 4	Const	35,000	1971 - 1972
					Prop	45,000	
					Total	80,000	

TABLE A-25

COST SUMMARY
HIGHWAY IMPROVEMENTS-WITH FREEWAY

(NT$ Million)

Section	I	II	III	IV	V	VI	VII	Total
Length in Kilometers	–	22.00	26.94	47.11	61.80	79.52	52.35	289.72
Construction Cost	–	188.00	215.28	308.00	662.60	567.20	373.90	2,314.98
Construction Cost/Km	–	8.54	7.96	6.54	10.72	7.12	7.14	7.99
Property Cost	–	190.00	106.04	331.00	768.10	307.88	661.20	2,364.22
Property Cost/Km	–	8.63	3.94	7.03	12.43	3.87	12.63	8.16
Total Cost	–	378.00	321.32	639.00	1,430.70	875.08	1,035.10	4,679.20
Total Cost/Km	–	17.17	11.90	13.57	23.15	11.00	19.77	16.15

HIGHWAY IMPROVEMENTS-WITHOUT FREEWAY

(NT$ Million)

Section	I	II	III	IV	V	VI	VII	Total
Length in Kilometers	50.13	70.10	52.39	184.95	175.00	208.85	174.21	915.63
Construction Cost	2,079.20	990.32	981.80	2,551.92	2,430.20	2,856.40	2,392.16	14,282.00
Construction Cost/Km	41.48	14.13	18.74	13.80	13.89	13.68	13.73	15.58
Property Cost	1,523.72	1,529.52	372.16	2,106.04	1,822.88	1,196.72	1,875.52	10,426.56
Property Cost/Km	30.40	21.82	7.10	11.39	10.42	5.73	10.76	11.39
Total Cost	3,602.92	2,519.84	1,353.96	4,657.96	4,253.08	4,053.12	4,267.68	24,708.56
Total Cost/Km	71.87	35.95	25.84	25.18	24.30	19.41	24.50	26.99

TABLE A-26

PERSONNEL AND LABOUR COSTS FOR TOLL COLLECTION ONLY

TOLL COLLECTION, BARRIER SYSTEM

T.H.Q.	Chief of Toll Collection	1	–	–
T. & K.	Toll Supervisor	2	12@ 3.5=42	84
"	Toll Ass't Supervisor	4	12@ 3=36	144
"	Toll Equip. Tech.	4	12@ 3=36	144
"	Toll Teller	10	12@ 2.5=30	300
"	Toll Ass't Teller	30	12@ 2=24	720
"	Secretary	2	12@ 3.5=42	84
"	Toll Custodian	2	12@ 2.5=30	60
"	Toll Collectors	240	12@ 2=24	5,760
"	Other Expenses			
	Houses & Cloth Average @ 12 x 0.8			2,800
	Total			10,096

TOLL COLLECTION, CLOSED SYSTEM

		1	1	–
T.H.Q.	Chief of Toll Collection	1	–	–
T. & K.	Toll Supervisor	2	12@ 3.5=42	84
"	Toll Ass't Supervisor	4	12@ 3=36	144
"	Toll Equip. Tech.	4	12@ 3=36	144
"	Toll Teller	10	12@ 2.5=30	300
"	Toll Ass't Teller	30	12@ 2=24	720
"	Secretary	2	12@ 3.5=42	84
"	Toll Custodian	2	12@ 2.5=30	60
"	Toll Collectors	390	12@ 2=24	9,360
"	Other Expenses			
	House & Cloth Average @ 12 x 0.8			4,262
	Total			15,158

TABLE A-27

ANNUAL EQUIPMENT COSTS (NT$ 000)
BASED ON 1969 VALUES

Description	C.I.F. at Keelung	% Tax Rate	Total Cost in Taiwan	K.M. of Usage	Hours of Usage	Gas	Lubric-ation	Tires and Tubes	Spare Parts	Deprec-iation	Annual Cost per Each Veh	Number	Total Cost
Truck ½ ton pick up	120	50	180	24,700		24.3	0.3	2.5	5.0	25.7	57.8	12	693.6
Truck ¾ ton pick up	200	50	200	19,600		33.6	0.5	2.2	8.1	42.9	87.2	10	872.0
Truck 3 ton dump H.D.	240	50	360	9,700		26.2	0.5	1.2	7.6	51.4	86.9	28	2,433.2
Truck 2 ton flat bed L.D.	240	50	360	3,800		11.6	0.1	0.3	8.2	51.4	71.6	5	358.0
Truck 1 ton flat bed L.D.	160	50	200	2,600		42.6	0.5	6.0	4.8	34.3	88.2	3	264 6
Truck 2 ton asphalt dist 20	200	50	300	380		12.8	0.1	0.1	5.0	42.9	60.9	1	61.0
Truck paint striper	800	50	1,200	680		24.1	0.4	4.4	24.1	171.4	224.4	1	224.4
Grader	1,400	25	1,750		160	3.4	0.3	4.0	26.8	250.0	284.5	11	3,129.5
Tractor TD-14 crawler w/dozer	1,400	25	1,750		75	5.9	0.3	–	9.6	250.0	265.8	2	531.6
Tracter w/bucket (Ford)	800	25	1,000		230	1.4	0.1	0.6	1.8	142.9	146.8	12	1,761.6
Tractor w/10 back hoe	400	25	500		230	4.6	0.3	–	1.0	71.4	77.3	1	77.3
Tractor Traxcavator	1,200	25	1,500		280	4.1	0.5	0.1	25.9	214.3	244.9	7	1,714.3

TABLE A-27 Con't

ANNUAL EQUIPMENT COSTS (NT$ 000)
(Cont'd)

Description	C.I.F. at Keelung	% Tax Rate	Total Cost in Taiwan	K.M. of Usage	Hours of Usage	Gas	Lubric-ation	Tires and Tubes	Spare Parts	Deprecia-tion	Annual Cost per Each Veh	Number	Total Cost
Tractor Crane 155 A	1,600	25	2,000		80	11.1	0.3	–	6.1	285.7	303.2	1	303.2
Roller Steel 5-8-ton	580	25	725		450	10.1	0.5	–	28.4	103.6	142.6	2	285.2
Roller Pneumatic tired	660	25	825		480	7.4	0.2	3.5	0.7	117.9	129.7	2	259.4
Concrete saw	120	25	150		–	–	–	–	2.2	21.4	23.6	1	23.6
Trencher	400	25	500		2	–	–	–	0.8	71.4	72.2	1	72.2
Street Marker	200	25	250		50	0.5	0.1	–	0.6	35.7	36.3	2	72.6
Police car	160	65	165	54,700		71.9	0.9	8.2	14.6	23.6	119.2	20	2,384.0
Dep Head Car	100	65	165	54,700		31.4	0.4	3.6	6.4	23.6	65.4	12	785.0
										Subtotal			16,311
Communication Equipment			6,000*							300		1 L.S.	300
										Total			16,611

* Less than current U.S. prices to conform with local costs.

TABLE A-28

ANNUAL MATERIAL COSTS

BASED ON 1969 VALUES

ITEM	AMOUNT	UNIT COST	ANNUAL COST (NT$000)
Asphalt Concrete	$15{,}000^{T}$	480	7,200
Pavement Striping	1 L.S.	–	1,350
Shoulder Repair	1 L.S.	–	70
Mowing & Weed Control	1 L.S.	–	50
Landscaping	1 L.S.	–	15
Drainage & Erosion	1 L.S.	–	35
Fence Repair	200^{M}	200	40
Guardrail Repair	$1{,}400^{M}$	250	350
Sign-Del-Marker Rpr	1 L.S.	–	700
Bridge Repair	1 L.S.	–	3,500
Building Maint	1 L. S.	–	700
Utilities Maint	1 L.S.	–	1,440
Utilities	1 L.S.	–	2,8 0
Small Tools & Eqpt	1 L.S.	–	150
Shopwork	1 L.S.	–	150
Others			557
TOTAL			19,107

TABLE A-29

COMPARISON OF TOLL SYSTEMS OPERATION

BASED ON 1969 VALUES

(NT$000)

	TOLL COLLECTION BARRIER SYSTEM		TOLL COLLECTION CLOSED SYSTEM	
PERSONNEL	COST	%	COST	%
TOLL COLLECTION	10,096	18	15,158	25
MAINTENANCE	10,092	18	10,092	17
EQUIPMENT	16,611	30	16,611	27
MATERIAL	19,107	34	19,107	31
TOTAL	55,906	100	60,968	100

TOTAL MAINTENANCE = NT$45,810,000/YEAR

NT$45,810,000 ÷ 375 = NT$122,160/KM/YEAR

MAINTENANCE & TOLL COLLECTION = NT$55,906,000/YEAR

= NT$55,906,000 ÷ 375 = NT$149,000/KM/YEAR

TABLE A-30

MAINTENANCE AND OPERATION COSTS PER KM
(NT$ 000)

Year	Percent Change 1975	Operation Expense/Year Maintenance Orig.	Maintenance Adj.	Maintenance & Operation Orig.	Maintenance & Operation Adj.
1975		122	122	149	149
76	9	133	126	162	157
77	10	134	134	164	164
78	22	149	142	182	175
79	23	150	150	183	183
80	19	145	155	177	193
81	24	151	164	185	202
82	27	155	173	189	211
83	41	172	178	210	220
84	69	206	200	252	247
85	74	212	220	259	273
86	98	242	244	295	302
87	113	260	268	318	327
88	146	300	288	367	354
89	153	309	312	377	383
90	169	329	334	401	408
91	181	343	355	419	435
92	201	368	378	449	461
93	223	395	400	482	488
94	250	428	420	522	515
95	263	443	443	541	541

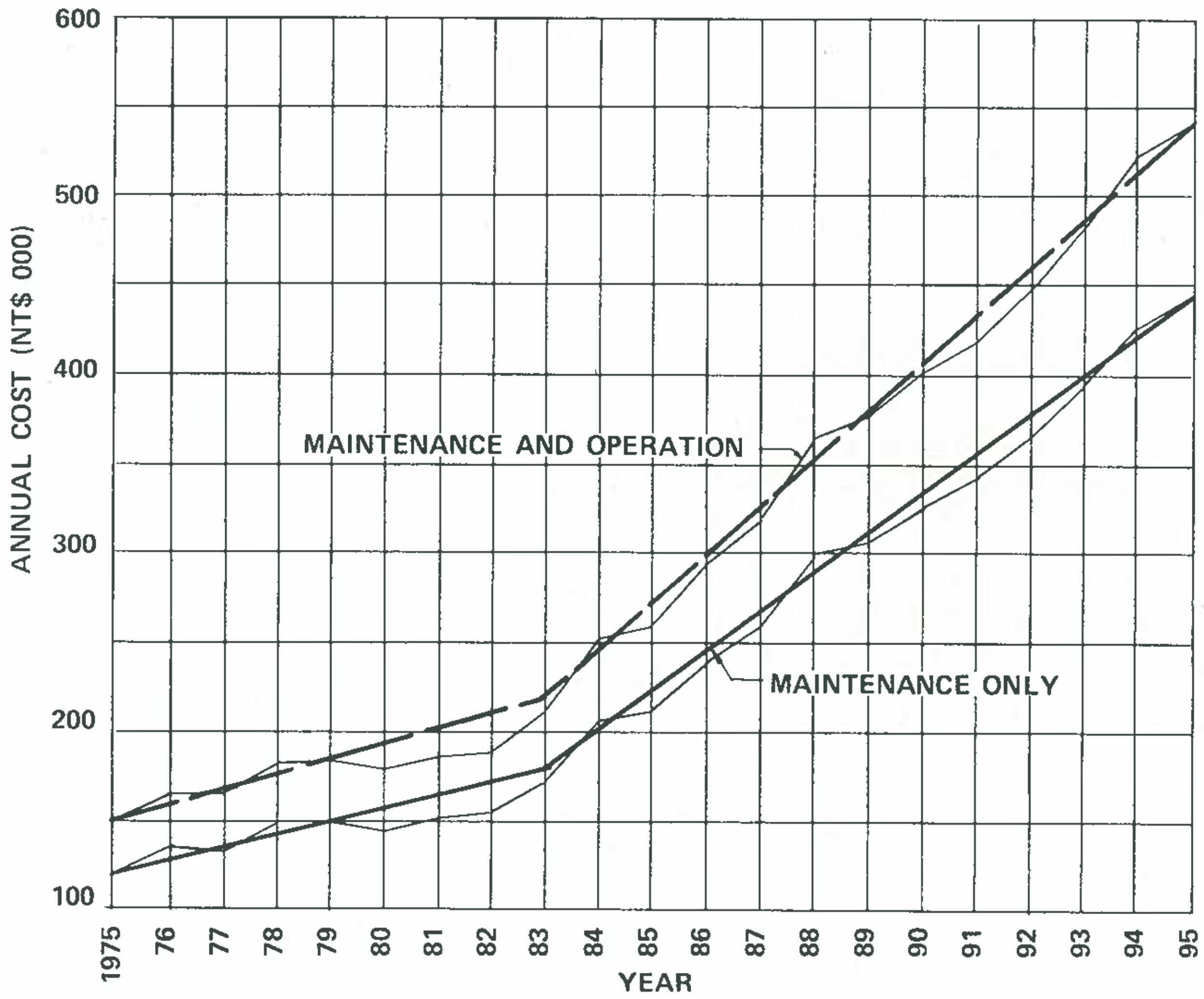


TABLE A-31

PROPOSED FREEWAY CONSTRUCTION SCHEDULE

Section No.	Section Limits	Length (Km)	Initial Number of Lanes	Opening Date	Ultimate No. of Lanes	Widening Date
IA	Neihu-Keelung	14.7	4	1975	6	1987
IB	Taipei-Neihu	11.2	6	1976	6	
	Sanchung-Taipei	2.4	8	1976	8	
II	Sanchung-Linkou	13.0	6	1974	8	1982
	Linkou-Taoyuan	11.1	4	1974	6	1978
	Taoyuan-Yangmei	17.6	4	1974	4	–
III	Yangmei-Hsinchu	21.6	4	1977	6	1988
IV	Hsinchu-Tantzu	80.7	4	1978	4	–
	Tantzu-Taichung	5.2	4	1978	6	1986
V	Taichung-Changhua	19.8	4	1977	6	1986
	Changhua-Tounan	44.6	4	1977	4	–
VI	Tounan-Chiayi	21.5	4	1978	4	–
	Chiayi-Tainan	55.8	4	1977	4	–
VII	Tainan-Nantzu	38.5	4	1977	4	–
	Nantzu-North Fengshan	11.0	4	1977	6	1987
	North Fengshan-South Fengshan	3.0	4	1977	4	–
Total	Keelung-Fengshan	371.7	4.14 (weighted average)		4.94 (weighted average)	

TABLE A-32

HIGHWAY IMPROVEMENT PROGRAM WITH FREEWAY

Section Number	Action	Highway	Between	Lanes	Opening Date
1	Widen	MacArthur	Taipei-Keelung	4	1975
	Build	Taipei Freeway	Taipei-Erchung	6	1975
	Build	2nd Freeway*	Taipei-Panchio	8	1985
	Widen	M-A Freeway	Taipei-Keelung	6	1987
2	Widen	1	Taipei-Taoyuan	4	1972-74
	Build	Freeway	Erhchung-Linkou	6	1974
	Build	Freeway	Linkou to Airport Road	6	1974
	Build	Freeway	Airport Rd-Yangmei	4	1974
	Widen	Freeway	Erhchung-Linkou	8	1982
	Build	2nd Freeway*	Taipei-Taoyuan-Chungli	4	1985
	Widen	2nd Freeway*	Taipei-Taoyuan	6	1989
3	Improve	115-118	Yangmei-Hsinchu	2 clear	1972
	Build	Freeway	Yangmei-Hsinchu	4 clear	1977
	Widen	Freeway	Yangmei-Hsinchu	6	1989
4	Widen	117	Hsinchu-Miaoli	2 clear	1972
	Build	Freeway	Taichung-Miaoli-Hsinchu	4	1978
	Widen	Freeway	Taichung-Tantzu	6	1987
5	Widen	12	Taichung-Tatu Bridge	4	1972
	Widen	3	Taichung-Nantou	4	1976
	Build	Freeway	Tounan-Taichung N	4	1978
	Widen	Freeway	Changhua S-Taichung N	6	1987
6	Improve	145	Tuku-Potzu (bypass)	2 clear	1972
	Build	Freeway	Chiayi-Tainan	4	1977
	Build	Freeway	Chiayi-Tounan	4	1978
	Improve	1-165	Hsinchu-Chiayi	2 clear	1986
7	Widen	183	Nantzu-Fengshan-Harbor	2 clear	1972
	Widen	1	Tainan-Kaohsiung	4	1973
	Build	Freeway	Fengshan-Nantzu	4	1977
	Build	Freeway	Nantzu-North of Tainan	4	1977
	Widen	Freeway	Fengshan-Nantzu	6	1989

* Not included in cost estimate

TABLE A-33

HIGHWAY IMPROVEMENT PROGRAM WITHOUT FREEWAY

Section Number	Action	Highway	Between	Lanes	Opening Date
1	Widen	MacArthur	Taipei-Keelung	4	1975
	Build	Expressway	Taipei-Erhchung	8	1975
	Build	Expressway*	Taipei-Panchiao	8	1982
	Widen	5	Taipei-Keelung	4	1985
2	Widen	1	Erchhung-Taoyuan-Yangmei	4**	1972-74
	Build	1	Sanchung-Erhchung	4	1974
	Widen	1	Erhchung-Taoyuan-Yangmei	6**	1978
	Rebuild	105, 106, 109	Erhchung-Linkou-Airport-Taoyuan	4**	1979
	Rebuild	114*	Taipei-Yingko-Chungli	4	1983
	Widen	110*	Taoyuan-Yingko-Sanchia	4	1983
	Widen	3*	Taipei-Sanchia	4	1987
3	Improve	115-118	Yangmei-Hsinchu	2 clear	1972
	Widen	1	Chungli-Hsinchu	4	1977
	Widen	115-118	Chungli-Hsinchu	4	1983
	Widen	1	Chungli-Hsinchu	6	1987
4	Widen	117	Hsinchu-Miaoli	2 clear	1972
	Widen	1	Tatu Bridge-Hsinchu	4	1978
	Widen	125	Fengyuan-Wujih	4	1978
	Widen	3	Taichung-Fengyuan	6	1980
	Widen	117	Fengyuan-Hsinchu	4	1984
5	Widen	12	Taichung-Tatu Bridge	4	1972
	Widen	3	Taichung-Nantou	4	1976
	Improve	145	Tuku-Hsilo-Changhua	2 clear	1978
	Build	1C	Changhua bypass	6	1978
	Widen	1	Tounan-Changhua	4	1978
	Widen	1	Hsilo Bridge	6	1978
	Widen	12	Taichung-Tatu Bridge	6	1980
	Build	145	Tuku-Wutsio	4	1985
6	Improve	145	Tuku-Potzu (bypass)	2 clear	1972
	Widen	1	Tainan-Chiayi-Tounan	4	1977-78
	Widen	145	Tainan-Potzu-Tounan	4	1985
	Improve	165	Hsinshih-Chiayi	2	1986
	Widen	1	Hsinshih-Kuantien	6	1986
7	Connect	183-186-177	Fengshan-Tainan	2 clear	1972-77
	Widen	1	Tainan-Fengshan	4	1973
	Widen	181+175	Kaohsiung-Tainan	4	1980
	Widen	183-186-177	Fengshan-Hsinshih	4	1985

Note: * - not included in cost estimate. **- additional climbing lanes needed.

TABLE A-34

SECTION I — BARRIER SYSTEM

SCHEDULE OF COSTS OF HIGHWAY IMPROVEMENTS WITH FREEWAY AND DEDUCTION OF TAXES
(NT$ MILLIONS)

	Freeway*							
	Property		Construction		Maintenance		Total	
Year	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax
1971								
1972	208.7	177.4					208.7	177.4
1973	848.3	721.1	635.2	557.7			1,483.5	1,278.8
1974			1,133.0	1,001.5			1,133.0	1,001.5
1975			1,122.3	992.1			1,122.3	992.1
1976					4.5	3.9	4.5	3.9
1977					4.7	4.1	4.7	4.1
1978					5.0	4.3	5.0	4.3
1979					5.2	4.5	5.2	4.5
1980					5.5	4.7	5.5	4.7
1981					5.7	4.9	5.7	4.9
1982					6.0	5.2	6.0	5.2
1983					6.2	5.4	6.2	5.4
1984					7.0	6.1	7.0	6.1
1985					7.7	6.7	7.7	6.7
1986			167.0	147.6	8.5	7.4	175.5	155.0
1987					9.2	8.0	9.2	8.0
1988					10.0	8.7	10.0	8.7
1989					10.8	9.5	10.8	9.5
1990					11.5	10.1	11.5	10.1
1991					12.3	10.8	12.3	10.8
1992					13.0	11.4	13.0	11.4
1993					13.8	12.1	13.8	12.1
1994					14.5	12.7	14.5	12.7
1995					15.2	13.3	15.2	13.3
Total	1,057.0	898.5	3,057.5	2,698.9	176.3	153.8	4,290.8	3,751.2

Highways with freeway							
Property		Construction		Maintenance		Total	
W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax
None							

* Including access roads.

TABLE A-35

SECTION II – BARRIER SYSTEM

SCHEDULE OF COSTS OF HIGHWAY IMPROVEMENTS WITH FREEWAY AND DEDUCTION OF TAXES
(NT$ MILLIONS)

	Freeway*								Highways with freeway							
	Property		Construction		Maintenance		Total		Property		Construction		Maintenance		Total	
Year	W. Tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax
1971	282.2	239.9	116.3	104.7			398.5	344.6	145.0	95.7	79.0	71.1			224.0	166.8
1972	949.4	807.0	930.6	837.5			1,880.0	1,644.0	45.0	29.7	79.0	71.1	2.9	2.5	126.9	103.3
1973			530.6	477.5			530.6	477.5			30.0	27.0	3.0	2.6	33.0	29.6
1974			410.6	369.5			410.6	369.5					5.8	5.1	5.8	5.1
1975					6.6	5.6	6.6	5.6					5.9	5.1	5.9	5.1
1976					7.0	6.0	7.0	6.0					6.0	5.2	6.0	5.2
1977					7.3	6.2	7.3	6.2					6.1	5.3	6.1	5.3
1978					7.7	6.6	7.7	6.6					6.2	5.4	6.2	5.4
1979					8.1	6.9	8.1	6.9					6.3	5.5	6.3	5.5
1980					8.4	7.1	8.4	7.1					6.4	5.6	6.4	5.6
1981			208.2	187.4	8.8	7.5	217.0	194.9					6.5	5.7	6.5	5.7
1982					9.2	7.8	9.2	7.8					6.6	5.7	6.6	5.7
1983					10.3	8.8	10.3	8.8					6.7	5.8	6.7	5.8
1984					11.4	9.7	11.4	9.7					6.9	6.0	6.9	6.0
1985					12.5	10.6	12.5	10.6					7.0	6.1	7.0	6.1
1986					13.6	11.6	13.6	11.6					7.1	6.2	7.1	6.2
1987					14.7	12.5	14.7	12.5					7.3	6.4	7.3	6.4
1988					15.8	13.4	15.8	13.4					7.5	6.5	7.5	6.5
1989					16.7	14.2	16.7	14.2					7.7	6.7	7.7	6.7
1990					18.0	15.3	18.0	15.3					7.8	6.8	7.8	6.8
1991					19.2	16.3	19.2	16.3					7.9	6.9	7.9	6.9
1992					20.3	17.3	20.3	17.3					8.1	7.1	8.1	7.1
1993					21.4	18.2	21.4	18.2					8.3	7.2	8.3	7.2
1994					22.5	19.1	22.5	19.1					8.5	7.4	8.5	7.4
1995					23.5	20.0	23.5	20.0					8.7	7.6	8.7	7.6
Total	1,231.6	1,046.9	2,196.3	1,976.6	283.0	240.7	3,710.9	3,264.2	190.0	125.4	188.0	169.2	161.2	140.4	539.2	435.0

* Including access roads

TABLE A-36

SECTION III – BARRIER SYSTEM

SCHEDULE OF COSTS OF HIGHWAY IMPROVEMENTS WITH FREEWAY AND DEDUCTION OF TAXES
(NT$ MILLIONS)

	Freeway*								Highway with freeway							
	Property		Construction		Maintenance		Total		Property		Construction		Maintenance		Total	
Year	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax
1971									106.0	70.0	215.3	193.8			321.3	263.8
1972													3	2.6	3	2.6
1973													3	2.6	3	2.6
1974	241.0	159.1	4.5	4.1			245.5	163.2					4	3.5	4	3.5
1975			399.3	359.4			399.3	359.4					4	3.5	4	3.5
1976			399.0	359.1			399.0	359.1					4	3.5	4	3.5
1977					3.4	3.0	3.4	3.0					4	3.5	4	3.5
1978					3.6	3.1	3.6	3.1					4	3.5	4	3.5
1979					3.8	3.3	3.8	3.3					4	3.5	4	3.5
1980					4.0	3.5	4.0	3.5					4	3.5	4	3.5
1981					4.2	3.7	4.2	3.7					4	3.5	4	3.5
1982					4.4	3.8	4.4	3.8					4	3.5	4	3.5
1983					4.6	4.0	4.6	4.0					4	3.5	4	3.5
1984					4.7	4.1	4.7	4.1					5	4.4	5	4.4
1985					5.3	4.6	5.3	4.6					5	4.4	5	4.4
1986					5.9	5.1	5.9	5.1					5	4.4	5	4.4
1987			137.7	123.9	6.5	5.7	144.2	129.6					5	4.4	5	4.4
1988					7.0	6.1	7.0	6.1					5	4.4	5	4.4
1989					7.6	6.6	7.6	6.6					5	4.4	5	4.4
1990					8.2	7.1	8.2	7.1					5	4.4	5	4.4
1991					8.8	7.7	8.8	7.7					5	4.4	5	4.4
1992					9.3	8.1	9.3	8.1					5	4.4	5	4.4
1993					9.9	8.6	9.9	8.6					5	4.4	5	4.4
1994					10.5	9.1	10.5	9.1					5	4.4	5	4.4
1995					11.1	9.7	11.1	9.7					5	4.4	5	4.4
Total	241.0	159.1	940.5	846.5	122.8	106.9	1,304.3	1,112.5	106.0	70.0	215.3	193.8	106	93.0	427.3	356.8

* Including access roads.

TABLE A-37

SECTION IV – BARRIER SYSTEM

SCHEDULE OF COSTS OF HIGHWAY IMPROVEMENTS WITH FREEWAY AND DEDUCTION OF TAXES
(NT$ MILLIONS)

	Freeway*								Highway with freeway							
	Project		Construction		Maintenance		Total		Property		Construction		Maintenance		Total	
Year	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax
1971									251.0	188.3	266.0	239.4			517.0	427.7
1972									80.0	60.0	42.0	37.8			122	97.8
1973	85.4	64.1					85.4	64.1					6	5.2	6	5.2
1974	293.5	220.1	248.0	213.3			541.5	433.4					6	5.2	6	5.2
1975	293.5	220.1	1,094.9	941.6			1,388.4	1,161.7					6	5.2	6	5.2
1976			1,094.9	941.6			1,094.9	941.6					7	6.1	7	6.1
1977			1,095.0	941.7			1,095.0	941.7					7	6.1	7	6.1
1978					13.7	11.9	13.7	11.9					7	6.1	7	6.1
1979					14.4	12.5	14.4	12.5					8	7.0	8	7.0
1980					15.1	13.1	15.1	13.1					8	7.0	8	7.0
1981					15.9	13.8	15.9	13.8					8	7.0	8	7.0
1982					16.7	14.5	16.7	14.5					8	7.0	8	7.0
1983					17.4	15.1	17.4	15.1					9	7.8	9	7.8
1984					18.1	15.8	18.1	15.8					9	7.8	9	7.8
1985			21.5	18.5	18.9	16.4	40.4	34.9					9	7.8	9	7.8
1986					21.1	18.4	21.1	18.4					9	7.8	9	7.8
1987					23.5	20.5	23.5	20.5					9	7.8	9	7.8
1988					25.8	22.5	25.8	22.5					9	7.8	9	7.8
1989					28.0	24.4	28.0	24.4					10	8.7	10	8.7
1990					30.3	26.4	30.3	26.4					10	8.7	10	8.7
1991					32.7	28.5	32.7	28.5					10	8.7	10	8.7
1992					35.0	30.5	35.0	30.5					10	8.7	10	8.7
1993					37.2	32.4	37.2	32.4					10	8.7	10	8.7
1994					39.5	34.4	39.5	34.4					10	8.7	10	8.7
1995					41.8	36.4	41.8	36.4					10	8.7	10	8.7
Total	672.4	504.3	3,554.3	3,056.7	445.1	387.5	4,671.8	3,948.5	331.0	248.3	308.0	277.2	195.0	169.6	834.0	695.1

* Including access roads.

TABLE A-38

SECTION V – BARRIER SYSTEM

SCHEDULE OF COSTS OF HIGHWAY IMPROVEMENTS WITH FREEWAY AND DEDUCTION OF TAXES
(NT$ MILLIONS)

	Freeway*								Highways with freeway							
	Property		Construction		Maintenance		Total		Property		Construction		Maintenance		Total	
Year	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax
1971									182.9	142.7	120.2	108.2			303.1	250.9
1972									45.0	35.1	35.0	31.5	2	1.7	82.0	68.3
1973									160.0	124.8	110.0	99.0	2	1.7	272.0	225.5
1974	106.6	83.2					106.6	83.2					5	4.4	5.0	4.4
1975	435.5	339.7	56.2	46.7			491.7	386.4	380.2	296.6	397.4	357.7	6	5.2	783.6	659.5
1976	436.0	340.1	1,409.4	1,169.8			1,845.4	1,509.9					13	11.3	13	11.3
1977			1,409.4	1,169.8			1,409.4	1,169.8					14	12.2	14	12.2
1978					10.8	9.4	10.8	9.4					14	12.2	14	12.2
1979					11.3	9.8	11.3	9.8					14	12.2	14	12.2
1980					11.9	10.4	11.9	10.4					15	13.1	15	13.1
1981					12.5	10.9	12.5	10.9					15	13.1	15	13.1
1982					13.0	11.3	13.0	11.3					16	13.9	16	13.9
1983					13.6	11.8	13.6	11.8					16	13.9	16	13.9
1984					14.2	12.4	14.2	12.4					16	13.9	16	13.9
1985			155.4	129.0	15.8	13.8	171.2	142.8					17	14.8	17	14.8
1986					17.6	15.3	17.6	15.3					17	14.8	17	14.8
1987					19.3	16.8	19.3	16.8					17	14.8	17	14.8
1988					21.0	18.3	21.0	18.3					18	15.7	18	15.7
1989					22.7	19.8	22.7	19.8					18	15.7	18	15.7
1990					24.5	21.3	24.5	21.3					20	17.4	20	17.4
1991					26.2	22.8	26.2	22.8					20	17.4	20	17.4
1992					27.9	24.3	27.9	24.3					21	18.3	21	18.3
1993					29.6	25.8	29.6	25.8					21	18.3	21	18.3
1994					31.3	27.2	31.3	27.2					22	19.1	22	19.1
1995					33.0	28.7	33.0	28.7					22	19.1	22	19.1
Total	978.1	763.0	3,030.4	2,515.3	356.2	310.1	4,364.7	3,588.4	768.1	599.2	662.6	596.4	361	314.2	1,791.7	1,509.8

* Including access roads.

TABLE A-39

SECTION VI — BARRIER SYSTEM

SCHEDULE OF COSTS OF HIGHWAY IMPROVEMENTS WITH FREEWAY AND DEDUCTION OF TAXES
(NT$ MILLIONS)

	Freeway*								Highways with freeway							
	Property		Construction		Maintenance		Total		Property		Construction		Maintenance		Total	
Year	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax
1971									104.6	90.0					104.6	90.0
1972											273.2	245.9	5	4.3	278.2	250.2
1973	2.4	2.1	18.9	16.8			21.3	18.9					5	4.3	5	4.3
1974	115.7	99.5	807.6	718.8			923.3	818.3					5	4.3	5	4.3
1975	115.7	99.5	807.6	718.8			923.3	818.3					5	4.3	5	4.3
1976			807.6	718.8			807.6	718.8					5	4.3	5	4.3
1977			807.9	719.0	11.6	10.1	819.5	729.1					6	4.3	6	5.2
1978					12.3	10.7	12.3	10.7					6	5.2	6	5.2
1979					12.9	11.2	12.9	11.2					6	5.2	6	5.2
1980					13.6	11.8	13.6	11.8					6	5.2	6	5.2
1981					14.3	12.4	14.3	12.4					6	5.2	6	5.2
1982					15.0	13.1	15.0	13.1					6	5.2	6	5.2
1983					15.6	13.6	15.6	13.6					7	6.0	7	6.0
1984					16.3	14.2	16.3	14.2	203.3	174.8			7	6.0	210.3	180.8
1985					17.0	14.8	17.0	14.8			294.0	264.6	7	6.0	301.0	270.6
1986					19.0	16.5	19.0	16.5					14	12.0	14	12.0
1987					21.1	18.4	21.1	18.4					15	12.9	15	12.9
1988					23.2	20.2	23.2	20.2					15	12.9	15	12.9
1989					25.2	21.9	25.2	21.9					15	12.9	15	12.9
1990					27.3	23.8	27.3	23.8					16	13.8	16	13.8
1991					29.4	25.6	29.4	25.6					16	13.8	16	13.8
1992					31.5	27.4	31.5	27.4					16	13.8	16	13.8
1993					33.5	29.2	33.5	29.2					16	13.8	16	13.8
1994					35.6	31.0	35.6	31.0					16	13.8	16	13.8
1995					37.6	32.7	37.6	32.7					16	13.8	16	13.8
Total	233.8	201.1	3,249.6	2,892.2	412.0	358.6	3,895.4	3,451.9	307.9	264.8	567.2	510.5	237.0	204.2	1,112.1	979.5

* Including access roads.

TABLE A-40

SECTION VII – BARRIER SYSTEM

SCHEDULE OF COSTS OF HIGHWAY IMPROVEMENTS WITH FREEWAY AND DEDUCTION OF TAXES
(NT$ MILLIONS)

	Freeway*								Highways with freeway							
	Property		Construction		Maintenance		Total		Property		Construction		Maintenance		Total	
Year	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax
1971									1,111.2	756.1	396.5	364.8			1,507.7	1,120.9
1972									361.9	246.1	250.0	230.0	3.7	3.1	615.6	479.2
1973	1,330.2	905.4					1,330.2	905.4			250.0	230.0	3.7	3.1	253.7	233.1
1974			800.0	719.6			800.0	719.6					8.0	6.6	8.0	6.6
1975			800.0	719.6			800.0	719.6					9.0	7.5	9.0	7.5
1976			561.5	504.8	8.4	7.3	569.9	512.1					10.0	8.3	10.0	8.3
1977					8.9	7.7	8.9	7.7					10.0	8.3	10.0	8.3
1978					9.3	8.1	9.3	8.1					11.0	9.1	11.0	9.1
1979					9.8	8.5	9.8	8.5					11.0	9.1	11.0	9.1
1980					10.3	9.0	10.3	9.0					12.0	10.0	12.0	10.0
1981					10.8	9.4	10.8	9.4					12.0	10.0	12.0	10.0
1982					11.3	9.8	11.3	9.8					13.0	10.8	13.0	10.8
1983					11.8	10.3	11.8	10.3					13.0	10.8	13.0	10.8
1984					12.3	10.7	12.3	10.7					13.0	10.8	13.0	10.8
1985					13.7	11.9	13.7	11.9					14.0	11.6	14.0	11.6
1986			185.0	166.5	15.3	13.3	200.3	179.8					14.0	11.6	14.0	11.6
1987					16.8	14.6	16.8	14.6					14.0	11.6	14.0	11.6
1988					18.2	15.8	18.2	15.8					15.0	12.5	15.0	12.5
1989					19.7	17.1	19.7	17.1					15.0	12.5	15.0	12.5
1990					21.2	18.4	21.2	18.4					15.0	12.5	15.0	12.5
1991					22.7	19.8	22.7	19.8					14.0	11.6	14.0	11.6
1992					24.2	21.1	24.2	21.1					16.0	13.3	16.0	13.3
1993					25.7	22.4	25.7	22.4					16.0	13.3	16.0	13.3
1994					27.1	23.6	27.1	23.6					17.0	14.1	17.0	14.1
1995					28.7	25.0	28.7	25.0					17.0	14.1	17.0	14.1
Total	1,330.2	905.4	2,346.5	2,110.5	326.2	283.8	4,022.9	3,299.7	1,473.1	1,002.2	896.5	824.8	296.4	246.2	2,666.0	2,073.2

* Including access roads.

TABLE A-41

ENTIRE FREEWAY – BARRIER SYSTEM

SCHEDULE OF COSTS OF HIGHWAY IMPROVEMENTS WITH FREEWAY AND DEDUCTION OF TAXES
(NT$ MILLIONS)

	Freeway*								Highways with freeway							
	Property		Construction		Maintenance		Total		Property		Construction		Maintenance		Total	
Year	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax
1971	282.2	239.9	116.3	104.7			398.5	344.6	1,900.7	1,342.8	1,077.0	978.0	–	–	2,977.7	2,320.8
1972	1,158.1	984.4	930.6	837.5			2,088.7	1,821.9	531.9	366.9	679.2	616.3	20.9	17.7	1,232.0	1,000.9
1973	2,266.3	1,692.7	1,185.7	1,052.0			3,452.0	2,744.7	160.0	124.8	390.0	353.0	27.0	23.0	577.0	500.8
1974	756.8	561.9	3,402.7	3,026.0			4,159.5	3,587.9	–	–	–	–	32.8	28.1	32.8	28.1
1975	844.7	659.3	4,280.3	3,778.2	6.6	5.6	5,131.6	4,443.1	380.2	296.6	397.4	357.7	36.9	31.8	814.5	686.1
1976	436.0	340.1	4,272.4	3,694.1	19.9	17.2	4,728.3	4,051.4					44.0	37.7	44.0	37.7
1977			3,312.3	2,830.5	35.9	31.1	3,348.2	2,861.6					47.1	40.6	47.1	40.6
1978					62.4	54.1	62.4	54.1					48.2	41.5	48.2	41.5
1979					65.5	56.7	65.5	56.7					49.3	42.5	49.3	42.5
1980					68.8	59.6	68.8	59.6					51.4	44.4	51.4	44.4
1981			208.2	187.4	72.2	62.6	280.4	250.0					51.5	44.5	51.5	44.5
1982					75.6	65.5	75.6	65.5					54.6	47.1	54.6	47.1
1983					79.5	69.0	79.5	69.0					56.7	48.8	56.7	48.8
1984					84.0	73.0	84.0	73.0	203.3	174.8			56.9	48.9	260.2	223.7
1985			176.9	147.5	90.9	78.8	267.8	226.3			294.0	264.6	60.0	51.7	356.0	316.3
1986			352.0	314.1	101.0	87.6	453.0	401.7					66.1	56.8	66.1	56.8
1987			137.7	123.9	111.1	96.5	248.8	220.4					67.3	57.9	67.3	57.9
1988					121.0	105.0	121.0	105.0					69.5	59.8	69.5	59.8
1989					130.7	113.5	130.7	113.5					70.7	60.9	70.7	60.9
1990					141.0	122.4	141.0	122.4					71.8	61.6	71.8	61.6
1991					151.3	131.5	151.3	131.5					72.9	62.8	72.9	62.8
1992					161.2	140.1	161.2	140.1					75.1	64.6	75.1	64.6
1993					171.1	148.7	171.1	148.7					76.3	65.7	76.3	65.7
1994					181.0	157.1	181.0	157.1					78.5	67.5	78.5	67.5
1995					190.9	165.8	190.9	165.8					78.7	67.7	78.7	67.7
Total	5,744.1	4,478.3	18,375.1	16,095.9	2,121.6	1,841.4	26,240.8	22,415.6	3,176.1	2,305.9	2,837.6	2,569.6	1,364.2	1,173.6	6,043.4	6,049.1

* Including access roads.

