THE PORTLAND TRANSIT MALL IMPACT STUDY

TRAFFIC EFFECTS ANALYSIS

BUREAU OF PLANNING
CITY OF PORTLAND, OREGON
NOVEMBER, 1981

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This report is part of the Portland Transit Mall Impact Study. It was prepared by the City of Portland, Bureau of Planning to provide technical information on certain elements of the Mall study. The report was prepared under contract to METRO, which has copies of the complete Impact Study.

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INTRODUCTION

BACKGROUND

Transit malls are a relatively new form of municipal projects; they have been constructed in the U.S. only within the last 15 years. In the 1970's a new wave of concern over deteriotating business conditions in downtowns combined with increased concern over traffic congestion and environmental problems brought renewed interest in transit improvements as a partial solution. Recognizing that fixed guideway systems are expensive, most cities have begun to focus attention on improving bus service by means of operational measures. Examples are: priority signalization, preferential lanes, improved loading facilities, route rationalization, and improved scheduling. In particular, there has been a trend toward consolidation of routes onto fewer streets in order to make more efficient use of preferential treatment, while also simplifying the transit system and making transfers easier. Also, under the general heading of "Transportation Systems Management," public officials are encouraging carpools, transit usage, shorter trips and pedestrianization to otherwise mitigate the growth of auto congestion.

Transit malls represent a combination of two trends: (1) pedestrian malls and (2) preferential treatment for buses on city streets. They consist of relatively auto free areas which retain a roadway reserved for transit vehicles. Auto access is denied or limited strictly to local traffic and cross-street traffic. Typically, sidewalks are widened and other pedestrian amenities are added. By addressing the needs of pedestrians and facilitating the operation of transit, the mall becomes an important part of the collection-distribution process of a city wide or regional transit system.

A transit mall can be viewed as a compromise shopping mall, designed to satisfy merchants who may feel that some vehicular access is essential to their business. This compromise view is based on the notion that neither pedestrian needs nor transit volumes taken by themselves are sufficient to justify removing entire streets from automobile use, but together they are. Further, pedestrian and transit uses are considered complementary uses. By combining the two, a special focus may be created in the downtown area that brings people together, stimulates business, encourages bus ridership, improves transit service, enhances environmental quality, and stimulates development in a pattern that can be better served by transit.

HISTORICAL DEVELOPMENT OF PORTLAND, OREGON'S TRANSIT MALL

While the concept of segregating transit from auto traffic on Portland's downtown streets was advanced as a solution to downtown traffic problems as early as the 1950's, the idea of a transit mall for Portland, Oregon was initiated in 1970 by a coalition of downtown business leaders and property owners. A Downtown Plan Study Group was formed, involving the City of Portland, Multnomah County and a variety of private consultants. Shortly thereafter, a Technical Advisory Committee, composed of technical personnel from various public agencies, was also formed, as well as a Citizen Advisory Committee.

After 15 months of discussion and study, a report (Planning Guidelines - Portland Downtown Plan) was published which included a transit mall concept for Fifth and Sixth Avenues.

The transit mall concept was identified as an integral element in the Downtown Plan and reiterated in the City's Transportation Control Strategy for Federal Air Quality Standards (1972). Therefore, the transit mall concept should not be viewed as an independent project but as a part of a much broader public and private investment plan.

Through a program funded by the Urban Mass Transportation Administration (UMTA), the Tri-County Metropolitan Transportation District of Oregon (Tri-Met) initiated a feasibility study for a Portland Transit Mall in January of 1973. The results of the study were favorable. This effort was followed by a preliminary design, completed in December of 1975. The funding for the Transit Mall was available under the Urban Mass Transportation Act of 1964 as amended. This act authorized the Secretary of Transportation to provide additional assistance for the development of comprehensive and coordinated mass transportation systems, both public and private, in metropolitan and other urban areas, and for other purposes. The construction was a $15 million project funded 80 per cent by UMTA and 20 per cent by Tri-Met. Construction began in February, 1976; partial operation started in December, 1977; the Mall was completed early in 1978.

The Transit Mall is located in the heart of Portland's Central Business District (see Figure A), is eleven blocks long (½ mile), and consists of two one-way streets, S.W. Fifth and Sixth Avenues. Physically, the Transit Mall involved reconstructing all improvements within the street right-of-way. This included widening existing 15' sidewalks to 26' along the right lane of each avenue where buses load. Sidewalks on the opposite side of the street were widened from 15' to 18' where there is auto access and to 30' in other blocks. Sidewalks were reconstructed with brick paving and granite curbs. London plane trees, spaced at approximately 25 feet, line the two avenues. This boulevard treatment is enhanced by refurbished historic street light standards and other street furniture. Most significant among the items of street furniture are 31 bronze-clad, glass roofed bus shelters located at bus stops.

An access lane for automobiles was provided in all but six blocks on the two Mall streets. These access lanes do not

FIGURE A

PORTLAND CENTRAL BUSINESS DISTRICT

TRANSIT MALL

0 1200'

allow through traffic, since they run for no more than three continuous blocks. Access from cross streets to these lanes is made by turning left into the Mall street. Cross street traffic is not allowed to turn right into the access lane because this would require turning across the bus lane. The widened sidewalks allow room for people waiting for buses, as well as 250 trees, 31 bus shelters, 54 benches, 34 bicycle bollards, 112 trash containers, 48 banner poles, 84 light bollards, 8 trip planning kiosks, plus display kiosks, concession stands and other features. It has been proposed that the Transit Mall eventually be extended a few blocks to connect with a regional transportation center at the northern end of the downtown. This would provide a link between suburban transit stations, shuttle buses, inter-city buses, Amtrak, and future transit improvements such as light rail.

OBJECTIVES OF THE PORTLAND TRANSIT MALL

Several objectives influenced the design of the Transit Mall. An important objective was to provide a more efficient, convenient transportation alternative for commuters and shoppers. Transit improvements were expected to increase transit use. This, in turn, was expected to promote more efficient land use, reduce energy consumption and reduce pollution. Another objective was to revitalize the downtown area.

The Mall design incorporates a number of features aimed at improving the efficiency and hence the attractiveness of transit. Two lanes on each avenue are designated exclusive bus rights-of-way. They are intended to increase transit capacity and reduce bus travel time by minimizing conflicts between autos and buses. A third lane, adjacent to the two transit lanes in eight of the eleven blocks, provides limited access to non-transit vehicles. The three blocks which do not have this lane act as a barrier to non-transit vehicles which could otherwise use the Mall as a through north-south route. Non-transit vehicles may also cross the Mall on all east-west cross streets. This provides additional access while minimizing auto-bus conflict.

The Mall was also designed to encourage transit by making it more convenient and comfortable. Downtown bus stops were centralized to make transfers easier. Comprehensive route and schedule information are available at bus stops and information kiosks. Sheltered waiting areas and other services are provided. These and other features were included to make it easier for people to understand and use the transit system.

In addition to basic transit improvements, the Mall was designed to provide an environment inviting to residents and visitors, thereby making downtown businesses more competitive with suburban locations. Pedestrian amenities include widened sidewalks, street trees and landscaping, separation of passenger waiting zones from the store fronts and sidewalks, improved street lighting, street furnishings, and more attractive street graphics, signing and traffic control devices.

Finally, it was hoped that the completed Mall would stimulate growth in the downtown area, through stabilization or growth in the number of retail firms, lower vacancy rates, lower turnover rates, increased retail sales and other business activity, greater private and public investments, and more jobs.

THE PORTLAND TRANSIT MALL IMPACT STUDY

The Portland Transit Mall Impact Study was funded by the Urban Mass Transportation Administration to analyze a wide range of impacts related to the Portland Transit Mall. This study is a joint project involving the following agencies: Metropolitan Service District, City of Portland--Bureau of Planning, Tri-

County Metropolitan Transportation District of Oregon, Center for Urban Studies--Portland State University.

The purpose of the study is to provide useful information for public and private organizations at both the national and local level. At the national level, results of the study will help answer questions that are asked of Portland by other local governmental agencies. These agencies have expressed interest in Portland's experience with a transit mall and possible applications to their locale. They are also interested in the transportation-land use interactions that can be achieved through investments in transit. At the local level, information will be used in assessing impacts that relate to the operation, maintenance and possible extension of the Transit Mall.

This study evaluates a wide range of impacts which can be attributed to the construction and operation of Portland's Transit Mall. At the same time it must be recognized that the impacts of the Portland Transit Mall are difficult to isolate from a series of other public and private activities occurring during the same time period.

The specific impacts that were identified, measured and analyzed by this study and the agencies conducting this research are:

I. Tri-County Metropolitan Transportation District of Oregon
   A. Transit Operation Impacts
   B. Safety Impacts
      1. Traffic Accidents
      2. Crime
   C. Supervision
   D. Transit Users Survey

II. The City of Portland--Bureau of Planning

A. Environmental Impacts
   1. Noise
   2. Air Quality
B. Economic and Land Use Impacts
   1. Economic and Land Use Overview
   2. Downtown Buildings: New Construction, Major Renovation and Demolition
   3. Retail Firm Location and Re-Location Movements
C. Traffic Impacts
D. Pedestrian/Parking Survey

III. Center for Urban Studies--Portland State University
A. Downtown Employee Impact Survey
   1. Travel Behavior
   2. Mode Changes
   3. Environmental Attitudes and Perception
   4. Design Aspects
B. Retial Firm Locational Decision Impact Survey
   1. Effects of Transit Mall during construction
   2. Effects of Transit Mall after construction
C. Economic and Land Use Impacts
   1. Changes in Land Values
   2. Changes in Rental Values
D. Downtown Revitalization Impacts
E. Institutional Networks

The following report is one of a series published by the Portland Transit Mall Impact Study. The contents of this report will be integrated into a Final Report.

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TRAFFIC EFFECTS ANALYSIS

PURPOSE OF REPORT

Traffic Effects Analysis Objectives

This report addresses the effects, in downtown Portland, of the Transit Mall on traffic circulation, transit efficiency and use, pedestrian circulation, parking and local access and other traffic-related matters. It was determined that the most appropriate analysis of these effects would involve a comparison of 1980 modelled (or simulated) traffic conditions with the Mall, against 1980 modelled (or simulated) traffic conditions had the Mall never been built.

This report was able to use a traffic model previously developed to assess the potential downtown traffic impacts of various options for transit improvements between downtown and areas west of the City. Traffic models are a technique for simulating traffic conditions for any given year. The models consist of a set of mathematical procedures which are outlined in the following section entitled APPROACH. It is important to understand this process in order to understand how conclusions in this report were reached.

Questions Addressed In the Report

This analysis of traffic effects was concerned with several modes of travel, and the impacts the Transit Mall has had within modes of travel with respect to volumes, efficiency, congestion, ease of circulation, and access to property.

Whether the Mall stimulated growth in transit patronage, and whether traffic volumes and total downtown vehicular travel increased or decreased were the questions of particular interest. Also of interest were the very direct effects of removing on-street parking and direct access to property in some blocks of the Mall. Additionally, a determination was needed regarding the effects the Mall has had in improving the speed and efficiency of downtown transit operations.

