HE310
O2
H66
1967
v.1

Legislative Reference Bureau
State Capitol
Honolulu, Hawaii 96813

# OAHU TRANSPORTATION STUDY

1967

## Volume I

*economic*
*population*
*land use*

AR00031486

*The preparation of this document was financially aided through a Federal Grant from the Department of Housing and Urban Development, under the Urban Planning Assistance Program authorized by Section 701 of the Housing Act of 1954, as amended, and by Federal Aid Highway Planning and Research funds authorized by the Bureau of Public Roads of the Department of Transportation and the Division of Highways, Hawaii Department of Transportation.*

AR00031487

1203409
9212058

HE310
02
H66
1967
V.1

# OAHU TRANSPORTATION STUDY

VOLUME I

ECONOMIC, POPULATION, AND LAND USE

1967

LEGISLATIVE REFERENCE BUREAU
MAY 24 1968
STATE OF HAWAII

*Sponsoring Agencies*

STATE OF HAWAII
*John A. Burns, Governor*

CITY AND COUNTY OF HONOLULU
*Neal S. Blaisdell, Mayor*

*In Cooperation With*

U. S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
*Robert C. Weaver, Secretary*

U. S. DEPARTMENT OF TRANSPORTATION, BUREAU OF PUBLIC ROADS
*Francis C. Turner, Director*

AR00031488

# STUDY ORGANIZATION

## POLICY COMMITTEE

### *Executive Members*

SHELLEY M. MARK, *Chairman and Project Administrator*
*Director of Planning and Economic Development* ..... State of Hawaii

FUJIO MATSUDA
*Director of Transportation* ..... State of Hawaii

FRANK SKRIVANEK
*Director of Planning* ..... City and County of Honolulu

HENRY TUCK AU
*Director of Traffic* ..... City and County of Honolulu

### *Members*

GEORGE S. IZUTA
*Area Coordinator* ..... Department of Housing and Urban Development

JOHN N. STORRS
*Engineering Coordinator* ..... Bureau of Public Roads



AR00031489

## *TECHNICAL ADVISORY COMMITTEE*

GEORGE MORIGUCHI
*Planning Coordinator* ..... State of Hawaii

ALBERT C. ZANE
*Chief Engineer* ..... Hawaii Highways Division

OWEN MIYAMOTO
*Airports Engineer* ..... Hawaii Airports Division

RICHARD IMAHIRO
*Community Social Planning Coordinator* ..... State Public Welfare Division

WILLIAM HONG
*Deputy Traffic Engineer* ..... City Traffic Department

JAMES TANAKA
*City Planner* ..... City Planning Department

PHILIP D. BROWN
*Project Director* ..... City Community Renewal Program

PHILIP CHOY
*Chief Planner, Urban Renewal* ..... Honolulu Redevelopment Agency

GEORGE IZUTA
*Area Coordinator* ..... Department of Housing and Urban Development

JOHN N. STORRS
*Engineering Coordinator* ..... Bureau of Public Roads

RICHARD T. PUCKEY
*Chief, Airports Division* ..... Federal Aviation Agency



AR00031490

## CITIZEN ADVISORY COMMITTEE

### *Executive*

CHAIRMAN

FRANKLIN Y. K. SUNN (1965)
*President of Sunn, Low, Tom & Hara*
*Representing American Society of Civil Engineers, Hawaii*

OTTO ORENSTEIN (1966)
*Business Research Analyst*
*Hawaiian Telephone Company*
*Representing American Statistical Association, Hawaii*

NATHANIEL R. POTTER, JR. (1967)
*Secretary-Treasurer/Sales Manager*
*Hawaiian Cement Corporation*
*Representing Hawaii Manufacturers Association*

VICE-CHAIRMEN

CLYDE KIMBALL JACOBSEN (1965-1967)
*Editor, Hawaii Business & Industry*
*Representing Chamber of Commerce of Honolulu, Highway & Transportation Subcommittee*

SECRETARY

KENJI ONODERA (1965)
*Vice President of Roehrig, Onodera, & Kinder*
*Representing American Institute of Architects*

JANE SILVERMAN (1966)
*Park Historian, State Department of Land and Natural Resources*
*Representing Hawaii Library Association*

LUCILLE CREPS (1967)
*Representing The Outdoor Circle*

### *Chairmen of Standing Committees*

Subcommittee on Population, Economics, and Land Use

OTTO ORENSTEIN
*Business Research Analyst*
*Hawaiian Telephone Company*

Subcommittee on Mass Transit

AARON LEVINE
*Executive Vice President*
*Oahu Development Conference*

Subcommittee on Transportation Planning Objectives

DON HOUSE
*Vice-President & Secretary*
*Oahu Transport Company*

Subcommittee on Highways

GORDON BRADLEY
*Vice President*
*Bradley & Wong*



AR00031491

## *KEY STUDY STAFF*

AH LEONG KAM
*Project Director*

DAVID S. KAWASAKI
*Trip Distribution and Traffic Assignment*

JAMES S. TANAKA
*Land Use*

DR. ROBERT W. RIDER
*Economics*

ROBERT C. SCHMITT
*Population*

RICHARD K. Y. TONG
*Data Processing*

## *SPECIAL CONSULTING SERVICES*

DR. ROLAND A. ARTLE
*Chairman*
*Department of Economics*
*University of Gothenburg*
*Gothenburg, Sweden*

DR. RONALD S. GRAYBEAL
*Assistant Professor*
*Center for Real Estate and Urban Economics*
*University of California, Berkeley*

MODAL SPLIT AND TRANSIT ANALYSIS

DANIEL, MANN, JOHNSON AND MENDENHALL

ALAN M. VOORHEES & ASSOCIATES

## *SPECIAL EXPERT ADVISORY SERVICES*

DR. J. DOUGLAS CARROLL, JR.

ROGER L. CREIGHTON

JOHN R. HAMBURG

DAVID K. WITHEFORD



AR00031492

# ACKNOWLEDGMENTS

To list every individual and organization who contributed to the progress of the Oahu Transportation Study would be a formidable undertaking. Splendid cooperation was given at all levels--from the heads of governments sponsoring the study to the people and business firms of the Metropolitan Area of Honolulu.

Special acknowledgment is extended to D. L. Pollard, Director, Planning Branch, Programs Coordination and Services Office, Department of Housing and Urban Development; to C. H. Spamer, Regional Planning & Research Engineer, Bureau of Public Roads; and to J. B. Dalhouse, Division Engineer, Bureau of Public Roads, for their support and encouragement to the study staff. In addition, technical assistance above and beyond financial support was received from personnel of the Highways Division, Department of Transportation; the Economic and Planning Division, Department of Planning and Economic Development; and the Planning and Traffic Departments of the City and County of Honolulu.

The study employees merit particular praise. They displayed an unusual degree of willingness and devotion throughout the very demanding tasks involved in data collecting, coding, processing, and analyzing, and in the other tasks necessary for a complete and accurate report.

Finally, warm thanks are extended to members of the Citizen Advisory Committee, who spent many hours of their own in attaining the ultimate goal of genuine citizen participation in the decision-making process.

To all, the Policy Committee of the Oahu Transportation Study wishes to express its grateful appreciation.



AR00031493

## NOTES ABOUT THIS REPORT

This volume is the first of a series of three volumes which are being issued to provide information about the purpose, the design, the estimates, and the recommendations of the Oahu Transportation Study.

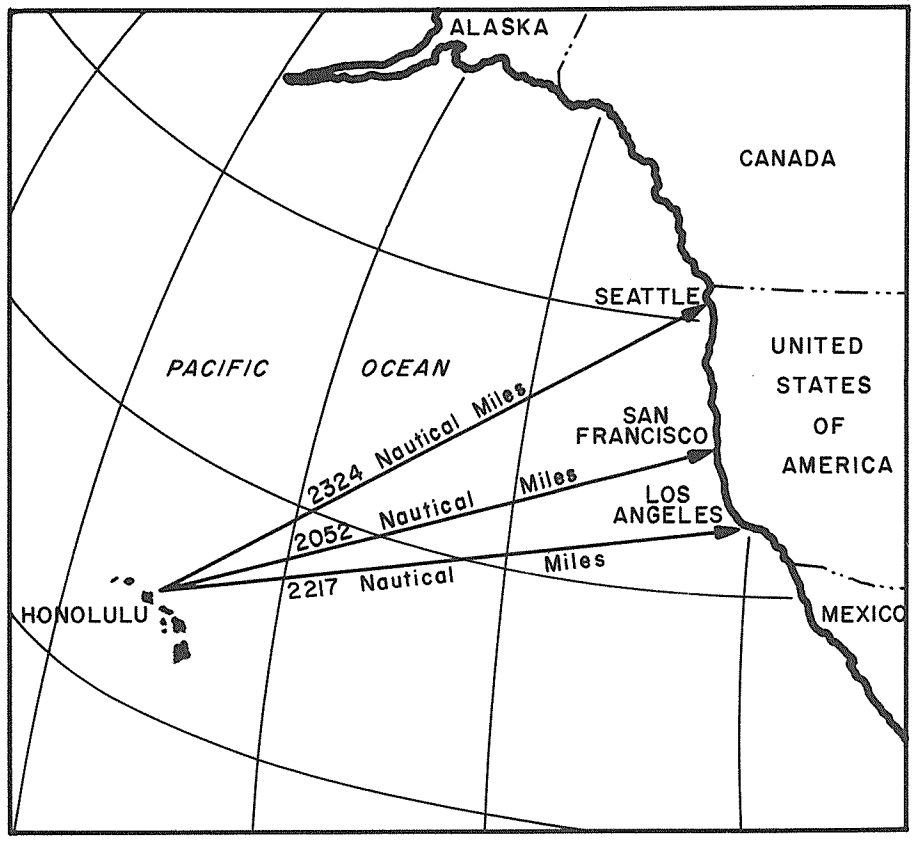
The transportation planning process and the inventory, assumptions, and forecasts of socio-economic and land-use data are discussed in this publication. Transportation facilities, including mass transportation, travel patterns and forecasts, terminal facilities, etc., will be discussed in Volume II. In Volume III, the transportation goals, objectives and restraints, the tests and evaluations, and the recommended transportation plans will be discussed.



AR00031494

## GEOGRAPHICAL LOCATION OF THE STUDY AREA

The State of Hawaii, the 50th and newest state in the Union, is separated from her nearest sister state by more than 2,000 miles of ocean. It is the most remote of the world's civilized land. Within the State lies the Island of Oahu, known as the Standard Metropolitan Statistical Area of Honolulu, in which the City of Honolulu is located.






AR00031495

*VOLUME I*

*ECONOMIC, POPULATION, AND LAND USE*

*Contents*


| Chapter | | Page |
|---|---|---|
| I. | INTRODUCTION | I- 1 |
| | A. The Problem | 1 |
| | B. The Oahu Transportation Study | 3 |
| | 1. Inception of the Study | 3 |
| | 2. The Study Area | 4 |
| | 3. Organization of the Study Staff | 5 |
| | 4. Program Direction | 7 |
| | C. The Transportation Planning Process | 8 |
| | 1. Scope | 8 |
| | 2. Cooperative Procedures | 11 |
| | Appendix | |
| | I-A. Census Tract and Origin-Destination Zone Maps. | I- A |
| II. | POPULATION STUDY | II- 1 |
| | A. Introduction | 1 |
| | B. Recent Population Trends | 1 |
| | 1. Armed Forces | 4 |
| | 2. Birth and Death Rates | 4 |
| | 3. In- and Out-Migration | 5 |
| | C. Future Population | 6 |
| | 1. Cohort-Survival Method of Projecting | 6 |
| | 2. Assumptions | 6 |
| | 3. Results | 8 |
| | D. Population Distribution | 8 |
| III. | ECONOMIC BASE STUDY | III- 1 |
| | A. Introduction | 1 |
| | B. Economic Projection for Oahu, the Study Area | 2 |
| | 1. Population | 3 |
| | 2. Employment | 4 |
| | 3. Income | 7 |
| | 4. Production of Goods and Services | 7 |
| | 5. Some Requirements for Growth | 7 |
| | C. Distribution of Economic Activities | 10 |




AR00031496

| Chapter | | Page |
|---|---|---|
| III. | Appendix | |
| | III-A. Economic Model--Land-Use Model Employment Sector Relationship . . . . . | III- A |
| IV. | LAND USE STUDY . . . . . | IV- 1 |
| | A. Introduction . . . . . | 1 |
| | B. Land-Use Inventory . . . . . | 2 |
| | 1. The Parcel . . . . . | 2 |
| | 2. Land-Use Classification . . . . . | 3 |
| | 3. Basic Files . . . . . | 5 |
| | 4. Quality Control . . . . . | 5 |
| | C. Existing Land Use . . . . . | 6 |
| | 1. Brief History of Physical Development . . . . | 6 |
| | 2. Gross Usage . . . . . | 8 |
| | 3. Commercial Land Use . . . . . | 10 |
| | 4. Industrial Land-Use . . . . . | 15 |
| | 5. Residential Land . . . . . | 18 |
| | 6. Street and Highway Lands . . . . . | 22 |
| | 7. Vacant and Agriculture Land . . . . . | 23 |
| | 8. Lands Available for Development . . . . . | 24 |
| | D. Future Land Uses and Locations . . . . . | 26 |
| | 1. Overview of the Land-Use Model . . . . . | 27 |
| | 2. Outputs of the Residential Submodel . . . . . | 32 |
| | 3. Outputs of the Commercial, Public, and Industrial Submodels . . . . . | 43 |
| | Appendix | |
| | IV-A. Tables Concerning Existing Land Use . . . . . | IV- A |
| | IV-B. The Demand for and Distribution of Residential, Commercial, and Industrial Development . . . | B |
| | IV-C. Tables Concerning Residential Submodel . . . . | C |
| | IV-D. Tables Concerning Retail, Public, and Industrial Submodels . . . . . | D |




AR00031497

| Table | | Page |
|---|---|---|
| | **II. Population Study** | |
| 2.1 | Population changes in Judicial District of Oahu, 1930 to 1960 | II- 3 |
| .2 | Military population on Oahu, as of April 1960 and 1965 | 4 |
| .3 | Summary of live births, deaths, and net migration rates per thousand of civilian population | 5 |
| .4 | Population estimate based on Cohort-Survial Method | 8 |
| | **III. Economic Base Study** | |
| 3.1 | Past and projected population, personal income, and per-capita personal income for Oahu, 1960 to 1985 | III- 4 |
| .2 | Past and projected values of employment in the private sector of Oahu's economy, 1960 through 1985 | 5 |
| .3 | Past and projected values of employment in the government sector of Oahu's economy | 6 |
| .4 | Past and projected values of output in the private sector of Oahu's economy | 8 |
| .5 | Past and projected growth of selected major expenditure categories in Oahu, 1960 to 1985 | 9 |
| 3.A1 | Economic model, standard industrial classification, land use model employment sector relationship | III-A-1 |
| | **IV. Land Use Study** | |
| 4.1 | Summary of Oahu land usage, 1964 | IV- 8 |
| .2 | Comparison of land use on Oahu with that in Mainland cities | 9 |
| .3 | Summary of existing commercial use outside and within general-planned commercial land on Oahu in 1964 | 14 |
| .4 | Ratios of commercial acreages to population and dwelling units on Oahu in 1964 | 15 |
| .5 | Ranking of the 15 largest industrial land uses on Oahu in 1964 | 16 |
| .6 | Distribution of industrial floor area on Oahu in 1964 | 17 |
| .7 | Summary of vacant usable and unusable lands on Oahu in 1964 | 24 |




AR00031498

| Table | | Page |
|---|---|---|
| 4.8 | Summary of urban and nonurban vacant usable land on Oahu in 1964 | IV-25 |
| .9 | Summary of urban vacant usable land on Oahu in 1964 by urban-use designation | 25 |
| .10 | Summary of agricultural urban land on Oahu in 1964 by urban-use designation | 25 |
| .11 | Input and output variables in the Oahu Transportation Study Land-Use Model | 29 |
| .12 | Family size of household in 1985 | 37 |
| .13 | Ratios of population distributions on Oahu, 1964 and 1985 | 45 |
| .14 | Number of acres of commercial retail, commercial services, and total commercial serving each 100 dwelling units on Oahu, 1964 and 1985 | 46 |
| .15 | Projected distribution of industrial land on Oahu in 1985 | 57 |
| 4.A1 | Oahu land-use summary for 1964 | IV-A-1 |
| .A2 | Distribution of commercial land and floor areas for retail trade and commercial services, 1964 | A-2 |
| .A3 | Land and floor areas for commercial-retail and commercial-services categories, 1964 | A-3 |
| .A4 | Summary of uses within general plan commercial areas on Oahu in 1964 | A-4 |
| .A5 | Ratio of commercial floor area to its land use on Oahu in 1964 | A-5 |
| .A6 | Distribution of generalized industrial land use and industrial floor area by Planning District on Oahu, 1964 | A-6 |
| .A7 | Percent of district's industrial floor area concealed in secondary use on Oahu in 1964 | A-7 |
| .A8 | Summary of existing industrial use outside and within general-planned industrial land on Oahu in 1964 | A-8 |
| .A9 | Summary of uses within general-planned industrial areas on Oahu in 1964 | A-9 |
| .A10 | Summary of lot sizes of available, general-planned industrial land on Oahu, 1964 | A-10 |
| .A11 | Distribution of residential land use by Planning District on Oahu in 1964 | A-11 |
| .A12 | Distribution of dwelling units by Planning District on Oahu in 1964 | A-12 |




AR00031499

| Table | | Page |
|---|---|---|
| 4.A13 | Residential housing units concealed in commercial and industrial uses on Oahu in 1964 . . . | IV-A-13 |
| .A14 | Number and location of under-developed, single-family residential parcels by Planning Districts on Oahu in 1964 . . . . . | A-14 |
| .A15 | Distribution of land general-planned for residential purposes on Oahu in 1964 . . . . . | A-15 |
| .A16 | Land uses within area general-planned for single-family residential purposes on Oahu in 1964 . . . . . | A-16 |
| .A17 | Land uses within areas general-planned for multi-family residential purposes on Oahu in 1964 . . . . . | A-17 |
| .A18 | Distribution of holding capacities in areas general-planned single-family residential on Oahu in 1964 . . | A-18 |
| .A19 | Streets and highways distribution on Oahu . . . . . | A-19 |
| .A20 | Distribution of all vacant land by Planning Districts on Oahu in 1964 . . . . . | A-20 |
| .A21 | Distribution of agricultural and extractive land by Planning Districts on Oahu in 1964 . . . . . | A-21 |
| .A22 | Probable future use of vacant urban lands on Oahu, 1964 . | A-22 |
| .A23 | Probable future use of agricultural land by Planning Districts on Oahu . . . . . | A-23 |
| 4.B1 | Ratio of new houses to new employees . . . . . | IV-B-2 |
| .B2 | Land-absorption coefficients for single-family-dwelling developments . . . . . | B-5 |
| .B3 | Family size per household by income class on Oahu in 1960 | B-7 |
| .B4 | Forecast of retail employment . . . . . | B-8 |
| .B5 | Total demand distribution home-based and work-based trips | B-9 |
| .B6 | Different demands for retail activities . . . . . | B-10 |
| .B7 | Land-absorption coefficient for retail development . . | B-11 |
| .B8 | Activities allocated by public and industrial submodels . | B-12 |
| .B9 | Land and floor-area absorption coefficients . . . . . | B-13 |
| 4.C1 | Past and project distribution of population by Planning District on Oahu, 1960 to 1985 . . . . . | IV-C-1 |
| .C2 | Past and projected distribution of population by census tract, 1965 and 1985 . . . . . | C-2 |
| .C3 | Distribution of dwelling units on Oahu . . . . . | C-3 |
| .C4 | Past and projected single-family residential land use on Oahu, 1964 and 1985 . . . . . | C-4 |




AR00031500

| Table | | Page |
|---|---|---|
| 4.C5 | Past and projected multi-family residential land use on Oahu in 1964 and 1985 | IV-C-5 |
| 4.D1 | Distribution of commercial land on Oahu, 1964 and 1985 | IV-D-1 |
| .D2 | Commercial floor area on Oahu, 1964 and 1985 | D-2 |
| .D3 | Commercial floor area to land area relationship on Oahu, 1964 and 1985 | D-3 |
| .D4 | Distribution of industrial land on Oahu, 1964 and 1985 | D-4 |
| .D5 | Projected percent of employees in private industry on Oahu, for three income classes, 1970 through 1985 | D-5 |
| .D6 | Employment Distribution | D-6 |
| .D7 | Land Use Summary by Census Tract, 1964 and 1985 | D-7 |


## *Illustrations*

Figure


I. Introduction

| | | |
|---|---|---|
| 1.1 | The Study Area, Island of Oahu | I- 4 |
| .2 | Oahu Transportation Study Organization | 5 |
| .3 | The Transportation Planning Process | 9 |

II. Population Study

| | | |
|---|---|---|
| 2.1 | Civilian Population Growth | II- 2 |
| .2 | Judicial Districts of Oahu | 3 |

IV. Land-Use Study

| | | |
|---|---|---|
| 4.1 | Commercial Land-Use Components | IV-11 |
| .2 | Planning Districts | 12 |
| .3 | Oahu Transportation Study Models | 27 |
| .4 | Percent of Total Population Between Honolulu and Outlying Districts | 32 |
| .5 | Estimated Population by Planning Districts | 33 |
| .6 | Population Distribution, 1960-1985, by Census Tract | 35 |
| .7 | Population Distribution, 1960-1985, by Census Tract | 39 |




AR00031501

| Figure | | Page |
|---|---|---|
| 4.8 | Distribution of Single-Family Residential Land by Planning District, 1964 and 1985 | IV-41 |
| .9 | Distribution of Multi-Family Residential Land by Planning District, 1964 and 1985 | 42 |
| .10 | Comparison of 1964 and 1985 Commercial Land Area | 43 |
| .11 | Distribution of Commercial Land by Planning District, 1964 and 1985 | 44 |
| .12 | Comparison of 1964 and 1985 Commercial Floor Area | 46 |
| .13 | Commercial Retail Floor Area, 1960-1985, by Census Tract | 47 |
| .13a | Commercial Retail Floor Area, 1960-1985, by Census Tract | 49 |
| .14 | Commercial Services Floor Area, 1960-1985, by Census Tract | 51 |
| .14a | Commercial Services Floor Area, 1960-1985, by Census Tract | 53 |
| .15 | Comparison of 1964 and 1985 Industrial Land Areas | 55 |
| .16 | Distribution of Industrial Land by Planning District 1964 and 1985 | 56 |
| .17 | Comparison of 1964 and 1985 Industrial Floor Area | 57 |
| .18 | Comparison of 1964 and 1985 Areas of Public and Quasi-Public Building and Open-Space Land | 58 |
| .19 | Oahu Employment Pie, 1965 and 1985 | 60 |
| .20 | Employment Forecast | 61 |
| .21 | Employment Distribution, 1960-1985, by Census Tract | 63 |




AR00031502

# 1 Introduction

# I. INTRODUCTION

## A. THE PROBLEM

In 1965, there were over 617,000 people on the Island of Oahu, over 198,000 people employed, over 145,000 dwelling units, and over 244,000 registered motor vehicles. In 1985, the number of people is expected to reach 1,050,000, the number employed to reach 342,000, the number of dwelling units to reach 267,000, and the number of motor vehicles to exceed 360,000. This dynamic growth will produce a tremendous pressure of demand on Oahu's existing, already strained transportation system.

This growing problem of urban environment, car ownership, traffic congestion, parking, public and private transportation services, and the like, makes Honolulu no different from any other U. S. city. The problem was exemplified by President John F. Kennedy's special message to Congress, March 9, 1961, when he said:

> "Nothing is more dramatically apparent than the inadequacy of transportation in our urban areas. The solution cannot be found only in the construction of highways--vital as the job is. Other means of transportation which use less space and equipment must be improved and expanded. Perhaps even more important, planning for transportation and land use must go hand in hand as two inseparable aspects of the same process."

Comprehensive planning is a first step in achieving good urban transportation. In a joint report to the President of the United States early in 1962, both the Department of Commerce and the Department of Housing and Urban Development (then Housing and Home Finance Agency, HHFA) documented the fact that:

> "...Planning should be a continuing process and should include all the interdependent parts of the urban community and all agencies and jurisdictions involved, and should be coordinated with policy making and administration. Transportation planning should be a part of systematic land use and development planning. It should be for the system as a whole rather than for its individual components--private vehicles, buses or rail transit."



AR00031505

Thus, a continuing, cooperative, comprehensive transportation planning process became a requirement if a State wished Federal aid for highway improvements in urban areas of more than 50,000 population. The Highway Act of 1962, Public Law 87-866, 76 Stat. 1148, states:

> "It is declared to be in the national interest to encourage and promote the development of transportation systems, embracing various modes of transport in a manner that will serve the States and local communities efficiently and effectively. To accomplish this objective the Secretary shall cooperate with the States, as authorized in this title, in the development of long-range highway plans and programs which are properly coordinated with plans for improvements in other affected forms of transportation and which are formulated with due consideration of their probable effect on the future development of urban areas of more than fifty thousand population. After July 1, 1965, the Secretary shall not approve under Section 105 of this title any program for projects in any urban area of more than fifty thousand population unless he finds that such projects are based on a continuing, comprehensive transportation planning process carried on cooperatively by State and local communities in conformance with the objectives stated in this section."

The Urban Mass Transit Act of 1964 provides federal assistance in the form of loans and grants for transit facilities and equipment necessary to carry out a program for a unified or officially coordinated mass transportation system. This Act also refers to the requirement for this continuing, cooperative, comprehensive transportation planning process, stating in part:

> "...that the facilities and equipment for which the assistance is sought are needed for carrying out a program meeting criteria established... for a unified or officially coordinated urban transportation system as a part of the comprehensively planned development of the urban area, and are necessary for the sound, economic, and desirable development of such area."

To assure the achievement of these requirements, both the Department of Commerce and the Department of Housing and Urban Development have established procedures for financial assistance in carrying out the continuing, cooperative, comprehensive transportation planning process. Thus, projects under the process can be financially aided through Federal Grants from the Department of Housing and Urban Development, under the Urban Planning Assistance Program authorized by the Bureau of Public Roads.

The assurance of continued flow of Federal aid to Hawaii is one justification for the need for a transportation planning process. Additionally,



AR00031506

we cannot overlook the fact that there was and still is a need in Honolulu for a long-range transportation plan which will tie together the other elements of comprehensive planning--the State's General Plan, plans for open spaces, plans for outdoor recreation, community and urban renewal plans, etc. These Federally aided programs are being undertaken today by the various State and City agencies. Of utmost importance, cooperation between the State and the City and County of Honolulu is mandatory if any proposal is to succeed.

## B. THE OAHU TRANSPORTATION STUDY

### 1. INCEPTION OF THE STUDY

The decision to undertake a continuing, cooperative, comprehensive transportation planning study for the Island of Oahu was made on August 28, 1961, at a meeting between the heads and staff members of the Planning Department of the City and County of Honolulu and the State Highways Division. Since both the then Governor and the Mayor had advocated this study, it was agreed that a joint State-City application be made for a Federal grant under Section 701 of the Housing Act, as amended in 1961. On February 12, 1962, the then Governor officially designated the State Director of Planning to act as the coordinator and administrator responsible for initiating applications for Federal grants and administering the transportation study.

In May 1962, Act 30, Session Laws of Hawaii, 1962, specifically authorized the "preparation of a workable program to guide integrated, comprehensive transportation development on Oahu for the next 20 to 40 years." Prior to the passage of this Act, the Council of the City and County of Honolulu, by its Resolution No. 69, dated April 3, 1962, stated the City's intent to participate in this joint undertaking.

On November 15, 1962, an Application for Urban Planning Grant was submitted and on March 1, 1963, the application was approved by the Regional Director of Urban Renewal, HHFA, officially making the Oahu Transportation Study a joint project of the State and the City and County of Honolulu. The Urban Planning Grant Contract (Project No. Hawaii P-13) was executed on May 8, 1963, between the State of Hawaii and the U. S. Department of Housing and Urban Development (then HHFA).



AR00031507

## 2. THE STUDY AREA

Although the Federal Aid Highway Act of 1962 confines the approval by the Secretary of programs for projects only in urban areas of more than 50,000 population, the entire Island of Oahu - the Standard Metropolitan Area of Honolulu - was considered the study area (Fig. 1.1). This area included all the areas of probable expansion during the period for which facilities are to be planned.

The study area is considered an "internal area" which consists of 113 Census Tracts and 159 Traffic Zones. (The Census Tracts and Traffic Zones are shown in Appendix I-A.)

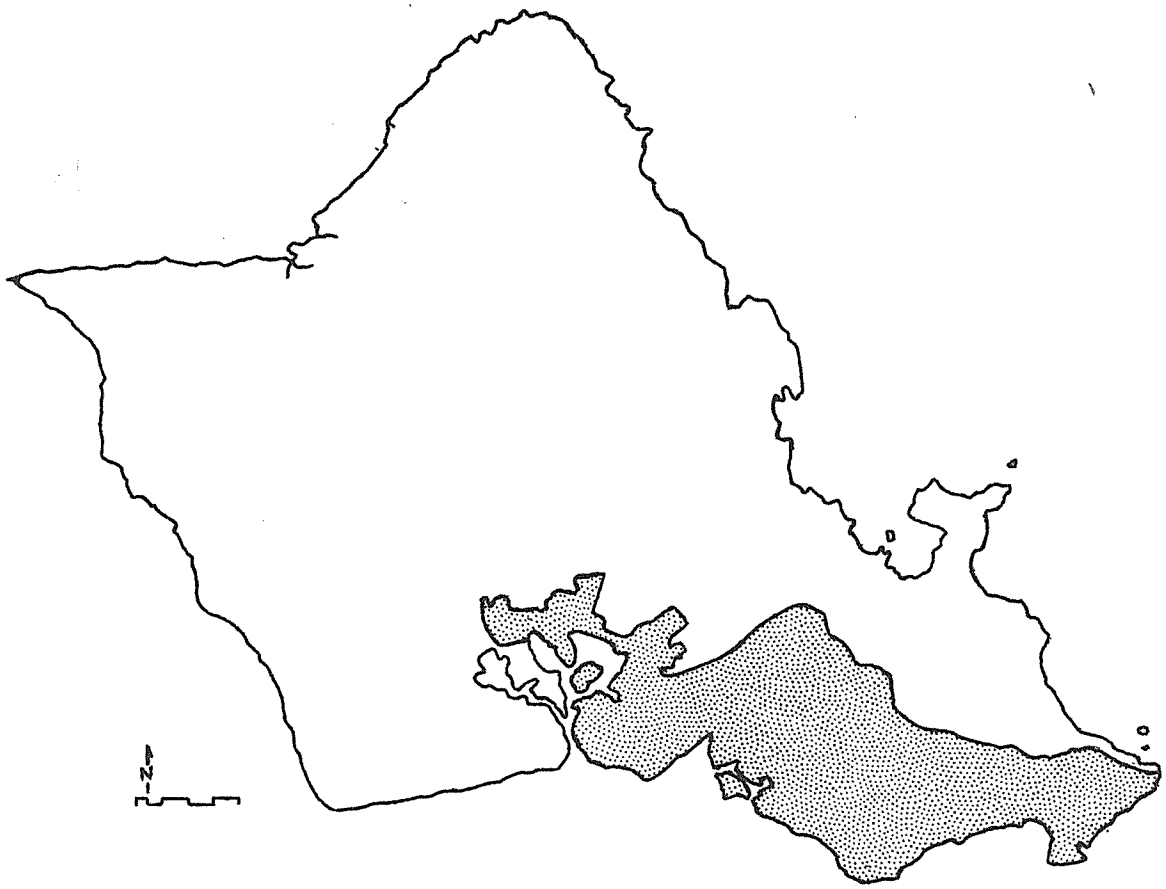


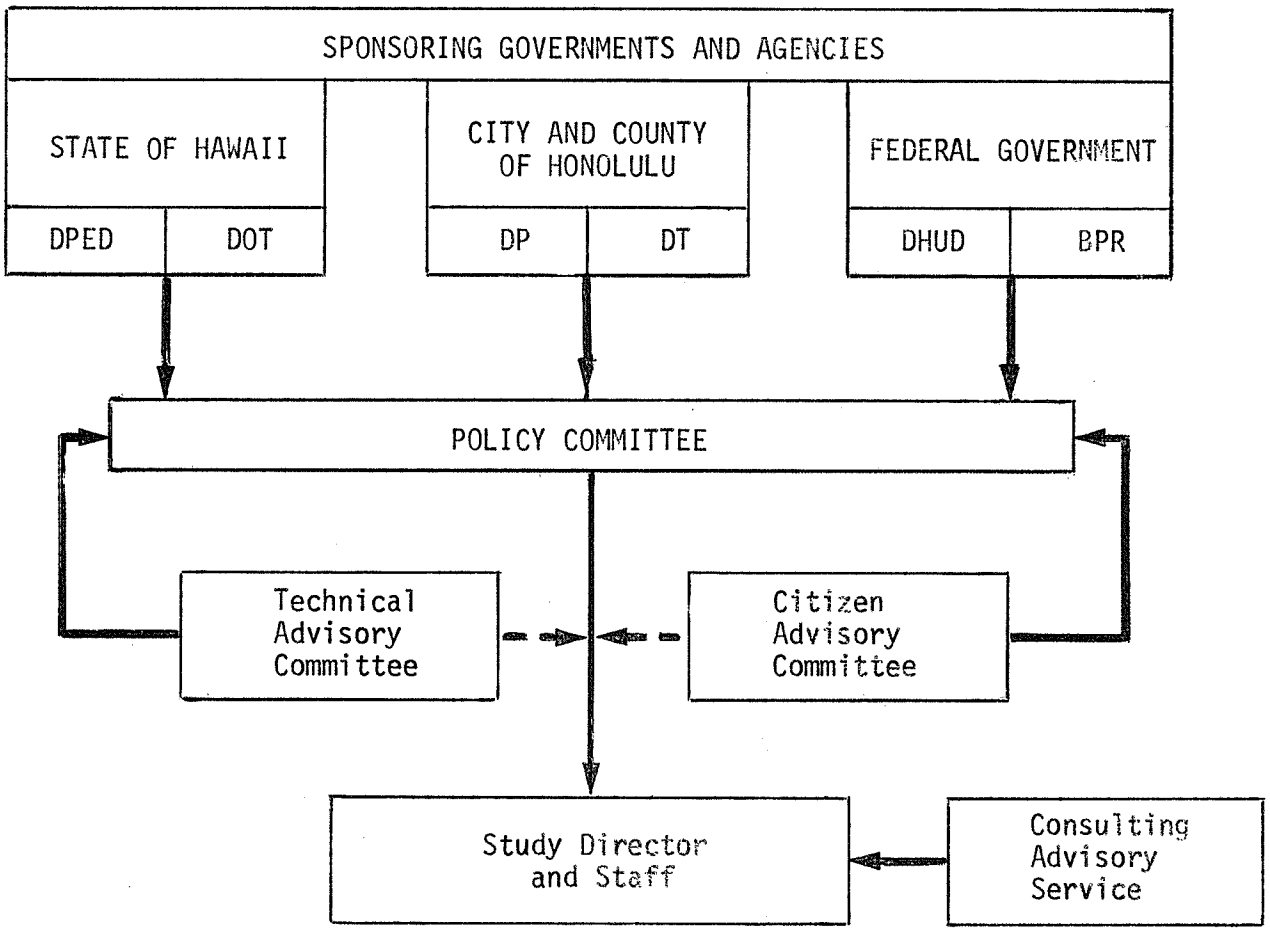

FIG. 1.1. THE STUDY AREA, ISLAND OF OAHU.



AR00031508

## 3. ORGANIZATION OF THE STUDY STAFF

The Oahu Transportation Study is sponsored by the State of Hawaii, the City and County of Honolulu, and the Federal Government. The respective participating agencies and their relationships are shown in Fig. 1.2.




DPED - Department of Planning and Economic Development
DOT - Department of Transportation
DP - Department of Planning
DT - Department of Traffic
DHUD - Department of Housing and Urban Development
BPR - Bureau of Public Roads

FIG. 1.2. OAHU TRANSPORTATION STUDY ORGANIZATION.



AR00031509

a. Policy Committee. Policy direction for the Study is provided by a Policy Committee, composed of representatives of the sponsoring agencies. The executive membership consists of the Directors of the State Department of Planning and Economic Development, State Department of Transportation, City and County Department of Planning, and City and County Department of Traffic. The Director of the Department of Planning and Economic Development, in his role of State Administrator of DHUD-funded projects, is Project Administrator. He is also Chairman of the Policy Committee. For the conduct of Study activities, the Study Staff is responsible through the Study Director to the Policy Committee.

Sessions of the Policy Committee are attended by officials of the U. S. Bureau of Public Roads and the U. S. Department of Housing and Urban Development. These Federal representatives serve as nonvoting members on the Policy Committee.

b. Technical Advisory Committee. Appointed by the Policy Committee, a Technical Advisory Committee serves as technical liaison between the Study Director and the Policy Committee. Its members also act as technical advisors to the Study Staff. This Committee is composed of members from the following agencies:

1. Department of Planning and Economic Development
   State of Hawaii
2. Highways Division, Department of Transportation
   State of Hawaii
3. Airports Division, Department of Transportation
   State of Hawaii
4. Department of Social Services
   State of Hawaii
5. Planning Department
   City and County of Honolulu
6. Traffic Department
   City and County of Honolulu
7. Community Renewal Program
   City and County of Honolulu
8. Honolulu Redevelopment Agency
   City and County of Honolulu
9. Bureau of Public Roads
   U. S. Department of Transportation



AR00031510

10. U. S. Department of Housing and Urban Development

11. Airports Division
Federal Aviation Agency

c. Citizen Advisory Committee. Advice on community planning goals and objectives is provided by the Citizen Advisory Committee, which serves as the means for direct citizen participation in the continuing planning process. Members of this Committee are jointly appointed by the Governor of Hawaii and the Mayor of Honolulu. This Advisory Committee, formed on January 11, 1965, consists of members from 39 professional, business, and civic organizations.

The Citizen Advisory Committee has four Standing Subcommittees, which form special task forces, supporting the Oahu Transportation Study in four specific study tasks:

1. Population, Economics, and Land Use
2. Mass Transit
3. Highways
4. Transportation Planning Objectives.

The current officers of the Citizen Advisory Committee and the chairmen of the Standing Subcommittees form a Steering Committee for this group, functioning as an executive committee.

d. Expert Advisory Service. Specialists are engaged by contract on an "on-call" basis and their activities are confined to "over-the-shoulder" type of supervision.

4. PROGRAM DIRECTION

One objective of the Study was that a Study staff would accomplish all phases of the work - i.e., data collection and inventory, analysis, projection, planning, testing and evaluation, and reporting. It became necessary to have personnel thoroughly indoctrinated in the team approach to the total work program and in the technical processes involved in order to obtain a staff able to carry on the "continuing" aspect of the planning process after the initial contract was completed.



AR00031511

## C. THE TRANSPORTATION PLANNING PROCESS

### 1. SCOPE

The comprehensive character of the planning process requires that the following aspects of the entire Study Area, the Island of Oahu (Fig. 1.2), be objectively analyzed and evaluated:

1. The population, economic, and land-use elements,
2. Future demands on all modes of transportation, both public and private, for both persons and goods,
3. Terminal and transfer facilities and traffic-control systems, and
4. The entire area that is expected to be urbanized within the forecast period and within which the forces of development are interrelated.

There are four well-defined phases in the transportation planning process:

1. Inventory of existing conditions
2. Forecast of future conditions and requirements
3. Preparation and testing of plans for satisfying the needs
4. Maintenance of the process on a continuing basis.

Details of these phases are outlined in Fig. 1.3.

a. Inventory of Existing Conditions. This fact-gathering-and-analysis phase of the Study has been concerned with existing travel and with the elements that generate it. Analysis of the data collected has provided the basic information necessary to determine present trip-generation characteristics and to forecast future urban growth.

b. Forecast of Future Conditions and Requirements. This phase of the Study is concerned with the development of forecasting techniques and their use in determining the future growth and requirements of the Study Area. The population forecast was first in order, because all measures of urban activities are related to the number of people living in the area. Next were forecasts of employment by industry classification, and of personal income; these gross estimates formed the controls from which land-use requirements were determined. Forecasts of the demand for and of the location of land uses were next; the demand for land areas on which to live and work was established in relationship to the locational behavior and the requirements of residents and employees. Forecasts of car ownership lead to a forecast of future trip



AR00031512

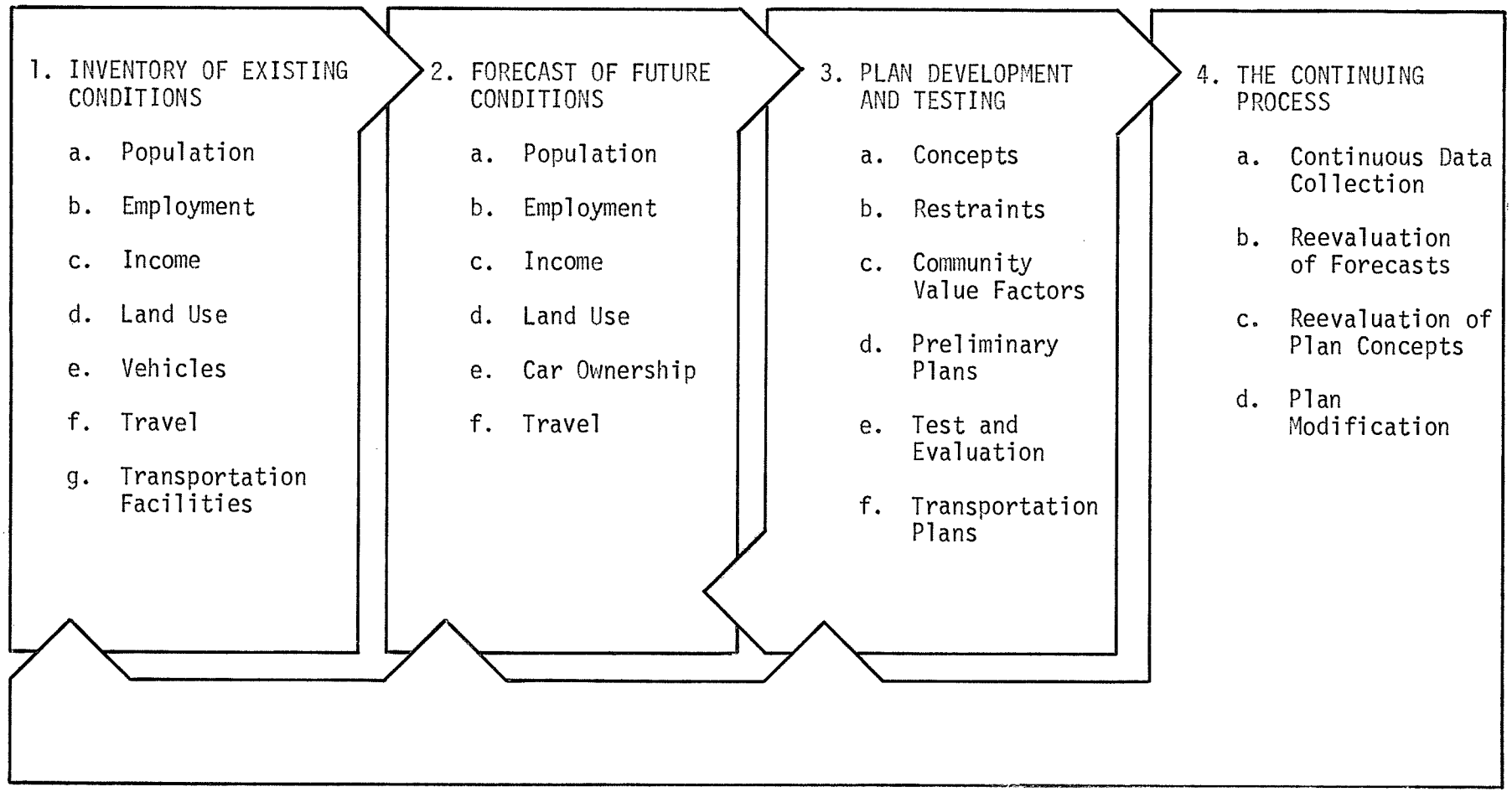



FIG. 1.3. THE TRANSPORTATION PLANNING PROCESS



AR00031513

making. Area-wide forecasts of trip making by travel purpose, without regard to mode of travel, were allocated on the basis of trip volumes generated by the forecast land developments, employment, and residents. The known patterns of present trip distribution by trip purpose between zones provides the means for forecasting future interzonal travel. Finally, the known characteristics of the trip maker provides the basis for forecasting the future mode of travel and the known vehicle-occupancy factors provide the basis for conversion to equivalent modal vehicles.

c. Plan Development and Testing. This phase deals directly with the elements of a transportation plan and with the attempts to bring these elements into balanced relationships. Initial guides established by the Study were to develop a planned network of transportation facilities that will:

1. Provide adequately for present and future traffic demands,
2. Provide adequately for an improved level of service, and
3. Provide for better land development.

These guides were believed to be those that will directly contribute most toward achieving the goal of making Oahu a desirable place in which to live.

There are several critical restraints to the process of plan development--the target date (1985), the Oahu General Plan, existing conditions, and the lack of funds for building facilities.

d. The Continuing Process. The transportation plan developed in this report marks only the initial phase of the Oahu Transportation Study. Planning is properly a continuing function, and for this reason, there will be continual reevaluation of all the elements leading to the plan, and of the plan itself.

Continuous feedback is essential to the successful function of the plan. Population growth, predicted (or, more important, unpredicted) shifts in population centers, changes in forecast land use--all have to be measured, analyzed, evaluated, and reevaluated to appraise their influence on the transportation plan as designed to handle the forecast situation. The planning must be flexible enough to be adapted to significant variations from the predicted requirements.



AR00031514

## 2. COOPERATIVE PROCEDURES

The cooperative character of the transportation planning process requires the establishment of a formal procedure, supported by a written memorandum of understanding, between the State highway department and the governing bodies of the local communities for carrying out the transportation planning process in a manner that will insure that the planning decisions are reflective of and responsive to both the programs of the State highway department and the needs and desires of the local communities.

This commitment was effected on July 2, 1964, by the Governor, the Mayor of Honolulu, and the members of the Oahu Transportation Study Policy Committee, who agreed that the Policy Committee be continued as an officially coordinating body between the State and the City and County of Honolulu to carry out the objectives of a continuing, cooperative, comprehensive transportation planning process within the urban area of Honolulu. They also agreed that the Policy Committee's specific duties shall be to formulate and coordinate the updating procedures and effect the assignment of activities and financial responsibilities of each member agency.



AR00031515

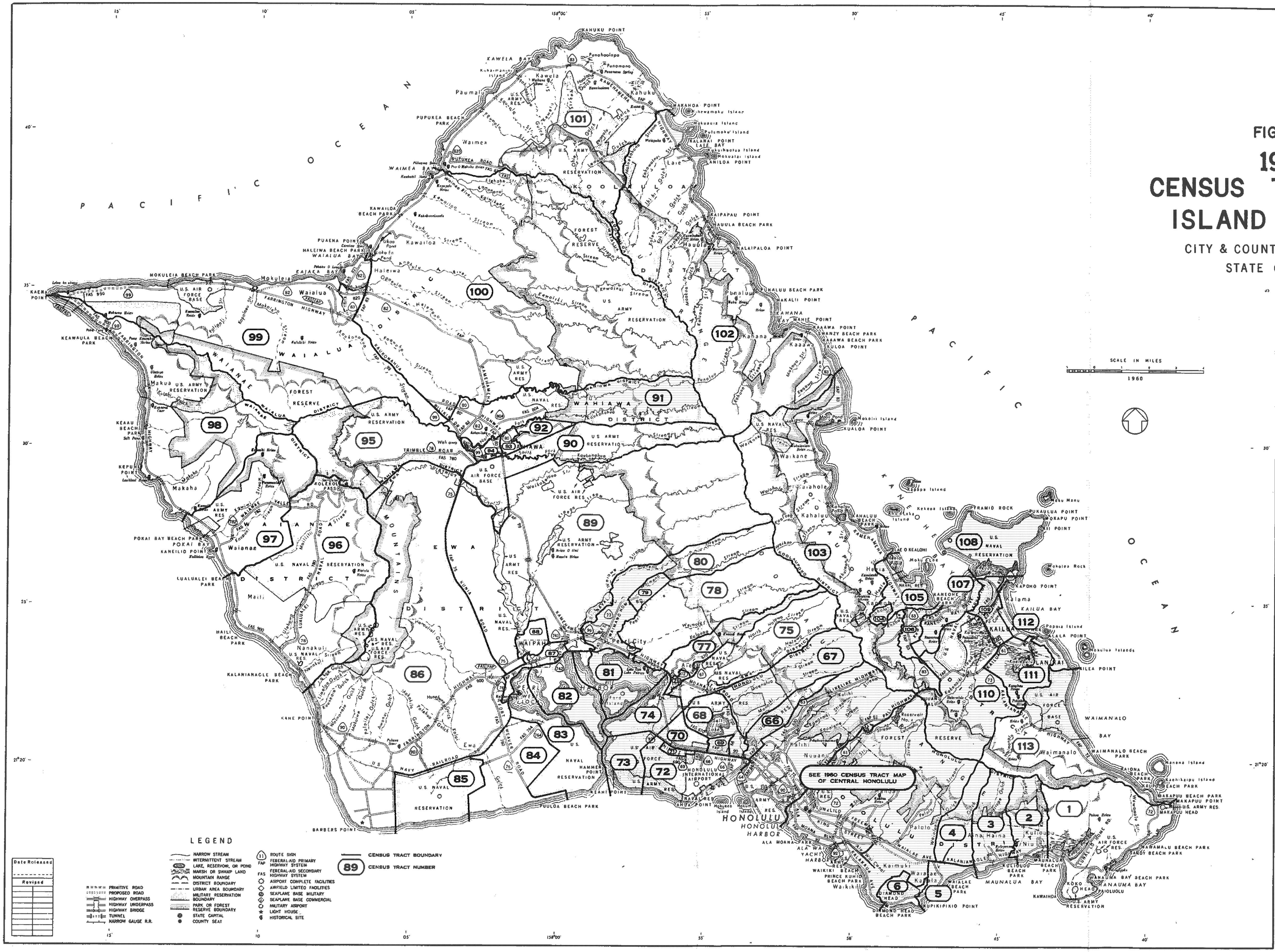
# APPENDIX I-A. CENSUS TRACT AND ORIGIN-DESTINATION ZONE MAPS

FIG. I.A.I.

# 1960 CENSUS TRACT MAP ISLAND OF OAHU

CITY & COUNTY OF HONOLULU

STATE OF HAWAII



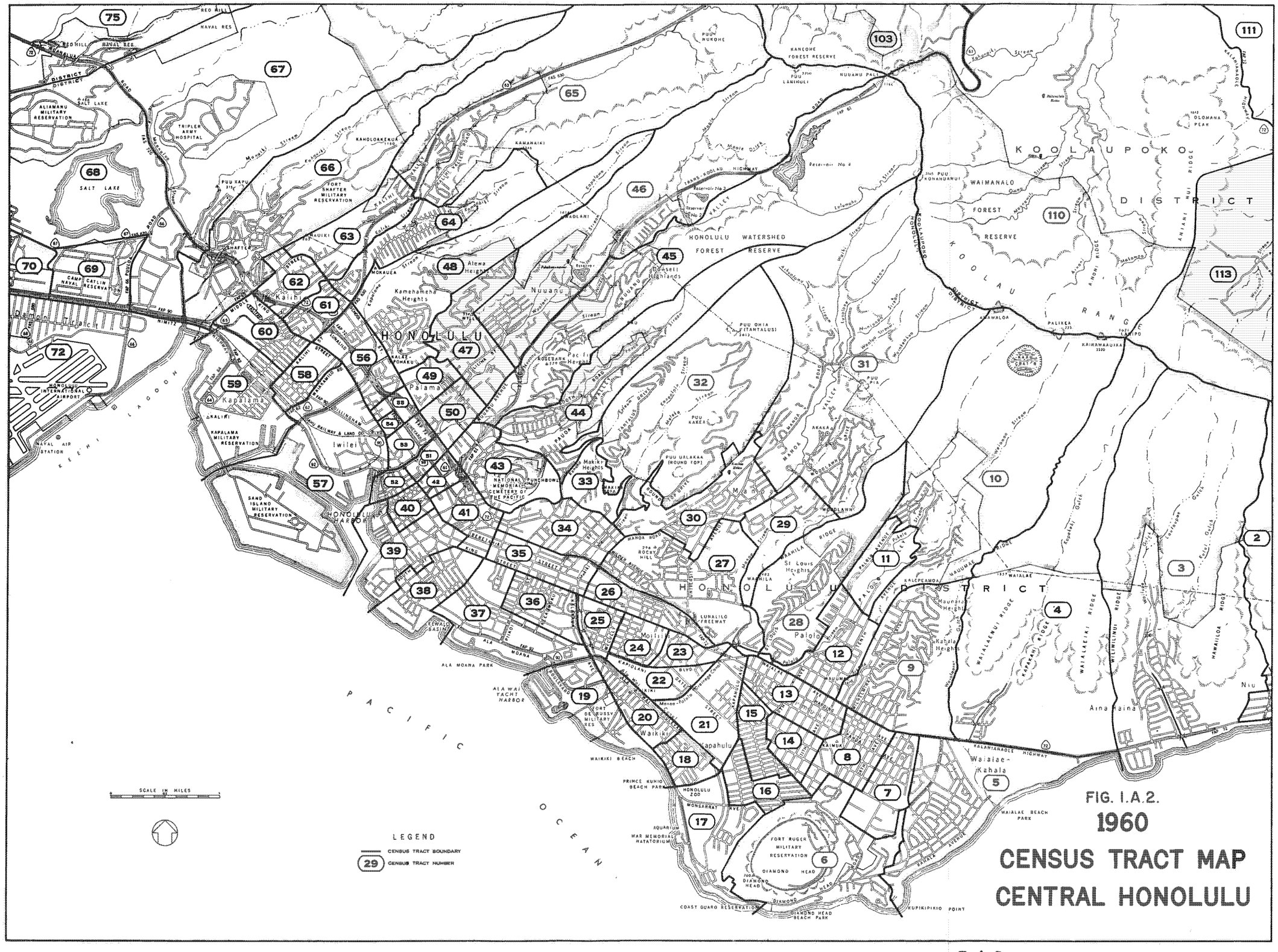



FIG. I.A.2.

# 1960 CENSUS TRACT MAP CENTRAL HONOLULU



AR00031520

FIG. I.A.3

# ZONE MAP

1960 HONOLULU METROPOLITAN AREA
TRAFFIC SURVEY

# ISLAND OF OAHU

CITY & COUNTY OF HONOLULU
STATE OF HAWAII

SCALE IN MILES
1960

SEE 1960 ZONE MAP OF CENTRAL HONOLULU

LEGEND

- PRIMITIVE ROAD
- PROPOSED ROAD
- HIGHWAY OVERPASS
- HIGHWAY UNDERPASS
- HIGHWAY BRIDGE
- TUNNEL
- NARROW GAUGE R.R.
- NARROW STREAM
- INTERMITTENT STREAM
- LAKE, RESERVOIR, OR POND
- MARSH OR SWAMP LAND
- MOUNTAIN RANGE
- DISTRICT BOUNDARY
- URBAN AREA BOUNDARY
- MILITARY RESERVATION BOUNDARY
- PARK OR FOREST RESERVE BOUNDARY
- STATE CAPITAL
- COUNTY SEAT
- ROUTE SIGN
- FAP FEDERAL-AID PRIMARY HIGHWAY SYSTEM
- FAS FEDERAL-AID SECONDARY HIGHWAY SYSTEM
- AIRPORT COMPLETE FACILITIES
- AIRFIELD LIMITED FACILITIES
- SEAPLANE BASE MILITARY
- SEAPLANE BASE COMMERCIAL
- MILITARY AIRPORT
- LIGHT HOUSE
- HISTORICAL SITE
- CENSUS TRACT BOUNDARY
- O.D. ZONE BOUNDARY
- 930 O.D. ZONE NUMBER

Data Released
Revised

I-A-5

AR00031521

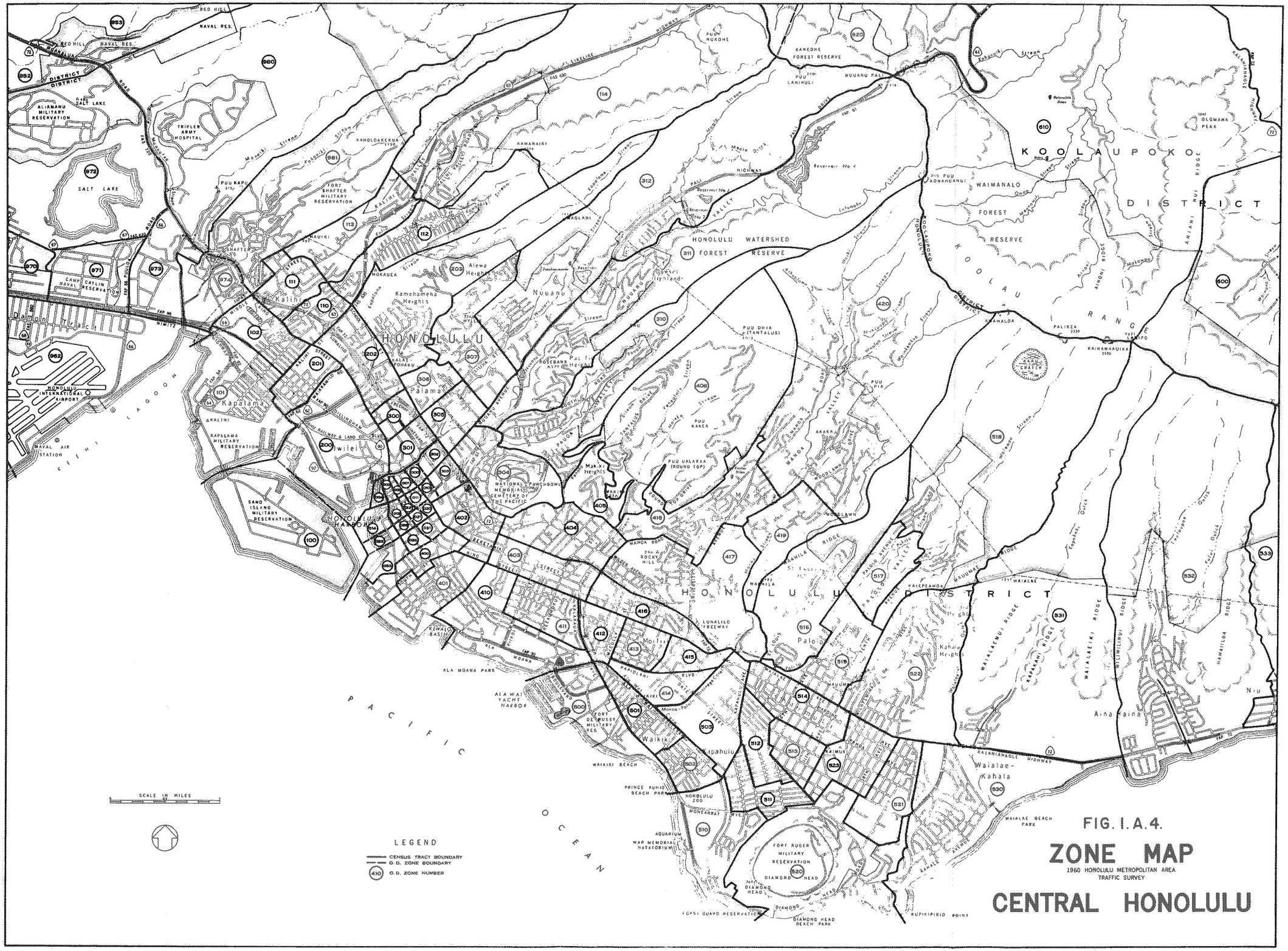



FIG. I.A.4.

# ZONE MAP

1960 HONOLULU METROPOLITAN AREA TRAFFIC SURVEY

## CENTRAL HONOLULU



AR00031522

## O-D SURVEY ZONE TO EQUIVALENT O-D ZONE CONVERSION TABLE

| O-D Survey Zone | Equiv. O-D Zone | O-D Survey Zone | Equiv. O-D Zone | O-D Survey Zone | Equiv. O-D Zone | O-D Survey Zone | Equiv. O-D Zone |
|---|---|---|---|---|---|---|---|
| 000 | 1 | 312 | 40 | 534 | 80 | 812 | 120 |
| 001 | 2 | 400 | 41 | 535 | 81 | 820 | 121 |
| 002 | 3 | 401 | 42 | 536 | 82 | 821 | 122 |
| 003 | 4 | 402 | 43 | 600 | 83 | 822 | 123 |
| 004 | 5 | 403 | 44 | 610 | 84 | 900 | 124 |
| 010 | 6 | 404 | 45 | 611 | 85 | 901 | 125 |
| 011 | 7 | 405 | 46 | 612 | 86 | 902 | 126 |
| 012 | 8 | 406 | 47 | 613 | 87 | 910 | 127 |
| 013 | 9 | 410 | 48 | 614 | 88 | 911 | 128 |
| 014 | 10 | 411 | 49 | 615 | 89 | 912 | 129 |
| 020 | 11 | 412 | 50 | 616 | 90 | 920 | 130 |
| 021 | 12 | 413 | 51 | 617 | 91 | 921 | 131 |
| 022 | 13 | 414 | 52 | 618 | 92 | 922 | 132 |
| 023 | 14 | 415 | 53 | 619 | 93 | 923 | 133 |
| 031 | 15 | 416 | 54 | 620 | 94 | 924 | 134 |
| 032 | 16 | 417 | 55 | 621 | 95 | 925 | 135 |
| 033 | 17 | 418 | 56 | 622 | 96 | 926 | 136 |
| 100 | 18 | 419 | 57 | 623 | 97 | 927 | 137 |
| 101 | 19 | 420 | 58 | 624 | 98 | 930 | 138 |
| 102 | 20 | 500 | 59 | 625 | 99 | 931 | 139 |
| 110 | 21 | 501 | 60 | 626 | 100 | 932 | 140 |
| 111 | 22 | 502 | 61 | 627 | 101 | 933 | 141 |
| 112 | 23 | 503 | 62 | 630 | 102 | 934 | 142 |
| 113 | 24 | 510 | 63 | 640 | 103 | 940 | 143 |
| 114 | 25 | 511 | 64 | 641 | 104 | 941 | 144 |
| 200 | 26 | 512 | 65 | 642 | 105 | 942 | 145 |
| 201 | 27 | 513 | 66 | 650 | 106 | 950 | 146 |
| 202 | 28 | 514 | 67 | 700 | 107 | 951 | 147 |
| 203 | 29 | 515 | 68 | 710 | 108 | 952 | 148 |
| 300 | 30 | 516 | 69 | 711 | 109 | 953 | 149 |
| 301 | 31 | 517 | 70 | 720 | 110 | 960 | 150 |
| 302 | 32 | 518 | 71 | 730 | 111 | 961 | 151 |
| 303 | 33 | 520 | 72 | 731 | 112 | 962 | 152 |
| 304 | 34 | 521 | 73 | 732 | 113 | 970 | 153 |
| 305 | 35 | 522 | 74 | 740 | 114 | 971 | 154 |
| 306 | 36 | 523 | 75 | 741 | 115 | 972 | 155 |
| 307 | 37 | 530 | 76 | 742 | 116 | 973 | 156 |
| 310 | 38 | 531 | 77 | 800 | 117 | 974 | 157 |
| 311 | 39 | 532 | 78 | 810 | 118 | 980 | 158 |
| | | 533 | 79 | 811 | 119 | 981 | 159 |



AR00031523

# II Population Study

AR00031524

# II. POPULATION STUDY

## A. INTRODUCTION

Population forecast is fundamental to all measures of urban activity. The population and economic forecasts together form the basis for estimating future land use and travel demands, since the number of people and jobs are the major factors in trip making.

## B. RECENT POPULATION TRENDS

World War II marked the transition between two major demographic periods in Hawaii. The one that ended was characterized by large-scale importation of Asian laborers, urbanization, increased reproduction in the existing population, drastically lowered mortality rates, and rapid growth. The new period, still in progress today, has been one of wartime dislocation and readjustment, metropolitanization and suburbanization, heavy influxes of both military and civilian personnel from the mainland United States, and, less than 10 years ago, Statehood. Figure 2.1 shows the growth.

Population on Oahu increased rapidly during the war, slacked off for several years thereafter, and then resumed its long-time growth trend. Population rose from 372,000 in 1954 to 613,313 in 1965.

Post-war growth was much more rapid in "rural Oahu" than in the City of Honolulu. The city proper increased from 248,034 inhabitants in April 1950 to 344,500 in 1965, an increase of 139 percent, while the remainder of the island increased from 104,986 to 273,000, or 260 percent. The city accounted for 70.3 percent of the Oahu total in 1950 and only 55.8 percent in 1965. Table 2.1 shows the growth as function of Judicial Districts on Oahu, and the locations of these districts are shown in Fig. 2.2.



AR00031525

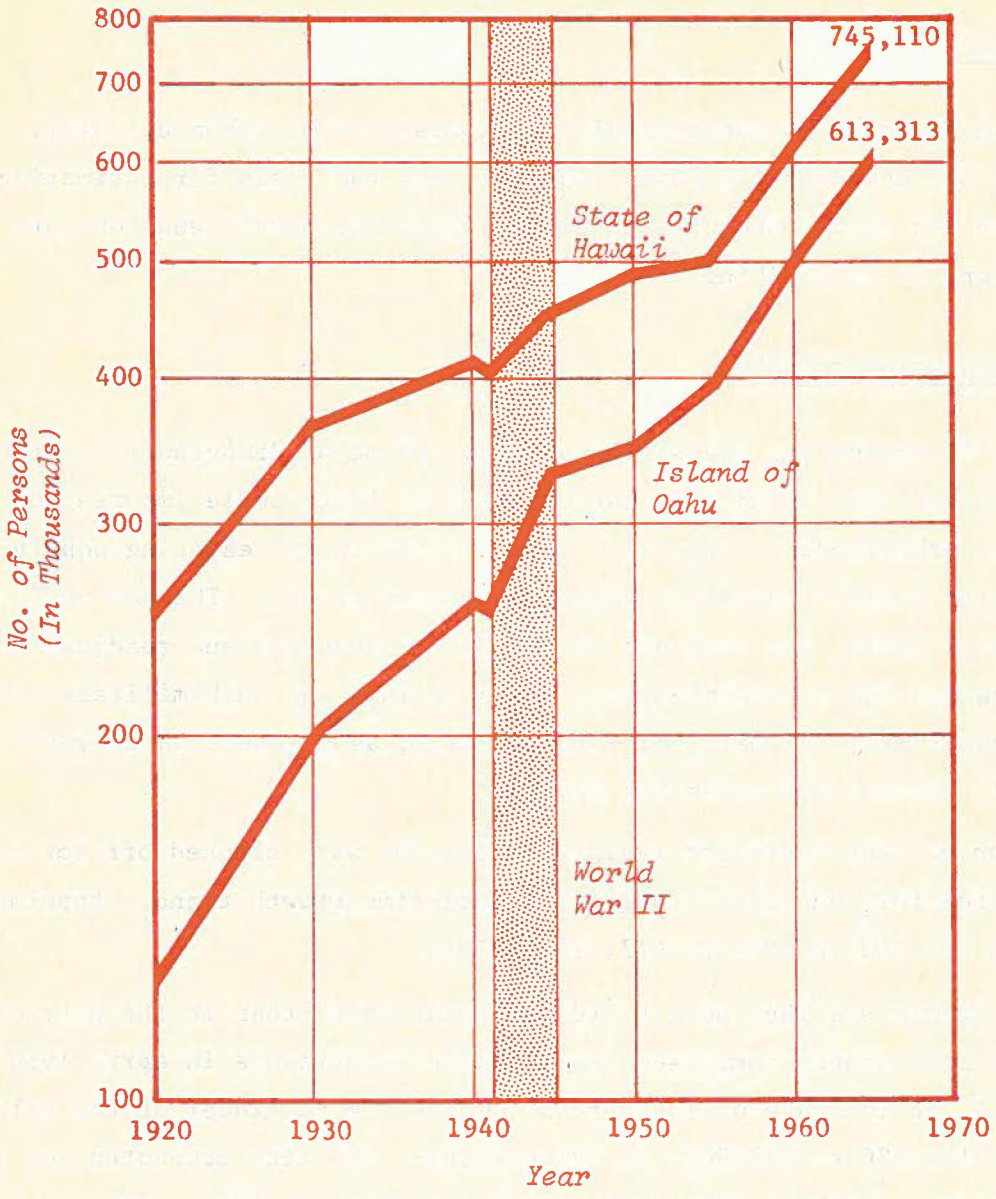



FIG. 2.1. CIVILIAN POPULATION GROWTH.



AR00031526

Table 2.1. Population Changes in Judicial Districts of Oahu, 1930 to 1960

| Judicial Districts | Numbers of Residents at 10-Year Intervals | | | | Growth |
|---|---|---|---|---|---|
| | 1930 | 1940 | 1950 | 1960 | |
| Ewa | 25,507 | 30,602 | 46,602 | 78,666 | 3X |
| Honolulu | 137,582 | 179,326 | 248,034 | 294,179 | 2X |
| Koolauloa | 5,258 | 4,968 | 5,223 | 8,043 | 1.5X |
| Koolaupoko | 6,385 | 9.006 | 20,779 | 60,238 | 9.5X |
| Wahiawa | 18,103 | 22,417 | 17,363 | 34,595 | 2X |
| Waialua | 8,129 | 8,397 | 7,906 | 8,221 | 1X |
| Waianae | 1,923 | 2,948 | 7,024 | 16,452 | 8.5X |

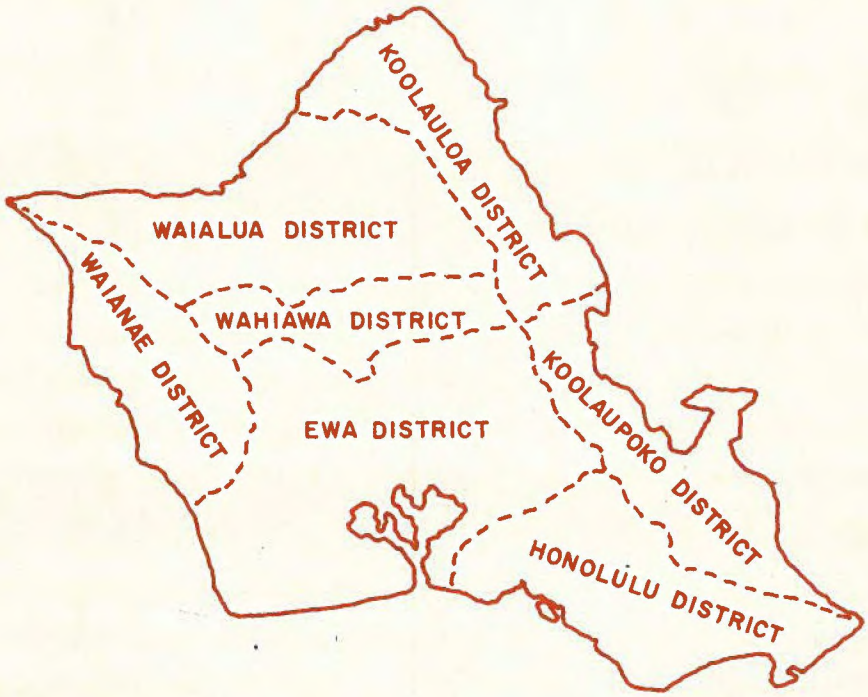



FIG. 2.2. JUDICIAL DISTRICTS OF OAHU.



AR00031527

## 1. ARMED FORCES

Members of the armed forces and their dependents have constituted an important segment of the population in recent years. According to the 1960 Unived States Census, 112,843 of the 632,772 residents of the State were in this category. For the City and County of Honolulu, the April 1965 estimate showed 125,907 military personnel and dependents and 491,648 other civilians. Table 2.2 shows the figures for both the State of Hawaii and the Island of Oahu.

Table 2.2 Military Population on Oahu, as of April 1960 and 1965

| | State of Hawaii | | Island of Oahu | |
|---|---|---|---|---|
| | 1960 | 1965 | 1960 | 1965 |
| Armed Forces | 52,881 | 56,336 | 52,570 | 55,914 |
| Dependents | 60,057 | 70,456 | 59,661 | 69,993 |
| Total | 112,938 | 126,792 | 112,231 | 125,907 |

## 2. BIRTH AND DEATH RATES

Both birth and death rates have been declining for a number of years. The birth rate for Oahu (based on civilian population, including military dependents) reached a postwar peak of 38.6 per thousand persons in 1953, then dropped progressively to only 26.2 in 1965. The death rate for civilians was 5.9 per thousand persons during the immediate postwar period but reached 4.8, an all-time low, in 1965.

Age-specific birth rates (for a five-year period centering on the 1960 U. S. Census) show fertility to be greatest for women 20 to 24 years old. For the State as a whole, annual live births per 1,000 women in this age group reached 473 for military dependents and 231 for other women.

Life expectancy at birth, under 1959-1961 conditions, was 69.1 years for males and 73.2 years for females; corresponding figures for 1939-1941 were 59.5 and 62.6. The most recent data indicate that in Hawaii males live about 2.5 years longer than their mainland counterparts but that there is little difference between females in the Islands and on the Mainland.

The annual mortality rate in Hawaii during the 1958-1962 period



AR00031528

ranged from 0.3 death per 1,000 population for females 5 to 14 years old to 174.2 deaths per 1,000 population for males 85 and over. Age-specific mortality rates were somewhat lower in Hawaii than on the Mainland for all age groups.

Table 2.3 summarizes the birth and death rates in the State and the Island for a 15-year period, 1950-1965.

Table 2.3. Summary of Live Births, Deaths, and Net Migration Rates per Thousand of Civilian Population

| 12-Month Ending June 30 | Live Births | | Deaths | | Net Migration* | |
|---|---|---|---|---|---|---|
| | State of Hawaii | Island of Oahu | State of Hawaii | Island of Oahu | State of Hawaii | Island of Oahu |
| 1951 | 29.2 | 31.4 | 6.0 | 5.9 | -25.1 | -17.8 |
| 1952 | 32.1 | 35.3 | 6.2 | 5.9 | -45.8 | -44.9 |
| 1953 | 34.7 | 38.6 | 5.9 | 5.7 | -16.3 | -11.7 |
| 1954 | 33.5 | 37.7 | 6.1 | 5.9 | -14.5 | -13.9 |
| 1955 | 33.3 | 36.7 | 6.3 | 6.1 | + 9.2 | +17.4 |
| 1956 | 33.9 | 37.5 | 6.1 | 8.6 | +12.3 | +29.1 |
| 1957 | 32.0 | 35.5 | 6.1 | 5.7 | +23.6 | +40.1 |
| 1958 | 30.6 | 33.6 | 5.9 | 5.4 | +15.3 | +31.9 |
| 1959 | 29.4 | 32.2 | 5.5 | 5.0 | +11.4 | +20.3 |
| 1960 | 29.1 | 31.8 | 5.9 | 5.4 | + 1.4 | + 7.7 |
| 1961 | 28.9 | 31.5 | 5.6 | 5.2 | + 5.9 | +13.7 |
| 1962 | 28.4 | 30.7 | 5.4 | 4.9 | +13.7 | +16.9 |
| 1963 | 27.2 | 29.3 | 5.6 | 5.1 | + 8.7 | +14.1 |
| 1964 | 26.1 | 28.0 | 5.5 | 5.0 | + 8.4 | +14.1 |
| 1965 | 24.6 | 26.2 | 5.3 | 4.8 | +19.6 | +24.6 |

* Includes Military Inductions and Separations.

3. IN- AND OUT-MIGRATION

In-migrants have exceeded out-migrants since late 1954. Statistics on net civilian passenger movement (which includes visitors and military dependents as well as residents) indicate a net out-migration in excess of 93,000 between mid-1948 and mid-1954. Since then, every year has brought a net gain, ranging from 800 in fiscal 1960 to 13,600 in 1965. Data restricted to Oahu show similar trends. Even the Neighbor Islands appear to be reaching a point at which in-migrants will balance out-migrants. The net changes are summarized in Table 2.3



AR00031529

## C. FUTURE POPULATION

The trends and relationships revealed in the analysis described in the previous sections were used as a basis for population projections to 1985. Such projections were prepared by age, sex, military status, and broad geographic area (that is, for Oahu and the combined Neighbor Islands) at intervals of five years, using the cohort-survival method. These projections were then compared with corresponding values based on arithmetic and geometric extrapolation and on projections and forecasts prepared by other agencies and individuals.

### 1. COHORT-SURVIVAL METHOD OF PROJECTING

This method requires separate analyses of births, deaths, and net migration, all classified by age, sex, and (as used here) military status. To avoid the distortions inherent in data not adjusted for the unique fertibility, mortality, and migration patterns of members of the armed forces and their dependents, these groups were treated separately. Births in civilian households were projected by sex of child and age of mother. Deaths and net migration among civilians other than military dependents were projected by age and sex. Estimates for military personnel and their dependents were added as a final step.

All data for future years refer to resident population. Totals thus include residents temporarily absent but exclude visitors present. Data on armed forces include those stationed ashore plus those aboard Navy and Coast Guard ships homeported in Hawaii.

### 2. ASSUMPTIONS

a. Birth and Death Rates. Birth rates were based on current levels in the Islands and anticipated national trends. Future national levels of age-specific fertility were assumed to lie midway between the "Series B" and "Series C" projections recently published by the U. S. Bureau of the Census [Ref. 1, p. 63]. (The former, B, might be described as "moderately high"; the latter, C, as "moderately low". These projections are now being revised downward, but details have not as yet been released.) It was further assumed that



AR00031530

age-specific fertility rates for Hawaii (exclusive of military personnel and dependents) would gradually converge near the end of the century.

Age-sex-specific death rates for Hawaii (again excluding the armed forces and their dependents) were similarly based on anticipated national trends [Ref. 1, p. 64]. In view of the substantial similarity of rates for the two areas in recent years, no difference was assumed after 1965.

These assumptions indicate a relatively rapid decline in age-specific fertility rates and a more gradual decline in age-sex-specific mortality rates in Hawaii during the next 25 years. They thus represent extensions of trends already evident both in Hawaii and on the mainland.

b. In- and Out-Migration. Future net migration for Oahu was based on a preliminary Statewide estimate of average annual net in-migration for 1960-1965 (10,014, excluding armed forces and their dependents) and the age and sex distribution of intended residents (excluding military personnel, students, and their dependents) during fiscal 1964 and calendar 1965. All net in-migration was allocated to Oahu while net migration for the other counties of the State was assumed to be zero.

c. Armed Forces. The numbers of armed forces and their dependents were held constant at approximately their mid-1964 levels, when there were about 60,000 military personnel and 70,000 military dependents in the State. It was further assumed that 15,000 of the military personnel would be crews of Navy and Coast Guard ships homeported in Hawaii and 45,000 would be servicemen stationed ashore. Age and sex of both personnel and dependents were held proportional to their distribution in 1960 [Ref. 2, Table 2]. Geographic distribution was based on data for April 1, 1965.

No assumptions were made regarding components of change in the military population and their dependents. Such projections were unnecessary, since the age and sex distributions of these groups were simply kept proportional to those reported by the 1960 U. S. Census for Hawaii. Conventional migration rates for such groups are, moreover, misleading and difficult to compare with data for other groups, chiefly because of the rapid turnover of locally born military dependents.



AR00031531

3. RESULTS

The resulting projections of total population point to a 1985 State-wide figure of 1,217,000 and an Oahu figure of 1,050,000 (Table 2.4). Projections indicate a decline of the sex ratio from 1,148 males per 1,000 females as reported in the 1960 Census to 1,114 in 1965, and to 1,033 in 1985.

Table 2.4. Population Estimate Based on Cohort-Survival Method

| Year | Population | |
|---|---|---|
| | State of Hawaii | Island of Oahu |
| 1965 | 747,000 | 618,000 |
| 1970 | 849,000 | 713,000 |
| 1975 | 962,000 | 816,000 |
| 1980 | 1,086,000 | 930,000 |
| 1985 | 1,217,000 | 1,050,000 |

An older population is in prospect. In 1960, the median age for the State was 24.3 years. The estimated median for 1965 was 24.1 years and for 1985, 26.2 years.

D. POPULATION DISTRIBUTION

Population distribution is determined through a residential submodel which establishes the spatial supply and the spatial demand for each type of housing, and then matching supply and demand wherever possible to achieve an equilibrium in the housing market (see Appendix IV-B). The housing stock for each census tract is updated for each five-year period to produce forecasts for 1970, 1975, 1980, and 1985.



AR00031532

## REFERENCES


1. U. S. Bureau of the Census, "Projections of the Population of the United States, by Age and Sex: 1964 to 1985. With Extensions to 2010." Current Population Reports, Population Estimates, Series P-25, No. 286, July 1964, pp. 63, 64.

2. Hawaii Department of Planning and Economic Development, "Characteristics of the Population by Military Status, 1960," Statistical Report 33, July 26, 1965, pp. 4, 5.




AR00031533

AR00031534

# III Economic Base Study

# III. ECONOMIC BASE STUDY

## A. INTRODUCTION

An economic analysis of the Study Area provides the data needed to estimate the total change in the level of economic activity from the present to the forecast year. This forecast of future economic activity, together with the population forecast, provides the basic input totals for the land-use and travel forecasts.

An important product of an economic study is a forecast of employment. From an urban-transportation-planning point of view, employment is the best single indicator of the level of economic activity to be expected in the Study Area in the future.

The approach employed by the Oahu Transportation Study begins by establishing certain goals for the economy and then asks what level of economic activity will be required to realize these goals. The required levels may be regarded as anticipated levels of economic activity that are capable of being realized depending on appropriate decisions in public and private sectors of the economy.

In order to specify the required levels of economic activity, the economic planning model simulates, through a series of mathematical expressions, the key relationships among the many components of the economy and thereby "recreates" the primary forces that affect the pattern and nature of the economy's growth. These basic (or structural) relationships, which themselves are assumed to change over time, provide the basis for predicting the future required growth pattern. The model in its present form satisfies four goals.

The first and most important of the goals is the level of population in 1985. The concern here centers on defining the levels of activity that must be realized in future years to be compatible with specified levels of population. The test of the compatibility between the anticipated population level and the level of economic activity is in the ability of the economy to generate



AR00031536

sufficient levels of activity to produce the required number of jobs and to maintain a desired relationship between income and population. That is, the planner ultimately seeks as goals the maintenance of full employment and the growth of per capita income.

The second goal is the distribution of income. This goal arises from concern over the fact that at present the most significant elements of growth in Hawaii are generating lower-wage employment opportunities. By increasing the rate at which high- and middle-income grups will grow relative to the low-income group, the movement of families from low- to higher-income groups can be accelerated. Thus, one can examine the implications of this movement on the required rate of growth of the economy's major sectors.

The third goal is the fiscal policies of the State and County governments; and the fourth goal is the external trade relationships of Oahu and the Neighbor Islands with each other and the rest of the world. In addition, a number of other assumptions, which may be regarded as goals, have been injected into the analysis. These pertain to the future growth of specific economic sectors and other related elements.

The Oahu Transportation Study's economic planning model is an abstraction of the interaction of economic phenomena in the "real world" and, by its very nature, is a simplification of the economy. Such a simplification is essential in order to isolate and analyze the primary relationships affecting the growth of outputs, income, and employment.

The model is designed for application on a continuing basis; it can be extended and improved. In addition, new information can be incorporated into the model as this information becomes available, so that the model will constantly reflect the current economic environment. Thus changes in population growth, patterns of government expenditure, levels of exports, tax rates, and other factors can be incorporated into the model so that one can trace the actual growth pattern of the economy through time.

## B. ECONOMIC PROJECTION FOR OAHU, THE STUDY AREA

Receipts from service businesses, which include hotel receipts and receipts from other businesses performing personal, business, and



AR00031537

professional services, increased most rapidly on Oahu during the period from 1954 to 1958, but their rate of growth fell slightly from 1958 to 1963. The levels of growth of receipts from retail sales have grown at an increasingly rapid pace during each of the periods: 1948-1954, 1954-1958, and 1958-1963.

The primary source of growth in employment was in the service sector, which was not only the most rapidly growing sector but, in addition, the second largest employer in the private component of the Oahu economy. The business comprising this sector employed approximately 39,000 persons in 1965, exceeded only by employment in retail trade, which generated a total of 46,000 jobs in that year. It is also of interest that the rate of growth of employment in retail trade exceeded the growth of all other major industrial sectors except the service sector. Thus, Oahu's two top employers were also the most important source of new employment opportunities. This trend, in combination with generally relatively modest increases or actual decreases elsewhere in the economy, resulted in a growing concentration of employment within these sectors, from 52 percent of total private employment in 1960 to a substantial 57 percent in 1965.

## 1. POPULATION

The assumed rate of growth of population for Oahu will expand from the current level of 618,000 to more than a million persons by 1985 (Table 3.1). Since our ultimate goal is the maintenance of full employment and rising levels of income per person, the population assumption is a crucial one. It will be the key determinant of the number of jobs that must be generated and the level of personal income that must be achieved. In considering this assumption of population growth, as well as the various measures of economic activity, it is well to remember that such estimates can only be interpreted as providing an indication of the general dimensions of the future economic structure and the relative magnitudes of the levels of industrial activity.

It is obvious that a primary determinant of the rate of population growth is in fact the rate of growth of employment opportunities and income generated by the economy. When deviations occur between the growth path required to implement the goals and that realized - or the required rates themselves change as objectives are more precisely defined - appropriate adjustments will be made to the expectations.



AR00031538

Table 3.1. Past and Projected Population,* Personal Income, and Per-Capita Personal Income for Oahu, 1960 to 1985

| Year | Population | Personal Income (Billion $) | Per-Capita Personal Income ($) |
|---|---|---|---|
| 1960 | 493,000 | 1.2 | 2,500 |
| 1965 | 584,000 | 1.6 | 2,700 |
| 1970 | 677,000 | 2.2 | 3,200 |
| 1975 | 780,000 | 3.0 | 3,800 |
| 1980 | 894,000 | 3.8 | 4,200 |
| 1985 | 1,014,000 | 4.7 | 4,600 |

*Excludes armed forces afloat and in barracks.

2. EMPLOYMENT

The primary source of new employment opportunities throughout the projection period is found in the service sectors and in retail trade. It is estimated that, by the end of the first ten years of the projection period, the service sector will displace retail trade as the primary source of employment opportunities. In addition, the trend of the 1960 to 1965 period, during which employment opportunities become increasingly concentrated in these sectors, will continue throughout the projection period. The proportion of employment concentrated in these sectors is anticipated to increase from the 1965 level of 65 percent to levels which will approach 70 percent by 1985 (Table 3.2).

Within the service sector, the area of banking and finance reigns as the largest employer. This industry includes businesses engaged in providing banking, finance, insurance, real estate, and business services (except firms classified in research and development). All industries within the service sector, including the largest, are growing rapidly, but the smallest in terms of present number of employees is the most dynamic. In 1960, an estimated 1,000 persons were engaged in businesses classified as primarily research and development. By 1965, this number had increased to almost 6,000. Knowledge of this new industry is negligible and the employment trend anticipated here is little more than an assumption that relatively rapid rates would be sustained through 1975.



AR00031539

Table 3.2. Past and Projected Values of Employment in the Private Sector of Oahu's Economy, 1960 through 1985

| Year | Employment by Private Sector of Oahu Economy (1000 persons) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Agricultural Complex* | Manufacturing ** | Contract Construction | Wholesale Trade and Transportation† | Utilities and Communications | Retail Trade ‡ | Services †† | Totals |
| 1960 | 13.3 | 7.6 | 15.5 | 18.1 | 3.8 | 38.7 | 28.9 | 125.9 |
| 1965 | 12.2 | 8.5 | 15.6 | 20.7 | 4.3 | 45.8 | 38.5 | 145.6 |
| 1970 | 11.2 | 9.9 | 17.9 | 24.2 | 5.1 | 57.0 | 52.5 | 177.8 |
| 1975 | 10.4 | 11.1 | 14.5 | 28.1 | 5.8 | 70.3 | 68.8 | 209.0 |
| 1980 | 9.5 | 12.0 | 13.9 | 30.6 | 6.4 | 78.6 | 85.7 | 236.7 |
| 1985 | 8.5 | 12.4 | 13.3 | 32.0 | 6.8 | 83.4 | 102.7 | 259.1 |

*Sugar, pineapple, other agriculture, forestry, mining, and food processing

**Textiles, apparel, printing, publishing, and other manufacturing

†Includes trucking and warehousing

‡Includes eating and drinking establishments, and amusements

††Banking and finance, hotels, health and professional services, education and other services, and research and development



AR00031540

The wholesale and transportation sector was, in 1965, and is expected to remain the third largest employer on Oahu. The gains in new employment opportunities in this, as in other industrial sectors in the Oahu economy, however, are anticipated to be relatively modest when contrasted with the service sector.

Contract construction ranks as the next most important employer. A relatively rapid increase in this industry is expected during the 1965 to 1970 period as construction of the interstate highway system is accelerated during the period from 1967 to 1972. The decline in employment levels following this construction period results in the realization of the relatively slow growth rate for the 1970 to 1975 period. Changes from the expected pattern of expenditures can readily be incorporated into the model, and employment levels can consequently be adjusted to reflect the new pattern of demand for employment by the construction industry.

Of the remaining sectors, manufacturing (other than food processing), utilities, and communications are expected to continue as relatively minor sources of new employment. Finally, employment within the agricultural complex is expected to continue to decline throughout the projection period. The primary exception to declining employment in the agricultural sector is in the food-processing industry, which registers small gains in employment.

In general, the anticipated pattern of employment in the private component of the Oahu economy will be increasingly oriented toward the service and trade sectors, continuing the general pattern observed in the 1960 to 1965 period. Private employment will continue to account for approximately three-fourths of total civilian employment with the remaining jobs generated by Federal, State, and County governments (Table 3.3).

Table 3.3. Past and Projected Values of Employment in the Government Sector of Oahu's Economy

| Year | Employment by Government Agencies (1000 persons) | | |
|---|---|---|---|
| | Military | Defense | Nondefense |
| 1960 | 42.2 | 18.5 | 24.5 |
| 1965 | 47.9 | 18.5 | 30.1 |
| 1970 | 44.8 | 18.0 | 39.2 |
| 1975 | 43.0 | 17.0 | 49.2 |
| 1980 | 41.2 | 17.0 | 59.8 |
| 1985 | 39.6 | 17.0 | 70.1 |



AR00031541

3. INCOME

Participation in current production of goods and services, indicated by the anticipated employment structure, will generate income levels as presented in Table 3.1. Personal income is anticipated to grow in this projected economy at a more rapid rate than population. Civilian per-capita personal income tends to increase throughout the projection period at a slightly inincreasing rate, reaching a level of $5,562 in 1985. The precise dollar-income estimate, of course, provides, as in the case of population and employment, only an indication of the general magnitude and the direction of the economy's growth.

4. PRODUCTION OF GOODS AND SERVICES

The basis for the formation of new employment opportunities and income is the expanding production of Oahu's industries in response to a growing demand.

The retail trade and service sectors are the economy's most important industries in terms of both total values of output and anticipated growth production (Table 3.4). However, the output of other industrial sectors, though not primary producers of new employment opportunities, is also expected to grow at relatively rapid rates. By 1985 these sectors are expected to account for close to 50 percent of total output compared to 70 percent of employment. It is the combination of rapid growth of output plus relatively slow growth of output per worker that makes the service sector and retail trade the economy's primary job producer.

In the agricultural industries at the other extreme, an expansion of output is accompanied by decreases in employment, as can be seen by comparing the appropriate columns in Tables 3.2 and 3.4.

5. SOME REQUIREMENTS FOR GROWTH

The growth of output for goods and services occurs in response to demand. The composition of demand will, of course, affect the structure of the economy--the relative importance of industries and growth of employment and income. Some of the important components of demand giving rise to the projected output are presented in Table 3.4. Over the long run some of these components may gain added strength, others may deteriorate, giving rise, as suggested previously, to a slightly different pattern of growth.



AR00031542

Table 3.4. Past and Projected Values of Output in the Private Sector of Oahu's Economy

| Year | Output of Private Sector of Oahu Economy ($1,000,000)* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Agricultural Complex** | Manufacturing *** | Contract Construction | Wholesale Trade and Transportation† | Utilities and Communications | Retail Trade‡ | Services†† | Totals |
| 1960 | 230.7 | 123.3 | 250.0 | 225.5 | 70.7 | 254.9 | 230.9 | 1386.0 |
| 1965 | 282.7 | 174.6 | 349.4 | 325.8 | 110.7 | 368.8 | 380.3 | 1992.3 |
| 1970 | 350.9 | 252.6 | 499.3 | 478.6 | 170.1 | 570.2 | 624.4 | 2946.1 |
| 1975 | 442.5 | 359.4 | 551.2 | 690.2 | 254.7 | 878.0 | 997.7 | 4173.7 |
| 1980 | 548.7 | 494.4 | 700.5 | 948.4 | 373.6 | 1236.3 | 1480.7 | 5782.6 |
| 1985 | 678.3 | 664.2 | 881.0 | 1266.7 | 536.2 | 1677.2 | 2119.7 | 7823.3 |

*In current dollars

**Sugar, pineapple, other agriculture, forestry, mining, and food processing

***Textiles, apparel, printing, publishing, and other manufacturing

†Includes trucking and warehousing

‡Includes eating and drinking establishments, and amusements

††Banking and finance, hotels, health and professional services, education and other services, and research and development



AR00031543

Analyses of alternative patterns of demand indicate that the sought for growth of per-capita income and employment opportunities are heavily dependent on the expansion of the visitor industry, which has a potential to reach magnitudes well in excess of other known sources of growth. This is illustrated in Table 3.5, which represents a pattern of selected expenditures that is compatible with the growth of output, employment, and income previously discussed.

Table 3.5. Past and Projected Growth of Selected Major Expenditure Categories in Oahu, 1960 to 1985

| Year | Expenditure Category (Million $)* | | | | | | |
|---|---|---|---|---|---|---|---|
| | Visitors | Exports | Investment | | Federal Defense | Household | Total |
| | | | Private | Public | | | |
| 1960 | 123.4 | 106.2 | 210.4 | 62.9 | 370.0 | 832.2 | 1705.1 |
| 1965 | 219.0 | 118.5 | 284.9 | 89.3 | 455.0 | 1135.6 | 2302.3 |
| 1970 | 467.0 | 130.3 | 358.9 | 176.0 | 478.0 | 1551.9 | 3162.1 |
| 1975 | 910.6 | 140.6 | 496.2 | 116.6 | 519.0 | 2104.1 | 4287.1 |
| 1980 | 1391.9 | 151.9 | 654.7 | 137.7 | 555.0 | 2785.6 | 5676.8 |
| 1985 | 1981.9 | 164.2 | 838.8 | 168.6 | 590.0 | 3620.6 | 7364.1 |

*Current dollars

The expansion of visitor expenditures should be quite rapid during the next decade and may be interpreted as an optimistic influence of anticipated changes in the technology of the transportation industry. They represent a source of demand for goods and services that becomes increasingly important through time, far exceeding the anticipated magnitude of defense expenditures and expenditures for such traditional exports as sugar, pineapple, and apparel.

A possible alternative pattern of demand may occur as a result of a slower-than-anticipated expansion of visitor expenditures accompanied by a more rapid growth than anticipated in the demand for the services of research and development firms by the Federal government. This possibility alters the projected economy in a number of ways, for example, the pattern of employment is altered (e.g., fewer persons are employed in retail trade) influencing the distribution of income as more higher-income employment opportunities are generated.



AR00031544

If visitor expenditures grow at the anticipated rate and demand for the services of research and development firms exceeds expectations, then output, income, employment, and population will also exceed anticipated levels.

The examination of alternative patterns of growth gives emphasis to the importance of visitor expenditures to the economy (Table 3.5). Potential for growth can be found in other components of the economy but nowhere else does this potential reach the magnitude that is present in the visitor industry - 1600-percent growth in the 25-year period.

The expansion of this industry has been often discussed as undesirable since it tends to give rise to a pattern of growth that is heavily oriented toward labor-intensive, low-wage industries such as retail trade and personal services. But this pattern of growth is not likely to be appreciably altered during the projection period. The visitor industry constitutes a primary basis for expansion of employment opportunities and growth of income.

## C. DISTRIBUTION OF ECONOMIC ACTIVITIES

As economic studies must seek to express a rational judgment about the future level of economic activity in the Study Area and the resultant impact it will have on the physical development of the community, the distribution of economic-activity forecasts is usually accomplished in the land-use phase of the comprehensive planning process. Thus, the above statements refer only to estimated totals of the broad categories of activities anticipated in the period to 1985.



AR00031545

# APPENDIX III-A. ECONOMIC MODEL--LAND USE MODEL EMPLOYMENT SECTOR RELATIONSHIP

Table 3.A1. Economic Model, Standard Industrial Classification, Land Use Model Employment Sector Relationship

| Sector | Economic Model | Standard Industrial Classification | | Sector | Land Use Model |
|---|---|---|---|---|---|
| | Employer Unit | S.I.C. No. | Employer Unit | | Employer Unit |
| 1. | Sugar, Field & Mill | 0119 | Field Crops, Sugar | 1. | Sugar & Pineapple, Field & Mill (Portion) |
| | | 2060 | Sugar Processing | | |
| 2. | Pineapple Field & Canning | 0122 | Field Crops, Pineapple | 1. | Sugar & Pineapple, Field & Mill (Portion) |
| | | 2034 | Pineapple Canning | | |
| 3. | Other Agriculture, Forestry, Fisheries, & Mining | 0123 | Vegetable Farms | 2. | Other Agriculture |
| | | 0133 | Poultry Farms | | |
| | | 0132 | Dairy Farms | | |
| | | 0193 | Animal Specialties, Foxes, Mink, etc. | | |
| | | 0192 | Horticultural Specialties, Including Green Houses | | |
| | | 0140 | General Farms | | |
| | | 0139 | Hog Farms | | |
| | | 0110 | Field Crops Other Than Sugar & Pineapple | | |
| | | 1441 | Sand & Gravel Mining | | |
| | | 1400 | Metallic & Non-Metallic Mining, Excluding Sand & Gravel | | |
| | | 1310 | Petroleum & Gas Wells | | |
| | | 0980 | Fishery Services | | |
| | | 0919 | Miscellaneous Marine Products | | |
| | | 0913 | Shell Fish | | |
| | | 0912 | Fin Fish | | |
| | | 0860 | Gathering of Forest Products, NEC | | |
| | | 0850 | Forestry Service | | |
| | | 0840 | Gathering of Gum & Bark | | |
| | | 0820 | Forest Nurseries and Tree & Seed Gathering, Extracting | | |
| | | 0811 | Timber Farms | | |



AR00031548

Table 3.A1 - continued

| Sector | Economic Model Employer Unit | S.I.C. No. | Standard Industrial Classification Employer Unit | Sector | Land Use Model Employer Unit |
|---|---|---|---|---|---|
| | | 0214 | Institutional Farms | | |
| | | 0199 | N.E.C.* | | |
| 4. | Other Food Processing | 2020 | Dairy Products - Egg Prep. & Packaging | 3. | Other Food Processing |
| | | 2010 | Meat Products | | |
| | | 2090 | N.E.C. Food & Kindred Products | | |
| | | 2080 | Beverage Industry | | |
| | | 2070 | Confectionary & Related Products | | |
| | | 2050 | Bakery Products | | |
| | | 2040 | Grain Mill Products | | |
| | | 2030 | Canning & Preserving, Fruits, Vegetables, & Seafoods, Other Than Pineapples | | |
| 5. | Apparel, Textiles, Printing, Publishing & Related Manufacturing | 2260 | Dyeing & Finishing Textile Mills | 4. | Apparel, Textiles, Printing & Publishing |
| | | 2250 | Knitting Mills | | |
| | | 2240 | Narrow Fabrics & Other Small Wares Mills | | |
| | | 2210 | Broadwoven Fabric Mills | | |
| | | 2740 | Miscellaneous Publishing | | |
| | | 2730 | Books | | |
| | | 2720 | Periodicals--Publishing, Publishing & Printing | | |
| | | 2710 | Newspapers--Publishing, Publishing & Printing | | |
| | | 2390 | Miscellaneous Fabricated | | |
| | | 2380 | Miscellaneous Apparel & Accessories Textile Products | | |
| | | 2370 | Fur Goods | | |

*Not elsewhere classified



AR00031549

Table 3.A1 - continued

| Sector | Economic Model | Standard Industrial Classification | | Sector | Land Use Model |
|---|---|---|---|---|---|
| | Employer Unit | S.I.C. No. | Employer Unit | | Employer Unit |
| | | 2360 | Girls, Children's & Infants Outerwear | | |
| | | 2350 | Hats, Caps & Millinery | | |
| | | 2330 | Women's, Misses' & Junior's Clothing | | |
| | | 2320 | Men's, Youths' & Boys' Furnishings, Work Clothing | | |
| | | 2310 | Men's, Youths' & Boys' Suits, Coats & Overcoats | | |
| | | 2290 | N.E.C. Textile Mill Products | | |
| | | 2280 | Yarn & Thread Mills | | |
| | | 2270 | Floor Covering Mills | | |
| | | 3190 | N.E.C. Leather & Leather Products | | |
| | | 3170 | Handbags & Other Personal Leather Goods | | |
| | | 3160 | Luggage | | |
| | | 3150 | Leather Gloves & Mittens | | |
| | | 3140 | Footwear, Except Rubber | | |
| | | 3130 | Boots & Shoe Cut Stock & Finishing | | |
| | | 3120 | Industrial Leather Belting & Packing | | |
| | | 3110 | Leather Tanning & Finishing | | |
| | | 3070 | Plastic Products N.E.C. | | |
| | | 3060 | Fabricated Rubber Products, N.E.C. | | |
| | | 3030 | Reclaimed Rubber | | |
| | | 3020 | Rubber Footwear | | |
| | | 3010 | Tires & Tubing | | |
| | | 2799 | Printing, Publishing & Allied Industries | | |
| | | 2790 | Service Industries for Printing Trade | | |
| | | 2780 | Bookbinding & Related Industries | | |



AR00031550

Table 3.A1 - continued

| Sector | Economic Model Employer Unit | S.I.C. No. | Standard Industrial Classification Employer Unit | Sector | Land Use Model Employer Unit |
|---|---|---|---|---|---|
| | | 2770 | Greeting Card Manufacturing | | |
| | | 2760 | Manifold Business Forms--Manufacturing | | |
| | | 2750 | Commercial Printing | | |
| | | 3990 | N.E.C. Miscellaneous Manufacturing Industries | | |
| | | 3960 | Costume Jewelry, Costume Novelties, Buttons, etc. | | |
| | | 3950 | Pens, Pencils, Other Office & Artist's Materials | | |
| | | 3940 | Toys, Amusement, Sporting & Athletic Goods | | |
| | | 3930 | Musical Instruments & Parts | | |
| | | 3910 | Jewelry, Silverware & Plated Ware | | |
| 6. | Other Manufacturing | 3890 | N.E.C. Prof. Scientific Photo, Optical, Chronometer Goods | 5. | Other Manufacturing |
| | | 3870 | Watches, Clocks, Clockwork Operated Devices & Parts | | |
| | | 3860 | Photographic Equipment & Supplies | | |
| | | 3850 | Ophthalmic Goods | | |
| | | 3840 | Surgical, Medical & Dental Instruments & Supplies | | |
| | | 3830 | Optical Instruments & Lenses | | |
| | | 3820 | Instruments for Measuring, Controlling, Indicating, Physical, etc. | | |
| | | 3810 | Eng., Lab., Scientific & Research Equipment, Associated Equipment | | |
| | | 3790 | Miscellaneous Transportation Equipment N.E.C. | | |
| | | 3750 | Motorcycles, Bicycles & Parts | | |



AR00031551

Table 3.A1 - continued

| Sector | Economic Model Employer Unit | Standard Industrial Classification S.I.C. No. | Employer Unit | Sector | Land Use Model Employer Unit |
|---|---|---|---|---|---|
| | | 3740 | Railroad Equipment | | |
| | | 3730 | Ship & Boat Building Repair | | |
| | | 3720 | Aircraft & Parts | | |
| | | 3710 | Motor Vehicles & Motor Vehicle Equipment | | |
| | | 3690 | N.E.C. Electrical Machinery | | |
| | | 3670 | Electronic Components & Accessories | | |
| | | 3660 | Communication Equipment | | |
| | | 3650 | Radio Television Receiving Sets, etc. | | |
| | | 3640 | Electric Lighting & Wiring Equipment | | |
| | | 3630 | Household Appliances | | |
| | | 3620 | Electrical Industrial Apparatus | | |
| | | 3610 | Electric Transmission & Distribution Equipment | | |
| | | 2820 | Plastic Materials, etc. | | |
| | | 2810 | Industrial Inorganic & Organic Chemicals | | |
| | | 2950 | Paving & Roofing Materials | | |
| | | 2910 | Petroleum Refining | | |
| | | 2890 | N.E.C. Chemicals & Allied Products | | |
| | | 2870 | Agricultural Products Chemicals | | |
| | | 2860 | Gum & Wood Chemicals | | |
| | | 2850 | Paints, Varnishes, Lacquers, etc. | | |
| | | 2840 | Soaps, Detergents, etc. | | |
| | | 2830 | Drugs | | |
| | | 2999 | N.E.C. Petroleum Refining & Related Industries | | |
| | | 2990 | Miscellaneous Products of Petroleum & Coal | | |
| | | 3211 | Flat Glass | | |



AR00031552

Table 3.A1 - continued

| Sector | Economic Model | Standard Industrial Classification | | Sector | Land Use Model |
|---|---|---|---|---|---|
| | Employer Unit | S.I.C. No. | Employer Unit | | Employer Unit |
| | | 3590 | N.E.C. Machinery-Except Electrical | | |
| | | 3580 | Service Industry Machinery | | |
| | | 3570 | Office, Computing & Accounting Machines | | |
| | | 3560 | General Industrial Machinery & Equipment | | |
| | | 3550 | Special Industrial Machines, Except Metal Working Machines | | |
| | | 3540 | Metal Working Machinery & Equipment | | |
| | | 3530 | Construction, Mining & Equipment | | |
| | | 3520 | Farm Machinery & Equipment | | |
| | | 3510 | Engines & Turbines | | |
| | | 3490 | N.E.C. Fabricated Metal Products, Excluding Ord. Mach. & Trans. Equipment | | |
| | | 3470 | Coating, Engraving & Allied Services | | |
| | | 3461 | Metal Stampings | | |
| | | 3450 | Screw Machine Products & Bolts, etc. | | |
| | | 3440 | Fabricated Structural Metal Products, etc. | | |
| | | 3430 | Heating Apparatus (Except Electric, etc.) | | |
| | | 3420 | Cutlery, Handtools & General Hardware | | |
| | | 3411 | Metal Cans | | |
| | | 3390 | N.E.C. Primary Metal Industries | | |
| | | 3360 | Non-Ferrous Foundries | | |
| | | 3350 | Rolling, Drawing, & Extruding, etc. | | |
| | | 3340 | Secondary Smelting & Refining, etc. | | |



AR00031553

Table 3.A1 - continued

| Sector | Economic Model | Standard Industrial Classification | | Sector | Land Use Model |
|---|---|---|---|---|---|
| | Employer Unit | S.I.C. No. | Employer Unit | | Employer Unit |
| | | 3330 | Primary Smelting & Refining, etc. | | |
| | | 3320 | Iron & Steel Foundries | | |
| | | 3310 | Blast Furnaces, Steelwork, etc. | | |
| | | 3290 | Abrasives, Asbestos, etc. | | |
| | | 3281 | Cut Stone & Stone Products | | |
| | | 3270 | Concrete, Gypsum & Plaster Products | | |
| | | 3260 | Pottery & Related Products | | |
| | | 3250 | Structural Clay Products | | |
| | | 3241 | Cement, Hydraulic | | |
| | | 3220 | Glass & Glassware, Pressed or Blown | | |
| | | 2411 | Logging Camps & Contractors | | |
| | | 2490 | N.E.C. Wood Preserving | | |
| | | 2440 | Wooden Containers | | |
| | | 2430 | Millwork, Veneer, Plywood, etc. | | |
| | | 2420 | Sawmills & Planing Mills | | |
| | | 2690 | N.E.C. Paper & Allied Products | | |
| | | 2660 | Building Paper & Building Board Mills | | |
| | | 2650 | Paperboard Containers & Boxes | | |
| | | 2640 | Converted Paper & Paperboard Products, etc. | | |
| | | 2630 | Paperboard Mills | | |
| | | 2620 | Paper Mills, Except Building Paper Mills | | |
| | | 2610 | Pulp Mills | | |
| | | 2540 | N.E.C. Venetian Blinds & Shade, etc. | | |
| | | 2540 | Partitions, Shelving, Lockers, etc. | | |
| | | 2530 | Public Buildings & Related Furniture | | |



AR00031554

Table 3.A1 - continued

| Sector | Economic Model Employer Unit | S.I.C. No. | Standard Industrial Classification Employer Unit | Sector | Land Use Model Employer Unit |
|---|---|---|---|---|---|
| | | 2520 | Office Furniture | | |
| | | 2510 | Household Furniture | | |
| 7. | Contract Construction | 1799 | N.E.C. Construction Services | 6. | Contract Construction |
| | | 1799 | N.E.C. Special Trade Contractors | | |
| | | 1795 | General Wrecking Concerns with Storage Yards | | |
| | | 1781 | Water Well Drilling | | |
| | | 1771 | Concrete Work | | |
| | | 1761 | Roofing & Sheet Metal Work | | |
| | | 1511 | General Building Contractors | | |
| | | 1711 | Plumbing, Heating & Air Conditioning | | |
| | | 1600 | General Highway & Heavy Equipment Contractors | | |
| | | 1750 | Carpentry & Wood Flooring | | |
| | | 1740 | Masonry, Stonework, Tile, Plastering | | |
| | | 1731 | Electrical Work | | |
| | | 1721 | Painting, Paper Hanging, Decorating | | |
| 8. | Wholesale, Trade, Trucking, Warehousing & Related Services | 4731 | Stock Yards | 7. | Wholesale Trade |
| | | 4299 | N.E.C. Yard Use | | |
| | | 4225 | General Merchandise & Industrial Products | | |
| | | 4224 | Household Goods Warehousing & Storage | | |
| | | 4223 | Food Lockers | | |
| | | 4222 | Refrigerated Warehousing Except Food Lockers | | |
| | | 4221 | Grain Elevators & Storage | | |
| | | 4221 | Other Farm Products | | |



AR00031555

Table 3.A1 - continued

| Sector | Economic Model | Standard Industrial Classification | | Sector | Land Use Model |
|---|---|---|---|---|---|
| | Employer Unit | S.I.C. No. | Employer Unit | | Employer Unit |
| | | 5099 | N.E.C. Wholesalers with Stock | | |
| | | 5099 | N.E.C. Wholesalers without Stock | | |
| | | 5099 | N.E.C. Extensive Yard Use | | |
| | | 5099 | N.E.C. Wholesalers with Stock | | |
| | | 5098 | Lumber Storage | | |
| | | 5093 | Junk, Salvage, Scrap Iron & Metal Yards | | |
| | | 5092 | Petroleum Bulk Plants & Terminals | | |
| | | 5090 | Petroleum Products & Raw Materials | | |
| | | 5080 | Machinery, Equipment & Supplies | | |
| | | 5080 | Machinery, Equipment & Supplies | | |
| | | 5060 | Electrical Goods & Hardware | | |
| | | 5060 | Electrical Goods, Hardware & Supplies | | |
| | | 5050 | Farm Products, Raw Materials | | |
| | | 5050 | Farm Products & Raw Materials | | |
| | | 5040 | Groceries & Related Items | | |
| | | 5040 | Groceries & Related Products | | |
| | | 5030 | Dry Goods & Apparel | | |
| | | 5030 | Dry Goods & Apparel | | |
| | | 5022 | Drugs, Chemicals & Allied Products | | |
| | | 5020 | Drugs, Chemicals, Allied Products | | |
| | | 5010 | Motor Vehicles & Equipment | | |
| | | 5010 | Motor Vehicles & Equipment | | |
| | | 5099 | Petroleum Products, Raw Materials Wholesalers without Stock | | |
| 9. | Other Transportation | 4172 | Maintenance & Storage--Buses & Streetcars | 8. | Other Transportation |
| | | 4172 | Maintenance & Storage--Tour Buses | | |
| | | 4172 | Maintenance & Storage--Taxicabs | | |
| | | 4172 | Maintenance & Storage--School Buses | | |



AR00031556

Table 3.A1 - continued

| Sector | Economic Model Employer Unit | S.I.C. No. | Standard Industrial Classification Employer Unit | Sector | Land Use Model Employer Unit |
|---|---|---|---|---|---|
| | | 4121 | Passenger Terminals--Taxicabs | | |
| | | 4111 | Passenger Terminals--Subway--Elevated | | |
| | | 4111 | Maintenance & Storage--Subway Elevated Cars | | |
| | | 4111 | Passenger Terminals--Buses & Street Cars | | |
| | | 4099 | N.E.C. Railroads | | |
| | | 4299 | N.E.C. Buses, School Buses & Subway Elevated | | |
| | | 4462 | Maintenance & Storage--Vessels | | |
| | | 4583 | Freight Terminals--Air Transportation | | |
| | | 4582 | Maintenance & Storage--Airplanes | | |
| | | 4582 | Airfields | | |
| | | 4462 | Piers & Docks | | |
| | | 4699 | N.E.C. Water & Pipeline Transportation | | |
| | | 4600 | Pipeline Rights-of-Way | | |
| | | 4599 | N.E.C. Air Transportation | | |
| | | 4583 | Passenger Terminals--Air Transportation | | |
| | | 4013 | Freight Railroad Terminals | | |
| | | 4013 | Roundhouse & Maintenance | | |
| | | 4013 | Switchyards | | |
| | | 4013 | Passenger Railroad Terminals | | |
| | | 0000 | Rights-of-Way | | |
| | | 4231 | Truck Terminals | 9. | Utilities & Communications (Portions) |
| | | 4212 | Maintenance & Storage-Trucks | | |
| | | 4789 | N.E.C. Motor Freight Transportation | | |



AR00031557

Table 3.A1 - continued

| Sector | Economic Model Employer Unit | S.I.C. No. | Standard Industrial Classification Employer Unit | Sector | Land Use Model Employer Unit |
|---|---|---|---|---|---|
| 10. | Utilities & Communication | 4811 | Telephone Communication Centers | | |
| | | 4999 | N.E.C. Utilities | | |
| | | 4953 | Refuse Plants--Incinerators | | |
| | | 4953 | Refuse Disposal Site | | |
| | | 4952 | Sanitary Pump Stations | | |
| | | 4952 | Sanitary Plants | | |
| | | 4941 | Water Reservoirs | | |
| | | 4941 | Water Pump Stations | | |
| | | 4925 | Gas Plants | | |
| | | 4925 | Gas Sub-Station or Rights-of-Way | | |
| | | 4911 | Electric Plants | | |
| | | 4911 | Electric Sub-Stations or Rights-of-Way | | |
| | | 4899 | Booster Station-Telegraph | | |
| | | 4899 | Booster Station-Radio & Television | | |
| | | 4899 | N.E.C. Communications | | |
| | | 4899 | Booster Station-Telephone | | |
| | | 4833 | Television Broadcasting | | |
| | | 4832 | Radio Broadcasting | | |
| | | 4821 | Telegraph Communication Centers | | |
| | | 7351 | News Syndicates | | |
| 11. | Retail Trade (excluding Eating & Drinking Places) | 5410 | Super Markets | 10. | Retail Convenience Goods (Portion) |
| | | 5411 | General Groceries | | |
| | | 5411 | Delicatessens | | |
| | | 5422 | Meat & Poultry Stores (Retail) | | |
| | | 5423 | Fish & Seafood Stores (Retail) | | |
| | | 5431 | Fruit Stores & Vegetable Markets | | |
| | | 5441 | Candy, Nut & Confectionery Stores | | |
| | | 5451 | Dairy Products Store (Retail) | | |
| | | 5499 | N.E.C. Food Stores (Retail) | | |
| | | 5460 | Retail Bakeries | | |



AR00031558

Table 3.A1 - continued

| Sector | Economic Model Employer Unit | S.I.C. No. | Standard Industrial Classification Employer Unit | Sector | Land Use Model Employer Unit |
|---|---|---|---|---|---|
| | | 5912 | Drug Stores, Except Apothecaries | | |
| | | 5912 | Apothecaries | | |
| | | 5971 | Jewelry Stores | 11. | Retail Shopping Goods |
| | | 5722 | Household Applicance Store | | |
| | | 5713 | Floor Covering Store | | |
| | | 5712 | Furniture Store | | |
| | | 5710 | Home Furnishing, Except Appliances | | |
| | | 5681 | Furrier & Fur Shops | | |
| | | 5671 | Custom Tailors & Dressmaking Shops | | |
| | | 5660 | Shoe Stores | | |
| | | 5651 | Family Apparel Stores | | |
| | | 5641 | Children's & Infant's Wear Stores | | |
| | | 5631 | Millinery | | |
| | | 5621 | Women's, Girls' Apparel & Accessories | | |
| | | 5610 | Men's, Boys' Apparel & Accessories | | |
| | | 5699 | N.E.C. Apparel & Accessories | | |
| | | 5930 | Second Hand Establishments | | |
| | | 5399 | Army Surplus Store | | |
| | | 5392 | General Merchandise & Dry Goods | | |
| | | 5351 | Direct Selling Organizations | | |
| | | 5341 | Merchandise Vending Machine Operators | | |
| | | 5331 | Limited Price Variety Stores | | |
| | | 5320 | Mail Order Houses | | |
| | | 5311 | Department Stores | | |
| | | 5399 | N.E.C. General Merchandise | | |
| | | 5211 | Lumber Dealers | 12. | Retail Other Goods |
| | | 5231 | Paints, Glass, Wallpaper | | |
| | | 5212 | Other Building Materials Dealers | | |



AR00031559

Table 3.A1 - continued

| Sector | Economic Model Employer Unit | S.I.C. No. | Standard Industrial Classification Employer Unit | Sector | Land Use Model Employer Unit |
|---|---|---|---|---|---|
| | | 5299 | N.E.C. Lumber & Building Materials | | |
| | | 5252 | Farm Equipment | | |
| | | 5251 | Hardward Stores | | |
| | | 5241 | Electrical Supply Stores | | |
| | | 5999 | Office, Store Machine, Equipment and Supplies | | |
| | | 5998 | Optical Goods | | |
| | | 5997 | Gifts, Novelties & Souvenirs | | |
| | | 5996 | Camera & Photo Supplies | | |
| | | 5992 | Florists | | |
| | | 5952 | Sporting Goods & Bicycles | | |
| | | 5921 | Liquor Stores | | |
| | | 5599 | Other, Motor Vehicle & Accessories | | |
| | | 5599 | Marine Accessories | | |
| | | 5599 | Boats, New & Used | | |
| | | 5591 | Household Trailers | | |
| | | 5541 | Gasoline Service Stations | | |
| | | 5531 | Tires, Batteries, Auto Parts & Accessories | | |
| | | 5521 | Auto, Truck Motorcycle Dealers - Used | | |
| | | 5511 | Auto, Truck, Motorcycle Dealers - New & Used | | |
| | | 5999 | N.E.C. Retail Trade Stores | | |
| | | 4721 | Travel Agencies | 13. | Retail Personal Services (Portion) |
| | | 7241 | Barber Shops | | |
| | | 7231 | Beauty Shops | | |
| | | 7221 | Photographic Studios, Including Commercial | | |
| | | 7211 | Laundries, Cleaning & Dyeing | | |
| | | 7251 | Shoe Repair, Shine, Hat Cleaning | | |



AR00031560

Table 3.A1 - continued

| Sector | Economic Model | Standard Industrial Classification | | Sector | Land Use Model |
|---|---|---|---|---|---|
| | Employer Unit | S.I.C. No. | Employer Unit | | Employer Unit |
| | | 7261 | Funeral Services & Crematories | | |
| | | 7271 | Cleaning, Pressing & Alterations | | |
| | | 7299 | Dressmaker's, Customer Supplies Material | | |
| | | 7299 | N.E.C. Personal Services | | |
| | | 7511 | Auto and Truck Laundries | 14. | Retail Business Services (Portion) |
| | | 7541 | Auto Laundries | | |
| | | 7538 | General Repair Shops, No Sales | | |
| | | 7534 | Tire & Tube Service, No Sales Outlet | | |
| | | 7533 | Radiator Repair | | |
| | | 7531 | Body & Fender Repair | | |
| | | 7699 | Typewriter Repair | | |
| | | 7699 | N.E.C. Miscellaneous Repair & Related Services | | |
| | | 7694 | Armature Rewinding, Motor Repair and Rewinding | | |
| | | 7641 | Re-Upholstery & Furniture Repair | | |
| | | 7631 | Watch, Clock & Jewelry Repair | | |
| | | 7621 | TV & Radio Repair | | |
| | | 7621 | Electrical Repair Shops, Excluding TV & Radio | | |
| | | 7213 | Linen & Uniform Supply Services | | |
| | | 7599 | N.E.C. Automotive Repair Shops | | |
| | | 7522 | Garage Parking | | |
| | | 7521 | Open Lot for Parking | | |
| | | 7520 | Municipal Parking | | |
| | | 7699 | General Fixit Shops, Lawn Mower Repair, etc. | | |
| | | 7549 | N.E.C. Parking Services | | |



AR00031561

Table 3.A1 - continued

| Sector | Economic Model | Standard Industrial Classification | | Sector | Land Use Model |
|---|---|---|---|---|---|
| | Employer Unit | S.I.C. No. | Employer Unit | | Employer Unit |
| 12. | Eating & Drinking Places & Amusement Services | 5812 | Eating Places without Drive-In Facilities | 10. | Retail Convenience Goods (Portion) |
| | | 5812 | Eating Places with Drive-In Facilities | | |
| | | 5813 | Taverns & Bars | | |
| | | 5899 | N.E.C. Eating & Drinking Places | | |
| | | 5812 | Ice Cream Establishments | | |
| | | 5812 | Roadside Stands-All Types | | |
| | | 7811 | Motion Picture Prod. & Distributors | 13. | Retail Personal Services (Portion) |
| | | 7949 | Amusement Parks | | |
| | | 7949 | Penny Arcade | | |
| | | 7949 | Auditoriums, Armories, Field Houses | | |
| | | 7949 | N.E.C. Comm. Amusement & Recreation Outdoor-Private | | |
| | | 7945 | Roller & Ice Skating Rinks | | |
| | | 7942 | Golf Courses (Private), Country Clubs | | |
| | | 7941 | Stadia | | |
| | | 7931 | Billiard & Pool & Bowling Alleys | | |
| | | 7921 | Legitimate Theaters | | |
| | | 7911 | Dance Halls, Studios, Hula Studios | | |
| | | 7831 | Motion Picture Theaters Except Drive-In | | |
| | | 7830 | Drive-In Theaters | | |
| | | 7949 | N.E.C. Sports Operators & Promoters | | |
| | | 7032 | Camps (Boy Scouts, etc.) | 16. | Public Amusement (Outdoor Activities) |
| | | 7032 | Fishing Sites | | |
| | | 7949 | Marinas | | |
| | | 7949 | Golf Course (Public) | | |
| | | 7949 | Subdivision Community Centers | | |



AR00031562

Table 3.A1 - continued

| Sector | Economic Model | Standard Industrial Classification | | Sector | Land Use Model |
|---|---|---|---|---|---|
| | Employer Unit | S.I.C. No. | Employer Unit | | Employer Unit |
| | | 7949 | N.E.C. Recreation | | |
| | | 7949 | Subdivision Parks | | |
| | | 7949 | Boating Areas | | |
| | | 7949 | Gun Clubs | | |
| | | 7948 | Race Tracks | | |
| | | 7946 | Riding Academies | | |
| | | 7945 | Skating Rinks (Public) | | |
| | | 7944 | Swimming Pools | | |
| | | 7943 | Bathing Beaches | | |
| 13. | Banking & Finance | 7321 | Consumer Credit Reporting | 14. | Retail Business Services (Portion) |
| | | 7310 | Advertising Firms | | |
| | | 7340 | Services to Dwellings, Window Cleaning, Insect Exterminating | | |
| | | 7332 | Blueprinting & Photocopying Service | | |
| | | 7331 | Duplicating, Addressing & Mailing Service | | |
| | | 7399 | N.E.C. Misc. Business Services | | |
| | | 7392 | Business & Management Consulting | | |
| | | 7391 | Research--Testing--Development Labs. | | |
| | | 7361 | Employment Agencies | | |
| | | 6720 | Security-Brokerage-Holding-Investment Companies | | |
| | | 6551 | Cemeteries | | |
| | | 6551 | Subdivision & Development Companies | | |
| | | 6541 | Title Abstract Companies | | |
| | | 6053 | Currency Exchange | | |
| | | 6000 | Banks | | |
| | | 6531 | Real Estate Companies, Agents-Brokers-Managers | | |



AR00031563

Table 3.A1 - continued

| Sector | Economic Model Employer Unit | S.I.C. No. | Standard Industrial Classification Employer Unit | Sector | Land Use Model Employer Unit |
|---|---|---|---|---|---|
| | | 6300 | Insurance-Brokerage-Carrier Cos. | | |
| | | 6140 | Credit Agencies Other Than Banks | | |
| | | 6120 | Savings & Loan Associations Other Than Banks | | |
| | | 0000 | N.E.C. Finance, Insurance & Real Estate | | |
| 14. | Hotels | 7011 | Hotels, year around | 17. | Hotels |
| 15. | Health, Legal & Professional Services (Except Education) | 8011 | Physicians & Surgeons | 13. | Retail Personal Services (Portion) |
| | | 8041 | Chiropractors | | |
| | | 8031 | Osteopaths | | |
| | | 8021 | Dental & Dental Surgeons | | |
| | | 8070 | Medical & Dental Laboratories | | |
| | | 8099 | N.E.C. Medical & Health Services | | |
| | | 8099 | Optometrists | | |
| | | 8099 | Radiologists | | |
| | | 8111 | Legal Offices | 14. | Retail Business Services (Portion) |
| | | 8911 | Engineering Offices | | |
| | | 8911 | Architectural Offices | | |
| | | 8931 | Accounting, Auditing, & Bookkeeping | | |
| | | 8921 | Non-Profit Educational & Scientific Research | | |
| | | 8999 | N.E.C. Professional Services | | |
| | | 8999 | N.E.C. Consumer Services | | |
| | | 8061 | Public Hospitals, City & County | 15. | Public & Quasi-Public (Portion) |
| | | 8061 | State Hospitals | | |
| | | 8099 | Homes for Aged | | |
| | | 8099 | Orphanages | | |
| | | 8099 | N.E.C. Hospitals | | |



AR00031564

Table 3.A1 - continued

| Sector | Economic Model Employer Unit | S.I.C. No. | Standard Industrial Classification Employer Unit | Sector | Land Use Model Employer Unit |
|---|---|---|---|---|---|
| | | 8099 | Deaf & Blind Homes & Institutions | | |
| | | 8099 | Outpatient Clinics | | |
| | | 8099 | Mental Institutions | | |
| | | 8099 | N.E.C. Institutional Facilities | | |
| | | 8061 | Military Hospitals | | |
| | | 8092 | Sanatoria | | |
| | | 8092 | Convalescent & Nursing Homes | | |
| | | 8071 | Medical Research Institutions | | |
| | | 8061 | Private Hospitals | | |
| 16. | Education & Other Services (Including Domestics) | 8699 | Other Educ., Relig. + C | | |
| | | 8699 | N.E.C. Religious Institutions | | |
| | | 8699 | N.E.C. Charitable, Non-Profit Organizations | | |
| | | 8699 | Neighborhood or Settlement House | | |
| | | 8671 | Salvation Army | | |
| | | 8671 | Red Cross | | |
| | | 8661 | Convents & Monasteries | | |
| | | 8661 | Churches & Synagogues | | |
| | | 8651 | Political Organizations | | |
| | | 8641 | Civil, Social & Fraternal | | |
| | | 8641 | Y.M.C.A., Y.W.C.A. | | |
| | | 8631 | Unions | | |
| | | 8611 | Business Associations | | |
| | | 8499 | N.E.C. Cultural Centers | | |
| | | 8411 | Art Galleries | | |
| | | 8411 | Museums | | |
| | | 8299 | N.E.C. Educational Institutions | | |
| | | 8299 | Language Schools | | |
| | | 8242 | Vocational Schools | | |
| | | 8242 | Business Schools | | |
| | | 8211 | Secondary Schools | | |



AR00031565

Table 3.A1 - continued

| Sector | Economic Model | Standard Industrial Classification | | Sector | Land Use Model |
|---|---|---|---|---|---|
| | Employer Unit | S.I.C. No. | Employer Unit | | Employer Unit |
| | | 8231 | Libraries | | |
| | | 8221 | Junior Colleges, Colleges, Universities + Professional Schools | | |
| | | 8211 | Elementary Schools | | |
| | | 8211 | Nurseries & Kindergartens | | |
| 17. | Non-Defense Government Employees | 9190 | Federal Offices | 15. | Public Administration (Portion) |
| | | 9181 | Federal Courts | | |
| | | 9279 | Regional Parks | | |
| | | 9190 | Branch Post Office | | |
| | | 9190 | Other Postal Outlets | | |
| | | 9190 | Central Post Office | | |
| | | 9379 | Arenas | | |
| | | 9290 | State Offices | | |
| | | 9281 | State Courts | | |
| | | 9379 | Community Centers | | |
| | | 9379 | N.E.C. Indoor Public Recreation Buildings | | |
| | | 9379 | Playgrounds, Playfields, Tot Lots | | |
| | | 9379 | Boating Areas | | |
| | | 9379 | Camps & Campgrounds | | |
| | | 9379 | Swimming Pools | | |
| | | 9379 | Golf Courses | | |
| | | 9379 | Marinas | | |
| | | 9379 | Beach Parks | | |
| | | 9379 | Bathing Beaches | | |
| | | 9490 | Foreign Country Offices | | |
| | | 9390 | Police Stations | | |
| | | 9390 | Fire Stations | | |
| | | 9390 | County Offices | | |
| | | 9390 | Municipal Offices | | |
| | | 9390 | N.E.C. Public Safety, Adm. | | |



AR00031566

Table 3.A1 - continued

| Sector | Economic Model | Standard Industrial Classification | | Sector | Land Use Model |
|---|---|---|---|---|---|
| | Employer Unit | S.I.C. No. | Employer Unit | | |
| | | 9384 | Botanical Parks, Arboreta | | |
| | | 9384 | Zoological Gardens | | |
| | | 9381 | Municipal Courts | | |
| | | 9381 | County Courts | | |
| | | 9379 | N.E.C. Outdoor Public Land Rec. | | |
| | | 9379 | Fishing Sites | | |
| | | 9379 | N.E.C. Outdoor Public Water Based Rec. | | |
| 18. | Military Personnel | 91 | Military Personnel | 21. | Military Personnel |
| 19. | Defense Government Employees | 91 | Federal Government excluding Military & Non-Defense Employees | 22. | Civilian Defense Employees |



AR00031567

# IV Land Use Study

# IV. LAND-USE STUDY

## A. INTRODUCTION

Land use is considered to be the best available base for studying urban-area activities. The type, intensity, and spatial distribution of land use determines the number and variety of trips generated by each sub-area of the region.

Land use and transportation planning are closely interrelated; they cannot be developed independently because each affects the other.

A complete inventory of existing land use is required to determine the quantitative relationships existing between land use and travel for transportation planning. Such an inventory, when coupled with a knowledge of historic development patterns, provides one of the best bases for understanding urban activity and for determining future land-use patterns.

A land-use forecast is not a land-use plan. A land-use plan is really a set of policies in graphic form. It is policy that shapes metropolitan areas, not whatever maps planners may wish to draw. Policies affecting highway or home construction, sewer service, park acquisition, and commercial and industrial development have an obvious impact on the way a metropolitan area grows. Alter these policies and you alter the pattern of growth.

The City and County of Honolulu, the Study Area, has an officially adopted set of policies, The Oahu General Plan, which guides overall development of the county in harmony with long-range objectives. This General Plan, adopted in 1964, presents in broad and general fashion the locations and boundaries of the various land-use designations. The objective of the land-use forecast in the Oahu Transportation Study is to forecast the requirements for land areas in which to live and work within the constraints of this General Plan.

Land-use forecasts were accomplished by a simulation model that traces out the evolution, step by step through time, of the many interdependent variables that determine land development on Oahu. The model contains four sub-models



AR00031569

that locate residents, retail employees, public employees, and industrial employees. Each submodel operates independently because of differences in the locational behavior of its location. Twenty-eight forecast values identified by census tract are produced by the land use model.

## B. LAND-USE INVENTORY

Existing land-use information was not available on a uniform, areawide basis for Oahu in a form suitable for both land-use and transportation planning. Consequently, an extensive existing land-use survey was required. The decision to collect data at the smallest unit of land measure, the parcel unit, rather than at the block or zone level, was to secure more refined data and to avoid duplication of work, to effect close coordination between the Oahu Transportation Study and the other Federally aided planning projects, and to effect ease in updating the data in the continuing, comprehensive, planning process.

### 1. THE PARCEL

The parcel of land defined by the tax key is the smallest unit of land measure for assessment and tax-account purposes. It is considered by the Land-Use Inventory as a single site containing an autonomous organization of activities.

As recorded at the Department of Taxation, State of Hawaii, the plan, which is made up of many parcels, comprises one taxation map. At the time of the Land-Use Inventory, there were 2,100 plats for the Study Area; the plat was used as a measure of work progress.

The tax zone (nine in the Study Area) was used by the inventory as a work area. Office and field activities were completed on a zone-by-zone basis to insure that all parcels were included. In many instances, parcel areas extended into other designated boundaries, but never across a tax-map zone boundary.

The block was used by the inventory as the basic unit for assembly of detailed information concerning parcel, structure, establishment, and street areas. Two types of blocks were utilized: 1) census blocks as designated by the 1960 Bureau of Census, and 2) land-use blocks established by the Oahu



AR00031570

Transportation Study. Where census blocks were too large to suit the needs of the inventory, they were subdivided and classified as land-use blocks; and where census blocks were lacking, land-use blocks were designated by the Study.

## 2. LAND-USE CLASSIFICATION

The most perplexing problem encountered in the organization of the Land-Use Inventory was the selection of a land-use classification system. Because of the multiple-purpose aspect in this inventory phase of the planning process, great care was exercised in deciding which land-use groupings would satisfy the needs of the agencies that would use the inventory. Considerable reliance was placed on expertise received from the Planning Departments of both the City and County of Honolulu and the State of Hawaii.

Four separate land-use systems were adopted to permit the inventory to be of maximum utility.

a. State Land-Use Designation. To preserve, to protect, and to encourage the development of lands in the State for those uses to which they are best suited for the public welfare and to create a complementary assessment basis according to the contribution to which they are best suited, the Legislature of the State of Hawaii enacted Act 187 which gave the State the power to zone all lands into one of four categories - urban, rural, agriculture, and conservation. The law was designed to preserve the State's vanishing agricultural lands, not only to assure a continued yield from those lands, but also to protect the State's natural beauty. Equally important was the intent to secure compact development of urban areas, thus holding down the cost of facilities and services.

The law created a State Land Use Commission which shall establish the boundaries of the land categories and which shall make a comprehensive review of the classification and districting of all lands of the regulations at the end of every five years following the adoption thereof. Thus, the Land-Use Inventory utilized a simple one-digit, four-category classification to permit this State-wide land-use designation in the land-use files.

b. General-Plan Designation. The General Plan, adopted in 1964 for the City and County of Honolulu, was designed to assure the coordinated development of the City and to promote the general welfare and prosperity of its



AR00031571

people. It established, in part, a pattern of land use for the most desirable use of land for recreation, residential, agricultural, commercial, industrial, and other purposes. This land-use inventory provided a two-digit, ten-category classification to permit this General Plan designation to be incorporated into the land use files [Ref. 1, Appendix D].

General Plan maps and reports are the principal documents used in the recording of the General Plan designations.

c. Generalized and Detailed Land-Use Classification [Ref. 1, Appendix B]. A four-digit classification system has been devised to identify the predominant use of the unit of land. The first three digits identify 123 generalized land uses while the fourth digit provides for 504 detailed land-use classifications of the generalized uses.

This system of generalized and detailed land-use classification system was motivated primarily by the desire to maintain the relationship with the land-use designations employed by the 1960 Origin-Destination Traffic Survey and to permit the grouping of land activities to serve the needs of other planning agencies.

d. Zoning Classification. Zoning is a scheme for defining an area for the purpose of regulating use, density of population, coverage of lots, bulk of structures, and general land-development provisions. Oahu's zoning laws date back to the early 1920's when they were made a part of the Building Code. As planning became recognized as a special field, the zoning ordinances were administered by the City Planning Commission.

From time to time, the zoning laws have been amended to keep pace with the change in living conditions, the trends of land uses, and the demands for the creation of better living conditions. The land-use inventory employed a two-digit code to identify the nine major and 24 minor zoning classifications [Ref. 1, Appendix C]. Information relative to adopted zoning was extracted from official zoning maps, which show the zoning as enacted by the City and County of Honolulu.

Pending before the City Council is a new Comprehensive Zoning Ordinance that implements the purpose and intent of the General Plan and provides reasonable standards with respect to the location, height, bulk, size of



AR00031572

buildings and other structures, yard areas, courts, off-street parking facilities and other open spaces, density of population, and the use of buildings, structures, and land for trade, industry, business, residence, or other purposes. The land-use inventory has provided, though not presently utilized, codes for these new designations.

3. BASIC FILES

The data collected from the land-use inventory were divided into three separate files.

a. The Parcel File. This file contains detailed information with respect to each parcel of land, such as General-Plan designation, generalized land use, zoning, land area, land tenure and number of separate structures.

b. The Structure File. This file contains data with respect to the structures (building and/or improvements) on each parcel. For each structure, the information includes total floor area, ground-floor area, exterior structural material, age and condition, type of occupancy, and parking facilities.

c. The Establishment File. This file supplements the parcel and structure files. The primary purpose of this record is to supply information relative to the business establishments such as area per floor, area per establishment, capacity, number of employees, gross income license number and type of business operation.

4. QUALITY CONTROL

In order to produce a high-quality inventory, careful attention was given to quality control. Quality-control checks included verification of data that were directly comparable among the parcel, structure, and establishment files; machine editing of each recorded field of the files; verification of land-use classification on a sample basis by field inspection; and control balancing of measured totals by plats, by tax-key divisions, and by the Study Area as a whole [Ref. 1, Appendixes F and G; Ref. 4, p. 68].



AR00031573

## C. EXISTING LAND USE

### 1. BRIEF HISTORY OF PHYSICAL DEVELOPMENT

Oahu with its many natural bays and beaches offered the early Hawaiians opportunities to establish many villages along its shoreline. The center of early development, however, was at Honolulu Harbor, at which time Waikiki was occupied as a village situated on the beach. In 1804, King Kamehameha established his capital in the area near the waterfront of Honolulu.

As fresh water became available, the Schofield Saddle, Ewa flats, and slopes of the Koolau Mountains were used for the cultivation of sugar cane and pineapples. Within each of these areas, a small town with its commercial area grew in much the same manner as farm cities developed in the mid-west. Later, the lands in the Waimanalo, Waialua, Kahuku, and Waianae districts were also utilized for sugar cane, and again small towns arose to provide the needs of the farming people. Most of these towns were centered around the mill and the small residential tracts created away from the commercial areas throughout the large sugar or pineapple fields to minimize the travel time from home to the fields. Kailua and Lanikai developed as weekend or summer recreational areas for those who could afford them. Today, the towns generally form the nucleus of the commercial areas of the various districts.

In the early 1900's major reclamation projects were initiated in Honolulu to fill and eliminate the swamp lands, which were considered deleterious to the public health. While major residential developments were centered around Honolulu, with subdivisions extending into the valley areas and along the slopes of the mountain ridges, the development of military bases in the rural areas of Oahu tended to stabilize the economy of the rural towns, such as Waianae, Wahiawa, Waialua-Haleiwa, Waipahu and Kailua.

During World War II, physical development on Oahu, other than for military uses, came to a virtual standstill. The relaxation of military restrictions, the availability of material for construction, and the savings of the people after the war created a great demand for new quarters with more breathing space.

The automobile decreased the public's dependence on public transit and people found it no longer necessary to live near the public transit system.



AR00031574

Owners of large tracts of land either sold portions of their land to developers or entered into the development field themselves. The first developments were extensions of existing residential areas or filling in of open-space areas between residential developments. Areas such as Waialae-Kahala, Palolo, and Aina Haina were developed to meet the housing needs of the people. Other persons found it more feasible to cross the Koolau Range into Kaneohe and Kailua because of the low cost of fee-simple properties and leaseholds there. Certain lands west of Honolulu were also developed.

The changes in agricultural practices, in scientific means of obtaining greater production per acre of land, and in business mergers permitted the release of marginal agricultural lands for development. Most of these areas were within 10 miles from the heart of the City of Honolulu, and they were considered suburban areas or dormitory areas of Honolulu.

As a result of a step-up in military activities during the Korean War and subsequent years, enlargement and modernization of some of the military bases increased activity in the surrounding neighborhoods and districts. Also, the Capehart Act provided homes for military families to meet about 50 percent of the military requirements. Military activities centralized at Barber's Point Naval Air Station brought about the Ewa Beach and Waianae developments. Increase of the Marine activities at Kaneohe Marine Corps Air Station created a demand for residential and apartment areas in Windward Oahu. Additional civilian and military personnel at Pearl Harbor and Hickam Air Force Base provide a boost for more residential developments.

In the last ten years, activities in tract housing developments and demands for apartment and co-op apartment living have increased. There is presently a trend in development of estate-type residential lots deep in the valleys and along mountain ridges. There are also increased activities in urban renewal where new co-operative apartments, and office and financial buildings now exceed heights of 15 to 20 stories.

A notable development on Oahu has occurred in the past few years. As a result of more leisure time, shorter working hours, and the desire for new recreational outlets, together with the influx of immigrants from the Mainland, interest in outdoor recreational facilities has increased, especially a deeper appreciation of the natural attributes and assets offered to persons working and living on Oahu.



AR00031575

## 2. GROSS USAGE

The Land-Use Inventory revealed that Oahu had a total land area of 381,310 acres, 595.8 square miles, in 1964. Approximately 51 percent of the total area (193,146 acres) was in use and 49 percent (188,164 acres) was undeveloped, vacant land (Table 4.1). Approximately 25 percent of the total vacant land (46,960 acres) was classed as usable and 75 percent (141,204 acres) as unusable - i.e., forest reserves, lakes, islets, canals, steep lands (slopes over 20 percent), derelict land, etc.

Vacant usable land represents only 12.4 percent of Oahu's total acreage. Land within this category which has been designated in the General Plan for urban use totals approximately 27 square miles (17,387 acres).

Table 4.1. Summary of Oahu Land Usage, 1964

| Usage | Area | | Percent Total Area |
|---|---|---|---|
| | (sq mi) | (acres) | |
| Total Land in Use | 302 | 193,146 | 50.6 |
| Total Unused Open Space | | | |
| Unusable Land | 221 | 141,204 | 37.0 |
| Usable Land | | | |
| Non-urban Land | 46 | 29,573 | 7.8 |
| Urban Land | 27 | 17,387 | 4.6 |
| Total Area | 596 | 381,310 | 100.0 |

Honolulu District has 14.3 percent of the total Oahu land area (54,561 acres). Approximately 48.7 percent of Honolulu District's land (26,588 acres) was used. In comparison, the outlying districts have approximately 6 times more land (326,749 acres) and approximately 6.3 times more used land (166,560 acres) than Honolulu District. However, more than 82 percent of the used land in the outlying districts was in agricultural (93,131 acres) and military (43,630 acres) usage as compared to only 23 percent for Honolulu District. Except for commercial and public building uses, the outlying districts exceed Honolulu District in land development for other categories of land use.



AR00031576

The 1964 Land-Use Summary is presented in Table 4.A1 in Appendix IV-A.*

A comparison of land use in Honolulu District with that in other American cities is shown in Table 4.2. In this comparison, residential land includes both single- and multi-family dwellings; industrial includes both heavy and light industry; commercial includes wholesaling, retailing and service uses; and "other public" category includes schools, public buildings, parks playgrounds, and cemeteries as well as related public and semi-public uses. Military and agricultural lands have been eliminated from Honolulu District's developed land because they are not normally urban components, especially when land-category proportions are used for comparison with other cities. Although the definitions of the six major categories are not precisely uniform for all cities, they are reasonably comparable and thus are suitable for many types of land-use analysis.

Table 4.2. Comparison of Land Use on Oahu with That in Mainland Cities

| Type of Use | Mainland | | Oahu* | | |
|---|---|---|---|---|---|
| | Large Cities (Ref. 2) (%) | Cities (Ref. 3) (%) | Honolulu District (%) | Outlying Districts (%) | Island Total (%) |
| Residential | 39.0 | 28.0 | 38.4 | 48.3 | 44.3 |
| Industrial | 10.9 | 11.8 | 11.7 | 13.3 | 12.7 |
| Commercial | 4.8 | 2.7 | 4.8 | 1.9 | 3.0 |
| Road and Highway | 25.7 | 27.6 | 16.4 | 13.7 | 14.8 |
| Other Public | 19.6 | 29.9 | 28.7 | 22.8 | 25.2 |
| Total Developed | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

*Excludes military, agricultural and unused open space lands.

Residential uses, roads and highways account for between 55 and 65 percent of all developed land within major American cities and urban areas.

---

*All tables with the letter A as part of the number - i.e., Table 4.A1, 4.A2, etc. - are in Appendix IV-A at the end of this chapter; these are detailed tables that would interrupt the text.



AR00031577

Comparable percentages for Honolulu District, Oahu's outlying districts, and Oahu's total developed land are approximately 54 percent, 62 percent and 59 percent, respectively, well within the overall range.

The higher percentage for residential land for Oahu indicate that land is developed at a somewhat lower density than that found in most American cities and urban areas. The relatively low proportion of high-rise residential structures on Oahu accounts in part for this difference. The high proportion of land devoted to "Other Public" category may be explained by the fact that Honolulu is a "capitol city" housing practically all government agencies and by a history of a lack of high-rise public structures. The low percentage of land used for roads and highways can largely be traced to Oahu's system of subdividing lands as compared to the checker-board or grid system found in most American cities and urban areas. Commercial and industrial uses on Oahu may, for all practical purposes, be said to be essentially the same as other American cities and urban areas.

3. COMMERCIAL LAND USE

Commercial-land-use components [Ref. 1, pp. 45-65] are illustrated in Fig. 4.1. This category of use does not include wholesale establishments, warehousing, and storage. Hospitals are not included in the "Medical and Health Services" but rather are treated as part of "Public and Quasi-Public Buildings" sector.

The fact that commercial land represents less than 1 percent of the total developed land on Oahu should not detract from its importance, since it represents a source for approximately 45 percent of the Study Area's employment and 32 percent of the Study Area's dollar value of output. In terms of transportation planning, commercial land is a major traffic attractor. Figure 4.2 shows the 16 planning districts (PD) on Oahu.

Although the downtown planning district (PD 3) has almost one-third of the commercial floor space, PD 4 (covering approximately 15 percent less area than the downtown district) is the largest user of commercial land.

Table 4.A2 is a detailed compilation of commercial-land distribution among the planning districts. The important points of the tables are:



AR00031578

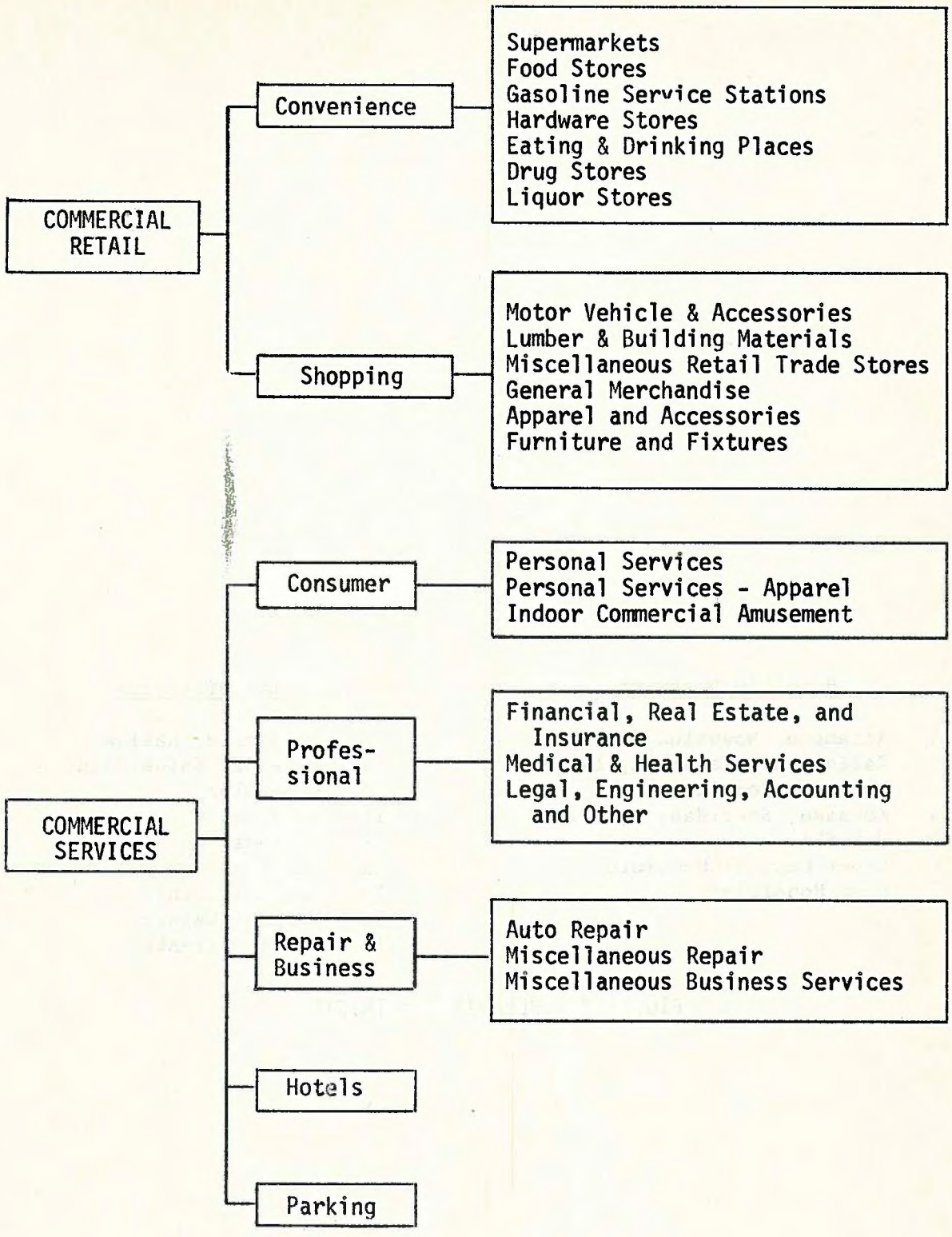
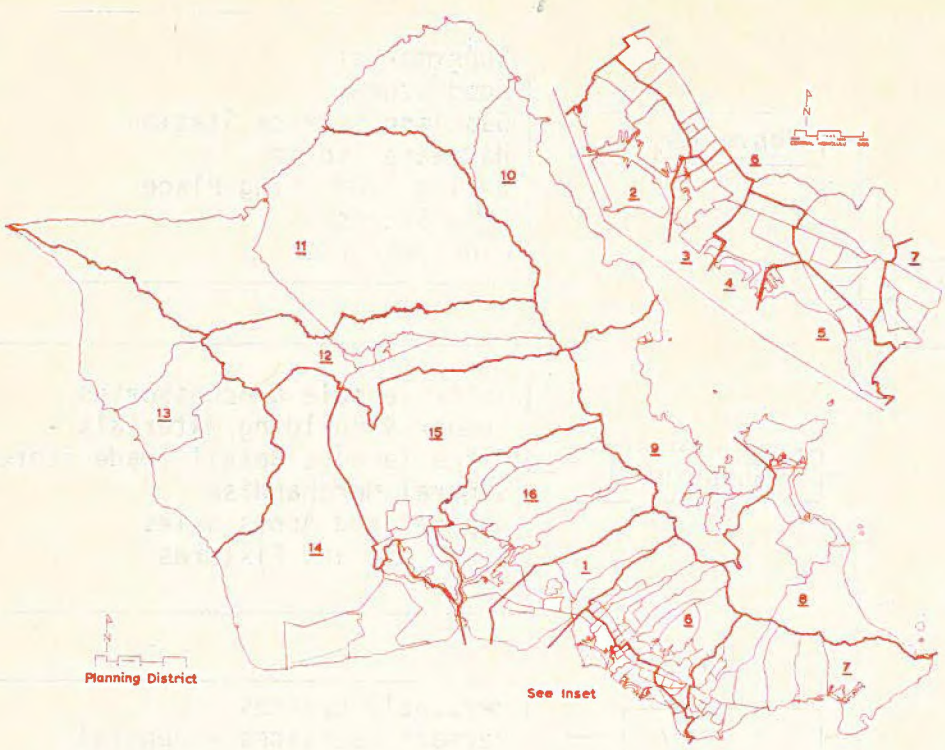



FIG. 4.1. COMMERCIAL LAND-USE COMPONENTS.



AR00031579




**Honolulu District**

1 Aliamanu, Moanalua, Airport
2 Kalihi Kai, Kapalama, Iwilei
3 Downtown Honolulu
4 Kakaako, Sheridan, Ala Moana
5 Waikiki
6 Upper Central Honolulu
7 East Honolulu

**Outlying Districts**

8 Waimanalo, Kailua
9 Kaneohe, Kuloa Point
10 Koolauloa
11 Waialua
12 Wahiawa
13 Waianae
14 Ewa-Honouliuli
15 Waipahu-Waipio
16 Pearl City-Aiea

FIG. 4.2. PLANNING DISTRICTS.



AR00031580

1. Over 80 percent of commercial retail and almost 90 percent of commercial services area were in the Honolulu area.
2. More than two-fifths of commercial services' floor area was in one (the downtown) planning district.
3. More than two-fifths (44 percent) of the commercial retail services' floor area was concentrated in two planning districts--PD 3 and PD 4.

The foregoing points confirm the strongly centralized composition of Oahu's commercial land.

Commercial Retail exceeds Commercial Services as a land user, with approximately 70 percent of the commercial land having its primary land use classified as retail. In terms of use of floor area, however, the disparity becomes smaller, with 55 percent of the floor area in retail use and 45 percent in services.* These proportions do not include the floor areas for hotels, which practically reverse the proportions.

Table 4.A3 lists the components, gives the number of establishments, quantifies land and floor areas, and ranks the various components by magnitude of land or floor areas within the commercial-land-use sector. In terms of absolute numbers, there were more service establishments than retail establishments although the total floor area used by services was less than retail--if "Hotels" floor area is excluded. Thus, on the average, the service establishment has a smaller floor-area requirement than does retail. Again, Finance, Insurance and Real Estate has the largest floor area aggregate in the Services category while in Retail trade, it was Eating and Drinking Places. Conversely, the largest land users in the Retail trade sector were the Food Stores (i.e., general groceries, bakeries, fruit and vegetable stores, etc.) while in commercial services, it was the parking services. Three points should be noted in using Table 4.A3.

---

*Technical Note: If the two statements appear paradoxical, this is due in part to classification technicalities. In general, in determining the land-use classification of a parcel of land with mixed uses, such as a shopping center, the predominant use was established, generally based on: a) the dominant first-floor use of a high-rise or other multi-floor building, or b) the use containing the largest floor area. Service-type establishments generally require smaller offices and would not meet the two listed criteria with the frequency that retail-type establishments do. For a more precise explanation of classification procedures, read Ref. 4.



AR00031581

1. The Medical and Health Services category did not include hospitals, which were classified as Public Buildings.
2. The inclusion of laundry plants in Miscellaneous Business Services accounted in part for the large floor-area figure.
3. Parking Services included only those parking areas located within structures.

Table 4.A4 shows the number of acres of land which has been general-planned for commercial purposes in each planning district. This amount of land is divided almost equally between Honolulu District and the outlying districts.

Within general-planned commercial areas, approximately 80 percent (1,141 acres) of the total area was in various uses: commercial use accounted for approximately 45 percent; "other" use - industrial, multi-family residential and streets (i.e., land which would not revert readily to commercial use) - accounted for 18 percent; single-family residential, 11 percent; and agricultural land, 6 percent (Table 4.3). The remaining 20 percent was in vacant land.

Table 4.3. Summary of Existing Commercial Use Outside and Within General-Planned Commercial Land on Oahu in 1964

| District | Commercial Use Outside Commercial Land (acres) | Commercial Use Within Commercial Land (acres) | Total Existing Commercial Use (acres) |
|---|---|---|---|
| Honolulu | 392 | 507 | 899 |
| Outlying | 246 | 305 | 551 |
| Total | 638 | 812 | 1,450 |

Analysis of the uses of the designated commercial land indicated that residential use accounted for the biggest percentage of the misuse, or non-conformity to the general-planned commercial use, hindering the rate of fulfillment of the commercial general plan.

Although there was more land in commercial use (1,450 acres) than was general-planned for that purpose (1,433 acres), 57 percent of the total



AR00031582

existing commercial use (812 acres) was on land not designated for commercial use.

The ratio of floor area to land area gives an indication of the intensity of development. Table 4.A5 reveals that, on the average, commercial development on an acre of land in the Honolulu District was approximately 3.5 times that on an acre of land in the outlying districts. For commercial land on either a per-100-dwelling or on a per-100-person basis, the respective ratios were approximately the same for Honolulu District as for the outlying districts (Table 4.4).

Table 4.4. Ratios of Commercial Acreages to Population and Dwelling Units on Oahu in 1964

| District | Commercial Retail | | Commercial Services | | All Commercial | |
|---|---|---|---|---|---|---|
| | Per 100 D.U.* | Per 100 Persons | Per 100 D.U. | Per 100 Persons | Per 100 D.U. | Per 100 Persons |
| Honolulu | 0.64 | 0.18 | 0.35 | 0.10 | 0.99 | 0.27 |
| Outlying | 0.79 | 0.17 | 0.21 | 0.04 | 1.00 | 0.21 |
| Average | 0.70 | 0.17 | 0.29 | 0.07 | 0.99 | 0.25 |

*D.U. = Dwelling unit

4. INDUSTRIAL-LAND USE

Industrial land is land, with or without buildings, concerned with the manufacturing, treating, processing or fabricating of goods or material, public communication, public transportation, public power, wholesaling, storage, and construction [Ref. 1].

Industrial land is also a traffic generator that occupies 6,352 acres, or approximately 3 percent of the developed land on Oahu. Slightly over one-third (37.4 percent) of this land is situated within Honolulu District. The largest user of industrial land in Honolulu District is the Honolulu International Airport (PD 1), which involves some 1,171 acres. The largest user of industrial land in the outlying districts is the Campbell Industrial Park (PD 14), which involves some 1,576 acres. These two users represent more than 43 percent of the land in industrial use. Table 4.A6 shows the planning districts in which industrial usage predominates.



AR00031583

The ranking of 15 industrial land users in 1964 is shown in Table 4.5. Since airfields, which require large acreages of land, are included in the classification "Air Transportation," it is not surprising to find this classification in the first position. Water Reservoirs and Pump Stations are in close second place. The Transportation, Communications, and Utilities category occupies not only the first three positions but represents over 63 percent of the total land area occupied by the 15 largest industrial land users.

Table 4.5. Ranking of the 15 Largest Industrial Land Uses on Oahu in 1964

| Rank | Classification | Area (acres) |
|---|---|---|
| 1 | Air Transportation | 1,198.8 |
| 2 | Water Reservoir and Pump Stations | 1,127.5 |
| 3 | Electric Plants | 610.8 |
| 4 | Stone, Clay and Glass Products | 543.8 |
| 5 | Food and Kindred Products | 416.3 |
| 6 | Sanitary and Refuse | 336.7 |
| 7 | Special Trade Construction and Storage Yards | 272.2 |
| 8 | Other Transportation (wharf facilities) | 209.7 |
| 9 | Petroleum Refining and Related Industries | 209.5 |
| 10 | Storage, Extensive Yard Use | 208.2 |
| 11 | Storage, Nonextensive Yard Use | 203.1 |
| 12 | Wholesalers with Stock | 168.2 |
| 13 | Construction | 152.1 |
| 14 | Railroad Yards | 150.0 |
| 15 | Communications | 145.4 |

Although industrial land use is greatest for the Transportation, Communication, and Utilities category, the floor area associated with this category is the least (Table 4.6). Also, although approximately two-thirds of the land in use for industrial purposes was in the outlying districts (7,950 acres against 4,754 acres), 88 percent of the floor area used for industrial purposes was in the Honolulu District (352,500 sq. ft. against 47,500 sq. ft.).

Although tabulations of floor area include all floor area occupied by industrial use, their relationships to total land used for industrial purposes are difficult to ascertain because some industrial floor areas are located in nonindustrial structures for which lands have been classified other than for



AR00031584

industrial use. For example, a garment-manufacturing company occupied space in a structure of predominately retail use; the land was classified as commercial use rather than as industrial use. Table 4.A7 shows the percent of industrial floor area concealed and considered secondary use of the land.

Table 4.6. Distribution of Industrial Floor Area on Oahu in 1964

| Planning District | Industrial Floor Area (1000 sq ft) | | | Total |
|---|---|---|---|---|
| | Manufacturing | Transportation, Communication, Utilities | Commercial, Wholesale, Storage, Construction | |
| Honolulu | 5,803 | 4,100 | 7,560 | 17,463 |
| Outlying | 1,277 | 459 | 627 | 2,363 |
| Total | 7,080 | 4,559 | 8,187 | 19,826 |

The General Plan is the most restraining factor guiding the direction of future industrial expansion. Tables 4.A8 and 4.A9 detail the distribution of land general-planned for industrial purposes and lands that are and are not available for future industrial development.

There are two planning districts with outstandingly large areas general-planned for industrial activities. The 1,523 acres recorded for PD2 are distributed among four census tracts as listed below:

| Census Tract | Place | Acres |
|---|---|---|
| 57 | Iwilei-Sand Island | 928 |
| 58 | Waiakamilo | 47 |
| 59 | Lower Kalihi Kai | 442 |
| 60 | Upper Kalihi Kai | 106 |

General-planned industrial acreages in these four census tracts represent 65.9 percent of the total general-planned industrial acreages in Honolulu District.

The 3,383 acres recorded in PD 14 (Ewa-Honouliuli) are located in Census Tract 86 (see Appendix I-A) which include the Campbell Industrial Park and the Hawaiian Electric Power Plan located immediately north of Kahe Point.