TABLE A-42

ENTIRE FREEWAY - CLOSED SYSTEM

SCHEDULE OF COSTS OF HIGHWAY IMPROVEMENTS WITH FREEWAY AND DEDUCTION OF TAXES
(NT$ MILLIONS)

	Freeway*							
	Property		Construction		Maintenance		Total	
Year	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax
1971	295.8	251.8	120.8	108.7	–	–	416.6	360.5
1972	1,213.8	1,033.4	966.5	869.7	–	–	2,180.3	1,903.1
1973	2,319.8	1,737.8	1,332.2	1,183.1	–	–	3,652.0	2,920.9
1974	848.6	628.9	3,533.8	3,142.1	–	–	4,382.4	3,771.0
1975	885.2	692.1	4,443.2	3,921.6	7.2	6.1	5,328.4	4,619.8
1976	457.0	357.0	4,224.8	3,663.3	21.7	18.8	4,708.5	4,039.1
1977	–	–	3,441.9	2,941.4	39.1	33.8	3,481.0	2,974.8
1978	–	–	–	–	68.0	59.0	68.0	59.0
1979	–	–	–	–	71.4	61.8	71.4	61.8
1980	–	–	–	–	75.0	65.0	75.0	65.0
1981	–	–	216.2	194.6	78.7	68.3	294.9	262.9
1982	–	–	–	–	82.4	71.4	82.4	71.4
1983	–	–	–	–	86.7	75.2	86.7	75.2
1984	–	–	–	–	91.6	79.6	91.6	79.6
1985	–	–	183.7	153.2	99.1	85.9	282.8	239.1
1986	–	–	348.3	12.7	110.1	95.5	458.4	408.2
1987	–	–	143.0	128.7	121.2	105.2	264.2	233.9
1988	–	–	–	–	132.0	114.5	132.0	114.5
1989	–	–	–	–	142.5	123.8	142.5	123.8
1990	–	–	–	–	153.8	133.5	153.8	133.5
1991	–	–	–	–	165.0	143.4	165.0	143.4
1992	–	–	–	–	175.8	152.8	175.8	152.8
1993	–	–	–	–	186.6	162.2	186.6	162.2
1994	–	–	–	–	197.4	171.3	197.4	171.3
1995	–	–	–	–	208.3	180.9	208.3	180.9
Total	6,020.2	4,701.0	18,959.4	16,618.7	2,313.6	2,008.0	27,293.2	23,327.7

* Including access roads.

TABLE A-43

SECTION I

SCHEDULE OF COSTS OF ALTERNATIVE HIGHWAY IMPROVEMENTS AND DEDUCTION OF TAXES
(NT$ MILLIONS)

Years	Property		Construction		Maintenance		Total	
	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax	W. tax	W/O tax
1971	–	–	–	–	–	–	–	–
1972	425.9	281.1	–	–	–	–	425.9	281.1
1973	300.0	198.0	921.1	829.0	–	–	1,221.1	1,027.0
1974	–	–	827.0	744.3	–	–	827.0	744.3
1975	–	–	–	–	11.4	9.9	11.4	9.9
1976	–	–	–	–	11.8	10.3	11.8	10.3
1977	–	–	–	–	12.1	10.5	12.1	10.5
1978	–	–	–	–	12.5	10.9	12.5	10.9
1979	–	–	–	–	12.8	11.1	12.8	11.1
1980	–	–	–	–	13.1	11.4	13.1	11.4
1981	–	–	–	–	13.5	11.8	13.5	11.8
1982	–	–	–	–	13.8	12.0	13.8	12.0
1983	400.0	264.0	–	–	14.2	12.4	414.2	276.4
1984	397.2	262.2	231.1	208.0	14.5	12.6	642.8	482.8
1985	–	–	100.0	90.0	14.9	13.0	114.9	103.0
1986	–	–	–	–	21.7	18.9	21.7	18.9
1987	–	–	–	–	22.4	19.5	22.4	19.5
1988	–	–	–	–	23.0	20.0	23.0	20.0
1989	–	–	–	–	23.7	20.6	23.7	20.6
1990	–	–	–	–	24.4	21.3	24.4	21.3
1991	–	–	–	–	25.1	21.9	25.1	21.9
1992	–	–	–	–	25.7	22.4	25.7	22.4
1993	–	–	–	–	26.4	23.0	26.4	23.0
1994	–	–	–	–	27.0	23.5	27.0	23.5
1995	–	–	–	–	27.7	24.1	27.7	24.1
Totals	1,523.1	1,005.3	2,079.2	1,871.3	391.7	341.1	3,994.0	3,217.7

TABLE A-44

SECTION II

SCHEDULE OF COSTS OF ALTERNATIVE HIGHWAY IMPROVEMENTS AND DEDUCTION OF TAXES
(NT$ MILLIONS)

Years	Property		Construction		Maintenance		Total Costs	
	W/tax	W/O tax	W/tax	W/O tax	W/tax	W/O tax	W/tax	W/O tax
1971	145.0	95.7	79.0	71.1	–	–	224.0	166.8
1972	841.4	555.4	79.0	71.1	2.9	2.5	923.3	629.0
1973	–	–	164.3	147.9	3.0	2.6	167.3	150.5
1974	–	–	164.3	147.9	9.2	8.0	173.5	155.9
1975	–	–	–	–	10.5	9.1	10.5	9.1
1976	285.8	188.6	110.4	99.4	10.8	9.4	407.0	297.4
1977	–	–	128.0	115.2	11.2	9.7	139.2	124.9
1978	257.4	169.9	110.4	99.4	11.5	10.0	379.3	279.3
1979	–	–	155.0	139.5	21.2	18.4	176.2	157.9
1980	–	–	–	–	29.7	25.8	29.7	25.8
1981	–	–	–	–	30.6	26.6	30.6	26.6
1982	–	–	–	–	31.5	27.3	31.5	27.3
1983	–	–	–	–	32.5	28.2	32.5	28.2
1984	–	–	–	–	33.4	29.0	33.4	29.0
1985	–	–	–	–	34.3	29.8	34.3	29.8
1986	–	–	–	–	35.2	30.6	35.2	30.6
1987	–	–	–	–	36.1	31.3	36.1	31.3
1988	–	–	–	–	37.1	32.2	37.1	32.2
1989	–	–	–	–	38.0	33.0	38.0	33.0
1990	–	–	–	–	38.9	33.8	38.9	33.8
1991	–	–	–	–	39.8	34.5	39.8	34.5
1992	–	–	–	–	40.7	35.3	40.7	35.3
1993	–	–	–	–	41.7	36.2	41.7	36.2
1994	–	–	–	–	42.6	37.0	42.6	37.0
1995	–	–	–	–	43.5	37.8	43.5	37.8
Totals	1,529.6	1,009.6	990.4	891.4	665.9	578.1	3,185.9	2,479.1

TABLE A-45

SECTION III

SCHEDULE OF COSTS OF ALTERNATIVE HIGHWAY IMPROVEMENTS AND DEDUCTION OF TAXES
(NT$ MILLONS)

Years	Property		Construction		Maintenance		Total Costs	
	W/tax	W/O tax	W/tax	W/O tax	W/tax	W/O tax	W/tax	W/O tax
1971	106.0	70.0	215.3	194.0	–	–	321.3	264.0
1972	–	–	–	–	3.4	3.0	3.4	3.0
1973	–	–	–	–	3.5	3.0	3.5	3.0
1974	–	–	–	–	3.6	3.1	3.6	3.1
1975	224.0	147.9	–	–	3.8	3.2	227.8	151.1
1976	–	–	377.5	340.3	10.3	8.9	387.8	349.2
1977	–	–	–	–	10.6	9.2	10.6	9.2
1978	–	–	–	–	10.9	9.5	10.9	9.5
1979	–	–	–	–	11.2	9.7	11.2	9.7
1980	–	–	–	–	11.5	10.0	11.5	10.0
1981	–	–	–	–	11.7	10.2	11.7	10.2
1982	42.1	27.8	90.0	81.1	12.2	10.6	144.3	119.5
1983	–	–	96.1	86.6	12.5	10.8	108.6	97.4
1984	–	–	–	–	16.2	14.1	16.2	14.1
1985	–	–	–	–	16.7	14.5	16.7	14.5
1986	–	–	100.0	90.1	17.3	15.0	117.3	105.1
1987	–	–	100.6	90.7	17.8	15.4	118.4	106.1
1988	–	–	–	–	25.8	22.4	25.8	22.4
1989	–	–	–	–	26.6	23.1	26.6	23.1
1990	–	–	–	–	27.5	23.9	27.5	23.9
1991	–	–	–	–	28.3	24.6	28.3	24.6
1992	–	–	–	–	29.1	25.3	29.1	25.3
1993	–	–	–	–	29.9	26.0	29.9	26.0
1994	–	–	–	–	30.8	26.7	30.8	26.7
1995	–	–	–	–	31.6	27.4	31.6	27.4
Totals	372.1	245.7	979.5	882.8	402.8	349.6	1,754.4	1,478.1

TABLE A-46

SECTION IV

SCHEDULE OF COSTS OF ALTERNATIVE HIGHWAY IMPROVEMENTS AND DEDUCTION OF TAXES
(NT$ MILLIONS)

Years	Property		Construction		Maintenance		Total Costs	
	W/tax	W/O tax	W/tax	W/O tax	W/tax	W/O tax	W/tax	W/O tax
1971	280.4	210.4	266.0	239.4	–	–	546.4	449.8
1972	80.0	60.0	42.0	37.8	–	–	122.0	97.8
1973	–	–	–	–	9.0	7.8	9.0	7.8
1974	48.3	36.2	–	–	9;0	7.8	57.3	44.0
1975	440.8	330.7	–	–	9.0	7.8	449.8	338.5
1976	–	–	571.4	514.3	9.0	7.8	580.4	522.1
1977	–	–	571.4	514.3	9.0	7.8	580.4	522.1
1978	300.0	225.0	-	–	35.8	31.1	335.8	256.1
1979	341.6	256.3	100.0	90.0	35.8	31.1	477.4	377.4
1980	–	–	89.0	80.1	35.8	31.1	124.8	111.2
1981	33.7	25.3	–	–	45.6	39.7	79.3	65.0
1982	211.3	158.5	329.6	296.6	45.6	39.7	586.5	494.8
1983	369.9	274.5	250.0	225.0	45.6	39.7	665.5	539.2
1984	–	–	332.8	299.5	52.4	45.6	385.2	345.1
1985	–	–	–	–	77.0	67.0	77.0	67.0
1986	–	–	–	–	77.0	67.0	77.0	67.0
1987	–	–	–	–	77.0	67.0	77.0	67.0
1988	–	–	–	–	77.0	67.0	77.0	67.0
1989	–	–	–	–	77.0	67.0	77.0	67.0
1990	–	–	–	–	89.0	77.4	89.0	77.4
1991	–	–	–	–	89.0	77.4	89.0	77.4
1992	–	–	–	–	89.0	77.4	89.0	77.4
1993	–	–	–	–	89.0	77.4	89.0	77.4
1994	–	–	–	–	89.0	77.4	89.0	77.4
1995	–	–	–	–	100.0	87.0	100.0	87.0
Totals	2,106.0	1,576.9	2,552.2	2,296.8	1,271.6	1,106.0	5,929.8	4,979.9

TABLE A-47

SECTION V

SCHEDULE OF COSTS OF ALTERNATIVE HIGHWAY IMPROVEMENTS AND DEDUCTION OF TAXES
(NT$ MILLIONS)

	Property		Construction		Maintenance		Total Costs	
Years	W/tax	W/O tax	W/tax	W/O tax	W/tax	W/O tax	W/tax	W/O tax
1971	182.9	142.7	120.2	108.2			303.1	250.9
1972	121.5	94.8	44.0	39.6	2.0	1.7	167.5	136.1
1973	160.0	124.8	110.0	99.0	2.0	1.7	272.0	225.5
1974	—	—	—	—	5.0	4.4	5.0	4.4
1975	380.2	296.6	397.4	357.7	6.0	5.2	783.6	659.5
1976	641.4	500.4	161.8	145.6	13.0	11.3	816.2	657.3
1977	330.9	258.1	1,397.9	1,258.1	14.0	12.2	1,742.8	1,528.4
1978	—	—	—	—	47.4	41.2	47.4	41.2
1979			73.5	66.2	47.4	41.2	120.9	107.4
1980					47.4	41.2	47.4	41.2
1981					51.1	44.5	51.1	44.5
1982					51.1	44.5	51.1	44.5
1983					51.1	44.5	51.1	44.5
1984	5.9	4.6	125.3	112.8	51.1	44.5	182.3	161.9
1985					66.8	58.1	66.8	58.1
1986					66.8	58.1	66.8	58.1
1987					66.8	58.1	66.8	58.1
1988					66.8	58.1	66.8	58.1
1989					66.8	58.1	66.8	58.1
1990					76.0	66.2	76.0	66.2
1991					76.0	66.2	76.0	66.2
1992					76.0	66.2	76.0	66.2
1993					76.0	66.2	76.0	66.2
1994					76.0	66.2	76.0	66.2
1995					86.0	74.8	86.0	74.8
Totals	1,822.7	1,421.9	2,430.1	2,187.2	1,212.6	1,034.4	5,465.4	4,643.5

TABLE A-48

SECTION VI

SCHEDULE OF COSTS OF ALTERNATIVE HIGHWAY IMPROVEMENTS AND DEDUCTION OF TAXES
(NT$ MILLIONS)

Years	Property		Construction		Maintenance		Total Costs	
	W/tax	W/O tax	W/tax	W/O tax	W/tax	W/O tax	W/tax	W/O tax
1971	104.6	90.0	–	–	–	–	104.6	90.0
1972	–	–	273.2	245.9	5.0	4.3	278.2	250.2
1973	–	–	–	–	5.0	4.3	5.0	4.3
1974	245.2	210.9	253.9	228.5	5.0	4.3	504.0	443.7
1975	245.2	210.9	253.8	228.4	5.0	4.3	504.0	443.6
1976	–	–	253.8	228.4	5.0	4.3	258.8	232.7
1977	–	–	253.8	228.4	6.3	5.4	260.1	233.8
1978	–	–	–	–	32.0	27.6	32.0	27.6
1979	–	–	–	–	32.0	27.6	32.0	27.6
1980	–	–	–	–	32.2	27.7	32.2	27.7
1981	–	–	–	–	32.2	27.7	32.2	27.7
1982	–	–	–	–	32.2	27.7	32.2	27.7
1983	64.6	55.6	–	–	32.2	27.7	96.8	83.3
1984	333.9	287.2	554.7	499.2	32.2	27.7	920.8	814.1
1985	203.3	174.8	783.9	705.5	32.2	27.7	1,019.4	908.0
1986	–	–	229.3	206.4	63.2	54.5	292.5	260.9
1987	–	–	–	–	76.8	66.2	76.8	66.2
1988	–	–	–	–	76.8	66.2	76.8	66.2
1989	–	–	–	–	76.8	66.2	76.8	66.2
1990	–	–	–	–	83.9	72.3	83.9	72.3
1991	–	–	–	–	83.9	72.3	83.9	72.3
1992	–	–	–	–	83.9	72.3	83.9	72.3
1993	–	–	–	–	83.9	72.3	83.9	72.3
1994	–	–	–	–	83.9	72.3	83.9	72.3
1995	–	–	–	–	96.9	83.5	96.9	83.5
Totals	1,196.8	1,029.4	2,856.4	2,570.7	1,098.5	946.4	5,151.7	4,546.5

TABLE A-49

SECTION VII

SCHEDULE OF COSTS OF ALTERNATIVE HIGHWAY IMPROVEMENTS AND DEDUCTION OF TAXES
(NT$ MILLIONS)

	Property		Construction		Maintenance		Total Costs	
Years	W/tax	W/O tax	W/tax	W/O tax	W/tax	W/O tax	W/tax	W/O tax
1971	1,071.2	728.4	396.5	364.8	–	–	1,467.7	1,093.2
1972	361.9	246.1	250.0	230.0	3.7	3.1	615.6	479.2
1973	–	–	250.0	230.0	3.7	3.1	253.7	233.1
1974	–	–	–	–	8.0	6.6	8.0	6.6
1975	–	–	–	–	9.0	7.5	9.0	7.5
1976	–	–	350.1	322.1	10.0	8.3	360.1	330.4
1977	–	–	–	–	10.0	8.3	10.0	8.3
1978	200.0	136.0	182.7	168.1	11.0	9.1	393.7	313.2
1979	242.4	164.8	300.0	276.0	11.0	9.1	553.4	449.9
1980	–	–	300.0	276.0	28.4	23.7	328.4	299.7
1981	–	–	–	–	49.7	41.5	49.7	41.5
1982	–	–	–	–	49.7	41.5	49.7	41.5
1983	–	–	–	–	49.7	41.5	49.7	41.5
1984	–	–	181.9	167.4	49.7	41.5	231.6	208.9
1985	–	–	181.0	166.5	49.7	41.5	230.7	208.0
1986	–	–	–	–	76.7	64.1	76.7	64.1
1987	–	–	–	–	76.7	64.1	76.7	64.1
1988	–	–	–	–	76.7	64.1	76.7	64.1
1989	–	–	–	–	76.7	64.1	76.7	64.1
1990	–	–	–	–	86.0	71.9	86.0	71.9
1991	–	–	–	–	86.0	71.9	86.0	71.9
1992	–	–	–	–	86.0	71.9	86.0	71.9
1993	–	–	–	–	86.0	71.9	86.0	71.9
1994	–	–	–	–	86.0	71.9	86.0	71.9
1995	–	–	–	–	99.0	82.7	99.0	82.7
Totals	1,875.5	1,275.3	2,392.2	2,200.9	1,179.1	984.9	5,446.8	4,461.1

Appendix B

EXTRACTION OF TAXES FROM VEHICLE OPERATING COSTS

Since the payment of taxes and tolls does not directly affect the consumption of national economic resources, such payment does not constitute an economic cost to the economy. Thus, when the aim of an analysis is to derive an economic value for a proposal being investigated, such taxes and other transfer payments should be extracted from both the costs and the cost savings (or other benefits) of the proposal.

In the case of this study, tolls were first calculated as explained in Chapter III, and then deducted from the total financial costs of vehicle operations. Taxes were then extracted from the remaining user costs as illustrated in Tables B-1 and B-2.

The cost per vehicle-hour was known approximately (although not precisely since there were time cost adjustments for rolling and for hilly terrain); this cost was multiplied by the indicated numbers of vehicle-hours for the respective vehicle types to obtain the total time cost of vehicle operation. The percentages that taxes represented of total time cost were known from the feasibility study; application of these percentages to total time costs gave the amounts of time cost taxes.

When time costs and tolls were both deducted from user costs, the remainder represented the distance costs of operation. Different percentages, also known from the feasibility study, were applied to these costs in order to determine the tax portions.

Finally, the time costs less taxes were added to the distance costs less taxes to arrive at total user costs less taxes and tolls.

TABLE B-1

EXTRACTION OF TAXES AND TOLLS FROM VEHICLE OPERATING COSTS

SECTION II – TOLL SCHEDULE B_3 – 1990
(NT$ PER DAY)

Cost Item	Types of Vehicles			
	Autos & Taxis	Light Trucks	Heavy Trucks	Buses
Daily vehicle user costs	8,383,753	1,725,668	5,755,247	1,203,135
Toll revenues	1,026,000	136,800	638,400	182,400
User costs less tolls	7,357,753	1,588,868	5,116,847	1,020,735
Vehicle-hours	54,627	11,707	21,105	2,122
User cost per vehicle-hr.	74	43	60	270
Total time costs	4,042,398	503,401	1,266,300	572,940
Taxes as % of time costs	3.25	8.45	8.00	1.78
Total taxes in time costs	131,378	42,537	101,304	10,198
Time costs less taxes	3,911,020	460,864	1,164,996	562,742
Distance costs (i.e. operatnig cost less tolls & time costs)	3,315,355	1,085,467	3,850,547	447,795
Taxes as % of distance costs	31.00	28.82	22.22	22.22
Total taxes in distance costs	1,027,760	312,832	855,592	99,500
Distance costs less taxes	2,287,595	772,635	2,994,956	348,295
User costs less taxes & tolls	6,198,615	1,233,499	4,159,952	911,037
Total taxes and tolls	2,185,138	492,169	1,595,296	292,098

TABLE B-2

EXTRACTION OF TAXES AND TOLLS FROM VEHICLE OPERATING COSTS

ENTIRE FREEWAY NETWORK – TOLL SCHEDULE C_4 – 1969
(NT$ PER DAY)

Cost Item	Types of Vehicles			
	Autos & Taxis	Light Trucks	Heavy Trucks	Buses
Daily vehicle user costs	2,420,728	743,854	4,850,675	1,607,381
Toll revenues	150,960	31,940	416,760	158,710
User costs less tolls	2,269,768	711,914	4,433,915	1,448,671
Vehicle-hours	17,930	5,537	20,803	3,240
User cost per vehicle-hr.	74	43	60	270
Total time costs	1,326,820	238,091	1,248,180	874,800
Taxes as % of time costs	3.25	8.45	8.00	1.78
Total taxes in time costs	43,122	20,119	99,854	15,571
Time costs less taxes	1,283,698	217,972	1,148,326	859,229
Distance costs (i,e, operating cost less tolls & time costs)	942,948	473,823	3,185,735	573,871
Taxes as % of distance costs	31.00	28.82	22.22	22.22
Total taxes in distance costs	292,314	136,555	707,870	127,514
Distance costs less taxes	650,634	337,268	2,477,865	446,357
User Costs less taxes & tolls	1,934,332	555,240	3,626,191	1,305,586
Total taxes and tolls	486,396	188,614	1,224,484	301,795

Appendix C

BENEFIT-COST ANALYSIS OF FREEWAY SECTIONS

An integral part of the freeway feasibility study was the determination of rates of return for each of seven freeway sections. This was helpful in establishing construction priorities among sections, and in making selections between possible alternative routes in some sections.

A construction schedule has now been established (see Chapter I, Table I-2); work on the northern sections (as far south as Hsinchu) is already well underway; and design of the southern sections (Chiayi-Fengshan) has recently begun. Thus, very little flexibility with regard to construction timing remains, and a re-examination of construction priorities is of much less importance in the present study than was the original examination in the feasibility study. For this reason, the re-examination was relegated in this study to an appendix. Only the freeway costs with the barrier system are considered herein, since it has previously been determined that this study is recommending the barrier system.

The right-of-way, construction, and maintenance and operating costs are shown section-by-section and year-by-year in Appendix A to this chapter, both for the with-freeway, and the without-freeway, investment alternatives. Table C-1 shows the incremental costs (exclusive of taxes) of the freeway alternative; as was done for the entire freeway in Table III-1, Table C-1, shows first the gross without-tax costs of the freeway alternative in each section, then the costs of alternative highway investments are shown, and finally the costs of the two investment alternatives are netted out. A comparison of the undiscounted incremental costs calculated in the present study for each section and the respective cost increments found at the time of the feasibility study is shown following.

COST INCREMENTS (NT$ MILLION)

SECTIONS	Feasibility Study	Toll Study	Difference
I	318	534	216
II	732	1,220	488
III	16	– 8	– 24
IV	– 281	– 336	– 55
V	552	454	– 98
VI	– 87	– 116	– 29
VII	50	912	862

In Section I the increase in incremental costs resulted from the cost revisions in the Taipei area; since the increase in freeway costs exceeded the amount of rise in the costs of alternative highway improvements, the net result was an increase in the incremental costs of the freeway alternative.

The sizable increase in Section II incremental cost results from the additional of an on-going Highway 1 improvement to the costs of related highways with the freeway alternative.

The slight diminution of cost increments in Sections III through VI largely results from the addition of 1991-1995 maintenance costs to the cost totals.

The considerable rise in incremental costs in Section VII results from the addition of the costs of an on-going project to widen Highway 1 to four lanes over the full length of the Section.

When the incremental costs are discounted at 15 percent, the comparisons between feasibility study totals and the totals calculated in the present study are as shown below.

Discounted (@ 15%) Cost Increments (NT$ million)

Sections	Feasibility Study	Toll Study	Difference
I	806	677	– 129
II	1,210	1,414	204
III	290	172	– 118
IV	977	631	– 346
V	1,090	417	– 673
VI	1,133	673	– 460
VII	988	1,288	300

Wherever the incremental costs were reduced, of course, the rate of return would tend to be raised. As mentioned in the above discussion of the undiscounted incremental costs, the addition of five years (1991-1995) of maintenance costs tends to reduce incremental costs, since the freeway would reduce the overall cost of highway maintenance in the corridor. Unlike the undiscounted costs, however, the discounted incremental costs would also be affected by any changes in the scheduling of highway investment. For both technical and financial reasons, freeway construction had to be rescheduled from the time table assumed in the feasibility study. If no similar rescheduling of alternative highway investments would be done, the disconuted cost increments of the freeway investment would tend to be lowered. The alternative highway investments were rescheduled, however, in order that additional capacity (except for those improvements which would be made with both investment alternatives) would not be provided in years prior to the scheduled openings of the several freeway sections. (The alternatives to rescheduling these highway investments were: (1) calculate the user savings of this investment alternative in the years before the various freeway sections would be scheduled to open; or (2) add these early year highway investments to the freeway alternative also, so that neither alternative would have a vehicle operation advantage over the other until the freeway would be opened to traffic in each section. The first of these alternatives was discarded because it would have required many additional computer assignments with other networks in other years. The second adjustment alternative was deemed to be unrealistic since much of the capacity of such freeway-related highway improvements would then only be required for a period of about one to three years).

Table C-2 shows the incremental costs discounted at various rates. The table also shows discounted benefits (undiscounted benefits for each freeway section were shown in Table III-4), the net present values of benefits, and benefit-cost ratios. A comparison is shown following of the discounted (@ 15 percent) user savings benefits found for each section in the feasibility study and in this study.

	Discounted (@ 15% User Savings (NT$ Million)		
Sections	Feasibility Study	Toll Study	Difference
I	1,167	627	– 540
II	2,543	3,269	726
III	920	682	– 238
IV	1,457	1,202	– 255
V	1,081	530	– 551
VI	1,556	1,498	– 58
VII	1,703	1,111	– 592

The large reductions in discounted benefits in Sections I, V, and VII result primarily from the considerable effects that the imposition of tolls (with schedule B3) is estimated to have on deterring diversion to the freeway in those areas. In Section VII, especially, where the adjusted computer results indicated that truck traffic at the freeway toll plaza would be quite small even in 1990, the imposition of tolls would greatly reduce the desirability of using the freeway. For these three sections, consideration might advantageously be given to imposing lower toll rates than would be imposed in other sections. An alternative remedial action in Section VII might be to move the plaza from the proposed location south of Nantze to a location to the north of Nantze.

The benefits shown above for Section II are much higher in this study than they were in the feasibility study, since benefits after the freeway would reach capacity were not assumed to decline in subsequent years, but were maintained through 1995 at the capacity level. The feasibility study assumed that a second freeway would open to traffic in Section II in 1982, and that a considerable amount of north-south freeway traffic would be diverted thereto, with a resultant diminution of north-south freeway user savings. Whether or not such a second freeway would actually open, however, the indicated benefits of the first freeway should more properly be maintained, since the second freeway should only be credited with the incremental user savings in the corridor, and thus would not be given credit for savings which would have accrued to highway users even in the event that the second freeway would not have opened.

The internal rates of return found in the present study for each freeway section are shown below. For comparison, the rates of return found in the feasibility study are also shown.

	Internal Rates of Return (%)	
Sections	Toll Study	Feasibility Study
I	14.5	18.9
II	25.0	26.0
III	32.9	30.0
IV	21.2	18.4
V	18.2	15.0
VI	24.9	18.7
VII	14.0	21.2

In Section VII, the substantial decline in the freeway rate of return results primarily from the addition to the freeway alternative costs of the substantial cost of improving Highway 1 in that area. Actually, the internal rate of return expected in Section VII was reduced to an even greater extent than is indicated. At the time of the feasibility study, two alternative routes were examined in Section VII. The recommended alternative was the west freeway alignment on which there would be an estimated 28.4 percent rate of return; the east alternative freeway alignment was forecast to bring a 21.2 percent rate of return. Because of other construction plans along the route of the west alternative, however, that route is no longer available to the freeway.

TABLE C-1

SECTION-BY-SECTION INCREMENTAL COSTS* OF THE FREEWAY INVESTMENT ALTERNATIVE (NT$ MILLION)

Years	Section I			Section II			Section III			Section IV			Section V			Section VI			Section VII		
	Fwy. & Rel. Hwys	Alter. Hwys.	Net cost	Fwy. & Rel. Hwys	Alter. Hwys.	Net cost	Fwy. & Rel. Hwys	Alter. Hwys.	Net cost	Fwy. & Rel. Hwys	Alter. Hwys	Net cost	Fwy. & Rel. Hwys	Alter. Hwys.	Net cost	Fwy. & Rel. Hwys	Alter. Hwys.	Net cost	Fwy. & Rel. Hwys	Alter. Hwys.	Net cost
1971	—	—	—	511	167	344	264	264	—	428	450	- 22	251	251	—	90	90	—	1,121	1,093	28
1972	177	281	- 104	1,748	629	1,119	3	3	—	98	98	—	68	136	- 68	250	250	—	479	479	—
1973	1,279	1,027	252	507	151	356	3	3	—	69	8	61	226	226	—	23	4	19	1,138	233	905
1974	1,001	744	257	375	156	219	166	3	163	438	44	394	88	4	84	822	444	378	1,727	7	720
1975	992	10	982	11	9	2	363	151	212	1,167	339	828	1,046	660	386	822	444	378	728	8	720
1976	4	10	- 6	11	297	- 286	363	349	14	948	522	426	1,521	657	864	723	233	490	520	330	190
1977	4	10	- 6	11	125	- 114	7	9	- 2	948	522	426	1,182	1,528	346	734	234	500	16	8	8
1978	4	11	- 7	12	279	- 267	7	10	- 3	18	256	- 238	21	41	- 20	16	28	- 12	17	313	- 296
1979	5	11	- 6	12	158	- 146	7	10	- 3	19	377	- 358	22	107	- 85	16	28	- 12	18	450	- 432
1980	5	11	- 6	13	26	- 13	7	10	- 3	20	111	- 91	23	41	- 18	17	28	- 11	19	300	- 281
1981	5	12	- 7	201	26	175	8	10	- 2	21	65	- 44	24	45	- 21	17	28	- 11	19	41	- 22
1982	5	12	- 7	13	27	- 14	8	120	- 112	22	495	- 473	25	45	- 20	18	28	- 10	20	41	- 21
1983	5	276	- 271	15	28	- 13	8	97	- 89	23	539	- 516	26	45	- 19	20	83	- 63	21	42	- 21
1984	6	483	- 477	16	29	- 13	8	14	- 6	24	345	- 321	26	162	- 136	195	814	- 619	22	209	- 187
1985	7	103	- 96	17	30	- 13	9	15	- 6	43	67	- 24	158	58	100	286	908	- 622	24	208	- 184
1986	155	19	136	18	31	- 13	9	105	- 96	26	67	- 41	30	58	- 28	29	261	- 232	192	64	128
1987	8	20	- 12	19	31	- 12	134	106	28	29	67	- 38	32	58	- 26	31	66	- 35	27	64	- 37
1988	9	20	- 11	20	32	- 12	10	22	- 12	31	67	- 36	34	58	- 24	33	66	- 33	28	64	- 36
1989	10	21	- 11	21	33	- 12	11	23	- 12	32	67	- 35	36	58	- 22	35	66	- 31	29	64	- 35
1990	10	21	- 11	22	34	- 12	11	24	- 13	34	77	- 43	38	66	- 28	38	72	- 34	30	72	- 42
1991	11	22	- 11	23	35	- 12	12	25	- 13	37	77	- 40	41	66	- 25	40	72	- 32	32	72	- 40
1992	11	22	- 11	24	35	- 11	12	25	- 13	40	77	- 37	42	66	- 24	41	72	- 31	34	72	- 38
1993	12	23	- 11	25	36	- 11	13	26	- 13	41	78	- 37	44	66	- 22	43	72	- 29	35	72	- 37
1994	13	24	- 11	26	37	- 11	13	27	- 14	43	78	- 35	46	67	- 21	45	72	- 27	38	72	- 34
1995	13	24	- 11	28	38	- 10	14	27	- 13	45	87	- 42	48	75	- 27	47	84	- 37	39	83	- 44
Totals	3,751	3,217	534	3,699	2,479	1,220	1,470	1,478	- 8	4,644	4,980	- 336	5,098	4,644	454	4,431	4,547	- 116	5,373	4,461	912

* Excluding all taxes

TABLE C-2

SECTION-BY-SECTION DISCOUNTED COSTS AND BENEFITS, NET PRESENT VALUE OF BENEFITS, AND BENEFIT-COST RATIOS (MONETARY FIGURES IN NT$ MILLIONS)

Freeway Section & Item	Discount Rates 10%	15%	20%	25%	30%	35%
Section I						
Incremental costs	724	677	626	–	–	–
Benefits	1,149	627	372	–	–	–
Net present value	425	– 50	– 254	–	–	–
Benefit-cost ratio	1.59	0.93	0.59			
Section II						
Incremental costs	1,401	1,414	1,407	1,388	–	–
Benefits	5,563	3,269	2,068	1,382	–	–
Net present value	4,162	1,855	661	– 6	–	
Benefit-cost ratio	3.97	2.3	1.47	1.00	–	–
Section III						
Incremental costs	167	172	167	154	140	126
Benefits	1,254	682	399	248	164	111
Net present value	1,087	510	232	94	24	– 15
Benefit-cost ratio	7.51	3.97	2.39	1.61	1.17	0.88
Section IV						
Incremental costs	558	631	620	581	–	–
Benefits	2,288	1,202	678	405	–	–
Net present value	1,730	571	58	– 176	–	–
Benefit-cost ratio	4.09	1.90	1.09	0.70	–	–
Section V						
Incremental costs	473	417	358	–	–	–
Benefits	94	530	304	–	–	–
Net present value	521	113	– 54	–	–	–
Benefit-cost ratio	2.10	1.27	0.85	–	–	–
Section VI						
Incremental costs	653	673	631	508	–	–
Benefits	2,870	1,498	845	502	–	–
Net present value	2,217	825	214	– 6	–	–
Benefit-cost ratio	4.40	2.23	1.34	0.99	–	–
Section VII						
Incremental costs	1,313	1,288	1,219	–	–	–
Benefits	2,075	1,111	642	–	–	–
Net present value	762	– 177	– 577	–	–	–
Benefit-cost ratio	1.58	0.86	0.53	–	–	–

Appendix D

MODAL SPLIT WITH THE PREFERRED TOLL SYSTEM

Introduction

The freeway will constitute a major improvement in the highway system of the western corridor of Taiwan; thus, it should increase the attractiveness of highway transport relative to transport via the existing West Line Railway, and would be expected, therefore, to result in the conversion of some railway traffic to the highway system.

As noted in this study's highway capacity analysis (Chapter II), the freeway would be expected to become congested in Section II by 1984, and in most other sections prior to 1995, even without any traffic converted from the railway. If any sizable volumes of railway traffic would be converted to the freeway, congestion would occur in still earlier years. In order that strains on the freeway capacity might be avoided, at least until 1990 (except in Section II), therefore, it would be desirable that the railway continue to be heavily utilized. This should occur naturally, even if there would be a large initial conversion of railway traffic to the freeway; that is, if the railway should lose a large portion of its traffic to the freeway, and, as a result, would possess excess capacity at the time when the freeway would begin to be congested, the congested highway conditions would be likely to stimulate a reconversion of traffic to the less-congested railway facility. By about 1990, traffic volumes on both facilities would be expected to be approaching capacity (assuming that no major expansion of railway capacity is made prior to that time).

The question of modal split in earlier years is nevertheless of importance; an approximation of the extent to which railway traffic might initially be converted to the freeway must be known in order to accurately schedule railway investment needs.

The question has been examined by several studies over the past few years. The freeway feasibility study compared an improved railway system to a toll-free freeway facility, and concluded that there would be about 40 percent of railway freight traffic which might be converted to highway transport, but that there would be little or no passenger traffic converted, after improvements to the railway had been completed.

An island-wide transportation study, conducted during 1970, compared the freeway, with assumed toll levels, to an unimproved railway system. The study concluded that trucking would improve its competitive position relative to the railway, but that this improvement would result primarily from the increasing average size of heavy trucks, rather than because of the opening of the freeway. Where passenger traffic was concerned, however, the study forecast a substantial conversion of railway traffic to the freeway; specifically, it forecast that 20 percent of railway passengers and 43 percent of railway passenger-kilometers would be converted to highway travel in 1980.

In 1970-1971, a railway electrification study was conducted, which analyzed modal split on the basis of economic costs, instead of financial costs or charges. This study estimated that the railway-highway breakeven distance for freight haulage (with no private railway sidings) would rise from less than 150 kilometers, without the freeway, to around 250 kilometers, after the freeway has been completed. With one private siding, the breakeven distance was calculated to lengthen from about 60 kilometers to over 100 kilometers. With two private sidings, the railway was calculated to provide freight service more cheaply over all distances. This forecast improvement in the competitive position of highway trucking relative to the railway was estimated to have the effect of reducing 1980 railway freight cargoes by about 12 percent.

Where passengers were concerned, the electrification study estimated that the opening of the freeway would result in a conversion of about 8.5 percent of 1980 traffic (in terms of passenger-kilometers) from an electrified railway to the freeway. When intercity trips of more than 100 kilometers distance were considered separately, however, conversion of railway traffic was expected to rise to a 13-24 percent range (the exact percentage being dependant on the length of trip) with an electrified railway, and to a range of 19-29 percent with a dieselized railway.

The following sections of this appendix consider future model split for freight and long-distance passengers, in the light of the recommended toll rates. The analysis is based on financial costs, since it is expected that these will determine the actual patterns of future traffic.

THE EFFECT OF THE FREEWAY ON FREIGHT MODAL SPLIT

The extent to which the freeway would alter the competitive position of the highways with regard to freight transport would depend on the extent to which heavy truck operating costs would be lowered. The computer data indicate the comparison, shown below, of heavy truck operation with and without the freeway in 1969.

	Operating Cost (NT$ per kilometer)	
	Unadjusted for Distance Savings	Adjusted for Distance Savings
Arterial network (without freeway)	3.90	3.90
Freeway network – without tolls	3.43	3.34
Freeway network – with tolls (NT$20/barrier)	3.89	3.75

As the figures indicate, the financial saving with the freeway and toll charges of NT$20 per barrier would be small (less than four percent), and since the railroad, too, might be expected to lower slightly its average financial ton-kilometer costs in the future, there would seem to be no improvement in the trucking competitive position.

The above analysis relates only to average-sized 1969 trucks, however, since it is the operating costs of these trucks which are reflected in the computer data.

The island-wide study, referred to above, estimated the operating costs of a 14-ton truck as NT$3.54 per kilometer (i.e., distance costs) and NT$1.59 per minute (i.e., time costs). If such a truck were to travel over the arterial network at the average speed (viz., 43.5 kilometers per hour), indicated by the computer data for heavy trucks in 1969, then the average cost per vehicle-kilometer (without adjustments for grade) would be NT$5.73. The average cost per vehicle-kilometer on the toll-free freeway network (with an average speed of 59.8 kilometers per hour) would be NT$5.14, whilst, with tolls and stopping costs, the average cost would become NT$5.56 per kilometer (toll charges per kilometer would not be altered from the NT$0.35 cost for average-sized trucks, but stopping costs per kilometer would climb from NT$0.048 to about NT$0.072). Adjusted for distance savings, the respective freeway network operating costs would become NT$5.01 and NT$5.42 per kilometer. The percentage saving with tolls would be 9.5 percent. Compared to this, the increased truck size, itself, would mean a cost reduction per ton-kilometer of 30 percent; i.e., assuming a constant ratio of average load to capacity (viz., 0.65, according to the April 1969 O-D survey) for all sizes of trucks, the per ton-kilometer cost at 60 kilometers per hour (with no adjustment for grade) would be reduced from NT$0.80 to NT$0.56. Thus, the effect of the freeway, with tolls, on the modal split for freight would be far less than the effects of the increasing average truck sizes (of course, the freeway will be responsible in part for the trend to increasing use of larger-sized trucks).