Downtown and Regional Transportation Systems

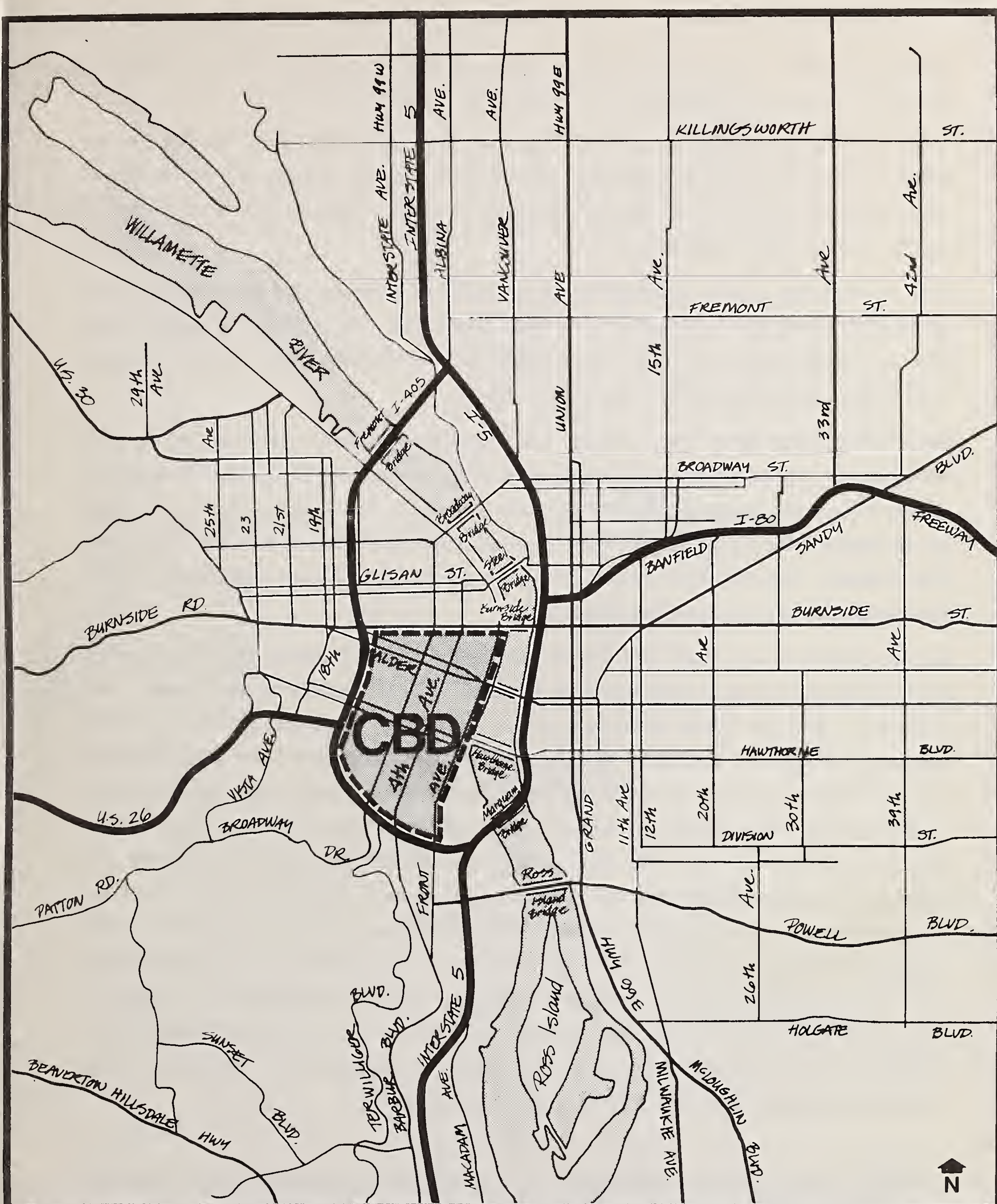
During the late 1960's and early 1970's, downtown office growth and increased employment generated concern over the negative impacts of potential traffic increases. The City began, in 1972, to prevent these impacts by adopting policies to curtail traffic growth and to encourage greater use of transit. These policies included commitments by the City to:

1. Improve access to and within downtown for transit.
2. Coordinate transit investments with development by bringing improved transit services closer to existing and planned employment densities.
3. Limit access by automobile by reducing commuter parking (long-term parking) while maintaining or even increasing the parking supply to support the retail core (short-term parking).(1)

One of the major projects partially stimulated by these policies was the Portland Transit Mall, constructed between 1976 and early 1978.

Improved transit access to downtown is important to the region as well as downtown. Effectively controlling the growth of vehicular traffic to and from downtown through increasing the proportion of those trips made by transit is of more importance to the operation of the freeway and major arterial system serving downtown than to the operation of downtown streets themselves. Understanding this is the key to understanding the context of the entire Traffic Effects Analysis, for this report was concerned primarily with the operation of downtown streets rather than the regional highway system. The effects of the Mall on regional traffic congestion levels are probably several times greater than in downtown. Regional traffic facilities providing the primary access to downtown are shown in Figure 1.

Downtown Portland is the most intensively developed piece of real estate in Oregon even though access to it is constrained by the natural setting.(2) To the west and south, the West Hills and Marquam Hill rise from near sea level on the edge of downtown to elevations approaching 1000 feet. The Willamette River bounds downtown on the east and then curves around the area on the north, requiring eight bridges to connect downtown with north and east sections of the city. In short, there are significant natural barriers to unconstrained travel in and out of downtown in all directions. The lack of unconstrained travel in this sense means only that the routes entering and leaving downtown Portland are restricted in number. Cities such as Phoenix and Los Angeles, on the other hand, have downtowns set into a street grid which continues outside of downtown, so the number of streets entering and leaving downtown Phoenix or Los Angeles are more numerous than in Portland.(3) CBD-oriented



The
Portland Transit Mall Impact Study

PORTLAND CBD REGIONAL ACCESS ROUTES

fig. 1

travel in Portland is more concentrated. And yet, downtown Portland has been able to maintain its relative accessibility to a large share of regional travel.

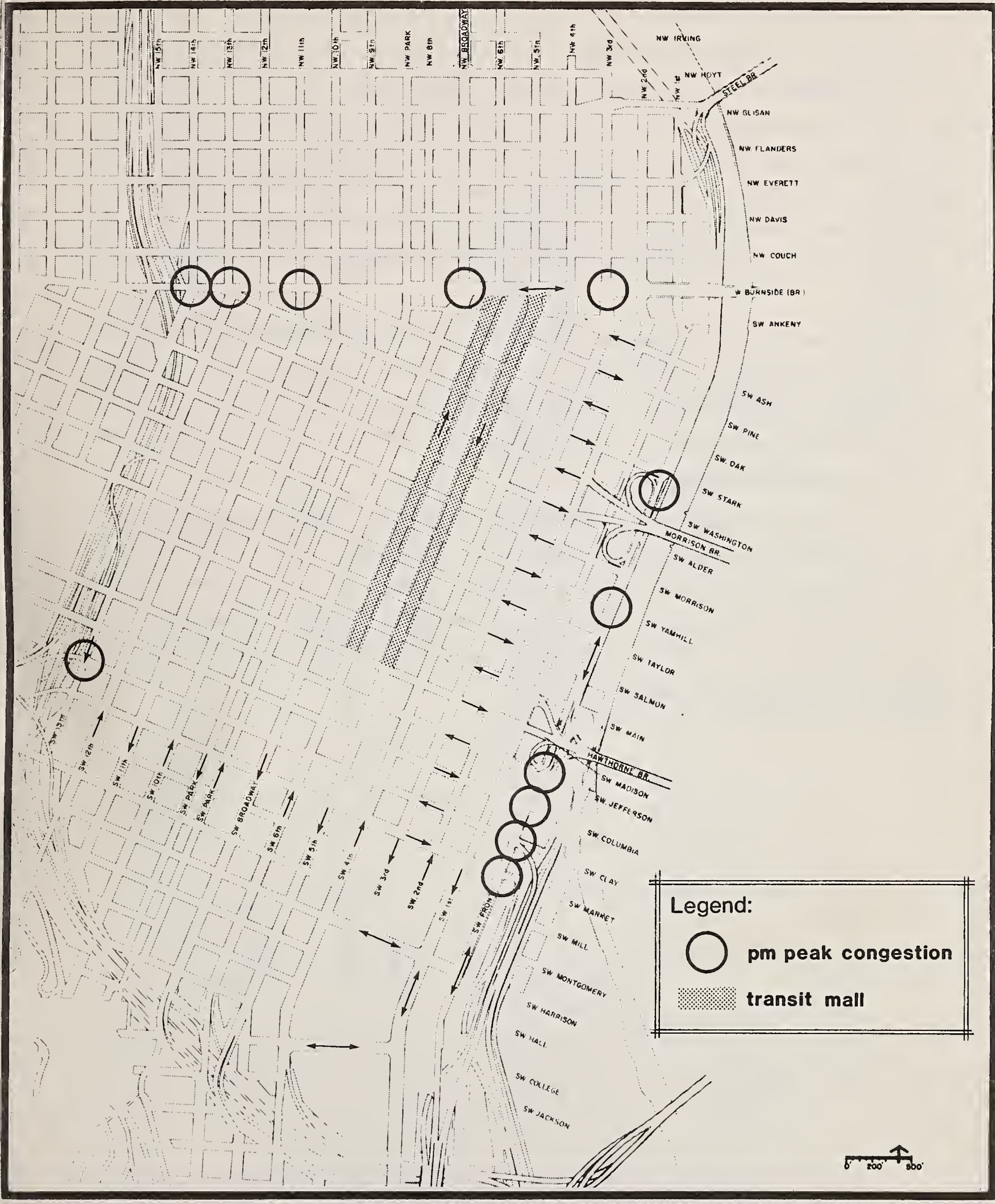
In spite of theoretical limitations on access, the downtown, or central business district (CBD), has shown steady employment growth over the last 15 years. Furthermore, projections indicate that the growth can continue if the transportation system can be improved as needed to support it.(4)

Most of the street system in downtown is comprised of a regular grid of relatively small blocks each about 200-feet square. The small block size affects traffic characteristics because it discourages high traffic speeds, and because the number and regular spacing of streets is suited to one-way traffic operation.(5)

Recent studies indicate that traffic conditions are relatively uncongested on the downtown streets with a few morning peak hour congestion points on Front Avenue and Market Street, and at the end of the Morrison Bridge.(6) Evening peak hour congestion can be expected on Burnside, on Front Avenue, and in the vicinity of Clay Street and 13th Avenue. Evening peak congestion points are noted in Figure 2 which also shows directional flow on the downtown street grid.

Traffic conditions are more sensitive to congestion on the freeway system and other major highways leading to downtown. In fact, the lack of capacity to carry much more peak hour traffic on these downtown access routes may limit the growth of traffic volumes on downtown streets in future years.(7) Both Interstate-5 and Interstate-405 have a greater capacity to move vehicular traffic past a point than any downtown street, but the sheer number of lanes available on downtown streets to carry traffic north and south and east and west within and across the CBD far exceeds the theoretical capacity of the freeway system in the area. Today both Interstate-5 and Interstate-405 show congested conditions for both the north-south and east-west travel directions around downtown during peak hours.(8) A relatively minor increase (about 10%) in vehicular traffic to and from downtown would add significant congestion potential to the freeway system but would hardly be noticed on downtown streets. The downtown streets, while flowing slower than the freeways due to more traffic interruptions, are still flowing far below their rated capacity.

In 1980, 391,990 vehicles, including those just passing through, entered and left the CBD on an average weekday. Overall, vehicular traffic at access points to downtown Portland grew about 2% per year from 1976 through 1980. Prior to 1976 total vehicle



Portland Transit Mall Impacts Study	**PORTLAND CBD STREETS** (& Congestion Locations)	fig. **2**

volumes showed no pattern of increase or decrease between 1960 and 1975. The growth from 1976 to 1980 has been on the non-freeway bridges crossing the Willamette River, and on east-west routes in general. This growth probably represents an increase in relatively short trips diverting from the more and more congested freeway loop around downtown back to less congested non-freeway routes. This kind of traffic growth has a limit, however, because a point is quickly reached in which the short trips that can use downtown streets to advantage are already on the downtown streets rather than on the freeways.

Figure 3A shows the range of average weekday traffic volumes on downtown streets for 1980.(9)(10) The traffic volumes given in Figure 3A are averages of 24-hour counts taken by the City of Portland in 1980 excluding Saturdays and Sundays. Daily bus volumes have been subtracted from the volumes in Figure 3A. Average weekday bus volumes are reported in Figure 3B.

Burnside and Front Avenues carry the heaviest volumes of traffic, and Broadway and Fourth Avenues are the next most heavily used. Other high traffic volume streets in downtown include: (1) the west end of the Morrison Bridge at Washington and Alder; (2) 2nd and 3rd Avenues between the Morrison and Hawthorne Bridges; (3) Clay and Market Streets from Front to 13th; and (4) routes entering and leaving the south end of downtown including 1st, 5th and 6th Avenues.