AR00031585

No industrial activities have been general-planned for PD 5 (Waikiki) and PD 6 and 7 (residential areas of Honolulu). However, land presently in use for industrial purposes exist in these areas.

Within general-planned industrial areas, approximately 73 percent of the total acres (5,166 acres) was in various uses. Industrial use accounted for approximately 28 percent; "other" use - multi-family residential, public and quasi-public buildings and open spaces, and highways and streets (i.e., land which would not revert readily to industrial use) - accounted for approximately 14 percent; single-family residential, 3 percent; agricultural land, 28 percent. Vacant land accounted for 27 percent.

Although there appears to be almost as much land in current industrial use (6,352 acres) as there is land general-planned for that purpose (7,085 acres), approximately 68 percent of the existing use was on land not designated for industrial. It should be noted, however, that lands used by airports and utilities are not classified as industrial uses under the General Plan. If these uses were transferred to other categories, then encroachment of industrial uses into areas general-planned other than for industrial purposes would represent approximately only 32 percent or 2,057 acres.

One requirement of sound growth and development of existing and new industries is that the area must be large enough to accommodate a group of industries with allowance for plan expansion [Ref. 5]. Thus in establishing industrial development, the size of lots is a very important consideration. Small lots in conjunction with multiple ownership can and often does present complications in the assembly of land.

Table 4.A10 summarizes the lot sizes of areas available, general-planned for industrial development. In general, lot sizes are larger in outlying districts than in Honolulu District and are generally much larger for undeveloped land.

## 5. RESIDENTIAL LAND

Residential land is the largest single land type (excluding agriculture, military and unused open space) on Oahu. The disposition of residential development is without question one of the strongest single forces shaping the



AR00031586

travel patterns of Oahu. For example, the home of the trip maker was involved in over three-fourths of all trips made on Oahu.

a. Residential Land-Use Components. The components of residential land use are listed below.

1. Single-family
2. Duplex
3. Multi-family
   - Apartment
   - Apartment hotel
   - Low-cost public housing
4. Miscellaneous
   - Rooming and boarding houses
   - Dormitories
   - Others not elsewhere classified

In the analysis that follows, concern involved only two of the residential groupings - single-family (including duplexes), and multi-family.

b. Distribution of Residential Land. In 1964, nearly 6 percent of the total land on Oahu (22,157 acres) was used for residential purposes. This usage, when compared to the total developed lands (excluding areas used for agriculture, military, and unused open spaces), represented the greatest consumer (44.3 percent) of the total developed urban lands. Of the total land in use for residential purpose, over one-third (35.1 percent) was in Honolulu District, with the remaining 64.9 percent in the outlying districts.

Separated into residential components, multi- and single-family, the 1964 land-use inventory revealed that 3.7 percent of the total residential land in use was for multi-family purpose. Honolulu District accounted for over 77.8 percent of this usage; and while single-family purpose represented 96.3 percent of the total residential land in use, 66.7 percent of this usage was in the outlying districts.

The 1964 distribution of residential land use is shown in Table 4.A11.

c. Distribution of Dwelling Units (D.U.). The distribution of dwelling units by planning districts is shown in Table 4.A12. In 1964, there was a total of 145,510 dwelling units on Oahu. While Honolulu District accounted for only slightly over one-third of the total residential land in use, 61.5



AR00031587

family and agricultural acreages designated for single-family purpose by the General Plan. These acreages are translated into equivalent dwelling units in both existing and permitted categories. Permitted housing represents a full-capacity measure - i.e., the number of dwelling units that can be located in the subject area. Unused permitted housing, of course, indicates the room for expansion.

Table 4.A18 reveals that existing single-family dwelling units wholly within areas designated for single-family purpose by the General Plan totaled 68,839 and, although it is almost evenly distributed between Honolulu District and the Outlying Districts, it represented about 75 percent of the total single-family dwelling units on Oahu in 1964. The remaining 25 percent (23,961 units) was on lands designated for use other than for single-family residential.

Holding capacities indicate that single-family developments wholly within areas general-planned for that purpose have attained in total only 23.3 percent of their full measure. This, therefore, means that there is ample room for increased number of single-family housing developments.

6. STREET AND HIGHWAY LANDS

Streets and highways used the third largest amount of land on Oahu in 1964, with 14.8 percent of the total developed lands; residential land use was first with 44.3 percent and public-open-space use was second with 15.7 percent.* A comparison of street and highway use with that of other American cities and urban areas was shown in Table 4.2.

Oahu has a much smaller proportion of its developed lands devoted to streets and highways than do cities on the Mainland. Unlike other cities, Oahu has neither a system of gridiron streets nor a system of midblock alleys so prevalent in other American cities and urban areas.

The requirement for streets is expected in all communities since land cannot realistically be developed without streets - where there is development there must also be traffic.

---

*Developed lands exclude agriculture, military, and unused open-space lands.



AR00031588

The relationship of street and highway use to development varies with with the extent of development. The highest percentage of land devoted to street and highway use was found in downtown Honolulu (23 percent). Two other areas, Wahiawa and Waipahu, which originally were developed as plantation towns, also showed a high percentage of land devoted to streets and highways. The relatively low percentages found in other areas on Oahu can be traced to the comparatively high percentage of public open spaces in those areas. Table 4.A19 shows, by planning district, the amount of land devoted to street and highway use, by percentages.

7. VACANT AND AGRICULTURE LANDS

Vacant land is classified as either usable or unusable. Usable land includes unused or idle land normally having a slope less than 20 percent. Unusable land includes forest reserves, lakes, islets, canals, steep lands (slopes greater than 20 percent) and derelict land (abandoned gravel pits). Land in temporary use (grazing, for example) is not considered vacant. It should be noted that vacant-military land is classified as military and not vacant-usable land. The underdeveloped portion of a lot, although considered part of the supply sector in the land-use model, is not included in the following tables.

The Agricultural category includes land in agricultural and extractive use, agricultural field crops and livestock, and mining and quarrying.

In 1964, nearly one-half (49.4 percent) of the total land on Oahu was in unused open space (188,164 acres) and nearly one-fourth (24.7 percent or 94,474 acres) was in agricultural use. It should be noted, however, that only those portions within these respective uses which have been designated for urban use by the General Plan are the basic sources of available space for further developments.

a. Vacant Land. The distribution of vacant usable and unusable lands is summarized in Table 4.7 and is presented in detail in Table 4.A20. It has been stated earlier that nearly half of the total 596 square miles of land on Oahu was in unused open space. Of this 294 square miles of vacant land, nearly three-fourths, or 220.6 square miles, were classified as vacant



AR00031589

unusable lands. It should be pointed out that by no means are the remaining 73.4 square miles of vacant usable land available for urban use.

Table 4.7. Summary of Vacant Usable and Unusable Lands on Oahu in 1964

| Category | Vacant Land | | | | | |
|---|---|---|---|---|---|---|
| | Honolulu District | | Outlying Districts | | Total | |
| | (sq mi) | (acres) | (sq mi) | (acres) | (sq mi) | (acres) |
| Usable | 13.96 | 8,937 | 59.42 | 38,023 | 73.38 | 46,960 |
| Unusable | 29.75 | 19,038 | 190.88 | 122,166 | 220.63 | 141,204 |
| Total | 43.71 | 27,975 | 250.30 | 160,189 | 294.01 | 188,164 |

b. Agriculture Land. Agriculture land accounted for nearly one-fourth of the total land on Oahu in 1964. Table 4.A21 shows the distribution of this usage by planning districts. As in the case of vacant land, not all agriculture land is available for urbanization.

Less than 2 percent of the total land in Honolulu District (2.09 square miles) was in agriculture use. These agricultural lands are nestled deep in the several valleys in Honolulu. It is obvious, therefore, that the remaining agriculture lands on Oahu are in the Outlying Districts.

8. LANDS AVAILABLE FOR DEVELOPMENT

The two basic sources of space which are considered likely to be available for future development are: 1) vacant usable land and 2) agricultural land that has been designated for urban use in the General Plan.

a. Vacant Urban Land. Table 4.8 shows the magnitude and the allocation of the vacant usable land that has been designated for urban and non-urban purposes by the General Plan. Table 4.9 summarizes the vacant urban land by the five uses comprising the urban classifications. The distribution of this land by planning districts is shown in Table 4.A22.

Under current designation, the General Plan allocates the preponderance of this vacant urban land to residential use within each Planning District except Planning District 2, in which the General Plan allocated almost all of the vacant urban land to industrial use. This district is primarily an industrial area and the large trace of land on Sand Island that is vacant has been earmarked for industrial use by the General Plan.



AR00031590

Table 4.8. Summary of Urban and Nonurban Vacant Usable Land on Oahu in 1964

| Planning District | Vacant Usable Land | | General-Planned Use | | | |
|---|---|---|---|---|---|---|
| | | | Urban | | Nonurban | |
| | (sq mi) | (acres) | (sq mi) | (acres) | (sq mi) | (acres) |
| Honolulu | 13.96 | 8,937 | 9.62 | 6,157 | 4.34 | 2,780 |
| Outlying | 59.42 | 38,023 | 17.55 | 11,230 | 41.87 | 26,793 |
| Total | 73.38 | 46,960 | 27.17 | 17,387 | 46.21 | 29,573 |

Table 4.9. Summary of Urban Vacant Usable Land on Oahu in 1964 by Urban-Use Designation

| Use | Area | | Percent of Total |
|---|---|---|---|
| | (sq mi) | (acres) | |
| Residential | 20.29 | 12,987 | 74.9 |
| Resort | 0.34 | 214 | 1.2 |
| Commercial | 0.46 | 292 | 1.6 |
| Industrial | 3.00 | 1,919 | 11.0 |
| Special | 3.08 | 1,975 | 11.3 |
| Total | 27.17 | 17,387 | 100.0 |

b. Agricultural Urban Land. Agricultural purposes utilized a total of 147 square miles within the Study Area in 1964. Of this total acreage, approximately 88 percent (128 square miles) was retained by the General Plan for nonurban use (agriculture and open space). The remaining 19 square miles that have been designated by the General Plan as urban use are allocated to the urban uses as shown in Table 4.10.

Table 4.10. Summary of Agricultural Urban Land on Oahu in 1964 by Urban-Use Designation

| Use | Area | | Percent of Total |
|---|---|---|---|
| | (Sq Mi) | (acres) | |
| Residential | 13.13 | 8,403 | 68.4 |
| Commercial | 0.14 | 90 | 0.7 |
| Industrial | 3.84 | 2,460 | 20.0 |
| Special | 2.10 | 1,344 | 10.9 |
| Total | 19.21 | 12,297 | 100.0 |



AR00031591

As in the allocation of vacant urban land, a major portion of agricultural urban land is designated for residential purposes. The detailed distribution of this agricultural urban land by planning district is shown in Table 4.A23.

c. Summary. In summary, the study of vacant and agricultural land reveals the following points.

1. There were 294 square miles of vacant land in the Study Area.
2. Of the 294 square miles, 73 square miles were usable and 221 square miles, unusable (in forest reserves, etc.).
3. The General Plan designated 27 of the 73 square miles of vacant usable land as being appropriate for urban development.
4. Of the 147 square miles of agricultural land in use, 116 square miles were designated by the General Plan for agricultural purposes and 12 square miles for open space.
5. The remaining 19 square miles of agricultural urban land represented land suitable for urban use.
6. Despite the withdrawal of approximately 30 square miles of agricultural and general-planned nonagricultural land, the aggregate reduction in agricultural-land use was compensated by 21 square miles of vacant usable land being general-planned for agricultural purposes.
7. The Study Area has aggregated 46 square miles of vacant-urban and agricultural-urban land that is general-planned for urban purposes.

## D. FUTURE LAND USES AND LOCATIONS

Forecasting the future location and intensity of activities on Oahu is a substantial undertaking. This task is particularly difficult because an immense number of different influences are at work. A practical forecasting procedure, therefore, requires that study be focused on a few predominating courses of change and on the compelling limitations imposed by the natural environment. If these forces can be shown to be working together in one direction, it would be difficult to dispute such a trend as a reasonable projection. It would not be likely that the lesser forces which are known to be in operation would combine to overcome this tendency.

It should be emphasized that a land-use forecast is not a land-use plan. For Oahu, a General Plan has been accepted that graphically expressed the set of policies adopted by the City Council in 1964. Therefore, the objective of the land-use forecast in this study is to forecast the requirements for land use and to locate them within the constraints of this General Plan.



AR00031592

A single land-use forecast was prepared for testing and evaluating the 1985 transportation plans.* A simulation model was developed for this purpose. Since the overall procedure was somewhat complex, every effort was made to ensure that the components represented the best methods of data collection, analysis, and projection obtainable.

## 1. OVERVIEW OF THE LAND-USE MODEL

The relationship of the Land-Use Model to the other models in the study is shown in Fig. 4.3, in which three models are used to obtain the required forecasts. First, the Economic Model forecasts the level of employment in 16 industries; these predictions provide inputs to the Land-Use Model, which forecasts where the new employees will work and reside. Next, the Traffic Model uses forecasts of homesites and worksites to forecast the demand for transportation services. The dotted lines indicate feedbacks within the system; for example, the availability of transportation facilities affects land uses, and the availability of land affects the growth of industrial employment.

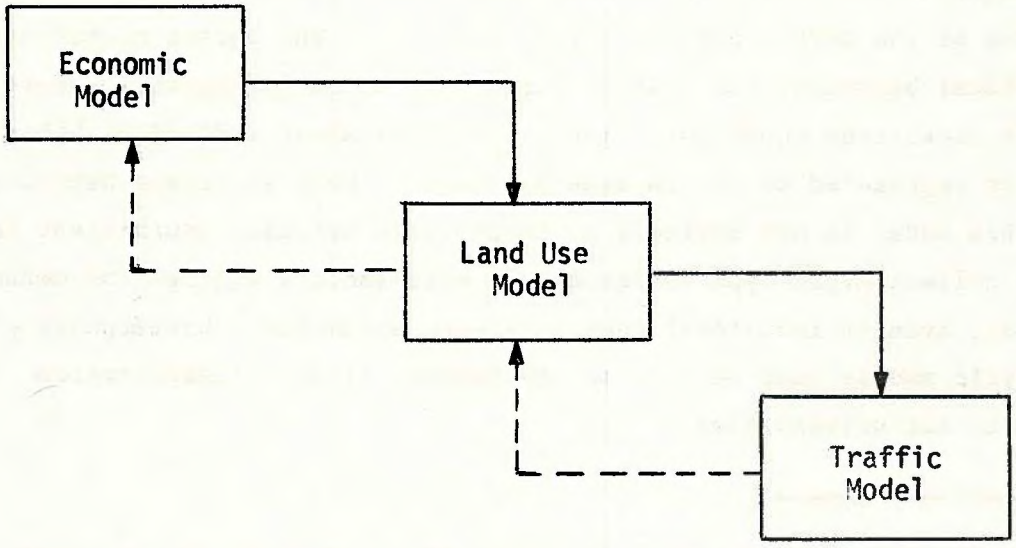



FIG. 4.3. OAHU TRANSPORTATION STUDY MODELS.

*This includes a preliminary forecast and a finer forecast from a feedback into the process.



AR00031593

The Land-Use Model contains four submodels, which locate residents, industrial employees, retail employees, and public employees. The Land-Use Model accepts the inputs identified in Table 4.11, activates its submodels, and prints out forecast values for the output variables (also identified in Table 4.11) by census tract. The census-tract forecasts are later separated into origin and destination zones. This process is repeated for each five-year period to produce forecasts for 1970, 1975, 1980, and 1985. The Land-Use Model calls on its submodels one at a time in roughly the following order: residential, retail, public, and industrial.*

a. Design of the Land-Use Model. The Land-Use Model is designed as a simulation model, which simulates or traces out the evolution, step by step through time, of the many interdependent variables (input, intermediate, and output variables) that determine land development. The usefulness of simulation is that it provides hindsight in advance of action.

Each land-use submodel contains equations that describe mathematically the locational behavior of its locator or activity. The design of each submodel is more an art than a science. The optimal of "best" design is one that balances the conflicts between theoretical elegance, data availability, purpose of the model, and financial resources. The equations reflect some individual behavior, but most equations are of an aggregative nature. One desires micro-type equations - i.e., equations about individual behavior which can be aggregated to obtain equations about their aggregate behavior. However, this model is not entirely micro-analytic because insufficient funds existed to collect micro-type variables and satisfactory aggregation methods do not exist, even if individual equations were estimated. Development of micro-analytic models must be left to the larger, richer transportation studies or to the universities.

---

*This sequence is very important. The residential submodel is run before the retail submodel because retail location generally follows residential location. The public and industrial submodels are run last because other activities can generally outbid them; however, if desired, public activities can be located anywhere to reflect the real priority of public land use. Of course, there is competition even among these users, so they are located one at a time, the highest site bidder being located first. This submodel sequence is the same as that used by the Penn-Jersey Study but differs from that in the Lowry Study; the Lowry Model was not incremental and, therefore, it located industrial employment first in recognition of the importance of the journey-to-work trip.



AR00031594

Table 4.11. Input and Output Variables in the Oahu Transportation Study Land-Use Model

| Input | | Output | |
|---|---|---|---|
| Variable | Data | Variable | Data |
| Status | Land Use--23 Types by Census Tract | Land Use--No. of Acres in: | Residential |
| | Housing Stock--3 Value Types | | Manufacturing |
| | Employment--3 Types | | Transportation, Communication, Utilities |
| | Population | | Retail, Wholesale, Storage, Construction |
| Policy | Transportation System | | Retail Services |
| | Capital Improvement Program | | Public and Quasi-Public Buildings |
| | General-Plan Codes | | Public and Quasi-Public Open Space |
| | Land-Tenure System | | Unused Open Space |
| Exogenous | Employment Forecasts, 16 Industries | | Agriculture and Extracting |
| | Population | | Military |
| | Various Coefficients | | Hotels |
| | | | Highways and Streets |
| | | Floor Area--No. of Sq Ft in: | Manufacturing |
| | | | Retail, Wholesale, Storage, Construction |
| | | | Retail |
| | | | Retail Service |
| | | | Hotels |
| | | | Public and Quasi-Public Buildings |
| | | Population--No. of: | Families, by Income<br>High-Income<br>Middle-Income<br>Low-Income |
| | | | People, by Census Tract |
| | | | People Employed, by Income<br>High-Income<br>Middle-Income<br>Low-Income |



AR00031595

Since the purpose of the Land-Use Model is to assist the planner and/or policy maker, each equation system contains policy or instrumental variables that are controllable by the policy maker. In addition, each question system contains status variables that describe the status of the land-use system at a point in time. Exogenous variables, which affect but are not affected by the land-use system, are also present. These three main types of variables were identified in Table 4.11.

The complexity of the Oahu Transportation Study Land-Use Model makes it very difficult to describe the model unambiguously. Actually the best description is the computer program written in Fortran IV for both the IBM 7094 and 7040.

b. Distinguishing Characteristics of the OTS Land-Use Model. Since the pioneering land-use effort of the Chicago Area Transportation Study, several different land-use models have been developed, ranging from the less sophisticated, purely judgmental models to the mathematical-programming models, employing optimizing techniques. While there is no concensus on the "best" conceptual framework, a concensus exists on at least the following four criteria:

1. The model should employ the building-block approach and contain several intercommunicating submodels.
2. The model should be time-recursive and make stepwise projections in intervals of two, five, or ten years.
3. The model should be incremental and allocate changes in land use rather than determine the entire land-use system each projection period.
4. The model should be designed for planning purposes and thus contain variables controllable by the public decision-maker.

All of the above design criteria are incorporated into the Oahu Transportation Study Land-Use Model; some additional features of this model should also be noted:

1. The model emphasizes planning; thus it includes policy or instrumental variables, the most important being the State General Plan land-use codes. The model can show the land-use distribution resulting from any combination of General Plan Codes.
2. The model determines and utilizes the spatial distribution of income or purchasing power. Income by small areas is especially important for traffic-generation, retail-market-potential, and transit analyses.
3. The model contains a heterogeneous-housing sector; six types of housing are allocated--two structure types (single and multiple) and three value classes.



AR00031596

4. Since most privately-used land is leased land, the model incorporates Hawaii's peculiar land-tenure system as an explanatory variable.

5. The model is highly heterogeneous over time, activity, and space. Temporal separation is achieved by breaking down the 20-year forecast (1965 - 1985) into four 5-year forecasts; in addition, dynamicism is achieved by allowing almost every coefficient to change for each forecast. Activity diversity is achieved by dividing industrial employment into seven types, retail employment into six types, public employment into two types, and, as mentioned earlier, housing into six types. Spatial diversity was achieved by dividing into 113 Census Tracts and later to 159 origin and destination zones.

6. The model contains a demolition subroutine. Thus, over time, as population densities rise and old single-family dwellings become uneconomical to maintain, the model demolishes single-family houses, constructs multiple-family houses, and reallocates displaced people elsewhere.

c. Applications of the Land-Use Model. The model can be used to help answer a wide variety of questions that relate to policy formation or forecasting. Public decision-makers who want to determine the "best" public policy will want to use the model for policy formation. Alternative policies can be tested by asking questions such as "What will be the effect of policy X or policy Y on the community?" A few of the practically infinite number of policy questions that can be answered by the model are listed below:

1. How would a new highway, new transit system, or some improved form of transportation between points A and B affect the community?

2. How would alternative configurations of General Plan codes affect the community?

3. What would be the effect of the location of a new univeristy, new hospital, or a new oil refinery upon the community?

4. What would be the spatial effect of a strong open-space program or implementation of the satellite-city concept?

d. Areas for Improving the Model. At the present stage of the model's development, the following can be said on behalf of the model. First, it provides a framework for forecasting urban development; most factors are included and every factor is in its proper place. Second, it is entirely reproducible, so another research can study the methodology and continue work on improving specific parts of the model. Third, it provides forecasts about urban development which could be done only by a computer model.

Land-use modeling, like transportation planning, must be a continuing process. Some general areas for improvement are the following:



AR00031597

1. All coefficients should be endogenized. Presently, the model requires several coefficient values to be determined outside the model. These values should be determined within the model.
2. Several coefficients should be permitted to vary spatially. This would help solve the problem of second-story use.
3. Feedbacks to the economic model should be established so that land availability can constrain industrial expansion.
4. Extensive sensitivity analysis should be conducted to indicate important areas for further research. This analysis would show which coefficients are more important than others and guide future research.
5. Simulation experiments should be conducted to help assess the optimal spatial distribution of activities.
6. Analysis subroutines should be written to summarize the model's output and thus facilitate analysis.
7. An information system should be designed to provide continuous data to maintain the model's operability and usefulness.

## 2. OUTPUTS OF THE RESIDENTIAL SUBMODEL*

a. Population. The population distributions indicate that Honolulu District will still account for more than half of the population on Oahu in 1985 but the trend (Fig. 4.4) indicates that the Outlying Districts are gradually gaining in their representation. It is quite conceivable that the Outlying Districts will account for more than half the total population by 1990.

Table 4.C1 and Fig. 4.5 show the distribution of population by planning districts for the years 1960 to 1985, and Fig. 4.6 shows the 1960 and 1985 distributions of population by census tracts.

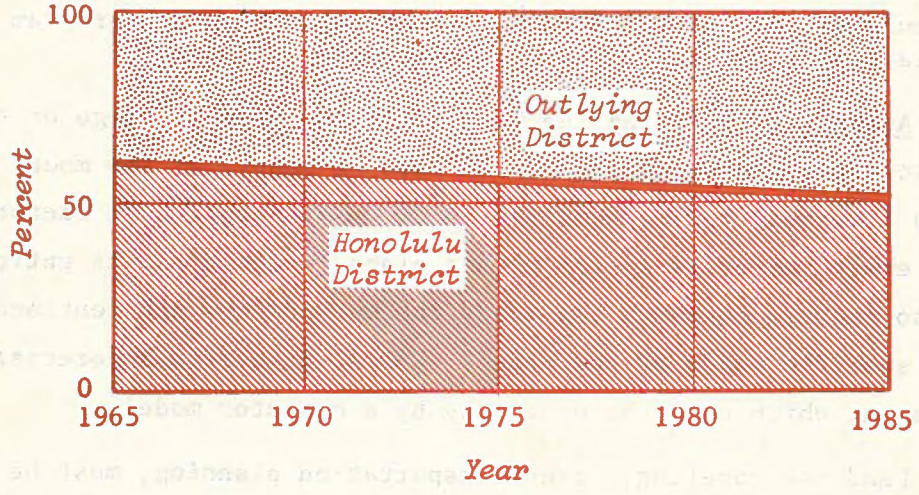
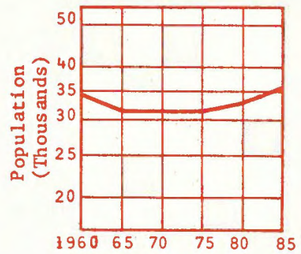



FIG. 4.4. PERCENT OF TOTAL POPULATION BETWEEN HONOLULU AND OUTLYING DISTRICTS.

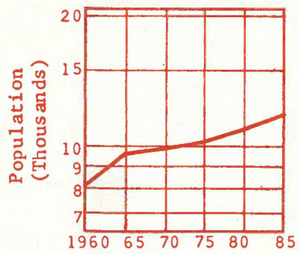
*See Appendix IV-B1.



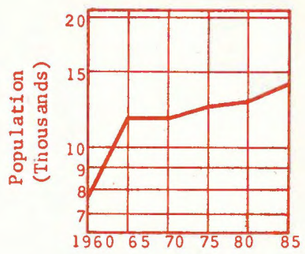
AR00031598



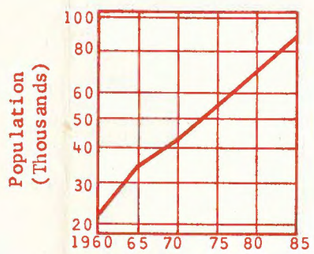
Planning District 12



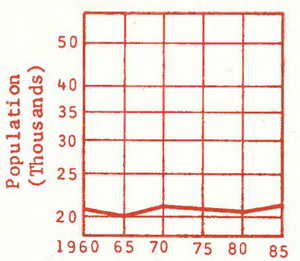
Planning District 11



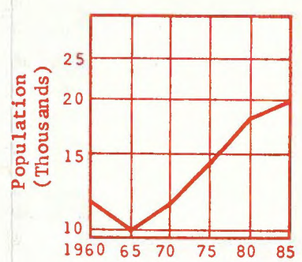
Planning District 10



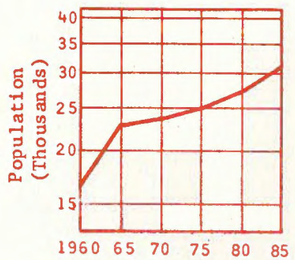
Planning District 9



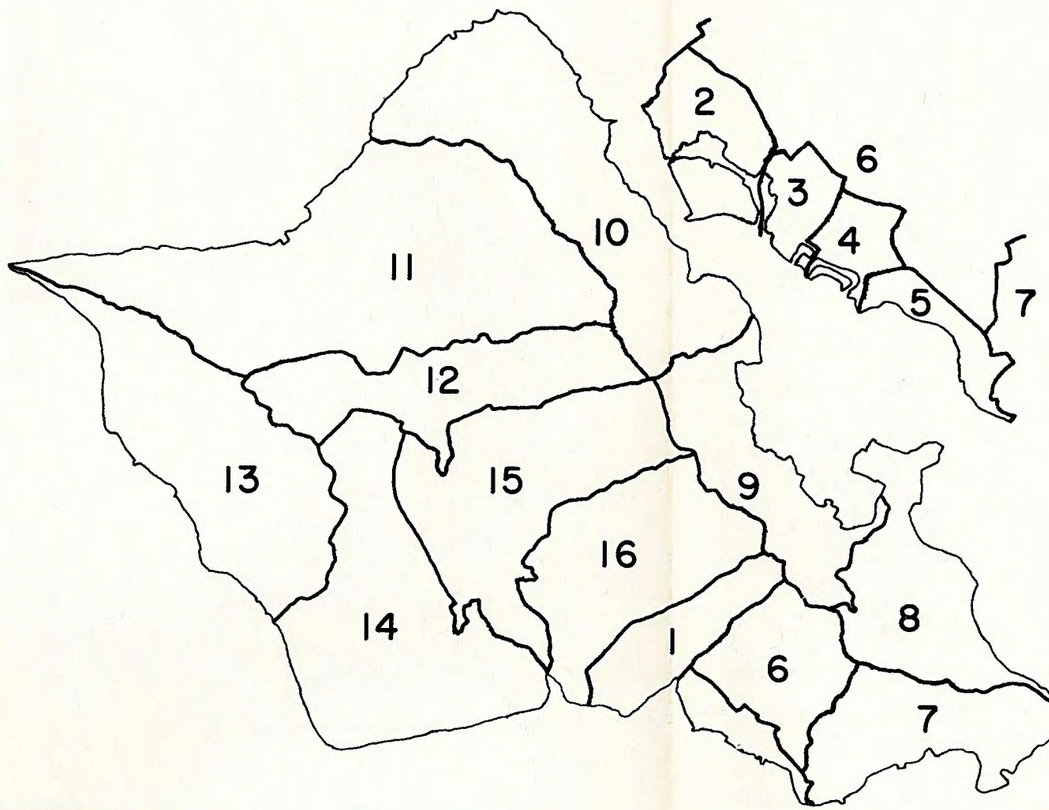
Planning District 2

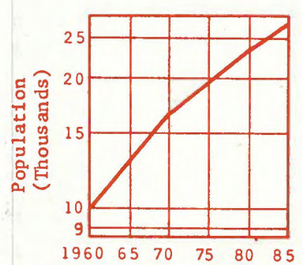


Planning District 3

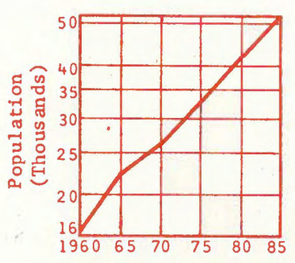


Planning District 13

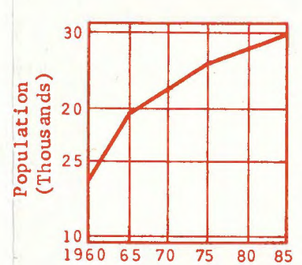


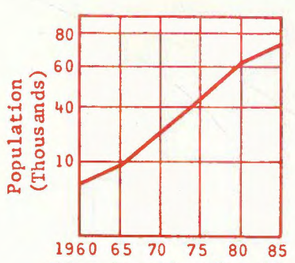
Planning District 4



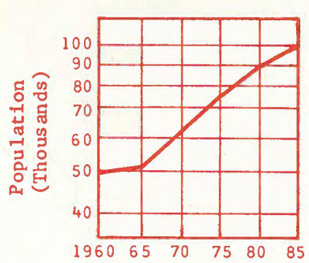
Planning District 14



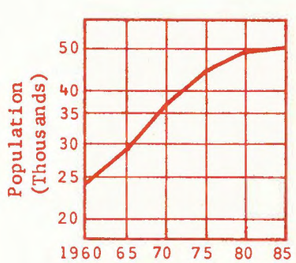
Planning District 5



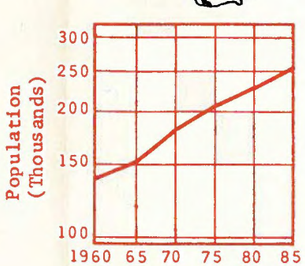
Planning District 15



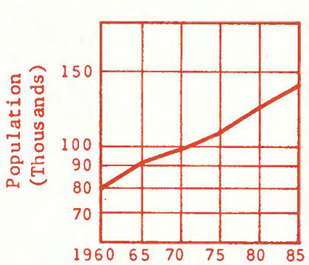
Planning District 16



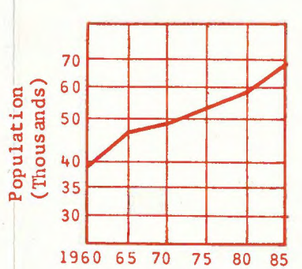
Planning District 1



Planning District 6



Planning District 7



Planning District 8

**FIG. 4.5.**
**ESTIMATED POPULATION BY PLANNING DISTRICT.**



AR00031599

FIG. 4.6.

# POPULATION DISTRIBUTION 1960-1985 BY CENSUS TRACT

(INCLUDES MILITARY PERSONNEL)

'85 - 12,000

'60 - 6,000

- 0

SCALE 1 0 1 2 3 MILES

SEE INSET



AR00031600

b. Dwelling Units. The total 1985 civilian housing requirements and their distribution and 1964-1985 comparison of Planning Districts are shown in Table 4.C3. Figure 4.7 shows the 1960 and 1985 distributions of dwelling units by census tracts.

Excluding dwelling units within military reservations, a total housing requirement of 261,961 units would be required to shelter the estimated civilian population of 1,014,400 by 1985. This requirement represents an anticipated growth of 80 percent in the next 20 years. Although there will still be more dwelling units in Honolulu District in 1985, much of the growth is expected to take place in the Outlying Districts.

Table 4.12 shows the persons per civilian household anticipated in 1985 for Honolulu and the Outlying Districts.

Table 4.12. Family Size of Household in 1985

| Planning District | Civilian | | Persons Per D.U. |
|---|---|---|---|
| | Population | No. of D.U. | |
| Honolulu | 537,979 | 144,028 | 3.73 |
| Outlying | 476,421 | 117,933 | 4.04 |
| TOTAL | 1,014,400 | 261,961 | 3.87 |

c. Single-Family Residential Land. The total equivalent single-family land requirement for civilian housing and its distribution and 1964-1985 comparison by planning district are shown in Table 4.C4.

Viewed at Study Area level, it is anticipated that there will be an increase of 12,181 acres in single-family land in the next 20 years. The changes from 1964 occurring within certain planning districts reflect some striking variations. For example, all single-family lands now in Planning Districts 3 and 4 disappear by 1985, whereas, in Planning District 1, single-family land will increase over seven times, and will approximately double in Planning Districts 7, 9, 14, 15, and 16. (Fig. 4.8).

d. Multi-Family Residential Land. Table 4.C5 and Fig. 4.9 show the total 1964 and 1985 multi-family land requirements and their distribution by planning districts. The estimate shows that 844 acres of multi-family development will be added in the next 20 years.



AR00031601

# FIG. 4.7.
# DWELLING UNITS
# 1960-1985
# BY CENSUS TRACT
(INCLUDES MILITARY DWELLING UNITS)

'85 – 4,000
'60 – 2,000
– 0

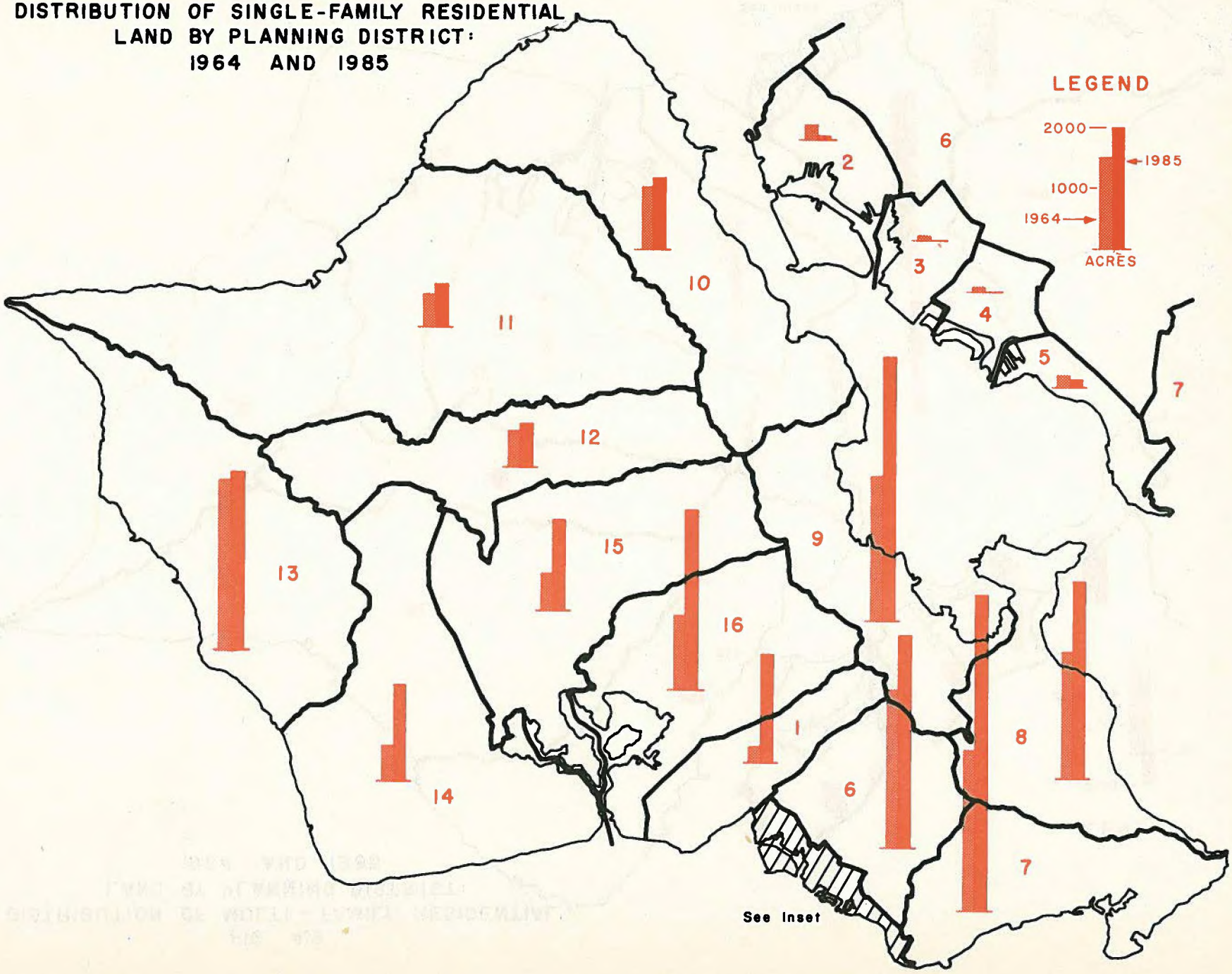
SCALE 1 0 1 2 3 MILES

SEE INSET



AR00031602

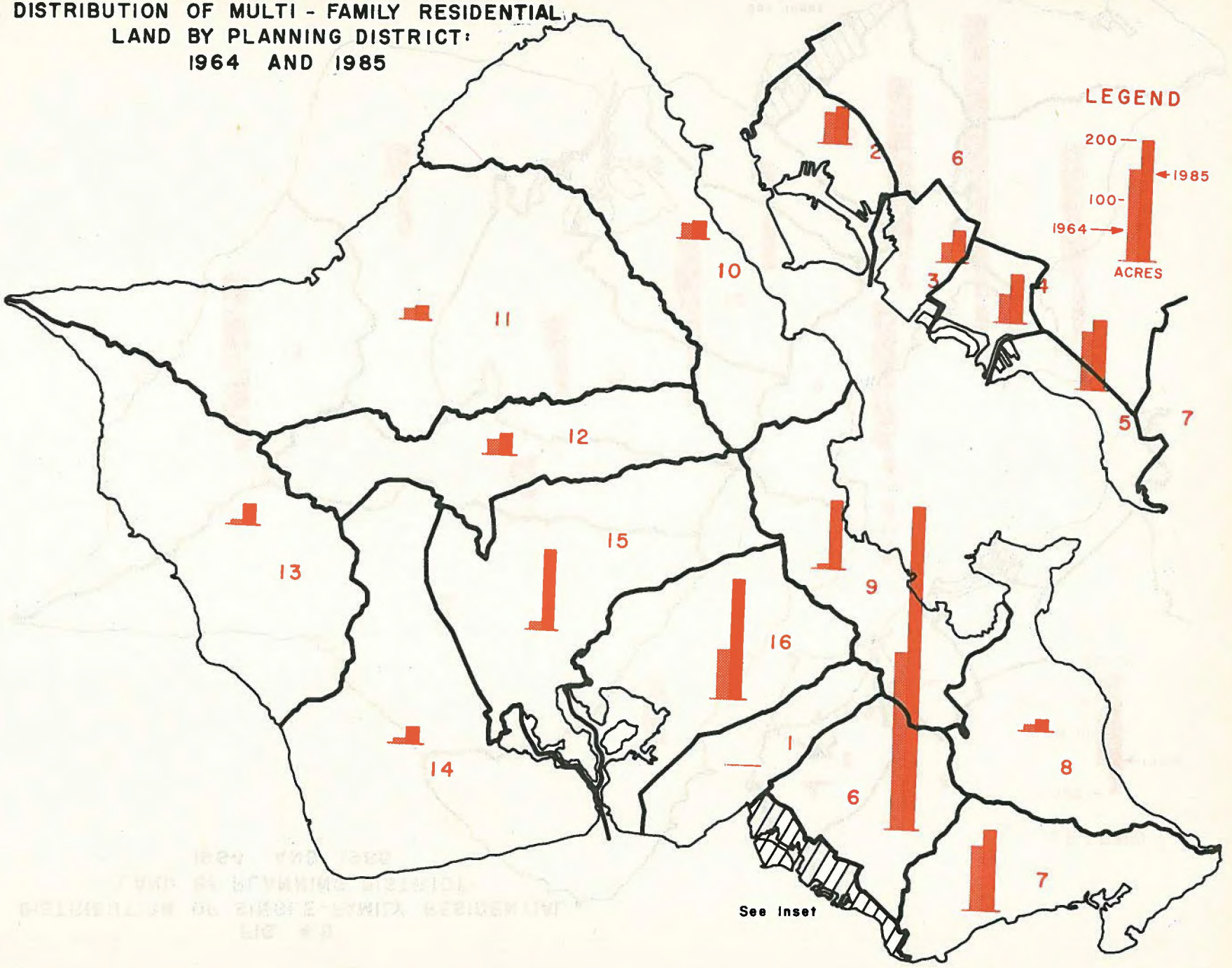
FIG. 4.8
DISTRIBUTION OF SINGLE-FAMILY RESIDENTIAL LAND BY PLANNING DISTRICT: 1964 AND 1985






AR00031603

FIG. 4.9
DISTRIBUTION OF MULTI - FAMILY RESIDENTIAL LAND BY PLANNING DISTRICT: 1964 AND 1985






AR00031604

3. OUTPUTS OF THE COMMERCIAL, PUBLIC, AND INDUSTRIAL SUBMODELS*

a. Commercial Land. The model predicts that by 1985 the commercial land use for the Island of Oahu will increase by 50.4 percent over the inventory-year stock of 1,450 acres (Table 4.D1). Rates of commercial land in 1985 between Honolulu and the outlying areas will change only slightly from those in 1964.

Of the 2,181 acres in commercial use, 1,518 acres will be in commercial retail use and 663 acres will be in commercial service use (Fig. 4.10).

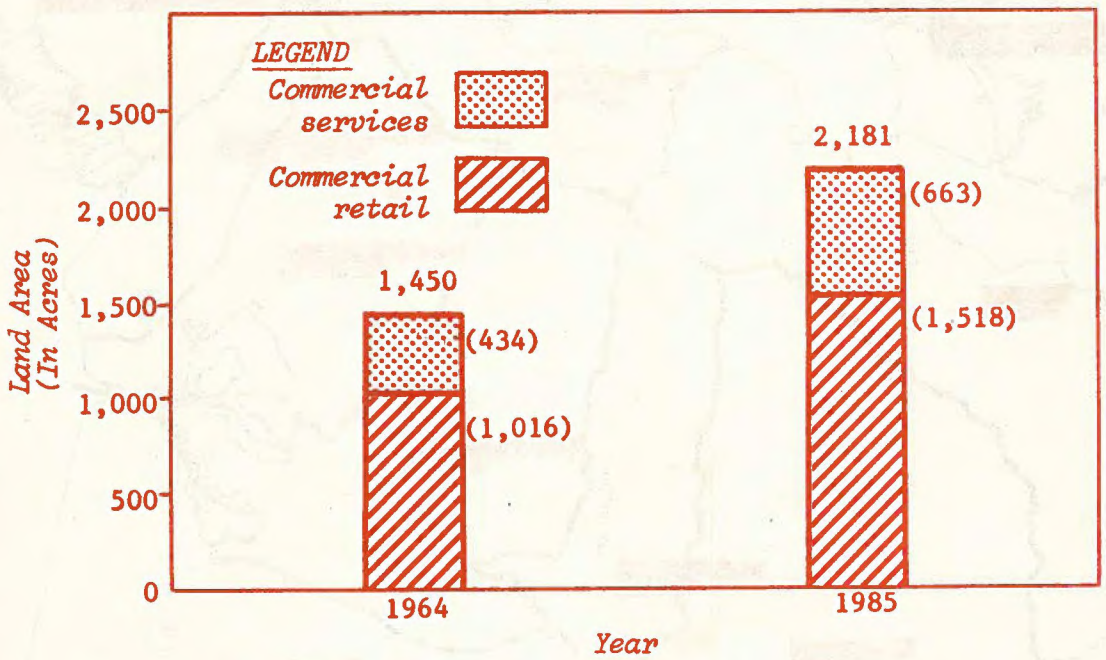



FIG. 4.10. COMPARISON OF 1964 AND 1985 COMMERCIAL LAND AREA.

Land areas in retail and in services uses for each Census Tract are listed in Table 4.D7. Figure 4.11 shows the 1964 and 1985 distribution of commercial land use.

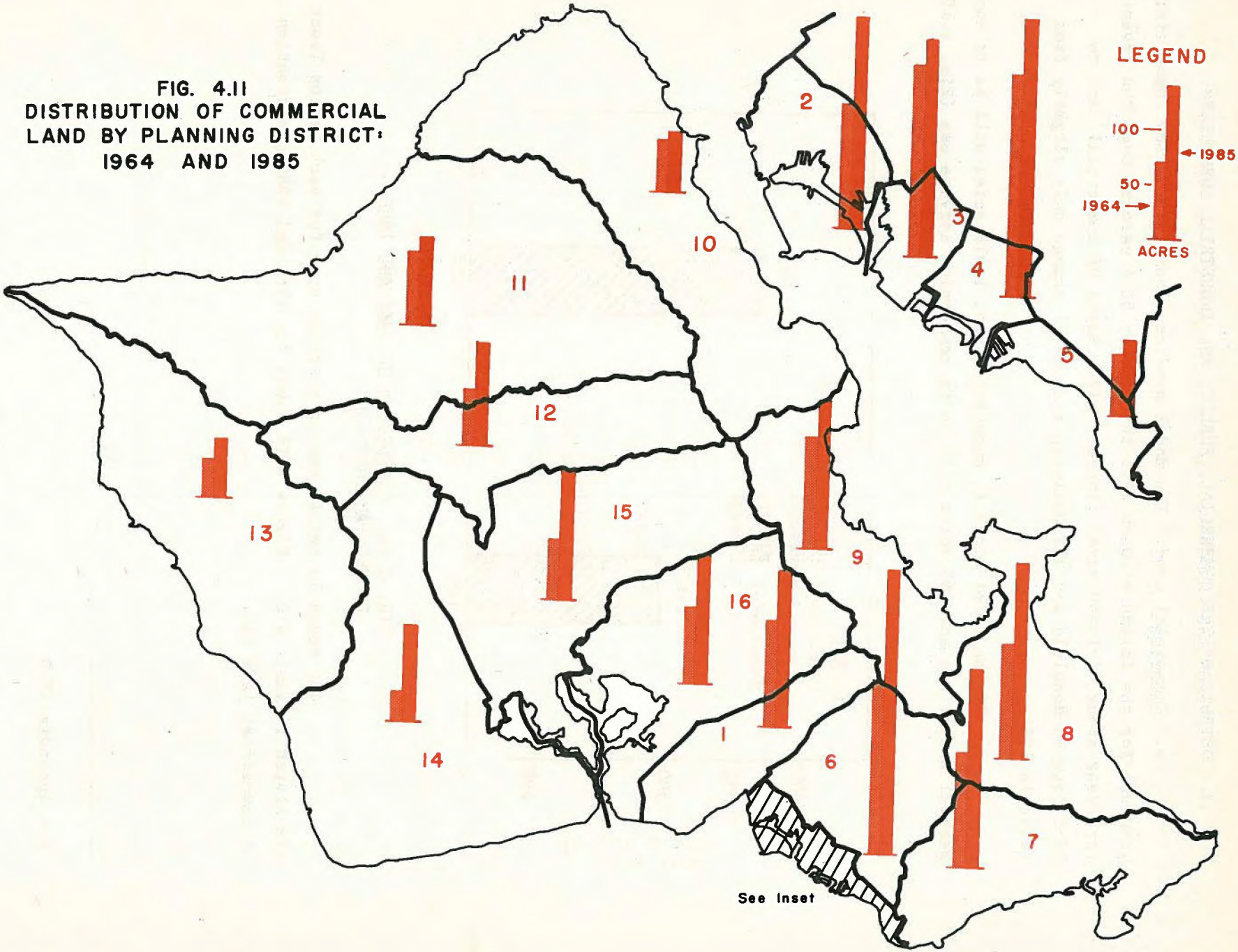
---

*See Appendix IV-D



AR00031605

FIG. 4.11
DISTRIBUTION OF COMMERCIAL LAND BY PLANNING DISTRICT: 1964 AND 1985






AR00031606

Commercial land is responsive to population changes, with stores locating as closely as possible to the residences of its customers. The ratios of distribution in population listed in Table 4.13 are quite similar to the commercial ratio, thus reflecting the tendency of commercial use to respond to changes in population distribution.

Table 4.13. Ratios of Population Distributions on Oahu, 1964 and 1985

| District/Study Area | Ratio (%) | |
|---|---|---|
| | 1964 | 1985 |
| Honolulu District | 55.5 | 53.0 |
| Outlying Districts | 44.5 | 47.0 |

b. Commercial Floor Area. A total increase of nearly 30-million square feet of commercial floor area is anticipated by 1985, an approximately 150-percent increase over the 20-million square feet available today. Of this 30, 24 million will be located in the Honolulu area (Table 4.D2). The bulk of this increase will also occur in commercial-service sector. Where in the past commercial-service uses accounted for only 45.5 percent of the commercial floor area, by 1985 they will have increased to 56 percent of the total (Fig. 4.12). Service floor area will amount to 27.9 million and retail floor area will be 21.8 million square feet.

Floor areas in retail and in services uses for each census tract are listed in Table 4.D7.

The data also reveal that, where the commercial land is distributed nearly equally between the Honolulu and outlying areas, the floor area in commercial use is distributed as 83 percent in the Honolulu area and only 17 percent in the outlying areas. This means that commercial land in Honolulu will continue to be more intensely developed than in the outlying areas. An acre of commercial land in Honolulu will house nearly four times more floor area of commercial use than an acre of commercial land in the outlying areas (Table 4.D3). The greatest increase will occur in Central Honolulu's business and shopping areas, Planning Districts 2, 3, and 4.



AR00031607

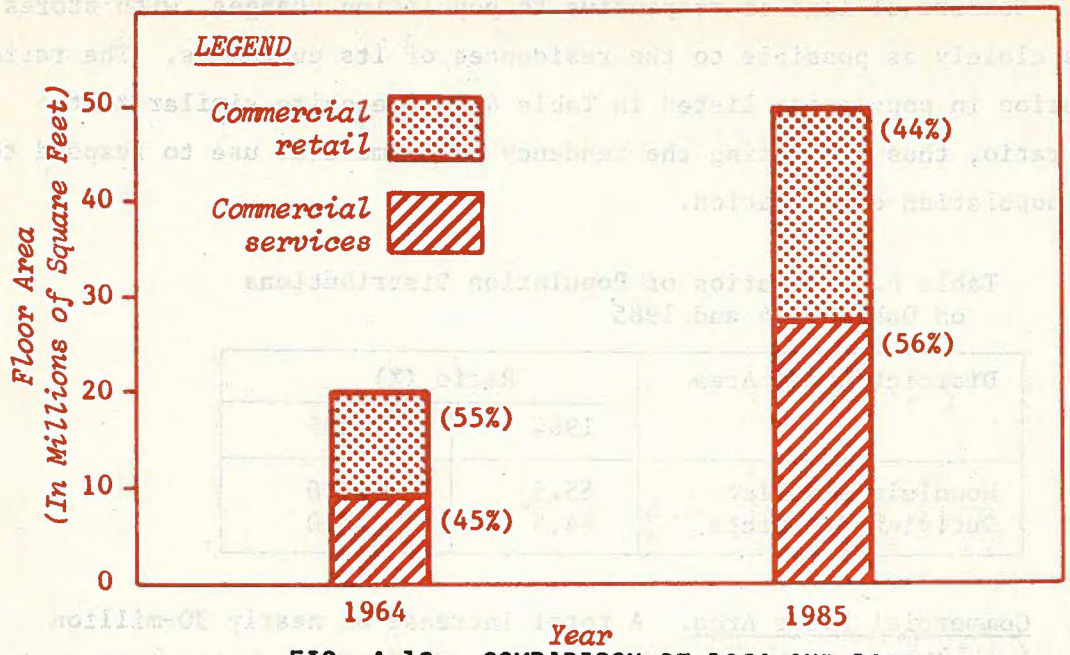



FIG. 4.12. COMPARISON OF 1964 AND 1985 COMMERCIAL FLOOR AREA.

A comparison of commercial-use intensity measured in terms of number of acres of commercial land per 100 dwelling units indicates a 16-percent decrease from the 1964 to the 1985 rate (Table 4.14). As mentioned earlier, however, the floor-area developed on an acre of commercial land will be much greater than it is today. The data in Table 4.D3 reveal that an acre of commercial land will have nearly 65 percent more floor area in 1985 than in 1964.

Table 4.14. Number of Acres of Commercial Retail, Commercial Services, and Total Commercial Serving Each 100 Dwelling Units on Oahu, 1964 and 1985

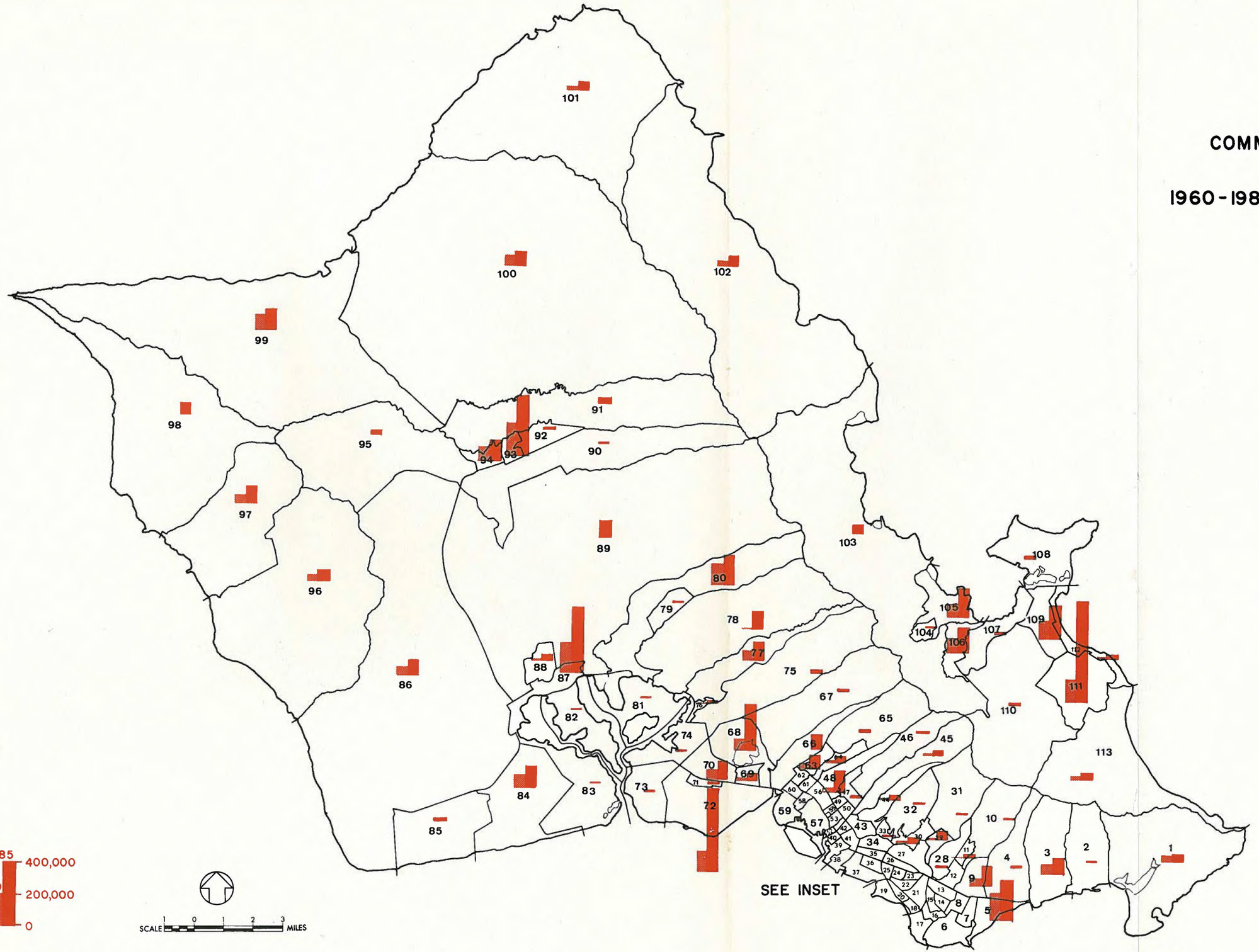
| District | No. of Acres/100 D.U. | | | | | |
|---|---|---|---|---|---|---|
| | Commercial Retail | | Commercial Services | | All Commercial | |
| | 1964 | 1985 | 1964 | 1985 | 1964 | 1985 |
| Honolulu | 0.64 | 0.62 | 0.35 | 0.27 | 0.99 | 0.89 |
| Outlying | 0.79 | 0.53 | 0.21 | 0.23 | 1.00 | 0.76 |
| Average for Study Area | 0.70 | 0.58 | 0.29 | 0.25 | 0.99 | 0.83 |

Figure 4.13 shows the comparison of commercial retail floor area by census tract for 1960 and 1985. Similar comparison of service floor area for 1960 and 1985 is shown in Fig. 4.14.



AR00031608

FIG. 4.13
COMMERCIAL RETAIL
FLOOR AREA
1960-1985 BY CENSUS TRACT






AR00031609

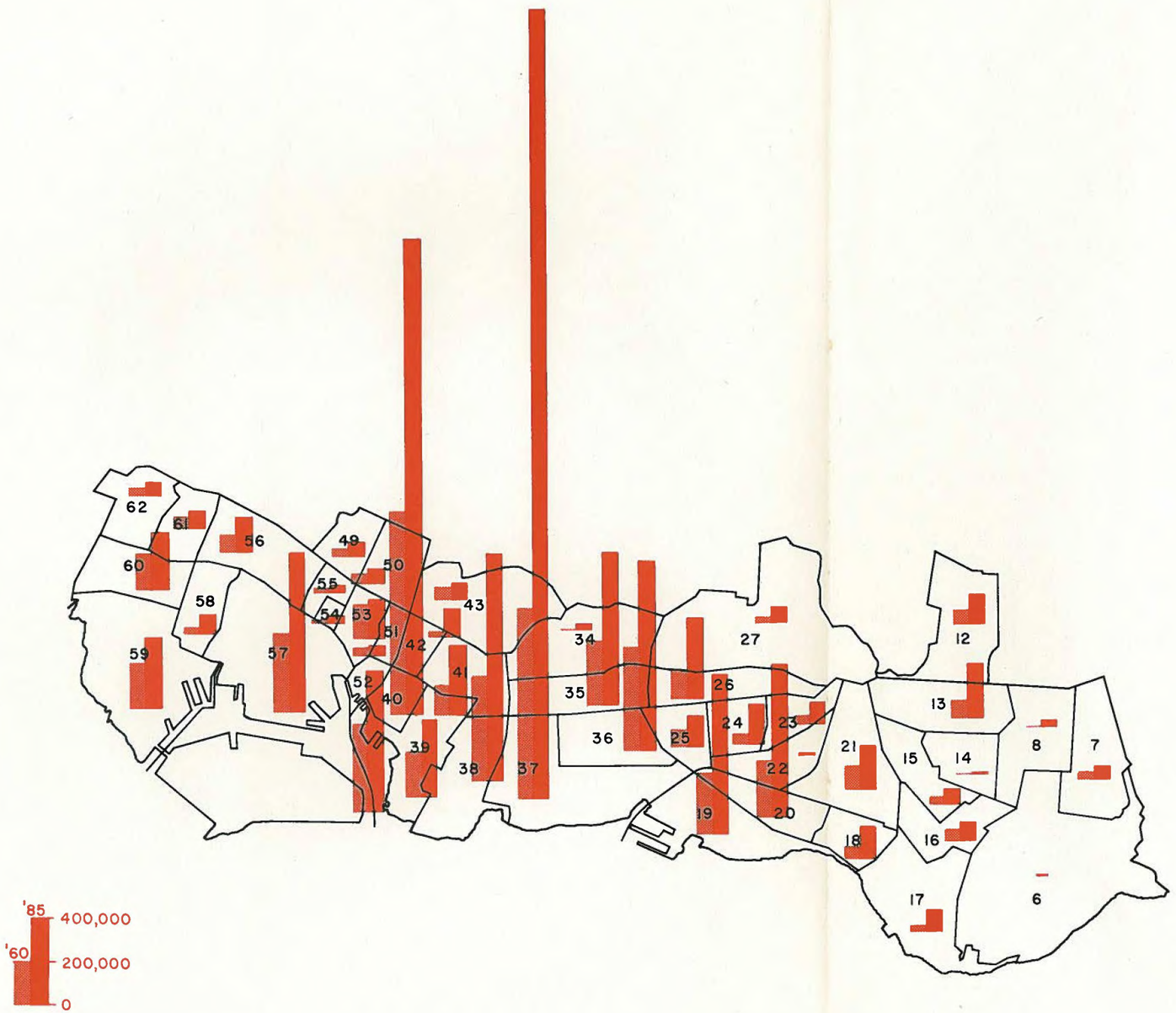


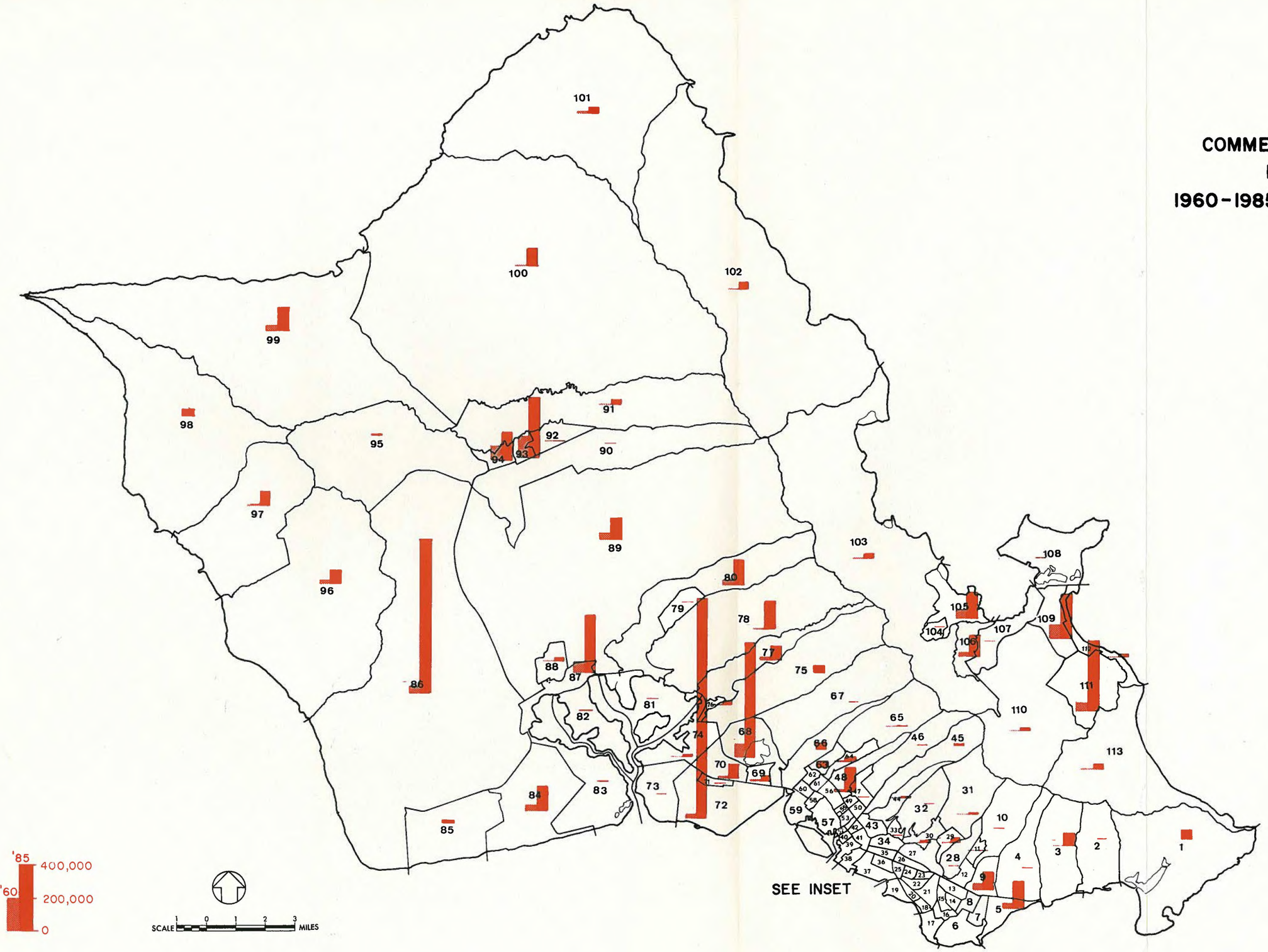

FIG. 4.13a
COMMERCIAL RETAIL
FLOOR AREA
1960-1985 BY CENSUS TRACT



AR00031610

FIG. 4.14

# COMMERCIAL SERVICES FLOOR AREA 1960-1985 BY CENSUS TRACT






AR00031611

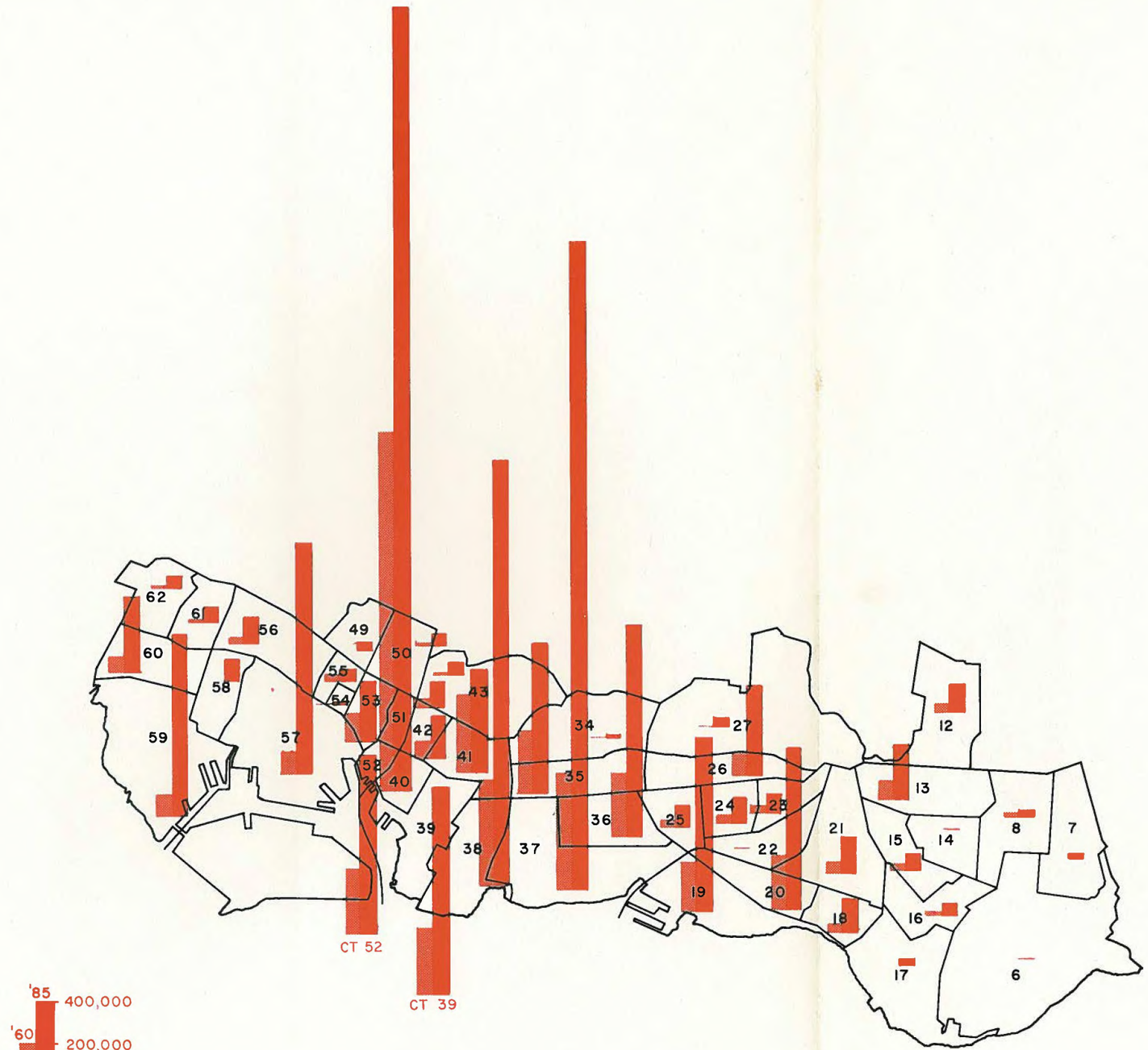



FIG. 4.14a
COMMERCIAL SERVICES
FLOOR AREA
1960-1985 BY CENSUS TRACT



AR00031612

c. Industrial Land. Table 4.D4 shows the total land requirements for 1964 and 1985 and its distribution by planning districts. The projections show that by 1985 total land in industrial use will increase to 7,865 acres, an increase of 23.8 percent from 1964. Unlike the commercial forecast, 89 percent of this growth will take place in the outlying areas, the greatest growth to be in P.D. 14. The growth in this region, where the Campbell Industrial Park complex is situated, will account for 1,215 of the 1,513-acre increase. Figure 4.16 shows the distribution of industrial land throughout each planning district for both the inventory and the design year.

The 7,865 acres is composed of 1,605 acres in manufacturing; 4,912 acres in transportation, communication, and utilities; and 1,279 acres in commercial wholesale, storage and construction. The growth in each sector is depicted in Fig. 4.15. Data by Census Tract are listed in Table 4.D7.

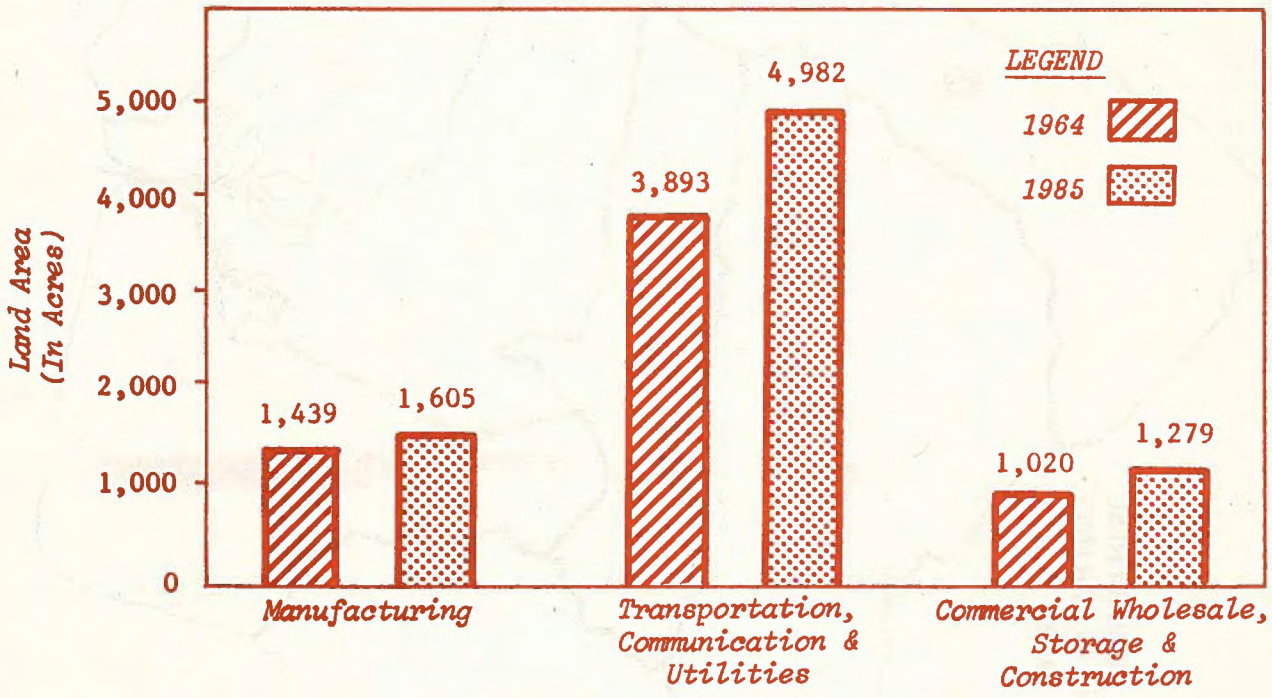


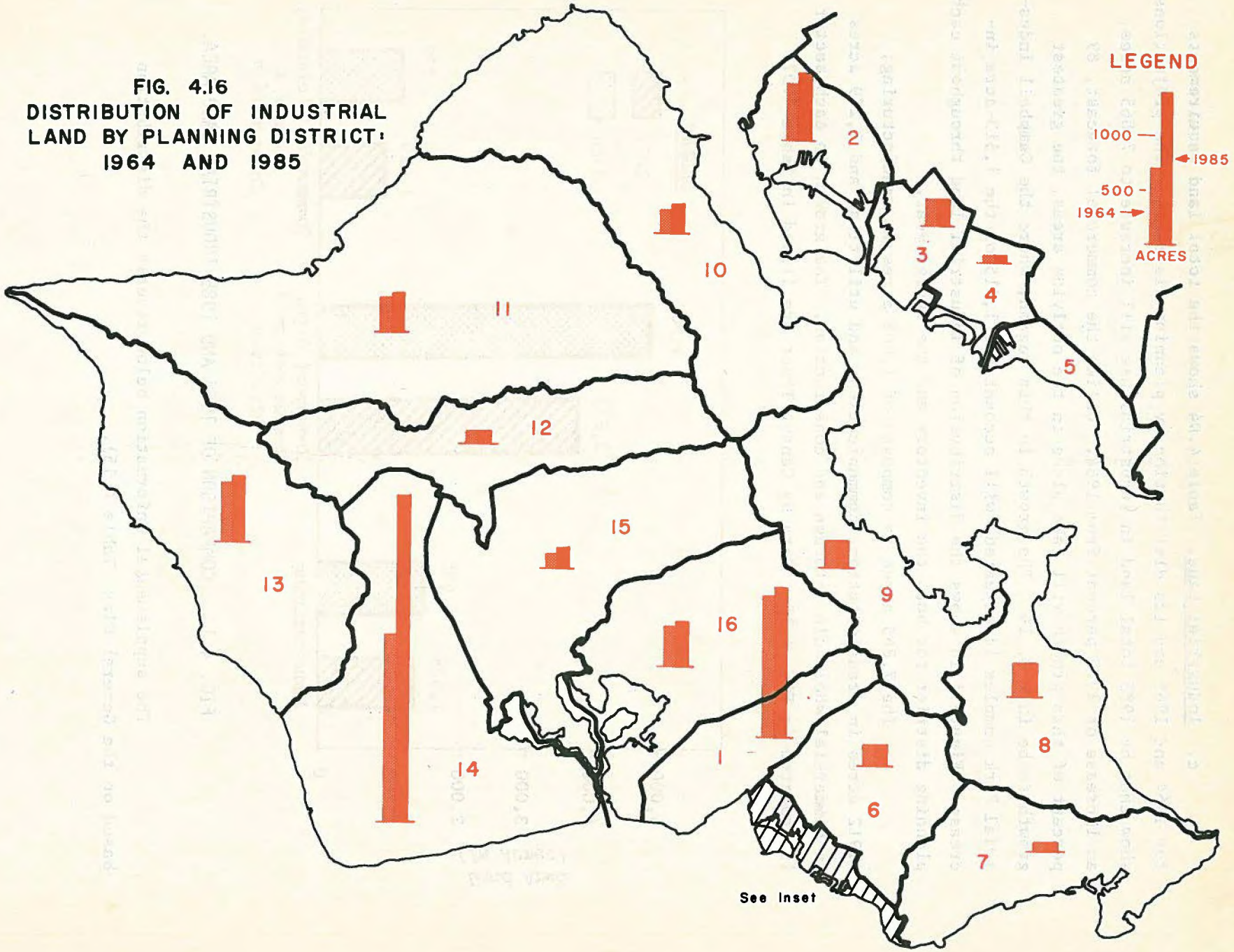

FIG. 4.15. COMPARISON OF 1964 AND 1985 INDUSTRIAL LAND AREA.

The supplemental information below reveals the distribution based on the General Plan (Table 4.15).



AR00031613

FIG. 4.16
DISTRIBUTION OF INDUSTRIAL LAND BY PLANNING DISTRICT: 1964 AND 1985






AR00031614

Table 4.15. Projected Distribution of Industrial Land on Oahu in 1985

| Planning District | Industrial Land Distribution in 1985 (acres) | | | | Available for Industrial Development After 1985 |
|---|---|---|---|---|---|
| | General-Planned Industrial | Estimated Industrial Use in 1985 | Airport and Utilities | Charge Against General Plan | |
| Honolulu | 2,311 | 2,542 | 1,333 | 1,209 | 1,102 |
| Outlying | 4,774 | 5,323 | 948 | 4,375 | 399 |
| TOTAL | 7,085 | 7,865 | 2,281 | 7,865 | 1,501 |

In interpreting this tabulation, note that adjustments have been made to exclude the airport complex and utilities not classified as Industrial Use in the General Plan. The table clearly indicates that, even after the expected development for the design year is considered, there will be considerable acreage remaining for subsequent industrial expansion.

d. Industrial Floor Area. Figure 4.17 is a compilation of present and future industrial floor area. Since floor-area statistics for the category Transportation, Communication, and Utilities is not an output of the model, the 1985 value has been purposely omitted.

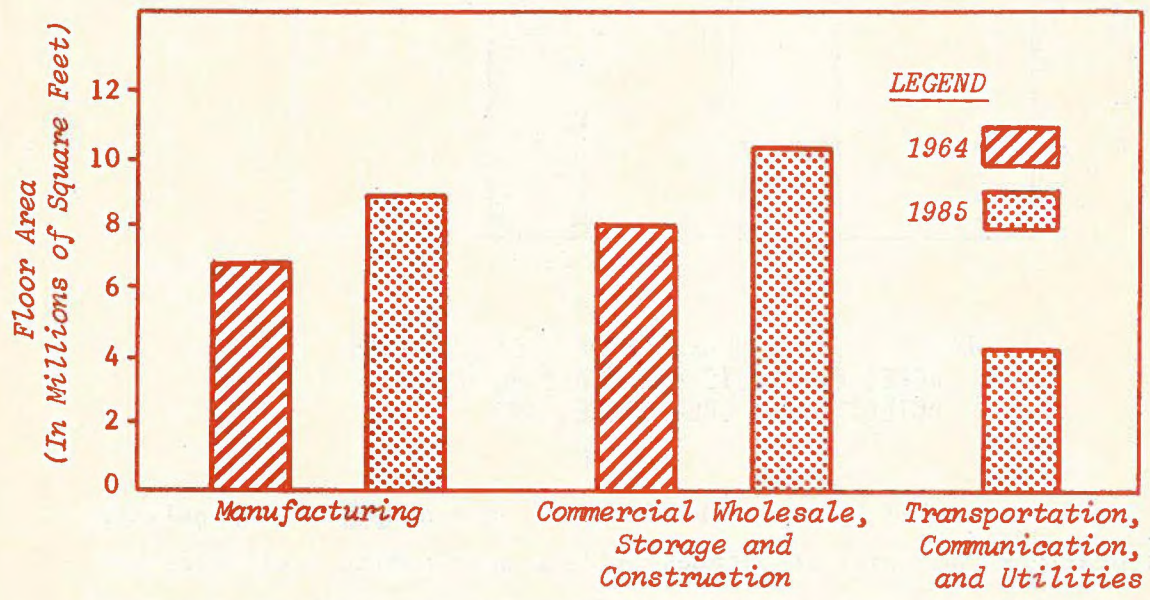



FIG. 4.17. COMPARISON OF 1964 AND 1985 INDUSTRIAL FLOOR AREA.



AR00031615

e. Public and Quasi-Public Land. The public and quasi-public sector includes, in addition to City and State governmental facilities, such facilities as hospitals, chartiable and nonprofit organizations, miscellaneous health and medical facilities, educational and religious institutions, and cultural centers.

Figure 4.18 reflects a total increase of 1,037 acres in this sector between 1964 and 1985.

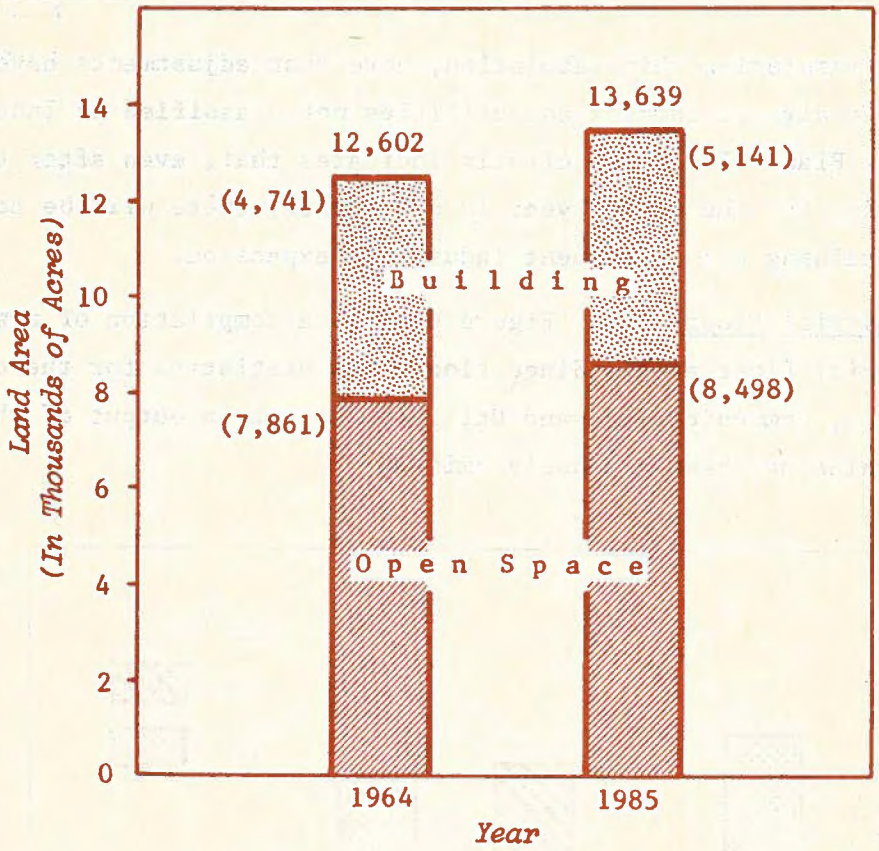



FIG. 4.18. COMPARISON OF 1964 AND 1985 ACRES OF PUBLIC AND QUASI-PUBLIC BUILDING AND OPEN SPACE LAND.

In comparing this growth of only 8 percent with the population growth of nearly 90 percent, it becomes evident that public facilities are expanding at a very low rate. The population served per acre of open-space land increase from 74 persons per acre to 119 persons per acre. Detailed distribution by Census Tract is listed in Table 4.D7.



AR00031616

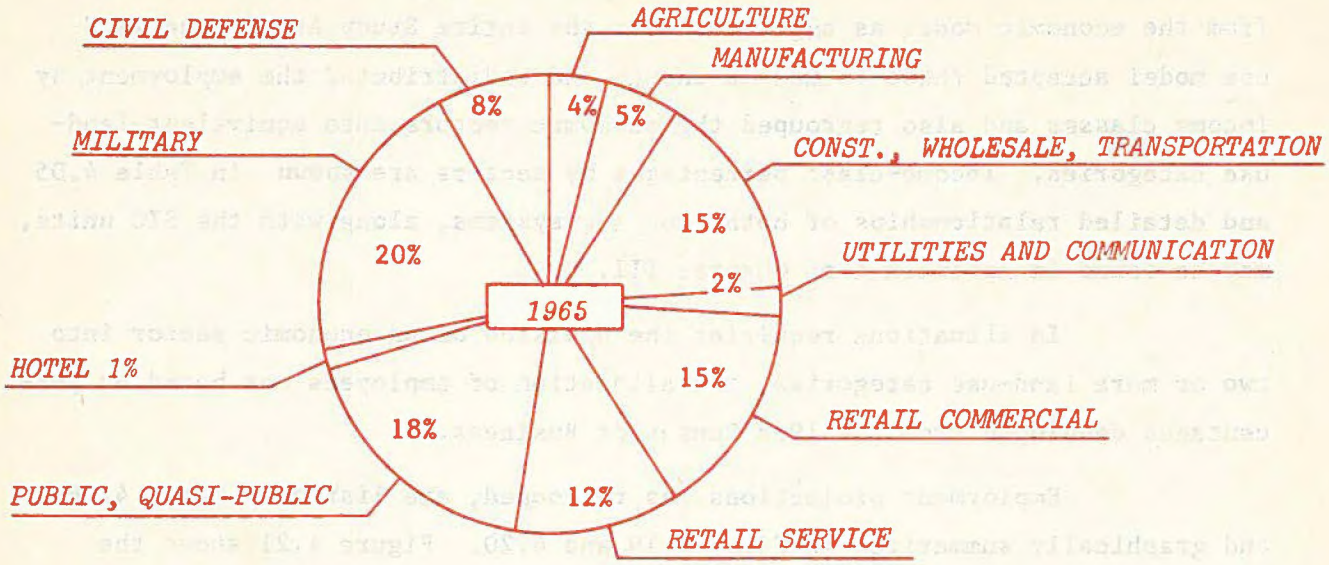
f. Employment. Employment projections by economic sectors for each time period (as listed in Tables 3.2 and 3.3 in Chapter III) were obtained from the economic model as aggregates for the entire Study Area. The land-use model accepted these values as inputs and redistributed the employment by income classes and also regrouped the economic sectors into equivalent-land-use categories. Income-class percentages by sectors are shown in Table 4.D5 and detailed relationships of both grouping systems, along with the SIC units, may be found in Appendix A of Chapter III.

In situations requiring the division of an economic sector into two or more land-use categories, the allocation of employees was based on percentages developed from the 1963 Census of Business.

Employment projections, as regrouped, are listed in Table 4.D6 and graphically summarized in Figs. 4.19 and 4.20. Figure 4.21 shows the 1960 and 1985 distributions of employment.



AR00031617



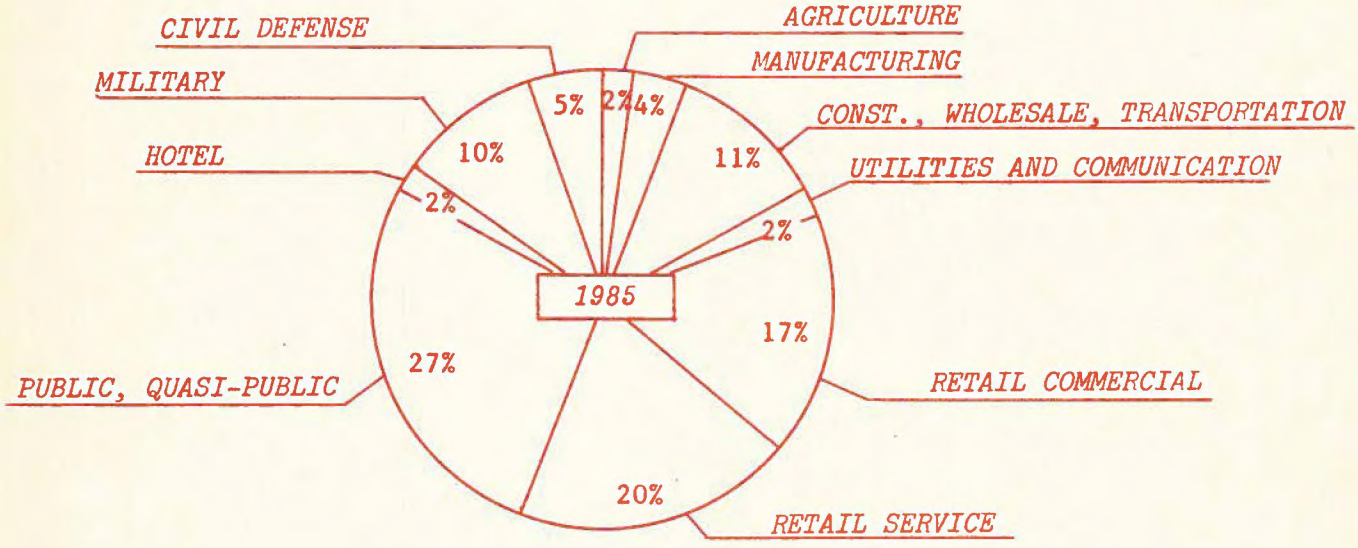




FIG. 4.19. OAHU EMPLOYMENT PIE, 1965 AND 1985.



AR00031618

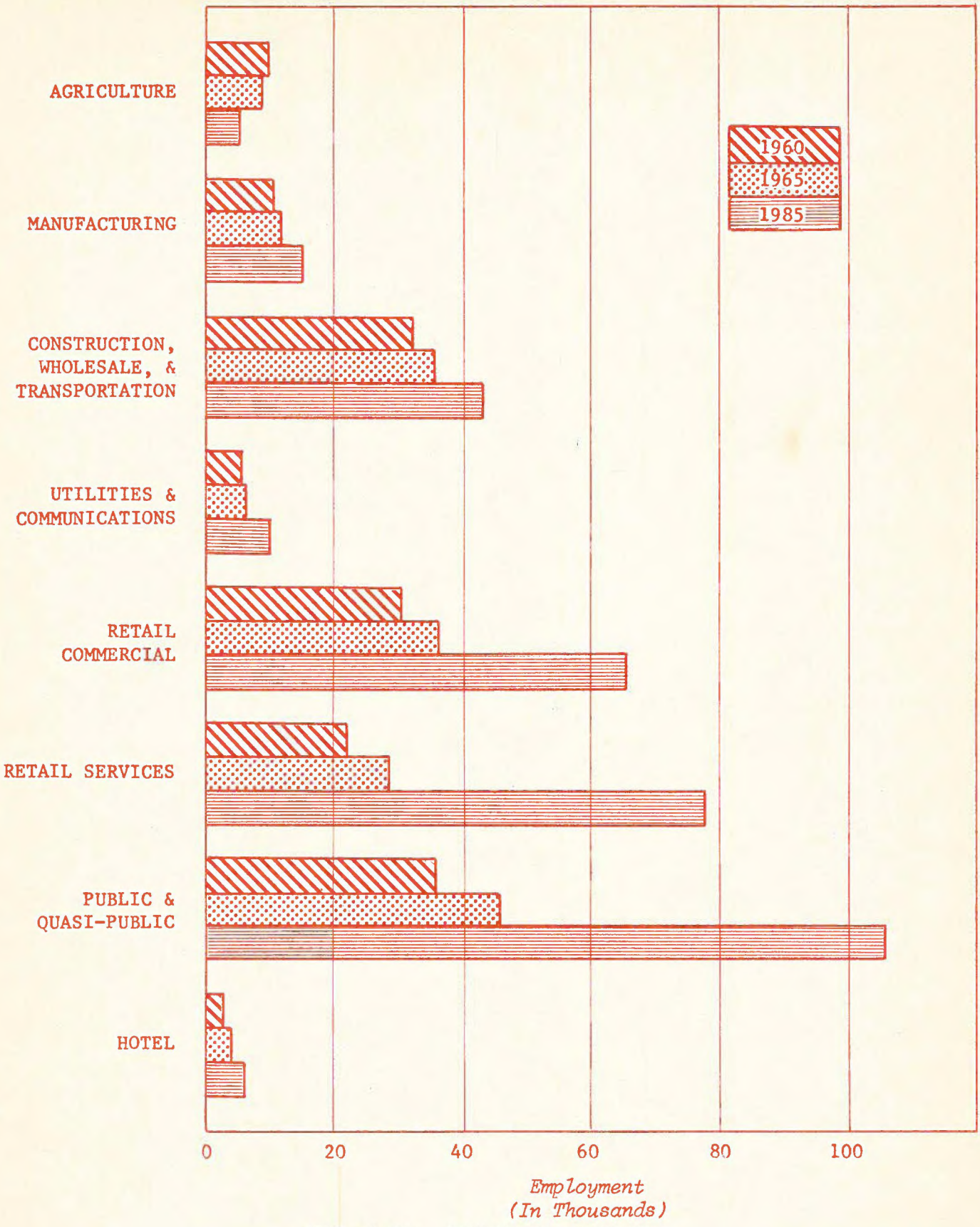



FIG. 4.20. EMPLOYMENT FORECAST.



AR00031619

AR00031620

# FIG. 4.21
# EMPLOYMENT DISTRIBUTION 1960-1985 BY CENSUS TRACT
(INCLUDES MILITARY PERSONNEL)

'85 – 12,000
'60 – 6,000
– 0

SCALE 1 0 1 2 3 MILES

SEE INSET



AR00031621

## REFERENCES


1. "Description of Land Use Inventory Files," Oahu Transportation Study, May 1966.

2. "Recent Land Use Trends in Forty-Eight Large American Cities," Memorandum RM 3664-1-FF, Rand Corporation, 1963.

3. Harland Bartholomew, Land Use in American Cities, Revised Edition, Harvard University Press, Cambridge Mass., 1955.

4. "Land Use Procedures Manual," City and County of Honolulu Planning Department, 1964, p. 34.

5. "General Plan," City and County of Honolulu, May 1964.

6. F. Stuart Chapin, Jr., Urban Land Use Planning, Harper and Brothers, New York, 1957, p. 189.




AR00031622

# APPENDIX IV-A. TABLES CONCERNING EXISTING LAND USE

Table 4.A1. Oahu Land-Use Summary for 1964

| Land Classification | Honolulu District | | | | Outlying Districts | | | | Total for Study Area | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Land | | | Density | Land | | | Density | Land | | | Density |
| | Area (acres) | % of Developed Area | % of Total Area | Acres per 100 Persons | Area (acres) | % of Developed Area | % of Total Area | Acres per 100 Persons | Area (acres) | % of Developed Area | % of Total Area | Acres per 100 Persons |
| Residential | 7,766 | 38.4 | 14.2 | 2.37 | 14,391 | 48.3 | 4.4 | 5.48 | 22,157 | 44.3 | 5.8 | 3.75 |
| Industrial | 2,377 | 11.7 | 4.4 | 0.73 | 3,975 | 13.3 | 1.2 | 1.52 | 6,352 | 12.7 | 1.7 | 1.08 |
| Commercial | 899 | 4.5 | 1.6 | 0.28 | 551 | 1.8 | 0.2 | 0.21 | 1,450 | 2.9 | 0.4 | 0.25 |
| Hotel | 70 | 0.3 | 0.1 | 0.02 | 3 | 0.1 | -- | -- | 73 | 0.1 | -- | 0.01 |
| Public Buildings | 2,469 | 12.2 | 4.5 | 0.75 | 2,272 | 7.6 | 0.7 | 0.87 | 4,741 | 9.5 | 1.2 | 0.80 |
| Public Open Spaces | 3,339 | 16.5 | 6.1 | 1.02 | 4,522 | 15.2 | 1.4 | 1.72 | 7,861 | 15.7 | 2.1 | 1.33 |
| Highways and Streets | 3,320 | 16.4 | 6.1 | 1.01 | 4,085 | 13.7 | 1.3 | 1.56 | 7,405 | 14.8 | 1.9 | 1.26 |
| Total Developed | 20,240 | 100.0 | 37.0 | 6.18 | 29,799 | 100.0 | 9.2 | 11.36 | 50,039 | 100.0 | 13.1 | 8.48 |
| Agriculture | 1,343 | -- | 2.5 | 0.41 | 93,131 | -- | 28.5 | 35.23 | 94,474 | -- | 24.8 | 15.89 |
| Military | 5,003 | -- | 9.2 | 1.53 | 43,630 | -- | 13.3 | 16.94 | 48,633 | -- | 12.8 | 8.39 |
| Total Land in Use | 26,586 | -- | 48.7 | 8.12 | 166,560 | -- | 51.0 | 63.53 | 193,146 | -- | 50.7 | 32.76 |
| Unused Open Space | 27,975 | -- | 51.3 | 8.54 | 160,189 | -- | 49.0 | 61.10 | 188,164 | -- | 49.3 | 31.91 |
| TOTAL AREA | 54,561 | | 100.0 | 16.66 | 326,749 | -- | 100.0 | 124.63 | 381,310 | -- | 100.0 | 64.67 |



AR00031626

Table 4.A2. Distribution of Commercial Land and Floor Areas for Retail Trade and Commercial Services, 1964

| Planning District | Commercial Usage* | | Commercial Floor Area* | | Commercial Retail Area | | Commercial Services Area | | Hotels Area | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Acres | Percent of Total | Sq Ft | Percent of Total | Acres | Floor Area (sq ft) | Acres | Floor Area (sq ft) | Sq Ft | Floor Area (sq ft) |
| Honolulu District | | | | | | | | | | |
| 1 | 94 | 6.5 | 1,027,190 | 5.1 | 52 | 600,728 | 42 | 426,462 | 1 | 35,424 |
| 2 | 113 | 7.8 | 1,261,607 | 6.3 | 84 | 895,168 | 29 | 366,439 | 0 | 8,634 |
| 3 | 173 | 11.9 | 6,281,276 | 31.2 | 71 | 2,338,598 | 102 | 3,942,678 | 1 | 147,794 |
| 4 | 203 | 14.0 | 3,939,025 | 19.6 | 157 | 2,490,623 | 46 | 1,448,402 | 0 | 0 |
| 5 | 58 | 4.0 | 1,596,465 | 7.9 | 34 | 723,650 | 24 | 872,815 | 66 | 4,654,532 |
| 6 | 156 | 10.8 | 2,014,413 | 10.0 | 101 | 1,277,649 | 55 | 736,764 | 2 | 26,140 |
| 7 | 102 | 7.0 | 1,028,227 | 5.1 | 81 | 671,094 | 21 | 357,133 | 0 | 0 |
| Subtotal | 899 | 62.0 | 17,148,203 | 85.2 | 580 | 8,997,510 | 319 | 8,150,693 | 70 | 4,872,524 |
| Outlying Districts | | | | | | | | | | |
| 8 | 102 | 7.0 | 677,084 | 3.4 | 79 | 451,812 | 23 | 225,272 | 3 | 125,664 |
| 9 | 101 | 7.0 | 330,771 | 1.6 | 95 | 237,527 | 6 | 93,244 | 0 | 0 |
| 10 | 48 | 3.3 | 68,057 | 0.3 | 47 | 53,937 | 1 | 14,120 | 0 | 2,829 |
| 11 | 66 | 4.5 | 187,173 | 0.9 | 57 | 140,426 | 9 | 46,747 | 0 | 0 |
| 12 | 50 | 3.4 | 553,963 | 2.8 | 27 | 312,756 | 23 | 241,207 | 0 | 0 |
| 13 | 35 | 2.4 | 174,115 | 0.9 | 23 | 130,765 | 12 | 43,350 | 0 | 0 |
| 14 | 27 | 1.9 | 228,213 | 1.1 | 19 | 126,624 | 8 | 101,589 | 0 | 0 |
| 15 | 53 | 3.7 | 390,616 | 1.9 | 46 | 265,840 | 7 | 124,776 | 0 | 0 |
| 16 | 69 | 4.8 | 374,250 | 1.9 | 43 | 269,148 | 26 | 105,102 | 0 | 0 |
| Subtotal | 551 | 38.0 | 2,984,242 | 14.8 | 436 | 1,988,835 | 115 | 995,407 | 3 | 128,493 |
| TOTAL | 1,450 | 100.0 | 20,132,445 | 100.0 | 1,016 | 10,986,345 | 434 | 9,146,100 | 73 | 5,001,017 |

*Values exclude hotels.



AR00031627

Table 4.A3. Land and Floor Areas for Commercial-Retail and Commercial-Services Categories, 1964

| Land Use | Number of Establishments | Land Area (acres) | Floor Area (sq ft) | Mean Floor Area per Establishment (sq ft) | Rank by Land Area | Rank by Floor Area |
|---|---|---|---|---|---|---|
| Commercial Retail | | | | | | |
| Supermarkets | 61 | 123 | 888,312 | 14,562 | 5 | 6 |
| Food Stores | 656 | 197 | 1,000,281 | 1,525 | 1 | 5 |
| General Merchandise | 170 | 128 | 1,838,001 | 10,812 | 4 | 2 |
| Apparel and Accessories | 375 | 20 | 744,332 | 1,985 | 10 | 7 |
| Furniture, Furnishings and Equipment | 152 | 40 | 699,999 | 4,605 | 9 | 8 |
| Service Stations | 332 | 134 | 584,653 | 1,761 | 3 | 9 |
| Motor Vehicles, Sales and Service | 202 | 92 | 1,193,709 | 5,909 | 6 | 3 |
| Lumber and Building Materials | 46 | 50 | 393,574 | 8,556 | 8 | 10 |
| Hardware Stores | 36 | 5 | 105,160 | 2,921 | 12 | 12 |
| Eating and Drinking Places | 902 | 163 | 2,047,269 | 2,270 | 2 | 1 |
| Drug Stores | 92 | 6 | 292,606 | 3,181 | 11 | 11 |
| Liquor Stores | 40 | 2 | 77,088 | 1,927 | 13 | 13 |
| Miscellaneous Retail Trade Stores | 682 | 56 | 1,121,361 | 1,644 | 7 | 4 |
| Subtotal | 3,746 | 1,016 | 10,986,345 | 2,933 | | |
| Commercial Services | | | | | | |
| Personal Services | 945 | 27 | 769,962 | 815 | 6 | 7 |
| Personal Services, Apparel | 352 | 28 | 550,377 | 1,564 | 5 | 9 |
| Commercial Amusement, Indoor | 241 | 67 | 1,049,999 | 4,357 | 3 | 4 |
| Finance, Insurance, Real Estate | 869 | 44 | 1,702,836 | 1,960 | 4 | 1 |
| Medical and Health Services | 742 | 27 | 839,342 | 1,131 | 6 | 5 |
| Legal, Engineering and Other Professional | 558 | 15 | 649,698 | 1,164 | 8 | 8 |
| Automobile Repair Service | 336 | 69 | 829,470 | 2,469 | 2 | 6 |
| Miscellaneous Repair Service | 231 | 19 | 349,483 | 1,513 | 7 | 10 |
| Miscellaneous Business Service | 352 | 12 | 1,137,911 | 3,233 | 9 | 3 |
| Parking Service | 236 | 126 | 1,267,022 | 5,369 | 1 | 2 |
| Subtotal | 4,862 | 434 | 9,146,100 | 1,881 | | |
| Hotels | 60 | 73 | 5,001,017 | | | |
| TOTAL | 4,922 | 507 | 14,147,117 | 2,874 | | |



AR00031628

Table 4.A4. Summary of Uses within General Plan Commercial Areas on Oahu in 1964

| Planning District | Total | | Land in Developed Use | | | | Vacant Land |
|---|---|---|---|---|---|---|---|
| | Acres | Percent | Commercial | Other | Single-Family Residential | Agriculture | |
| Honolulu | | | | | | | |
| 1 | 45 | 3.1 | 13 | -- | -- | -- | 32 |
| 2 | 25 | 1.8 | 13 | 4 | 7 | -- | 1 |
| 3 | 161 | 11.2 | 91 | 54 | 1 | -- | 15 |
| 4 | 208 | 14.5 | 135 | 40 | 12 | -- | 21 |
| 5 | 88 | 6.1 | 37 | 44 | 3 | -- | 4 |
| 6 | 101 | 7.1 | 43 | 27 | 16 | 1 | 13 |
| 7 | 92 | 6.4 | 60 | 13 | 10 | -- | 9 |
| Subtotal | 720 | 50.2 | 392 | 183 | 49 | 1 | 95 |
| Outlying | | | | | | | |
| 8 | 81 | 5.7 | 41 | 15 | 4 | -- | 21 |
| 9 | 155 | 10.8 | 46 | 20 | 36 | 9 | 44 |
| 10 | 44 | 3.1 | -- | 3 | 22 | 9 | 10 |
| 11 | 31 | 2.2 | 8 | 2 | 12 | -- | 9 |
| 12 | 75 | 5.2 | 34 | 17 | 9 | -- | 15 |
| 13 | 58 | 4.1 | 25 | 4 | 14 | -- | 15 |
| 14 | 45 | 3.1 | 13 | -- | 2 | 5 | 25 |
| 15 | 118 | 8.2 | 22 | 4 | 1 | 67 | 24 |
| 16 | 106 | 7.4 | 57 | 10 | 5 | -- | 34 |
| Subtotal | 713 | 49.8 | 246 | 75 | 105 | 90 | 197 |
| TOTAL | 1,433 | 100.0 | 638 | 258 | 154 | 91 | 292 |



AR00031629

Table 4.A5. Ratio of Commercial Floor Area To its Land Use on Oahu in 1964

| Planning District | Floor Area/Acre * | | |
|---|---|---|---|
| | Commercial Retail | Commercial Service | Commercial Retail and Service |
| Honolulu | | | |
| 1 | 11.6 | 10.2 | 10.9 |
| 2 | 10.7 | 12.6 | 11.2 |
| 3 | 32.9 | 39.0 | 36.5 |
| 4 | 15.9 | 32.2 | 19.5 |
| 5 | 21.3 | 36.4 | 27.5 |
| 6 | 12.7 | 13.6 | 13.0 |
| 7 | 8.3 | 17.0 | 10.1 |
| Subtotal | 15.5 | 25.8 | 19.1 |
| Outlying | | | |
| 8 | 5.7 | 9.8 | 6.6 |
| 9 | 2.5 | 15.5 | 3.3 |
| 10 | 1.1 | 14.1 | 1.4 |
| 11 | 2.5 | 5.2 | 2.8 |
| 12 | 11.6 | 10.5 | 11.1 |
| 13 | 5.7 | 3.6 | 5.0 |
| 14 | 1.0 | 12.7 | 8.5 |
| 15 | 5.8 | 17.8 | 7.4 |
| 16 | 6.3 | 4.0 | 5.4 |
| Subtotal | 3.6 | 8.7 | 5.4 |
| TOTAL | 9.7 | 21.2 | 13.9 |

*Ratio reflects floor area in 1,000 square feet.



AR00031630

Table 4.A6. Distribution of Generalized Industrial Land Use and Industrial Floor Area by Planning District on Oahu, 1964

| Planning District | Manufacturing | | | Transportation, Communication, Utilities | | | Wholesale, Storage, Construction | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Land Area | | Floor Area | Land Area | | Floor Area | Land Area | | Floor Area | Land Area | | Floor Area |
| | (acres) | (%) | (%) | (acres) | (%) | (%) | (acres) | (%) | (%) | (acres) | (%) | (%) |
| Honolulu | | | | | | | | | | | | |
| 1 | 13 | 0.9 | 3.4 | 1,159 | 29.8 | 15.3 | 101 | 9.9 | 16.8 | 1,273 | 20.0 | 11.6 |
| 2 | 152 | 10.6 | 50.6 | 170 | 4.4 | 32.1 | 184 | 18.0 | 25.8 | 506 | 8.0 | 36.1 |
| 3 | 33 | 2.3 | 17.0 | 121 | 3.1 | 35.7 | 87 | 8.5 | 34.1 | 241 | 3.8 | 28.4 |
| 4 | 15 | 1.0 | 6.9 | 5 | 0.1 | 2.7 | 48 | 4.7 | 12.8 | 68 | 1.1 | 8.4 |
| 5 | -- | -- | 0.1 | 5 | 0.1 | 0.9 | -- | -- | 0.1 | 5 | 0.1 | 0.3 |
| 6 | 19 | 1.3 | 3.5 | 167 | 4.3 | 1.4 | 12 | 1.2 | 2.5 | 198 | 3.1 | 2.6 |
| 7 | 16 | 1.1 | 0.6 | 67 | 1.7 | 1.9 | 3 | 0.3 | 0.2 | 86 | 1.3 | 0.7 |
| Subtotal | 248 | 17.2 | 82.1 | 1,694 | 43.5 | 90.0 | 435 | 42.6 | 92.3 | 2,377 | 37.4 | 88.1 |
| Outlying | | | | | | | | | | | | |
| 8 | 118 | 8.2 | 0.7 | 178 | 4.6 | 0.7 | 12 | 1.2 | 0.5 | 308 | 4.8 | 0.6 |
| 9 | 193 | 13.4 | 0.2 | 45 | 1.1 | 0.3 | 18 | 1.8 | 0.3 | 256 | 4.0 | 0.3 |
| 10 | -- | -- | * | 148 | 3.8 | 0.8 | 107 | 10.4 | 0.2 | 255 | 4.0 | 0.3 |
| 11 | 22 | 1.5 | 2.7 | 305 | 7.8 | 0.4 | 8 | 0.8 | 0.2 | 335 | 5.3 | 1.1 |
| 12 | 35 | 2.5 | 0.1 | 58 | 1.5 | 0.5 | 10 | 1.0 | 0.7 | 103 | 1.6 | 0.4 |
| 13 | 257 | 17.9 | 1.4 | 181 | 4.6 | 0.9 | 102 | 10.0 | 0.2 | 540 | 8.5 | 0.8 |
| 14 | 532 | 37.0 | 5.4 | 1,026 | 26.4 | 1.2 | 118 | 11.6 | 3.6 | 1,676 | 26.4 | 3.7 |
| 15 | 15 | 1.0 | 4.1 | 108 | 2.8 | 1.0 | 12 | 1.2 | 0.4 | 135 | 2.2 | 1.9 |
| 16 | 19 | 1.3 | 3.3 | 150 | 3.9 | 4.2 | 198 | 19.4 | 1.6 | 367 | 5.8 | 2.8 |
| Subtotal | 1,191 | 82.8 | 17.9 | 2,199 | 56.5 | 10.0 | 585 | 57.4 | 7.7 | 3,975 | 62.6 | 11.9 |
| TOTAL | 1,439 | 100.0 | 100.0 | 3,893 | 100.0 | 100.0 | 1,020 | 100.0 | 100.0 | 6,352 | 100.0 | 100.0 |

*Less than one-tenth of one percent.



AR00031631

Table 4.A7. Percent of District's Industrial Floor Area Concealed As a Secondary Use on Oahu in 1964

| Planning District | Percent |
|---|---|
| Honolulu | |
| 1 | 1.9 |
| 2 | 2.3 |
| 3 | 8.5 |
| 4 | 14.2 |
| 5 | 51.7 |
| 6 | 13.3 |
| 7 | 23.8 |
| Subtotal | 6.0 |
| Outlying | |
| 8 | 10.6 |
| 9 | 17.4 |
| 10 | 7.0 |
| 11 | 3.9 |
| 12 | 10.0 |
| 13 | 1.6 |
| 14 | 34.3 |
| 15 | 1.7 |
| 16 | 2.1 |
| Subtotal | 13.5 |
| TOTAL | 6.9 |



AR00031632

Table 4.A8. Summary of Existing Industrial Use Outside and Within General-Planned Industrial Land on Oahu in 1964

| Planning District | Area of General-Planned Industrial Use (acres) | | |
|---|---|---|---|
| | Within Industrial Land | Outside Industrial Land | Total |
| Honolulu | | | |
| 1 | 115 | 1,158 | 1,273 |
| 2 | 495 | 11 | 506 |
| 3 | 195 | 46 | 241 |
| 4 | 49 | 19 | 68 |
| 5 | -- | 5 | 5 |
| 6 | -- | 198 | 198 |
| 7 | -- | 86 | 86 |
| Subtotal | 854 | 1,523 | 2,377 |
| Outlying | | | |
| 8 | 99 | 209 | 308 |
| 9 | 20 | 236 | 256 |
| 10 | 26 | 229 | 255 |
| 11 | 22 | 313 | 335 |
| 12 | 9 | 94 | 103 |
| 13 | 43 | 497 | 540 |
| 14 | 878 | 798 | 1,676 |
| 15 | 12 | 123 | 135 |
| 16 | 51 | 316 | 367 |
| Subtotal | 1,160 | 2,815 | 3,975 |
| TOTAL | 2,014 | 4,338 | 6,352 |



AR00031633

Table 4.A9. Summary of Uses within General-Planned Industrial Areas on Oahu in 1964

| Planning District | General-Planned | | Land in Developed Use (acres) | | | | Vacant Acres |
|---|---|---|---|---|---|---|---|
| | Acres | Percent of Total | Industrial | Other | Single-Family Residential | Agriculture | |
| Honolulu | | | | | | | |
| 1 | 317 | 4.5 | 115 | 84 | -- | -- | 118 |
| 2 | 1,523 | 21.5 | 495 | 438 | 81 | -- | 509 |
| 3 | 356 | 5.0 | 195 | 137 | 3 | -- | 21 |
| 4 | 115 | 1.6 | 49 | 58 | 2 | -- | 6 |
| 5 | -- | -- | -- | -- | -- | -- | -- |
| 6 | -- | -- | -- | -- | -- | -- | -- |
| 7 | -- | -- | -- | -- | -- | -- | -- |
| Subtotal | 2,311 | 32.6 | 854 | 717 | 86 | -- | 654 |
| Outlying | | | | | | | |
| 8 | 139 | 2.0 | 99 | 23 | -- | 17 | -- |
| 9 | 103 | 1.5 | 20 | 11 | 23 | 17 | 32 |
| 10 | 82 | 1.2 | 26 | -- | -- | 53 | 3 |
| 11 | 40 | 0.6 | 22 | 2 | 8 | 4 | 4 |
| 12 | 33 | 0.5 | 9 | 6 | 3 | 8 | 7 |
| 13 | 393 | 5.5 | 43 | 11 | -- | 138 | 201 |
| 14 | 3,383 | 47.7 | 878 | 164 | 22 | 1,378 | 941 |
| 15 | 450 | 6.3 | 12 | 20 | 82 | 327 | 9 |
| 16 | 151 | 2.1 | 51 | 11 | 2 | 19 | 68 |
| Subtotal | 4,774 | 67.4 | 1,160 | 248 | 140 | 1,961 | 1,265 |
| TOTAL | 7,085 | 100.0 | 2,014 | 965 | 226 | 1,961 | 1,919 |



AR00031634

Table 4.A10. Summary of Lot Sizes of Available, General-Planned Industrial Land on Oahu, 1964

| Type of Land Use | Honolulu | | | Outlying | | | Study Area | | |
|---|---|---|---|---|---|---|---|---|---|
| | Land Area (acres) | No. of Lots | Median Lot Size (sq ft) | Land Area (acres) | No. of Lots | Median Lot Size (sq ft) | Land Area (acres) | No. of Lots | Median Lot Size (sq ft) |
| Residential Single Family | 86 | 750 | Under 5,000 | 140 | 117 | 6,293 | 226 | 867 | Under 5,000 |
| Vacant Usable | 654 | 354 | 16,524 | 1,265 | 126 | Over 45,000 | 1,919 | 480 | 20,114 |
| Agricultural* | -- | -- | -- | 1,961 | -- | -- | 1,961 | -- | -- |

*Statistics on number of lots and median lot size are not available.



AR00031635

Table 4.A11. Distribution of Residential Land Use by Planning District on Oahu in 1964

| Planning District | Type of Land Use | | | | Total | |
|---|---|---|---|---|---|---|
| | Multi-Family Residential | | Single-Family Residential | | | |
| | Area (acres) | Percent | Area (acres) | Percent | Area (acres) | Percent |
| Honolulu | | | | | | |
| 1 | -- | -- | 254 | 1.2 | 254 | 1.2 |
| 2 | 50 | 6.2 | 115 | 0.5 | 165 | 0.7 |
| 3 | 31 | 3.8 | 30 | 0.1 | 61 | 0.3 |
| 4 | 46 | 5.7 | 48 | 0.2 | 94 | 0.4 |
| 5 | 96 | 11.8 | 132 | 0.6 | 228 | 1.0 |
| 6 | 300 | 36.9 | 3,265 | 15.3 | 3,565 | 16.1 |
| 7 | 109 | 13.4 | 3,289 | 15.4 | 3,398 | 15.3 |
| Subtotal | 632 | 77.8 | 7,133 | 33.3 | 7,765 | 35.0 |
| Outlying | | | | | | |
| 8 | 11 | 1.4 | 2,268 | 10.6 | 2,279 | 10.3 |
| 9 | 3 | 0.4 | 3,312 | 15.5 | 3,315 | 15.0 |
| 10 | 27 | 3.3 | 1,463 | 6.9 | 1,490 | 6.7 |
| 11 | 16 | 2.0 | 530 | 2.5 | 546 | 2.5 |
| 12 | 23 | 2.8 | 703 | 3.3 | 726 | 3.3 |
| 13 | 5 | 0.6 | 3,343 | 15.7 | 3,348 | 15.1 |
| 14 | 1 | 0.1 | 630 | 3.0 | 631 | 2.8 |
| 15 | 11 | 1.4 | 656 | 3.1 | 667 | 3.0 |
| 16 | 83 | 10.2 | 1,307 | 6.1 | 1,390 | 6.3 |
| Subtotal | 180 | 22.2 | 14,212 | 66.7 | 14,392 | 65.0 |
| TOTAL | 812 | 100.0 | 21,345 | 100.0 | 22,157 | 100.0 |



AR00031636

Table 4.A12. Distribution of Dwelling Units by Planning District on Oahu in 1964

| Planning District | Single-Family | | Multi-Family | | Military Family | Total | |
|---|---|---|---|---|---|---|---|
| | D.U. | Percent | D.U. | Percent | D.U.* | D.U. | Percent |
| Honolulu | | | | | | | |
| 1 | 1,654 | 1.8 | -- | -- | 4,887 | 6,541 | 4.5 |
| 2 | 2,181 | 2.3 | 2,234 | 5.7 | -- | 4,415 | 3.0 |
| 3 | 752 | 0.8 | 3,075 | 7.9 | -- | 3,827 | 2.6 |
| 4 | 1,036 | 1.1 | 2,952 | 7.5 | 10 | 3,998 | 2.7 |
| 5 | 1,278 | 1.4 | 9,366 | 24.0 | -- | 10,644 | 7.3 |
| 6 | 23,724 | 25.6 | 15,465 | 39.5 | -- | 39,189 | 26.9 |
| 7 | 19,118 | 20.6 | 1,843 | 4.7 | 89 | 21,050 | 14.5 |
| Subtotal | 49,743 | 53.6 | 34,935 | 89.3 | 4,986 | 89,664 | 61.5 |
| Outlying | | | | | | | |
| 8 | 9,121 | 9.8 | 466 | 1.2 | 1,123 | 10,710 | 7.4 |
| 9 | 7,040 | 7.6 | 112 | 0.3 | -- | 7,152 | 4.9 |
| 10 | 2,634 | 2.8 | 101 | 0.3 | -- | 2,735 | 1.9 |
| 11 | 2,251 | 2.4 | 140 | 0.4 | 33 | 2,424 | 1.7 |
| 12 | 4,313 | 4.7 | 832 | 2.1 | 2,852 | 7,997 | 5.5 |
| 13 | 4,861 | 5.3 | 108 | 0.3 | 104 | 5,073 | 3.5 |
| 14 | 3,094 | 3.3 | 92 | 0.2 | 1,729 | 4,915 | 3.4 |
| 15 | 3,006 | 3.2 | 583 | 1.5 | 25 | 3,614 | 2.5 |
| 16 | 6,737 | 7.3 | 1,735 | 4.4 | 2,754 | 11,226 | 7.7 |
| Subtotal | 43,057 | 46.4 | 4,169 | 10.7 | 8,620 | 55,846 | 38.5 |
| TOTAL | 92,800 | 100.0 | 39,104 | 100.0 | 13,606 | 145,510 | 100.0 |

*Values exclude units in military barracks and vessels.



AR00031637

Table 4.A13. Residential Housing Units Concealed in Commercial and Industrial Uses on Oahu in 1964

| Planning District | Single-Family Units | Multi-Family Units | Total |
|---|---|---|---|
| Honolulu | | | |
| 1 | -- | -- | -- |
| 2 | 153 | 369 | 522 |
| 3 | 113 | 875 | 988 |
| 4 | 112 | 292 | 404 |
| 5 | 9 | 566 | 575 |
| 6 | 85 | 129 | 214 |
| 7 | 57 | 71 | 128 |
| Subtotal | 529 | 2,302 | 2,831 |
| Outlying | | | |
| 8 | 28 | 39 | 67 |
| 9 | 35 | 19 | 54 |
| 10 | 103 | -- | 103 |
| 11 | 32 | 6 | 38 |
| 12 | 138 | 173 | 311 |
| 13 | 58 | 3 | 61 |
| 14 | 13 | 12 | 25 |
| 15 | 25 | 108 | 133 |
| 16 | 57 | 29 | 86 |
| Subtotal | 489 | 389 | 878 |
| TOTAL | 1,018 | 2,691 | 3,709 |



AR00031638

Table 4.A14. Number and Location of Under-Developed, Single-Family Residential Parcels by Planning Districts on Oahu in 1964

| Planning District | No. of Under-Developed Parcels | No. of Existing D.U. Units | D.U.-Unit Housing Capacity | Potential D.U. Supply |
|---|---|---|---|---|
| Honolulu | | | | |
| 1 | 12 | 22 | 192 | 170 |
| 2 | -- | -- | -- | -- |
| 3 | -- | -- | -- | -- |
| 4 | -- | -- | -- | -- |
| 5 | 63 | 86 | 349 | 263 |
| 6 | 858 | 1,263 | 3,848 | 2,585 |
| 7 | 909 | 1,244 | 5,106 | 3,862 |
| Subtotal | 1,842 | 2,615 | 9,495 | 6,880 |
| Outlying | | | | |
| 8 | 356 | 441 | 1,285 | 844 |
| 9 | 585 | 972 | 6,404 | 5,432 |
| 10 | 717 | 970 | 4,449 | 3,479 |
| 11 | 180 | 277 | 1,097 | 820 |
| 12 | 142 | 260 | 669 | 409 |
| 13 | 756 | 1,292 | 5,473 | 4,181 |
| 14 | 105 | 482 | 1,001 | 519 |
| 15 | 70 | 103 | 344 | 241 |
| 16 | 180 | 271 | 760 | 489 |
| Subtotal | 3,091 | 5,068 | 21,482 | 16,414 |
| TOTAL | 4,933 | 7,683 | 30,977 | 23,294 |



AR00031639

Table 4.A15. Distribution of Land General-Planned for Residential Purposes on Oahu in 1964

| Planning District | Single-Family | | Multi-Family | | Total | |
|---|---|---|---|---|---|---|
| | Land Area (acres) | Percent | Land Area (acres) | Percent | Land Area (acres) | Percent |
| Honolulu | | | | | | |
| 1 | 3,239 | 7.2 | -- | -- | 3,239 | 6.8 |
| 2 | 9 | -- | 63 | 2.1 | 72 | 0.1 |
| 3 | -- | -- | 58 | 1.9 | 58 | 0.1 |
| 4 | -- | -- | 114 | 3.7 | 114 | 0.2 |
| 5 | 102 | 0.2 | 252 | 8.2 | 354 | 0.7 |
| 6 | 4,247 | 9.5 | 1,149 | 37.5 | 5,396 | 11.3 |
| 7 | 9,899 | 22.0 | 66 | 2.2 | 9,965 | 20.8 |
| Subtotal | 17,496 | 38.9 | 1,702 | 55.6 | 19,198 | 40.0 |
| Outlying | | | | | | |
| 8 | 4,052 | 9.0 | 47 | 1.5 | 4,099 | 8.5 |
| 9 | 6,470 | 14.5 | 306 | 10.0 | 6,776 | 14.1 |
| 10 | 2,930 | 6.5 | 6 | 0.2 | 2,936 | 6.1 |
| 11 | 1,093 | 2.5 | 37 | 1.2 | 1,130 | 2.4 |
| 12 | 829 | 1.8 | 89 | 2.9 | 918 | 1.9 |
| 13 | 2,029 | 4.5 | 273 | 8.9 | 2,302 | 4.8 |
| 14 | 3,277 | 7.3 | 60 | 2.0 | 3,337 | 7.0 |
| 15 | 2,435 | 5.4 | 275 | 9.0 | 2,710 | 5.6 |
| 16 | 4,289 | 9.6 | 267 | 8.7 | 4,556 | 9.6 |
| Subtotal | 27,404 | 61.1 | 1,360 | 44.4 | 28,764 | 60.0 |
| TOTAL | 44,900 | 100.0 | 3,062 | 100.0 | 47,962 | 100.0 |



AR00031640

Table 4.A16. Land Uses Within Area General-Planned for Single-Family Residential Purposes on Oahu in 1964

| Planning District | Used for Single-Family Purposes | | Used for Other Purposes | | | | Total Land Area (acres) |
|---|---|---|---|---|---|---|---|
| | | | Available for Single-Family Development | | Not Available for Single-Family Development | | |
| | Land Area (acres) | Percent | Land Area (acres) | Percent | Land Area (acres) | Percent | |
| Honolulu | | | | | | | |
| 1 | 254 | 7.8 | 1,463 | 45.2 | 1,522 | 47.0 | 3,239 |
| 2 | -- | -- | 7 | 77.8 | 2 | 22.2 | 9 |
| 3 | -- | -- | -- | -- | -- | -- | -- |
| 4 | -- | -- | -- | -- | -- | -- | -- |
| 5 | 81 | 79.4 | 5 | 4.9 | 16 | 15.7 | 102 |
| 6 | 2,576 | 60.7 | 792 | 18.6 | 879 | 20.7 | 4,247 |
| 7 | 3,262 | 33.0 | 3,493 | 35.3 | 3,144 | 31.7 | 9,899 |
| Subtotal | 6,173 | 35.3 | 5,760 | 32.9 | 5,563 | 31.8 | 17,496 |
| Outlying | | | | | | | |
| 8 | 1,751 | 43.2 | 1,753 | 43.3 | 548 | 13.5 | 4,052 |
| 9 | 2,071 | 32.0 | 3,131 | 48.4 | 1,268 | 19.6 | 6,470 |
| 10 | 699 | 23.8 | 1,529 | 52.2 | 702 | 24.0 | 2,930 |
| 11 | 305 | 27.9 | 668 | 61.1 | 120 | 11.0 | 1,093 |
| 12 | 639 | 77.1 | 107 | 12.9 | 83 | 10.0 | 829 |
| 13 | 931 | 45.9 | 1,091 | 53.8 | 7 | 0.3 | 2,029 |
| 14 | 374 | 11.4 | 2,786 | 85.0 | 117 | 3.6 | 3,277 |
| 15 | 479 | 19.7 | 1,912 | 78.5 | 44 | 1.8 | 2,435 |
| 16 | 1,055 | 24.6 | 2,504 | 58.4 | 730 | 17.0 | 4,289 |
| Subtotal | 8,304 | 30.3 | 15,481 | 56.5 | 3,619 | 13.2 | 27,404 |
| TOTAL | 14,477 | 32.2 | 21,241 | 47.3 | 9,182 | 20.5 | 44,900 |



AR00031641

Table 4.A17. Land Uses Within Areas General-Planned for Multi-Family Residential Purposes on Oahu in 1964

| Planning District | Used for Multi-Family Residential Purposes | | Used for Other Purposes | | | | Total Land Area (acres) |
|---|---|---|---|---|---|---|---|
| | | | Available for Multi-Family Development | | Not Available for Multi-Family Development | | |
| | Land Area (acres) | Percent | Land Area (acres) | Percent | Land Area (acres) | Percent | |
| Honolulu | | | | | | | |
| 1 | -- | -- | -- | -- | -- | -- | -- |
| 2 | 23 | 36.5 | 26 | 41.3 | 14 | 22.2 | 63 |
| 3 | 24 | 41.4 | 24 | 41.4 | 10 | 17.2 | 58 |
| 4 | 35 | 30.7 | 45 | 39.5 | 34 | 29.8 | 114 |
| 5 | 87 | 34.5 | 46 | 18.3 | 119 | 47.2 | 252 |
| 6 | 272 | 23.7 | 635 | 55.3 | 242 | 21.0 | 1,149 |
| 7 | 30 | 45.5 | 30 | 45.5 | 6 | 9.0 | 66 |
| Subtotal | 471 | 27.7 | 806 | 47.3 | 425 | 25.0 | 1,702 |
| Outlying | | | | | | | |
| 8 | 9 | 19.1 | 35 | 74.5 | 3 | 6.4 | 47 |
| 9 | 1 | 0.3 | 240 | 78.5 | 65 | 21.2 | 306 |
| 10 | -- | -- | 3 | 50.0 | 3 | 50.0 | 6 |
| 11 | -- | -- | 34 | 91.9 | 3 | 8.1 | 37 |
| 12 | 12 | 13.5 | 52 | 58.4 | 25 | 28.1 | 89 |
| 13 | -- | -- | 76 | 27.8 | 197 | 72.2 | 273 |
| 14 | -- | -- | 60 | 100.0 | -- | -- | 60 |
| 15 | 7 | 2.5 | 37 | 13.5 | 231 | 84.0 | 275 |
| 16 | 71 | 26.6 | 70 | 26.2 | 126 | 47.2 | 267 |
| Subtotal | 100 | 7.4 | 607 | 44.6 | 653 | 48.0 | 1,360 |
| TOTAL | 571 | 18.7 | 1,413 | 46.1 | 1,078 | 35.2 | 3.062 |



AR00031642

Table 4.A18. Distribution of Holding Capacities in Areas General-Planned Single-Family Residential on Oahu in 1964

| Planning District | Vacant Permitted D.U. | General-Planned | | | | Holding Capacity | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Single-Family | | Agriculture | | Existing D.U. | Permitted D.U. | Unused Permitted D.U. | Percent Attained |
| | | Existing D.U. | Permitted D.U. | Existing D.U. | Permitted D.U. | | | | |
| Honolulu | | | | | | | | | |
| 1 | 14,296 | 1,603 | 1,768 | -- | -- | 1,603 | 16,064 | 14,461 | 10.0 |
| 2 | 61 | -- | -- | -- | -- | -- | 61 | 61 | -- |
| 3 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5 | 35 | 233 | 486 | -- | -- | 233 | 521 | 288 | 44.7 |
| 6 | 8,282 | 14,374 | 15,954 | 95 | 358 | 14,469 | 24,594 | 10,125 | 58.8 |
| 7 | 20,646 | 17,682 | 20,414 | 327 | 7,386 | 18,009 | 48,446 | 30,437 | 37.2 |
| Subtotal | 43,320 | 33,892 | 38,622 | 422 | 7,744 | 34,314 | 89,686 | 55,372 | 38.3 |
| Outlying | | | | | | | | | |
| 8 | 8,811 | 8,291 | 8,795 | 14 | 7,361 | 8,305 | 24,967 | 16,662 | 33.3 |
| 9 | 22,978 | 5,784 | 11,756 | 187 | 6,152 | 5,971 | 40,886 | 34,915 | 14.6 |
| 10 | 5,556 | 1,826 | 5,520 | 71 | 10,164 | 1,897 | 21,240 | 19,343 | 8.9 |
| 11 | 4,015 | 1,277 | 2,035 | 27 | 8,415 | 1,304 | 14,465 | 13,161 | 9.0 |
| 12 | 859 | 3,372 | 3,501 | 23 | 66 | 3,395 | 4,426 | 1,031 | 76.7 |
| 13 | 7,491 | 3,002 | 7,140 | 84 | 981 | 3,086 | 15,612 | 12,526 | 19.8 |
| 14 | 11,180 | 2,305 | 2,767 | 101 | 4,405 | 2,406 | 18,352 | 15,946 | 13.1 |
| 15 | 6,383 | 1,959 | 2,163 | 75 | 23,167 | 2,034 | 31,713 | 29,679 | 6.4 |
| 16 | 9,035 | 6,104 | 6,468 | 23 | 18,190 | 6,127 | 33,693 | 27,566 | 18.2 |
| Subtotal | 76,305 | 33,920 | 50,145 | 605 | 78,901 | 34,525 | 205,354 | 170,829 | 16.8 |
| TOTAL | 119,628 | 67,812 | 88,767 | 1,027 | 86,645 | 68,839 | 295,040 | 226,201 | 23.3 |



AR00031643

Table 4.A19. Streets and Highways Distribution on Oahu

| Planning District | Developed* (acres) | Streets and Highways (acres) | Percent in Street Use |
|---|---|---|---|
| Honolulu | | | |
| 1 | 2,563 | 346 | 13.5 |
| 2 | 1,070 | 207 | 19.3 |
| 3 | 852 | 199 | 23.4 |
| 4 | 736 | 161 | 21.9 |
| 5 | 830 | 134 | 16.1 |
| 6 | 7,174 | 1,308 | 18.2 |
| 7 | 7,015 | 965 | 13.8 |
| Subtotal | 20,240 | 3,320 | 16.4 |
| Outlying | | | |
| 8 | 4,185 | 745 | 17.8 |
| 9 | 5,355 | 538 | 10.0 |
| 10 | 2,685 | 352 | 13.1 |
| 11 | 3,337 | 288 | 8.6 |
| 12 | 1,383 | 321 | 23.2 |
| 13 | 4,760 | 476 | 10.0 |
| 14 | 3,007 | 495 | 16.5 |
| 15 | 1,531 | 349 | 22.8 |
| 16 | 3,556 | 521 | 14.7 |
| Subtotal | 29,799 | 4,085 | 13.7 |
| TOTAL | 50,039 | 7,405 | 14.8 |

*Developed area excludes Agriculture, Military and Unused Open Space



AR00031644

Table 4.A20. Distribution of All Vacant Land by Planning Districts on Oahu in 1964

| Planning District | Total Land in Use (acres) | Vacant Land (acres) | | | Total Land in Study Area (acres) |
|---|---|---|---|---|---|
| | | Usable | Unusable | Total | |
| Honolulu | | | | | |
| 1 | 7,178 | 1,663 | 3,447 | 5,110 | 12,288 |
| 2 | 1,310 | 545 | 3 | 548 | 1,858 |
| 3 | 879 | 42 | -- | 42 | 921 |
| 4 | 736 | 38 | -- | 38 | 774 |
| 5 | 902 | 29 | 3 | 32 | 934 |
| 6 | 7,506 | 1,313 | 7,731 | 9,044 | 16,550 |
| 7 | 8,075 | 5,307 | 7,854 | 13,161 | 21,236 |
| Subtotal | 26,586 | 8,937 | 19,038 | 27,975 | 54,561 |
| Outlying | | | | | |
| 8 | 10,448 | 4,342 | 6,843 | 11,185 | 21,633 |
| 9 | 8,690 | 4,359 | 8,181 | 12,540 | 21,230 |
| 10 | 12,704 | 3,514 | 27,174 | 30,688 | 43,392 |
| 11 | 34,025 | 2,724 | 33,783 | 36,507 | 70,532 |
| 12 | 19,546 | 610 | 5,335 | 5,945 | 25,491 |
| 13 | 18,291 | 7,535 | 12,684 | 20,219 | 38,510 |
| 14 | 29,821 | 7,987 | 5,309 | 13,296 | 43,117 |
| 15 | 22,705 | 1,177 | 12,330 | 13,507 | 36,212 |
| 16 | 10,330 | 5,775 | 10,527 | 16,302 | 26,632 |
| Subtotal | 166,560 | 38,023 | 122,166 | 160,189 | 326,749 |
| TOTAL | 193,146 | 46,960 | 141,204 | 188,164 | 381,310 |



AR00031645

Table 4.A21. Distribution of Agricultural and Extractive Land by Planning Districts on Oahu in 1964

| Planning District | Land in Agricultural and Extractive Use | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Agriculture | | | | Mining and Quarrying | | Total | |
| | Field Crops | | Livestock | | | | | |
| | Acres | Percent | Acres | Percent | Acres | Percent | Acres | Percent |
| Honolulu | | | | | | | | |
| 1 | -- | -- | -- | -- | -- | -- | -- | -- |
| 2 | -- | -- | -- | -- | -- | -- | -- | -- |
| 3 | -- | -- | -- | -- | -- | -- | -- | -- |
| 4 | -- | -- | -- | -- | -- | -- | -- | -- |
| 5 | -- | -- | -- | -- | -- | -- | -- | -- |
| 6 | 332 | 0.4 | -- | -- | -- | -- | 332 | 0.3 |
| 7 | 225 | 0.3 | 778 | 5.1 | -- | -- | 1,003 | 1.1 |
| Subtotal | 557 | 0.7 | 778 | 5.1 | -- | -- | 1,335 | 1.4 |
| Outlying | | | | | | | | |
| 8 | 714 | 0.9 | 2,361 | 15.5 | -- | -- | 3,075 | 3.2 |
| 9 | 1,700 | 2.2 | 1,616 | 10.6 | -- | -- | 3,316 | 3.5 |
| 10 | 8,414 | 10.8 | 1,598 | 10.5 | -- | -- | 10,012 | 10.6 |
| 11 | 24,687 | 31.6 | 4,924 | 32.3 | 95 | 8.9 | 29,706 | 31.5 |
| 12 | 1,817 | 2.3 | 31 | 0.2 | -- | -- | 1,848 | 2.0 |
| 13 | 2,018 | 2.6 | 1,381 | 9.1 | 201 | 18.8 | 3,600 | 3.8 |
| 14 | 16,910 | 21.6 | 2,376 | 15.6 | 771 | 72.3 | 20,057 | 21.2 |
| 15 | 18,546 | 23.7 | 123 | 0.8 | -- | -- | 18,669 | 19.8 |
| 16 | 2,783 | 3.6 | 51 | 0.3 | -- | -- | 2,834 | 3.0 |
| Subtotal | 77,589 | 99.3 | 14,461 | 94.9 | 1,067 | 100.0 | 93,117 | 98.6 |
| TOTAL | 78,146 | 100.0 | 15,239 | 100.0 | 1,067 | 100.0 | 94,452 | 100.0 |

*Excluded are 22 acres of fisheries (PD 3, 8 acres; PD 9, 14 acres)



AR00031646

Table 4.A22. Probable Future Use of Vacant Urban Lands on Oahu, 1964

| Planning District | Residential | | Commercial | | Industrial | | Resort | | Special Uses | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Acres | % | Acres | % | Acres | % | Acres | % | Acres | % | Acres | % |
| Honolulu | | | | | | | | | | | | |
| 1 | 1,463 | 11.3 | 32 | 11.0 | 118 | 6.1 | -- | -- | 44 | 2.2 | 1,657 | 9.5 |
| 2 | 7 | 0.1 | 1 | 0.3 | 509 | 26.5 | -- | -- | 8 | 0.4 | 525 | 3.0 |
| 3 | -- | -- | 15 | 5.1 | 21 | 1.1 | -- | -- | 3 | 0.2 | 39 | 0.2 |
| 4 | -- | -- | 21 | 7.2 | 6 | 0.3 | -- | -- | 1 | -- | 28 | 0.2 |
| 5 | 5 | -- | 4 | 1.4 | -- | -- | -- | -- | 1 | -- | 10 | 0.1 |
| 6 | 724 | 5.6 | 13 | 4.5 | -- | -- | -- | -- | 14 | 0.7 | 751 | 4.3 |
| 7 | 2,566 | 19.7 | 9 | 3.1 | -- | -- | -- | -- | 572 | 29.0 | 3,147 | 18.1 |
| Subtotal | 4,765 | 36.7 | 95 | 32.6 | 654 | 34.0 | -- | -- | 643 | 32.5 | 6,157 | 35.4 |
| Outlying | | | | | | | | | | | | |
| 8 | 810 | 6.2 | 21 | 7.2 | -- | -- | 3 | 1.4 | 309 | 15.7 | 1,143 | 6.6 |
| 9 | 1,927 | 14.8 | 44 | 15.1 | 32 | 1.7 | 36 | 16.8 | 217 | 11.0 | 2,256 | 13.0 |
| 10 | 607 | 4.7 | 10 | 3.4 | 3 | 0.2 | -- | -- | 43 | 2.2 | 663 | 3.8 |
| 11 | 248 | 1.9 | 9 | 3.1 | 4 | 0.2 | 117 | 54.7 | 8 | 0.4 | 386 | 2.2 |
| 12 | 79 | 0.6 | 15 | 5.1 | 7 | 0.4 | -- | -- | 10 | 0.5 | 111 | 0.6 |
| 13 | 748 | 5.8 | 15 | 5.1 | 201 | 10.5 | 58 | 27.1 | 354 | 17.9 | 1,376 | 7.9 |
| 14 | 2,279 | 17.6 | 25 | 8.6 | 941 | 49.0 | -- | -- | 277 | 14.0 | 3,522 | 20.3 |
| 15 | 351 | 2.7 | 24 | 8.2 | 9 | 0.5 | -- | -- | 7 | 0.4 | 391 | 2.3 |
| 16 | 1,173 | 9.0 | 34 | 11.6 | 68 | 3.5 | -- | -- | 107 | 5.4 | 1,382 | 7.9 |
| Subtotal | 8,222 | 63.3 | 197 | 67.4 | 1,265 | 66.0 | 214 | 100.0 | 1,332 | 67.5 | 11,230 | 64.6 |
| TOTAL | 12,987 | 100.0 | 292 | 100.0 | 1,919 | 100.0 | 214 | 100.0 | 1,975 | 100.0 | 17,387 | 100.0 |



AR00031647

Table 4.A23. Probable Future Use of Agricultural Land by Planning Districts on Oahu

| Planning District | Urban | | | | | | | | Nonurban | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Residential | | Commercial | | Industrial | | Special Uses | | | | | |
| | Acres | % | Acres | % | Acres | % | Acres | % | Acres | % | Acres | % |
| Honolulu | | | | | | | | | | | | |
| 1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 6 | 68 | 0.8 | 1 | 1.1 | -- | -- | 6 | 0.5 | 257 | 0.3 | 332 | 0.3 |
| 7 | 927 | 11.0 | -- | -- | -- | -- | 35 | 2.6 | 41 | 0.1 | 1,003 | 1.1 |
| Subtotal | 995 | 11.8 | 1 | 1.1 | -- | -- | 41 | 3.1 | 298 | 0.4 | 1,335 | 1.4 |
| Outlying | | | | | | | | | | | | |
| 8 | 943 | 11.2 | -- | -- | 516 | 21.0 | 2 | 0.1 | 1,614 | 2.0 | 3,075 | 3.2 |
| 9 | 1,205 | 14.4 | 9 | 10.0 | 17 | 0.7 | 16 | 1.2 | 2,069 | 2.5 | 3,316 | 3.5 |
| 10 | 922 | 11.0 | 9 | 10.0 | 53 | 2.1 | -- | -- | 9,028 | 11.0 | 10.012 | 10.6 |
| 11 | 420 | 5.0 | -- | -- | 4 | 0.2 | 32 | 2.4 | 29,250 | 35.6 | 29,706 | 31.5 |
| 12 | 28 | 0.3 | -- | -- | 8 | 0.3 | -- | -- | 1,812 | 2.2 | 1,848 | 2.0 |
| 13 | 343 | 4.1 | -- | -- | 138 | 5.6 | -- | -- | 3,119 | 3.8 | 3,600 | 3.8 |
| 14 | 507 | 6.0 | 5 | 5.6 | 1,378 | 56.0 | -- | -- | 18,167 | 22.1 | 20,057 | 21.2 |
| 15 | 1,710 | 20.4 | 66 | 73.3 | 327 | 13.3 | 1,187 | 88.3 | 15,379 | 18.7 | 18,669 | 19.8 |
| 16 | 1,330 | 15.8 | -- | -- | 19 | 0.8 | 66 | 4.9 | 1,419 | 1.7 | 2,834 | 3.0 |
| Subtotal | 7,408 | 88.2 | 89 | 98.9 | 2,460 | 100.0 | 1,303 | 96.9 | 81,857 | 99.6 | 93,117 | 98.6 |
| TOTAL | 8,403 | 100.0 | 90 | 100.0 | 2,460 | 100.0 | 1,344 | 100.0 | 82,155 | 100.0 | 94,452 | 100.0 |

N.B. Figures exclude 22 acres of Fisheries.



AR00031648

# APPENDIX IV-B. THE DEMAND FOR AND DISTRIBUTION OF RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL DEVELOPMENT

AR00031651

1. DEMAND FOR AND DISTRIBUTION OF RESIDENTIAL DEVELOPMENT

The residential submodel was designed to estimate the housing demand for six types of dwelling units and to determine the spatial developments of these units by Census Tracts.* The main operations are shown in Fig. 4.B1.

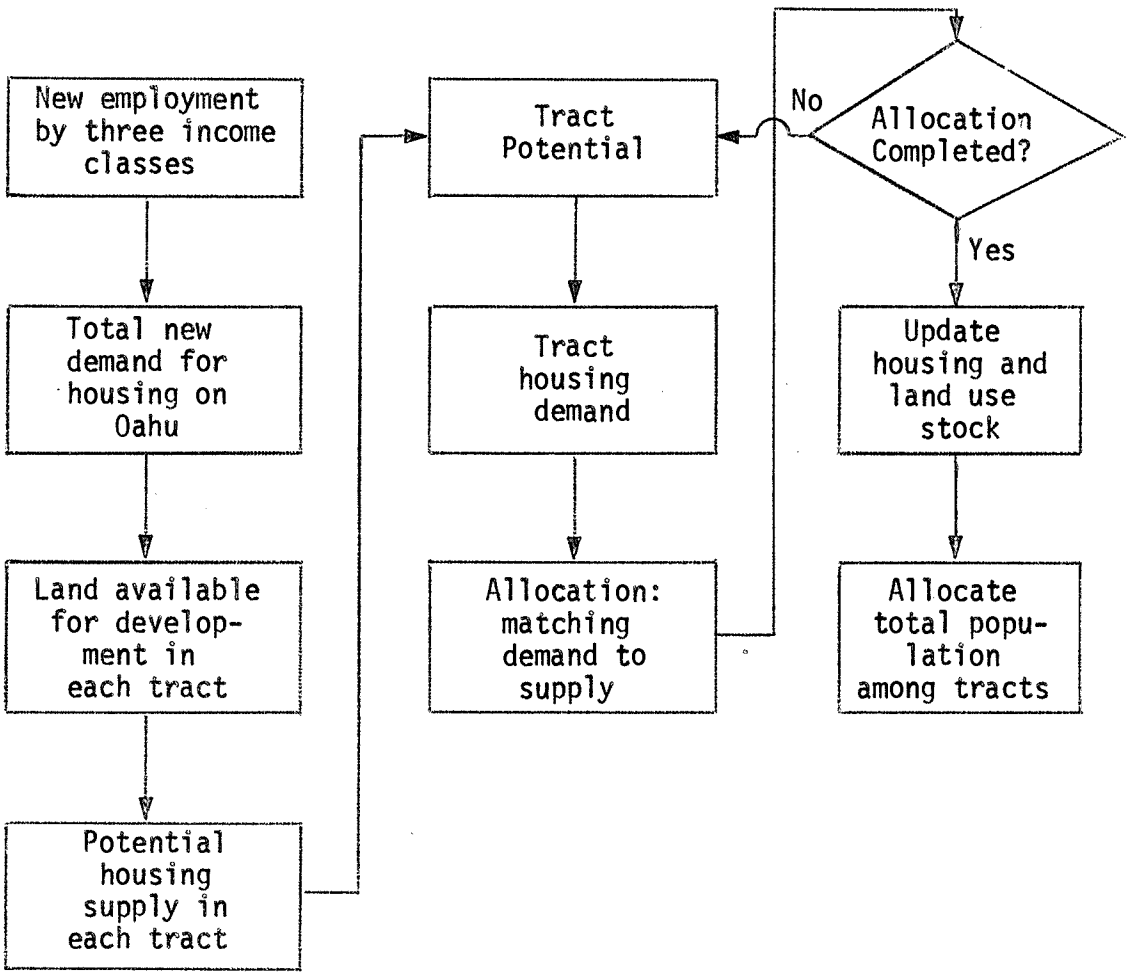



FIG. 4.B1. OTS RESIDENTIAL SUBMODEL FLOW CHART.

---

*The six types of dwelling units are:

Single Family { high income, medium income, low income }

Multi-Family { high income, medium income, low income }



AR00031652

a. Employees by Income Classes. The process of determining the demand for new housing proceeds first by determining the number of new employees in each of three income classes. New employment by income class for each period was obtained from the State economic model. Coefficients showing the percent of each industry's employment in each income class were obtained from the economic model and applied to industry forecasts to obtain employees by three income classes. For the forecast period, high income is considered to be over $15,000; middle income, $7,500 to $14,999; and low income, below $7,500.

b. New Housing Demand. Following the determination of total new employees by income class, the process transforms them into demand for new houses. By applying the ratio of new houses to new employees (Table 4.B1), we obtain the demand for total housing. The ratio of single-family housing to total housing can then be applied to obtain the demand for single-family housing in each income class.

Existing data on the ratio of housing information by income class revealed that the ratio of the change in all dwelling units to the change in all employment during 1960 - 1965 was 1.00. Information gathered from census reports revealed that, for high-income neighborhoods, the ratio of households to employees ranged between 0.50 and 0.58 in the 1960 - 1965 period and that, for low-income neighborhoods, the ratio was 0.89. This means that there are generally more wage earners per family in high-income neighborhoods than in low-income areas and that, as a consequence, the low-income area has a greater need for dwelling units per wage earner. On the basis of this knowledge, values were established for each income level which represent the ratio of new houses to new employees, as shown in Table 4.B1.

Table 4.B1. Ratio of New Houses to New Employees

| Forecast Period | New House/New Employee in Income Class | | |
|---|---|---|---|
| | High | Medium | Low |
| 1970 | 0.64 | 0.77 | 0.89 |
| 1975 | 0.74 | 0.77 | 0.89 |
| 1980 | 0.80 | 0.80 | 0.89 |
| 1985 | 0.80 | 0.80 | 0.89 |



AR00031653

The total change in single-family houses was 63 percent of the total change in all housing for the period 1960 - 1965. Inadequate data existed to estimate this percent for each income class and structure type, so the values were subjectively established at constant levels, for the purpose of this estimate, as: high income, 0.80; medium income, 0.60; and low income, 0.40.

c. Land Supply. The availability of land for residential development within a census tract influences the holding capacity of the tract. This supply consists of all vacant usable and agricultural lands that have been general-planned for residential uses.

There are options (land tenure or General Plan code options), however, which one may apply to condition the availability of land for the forecat period in question. For example, when the land-tenure option is not considered, all agricultural lands general-planned for residential use would be assumed available for development. When the land-tenure option is considered, then certain leased agricultural lands general-planned for residential use would be either withheld from or included in (depending on their lease expiration dates) lands available for development during the forecast period under consideration. In these study estimates, the lease option was not used and the lands are considered as available for development.

When the General Plan Code option is applied, all vacant usable and agricultural lands general-planned for residential use, and some "misused" lands now in another use within the limits of the General Plan for residential use, would be available for development. It should be emphasized that not all "misused" lands would really become available because of the conversion cost and therefore we would require a demolition function or percent to determine the extent of the availability of these "misused" lands. On the other hand, if the General Plan Code were not used, then the "misused" lands would not be included in our calculation of available lands. In these study estimates, the General Plan Code was used.

Special adjustments were required to increase the available supply by adding 3,366 acres of land from "underdeveloped" residential parcels.

Suitability factors were assigned each census tract to serve as a basis for apportioning the available land of the tract into types of housing developments. These suitability factors were determined by the study staff in



AR00031654

coordination with State and City-County planners. The estimates for each census tract were prepared by evaluating the following factors:

1. 1960 census distribution of income classes
2. Proximity to seashore
3. View sites
4. Proximity to other-value homes
5. Climate
6. Lot Size
7. Predominant uses.

When determining available land for multi-family developments, a demolition factor (or percent) is applied to convert "misused" land for its intended purpose. This demolition factor becomes applicable only when the estimated probable density of the census tract approaches its maximum permissible density. When this occurs, 35 percent of the remaining "misused" land within the tract in question is released for multi-family development.

d. Potential Housing Supply. The potential housing supply for each census tract indicates the number of units the census tract could accommodate without exceeding its maximum permissible density.

The potential housing supply of each tract for each forecast period was determined by dividing land supply by applicable land-absorption coefficients, which vary by tract for multi-family dwelling units.

Land-absorption coefficients for single-family housing for each income class were determined subjectively by the investigator and reviewed by State and City-County planners before application. In these study estimates, land-absorption coefficients for single-family dwelling units were fixed (see Table 4.B2).

Land-absorption coefficients for multi-family dwelling units, however, were computed by regression equations derived from multi-family density data for structures built during 1960 to 1964 and from people-density data during the same period. Different regression equations were used for three separate graphical areas - Honolulu, Waikiki, and outlying areas.

People density, an indicator for land value, is determined as a ratio of population plus employment to used and unusable land area. There is no actual land value such as tax valuation, but empirical evidence supports the use of this indicator for land values.



AR00031655

Table 4.B2. Land-Absorption Coefficients for Single-Family-Dwelling Developments

| Income Class | Land-Absorption Coefficient (acre/hh)* | Comparable Expansion | |
|---|---|---|---|
| | | (sq ft/hh) | (D.U./acre) |
| High | 0.222 | 9,670 | 4.5 |
| Medium | 0.155 | 6,752 | 6.4 |
| Low | 0.133 | 5,214 | 8.3 |

*hh = household

e. Tract Potential. A census tract's potential - its ability to compete with other census tracts for the total housing requirements - is dependent on its accessibility and its opportunity or supply potential. The greater its accessibility and its housing-supply potential, relative to other tracts, the greater its choice will be for residential development.

The accessibility index ($A^{\partial}$), computed for each census tract depends on its employee stock and its empirically derived travel-time factor (friction factor) which expresses the average area-wide effect of spatial separation on journey-to-work trip interchange between census tracts. Although friction factors, once calibrated for an area, are held constant, a tract's accessibility is sensitive to changes in travel time between census tracts, thus pointing out the influence of a transportation system to land use.

The exponent ($\partial$) appearing in the accessibility index is empirically derived and reflects the pressures to utilize the higher-priced land or the influence of accessibility on land development. This exponent was estimated by a search algorithm which minimized the error sum of squares between actual and predicted development.

The data utilized were: change in dwelling units, 1960 - 1964; accessibility indices determined by using the 1960 "skim-tree"* table and the friction factors computed from the 1960 trip data; and the actual change in

*"Skim-tree" is a tabulation of the shortest surface travel time between the centroid of any tract to the centroid of every other tract.



AR00031656

dwelling units plus the supply of potential units. The estimated value of this exponent is 1.24.

f. Tract Housing Demand. It is now possible to determine the dwelling units necessary to locate within a census tract. This housing demand of each tract is determined by multiplying the total housing requirements by the respective tract's potential.

g. Matching Supply and Demand. Once the spatial supply and spatial demand for each type of housing have been determined, the process matches these respective supply and demand of each census tract wherever possible to achieve an equilibrium in the housing market. For example, when the computed housing demand for a tract is equal to or less than its computed potential housing supply, the entire housing demand is assigned or allocated to the tract. When the housing demand for a tract is greater than its potential supply, the amount of housing equal to its supply is assigned or allocated to the tract; the remaining or unsatisfied housing demand is accumulated, and, after all census tracts have been examined (i.e., their respective supplies being matched with their respective demands) the accumulated access housing requirement is reallocated among the census tracts that have a balance of housing supply. In successive allocations, new housing potentials and demands are computed for each tract that has a housing supply, and the matching process is repeated until: the excess has been completely assigned, the excess is less than 10 dwelling units, or there have been 15 iterative allocations.

h. Housing and Land Stock. The housing and land stocks of each census tract are updated after the allocation process is completed for each forecast period. In this stock-keeping process, new houses allocated to census tracts in a forecast period are added to their respective stock existing at the beginning of the forecast period. With respect to the land stock, the process is similar except that the new housing is converted to equivalent land by its respective land-absorption coefficients.

i. Population Distribution. Total population estimates for each forecast period are inputs in the Land-Use Model. Their distributions among the census tracts are in direct proportion to the tract's population with respect to the total population, based on initial estimates by the Land-Use Model. Land-Use-Model estimates of the tract's population are based on persons/



AR00031657

household values computed from data contained in the 1960 Census of Population and Housing. Thus, values based on the 1960 Census are shown in Table 4.B3.

Table 4.B3. Family Size per Household by Income Class on Oahu in 1960

| Income Class | Persons per Household |
|---|---|
| High | 3.6 |
| Medium | 3.8 |
| Low | 4.0 |

## 2. DEMAND FOR AND DISTRIBUTION OF COMMERCIAL ACTIVITY

Retail activities identified in the model are composed of retail convenience goods, retail shopping goods, retail specialty goods, personal personal services, and business services. Although utilized in the model in detailed classes, the final results are grouped into two major categories as shown below.

| | |
|---|---|
| Commercial Retail: | Convenience goods |
| | Shopping goods |
| | Specialty goods |
| Commercial Service: | Personal services |
| | Business service |

The three retail activities are allocated by a modification of the market-potential algorithm (procedure for solving the problem). The two service activities are allocated by the regression equation in the industrial submodel described in Section IV.D.3. They are allocated in the industrial submodel because their locational behavior is very similar to that of industrial firms.

The commercial submodel evaluates the market potential of every census tract and allocates new stores according to each tract's relative attractiveness. Demand in the model is measured in terms of retail employees. The main operations are diagrammed in Fig. 4.B2. Each operation of the diagram is explained in the following sections giving particulars of the more important inputs. Since the activities of the retail submodel are closely related to the industrial submodels, the results of the output will be combined and explained in the final section.



AR00031658

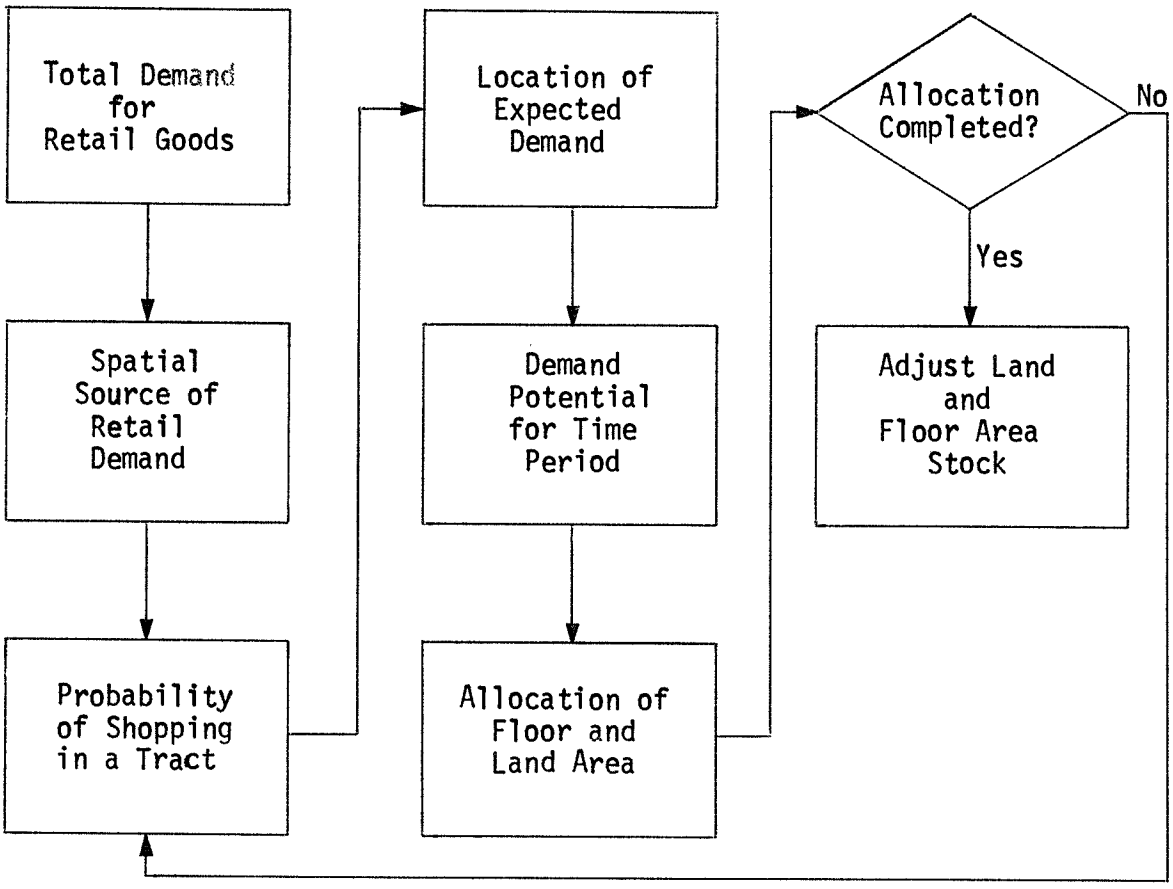



FIG. 4.B2. COMMERCIAL SUBMODEL FLOW CHART

a. Total Demand for Retail Goods. Demand is measured in terms of employees. The employment is obtained from the economic model, but in order to use it in the Land-Use Model, which has basically a land-use grouping of categories, the employment forecast is broken down into equivalent-land-use-model groupings. The resulting employment-forecast values for the three retail activities are presented in Table 4.B4.

Table 4.B4. Forecast of Retail Employment

| Year | No. of Persons Employed | | |
|---|---|---|---|
| | Convenience Goods | Shopping Goods | Specialty Goods |
| 1960 | 16,228 | 8,536 | 6,056 |
| 1965 | 19,576 | 9,831 | 6,976 |
| 1970 | 25,009 | 11,808 | 8,378 |
| 1975 | 31,736 | 14,014 | 9,943 |
| 1980 | 35,650 | 15,535 | 11,022 |
| 1985 | 37,795 | 16,494 | 11,703 |



AR00031659

b. Spatial Source of Retail Demand. The model now separates total demand into homesite and worksite demand. In simple terms, the homesite demand is the number of employees required to satisfy the demand of, say, 100 homes. The worksite demand is the number of employees required to satisfy the demand of 100 employees who will probably shop from their worksite.

The percent distribution of total demand for retail goods by home-based trips and work-based trips are estimates based on retail studies for Pittsburgh and Washington. These values used as inputs are listed in Table 4.B5.