The conclusion, then, is that the freeway, itself (with the recommended toll charges), should not substantially affect (at least, not directly) the competitive position of the highways relative to the railway with regard to freight.

THE EFFECT OF THE FREEWAY ON MODAL SPLIT OF LONG-DISTANCE PASSENGER TRAFFIC

As discussed in Chapter V of this study, the freeway might have a considerable effect on railway passenger volumes, but this would in part depend upon the design of bus operations which would finally be adopted. If trunkline operations were established between the four largest cities, a considerable portion of the railway passenger trips between these cities might be converted to traveling by freeway buses, which would be nearly as rapid and as comfortable as the railway, and would be much more convenient with regard to flexibility of times of arrival and departure.

The recommended toll charge on buses is NT$40 per barrier, which is twice the rate that was recommended to be levied on heavy trucks. The toll rate charged to buses would more than counter-balance the financial benefits of the freeway to the bus operators, i.e., the freeway with the recommended toll charge would mean a financial loss to bus operators, if they could not pass the costs of toll charges on to the passengers. Since the passengers would be reaping a great deal of value from the freeway, in terms of time savings and comfort, however, it would seem only logical that their fares should be raised.

The existing express bus and express railway passenger fares for trips between the city pairs of Taipei-Taichung, Taipei-Kaohsiung, and Taichung-Kaohsiung are shown following. There are at present no scheduled daytime through bus trips between Taipei and Kaohsiung. The least expensive railway and bus fares shown are for travel via non-airconditioned equipment.

City Pairs	Express Rail Fares (NT$)	Express Bus Fares (NT$)
Taipei-Taichung	117	–
	97	71
	68	56
Taichung-Kaohsiung	143	–
	118	85
	83	–

Taipei-Kaohsiung	260	–
	215	156*
	151	141*

* With a transfer at Taichung

Travel time via bus is four hours between Taipei and Taichung, and four and one-half hours between Taichung and Kaohsiung; if a trip were being made between Taipei and Kaohsiung, additional time would be entailed in making a transfer at Taichung. Travel time via the railway is approximately three hours between Taipei and Taichung, and slightly more than that between Taichung and Kaohsiung. Thus, travellers save about one hour by taking the railway between Taipei and Taichung; in addition of course, they are freed from the discomfort of traveling under congested highway conditions. For these benefits, they are willing to pay a fare increment of NT$26 (comparing two airconditioned trips). Between Taichung and Kaohsiung, the time saving would be nearly one and one-half hours, and the fare increment would be NT$33. Considering the necessity for bus passengers to transfer at Taichung, the total time saving with the railway, over the Taipei-Kaohsiung trip, would be in excess of two and one-half hours; the total fare increment would be NT$59.

A bus trip between Taipei and Taichung, using the freeway, would pass through four toll plazas, whilst, between Taichung and Kaohsiung, five plazas would be passed through. Toll payment by the operator would amount to NT$160 over the former trip, and NT$200 over the trip between Taichung and Kaohsiung. If the average number of passengers per bus would be 35 (as assumed in both the feasibility study and this study, on the basis of the findings of the April 1969 O-D survey), and if all of the costs of the toll charges would be passed on to the passengers, then the fare increase for the Taipei-Taichung trip would need to be NT$5 (rounded to the nearest full NT dollar), and the increase for the Taichung-Kaohsiung trip would need to be NT$6. Thus, the fare increment which would be paid on the railway would be reduced as shown following.

City Pairs (trips)	Adjusted Fare Increment Paid for Railway Travel
Taipei-Taichung	NT$21
Taichung-Kaohsiung	NT$27
Taipei-Kaohsiung	NT$48

Whereas the fare disadvantage of railway travel would have been reduced slightly, however, the travel advantages of the railway may have been entirely eliminated. Bus travel time from a Taipei terminal adjacent to the freeway to a similar facility near Taichung (a distance of approximately 150 kilometers via the freeway) would be approximately one hour and forty-five minutes; there would be a saving of more than two hours compared to present bus service, and a saving of more than one hour compared to present railway service (for passengers who would desire to leave from and/or arrive at the central business districts of cities, however, the time savings of the freeway, compared to present day railway service, would be much less, since the railway would provide direct service between these points).

The bus travel time between Taichung and Kaohsiung, via the freeway, would be approximately two hours and fifteen minutes (without a stopover at the Tainan terminal), which would be just one-half the time required for express bus trips at the present time. Again, there would be about a one-hour saving compared to present day railway service.

Assuming stopovers at the Taichung and Tainan terminals (which would be located adjacent to the freeway) of no longer than fifteen minutes, the Taipei-Kaohsiung trip would require a total time of four and one-half hours. Thus, bus passengers would be saving a minimum of four hours compared to present bus service; moreover, they would not be inconvenienced by having to transfer at Taichung, and the ride might be equally as comfortable as railway travel, since, at least for a period of several years, the freeway would remain uncongested. For all of this improvement of service, the passengers would be asked to pay an additional NT$11, in order for the operator to meet the costs of toll charges.

The freeway bus service, over the Taipei-Kaohsiung trip, would show a time saving compared to present day railway service of more than one and one-half hours. The railway electrification study, referred to in an earlier section of this appendix, indicated, however, that an electrified railway would be able to make the trip in about five hours. Hence, the time savings with the freeway bus compared to an electrified railway would be reduced to only one-half hour for passengers desiring to leave from and/or arrive at outlying areas of the two cities, whilst, where passengers desiring to depart from and/or arrive at the central business districts of these cities would be concerned, the time savings of freeway bus travel might be virtually eliminated.

Freeway bus service, with trunkline operations, should therefore be roughly equivalent to the passenger service which would be provided with an electrified railway. Since this would be so, railway fares would need to be reduced if the railway were to keep a substantial portion of its express passenger traffic which would move between the four largest cities of Taiwan. If passenger terminals were not located adjacent to the freeway at points other than near these four cities, then smaller portions of the railway traffic, which would begin, or terminate, at those points, would be expected to be converted.

Even if the railway would reduce its fares to bus levels for trips between the four major cities, freeway buses would still be expected to take roughly one-half of that total passenger traffic, which would mean that there would be a sizable conversion of traffic from the railway.

Appendix E
SENSITIVITY ANALYSIS

INTRODUCTION

As pointed out in Chapter III, the precision of this study's estimate of the rate of return on the incremental cost of the freeway alternative rests on a number of factors, and, adjustment of any one of them, might be expected to affect the estimated rate of return. The discussion which follows attempts to assess the effects on the rate of return estimate when various adjustments are made, or when various other factors, having some bearing on the actual return on the freeway investment, but not previously taken into account, are given consideration. Specifically, the discussion which follows examines the probable effects, on the estimated rate of return, of the several items listed below.

(1) Adjustments of traffic forecasts. Three cases are examined: (a) adjustment according to Appendix A of Chapter I; (b) holding bus and light truck forecasts constant, but reducing heavy truck and auto savings forecasts by twenty-five percent; and (c) holding heavy truck and auto forecasts constant, but raising bus and light truck forecasts by thirty-three percent.

(2) Adding benefits for forecast auto and bus induced traffic volumes.

(3) Inclusion of benefits for the improved highway safety with the freeway alternative.

Each of these items is discussed separately in the sections of this appendix which follow.

ADJUSTED TRAFFIC FORECASTS

In Appendix A (Chapter I), the vehicle registration forecasts for 1990 were revised as follows: auto registrations were reduced by 25 percent; bus registrations were increased by 50 percent; and light truck registrations were raised by 100 percent. No adjustment was made for the heavy truck forecast (in terms of 1969 truck equivalents). If the user savings for these same vehicle types were adjusted by the same factors, the results would be as shown following.

Vehicle Type	Unadjusted Savings (NT$ Million)	Factor	Adjusted Savings (NT$ Million)
Auto	2,210	0.75	1,658
Light Truck	217	2.00	434
Heavy Truck	1,546	1.00	1,546
Bus	677	1,50	1,016
Total Vehicles	4,650		4,654

It can be seen that altering the traffic forecasts according to Appendix A would have only negligible effect on user savings and on the rate of return.

If light truck and bus forecasts would be held constant, while both auto and heavy truck forecasts would be reduced by twenty-five percent, however, the user savings forecast for 1990 would decline considerably, to only NT$3,711 million before adjustments for airport traffic and freeway capacity limitations, and to NT$3,689 million after these adjustments would be made. In that case, undiscounted user savings over the 1975-1995 period would total NT$56,759 million (compared to this study's estimate of NT$70,398 million for the freeway with toll schedule B_3). The year-by-year savings with this revised forecast are shown in Table E-1. The comparison of discounted benefits, with the lower traffic forecast, to this study's estimate of benefits and costs at various discount rates is shown below.

	Discount Rates 15%	20%
Study forecast of discounted benefits (NT$ Mil.)	8,919	5,308
User benefits with lower traffic forecast (NT$ Mil.)	7,305	4,372
Incremental Costs	5,279	5,026
Ratio of lower benefit total to costs	1.38	0.87

The new internal rate of return, with lower auto and truck forecasts, would be 18.7 percent.

If the feasibility study auto and heavy truck forecasts would be assumed to be reasonably accurate, but light truck and bus forecasts would be deemed to be quite conservative (as suggested in Appendix A to Chapter 1), then benefits would need to be adjusted upward. If both light truck and bus savings would be adjusted upward by 33 percent, then total undiscounted 1990 user savings would be NT$4,945 million, before adjustments for airport traffic and capacity limitations, and NT$4,915 million, after these adjustments. The year-by-year benefits with this forecast are also shown in Table E-1.

The total undiscounted benefits for the 1975-1995 period would be NT$74,676 million, which would only be about 6.1 percent higher than the total forecast by this study. A comparison between the discounted totals of these higher benefits, and the discounted benefits and costs forecast in Chapter III is shown following.

	Discount Rates	
	20%	25%
Study forecast of discounted benefits (NT$ Mil.)	5,308	3,359
User benefits with higher traffic forecast (NT$ Mil.)	5,599	3,541
Incremental costs	5,026	4,687
Ratio of Higher benefit total to costs	1.11	0.75

The revised estimate of the rate of return on the incremental cost of the freeway with higher bus and light truck forecasts would be 21.5 percent.

BENEFITS OF INDUCED TRAFFIC

There were no benefits calculated in Chapter III for induced traffic volumes. The effect of these volumes on toll revenue was examined, however, and they were found to increase toll revenue by an average of nearly nine percent over the 1975-1995 period. These same induced traffic volumes, if they would be normal growth traffic (i.e., traffic which would be expected to use the highway system regardless of whether or not the freeway would come into existence), would increase user savings by an average of 9.8 percent over 1975-1995; because they are induced traffic, however, and not normal growth traffic volumes, they would only affect benefits by about half that extent, i.e., they would be expected to increase user benefits by about 4.9 percent over the period.

In order to understand why estimated user savings benefits should be halved in determining the benefits deriving from induced traffic volumes, the nature of induced traffic should be remembered. New traffic comes into existence because the cost per given quantity of utility declines. Some of the induced traffic would come into existence if there were even a very small lowering of the cost; the benefits of the freeway for these volumes would be nearly equal to the savings for an equivalent volume of normal growth traffic, since their economic saving would be equal to the difference between the cost they would be willing to incur and the cost which they would actually incur for highway travel. There would be other volumes, however, which could only be induced with the full cost improvement provided by the freeway; for these volumes, the economic benefits would be negligible. On the average, the benefits accruing to an induced vehicle trip would be about one-half of the cost improvement for that trip.

If, then, benefits from induced traffic would mean a 4.9 percent increase in total incremental benefits of the freeway, then this study's discounted benefit totals and benefit-cost ratios would be altered to those shown below.

	Discount Rates		
	15%	20%	25%
User benefits revised for induced traffic (NT$ Mil.)	9,355	5,568	3,524
Revised benefit-cost ratios	1.77	1.18	0.75

The revised estimate of the rate of return would be 22.1 percent.

BENEFITS OF SAFETY IMPROVEMENT

Any precise estimate of the extent to which the North-South Freeway might be expected to improve highway safety in the western corridor would be difficult to make, and, once made, the economic value of such improvement would, nevertheless, still be difficult to assess. As noted in the feasibility study, however, it can generally be expected that a given amount of travel on a divided, limited-access highway facility would produce only about one-third as many accidents as would occur on roads which were not divided, and which had unlimited access.

For the analysis of safety benefits included herein, a more precise estimate was obtained of the extent to which the freeway might be expected to reduce traffic accidents. One study* compared two- and four-lane, free-access facilities to freeway

* Traffic Control & Roadway Elements — Their Relationship to Highway Safety/ revised, Slatterly & Cleveland, published by Automotive Safety Foundation, 1969.

operation. A two-lane, undivided, free-access facility with an ADT of 20,000 mixed vehicles might be expected to have about 2.55 accidents per million vehicle-kilometers. With a four-lane facility of a similar type and an ADT of 20,000 vehicles, the accident rate would rise slightly to 2.75 accidents per million vehicle-kilometers. An average of the two facilities, if given equal weight, would be 2.65 accidents per million vehicle-kilometers.

A freeway facility handling only 20,000 vehicles per day would be expected to have an accident rate of only 0.65 accidents per million vehicle kilometers; with an ADT of 40,000 vehicles, the rate would climb to 0.95.

Comparing the average for the two- and four-lane free-access facilities and the latter figure indicated for the freeway, the latter would reduce accidents by nearly 64 percent, or by 1.7 accidents per million vehicle-kilometers.

The referenced study indicated that, with an ADT of around 20,000 vehicles, the average severity of an accident would be greater on freeway facilities than on free-access, undivided highways; the freeway would be expected to produce about 22 percent more injuries per given number of accidents. If then, this relationship were applied to the accident saving percentage, indicated above, the freeway would be expected to reduce the numbers of personal injuries by about 56 percent.

The safety record on Highway 1 is shown in Table E-2. If provision of a freeway could have eliminated 64 percent of these accidents and 56 percent of the injuries, then 7,805 fewer accidents would have occurred, and 1,182 lives would have been saved over 1961-1970. If the economic value of the average life in Taiwan could be viewed as one-half the average life span (over 60 years) times the average per capita income (about NT$10,000 in 1969), then the total economic value of the lives which were might have been saved with the existence of a freeway, over the 1961-1970 period, would be NT$355 million.

There is a dearth of information regarding the seriousness of personal injuries, and the costliness of property damage. Thus, in an attempt to assess the full cost saving from the prevention of highway accidents, some assumptions must be made. If it is assumed that the average injury would be equivalent to four weeks of total disability (or eight weeks of 50 percent reduction of effectiveness, etc.), then the average economic loss from forced inactivity per injury might be calculated as follows:

$$\text{Economic loss} = (4 \div 52) \times \text{NT\$10,000} = \text{NT\$770}$$

In addition, of course, there would be the cost of medical expenses; if it would be assumed that this average cost would be roughly equivalent to the value of forced inactivity, then the total average value of a highway injury would be in the neighborhood of NT$1,500.

If, then, existence of the freeway would have reduced injuries by 56 percent, or approximately 8,880 injuries over the 1961-1970 period, the total economic benefit of that reduction would be NT$13.3 million.

If, in the average accident, two vehicles would be involved, and each would suffer NT$6,000 in damages, then the economic value of property loss in the 7,805 accidents, which might have been prevented with the freeway over 1961-1970, would be NT$93.8 million.

The total economic savings which might have been realized from the highway safety improvement with the freeway, over 1961-1970, would have been NT$462 million.

The value in 1970, alone, would be as shown below.

Item	Number Prevented	Unit Value (NT$)	Total Value (NT$ Million)
Accidents	1,750	12,000	21.0
Injuries	2,075	1,500	3.1
Deaths	257	300,000	77.1
Total value	–		101.2

Thus, in 1970, economic savings deriving from greater highway safety would have increased the year's hypothetical user savings (NT$611 million) by about 16.6 percent. If it were assumed that future growth of safety benefits, which would have averaged more than 21 percent per annum over 1961-1970 (from a 1961 value of NT$17.6 million), would at least keep pace with the growth of user savings through 1995, then discounted user benefits would be as shown below.

	Discount Rates			
	10%	15%	20%	25%
User savings (NT$ Million)	16,193	8,919	5,308	3,359
Benefits from improved safety (NT$ Mil.)	2,688	1,481	881	558
Total benefits	18,881	10,400	6,189	3,917
Revised benefit-cost ratios	3.57	1.97	1.24	0.84

The revised rate of return for the freeway with the barrier network and toll schedule B3 would be 23.0 percent.

Another approach to calculating safety benefits of the freeway would be to apply the figure, calculated above, of 1.7 potential accidents prevented by the freeway per million vehicle-kilometers. Applying this rate to the hypothetical 1969 freeway total of 956 million vehicle-kilometers, a total of 1,625 accidents would have been prevented by the freeway in that year.

In 1969, there were approximately 1.4 injuries and 0.16 deaths per accident on highway 1. If the severity of accidents on the freeway would on the average be 22 percent greater than other highway accidents, then the freeway would experience 1.7 injuries and nearly 0.2 deaths per accident. A theoretical total of 908 freeway accidents (i.e., 0.95 per million vehicle-kms), in 1969, would have then produced 1,540 injuries and 182 deaths. On arterials, however, the same volumes of potential freeway traffic would have produced 2,533 accidents, 3,550 injuries, and 405 deaths. The freeway would have, according to these calculations, prevented a total of 2,010 injuries and 223 deaths. Using the unit values shown above to convert this safety improvement to monetary benefits, the prevention of accidents, injuries, and deaths, in 1969, would have been worth NT$19.5 million, NT$3.0 million, and NT$66.9 million, respectively, for a total of NT$89.4 million. This would have been equivalent to approximately 17.1 percent of hypothetical user savings in 1969.

In 1990, there would be approximately 6,385 million freeway vehicle-kilometers (after adjustments for capacity, airport traffic, etc.). The safety benefits which these might produce are shown calculated in table E-3. The total of NT$600.3 million of safety benefits, in 1990, would be equivalent to 13.0 percent of estimated user savings in that year.

The average (1969 and 1990) increase in benefits represented by improved highway traffic safety would be about 15.0 percent. If this percentage of benefits would be added to the discounted user cost savings totals, the new benefit totals shown below would result.

	Discount Rates		
	15%	20%	25%
Revised benefit totals	10,257	6,104	3,863
Benefit-cost ratios	1.94	1.22	0.82

Using this second method to calculate the benefits of freeway improvement of highway traffic safety, the rate of return estimate would be 22.8 percent.

TABLE E-1

USER SAVINGS WITH ALTERED TRAFFIC FORECASTS
(NT$ MILLIONS)

Years	User Savings: With 25 percent lower 1990 Auto & Heavy Truck Forecasts		With 33 percent Higher bus & Light Truck forecasts	
	Hypothetical* Savings	Projected Actual Savings	Hypothetical* Savings	Projected Actual Savings
1971	674	–	699	–
1972	742	–	794	–
1973	819	–	902	–
1974	909	–	1,027	–
1975	764	240	882	278
1976	747	534	903	645
1977	548	867	671	1,064
1978	–	1,561	–	1,939
1979	–	1,719	–	2,160
1980	–	1,891	–	2,401
1981	–	2,075	–	2,658
1982	–	2,274	–	2,936
1983	–	2,484	–	3,230
1984	–	2,706	–	3,540
1985	–	2,853	–	3,745
1986	–	3,008	–	3,963
1987	–	3,169	–	4,187
1988	–	3,337	–	4,422
1989	–	3,510	–	4,664
1990	–	3,689	–	4,915
1991	–	3,868	–	5,166
1992	–	4,052	–	5,423
1993	–	4,193	–	5,620
1994	–	4,320	–	5,798
1995	–	4,409	–	5,922
Totals	5,203	56,759	5,878	74,676

* From freeway sections which would not yet be opened to traffic.

TABLE E-2

SAFETY RECORD ON HIGHWAY 1

Years	Number of Accidents	Number of Persons Injured	Number of Deaths
1961	315	342	82
1962	393	504	59
1963	431	521	49
1964	555	656	106
1965	868	1,044	143
1966	1,060	1,333	193
1967	1,393	1,818	246
1968	1,769	2,265	326
1969	2,676	3,679	447
1970	2,735	3,705	459
Totals	12,195	15,865	2,110

Source: Taiwan Highway Bureau

TABLE E-3

FORECAST 1990 FREEWAY SAFETY BENEFITS

Accidents		
Freeway (0.95 per million veh-kms)	–	6,066
Arterials (2.65 per million veh-kms; Fwy veh-kms only)	–	16,920
Savings in accidents (Numbers)	–	10,854
Value (NT$12,000 per accident)	–	NT$130.2 Mil.
Injuries		
Freeway (1.7 per accident)	–	10,310
Arterials (1.4 per accident)	–	23,690
Savings in injuries (Numbers)	–	13,380
Value (NT$1,500 per injury)	–	NT$ 20.1 Mil.
Deaths		
Freeway (0.20 per accident)	–	1,210
Arterials (0.16 per accident)	–	2,710
Savings in deaths (Numbers)	–	1,500
Value (NT$300,000 per death)	–	NT$450.0 Mil.
Total 1990 value of freeway safety benefits	–	NT$600.3 Mil.

Appendix F

EFFECTS OF EXTENDING THE PERIOD OF THE INITIAL STAGE OF FREEWAY CONSTRUCTION

Introduction

Elsewhere in this study, the analysis considers that the freeway is to be constructed according to the Government's current construction schedule, which calls for completion of the freeway (through from Keelung to Fengshan, but not including later widening of several freeway sections) over the 1971-1977 period. The financial analysis in Chapter III, however, indicates that such a construction schedule might prove financially difficult to manage, since, with the current financing scheme, debt service requirements could then not be met in any year prior to 1982.

The possibility exists, then, that the construction schedule might be extended for some period of years, so that debt service requirements would be somewhat less burdensome in the near term.

The sections of this appendix which follow discuss three alternative schedulings of freeway investment, and the economic and financial effects which might be expected to result from defferal of some portion of the freeway investment.

Alternative Schedules for Freeway Construction

The current construction schedule for the freeway was indicated in Chapter I. This schedule is shown again, together with three alternative schedules in Table F-1. Because work on the freeway sections which would extend from Keelung to Yangmei is well advanced, no changes in scheduled completion dates were made for these sections.

The Tainan-Kaohsiung (Fengshan) section is currently scheduled to be completed by end-1976; this completion date was adjusted in only one alternative schedule (and then only by one year, i.e., end-1977) because existing congestion and forecast traffic growth for the area indicate that the freeway should be provided in that area as soon as possible.

The Yangmei-Hsinchu section is currently scheduled for completion by end-1976. The section was found, by both the feasibility study and this study, to produce the highest rate of return of any freeway section on the incremental costs of the freeway investment alternative. Accordingly, it would seem inadvisable to delay completion of this section for any period of years, and the alternative schedules for freeway construction, therefore, only call for a one-year delay with Alternative B and a delay of two years with Alternative C.

The Hsinchu-Taichung section is currently scheduled to be completed by end-1977. This would be deferred by only one year, to end-1978, with Alternatives A and B, but would be deferred for three years with Alternative C. Substantial distance savings in this section result in a high rate of return estimate, and the importance of a Taipei-Taichung freeway connection (especially, after the planned new Taichung port will have opened) suggests that construction of this section ought not be delayed for many years.

As explained in the footnote to Table F-1, the Tounan-Tainan section might actually be constructed as two different sections. The Chiayi-Tainan portion of the section is currently under design, but the initial portion to be constructed may only be from Tainan to Hsinying. On the theory that future highway travel between Tainan and Tounan will be of less importance than the travel between Hsinchu and Taichung, the completion date for the former section was deferred beyond the date for completing the Hsinchu-Taichung section (with two alternative schedules). With Alternative C, the completion of the Tounan-Tainan section would be deferred for six years.

The Taichung-Tounan section was found to give the lowest rate of return of the central freeway sections. Accordingly, construction of this section is shown in Table F-1 as being delayed for the longest period, viz., three years with Alternative A, five years with Alternative B, and eight years with Alternative C.

The year-by-year investment costs for the entire freeway with alternative construction schedules A, B, and C are shown in Tables F-2; F-3, and F-4, respectively.

Economic Effects of Extending the Period of Construction

The feasibility study indicated that the entire freeway would be needed by 1975. Since the time of the feasibility study, highway freight haulage has grown about as expected, but the growth of bus, light truck, and auto traffic has exceeded the forecasts for the early years; thus, if it were possible, and if no other new highway capacity were to be provided, it would be desirable to construct the entire freeway sometime before 1975.

It is not possible, however. Moreover, other new highway capacity (notably, improvements to Highway 1) is being provided. Even with other planned highway improvements, however, the capacity analysis of this study found that every freeway section would be needed by 1978, which is in accordance with the Government's current construction schedule.

If construction of the freeway would then be delayed, and no additional highway improvements with the freeway investment alternative (referred to in the feasibility study, and elsewhere in this study, as "related highway improvements") would be made, then a breakdown in highway traffic (that is, forced flow conditions and F level of service) would be expected to occur, which would have the effect of seriously constraining economic growth.

To prevent this, other related highway improvements could be made with the freeway alternative. If this were done, however, the incremental costs of the freeway investment alternative would grow, while the benefits to be derived from the freeway over any given period would tend to diminish (since greater alternative capacity would be provided, and smaller volumes would therefore use the freeway). Thus, the estimate of the freeway alternative rate of return would tend to be lowered.

If, however, it would be assumed that a period of extreme highway congestion would be permitted with either the freeway investment alternative or the alternative program of highway improvements, then both could be similarly rescheduled to later years, and incremental freeway costs, either undiscounted or discounted, would not be expected to vary significantly from those shown in Tables III-1 and C-1 (Appendix C to Chapter III). Benefits of the incremental freeway investment, in this case, would tend to rise since the various freeway sections would be opening in later years, when traffic volumes would be higher. Thus, the rate of return estimate would tend to climb as construction would be delayed until later and later years, up to the point where the various freeway sections would be filled to capacity in the first year of operation.

This latter approach to investigating the economic effects of extending the construction schedule of the freeway was used in this appendix. It should be remembered from the foregoing discussion, however, that the analysis presented herein does not purport to show the economic advisability of delaying freeway construction. Rather, it is only meant to indicate the desirability of the delayed freeway investment relative to a similarly-delayed highway improvement program

Tables F-5 through F-7 indicate the revised incremental costs of the freeway investment with alternative schedulings of freeway investment. The altered user savings totals are shown in Tables F-8 through F-10. With alternatives B and C, the study period had to be extended to the year 2000, in order to permit every freeway section to operate for a minimum of 15 years. So that the results with each of the three alternatives would be at least roughly comparable, the benefits and costs of any section after its twentieth year of operation were not included in the analysis.

The benefit-cost ratios and the rate of return estimates, which result from the altered time series of benefits and incremental costs, are shown in Table F-11. The rate of return would be 21.7 percent with Alternative A (completion by 1980), 22.0 percent with Alternative B (completion by 1982), and 23.1 percent with Alternative C (completion by 1985). To say that "the rate of return on the incremental cost of the freeway tends to grow as construction is deferred for a longer and longer time", however, is to say nothing more than "with higher traffic volumes, the freeway becomes more attractive relative to the alternative program of highway improvements".

Financial Effects of Extending the Period of Construction

The whole object of extending the freeway construction period would be to lessen the burden of debt service in the early years of operation. With deferral of the opening dates of various freeway sections, of course, toll revenues in the early years, as well as debt service requirements, would decline. Tables F-12 and F-13 show the altered year-by-year revenue totals which might be expected to be received with alternative construction schedules A, B, and C. Some of the early year totals are reduced from those indicated in Chapter III, based on the present schedule for construction. With the inclusion of revenue expected to be received over the 1996-2000 period, however, the undiscounted totals with the alternative construction schedules become much higher than the total shown in Chapter III for the 1971-1995 period. Table F-14 shows total revenues with the inclusion of tolls received from induced traffic volumes.

Table F-15 indicates how these toll revenues would compare with total freeway costs (including all investment costs and maintenance and operation costs, and all taxes on these various costs) when both revenue and costs are discounted at a rate of eight percent per annum. Revenue obtained with Alternative A would cover 92.6 percent of costs; revenue with Alternative B would cover 94.3 percent of costs; and, with Alternative C, 96.2 percent of all costs would be covered over the 1971-2000 period.

As indicated in Chapter III, however, a more meaningful comparison of revenues with costs is arrived at by examining both revenues and financial requirements on a year-by-year basis. In the Chapter III discussion of revenue sufficiency, it was indicated that, of the initial NT$5,050 million for financing freeway investment, approximately 26.1 percent would be obtained from foreign exchange loans and 34.1 percent would be provided by local currency bond issues. The ensuing analysis in this section assumes that the above percentages would obtain for the entire freeway investment.

Tables F-16 through F-18 indicate the debt service requirements on foreign exchange loans which would result with alternative construction schedules A, B, and C. For quick comparison, the peak years and amounts with each alternative are shown below.

	Peak Year	Peak Amount (NT$ Millions)
Alternative A	1981	717
Alternative B	1983	690
Alternative C	1986	671

Tables F-19 through F-21 compare forecast toll revenues (including revenues from induced traffic) with financial requirements for covering all service on foreign exchange debt, for meeting all maintenance and operation costs, and for financing all stage II construction (viz., the widening of various freeway sections). As these tables show, expected revenue would be sufficient in every year after the freeway would begin to operate to cover all of these costs.

Service on local currency debt must also be covered, of course. Table F-22 shows the expected incurrence of domestic debt obligations with each of the construction schedule alternatives. Assuming that all of this debt continues to be in the form of seven-year bonds, with equal annual repayments scheduled at the ends of the third through seventh years, annual principal repayments would be as shown in Tables F-23 through F-25.

The calculation of year-by-year total debt service is shown in Tables F-26 through F-28. Again, for purposes of allowing a quick comparison, peak years and peak amounts with each alternative construction schedule are shown below.

	Peak Year	Peak Amount (NT$ Millions)
Alternative A	1979	1,468
Alternative B	1979	1,247
Alternative C	1979	956

Regardless of which construction schedule would be chosen, toll revenues available to cover local currency debt service would be inadequate to cover all service in every year prior to 1982. In 1982, Alternatives B and C would produce small surpluses of revenue over debt service requirements, Alternative A would produce its first surplus in 1983. In every year thereafter, there would be steadily growing surpluses until 1997 (not shown in the tables) when all sections of the freeway would carry capacity volumes of traffic. The levels of cumulative shortfalls of revenue, which would be reached by end-1982, are shown below for each of the three construction schedule alternatives. Each alternative would attain a cumulative surplus by end-1988, and these levels, also, are indicated below.

	End-1982 cumulative shortfall (NT$ Million)	End-1988 cumulative surplus (NT$ Million)
Alternative A	6,112	1,573
Alternative B	5,429	1,194
Alternative C	4,310	1,168

It can be seen from these figures that Alternative C would have a distinct advantage in reducing the level of end-1982 cumulative shortfall, but that, by end-1988, this financial advantage would have been entirely dissipated.

TABLE F-1

ALTERNATIVE SCHEDULES FOR FREEWAY CONSTRUCTION

Freeway Sections	Present Status	Current Construct. Schedule Completion dates	Alternative construction Schedules Completion Dates A	B	C
Sanchung-Chungli	Under construction	Mid-1974	Mid-1974	Mid-1974	Mid-1974
Chungli-Yangmei	Final design completed	End-1974	End-1974	End-1974	End-1974
Taipei-Sanchung	Final design completed	Mid-1975	Mid-1975	Mid-1975	Mid-1975
Keelung-Neihu	Under final design	Mid-1975	Mid-1975	Mid-1975	Mid-1975
Neihu-Taipei	Under final design	End-1975	End-1975	End-1975	End-1975
Tainan-Kaohsiung	Under preliminary design	End-1976	End-1976	End-1976	End-1977
Yangmei-Hsinchu	Under final design	End-1976	End-1976	End-1977	End-1978
Hsinchu-Taichung	Work discontinued	End-1977	End-1978	End-1978	End-1980
Tounan-Tainan*	Under preliminary design	End-1977	End-1978	End-1980	End-1983
Taichung-Tounan	Work discontinued	End-1977	End-1980	End-1982	End-1985

* Although the Tounan-Tainan section has been divided into two sections (viz., Tounan-Chiayi and Chiayi-Tainan) for design purposes, and may also be constructed as two sections having different completion dates, the analysis in this appendix considered Tounan-Tainan as one section since available cost information and vehicle operating results are not broken down for the two design sections, and since, in any case, the section may be divided at Hsinying, rather than at Chiayi, for construction purposes.

TABLE F-2

ALTERNATIVE A SCHEDULING OF FREEWAY INVESTMENT (INCLUDING TAXES)
(NT$ MILLIONS)

Years	Section I, II, III, & VII* Right-of-way & construction	Section I, II, III, & VII* Maintenance & Operation	Total	Section IV** R-O-W & Const.	Section IV** Maint. & Oper.	Total	Section V*** R-O-W & Const.	Section V*** Maint. & Oper.	Total	Section VI** R-O-W & Const.	Section VI** Maint. & Oper.	Total	Entire Freeway R-O-W & Const.	Entire Freeway Maint. & Oper.	Entire Freeway Total Undiscounted	Entire Freeway Total Disc. @8%
1971	398.5	–	398.5	–	–	–	–	–	–	–	–	–	398.5	–	398.5	399
1972	2,088.7	–	2,088.7	–	–	–	–	–	–	–	–	–	2,088.7	–	2,088.7	1,934
1973	3,344.3	–	3,344.3	–	–	–	–	–	–	–	–	–	3,344.3	–	3,344.3	2,866
1974	2,589.1	–	2,589.1	85.4	–	85.4	–	–	–	21.3	–	21.3	2,695.8	–	2,695.8	2,141
1975	2,321.6	6.6	2,328.2	541.5	–	541.5	–	–	–	923.3	–	923.3	3,786.4	6.6	3,793.0	2,788
1976	960.5	11.5	972.0	1,388.4	–	1,388.4	–	–	–	923.3	–	923.3	3,272.2	11.5	3,283.7	2,236
1977	–	24.3	24.3	1,094.9	–	1,094.9	106.6	–	106.6	807.6	–	807.6	2,009.1	24.3	2,033.4	1,281
1978	–	25.6	25.6	1,095.0	–	1,095.0	491.7	–	491.7	807.9	–	807.9	2,394.6	25.6	2,420.2	1,411
1979	–	26.9	26.9	–	13.7	13.7	1,845.4	–	1,845.4	–	12.3	12.3	1,845.4	52.9	1,898.3	1,025
1980	–	28.2	28.2	–	14.4	14.4	1,409.4	–	1,409.4	–	12.9	12.9	1,409.4	55.5	1,464.9	733
1981	208.2	29.5	237.7	–	15.1	15.1	–	10.2	10.2	–	13.6	13.6	208.2	68.4	276.6	128
1982	–	30.9	30.9	–	15.9	15.9	–	10.8	10.8	–	14.3	14.3	–	71.9	71.9	31
1983	–	32.9	32.9	–	16.7	16.7	–	11.5	11.5	–	15.0	15.0	–	76.1	76.1	30
1984	–	35.4	35.4	–	17.4	17.4	–	12.2	12.2	–	15.6	15.6	–	80.6	80.6	30
1985	–	39.2	39.2	21.5	18.1	39.6	155.4	13.7	169.1	–	16.3	16.3	176.9	87.3	264.2	90
1986	352.0	43.3	395.3	–	20.3	20.3	–	14.4	14.4	–	17.0	17.0	352.0	95.0	447.0	141
1987	137.7	47.2	184.9	–	21.1	21.1	–	15.1	15.1	–	19.0	19.0	137.7	102.4	240.1	70
1988	–	51.0	51.0	–	23.5	23.5	–	15.8	15.8	–	21.1	21.1	–	111.4	111.4	30
1989	–	54.8	54.8	–	25.8	25.8	–	17.5	17.5	–	23.2	23.2	–	121.3	121.3	30
1990	–	58.9	58.9	–	28.0	28.0	–	19.3	19.3	–	25.2	25.2	–	131.4	131.4	30
1991	–	63.0	63.0	–	30.3	30.3	–	21.0	21.0	–	27.3	27.3	–	141.6	141.6	30
1992	–	66.8	66.8	–	32.7	32.7	–	22.7	22.7	–	29.4	29.4	–	151.6	151.6	30
1993	–	70.8	70.8	–	35.0	35.0	–	24.5	24.5	–	31.5	31.5	–	161.8	161.8	30
1994	–	74.6	74.6	–	37.2	37.2	–	26.2	26.2	–	33.5	33.5	–	171.5	171.5	29
1995	–	78.5	78.5	–	39.5	39.5	–	27.9	27.9	–	35.6	35.6	–	181.5	181.5	29
1996	–	82.4	82.4	–	41.8	41.8	–	29.6	29.6	–	37.6	37.6	–	191.4	191.4	28
1997	–	86.3	86.3	–	44.1	44.1	–	31.3	31.3	–	39.6	39.6	–	201.3	201.3	27
1998	–	90.2	90.2	–	46.4	46.4	–	33.0	33.0	–	41.8	41.8	–	211.4	211.4	26
1999	–	94.1	94.1	–	48.8	48.8	–	34.7	34.7	–	44.0	44.0	–	221.6	221.6	26
2000	–	98.0	98.0	–	51.2	51.2	–	36.4	36.4	–	46.2	46.2	–	231.8	231.8	25
Totals	12,400.6	1,350.9	13,751.5	4,226.7	637.0	4,863.7	4,008.5	427.8	4,436.3	3,483.4	572.0	4,055.4	24,119.2	2,987.7	27,106.9	17,704

* Costs according to current schedule.
** One-year Construction Delay.
*** Three-year Construction Delay.