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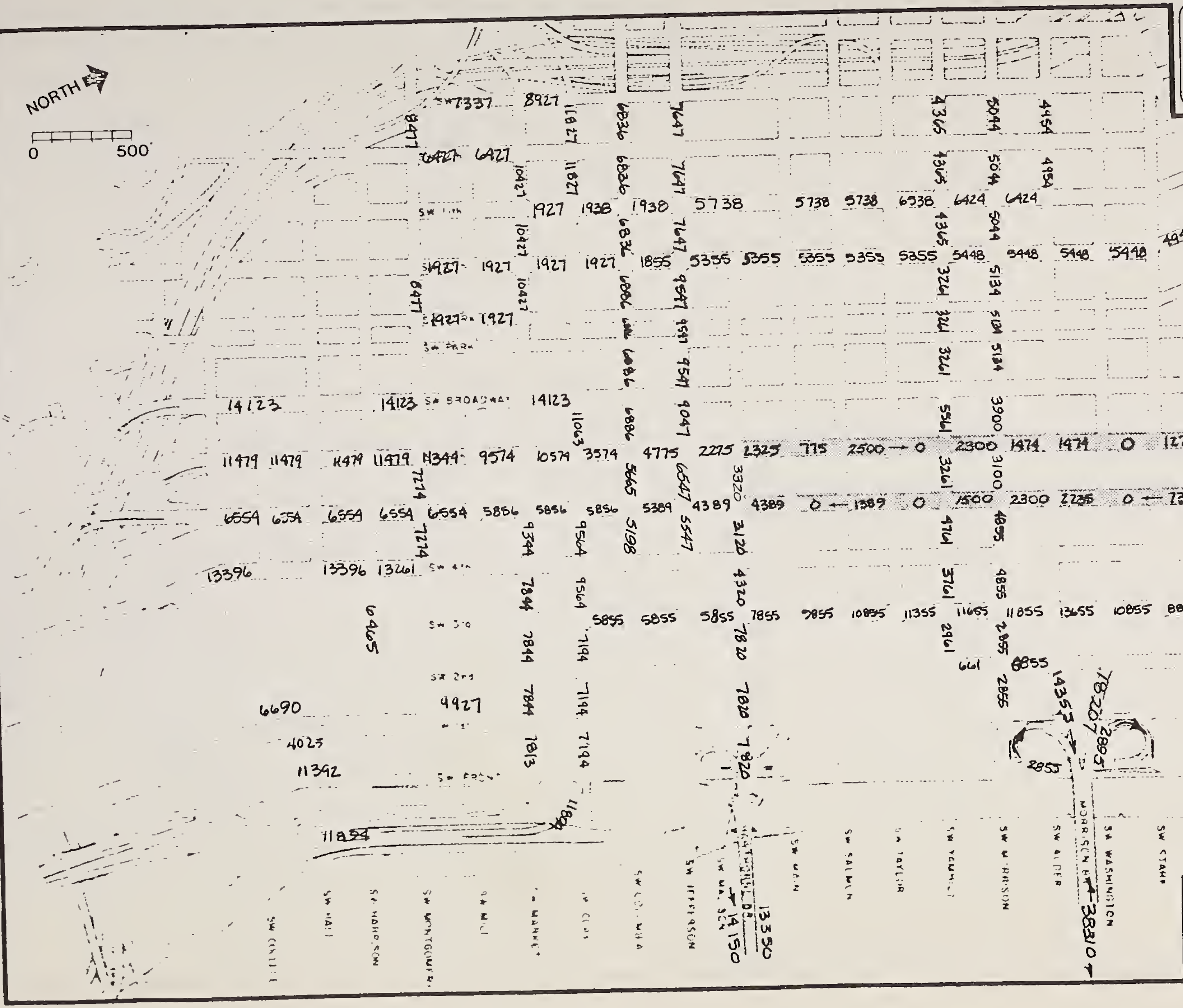
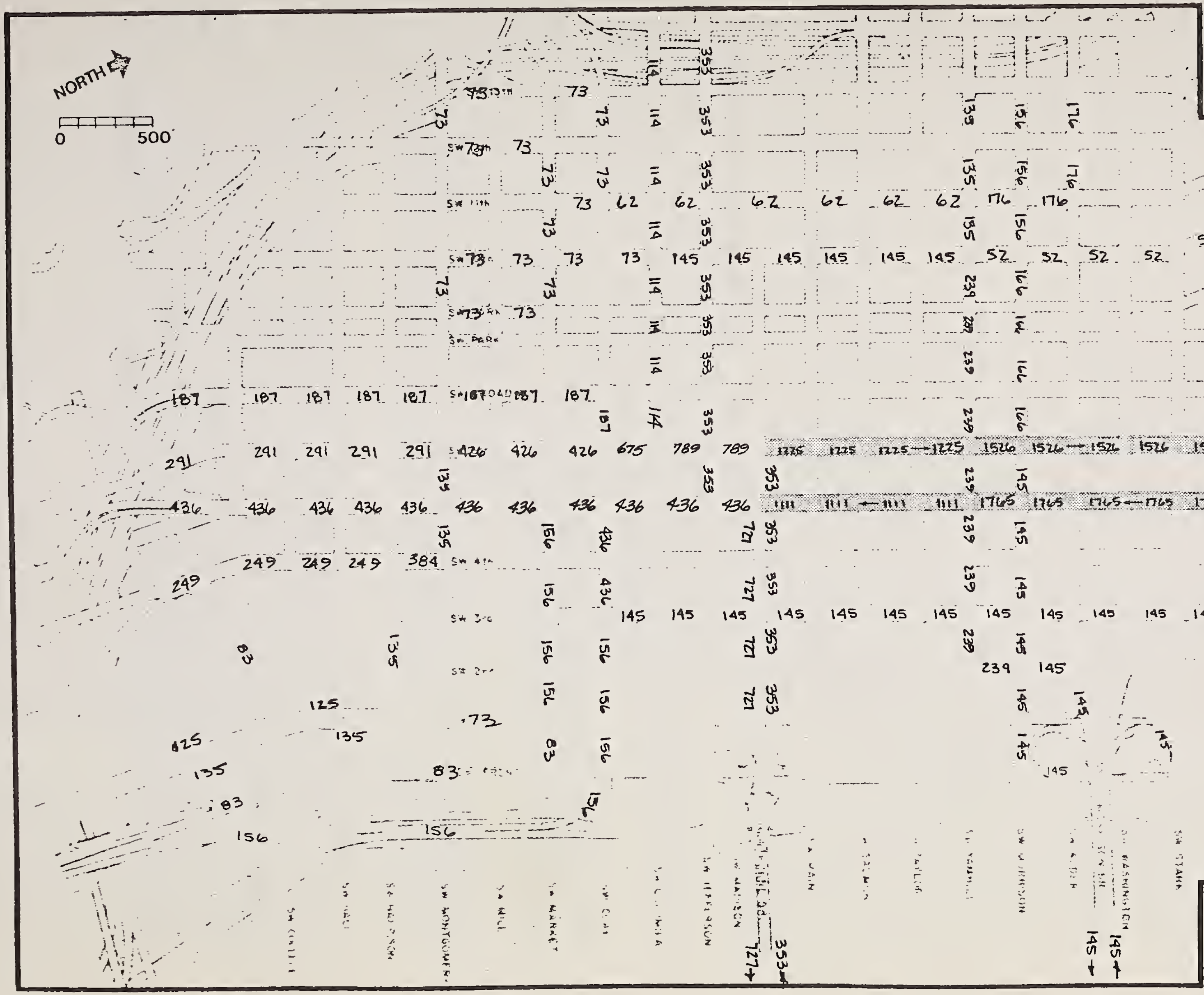


AVERAGE WEEKDAY TRAFFIC VOLUMES
(MALL CONDITION–1980 Traffic Counts (not including buses))

fig. 3A

The
Portland Transit Mall Impact Study



AVERAGE WEEKDAY BUS VOLUMES
(MALL CONDITION – 1980 Bus Counts)

fig. 3B

APPROACH

Assumptions and Limitations

A basic understanding of this report requires some knowledge of a "traffic model" and what the limitations are in using a model, because most of the study results are based upon interpreting the results of the model calculations. There are two general types of traffic models (macro and micro) and each has limitations. Macro traffic models include those used in this analysis and deal with overall travel in the region. Traffic volumes and transit patronage on major routes or entering and leaving an important area such as downtown are the normal products of macromodels. Such models cannot accurately simulate traffic turning volumes at intersections, nor can such models be expected to accurately estimate traffic volumes on individual downtown blocks because the level of detail required for such accuracy is unavailable in terms of theory, data, computer size, and software. Macromodels can, however, accurately simulate traffic volume and transit patronage estimates on major routes and on groups of streets entering and leaving downtown. Micromodels, on the other hand, commonly deal with highly detailed simulations of traffic flow at a single intersection or between a few intersections. Delay, conflicts, turns, average and spot speeds, and many other measures are the usual products of micromodels. These models are normally used in research, operations and design applications where changes in signal operation or other traffic control are being considered. They are too cumbersome to use in an analysis such as this where all regional travel near downtown is considered.

The model and analytical methods are also based upon a number of assumptions which simplify the modelling task. These assumptions are listed below.

1. The Morrison East and West public parking garages were not assumed to have been built under non-Mall conditions. These garages were built in part to replace on-street parking lost in constructing the Mall.
2. Street and sidewalk dimensions, on-street parking and other curb uses which actually existed before the Mall was built were assumed for the 1980 non-Mall simulation.
3. No changes in the way Tri-Met operated the system in 1975 were assumed for non-Mall conditions. This means that loop routing and the distribution of routes throughout the CBD were retained as they were in 1975, and no exclusive bus lanes were considered for non-Mall conditions, even when increased transit traffic appeared to warrant such measures. Instead, excess bus traffic on any one street was reallocated to streets that could take it. Only 90 buses per hour were allowed

on streets in mixed traffic on the basis that higher bus volumes result in operations so poor that the objectives of providing added service are defeated.

4. No differences in downtown land use or employment totals by block were assumed between 1980 conditions and between Mall and non-Mall conditions because there are no data nor models with enough precision to indicate what these differences might be, if any. Therefore, the trip tables used for the 1980 Mall and non-Mall conditions were virtually identical. Minor revisions were made for the non-Mall simulation to reopen Fifth and Sixth Avenues to traffic, to delete the Morrison East and West parking garages, and to restore curb parking on 5th and 6th Avenues.
5. Fareless Square (free fare service in the CBD) was assumed to be in effect for both conditions. Fareless Square covers an area of more than 300 square blocks in downtown Portland and Old Town. It is in operation at all times except 3 PM to 7 PM.
6. No changes were assumed in the parking lid, an imposed limit of 38,870 parking spaces in the CBD.
7. Changes in mode split and transit use were assumed to be minor. Therefore, no adjustments were made to the trip tables in the assignment of traffic to the Mall and non-Mall simulations. However, estimates of Mall impacts on mode split and transit use were derived as part of this analysis.
8. For purposes of the model, no differences in transit fares or parking costs were assumed between 1980 Mall and non-Mall conditions even though a lower use of transit for the non-Mall condition would result in higher downtown parking utilization, hence a potential for higher parking costs.
9. The signalization changes made for improving transit operation on the Mall were not assumed for the non-Mall condition. Signalization changes for the Mall were simply changing 5th and 6th Avenues to a simultaneous or "zero offset" timing from a "quarter-cycle offset" timing pattern under non-Mall conditions. Signal offset timing refers to the timing relationship between successive signals on a route so that the beginning of green is delayed or "offset" at a signal until traffic from a previous signal on the route can reach it.

Traffic Modelling Process

In order to simulate 1980 downtown traffic volumes for both Mall and non-Mall conditions, data and methods from a METRO regional transportation modelling process were used. All macro traffic models are developed according to the same general process summarized below.(12)(13) Following the summary is a discussion of the adjustments made for this analysis to the METRO regional transportation model for the 1980 Mall and non-Mall simulations of traffic conditions.

1. Trip Generation

   A statistical relationship is established between land use (usually population, jobs and other data such as retail floor space) and the number of trips "produced" or "attracted" each day to that use. This is the "trip generation" function of the model. The entire geographic area under study is divided into subareas ("traffic analysis zones") to more accurately locate potential trip production. This information was originally developed for the METRO model through large surveys conducted in the 1960's in which thousands of people in the Portland area were interviewed about the trips they made on a specific day. These surveys were selectively updated by METRO.

   The following is an example of "trip generation":

   The average single family household surveyed will have five vehicle trips outbound and five vehicle trips inbound on a particular day. In a zone with 100 houses, there would be (5 x 100)=500 trips out from and 500 trips into the houses in the zone per day.

2. Trip Distribution or Trip Table

   Once estimates are made of how many trips are likely to be made on an average day for any given traffic analysis zone (which may be as small as a few city blocks), further estimates must be made as to where these trips will go. For example, trips which are "produced" at home are "attracted" to zones with jobs, shopping, industry, parks, schools, or the homes of friends. The separation in terms of travel time between a zone in which trips are produced and a zone to which these trips are potentially attracted determines how many trips will be made between the two zones. The closer the zones are to each other, the more likely it is that trips produced in one zone will travel to the other and back. A greater proportion of the trips "produced" in the Washington Park area will go downtown than, say, trips produced in Oregon City.

   The model used to estimate how trips are distributed among the zones is called the "gravity model." It is called this because the probability of a trip being made between zones decreases roughly in inverse proportion to the square of the distance (or travel time separation) between the zones, much as is the case with the gravitational attraction between objects in space; hence the label "gravity model." The output from this step is a "trip table," which is merely a matrix listing the number of trips between each zone to all other zones in the study area.

3. Trip or Traffic Assignment

   Defining the separation between zones is done with a computer-encoded map of the highway and transit system. This map describes the distances and travel speeds between intersections throughout the area. A sophisticated method is used for programming the computer to calculate the best routes between the zones. The trips in the trip table from Step 2 are "assigned" to the computer-encoded map, and the result is a listing of traffic volumes by direction on each street between intersections. In other words, the modelling process has estimated traffic counts on the streets and highways without taking traffic counts.

4. Adjustments to Model Output/Calibration

   The model output is "calibrated" to approximate real traffic counts. The counts estimated by the computer are compared to actual traffic counts. Speeds and other model variables on the computer map are then adjusted to make the model count estimates approach the actual counts.