Table 4.B5. Total Demand Distribution
Home-Based and Work-Based Trips

| Retail Activity | Demand (%) from | |
|---|---|---|
| | Home-Base | Work-Base |
| Convenience Goods | 90 | 10 |
| Shopping Goods | 70 | 30 |
| Specialty Goods | 50 | 50 |

The total household demand thus established as the control must be distributed to each census tract. Utilizing the household/income-class distribution established by the residential submodel, the model proceeds to determine the location of the demand for employees by tract. Each of the three household-income levels creates its own rate of demand and is expressed as the demand/household coefficient (Table 4.B6). The demand for each type of retail activity per income class was determined from 1963 data for middle-income households. This figure was lowered 20 percent for low-income households and raised 20 percent for high-income households. These values, which actually decrease over time, do not vary in the model since they are already considered in the economic model that established the employment values.

The worksite demand obtained earlier is also distributed to each tract; the procedure is identical to homesite-demand distribution. The demand for retail employees created by each worksite employee, caused by people walking and shopping from their worksite, is also shown in Table 4.B6. The values were determined using 1963 employment and applying the work-base-demand distribution percentages for each retail activity.



AR00031660

Table 4.B6. Different Demands for Retail Activities

| Retail Activity | Demand/Household Coefficient | | | Demand/Worksite Coefficient | | |
|---|---|---|---|---|---|---|
| | Income Class | | | Income Class | | |
| | High | Medium | Low | High | Medium | Low |
| Convenience Goods | 0.072 | 0.066 | 0.060 | 0.00608 | 0.00507 | 0.00406 |
| Shopping Goods | 0.058 | 0.053 | 0.048 | 0.01475 | 0.01230 | 0.00983 |
| Specialty Goods | 0.031 | 0.028 | 0.025 | 0.01286 | 0.01072 | 0.00858 |

c. Probability of Shopping in a Tract. This function determines the percentage of people in a tract who will shop in another tract a certain distance away; it is really a gravity model and comes from Riley's Law of Retail Gravitation. It determines where people will probably shop. The model equates opportunity to shop in a tract expressed as employees divided by the time-distance factor between the tracts, then divided by all the possible alternatives that are available to the shopper. Therefore, the greater the number of alternatives the less the probability to shop in the tract. The model thus creates an attractiveness index for the tract and all competitive tracts.

The probability is computed by tentatively locating a minimum-size store in the tract. This tentative placement simulates the feasibility-testing process of actual locational decision-making. It also provides probabilities for each tract and, thereby, enables tracts without retail employment to obtain retail employment.

The derivation of the minimum-size firm in terms of number of employees (listed below) was taken to be the average size reported in the 1963 Census of Business.

| Retail Activity | No. of Employees |
|---|---|
| Convenience Goods | 6.36 |
| Shopping Goods | 15.50 |
| Specialty Goods | 8.67 |

d. Location of Expected Demand. Multiplying the probabilities established previously with the homesite demand and adding that result to the worksite demand yields the expected demand for each census tract. Unlike the other activities, no restrictions on available land based on the General Plan



AR00031661

was imposed on this algorithm. On the basis that commercial use is the highest use, it preempts all other uses.

e. Demand Potential for Time Period. The expected minus the existing employees determines the demand potential for the tracts for the time period in question. It is quite possible to have an expected demand less than the actual demand. If that occurs, some of the sources of retail employment must be removed. This situation could be caused by population redistribution and/or growth of competitive stores nearby. The sources of employment in this case are reallocated elsewhere by the same procedure used for new sources of employment.

f. Allocation of Retail Land and Floor Area. After employees are allocated into each of the tracts, the model proceeds to relate the employee back to the land by means of the land-absorption coefficient (Table 4.B7). The values were determined subjectively on the basis of 1964 values. The coefficient is a ratio of acres to employee.

Table 4.B7. Land-Absorption Coefficient for Retail Development

| Retail Activity | Land-Absorption Coefficient | Employee/Acre |
|---|---|---|
| Convenience Goods | 0.02 | 50.0 |
| Shopping Goods | 0.03 | 33.0 |
| Specialty Goods | 0.08 | 12.5 |

## 3. DEMAND AND DISTRIBUTION OF PUBLIC AND INDUSTRIAL DEVELOPMENTS

The public and industrial submodels allocate not only public and industrial uses but, because of its locational characteristics, it also allocates retail personal and business-service uses. The same allocation algorithm is used for these different activities because it is flexible enough to capture the peculiarities of their individual locational process. The various activities allocated by this algorithm are described in Table 4.B8. The table also relates the detailed classes used in the operation of the model to the final output variables reported by the model. The main points diagrammed in Fig. 4.B3 are explained in depth in the following sections.



AR00031662

Table 4.B8. Activities Allocated by Public and Industrial Submodels

| Output Variable | Land-Use Variable |
|---|---|
| Manufacturing | Food Processing<br>Apparel, Textile, Printing Manufacturing |
| Transportation, Communication and Utilities | Transportation Utilities and Communication |
| Commercial Wholesale, Storage and Construction | Contract Construction<br>Wholesale Trade, Storage, Trucking |
| Public and Quasi-Public Buildings | Public and Quasi-Public Buildings |
| Public and Quasi-Public Open Space | Public and Quasi-Public Open Space |
| Commercial Service | Retail Personal Service<br>Retail Business Service |

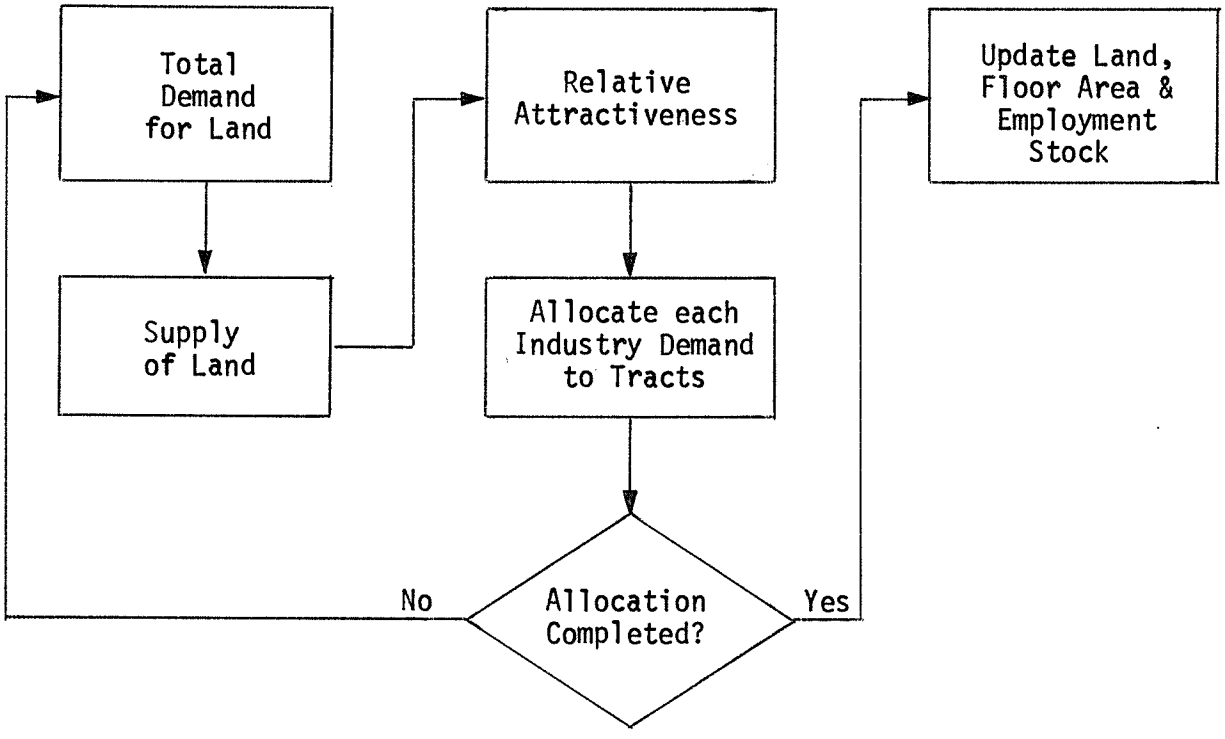



FIG. 4.B3. PUBLIC AND INDUSTRIAL SUBMODEL FLOW CHART



AR00031663

The floor area distribution follows in similar manner, utilizing the floor area absorption coefficient of 367 sq ft of floor area per employee.

a. Floor and Land-Area Stock. The stock of retail floor area and land area are adjusted after the allocation process for each of the time periods. The respective floor and land areas are always added to the existing stock.

b. Total Demand for Land. The process of determining the total demand for land for each of the uses indicated in Table 4.B8 proceeds first by obtaining the number of new employees projected for the time period from the economic model. It then converts this measure to its equivalent land requirement. The factors to accomplish the conversion are identified as the land and floor-area absorption coefficients (Table 4.B9). The land-absorption coefficient expresses acres per employee and the floor-area absorption coefficient as square feet of building area per employee. These values were determined by a subjective modification of their 1964 values. The values were modified to achieve a more accurate marginal coefficient which would reflect future rates.

Table 4.B9. Land and Floor-Area Absorption Coefficients

| Category | Land-Absorption Coefficient | Employee per Acre | Floor-Area Absorption Coefficient |
|---|---|---|---|
| Manufacturing | | | 450 |
| Food Processing | 0.07 | 14 | |
| Apparel, Textile, Printing | 0.01 | 100 | |
| Other Manufacturing | 0.05 | 20 | |
| Transportation, | 0.07 | 20 | |
| Utilities, and Communications | 0.18 | 5.5 | |
| Commercial Wholesale, Storage, and Construction | | | 312 |
| Contract Construction | 0.01 | 100 | |
| Wholesale Trade, Storage, and Trucking | 0.04 | 25 | |
| Retail Services | | | 389 |
| Personal Services | 0.02 | 50 | |
| Business Services | 0.03 | 33 | |
| Public and Quasi-Public Buildings | 0.16 | 6 | 787 |
| Public and Quasi-Public Open Space | 3.55 | 0.3 | |



AR00031664

c. Supply of Land. Following the determination of the total demand for land, the supply of land available for development within each Census Tract was considered. The supply consists of all vacant usable and agricultural land. This supply is altered when the General Plan limits are considered. Utilizing this option, the supply consists of land general-planned for the activity but now in vacant-usable, agricultural, or single-family use.

d. Relative Attractiveness. The supply established, the model proceeds to evaluate the relative attractiveness of each tract in relation to all other tracts. It is defined as:

$$\frac{\text{Industrial Land Use}}{\text{Industrial Land Used + Industrial Land Available}}$$

This definition adjusts for the size of each tract so that if two tracts of equal desirability were combined, there would be no changes in the measure of attractiveness. The relative attractiveness is further modified by including industrial, commercial and population preference variables and a land-value variable. The first three variables provide the measure of how close a tract is to all other tracts in terms of industrial and commercial land uses and population. The last variable is actually a surrogate for the land value utilized and explained earlier in the residential submodel. The preference function operates roughly in the following manner: If industry "K" is repelled by high land values, but attracted to other industries, it would have a large demand for land in tracts having low land values and large industrial land use.

e. Allocation of Industry Demand to Tracts. The relative attractiveness is weighted initially to obtain the percentage allocation for each tract. The percent allocation is normalized so that it sums to 100 percent and is then multiplied by the total industrial-land requirements to obtain the distribution of land into each of the tracts. If, during this allocation process, the demand is less than the supply, the allocation is made for the tract. If demand exceeds supply, then the algorithm uses misused land or the single-family residential use general-planned for industrial use. As in the multi-family residential routine, use of misused land implies demolishing single-family homes to provide additional land for that particular industry.



AR00031665

If the demand still cannot be satisfied, this excess is accumulated and reallocated by the same procedure only after all of the tracts have been examined at least once.

f. Updating of Land, Floor Area, and Employment Stock. The inventory stocks of land area, floor area, and employment are adjusted after the allocation process for the time period. In respect to floor area, the employment distributed to the tracts is converted to floor-area measure, being the floor-area absorption coefficient.



AR00031666

# APPENDIX IV-C. TABLES CONCERNING RESIDENTIAL SUBMODEL

AR00031668

Table 4.C1. Past and Projected Distribution of Population by Planning District on Oahu, 1960 to 1985

| Planning District | Population† | | | | | |
|---|---|---|---|---|---|---|
| | 1960* | 1965 | 1970 | 1975 | 1980 | 1985 |
| Honolulu | | | | | | |
| 1 | 23,470 | 28,953 | 37,851 | 46,032 | 49,603 | 50,560 |
| 2 | 20,581 | 20,015 | 21,071 | 20,590 | 20,410 | 20,804 |
| 3 | 11,539 | 10,041 | 11,942 | 14,383 | 18,263 | 19,932 |
| 4 | 9,990 | 12,625 | 16,541 | 19,280 | 23,121 | 26,864 |
| 5 | 31,503 | 19,557 | 22,521 | 25,281 | 27,792 | 29,954 |
| 6 | 135,865 | 151,643 | 181,003 | 204,623 | 226,443 | 250,133 |
| 7 | 79,230 | 91,854 | 98,940 | 107,920 | 121,905 | 139,732 |
| Subtotal | 294,178 | 334,688 | 389,869 | 438,109 | 487,537 | 537,979 |
| Outlying | | | | | | |
| 8 | 38,722 | 46,198 | 48,415 | 52,557 | 59,266 | 67,457 |
| 9 | 21,516 | 34,683 | 43,525 | 55,273 | 70,612 | 88,372 |
| 10 | 8,043 | 12,107 | 12,195 | 12,502 | 13,171 | 14,138 |
| 11 | 8,221 | 9,610 | 9,810 | 10,305 | 11,074 | 12,083 |
| 12 | 34,595 | 31,927 | 31,563 | 31,914 | 33,078 | 35,542 |
| 13 | 16,452 | 22,687 | 23,264 | 25,015 | 27,830 | 31,367 |
| 14 | 16,449 | 22,389 | 26,407 | 33,307 | 42,341 | 52,103 |
| 15 | 13,374 | 18,189 | 29,538 | 45,491 | 60,232 | 73,441 |
| 16 | 48,843 | 51,612 | 62,814 | 75,927 | 89,259 | 101,918 |
| Subtotal | 206,215 | 249,402 | 287,531 | 342,291 | 406,863 | 476,421 |
| TOTAL | 500,393 | 584,090 | 677,400 | 780,400 | 894,400 | 1,014,400 |

*U. S. Census of Population.

†Values for 1965-1985 exclude military and crews of vessels.



AR00031670

Table 4.C2. Past and Projected Distribution of Population by Census Tract, 1965 and 1985

| Census Tract | 1965 | 1985 | Census Tract | 1965 | 1985 | Census Tract | 1965 | 1985 |
|---|---|---|---|---|---|---|---|---|
| 1 | 6,677 | 35,710 | 39 | 832 | 788 | 71 | 10,440 | 14,409 |
| 2 | 4,618 | 7,785 | 40 | 290 | 275 | 78 | 4,316 | 29,343 |
| 3 | 7,067 | 14,781 | 41 | 5,096 | 15,245 | 79 | 844 | 800 |
| 4 | 4,476 | 5,727 | 42 | 1,251 | 1,186 | 80 | 14,929 | 29,227 |
| 5 | 4,779 | 5,138 | 43 | 6,311 | 13,506 | 81 | 1,485 | 1,481 |
| 6 | 1,942 | 2,160 | 44 | 7,341 | 8,820 | 82 | 133 | 126 |
| 7 | 4,548 | 4,619 | 45 | 4,684 | 7,618 | 83 | 6,813 | 6,549 |
| 8 | 5,391 | 5,446 | 46 | 4,633 | 6,448 | 84 | 7,237 | 8,635 |
| 9 | 10,140 | 15,158 | 47 | 6,163 | 7,364 | 85 | 2,213 | 2,098 |
| 10 | 3,806 | 5,312 | 48 | 7,436 | 7,290 | 86 | 6,126 | 34,821 |
| 11 | 5,096 | 5,205 | 49 | 3,522 | 4,227 | 87 | 7,709 | 12,736 |
| 12 | 8,115 | 7,847 | 50 | 4,789 | 5,300 | 88 | 4,874 | 4,840 |
| 13 | 5,826 | 4,710 | 51 | 10 | 9 | 89 | 5,473 | 55,739 |
| 14 | 3,328 | 3,260 | 52 | 1,252 | 1,187 | 90 | 984 | 933 |
| 15 | 5,376 | 5,149 | 53 | 1,216 | 4,114 | 91 | 2,544 | 2,471 |
| 16 | 5,779 | 5,548 | 54 | 2,382 | 2,463 | 92 | 8,320 | 8,980 |
| 17 | 3,232 | 5,017 | 55 | 2,696 | 3,235 | 93 | 5,388 | 7,868 |
| 18 | 5,176 | 9,593 | 56 | 6,800 | 8,066 | 94 | 4,831 | 5,943 |
| 19 | 4,972 | 5,220 | 57 | 3,531 | 3,723 | 95 | 9,860 | 9,347 |
| 20 | 6,177 | 10,124 | 58 | 4,168 | 4,702 | 96 | 12,348 | 14,808 |
| 21 | 3,464 | 4,439 | 59 | 5,364 | 5,085 | 97 | 6,110 | 6,672 |
| 22 | 3,833 | 5,078 | 60 | 6,952 | 7,294 | 98 | 4,229 | 9,887 |
| 23 | 4,458 | 14,718 | 61 | 3,298 | 3,515 | 99 | 7,718 | 10,089 |
| 24 | 6,606 | 24,664 | 62 | 6,729 | 7,872 | 100 | 1,892 | 1,994 |
| 25 | 4,609 | 11,243 | 63 | 7,242 | 7,112 | 101 | 4,237 | 4,440 |
| 26 | 5,072 | 6,732 | 64 | 6,918 | 12,075 | 102 | 7,870 | 9,698 |
| 27 | 7,931 | 10,864 | 65 | 3,852 | 5,938 | 103 | 10,527 | 36,706 |
| 28 | 4,890 | 5,177 | 66 | 2,768 | 2,624 | 104 | 842 | 798 |
| 29 | 1,750 | 3,820 | 67 | 4,073 | 21,771 | 105 | 10,688 | 25,138 |
| 30 | 5,285 | 5,974 | 68 | 5,438 | 10,359 | 106 | 6,946 | 9,465 |
| 31 | 7,690 | 11,232 | 69 | 5,018 | 4,757 | 107 | 5,680 | 16,265 |
| 32 | 1,430 | 3,249 | 70 | 5,262 | 4,988 | 108 | 4,646 | 4,404 |
| 33 | 1,243 | 1,461 | 71 | 4,040 | 3,830 | 109 | 14,588 | 15,593 |
| 34 | 12,260 | 31,696 | 72 | 2,354 | 2,231 | 110 | 2,614 | 7,732 |
| 35 | 5,034 | 12,955 | 73 | 5,685 | 5,389 | 111 | 11,107 | 22,952 |
| 36 | 6,542 | 12,842 | 74 | 2,612 | 2,476 | 112 | 6,868 | 8,469 |
| 37 | 1,049 | 1,067 | 75 | 5,910 | 13,683 | 113 | 6,375 | 8,307 |
| 38 | 1,310 | 1,242 | 76 | 5,391 | 5,110 | | | |
| | | | | | | TOTAL | 584,090 | 1,014,400 |



AR00031671

Table 4.C3. Distribution of Dwelling Units on Oahu*

| Planning District | 1964 | | 1985 | | Percent Change 1964-1985 |
|---|---|---|---|---|---|
| | No. of Units | Percent of Total District | No. of Units | Percent of Total District | |
| Honolulu | | | | | |
| 1 | 6,541 | 4.5 | 12,938 | 4.9 | 97.8 |
| 2 | 4,415 | 3.0 | 4,243 | 1.6 | 3.9 |
| 3 | 3,827 | 2.6 | 6,245 | 2.4 | 63.2 |
| 4 | 3,998 | 2.7 | 7,420 | 2.8 | 85.6 |
| 5 | 10,644 | 7.3 | 13,270 | 5.1 | 24.7 |
| 6 | 39,189 | 26.9 | 64,823 | 24.7 | 65.4 |
| 7 | 21,050 | 14.5 | 35,089 | 13.4 | 66.7 |
| Subtotal | 89,664 | 61.5 | 144,028 | 54.9 | 60.6 |
| Outlying | | | | | |
| 8 | 10,710 | 7.4 | 17,027 | 6.5 | 59.0 |
| 9 | 7,152 | 4.9 | 21,708 | 8.3 | 203.5 |
| 10 | 2,735 | 1.9 | 3,370 | 1.3 | 23.2 |
| 11 | 2,424 | 1.7 | 3,133 | 1.2 | 29.2 |
| 12 | 7,997 | 5.5 | 9,319 | 3.6 | 16.5 |
| 13 | 5,073 | 3.5 | 7,554 | 2.9 | 48.9 |
| 14 | 4,915 | 3.4 | 12,816 | 4.9 | 160.8 |
| 15 | 3,614 | 2.5 | 18,003 | 6.9 | 398.1 |
| 16 | 11,226 | 7.7 | 25,003 | 9.5 | 122.7 |
| Subtotal | 55,846 | 38.5 | 117,933 | 45.1 | 111.2 |
| TOTAL | 145,510 | 100.0 | 261,961 | 100.0 | 80.0 |

*Values exclude units in military barracks and vessels.



AR00031672

Table 4.C4. Past and Projected Single-Family Residential Land Use on Oahu,* 1964 and 1985

| Planning District | Single-Family Residential Area, 1964 (acres) | | | Single-Family Residential Area, 1985 (acres) | | Percent Change 1964-1985 |
|---|---|---|---|---|---|---|
| | Single-Family Land Use | Adjusted Single-Family Land Use† | Percent of Adjusted Total | Single-Family Land Use | Percent of Total | |
| Honolulu | | | | | | |
| 1 | 254 | 226 | 1.3 | 1,730 | 5.7 | 665.5 |
| 2 | 115 | 115 | 0.6 | 27 | 0.1 | - 76.5 |
| 3 | 30 | 30 | 0.2 | 0 | 0 | -100.0 |
| 4 | 48 | 48 | 0.3 | 0 | 0 | -100.0 |
| 5 | 132 | 98 | 0.5 | 77 | 0.3 | - 21.4 |
| 6 | 3,265 | 2,805 | 15.6 | 3,638 | 12.1 | 29.7 |
| 7 | 3,289 | 2,739 | 15.2 | 5,315 | 17.6 | 94.0 |
| Subtotal | 7,133 | 6,061 | 33.7 | 10,787 | 35.8 | 78.0 |
| Outlying | | | | | | |
| 8 | 2,268 | 2,139 | 11.9 | 3,362 | 11.1 | 57.2 |
| 9 | 3,312 | 2,418 | 13.4 | 4,489 | 14.9 | 85.6 |
| 10 | 1,463 | 1,032 | 5.7 | 1,116 | 3.7 | 8.1 |
| 11 | 530 | 434 | 2.4 | 506 | 1.7 | 16.6 |
| 12 | 703 | 631 | 3.5 | 695 | 2.3 | 10.1 |
| 13 | 3,343 | 2,850 | 15.8 | 2,990 | 9.9 | 4.9 |
| 14 | 630 | 570 | 3.2 | 1,616 | 5.4 | 183.5 |
| 15 | 656 | 618 | 3.4 | 1,538 | 5.1 | 148.9 |
| 16 | 1,307 | 1,226 | 6.8 | 3,061 | 10.1 | 149.7 |
| Subtotal | 14,212 | 11,918 | 66.3 | 19,373 | 64.2 | 62.6 |
| TOTAL | 21,345 | 17,979 | 100.0 | 30,160 | 100.0 | 67.8 |

*Excludes single-family lands in military areas.

†Adjusted Single-Family Land Use excludes underdeveloped portion of the residential lot areas.



AR00031673

Table 4.C5. Past and Projected Multi-Family Residential Land Use on Oahu in 1964 and 1985

| Planning District | Multi-Family Residential Land Area | | | | Percent Change 1964-1985 |
|---|---|---|---|---|---|
| | 1964 | | 1985 | | |
| | Acres | Percent of Total | Acres | Percent of Total | |
| Honolulu | | | | | |
| 1 | -- | -- | 0 | -- | -- |
| 2 | 50 | 6.2 | 59 | 3.6 | 18.0 |
| 3 | 31 | 3.8 | 53 | 3.2 | 71.0 |
| 4 | 46 | 5.7 | 82 | 4.9 | 78.3 |
| 5 | 96 | 11.8 | 117 | 7.1 | 21.9 |
| 6 | 300 | 36.9 | 551 | 33.3 | 83.7 |
| 7 | 109 | 13.4 | 134 | 8.1 | 22.9 |
| Subtotal | 632 | 77.8 | 996 | 60.2 | 57.6 |
| Outlying | | | | | |
| 8 | 11 | 1.4 | 19 | 1.1 | 72.7 |
| 9 | 3 | 0.4 | 114 | 6.9 | 3,700.0 |
| 10 | 27 | 3.3 | 28 | 1.7 | 3.7 |
| 11 | 16 | 2.0 | 19 | 1.1 | 18.8 |
| 12 | 23 | 2.8 | 36 | 2.2 | 56.5 |
| 13 | 5 | 0.6 | 33 | 2.0 | 560.0 |
| 14 | 1 | 0.1 | 28 | 1.7 | 2,700.0 |
| 15 | 11 | 1.4 | 181 | 10.9 | 1,545.5 |
| 16 | 83 | 10.2 | 202 | 12.2 | 143.4 |
| Subtotal | 180 | 22.2 | 660 | 39.8 | 266.7 |
| TOTAL | 812 | 100.0 | 1,656 | 100.0 | 103.9 |



AR00031674

# APPENDIX IV-D. TABLES CONCERNING RETAIL, PUBLIC, AND INDUSTRIAL SUBMODELS

Table 4.D1. Distribution of Commercial Land on Oahu, 1964 and 1985

| Planning District | Commercial Land Area | | | | Percent Change 1964–1985 |
|---|---|---|---|---|---|
| | 1964 | | 1985 | | |
| | Acres | Percent of Total | Acres | Percent of Total | |
| Honolulu | | | | | |
| 1 | 94 | 6.5 | 142 | 6.5 | 51.1 |
| 2 | 113 | 7.8 | 189 | 8.7 | 67.3 |
| 3 | 173 | 11.9 | 196 | 9.0 | 13.3 |
| 4 | 203 | 14.0 | 252 | 11.5 | 24.1 |
| 5 | 58 | 4.0 | 69 | 3.2 | 19.0 |
| 6 | 156 | 10.8 | 257 | 11.8 | 64.7 |
| 7 | 102 | 7.0 | 177 | 8.1 | 73.5 |
| Subtotal | 899 | 62.0 | 1,282 | 58.8 | 42.6 |
| Outlying | | | | | |
| 8 | 102 | 7.0 | 175 | 8.0 | 71.6 |
| 9 | 101 | 7.0 | 133 | 6.1 | 31.7 |
| 10 | 48 | 3.3 | 54 | 2.5 | 12.5 |
| 11 | 66 | 4.5 | 80 | 3.7 | 21.2 |
| 12 | 50 | 3.4 | 92 | 4.2 | 84.0 |
| 13 | 35 | 2.4 | 52 | 2.4 | 48.6 |
| 14 | 27 | 1.9 | 84 | 3.8 | 211.1 |
| 15 | 53 | 3.7 | 114 | 5.2 | 115.1 |
| 16 | 69 | 4.8 | 115 | 5.3 | 66.7 |
| Subtotal | 551 | 38.0 | 899 | 41.2 | 63.2 |
| TOTAL | 1,450 | 100.0 | 2,181 | 100.0 | 50.4 |



AR00031678

Table 4.D2. Commercial Floor Area on Oahu, 1964 and 1985

| Planning District | Commercial Floor Area | | | | Percent Change 1964-1985 |
|---|---|---|---|---|---|
| | 1964 | | 1985 | | |
| | Million Sq Ft | Percent Distribution by Planning District | Million Sq Ft | Percent Distribution by Planning District | |
| Honolulu | | | | | |
| 1 | 1.0272 | 5.1 | 3.3545 | 6.7 | 226.6 |
| 2 | 1.2616 | 6.3 | 3.9619 | 8.0 | 214.0 |
| 3 | 6.2813 | 31.2 | 13.5369 | 27.2 | 115.5 |
| 4 | 3.9390 | 19.6 | 10.3010 | 20.7 | 161.5 |
| 5 | 1.5965 | 7.9 | 3.5804 | 7.2 | 124.3 |
| 6 | 2.0144 | 10.0 | 4.5218 | 9.1 | 124.5 |
| 7 | 1.0282 | 5.1 | 2.3028 | 4.6 | 124.0 |
| Subtotal | 17.1482 | 85.2 | 41.5593 | 83.5 | 142.4 |
| Outlying | | | | | |
| 8 | 0.6771 | 3.4 | 1.7281 | 3.5 | 155.2 |
| 9 | 0.3308 | 1.6 | 0.7636 | 1.5 | 130.8 |
| 10 | 0.0680 | 0.3 | 0.1709 | 0.3 | 151.3 |
| 11 | 0.1872 | 0.9 | 0.4621 | 0.9 | 146.8 |
| 12 | 0.5540 | 2.8 | 1,1976 | 2.4 | 116.2 |
| 13 | 0.1741 | 0.9 | 0.4594 | 0.9 | 163.9 |
| 14 | 0.2282 | 1.1 | 1.3753 | 2.8 | 502.7 |
| 15 | 0.3906 | 1.9 | 1.0744 | 2.2 | 175.1 |
| 16 | 0.3742 | 1.9 | 1.0080 | 2.0 | 169.4 |
| Subtotal | 2.9842 | 14.8 | 8.2394 | 16.5 | 176.1 |
| TOTAL | 20.1324 | 100.0 | 49.7987 | 100.0 | 147.4 |

Source: OTS Commercial Land Use Report, Table C-1.
OTS Land Use Model 03 of 05/11/67.



AR00031679

Table 4.D3. Commercial Floor-Area to Land-Area Relationship on Oahu, 1964 and 1985

| Planning District | Commercial Floor Area/Acre of Land (1000 sq ft) | |
|---|---|---|
| | 1964 | 1985 |
| Honolulu | | |
| 1 | 10.9 | 23.6 |
| 2 | 11.2 | 21.0 |
| 3 | 36.5 | 69.1 |
| 4 | 19.5 | 40.9 |
| 5 | 27.5 | 51.9 |
| 6 | 13.0 | 17.6 |
| 7 | 10.1 | 13.0 |
| Subtotal | 19.1 | 32.4 |
| Outlying | | |
| 8 | 6.6 | 9.9 |
| 9 | 3.3 | 5.7 |
| 10 | 1.4 | 3.2 |
| 11 | 2.8 | 5.8 |
| 12 | 11.1 | 13.0 |
| 13 | 5.0 | 8.8 |
| 14 | 8.5 | 16.4 |
| 15 | 7.4 | 9.4 |
| 16 | 5.4 | 9.8 |
| Subtotal | 5.4 | 9.2 |
| TOTAL | 13.9 | 22.8 |

Source: OTS Commercial Land Use Report, Table No. C-8.
OTS Land Use Model 03 of 05/11/67.



AR00031680

Table 4.D4. Distribution of Industrial Land on Oahu, 1964 and 1985

| Planning District | Industrial Land Area | | | |
|---|---|---|---|---|
| | 1964 | | 1985 | |
| | Acres | Percent by Planning District | Acres | Percent by Planning District |
| Honolulu | | | | |
| 1 | 1,273 | 20.0 | 1,338 | 17.0 |
| 2 | 506 | 8.0 | 602 | 7.6 |
| 3 | 241 | 3.8 | 243 | 3.1 |
| 4 | 68 | 1.1 | 69 | 0.9 |
| 5 | 5 | 0.1 | 5 | 0.1 |
| 6 | 198 | 3.1 | 199 | 2.5 |
| 7 | 86 | 1.3 | 86 | 1.1 |
| Subtotal | 2,377 | 37.4 | 2,542 | 32.3 |
| Outlying | | | | |
| 8 | 308 | 4.8 | 307 | 3.9 |
| 9 | 256 | 4.0 | 259 | 3.3 |
| 10 | 255 | 4.0 | 263 | 3.3 |
| 11 | 335 | 5.3 | 341 | 4.3 |
| 12 | 103 | 1.6 | 103 | 1.3 |
| 13 | 540 | 8.5 | 590 | 7.5 |
| 14 | 1,676 | 26.4 | 2,891 | 36.8 |
| 15 | 135 | 2.2 | 194 | 2.5 |
| 16 | 367 | 5.8 | 375 | 4.8 |
| Subtotal | 3,975 | 62.6 | 5,323 | 67.7 |
| TOTAL | 6,352 | 100.0 | 7,865 | 100.0 |



AR00031681

Table 4.D5. Projected Percent of Employees in Private Industry on Oahu, for Three Income Classes, 1970 through 1985

| Economic Model Category | Forecast Period Ending | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1970 | | | 1975 | | | 1980 | | | 1985 | | |
| | High | Middle | Low | High | Middle | Low | High | Middle | Low | High | Middle | Low |
| Sugar, field and mill | 0.179 | 0.281 | 0.539 | 0.224 | 0.258 | 0.516 | 0.281 | 0.231 | 0.488 | 0.345 | 0.198 | 0.455 |
| Pineapple, field & canning | 0.106 | 0.304 | 0.588 | 0.149 | 0.283 | 0.567 | 0.200 | 0.257 | 0.543 | 0.255 | 0.228 | 0.515 |
| Other agriculture, forestry, fisheries & mining | 0.215 | 0.351 | 0.433 | 0.240 | 0.339 | 0.420 | 0.269 | 0.326 | 0.405 | 0.296 | 0.313 | 0.390 |
| Other food processing | 0.123 | 0.303 | 0.572 | 0.180 | 0.275 | 0.544 | 0.249 | 0.240 | 0.511 | 0.334 | 0.196 | 0.469 |
| Apparel, textiles, printing, publishing and related manufacturing | 0.198 | 0.333 | 0.467 | 0.247 | 0.299 | 0.452 | 0.308 | 0.258 | 0.434 | 0.377 | 0.209 | 0.413 |
| Other manufacturing | 0.095 | 0.276 | 0.628 | 0.136 | 0.263 | 0.600 | 0.186 | 0.247 | 0.567 | 0.244 | 0.228 | 0.527 |
| Contract construction | 0.138 | 0.351 | 0.510 | 0.181 | 0.334 | 0.484 | 0.232 | 0.314 | 0.454 | 0.290 | 0.291 | 0.418 |
| Wholesale trade, trucking warehousing and related services | 0.139 | 0.285 | 0.574 | 0.153 | 0.301 | 0.544 | 0.171 | 0.317 | 0.512 | 0.185 | 0.335 | 0.478 |
| Other transportation | 0.091 | 0.422 | 0.485 | 0.135 | 0.405 | 0.458 | 0.188 | 0.385 | 0.427 | 0.246 | 0.362 | 0.391 |
| Utilities & communication | 0.194 | 0.447 | 0.357 | 0.268 | 0.391 | 0.340 | 0.358 | 0.324 | 0.318 | 0.466 | 0.241 | 0.292 |
| Retail trade (excluding eating & drinking places | 0.128 | 0.359 | 0.511 | 0.145 | 0.384 | 0.469 | 0.165 | 0.409 | 0.426 | 0.182 | 0.436 | 0.380 |
| Eating and drinking places and amusement services | 0.100 | 0.237 | 0.662 | 0.112 | 0.262 | 0.624 | 0.127 | 0.289 | 0.584 | 0.139 | 0.318 | 0.541 |
| Banking and Finance | 0.222 | 0.389 | 0.388 | 0.251 | 0.399 | 0.348 | 0.285 | 0.410 | 0.305 | 0.318 | 0.422 | 0.259 |
| Hotels | 0.080 | 0.334 | 0.585 | 0.099 | 0.334 | 0.565 | 0.120 | 0.335 | 0.545 | 0.139 | 0.335 | 0.524 |
| Health, legal and other professional services (except education) | 0.430 | 0.224 | 0.344 | 0.460 | 0.212 | 0.327 | 0.492 | 0.199 | 0.309 | 0.524 | 0.185 | 0.290 |
| Education and other services (including domestics) | 0.063 | 0.437 | 0.499 | 0.088 | 0.452 | 0.458 | 0.118 | 0.469 | 0.403 | 0.147 | 0.489 | 0.363 |



AR00031682

Table 4.D6. Employment Distribution

| Economic Category | No. of People Employed in the Period Ending | |
|---|---|---|
| | 1960 | 1985 |
| Sugar and pineapples, field and mill | 7,764 | 3,263 |
| Other agriculture | 2,994 | 2,202 |
| Other food processing | 2,723 | 3,119 |
| Apparel, textile | 4,179 | 6,013 |
| Other manufacturing | 3,594 | 6,485 |
| Contract construction | 15,539 | 13,345 |
| Wholesale trade | 12,250 | 21,211 |
| Other transportation | 4,765 | 8,651 |
| Utilities & communication | 5,016 | 9,037 |
| Retail convenience goods | 16,228 | 37,795 |
| Retail shopping goods | 8,536 | 16,494 |
| Retail other goods | 6,056 | 11,703 |
| Retail personal services | 7,355 | 20,654 |
| Retail business services | 14,666 | 57,283 |
| Public administration | 34,574 | 100,572 |
| Public amusement (outdoor activities) | 1,837 | 4,997 |
| Hotel | 3,140 | 6,985 |
| Military personnel | 42,236 | 39,600 |
| Civil defense employees | 18,550 | 17,000 |
| TOTAL EMPLOYEES | 212,002 | 386,409 |

Source: State of Hawaii, Department of Planning and Economic Development. Revised output of the Economic Model, September 1966. Calculated from OTS Land Use Model 02 of 08/11/66 data.



AR00031683

# TABLE 4.D7. LAND USE SUMMARY by CENSUS TRACT, 1964 & 1985

| CENSUS TRACT | DWELLING UNITS 1964 | DWELLING UNITS 1985 | RESIDENTIAL LAND (Acres) 1964 | RESIDENTIAL LAND (Acres) 1985 | MANUFACTURING LAND (Acres) 1964 | MANUFACTURING LAND (Acres) 1985 | TRANSPORTATION, COMMUNICATION, UTILITIES LAND (Acres) 1964 | TRANSPORTATION, COMMUNICATION, UTILITIES LAND (Acres) 1985 | COMMERCIAL--WHOLESALE, STORAGE, CONSTRUCTION LAND (Acres) 1964 | COMMERCIAL--WHOLESALE, STORAGE, CONSTRUCTION LAND (Acres) 1985 | COMMERCIAL--RETAIL LAND (Acres) 1964 | COMMERCIAL--RETAIL LAND (Acres) 1985 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1,056 | 9,013 | 436 | 1,785 | 15 | 15 | 13 | 13 | 0 | 0 | 11 | 11 |
| 2 | 1,042 | 1,948 | 251 | 366 | 0 | 0 | 4 | 4 | 0 | 0 | 6 | 12 |
| 3 | 1,655 | 3,846 | 384 | 747 | 0 | 0 | 4 | 4 | 0 | 0 | 8 | 12 |
| 4 | 747 | 1.158 | 137 | 286 | 0 | 0 | 14 | 13 | 0 | 0 | 0 | 1 |
| 5 | 1,807 | 1,957 | 378 | 379 | 0 | 0 | 1 | 1 | 0 | 0 | 25 | 32 |
| 6 | 558 | 646 | 115 | 117 | 0 | 0 | 7 | 7 | 0 | 0 | 0 | 1 |
| 7 | 917 | 993 | 123 | 125 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 |
| 8 | 1,334 | 1,413 | 148 | 145 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 2 |
| 9 | 2,235 | 3,725 | 341 | 402 | 0 | 0 | 14 | 13 | 0 | 0 | 4 | 10 |
| 10 | 786 | 1,232 | 196 | 219 | 0 | 0 | 2 | 2 | 3 | 3 | 0 | 1 |
| 11 | 1,129 | 1,226 | 109 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| 12 | 1,789 | 1,795 | 178 | 173 | 0 | 0 | 2 | 2 | 0 | 0 | 8 | 15 |
| 13 | 1,395 | 1,374 | 123 | 106 | 1 | 1 | 1 | 1 | 0 | 0 | 6 | 18 |
| 14 | 802 | 827 | 87 | 87 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 15 | 1,202 | 1,193 | 101 | 97 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 8 |
| 16 | 1,405 | 1,407 | 105 | 103 | 0 | 0 | 0 | 1 | 0 | 0 | 5 | 8 |
| 17 | 1,393 | 1,856 | 109 | 94 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 8 |
| 18 | 2,964 | 3,996 | 49 | 37 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 |
| 19 | 2,426 | 2,520 | 26 | 22 | 0 | 0 | 2 | 2 | 0 | 0 | 13 | 13 |
| 20 | 3,861 | 4,898 | 44 | 41 | 0 | 0 | 3 | 3 | 0 | 0 | 16 | 18 |
| 21 | 1,021 | 1,216 | 36 | 26 | 3 | 3 | 3 | 3 | 0 | 0 | 10 | 16 |
| 22 | 1,431 | 1,778 | 35 | 38 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 1 |
| 23 | 1,432 | 3,956 | 41 | 38 | 0 | 0 | 0 | 1 | 1 | 2 | 5 | 9 |
| 24 | 2,065 | 6,591 | 56 | 53 | 0 | 1 | 0 | 0 | 1 | 1 | 3 | 10 |
| 25 | 1,605 | 3,194 | 42 | 36 | 2 | 2 | 0 | 0 | 0 | 0 | 7 | 14 |
| 26 | 1,782 | 2,126 | 56 | 44 | 1 | 1 | 1 | 1 | 5 | 5 | 12 | 26 |
| 27 | 3,426 | 4,183 | 162 | 164 | 1 | 1 | 1 | 1 | 0 | 0 | 4 | 8 |
| 28 | 1,191 | 1,336 | 186 | 202 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 2 |
| 29 | 356 | 931 | 71 | 145 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 7 |
| 30 | 1,551 | 1,788 | 261 | 278 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 |
| 31 | 1,843 | 2,920 | 367 | 546 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 32 | 352 | 877 | 178 | 188 | 0 | 0 | 6 | 6 | 0 | 0 | 0 | 1 |
| 33 | 300 | 378 | 72 | 75 | 0 | 0 | 31 | 30 | 0 | 0 | 0 | 1 |
| 34 | 4,688 | 9,534 | 167 | 182 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 35 | 1,682 | 3,550 | 46 | 38 | 2 | 3 | 1 | 1 | 2 | 2 | 23 | 34 |
| 36 | 1,859 | 3,403 | 41 | 38 | 8 | 8 | 1 | 1 | 7 | 9 | 26 | 56 |
| 37 | 457 | 467 | 7 | 6 | 5 | 5 | 3 | 2 | 39 | 38 | 108 | 118 |
| 38 | 292 | 266 | 4 | 1 | 25 | 26 | 32 | 32 | 44 | 45 | 25 | 38 |
| 39 | 174 | 168 | 1 | 1 | 5 | 6 | 75 | 74 | 32 | 32 | 10 | 11 |
| 40 | 19 | 19 | 0 | 0 | 0 | 0 | 2 | 2 | 5 | 5 | 14 | 15 |
| 41 | 1,643 | 4,093 | 46 | 41 | 2 | 2 | 7 | 7 | 2 | 2 | 5 | 11 |
| 42 | 590 | 590 | 8 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 6 |
| 43 | 1,482 | 3,110 | 109 | 104 | 0 | 0 | 2 | 2 | 0 | 0 | 4 | 8 |
| 44 | 1,418 | 1,891 | 189 | 218 | 2 | 2 | 1 | 1 | 0 | 0 | 1 | 2 |
| 45 | 1,149 | 1,972 | 283 | 339 | 0 | 0 | 9 | 9 | 0 | 0 | 1 | 2 |
| 46 | 1,065 | 1,598 | 197 | 241 | 0 | 0 | 31 | 30 | 0 | 0 | 0 | 1 |
| 47 | 1,323 | 1,648 | 225 | 230 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 1 |
| 48 | 1,463 | 1,498 | 148 | 145 | 1 | 1 | 3 | 3 | 0 | 0 | 10 | 16 |
| 49 | 727 | 940 | 52 | 53 | 0 | 0 | 1 | 1 | 0 | 0 | 4 | 8 |
| 50 | 1,346 | 1,522 | 70 | 68 | 1 | 1 | 0 | 0 | 0 | 0 | 5 | 7 |
| 51 | 373 | 373 | 2 | 2 | 0 | 0 | 0 | 0 | 2 | 2 | 1 | 1 |
| 52 | 736 | 736 | 0 | 0 | 1 | 1 | 5 | 5 | 2 | 2 | 11 | 12 |
| 53 | 319 | 1,107 | 10 | 23 | 0 | 0 | 0 | 0 | 1 | 1 | 8 | 9 |
| 54 | 414 | 468 | 15 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 55 | 632 | 793 | 21 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| 56 | 1,371 | 1,684 | 88 | 81 | 0 | 0 | 3 | 3 | 2 | 2 | 6 | 13 |
| 57 | 1,327 | 1,358 | 19 | 12 | 81 | 81 | 94 | 96 | 98 | 107 | 38 | 64 |
| 58 | 771 | 879 | 41 | 32 | 12 | 12 | 2 | 6 | 0 | 12 | 4 | 10 |
| 59 | 994 | 756 | 43 | 11 | 30 | 31 | 69 | 77 | 66 | 101 | 27 | 36 |
| 60 | 1,323 | 1,250 | 62 | 31 | 29 | 29 | 5 | 7 | 20 | 43 | 15 | 24 |
| 61 | 658 | 738 | 57 | 56 | 1 | 1 | 0 | 0 | 0 | 0 | 4 | 6 |
| 62 | 881 | 1,253 | 72 | 76 | 0 | 0 | 0 | 0 | 1 | 1 | 4 | 7 |
| 63 | 1,133 | 1,176 | 121 | 122 | 0 | 0 | 73 | 72 | 0 | 0 | 3 | 8 |
| 64 | 1,199 | 2,614 | 143 | 346 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 |
| 65 | 757 | 1,339 | 222 | 238 | 7 | 7 | 0 | 0 | 0 | 0 | 0 | 1 |
| 66 | 753 | 753 | 0 | 0 | 0 | 0 | 4 | 3 | 0 | 0 | 0 | 0 |
| 67 | 795 | 5,805 | 134 | 1,243 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| 68 | 1,038 | 2,425 | 120 | 487 | 6 | 6 | 7 | 10 | 71 | 75 | 25 | 33 |
| 69 | 936 | 936 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 2 |
| 70 | 1,510 | 1,510 | 0 | 0 | 0 | 0 | 12 | 12 | 0 | 0 | 8 | 8 |
| 71 | 1,014 | 1,014 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 72 | 495 | 495 | 0 | 0 | 7 | 7 | 1,134 | 1,189 | 30 | 34 | 18 | 30 |
| 73 | 1,399 | 1,399 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 74 | 779 | 779 | 0 | 0 | 0 | 0 | 10 | 10 | 28 | 28 | 1 | 2 |
| 75 | 1,115 | 3,197 | 179 | 470 | 0 | 0 | 69 | 69 | 139 | 141 | 3 | 5 |
| 76 | 1,112 | 1,112 | 49 | 91 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| 77 | 2,429 | 3,622 | 675 | 803 | 16 | 16 | 4 | 4 | 1 | 1 | 6 | 18 |
| 78 | 1,156 | 1,757 | 131 | 848 | 3 | 3 | 20 | 23 | 16 | 16 | 5 | 12 |
| 79 | 35 | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 2,904 | 6,786 | 338 | 1,032 | 0 | 0 | 12 | 13 | 14 | 14 | 25 | 31 |
| 81 | 297 | 316 | 17 | 19 | 0 | 0 | 35 | 37 | 0 | 0 | 0 | 1 |
| 82 | 7 | 7 | 0 | 0 | 0 | 0 | 45 | 46 | 0 | 0 | 0 | 1 |
| 83 | 1,186 | 1,209 | 11 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 84 | 1,822 | 2,271 | 273 | 308 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 16 |
| 85 | 574 | 574 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 86 | 1,333 | 8,762 | 346 | 1,331 | 532 | 675 | 1,026 | 1,939 | 118 | 277 | 8 | 11 |
| 87 | 1,480 | 2,868 | 158 | 357 | 1 | 1 | 16 | 24 | 5 | 5 | 24 | 40 |
| 88 | 808 | 864 | 92 | 100 | 14 | 14 | 10 | 10 | 0 | 0 | 9 | 11 |
| 89 | 1,319 | 14,264 | 417 | 1,262 | 0 | 7 | 37 | 76 | 7 | 11 | 13 | 36 |
| 90 | 264 | 264 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 91 | 516 | 522 | 59 | 59 | 34 | 34 | 41 | 41 | 0 | 0 | 2 | 4 |
| 92 | 2,006 | 2,291 | 428 | 411 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| 93 | 1,351 | 2,041 | 110 | 122 | 1 | 1 | 6 | 6 | 10 | 10 | 17 | 32 |
| 94 | 1,281 | 1,633 | 127 | 138 | 0 | 0 | 9 | 9 | 0 | 0 | 8 | 12 |
| 95 | 2,579 | 2,568 | 2 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 2 |
| 96 | 2,582 | 3,363 | 825 | 704 | 238 | 243 | 11 | 43 | 70 | 72 | 14 | 16 |
| 97 | 1,482 | 1,689 | 841 | 775 | 19 | 21 | 83 | 92 | 31 | 31 | 8 | 12 |
| 98 | 1,009 | 2,502 | 1,682 | 1,544 | 0 | 0 | 87 | 87 | 1 | 1 | 1 | 5 |
| 99 | 1,941 | 2,637 | 407 | 414 | 22 | 22 | 77 | 78 | 2 | 2 | 50 | 53 |
| 100 | 483 | 496 | 139 | 111 | 0 | 1 | 228 | 232 | 6 | 6 | 7 | 9 |
| 101 | 1,042 | 1,149 | 629 | 541 | 0 | 1 | 131 | 137 | 29 | 30 | 32 | 33 |
| 102 | 1,693 | 2,221 | 861 | 603 | 0 | 0 | 17 | 17 | 78 | 78 | 15 | 17 |
| 103 | 2,058 | 8,941 | 2,037 | 2,581 | 188 | 188 | 3 | 4 | 16 | 16 | 50 | 52 |
| 104 | 12 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 105 | 2,200 | 6,150 | 651 | 776 | 2 | 2 | 24 | 25 | 1 | 1 | 21 | 31 |
| 106 | 1,671 | 2,409 | 360 | 419 | 3 | 4 | 16 | 16 | 1 | 1 | 24 | 30 |
| 107 | 1,211 | 4,196 | 267 | 827 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 2 |
| 108 | 1,115 | 1,115 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 109 | 3,421 | 3,881 | 548 | 593 | 0 | 0 | 127 | 127 | 1 | 1 | 10 | 18 |
| 110 | 551 | 1,995 | 278 | 637 | 95 | 94 | 13 | 13 | 0 | 0 | 47 | 48 |
| 111 | 2,555 | 5,844 | 474 | 1,054 | 7 | 8 | 6 | 6 | 9 | 9 | 17 | 52 |
| 112 | 1,877 | 2,419 | 497 | 549 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| 113 | 1,191 | 1,773 | 482 | 548 | 16 | 16 | 32 | 32 | 2 | 1 | 4 | 6 |
| TOTAL | 145,510 | 261,961 | 22,157 | 31,816 | 1,439 | 1,604 | 3,893 | 4,982 | 1,020 | 1,279 | 1,016 | 1,518 |

| CENSUS TRACT | COMMERCIAL--SERVICE LAND (Acres) 1964 | COMMERCIAL--SERVICE LAND (Acres) 1985 | PUBLIC AND QUASI-PUBLIC BUILDINGS LAND (Acres) 1964 | PUBLIC AND QUASI-PUBLIC BUILDINGS LAND (Acres) 1985 | PUBLIC AND QUASI-PUBLIC OPEN SPACE LAND (Acres) 1964 | PUBLIC AND QUASI-PUBLIC OPEN SPACE LAND (Acres) 1985 | AGRICULTURE AND EXTRACTIVE LAND (Acres) 1964 | AGRICULTURE AND EXTRACTIVE LAND (Acres) 1985 | MILITARY LAND (Acres) 1964 | MILITARY LAND (Acres) 1985 | HOTEL LAND (Acres) 1964 | HOTEL LAND (Acres) 1985 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 2 | 39 | 55 | 1,880 | 1,899 | 958 | 908 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 7 | 7 | 3 | 3 | 45 | 45 | 0 | 0 | 0 | 0 |
| 3 | 0 | 2 | 32 | 32 | 5 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 38 | 38 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 2 | 5 | 9 | 8 | 173 | 173 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 3 | 3 | 14 | 14 | 0 | 0 | 57 | 57 | 0 | 0 |
| 7 | 0 | 1 | 37 | 37 | 27 | 27 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 3 | 3 | 16 | 16 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 3 | 6 | 17 | 17 | 10 | 10 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 0 | 31 | 31 | 7 | 8 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 3 | 4 | 10 | 10 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 7 | 9 | 16 | 16 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 0 | 0 | 4 | 4 | 6 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 1 | 2 | 7 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 0 | 1 | 7 | 7 | 161 | 168 | 0 | 0 | 0 | 0 | 1 | 9 |
| 18 | 2 | 2 | 18 | 18 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 20 |
| 19 | 13 | 13 | 3 | 3 | 147 | 147 | 0 | 0 | 72 | 72 | 54 | 63 |
| 20 | 9 | 9 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 8 | 17 |
| 21 | 3 | 3 | 38 | 38 | 151 | 151 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | 0 | 0 | 31 | 31 | 32 | 32 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 3 | 3 | 9 | 9 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 4 | 4 | 1 | 1 | 9 | 9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 3 | 3 | 17 | 17 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 15 | 14 | 22 | 22 | 4 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 | 1 | 1 | 334 | 337 | 12 | 30 | 7 | 0 | 0 | 0 | 0 | 0 |
| 28 | 0 | 0 | 60 | 60 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29 | 1 | 2 | 10 | 10 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | 0 | 0 | 15 | 15 | 0 | 3 | 4 | 0 | 0 | 0 | 0 | 0 |
| 31 | 1 | 1 | 48 | 48 | 25 | 25 | 186 | 185 | 0 | 0 | 0 | 0 |
| 32 | 0 | 0 | 0 | 0 | 0 | 0 | 73 | 66 | 0 | 0 | 0 | 0 |
| 33 | 0 | 0 | 22 | 22 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 34 | 1 | 1 | 26 | 26 | 8 | 8 | 9 | 0 | 0 | 0 | 0 | 0 |
| 35 | 15 | 14 | 37 | 37 | 11 | 11 | 0 | 0 | 0 | 0 | 0 | 0 |
| 36 | 17 | 16 | 7 | 7 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | 14 | 14 | 54 | 54 | 98 | 89 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38 | 26 | 26 | 32 | 32 | 6 | 6 | 8 | 0 | 0 | 0 | 0 | 2 |
| 39 | 30 | 29 | 57 | 57 | 3 | 3 | 0 | 0 | 19 | 19 | 0 | 0 |
| 40 | 20 | 20 | 6 | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 41 | 11 | 11 | 39 | 39 | 5 | 5 | 0 | 0 | 0 | 0 | 1 | 4 |
| 42 | 4 | 5 | 12 | 12 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 43 | 1 | 2 | 37 | 37 | 99 | 99 | 0 | 0 | 0 | 0 | 1 | 4 |
| 44 | 0 | 0 | 7 | 7 | 10 | 11 | 37 | 20 | 0 | 0 | 0 | 0 |
| 45 | 0 | 1 | 27 | 27 | 26 | 26 | 8 | 8 | 0 | 0 | 0 | 0 |
| 46 | 0 | 0 | 10 | 10 | 134 | 134 | 1 | 0 | 0 | 0 | 0 | 0 |
| 47 | 0 | 0 | 18 | 19 | 17 | 26 | 0 | 0 | 0 | 0 | 0 | 0 |
| 48 | 3 | 4 | 445 | 445 | 7 | 7 | 1 | 0 | 0 | 0 | 0 | 0 |
| 49 | 0 | 1 | 17 | 17 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | 2 | 2 | 32 | 32 | 5 | 6 | 1 | 0 | 0 | 0 | 0 | 0 |
| 51 | 4 | 4 | 1 | 1 | 12 | 12 | 0 | 0 | 0 | 0 | 0 | 0 |
| 52 | 7 | 7 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 53 | 7 | 7 | 7 | 7 | 7 | 7 | 0 | 0 | 0 | 0 | 1 | 1 |
| 54 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 55 | 1 | 1 | 6 | 6 | 6 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 56 | 5 | 5 | 54 | 54 | 0 | 9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 57 | 9 | 27 | 13 | 13 | 1 | 4 | 0 | 0 | 185 | 185 | 0 | 1 |
| 58 | 3 | 4 | 21 | 21 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 59 | 10 | 17 | 40 | 40 | 0 | 0 | 0 | 0 | 55 | 55 | 0 | 0 |
| 60 | 7 | 7 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 61 | 2 | 2 | 9 | 9 | 10 | 10 | 0 | 0 | 0 | 0 | 0 | 0 |
| 62 | 2 | 2 | 11 | 12 | 2 | 2 | 4 | 0 | 0 | 0 | 0 | 0 |
| 63 | 0 | 0 | 28 | 28 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 64 | 0 | 1 | 5 | 5 | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| 65 | 0 | 0 | 80 | 80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 66 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,399 | 1,399 | 0 | 0 |
| 67 | 0 | 0 | 364 | 364 | 103 | 103 | 0 | 0 | 125 | 125 | 0 | 0 |
| 68 | 6 | 22 | 2 | 2 | 0 | 0 | 0 | 0 | 459 | 459 | 0 | 0 |
| 69 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 243 | 243 | 0 | 0 |
| 70 | 7 | 7 | 44 | 44 | 0 | 0 | 0 | 0 | 604 | 604 | 0 | 0 |
| 71 | 0 | 0 | 9 | 9 | 0 | 0 | 0 | 0 | 219 | 219 | 0 | 0 |
| 72 | 28 | 38 | 1 | 6 | 72 | 76 | 0 | 0 | 1,566 | 1,566 | 1 | 7 |
| 73 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,464 | 1,464 | 0 | 0 |
| 74 | 1 | 1 | 25 | 25 | 0 | 0 | 14 | 14 | 1,069 | 1,069 | 0 | 0 |
| 75 | 0 | 2 | 243 | 244 | 7 | 16 | 403 | 253 | 213 | 213 | 0 | 0 |
| 76 | 0 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 87 | 87 | 0 | 0 |
| 77 | 2 | 6 | 83 | 77 | 392 | 393 | 5 | 5 | 6 | 6 | 0 | 0 |
| 78 | 18 | 23 | 4 | 5 | 0 | 19 | 1,853 | 1,853 | 0 | 0 | 0 | 0 |
| 79 | 0 | 0 | 364 | 364 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 5 | 11 | 54 | 62 | 35 | 73 | 559 | 261 | 322 | 322 | 0 | 0 |
| 81 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 779 | 779 | 0 | 0 |
| 82 | 0 | 0 | 0 | 0 | 0 | 0 | 864 | 863 | 870 | 870 | 0 | 0 |
| 83 | 0 | 0 | 43 | 43 | 0 | 0 | 6 | 6 | 3,079 | 3,079 | 0 | 0 |
| 84 | 5 | 10 | 13 | 25 | 13 | 33 | 2,744 | 2,744 | 0 | 0 | 0 | 0 |
| 85 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3,671 | 3,671 | 0 | 0 |
| 86 | 3 | 46 | 74 | 88 | 36 | 57 | 17,307 | 17,307 | 7 | 7 | 0 | 0 |
| 87 | 5 | 17 | 59 | 60 | 17 | 21 | 371 | 276 | 0 | 0 | 0 | 0 |
| 88 | 0 | 1 | 79 | 79 | 1 | 1 | 423 | 423 | 0 | 0 | 0 | 0 |
| 89 | 2 | 8 | 14 | 122 | 157 | 173 | 17,011 | 16,918 | 1,635 | 1,635 | 0 | 0 |
| 90 | 0 | 0 | 41 | 41 | 0 | 0 | 0 | 0 | 7,631 | 7,631 | 0 | 0 |
| 91 | 0 | 1 | 8 | 8 | 2 | 4 | 1,799 | 1,799 | 685 | 685 | 0 | 0 |
| 92 | 0 | 1 | 56 | 56 | 28 | 33 | 20 | 20 | 0 | 0 | 0 | 0 |
| 93 | 15 | 26 | 9 | 9 | 8 | 10 | 29 | 16 | 0 | 0 | 0 | 0 |
| 94 | 8 | 12 | 17 | 17 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 95 | 0 | 0 | 11 | 11 | 0 | 0 | 0 | 0 | 7,999 | 7,999 | 0 | 0 |
| 96 | 7 | 10 | 124 | 155 | 119 | 138 | 767 | 767 | 9,926 | 9,926 | 0 | 0 |
| 97 | 3 | 6 | 40 | 77 | 65 | 119 | 2,639 | 2,639 | 3 | 3 | 0 | 0 |
| 98 | 2 | 3 | 10 | 12 | 3 | 22 | 194 | 194 | 2 | 2 | 0 | 0 |
| 99 | 4 | 9 | 42 | 57 | 75 | 97 | 11,248 | 11,248 | 701 | 701 | 0 | 0 |
| 100 | 5 | 9 | 3 | 4 | 1,982 | 1,982 | 18,458 | 18,458 | 281 | 281 | 0 | 0 |
| 101 | 0 | 2 | 46 | 47 | 289 | 292 | 5,518 | 5,533 | 4 | 4 | 0 | 0 |
| 102 | 1 | 2 | 152 | 168 | 53 | 81 | 4,494 | 4,494 | 3 | 3 | 0 | 0 |
| 103 | 1 | 2 | 65 | 109 | 626 | 659 | 3,019 | 2,819 | 5 | 5 | 0 | 0 |
| 104 | 0 | 0 | 152 | 152 | 0 | 41 | 0 | 0 | 0 | 0 | 0 | 0 |
| 105 | 4 | 9 | 56 | 56 | 22 | 22 | 97 | 22 | 0 | 0 | 0 | 0 |
| 106 | 1 | 6 | 57 | 57 | 72 | 73 | 48 | 34 | 0 | 0 | 0 | 0 |
| 107 | 0 | 1 | 4 | 4 | 91 | 91 | 166 | 66 | 0 | 0 | 0 | 0 |
| 108 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,621 | 1,621 | 0 | 0 |
| 109 | 9 | 16 | 27 | 29 | 10 | 19 | 0 | 0 | 0 | 0 | 0 | 0 |
| 110 | 2 | 3 | 100 | 176 | 2 | 160 | 1,449 | 1,359 | 0 | 0 | 0 | 0 |
| 111 | 11 | 27 | 160 | 168 | 202 | 229 | 490 | 490 | 4 | 4 | 0 | 0 |
| 112 | 0 | 1 | 7 | 7 | 44 | 44 | 0 | 0 | 0 | 0 | 3 | 21 |
| 113 | 1 | 2 | 27 | 30 | 169 | 175 | 1,136 | 1,136 | 1,563 | 1,563 | 0 | 3 |
| TOTAL | 434 | 663 | 4,741 | 5,141 | 7,861 | 8,498 | 94,474 | 93,249 | 48,633 | 48,633 | 73 | 152 |

| CENSUS TRACT | MANUFACTURING FLOOR AREA (Square Feet) 1964 | MANUFACTURING FLOOR AREA (Square Feet) 1985 | COMMERCIAL--WHOLESALE, STORAGE, CONSTRUCTION FLOOR AREA (Square Feet) 1964 | COMMERCIAL--WHOLESALE, STORAGE, CONSTRUCTION FLOOR AREA (Square Feet) 1985 | COMMERCIAL--RETAIL FLOOR AREA (Square Feet) 1964 | COMMERCIAL--RETAIL FLOOR AREA (Square Feet) 1985 | COMMERCIAL--SERVICE FLOOR AREA (Square Feet) 1964 | COMMERCIAL--SERVICE FLOOR AREA (Square Feet) 1985 | HOTEL FLOOR AREA (Square Feet) 1964 | HOTEL FLOOR AREA (Square Feet) 1985 | PUBLIC AND QUASI-PUBLIC BUILDINGS FLOOR AREA (Square Feet) 1964 | PUBLIC AND QUASI-PUBLIC BUILDINGS FLOOR AREA (Square Feet) 1985 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 28,384 | 28,400 | 1,920 | 1,900 | 42,055 | 43,040 | 23,502 | 60,200 | 0 | 0 | 37,936 | 44,380 |
| 2 | 0 | 0 | 0 | 0 | 1,351 | 16,570 | 0 | 6,180 | 0 | 0 | 14,104 | 14,100 |
| 3 | 40 | 0 | 715 | 700 | 59,073 | 101,990 | 22,902 | 76,490 | 0 | 0 | 93,898 | 93,900 |
| 4 | 0 | 0 | 0 | 0 | 0 | 13,570 | 0 | 4,790 | 0 | 0 | 228,493 | 228,490 |
| 5 | 0 | 0 | 0 | 0 | 176,170 | 250,400 | 34,783 | 171,290 | 0 | 0 | 14,082 | 14,080 |
| 6 | 0 | 0 | 0 | 0 | 0 | 9,240 | 0 | 3,010 | 0 | 0 | 0 | 10,870 |
| 7 | 0 | 0 | 0 | 0 | 33,844 | 59,260 | 0 | 23,950 | 0 | 0 | 140,161 | 140,160 |
| 8 | 0 | 0 | 0 | 0 | 4,311 | 30,250 | 14,060 | 30,340 | 0 | 0 | 164,884 | 164,900 |
| 9 | 407 | 400 | 8,146 | 8,100 | 52,043 | 130,330 | 37,886 | 107,930 | 0 | 0 | 39,977 | 39,980 |
| 10 | 0 | 0 | 0 | 0 | 0 | 9,240 | 0 | 2,830 | 0 | 0 | 11,772 | 11,770 |
| 11 | 0 | 0 | 0 | 0 | 7,565 | 16,990 | 841 | 7,060 | 0 | 0 | 138,945 | 143,100 |
| 12 | 3,000 | 3,000 | 1,788 | 1,800 | 85,155 | 139,170 | 52,128 | 136,110 | 0 | 0 | 138,547 | 138,550 |
| 13 | 10,170 | 10,200 | 0 | 0 | 116,981 | 251,770 | 114,737 | 268,310 | 0 | 0 | 204,416 | 204,420 |
| 14 | 0 | 0 | 0 | 0 | 500 | 10,200 | 0 | 3,190 | 0 | 0 | 36,830 | 36,830 |
| 15 | 0 | 0 | 2,456 | 2,500 | 38,662 | 73,900 | 37,451 | 81,300 | 0 | 0 | 4,950 | 4,950 |
| 16 | 0 | 0 | 0 | 0 | 53,384 | 84,320 | 18,843 | 59,160 | 0 | 0 | 45,792 | 45,790 |
| 17 | 0 | 0 | 0 | 0 | 32,522 | 103,090 | 0 | 36,180 | 77,850 | 629,470 | 39,213 | 47,380 |
| 18 | 1,175 | 1,200 | 1,422 | 1,400 | 58,521 | 148,980 | 86,351 | 165,260 | 463,336 | 1,672,630 | 109,982 | 109,980 |
| 19 | 3,742 | 3,700 | 330 | 300 | 345,459 | 752,130 | 372,170 | 856,960 | 3,651,905 | 6,463,510 | 255,193 | 255,190 |
| 20 | 1,097 | 1,100 | 5,731 | 5,700 | 287,148 | 716,660 | 414,294 | 801,240 | 461,441 | 1,816,650 | 75,260 | 75,260 |
| 21 | 29,397 | 29,400 | 19,397 | 19,400 | 109,759 | 206,430 | 57,992 | 186,580 | 0 | 0 | 179,421 | 184,600 |
| 22 | 0 | 0 | 0 | 0 | 0 | 12,360 | 0 | 3,860 | 0 | 0 | 138,799 | 138,800 |
| 23 | 5,568 | 5,600 | 28,979 | 29,000 | 41,150 | 106,940 | 38,797 | 99,010 | 0 | 0 | 84,031 | 84,030 |
| 24 | 13,739 | 13,700 | 9,727 | 9,700 | 47,672 | 189,560 | 44,443 | 124,570 | 0 | 0 | 29,279 | 29,280 |
| 25 | 44,078 | 44,100 | 2,654 | 2,700 | 92,586 | 146,970 | 37,640 | 110,680 | 0 | 0 | 489,306 | 489,310 |
| 26 | 12,412 | 12,400 | 62,636 | 62,600 | 269,536 | 384,210 | 178,542 | 446,030 | 0 | 0 | 226,033 | 226,050 |
| 27 | 2,116 | 2,100 | 888 | 900 | 30,434 | 75,480 | 6,768 | 38,850 | 0 | 0 | 2,111,097 | 2,225,860 |
| 28 | 0 | 0 | 0 | 0 | 0 | 15,350 | 0 | 5,030 | 0 | 0 | 192,036 | 192,040 |
| 29 | 0 | 0 | 0 | 0 | 36,771 | 57,490 | 9,488 | 38,570 | 0 | 0 | 20,586 | 20,650 |
| 30 | 0 | 0 | 0 | 0 | 17,346 | 34,420 | 3,946 | 20,110 | 0 | 0 | 54,195 | 54,220 |
| 31 | 0 | 0 | 0 | 0 | 0 | 9,390 | 3,100 | 7,910 | 0 | 0 | 45,382 | 45,380 |
| 32 | 0 | 0 | 0 | 0 | 0 | 10,330 | 0 | 3,900 | 0 | 0 | 0 | 0 |
| 33 | 0 | 0 | 0 | 0 | 0 | 9,240 | 0 | 3,480 | 0 | 0 | 148,150 | 148,160 |
| 34 | 0 | 0 | 1,236 | 1,200 | 6,075 | 22,370 | 4,898 | 14,750 | 0 | 0 | 223,074 | 223,070 |
| 35 | 61,060 | 61,100 | 46,595 | 46,600 | 411,326 | 720,720 | 311,076 | 742,770 | 0 | 0 | 669,355 | 721,140 |
| 36 | 277,068 | 277,100 | 132,879 | 142,320 | 533,458 | 896,810 | 446,313 | 1,042,590 | 0 | 0 | 137,295 | 137,290 |
| 37 | 149,276 | 149,300 | 867,490 | 867,500 | 1,545,839 | 3,706,310 | 691,013 | 3,191,810 | 0 | 0 | 558,831 | 564,010 |
| 38 | 791,637 | 793,340 | 1,311,258 | 1,313,950 | 605,736 | 1,067,060 | 637,154 | 2,099,980 | 11,594 | 120,660 | 220,223 | 277,180 |
| 39 | 136,840 | 136,800 | 674,551 | 674,600 | 210,540 | 366,110 | 335,520 | 1,015,110 | 0 | 0 | 1,050,575 | 1,133,430 |
| 40 | 44,377 | 44,400 | 560,791 | 560,800 | 870,871 | 2,232,300 | 2,156,297 | 3,849,030 | 96,560 | 96,600 | 373,687 | 391,810 |
| 41 | 164,346 | 164,300 | 36,553 | 36,600 | 145,508 | 331,540 | 259,979 | 511,610 | 2,960 | 248,650 | 766,393 | 805,230 |
| 42 | 533 | 500 | 0 | 0 | 86,549 | 133,250 | 101,879 | 210,440 | 0 | 0 | 218,426 | 218,430 |
| 43 | 0 | 0 | 1,056 | 1,100 | 54,430 | 81,450 | 19,912 | 66,170 | 5,314 | 250,440 | 336,675 | 341,860 |
| 44 | 82,065 | 82,100 | 0 | 0 | 11,748 | 23,430 | 344 | 10,240 | 0 | 0 | 55,874 | 55,890 |
| 45 | 0 | 0 | 0 | 0 | 17,215 | 29,680 | 0 | 13,680 | 0 | 0 | 106,896 | 106,900 |
| 46 | 0 | 0 | 0 | 0 | 1,084 | 13,260 | 0 | 5,150 | 0 | 0 | 43,889 | 43,890 |
| 47 | 0 | 0 | 0 | 0 | 0 | 9,240 | 0 | 3,130 | 0 | 0 | 106,384 | 106,840 |
| 48 | 23,467 | 23,500 | 0 | 0 | 64,978 | 129,940 | 53,346 | 153,000 | 0 | 0 | 871,515 | 881,870 |
| 49 | 2,420 | 2,400 | 807 | 800 | 34,593 | 69,760 | 7,123 | 39,380 | 0 | 0 | 177,330 | 177,330 |
| 50 | 7,066 | 7,100 | 1,897 | 1,900 | 51,108 | 72,440 | 21,474 | 55,730 | 0 | 0 | 201,033 | 201,070 |
| 51 | 360 | 400 | 28,294 | 28,300 | 18,266 | 48,440 | 56,380 | 130,900 | 0 | 0 | 40,815 | 40,810 |
| 52 | 67,505 | 67,500 | 185,221 | 185,200 | 401,128 | 665,200 | 395,469 | 875,940 | 36,680 | 20,690 | 22,048 | 22,050 |
| 53 | 4,312 | 4,300 | 43,345 | 43,300 | 136,528 | 183,150 | 130,660 | 295,650 | 20,826 | 134,600 | 125,686 | 125,690 |
| 54 | 0 | 0 | 0 | 0 | 9,820 | 26,930 | 2,439 | 13,460 | 0 | 0 | 19,800 | 19,800 |
| 55 | 850 | 900 | 3,980 | 4,000 | 12,384 | 29,290 | 23,699 | 48,670 | 0 | 0 | 58,920 | 58,920 |
| 56 | 6,173 | 6,200 | 22,646 | 22,600 | 86,682 | 163,450 | 34,385 | 131,480 | 0 | 0 | 507,125 | 513,510 |
| 57 | 2,512,584 | 2,513,490 | 1,231,408 | 1,307,170 | 429,945 | 755,180 | 137,456 | 1,133,260 | 8,634 | 90,310 | 237,985 | 241,650 |
| 58 | 488,067 | 488,430 | 3,152 | 99,120 | 39,639 | 92,140 | 24,581 | 104,640 | 0 | 0 | 194,823 | 194,820 |
| 59 | 478,916 | 481,630 | 728,862 | 1,020,960 | 253,673 | 331,270 | 113,335 | 896,220 | 0 | 0 | 159,724 | 163,870 |
| 60 | 99,043 | 99,230 | 150,590 | 331,840 | 171,911 | 274,580 | 91,067 | 374,610 | 0 | 0 | 29,469 | 29,470 |
| 61 | 4,060 | 4,100 | 1,068 | 1,100 | 53,229 | 77,030 | 25,017 | 78,400 | 0 | 0 | 71,248 | 71,260 |
| 62 | 0 | 0 | 1,020 | 1,000 | 40,960 | 63,830 | 24,544 | 62,790 | 0 | 0 | 90,196 | 90,200 |
| 63 | 3,116 | 3,100 | 0 | 0 | 35,702 | 89,200 | 0 | 35,450 | 0 | 0 | 135,401 | 140,580 |
| 64 | 0 | 0 | 2,276 | 2,300 | 12,308 | 35,410 | 6,407 | 25,620 | 0 | 0 | 38,212 | 38,210 |
| 65 | 3,536 | 3,500 | 0 | 0 | 3,551 | 14,240 | 1,800 | 8,600 | 0 | 0 | 97,611 | 97,610 |
| 66 | 0 | 0 | 0 | 0 | 0 | 88,660 | 0 | 42,360 | 0 | 0 | 0 | 0 |
| 67 | 0 | 0 | 0 | 0 | 0 | 11,220 | 0 | 4,540 | 0 | 0 | 34,073 | 34,070 |
| 68 | 112,314 | 113,490 | 798,687 | 889,590 | 231,444 | 292,160 | 91,280 | 724,030 | 0 | 0 | 4,000 | 4,000 |
| 69 | 0 | 0 | 0 | 0 | 16,985 | 42,160 | 10,000 | 36,790 | 0 | 0 | 0 | 0 |
| 70 | 400 | 400 | 0 | 0 | 59,544 | 110,570 | 11,202 | 88,170 | 0 | 0 | 116,776 | 116,780 |
| 71 | 0 | 0 | 0 | 0 | 0 | 11,690 | 0 | 5,370 | 0 | 0 | 64,727 | 64,730 |
| 72 | 125,933 | 132,980 | 577,639 | 649,630 | 292,755 | 510,830 | 313,980 | 1,385,940 | 35,424 | 462,450 | 174,045 | 180,920 |
| 73 | 0 | 0 | 0 | 0 | 0 | 14,150 | 0 | 6,460 | 0 | 0 | 0 | 0 |
| 74 | 0 | 0 | 1,728 | 1,700 | 4,207 | 18,430 | 1,120 | 10,800 | 0 | 0 | 83,250 | 88,430 |
| 75 | 950 | 1,000 | 48,485 | 48,500 | 3,675 | 17,440 | 0 | 44,580 | 0 | 0 | 61,400 | 62,130 |
| 76 | 0 | 0 | 7,500 | 7,500 | 9,540 | 18,740 | 2,320 | 15,130 | 0 | 0 | 50,780 | 50,780 |
| 77 | 198,790 | 199,080 | 1,552 | 2,180 | 62,833 | 111,370 | 18,801 | 87,870 | 0 | 0 | 326,904 | 334,670 |
| 78 | 37,990 | 41,390 | 56,971 | 62,260 | 48,658 | 113,660 | 45,414 | 171,180 | 0 | 0 | 13,781 | 14,420 |
| 79 | 0 | 0 | 0 | 0 | 0 | 9,240 | 0 | 3,680 | 0 | 0 | 194,973 | 194,970 |
| 80 | 0 | 1,030 | 11,541 | 13,440 | 140,235 | 187,170 | 37,447 | 161,900 | 0 | 0 | 388,240 | 404,340 |
| 81 | 0 | 4,200 | 0 | 1,630 | 0 | 10,510 | 0 | 5,720 | 0 | 0 | 0 | 0 |
| 82 | 0 | 0 | 0 | 0 | 0 | 9,240 | 0 | 6,600 | 0 | 0 | 0 | 50 |
| 83 | 0 | 0 | 0 | 0 | 0 | 9,550 | 0 | 3,550 | 0 | 0 | 103,400 | 103,400 |
| 84 | 0 | 0 | 440 | 400 | 76,250 | 131,460 | 50,660 | 150,440 | 0 | 0 | 95,158 | 104,380 |
| 85 | 0 | 0 | 0 | 0 | 0 | 13,610 | 3,500 | 14,300 | 0 | 0 | 0 | 0 |
| 86 | 384,541 | 2,135,640 | 299,950 | 1,903,140 | 50,374 | 90,930 | 47,429 | 961,480 | 0 | 0 | 132,518 | 138,190 |
| 87 | 5,432 | 10,370 | 23,168 | 31,940 | 188,725 | 409,990 | 100,515 | 361,200 | 0 | 0 | 256,022 | 259,920 |
| 88 | 286,671 | 286,700 | 0 | 0 | 10,049 | 34,640 | 2,132 | 19,930 | 0 | 0 | 41,366 | 41,370 |
| 89 | 0 | 79,020 | 6,079 | 55,750 | 67,066 | 102,460 | 22,129 | 130,380 | 0 | 0 | 82,500 | 125,640 |
| 90 | 0 | 0 | 0 | 0 | 0 | 9,240 | 0 | 6,400 | 0 | 0 | 145,910 | 145,910 |
| 91 | 1,024 | 1,000 | 10,000 | 10,000 | 16,633 | 36,730 | 100 | 25,200 | 0 | 0 | 24,609 | 24,690 |
| 92 | 0 | 0 | 0 | 0 | 0 | 12,870 | 1,000 | 5,380 | 0 | 0 | 249,002 | 254,400 |
| 93 | 3,398 | 3,690 | 45,608 | 45,880 | 208,048 | 375,040 | 151,769 | 375,020 | 0 | 0 | 93,922 | 98,100 |
| 94 | 1,200 | 1,200 | 1,191 | 1,200 | 88,075 | 131,230 | 88,338 | 182,160 | 0 | 0 | 82,896 | 82,900 |
| 95 | 0 | 0 | 0 | 0 | 0 | 27,040 | 0 | 11,320 | 0 | 0 | 47,938 | 47,940 |
| 96 | 74,333 | 124,360 | 4,674 | 22,280 | 42,756 | 69,270 | 15,701 | 75,860 | 0 | 0 | 166,319 | 178,830 |
| 97 | 28,917 | 45,700 | 3,756 | 9,160 | 67,768 | 108,960 | 25,649 | 100,720 | 0 | 0 | 214,411 | 234,300 |
| 98 | 0 | 0 | 1,176 | 1,200 | 20,241 | 69,620 | 2,000 | 34,920 | 0 | 0 | 32,798 | 33,410 |
| 99 | 187,959 | 190,540 | 8,010 | 8,910 | 84,192 | 125,920 | 36,823 | 144,110 | 0 | 0 | 240,221 | 250,460 |
| 100 | 0 | 6,790 | 12,174 | 14,890 | 56,234 | 79,970 | 9,924 | 112,100 | 0 | 0 | 22,502 | 23,080 |
| 101 | 0 | 9,470 | 7,884 | 11,130 | 15,804 | 34,780 | 9,286 | 38,340 | 2,829 | 0 | 135,634 | 139,540 |
| 102 | 700 | 700 | 12,460 | 12,500 | 38,133 | 57,240 | 4,834 | 40,560 | 0 | 0 | 986,340 | 993,080 |
| 103 | 3,060 | 6,200 | 1,230 | 2,350 | 35,920 | 54,700 | 300 | 29,660 | 0 | 0 | 113,670 | 131,470 |
| 104 | 0 | 0 | 0 | 0 | 0 | 9,240 | 0 | 3,030 | 0 | 0 | 367,035 | 367,450 |
| 105 | 2,302 | 3,200 | 8,956 | 9,630 | 95,662 | 184,180 | 59,157 | 166,840 | 0 | 0 | 219,148 | 234,680 |
| 106 | 12,666 | 12,870 | 15,930 | 16,100 | 104,920 | 158,700 | 33,787 | 135,440 | 0 | 0 | 165,573 | 165,610 |
| 107 | 0 | 0 | 0 | 0 | 1,025 | 16,160 | 0 | 5,630 | 0 | 0 | 9,890 | 9,890 |
| 108 | 0 | 0 | 0 | 0 | 0 | 11,700 | 0 | 4,210 | 0 | 0 | 0 | 0 |
| 109 | 1,800 | 1,800 | 6,035 | 6,000 | 129,016 | 211,000 | 119,682 | 278,190 | 0 | 0 | 178,700 | 184,460 |
| 110 | 18,462 | 18,500 | 0 | 0 | 992 | 13,880 | 4,024 | 13,590 | 0 | 0 | 205,150 | 235,520 |
| 111 | 17,611 | 18,680 | 27,695 | 28,440 | 284,304 | 636,950 | 90,686 | 434,910 | 0 | 0 | 429,424 | 437,830 |
| 112 | 0 | 0 | 0 | 0 | 16,390 | 29,050 | 820 | 20,100 | 124,000 | 1,386,480 | 56,896 | 56,900 |
| 113 | 9,026 | 9,000 | 3,300 | 3,300 | 21,110 | 37,100 | 10,060 | 37,370 | 1,664 | 167,510 | 57,318 | 58,610 |
| TOTAL | 7,079,481 | 9,029,020 | 8,187,583 | 10,711,590 | 10,986,345 | 21,844,730 | 9,146,100 | 27,954,080 | 5,001,017 | 13,560,650 | 19,928,487 | 20,610,400 |



AR00031684

City and County of Honolulu, Hawaii 96813

HI
TORU

~~Preliminary~~

# OAHU TRANSPORTATION STUDY

1967

## Volume II

*mass transportation*
*transportation facilities*
*travel patterns, volumes & forecasts*

HI 112.1
(c.2)

AR00031686

*The preparation of this document was financially aided through a Federal Grant from the Department of Housing and Urban Development, under the Urban Planning Assistance Program authorized by Section 701 of the Housing Act of 1954, as amended, and by Federal Aid Highway Planning and Research funds authorized by the Bureau of Public Roads of the Department of Transportation and the Division of Highways, Hawaii Department of Transportation.*

AR00031687

Mass Transit Library Copy

# OAHU TRANSPORTATION STUDY

VOLUME II

MASS TRANSPORTATION
TRANSPORTATION FACILITIES
TRAVEL PATTERNS, VOLUMES & FORECASTS

1967

*Sponsoring Agencies*

STATE OF HAWAII
*John A. Burns, Governor*

CITY AND COUNTY OF HONOLULU
*Neal S. Blaisdell, Mayor*

*In Cooperation With*

U. S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
*Robert C. Weaver, Secretary*

U. S. DEPARTMENT OF TRANSPORTATION
*Francis C. Turner, Director*

AR00031688

# STUDY ORGANIZATION

## POLICY COMMITTEE

### *Executive Members*

SHELLEY M. MARK, *Chairman and Project Administrator*
*Director of Planning and Economic Development* ..... State of Hawaii

FUJIO MATSUDA
*Director of Transportation* ..... State of Hawaii

FRANK SKRIVANEK
*Director of Planning* ..... City and County of Honolulu

HENRY TUCK AU
*Director of Traffic* ..... City and County of Honolulu

### *Members*

GEORGE S. IZUTA
*Area Coordinator* ..... Department of Housing and Urban Development

JOHN N. STORRS
*Engineering Coordinator* ..... Bureau of Public Roads



AR00031689

## *TECHNICAL ADVISORY COMMITTEE*

GEORGE MORIGUCHI
*Planning Coordinator* ..... State of Hawaii

ALBERT C. ZANE
*Chief Engineer* ..... Hawaii Highways Division

OWEN MIYAMOTO
*Airports Engineer* ..... Hawaii Airports Division

RICHARD IMAHIRO
*Community Social Planning Coordinator* ..... State Public Welfare Division

WILLIAM HONG
*Deputy Traffic Engineer* ..... City Traffic Department

JAMES TANAKA
*City Planner* ..... City Planning Department

PHILIP D. BROWN
*Project Director* ..... City Community Renewal Program

PHILIP CHOY
*Chief Planner, Urban Renewal* ..... Honolulu Redevelopment Agency

GEORGE IZUTA
*Area Coordinator* ..... Department of Housing and Urban Development

JOHN N. STORRS
*Engineering Coordinator* ..... Bureau of Public Roads

RICHARD T. PUCKEY
*Chief, Airports Division* ..... Federal Aviation Agency



AR00031690

## CITIZEN ADVISORY COMMITTEE

### *Executive*

**CHAIRMAN**

FRANKLIN Y. K. SUNN (1965)
*President of Sunn, Low, Tom & Hara*
*Representing American Society of Civil Engineers, Hawaii*

OTTO ORENSTEIN (1966)
*Business Research Analyst*
*Hawaiian Telephone Company*
*Representing American Statistical Association, Hawaii*

NATHANIEL R. POTTER, JR. (1967)
*Secretary-Treasurer/Sales Manager*
*Hawaiian Cement Corporation*
*Representing Hawaii Manufacturers Association*

**VICE-CHAIRMEN**

CLYDE KIMBALL JACOBSEN (1965-1967)
*Editor, Hawaii Business & Industry*
*Representing Chamber of Commerce of Honolulu, Highway & Transportation Subcommittee*

**SECRETARY**

KENJI ONODERA (1965)
*Vice President of Roehrig, Onodera, & Kinder*
*Representing American Institute of Architects*

JANE SILVERMAN (1966)
*Park Historian, State Department of Land and Natural Resources*
*Representing Hawaii Library Association*

LUCILLE CREPS (1967)
*Representing The Outdoor Circle*

### *Chairmen of Standing Committees*

**Subcommittee on Population, Economics, and Land Use**

OTTO ORENSTEIN
*Business Research Analyst*
*Hawaiian Telephone Company*

**Subcommittee on Mass Transit**

AARON LEVINE
*Executive Vice President*
*Oahu Development Conference*

**Subcommittee on Transportation Planning Objectives**

DON HOUSE
*Vice-President & Secretary*
*Oahu Transport Company*

**Subcommittee on Highways**

GORDON BRADLEY
*Vice President*
*Bradley & Wong*



AR00031691

## KEY STUDY STAFF

AH LEONG KAM
*Project Director*

DAVID S. KAWASAKI
*Trip Distribution and Traffic Assignment*

JAMES S. TANAKA
*Land Use*

DR. ROBERT W. RIDER
*Economics*

ROBERT C. SCHMITT
*Population*

RICHARD K. Y. TONG
*Data Processing*

## SPECIAL CONSULTING SERVICES

DR. ROLAND A. ARTLE
*Chairman*
*Department of Economics*
*University of Gothenburg*
*Gothenburg, Sweden*

DR. RONALD S. GRAYBEAL
*Assistant Professor*
*Center for Real Estate and Urban Economics*
*University of California, Berkeley*

MODAL SPLIT AND TRANSIT ANALYSIS

DANIEL, MANN, JOHNSON AND MENDENHALL

ALAN M. VOORHEES & ASSOCIATES

## SPECIAL EXPERT ADVISORY SERVICES

DR. J. DOUGLAS CARROLL, JR.

ROGER L. CREIGHTON

JOHN R. HAMBURG

DAVID K. WITHEFORD



AR00031692

# ACKNOWLEDGMENTS

To list every individual and organization who contributed to the progress of the Oahu Transportation Study would be a formidable undertaking. Splendid cooperation was given at all levels--from the heads of governments sponsoring the study to the people and business firms of the Metropolitan Area of Honolulu.

Special acknowledgment is extended to D. L. Pollard, Director, Planning Branch, Programs Coordination and Services Office, Department of Housing and Urban Development; to C. H. Spamer, Regional Planning & Research Engineer, Bureau of Public Roads; and to J. B. Dalhouse, Division Engineer, Bureau of Public Roads, for their support and encouragement to the study staff. In addition, technical assistance above and beyond financial support was received from personnel of the Highways Division, Department of Transportation; the Economic and Planning Division, Department of Planning and Economic Development; and the Planning and Traffic Departments of the City and County of Honolulu.

The study employees merit particular praise. They displayed an unusual degree of willingness and devotion throughout the very demanding tasks involved in data collecting, coding, processing, and analyzing, and in the other tasks necessary for a complete and accurate report.

Finally, warm thanks are extended to members of the Citizen Advisory Committee, who spent many hours of their own in attaining the ultimate goal of genuine citizen participation in the decision-making process.

To all, the Policy Committee of the Oahu Transportation Study wishes to express its grateful appreciation.



AR00031693

## NOTES ABOUT THIS REPORT

This volume is the second of a series of three volumes which are being issued to provide information about the purpose, the design, the estimates, and the recommendations of the Oahu Transportation Study.

Transportation facilities, including mass transportation, travel patterns and forecasts, terminal facilities, etc., are discussed in this publication. In Volume I, the transportation planning process and the inventory, assumptions, and forecasts of socio-economic and land-use data are discussed. The transportation goals, objectives and restraints, the tests and evaluations, and the recommended transportation plans will be discussed in Volume III.

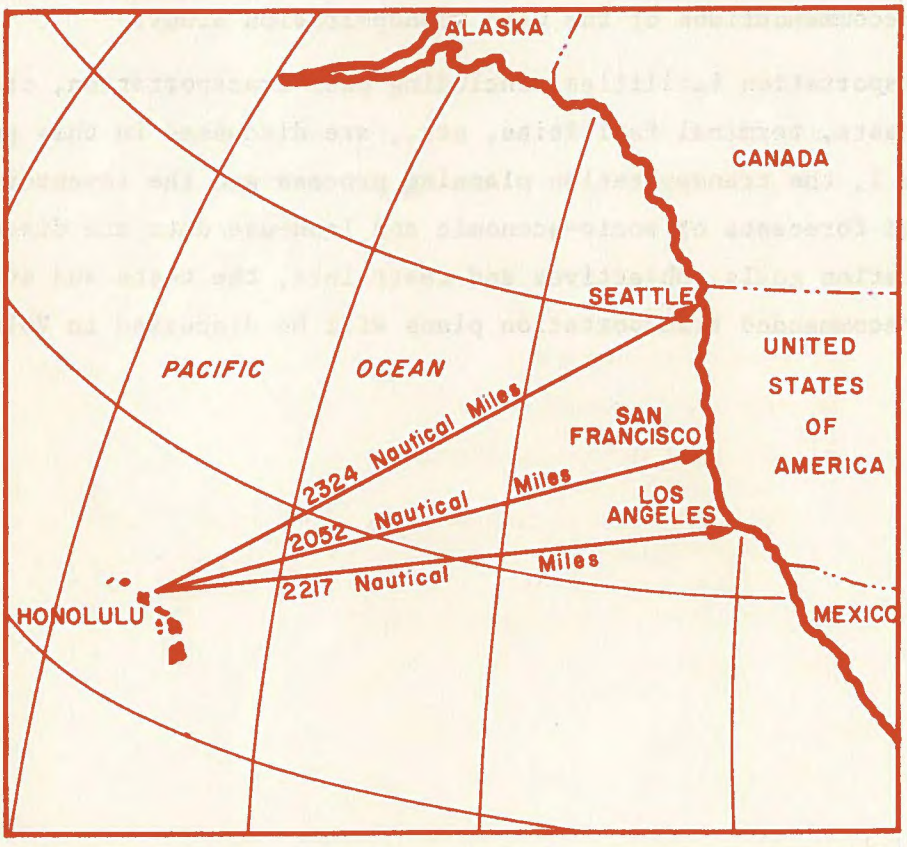




AR00031694

# GEOGRAPHICAL LOCATION OF THE STUDY AREA

The State of Hawaii, the 50th and newest state in the Union, is separated from her nearest sister state by more than 2,000 miles of ocean. It is the most remote of the world's civilized land. Within the State lies the Island of Oahu, known as the Standard Metropolitan Statistical Area of Honolulu, in which the City of Honolulu is located.






AR00031695

VOLUME II

MASS TRANSPORTATION
TRANSPORTATION FACILITIES
TRAVEL PATTERNS, VOLUMES & FORECASTS

*Contents*


| Chapter | | Page |
|---|---|---|
| V. | ACCIDENT STUDY | V- 1 |
| | A. Introduction | 1 |
| | B. Traffic Accidents | 1 |
| | C. Traffic-Accident Rates | 2 |
| | D. Traffic-Accident Costs | 5 |
| | E. Age Groups of Drivers Involved in Traffic Accidents | 6 |
| | F. Motorcycle and Motorscooter Accidents | 7 |
| | G. Intersection Accidents | 8 |
| | Appendix | |
| V-A. | Tables Concerning Number of Accidents | V- A |
| VI. | LOCAL-TRANSIT STUDY | VI- 1 |
| | A. Introduction | 1 |
| | B. Equipment Inventory | 3 |
| | C. Routes and Coverage | 3 |
| | D. Operational Data and Trends | 7 |
| | 1. Schedule Speeds | 7 |
| | 2. Miles Operated per Revenue Passenger | 7 |
| | 3. Fare Structure | 9 |
| | 4. Patronage Trends | 10 |
| | 5. Operating Revenue and Expense | 11 |
| | E. School-Bus Transit | 13 |
| | Appendix | |
| VI-A. | HRT Routes and Headways | VI- A |
| VII. | AUTOMOBILE OWNERSHIP STUDY | VII- 1 |
| | A. Introduction | 1 |




AR00031696

| Chapter | | | Page |
|---|---|---|---|
| VII. | B. | Brief History | VII- 1 |
| | C. | Motor-Vehicle Registration | 2 |
| | D. | Car Ownership | 3 |
| | E. | Car Usage | 5 |
| | F. | Forecast of Car Ownership | 6 |
| | | 1. Forecast Equations | 6 |
| | | 2. Special Tracts | 8 |
| | | 3. 1985 Car Ownership | 8 |
| | | 4. Saturation Indicators | 13 |
| | Appendix | | |
| VII-A. | | Tables Concerning Car-Ownership Forecast | VII- A |
| VIII. | | TRAVEL PATTERNS & VOLUMES | VIII- 1 |
| | A. | Introduction | 1 |
| | B. | Monthly Traffic Variations | 2 |
| | C. | Daily Traffic Variations | 3 |
| | D. | Directional Distribution of Peak-Hour Traffic | 5 |
| | E. | Traffic-Flow Maps | 6 |
| IX. | | ORIGIN-DESTINATION TRAFFIC STUDY | IX- 1 |
| | A. | Introduction | 1 |
| | B. | Internal Survey | 1 |
| | | 1. Dwelling-Unit Survey | 2 |
| | | 2. Truck and Taxi Survey | 3 |
| | | 3. U-Drive Vehicle Survey | 5 |
| | C. | Mode of Travel | 5 |
| | D. | Trip Purpose and Land Use | 6 |
| | E. | Home-Based Travel | 9 |
| | F. | Automobile Occupancy | 9 |
| | G. | Trip Length | 11 |
| | H. | Trip Generation | 13 |
| | | 1. Development of Person-Trip Production and Attraction Equations | 13 |
| | | 2. Development of Commercail-Trip Production and Attraction Equations | 16 |
| | | 3. Person-Trip Forecasts | 17 |
| | | 4. Truck-Trip Forecast | 21 |




AR00031697

| Chapter | | | Page |
|---|---|---|---|
| IX. | I. | Trip-Distribution Analyses | IX-22 |
| | | 1. Present Use of the Gravity Model | 23 |
| | | 2. Person- and Commercial-Trip Distributions in 1985 | 25 |
| | J. | Trips by Mode of Travel | 28 |
| | | 1. Mass Transit Riders | 28 |
| | | 2. Equivalent Automobile Trips | 30 |
| | Appendix | | |
| | IX-A. | Trip Production and Attraction | IX-A |
| | | 1. Introduction | A-1 |
| | | 2. Linking 1960 O-D Trip Records | A-4 |
| | | 3. Definitions of Trip Production and Trip Attraction | A-6 |
| | IX-B. | Trip Generation Equations and Trip End Estimates | IX-B |
| | IX-C. | Calibration of the Gravity Model | IX-C |
| | | 1. Spatial Separation Between Zones | C-1 |
| | | 2. Intrazonal Travel Time | C-4 |
| | | 3. Terminal Time | C-8 |
| | | 4. Person-Trip-Model Calibrations | C-8 |
| | | 5. Commercial Trip Model Calibration | C-16 |
| | IX-D. | Future Transit Usage | IX-D |
| | | 1. Introduction | D-1 |
| | | 2. Factors Influencing Transit Usage | D-1 |
| | | 3. Development of Modal-Split Model | D-2 |
| | | 4. Final Modal-Split Relationships | D-10 |
| | | 5. Home-Based School and Non-Home-Based Trips | D-10 |
| | | 6. Forecasting of Future Transit Usage | D-15 |
| | | 7. Assumed Highway and Transit Improvements in Relation to Future Transit Use | D-15 |
| | | 8. Other Factors Related to Estimating Future Modal Split | D-19 |
| | | 9. Analysis and Interpretation of Transit-Use Estimates | D-19 |
| X. | | TERMINAL FACILITIES | X- 1 |
| | A. | Parking in Downtown Honolulu | 1 |
| | | 1. Present Facilities | 1 |
| | | 2. Future Parking Demand | 7 |
| | B. | Honolulu International Airport | 10 |
| | | 1. Introduction | 10 |
| | | 2. Factors Contributing to Expansion | 11 |
| | | 3. Preliminary Estimates of Arrivals | 14 |
| | | 4. Passenger Movements | 16 |
| | | 5. Airport Transfer | 18 |




AR00031698

Chapter | Page

X. 6. Existing Parking and Access Volumes . . . . . X-23
7. Future Studies . . . . . 23
C. Honolulu Stadium . . . . . 24
1. Seating Statistics . . . . . 25
2. Parking Requirements . . . . . 25
3. Access Standards . . . . . 26
4. Future Studies . . . . . 27

## *Tables*

Table

V. Accident Study

5.1 Record of traffic accidents on Oahu . . . . . V- 1
.2 Percent of major accidents by day of week on Oahu . . . 2
.3 Guiding traffic-accident rates per 100-million-vehicle miles by street type . . . . . 3
.4 Traffic-accident rates per 100-million vehicle miles on Oahu . . . . . 4
.5 Personal and economic losses resulting from traffic-accident injuries on Oahu . . . . . 6
.6 Motor-vehicle-accident cost per vehicle mile on Oahu . . 6
.7 Percent of drivers by age group involved in automobile accidents on Oahu . . . . . 7
.8 Accidents involving motorcycle or motorscooter on Oahu . 8
.9 Percent of intersection and non-intersection motor-vehicle accidents . . . . . 9
5.A1 Number of accidents on roads and streets on Oahu . . . V-A-1
.A2 Intersections having more than 20 accidents a year for three or more years, 1961-1966 on Oahu . . A-2
.A3 Intersections having 10 to 19 accidents a year for three or more years, 1961-1966 on Oahu . . . . A-2
.A4 Intersections having 5 to 9 accidents for any one year, 1961-1966 on Oahu . . . . . A-4



AR00031699

| Table | | Page |
|---|---|---|
| | VI. Local-Transit Study | |
| 6.1 | Comparison of transit equipment and patronage on Oahu in 1960 | VI- 2 |
| .2 | Equipment inventory for HRT in 1966 | 4 |
| .3 | Line speeds on HRT routes | 7 |
| 6.A1 | Existing HRT routes and average headways | VI-A-1 |
| | VII. Automobile Ownership Study | |
| 7.1 | Motor vehicle registrations on Oahu | VII- 2 |
| .2 | Person trips by mode of travel on Oahu in 1960 | 5 |
| .3 | Past and projected car ownership statistics by grouped census tracts on Oahu, 1960 and 1985 | 8 |
| 7.A1 | Car-ownership forecast by census tract | VII-A-1 |
| .A2 | 1985 car-ownership forecast by equivalent origin-destination zones | A-3 |
| | IX. Origin-Destination Traffic Study | |
| 9.1 | Summary of dwelling-unit sample-selection activity on Oahu in 1960 | IX- 3 |
| .2 | Summary of dwelling-unit interviewing activity on Oahu in 1960 | 3 |
| .3 | Summary of truck and taxi sample-selection activity on Oahu in 1960 | 4 |
| .4 | Summary of truck and taxi interviewing activity on Oahu in 1960 | 4 |
| .5 | Person-trip summary on Oahu in 1960 | 6 |
| .6 | Percent trip purpose by mode of travel on Oahu in 1960 | 6 |
| .7 | Automobile occupancy by purpose of trip on Oahu in 1960 | 11 |
| .8 | Independent variables considered in the development of trip-generating equations | 15 |
| .9 | Initial estimates of production and attraction person trips in 1985 by purpose | 18 |
| .10 | Adjusted home-based production person trips and trip attraction adjustment factors in 1985 | 19 |
| .11 | Estimate of non-home-based person trips in 1985 | 19 |
| .12 | Summary of person trips on Oahu in 1960 and 1985, by purpose | 20 |




AR00031700

| Table | | Page |
|---|---|---|
| 9.13 | Summary of results of gravity model application to 1985 trip ends | IX-25 |
| .14 | Comparison of trip lengths between 1960 observed and simulated, and 1985 travel | 27 |
| .15 | Summary of 1960 observed and 1985 estimated transit riders | 31 |
| 9.A1 | Expanded 1960 O-D person trips by modes | IX-A-5 |
| .A2 | Comparison of person trips by mode of travel after linking | A-6 |
| 9.B1 | 1985 production and attraction person trips | IX-B-3 |
| .B2 | 1985 production and attraction commercial trips | B-8 |
| 9.C1 | Intra-zonal driving time (minutes) | IX-C-7 |
| .C2 | Zonal terminal time (minutes) | C-9 |
| .C3 | Comparison of 1960 observed and simulated volumes at Manana and Trans-Koolau screenlines | C-10 |
| .C4 | Comparison of person hours of travel between 1960 observed and simulated trip distributions | C-12 |
| .C5 | Summary of network time penalties in the person-trip gravity models | C-12 |
| .C6 | Travel time factors person trip purposes | C-14 |
| .C7 | Summary of vehicle hours of travel and average trip length between 1960 observed and simulated commercial-trip distribution | C-17 |
| .C8 | Summary of network time penalties commercial-trip gravity model | C-18 |
| .C9 | Travel time factors commercial trips | C-18 |
| 9.D1 | Person trips by travel mode and trip purpose on Oahu in 1960 | IX-D-3 |
| .D2 | Trip categories for modal-split analysis of 1960 linked O-D trips | D-3 |
| .D3 | Percent of total work trips by transit, stratified by parking cost, auto ownership, travel time difference | D-5 |
| .D4 | Typical present and future transit travel times to downtown Honolulu | D-18 |
| .D5 | Comparison of 1960 observed and 1985 estimated transit and total trips by purpose | D-20 |
| .D6 | Comparison of transit usage in Honolulu and other cities | D-22 |




AR00031701

| Table | | Page |
|---|---|---|
| 9.D7 | Comparison of travel to or from the CBD in various cities | IX-D-23 |
| .D8 | Comparison of average trip times by components of total trip--system no. 1 vs. system no. 2 | D-24 |
| | X. Terminal Facilities | |
| 10.1 | 1960 parking inventory in downtown Honolulu | X- 2 |
| .2 | Capacities of municipal parking lots in downtown Honolulu in 1967 | 3 |
| .3 | 1960 Auto-driver trips with destinations within downtown Honolulu by trip purpose | 5 |
| .4 | Percent of parking by type in downtown Honolulu in 1960 | 5 |
| .5 | Estimated 1985 person and auto-driver trips with destinations in downtown Honolulu | 8 |
| .6 | Transit trips with destinations downtown Honolulu - observed 1960, estimated 1985 | 8 |
| .7 | Estimated parking-space requirements for downtown Honolulu in 1985 | 9 |
| .8 | Summary of passenger arrivals to the State | 16 |
| .9 | Summary of passenger movements at Honolulu International Airport | 17 |
| .10 | Airline-traffic forecast | 18 |
| .11 | Breakdown of airport-transfer modes used by visitors | 20 |
| .12 | Seating statistics of Honolulu Stadium | 26 |


## *Illustrations*


| Figure | | |
|---|---|---|
| | VI. Local-Transit Study | |
| 6.1 | Bus Routes 1964 | VI- 5 |
| .2 | Bus Miles per Revenue Passenger | 8 |
| .3 | Fare Trends on Oahu | 9 |




AR00031702

| Figure | | Page |
|---|---|---|
| 6.4 | Trend in Revenue Passengers, U.S. and Honolulu | VI-10 |
| .5 | Total Annual Revenue Passengers | 11 |
| .6 | HRT Operating Revenues and Expenses | 12 |
| | VII. Automobile Ownership Study | |
| 7.1 | Percent Passenger Vehicles of Total Vehicle Registration. | VII- 3 |
| .2 | Car Ownership and Household Income - 1960 | 4 |
| .3 | Auto Driver Trips and Car Ownership - 1960 | 6 |
| .4 | Car-Ownership Forecast Equations | 7 |
| .5 | Comparison of 1960 and 1985 Car Ownership between Honolulu and Outlying District | 9 |
| .6 | Automobile Ownership, 1960-1985 by Census Tract | 11 |
| .7 | Persons per Registered Automobile, 1950 to 1965 and Estimated to 1985 | 14 |
| | VIII. Travel Patterns & Volumes | |
| 8.1 | Monthly Traffic Variations | VIII- 3 |
| .2a | Daily Traffic Variation | 4 |
| .2b | Counting Station Locations | 4 |
| .2c | Hourly Traffic Variation | 4 |
| | IX. Origin-Destination Traffic Study | |
| 9.1 | Person Trips by Land Use on Oahu in 1960 | IX- 8 |
| .2 | Distribution of Home-Based Person Trips on Oahu in Oahu in 1960 | 10 |
| .3 | Distribution of Auto Trips by Length and Purpose on Oahu in 1960 | 12 |
| .4 | Estimate of Home-Based Production Trips in 1985 Based on 1960 Data | 17 |
| .5 | Estimate of Truck Trips on Oahu in 1985, Based on 1960 Data | 21 |
| .6 | Summary of 1960 and 1985 Trip Length Distribution of Person Trips by Purpose | 26 |
| .7 | Comparison of Commercial Trip Time Distribution in 1960 and 1985 | 27 |
| .8 | Diagram of Estimated 1985 Vehicle Volumes | 33 |
| 9.A1 | Linking of "Service-Passenger" Trip | IX-A-3 |
| .A2 | Linking of "Change-Travel-Mode" Trip | A-3 |




AR00031703

| Figure | | Page |
|---|---|---|
| 9.A3 | Trips Made by Resident of Zone 1 | IX-A-7 |
| .A4 | Trips Made by Resident of Zone 3 | A-7 |
| 9.C1 | Sample Network for Minimum Path Calculations | IX-C-2 |
| .C2 | Minimum Time Path Tree from Zone 1 | C-3 |
| .C3 | Example Determination of Intrazonal Travel Time | C-5 |
| .C4 | Percent-Root-Mean Square Error between Observed and Simulated Trip Distribution | C-11 |
| .C5 | Trip-Length Distribution of Person Trips by Purpose | C-13 |
| .C6 | Trip-Length Distribution: Commercial Trips | C-17 |
| 9.D1 | Percent Transit vs. Equivalent Travel Time Difference Stratified by Auto Ownership | IX-D-7 |
| .D2 | Oahu Modal Split Relationships Work Trips | D-11 |
| .D3 | Oahu Modal Split Relationships Non-Work Trips | D-13 |
| .D4 | Generalized Procedure for Estimating Future Travel by Transit and Auto Modes | D-16 |
| .D5 | Transit System No. 1 Estimated 1985 Average Weekday Passenger Volumes Island of Oahu | D-27 |
| .D6 | Transit System No. 1 Estimated 1985 Average Weekday Passenger Volumes Island of Oahu | D-29 |
| .D7 | Transit System No. 2 Estimated 1985 Passenger Volumes Island of Oahu | D-31 |
| .D8 | Transit System No. 2 Estimated 1985 Average Weekday Passenger Volumes Island of Oahu | D-33 |
| .D9 | Transit System No. 2 Estimated 1985 Average Weekday Passenger Volumes Honolulu CBD | D-35 |
| .D10 | Rail Rapid Transit Peak Hour Volumes for Honolulu and Other Selected Cities | D-37 |
| | **X. Terminal Facilities** | |
| 10.1 | Parking Study-Sub Areas | X- 2 |
| .2 | Existing Municipal Parking Lots - 1967 | 4 |
| .3 | Hourly Vehicle Accumulation and Parking Spaces Available Honolulu CBD: 1960 | 6 |
| .4 | Weekday Parking Occupancy at the Kaahumanu and Alakea-Richards Parking Lots | 7 |
| .5 | Comparison of Common and Regular Fares for Five Typical Multiple-Stop Itineraries | 13 |
| .6 | Honolulu Stadium Site | 24 |




AR00031704

# V Accident Study

# V. ACCIDENT STUDY

## A. INTRODUCTION

The purpose of this accident study was to identify locations having high accident occurrences in order that corrective measures may be considered by appropriate governmental agencies. Accident data were compiled exclusively from police records by the Traffic Engineering Section of the Highways Division, Department of Transportation.

Reported accidents include only those sustaining property damages of $100 or more and those involving injuries. Accidents occurring on private properties such as on military reservations and on private access roads are not included in the analysis.

## B. TRAFFIC ACCIDENTS

During the past six years, the number of accidents and the fatal and nonfatal injuries have increased significantly--nearly 30 percent, or an overall annual average increase of approximately 5 percent.

Fatal and nonfatal-injury accidents have increased at a much higher rate than total accidents. During this same six-year period (1961-1966), these injury accidents have increased approximately 45 percent. Recent experience shows that more than 54 percent of the total accidents resulted into injuries (Table 5.1).

Table 5.1. Record of Traffic Accidents on Oahu

| Year | Injury Accidents | | | Total Accidents |
|---|---|---|---|---|
| | Fatal | Non-Fatal | Total | |
| 1961 | 52 | 3,088 | 3,140 | 6,546 |
| 1962 | 66 | 3,181 | 3,247 | 6,906 |
| 1963 | 53 | 3,221 | 3,274 | 6,558 |
| 1964 | 68 | 3,930 | 3,998 | 7,175 |
| 1965 | 71 | 4,282 | 4,353 | 7,929 |
| 1966 | 75 | 4,477 | 4,552 | 8,475 |



AR00031706

Table 5.2 reveals that the respective percentage of total accidents for each day of week does not vary from year to year. The past six-year experience indicates that each day of week, except Friday and Saturday, would account between 12 and 13 percent of the total accidents, with Friday and Saturday each accounting between 5 to 6 percent more.

Table 5.2. Percent of Major Accidents by Day of Week on Oahu

| Year | Percent of Major Accidents | | | | | | |
|---|---|---|---|---|---|---|---|
| | Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
| 1962 | 13.3 | 13.0 | 11.8 | 12.2 | 13.1 | 17.6 | 19.0 |
| 1963 | 13.7 | 11.7 | 13.0 | 11.9 | 13.6 | 16.6 | 19.5 |
| 1964 | 12.9 | 12.2 | 11.8 | 13.9 | 13.5 | 17.0 | 18.7 |
| 1965 | 12.8 | 11.9 | 12.7 | 13.8 | 12.8 | 17.2 | 18.8 |
| 1966 | 13.0 | 12.6 | 12.0 | 13.1 | 13.3 | 17.5 | 18.5 |
| Avg. | 13.2 | 12.2 | 12.2 | 13.0 | 13.3 | 17.2 | 18.9 |

Table 5.A1 shows the accident experiences on roads under State and County jurisdiction. Streets within the urban place of Honolulu, Waipahu, Pearl City, Aiea, Kailua, Lanikai, Kaneohe, and Wahiawa were classified as urban for the purpose of this accident study. All other streets were classified as rural.

On the basis of improved mileages and vehicle miles of travel, generally roads under State jurisdiction are much safer than roads and streets under County jurisdiction, considering the fact that improved road mileage under State jurisdiction accounts for only approximately a fourth of the total improved roads and streets on Oahu and that the vehicle miles of travel on State roads approximate that occurring on County roads and streets. On the basis of death per accident, however, State roads were more "life" costly than County streets.

## C. TRAFFIC-ACCIDENT RATES

The quality of service that a street system provides depends on how well each street is performing, in accordance with its primary purpose, in relation to other street systems. The degree to which any system fulfills its basic purpose varies directly with the operational characteristics and the design.



AR00031707

The highest quality of service will be obtained when there is complete compatibility between these factors and the purpose of the system.

Generally speaking, accident rates are an index of safety, and represent one of the factors used to adjust operational controls and design features on each system. Table 5.3 shows the National Committee on Urban Transportation's suggested guiding accident rates for existing streets. The values given are to be considered as a guide to appraise relative safety of travel and should not be construed as an ultimate goal or standard.

Table 5.3. Guiding Traffic-Accident Rates per 100-Million-Vehicle Miles by Street Type

| Type of Street | Fatal Accidents | Injury Accidents |
|---|---|---|
| | not more than | not more than |
| Expressway | | |
| Full Control | 2 | 60 |
| Partial Control | 3 | 100 |
| Major Arterial | | |
| Divided | 5 | 150 |
| Undivided | 6 | 200 |
| Collector | 4 | 80 |
| Local | | |
| Business | 1 | 20 |
| Industrial | 1 | 20 |
| Residential | 1 | 10 |

True exposure to accidents is approximated by the miles of travel by motor vehicles rather than by either population or vehicle registration. In determining ratios, a fatal accident as defined as an accident in which one or more persons is killed, and an injury accident as an accident in which one or more persons is killed or injured. These rates are expressed on a per 100-million-vehicle-mile basis.

Table 5.4 shows the accident rates experienced on Oahu's roads and streets. Because of the lack of vehicle-mile data by type of street, this table could not be expressed in the same fashion as in Table 5.3.

Since expressway mileages on Oahu are relatively insignificant and since they have existed only recently, values appearing in Table 5.4 are suitable



AR00031708

for gross comparisons with values for major arterials even though their "make-ups" are not precisely uniform.

Table 5.4. Traffic-Accident Rates per 100-Million Vehicle Miles on Oahu

| Year | Accident Rate per 100-Million Vehicle Miles | |
|---|---|---|
| | Fatal | Injury* |
| 1961 | 3.3 | 200 |
| 1962 | 4.5 | 220 |
| 1963 | 3.5 | 216 |
| 1964 | 4.2 | 249 |
| 1965 | 3.7 | 227 |
| 1966 | 3.9 | 235 |

*Injury accidents include all fatal and nonfatal injuries.

Fatal-accident rates are less than the current national rate of 5.6 deaths per 100-million vehicle miles and, in general, are comparable with those minimum desirable standards suggested by the National Committee on Urban Transportation. Injury-accident rates, however, exceed those maximum rates set for arterial highways. It is reasonable to assume that, as vehicle travel increases, the number of accidents will also increase, and this information of injury-accident rates should justify continued surveillance so that economic loss due to this type of accident may be reduced.

Freeways have consistently been found to be safer than routes of lower design standards. Comprehensive studies of traffic-accident frequency and fatality rates conducted by the Bureau of Public Roads [Ref. 5.1] in 30 different states and involving about 27-billion vehicles miles of travel on 2,590 miles of highway revealed that:

1. Control of access substantially reduces accidents and fatalities.
2. Urban freeways are twice as safe as city streets in terms of fatalities and about three times in terms of total accidents.



AR00031709

3. Urban freeways saved about two lives per 100-million vehicle miles.
4. Rural freeways saved over five lives per 100-million vehicle miles.

## D. TRAFFIC-ACCIDENT COSTS

The aggregate cost of highway accidents is determined by the number of accidents, the average accident severity, and the unit monetary value of the losses. The first two factors may be modified by changes in road conditions, whereas the third depends on the general level of the economy.

Accident cost is one of the most useful measures of the importance of accident-prevention work. It is also a major component of road-user cost and, as such, it is an important element for inclusion in road-user-benefit analyses. It is not possible, however, from information now available, to make calculations of exact costs; thus, the estimates made here can only be approximate.

The calculable costs of motor-vehicle accidents are wage loss, medical expense, overhead cost of insurance, and property damage. Wage loss includes loss of wages (or the value of services) resulting from temporary inability to work, lower wages when returned to work as a result of permanent partial disability, and the present value of anticipated future earnings for permament total disability or death. Medical expense includes doctor's and hospital's fees. Overhead cost of insurance includes all administrative, selling, and claims-settlement expenses for insurance companies and self-insurers, but not payments on claims. Claim payments are included in wage loss and medical expense. The National Safety Council provides the following values for the costs of all these items per case in 1965:

| | |
|---|---|
| Death ..... | $35,000 |
| Nonfatal injury ..... | 1,900 |
| Property-damage accident.. | 320 |

Table 5.5 records the number of fatal and nonfatal injuries for Oahu from 1961 to 1966 and shows the economic loss as a result of these injuries and property-damage accidents.

Motor-vehicle-accident costs for Oahu have increased steadily at an approximate annual rate of $1,000,000 per year. In the last six-year period, the economic loss has totalled over $91 million.



AR00031710

Table 5.5. Personal and Economic Losses Resulting from Traffic-Accident Injuries on Oahu

| Year | Persons Injured | | | Estimated Costs ($1,000,000) | | | |
|---|---|---|---|---|---|---|---|
| | Fatal | Nonfatal | Total | Fatal | Nonfatal | Property Damage | Total |
| 1961 | 55 | 4,428 | 4,483 | 1.9 | 8.5 | 2.1 | 12.5 |
| 1962 | 71 | 4,633 | 4,704 | 2.5 | 9.0 | 2.2 | 13.7 |
| 1963 | 58 | 4,680 | 4,738 | 2.0 | 9.0 | 2.1 | 13.1 |
| 1964 | 74 | 5,881 | 5,955 | 2.6 | 11.0 | 2.3 | 15.9 |
| 1965 | 78 | 6,383 | 6,461 | 2.7 | 12.0 | 2.5 | 17.2 |
| 1966 | 86 | 6,780 | 6,866 | 3.0 | 13.0 | 2.7 | 18.7 |

Between 1961 and 1966, travel aggregated approximately 100-billion vehicle miles. The average accident cost per vehicle mile amounted to 0.91 cent (Table 5.6), a figure that approaches about a third of the unit cost of fuel under good operating conditions. It is very conceivable to expect accident cost to increase to approximately 1.15 cents per vehicle mile by 1975, 1.26 cents per vehicle mile by 1980, and 1.36 cents per vehicle mile by 1985.

Table 5.6. Motor-Vehicle-Accident Cost per Vehicle Mile on Oahu

| Year | Vehicle Miles Traveled (100-million vehicle miles) | Accident Cost ($1,000,000) | Cost Per Vehicle Mile (¢) |
|---|---|---|---|
| 1961 | 15.7 | 12.5 | 0.80 |
| 1962 | 14.7 | 13.7 | 0.93 |
| 1963 | 15.2 | 13.1 | 0.86 |
| 1964 | 16.1 | 15.9 | 0.99 |
| 1965 | 19.1 | 17.2 | 0.90 |
| 1966 | 19.4 | 18.7 | 0.96 |
| | Total 100.2 | | Avg. 0.91 |

## E. AGE GROUPS OF DRIVERS INVOLVED IN TRAFFIC ACCIDENTS

Table 5.7 reveals that teenage-driver involvement in all accidents remained at a constant rate, year after year, of about 13 percent. Age group 25-34 years has consistently led the age groupings in having the most number of driver involvements. It should be noted, however, that the percents of driver involvement of this age group (25 to 34 years) and of age group 35 to 44 years are gradually decreasing.



AR00031711

Table 5.7. Percent of Drivers by Age Group Involved in Automobile Accidents on Oahu

| Age Group | Percent of Drivers Involved in Accidents | | | | | | Average |
|---|---|---|---|---|---|---|---|
| | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | |
| Under 15 | 1.6 | 1.3 | 1.0 | 1.2 | 1.2 | 1.1 | 1.2 |
| 16 | 2.0 | 2.0 | 2.1 | 1.8 | 1.8 | 1.8 | 1.9 |
| 17 | 2.9 | 3.1 | 2.7 | 2.9 | 2.9 | 3.0 | 2.9 |
| 18-19 | 7.1 | 7.1 | 6.5 | 7.3 | 7.3 | 7.3 | 7.1 |
| 20-24 | 18.3 | 18.8 | 19.4 | 19.7 | 20.6 | 20.4 | 19.5 |
| 25-34 | 25.8 | 24.4 | 24.7 | 23.9 | 22.9 | 22.3 | 24.0 |
| 35-44 | 20.7 | 20.3 | 20.1 | 19.6 | 19.2 | 18.3 | 19.7 |
| 45-54 | 12.3 | 12.8 | 12.9 | 12.6 | 12.6 | 12.8 | 12.7 |
| 55-64 | 5.2 | 5.5 | 6.3 | 6.4 | 6.2 | 6.5 | 6.0 |
| 65-74 | 1.3 | 1.5 | 1.6 | 1.7 | 1.7 | 2.0 | 1.7 |
| Over 75 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Not Stated | 2.6 | 2.9 | 2.4 | 2.6 | 3.3 | 4.2 | 3.0 |

Driver involvement of age group 20 to 24 years is increasing each year and deserves critical licensing reexamination not only because it accounts for a relatively large number of accidents but that it accounted for approximately 29 percent of the fatal injuries in 1966.

## F. MOTORCYCLE AND MOTORSCOOTER ACCIDENTS

The recently established "Hawaii Highway Safety Act of 1967" now requires operators (and their passengers) of motorcycles and motorscooters to wear safety helmets, safety glasses, goggles, or face shields, on motorcycles or motorscooters that are not equipped with windscreens or windshields, and any other protective devices required by rules and regulations adopted by the State Highway Safety Coordinator. The need for strengthening the safety requirements of this mode of transportation can be justified by the growing number of accidents and injuries involving the motorcycle and the motorscooter.

In the last six years, accidents involving the motorcycle or motorscooter have increased 167 percent, from 221 in 1961 to 591 in 1966 (Table 5.8). About 93 percent of the total accidents of this type each year resulted in injury. In 1966, nearly 15 percent of the total fatal-traffic injuries involved the motorcycle or motorscooter.



AR00031712

Table 5.8. Accidents Involving Motorcycle or Motorscooter on Oahu

| Year | Motorcycle or Motorscooter Injury Accidents | | | Total Accidents |
|---|---|---|---|---|
| | Fatal | Nonfatal | Total | |
| 1961 | 9 | 200 | 209 | 221 |
| 1962 | 8 | 170 | 178 | 193 |
| 1963 | 3 | 254 | 257 | 281 |
| 1964 | 9 | 359 | 368 | 390 |
| 1965 | 13 | 424 | 437 | 467 |
| 1966 | 16 | 534 | 550 | 591 |

## G. INTERSECTION ACCIDENTS

Accidents at intersections represent a significant portion of the total accidents on Oahu--averaged for the past six years, they represent about 39 percent. While collisions involving two or more motor vehicles represented 73 percent of the total accidents, approximately a third of these (33.6 percent) were at an intersection. This collision type of accident makes up about 86 percent of the total accidents at intersections (Table 5.9).

Intersections having five or more accidents for any one year are investigated by both the Highways Division of the State Department of Transportation and the Traffic Department of the City and County of Honolulu. Both agencies employ measures designed to reduce accidents at these intersections.

Table 5.A2 lists intersections having 20 or more accidents for three or more years during the last six years. This study recommends immediate redesign of these intersections to make them relatively accident free. If these intersections are within the limits of projects for which major reconstruction has been recommended but not for within the immediate future, the study recommends immediate interim measures directed at reducing the number of accidents.

Table 5.A3 lists intersections having 10 to 19 accidents for three or more years during the last six years. This study recommends redesign of these intersections and that they be given priority following those intersections listed in Table 5.A2. Since redesign would not be immediate, this study



AR00031713

recommends also that these intersections be given interim measures directed at reducing the number of accidents.

Table 5.A5 lists having 5 to 9 accidents during any one year during the past six years. These intersections should receive routine investigations by both State and City traffic agencies and corrective measures should be taken when their needs become known.

Table 5.9. Percent of Intersection and Non-Intersection Motor-Vehicle Accidents

| Location of Accident | Year | Percent of Accidents by Type of Collision | | | | |
|---|---|---|---|---|---|---|
| | | With Pedestrian | With Another Vehicle | With Non-Motor Vehicle, Bicycle, etc. | With Fixed Object | With Other |
| Intersection | 1961 | 2.4 | 28.0 | 0.4 | 2.3 | 0.5 |
| | 1962 | 2.4 | 35.7 | 0.3 | 2.1 | 0.4 |
| | 1963 | 2.1 | 36.0 | 0.3 | 2.8 | 0.5 |
| | 1964 | 2.6 | 34.3 | 0.3 | 2.3 | 0.4 |
| | 1965 | 1.8 | 32.9 | 0.3 | 2.2 | 0.3 |
| | 1966 | 2.3 | 34.8 | 0.3 | 3.4 | 0.4 |
| Avg. | | 2.3 | 33.6 | 0.3 | 2.5 | 0.4 |
| Non-Intersection | 1961 | 4.5 | 43.6 | 0.7 | 9.9 | 7.7 |
| | 1962 | 3.4 | 37.5 | 0.6 | 12.2 | 5.4 |
| | 1963 | 3.3 | 37.7 | 0.3 | 12.1 | 4.9 |
| | 1964 | 3.2 | 38.3 | 0.7 | 13.1 | 4.8 |
| | 1965 | 3.0 | 41.2 | 0.5 | 13.5 | 4.3 |
| | 1966 | 2.6 | 38.2 | 0.4 | 13.5 | 4.1 |
| Avg. | | 3.4 | 39.4 | 0.5 | 12.4 | 5.2 |



AR00031714

# APPENDIX V-A. TABLES CONCERNING NUMBER OF ACCIDENTS

Table 5.A1. Number of Accidents on Roads and Streets on Oahu

| Locale | Year | No. of Accidents on Roads and Streets under State Jurisdiction | | | | No. of Accidents on Roads and Streets under County Jurisdiction | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Injury Accidents | | | All Accidents | Injury Accidents | | | All Accidents |
| | | Fatal | Nonfatal | Total | | Fatal | Nonfatal | Total | |
| Urban Streets | 1961 | 26 | 1,075 | 1,101 | 2,263 | 24 | 1,916 | 1,940 | 4,107 |
| | 1962 | 32 | 1,049 | 1,081 | 2,237 | 30 | 2,016 | 2,046 | 4,460 |
| | 1963 | 21 | 1,083 | 1,104 | 2,114 | 24 | 2,001 | 2,025 | 4,222 |
| | 1964 | 37 | 1,420 | 1,457 | 2,560 | 24 | 2,432 | 2,456 | 4,466 |
| | 1965 | 31 | 1,700 | 1,731 | 3,093 | 29 | 2,495 | 2,524 | 4,675 |
| | 1966 | 27 | 1,341 | 1,368 | 2,429 | 27 | 2,537 | 2,564 | 5,005 |
| Rural Roads | 1961 | 2 | 76 | 78 | 133 | -- | 21 | 43 | 64 |
| | 1962 | 3 | 89 | 92 | 151 | 1 | 27 | 53 | 81 |
| | 1963 | 8 | 92 | 100 | 151 | -- | 45 | 71 | 116 |
| | 1964 | 7 | 56 | 63 | 118 | -- | 22 | 31 | 53 |
| | 1965 | 8 | 66 | 74 | 122 | 3 | 21 | 39 | 63 |
| | 1966 | 17 | 437 | 454 | 752 | 4 | 162 | 166 | 289 |



AR00031716

Table 5.A2. Intersections Having More Than 20 Accidents A Year for Three or More Years, 1961-1966 on Oahu

| Intersection | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| State Jurisdiction | | | | | | |
| Kamehameha Highway - Middle Street | 30 | 23 | -- | 29 | 35 | 23 |
| Nimitz Highway - Fort Kam Road | 11 | 21 | 21 | 27 | 7 | 19 |
| City and County Jurisdiction | | | | | | |
| Kapiolani Boulevard - McCully Street | 13 | 17 | 20 | 11 | 20 | 20 |

Table 5.A3. Intersections Having 10 to 19 Accidents a Year for Three or More Years, 1961-1966 on Oahu

| Intersection | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| State Jurisdiction | | | | | | |
| Ala Moana Boulevard - Kalia - Ena Road | 9 | 21 | 10 | 19 | 15 | 8 |
| Castle Junction - Hobron Lane | -- | -- | 13 | 6 | 14 | 12 |
| Dillingham Boulevard - | | | | | | |
| Kalihi Street | 21 | 7 | 18 | 19 | 17 | 21 |
| Mokauea Street | 18 | 18 | 14 | 16 | 7 | 10 |
| Waiakamilo Street | 15 | 17 | 11 | 13 | 20 | 17 |
| Kamehameha Highway - | | | | | | |
| Center Drive | 12 | 19 | -- | -- | 11 | 7 |
| Makalapa Gate | 8 | 15 | -- | 12 | 18 | 11 |
| Likelike Highway - School Street | 10 | 16 | 9 | 9 | 17 | 14 |
| Moanalua Road - Puuloa Road | 8 | 8 | 10 | 12 | 11 | 9 |
| Middle Street - King Street | -- | -- | -- | 15 | 12 | 11 |



AR00031717

Table 5.A3 - continued

| Intersection | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| Nimitz Highway - | | | | | | |
| Lagoon Drive | 6 | 7 | 9 | 10 | 10 | 17 |
| Main Street (Ewa) | 12 | 10 | 8 | 8 | 9 | 14 |
| Waiakamilo Street | 8 | 10 | 17 | 12 | 15 | 12 |
| Pali Highway - | | | | | | |
| School Street | -- | 9 | 12 | 8 | 15 | 12 |
| Vineyard Boulevard - | | | | | | |
| Liliha Street | 10 | 11 | 8 | 21 | 23 | 12 |
| Nuuanu Avenue | 13 | 24 | 12 | 16 | 12 | 11 |
| Pali Highway | 6 | 10 | 8 | 18 | 14 | -- |
| Punchbowl Street | 10 | 22 | 12 | 13 | 10 | 24 |
| City and County Jurisdiction | | | | | | |
| Ala Moana Boulevard - | | | | | | |
| Atkinson Drive | 9 | 15 | 8 | 15 | 7 | 13 |
| Piikoi Street | 14 | 16 | 7 | 12 | 14 | 13 |
| Ward Avenue | 19 | 18 | 18 | 16 | 13 | 10 |
| Beretania Street - | | | | | | |
| Keeaumoku Street | 13 | 10 | -- | 8 | 8 | 19 |
| Dillingham Boulevard - | | | | | | |
| Kohou Street | 17 | 19 | 7 | 12 | 12 | 10 |
| Kapiolani Boulevard - | | | | | | |
| Kalakaua Avenue | 12 | 9 | 16 | 8 | 11 | 15 |
| Keeaumoku Street | 17 | 18 | 16 | 20 | -- | 11 |
| McCully Street | 13 | 17 | 20 | 11 | 20 | 20 |
| Piikoi Street | 8 | 9 | 17 | -- | 16 | 10 |
| Pumehana Street | 5 | 11 | 14 | 11 | 5 | 11 |
| Ward Avenue | 10 | 7 | -- | 10 | 7 | 16 |
| King Street - | | | | | | |
| Kalihi Street | 14 | 15 | 13 | 12 | 10 | 14 |
| Keeaumoku Street | 10 | 15 | 7 | 9 | 9 | 17 |
| Piikoi Street | 8 | 9 | -- | 11 | 11 | 12 |
| Dillingham-Liliha Street | 13 | 14 | 13 | -- | -- | -- |
| Lunalilo Street - | | | | | | |
| Victoria Street | 15 | 13 | 18 | 15 | 16 | 13 |



AR00031718

Table 5.A4. Intersections Having 5 to 9 Accidents for Any One Year, 1961-1966 on Oahu

| Intersection | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| State Jurisdiction | | | | | | |
| Ala Moana Boulevard - | | | | | | |
| Kalia - Ena Road | 9 | 21 | 10 | 19 | 15 | 8 |
| Kalakaua Avenue | -- | -- | -- | 6 | -- | -- |
| Hobron Lane | -- | -- | 13 | 6 | 14 | 12 |
| Dillingham Boulevard - | | | | | | |
| Kaiwiula Street | 5 | 41 | 8 | 13 | -- | -- |
| Kalihi Street | 21 | 7 | 18 | 19 | 17 | 21 |
| Mokauea Street | 18 | 18 | 14 | 16 | 7 | 10 |
| Winant Street | -- | 6 | 6 | -- | 5 | -- |
| Puuhale Road | -- | -- | 5 | -- | -- | -- |
| Farrington Highway - | | | | | | |
| Pahu Street | -- | -- | 8 | -- | -- | -- |
| Barber's Point Access Road | -- | -- | -- | -- | -- | 5 |
| Kunu Road | -- | -- | -- | -- | -- | 5 |
| Lookane Street | -- | -- | -- | -- | -- | 7 |
| Piliana Road | 6 | 5 | -- | -- | -- | 5 |
| Waipahu Depot Road | 8 | -- | 8 | 5 | -- | 5 |
| Fort Weaver Road | 6 | 7 | 6 | 6 | -- | -- |
| Fort Weaver Road - | | | | | | |
| Fort Weaver | 7 | -- | -- | -- | -- | -- |
| Westlock Road | 6 | -- | -- | -- | -- | -- |
| Kalaeloa Boulevard | -- | -- | -- | 5 | -- | -- |
| Paiwa Street | -- | -- | -- | -- | 6 | -- |
| Leokane Street | -- | -- | -- | -- | 5 | -- |
| Piliana Road | -- | -- | -- | -- | 5 | -- |
| Halekauwila Street - | | | | | | |
| Richards Street | 5 | 7 | -- | -- | 8 | 5 |
| Bishop Street | -- | -- | 7 | 8 | 7 | -- |
| Harding Avenue - | | | | | | |
| Kapahulu Avenue | -- | -- | 7 | 6 | 5 | 6 |
| Kalanianaole Highway - | | | | | | |
| Kailua Road | -- | 5 | -- | -- | -- | -- |
| Kilauea Avenue | -- | 7 | -- | -- | -- | -- |
| Ainakoa Drive | -- | -- | 5 | 5 | 6 | -- |
| Ehukai-Sandy Beach | -- | -- | -- | 5 | -- | -- |
| Waikui Drive | -- | -- | 5 | -- | -- | 5 |
| East Hind Drive | -- | -- | -- | -- | 6 | -- |
| Kapaa Quarry Road | -- | -- | -- | -- | 6 | -- |



AR00031719

Table 5.A4 - continued

| Intersection | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| Maunawili Junction - | | | | | | |
| Auloa Road | -- | -- | -- | -- | -- | 5 |
| Hanauma Bay Road | -- | -- | -- | -- | -- | 5 |
| Hawaii Loa Street | -- | -- | -- | -- | -- | 5 |
| Kapaa Quarry Road | -- | -- | -- | -- | -- | 8 |
| Lunalilo Home Road | -- | -- | -- | -- | -- | 7 |
| Kamehameha Highway - | | | | | | |
| Aiea Kai Place | -- | -- | -- | -- | -- | 5 |
| Center Drive - Plant Drive | 12 | 19 | -- | -- | 11 | 7 |
| Halawa Gate | 8 | 8 | -- | -- | -- | 18 |
| Hale Street | 11 | 7 | -- | -- | -- | 6 |
| Honomanu Street | 8 | 11 | -- | 9 | -- | -- |
| Laumaka Street | 8 | 5 | -- | -- | -- | -- |
| Makalapa Gate | 8 | 15 | -- | 12 | 18 | 11 |
| Moanalua Road (Waiau) | 9 | -- | -- | 5 | -- | 10 |
| Pearl Harbor Spur | 7 | 5 | -- | 6 | 5 | 9 |
| Keaahala Road | -- | -- | -- | 5 | -- | -- |
| Hekaha Street | -- | 8 | -- | -- | 6 | 7 |
| Likelike Highway | -- | 6 | -- | -- | -- | -- |
| Puu Poni Street | -- | 7 | -- | -- | -- | -- |
| Wilikina Drive | -- | 7 | -- | 5 | 5 | -- |
| Moanalua Road (Kalauao) | -- | 7 | -- | 7 | -- | 6 |
| California Avenue | -- | -- | 5 | -- | -- | -- |
| Farrington Highway | -- | -- | 5 | -- | -- | -- |
| Fort Kam Access Road | -- | -- | 8 | 6 | -- | -- |
| Hale Street | -- | -- | 10 | 8 | 11 | -- |
| Laulima Street | -- | -- | 6 | 6 | -- | -- |
| Laumaka Street | -- | -- | 8 | 6 | 6 | -- |
| Waimano Home Road - | | | | | | |
| Lihua Avenue | -- | -- | 18 | 9 | -- | -- |
| Likelike Highway | -- | -- | 13 | -- | 5 | -- |
| Kalauao Cut-Off Road | -- | -- | 6 | -- | -- | -- |
| Olive Avenue | -- | -- | 5 | -- | -- | -- |
| Salt Lake Boulevard | -- | -- | 6 | -- | 6 | -- |
| Paleka Road - Waikalua Road | -- | -- | 6 | -- | 6 | -- |
| Hekaha Street | -- | -- | -- | -- | 6 | -- |
| Honomanu Street | -- | -- | -- | -- | 9 | -- |
| Lipoa Place | -- | -- | -- | -- | 6 | -- |
| Wright Avenue | -- | -- | -- | -- | 5 | -- |
| Likelike Highway - | | | | | | |
| Kulakokea Road | 12 | -- | 8 | -- | 12 | 6 |
| Kamehameha Highway | 5 | -- | -- | -- | -- | -- |
| School Street | 10 | 16 | 9 | 9 | 17 | 14 |
| Valley View Drive | 6 | -- | -- | -- | -- | -- |



AR00031720

Table 5.A4 - continued

| Intersection | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| Moanalua Road - | | | | | | |
| Halawa Heights Road | 7 | 12 | 9 | 11 | 7 | -- |
| Ala Aolani Road | -- | -- | -- | -- | -- | 5 |
| Hale Street | 8 | -- | 7 | 5 | -- | 5 |
| Puuloa Road | 8 | 8 | 10 | 12 | 11 | 9 |
| Jarret White Road | -- | 6 | 5 | 5 | 5 | 10 |
| Kinau Street - | | | | | | |
| Lusitana Street | -- | -- | 6 | -- | -- | -- |
| Lagoon Drive - | | | | | | |
| York Town Avenue | -- | -- | 5 | -- | -- | -- |
| Likelike Highway - | | | | | | |
| Anoi Road | -- | -- | -- | 5 | 8 | -- |
| Kam Highway | -- | -- | -- | 6 | -- | -- |
| Kahekili Highway | -- | -- | -- | -- | -- | 7 |
| Kalihi Street | -- | -- | -- | -- | -- | 6 |
| Kam Highway | -- | -- | -- | -- | -- | 8 |
| Middle Street - | | | | | | |
| Ramp M-1 | -- | -- | -- | 8 | 5 | 16 |
| Nimitz Highway - | | | | | | |
| Fort Kam | 11 | 21 | 21 | 27 | 7 | 19 |
| Hickam Gate | 6 | -- | -- | -- | -- | -- |
| Kalihi Street | 6 | 8 | 7 | 6 | 6 | 7 |
| Lagoon Drive | 6 | 7 | 9 | 10 | 10 | 17 |
| Main Street (Ewa) | 12 | 10 | 8 | 8 | 9 | 14 |
| Main Street (Koko Head) | 4 | -- | -- | -- | -- | -- |
| Middle Street | 6 | -- | -- | -- | -- | 5 |
| Pacific | 7 | -- | 9 | 5 | -- | -- |
| Pearl Harbor Spur | 7 | -- | -- | 5 | 5 | 9 |
| Sand Island Access | 5 | 8 | 7 | -- | -- | -- |
| Smith Street | 9 | 10 | 5 | 8 | 10 | 7 |
| Waiakamilo Street | 8 | 10 | 17 | 12 | 15 | 12 |
| Fort Street | -- | 7 | -- | 6 | -- | -- |
| Mokauea Street | -- | 9 | 5 | -- | 7 | -- |
| Puuhale Street | -- | -- | 13 | 7 | 5 | 13 |
| Nuuanu Avenue | -- | -- | -- | 5 | 5 | -- |
| Rodgers Boulevard | -- | -- | -- | -- | 5 | -- |
| Ohohia Street | -- | -- | -- | -- | -- | 6 |
| Pacific Street (inbound) | -- | -- | -- | -- | -- | 5 |
| Pacific Street (outbound) | -- | -- | -- | -- | -- | 6 |
| Paiea Street | -- | -- | -- | -- | -- | 8 |
| Mokapu Boulevard - | | | | | | |
| Kalaheo Avenue | -- | -- | -- | 8 | -- | -- |



AR00031721

Table 5.A4 - continued

| Intersection | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| Nuuanu Avenue - | | | | | | |
| School Street | -- | -- | -- | -- | 5 | 5 |
| Wyllie Street | -- | -- | -- | -- | 6 | -- |
| Pali Highway - | | | | | | |
| Beretania Street | -- | 11 | 7 | 6 | -- | 6 |
| School Street | -- | 9 | 12 | 8 | 15 | 12 |
| Wyllie Street | -- | -- | -- | 8 | 24 | -- |
| Ramp L (Pauoa Road) | -- | -- | -- | -- | 6 | 7 |
| Puuloa Road - | | | | | | |
| Puholoa St. - Peltier Ave. | -- | -- | 5 | -- | 8 | 8 |
| Kilihau Street | -- | -- | -- | 6 | 7 | -- |
| Salt Lake Boulevard - | | | | | | |
| Hale Street | -- | -- | -- | -- | 5 | -- |
| Pakini Street | -- | -- | -- | -- | 5 | -- |
| Vineyard Boulevard - | | | | | | |
| College Walk | 5 | -- | -- | 10 | 5 | 6 |
| Liliha Street | 10 | 11 | 8 | 21 | 23 | 12 |
| Palama Street | 9 | -- | -- | -- | -- | 7 |
| Pali Highway | 6 | 10 | 8 | 18 | 14 | -- |
| Queen Emma | 7 | 7 | 6 | 9 | 10 | 9 |
| Miller Street - Lusitana | -- | -- | -- | -- | -- | 5 |
| Pua Lane | -- | -- | -- | -- | -- | 7 |
| Waialae Avenue - | | | | | | |
| Kapahulu - Kapiolani | -- | -- | 9 | 14 | 19 | 21 |
| Kilauea Avenue | -- | -- | 5 | 5 | 6 | 7 |
| 21st Avenue | -- | -- | 5 | -- | -- | -- |
| Hunakai Street | -- | -- | 5 | 9 | 13 | 6 |
| Waimanalo Junction | -- | -- | 8 | -- | -- | -- |
| Kam Highway - | | | | | | |
| Kanuku Street | -- | -- | -- | -- | -- | 8 |
| Kilani Avenue | -- | -- | -- | -- | -- | 5 |
| Moanalua Avenue (Aiea Interchange) | -- | -- | -- | -- | -- | 5 |
| Paleka Road - Waikalua Road | -- | -- | -- | -- | -- | 8 |
| Salt Lake Boulevard | 5 | -- | -- | -- | -- | 6 |
| Elliot Street | -- | -- | -- | -- | 15 | 7 |
| Lagoon Drive - | | | | | | |
| Waiwai Loop | -- | -- | -- | -- | -- | 5 |
| Lunalilo Freeway - | | | | | | |
| Ramp D (Pali Highway) | -- | -- | -- | -- | -- | 7 |
| Lusitana Street - | | | | | | |
| Punchbowl Street | -- | -- | -- | -- | -- | 8 |



AR00031722

Table 5.A4 - continued

| Intersection | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| City and County Jurisdiction | | | | | | |
| Ala Moana Boulevard - | | | | | | |
| Atkinson Drive | 9 | 15 | 8 | 15 | 7 | 13 |
| Channel Street | 6 | 5 | -- | -- | -- | -- |
| Cooke Street | 6 | 5 | 5 | 7 | 6 | -- |
| Coral Street | 6 | 6 | -- | -- | -- | 5 |
| Koula Street | 8 | 5 | 5 | 6 | -- | 9 |
| Piikoi Street | 14 | 16 | 7 | 12 | 14 | 13 |
| Queen Street | 9 | 5 | 6 | 6 | -- | 14 |
| South Street | 7 | 7 | 9 | 12 | 10 | 8 |
| Auahi Street | -- | -- | 10 | 5 | 6 | 5 |
| Ala Moana Park Drive (Ewa end) | -- | -- | 5 | -- | -- | -- |
| Ahui Street | -- | -- | -- | 5 | -- | -- |
| Kamakee Street | -- | -- | -- | -- | 6 | -- |
| Keawe Street | -- | -- | -- | -- | 6 | -- |
| Ala Wai Boulevard - | | | | | | |
| Kalaimoku Street | -- | -- | -- | -- | -- | 5 |
| Liliuokalani Avenue | -- | -- | -- | -- | -- | 6 |
| McCully Street | 8 | 10 | 7 | 8 | 7 | 11 |
| Paki Avenue | -- | -- | -- | -- | 9 | 11 |
| Seaside Avenue | -- | -- | -- | -- | -- | 6 |
| Lewis Road | -- | 5 | -- | -- | -- | -- |
| Kanekapolei Place | -- | -- | -- | 5 | -- | -- |
| Kaiulani Avenue | -- | -- | -- | -- | 5 | -- |
| Beretania Street - | | | | | | |
| Alapai Street | 5 | 11 | 5 | 17 | 8 | 5 |
| Kalakaua Avenue | -- | -- | -- | -- | -- | 7 |
| Kapiolani Boulevard | -- | -- | -- | -- | -- | 7 |
| Keeaumoku Street | 13 | 10 | -- | 8 | 8 | 19 |
| Makiki Street | -- | -- | -- | -- | -- | 5 |
| McCully Street | -- | 5 | -- | -- | 5 | 7 |
| Pensacola Street | 6 | 8 | 6 | 7 | 6 | 7 |
| Piikoi Street | 8 | 12 | 5 | -- | -- | 8 |
| Punchbowl Street | 9 | 5 | 5 | 7 | 12 | 6 |
| Queen Emma Street | -- | -- | -- | -- | -- | 5 |
| Ward Avenue | 6 | 5 | -- | 6 | 6 | 14 |
| Alakea Street | 5 | -- | -- | -- | -- | -- |
| Bishop Street | 6 | -- | -- | -- | -- | -- |
| Nuuanu Avenue | 6 | -- | -- | -- | -- | -- |
| Victoria Street | 10 | 5 | 5 | 7 | 9 | -- |
| Miller Street | -- | -- | 6 | 6 | 8 | -- |
| Punahou Street | -- | -- | -- | 6 | -- | -- |
| Smith Street | -- | -- | -- | 5 | -- | -- |



AR00031723

Table 5.A4 - continued

| Intersection | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| Bishop Street - | | | | | | |
| Hotel Street | -- | -- | -- | -- | -- | 6 |
| King Street | -- | -- | -- | -- | -- | 5 |
| Merchant Street | -- | -- | -- | -- | -- | 5 |
| Queen Street | -- | -- | -- | -- | -- | 5 |
| Campbell Avenue - | | | | | | |
| Castle Street | -- | -- | -- | -- | -- | 5 |
| Dillingham Boulevard - | | | | | | |
| Kohou Street | 17 | 19 | 7 | 12 | 12 | 10 |
| Kokea Street | 10 | 6 | 9 | 9 | 7 | 7 |
| Harding Avenue - | | | | | | |
| Kapahulu Avenue | 5 | -- | -- | -- | -- | -- |
| 6th Avenue | 6 | 7 | 5 | -- | -- | -- |
| 11th Avenue | -- | 6 | -- | -- | -- | 6 |
| 7th Avenue | -- | -- | -- | -- | -- | 5 |
| Koko Head Avenue | -- | 5 | -- | -- | -- | -- |
| 12th Avenue | -- | 6 | -- | -- | -- | -- |
| Houghtailing Street - | | | | | | |
| Hala Drive | -- | -- | 5 | 5 | 6 | 6 |
| Halekauwila Street - | | | | | | |
| South Street | -- | -- | -- | 7 | 5 | -- |
| Hotel Street - | | | | | | |
| Punchbowl Street | -- | -- | -- | 8 | 9 | -- |
| Fort Weaver Road - | | | | | | |
| Fort Weaver Spur | -- | 8 | 6 | 5 | -- | -- |
| Kaheka Street - | | | | | | |
| Makaloa Street | -- | -- | -- | -- | 8 | 7 |
| Kanunu Street | -- | -- | -- | -- | 9 | -- |
| Kahuanani Street - | | | | | | |
| Kahuanui Street | -- | -- | -- | -- | -- | 5 |
| Kailua Road - | | | | | | |
| Hoolai Road | -- | -- | -- | -- | -- | 5 |
| Kainehe St. - Hamakua Dr. | -- | -- | -- | -- | 6 | 7 |
| Kuulei Road - Oneawa | -- | -- | -- | -- | -- | 7 |
| Oneawa Road | -- | -- | 5 | 5 | 6 | -- |
| Kalakaua Avenue - | | | | | | |
| Ena Road | -- | -- | 6 | 6 | -- | 14 |
| Kaiulani Avenue | 5 | 8 | 6 | -- | -- | 7 |
| Kalaimoku Street | -- | -- | -- | -- | -- | 6 |
| Kapahulu Avenue | -- | -- | -- | -- | 9 | 5 |



AR00031724

Table 5.A4 - continued

| Intersection | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| Kalakaua Avenue - continued | | | | | | |
| Lewis Road | -- | -- | 5 | 7 | -- | 5 |
| McCully Street | -- | -- | -- | -- | 5 | 5 |
| Saratoga Road | -- | -- | -- | 6 | -- | 11 |
| Uluniu Avenue | -- | -- | 6 | 7 | -- | 8 |
| Ala Wai Boulevard | 6 | 20 | 16 | 8 | 14 | -- |
| Beach Walk | -- | -- | -- | -- | 5 | -- |
| King Street | -- | -- | -- | 7 | 6 | -- |
| Fern Street | -- | -- | -- | 5 | -- | -- |
| Kuhio Avenue | -- | 5 | -- | 6 | -- | -- |
| Royal Hawaiian Avenue | -- | -- | 5 | 7 | -- | -- |
| Seaside Avenue | 5 | -- | 5 | 5 | -- | -- |
| Liliuokalani Avenue | -- | -- | 8 | -- | -- | -- |
| Philip Street | 5 | 6 | -- | -- | -- | -- |
| Kuamoo Street | 5 | -- | -- | -- | -- | -- |
| Kapahulu Avenue - | | | | | | |
| Ala Wai Boulevard | 7 | -- | -- | 12 | -- | -- |
| Paki Avenue | -- | 7 | -- | 6 | -- | 5 |
| Kaimalu Avenue | -- | -- | -- | 7 | 5 | -- |
| Date Street | -- | -- | -- | -- | -- | 5 |
| Kapiolani Boulevard - | | | | | | |
| Atkinson Drive | 8 | 10 | 9 | -- | 11 | 9 |
| Cooke Street | -- | 5 | 8 | -- | -- | 6 |
| Date Street - Kamoku Street | 6 | -- | -- | 6 | -- | 6 |
| Hauoli Street | 8 | -- | 8 | 7 | 8 | 12 |
| Kehaka Street - Mahukona | -- | -- | -- | 10 | 8 | 13 |
| Kalakaua Avenue | 12 | 9 | 16 | 8 | 11 | 15 |
| Kalauokalani Way | -- | 5 | 5 | 5 | -- | 5 |
| Konaiki Street | -- | -- | 8 | -- | 7 | 5 |
| Piikoi Street | 8 | 9 | 17 | -- | 16 | 10 |
| Pumehana Street | 5 | 11 | 14 | 11 | 5 | 11 |
| Sheridan Street | 6 | 5 | 5 | 6 | 5 | 5 |
| South Street | 9 | -- | 5 | -- | 11 | 6 |
| University Avenue | -- | -- | 5 | -- | -- | 5 |
| Ward Avenue | 10 | 7 | -- | 10 | 7 | 16 |
| Beretania Street | -- | -- | -- | -- | 6 | -- |
| Kamakee Street | -- | 7 | -- | 7 | 7 | -- |
| King Street (City Hall) | -- | -- | -- | -- | 5 | -- |
| Mahukona Street | 12 | 8 | 9 | 12 | 5 | -- |
| Kaimuki Avenue | -- | -- | -- | 7 | -- | -- |
| Pensacola Street | -- | -- | 8 | 5 | -- | -- |
| Keeaumoku Street - | | | | | | |
| Nehoa Street | -- | 5 | 7 | 11 | 7 | 8 |
| Young Street | 13 | -- | 5 | -- | 6 | 9 |
| Rycroft Street | -- | -- | -- | -- | 8 | -- |
| Mahaloa Street | -- | -- | 5 | 5 | -- | -- |



AR00031725

Table 5.A4 - continued

| Intersection | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| Kinau Street - | | | | | | |
| Pensacola Street | 5 | 11 | -- | 7 | 9 | 8 |
| Piikoi Street | 10 | 6 | 7 | 12 | 5 | 9 |
| Ward Avenue | -- | -- | -- | 16 | 8 | 6 |
| Keeaumoku Street | 10 | 9 | 6 | 7 | 6 | -- |
| Victoria Street | -- | -- | 12 | 5 | 6 | -- |
| King Street - | | | | | | |
| Iwilei Road | 6 | -- | -- | 9 | -- | 7 |
| Kapiolani Boulevard | 15 | 7 | 7 | -- | -- | 5 |
| Keeaumoku Street | 10 | 15 | 7 | 9 | 9 | 17 |
| McCully Street | 8 | 8 | -- | 5 | 8 | 7 |
| Mokauea Street | -- | 5 | -- | -- | -- | 6 |
| Palama Street | -- | 6 | -- | -- | 5 | 5 |
| Pensacola Street | -- | 9 | 7 | -- | 8 | 5 |
| Piikoi Street | 8 | 9 | -- | 11 | 11 | 12 |
| Punahou Street | 7 | -- | 5 | 12 | -- | 15 |
| Punchbowl Street | 6 | -- | 6 | -- | 11 | 8 |
| River Street | -- | -- | -- | -- | 7 | 8 |
| South Street | -- | -- | -- | -- | 6 | 8 |
| University Avenue | 6 | 8 | 6 | 7 | 9 | 10 |
| Kam IV Road | 5 | -- | -- | -- | -- | -- |
| Victoria Street | -- | -- | -- | -- | -- | 5 |
| Waiakamilo Street | -- | 5 | -- | -- | 7 | 10 |
| Ward Avenue | 11 | 5 | 6 | 5 | 9 | 12 |
| Kokea Street | 9 | 9 | -- | 8 | 6 | -- |
| Alakea Street | 5 | -- | 6 | 7 | -- | -- |
| Alapai Street | -- | -- | -- | 5 | -- | -- |
| Kohou Street | -- | 7 | -- | 5 | -- | -- |
| Peterson Lane | -- | -- | 5 | 5 | -- | -- |
| Richards Street | -- | -- | -- | 5 | -- | -- |
| Winant Street | -- | -- | -- | 5 | -- | -- |
| Aala Street | -- | -- | 5 | -- | -- | -- |
| Houghtailing Street | 9 | -- | -- | -- | -- | -- |
| Kalakaua Avenue | 7 | 13 | 8 | -- | -- | -- |
| Maunakea Street | -- | -- | 8 | -- | -- | -- |
| Isenberg Street | -- | 7 | -- | -- | -- | -- |
| Mililani Street | -- | 5 | -- | -- | -- | -- |
| Bishop Street | 5 | -- | -- | -- | -- | -- |
| Koko Head Avenue - | | | | | | |
| Pahoa Avenue | -- | -- | -- | -- | -- | 5 |
| Kona Street - | | | | | | |
| Mahukona Street | -- | -- | -- | -- | -- | 8 |
| Kuhio Avenue - | | | | | | |
| Lewers Street | -- | -- | -- | -- | 5 | 7 |
| Kalaimoku Street | -- | -- | -- | -- | -- | 6 |
| Seaside Avenue | -- | -- | -- | -- | -- | 6 |
| Walena Street | -- | -- | -- | -- | -- | 5 |



AR00031726

Table 5.A4 - continued

| Intersection | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| Kukui Street - | | | | | | |
| Nuuanu Avenue | -- | -- | -- | -- | -- | 5 |
| Liliha Street - | | | | | | |
| Kukui Street | -- | 7 | 9 | 8 | -- | 11 |
| Judd Street | 7 | 5 | -- | -- | -- | -- |
| Kuakini Street | 6 | 6 | -- | -- | -- | -- |
| School Street | -- | 9 | 11 | 9 | -- | -- |
| Leahi Avenue - | | | | | | |
| Monsarrat Avenue | -- | 5 | -- | -- | -- | -- |
| Lunalilo Street - | | | | | | |
| Pensacola Street | -- | 8 | -- | -- | 9 | 7 |
| Piikoi Street | -- | 8 | -- | 5 | -- | 6 |
| Ward Avenue | -- | -- | -- | -- | -- | 5 |
| McCully Street - | | | | | | |
| Citron Street | 5 | 5 | 5 | -- | -- | -- |
| Miller Street - | | | | | | |
| Rose Street | -- | -- | 9 | -- | -- | 8 |
| Nehoa Street - | | | | | | |
| Auwaiolimu Street | -- | -- | -- | -- | -- | 6 |
| Moanalua Road - | | | | | | |
| Aiea Heights Road | -- | -- | -- | 5 | -- | -- |
| Kaimakani Street | -- | -- | -- | 6 | -- | -- |
| Nuuanu Avenue - | | | | | | |
| Hotel Street | -- | -- | -- | 5 | -- | -- |
| Kuakini Street | 8 | 10 | -- | 8 | -- | -- |
| Kukui Street | -- | -- | 9 | -- | -- | -- |
| School Street | -- | 12 | 8 | -- | -- | -- |
| Bates Street | 5 | 5 | -- | -- | -- | -- |
| Pauoa Road | 5 | 12 | -- | -- | -- | -- |
| Wyllie Street | -- | 5 | -- | -- | -- | -- |
| Judd Street | 5 | -- | -- | -- | -- | -- |
| Pensacola Street - | | | | | | |
| Young Street | 7 | 7 | 7 | 5 | 6 | 6 |
| Prospect Street | -- | -- | -- | -- | 7 | -- |
| Pahoa Avenue - | | | | | | |
| 12th Avenue | -- | -- | -- | 6 | -- | -- |
| 18th Avenue | -- | -- | 6 | -- | -- | -- |
| 11th Avenue | -- | -- | 6 | -- | -- | -- |
| Hunakai Street | -- | -- | 5 | -- | -- | -- |
| Piikoi Street - | | | | | | |
| Waimanu Street | -- | -- | -- | -- | 6 | 6 |
| Young Street | 9 | 14 | 13 | -- | 5 | -- |



AR00031727

Table 5.A4 - continued

| Intersection | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| Punahou Street - | | | | | | |
| Young Street | -- | 5 | -- | -- | 5 | 6 |
| Punchbowl Street - | | | | | | |
| Miller Street | -- | -- | 5 | -- | -- | -- |
| Queen Street | -- | -- | -- | -- | 5 | 7 |
| Queen Street - | | | | | | |
| Alakea Street | 10 | 6 | 8 | -- | -- | 9 |
| Bishop Street | -- | -- | 7 | -- | -- | -- |
| South Street | -- | -- | 8 | -- | -- | -- |
| School Street - | | | | | | |
| Iolani Avenue | -- | -- | -- | 6 | -- | -- |
| Houghtailing Street | 6 | 5 | 5 | 8 | -- | 10 |
| Kam IV Road | 7 | 10 | 5 | 5 | 5 | 6 |
| Lanikila Avenue | 6 | 7 | -- | -- | 8 | 6 |
| Palama Street | 5 | -- | -- | -- | 8 | 5 |
| Makuahine Street | -- | -- | -- | 8 | 11 | -- |
| Kapalama Avenue | -- | -- | -- | 8 | -- | -- |
| Gulick Avenue | -- | -- | 8 | -- | -- | -- |
| South Street - | | | | | | |
| Halekauwila Street | 5 | 7 | 6 | -- | -- | 5 |
| Pohukaina Street | -- | -- | -- | -- | -- | 5 |
| Auahi Street | -- | 7 | 5 | -- | 5 | -- |
| University Avenue - | | | | | | |
| Date Street | -- | -- | -- | 5 | -- | 9 |
| Dole Street | 8 | -- | 8 | 7 | -- | 8 |
| Kaala Street | -- | -- | -- | 5 | -- | -- |
| Metcalf Street | 5 | -- | -- | -- | -- | -- |
| Waialae Avenue - | | | | | | |
| 21st Avenue | 9 | -- | -- | -- | -- | -- |
| 11th Avenue | -- | -- | -- | 5 | -- | 10 |
| 9th Avenue | -- | -- | -- | -- | 6 | 11 |
| Palolo Avenue | -- | -- | 14 | 8 | 8 | 14 |
| St. Louis Drive | -- | -- | 7 | 7 | 9 | 8 |
| 2nd Avenue | 5 | -- | 9 | 6 | 6 | 5 |
| 6th Avenue | 7 | -- | 5 | 9 | 12 | 6 |
| 10th Avenue | -- | -- | 7 | 5 | 7 | 6 |
| 3rd Avenue | 7 | -- | -- | -- | 5 | 9 |
| 7th Avenue | -- | -- | -- | 8 | 6 | -- |
| Hunakai Street | -- | 5 | -- | -- | -- | -- |
| King Street | -- | 7 | -- | -- | -- | -- |
| 16th Avenue | -- | 7 | -- | -- | -- | -- |
| 10th Avenue | -- | 9 | -- | -- | -- | -- |



AR00031728

Table 5.A4 - continued

| Intersection | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| Ward Avenue - | | | | | | |
| Kawaihao Street | -- | -- | -- | 5 | -- | 5 |
| Halekauwila Street | -- | -- | -- | -- | -- | 5 |
| Waimanu Street | -- | -- | -- | -- | 5 | -- |
| Auahi Street | -- | -- | -- | 5 | -- | -- |
| Green Street | 12 | 6 | 5 | 6 | -- | -- |
| Wilder Avenue - | | | | | | |
| Keeaumoku Street | 5 | -- | -- | -- | 7 | 5 |
| Metcalf Street | -- | -- | 7 | -- | 6 | 5 |
| Piikoi Street | 5 | 8 | -- | -- | 7 | 5 |
| Punahou Street | 8 | 6 | 6 | 6 | 7 | -- |
| Alexander Street | -- | -- | -- | -- | 5 | -- |
| Makiki Street | -- | -- | -- | 5 | 7 | -- |
| Pensacola Street | 6 | 9 | -- | -- | -- | -- |
| Vineyard Street - | | | | | | |
| Houghtailing Street | 11 | 12 | 7 | -- | -- | -- |
| Kokea Street | 10 | 14 | 8 | -- | -- | -- |
| Palama Street | 5 | 8 | -- | -- | -- | -- |
| Monsarret Avenue - | | | | | | |
| Leahi Avenue | -- | -- | -- | 5 | -- | -- |
| Hotel Street - | | | | | | |
| River Street | 7 | 7 | -- | -- | -- | -- |
| Algaroba Street - | | | | | | |
| Pumehana Street | -- | -- | 5 | -- | -- | -- |
| Hotel Street - | | | | | | |
| Bishop Street | -- | -- | 5 | -- | -- | -- |
| St. Louis Drive - | | | | | | |
| Dole Street | -- | -- | 5 | -- | -- | -- |
| Kilauea Avenue - | | | | | | |
| 12th Avenue | -- | -- | 5 | 6 | -- | -- |
| Date Street - | | | | | | |
| Mahiai Street | -- | -- | -- | 5 | -- | -- |



AR00031729

# VI Local Transit Study

AR00031730

# VI. LOCAL-TRANSIT STUDY

## A. INTRODUCTION

Present transit service on Oahu is provided by three companies--the Honolulu Rapid Transit Company, Ltd., Wahiawa Transport System, Ltd., and the Leeward Bus Company, Ltd. The Wahiawa Transport System is in common ownership with Honolulu Rapid Transit, which provides the vast majority of transit service. Leeward Bus Company is an independent operation.