TABLE F-3

ALTERNATIVE B SCHEDULING OF FREEWAY INVESTMENT (INCLUDING TAXES)
(NT$ MILLIONS)

Years	Section I, II, & VII* Right-of-way & Construction	Section I, II, & VII* Maintenance & Operation	Section I, II, & VII* Total	Section III** R-O-W & Const.	Section III** Maint. & Oper.	Section III** Total	Section IV** R-O-W & Const.	Section IV** Maint. & Oper.	Section IV** Total	Section V*** R-O-W & Const.	Section V*** Maint. & Oper.	Section V*** Total	Section VI**** R-O-W & Const.	Section VI**** Maint. & Oper.	Section VI**** Total	Entire Freeway R-O-W & Const.	Entire Freeway Maint. & Oper.	Entire Freeway Total Undiscounted	Entire Freeway Total Disc. @8%
1971	398.5	–	398.5	–	–	–	–	–	–	–	–	–	–	–	–	398.5	–	398.5	399
1972	2,088.7	–	2,088.7	–	–	–	–	–	–	–	–	–	–	–	–	2,088.7	–	2,088.7	1,934
1973	3,344.3	–	3,344.3	–	–	–	–	–	–	–	–	–	–	–	–	3,344.3	–	3,344.3	2,866
1974	2,343.6	–	2,343.6	–	–	–	85.4	–	85.4	–	–	–	–	–	–	2,429.0	–	2,429.0	1,929
1975	1,922.3	6.6	1,928.9	245.5	–	245.5	541.5	–	541.5	–	–	–	–	–	..	2,709.3	6.6	2,715.9	1,996
1976	561.5	11.5	573.0	399.3	–	399.3	1,388.4	–	1,388.4	–	–	–	21.3	–	21.3	2,370.5	11.5	2,382.0	1,501
1977	–	20.9	20.9	399.0	–	399.0	1,094.9	–	1,094.9				923.3	–	923.3	2,417.2	20.9	2,438.1	1,536
1978	–	22.0	22.0	–	3.4	3.4	1,095.0	–	1,095.0	–	–	–	923.3	–	923.3	2,018.3	25.4	2,043.7	1,192
1979	–	23.1	23.1	–	3.6	3.6	–	13.7	13.7	106.6	–	106.6	807.6	–	807.6	914.2	40.4	954.6	516
1980	–	24.2	24.2	–	3.8	3.8	–	14.4	14.4	491.7	–	491.7	807.9	–	807.9	1,299.6	42.4	1,342.0	671
1981	380.2	25.3	233.5	–	4.0	4.0	–	15.1	15.1	1,845.4	–	1,845.4	–	12.3	12.3	2,053.6	56.7	2,110.3	977
1982	–	26.5	26.5	–	4.2	4.2	–	15.9	15.9	1,409.4	–	1,409.4	–	12.9	12.9	1,409.4	59.5	1,468.9	630
1983	–	28.3	28.3	–	4.4	4.4	–	16.7	16.7	–	10.2	10.2	–	13.6	13.6	–	73.2	73.2	29
1984	–	30.7	30.7	–	4.6	4.6	–	17.4	17.4	–	10.8	10.8	–	14.3	14.3	–	77.8	77.8	29
1985	–	33.9	33.9	–	4.7	4.7	21.5	18.1	39.6	155.4	12.3	167.7	–	15.0	15.0	176.9	84.0	260.9	89
1986	352.0	37.4	389.4	–	5.3	5.3	–	20.3	20.3	–	13.0	13.0	–	15.6	15.6	352.0	91.6	443.6	140
1987	–	40.7	40.7	137.7	5.9	143.6	–	21.1	21.1	–	13.7	13.7	–	16.3	16.3	137.7	97.7	235.4	69
1988	–	44.0	44.0	–	6.5	6.5	–	23.5	23.5	–	14.4	14.4	–	17.0	17.0	–	105.4	105.4	28
1989	–	47.2	47.2	–	7.0	7.0	–	25.8	25.8	–	15.1	15.1	–	19.0	19.0	–	114.1	114.1	29
1990	–	50.7	50.7	–	7.6	7.6	–	28.0	28.0	–	15.8	15.8	–	21.1	21.1	–	123.2	123.2	29
1991	–	54.2	54.2	–	8.2	8.2	–	30.3	30.3	–	17.5	17.5	–	23.2	23.2	–	133.4	133.4	29
1992	–	57.5	57.5	–	8.8	8.8	–	32.7	32.7	–	19.3	19.3	–	25.2	25.2	–	143.5	143.5	29
1993	–	60.9	60.9	–	9.3	9.3	–	35.0	35.0	–	21.0	21.0	–	27.3	27.3	–	153.5	153.5	28
1994	–	64.1	64.1	–	9.9	9.9	–	37.2	37.2	–	22.7	22.7	–	29.4	29.4	–	163.3	163.3	28
1995	–	67.4	67.4	–	10.5	10.5	–	39.5	39.5	–	24.5	24.5	–	31.5	31.5	–	173.4	173.4	27
1996	–	70.7	70.7	–	11.1	11.1	–	41.8	41.8	–	26.2	26.2	–	33.5	33.5	–	183.3	183.3	27
1997	–	74.0	74.0	–	11.7	11.7	–	44.1	44.1	–	27.9	27.9	–	35.6	35.6	–	193.3	193.3	26
1998	–	77.3	77.3	–	12.3	12.3	–	46.4	46.4	–	29.6	29.6	–	37.6	37.6	–	203.2	203.2	25
1999	–	80.6	80.6	–	12.9	12.9	–	48.8	48.8	–	31.3	31.3	–	39.6	39.6	–	213.2	213.2	25
2000	–	83.9	83.9	–	13.5	13.5	–	51.2	51.2	–	33.0	33.0	–	41.8	41.8	–	223.4	223.4	24
Totals	11,219.1	1,163.6	12,382.7	1,181.5	173.2	1,354.7	4,226.7	637.0	4,863.7	4,008.5	358.3	4,366.8	3,483.4	481.8	3,965.2	24,119.2	2,813.9	26,933.1	16,857

* Costs not rescheduled from present schedule.
** One-year delay in construction.
*** Five-year delay in construction.
**** Three-year construction delay.

TABLE F-4

ALTERNATIVE C SCHEDULING OF FREEWAY INVESTMENT (INCLUDING TAXES)
(NT$ MILLION)

Years	Section I & II*			Section III**			Section IV***			Section V****			Section VI*****			Section VII******			Entire Freeway			
	Right-of-way & Construction	Maintenance & Operation	Total	R-O-W & Const.	Maint. & Oper.	Total	R-O-W & Const.	Maint. & Oper.	Total	R-O-W & Const.	Maint. & Oper.	Total	R-O-W & Const.	Maint. & Oper.	Total	R-O-W & Const.	Maint. & Oper.	Total	Right-of-way & Construction	Maintenance & Operation	Total Undiscounted	Total Disc. @8%
1971	398.5	–	398.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	398.5	–	398.5	399
1972	2,088.7	–	2,088.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2,088.7	–	2,088.7	1,934
1973	2,014.1	–	2,014.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2,014.1	–	2,014.1	1,726
1974	1,543.6	–	1,543.6	–	–	–	–	–	–	–	–	–	–	–	–	1,330.2	–	1,330.2	2,873.8	–	2,873.8	2,282
1975	1,122.3	6.6	1,128.9	–	–	–	–	–	–	–	–	–	–	–	–	800.0	–	800.0	1,922.3	6.6	1,928.9	1,418
1976	–	11.5	11.5	245.5	–	245.5	85.4	–	85.4	–	–	–	–	–	–	800.0	–	800.0	1,130.9	11.5	1,142.4	778
1977	–	12.0	12.0	399.3	–	399.3	541.5	–	541.5	–	–	–	–	–	–	561.5	–	561.5	1,502.3	12.0	1,514.3	954
1978	–	12.7	12.7	399.0	–	399.0	1,388.4	–	1,388.4	–	–	–	–	–	–	–	8.4	8.4	1,787.4	21.1	1,808.5	1,055
1979	–	13.3	13.3	–	3.4	3.4	1,094.9	–	1,094.9	–	–	–	21.3	–	21.3	–	8.9	8.9	1,116.2	25.6	1,141.8	617
1980	–	13.9	13.9	–	3.6	3.6	1,095.0	–	1,095.0	–	–	–	923.3	–	923.3	–	9.3	9.3	2,018.3	26.8	2,045.1	1,023
1981	208.2	14.5	222.7	–	3.8	3.8	–	13.7	13.7	–	–	–	923.3	–	923.3	–	9.8	9.8	1,131.5	41.8	1,173.3	543
1982	–	15.2	15.2	–	4.0	4.0	–	14.4	14.4	106.6	–	106.6	807.6	–	807.6	–	10.3	10.3	914.2	43.9	958.1	411
1983	–	16.5	16.5	–	4.2	4.2	–	15.1	15.1	491.7	–	491.7	807.9	–	807.9	–	10.8	10.8	1,299.6	46.6	1,346.2	534
1984	–	18.4	18.4	–	4.4	4.4	–	15.9	15.9	1,845.5	–	1,845.4	–	12.3	12.3	–	11.3	11.3	1,845.4	62.3	1,907.7	702
1985	–	20.2	20.2	–	4.6	4.6	21.5	16.7	38.2	1,564.8	–	1,564.8	–	12.9	12.9	–	11.8	11.8	1,586.3	66.2	1,652.5	562
1986	167.0	22.1	189.1	–	4.7	4.7	–	17.4	17.4	–	11.1	11.1	–	13.6	13.6	185.0	12.3	197.3	352.0	81.2	433.2	136
1987	–	23.9	23.9	137.7	5.3	143.0	–	18.1	18.1	–	11.7	11.7	–	14.3	14.3	–	13.7	13.7	137.7	87.0	224.7	66
1988	–	25.8	25.8	–	5.9	5.9	–	20.3	20.3	–	12.3	12.3	–	15.0	15.0	–	15.3	15.3	–	94.6	94.6	26
1989	–	27.5	27.5	–	6.5	6.5	–	21.1	21.1	–	13.0	13.0	–	15.6	15.6	–	16.8	16.8	–	100.5	100.5	25
1990	–	29.5	29.5	–	7.0	7.0	–	23.5	23.5	–	13.7	13.7	–	16.3	16.3	–	18.2	18.2	–	108.2	108.2	25
1991	–	31.5	31.5	–	7.6	7.6	–	25.8	25.8	–	14.4	14.4	–	17.0	17.0	–	19.7	19.7	–	116.0	116.0	25
1992	–	33.3	33.3	–	8.2	8.2	–	28.0	28.0	–	15.1	15.1	–	19.0	19.0	–	21.2	21.1	–	124.8	124.8	25
1993	–	35.2	35.2	–	8.8	8.8	–	30.3	30.3	–	15.8	15.8	–	21.1	21.1	–	22.7	22.7	–	133.9	133.9	25
1994	–	37.0	37.0	–	9.3	9.3	–	32.7	32.7	–	17.5	17.5	–	23.2	23.2	–	24.2	24.2	–	143.9	143.9	24
1995	–	38.7	38.7	–	9.9	9.9	–	35.0	35.0	–	19.3	19.3	–	25.2	25.2	–	25.7	25.7	–	153.8	153.8	24
1996	–	40.4	40.4	–	10.5	10.5	–	37.2	37.2	–	21.0	21.0	–	27.3	27.3	–	27.1	27.1	–	163.5	163.5	24
1997	–	42.1	42.1	–	11.1	11.1	–	39.5	39.5	–	22.7	22.7	–	29.4	29.4	–	28.7	28.7	–	173.5	173.5	23
1998	–	43.8	43.8	–	11.7	11.7	–	41.8	41.8	–	24.5	24.5	–	31.5	31.5	–	30.3	30.3	–	183.6	183.6	22
1999	–	45.5	45.5	–	12.3	12.3	–	44.1	44.1	–	26.2	26.2	–	33.5	33.5	–	31.9	31.9	–	193.5	193.5	23
2000	–	47.2	47.2	–	12.9	12.9	–	46.4	46.4	–	27.9	27.9	–	35.6	35.6	–	33.5	33.5	–	203.5	203.5	22
Totals	7,542.4	678.3	8,220.7	1,181.5	159.7	1,341.2	4,226.7	537.0	4,763.7	4,008.5	266.2	4,274.7	3,483.4	362.8	3,846.2	3,676.7	421.9	4,098.6	24,119.2	2,425.9	26,545.1	15,453

* Costs According to Current Schedule.
** Two-year Delay in Construction.
*** Three-year Delay in Construction.
**** Eight-year Delay in Construction.
***** Six-year Construction Delay.
****** One-year Construction Delay.

TABLE F-5

FREEWAY INCREMENTAL COSTS WITH ALTERNATIVE A SCHEDULING OF INVESTMENT (EXCLUDING TAXES)
(NT$ MILLION)

Years	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Entire Freeway Undiscounted	Entire Freeway Discounted @ 10%	Discounted @ 15%	Discounted @ 20%	Discounted @ 25%	Discounted @ 30%
1971	—	344	—	- 22	—	—	28	350	350	350	350	350	350
1972	-104	1,119	—	—	- 68	—	—	947	861	824	789	758	728
1973	252	356	—	—	—	—	905	1,513	1,250	1,144	1,050	968	896
1974	257	219	163	61	—	19	720	1,439	1,081	947	835	737	655
1975	982	2	212	394	—	378	720	2,688	1,836	1,538	1,296	1,102	941
1976	-6	- 286	14	828	—	378	190	1,118	694	556	449	367	301
1977	- 6	- 114	- 2	426	84	490	8	886	500	383	297	232	183
1978	- 7	- 267	- 3	201	386	500	- 296	514	264	193	143	108	82
1979	- 6	- 146	- 3	- 359	864	- 12	- 432	- 94	- 44	- 31	- 22	- 16	- 12
1980	- 6	- 13	- 3	- 92	- 412	- 12	- 281	- 819	- 347	- 233	- 159	- 110	- - 77
1981	- 7	175	- 2	- 44	- 20	- 11	- 22	- 69	27	17	11	7	5
1982	- 7	- 14	- 112	- 473	- 19	- 11	- 21	- 657	- 230	- 141	- 89	- 57	- 37
1983	- 271	- 13	- 89	- 516	- 18	- 66	- 21	- 994	- 317	- 186	- 111	- 69	- 43
1984	- 477	- 13	- 6	- 321	- 134	- 623	- 187	- 1,761	- 511	- 287	- 164	- 97	- 58
1985	- 96	- 13	- 6	- 24	100	- 626	- 184	- 849	- 223	- 120	- 66	- 37	- 21
1986	136	- 13	- 96	- 41	- 28	- 232	128	- 146	- 35	- 18	- 9	- 5	- 3
1987	- 12	- 12	28	- 38	- 26	- 35	- 37	- 132	- 29	- 14	- 7	- 4	- 2
1988	- 11	- 12	- 12	- 36	- 24	- 33	- 36	- 164	- 32	- 15	- 7	- 4	- 2
1989	- 11	- 12	- 12	- 35	- 22	- 31	- 35	- 158	- 28	- 13	- 6	- 3	- 1
1990	- 11	- 12	- 13	- 43	- 28	- 34	- 42	- 183	- 30	- 13	- 6	- 3	- 1
1991	- 11	- 12	- 13	- 40	- 25	- 32	- 40	- 173	- 26	- 11	- 5	- 2	- 1
1992	- 11	- 11	- 13	- 37	- 24	- 31	- 38	- 165	- 22	- 9	- 4	- 2	- 1
1993	- 11	- 11	- 13	- 37	- 22	- 29	- 37	- 160	- 20	- 7	- 3	- 1	—
1994	- 11	- 11	- 14	- 35	- 21	- 27	- 34	- 153	- 17	- 6	- 2	- 1	—
1995	- 11	*	- 13	- 42	- 27	- 37	- 44	- 174	- 18	- 6	- 2	- 1	—
1996	*	—	- 13	- 41	- 26	- 35	- 43	- 158	- 15	- 5	- 2	- 1	—
1997	—	—	*	- 41	- 24	- 34	*	- 99	- 8	- 3	- 1	—	—
1998	—	—	—	- 41	- 21	- 33	—	- 95	- 7	- 2	—	—	—
1999	—	—	—	*	- 28	*	—	- 28	- 2	- 1	—	—	—
2000	—	—	—	—	- 27	—	—	- 27	- 2	—	—	—	—
Totals	534	1,230	- 21	- 448	390	- 219	869	2,335	4,900	4,831	4,555	4,216	3,883

* Excluding incremental costs beyond 20 years of operations.

TABLE F-6

FREEWAY INCREMENTAL COSTS WITH ALTERNATIVE B SCHEDULING OF INVESTMENT (EXCLUDING TAXES)
(NT$ MILLION)

Years	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Entire Freeway					
								Undiscounted	Discounted				
									@ 10%	@ 15%	@ 20%	@ 25%	@ 30%
1971	—	344	—	- 22	—	—	28	350	350	350	350	350	350
1972	- 104	1,119	—	—	- 68	—	—	947	861	824	789	758	728
1973	252	356	—	—	—	—	905	1,513	1,250	1,144	1,050	968	896
1974	257	219	—	61	—	—	720	1,257	944	827	728	644	572
1975	982	2	163	394	—	—	720	2,261	1,544	1,293	1,090	927	791
1976	- 6	- 286	212	828	—	19	190	957	594	476	385	314	257
1977	- 6	- 114	14	426	—	378	8	706	398	305	237	185	146
1978	- 7	- 267	- 2	201	—	378	- 296	7	4	3	2	1	1
1979	- 6	- 146	- 3	- 359	84	490	- 432	- 372	- 174	- 122	- 87	- 63	- 46
1980	- 6	- 13	- 3	- 92	386	500	- 281	491	208	139	95	66	46
1981	- 7	175	- 3	- 44	864	- 12	- 22	951	367	235	154	102	69
1982	- 7	- 14	- 112	- 473	- 412	- 12	- 21	- 1,051	- 368	- 226	- 142	- 90	- 59
1983	- 271	- 13	- 89	- 516	- 20	- 66	- 21	- 996	- 318	- 186	- 112	- 69	- 43
1984	- 477	- 13	- 6	- 321	- 136	- 623	- 187	- 1,763	- 511	- 287	- 164	- 97	- 58
1985	- 96	- 13	- 6	- 24	100	- 626	- 184	- 849	- 223	- 120	- 66	- 37	- 21
1986	136	- 13	- 96	- 41	- 28	- 232	128	- 146	- 35	- 18	- 9	- 5	- 3
1987	- 12	- 12	28	- 38	- 26	- 35	- 37	- 132	- 29	- 14	- 7	- 4	- 2
1988	- 11	- 12	- 12	- 36	- 24	- 33	- 36	- 164	- 32	- 15	- 7	- 4	- 2
1989	- 11	- 12	- 12	- 35	- 22	- 31	- 35	- 158	- 28	- 13	- 6	- 3	- 1
1990	- 11	- 12	- 12	- 43	- 28	- 34	- 42	- 182	- 30	- 13	- 6	- 3	- 1
1991	- 11	- 12	- 13	- 40	- 25	- 32	- 40	- 173	- 26	- 11	- 5	- 2	- 1
1992	- 11	- 11	- 13	- 37	- 24	- 31	- 38	- 165	- 22	- 9	- 4	- 1	- 1
1993	- 11	- 11	- 13	- 37	- 22	- 29	- 37	- 160	- 20	- 7	- 3	- 1	—
1994	- 11	- 11	- 13	- 35	- 21	- 27	- 34	- 152	- 17	- 6	- 2	- 1	—
1995	- 11	*	- 14	- 42	- 27	- 37	- 44	- 175	- 18	- 6	- 2	- 1	—
1996	*	—	- 13	- 41	- 26	- 35	- 43	- 158	- 15	- 5	- 2	- 1	—
1997	—	—	- 13	- 41	- 24	- 34	*	- 112	- 9	- 3	- 1	—	—
1998	—	—	*	- 41	- 21	- 33	—	- 95	- 7	- 2	- 1	—	—
1999	—	—	—	*	- 28	- 32	—	- 60	- 4	- 1	—	—	—
2000	—	—	—	—	- 27	- 40	—	- 67	- 4	- 1	—	—	—
Totals	534	1,230	- 31	- 448	425	- 269	869	2,310	4,630	4,531	4,254	3,933	3,618

* Excluding incremental costs beyond 20 years of operations.

TABLE F-7

FREEWAY INCREMENTAL COSTS WITH ALTERNATIVE C SCHEDULING OF INVESTMENT
(NT$ MILLION)

Years	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Entire Freeway Undiscounted	Entire Freeway Discounted @ 10%	@ 15%	@ 20%	@ 25%	@ 30%
1971	—	344	—	- 22	—	—	28	350	350	350	350	350	350
1972	- 104	1,119	—	—	- 68	—	—	947	861	824	789	758	728
1973	252	356	—	—	—	—	—	608	502	460	422	389	360
1974	257	219	—	—	—	—	905	1,381	1,037	909	800	707	628
1975	982	2	—	—	—	—	720	1,704	1,164	975	821	699	596
1976	- 6	- 286	163	61	—	—	720	652	405	324	262	214	175
1977	- 6	- 114	212	394	—	—	190	676	381	292	226	177	140
1978	- 7	- 267	14	603	—	—	- 296	47	24	18	13	10	7
1979	- 6	- 146	- 2	80	—	19	- 432	- 487	- 227	- 159	- 113	- 82	- 60
1980	- 6	- 13	- 3	346	—	378	- 281	421	179	120	82	56	40
1981	- 7	175	- 3	- 44	—	378	- 22	477	184	118	77	51	35
1982	- 7	- 14	- 112	- 473	84	490	- 21	- 53	- 19	- 11	- 7	- 5	- 3
1983	- 271	- 13	- 89	- 516	386	444	- 21	- 80	- 26	- 15	- 9	- 6	- 3
1984	- 477	- 13	- 6	- 321	864	- 619	- 187	- 759	- 220	- 124	- 71	- 42	- 25
1985	- 96	- 13	- 6	- 24	- 399	- 622	184	- 1,344	- 353	- 190	- 105	- 59	- 34
1986	136	- 13	- 96	- 41	- 20	- 232	128	- 138	- 33	- 17	- 9	- 5	- 3
1987	- 12	- 12	28	- 38	- 19	- 35	- 37	- 125	- 27	- 13	- 7	- 4	- 2
1988	- 11	- 12	- 12	- 36	- 18	- 33	- 36	- 158	- 31	- 15	- 7	- 4	- 2
1989	- 11	- 12	- 12	- 35	- 21	- 31	- 35	- 157	- 28	- 13	- 6	- 3	- 1
1990	- 11	- 12	- 13	- 43	- 20	- 34	- 42	- 175	- 29	- 12	- 5	- 2	- 1
1991	- 11	- 12	- 13	- 40	- 28	- 32	- 40	- 176	- 26	- 11	- 5	- 2	- 1
1992	- 11	- 11	- 13	- 37	- 26	- 31	- 38	- 167	- 23	- 9	- 4	- 2	- 1
1993	- 11	- 11	- 13	- 37	- 24	- 29	- 37	- 162	- 20	- 7	- 3	- 1	- 1
1994	- 11	- 11	- 14	- 35	- 22	- 27	- 34	- 154	- 17	- 6	- 2	- 1	- 1
1995	- 11	*	- 13	- 42	- 28	- 37	- 44	- 175	- 18	- 6	- 2	- 1	- 1
1996	*	—	- 13	- 41	- 25	- 35	- 43	- 157	- 14	- 5	- 2	- 1	—
1997	—	—	- 13	- 39	- 24	- 34	- 41	- 151	- 13	- 4	- 1	- 1	—
1998	—	—	- 13	- 38	- 22	- 33	*	- 106	- 8	- 2	- 1	—	—
1999	—	—	*	- 37	- 21	- 32	—	- 90	- 6	- 2	- 1	—	—
2000	—	—	—	- 44	- 27	- 40	—	- 111	- 7	- 2	- 1	—	—
Totals	534	1,230	- 42	- 499	522	- 227	820	2,338	3,942	3,767	3,481	3,190	2,921

* Excluding incremental costs beyond 20 years of operations.

TABLE F-8

FREEWAY USER SAVINGS WITH ALTERNATIVE A SCHEDULING OF INVESTMENT (EXCL. TAXES)*
(NT$ MILLION)

Years	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Entire Freeway Undiscounted	Discounted @ 10%	@ 15%	@ 20%	@ 25%	@ 30%
1971	–	–	–	–	–	–	–	–	–	–	–	–	–
1972	–	–	–	–	–	–	–	–	–	–	–	–	–
1973	–	–	–	–	–	–	–	–	–	–	–	–	–
1974	–	–	–	–	–	–	–	–	–	–	–	–	–
1975	–	269	–	–	–	–	–	269	184	154	130	110	94
1976	87	532	–	–	–	–	–	619	384	308	249	203	167
1977	99	594	131	–	–	–	193	1,017	574	439	341	266	211
1978	112	663	144	–	–	–	217	1,136	641	491	317	239	181
1979	126	737	158	288	–	358	243	1,910	892	625	445	321	235
1980	141	818	173	321	–	399	271	2,123	900	603	412	284	200
1981	157	906	189	356	168	442	301	2,519	972	622	408	270	184
1982	175	1,001	206	394	181	488	333	2,778	972	597	375	239	156
1983	193	1,103	224	434	194	537	367	3,052	974	571	342	211	131
1984	212	1,211	243	476	208	588	403	3,341	969	545	311	184	110
1985	232	1,211	263	521	222	642	441	3,532	929	498	276	155	88
1986	254	1,211	284	568	238	699	481	3,735	893	459	243	131	75
1987	276	1,211	306	616	254	759	522	3,944	860	422	213	110	59
1988	299	1,211	329	667	271	820	566	4,163	824	387	187	96	50
1989	323	1,211	353	719	288	884	610	4,388	790	355	167	79	39
1990	348	1,211	377	774	306	950	656	4,622	758	324	143	65	32
1991	373	1,211	402	828	324	1,016	702	4,856	724	296	126	58	24
1992	398	1,211	427	883	342	1,084	750	5,095	688	270	112	46	20
1993	423	1,211	452	883	361	1,152	797	5,279	649	243	95	37	16
1994	449	1,211	477	883	361	1,220	844	5,445	610	218	82	33	11
1995	747	**	502	883	361	1,286	844	4,350	444	152	57	22	9
1996	**	–	502	883	361	1,286	844	3,876	357	116	39	16	4
1997	–	–	**	883	361	1,286	**	2,530	213	66	23	8	3
1998	–	–	–	883	361	1,286	–	2,530	192	58	18	5	3
1999	–	–	–	**	361	**	–	361	25	7	2	1	–
2000	–	–	–	–	361	–	–	361	23	6	2	1	–
Totals	5,151	19,944	6,142	13,143	5,884	17,182	10,385	77,831	16,441	8,832	5,115	3,190	2,102

* Excluding Hypothetical Savings in Years Before the Various Freeway Sections would open.
** Excluding Benefits Beyond 20 years of Operation.

TABLE F-9

FREEWAY USER SAVINGS WITH ALTERNATIVE B SCHEDULING OF INVESTMENT (EXCL. TAXES)*
(NT$ MILLION)

Years	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Entire Freeway Undiscounted	Discounted @ 10%	@ 15%	@ 20%	@ 25%	@ 30%
1971	–	–	–	–	–	–	–	–	–	–	–	–	–
1972	–	–	–	–	–	–	–	–	–	–	–	–	–
1973	–	–	– –	–	–	–	–	–	–	–	–	–	–
1974	–	–	–	–	–	–	–	–	–	–	–	–	–
1975	–	269	–	–	–	–	–	269	184	154	130	110	94
1976	87	532	–	–	–	–	–	619	384	308	249	203	167
1977	99	594	–	–	–	–	193	886	500	383	297	232	183
1978	112	663	144	–	–	–	217	1,136	641	491	317	239	181
1979	126	737	158	288	–	–	243	1,552	725	508	362	261	191
1980	141	818	173	321	–	–	271	1,724	731	490	334	231	162
1981	157	906	189	356	–	442	301	2,351	907	581	381	252	172
1982	175	1,001	206	394	–	488	333	2,597	909	558	351	223	145
1983	193	1,103	224	434	194	537	367	3,052	974	571	342	211	131
1984	212	1,211	243	476	308	588	403	3,341	969	545	311	184	110
1985	232	1,211	263	521	222	642	441	3,532	929	498	276	155	88
1986	254	1,211	284	568	238	699	481	3,735	893	459	243	131	75
1987	276	1,211	306	616	254	759	522	3,944	860	422	213	110	59
1988	299	1,211	329	667	271	820	566	4,163	824	387	187	96	50
1989	323	1,211	353	719	288	884	610	4,388	790	355	167	79	39
1990	348	1,211	377	774	306	950	656	4,622	758	324	143	65	32
1991	373	1,211	402	828	324	1,016	702	4,856	724	296	126	58	24
1992	398	1,211	427	883	342	1,084	750	5,095	688	270	112	46	20
1993	423	1,211	452	883	361	1,152	797	5,279	649	243	95	37	16
1994	449	1,211	477	883	361	1,220	844	5,445	610	218	82	33	11
1995	474	**	502	883	361	1,286	844	4,350	444	152	57	22	9
1996	**	–	502	883	361	1,286	844	3,876	357	116	39	16	4
1997	–	–	502	883	361	1,286	**	3,032	255	79	27	9	3
1998	–	–	**	883	361	1,286	–	2,530	192	58	18	5	3
1999	–	–	–	**	361	1,286	–	1,647	114	33	10	3	2
2000	–	–	–	–	361	1,286	–	1,647	104	28	8	3	–
Totals	5,151	19,944	6,513	13,143	5,535	18,997	10,385	79,668	16,115	8,527	4,877	3,014	1,971

* Excluding hypothetical savings in years before the various freeway sections would open.
** Excluding benefits beyond 20 years of operation.

TABLE F-10

FREEWAY USER SAVINGS WITH ALTERNATIVE C SCHEDULING OF INVESTMENT (EXCL. TAXES)*
(NT$ MILLION)

Years	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Entire Freeway Undiscounted	Discounted @ 10%	Discounted @ 15%	Discounted @ 20%	Discounted @ 25%	Discounted @ 30%
1971	–	–	–	–	–	–	–	–	–	–	–	–	–
1972	–	–	–	–	–	–	–	–	–	–	–	–	–
1973	–	–	–	–	–	–	–	–	–	–	–	–	–
1974	–	–	–	–	–	–	–	–	–	–	–	–	–
1975	–	269	–	–	–	–	–	269	184	154	130	110	94
1976	87	532	–	–	–	–	–	619	384	308	249	203	167
1977	99	594	–	–	–	–	–	693	391	299	232	182	143
1978	112	663	–	–	–	–	217	992	509	373	277	208	158
1979	126	737	158	–	–	–	243	1,264	590	413	295	212	155
1980	141	818	173	–	–	–	271	1,403	595	398	272	188	132
1981	157	906	189	356	–	–	301	1,909	737	472	309	204	139
1982	175	1,001	206	394	–	–	333	2,109	738	453	285	181	118
1983	193	1,103	224	434	–	–	367	2,321	740	434	260	160	100
1984	212	1,211	243	476	–	588	403	3,133	909	511	291	172	103
1985	232	1,211	263	521	–	642	441	3,310	871	467	258	146	83
1986	254	1,211	284	568	238	699	481	3,735	893	459	243	131	75
1987	276	1,211	306	616	254	759	522	3,944	860	422	213	110	59
1988	299	1,211	329	667	271	820	566	4,163	824	387	187	96	50
1989	323	1,211	353	719	288	884	610	4,388	790	355	167	79	39
1990	348	1,211	377	774	306	950	656	4,622	758	324	143	65	32
1991	373	1,211	402	828	324	1,016	702	4,856	724	296	126	58	24
1992	398	1,211	427	883	342	1,084	750	5,095	688	270	112	46	20
1993	423	1,211	452	883	361	1,152	797	5,279	649	243	95	37	16
1994	449	1,211	477	883	361	1,220	844	5,445	610	218	82	33	11
1995	474	**	502	883	361	1,286	844	4,350	444	152	57	22	9
1996	**	–	502	883	361	1,286	844	3,876	357	116	39	16	4
1997	–	–	502	883	361	1,286	844	3,876	326	101	35	12	4
1998	–	–	502	883	361	1,386	**	3,032	230	70	27	6	3
1999	–	–	**	883	361	1,286	–	2,530	175	51	15	5	2
2000	–	–	–	883	361	1,286	–	2,530	159	43	13	4	1
Totals	5,151	19,944	6,871	14,300	4,911	17,530	11,046	79,743	15,135	7,789	4,412	2,686	1,741

* Excluding Hypothetical Savings in Years Before the Various Freeway Sections would open.
** Excluding Benefits Beyond 20 years of Operation.

TABLE F-11

BENEFIT-COST RATIOS WITH ALTERNATIVE SCHEDULING OF INVESTMENT

Alternative construction Schedules	Undiscounted	Discount rates				
		10%	15%	20%	25%	30%
Current Schedule						
Benefits (NT$)	70,398	16,193	8,919	5,308	3,359	2,237
Incremental Costs (NT$)	2,663	5,243	5,279	5,026	4,687	4,342
Net Present Value	67,735	10,900	3,640	282	– 1,328	– 2,105
Benefit-Cost Ratios	26.44	3.06	1.69	1.06	0.72	0.52
Alternative A						
Benefits (NT$ Mil.)	77,831	16,441	8,832	5,115	3,190	2,102
Incremental costs (NT$ Mil.)	2,335	4,900	4,831	4,555	4,216	3,883
Net present value	75,496	11,541	4,001	560	– 1,026	– 1,781
Benefit-cost ratios	33.33	3.36	1.83	1.12	0.76	0.54
Alternative B						
Benefits (NT$ Mil.)	79,668	16,115	8,527	4,877	3,014	1,971
Incremental costs (NT$ Mil.)	2,310	4,630	4,531	4,254	3,933	3,618
Net present value	77,358	11,485	3,996	623	– 919	– 1,647
Benefit-cost ratios	34.39	3.48	1.88	1.15	0.77	0.55
Alternative C						
Benefits (NT$ Mil.)	79,743	15,135	7,789	4,412	2,686	1,741
Incremental costs (NT$ Mil.)	2,338	3,942	3,767	3,481	3,190	2,921
Net present value	77,405	11,193	4,022	931	504	– 1,180
Benefit-cost ratios	34.11	3.84	2.07	1.27	0.84	0.60

Rates of Return:

Current Schedule	:	20.9
Alternative A	:	21.7
Alternative B	:	22.0
Alternative C	:	23.1

TABLE F-12

FREEWAY TOLL REVENUE WITH ALTERNATIVE A SCHEDULING OF FREEWAY INVESTMENT*
(NT$ MILLIONS)

Years	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Undiscounted	Discounetd @ 8%
1971	–	–	–	–	–	–	–	–	–
1972	–	–	–	–	–	–	–	–	–
1973	–	–	–	–	–	–	–	–	–
1974	–	–	–	–	–	–	–	–	–
1975	–	191	–	–	–	–	–	191	140
1976	82	225	–	–	–	–	–	307	209
1977	92	263	96	–	–	–	91	542	341
1978	102	304	108	–	–	–	101	615	359
1979	114	349	120	180	–	274	112	1,149	620
1980	127	397	133	200	–	307	124	1,288	644
1981	141	448	147	221	96	342	136	1,531	709
1982	156	503	163	244	106	379	150	1,701	730
1983	171	562	179	269	117	419	164	1,881	747
1984	188	623	196	294	128	460	179	2,068	761
1985	205	623	213	321	141	504	195	2,202	749
1986	223	623	232	350	153	550	212	2,343	738
1987	243	623	252	379	166	598	229	2,490	727
1988	262	623	272	410	180	648	248	2,643	714
1989	283	623	293	442	194	700	266	2,801	700
1990	305	623	315	474	209	753	285	2,964	688
1991	325	623	337	508	224	807	304	3,128	673
1992	347	623	359	541	239	862	324	3,295	656
1993	368	623	382	541	254	917	344	3,429	631
1994	390	623	404	541	254	971	364	3,547	603
1995	411	623	426	541	254	1,026	364	3,645	576
1996	433	623	426	541	254	1,026	364	3,667	536
1997	455	623	426	541	254	1,026	364	3,689	498
1998	455	623	426	541	254	1,026	364	3,689	461
1999	455	623	426	541	254	1,026	364	3,689	428
2000	455	623	426	541	254	1,026	364	3,689	395
Totals	6,788	13,833	6,757	9,161	3,985	15,647	6,012	62,183	15,033**

* Excluding revenue from induced traffic volumes.

** This would be NT$357 million lower than the discounted 1971-2000 total of NT$15,340 million with the current construction schedule.

TABLE F-13

FREEWAY TOLL REVENUE WITH ALTERNATIVES B AND C SCHEDULINGS OF FREEWAY INVESTMENT*
(NT$ MILLION)

Alternative Construction Schedules & Years	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Entire Freeway Undiscounted	Entire Freeway Discounted @8%
Alternative B									
1971-1976**	82	416	–	–	–	–	–	498	349
1977	92	263	–	–	–	–	91	446	281
1978	102	304	108	–	–	–	101	615	359
1979	114	349	120	180	–	–	112	875	473
1980	127	397	133	200	–	–	124	981	491
1981	141	448	147	221	–	342	136	1,435	664
1982	156	503	163	244	–	379	150	1,595	684
1983-2000**	5,974	11,153	5,990	8,316	3,783	14,345	5,298	54,859	11,280
Totals: Alternative B	6,788	13,833	6,661	9,161	3,783	15,066	6,012	61,304	14,581
Alternative C									
1971-1976**	82	416	–	–	–	–	–	498	349
1977	92	263	–	–	–	–	–	355	224
1978	102	304	–	–	–	–	101	507	296
1979	114	349	120	–	–	–	112	695	375
1980	127	397	133	–	–	–	124	781	391
1981	141	448	147	221	–	–	136	1,093	506
1982	156	503	163	244	–	–	150	1,216	522
1983	171	562	179	269	–	–	164	1,345	534
1984	188	623	196	294	–	460	179	1,940	714
1985	205	623	213	321	–	504	195	2,061	701
1986-2000**	5,410	9,345	5,402	7,432	3,397	12,962	4,760	48,708	9,023
Totals: Alternative C	6,788	13,833	6,553	8,781	3,397	13,926	5,921	59,199	13,635

* Excluding revenue from induced traffic.

** Identical to the revenue totals shown with Alternative A construction schedule in Table F-12.

TABLE F-14

TOTAL REVENUE (INCL. TOLLS FROM INDUCED TRAFFIC)
WITH ALTERNATIVE CONSTRUCTION SCHEDULES
(NT$ MILLION)

Year	Current Schedule	Alternative A	Alternative B	Alternative C
1975	208	208	208	208
1976	335	335	335	335
1977	591	591	486	387
1978	1,187	670	670	553
1979	1,336	1,252	954	758
1980	1,498	1,404	1,069	851
1981	1,669	1,669	1,564	1,191
1982	1,854	1,854	1,739	1,325
1983	2,050	2,050	2,050	1,466
1984	2,254	2,254	2,254	2,115
1985	2,400	2,400	2,400	2,246
1986	2,554	2,554	2,554	2,554
1987	2,714	2,714	2,714	2,714
1988	2,881	2,881	2,881	2,881
1989	3,053	3,053	3,053	3,053
1990	3,231	3,231	3,231	3,231
1991	3,410	3,410	3,410	3,410
1992	3,592	3,592	3,592	3,592
1993	3,738	3,738	3,738	3,738
1994	3,866	3,866	3,866	3,866
1995	3,973	3,973	3,973	3,973
1996	3,997	3,997	3,997	3,997
1997	4,021	4,021	4,021	4,021
1998	4,021	4,021	4,021	4,021
1999	4,021	4,021	4,021	4,021
2000	4,021	4,021	4,021	4,021
Totals	68,475	67,780	66,822	64,528
Totals Disc. 8%	16,780	16,386	15,893	14,862

TABLE F-15

COVERAGE OF FREEWAY COSTS* BY TOLL REVENUE
(DISCOUNTED @ 8 PERCENT)

	1971-1990	1971-1995	1971-2000
Current Construction Schedule			
Freeway costs* (NT$ Mil.)	18,435	18,591	18,740
Toll revenue** (NT$ Mil.)	10,828	14,250	16,780
Coverage (%)	58.7	76.6	89.6
Alternative A Construction Schedule			
Freeway costs** (NT$ Mil.)	17,430	17,578	17,704
Toll revenue** (NT$ Mil.)	10,434	13,856	16,386
Coverage (%)	60.0	78.8	92.6
Alternative B Construction Schedule			
Freeway costs* (NT$ Mil.)	16,589	16,730	16,857
Toll Revenue** (NT$ Mil.)	9,941	13,363	15,893
Coverage (%)	60.0	79.9	94.3
Alternative C Construction Schedule			
Freeway costs* (NT$ Mil.)	15,216	15,339	15,453
Toll Revenue** (NT$ Mil.)	8,910	12,332	14,862
Coverage (%)	58.6	80.4	96.2

* Including the with-tax costs of investment, maintenance, and operations.
** Including revenue from induced traffic.