5. Traffic and Transit Forecasts and Their Use

   Other steps can take place after reasonably accurate estimates of traffic volumes have been made with the model such as "splitting" travel into transit trips and auto trips, and, of course, forecasting future-year traffic counts once zone data have been changed to reflect development and growth. Forecasting is the primary use of the traffic modelling process - to answer questions such as "will more roads and transit routes be needed to support the economic growth over the next decade?" Obviously, the kinds of questions that can be addressed with some confidence are greatly expanded through use of the traffic model process. Traffic models can relate land use and transportation characteristics which simple extrapolation of trends in traffic volumes on particular routes cannot.

This analysis used the regional transportation modelling procedures developed by METRO to estimate what traffic would be like downtown without the Mall. It was necessary to "forecast" or simulate traffic volumes with the Mall for 1980 to determine whether modifications made to the METRO model reasonably estimated the traffic counts of Figure 3A. The results of these tests are explained in Appendix 1.

Minor adjustments were made to the computer-encoded map of downtown used in an earlier study (14) to represent the 1980 downtown street system under non-Mall conditions and the same trip table used in the "calibration" was assigned to the non-Mall system. This modelling process completed a substantial amount of the technical work for the analysis. Subsequent work drew upon the comparison of Mall and non-Mall model output plus many of the other downtown traffic studies and assorted data available at the City, METRO, and Tri-Met.(11, 14, 15, 16, 17) A complete description of the changes made to the METRO model is given in Appendix 1.

ANALYSIS AND STUDY CONCLUSIONS

Introduction

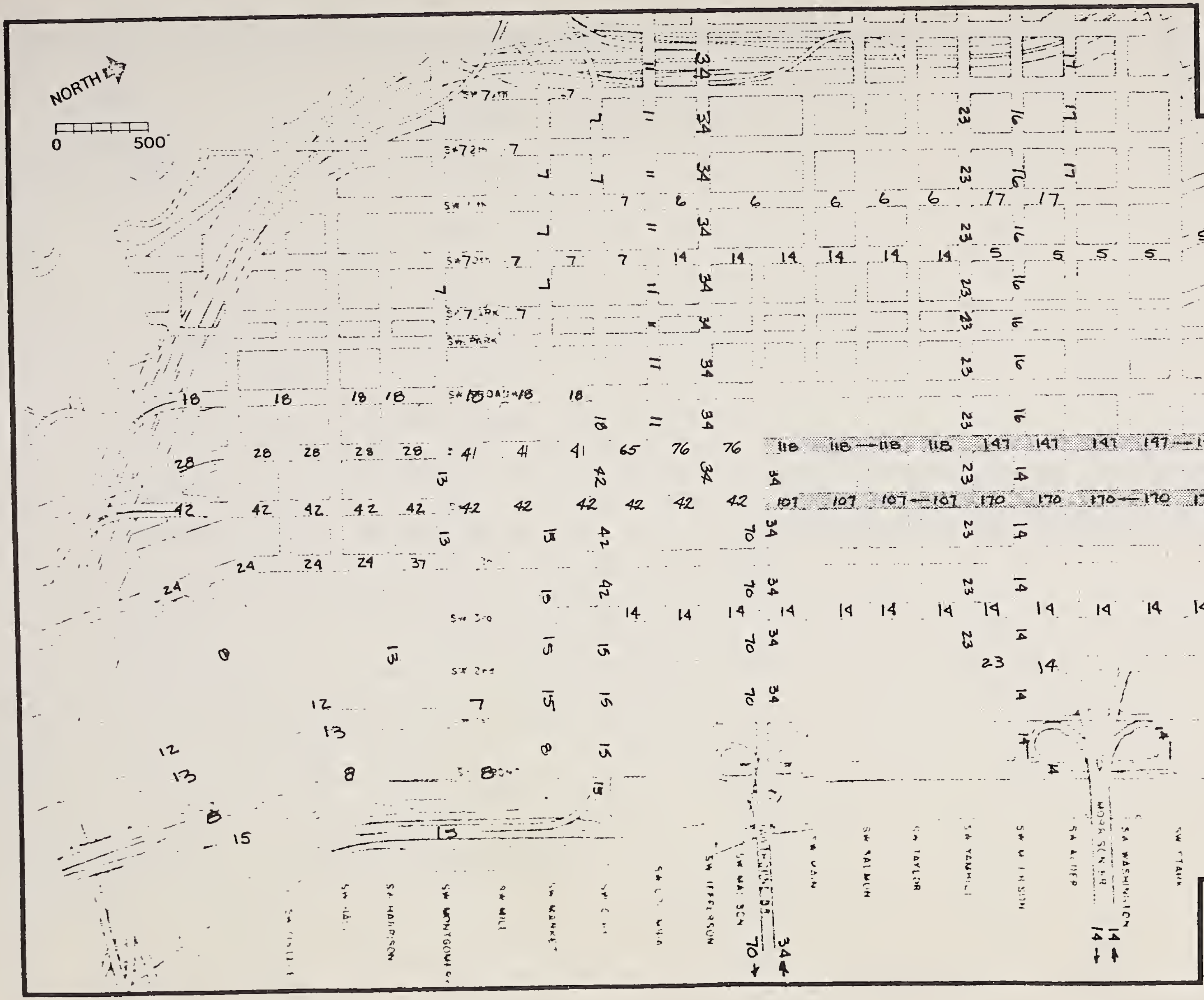
The results of analyzing the model output follow under four subheadings in this section: 1) traffic circulation, 2) transit efficiency and use, 3) pedestrian circulation, and 4) parking and local access. The comparison of Mall and non-Mall data is given as average weekday traffic volumes (24-hour Monday through Friday) and afternoon peak-hours (5:00 to 6:00 PM on Monday through Friday). Bus volume data are also included for midday (11 AM to 12 noon Monday through Friday). All average weekday traffic volumes, unless otherwise noted, include all vehicles (cars, motorcycles, trucks) except buses which are separately identified. Average weekday traffic volumes are usually used to show relative magnitudes of traffic flow. Peak-hour volumes are commonly used to analyze the congestion potential of a traffic system. Midday data are most useful for transit planning and are not included in the parking, traffic circulation and pedestrian subsections of this report. Midday traffic volumes (typically 11 AM to noon) are roughly half the magnitude of PM peak-hour volumes. Parking accumulation normally peaks at this time in major city downtowns, and pedestrian activity from 11:30 AM to 1:30 PM is generally as high as during the evening peak hours. Most of the analysis in this report is based upon comparisons of Figures 4 and 5A for traffic volumes and upon comparisons of Figures 3B,C,D and 5B,C,D for bus volumes.

Traffic Circulation (excludes bus traffic)

Traffic circulation characteristics are described by daily vehicle-miles of travel, speeds and traffic congestion. A comparison of Figures 4 and 5A shows how average weekday traffic volumes would change between Mall and non-Mall conditions. For example, on Figure 4, Broadway between Oak and Stark has 10,803 cars and trucks per day, and Figure 5A (non-Mall) shows Broadway between Oak and Stark as having 9,399 cars and trucks per day, a reduction of 1,404 vehicles daily. Evening peak-hour volumes are close to 10% of the average weekday volume in both Figure 4 and 5A.

Weekday Vehicle Miles of Travel. Another way of comparing traffic other than a street-by-street comparison of volumes is by weekday vehicle-miles of travel in downtown under Mall and non-Mall conditions. "Vehicle-miles of travel" is a useful measure of travel activity. A "vehicle-mile" is merely one mile driven by one vehicle, or 0.1 mile driven by ten vehicles, and so on. In terms of travel, Table I shows the comparison between the Mall and non-Mall systems for the downtown. The model output indicates that the Mall has contributed to a 4.9% overall reduction of travel on

The
Portland Transit Mall Impact Study



PM PEAK-HOUR BUS VOLUMES
(MALL CONDITION – 1980 Bus Counts)

fig. **3C**

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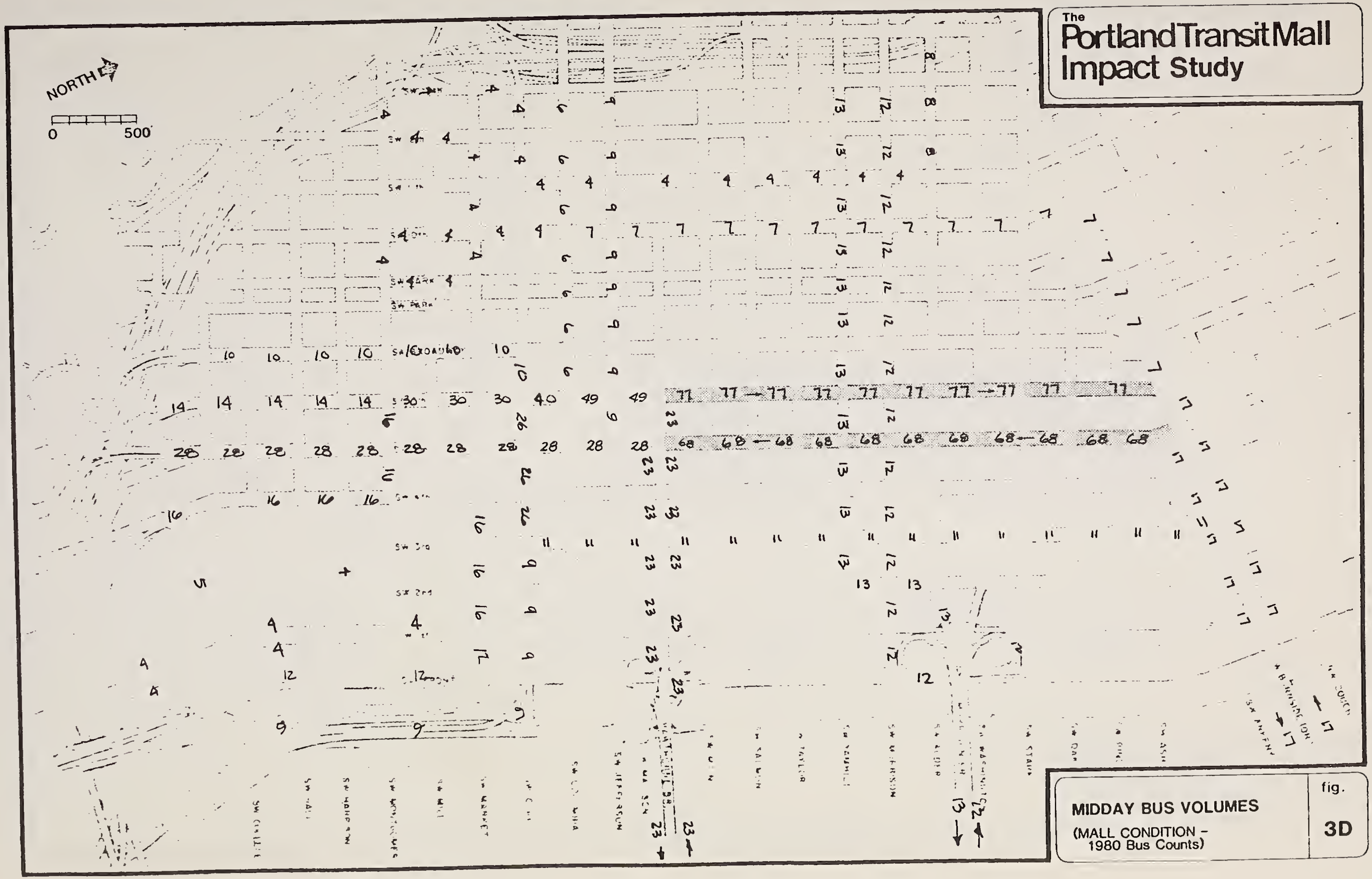

fig. 3D

MIDDAY BUS VOLUMES
(MALL CONDITION – 1980 Bus Counts)