Two other companies provide service in Honolulu--the Grey Line Hawaii Limited and the Trade Wind Transportation Company, furnishing scheduled daily tours from the major hotels; they are not involved in normal transit service. The Honolulu Rapid Transit Company also provides Around-the-Island tours and charter service in addition to its transit service.

Urban mass transit in the City of Honolulu is thus essentially that provided by the Honolulu Rapid Transit Company. The present company was originally known as the Honolulu Rapid Transit and Land Company, franchised by the Republic of Hawaii in 1898 to serve the Honolulu District. The company divorced itself from the land business in 1922, at which time it assumed its present name. The company passed through the streetcar and trolly-coach era and is now an all-bus operation.

The Wahiawa Transport System Limited furnishes inter-urban service between downtown Honolulu and the interior of Oahu to Wahiawa and Schofield Barracks. The company also operates local service linking the military and residential areas of central Oahu.

The Leeward Bus Company Limited is the smallest of the transit operations in Honolulu. Its present service is between downtown Honolulu and Barbers Point Air Station, with stops at Pearl City and Aiea. The 1960 Honolulu Metropolitan Area Traffic Survey notes a Windward Division of the Leeward Bus Company, which provided hourly service between Kailua and Honolulu. At that time this division also operated an hourly local service between Kailua and Lanikai.



AR00031731

The Windward Division has ceased operation and at the present time there is no scheduled transit service between Honolulu and the windward communities of Oahu.

The relative importance of the three transit operations is shown by the 1960 comparison of equipment and patronage, Table 6.1.

Table 6.1. Comparison of Transit Equipment and Patronage on Oahu in 1960

| Company | Total Scheduled Buses In Operation | Average Weekday Revenue Passengers |
|---|---|---|
| Honolulu Rapid Transit Company, Ltd. | 198 | 89,221 |
| Wahiawa Transport System, Ltd. | 42 | 2,768 |
| Leeward Bus Company, Ltd. | 14 | 3,421 |

In 1954, Honolulu Rapid Transit established an Around-the-Island tour service, which has shown constant increase in utilization and is a profitable operation. The significance of charter operations is shown by the fact that in 1955 HRT derived $70,880 in revenue from this activity but increased it to $253,363 by 1965.

The importance of the minor companies in providing mass-transit service to Honolulu is very limited. The Honolulu Rapid Transit Company is the prime mass-transit operator in Honolulu and, therefore, the discussion and analysis of mass transit in Honolulu is based on the activity of this company, which is referred to as the HRT.

The HRT operates under a Certificate of Public Convenience and Necessity granted by the Public Utilities Commission of the State of Hawaii. It is a stock company with 50,000 shares of $10-par-value preferred stock and 180,000 shares of $10-par-value common stock issued as of 1960.

HRT is currently, and in recent history, a profitable operation. In 1965, it had a passenger revenue of $4,580,040 and operating expense of $3,932,184, including all taxes and depreciation.

The company has secured permission to omit revenue expense of its Around-the-Island tour operation from transit-fare calculations. Therefore,



AR00031732

the analysis of service, revenue, and expense discussed herein is limited to transit-passenger revenue and expense. Revenues derived from car-card advertisements and charter service and other activity have not been included.

## B. EQUIPMENT INVENTORY

Table 6.2 shows bus equipment owned by HRT as of mid-1966. The fleet includes only ten air-conditioned units, purchased in 1966, which are utilized for charter service. Of the 233 units, 172 are in use by HRT, with the balance used by Wahiawa Transport System. The last major equipment purchase was in 1957, when 73 buses were acquired for use on HRT lines. There are currently 54 buses (29 percent of total HRT fleet) in use by HRT that are over 10 years old and may be ready for replacement.

One of the major problems facing transit operators is the size of bus inventory relative to utilization. An average ratio of peak-to-midday equipment utilization for 15 Mainland cities was found to be 2.69 [Ref. 6.1]. Based on HRT vehicle assignments, this peak-to-midday base in Honolulu is 1.81. Since no hour-by-hour volumes are available, it is not possible to determine if this indicates a higher-than-normal load factor during peak hours; however, observation of buses on the main routes would indicate it to be a combination of both.

## C. ROUTES AND COVERAGE

The area served by HRT is shown in Fig. 6.1, which shows routes in the urban areas. Coverage is good in the central areas of Honolulu, with the newly developed suburban areas, particularly those toward Koko Head, presently receiving only limited service. This condition is similar to that of most cities in that transit expansion has not kept pace with urban growth. HRT operates approximately 150 route miles, all on a local basis. There are no express or skip-stop operations in the system as presently run.

Appendix VI-A shows the existing routes, one-way mileage and average headways for a.m. peak, day base and p.m. peak. From this table, the buildup of service entering the CBD is apparent on major east-west routes. Also, the similarity between peak headways and day base is indicative of the low peak-to-midday ratio mentioned earlier.



AR00031733

Table 6.2. Equipment Inventory for HRT in 1966
Source: HRT Equipment Records

| Equipment Type | Transmission | No. | Passenger Capacity | User | Year Delivered |
|---|---|---|---|---|---|
| 4507 Diesel | Hydraulic | 29 | 45 | HRT | 1947 |
| 5105 Diesel | Hydraulic | 13 | 49 | HRT | 1953 |
| 4505 Diesel | Manual | 8 | 35* | HRT | 1942 |
| 4505 Diesel | Manual | 4 | 45 | HRT | 1942 |
| 5105 Diesel | Hydraulic | 73 | 49 | HRT | 1957 |
| 5301 Diesel | Hydraulic | 10** | 49 | HRT | 1962 |
| 5303 Diesel | Hydraulic | 13 | 49 | HRT | 1963 |
| 5303 Diesel | Hydraulic | 7 | 49 | HRT | 1964 |
| 4518 Diesel | Hydraulic | 10 | 45 | HRT | 1965 |
| 5303 Diesel | Hydraulic | 10† | 49 | HRT | 1966 |
| ACF Gasoline | Manual | 5†† | 30 | HRT | 1950 |
| 4507 Diesel | Hydraulic | 21 | 45 | WTS | 1947 |
| 5105 Diesel | Hydraulic | 2 | 49 | WTS | 1953 |
| 5105 Diesel | Hydraulic | 2 | 49 | WTS | 1957 |
| White Gasoline | Manual | 26 | 44 | WTS | 1945 |
| Buses Owned by HRT | | 233 | | | |

*Modified by cutting center section out - 154-inch wheel base (used in mountain runs).

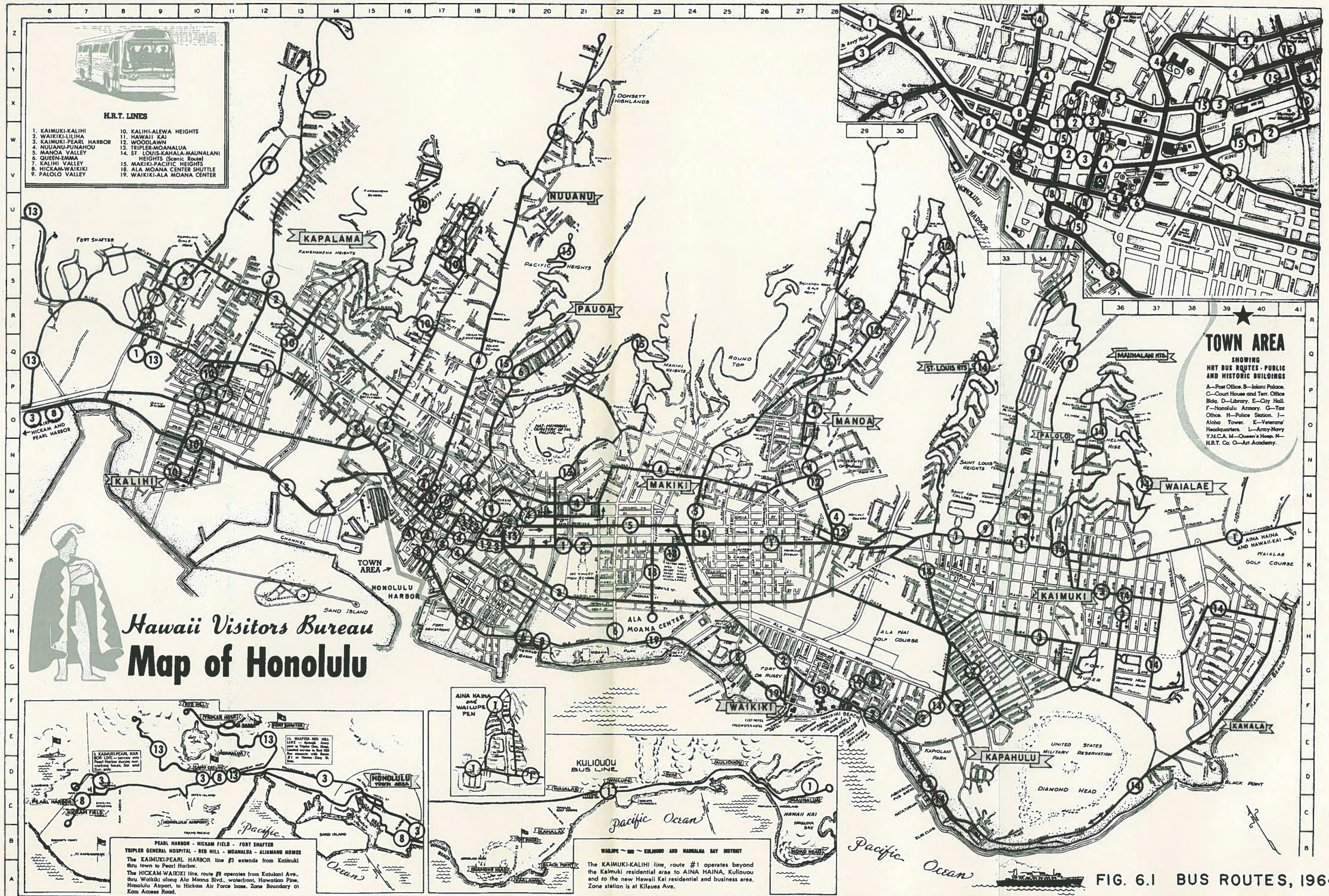
**Five used in charter service only.

†Air conditioned and used for charter service only.

††Two are converted to baggage vans for tour service to airport.



AR00031734




*Hawaii Visitors Bureau*

# Map of Honolulu

FIG. 6.1 BUS ROUTES, 1964



AR00031735

## D. OPERATIONAL DATA AND TRENDS

### 1. SCHEDULE SPEEDS

Table 6.3 shows the current average operating speeds on the HRT system. Since these are average speeds over the length of the lines, they may be expected to be substantially higher in outlying areas and reducing to values below those indicated on close-in sections. This reduction in speed is offset by more frequent service.

Table 6.3. Line Speeds on HRT Routes
Source: HRT Records

| Route | Destinations | Speed (mph) |
|---|---|---|
| 1 | Kaimuki-Kalihi | 11.40 |
| 2 | Waikiki-Liliha | 10.00 |
| 3 | Kaimuki-Pearl Harbor | 13.40 |
| 4 | Nuuanu-Punahou | 11.90 |
| 5 | Manoa Valley | 10.70 |
| 6 | Queen Emma | 10.40 |
| 7 | Kalihi Valley | 13.40 |
| 8 | Hickam-Waikiki | 13.40 |
| 9 | Palolo Valley | 10.30 |
| 10 | Kalihi-Alewa Heights | 12.60 |
| 12 | Woodlawn | 12.15 |
| 13 | Tripler-Moanalua | 15.02 |
| 14 | St. Louis-Kahala-Maunalani | 13.20 |
| 15 | Makiki-Pacific Heights | 11.66 |
| 18 | Ala Moana Center | 6.18 |
| 19 | Waikiki-Ala Moana Center | 8.30 |

### 2. MILES OPERATED PER REVENUE PASSENGER

The topography of Leeward Oahu has dictated that urban Honolulu take the form of a dense ribbon-type development. This characteristic results in an optimum configuration for transit service. The number of routes required to serve such an area is less than for a nonlinear or spread city form common in most Mainland locations, which require extensive diagonal and cross-town service.



AR00031736

An indicator of this characteristic is the vehicle miles of travel per revenue passenger. As shown in Fig. 6.2, Honolulu has not exceeded 0.23 mile travel per passenger since 1955, with the rate decreasing since 1960 to 0.21 in 1965. This is considerably less than the United States average of 0.323 mile per revenue passenger and increasing as a result of the national trend toward fewer transit riders.

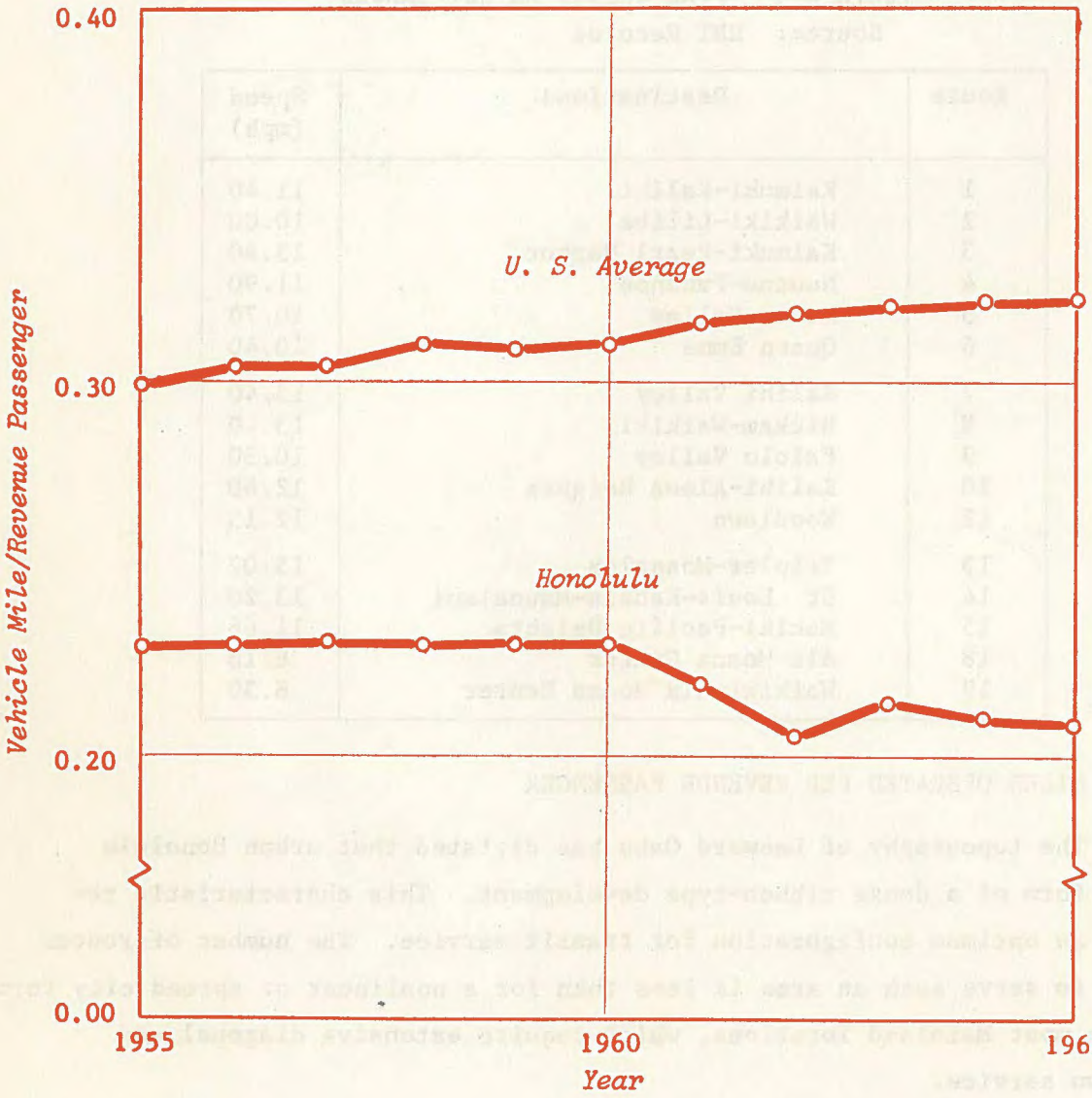



FIG. 6.2. BUS MILES PER REVENUE PASSENGER.



AR00031737

3. FARE STRUCTURE

Figure 6.3 shows the history of fare structure in HRT and indicates a fairly rapid rise in recent years. This is to be expected since labor rates and operating costs have also risen sharply on a national scale over these years. However, as fares rise, there is often a tendency for patronage to drop, at least partially offsetting the increased revenue generated by the higher fare. This downward spiral has been the cause for several transit properties in Mainland cities to cease operation or else be acquired by municipal agencies.

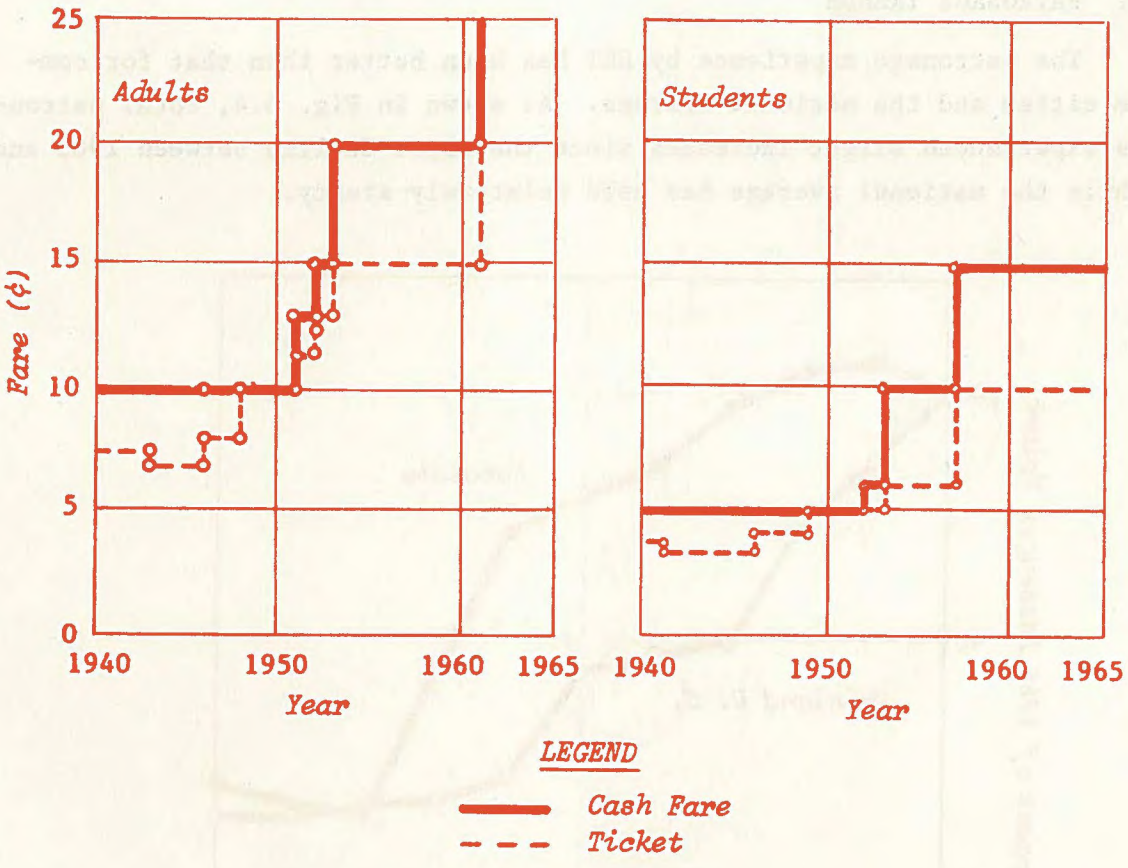



FIG. 6.3. FARE TRENDS ON OAHU.

Sources: PUC Report of March 1961 on HRT and 1965 HRT Financial Report.



AR00031738

In Honolulu this fare increase may be a contributing factor to the sharp drop in patronage between 1960 and 1963, since a fare decrease of $0.05 cash was authorized in 1961. However, in this case, the patronage drop did not result in a reduction in revenue. In fact, passenger revenue was up in 1963 over 1960 and has continued to rise, indicating that the fare increase more than offset the loss of patronage. This increase in operating revenue was also accompanied by a substantial reduction in operating cost, indicating that significant economies of operation were put into effect along with the fare increase. HRT has pending a request for fare increase as this report is written.

4. PATRONAGE TRENDS

The patronage experience by HRT has been better than that for comparable cities and the national average. As shown in Fig. 6.4, total patronage has experienced slight increases since the major decline between 1960 and 1963 while the national average has held relatively steady.

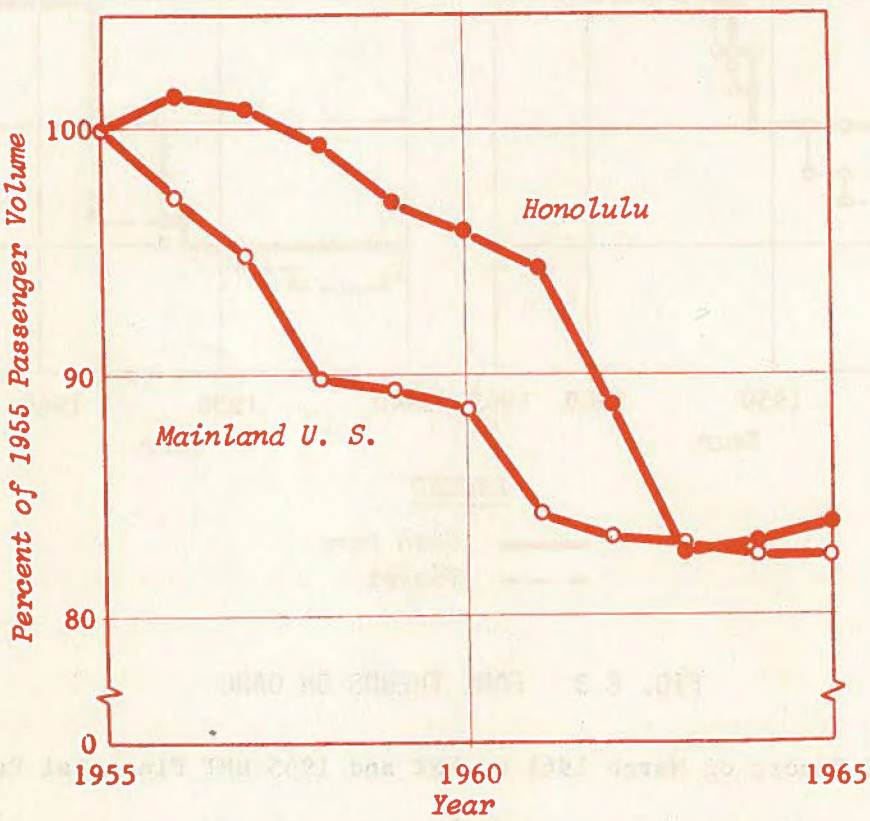



FIG. 6.4. TREND IN REVENUE PASSENGERS, U. S. AND HONOLULU

Source: National Data Transit Fact Book, 1966, Edition. Honolulu - HRT Annual Reports & 1960 PUC Application.



AR00031739

Figure 6.5 shows the trend in annual revenue passengers carried by HRT from 1955 to 1965 and indicates that school passengers have continued a steady, almost constant rate of decline since 1956 while adult revenue passengers are showing an increasing trend in recent years. This plot also indicates the effect of the recent fare increase reflected by a constant-slope relationship on the school passengers where no increase was granted compared to the sharp drop in adult revenue passengers between 1961 and 1963.

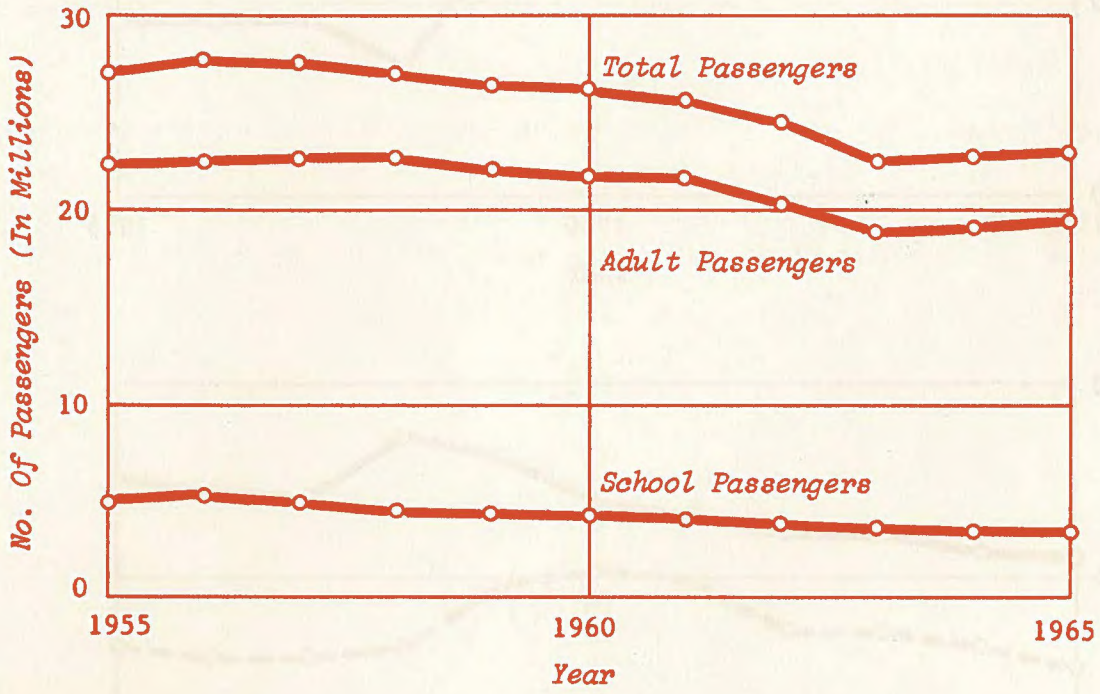



FIG. 6.5. TOTAL ANNUAL REVENUE PASSENGERS.

5. OPERATING REVENUE AND EXPENSE

Revenue from passenger service and operating expense for the last 10 years are shown in Fig. 6.6. Revenue includes only that derived from transit-passenger fares and operating expense includes all costs of operation, administration, and depreciation but excludes all local, state, and federal taxes. The comparison of expense to revenue shows an extremely favorable operating ratio. This operating ratio would seem to be a direct result of the low miles-per-revenue-passenger ratio shown earlier.



AR00031740

FIG. 6.6. HRT OPERATING REVENUES AND EXPENSES.



AR00031741

## E. SCHOOL-BUS TRANSIT

School bus means every motor vehicle owned by a public or governmental agency and operated for the transportation of children to or from school, or privately owned and operated for compensation for the transportation of children to or from school.

Except for those services maintained by the military for its school children, there are no special school routes maintained by private or governmental agencies for the transport of children to or from school. There is, however, school service provided by "school specials," which are operated in the following manner by HRT. Buses on selected routes leaving the a.m. peak service and entering the p.m. peak service do so at a school location convenient to their normal route rather than entering the route directly from the garage. In this way, students are taken from the bus stops at the school to transfer points or main lines to continue their trip. Schools served in this manner are: Ala Wai, Dole Intermediate, Hanahauoli, Kawananakoa and Maemae, Koko Head, Niu Valley Intermediate, Pohukaina, Punahou, Roosevelt, St. Francis Convent, Star of the Sea, Stevenson, University of Hawaii Elementary, and Hokulani.

Because many students reside far away from school and are without transportation as a result of the absence of established bus routes or because of economic hardship, they are thereby forced to walk to schools along dangerous highways with no sidewalks and cross major highways with no crosswalks or traffic signals. Therefore, the Fourth Legislature of the State of Hawaii enacted legislation authorizing the State Department of Education to provide suitable transportation for all school children in grades kindergarten to 12 and in special education classes. The Department shall adopt the policy, procedure, and programs it deems necessary to provide suitable transportation. In formulating the policy, procedure and program, the Department shall consider the school district, the school attendance area in which a school child normally resides, the distance the school child lives from the school, the availability of public carrier or other means of transportation, the frequency, regularity, and availability of public transportation, and the grade level, physical handicap, or special learning disability of a school child, and any such conditions and circumstances unique or peculiar to the area.



AR00031742

**Proposed rules relating to transportation of students are now before the Board of Education for public discussion and hearings. This public policy decision will generally decide the extent to which public mass transit is utilized for school trips.**



AR00031743

# APPENDIX VI-A. HRT ROUTES AND HEADWAYS

AR00031744

Table 6.A1. Existing HRT Routes and Average Headways
Source: Headways - Developed from "Inventory of Public Transit on Oahu", Tech. Memo 5001, prepared by R. W. Haselwood, October 1964. Mileage - HRT Vehicle Assignment Sheet.

| Route No. | Route Miles One Way | Destination | Average Headway (min) | | |
|---|---|---|---|---|---|
| | | | AM Peak | Mid-day | PM Peak |
| 1 | 18.40 | Kaimuki-Kalihi | | | |
| | | Eastbound | | | |
| | | CBD to Koko Head Ave. | 4.3 | 5.0 | 3.5 |
| | | Koko Head Ave. to Kealaolu Ave. | 5.7 | 10.0 | 7.0 |
| | | Kealaolu Ave. to Aina Haina | 10.7 | 15.0 | 15.0 |
| | | Aina Haina to Lunalilo Home Road | 30.0 | 60.0 | 30.0 |
| | | Westbound | | | |
| | | CBD to Aala Park | 3.6 | 5.0 | 4.3 |
| | | Aala Park to Houghtailing St. | 5.0 | 10.0 | 5.0 |
| | | Houghtailing St. to Kalihi | 5.0 | -- | 5.0 |
| 2 | 12.85 | Waikiki-Liliha | | | |
| | | Eastbound | | | |
| | | CBD to Piikoi Street | 3.8 | 6.0 | 4.5 |
| | | Piikoi St. to Kapahulu Ave. | 3.9 | 6.0 | 4.5 |
| | | Kapahulu Ave. to Kapiolani Park | 11.0 | 12.0 | 9.0 |
| | | Kapahulu Ave. to Campbell Ave. | 13.0 | 12.0 | 9.0 |
| | | Westbound | | | |
| | | CBD to Aala Park | 4.8 | 6.0 | 4.2 |
| | | Aala Park to Kalihi St. | 5.7 | 6.0 | 4.2 |
| | | Kalihi St. to Puunui Ave. | 13.0 | 12.0 | 8.0 |
| | | Kalihi St. to Middle St. | 10.0 | 12.0 | 9.0 |
| 3 | 18.60 | Kaimuki to Pearl Harbor | | | |
| | | Eastbound | | | |
| | | CBD to Waialae Ave. | 11.0 | 20.0 | 11.0 |
| | | Westbound | | | |
| | | CBD to Aala Park | 7.4 | 20.0 | 30.0 |
| | | Aala Park to Navy Main Gate | 23.0 | 20.0 | 30.0 |
| 4 | 9.60 | Nuuanu-Punahou | | | |
| | | Eastbound | | | |
| | | CBD to University - Moiliili | 13.0 | 20.0 | 13.0 |
| | | University - Moiliili to Kaala St. | 30.0 | 40.0 | 30.0 |
| | | Westbound | | | |
| | | CBD to Nuuanu, Dowsett Ave. | 18.0 | 20.0 | 15.0 |
| 5 | 5.85 | Manoa Valley | | | |
| | | Northbound | | | |
| | | Bishop St. to Manoa Valley | 15.0 | 30.0 | 15.0 |
| | | Manoa Valley to Manoa Gardens | 30.0 | 30.0 | 30.0 |



AR00031745

Table 6.A1 - continued

| Route No. | Route Miles One Way | Destination | Average Headway (min) | | |
|---|---|---|---|---|---|
| | | | AM Peak | Mid-day | PM Peak |
| 6 | 5.75 | Queen Emma | | | |
| | | Eastbound | | | |
| | | CBD to Ala Moana Center | 15.0 | 16.0 | 15.0 |
| | | Northbound | | | |
| | | CBD to Pauoa Valley | 13.0 | 16.0 | 12.0 |
| 7 | 6.00 | Kalihi Valley | | | |
| | | Kalihi Kai | 18.0 | 25.0 | 15.0 |
| | | Kalihi Valley | 18.0 | 25.0 | 23.0 |
| 8 | 15.35 | Hickam-Waikiki | | | |
| | | Eastbound | | | |
| | | CBD to Ala Moana Center | 23.0 | 30.0 | 30.0 |
| | | Ala Moana Center to Waikiki | 23.0 | 60.0 | 30.0 |
| | | Westbound | | | |
| | | CBD to Hickam Field | 45.0 | 60.0 | 60.0 |
| 9 | 4.65 | Palolo Valley | 20.0 | 25.0 | 18.0 |
| 10 | 7.60 | Kalihi-Alewa Heights | | | |
| | | Kalihi Kai | 30.0 | 60.0 | 30.0 |
| | | Alewa Heights | 15.0 | 60.0 | 30.0 |
| 12 | 5.00 | Woodlawn | 23.0 | 35.0 | 23.0 |
| 13 | 12.15 | Tripler-Moanalua | | | |
| | | Northbound | | | |
| | | Kamehameha Hwy. to Tripler Hospital | 30.0 | 26.0 | 30.0 |
| | | Tripler Hospital to Red Hill | 30.0 | 210.0 | 30.0 |
| | | Westbound | | | |
| | | Kamehameha Hwy. to Aliamanu | 60.0 | 48.0 | 60.0 |
| 14 | 16.45 | St. Louis-Kahala-Maunalani | | | |
| | | Northbound | | | |
| | | Waialae Ave. to Maunalani Heights | 30.0 | 60.0 | 23.0 |
| | | Southbound | | | |
| | | Waialae Ave. to St. Louis Heights | 30.0 | 60.0 | 30.0 |
| 15 | N.A. | Makiki-Pacific Heights | | | |
| | | So. Beretania St. to Makiki | 20.0 | 40.0 | 20.0 |
| | | Makiki to Pacific Heights | 60.0 | 120.0 | 60.0 |
| 18 | 1.70 | Ala Moana Center | | | |
| | | Ala Moana Center to Young St. | 15.0 | 15.0 | 15.0 |
| 19 | N.A. | Waikiki-Ala Moana Center | | | |
| | | Ala Moana Center to Waikiki | -- | 30.0 | 30.0 |



AR00031746

# VII Automobile Ownership Study

# VII. AUTOMOBILE OWNERSHIP STUDY

## A. INTRODUCTION

Estimate of future car ownership is important because future trip generation is directly affected by this forecast. In the Oahu Transportation Study, car ownership appears as an independent variable in nearly all home-based-production, person-trip-generation equations. Also, estimate of the percent transit riders is dependent on the ratio of cars per dwelling unit at the production zone.

Car-ownership forecast equations derived in this study were based entirely on findings of the 1960 origin-destination survey and thus are characterized by two important limitations. First, use of cross-sectional data for a single point in time precludes the possibility of taking automatic account of changes in regression coefficients over time. Second, statistics from a relatively small sample (1/15 of all households) are subject to considerable sampling variations. Such variation is especially important in cross tabulations of data for small-population tracts. The use of the 1960 origin-destination survey, however, is justified by the lack of anything better.

This study recognizes that additional factors other than those considered must be made a part of future forecasting techniques. For example, quality of public transportation is a factor, since areas with efficient and frequent public transit often have lower car ownership and use than areas of poor transit service. Attitudes toward car ownership also change under varying conditions of congestion, high operating costs, improved transportation, consumer expenditures, price and wage inflation, changes in urban structure, etc., the lack of which prevented a more refined correlation analysis.

## B. BRIEF HISTORY

Up to December 12, 1906, the automobile was not registered and was allowed to roam at will. Subsequently, the 100 cars in Honolulu were required



AR00031748

to wear number plates. By 1909, there were 329 cars registered in Honolulu; by 1912, there were 1,015; by 1913, 1,264; by 1914, 1,782; by 1916, 2,993; by 1922, 9,115; by 1923, 11,931; and by 1924, 14,466. Uniform annual registration throughout the State of Hawaii began in 1960 under the legislative act of 1929.

## C. MOTOR-VEHICLE REGISTRATION

Table 7.1 shows the motor-vehicle registrations of taxable and nontaxable State, City, and private vehicles (but excludes federal vehicles) for the past six years.

Table 7.1. Motor Vehicle Registrations on Oahu

| Year | Motor-Vehicle Registration | | | |
|---|---|---|---|---|
| | Passenger Vehicles | Trucks | Buses | Total |
| 1961 | 169,773 | 20,479 | 401 | 190,653 |
| 1962 | 180,114 | 20,276 | 393 | 200,783 |
| 1963 | 190,362 | 20,808 | 406 | 211,576 |
| 1964 | 204,815 | 21,746 | 406 | 226,967 |
| 1965 | 220,757 | 22,941 | 418 | 244,116 |
| 1966 | 230,590 | 23,791 | 429 | 254,810 |

Note: Figures include taxable, nontaxable state, city, and private vehicles but exclude federal vehicles.

Since 1961, total motor-vehicle registrations have increased 33 percent while motor vehicles in the passenger category have increased 36 percent. On an average, total vehicle registrations in the last six years have increased approximately 12,800 vehicles per year; of this increase, about 95 percent represented passenger vehicles.

Trends in the ratio of total passenger vehicles to total vehicle registrations indicate that we can expect total passenger-vehicle registrations (Fig. 7.1).



AR00031749

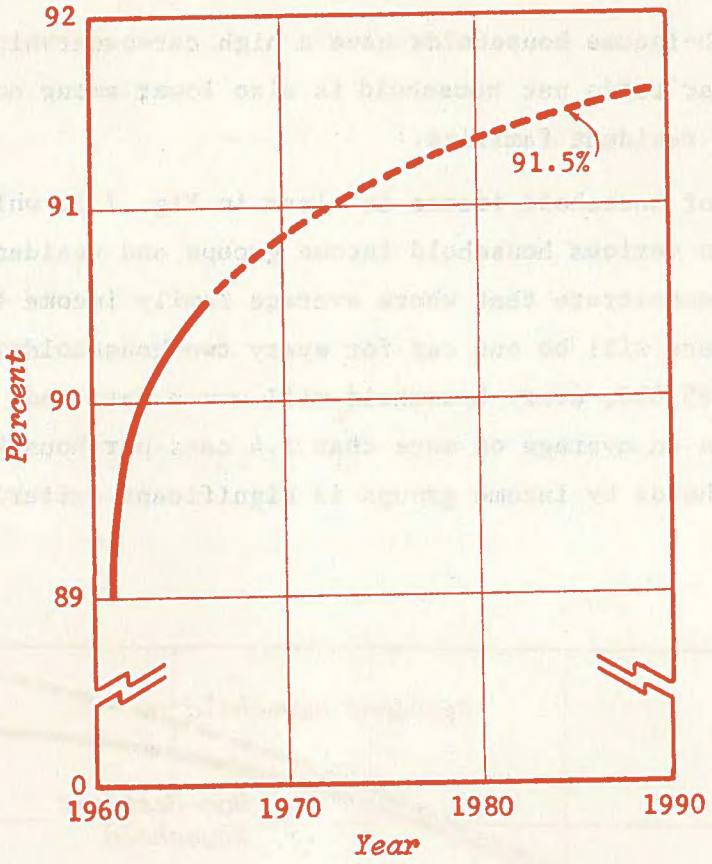



FIG. 7.1. PERCENT PASSENGER VEHICLES OF TOTAL VEHICLE REGISTRATION.

## D. CAR OWNERSHIP

The automobile in Hawaii has become a part of the economic and social life of its people. Vehicle registrations per thousand persons have increased threefold since 1960 and are continuing to increase at a substantial rate.

Vehicle registrations, however, are generally above automobile-ownership figures because 1) they include business and governmental automobiles, and 2) they are a count of license plates which have been sold over a whole year. True ownership is the number of vehicles owned as of one point in time. On Oahu, for example, the total number of automobiles garaged at residences in 1960 was 134,427 which represented 84.8 percent of the total automobiles registered in 1960.

Car ownership is related to socio-economic status within a community; on Oahu, for example, the lowest car ratio per household is in the low-income



AR00031750

group, whereas, high-income households have a high car-ownership ratio. However, on Oahu, car ratio per household is also lower among nonresident families than among resident families.

The influence of household income is clear in Fig. 7.2, which shows how ownership relates to various household income groups and residency status on Oahu. The curves demonstrate that where average family income is less than $4,000 annually, there will be one car for every two households; where income averages more than $5,000, every household will own a car; and, at higher incomes, there will be an average of more than 1.4 cars per household. Thus, the number of households by income groups is significant criteria in determining car ownership.

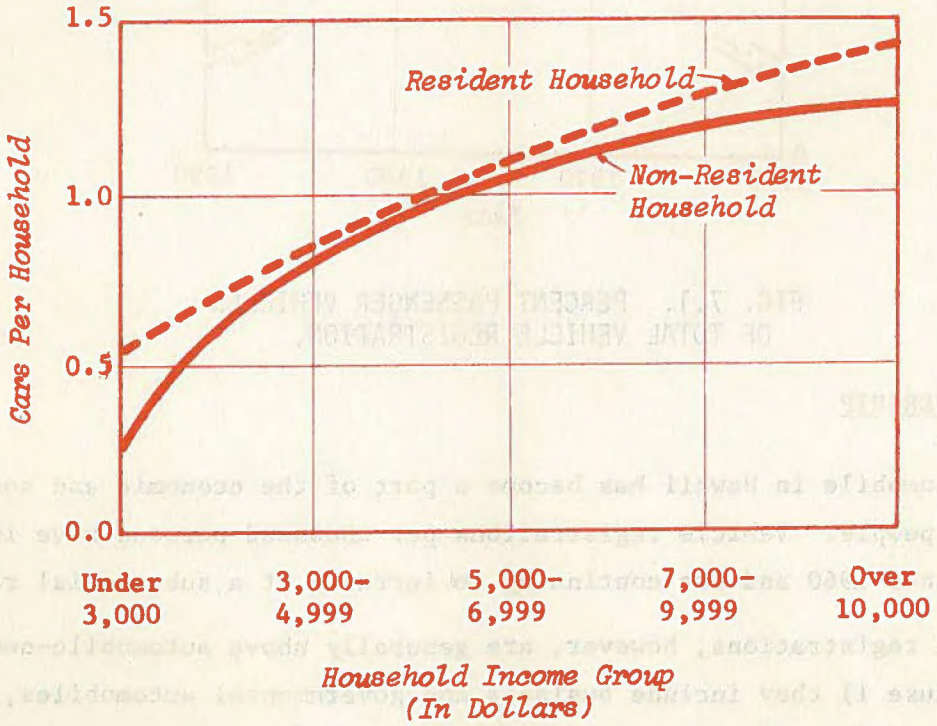



FIG. 7.2. CAR OWNERSHIP AND HOUSEHOLD INCOME - 1960.

The number of vehicles per dwelling unit varies from area to area on Oahu. On the average, however, there were, in 1960, 1.15 automobiles per resident family, 0.60 automobile per nonresident family, or an overall average of 0.97 automobile per family. This car ownership was an increase of 52 percent over that in Honolulu in 1947.



AR00031751

Car ownership per resident household on Oahu in 1960 was slightly higher than the national average. For example, single-car families represented 57 percent while the national average was 56.9 percent; two-or-more-car families represented 26.1 percent, while the national average was 21.5 percent.

## E. CAR USAGE

People on Oahu are highly automobile oriented, as is clearly illustrated in Table 7.2 where more than half of the total person trips made in 1960 were by auto drivers and more than a third were by passengers in an automobile.

Table 7.2. Person Trips by Mode of Travel on Oahu in 1960

| Mode of Travel | Person Trips | Percent of Total |
|---|---|---|
| Auto Driver | 644,175 | 51.2 |
| Auto Passenger | 464,920 | 37.0 |
| Bus Passenger | 130,581 | 10.4 |
| Taxi Passenger | 4,798 | 0.3 |
| Truck Passenger | 13,241 | 1.1 |
| TOTAL | 1,257,715 | 100.0 |

Note: Values represent unlinked person trips.

The amount of daily automobile travel on Oahu is directly related to the availability of an automobile. This relationship between car ownership and car travel is clearly illustrated in Fig. 7.3, which shows that a one-car family makes an average of five vehicle trips per day; a two-car family, an average of eight vehicle trips per day; and a five-car family, an average of eighteen vehicle trips per day. The number of driver trips per car in multi-car families, however, tends to average a little less as successive cars are acquired.



AR00031752

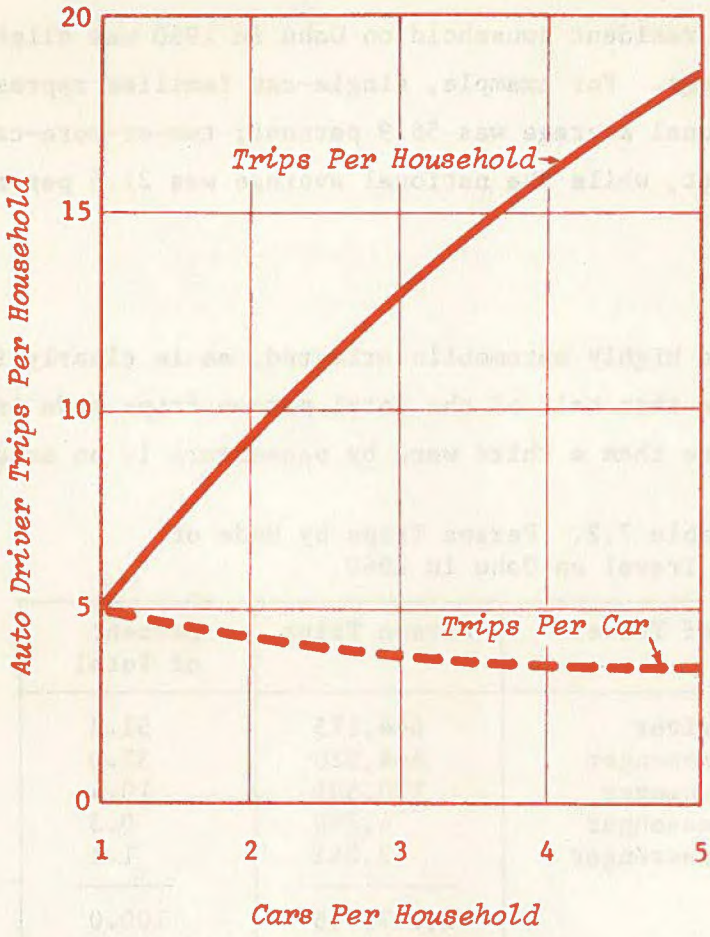



FIG. 7.3. AUTO DRIVER TRIPS AND CAR OWNERSHIP - 1960.

## F. FORECAST OF CAR OWNERSHIP

### 1. FORECAST EQUATIONS

The variables chosen to enter into the derivation of the car ownership forecasting formulas were: 1) household, 2) population, and 3) household by income group.

It was observed that the 1960 origin-destination survey contained a number of zones of uncommon characteristics, in the following categories:

1. Military areas
2. Marginally developed areas
3. Highly tourist-oriented (hotel) areas
4. Central business districts



AR00031753

5. Current renewal areas
6. Institutional areas

Zones generally falling in these categories were removed from the observations in the development of the car-ownership forecast formula.

The evaluation of the statistical stability and the reasonableness of the multiple-regression equations indicates that forecasts of car ownership by census tracts can best be obtained for Oahu by the use of the two equations shown in Fig. 7.4.

Equation Applicable
Census Tracts 1-65

*Car Ownership* =

*37.59227*
+
*1.75708 x Number of Medium-Income Household ($7,500-$14,999)*
+
*0.64314 x Number of Low-Income Household ($0-$7,499)*
+
*2.29512 x Number of High-Income Household (over $15,000)*

Equation Applicable
to Census Tracts 66-113

*Car Ownership* =

*-22.0672*
+
*1.71463 x Number of Medium-Income Household ($7,500-$14,999)*
+
*0.99561 x Number of Low-Income Household ($0-$7,499)*
+
*2.05832 x Number of High-Income Household (over $15,000)*

FIG. 7.4. CAR-OWNERSHIP FORECAST EQUATIONS.

Source: Oahu Transportation Study, September 1966.



AR00031754

Forecasting car ownership by census tracts on the basis of household by low-, medium-, and high-income groups rather than on the basis of either total household or total population is logical because car ownership on Oahu is heavily influenced by household income. The forecast will thus reflect the varying degrees of household income among the census tracts.

2. SPECIAL TRACTS

Forecasts of car ownership in census tracts that contain major single-activity land uses such as airports, military installations, etc., are treated separately. Because such census tracts have special characteristics, meaningful forecasts are obtained by using rates related to the activities which are measurable within the respective census tracts.

3. 1985 CAR OWNERSHIP

Car ownership on Oahu is expected to reach 360,352 by 1985, a forecast representing 2.68 times the value of 1960 (Table 7.3). While in 1960 there were 1.22 times more cars owned within Honolulu District than in the Outlying Districts, this trend will reverse and, by 1985, there will be 1.1 times more cars owned within the Outlying Districts than in Honolulu District (Fig. 7.5). Car ownership for 1960 and 1985 by census tracts is shown in Fig. 7.6. Also, a detailed listing of car ownership by census tract for 1960 and 1985 is shown in Table 7.A1 and by origin-destination zones for 1985 in Table 7.A2.

Table 7.3. Past and Projected Car Ownership Statistics by Grouped Census Tracts on Oahu, 1960 and 1985

| Census Tracts | Car Ownership | | Cars per Household | | Persons per Car | |
|---|---|---|---|---|---|---|
| | 1960 | 1985 | 1960 | 1985 | 1960 | 1985 |
| 1-65 | 73,848 | 171,789 | 1.09 | 1.24 | 3.46 | 2.87 |
| 65-113 | 60,579 | 188,563 | 0.86 | 1.15 | 3.71 | 2.96 |
| TOTAL | 134,427 | 360,352 | 0.97 | 1.19 | 3.57 | 2.91 |

It should be noted that auto registration is generally above car ownership and might be estimated at approximately 1.18 times car ownership.



AR00031755

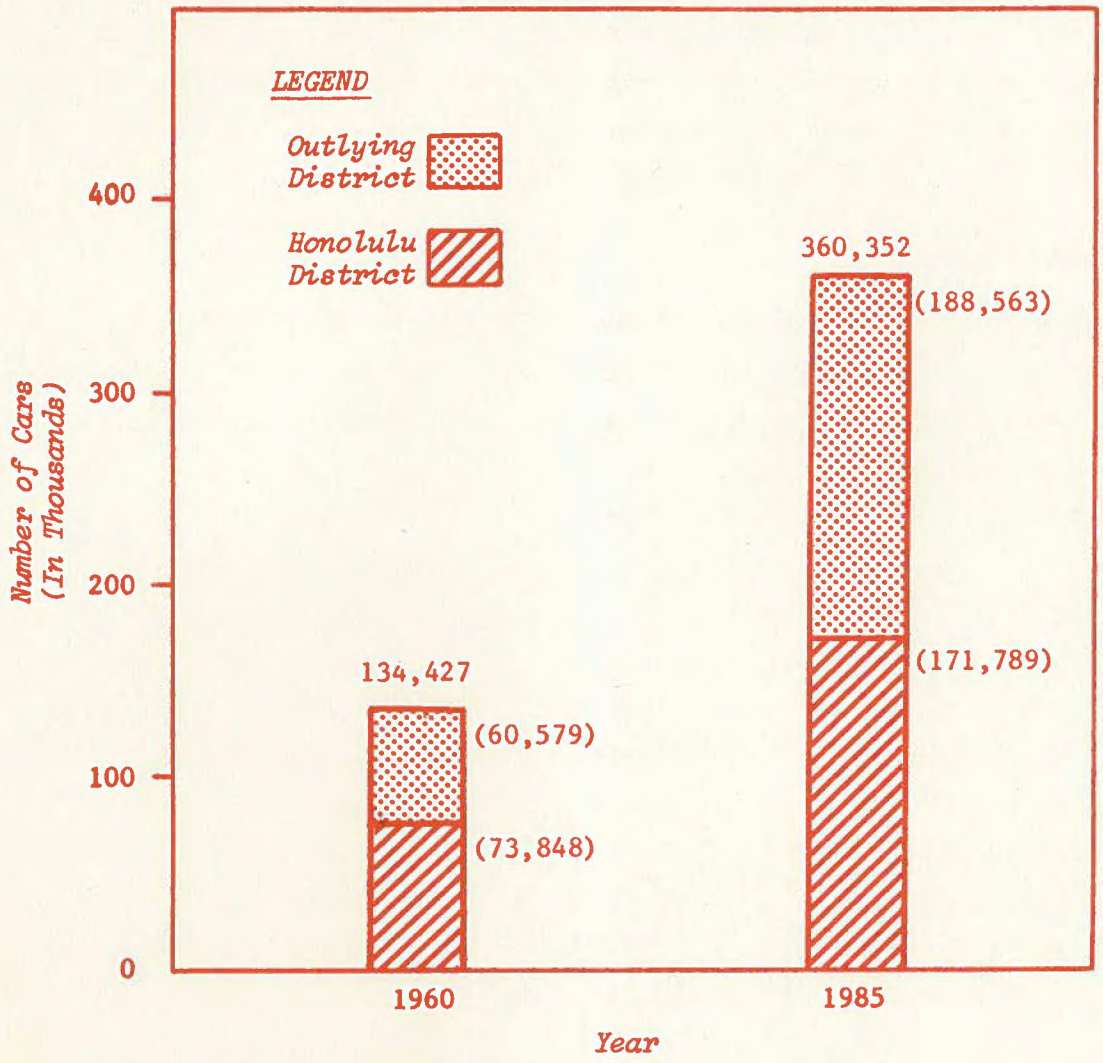



FIG. 7.5. COMPARISON OF 1960 AND 1985 CAR OWNERSHIP BETWEEN HONOLULU AND OUTLYING DISTRICTS.



AR00031756

FIG. 7,6

# AUTOMOBILE OWNERSHIP 1960-1985 BY CENSUS TRACT

'85 — 4,000

'60 — 2,000

0

SCALE 1 0 1 2 3 MILES

SEE INSET

AR00031757

## 4. SATURATION INDICATORS

Most analysts anticipate that eventually the rate of ownership will reach some point of stability, or a saturation level. In the article, "Need We Fail in Forecasting?", Kanwit, Steele, Todd, and Need stated that no one can safely predict yet what these saturation points are, but that the long-term-trend lines appear to be stabilizing in some areas of high-density registrations, and that it has been believed in some quarters that a practical limit will have been reached when there is one motor vehicle registered for each operator licensed.

Schmidt and Campbell in High Traffic Estimation, Eno Foundation, 1956, stated that there has been some thought that the limit for passenger cars will be reached with two cars per household; on this basis, the limit would be 1.7 persons per passenger car.

In Future Highways and Urban Growth, Wilbur Smith and Associates, after comparing ownership rates in urban study areas, concluded that it appears an ownership ratio of about one car for every 2.5 persons represents a normal saturation level. In relating licensed drivers to family income and car ownership, they concluded that it would appear that high-income families may be gradually approaching an upper limit of car ownership (one licensed driver per car owned).

Researchers generally agree that saturation will be attained when ownership rate remains stable for a reasonable period of time, perhaps 3 to 5 years.

On the basis of the commentaries on saturation, Kanwit, et. al., Schmidt and Campbell, and the paragraph immediately above, car ownership on Oahu does not appear to reach its saturation point before 1985. This is illustrated in Fig. 7.7, which shows a continual decline in the persons per passenger-car registration, with no sign of stability occurring within the period of the plot.



AR00031758

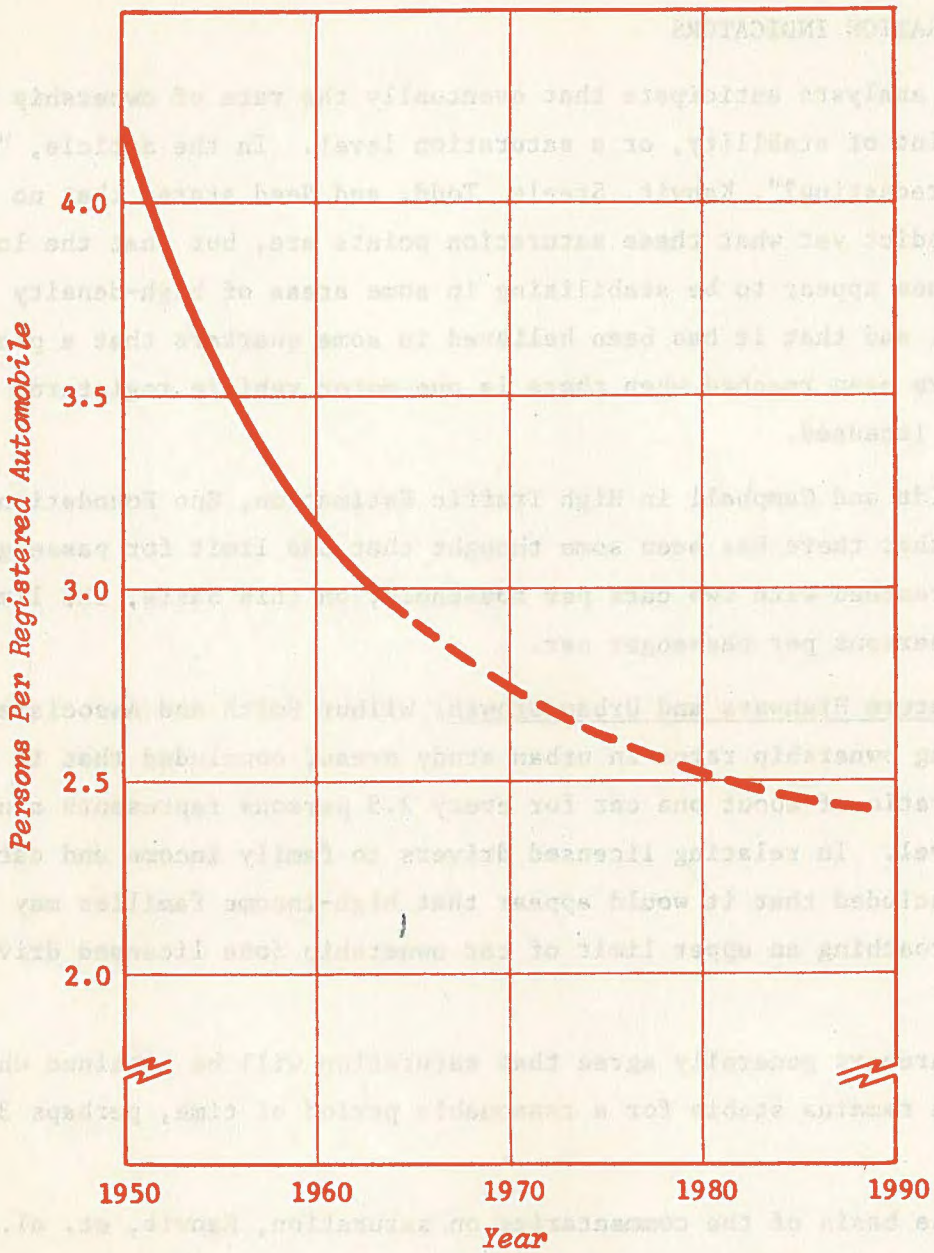



FIG. 7.7. PERSONS PER REGISTERED AUTOMOBILE, 1950 TO 1965 AND ESTIMATED TO 1985.



AR00031759

# APPENDIX VII-A. TABLES CONCERNING CAR-OWNERSHIP FORECAST

Table 7.A1. Car-Ownership Forecast by Census Tract

| Census Tract | Car Ownership | | Car per Household | | Census Tract | Car Ownership | | Car per Household | |
|---|---|---|---|---|---|---|---|---|---|
| | 1960 | 1985 | 1960 | 1985 | | 1960 | 1985 | 1960 | 1985 |
| 1 | 1,005 | 17,178 | 1.72 | 1.91 | 41 | 986 | 3,870 | 0.64 | 0.95 |
| 2 | 1,288 | 3,181 | 1.55 | 1.63 | 42 | 144 | 563 | 0.33 | 0.95 |
| 3 | 2,232 | 7,146 | 1.57 | 1.86 | 43 | 1,425 | 3,128 | 1.07 | 1.01 |
| 4 | 521 | 1,953 | 1.35 | 1.69 | 44 | 1,793 | 2,133 | 1.30 | 1.13 |
| 5 | 2,246 | 3,782 | 1.67 | 1.93 | 45 | 1,507 | 2,595 | 1.55 | 1.32 |
| 6 | 638 | 1,239 | 1.65 | 1.92 | 46 | 1,395 | 2,098 | 1.41 | 1.31 |
| 7 | 1,215 | 1,472 | 1.45 | 1.48 | 47 | 1,515 | 2,345 | 1.24 | 1.42 |
| 8 | 1,669 | 1,851 | 1.35 | 1.31 | 48 | 1,720 | 1,828 | 1.11 | 1.22 |
| 9 | 3,034 | 5,838 | 1.38 | 1.57 | 49 | 567 | 1,034 | 0.83 | 1.10 |
| 10 | 957 | 1,710 | 1.27 | 1.39 | 50 | 1,123 | 1,734 | 1.04 | 1.14 |
| 11 | 825 | 1,296 | 1.00 | 1.06 | 51 | 198 | 372 | 0.30 | 1.00 |
| 12 | 2,120 | 2,274 | 1.23 | 1.27 | 52 | 51 | 619 | 0.08 | 0.84 |
| 13 | 1,863 | 1,850 | 1.46 | 1.35 | 53 | 980 | 957 | 0.47 | 0.86 |
| 14 | 837 | 1,115 | 1.20 | 1.35 | 54 | 283 | 370 | 0.62 | 0.79 |
| 15 | 1,454 | 1,439 | 1.35 | 1.21 | 55 | 506 | 830 | 0.94 | 1.05 |
| 16 | 1,342 | 1,667 | 1.09 | 1.18 | 56 | 1,324 | 1,812 | 0.97 | 1.08 |
| 17 | 1,009 | 2,424 | 1.23 | 1.31 | 57 | 727 | 2,952 | 0.78 | 0.78 |
| 18 | 998 | 3,375 | 0.61 | 0.84 | 58 | 902 | 849 | 1.02 | 0.97 |
| 19 | 1,061 | 2,330 | 0.76 | 0.92 | 59 | 1,039 | 956 | 1.04 | 1.26 |
| 20 | 1,074 | 4,994 | 0.56 | 1.02 | 60 | 1,177 | 1,369 | 1.03 | 1.10 |
| 21 | 813 | 1,517 | 0.98 | 1.25 | 61 | 771 | 914 | 1.34 | 1.24 |
| 22 | 738 | 2,012 | 0.94 | 1.13 | 62 | 1,038 | 1,168 | 1.00 | 0.93 |
| 23 | 1,174 | 4,524 | 1.09 | 1.14 | 63 | 1,131 | 1,258 | 1.11 | 1.07 |
| 24 | 1,577 | 7,414 | 0.95 | 1.12 | 64 | 1,411 | 2,399 | 1.42 | 0.92 |
| 25 | 1,139 | 3,898 | 0.95 | 1.22 | 65 | 836 | 1,410 | 1.50 | 1.05 |
| 26 | 1,228 | 2,458 | 1.00 | 1.16 | 66 | 521 | 783 | 0.55 | 0.55 |
| 27 | 2,077 | 7,592 | 1.04 | 0.76 | 67 | 774 | 11,278 | 0.78 | 1.79 |
| 28 | 1,362 | 2,057 | 1.37 | 1.54 | 68 | 1,217 | 3,496 | 1.24 | 1.44 |
| 29 | 403 | 1,426 | 1.22 | 1.53 | 69 | 952 | 1,101 | 1.05 | 1.18 |
| 30 | 2,125 | 2,940 | 1.58 | 1.64 | 70 | 1,455 | 1,599 | 1.02 | 1.06 |
| 31 | 1,635 | 4,984 | 1.47 | 1.71 | 71 | 924 | 1,044 | 0.87 | 1.03 |
| 32 | 468 | 1,708 | 1.72 | 1.95 | 72 | 752 | 325 | 0.52 | 0.66 |
| 33 | 521 | 718 | 2.06 | 1.90 | 73 | 1,586 | 4,200 | 1.17 | 1.17 |
| 34 | 3,537 | 12,348 | 1.07 | 1.30 | 74 | 2,405 | 3,640 | 0.32 | 0.32 |
| 35 | 1,186 | 3,695 | 0.84 | 1.04 | 75 | 1,357 | 5,093 | 0.97 | 1.25 |
| 36 | 1,099 | 3,803 | 0.90 | 1.12 | 76 | 942 | 1,137 | 0.88 | 1.02 |
| 37 | 265 | 453 | 0.65 | 0.97 | 77 | 1,896 | 5,238 | 1.41 | 1.45 |
| 38 | 302 | 342 | 0.73 | 1.29 | 78 | 1,225 | 10,851 | 1.32 | 1.40 |
| 39 | 262 | 212 | 1.14 | 1.26 | 79 | 8 | 36 | 1.00 | 1.00 |
| 40 | -- | 11 | -- | 0.58 | 80 | 2,434 | 8,916 | 1.23 | 1.31 |



AR00031761

Table 7.A1 - continued

| Census Tract | Car Ownership | | Car per Household | | Census Tract | Car Ownership | | Car per Household | |
|---|---|---|---|---|---|---|---|---|---|
| | 1960 | 1985 | 1960 | 1985 | | 1960 | 1985 | 1960 | 1985 |
| 81 | 857 | 575 | 1.06 | 1.02 | 98 | 946 | 2,909 | 1.39 | 1.16 |
| 82 | 119 | 6 | 0.50 | 0.85 | 99 | 1,744 | 3,130 | 1.22 | 1.19 |
| 83 | 1,353 | 1,771 | 1.07 | 1.46 | 100 | 471 | 812 | 0.88 | 1.10 |
| 84 | 1,509 | 2,717 | 1.21 | 1.20 | 101 | 719 | 1,299 | 1.09 | 1.13 |
| 85 | 1,654 | 1,567 | 0.45 | 0.45 | 102 | 1,111 | 2,529 | 1.25 | 1.14 |
| 86 | 1,163 | 10,723 | 1.09 | 1.22 | 103 | 1,408 | 12,458 | 1.39 | 1.39 |
| 87 | 1,110 | 3,571 | 1.19 | 1.23 | 104 | 31 | 13 | 0.62 | 1.08 |
| 88 | 647 | 1,088 | 1.02 | 1.26 | 105 | 1,800 | 8,988 | 1.15 | 1.46 |
| 89 | 930 | 19,158 | 1.19 | 1.14 | 106 | 1,480 | 3,193 | 1.31 | 1.33 |
| 90 | 265 | 564 | 0.74 | 0.74 | 107 | 888 | 7,702 | 1.33 | 1.84 |
| 91 | 770 | 1,077 | 0.81 | 1.09 | 108 | 1,840 | 3,370 | 0.37 | 0.74 |
| 92 | 2,152 | 3,023 | 1.28 | 1.32 | 109 | 3,674 | 5,435 | 1.26 | 1.40 |
| 93 | 911 | 2,460 | 0.85 | 1.21 | 110 | 420 | 3,535 | 1.32 | 1.77 |
| 94 | 821 | 2,006 | 0.98 | 1.23 | 111 | 1,969 | 9,207 | 1.28 | 1.58 |
| 95 | 2,558 | 2,829 | 0.27 | 0.27 | 112 | 2,372 | 4,029 | 1.55 | 1.67 |
| 96 | 2,094 | 3,859 | 1.06 | 1.10 | 113 | 1,433 | 2,236 | 1.31 | 1.26 |
| 97 | 912 | 1,987 | 1.10 | 1.18 | TOTAL | 134,427 | 360,352 | 0.97 | 1.19 |



AR00031762

Table 7.A2. 1985 Car-Ownership Forecast
by Equivalent Origin-Destination Zones

| O-D Zone | No. of Autos | O-D Zone | No. of Autos | O-D Zone | No. of Autos | O-D Zone | No. of Autos |
|---|---|---|---|---|---|---|---|
| 1 | 371 | 41 | 160 | 81 | 307 | 121 | 1,618 |
| 2 | 501 | 42 | 342 | 82 | 5,455 | 122 | 2,241 |
| 3 | 118 | 43 | 3,870 | 83 | 2,236 | 123 | 0 |
| 4 | 0 | 44 | 3,695 | 84 | 2,050 | 124 | 7,769 |
| 5 | 0 | 45 | 12,348 | 85 | 1,485 | 125 | 2,637 |
| 6 | 8 | 46 | 718 | 86 | 556 | 126 | 317 |
| 7 | 8 | 47 | 1,708 | 87 | 7,560 | 127 | 1,567 |
| 8 | 3 | 48 | 453 | 88 | 1,091 | 128 | 2,717 |
| 9 | 0 | 49 | 3,803 | 89 | 2,112 | 129 | 1,771 |
| 10 | 0 | 50 | 3,898 | 90 | 1,917 | 130 | 6 |
| 11 | 0 | 51 | 7,414 | 91 | 2,989 | 131 | 489 |
| 12 | 0 | 52 | 2,012 | 92 | 2,446 | 132 | 864 |
| 13 | 0 | 53 | 4,524 | 93 | 3,370 | 133 | 2,218 |
| 14 | 0 | 54 | 2,458 | 94 | 600 | 134 | 1,088 |
| 15 | 15 | 55 | 7,592 | 95 | 1,699 | 135 | 1,183 |
| 16 | 0 | 56 | 2,940 | 96 | 3,089 | 136 | 13,788 |
| 17 | 37 | 57 | 1,426 | 97 | 13 | 137 | 4,187 |
| 18 | 1,887 | 58 | 4,984 | 98 | 4,811 | 138 | 575 |
| 19 | 956 | 59 | 2,330 | 99 | 4,177 | 139 | 853 |
| 20 | 1,369 | 60 | 4,994 | 100 | 3,193 | 140 | 1,660 |
| 21 | 914 | 61 | 3,375 | 101 | 7,702 | 141 | 6,403 |
| 22 | 1,168 | 62 | 1,517 | 102 | 7,070 | 142 | 36 |
| 23 | 2,399 | 63 | 2,424 | 103 | 379 | 143 | 10,851 |
| 24 | 1,258 | 64 | 1,667 | 104 | 1,261 | 144 | 5,238 |
| 25 | 1,410 | 65 | 1,439 | 105 | 889 | 145 | 1,137 |
| 26 | 1,065 | 66 | 1,115 | 106 | 1,299 | 146 | 4,200 |
| 27 | 849 | 67 | 1,850 | 107 | 812 | 147 | 3,640 |
| 28 | 1,812 | 68 | 2,274 | 108 | 2,633 | 148 | 2,497 |
| 29 | 1,828 | 69 | 2,057 | 109 | 497 | 149 | 2,596 |
| 30 | 1,200 | 70 | 1,296 | 110 | 1,077 | 150 | 0 |
| 31 | 957 | 71 | 1,710 | 111 | 2,006 | 151 | 1,044 |
| 32 | 1 | 72 | 1,239 | 112 | 2,460 | 152 | 325 |
| 33 | 555 | 73 | 1,472 | 113 | 3,023 | 153 | 1,599 |
| 34 | 3,128 | 74 | 5,838 | 114 | 2,829 | 154 | 1,101 |
| 35 | 1,734 | 75 | 1,851 | 115 | 374 | 155 | 3,496 |
| 36 | 1,034 | 76 | 3,782 | 116 | 190 | 156 | 0 |
| 37 | 2,345 | 77 | 1,953 | 117 | 2,909 | 157 | 415 |
| 38 | 2,133 | 78 | 7,146 | 118 | 398 | 158 | 11,278 |
| 39 | 2,595 | 79 | 3,181 | 119 | 666 | 159 | 368 |
| 40 | 2,098 | 80 | 11,416 | 120 | 923 | | |
| | | | | | | TOTAL | 360,352 |



AR00031763

# VIII Travel Patterns And Volumes

# VIII. TRAVEL PATTERNS & VOLUMES

## A. INTRODUCTION

Systematic observations of vehicular movements indicate that there are repetitive patterns in traffic flow in any metropolitan area. Not only are there volume patterns, but also there are patterns within patterns. There is an hourly cycle of movements during the day, and a monthly or seasonal pattern during the year.

The measurement of traffic volumes is an important phase of an urban-transportation study. It provides essential planning data on:

1. The degree the street system is being used by traffic and the demand being imposed on each segment of the street system.
2. The average daily traffic (ADT), the morning and evening peak-hour volumes, and hourly and directional distribution of traffic throughout the day.
3. The vehicle classification at points representative of conditions on different types of streets in the system.
4. The load factor, the peak-hour factor, and other controlling features of the intersection, which are essential elements in the determination of intersection capacity.
5. The influence of existing traffic regulations and controls, such as traffic-signal timing, parking regulations, and turn restrictions on the capacity of the street section or street intersection.
6. The development of priority programs for street maintenance and construction.

The Highways Division of the State Department of Transportation, in cooperation with the Bureau of Public Roads, maintains an annual, state-wide traffic-counting program.* Although traffic counts are made at selected

---

*The Highway Planning Section, Highways Division, Department of Transportation, prepares a Traffic Summary for counties of the State each year.



AR00031765

stations on roads and streets under City jurisdiction, the principal concern of the State's traffic-counting program is generally focused on its State Highway System.

The Traffic Department of the City and County of Honolulu does possess traffic-counting equipment and does make traffic counts, but for specific problem studies only. The City does not maintain a continuing traffic-counting program similar to that of the State.

The Highways Division is currently reevaluating its traffic-counting procedures and program. The Oahu Transportation Study recommends that a continuing, cooperative traffic-counting program be developed between the State and the City. Leadership in this area should come from the Highways Division.

As a contribution to the Oahu Transportation Study, the Traffic Department of the City and County of Honolulu entered into an agreement with Community Planning, Inc., to execute that phase of the Oahu Transportation Study relating to the inventory of the existing transportation system. As a part of the scope of work, traffic-volume counts [Ref. 8.1] were made at a number of street intersections not normally covered in the State's traffic-counting program.

## B. MONTHLY TRAFFIC VARIATIONS

Monthly variations in vehicular volumes on Oahu are minor and insignificant. Average-day volumes for the month generally fall within a range of ±10 percent from the average day of the year (Fig. 8.1). Travel is highest during the month of January and lowest among the summer months (June, July, and August). Average-day volumes during transitional months (i.e., months in which schools "let out" and/or begin) appear to be equal to the average-day volume of the year.



AR00031766

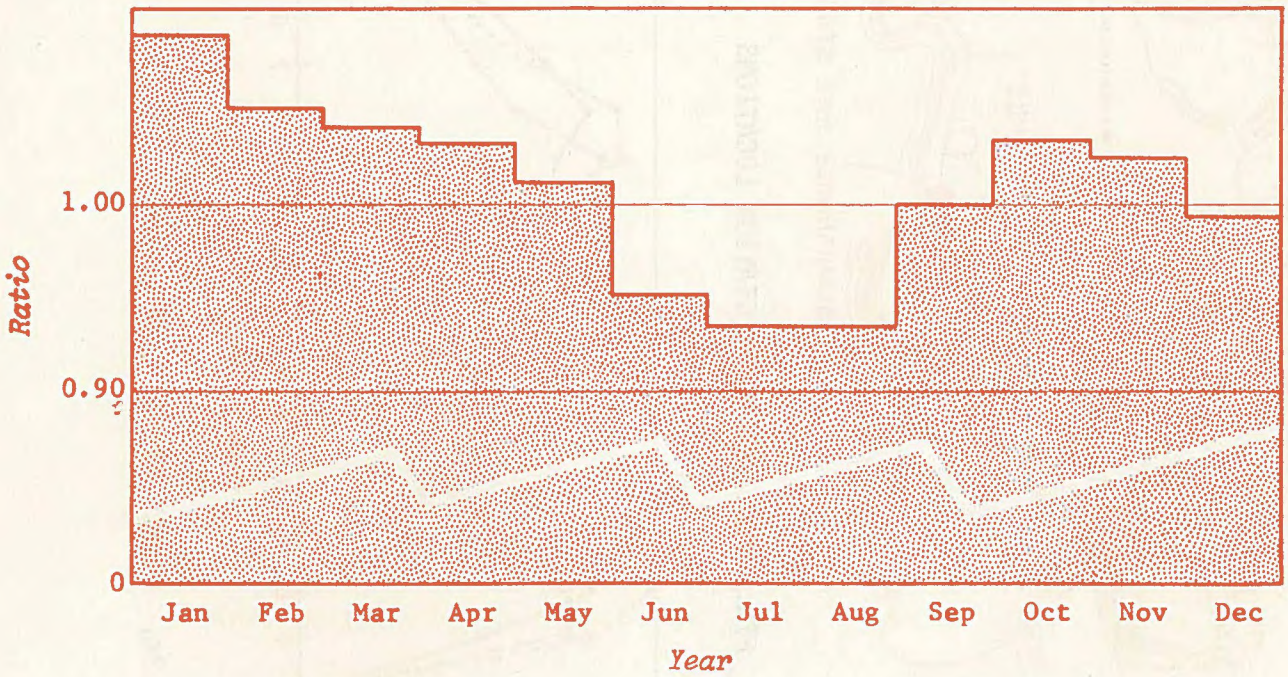



FIG. 8.1 MONTHLY TRAFFIC VARIATIONS.

C. DAILY TRAFFIC VARIATIONS

Figures 8.2a and 8.2c show daily and hourly traffic-volume fluctuations at three locations controlling access to the Central Honolulu area. Specific locations are shown in Figure 8.2b. In order to obtain complete data on the vehicular movements, stations were maintained on each of the highways leading into the area. For instance, stations were maintained on Pali Highway and Likelike Highway at the approximate location shown on the drawing. Likewise, stations were maintained on Moanalua Road, Kamehameha Highway, and Nimitz Highway at the Moanalua Stream crossings.



AR00031767

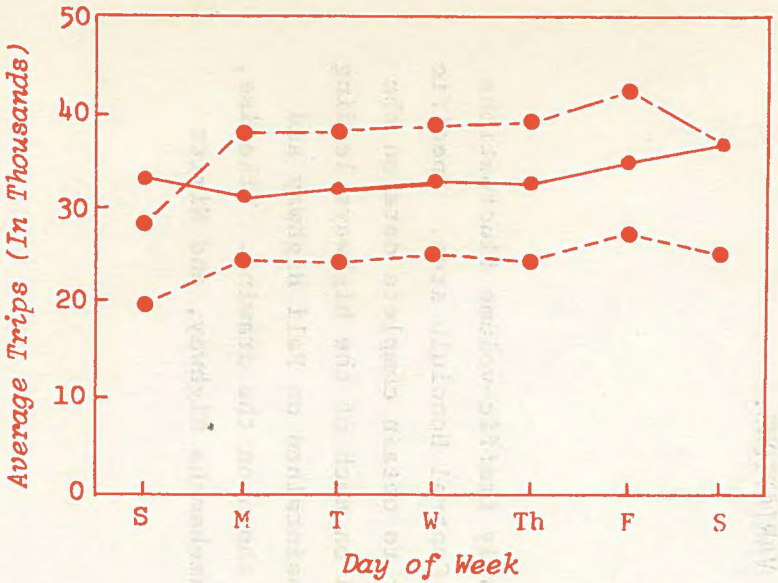



FIG. 8.2a. DAILY TRAFFIC VARIATION.

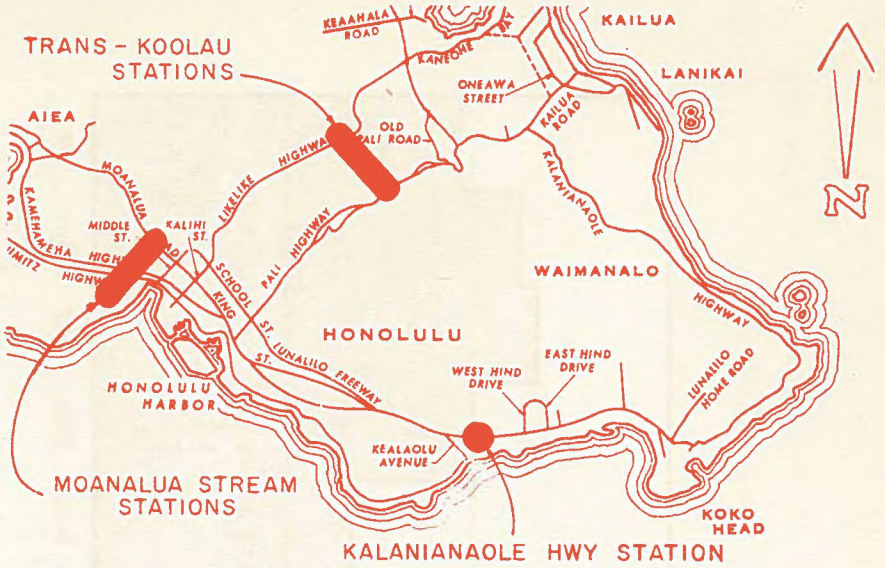



FIG. 8.2b. COUNTING STATION LOCATIONS

*LEGEND*

*Trans-Koolau - Pali and Likelike Hwys.*

*Kalanianaole Hwy. at Kapakahi Bridge*

*Moanalua Stream, Moanalua Road, Kamehameha Hwy., Nimitz Hwy.*

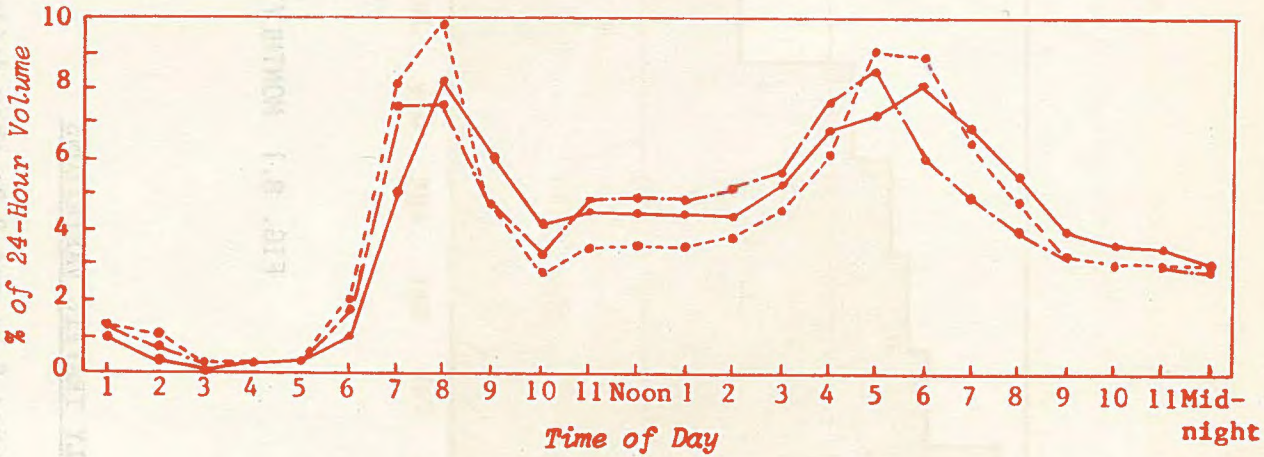



FIG. 8.2c. HOURLY TRAFFIC VARIATION

AR00031768

Counts were taken by the State Department of Transportation at each station for one full week during each month of the year.

Those characteristics of traffic volumes most apparent are:

1. Weekday volumes: high on Friday.
2. Hourly volumes: a secondary peak at 5:00-7:00 p.m., on Kalanianaole Highway and Trans-Koolau at 4:00-5:00 p.m., on MOanalua Stream. Primary peak at 7:00-9:00 a.m., at all locations.

The early peak in the afternoon on the Moanalua Stream locations may be attributed to the early closing of work at the major Federal Defense installations located just west of the stations and the proximity of the Central Business District relative to the other stations. Generally, however, the weekday and hourly patterns observed in the Study Area are quite typical of those experienced throughout the nation.

## D. DIRECTIONAL DISTRIBUTION OF PEAK-HOUR TRAFFIC

Directional movements in terms of percentages within the peak hours, a.m. and p.m., are shown below:

| Location | Directional Distribution (%) Peak Hour AM | PM |
|---|---|---|
| Trans- Koolau | | |
| Southbound | 84 | 25 |
| Northbound | 16 | 75 |
| Kalanianaole Highway | | |
| Eastbound | 23 | 72 |
| Westbound | 77 | 28 |
| Moanalua Stream | | |
| Eastbound | 42 | 64 |
| Westbound | 58 | 36 |

The very heavy directional movement in the Leeward direction in the morning peak and in the reverse direction in the afternoon peak on the Trans-Koolau facilities is attributed to the distinct differences in the social characteristics of the area. The Windward area, encompassing the major communities of Kaneohe, Kailua and Waimanalo, may be generally categorized as



AR00031769

"bedroom" communities with relatively limited commercial activity. Thus, a major portion of the working populace is employed in the Leeward area.

As shown by the distribution on the Kalanianaole Highway station, the travel characteristics are quite like those of the Trans-Koolau facilities. Again, the East Oahu area is primarily a residential suburb, with Central Honolulu presenting employment opportunities to the residents.

The Moanalua Stream stations, in contrast, are located between the two major employment divisions of Leeward Oahu. To the east of the stream are located the major commercial and governmental centers of the City and to the west, the industrial centers, ranging from small manufacturing plants to the massive Pearl Harbor Naval Shipyard and Honolulu International Airport. Both areas present unequalled employment opportunities to all residents of the Island. In view of the employment distribution and realizing that these two Leeward areas also provide residential land to house the majority of Oahu's population, the travel distribution appears reasonable.

## E. TRAFFIC-FLOW MAPS

Figures 8.3 to 8.9 show the 1966 traffic flows on principal streets and highways on Oahu.



AR00031770

## REFERENCES

1. Inventory Report of the Existing Oahu Transportation System, July 1964, for detailed traffic-counts information. City and County of Honolulu, Department of Traffic--prepared by Community Planning, Inc., Honolulu, Hawaii.



AR00031771

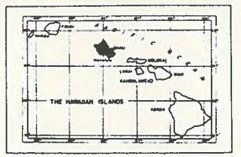
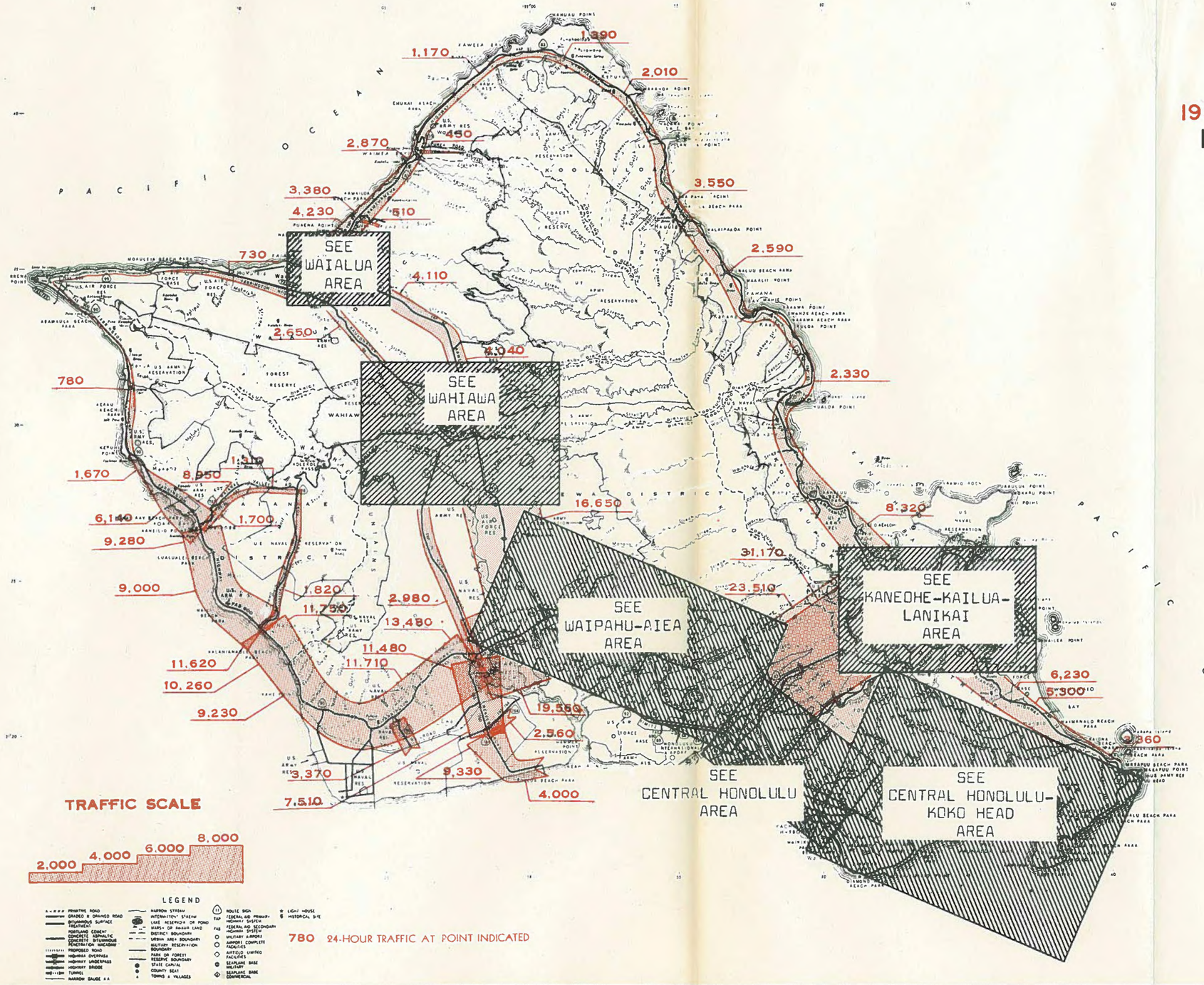



FIG. 8.3.

# 1966 TRAFFIC FLOW MAP
# ISLAND OF OAHU

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION

SCALE IN MILES
1961






AR00031772

FIG. 8.4.

# 1966 TRAFFIC FLOW MAP

## WAIPAHU-AIEA AREA

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION

LEGEND

530 24-HOUR TRAFFIC AT POINT INDICATED

SCALE IN FEET
2000 0 2000 4000 6000
1965

LEGEND

- DRAW BRIDGE
- PROPOSED ROAD
- MOUNTAIN RANGE
- URBAN AREA BOUNDARY
- MILITARY RESERVATION BOUNDARY
- PARK OR FOREST RESERVE BOUNDARY
- (11) ROUTE SIGN
- FAP FEDERAL-AID PRIMARY HIGHWAY SYSTEM
- FAS FEDERAL-AID SECONDARY HIGHWAY SYSTEM
- ARMORY
- STATE CAPITAL
- COUNTY SEAT
- RADIO OR TV STATION
- POLICE STATION
- LIGHT HOUSE
- POST OFFICE
- GOVERNMENT BUILDING
- COURTHOUSE
- FIRE ENGINE HOUSE
- TRIANGULATION STATION
- PUBLIC LIBRARY
- PUMPING STATION
- SCHOOLHOUSE
- CORRECTIONAL INSTITUTION
- GOLF COURSE OR COUNTRY CLUB
- SP SMALL PARK
- MUSEUM
- CHURCH AND SCHOOL
- HOSPITAL
- INCINERATER
- RUBBISH DUMP
- DRIVE-IN THEATER
- SUGAR MILL
- CENTRAL BUSINESS DISTRICT
- J JUNKYARD

TRAFFIC SCALE
10,000 20,000 30,000 40,000



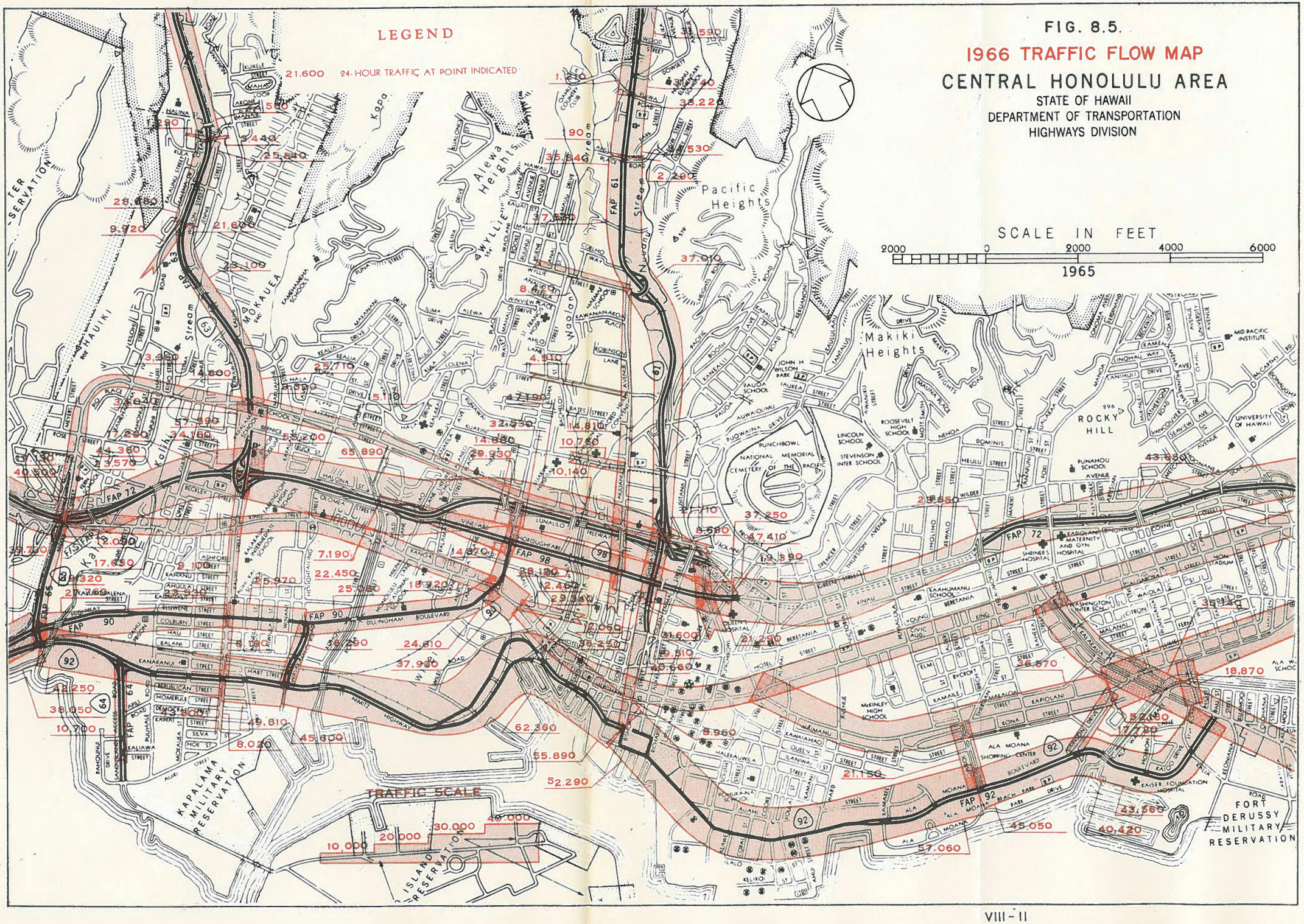
AR00031773

FIG. 8.5.

# 1966 TRAFFIC FLOW MAP

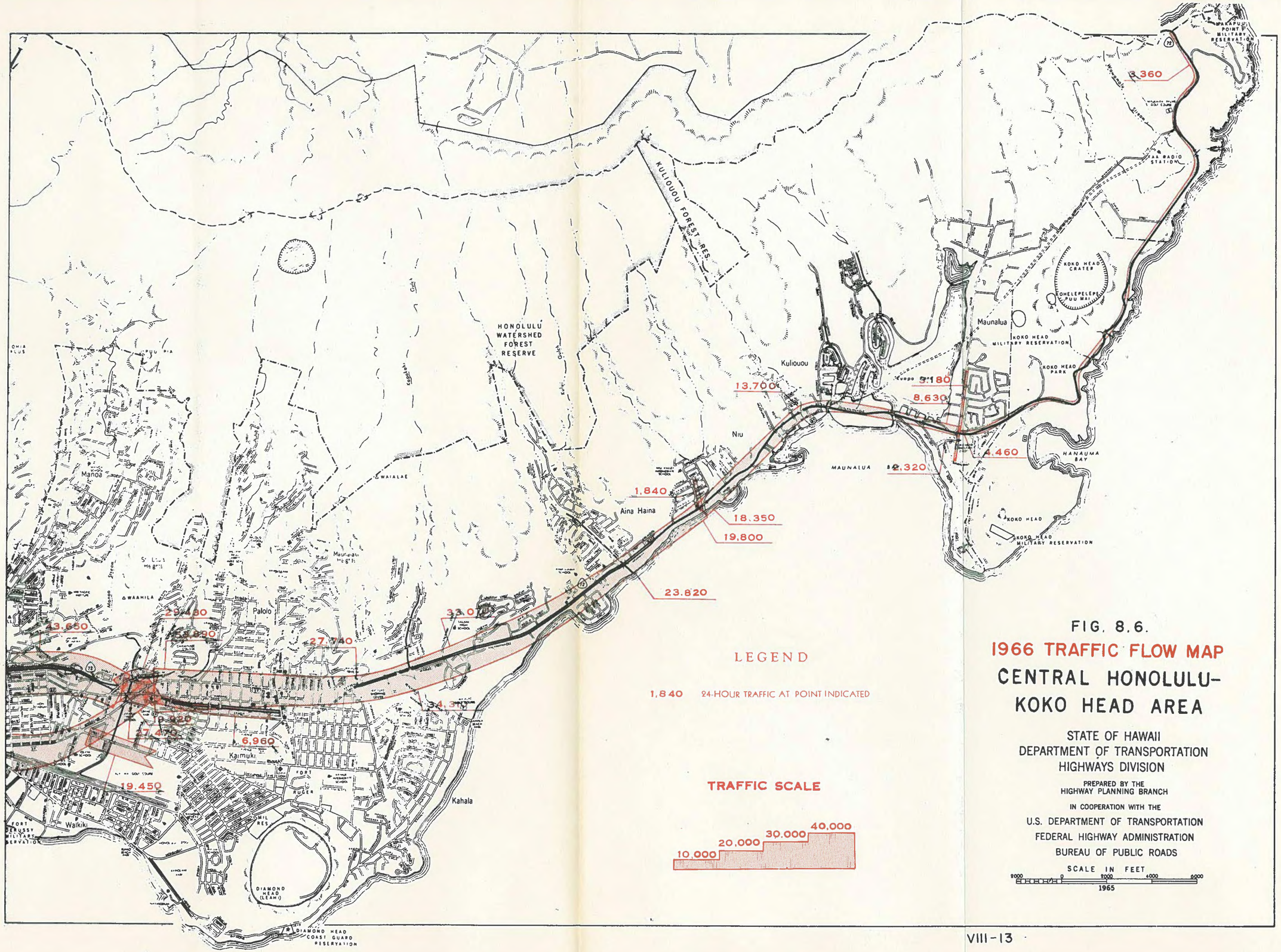
## CENTRAL HONOLULU AREA

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION






AR00031774




LEGEND

1,840 24-HOUR TRAFFIC AT POINT INDICATED

TRAFFIC SCALE

10,000 20,000 30,000 40,000

FIG. 8.6.

# 1966 TRAFFIC FLOW MAP

# CENTRAL HONOLULU-KOKO HEAD AREA

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION

PREPARED BY THE
HIGHWAY PLANNING BRANCH

IN COOPERATION WITH THE

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
BUREAU OF PUBLIC ROADS

SCALE IN FEET

2000 0 2000 4000 6000

1965



AR00031775

FIG. 8.7.

# 1966 TRAFFIC FLOW MAP

## KANEOHE-KAILUA-LANIKAI AREA

STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION

SCALE IN MILES

KANEOHE BAY

KANEOHE MARINE CORPS AIR STATION

KANEOHE

KAILUA

LANIKAI

KAPAA TRAINING AREA NAVAL RESERVATION

PODMORE MILITARY RESERVATION

BELLOWS AIR FORCE BASE

PUU PAPAA

ONEAWA

KEALALU

Kawainui Swamp

Popoia Island

Kaelepulu Pond

Kawainui Stream

Kaelepulu Stream

Heeia Stream

Keaalaa Stream

Kaneohe Stream

Kawa Stream

Kapoolani Stream

Moanalua Stream

Waikalua Stream

Waiahole Stream

Waiahole Ditch

Waiahole Reservoir

Kaneohe Reservoir

HAWAII STATE HOSPITAL

KANEOHE YACHT CLUB

KANEOHE BEACH PARK

PEDESTRIAN OVERPASS

BENJAMIN PARKER SCHOOL

HEEIA ELEMENTARY SCHOOL

KAAHUMANU CIRCLE

KAINALU ELEMENTARY SCHOOL

KAELEPULU ELEMENTARY SCHOOL

KAILUA HIGH & ELEMENTARY SCHOOL

KAILUA SHOPPING CENTER

KAHALUU ELEMENTARY SCHOOL

HAWAIIAN MEMORIAL PARK

KAILUA BEACH PARK

PAUAHILANI (PARK)

PACIFIC GOLF COURSE

MARKER 603

MARKER 399

KUPAU STREET

LOHO STREET

AKAHAI ST.

MANULANI ST.

KAMEHAMEHA HIGHWAY

KALANIANAOLE HIGHWAY

KAILUA ROAD

KEOLU DRIVE

MOKULUA DRIVE

PAKOLEA DRIVE

POOPOOPOI PLACE

LANIKAI PLACE

ALALA ROAD

AUWINALA ROAD

WANAAO ROAD

KAMANI STREET

KAWAILOA ROAD

KAILUA BEACH PARK

KAILUA ROAD

KAMEHAMEHA HIGHWAY

KALANIANAOLE HIGHWAY

FAP 61

FAP 72

FAS 630

FAS 638

H-3

INTERSTATE

PROPOSED

7,430
7,680
5,280
3,670
10,260
8,120
17,180
9,990
15,600
16,840
3,780
3,610
17,630
30,950
6,930
26,890
7,490
6,240
25,700
29,340
32,880
15,650
16,050
690
29,850
23,510

## LEGEND

- PROPOSED ROAD
- PRIVATE ROAD
- HIGHWAY OVERPASS
- HIGHWAY UNDERPASS
- HIGHWAY BRIDGE
- TUNNEL
- NARROW GAUGE R.R.
- NARROW STREAM
- INTERMITTENT STREAM
- IRRIGATION DITCH
- LAKE, RESERVOIR, OR POND
- MARSH OR SWAMP LAND
- MOUNTAIN RANGE
- SINK OR DEPRESSION
- DISTRICT BOUNDARY
- URBAN AREA BOUNDARY
- MILITARY RESERVATION BOUNDARY
- PARK OR FOREST RESERVE BOUNDARY
- HAWAII STATE HOSPITAL BOUNDARY
- FAP FEDERAL-AID PRIMARY HIGHWAY SYSTEM
- FAS FEDERAL-AID SECONDARY HIGHWAY SYSTEM
- (11) ROUTE SIGN TRIANGULATION STATION
- FIRE ENGINE HOUSE
- POLICE STATION
- POST OFFICE
- COURTHOUSE
- SCHOOLHOUSE
- GOLF COURSE OR COUNTRY CLUB
- SMALL PARK
- YACHT CLUB
- CEMETERY
- HOSPITAL
- CENTRAL BUSINESS DISTRICT

690 24-HOUR TRAFFIC AT POINT INDICATED

## TRAFFIC SCALE

5,000 10,000 15,000 20,000



AR00031776

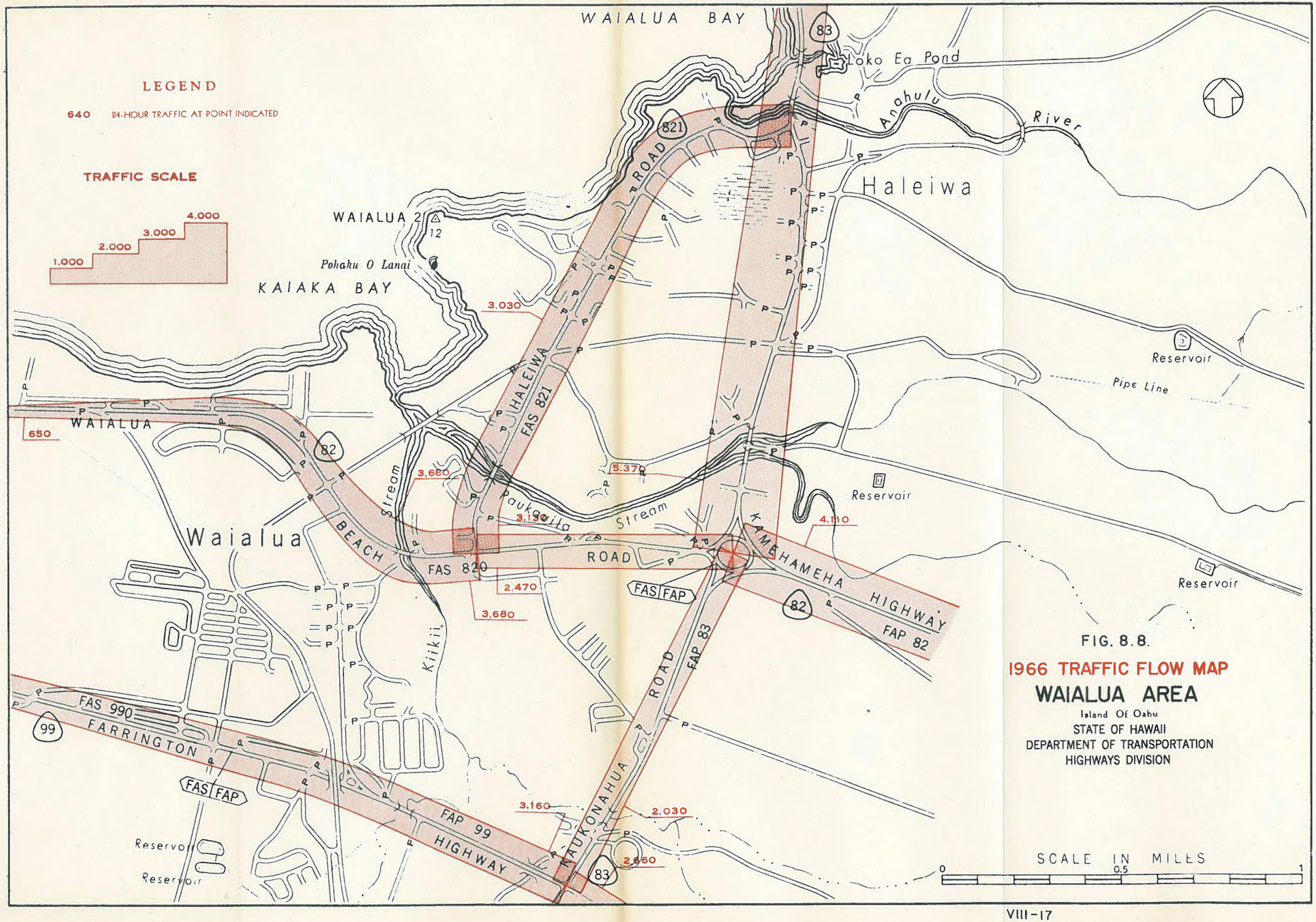



FIG. 8.8.

## 1966 TRAFFIC FLOW MAP

## WAIALUA AREA

Island Of Oahu
STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION



AR00031777

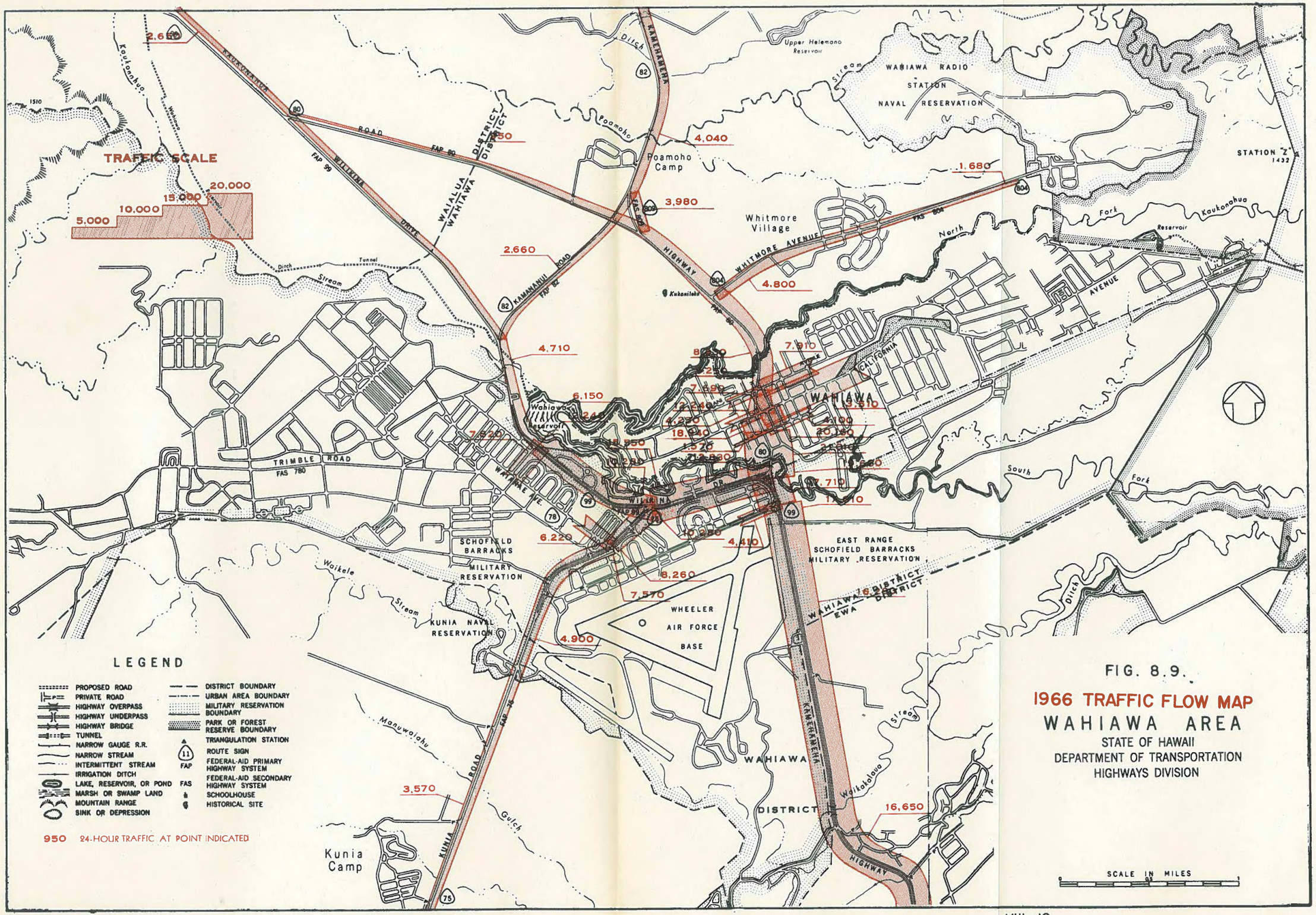



FIG. 8.9.

# 1966 TRAFFIC FLOW MAP
## WAHIAWA AREA
STATE OF HAWAII
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION



AR00031778

# IX Origin Destination Traffic Study

# IX. ORIGIN - DESTINATION TRAFFIC STUDY

## A. INTRODUCTION

The Origin-Destination Survey is the backbone of a comprehensive inventory and analysis of existing travel conditions. It is also the most complex and time-consuming of the various surveys involved in an urban-transportation study.

The primary reason for taking an inventory of travel is to discover those evidences of orderliness in travel which make it possible to estimate the traffic and mass-transportation demands of the future. These estimates are necessary if plans are to be prepared. With measured regularities, it is also possible to test plans so as to know whether proposed transportation improvements, once built, will accommodate the traffic demands thrown on them.

A second reason for taking a travel inventory is to describe travel clearly in objective terms. This is necessary to gain an accurate perspective, to see the parts in proper relationship to the whole, and to understand the characteristics of each kind of travel and the forces acting upon it. Further, it is fundamental that stock must be taken of existing amounts of travel as a base for forecasting and planning, and for comparison with the supply of transportation services.

The Origin-Destination Survey for Oahu was conducted by the Highway Planning section of the Highways Division, State Department of Transportation. The survey period began late in July 1960 and extended into the later part of January 1961. The wealth of information, stored on magnetic tapes, was contributed to the Oahu Transportation Study for continued processing and analysis.

## B. INTERNAL SURVEY

The Origin-Destination Survey for Oahu is an internal survey because the entire Island of Oahu was considered the study area. The shoreline formed a natural cordon which, by its nature, provided no access into the study area by streets or highways.



AR00031780

1. DWELLING-UNIT SURVEY

The technique employed in the survey was to select a representative cross section (or sample) of dwelling units on Oahu and obtain desired information by interviewing the occupants of those dwelling units. The information obtained was expanded on the basis of the sampling rate to provide information representative of the entire population of Oahu.

The number of dwelling units selected was determined on the basis of national sampling-rate standards. On the basis of these standards, a 6.67-percent sample of the dwelling units on Oahu was selected.

A dwelling unit is defined as follows (based principally on the Bureau of the Census definition):

> "A group of rooms or a single room, occupied or intended for occupancy as separate living quarters, by a family or group of persons living together or by a person living alone."

Examples under this definition are: single rooms in large rooming houses (10 rooms or more), apartments in any multiple dwelling unit, units of a duplex, single-family homes, single bunks in barracks or vessels, tourist cabins, house-boats, and rooms of permanent guests of hotels.

Thus, housing areas within military areas were also included in the survey and followed the same sampling ratio as those in the civilian areas of Oahu. Bachelor military servicemen living on post or vessels were sampled at the same rate, but selection was on the basis of a roster either by company, by fighter wing group, by vessel, etc.

Tourists vacationing on Oahu, residing in hotels and paying a daily room rate were not included in the survey.

Table 9.1 shows the results of this method of selection for which personal interviews were made. Table 9.2 shows the extent to which the interviews were completed.



AR00031781

Table 9.1. Summary of Dwelling-Unit Sample-Selection Activity on Oahu in 1960

| Area | Dwelling Units | |
|---|---|---|
| | Counted | Sampled |
| Civilian Housing | 106,730 | 7,347 |
| Military Housing | 13,237 | 882 |
| Military Servicemen | 30,592 | 1,716 |
| TOTAL | 150,559 | 9,945 |

Table 9.2. Summary of Dwelling-Unit Interviewing Activity on Oahu in 1960

| Interviews | Number | Percent of Total |
|---|---|---|
| Interviews Completed | 8,612 | 86.6 |
| No Interviews | | |
| Dwellings Vacant | 793 | 8.0 |
| Dwellings "missed" | 540 | 5.4 |
| TOTAL | 9,945 | 100.0 |

2. TRUCK AND TAXI SURVEY

The technique employed in the Truck and Taxi Survey was basically the same as that employed in the Dwelling Unit Survey, and the travel data obtained related principally to commercial movements.

In order to obtain accuracy equal to that obtained in the Dwelling Unit Survey, it was necessary to increase the size of the sample, because of the smaller universe of trucks and taxis. For this reason a sampling of 20 percent of the trucks was selected from the registration records of the City and County of Honolulu and the various branches of the Federal Government, including the military, and a sampling ratio of 100 percent of taxis was taken from the records of the Honolulu Police Department.

Nonscheduled buses were included in the Taxi Survey; such buses included school buses, institutional buses, government and military buses, etc.

For the Truck and Taxi Survey, the U. S. Bureau of Public Roads defined a trip as "the one-way travel between each stop, provided the stop is



AR00031782

necessary in the course of the day's work." Certain trucks make a great many stops which are only a block or two apart, i.e., daily deliveries of milk, bread, laundry, etc. Short trips of this nature are not significant; hence, only trips which were approximately two city blocks or greater in length were recorded.

Tables 9.3 and 9.4 show the truck and taxi sample-selection activity and the extent of interviewing completion.

Table 9.3. Summary of Truck and Taxi Sample-Selection Activity on Oahu in 1960

| | Universe | Sample |
|---|---|---|
| Trucks | | |
| Civilian | 17,335 | 3,467 |
| National Guard | 335 | 67 |
| Military | 2,514 | 502 |
| Subtotal | 20,184 | 4,036 |
| Taxis | 858 | 858 |
| Nonscheduled Buses | | |
| Civilian | 150 | 150 |
| Military | 231 | 231 |
| Subtotal | 381 | 381 |
| TOTAL | 21,423 | 5,275 |

Table 9.4. Summary of Truck and Taxi Interviewing Activity on Oahu in 1960

| Interviews | Trucks | | Taxis | | Buses (Nonscheduled) | |
|---|---|---|---|---|---|---|
| | Number | Percent of Total | Number | Percent of Total | Number | Percent of Total |
| Interviews Completed | 3,300 | 81.0 | 808 | 94.2 | 377 | 99.0 |
| No Interviews | | | | | | |
| Out of service, junked, etc. | 686 | 17.0 | -- | -- | 4 | 1.0 |
| Refusals, etc. | 50 | 1.2 | 50 | 5.8 | -- | -- |
| TOTAL | 4,036 | 100.0 | 858 | 100.0 | 381 | 100.0 |



AR00031783

### 3. U-DRIVE VEHICLE SURVEY

There were 21 U-Drive agencies operating 809 vehicles on Oahu in 1960. Pre-visits made at a few large agencies revealed that vehicles may be rented from and returned to any one of a number of outlets operated by the agency. Users may have their rentals attached to their hotel bills or procured through credit cards, thus, never having to return to the agency.

Attempts were made to obtain trip information from persons renting U-Drive vehicles by arranging with the agencies to hand to each user when the keys were delivered a questionnaire with a self-return address envelope. The results of the two agencies surveyed revealed that the number of trips made by persons who normally would not have been sampled in the other phases of the Origin-Destination Survey was not significant. The U-Drive Vehicle Survey was then dropped because the total number of usable trips would not affect the "completeness" of the Origin-Destination Survey and because the number of man-hours needed would not justify its continuance.

## C. MODE OF TRAVEL

A person trip is defined as a one-way journey from one point to another. An auto-driver trip is considered a person trip because the driver is being transported. Since not all people are drivers, people also travel as passengers in cars, buses, taxis and trucks. Although walking trips, trips by bicycle, etc., are considered person trips, they are not recorded in the 1960 Origin-Destination Survey. Trips of children under five years were also not included.

Honoluluans, in 1960, made approximately 1¼ million trips on Oahu on an average weekday. One fundamental conclusion becomes obvious from the trip-volume summaries shown in Table 9.5:

1. The automobile was overwhelmingly the choice for person travel. About 88 percent of all person trips in 1960 were made either as an automobile driver or passenger.

About 58 percent of all person trips made by automobiles were made by automobile drivers. Buses carried slightly over 10 percent of all person trips.



AR00031784

Table 9.5. Person-Trip Summary on Oahu in 1960

| Travel Mode | Person Trips | Percent of Total |
|---|---|---|
| Auto-Driver Trips | 644,175 | 51.2 |
| Passenger Trips in | | |
| passenger cars | 464,920 | 37.0 |
| buses | 130,581 | 10.4 |
| trucks | 13,241 | 1.1 |
| taxis | 4,798 | 0.3 |
| TOTAL | 1,257,715 | 100.00 |

## D. TRIP PURPOSE AND LAND USE

Every trip has a purpose, the most common being "to go home," (Table 9.6). For all travel modes, 38 percent of all person trips were homeward bound. Since a comparable number of additional trips to other destinations also originated there, the home of the trip maker was involved in over three-fourths (76 percent) of all trips as either the origin or the destination. Thus, the home is a base from which travel patterns are organized.

Table 9.6. Percent Trip Purpose by Mode of Travel on Oahu in 1960

| Trip Purpose | Driver | Passenger | | | | All Modes |
|---|---|---|---|---|---|---|
| | | Auto | Bus | Truck | Taxi | |
| Work | 18.7 | 8.1 | 20.6 | 48.8 | 11.9 | 15.3 |
| Business | 4.5 | 1.8 | 1.7 | 2.6 | 2.0 | 3.2 |
| Medical-Dental | 1.1 | 2.0 | 1.6 | 0.2 | 5.4 | 1.5 |
| School | 1.0 | 6.8 | 15.0 | 0.7 | 0.7 | 4.6 |
| Social-Recreational | 13.1 | 25.8 | 7.9 | 4.1 | 16.1 | 17.1 |
| Change-Travel Mode | 0.4 | 1.2 | 2.4 | 4.7 | 8.1 | 1.0 |
| Eat Meal | 3.5 | 3.4 | 0.6 | 1.7 | 1.7 | 3.1 |
| Shopping | 11.5 | 10.4 | 4.7 | 0.2 | 4.6 | 10.3 |
| Serve Passenger | 10.6 | 0.7 | 0.1 | -- | 0.6 | 5.7 |
| Home | 35.6 | 39.8 | 45.5 | 37.0 | 48.9 | 38.2 |

Work trips make up 15 percent of all person trips. Again, an equal number must come from work as go to work, so it can be said that roughly 30 percent of all person-travel is work oriented.



AR00031785

Work purposes out-rank all others in the production of trips originating at the home. On the average weekday, over one-fourth (28 percent) of the total person trips leaving home was to go to work. The principal components of both the morning and evening traffic peaks that tax street capacity are the vehicles that are taking people to or from work.

Social-recreational trips and shopping trips combined accounted for over one-fourth (27 percent) of all person-trips. Other trip purposes were individually much less important. These less-important trip purposes combined make up less than one-fifth (19 percent) of all person trips.

There is a strong influence and logical correspondence between trip purposes and the land use to which the trip is destined (Fig. 9.1). While but 38 percent of all person trips are returning to their homes, 45 percent of all person trips are destined to residential lands. The reason for the difference is that a number of work and social-recreational trips are made to residential land. Work trips by domestics and servicemen and visits by families or friends are good examples. Residential land, like the home itself, is of great importance in fixing travel patterns.

Trips made to service and retail establishments make up 23 percent of all person travel. These types of activities fall in the broad category of commercial land use. Thus, slightly over two-fifths of those trips not bound to residential land were bound to commercial land.

Public buildings (schools, churches, post offices, and the like) attract also about 23 percent of all trips. The remaining land uses (such as manufacturing, public open space and transportation) are minor generators of travel, as might be expected.



AR00031786

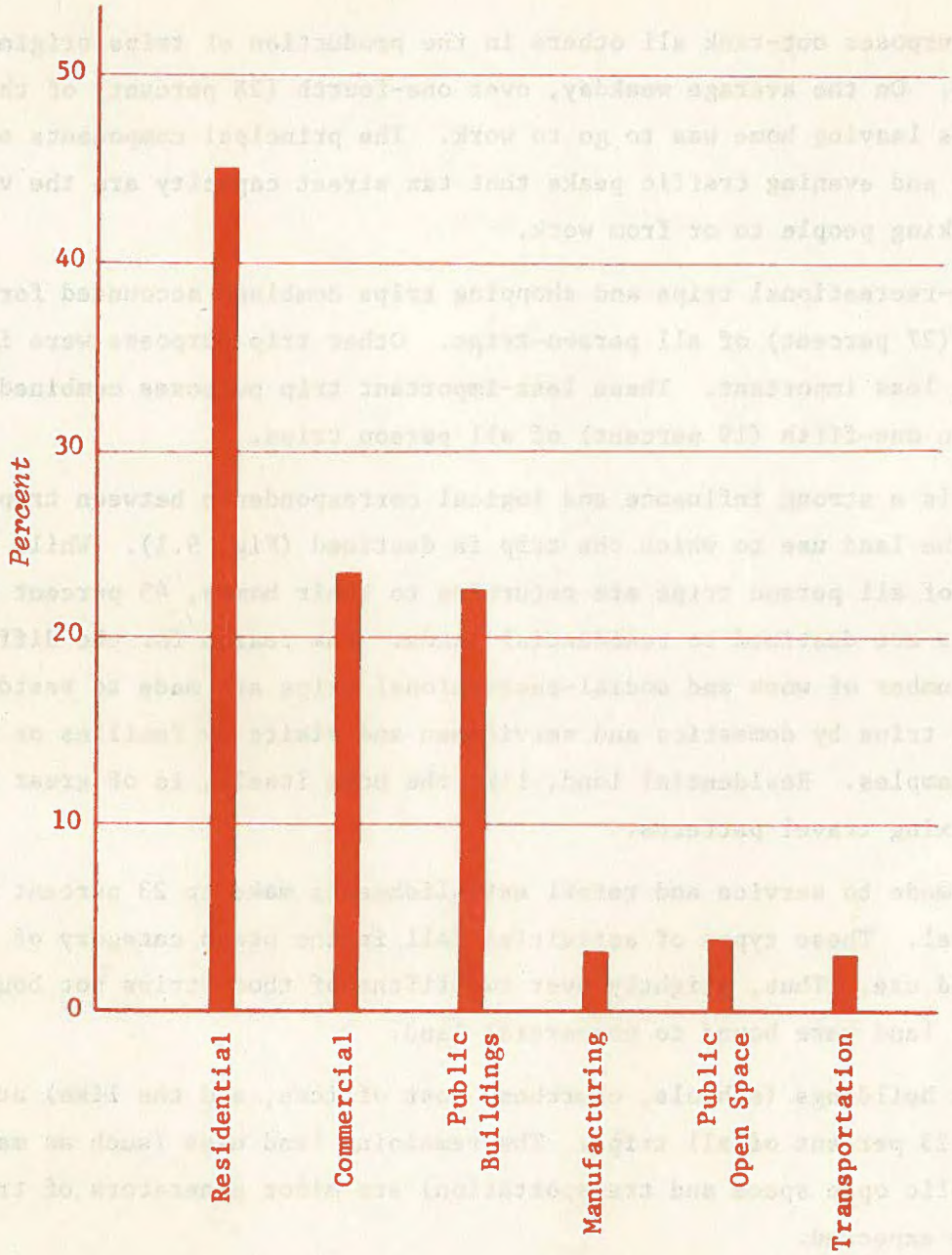



FIG. 9.1. PERSON TRIPS BY LAND USE ON OAHU IN 1960.



AR00031787

## E. HOME-BASED TRAVEL

The disposition of residential development is without question one of the strongest single forces shaping the travel patterns of Oahu. On Oahu, the home of the trip maker was involved in over three-fourths of all trips. Of these home-based trips, work and social-recreational travel constituted the most important trip categories.

Of all the person trips which began and ended at the home, about 12 percent relied upon the local transit as a means of transportation. Thus, 88 percent of the total home-based trips relied upon the automobile as a means of transportation.

While only about 18 percent of the home-based work trips were by transit, its ridership on transit constituted the largest representation. School trips were next in significance.

Figure 9.2 shows the distribution of home-based person trips by three types of breakdown.

## F. AUTOMOBILE OCCUPANCY

Person trips by automobile are accounted for in terms of the auto driver, accompanied by a variable number of passengers. Many shopping and social-recreational trips would normally not be made by a single-family member unless others could accompany him. Work trips, on the other hand, are quite likely to be made by the driver alone.

Average auto occupancy for all trip purposes was found to be 1.81 persons per car (Table 9.7) while work trips showed an average occupancy of 1.22 persons per car. The overall has been remarkably stable; the average reported for 1952 was also 1.8 persons per car [Ref. 1].



AR00031788

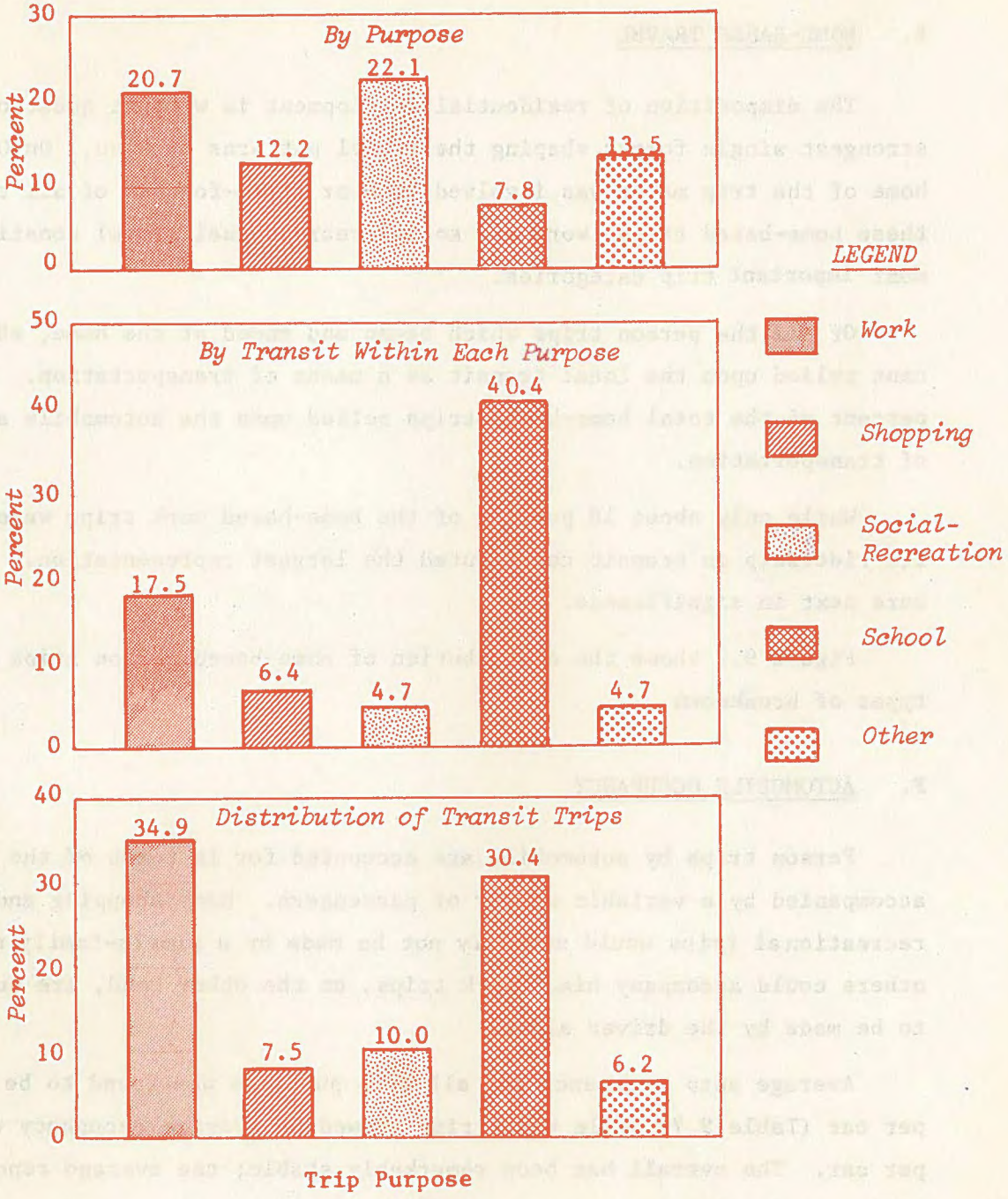



FIG. 9.2. DISTRIBUTION OF HOME-BASED PERSON TRIPS ON OAHU IN 1960.



AR00031789

Table 9.7. Automobile Occupancy by Purpose of Trip on Oahu in 1960

| Trip Purpose | Auto Occupancy |
|---|---|
| Work | 1.22 |
| Business | 1.58 |
| Medical-Dental | 2.20 |
| School | 1.33 |
| Social-Recreational | 2.26 |
| Change-Travel Mode | 1.39 |
| Eat Meal | 1.97 |
| Shopping | 2.05 |
| Average | 1.81 |

## G. TRIP LENGTH

There is regularity of travel by trip length--i.e., the number of trips made varies systematically with trip length. Trips are made most frequently for short distances; as distances increase, progressively fewer trips are made. The frequency distribution of trips by length and by purpose is shown in Fig. 9.3.

The trip maker has a whole spectrum of needs, which ranges from daily needs, such as work, shopping and school, to the less-frequently-felt needs for recreation, for medical care, and for vacations. To meet these requirements, stores, services, churches, factories, hospitals, etc., are located at difference intervals throughout an urban area. Food stores are close together because people must buy food frequently. Department stores are farther apart because shopping trips for clothing and furniture are made less frequently. Moreover, each kind of urban activity has its own internal requirements which affect spacing, among which are the collection, handling, storage, and distribution of goods. Generally, the more specialized the activity, the farther it is located from the average traveler.

Thus, purpose has a great deal to do with trip length. Shopping trips, as might be expected, are usually short, averaging 2.5 miles in length for Oahu. The longest trips were those made to work, with an average length of 5.0 miles. Trips to home from any outside point averaged 4.1 miles; those made for social-recreation were 3.8 miles in length; and those made for school were 3.3 miles in length.



AR00031790

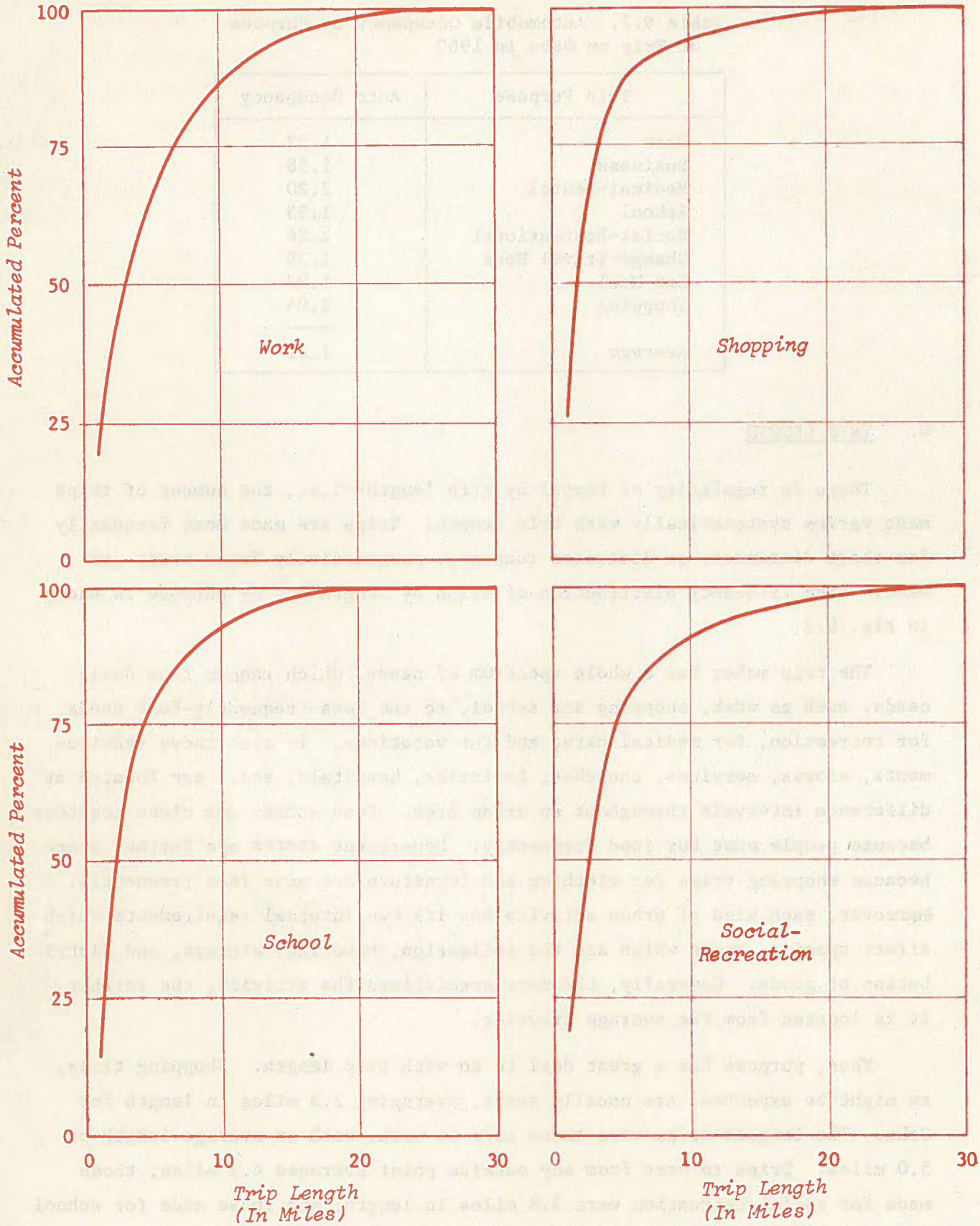



FIG. 9.3. DISTRIBUTION OF AUTO TRIPS BY LENGTH AND PURPOSE ON OAHU IN 1960.



AR00031791

The preceding data have shown that, when dealing with large masses of trips, there do exist regularities in travel patterns. The behavior of a single person cannot be predicted successfully, but major transportation facilities are not planned for single persons or for even small groups.

## H. TRIP GENERATION

The forecasting of future travel volumes produced from and attracted to a traffic zone in a study area is an essential phase of a continuing, cooperative, comprehensive transportation study. The process of estimating these future trips in quantitative terms includes primarily the following two steps: 1) the determination of the relationships between trip productions and attractions and various land-use and socio-economic factors; and 2) the utilization of these relationships to estimate future trips in conjunction with forecasts of applicable socio-economic and land-use factors. The following describes the methods employed by the Oahu Transportation Study in the development of trip generation estimating equations which were used to forecast 1985 person trips.

### 1. DEVELOPMENT OF PERSON-TRIP PRODUCTION AND ATTRACTION EQUATIONS

Using statistical regression analysis, socio-economic and land-use information were related to the number of trips by specific trip purposes and were reduced to mathematical equations. In this equation-development process, all of the parameters that could logically be related to the frequencies of the various trip purposes were tested, and only those parameters which had a significant effect on the number of trips generated were retained in the final equations.

For the most part, these equations were formulated by relating 1960 trips by purpose derived from the 1960 Origin-Destination survey to land uses and to other socio-economic factors available for the same year. Six trip stratifications were included in the present study:

1. Home-based work trips
2. Home-based shopping trips
3. Home-based social-recreation trips



AR00031792

4. Home-based school trips
5. Home-based "other" trips and
6. Non-home-based trips.

An all-purpose, total equation was also developed for home-based trips, so that a grand total of trip productions could be provided to control trip estimates. (See Appendix IX.A for a discussion of trip production and trip attraction).

Independent variables thought to be significantly influential in generating trips are shown in Table 9.8. These independent variables were analyzed singly and in various combinations with one another. Selection of independent variables to be included in the estimating equations was dependent on the degree of association between each of two logical combinations of independent variables. Solutions of these equations involved various logical combinations of independent variables. Final selections of the predictive equations were based on the highest degree of association between the independent and dependent variables in the equations, the significance of the regression coefficient of each independent variable in the equations, and the check on the overall reasonableness of the apparent statistical relationship.

Suitability checks were made of the estimating equations by an analysis of their residuals--i.e., difference between the trips estimated by the predictive equations and the observed survey trips. It was found that the geographic distribution of the residuals indicated a general overstatement of trips in the outlying districts and generally an understatement for the Honolulu District. Thus, to avoid any geographic bias in the prediction of future trips, separate predictive equations were developed for these areas.

Home-based production equations were developed on the basis of 65 observations (Census Tracts 1-65) for the Honolulu District area and 46 observations (Census Tracts 66-113) for the outlying area. Census Tract 79 (Waimano Training Home and Hospital) and Census Tract 104 (Hawaii State Hospital) were considered to have individual characteristics quite dissimilar to the rest of the Study Area and were thus excluded as observations in the equation-development process.



AR00031793

Table 9.8. Independent Variables Considered in the Development of Trip-Generating Equations

| Production Equations | Land Area in Acres | Attraction Equations<br>Floor Area in Sq Ft | Other Variables |
|---|---|---|---|
| Population | Residential | Manufacturing | School Enrollment |
| Dwelling Units | Manufacturing | Transportation, Communications, and Utilities | Dwelling Units |
| Auto Ownership | Transportation, Communications, and Utilities | Commercial - Retail | Population |
| Population Residential Density | Commercial - Warehouse, Storage, and Construction | Commercial - Service | Employment (job site) |
| Dwelling Unit Residential Density | Commercial - Retail | Public Buildings | |
| School-Age Population (ages 5 - 17) | Commercial - Services | Agriculture and Extractives | |
| Log of Population Residential Density | Public Buildings | | |
| Log of Dwelling Unit Residential Density | Public Open Space | | |
| Acres Residential | Agriculture and Extractives | | |



AR00031794

The following military census tracts also were omitted in the development of home-based attractions and non-home-based trip equations:

C.T. 66 Fort Shafter
C.T. 73 Hickam Air Force Base
C.T. 74 Pearl Harbor
C.T. 85 Barber's Point Naval Air Station
C.T. 95 Schofield Barracks
C.T. 108 Kaneohe Marine Corps Air Station

The equations resulting from the trip analysis are shown in Appendix IX.B. Total home-based production equations (control equations) for Honolulu District and for outlying districts are given below.

HONOLULU DISTRICT

Total Home-Based Trips = 657.08386 + 6.44492 autos by C.T.
+ 1.71666 dwelling units by C.T.

OUTLYING DISTRICTS

Total Home-Based Trips = -911.46411 + 3.68143 autos by C.T.
+ 0.47995 population by C.T.
+ 1091.47101 $\log \frac{\text{dwelling units}}{\text{Land Use residential (acres)}}$

2. DEVELOPMENT OF COMMERCIAL-TRIP PRODUCTION AND ATTRACTION EQUATIONS

The forecasting of truck trips is also an integral part of trip generation. Their estimates will show the movements of goods on the roads and streets. Although truck trips are not considered heavy on Oahu's roads and streets, their affect on traffic flow is approximately equivalent to that of between three and five passenger vehicles.

Production and attraction trips for trucks were determined in the same manner as for non-home-based person trips, where each trip origin represented a production, and where each trip destination represented an attraction.

Solution and selection of a truck-trip estimating equation followed the same procedure mentioned earlier for person-trip estimating equations.



AR00031795

The final estimating equation for truck trips follows:

Truck Trips = 566.60535 + 0.81641 x Employment by job site
- 0.00680 x Floor Area Commercial Service*
+ 0.00111 x Floor Area Commercial Retail

3. PERSON-TRIP FORECASTS

Forecasts of future person trips were accomplished by the use of the person-trip equations shown in Appendix IX.B. Forecast values by census tracts of those particular land uses and socio-economic factors were inserted for the respective independent variables in the equations. Figure 9.4 shows the estimated 1985 control total of home-based productions trips (all purpose). It should be noted that initial 1985 estimates of person trips by purpose were adjusted to sum this control total.

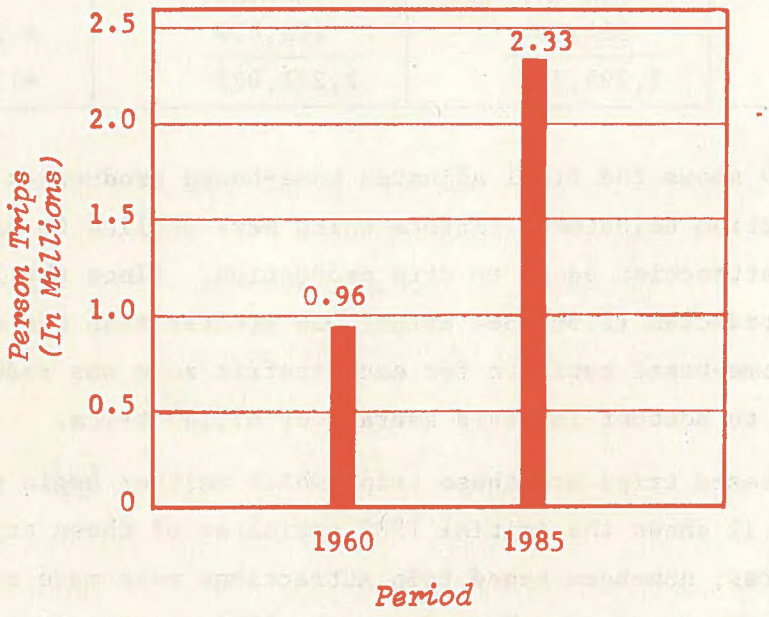



FIG. 9.4. ESTIMATE OF HOME-BASED PRODUCTION TRIPS IN 1985 BASED ON 1960 DATA.

*Floor areas are in square feet.



AR00031796

Table 9.9 shows the initial estimates and differences of production and attraction person trips in 1985 by trip purpose. In almost all instances, estimates for trip attractions were less than trip productions. In theory, however, trip productions and trip attractions should be equal. In normalizing the trip, trip production was given priority over trip attraction because there is greater stability when predicting trips at the home end or production end of the trip. An exception is made of school trips, where it was found that school enrollment at the attraction end was much more stable as the independent variable.

Table 9.9. Initial Estimates of Production and Attraction Person Trips in 1985 by Purpose

| Trip Purpose | A Trip Production | B Trip Attraction | Difference: A Less B |
|---|---|---|---|
| Work | 687,299 | 600,081 | + 87,218 |
| Shopping | 398,780 | 333,339 | - 65,441 |
| Social-Recreation | 688,119 | 701,481 | - 13,362 |
| School | 296,901 | 296,901 | -- |
| Other | 324,285 | 290,020 | + 34,265 |
| TOTAL | 2,395,384 | 2,221,822 | +173,562 |

Table 9.10 shows the final adjusted home-based production person trips and the trip-attraction adjustment factors which were applied to each traffic zone to make trip attraction equal to trip production. Since the initial estimate of trip producton (2,395,384 trips) was greater than the control total (2,328,239), the home-based estimate for each traffic zone was reduced by a factor of 0.971969 to account for this average of 67,145 trips.

Non-home-based trips are those trips which neither begin nor end at the home. Table 9.11 shows the initial 1985 estimates of these trips. In these study estimates, non-home-based trip attractions were made equal to the non-home-based trip productions. Therefore, the 1985 non-home-based trip estimate is 489,610 trips.



AR00031797

Table 9.10. Adjusted Home-Based Production Person Trips and Trip Attraction Adjustment Factors in 1985

| Trip Purpose | Adjusted Trip Production | Adjustment Factor |
|---|---|---|
| Home | 668,033 | 1.113238 |
| Shopping | 387,602 | 1.162786 |
| Social-Recreation | 668,830 | 0.953454 |
| School | 288,579 | 0.878090 |
| Other | 315,195 | 1.086804 |
| TOTAL | 2,328,239 | 1.047896 |

Table 9.11. Estimate of Non-Home-Based Person Trips in 1985

| Non-Home-Based Trips | Estimated Trips |
|---|---|
| Production | 489,610 |
| Attraction | 449,342 |

Table 9.12 summarizes the 1985 person trips by trip purpose and compares their growth from the base year, 1960,to 1985. It is estimated that persons on Oahu will make 2,817,849 daily trips in 1985. This daily travel by persons will represent a total increase of daily travel of 2.37 times that made in 1960. Future composition of travel by trip purpose will be relatively the same as that found in 1960. There will be as many home-to-work trips as there will be social-recreation trips, and they, combined, will represent slightly over 47 percent of all person trips.

In 1985, people will make on an average about 2.68 trips per day per person. This rate represents an increase of about 0.30 more trips per person when compared to the 1960 per-capita trip rate.



AR00031798

Table 9.12. Summary of Person Trips on Oahu in 1960 and 1985, by Purpose

| Trip Purpose | 1960 | | 1985 | | Growth | |
|---|---|---|---|---|---|---|
| | Person Trips | Percent of Total | Person Trips | Percent of Total | Person Trips | Percent of Total |
| Home-Based Trips | | | | | | |
| Work | 288,807 | 24.2 | 668,033 | 23.7 | 379,226 | 2.31 |
| Shopping | 156,728 | 13.1 | 387,602 | 13.8 | 230,874 | 2.47 |
| Social-Recreation | 284,310 | 23.9 | 668,830 | 23.7 | 384,520 | 2.35 |
| School | 100,025 | 8.4 | 288,579 | 10.2 | 188,554 | 2.89 |
| Other | 129,355 | 10.9 | 315,195 | 11.2 | 185,840 | 2.44 |
| Non-Home-Based Trips | 231,980 | 19.5 | 489,610 | 17.4 | 257,630 | 2.11 |
| TOTAL | 1,191,205 | 100.0 | 2,817,849 | 100.0 | 1,626,644 | 2.37 |



AR00031799

4. TRUCK-TRIP FORECAST

The forecast of truck trips in 1985, utilizing the forecasting equation described earlier, is 166,495, which represents an increase of more than 51,100 truck trips, or approximately a 44 percent increase over the 1960 number [Fig. 9.5].

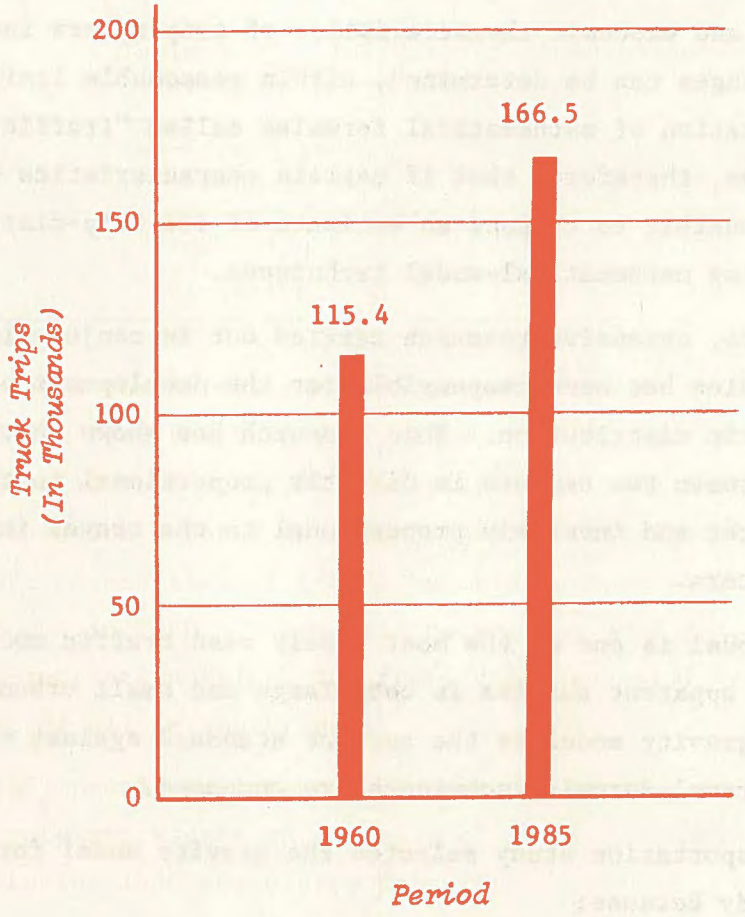



FIG. 9.5. ESTIMATE OF TRUCK TRIPS ON OAHU IN 1985, BASED ON 1960 DATA.



AR00031800

## I. TRIP-DISTRIBUTION ANALYSES

The forecasts of person and commercial trips conclude the initial portion of the travel forecast. Still to be accomplished are: 1) the linking of the trip productions with trip attractions, 2) the division of these interzonal movements into travel modes, and 3) the conversion of modal movements into equivalent modal vehicles. The following deals with the first of the three remaining steps in the travel forecast.

Analysis of many travel-habit studies in relation to the use of land and the various social and economic characteristics of trip makers indicate that zonal-trip interchanges can be determined, within reasonable limits of accuracy, by the application of mathematical formulas called "traffic distribution models." It follows, therefore, that if certain characteristics of an area are known, it is possible to compute an estimate of its trip-distribution patterns by utilizing mathematical-model techniques.

In recent years, extensive research carried out in conjunction with major transportation studies has been responsible for the development of the gravity-model concept of trip distribution. This research has shown that the distribution of trips between two centers is directly proportional to the opportunities at each center and inversely proportional to the travel impedance separating the centers.

The gravity model is one of the most widely used traffic models and it has been used with apparent success in both large and small urban areas. In many respects the gravity model is the current standard against which all other inter-area travel-formula techniques are compared.

The Oahu Transportation Study selected the gravity model for use in its transportation study because:

1. The gravity model concept is simple and well documented.
2. The Oahu Transportation Study has the necessary survey data for a successful calibration of the gravity model.
3. There exists and is available a complete package of computer programs for the calibration of the gravity model and for the traffic assignments of the output from the model.
4. There exists voluntary technical assistance from the Bureau of Public Roads in accomplishing the calibration of the gravity model.



AR00031801

## 1. PRESENT USE OF THE GRAVITY MODEL

In applying a gravity-model trip-distribution formula to Oahu, we make full use of the experiences of the early researchers. It is customary today, for example, to develop the parameters in the gravity-model formula individually for each urban area under study. Furthermore, these parameters are developed for each of several different categories of trips. These categories take into account the basic reason for making trips and are generally referred to as trip-purpose categories. The gravity model formula is expressed today as follows:

$$T_{i-j} = P_i \frac{A_j \, F_{(t_{i-j})} \, K_{(i-j)}}{\sum_{x-1}^{n} A_x \, F_{(t_{i-x})} \, K_{(i-x)}}$$

where: $T_{i-j}$ = trips produced in zone $i$ and attracted to zone $j$

$P_i$ = trips produced by zone $i$

$A_j$ = trips attracted to zone $j$

$F_{(t_{i-j})}$ = empirically derived travel time factor which expresses the area-wide separation of trip interchange between zones which are $t_{i-j}$ apart. This factor is equal to $1/t^n$ where $n$ would vary according to the value of $t$.

$K_{i-j}$ = a specific zone-to-zone adjustment factor to allow for the incorporation of the effect on travel patterns of defined social or economic linkages not otherwise accounted for in the gravity model formulation.



AR00031802

The use of a set of travel-time factors to express the effect of spatial separation on zonal-trip interchange, rather than the traditional inverse exponential function of time, simplifies the computational requirements of the model. The use of these factors also provides for consideration of the fact that the effect of spatial separation generally increases as the separation increases. This could not be provided for in any convenient way otherwise.

The travel-time factors (often called "friction factors") express the effect that spatial separation has on trip interchange. These factors are a measure of the impedance to interzonal travel due to the spatial separation between the zones. In effect, these factors measure the probability of trip making at each 1-minute increment of travel time. There is one travel-time factor for each 1 minute of travel time in the area. Mathematically, this factor is inversely proportional to the travel time between zones raised to some power which varies depending on the travel-time increment.

To obtain travel-time factors for the present period, it is currently necessary to go through a process of trial and adjustment, mainly because the specific function that values follow has not yet been satisfactorily determined. The travel-time factors of the present period are usually assumed to remain the same for the future.

Various assumptions are implied in the use of the gravity model, as listed below.

1. An average travel pattern can be applied to all zones within the urban area, regardless of the social and economic characteristics of the zonal population.
2. The average length of a trip is entirely influenced by the closeness, or remoteness, of the attractive forces that cause trips to occur.
3. Trip-length distribution (by purpose) remain constant throughout the urban area.
4. Distance (travel time) between zones remains constant and can be accurately determined for the particular time period chosen.
5. The average travel pattern is independent of zonal locations (i.e., whether the two zones involved are radial or circumferential to each other).



AR00031803

Perhaps the distinguishing features of the model are that trips can be distributed directionally from and to land uses, and that this is done on the basis of the probability that a trip origin from a specific zone and land use will find a destination at a specific zone and land use "x" minutes away.

It has been mentioned earlier that travel-time factors vary between urban areas and that, for best results, they should be calculated specifically for the area in which the study is being undertaken. Discussion of the calibration of the gravity model for Oahu is found in Appendix IX.C.

## 2. PERSON- AND COMMERCIAL-TRIP DISTRIBUTIONS IN 1985

A high degree of success in synthesizing 1960 travel was achieved and the distributions of the 1985-forecast trip productions and attractions of both the person trips and commercial trips were undertaken with considerable confidence. Table 9.13 summarizes the hours of travel and average trip length of the estimated 1985 trip distribution. Figures 9.6 and 9.7 illustrate the comparisons of the trip-length frequencies between the 1960 observed and the 1985 forecast of travel.

On the average, trip lengths (minutes) were anticipated to increase during the forecast period (Table 9.14). The increase is reasoned to result primarily from the greater spatial separation between land uses, as a result of the expanded area of land development by 1985.

Table 9.13. Summary of Results of Gravity Model Application to 1985 Trip Ends

| Purpose of Person Trip | No. of Person Trips | | | |
|---|---|---|---|---|
| | No. of Trips | Intrazonal Trips | Total Travel Time (hr) | Average Trip Length (miles) |
| Home-Based | | | | |
| Work | 668,033 | 40,966 | 222,724 | 20.00 |
| Shop | 387,602 | 35,378 | 93,715 | 14.51 |
| Social-Recreational | 668,830 | 55,440 | 187,622 | 16.83 |
| School | 288,579 | 64,983 | 61,918 | 12.87 |
| Other | 315,195 | 34,746 | 84,469 | 16.08 |
| Non-Home-Based | 489,610 | 74,696 | 110,371 | 13.53 |
| Commercial Trips | 166,495 | 31,786 | 37,530 | 13.52 |



AR00031804

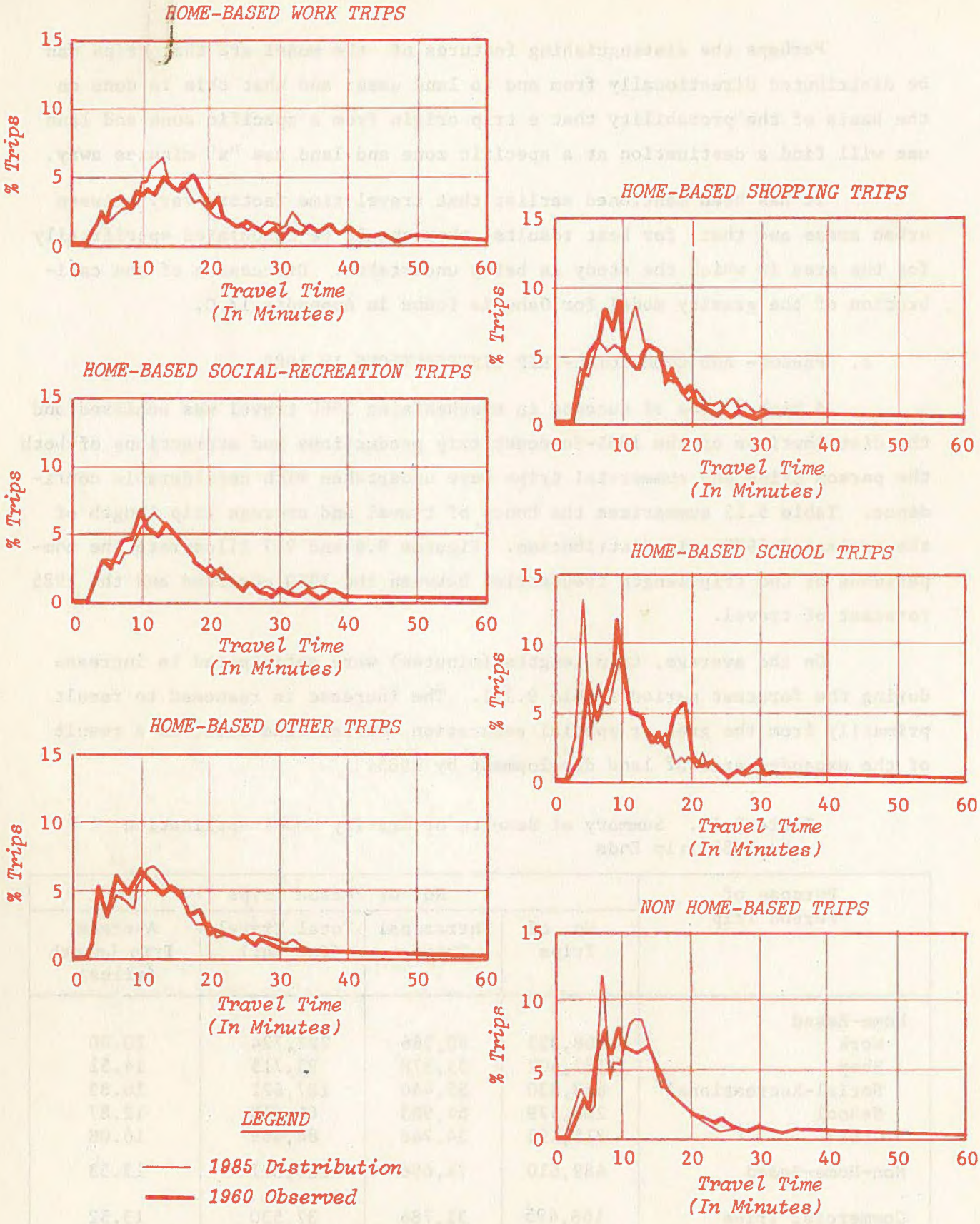



FIG. 9.6. SUMMARY OF 1960 AND 1985 TRIP LENGTH DISTRIBUTION OF PERSON TRIPS BY PURPOSE.