TABLE F-I6

DEBT SERVICE ON FOREIGN EXCHANGE LOANS WITH ALTERNATIVE A SCHEDULING OF FREEWAY INVESTMENT
(NT$ MILLIONS)

	Section I & II			Section III			Section IV			Section V			Section VI			Section VII			Entire Freeway		
Years	Prin.*	Int.**	Total	Prin.*	Int.**	Total	Prin.*	Int.**	Total	Prin.*	Int.**	Total	Prin.*	Int.**	Total	Prin.	Int.**	Total	Principal	Interest	Total
1971	–	9	9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9	9
1972	–	17	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	17	17
1973	12	36	48	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12	36	48
1974	30	49	79	–	–	–	–	–	–	–	–	–	–	–	–	–	10	10	30	59	89
1975	38	71	109	–	4	4	–	–	–	–	–	–	–	7	7	–	30	30	38	112	150
1976	76	111	187	–	13	13	–	12	12	–	–	–	–	22	22	–	49	49	76	207	283
1977	109	106	215	18	18	36	–	36	36	–	–	–	–	37	37	60	59	119	187	256	443
1978	112	100	212	18	17	35	–	59	59	–	–	–	–	52	52	60	55	115	190	283	473
1979	116	93	209	18	15	33	73	71	144	–	16	16	60	59	119	60	51	111	327	305	632
1980	119	85	204	18	14	32	73	67	140	–	49	49	60	55	115	61	48	109	331	318	649
1981	124	79	203	18	13	31	73	62	135	67	65	132	60	51	111	61	44	105	403	314	717
1982	128	71	199	18	12	30	73	57	130	67	61	128	60	47	107	61	40	101	407	288	695
1983	132	63	195	18	11	29	73	52	125	67	57	124	60	43	103	61	36	97	411	262	673
1984	136	56	192	18	9	27	73	48	121	67	52	119	60	40	100	61	32	93	415	237	652
1985	141	47	188	18	8	26	73	43	116	67	48	115	61	36	97	61	28	89	421	210	631
1986	147	39	186	18	7	25	73	38	111	67	44	111	61	32	93	61	24	85	427	184	611
1987	122	30	152	18	6	24	73	33	106	67	39	106	61	28	89	61	20	81	402	156	558
1988	128	21	149	18	5	23	73	29	102	67	35	102	61	24	85	61	16	77	408	130	538
1989	134	13	147	18	4	22	73	24	97	67	31	98	61	20	81	61	12	73	414	104	518
1990	66	4	70	19	2	21	73	19	92	67	26	93	61	16	77	61	8	69	347	75	422
1991	–	–	–	19	1	20	74	14	88	67	22	89	61	12	73	61	4	65	282	53	335
1992	–	–	–	–	–	–	74	10	84	67	17	84	61	8	69	–	–	–	202	35	237
1993	–	–	–	–	–	–	74	5	79	67	13	80	61	4	65	–	–	–	202	22	224
1994	–	–	–	–	–	–	–	–	–	67	9	76	–	–	–	–	–	–	67	9	76
1995	–	–	–	–	–	–	–	–	–	68	4	72	–	–	–	–	–	–	68	4	72
1996	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1997	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1998	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1999	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Totals	1,870	1,100	2,970	272	159	431	1,098	679	1,777	1,006	588	1,594	909	593	1,502	912	566	1,478	6,067	3,685	9,752

* Except for the loans arranged for financing the Neihu-Yangmei section, all foreign exchange loans are assumed repayable in equal annual installments over a 15-year period, beginning the year after construction is scheduled to be completed in the various section.

** An average rate of 6.5 percent per annum is assumed.

TABLE F-17

DEBT SERVICE ON FOREIGN EXCHANGE LOANS WITH ALTERNATIVE B SCHEDULING OF FREEWAY INVESTMENT
(NT$ MILLIONS)

Years	Section I & II			Section III			Section IV			Section V			Section VI			Section VII			Entire Freeway		
	Prin.*	Int.**	Total	Prin.*	Int.**	Total	Prin.*	Int.**	Total	Prin.*	Int.**	Total	Prin.*	Int.**	Total	Prin.*	Int.**	Total	Prin.*	Int.**	Total
1971	–	9	9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9	9
1972	–	17	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	17	17
1973	12	36	48	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12	36	48
1974	30	49	79	–	–	–	–	–	–	–	–	–	–	–	–	–	10	10	30	59	89
1975	38	71	109	–	–	–	–	–	–	–	–	–	–	–	–	–	30	30	38	101	139
1976	76	111	187	–	4	4	–	12	12	–	–	–	–	–	–	–	49	49	76	176	252
1977	109	106	215	–	13	13	–	36	36	–	–	–	–	7	7	60	59	119	169	221	390
1978	112	100	212	18	18	36	–	59	59	–	–	–	–	22	22	60	55	115	190	254	444
1979	116	93	209	18	17	35	73	71	144	–	–	–	–	37	37	60	51	111	267	269	536
1980	119	85	204	18	15	33	73	67	140	–	–	–	–	52	52	61	48	109	271	267	538
1981	124	79	203	18	14	32	73	62	135	–	16	16	60	59	119	61	44	105	336	274	610
1982	128	71	199	18	13	31	73	57	130	–	49	49	60	55	115	61	40	101	340	285	625
1983	132	63	195	18	12	30	73	52	125	67	65	132	60	51	111	61	36	97	411	279	690
1984	136	56	192	18	11	29	73	48	121	67	61	128	60	47	107	61	32	93	415	255	670
1985	141	47	188	18	9	27	73	43	116	67	57	124	60	43	103	61	28	89	420	227	647
1986	147	39	186	18	8	26	73	38	111	67	52	119	60	40	100	61	24	85	426	201	627
1987	122	30	152	18	7	25	73	33	106	67	48	115	61	36	97	61	20	81	402	174	576
1988	128	21	149	18	6	24	73	29	102	67	44	111	61	32	93	61	16	77	408	148	556
1989	134	13	147	18	5	23	73	24	97	67	39	106	61	28	89	61	12	73	414	121	535
1990	66	4	70	18	4	22	73	19	92	67	35	102	61	24	85	61	8	69	346	94	440
1991	–	–	–	19	2	21	74	14	88	67	31	98	61	20	81	61	4	65	282	71	353
1992	–	–	–	19	1	20	74	10	84	67	26	93	61	16	77	–	–	–	221	53	274
1993	–	–	–	–	–	–	74	5	79	67	22	89	61	12	73	–	–	–	202	39	241
1994	–	–	–	–	–	–	–	–	–	67	17	84	61	8	69	–	–	–	128	25	153
1995	–	–	–	–	–	–	–	–	–	67	13	80	61	4	65	–	–	–	128	17	145
1996	–	–	–	–	–	–	–	–	–	67	9	76	–	–	–	–	–	–	67	9	76
1997	–	–	–	–	–	–	–	–	–	68	4	72	–	–	–	–	–	–	68	4	72
1998	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1999	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Totals	1,870	1,100	2,970	272	159	431	1,098	679	1,777	1,006	588	1,594	909	593	1,502	912	566	1,478	6,067	3,685	9,752

* Except for the loans arranged for financing the Neihu-Yangmei section, all foreign exchange loans are assumed repayable in equal annual installments over a 15-year period, beginning the year after construction is scheduled to be completed in the various sections.

** An average rate of 6.5 percent per annum is assumed.

TABLE F-18

DEBT SERVICE ON FOREIGN EXCHANGE LOANS WITH ALTERNATIVE C SCHEDULING OF FREEWAY INVESTMENT
(NT$ MILLIONS)

Years	Section I & II			Section III			Section IV			Section V			Section VI			Section VII			Entire Freeway		
	Prin.*	Int.**	Total	Prin.*	Int.**q	Total	Prin.*	Int.**	Total	Prin.*	Int.**	Total	Prin.*	Int.**	Total	Prin.*	Int.**	Total	Prin.*	Int.**	Total
1971	–	9	9	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	9	9
1972	–	17	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	17	17
1973	12	36	48	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12	36	48
1974	30	49	79	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	30	49	79
1975	38	71	109	–	–	–	–	–	–	–	–	–	–	–	–	–	10	10	38	81	119
1976	76	111	187	–	–	–	–	–	–	–	–	–	–	–	–	–	30	30	76	141	217
1977	109	106	215	–	4	4	–	–	–	–	–	–	–	–	–	–	49	49	109	159	268
1978	112	100	212	–	13	13	–	12	12	–	–	–	–	–	–	60	59	119	172	184	356
1979	116	93	209	18	18	36	–	36	36	–	–	–	–	–	–	60	55	115	194	202	396
1980	119	85	204	18	17	35	–	59	59	–	–	–	–	7	7	60	51	111	197	219	416
1981	124	79	203	18	15	33	73	71	144	–	–	–	–	22	22	61	48	109	276	235	511
1982	128	71	199	18	14	32	73	67	140	–	–	–	–	37	37	61	44	105	280	233	513
1983	132	63	195	18	13	31	73	62	135	–	–	–	–	52	52	61	40	101	284	230	514
1984	136	56	192	18	12	30	73	57	130	–	17	17	60	59	119	61	36	97	348	236	584
1985	141	47	188	18	11	29	73	52	125	–	51	51	60	55	115	61	32	93	353	249	602
1986	147	39	186	18	9	27	73	48	121	69	68	137	60	51	111	61	28	89	428	243	671
1987	122	30	152	18	8	26	73	43	116	69	64	133	60	47	107	61	24	85	403	216	619
1988	128	21	149	18	7	25	73	38	111	69	59	128	60	43	103	61	20	81	409	088	597
1989	134	13	147	18	6	24	73	33	106	69	55	124	60	40	100	61	16	77	415	163	578
1990	66	4	70	18	5	23	73	29	102	70	50	124	61	36	97	61	12	73	349	136	485
1991	–	–	–	18	4	22	73	24	97	70	46	116	61	32	93	61	8	69	283	114	397
1992	–	–	–	19	2	21	73	19	92	70	41	111	61	28	89	61	4	65	284	94	378
1993	–	–	–	19	1	20	74	14	88	70	36	106	61	24	85	–	–	–	224	75	299
1994	–	–	–	–	–	–	74	10	84	70	32	102	61	20	81	–	–	–	205	62	267
1995	–	–	–	–	–	–	74	5	79	70	27	97	61	16	77	–	–	–	205	48	253
1996	–	–	–	–	–	–	–	–	–	70	23	93	61	12	73	–	–	–	131	35	166
1997	–	–	–	–	–	–	–	–	–	70	18	88	61	8	69	–	–	–	131	26	157
1998	–	–	–	–	–	–	–	–	–	70	14	84	61	4	65	–	–	–	131	18	149
1999	–	–	–	–	–	–	–	–	–	70	9	79	–	–	–	–	–	–	70	9	79
2000	–	–	–	–	–	–	–	–	–	70	5	75	–	–	–	–	–	–	70	5	75
Totals	1,870	1,100	2,970	272	159	431	1,098	679	1,777	1,046	615	1,661	909	593	1,502	912	566	1,478	6,107	3,712	9,819

*

* Except for the loans arranged for financing the Neihu-Yangmei section, all foreign exchange loans are assumed repayable in equal annual installments over a 15-year period, beginning the year after construction is scheduled to be completed in the various sections.

** An average rate of 6.5 percent per annum is assumed.

TABLE F-19

TOLL REVENUE COVERAGE OF FOREIGN EXCHANGE LOAN DEBT SERVICE, ANNUAL MAINTENANCE AND OPERATION COSTS, & NEW CONSTRUCTION WITH ALTERNATIVE A SCHEDULING OF FREEWAY INVESTMENT COSTS (NT$ MILLIONS)

Years	Service on Foreign Exchange Debt	Maint. & Oper. Costs	New Construction	Funds Requirements (Excluding service on local debt)	Toll revenue*	Revenue available for service on local debt Annual	Cumulative
1971	9	–	–	9	–	-9	-9
1972	17	–	–	17	–	-17	-26
1973	48	–	–	48	–	-48	-74
1974	89	–	–	89	–	-89	-163
1975	150	7	–	157	208	51	-112
1976	283	12	–	295	335	40	-72
1977	443	24	–	467	591	124	52
1978	473	26	–	499	670	171	223
1979	632	53	–	685	1,252	567	790
1980	649	56	–	705	1,404	699	1,489
1981	717	68	208	993	1,669	676	2,165
1982	695	72	–	767	1,854	1,087	3,252
1983	673	76	–	749	2,050	1,301	4,553
1984	652	81	–	733	2,254	1,521	6,074
1985	631	87	177	895	2,400	1,505	7,579
1986	611	95	352	1,058	2,554	1,496	9,075
1987	558	102	138	798	2,714	1,916	10,991
1988	538	111	–	649	2,881	2,232	13,223
1989	518	121	–	639	3,053	2,414	15,637
1990	422	131	–	553	3,231	2,678	18,315
1991	335	142	–	477	3,410	2,933	21,248
1992	237	152	–	389	3,592	3,203	24,451
1993	224	162	–	386	3,738	3,352	27,803
1994	76	172	–	248	3,866	3,618	31,421
1995	72	182	–	254	3,973	3,719	35,140
1996	–	191	–	191	3,997	3,806	38,946
1997	–	201	–	201	4,021	3,820	42,766
1998	–	211	–	211	4,021	3,810	46,576
1999	–	221	–	211	4,021	3,800	50,376
2000	–	232	–	232	4,021	3,789	54,165
Totals	9,752	2,988	875	13,615	67,780	54,165	–

* Including revenue from induced traffic.

TABLE F-20

TOLL REVENUE COVERAGE OF FOREIGN EXCHANGE LOAN DEBT SERVICE, ANNUAL MAINTENANCE AND OPERATION COSTS, & NEW CONSTRUCTION WITH ALTERNATIVE B SCHEDULING OF FREEWAY INVESTMENT COSTS (NT$ MILLIONS)

Years	Service on Foreign Exchange Debt	Maint. & Oper. Costs	New Construction	Funds Requirements (Excluding service on local debt)	Toll revenue*	Revenue available for service on local debt Annual	Cumulative
1971	9	–	–	9	–	-9	-9
1972	17	–	–	17	–	-17	-26
1973	48	–	–	48	–	-48	-74
1974	89	–	–	89	–	-89	-163
1975	139	7	–	146	208	62	-101
1976	252	12	–	264	335	71	-30
1977	390	21	–	411	486	75	45
1978	444	25	–	469	670	201	246
1979	536	40	–	576	954	378	624
1980	538	42	–	580	1,069	489	1,113
1981	610	57	208	875	1,564	689	1,802
1982	625	60	–	685	1,739	1,054	2,856
1983	690	73	–	763	2,050	1,287	4,143
1984	670	78	–	748	2,254	1,506	5,649
1985	647	84	177	908	2,400	1,492	7,141
1986	627	92	352	1,071	2,554	1,483	8,624
1987	576	98	138	812	2,714	1,902	10,526
1988	556	105	–	661	2,881	2,220	12,746
1989	535	114	–	649	3,053	2,404	15,150
1990	440	123	–	563	3,231	2,668	17,818
1991	353	133	–	486	3,410	2,924	20,742
1992	274	144	–	418	3,592	3,174	23,916
1993	241	154	–	395	3,738	3,343	27,259
1994	153	163	–	316	3,866	3,550	30,809
1995	145	173	–	318	3,973	3,655	34,464
1996	76	183	–	259	3,997	3,738	38,202
1997	72	193	–	265	4,021	3,756	41,958
1998	–	203	–	203	4,021	3,818	45,776
1999	–	213	–	213	4,021	3,808	49,584
2000	–	223	–	223	4,021	3,798	53,382
Totals	9,752	2,814	875	13,440	66,822	53,382	–

* Including revenue from induced traffic.

TABLE F-21

TOLL REVENUE COVERAGE OF FOREIGN EXCHANGE LOAN DEBT SERVICE, ANNUAL MAINTENANCE AND OPERATION COSTS, & NEW CONSTRUCTION WITH ALTERNATIVE C SCHEDULING OF FREEWAY INVESTMENT COSTS
(NT$ MILLIONS)

Years	Service on Foreign Exchange Debt	Maint. & Oper. Costs	New Construction	Funds Requirements (Excluding service on local debt)	Toll Revenue*	Revenue available for service on local debt Annual	Cumulative
1971	9	—	—	9	—	- 9	- 9
1972	17	—	—	17	—	- 17	- 26
1973	48	—	—	48	—	- 48	- 74
1974	79	—	—	79	—	- 79	- 153
1975	119	7	—	126	208	82	- 71
1976	217	12	—	229	335	106	35
1977	268	12	—	280	387	107	142
1978	356	21	—	377	553	176	318
1979	396	26	—	422	758	336	654
1980	416	27	—	443	851	408	1,062
1981	511	42	208	761	1,191	430	1,492
1982	513	44	—	557	1,325	768	2,260
1983	514	47	—	561	1,466	905	3,165
1984	584	62	—	646	2,115	1,469	4,634
1985	602	66	22	690	2,246	1,556	6,190
1986	671	81	352	1,104	2,554	1,450	7,640
1987	619	87	138	844	2,714	1,870	9,510
1988	597	95	—	692	2,881	2,189	11,699
1989	578	101	—	679	3,053	2,374	14,073
1990	485	108	—	593	3,231	2,638	16,711
1991	397	116	—	513	3,410	2,897	19,608
1992	378	125	—	503	3,592	3,089	22,697
1993	299	134	—	433	3,738	3,305	26,002
1994	267	144	—	411	3,866	3,455	29,457
1995	253	154	—	407	3,973	3,566	33,023
1996	166	163	—	329	3,997	3,668	36,691
1997	157	173	—	330	4,021	3,691	40,382
1998	149	183	—	332	4,021	3,689	44,071
1999	79	193	—	272	4,021	3,749	47,820
2000	75	203	—	278	4,021	3,743	51,563
Totals	9,819	2,426	720	12,965	64,528	51,563	—

* Including revenue from induced traffic.

TABLE F-22

ESTIMATED FUNDS REQUIRED FROM DOMESTIC BOND ISSUES WITH ALTERNATIVE SCHEDULES OF INVESTMENT*
(NT$ MILLIONS)

Years	Funds Required Alternative A	Alternative B	Alternative C
1971	136	136	136
1972	712	712	712
1973	1,140	1,140	687
1974	919	828	980
1975	1,291	924	655
1976	1,116	809	386
1977	685	824	512
1978	817	688	609
1979	629	312	381
1980	480	443	688
1981	—	629	315
1982	—	480	312
1983	—	—	443
1984	—	—	629
1985	—	—	534
Totals	7,925	7,925	7,979**

* Requirements are estimated as a constant 34.1 percent of stage I (i.e., excluding later widening) investment costs.

** Includes NT$54 million for construction in Section V, which would be considered stage II construction in the cases of the current construction schedule and Alternatives A and B.

TABLE F-23

PRINCIPAL REPAYMENTS ON LOCAL CURRENCY DEBT WITH ALTERNATIVE A SCHEDULING OF INVESTMENT
(NT$ MILLIONS)

Years in which repayments made	Years in which funds originally used										Annual Repayment Totals
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	
1974	27										27
1975	27	142									169
1976	27	142	228								397
1977	27	142	228	183							580
1978	28	143	228	184	258						841
1979		143	228	184	258	223					1,036
1980			228	184	258	223	137				1,030
1981				184	258	223	137	163			965
1982					259	223	137	163	125		907
1983						224	137	163	126	96	746
1984							137	164	126	96	523
1985								164	126	96	386
1986									126	96	222
1987										96	96
Totals	136	712	1,140	919	1,291	1,116	685	817	629	480	7,925

TABLE F-24

PRINCIPAL REPAYMENTS ON LOCAL CURRENCY DEBT WITH ALTERNATIVE B SCHEDULING OF INVESTMENT
(NT$ MILLIONS)

Years in which repayments made	Years in which funds originally used												Annual Repayment Totals
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	
1974	27												27
1975	27	142											169
1976	27	142	228										397
1977	27	142	228	165									562
1978	28	143	228	165	184								748
1979		143	228	166	185	161							883
1980			228	166	185	162	164						905
1981				166	185	162	165	137					815
1982					185	162	165	137	62				711
1983						162	165	138	62	88			615
1984							165	138	62	88	125		578
1985								138	63	89	126	96	512
1986									63	89	126	96	374
1987										89	126	96	311
1988											126	96	222
1989												96	96
Totals	136	712	1,140	828	924	809	824	688	312	443	629	480	7,925

TABLE F-25

PRINCIPAL REPAYMENTS ON LOCAL CURRENCY DEBT WITH ALTERNATIVE C SCHEDULING OF INVESTMENT
(NT$ MILLIONS)

Years in which repayments made	Years in which funds originally used															Annual Repayment Totals
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	
1974	27															27
1975	27	142														169
1976	27	142	137													306
1977	27	142	137	196												502
1978	28	143	137	196	131											635
1979		143	138	196	131	77										685
1980			138	196	131	77	102									644
1981				196	131	77	102	121								627
1982					131	77	102	122	76							508
1983						78	103	122	76	137						516
1984							103	122	76	137	63					501
1985								122	76	138	63	62				461
1986									77	138	63	62	88			428
1987										138	63	62	88	125		476
1988											63	63	89	126	106	447
1989											63	63	89	126	107	385
1990													89	126	107	322
1991														126	107	233
1992															107	107
Totals	136	712	687	980	655	386	512	609	381	688	315	312	443	629	534	7,979

TABLE F-26

SERVICE ON LOCAL CURRENCY BONDS WITH ALTERNATIVE A SCHEDULING OF FREEWAY INVESTMENT & COVERAGE BY AVAILABLE TOLL REVENUE
(NT$ MILLIONS)

Years	Amount outstanding at start of period	Principal: New Debt	Principal: Principal re-payments**	Principal: Net change in amount of principal outstanding	Amount outstanding at end of period	Average amount outstanding during period	Interest**	Total Debt Service	Toll revenue available after meeting all foreign currency debt service, maint. & oper. costs, & costs of new construction***	Surplus or deficit (-) of funds available for covering all local currency debt service: Annual	Surplus or deficit (-) of funds available for covering all local currency debt service: Cumulative
1971	—	136	—	136	136	68	6	6	-9	-15	-15
1972	136	712	—	712	848	492	46	46	-17	-63	-78
1973	848	1,140	—	1,140	1,988	1,418	133	133	-48	-181	-259
1974	1,988	919	27	892	2,880	2,434	229	256	-89	-345	-604
1975	2,880	1,291	169	1,122	4,002	3,441	323	492	51	-441	-1,045
1976	4,002	1,116	397	719	4,721	4,362	410	807	40	-767	-1,812
1977	4,721	685	580	105	4,826	4,774	449	1,029	124	-905	-2,717
1978	4,826	817	841	-24	4,802	4,814	453	1,294	171	-1,123	-3,840
1979	4,802	629	1,036	-407	4,395	4,598	432	1,468	567	-901	-4,741
1980	4,395	480	1,030	-550	3,845	4,120	387	1,417	699	-718	-5,459
1981	3,845	—	965	-965	2,880	3,362	316	1,281	676	-605	-6,064
1982	2,880	—	907	-907	1,973	2,426	228	1,135	1,087	-48	-6,112
1983	1,973	—	746	-746	1,227	1,600	150	896	1,301	405	-5,707
1984	1,227	—	523	-523	704	966	91	614	1,521	907	-4,800
1985	704	—	386	-386	318	511	48	434	1,505	1,071	-3,729
1986	318	—	222	-222	96	207	19	241	1,496	1,255	-2,474
1987	96	—	96	-96	—	48	5	101	1,916	1,815	-659
Totals	—	7,925	7,925	—	—	—	3,725	11,650	10,991	-659	—

* See Table F-22
** @ 9.4 percent per annum.
*** See Table F-18

TABLE F-27

SERVICE ON LOCAL CURRENCY BONDS WITH ALTERNATIVE B SCHEDULING OF FREEWAY INVESTMENT & COVERAGE BY AVAILABLE TOLL REVENUE
(NT$ MILLIONS)

Years	Amount outstanding at start of period	Principal: New Debt	Principal: Principal repayments*	Principal: Net change in amount of principal outstanding	Principal: Amount outstanding at end of period	Average amount outstanding during period	Interest**	Total Debt Service	Toll revenue available after meeting all foreign currency debt service, maint. & oper. costs, & costs of new construction***	Surplus or deficit (-) of funds available for covering all local currency debt service: Annual	Surplus or deficit (-): Cumulative
1971	–	136	–	136	136	68	6	6	- 9	- 15	- 15
1972	136	712	–	712	848	492	46	46	- 17	- 63	- 78
1973	848	1,140	–	1,140	1,988	1,418	133	133	- 48	- 181	- 259
1974	1,988	828	27	801	2,789	2,389	225	252	- 89	- 341	- 600
1975	2,789	924	169	755	3,544	3,167	298	467	62	- 405	- 1,005
1976	3,544	809	397	412	3,956	3,750	353	750	71	- 679	- 1,684
1977	3,956	824	562	262	4,218	4,087	384	946	75	- 871	- 2,555
1978	4,218	688	748	- 60	4,158	4,188	394	1,142	201	- 941	- 3,496
1979	4,158	312	883	- 571	3,587	3,873	364	1,247	378	- 869	- 4,365
1980	3,587	443	905	- 462	3,125	3,356	315	1,220	489	- 731	- 5,096
1981	3,125	629	815	- 186	2,939	3,032	285	1,100	689	- 411	- 5,507
1982	2,939	480	711	- 231	2,708	2,823	265	976	1,054	78	- 5,429
1983	2,708	–	615	- 615	2,093	2,401	226	841	1,287	446	- 4,983
1984	2,093	–	578	- 578	1,515	1,804	170	748	1,506	758	- 4,225
1985	1,515	–	512	- 512	1,003	1,259	118	630	1,492	862	- 3,363
1986	1,003	–	374	- 374	629	816	77	451	1,483	1,032	- 2,331
1987	629	–	311	- 311	318	474	45	356	1,902	1,546	- 785
1988	318	–	222	- 222	96	207	19	241	2,220	1,979	1,194
1989	96	–	96	- 96	–	48	5	101	2,404	2,303	3,497
Totals	–	7,925	7,925	–	–	–	3,728	11,653	15,150	3,497	–

* See Table F-23
** @ 9.4 percent per annum
*** See Table F-19

TABLE F-28

SERVICE ON LOCAL CURRENCY BONDS WITH ALTERNATIVE C SCHEDULING OF FREEWAY INVESTMENT & COVERAGE BY AVAILABLE TOLL REVENUE
(NT$ MILLIONS)

Years	Principal: Amount out-standing at start of period	Principal: New Debt	Principal: Principal re-payments**	Principal: Net change in amount of principal outstanding	Principal: Amount outstanding at end of period	Average amount outstanding during period	Interest**	Total Debt Service	Toll revenue available after meeting all foreign currency debt service, maint. & oper. costs, & costs of new construction***	Surplus or deficit (-) of funds available for covering all local currency debt service: Annual	Surplus or deficit (-) of funds available for covering all local currency debt service: Cumulative
1971	–	136	–	136	136	68	6	6	- 9	- 15	- 15
1972	136	712	–	712	848	492	46	46	- 17	- 63	- 78
1973	848	687	–	687	1,535	1,190	112	112	- 48	- 160	- 238
1974	1,535	980	27	953	2,488	2,012	189	216	- 79	- 295	- 533
1975	2,488	655	169	486	2,974	2,731	257	426	82	- 344	- 877
1976	2,974	386	306	80	3,054	3,014	283	589	106	- 483	- 1,360
1977	3,054	512	502	10	3,064	3,059	288	790	107	- 683	- 2,043
1978	3,064	609	635	- 26	3,038	3,051	287	922	176	- 746	- 2,789
1979	3,038	381	685	- 304	2,734	2,886	271	956	336	- 620	- 3,409
1980	2,734	688	644	44	2,778	2,756	259	903	408	- 495	- 3,904
1981	2,778	315	627	- 312	2,466	2,622	246	873	430	- 443	- 4,347
1982	2,466	312	508	- 196	2,270	2,368	223	731	768	37	- 4,310
1983	2,270	443	516	- 73	2,197	2,234	210	726	905	179	- 4,131
1984	2,197	629	501	128	2,325	2,261	213	714	1,469	755	- 3,376
1985	2,325	534	461	73	2,398	2,361	222	683	1,556	873	- 2,503
1986	2,398	–	428	- 428	1,970	2,184	205	633	1,450	817	- 1,686
1987	1,970	–	476	- 476	1,494	1,732	163	639	1,870	1,231	- 455
1988	1,494	–	447	- 447	1,047	1,270	119	566	2,189	1,623	1,168
1989	1,047	–	385	- 385	662	855	80	465	2,374	1,909	3,077
1990	662	–	322	- 322	340	501	47	369	2,638	2,269	5,346
1991	340	–	233	- 233	107	224	21	254	2,897	2,643	7,989
1992	107	–	107	- 107	–	54	5	112	3,089	2,977	10,966
Totals	–	7,979	7,979	–	–	–	3,752	11,731	22,697	10,966	–

* See Table F-24
** @ 9.4 percent per annum
*** See Table F-20

Appendix G

ADJUSTMENTS TO THE RECOMMENDED BARRIER TOLL NETWORK

INTRODUCTION

The barrier toll-collection network developed in this study was discussed with government officials early in the study and was approved for testing. Results subsequently showed that the selected system produced substantial financial returns in the form of toll revenue, while permitting the retention of the major portion of the benefits estimated for the no-toll situation. Whilst these results were favorable, however, it is possible that the shifting of one or more toll plazas might improve the financial or economic return. Total toll revenue might also be increased by the addition of one or more barriers to the network.

Three possible adjustments to the recommended barrier network are given consideration in this appendix. These are listed below.

- Adding a toll barrier in Section V of the freeway, between Taichung and Changhua;
- Shifting the Section VII toll plaza from south of Nantzu to north of Kangshan; and
- Shifting the toll plaza in Section I from north of Hsichih interchange to the south of that interchange.

These adjustments to the recommended network are discussed separately in the following sections. The analysis centers on the engineering aspects and the financial effects. These latter are not estimated precisely, however, as no additional computer assignments were made, so that not all changes to be expected in the travel patterns are known. The likely alterations in the patterns of important short-distance traffic were estimated, however.

Although no thorough economic analysis is done in this appendix, some general comments regarding the economic effects of adjustments to the recommended barrier system are given in the discussions of each of the proposed adjustments.

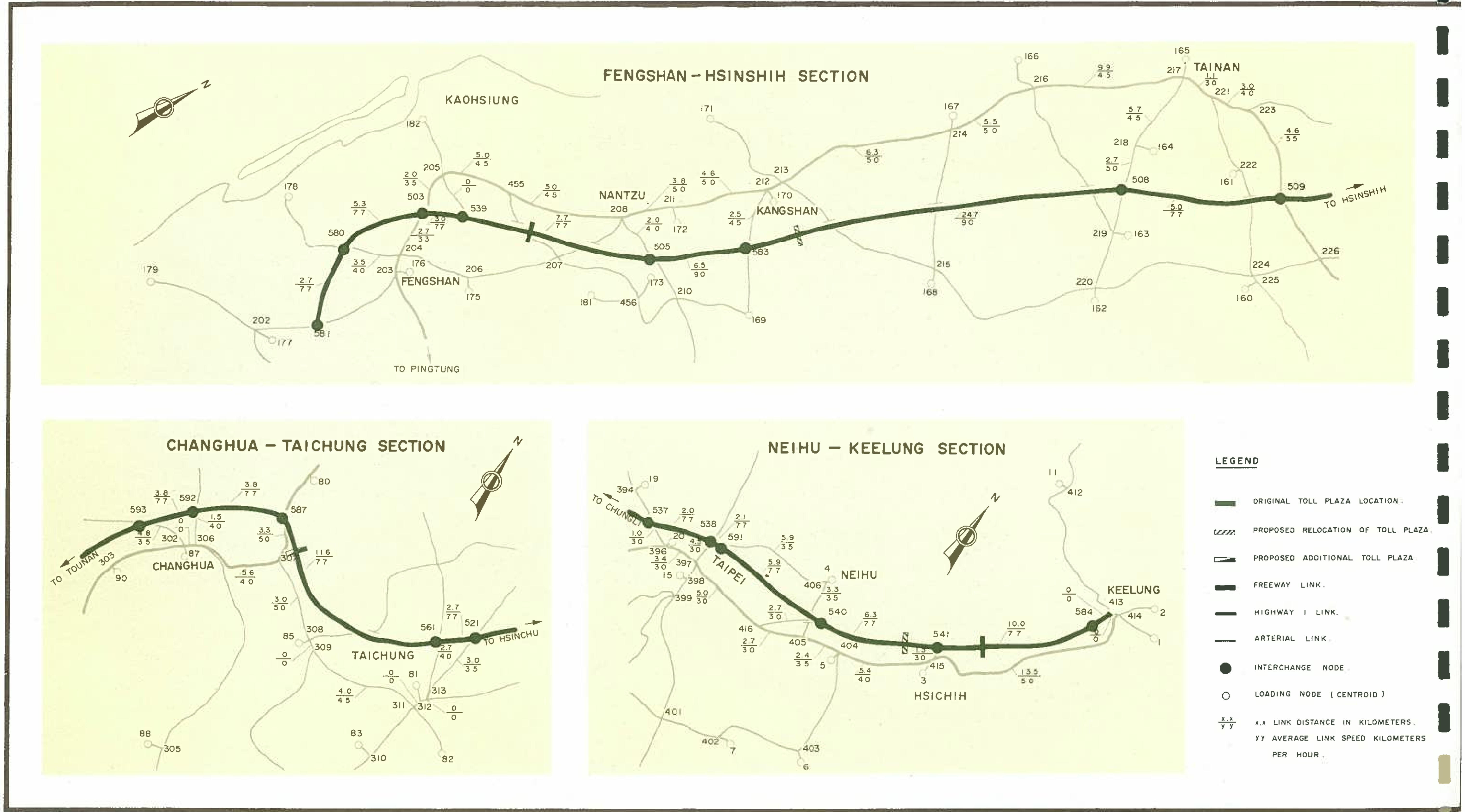
AN ADDITIONAL TOLL PLAZA IN SECTION V

Elsewhere in this study, it has been assumed that the Taichung-Changhua area would be a zone of free travel, i.e., no toll barrier would be located between the two cities, so that local traffic using the freeway would not be charged for its use. This arrangement was deemed to be desirable since toll-free travel would tend to maximize the portion of local traffic which would use the freeway. Conversely, the location of a plaza between Taichung and Changhua would tend to reduce freeway traffic volumes and freeway benefits. The addition of a plaza would also have the effect of raising the costs of freeway right-of-way, construction, maintenance, and operation. The twin effects on freeway benefits and on freeway costs would lower the estimates of rate of return on Section V of the freeway and on the entire facility.

Although the addition of a toll plaza to the recommended barrier network would be expected to have some adverse economic effects, the net financial effects for the government would be expected to be positive. Investment and operating costs would be only slightly higher than without the plaza, and net additional toll revenue should be substantially more than sufficient to counterbalance the incremental cost outlays (gross revenues at the proposed additional plaza would exceed net additional toll revenue by the amount of diminution, caused by the new plaza, of revenues at other freeway barriers).

Exhibit 49 shows the Taichung-Changhua area, and the proposed toll plaza location. A toll plaza site closer to Taichung was avoided because of the expected expansion of the urbanized area of that city, and the desire to keep the plaza out of the urban areas. Also, the section of the alignment selected for the possible location of a toll plaza would be straighter than the alignment nearer to Taichung.

The addition of a plaza between Taichung and Changhua would not be expected to greatly affect the choices of travel routes for long-distance traffic (and, thus, would not significantly diminish toll receipts at other plazas), but would have a more marked effect on local traffic route selection. The following analysis only attempts to measure the effects which the proposed additional plaza would have



COMPREHENSIVE TOLL ROAD STUDY
NORTH-SOUTH FREEWAY TAIWAN

ALTERNATIVE TOLL PLAZA LOCATIONS

DE LEUW, CATHER INTERNATIONAL-CHICAGO

on local traffic moving between Taichung and Changhua. Ignoring the effects which the imposition of an additional toll between Taichung and Changhua would have on longer distance traffic volumes may produce a small error in traffic patterns in the hypothetical 1969 situation with the freeway. By 1990, however, the alternative highways would be filled to capacity, so that there could, in any case, be no additional shifting of traffic from the freeway to the arterials.

Exhibit 49 shows the alternative routes for traffic moving between the central business district (CBD) of Taichung (node 81) and the CBD of Changhua (node 87). The cost comparisons of moving between these points by using the freeway and by using highways 12 and 1 are shown below.

	User costs (NT$)			Cost Savings (NT$)	
		Freeway			
	Hwy. 12 & 1	w/o tolls	with tolls*	w/o tolls	with tolls
Autos	47	41	57	6	– 10
Heavy trucks	67	67	90	–	– 23
Buses	152	130	176	22	– 24

* Including incremental user costs of toll stops

As indicated by this study's diversion curves (Exhibit 6), there would be 100 percent diversion to the lower cost facility when that facility could produce a saving of NT$40 per trip for light vehicles and NT$130 per trip for heavy trucks. Because bus operators are normally well informed regarding costs of moving by alternative routes, it is more reasonable to assign bus traffic by the all-or-nothing technique, rather than by using diversion assignments.

With the cost differentials indicated above for light vehicles, approximately 62 percent of Taichung-Changhua traffic (i.e., volumes moving between nodes 81 and 87) would move via the freeway in the absence of tolls, whereas the imposition of tolls would tend to reduce this portion to only 29 percent of the total. Where heavy trucks are concerned, the comparable figures would be 50 percent and 35 percent, respectively. The greatest shift, however, would be in the Taichung-Changhua express bus traffic; without tolls, 100 percent of these vehicles would use the freeway, but, with tolls, 100 percent would tend to use the alternative highways.

When these percentages are applied to actual 1969 daily 81-87 volumes, and the volumes forecast for 1990, the results are as shown below.

	Light vehicles	Hvy. trucks	Exp. buses
1969			
81-87 volumes	1756	216	53
Number using fwy w/o tolls	1088	108	53
Number using fwy. with tolls	509	76	–
Diversion from fwy. with tolls	581	32	53
1990			
81-87	49,142	1,714	184
Number using fwy. w/o tolls	30,442	857	184
Number using fwy. with tolls	14,251	600	–
Diversion from fwy. with tolls	16,191	257	184

Subtracting these diverted local traffic volumes from the computer-indicated totals for the freeway with schedule B_3, but with no plaza between Taichung and Changhua, the results are as shown following.

	Light vehicles	Hvy. trucks	Exp. buses
1969			
Freeway volumes	1924	2140	472
Less diverted local traffic	581	32	53
Adjusted fwy. volumes	1343	2108	419
1990			
Freeway volumes	48,132	15,980	1,728
Less diverted local traffic	16,191	257	184
Adjusted fwy. volumes	31,941	15,723	1,544

The figures for 1990, however, are unadjusted for the results of Highway 1 capacity analysis. This highway would be expected to accommodate only 40,000 passenger car equivalents in 1990. The results of this analysis are indicated below.

	Lt. vehs.	Hvy. trucks	Exp. buses	PCE
Highway 1 volumes w/o diverted vols.	29,892	3,788	–	37,468
Diverted volumes	16,191	257	184	17,073
Unadjusted new totals	46,083	4,045	184	54,541
Adjusted totals*	33,800	2,965	135	40,000
Volumes reassigned to freeway	12,283	1,080	49	14,541
Adjusted 1990 Fwy. volumes	44,224	16,803	1593	81,016

* Adjusted by using a constant factor of 0.7333 (i.e., 40,000 ÷ 54,541).

With the volumes, indicated above, at the freeway toll barrier, the daily and annual toll revenues (exclusive of revenue from induced traffic volumes) would be as shown below.