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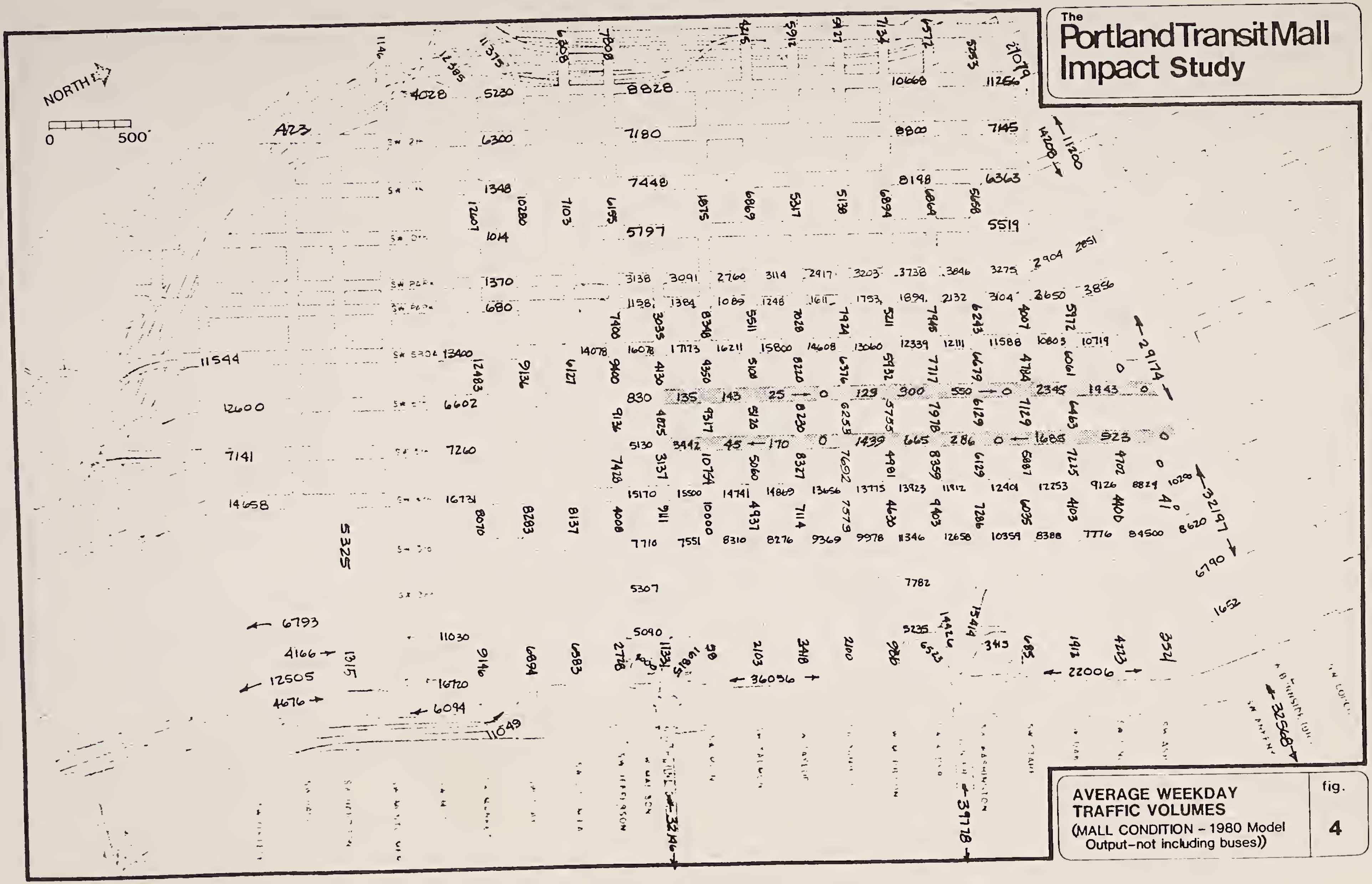

AVERAGE WEEKDAY TRAFFIC VOLUMES
(MALL CONDITION – 1980 Model Output–not including buses))

fig. 4

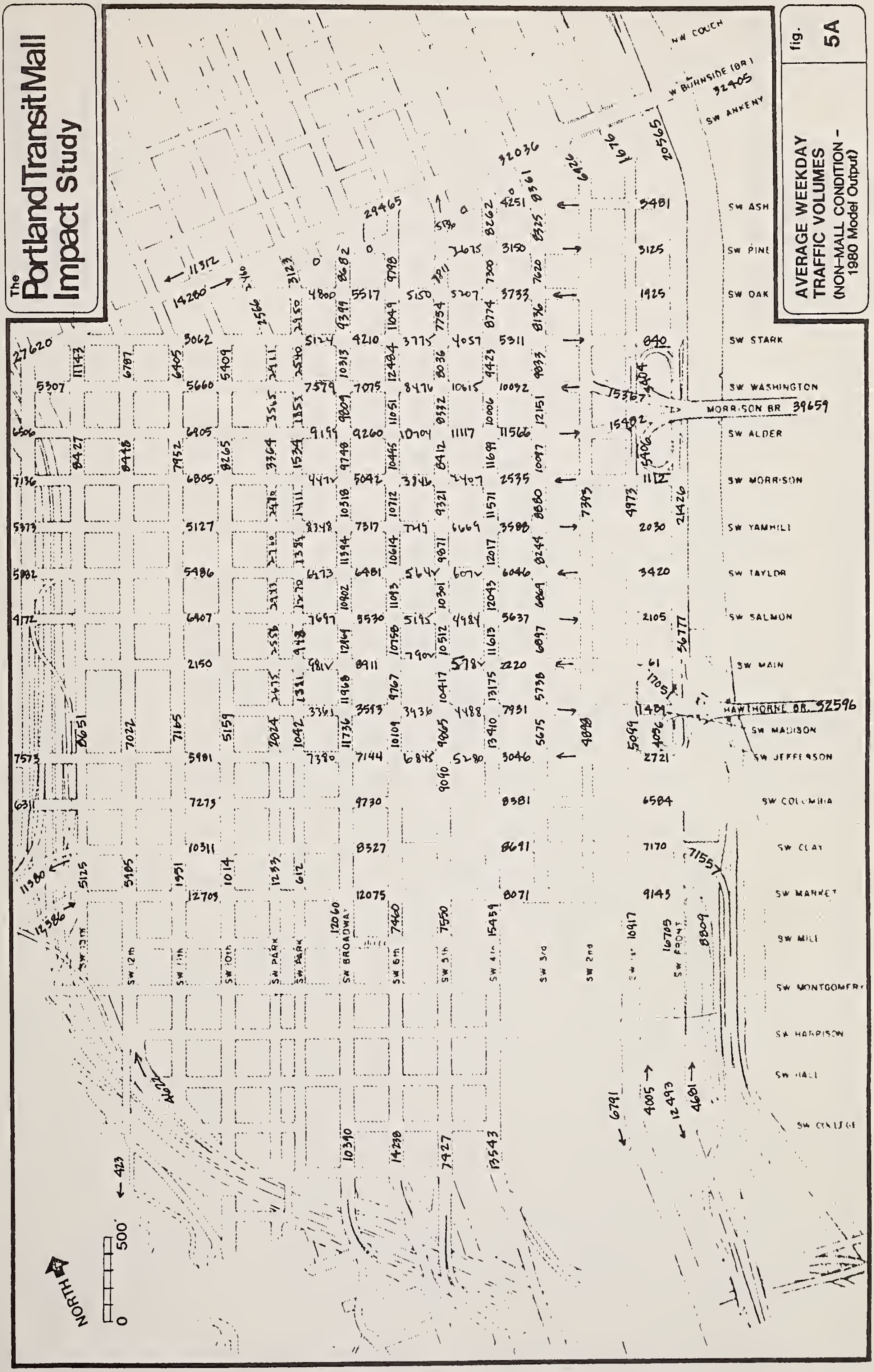
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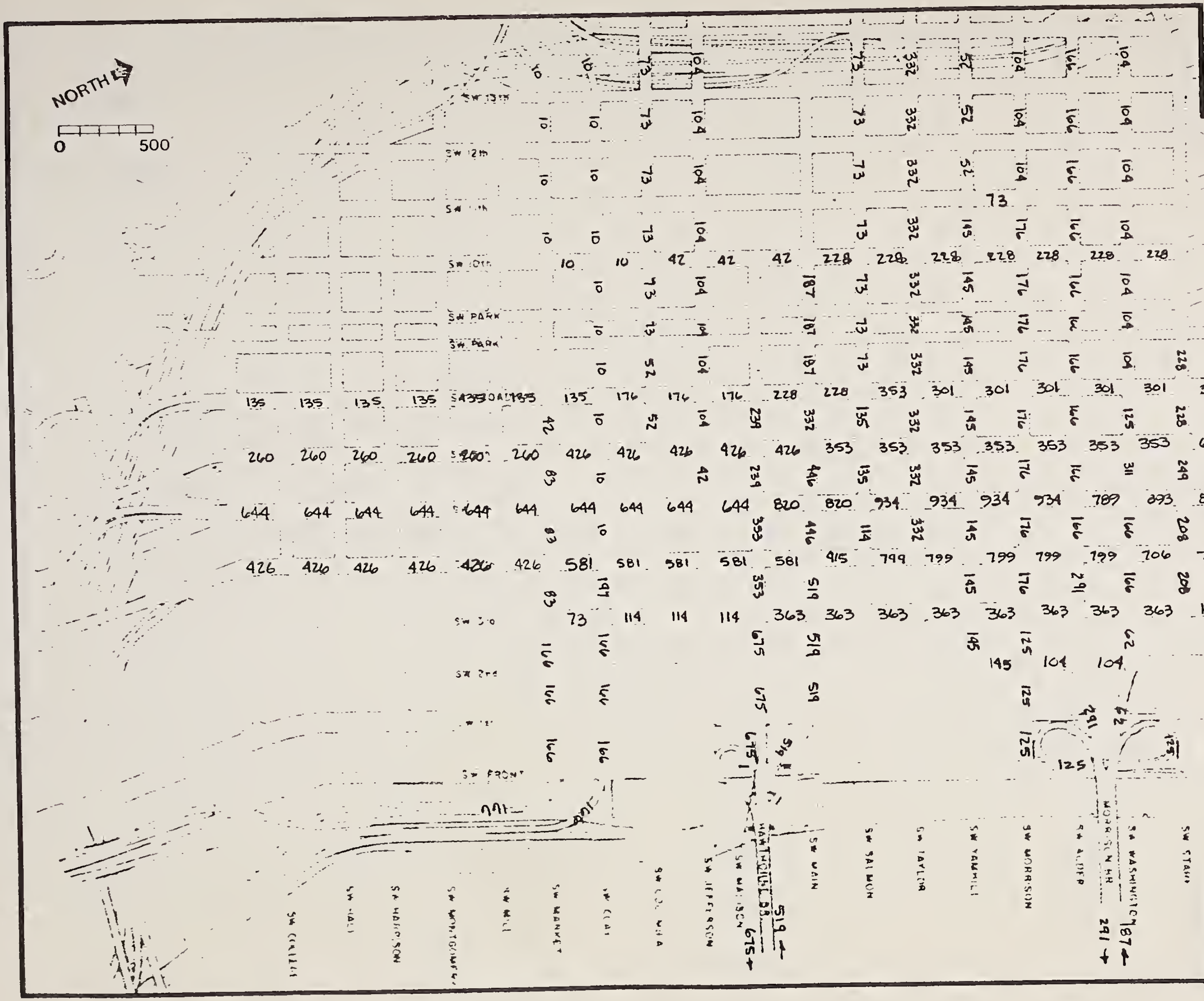
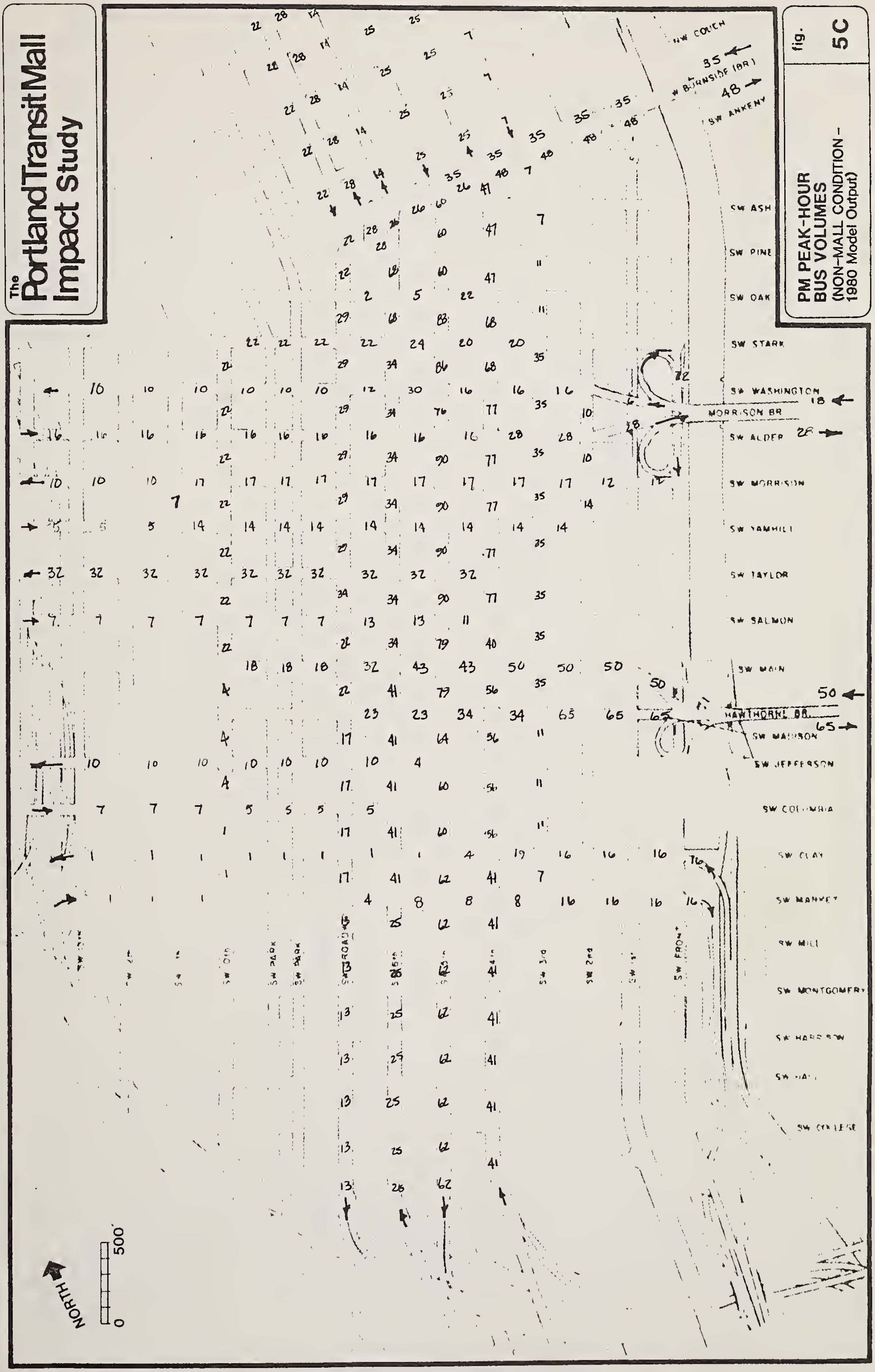
fig. 5A
AVERAGE WEEKDAY TRAFFIC VOLUMES
(NON-MALL CONDITION - 1980 Model Output)
NORTH
0
500'
NW COUCH
W BURNSIDE (BR)
SW ANKENY
SW ASH
SW PINE
SW OAK
SW STARK
SW WASHINGTON
MORRISON BR. 39659
SW ALDER
SW MORRISON
SW YAMHILL
SW TAYLOR
SW SALMON
SW MAIN
HAWTHORNE BR. 52596
SW MADISON
SW JEFFERSON
SW COLUMBIA
SW CLAY
SW MARKET
SW MILL
SW MONTGOMERY
SW HARRISON
SW HALL
SW COLLEGE
SW 13th
SW 12th
SW 11th
SW 10th
SW PARK
SW PARK
SW BROADWAY
SW 6th
SW 5th
SW 4th
SW 3rd
SW 2nd
SW 1st
SW FRONT