AR00031805

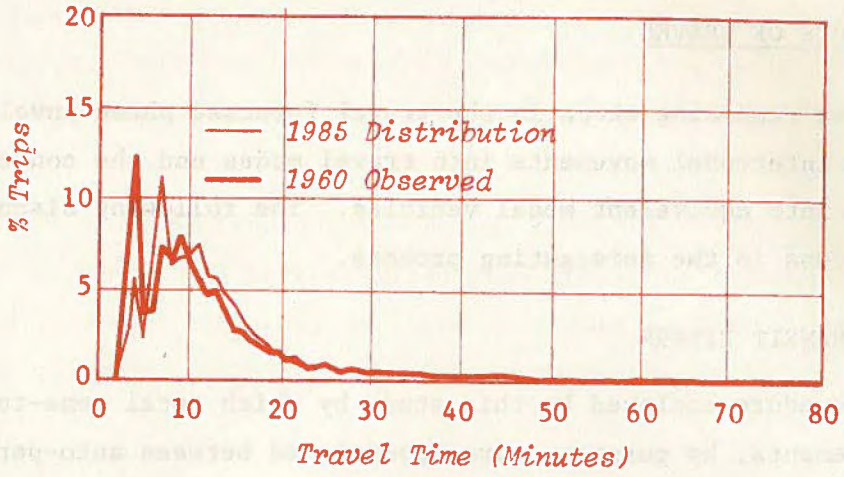



FIG. 9.7. COMPARISON OF COMMERCIAL TRIP TIME DISTRIBUTION IN 1960 AND 1985.

Table 9.14. Comparison of Trip Lengths Between 1960 Observed and Simulated, and 1985 Travel

| Trip Purpose | Trip Length (min) | | |
|---|---|---|---|
| | Observed 1960 | Simulated 1960 | 1985 |
| Home-Based | | | |
| Work | 20.5 | 20.3 | 20.0 |
| Shopping | 12.6 | 12.3 | 14.5 |
| Social-Recreation | 16.4 | 16.0 | 16.8 |
| School | 12.8 | 12.7 | 12.9 |
| Other | 15.8 | 15.9 | 16.1 |
| Non-Home-Based | 13.9 | 13.5 | 13.5 |
| Commercial | 12.4 | 12.5 | 13.5 |



AR00031806

## J. TRIPS BY MODE OF TRAVEL

The last two remaining steps in the travel forecast phase involved the division of the interzonal movements into travel modes and the conversion of modal movements into equivalent modal vehicles. The following discusses these two remaining steps in the forecasting process.

### 1. MASS TRANSIT RIDERS

The procedure employed by this study by which total zone-to-zone person-trip movements, by purpose, were apportioned between auto-person and transit-person trips is a post-distribution, interchange-type procedure or model (Appendix IX.D). It has been found that the best family of modal-split-estimating curves relates percent transit trips to[1] autos per dwelling unit at the production zone,[2] the transit-time difference for the interchange, and[3] average 9-hr parking cost at the attraction zone. The family of curves developed was applicable to the total distribution of home-based-work and home-based other person-vehicle trips. Estimates of transit school trips were based on trends in school-trip transit patronage. Estimates for future non-home-based transit trips were based on results of the transit home-based other, non-school transit estimates (Appendix IX-D).

The dominant determinant for transit trips is the average parking cost at the attraction zone. Average parking cost for each zone in 1960 was computed on the basis of the number of stalls, the 9-hr parking rate, and the occupancy rate for each type of parking available. It was reasoned that future increase in parking costs would parallel the future increase in personal income and household expenditures for goods and services. On the whole, a factor of 1.88 was applied to the 1960 average 9-hr parking cost for each zone.

For zones that have been estimated to lose a considerable amount of parking area in the forecast period, the application of 1.88 resulted in an unreasonable parking cost; therefore, a maximum 9-hr parking cost of $1.40 was set for such a zone. Generally, these zones occur in the Central Business District, where vacant areas temporarily used for parking in 1960 will not be available in the forecast period.



AR00031807

The transit-time difference for each group of trip interchanges is equal to the "equivalent" transit time minus the auto time between the points of origin and destination of the trip interchanges. "Equivalent" transit time equals 2.5 times the excess time plus transit running time. The excess time associated with public transit consists of the walk, wait, and transfer times.

The characteristics of the transit network from which equivalent transit times were obtained were based upon a transit system operation of the following:

1. Maximum speed of 50 miles per hour
2. Average scheduled speed approaching 30 mph
3. Acceleration and deceleration rates of 3 mph/sec
4. 4-min headways
5. Maximum station stop of 20 sec
6. Operation on exclusive right-of-way
7. Integration with surface bus feeders throughout.

Four transit-rider estimates were accomplished in this study. The first two estimates (see Chapter VI, on Local Transit Study), which were made during the early stages of this study, were for the purpose of providing data relating to the potential of a rapid-transit-system concept for Honolulu. Investigators of the early study concluded that there is a potential for this system and that the rapid-transit concept should be incorporated into all long-range transportation plans for Oahu. This early investigation also provided information relating to the adequacy and nonadequacy of the tested transportation system to serve the travel demand through certain corridors.

Based on these preliminary findings, the Oahu Transportation Study modified the earlier-tested freeway-arterial networks but maintained the rapid-transit-system network, which was devised earlier by its mass-transit consultant, and determined a new set of 1985 land-use, trip-generation and -distribution, and transit-rider estimates. Holding the newly developed spatial demand and distribution of land uses and travel, the Oahu Transportation Study, as an alternate transit-rider estimate, modified its arterial-highway networks in that section between Waialae and Hawaii Kai, and replaced the surface-bus feeder by extending the rapid-transit system in that area.



AR00031808

Also, for this alternate transit-rider estimate, the operating characteristics of the rapid system were altered to give the maximum advantage to the system. The change in headway was from 4 to 2 minutes and the loading nodes were fixed at a maximum of 4-minute walk time.

The results of these two transit-rider estimates are shown in Table 9.15.

Forecasts of transit trips show an overall percentage increase from 10.7 percent in 1960 to 12 or to 13 percent in 1985. Much more pronounced than the percentage increase in transit trips is the absolute increase--from 125,440 in 1960 to 337,400 - 363,100 in 1985. Although this represents a very considerable increase, it is not unreasonable after study of the underlying assumptions which include:

1. Construction of an extensive, high-speed, high capacity rapid-transit system and attendant feeder-bus system
2. Limitations on highway improvements resulting in net losses in highway speed by 1985 along a number of congested corridors
3. Increased intensity of development in commercial areas and the accompanying elimination of surface parking resulting in sharply increased parking costs
4. Fairly conservative growth in automobile ownership.

The forecast of future modal split, when examined in light of experiences in other cities and the reasonableness of the underlying conditions, indicates the estimates to represent a reasonably optimistic maximum 1985 transit usage.

## 2. EQUIVALENT AUTOMOBILE TRIPS

The conversion of the modal movements into equivalent modal vehicles is the last step in the forecasting phase of the transportation-planning process. The conversion of transit person trips into equivalent transit vehicles has been briefly discussed in Chapter VI. The following discusses the conversion of auto-person and truck trips into equivalent auto trips.

Converting auto-person trips to automobile trips was accomplished by dividing the trip interchanges by the appropriate auto-occupancy factor. It was observed that auto occupancy varied depending on the purpose of the trip and on the place or the attraction to which the trip was made.



AR00031809

Table 9.15. Summary of 1960 Observed and 1985 Estimated Transit Riders

| Purpose | 1960 Person Trips | | | Estimated 1985 Person Trips | | | | |
|---|---|---|---|---|---|---|---|---|
| | Total* | Transit | Percent Transit | Total | Adjusted System | | Extended System | |
| | | | | | Transit | Percent Transit | Transit | Percent Transit |
| Home-Based Work | 281,030 | 45,990 | 16.4 | 668,033 | 151,955 | 22.7 | 162,684 | 24.4 |
| Home-Based Other | 566,210 | 30,520 | 5.4 | 1,371,627 | 119,896 | 8.7 | 131,612 | 9.6 |
| Home-Based School | 99,750 | 39,760† | 39.4 | 288,579 | 29,273 | 10.1 | 29,273 | 10.1 |
| Non-Home-Based | 227,950 | 9,170 | 4.0 | 489,610 | 36,295 | 7.4 | 39,544 | 8.1 |
| TOTAL | 1,174,940 | 125,440 | 10.7 | 2,817,849 | 337,419 | 12.0 | 363,113 | 12.9 |

*Truck and Taxi Passengers are excluded from totals.

†Includes riders on nonscheduled and private buses.



AR00031810

Auto-occupancy factors, therefore, were developed for each zone by home-based work, home-based other, home-based school, and non-home-based trips on the basis of the attraction end of the 1960 observed trips.

Similarly, future truck trips were factored to equivalent auto trips by applying the weighted truck-auto equivalence factor computed for the zone to the truck interchanges to that zone. The weighted truck-auto equivalent factor for each zone was computed by first determining the type of truck trips observed in 1960 for the zone and then weighting their extensions on the basis of the following equivalencies:

| | | Auto Equivalent |
|---|---|---|
| 1. Panels and pickups | = | 1.0 |
| 2. Two-axle, single tire | = | 1.5 |
| 3. Two-axle, dual tires | = | 2.0 |
| 4. Three-axle single units | = | 2.5 |
| 5. Semi- or full-trailer combinations | = | 3.0 |

It should be noted that initial results yield nondirectional movements between every zone of production and all zones of attraction, which, when assigned to the transportation network, would produce nondirectional volumes. Since the transportation systems to be tested contain one-way streets and turn prohibitors that affect the direction of travel, the nondirectional movements were converted to directional volumes between origin and destination zones. The percentage split applied in this conversion was 50-50. As a result, final equivalent automobile trips were 1,530,966. Figure 9.8 shows a summary diagram of this volume.



AR00031811

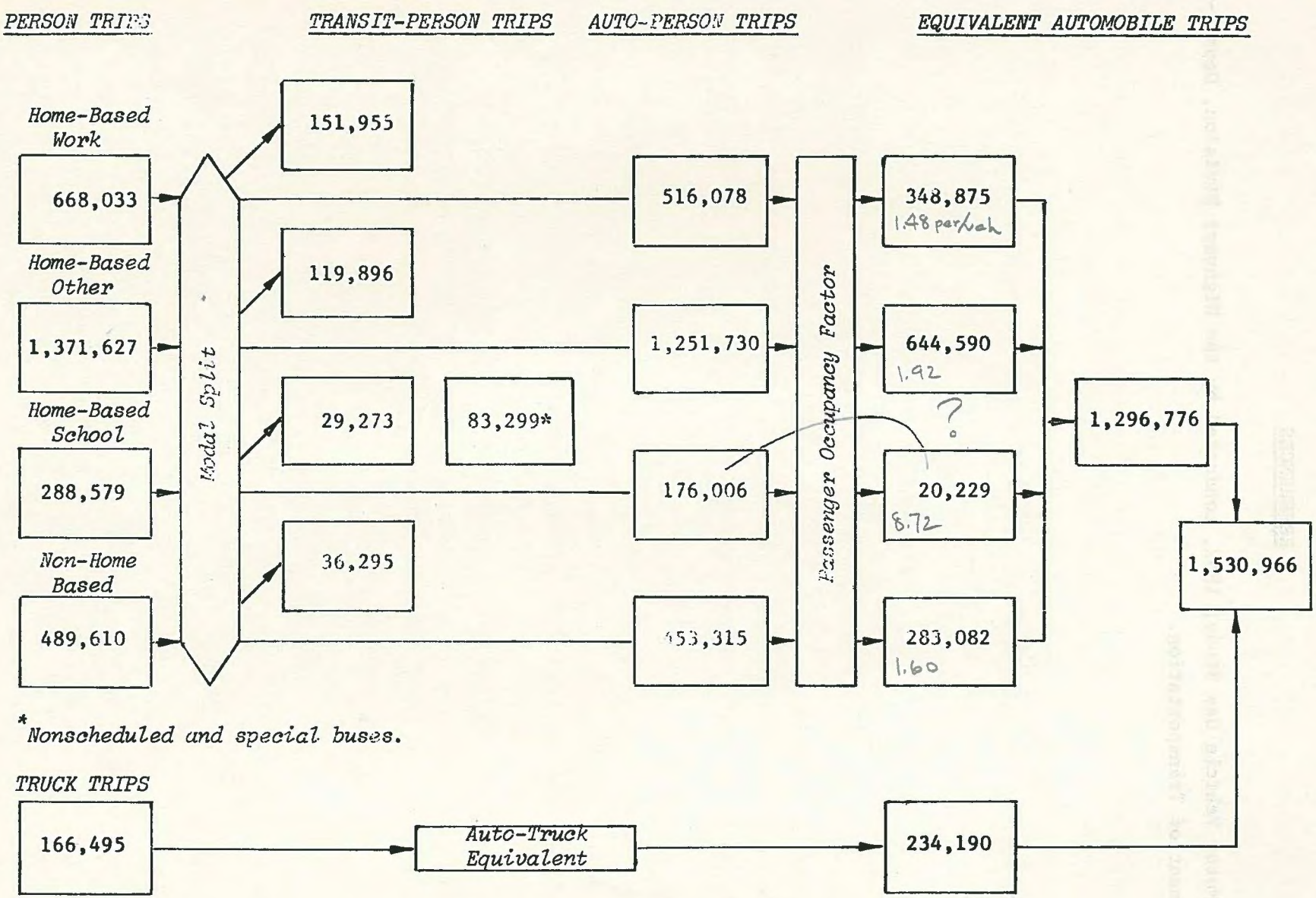


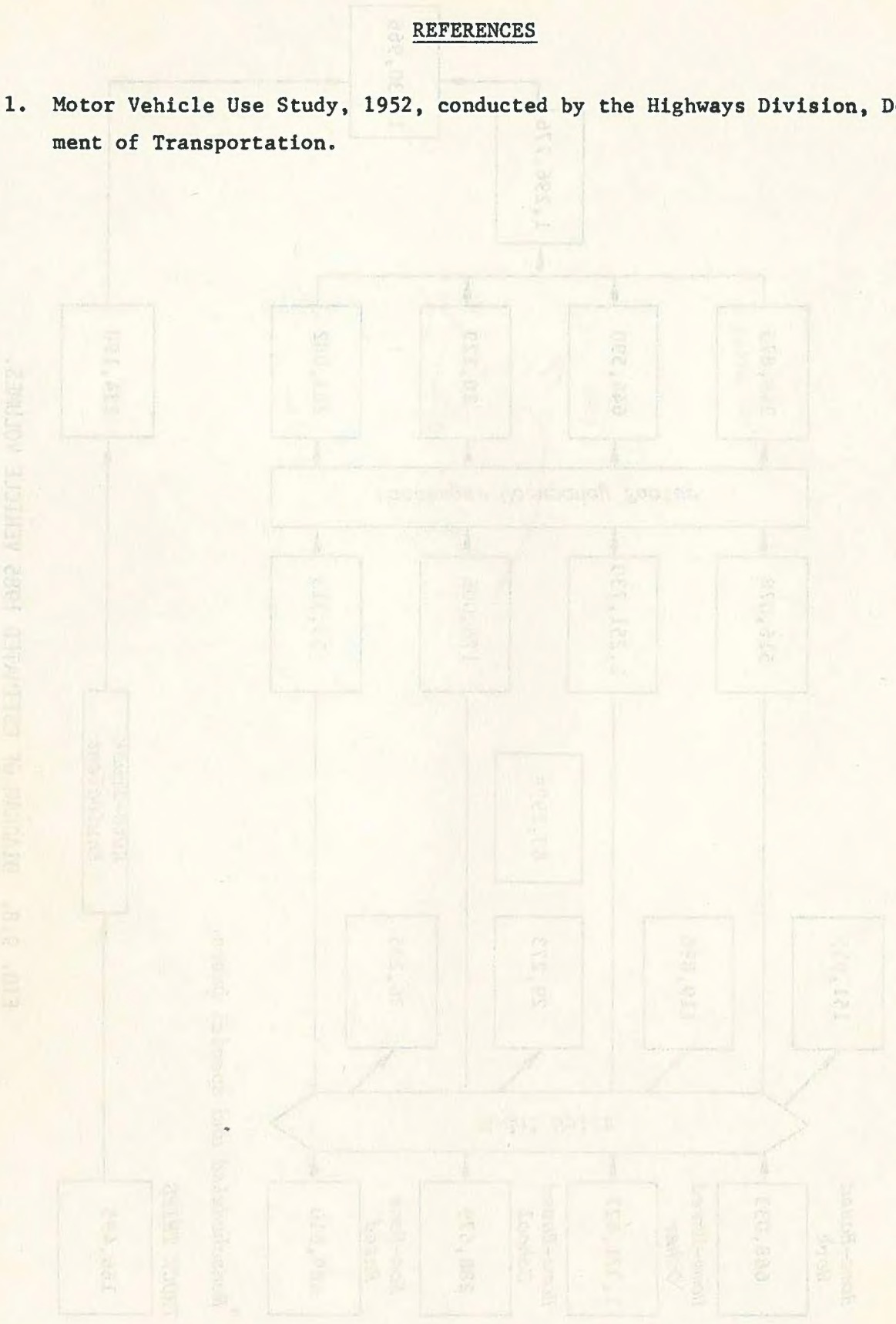

FIG. 9.8. DIAGRAM OF ESTIMATED 1985 VEHICLE VOLUMES.



AR00031812

## REFERENCES

1. Motor Vehicle Use Study, 1952, conducted by the Highways Division, Department of Transportation.





AR00031813

# APPENDIX IX-A. TRIP PRODUCTION AND ATTRACTION

# 1. INTRODUCTION

The first step in the analysis of travel characteristics for Oahu involved the investigation of factors influencing the generation (production and attraction) of person trips by purpose and the determination of person-trip production and attraction equations that would observe trip-making characteristics. Before the amount of travel generated by each zone, as observed in the home-interview origin-destination (O-D) survey, however, could be related to a variety of community characteristics--such as population, the number of dwelling units, the number of families, the number of cars owned, etc.--certain travel made by the same person must be altered in order to establish the true destination of the journey, trip purpose, and, in some cases, the mode of travel.

In a standard O-D survey, a trip is defined as the one-way travel between two points for a specific purpose. Thus, in such surveys, many journeys made by a trip maker have to be represented by two or more trip records even though only one journey is involved.

For example, one trip ends and another begins every time a person changes his mode of travel, or an auto driver stops to serve a passenger, or when the trip maker reaches his ultimate destination. In the first two cases, if each of these trips were analyzed separately, the relationships among 1) the actual starting point, 2) the ultimate starting point, and 3) the trip purpose would be lost. It would also be difficult to relate the type and intensity of trip making to the type and intensity of the use of land. Consequently, it is usually desirable to combine or "link" trips which have a "purpose to" or "purpose from" of either "change travel mode" or "serve passenger" so that the relationship between the purpose of the trip and the ultimate destination of the trip is preserved.

The major purpose for trip linking is to alleviate the problems encountered during the trip-generation phase of a transportation study when using trip records of "change travel mode" and "serve passenger". First, it is very difficult to obtain data that will correlate with these types of trips. Second, estimating equations for these types of trips results in high standard error of estimate. Third, trip files that are not linked and that possess



AR00031815

a considerable number of "serve-passenger" trips may result in unstable work-trip production equations.

To illustrate the "serve-passenger" and the "change-travel-mode" trips that are linked, consider the two following examples.

Figure 9.A1 illustrates an auto driver, driving his car from his home to the home of a co-worker, and they both proceed to work. In an O-D survey, this journey would be recorded as two separate auto-driver trips. The first trip would be recorded from "home" to "serve passenger" and the second trip from "serve passenger" to "work". Since the auto driver's ultimate purpose of this journey was to get from home to work, it is desirable, for analytical purposes, to "link" these two trip records into one which covers the entire journey. In this case, the auto driver's "linked" trip would become a home-to-work trip by automobile.

An example of "change travel mode" is illustrated in Fig. 9.A2. A person drives his car from his home to a fringe-area parking lot, where he boards a bus and rides to work. In this case, this journey would be recorded as two separate trips. The first trip would be recorded as an "auto-driver" trip from "home" to "change travel mode". The second trip would be recorded as a "transit-passenger" trip from "change travel mode" to "work". Since the ultimate purpose of this journey was to get from home to work, these two trip records would be "linked" into one trip that covers the entire journey.

The mode of travel is assigned according to the priority mode dictated by the investigator. If the priority lists transit preferable to the automobile, the "linked" trip in Fig. 9.A2 would be a trip from home to work by bus; if the priority mode was given to the automobile, the "linked" trip would result in a trip from home to work by automobile.

Two conditions encountered in the trip-linking process require special handling. The first of these occurs, for example, when a person drives from "home" to "serve passenger" and then returns home. If these two recorded trips were "linked", it would result in a home-to-home trip. As this is an undesirable situation, the trip purposes were adjusted by changing the "serve passenger" to "personal business." Thus, the first trip from "home" to "serve passenger" would be adjusted to a trip from "home" to "personal business" and



AR00031816

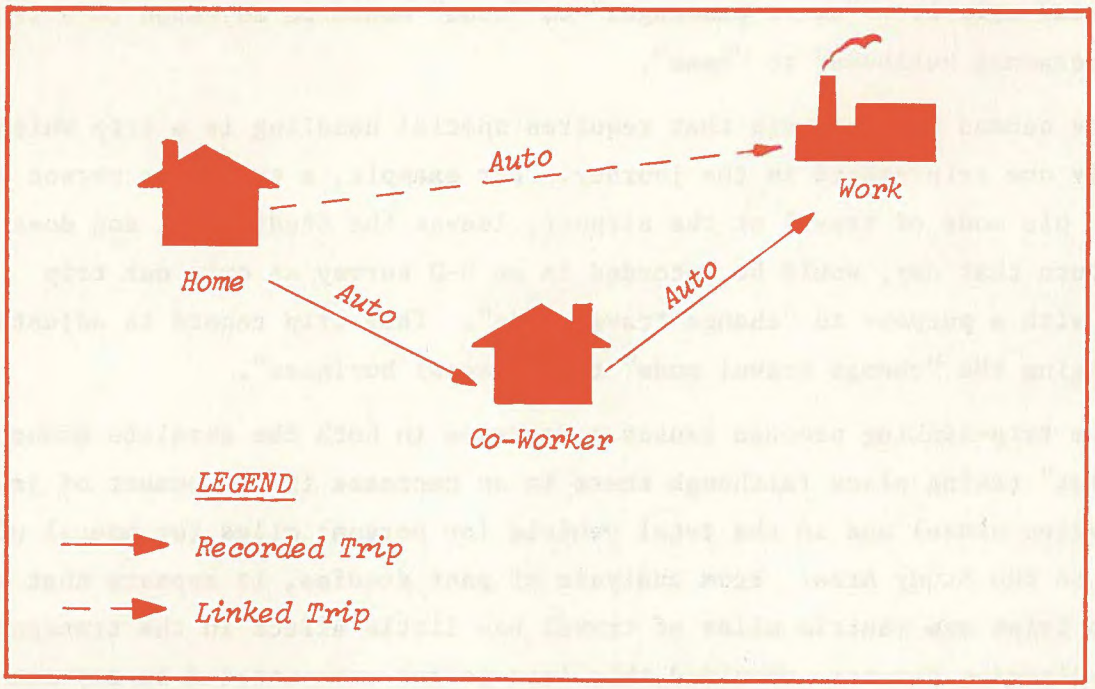



FIG. 9.A1. LINKING OF "SERVE-PASSENGER" TRIP.

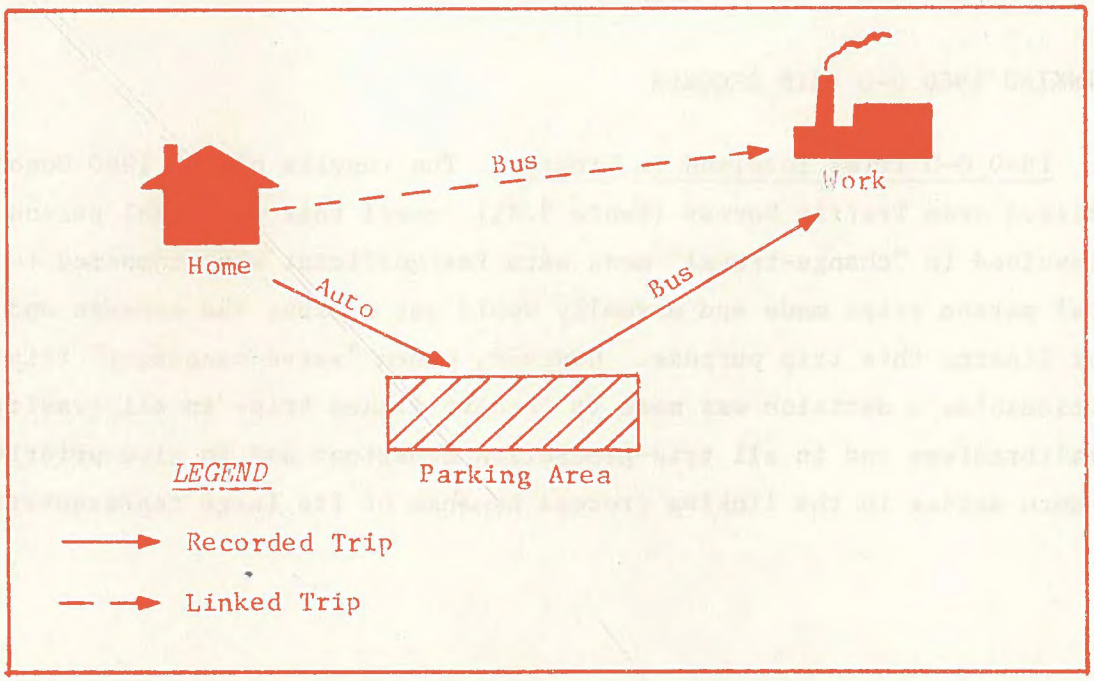



FIG. 9.A2. LINKING OF "CHANGE-TRAVEL-MODE" TRIP.



AR00031817

the second trip from "serve passenger" to "home" would be adjusted to a trip from "personal business" to "home".

The second type of trip that requires special handling is a trip which has only one trip record in the journey. For example, a trip by a person who changes his mode of travel at the airport, leaves the Study Area, and does not return that day, would be recorded in an O-D survey as only one trip record with a purpose to "change travel mode". This trip record is adjusted by changing the "change travel mode" to "personal business".

The trip-linking process causes a decrease in both the absolute number of "trips" taking place (although there is no decrease in the number of journeys taking place) and in the total vehicle (or person) miles (or hours) of travel in the Study Area. From analysis of past studies, it appears that the loss in trips and vehicle miles of travel has little affect in the transportation-planning process, provided this loss is not concentrated in any one part of the Study Area.

Because of this loss, the trip-linking process is accomplished after the basic (O-D) trip data have been edited, adjusted to screenline counts, and trip-end summary tables have been prepared.

## 2. LINKING 1960 O-D TRIP RECORDS

a. 1960 O-D Trips Involved in Linking. The results of the 1960 Honolulu Metropolitan Area Traffic Survey (Table 9.A1), reveal that the total person trips involved in "change-travel" mode were insignificant when compared to the total person trips made and normally would not warrant the expense and time for linking this trip purpose. However, since "serve-passenger" trips were noticeable, a decision was made to involve linked trips in all gravity-model calibrations and in all trip-generation equations and to give priority to the auto driver in the linking process because of its large representation.



AR00031818

Table 9.A1. Expanded 1960 O-D Person Trips by Modes

| Mode of Travel | Change Travel | Serve Passenger | All Purposes |
|---|---|---|---|
| Auto Drivers | 2,612 | 68,047 | 644,175 |
| Auto Passengers | 5,787 | 3,135 | 464,920 |
| Bus Passengers | 3,109 | 72 | 130,581 |
| Taxi Passengers | 391 | 30 | 4,798 |
| Truck Passengers | 619 | 0 | 13,241 |
| TOTAL | 12,518 | 71,284 | 1,257,715 |
| Horizontal % | 1.0 | 5.7 | 100.0 |

b. Trip Records After Linking. Trip linking of the 1960 O-D data was accomplished by personnel of both the Urban Planning Division, U. S. Bureau of Public Roads, Washington, D. C., and the Oahu Transportation Study. Data processing utilized electronic computers at Service Bureau Corporation, Palo Alto, California, and at the U. S. Bureau of Public Standards, Washington, D. C.

The trip-linking program produced the following totals after every record had been processed.

| Item | No. of Records |
|---|---|
| Total records processed | 59,990 |
| Total records adjusted | 2,887 |
| Total records requiring linking | 6,319 |
| Total records unchanged | 47,782 |
| Total records after linking | 53,556 |

It was noticed that the total records processed were four more than the control total of 56,986 and that the total records after linking contained five labeled "end" cards. These discrepancies in the record count, however, would not affect the calibration of the Gravity Model.

Table 9.A2 shows the reduction in the trip records by mode of travel in the 1960 O-D survey by the linking process.

c. Person Trips After Linking. There were 1,257,715 expanded person trips before linking and 1,191,207 after, or a reduction of 5.3 percent. Auto-driver trips represent 81.3 percent of this total reduction.



AR00031819

Table 9.A2. Comparison of Person Trips by Mode of Travel After Linking

| Mode of Travel | Total Person Trips | | | |
|---|---|---|---|---|
| | 1960 O-D Survey | After Linking | Change | |
| | | | No. | % |
| Auto Driver | 644,175 | 590,120 | -54,055 | - 8.4 |
| Auto Passenger | 464,920 | 459,384 | - 5,536 | - 1.2 |
| Bus Passenger | 130,581 | 125,433 | - 5,148 | - 3.9 |
| Taxi Passenger | 4,798 | 4,110 | - 688 | -14.3 |
| Truck Passenger | 13,241 | 12,160 | - 1,081 | - 8.2 |
| TOTAL | 1,257,715 | 1,191,207 | -66,508 | - 5.3 |

Table 9.A2 shows the comparison in total person trips by mode of travel between the 1960 O-D survey and the linking process.

## 3. DEFINITIONS OF TRIP PRODUCTION AND TRIP ATTRACTION

Confusion often exists among these terms: production, attraction, home-based, and non-home-based.

To demonstrate the production and attraction definition, it is first necessary to class all trips as either "home-based" or "non-home-based". Home-based trips always have one end at the residence of the trip maker. Non-home-based trips have neither end at the residence of the trip maker. Home-based trips are always produced at the residence of the trip maker and are always attracted at the end of the trip not identified as the residence of the trip maker. Non-home-based trips are always produced at the origin and attracted by the destination. The following example illustrates the differences.

Figure 9.A3 schematically represents trips made by occupants of a given dwelling unit of Zone 1, while Fig. 9.A4 represents trips made by a resident of Zone 2. The "tail" of the arrow represents an origin of a trip, while the head of the arrow represents a destination.



AR00031820

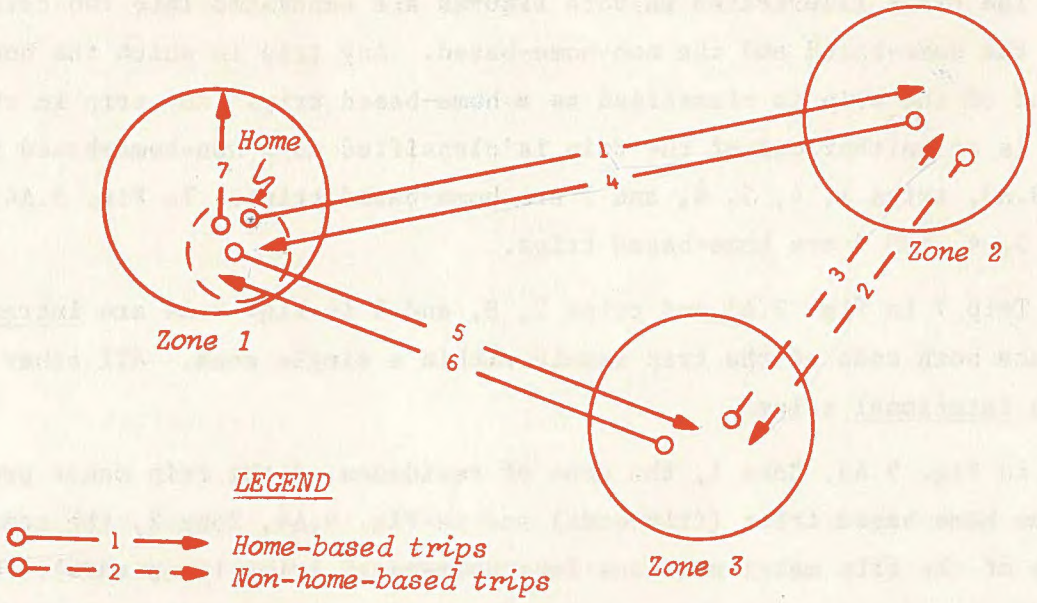



FIG. 9.A3. TRIPS MADE BY RESIDENT OF ZONE 1.

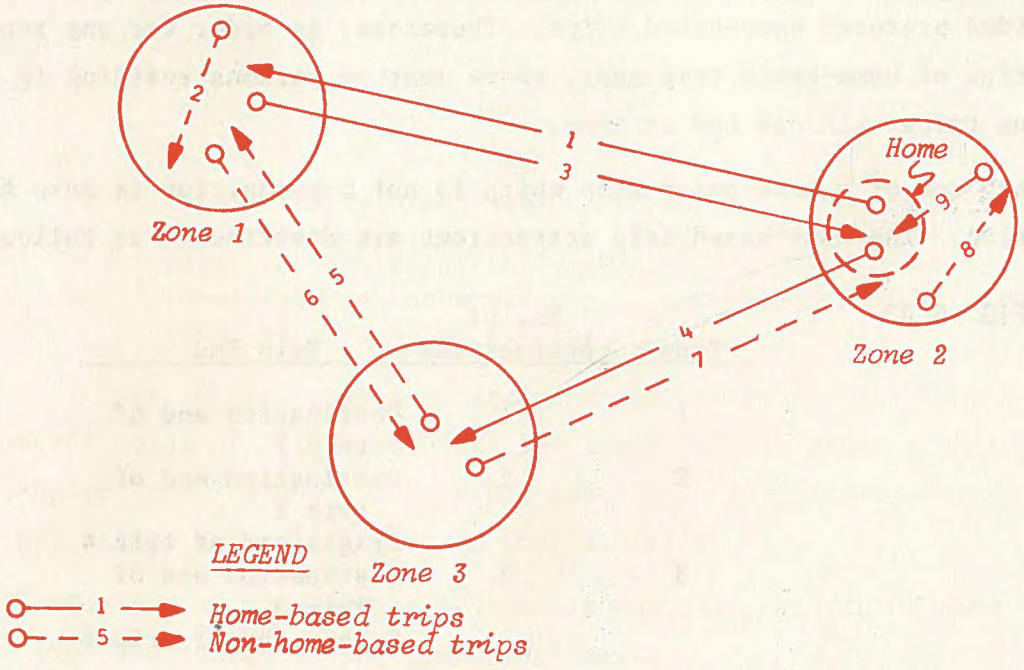



FIG. 9.A4. TRIPS MADE BY RESIDENT OF ZONE 3.



AR00031821

The trips illustrated in both figures are separated into two categories: the home-based and the non-home-based. Any trip in which the home is one end of the trip is classified as a home-based trip. Any trip in which the home is at neither end of the trip is classified as a non-home-based trip. In Fig. 9.A3, trips 1, 4, 5, 6, and 7 are home-based trips. In Fig. 9.A4, trips 1, 3, 4, and 9 are home-based trips.

Trip 7 in Fig. 9.A3 and trips 2, 8, and 9 in Fig. 9.A4 are intrazonal trips since both ends of the trip remain within a single zone. All other trips are interzonal trips.

In Fig. 9.A3, Zone 1, the zone of residence of the trip maker produces five home-based trips (trip ends) and in Fig. 9.A4, Zone 2, the zone of residence of the trip maker produces four home-based trips (trip ends). Note that in Fig. 9.A3 the origin of trip 1, the destination of trip 4, the origin of trip 5, the destination of trip 6, and the origin of trip 7 are trip productions: similarly, in Fig. 9.A4, the origin of trip 1, the destination of trip 3, the origin of trip 4 and the destination of trip 9 are trip productions. In both Fig. 9.A3 and Fig. 9.A4, only those zones in which the trip maker resided produced home-based trips. Therefore, in order for any zone to be productive of home-based trip ends, there must be persons residing in that zone making trips with one end at home.

Any end of a home-based trip which is not a production is said to be an attraction. The home-based trip attractions are distributed as follows:

FIG. 9.A3

| Zone | No. of Attractions | Trip End |
|---|---|---|
| 1 | 1 | Destination end of trip 7 |
| 2 | 2 | Destination end of trip 1 |
| | | Origin end of trip 4 |
| 3 | 2 | Destination end of trip 5 |
| | | Origin end of trip 6 |
| TOTAL | 5 | |



AR00031822

FIG. 9.A4

| Zone | No. of Attractions | Trip End |
|---|---|---|
| 1 | 2 | Destination end of trip 1 |
| | | Origin end of trip 3 |
| 2 | 1 | Origin end of trip 9 |
| 3 | 1 | Destination end of trip 4 |
| TOTAL | 4 | |

The non-home-based trips are trips 2 and 3 in Fig. 9.A3 and trips 2, 5, 6, 7, and 8 in Fig. 9.A4. For non-home-based trips, the production end of a trip is its origin and the attraction end is its destination. The non-home-based trip productions are distributed as follows:

FIG. 9.A3

| Zone | No. of Productions | Trip End |
|---|---|---|
| 1 | 0 | |
| 2 | 1 | Origin end of trip 2 |
| 3 | 1 | Origin end of trip 3 |
| TOTAL | 2 | |

FIG. 9.A4

| Zone | No. of Productions | Trip End |
|---|---|---|
| 1 | 2 | Origin end of trip 2 |
| | | Origin end of trip 6 |
| 2 | 1 | Origin end of trip 8 |
| 3 | 2 | Origin end of trip 5 |
| | | Origin end of trip 7 |
| TOTAL | 5 | |

The distribution of the non-home-based attractions are as follows:

FIG. 9.A3

| Zone | No. of Attractions | Trip End |
|---|---|---|
| 1 | 0 | Destination end of trip 3 |
| 2 | 1 | |
| 3 | 1 | Destination end of trip 2 |
| TOTAL | 2 | |



AR00031823

FIG. 9.A4

| Zone | No. of Attractions | Trip End |
|---|---|---|
| 1 | 2 | Destination end of trip 2 |
| | | Destination end of trip 5 |
| 2 | 2 | Destination end of trip 7 |
| | | Destination end of trip 8 |
| 3 | 1 | Destination end of trip 6 |
| TOTAL | 5 | |

It should be noted that there are always as many productions as attractions on a total-study area basis since each trip has two ends.

If one superimposed Fig. 9.A3 on Fig. 9.A4, the gross effect would be that of having considered trips made by persons residing in both Zones 1 and 2. If all internal trips by all residents of the zones were recorded, total trip productions and attractions could be determined. If one interviewed each resident of Zone 1 and determined the trips produced by and attracted to each of the three zones for both home-based and non-home-based trips, one would have the following information:

1. The total number of trip productions produced by Zone 1.
2. The number of home-based trip attractions in each zone would correspond only to the distribution of the attraction ends of trips produced by the residents of Zone 1.
3. The non-home-based productions and attractions, likewise would correspond only to the distribution of the non-home-based trips made by the residents of Zone 1.



AR00031824

# APPENDIX IX-B. TRIP GENERATION EQUATIONS AND TRIP END ESTIMATES

1. HONOLULU DISTRICT, CENSUS TRACTS 1-65

| Trip Purpose | Production Equations | Attraction Equations |
|---|---|---|
| Home-Based Work Trips | $= -57.88239 + 0.49348\ X_3 + 0.80999\ X_1$ | $= -219.72104 + 1.77546\ X_{10}$ |
| Home-Based Shopping Trips | $= 138.08990 + 1.35764\ X_1$ | $= -15.50641 + 0.01688\ X_7$ |
| Home-Based Social-Recreation Trips | $= 115.22717 + 1.79465\ X_1 + 0.83379\ X_2$ | $= 259.01022 + 0.00418\ X_{11} + 1.83630\ X_2$ |
| Home-Based School Trips | $= 64.67460 + 9.13889\ X_6$ | $= -517.30338 + 1.28682\ X_{12}$ |
| Home-Based Other Trips | $= -42.73584 + 0.67880\ X_2 + 0.49358\ X_1$ | $= 280.52690 + 0.00260\ X_{11} + 0.00218\ X_8$ |
| Non-Home-Based Trips | $= 108.05679 + 0.01794\ X_7 + 0.00411\ X_8 - 0.00052\ X_9$ | $= 296.71634 + 0.02240\ X_7 + 0.00319\ X_8 - 0.00583\ X_9$ |

Descriptions of Independent Variables:

$X_1$ = Autos by C.T.

$X_2$ = Dwelling Units by C.T.

$X_3$ = Population by C.T.

$X_4 = \log \frac{\text{Dwelling Units}}{\text{L.U. Residential in Acres}}$

$X_5 = \log \frac{\text{Population}}{\text{L.U. Residential in Acres}}$

$X_6$ = L.U. Residential in Acres

$X_7$ = Commercial Retail floor area (sq ft)

$X_8$ = Public Buildings floor area (sq ft)

$X_9$ = Commercial Services floor area (sq ft)

$X_{10}$ = Employment by C.T.

$X_{11}$ = Commercial Retail + Services + Hotels

$X_{12}$ = School Enrollment by C.T.



AR00031826

## 2. OUTLYING DISTRICTS, CENSUS TRACTS 66-113

| Trip Purpose | Production Equations | Attraction Equations |
|---|---|---|
| Home-Based Work Trips | $= 2.92310 + 1.15273\ X_1 + 0.16333\ X_3$ | $= -94.79161 + 1.38106\ X_{10}$ |
| Home-Based Shopping Trips | $= -384.42337 + 0.89048\ X_1 - 0.10509\ X_2^2 + 323.54735\ X_5$ | $= -15.50641 + 0.01688\ X_7$ |
| Home-Based Social-Recreation Trips | $= -751.86908 + 1.73380\ X_1 + 534.86189\ X_4$ | $= 209.54480 + 0.00788\ X_{11} + 0.62217\ X_2$ |
| Home-Based School Trips | $= 64.67460 + 9.13889\ X_6$ | $= -517.30338 + 1.28682\ X_{12}$ |
| Home-Based Other Trips | $= -41.33675 + 0.84933\ X_1$ | $= -128.02964 + 0.00817\ X_7 + 0.49737\ X_2 + 0.00017\ X_9$ |
| Non-Home-Based Trips | $= -74.85384 + 0.00751\ X_7 + 0.52994\ X_2 + 0.00115\ X_9$ | $= -131.01064 + 0.01000\ X_7 + 0.55818\ X_2 - 0.00103\ X_9$ |

Descriptions of Independent Variables:

$X_1$ = Autos by C.T.

$X_2$ = Dwelling Units by C.T.

$X_3$ = Population by C.T.

$X_4 = \log \frac{\text{Dwelling Units}}{\text{L.U. Residential in Acres}}$

$X_5$ $\log \frac{\text{Population}}{\text{L.U. Residential in Acres}}$

$X_6$ = L.U. Residential in Acres

$X_7$ = Commercial Retail floor area (sq ft)

$X_8$ = Public Buildings floor area (sq ft)

$X_9$ = Commercial Services floor area (sq ft)

$X_{10}$ = Employment by C.T.

$X_{11}$ = Commercial Retail + Services + Hotels floor area (sq ft)

$X_{12}$ = School Enrollment by C.T.



AR00031827

RED FIGURES ON MAP

Table 9.B1. 1985 Production and Attraction Person Trips

| Equivalent O-D Zones | Production | | | | | | Attraction | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Home-Based | | | | | Non-Home-Based | Home-Based | | | | | Non-Home-Based |
| | Work | Shopping | Social-Recreation | School | Other | | Work | Shopping | Social-Recreation | School | Other | |
| 1 | 240 | 623 | 1,060 | 70 | 382 | 1,026 | 621 | 442 | 1,365 | 0 | 661 | 816 |
| 2 | 772 | 770 | 1,448 | 49 | 600 | 5,873 | 3,972 | 3,286 | 3,079 | 0 | 2,228 | 5,890 |
| 3 | 182 | 181 | 340 | 12 | 141 | 2,756 | 1,233 | 1,519 | 1,216 | 0 | 1,026 | 2,801 |
| 4 | 0 | 0 | 0 | 0 | 0 | 2,931 | 2,299 | 1,676 | 1,513 | 0 | 1,483 | 2,248 |
| 5 | 0 | 0 | 0 | 0 | 0 | 117 | 824 | 39 | 12 | 0 | 33 | 133 |
| 6 | 13 | 12 | 21 | 2 | 8 | 1,065 | 746 | 578 | 1,015 | 0 | 812 | 477 |
| 7 | 242 | 102 | 101 | 39 | 143 | 6,283 | 6,024 | 6,701 | 2,185 | 352 | 2,261 | 6,471 |
| 8 | 111 | 47 | 46 | 18 | 66 | 5,130 | 3,367 | 5,650 | 1,606 | 0 | 1,551 | 5,582 |
| 9 | 0 | 0 | 0 | 0 | 0 | 9,543 | 10,852 | 10,687 | 4,707 | 594 | 4,654 | 7,137 |
| 10 | 0 | 0 | 0 | 0 | 0 | 54 | 1,514 | 0 | 50 | 0 | 83 | 0 |
| 11 | 0 | 0 | 0 | 0 | 0 | 9,265 | 8,682 | 9,854 | 3,474 | 890 | 3,626 | 8,628 |
| 12 | 0 | 0 | 0 | 0 | 0 | 1,670 | 4,695 | 1,708 | 1,662 | 19 | 1,757 | 0 |
| 13 | 0 | 0 | 0 | 0 | 0 | 7,873 | 10,675 | 9,198 | 5,043 | 0 | 4,841 | 3,901 |
| 14 | 0 | 0 | 0 | 0 | 0 | 54 | 845 | 0 | 0 | 0 | 34 | 47 |
| 15 | 34 | 29 | 43 | 4 | 12 | 1,156 | 1,655 | 11 | 41 | 0 | 703 | 972 |
| 16 | 0 | 0 | 0 | 0 | 0 | 1,989 | 1,302 | 18 | 345 | 0 | 1,524 | 1,080 |
| 17 | 86 | 73 | 109 | 11 | 30 | 324 | 1,901 | 147 | 136 | 0 | 131 | 338 |
| 18 | 3,339 | 2,581 | 5,330 | 99 | 2,476 | 0 | 4,312 | 0 | 4,306 | 0 | 0 | 0 |
| 19 | 3,060 | 3,027 | 2,393 | 146 | 917 | 6,259 | 16,300 | 6,484 | 6,463 | 265 | 4,161 | 3,285 |
| 20 | 4,407 | 1,941 | 3,513 | 304 | 1,439 | 4,960 | 5,755 | 5,371 | 5,022 | 338 | 2,209 | 4,747 |
| 21 | 2,331 | 1,340 | 2,305 | 505 | 884 | 1,742 | 763 | 1,494 | 2,158 | 653 | 913 | 1,953 |
| 22 | 4,611 | 1,676 | 3,165 | 663 | 1,345 | 1,591 | 429 | 1,235 | 2,945 | 1,591 | 876 | 1,796 |
| 23 | 7,591 | 3,300 | 6,415 | 2,831 | 2,834 | 887 | 367 | 667 | 5,068 | 13 | 568 | 1,157 |
| 24 | 4,324 | 1,794 | 3,259 | 1,034 | 1,337 | 2,268 | 1,754 | 1,733 | 2,802 | 1,828 | 990 | 2,764 |
| 25 | 3,874 | 1,994 | 566 | 1,965 | 1,518 | 760 | 181 | 262 | 2,682 | 538 | 601 | 956 |
| 26 | 1,875 | 1,449 | 2,992 | 55 | 1,390 | 14,060 | 48,922 | 14,805 | 10,440 | 6,926 | 6,469 | 12,397 |
| 27 | 2,844 | 1,255 | 2,306 | 317 | 946 | 2,507 | 5,352 | 1,791 | 2,571 | 3,112 | 1,323 | 2,585 |
| 28 | 5,137 | 4,113 | 4,637 | 704 | 1,939 | 5,082 | 3,037 | 3,190 | 4,371 | 6,026 | 2,355 | 5,262 |
| 29 | 4,810 | 2,547 | 4,515 | 1,222 | 2,806 | 5,984 | 4,621 | 2,533 | 3,997 | 3,643 | 3,194 | 5,589 |
| 30 | 2,788 | 3,586 | 3,338 | 400 | 1,683 | 1,516 | 589 | 1,067 | 3,173 | 112 | 1,131 | 1,898 |
| 31 | 2,670 | 1,397 | 2,679 | 241 | 1,148 | 3,757 | 2,347 | 3,577 | 4,630 | 1,048 | 2,336 | 3,353 |
| 32 | 1 | 2 | 3 | 0 | 1 | 51 | 329 | 24 | 250 | 0 | 248 | 0 |
| 33 | 913 | 865 | 1,552 | 122 | 610 | 2,222 | 720 | 721 | 1,635 | 773 | 981 | 2,521 |
| 34 | 8,776 | 4,262 | 8,089 | 891 | 3,511 | 2,940 | 2,106 | 1,580 | 7,278 | 4,619 | 2,240 | 3,079 |
| 35 | 3,724 | 2,422 | 4,370 | 606 | 1,795 | 2,205 | 1,872 | 1,403 | 3,423 | 448 | 1,143 | 2,436 |



AR00031828

Table 9.B1 - continued

| Equivalent O-D Zones | Production | | | | | | Attraction | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Home-Based | | | | | Non-Home-Based | Home-Based | | | | | Non-Home-Based |
| | Work | Shopping | Social-Recreation | School | Other | | Work | Shopping | Social-Recreation | School | Other | |
| 36 | 2,742 | 1,499 | 2,677 | 484 | 1,075 | 2,068 | 753 | 1,351 | 2,327 | 1,895 | 1,034 | 2,392 |
| 37 | 5,238 | 3,229 | 5,538 | 1,903 | 3,605 | 711 | 1,199 | 164 | 3,182 | 747 | 593 | 900 |
| 38 | 5,848 | 2,949 | 5,365 | 1,807 | 2,229 | 753 | 100 | 442 | 3,691 | 842 | 533 | 1,024 |
| 39 | 5,599 | 3,558 | 6,237 | 2,776 | 2,505 | 1,073 | 468 | 564 | 3,873 | 1,046 | 680 | 1,333 |
| 40 | 4,657 | 2,902 | 5,067 | 1,986 | 2,020 | 524 | 377 | 242 | 3,118 | 73 | 461 | 767 |
| 41 | 368 | 312 | 466 | 46 | 129 | 7,230 | 27,986 | 3,408 | 3,963 | 0 | 4,419 | 4,313 |
| 42 | 802 | 585 | 923 | 63 | 297 | 19,298 | 41,493 | 10,464 | 10,361 | 64 | 10,252 | 13,991 |
| 43 | 10,238 | 5,241 | 10,179 | 385 | 4,516 | 9,099 | 16,929 | 3,245 | 8,823 | 1,561 | 5,298 | 7,964 |
| 44 | 8,978 | 5,010 | 9,434 | 361 | 4,074 | 15,615 | 19,671 | 14,128 | 18,444 | 2,681 | 6,149 | 15,702 |
| 45 | 24,837 | 16,428 | 29,378 | 1,516 | 12,173 | 1,419 | 1,334 | 421 | 17.088 | 2,443 | 938 | 1,550 |
| 46 | 1,210 | 1,082 | 1,671 | 658 | 552 | 881 | 69 | 163 | 959 | 2,208 | 692 | 1,042 |
| 47 | 2,844 | 2,388 | 1,976 | 1,569 | 1,357 | 291 | 41 | 185 | 1,840 | 0 | 346 | 550 |
| 48 | 804 | 732 | 1,280 | 106 | 483 | 67,258 | 39,347 | 72,729 | 42,834 | 6,376 | 21,133 | 72,469 |
| 49 | 9,041 | 5,152 | 9,504 | 361 | 4,028 | 16,219 | 14,765 | 17,585 | 20,903 | 43 | 6,110 | 16,066 |
| 50 | 8,399 | 5,278 | 9,500 | 349 | 3,935 | 4,698 | 1,684 | 2,866 | 6,866 | 3,875 | 2,192 | 4,908 |
| 51 | 24,479 | 9,918 | 26,084 | 485 | 7,864 | 3,564 | 1,816 | 3,702 | 13,038 | 0 | 1,262 | 4,260 |
| 52 | 3,964 | 2,790 | 5,063 | 363 | 2,097 | 898 | 284 | 224 | 3,425 | 2,124 | 679 | 1,083 |
| 53 | 10,559 | 6,104 | 11,210 | 362 | 4,739 | 2,320 | 1,535 | 2,081 | 7,995 | 1,935 | 1,086 | 2,596 |
| 54 | 5,014 | 3,378 | 6,122 | 413 | 2,541 | 7,698 | 5,231 | 7,523 | 7,279 | 102 | 3,187 | 7,653 |
| 55 | 14,213 | 10,152 | 20,635 | 1,372 | 9,528 | 10,590 | 29,647 | 1,464 | 16,431 | 41,197 | 5,901 | 9,656 |
| 56 | 5,066 | 4,013 | 6,689 | 2,287 | 2,548 | 938 | 441 | 657 | 3,595 | 0 | 587 | 1,224 |
| 57 | 2,898 | 2,016 | 3,353 | 1,223 | 1,257 | 1,204 | 437 | 1,110 | 2,260 | 998 | 625 | 1,554 |
| 58 | 9,242 | 6,711 | 11,172 | 4,439 | 4,276 | 459 | 132 | 166 | 5,428 | 2,725 | 461 | 660 |
| 59 | 4,280 | 3,208 | 6,219 | 261 | 2,739 | 14,205 | 17,075 | 5,160 | 36,832 | 0 | 23,721 | 14,123 |
| 60 | 8,728 | 6,724 | 12,793 | 383 | 5,586 | 12,858 | 11,587 | 4,917 | 22,111 | 0 | 9,905 | 12,987 |
| 61 | 7,191 | 4,588 | 9,238 | 355 | 4,214 | 3,147 | 4,333 | 1,017 | 15,162 | 1,223 | 6,180 | 3,292 |
| 62 | 3,268 | 2,136 | 3,744 | 262 | 1,488 | 4,473 | 3,642 | 4,034 | 3,942 | 2,624 | 1,853 | 4,818 |
| 63 | 4,251 | 3,333 | 5,844 | 810 | 3,520 | 2,133 | 4,912 | 702 | 6,560 | 310 | 2,590 | 2,774 |
| 64 | 3,869 | 2,334 | 4,160 | 882 | 1,686 | 1,778 | 559 | 1,637 | 3,282 | 21 | 818 | 2,165 |
| 65 | 3,536 | 2,033 | 3,589 | 838 | 1,436 | 1,412 | 963 | 1,433 | 2,954 | 0 | 755 | 1,628 |
| 66 | 2,370 | 1,606 | 2,726 | 758 | 1,039 | 441 | 111 | 183 | 1,748 | 461 | 430 | 680 |
| 67 | 4,061 | 2,576 | 4,453 | 910 | 1,752 | 5,326 | 3,442 | 4,923 | 4,725 | 1,798 | 2,258 | 5,474 |
| 68 | 5,486 | 3,135 | 5,533 | 1,448 | 2,234 | 3,104 | 1,402 | 2,714 | 4,487 | 623 | 1,411 | 3,337 |
| 69 | 4,003 | 2,849 | 4,783 | 1,681 | 1,826 | 1,170 | 28 | 284 | 2,667 | 3,249 | 817 | 1,334 |
| 70 | 3,447 | 1,845 | 3,366 | 937 | 1,389 | 997 | 850 | 315 | 2,489 | 2,874 | 712 | 1,191 |



AR00031829

Table 9.B1 - continued

| Equivalent O-D Zone | Production | | | | | | Attraction | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Home-Based | | | | | Non-Home-Based | Home-Based | | | | | Non-Home-Based |
| | Work | Shopping | Social-Recreation | School | Other | | Work | Shopping | Social-Recreation | School | Other | |
| 71 | 3,808 | 2,391 | 4,094 | 1,810 | 1,592 | 321 | 73 | 163 | 2,452 | 0 | 367 | 572 |
| 72 | 1,953 | 1,769 | 2,797 | 1,092 | 980 | 317 | 2,966 | 164 | 1,427 | 0 | 365 | 568 |
| 73 | 3,284 | 2,076 | 3,484 | 1,062 | 1,320 | 1,735 | 622 | 1,145 | 2,317 | 2,891 | 872 | 2,105 |
| 74 | 11,798 | 7,838 | 13,314 | 3,278 | 5,217 | 2,554 | 1,523 | 2,540 | 7.718 | 498 | 1,073 | 2,957 |
| 75 | 3,969 | 2,577 | 4,486 | 1,223 | 1,779 | 1,313 | 1,009 | 576 | 2,962 | 1,048 | 867 | 1,441 |
| 76 | 5,384 | 5,125 | 8,295 | 3,100 | 3,065 | 4,569 | 3,244 | 4,897 | 5,355 | 516 | 1,530 | 5,396 |
| 77 | 4,217 | 2,712 | 4,457 | 2,352 | 1,659 | 1,288 | 114 | 249 | 2,347 | 4,575 | 898 | 1,419 |
| 78 | 12,659 | 9,564 | 15,694 | 6,053 | 5,294 | 2,284 | 973 | 1,984 | 7,692 | 1,828 | 1,031 | 2,653 |
| 79 | 6,169 | 4,332 | 7,239 | 2,989 | 2,770 | 460 | 222 | 307 | 3,748 | 1,142 | 402 | 738 |
| 80 | 20,306 | 15,154 | 12,541 | 9,557 | 9,401 | 1,011 | 1,302 | 795 | 10,948 | 6,939 | 572 | 1,145 |
| 81 | 546 | 407 | 337 | 257 | 253 | 20 | 42 | 26 | 345 | 0 | 67 | 0 |
| 82 | 9,702 | 7,241 | 5,992 | 4,566 | 4,492 | 0 | 946 | 6 | 5,145 | 0 | 63 | 0 |
| 83 | 3,822 | 1,749 | 3,298 | 4,546 | 1,806 | 1,186 | 1,329 | 710 | 3,069 | 2,201 | 1,155 | 1,298 |
| 84 | 3,001 | 1,637 | 3,180 | 2,999 | 1,669 | 625 | 2,476 | 118 | 885 | 2,821 | 605 | 687 |
| 85 | 2,174 | 1,185 | 2,304 | 2,172 | 1,209 | 477 | 2,557 | 137 | 704 | 2,217 | 460 | 520 |
| 86 | 842 | 448 | 916 | 514 | 457 | 349 | 2,708 | 400 | 445 | 2,173 | 368 | 424 |
| 87 | 11,453 | 6,091 | 12,457 | 6,991 | 6,207 | 3,264 | 2,148 | 1,710 | 4,196 | 3,078 | 3,327 | 3,718 |
| 88 | 1,653 | 879 | 1,798 | 1,009 | 896 | 4,692 | 1,095 | 10,374 | 7,078 | 3,802 | 5,060 | 5,721 |
| 89 | 3,072 | 1,698 | 3,352 | 2,337 | 1,723 | 810 | 612 | 422 | 4,968 | 644 | 807 | 920 |
| 90 | 2,788 | 1,542 | 3,042 | 2,122 | 1,563 | 639 | 1,037 | 130 | 7,453 | 1,197 | 623 | 702 |
| 91 | 4,709 | 2,409 | 4,869 | 2,649 | 2,446 | 2,452 | 267 | 3,051 | 3,854 | 332 | 2,481 | 2,712 |
| 92 | 3,852 | 1,971 | 3,984 | 2,168 | 2,001 | 1,434 | 2,578 | 1,072 | 2,323 | 2,436 | 1,402 | 1,493 |
| 93 | 1,891 | 938 | 2,639 | 2,248 | 1,205 | 1,992 | 5,437 | 937 | 1,671 | 87 | 1,406 | 2,078 |
| 94 | 954 | 475 | 595 | 1,001 | 494 | 255 | 206 | 77 | 295 | 0 | 259 | 299 |
| 95 | 2,698 | 1,345 | 1,683 | 2,832 | 1,397 | 715 | 465 | 199 | 828 | 1,915 | 731 | 832 |
| 96 | 4,906 | 2,444 | 3,059 | 5,148 | 2,540 | 1,180 | 826 | 63 | 1,387 | 1,994 | 1,193 | 1,353 |
| 97 | 21 | 5 | 0 | 57 | 0 | 111 | 570 | 0 | 45 | 0 | 130 | 135 |
| 98 | 7,518 | 3,882 | 7,967 | 3,364 | 3,950 | 2,979 | 3,086 | 2,970 | 4,144 | 5,537 | 3,066 | 3,435 |
| 99 | 6,527 | 3,370 | 6,916 | 2,920 | 3,429 | 1,780 | 1,285 | 626 | 2,341 | 2,606 | 1,786 | 1,983 |
| 100 | 5,082 | 2,570 | 5,044 | 3,421 | 2,596 | 2,550 | 1,491 | 3,096 | 3,839 | 3,358 | 2,597 | 2,899 |
| 101 | 11,215 | 6,271 | 12,615 | 6,695 | 6,318 | 2,277 | 429 | 299 | 2,853 | 804 | 2,274 | 2,579 |
| 102 | 11,227 | 5,595 | 7,002 | 11,783 | 5,814 | 2,958 | 1,875 | 717 | 3,627 | 4,068 | 3,002 | 3,374 |
| 103 | 334 | 294 | 209 | 734 | 307 | 218 | 523 | 129 | 277 | 383 | 221 | 254 |
| 104 | 1,109 | 978 | 696 | 2,440 | 1,021 | 878 | 526 | 753 | 1,329 | 526 | 874 | 980 |
| 105 | 782 | 689 | 491 | 1,718 | 720 | 483 | 1,036 | 224 | 646 | 3,874 | 482 | 552 |



AR00031830

Table 9.B1 - continued

| Equivalent O-D Zones | Production | | | | | | Attraction | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Home-Based | | | | | Non-Home-Based | Home-Based | | | | | Non-Home-Based |
| | Work | Shopping | Social-Recreation | School | Other | | Work | Shopping | Social-Recreation | School | Other | |
| 106 | 2,153 | 918 | 1,628 | 4,400 | 324 | 839 | 1,746 | 665 | 1,431 | 1,155 | 798 | 892 |
| 107 | 1,267 | 655 | 1,050 | 1,010 | 630 | 1,044 | 1,319 | 1,551 | 2,080 | 0 | 989 | 1,050 |
| 108 | 4,297 | 2,105 | 4,174 | 2,842 | 2,140 | 2,181 | 1,702 | 2,357 | 3,482 | 2,585 | 2,176 | 2,381 |
| 109 | 812 | 397 | 788 | 537 | 404 | 253 | 2,038 | 96 | 311 | 816 | 255 | 291 |
| 110 | 1,676 | 945 | 1,643 | 724 | 849 | 753 | 5,813 | 703 | 1,251 | 623 | 725 | 829 |
| 111 | 3,186 | 1,709 | 3,208 | 1,161 | 1,615 | 1,985 | 1,222 | 2,558 | 3,523 | 1,024 | 1,942 | 2,076 |
| 112 | 3,992 | 2,114 | 4,050 | 1,039 | 1,991 | 4,255 | 3,838 | 7,343 | 7,046 | 9 | 4,364 | 4,764 |
| 113 | 4,815 | 2,430 | 4,752 | 3,350 | 2,455 | 1,242 | 1,089 | 235 | 1,696 | 5,015 | 1,214 | 1,385 |
| 114 | 5,913 | 1,466 | 4,689 | 4,743 | 2,295 | 2,939 | 13,811 | 2,523 | 3,644 | 1,944 | 3,143 | 2,743 |
| 115 | 572 | 287 | 487 | 454 | 283 | 259 | 1,207 | 82 | 484 | 1,242 | 226 | 264 |
| 116 | 290 | 146 | 247 | 231 | 143 | 147 | 225 | 81 | 285 | 1,147 | 130 | 151 |
| 117 | 4,334 | 2,142 | 2,249 | 12,445 | 2,361 | 1,814 | 760 | 1,349 | 2,469 | 1,872 | 1,838 | 2,099 |
| 118 | 658 | 294 | 560 | 1,257 | 321 | 256 | 245 | 216 | 336 | 2,447 | 262 | 302 |
| 119 | 1,100 | 492 | 936 | 2,103 | 536 | 771 | 217 | 1,209 | 1,122 | 1,701 | 800 | 917 |
| 120 | 1,523 | 681 | 1,297 | 2,912 | 743 | 728 | 4,247 | 696 | 1,319 | 0 | 699 | 740 |
| 121 | 2,690 | 1,211 | 2,458 | 2,422 | 1,263 | 845 | 2,719 | 293 | 1,079 | 1,294 | 848 | 961 |
| 122 | 3,726 | 1,678 | 3,404 | 3,354 | 1,749 | 1,472 | 2,063 | 1,049 | 2,199 | 1,716 | 1,464 | 1,617 |
| 123 | 285 | 128 | 260 | 256 | 133 | 77 | 377 | 0 | 95 | 0 | 76 | 85 |
| 124 | 12,707 | 6,128 | 12,871 | 7,778 | 2,155 | 3,414 | 20,578 | 219 | 3,978 | 6,619 | 3,439 | 3,593 |
| 125 | 4,314 | 2,080 | 4,369 | 2,641 | 732 | 1,500 | 5,974 | 758 | 2,116 | 1,077 | 1,490 | 1,504 |
| 126 | 518 | 250 | 525 | 317 | 88 | 1,443 | 5,057 | 789 | 7,211 | 0 | 653 | 0 |
| 127 | 2,537 | 1,037 | 2,486 | 2,167 | 1,254 | 3,763 | 9,348 | 973 | 1,090 | 817 | 1,463 | 4,057 |
| 128 | 4,417 | 2,200 | 4,299 | 2,531 | 2,202 | 2,289 | 2,483 | 2,562 | 3,665 | 2,186 | 2,283 | 2,502 |
| 129 | 3,010 | 1,440 | 965 | 2,730 | 1,422 | 642 | 483 | 170 | 1,016 | 3,362 | 600 | 693 |
| 130 | 25 | 5 | 26 | 490 | 5 | 6 | 193 | 163 | 0 | 0 | 34 | 0 |
| 131 | 824 | 399 | 789 | 400 | 398 | 1,872 | 1,630 | 3,750 | 3,440 | 705 | 1,899 | 2,022 |
| 132 | 1,454 | 704 | 1,393 | 706 | 704 | 1,665 | 1,318 | 3,139 | 2,455 | 3,467 | 1,771 | 2,005 |
| 133 | 3,733 | 1,808 | 3,576 | 1,812 | 1,806 | 1,403 | 566 | 1,140 | 1,800 | 1,704 | 1,449 | 1,637 |
| 134 | 1,979 | 1,008 | 1,590 | 858 | 858 | 666 | 1,911 | 662 | 1,122 | 0 | 639 | 738 |
| 135 | 1,898 | 927 | 1,142 | 635 | 974 | 548 | 93 | 0 | 622 | 8,934 | 555 | 632 |
| 136 | 22,115 | 10.801 | 13,303 | 7,394 | 11,353 | 6,807 | 6,179 | 763 | 8,487 | 8,744 | 6,839 | 7,581 |
| 137 | 6,716 | 3,280 | 4,040 | 2,245 | 3,448 | 2,426 | 5,321 | 1,230 | 2,845 | 1,331 | 2,517 | 2,871 |
| 138 | 921 | 364 | 475 | 1,630 | 434 | 308 | 460 | 188 | 654 | 0 | 259 | 306 |
| 139 | 1,398 | 679 | 1,406 | 848 | 700 | 747 | 498 | 1,035 | 897 | 1,361 | 804 | 935 |
| 140 | 2,723 | 1,322 | 2,739 | 1,650 | 1,363 | 1,733 | 2,971 | 2,453 | 2,739 | 1,210 | 1,775 | 1,946 |



AR00031831

Table 9.B1 - continued

| Equivalent O-D Zones | Production | | | | | | Attraction | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Home-Based | | | | | Non-Home-Based | Home-Based | | | | | Non-Home-Based |
| | Work | Shopping | Social-Recreation | School | Other | | Work | Shopping | Social-Recreation | School | Other | |
| 141 | 10,497 | 5,097 | 10,561 | 6,364 | 5,257 | 2,633 | 1,102 | 168 | 3,212 | 4,992 | 2,642 | 2,962 |
| 142 | 4 | 0 | 3 | 57 | 7 | 49 | 571 | 0 | 59 | 0 | 0 | 20 |
| 143 | 16,819 | 8,710 | 10,439 | 6,862 | 3,223 | 5,086 | 2,305 | 2,213 | 6,941 | 4,375 | 5,095 | 5,621 |
| 144 | 8,145 | 4,183 | 8,437 | 6,500 | 4,284 | 2,782 | 2,697 | 2,167 | 3,845 | 8,246 | 2,824 | 3,175 |
| 145 | 2,088 | 1,048 | 1,751 | 785 | 898 | 673 | 63 | 350 | 1,114 | 341 | 631 | 721 |
| 146 | 5,911 | 3,317 | 6,878 | 2,809 | 3,427 | 6,356 | 18,086 | 4,059 | 5,259 | 790 | 3,685 | 6,419 |
| 147 | 6,154 | 2,172 | 6,291 | 1,847 | 2,965 | 5,313 | 26,110 | 2,015 | 3,045 | 4,694 | 3,246 | 4,921 |
| 148 | 3,934 | 2,003 | 4,087 | 1,943 | 2,043 | 1,102 | 36 | 138 | 1,505 | 1,124 | 1,079 | 1,200 |
| 149 | 4,086 | 2,080 | 4,245 | 2,017 | 2,121 | 1,160 | 1,865 | 186 | 1,573 | 0 | 1,142 | 1,270 |
| 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1,621 | 248 | 0 | 0 |
| 151 | 1,781 | 863 | 1,449 | 1,316 | 821 | 557 | 112 | 212 | 930 | 2,286 | 514 | 595 |
| 152 | 721 | 326 | 252 | 635 | 228 | 5,618 | 17,577 | 10,008 | 16,598 | 0 | 4,920 | 4,169 |
| 153 | 2,574 | 1,287 | 2,409 | 1,742 | 1,280 | 1,657 | 842 | 2,152 | 2,589 | 4,269 | 1,675 | 1,882 |
| 154 | 1,988 | 920 | 1,481 | 1,605 | 869 | 780 | 400 | 809 | 1,348 | 0 | 748 | 844 |
| 155 | 5,465 | 2,814 | 5,523 | 3,962 | 2,846 | 1,263 | 217 | 0 | 1,484 | 2,124 | 1,267 | 1,418 |
| 156 | 0 | 0 | 0 | 0 | 0 | 2,974 | 9,237 | 5,716 | 7,789 | 0 | 2,632 | 2,285 |
| 157 | 743 | 311 | 586 | 639 | 321 | 1,663 | 3,002 | 738 | 931 | 0 | 863 | 2,070 |
| 158 | 16,175 | 9,132 | 18,631 | 10,501 | 9,270 | 3,358 | 2,493 | 202 | 4,060 | 3,143 | 3,371 | 3,811 |
| 159 | 660 | 276 | 521 | 567 | 286 | 1,566 | 8,413 | 739 | 880 | 444 | 813 | 1,957 |



AR00031832

Table 9.B2. 1985 Production and Attraction Commercial Trips

| Equivalent O-D Zones | Production | Attraction | Equivalent O-D Zones | Production | Attraction | Equivalent O-D Zones | Production | Attraction | Equivalent O-D Zones | Production | Attraction |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 152 | 153 | 41 | 3,424 | 3,424 | 81 | 145 | 146 | 121 | 775 | 775 |
| 2 | 569 | 568 | 42 | 5,365 | 5,364 | 82 | 261 | 261 | 122 | 595 | 595 |
| 3 | 294 | 294 | 43 | 3,210 | 3,209 | 83 | 663 | 662 | 123 | 287 | 287 |
| 4 | 171 | 171 | 44 | 4,304 | 4,303 | 84 | 818 | 818 | 124 | 3,736 | 3,737 |
| 5 | 287 | 287 | 45 | 634 | 635 | 85 | 830 | 830 | 125 | 1,084 | 1,084 |
| 6 | 52 | 52 | 46 | 368 | 367 | 86 | 860 | 859 | 126 | 921 | 921 |
| 7 | 535 | 535 | 47 | 364 | 364 | 87 | 718 | 718 | 127 | 4,091 | 4,091 |
| 8 | 297 | 297 | 48 | 10,116 | 10,117 | 88 | 985 | 985 | 128 | 903 | 902 |
| 9 | 961 | 962 | 49 | 2,865 | 2,865 | 89 | 363 | 363 | 129 | 459 | 460 |
| 10 | 430 | 429 | 50 | 801 | 802 | 90 | 416 | 416 | 130 | 371 | 371 |
| 11 | 770 | 770 | 51 | 925 | 925 | 91 | 223 | 223 | 131 | 440 | 440 |
| 12 | 417 | 417 | 52 | 421 | 421 | 92 | 610 | 610 | 132 | 592 | 592 |
| 13 | 949 | 949 | 53 | 675 | 675 | 93 | 253 | 254 | 133 | 368 | 368 |
| 14 | 362 | 362 | 54 | 1,195 | 1,194 | 94 | 213 | 213 | 134 | 868 | 868 |
| 15 | 482 | 482 | 55 | 6,580 | 6,579 | 95 | 268 | 269 | 135 | 272 | 272 |
| 16 | 153 | 153 | 56 | 473 | 472 | 96 | 314 | 314 | 136 | 1,407 | 1,407 |
| 17 | 538 | 538 | 57 | 487 | 487 | 97 | 23 | 22 | 137 | 1,613 | 1,613 |
| 18 | 1,224 | 1,224 | 58 | 335 | 336 | 98 | 1,029 | 1,029 | 138 | 450 | 449 |
| 19 | 1,771 | 1,771 | 59 | 3,485 | 3,485 | 99 | 497 | 497 | 139 | 412 | 412 |
| 20 | 1,176 | 1,175 | 60 | 2,421 | 2,421 | 100 | 782 | 783 | 140 | 795 | 795 |
| 21 | 484 | 485 | 61 | 1,169 | 1,170 | 101 | 461 | 460 | 141 | 399 | 399 |
| 22 | 424 | 424 | 62 | 1,149 | 1,148 | 102 | 495 | 495 | 142 | 14 | 14 |
| 23 | 442 | 442 | 63 | 1,573 | 1,573 | 103 | 279 | 279 | 143 | 725 | 725 |
| 24 | 877 | 876 | 64 | 533 | 533 | 104 | 275 | 274 | 144 | 1,104 | 1,105 |
| 25 | 340 | 340 | 65 | 506 | 505 | 105 | 367 | 367 | 145 | 340 | 340 |
| 26 | 8,800 | 8,800 | 66 | 344 | 345 | 106 | 761 | 762 | 146 | 3,952 | 3,953 |
| 27 | 1,394 | 1,395 | 67 | 983 | 982 | 107 | 551 | 550 | 147 | 9,797 | 9,797 |
| 28 | 1,066 | 1,065 | 68 | 630 | 631 | 108 | 545 | 546 | 148 | 174 | 174 |
| 29 | 1,206 | 1,207 | 69 | 374 | 375 | 109 | 694 | 694 | 149 | 550 | 549 |
| 30 | 738 | 738 | 70 | 543 | 542 | 110 | 1,893 | 1,893 | 150 | 248 | 248 |
| 31 | 431 | 432 | 71 | 341 | 341 | 111 | 459 | 460 | 151 | 331 | 330 |
| 32 | 96 | 96 | 72 | 967 | 967 | 112 | 1,321 | 1,321 | 152 | 1,742 | 1,742 |
| 33 | 319 | 319 | 73 | 581 | 581 | 113 | 626 | 625 | 153 | 608 | 608 |
| 34 | 818 | 819 | 74 | 721 | 722 | 114 | 2,855 | 2,854 | 154 | 434 | 435 |
| 35 | 775 | 776 | 75 | 541 | 541 | 115 | 450 | 450 | 155 | 278 | 278 |
| 36 | 591 | 591 | 76 | 1,267 | 1,266 | 116 | 251 | 251 | 156 | 1,068 | 1,067 |
| 37 | 602 | 602 | 77 | 386 | 387 | 117 | 630 | 629 | 157 | 2,209 | 2,209 |
| 38 | 399 | 399 | 78 | 619 | 619 | 118 | 277 | 277 | 158 | 995 | 996 |
| 39 | 484 | 484 | 79 | 415 | 414 | 119 | 326 | 326 | 159 | 1,572 | 1,572 |
| 40 | 439 | 439 | 80 | 341 | 341 | 120 | 983 | 984 | | | |



AR00031833

# APPENDIX IX-C. CALIBRATION OF THE GRAVITY MODEL

## 1. SPATIAL SEPARATION BETWEEN ZONES

The spatial separation between zones can be measured by any one of several parameters--i.e., travel time, cost, distance, speed, etc. To date, the most effective measure seems to be travel time.

The total travel time between zones is composed of 1) the minimum-path driving time between zones plus 2) the terminal time at both ends of the trip. Terminal time at both ends of the trip is added to driving time to allow for differences in parking and walking times in these zones, as caused by differences in congestion and parking facilities. This allowance adjusts driving time to a more realistic measure of the actual spatial separation between zones.

For any study period, the minimum-path driving time between each pair of zones is obtained by the traffic-assignment process. The data processed by the traffic-assignment routine are taken from a field survey, which records the distance and speed of travel over major routes of the transportation system. To illustrate the theory or steps involved in determining the minimum path from one node to all other nodes in a network, consider the following example.

In figure 9.C1 each street or major arterial intersection in the sample network is designated by a node number. The two zone centroids or home nodes, indicated by circles, are assigned centroid numbers, (1) and (40) . The measure of travel resistance between nodes is in terms of time in minutes (shown as T = 2.0). This factor, however, could be any consistent variable such as cost, distance, or speed. The object of the sample problem is to determine the the minimum-time path from centroid (1) to all other nodes in the network, as follows:

Starting at node (1) , the process proceeds outward to all connecting nodes, recording at each node the travel time to it. Thus, the time to get to node 2 is 2.0 minutes, and the time to get to node 20 is 2.0 minutes. Next, the process proceeds by considering the node closest in time to node (1) (the home node). In this case, either node 2 or 20 could be next since the time to each is 2.0 minutes. However, the process considers the lower numbered node



AR00031835

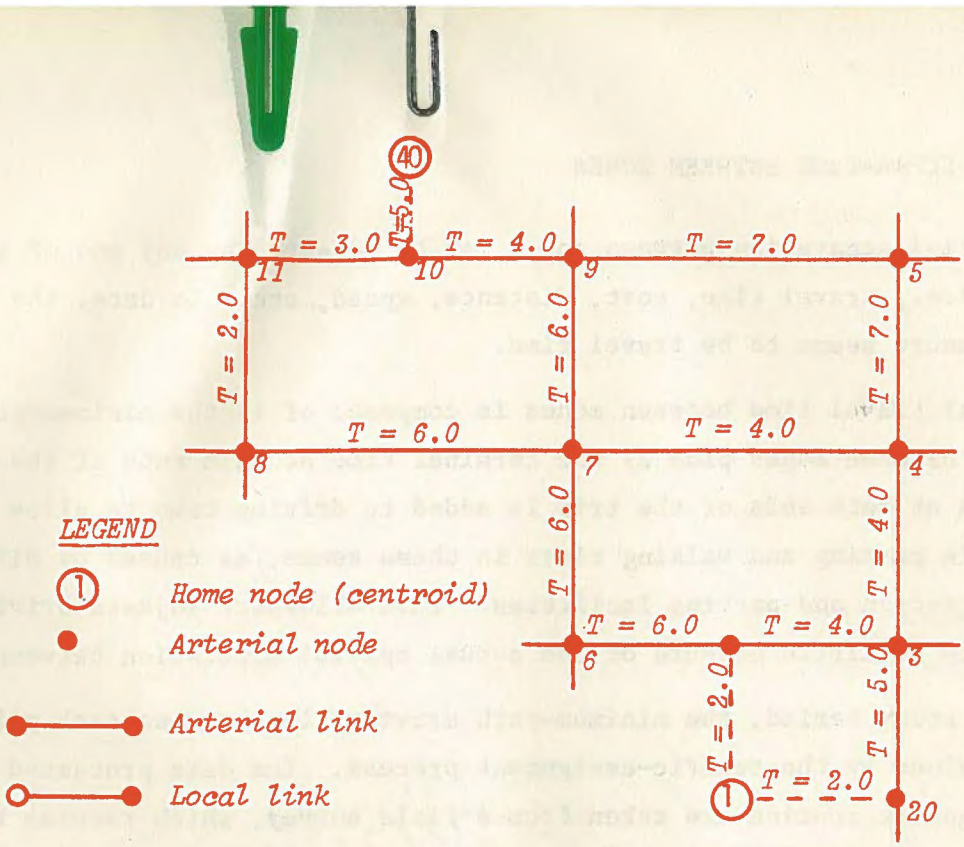



FIG. 9.C1. SAMPLE NETWORK FOR MINIMUM PATH CALCULATIONS.

first--i.e., node 2 is considered before node 20 in this situation. Thus, the cumulative times from node (1) through node 2 to nodes 3 and 6 are recorded:

Via node 2, cumulative time to node 3 = 6.0 min

cumulative time to node 6 = 8.0 min.

Node 20, which is next closer in time to node (1), is considered next, thus:

Via node 20, cumulative time to node 3 = 7.0 min.

At this point, two routes have been calculated to node 3, the one by way of node 2 requiring 6.0 minutes and the other by way of node 20 requiring 7.0 minutes. Since the minimum-time path is desired, the process maintains the first route (4.0 minutes via node 2), and the higher value (5.0 minutes via node 20) is dropped.

The process continues, always considering the node closer in time to node (1) first; thus,



AR00031836

Via node 3, cumulative time to node 4 = 10.0 min
cumulative time to node 7 = 14.0 min.
Via node 4, cumulative time to node 5 = 17.0 min
cumulative time to node 7 = 14.0 min.
Via node 6, cumulative time to node 7 = 14.0 min.

Here again, two routes have been calculated to node 7--one via the path (1)-2-3-4-7 and the other via the path (1)-2-6-7--each requiring 14.0 minutes. In this case, the process maintains the route built to node 7 first ((1)-2-6-7) while the second route ((1)-2-3-4-7) is dropped.

The process continues, node 7 (14.0 minutes) being considered before node 5 (17.0 minutes) beacuse it is closer in time to node (1); thus,

Via node 7, cumulative time to node 8 = 20.0 min
cumulative time to node 9 = 20.0 min.
Via node 5, cumulative time to node 9 = 24.0 min.

Here again, two routes have been calculated to node 9, the minimum time being maintained while the higher time is dropped. This minimum-path-building process is continued until all nodes have been reached from the centroid zone or node (1). Figure 9.C2 shows the final-minimum-path tree from centroid (1) to centroid (40).

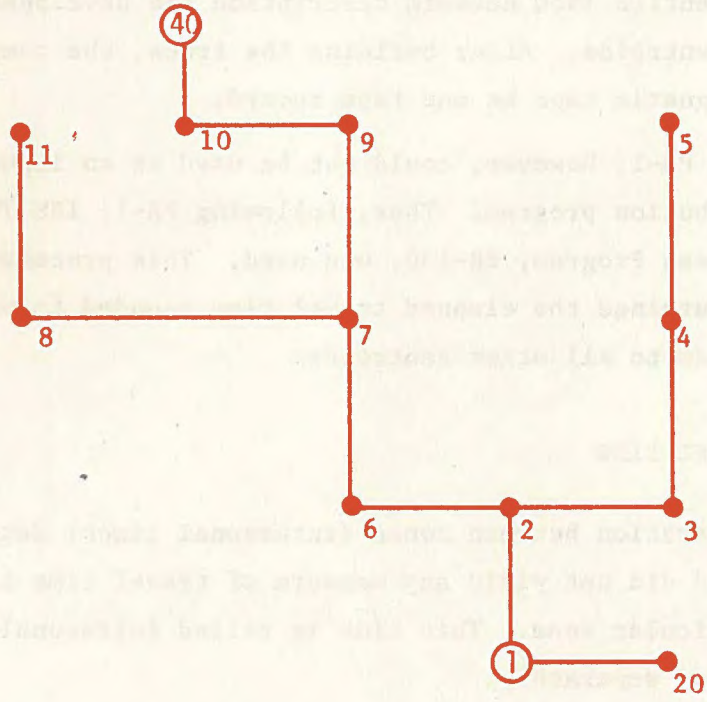



FIG. 9.C2. MINIMUM TIME PATH TREE FROM ZONE 1.



AR00031837

The same procedure is used to calculate the minimum paths for centroid (40) or for all traffic zones in the Study Area. In traffic assignment, the interest is usually in routings from zone centroids to other zone centroids. In the example above, only the minimum-path trees from zones (1) and (40) would be calculated to obtain routings from (1) to (40) and from (40) to (1). The reverse routing--i.e., from (40) to (1), may not be the same because the arterial links may not have the same travel time in both directions. If they were equal, however, the routings would be identical.

For gravity-model calibration, it is usually wise to evaluate the minimum paths to assure that the times assigned to the arterial links are reflective of the period in which the calibration of the gravity model is to be based. This evaluation was accomplished by assigning the O-D trip volumes between zones to their respective minimum-time paths and repeating the entire process until the assignment reproduced the vehicular travel that was taking place on the existing transportation network as accurately as possible. When this was accomplished, the resultant speeds (travel times) were assumed to be realistic and to be reflective of the base period.

Minimum-path travel times were computed for all zone-to-zone pairs by the use of the IBM 7090/7094 Build Trees Program, PR-1. This computer program read and stored the entire 1960 network description and developed the minimum-path trees for 159 centroids. After building the trees, the computer wrote it in binary on a magnetic tape as one tape record.

The format from PR-1, however, could not be used as an input to the gravity-model distribution program. Thus, following PR-1, IBM 7090/7094 Skim and Update Binary Trees Program, PR-130, was used. This procedure yielded a binary tape which contained the elapsed travel time rounded to whole minutes from all 159 centroids to all other centroids.

## 2. INTRAZONAL TRAVEL TIME

The spatial separation between zones (interzonal times) determined in the manner just described did not yield any measure of travel time for trips that did not leave a particular zone. This time is called intrazonal-travel time, and it must be derived separately.



AR00031838

The simplest procedure for determining intrazonal travel time is to analyze the links of the transportation system within each zone in the Study Area. To illustrate this procedure, consider the following example, shown in Fig. 9.C3.

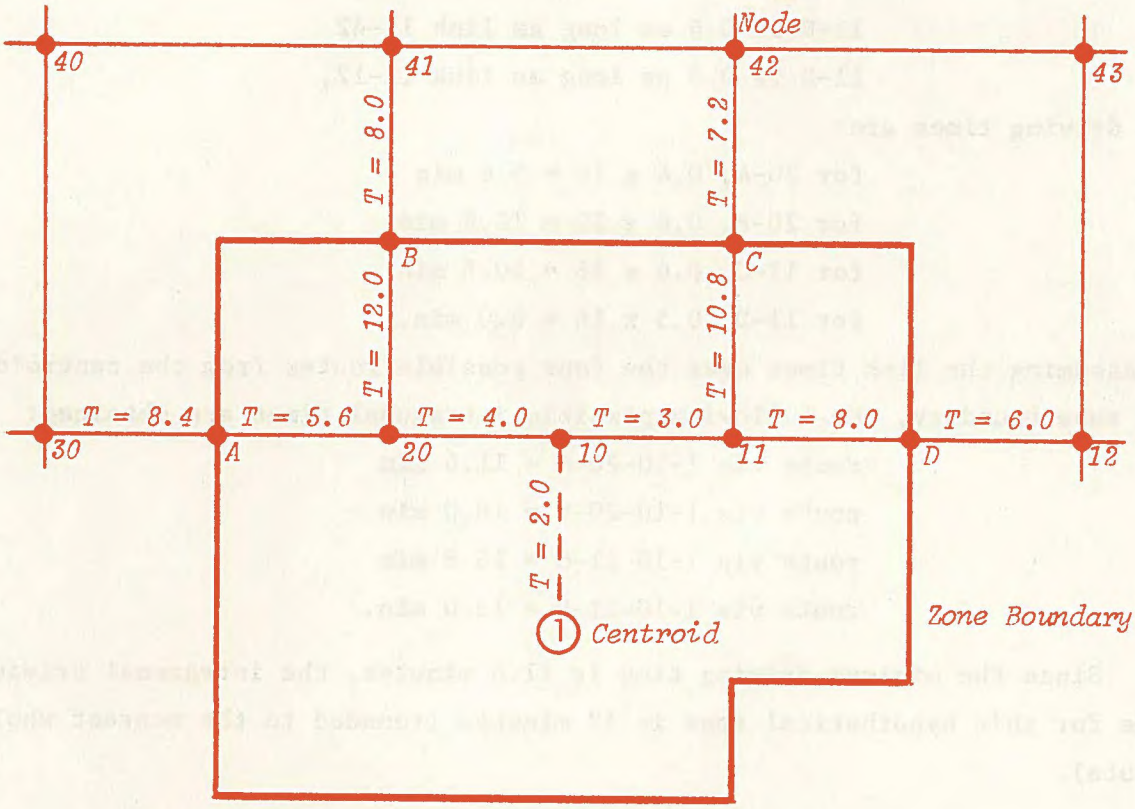



FIG. 9.C3. EXAMPLE DETERMINATION OF INTRAZONAL TRAVEL TIME.

Intrazonal driving times are the minimum times to drive from the zone centroid to the zone boundary. By comparing the cumulative link times on all possible links from the centroid to the zone boundary, the intrazonal times may be determined.



AR00031839

Figure 9.C3 shows four possible routes from the centroid to the zone boundary. For links 20-30, 20-41, 11-42, and 11-12, the driving times are 14, 20, 18, and 14 minutes, respectively. The driving times from nodes 20 and 11 to the zone boundary, points A, B, C, and D, are estimated on the basis of what portion of the link lies inside the zone. Thus, if

20-A is 0.4 as long as link 20-30
20-B is 0.6 as long as link 20-41
11-C is 0.6 as long as link 11-42
11-D is 0.5 as long as link 11-12,

the driving times are:

for 20-A, 0.4 x 14 = 5.6 min
for 20-B, 0.6 x 20 = 12.0 min
for 11-C, 0.6 x 18 = 10.8 min
for 11-D, 0.5 x 16 = 8.0 min.

By assuming the link times over the four possible routes from the centroid to the zone boundary, the following possible intrazonal times are obtained:

route via 1-10-20-A = 11.6 min
route via 1-10-20-B = 18.0 min
route via 1-10-11-C = 15.8 min
route via 1-10-11-D = 13.0 min.

Since the minimum driving time is 11.6 minutes, the intrazonal driving time for this hypothetical zone is 12 minutes (rounded to the nearest whole minute).

In the gravity-model calibration for Oahu, intrazonal driving times were derived for all 159 zones in a study area. These derived values were then inserted in the binary tape that contained the interzonal travel times by using the IBM 7090/7094 Update Skim Trees Program, PR-130. In this study estimate, intrazonal travel times, once determined, were not further adjusted throughout the calibration of the gravity model. Table 9.C1 lists the intrazonal travel times used by this study.



AR00031840

Table 9.C1. Intra-Zonal Driving Time (Minutes)

| O-D Zone | Time | O-D Zone | Time | O-D Zone | Time | O-D Zone | Time |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 41 | 2 | 81 | 2 | 121 | 4 |
| 2 | 1 | 42 | 2 | 82 | 3 | 122 | 5 |
| 3 | 1 | 43 | 2 | 83 | 7 | 123 | 6 |
| 4 | 1 | 44 | 3 | 84 | 1 | 124 | 2 |
| 5 | 1 | 45 | 3 | 85 | 1 | 125 | 2 |
| 6 | 1 | 46 | 1 | 86 | 1 | 126 | 3 |
| 7 | 2 | 47 | 1 | 87 | 2 | 127 | 3 |
| 8 | 1 | 48 | 3 | 88 | 2 | 128 | 2 |
| 9 | 1 | 49 | 1 | 89 | 2 | 129 | 2 |
| 10 | 1 | 50 | 1 | 90 | 1 | 130 | 1 |
| 11 | 1 | 51 | 1 | 91 | 2 | 131 | 1 |
| 12 | 1 | 52 | 3 | 92 | 2 | 132 | 2 |
| 13 | 1 | 53 | 2 | 93 | 4 | 133 | 2 |
| 14 | 1 | 54 | 2 | 94 | 1 | 134 | 1 |
| 15 | 1 | 55 | 4 | 95 | 1 | 135 | 2 |
| 16 | 1 | 56 | 2 | 96 | 2 | 136 | 2 |
| 17 | 1 | 57 | 1 | 97 | 1 | 137 | 1 |
| 18 | 1 | 58 | 2 | 98 | 2 | 138 | 2 |
| 19 | 3 | 59 | 2 | 99 | 2 | 139 | 2 |
| 20 | 1 | 60 | 2 | 100 | 2 | 140 | 2 |
| 21 | 1 | 61 | 1 | 101 | 3 | 141 | 1 |
| 22 | 1 | 62 | 2 | 102 | 7 | 142 | 1 |
| 23 | 1 | 63 | 2 | 103 | 5 | 143 | 2 |
| 24 | 3 | 64 | 1 | 104 | 5 | 144 | 2 |
| 25 | 1 | 65 | 1 | 105 | 4 | 145 | 2 |
| 26 | 3 | 66 | 2 | 106 | 9 | 146 | 2 |
| 27 | 1 | 67 | 1 | 107 | 2 | 147 | 2 |
| 28 | 2 | 68 | 1 | 108 | 3 | 148 | 1 |
| 29 | 1 | 69 | 2 | 109 | 3 | 149 | 3 |
| 30 | 1 | 70 | 2 | 110 | 5 | 150 | 1 |
| 31 | 2 | 71 | 1 | 111 | 1 | 151 | 1 |
| 32 | 1 | 72 | 2 | 112 | 1 | 152 | 3 |
| 33 | 1 | 73 | 2 | 113 | 2 | 153 | 2 |
| 34 | 1 | 74 | 2 | 114 | 2 | 154 | 2 |
| 35 | 1 | 75 | 2 | 115 | 2 | 155 | 1 |
| 36 | 1 | 76 | 3 | 116 | 1 | 156 | 2 |
| 37 | 3 | 77 | 2 | 117 | 4 | 157 | 1 |
| 38 | 1 | 78 | 3 | 118 | 1 | 158 | 2 |
| 39 | 1 | 79 | 2 | 119 | 2 | 159 | 2 |
| 40 | 1 | 80 | 7 | 120 | 6 | | |



AR00031841

## 3. TERMINAL TIME

As previously discussed, spatial separations between zones are more realistically indicated by zone-to-zone travel times, which are the sum of the over-the-road driving times and the terminal times within the origin and destination zones. Thus, it was then necessary to develop a measure of terminal time for each zone and to combine it with the over-the-road (interzonal) travel times.

There are no absolute rules for estimating terminal times. Factors that affect terminal times are related to the amount of congestion in a zone and may consist of the following conditions:

1. The time spent in cruising for a parking place at a non-home destination end of a trip.
2. The time spent in walking from a parking place to an actual destination of a trip, be it an office, store, recreation facility, or home.
3. The time spent in walking from a trip origin, be it the home, an office, or other such origin, to the parking lot.
4. The time spent in getting from the parking lot to the street system at the origin end of the trip.

Table 9.C2 lists the terminal times that were subjectively derived. These terminal times also were used without further adjustment throughout the calibration process.

## 4. PERSON-TRIP-MODEL CALIBRATIONS

The objective of the trip-distribution analysis was to obtain the set of travel-time factors that express the people's desire to travel from one zone to another. This determining process normally begins with a set of assumed travel-time factors and follows a set of recursive steps to determine new factors that more nearly approximate the trip distribution observed in an O-D survey. A comparison is made between observed and simulated trip-frequency distributions after each step. The travel-time factors are adjusted until:

1. The simulated trip-length frequency distribution matches or closely matches the observed trip-length frequency distribution
2. The differences between simulated and observed average trip lengths fall within ±3 percent of each other



AR00031842

Table 9.C2. Zonal Terminal Time (Minutes)

| O-D Zone | Time | O-D Zone | Time | O-D Zone | Time | O-D Zone | Time |
|---|---|---|---|---|---|---|---|
| 1 | 3 | 41 | 3 | 81 | 2 | 121 | 1 |
| 2 | 4 | 42 | 3 | 82 | 1 | 122 | 1 |
| 3 | 4 | 43 | 3 | 83 | 1 | 123 | 1 |
| 4 | 4 | 44 | 2 | 84 | 1 | 124 | 1 |
| 5 | 3 | 45 | 1 | 85 | 1 | 125 | 1 |
| 6 | 3 | 46 | 1 | 86 | 1 | 126 | 2 |
| 7 | 5 | 47 | 1 | 87 | 1 | 127 | 2 |
| 8 | 5 | 48 | 2 | 88 | 1 | 128 | 1 |
| 9 | 5 | 49 | 2 | 89 | 1 | 129 | 1 |
| 10 | 2 | 50 | 2 | 90 | 1 | 130 | 1 |
| 11 | 4 | 51 | 2 | 91 | 1 | 131 | 1 |
| 12 | 4 | 52 | 1 | 92 | 1 | 132 | 3 |
| 13 | 4 | 53 | 2 | 93 | 1 | 133 | 1 |
| 14 | 3 | 54 | 2 | 94 | 1 | 134 | 1 |
| 15 | 3 | 55 | 3 | 95 | 1 | 135 | 1 |
| 16 | 4 | 56 | 1 | 96 | 1 | 136 | 1 |
| 17 | 4 | 57 | 1 | 97 | 1 | 137 | 1 |
| 18 | 1 | 58 | 1 | 98 | 1 | 138 | 1 |
| 19 | 2 | 59 | 2 | 99 | 1 | 139 | 1 |
| 20 | 1 | 60 | 5 | 100 | 1 | 140 | 1 |
| 21 | 1 | 61 | 5 | 101 | 1 | 141 | 1 |
| 22 | 1 | 62 | 1 | 102 | 1 | 142 | 1 |
| 23 | 1 | 63 | 2 | 103 | 1 | 143 | 1 |
| 24 | 1 | 64 | 1 | 104 | 1 | 144 | 1 |
| 25 | 1 | 65 | 1 | 105 | 1 | 145 | 1 |
| 26 | 2 | 66 | 1 | 106 | 1 | 146 | 2 |
| 27 | 3 | 67 | 4 | 107 | 1 | 147 | 2 |
| 28 | 3 | 68 | 2 | 108 | 1 | 148 | 1 |
| 29 | 1 | 69 | 1 | 109 | 1 | 149 | 1 |
| 30 | 3 | 70 | 1 | 110 | 1 | 150 | 1 |
| 31 | 3 | 71 | 1 | 111 | 1 | 151 | 1 |
| 32 | 3 | 72 | 1 | 112 | 2 | 152 | 2 |
| 33 | 3 | 73 | 1 | 113 | 1 | 153 | 1 |
| 34 | 1 | 74 | 2 | 114 | 1 | 154 | 1 |
| 35 | 1 | 75 | 2 | 115 | 1 | 155 | 1 |
| 36 | 1 | 76 | 1 | 116 | 1 | 156 | 1 |
| 37 | 1 | 77 | 1 | 117 | 1 | 157 | 1 |
| 38 | 1 | 78 | 1 | 118 | 1 | 158 | 1 |
| 39 | 1 | 79 | 1 | 119 | 1 | 159 | 1 |
| 40 | 1 | 80 | 1 | 120 | 1 | | |



AR00031843

3. The differences between simulated and observed hours of travel fall within ±3 percent of each other
4. The simulated zonal attractions approximate the observed zonal attractions.

The Oahu Transportation Study was fortunate to have calibrated a gravity model for auto-driver trips in the early stages of the study. Thus, the study began its calibration of the gravity models for each of the six person-trip purposes: home-based work, shopping, social-recreation, school, and other trips, and non-home-based trips by utilizing travel-time factors which were developed for the auto-driver trips. Two iterations were specified for each run of the Gravity Model, and the total process required seven calibrations before the travel-time functions were considered adequate in synthesizing the 1960 travel.

It should be noted that the adjusted travel-time factors in the second calibration produced results within the desirable limits specified above. Analysis of this calibration by means of district-to-district movements and screenline comparisons, however, disclosed definite deficiencies at two major screenlines: the Trans-Koolau and the Manana screenlines (Table 9.C3). The differences between the simulated and observed volumes indicated a definite need for time penalities to correct the bias.

Table 9.C3. Comparison of 1960 Observed and Simulated Volumes at Manana and Trans-Koolau Screenlines

| Condition (1960) | Screenlines | | | |
|---|---|---|---|---|
| | Manana | | Trans-Koolau | |
| | E-bound | W-bound | N-bound | S-bound |
| Observed | 29,951 | 18,710 | 11,527 | 39,292 |
| Gravity-Model 2 Simulated | 38,534 | 17,486 | 16,107 | 48,687 |
| % Difference | + 28.7 | - 6.5 | + 39.7 | + 23.9 |
| Gravity-Model 7 Simulated | 32,668 | 16,569 | 11,175 | 43,141 |
| % Difference | + 9.1 | - 11.4 | - 3.0 | + 9.8 |



AR00031844

To correct this bias condition, five additonal calibrations were required. Each successive run following the second calibration required adjustments to be made in the network by inserting time penalties and/or by changing the travel-time factors. Screenline comparisons of volumes resulting from the seventh calibration are indicated in Table 9.C3.

A statistical analysis was made of district-to-district movements. Root-mean-square error was computed for each volume group. The results of this analysis for the final calibration is shown in Fig. 9.C4, which illustrates the relative accuracy of the gravity models.

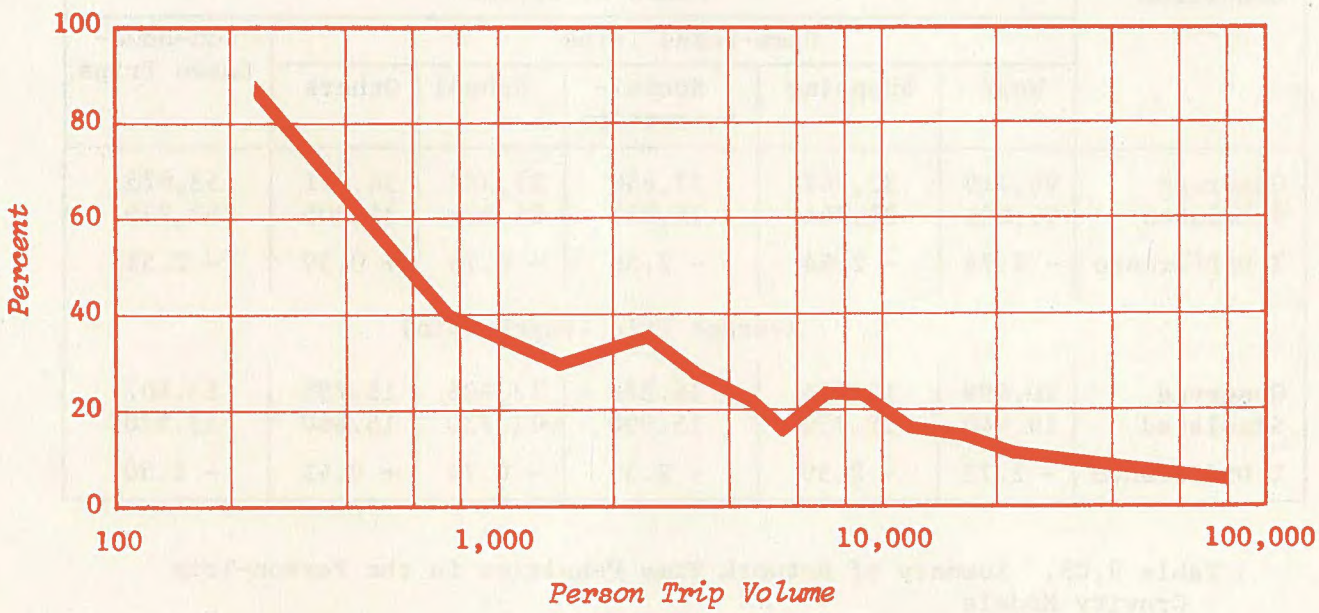



FIG. 9.C4. PERCENT-ROOT-MEAN SQUARE ERROR BETWEEN OBSERVED AND SIMULATED TRIP DISTRIBUTION.



AR00031845

Table 9.C4 shows the comparison of person hours of travel and the average trip length (in minutes) by trip purpose between the 1960 observed and simulated trip distributions; Table 9.C5 lists the location and time penalities required in the calibration of the respective gravity models; and the graphs in Fig. 9.C5 illustrate the trip-length frequency curves between the 1960 observed and simulated trip distributions of each trip purpose. A list of the final travel-time factors for each trip purpose is found in Table 9.C6.

Table 9.C4. Comparison of Person Hours of Travel Between 1960 Observed and Simulated Trip Distributions

| Condition | Hours of Travel | | | | | |
|---|---|---|---|---|---|---|
| | Home-Based Trips | | | | | Non-Home-Based Trips |
| | Work | Shopping | Social-Recreation | School | Others | |
| Observed | 98,715 | 32,567 | 77,650 | 21,388 | 34,071 | 53,625 |
| Simulated | 96,001 | 31,744 | 75,811 | 21,224 | 34,205 | 52,275 |
| % Difference | - 2.74 | - 2.54 | - 2.36 | - 0.76 | + 0.39 | - 2.51 |
| | Average Trip Length (min) | | | | | |
| Observed | 20.499 | 12.576 | 16.379 | 12.826 | 15.795 | 13.867 |
| Simulated | 19.940 | 12.250 | 15.990 | 12.730 | 15.860 | 13.520 |
| % Difference | - 2.72 | - 2.59 | - 2.37 | - 0.74 | + 0.41 | - 2.50 |

Table 9.C5. Summary of Network Time Penalties in the Person-Trip Gravity Models

| Location | Time (min) | Direction |
|---|---|---|
| Kamehameha Highway | | |
| between Haleiwa and Kahuku | 4.0 | Both |
| between Wahiawa and Waipahu | 4.0 | E-bound |
| between Waipahu and Pearl City | 6.0 | E-bound |
| immediately west of Middle Street | 3.0 | Both |
| Likelike Highway - Koolau Range ridge | 6.0 | Both |
| Pali Highway - Koolau Range ridge | 6.0 | Both |
| Nimitz Highway - immediately west of Middle Street | 3.0 | Both |
| Kalanianaole Highway - between Waimanalo and Makapuu | 6.0 | Both |
| Kunia Road - between Wahiawa and Waipahu | 4.0 | E-bound |
| Moanalua Highway - immediately west of Middle Street | 3.0 | Both |



AR00031846

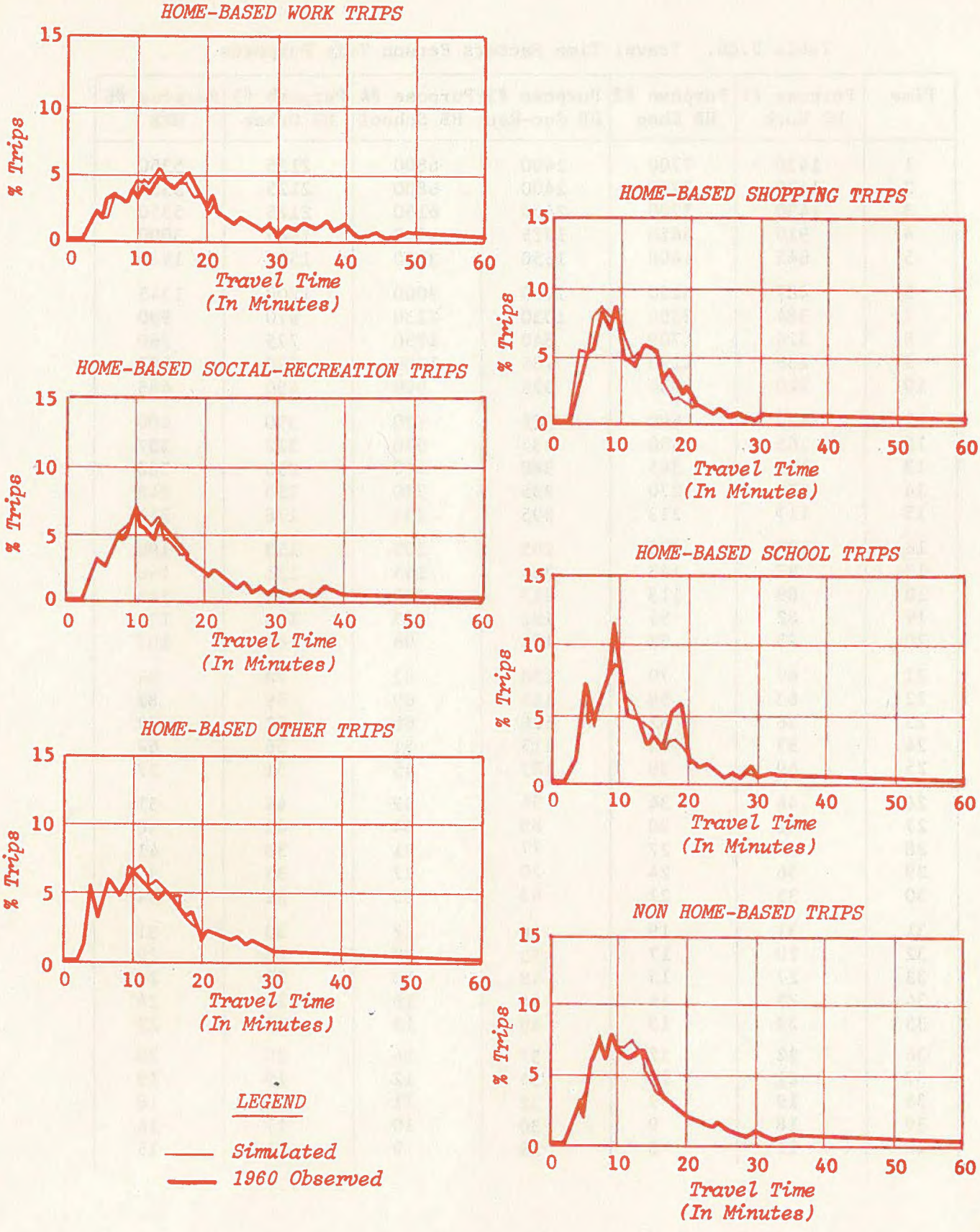



FIG. 9.C5. TRIP-LENGTH DISTRIBUTION OF PERSON TRIPS BY PURPOSE



AR00031847

Table 9.C6. Travel Time Factors Person Trip Purposes

| Time | Purpose #1 HB Work | Purpose #2 HB Shop | Purpose #3 HB Soc-Rec | Purpose #4 HB School | Purpose #5 HB Other | Purpose #6 NHB |
|---|---|---|---|---|---|---|
| 1 | 1430 | 7700 | 2400 | 6800 | 2125 | 5350 |
| 2 | 1430 | 7700 | 2400 | 6800 | 2125 | 5350 |
| 3 | 1430 | 7700 | 2400 | 6160 | 2125 | 5350 |
| 4 | 910 | 5450 | 1925 | 4900 | 1845 | 3000 |
| 5 | 645 | 4400 | 1550 | 3900 | 1500 | 1940 |
| 6 | 487 | 3250 | 1260 | 3000 | 1200 | 1345 |
| 7 | 384 | 2350 | 1030 | 2230 | 970 | 990 |
| 8 | 310 | 1700 | 840 | 1750 | 775 | 760 |
| 9 | 259 | 1190 | 705 | 1300 | 620 | 600 |
| 10 | 220 | 840 | 595 | 980 | 490 | 485 |
| 11 | 190 | 600 | 505 | 720 | 390 | 400 |
| 12 | 165 | 450 | 435 | 540 | 312 | 337 |
| 13 | 146 | 345 | 380 | 410 | 255 | 288 |
| 14 | 130 | 270 | 335 | 320 | 213 | 248 |
| 15 | 117 | 213 | 295 | 255 | 178 | 217 |
| 16 | 106 | 175 | 265 | 205 | 153 | 190 |
| 17 | 97 | 143 | 238 | 165 | 131 | 166 |
| 18 | 89 | 113 | 213 | 138 | 114 | 145 |
| 19 | 82 | 95 | 192 | 113 | 100 | 125 |
| 20 | 75 | 82 | 173 | 96 | 88 | 107 |
| 21 | 69 | 70 | 158 | 82 | 78 | 94 |
| 22 | 63 | 59 | 141 | 69 | 69 | 82 |
| 23 | 58 | 52 | 128 | 60 | 62 | 72 |
| 24 | 53 | 45 | 115 | 51 | 56 | 64 |
| 25 | 49 | 39 | 105 | 45 | 51 | 57 |
| 26 | 46 | 34 | 94 | 39 | 46 | 51 |
| 27 | 42 | 30 | 85 | 34 | 42 | 46 |
| 28 | 39 | 27 | 77 | 31 | 38 | 41 |
| 29 | 36 | 24 | 70 | 27 | 35 | 37 |
| 30 | 33 | 21 | 63 | 25 | 32 | 34 |
| 31 | 31 | 19 | 58 | 22 | 30 | 31 |
| 32 | 29 | 17 | 53 | 20 | 28 | 29 |
| 33 | 27 | 15 | 48 | 18 | 26 | 26 |
| 34 | 25 | 14 | 44 | 16 | 24 | 24 |
| 35 | 23 | 13 | 40 | 15 | 22 | 22 |
| 36 | 22 | 12 | 37 | 14 | 20 | 20 |
| 37 | 21 | 10 | 34 | 12 | 19 | 19 |
| 38 | 19 | 9 | 32 | 11 | 18 | 18 |
| 39 | 18 | 9 | 30 | 10 | 17 | 16 |
| 40 | 17 | 8 | 28 | 9 | 16 | 15 |



AR00031848

Table 9.C6 - continued

| Time | Purpose #1 HB Work | Purpose #2 HB Shop | Purpose #3 HB Soc-Rec | Purpose #4 HB School | Purpose #5 HB Other | Purpose #6 NHB |
|---|---|---|---|---|---|---|
| 41 | 16 | 8 | 26 | 9 | 15 | 14 |
| 42 | 15 | 7 | 24 | 8 | 14 | 13 |
| 43 | 15 | 6 | 22 | 7 | 13 | 12 |
| 44 | 14 | 6 | 21 | 7 | 12 | 12 |
| 45 | 13 | 5 | 20 | 6 | 12 | 11 |
| 46 | 12 | 5 | 18 | 6 | 11 | 10 |
| 47 | 12 | 5 | 17 | 5 | 11 | 10 |
| 48 | 11 | 4 | 16 | 5 | 10 | 9 |
| 49 | 11 | 4 | 15 | 5 | 10 | 9 |
| 50 | 10 | 4 | 14 | 4 | 9 | 8 |
| 51 | 10 | 3 | 14 | 4 | 9 | 8 |
| 52 | 10 | 3 | 13 | 4 | 8 | 7 |
| 53 | 9 | 3 | 12 | 4 | 8 | 7 |
| 54 | 9 | 3 | 11 | 3 | 7 | 7 |
| 55 | 8 | 3 | 11 | 3 | 7 | 6 |
| 56 | 8 | 3 | 10 | 3 | 7 | 6 |
| 57 | 8 | 2 | 10 | 3 | 7 | 6 |
| 58 | 7 | 2 | 9 | 3 | 6 | 5 |
| 59 | 7 | 2 | 9 | 3 | 6 | 5 |
| 60 | 7 | 2 | 8 | 2 | 6 | 5 |
| 61 | 7 | 2 | 8 | 2 | 6 | 5 |
| 62 | 6 | 2 | 8 | 2 | 5 | 4 |
| 63 | 6 | 2 | 7 | 2 | 5 | 4 |
| 64 | 6 | 2 | 7 | 2 | 5 | 4 |
| 65 | 6 | 1 | 7 | 2 | 5 | 4 |
| 66 | 5 | 1 | 6 | 2 | 5 | 4 |
| 67 | 5 | 1 | 6 | 2 | 4 | 4 |
| 68 | 5 | 1 | 6 | 2 | 4 | 3 |
| 69 | 5 | 1 | 6 | 1 | 4 | 3 |
| 70 | 5 | 1 | 5 | 1 | 4 | 3 |
| 71 | 5 | | 5 | 1 | 4 | 3 |
| 72 | 4 | | 5 | 1 | 4 | 3 |
| 73 | 4 | | 5 | 1 | 4 | 3 |
| 74 | 4 | | 5 | 1 | 3 | 3 |
| 75 | 4 | | 4 | 1 | 3 | 3 |
| 76 | 4 | | 4 | 1 | 3 | 2 |
| 77 | 4 | | 4 | 1 | 3 | 2 |
| 78 | 4 | | 4 | 1 | 3 | 2 |
| 79 | 4 | | 4 | 1 | 3 | 2 |
| 80 | 4 | | 4 | 1 | 3 | 2 |



AR00031849

Table 9.C6 - continued

| Time | Purpose #1 HB Work | Purpose #2 HB Shop | Purpose #3 HB Soc-Rec | Purpose #4 HB School | Purpose #5 HB Other | Purpose #6 NHB |
|---|---|---|---|---|---|---|
| 81 | 3 | | 3 | | 3 | 2 |
| 82 | 3 | | 3 | | 3 | 2 |
| 83 | 3 | | 3 | | 3 | 2 |
| 84 | 3 | | 3 | | | 2 |
| 85 | 3 | | 3 | | | 2 |
| 86 | 3 | | 3 | | | 2 |
| 87 | 3 | | 3 | | | 2 |
| 88 | 3 | | 3 | | | 2 |
| 89 | 3 | | 3 | | | 2 |
| 90 | 3 | | 3 | | | 2 |
| 91 | 3 | | 2 | | | |
| 92 | | | 2 | | | |
| 93 | | | 2 | | | |
| 94 | | | 2 | | | |
| 95 | | | 2 | | | |
| 96 | | | 2 | | | |
| 97 | | | 2 | | | |
| 98 | | | 1 | | | |
| 99 | | | 1 | | | |
| 100 | | | 1 | | | |

In summary, a high degree of success was achieved in synthesizing the 1960 observed trip distribution. Therefore, the distribution of the 1985 forecast of person-trip productions and attractions could be undertaken with considerable confidence.

## 5. COMMERCIAL TRIP MODEL CALIBRATION

The calibration of the commercial gravity-distribution model was accomplished in a similar manner. It should be noted that no stratification was attempted to segregate small commercial vehicles from medium and heavy commercial vehicles.

Three calibrations were required, beginning with the same travel-time factors for auto-driver trips to produce friction that would satisfactorily simulate the 1960 observed commercial-trip distributions.



AR00031850

Table 9.C7 shows the comparison of the vehicle hours of travel and the average trip length between the 1960 observed and simulated trip distribution, and Table 9.C8 lists the network location and time penalties required in the calibration of the model. Figure 9.C6 illustrates the trip-length frequency curves between the 1960 observed and simulated commercial-trip distributions. Travel-time factors are listed in Table 9.C9.

Table 9.C7. Summary of Vehicle Hours of Travel and Average Trip Length Between 1960 Observed and Simulated Commercial-Trip Distribution

| Condition | Travel Time (hr) | Trip Length (min) |
|---|---|---|
| Observed | 23,769 | 12.363 |
| Simulated | 23,967 | 12.47 |
| % Difference | + 0.83 | + 0.89 |

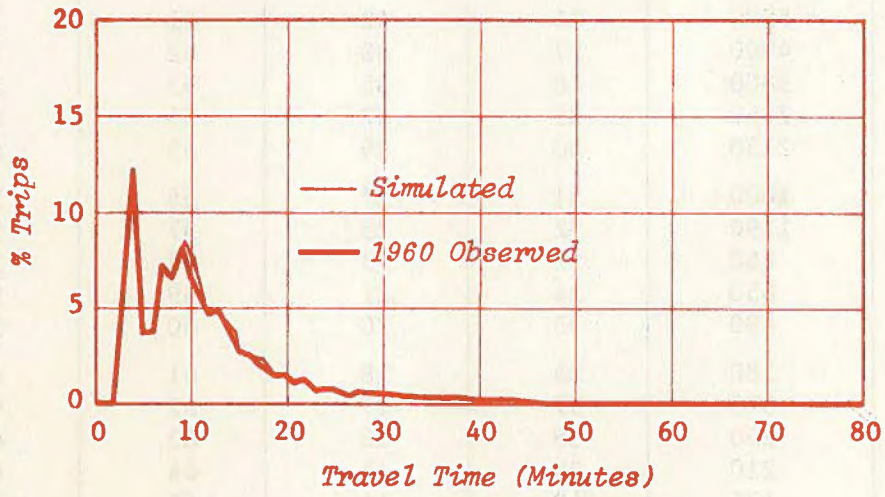



FIG. 9.C6. TRIP-LENGTH DISTRIBUTION: COMMERCIAL TRIPS



AR00031851

Table 9.C8. Summary of Network Time Penalties Commercial-Trip Gravity Model

| Location | Time (min) | Direction |
|---|---|---|
| Kamehameha Highway | | |
| between Haleiwa and Kahuku | 4.0 | E-bound |
| immediately west of Middle Street | 3.0 | Both |
| Likelike Highway - Koolau Range ridge | 6.0 | S-bound |
| Pali Highway - Koolau Range ridge | 6.0 | S-bound |
| Kalanianaole Highway - between Waimanalo and Makapuu | 6.0 | W-bound |
| Nimitz Highway - immediately west of Middle Street | 3.0 | Both |
| Moanalua Highway - immediately west of Middle Street | 2.0 | Both |

Table 9.C9. Travel Time Factors Commercial Trips

| Time | Factor | Time | Factor | Time | Factor |
|---|---|---|---|---|---|
| 1 | 5800 | 26 | 42 | 51 | 7 |
| 2 | 4900 | 27 | 38 | 52 | 7 |
| 3 | 3800 | 28 | 35 | 53 | 7 |
| 4 | 2850 | 29 | 32 | 54 | 6 |
| 5 | 2150 | 30 | 29 | 55 | 6 |
| 6 | 1600 | 31 | 27 | 56 | 5 |
| 7 | 1190 | 32 | 25 | 57 | 5 |
| 8 | 880 | 33 | 23 | 58 | 5 |
| 9 | 650 | 34 | 21 | 59 | 5 |
| 10 | 490 | 35 | 20 | 60 | 5 |
| 11 | 380 | 36 | 18 | 61 | 4 |
| 12 | 305 | 37 | 17 | 62 | 4 |
| 13 | 250 | 38 | 16 | 63 | 4 |
| 14 | 210 | 39 | 15 | 64 | 4 |
| 15 | 175 | 40 | 14 | 65 | 3 |
| 16 | 145 | 41 | 13 | 66 | 3 |
| 17 | 125 | 42 | 12 | 67 | 3 |
| 18 | 108 | 43 | 12 | 68 | 3 |
| 19 | 94 | 44 | 11 | 69 | 2 |
| 20 | 82 | 45 | 10 | 70 | 2 |
| 21 | 73 | 46 | 10 | 71 | 2 |
| 22 | 64 | 47 | 9 | 72 | 2 |
| 23 | 58 | 48 | 9 | 73 | 2 |
| 24 | 52 | 49 | 8 | 74 | 2 |
| 25 | 46 | 50 | 8 | 75 to 95 | 1 |



AR00031852

# APPENDIX IX-D. FUTURE TRANSIT USAGE

## 1. INTRODUCTION

Evaluation of potential future transportation systems necessitates the rational allocation of estimated future travel demand to the highway and mass-transit components of such systems. This in turn requires a decision mechanism that can reliably predict a trip maker's choice between auto and mass-transit modes of travel. Such a decision mechanism has come to be termed a "modal-choice model" or "modal-split model." Simply stated, a modal-split model is an explicit relationship between choice of travel mode and the characteristics of both the trip maker and the transportation system. This relationship is based on extensive observation of how people actually choose their travel mode when faced with an array of travel conditions and opportunities.

The development of a modal-split model makes possible the testing of a number of alternative systems operating under varying assumed future conditions at a minimum of time and expense. It also allows the comparison of alternatives using the same explicit assumptions for each and minimizing the subjective judgment of the analyst.

The following discusses the development of a modal-split model for Oahu, the use of this model to estimate future transit usage, and the analysis and interpretation of the estimate.

## 2. FACTORS INFLUENCING TRANSIT USAGE

Considerable research has been conducted in recent years into the factors influencing transit usage. This research has demonstrated that the choice of travel mode is highly correlated with such variables as trip purpose, relative auto and transit travel times, relative auto and transit travel costs, transit headways and number of transfers, residential and employment densities, auto ownership, and income.

The purpose for which a trip is made transcends all other factors influencing transit usage. Characteristically, the propensity to use transit differs significantly for different trip purposes. Fortunately, the greatest propensity to choose transit is exhibited for work trips, which occur during peak periods of travel and are the root of the urban transportation problem. Mass transit is thus capable of relieving congestion on a highway system which it complements.



AR00031854

For a given trip, or group of trips having the same purpose, the variables influencing transit use fall into three general categories: characteristics related to the trip origin, characteristics related to the trip destination and characteristics related to the interchange between the origin and destination.

In Honolulu today, even casual observation reveals varying levels of residential density, auto ownership, and income (origin characteristics), varying levels of employment density and parking cost (destination characteristics), and varying levels of highway and transit service (interchange characteristics). Through application of mathematical and statistical techniques, and with the aid of electronic computers, it is possible to develop relationships between these factors and the observed choices of travel mode. Such relationships form the basis for the "modal-split model". Statistical and logical checks on these relationships are also available and, when satisfied, these checks assure an acceptable degree of confidence in the use of the mode-choice relationships for estimating future transit usage.

## 3. DEVELOPMENT OF MODAL-SPLIT MODEL

Development of the modal-split model for Oahu relied heavily on prior data collection for information on transit usage and related factors. The primary source of data consisted of a home-interview O-D survey in 1960. A summary of 1960 person trips by travel mode and trip purpose, based on that survey, is presented in Table 9.D1.

Since transit usage is related to trip purpose it would be desirable to develop mode-of-choice relationships for each of the trip-purpose categories shown in Table 9.D2. However, transit usage as a percent of total travel is typically quite low compared to auto travel. In Honolulu only 10.5 percent of all trips was by transit. This fact, combined with the low sample rate of home-interview survey, results in a relatively low number of actual transit-trip observations compared to the expanded survey data. When these transit-trip observations are subdivided by trip purpose as shown in Table 9.D1, then not all of the individual trip categories contain enough trip observations to allow development of statistically reliable relationships. It becomes necessary, therefore, to combine the individual trip categories into meaningful



AR00031855

groups for which reliable choice-of-mode relationships can be developed. With these factors in mind, four trip categories were developed for analysis, as shown in Table 9.D2.

Table 9.D1. Person Trips by Travel Mode and Trip Purpose on Oahu in 1960

| Travel Mode | Home-Based Trips | | | | | Non-Home-Based Trips | Total |
|---|---|---|---|---|---|---|---|
| | Work | Shop | Soc-Rec | School | Other | | |
| Auto, Driver | 167,346 | 88,875 | 105,013 | 9,592 | 82,992 | 136,301 | 590,119 |
| Auto, Passenger | 67,689 | 57,470 | 163,619 | 50,398 | 37,728 | 82,479 | 459,383 |
| Bus, Passenger | 45,989 | 9,889 | 13,461 | 39,759 | 7,165 | 9,170 | 125,433 |
| Taxi, Passenger | 955 | 468 | 1,435 | 114 | 846 | 292 | 4,110 |
| Truck, Passenger | 6,828 | 26 | 782 | 162 | 624 | 3,738 | 12,160 |
| TOTAL | 288,807 | 156,728 | 284,310 | 100,025 | 129,355 | 231,980 | 1,191,205 |

Table 9.D2. Trip Categories for Modal-Split Analysis of 1960 Linked O-D Trips

| Trip Category | No. of Trips | % of Total Trips | % by Transit |
|---|---|---|---|
| Home-Based, Auto and Transit Person Trips | | | |
| Work | 281,024 | 23.6 | 16.4 |
| School | 99,749 | 8.4 | 39.8 |
| Other | 566,212 | 47.5 | 5.4 |
| Non-Home-Based, Truck and Taxi Person Trips | 244,220 | 20.5 | 3.8 |
| TOTAL | 1,191,205 | 100.0 | 10.5 |

The most important category is that of home-based work trip. Next in importance is the home-based non-work, non-school (home-based "other") trip category. Although this category combines a number of dissimilar trip purposes, further breakdown is impractical on the basis of the available data. School trips must be isolated, as they are not susceptible to the normal



AR00031856

factors influencing transit use but rather are strongly influenced by policy decisions of schools and other public officials.

The analytical approach to the development of a modal-split model for Honolulu took the following form. First, for each trip observation, tabulations were made of the origin zone, destination zone, and interchange variables thought to be significantly influential in the choice of travel mode. These included:

1. Origin Zone Variables
   - Gross family income in $100's
   - Auto-ownership rate expressed as autos per dwelling
   - Auto-ownership rate expressed as autos per person
   - Residential density expressed as dwellings per residential acre
2. Destination Zone Variables
   - Employment density expressed as employees per gross acre
   - Average nine-hour parking cost in dollars
3. Interchange Variable
   - Equivalent transit travel time minus auto travel time

     Difference in equivalent transit travel time to auto travel time (equivalent transit travel time equals total transit travel time in which walk, wait, and transfer times have been weighted by 2.5). Several studies of modal choice have shown that riders regard this excess time (walk, wait and transfer time) as more of an impediment to transit travel than time spent on the transit vehicle. Using data from O-D surveys in Washington, D.C., and Calgary, Alberta, Canada, we developed linear regression equations in which the proportion of total trips by transit was related to, among other things, transit running time and transit excess time, both entered in the regression equations as separate variables. The calibrated equations, which faithfully reproduced existing modal-split patterns, indicated the excess time variable to be 2.5 to 3.0 times as important as the running-time variable.

With these variables tabulated or arrayed for each trip observation from the O-D survey, it was possible to test the ability of various combinations of these variables to estimate the average observed proportion of trips by transit for each pair of origin zone and destination zone--i.e., each zone-to-



AR00031857

zone interchange. This was accomplished by stratifying or classifying the trip observations into groups of trips in accordance with values of selected variables to each trip, and calculating for each group the proportion of total trip observations for which transit was the selected mode of travel. An example of such a stratification is shown in Table 9.D3, which also shows the attendant problems in the use of small-sample, home-interview survey data for estimating transit use. Note that, even with the relatively small number of groups used in Table 9.D3 for stratifying transit use, there were still a number of categories in which less than ten trip observations were found.

Table 9.D3. Percent of Total Work Trips by Transit, Stratified by Parking Cost, Auto Ownership, Travel Time Difference

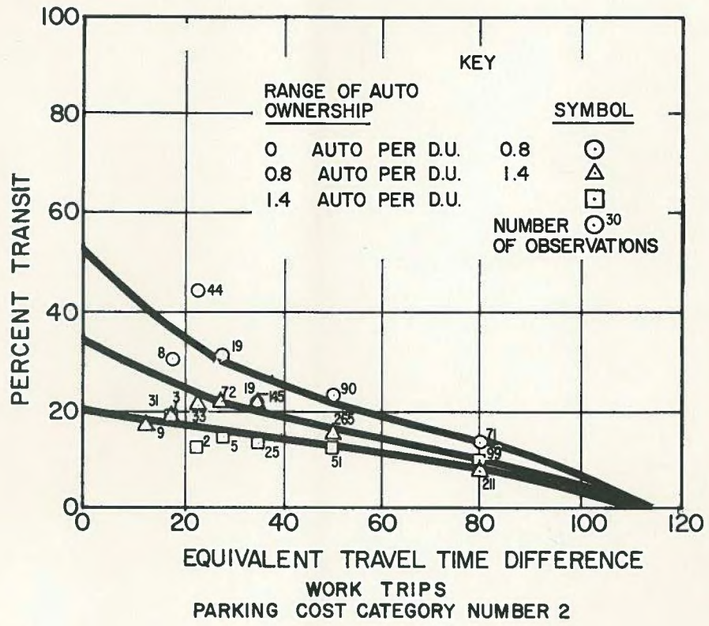
| Avg. Cost of 9-hr Parking ($) | Autos per Dwelling | Travel-Time Difference | | |
|---|---|---|---|---|
| | | 0 - 20 min | 21 - 40 min | Over 41 min |
| 0 - 0.20 | 0 - 0.80 | 30* | 31 | 18 |
| | 0.81 - 1.20 | 16 | 23 | 12 |
| | Over 1.20 | 22* | 16 | 10 |
| 0.21 - 0.80 | 0 - 0.80 | 73 | 44 | 41 |
| | 0.81 - 1.20 | 48 | 28 | 25 |
| | Over 1.20 | 32 | 28 | 10 |
| Over 0.80 | 0 - 0.80 | 45* | 60* | 100* |
| | 0.81 - 1.20 | 74 | 35* | 39* |
| | Over 1.20 | 70* | 54 | 26* |

*Indicates that a sample of less than ten trip observations from the home-interview survey fall into this category.

After the trip data had been stratified by various combinations of origin zone, destination zone, and interchange variables, series of graphs were plotted for each combination and smooth continuous relationships were developed as shown in Fig. 9.D1. In so doing, greater weight was given to values of percent transit for which there was a larger number of observations.



AR00031858



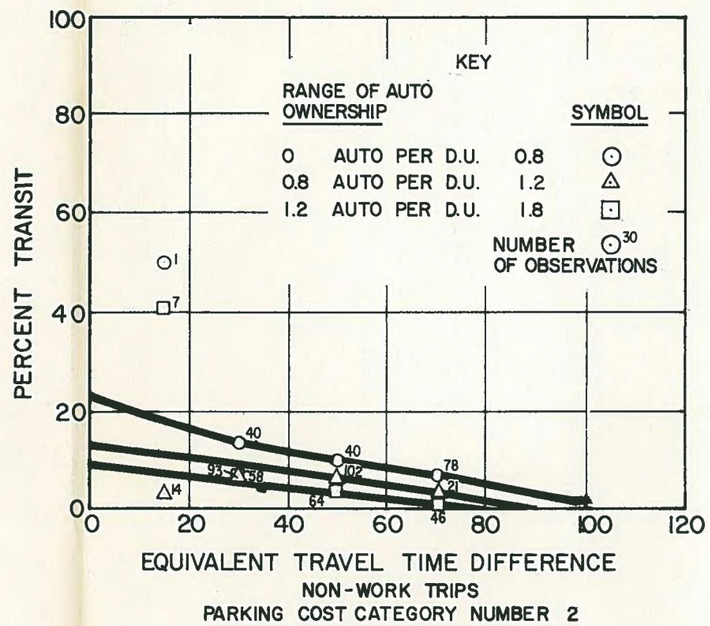
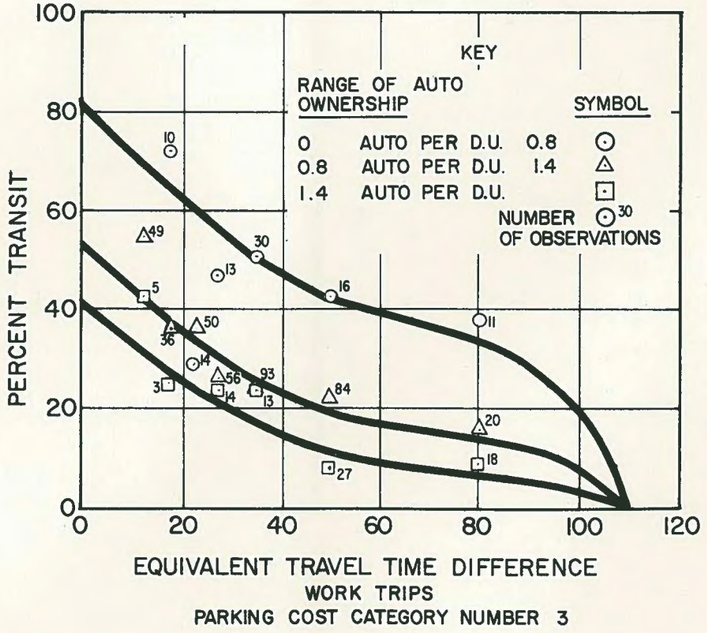
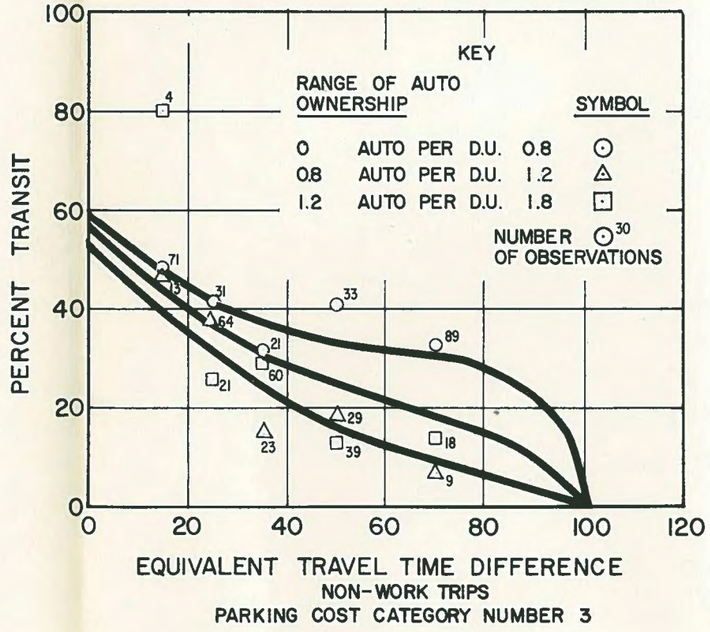




FIG. 9.DI. PERCENT TRANSIT VS. EQUIVALENT TRAVEL TIME DIFFERENCE.






AR00031859

The group of curves exhibiting the best ability to estimate transit usage related percent transit to auto ownership, travel-time difference, and parking cost. The relationship illustrated by this family of curves may be expressed mathematically in the following form:

$$PRPTRN_{i-j} = f(AUTODU_i, TTDIFF_{i-j}, PKCOST_j)$$

where: $PRPTRN_{i-j}$ = estimated proportion of total person trips from zone i to zone j which will use transit mode of travel.

$AUTODU_i$ = average number of autos per dwelling in zone i.

$TTDIFF_{i-j}$ = difference in equivalent transit travel time and auto travel time from zone i to zone j, where equivalent transit travel time equals 2.5 times transit excess time plus transit running time.

$PKCOST_j$ = average 9-hr parking cost in zone j.

The relationship described by this family of curves was programmed into a mathematical computational procedure for use on a high-speed electronic computer. A mathematical modal-split model was thus formulated, which, when given total trips between each pair of zones, average auto ownership for each zone, average parking cost for each zone, and zone-to-zone transit and auto travel times, will produce estimates of the number of trips between each pair of zones by transit and by auto. Given auto occupancy, the model will also estimate the number of auto drivers and auto passengers for each zone-to-zone movement.

In order to test the ability of the model to produce reliable estimates of transit use, the model was used to estimate observed 1960 transit usage from 1960 values of auto ownership, parking cost, and transit and auto travel times. Results of this estimate were compared with observed transit use and, where necessary, adjustments were made to correct for bias and irregularities in the results. This comparison and adjustment procedure was continued until the model was satisfactorily reproducing the observed pattern of 1960 transit usage.

Statistical checks performed on the final estimated vs. observed transit use indicated that the model could be used with confidence to estimate future transit use given future values of the related variables.



AR00031860

## 4. FINAL MODAL-SPLIT RELATIONSHIPS

The families of curves on which the modal-split models for work trips and non-work trips were based appear in Figs. 9.D2 and 9.D3, respectively. It is evident from these curves that the change in modal split between now and 1985 is related to present values of the factors influencing transit use. For example, note that the greatest decrease in transit use with respect to auto ownership occurs in the lower ranges of auto ownership. This is logical in that greater change would be expected for a family obtaining their first car than for a family obtaining their second or third car. Honolulu now has an average auto ownership rate of approximately one auto per dwelling; therefore, many families are presently within the range of greatest potential change.

With respect to equivalent-travel-time difference, the greatest percentage increases in transit use can be expected to occur for zone-to-zone interchanges where the travel time difference is now greater than 30 equivalent minutes, which includes a great majority of the interchanges, and for which future transit service will be improved to the extent that this difference will be reduced below 30 equivalent minutes. The greatest increase will be observed between outlying areas that are now poorly serviced by transit but that in the future will be well served by rapid transit, and zones in central Honolulu. This latter potential change in modal split would be strongly reinforced by expected increases in parking costs in the central Honolulu area.

## 5. HOME-BASED SCHOOL AND NON-HOME-BASED TRIPS

For the following reasons, modal-split relationships were not developed for home-based school trips or for non-home-based trips. School trips, as indicated previously, are not influenced by the factors normally affecting transit use. Public-policy decisions generally decide the extent to which public mass transit is utilized for school trips. Estimates of future transit school trips were based on an analysis of past trends and projection of these trends to the future estimate year.

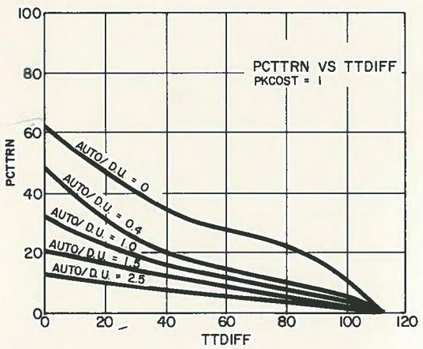


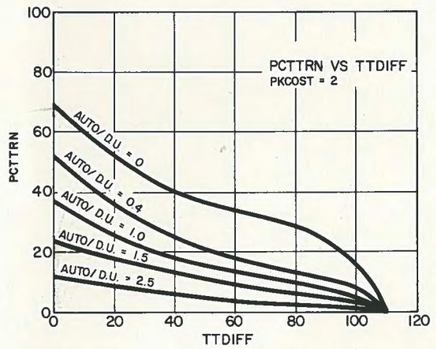
AR00031861

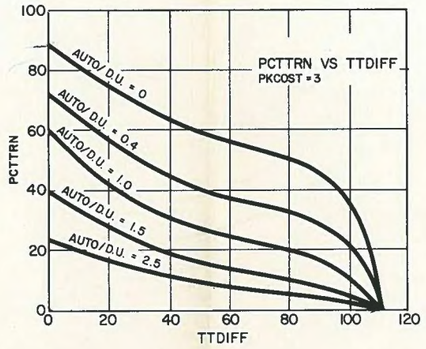
FIG. 9.D2.

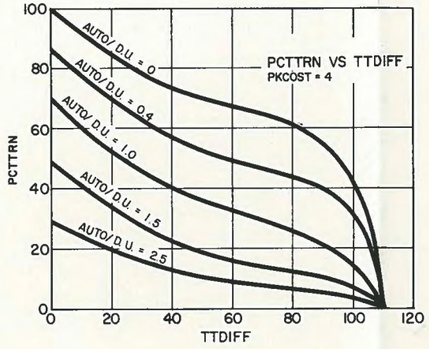
# OAHU MODAL SPLIT RELATIONSHIPS

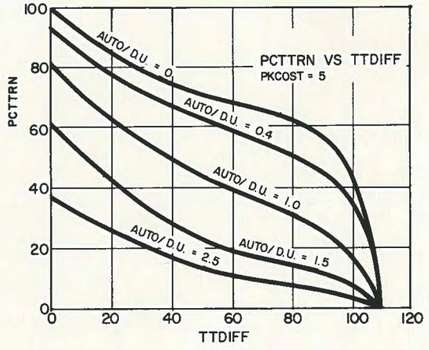
WORK TRIPS

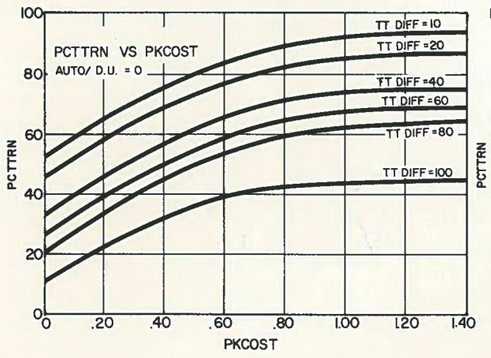


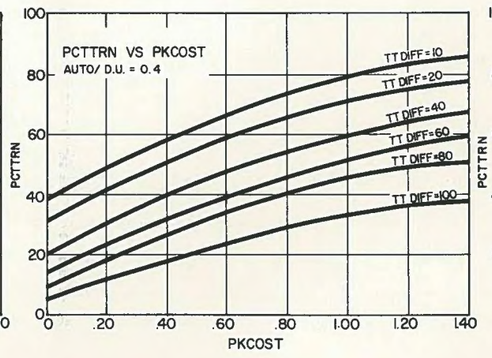



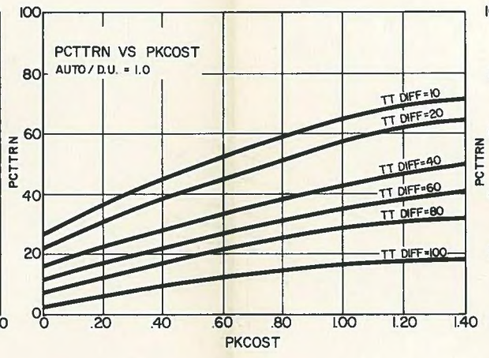



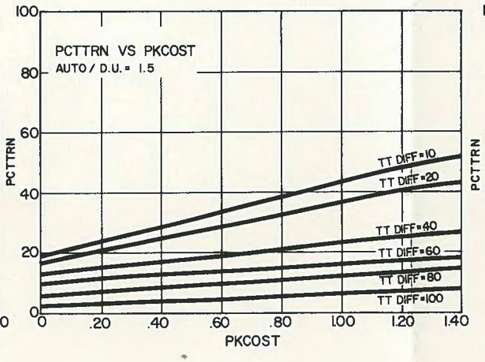



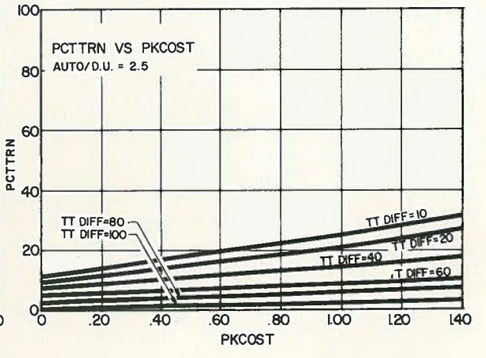



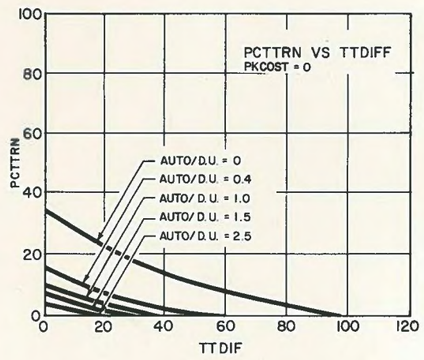


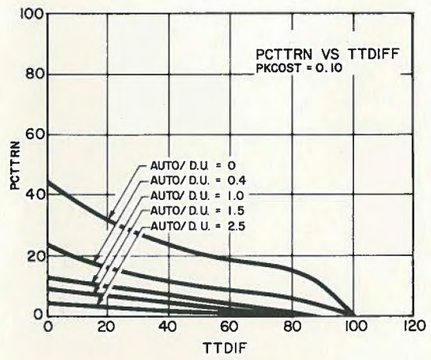

AR00031862

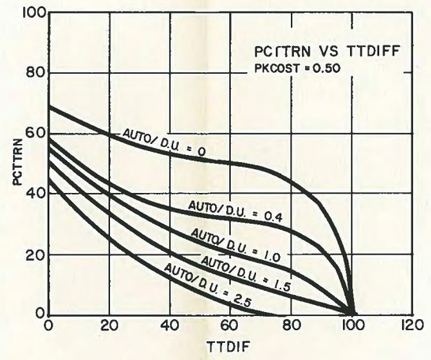
FIG. 9.D3.

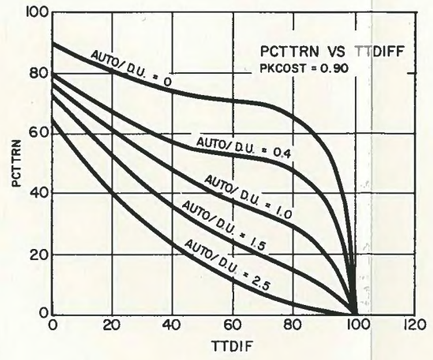
# OAHU MODAL SPLIT RELATIONSHIPS

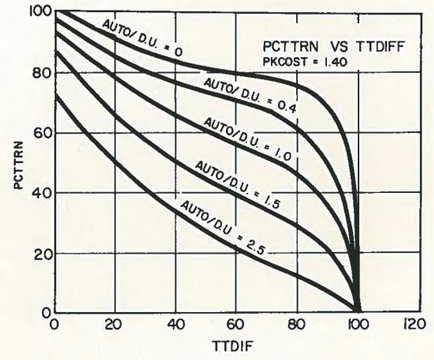
NON-WORK TRIPS

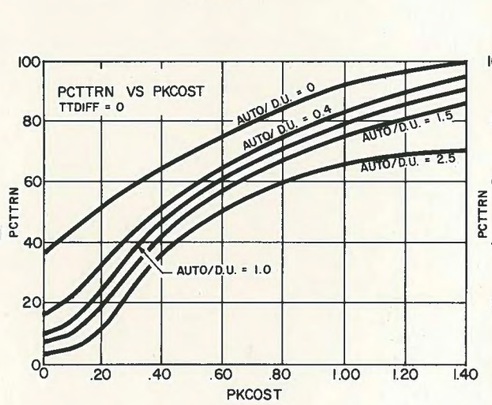


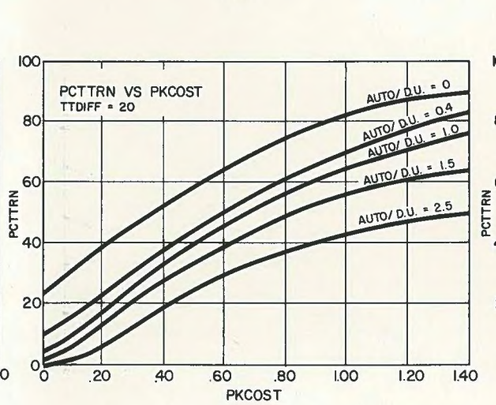



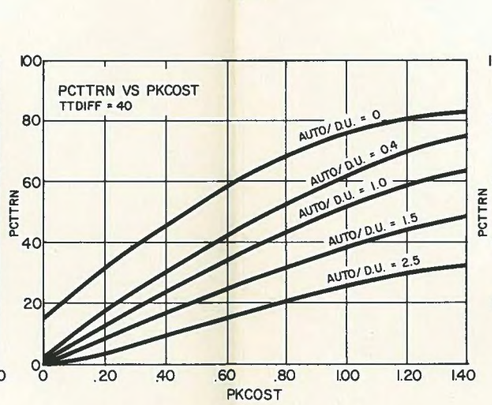



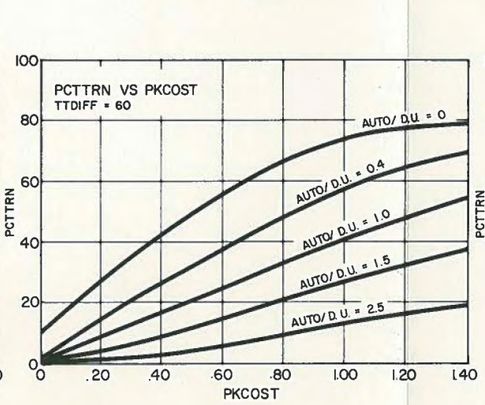



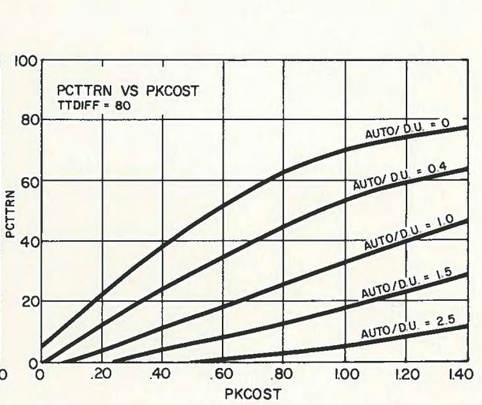






AR00031863

Satisfactory mode-of-choice relationships for non-home-based (NHB) trips are extremely difficult to develop. An important reason for this is that it is difficult to relate the use of transit for NHB trips to the social-economic or home-related characteristics of the trip maker. Then, too, NHB trips accounted for only 7.3 percent of the Honolulu transit trips in 1960. For these reasons, estimates of future NHB transit trips were determined by using a constant growth factor based on the growth in home-based-other transit trips.

## 6. FORECASTING OF FUTURE TRANSIT USAGE

In a generalized manner, Fig. 9.D4 illustrates the steps leading up to and including the application of the modal-split model to allocate total future travel demand to auto and transit modes of travel. The basic procedures shown may be summarized as:

Data collection and review

Model formulation and calibration

Forecasting of future land-use, transportation, and socio-economic development

Forecasting of future total travel demand

Allocation of future travel demand by mode of travel.

Implicit in the use of the modal-split model to allocate future travel demand by mode is the assumption that the relationships developed from the base-year data will remain stable throughout the estimating period. Recent research using time-series data in Toronto, Canada, and elsewhere lends validity to this assumption. In order to make the assumption of stability, it is particularly important that the relationships adhere to logic as well as to purely statistical reliability.

## 7. ASSUMED HIGHWAY AND TRANSIT IMPROVEMENTS IN RELATION TO FUTURE TRANSIT USE

The degree of transit use will in large part be determined by the relative levels of transit and highway improvements assumed. In the first phase of the Oahu Transportation Study, two assumed systems were developed to test the potential of a rapid-transit system.



AR00031864

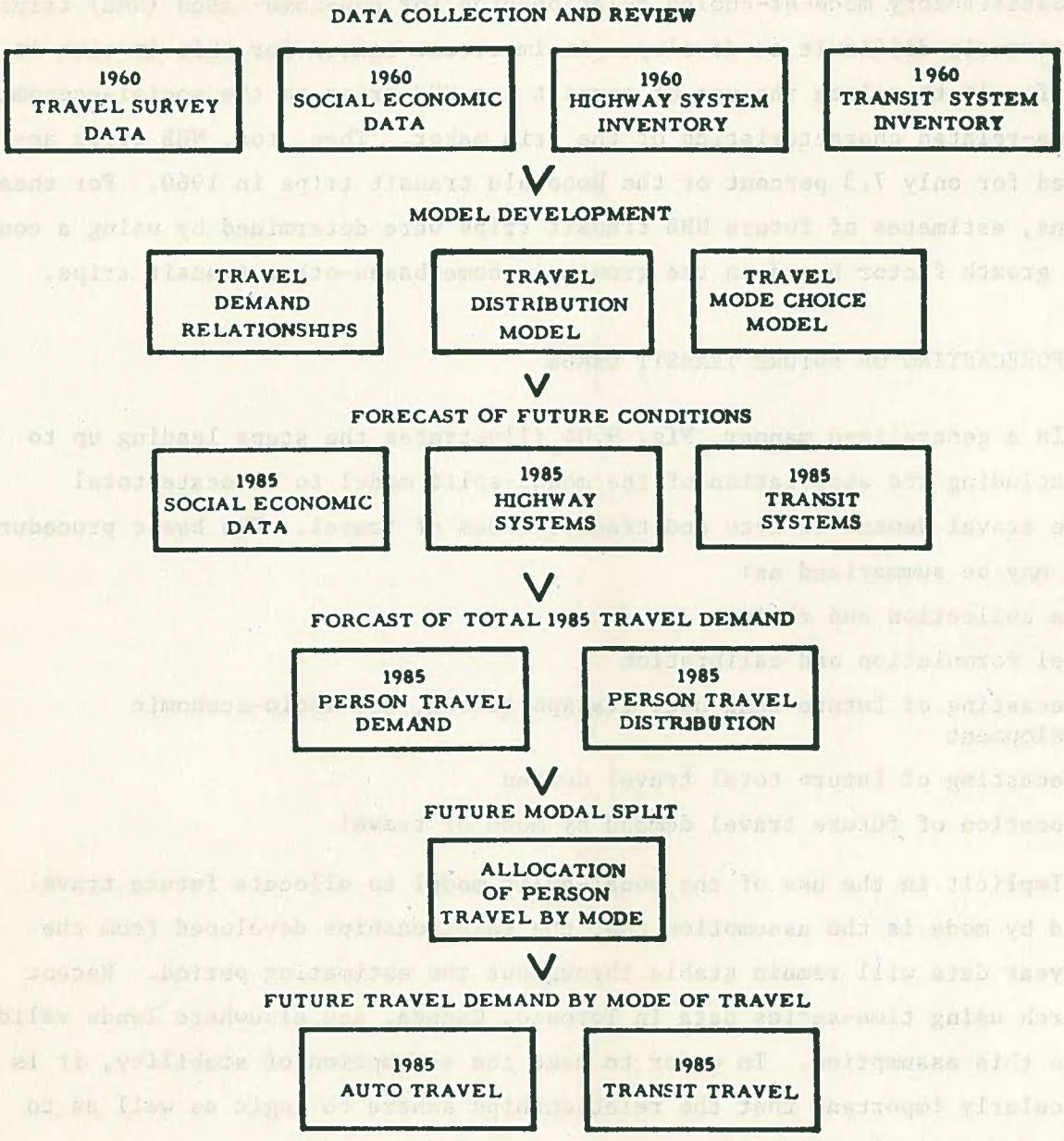



FIG. 9.D4. GENERALIZED PROCEDURE FOR ESTIMATING FUTURE TRAVEL BY TRANSIT AND AUTO MODES.



AR00031865

Potential 1985 System No. 1 assumes additional construction of only the highway facilities which are now committed. Assumed improvement in transit service, on the other hand, is considerable. In System No. 1 is envisioned an extensive rail rapid-transit system, which, combined with local feeder bus routes operating at frequent headways, serves virtually all of the contiguous Honolulu urban development. Feeder buses would operate at considerably greater frequency than is presently available in most residential areas.

Potential 1985 System No. 2 assumes construction of highway facilities in addition to those now committed as well as the improvement of a number of major existing highways.

Transit service for System No. 2, as for System No. 1, is assumed to be considerably improved over present transit service but with transit service provided entirely by buses. Whereas limited-stop express bus service is now nonexistent, System No. 2 envisions express bus service between downtown Honolulu and a number of outlying urban areas including: the Pearl Harbor-Hickam area, Pearl City, Wahiawa, the Kaneohe and Kailua areas, and the Waialae area. Local transit service for System No. 2 within the central Honolulu area (roughly the contiguous urban area between the Fort Shafter Military Reservation and Diamond Head) is comparable to the present local service. Essentially, then, transit System No. 2 is the present system with an express bus system superimposed, plus the addition of local service within most outlying urban areas designed to feed the express buses. Outlying-to-downtown transit travel can thus be expected to exhibit a greater percent increase, or lower percent decrease, relative to transit travel within central Honolulu. This change will in turn tend to increase the average transit-trip distance for System No. 2 compared to the present system.

Typical transit travel times for future Systems No. 1 and No. 2 and for the present are shown in Table 9.D4. In general, System No. 1 provides significantly better service to all urban areas than is provided by the existing system. System No. 2 provides better service than the present system for only those trips to downtown which originate outside of the central Honolulu area, as expected. The longer the trip distance, the greater is the time savings generally afforded by System No. 1. An exception to this is travel to and from the Windward areas where the two systems, on the average, provide equal service.



AR00031866

Table 9.D4. Typical Present and Future Transit Travel Times to Downtown Honolulu

| Originating Area | Equivalent Transit Travel Time to Downtown (min) | | |
|---|---|---|---|
| | 1960 System | 1985 System | |
| | | No. 1 | No. 2 |
| Kaneohe - Kailua | 190 | 85 | 91 |
| Aina Haina | 67 | 53 | 63 |
| Kaimuki | 45 | 36 | 45 |
| Waikiki | 47 | 36 | 46 |
| Aiea | 84 | 54 | 75 |
| Pearl City | 93 | 59 | 91 |
| Wahiawa | 109 | 73 | 106 |

When comparing the service levels provided by Systems No. 1 and No. 2, it should be stated that the estimates of travel time for System No. 1 are much more reliable than those for System No. 2. This results from the fact that System No. 1 has the advantage of operating over exclusive rights of way along the trunk portions of the system. Conversely, System No. 2 buses must operate mixed with other vehicular traffic throughout the entire system. Experience indicates that operation under those conditions is uncertain. If congestion occurs on future highways, System No. 2 will be affected to a considerably greater extent than will System No. 1.

The modal-split model developed for Honolulu includes the effect of relative transit and auto travel times. The likelihood that congestion will occur on the future highway systems, therefore, must be considered as it will have a direct effect on the estimated modal split. Analyses were made to determine the extent to which highway congestion may be expected on Systems No. 1 and No. 2. These analyses took the form of a comparison of estimated highway volumes and capacities crossing a number of major screenlines. For each screenline, a ratio of the total volume to total capacity across the screenline was computed.

Using a curve relating percent of free-flow speed and volume/capacity ratio, speed-adjustment factors were developed. These adjustment factors were then applied to both the highway speeds and transit schedule speeds for Systems No. 1 and No. 2. Speeds on the rapid-transit system, of course, were not influenced by these adjustments.