	Toll Revenues	
	Daily (NT$)	Annual (NT$ Million)
1969		
Light vehicles*	20,145	7
Heavy trucks**	42,800	15
Buses*	16,760	6
Total	79,705	28
1990		
Light vehicles	663,360	242
Heavy trucks	336,060	119
Buses	63,720	23
Total	1,063,140	384

* Expanded to annual by a factor of 365.
** Expanded to annual by a factor of 354.

As a comparison with the above totals, the barrier plaza previously located in Section V (south of Changhua) would have realized an estimated NT$21 million in 1969, and is projected to reap NT$209 million in 1990. The entire ten barriers of the recommended network would have brought in an estimated NT$302 million in 1969, and are foreseen to bring in NT$2,964 million in 1990.

SHIFT OF THE SITE OF THE PLAZA IN SECTION VII

The proposed shift of the Section VII toll plaza would be from a location south of Nantzu to a site just to the north of Kangshan; the shift would be from a six-lane freeway section to a four-lane section. Unlike the adjustment to the recommended network discussed in the preceding section, the adjustment proposed here would not be directed at increasing toll revenues; revenues might even be expected to fall with the shift to a four-lane section. The estimate of the economic return on this freeway section fell consdierably in this study from the estimate of the feasibility study (which considered a toll-free facility), however, and the shift of the plaza site would be an attempt to increase utilization of the freeway, and total freeway benefits.

Whether the plaza would be located south of Nantzu or north of Kangshan, it would be expected to have a considerable effect on the portions of Tainan-Kaohsiung traffic which would use the freeway for the full distance between the two cities. The Kangshan location, however, would have much lesser diversionary effects on long-distance traffic (i.e., volumes originating from, or destined to, somewhere north of Tainan) and on traffic moving between Kaohsiung and either Nantzu or Kangshan.

Traffic moving longer distances would be inclined to stay on the freeway if the plaza would be located north of Kangshan, since the freeway route would have a large cost advantage compared with the possibility of leaving the freeway to by-pass the Kangshan plaza. Exhibit 49 shows the Tainan-Kaohsiung area, and the two alternative locations for the toll plaza on the freeway. Long-distance traffic moving southward, and wishing to avoid the plaza north of Kangshan, would have the option of leaving the freeway at node 509. The costs of moving from there to the freeway interchange at Kangshan would be NT$96 for autos and NT$135 for heavy trucks. The costs of moving along the freeway between the same two points would be NT$55 for autos and NT$93 for trucks in the absence of tolls. With tolls, these costs of operating on the freeway would rise to NT$71 for autos, and NT$116 for heavy trucks. The savings for autos over this stretch would still be NT$25, whilst heavy trucks would still realize a cost advantage of NT$19. Since these advantages are sizable, long-distance volumes would be expected to remain on the freeway with the plaza located at Kangshan.

In the case of locating a plaza to the south of Nantzu, diversion of long-distance traffic might prove to be considerably greater. If an auto would leave the freeway at node 505 (north of Nantzu) to travel to node 205 (on the way to the Kaohsiung CBD and/or the existing harbor area), the total cost would be NT$32. By staying on the freeway, the cost of moving between the same two points would be NT$27, without tolls, and NT$43, with tolls. For a heavy truck, the respective figures would be NT$46, NT$41, and NT$64. The freeway with tolls would mean a cost disadvantage of NT$11 for autos, and NT$18 for heavy trucks.

Even express buses might be inclined to leave the freeway. The cost of moving from point 505 to 205 via arterials would be NT$102, whereas traveling on the freeway and paying a toll charge would mean a total cost of NT$130.

Not only would the operating costs be favorable for long-distance traffic to leave the freeway in the case of locating a plaza south of Nantzu, and unfavorable for such traffic to leave the freeway in the case of locating the plaza to the north of Kangshan, but driver psychology would also tend to stimulate diversion in the first instance and retard it in the latter case. If a driver would leave the freeway at node 505 (north of Nantzu), he would almost immediately enter Kaohsiung urban traffic, and would feel nearer to his destination; he would not consider returning to the freeway. If a driver would leave the freeway north of Tainan, on the other hand, he would have to face the slowdown of Tainan urban traffic, and would be inclined to feel quite distant from his destination; moreover, he would be aware of having to return to the freeway, and of having to travel a much longer route than if he had stayed on the freeway. All things considered, it would be quite attractive to long-distance traffic to avoid a plaza located south of Nantzu (until such time as alternative highways would be filled to capacity), whereas, it would be quite unattractive to long-distance volumes to leave the freeway to avoid a plaza to the north of Kangshan. (The computer assignments may have understated somewhat the likelihood of diversion from the freeway with a plaza to the south of Nantzu. Assignments were made to the freeway and arterials on the basis of total costs of trips. After trips were assigned to the freeway, the computer took into account the possibility that drivers might seek to avoid toll plazas by determining whether or not the cost of leaving the freeway and traveling by an arterial to some point would be less than two-thirds of the cost of traveling to the same point via the freeway link with a toll plaza. If the cost of leaving the freeway would be less than two-thirds of the cost of remaining on the freeway, the vehicle trips were indicated as leaving the freeway before they would need to pay the toll. The factor of two-thirds was obtained from experience with toll facilities, and is an estimate of the cost advantage which drivers would need to have to leave a high-speed, uncongested freeway, for travel on a lower standard facility, in order to avoid a toll charge. While this factor may be a reasonable estimate of the cost advantage needed to create avoidance of toll plazas located on intermediate links of a freeway trip, however, it may overstate the advantage required to keep vehicles off a freeway at the beginning of their trips or to get them to leave the freeway over what would be the prospective last link travelled of their freeway trip. In the case of the toll study trip assignments, the possible overstatement of the cost advantage required to create diversion from the freeway at one end of a vehicle trip would not result in any significant error in the cases of the eight barrier plazas located in rural areas, since only relatively few trips would begin or end in the neighborhood of these plazas. In the other two instances, however, viz., the plazas located to the south of Nantzu in Section VII and to the north of Hsichih in Section I, the surrounding areas are more urban, and a larger number of trips might, then, avoid paying the tolls at those plazas, with very small cost advantages, or even slight disadvantages, associated with diverting from the freeway.)

Where Tainan-Kaohsiung (217-205) trips are concerned, both toll plaza locations would create considerable diversion from the freeway in the years prior to the time when alternative highways would be filled to capacity. The user costs of Tainan-Kaohsiung traffic, moving by various routes, are shown below.

Route	Auto trip cost (NT$)	Heavy truck trip cost (NT$)	Bus trip cost (NT$)
Hwy.1(217-205)	113	162	330
Fwy.(217-508-503-205)-w/o tolls	106	169	322
Fwy.(217-508-503-205)-with tolls	122	192	368
Hwy.1-Fwy.(217-212-583-503-205)*	111	159	357
Fwy.-Hwy.1(217-508-505-208-205)**	111	174	340

* With the plaza north of Kangshan.
** With the plaza south of Nantzu.

As can be seen from the above cost estimates, the freeway with tolls would be considerably less attractive than alternative routes. The average cost saving, for Tainan-Kaohsiung auto trips, deriving from the choice of some route other than going through the toll plaza, would be NT$10; with this saving, approximately 71 percent would choose alternative routes, while only 29 percent would prefer the freeway.

For heavy trucks, the average cost saving of using alternative routes would be NT$32, and about 70 percent would use these routes, while only 30 percent would tend to use the freeway.

Assuming that all bus operators would choose the least cost routes, no Tainan-

Kaohsiung trips would be inclined to use the freeway for any distance, regardless of whether the toll plaza might be located south of Nantzu or north of Kangshan.

From the foregoing discussion, the freeway with a toll plaza to the north of Kangshan would be expected to retain nearly all trips which would begin or end to the north of Tainan and extend to Kaohsiung. Only small percentages of Tainan-Kaohsiung trips, however, would be expected to use the freeway. Trips between Kaohsiung and either Nantzu or Kangshan, of course, would not be required to pay tolls, and would therefore tend to use the freeway to a much greater extent than if the plaza would be located south of Nantzu. Although no attempt will be made here to calculate precisely the economic effect of the improved freeway utilization resulting from a shifting of the plaza site from south of Nantzu to north of Kangshan, it is clear that freeway benefits would increase. The Section VII rate of return would be improved, not only by these increased benefits, but also by the decreased costs of constructing and operating a plaza on a four-lane section, rather than on a six-lane section in a more highly developed area.

Toll revenue, however, would diminish somewhat from the totals indicated elsewhere in this report for the Nantzu plaza. The volumes assigned to the Tainan-Kangshan freeway link, with the plaza located to the south of Nantzu, and to the parallel section of Highway 1, are shown below for 1969 and 1990.

	Freeway	Highway 1	Totals
1969			
Light vehicles	1332	1300	2632
Heavy trucks	2078	1232	3310
Buses	512	8	520
Totals	3922	2540	6462
1990			
Light vehicles	16,220	15,936	32,156
Heavy trucks	14,936	8,936	23,872
Buses	2,076	40	2,116
Totals	33,232	24,912	58,144

According to the cost analysis presented above, with a plaza located to the south of Nantzu, it would be about equally attractive for a Tainan-Kaohsiung auto trip to travel along Highway 1 for the full distance (NT$113), or to travel on the freeway for the portion of the trip from Tainan to north of Nantzu, and on arterials for the remainder of the trip from Kaohsiung to Nantzu (NT$111).

With the plaza located north of Kangshan, the cost (for the full trip) which autos would incur by traveling on the Tainan-Kangshan freeway link would be NT$122.

In the first instance, Tainan-Kaohsiung auto trips would be split about equally between the freeway north of Kangshan and Highway 1. But, with the plaza located north of Kangshan, only 30 percent of these auto trips would use the northern portion of Section VII. Thus, 20 percent of Tainan-Kaohsiung auto trips would be lost on the Tainan-Kangshan freeway link with the proposed shift of the plaza site.

Where Tainan-Kaohsiung heavy truck trips are concerned, 42 percent would use the Tainan-Kangshan freeway link with the plaza located south of Nantzu (and with only a NT$12 cost disadvantage), whilst the portion would fall to only about 32 percent with a plaza north of Kangshan (and with a NT$30 cost disadvantage). Hence, approximately ten percent of these heavy truck trips would be lost to the Tainan-Kangshan link with the shift of the plaza site.

Tainan-Kaohsiung bus trips would not use the freeway in either case, so that there would be no shift of these volumes.

Total Tainan-Kaohsiung light vehicle and heavy truck trips are shown below. The portions which would shift from the freeway to Highway 1, over the Tainan-Kangshan stretch, are also shown (the percentage of auto trips lost is applied to total light vehicles, i.e., including light trucks, since the operating costs of these vehicles, including toll charges, are about the same, and since, in any case, the percentage used is only an approximation).

	Tainan-Kaohsiung Average daily vehicle trips	
	Light vehicles	Heavy trucks
1969		
Total	1596	781
Portion shifted to Hwy. 1*	319	78
1990		
Total	13,025	4,227
Portion shifted to Hwy. 1*	2,605	423

* In the Kangshan-Tainan area only — with the shift of the plaza site from south of Nantzu to north of Kangshan.

In 1990, Highway 1 to the north of Kangshan would be carrying a total of approximately 34,000 PCE per day, with the freeway plaza located south of Nantzu. According to the diversion estimated above to occur with the proposed shift of the plaza site, an additional 3,450 PCE per day would be directed to Highway 1, resulting in an increased total of 37,450 PCE; this would still be less than the highway's estimated capacity of 40,000 PCE per day (assuming completion of Highway 1 widening between Tainan and Nantzu), so that the shift would not be restrained through 1990.

The revised totals of daily freeway volumes which would go through a plaza located to the north of Kangshan are shown below. Daily and annual toll revenues are also indicated.

	Daily fwy. volumes	Daily toll revenue (NT$)	Annual revenue (NT$ Mil.)
1969			
Light vehicles*	1,013	15,195	6
Heavy trucks**	2,000	40,000	14
Buses*	512	20,480	7
Totals	3,525	75,675	27
1990			
Light vehicles*	13,615	204,225	75
Heavy trucks**	14,513	290,260	103
Buses*	2,076	83,040	30
Totals	30,204	577,525	208

* Daily revenue expanded to annual totals by using a factor of 365.
** Daily revenue expanded to annual totals by using a factor of 354.

For comparison, the plaza located south of Nantzu is estimated elsewhere in this study to bring in revenue totalling NT$36 million in the hypothetical 1969 situation, and NT$285 million in 1990. On the average over the entire period, the proposed shift of the toll plaza would lower Section VII revenue 26 percent from those totals estimated elsewhere in this study. These latter totals, however, were based on computer assignments which may not have estimated fully (for reasons explained above) the diversion from the freeway which would be created by a plaza located south of Nantzu. Hence, the actual reduction in prospective tolls which would result from the proposed shift of the plaza site might be expected to be something less than the 26 percent estimated above.

SHIFT OF THE TOLL PLAZA SITE IN SECTION I

The recommended barrier network included a toll plaza in Section I of the freeway just to the north of the Hsichih interchange (see Exhibit 49). It has been proposed that this plaza be shifted to a suitable location to the south of the Hsichih interchange. Due to alignment curvature and the need for several structures in the area just south of the interchange, the alternative site would need to be in the area of Neihu. In that area, right-of-way would be costly, and the plaza would likely interfere with local development plans. Thus, from the viewpoint of highway design, the location north of the Hsichih interchange should be preferred.

Based upon computer output, there would be very little difference between the two locations from the standpoints of financial and economic returns. The volumes of traffic assigned by the computer to freeway links 540-541 (Neihu-Hsichih) and 541-584 (Hsichih-Keelung) are nearly the same in both 1969 and 1990. These volumes are indicated below for both the no-toll situation and the situation with a plaza on link 541-584 (with schedule B_3 toll charges).

	Freeway Volumes			
	W/O tolls		With tolls*	
	540-541	541-584	540-541	541-584
1969				
Light vehicles	3,672	3,642	2,388	2,268
Heavy trucks	2,132	2,108	1,684	1,660
Buses	620	612	620	612
Totals	6,424	6,362	4,692	4,540
1990				
Light vehicles**	42,992	42,340	38,724	38,072
Heavy trucks**	13,350	12,978	9,484	9,112
Buses	2,260	2,228	2,260	2,228
Totals	58,602	57,546	50,468	49,412

* With B_3 tolls imposed on link 541-584 only.
** After adjustments for capacity analysis, and for a revised forecast of heavy truck traffic in Section I.

The differences in volumes between link 540-541 and link 541-584 are only those volumes which would be moving between Neihu and Hsichih; in 1969, these vehicles would number only 64, and, in 1990, they would total 1,056 per day. If the toll plaza would be located on link 540-541, instead of link 541-584, these volumes originating at, or destined to, Hsichih might be diverted to Highway 5, so that volumes on link 540-541 would be no higher than indicated 541-584 volumes.

As noted in the preceding section of this appendix, however, the computer may have overstated the cost advantage required to create diversion from the freeway near vehicle trip ends. In, perhaps, two instances this might have resulted in a significant overstatement of the volumes to be expected at a toll plaza. These two instances are concerned with the plazas located near the two termini of the freeway. The plaza location to the south of Nantzu, near to Kaohsiung, was discussed in the preceding section; the possible trip end diversion in that instance might be somewhat serious since Highway 1, with four lanes, could accommodate 40,000 PCE per day.

In the case of a barrier located on link 541-584, too, there might be a strong tendency for traffic to divert. In this instance, however, the alternative highway (Highway 5) would only have a capacity of 12,000 PCE per day, so that traffic diversion could not grow after the first few years of operation.

The pertinent user costs in determining the likelihood of toll barrier avoidance, in the cases of a barrier site on link 540-541 or on link 541-584, are indicated below. Auto costs are shown for all light vehicles, i.e., including autos and light trucks.

	Taipei-Keelung vehicle trip costs (NT$)		
Route	Light vehicles	Heavy trucks	buses
Highway 5 (397-414)	82	114	268
Freeway (538-413)--w/o tolls	44	71	131
Freeway (538-413)–with tolls	60	94	177
Hwy. 5-Fwy. (397-415-541-413)*	74	104	238
Fwy.–Hwy. 5 (538-541-415-414)**	62	95	195

* With plaza south of Hsichih (on link 540-541).
** With plaza north of Hsichih (on link 541-584).

As can be seen from the above cost figures, the freeway with tolls would maintain a sizable cost advantage over the alternative of using Highway 5 for the full distance between Taipei and Keelung. The avoidance of the plaza by only using the freeway for a part of the distance would be much more attractive, however. If the plaza were located to the north of the Hsichih interchange, avoidance of the plaza by using Highway 5 link 415-414 would be about equally attractive, for both light vehicles and heavy trucks, with staying on the freeway and paying the toll, so that approximately 50 percent of these volumes might prefer to divert to Highway 5. Express buses, however, would still tend to remain on the freeway.

If the plaza would be located to the southwest of the Hsichih interchange, avoidance of tolls by leaving the freeway would be less attractive, and only about 22 percent of Taipei-Keelung light vehicle trips and 45 percent of Taipei-Keelung heavy truck trips would tend to divert to Highway 5. An important point is that, the diversion percentages indicated with a plaza on link 541-584 (viz., 50 percent for both light vehicles and heavy trucks) would apply to all light vehicle and heavy truck trips moving between Taipei and Keelung, including all of these trips which would have their origin or destination to the south of Taipei, whereas the diversion percentages indicated with a plaza on link 540-541 would apply to only Taipei-Keelung trips, and not to any longer-distance trips. The reason for this is that the above cost analysis took into account only one transfer between the freeway and alternative highways, whereas, if longer-distance traffic were to seek to avoid a plaza located to the southwest of Hsichih, then two transfers between the freeway and alternative highways would be required.

The cost for autos of leaving the freeway at node 537 and traveling to node 397 would be NT$15; the cost of traveling along the freeway from node 537 to node 538 would only be NT$4, so that leaving the freeway would involve incremental user costs for autos of NT$11. Adding this increment to the NT$14 increment (i.e., NT$74 less NT$60), calculated above, gives a total additional cost of NT$25 for avoiding the plaza. With a saving of that magnitude, only about seven percent of long-distance auto trips might tend to divert. If driver psychology is also taken into account, as well as the discomfort of traveling under congested conditions (which was not given any value in this study's estimates of user costs), then no long-distance auto trips might be expected to divert from freeway link 540-541 with a toll plaza.

From the foregoing discussion, it can be seen that, from the point of view of improving freeway utilization, a plaza location to the southwest of the Hsichih interchange might be preferable to a site to the northeast of that interchange. Since there seems to exist no good location for a plaza on link 540-541, however, consideration might be given, alternatively, to discouraging diversion from a barrier on link 541-584 by lowering the toll charges.

The recommended charges would be considerably higher than the existing charges on Macarthur Expressway; these latter are only NT$5 for light vehicles and NT$10 for heavy vehicles. The charges on the freeway in Section I would represent payment for approximately 26 kilometers of travel, whilst the charges on Macarthur pay for about 20 kilometers of travel. The per-kilometer charges for the freeway with schedules B_2 (NT$10 for light vehicles, NT$15 for heavy trucks, and NT$30 for buses) and B_3 (NT$15 for light vehicles, NT$20 for heavy trucks, and NT$40 for buses), and for the existing facility, are shown below.

	Toll Charges per vehicle-kilometer (NT$)		
	Light vehicles	Heavy trucks	Buses
Macarthur Expressway	0.25	0.50	0.50
Freeway with B_2 tolls	0.38	0.58	1.15
Freeway with B_3 tolls	0.58	0.77	1.54

If B_2 tolls were imposed on Section I, instead of the B_3 tolls which are being recommended by this study for the entire toll-collection system, the cost advantages of using the freeway for the entire distance between Taipei and Keelung, compared with using the freeway only to node 541, and then diverting to Highway 5, would be NT$7 for autos and NT$6 for heavy trucks. The lowering of toll charges would tend to reduce auto diversion from link 541-584 by about ten percent, but would only lower heavy truck diversion by about three percent.

As noted earlier, the diversion from the freeway in Section I could not continue for many years unless Highway 5 would be improved; this study's capacity diagram for Screenline 1 (crossing freeway Section I) indicates that an unimproved Highway 5 would be filled to capacity in 1978. After that year, all traffic increments would need to use the freeway, whether or not they would prefer doing so given the choice of Highway 5, with existing operating conditions. Thus, diversion from the freeway Hsichih-Keelung link might only be a problem for two or three years after Section I of the freeway would open.

SUMMARY AND RECOMMENDATIONS

The discussions in the preceding sections of this appendix have indicated that each proposed adjustment would have both advantages and disadvantages. In the case of the additional toll plaza in Section V, which would be located between Taichung and Changhua, the adjustment would produce substantial amounts of additional revenue, but only at the cost of a marked reduction in utilization of the freeway by local Taichung-Changhua traffic. In the case of the proposed shift of the Section VII plaza, some revenues might be lost with a location north of Kangshan, compared with a location south of Nantzu (especially, in the years after Highway 1 would reach capacity and diversion from a plaza to the south of Nantzu could no longer increase), but freeway utilization and economic benefits in the early years would be increased. In the last case discussed, the proposed shift would be undesirable from the viewpoint of highway design, but might be desirable from the standpoint of increasing freeway utilization and toll revenue.

Although a plaza between Taichung and Changhua would substantially increase revenue, that freeway section would not open to traffic until 1978 (at the earliest). Elsewhere in this study, it has been indicated that toll revenue might be expected to become sufficient to cover all annual requirements for funds (including requirements for debt service, maintenance, operations, and new construction) by 1982 or 1983. Thus, revenue from this plaza would only be needed for a period of four or five years (at the most, depending upon the final date of Section V opening). As against this financial benefit, the adverse economic effects would continue for as long as the plaza would operate, and the costs of freeway right-of-way, construction, maintenance, and operation would be raised. Moreover, the recommended network located barriers at roughly equal intervals, so that, with an additional plaza in Section V, barriers would either need to be closer together over the central portion of the freeway, or interval adjustments would have to be made over the entire Taipei-Kaohsiung section. Weighing together the various financial and economic effects foreseen to derive from this barrier, this study recommends that no barrier be located between Taichung and Changhua.

The proposed shift of the plaza site in Section VII is recommended. The plaza site south of Nantzu would be expected to result in substantial diversion from the freeway. If the plaza location would be moved to the north of Kangshan, a considerable amount of Tainan-Kaohsiung trips would still divert from the freeway, but longer distance trips, and trips entirely within the Kangshan-Fengshan area, would be expected to remain on the freeway. The increased utilization of the freeway with a plaza to the north of Kangshan, would result in higher freeway benefits and an improved rate of return on the freeway section. Toll revenue might not be much lower with the shift to a four-lane location from the six-lane location to the south of Nantzu, at least in the years when the section of Highway 1 paralleling the freeway south of Nantzu would have sufficient capacity for handling the substantial traffic volumes which might wish to avoid a freeway toll plaza located south of Nantzu. The location to the north of Kangshan would have the added advantage of encouraging, regional development to the south, whilst the site south of Nantzu would require valuable land, and would interfere with plans for local development.

The proposed shift of the Section I plaza site is not recommended. The only suitable location for a toll plaza between Neihu and Hsichih would be close to Neihu, and would interfere with development of the Neihu area. The toll revenue and the economic benefits might be somewhat lower with a plaza located between Hsichih and Keelung when the freeway would first open, but diversion from that freeway link could only be expected to grow for about a two or three-year period after freeway opening. At that time, the traffic on Highway 5 should have reached the capacity of that highway, and no additional freeway volumes would be diverted.

CHAPTER

IV

APPENDICES

Appendix A

RULES AND REGULATIONS FOR USE OF THE TOLL ROAD

INTRODUCTION

Freeways normally improve highway traffic safety markedly compared with safety conditions on undivided, free-access highways. In order to assure such improvement with the North-South Freeway, it will be necessary for the freeway-operating agency to develop a set of rules and regulations for using the freeway, and to see that these are strictly enforced once the freeway has been opened to traffic.

In addition to safety considerations, certain traffic might be destructive of the freeway itself, and such traffic should be prohibited from using the freeway.

Following, are some suggested rules and regulations, which might be applied to the North-South Freeway.

Traffic Regulations

Speed Limits

Vehicles shall not be operated on the toll road at a speed greater than 100 kilometers per hour. Where signs are erected indicating a particular speed all vehicles within the area or zone or sections where such signs are erected shall not at any time be operated in excess of the speed indicated by said signs. No vehicle shall be operated on the toll road at a speed less than 65 kilometers per hour except when necessary to do so because of inclement weather or other hazards existing upon the toll road. (Operation of special types of equipment, such as cranes, construction equipment, etc., not capable of maintaining a minimum speed of 65 kilometers per hour on the toll road shall be permitted on proof of adequate liability insurance in effect concerning such vehicles.)

Uniform Direction of Traffic

No vehicle shall be operated, pushed, or otherwise caused to be moved in a direction which is against the normal flow of traffic on any traffic lane, deceleration lane, acceleration lane, access ramp, shoulder, or other travel way on the toll road. Upon entering a traffic lane from a service area, interchange or access ramp, the operator of a vehicle shall use the acceleration lane and he shall enter the toll road with caution so as not to interfere with or endanger other traffic.

Use of Median Strip

The median strip of the toll road system is the area separating traffic moving in opposite directions. No person or persons shall operate a vehicle across such median strip. Driving a vehicle on such median strip is prohibited. Parking, standing or stopping on such median strip is prohibited. These provisions shall not apply to authorized vehicles (i.e., highway patrol vehicles, toll road official vehicles, maintenance vehicles, and emergency vehicles operated under agreement with the toll road authority when operated in the performance of their official duties) provided that the operator uses caution so as not to interfere with or endanger traffic.

U–Turns

The making of a U-Turns at any point on the toll road system is prohibited. Exempted from the provisions of this paragraph are authorized vehicles (as described above).

Driving in Traffic Lane, Overtaking and Passing

Lane traffic (the right to drive in right or left lane of traffic going in same direction) is authorized on the toll road. A vehicle shall be driven as nearly as practicable entirely within a single lane, and shall not be moved from such lane until the operator has first ascertained that such movement can be made with safety. A driver of a vehicle may overtake and pass upon the left side of another vehicle only when this can be done by staying within lane two, but said overtaking and passing cannot be done if the driver has to drive off the main portion of the toll road. Any driver of a vehicle intending to change lanes shall give proper and sufficient signal of intention to move to the right or left before making said lane change, and even then he shall yield the right-of-way.

Parking, Stopping or Standing of Vehicles on Traffic, Deceleration or Acceleration Lanes.

No vehicle on the toll road system shall be parked, stopped, or allowed to stand on the traffic lanes, acceleration lanes, deceleration lanes, bridges, structures, access ramps, or on shoulders in front of service areas between the traffic lane and the service area, or at any other place where posted to the contrary.

Parking, standing or stopping on the shoulder of the toll road shall be permitted only in an emergency, or when authorized by a patrolman, and then only on the shoulder to the right of the traffic lane facing in the direction of travel and only on condition that all wheels and projecting parts of the vehicle and load shall be completely clear of the travel lane.

In the event that it is necessary for the operator of a truck or tractor-trailer to leave such vehicle on the toll road unattended and it is impossible or impractical, in the opinion of a patrol officer, to have such vehicle towed off the toll road, the operator shall obtain a parking permit from a patrolman before leaving the toll road. The provisions of this paragraph shall not apply to toll road construction vehicles, or to patrol cars, maintenance or official toll road authority vehicles.

Accidents

In addition to the provisions of the traffic laws of the Republic of China the operator of a vehicle involved in an accident on the toll road system, resulting in injury or death to any person or damage to any property, real or personal, shall immediately stop such vehicle at the scene of the accident, render such assistance as may be needed, and give his name, address, license and registration number to the person injured or the person sustaining the damage and to a member of the highway patrol or to a toll collector at the nearest toll booth.

Impounding of Vehicles

Vehicles illegally parked or abandoned on the toll road system may be towed off and impounded. Such vehicles may not be removed from the storage compound until after the payment of towing, storage and other charges.

Following too Closely

The operator of a passenger car shall not follow within thirty-six (36) meters of another vehicle, and the operator of any truck or tractor shall not follow within fifty-four (54) meters of another vehicle.

Obedience to Officers, Signs, and Signals

No person shall fail, neglect or refuse to comply with any order of a member of the highway patrol, the collectors in toll booths, or maintenance employees while they are performing official duties on the toll road. No person shall fail, neglect or refuse to comply with any traffic control sign, signal or device erected or displayed on the toll road system, unless directed otherwise by patrolman or toll road employee.

Sirens and Spotlights

Use of spotlights and sirens on the toll road is not permitted, except for emergency vehicles (i.e., highway patrol cars, ambulances, tow trucks, or fire-engines), when used in emergency situations.

Limitations on Use of The Toll Road

Entry upon, and use of, the toll road by the following is prohibited:

Pedestrians;

Bicycles with or without motors, motor scooters, motorcycles, and three-wheeled vehicles;

Animals or animal drawn vehicles;

Farm implements or machinery, either self-propelled or towed;

Vehicles loaded with poultry or livestock not properly confined;

Vehicles with improperly secured loads;

Vehicles which, in the judgment of toll collection personnel or a highway patrolman, are unsafe;

Vehicles with deflated pneumatic tires, or with tires in such condition, in the judgment of toll collection personnel or a highway patrolman, as to be unsafe for use upon the toll road;

Vehicles with metal tires, or solid tires worn to metal;

Vehicles exceeding the weight limitations of the vehicle and traffic laws, except when carrying a special permit issued by the toll road authority;

Vehicles transporting explosives, atomic or fissionable materials, when not in compliance with applicable rules and regulations and the laws of the Republic of China, and vehicles carrying explosives and detonators or caps in the same load;

Vehicles in tow by non-rigid connection (not permitted to enter the toll road under any circumstance);

Disabled vehicles in tow (passenger vehicles which become disabled while using the toll road shall be removed either by being towed or pushed by an emergency vehicle from a toll road service area, a contract wrecker or an emergency vehicle of the patron's choice; trucking and bus company vehicles which become disabled, and which must be removed either by towing or pushing, shall be removed either by company-owned and operated service units, by agencies operating under contract with the companies whose vehicles are disabled, or by emergency vehicles from the toll road contract garage); and

Vehicles with loads extending more than 0.15 meters beyond the sides or more than 1.20 meters beyond the body of the vehicle or other supporting member, except when properly flagged for daytime travel or properly lighted for nighttime travel.

In addition to the above, vehicles of any type may not use the toll road whenever their dimensions, including the dimensions of their loads, if any, exceed 4.05 meters in height, 2.40 meters in width, or 15 meters in length, except when they have been issued a current, valid special permit by the toll road authority. These special permits may increase the maximum dimensions to 4.2 meters in height, 3.0 meters in width, and 18 meters in length. Even if a vehicle would exceed 18 meters in length or 3.0 meters in width, it still might be permitted use of the toll road if, after obtaining a special permit, it would also be given approval for freeway use by any highway patrol officer, except that no vehicle exceeding 2.4 meters in height or 3.30 meters in width shall be permitted to use the toll road under any circumstances. The special permits shall be valid only for daytime travel. Toll collectors shall record the date and number of each permit, the date of movement permitted therein, the oversized dimensions of the vehicle and (if applicable) load transported, and the date and time of entry onto the toll road.

It may also be necessary to exclude a certain type or class of vehicle from the toll road on particular occasions. For example, experience has shown that house trailers, particularly those that are over length are hazardous during periods of strong or gusty winds. Toll road patrolmen will advise headquarters when this condition exists in their area. Headquarters will notify toll plazas of the restriction to be placed on house trailers during these periods.

In addition to highway vehicles which may not use the toll road, use of the road system for landing of aircraft is prohibited, except on the emergency landing strips provided for this purpose.

It shall be the duty of the toll collection personnel and the highway patrolmen to enforce the provisions set forth above, and all persons shall comply with the orders given by such employees and officers to prevent the use of, or entry upon, the toll road by any of the aforesaid forbidden vehicles.

Other Toll Road Regulations

Hitchhiking and Loitering

Solicitation of rides, commonly known as hitchhiking, on any portion of the toll road is prohibited. Loitering in or about toll plazas or any other portion of the toll road is prohibited. Stopping of vehicles by patrons for the purpose of picking up or discharging hitchhikers is prohibited.

Waste and Rubbish

Littering or disposing of bottles, cans, paper, waste or rubbish of any kind on the toll road is prohibited.

Damage to Property

No person shall cut, mutilate or remove any trees, shrubs or plants located on the toll road, nor shall he deface, damage, mutilate or remove any sign, delineator, structure, fence, or any other property of the toll road.

Alcoholic Beverages, Gambling and Weapons

The consumption of alcoholic beverages, participation in games of chance and brandishing of weapons by any person is prohibited on the toll road. Patrons obviously under the influence of drugs or intoxicating beverages shall be refused entry upon the toll road.

Solicitation of Funds and Other Commercial Activity

No person shall solicit funds for any purpose on the toll road without a written permit granted by the management. Commercial activity of any nature on the toll road without the written permission of the toll road authority, is prohibited. No person shall post, distribute, or display signs, advertisements, circulars, or any printed or written matter on the toll road without written permission from the toll road authority.

Appendix B

TRAFFIC CONTROL AND LAW ENFORCEMENT PROCEDURES

ENFORCEMENT POLICY

Uniform enforcement is essential to a successful traffic law enforcement program. The public does not object to strict enforcement which is just and impartially administered. They prefer it to laxity in enforcement. What the public does object to is lack of uniformity in enforcement.

To achieve a high degree of uniform enforcement, standards must be established upon which to base decisions as to what form of enforcement actions will be taken following violations.

These standards are provided in the form of enforcement policies. The policies do not replace the intelligence or good judgment of the officer; such traits are necessary to apply the policy following consideration of the circumstance and conditions surrounding the violation. Similar violations cannot be disposed of in an identical manner when the conditions and circumstances surrounding them vary greatly. A violation which would normally warrant a written warning can justifiably be cause for arrest when surrounding conditions increase its seriousness; likewise, with respect to minor violations. Deliberate violators should normally be afforded less leniency than unintentional violators. On the other hand, extenuating circumstances occasionally arise which would justify a written warning or no enforcement action where an arrest would otherwise normally be made. An example would be a person caught speeding while rushing a victim of poisoning to a hospital; however, even here, the seriousness of the violation may be too great to permit it to be entirely disregarded.

Generally, in the absence of extenuating circumstances, enforcement policies should be adhered to.

TRAFFIC VIOLATIONS

Stopping the Violator. Patrol officers should strive to develop an awareness of the importance of selecting a proper location for stopping the violator. A place should be selected where it is possible to stop the violator promptly, efficiently, and safely. If carelessly done, it may be dangerous to the officer, the violator and to other road users.

Selecting a good location to stop is an important decision for the following reasons:

a. If the violator becomes confused and has an accident, both the patrolman and the department may be severely criticized; and

b. If the location is not carefully selected, the violator's vehicle may bog down in soft ground or become stuck in sand, or on the shoulder of the roadway.

The officer should endeavor to find a location where there is plenty of room. In rural areas this would be off the traveled portion of the highway where there is a good hard shoulder. The officer should avoid stopping the violator in driveways or filling stations, places of business or on private property.

Heavy or oversized vehicles pose a special stopping problem. The location selected should support the weight of the vehicle, and its extra width, length, or height should not create a hazard to other traffic.

If there is not a suitable location nearby to stop a violator, the officer may have to follow for some distance before making the stop. It's usually better to follow the violator for an extra mile or two to find a safe place than to risk serious congestion or accident. There will be cases where there is need to stop a violator almost immediately, for example, a drinking driver, but where possible, such places as the crests of hills, curves, and intersections should be avoided. Also to be avoided are: Places with neon signs, parks, amusement centers, picnic areas, drive-in movies, and other spots where motorists may be subject to distraction; and lonely roads or out-of-the-way places where no help would be readily available if the violator attacked the officer, or otherwise became unruly.

Darkness makes the task of selecting a stopping place more difficult. A spot should be picked which would be visible to approaching traffic for at least 400 feet in each direction, and, whenever possible, a place which has some illumination would be desirable. (This will give an increase in safety and make it easier to write a citation or warning ticket.)

Signaling Other Traffic. After the officer has decided where to stop the violator, he should first look in his mirror, to determine when he may stop safely, before he actually begins the stopping procedure. If there is anyone directly behind, he should be sure the vehicle is alerted to the maneuver about to be undertaken. Then he should edge out slightly into the left lane and look at the roadway ahead, to determine whether there are view obstructions within the distance required to stop, and to check for approaching traffic that may endanger him during the stopping maneuver. If there would be any question that following or oncoming drivers had seen his signals, he should remain behind the violator, and wait for other traffic to slow down or make way for the patrol vehicle.

Coming Abreast The Violator. The patrolman may not have to leave the lane of traffic to signal the violator to come to a stop. Particularly at night, violators probably will stop for the red turret light while the officer would be directly behind him. It's also a good idea to flick the headlights from high to low beam several times while the red turret light is on.

If the violator would not stop when the officer would use his lights, the officer should move into the left lane and take a position almost abreast of him to signal him to stop.

He should have the front end of the patrol car abreast of the rear part of the door on the driver's side of the violating vehicle, or even farther forward if necessary, to be certain that the motorist would observe the patrol vehicle.

Signaling the Violator. The officer should tap the horn lightly several times to attract the motorist's attention. Except under emergency conditions, he should not use the siren. The sudden noise may confuse or distract the motorist, causing him to swerve into other lanes or off the roadway. The officer should allow enough distance between the patrol vehicle and the violator's vehicle so that any swerving movement on the part of the violator would not cause the officer to run into the side of other vehicles.

Having attracted the violator's attention, the officer should motion to him by hand to tell him what to do. Most violators would understand if the officer just pointed to the side of the road. At night, the officer should turn on his right-turn indicator. If the violator would not stop immediately, the officer should not assume he is going to ignore the signal to stop. Maybe, the violator would have failed to hear or understand the signal.

The officer should use the siren only as an emergency or last resort device. If it becomes necessary, he should first drop back so that the front end of his vehicle is slightly behind, and clear to the left, of the violator's car.

Difficulties In Stopping Violators. Motorists react differently to the officer's stop signal. The most frequent difficulty is caused by the violator who stops abruptly. This may force the patrol vehicle to overtake and end up ahead of the motorist's vehicle. Before turning on the red light, the officer should be certain there is enough distance between the violator ahead so that, if he comes to a sudden stop on seeing the red light, the patrol vehicle will not run into his rear.

As the patrolman moves into the position to signal, he should take his foot off the accelerator and put it on the brake pedal, being careful not to apply the brake. In most cases, the speed gained from moving into the signaling position would keep the patrol car in position long enough for the officer to make his signals understood. (Some officers find it helpful to put their left foot on the brake pedal as they move into the stopping position, thus giving instantaneous braking and acceleration control during the stopping maneuver.)

Sometimes a motorist will stop on the traveled portion of the roadway. When this occurs, the officer should remain behind the violator's car and warn other traffic with the patrol car's red lights. The officer should then do one of two things:

a. If his movement up to the violator's vehicle would be hazardous because of other traffic, he should signal the violator from within his patrol car. Use of the siren or horn to attract the violator's attention, followed by a hand signal as described earlier, might produce the desired results.

b. If other traffic is not a problem or when the violator fails to respond to the officer's signal, he should approach the vehicle and tell the driver just what to do.

When dealing with a suspected drinking driver, the officer should not signal him over from within the patrol car. The violator usually would not heed his signal and any further operation of the vehicle by the offender might be embarrassing in court. In these cases, the officer should have the driver move over, and the officer himself should drive the car off the road.

Sometimes a person will intentionally refuse to stop. When this happens, the officer may radio ahead for assistance and give instructions for a roadblock or he may have to forcefully stop the motorist. The latter alternative, however, is not advisable, unless the violation is continuing or of a serious nature. A full description of the vehicle, registration number, and an accurate description of the driver should gain a conviction even when the driver is only apprehended at a later time.