The
Portland Transit Mall Impact Study

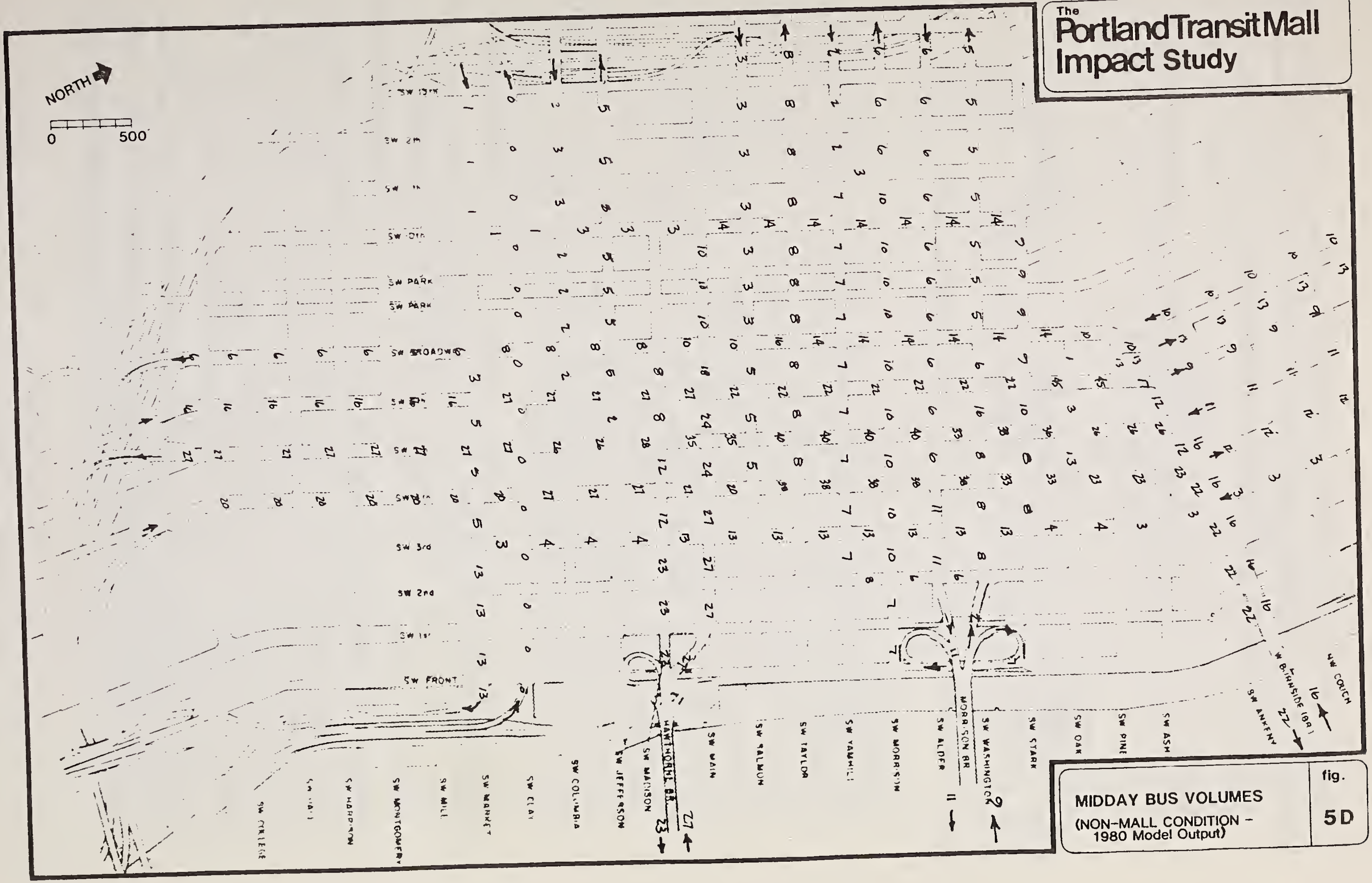


AVERAGE WEEKDAY BUS VOLUMES (NON-MALL CONDITION – 1980 Model Output)

fig. 5B


The Portland Transit Mall Impact Study
fig. 5C
PM PEAK-HOUR BUS VOLUMES
(NON-MALL CONDITION – 1980 Model Output)
NORTH
0 500
SW COUCH
W BURNSIDE (BR.)
SW ANKENY
SW ASH
SW PINE
SW OAK
SW STARK
SW WASHINGTON
MORRISON BR.
SW ALDER
SW MORRISON
SW YAMHILL
SW TAYLOR
SW SALMON
SW MAIN
HAWTHORNE BR.
SW MADISON
SW JEFFERSON
SW COLUMBIA
SW CLAY
SW MARKET
SW MILL
SW MONTGOMERY
SW PARK
SW BROADWAY
SW FRONT

The Portland Transit Mall Impact Study



MIDDAY BUS VOLUMES (NON-MALL CONDITION – 1980 Model Output)

fig. 5D

downtown streets. This output must be used with caution; however, with fewer miles of downtown streets on which to drive (i.e., the Mall is removed as a significant auto route in the Mall simulation), it is reasonable that fewer miles of travel would result.

TABLE I

COMPARISON OF 1980 WEEKDAY VEHICLE MILES OF DOWNTOWN TRAVEL
(without transit)

With Mall			Without Mall			% Change		
East-West	North-South	Total	East-West	North-South	Total	East-West	North-South	Total
64,833	88,778	153,611	62,962	98,217	161,179	-2.9%	+10.6%	+4.9%

Traffic Volumes. The model indicates that the general effects of removing the Mall include a 15% to 30% reduction in traffic volumes on Broadway and 4th and smaller reductions of 10% on Park and 3rd both for average weekday and PM peak. There is no regular effect on the east-west streets except that there is a 2.9% reduction overall in volume on the non-Mall system and obviously, there are dramatic increases in traffic volumes on the two Mall streets, 5th and 6th Avenues. Overall, total traffic volumes in downtown would go up without the Mall. While the model reallocated the Mall volumes, there is some added through traffic in downtown, too, which can be deduced from the higher daily vehicle miles of travel reported in Table 1 with the non-Mall system. This also appears in Table V in Appendix 1 which shows a 2.3% increase in total traffic volumes entering and leaving downtown. This extra traffic is probably trips diverting off the freeway loop to downtown streets because the opening of 5th and 6th Avenues in the non-Mall system represents an advantage in travel time to some trips using the freeway under the Mall system. The 10.6% increase in north-south travel (Table 1) is probably due to this added through traffic and a diversion of traffic from east-west streets to north-south streets. For example, under Mall conditions, a driver wishing to travel north from Broadway and Salmon would likely drive east on Salmon to 4th, then north on 4th. With 6th open, less travel on Salmon (and, therefore, less east-west travel) would be oriented to getting to 4th Avenue.

Speeds. Traffic speeds in an urban grid of streets with signalized intersections are affected primarily by "signal offset" timing rather than traffic volume excepting conditions when volumes or rates of flow approach capacity.(18) "Signal offset timing" refers to the timing relationship between successive signals on a route so that the beginning of green is delayed, or "offset" at a signal until traffic from a previous signal on the route can reach it. The average speeds of all non-transit vehicles on downtown Portland streets are close to 15 mph in the peak and midday because the signals are timed for progressed movement at that speed. This is achieved through an "offset" or a delay of beginning green for each successive signal on a downtown one-way street of approximately nine seconds, the time it takes to travel one 200-foot long block at 15 miles per hour. Average speeds lower than 15 miles per hour will occur in such a system because of varying proportions of traffic slowing for turns, pedestrian interference, on-street parking activity and other significant congestion. There are no significant differences in these factors between Mall and non-Mall conditions, so there is no significant difference in average, non-transit vehicle speeds either all day or in peak hours.

Traffic Congestion. Generally, with or without the Mall, no intersection in the CBD except a few freeway and bridge ramp terminals on Front Street operates at volumes nearing the capacity of the street. All other intersections in the downtown with or without the Mall will operate at level of service "C"* or better. The few PM-peak hour traffic congestion points in downtown (ie. intersections on Burnside, Front Avenue and at 13th and Clay) get less congested without the Mall, but this does not have a significant effect on most streets. Of particular importance is the reduction of traffic pressure on Market and Clay at Front Avenue without the Mall. An average weekday volume of 10,000 vehicles on Front Avenue between the Hawthorne and Morrison Bridges were reallocated to other CBD streets by the model.

*Level of Service is a term used to describe the quality of traffic flow with level "C" descriptive of average conditions.

Transit Efficiency and Use

Volumes. An examination was made of average weekday, PM peak hour and midday bus volumes with the Transit Mall in 1980, and these are shown in Figures 3B, 3C, and 3D. These bus volumes were derived from Tri-Met Schedules and supplementary data. The highest volumes, of course, are in the PM peak on the Transit Mall, 5th and 6th Avenues between Jefferson and Burnside with 170 buses per hour northbound on 5th Avenue, and 147 southbound on 6th Avenue during the PM peak hour. South of Columbia Street (Figure 3C), bus volumes decrease to 62 southbound buses on 5th and 41 buses northbound on 6th. A total of 104 buses proceed east and west between the Mall and the Hawthorne Bridge and 34 buses proceed westbound from 5th Avenue on Jefferson across I-405 and 11 per hour return on SW Columbia Street from the west to 6th Avenue. Except for the Transit Mall streets, none of the streets exhibit more than 62 buses/hour in the PM peak in regular traffic lanes (i.e. lanes with automobiles, bus and truck traffic).

Studies in Portland and in Seattle indicate that up to 90 buses per hour can be mixed with other vehicles in regular traffic lanes on downtown streets without substantial delays being incurred.(19)(20) For this analysis therefore, 90 buses/hour in mixed traffic was used as the capacity of each of the downtown streets for non-Mall conditions. Figures 5B and 5C show the resulting PM peak and midday transit volumes without the Mall for 1980. Only one street, 5th Avenue had a demand of over 90 buses per hour assigned to it. That excess demand was rerouted to Broadway.