AR00031867

## 8. OTHER FACTORS RELATED TO ESTIMATING FUTURE MODAL SPLIT

Future estimates of auto ownership, although on the conservative side when compared to estimates for other urban areas, appear to be reasonable and well founded. Within the Honolulu urban area, average auto ownership is expected to rise from 1.09 autos per dwelling in 1960 to 1.24 autos per dwelling in 1985. Corresponding rates for nonurban areas are 0.86 autos per dwelling in 1960 and 1.15 autos per dwelling in 1985.

Estimates of future parking costs were also produced. Considerable increase in average parking costs is expected based on the following considerations:

1. The growth rates for per capita income and per capita expenditures on services
2. The scarcity of land in intensely developed areas
3. The conversion of parking supply from surface parking lots to multi-level parking garages due to the development pressures of higher-type land uses
4. Announced intentions of raising parking meter rates.

Based on these considerations, the assumed parking costs appear to be justified. Central Business District parking-cost estimates compare favorably with those developed for Washington, D. C., and are considerably below those assumed in a similar study in Calgary, Canada.

Land-development patterns and intensities will also play an important role in the future use of transit for urban travel. If a rapid-transit system were built, intense residential and commercial developments would very likely cluster around many of the stations and attract additional transit usage. The forecasts of future developments do not have this factor built into them. Therefore, the transit estimates produced were underestimated to the extent that construction of a rapid-transit system would produce development patterns that reinforce transit usage.

## 9. ANALYSIS AND INTERPRETATION OF TRANSIT-USE ESTIMATES

Total person-trip travel demand and estimated 1985 person trips by transit mode of travel are shown in Table 9.D5. Estimates of the home-based non-school transit trips were obtained from the modal-split model developed for



AR00031868

this study. Estimates of 1985 home-based transit school trips, for reasons previously discussed, were obtained by factoring the 1960 trips based on a trend analysis. This analysis indicated that by 1985 transit school trips will have declined to 71 percent of their 1960 number; 1960 transit school trips were thus factored by 0.71, with the exception of trips to and from the zone containing the University of Hawaii. The large expected increase in enrollment was assumed to approximately balance the downward transit-use trend so that in 1985 the absolute number of trips to and from this zone would be the same as in 1960. This estimate of transit school trips was assumed to hold for both systems. For reasons previously discussed, non-home-based trips for each system were increased by a constant factor equal to the ratio of 1985 to 1960 home-based "other" trips for each system.

Table 9.D5. Comparison of 1960 Observed and 1985 Estimated Transit and Total Trips by Purpose

| Year | Trip Purpose | No. of Trips | | % Transit |
|---|---|---|---|---|
| | | Transit | Total* | |
| 1960 | Home-Based | | | |
| | Work | 45,990 | 281,030 | 16.4 |
| | School | 39,760 | 99,750 | 39.8 |
| | Other | 30,520 | 566,210 | 5.4 |
| | Non-Home-Based | 9,170 | 227,950 | 4.0 |
| | TOTAL | 125,440 | 1,174,940 | 10.7 |
| 1985 | | | | |
| System 1 | Home-Based | | | |
| | Work | 153,290 | 640,359 | 23.9 |
| | School | 29,265 | 286,421 | 10.2 |
| | Other | 119,892 | 1,308,485 | 9.2 |
| | Non-Home-Based | 36,079 | 491,365 | 7.3 |
| | TOTAL | 338,526 | 2,726,630 | 12.4 |
| 1985 | | | | |
| System 2 | Home-Based | | | |
| | Work | 122,496 | 640,359 | 19.1 |
| | School | 29,265 | 286,421 | 10.2 |
| | Other | 99,869 | 1,308,485 | 7.6 |
| | Non-Home-Based | 30,096 | 491,365 | 6.1 |
| | TOTAL | 281,726 | 2,726,630 | 10.3 |

*Truck and Taxi Passengers are excluded from total.



AR00031869

As indicated in Table 9.D5, the overall percentage of person trips by transit is estimated to increase from 10.7 percent in 1960 to 12.4 percent for 1985 System No. 1, and to decrease to 10.3 percent for 1985 System No. 2. In total, the estimate of transit trips for System No. 1 is 20 percent higher than that for System No. 2.

Much more pronounced than the percent increase in transit trips is the absolute increase--from 125,440 in 1960, to 338,526 in 1985 for System No. 1. Although this represents a very considerable increase it is not unreasonable after study of the underlying assumptions, which include:

1. Construction of an extensive high-speed, high-capacity rapid-transit system and attendant feeder-bus system
2. Construction of only limited highway improvements resulting in net losses in highway speeds by 1985 along a number of congested corridors
3. Increased intensity of development in commercial areas and the accompanying elimination of surface parking, resulting in sharply increased parking costs
4. Fairly conservative growth in automobile ownership.

All of these factors contribute to the increase in transit trips, resulting in what may be termed an optimistic transit travel estimate--which is what was intended.

The difference between the System No. 1 and System No. 2 estimates appears quite reasonable when consideration is given to the conditions assumed. The only variables in the two estimates are the highway and transit systems themselves. However, it must be noted that the performance of the buses in System No. 2 is much less reliable since these buses must operate on the highway system mixed with other traffic. The limitations on the amount of increase in highway capacity in certain corridors, when compared to projected increases in highway-traffic volumes, indicate that System No. 2 has potential breakdown conditions inherent to it.

The estimates of 1985 transit use are also reasonable when compared to observations in other urban areas shown in Table 9.D6. On the basis of average weekday transit trips per capita and the percent of all trips by transit, the estimates for Honolulu fall well within the range of observed values. Comparison of travel to or from the Central Business District (CBD) in Honolulu and



AR00031870

other cities, shown in Table 9.D7, further supports the reasonableness of the future transit travel estimates. The relative importance of the CBD within the total Study Area is decreasing as expected and transit is serving a greater proportion of the trips to the CBD. However, the estimated percent of trips by transit to the CBD is well below the levels observed in a number of other cities--less than half that observed in Chicago, for example.

Table 9.D6. Comparison of Transit Usage in Honolulu and Other Cities

| City | Year of Study | Population in Study Area | Urbanized Area Population | Percent Internal Trips by Transit | Average Weekday Transit Trip per Capita |
|---|---|---|---|---|---|
| HONOLULU | 1960 | 480,105 | 308,060 | 10.7 | 0.26 |
| System 1 | 1985 | 1,014,390 | 568,980 | 12.4 | 0.33 |
| System 2 | 1985 | 1,014,390 | 568,980 | 10.3 | 0.28 |
| Chicago | 1956 | 5,169,633 | 5,959,000 | 24.3 | 0.46 |
| Detroit | 1953 | 2,968,875 | 3,539,000 | 16.7 | 0.30 |
| Washington | 1955 | 1,568,522 | | 24.3 | 0.41 |
| Pittsburgh | 1958 | 1,472,099 | 1,805,000 | 20.3 | 0.33 |
| St. Louis | 1957 | 1,275,454 | 1,667,693 | 15.6 | 0.30 |
| Houston | 1953 | 878,629 | 1,139,678 | 12.9* | 0.29 |
| Kansas City | 1957 | 857,550 | 921,121 | 9.9 | 0.22 |
| Atlanta | 1961 | 700,104 | 768,125 | 10.0 | 0.24 |
| Memphis | 1964 | 647,728 | 544,505 | 6.4 | 0.13 |
| Phoenix | 1957 | 397,395 | 552,043 | 6.4 | 0.15 |
| Nashville | 1959 | 357,585 | 346,729 | 7.7 | 0.18 |
| Charlotte | 1958 | 202,272 | 209,551 | 7.3 | 0.17 |

*Reported as 6 percent 1959-1960.

N.B. Comparable data taken from various O-D surveys.



AR00031871

Table 9.D7. Comparison of Travel to or from the CBD in Various Cities

| City | Population in Study Area | % of Total Area Trips to or from CBD | | Trips Per Capita to or from CBD | % of CBD Trips by Transit |
|---|---|---|---|---|---|
| | | Transit Trips | Total Person Trips | | |
| HONOLULU | | | | | |
| 1960 O-D | 480,105 | 21.1 | 9.5 | 0.25 | 23.0 |
| 1985 | | | | | |
| System 1 | 1,014,390 | 19.8 | 7.1 | 0.19 | 34.8 |
| System 2 | 1,014,390 | 21.6 | 7.1 | 0.19 | 31.6 |
| Chicago | 5,169,663 | 27.2 | 9.2 | 0.18 | 71.0 |
| Detroit | 2,968,875 | 25.1 | 9.8 | 0.17 | 43.2 |
| St. Louis | 1,275,454 | 33.8 | 10.6 | 0.20 | 46.8 |
| Atlanta | 700,104 | 31.0 | 13.3 | 0.27 | 28.6 |
| Houston | 878,629 | 36.5 | 19.0 | 0.40 | 26.0 |
| Kansas City | 857,550 | 40.3 | 11.4 | 0.24 | 30.4 |
| Memphis | 647,728 | 37.6 | 10.1 | 0.19 | 22.5 |
| Phoenix | 397,395 | 72.5 | 15.4 | 0.33 | 10.7 |
| Nashville | 357,585 | 50.5 | 16.3 | 0.36 | 20.3 |
| Charlotte | 202,272 | 46.5 | 23.5 | 0.52 | 13.9 |

Sources: Memphis: 1964 Memphis OD Survey;
Honolulu: OD Survey;
Other Cities: Future Highways and Urban Growth, Wilbur Smith and Associates, February 1961.

Figures 9.D5 and 9.D6 show the total estimated transit-route volumes for System No. 1 and Figs. 9.D7, 9.D8, and 9.D9 the estimated transit volumes on System No. 2 for all purposes of travel other than for school purpose. School trips were handled independently, as they must be analyzed separately in the financial analysis. As shown in Fig. 9.D6, the maximum two-way daily volume observed on the rapid-transit system occurs on the Ewa leg just before it splits into the Mauka and Makai legs. The two-way volume at this point is in excess of 102,000 passengers per day. The maximum-load-point volume for the peak hour, peak direction of flow corresponding to this daily volume, is estimated at 13,800. This figure, on which equipment requirements are based, is compared with typical values observed in other cities in Fig. 9.D10. It is evident from this comparison that serious consideration of a rapid-transit system is warranted in Honolulu.



AR00031872

By way of comparison, transit-route volumes for System No. 2, shown in Figs. 9.D7, 9.D8, and 9.D9 are far more evenly distributed by route and by highway facility. The maximum two-way load observed for transit System No. 2 is 28,000 passengers per day on Route 2 in the Waikiki area.

A comparison of average trip times by components of the total trip time is presented in Table 9.D8 for System No. 1 vs. System No. 2. System-wide average total trip time per passenger for System No. 1 is 20 percent lower than the corresponding value for System No. 2--28.8 min for System No. 1 compared to 34.8 min for System No. 2. The average time for System No. 1 is also a more reliable value since, as was previously noted, there are potential breakdown conditions in System No. 2.

Table 9.D8. Comparison of Average Trip Times by Components of Total Trip-- System No. 1 vs. System No. 2

| Trip Component | Average Trip Time (real minutes) | |
|---|---|---|
| | System No. 1 | System No. 2 |
| Walk Time | 8.7 | 8.8 |
| Wait and Transfer Time | 5.6 | 7.9 |
| Bus Running Time | 8.6 | 18.1 |
| Rapid Transit Running Time | 5.9 | -- |
| Avg. Total-Trip Time | 28.8 | 34.8 |

In summary, examination of the estimates of future modal-split in light of experience in other cities, and its reasonableness in view of the underlying assumptions, indicates that the estimates for System No. 1 represent a reasonable optimistic maximum 1985 transit usage. Further, the 20 percent lower estimate of transit usage for System No. 2 is a reasonable differential considering the differences in the two systems tested and the assumed future conditions.

It should be remembered that the estimates produced by this study are preliminary in nature--a first look. Consequently, there are a number of factors not explicitly considered by the study, including:



AR00031873

1. Extension of rapid-transit lines where warranted by preliminary demand estimates
2. Expansion of System No. 1 bus network to include service paralleling rapid-transit lines in areas where 1985 System No. 1 highway volumes are beyond highway capacity, resulting in significant congestion
3. Refinement of assumed future land-development patterns and intensities to reflect impact of rapid-transit system.

The development of refined estimates of future transit usage should investigate these and other additional factors not previously studied.

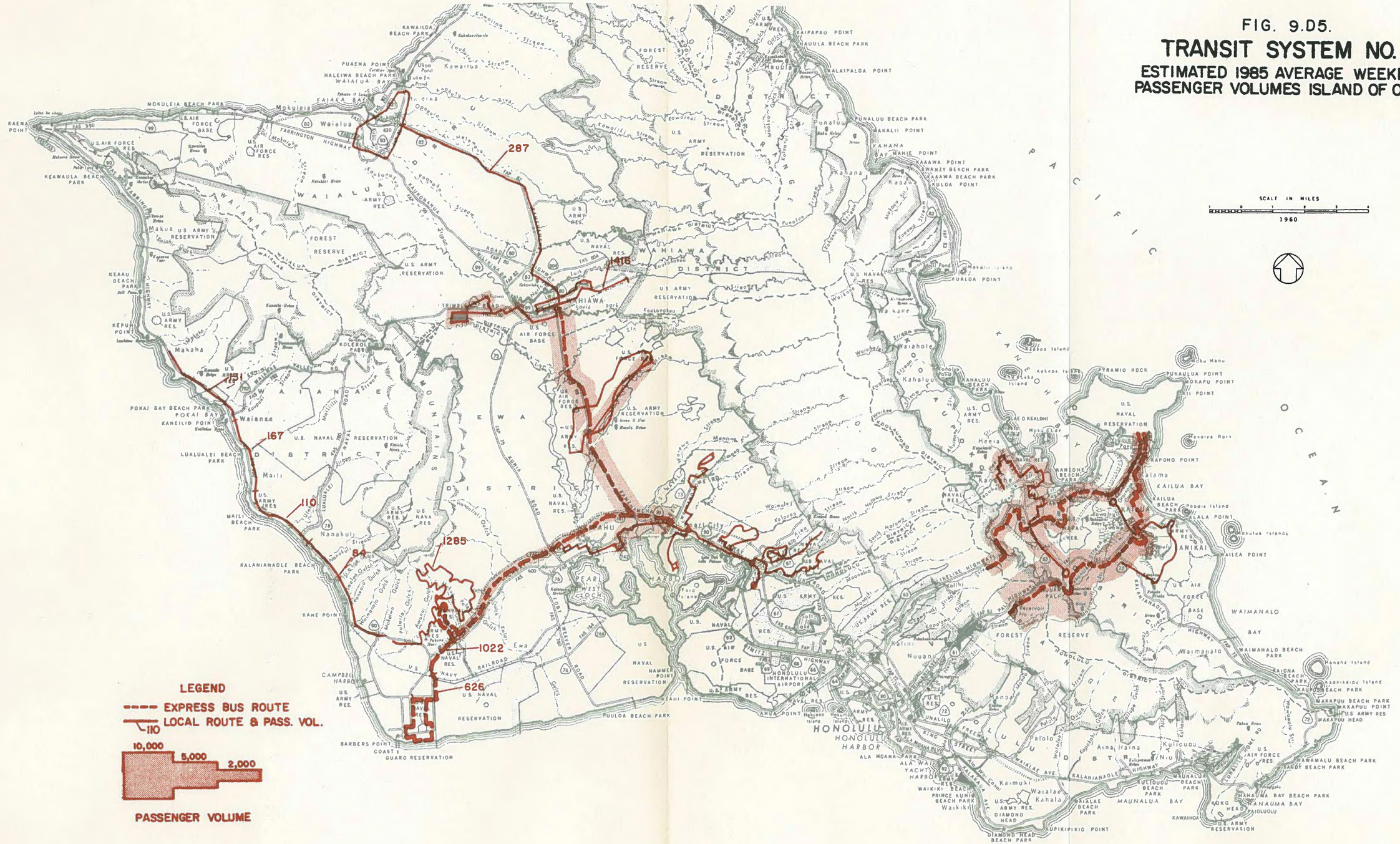


AR00031874

FIG. 9.D5.

# TRANSIT SYSTEM NO. 1

## ESTIMATED 1985 AVERAGE WEEKDAY PASSENGER VOLUMES ISLAND OF OAHU






AR00031875

FIG. 9.D6.

# TRANSIT SYSTEM NO. I

## ESTIMATED 1985 AVERAGE WEEKDAY PASSENGER VOLUMES ISLAND OF OAHU

FIG. 9.D7.

# TRANSIT SYSTEM NO. 2

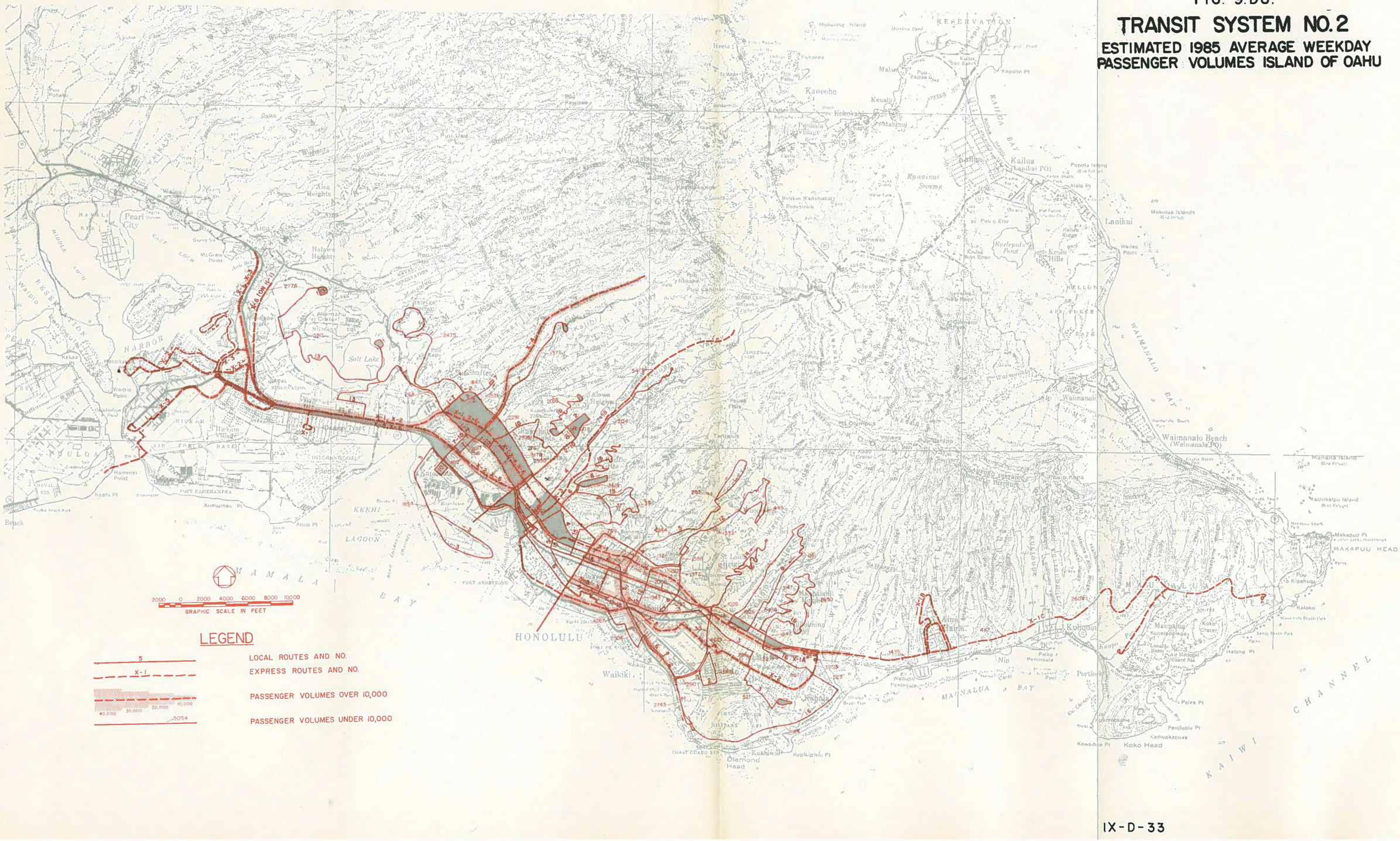
## ESTIMATED 1985 PASSENGER VOLUMES
## ISLAND OF OAHU

AR00031877

FIG. 9.D8.

# TRANSIT SYSTEM NO. 2

## ESTIMATED 1985 AVERAGE WEEKDAY PASSENGER VOLUMES ISLAND OF OAHU




IX-D-33

AR00031878

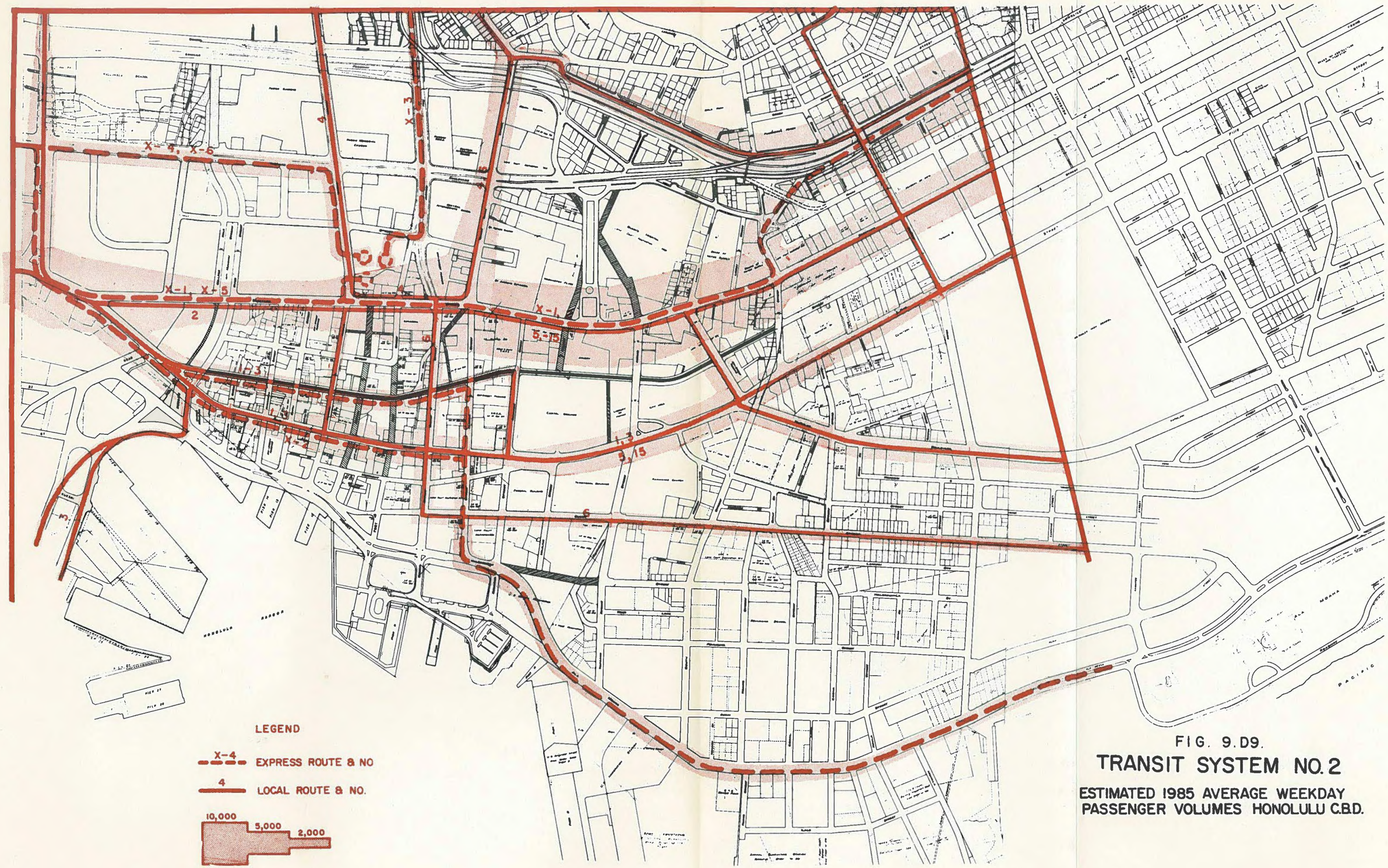



FIG. 9.D9.

## TRANSIT SYSTEM NO. 2

ESTIMATED 1985 AVERAGE WEEKDAY PASSENGER VOLUMES HONOLULU C.B.D.



AR00031879

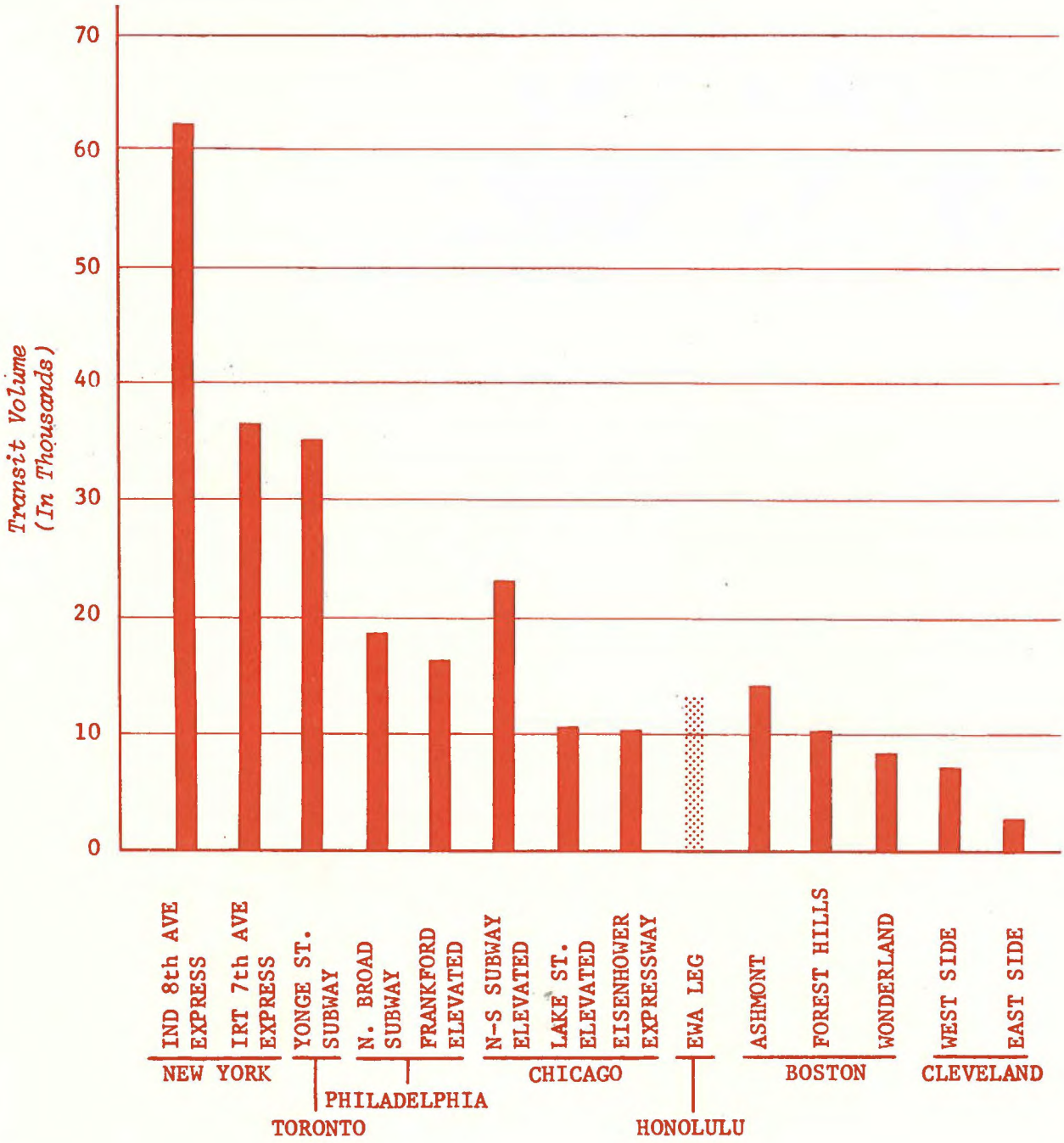



FIG. 9.D10. RAIL RAPID TRANSIT PEAK HOUR VOLUMES FOR HONOLULU AND OTHER SELECTED CITIES.

Typical Maximum Load Point Volumes, Prevailing Direction Only



AR00031880

# X Terminal Facilities

# X. TERMINAL FACILITIES

The effectiveness and efficiency of an urban transportation system is dependent to a large measure on the availability of adequate terminal and transfer facilities at trip origins and destinations. At a first glance, parking and access within the Central Business District of Honolulu, the new Honolulu Stadium, and the Honolulu International Center appear to be the major terminal facilities requiring extensive study. All of these terminals mentioned above are currently under study by out-of-state consultants under contract by respective State and City agencies.

## A. PARKING IN DOWNTOWN HONOLULU

### 1. PRESENT FACILITIES

In early 1959, the City and County Traffic Department staff, under the general direction of Deleuw, Cather and Company, conducted a comprehensive traffic and parking survey of the downtown area of Honolulu. In subsequent years, this area was under continual surveillance by the same Traffic Department. In 1964, under the Oahu Transportation Study's inventory activities, detailed land-use and curb-inventory studies were conducted by the City Planning Department and the City Traffic Department, respectively, as their contribution to this Oahu Transportation Study. Since the origin-destination traffic survey was conducted in 1960 (the base year of the OTS study), efforts were made to recreate the parking situation for 1960 and to correlate the parking demands of that period from the results of the origin-and-destination survey. Also, an estimate was made of the future requirements for parking, utilizing the travel forecasts for the downtown area.

A summary of the base year (1960) parking inventory is presented in Table 10.1.



AR00031882

Table 10.1. 1960 Parking Inventory in Downtown Honolulu

| Sub-Area* | No. of Spaces | | | | |
|---|---|---|---|---|---|
| | Curb Parking** | Municipal Lots | Commercial | Free (Customer and Employee) | Total |
| 1 | 144 | 170 | 173 | 30 | 517 |
| 2 | 141 | 244 | 223 | 76 | 684 |
| 3 | 261 | 227 | 1,520 | 371 | 2,379 |
| 4 | 321 | 274 | 990 | 545 | 2,130 |
| TOTAL | 867 | 915 | 2,906 | 1,022 | 5,710 |

*See Fig. 10.1.

**Both metered and unmetered.

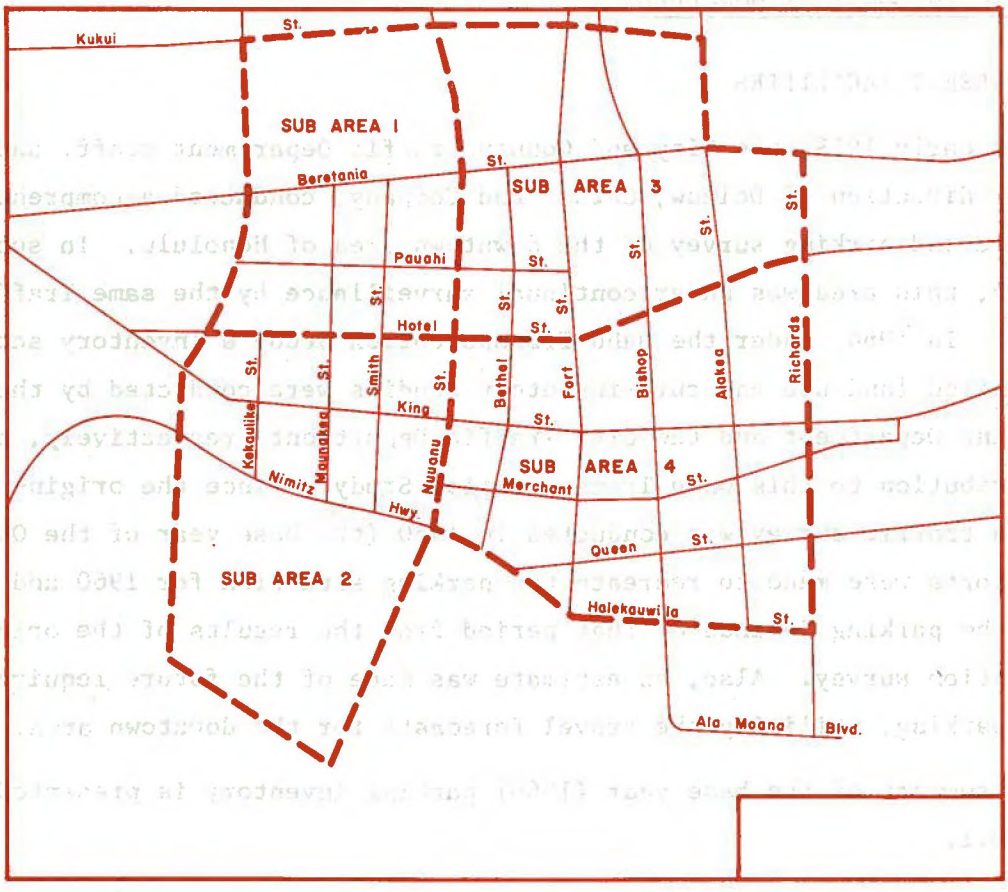



FIG. 10.1. PARKING STUDY-SUB AREAS.



AR00031883

According to a recent survey by the City Traffic Department, servicing the area today are 5,960 parking spaces of all types. These include 664 street or curb-side parking spaces, 2,202 spaces in privately owned off-street parking lots and buildings, and 1,426 spaces in seven City-owned off-street parking lots and buildings (Table 10.2). The locations of these areas are shown in Fig. 10.2.

Table 10.2. Capacities of Municipal Parking Lots in Downtown Honolulu in 1967

| Name of Facility | No. of Existing Spaces |
|---|---|
| Bishop - Kukui | 220 |
| Alakea - Richards | 230 |
| Kaahumanu | 395 |
| Beretania - Smith | 170 |
| Maunakea - Smith | 265 |
| Kekaulike | 69 |
| River | 77 |
| TOTAL | 1,426 |

Comparing this recent survey with that of 1960, it is found that there has been an increase of a total of 250 spaces of all types. The most noticeable change has been in the municipal parking lots, where the space increase has been 1.6 times, or 511 parking spaces. Conversely, a decrease occurred in the private, commercial lots and in the street or curb-side parking. This decrease in curb-side parking is, in some respects consistent with the parking objective of removing parked vehicles from the traffic lanes, especially during the day.

The 1960 Origin-Destination Traffic Survey reported 26,789 trips with a destination within the downtown area. These trips are shown in Table 10.3 by purpose. The survey revealed that nearly one-third (31.7 percent) of the auto trips into town was for the purpose of work, and another one-third (33.8 percent) was for business and shopping purposes. Approximately 18 percent of the trips destined to town for the purpose of serving a passenger. It is reasoned that a good portion of the "serve-passenger trips" did not actually park in the downtown area. Trips with a destination within the downtown area are shown by type of parking in Table 10.4.



AR00031884

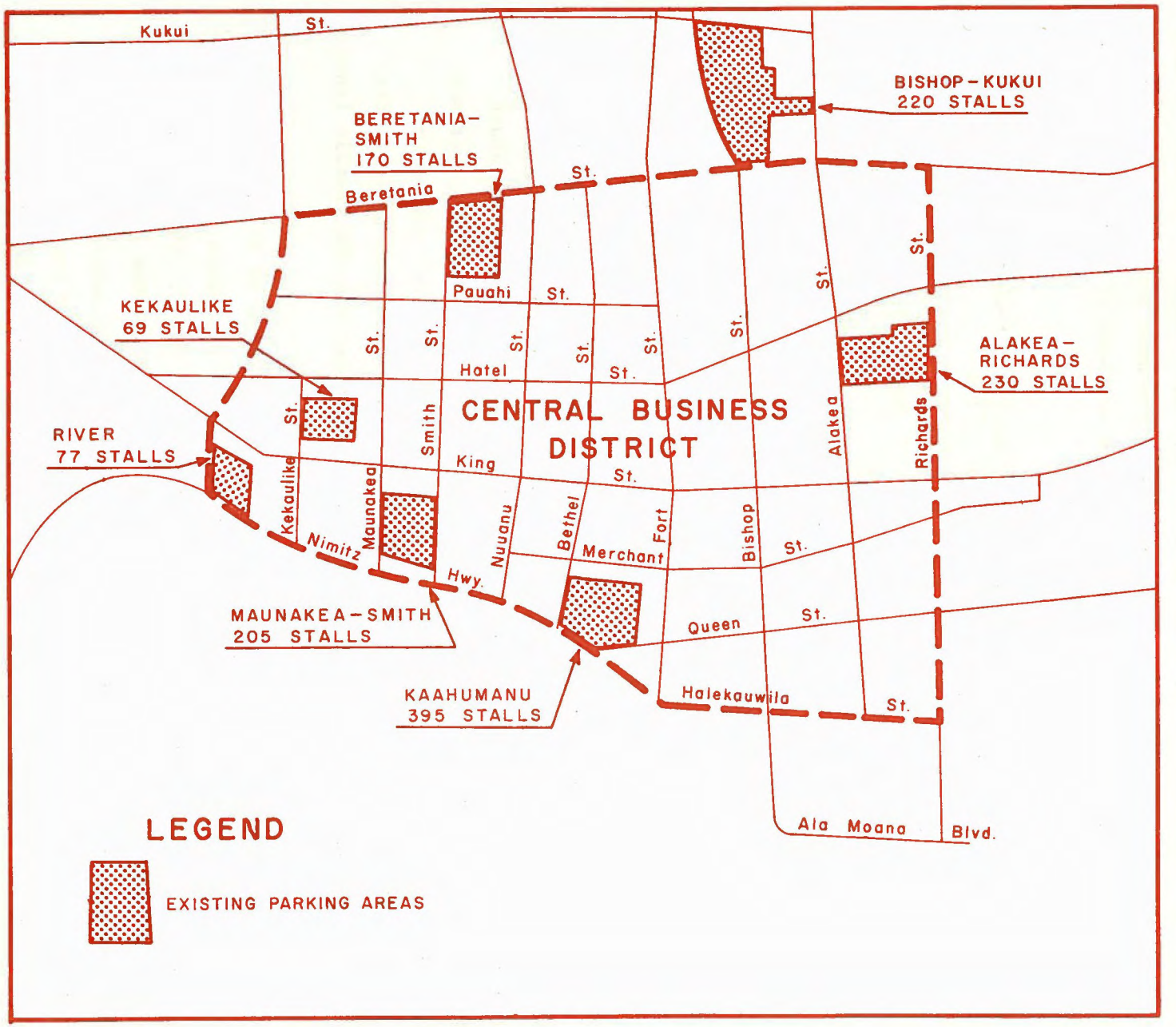



FIG. 10.2. EXISTING MUNICIPAL PARKING LOTS - 1967.



AR00031885

Table 10.3. 1960 Auto-Driver Trips with Destinations Within Downtown Honolulu by Trip Purpose

| Trip Purpose | No. of Trips | Percent of Total |
|---|---|---|
| Work | 8,481 | 31.7 |
| Business | 3,008 | 11.2 |
| Medical - Dental | 780 | 2.9 |
| School | 55 | 0.2 |
| Social - Recreation | 1,898 | 7.1 |
| Change Travel Mode | 176 | 0.7 |
| Eat Meal | 1,312 | 4.9 |
| Shopping | 6,061 | 22.6 |
| Serve Passenger | 4,882 | 18.2 |
| Home | 136 | 0.5 |
| TOTAL | 26,789 | 100.0 |

Table 10.4. Percent of Parking by Type in Downtown Honolulu in 1960

| Type of Parking | Percent |
|---|---|
| Not Parked | 16.2 |
| Parked | |
| Street - free | 8.6 |
| Street - metered | 28.1 |
| Lot - free | 19.4 |
| Lot - paid | 22.6 |
| Garage - free | 0.8 |
| Garage - paid | 3.8 |
| Residence | 0.5 |

The graphical patterns of accumulated vehicles in the downtown area from 7:00 a.m. through 6:00 p.m., are shown in Fig. 10.3. The plots were not reduced by 16 percent to allow for trips not requiring parking. The patterns indicate that parking spaces available in 1960 were distributed consistent with the trip destinations. Although sub-area 3 shows an over-supply of spaces, it is suspected that a good portion of the trips destined to sub-area 4 parked in sub-area 3. If this were not the case, then the parking-space turnover accounted for most of the demand for parking in sub-area 4.



AR00031886

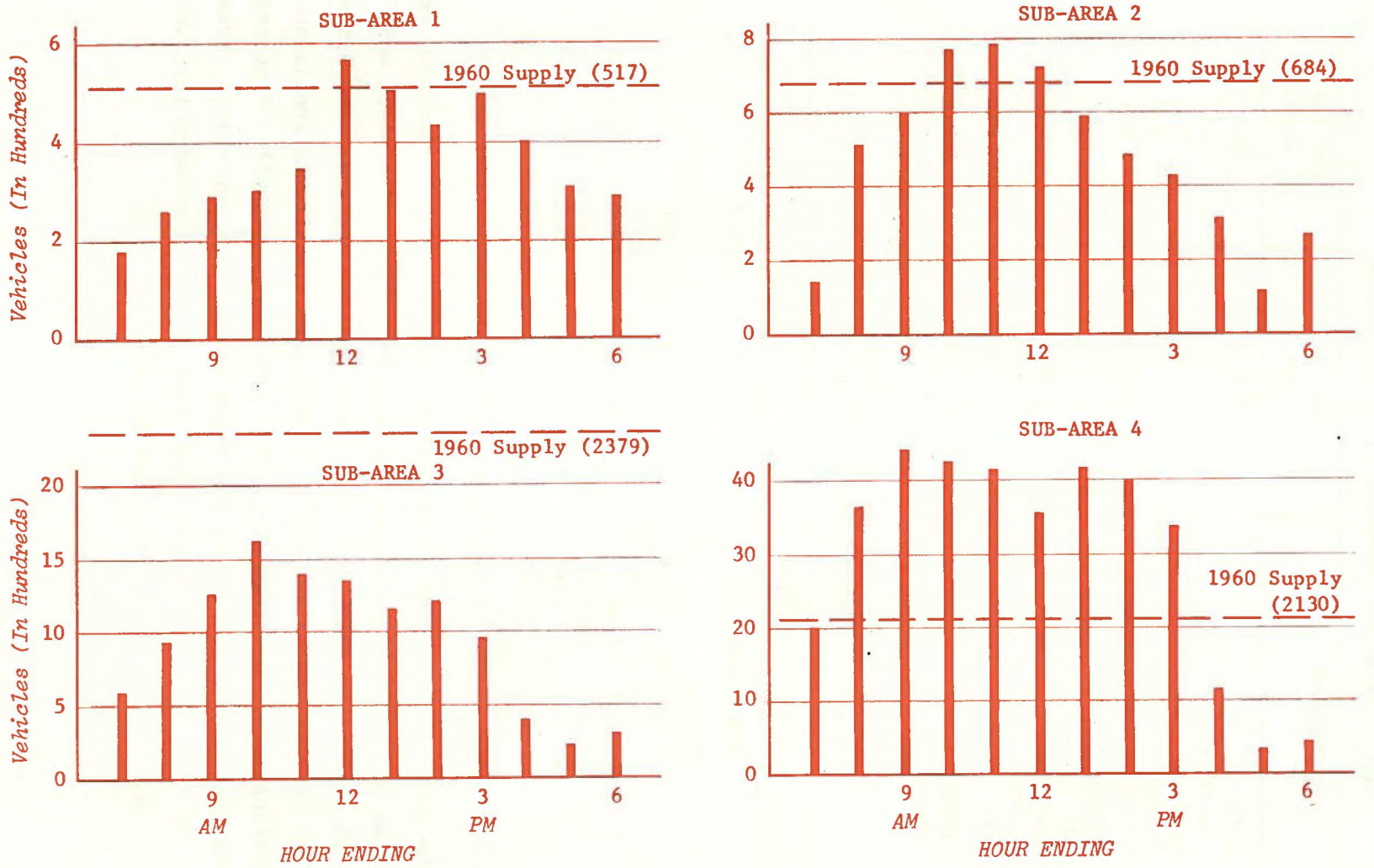



FIG. 10.3. HOURLY VEHICLE ACCUMULATION AND PARKING SPACES AVAILABLE HONOLULU CBD: 1960.



AR00031887

From a recent City Traffic Department survey of space use in two municipal lots, it is reasonable to conclude that parkers are making extensive use of municipal lots (Fig. 10.4).

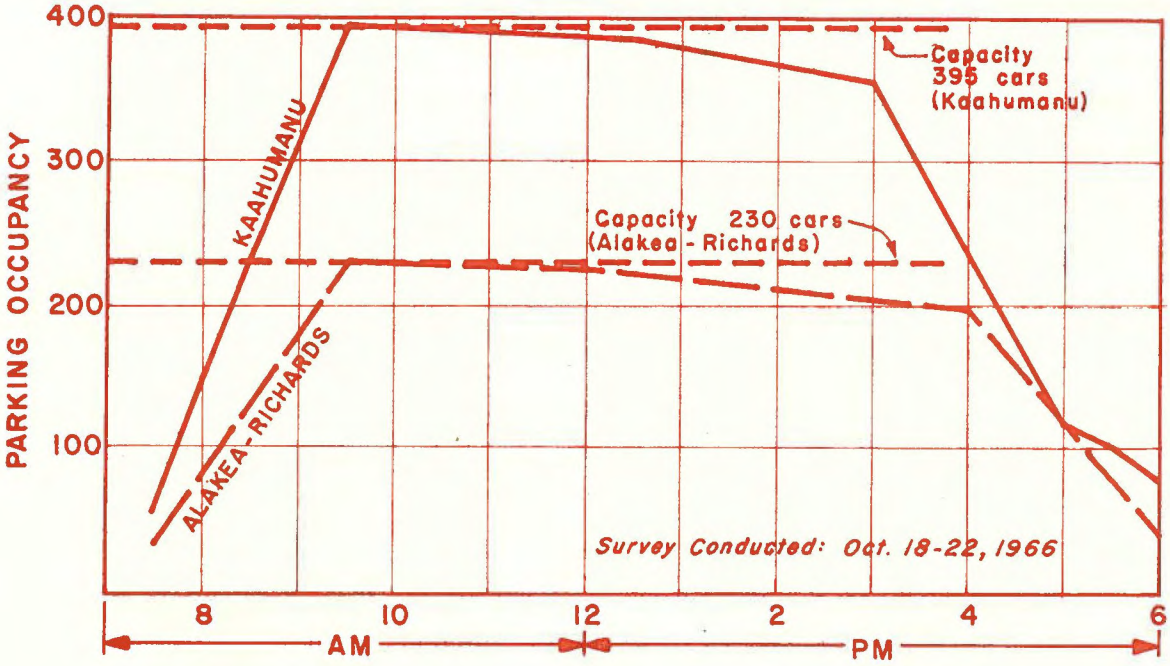



FIG. 10.4. WEEKDAY PARKING OCCUPANCY AT THE KAAHUMANU AND ALAKEA-RICHARDS PARKING LOTS.

## 2. FUTURE PARKING DEMAND

Consideration must, by necessity, be given to the nature of trips since, as basic trip characteristics differ by purpose of the trip, so do the parking characteristics. For example, work trips are associated with all-day parking; shopping trips with transient-type parking, usually in the range of 1 to 2 hours; and the remaining miscellaneous trip purposes, which are also transient in nature, require short parking duration. Thus, for the purpose of this parking estimate, the total spectrum of trip categories was classified into three major trip types--work trips, shopping trips, and miscellaneous trips--for their obvious impact on the destination subareas, particularly if the area in question was a high-employment center or predominantly of intense commercial use.



AR00031888

Table 10.5 shows the 1985 person and auto-driver trips having destinations within downtown Honolulu. The estimates indicate an increase of approximately two times of person and auto-driver trips from the base year (1960). The number of vehicular trips for the purpose of work is expected to increase by only 1.3 times the base-year work trips, but shopping and miscellaneous trips are expected to experience greater growth--an increase of three times the base-year conditions. The low increase in work-trip attractions by automobile to the downtown area is due to the effect of the mass-transit systems. The impact of this rapid-transit system on work trips destined to downtown is presented in Table 10.6.

Table 10.5. Estimated 1985 Person and Auto-Driver Trips with Destinations in Downtown Honolulu

| Sub-Area | Person Trips | | | Auto-Driver Trips | | | |
|---|---|---|---|---|---|---|---|
| | Transit | Auto | Total | Work | Shopping | Misc. | Total |
| 1 | 3,819 | 7,429 | 11,248 | 598 | 652 | 5,816 | 7,066 |
| 2 | 3,374 | 5,676 | 9,050 | 747 | 489 | 4,192 | 5,428 |
| 3 | 11,024 | 19,504 | 30,558 | 2,122 | 2,634 | 11,551 | 16,307 |
| 4 | 19,911 | 29,504 | 49,415 | 4,531 | 3,708 | 15,663 | 23,902 |
| TOTAL | 38,128 | 62,143 | 100,271 | 7,998 | 7,483 | 37,222 | 52,703 |

Table 10.6. Transit Trips with Destinations Downtown Honolulu - Observed 1960, Estimated 1985

| Purpose of Trip | 1960 | | | 1985 | | |
|---|---|---|---|---|---|---|
| | Total | Transit Trips | Percent Transit | Total | Transit Trips | Percent Transit |
| Work | 15,366 | 5,043 | 32.8 | 27,353 | 14,267 | 52.2 |
| Shopping | 9,296 | 2,768 | 29.8 | 23,944 | 8,111 | 33.9 |
| Misc. | 21,409 | 3,835 | 17.9 | 48,974 | 15,750 | 32.2 |
| TOTAL | 46,071 | 11,646 | 25.3 | 100,271 | 38,128 | 38.0 |

Since work trips are predominantly all-day parkers, there should be sufficient spaces provided for them. For shopping and for miscellaneous trip attractions to the downtown area, a parking turnover factor should be applied to obtain future space requirements.



AR00031889

From the 1959 Parking Study conducted by Deleuw, Cather and Company the following turnover rates were found for downtown Honolulu:

| Description | Average Turnover |
|---|---|
| Legal Curb Space | 8.81 |
| Public Transient Off-Street Space | 2.80 |
| Weighted Average | 4.93 |

For planning purposes, the application of a single, weighted average factor would be appropriate. In the following 1985 estimate of space requirement, a 1-for-1 ratio was assumed for work attractions and a 1 for 4.93 ratio was assumed for shopping and miscellaneous attractions (Table 10.7).

Table 10.7. Estimated Parking-Space Requirements for Downtown Honolulu in 1985

| Sub-Area | All-Day Parking | Short-Term Parking | Total Parking Requirement |
|---|---|---|---|
| 1 | 598 | 1,312 | 1,910 |
| 2 | 747 | 949 | 1,696 |
| 3 | 2,122 | 2,877 | 4,999 |
| 4 | 4,531 | 3,929 | 8,460 |
| TOTAL | 7,998 | 9,067 | 17,065 |

With an improved mass-transit system, the 1985 parking-space requirement is estimated at 17.065. It is estimated also that approximately 10,000 more parking spaces would be required downtown if transit service were maintained at its present level of service. Thus, without an improved mass-transit system, 1985 parking space requirements would approximately be 27,000.

The most recent parking survey by the City Traffic Department revealed that there is presently a total of 5,960 available parking spaces in downtown Honolulu. Subtracting this from the 1985 estimate (with improved mass-transit) leaves a total of 11,105 parking spaces which need to be provided if the total 1985 estimated trip attractions to the downtown area are to be completely satisfied. It is most fortunate that a substantial number of the potential transit patronage is made up of commuting workers which affected a minimal estimate in the parking requirement.



AR00031890

The parking emphasis will shift toward the central portion or the heart of the commercial retail and business developments of the downtown area. Here, because of the intense land use, the prospects of satisfying the future demand are quite dismal. To minimize walking distance, one solution would be to increase the capacities of existing parking facilities. The other solution would be to provide parking on the perimeter of the downtown area, forcing motorists and passengers to walk longer distances. The latter possibility may not appeal to the motorist, especially to the transient parkers. Therefore, in the final analysis, failure of the motorists to find satisfactory parking spaces may discourage traffic to the Central Business District.

Downtown parking terminals should be planned concurrently with urban freeways and major downtown developments. Carefully planned downtown parking facilities can help achieve the desired functional segregation of pedestrian, auto, and service traffic within the city center.

The convenience and service aspects of parking should be emphasized. Thus, the design and rate schedules of core-area parking facilities should encourage short-term parking, and facilities for all-day parkers should be located on the fringes of downtown.

## B. HONOLULU INTERNATIONAL AIRPORT

### 1. INTRODUCTION

Congestion at the nation's airports represents an urgent problem. There is an increasing desire on the part of people everywhere to move from place to place rapidly, conveniently, and economically. They are, however, becoming increasingly frustrated by the realities of inadequate planning and uncoordinated action.

Airports have a special significance in transportation, not only because they constitute points of transportation between inter-city and intra-city travel, but also because, as speed of aircraft increases, the time spent on the ground relative to that in the air becomes a matter of increasing concern to the air traveler.



AR00031891

Ground travel to and from airports of course involves more than that of the air traveler. The activities of employees of airlines and activities of air travelers have distinctly different travel characteristics. While ground travel to and from airports is predominantly by highway, use of other modes is already important in some areas and will become more so with the accelerating growth of urban population and travel.

In November of 1966, the Department of Transportation obtained the consultive services of Leigh Fisher Associates of San Francisco for the preparation of an updated master plan for the Honolulu International Airport. This work by the consultant will be conceptual in nature and will be the result of thorough studies of the multitude of factors that determine the requirements for the physical plant of the Honolulu International Airport. In addition to the obvious basic need dictated by passenger and aircraft volumes, the plan will consider matters such as changes in aircraft technology, ground transportation and access, economic- and population-growth factors of the State, general aviation requirements, support facilities, the financial capability of the airport, noise in neighboring communities, and harmony with the City and State General Plan.

## 2. FACTORS CONTRIBUTING TO EXPANSION

Although forecasts indicate a worldwide annual growth in passenger traffic in excess of 20 percent, Hawaii's overseas and interisland traffic is expected to increase at the rate of nearly 30 percent per year.* The catalyst of increased air travel will be:

1. The $100 thrift fare and promises for even lower fares.
2. The common-fare proposals by overseas carriers.
3. Changes in travel patterns to Hawaii and across the Pacific.
4. The Boeing 747 jumbo jet scheduled to go into trans-pacific operation in late 1969.

---

*Address by O. Miyamoto, Airports Engineer, Department of Transportation, before the Chamber of Commerce of Honolulu, June 29, 1967.



AR00031892

5. Supersonic transports by the British-French consortium and by the United States.
6. Growth in general aviation.
7. Forecast expansion of air cargo shipments.

a. Price of Travel. The inception of the common air fare means that Honolulu International Airport is no longer the only regular destination airport in Hawaii for scheduled domestic overseas air carriers. Common air fare now enables West Coast passengers to fly to Hawaii, thence to Oahu for as little as $5.00 plus their $200 round-trip economy fare. The fares and stopover formula worked out by Aloha, Hawaiian, Pan American, United and Northwest Airlines and designed to stimulate Neighbor Island travel, particularly circle trips, which will bring increasing numbers of visitors in through Honolulu and out through Hilo or vice versa. Figure 10.5 shows how new common fares would compare with regular fares for five island itineraries.

Changes in air fares between Hawaii alone, however, do not provide sufficient data for an estimate of this influence. To test the influence of such changes, the analyst must include the changes that may have been made to competitive travel destinations--i.e., Florida, the West Indies, Europe and, indeed, almost all areas of the world.

Unquestionably, if personal income has an influence on travel, so too must the price of travel. But price of air fare is only one element in the price of a visit to any destination. Prices of hotel accommodations, meals, and other things all enter into the potential traveler's considerations as to where he will travel and whether he will travel at all.

b. Larger and Faster Aircraft. In 1967, the first of the stretched DC-8's became operational between the West Coast and Hawaii; in late 1969, the 490-passenger Boeing 747 will be landing in Honolulu; in 1971, the British-French Concorde supersonic transport will be flying in the Pacific; in 1974, the Boeing SST will bring Mach 2.7 travel to Hawaii; and in 1975, the 844-passenger, commercial version of the Lockheed C-5A may be involved. This raises, then, the further question of what effects larger aircrafts and reduced fares will have on Hawaii's passenger arrivals in the months and the years ahead.



AR00031893

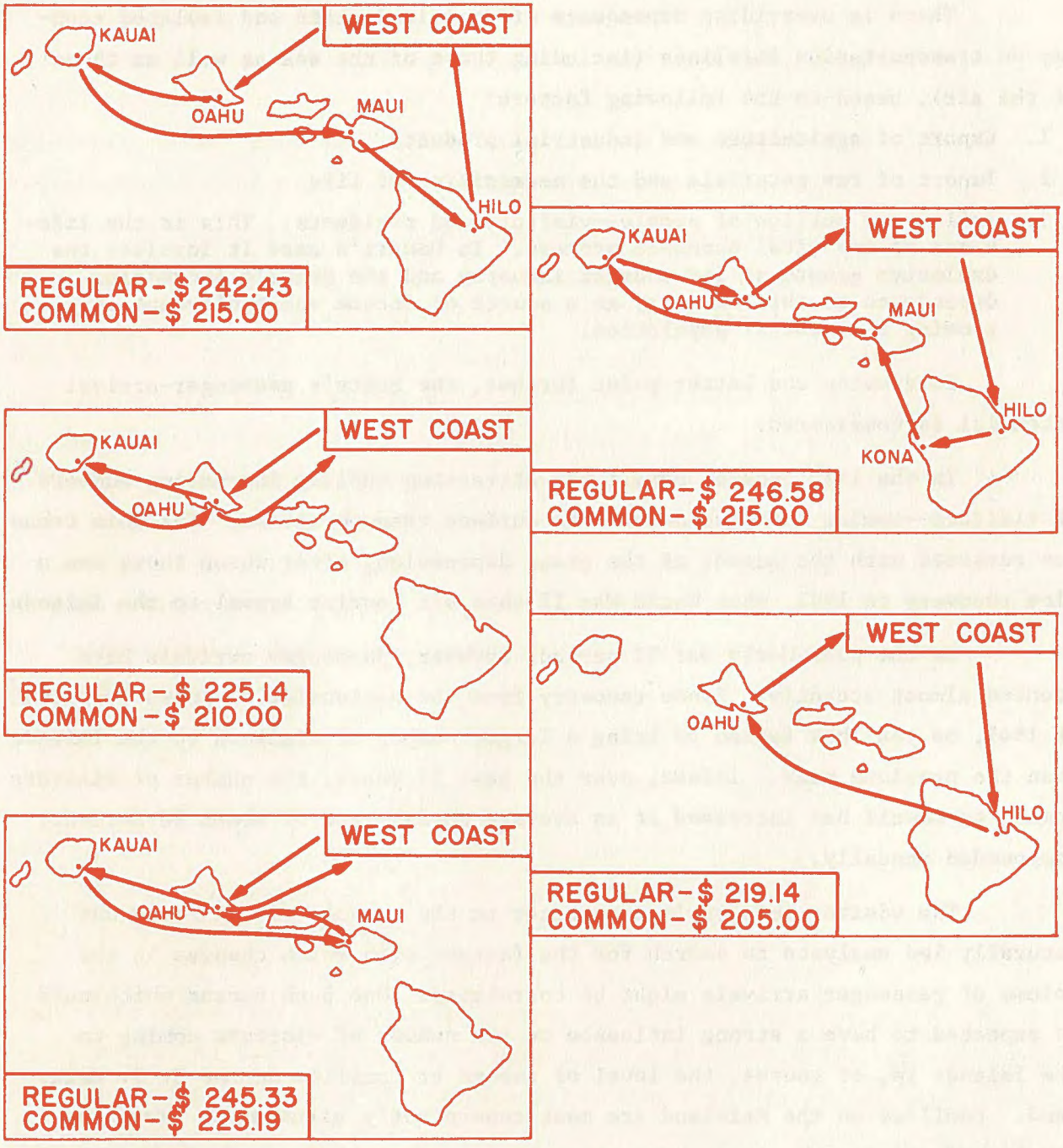



FIG. 10.5. COMPARISON OF COMMON AND REGULAR FARES FOR FIVE TYPICAL MULTIPLE-STOP ITINERARIES.



AR00031894

## 3. PRELIMINARY ESTIMATES OF ARRIVALS

There is overriding dependence of an island state and isolated economy on transportation lifelines (including those of the sea as well as those of the air), based on the following factors:

1. Export of agriculture and industrial products
2. Import of raw materials and the necessities of life
3. Inflow and outflow of people--visitors and residents. This is the lifeblood of any vital economic process. In Hawaii's case it involves the explosive growth of its tourist industry and the State's increasing dependence on this industry as a source of income and employment for growing residential population.

To develop the latter point further, the State's passenger-arrival potential is considered.

In the 1920 decade, Hawaii was attracting rapidly increasing numbers of visitors--coming then exclusively by surface transportation. But this trend was reversed with the advent of the great depression, after which there was a slow recovery to 1941, when World War II shut off tourist travel to the Islands.

In the post-World War II period, however, passenger arrivals have mounted almost steadily. Since recovery from the nationwide business recession of 1949, no year has failed to bring a larger number of visitors to the Islands than the previous year. Indeed, over the past 17 years, the number of visitors coming to Hawaii has increased at an average annual rate of about 20 percent, compounded annually.

The visitor industry's importance to the economy of the State has naturally led analysts to search for the factors with which changes in the volume of passenger arrivals might be correlated. One such factor which would be expected to have a strong influence on the number of visitors coming to the Islands is, of course, the level of income of families on the U. S. Mainland. Families on the Mainland are most conveniently situated to travel to Hawaii and, of course, it is here that the largest numbers of families are to be found with the income and desire to travel.

Changes in the total U. S. Disposable Personal (after-tax) Income reflect both a growing labor force (and population) and changes in per-capita income. In brief, changes in the aggregate of such income reflect both changes in the number of people who might travel and changes in the level



AR00031895

of affluence which makes it possible for people to travel. Changes in U. S. Disposable Personal Income (DPI) have indeed been closely associated with changes in passenger arrivals from the North American mainland.

If changes in U. S. DPI are taken to be the determinant of changes in the volume of westbound passenger arrivals, it has been found that a correlation analysis of percentage changes in such income with percentage changes in westbound arrivals over the years 1951-1965 yielded a remarkably high coefficient of determination--0.994. In other words, all except 0.6 percent of the variations in westbound passenger arrivals can be statistically accounted for by variations in U. S. DPI. On the average, each 1-percent increase in U. S. DPI has been accompanied by a 3.498 percent increase in westbound passenger arrivals in Hawaii.

In the 15 years 1951-65, a period which has covered three business recessions, DPI has increased at an average annual rate of 5 percent, compounded annually. If one projects this rate of income growth to 1970, Hawaii should in that year have a potential of 1,813,000 westbound-air-passenger arrivals. Further, if one assumes that the relatively small number of passengers who came by surface carrier in 1963-65 will continue into the future, then the 1970 potential for total westbound-passenger arrivals would be 1,863,000.

During the years 1951-65, eastbound-passenger arrivals increased even more rapidly than westbound arrivals. However, westbound arrivals still accounted for a predominant share of all arrivals--80 percent in 1966.

Further, the more rapid increases in eastbound arrivals during recent years may also be a reflection, at least in part, of Americans' propensity for travel, plus their increased incomes--and plus, of course, improvements in international air service. In any event, the indications are that a large percentage of the eastbound arrivals are residents of North America, returning from trans-Pacific points beyond Hawaii, or stopping off on round-the-world trips. Reports from the U. S. Immigration and Naturalization Service and other sources indicate that about half of all the eastbound-arrivals in Hawaii in 1965 were U. S. citizens.



AR00031896

Eastbound-passenger arrivals have demonstrated a rather steady upward trend since 1953-65. Accordingly, if we project this trend to 1970, the projection indicates that potential passengers from this direction will number 710,000 in that year.

To summarize, the passenger arrivals to the State in 1962, 1966 and the indicated potential in 1970 are shown in Table 10.8. In the projections to 1970, the implicit assumption is that the revolution of the future--reduced travel time, reduced fares and so on--will have the same average net effect as the revolution of the past.

Table 10.8. Summary of Passenger Arrivals to the State

| Passenger Arrivals | 1962 | 1966 | 1970 |
|---|---|---|---|
| Westbound: | | | |
| Air | 440,459 | 929,318 | 1,813,000 |
| Surface | 56,576 | 45,839 | 50,000 |
| Total | 497,035 | 975,157 | 1,863,000 |
| Eastbound: | | | |
| Air | 166,513 | 265,522 | 682,000 |
| Surface | 26,830 | 31,221 | 28,000 |
| Total | 193,343 | 296,743 | 710,000 |
| TOTAL ARRIVALS | 690,378 | 1,271,900 | 2,573,000 |

4. PASSENGER MOVEMENTS

During the fiscal year ending June 30, 1965, the number of air passengers moving through Honolulu International Airport totalled nearly three million (2,920,078). Of this total, 1,768,339 were overseas passengers passing through the main terminal (John Rogers Terminal), an increase of 16.7 percent over fiscal year 1964. Inter-island passengers exceeded the one million mark (1,151,739) for the first time, an increase of 13.4 percent over the previous year (Table 10.9).



AR00031897

Table 10.9. Summary of Passenger Movements at Honolulu International Airport

| Fiscal Years | Passenger Traffic | | | | | |
|---|---|---|---|---|---|---|
| | Foreign-Arrival | Overseas-Departure | Domestic-Arrival | Inter-Island | | |
| | | | | Outgoing | Incoming | Total |
| 1949 | | | | 174,433 | 174,486 | 348,919 |
| 1950 | | | | 188,678 | 190,425 | 379,103 |
| 1951 | | | | 200,982 | 206,076 | 407,058 |
| 1952 | 21,333 | 94,168 | 70,354 | 232,712 | 237,393 | 470,105 |
| 1953 | 22,418 | 109,001 | 85,689 | 249,413 | 252,551 | 501,964 |
| 1954 | 24,297 | 123,577 | 94,405 | 255,862 | 258,331 | 514,193 |
| 1955 | 34,487 | 155,175 | 117,509 | 259,063 | 260,957 | 520,020 |
| 1956 | 42,355 | 194,570 | 150,807 | 277,154 | 281,910 | 559,064 |
| 1957 | 52,156 | 228,713 | 171,289 | 285,153 | 290,334 | 575,487 |
| 1958 | 57,938 | 247,285 | 184,819 | 281,615 | 286,756 | 568,371 |
| 1959 | 67,362 | 270,189 | 201,265 | 305,317 | 308,000 | 613,317 |
| 1960 | 83,849 | 360,927 | 378,545 | 404,179 | 407,762 | 811,941 |
| 1961 | 113,075 | 456,227 | 335,239 | 391,974 | 396,227 | 788,201 |
| 1962 | 142,115 | 537,072 | 383,868 | 408,507 | 412,805 | 821,312 |
| 1963 | 188,049 | 648,491 | 459,489 | 424,707 | 429,386 | 854,093 |
| 1964 | 187,367 | 735,943 | 550,037 | 496,019 | 500,930 | 996,949 |
| 1965 | 212,091 | 878,773 | 677,475 | 575,084 | 576,620 | 1,151,704 |
| 1966 | 235,297 | 888,290 | 814,253 | 658,617 | 658,408 | 1,317,025 |

In 1966, approximately 75 percent of all visitors took a trip to one or more of the Neighbor Islands. This percentage has been increasing over the years, and a visit to the Neighbor Islands has become a part of the group sales pattern, as well as a recommended itinerary by agents.

> "Although statistics are somewhat confusing and contradictory, the present market mix between visitor and resident travelers is approximately 61 percent visitors, an increase of 50 percent in 1963. This mix should be increasing steadily to a percentage of approximately 72 percent visitors by 1970, and to perhaps 80 percent or more by 1975."*

Preliminary airline-traffic forecasts for the Honolulu International Airport by Leigh Fisher Associates are shown in Table 10.10.

---

*From address by S. C. Kennedy, Jr., Vice President, Sales, Hawaiian Airlines, before the Airport Planning Conference, Honolulu, January 23 and 24, 1967.



AR00031898

Table 10.10. Airline-Traffic Forecast

| Year | Annual Passengers | |
|---|---|---|
| | Probable | Possible |
| 1970 | 8,300,000 | 8,300,000 |
| 1975 | 10,400,000 | 11,100,000 |
| 1980 | 12,800,000 | 14,500,000 |
| 1985 | 15,800,000 | 18,500,000 |

5. AIRPORT TRANSFER

The transportation requirements of the tourist in Honolulu and Hawaii in general are somewhat different from those encountered in Mainland cities, where the preponderance of visitors arrive in their private automobiles. In Hawaii, where only a very few visitors have a private auto at their disposal, public transit--together with taxi, tour bus, and rental cars--plays a much more important role in the tourist movements.

Because of these unique travel requirements, information and analysis of the visitors' travel patterns and modal choice become important in evaluating any proposed transportation system. Since the 1960 origin-destination survey did not involve such trips, a separate study was undertaken as a part of the transit study with the aid of the Hawaii Visitors Bureau.

The initial steps in setting up this study involved an analysis of existing data collected by the HVB on their standard forms, distributed to all westbound visitors, and supplementary opinion surveys conducted by HVB. Since nearly 92 percent of all visitors to the Islands arrived by air and 86 percent of all existing guest accommodations on Oahu are located in Waikiki,* the trip distribution of arriving and departing visitors was clear. The question then was one of modal choice.

A method by which the more important aspects of tourist movement could be obained was developed. To accomplish this, a questionnaire was prepared which could supplement data developed from the Standard Visitor Questionnaire. With maximum cooperation from HVB, a sampling of recent

*HVB Visitor Plant Inventory, July 18, 1966.



AR00031899

visitors was undertaken. This sample was weighted to provide a representative sample based on geographic distribution of visitors from the Mainland. With a letter from HVB explaining the purpose, 1,500 forms were mailed out to these respondents. Excellent response was obtained, with 45.8 percent of the questionnaires completed and returned in usable form. These were then matched with the standard form.

Since only a portion of the standard data was necessary for this analysis, those items which were usable were extracted and punched onto IBM cards together with the special-form data for computer processing. A series of tabulations was developed which would provide an indication of the travel patterns and modal preference of the visitors.

a. Potential Transfer by Transit. As pointed out earlier, the advent of larger jet aircraft in the early 1970's portends unparalleled passenger volume at the Honolulu International Airport. This large volume may be expected to seriously tax the ability of present methods of transit to move people from the airport to destinations in Honolulu (primarily Waikiki) and other areas of Oahu. For example, to accommodate the passengers from a single 500-passenger aircraft would require ten buses of the type presently used in transit service, or thirty-three 15-passenger limousines, or 167 taxis (averaging three passengers per cab).

The problem becomes more acute when it is realized that Honolulu is presently served by two scheduled airlines from the Mainland, both flying similar schedules, plus the probability of serveral additonal carriers in the near future. Therefore, it is not inconceivable that five or six such aircraft could arrive in Honolulu within a very short span of time on any given day.

These factors point up the essential need to provide a means of dispersing these people quickly and conveniently through direct access to major visitor-destination areas. However, it must be realized that not all of these passengers would be willing to use a public transit system even if it were available and offered comparable or better convenience. Therefore, it becomes important to evaluate the potential utilization of such a system. At this point in the study, it is appropriate to approach this evaluation on a conservative basis.



AR00031900

Of those surveyed, nearly 64 percent indicated "pleasure" as their trip purpose, (versus 75 percent of total 1965 visitors to Hawaii). This group is considered to represent the largest potential for transit usage compared to business, visit relatives, convention, etc. Since nearly 70 percent of those indicating "business" as a trip purpose were either met or used U-Drive cars, this group is discounted even though some (16 percent) used the limousine service from the airport. A similar situation exists with those indicating combined "business and pleasure" as a trip purpose, with 53 percent met or using U-Drive and nearly 26 percent using taxis. Other trip purposes are negligible. Therefore, the use of "pleasure" purpose only in the airport-travel analysis provides a conservative estimate.

In considering the total percentage of potential transit riders, based on passenger choice, it is also necessary to evaluate the travel status--i.e., "tour group" or individual arrangement. This is particularly true since the "package tour" may be expected to grow in appeal as fares and costs are reduced even further by larger aircraft. Of those indicating travel status, 21 percent appeared in this category and of those 65 percent used "tour bus" as their mode of travel from airport to hotel. Therefore, in the following determination of transit potential, only 50 percent of the total "tour bus" mode will be assigned as transit potential since 80 percent of those on "tour group" status used this mode. In other modes, the "U-Drive" and "friend drove" categories are likely to remain at nearly their relative proportion, again using passenger preference as a measure. Table 10.11 details the percentage use of different modes of airport transfer by visitors.

Table 10.11. Breakdown of Airport-Transfer Modes Used by Visitors

| Travel Mode | Percent Total Visitors Using Mode | Percent Visitors on "Pleasure" Status Using Mode | Percent Total Transit Use |
|---|---|---|---|
| Taxi | 23.17 | 74.45 | 17 |
| U-Drive | 10.26 | 43.55 | -- |
| Tour Bus | 16.86 | 76.47 | 6 |
| Friend Drove | 28.89 | 42.54 | -- |
| Limousine | 20.23 | 84.25 | 17 |
| City Transit | 0.59 | Negligible | -- |
| TOTAL | 99.99 | | 40 |



AR00031901

Thus, given a satisfactory and workable transit system, a transit link providing direct service to the airport terminal could provide a major step in solving the ground transfer problems which may be expected in the future. To provide this link will require not only careful planning of the transit system itself but of the airport facilities as well.

One of the obvious areas that must be accommodated is baggage handling such that the passenger is relieved of physically transferring baggage from terminal to transit to hotel. The technology for doing this is essentially at hand with containerized baggage already in use in the aircraft. Modifications to loading and off-loading of these containers could provide through checking from Mainland terminal to Honolulu Hotel destination. In this respect, Honolulu-bound traffic is somewhat unique in that the destinations are well concentrated. If this problem is adequately treated, it could well result in even greater transit usage since even pickup of rental cars could then be more convenient to the visitor at the hotel rather than at the airport.

In the case of a fixed transit facility, additional consideration would be required to distribute the passengers from station stop to hotel entrance since not every hotel could be served directly. In the case of an all-bus system, this is less critical since each hotel can be included in the service route, however, at a sometimes severe time penalty for those destinations near the end of the line.

b. Transfer by Buses, Limousines, and Taxis. It has been previously stated that a transit link providing direct service to the airport terminal can provide a major step in solving the ground transfer problems which may be expected in the future. There are two peculiarities to Hawaii's arrivals which are not found anywhere else in the world and which compound the doubt that mass rapid transit is the mode for Hawaii's arriving and departing tourists. These two peculiarities are:

1. The lei greeting and
2. The prepaid transfers.

Probably no other single element in Hawaii's tourist "mystique" has the importance of the flower-lei greeting. Some 60 percent of all arriving visitors are now greeted with a flower lei. After many decades, this custom



AR00031902

has become an integral part of the magic that is Hawaii. All local travel agents, and in fact most Mainland travel agents, recognize that lei greeting occupies a place of almost unbelievable importance in the minds and hearts of most visitors to Hawaii, and this is especially so for the first-time arrivals.

The tour industry asserts that this lei greeting can never be sloughed off on the hotels. At the airport, visitors of all ages must be greeted and decorated at the earliest opportunity after arrival or else that critical moment which they have anticipated would be gone--never to be recaptured--and their Hawaii stay would be off to a bad start.

As a corollary to the lei greeting, the prepaid transfer is another phenomenon that contributes to the arriving passenger's image of himself as a V.I.P. in the hospitable world of Hawaii. Prepaid transfers enable the visitor to be paged, identified, lei-greeted, loaded, and transferred to his destination with a maximum of efficiency and visitor satisfaction. Here again, travel agencies assert that this prepaid transfer service is here to stay. The tour industry writes that thousands of travel agents the world over feel, and rightly, that once their client has been greeted he cannot be left to ride to his hotel in just any old means of transportation. He wants the tour operator he knows and trusts to move his visitors in the types of cars and by the caliber of drivers that he knows will be satisfactory. Estimates range between 30 and 50 percent of all arriving tourists reach their hotels via a prepaid transfer.

The group travelers are another matter, for almost without exception they are going to the same hotel. For groups of appreciable size, the tour agencies assert that the motor coach is the only answer, and almost without exception these would be pre-arranged, prepaid transfers.

Thus, for the millions of dollars being spent by the State and the travel and airline industries to entice the tourists to continually come to Hawaii, and if the mentioned peculiarities found only in Hawaii are to be preserved, then one could only conclude that the taxis and/or stretch-outs should be the principal mode for Hawaii's tourists. If this mode is the consensus of Hawaii's policy makers, then it follows that roadway facilities must be given appropriate weight with its counterpart, mass transit.



AR00031903

## 6. EXISTING PARKING AND ACCESS VOLUMES

Terminal facilities for automobiles and service vehicles are as much a part of a sound transportation system as the streets and highways that carry moving traffic. Airports include adequate parking and access facilities as important elements in their successful operations. The following paragraphs are based on summaries of the Leigh Fisher Associates' preliminary study of the access-road system and parking lots at Honolulu International Airport.

Based upon a seven-day count in May 1967, peak parking accumulation occurred on Monday at 1:00 p.m. During this peak accumulation, parking was distributed approximately equally between the Internal-Domestic lot and the Inter-island lot. Peak hourly in-flow and out-flow, however, occurred at the same time (1:00 p.m.) on Sunday, where 768 and 481 vehicles entered and left the parking lots, respectively.

The main overseas and Inter-island Terminal complex is serviced by two principal access roads: the north access, via Aolele Street; and the west access, via Fort Kamehameha Access Road. Peak hourly volumes for the east and west approaches occurred during periods corresponding to the "to and from work" hours (7:00 to 8:00 a.m. and 4:00 to 5:00 p.m.), whereas the peak volumes on the north approach fell within the period between 11:30 a.m. and 2:30 p.m.

The average entering and/or leaving volume, combined for all three approaches, ranged between 10,000 to 10,400 vehicles per day. The north approach to the airport accounted for 44 percent of the total two-way volume; the east approach, 40 percent; and the west approach, 16 percent.

## 7. FUTURE STUDIES

The Oahu Transportation Study awaits the outcome of the Airport Study by Leigh Fisher Associates. Since the airport will be conceptual in nature, OTS recommends a continuing comprehensive study to quantify the parking and trip-generating requirements of the future terminal complex. The objective of the future study would be to identify the travel movements to and from the airport and the particular routes over which these movements occur. Also, a complete inventory of existing parking, vehicular accumulation, and turnover



AR00031904

rates should be made. Knowledge of trip attraction by visitor type (residents or tourists) by arrival and departure is essential in determining existing relationships so that future parking requirements and trip-generation estimates may be made.

## C. HONOLULU STADIUM

As a result of an economic-feasibility analysis for a multi-purpose stadium by Western Management Consultants, Inc., in 1966, the City and County of Honolulu has moved forward in implementing the development of a new Honolulu Stadium of major-league caliber. The site selected for the Honolulu Stadium is known as the Halawa Housing Area Fig. 10.6. It lies at the junction of Kamehameha Highway and Moanalua Road, between downtown Honolulu and Pearl City, and is adjacent to the suburban community of Aiea. The site, to be acquired partially from private owners and partially from the Federal Government, totals approximately 100 acres.

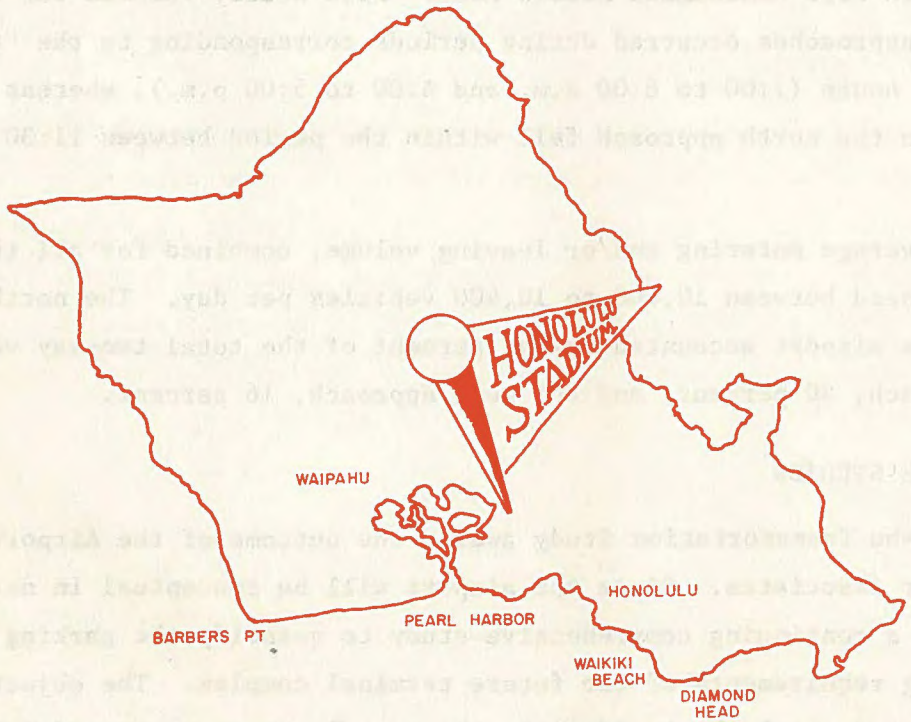



FIG. 10.6. HONOLULU STADIUM SITE.



AR00031905

This major terminal facility is situated also at the confluence of Interstate Highways H-1 and H-3--Moanalua and Kamehameha Highways. Because of this geographic setting, it was only natural to request direct access to the stadium side from the freeway system.

Direct ramp connections between Interstate Highways and any private area of roadside public area generally are strongly discouraged by the Bureau of Public Roads. An exception, however, might be made in the case of a heavy demand for direct access to the parking lots of a public stadium of this nature.

1. SEATING STATISTICS

The proposed Honolulu Stadium is a multi-purpose structure, designed for unobstructed viewing of either football or baseball from the greatest possible number of choice seats. The form of the structure is that of a giant horseshoe, with the two pincer arms providing ideal seating between goal lines for football, and with the closed end and one arm furnishing the most choice seats for baseball. The open end of the stadium can be filled in when a larger facility is needed in the future.

Table 10.12 shows the seating statistics for the proposed stadium. The initial configuration of the stadium will provide a maximum number (34,000) of choice seats for both football and baseball. The future expansion of the stadium, which will be accomplished by closing the open end of the horseshoe form, will add approximately 6,000 seats in each of the upper- and lower-level banks. In all, 12,220 more seats can be added when the open end is closed, to provide a total ultimate seating capacity of 46,414 seats.

2. PARKING REQUIREMENTS

The design of the first phase of the stadium by Western Management Consultants, Inc., (consultant for the stadium study) is based largely on private-automobile transportation, supplemented by public-bus service. When mass rapid transportation is developed in Honolulu, it is anticipated that a major station stop will be located at the stadium site, and that this facility will transport a large proportion of future stadium patrons.



AR00031906

Table 10.12. Seating Statistics of Honolulu Stadium

| Type of Seating | Seating Capacity |
|---|---|
| Football | |
| Total seating | 34,194 |
| Between goal lines | 20,416 |
| Moveable seats | 8,042 |
| Baseball | |
| Total seating | 32,314 |
| Between first and third bases | 11,458 |
| Moveable seats | 6,162 |
| Capacities by Levels | |
| Press and Restaurant level | 1,124 |
| Mezzanine level | 12,670 |
| Concourse level | 12,358 |
| Moveable - Football | 8,042 |
| Moveable - Baseball | 6,162 |
| Capacity of future seating | 12,220 |
| Total future capacity | 46,414 |

The stadium consultant estimated that, for the first increment of 34,000 seats, approximately 10,000 parking spaces would be required at capacity attendance, assuming that some 6,000 persons would use public transportation and that an average of three persons per car would arrive by private automobile. The provision of sufficient on-site parking facilities to accommodate capacity attendance cannot be justified on economic grounds according to the consultant, because of the infrequent use of perhaps 20 to 30 percent of the parking needs in stadium lots. The consultant does recommend ground-level parking for approximately 7,750 cars, and, in the case of events expected to attract capacity crowds, on-site "theater-style" parking could be used plus parking in the general area to meet parking needs.

The consultant concluded that a two-story parking structure will be needed to accommodate an additional 2,250 cars when the stadium is expanded to 46,000 seats, particularly if rapid-transit service is not then available.

3. ACCESS STANDARDS

Standards for design for access lanes and toll-collection booths were developed by the stadium consultant from studies made at Dodger Stadium in



AR00031907

California under several different conditions:

1. Unrestricted traffic flow into and from toll booths is an absolute requirement.
2. Maximum flow through one toll booth appears to be eight cars per minute.
3. Arrival traffic peak volume occurs 30 minutes prior to the game start.
4. Each access lane can handle a maximum of 1,000 cars per hour.
5. Arrival traffic volume is spread over two hours; departing traffic requires 45 minutes to clear the site.

## 4. FUTURE STUDIES

The effect this proposed Honolulu Stadium will have on trip generation and the resulting impact on the existing and planned highway network should be incorporated within the framework of the Oahu Transportation Study. This process should be carried through the analysis stage by testing various alternates for handling stadium-generated traffic during the hours of day and/or night these trips may be expected to occur. The stadium study has not developed sufficient data to permit the State to be in a position to evaluate and to recommend for Bureau of Public Roads' consideration the proposals for accommodating the overall traffic requirements on the affected segments of Federal-aid routes.

The Oahu Transportation Study recommends that further study be made of the access to the stadium site. The objective of the study would be to identify the travel movements to the stadium and the particular routes over which these movements occur. These specific movements, when combined with the remaining area-wide travel, represent the travel demand on the transportation network. With this known information, alternate network configurations in the vicinity of the stadium can be established and their corresponding traffic volumes can be analyzed using the traffic assignment process. The results of these traffic assignments can be evaluated to select a plan consisting of new facilities integrated with the exisiting network which would effectively service stadium traffic.



AR00031908

HI 112.1
(c.2)

State of HI, and C&C of Honolu
AUTHOR
Vol. II
OAHU TRANSPORTATION STUDY
TITLE
1967

| DATE LOANED | BORROWER'S NAME | DATE RETURNED |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

HI 112.1
(c. 2)

DATE LOANED

| | | | |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| GAYLORD 3563 | | | PRINTED IN U.S.A. |

AR00031909

HE310
O2
H66
1967
v.3

Legislative Reference Bureau
State Capitol
Honolulu, Hawaii 96813

# OAHU TRANSPORTATION STUDY

1967

## Volume III

*plan development & plans*

AR00031910

*The preparation of this document was financially aided through a Federal Grant from the Department of Housing and Urban Development, under the Urban Planning Assistance Program authorized by Section 701 of the Housing Act of 1954, as amended, and by Federal Aid Highway Planning and Research funds authorized by the Bureau of Public Roads of the Department of Transportation and the Division of Highways, Hawaii Department of Transportation.*

AR00031911

1203409
9212058

HE310
.02
H66
1967
v.3

# OAHU TRANSPORTATION STUDY

VOLUME III

PLAN DEVELOPMENT & PLANS

1967

LEGISLATIVE REFERENCE BUREAU
MAY 24 1968
STATE OF HAWAII

*Sponsoring Agencies*

STATE OF HAWAII
*John A. Burns, Governor*

CITY AND COUNTY OF HONOLULU
*Neal S. Blaisdell, Mayor*

*In Cooperation With*

U. S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
*Robert C. Weaver*

U. S. DEPARTMENT OF TRANSPORTATION, BUREAU OF PUBLIC ROADS
*Francis C. Turner, Director*

AR00031912

# STUDY ORGANIZATION

## POLICY COMMITTEE

### *Executive Members*

**SHELLEY M. MARK,** *Chairman and Project Administrator*
*Director of Planning and Economic Development* ..... **State of Hawaii**

**FUJIO MATSUDA**
*Director of Transportation* ..... **State of Hawaii**

**FRANK SKRIVANEK**
*Director of Planning* ..... **City and County of Honolulu**

**HENRY TUCK AU**
*Director of Traffic* ..... **City and County of Honolulu**

### *Members*

**GEORGE S. IZUTA**
*Area Coordinator* ..... **Department of Housing and Urban Development**

**JOHN N. STORRS**
*Engineering Coordinator* ..... **Bureau of Public Roads**



AR00031913

## TECHNICAL ADVISORY COMMITTEE

GEORGE MORIGUCHI
*Planning Coordinator* ..... State of Hawaii

ALBERT C. ZANE
*Chief Engineer* ..... Hawaii Highways Division

OWEN MIYAMOTO
*Airports Engineer* ..... Hawaii Airports Division

RICHARD IMAHIRO
*Community Social Planning Coordinator* ..... State Public Welfare Division

WILLIAM HONG
*Deputy Traffic Engineer* ..... City Traffic Department

JAMES TANAKA
*City Planner* ..... City Planning Department

PHILIP D. BROWN
*Project Director* ..... City Community Renewal Program

PHILIP CHOY
*Chief Planner, Urban Renewal* ..... Honolulu Redevelopment Agency

GEORGE IZUTA
*Area Coordinator* ..... Department of Housing and Urban Development

JOHN N. STORRS
*Engineering Coordinator* ..... Bureau of Public Roads

RICHARD T. PUCKEY
*Chief, Airports Division* ..... Federal Aviation Agency



AR00031914

## CITIZEN ADVISORY COMMITTEE

### *Executive*

**CHAIRMAN**

**FRANKLIN Y. K. SUNN (1965)**
*President of Sunn, Low, Tom & Hara*
*Representing American Society of Civil Engineers, Hawaii*

**OTTO ORENSTEIN**
*Business Research Analyst*
*Hawaiian Telephone Company*
*Representing American Statistical Association, Hawaii*

**NATHANIEL R. POTTER, JR. (1967)**
*Secretary-Treasurer/Sales Manager*
*Hawaiian Cement Corportation*
*Representing Hawaii Manufacturers Association*

**VICE-CHAIRMEN**

**CLYDE KIMBALL JACOBSEN (1965-1967)**
*Editor, Hawaii Business & Industry*
*Representing Chamber of Commerce of Honolulu, Highway & Transportation Subcommittee*

**SECRETARY**

**KENJI ONODERA (1965)**
*Vice President of Roehrig, Onodera, & Kinder*
*Representing American Institute of Architects*

**JANE SILVERMAN (1966)**
*Park Historian, State Department of Land and Natural Resources*
*Representing Hawaii Library Association*

**LUCILLE CREPS (1967)**
*Representing The Outdoor Circle*

### *Chairmen of Standing Committees*

**Subcommittee on Population, Economics, and Land Use**

**OTTO ORENSTEIN**
*Business Research Analyst*
*Hawaiian Telephone Company*

**Subcommittee on Mass Transit**

**AARON LEVINE**
*Executive Vice President*
*Oahu Development Conference*

**Subcommittee on Transportation Planning Objectives**

**DON HOUSE**
*Vice-President & Secretary*
*Oahu Transport Company*

**Subcommittee on Highways**

**GORDON BRADLEY**
*Vice President*
*Bradley & Wong*



AR00031915

## KEY STUDY STAFF

**AH LEONG KAM**
*Project Director*

**DAVID S. KAWASAKI**
*Trip Distribution and Traffic Assignment*

**JAMES S. TANAKA**
*Land Use*

**DR. ROBERT W. RIDER**
*Economics*

**ROBERT C. SCHMITT**
*Population*

**RICHARD K. Y. TONG**
*Data Processing*

## SPECIAL CONSULTING SERVICES

**DR. ROLAND A. ARTLE**
*Chairman*
*Department of Economics*
*University of Gothenburg*
*Gothenburg, Sweden*

**DR. RONALD S. GRAYBEAL**
*Assistant Professor*
*Center for Real Estate and Urban Economics*
*University of California, Berkeley*

**MODAL SPLIT AND TRANSIT ANALYSIS**

**DANIEL, MANN, JOHNSON AND MENDENHALL**

**ALAN M. VOORHEES & ASSOCIATES**

## SPECIAL EXPERT ADVISORY SERVICES

**DR. J. DOUGLAS CARROLL, JR.**

**ROGER L. CREIGHTON**

**JOHN R. HAMBURG**

**DAVID K. WITHEFORD**



AR00031916

# ACKNOWLEDGMENTS

To list every individual and organization who contributed to the progress of the Oahu Transportation Study would be a formidable undertaking. Splendid cooperation was given at all levels--from the heads of governments sponsoring the study to the people and business firms of the Metropolitan Area of Honolulu.

Special acknowledgment is extended to D. L. Pollard, Director, Planning Branch, Programs Coordination and Services Office, Department of Housing and Urban Development; to C. H. Spamer, Regional Planning & Research Engineer, Bureau of Public Roads; and to J. B. Dalhouse, Division Engineer, Bureau of Public Roads, for their support and encouragement to the study staff. In addition, technical assistance above and beyond financial support was received from personnel of the Highways Division, Department of Transportation; the Economic and Planning Division, Department of Planning and Economic Development; and the Planning and Traffic Departments of the City and County of Honolulu.

The study employees merit particular praise. They displayed an unusual degree of willingness and devotion throughout the very demanding tasks involved in data collecting, coding, processing, and analyzing, and in the other tasks necessary for a complete and accurate report.

Finally, warm thanks are extended to members of the Citizen Advisory Committee, who spent many hours of their own in attaining the ultimate goal of genuine citizen participation in the decision-making process.

To all, the Policy Committee of the Oahu Transportation Study wishes to express its grateful appreciation.



AR00031917

# NOTES ABOUT THIS REPORT

This volume is the third of a series of three volumes which are being issued to provide information about the purpose, the design, the estimate, and the recommendations of the Oahu Transportation Study.

The transportation goals, objectives and restraints, the tests and evaluations, and the recommended transportation plans are discussed in this volume. Basic agreement has been reached by the State and City representatives on important traffic routes to guide transportation development on Oahu for the next 20 years.

The transportation planning process and the inventory, assumptions and forecasts of socio-economic and land-use data are discussed in Volume I of this series. Volume II contains the discussion on transportation facilities, including mass transportation, travel pattern and forecasts, terminal facilities, etc.

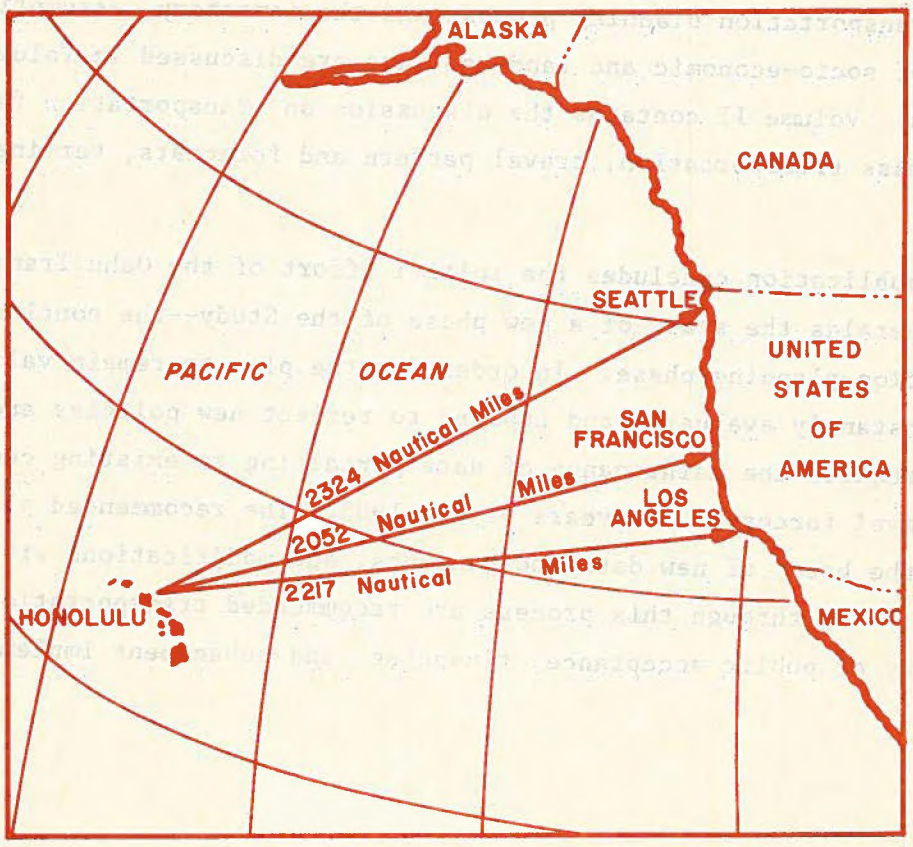
This publication concludes the initial effort of the Oahu Transportation Study and heralds the start of a new phase of the Study--the continuing transportation-planning phase. In order for the plan to remain valid, it must be constantly evaluated and updated to reflect new policies and data. This will require the maintenance of data pertaining to existing conditions and the travel forecasts for years beyond 1985. The recommended plan will be tested on the basis of new data and concepts, and modifications will be made as needed. Only through this process are recommended transportation improvements worthy of public acceptance, financing, and subsequent implementation.



AR00031918

# GEOGRAPHICAL LOCATION OF THE STUDY AREA

The State of Hawaii, the 50th and newest state in the Union, is separated from her nearest sister state by more than 2,000 miles of ocean. It is the most remote of the world's civilized land. Within the State lies the Island of Oahu, known as the Standard Metropolitan Statistical Area of Honolulu, in which the City of Honolulu is located.






AR00031919

VOLUME III

PLAN DEVELOPMENT & PLANS

## Contents


| Chapter | | | Page |
|---|---|---|---|
| XI. | PLAN DEVELOPMENT | | XI- 1 |
| | A. | Introduction | 1 |
| | B. | Transportation Goals | 2 |
| | | 1. Ease of Movement | 3 |
| | | 2. Integration of the Transportation System with Land Use | 3 |
| | | 3. Availability of Variety of Modes of Travel | 3 |
| | | 4. Preservation of Oahu's Beauty and Amenities | 4 |
| | | 5. Safety | 4 |
| | | 6. Balanced Transportation System | 4 |
| | C. | Transportation Objectives | 5 |
| | D. | Planning Restraints | 7 |
| | | 1. Planning Scale | 7 |
| | | 2. Target Date | 8 |
| | | 3. Existing and Committed Conditions | 8 |
| | E. | Community-Value Factors | 10 |
| | | 1. Honolulu Area | 11 |
| | | 2. Honolulu Waterfront | 11 |
| | | 3. Downtown Honolulu to Kaena Point | 12 |
| | | 4. Kaena Point to Haleiwa | 13 |
| | | 5. Northshore | 13 |
| | | 6. Kalanianaole Highway | 14 |
| | | 7. Diamond Head Road | 15 |
| | | 8. Nuuanu Pali | 16 |
| | | 9. Historic and Cultural Sites | 17 |
| | F. | Plan Concepts and Elements | 19 |
| | | 1. Mass Transit | 19 |
| | | 2. Road Types | 34 |
| XII. | PLANS | | XII- 1 |
| | A. | Mass Transit Facilities | 1 |
| | | 1. Factors Influencing the Potential Impact of Mass Transit on Land Use | 3 |
| | | 2. Impact on Highway Facilities | 12 |
| | | 3. Impact on Parking Facilities | 14 |




AR00031920

| Chapter | | | Page |
|---|---|---|---|
| XII. | 4. | Impact on Pedestrian Facilities | XII-16 |
| | 5. | Impact on the Future City | 16 |
| | 6. | Planning and Urban-Design Considerations | 19 |
| | 7. | Freight on Rapid Transit | 20 |
| | 8. | Cost of Future Transit System | 30 |
| | 9. | Study Recommendations | 41 |
| | 10. | Continued Transit Planning | 42 |
| | B. | Street and Highway Facilities | 47 |
| | 1. | Alternate Plans | 47 |
| | 2. | Evaluation of Street and Highway Facilities | 61 |
| | 3. | Systems Evaluation | 90 |
| | C. | The Recommended Plan | 94 |
| | 1. | Introduction | 94 |
| | 2. | Plan Logic | 95 |
| | 3. | Transit-Plan Description | 96 |
| | 4. | Freeway and Arterial Street Plan Description | 99 |
| | Appendix | | |
| XII-A. | | Traffic Assignment | XII-A |
| | 1. | Introduction | A-1 |
| | 2. | Preparing Computer Input Data | 2 |
| | 3. | Computer Operation | 4 |
| | 4. | Accuracy of Traffic Assignments | 6 |
| XII-B. | | Further Evaluation of East Honolulu Transit | XII-B |
| XII-C. | | Street and Highway Cost Estimates | XII-C |
| XIII. | | FINANCIAL RESOURCES | XIII- 1 |
| | A. | Introduction | 1 |
| | B. | Financial Condition and Funded Debt | 2 |
| | C. | State Highway and Street Income and Expenditure | 8 |
| | 1. | Highway Financing | 8 |
| | 2. | State Highway Fund | 8 |
| | 3. | Federal-Aid Fund | 13 |
| | 4. | Interstate Fund | 15 |
| | 5. | Congressional Policy | 16 |
| | 6. | Highway Revenue Bonds | 17 |
| | 7. | General-Obligation Bonds | 18 |
| | D. | City and County Highway and Street Income and Expenditures | 20 |
| | E. | Mass-Transit Financing | 26 |
| | 1. | Local Share of the Project Cost | 28 |
| | 2. | Forms of Public Financing | 29 |
| | 3. | Public Agency Responsible for Transit | 31 |
| | 4. | Honolulu as Major Transit Agency | 34 |




AR00031921

Chapter Page

XIII. 5. Existing Transit . . . . . XIII-34
6. Annual Costs with General-Obligation Bonds . . 35
F. Conclusions . . . . . 39

## *Tables*

Table

XII. Plans

12.1 Comparison of 1985 downtown-parking-space requirements in Honolulu with and without rapid transit . . . . XII-15
.2 Capital cost summary for rapid fixed- and flexible-facility systems . . . . . 34
.3 Comparison of extimated revenue and operating costs for rapid and flexible transit systems . . . . . 39
.4 Supplementary capital-cost summary for subway construction . . . . . 41
.5 Summary of 1985 roadway capacities and average assigned traffic volumes in west Oahu . . . . . 64
.6 Summary of 1985 roadway capacities and average assigned traffic volumes in Pearl Harbor complex . . . . . 69
.7 Summary of 1985 roadway capacities and average assigned traffic volumes in Trans-Koolau corridor . . . . . 70
.8 Observed 24-hour traffic on Kalanianaole Highway at Kapakahi Bridge in 1967 . . . . . 74
.9 Comparison of 1985 estimates of autos and person trips in Oahu and east Honolulu . . . . . 77
.10 Summary of trip generation in Waikiki . . . . . 80
.11 Summary of employment and floor areas in Waikiki . . . 80
.12 Operating characteristics of plan alternates . . . . 90
.13 Comparisons of speeds and costs of alternate plans . . 91
.14 Comparison of user costs under alternate plans . . . . 93
.15 Comparison of average daily user and improvement costs per vehicle mile under alternate plans for the period 1965-1985 . . . . . 94



AR00031922

| Table | | Page |
|---|---|---|
| 12.16 | Statistical aspects of the recommended 1985 Mass-Transit System | XII- 98 |
| .17 | Statistical review of the recommended Freeway-Arterial Street System | 109 |
| 12.B1 | Comparison of estimated 1985 usage of Mass-Transit System on Oahu, by trip purpose | XII-B-3 |
| .B2 | Comparison of estimated 1985 usage of initial, adjusted, and extended Mass-Transit Systems, evaluated by early and recent Modal-Split Analyses, for east Honolulu by trip purpose | B-4 |
| 12.C1 | Street and Highway Cost Estimates | XII-C-1 |


XIII. Financial Resources


| | | |
|---|---|---|
| 13.1 | Available bonding capacity, City and County of Honolulu, December 31, 1966 | XIII- 4 |
| .2 | Estimated City and County Capital-Improvement Project requirements, 1966/67 through 1971/72 | 5 |
| .3 | Information about the funded debt of the State of Hawaii as of December 31, 1966 | 6 |
| .4 | Estimated Capital-Improvement-Project requirements for the State of Hawaii-all funds, 1966/67 through 1971/72 | 7 |
| .5 | Percentage revenues by source | 7 |
| .6 | Schedule of tax rates per gallon of liquid fuel, effective July 1, 1957 | 8 |
| .7 | Gallons of fuel consumed and taxable for highway revenues, City and County of Honolulu, 1960 to 1966 | 9 |
| .8 | State liquid-fuel-tax revenues, City and County of Honolulu, 1960 to 1966 | 9 |
| .9 | Statement of Receipts, State Highway Funds, 1960 through 1966 | 10 |
| .10 | Estimated future revenues and obligations of the State Highway Fund, 1968 to 1977 | 11 |
| .11 | Statement of expenditures, State Highway Funds, 1960 through 1966 | 12 |
| .12 | Apportionment of Federal-Aid Funds authorized to the State of Hawaii, 1950 through 1972 | 14 |
| .13 | Anticipated Financing of Hawaii's Interstate System | 16 |
| .14 | Highway Revenue Bonds, Series A, B, C, and D | 17 |




AR00031923

| Table | | Page |
|---|---|---|
| 13.15 | Amortization table for Highway Revenue Bonds, Series A, B, C, and D | XIII-17 |
| .16 | Hawaii County extra fuel tax, calendar years 1947 through 1966 | 19 |
| .17 | Public-Improvement Bonds issued for Act 73-S.L. 1947 as amended | 19 |
| .18 | Amortization table for Public Improvement Bonds, Act 73 | 19 |
| .19 | General-fund revenues, 1960 through 1966 | 21 |
| .20 | Highway-fund revenues, 1960 through 1966 | 22 |
| .21 | Assessed valuations and annual tax rates, City and County of Honolulu, 1957 through 1966 | 23 |
| .22 | Assessment rates for 1965 and 1966 | 24 |
| .23 | County liquid-fuel tax revenue, 1960 through 1966 | 25 |
| .24 | Weight-tax revenues from regular registration fees, 1960 through 1966 | 25 |
| .25 | Revenues from operators' licenses, permits, motor-vehicles plates, tags, etc., 1960 through 1966 | 25 |
| .26 | General-fund operating expenditures, 1960 through 1966 | 27 |
| .27 | Highway-fund operating expenditures, 1960 through 1966 | 27 |
| .28 | Details of most recent Hawaii and Honolulu General-Obligation Bond sales | 35 |
| .29 | Annual interest and principal requirements for $200,000,000 Bonds at 4-percent interest, maturities in the third to the twentieth years, with a 24-year maximum (present maturity schedule pattern) | 37 |
| .30 | Annual interest and principal requirements for $200,000,000 Bonds at 4-percent interest, maturities in fifth to thirty-fifth years with a 39-year maximum (longest maturity schedule permitted by law) | 38 |




AR00031924

| Figure | | Page |
|---|---|---|
| | XII. Plans | |
| 12.1 | Comparison of Screenline Volumes in 1960 and 1985 | XII- 49 |
| .2 | 24-Hour Non-Directional Capacity 1985 Highway Plan 1.10 | 53 |
| .3 | 24-Hour Non-Directional Capacity 1985 Highway Plan 1.20 | 55 |
| .4 | 24-Hour Non-Directional Capacity 1985 Highway Plan 1.30 | 57 |
| .5 | 24-Hour Non-Directional Capacity 1985 Highway Plans 1.10, 1.20 & 1.30 | 59 |
| .6 | Screenlines and Key Points in West Oahu | 64 |
| .7 | Pearl City Corridor | 67 |
| .8 | Pearl Harbor Complex | 69 |
| .9 | Kaneohe-Kailua Complex | 72 |
| .10 | Hourly Traffic Variation on Kalanianaole Highway in 1967 | 74 |
| .11 | Comparison of 1965 and 1985 Estimate of Dwelling Units in East Honolulu | 75 |
| .12 | Comparison of 1965 and 1985 Estimates of Population in East Honolulu | 76 |
| .13 | Arterial Network of Waikiki Under Plan Alternates 1.2 and 1.3 | 80 |
| .14 | Map Showing Manoa-Palolo Stream Connector | 82 |
| .15 | Plan Alternate 1.1, Non-Directional Volumes | 85 |
| .16 | Plan Alternate 1.2, Non-Directional Volumes | 86 |
| .17 | Plan Alternate 1.3, Non-Directional Volumes | 87 |
| .18 | Automobile User Costs Related to Average Speed | 92 |
| .19 | Annual Capital and User Costs Under Alternate Plans | 93 |
| .20 | Rapid Transit Corridor of Recommended Mass Transit System | 97 |
| .21 | Recommended 1985 Freeway-Arterial Street Plan, Island of Oahu | 101 |
| .22 | Recommended 1985 Freeway-Arterial Street Plan, Central Honolulu | 103 |
| .23 | Recommended Improvements in the 1985 Freeway-Arterial Street Plan, Island of Oahu | 105 |




AR00031925

| Figure | | Page |
|---|---|---|
| 12.24 | Recommended Improvements in the 1985 Freeway-Arterial Street Plan, Central Honolulu . . . . . | XII-107 |
| 12.A1 | Network Coding for Traffic Assignment . . . . . | XII-A-2 |
| .A2 | Capacity Restraint Relationship . . . . . | A-5 |




AR00031926

AR00031927

# XI Plan Development

AR00031929

# XI. PLAN DEVELOPMENT

## A. INTRODUCTION

The transportation planning process is characterized by four essential different activities. Phase One, An Inventory of Existing Conditions, involved measurement, analysis, and reporting of factual data. Phase Two, Forecasts of Future Conditions and Requirements, required a carefully prepared forecast probing into an uncertain future. Phase Three, Preparation and Testing of Plans, is concerned with not what is or with not what will be but rather with what should be. Phase Four, Continuing Program, involves the continual reevaluation of all elements leading to the plan and of the plan itself.

Prior inventories and forecasts of land development, population and employment distribution, and travel patterns have established the probable size, shape, and internal activities of Oahu in 1985. This work has thus scaled the conditions that will largely govern, within the constraints of the General Plan, the dimensions of a planned transportation system. Many plans may be adequate in relation to forecast conditions, and the critical task at hand is to select the best plan.

The Oahu Transportation Study is a part of Oahu's comprehensive planning process. The overall objective of this study "is to provide for the Island of Oahu a transportation system designed for the future movement of people and goods, fully coordinated with public and private land development plans, and economically feasible to construct and use" [Ref. 1]. It is mandated to function as an element in "a program...for a unified or officially coordinated urban transportation system as a part of a comprehensively planned development of the urban area," and as a facility "necessary for the sound, economic and desirable development of such area" [Ref. 2]. To these ends, the Oahu Transportation Study seeks to provide a choice of informed decisions that will best achieve the goals of the community.



AR00031930

The transportation planning process can operate soundly and effectively, and the Oahu Transportation Study can fulfill its mission, only if the relevant goals of the community are correctly stated and converted into criteria to guide the formulation of all elements of the plan and to measure the worth of specific proposals. Transportation goals are broadly stated concepts, the accomplishment of which would represent achievement of an end result. In order to coordinate effort and evaluate progress, it is necessary that more specific objectives be defined, the achievement of each of which would represent fulfillment of a purpose which is a component of the goal. Thus, the development by this Study of a comprehensive transportation plan for Oahu begins with identification of goals and objectives.

The Oahu Transportation Study is confronted with choosing alternatives in developing the best transportation system for Oahu and in achieving those goals and objectives. The choices will be made in relation to questions involving physical, social, esthetic and economic values.

The Oahu Transportation Study accepts the premise that transportation facilities should be planned in response to people's wishes--where they want to travel and when they wish to go. The kind of city the community wishes to create should determine the type and design of the transportation system finally selected. Because of its physical form and its functional relationship to the growth and character of the city, the transportation system is a basic force in shaping the course of community development. The planning process should result in the analysis and presentation of the array and ramifications of the alternatives available for satisfying the transportation needs of the community, from which the policy makers may make choices after informed public discussion.

## B. TRANSPORTATION GOALS

Any statement of urban transportation goals must be made within the framework of goals for comprehensive planning, of which transportation planning is a major component. Basic goals associated with comprehensive planning are directed toward attaining the most desirable place for people to live, work, and pursue happiness with maximum service, amenity, economic opportunity, and safety. These basic goals must also be applied to the development of a transportation plan for Oahu. The achievement of these basic comprehensive-



AR00031931

planning and transportation goals will require a clearly defined set of transportation planning objectives.

1. EASE OF MOVEMENT

The rapid population growth experienced in Honolulu and the Island of Oahu during the past two decades is almost certain to continue into the future. The existing transportation system is already strained, and the pressure of demand will increase with population growth. Today's traffic problem foreshadow even more difficult problems to come. Future transportation requirements must be anticipated and properly planned for or they will become overwhelming. Therefore, ease of movement throughout Oahu, whereby people and goods can move efficiently, safely, comfortably, and economically between desired points, is an immediate transportation goal. The most important basic principle of a sound transportation policy is that the transportation system meets the needs of the community for transporting both passengers and goods, within the limits of economic practicability, determined in light of the value to the community goals and objectives furthered by the transportation system.

2. INTEGRATION OF THE TRANSPORTATION SYSTEM WITH LAND USE

Integrating the transportation system with land use is a critical transportation goal. Transportation and land use must be planned together. The land-use pattern determines the amount and spatial distribution of travel within an urban area; conversely, the transportation system is one of the most important determinants of the future land-use pattern, for it forms a framework for urban development. The location, design, and construction of transportation facilities form an orderly and relatively lengthy process. Expenditures for these facilities are great not only in terms of money but also in terms of the amount of critical land use. The facilities themselves represent a permanent community investment requiring long-range financing.

3. AVAILABILITY OF VARIETY OF MODES OF TRAVEL

The needs and desires of all significant segments of the community must be recognized, including those for whom the automobile is not a satisfactory or available means of transportation. There is acceptance of a community responsibility for providing, through private enterprise or public operation,



AR00031932

transportation facilities to enable individuals to travel from their homes to places of employment, recreation, and trade and to have access to community services. Availability of that variety of modes of travel which will best serve the different requirements evident in the community is therefore a transportation goal. The existence of this goal requires inclusion, in the comprehensive transportation plan, of public mass-transit facilities of sufficient capacity and convenience to permit, where concentrations of population exist, reasonable participation in the economic and social life of the community without recourse to privately owned automobiles.

4. PRESERVATION OF OAHU'S BEAUTY AND AMENITIES

The comprehensive transportation plan must not frustrate the community's efforts to achieve goals having parity or superior rank when compared to the goals toward which the plan is directed. The preservation of Oahu's beauty and amenities is a high-ranking community goal, and therefore a transportation goal. Precise monetary measurement cannot be made of the value to the community of sea and mountain vistas, freedom from air pollution, safe and quiet residential areas, and other existing desirable features of our environment. Recognition of this goal involves appropriate evaluation and avoidance of esthetic and other environmental damage in the planning process.

5. SAFETY

There seem to be few activities more hazardous in urban life than those in which the individual engages for the sole purpose of moving from place to place. These include hazards of contesting automobile traffic as a pedestrian, of competing in automobiles for space on crowded streets, and of exposure to driver error on freeways. Solution of the problem of traffic congestion by achieving greater speeds at the cost of increased risk is not acceptable. Transportation goals include adequate consideration of safety factors in the course of improvements in current modes of transportation, as well as increased speed, comfort, and cost reduction.

6. BALANCED TRANSPORTATION SYSTEM

A comprehensive transportation goal, somewhat embracing those previously stated but deserving of separate statement, is that of providing a



AR00031933

balanced transportation system offering facilities for individual and mass movement.

If Oahu must be made a better place in which to live and work, a balanced transportation system must be obtained. Each mode of transportation has specific advantages over others. In a balanced system each mode is utilized to its best advantage, interrelated with other modes.

Balanced transportation systems may include highways, expressways, freeways, high-volume rail transportation--all of which must be coordinated with an overall transportation plan. Bus systems may be necessary for feeder and distribution services, as well as for lower-density routes.

Advantages of balanced transportation are several; it will:

1. Provide the optimum transportation service with the least expenditure of public funds.
2. Provide a healthier overall metropolitan area, keep more property on the tax rolls, reduce expensive urban sprawl, contribute to the financial stability of the suburbs, as well as the central city, and enhance property values.
3. Result in more miles of rural highways being built because it will reduce the diversion of highway funds for purchase of expensive urban routes.
4. Provide travelers with a high degree of speed, safety, comfort, and convenience.

## C. TRANSPORTATION OBJECTIVES

Formally stated, the initial objectives of a transportation planning process are to develop a system of transportation facilities that will:

1. Provide for adequate present and future traffic demands and land-service requirements
2. Furnish an improved level of service
3. Promote better land use.

Productive activities of the population take place on spatially separated land developments. Access to and interchange between these land uses is a basic requirement to the urban way of life. Thus, an adequate transportation system which provides a means for access and interchange is an essential element in a productive urban society.



AR00031934

Adequate service to developed lands includes access to and interchange between land uses served by transportation facilities and neighborhoods or high-trip-generating areas. For this service to be adequate, it must be such that existing land activities are sustained and that the potential for expansion of the activities and the development of new land uses is not unduly restrained by the lack of adequate transportation facilities.

Adequately providing for traffic demands and land-service requirements, therefore, must be a primary objective. The specific form and detail of transportation plans, however, may vary greatly and yet satisfy this primary objective. Within the limits of the planning restraints, adequate facilities depend on the values assigned and the balanced attained between improving level of service and promoting better land development.

People place high values on time, safety, attractiveness of the facility, and economy. Transportation planners should accept present levels of service and extend them into the future only when they are satisfactory. In other cases, they must establish an increasingly higher standard in urban transport involving faster, safer, and less costly travel. Improved levels of service promote increased economic productivity and enhanced opportunities to share in social and cultural experiences.

However, improving the level of service is an objective which could be compromised by economic or planning restraints. Judging what level of service should be provided entails consideration of costs involved and policy decisions by the community on the investments it is willing to make to attain its objectives. Care must be taken that indirect costs and benefits, although not readily expressed in dollars, are included in the cost-benefit analysis. Costs to the community from defacement of natural beauty, creation of unsightly structures, noise, and air pollution are to be weighed against user benefits.

Establishing a framework of transportation facilities which will promote desirable and logical land use is a critical objective of the transportation planning process.

The transportation system is a major structural element of the community. It serves both as a circulatory system and as a skeletal system, providing a



AR00031935

relatively permanent framework within which neighborhoods and land uses may develop. Preservation of neighborhoods and stabilization of land uses are among benefits to be realized.

Transportation facilities and traffic are also to be viewed in terms of their harmony with adjacent land uses. For example, when freeways are required to response to traffic demands and land-service requirements, and can also be located to buffer and separate incompatible land uses, then a desirable structural element promoting good land development is achieved.

## D. PLANNING RESTRAINTS

Statements of goals and objectives give direction to the development of plans and represent important commitments for the transportation planning process. Plan development, however, is influenced to varying degrees by many other factors--these are restraints and, together with objectives, they further limit the avenues of approach in seeking solutions to the long-range transportation problems of Oahu.

### 1. PLANNING SCALE

The primary task of the Oahu Transportation Study is to provide measures of the magnitude of future travel demand and to recommend a system of transportation facilities in response to these measures and in accordance with established objectives. At the system level, OTS must be concerned with the whole and the manner in which the parts are integrated. Although the system will be built piecemeal, it must be planned and tested as though it were constructed overnight. It is no longer acceptable to consider one facility at a time, for one affects the other. The solution to urban-sprawl needs is an integrated system of facilities.

Of specific concern are system design features, including concern for the types of facilities forming the whole, the spacing, and the extent and balance of facility types in relation to total travel needs. A plan thus conceived and constrained as to details provides the best basis for plan implementation.

In considering an area encompassing 596 square miles and over a million persons by 1985, it is readily apparent that such matters as the timing



AR00031936

of traffic-signal progressive systems and other detailed operational matters are not considerations of the study. Also, final design of specific major streets, expressways, interchanges, or precise positioning of freeways, is not the principal function of the Oahu Transportation Study. Advancements of desirable standards for geometric street designs, locations for interchanges, and recommended corridor alignments for new major transportation facilities are proper functions of the transportation planning process.

2. TARGET DATE

The time span places specific limits on what is needed and what can be accomplished. The target date selected for the Oahu Transportation Study is 1985, when population growth should reach about 1,050,000. A target year permits officials to prepare long-range improvement programs based on specific needs and time intervals in which financing arrangements can be planned.

The length of the planning period is important. Selecting a time too far in the future increases the probability of error in forecasting. It also increases the likelihood of unforeseeable technological advances becoming increasingly important in transportation systems. A shorter period, on the other hand, does not allow sufficient time to change materially or to improve the present system.

Growth and increasing transport needs will not end in 1985. The plan developed by OTS, therefore, should not be viewed as an ultimate system beyond which additional improvements are impractical to achieve. The plan, however, must have practical extensions to serve an expanding area and the reserve to increase the capacity of planned facilities. The State of Hawaii and the City and County of Honolulu are committed by executive agreement to implement a continuous transportation planning process that will provide continuing reexamination of the plan and determine what changes are required.

3. EXISTING AND COMMITTED CONDITIONS

The most positive restraints considered by the Oahu Transportation Study are the transportation facilities and land developments already in existence. These conditions have evolved over the years in response to complex economic and social factors. Although massive industrial, business, or housing



AR00031937

subdivisions, urban renewal, or freeway construction may radically change prior economic, social, or physical conditions, they are not usually subject to rapid or indiscriminate change without these major influences.

The Oahu General Plan, which represents an officially adopted set of policies and which guides the overall coordinated development on Oahu in harmony with long-range comprehensive objectives, is a firm commitment to the people on Oahu. Although the major components of the General Plan will endure, however, it is reasonable to expect that such adopted policies will undergo changes based on more current data. Such current data will include the comprehensive transportation plan adopted by the community. To the extent that the General Plan is based on assumptions with respect to transportation solutions, the presentation of alternate solutions by the Oahu Transportation Study is a portion of the continuous Oahu comprehensive planning process and is within the restraints imposed by the General Plan.

Another firm commitment that has already become an integral part of Oahu is the Interstate Highway System. Although this system is not fully completed, its corridor has been established and is not subject to alteration. Here again, interchange locations may be added in time and others may undergo redesign based on more current data, but the major components of the facility will endure.

Another important restraint to plan development is the existence of land-use patterns that are closely allied with the existing street network. Literally, hundreds of millions of dollars have been invested in the street networks and in the developments abutting the arterial or highway system and like amounts have been invested in interior lands within the areas formed by the existing network.

Still another area of commitment lies in the plans that have been devised in the past and that represent extensive study and coordination between public and private interests. The Civic Center Plan, announced or planned urban-renewal areas, etc., are typical examples of these commitments.



AR00031938

## E. COMMUNITY-VALUE FACTORS

Transportation of people and goods is not an end in itself; is a means to satisfy human needs. It is not sufficient that thoroughfare plans be based on the utilitarian scale of vehicular movements alone. Rather, other thoroughfare aspects should be considered--such as open space, walkways, scenic vistas for the motorists.

Every level of Hawaii's economic activity is represented on Oahu. Although compounded by explosive growth and complexity, the prerequisites on which Hawaii's continued prosperity depends are basically the same for Oahu as for the more idyllic neighbor islands.

In the absence of mineral resources and major marketing areas, Hawaii's major economic resources are anchored in plantation-agriculture, research and development, and tourism. Each of these economic cornerstones, including partly even the military establishment, predominates on Oahu. Each of them depends uniquely on educational, cultural, climatic, and scenic resources in order to persevere against growing world-wide competition.

Economic survival will depend on the preservation of Hawaii's irreplaceable multicultural climate, composed of the heritage of its indigenous and immigrated peoples and the unmatched kindliness, innate courtesy and friendliness of its people expressed in the Spirit of Aloha which pervades life on the island.

Economic survival will depend, too, on the protection of the purity of Hawaii's air and the unobstructed flow of the tradewind cooling its subtropical warmth; on the clean, spaciousness of its beaches, the languid lapping of the surf, and the crashing of wave masses against the shorelands, which are endangered by overbuilding.

It will also depend on the visual continuity of the green mountain slopes, which descend to the urban areas and extend by way of tree-lined streets, parks, and other landscaped areas down to the sea. These, too, are imperiled by speculative sprawl and inadequate planning processes.

Oahu's economic survival will require not only an efficient transportation network, designed to satisfy all modern criteria for speed, safety, and



AR00031939

convenience, but one that has been designed to maintain and complement Oahu's attractions and assets, to increase their numbers and sizes, and to make them available to one of the most commonly used forms of visitor satisfactions: sightseeing by car, driving for pleasure and for recreation.

The occasion for construction or alteration of any highway or other space for transportation should be utilized to acquire more open space for recreation and beautification, and as a buffer between various land uses.

1. HONOLULU AREA

Serving as an example worthy of praise and emulation, the proposed link between Nimitz Highway and Ala Moana will utilize federal highway-beautification funds to purchase and to landscape all land adjacent to the Honolulu waterfront and enable the completion of the Civic Center concept of a continuous, landscaped open space from Punchbowl to the sea.

How important would it be to the first impression that the visitors to Honolulu would gain when coming through the city from the airport, if this example set on the makai end of the Civic Center could be extended to Keehi Lagoon Park and to the Airport Access Road on the one side, and to the Ala Moana Park and Kapiolani Park on the other side.

The disaster brought onto the world by the attack on Pearl Harbor, and the men and women who lost their lives because of it, should be memoralized by a War Memorial Boulevard along this thoroughfare.

2. HONOLULU WATERFRONT

Access and circulation requirements along the Honolulu waterfront, generated by the various maritime industrial uses--such as the container-facilities yard, food-distribution center, oceanographic-research center, commercial fishing, trade zone, concentration of governmental offices, and the CBD--will demand grade separation between the Nimitz - Ala Moana Boulevards and the various mauka-makai roads.

Pressure to elevate the arterial along the waterfront to facilitate bypass and through traffic, as well as to provide access to the areas makai of it, will mount. Arguments for a viaduct will sound so logical even be so logical, that they will be difficult to resist and to refute. Nevertheless,



AR00031940

community attitudes and attachments to the seashore are so powerful and so ingrained that the people will strongly resist being cut off from the ocean, either physically or visually.

3. DOWNTOWN HONOLULU TO KAENA POINT

The highway leading from the urbanized area of downtown Honolulu to Pearl City will become the chief access to Makaha and other areas of great resort potential. This highway needs setback areas, landscape screening, and other even more drastic measures to conceal the sordid, clustered ugliness, which obsolete zoning laws were not able to prevent.

One threatened and irreplaceable asset is the drive along H-2 from Pearl City to Wahiawa and beyond. It leads through the only major open space on Oahu. Except in the Kamuela area of the Big Island, nowhere else does the island resident, accustomed to the narrowness of this land strips between mountains and sea, experience such an "American" expanse of land as where the Koolau Range and the Waianae Mountains are more than 10 miles apart. This luxuriant sense of "the wide open spaces," which historically is probably the basis for the American idea of freedom and independence, should not be permitted to be lost to future generations.

To achieve this open space, the corridors of the highway should be protected with setbacks of not less than a mile depth, within which only occasional, well-screened buildings would be permitted, and tract housing, subdivisions, and satellite towns would be prevented.

The highway connecting Nanakuli, Maile, and Waianae with Makaha and beyond should be protected against similar despoilation. Most of it is still open space, with majestic vistas over the shoreline, canefields, and mountain ranges.

Makaha Beach, probably the best and most famous surfing area of the world, and a vital asset to Oahu's continuing attraction as a resort destination, should be widened by locating the highway further inland than now, even if this action should require a tunnel bored through the mountain.



AR00031941

4. KAENA POINT TO HALEIWA

The fact that the Kaena Point Road has not yet been linked offers a wonderful opportunity to create a scenic drive of magnificent grandeur. From the Kaneana Cave, an attraction in itself, this road follows a rugged shoreline, winds through the untended wilderness of Makua Valley to Mokuleia and Haleiwa. Because of the promontory formation of the shoreline, the potential scenic drive would offer sweeping vistas along the northshore as well as the west side of Oahu, and the opportunity to view the Waianae Mountains from both front and back.

The climatic, geologic, and scenic aspects of this area are ideal for a major wilderness park, with trails and drives up, perhaps even to Mount Kaala, the highest peak on Oahu. The multiple recreational potentials of this area would become of major importance to the attractiveness of Makaha and Haleiwa as visitor-destination areas from the otherwise unstoppable overbuilding of Waikiki.

5. NORTHSHORE

The residential and other urbanized developments along Oahu's northshore from Haleiwa to Makapuu should be permitted to consolidate into cluster villages or towns by relocating the highway corridor, which now dissects them, into the foothills of the mountains. Their single-line development, once practical along quiet country roads, has proved detrimental both to the effective and safe use of the roads and to the maintenance of desirable, peaceful residential living conditions.

The entire northshore roadway, like all other transportation corridors on Oahu and the rest of Hawaii, should be designed and conserved as a scenic drive or a parkway and should be developed to exploit fully all recreational potentials. It should loop around urbanized areas in a manner that will encourage their growth into cohesive residential entities provided with enough room for needed services and amenities, for open spaces for recreation, and for sufficient buffer areas between the residents and the road.

Where the alignment leads through steeper land--cutting, for example, through Kahana Valley, destined to become State park, botanical garden, and exotic visitor attraction--avoidance of excessive cuts and fills becomes a



AR00031942

most important and most difficult challenge. Dividing the roadway into separate one-way roads, each hugging the land on different elevations, would reduce the road width and, therefore, cuts and fills. Where the divided road would not suffice, tunnels, galleries, arcades, viaducts, or bridges should be constructed.

6. KALANIANAOLE HIGHWAY

Imaginative, cohesive design would be especially important along a natural scenic road, such as Kalanianaole Highway leading through Koko Head Crater Park between Makapuu Beach Park and Hanauma Bay Beach Park. Should the widening of this road ever be required, it should be either completely recessed into the mountain cliffs by galleries or built partly or completely protruding from the slope and supported by well-designed arcades. Where crossing crevices, gulches, or valleys, such arcaded structures would then continue as free-spanning bridges or as viaducts.

Lookouts and overlooks, such as Halona Lookout at the Blowhole, should be located at natural outcroppings of the cliff, with the knobs cut off the rising ridges, or at natural indentations of the mountain slope, created by lateral valleys.

The upgrading of Kalanianaole Highway beyond six lanes between Koko Head and Diamond Head would cause such undesirable disruption of existing, well-ordered residential land uses that it should be avoided. The road alignment should, therefore, either be carried inland, elevated as viaduct, or daringly located far offshore on the reef line. If located inland, conditions for its alignment and design could be similar to those on the northshore.

Viaducts, of course, are all too often the direct cause of blight. They usually disrupt the visual continuity of land forms and land uses, create sunless areas barren of vegetation, and are often bulky, massive, and overpowering. They spread over large areas, and generate noise and dust. Only imaginative, sympathetic design and public-spirited determination can overcome these serious detriments.

Such structures should always be precise and forthright visual statements of their functional purposes, detailed to fulfill their objectives with the smallest amount and variety of materials and the greatest economy of form.



AR00031943

They should not attempt to conceal their man-made origin, but be fitted and harmoniously composed into the land or city-scape.

Slabs, beams, and parapets should have continuous, unbroken lines and be as slender as good structural design makes possible. The structure should be elevated as high above grade as necessary to frame favorably the desirable landscape elements of the background and not to interrupt the visual continuity. Their vertical support members should be spaced at regular distances and as far apart as structurally safe.

A reef-aligned highway could provide an unusual, exciting, and esthetic drive. If it were far enough removed off-shore, so that distance would diminish dimensions and thicknesses to thin lines, paralleling the ocean horizon, views from inland should not be disturbed.

Depending on the vantage points from which a reef highway would be viewed, the road slabs should either be close to the water surface or be super-elevated, by elongated, widely spaced, vertical supports, so that the horizon line of the ocean will not be blocked.

The results of responsible research studies should be applied to guide the design efforts, so as not to disturb the ecology of the coral reefs, the marine plant life, and the animal population of the sea.

The creation of sheltered bodies of water between the shore and the reef could add much needed spaces and facilities for calm-water sport activities.

Reef islets, as well as suitable areas along the shoreline, should be set aside as picnic and camping areas, satisfying some of the predominantly water-oriented recreation preference of many people, both residents and visitors.

7. DIAMOND HEAD ROAD

Diamond Head is the best known landmark of Hawaii. It symbolizes to the world the beauty and history of Hawaii. Its visual preservation is mandatory. Oahu's and Hawaii's success in resolving the conflict between private and public interest, fought at this time before the watchful audience of the world, will be construed as proof that planning technique has progressed in



AR00031944

Hawaii to a point that will encourage the optimum development of its land without damage to those characteristics which made it attractive and beautiful in the first place.

Many knowledgeable people on Oahu feel that Diamond Head Road, skirting the foothill of this sacred mountain and framing luxurious residential properties, should under no circumstances be allowed to be widened. They feel that other corridors, perhaps along Monsarrat Avenue and linking with the reef highway, should be established. Diamond Head Road, winding and charming, with lookout areas to view the misty neighbor islands in the distance, should be preserved for leisurely recreation driving.

More pessimistic, or perhaps, realistic Oahu residents concede that eventual widening and realignment of Diamond Head Road cannot be avoided, especially if residential uses would be rezoned for higher density development. Should widening of this scenic road become necessary, excavation into the flank of the mountain, resulting in steeper and higher cuts, must be prevented. Either a parallel road should be tunneled into the mountain slope as gallery or arcaded structure, or should extend into the private properties, perhaps cantilevering over off-street parking facilities. The galleries form of road expansion could be elevated several feet above the existing road, or conversely, the road widening on the makai side could be lowered to improve visibility for persons in a car.

The visual enjoyment of this road is of such importance that a separated pedestrian walk leading to Diamond Head Park should be provided on the ocean side.

8. NUUANU PALI

The H-3 corridor at the foothills of the Nuuanu Pali where damage to one of the most breathtaking panoramic view on Oahu, if not of the State, should be avoided, even should it cost much money.

The deeply crenelated mountain cliffs, casting deep shadow lines like artful draperies on antique sculpture, must be protected against any defacement. Excavations would there result in visually disastrous cuts. The integrity of this mountain wall, to be seen by the Hawaii Loa College community and by thousands of commuters, can be retained only if all cut and fill operations



AR00031945

are replaced by tunnels and appropriately designed arcades and viaducts in a manner not to be outdone by European examples.

Even the planned interchange of H-3 and Kamehameha Highway, because it will dominate the composition of the vista with the adjacent planned college, as seen from the Pali Lookout, needs to be carefully and knowledgeably designed, so as not to destroy but rather to, hopefully, enhance the enjoyment of residents and visitors alike, who take the pilgrimage up to the historical lookout to refresh their souls and to reinvigorate their creative energies.

9. HISTORIC AND CULTURAL SITES

Equally important as the protection of the natural and scenic resources to the individual, social, and economic welfare of the people is the preservation of historic, traditional, and cultural values.

Recommended, therefore, for physical protection and preservation are objects, structures, sites, and areas of archaeologic, historic, religious, cultural, traditional, architectural, and environmental value.

Of archaeologic importance are the remnants and sites left to us by the pre-monarchical Hawaiian people. Among them are the following Heiaus: Kamaile (Waianae), Kaneaki (Makaha), Kukaoo (Manoa), Ulupo (Kailua), Puuomahuka (Waimea); petroglyphs along the Nuuanu Stream, Waipahu, Keau Beach, Sunset Beach, Koko Head, Moanalua; caves in Makaniolu, Kuliouou; the Molii Fishponds (Kualoa), Huihua (Kahana) and others at Heeia, Kahaluu, Mokapu; taro patches in Waiahole Valley. Outstanding among the sites are Leahi on Diamond Head, Puu Ualakaa on Tantalus, and the famous Kukauiloko Birth Stones near Wahiawa.

Of historic interest are the many objects, buildings, and places that were: used by the Hawaiian monarchy; associated with the founding and activities of the missions; connected with significant events in the political, social, or ethnic evolution of the peoples of Oahu; connected with the lives of leading figures in the religious, cultural, governmental, social, and economic development of Hawaii. Finally, the following specific structures should be preserved: Iolani Palace (1882), Iolani Barracks (1871), Judiciary Building (1874), Royal Burial Ground, Kapuaiwa Building in the Honolulu Civic Center, Queen Emma House on the Pali Highway, Royal Mausoleum on Nuuanu Avenue, Kamehameha V Post Office on Bethel Street, the Court House at Bishop and Queen,



AR00031946

the Mission Frame House (1821), Printing House (1842), Adobe School House (1935), Mission Memorial Building (1916), and many more.

Among religious buildings of confirmed importance are the First Church of Christ on Punahou, Central Union at Punahou and Beretania, Latter Day Saint's Churches on Beretania and at Laie, First Chinese Church on South King Street, First Methodist at Beretania and Victoria, St. Andrews at Beretania and Queen Emma, Kailua Missionary Baptist Church, Honpa Hongwanji Mission on Pali Highway, Soto Mission on Nuuanu, Todaiji Hawaii Bekkaku Honzan near the Oahu Country Club, Temple Emmanuel on Nuuanu.

There is, of course, the Honolulu Academy of Arts, which is considered by many to be prototypical for a Hawaiian style in architecture. Much smaller, but of similar importance is the C. W. Brewer Building on Fort Street. It, too, is a masterpiece by the late Bertram Goodhue. There is the beautiful Alexander and Baldwin Building on Merchant and the U. S. Immigration Station on Ala Moana.

Of great importance to the enclosure and composition of the Honolulu Civic Center are the Army-Navy YMCA building on Hotel and the Hawaiian Electric Building on Merchant Street.

The Board of Water Supply, Honolulu Concert Hall, I.B.M. Building, the office building on 320 Ward Avenue, the Campbell Building, Financial Plaza and, of course, the Capitol are outstanding and valuable examples of architecture which should be saved for posterity.

Posterity will also regret that not enough buildings stemming from the early immigration of the forebears of our present residents of Japanese ancestry have been preserved.

Enough buildings of such tradition, and certainly of value to a more picturesque environment, remembering the mores and customs of our people of Chinese origin still exist in Chinatown, downtown Honolulu.

At least some clusters of these buildings should be selected for preservation. They could surround a future park, where senior citizens can sit in the sun and dream of days past, or they could become community centers for the aged, or museums where costumes, furniture, and other crafts of China



AR00031947

could be displayed. They could also serve as bazaar, where Oriental food could be sold.

Entire towns, like Haleiwa, still carry with them the flavor and nostalgic charm of the Victorian era. Skilled restoration and sympathetic complementary fitting-in of newer developments, could create resort towns of peculiarly old-time Hawaiian character, and should be preserved. The reasons for preservations are at least as much economic as of human and humanistic interest.

Some of the very oldest, most revered historic relics are especially prone to the bulldozer of the transportation builder. Many of them are very old and at least their age should be honored and respected; all of them are excellent, and certainly, irreplaceable elements of natural beauty. The more urbanized area environment is becoming, the more important will it be for the mental and physical health, for the moral fiber and the civic pride of our people, to retain these monuments.

## F. PLAN CONCEPTS AND ELEMENTS

In the following text, of specific concern are transportation-facility types, their land-use and traffic-service functions, their design and ability to provide adequate service, the manner in which they are integrated into a system, and the ways in which they interact with land developments.

### 1. MASS TRANSIT

The Oahu Transportation Study has, as its basic objective, the development of a transportation system designed for the future movement of people and goods, fully coordinated with public and private land-development plans, and economically feasible to construct and use. The role mass transit could serve as an element of the overall transportation system could conceivably vary from nothing to a substantial share of all passenger trips. The process of determination of the optimum allocation of travel to different modes involves many complex factors. In order to analyze these, it is important to identify certain goals and objectives for a regional transportation system. Among these would be the following:



AR00031948

1. The system should be a modern, integrated complex with each element or component performing the type of service for which it is best suited and operating at its optimum speed and capacity.
2. The transportation system should contribute to a more livable and more serviceable community.

Within the context of these broad goals, the analysis of modal choice and extent of transit service can be made. A guideline from the American Society of Civil Engineers is helpful in this regard. In the ASCE "Principles of a Sound Transportation Policy" [Ref. 3], it is stated that,

> "Where travel demand is concentrated in time or in space, mass transportation may be required; when travel is dispersed over time or space, public transportation may not be justified."

With these basic objectives of transit service should go certain considerations of how the transit system can affect the community and its development patterns. In this vein, transit can have far-reaching effects. It should permit the Central Business District to function as the heart and nerve center of the region and allow it to attain higher concentrations of economic activity with improved access and mobility. In addition, transit should serve to develop and encourage subregional centers and increase the intensity of use of outlying industrial, commercial, and residential development. It should make possible a planned community with clustered patterns of development.

These considerations of transit should be applied to Honolulu. Honolulu is an area of concentrated travel in terms of both time and space. It is a linear city confined by mountains and ocean with a heavy traffic volume parallel to the long axis of the city. Congestion and delay are already being experienced and all indications are for continued growth of the city with increasing demand for travel. Close-in urban land is in short supply, and provisions of additional high-capacity freeways is not possible without severe penalty to development in the downtown sections through further reduction of land area. Parking in the central city is in short supply, and land value precludes extensive surface parking. Therefore, provision of adequate terminal facilities can only be made at high cost through parking structures.

Under these circumstances, and assuming that the indicated patterns of development continue, it may be assumed that provision of a high-quality



AR00031949

and high-capacity transit system will afford in part a realistic solution to the future travel demands.

a. Definitions of Transit Elements. Since public transit can serve many different trip purposes and can take many forms, it is necessary to define the various types of transit.

1. Mass Transit--scheduled public transportation in vehicles capable of carrying large groups and their incidental baggage and operating on specified routes; normally confined to an urban or metropolitan area
2. Local Transit--Mass Transit generally operating on public streets intermixed with other street traffic and designed to furnish service to all areas adjacent to the routes by stops spaced at frequent intervals
3. Rapid Transit--Mass Transit operating on exclusive, grade-separated rights-of-way and providing limited-stop, express service, without interference from other traffic or pedestrians
4. Rail Rapid Transit--Rapid Transit utilizing rails or other fixed system of guidance for the vehicles and operating over exclusive rights-of-way
5. Fixed-Facility Rapid Transit--this general category includes conventional rail systems, all of the various "monorail" concepts, Westinghouse Expressway, and many of the advanced concepts using air-bearing vehicles, etc.
6. Flexible Mass Transit--This general category essentially represents bus transit. It could also be expanded to include some of the innovational concepts of personalized public transit proposed in recent years such as StaRRcar, Commucar, Teletrans, etc. These, however, are purely in the research stages and are untested in hardware or system concept. The category can also include bus rapid transit, in which the buses operate on an exclusive, grade-separated roadway for major portions of the route and use surface streets only for collection and distribution. This method, however, approaches the fixed-facility concept in both operational characteristics and cost (and may have higher operating costs). This approach also lacks operational history.

It is next in order to analyze each of these elements to determine desirable service standards and design criteria.

b. Oahu Service. The first major problem posed by the transit analysis concerns a definition of the extent to which transit should be provided to serve the entire Island of Oahu, and the standards of such service. The requirements for Oahu transit service involve the following:



AR00031950

| | |
|---|---|
| Trip Length*: | Long |
| Volume: | Light |
| Speed Requirement: | Medium to high |
| Cost: | As low as possible, consistent with trip length. |

The distribution of population and travel volumes related to highway capacity indicates that transit volumes outside of Metropolitan Honolulu would be relatively light, considering trip purpose and other conditions. In most areas, transit service can be provided as a public convenience without the heavy cost of fixed facilities by using existing or projected freeways or expressways. Thus, maximum utilization can be made of such facilities with only the small additional expense of bus turnouts. The service would consist primarily of express buses operated during peak periods, with limited service furnished during off-peak periods.

Standards for bus loading, frequency of service, frequency of transit stops, speed, and regularity of service are published by the National Committee on Urban Transportation [Ref. 4]. The standards for surface mass-transit routes as recommended therein follow:

1. Routes should be direct with respect to origins and destinations of passengers, connecting principal residential areas with the community's major commercial and industrial centers.
2. Cross-travel and interchange to and from secondary centers, such as schools and so on, should be made reasonably easy, with a minimum of transferring consistent with economy.
3. Routes should be free of duplication, except where they converge.
4. Feeder routes connecting with arterial routes, or extensions of regular routes, should be utilized (where justified) in sparsely populated areas.
5. A route should draw from areas not less than one-quarter mile on both sides thereof, and this distance should be greater than one-quarter mile in thinly populated or restricted areas.
6. Availability and accessibility to patrons are the marks of well planned transit routes. Subdivision design should make provision for continuous-transit routes readily accessible to pedestrians. Streets adequate for transit-vehicle movement, with areas properly located for stops and interchanges betwee routes, should be developed.

---

*Trip length as used in this discussion is comparative, relating to trips on Oahu.



AR00031951

7. Each route should include a minimum number of turning movements and have adequate provision for turn-around at both ends and for layover at one or both ends where necessary.
8. Routes should possess reasonable long-term flexibility (not necessarily day-to-day flexibility) so that they may meet changing conditions.
9. The combination of route and the service operated on it must meet public needs.
10. Overall operations must be capable of providing a fair return on the investment required.

c. Honolulu Metropolitan Service. In Metropolitan Honolulu, the basic, overall linear configuration of the city is suited to a rapid-transit operation. The primary travel patterns are and may be expected to remain basically east-west in orientation. The service requirements for mass transit in and through the Honolulu Metropolitan area involve the following:

| | |
|---|---|
| Trip Length: | Medium to short |
| Volume: | Medium to heavy |
| Speed Requirement: | Medium |
| Cost: | As low as possible consistent with standards of service and community acceptance. |

The criteria for development of a rapid-transit system would include the following factors:

1. Speed

   Maximum of 50 mph line speed

   Average scheduled speed approaching 30 mph

   Acceleration Rate: 3.0 mph per sec

   Deceleration Rate: 3.0 mph per sec

2. Capacity (Minimum limit of ultimate expansion)

   30,000 passengers per lane, per hour

   90-sec headways

   Maximum station stop: 20 sec

   Grade-separated rights-of-way.

3. Convenience

   Careful design of interchange stations for ease in transfer

   Escalators from lower to higher levels (minimum requirements)

   Parking areas adjacent to outer-limit stations

   Distribution system in Central Business District

   Integration with surface-bus feeders throughout



AR00031952

4. Comfort

   Adequate seat dimensions

   Internal temperature control (air conditioning)

   Low noise levels

   Pleasing appearance

   Smooth riding qualities

   Seats for majority of passengers

5. Safety

   Safe and reliable

   Automatic control with fail-safe features

   Easy evacuation in case of emergency

6. Esthetics

   Pleasing appearance of stations and way structures

   Ultramodern exterior and interior design

7. Maintenance and Operation

   Lightweight equipment

   Interchangeability of equipment between lines

   Line connections to central maintenance area

   No more or less than one operator per vehicle

   Practical and convenient collection of fares

   Electrical propulsion system.

The foregoing minimum requirements cover the principal areas to be considered in developing a modern rapid-transit system that will assume its proper role in the Honolulu Metropolitan area.

Speed is recognized as a major factor and must be produced in order for the system to develop patronage. The system must have high-capacity capability in order to function properly in the short rush-hour periods. Convenience and comfort are essential to the success of a rapid-transit facility in this era of escalators and air conditioning.

In addition, the ultimate design of the system should consider the needs and requirements of the total community. As the system selected for application to Honolulu approaches the design phases, these considerations should be incorporated. Both up and down escalators should be provided for vertical transfer and at least one elevator should be installed at each grade-



AR00031953

separated station for nonambulatory patrons. A high standard of audio and visual information and direction displays should be incorporated. Stations must be well lighted and ventilated (air conditioning is generally not warranted in station areas because of the short duration of passenger stay). Restrooms should provide at least a portion of the facilities suitable for use by handicapped persons (standards are available as design guides). In addition to these design items, certain operational considerations should be made. For example, handicapped individuals should be given priority status in the use of a designated portion of the loading platform and in some portion of the car or cars. At least one special gate or turnstile should be provided which is capable of passing a wheelchair with fare-collection facilities at an appropriate height.

Other considerations that are important from both the passenger and the operator viewpoint are safety, esthetics, and types of equipment.

Any one of these systems could be adapted to comparable standards of headway, speed, performance, comfort, etc. The primary variable is cost. Previous studies for Los Angeles, San Francisco, Washington, D. C., and other locations, have shown that none of the systems now in an operational status* could equal the conventional transit in cost when developed to equivalent operational standards. Therefore, a conventional rail system could be used as the standard or yardstick against which to evaluate system costs.

d. Feeder and Distribution Service. In Metropolitan Honolulu there will be a requirement for feeder and distribution service in conjunction with the rapid-transit system. In addition, there will be local and some express service in areas not served by rapid transit. Characteristic requirements of feeder, distribution, and local service are as follows:

| | |
|---|---|
| Trip length: | Short |
| Volume: | Low to medium |
| Speed Requirement: | Low |
| Cost: | Low. |

*Except Westinghouse Expressway, which had not been developed at the time of the comparative studies.



AR00031954

It is important to regard each of these as elements of an integrated and coordinated system. Schedules should be coordinated for convenience of patrons and to minimize waiting time. The standards of service for feeder, distribution, and local transit service should be as outlined previously (page XI-22, Ref. 4).

e. Airport Service. Service to and from Honolulu International Airport requires special consideration. Work trips for employment in the airport vicinity can be served by the rapid-transit system. For visitor service to the airport, the following requirements are outlined:

| | |
|---|---|
| Trip Length: | Medium |
| Volume: | Low |
| Speed Requirement: | High |
| Cost: | Moderate consistent with service. |

In terms of the airport passenger, some major considerations must be accommodated to make the system usable and attractive.

First, the problem of baggage handling must be solved. This requires that the passenger not be required to personally transfer his luggage from the airport terminal to transit vehicle. The ideal would be for a through check from Mainland origin to Honolulu hotel. Technology for accomplishing this is available; however, overall costs (both to transit system and airlines) may not be justifiable. Lacking this capability, a minimum convenience would be baggage claim at a terminal station convenient to the hotels with transfer (both passenger and luggage) from terminal to hotel by special bus.

Second, since many of the potential passengers will not know the location of their hotel relative to the transit system, an information display listing appropriate lines and station stops (including hotel connection) for each hotel or group of hotels, will be necessary. Similar displays will be required both in the airport-terminal deplaning area and in the transit stations. This display should include a route map and transit-station locations relative to hotels, and should also have system maps and schedules available to the prospective passenger.



AR00031955

The other major item consists of distribution to hotels from station stops since, obviously, not all hotels can be served directly. Various methods of accommodating this movement are available at varying costs. They range from mini-bus to fully automated distribution systems. The selection should be made consistent with cost and derived benefit, both to the passenger and the system.

f. Advantages and Disadvantages of Fixed- and Flexible-Transit Concepts. There are certain comparable advantages and disadvantages to either concept of public transit. Some of the more important considerations should be mentioned at this point. One of the major advantages of a fixed-rail system is a very high passenger-carrying capacity, unmatched by any other present urban transportation system. Another advantage essential to attracting patronage in actual operation is that of high reliability and predictability. Since the system operates totally on exclusive, grade-separated rights-of-way, it can and must be precisely scheduled. In addition, it is capable of providing the highest line speeds for the same reasons. On the test lines in Honolulu, for example, average point-to-point speeds (including station stops at an average 0.4 mile spacing) approach 30 mph, while bus speeds through comparable areas are 12 to 13 mph.

Since any transit system must operate as close as possible to a set schedule, surface-bus operation suffers a speed penalty in that scheduled speeds must, in part at least, reflect anticipated traffic delays. This often results in what seems to passengers as unnecessary waiting time at some stops in the route to maintain schedule. In addition, surface-bus transit is not as reliable as fixed-rail service since not all traffic delays can be predicted. Therefore, one of the major problems in bus operation (this is applicable to the modal-split results produced in this program) is the ability of the system to operate at the specified level of speed and headway.

A much-less-tangible but very real advantage to rail transit is its ability to influence growth and development patterns of an urban area. Because of its passenger-carrying capacity and since the route is permanent, it has a tendency to attract development and density into close proximity with it. It can also generate added subcenters at greater physical distance since access time is reduced. While this condition also applies to bus transit,



AR00031956

it applies at a greatly reduced scale. Bus lines can readily be changed and extended to reflect growth and development, while fixed facilities are more costly to change, both in terms of time and money. Hence, the propensity to locate near a bus route is much less pronounced.

The greatest disadvantage to rail rapid transit is the very high initial captial cost involved before a single person can be moved. A bus system can be initiated with only a relatively small initial capital outlay and built up over time, producing at least some revenue all the while. A fixed-facility system cannot. Rapid systems can be "built small" initially by omitting such items as automatic train control, automated fare collection, escalators, etc.; however, subsequent installation of these systems generally increase the overall cost above what it would have been if they had been installed initially. It may also be "scaled down" to meet only current needs; but the most expensive portion of the route will still be required--that is, through the heaviest urban area. In any event, just providing structure, right-of-way, and rolling stock represents a large initial outlay of capital and, therefore, large annual debt-payment requirements. Whether an equivalent total annual cost of providing transportation (through street and highway improvement), with or without the transit system, would be necessary, is a point which can be debated both pro and con. This argument will not be presented here since it is largely a function of public policy.

Another less critical disadvantage to rail transit is that a high percentage of users would be required to transfer en route. This is still necessary in bus trips but, since the bus routing is more flexible, the transfer requirements may be expected to be reduced. (HRT, in 1965, provided free transfer to approximately 31.4 percent of total passengers.)

These, then, are some of the significant factors to be evaluated in the ultimate decision of which system will be committed to development and the sequence in which the development should occur.

g. Transfer Technology. For the Oahu Transportation Study, at this point in its investigative program, the following questions concerning transit technology must be answered:

1. Is the state of the art of transit technology such that systems are available to provide the necessary service within the criteria requirements as previously outlined?



AR00031957

2. Are transit developments possible in the foreseeable future which would grossly affect the type of service to be considered?

It is important to place the considerations of transit technology in the proper context. Transit systems are simply the means of providing certain types of service required by the community. The systems are not an end unto themselves. In particular, the search for transit systems for application to the service requirements as outlined must be constrained by two factors:

1. Such a system must be adaptable to the service in Hawaii under the specific criteria.
2. The system must be capable of being put into safe, reliable operation within the projected date for commencement of service.

Most public agencies considering transit must rely on systems which are in an advanced state of development in order that they can be assured of on-schedule operational capability and predictable costs. Research and development costs for unproven systems can amount to many millions of dollars and such systems sometimes require years of "debugging" before they can be considered operational. It is unreasonable to expect a public agency to bear all such costs and the time delay involved in the development of an entirely new and untried system. In reviewing systems proposed for use in Hawaii, it must be determined if the system has actually been successfully applied elsewhere under reasonably similar conditions, and/or if a test facility has been constructed with full development and engineering completed and proved by operational testing.

The challenge to the engineer faced with the choice of a system for a specific application is to find an advanced system taking full advantage of the state of the art in transit technology while still recognizing the required constraints. No one wants a system that will be obsolete at an early date.

The previous sections outlined the need for consideration of two types of public transit modes as part of an overall transportation system. The technology of each of these modes will be discussed in succeeding paragraphs.

1. Oahu Service--The requirements for public-transit service around the Island of Oahu have been previously outlined. With the anticipated



AR00031958

relatively small demand for public transit outside of the Honolulu area, an exploration of transit technology must be made in the light of the necessity to keep costs low, consistent with anticipated patronage and revenue. This type of service requirement provides an ideal opportunity for joint usage of the highway facilities by the transit bus and eliminates the need for fixed facilities.

Bus systems are also undergoing a change as a result of current technology. In the motive subspectrum, the gas-turbine engine looks promising. Industry sources claim a high degree of reliability and maintainability, and all indications are that actual maintenance costs might be cut in half with respect to those of conventional internal-combustion engines. However, the engines themselves are not considered economically sound for short-haul transportation operations at this time because of high fuel-consumption rates. A more efficient engine that would meet anticipated bus-system needs would be largely dependent on metallurgical technology and may be available in five years.

Articulated coaches are in extensive use in Europe. San Francisco Bay Area's Alameda-Contra Costa Transit District is successfully utilizing an articulated coach in their Trans-Bay operation. The vehicle, however, is a modified transcontinental coach originally built in Germany. Additional design changes would be required for regular transit usage. One such modification would be for additional doors.

2. Honolulu Metropolitan Transit Lines--In order to provide the kind of service required to fit into the modern transportation system, present rapid transit must meet certain requirements. Modern transit must be fast, dependable, and capable of high inter-station speeds. Station spacings must be a balance between average line speed and passenger-service demands. On this basis, dense urban areas may require spacings of 0.5 mile or less, and suburban, 0.75 to 1.5 miles. The vehicles must be of modern design, provide seats for as many passengers as possible, and have wide door openings to facilitate loading and unloading. The transit vehicles must be comfortable and safe to use and economic to operate. The system should be capable of expansion and extension as the city grows and must have adequate passenger-handling capacity to meet present and future peak-period demands. Air conditioning must eventually be placed in most rapid equipment, and research must be directed toward the development of better gears to make higher speeds safe, vibration-free, and quiet. The cost of operation must be reduced by automation and other means. Current efforts to attain these goals are best illustrated by a review of systems under construction or operating in other cities.

h. Rail Rapid Transit. Most illustrative of the effect of current technology on rail rapid-transit systems is San Francisco's Bay Area Rapid Transit District (BARTD). Although much has been written about BARTD, the real effect of recent technology shows up in automation, ticket handling, computer-controlled headway, and an improved braking system. Washington, D. C., now has a new rapid-transit system under construction, and many cities



AR00031959

have been developing new equipment and experimenting with new ideas. The Chicago Transit Authority has built the first combined rapid-transit - freeway facility in the Congress Street Expressway, which provides for rapid transit in its median. The Authority has also carried out extensive experiments with new high-speed, lightweight cars and has shown that transit patrons can be diverted from automobiles in its highly successful Skokie "Swift" demonstration. Philadelphia has purchased a number of attractive, stainless-steel cars for service on the Market-Frankford subway-elevated line. Toronto is demonstrating new techniques of subway construction and now has its Bloor Street facility completed. The previously constructed Yonge Street subway has already carried in excess of 40,000 passengers per hour and has diverted a substantial number of passengers from surface travel. It has caused a marked rise in real estate values in its vicinity and has sparked extensive high-rise developments near its stations. Other cities such as Boston and Cleveland have taken over railroad properties and, by improved service and equipment, have attracted increased patronage.

The newest subway in North America has recently opened in Montreal, when the first two routes of the City's $213-million Metro were put into service. This system features the use of rubber-tired rapid-transit equipment, patterned after similar equipment used in the Paris Metro. In just two months, the Metro Subway has attracted an average of 350,000 riders each weekday.

i. Rapid Transit in Europe. In many aspects of transit research and development, European cities have taken the lead. In these cities, most of which were developed well before the advent of the automobile, there is much more dependence on transit. It was just not possible to build the freeways and parking lots and, therefore, these cities have relied on rapid transit for a modern solution of person movement to a much greater extent than their American counterparts. The London system, while probably the world's oldest subway, has been carrying out a modernization program. New, lightweight, aluminum cars have been purchased, new escalators are being installed in many of the stations, and a new signal-control system is in operation.



AR00031960

In Paris, the emphasis has been on the development of rubber-tired trains to reduce noise and improve riding qualities. Lower operating cost and increased public acceptance are claimed. Milan has completed a new subway system that features conventional rail cars. In Stockholm, the subway is demonstrating how rapid transit can affect the growth of the city. A new shopping center and an extensive suburban area have grown up around the Vallingby and Farsta terminals, which have been cited as splendid examples of modern planning for coordinated land use and transportation. In Moscow, the Russians have developed a system featuring deep, impressive stations, high-speed escalators, and short-headway trains.

Lisbon also has a new subway and is planning extensions. Rome has had a short subway for some time and is now contemplating an extension across the Tiber. Other examples of new subway construction can be found in Frankfurt, Rotterdam, and in Haifa, Israel.

j. Monorail. To many, modern rapid transit means monorail. Certainly, fewer words have been more overworked. Monorail began with the now antiquated "Schwebebahn" or swinging railway near Wuppertal, Germany. This classic monorail system has been in operation since 1901 and is cited as the justification for the claims of millions of passenger miles of safe operation. While it is quite slow and noisy, it still is ably performing the service for which it is so aptly suited--i.e., providing transit service in the narrow tortuous Wupper Valley.

Because of problems of stability under varying wind conditions in the suspended variety and the difficulties encountered in the switching operations common to both the suspended and supported systems, no major mass-transportation system has chosen monorail since the late 1800's. However, monorails have been used for simple line-haul functions, such as in the Seattle and New York World's Fairs, at Disneyland, and other locations, such as Tokyo and Turin.

k. New System Concepts. One of the newest approaches to rapid transit is the tracked-air-cushion vehicle (TACV) combining the traditional transit-type vehicle with an entirely new suspension system--an air cushion. The air-cushion concept is not a new one; however, the TACV employs a train rather than an individual-vehicle concept. As the name applies, this air-



AR00031961

bearing vehicular system has been conceived to operate over its own roadway. A linear induction motor supplies the motive power. This particular concept is also under development in both France and the United Kingdom. There has been considerable recent publicity about a French "Aerotrain" which has been constructed at a test tract south of Paris and which has been tested at speeds up to 188 mph. Such high speeds cannot be utilized in ordinary rapid-transit service because of the frequency of stations. The inventor states that the system "is intended to complement the car for distances between 70 and 140 miles."

The Westinghouse Electric Corporation has developed a Transit Expressway that offers interesting possibilities. The basic approach is to miniaturize the rapid-transit train. Vehicles operate on rubber tires and are tied to the roadway via a lateral guidance assembly. The system is fully automated and vehicles can move singly or in trains, providing a flexible operating regime. Capacity of the system, as presently conceived, is 6,300 passengers per hour at a seat mile cost of 1.4 to 1.7 cents. A small experimental section has been built and is being operated in Metropolitan Pittsburgh.

The Hybrid Vehicle combines both fixed and flexible modes. As a transportation concept, it is similar in some respects to bus rapid transit in that it is capable of providing its own feeder system. The major difference in cept, however, is the variation in motive power dependent on the vehicle's operation over either the fixed or flexible component of the system. Individual vehicles functioning under their own power on feeder routes may be formed into trains to operate under a common system motive power over the fixed portion of the system. At the moment, Hybrid systems exist only in concept and have not been developed.

1. Feeder and Distribution Service. For regular service in feeding passengers to rail rapid transit and distribution at areas of concentrated employment or other activity, primary dependence will continue to be on the bus.*

---

*Several experiments in the use of buses for distribution service have been carried out, the most notable of which is the minibus demonstration in Washington, D. C.