In most situations, the driver, after noticing the signals from the officer, would pull over to the shoulder of the road and stop. Here is where timing is most important. The officer should be prepared to apply his brakes, so that he could stop his vehicle behind the violator's. (He should not start to move behind the violator until after sharp braking has been completed.)

Sometimes traffic, weather, and road conditions would make it necessary for the officer to deviate from the procedures outlined here, but he should never move or park in front of the violator.

Proper Parking and Approaching Procedures. After the violator has been stopped, the officer should place his vehicle eight to fifteen feet behind the violator. The officer should have the left edge of his vehicle two or three feet to the left of the violator's vehicle, except in those cases where heavy traffic conditions or road conditions make this position hazardous to other road users. The distance between the patrol car and the violator's car would reduce the possibility of a three-car accident if a motorist should run into the rear of the patrol vehicle. By parking slightly to the left of the violator's vehicle, the officer reduces the possibility of being struck by an overtaking motorist while he is talking to the violator.

The officer is subject to the same emotional upsets as the violator, but it's his business to control his emotions. Before approaching the violator, he should stop and take stock of the situation. If necessary, he should remain in his car for a few moments until he has "cooled off" sufficiently to act in an impersonal manner. He can effectively use some of this time to write down the license number of the violator's vehicle and observe the passengers within (he should watch especially for any change in positions between a passenger and the driver, or any other suspicious or unusual movement in the violator's vehicle).

After composing himself sufficiently, the officer should step out of his vehicle, watching for traffic as he gets out. This part of stopping and approaching the violator exposes the officer to the greatest personal danger and the following few seconds are critical ones.

Depending upon the conditions, one of the three following methods may be used in approaching the violator's vehicle:

a. Normal with passenger in rear seat – The officer should pause just to the rear of the rear window, then place himself at the front edge of the driver's door, facing the rear. This would allow him to watch the driver, any persons in the rear seat, and oncoming traffic.

b. Possible dangerous driver – especially without rear seat passengers – The officer should stop just to the rear of the driver's window, facing the vehicle. He should stay back of rear edge of the driver's door. This would keep the driver at a disadvantage and give the officer the advantage if danger should arise. In this method and the preceding one, he should keep off the highway, but leave enough room between himself and the vehicle to use his hands.

c. On heavily traveled streets, where an approach from the left side would be hazardous to the officer and to other traffic, and under some other conditions that make a left-side approach inadvisable, the approach should be made from the right – The officer should pause just to the rear of the right rear window, then place himself at the front edge of the right front door, facing the rear of the vehicle. This would tend to disconcert the driver because most drivers would expect him to approach from the left side.

When two officers are patrolling together, one should approach the violator's vehicle in the same manner as described above, while the other would assume a position where he could be of assistance if the need would arise. He might do either of two things:

a. Leave the patrol vehicle and stand just to the right of the passenger side with the front door open; or

b. Leave the patrol vehicle and take up a position to the rear and to the right of the violator's vehicle that would allow him to watch all occupants in both the front and rear of the vehicle.

Both positions would permit the second officer to observe the actions of the violator while in a protected position. After the initial contact is over, and the threat of danger or resistance is past, the second officer might protect the scene by working traffic.

The officer should never lean against the violator's car. He should be especially alert for any unusual movements, and look at the floor and rear seat for anything which may be hidden. The officer should notice the violator and passengers. He should stand at an angle so that he would be able to look behind the vehicle and inside it at the same time. He should use his left hand for accepting papers from the motorist.

Regardless of how innocent the situation may appear, the officer should never go in front of the vehicle to write the citation or to look at the registration plate. There is always the possibility of being run down by the motorist, either deliberately or through nervousness. If it is necessary to examine the front of the vehicle, he should go around the rear of the vehicle and proceed to the front along the right side of the violator's vehicle. He should stand to the right and slightly ahead of the vehicle while making the examination.

When examining the vehicle from the rear, writing a citation, or talking to the driver when he is out of his vehicle, the officer should never allow the driver or anyone else, including himself, to stand between two stopped vehicles.

It is preferable for the officer to write the citation or make notes at the right front fender of the patrol vehicle with the violator standing in front of, and slightly to the right of, the right front headlight of the patrol vehicle. It is not always practical to have the driver get out of his vehicle, however, and in this event the officer should, after he has secured the violator's license, write the ticket at the right front fender of the patrol vehicle.

Stopping An Approaching Violator. Stopping the violator who is approaching from the opposite direction is a special problem. For his own protection, the officer should not leave his vehicle and attempt to stop the violator by hand signals. This would exposes him to the maximum danger from other traffic and the violator himself.

To stop an oncoming vehicle, the officer should drive onto the shoulder of the road on his side and turn on the top mount lights. He should not attempt to turn around until after the violator has passed his position. He should use his turret light to reduce the speed of the violator and alert other traffic in the area that he is going to do something unusual. Many times, hand gestures directed to the approaching vehicle will bring him to a stop. After he has come to a stop, the officer should turn about and place the patrol vehicle behind the violator's vehicle in the prescribed manner. If the violator fails to heed the officer's signal, he should wait until the violator has passed, and then turn around and stop him in the usual manner.

Stopping the Following Violator. Another special stopping problem is stopping the violator or wanted vehicle which is approaching from the rear. To stop such a vehicle, the officer should drive to the extreme right-hand side of the roadway, allow the vehicle to pass, and then stop him in the usual manner.

Stopping Special Vehicles. Certain types of vehicles create special problems; for example, trailer units, very long or very wide vehicles, house trailers, and heavy equipment. As a general rule, the problem offered here is in the selection of a suitable location for stopping. Most truck drivers are carefully selected and are mindful of all traffic both front and rear. Generally they will respond at once to blinking red lights and will pull off in a good location.

ACCIDENT INVESTIGATION

The following activities are listed in the approximate order in which they should be performed. However, urgency dictates, and seldom will the procedure followed be in the order outlined. The investigator should take care of what appears to be most urgent at the moment and, while engaged in that phase of the investigation, he should be planning the next phase.

The patrol car should proceed safely to the accident scene, and park where it would not constitute a hazard, and, when feasible, where headlights will illuminate the scene without blinding traffic, or where red lights can be used to give additional warning to traffic.

The officer should protect the scene from further accident. He may request competent bystanders to assist him, advising them of what to do and alerting them to dangers. When approaching the scene, special hazards can usually be detected; if none, the officer should provide for the injured first. He should be alert to power lines down or the possibility of fire.

The officer should determine the extent of injuries and, when necessary, give first aid, and/or call an ambulance, doctor, or coroner. Unless vehicle is in danger of fire or further collision there is no point in removing an injured person from it until the ambulance arrives, provided appropriate first aid can be given to the person where he is situated. (Where there is property of obvious value, i.e., billfold, cash, watch, rings, pins, etc., on the body of a deceased person, the following precaution shall be taken. The officer should itemize each article on a property receipt and place the items as listed in a large manila envelope or other container and have the collection, listing, and sealing witnessed by at least one person at the scene and more if possible. He should attach the property receipt to the envelope or container. These personal effects may be turned over, in order of preference, to the next of kin, mortuary, or other responsible party. The party to whom the property is released shall be requested to attest receipt of the articles by signature on the property receipt which should be retained as an official record for a period of not less than six months.)

The officer should seek out and positively identify drivers, not only with respect to name and addresses, but also with respect to certainty that these persons actually were the drivers. When a driver is inexplicably absent, the officer should assume the accident is a hit-and-run incident and proceed with investigation as such. The officer should locate and identify witnesses, and ask them to remain at the scene.

The officer should look over the scene and vehicles to get a general idea of what took place. He should mark locations, and measure and/or photograph evidence which may soon be destroyed.

He then should interview drivers and witnesses and obtain written and signed statements, when possible, and when of assistance.

The officer should then proceed as follows: (1) call tow trucks desired by persons in charge of vehicles, or when vehicle is unattended use his own judgement on which tow to call; (2) examine vehicles and highways systematically, looking for evidence which verifies or disproves drivers' and witnesses' statements (he should observe traffic control devices, markings and signs, obstructions to view, highway defects, etc.); (3) take photographs, prepare diagrams and take measurements; (4) mentally review what evidence is necessary to convict on contemplated charge; (5) re-examine scene for evidence which is needed and presently lacking, questioning drivers and witnesses again if necessary; (6) review all notes for completeness; and (7) make arrangements with accused to appear in court if charge is decided upon.

Finally, after all legal details have been taken care of, the officer should see that all debris at the scene of the wreckage is cleared away he should not leave the scene until this has been completed.

After leaving the scene, the officer still has some responsibilities regarding the accident. He should: (1) interview witnesses and injured not interviewed at scene; (2) if serious accident at night, he should return in daylight to check for things not observed during darkness; (3) complete accident report so far as possible and forward it with daily report for day accident was investigated (if additional information becomes available later, he should forward a supplemental report); and (4) notify toll road maintenance office of any highway fixtures damaged in accident.

Appendix C
MAINTENANCE PROCEDURES

Toll road maintenance is the preserving, upkeep, and restoration of roadway, roadside, structures and facilities as nearly as possible in their original condition as constructed or as subsequently improved. It also comprises the operation of special safety devices and illuminating equipment.

This appendix briefly covers only the more important elements of maintenance operation. The chief engineer should establish detailed inspection and maintenance procedures for his staff and training programs on different types of maintenance methods for all occasions. Safety rules should be listed and all workmen required to attend instruction courses periodically. These courses should have instructors versed in the modern safety and repair methods most desirable to do a complete job for a high-speed toll highway.

1. Maintenance of Traveled Way

The most important part of maintenance on a toll road is the traveled way. This covers the restoration and repair of both surface and base within that portion of the roadway for the movement of vehicles. If any hole or roughness in the pavement is not repaired expeditiously, its deterioration under heavy traffic and weather accelerates.

a. Flexible Type Pavements

The best procedure to combat problems with this type of pavement is to have, in each maintenance area, a supply of asphaltic patching mix and to take care of any pavement problems as soon as they occur.

The section foreman can then have a truck loaded with mix in whichever yard is nearest to where pavement patching is required. After hauling the mix to the desired location, the truck should be parked on the outside shoulder. Adequate warning signs should be put up on the shoulder, where traffic can see them about one kilometer before coming to the repair location.

In patching potholes, all loose material must be removed and the area must be shaped evenly with sloping sides to the depth of the holes; then bottom and sides must be primed using SC-70, SC-250, SC-800, or emulsified penetration type asphalt. The premixed materials should be placed and the workmen should tamp the material flush with the pavement surface with hand tempers for small patches, and by rolling for larger areas, before opening the lane again to traffic. All loose material and signs must be quickly removed after the work is completed.

If the pavement is only cracked it will not need extra material but can be sealed by filling the crack with asphaltic seal oil and applying dry sand to the top to keep the oil from being displaced by traffic. It is important that, during these repair activities, a flagman warn traffic to drive slowly past the operation.

If the surface becomes too rough to be handled conveniently by individual patch methods, an overlay machine can be used to put a five-centimeter layer of mix over the distressed area.

b. Rigid Type Pavements

When the base under the concrete slab surface of the road settles due to improper compaction or a bad soil condition this creates cracking of the slab and sinking.

If a change in grade creates a dip hazardous to traffic, signs should be erected to warn drivers. Then a detour around the trouble spot should be constructed, and the pavement raised to its original position by mud-jacking.

The mud-jacking process consists of drilling holes through the sunken slab at intervals of approximately five feet, and pumping cement mix materials through a tube into the hold under the slab until the pavement is jacked up to the correct position. The material used in mud-jacking should have a low shrinkage factor and be as coarse or granular a texture as will flow through the equipment and spread under the pavement. This may have to be done in more than one operation if the lift is more than three or four inches. If more than one operation is required, time should be taken to allow the mix pumped under the pavement to set and hold the base solid; then new material should be pumped to raise the pavement further as needed.

In cases where the pavement has pushed up or blown out, which generally happens at construction or expansion joints, an air hammer may be used to cut the pavement in a proper manner, extract the excess concrete, install an elastic expansion joint and smooth the repaired slabs with asphaltic materials or quick set cement concrete. A detour would have to be maintained around the repair area until the cement has set.

If the concrete surface of the slab is only cracked, but not settled or buckled it may be repaired in the following manner: the cracks may be cleaned of mud and dirt by using a router, which also provides room for induction of asphaltic crack filler; then the excess filler must be cleaned off, to conform to the surface of the pavement. In this manner, the crack failure would be sealed, and the continuity of profile of the road would be preserved.

Patching with bituminous material is also possible. All loose and foreign matter should be removed and the area thoroughly cleaned and lightly primed. After priming, a base coarse of penetration macadam or of premixed bituminous material, using coarse aggregate, may be placed. Upon this base course may be placed a wearing course, which may be covered first by a light seal of bituminous material and then with pea gravel or fine screenings, and thereafter rolled.

2. Maintenance of Shoulders

The shoulders should be maintained over their full width, smooth and flush with the traveled way. Shoulder maintenance is a year-round job and requires continual attention. This maintenance is of the utmost importance, because the failure of many surfaces starts at the inside edge of the shoulder. The shoulders should always be properly sloped to insure adequate drainage and safe driving. Shoulders should be maintained with the same type of material with which they were constructed. Due to hazards of traffic, shoulder work should be confined to one side of the highway at a time.

3. Maintenance of Bridges and Drainage Structures

The bridge structures should be inspected often and all plates, rocker and expansion devises should be painted and rust-proofed, annually, at least. If the deck of any structure becomes badly cracked it should be patched or sealed in the manner described previously for the road way. It is especially important to keep moisture from rusting the reinforcing steel in the decks in order to maintain full stress resistance in the structure.

Damaged bridge railings should always be replaced as soon as possible. Barricades or temporary rail panels should be installed to safeguard vehicular traffic until railing restoration can be made. Steel or aluminum railings frequently are so extensively damaged that replacement of panels may be more economical than straightening or replacing miscellaneous pieces.

In making structure inspection, maintenance personnel should observe the following points:

a. Condition of approaches;
b. Condition of deck (including excessive wear or vibration);
c. Condition of deck wearing surface;
d. Condition of curbs and railing;
e. Condition of paint on steel surfaces;
f. Cracked or broken stringers;
g. Looseness and undue vibration of steel truss members;
h. Crushed bearings;
i. Broken chord members and sheared splices;
j. Condition of expansion bearings and deck expansion joints;
k. Condition of piles, piers and abutments;
l. Accumulation of dirt and debris;
m. Erosion or scour;
n. Spalled concrete; and
o. Condition of stream channels.

The small drainage structures are very susceptible to filling with silt soon after being put in operation. The loose soil during construction makes this very possible. It is important for the section foremen to inspect these often at first and use hand tools if necessary to take all silt and debris out of the channel both ways, upstream and downstream, from the tube or box. If there have been large slides near the channel it might be necessary to use the proper earthmoving machine from the nearest maintenance area to remove the material from the flow line of the drainage channel.

It is necessary to check culvert outlets for possible undercutting and erosion. This is especially important for culverts installed on steep grades. Where cross pipes and siphons are installed for the purpose of converting irrigation water, maintenance of the installation may be the responsibility of others. These cases should be checked to clearly determine maintenance responsibility.

Heavy rains may cause erosion to the landscape and this should be minimized by constructing, where necessary, small dams and terraces. Ditches which carry large amounts of water during heavy rainfall should be noted by the maintenance foreman and when time is available ditch lining with masonry stone and concrete should be installed.

4. Maintenance of Signs

All signs should be maintained in their proper location, cleaned and legible at all times. Damaged and missing signs should be replaced immediately. Adequate sign maintenance requires a suitable schedule for inspection, cleaning and replacement. All signs should be inspected at least twice a year. Night inspection of signs is also necessary and should be done at least every six months.

Superintendents and other authority employees who frequently travel the toll road should be instructed to report immediately any damaged or obscured signs. Special care should be taken to see that weeds and shrubbery are not allowed to obstruct signs. The sign foreman should have an extra supply of letters and panels to replace those signs which have become damaged.

The sign superintendent should be provided with a sign washer, consisting of two tanks, a small compressor and hoses. The practice which has given satisfactory results is to use a small amount of detergent in the tanks. The other tank should contain rinse water. Overhead signs should be cleaned with a liquid or paste cleaner that will dry and leave a film of powder on the surface, which can then be wiped off with a mop or rag. The regular sign washer would perhaps spray cars passing under the structure and, for this reason, the dry wash method is recommended.

Procelain enamel signs may be repaired by painting the damaged surface with touchup enamel. These enamels should perfectly match the sign surface, and under most weather conditions will dry to touch within 10 to 15 minutes. Reflective sheeting material is very sensitive and, in washing and cleaning these signs, extreme care should be exercised so as not to scratch or deface this film. Reflective letters may be replaced on porcelain signs and reflective sheeting material, affixed to aluminum, may also be repaired with patches.

5. Maintenance of Lighting

In order to insure the proper operation at all times of highway lighting and illuminated signs it is essential that a policy of periodic night inspection, at least once a month or more frequently if necessary, be established. A cleaning schedule should be set up so that all luminaires will be kept clean, as dirt on lamps, reflectors and enclosing glassware can reduce light output by as much as 60 percent.

In cleaning, where possible, the reflector and glassware should be removed and should be scrubbed with a soft brush in a cleaning solution and then rinsed with clean water. If the parts cannot be removed to the ground, a cleaning agent that requires no rinsing can be used. The glass surfaces can be cleaned with steel wool and wiped off with a clean dry cloth.

Lamp replacements should be made promptly, as the installation generally illuminates unusual conditions requiring additional care and alertness on the part of the motorist. Accurate records should be kept indicating the location of the lamp, installation date, removal date, and hours of burning.

6. Maintenance of Roadside Vegetation

Aesthetic and functional requirements are prerequisites in the designing and planting of roadsides and should be the guideline in the maintenance, too. Weeds should be kept under control to the extent that they not be permitted to become unsightly or damaging to the ornamental plants. Watering and control of pests should be adjusted to plant requirements rather than to a time schedule.

Newly planted trees or shrubs should not be fertilized until after new growth indicates the plant is established and capable of using fertilizer. The lack of vigorous growth and deep green coloring in the foliage of a plant is the best indication of the need for fertilizing. Poor drainage, insufficient water, root diseases or hot weather could result in similar symptoms, but one of the most common causes is lack of fertility.

Watering may be required to maintain sufficient moisture in the root-zone of plants to maintain proper growing conditions. As a rule, shallow-rooted plants such as grasses, annual flowers and certain shrubs, require frequent watering for a short period of time while deep-rooted plants such as perennial flowers, trees and shrubs require watering less frequently, but deeper into the soil.

Chemical weed control is the most effective method available for large plantings. The chemical material must be selected according to the needs of the job, the weather, the soils, and the characteristics of the herbicide.

7. Maintenance of Equipment

The Section Maintenance Department is responsible for care, proper use, and preventive maintenance of the toll road equipment. The foreman, through the operator assigned to a piece of equipment, is responsible for its daily use and periodic service. Operators are responsible for detecting signs of faulty equipment. Equipment in need of repairs should never be kept in service. Equipment which cannot be returned nightly to the maintenance yard, must be parked in a safe place near habitation if possible and locked securely.

Equipment shall not be transferred from one maintenance district to another without the permission of the deputy chief engineer of equipment.

The motor vehicles which belong to the toll road should have an inspection by the shop superintendents each week and be given any preventative maintenance which the inspection shows they need. The deputy chief engineer of equipment and material should set up these inspections in a systematic manner so as not to disrupt orderly daily operations. The section foremen should each check over the rolling stock used in their section and all equipment which needs attention should be scheduled for movement to the district shop in whichever district it belongs, so that the shop mechanics may do whatever is needed to keep it in top shape for good service.

8. Traffic Control and Safety

It is the duty of the Maintenance Department to keep the toll road open to traffic and to provide for its safe movement. The department's first consideration should be the convenience and safety of travellers on the toll road.

In an emergency, the first duty of the Department is to keep the road or bridge open to traffic or to provide a safe detour.

If the pavement is flooded but passable, stakes with reflectors should be placed at the edge of the traveled way to mark it, and flagmen with red lanterns should be furnished to slow down and direct traffic. Torches should never be used as a warning where there is danger of setting fires.

In the event of an injury, the injured person should be placed in the charge of the highway patrol, which will have had training in this duty.

In the event of any emergency, the first action which should be taken is the notification of the headquarters dispatcher who would get the information to the correct persons.

Appendix D
COMMUNICATION PROCEDURES

GENERAL INSTRUCTIONS

Dispatchers or operators going off duty should advise their relief of any information or instructions regarding important happenings or pending traffic with which the new operator should be familiar. This should also include any completed traffic upon which a question might arise later. Even though there is no pending or important traffic at the time, the dispatcher going off duty should advise his relief of anything which might prove beneficial, such as, mobile units in service, their location, assignments, etc.

Dispatchers should remain at their positions at all times when on duty unless it becomes necessary in the course of their duties to leave temporarily, in which case they should have some other authorized person relieve them. No dispatcher should leave his position at the end of his shift until relieved by the oncoming dispatcher. If relief doesn't show up, he should notify his commanding officer.

Dispatchers should keep their operating position clear and orderly at all times and should never turn the position over to the next shift without thoroughly policing the position, replacing books, note pads, etc., which have been used during the shift and in general, straightening up the operating room.

Upon changing shifts, oncoming dispatchers should check their equipment to ascertain if it is in proper working condition, and familiarize themselves with the day's traffic from the log sheet.

When answering the telephone, courtesy is the first requirement. A dispatcher's reply should be positive and businesslike, but never harsh. Outside lines should be answered by giving the name of the agency and designation of the speaker.

Cases may arise where the dispatcher is not in possession of the information requested. In such cases he should never use the response, "I don't know," but should advise the person inquiring that he will be glad to obtain the information desired and call them back, or that he will have an officer that has the information call them.

In dispatching police information, a clear, easily understood tone, a monotone, with no particular emphasis, is easier to copy than one in which an attempt is made to mimic a commercial radio announcer. The voice should be distinct, but without apparent effort to speak each syllable separately.

In order to be able to efficiently perform his duty as a dispatcher, one must be familiar with the geography of the country. He must be acquainted with the larger cities, main highways, rivers and know their general locations. A dispatcher should be thoroughly familiar with the counties, county seats, highways, rivers and other points of interest within his area and those surrounding. If during operation, the name of some town, highway or river comes up with which he is not familiar, he should take the time to look it up, in order that he may be acquainted with it in the future.

ITEMS

An item is a general broadcast of information of lasting interest, usually of criminal nature, for the attention of law enforcement officers.

Broadcasts concerning stolen cars should be written up in the following manner: where stolen, time stolen, date stolen, color of car, year, make, body style, license number, motor number and authority for theft report. Any other pertinent information which might lead to the recovery of the vehicle may be included. Minor details such as "rip in upholstery" or "small dent in right rear fender" should be avoided.

In broadcasts concerning wanted persons, the following order should be followed in giving descriptions: Name, color, sex, age, height, weight, hair, eyes, complexion, build, marks, limps, and any other pertinent information that might lead to the apprehension of the subject. In items concerning wanted persons, the crime for which the person is wanted should be stated. In items or general information where persons are wanted for investigation, the purpose of the investigation should be stated. Where the subject is known to be armed, or believed to be dangerous, a statement to this effect should be included.

Items concerning both persons and cars should be written in such a manner that the description of the car will immediately follow the name of the person. Any further description of the person will follow the information on the car.

Many times requests will be received to broadcast information when it is doubtful if the information is important enough, or enough information is available, to qualify as an item. In these cases, information should be handled as a "General Information", if broadcast at all. (This is just one instance where the dispatcher must exercise his good judgment.)

Each item broadcast should carry an authority. This should be the authority for issuance of the warrant and would usually be the department actually contacted by the complaintant.

Items should be dispatched at a reasonable speed, repeating each phrase, with proper enunciation to permit accurate copying.

When information is added to an item, it should be combined with the information already given in the item in such a manner as to make the broadcast complete in itself. When additional information is of interest to only one or two stations, it can best be handled by sending a message to the interested stations.

The consent of the original authority is required for any cancellation of an item although any station may originate the cancellation as long as it has been authorized by the original authority. Cancellations should be broadcast as soon as possible, so all officers may have this information. Senior dispatchers should be responsible for seeing that a check is made periodically for possible cancellation of any items originated by his station.

GENERAL INFORMATION

A general information broadcast is one giving information usually of non-criminal nature, pertaining to a limited area and with a limited time element, such as "attempts to locate", etc. Also, it can be of a criminal nature, where not enough information is available to make an item, but enough is available to broadcast. The final decision on whether the information warrants being carried as an item or as general information is up to the toll road dispatcher.

MESSAGES

Messages consist of four parts:

1. Preamble (message number originating station, priority if specified, filing time, data).
2. Address (department to whom the message is directed).
3. Text (information being transmitted to addressee).
4. Signature (name of originating authority).

OPERATING PROCEDURE

To call a local station, base stations should proceed by first announcing their name, followed by the name of the station it is desired to contact.

To call a local mobile unit, all that should be necessary is to call the unit number. It should not be necessary to announce the name of the calling station.

Calls should not be repeated immediately. A reasonable length of time should be allowed for the station or unit to answer before calling again. If no contact can be established after the call-up has been repeated twice (with the prescribed interval between calls), the station should sign off and wait a few minutes before further attempts to make contact are made.

A suggested procedure for a mobile unit to answer a call is to give his number, followed by his location. This procedure will often cut down on air time, as the dispatcher knows at once the location of the vehicle, and will probably save an additional transmission to inquire the location of the unit.

A five second tone signal should be transmitted in the following cases:

1. To announce broadcast of items or cancellations;
2. To announce emergency conditions;
3. To announce the station in or out of service;
4. Preceding any emergency or urgent broadcast; and
5. Preceding summaries and weather broadcasts.

The tone signal should not be used excessively. To do so would greatly reduce its value as an alert signal.

At no time should a dispatcher transmit continuously for more than 30 seconds. Long items of dispatches should be divided into 30 second intervals and a pause of two to five seconds allowed between intervals. Such pauses will permit stations or mobile units with emergency or high priority traffic to interrupt routine broadcasts and, in addition, will permit the persons copying to ask for fills and repeats.

Appendix E

GENERAL RULES AND INSTRUCTIONS FOR TOLL COLLECTION SECTION

INTRODUCTION

The suggested rules, regulations, and instructions presented in this appendix would be for the guidance of the personnel of the toll collection section of the freeway-operating agency. These rules, etc. and/or others should be adopted by the agency, and put together in the form of a manual of toll-collection rules and procedures. Once written, this manual could be revised from time to time as the necessity might arise, to present new rules and instructions which would supersede or supplement others. Whenever problems might arise which would not be covered by the manual, employees should be instructed to bring the matters immediately to the attention of the Deputy Director-Operations, with a request for special instruction.

The manual of toll collection rules and procedures might include, but need not be limited to, the following:

1. Job titles and descriptions of toll collection personnel (see Chapter IV and Appendix F to Chapter IV of this study for job descriptions).
2. A discussion of toll collection equipment.
3. Work shifts and work schedules.
4. A discussion of when permission to use toll road should and should not be given.
    a. Limitations of toll road use (see Appendix A to Chapter IV)
    b. Toll charges and requirements to pay same
    c. Vehicles in wrong lane at plaza
    d. Drivers ill, intoxicated, or under the influence of drugs
    e. Emergency vehicles
    f. Authorized toll road vehicles
    g. Procedures for declining permission to use toll road
5. Method of toll collection and reporting.
    a. Collection from vehicles
    b. Toll collector reports
    c. Collection from toll booths
    d. Checking collected amounts
    e. Toll teller reports
6. Procedures for dealing with special occurrances.
    a. Traffic accidents
    b. Robbery or attempted robbery
    c. Weather hazards
    d. Injury or illness of toll collection personnel
    e. Military maneuvers
    f. Lost or abandoned property
    g. Hitchhikers
    h. Solicitors
7. General rules of conduct.
8. Uniforms and equipment.

As noted parenthetically above, some of these items are discussed elsewhere in this study. Suggested items for inclusion in the manual are given below.

Shift Designations

The shift designations of personnel working on a shift basis shall be as follows:

Shift – 1	12:00 P.M.	to	8:00 A.M.
Shift – 2	8:00 A.M.	to	4:00 P.M.
Shift – 3	4:00 P.M.	to	12:00 P.M.

Because of traffic patterns which might develop, it may become necessary to assign personnel to shifts other than those designated above. When such is the case, the regular shift number shall be used followed by a letter to indicate the irregular shift as follows:

"A" – Two hours after start of normal shift.
"B" – Four hours after start of normal shift.
"C" – Six hours after start of normal shift.

Work Schedules

The necessity of providing personnel for operation of the toll collection system seven days a week, twenty-four hours a day, makes it impractical for the Authority to regard normal days off, such as weekends and holidays given to administration personnel. Collectors shall be given compensating time off for legal holidays; however, such time shall be non-accumulative.

General Rules of Conduct

1. Each employee of the Toll Collection Section shall have access to a copy of this manual which must be kept in good condition and available for immediate reference when on duty.
2. Employees shall familiarize themselves with and promptly obey all rules. When in doubt as to the meaning of any of the rules, the employee shall contact his immediate superior for an explanation.
3. Employees shall promptly obey all orders issued directly by the Chief of Toll Collection.
4. The usual procedure for an employee to follow in submitting a report to the Chief of Toll Collection is through such employee's immediate superior.
5. Even though assigned fixed hours of duty, all employees except those on sick leave shall be subject to "call" in emergencies.
6. Employees shall fully co-operate with other Authority employees in toll road matters and in the proper care and maintenance of all Authority property.
7. Employees shall be punctual in reporting for their respective hours of duty.
8. Employees shall be courteous and orderly in all contacts and dealings with the public.
9. Employees shall hear patrons' complaints and criticisms politely. All complaints shall be reported to an immediate superior at the earliest opportunity. Any complaint of an unusual nature shall be fully recorded. The Collector should refer patrons wishing to register a complaint regarding an overcharge or requesting a refund, directly to the Chief of Toll Collection.
10. An employee's name and identification number shall be given promptly and pleasantly to anyone upon request.
11. Employees who find lost or abandoned property, or who receive information concerning lost articles, shall promptly report such matters to their immediate superior.
12. All accidents witnessed by a Collector shall be immediately reported to Headquarters.
13. Employees shall not accept tips or articles of value from patrons in payment of personal services or as a pledge for payment of tolls.
14. Solicitation of rides from patrons, except in cases of emergency, is prohibited.
15. Solicitation of funds for charity, except when authorized by the Chief of Toll Collection, is prohibited.
16. Employees shall not incur a liability chargeable against the Authority, nor shall they sell, give away, destroy or otherwise dispose of Authority property unless properly authorized to do so.
17. An employee shall not leave his assignment during a tour of duty except in case of absolute emergency and then only when proper relief is provided. If it is found necessary to leave an assignment, then the employee must notify his immediate superior before leaving.
18. An employee who is unable to report for duty shall notify his immediate superior as early as possible before the commencement of his tour of duty. Such a report shall be made as follows:

    a. Either in person, or by telephone.

    b. If unable to report either in person or by telephone, then another person of responsible age should make the report in person or by telephone.

    Where the Supervisor cannot be contacted, such reports shall be made to the Chief of Toll Collection. In the event neither a Supervisor nor the Chief of Toll Collection can be contacted, employees shall report to Headquarters requesting they deliver the message to the proper person.
19. Collectors shall not leave a post until the arrival of a relief Collector.

20. Employees shall not use the Authority telephones or communication system for personal calls except in the case of an emergency.

21. Employees shall use Authority facilities and equipment including heat, light, stationery and other similar commodities with due regard for economy and efficiency.

Uniforms and Equipment

1. Employees shall maintain all articles of uniform and equipment assigned to them in a clean, neat and serviceable condition.

2. Employees shall be properly uniformed at all times while on duty. The Chief of Toll Collection will issue all orders for uniform changes.

3. No badges, medals, or other insignia shall be worn on uniforms, except name plates.

4. No employee shall either wear, use, display, or have in his possession any toll road badge or keys not assigned to him.

5. When an article of uniform or equipment is damaged or lost, this damage or loss must be reported to the collector's immediate supervisor or to the Chief of Toll Collection.

Appendix F
JOB DESCRIPTIONS

Communication Section

Electronics Communications Technician

Definition of Work

This is technical and skilled work in the installation, testing, maintenance, and operation of electronic communications equipment in accordance with regulations of the Ministry of Communications.

Work involves the operation, maintenance, and repair of radio or television communications broadcasting equipment and may involve installation, maintenance, and repair of closed-circuit or broadcasting television systems. Work requires determining that the radio and television broadcasting is performed in accordance with, and operating records are maintained as required by, the rules and regulations of the Ministry of Communications. There may be considerable contact with officials in broadcasting activities. Work is performed under general supervision in accordance with detailed policies, rules, and regulations and is reviewed for results obtained.

Examples of Work Performed

Installs, tests, and maintains base station, radio control, and repeater station receivers and transmitters, microwave, and associated components.

Installs, tests, and maintains studio audio equipment, frequency modulation transmitters, video tape recorders, and television cameras for closed circuit television.

Installs, tests, and maintains sophisticated television broadcasting systems; designs modifications in systems components; assists in planning new equipment requirements.

Instructs his staff in the proper operation and use of radio broadcasting, closed circuit television, and associated equipment.

Keeps daily log of transmissions over the air, with time, items, authority, and nature of the call.

Tests such operating factors as transmitter frequency, modulation, and power input, and keeps station logs and other operating records.

Required Knowledge, Abilities, and Skills

Considerable knowledge of the rules and regulations of the Ministry of Communications pertaining to the transmission of standard radio broadcasts.

Ability to read and interpret electrical drawings and schematics.

Ability to interpret and apply written rules and regulations.

Ability to schedule and review the work of others.

Education and Experience

Graduation from high school, supplemented by special courses in the installation, operation, and maintenance of radio broadcasting equipment; and experience in the operation and maintenance of radio broadcasting equipment.

Chief Dispatcher

Definition of Work

This is supervisory work in the transmitting and receiving of messages by radio telephone, in accordance with rules and regulations of the Ministry of Communications.

Work involves organizing and directing the work of several radio telephone operators transmitting and receiving messages by radio telephone. Work includes informing personnel of changes in policy or procedure and reviewing and evaluating their work. Work is performed in compliance with the regulations of the Ministry of Communications in regard to broadcasting and maintaining a station log of all broadcasts and within the framework of agency policies and directives.

Examples of Work Performed

Schedules personnel for the continuous operation of a division radio station, reviews their work, resolves or refers problems encountered, and makes annual performance evaluations.

Trains new personnel in the operation of radio telephone transmitters and receivers and the teletype, and conducts meetings to review problems and disseminate information and instructions.

Reviews and participates in the updating and maintenance of files of dispatchers, correspondence in letter or radio message form, and miscellaneous information.

Sees that dispatchers comply with the Ministry of Communications regulations.

Transmits voice transmissions over several transmitters and monitors several receivers in receiving messages, to and from highway patrol units, police departments, and others.

Determines adherence to instructions and participates in the maintenance of a station log of all items and calls transmitted over the air.

Required Knowledge, Abilities, and Skills

Knowledge of the rules and regulations of the Ministry of Communications pertaining to the transmission and receiving messages.

Knowledge of the operation of radio transmitting, receiving, and testing devices.

Ability to follow oral and written instructions.

Ability to plan, assign, and supervise the work of others.

Ability to train new employees in the operation of radio telephone and teletype equipment.

Skill in the operation of radio telephone and teletype receiving and transmission equipment.

Education and Experience

Graduation from high school; and experience as a radio telephone operator.

Dispatcher

Definition of Work

This is specialized work in transmitting and receiving messages by radio telephone in accordance with the regulations of the Ministry of Communications.

Work involves transmitting and receiving messages and alarms on radio telephone and teletype systems. Work involves the responsibility for compliance with the regulations of the Ministry of Communications in regard to broadcasting and maintaining a station log of all broadcasts. Employees receive specific instructions from supervisor who reviews work for accuracy and compliance with instructions and applicable rules and regulations.

Examples of Work Performed

Transmits voice transmissions over several transmitters, and monitors several receivers in receiving messages, to and from highway patrol units, police departments, maintenance forces and others.

Determines the proper notifications in case of automobile, or other accidents, makes arrangements for relays of blood, medicine, rabies speciments, etc., and notifies relatives and others in case of non-fatal illness or injury.

Types on a radio log sheet, all radio transmissions and items received, and other pertinent information, and file records.

Required Knowledge, Abilities, and Skills

Knowledge of the rules and regulations of the Ministry of Communications pertaining to the transmission of messages.

Some knowledge of the operation of radio transmitting, receiving, and testing devices.

Ability to follow oral and written instructions.

Ability to operate a typewriter by touch system at a reasonable rate of speed.

Ability to spell, speak distinctly, and use good grammer.

Skill in the operation of radio transmitting and receiving devices.

Education and Experience

Graduation from high school; and some experience in operating radio transmitting and receiving devices.

2. Highway Patrol Section

Patrol Lieutenant

Definition of Work

The Patrol Lieutenant is in charge of traffic and law enforcement for a division of the toll road under the Patrol Captain.

Work consists of maintaining orders, supervising traffic and giving public instructions to patrolmen under his command. He helps the captain organize and put on classes of general police instruction for his command, and in general helps the captain run the organization in his area.

He must keep physically and mentally alert in order to be ready for emergency duty at accidents or other unusual trouble. He must be ready to help bring order out of any chaotic problem on the toll road.

Education and Experience

He must be graduated from high school and have had police school instruction courses and working experience under a qualified superior for a minimum of three years.

Patrolman

Definition of Work

Patrolmen on the toll road must be physically strong, mentally alert, of good reputation and habits, and have ability to exercise judgement in emergency situations.

Work consists of carrying out orders of their superior officers, viewing with discernment the flow of traffic, being alert to safety rules, and being able to spot quickly wrongdoers on the road.

They must attend instructional schools and learn all the rules and regulations of the organization well.

Education and Experience

Consists of grade school education with training in law enforcement by competent officer of the law.

3. Toll Collection Section

Toll Collection Supervisor

Definition of Work

This is supervisory and administrative work in the toll collection section.

Work involves responsibility for the toll plaza area and supervision of toll collectors assigned to their respective divisions. The work is reviewed by an administrative superior for overall effectiveness and attainment of objectives within the assigned function.

Examples of Work Performed

Supervisor is directly responsible for the toll plaza area and the supervision of toll collectors and tellers assigned to their respective divisions.

Submits monthly reports to the Chief of Toll Collection such as: toll road use record, supervisors' rating reports, time sheets, supervisors' authorization reports, and inspection reports.

Provides on-the-job training of new collectors consisting of two weeks of comprehensive study of the collectors' manual, memorandums, and their practical application.

Authorizes transactions that are irregular in nature such as the acceptance of personal checks on banks, etc.

Arranges vacation schedules for all toll collectors assigned to his plaza for approval by the Chief of Toll Collection.

Schedules meetings with toll collectors.

Required Knowledge, Abilities, and Skills

Considerable knowledge of the principles of effective supervision and administration.

Ability to plan and administer the work of a large staff of employees.

Ability to speak effectively in public.

Ability to establish and maintain effective working relationships with associates, subordinates, public officials, and the public.

Education and Experience

Graduation from highschool, supplemented by supervisory experience.

Toll Collector

Definition of Work

This is responsible work in Toll Collection Section.

Toll collectors are directly responsible to the supervisor in charge of their respective plazas.

Examples of Work Performed

Know correct classification of tolls at the entry lanes and collect the proper tolls.

Operates the radio and telephone in the entry lane toll booth in connection with properly handling the collection of tolls and other toll road business.

During a tour of duty, each collector is accountable for all vehicles crossing his lane, and vehicle numbers must balance out with the amount of money collected.

Required to handle all irregular transactions as outlined under operating procedures in the collector's manual.

Issue information to patrons, when it is requested, relative to road information, restaurants, motels, etc.