The simulation of non-Mall bus volumes was not carried out by use of the traffic model. Rather, the 1975 Tri-Met route map was used, and 1980 scheduled bus volumes for the average weekday, PM peak and midday were assigned manually, route by route, to the CBD streets. The 1975 routing in the CBD was characterized by loop routing while the Mall routing is through-routed. The same number of buses enter and leave the CBD under both Mall and non-Mall conditions. The two major differences between them are (1) the presence of buses on many streets of the CBD under non-Mall conditions not serviced by transit under Mall conditions, and (2) the concentration of bus volumes on the Mall with volumes almost twice as high as any street under non-Mall conditions.

Daily Miles of Travel. Weekday vehicle (bus) miles of travel were calculated for both Mall and non-Mall conditions. Weekday bus miles of travel in 1980 for all downtown streets with the Mall total 2,906. Under non-Mall conditions, 1980 weekday bus miles of travel would be 3,179, 9.4% higher than conditions with the Mall. The higher number of miles travelled without the Mall is due to the higher incidence of loop routing in the 1975 system. "Loop routing" means a route enters downtown, travels all or partway through, and then loops back for the outbound portion of the route. Each bus on the route traverses the downtown area twice. Through routed buses, on the other hand, change from inbound to outbound partway through downtown and do not loop back through, and it is this feature which serves to reduce bus miles travelled between the Mall and non-Mall conditions.

Speeds. Tri-Met data collected for 1980 bus running speeds on the Transit Mall and other streets in the downtown show that the average bus speed in downtown is 4.4 MPH in the PM peak hour which includes travel time for moving, stopping and starting for signals and, boarding and alighting passengers, and other traffic delays.(21)

Table II portrays average bus speeds for all day, peak and midday for both Mall and non-Mall conditions. Through use of traffic engineering analysis techniques which consider signal timing, bus stop location, acceleration characteristics of transit vehicles, and average time stopped for passengers boarding and alighting at each bus stop, it has been determined that bus speeds over an average weekday (24-hour period) on all downtown streets without the Transit Mall would be 3.5 MPH overall. There are equally significant changes during the PM peak (34% higher speeds for Mall conditions) and during midday (46% faster for Mall conditions). These differences in speed are mainly the result of two factors: (1) changes in signal timing on the Mall from a quarter cycle offset to a zero offset, and (2) elimination of most traffic impedances from the paths of buses on the Mall. Therefore, the Transit Mall has increased average bus speeds in downtown by 43% over simulated speeds without the Mall. This converts to a time-saving of approximately four minutes for buses traveling through downtown assuming that they travel 0.8 mile in the CBD. This four-minute savings with the Transit Mall is a significant input to the mode split model which is used to adjust patronage given changes in transit system speed and convenience compared to the automobile. Only a two-minute time savings was entered into the mode split model, because the average time savings for any particular bus rider depends on where they get on or off the bus. Some will travel almost through the CBD and save four minutes; others will get on or off at the first CBD stop with little or no time savings. The average savings of time per patron, then, is approximately two minutes.

TABLE II
COMPARISON OF BUS SPEEDS

	Average Speeds					
	Average Weekday		Peak (5-6 PM)		Midday	
Direction	Mall	Non-Mall	Mall	Non-Mall	Mall	Non-Mall
North-South Streets	5.34 MPH	3.62 MPH	5.10 MPH	3.35 MPH	5.40 MPH	3.69 MPH
East-West Streets	3.30 MPH	3.30 MPH	3.14 MPH	3.14 MPH	3.34 MPH	3.34 MPH
All Streets Average	5.02 MPH	3.50 MPH	4.40 MPH	3.28 MPH	5.17 MPH	3.55 MPH

Bus Patron Access. Average walking distances between patron origins/destinations and the nearest bus stop were calculated for transit patrons for both the Mall and non-Mall conditions in 1980. Methods of calculating these averages are reported in Appendix 3. The average walking distance for patrons with the Transit Mall is 531 feet, and the average walking distance if no Transit Mall were built would be 689 feet, 158 feet further, which means that the walk to and from the bus would take an extra 45 seconds on the average. This added walking distance may slightly affect the proportion of people using buses. The basic reason the average walking distance increases is due to the greater volume of buses on north-south streets between Broadway and I-405. This area is farther away from the greatest number of bus patron origins/destinations.

Patronage. Actual counts of bus patrons entering and passing through downtown in 1980 were compared to the number of people both entering and passing through downtown Portland by car.(22)(23) This comparision in turn allows a direct calculation of the proportion of trips made by transit (mode split) both in the PM peak hour and for the average weekday with the Mall. The mode-split for the average weekday indicates that 31% of all people entering downtown use the bus, and this number increases to 44% during peak hours. If all CBD cordon crossings are considered, 35% of all people crossing the cordon (entering and passing through) are on a bus during the PM peak hour.

Estimates of changes in mode split due to changes in the attractiveness of using buses compared to using an automobile (i.e., shorter travel times, more convenient routing, higher parking costs, etc.) can be made by a mode split model. Some very elaborate models, like the METRO model, can compare the relative attractiveness of transit to automobiles for each zone-to-zone movement. This kind of model is used for forecasting future mode split data for a test or evaluation of an assumed transit and highway system. However, this analysis required an estimate of change from a known situation today, so a "pivot-point" type of model was employed to adjust existing mode split data.(24)(25) (This type of analysis is explained in Appendix 2). In most mode split models, the proportion of people using buses is sensitive to many variables including auto and bus travel times, walking distances between a destination and a parking location or bus stop, the price of travel by car and by bus and other factors. The main differences capable of analysis in this study are walking distance and bus travel speed changes.

Considering the lower bus travel speeds plus the additional walking time if the Mall had not been built, the model indicates that the construction of the Transit Mall has increased bus patronage to and from downtown Portland by 1.8% (i.e., the sum of patronage gains from increased bus speed and reduced walk distance) both during the PM peak hour and for the average weekday. The adjusted figure for mode split for non-Mall conditions for the average weekday is 29.2% and 42.2% for the PM peak hour. Looking at it another way, an additional 230 cars would be trying to come to downtown during the peak hours (an increase of 0.6%) and 2,000 additional cars would be trying to get downtown during the average weekday (an increase of 0.5%) if the Transit Mall had never been built. The added bus riders due to the Mall number about 1,650 on the average weekday or over 500,000 during 1980.

The Mall is but one of many improvements and changes in the transit system that has caused Tri-Met ridership to increase from 93,100 average daily riders in 1975 to 134,200 average daily riders in 1979. The Transit Mall and its related transit improvements accont for only 1.8% of this overall 44% increase, according to this analysis. Other factors beyond the range of this analysis are responsible for the remaining 42.2% increase in ridership. Some of these factors are higher parking prices and a tighter parking supply; more congestion on access routes to and from downtown; inflation which reduces discretionary income used for the second car and commuting purposes; and rapidly increased fuel prices along with added and more attractive bus service.

Pedestrian Circulation

The rerouting of buses with the Mall to fewer streets in the CBD has decreased the number of bus stops which in turn increases the number of people boarding and alighting from buses at each stop, especially along the Transit Mall. This affects pedestrian volumes on downtown sidewalks. Generally, the Transit Mall has focused pedestrian activity to the center of the CBD. During PM peak hours an average of thirteen people get on or off each bus at a stop on the Transit Mall. Under non-Mall conditions that figure is cut by two-thirds to approximately four people boarding and alighting per bus stop per bus.(26) Using the bus volumes in Figure 5C, an average of 180 pedestrians per hour would be walking along downtown streets either toward or away from their bus under non-Mall conditions. During the PM peak hour, buses on the Transit Mall average approximately 600 people/hour on each block in terms of accepting and discharging passengers. During PM peaks only about 25% of the total pedestrian volumes on the streets are bus patrons except on the Mall streets and other downtown streets where service is focused, Morrison, Yamhill, Main and Madison. (Midday pedestrian volumes are approximately 75% of peak-hour volumes.) On these streets, bus patrons represent up to 75% of the total pedestrian volumes during the peak hours.

Pedestrian volumes on other streets downtown are somewhat low outside of the retail core of several blocks centered at 5th and Morrison, not usually exceeding 500 or 600 people/hour. More commonly there are 100-400 people/hour along any one sidewalk.(27) Without the Mall there would be 90 buses in the peak hour along 5th, 77 buses/hour along 4th, and 30 to 35 buses along 3rd, 6th and Broadway. This would cause pedestrian volumes to increase on the non-Mall streets by an average of 125-150 people in the peak hour, peak-hour pedestrian volumes on 5th would be cut by about 33%, and on 6th, pedestrian volumes would be reduced by 60 - 70%. Thus, if the Transit Mall had not been built there would be higher peak-hour pedestrian volumes on 3rd, 4th, and Broadway, and on several of the east-west cross streets between Market and Burnside.

Parking and Local Access.

In 1975, the City of Portland established a lid of 39,467 parking places as the maximum number permitted in downtown Portland. This limit was based on an inventory of present and committed spaces and was later revised downward to 38,870. It is this latter figure which constitutes the current lid.(28)

Over the past five years the downtown parking supply has remained about the same; the construction of new spaces has offset the loss of others. While the number of parking spaces has remained stable, the type (i.e., curbside, service lot or parking garage) and their location have fluctuated due to public and private actions. There has been a significant reduction in the number of dispersed curb spaces with corresponding increases in centralized off-street parking in private and public garages. As a result the number of spaces has increased in some downtown areas particularly near the retail stores with corresponding decreases in other areas. A total of 308 curb parking spaces were eliminated as a direct result of the Transit Mall construction due to: (1) street changes on both sides of 5th and 6th Avenues; (2) creation of new truck-loading zones on almost all the east-west cross streets between Burnside and Madison; and (3) traffic flow improvements (sheltered turn lanes) on 4th and Broadway. Two new public parking garages (Morrison East and Morrison West) were constructed to offset the elimination of curb parking on 5th and 6th due to the Mall.(29)

The changes in loading and access with the Mall were the greatest for those businesses and institutions on 5th and 6th Avenues that depended solely on sidewalk deliveries and a curbside loading zone. A few buildings have no frontage on a cross street. These merchants are now required to hand-cart goods to and from new loading zones on the nearest cross street. In no case is this distance greater than 100 feet. Most businesses facing the Mall also have 100 feet of frontage on an east-west cross street. In these cases, placement of a loading zone was less important. Several relocated their sidewalk elevators to a side-street location. Two of the three department stores on 5th Avenue which loaded goods on Alder Street between 5th and 6th, created conditions that interfered with pedestrian use of the sidewalk. Both stores now operate more of their loading activity in the off-peak time and have developed warehousing outside of the CBD.(30)

Delivery of bulky goods such as office furnishings and heavy machinery are allowed under special permit that make it possible for a van to operate and park on the Transit Mall during nighttime hours. Drop boxes used for collecting building remodeling waste are allowed special permits for placement on the Mall sidewalks. The boxes are dropped off and picked up during nighttime hours. Collection of ordinary refuse is at the cross street loading zones adjacent to the Mall. Without the Mall, none of these provisions would be necessary. Restriction of goods loading to nighttime hours and cross street loading zones has imposed some minor added costs for downtown businesses and buildings on and near the Mall.

SUMMARY

The Traffic Effects Analysis is only as complete as permitted by the analytical limitations of traffic models. The study was also limited by the geographic scope in that many Transit Mall impacts may be more significant to the regional transportation system than to downtown traffic circulation.

Traffic Circulation

Total travel in terms of miles travelled would rise 4.9% and the number of vehicles entering and leaving downtown would rise 2.3% without the Transit Mall. No real effects were determined for overall traffic speeds and changes in congestion levels except that existing congested intersections on Front Street and along Burnside would see substantial improvement without the Mall due to some traffic rerouting to 5th and 6th Avenues.

Transit Efficiency and Use

Significant changes include: (1) the diffusion of bus volumes over most of the downtown streets without the Mall as compared to the relative concentration of bus volumes on a few streets with the Mall, (2) a 10% decrease in downtown bus miles of travel with the Mall, (3) an increase in overall bus system speeds by 43% with the Mall (from 3.50 miles per hour weekday average under non-Mall conditions to 5.02 miles per hour with the Mall with similar increases during midday and the PM peak hour), (4) a 158-foot average increase in walking distance for non-Mall conditions over Mall conditions, and (5) an increase of at least 1.8% in CBD bus patronage with the Mall due to the increased average speeds and reduced walking distances.

Pedestrian Circulation

The Mall has concentrated pedestrian activity to the Mall area and nearby portions of cross streets as opposed to a more even distribution of pedestrian volumes to most downtown streets without the Mall.

Parking and Local Access

Parking supply has shifted from the more dispersed on-street parking before Mall construction to more centralized off- street parking with the Mall. Loading of goods has become a problem of varying importance to merchants located on the Mall because most loading has been displaced to farther away side- street zones or to nighttime hours.