AR00031962

As volume builds up, consideration is given to the addition of fixed facilities in order to minimize operating costs. Among fixed systems capable of providing secondary distributor service are moving sidewalks, the Stephens-Adamson Carveyor System, the Lockheed/Fussell System, and others.

m. Airport Service. The special consideration of service to the airport requires the evaluation of trip purpose and type of passenger. Work trips for employment in the vicinity of the airport can be accommodated by the regular rapid-transit system; however, added consideration must be given to problems of baggage handling and passenger distribution. Because of these factors, it may be desirable to segregate airport passengers from normal transit riders either on special cars or a separate train on an express basis. With modern automation and control systems, it is possible to operate special airport cars with baggage facilities interspersed with regular transit service and to provide a special terminal or terminals where such vehicles can be switched off the main transit line. Several cities in the world have provisions for transit service to serve airports. In Japan, an Alweg monorail provides service from Haneda Airport to Downtown Tokyo. In Cleveland, Ohio, a 4-mile, $14 million extension of the CTS system is being constructed to connect a downtown route with Hopkins International Airport.

2. ROAD TYPES

The type and degree of service provided by each segment of the total street and highway system will vary over a wide range of either movement or access or a combination of the two services. The criteria employed to appraise service and guide design are based on the following premises:

1. "To develop good street transportation adequately serving various land uses and to insure logical community development, it is desirable to establish a network of streets divided into systems, each system accommodating either movement and/or access to a varying, but distinctly different degree.
2. "The purpose of each street system must govern the selection of the structural features, the visible dimensions of streets, and the use of any control devices or measures, in order that the basic service of each system may be maintained and improved.
3. "Terminal facilities--which include any space, area, structure or appurtenance, either on or off the streets, used for the parking of vehicles and the loading of persons or goods--are an integral part of street transportation and must be considered in providing satisfactory service." (Ref. 4).



AR00031963

The National Committee on Urban Transportation classified roads as local, collector, major, and expressway. In developing a future network for Oahu, it was found useful to alter these classes slightly and expand them to include a freeway category. The expressway classification, which excluded freeways, was retained.

The consideration for establishing road classes is primarily a functional one, and the design and financing should be directly related to its function. The five classifications are discussed with respect to their relative function of serving abutting land uses and traffic--serving traffic being equivalent to serving nonabutting land uses.

The quantitative standards presented in this text were established around these road classifications and with the two essential planning goals in mind--increase safety and reduce travel time. Recommendations of specific highway or street design are not part of this study. If is believed that, given the roadway cross-sectional and intersectional features and speeds, the detailed engineering design work will of necessity produce the required engineering data.

a. Freeways. Freeways are the highest order of the road-type spectrum. Their function is to accommodate extremely high volumes of traffic and interconnect broad residential areas with employment centers, the Central Business District, and other concentrations of high trip-generating land. developments. Freeways are fully controlled-access roadways.

Freeways may be constructed at grade or may be elevated or depressed. In general, elevated viaducts are constructed in areas of intense existing development where rights-of-way are expensive, where the space beneath can be used for surface traffic or parking, and where cross-traffic is not interrupted. Less disruption to existing development and activities and less right-of-way cost are the main advantages in elevated-viaduct constructions.

Depressed freeways and at-grade freeways between interchanges are generally more acceptable for construction on Oahu. The disadvantages of additional right-of-way and disruption of underground facilities are more than offset by Oahu's esthetic advantages. Depressed freeways not only



AR00031964

isolate heavy traffic from surrounding developments, but also remove the facility as a visual barrier and provide additional open space which, if properly landscaped, can enhance the visual impact of the urban landscape to the motorists and roadside viewer alike.

The interconnection of freeways is accomplished by interchanges. All major movements at the junction of two urban freeways should be served by direct connections. This requirement is basic in order for freeways to function as an integrated network. In no case should movements between freeways be controlled by conventional signals as is required with diamond interchanges.

In locating freeways within urban areas, it is important to place them so as to cause minimum disruption to land developments and to urban activities. Although it is not always possible, freeways should be located along natural or man-made barriers.

b. Expressways. Functionally, expressways are the intermediate road type between streets and freeways. While major streets furnish an equally balanced service to traffic and adjacent developments, and while freeways exclusively serve traffic with only incidental service to adjacent land uses, expressways provide a primary service to traffic and a secondary service to abutting lands. Expressways are only partially controlled-access roadways.

The primary consideration in determining the type of service is the degree of access provided to adjacent properties. Local, collector, and major streets provide free access. Driveway controls and frequency of median openings found on these streets do not limit access, but rather make the properties more accessible through efficient handling of traffic. Freeway design, on the other hand, requires complete control of access and thereby total elimination of traffic conflicts caused by adjoining properties. Expressways require partial control of access. Traffic is better served and the service provided to adjacent properties is efficient and convenient but only to restricted movements.

Expressways may be considered alternates to freeways within restricted areas where freeway construction is considered objectionable. In such an area, major streets cannot adequately serve traffic or adjacent lands. Under these conditions, the service provided to abutting developments by expressways is superior to the service that overloaded major streets can



AR00031965

provide. Major streets operating well over design capacity produce congestion, delay, and accidents, and the heavy volume of through travel imposes a real barrier to vehicles crossing opposing traffic streams.

The number of lanes may vary from four to a maximum eight lanes. All traffic lanes should be 12-ft wide with 2-ft clearances at vertical curbs. In rural areas, curbs are not necessary. Through trips should enjoy relatively uninterrrupted flow at speeds of 35 - 45 mph. Removal of at-grade signalized intersections, all right-angle crossings, and left-turn movements should be encouraged and parking should be discouraged.

c. Major Streets. Major streets have as their function the movements of a large volume of traffic and the provision of access to intensive land uses abutting them. They serve those major movements within or through the metropolitan area that cannot and should not be accommodated by local or collector streets and that are not handled by expressways or freeways. They should be planned or improved to serve trips which exceed one mile in length, although much longer trips are commonplace, particularly where few freeways or expressways exist.

Efficient flow of large volumes of traffic and free access and convenient service to abutting land uses are achieved on properly designed major streets. Minimum width of traffic lanes should be 10 ft, preferably 12 ft, with additional 2-ft clearance at vertical curbs. The number of through traffic lanes should not exceed six or be less than four. Speeds on major streets should fall within 25 - 35 mph.

Medians on major streets should be provided where possible. Medians allow left-turning vehicles to be physically separated from through movements, provide refuge islands for pedestrians, and effectively separate opposing traffic flows.

Parking should not normally be permitted on major streets. Limited right-of-way and high land values require that street space be devoted entirely to the task of moving cars rather than storing them. Not only do parked vehicles use expensive street space, but they also interfere with efficient movement in adjacent traffic lanes.



AR00031966

Feeder-bus transportation is expected to use major streets and to provide increased service by 1985. To promote good mass-transit service and to remove a capacity limitation from major streets, curb setbacks should be provided for bus stops.

In the Central Business District, design standards must sometimes be compromised for economic reasons. In these areas, traffic-control techniques are important. All means and devices available to highway and traffic engineers should be employed to provide maximum ease and safety of traffic flow. Safe, efficient movement will benefit both motorists and roadside business.

d. Collector Streets. Collector streets serve the internal-traffic movement within an area of the city and connect this area with major streets or expressways. They are to provide access and service to abutting land, whether residential, industrial, or commercial, and at the same time, accommodate local-traffic movement.

Collector streets should be designed to serve short trips, which are generally one mile or less in length. To meet this requirement, these collector streets should not exceed 1.5 or 2 miles in length. Thus, to discourage long through trips, careful positioning and interrupted alignments of collector streets are essential.

Many streets will be classified as collector because of their function at a particular point in time. As time passes and the areas around these streets develop, many of the streets will take on a different character and will be called on to provide a greater service to traffic. In obtaining rights-of-way for these streets, their ultimate function must be considered.

e. Local Streets. Local streets are at the low end of the road-type spectrum. These roads function solely to provide access and service to abutting land.

Cross sections of local streets serving the needs of business, industry, or other land uses may vary substantially because of the type and volume of the traffic. The basic functions of these streets, however, do not change.



AR00031967

Local streets should not be continuous for distances greater than 0.5 mile, so that trips exceeding this length are forced onto collectors.

In keeping with the established scale at which this Study Staff will plan, local streets are not considered.



AR00031968

## REFERENCES


1. Oahu Transportation Study, Study Description, 1964.
2. Urban Mass Transportation Act of 1964.
3. "Principles of a Sound Transportation Policy, ASCE Transactions, Vol. 129, 1964, pp. 484-487.
4. Procedure Manual No. 8A, "Recommended Standards, Warrants, and Objectives for Transit Services and Facilities," Public Administration Service.
5. National Committee on Urban Transportation, "Better Transportation for Your City."




AR00031969

# XII Plans

AR00031971

# XII. PLANS

The Oahu Transportation Study has carefully documented the facts, the procedures and the considerations involved in the transportation planning process. Proceeding from this knowledge, the following text will trace the Study's initial planning efforts. Included will be a discussion on the role of mass transit, an analysis of alternate road networks, and finally, a presentation of a mass-transit system and a freeway-arterial network, including overall cost.

## A. MASS TRANSIT FACILITIES

An integrated and balanced network of transportation facilities requires that all modes of travel be carefully considered. On Oahu, transit facilities are not extensive and have therefore not received much attention in the past. It is important, however, to realize that these facilities have provided a necessary daily service to thousands of users and will continue to provide an important service to many more thousands in the future.

Of equal or greater importance in planning for the future is that mass transit, in its present or an improved form, must not be overlooked simply because its service has been limited. A careful review of past, present, and anticipated conditions should govern decisions of policy with respect to transit.

Present commercial transit in Honolulu consists entirely of buses operated under franchise by one privately owned firm, the Honolulu Rapid Transit Company, Limited. Service by this company has been keyed directly to demand and has therefore been primarily oriented to the Honolulu District, with no service offered for other movements outside of the central activities of Honolulu.

Although public mass transit is but one component of the total transportation system, the extent to which it is utilized can affect the demand for



AR00031972

other transportation facilities. Rapid transit, in particular, can have a significant impact on highway-capacity requirements, parking-space needs, and pedestrian volumes. The detailed effect of future transit usage on other transportation facilities can be determined only through continued testing and evaluation. Based on the preliminary estimates developed by this study, however, we can present a number of findings.

The major corridors of travel demand in Honolulu both now and in the future will be east-west oriented and restricted to the narrow space between the mountains and the sea. This constriction on movement means that transportation facilities of high capacity must be provided in a relatively narrow band. Such a focusing of travel demand enhances the opportunities of providing good rapid-transit service, but it also makes the provision of adequate highway capacity more difficult. The amount of congestion experienced on the highways will affect the usage of the rapid-transit system.

In early transit-usage estimates, it was noted that the estimates were based on an assumed level of future highway congestion (or highways speeds). The estimates of future highway speeds were developed by examination of estimated future highway vehicular volumes compared to future capacity across several traffic screenlines. When the modal-split model was run and new highway volumes were developed, these new estimates were compared to the capacity. Refined estimates of transit usage will require that successive runs of the modal-split model be made, adjusting highway speeds between runs until a balance is obtained between highway volume and capacity.

To refresh the reader's recollection, we summarize below the significant features of Systems No. 1 and No. 2, which are discussed in following paragraphs. Detailed descriptions of these systems are in Volume II, Chapter IX.

Based on an analysis of the one model run, it appears that:

1. In both System No. 1 and System No. 2, transit usage has been underestimated in central Honolulu in the vicinity of the Manoa-Palolo and Ala Moana-Makiki (between downtown and Manoa-Palolo) screenlines, and in the corridor between the Diamond Head and Koko Head areas as indicated by an analysis of the Kahala screenline.
2. Analysis of the Pearl City and Moanalua screenlines indicates that, for both Systems No. 1 and No. 2, transit usage is being overestimated in the Pearl City-Pearl Harbor areas.



AR00031973

3. Transit usage in the vicinity of the Kapalama and Nuuanu screenlines between downtown Honolulu and Pearl Harbor, and between the Windward areas and central Honolulu, as indicated by the Kaneohe screenline, appears to have been overestimated for System No. 2.

To put these generalizations in perspective, it should be noted that the transit estimates were less sensitive to highway-speed changes than to any of the other modal-split variables. This is particularly true for System No. 2 as this is an all-bus system, and bus speeds, as well as auto speeds, would be affected by congestion.

Guided by these general comments, we can discuss the impact of the estimated future transit usage on future land-use and transit facilities.

## 1. FACTORS INFLUENCING THE POTENTIAL IMPACT OF MASS TRANSIT ON LAND USE

The factors that may have a bearing on the impact of mass transit, for purposes of this discussion, are divided into three categories.

1. Public and quasi-public policies involve those decisions, programs, plans, and goals which will affect the formation of the future development pattern of land uses in the City and County of Honolulu. The agencies involved in these areas include the Honolulu City and County Planning Commission, the Honolulu Redevelopment Agency, and the Community Renewal Program.
2. The second group of factors includes physical barriers to development, comprising several elements. The first is the existing structures and open spaces of a usually public or quasi-public nature which are in good condition, are in the proper location with regard to their service areas, and are of historical importance and/or expensive to replace. The second element is comprised of physical elements, either natural or man-made, which in combination block pedestrian movement or act as a barrier to continuity between one area and another. These latter elements qualify as barriers depending on location, but may include high-speed freeways or controlled-access highways with widely separated pedestrian crossings, urban arterial streets with infrequent pedestrian crossings and complex intersections, and major canals or drainage courses with infrequent crossings.
3. Land tenure, ownership patterns, and land-value patterns constitute the third group of factors that may have a negative or positive bearing on the potential of the impact of a rapid-transit system and a flexible transit system on land-use patterns.

a. Planning Commission Policies. One of the most significant influences in the determination of the future pattern and distribution of land uses is the policies of the Honolulu City and County Planning Commission. Two documents within the jurisdiction of this Commission represent the land-use



AR00031974

policies of the City and County; they are the General Plan of Oahu and the Proposed Comprehensive Zoning Ordinance. The zoning ordinance has not been adopted and the General Plan is currently being updated. Therefore, pending completion and adoption, each must be viewed only as the intent of current public policy. At this point in their development, they also represent an opportunity to reflect the policy goals relating community structure and form to public transportation. Generally speaking, a review of work in progress on the General Plan indicates the continuance of the existing land-use pattern, with densities and uses reflecting the proposed zoning ordinance.

In an overall sense, the proposed zoning ordinance does not reflect transit location and may be expected to reduce the potential impact of the rapid-transit system on land use. There are two major reasons to support this conclusion--the first has to do with the requirements for parking within each zone; the second involves the land-use pattern and type of development that it fosters.

The provision of extensive parking for commercial areas not only places the auto in competition with the transit system proposed, but also pre-empts land that could be used for other purposes. This is particularly true in major employment areas such as the CBD, Civic Center, and a concentrated office center that could develop along Kapiolani Boulevard between the Civic Center and Ala Moana.

The linear pattern of commercial use plus the amount of area proposed for apartments tends to encourage the continuance of the existing structure of random areas of routine development with intervening expanses of much less intense utilization. The proposed zoning allows for a strip pattern of community-oriented commercial development and a scattered and/or "layering out" of future growth in the apartment category.

Thus, the proposed zoning ordinance applied to the present General Plan tends to reduce the potential impact of a rapid-transit system on the land-use pattern, both in the general as well as specific sense.

With the exception of the requirements for parking, which would place the use of the automobile in greater competition with that of the bus system, the proposed zoning ordinance would have only a moderate effect on the net impact of a flexible transit system. This statement is supported



AR00031975

mainly by the fact that both the zoning ordinance and the transit system generate a continuation of the existing land-use pattern.

The pattern envisioned by the General Plan would be similar to that produced by the transit system alone. The express routes would still serve the most intensely developed commercial, residential, and industrial areas, and the local systems would cover the less-concentrated centers.

The basic effect of the ordinance on the impact of a flexible system on land use is to reduce the range of uses along the routes. The ordinance does not change the spread pattern of uses, which the system on its own would reinforce.

b. Honolulu Redevelopment Agency Plans. Second only to the rebuilding process carried on constantly as the result of the requirements of the private sector for additional space, the urban-renewal program is the most important program geared directly to rebuilding the city. Whereas the private sector has concentrated its efforts on the older, obsolete, as well as the underutilized portions of Honolulu, the Honolulu Redevelopment Agency has directed its efforts at abolishing structural and environmental blight.

Of all the projects undertaken by the Honolulu Redevelopment Agency, only one has been completed, the Queen Emma Project. Though the actual area devoted to urban renewal is small in comparison to the total area that is deteriorated, and affects only one segment of the transit corridor, its impact on the rapid-transit system is significant in two aspects.

First, it is a tool for upgrading and changing a large deteriorated section of the city that, because of the extent of environmental blight, would not otherwise be improved. As a pocket of improvement, the projects mentioned can act, perhaps, as catalysts to private redevelopment. More important, however, is the fact that urban renewal, given proper direction, can help to reshape the development pattern.

Second, though urban-renewal projects are geared to take advantage of the improved accessibility provided by transit through the more efficient utilization of land, their effect is mitigated by several factors. Urban renewal, in a general sense, is a time-consuming and involved process, limited to deteriorated areas and not always a catalyst to the improvement of



AR00031976

adjacent deteriorated areas by private initiative. In order to maximize the effect of urban renewal along the remainder of the transit corridor within the deteriorated areas of Honolulu--e.g., the Kalihi and Kapalama Districts--an extensive program may be required, timed with the introduction of the system.

c. Community Renewal Program. The goals and objectives of the Community Renewal Program of the City and County of Honolulu are generally understood* as the following:

1. To assess the condition of the physical and social environment of the City and County of Honolulu.
2. To determine the total renewal needs and goals and objectives of the Island.
3. To develop a program for the improvement and restructuring of the physical environment in line with other public-improvement projects executed by other Federal, State, and Local agencies.
4. To establish priorities for the execution of community-wide renewal actions.
5. To coordinate these projects with transit, poverty, highway, and other public improvement programs.

Though still in its initial phase of operation, the Community Renewal Program has developed a conceptual framework for its future activities that includes the following:

1. The development of satellite towns outside of the corporate limits of Honolulu to house lower-income families who work in and around Honolulu through:
   a. Provision of subsidies for land acquisition and/or rents, as well as low-cost loans for those who will purchase homes.
   b. Development of transit to serve these outlying areas, first high-speed express buses and later a fixed system as demand increases. Since the transit system will obviously not be able to pay for itself because of high cost and low initial ridership, it too should be subsidized.
2. Concurrent with the development of satellite towns, CRP proposes to judiciously demolish segments of the deteriorated sections of downtown Honolulu. Emphasis would be given to those areas immediately around transit stations.
3. The establishment of a high-intensity, pedestrian-oriented urban core.

---

*Based on an interview with the then Project Director, Philip D. Brown.



AR00031977

The Community Renewal Program (CRP) does not contend that all of this demolished land will be absorbed immediately. It is proposed that, on an interim basis, the land cleared in the inner city be devoted to areas for parks and parking. The attempt would be made during this interim period to establish an open-space-pedestrian system that would remain after the open spaces and parking lots around these pre-planned parks are developed for residential, commercial, and industrial uses. As yet, no program for the implementation of this concept has been devised. Potential project sites, financing, and urban effect are in the study phases.

Although the basic intent of the CRP program concept described above is to "maximize" the utilization of a fixed transit system, it is too early in the program to ascertain how this goal could be attained. Considerations of costs, timing, and the location of renewal projects adjacent to transit stops are of primary importance.

The effect of CRP on the impact of a rapid-transit system has both negative and positive aspects. The realization of new satellite towns may reduce the demand for land in the inner city to the extent that in-town rebuilding would not occur at the expected density, thus reducing the intra-urban demand and increasing the inter-urban movement, much like a commuter railroad service. This outcome remains for further analysis to determine. On the other hand, a coordinated community-renewal-transit program, carefully staged, could result in creating the type of city structure that would take maximum advantage of intra-urban transit.

Essentially, the Community Renewal Program has little reference to a flexible transit system; however, given the ability of the transit system to successfully transfer people from cars to buses, the CRP could be instrumental in concentrating development in the urbanized portion of Honolulu that is tied to lower-density satellite cities by express bus routes. In this sense, the kind of transit utilized is less important than the need to devise the means by which the land around the system is most efficiently utilized to promote optimum use of the system.

d. Physical Barriers to Development. In a study of the impact of transit on land use, a consideration of the physical barriers to development is of importance for three reasons. First, it serves to identify those



AR00031978

permanent (as well as semi-permanent) locations of particular uses or facilities which by themselves influence the form and pattern of future growth. Thus, a large park, a grouping of public uses, a freeway, a major arterial street, mountains, or a waterway may act as the line or area of demarcation between one part of the city and another. Second, these factors may have a tendency to limit or maximize the effect that a transit system could, on its own, have in reshaping the form and structure of future growth. Thus, a particular arrangement of pre-empted land, in public or institutional use, for example, or the presence of other physical obstructions in the path of the transit system, may have an important influence in both routing and impact.

For purposes of this level of analysis, it was assumed that public uses--parks, schools, churches, hospitals, fire and police stations, and the like--are more or less permanent in their location. Major urban arterials, complex intersections, and high-speed expressways and freeways were classified as those physical elements which act as breaks or barriers in the continuity of development between one area and another.

In general, major physical barriers have less of an effect on reducing the impact of the rapid-transit system on land use than do the permanent uses. A rapid system, whether it is designed to operate underground or above grade, can bridge these dividers, thus effectively providing "pedestrian" connection from one area or district to another at the transit stations. In the case of permanent uses, the potential for the concentration of high-density uses adjacent to stops is reduced to the extent that these permanent uses pre-empt the land in those locations.

A flexible system uses existing and future freeways, highways, and major arterials, and it is assumed that bus stops will consist of no more than reserved areas along curbs. These roadway dividers will not change the impact of the system on the overall pattern of land uses. Moreover, since bus stops are not fixed to certain corners and can be replanned at any time to meet transit demand, the location of permanent uses does not inhibit the layering over of the existing arrangement of uses that the system will, to some extent, encourage. Any concentration of new growth along bus routes will merely "skip over" such permanent places.



AR00031979

e. Land Tenure, Ownership Patterns, and Trends of Development. These three factors have a basic influence on the locations at which private development in Honolulu will occur. In this regard, ownership patterns and land tenure play the most important role. Not only is there a shortage of buildable land on Oahu, but a large portion of this buildable land is held by estates. The remaining portion is in individual ownership. Both types of ownerships exert negative and positive influences in the upgrading and redevelopment of land in Honolulu.

In a positive sense, estate land has somewhat the same potential for redevelopment as does urban renewal. This is true to the extent that most estate land is in the form of large blocks, eliminating the time-consuming process of first buying up individually owned parcels and then demolishing and replacing existing structures. In addition, this potentiality for the redevelopment of estate lands has recently been given impetus as the result of a recent ruling by the Supreme Court of the State of Hawaii. All lands are now assessed at their highest and best use, even though they are not being put to that level of use. Thus, estates will be forced to maximize the income from these lands in order to offset the cost of increase taxes.

In a negative sense, lease-held or estate-owned lands may be as difficult to redevelop as parcels in fee-simple ownership. Each segment of estate land is broken into individual leases. Depending on the provisions of the base length of lease and the conditions under which the lease can be broken, redevelopment of estate lands may be delayed.

Fee-simple lands on Oahu generally are more difficult to upgrade than estate-owned lands. In addition to the proliferation of small parcels, fee-simple lands are inflated in value. The unwillingness of landowners to sell until they receive "the proper value" for their land, in some areas, makes parcel assemblage and redevelopment so difficult as to make the land undesirable.

f. Economic Considerations. The problem created for City Government by the introduction of a rail rapid-transit system is that it must be financed. Because city revenues depend so heavily on property taxes, and thus on the level of assessments, any public investment that can accelerate urban expansion and boost real-estate values could push assessments to the point where



AR00031980

increased tax revenues may be as great as the financial burden incurred. The question as to whether the introduction of rapid transit in Honolulu would, by itself, tend to enhance land values to cover the system's development and capital costs depends greatly on whether or not the changes in land uses associated with rapid transit do occur and whether these changes actually bring about an increase in aggregate community real-estate values [Ref. 1].

For example, the post-war introduction of rapid transit in the City of Toronto was accompanied by an enormous building boom. Some in Toronto have argued that the transit line triggered the boom. The Toronto Real Estate Board, for example, estimated that, of the $15-billion increase in appraised value of land and facilities in metropolitan Toronto over the last ten years, $10-billion is directly attributable to the effects of the 4-1/4-mile Yonge Street transit line. "Properties along the line have doubled and tripled in value, and in some instances, have increased by as much as 1,000 percent. Sales of $125 to $150 per square foot are commonplace near downtown stations."*

There is, however, some question as to validity of these estimates. As the Metropolitan Toronto Planning Board wrote:

> "While it is possible to show that the Yonge Street Corridor has shown the greatest assessment increase within the City of Toronto, no one is able to state what would have occurred had the subway not been developed. The very fact that the subway was constructed along the line of greatest potential obviates easy conclusions that it was the subway per se which attracted the development."

(1) Type of Land Affected. Rapid transit is likely to affect the value of most private land. However, the impact on some land uses is more readily identified than on others. The impact on residential land, for example, is comparatively easy to determine; it is less so for industrial and other uses.

There are monetary, time, and convenience benefits associated with rapid transit compared with other forms of transportation, and these benefits provide at least a rough measure of the value of living in residential areas

---

*Address by P. Warren Heenan, Past President and member of the Toronto Real Estate Board, before the Institute of Rapid Transit Workshop Conference, IRT Annual Meeting, Boston, Massachusetts, June 15, 1966.



AR00031981

with transit compared with areas without transit, all other things (public policy zoning, amenities, etc.) held equal.

On the other hand, choice of location for industrial, commercial services, or headquarters of business functions is governed, to a greater extent, by a number of considerations, such as cost and availability of land, work or communication interdependencies with other firms, labor supplies, etc. Lack of adequate data at this time, showing the importance of the transportation consideration relative to all others, precludes any meaningful appraisal of the impact of rapid transit on non-retail business and industrial locations. Consequently, this area of the economy was considered in this study at this time.

It is possible to identify in at least a general way, however, the changes that will probably take place in retail sales and some services. A change in the form of transportation by a number of Honolulu's citizens is likely to have an effect on shopping habits and, thus, store locations. Some commercial areas will grow relative to others and, to a degree, these changes are potentially measurable. It is not possible, however, to quantify this impact until more finite estimates are made of the redistributive effect on population, employment, zoning and land use, etc., prompted by the overlaying of a transit network on the region.

(2) Means Whereby Residential Land Values are Affected by Transit. Rapid transit is likely to have two effects on residential areas. One, because it represents in a sense an increase in real income to a given neighborhood through reduced transportation time and costs, it can result in added incentive for more persons to live there. Because of this greater demand, prices of properties near transit may be bid up, even though dwelling unit and population densities do not change.

The second effect is that land prices may be bid up to the extent that land will have a reuse potential, to a higher and better use, and apartments (and thus greater densities) begin to replace single-family units or larger apartments replace those with fewer units. Here, demand increases, but supply, in the form of more dwelling units, also increases to meet the new demand.



AR00031982

With respect to the first effect, the value of locating near rapid transit is related directly to savings in cost and time resulting from use of this mode over alternative forms of transportation. The major cost savings would be for work trips, although accessibility to shopping centers, cultural and sporting events, government affairs, and other major focal points are important also.

## 2. IMPACT ON HIGHWAY FACILITIES

Analysis of the east-west corridor volumes in the central portion of the urban Honolulu area in the vicinity of the Manoa-Palolo and Ala Moana-Makiki screenlines strongly indicates a highway-capacity deficiency toward the later part of the forecast period. Indications are that congestion would be quite severe on highway System No. 1 and that, even if the improvements envisioned in highway System No. 2 were installed, congestion would be moderate. It is clear, therefore, that both the highway improvements and the rapid-transit system will be required by 1985.

The capacity of the major east-west streets and highways at the Ala Moana-Makiki screenline ranges from approximately 240,000 vehicles per day for System No. 1 to 300,000 vehicles per day for System No. 2 (both directions). Forecast highway volumes for 1985 indicate a demand of about 300,000 vehicles per day, with some variance depending on which transit system is adopted. Thus, additional highway capacity of up to six freeway lanes is indicated for this screenline.

At the Manoa-Palolo screenline, east-west capacity is about 290,000 vehicles per day, without the Makai Arterial, whereas forecast volumes are in the vicinity of 320,000 to 360,000 vehicles per day. There thus appears to be a definite need for the additional capacity provided by the Makai Arterial.

At the same time, the rail rapid-transit system will be carrying approximately 85,000 to 90,000 passengers per day at the Manoa-Palolo screenline and 125,000 passengers per day at the Ala Moana-Makiki screenline. Improved transit therefore can influence the requirements for highway capacity as the rail transit system will be carrying the equivalent of six to eight freeway lanes in this area.



AR00031983

East-west-corridor volumes to the west of the CBD, in the vicinity of the Kapalama and Nuuanu screenlines, indicate similar capacity deficiencies by 1985 unless the improvements indicated in System No. 2 are carried out. For System No. 1, highway-capacity deficiencies on the order of 50,000 to 60,000 vehicles per day are indicated for these screenlines, whereas, even if the improvements envisioned in System No. 2 are made, a capacity deficiency of 30,000 vehicles per day is estimated for the Kapalama screenline. Although it is clear even from the preliminary estimates that the rail system can attract some 60,000 to 85,000 passengers per day in this corridor by 1985, six-lane freeway or its equivalent would be required in view of the fact that transit system volumes are peak-hour oriented in nature.

Perhaps the most clear-cut capacity deficiency on the highway system is noted just to the east of Diamond Head in the vicinity of the Kahala screenline. Neither System No. 1 nor System No. 2 has capacity in excess of 40,000 vehicles per day in that area, whereas the highway forecasts indicate volumes on the order of 80,000 to 90,000 vehicles per day crossing this screenline. Future studies should consider the possibility of extending the rapid-transit system to the east of its System No. 1 terminus to the Hawaii Kai area.* Such an extension may well relieve, or at least delay, the need for construction of the extensive additional highway facilities needed in light of the preliminary estimates made in the course of this study.

East-west highway capacity in the vicinity of the Moanalua and Pearl City screenlines indicates that the highway-capacity plan of 140,000 vehicles per day for either System No. 1 or System No. 2 is adequate throughout the forecast period.

The highway capacity of approximately 105,000 vehicles per day across to the Windward areas of Kaneohe and Kailua assumed in both systems appears to be adequate for either system.

Highway capacity to Wahiawa across the Waipio screenline, with a capacity of 78,000 vehicles per day and volumes of 50,000 to 60,000, appears to be more than adequate throughout the forecast period.

---

*This future study is discussed on page 72.



AR00031984

The above observations relating to highway-capacity deficiencies and the impact of future transit usage thereon, are based on a single run of the Honolulu modal-split model. In order to obtain more reliable estimates of future highway needs, additional runs of the model are essential so that a balance can be obtained between the assumed highway-facility speeds and capacities and those that actually result on assignment of the highway trips predicted by the model. The decision to increase highway capacity, or to decrease assumed highway speeds, in order to obtain such a balance is a matter of public policy, which must be guided by more detailed economic analyses than are within the scope of this study.

### 3. IMPACT ON PARKING FACILITIES

Most parking in the Honolulu area occurs on streets or in surface lots. The land area presently required for parking is particularly evident in the central area of the city. It is expected that future parking demand will be increasingly supplied through construction of parking garages. A rapid-transit system would reduce the need for parking space, particularly in the CBD, Waikiki, and other densely developed areas.

Downtown Honolulu had a total parking-space inventory of about 8,640 spaces in 1960*. The majority of the spaces in the CBD are for long-term parking by workers employed downtown.

Because of increases in downtown employment and additional commercial development, considerable additional CBD parking demand will be generated in the future. Construction of a rapid-transit system could significantly reduce this demand and will allow downtown development which might not otherwise be economically feasible because of parking space and highway-capacity limitations.

This is not to say that additional parking beyond that presently available in the downtown area will not be required. Regardless of the total number of actual spaces that may be required, however, it is possible to

---

*Since 1960, there has been an increase in parking spaces in Municipal lots but a decrease in curb and commercial parking.



AR00031985

estimate the number that will not be required if a rapid-transit system is available to relieve the commuter demand for parking.

Using estimates of the 1985 transit trips to the CBD with and without rapid transit, a determination was made of the difference in 1985 CBD parking-space requirements with and without rapid transit, as shown in Table 12.1. It is estimated that approximately 10,000 more parking spaces would be required downtown if transit service were maintained at its present level of service than would be needed with a rapid-transit system envisioned in System No. 1. Actually, the difference between the additional spaces required in 1985 if no improvement were made in transit service and the additional spaces if a rapid-transit system were built would be even greater than 10,000, as considerable improvement would be required to offset the present downtown trend in transit patronage. If this additional parking-space demand were supplied by construction of multi-level parking garages, to which there is no apparent alternative, then, on a typical cost of $2,000 per parking space, an investment of $20 million would be required. In addition, considerable space would be absorbed by parking which might otherwise return greater economic benefit.

Table 12.1. Comparison of 1985 Downtown-Parking-Space Requirements in Honolulu With and Without Rapid Transit

| Trip Purpose | Estimated 1985 Daily Transit Trips to CBD | | | Reduction in Parking-Space Requirements** With Rapid Transit |
|---|---|---|---|---|
| | With Present System* | With Rapid Transit | Difference (No. of Trips) | |
| Work | 10,401 | 27,742 | 17,341 | 7,120 |
| Other | 14,647 | 39,469 | 24,822 | 3,000 |
| TOTAL | 25,048 | 67,211 | 42,162 | 10,120 |

*If transit service is maintained at this present level, it is assumed that 1985 transit trips will approximate observed 1960 transit trips to CBD.

**Based on accepted parking-space requirements per person trip for work and other purposes [Ref. 12.2].



AR00031986

4. IMPACT ON PEDESTRIAN FACILITIES

Rapid transit in Honolulu will cause many persons to convert from autos to mass transit. Pedestrian circulation requirements would thus be changed. Downtown rapid-transit stations must be designed into the downtown plan so that the need for efficient distribution of large numbers of pedestrians can be accommodated.

Additional studies must be made as rapid-transit plans are refined to assure that the distribution efficiencies are realized. Consideration must be given to pedestrian capacity, conflict with vehicular traffic, mechanical pedestrian-distribution devices, grade-separated pedestrian facilities, and integration of pedestrian facilities into buildings either above or below street grades.*

Detailed investigation into the impact of rapid transit on other transportation facilities must be undertaken as more detailed information on the rapid-transit system itself becomes available.

5. IMPACT ON THE FUTURE CITY [Ref. 1]

It has been assumed for purposes of this discussion that the primary area of influence is a one-quarter-mile radius or five-minute walking distance primarly radiating from each transit stop and to a lesser extent along the length of the transit corridor. The primary area of impact is, thus, the transit corridor within which the fixed facility is to be located. The secondary area of influence is a quarter-mile or five-minute walking distance from a bus stop along each of the feeder-bus routes.

a. Rapid (Fixed Facility) Transit. The fixed facility, because of its ability to move large volumes of people in multiple vehicle arrangements at frequent intervals along an unchanging alignment without interruption from other modes of transport, can cause significant impact on the use of land in proximity to the corridor. More specifically, the primary area within which this effect is most intense is around the entrances and exits of the system.

*These matters are now being investigated by Victor Gruen and Associates, CBD consultants, for the City and County of Honolulu.



AR00031987

The location of a transit stop at any point along the corridor immediately increases its accessibility to other points within that part of the land-use structure through which the facility passes. It also causes increased demand for the land around the stop, because of increased accessibility. The net result of this chain of causes and effects is a tendency for the land-use pattern to become reorganized and restructured.

In general terms, this could mean for Honolulu an intensification of development around each of the transit stops. It could also mean the strengthening of existing centers and the establishment of new ones. The existing pattern of land uses does, however, have a bearing on the distribution of these changes. This means an intensification of development, especially within Waikiki, at Ala Moana Center, Civic Center, and the CBD. Within the areas between these major generators--along the Beretania corridor and Kapiolani Boulevard--new clusters of high-density development could occur.

On the fringes of this total urban corridor, especially at the beginning of the fixed-facility corridor, there could be a tendency for the clustering of local convenience-retail and some multiple-residential development.

As for accessibility, the rapid-transit system can bring areas closer together in terms of time, enabling the development of continuity as well as new points of transition between existing activity centers. Waikiki will be on a direct line with the airport, the CBD, Civic Center, and Ala Moana Center. By means of a ride on a feeder-bus route, all of Honolulu has access to the transit corridor that connects the resident population with the major civilian-employment areas in the downtown as well as the military employment areas at Hickam AFB and beyond, toward Pearl City. The rapid-transit system could also act as the generating force for the renewal of deteriorated sections of the city.

In summary, a rapid-transit system can effect change in three ways:

1. It offers the opportunity for concentration of development along a given corridor.
2. Second, the location of station stops within the corridor has a tendency to distribute the development, not only to existing high-intensity activity centers, but also to areas that would not have otherwise become more concentrated.



AR00031988

3. Third, this regrouping of growth has a tendency to create a new pattern of development--i.e., the clustering of activities joined by groups of low-intensity development and open space.

In terms of Honolulu, these changes mean: 1) continued concentration of resort development in Waikiki, 2) continued growth and diversification of Ala Moana Center as an expansion area for office development and apartments related to the Civic Center and CBD, 3) revitalization of the Beretania corridor, with a clustering of activities around station stops, and 4) the restructuring of downtown Honolulu into a continuous series of sectors of more intense development than now, oriented internally to pedestrian movement, stretching from the CBD to Waikiki.

b. Flexible Mass Transit. The flexible system, in contrast to the rapid system, operates in a flexible alignment in the same channel with private motor vehicles. Similarly, and because of the flexibility of routing, the location of stops is not fixed at a given point.

In addition, whereas in the fixed portion of the rapid-system passengers can be moved in large volumes in multiple-car arrangements, in the flexible system the same movement is accommodated by one or possibly two vehicles with smaller passenger capacities. The design of the flexible system, therefore, permits interruption of private vehicular traffic and, as a result, indicates not only slower movement of transit vehicles than in the rapid system, but also the inability of the system to move an equal number of people within a given period of time.

Without making assumptions as to the number of riders who can be expected to use the flexible system and the corresponding reduction in private-motor-vehicle traffic, it can be stated that the flexible system would have a much different impact on land use than would the rapid system. Holding equal all other factors that would influence this impact, it can be expected that the flexible system would reinforce the existing pattern and concentration of land-use activities.

There are two reasons for this. The first has to do with the flexibility of a bus system and the second concerns the type of service provided various areas in Honolulu.



AR00031989

Uncommitted as it is to a fixed, visible alignment or stops, a bus system has the ability to change its routing and stops to serve areas of concentration. Moreover, the fact that a bus system usually locates stops with greater frequency along a given route (sometimes at every other corner) than does a fixed-alignment transit system provides uniformity of access along a given route. As a result of this, development will have a tendency to concentrate within existing centers of activity as well as spread equally along the corridor. Development would take the form of another layer over the existing land-use density framework of the city. Since the system is designed to serve the most concentrated portions of the city, it could be anticipated that such growth might occur in the same way without the introduction of an improved bus system.

Thus, the impact of a flexible system on the land-use pattern of Honolulu, holding all other factors in abeyance, is that of continuing, if not spreading out more evenly, future growth on the existing framework. If in fact the system actually does have an impact of its own, apart from what would have occurred without it, the Beretania corridor and Kalihi areas will remain at much the same level of intensity of development, while the Civic Center, CBD, Ala Moana, and Makiki areas, along with Waikiki, will grow in much the same manner as projected.

## 6. PLANNING AND URBAN-DESIGN CONSIDERATIONS

The final area of impact to be considered at this time concerns the impact of a transit system on the urban design features of the community. As discussed previously, a rapid-transit system tends to have a catalytic influence on the reorganization of the pattern and intensity of land uses around each station stop. It is also clear that simply placing the transit system in a particular location is no assurance of a beneficial effect. In fact, under certain circumstances, the effect in the immediate area of influence could well be negative.

Since overhead construction in existing street right-of-way is the least expensive fully grade-separated system and, therefore, provides the greatest system coverage for a given cost, it should receive serious consideration. Unfortunately, this configuration is also the most likely to have a negative impact on adjacent properties outside station areas. Subway, on the



AR00031990

other hand, has little or no impact except in the area of stations. (The derived impact through accessibility may be considered essentially equal in either case, hence, the impact considered here is largely visual.) Therefore, if overhead construction is to be used, it must receive careful treatment to produce a maximum positive impact rather than creating an element of physical blight.

## 7. FREIGHT ON RAPID TRANSIT

In general, the purpose of the present study of mass transit in Honolulu and Oahu is to determine the applicability of alternative forms of mass transit in meeting the transportation needs of the region. The primary concern in such a study is the transportation of people, particularly during peak hours during the home to work and return commuting periods. This is the function for which transit, and particularly rapid transit is ideally suited and therefore must be the basic criterion for its location, equipment selection, operation and justification.

Since construction of a rapid transit facility, however, requires a substantial capital investment and is sometimes represented as being quite expensive for the limited time of its effective use each day, every effort should be made to maximize its utility within the community. Several potentials exist for increased utilization, such as inducements to use the system in off-peak periods for shopping, social, recreation, and other nonwork-oriented trips. Another potential is in the area of freight handling.

The Origin and Destination Study conducted in 1960 provided data on truck movements throughout Oahu. These data were analyzed to provide trip ends within each study zone, broken down by trips into and out of every zone from every other zone, as well as trips entirely within each zone. From an analysis of these trip-end tables, it is possible to define the areas that generate the largest volume of truck traffic. Since virtually all goods are transported by truck on the Island of Oahu, it is apparent that areas of major truck traffic are also major origin and destination points for goods and commodities.

From the above analysis, it is possible to locate zones that show a high level of truck activity: the CBD and Honolulu Harbor, a small portion of



AR00031991

the Civic Center (Post Office), the Iwilei and Kapalama industrial areas, the industrial area ewa of Kewalo Basin, Ala Moana, and Pearl Harbor. It should also be pointed out that not all of the trip ends involve freight (or goods) hauling. Also included are all trips of service, repair, and maintenance vehicles, including pickups and panel trucks. Therefore, analysis of the trip ends alone is not sufficient to relate goods handling to the potential rapid-transit system. It is necessary, in addition, to examine the land-use characteristics and the commodity types handled.

Of the areas indicating major truck trip-end locations, only Iwilei and the military areas show a large volume of intrazonal trips that indicate major local distribution centers. Essentially, what is indicated is a high percentage of individual destinations within each of these traffic generators from regional-distribution areas. Further, when the small O-D zones are aggregated into somewhat larger districts of comparable land use, it becomes apparent that large numbers of these trips are made to zones immediately adjacent and relatively few are of significant length. This observation is borne out by an analysis of trip length; more than half (54.7 percent) of the total truck trips made on Oahu use only 10 min or less in length, and 20.6 percent are 5 min or less. The highest single trip-length volume occurs at a 4-min trip (13,608 trips, or 11.8 percent of total trips). Further indication of short trip length in the urban area is found in a study of the Honolulu waterfront, carried out in 1961, which showed that, in 1960, 90 percent of the total truck trips from the harbor area were within a 2-mile radius of Pier No. 2 and that 60 percent were within a mile.

Consideration of goods handling on rapid transit could involve anything from moving small parcels, as a courtesy to transit patrons, to full-scale freight operation. Therefore, it is essential to look at the various operational requirements that could be involved over this spectrum. This discussion will be limited to rail systems, since freight is of much less concern on an all-bus system.

The operations aspect to be considered include duration of station stop time, loading and unloading methods, personnel requirements, security,



AR00031992

acceleration and deceleration of trains, headway requirements for passenger trains, grades, power requirements, etc. In addition to operational differences are several items of cost consideration; these include station size, structural adequacy of overhead sections, truck access and loading docks at stations, handling equipment, platforms and platform height, added maintenance of way caused by increased loads, etc. At this point in the study, no attempt will be made to solve the problems imposed. Instead, only discussion of general effect will be included.

a. Station Delay Time. It is possible to adapt rapid-transit lines to the movement of goods under special conditions. Containerized shipments and mail in sacks can be handled. The use of these methods requires mechanized handling of containers to hold the station delay to a value no greater than the 20 seconds often assumed as station delay for rapid-transit equipment. Any equipment (and automated handling devices or systems) involved in this load-unload operation or distribution system would be required to have a high degree of reliability, since any delay in a combined passenger/freight operation could result in tying up the total system.

b. Internal Handling and Distribution. Trainmen will be required for operation of the freight-handling devices, and platform space must be reserved for freight use. If station platforms are lengthened for this purpose, the added capital cost must be considered. It may be possible to use movable barriers to set aside parts of station platforms for freight use.

However, after unloading on the platform, some means of getting the goods to the point of actual use must be provided. In the case of major freight destinations (such as Ala Moana or a central post office), it may be possible to move the cargo by conveyor to a central receiving point in the destination area. Unless separate loading areas are provided (requiring either added platform length or time penalty for separate stops) such equipment could be extremely hazardous to passengers under a joint operation. The provision of such facilities becomes one of economic trade-off, particularly when the system is grade-separated (subway or overhead). In less-concentrated areas of cargo destination, a distribution center would be required to permit truck distribution to disparate destinations.



AR00031993

c. Security. In addition to the safety of passengers, the question of liability for theft or pilferage must also be considered if packaged or containerized goods are to be loaded and unloaded automatically and distributed at low-density points on the system. The entire operation must be confined to a secured area into which only authorized personnel would be admitted, and guards would be required in most installations.

d. Headways and Performance. At peak hours, headways of 2 min are usual in rapid transit and it is stated that 1½-min headways may be used, as in the BARTD system now under construction and on some lines of London Underground. Performance of rapid-transit trains usually involves accelerations of 2½ to 3½ mphps, and maximum speeds of 55 to 80 or 90 mph. It is obviously not possible to secure accelerations of the same magnitude with locomotive-hauled freight cars. If all bogies are powered, it is possible to conform to these speeds--however, at a penalty of motor size and power demands.

To accommodate varying passenger-load demand from peak to base requires either variable car make-up or variable headway. For freight handling, the latter has better prospects of feasibility. Even so, unless very rapid loading can be provided, this requires that freight and passenger service be conducted by separate trains, since the slowing of base service by prolonged stops to work freight would degrade service and make rapid transit unable to compete with the automobile except at peak hours. Freight trains running between passenger trains would be able to make up stop delays if not all stations are freight stations. If all stations are to be freight stations, some provision of run-around tracks for freights to be passed by passenger trains might be necessary. The added cost of these would be large on subway lines, and substantial even on elevated structures. Sidings could be adapted only to run-through operation, as it would be objectionable for the freights to back out into a main line.

e. Costs and Revenues. As pointed out, provision of added station area, extensive automation and equipment, distribution methods, right-of-way, added personnel, higher power requirements, heavier cars and structures, etc., will all add considerable cost to an already expensive system. It is, therefore, generally not reasonable to assume that the revenue-producing ability of



AR00031994

rapid transit can be improved commensurately by addition of full freight capability. If anything, the opposite may be expected.

If freight movements are made only late at night and early morning hours when passenger volume is at a minimum, many of the operational problems can be reduced or eliminated. However, then the economics of the additional expenditure become even more questionable. This is apparent since highways and other traffic facilities are also very lightly used during these hours. Numbers of lanes and other design requirements could not be reduced because they must be predicted on maximum demands to accommodate daytime traffic in any event. Therefore, before a system is committed to freight handling, the specifics of the particular installation must be very carefully evaluated.

f. Marine Cargo. There are several negative factors to handling marine cargo via rapid transit. First is the average trip length of goods leaving the harbor area. As pointed out earlier, average truck trip length is less than 2 miles, and this is too short to be considered economical for transit application. From this trip length, it would appear that the majority of all goods are sent to centrally located distribution centers where jobbers, wholesalers, and major retail outlets maintain warehousing.

One notable exception is the Ala Moana Center, in which a central container-receiving center is maintained to break down containers and distribute goods to the retail outlet. However, there is no comparable concentration of consumer goods elsewhere on Oahu and it is questionable if another of equal magnitude could be supported.

Eighty to 90 percent of all cargo (excluding bulk) handled by Matson Navigation Company is containerized and, of that, 75 to 80 percent goes directly over the road in container lots. On that basis, an extremely large destination concentration would be necessary to permit rapid-transit application. For example, the military is a major recipient of container cargo, primarily at three locations--Pearl Harbor, Fort Shafter, and Schofield Barracks. During the first nine months of 1966, the Navy received 1,700 containers and the Army, 1,100; on an annual basis these represent 2,260 and 1,470, respectively. Matson representatives estimate a future potential for 3,000 to 4,000 additional units annually for a combined total of approximately 7,000 units



AR00031995

per year. In terms of present transport methods, this represents 7,000 annual truck trips to and from the bases. If carried by transit (assuming six-car trains and two containers per car), this would require only 584 trips for the combined service, or slightly over two trips per day on a six-day schedule.

Receipt of containers at the harbor is not uniform, however; instead, they have extreme peaking factors which require immediate dispatch. As ships get larger and arrive in groups, these peaks are expected to increase. Therefore, a system could be saturated one day and virtually empty the next, further complicating the scheduling and operation of a rapid-transit system.

Other negative factors of marine containers are the size and weight. Matson containers are 8-ft wide, 8.5-ft high and 24-ft long. The maximum gross weight is 50,000 lb. Obviously, not all containers will reach maximum load; however, the car and structure would have to be designed to accept the maximum. Therefore, a loaded car (55-ft long with two containers) may be expected to have a maximum gross weight of 125,000 to 150,000 lb. A comparable-length transit car of modern design may be expected to weigh 50,000 lb or less empty and approximately 72,000 lb at peak schedule loading (150 passengers at 150-lb average). The impact on structural demands, if any portion of the system were elevated, and the power requirements to provide comparable performance, are apparent.

From the service standpoint, the location of the harbor area, particularly the container yards, is a major deterrent to direct connection by the system. A location this far makai would provide inadequate passenger service to the CBD and most of the Civic Center as well; therefore, a connection to the harbor would require either parallel trackage or a subway connection through the most difficult section of Honolulu from a construction standpoint.

These considerations of short trip length, requirements for heavy concentrations of destinations at service points, increased structural and power requirements, increased system costs and operational problems, plus an off-line location would indicate that inclusion of marine cargo is not practical for a transit system in Honolulu. The impact of future developments at Barber's Point or other distant locations cannot be evaluated on present data; however, even if rail service appeared warranted, the total economics of



AR00031996

combining services within the urban area versus a separate line to the Pearl City area, where joint use of at-grade trackage to Barber's Point could be used, would require detailed analysis.

g. Air Cargo. Of all potential cargo-transport possibilities, the transportation of air cargo to one or more central distribution points in the urban complex seems most favorable. There are some fundamental reasons for this: 1) a single O-D point (with limited distribution) at Honolulu International Airport which is coincident with a point of high passenger potential; 2) a more favorable volume-density relationship of air cargo; 3) an apparent longer trip length for much of the air-cargo volume; 4) the probability of baggage and air-cargo handling compatibility; 5) the high volume of mail handled at the airport.

Considered separately, the first point is perhaps the most significant: the Airport Complex provides a significant concentration of both goods and people. It is also a point of both origin and destination for both. The spatial separation of passenger and freight facilities is favorable and would lend itself ideally to automated freight handling. The urban-destination points of air cargo are more closely related to passenger trip ends. For example, it was shown in the discussion of commodity breakdown [Ref. 1] that over 50 percent of incoming air cargo consists of department-store merchandise; hence, the CBD, Ala Moana, and Waikiki would be logical drop-off points. These points are also directly related to airport-oriented person trips--CBD and Civic Center are growing centers of business, Ala Moana also has this business-trip potential coupled with apartments and apartment hotels, and Waikiki is the tourist center with apartment-hotel and resort-hotel attractions. These are also major attractions for commuter trips and, hence, are on line. (This statement would also apply to intra-urban distribution, provided that an equal condition of freight origin were located or developed on line.)

The second point is directly related to system cost. The new family of air-cargo containers bases their incentive-rate structure on a minimum density of 7 lb/cu ft [Ref. 3]. The stated maximum load of 10,000 lb and an indicated maximum capacity of 520 cu ft provide a maximum density of just over 19 lb/cu ft (compared with 35.3 for a Matson container). The



AR00031997

savings in handling these containers would lie in lighter and faster loading devices, smaller container size, smaller distribution equipment within station areas, etc. Another cost factor stems from the impact of freight operations on structure and power systems on the rapid lines. The indicated volume-density ratios of air cargo are approximately half those of marine containers. On this basis, vehicle cargo loads would be virtually equal to loaded passenger vehicles and structure and power could be comparable for comparable performance.

Longer trip length would make the use of the transit more inviting. No data are presently available on actual trip length from the air-cargo terminal. However, on the basis of geographic location and cargo types, it is reasonable to assume longer trip lengths than from the harbor area, for example. Hence, location of about four distribution centers in areas such as Pearl City, CBD, Waikiki, and Waialae (Ala Moana may be a self-contained location) would also coincide with major passenger movement and provide sufficient distance to make transit application feasible. Again, the question of volume related to equipment utilization must be carefully evaluated.

In order to assure use of the transit system by tourists as a means of getting to their hotels, it is essential to solve the problem of baggage handling. Since this also is containerized and has concentrated points of origin and destination, the problems are reduced somewhat. In automating the system, it may be possible to code the baggage at the Mainland point of origin, where it will be placed in a proper container checked directly to the hotel in Waikiki. Lacking automation, the sorting of baggage could be accomplished manually at the Honolulu end and handled much as current small articles of air freight, with delivery and claim still being at the hotel. However, it must be recognized that such operation would be slow and costly considering the volume to be handled. Since passenger distribution to hotels is also a problem to be dealt with in making this mode attractive, development of a hybrid vehicle may be warranted for use on this segment of the route. Again, the economics of such development would require careful evaluation against the benefits to be gained. Since the current study does not involve system or equipment analysis, this must be deferred to later study.



AR00031998

The final point in air-cargo handling is in the volume of airmail handled annually in Honolulu. Since this element of freight has both highly concentrated origin and destination, it presents an ideal cargo for transit application. It must be pointed out, however, that use of transit to transport mail has been studied in other areas and has not been adopted. Details of the studies and the findings and conclusions have not been available. One apparent problem is security, and it may be that the added costs incurred in providing adequate security measures on a transit system would be one of the deciding factors.

h. Intra-Urban Goods. Some potential may exist for this type of goods handling. Its applicability will depend on several factors, such as:

1. Final route location, system configuration, and equipment selection
2. Sufficient concentrations of appropriate goods O-D, and convenience to the station locations to warrant the added cost and operational problems.
3. Development of adequate loading and distribution systems
4. Future zoning (as a guide to location of distribution centers); etc.

A detailed evaluation of this potential would require an in-depth study of commodity movements by type, origin and destination, distribution methods, flow patterns, and volumes. In addition, the overall economics of the service would have to be examined carefully in terms of potential reduction in passenger volume (through possible compromise between goods O-D patterns and passenger-trip desires). Such an analysis is beyond the scope of this current study; however, some comment on potential effects can be made.

The present study alignment connects several areas of concentrated commercial activity, these include the CBD, Ala Moana Center, and Waikiki. Lesser commercial developments include the Waialae Center, Kaimuki, the Beretania corridor, Aiea, and Pearl City. The routing is also within a reasonable distance of the present industrial and warehousing areas. Therefore, on the surface it would seem that some potential exists for transporting commercial goods between these points.

The success of any such use, however, depends on the development pattern around stations and the extent of commercial growth that develops at these existing subcenters. As pointed out, Ala Moana has a central container-receiving point already. The CBD and Waikiki, while relatively concentrated,



AR00031999

do not have major central-distribution centers. Therefore, any distribution in these centers of activity is likely to involve truck movements in any event. The same is essentially true for the less-concentrated areas and results in double handling of goods and attendant increase in costs. This factor, coupled with added system costs, makes the provision of intra-urban distribution of questionable value.

There is also a potential for efficiency loss in the local distribution by truck from terminal areas. For example, under present operational methods, a local-distribution vehicle can leave a warehouse with a full load, making several deliveries en route to the farthest destination of that particular trip. This vehicle is also essentially unlimited in range and service areas. Therefore, numbers of vehicles and equipment can be balanced to volume demands. However, if local distribution is made from several smaller centers (transit locations) the range and service area are materially reduced, as well as volume. Under these circumstances, the result could be lower equipment utilization to provide equivalent service through smaller loads and shorter trips (if not a greater total number of trips).

Clearly, these factors depend on volume. Therefore, the limited analysis possible with present data indicates that additional costs involved in system development, plus additional handling and potential distribution inefficiency, would result in higher-than-current costs to move goods in Honolulu. Under these circumstances, it is unlikely that the system would be utilized or else would require additional public subsidy to compete with standard truck distribution. In any event, before a commitment to handle intra-urban distribution of goods is made, the data on commodity type, volume, distribution, etc., should be gathered and carefully analyzed. Such analysis would make possible a determination of the total economic value of carrying or not carrying these types of goods.

i. Summary. The potential for application of cargo handling to rapid transit in Honolulu may be summarized as follows:

1. Air cargo, baggage and mail--possible
2. Intra-urban goods--highly questionable
3. Marine container cargo--poor.



AR00032000

On the basis of this preliminary analysis of current conditions of goods movement in Honolulu combined with current "state-of-the-art" in applying freight-handling devices to transit vehicles, stations, and operations, cargo handling by rapid transit (aside from tourist baggage) does not appear warranted. However, since detailed analyses of commodity movement and the economics of transit application were beyond the scope of this study, it may be premature to completely rule out cargo transport. As the future urban plan of the city (relating to land use, zoning, etc.) and the CRP program become established, present distribution patterns may change and self-sustaining centers of cargo destination may evolve. Therefore, it is suggested that, in subsequent tasks in transit planning for Oahu, it may be desirable to undertake a detailed analysis of cargo movement in light of then-current plans for future growth. Such a study must also include a careful analysis of the economics of transit-cargo movement as present methods in terms of both cost to the shipper and incremental cost to the taxpayer, who will be required to pay for construction of the transit line.

## 8. COST OF FUTURE TRANSIT SYSTEM

One of the most critical aspects of providing transit service, and particularly fixed-facility rapid transit, is the cost element. A major initial capital outlay is required for construction and equipment purchase, right-of-way, etc., under a fixed system. Another element of cost to be considered is maintenance and operation. This latter is true of both fixed and flexible transit systems and may become even more significant in the future as labor costs continue to rise. In this respect, an all-bus system is likely to be more critical than is a fixed facility system since each vehicle (with capacities of 50 to 70 persons) requires one driver. It is not inconceivable that bus transit in the future may carry a higher-per-mile operating cost than fixed transit. This cost can be even more significant in terms of passenger capacity per revenue mile. Such cost for fixed transit, on the other hand, with growing automation, may hold steady or even decline somewhat.

Related to cost is the potential revenue to be derived from the proposed transit system. This is an important element since it will give an indication of the amount of public funding required to balance fare-box income in meeting the total expenses of the system. Experience has shown that



AR00032001

virtually all rail rapid systems require a public subsidy; this is also true in most bus systems (Honolulu being a notable exception). The most optimistic view generally accepted is that the fare-box revenue will pay the cost of rolling stock and operating expense in the case of fixed-facility transit.

The costs developed in this study are concept costs only, since a great many unknowns still exist. These costs are based on current experience in developing new systems on the Mainland and on Honolulu conditions after discussions with contractors and estimators in Honolulu; they reflect current (1966) prices and wages and do not include escalation. Stations and facilities are based on standard design and do not include unique features. Landscaping and other community-beautification aspects are not included. Therefore, the estimates contained herein should be considered as representing a practical minimum construction cost for an operable system.

Revenue projections are based on the results of the modal-split model; however, the policy of fare structure is not determined. For revenue projections, a fare of $0.25 per trip is assumed and no zone fare is used. Transfer volumes and other factors determining revenue have been based on present experience in HRT transit operations and modified to suit the appropriate system. It is apparent that the optimum revenue-to-cost ratio may not be coincident with the optimum usage of the system. The attempt in this study has been to "optimize" usage through short headways and a high frequency of service. It should also be borne in mind that revenue projections are based on 1985 modal-split estimates. It is highly unlikely that these volumes would be reached much earlier; therefore, the revenue picture also reflects 1985 conditions (assuming constant fare). Therefore, additional study must be given in terms of refinement before a clear-cut revenue projection can be made. The aim then, is a preliminary indication of the amount of public expenditure required.

a. Capital Cost.

(1) Rapid-Transit System

Track and Structure. This includes trackage and all appurtenances; aerial-support structure, foundation, beamways, and columns; excavation, concrete work, dewatering, street repair, utility relocation, backfill, maintenance of traffic, electric (lighting), and drainage for subway. Some



AR00032002

comment should be made on these costs relating to subway construction. One potentially major cost is omitted entirely--underpinning of adjacent structures. Present data on foundation type and condition is inadequate to permit any realistic estimate of this item. Dewatering costs cannot be predicted accurately without detailed soil studies and frequent borings. However, based upon observation of Honolulu construction and contractors' experience, an allowance of $300 per lineal foot has been included for estimating purposes.

Electrification and Train Control. This includes substations, feeders, supervisory control, and all necessary appurtenances to provide electric power for propulsion; total wayside and on-board train-control equipment for automatic control of train running, train safety, line supervision and communication, and central control equipment.

Stations. This includes total cost of station (except trackage and train control) including construction, station finish, fare collection, and escalators (up and down).

Parking. This includes an allowance on a per-line basis for an estimated number of parking spaces required for "park and ride" operation. The estimate is based on experience in Cleveland and Chicago relating to percent of transit users using this method. A 1964 study of two stations (West Park and Triskett) on the Cleveland system provided the following data:

| Auto Arrivals | Utilization of Facilities (%) | |
|---|---|---|
| | West Park Station | Triskett Station |
| Parking | 31.1 | 49.2 |
| Drop-off | 14.9 | 14.8 |
| TOTAL | 46.0 | 64.0 |

Similar relationships were found in an earlier Chicago study, in which over 50 percent arrived by auto. On this basis it was assumed that, at stations requiring parking, an overall average of 40 percent of turnstile volume would use parking facilities. It is also evident that, in heavy destination areas (such as Pearl Harbor), large portions of the fares would be from return trips not needing parking. Therefore, total parking was reduced by 50 percent to reflect the return portion of trips entering the station. No



AR00032003

parking is contemplated from University Avenue to Middle Street in the Honolulu area and only at the Kapahulu Terminal in Waikiki. On this basis parking requirements are:

| Leg | Spaces |
|---|---|
| Ewa | 6,580 |
| Mauka | 3,380 |
| Waikiki | 650 |
| TOTAL | 10,610 |

Since many of these will require structure, an average cost of $2,000 per space is used to include structure (where needed) and land acquisition. It should be pointed out, however, that while this cost is attributed to the transit system, it in fact represents a net saving, since without the transit at least an equal number of spaces would be required in the central city area alone, at a considerably higher cost since virtually all would require structure.

Yards and Shops. This includes all buildings, fencing, paving, track, and equipment necessary for train inspection and maintenance.

Right-of-Way. Estimated on the basis of net area taken, including street widening and private right-of-way where required. Where easements were considered feasible (Waialae tunnel for example) costs were assigned at 50 percent of right-of-way equivalent. Right-of-way costs are based on the average 1965 assessed square-foot value in the area taken.

Engineering. A factor of 10 percent of all construction cost to cover engineering and supervision.

Contingencies. A factor of 15 percent of all construction, right-of-way, and engineering cost to cover contingencies.

(2) Flexible Transit System

Capital costs on the all-bus system include only special bus-loading areas on express routes. (Cost of equipment is covered under revenue and operating cost.) These special bus turnouts are assumed to be 100 ft long and 12 ft wide. Cost includes purchase of added right-of-way at each station at an average cost of $5 per square foot. On Lunalilo Freeway,



AR00032004

cost also includes a provision for retaining walls (assumed 10 ft high) at 50 percent of the stops. A simple open-sided shelter with benches is assumed at each stop. Cost for the shelter is estimated at $1,800 each. Provision is made for 34 such locations in Honolulu and 26 at other locations served by express routes. Total capital cost is estimated at $760,000, including 15 percent contingency.

Table 12.2 presents a summary of capital costs by line for the Rapid System and in total for the Flexible System.

Table 12.2. Capital Cost Summary* for Rapid Fixed- and Flexible-Facility Systems

| System | Item | Costs ($1,000) | | | |
|---|---|---|---|---|---|
| | | Ewa Leg** | Mauka Leg | Waikiki Leg | Total |
| Rapid | Trackage | 3,280 | 1,478 | 875 | 5,633 |
| | Structure | | | | |
| | Overhead | 26,832 | 7,817 | 5,882 | 40,531 |
| | At Grade | 751 | 191 | 99 | 1,041 |
| | Subway | 10,982 | 14,374 | 9,206 | 34,562 |
| | Tunnel | -- | 11,489 | -- | 11,489 |
| | Electrification and Control | 12,300 | 5,720 | 3,310 | 21,330 |
| | Stations | | | | |
| | Overhead | 11,400 | 6,650 | 6,650 | 24,700 |
| | At Grade | 250 | -- | -- | 250 |
| | Subway | 4,080 | 8,160 | 2,040 | 14,280 |
| | Parking | 13,160 | 6,760 | 1,300 | 21,220 |
| | Subtotal | 83,035 | 62,639 | 29,362 | 175,036 |
| | Yards & Shops | | | | 4,350 |
| | 10 Percent Engineering on All Above | | | | 17,939 |
| | Right-of-Way | | | | 6,676 |
| | 15 Percent Contingency on All Above | | | | 30,600 |
| | TOTAL | | | | 237,601 |
| Flexible | TOTAL | | | | 760 |

*Excludes cost of rapid transit extension to Hawaii Kai

**Includes CBD station



AR00032005

(3) Alternative Systems

To gain an insight into potential cost for other than a conventional rail system for application to System No. 1, discussions were held with Westinghouse Electric Corporation representatives regarding use of the Westinghouse Transit Expressway. Line volumes at important points along the fixed route, along with preliminary plan and profile drawings and train-performance requirements, were given to Westinghouse.

An estimate of construction cost based on these data was prepared and delivered. Also included was a train-performance study based on running an empty seven-car train over the test system. Results of this performance program check closely with those presented elsewhere in this report for the conventional system in terms of average speeds. It is assumed here that similar performance would be available with loaded trains.

By way of comparison, the Westinghouse system indicated 223 cars required at a 1966 cost of $32,781,000 (approximately $147,000 each). Construction-cost estimates included stations, roadway, yards and shops, spares, electrification and train control, plus miscellaneous start-up costs. Structure was included only for the overhead portions of the route based on a steel structure similar to that erected in Pittsburgh. Construction costs were estimated at $99.4 million and operating costs at $0.40 per car mile. If the cost of subway construction were added to this estimate on the same basis used in this report (excluding trackage, etc.) the cost would be approximately $58 million more. Other items excluded from the estimate include all excavation, backfill, and street repair at stations or at-grade sections of the route. It would appear, therefore, that a minimum cost for this system installed in Honolulu would range from $150 to $170 million plus cars. Adding parking structure, right-of-way, and contingencies, the total cost would appear comparable to that estimated for conventional rail transit.

b. Revenue and System Operating Costs.

(1) Rapid System

Revenue. Revenue determination for the rapid system is based upon a flat $0.25 fare and $0.15 school fare. Free transfers are assumed for all feeder routes serving either the rail system or express-bus



AR00032006

routes to the Windward side, Barber's Point, and Wahiawa. An additional $0.25 fare is assumed for all trips transferring between express bus and rapid lines. The modal-split analysis produced a total of 309,261 nonschool trips on an average weekday. A separate analysis of the express routes indicated that this volume included a total of 21,010 passengers transferring between the rail and express-bus systems, which would produce an additional fare. On this basis, the system would produce an estimated $23.9 million annually, based on an annualization factor of 290 times average weekday passenger volumes. School-trip tranfers between express and rail systems were found to be negligible. Therefore, school fare can be applied directly to the projected 29,265 trips, which produce an additional $0.8 million, for a total of $24.7 million annual revenue estimated for 1985.

Operating Cost. The operating cost for the bus feeders was developed using the HRT operating expense as a basis. The costs were developed excluding all taxes and depreciation. The last full year of operating data available (1965) showed a cost of 70.12 cents per mile, while the first nine months of 1965 indicated a rise to 76.19 cents. The recent wage increase granted HRT employees will have a further effect on this operating cost; however, the impact has not been determined at this time. Therefore, a cost of 76.19 cents per mile is used for the local feeder routes.

Since operating cost on a per-mile basis is partly a function of congestion, frequency of stops, speed, etc., the express routes may be expected to have lower costs. Again using HRT as a base and adjusting resulted in a cost of 53.8 cents per mile for these routes.

Since there is no history of rapid-transit costs in Honolulu to use as a basis for estimating, system costs in other operating properties were compared. Operating costs for rail-rapid-transit systems, developed in "Urban Rail Transit" [Ref. 4], showed 1960 costs for Cleveland, Toronto, Philadelphia, Chicago, and New York. Costs ranged from 45.6 cents in Cleveland to 69.8 cents in New York. Updating these data for Cleveland and New York to more recent values on comparable basis showed a 1965 cost in Cleveland of 66.46 cents while for the year ended June 30,1966, costs in New York had risen to 84.45 cents per mile. Therefore, a cost of 85 cents is used in estimating operating costs in Honolulu in order to provide a more conservative estimate in an unknown situation, again excluding all taxes and depreciation.



AR00032007

To determine car and bus miles, an operating schedule showing train consist and headways was developed for AM and PM peak hours, day, night, and owl service. Applying the per-mile costs to the mileage developed results in a total estimated annual cost of $19.6 million.

Depreciation. Transit cars for this system were assumed as 55-60 ft cars, with approximately 50-60 seats per car, to hold fairly uniform headways under changing-volume conditions and to vary capacity by changing train consist. Current trends are toward larger cars in the range of 70-75 ft, with approximately 75 seats per car. Some economy of scale may be available in this area and should be investigated thoroughly in subsequent phases when equipment analysis is undertaken. Costs are based on recent purchases of cars in the 50-60-ft range. For estimating purposes, a cost of $120,000 per transit car is used. Including spares, 230 cars will be required to meet the 1985 peak-hour demands. Equipment costs are based upon a 20-year useful life for rapid-transit vehicles and 10 years for buses, amortized over their useful life on a straight-line depreciation at 5 percent. On this basis, the annual depreciation (replacement fund) would be $2.2 million for rapid-transit cars.

It is assumed that the HRT equipment on hand at the time of initial operation of System No. 1 would form the basis for the feeder- and express-bus systems. This is assumed regardless of whether the system is under one ownership or whether the bus operation remains as a franchise operation. It is also assumed that equipment standards and routing would be controlled by the rapid-system operator; however, since no schedule of implementation is available, it is assumed that by 1985 (target year for this study) a program of replacement would have been installed which would provide the required number of buses. Based on the current price of $34,000 for a typical G.M. TDH5303 transit bus, amortized on straight-line depreciation at 5.0 percent and with no salvage value, the acquisition of 197 buses (including spares) would result in an annual cost of $868,000 which would be established to replace the fleet, assuming a 10-year useful life.

(2) Flexible System

Revenue. The basic fare on System No. 2 is also assumed at $0.25 and $0.15 for school trips. All transfers are assumed to be free;



AR00032008

however, a zone fare of $0.25 is applied for trips beyond Pearl City. In the modal-split analysis 252,461 daily nonschool trips were predicted for 1985 to which are added 6,246 transfer fares, to arrive at total average weekday fares. This produces an estimated annual revenue of $19.4 million. School fares will contribute an additional $0.8 million for a total System No. 2 estimated revenue of $20.2 million.

Operating Costs. Operating costs for the buses were developed in the same manner as for System No. 1, and the same per mile costs were applied. Detailed bus schedules were developed and annual miles were determined. Estimated annual operating costs for System No. 2 are $8.96 million.

Depreciation. Four basic bus types are assumed for this system, including SDM 4502, SDM 5302, TDH 4519, and TDH 5303. Original cost of the fleet of 212 buses required for the scheduled service is $7.25 million, based on current prices. Again, using a 10-year amortization at 5 percent with no salvage value results in an annual depreciation cost of $939,000 to permit a continuing renewal and replacement program based on the assumed 10-year useful life.

(3) Summary

Table 12.3 presents a summary of revenue and operating cost for both Rapid and Flexible Systems. In both systems, a net income is indicated. It should be pointed out, however, that both the revenue and operational costs are based on 1985 projections of patronage using current prices. Recognizing the trend in labor costs, these relationships may not be valid by 1985. The basic fare structure assumed for this estimate, however, is conservative and a possibility exists that increased revenue could be derived if this level of patronage is actually reached. In addition, there is a potential increase in revenue to the rapid system from tourist usage, which is not reflected in these estimates. While come tourist revenue would apply to the flexible system, it is considered to have less potential.

Another factor relating to the net surplus is the estimate of patronage. Several factors can have a significant effect on this element. The modal split developed in this test is a result of a single pass through the model without benefit of subsequent adjustments of speed relationships or



AR00032009

distributional affects on population and employment. Parking costs are another major variable with significant impact. Costs used in this pass through the model reflect a very high cost, particularly in the CBD. This factor is most likely to have its greatest impact on the fexible system since, with its greater orientation toward highway facilities, it is likely that extensive pressure would be produced for additional parking in the CBD area resulting in much lower fees than estimated. With decreasing parking cost, travel-time difference becomes relatively more important and bus transit is at a serious disadvantage in competition with the private automobile.

Table 12.3. Comparison of Extimated Revenue and Operating Costs for the Rapid and Flexible Transit Systems

| Item | Rapid System | | Flexible System | |
|---|---|---|---|---|
| | Costs ($1,000) | Income ($1,000) | Costs ($1,000) | Revenues ($1,000) |
| Passengers | | 24,726 | | 20,184 |
| Operations | | | | |
| Rail | 11,686 | | -- | |
| Bus | 7,899 | | 8,958 | |
| Depreciation | | | | |
| Rail | 22,668 | | -- | |
| Bus | 868 | (22,668) | 939 | ( 9,897) |
| Net Income* | 22,668 | 2,058 | 9,897 | 10,287 |

*Before debt service.

In essence, this analysis clearly indicates that, while this estimate does not provide adequate coverage, passenger revenues from the rapid system could be developed sufficiently to pay operating costs plus debt service on the transit vehicles. However, it also indicates that no income from revenue will be available for reduction of construction debt.

This estimate for the flexible system provides an early optimistic picture; however, it is highly probable that subsequent iterations of the modal reflecting conditions discussed above will significantly reduce patronage. Even with such reduction, this system can be expected to pay for debt service on transit equipment and, probably, the capital costs associated



AR00032010

with providing bus stops. A detailed equipment-replacement program was developed using the current HRT buses as a base assumed to begin in 1967. Using revenue-bond financing at 5 percent on a 10-year debt retirement, the maximum annual debt service of $1,160,000 would occur in the 10th year. This service cost would then reduce to $197,000 in the 20th year and zero in the 21st. Assuming a minimum-coverage net income of 1.5 times annual debt service this would require a maximum net income of $1,740,000 in the 10th year, which seems quite possible.

(4) Potential Added Costs for the Rapid System.

It was pointed out earlier in this section that the cost estimate shown would likely represent a <u>minimum</u> rapid-transit-system cost. This minimum cost results from extensive use of overhead facilities along public-street rights-of-way, minimum use of subway and private rights-of-way, and minimum station size. There are indications that such an approach may not be acceptable in actual implementation and that added subway sections may be required.

Attempting to apply the average construction costs developed in this estimate to small segments of route is very questionable because of lack of data relating to construction problems that might be encountered at specific locations; the development of such data was beyond the scope of this study. For example, dewatering costs used in the estimate are considered valid for application to a substantial length but could vary widely at any specific location. Subway installation in the Waikiki area and along Kapiolani Boulevard may be expected to present more serious dewatering problems than a more mauka location. Groundwater at a construction site on Kuhio, for example, was observed at approximately 2 ft below ground surface.

Further, underpinning costs (not included in the estimate) may be expected to be higher because of a greater number of large structures than were assumed in the original estimate. Also, even if underpinnings were minimum (because of pile foundations), the potential surface settlement resulting from dewatering of an excavation 30 ft or more in depth could present a serious problem. Before any meaningful cost estimate for subway construction in these areas can be given, a great deal more detail must go into the design data.



AR00032011

An estimate of total cost for subway construction from Middle Street throughout Honolulu (approximately 50 percent of the total system mileage) is summarized in Table 12.4. This "order-of-magnitude" estimate has been prepared using the unit costs developed in the initial estimate and applied to the total length of the route. All elements other than structure and stations are held constant from the previous estimate.

Table 12.4. Supplementary Capital-Cost Summary for Subway Construction

| Item | Total Cost ($1,000) |
|---|---|
| Trackage | 5,633 |
| Electrification and Control | 21,330 |
| Parking | 21,220 |
| Yards and Shops | 4,350 |
| Structure and Stations | |
| Overhead (from Pearl City to Middle Street) | 32,848 |
| Subway (remainder of System) | 200,266 |
| Subtotal | 285,647 |
| 10% Engineering (on Subtotal) | 28,565 |
| Right-of-Way | 6,676 |
| Subtotal | 320,888 |
| 15% Contingency | 48,133 |
| TOTAL | 369,021 |

## 9. STUDY RECOMMENDATIONS

Preliminary estimates of future ridership, revenues, and capital costs have been made of a potential mass-transit system (including fixed-rail) for Oahu. The Study conclusion is that there is a potential for a rapid system for Oahu in the future. Recognizing the problems and limitations involved in financing a rapid-transit system and also assuming that solutions may be found to these problems, the Study makes these recommendations:

1. That a rapid-transit system be adopted in all long-range transportation plans for Oahu. This recommendation is made for the following reasons:



AR00032012

a. It will produce a significantly higher level of service than an all-flexible system.

b. It has a much greater potential for influencing the shape and pattern of the future community than an all-flexible system.

c. It affords a practical method of alleviating traffic congestion in the concentrated areas of Honolulu.

d. It affords a great potential for accommodating the heavy tourist movements to and from the airport anticipated in the near future.

e. It provides the most predictable transportation mode in terms of travel time.

f. Coupled with street and highway facilities, it affords a reasonably adequate transportation capacity to meet the estimated 1985 travel demands.

g. It provides an alternative to the requirement for extensive parking facilities in the urban areas and therefore promotes a more productive use of high-value land areas.

2. That in the interim the present bus system be expanded and improved.

3. That areas of joint City-State-Federal interest and concern be explored for the possibility of joint financing of the system.

4. That the second phase of study outlined below be undertaken at the earliest possible time.

## 10. CONTINUED TRANSIT PLANNING

Since transit planning is only one element of the total comprehensive transportation development in Oahu, it must be coordinated with future highway programs and reflected in the future land-use plan. The Oahu Transportation Study staff has developed a series of computer models that can provide the essential tools in developing these future plans. They are also charged with the responsibility of developing the comprehensive transportation plan for 1985. Therefore, future transit planning must be coordinated to the maximum extent with the Oahu Transportation Study program. In any event, it is essential that the development of land-use plans, community-renewal programs, urban-renewal and other development programs be carefully and thoroughly coordinated with comprehensive transportation planning and that transportation planning recognize these developments as vital influences.

The major purpose of Phase I, the Transit Study of the Oahu Transportation Study, was to provide a first look at the feasibility of rapid transit to determine if it warranted further study--that is, whether it could



AR00032013

divert a substantial amount of ridership and could have an influence on requirements for highway construction in the future.

The results of the Phase I study show conclusively that transit can handle large numbers of passengers, that the linearity and density of the city and the focusing of transportation demand is such that a rapid-transit system can influence the demand for additional highways in some corridors, and that rapid transit should definitely be given serious consideration in any future transportation plans.

While the present study clearly indicates a requirement for transit, it leaves a number of questions unanswered such as:

1. What is the best possible solution for location of lines, stations, branch extensions, park 'n' ride lots, and other details of the system?
2. What equipment should be used on the system--steel wheel on steel rail, rubber-tired trains, or buses running on separate rights-of-way?
3. What are the street and highway requirements that will arise in conjunction with the proposed rapid-transit system?
4. What is a precise estimate of revenues that might be expected from the fare box with different system locations and under land uses reflecting redistribution affected by transit?
5. What staging program will allow evolution of the system over time in the most advantageous balance of service and financing?
6. And, depending on the outcome of the above questions, what is a detailed step-by-step organization, financing, and development plan, including proper and equitable handling of the existing bus operation?

Further studies are needed to develop accurate answers to such questions. These answers must reflect technical considerations and also exploit the potentials of public debate, which tends to bring out the issues and clarify the goals and objectives on which many decisions are based, particularly as they relate to the desired form and pattern of the city.

The major steps are discussed below, with a suggested action program aimed at answering these questions, refining the future transportation plan, and beginning its implementation.

a. Short-Range Transit Program. This is essentially an interim program aimed at improving the present bus-transit system and preparing for integration into the feeder and express system when the fixed facility is



AR00032014

available. This study should be undertaken at the earliest possible time. Elements in this short-range program include:

1. Optimization of Bus-Transit Operation
   a. New Service Areas
      Immediate - by 1968
      Near future - by 1975
      Routes and headways
      Estimated patronage
   b. Service Improvements
      Express and limited service
      Freeway utilization
      Experimental programs involving service, equipment, and operating practices
      Downtown investigations, including bus priority (exclusive bus lanes), traffic-signal adjustment, stop-and-transfer adjustment
      Service modifications relating to routes and headways and transfer points
   c. Operating Practices
      Bus stops and schedules
      Equipment utilization
      Equipment replacement, maintenance, and appearance
2. Analysis of Fare Structure
   a. Patronage - fare relationships
   b. Fare - total-income relationships
3. Revenue - Cost Analysis of Short-Range Improvement Programs
4. Interim Transit Management - Financing
   a. Define service improvement feasible with present management without financial support and with financial support consisting of tax relief, indirect support, or direct financial support. If support is needed, the means and responsibility for its provision (local, state, and federal) would also be investigated.
   b. Advantages, if any, of alternate forms of management of present bus operation.

b. Long-Range Master Transit Plan. This element of transportation planning is essentially a continuation and refinement of the Phase I studies, in greater depth to provide more precise answers. The program should be capable of rapid progress, since most of the necessary tools are available in the form of computer programs such as the econometric model and land-use model and the modal-split model developed in this study.



AR00032015

In the development of a Master Transit Plan, the increments or stages should not be tied to specific points in time. Rather, they should relate to stages of economic growth, and urban development, since these are the elements that demand the transportation service. These elements can vary under the influence of many factors that cannot be accurately predicted on a long-range base, and the rates at which growth occurs may be more or less rapid than anticipated. Therefore, the program of implementation should be based on a constant reassessment of the projections to assure a program balanced, to the maximum extent permitted by financing and construction lead time, with the development pattern.

With this objective in mind, the following steps are considered applicable:

(1) Legal and Constitutional Requirements. Probably the first action necessary in plan development is the determination of the legislative or referendum actions necessary to increase debt capacity or develop alternative joint-financing schemes. If these actions are found either impractical or undesirable, the maximum financial capacity should be determined. This step is essential, since it will be the largest single influence on the extent of the first increment of system development as well as on subsequent extensions. This step also involves definative discussions with State and Federal governments to determine the maximum extent of participation to be expected.

(2) System Definition. Several elements of this step can proceed concurrently with step (1); these include vehicle and hardware analyses leading to system selection and definition of community criteria standards for route configuration (overhead, at-grade, and underground) in various situations of land use. Special studies can be undertaken, including a more detailed investigation and projection of such tourist considerations as vehicle design to accommodate baggage handling, station layout and information systems, Waikiki distribution, etc., and costs. Similar studies can be done on other cargo handling, particularly as related to air-freight and mail, leading to conceptual design alternatives on which to base the determination of their feasibility.

The most important element of this step is the definition of the long-range program. This will involve projecting development as far as



AR00032016

practical (beyond 1985, if possible) and, through successive applications of the econometric model, land-use model, and modal-split model, arriving at the maximum extent of transit applicable. Steps in this process include:

1. Examine in detail the results of the highway and transit network loadings developed in Phase I for clues on where alternatives to the present networks could be developed by changing alignments, extending lines, adjusting highway capacities, etc., with a view toward balancing capacities with demands and maximizing transit usage, thus reducing overall transport costs. This examination may require running selected links of the highway system and perhaps of the transit in order to gain insight into the loading patterns on the networks.
2. Study and determine the effect the rapid transit might have on land-use development patterns. Redistribute land-use, population, and employment to conform with the rapid-transit impact. This redistribution should be done simultaneously and in conjunction with the development of alternatives of system extent so that the interrelationship between land use and transit service can be exploited to develop the most favorable overall land-use development patterns.
3. Generate future trips for the resulting land-use distribution and distribute these trips to determine a new estimate of total travel demand. Refine the estimates of factors influencing modal split and develop transit-passenger estimates for alternative systems using the new distribution of travel demand. An analysis of the assignments of these trips to the respective highway and transit networks will indicate the relative volume and capacity balance and provide a basis for determining the maximum desirable extent of fixed-facility transit. With the analysis of Phase I results as a starting point, a limited number of successive iterations will indicate an optimum balance. On the other hand, if for some specific reason testing of one or more alternative land-use plans or system locations was considered advisable by any of the responsible governmental agencies, additional runs could be made with a minimum of effort and also could be related to successive levels of economic growth and urban development.

(3) First Increment Selection and Preliminary Design. Once the available financing capacity is determined, Step (1), the general routes and system extent known, Step (2), the phasing of the total program can be determined and preliminary design can be started on the initial increment of a fixed-facility transit. This design will involve precise alignment and configuration, station location and preliminary design, system-performance specifications, and operational requirements, including train control and fare collection, capital and operating-cost analyses, precise patronage and revenue determinations, and a definitive financing program. In addition, all ancillary items such as secondary distribution, feeder routes and frequencies, fare structure and policy, management policy, etc., will be defined.



AR00032017

Throughout this phase of the work, a continuing public-information program must be carried on through the various media, as well as the interested civic groups and citizens' committees. This is an essential element if public support for the program is to be obtained.

It may be assumed that a public expression of willingness to undertake the construction of the system and the burden of payment will be required at this point. It is essential that all preliminary design, including planning and architectural considerations, be fully and completely outlined at this time and that all estimates of costs are of sufficient accuracy to assure financing under the proposed financing proposal.

## B. STREET AND HIGHWAY FACILITIES

The following section attempts to answer the question, "What the street and highway facilites will be required in conjunction with the proposed rapid-transit system?" No one is more aware than the Oahu Transportation Study staff of the difficulty and the complexity of the problems involved in the development of a freeway-arterial plan when the extent of the mass-transit system is not as yet fixed.

But the City and County of Honolulu is committed to planning for mass transit. This is evidenced by the enactment of enabling legislation by the Fourth State Legislature, which became law on June 13, 1967, permitting the City and County of Honolulu to move forward with confidence to establish by phase, development of a balanced mass-transportation system for Oahu. The Mayor's positive intent to move forward is indicated by his budget for 1967-68, which includes $200,000 for planning and consultative services having to do with mass transit. Thus, assumption on the part of the Oahu Transportation Study of rapid transit to be existing by 1985 is reasonable and inclusion of this concept in long-range transportation plans for Oahu is justifiable.

### 1. ALTERNATE PLANS

Having obtained a detailed description of 1985 traffic volumes may at first suggest that the remaining work of planning is relatively easy--simply provide the required capacity by a series of recommended street improvements. This is essentially what is involved, but there are many diverse and yet



AR00032018

interrelated problems, and there are usually several solutions to each problem. The best solutions are, of course, desired, but of even greater importance is to plan an entire network that fits together and works together in serving overall community needs. To achieve this, alternate solutions and plans must be compared. The crucial task is to select the best plan.

The alternate plans presented here endeavor to achieve the objectives by treating the plan elements in varying ways, yet keeping within the restraints of planning and accepted planning concepts. They have their origin in preliminary freeway-arterial tests involved in the Transit Study which disclosed definite weakness in the network system. The most critical planning area was determined to be the Honolulu District. As a measure of the impending traffic problem in this area, comparative 1960-1985 screenline volumes are shown in Fig. 12.1.

The dramatic increase in traffic volume over the base year clearly indicates the need for high-capacity roadways in the east-west direction. It is evident that Interstate Route H-1 will not be able to accommodate the future traffic demand for that facility even with the help of improved major and collector streets and a mass-transit system. It was therefore concluded that added roadway capacities will be required not only in Central Honolulu but also in the area east of Honolulu.

In east Honolulu, preliminary travel estimates indicate that Kalanianaole Highway, even improved to a six-lane facility supplemented with mass transit, would not provide sufficient added capacity to satisfy the 1985 travel demand for that corridor. Several alternatives were given serious consideration before a roadway plan was suggested for <u>testing</u>. Among the alternatives suggested were the following:

1. A viaduct (elevated highway) over the existing Kalanianaole Highway, with possibility of reversing the lanes during peak periods
2. A new facility inland of the existing Kalanianaole Highway, tunneling through a series of ridges where necessary
3. A moratorium on future developments to suppress travel in and out of east Honolulu
4. A new off-shore highway with a tunnel beneath Black Point, emerging in or near Fort Ruger.



AR00032019

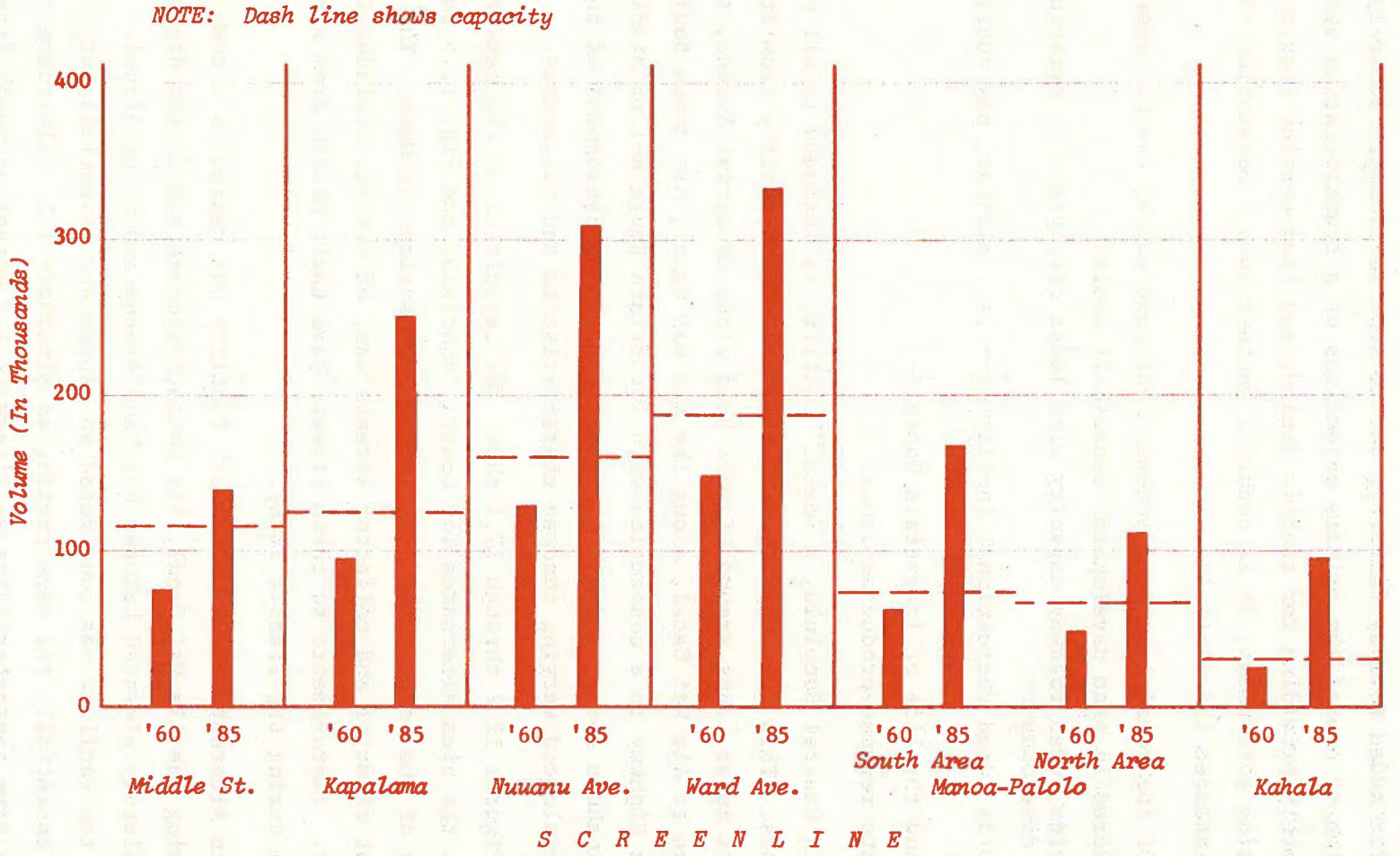



FIG. 12.1. COMPARISON OF SCREENLINE VOLUMES IN 1960 AND 1985.

AR00032020

A moratorium on developments has questionable merit; it might delay the need for added roadway facility, but to stop development entirely would be in violation of one of the primary objectives of a transportation system--that of "adequately providing for traffic demands and land-service requirements." In a changing government, it is doubtful whether such a moratorium policy could be extended indefinitely.

Of the remaining three schemes mentioned above, the off-shore facility was considered in plan development because it would:

1. Provide added roadway capacity with least disruption to existing land and developments
2. Provide added recreational facilities--i.e., marinas, new public beaches, etc.
3. Extend the life of Interstate Route H-1
4. Create revenue-producing lands.

In Central Honolulu, a "makai" facility is included in all plan developments. This facility continues the off-shore facility from its terminal at Fort Ruger, runs around Diamond Head along Monsarrat Avenue, then along Paki Avenue to Ala Wai Canal, along the Ala Wai Canal, Ala Moana Boulevard, and Nimitz Highway to a connection with Interstate Route H-1 at Middle Street. Between Kapahulu Avenue and Middle Street, the plan development of the "makai" facility evaluated varying roadway characteristics and alignments.

Figures 12.2 through 12.4 show the capacities of the network considered in the plan alternates for Central Honolulu, and Fig. 12.5 shows the capacities of the roadway system common to all systems on Oahu. The plan development of major and collector streets was, of course, included in all alternates. Improvements to these streets have their origin from earlier tests made during the Transit Study.

In Alternate 1.1, the "makai" facility was tested as a complete freeway following the Ala Wai Canal, Ala Moana Boulevard, and Nimitz Highway, and being completely elevated between Kalakaua Avenue and River Street. In Alternate 1.2, the facility was considered an expressway essentially at-grade and following essentially the same routing as Alternate 1.1. Alternate 1.3 possesses the same characteristics as Alternate 1.2 except at South Street, where



AR00032021

it tunnels under Honolulu Harbor, provides access to Sand Island, and terminates at Interstate Route H-1 at Middle Street.

Within the downtown area of Honolulu, a circumferential system was considered in all alternates under plan development. This system consists of the extensions of Liliha Street and South Street, which provide connections between the "makai" facility and the Interstate Route H-1 at both the west and the east boundaries of the Central Business District and the Civic Center complex.

The test and evaluation of the alternate plans are discussed below.



AR00032022

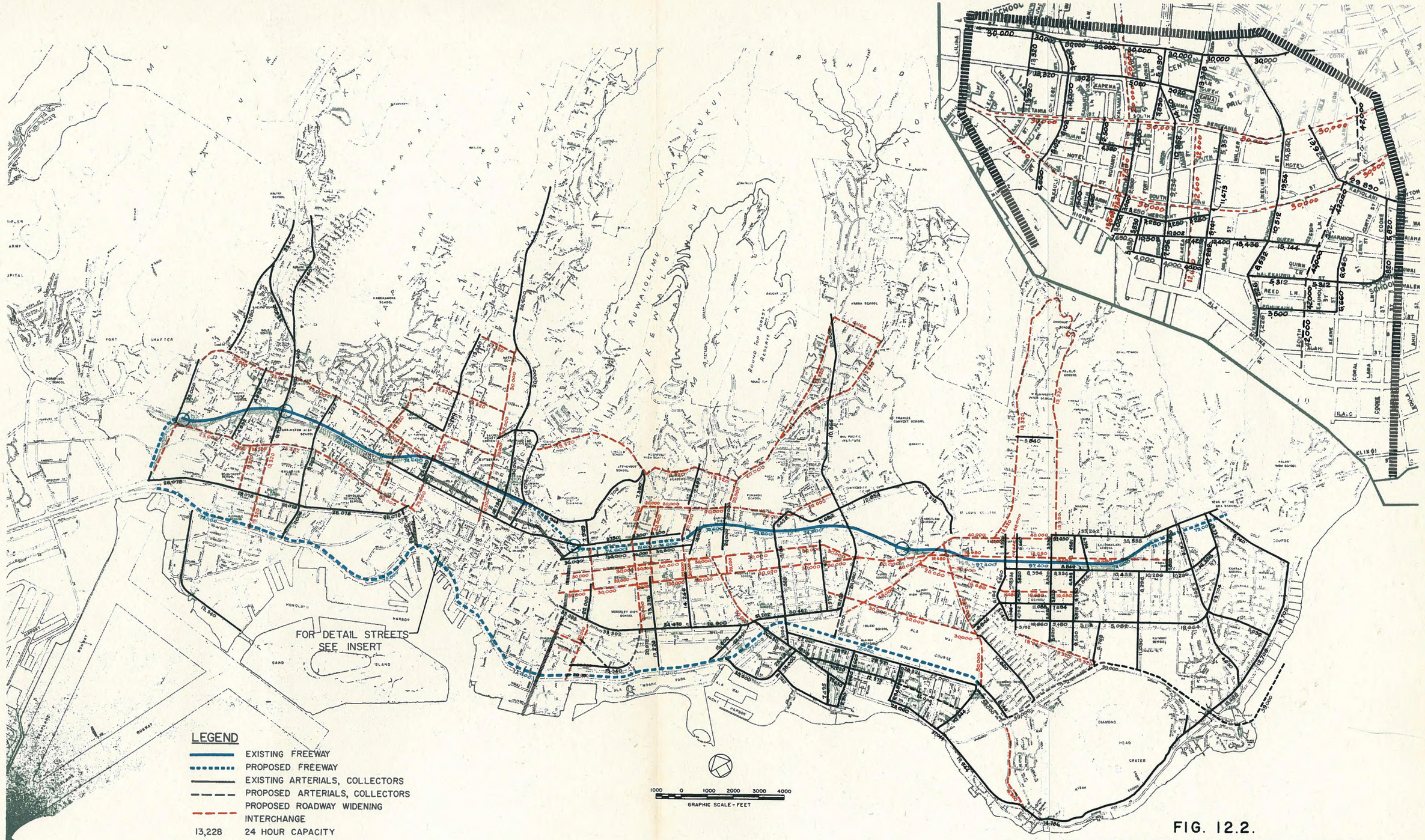



FIG. 12.2.
24 HOUR NON-DIRECTIONAL CAPACITY
1985 HIGHWAY PLAN 1.10



AR00032024

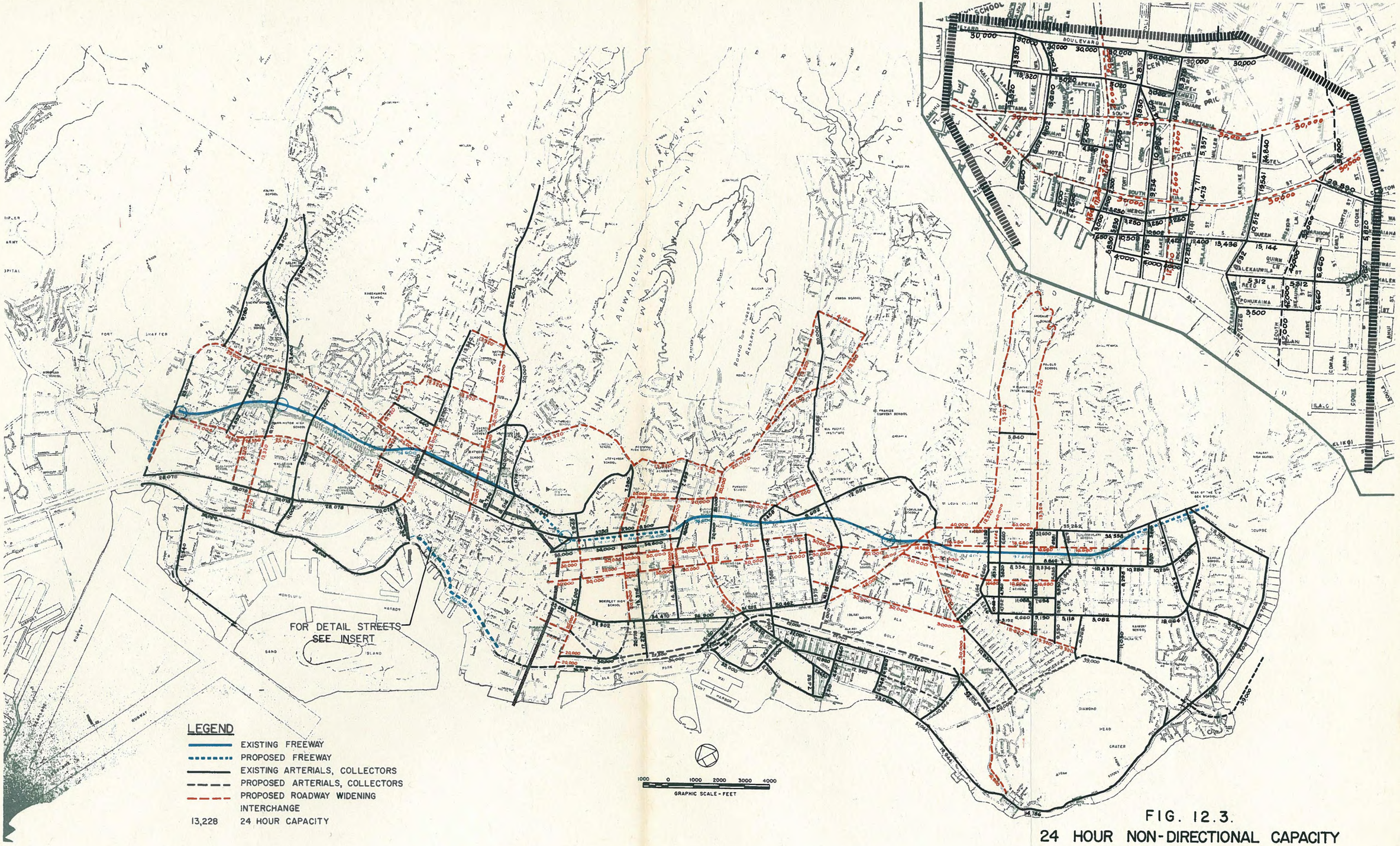



FIG. 12.3.
24 HOUR NON-DIRECTIONAL CAPACITY
1985 HIGHWAY PLAN 1.20



AR00032025

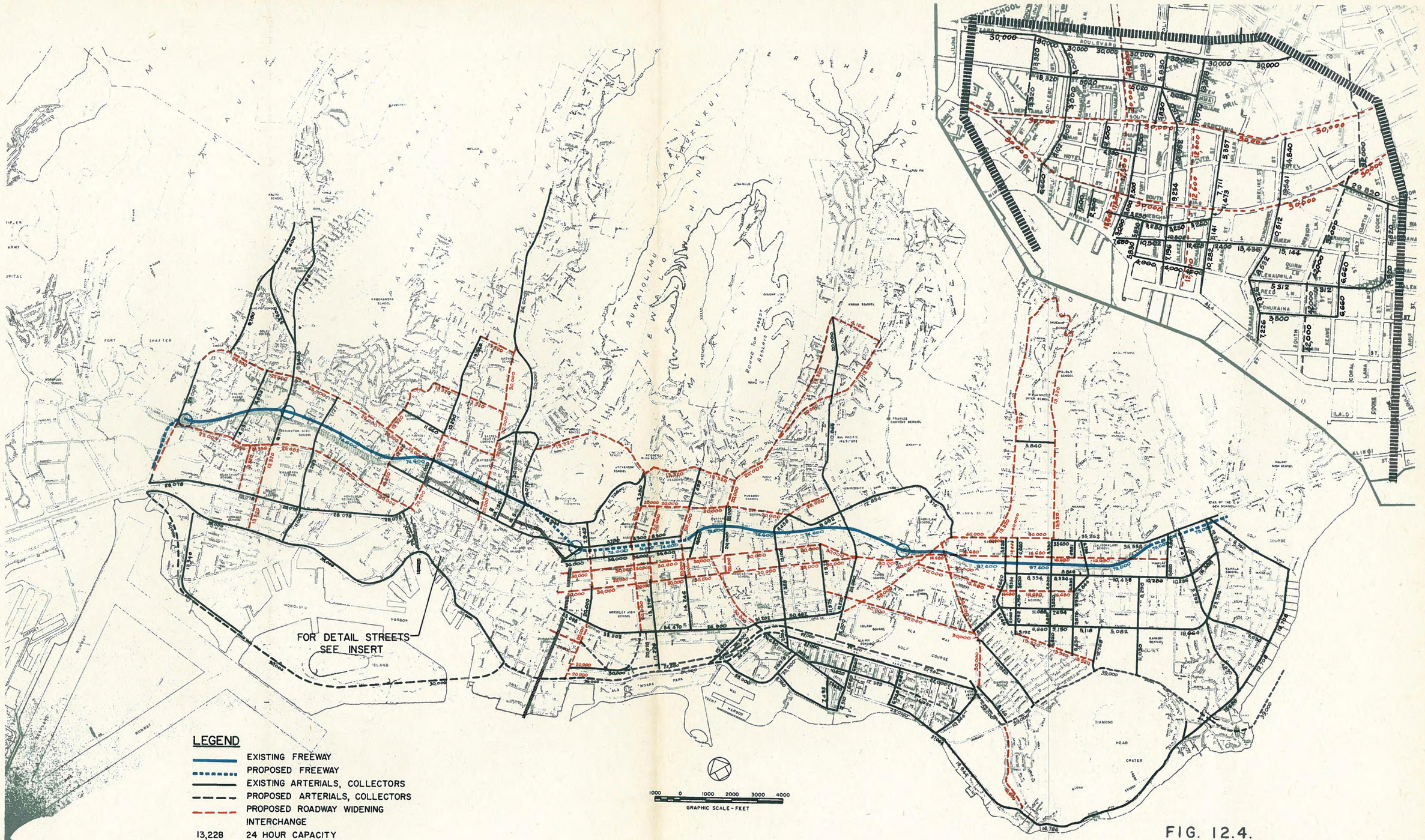


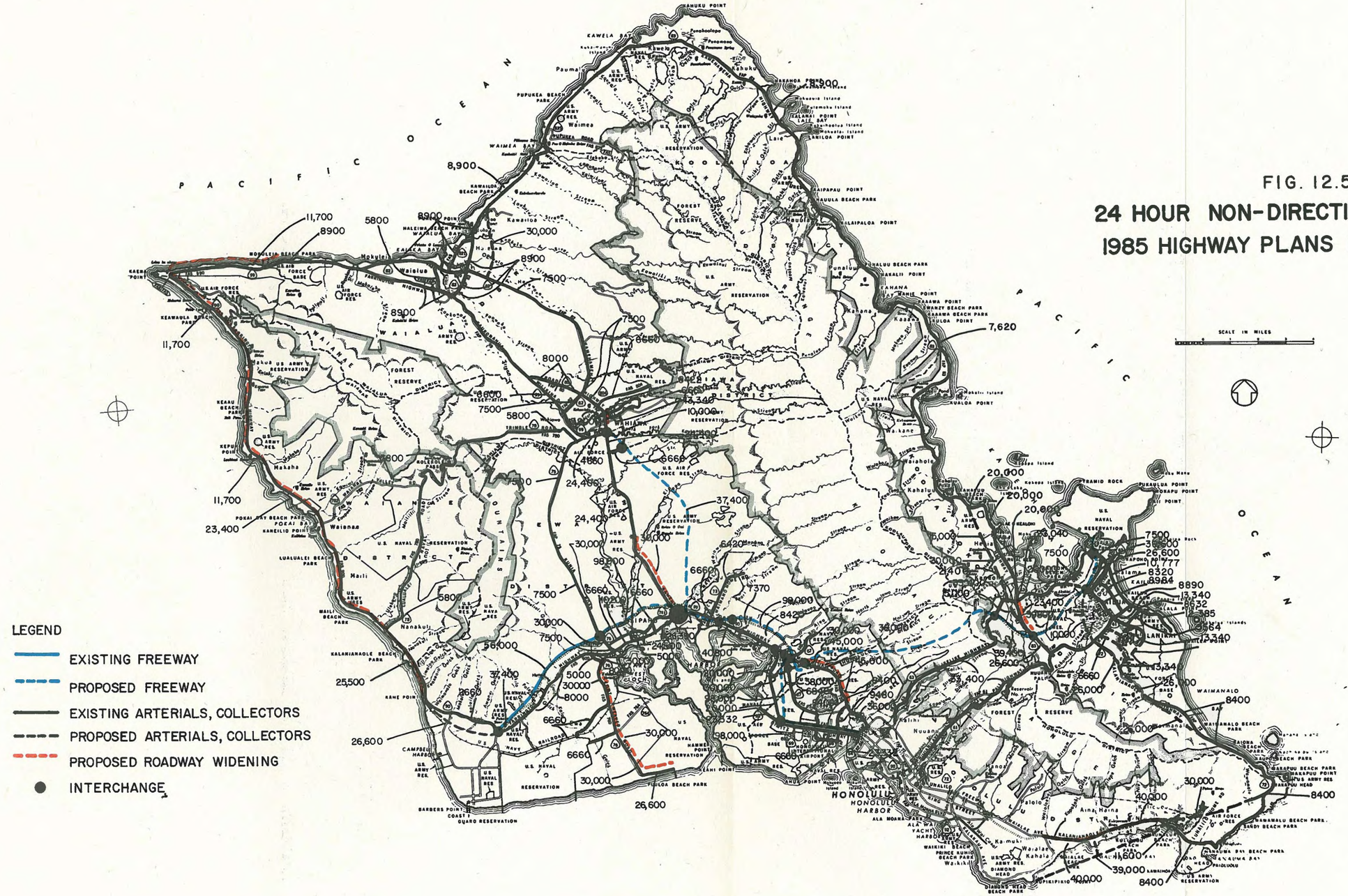

FIG. 12.4.
24 HOUR NON-DIRECTIONAL CAPACITY
1985 HIGHWAY PLAN 1.30



AR00032026

FIG. 12.5.

## 24 HOUR NON-DIRECTIONAL CAPACITY
## 1985 HIGHWAY PLANS 1.10, 1.20 & 1.30






AR00032027

## 2. EVALUATION OF STREET AND HIGHWAY FACILITIES

The estimate of the number of vehicles that will use each individual section of the transportation system is accomplished by traffic assignment (See Appendix 12.A for a full description of the method employed in this study).

In the outlying areas, evaluation of traffic assignments at key points and at screenlines provides convenient means of checking the adequacy of the freeway-arterial networks in accommodating the 1985 demand for travel from one area to another. Key points and screenlines were carefully chosen to minimize the possibility of trips' crossing the line or point twice between origin and destination.

One of the basic elements in evaluating existing and future streets and highways is the determination of roadway capacities. Although the need for this information is not questioned, the means by which capacities are obtained are not as clearly defined.

The Oahu Transportation Study followed the procedures outlined in the 1950 Highway Capacity Manual prepared by the Committee on Highway Capacity, Department of Traffic and Operations, Highway Research Board of the National Academy of Sciences, National Research Council. Capacity determinations were a joint operation involving the staffs of the Traffic Department, City and County of Honolulu, and of the Planning Branch, Highways Division, State Department of Transportation.

Practical capacities computed for urban streets were increased by a city factor of 1.20. These adjusted practical capacities for two-way and one-way streets were later converted to 24-hr capacities by dividing the capacities by 0.12 and 0.10, respectively.

City factors were not applied to freeway or major-highway capacities. Conversions of computed practical capacities to 24-hr capacities for these high-type facilities were based on the trends in peak-hour to 24-hr ratios for the area through which the facilities passed.

It is cautioned that there is now a new, recently issued 1965 Highway Capacity Manual. This manual, like the original 1950 edition, is primarily a practical guide. It facilitates determination of the roadway capacity, service volume or level of service which will be provided by either a new highway



AR00032028

design or an existing highway, under specific conditions. Alternately, given a certain traffic demand, the design necessary to accommodate that demand at a given level of service can be determined.

Because this manual represents a new approach to the complexities of traffic flow and ultimately will provide better answers to the many highway-capacity problems, this study recommends that roadway-capacity conclusions in this report be verified with the procedures of the new 1965 Highway Capacity Manual.

Figure 12.6 is a map of the West Oahu area discussed below, showing the roads and areas of concern, and Table 12.5 gives anticipated 1985 capacities and volumes of traffic.

a. Kahe Point. Farrington Highway at Kahe Point is the only highway facility available for trips entering and leaving the area between Nanakuli and Makua from the east. This "committed" highway in the alternate plans tested is a four-lane divided-highway facility, rural in nature. Anticipated travel produced from and attracted to this Nanakuli-Makua area by 1985 demands a facility no larger than a four-lane divided highway.

b. Campbell Industrial Park. The corridor between Campbell Industrial Park and Makakilo Village is serviced by Interstate Route H-1 and Farrington Highway. In the alternate plans, Interstate Route H-1 is a four-lane divided freeway and Farrington Highway is a two-lane, undivided rural highway as exists. The roadway capacities provided by these existing and "committed" facilities are more than adequate for the 1985 volumes demand of them.

c. Makakilo. The corridor between Makakilo Village and Kunia Road is serviced by the same two facilities mentioned in the previous paragraph; there are, however, more lanes (six) on the Interstate Route H-1 here. Again, roadway capacities provided by the two existing facilities are more than adequate to accommodate the 1985 travel through this corridor.

d. Kunia - Waipio Corridor. The corridor between Kunia Road and Wahiawa includes the urban area of Waipahu. The "committed" Interstate Route H-1 is an eight-lane freeway permitting motorists to bypass this urban area. Assignments show that Interstate Route H-1 would provide more than the necessary capacity for this facility by 1985.



AR00032029

The recently improved Farrington Highway through Waipahu has sufficient roadway capacity to accommodate the anticipated 1985 travel in this area. At present, Farrington Highway west is a two-lane, undivided road, and east is a four-lane, divided road.

Waipahu Street, tested as a four-lane collector street with added width for parking, through the commercial area of Waipahu, shows definite need for roadway capacity of this nature.

e. Kipapa. The corridor between Wahiawa and Waiawa includes Oceanic Developments. This corridor is serviced by Kunia Road, Kamehameha Highway, and Interstate Route H-2. Kunia Road was considered as existing under plan tests. In all plans, Kamehameha Highway was a four-lane divided highway. Interstate Route H-2 under both system tests was a four-lane divided freeway with an interchange (east-bound traffic only) at Oceanic Development.

The assignments show that both Kunia Road and Kamehameha Highway between Wahiawa and Oceanic Development have sufficient capacity to satisfy their 1985 demands for travel.

Interstate Route H-2 provides sufficient capacity for its 1985 demand for travel, with or without an interchange at Oceanic Development. It is calculated that the cost of providing on- and off-ramps for in-bound traffic at Oceanic Development would be lower than improving Kamehameha Highway to a four-lane divided highway for its full length between Oceanic Development and Waiawa.

f. Helemano. The corridor between Waialua-Haleiwa and Wahiawa is serviced by Kaukonahua Road and Kamehameha Highway. In all plans these facilities were considered two-lane highways, rural in character, and with no improvements.

Early traffic assignments revealed that an improved roadway around the northern shores of Oahu could induce some 3,000 vehicles per day to shift their choice of route from Kahuku to Honolulu by way of Kaneohe.

Slight improvements on both Kaukonahua Road and Kamehameha Highway through Helemano could very well handle the 1985 travel through this corridor.



AR00032030

FIG. 12.6. SCREENLINES AND KEY POINTS IN WEST OAHU.

Table 12.5. Summary of 1985 Roadway Capacities and Average Assigned Traffic Volumes in West Oahu

| Screenline | Facility | 24-Hr Roadway Capacity (vehicles) | Avg. Assigned Volume (vehicles) |
|---|---|---|---|
| Kahe Point | Farrington Highway | 25,500 | 23,200 |
| Campbell Industrial Park | Farrington Highway | 8,000 | 2,200 |
| | Interstate Route H-1 | 37,400 | 24,000 |
| Makakilo | Farrington Highway | 8,000 | 2,600 |
| | Interstate Route H-1 | 56,000 | 48,900 |
| Waipahu (West) | Interstate Route H-1 | 98,000 | 47,200 |
| | Waipahu Street | 20,000 | 6,600 |
| | Farrington Highway | 10,200 | 9,600 |
| (East) | Interstate Route H-1 | 98,000 | 47,200 |
| | Waipahu Street | 20,000 | 15,700 |
| | Farrington Highway | 28,200 | 13,500 |
| Kipapa | Kunia Road | 7,500 | 6,300 |
| | Kamehameha Highway | 30,000 | 8,500 |
| | Interstate Route H-1 | 57,400 | 47,200 |
| Helemano | Kaukonahua Road | 6,600 | 6,200 |
| | Kamehameha Highway | 7,500 | 4,500 |



AR00032031

g. Pearl City Corridor. The corridor between Waiawa and Waiau contains the urban place of Pearl City. Today, Kamehameha Highway is the only six-lane highway through this corridor. Freeway-arterial networks in early tests provide Interstate Route H-1 as an eight-lane "committed" freeway for traffic bypassing this urban place. Under these tests, on- and off-ramps (leeward) were shown on this freeway facility with Kamehameha Highway at Waiau. In addition, a roadway link simulating the cane-haul road, paralleling Kamehameha Highway, and connecting Waimano Home Road and Moanalua Road with a full interchange with Interstate Route H-1 at Waiau was considered to determine the effect of this network arrangement on the traffic demand for Kamehameha Highway between Waiawa and Waiau.

Traffic assignments in the early tests revealed that the interchange arrangements at Waiau between the Interstate Route H-1 and the arterial network resulted in inefficient use of Kamehameha Highway through the Pearl City corridor. Removing the on- and off-ramps between Kamehameha Highway and Route H-1 at Waiau and channeling these movements to the Waiawa Interchange would increase the utilization of the existing six-lane Kamehameha Highway. The removal of the leeward on- and off-ramps would not lessen the requirement of an eight-lane facility for Route H-1 through this Pearl City corridor. This area is shown in Fig. 12.7.

The existing roadway capacity of the two-lane Waimano Home Road was found in the early test to be wholly inadequate to satisfy its 1985 travel demand. Its improvement to a four-lane divided boulevard together with Kamehameha Highway could provide the principal accesses into Pearl City.

Early tests revealed that the interchange arrangement at Waiau between the cane-haul Moanalua Road and the Interstate Route H-1 has the effect of allowing some 14,000 vehicle trips per day to bypass Kamehameha Highway and Lehua Street - Waimano Home Road intersection. Placing the on- and off-ramps for the inbound (Honolulu-bound) traffic at Kamehameha Highway instead of at the cane-haul road would force this 14,000 trips to utilize the lower portion of Waimano Home Road. In plan development, it was reasoned that the improvement of Waimano Home Road together with certain changes of its intersection with Kamehameha Highway would provide sufficient capacity to accommodate these additional inbound trips. Also, having Interstate Route H-1



AR00032032

interchange at Kamehameha Highway would be in line with interchange locations involving Interstate and other Federal-aid primary routes.

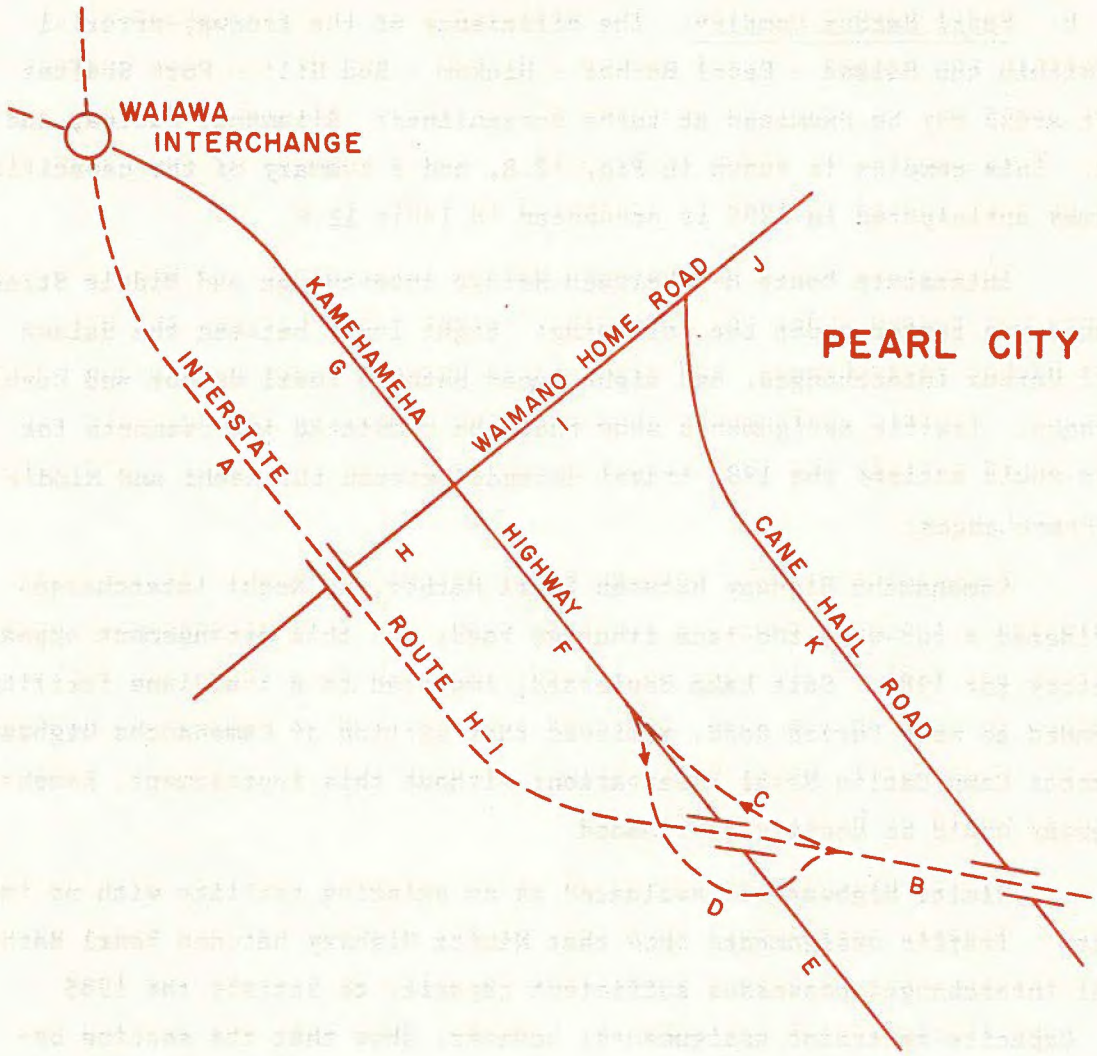
The suggested changes discussed above were thus incorporated in recent plan developments. Briefly, they are:

1. Waimano Home Road improved to four lanes
2. Interchange added between Kamehameha Highway and Interstate Route H-1 for Pearl City traffic, east-bound only
3. Complete separation between Interstate Route H-1 and the cane-haul road.

Traffic assignments for this adjusted plan development are shown in Fig. 12.7. It should be noted that traffic assignments immediately east of Waiau have been over-weighted to Kamehameha Highway because of the size and loading of the traffic zones and of the treatment of Moanalua Road as a two-lane, unimproved, rural roadway in the system analysis. OTS recommends improvement to this facility to service the potential growth of the upper regions of Waiau, Waimalu, and Kalauao. This improved connection between Pearl City and Aiea would relieve Kamehameha Highway, permitting it to function as a principal primary highway.



AR00032033


WAIAWA
INTERCHANGE
KAMEHAMEHA
HIGHWAY
G
WAIMANO HOME ROAD
I
J
PEARL CITY
INTERSTATE
A
H
ROUTE H-1
F
CANE HAUL ROAD
K
C
B
D
E

AR00032034

h. Pearl Harbor Complex. The efficiency of the freeway-arterial network within the Halawa - Pearl Harbor - Hickam - Red Hill - Fort Shafter - Airport areas may be examined at three screenlines: Aliamanu, Puuloa, and Moanalua. This complex is shown in Fig. 12.8, and a summary of the capacities and volumes anticipated in 1985 is presented in Table 12.6.

Interstate Route H-1 between Halawa Interchange and Middle Street Interchange was tested under the following: eight lanes between the Halawa and Pearl Harbor Interchanges, and eight lanes between Pearl Harbor and Keehi Interchanges. Traffic assignments show that the committed improvements for this area would satisfy the 1985 travel demands between the Keehi and Middle Street Interchanges.

Kamehameha Highway between Pearl Harbor and Keehi Interchanges was considered a two-way, two-lane frontage road, and this arrangement appears satisfactory for 1985. Salt Lake Boulevard, improved to a four-lane facility and extended to meet Puuloa Road, relieved that section of Kamehameha Highway which fronts Camp Catlin Naval Reservation; without this improvement, Kamehameha Highway would be heavily overloaded.

Nimitz Highway was evaluated as an existing facility with no improvements. Traffic assignments show that Nimitz Highway between Pearl Harbor and Keehi Interchanges possesses sufficient capacity to satisfy the 1985 travel. Capacity-restraint assignments, however, show that the section between Pearl Harbor Interchange and Hickam - Pearl Harbor Gates would be overly congested. Special treatment at Pearl Harbor Interchange to encourage fuller use of Kamehameha Highway for traffic into Pearl Harbor Naval Reservation would lessen the load on Nimitz Highway between the Interchange and the main Air Force and Naval Gates.



AR00032035

Table 12.6. Summary of 1985 Roadway Capacities and Average Assigned Traffic Volumes in Pearl Harbor Complex

| Screenline | Roadway Capacity (vehicles) | Average Assigned Volume (vehicles) for Alternate | | |
|---|---|---|---|---|
| | | 1.1 | 1.2 | 1.3 |
| Aliamanu | | | | |
| Nimitz Highway | 23,300 | 48,300 | 47,800 | 47,800 |
| Kamehameha Highway | 20,000 | 18,500 | 19,200 | 20,100 |
| Interstate Route H-1 | 98,000 | 64,700 | 69,600 | 69,300 |
| Salt Lake Boulevard | 16,000 | 13,400 | 13,700 | 12,900 |
| Moanalua Highway | 45,000 | 48,100 | 41,900 | 42,000 |
| | 202,300 | 193,000 | 192,200 | 192,100 |
| Puuloa | | | | |
| Nimitz Highway | 23,300 | 22,000 | 16,700 | 17,200 |
| Kamehameha Highway | 8,400 | 7,400 | 6,600 | 7,100 |
| Interstate Route H-1 | 98,000 | 82,600 | 93,300 | 93,300 |
| Salt Lake Boulevard | 16,000 | 8,000 | 8,900 | 7,800 |
| Moanalua Highway | 45,000 | 48,100 | 41,900 | 42,000 |
| | 190,700 | 168,100 | 167,400 | 167,400 |
| Moanalua | | | | |
| Nimitz Highway | 23,300 | 24,100 | 15,300 | 17,300 |
| Kamehameha Highway | 8,400 | 8,200 | 9,200 | 8,600 |
| Interstate Route H-1 | 98,000 | 82,600 | 93,300 | 93,300 |
| Salt Lake Boulevard | 11,000 | 6,900 | 7,300 | 6,500 |
| Moanalua Highway | 36,000 | 49,800 | 45,100 | 45,700 |
| | 176,700 | 171,600 | 170,200 | 171,400 |

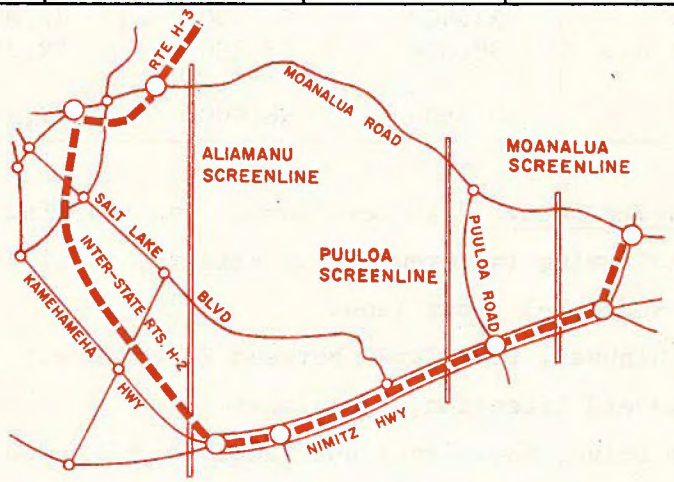



FIG. 12.8. PEARL HARBOR COMPLEX.



AR00032036

i. Trans-Koolau Corridor. Presently, the Pali and Likelike Highways are the only two four-lane facilities serving vehicular movements through this corridor. In the plan development, Interstate Route H-3 was considered "committed." These three facilities will provide a total of 12 lanes, which should accommodate more than 104,000 vehicles per day. (Route H-3 was considered a four-lane freeway facility in the test and evaluation phase.)

Twenty-four-hour traffic assignments to Interstate Route H-3 indicate that a four-lane facility with provision for future expansion to a six-lane facility might be in order (Table 12.7). It should be noted, however, that peak-hour vehicular movement through this corridor is highly directional. Therefore, the selection of the specific level of service should be appropriate for this new freeway facility. It is very likely that, in accordance with the 1965 Highway Capacity Manual, the selection of a level of service of either "B" or "B(rural conditions)" would dictate a six-lane facility for this Interstate Route.

Table 12.7. Summary of 1985 Roadway Capacities and Average Assigned Traffic Volumes in Trans-Koolau Corridor

| Facility | Roadway Capacity | Average Assigned Volume (vehicles) for Alternate | | |
|---|---|---|---|---|
| | | 1.1 | 1.2 | 1.3 |
| Pali Highway | 33,400 | 38,200 | 37,300 | 38,000 |
| Likelike Highway | 33,400 | 32,400 | 32,800 | 32,200 |
| Interstate Route H-3 | 38,000 | 28,300 | 29,300 | 29,200 |
| TOTAL | 104,800 | 98,900 | 99,400 | 99,400 |

j. Windward Oahu. Plan development for the windward area of Oahu consists of the following improvements to existing facilities (Fig. 12.9).

1. Interstate Route H-3, four lanes
2. Kamehameha Highway, four lanes between Pali Highway and Waiahole
3. Mokapu Boulevard Extension, four lanes
4. Kaneohe Bay Drive, four lanes continued to Mokapu Saddle Road
5. Kalanianaole Highway, four lanes from Kailua Road to Waimanalo
6. Mokapu Saddle Road, four lanes
7. Kahekili Highway, four lanes to Kahaluu.



AR00032037

Except for the Mokapu Boulevard Extension, 1985 travel demands warrant the plan developments of roadway facilities mentioned above. Mokapu Boulevard Extension does not show sufficient usage to warrant its being presently considered; it could, however, be considered as a parkway facility in conjunction with any recreational plan development of the Kawainui Swamp area. A parkway is a convenient type of facility where esthetic considerations are given more attention and where design features are more generous than usual. Such a facility could blend into the suburban landscape and commercial vehicles would be prohibited from its use. If such a facility becomes a reality, the Oahu Transportation Study recommends that it does not become a wedge for zoning adjacent properties for more extensive uses.

Kailua Road, a four-lane divided facility, was thought sufficient in plan development to satisfy the 1985 travel demands for that facility. That section between Waimanalo Junction and Kailua Town could conceivably be relieved, however, if traffic having origins and destinations in Keolu Hills could be encouraged to access and egress from Kalanianaole Highway. This is strongly recommended if the service life of that section of Kailua Road is to be extended.

That section of Kailua Road between Castle and Waimanalo Junctions and its signalized intersections with Kamehameha and Pali Highways will not possess sufficient capacities to satisfy the 1985 travel demands for those facilities. This Study, therefore, recommends that Kailua Road between Castle and Waimanalo Junctions be improved to a six-lane facility and that is intersection with Kamehameha and Pali Highways be completely grade-separated.

Another critical section of roadway disclosed by the traffic assignments is that portion of Likelike Highway between Interstate Route H-3 and Kamehameha Highway. Because of the heavy interchanging of traffic between Interstate Route H-3 and Likelike Highway, an additional lane in each direction should be provided in that section of Likelike Highway.



AR00032038

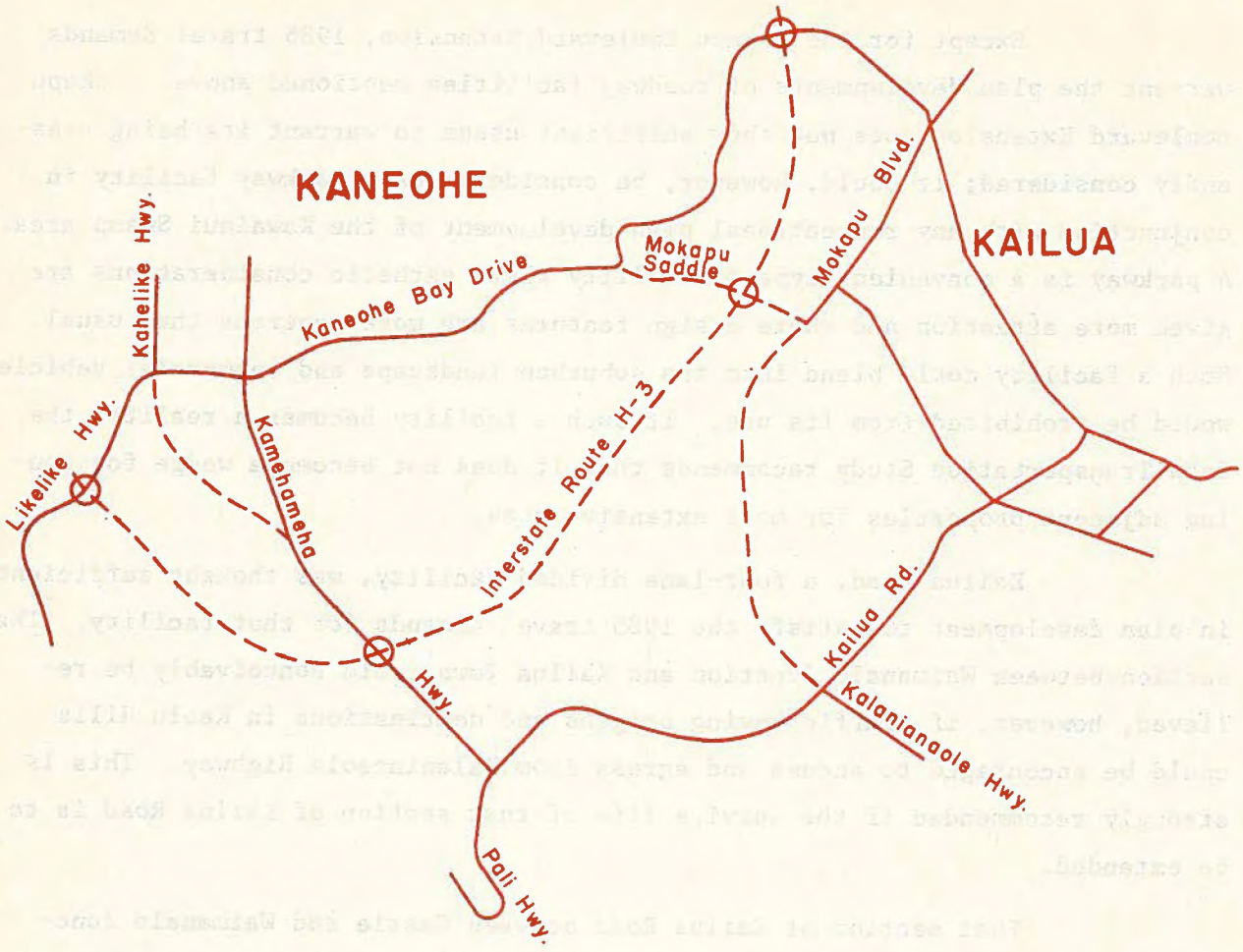



FIG. 12.9. KANEOHE-KAILUA COMPLEX.

k. North Oahu. In plan development, the existing two-lane rural highway serving North Oahu was considered to possess sufficient capacity to satisfy its 1985 demand for travel. Traffic assignments confirm this conclusion. It should be noted, however, that the existing highway, which was constructed many years ago, does not possess highway geometrics that are compatible with today's high-speed vehicles. Although the Study does not recommend a completely new facility to serve North Oahu, it does recommend that spot improvements be made in the alignment to minimize no-passing zones, to eliminate accident-prone areas, and to provide maximum safety to pedestrians in heavily congested beach areas and facilities.

l. East Honolulu. Initial traffic assignments in the Study's transit evaluation revealed that the most clear-cut capacity deficiency on the



AR00032039

highway system is just to the east of Diamond Head, in the vicinity of Aina Koa. Based on the analysis of the early transit study, it appeared that transit usage had been underestimated in this corridor between Diamond Head and Koko Head. Early recommendations suggest that further studies should consider the possibility of extending the rapid-transit system the east of its present terminus (Waialae Shopping Center) to the Hawaii Kai area. Such an extension, it is believed, may well relieve, or at least delay, the need for construction of the extensive additional highway facilities needed in light of the preliminary estimates made in the course of the earlier transit study.

The following text will discuss the probable size and scale of the future conditions of this area which will largely govern the dimensions of the planned transportation system. Appendix 12.B presents a discussion of a later transit evaluation of the suggested extension of the rapid-transit system to the Hawaii Kai area.

(1) Existing Facility. The total master-planned roadway width of Kalanianaole Highway is 120 ft. Those sections of the highway that are now four-lane divided possess a right-of-way width of 120 ft. Those four-lane undivided sections have a right-of-way width of 70 ft, with total setbacks of 50 ft. The master-plan map shows this 50-ft setback to be generally 25 ft on each side of the roadway; however, for a few sections, the total setback is either on the north or south side of the roadway.

Improvement on Kalanianaole Highway to a six-lane divided facility is physically possible within this 120 ft right-of-way. It is also physically possible to place within the mediam of this six-lane divided facility columns for the support of either a railed rapid-transit or a highway facility.

(2) Observed 24-Hour Traffic. Table 12.8 is a tabulation of the observed 24-hr vehicular traffic on Kalanianaole Highway in the vicinity of the Waialae Golf Course. Although Kalanianaole Highway has more use on Saturdays, Fridays are the most critical days of the week because of the home-based work trips occurring in the morning and in the afternoon peak hours. The point this Study makes is that Kalanianaole Highway is now experiencing volumes in excess of 37,000 vehicles per day, with only 15 percent of the areas being developed in east Honolulu.



AR00032040

Figure 12.10 shows the Friday traffic pattern on Kalanianaole Highway. Except for the actual values, this pattern is similar to those found on other major highways leading into downtown Honolulu.

Table 12.8. Observed 24-Hour Traffic on Kalanianaole Highway at Kapakahi Bridge in 1967

| Month | Day of Week | | | | | | |
|---|---|---|---|---|---|---|---|
| | Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
| January | 29,918 | 32,537 | 31,850 | 32,149 | 33,043 | 36,991 | 36,784 |
| February | 32,558 | 31,768 | 33,027 | 32,757 | 32,986 | 37,087 | 37,003 |
| March | 34,070 | 30,009 | 33,155 | 33,881 | 33,886 | 37,360 | 38,412 |
| April | 33,836 | 32,416 | 33,062 | 33,380 | 34,550 | 37,507 | 38,820 |
| May | 35,559 | 33,729 | 34,847 | 34,221 | 32,100 | 37,767 | 39,553 |
| June | 36,632 | 35,722 | 37,061 | 37,005 | 36,660 | 39,340 | 39,814 |
| July | 37,218 | 35,448 | 36,389 | 35,814 | 35,968 | 37,995 | 39,704 |

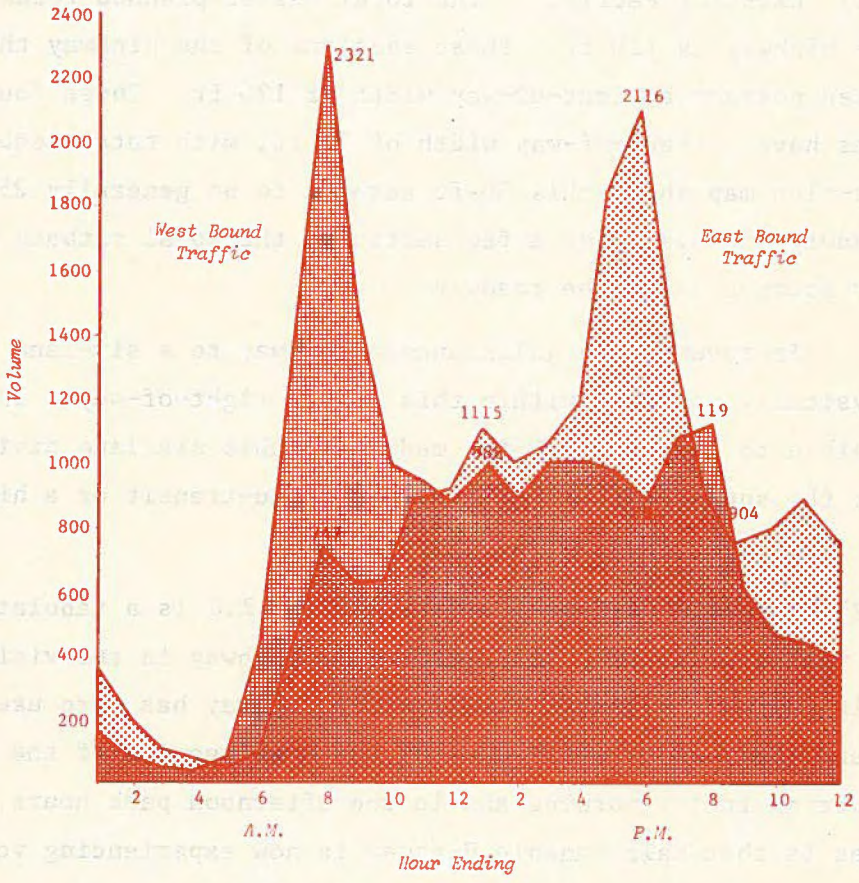



FIG. 12.10. HOURLY TRAFFIC VARIATION ON KALANIANAOLE HIGHWAY IN 1967.



AR00032041

(3) Dwelling Units. Figure 12.11 shows a comparison of the 1965 and 1985 estimates of dwelling units for east Honolulu, Census Tracts 1 through 4. The estimates show a total growth for the area of 15,965 dwelling units by 1985. The dwelling units demanded of this area represent about 6 percent of the total 1985 demand for Oahu.

The fastest growing area in east Honolulu is Hawaii Kai; the estimates show an increase by over 8½ times that of its 1965 housing total. This area in 1985 will have more dwellings than all the units estimated for Census Tracts 2, 3, and 4 put together.

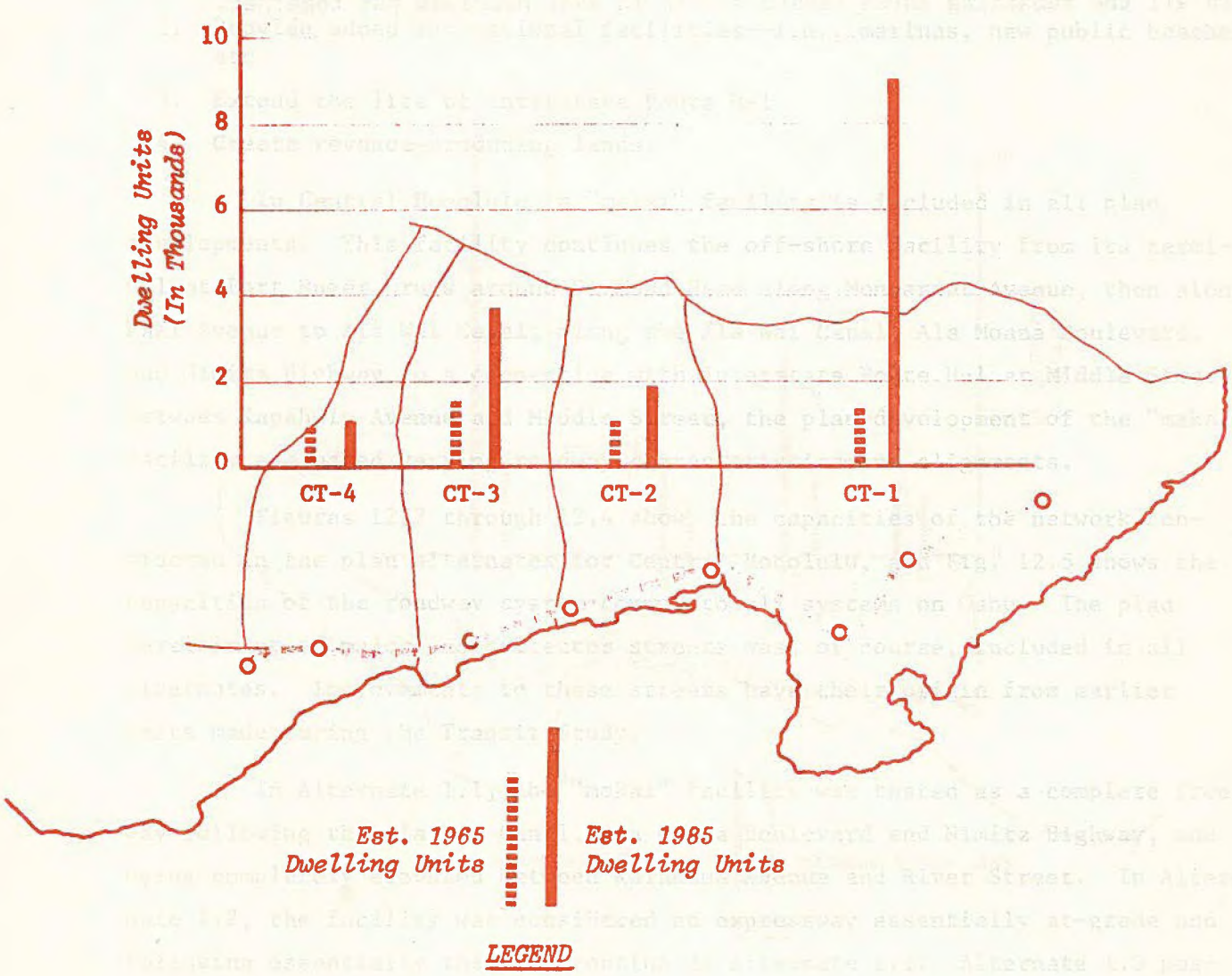



FIG. 12.11. COMPARISON OF 1965 AND 1985 ESTIMATE OF DWELLING UNITS IN EAST HONOLULU.



AR00032042

(4) Population. Figure 12.12 presents a comparison of the 1965 and 1985 estimates of population for east Honolulu, showing a total of 63,864 persons to be residing in the area in 1985, a growth representing nearly three times that of its 1965 population. This distribution of population to east Honolulu represents slightly over 6 percent of the 1985 estimated population for Oahu.

Hawaii Kai will have a 1985 population approximately five times that of 1965 and Aina Haina shows an approximate doubling of its 1965 population. There will be one-fourth more people living in Hawaii Kai than in all the remaining three census tracts in east Honolulu put together.

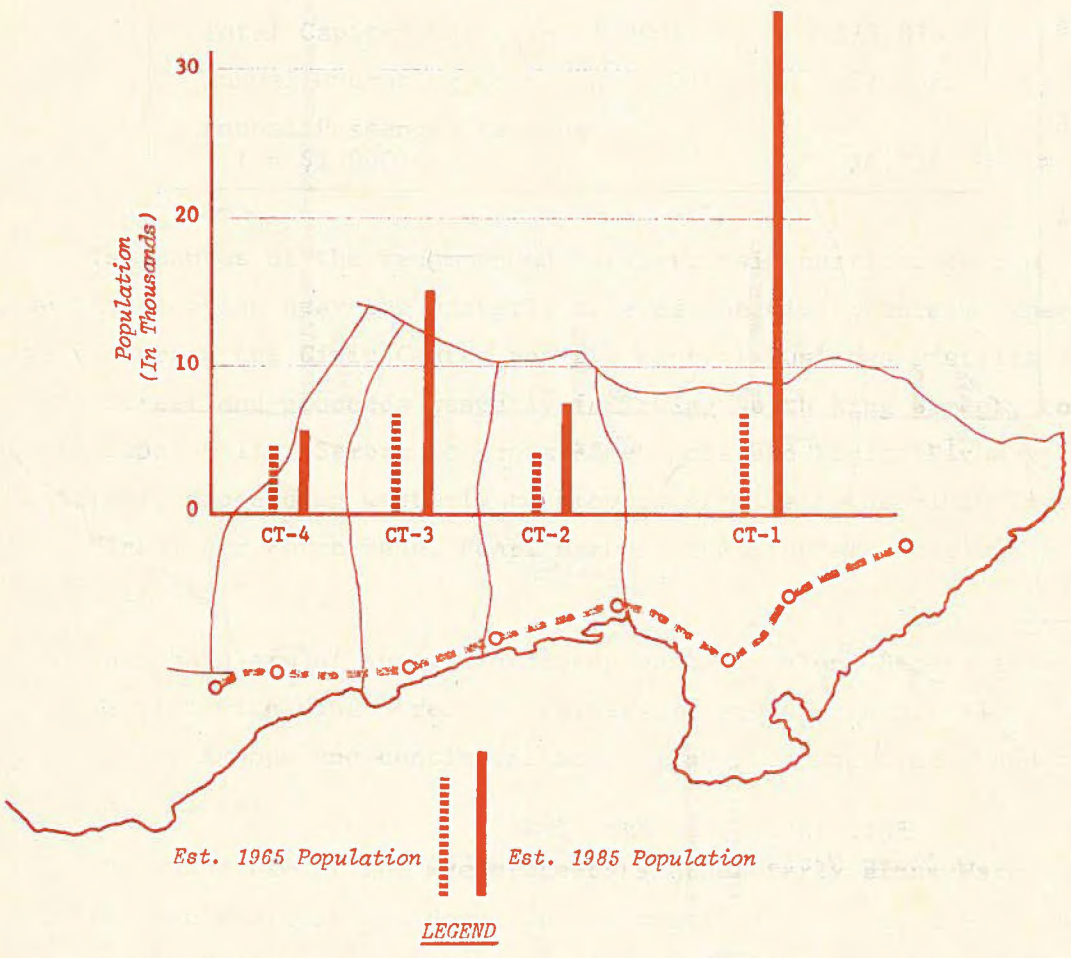



FIG. 12.12. COMPARISON OF 1965 AND 1985 ESTIMATES OF POPULATION IN EAST HONOLULU.



AR00032043

(5) Auto Ownership and Person Trips. Table 12.9 shows a comparison of 1985 estimates of auto ownership and person trips between the Study Area (Oahu) and east Honolulu. Estimates show auto ownership to increase nearly six times over 1965, with rates of 1.1 autos per dwelling unit in 1965 to 1.8 autos per dwelling unit in 1985. This high rate of auto ownership is reasonable and compatible with areas of high-income families.

Of the total 1985 person trips generated for Oahu, 252,984 person trips, or approximately nine percent of the Island's total, will be generated in east Honolulu. Of course, the modes by which these trips will be made will depend on the extent of the transportation system to be provided for the area.

Table 12.9. Comparison of 1985 Estimates of Autos and Person Trips in Oahu and East Honolulu

| Measures | Oahu | East Honolulu |
|---|---|---|
| Auto Ownership | 360,000 | 29,458 |
| Person Trips | 2,817,849 | 252,984 |

(6) Vehicular Traffic. With a rail-rapid-transit system serving east Honolulu, study estimates indicate that there will be about 106,400 vehicular trips generated by this area. Approximately 79 percent of this vehicular travel (84,100 trips) is expected to cross the Kahala screenline. Traffic patterns for east Honolulu indicate that this daily travel across the Kahala screenline would possess a peak morning volume of 6,300 vehicles moving westward into central Honolulu and/or beyond. To satisfy this peaking demand, roadway capacities from 5 to 6 lanes (directional) would be required. Thus, the Study's conclusion at this point is that even the combined capacities of a rail-rapid-transit extension to Hawaii Kai together with the six-lane highway facility (Kalanianaole Highway) would not completely solve the future transportation problem in east Honolulu.

It should be emphasized that the Study is concerned, at the system level, with the whole and with the manner in which the parts are integrated. If we eliminate consideration of adding roadways in east Honolulu and of integrating them with other facilities under consideration in the remaining



AR00032044

portion of the community, we will wind up with an understatement of the transportation requirements as viewed at the system level. Therefore, an off-shore facility together with mass transit for East Honolulu were considered in plan development.

m. Interstate Route H-1 (Central Honolulu). Interstate Route H-1 is the backbone of the freeway-arterial network through Central Honolulu. This freeway is expected to experience a heavy overload in 1985. Generally, the volume-to-capacity ratio that can be expected will be 1.60 at an average daily speed of 28 mph. Traffic assignments revealed that the provision of an additional freeway in the "makai" corridor could reduce the vehicular load on the freeway by some 10,000 vehicles per day in each direction; this reduction would, in effect, produce a higher average daily speed of 33 mph.

If no upgrading is accomplished, it can be expected that in 1985 the freeway through Central Honolulu (Interstate Route H-1) would assume the role of an expressway rather than that of a freeway. Thus, to extend the service and function life of the freeway access to and egress from it should be limited to permit only long trips. Short trips would then be encouraged to use the major and collector streets.

Upgrading Interstate Route H-1 through Central Honolulu is possible. Though recognizing that serious problems would occur if the upgrading were done on the existing roadway structure, this Study recommends that serious consideration be given to upgrading Route H-1. The Study also recommends that serious consideration be given to upgrading Kapiolani Boulevard by providing interchanges at, and/or grade separations of, critical intersections.

n. Waikiki. Though Waikiki is already densely developed, the greatest portion of Waikiki's growth is divided between that in resort hotels "makai" of Kalakaua Avenue and in apartment hotels "mauka" of Kalakaua Avenue, with increasing numbers of high-rise apartments rapidly appearing between Kuhio Avenue and Ala Wai Canal. The increased accessibility provided by a rapid-transit system could increase pressure for different land uses in Waikiki, as well as more intense development of the Ala Wai area.

In addition, it is possible that, while certain land uses, because of increased accessibility, will be developed at higher densities, there is



AR00032045

also a potential for a sorting out of other uses from the area. The demands for space for hotels on Waikiki may force office uses toward Ala Moana Center, the CBD, or the Airport rather than continuing to be developed at Waikiki.

Regardless of the competition for space, Waikiki should be considered, if it is not already, a unit of land, or a land-use cell, which would serve as a building block to urban development. Within this cell the requirements of land uses should have priority over those of transportation. Thus, an important characteristic of this cell is that only traffic destined for, or originating from, its land activities would use its local- and collector-street systems.

To protect the social and economic integrity of Waikiki, the Study's plan development considered all streets within the area to function as either local or collector streets. Kalakaua Avenue, therefore, was constrained to prevent its being used as an arterial for through traffic. The handling of through traffic would be by a new expressway facility along the Ala Wai Canal.

The expressway along the Ala Wai Canal is termed conceptual in nature and should not be construed to mean a specific location of the facility. In Plan Alternates 1.2 and 1.3, the expressway is a split facility (Fig. 12.13), with the eastbound lane planned to coexist with Ala Wai Boulevard and with the westbound lane to traverse along the "mauka" side of Ala Wai Canal. This concept was to minimize cost and to preserve the width of the canal. To preserve the park lands, however, the westbound land could be placed alongside Ala Wai Boulevard, over the canal, and have its "mauka" tree-lined area form the divider or median separating opposing traffic lanes.

In Plan Alternate 1.1, the facility along the Ala Wai Canal was a freeway, apart from Ala Wai Boulevard.

University Avenue, extended as a north entrance to Waikiki, was included in all Plan Alternates. Also, Kuhio Avenue was considered extended to Kapahulu Avenue.

Tables 12.10 and 12.11 compare the magnitude of present and estimated future conditions of Waikiki.



AR00032046

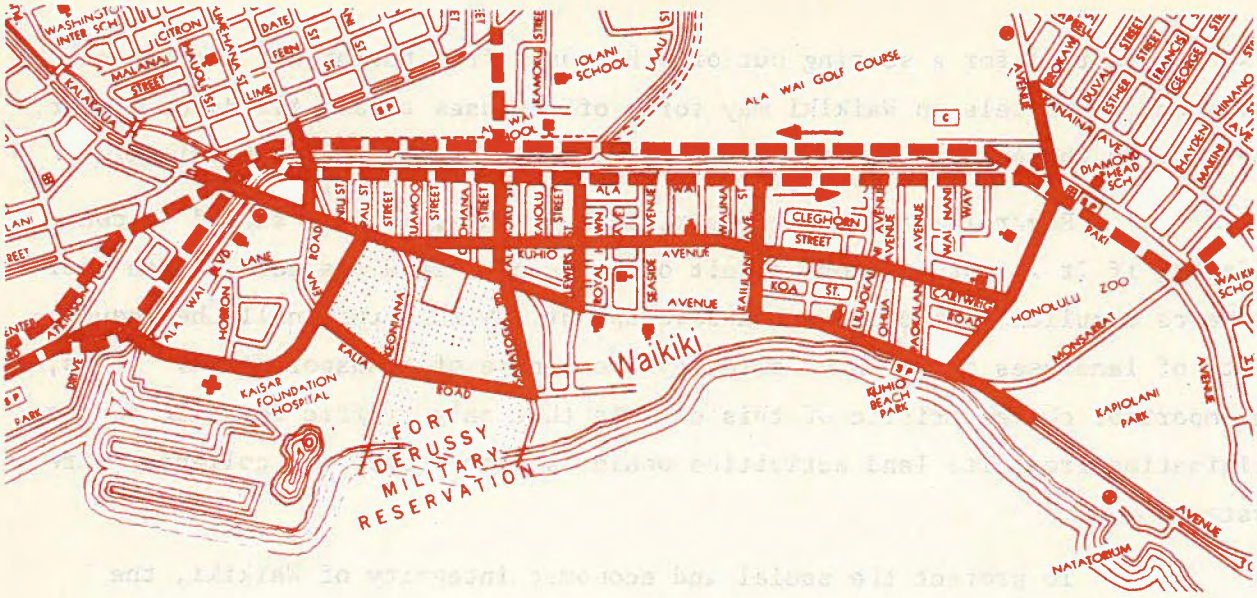



FIG. 12.13. ARTERIAL NETWORK OF WAIKIKI UNDER PLAN ALTERNATES 1.2 AND 1.3

Table 12.10. Summary of Trip Generation in Waikiki

| Year | Total Person Trips | Transit Trips* | % Transit | Vehicle Trips* |
|---|---|---|---|---|
| 1960 | 121,481 | 12,976 | 10.7 | 60,355 |
| 1985 | 298,756 | 59,428 | 19.9 | 129,702 |

*Excludes tourist travel

Table 12.11. Summary of Employment and Floor Areas in Waikiki

| Year | No. Persons Employed | Floor Area (sq ft) | | |
|---|---|---|---|---|
| | | Hotel | Commercial | |
| | | | Retail | Service |
| 1960 | 9,397 | 2,917,200 | 605,000 | 546,000 |
| 1985 | 16,744 | 9,952,800 | 1,617,800 | 1,823,500 |

Traffic assignments indicate that, in general, the local and collector streets within Waikiki (the land-use cell) have more than the necessary capacity to accommodate trips having either origins or destinations in



AR00032047

the area. It should be noted, however, that the streets must also be expected to accommodate internal movements (intrazonal traffic), which have not been accounted for in the traffic assignments. Thus, although assignments show satisfactory capacities in the network, careful consideration must be given to parking and circulation.

University Avenue, extended as a north entrance to Waikiki, can result in a very attractive addition. Assignments indicate that approximately 11,600 vehicular trips can be expected to enter Waikiki by way of this facility in 1985. The tests also indicate that this facility has a potential of inducing an additional 4,700 vehicles from Kapahulu Avenue--i.e., traffic diverted onto the expressway facility and on into Waikiki via University Avenue.

The provision of the expressway along the Ala Wai Canal successfully removed through traffic from Waikiki. It was obvious in the tests that the "makai" facility as a freeway attracted much more traffic than as an expressway. Yet, both have equal success in removing through traffic from Waikiki, which was the intent of describing a facility along the Ala Wai Canal (a natural barrier) so that Waikiki could be developed as a complete neighborhood cell.

o. Manoa-Palolo Stream Connector. This four-lane facility in plan development functions as an outer circumferential route connecting Interstate Route H-1 at Kapiolani Interchange with the planned "makai" facility along the Ala Wai Canal (see Fig. 12.14). Traffic assignments were accomplished with and without this connector in all plan developments. Future volumes on this facility range from 17,000 to 20,000 vehicles between Kapiolani Interchange and Date Street and from 20,000 to 23,000 vehicles per day between Date Street and the "makai" facility.

The impact of this connector on streets and highways within its influence has not been significant.

1. Tests revealed that approximately 3,700 vehicles would access to and egress from Interstate Route H-1 (Kaimuki section) solely to use this connector for their westbound movement, and another 3,000 freeway trips would change their routing, thus reducing westbound traffic by that amount on Interstate Route H-1 just west of Kapiolani Interchange.
2. The Manoa-Palolo Stream Connector had no appreciable effect on Waialae Avenue, Kapahulu Avenue, or Waikiki.



AR00032048

3. Eastbound traffic on Kapiolani Boulevard between Kapiolani Interchange and Date Street showed a decrease ranging from 2,000 to 8,000 vehicles per day (depending on Plan Alternates), and Date Street west of the connector showed a decrease of 2,000 to 5,000 vehicles per day.

Although traffic-assignment results do not indicate the importance of this Manoa-Palolo Stream Connector, this Study concludes that the value of this connector as an outer circumferential route depends on the manner in which the other connectors are described in the freeway-arterial network.