Required Knowledge, Abilities, and Skills

Ability to make change quickly and adequately, to keep traffic moving.

Ability to maintain an attitude of courtesy and good public relations in everyday contacts with the traveling public.

Education and Experience

Completion of eight school grades.

Teller

Definition of Work

This is responsible work in the Toll Collection Section.

The Head Teller is directly responsible to the Chief of Toll Collection.

Examples of Work Performed

Pick up money bags and reports, and remote recorder tapes.

Make change as needed at plazas and as ordered by the Chief of Toll Collection.

Deliver money to the bank, deliver reports of department heads and haul mail, other commodities, and documents between headquarters and the plazas.

Required Knowledge, Abilities and Skills

Ability to understand, interpret and transmit oral or written instructions.

Education and Experience

Graduation from high school.

Assistant Teller

Definition of Work

This is responsible work in the Toll Collection Section.

Assistant Teller is directly responsible to the Head Teller.

Examples of Work Performed

Assists Teller in picking up money bags and reports, and remote recorder tapes.

Make change as needed at plazas, and as ordered by the Head Teller.

Assists Head Teller in delivering money to the bank, and delivering reports to the toll audit section.

Comply with all reasonable requests of department heads to haul mail, other commodities, and documents between headquarters and the plazas.

Serves as teller when head teller is on vacation, sick leave, or otherwise unable to perform his duties.

Required Knowledge, Abilities, and Skills

Ability to understand, interpret, and transmit oral or written instructions.

Education and Experience

Graduation from high school.

Toll Equipment Technician II

Definition of Work

This is technical and skilled work in the maintenance and repair to toll collection equipment.

Work involves responsibility for the repair and maintenance of all toll collection equipment located at the toll road plazas.

Examples of Work Performed

Submits requisitions to the Chief of Toll Collection for supplies and spare parts needed in the proper maintenance of toll collection equipment and truck weigh scales.

Supervises the replacement of all worn out parts at all plazas and keeps the Chief of Toll Collection advised of the need for the purchase of large and expensive items for proper operation of the toll collection equipment, and any other equipment necessary for use in the repair of toll collection equipment.

When breakdowns in toll collection equipment are reported by a toll collector to headquarters via radio, headquarters will keep maintenance personnel advised so that the proper repairs can be made at the earliest possible time.

Required Knowledge, Abilities, and Skills

Considerable knowledge of the methods, practices, and equipment involved in installing, diagnosing defects in equipment, repairing, and maintaining toll collection equipment.

Ability to read and interpret drawings and schematics.

Ability to interpret and apply written rules and regulations.

Education and Experience

Graduation from high school. Specialized training in the installation, operation, and maintenance of toll collection equipment.

Toll Equipment Technician I

Definition of Work

This is technical and skilled work on the maintenance and repair of toll collection equipment.

Work involves repair and maintenance of all toll collection equipment located at all Toll Plazas.

Examples of Work Performed

Replacement of all worn out parts at all plazas.

Maintenance of the toll collection equipment and weigh scales.

Required Knowledge, Abilities, and Skills

Considerable knowledge of the methods, practices, and equipment involved in installing, diagnosing defects in, repairing and maintaining toll collection equipment.

Ability to read and interpret drawings and schematics.

Ability to interpret and apply written rules and regulations.

Education and Experience

Graduation from high school. Specialized training in the installation, and maintenance of toll collection equipment.

4. Accounting Section

Assistant Chief Accountant

Definition of Work

This is responsible professional administrative accounting work with supervisory responsibility for directing a major accounting program or assisting in directing an accounting system of a large agency.

Work involves performing advanced accounting duties personally or directing a staff of subordinate accountants and non-professional employees. An employee of this class acts as assistant fiscal officer or controller in an agency with fiscal operation of considerable scope and complexity. Work is performed under general supervision permitting wide discretion subject to administrative review.

Examples of Work Performed

Plans, assigns, and supervises the activities of a centralized accounting unit engaged in the preparation and maintenance of financial, budgetary, or payroll records; acts as internal auditor; studies, plans, and develops necessary cost accounting forms for effective fiscal control; coordinates multi-unit accounting methods and fiscal record keeping; advises on complex accounting or auditing problems.

Supervises internal accounting of all receipts and expenditures of a large financial operation, assigns and supervises the auditing of invoices and vouchers for accuracy, propriety, and requisite authority; supervises internal control system; supervises the installing and checking of uniform functional accounting procedures.

Supervises the assembling of data and formulates the operating budget.

Required Knowledge, Abilities, and Skills

Thorough knowledge of the principles and practices of accounting, budgeting, and financial administration.

Considerable knowledge of office procedures, practices, and equipment.

Ability to plan, organize, and direct effectively an agency program of accounting and fiscal services and controls.

Ability to evaluate, and to develop and install revisions in, established accounting systems, procedures, records, and controls.

Ability to train and provide guidance to employees in their duties.

Education and Experience

Graduation from an accredited four-year college or university, with major course work in accounting or business administration, and thorough experience in accounting and business management, including supervisory experience.

Accountant III

Definition of Work

This is professional accounting or financial administrative work of an advanced or supervisory nature.

Work involves program responsibility for the use of seasoned judgement and application of knowledge of accounting and agency requirements in a wide variety of accounting problems and in instructing both professional and non-professional employees in performing their duties. An employee of this class may have responsibility for directing a major portion of a fiscal program or assist in directing a large accounting system. Supervision may be exercised over a staff of professional and clerical assistants. Work is performed under the supervision of a technical superior and is subject to evaluation through conferences and the review of regular and special reports.

Examples of Work Performed

Supervises and reviews the work of general and budgetary accounting, contracts and payroll, auditing, and principal fiscal units; coordinates the operations of those units with other departmental activities.

Plans, supervises, and participates in the maintenance of a specialized accounting system, such as a large health insurance program or cost accounting system; supervises preparation of periodic balances and reports, the preparation and distribution of checks, and other related activities.

Supervises the compilation of financial data necessary for annual and other reports.

Provides professional advice to subordinates in the resolution of difficult accounting problems; answers inquiries pertaining to accounting procedures and policies.

Conducts studies and surveys of the accounting systems; develops recommendations for modifications and revisions; supervises the installation of accounting procedures and forms.

Supervises the collection of accounts due.

Required Knowledge, Abilities and Skills

Considerable knowledge of governmental accounting and budgeting principles and procedures.

Considerable knowledge of the principles of office management and of financial administration.

Ability to apply knowledge to the performance and solution of a wide variety of accounting or fiscal problems.

Ability to plan, assign, review, and supervise the work of a staff of professional accounting and non-professional employees.

Ability to evaluate, develop, and install new accounting forms, records, procedures, and controls.

Education and Experience

Graduation from an accredited four-year college or university, with major course work in accounting or business administration, and considerable experience in accounting and business management.

Accountant II

Definition of Work

This is professional accounting work involving accounting and auditing of a complex nature according to established procedures and regulations.

Work involves maintaining complex accounting records; performing audits of various agency and jurisdictional fiscal records to verify receipts, assets, proper disbursement of funds, correct accounting practices, and business methods. Work may also involve preparation and control of annual budgets or supervision of a moderate size accounting or bookkeeping staff. Specific instructions are usually given only at the commencement of new work or when new procedures are instituted. Generally work is reviewed at completion only for over-all standards of performance.

Examples of Work Performed

Maintains expenditure and budgetary control accounts and prepares necessary reports relating to account status.

Supervises and trains lower level accountants and clerical employees.

Prepares various fiscal and accounting data for the development of the agency budget; supervises and participates in the maintenance of budget accounts and in the preparation and reconciliation of budget reports.

May participate in or supervise preparation of annual budget.

Ascertains legality of receipts and disbursements.

Required Knowledge, Abilities, and Skills

Knowledge of accounting principles and methods and ability to apply and adapt established methods to varied accounting transactions.

Knowledge of office practices and procedures.

Knowledge of state laws and regulations relating to fiscal affairs and ability to interpret and apply such laws to various financial transactions.

Ability to instruct and supervise accounting and clerical employees.

Ability to make mathematical calculations rapidly and accurately.

Ability to interpret and prepare financial reports of considerable complexity.

Education and Experience

Graduation from an accredited four-year college or university, with major course work in accounting, and experience in professional accounting, auditing, or budgeting work.

Accountant I

Definition of Work

This is beginning level professional accounting work in the maintenance and review of fiscal records.

Work involves maintaining financial records in an administrative unit of moderate size, or assisting in the maintenance of accounts in a large department. Work is performed in accordance with established accounting regulations, procedures, and forms, but judgment is involved in adhering closely to these forms and procedures. Employees in this class may supervise the work of account clerks or other clerical employees. Work is performed under the supervision of a higher ranking fiscal or administrative officer and reports are checked for accuracy and conformance with departmental policy.

Examples of Work Performed

Maintains complete sets of accounts including subsidiary, general ledger, budgetary, and control accounts; makes appropriate entries and prepares necessary reports relating to account status; assists higher level accountants in maintaining more complex sets of books.

Performs audit assignments including checking accuracy of entries, examining routine accounting documents such as payrolls, purchase vouchers, cash receipts, and disbursement vouchers; verifies that all transactions are properly supported and in accordance with pertinent laws and regulations; verifies inventories, cash balances, and assets; and prepares necessary reports.

Examines various financial statements for completeness, internal accuracy, and conformance with uniform accounting classifications or other specific accounting requirements.

May supervise subordinate clerical or sub-professional personnel engaged in bookkeeping activities.

Acts as head cashier where considerable volume of money is received over the counter and through the mail and establishes controls to which other cashiers must balance.

Performs related work as required.

Required Knowledges, Abilities, and Skills

Knowledge of accounting principles and methods and ability to apply them to governmental accounting problems.

Ability to perform detailed work involving written or numerical data and to make mathematical computations with speed and accuracy.

Ability to prepare complete and accurate accounting reports and statements.

Ability to supervise a small group of employees engaged in minor bookkeeping or office routines.

Education and Experience

Graduation from an accredited four-year college or university, with major course work in accounting or business administration.

5. Data Processing Section

Computer Operations Supervisors

Definition of Work

This is responsible supervisory and technical work in the operation of electronic computers and auxiliary peripheral equipment.

Works involves the responsibility for planning, supervising, and participating in the operation of electronic computers and peripheral equipment in a moderate-sized electronic computer unit, or on an assigned shift in a large unit. Work involves scheduling equipment operations in accordance with the assigned work load, training operators, and developing procedures to achieve maximum production and utilization of equipment. Supervision is exercised over a staff of technical employees engaged in the operation of electronic computers and peripheral equipment. Work is performed independently within technical guidelines and procedures, and is reviewed by technical superiors through observation, reports, and results obtained.

Examples of Work Performed

Plans, supervises, and participates in the operation of electronic computers and peripheral equipment in a moderate-sized electronic computer unit, or on an assigned shift in a large unit.

Supervises subordinate computer operators and other technical employees engaged in the operation of electronic computers and peripheral equipment.

Prepares a detailed daily or shift schedule of programs to be processed to meet established priorities and deadlines; revises operating schedules to adjust for delays due to mechanical or program failure or emergency runs.

Reviews production, resolves difficulties, and corrects errors; maintains a smooth flow of information to and from computer users as part of a coordinated electronic data processing effort.

Prepares and maintains necessary records and reports.

Required Knowledge, Abilities, and Skills

Thorough knowledge of the methods and techniques of the operation and capabilities of an electronic computer and its peripheral equipment.

Considerable knowledge of methods of collection of data applicable to control of an electronic data processing system and to obtaining maximum utilization of the equipment.

Considerable knowledge of programming techniques, number systems, and codes used in electronic data processing.

Ability to train subordinate technical workers, and to plan, assign, and review their work.

Ability to read, interpret, and apply complex programs.

Ability to communicate effectively, orally and in writing.

Education and Experience

Graduation from high school, supplemented by training in the operation of electronic computers; and considerable progressively responsible experience in the operation of electronic computers and peripheral equipment, including supervisory experience.

Tabulating Equipment Operator

Definition of Work

This is routine work in the operation of a variety of tabulating machine equipment.

Work involves the responsibility for the rapid and accurate operation of a variety of tabulating machines in routine operations. Work may include routine wiring of plugboards from diagrams. Employees work with some independence on routine assignments but receive specific instructions on new assignments. Work is subject to review by inspection of production and control records or by visual check.

Examples of Work Performed

Performs routine tabulating machine work in the operation of sorters, collators, interpreters, and reproducers; performs more complex tabulating operations under the direction of a technical supervisor

Performs routine wiring tasks following diagrams prepared by others or upon detailed instructions; makes minor adjustments to tabulating equipment.

Prepares statistical and fiscal data, personnel rosters and lists, license applications and renewals, and related materials through the operation of machines.

Operates key punch, verifier, and related equipment as an incidental feature of work.

Files key punch cards, tabulates elementary statistical data, and performs other routine clerical tasks.

Required Knowledge, Abilities, and Skills

Knowledge of methods and equipment used in machine recording of accounting, statistical, and related data.

Some knowledge of general office practices and procedures.

Ability to perform routine wiring tasks following diagrams or written or oral instructions.

Ability to understand and carry out routine oral and written directions.

Skill in the operation of a variety of standard tabulating equipment.

Education and Experience

Graduation from high school, including or supplemented by training in the operation of various standard tabulating equipment.

6. Right-of-Way Section

Service Area Inspector

Definition of Work

This is routine field work making inspections and investigations of public lodgings and eating places to enforce compliance with sanitation and safety laws, rules, and regulations.

Work involves conducting field investigations and inspections of hotels, restaurants, apartments, rooming houses, boarding houses, and tourist cabin camps. Work includes responsibility for evaluating compliance with and reporting violations of laws and regulations governing sanitation and cleanliness, fire hazards, ventilation and heating, and licensing. An employee in this class works without immediate supervision in the field, but receives general supervision from the Chief of Right-of-Way Section. Assignments are reviewed through the submission of reports and on the basis of results achieved.

Examples of Work Performed

Inspects, in public eating places, dishes, silverware, refrigeration, stoves, cooking utensils, dishwashers, garbage disposal, plumbing, floors, and walls for proper sanitation and cleanliness; inspects, in public lodging places, the bedding, floors, walls and for general sanitation.

Checks heating, ventilation, gas connections, fire extinguishers, fire escapes, and other safety factors in sleeping and eating places; checks for possession of license, and, on occasion, collects license fees.

Prepares inspection reports, and issues notices to operators requiring improvement of facilities or methods; explains laws, rules, and regulations to owners and operators of public lodging and sleeping places.

Surveys towns and cities for new public lodging and eating establishments; advises and works with city and county health officials regarding the inspections being conducted.

Required Knowledge, Abilities, and Skills

Some knowledge of hotel and restaurant operations.

Some knowledge of hotel and restaurant practices and procedures, especially those related to sanitation and customer protection.

Some knowledge of what constitutes legal evidence.

Ability to establish and maintain effective working relationships with public and private officials and the general public.

Ability to conduct inspections of public lodging and eating places and to detect violations of sanitation and safety standards.

Ability to prepare standard reports.

Education and Experience

Graduation from high school, and some experience in the hotel or restaurant business.

7. Maintenance Section

Maintenance Superintendent

Definition of Work

This is responsible supervisory work in directing highway maintenance activities.

Work involves responsibility for planning, directing, and coordinating highway and bridge maintenance and repair activities in a highway district, or directing several specialized division crews. An employee in this class exercises supervision directly, or through subordinate supervisors, over a group of highway maintenancemen and equipment operators, mechanics, and a clerical staff. Considerable independence is exercised in planning, organizing, and executing work programs. Work is assigned by a maintenance supervisor who provides advice on major problems, and inspects work and reviews reports for satisfactory results and conformance to commission policies and requirements.

Examples of Work Performed

Inspects highways and bridges within an assigned district; determines repair and maintenance work required; directs and provides necessary instruction to subordinate supervisors to accomplish required work.

Supervises the division into specialized crews for such operations as traffic line painting, landscaping, resurfacing, oiling, mudjacking, and repairing bridges.

Reviews highway permit applications for work to be done within the highway right-of-way, such as driveways and utility installations; recommends approval or disapproval; inspects work in progress and, upon completion, to assure conformance with applicable practices, rules, and related requirements.

Determines materials, equipment and supplies needed, and prepares necessary documentation to request or obtain such.

Investigates complaints, by inspecting field conditions, meeting with interested individuals and groups, and explaining applicable policies and regulations, and determining and directing necessary corrective action.

Inspects accident damages to highway and bridge facilities and makes repair estimates.

Supervises district clerical and automotive repair and maintenance activities.

Required Knowledge, Abilities, and Skills

Considerable knowledge of the equipment, material, and practices used in highway and bridge maintenance and repair.

Considerable knowledge of the applicable work safety rules and procedures.

Ability to plan, organize, and coordinate diverse highway and bridge maintenance and repair programs and activities.

Ability to read and explain basic engineering plans and drawings.

Ability to establish and maintain effective working relations with subordinates, supervisors, public and private officials, and the general public.

Ability to prepare required reports, documentation, and correspondence.

Education and Experience

Graduation from high school, and considerable experience in highway and bridge maintenance and repair, including experience in a supervisory capacity.

Division Maintenance Superintendent

Definition of Work

This is supervisory work in directing highway maintenance activities.

Work involves responsibility for directing a group of highway maintenancemen and equipment operators performing general or specialized highway or bridge maintenance and repair. Employees, in this class, work with considerable independence in planning and executing general maintenance activities; however, specific instructions pertaining to programming, desired results, and work procedures are provided on new, specialized, or complex operations. Work is reviewed for results obtained through inspection and reports.

Examples of Work Performed

Supervises a crew of maintenancemen and equipment operators performing such work as patching and sealing road surfaces; mowing right-of-way; litter and trash clean-up; erecting, removing, and repairing fences, guard rails, and signs; seeding and sodding; painting traffic lines; cleaning and grading ditches and shoulders; resurfacing; repairing and cleaning drainage structures; and repairing bridge decks.

Maintains equipment, materials, and personnel and payroll records, and prepares related reports.

Investigates and determines action to take on complaints from the public.

Required Knowledge, Abilities, and Skills

Knowledge of the equipment, material, and practices used in highway and bridge maintenance and repair.

Knowledge of the applicable work safety rules and procedures.

Ability to organize and supervise employees performing manual, semi-skilled and skilled tasks.

Ability to read basic engineering plans and drawings.

Ability to operate highway and bridge maintenance equipment.

Ability to understand and follow written and oral instruction.

Ability to maintain records and prepare basic reports.

Ability to establish and maintain effective working relationships with subordinates, supervisors, and the public.

Sufficient physical stamina to work under adverse weather conditions for extended periods of time.

Education and Experience

Completion of the eighth school grade, and experience in highway maintenance and budgeting, including experience in a supervisory capacity.

Utility Superintendent

Definition of Work

This is technical administrative work supervising the operations and maintenance of mechanical equipment.

Work involves technical administrative and supervisory work in planning, organizing, and directing the operations and maintenance of a large physical plant. Supervises the operation and maintenance of an electric power and heating plant as well as plumbing, electric, water, refrigeration, and sewage disposal systems. Work includes assisting in planning and overseeing construction, alteration, and installation of related equipment, and supervises the maintenance, repair and alteration of buildings. Work is performed under general supervision and is reviewed through conferences, reports, and on the basis of results achieved.

Examples of Work Performed

Supervises the generation and distribution of steam and electric current, and the operation of water softeners, refrigeration systems, disposal plants, and other mechanical equipment.

Supervises skilled tradesmen, repairmen and unskilled workers in the operation of equipment and in maintenance and repair activities.

Inspects repairs and adjustments on engines and generators and directs installation of new equipment; lays out plants, and prepares specifications of the work and materials for installation of new equipment and repairs of installed equipment.

Prepares budget estimates of equipment and personnel needs; maintains cost records; interviews prospective employees and prepares personnel evaluation forms; prepares reports of operations and maintains related records.

Required Knowledge, Abilities and Skills

Thorough knowledge of the principles, methods, and practices used in operating, maintaining, and repairing high-pressure boilers, generators, turbines, refrigerating, and other mechanical equipment used in a large physical plant.

Thorough knowledge of the occupational hazards and safety precautions required in the operations and maintenance of mechanical systems.

Ability to supervise and direct skilled and unskilled workers.

Ability to plan, prepare specifications, and direct new installations and major repair projects.

Education and Experience

Graduation from high school, supplemented by some college level course work in mechanical engineering, and thorough experience, including supervisory experience, in the operation, maintenance, and repair of mechanical power systems.

Assistant Utility Superintendent

Definition of Work

This is journeyman level mechanical maintenance work in the operation of power, water, refrigeration, and other types of mechanical equipment systems.

Work involves skilled work, which may include performing supervisory duties, in the operation and maintenance of a power plant, water, refrigeration, disposal systems, or other mechanical equipment and in the maintenance of physical properties on an assigned shift. Responsible for checking pumps, reading meters, and inspecting related equipment, and making the required repairs and adjustments. Work is performed under general direction of a superior, and is reviewed through periodic inspections and on the basis of results achieved.

Examples of Work Performed

Participates in and may supervise the installation, alteration, operation, and maintenance of power plant equipment, refrigeration, and other mechanical systems, throughout an institution.

Makes rounds of powerhouses at regular intervals, reading gauges, adjusting equipment, and observing operation of all machines; keeps powerhouse log, recording gauge readings, fuel consumed, and power generated.

Performs preventive maintenance on mechanical equipment, including pumps, flowmeters, steam lines, and turbines; performs general plumbing and electrical work related to equipment.

Supervises semi-skilled and part-time employees; instructs subordinates in the proper care and use of tools, and procedures and methods of maintenance and repair.

Required Knowledge, Abilities, and Skills

Knowledge of the methods and practices used in the operation and maintenance of steam power plants and water, refrigeration, or other types of mechanical equipment systems.

Knowledge of the methods, processes, and tools, used to operate and maintain boilers, turbines, generators, steam engines, and other mechanical equipment.

Knowledge of the occupational hazards and necessary safety precautions of mechanical equipment maintenance and repair.

Ability to supervise and instruct subordinates.

Ability to maintain records and make standard reports.

Skill in the use of tools and in the operation of machines and equipment commonly used in machine maintenance and repair work.

Education and Experience

Completion of eight school grades, and experience in inspection, maintenance, and repair of mechanical equipment systems at the journeyman level.

Sign Shop Foreman

Definition of Work

This is supervisory and skilled work in directing the production of highway signs and markers.

Work involves responsibility for directing the activities of the highway sign shop. Work includes ordering materials and equipment, and supervising the receipt, production, and shipping of highway signs and markers. Work assignments are received in the form of numbers and types of signs needed from a supervisor who provides information pertaining to special layouts and applicable standards. Work is reviewed for overall quality and effectiveness in meeting production requirements.

Examples of Work Performed

Supervises and participates in the activities of the highway sign shop engaged in the production of signs and markers by silk screening and overlaying techniques, and directs related receiving, storage, and shipping activities.

Establishes work schedules and assigns and monitors work to meet production requirements.

Explains and demonstrates work procedures and methods.

Determines needs of, and requisitions, sign shop materials and equipment.

Provides for the maintenance of required inventory and related records.

Required Knowledge, Abilities, and Skills

Considerable knowledge of the methods, materials, and equipment used in the production of signs by silk screening and overlaying techniques.

Knowledge of the methods of preparing and maintaining inventory and production records.

Knowledge of storekeeping and shipping procedures.

Ability to plan and supervise the work of sign shop employees to meet production requirements.

Ability to interpret and instruct others in the use of rough layouts, standard drawings, and specifications.

Ability to operate and instruct others in the operation of the hand tools and specialized equipment used in the production of signs by silk screening or overlaying techniques.

Ability to prepare and maintain production and inventory records, and prepare related reports.

Education and Experience

Graduation from high school, and considerable experience in the production of signs by silk screening and overlaying techniques, including some experience in a supervisory capacity.

Section Foreman

Definition of Work

This is supervisory work over a large group of employees performing semi-skilled and unskilled tasks.

Work involves supervision of a large group of semi-skilled and unskilled workers engaged in the maintenance of a section of 40-50 km of toll road. Work may include some supervision of employees engaged in equipment operation, and routine construction and maintenance work. An employee in this class implements and follows through on general instructions received from a higher level supervisor. There is considerable latitude for work methods, but work may be inspected while in progress and is reviewed upon completion for results obtained.

Examples of Work Performed

Reviews landscaping plans, determines daily work schedule to implement plans, and obtains materials and equipment needed.

Plans, assigns, and reviews work of laborers and equipment operators.

Plans, assigns, and reviews work of semi-skilled help on routine maintenance or construction work.

Supervises the operation of tractors with attachments, and trucks in performing related groundskeeping duties.

Required Knowledge, Abilities, and Skills

Knowledge of equipment and methods used in semi-skilled and unskilled labor and maintenance work in relation to assigned tasks.

Knowledge of occupational hazards and safety precautions in laboring work.

Ability to assign work to, review work of, and instruct, a large group of subordinates.

Skill in the use of basic hand tools and the operation of related complex power equipment.

Education and Experience

Completion of eight school grades, and experience as crew leader of a moderate-size group of semi-skilled and unskilled workers.

8. Equipment and Materials Section

Shop Superintendent

Definition of Work

This is supervisory and minor administrative work in directing automotive maintenance and repair work at a central service shop and at field repair facilities.

Work involves supervising the work of subordinates engaged in maintenance and repair of automotive and related equipment. Directly supervises automotive repair and maintenance work at a central service area, and coordinates the work at field garages. Work also involves administrative responsibilities in terms of purchasing, assisting in preparing budget estimates, and interviewing and evaluating employees. Work is performed under general supervision and is reviewed through conferences and on the basis of results achieved.

Examples of Work Performed

Plans and assigns work to subordinate foremen and mechanics; checks work during progress and upon completion; makes such work decisions as are necessary; outlines for subordinates the procedure for repair work in highly complicated and difficult jobs.

Coordinates activities of several garages, and assists in taking physical inventories.

Recommends tire and battery replacements and oil to be used in automotive equipment; periodically inspects condition of assigned highway equipment.

Checks stock rooms to determine if adequate supplies are maintained; supervises the unloading and storing of materials in a division or headquarters yard.

Required Knowledge, Abilities, and Skills

Thorough knowledge of the standard practices, methods, tools, and equipment of the automotive mechanic's trade.

Thorough knowledge of the occupational hazards and necessary safety precautions of the automotive mechanic's trade.

Knowledge of safety engineering principles, practices, and procedures.

Ability to plan, supervise, and coordinate the work of skilled, semi-skilled, and unskilled employees.

Ability to direct and coordinate large-scale automotive repair and maintenance activities at a number of service areas.

Ability to prepare budget estimates, maintain records, and prepare standard reports.

Skill in the use and care of the tools and equipment used in the automotive mechanic's trade.

Education and Experience

Completion of eight school grades, and thorough experience in the maintenance and repair of automotive and related equipment, including considerable supervisory experience.

Automotive Mechanic II

Definition of Work

This is journeyman level work involving making inspections of automotive equipment or supervision of and participation in skilled automotive mechanic work.

Work involves responsibility for inspecting, evaluating, and reporting the mechanical condition of automotive equipment, or for supervising and participating in the maintenance and repair of automotive equipment. Employees in this class also have responsibility for maintaining records of work orders, preparing inspection reports, and maintaining inventory and supply records. Work is performed under general supervision and is reviewed on the basis of results achieved.

Examples of Work Performed

Inspects maintenance condition of automotive equipment and reports deviations from the standards and procedures of the equipment maintenance program.

Plans, lays out, and assigns work to mechanics and helpers; inspects work during process and upon completion.

Supervises and instructs subordinates in the repair and reconditioning of automobiles, trucks, tractors, graders, power shovels, and similar machinery commonly used on highway construction and maintenance activities.

Performs skilled repair and testing work on magnetos, carburetors, motors and other finely adjusted equipment.

Approves requisitions for parts; keeps shop records; makes reports; and supervises the maintenance of a perpetual inventory of all stock, tools and equipment.

Required Knowledge, Abilities, and Skills

Considerable knowledge of the standard practices, methods, tools, and equipment of the trade.

Considerable knowledge of the principles of internal combustion engines.

Considerable knowledge of the occupational hazards and necessary safety precautions of the trade.

Ability to instruct and supervise subordinate skilled and semi-skilled automotive mechanics.

Ability to make inspection of automotive equipment for serviceability and to prepare standard inspection reports.

Skill in the use of tools and in the operation of machines and equipment commonly used in the automotive mechanics trade.

Education and Experience

Completion of eight school grades; and considerable experience in the repair and maintenance of automotive equipment at the journeyman level.

Automotive Mechanic I

Definition of Work

This is journeyman level work involving the maintenance and repair of automotive equipment.

Work involves performing skilled tasks in the maintenance and repair of automotive equipment, including reconditioning motors and servicing and making adjustments on automotive and related equipment. Employees in this class also do some welding and body repair work on automotive equipment. Work is performed under general supervision and is inspected for quality of workmanship during progress and upon completion.

Examples of Work Performed

Repairs and conditions automobiles, trucks, graders, tractors, power mowers, and other mechanical equipment; reconditions motors by grinding valves, setting tappets and push rods, and repairing or replacing main and connection rod bearings.

Washes, polishes, and greases equipment, changes oil, and repairs tires and tubes; services batteries, adjusts brakes and lights and aligns wheels.

May occasionally perform oxyacetylene and electric welding or simple blacksmithing, as in forming, bending, and tempering iron and steel and repairing batteries; may make simple designs and fabricate specialized equipment.

Maintains standard shop records such as time, repair part orders, and records of job orders.

Required Knowledge, Abilities, and Skills

Knowledge of the standard practices, methods, tools, and equipment of the automotive mechanic's trade.

Knowledge of the principles of internal combustion engines.

Knowledge of the occupational hazards and safety precautions of the automotive mechanic's trade.

Ability to work independently and to understand and carry out oral and written instructions.

Skill in the use of tools and in the operation of equipment employed in the adjustment, repair, and maintenance of automotive and related equipment.

Skill in locating and adjusting defects in motor equipment.

Education and Experience

Completion of eight school grades, and some experience in automotive repair and maintenance work at the journeyman level.

Automotive Serviceman

Definition of Work

This is unskilled manual work performing routine maintenance and servicing of automotive equipment.

Work involves responsibility for performing routine tasks in servicing automotive equipment, including changing oil and water, checking batteries, lubricating, and general cleaning of equipment. Employees in this class also perform general custodial duties in maintaining service area buildings and grounds. Work is performed under direct supervision and is reviewed through inspection of work upon completion.

Examples of Work Performed

Services automobiles, trucks, tractors, and other automotive equipment with gasoline, oil, and water; checks and services batteries; checks and lubricates transmissions and differentials; washes and polishes automobiles and trucks; drains, cleans, and fills radiators.

Conducts routine inspections of the supply and condition of servicing materials and related dispensing devices and equipment.

Performs general custodial duties in maintaining service area buildings and grounds; cleans building areas, including sweeping floors and waxing and buffing surfaces; maintains yard areas, cutting grass, trimming trees, and general repair of outdoor fixtures.

Acts as night watchman, making periodic checks of service areas and equipment; makes deliveries and picks up automotive equipment.

Required Knowledge, Abilities, and Skills

Some knowledge of garage shop practices, techniques, methods, and tools used in servicing automotive equipment.

Some knowledge of the occupational hazards and safety precautions of the automotive trades.

Ability to perform routine tasks in servicing automotive equipment.

Ability to understand and carry out oral and written instructions.

Ability to perform general custodial duties in the maintenance of buildings and grounds.

Education and Experience

Completion of eight school grades; some general automotive maintenance or custodial experience.

Appendix G
EQUIPMENT REQUIREMENTS

A. Equipment Owned by Toll Road Authority

a) Administration Equipment

Equipment should consist of desks, adding machines, calculators, filing cabinets and general use requirements.

The chief engineer should have, in addition to general office equipment, an instrument room with surveying transit, level, level rods, flag poles and hand levels as needed.

The patrol captain should have, in addition to the required office furniture, a supply of pistols and other arms and ammunition as approved to equip his officers.

The chief of planning should have, in addition to regular office equipment, a supply of drafting instruments and drafting tables as needed.

All offices should be furnished automobiles for transportation in their work as determined by the department head and approved by the Director.

b) Maintenance equipment

The equipment to be furnished to the headquarters maintenance district should be as follows:

1	1/2 ton pickup truck
4	Truck (2-1/2 ton hydraulic dump)
1	Grader (diesel motor patrol)
4	Tractor and mower
2	Tractor w/bucket and loader
2	Tractor w/sickle bar mower
1	Tractor cat traxcavator w/bucket
1	Asphalt kettle (portable)
1	Road sweeper (mechanical with motor)
1	Material spreader single auger
1	Chain saw
1	Truck (flat bed w/hydraulic ladder - 2 1/2-ton)
1	Truck (flat bed w/winch and A frame - 2 1/2-ton)
1	Truck (flat bed w/ladder and winch and crane - 2 1/2-ton)
4	Truck ¾-ton pick-up w/powers body
1	Truck 2 1/2-ton - paint striper
1	Tractor with concrete mixer
1	Trailer (flat bed)
1	Centrifugal pump (portable)
1	Air compressor
1	Trailer flat bed 9-ton
1	Trailer 3-axle, 8-ton for backhoe
1	Roller (rubber-tired)
1	Bituminous distributor (portable)
2	Rollers (steel) 5-8-ton
1	Trailer-Low boy - 24-ton semi-trailer
1	Portable generator
1	Street marker w/trailer
1	Sludge tank and pump (portable)
1	Storage tank w/trailer (10,000 gal.)
1	Paint sprayer w/cart
1	Centrifugal pump w/hose (portable)
1	Sewer cleaner w/cable
1	Sink drain cleaner (auger)
1	Sand blaster w/filter
1	Pug mill mixer (portable)
1	Trencher w/trailer
1	Trailer tank transport (5000 gallons)
1	Power sweeper and loader w/broom
1	Tractor backhoe ditcher loader and bucket

A similar supply as above should be procured to equip the maintenance division at Kaohsiung.

The six smaller maintenance areas shall each have an equipment supply as follows:

1	ea	Truck - 1/2-ton pickup
3	ea	Truck - 2-1/2-ton dump
1	ea	Grader (diesel motor patrol)
1	ea	Material spreader (auger)
3	ea	Tractor - w/centrifugal mower
2	ea	Tractor - w/sickle mower
1	ea	Tractor - w/bucket and loader
1	ea	Asphalt kettle (portable)
1	ea	Road sweeper (motor-driven)
1	ea	Water tank and pump
1	ea	Material spreader on truck
2	ea	Power lawn mower (rotary)
1	ea	Trailer - tilt bed

c) Toll plaza equipment

All booths should be equipped with thermos, two-way radio, fire extinguisher, stool, table and electric fan.

The data processing equipment is kept in the toll audit room of the headquarters and tabulates and operates under the direction of chief of data processing.

d) Communication equipment

The equipment for communication on the toll road is most important for smooth operation.

In the dispatcher room at headquarters would be the console which would contain the broadcasting and receiving equipment for the system. It would be equipped with signal buttons which tell the technicians where there may be instrument trouble at any point along the road.

It would also contain a tape recorder to record all conversation on the two-way system. There would be an adjuster, which would enable the dispatcher to switch the broadcast or receiving from the maintenance channel to patrol or vice versa. The dispatcher would be furnished a public telephone so he might give information to anywhere it is desired.

Each principal office, as determined by the Director, should be equipped with broadcast and receiving equipment and a microwave set. Also the maintenance trucks and cars, patrol cars and administrators car should have two-way sets for communication.

Each office designated by the Director, as well as all maintenance shops, should have two-way and microwave equipment.

B. Equipment Furnished by Concessionaires

a) By service stations (at each station)

1. One 2-ton wrecker truck equipped with winch
2. One pickup with gas supply tank
3. Small standard repair items - tires, fan belts, motor hoses, etc.

b) By restaurants

All necessary cooking and feeding utensiles, dishes, custodial supplies, and all tools necessary to keep a restaurant clean and in proper operation to please toll road travellers.

Appendix H

RULES AND REGULATIONS FOR CONCESSIONS

Introduction

Although the freeway-operation agency will have a sizable staff to maintain and operate the freeway, the public will be little aware of the agency's efforts, at least if such efforts yield results which are at least reasonably satisfactory. The public will be much more aware of the quality of service provided at service stations and in restaurants. Even though these facilities will not be directly run by the freeway-operating agency, the quality of their service will reflect on the agency, and it therefore behooves the agency to assure that high service standards are maintained at these facilities.

The agency, moreover, must realize that, in granting concessions, it will be creating monopolies since travelers will have no alternative service station and restaurant facilities to choose from while on the freeway (actually, in the case of Taiwan, a monopoly already exists islandwide with regard to service stations, so that the freeway-operating agency would not be creating one in granting a concession). Whenever a monopoly is being created, legal steps must be taken to assure that the public will not be charged exorbitant prices.

In order to assure high service standards and reasonable prices, the freeway-operating agency must look to its contractual arrangements with concessionaires. The following sections of this appendix discuss some of the items which should be incorporated in the agency's contracts with the organizations which will operate the service stations and restaurants along the freeway.

Service Station Concession

The sale of petroleum products in Taiwan is already a China Petroleum Company (CPC) monopoly, so that there will be no need for bids, seeking the service station concession, to be submitted.

By virtue of its contract with the freeway-operating agency, however, the following, at least, should be obligatory upon CPC:

(1) The commencement of operations at the various locations whenever the freeway would begin to operate in the respective areas;

(2) The provision of 24-hour service with adequate staffing of the premises at all times;

(3) The maintenance of high standards of merchandise sold, services rendered, and cleanliness of the premises, so as to win and hold public esteem for the CPC, its services and products, and the toll road as a whole;

(4) The charging of prices which are in line with CPC prices in the surrounding area, for all products and services;

(5) The offering of an adequate variety of products and services to satisfy normal demand for petroleum products, tires, automotive parts, and services required to maintain the proper functioning of vehicles;

(6) The provision of emergency road service, including the stationing of at least one wrecker truck at each service station, and the quick operation of same whenever occurences would warrant;

(7) The keeping of satisfactory accounting records, including inventory records, and making same available at any time to the agency, upon request of the latter; and

(8) The improvement of facilities, equipment, service, merchandise, or cleanliness of premises whenever one or another of these is deemed unsatisfactory by the agency.

The agency, of course, would also have certain obligations to CPC, including, but not limited to, the following: construction of facilities; provision of adequate power and water; and provision of police protection.

Restaurant Concession

Unlike the case of service stations, where CPC currently has an islandwide monopoly for the sale of petroleum products and would have a monopoly along the entire length of the freeway, no monopoly exists in the area of restaurant operation. Prior to the awarding of concessions, therefore, bids should be invited. In order to increase the numbers of qualified bids, each restaurant location should be bid on separately.

The contracts between the agency and the operators which are selected for the various locations should oblige the operators to do, at least, the following:

(1) Commence operating whenever the respective freeway sections would open;

(2) Provide 24-hour service with adequate staffing of the premises at all times;

(3) Maintain high standards of food, beverages, and merchandise sold, services rendered, and cleanliness of the premises, so as to win and hold public esteem for the operator, his products and services, and the toll road as a whole;

(4) Avoid charging unreasonable prices;

(5) Offer a variety of foods and beverages which might reasonably be considered to be "popularly demanded" (but this stipulation should not be construed as meaning that an extensive variety must be offered at the expense of the efficiency of the operation);

(7) Improve facilities, equipment, services, food and beverages, merchandise, or cleanliness of premises whenever one or another of these is deemed unsatisfactory by the agency; and

(8) Keep satisfactory accounting records, and make same available at any time to the agency, upon request of the latter.

As in the case of the service stations, the government would also have an obligation to the operators to construct facilities: provide adequate power (including amounts for air-conditioning) and water; and provide police protection.