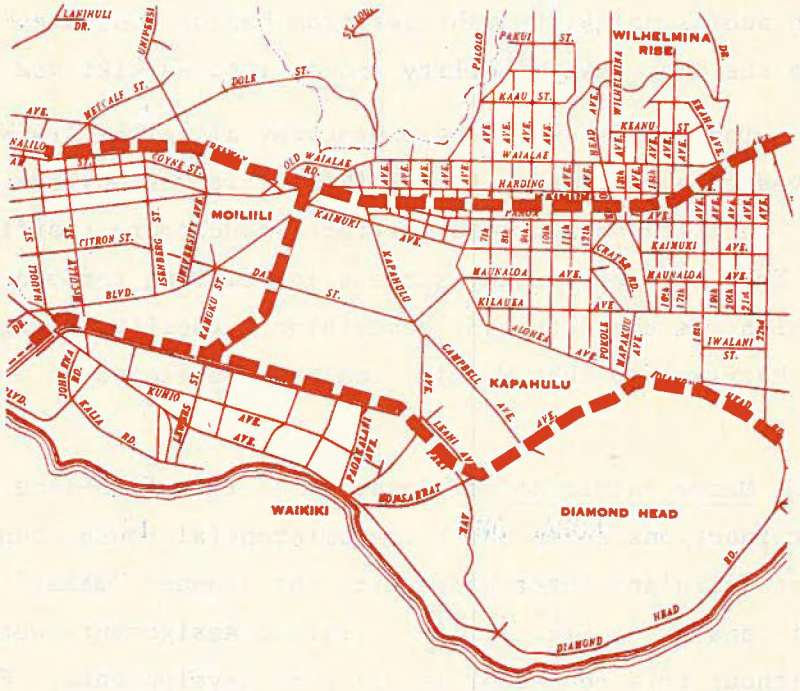



FIG. 12.14. MAP SHOWING MANOA-PALOLO STREAM CONNECTOR.

p. Central Business District and Civic Center. The Central Business District and the Civic Center are the hub of Oahu, as the center of financial and office service functions and seat of all governmental activities--City and County and State; for historical reasons, these two areas are of importance to the tourists as well. Hence, this area is a major trip attraction center for the entire Island of Oahu as well as for the Honolulu District and the tourist population.



AR00032049

The Central Business District is characterized as one of intense property development and utilization and high land valuation, consisting of numerous retail establishments, banks, theaters, and commercial enterprises. It is now undergoing a detailed study and analysis.

The Civic Center is made up of a cluster of cultural and governmental activities. The daily activities of the Civic Center are the events that determine the future of the State. The Civic Center, too, is undergoing a detailed study and analysis.

By 1985, the City's restricted-traffic corridor will carry many times the present volumes of cars. The most serious issue to be resolved is how to handle the heavy traffic that is anticipated through this narrow channel so that the social and economic integrity of the business and civic areas could be protected.

The following text discusses the plan developments and their tests and evaluations with the intent of providing meaningful information for policy decisions.

Plan developments have their origin from findings of the early Transit Study and from preliminary knowledge of the current planning of the Civic Center and the Central Business District by various private consultants under contract with the City and the State.

(1) Plan Alternate 1.1. This plan was tested and evaluated in accordance with the following conditions:

1. Interstate Route H-1, six lanes
2. Liliha Street, six lanes; Extension, four lanes
3. "Makai" Freeway, six-lane viaduct over six-lane Nimitz Highway
4. South Street Connector, six-lane expressway, grade-separated at Kapiolani Boulevard and King Street
5. Beretania, King, Nuuanu, Alakea, and Richards Streets, improved to six lanes
6. Existing Punchbowl Street and Kapiolani Extension
7. Closure of:
   Hotel Street (between Punchbowl and Alakea Streets)
   Fort Street (between Pauahi and Merchant Streets).



AR00032050

(2) Plan Alternate 1.2. This plan was tested and evaluated in accordance with the same network as in Plan Alternate 1.1, except for the following changes:

1. Makai Expressway, eight lanes with two two-lane frontage roads
2. South Street Connector, four-lane expressway with two two-lane frontage roads, and with grade separation at Kapiolani Boulevard, King Street and Beretania Street
3. Punchbowl Street (deleted between Beretania Street and Interstate Route H-1)
4. Kapiolani Extension (deleted).

(3) Plan Alternate 1.3. This plan was tested and evaluated in accordance with the same network as described for Plan Alternate 1.2, except for the following change: Makai Arterial as existing Nimitz Highway.

q. Tests and Evaluation. As a general summary of the analyses of the individual plan alternates, the ranking in terms of efficiency of the circumferential system is: First, Plan Alternate 1.1; second, Plan Alternate 1.2; and third, Plan Alternate 1.3. Each plan alternate is generally, although not completely, adequate in serving the CBD and the Civic Center. (Figs. 12.15 - 12.17.)

Interstate Route H-1 through this corridor is expected to be overloaded. None of the plan alternates appears to be able to relieve it, although Plan Alternate 1.1 has the greatest potential of doing so. Ramp movements involving the interchange between Vineyard Boulevard, South Street Connector, and Interstate Route H-1 will be most critical and will be a traffic-engineering marvel if the maze of movements can be successfully satisfied within the limited land area.

The "makai" facility is expected to be moderately overloaded in Plan Alternates 1.1 and 1.3, whereas a well-balanced loading can be expected in Plan Alternate 1.2. Under this balanced condition, anticipated operating speeds could be in the range of 30 to 35 mph.

The north-south circumferential connectors (Liliha and South Streets) appear to be least used in Plan Alternate 1.1; usage becomes much larger in Plan Alternates 1.2 and 1.3. On the basis of volume-to-capacity ratio, the operating characteristics of these facilities may be classed as free, normal, and normal-to-moderate for Alternates 1.1, 1.2, and 1.3, respectively.



AR00032051

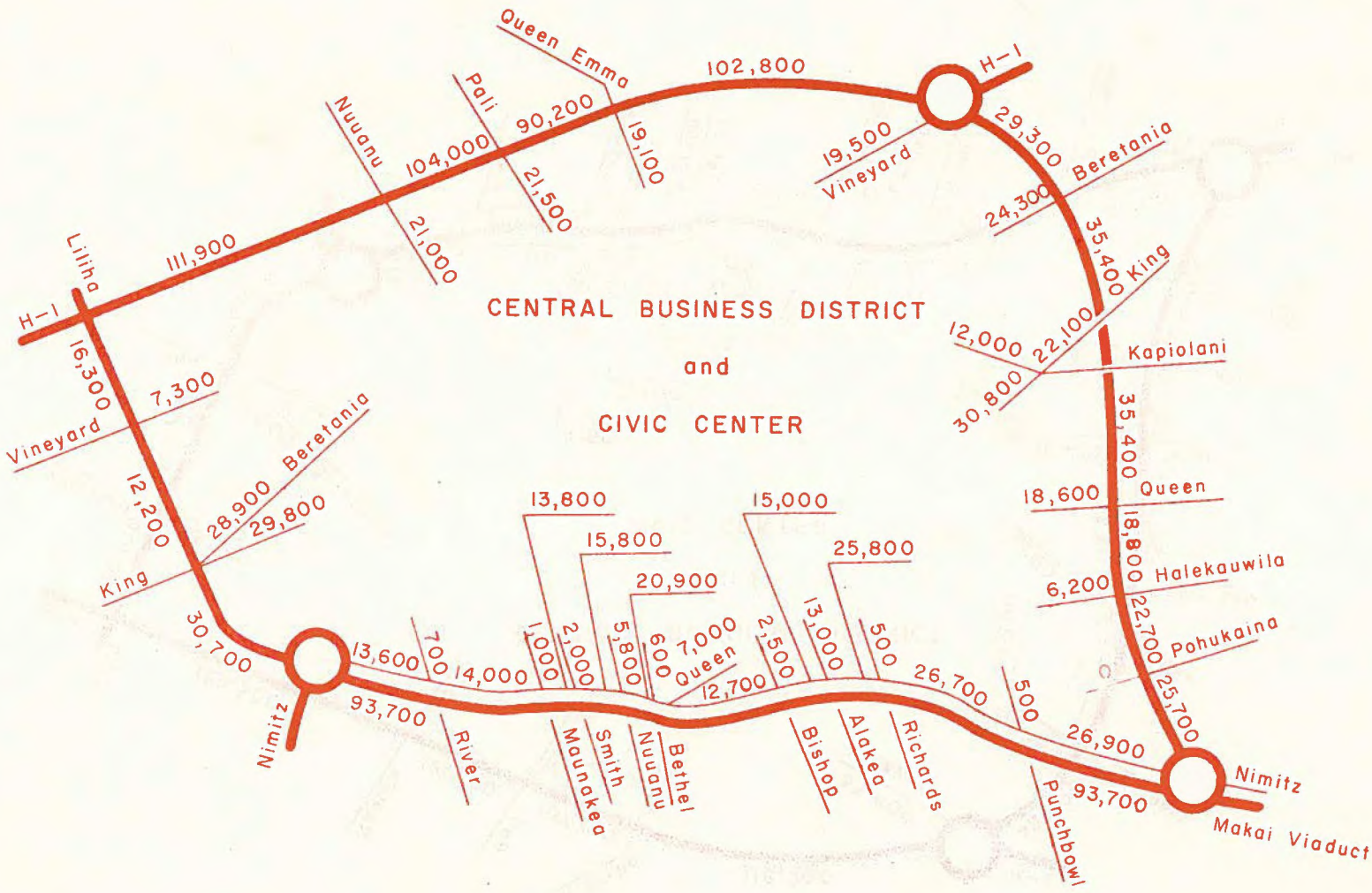



FIG. 12.15. PLAN ALTERNATE 1.1, NONDIRECTIONAL VOLUMES.



AR00032052

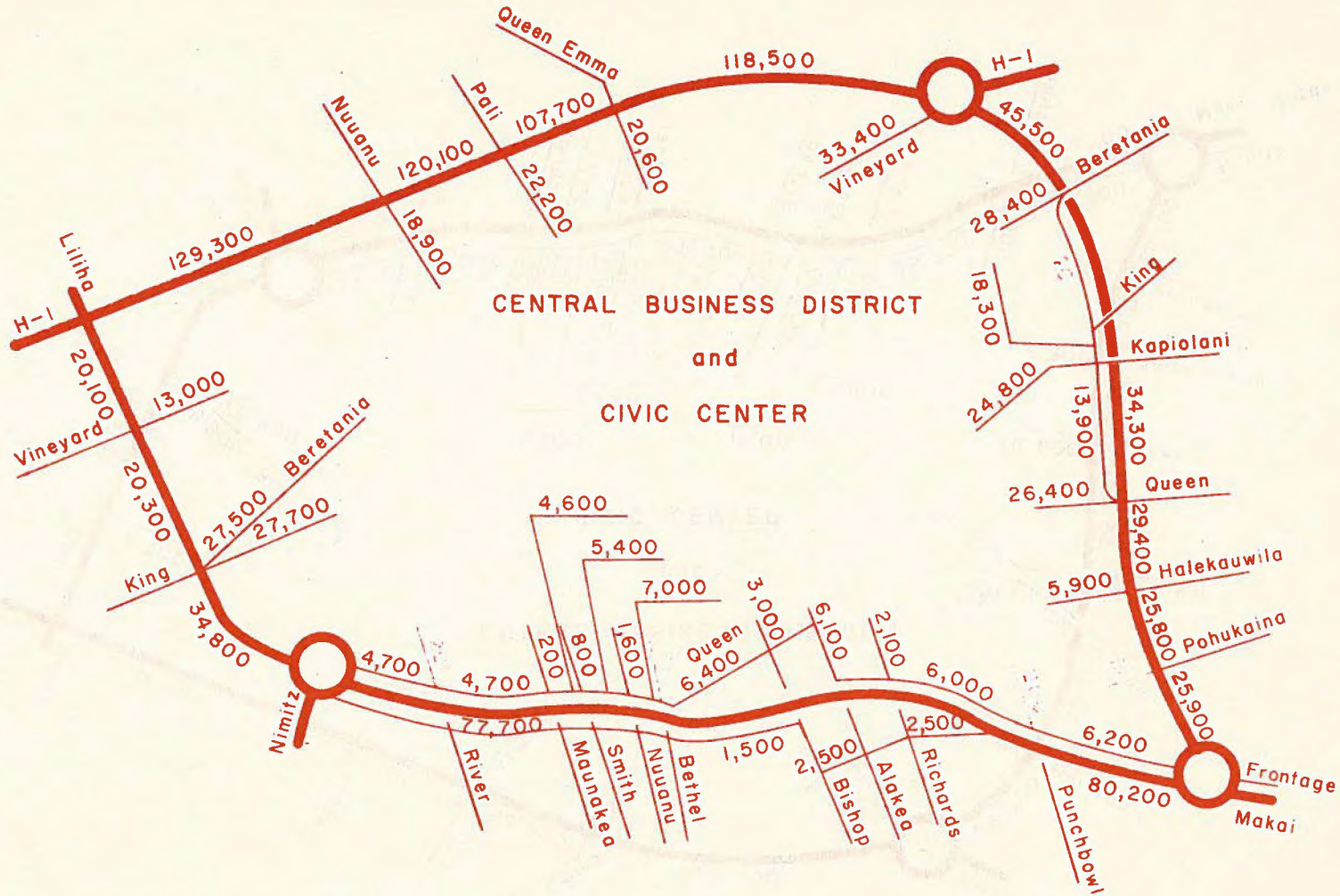



FIG. 12.16. PLAN ALTERNATE 1.2, NONDIRECTIONAL VOLUMES.

AR00032053

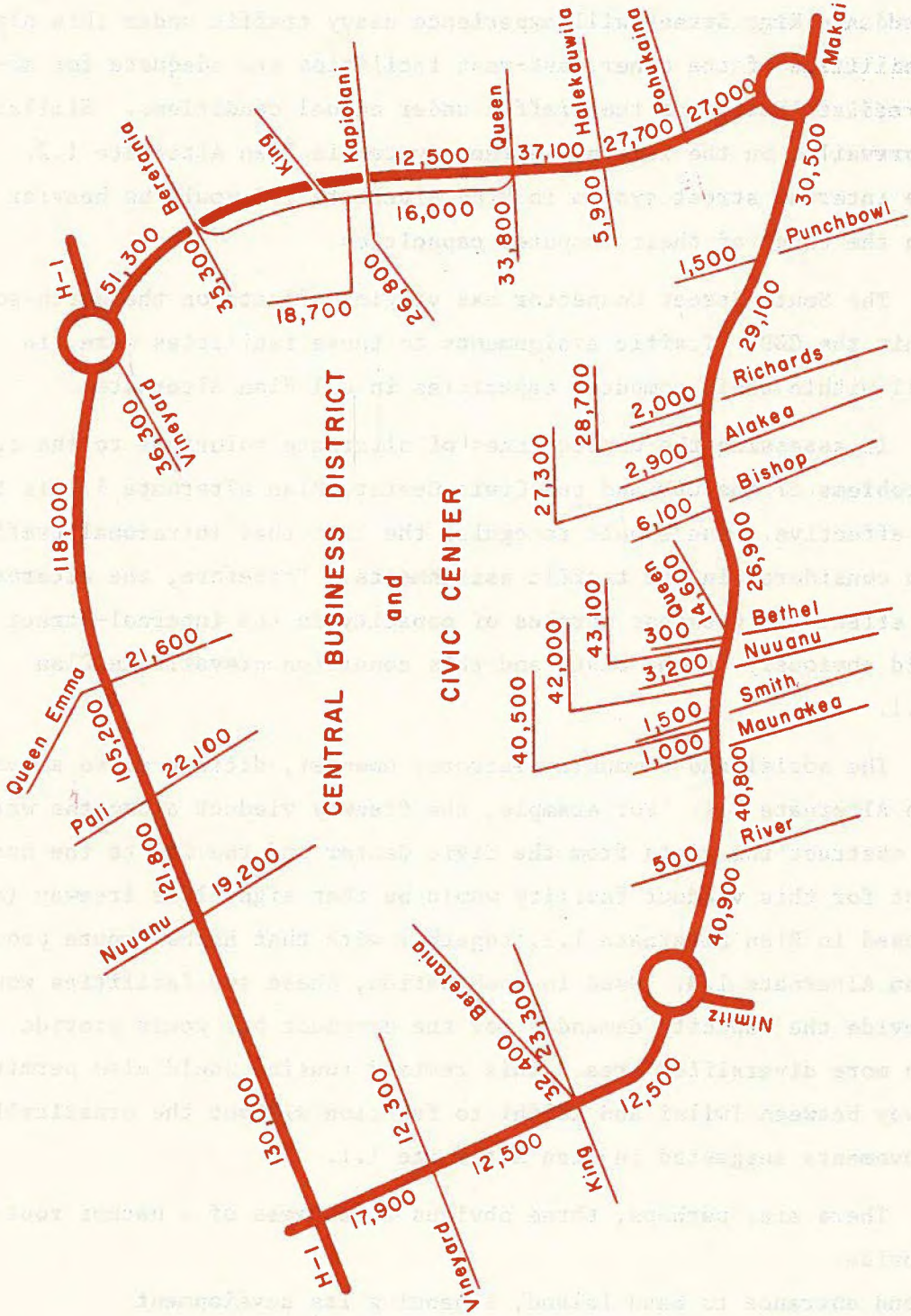



FIG. 12.17. PLAN ALTERNATE 1.3, NONDIRECTIONAL VOLUMES.



AR00032054

Regarding the internal street system, there are generally sufficient capacities in the major east-west streets in Plan Alternate 1.1. Vineyard Boulevard and King Street will experience heavy traffic under this plan, but the capabilities of the other east-west facilities are adequate for absorbing the redistribution of the traffic under actual conditions. Similar conditions prevailed on the internal street system in Plan Alternate 1.2. The usage of the internal street system in Plan Alternate 1.3 would be heavier but still within the range of their computed capacities.

The South Street Connector has varying affects on the north-south streets within the CBD. Traffic assignments to these facilities were, in general, well within their computed capacities in all Plan Alternates.

In assessing the consequences of alternate solutions to the transportation problems of the CBD and the Civic Center, Plan Alternate 1.1 is the most nearly effective. One should recognize the fact that intrazonal traffic has not been considered in the traffic assignments. Therefore, the alternate which would effect the greatest surplus of capacity in the internal-street network would obviously be the best, and this condition prevails in Plan Alternate 1.1.

The social and community factors, however, dictate close scrutiny of this Plan Alternate 1.1. For example, the freeway viaduct along the waterfront would obstruct the vista from the Civic Center and the CBD to the harbor. A replacement for this viaduct facility would be that eight-lane freeway (at grade) proposed in Plan Alternate 1.2, together with that harbor route proposed in Plan Alternate 1.3. Used in combination, these two facilities would not only provide the capacity demanded for the corridor but would provide service to a more diversified area. This revised routing would also permit Nimitz Highway between Iwilei and Kalihi to function without the drastically needed improvements suggested in Plan Alternate 1.1.

There are, perhaps, three obvious advantages of a harbor route; it would provide:

1. A second entrance to Sand Island, enhancing its development
2. A detour when Nimitz Highway is upgraded to freeway standards (at grade)
3. A fast and scenic route for tourist transfer between Waikiki and the Airport.



AR00032055

For the interior-street network of the CBD and the Civic Center, the following is summarized:

1. The proposed King Street widening (six lanes) to provide two-way movements could be justified on the basis of its service as a major street through the CBD.
2. Converting Fort Street into a pedestrian mall will not cause any adverse traffic conditions on the proposed street network in the CBD.
3. The closure of Hotel Street, Punchbowl Street, and Kapiolani Boulevard between King and Beretania Streets could be accomplished.

It is emphasized that the interior-street network was tested as though it were constructed overnight. In practice, however, the system would be built piecemeal. Thus, in implementing the closure of any one street, careful consideration must be given to the operation of the system at various stages because what is done with one facility will affect the other.

r. Makai Facility. The makai facility has been discussed for three critical areas within Honolulu District--namely, at East Honolulu, at Waikiki, and at the CBD and Civic Center. In plan development, this facility has been broadly described along natural and man-made barriers, disrupting existing land uses to a minimum.

Transit-patronage studies have indicated that the addition of improved transit can influence the requirements for highway capacity. A reasonable separation of the travel modes shows a definite need for a makai facility of up to six freeway lanes. The test of this facility revealed that it could entertain extreme volumes ranging from 70,000 to 100,000 vehicles per day.

As a minimum, the makai facility would require the following:

1. If it runs off-shore, four lanes between Hawaii Kai and Aina Haina
2. If it runs off-shore, six lanes between Aina Haina and Diamond Head
3. Diamond Head to Kapahulu Avenue, six-lane major street
4. Kapahulu Avenue to South Street, six freeway lanes; this section may instead be six expressway lanes provided Kapiolani is updated to at least a junior expressway
5. South Street to Liliha Street Extension, eight freeway lanes (at grade)
6. Nimitz Highway, existing six lanes
7. Harbor Route (South Street to Middle Street), four lanes.



AR00032056

## 3. SYSTEMS EVALUATION

An evaluation of the respective assignments reveals that all of the plans are generally, but not completely, adequate to accommodate the forecast travel. Particularly in the outlying areas, existing and planned capacities are greater than assigned volumes.

In Central Honolulu, however, all plans show definite deficiencies. The traffic loads on the freeways and expressways are generally high and exceed planned capacities. They exceed the capacity on Interstate Route H-1 from Middle Street to 6th Avenue. In Plan Alternate 1.1, however, the overload was not substantial. Plans 1.2 and 1.3 show severe overload on Interstate Route H-1, the increase resulting from the modification of the makai facility from a freeway to an expressway.

The major north-south streets, with certain exceptions such as Piikoi Street, displayed generally moderate loadings, at or below planned capacities on all plans. The most critical facilities were found in the Kakaako-Ala Moana District; the conditions strongly suggest the need for upgrading either Piikoi Street or Pensacola Street.

Because of the varying operational characteristics of the facility types and the unequal mileages of these facilities in the alternate plans, more than a visual review of assigned volumes is required in order to judge the relative level of service provided by each plan. Table 12.12 was prepared for this purpose, summarizing miles of travel and average driving speeds.

Table 12.12. Operating Characteristics of Plan Alternates

| Type of Facility | Plan 1.1 | | | Plan 1.2 | | | Plan 1.3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Travel | | Avg. Speed (mph) | Travel | | Avg. Speed (mph) | Travel | | Avg. Speed (mph) |
| | Daily Vehicle Miles | % | | Daily Vehicle Miles | % | | Daily Vehicle Miles | % | |
| Freeway | 5,119,000 | 36.5 | 43.4 | 2,814,000 | 32.9 | 43.2 | 2,697,000 | 31.6 | 43.7 |
| Expressway | 225,000 | 2.6 | 29.4 | 424,000 | 5.0 | 24.5 | 518,000 | 6.1 | 27.0 |
| Arterial | 5,195,000 | 60.9 | 20.7 | 5,315,000 | 62.1 | 15.2 | 5,329,000 | 62.3 | 15.2 |
| All Types | 8,539,000 | 100.0 | | 8,553,000 | 100.0 | | 8,544,000 | 100.0 | |



AR00032057

Any one of the plans can be considered generally adequate, although the traffic service they provided is not equal. Plan Alternate 1.1 provides the best traffic service.

A more meaningful analysis can be conducted by reviewing the relative speeds of the larger facilities through the Honolulu area. Such a comparison is presented in Table 12.13. The speeds indicated are 20 to 30 percent lower than the acceptable speed established by the National Committee on Urban Transportation. Nevertheless, Plan Alternate 1.1 again provides the best service.

Table 12.13. Comparisons of Speeds and Costs of Alternate Plans

| Plan Alternate | Speed (mph) | | Capital Costs ($1,000) | |
|---|---|---|---|---|
| | Freeway | Expressway | Total | Annual* |
| 1.1 | 32.2 | 29.4 | 648,375 | 60,304 |
| 1.2 | 27.0 | 24.5 | 648,472 | 60,312 |
| 1.3 | 27.3 | 27.0 | 651,090 | 60,521 |

*Eight percent times the capital investment cost plus annual maintenance cost. It has been found by experience that this method yields annual capital costs equal to a recovery rate of 7 percent applied to right-of-way cost over 100 years, structure cost over 40 years, and roadway cost over 20 years.

The costs involved in each plan alternate are vital considerations for they affect the selection of a final plan. Table 12.14 also compares these costs. A breakdown of the estimated highway capital costs is presented in Appendix 12.C.

Other costs often overlooked are those incurred by the users of a road network. These are costs that are susceptible to change by road-network design, and do not include such things as the original vehicle investment. User costs, for purposes of this evaluation, include the cost of time, accidents, and vehicle operation. In the derivation of these cost components, the unit cost per vehicle mile of travel developed by the Penn-Jersey Study was applied (Fig. 12.18). Although it is recognized that these unit costs should be adjusted to reflect Oahu's conditions, it was believed that the use of Penn-Jersey's user costs would produce results valid for plan comparisons.



AR00032058

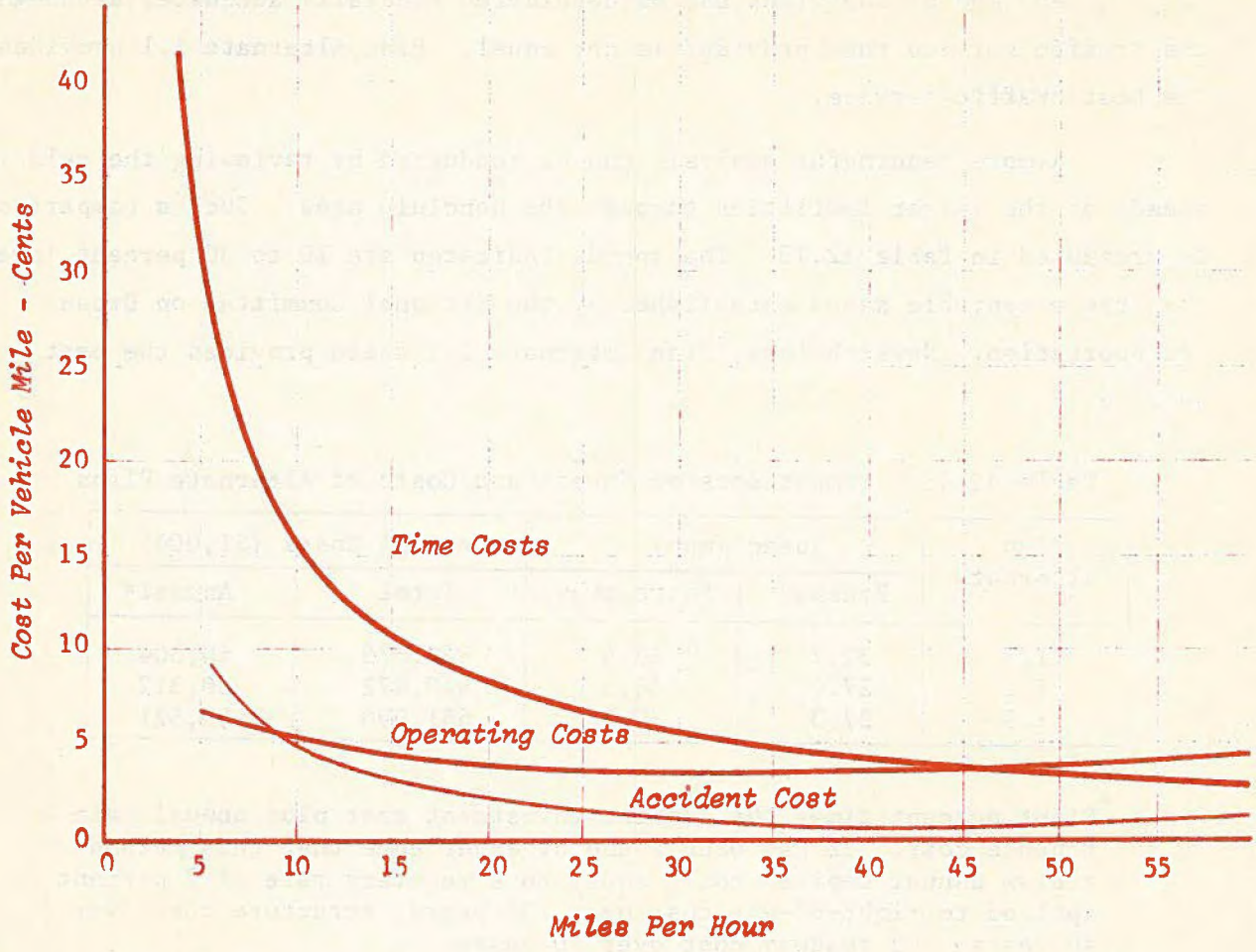



FIG. 12.18. AUTOMOBILE USER COSTS RELATED TO AVERAGE SPEED.

Table 12.14 compares the estimated user costs of each plan alternate. The comparison between annual user costs and annual capital costs shown in Fig. 12.19 is dramatic. Total user costs are approximately 5 to 7 times more expensive than plan implementation. It is also significant to note that the differences in annual user costs between Plan Alternate 1.1 and Plan Alternates 1.2 and 1.3 are both more than the total annual capital cost of Plan Alternate 1.1.

The values presented are a fair evaluation of the costs incurred by motorists in using the various road networks. However, it is recognized that user savings due to improved road networks are not directly transferable to income for public agencies to use in constructing new facilities. Moreover, the



AR00032059

average vehicle operator may be more conscious of a small increase in the gasoline tax than in the more expensive cost of travel caused by congestion and delay.

Table 12.14. Comparison of User Costs Under Alternate Plans

| Plan Alternate | Average User Costs ($1,000) | |
|---|---|---|
| | Daily | Annually |
| 1.1 | 895 | 326,783 |
| 1.2 | 1,149 | 419,443 |
| 1.3 | 1,152 | 420,528 |

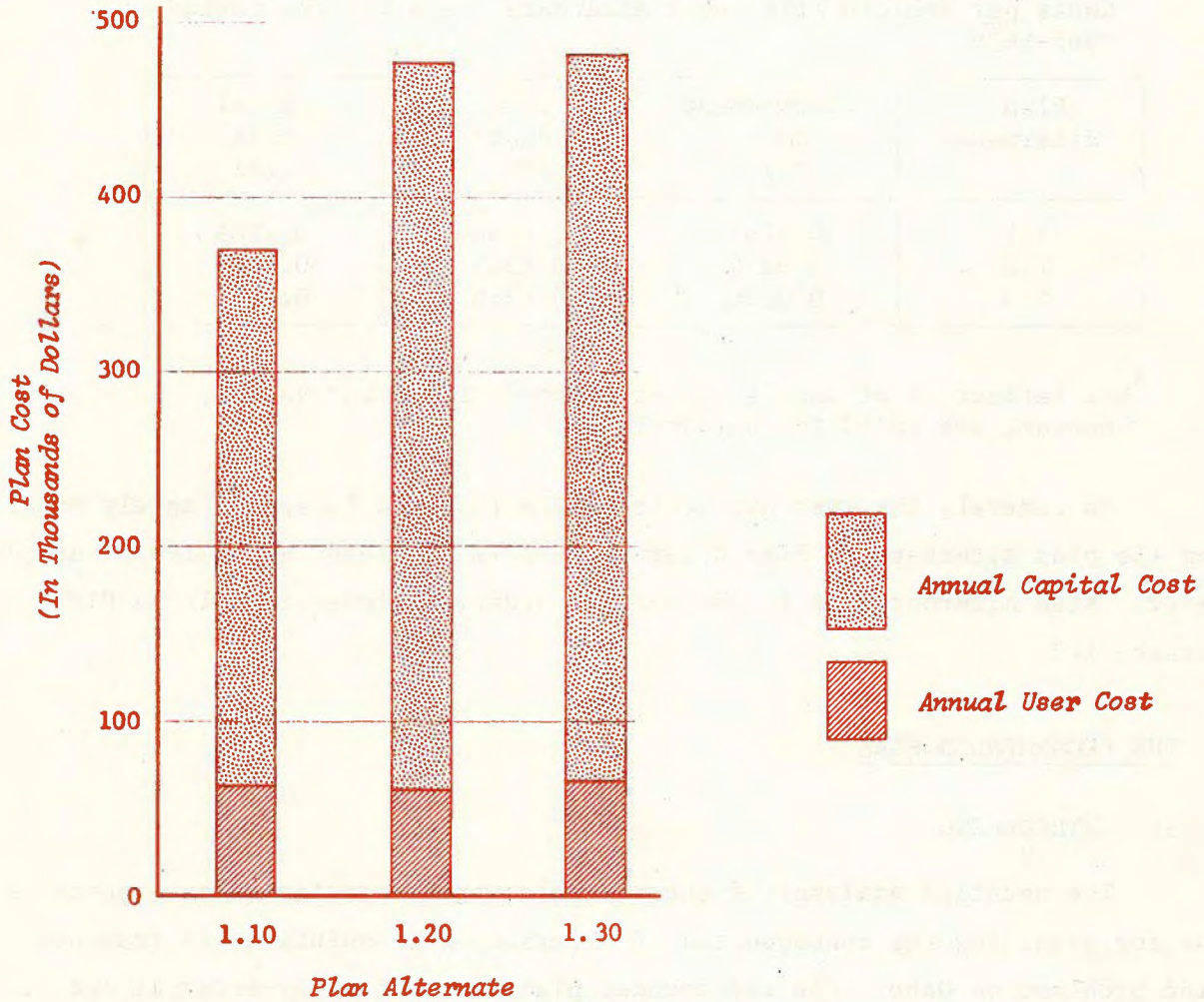



FIG. 12.19. ANNUAL CAPITAL AND USER COSTS UNDER ALTERNATE PLANS.



AR00032060

A final alternate-plan comparison is shown in Table 12.15. The data reflect the relative economies of both implementation and user costs when viewed on the basis of usage. The average 1965-1985 improvement cost to the users of any of the plan alternates would be approximately two and one-half cents (2½¢) per vehicle mile; for the motorist who drives 10,000 miles per year within Oahu, the average cost per year over the 20-year period would be $250. In contrast, user costs average about 16 cents per vehicle mile, or $1,600 per year. Inasmuch as these unit costs do not include such items as the motorist's investment in the purchase of the vehicle, it can be readily seen that the road user spends relatively little on road improvements when compared to his other costs for transportation.

Table 12.15. Comparison of Average Daily User and Improvement Costs per Vehicle Mile under Alternate Plans for the period 1965-1985

| Plan Alternate | Improvement Cost ($) | User Cost* ($) | Total Cost ($) |
|---|---|---|---|
| 1.1 | 0.0235 | 0.1048 | 0.1283 |
| 1.2 | 0.0235 | 0.1343 | 0.1578 |
| 1.3 | 0.0236 | 0.1348 | 0.1584 |

*Not reflective of Oahu's unit-cost conditions; the values, however, are valid for comparison.

In general, the cost per vehicle mile to build is approximately equal among the plan alternates. Plan Alternate 1.1 is the least expensive to use, however. Plan Alternate 1.2 is the next in order, followed closely by Plan Alternate 1.3.

## C. THE RECOMMENDED PLAN

### 1. INTRODUCTION

The detailed analyses of the plan alternates provided a comprehensive means for assessing the consequences of alternate plan solutions to transportation problems on Oahu. The recommended plan of the freeway-arterial network has evolved from this analytical process. The recommended improvements are



AR00032061

related to the choices offered in the plan alternates and their relationships to objectives, planning restraints, and current planning concepts.

It is emphasized that the transportation system recommended in this report should be considered as a structural element of the community, serving as a guide for future developments and improvements to the transportation system. It is a skeletal system providing a framework within which neighborhoods and land uses may be developed. It should not be taken as a final geometric design of specific major streets, freeways, interchanges, or precise positioning of the network.

The plan is based primarily on projected needs, cooperatively determined by the participating government agencies, and with careful consideration of other facets affecting transportation as well as traffic. It is not an ultimate system but is rather one to which either changes or additional improvements could be made.

It must be emphasized that the scheduling of projects and the selection of the exact locations will be done at a later date consistent with the established priority of the facility to be constructed. Therefore, the determination of the exact route location may not be made for several years.

This Study does not change the traditional responsibilities regarding the financing or implementation of the various recommended facilities. The plan can be accomplished in stages as funds become available. The determination as to how a particular recommended facility is to be financed will be a matter to be determined by the officials of the various agencies charged with such responsibilities.

## 2. PLAN LOGIC

Before detailed decisions could be considered, it was necessary to estalbish a certain strategy toward the task of planning. Certain basic questions were resolved. This strategy provided a framework within which to consider specific questions and contributed toward a consistent resolution of detailed planning problems.

An initial decision that greatly influenced the plan was that it should be realistic in terms of plan implementation. This meant that it should be



AR00032062

economically feasible; that it should have characteristics that lend itself to staging and programming; that it should not seriously violate the concepts and the social and community values concerned in transportation planning.

It should be noted that the costs of each of the plan alternates are prohibitively high, and even with any optimistic view of substantially greater funding, it would be difficult to finance these plans.

The implementation costs of the alternate plans establish an initial requirement; however the cost of the recommended plan need not be substantially different from the cost of the alternate plans, because land uses and community-value factors remain a prime objective.

The Study Staff believes that, to provide full capacity for a high level of service in 1985 would not be within the resources available and would not meet with general public acceptance. There would have to a balancing between level of service, land uses, community values, and costs. Thus, a decision was made to recommend a lower level of service with relatively more congestion to be tolerated. This policy, of course, should be re-evaluated during the continuing program.

The decision to provide a strong network of major and collector street and rapid-transit improvements would meet with general public acceptance. Many circumstances and current developments suggest that this is a valid position. The nation's increasing awareness of urban growth and related problems, the prospect of greater legislative representation for urban areas, the establishment of a cabinet-level post to deal with urban problems, and pilot traffic-operation programs for increasing capacity and safety--all tend to support the reasonableness of anticipated new federal programs to provide substantial aid in the implementation of arterial networks of roads and rapid transit.

The foregoing criteria provided a means for gauging the detailed planning questions. With a consistent point of view, decisions were channeled more directly to achieve objectives that had thus been clearly defined.

### 3. TRANSIT-PLAN DESCRIPTION

Figure 12.20 shows the rapid-transit corridor of the recommended mass-transit system and Table 12.16 summarizes the statistical aspects of the mass-transit system.



AR00032063

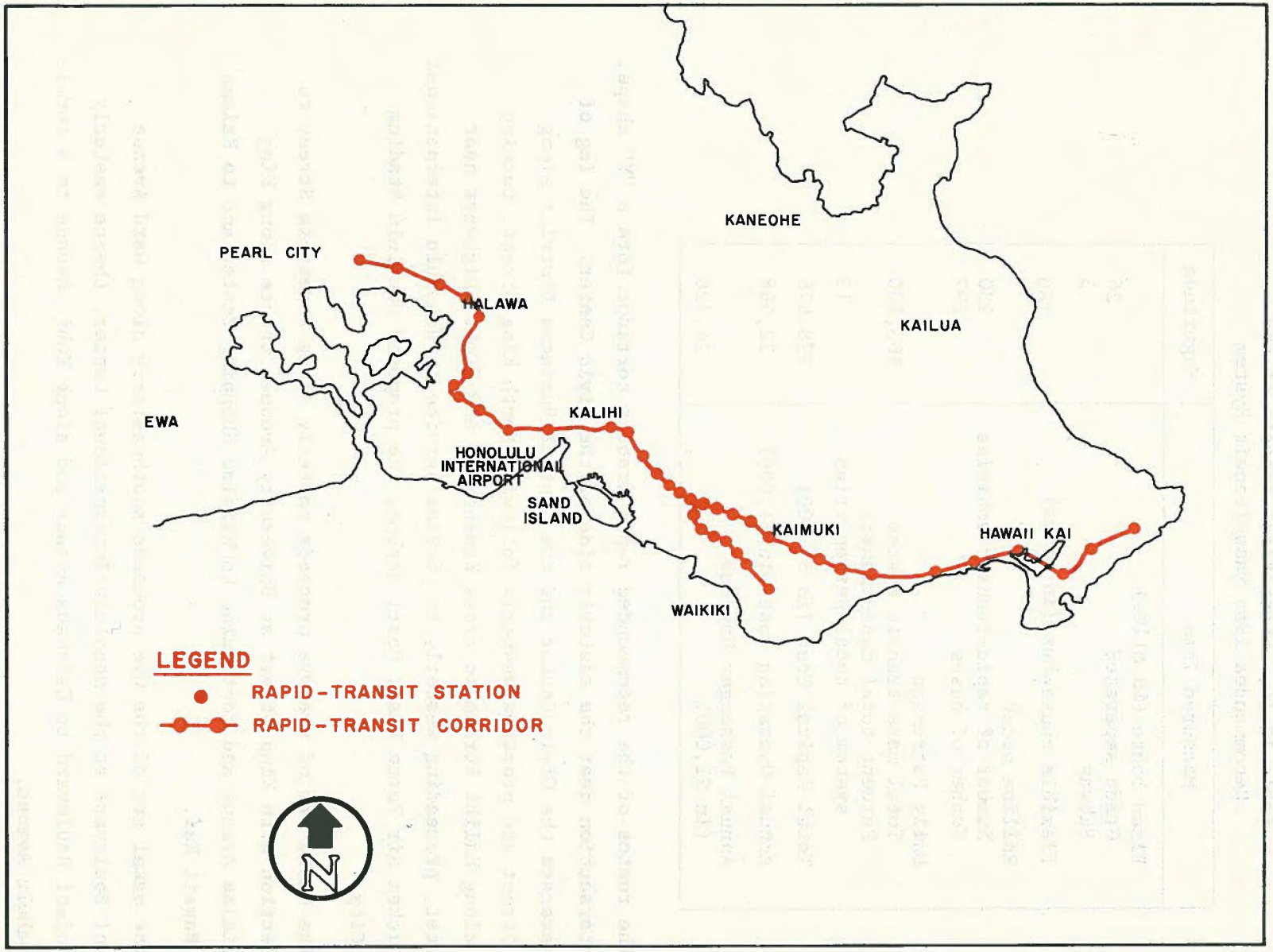



FIG. 12.20. RAPID TRANSIT CORRIDOR OF RECOMMENDED MASS TRANSIT SYSTEM.



AR00032064

Table 12.16. Statistical Aspects of the Recommended 1985 Mass-Transit System

| Measured Item | Magnitude |
|---|---|
| Fixed route (in miles) | |
| Grade separated | 26 |
| Subway | 3 |
| Flexible route-bus (in miles) | 180 |
| Rolling stock | |
| Number of rapid-transit vehicles | 230 |
| Number of buses | 197 |
| Daily Patronage | |
| Total mass-transit system | 363,100 |
| Percent total mass-transit system of total person trips | 13 |
| Total Capital Cost (in $1,000) | 278,876 |
| Annual Operating Cost (in $1,000) | 22,668 |
| Annual Passenger Revenue (in $1,000) | 24,726 |

The routes of the recommended rapid-transit corridor form a "Y" shape, with an intersection near the easterly side of the Civic Center. The leg of the wye traverses the Civic Center and the Central Business District along Beretania Street and proceeds westerly following North King Street, turning southerly along Kalihi Stream to cross Kamehameha and Nimitz Highways near Middle Street, proceeding westerly to provide service to Honolulu International Airport, Hickam Air Force Base, Pearl Harbor, the proposed Honolulu Stadium and Pearl City.

The mauka arm of the wye proceeds easterly along Beretania Street to its intersection with King Street at University Avenue, thence along King Street, Waialae Avenue and continuing to Waialae Shopping Center and to Kalama Valley in Hawaii Kai.

The makai arm of the wye proceeds southeasterly along Ward Avenue to Kapiolani Boulevard at the Honolulu International Center, thence easterly along Kapiolani Boulevard to Kalakaua Avenue and along Kuhio Avenue to a terminal at Kapahulu Avenue.



AR00032065

Extension of the transit service provided by this rapid-transit element to the suburbs would be accomplished by express buses. Service to Barber's Point area would be by express bus operating on Interstate Route H-1 between the rapid-transit terminal station at Pearl City and Campbell Industrial Park, with intermediate services to Makikilo.

To serve the Wahiawa and Schofield Barracks area, express buses would be operated on Interstate Route H-2. Feeder buses would extend this line within and to other towns beyond Wahiawa and Schofield. Two express-bus routes would serve Windward Oahu--the CBD-Kailua line using Pali Highway and the Halawa-Kaneohe line using Interstate Route H-3. These routes would be continuous forming a loop between the Honolulu CBD and the Halawa entrance to Pearl Harbor. These routes would also be served by local feeder services operating in Kaneohe, Kailua and Waimanalo.

It should be remembered that the estimates and plan developments produced by this study are initial in nature--a first look. Consequently, there are a number of factors not explicitly considered by this first study, including:

1. Further extension of rapid-transit lines where warranted by preliminary demand estimates
2. Expansion of the bus network to include service paralleling the rapid-transit corridor
3. Refinement of assumed future land-development patterns and intensities to reflect impact of the rapid-transit system.

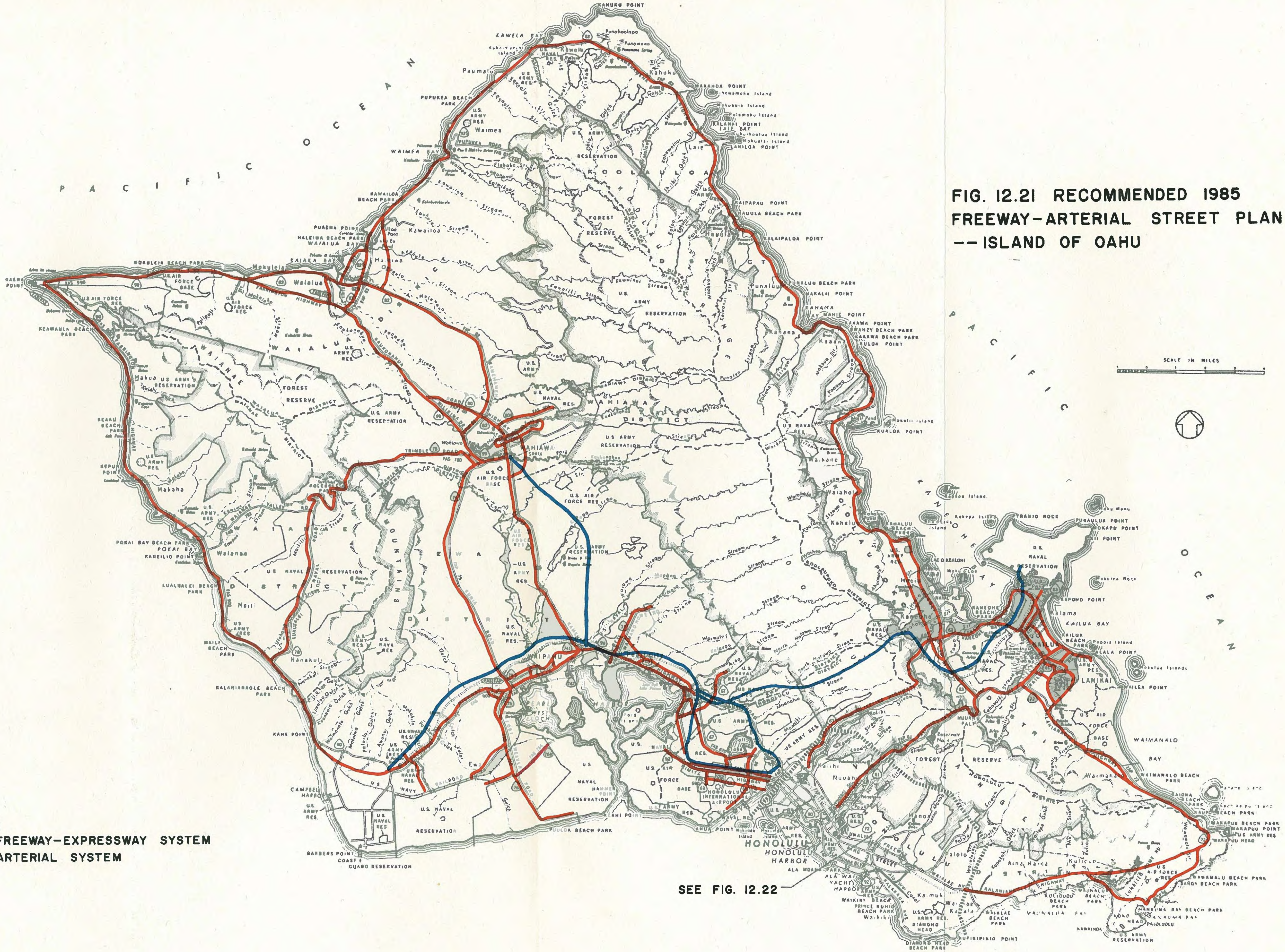
## 4. FREEWAY AND ARTERIAL STREET PLAN DESCRIPTION

The recommended network of freeways and arterial streets are shown in Figs. 12.21 and 12.22. Figures 12.23 and 12.24 show those major and collector streets on which improvements would be required by the plan. Table 12.17 provides a statistical summary of the recommended freeway and arterial street plan.



AR00032066

# FIG. 12.21 RECOMMENDED 1985 FREEWAY-ARTERIAL STREET PLAN -- ISLAND OF OAHU




## LEGEND

- FREEWAY-EXPRESSWAY SYSTEM
- ARTERIAL SYSTEM



AR00032068

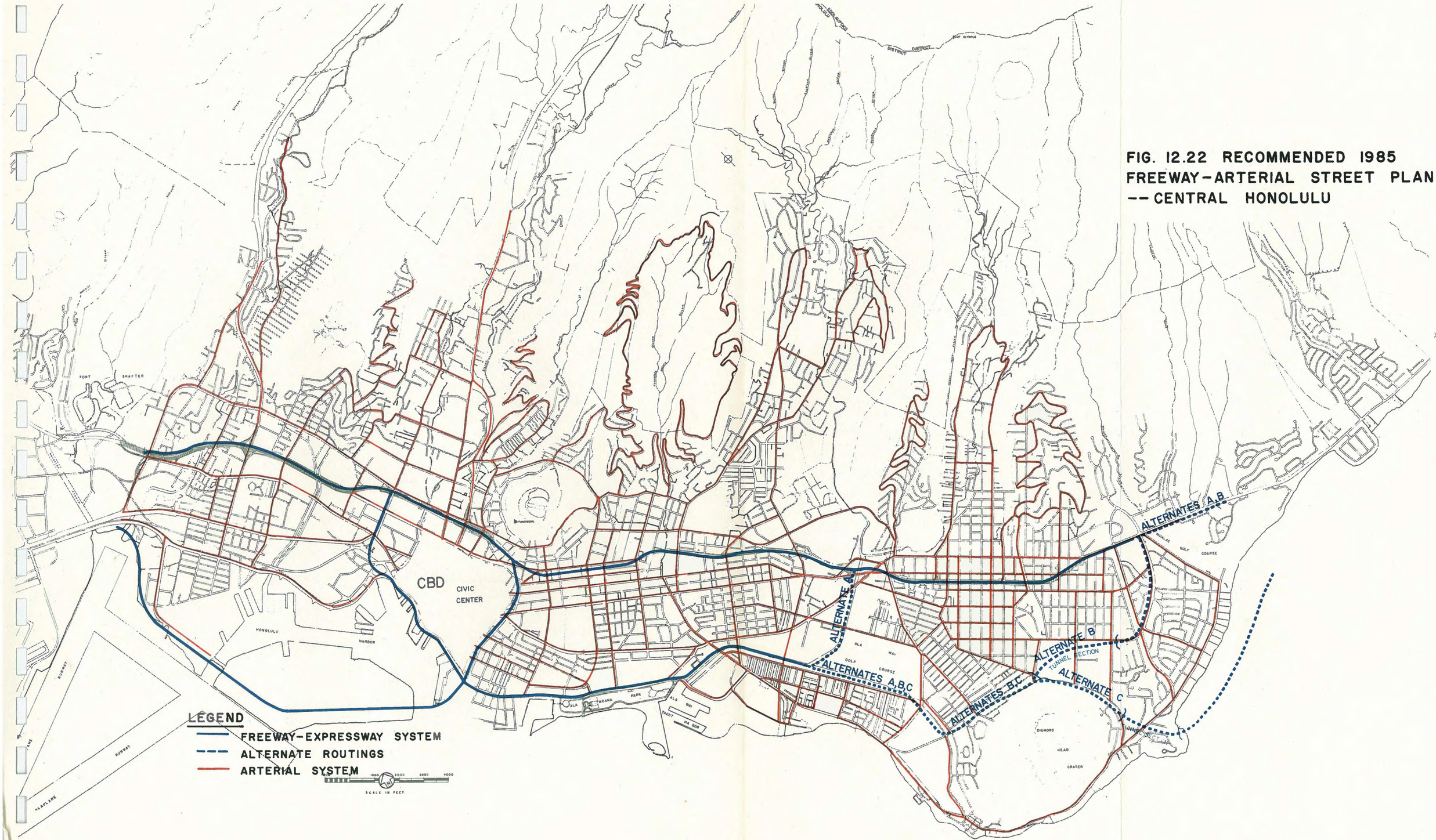



FIG. 12.22 RECOMMENDED 1985 FREEWAY-ARTERIAL STREET PLAN -- CENTRAL HONOLULU



AR00032069

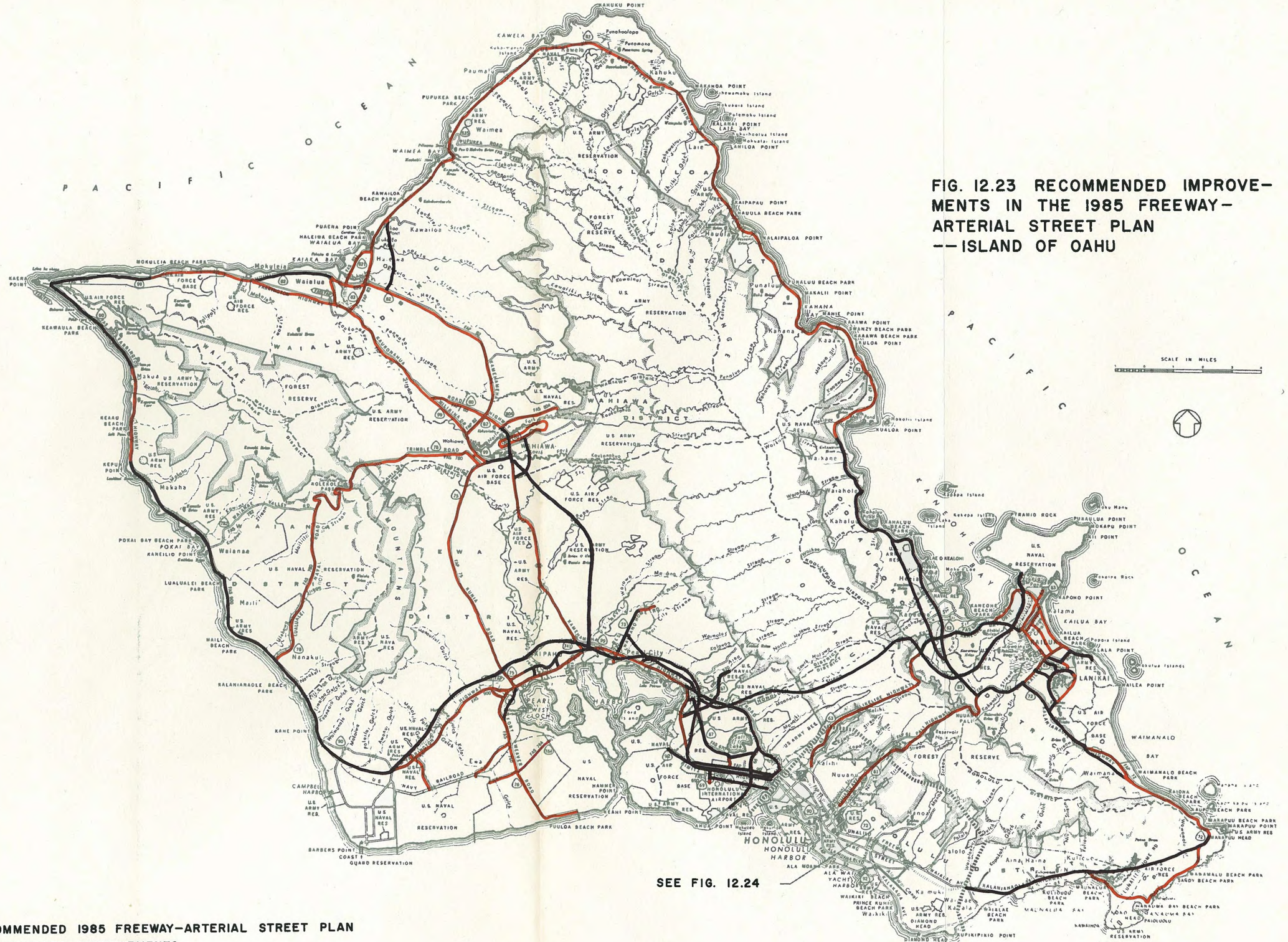



FIG. 12.23 RECOMMENDED IMPROVEMENTS IN THE 1985 FREEWAY-ARTERIAL STREET PLAN --ISLAND OF OAHU

LEGEND

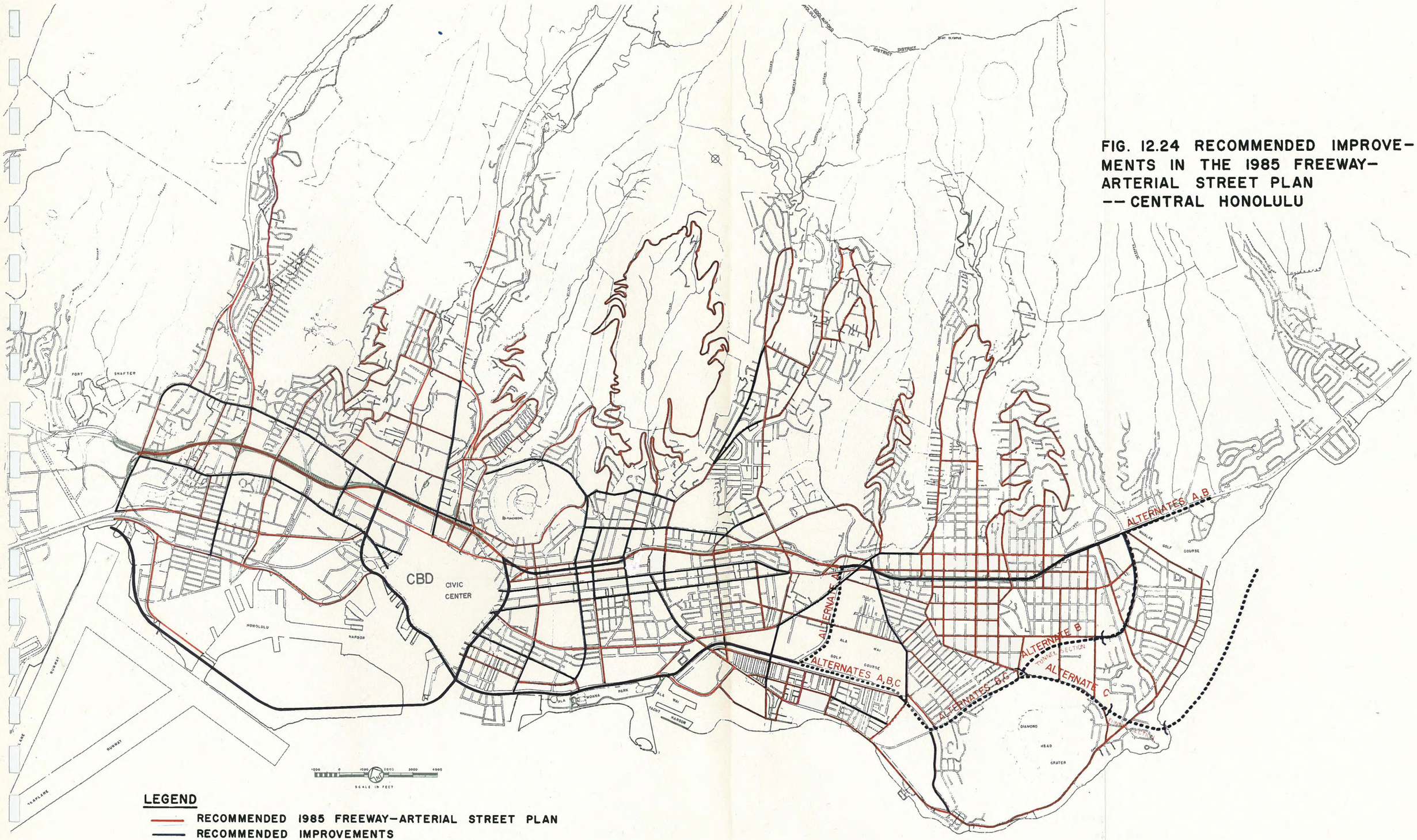
RECOMMENDED 1985 FREEWAY-ARTERIAL STREET PLAN

RECOMMENDED IMPROVEMENTS



AR00032070

FIG. 12.24 RECOMMENDED IMPROVEMENTS IN THE 1985 FREEWAY–ARTERIAL STREET PLAN
-- CENTRAL HONOLULU






AR00032071

Table 12.17. Statistical Review of the Recommended Freeway-Arterial Street System

| Measured Item | Magnitude |
|---|---|
| 1985 Street Mileage | |
| Freeways and Expressways | 67 miles |
| Major highways, streets and collectors | 476 |
| 1985 Daily Vehicle Travel | |
| Freeways | 2,894,300 miles |
| Expressways | 427,000 |
| Arterials | 5,117,000 |
| Average Estimated Speed | |
| Freeways | 43.7 mph |
| Expressways | 27.0 |
| Arterials | 15.2 |
| 1965-1985 Improvement Cost | |
| Total | $734,295,000 |
| Annual | 67,178,000 |
| 1985 Daily User Cost | $ 1,124,000 |
| Average Daily Costs per Vehicle Mile | |
| Improvements, 1965-1985 | $ 0.0264 |
| User Costs, 1985 | 0.1332 |
| Combined Average Daily Improvement and User Cost per Vehicle Mile | $ 0.1596 |

It is emphasized that it is not intended that the Oahu Transportation Study resolve every question of design and right-of-way over the entire freeway and arterial-street plan, but rather to establish a transportation structure within which the community may grow and develop. Thus, while the comprehensive planning approach is vital, it does not have the advantage of detailed planning and engineering data, or knowledge of precise land-ownership situations that might influence a specific decision. Therefore, the recommended freeway and arterial-street plan and improvements must be viewed with this limitation in mind.

Although a street-by-street description of every improvement would be thorough, only several of the more important street and highway decisions will be discussed.

The federal interstate-highway network (H-1, H-2, and H-3) which is considered "committed" in plan development, provides the structure from which



AR00032072

the freeway system was developed. Adequate freeway service to the leeward, Schofield, and windward areas can be provided by this existing or committed freeway network. That portion of Interstate Route H-1 between Middle Street and Aina Koa will be the most critical traffic-volume section in the committed network.

The greatest and most urgent need for freeway service is in the makai corridor between Middle Street and Kapahulu Avenue. Forecast volumes on the east-west major streets in this area establish this requirement. The study recommends that this makai facility be built at grade level and not as an elevated structure. This route would include two tunnels, under the two entrances to Honolulu Harbor, and a surface crossing of Sand Island. This arrangement of the freeway facility in this area permits unobstructed vista from the Civic Center and the CBD to the harbor and provides a service to a more diversified area, a detour when Nimitz Highway is upgraded, and a fast and scenic route for tourist movement between Waikiki and the Airport.

The north-south circumferential connectors between Interstate Route H-1 and Nimitz Highway along Liliha and South Streets are basic requirements for the recommended extensions of the existing freeway network. The provision of the north-south service is vital in order to permit the circulation of local traffic in the contemplated development plans of the Civic Center and the CBD.

The alignment of the makai facility along the Ala Wai Canal (a natural barrier) is considered vital in order to protect the social and ecnomic integrity of Waikiki. Tests indicate that the provison of this facility successfully removed through-traffic from this area.

University Avenue, extended as a north entrance to Waikiki, is recommended because it acts as a relief route for both McCully Boulevard and Kapahulu Avenue. Additionally, it provides direct service between Waikiki and the University of Hawaii.

The remaining segment of the freeway system is that portion of the extension to service east Honolulu. Forecast of volumes on Kalanianaole Highway establish that rapid-transit and roadway capacities equivalent to twelve (12) lanes would be required to satisfy the 1985 travel demand for this corridor.



AR00032073

The terrain of this route presents major construction and expansion difficulties. The study points out that there are alternate solutions for providing added roadway capacity. These possible solutions are:

1. An off-shore, reef highway along the shore of Maunalua Bay, together with a six-lane Kalanianaole Highway facility.
2. A viaduct with a maximum of six lanes, and six lanes on the road below it, to follow the present route of Kalanianaole Highway. This would be combined with an upgrading of Interstate Route H-1 between Aina Koa and Kapiolani Interchange. A major connecting highway link would be constructed between Interstate Route H-1 and the makai facility, following the alignment of the Manoa-Palolo drainage canal.
3. Instead of upgrading that section of Route H-1 and the Manoa-Palolo drainage-canal route, a link would be made by having the makai facility extend along Kilauea Avenue into the H-1 route.

A variety of special studies--such as study of inshore and reef ecology--would be required before an alignment can be recommended for this east-Honolulu area. Thus, the solutions to the problems of this area are subject to further engineering study.

As shown in Figs. 12.23 and 12.24, many other street and highway improvements are recommended throughout Oahu. The westside requires Farrington Highway to have roadway capacity equivalent to four lanes between the terminal of Interstate Route H-1 at Campbell Industrial Park and Makaha; Waipahu needs an improved Waipahu Street; the Pearl City-Aiea area requires a new and improved Moanalua Road; the Trans-Koolau Corridor requires added roadway capacity equivalent to six freeway lanes; the windward side needs improvements to Likelike Highway, Kamehameha Highway, and Kailua road.

The estimated improvement cost of the recommended freeway and arterial street plan is about $734.3 million, or approximately $6.9 million more annually than the least expensive Plan Alternate. The cost increase is not uniform among the street types; it could, however, be isolated principally to the new harbor route and to the placement of the makai freeway at grade.



AR00032074

## REFERENCES


1. Transit Planning and Modal Split Study Element, Oahu Transportation Study, 1966.
2. Parking in City Center, by Wilbur Smith and Associates, New Haven, May 1965.
3. Air Transport Association of America release, dated June 27, 1966.
4. A. Scheffer Lang and Richard M. Sobuman, Urban Rail Transit, The M.I.T. Press, Cambridge, Massachusetts, 1964.




AR00032075

# APPENDIX 12.A. TRAFFIC ASSIGNMENT

AR00032077

## 1. INTRODUCTION

Traffic assignment is a process of allocating a given set of trip interchanges to a specific transportation system. It is a positive means for determining or evaluating the capacity and spacing of arterial streets, expressways, and freeways in relation to future travel demands.

Existing or planned networks can be used in traffic assignments. If a particular network is shown to be unable to accommodate future travel, improvements can be made and the testing and evaluation process can be repeated.

The assignment process also permits the routing of trips with regard for the ability of streets to accommodate them or the effect of congestion and delay on time. For example, roads that have been loaded beyond their capacities undergo a speed reduction to account for congestion and delay that occur. Trips are usually assigned again using adjusted speeds and time, and the process is repeated until little improvement can be made in the speeds. Thus, the process resembles that daily travel occurrence wherein people seek the line of resistance as controlled by street capacity and volume density.

Traffic assignment is, thus, a powerful tool, which enables us to test a wide range of concepts. It allows us to evaluate some of the consequences of our decisions before highway construction takes place.

The limitations of traffic assignment must also be recognized. First, they are completely dependent on the validity of the travel forecasts; and, second, they do not directly consider or measure the effects of transportation policies on neighborhood or area development. Assignments provide factual data pertaining to traffic volume-capacity ratios and the relative level of traffic service provided; these data are essential to intelligent decision-making.

Realizing the increasing need for electronic-computer services to process the immense amount of data collected in urban-transportation studies, the U. S. Bureau of Public Roads has designed an entire battery of traffic-assignment programs and has arranged with data-processing agencies to provide contractual computer services for these traffic-assignment programs to



AR00032078

State highway departments or transportation studies. The Oahu Transportation Study has employed this entire traffic-assignment package in its work. The Study's data-processing involving these programs was accomplished at Service Bureau Corporation in Palo Alto, California.

## 2. PREPARING COMPUTER INPUT DATA

Figure 12.A1 shows a typical area within Oahu and illustrates the manner of coding (numbering) zones and road-network sections for computer input.

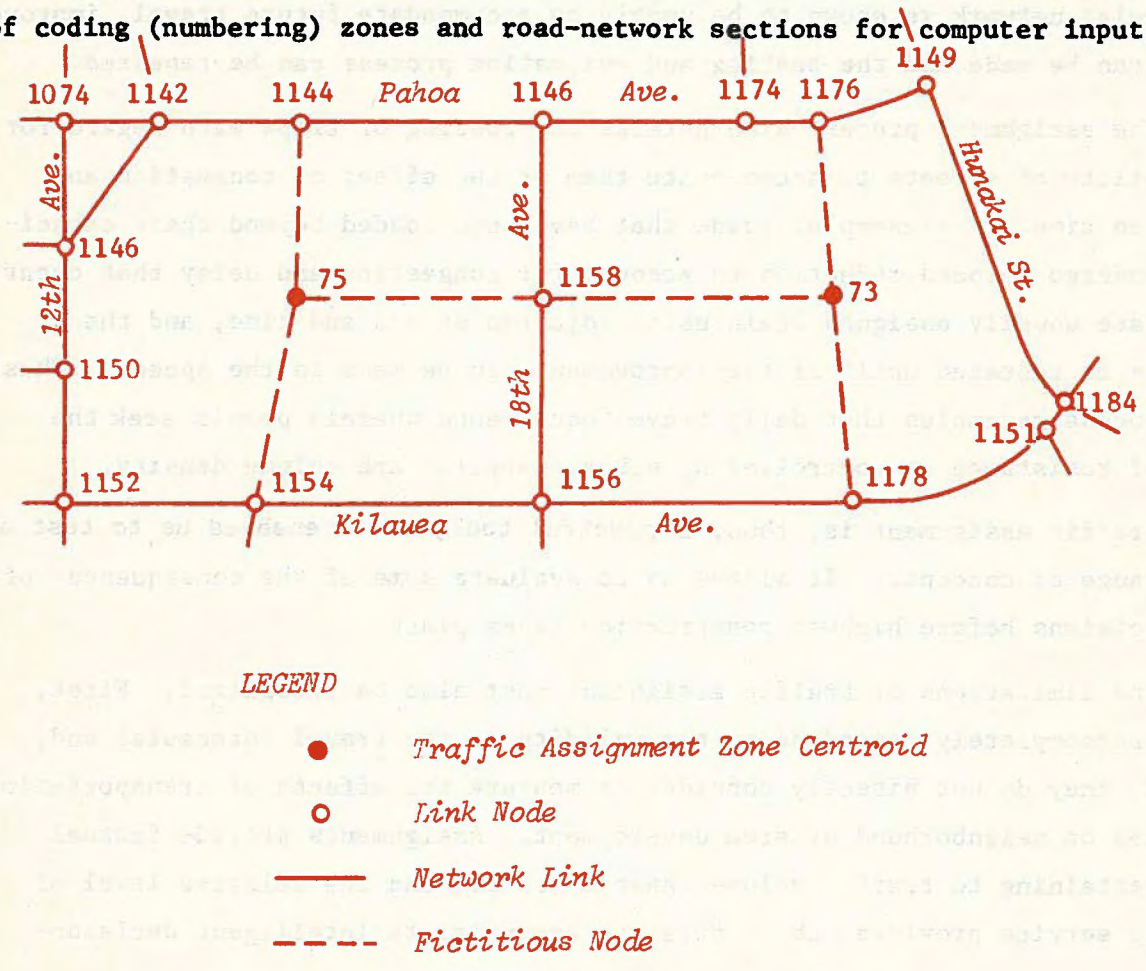



FIG. 12.A1. NETWORK CODING FOR TRAFFIC ASSIGNMENT.

In all, there were 159 traffic zones in the Oahu Transportation Study Area. They were identified by consecutively numbered zone centroids beginning with one. It should be noted that these centroid numbers are not always the same numbers that were assigned to respective traffic zones in the 1960



AR00032079

Origin-Destination Survey. Centroids are subjectively located within the zone on the basis of the center of traffic generation. Forecast trips originate at, and are destined for, these centroids in the assignment process.

Fictitious links (connections) were made between the zone centroids and the road network. These links take the place of the local street network, which is not being tested. They provide a portion of the route for assigned trips to follow when going to or from a zone centroid. The intersection of a fictitious link with one of the road in the network is called a node and is given a code number. These code numbers were not duplicated.

The road network is composed of arterial, freeway, and ramp links (road sections), which were also identified by node numbers at the ends of each link. Nodes are established at every intersection of two roads. A link is identified as arterial, freeway, or ramp by the range within which the code numbers fall.

Once the identifying code numbers have been established, each link (fictitious, arterial, freeway, or ramp) was identified independently, recorded on individual punch cards and was later machine edited and transferred onto magnetic tape. Each card contained the following information concerning each link:

1. Jurisdiction--i.e., state routes, city routes, collector streets, and others
2. Node numbers
3. An identification which allows the computer to recognize a right or left turn
4. One-way or two-way movement
5. Distance
6. Operating speed at capacity and/or time
7. Twenty-four-hour capacity (directional).

Some 3,000 punch cards (directional coding) were required for one of Oahu's planned-alternate road networks. These cards are referred to as the "network-description deck" and are the basic input for the assignment process.



AR00032080

## 3. COMPUTER OPERATION

Before traffic assignments were made, the first computer operation was to construct sample trees (minimum-time paths) from a few selected zones. This operation requires that the computer search out the fastest routes over the road network to each of the 159 zones from each of the several selected zones. (A description of this search process is described earlier in this report, Appendix IX.C.) It should be noted that a turn penalty of 0.3 min (18 sec) was applied to left and right turns in the network. Each set of minimum-time paths is called a tree. These selected trees were manually plotted and analyzed in search of network coding errors and illogical routings, which were then corrected. Once the coded network was thus proven satisfactory, traffic assignments were made.

As a first step in the assignment, the computer searches out minimum-time paths for all 159 traffic zones. Having completed this task, the computer routed trips over these paths. As trips were assigned or loaded onto the road network, the computer remembered the number of trips that used each link in the network. The computer's memory included the directional volume over each link and the turning volumes at each node. After all trips were assigned to the minimum-time paths, the computer provided a printout of the information it retained in its memory core.

The assignment process just described is known as a free assignment. All trips were routed over minimum-time paths without regard to the ability of streets to accommodate trips or the effect of congestion and delay time. In order to consider these important factors, restraint assignments were also carried out in all Oahu Transportation Study assignments.

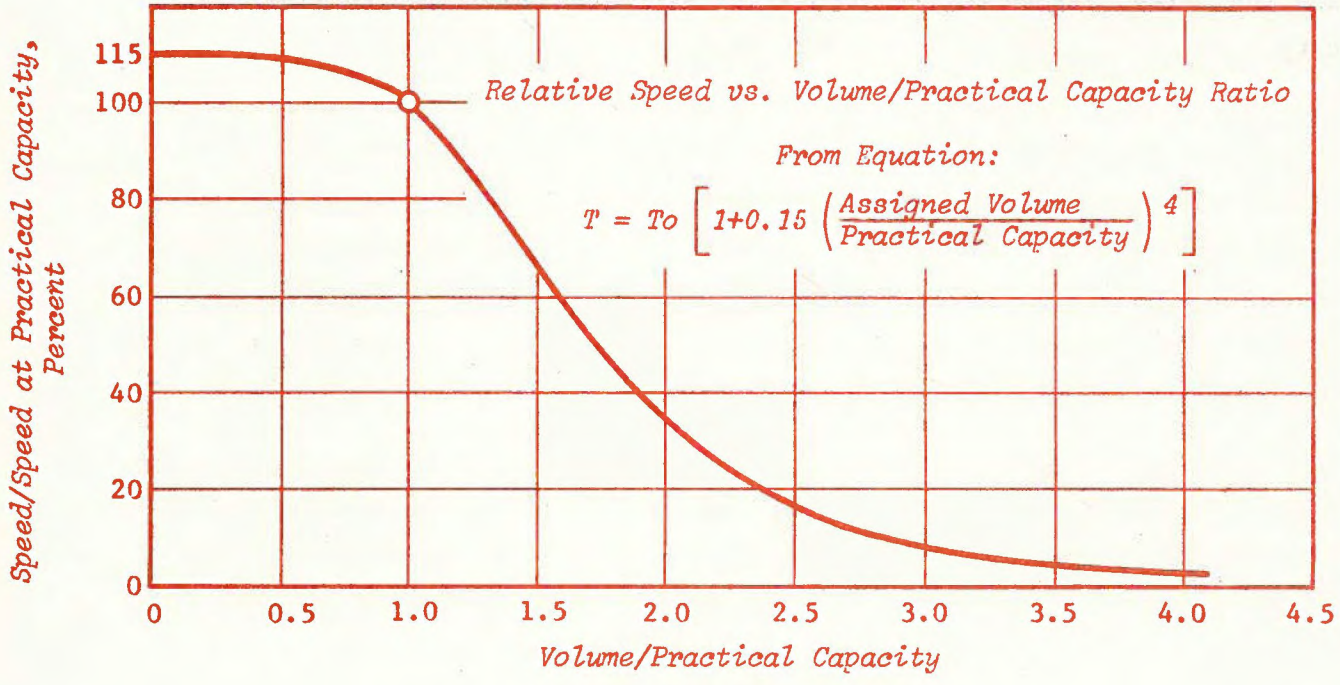
In an assignment using capacity restraints, the computer compares the free assigned volumes with link capacities. A volume-capacity ratio is established (Fig. 12.A2) and the link speed and/or time is adjusted up or down on the basis of this ratio. For example, roads that have been loaded beyond their capacity undergo a speed and/or time reduction to account for the congestion and delay that would be experienced when traffic volumes exceed capacities. Trips are assigned again using the adjusted speeds and times. This process is repeated several times until little improvement can be made in the volume-capacity ratios. Traffic volumes are thus more realistically and



AR00032081

even distributed over the road network. The process resembles the daily travel occurrence within a metropolitan region wherein people seek the lines of least resistance as controlled by street capacity and volume density.

In the Oahu Transportation Study, four iterations per capacity restraint assignment were made for each planned network; experience has shown that after four iterations, the accuracy of the assignment does not improve appreciably. The average of forecast trips resulting from the iterations are thus posted to the planned network. It should be noted that intrazonal trips are not involved in the Oahu Transportation Study traffic assignments.




*where:* $T$ = *Travel time at which assigned volume can travel on the subject link*

$T_0$ = *Base travel time at zero volume = travel time at practical capacity x 0.87.*

FIG. 12.A2. CAPACITY RESTRAINT RELATIONSHIP.



AR00032082

## 4. ACCURACY OF TRAFFIC ASSIGNMENTS

Errors in traffic assignment procedure are attributed to many sources, such as:

1. Inappropriate number of links in the network
2. Zone sizes being too large
3. Faulty link parameters
4. Assumptions of the minimum-time-path theory
5. Failure to assign the intrazonal trips, etc.

There appears to be no way to evaluate the portion of the total error that is contributed by each of the above factors. Experiences have shown, however, that 30 to 40-percent reduction in error may be attained by submitting the "free" assignment to automatic restraints according to link capacity.



AR00032083

# APPENDIX 12.B. FURTHER EVALUATION OF EAST HONOLULU TRANSIT

Trying to find and develop the optional system of transportation in response to the conditions and requirements of future travel can be very frustrating. For example, if there were only one mode of travel, a mass-transit system, between two points, we could reasonably assume that all trips between the two points would be by transit. On the other hand, if the mode were highway only, we could reasonably assume that the trips would be made by automobile, whether as a passenger or driver. When both highways and transit are available for the same movements, however, the two modes will compete with each other and the amount of patronage that would be credited to each mode would depend on the extents of the respective systems.

Two preliminary alternatives studied in the Transit Study established the basic strategy for the task of plan development. The first suggested a 1985 highway-arterial system that consisted of existing roadways plus those roadways already committed. For this plan, analyses of possible technology would be utilized to devise the most likely transit system, including fixed rail. This transportation system would suggest the transit capability because it presupposes in the testing procedure that additional highways would not be constructed.

The second alternative suggested a 1985 highway-arterial system that would consist of existing roadways and bus routes plus some extensions of bus routes into now undeveloped areas and the addition of some freeway bus transit on highways yet to be built.

Although both plans contained a transit system, the first plan might be said to be transit-oriented, while the latter might be said to be highway-oriented. The plan development of an off-shore highway to serve East Honolulu has its origin from the test and evaluation of these two systems.

In the off-shore highway scheme (Alternate 1.3), the transit concept tested in earlier schemes prevailed--i.e., the fixed rapid-transit system has an east terminus at Waialae Shopping Center and an extending service to Hawaii Kai by a feeder-bus system. The mass-transit system was also expanded to include an express bus service via the off-shore highway.



AR00032086

It cannot be over-emphasized that public mass transit is but one component of the total transportaton system, and the extent to which it is utilized can affect the demand for other transportation facilities. Rapid transit, in particular, can have a significant impact on highway-capacity requirements. It is therefore argued that the Study's plan development for East Honolulu should afford a fair test to mass transit and that the detailed effect of future transit usage on other transportation facilities can be determined only through continued testing and evaluation.

In this connection and in keeping with the established scale at which the Transportation Study will plan, another look at the maximum transit patronage was attempted by extending the rail rapid-transit system an additional 8 miles from its east terminus at Waialae Shopping Center to Kalama Valley in Hawaii Kai. To give maximum benefit to this system, the operating characteristics of the rapid transit for testing were the following:

1. A maximum speed of 50 mph
2. acceleration and deceleration rate of 3 mph/sec
3. Two-min headways
4. Maximum station stop of 20 sec
5. Operation on exclusive rights-of-way.

In addition, all load points in East Honolulu were assumed to possess a maximum walk time of 4 min. Roadway improvements in East Honolulu were kept to a minimum--i.e., maintaining Kalanianaole Highway only as an improved six-lane facility, but excluding the off-shore facility and its connecting improvements between Hawaii Kai and Ala Wai Canal.

Table 12.B1 compares the 1985 percent transit trips of the Study Area resulting from "modal split" runs extended system with those of the earlier runs, for Oahu, while Table 12.B2 compares similar information for East Honolulu.

Viewed from the Study Area level, the extension of the rail-rapid-transit system to Hawaii Kai did not appreciably increase total transit ridership on the system for Oahu. There were noticeable changes, however, in transit patronages between the Oahu system and that portion serving East Honolulu. Briefly the findings were that the transit extension to Hawaii Kai could double the



AR00032087

patronage for that mode as compared with the early and the adjusted systems and that this patronage would approximately equal the capacity of a four-lane divided highway.

On the basis of the assumed headways and walk times that went into the transit estimate for the extended rail-rapid-transit scheme, the resulting increased ridership is considered by this Study to be an optimistic transit-travel estimate. Yet, this is what was intended because the Study needed to know whether such extension of the rail-rapid transit to Hawaii Kai, together with a six-lane highway facility, would provide sufficient capacity to satisfy the modal movements through the corridor.

Table 12.B1. Comparison of Estimated 1985 Usage of Mass-Transit System on Oahu, by Trip Purpose

| Person-Trip Purpose | % Transit Trips | | |
|---|---|---|---|
| | System No. 1 | Adjusted System | Extended System |
| Home-Based Work | 23.9 | 22.7 | 24.4 |
| Home-Based Other | 9.2 | 8.7 | 9.6 |
| Home-Based School | 10.2 | 10.1 | 10.1 |
| Non-Home Based | 7.3 | 7.4 | 8.1 |
| TOTAL | 12.4 | 12.0 | 12.9 |



AR00032088

Table 12.B2. Comparison of Estimated 1985 Usage of Initial, Adjusted, and Extended Mass-Transit Systems, Evaluated by Early and Recent Modal-Split Analyses, for East Honolulu,* by Trip Purpose

| Trip Purpose | Early Model Split | | | Person Trip Total | New Modal Split | | | |
|---|---|---|---|---|---|---|---|---|
| | System No. 1 | | | | Adjusted System | | Extended System | |
| | Person Trip Total | Transit Trips | Percent Transit Trips | | Transit Trips | Percent Transit Trips | Transit Trips | Percent Transit Trips |
| Home-Based Work | 48,822 | 7,122 | 14.6 | 57,280 | 7,518 | 13.1 | 16,622 | 29.0 |
| Home-Based Other | 123,616 | 4,440 | 3.6 | 146,345 | 4,634 | 3.2 | 15,086 | 10.3 |
| Home-Based School | 33,424 | 4,280 | 12.8 | 38,417 | 4,280 | 11.1 | 4,280 | 11.1 |
| Non-Home-Based | 10,978 | 736 | 6.7 | 10,942 | 744 | 6.8 | 812 | 7.4 |
| TOTAL | 216,840 | 16,578 | 7.6 | 252,984 | 17,176 | 6.8 | 36,800 | 14.5 |

*Census Tracts 1, 2, 3, and 4.



AR00032089

# APPENDIX XII-C. STREET AND HIGHWAY COST ESTIMATES

# APPENDIX XII-C. STREET AND HIGHWAY COST ESTIMATES

Table 12.C1. Street and Highway Cost Estimate*
State Jurisdiction

| Facility | Length (miles) | Cost |
|---|---|---|
| Farrington Highway | 16.6 | $ 4,890,000 |
| Fort Weaver Road | 1.4 | 2,265,000 |
| Halawa Heights Road | 1.3 | 4,838,000 |
| Haleiwa By-Pass Road | 2.4 | 3,073,000 |
| Interstate Highway | 46.0 | 333,275,000 |
| Kailua Road | 1.8 | 2,328,000 |
| Kalanianaole Highway | | |
| Aina Koa - Niu | 4.3 | 5,349,000 |
| Waimanalo | 5.2 | 1,397,000 |
| Kamehameha Highway | | |
| Castle Junction - Kaneohe | 2.4 | 3,192,000 |
| Through Wahiawa | 1.1 | 1,845,000 |
| Kaneohe | 9.2 | 4,590,000 |
| Koko Head By-Pass Road | 4.0 | 14,222,000 |
| Likelike Highway | 0.9 | 1,197,000 |
| Liliha Street Extension | 0.2 | 3,431,000 |
| Moanalua Road | | |
| Aiea to Puuloa | 3.3 | 15,497,000 |
| Aiea to Waimalu | 2.7 | 875,000 |
| Mokapu Saddle Road | 1.5 | 2,059,000 |
| Salt Lake Boulevard | 2.5 | 900,000 |
| Second Access Road | | |
| to Wahiawa | 1.3 | 1,562,000 |
| South Street Connector | 0.8 | 6,640,000 |
| Waimano Home Road | 1.3 | 420,000 |
| Makai Freeway | 2.3 | 108,739,000 |
| Harbor Freeway | 2.9 | 182,660,000 |
| TOTAL | | $705,244,000 |
| Annual Maintenance Cost | | $ 2,726,000 |

*Cost based on 1965 prices.



AR00032094

Table 12.C1 - continued

Street and Highway Improvement Cost Estimate*
City and County Jurisdiction

| Facility | Length (mile) | Cost |
|---|---|---|
| Alakea Street | 0.44 | $ 1,089,000 |
| Auwaiolimu Street | 0.95 | 195,000 |
| Beretania Street | 3.33 | 3,072,000 |
| E. Manoa Road | 1.15 | 442,000 |
| Kahaluu Cutoff Road | 3.40 | 3,112,000 |
| Kalakaua Avenue | 0.48 | 806,000 |
| Kalihi Street | 0.62 | 531,000 |
| Kapahulu Avenue | 1.08 | 594,000 |
| Kapiolani Boulevard | 0.73 | 214,000 |
| King Street | 4.67 | 3,644,000 |
| Kuhio Avenue | 0.80 | 600,000 |
| Liliha Street | 0.22 | 261,000 |
| Manoa Avenue | 0.99 | 506,000 |
| Metcalf Avenue | 0.47 | 916,000 |
| Nehoa Street | 0.81 | 302,000 |
| Nuuanu Avenue | 1.45 | 1,243,000 |
| Oneawa Street | 0.50 | 315,000 |
| Paki Avenue | 0.95 | 343,000 |
| Palama Street | 0.41 | 162,000 |
| Pensacola Street | 1.47 | 2,340,000 |
| Piikoi Street | 0.57 | 834,000 |
| School Street | 1.92 | 1,231,000 |
| South Queen Street | 0.25 | 882,000 |
| University Avenue | 0.24 | 800,000 |
| Waialae Avenue | 0.85 | 577,000 |
| Ward Avenue | 0.92 | 1,861,000 |
| Waipahu Street | 1.90 | 950,000 |
| Wilder Avenue | 1.16 | 1,229,000 |
| TOTAL | | $29,051,000 |
| Annual maintenance cost | | $ 5,678,000 |

*Cost based on 1965 prices.



AR00032095

# XIII Financial Resources

# XIII. FINANCIAL RESOURCES

## A. INTRODUCTION

One of the more critical factors influencing programs devised to implement an urban-transportation-system plan is the availability of adequate financial resources. Unlimited funds would greatly simplify the task of the transportation planner. Under such conditions, it would not be necessary to consider what level of service should be provided--the highest level of service would be proposed. This is not to say, however, that additional funds are the remedy for all urban transportation problems. The full consequences of alternate policies are by no means completely understood on the basis of current experience and knowledge. Nevertheless, the plan must be gauged by what is economically feasible.

Since there are other competing public facilities--such as schools, water, sanitation, and parks--which are essential and which are also financed with public funds, the transportation plan must be coordinated with planning in the other sectors of public responsibility. The result should be that all public-works planning is unified in serving the broad community interest.

What is economically feasible is complicated by the consequences of not providing adequate facilities. A policy of no transportation improvements, for example, would obviously be a false economy. Taxpayers would save the right-of-way and construction costs, but would pay far more in delay, congestion, reduced land value, retarded development, and possible loss of economic and employment opportunities.

New facilities must be provided in the quantity and quality that can be justified on the basis of improved traffic-and land-service functions. It may be said that we cannot afford not to provide adequate transportaion. However, available capital outlays for improved transporation must be carefully weighed with the returns that will be realized from such investments.



AR00032098

The following text reviews past revenues and expenditures for transportation and discusses the overall financial condition of the local governmental units involved. Estimate of the revenues expected to be avilable for transportation improvements within the Study Area will be part of the continuing study.

## B. FINANCIAL CONDITON AND FUNDED DEBT

General-obligation bonds are the most commonly used method for public borrowing in Hawaii, as in the rest of the nation. General-obligation bonds are secured by the full faith and credit of the issuing agency, including the obligation to levy taxes without limitation as to rate or amount. The strong, unqualified security pledged to general-obligation bonds means that they will almost invariably be sold at interest rates lower than would be available for any other form of borrowing by state or local governments.

General-obligation bonds have fixed maturity dates and specified amounts of principal are payable on those dates. Interest is payable semi-annually at rates specified at the time bonds are sold.

General-obligation bonds are very flexible for the issuers since interest and principal can be paid from any available source of revenue. Property, general excise, and personal income taxes in addition to other sources can be used. The State of Hawaii, for instance, does not levy property taxes but finances a very substantial portion of its capital improvement needs with general-obligation bonds.

The State of Hawaii and the City and County of Honolulu both sell general-obligation bonds, at least one series having been sold annually by each since 1961/62. As well as established credits, salability of these bonds at reasonable rates is assured, with variations in interest dependent primarily on the municipal-bond market as a whole.

The Constitution limits the amount of general-obligation bonds which can be issued: 15 percent of assessed valuation for the state and 10 percent for any other political subdivision.

An alternative financing method which might have some application in mass transit is revenue bonds, which are payable solely from specified pledged



AR00032099

revenues. Property taxes or other general credit of the issuer are not pledged to payment of the bonds. Possible use of the revenue bond is further discussed in the financing of the transit system.

Both the State and the City and County can issue general-obligation bonds and revenue bonds. Both have the power to levy ad valorem property taxes, but the State does not actually do so.

The critical problem is that of bonding capacity. Strict limits are imposed by the State Constitution, and the State and the City and County additionally have adopted policies further restricting the incurring of debt.

The City and County of Honolulu has a constitutional debt limit of 10 percent of net taxable assessed valuation, with new debt incurred in any one year limited to 2 percent. These limits (Article VI, Section 3) apply to all political subdivisions. On the basis of recommendations of a Financial Advisory Committee appointed by the Mayor, Honolulu by policy attempts to limit its bonded debt to 5 percent of the market value of net real-property taxable valuations.

General-obligation bonds are authorized in the annual capital-budget ordinance, which specifies the capital improvements to be made during the fiscal year and makes appropriations from the general fund, from general-obligation bonds, or from any other City funds. Bonds are then issued at various times during the year by the Director of Finance. Capital-budget appropriations lapse if they have not been expended or encumbered at the end of the fiscal year.

Table 13.1 is a derivation of the City and County's available bonding capacity as of December 31, 1966. The tabulation shows a net available margin of approximately $104,000,000 based on the 10-percent legal limit, but only $29,811,628 based on the policy limit of 5 percent. Included in these totals are $28,425,000 of bonds authorized in the 1965/66 and 1966/67 capital-budget ordinances but not issued. The City held only one bond sale during 1965/66, $7,500,000 principal amount sold April 19, 1966. No additional sales were made in 1966.

Transportation must compete with many other capital-improvement needs of the City and County. Any indication of available bonding capacity or any



AR00032100

projection of future availability must be presented with full recognition that other municipal projects must also be financed over this period.

Table 13.1 Available Bonding Capacity, City and County of Honolulu, December 31, 1966

| Item | Bonding Capacity ($) |
|---|---|
| Assessed Valuation, 1966 (70% of market) | 2,601,500,000 |
| Legal Debt Limit (10%) | 260,150,000 |
| Bonds Outstanding | 127,584,000 |
| Bonds Authorized but Unissued | |
| 1965/66 $ 6,773,800 | |
| 1966/67 21,652,000 | 28,425,800 |
| Bonds Outstanding and Authorized | 156,009,800 |
| Net Available Debt Margin | 104,146,200 |
| Market Value Based on Assessed Valuation | 3,716,428,571 |
| Debt Limit by City Policy (5% of market) | 185,821,428 |
| Available Debt Margin by Policy | 29,811,628 |

Note: The actual amount of the indebtednes on the bonds outstanding is $127,584,000 less a cash reserve of $2,124,000. The cash reserve is provided one year in advance to cover all principal payments on bonds due in the succeeding year.

Table 13.2 shows estimated requirements for City funds for major projects in the capital budget in 1966/67 and the estimated total for 1966/67 through 1971/72. The bond authorization for 1966/67 is $21,652,000.

The City and County's capital budget for 1965/66 included a projection of future assessed valuations. No later projections have been published, but these earlier figures show generally annual increases of between $120 and $150 million, resulting in increasing legal bonding capacity by $12 to $15 million.

Present bonded indebtedness is being retired at about $7.5 million annually during this period. The capital budget provides for annual sales of $20 to $30 million of general-obligation bonds, with the result that total bonded debt can be expected to remain at the present level in ratio to assessed valuation, approximately 5 percent, including bonds authorized but unissued.



AR00032101

Table 13.2. Estimated City and County Capital-Improvement Project Requirements, 1966/67 through 1971/72

| Projects | Required Funding ($1,000) | |
|---|---|---|
| | 1966/67 | Six-Year Total |
| Circulation and Traffic | 5,028 | 28,745 |
| Drainage and Flood Control | 4,072 | 24,430 |
| Structures | 8,241 | 79,335 |
| Recreation | 5,858 | 27,159 |
| Public Safety | 526 | 5,875 |
| Public Utilities (Sewers) | 6,170 | 25,660 |
| Miscellaneous | 581 | 4,500 |
| TOTAL | 30,476 | 195,704 |
| Other Funding | | |
| Federal Aid and Other Funds for Projects Listed Above | 12,291 | 45,534 |
| Redevelopment Agency | 1,053 | 6,336 |
| Board of Water Supply | 350 | 5,940 |

Note: Federal aid and other outside funds are excluded.

The State's Constitutional debt limit is 15 percent of assessed valuation, but State policy is to attempt to limit debt to less than 10 percent.

The Governor submits a capital-improvement-project budget annually to the Legislature and, after hearings and debate, the Legislature adopts the capital-improvement project bill, which is submitted to the Governor for approval, reduction, or veto. After the bill becomes law, the Governor allocates funds to the approved projects and the Director of Finance sells bonds from time to time as funds are needed. The last State bond sale was May 25, 1966, for $10,000,000.

Table 13.3 summarizes the available bonding capacity of the State of Hawaii as of December 31, 1966. Although indebtedness is less than 15 percent of assessed valuation, the legal limit, outstanding and authorized limit, exceeds the 10 percent limit desired by State policy.



AR00032102

Table 13.3. Information about the Funded Debt of the State of Hawaii as of December 31, 1966

| Item | Funded Debt ($) | |
|---|---|---|
| Estimated Assessed Valuation for Tax Rate Purposes, 1967* | | 3,361,800,000 |
| Bonds Issued and Outstanding | | |
| General-Obligation Bonds of Territory | 64,754,000 | |
| General-Obligation Bonds of State | 100,048,800 | |
| General-Obligation Refunding Bonds of State | 38,720,000 | |
| Highway Revenue Bonds | 670,000 | |
| Aviation Revenue Bonds | 13,470,000 | 217,662,800 |
| Bonds Authorized but Unissued Pursuant To | | |
| Session Laws 1961-1965 | 81,095,686 | |
| Act 38, Session Laws of Hawaii 1966 | 80,956,032 | 162,051,718 |
| Total Funded Debt of the State of Hawaii | | 379,714,518 |
| Constitutional Debt Limit (15% of Assessed Valuation) | | 504,270,000 |
| Total Outstanding and Authorized but Unissued | | 379,714,518 |
| Constitutional Debt Margin | | 124,555,482 |
| Percentage of State's Funded Debt | | 11.29% |
| Percentage of Authorized Bonds Issued and Outstanding | | 6.47% |

*Estimate furnished by Department of Budget and Finance. 1966 valuation was $3,069,066 and debt margin was $80,645,382.

State bond authorizations do not lapse if funds remain unexpended or unencumbered at the end of a fiscal year. Authorizations remain valid indefinitely for designated projects but are reduced as general funds or money from other sources is spent for those projects.



AR00032103

Table 13.4 lists the projects included in the State Capital Improvement Project Bill for 1966/67 and the estimated six-year totals. Act 38 of the Session Laws of 1966, the Capital Improvement Project Bill, authorized a total of $81,820,000 in cash or general-obligation bonds for designated projects.

Table 13.4. Estimated Capital-Improvement-Project Requirements for the State of Hawaii - All Funds, 1966/67 through 1971/72

| Item | Required Funding ($1,000) | |
|---|---|---|
| | 1966/67 | 1966-72 |
| Natural Resources | 6,283 | 62,832 |
| Airports | 3,774 | 20,586 |
| Harbors | 10,386 | 86,675 |
| Highways | 45,415 | 292,064 |
| Education | 40,018 | 196,743 |
| Health and Welfare | 6,426 | 41,966 |
| General Services | 11,079 | 23,792 |
| Other | 2,500 | 7,465 |
| TOTALS | 125,881 | 732,123 |

Table 13.5 presents the percentage revenues of the State and of the City and County and the sources from which these revenues are derived. The revenue structures are characterized by a high degree of exclusiveness, with only motor-vehicle fuel taxes being levied concurrently by both. The City and County is primarily dependent on the property tax, which produces 65 percent of its total revenues. The State obtains 75 percent of its total income from the general excise tax, other business taxes, the income tax, and federal payments.

Table 13.5 Percentage Revenues by Source

| Revenue Source | % | Revenue Source | % |
|---|---|---|---|
| City and County of Honolulu | | State of Hawaii | |
| Real-Property Tax | 65.3 | General Excise Tax | 45.2 |
| Motor-Vehicle Weight Tax | 9.0 | Personal Income Tax | 22.5 |
| Motor-Vehicle Fuel Tax and Other Highway Taxes | 9.2 | Motor-Vehicle Fuel Tax | 10.0 |
| All Other | 16.5 | All Other | 22.3 |
| All Sources | 100.0 | All Sources | 100.0 |



AR00032104

## C. STATE HIGHWAY AND STREET INCOME AND EXPENDITURE

### 1. HIGHWAY FINANCING

Prior to Federal-aid participation in Hawaii, the construction and maintenance of roads by the counties and the Territory were from funds raised by taxation, from Loan Funds raised by the sale of bonds against the Territory's credit, and from funds derived from the sale of Territorial lands. During recent years, State highway construction and maintenance have been financed from four principal sources: the State Highway Fund (principally Motor Fuel Tax), Federal-aid, Highway Revenue Bonds, and the General Fund. Other monies are obtained from rentals, sales of improvements on condemned lands, grants, and contributions from the counties (usually for storm drains, sewers, etc., included in the highway contract). The Legislature has also authorized the issue of General Obligation Bonds for highway purposes.

### 2. STATE HIGHWAY FUND

The State Highway Fund is derived from the State Vehicle Fuel Tax which is imposed on all gasoline, diesel fuel, and butane used on highways. The tax on diesel fuel and butane not used on highways is also added to the Fund. Table 13.6 gives a breakdown on the sources of State Highway funds. Tables 13.7 and 13.8 present detailed information for the years 1960 through 1966.

Table 13.6. Schedule of Tax Rates per Gallon of Liquid Fuel, Effective July 1, 1957

| Source | Tax Rate/Gallon (¢) | | | |
|---|---|---|---|---|
| | State Tax | Extra State Fuel Tax | County Fuel Tax | Total Tax |
| Highway Use - Gasoline, Diesel, Butane | | | | |
| City and County of Honolulu | 5 | - | 3½ | 8½ |
| County of Maui | 5 | - | 5 | 10 |
| County of Hawaii | 5 | 3 | 3 | 11 |
| County of Kauai | 5 | - | 4 | 9 |
| Non-Highway Use - Diesel and Butane | | | | |
| All Counties | 1 | - | - | 1 |



AR00032105

Table 13.7. Gallons of Fuel Consumed and Taxable for Highway Revenues, City and County of Honolulu, 1960 to 1966

| Year | Fuel Consumed (gal) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Highway Use | | | | Non-Highway Use | | | |
| | Gasoline | Diesel | Butane | Total | Diesel | Butane | Total | Total |
| 1960 | 106,933,002 | 2,926,563 | 53,140 | 109,912,705 | 15,635,030 | 137,666 | 15,772,696 | 125,685,401 |
| 1961 | 111,894,823 | 2,754,892 | 57,209 | 114,706,924 | 18,223,055 | 498,293 | 18,721,348 | 133,428,272 |
| 1962 | 116,124,189 | 2,861,903 | 60,852 | 119,046,944 | 17,980,724 | 312,008 | 18,292,732 | 137,339,676 |
| 1963 | 118,876,230 | 2,907,480 | 52,088 | 121,835,798 | 20,638,767 | 342,699 | 20,981,466 | 142,817,264 |
| 1964 | 126,051,172 | 3,131,684 | 66,056 | 129,248,912 | 23,428,623 | 361,734 | 23,790,357 | 153,039,269 |
| 1965 | 133,028,140 | 3,599,207 | 70,694 | 136,698,041 | 22,938,690 | 356,046 | 23,294,736 | 159,992,777 |
| 1966 | 139,558,752 | 3,804,004 | 75,672 | 143,438,428 | 23,432,414 | 403,458 | 23,835,872 | 167,274,300 |

Table 13.8. State Liquid-Fuel-Tax Revenues, City and County of Honolulu, 1960 to 1966

| Year | Fuel Tax Revenue ($) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Highway Use | | | | Non-Highway Use | | | |
| | Gasoline | Diesel | Butane | Total | Diesel | Butane | Total | Total |
| 1960 | 5,346,650 | 146,328 | 2,657 | 5,495,635 | 156,350 | 1,377 | 157,727 | 5,653,362 |
| 1961 | 5,594,741 | 137,745 | 2,860 | 5,735,346 | 182,231 | 4,983 | 187,214 | 5,922,560 |
| 1962 | 5,806,210 | 143,095 | 3,043 | 5,952,348 | 179,807 | 3,120 | 182,927 | 6,135,275 |
| 1963 | 5,943,812 | 145,374 | 2,604 | 6,091,790 | 206,388 | 3,427 | 209,815 | 6,301,605 |
| 1964 | 6,302,559 | 156,584 | 3,303 | 6,462,446 | 234,286 | 3,617 | 237,903 | 6,700,349 |
| 1965 | 6,651,407 | 179,960 | 3,535 | 6,834,902 | 229,387 | 3,560 | 232,947 | 7,067,849 |
| 1966 | 6,977,938 | 190,200 | 3,784 | 7,171,922 | 234,324 | 4,034 | 238,358 | 7,410,280 |



AR00032106

The Highway Fund is used for the amortization of highway revenue bonds, administration, and maintenance. The balance, matched by Federal aid, is spent for new improvements throughout the State.

The Island of Hawaii has an extra State Tax, which the State collects and which is used exclusively for the retirement of an $8.1 million General Obligation Bond Issue to construct the Hamakua Coast Highway.

Table 13.9 shows the estimated revenues and obligations in the Highway Fund from 1968 to 1977. These estimates were prepared by the State Highways Division in connection with the 1967 Proposed State Highway System.

Table 13.9. Estimated Future Revenues and Obligations of the State Highway Fund, 1968 to 1977

| Year | Revenues ($1,000) | Obligations ($1,000) | Balance ($1,000) |
|---|---|---|---|
| 1968 | 11,139 | 10,323 | 816 |
| 1969 | 11,705 | 11,228 | 477 |
| 1970 | 12,256 | 11,701 | 555 |
| 1971 | 12,804 | 12,113 | 694 |
| 1972 | 13,319 | 12,429 | 890 |
| 1973 | 13,804 | 12,626 | 1,178 |
| 1974 | 14,210 | 12,742 | 1,468 |
| 1975 | 14,677 | 12,945 | 1,732 |
| 1976 | 15,257 | 13,199 | 2,058 |
| 1977 | 15,857 | 13,485 | 2,372 |

Under the present revenue structure, the balances in the Highway Fund appear insufficient to meet the Capital Improvements Program in the Interstate and regular (ABC) federal-aid highway programs. Past legislatures have recognized this fact and have made direct appropriation, which in effect replenished the Highway Fund and thus provided matching funds for the federal-aid highway programs.

Tables 13.10 and 13.11 show the Receipts and Expenditures under the State Highway Fund.



AR00032107

Table 13.10. Statement of Receipts, State Highway Funds, 1960 through 1966

| Type of Fund | Receipts ($) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| Fuel-Tax Collections | 7,816,336 | 8,120,187 | 8,419,975 | 8,618,063 | 9,125,522 | 9,655,499 | 10,101,681 |
| Appropriations | 984,333 | 5,221,934 | 6,620,189 | 8,109,563 | 8,563,064 | 3,449,196 | 3,142,956 |
| Federal Aid | 5,312,286 | 1,419,190 | 7,647,407 | 6,540,424 | 10,753,687 | 13,148,037 | 23,821,417 |
| Other Federal Funds | -- | -- | -- | -- | -- | -- | -- |
| Transfers from Local Government | -- | -- | -- | -- | -- | -- | -- |
| Highway Revenue Bonds | -- | -- | -- | -- | -- | -- | -- |
| Interest from Investments | 714,605 | 321,736 | 353,154 | 216,713 | 142,124 | 159,118 | 174,289 |
| Miscellaneous | 304,130 | 317,045 | 452,057 | 189,083 | 262,156 | 187,337 | 171,791 |
| GRAND TOTAL | 15,131,690 | 15,400,092 | 23,492,782 | 23,673,846 | 28,846,553 | 26,599,187 | 37,412,134 |



AR00032108

Table 13.11. Statement of Expenditures, State Highway Funds, 1960 through 1966

| Item | Expenditures ($) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| Capital Outlay on State System | 10,413,614 | 11,496,350 | 13,775,937 | 10,479,635 | 15,883,358 | 19,574,586 | 25,260,680 |
| Maintenance on State System | 2,862,798 | 2,947,622 | 2,800,943 | 3,032,998 | 2,937,032 | 3,540,063 | 3,809,596 |
| General Administration | 1,136,730 | 907,739 | 927,256 | 1,189,824 | 1,330,474 | 1,631,288 | 1,449.062 |
| Safety Education | -- | -- | -- | -- | -- | -- | -- |
| Debt Service | 3,659,018 | 3,794,672 | 3,811,546 | 3,798,264 | 3,881,028 | 3,868,428 | 7,818,465 |
| Local Roads and Streets | -- | 79,819 | 563,697 | 956,200 | 759,546 | 322,037 | 87,147 |
| Transferred to Local Governments | -- | -- | -- | -- | 65,000 | 45,000 | -- |
| State Park Roads, etc. | 13,677 | -- | -- | -- | -- | -- | -- |
| Non-Highway | 21,245 | -- | -- | -- | 16,930 | -- | 365,406 |
| GRAND TOTAL | 18,107,082 | 19,226,202 | 21,879,379 | 19,456,921 | 24,873,377 | 28,981,402 | 38,790,356 |



AR00032109

3. FEDERAL-AID FUNDS

Although the Federal Aid Act was passed in 1916 and funds were made available to all of the States of the Union in 1917, the Territory (now state) of Hawaii did not participate in the apportionment until the provisions of the Federal Aid Act, were amended to include the Territory of Hawaii by Act of Congress on March 10, 1924. Hawaii received its first apportionment of Federal funds amounting to $365,625 for the fiscal year ending June 30, 1925. To supply the deficiency for the years 1917 to 1925, Congress authorized an additional $880,000 (Act of February 23, 1931). As of June 30, 1960, Hawaii had received a total of $66,789,584 from this source.

Federal-aid funds are authorized for specific systems or purposes by Congress, generally every two years on a July 1 to June 30 fiscal-year basis. These funds, after deduction of administrative costs, are apportioned among the 50 states, the District of Columbia and Puerto Rico.

1. The A Fund. Primary funds are apportioned 1/3 in the ratio that the area of each state bears to the area of the United States; 1/3 in the ratio that the mileage of rural-mail delivery and star routes in each state bears to the total mileage of such routes in the U. S.; and 1/3 in the ratio that the population of each state bears to the total population of the nation.
2. The B Fund. Secondary funds are distributed in the same manner, except that rural population is used in the apportionment formula rather than the total population of the state. No state receives less than one-half percent of the total amount available in each of these categories.
3. The C Fund. Urban funds are apportioned in the ratio that the population of regions designated as "urban areas" in each state bears to the total urban population in the U. S. Each "urban area" must have a population of 5,000 or more based on the most recent decennial census.

Recent Federal-aid acts provide that 45 percent of the Federal funds for ABC Highways are to be spent on the Federal-aid primary system, 30 percent on the Federal-aid secondary system and 25 percent on the urban extensions of these two systems (Table 13.12).



AR00032110

Table 13.12. Apportionment of Federal-Aid Funds Authorized to the State of Hawaii, 1950 through 1972

| Fiscal Year | Apportionment of ABC Funds ($) | | | |
|---|---|---|---|---|
| | Primary | Secondary | Urban | Total |
| 1950 | 974,531 | 649,688 | 349,535 | 1,973,754 |
| 1951 | 974,531 | 649,688 | 349,535 | 1,973,754 |
| 1952 | 1,091,250 | 727,500 | 410,687 | 2,229,437 |
| 1953 | 1,082,813 | 721,878 | 407,089 | 2,211,777 |
| 1954 | 1,200,375 | 800,250 | 451,260 | 2,451,885 |
| 1955 | 1,206,563 | 804,375 | 453,586 | 2,464,524 |
| 1956 | 1,547,437 | 1,031,625 | 581,732 | 3,160,794 |
| 1957 | 1,828,687 | 1,219,125 | 687,430 | 3,735,242 |
| 1958 | 1,912,500 | 1,275,000 | 718,750 | 3,906,250 |
| 1959 | 4,365,051* | 1,305,938 | 736,190 | 6,407,179 |
| 1960 | 2,014,875 | 1,343,250 | 757,224 | 4,115,539 |
| 1961** | 1,776,483 | 1,373,625 | 774,347 | 3,924,455 |
| 1962** | 1,776,483 | 1,373,625 | 858,573 | 4,008,681 |
| 1963 | 2,055,234 | 1,370,156 | 857,833 | 4,283,223 |
| 1964 | 2,110,781 | 1,407,187 | 880,283 | 4,398,251 |
| 1965 | 2,155,359 | 1,436,906 | 898,874 | 4,491,139 |
| 1966 | 2,221,875 | 1,481,250 | 930,272 | 4,633,397 |
| 1967 | 2,216,250 | 1,477,500 | 927,917 | 4,621,667 |
| 1968 | 2,225,250 | 1,483,500 | 931,685 | 4,640,435 |
| 1969 | 2,225,250† | 1,483,500† | 931,685† | 4,640,435† |
| 1970 | 2,225,250† | 1,483,500† | 931,685† | 4,640,435† |
| 1971 | 2,225,250† | 1,483,500† | 931,685† | 4,640,435† |
| 1972 | 2,225,250† | 1,483,500† | 931,685† | 4,640,435† |

*Total includes "D" funds of $1,838,235 authorized by Sec. 2a, and "1" funds of $567,910 by Sec. 2a, of the 1958 Act. "L" funds advanced to the state are to be repaid by deducting one-half from 1962 and one-half from 1962 apportionments of ABC funds.

**Net apportionment after deducting repayable advances.

†Assumed same as F.Y. 1968 apportionment.



AR00032111

Primary funds (A Fund) may be used on both rural and urban extensions of the Federal-aid Primary System. Urban funds (C Fund) may be used only on urban extensions of the Primary or Secondary Systems. Secondary funds (B Fund) may be used only on the Secondary System.*

Construction projects may then be programmed and obligations may be incurred against these funds. Actual payments cannot be made from these funds until the beginning of the fiscal year for which they are authorized. These funds remain available for two years after the close of the fiscal year for which they are authorized, but are considered expended if they are covered by a formal project agreement--a contract for Federal funds. Federal monies are paid only after work has been satisfactorily accomplished and are reimbursements to the State for the Federal share of the cost of the work performed by, or on behalf of the State.

The cost of projects is shared equally by the Federal Government and the states--50-percent Federal funds and 50-percent State or local matching funds.

Regular federal-aid funds unexpended at the end of the availability period lapse.

4. INTERSTATE FUND

Interstate funds are apportioned to the states in accordance with the estimated cost of completing the Interstate System in each state as determined by state studies on re-evaluation of needs subject to the approval of the Congress.

Federal participation in the construction of the Interstate System is set at 90 percent of the cost of a project, with the remaining 10 percent to be paid by the State (Table 13.13). Interstate funds that lapse will be immediately reapportioned among the other states, whereas ABC funds that lapse are not reapportioned.

---

*The Federal Highway Act of 1962, approved October 23, 1962, now allows Federal participation in projects on the extensions of the Federal-aid secondary system into urban areas from available balances of apportionments of Federal-aid secondary funds.



AR00032112

Table 13.13. Anticipated Financing of Hawaii's Interstate System

| Fiscal Year | 90% Federal Funds ($) | 10% State Funds ($) | Total ($) |
|---|---|---|---|
| 1961-62 | 12,375,000* | 1,375,000 | 13,750,000 |
| 1962-63 | 18,794,100* | 2,088,200 | 20,882,300 |
| 1963-64 | 20,360,275* | 2,262,253 | 22,622,528 |
| 1964-65 | 21,036,308 | 2,337,367 | 23,373,675 |
| 1965-66 | 21,926,450 | 2,436,272 | 24,362,722 |
| 1966-67 | 25,472,100 | 2,830,233 | 28,302,333 |
| 1967-68 | 28,985,612 | 3,220,623 | 32,206,235 |
| 1968-69 | 32,265,000** | 3,585,000 | 35,850,000 |
| 1969-70 | 30,567,000** | 3,396,333 | 33,963,333 |
| 1970-71 | 30,567,000** | 3,396,333 | 33,963,333 |
| 1971-72 | 22,798,000** | 2,533,111 | 25,331,111 |

*Apportioned.

**Per Highway Act of 1966.

The Hawaii Omnibus Act, approved July 12, 1960, by the U. S. Congress, gave Hawaii a flat Interstate apportionment of $12,375,000 for fiscal year 1962.

5. CONGRESSIONAL POLICY

It is Congressional policy that it is unfair to tax motor-vehicle transportation unless the proceeds are applied to the construction, improvement, or maintenance of highways. Thus, one-third of any fiscal year's Federal-aid apportionment is withheld from any state that fails to use for highway purposes at least the amount then provided by law from state motor-vehicle registration fees, gasoline taxes, and other special taxes on motor-vehicle owners and operators.

As an incentive for states to enter into agreement with the Federal Government to control the use of and to improve areas adjacent to the Interstate System by controlling outdoor advertising, the Federal share of the cost of an Interstate project would be increased by half of 1 percent if such agreements were entered into by July 1, 1961.

Congressional policy requires that a State shall not allow ABC funds to lapse while taking advantage of the more favorable participating ratio for Interstate funds.



AR00032113

## 6. HIGHWAY REVENUE BONDS

The Legislature authorized the issuance of Highway Revenue Bonds in an amount not to exceed the sum of $50,000,000, the proceeds of which have been obligated to pay for Federal-aid System construction on specific facilities. The proceeds from the Liquid Fuel Tax (Highways) have been pledged to pay the principal and interest of this revenue bond. Details of this issue follow in Tables 13.14 and 13.15.

Table 13.14. Highway Revenue Bonds, Series A, B, C, and D

| Description | Date Issued | Amount ($) | Interest Rate (%) | Maturity Date |
|---|---|---|---|---|
| Series A | | | | |
| A1 - A2335 | 8-14-56 | 2,335,000 | 4.50 | 9-1-65 |
| A2336 - A12500 | 8-14-56 | 10,165,000 | 3.80 | 9-1-86 |
| Series B | | | | |
| B1 - B3395 | 9-1-57 | 3,395,000 | 5.50 | 9-1-69 |
| B3396 - B9405 | 9-1-57 | 6,010,000 | 4.75 | 9-1-82 |
| B9406 - B12500 | 9-1-57 | 3,095,000 | 4.80 | 9-1-87 |
| Series C | | | | |
| C1 - C1370 | 7-22-58 | 1,370,000 | 4.75 | 9-1-64 |
| C1370 - C6770 | 7-22-58 | 5,400,000 | 4.00 | 9-1-78 |
| C6771 - C12500 | 7-22-58 | 5,730,000 | 4.20 | 3-1-88 |
| Series D | | | | |
| D1 - D2675 | 7-21-59 | 2,675,000 | 5.00 | 9-1-69 |
| D2676 - D8300 | 7-21-59 | 5,625,000 | 4.25 | 9-1-82 |
| D8301 - D12500 | 7-21-59 | 4,200,000 | 4.30 | 3-1-89 |

Table 13.15. Amortization Table for Highway Revenue Bonds, Series A, B, C, and D

| Calendar Year | Outstanding Principal at Beginning of Calendar Year ($) | Payments | | |
|---|---|---|---|---|
| | | Principal ($) | Interest ($) | Total ($) |
| 1957 | 12,500,000 | -- | 491,345.00 | 491,345.00 |
| 1958 | 25,000,000 | 255,000 | 1,109,292.50 | 1,364,292.50 |
| 1959 | 37,245,000 | 520,000 | 1,659,464.70 | 2,179,464.70 |
| 1960 | 49,225,000 | 795,000 | 2,232,468.00 | 3,027,468.00 |



AR00032114

Table 13.15 - continued

| Calendar Year | Outstanding Principal at Beginning of Calendar Year ($) | Payments | | |
|---|---|---|---|---|
| | | Principal ($) | Interest ($) | Total ($) |
| 1961 | 48,430,000 | 1,075,000 | 2,097,690.00 | 3,172,690.00 |
| 1962 | 47,355,000 | 1,115,000 | 2,044,133.75 | 3,159,133.75 |
| 1963 | 46,240,000 | 1,160,000 | 1,988,540.00 | 3,148,540.00 |
| 1964 | 45,080,000 | 1,210,000 | 1,930,683.75 | 3,140,683.75 |
| 1965 | 43,870,000 | 1,260,000 | 1,870,965.00 | 3,130,965.00 |
| 1966 | 42,610,000 | 1,305,000 | 1,811,085.00 | 3,116,085.00 |
| 1967 | 41,305,000 | 1,350,000 | 1,751,057.50 | 3,101,057.50 |
| 1968 | 39,955,000 | 1,390,000 | 1,688,960.00 | 3,078,960.00 |
| 1969 | 38,565,000 | 1,435,000 | 1,625,007.50 | 3,060,007.50 |
| 1970 | 37,130,000 | 1,485,000 | 1,560,280.00 | 3,045,280.00 |
| 1971 | 35,645,000 | 1,530,000 | 1,497,421.25 | 3,027,421.25 |
| 1972 | 34,115,000 | 1,580,000 | 1,432,663.75 | 3,012,663.75 |
| 1973 | 32,535,000 | 1,635,000 | 1,365,735.00 | 3,000,735.00 |
| 1974 | 30,900,000 | 1,685,000 | 1,296,568.75 | 2,981,568.75 |
| 1975 | 29,215,000 | 1,740,000 | 1,225,303.75 | 2,965,303.75 |
| 1976 | 27,475,000 | 1,795,000 | 1,151,655.00 | 2,946,655.00 |
| 1977 | 25,680,000 | 1,860,000 | 1,075,673.75 | 2,935,673.75 |
| 1978 | 23,820,000 | 1,930,000 | 996,905.00 | 2,926,905.00 |
| 1979 | 21,890,000 | 2,000,000 | 914,885.00 | 2,914,885.00 |
| 1980 | 19,890,000 | 3,075,000 | 829,213.75 | 2,904,213.75 |
| 1981 | 17,815,000 | 2,140,000 | 740,363.75 | 2,880,363.75 |
| 1982 | 15,675,000 | 2,210,000 | 648,727.50 | 2,858,727.50 |
| 1983 | 13,465,000 | 2,285,000 | 553,895.00 | 2,838,895.00 |
| 1984 | 11,180,000 | 2,360,000 | 455,445.00 | 2,815,445.00 |
| 1985 | 8,820,000 | 2,440,000 | 353,790.00 | 2,793,790.00 |
| 1986 | 6,380,000 | 2,515,000 | 248,810.00 | 2,763,810.00 |
| 1987 | 3,865,000 | 1,915,000 | 146,990.00 | 2,061,990.00 |
| 1988 | 1,950,000 | 1,295,000 | 62,560.00 | 1,357,560.00 |
| 1989 | 655,000 | 655,000 | 14,082.50 | 669,082.50 |

7. GENERAL-OBLIGATION BONDS

In past years, the Legislature has authorized the issuance of General Obligation Bonds for highway purposes. In 1947, an $8,100,000 bond issue was authorized, the proceeds of which were used for Federal-aid System construction on the Hamakua Coast Highway, which was damaged by the 1946 tsunami or tidal wave. Also authorized was a Hawaii County Extra State Tax, an additional three cents per gallon, on fuel sold on the Island of Hawaii, the



AR00032115

revenues of which are used for payment of principal and interest of this bond. Details of this bond issue and tax revenues from it are shown in Tables 13.16 through 13.18.

Table 13.16. Hawaii County Extra Fuel Tax, Calendar Years 1947 through 1966

| Year | Fuel-Tax Revenues ($) | Year | Fuel Tax Revenues ($) | Year | Fuel Tax Revenues ($) |
|---|---|---|---|---|---|
| 1947 | 88,043 | 1954 | 393,915 | 1961 | 431,031 |
| 1948 | 230,792 | 1955 | 411,149 | 1962 | 446,814 |
| 1949 | 246,705 | 1956 | 414,222 | 1963 | 461,131 |
| 1950 | 250,894 | 1957 | 411,532 | 1964 | 488,699 |
| 1951 | 312,618 | 1958 | 377,092 | 1965 | 516,845 |
| 1952 | 402,315 | 1959 | 416,403 | 1966 | 534,422 |
| 1953 | 402,683 | 1960 | 429,122 | | |

Table 13.17. Public-Improvement Bonds Issued for Act 73-S.L. 1947 as amended

| Date Issued | Amount ($) | Interest Rate (%) | Maturity Date |
|---|---|---|---|
| Jun 1, 1950 | 3,000,000 | 1.60 | Jun 1965 |
| Dec 1, 1950 | 1,356,000 | 1.80 | Jun 1970 |
| Jul 2, 1951 | 644,000 | 2.50 | Jan 1971 |
| Apr 15, 1952 | 1,350,000 | 2.00 | Apr 1972 |
| Sep 15, 1953 | 1,345,288 | 2.90 | Sep 1973 |
| Nov 1, 1954 | 404,712 | 2.25 | May 1974 |

Table 13.18. Amortization Table for Public Improvement Bonds, Act 73

| Calendar Year | Outstanding Principal at Beginning of Year ($) | Payments | | |
|---|---|---|---|---|
| | | Principal ($) | Interest ($) | Total ($) |
| 1950 | -- | -- | 24,000.00 | 24,000.00 |
| 1951 | 4,356,000.00 | -- | 72,408.00 | 72,408.00 |
| 1952 | 5,000,000.00 | 306,354.86 | 102,008.00 | 408,362.86 |
| 1953 | 6,043,645.14 | 342,161.26 | 113,660.00 | 455,821.26 |
| 1954 | 7,046,771.88 | 417,086.26 | 147,620.96 | 564,707.22 |
| 1955 | 7,034,397.62 | 491,688.59 | 150,030.19 | 641,718.78 |



AR00032116

Table 13.18 - continued

| Calendar Year | Outstanding Principal at Beginning of Year ($) | Payments | | |
|---|---|---|---|---|
| | | Principal ($) | Interest ($) | Total ($) |
| 1956 | 6,542,709.03 | 514,103,41 | 142,584.14 | 656,687.55 |
| 1957 | 6,028,605.62 | 514,103.41 | 132,974.62 | 647,078.03 |
| 1958 | 5,514,502.21 | 514,103.41 | 122,860.77 | 636,964.18 |
| 1959 | 5,000,398.80 | 514,103.41 | 112,746.92 | 626,850.33 |
| 1960 | 4,486,295.39 | 514,103.41 | 102,633.07 | 616,736.48 |
| 1961 | 3,972,191.98 | 514,103.41 | 92,519.22 | 606,622.63 |
| 1962 | 3,458,088.57 | 514,103.41 | 82,405.37 | 596,508.78 |
| 1963 | 2,943,985.16 | 514,103.41 | 72,291.52 | 586,394.93 |
| 1964 | 2,429,881.75 | 511,103.41 | 62,177.68 | 573,281.09 |
| 1965 | 1,918,778.34 | 283,103.41 | 52,087.83 | 335,191.24 |
| 1966 | 1,635,674.93 | 283,103.41 | 43,845.97 | 326,949.38 |
| 1967 | 1,352,571.52 | 283,103.41 | 37,428.13 | 320,531.54 |
| 1968 | 1,069,468.11 | 283,103.41 | 31,010.28 | 314,113.69 |
| 1969 | 786,364.70 | 282,715.93 | 24,592.43 | 307,308.36 |
| 1970 | 503,648.77 | 207,233.35 | 18,174.58 | 225,407.93 |
| 1971 | 296,415.42 | 173,292.15 | 11,763.71 | 185,055.86 |
| 1972 | 123,123.27 | 99,463.21 | 6,701.63 | 106,164.84 |
| 1973 | 23,660.06 | 23,660.06 | 3,271.08 | 26,931.14 |
| 1974 | -- | -- | 266.18 | 266.18 |

## D. CITY AND COUNTY HIGHWAY AND STREET INCOME AND EXPENDITURES

The sources of revenue for the City and County of Honolulu for the implementation and maintenance of the streets and highways are generally the General and Highway Funds. Whereas the revenues of the General Fund are used for all functions of government except those activities specially provided for by earmarked revenues out of special funds, the Highway Fund is used to account for dispositon of proceeds from special revenues earmarked by law for highway and related activities (Tables 13.19 and 13.20).

A large portion of the General Fund, approximately 50 percent, is derived from the Real Property Tax. Prior to 1952, assessed valuations for real property were at approximately 33-1/3 percent of market values. A revaluation of all real property in the State, undertaken by the State Tax Commissioner in July 1951 and completed in March 1952, resulted in an increased level of total assessed valuations beginning with 1952. For the years 1952 through 1955,



AR00032117

Table 13.19. General-Fund Revenues, 1960 through 1966

| Sources of Revenue | Revenues ($) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| Real Property Tax | 16,280,288 | 10,323,348 | 21,531,767 | 23,885,761 | 27,739,158 | 34,722,939 | 49,898,146 |
| Licenses and Permits | 843,361 | 533,515 | 840,236 | 846,890 | 1,238,146 | 1,436,137 | 1,602,814 |
| Fines, Forfeits and Penalties | 884,691 | 506,442 | 830,562 | 1,033,383 | 1,320,429 | 1,231,222 | 71,232 |
| Use of Money and Property | 276,992 | 193,161 | 426,660 | 905,605 | 783,475 | 1,293,021 | 1,510,880 |
| From Other Agencies | 12,862,892 | 6,433,007 | 12,776,740 | 13,050,500 | 13,619,654 | 14,339,236 | 7,637,408 |
| For Current Services | 1,249,326 | 799,308 | 1,556,666 | 2,063,123 | 2,534,406 | 2,555,584 | 1,814,072 |
| Other Revenues | 793,036 | 552,137 | 847,310 | 1,067,224 | 977,229 | 2,544,352 | 1,251,974 |
| TOTAL | 33,190,586 | 19,340,918 | 38,809,941 | 42,852,486 | 48,212,497 | 58,122,491 | 63,786,526 |

Note: For the year 1960-1963, inclusive, General-Fund revenues did not include revenues from school pension, liquor commission, and improvement bond compromise since these were separate funds. For Fiscal years 1964-1966 inclusive, all of these revenues are included in the General Fund since these separate funds were abolished and merged with General Fund in Fiscal year 1964.



AR00032118

Table 13.20. Highway-Fund Revenues, 1960 through 1966

| Sources of Revenue | Revenues ($) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| Taxes | 4,631,054 | 2,848,165 | 5,042,783 | 5,218,266 | 5,470,527 | 5,786,680 | 6,132,352 |
| Licenses and Permits | 3,591,421 | 3,724,962 | 3,953,042 | 4,072,135 | 4,675,058 | 4,936,624 | 6,182,962 |
| Use of Money and Property | -- | -- | -- | -- | -- | -- | 3,055 |
| From Other Agencies | 19,843 | 30,164 | 56,027 | 292,413 | 60,959 | 54,128 | 321,567 |
| For Current Services | -- | -- | -- | -- | -- | 106,547 | 59,060 |
| Other Revenues | 55,307 | 29,369 | 266,018 | 103,144 | 442,158 | 93,622 | 76,105 |
| TOTAL | 8,297,625 | 6,632,660 | 9,317,870 | 9,685,958 | 10,648,702 | 10,977,601 | 11,775,101 |

Note: From 1964-1966 inclusive, Highway Fund revenues include parking-meter revenues since the Parking Meter Fund was abolished and merged with Highway Fund in fiscal year 1964.



AR00032119

assessed valuations were at approximately 60 percent of conservative market values. Beginning with 1956, assessed valuations have been at approximately 70 percent of current market values. Table 13.21 shows the valuations and rates, 1957 through 1966.

Table 13.21. Assessed Valuations and Annual Tax Rates, City and County of Honolulu, 1957 through 1966

| Year | Net Valuation ($) | Rate Per Thousand ($) |
|---|---|---|
| 1957 | 822,612,404 | 15.15 |
| 1958 | 870,751,281 | 15.15 |
| 1959 | 935,702,435 | 15.15 |
| 1960 | 1,527,489,601 | 11.70 |
| 1961 | 1,660,997,414 | 13.89 |
| 1962 | 1,840,901,885 | 13.89 |
| 1963 | 1,948,146,471 | 14.66 |
| 1964 | 2,166,552,480 | 14.66 |
| 1965 | 2,343,365,686 | 17.71* |
| 1966 | 2,601,522,866 | 19.21* |

*Composite of separate rates.

The State Director of Taxation has indicated that the higher valuations since 1956 are the result of various contributing factors, such as:

1. Increase in value of land through new subdivisions
2. Increase in value of improvements through new construction
3. Increase in value of realty through rise in market prices
4. Change in depreciation rates by recognizing greater residual value and life expectancy of building improvements
5. The increase from 60 to 70 percent in the uniform ratio of indicated market and depreciated replacement costs for the assessment value.

Enactment of the "Pittsburgh" land-tax measure resulted in the classification of properties into six classes. Effective January 1, 1965, the classes established were:

1. Single-family and two-family residence
2. Three-or-more-family apartment and hotel and resort
3. Commercial
4. Industrial



AR00032120

5. Agricultural
6. Conservation.

With the exception of the agricultural and conservation classes, which are taxed at a single rate, all other properties are subject to differential tax rates, which are applicable to buildings and to land.

The following rates per $1,000 of assessed valuation were established for calendar year 1965 and 1966 as shown in Table 13.22.

Table 13.22. Assessment Rates for 1965 and 1966

| Class | 1965 | | 1966 | |
|---|---|---|---|---|
| | Buildings ($) | Real Property Other Than Buildings ($) | Buildings ($) | Real Property Other Than Buildings ($) |
| 1 | 16.46 | 18.29 | 17.87 | 19.86 |
| 2 | 16.68 | 18.53 | 18.16 | 20.18 |
| 3 | 16.59 | 18.44 | 18.06 | 20.07 |
| 4 | 16.42 | 18.24 | 17.84 | 19.82 |
| 5 | 17.71 | 17.71 | 19.21 | 19.21 |
| 6 | 17.71 | 17.71 | 19.21 | 19.21 |

As indicated in the annual revenue tabulations, the Highway Fund is heavily, if not almost totally, dependent on the Taxes, Licenses, and Permits. Taxes in turn are dependent on the revenue derived from the 3½-cents-per-gallon fuel tax imposed on gasoline, diesel, and butane fuel used on highways (Tables 13.23, 13.24, and 13.25).

Likewise, the motor-vehicle weight tax is the major source of the revenue from Licenses and Permits. Up through 1966, the motor-vehicle-weight tax rates were ½ cent/lb of the net weight for passenger cars and 1 cent/lb on all other vehicles. Passenger vehicles include automobiles, buses, ambulances, hearses, and motorcycles. Included as all other vehicles are trucks, trailers, and other vehicles used to transport property. In 1967, the weight tax was increased to 3/4-cent/lb for passenger vehicles and 1½ cent/lb for all other vehicles.



AR00032121

Table 13.23. County Liquid-Fuel Tax Revenues, 1960 through 1966

| Year | Liquid-Fuel Tax Revenues ($) | | | | |
|---|---|---|---|---|---|
| | City and County of Honolulu | | | | All Counties |
| | Gasoline | Diesel | Butane | Total | |
| 1960 | 3,742,655 | 102,430 | 1,860 | 3,846,945 | 5,098,963 |
| 1961 | 3,916,319 | 96,421 | 2,002 | 4,014,742 | 5,288,577 |
| 1962 | 4,064,347 | 100,166 | 2,130 | 4,166,643 | 5,491,612 |
| 1963 | 4,160,668 | 101,762 | 1,823 | 4,264,253 | 5,616,244 |
| 1964 | 4,411,791 | 109,609 | 2,312 | 4,523,712 | 5,929,250 |
| 1965 | 4,655,985 | 125,972 | 2,474 | 4,784,431 | 6,270,452 |
| 1966 | 4,884,556 | 133,140 | 2,649 | 5,020,345 | 6,568,678 |

Table 13.24. Weight-Tax Revenues from Regular Registration Fees, 1960 through 1966

| Year | Weight Tax Revenues ($) | |
|---|---|---|
| | City and County of Honolulu | All Counties |
| 1960 | 3,558,868 | 4,865,274 |
| 1961 | 3,702,435 | 5,135,215 |
| 1962 | 3,795,186 | 5,270,460 |
| 1963 | 4,047,880 | 5,451,993 |
| 1964 | 4,245,211 | 5,701,407 |
| 1965 | 4,496,275 | 6,031,070 |
| 1966 | 4,721,345 | 6,333,139 |

Note: Interest and penalties are included as revenues.

Table 13.25. Revenues from Operator's Licenses, Permits, Motor-Vehicles Plates, Tags, etc., 1960 through 1966

| Year | Revenues from Licenses, Permits, etc., ($) | |
|---|---|---|
| | City and County of Honolulu | All Counties |
| 1960 | 358,719 | 441,479 |
| 1961 | 430,465 | 642,557 |
| 1962 | 398,936 | 501,095 |
| 1963 | 411,070 | 507,554 |
| 1964 | 458,256 | 590,429 |
| 1965 | 481,158 | 608,483 |
| 1966 | 507,521 | 633,955 |



AR00032122

Expenditures of the revenues discussed are presented in Tables 13.26 and 13.27. Only those expenditures thought to be applicable to street construction and for improvements and related activities are tabulated.

Total annual amount shown for the Highway Fund expenditures does not include provision for the Capital Improvement Program (CIP), which includes expenditures for, among other things, construction and reconstruction of highways, improvement-district projects, and street lighting. Contribution from the Highway Fund to the Capital-Improvement Fund has ranged from anywhere between one-half million dollars to three-and-one-half million dollars annually over the seven-year period.

## E. MASS-TRANSIT FINANCING

Selection of an effective means for financing the Oahu mass-transit system is essential to its success. This section of the report examines some of the alternative financing methods, their limitations, and their impact and effect on those who must ultimately pay the costs.

How the system can be financed will be influenced significantly by designation of the public agency responsible for mass transit. While other factors may be relevant in assigning major transit responsiblities, the ability to finance construction is perhaps the most important. The public agency or agencies who assume responsiblity for mass transit, or to whom responsibility is assigned, must be capable of financing the project.

This section emphasizes capital financing rather than the ability to conduct utility operations after a transit system is in service.

Total capital-cost requirements have been estimated in earlier sections of this volume--Table 12.17. Most of the capital cost of rail transit is in fixed facilities, which must be completed as a whole before service can be initiated.

Rail rolling stock, buses, and similar equipment can be acquired over a period of time, but initial requirements are relatively large because of the need to start with a fully operable system. Rolling stock has a shorter life than fixed facilities, and provision must be made for replacement.



AR00032123

Table 13.26. General-Fund Operating Expenditures, 1960 through 1966

| Item | Expenditures ($) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| Road Construction, Improvements, etc. | 183,710 | 86,798 | 150,050 | 144,128 | 69,310 | 195,209 | 219,932 |
| Highway Operation, etc. | 65,337 | 29,190 | 45,069 | 60,728 | 213,104 | 222,261 | 237,442 |
| TOTAL | 249,047 | 115,988 | 195,119 | 204,856 | 282,414 | 417,470 | 457,374 |

Table 13.27. Highway-Fund Operating Expenditures, 1960 through 1966

| Item | Expenditures ($) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| Road Construction, Improvements, etc. | 780,107 | 379,398 | 801,950 | 932,037 | 968,217 | 791,912 | 1,129,407 |
| Road Maintenance | 2,480,910 | 1,406,202 | 2,505,525 | 2,684,711 | 2,880,599 | 2,768,036 | 3,377,273 |
| Highway Operation, etc. | 3,198,513 | 2,209,163 | 5,526,199 | 3,534,047 | 4,044,960 | 4,342,795 | 4.585,045 |
| Debt Service | 855,670 | 422,780 | 612,067 | 819,001 | 807,145 | 800,917 | 771,186 |
| TOTAL | 7,315,200 | 4,417,543 | 9,445,741 | 7,969,796 | 8,700,921 | 8,703,660 | 9,862,911 |

Note: From 1964-1966, expenditures reflect Parking Meter Fund expenditures since Parking Meter Fund was merged with Highway Fund.



AR00032124

Analysis of operating revenues and expenses indicates that annual gross revenues will exceed expenses for the rail system. Expenses are at least partially a function of patronage, and the assumption can reasonably be made that revenues will cover operating expenses adequately if patronage is higher or lower than has been estimated. No operating subsidy is believed necessary once the rail system is in operation. Some pre-operating expenses will be incurred before any revenues are available, and these expenses appropriately can be capitalized.

Revenue estimates indicate that capital costs must be supported largely from sources other than operating income. A self-supporting system appears impossible, and a fundamental decision to be made is whether or not transit benefits are sufficient to warrant financial support from general governmental revenues. This financial support will be manifest in payment of some or all of the capital costs of the system, probably by payment of bond interest and principal.

1. LOCAL SHARE OF THE PROJECT COST

Federal grants are available for the planning and construction of mass-transit projects such as are proposed on Oahu. Costs to be borne locally in Hawaii will be reduced by the availability of federal assistance.

The amount of federal assistance to be received for a particular project cannot be determined at this time. It depends on the project cost and on competition among states and urban areas for available funds.

The Urban Mass Transportation Act of 1964 authorized grants of $395 million for three years and projects have been approved to date in 27 states. The present fiscal year is the last in this authorization, but in 1966 Congress extended this program for two years and authorized an additional $150 million per year. Hawaii can expect to participate in this latter $300 million.

Construction grants to any one state are limited to 12½ percent of the annual total. The most any single state will receive from the original $395 million, therefore, is about $49.5 million. The one-state maximum for the next two years' authorization ($300 million) is $18,750,000 per year. On this basis, present legislation could provide a maximum of $37.5 million for Hawaii. The potential benefits of transit on Oahu are evident from the analysis presented



AR00032125

in this report, and strong arguments can be made in Hawaii's behalf. Hawaii is a small state, however, and as such may have difficulty qualifying for the maximum.

Federal aid is available for transit planning and design as well as for construction on the basis of a two-thirds Federal contribution. These funds will be relatively much smaller than those for construction, and the specific amount will depend on the actual application. Although the amounts that might be expected cannot now be established accurately, this lack should not prevent drawing valid conclusions from the analyses in this report.

## 2. FORMS OF PUBLIC FINANCING

General-obligation bonds are considered to be the most common means of borrowing; an alternative means would be revenue bonds.

Salability of revenue bonds depends on the specific pledge of security. The Board of Water Supply uses revenue bonds effectively on a continuing basis and, because of an established record of earnings, have found them to be a successful financing method.

Revenue bonds do not count against the legal debt limits imposed by the Constitution under Section 3 of Article VI if bonds are issued under revenue statutes and the only security is the revenues of the enterprise or the public corporation issuing them.

Principal revenues that could be pledged to payment of mass-transit revenue bonds are the gross or net revenues of the transit system. Estimated revenues are insufficient, however, to support a successful revenue-bond issue for the entire transit system.

For revenue bonds to be salable requires that net revenues be definitely assured in an amount greater than annual bond-service requirements. A minimum guaranteed ratio of revenues to bond service is required, a ratio typically referred to as "coverage". A coverage ratio of 1.5 based on net revenues is common, especially for new projects for which revenues must be estimated prior to actual experience. Some projects with long, well established historical records of earnings or very strong guarantees of income can sell revenue bonds with coverage ratios lower than 1.5.



AR00032126

Financing Oahu transit revenue bonds will be difficult in the absence of an historic earnings record and with estimated gross revenues from the system only slightly in excess of operation and maintenance expenses. Revenue-bond financing might be used successfully for a limited part of the transit project, such as rolling stock for the rail system. It is more likely that revenue bonds can provide future financing for extensions or improvements once a record of earnings has been established.

The principal advantage of revenue bonds is that they are outside the legal debt limits, expressed as percentages of assessed valuation. Limited financing capacity using general-obligation bonds is a major problem for the rail-transit proposal, as will be discussed in later sections. Using revenue bonds for some of the project will serve to increase total financing capacity legally available for transit.

A significant disadvantage of revenue bonds, even if pledged revenues were great enough to make them salable, is the loss of some financial flexibility for the issuer. Ability to sell additional revenue bonds ranking on a parity with the original issue would be limited; fares would always have to be high enough to maintain the guaranteed coverage ratio; the right to lease, sell, or otherwise dispose of or encumber property would be limited; and other limitations on management discretion might be necessary.

Revenue bonds limit the sources from which bonds can be paid. In the case of the Board of Water Supply, this limitation has guaranteed a self-supporting water system. Some argue that revenue-bond financing encourages businesslike management practices. All of the advantages claimed for revenue bonds are also available for general-obligation bonds if management decides to pay bond costs from revenues and adopts policies designed to implement this decision.

Revenue bonds almost certainly cannot be considered for financing the entire rail-transit system because of the high cost involved and may have only limited application in all-bus system.

Some transit projects have utilized less conventional financing methods, such as nonprofit corporations and various lease and leaseback procedures. Under such procedures, acquisition or construction is by the



AR00032127

corporation, which issues tax-exempt bonds to finance the purchase. In most cases these bonds are secured by one or more leases with a public agency. If the contract between the corporation and public agency is valid and enforceable, and lease payments are large enough and continue long enough to amortize the bonds, a salable bond issue may result.

Such methods are not well suited for projects of the size and complexity inherent in the rail-mass-transit proposal. Nonprofit corporations have been used successfully for some projects on the order of $25,000,000 but to provide $200,000,000 for transit will be much more difficult. The transit proposal involves construction over an extended period of time. A lease could not be fully effective until construction is complete and the transit system is in service.

Hawaii has no precedent for large-scale use of lease and leaseback financing or tax-exempt bond issues for nonprofit corporations, and they may not be permitted under Hawaiian law.

The principal advantage of lease financing is that the bonded-debt limitations can be avoided. Among the disadvantages are probable higher cost of borrowing, higher incidental expenses, lack of financial flexibility during construction and after completion, and operating restrictions.

### 3. PUBLIC AGENCY RESPONSIBLE FOR TRANSIT

Public agencies with the authority and the capability to finance mass transit are the State of Hawaii and the City and County of Honolulu. There are no other levels of local government and no special districts. Proposals for forming a new special-purpose public agency for mass transit are discussed later in this report, p. 33

The following factors support the City and County of Honolulu for assuming responsibility for mass transit.

1. Service Area: The mass-transit system will lie entirely within the City and County and make service available to most of Oahu's population.
2. Urban Planning and Services: Transit is closely related to other urban functions of the City and County. Mass transit can be an important, perhaps decisive, element in determining the City's ability to implement its plans. The rate, extent, and quality of the City's growth will be



AR00032128

influenced significantly by transit development. Transit should be treated as an essential municipal function, not as a separate or separable activity.

3. Municipal Services: City departments now perform many functions that could be utilized in transit planning, construction, and operation.

4. Financial Powers: The City and County has the power to issue bonds, condemn property, and perform the other functions necessary to completion of the transit program. A transit system will enhance property values, making the property tax an appropriate source of funds to pay for the system.

The following factors support the State's participation in mass transit:

1. Transporation Involvement: The State has assumed and exercises major responsibility for almost all forms of transportation in the State; the only exceptions are local streets and roads.

2. Statewide Impact: Many important benefits of transit, such as service to tourists and visitors, have statewide impact and thus warrant statewide support.

3. Federal Assistance: Many federal-aid programs allocate money directly to states, possibly for reallocation to local governments. Direct State involvement in a program may facilitate receipt and use of federal funds, although in the case of transit this does not appear to be a factor.

4. Diversified revenues: Not all transit benefits can be measured directly in terms of assessed valuation, and the State can allocate transit costs more readily to tax sources other than real property.

5. State Services: The State has functioning departments whose skills and services can be used effectively in transit, including all of those now engaged in transportation planning, construction, and operation, and maintenance.

6. Financing Powers: The State can issue and sell bonds for transit improvements.

For the City and County of Honolulu to finance a mass-transit system of the magnitude indicated requires a top-priority commitment to transit by the Mayor and the City Council because project costs are large in relation to projected other needs. Transit necessarily must be assigned a position of high importance.

To finance mass transit successfully very probably will require deferment of other improvements planned by the City and County. To use general-obligation bonds will require exceeding the policy-imposed 5-percent debt



AR00032129

limit and approaching the 10-percent limit imposed by the Constitution. Finally, the ability of the City and County to finance mass transit is based on the reasonable assumption that taxable assessed valuation will continue to increase, that operating expenses can be met from operating revenues, and that motor-vehicle-fuel and weight-tax revenues will continue to be available.

Formation of a separate political subdivision has been proposed as a vehicle for financing and possibly for construction and operation of a mass-transit system on Oahu. Transit has been made the responsibility of independent governmental agencies in many American cities.

The Attorney General's Office has concluded that the law does not permit formation of a special district for transit. In a letter to the Oahu Transportation Study, he said in part:

> "The suggestion to create a political subdivision comprising all or a portion of the City and County of Honolulu for mass transit contemplates special legislation and would be indirect violation of the above-referenced constitutional provision (Sections 1 and 2 of Article VII) limiting the creation of political subdivisions only by general laws."

The principal reason for considering a new political subdivision would be to overcome the limitations of bonding capacity imposed on the State and the City and County. Even if the legislature in some way could create a new district, difficult problems would remain to be solved and obstacles would have to be overcome. Composition of the governing body would have to be agreed upon, for instance as well as assignment of powers which would be transferred from or shared with the established governmental units.

A serious disadvantage of introducing another political subdivision into the mass-transit picture is that this would separate one important municipal service from all others. Transit is not independent of other elements of urban development. Effective machinery for coordinating transit planning and operation with other municipal functions is essential, and chances for success appear best if all urban functions are under the same jurisdiction.



AR00032130

## 4. HONOLULU AS MAJOR TRANSIT AGENCY

The City and County of Honolulu is now the governmental agency with principal responsibility for mass transit. The enactment of enabling legislation by the Fourth State Legislature, which became law on June 13, 1967, permitted the City and County of Honolulu to move forward with confidence to establish by phase development a balanced mass-transportation system for Oahu.

The analysis presented above indicates, however, that unless other capital improvements are deferred or additional sources of revenues or financial assistance are obtained, Honolulu may be unable to sell enough general-obligation bonds to finance the recommended rail-transit system, even if the 5-percent policy limit of indebtedness is exceeded.

State financial assistance for the transit project appears appropriate for there is a statewide interest in mass transit. If the mass-transit system to be constructed cannot be financed within the limits of the City and County's available bonding capacity, the limitation can be overcome if the State sells bonds for a portion of the project. Detailed analysis of the system and its probable patronage may permit identification of certain elements--e.g., Honolulu Airport-Waikiki--as facilities which appropriately can be financed by the State.

## 5. EXISTING TRANSIT

The present Honolulu Rapid Transit should be involved in mass transit on a long-term, permanent basis, but disposition of HRT and its assets is not critical in the present financial analysis. This study has not included a detailed analysis of the value of the HRT system and facilities or the basis on which they could be acquired publicly.

The HRT can be acquired by a public agency such as the City and County at a price established (or approved) by the Public Utilities Commission. The City and County can enter the transit business without acquiring HRT assets or paying any indemnity, according to the authorities on Hawaiian public-utility law. The principal HRT asset of value to a future mass-transit system is its buses, which could be used in an improved and enlarged system.



AR00032131

The value of HRT's assets has been variously estimated at between $2.5 and $6.5 million. This cost is very small in relation to the total cost of the proposed rail-transit system, so that HRT cannot be regarded as very important to this system. If the all-bus mass-transit alternative is selected, the HRT may be regarded as a source of some of the buses needed.

6. ANNUAL COSTS WITH GENERAL-OBLIGATION BONDS

The State of Hawaii and the City and County of Honolulu issue general obligation bonds with similar terms and conditions. Honolulu represents almost 85 percent of the State's assessed valuation and produces a comparable share of State government revenue, so bonds of the State and the City and County are regarded as having about the same security. Both are rated "A" by Moody's.

The interest rates for Hawaii and Honolulu general-obligation bonds generally are close to the 20-bond average reported by The Bond Buyer at the time of sale, with Honolulu bonds selling at a slightly lower rate. The last sales of each were as shown in Table 13.28.

Table 13.28. Details of Most Recent Hawaii and Honolulu General-Obligation Bond Sales

| Bonds | Date of Sale | Principal Amount ($) | Coupon Rates (%) | Net Interest Rate (%) | Bond Buyer Average (%) |
|---|---|---|---|---|---|
| Honolulu | Apr 19, 1966 | 7,500,000 | 3.5-4.75 | 3.63 | 3.60 |
| Hawaii | May 25, 1966 | 10,000,000 | 3.8-4.75 | 3.88 | 3.72 |

The market weakened substantially after these sales and then improved again. The average rose to a 30-year high of 4.24 percent on August 25, 1966, and was reported at 3.76 percent on January 5, 1967.

For the purpose of computation in this report, an interest rate of 4 percent can be assumed for general-obligation bonds sold to finance mass transit. Bonds are to be sold over a period of several years, during which the market will fluctuate, but 4 percent can be considered a reasonable average of sales over the period. In general, increasing the amount of outstanding debt results in higher interest rates.



AR00032132

The Constitution imposes limits that are applicable to all general obligation bonds:

> "All bonds or other instruments of indebtedness for a term exceeding one year shall be in serial form maturing in substantially equal annual installments, the first installment to mature not later than five years from the date of issue of such series, and the last installment not later than 35 years from the date of such issue."

For the purpose of estimating annual costs of the rail-mass-transit system, sale of $200,000,000 of general obligation bonds in five annual installments is assumed. Each sale is assumed to be $40,000,000, although the need for funds may actually require larger amounts in some of the earlier years. This amount is within the 2-percent annual limit imposed by law.

Table 13.29 shows the annual interest and principal requirements if $200,000,000 of bonds are sold to mature in accordance with the pattern established by recent issues of State and Honolulu bonds, equal annual amounts of principal maturing in 18 installments beginning in the third year. The annual maturity for each series of $40,000,000 is $2,220,000.

Annual debt-service requirements reach a peak of $18,212,000 in the seventh year, which is the first year in which there are principal maturities for all five series. As debt is retired, annual requirements are reduced, and the last outstanding bonds are retired in Year 24.

The following schedule is designed to minimize annual bond-service requirements by extending maturities as long as possible. Each of the five series is retired in 31 annual installments from the fifth through the thirty-fifth year. Maximum annual debt service is shown as approximately $13,934,000, reached in the ninth year. The last bonds are retired in Year 39 (Table 13.30).

Maximum Annual Transit Debt Service

| | |
|---|---|
| 18-Year Maturity | $18,212,000 |
| 21-Year Maturity | 13,934,000 |

1966/67 Total Interest and Principal Requirements
(General Obligation)

| | |
|---|---|
| City and County of Honolulu | $11,163,713 |
| State of Hawaii | 18,571,644 |



AR00032133

Table 13.29. Annual Interest and Principal Requirements for $200,000,000 Bonds at 4-Percent Interest, Maturities in the Third to the Twentieth Years, with a 24-Year Maximum (Present Maturity Schedule Pattern)

| Year | Bonds Sold ($1,000) | Principal Amount Outstanding ($1,000) | Interest At 4% ($) | Principal Maturing ($1,000) | Total Bond Service ($1,000) |
|---|---|---|---|---|---|
| 1 | 40,000 | 40,000 | 1,600 | | 1,600 |
| 2 | 40,000 | 80,000 | 3,200 | | 3,200 |
| 3 | 40,000 | 120,000 | 4,800 | 2,220 | 7,020 |
| 4 | 40,000 | 157,780 | 6,311 | 4,440 | 10,751 |
| 5 | 40,000 | 193,340 | 7,734 | 6,660 | 14,394 |
| 6 | | 186,680 | 7,467 | 8,880 | 16,347 |
| 7 | | 177,800 | 7,112 | 11,100 | 18,212 |
| 8 | | 166,700 | 6,668 | 11,100 | 17,768 |
| 9 | | 155,600 | 6,224 | 11,100 | 17,324 |
| 10 | | 144,500 | 5,780 | 11,100 | 16,880 |
| 11 | | 133,400 | 5,336 | 11,100 | 16,436 |
| 12 | | 122,300 | 4,892 | 11,100 | 15,992 |
| 13 | | 111,200 | 4,448 | 11,105 | 15,553 |
| 14 | | 100,095 | 4,004 | 11,110 | 15,114 |
| 15 | | 88,985 | 3,559 | 11,115 | 14,674 |
| 16 | | 77,870 | 3,115 | 11,120 | 14,235 |
| 17 | | 66,750 | 2,670 | 11,125 | 13,795 |
| 18 | | 55,625 | 2,225 | 11,125 | 13,350 |
| 19 | | 44,500 | 1,780 | 11,125 | 12,905 |
| 20 | | 33,375 | 1,335 | 11,125 | 12,460 |
| 21 | | 22,250 | 890 | 8,900 | 9,790 |
| 22 | | 13,350 | 534 | 6,675 | 7,209 |
| 23 | | 6,675 | 267 | 4,450 | 4,717 |
| 24 | | 2,225 | 89 | 2,225 | 2,314 |
| 24-Yr Totals | 200,000 | | 92,040 | 200,000 | 292,040 |

Maximum debt service would be reduced if bonds were issued with a maturity schedule providing for equal annual total payments of interest plus principal. Under such an amortization schedule, principal payments increase as interest requirements decline. With such a schedule, not now permitted, a maximum of approximately $11,370,000 would be reached in Year 9 and continued through Year 35.

The amortized schedule requires payment of more total interest than an equal-principal schedule of the same length but the maximum requirements are lower.



AR00032134

Table 13.30. Annual Interest and Principal Requirements for $200,000,000 Bonds at 4-Percent Interest, Maturities in Fifth to Thirty-fifth Years with a 39-Year Maximum (Longest Maturity Schedule Permitted by Law)

| Year | Bonds Sold ($1,000) | Principal Amount Outstanding ($1,000) | Interest At 4$ ($) | Principal Maturing ($1,000) | Total Bond Service ($1,000) |
|---|---|---|---|---|---|
| 1 | 40,000 | 40,000 | 1,600 | | 1,600 |
| 2 | 40,000 | 80,000 | 3,200 | | 3,200 |
| 3 | 40,000 | 120,000 | 4,800 | | 4,800 |
| 4 | 40,000 | 160,000 | 6,400 | | 6,400 |
| 5 | 40,000 | 200,000 | 8,000 | 1,290 | 9,290 |
| 6 | | 198,710 | 7,948 | 2,580 | 10,528 |
| 7 | | 196,730 | 7,869 | 3,870 | 11,739 |
| 8 | | 192,260 | 7,690 | 5,160 | 12,850 |
| 9 | | 187,100 | 7,484 | 6,450 | 13,934 |
| 10 | | 180,650 | 7,226 | 6,450 | 13,676 |
| 15 | | 148,400 | 5,936 | 6,450 | 12,386 |
| 20 | | 116,150 | 4,646 | 6,450 | 11,096 |
| 25 | | 83,900 | 3,356 | 6,450 | 9,806 |
| 30 | | 51,650 | 2,066 | 6,450 | 8,516 |
| 31 | | 45,200 | 1,808 | 6,450 | 8,258 |
| 32 | | 38,750 | 1,550 | 6,450 | 8,000 |
| 33 | | 32,300 | 1,292 | 6,450 | 7,742 |
| 34 | | 25,850 | 1,034 | 6,455 | 7,489 |
| 35 | | 19,395 | 776 | 6,460 | 7,236 |
| 36 | | 12,935 | 517 | 5,170 | 5,687 |
| 37 | | 7,765 | 311 | 3,880 | 4,191 |
| 38 | | 3,885 | 155 | 2,590 | 2,745 |
| 39 | | 1,295 | 52 | 1,295 | 1,347 |
| 39-Yr Totals | 200,000 | | 160,053 | 200,000 | 360,053 |

City and County debt-management policies limit indebtedness so that interest and principal requirements are not to exceed 20 percent of the total budget. In 1962/63, debt service accounted for 19.5 percent, but the percentage has been reduced in subsequent years and the $13,921,000 budgeted for debt service was 17.2 percent in 1966/67. The latter figure includes about $2.4 million for state bonds for which interest and principal are paid by Honolulu.



AR00032135

Unless other capital improvements are deferred or additional revenues or financial assistance are obtained, added debt-service requirements for mass transit will increase annual requirements above the 20-percent level, even if the transit debt is less than the $200-million total required for the complete rail-transit system.

If the entire $200-million debt is assumed as supported by the City and County of Honolulu and serviced from property taxes, an evaluation of the effect of debt service for mass transit on property tax rates can be made. The annual requirement in the highest year has been computed as approximately $14,000,000 for the $200-million system and averages $10,450,000 during 27 years of full principal payments.

To raise this average amount on the present assessed valuation of the City and County would require an added tax rate of $4.00 per $1,000. If assessed valuation increases at 5 percent or more annually, it will reach $4.0 billion before the year of maximum debt service, resulting in a maximum equivalent tax rate of $3.50 per $1,000.

These rates should be regarded as entirely hypothetical and are presented for the purpose of indicating a magnitude of cost. They assume that all local costs will be financed by bonds of the City and County and further that all bond-service requirements will be met from taxes levied on real property. Neither of these assumptions is likely to apply to actual transit financing, but to compare the indicated rate for mass transit with the 1966/67 combined equivalent rate of $19.21 shows the relatively large commitment to transit that is demanded by the project.

The estimated average annual bond service represents about 13 percent of the current total annual expenditures of the City and County, and about 3 percent of the larger total budget of the State of Hawaii.

## F. CONCLUSIONS

Mass transit on Oahu should be financed, constructed, and operated by existing governments. The City and County of Honolulu now assumes responsibility for mass transit because its geographic limits encompass the transit-service area, because transit is so closely related to functions and services



AR00032136

for which Honolulu is responsible, and because Honolulu is financially and organizationally well equipped for the task.

The major problem is that of financing capacity. General-obligation bonds are the least expensive and most flexible financing method available and should be utilized if possible. The City and County has a legal debt limit and many other capital-improvement needs to fill. Prior studies have concluded that property-tax rates in Hawaii are comparatively low in relation to the rest of the United States, and City and County financing of transit may require increasing the real property tax.

Statewide interest in Oahu transit should be recognized and similarities should be noted between transit and other forms of transportation facilities for which the State carries the major financial burden. To reduce the need to issue Honolulu bonds as well as to recognize this statewide interest, some financial participation by the State would be desirable.

Under any circumstances, the building of a transit system of the type discussed in this report requires a very strong public commitment to transit. Transit must be given priority over some other public projects, and debt limits adopted in support of sound and conservative policies must be exceeded. To borrow funds required for the system requires careful planning and consideration of priorities but appears possible with close cooperation between the State and City and County of Honolulu.

The limitations on total debt and on variations in the bond maturity schedule are established by the State Constitution. The Constitution can be amended by action of the Legislature and the people.

This financing analysis is intended to explore some of the problems and implications involved in mass-transit proposals. No attempt has been made on the basis of these preliminary studies to develop a detailed and definitive financing plan. Emphasis has been on selecting appropriate governmental agencies cies to assume transit responsibility and on the alternate methods available for borrowing funds for mass-transit capital investment.

No comprehensive analysis has been made of the revenue structure of State and Local government or to determine which revenue sources should be



AR00032137

utilized to service transit debt. General revisions in revenue structure may be appropriate, and some further reallocation of functions and revenue sources may be needed.

A strong commitment to transit is necessary if the plans outlined in this report are to be implemented. Considerations of this section, as they affect assignment of transit responsibility and indicate alternative methods of financing, are intended to assist officials and members of the public who must decide whether or not to make the commitment required. Facts are essential to intelligent decisions, and this report is intended to provide some of those facts, which should lead to the discovery and development of others.



AR00032138

Date Due

| | | |
|---|---|---|
| OCT 2 1 1971 | | |
| NOV 13 1972 | | |
| SEP 4 1973 | | |
| APR 5 1974 | | |
| APR 3 1975 | | |
| MAY 6 1977 | | |
| NOV 2 4 1977 | | |
| APR 2 6 1979 | | |
| FEB 1 0 1987 | | |
| DEC 2 8 2011 | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

Library Bureau Cat. No. 1137