The Traffic Effects Analysis was not designed to complete research and analysis of the total range of potential Mall effects on traffic. Various kinds of surveys and added data collection efforts may have proven useful in separating the effects of gasoline price increases, inflation, increased route coverage and service, downtown growth and short-term social and travel behavior change. The finding of a 1.8% increase in transit patronage due to the Mall in this analysis shound be considered the very minimum change. The increased patronage due to the less quantifiable variables and attributes of the Mall is very likely higher than this 1.8%.

APPENDICES

APPENDIX 1: Traffic Forecasting Model Validation

The traffic forecasting model used in the Portland Transit Mall Traffic Effects Analysis was developed from a model used for the Westside Corridor Project.(31) The following briefly describes how that model was constructed. In addition to the description of the Westside Corridor model, changes and refinements to the model for use in this study are described along with the results of model validation which show the levels of accuracy for the model.

Westside Corridor Project Model Development for Automobile Traffic in the CBD

Task 5 of that study required the consultant to develop the "Base Case" traffic, transit and pedestrian projections for the year 1995. These traffic forecasts were to be based upon a demonstrated success in modelling 1977 traffic and pedestrian counts. To do this an extensive set of existing data and METRO- modelled trips was analyzed to determine whether modelled traffic volumes were close enough to the real data. It was not possible to accurately forecast traffic volumes on minor CBD streets (i.e., ones with low transit, traffic and pedestrian volumes). It was believed that model output should agree with measured data on major streets within a plus or minus 20 percent maximum error.

The first attempt to model 1977 CBD traffic flows from METRO 1977 trip tables resulted in the conclusion that modelled trips to and from the CBD were about 20 percent too low based upon a comparison of CBD assigned cordon crossings with 1977 CBD cordon counts. Further, trips made entirely within the CBD in the METRO 1977 trip table were concluded to be about 40 percent low compared to estimates made by the City's traffic consultant for the CBD Transportation Plan, and also as determined by an analysis of internal CBD screenlines.

The early assignments of the 1977 METRO trip tables did yield results indicating that the proportions of trip allocated to specific CBD streets were representative of actual counts except that assigned volumes were 20 percent to 50 percent too low. Table III shows the results. The conclusion was that the assignment errors were minimal, and that METRO assignment output could be factored to 1995 or any other year by comparing the proportionate changes in assigned traffic on each respective link. This is the process reported below. The process for factoring, then, depended upon assigning 1977 and future year trip tables to the CBD street system to develop expansion factors for 1977 traffic counts. To do this, the full procedures for developing a micro

TABLE III

1977 MODELLED AND COUNTED VOLUMES IN DOWNTOWN

1977 Metro Trip Table (Vehicular Trips)	Trips Produced	60,847	
	Trips Attracted	144,147	
	Less Intrazonal Trips	20,498	
	Total CBD Trips Crossing Cordon	184,495	
		92,250 (in)	
		92,250 (out)	

Cordon Location		In/Out Counts	Assigned	%
Total 1977 Cordon (no freeways)	In	169,235	137,530	81
	Out	167,810	132,124	79
	Both	337,045	269,654	80
North Screenline (NW Everett)	In	30,035	20,590	68
	Out	28,715	19,857	69
	Both	58,750	40,447	69
East Screenline (River)	In	64,460	50,962	79
	Out	54,710	44,319	81
	Both	119,170	95,281	80
South Screenline (I-405)	In	35,645	30,781	86
	Out	35,585	25,803	73
	Both	71,230	56,584	79
West Screenline (13th Avenue)	In	39,095	35,930	92
	Out	48,800	41,412	85
	Both	87,895	77,342	88
S/O Morrison (13th thru Front)		90,350	36,309	40
S/O Jefferson (13th thru Front) (North-South Traffic)		81,700	39,381	48
E/O Broadway (Burnside thru Lincoln) (East-West Traffic)		131,352	98,663	75
W/O Front (Burnside thru Lincoln) (East-West Traffic Including Bridges)		140,700	104,203	74
East-West Traffic Without Bridges		39,200	38,930	99

assignment to the Portland CBD had to be followed even though the model output, the assigned volumes, were not used directly. The following steps were used for the analysis: 1) development of a micro zone structure in the CBD; 2) development of a link node network in the CBD: 3) assignment of resulting trip tables to the link-node network; 4) the factoring process for 24-hour volumes; and 5) the factoring process to estimate PM peak volumes.

- o An "expanded" (i.e., subdivision of the 5 METRO zones to smaller zones) CBD traffic analysis zone structure was based upon on- and off-street parking. These new zones are as small as individual blocks in many cases. Use of the 1980 off-street parking map as well as the City's on-street link-by-link parking inventory was made. Basically, the two types of parking were added together for each zone. The result was 245 new CBD zones.
- o A "link-node network" was developed to serve the CBD zones. Each zone, of course, has a zone "centroid" where all auto trips will start or end, and these auto trips will be entered onto the link-node network (i.e., the computer input encoded map of the CBD) via access links corresponding to actual access points for parking in each CBD zone. The link-node network was essentially the same as the METRO-CBD network with added details for driveways. The DCO/TRANPLAN software package available through CDC in both Bellevue and Portland was used to build the CBD link-node highway network.
- o A new zone structure was developed outside the CBD using the METRO 99 and 265 zone structure. Basically, the 265 zone structure was used adjacent to the CBD, the 99 zone structure was used for an area of a moderate distance radius from the CBD, and the outer zones (Vancouver, Washington, etc.) were merged ("compressed") with the "externals" of the 99-zone structure. All the above was to track, for micro-assignment purposes, "non-divertible auto trips" oriented through or adjacent to the CBD as well as auto trips from outlying areas to the five CBD zones per METRO trip tables. The changing of the zone structure eliminated detail where not needed, and added detail where none exists now (METRO CBD zones 1 through 5). The CBD-bound trips were apportioned to the expanded CBD zone structure and overlayed onto the non-divertible through auto trips on CBD streets and adjacent freeways. The DCO/TRANPLAN program for building trip tables from "survey" data (in this case the METRO trip tables were treated as O & D survey data) was used to format the METRO output, and then another TRANPLAN matrix utility function was used to expand the METRO 5 zone CBD auto trip data to the new CBD zone structure.

- o Traffic assignments for both 1977 and 1995 were made using 1977 and 1995 trip tables assigned to 1977 and 1995 link-node networks respectively. A stochastic assignment was made rather than either a free or capacity restrained assignment.
- o The 1995 link volumes were divided by their corresponding 1977 link volumes to develop a factor for expanding 1977 ground counts on CBD streets. The resulting volumes represented 1995 24-hour volumes. PM peak volumes were estimated using the City's factor by link for PM peak traffic.

The model developed in the Westside Corridor project seems to perform as needed with respect to assignment accuracy, but the trip tables appear to be 20 percent to 50 percent low. The main use of the model was for understanding changes in traffic patterns due to either shifts in mode split or physical and operational changes on CBD streets.

Refinements and Changes to Traffic Model for Traffic Effects Analysis

An attempt was made to correct the trip tables and factor them to 1980 by using select link 1977 trip tables for the CBD cordon links and for the internal screenline links used in the Westside Corridor project. These internal screenlines are:

- o North-south screenlines parallel to Broadway, Fourth and Front.
- o East-west screenlines parallel to Burnside, Alder, Salmon, Jefferson and Harrison.

The assigned 1977 volumes on the select links were compared with 1977 traffic volumes, and zone-to-zone movements for those zones were factored up so that assigned volumes were comparable to counted volumes. Of course, many zone-to-zone movements occurred on several links (this is a stochastic assignment), and this was accounted for by developing an average factor for groups of zone to zone pairs in the trip tables. The 1977 zone-to-zone movements were factored up by 7% to account for general traffic growth 1977 to 1980. At that point the adjusted and corrected 1980 trip tables were assigned to the CBD network as in the Westside Corridor project, and this assignment (24-hour) was factored to describe PM peak conditions. This represented a modelled 1980 "with Mall" condition.

The CBD link-node network was revised as appropriate, essentially raising the speeds and allowing turns onto 5th and 6th Avenues so that traffic is once again attracted to these streets. Additionally, garages that were built because on-street parking was stripped off the mall streets changed the CBD zone structure. Zones were added for on-street parking on 5th and 6th Avenues and the two Morrison garages were deleted.

This modified the zone splits used in the Westside project assignments. This completed the model preparation for "non-Mall" 1980 traffic forecasts.

Results and Validation of Traffic Model

Figure 3A in the main body of this report shows 1980 average weekday traffic volumes (auto and truck) in the Portland CBD. This map was used to compare the model output (auto/truck output) shown by Figure 4 in the main body of the report. Table IV shows the comparison in summary form. Traffic models cannot normally forecast traffic volumes with less error than shown by the comparison of Figure 3A and Figure 4. The conclusion, then, is that with the model, the differences in traffic between having the Mall and not having the Mall can reasonably be estimated within 10% accuracy. For example, there is only a 3% error in estimating how many cars cross the CBD cordon (a line drawn around the downtown area) and the error rate for the four sides of the CBD cordon is also very low with 11% being the highest error between estimates and counts on the north.

TABLE IV

COMPARISON OF 1980 MODELLED AND COUNTED TRAFFIC VOLUMES
(AVERAGE WEEKDAY TRAFFIC - Without Bus Volumes)

Location	Counts (Figure 3A)	Model Output (Figure 4)	% Error*
Total East Crossings	119,924	121,635	1.4%
Total North Crossings	84,890	94,557	+11.4%
Total West Crossings	103,672	100,649	-2.9%
Total South Crossings	75,394	79,223	+5.1%
Total CBD Cordon	383,880	396,064	+3.2%

* Figure 3A volume divided by corresponding Figure 4 volume times 100 minus 100 = % difference

The computer map was recoded to represent 5th and 6th Avenues as auto streets and the same trip table used for the Mall was assigned to the downtown streets without the Mall. Figure 5A in the main body of the report shows the model output for 1980 traffic volumes if the Mall had not been built. The total traffic volume crossing the CBD cordon goes up 2.3%, probably because returning 5th and 6th Avenues to regular traffic circulation affords a better route for some trips through downtown between areas close to downtown than does Broadway or 4th. Some trips also may have diverted from the freeway loop around downtown to 5th or 6th Avenues due to minor time savings. Table V shows the comparison with the Mall and without the Mall for 1980 traffic volumes.

TABLE V

COMPARISON OF 1980 MALL AND NON-MALL TRAFFIC VOLUMES

(AVERAGE WEEKDAY TRAFFIC - Without Bus Volumes)

(Model Output Comparison - Figures 4 and 5A)

Location	1980 Mall	1980 Non-Mall	% Difference*
Total East Crossings	121,635	125,026	+2.5%
Total North Crossings	94,557	107,514	+13.7%
Total West Crossings	100,649	94,339	-6.3%
Total South Crossings	79,223	78,190	-1.3%
Total CBD Cordon	396,064	405,069	+2.3%

* Fluctuations of this magnitude are due more to statistical idiosyncracies of the trip table and assignment methodology rather than real differences between Mall and non-Mall conditions. A "t" test of significance shows these changes are real only at the 80% confidence interval for individual cordon crossings. The 2.3% increase for the total CBD cordon is significant at the 90% confidence interval.

Further checks were used to test the model for accuracy of internal CBD circulation. For this, "screenlines" were drawn parallel to major east-west and north-south streets in downtown. A "screenline" is merely a line drawn on a traffic volume map so that a summation of volume can be made over many streets at once. The estimated volume on any one street may vary quite widely from actual values - especially on low volume streets, but when the volumes on north-south streets crossing Burnside are added up, for example, wide variations are less likely to occur, and if they do, this signifies that some real problems exist in the model. Table VI shows the results of analysis of internal screenlines.

TABLE VI

ANALYSIS OF INTERNAL SCREENLINES IN CBD

(AVERAGE 1980 WEEKDAY TRAFFIC - Without Bus Volumes)

(With Mall)

Location	Model Volumes	Counted Volumes	% Error
Market Street*	87,685	90,294	-2.9%
Jefferson Street	124,173	116,902	+6.2%
Morrison Street	114,227	110,128	+3.7%
Front Street	146,064	148,836	-1.9%
4th Avenue	141,627	137,808	+2,8%
Broadway	127,508	128,962	-1.1%
10th Avenue	103,224	109,017	-5.3%
Overall Internal CBD	844,558	841,947	+0.3%

* The sum of volumes from all streets crossing Market Street (and so on) for all listed streets in Table VI.

APPENDIX 2: Mode Split Model

The mode split model used in this study is not a complete mode split model in the classic sense in that the model will not estimate the proportion of trips made by transit by comparing the relative utilities of travelling by automobile or by transit. These are the types of models used by METRO to estimate percent transit use fo each interchange of trips between zones in the entire urban area. An excellent discussion of the theory and application of these models can be found in several references.(32)(33)(34).

The model used in this study is derived from the more complete models, but the model only adjusts a known mode split in a corridor or in a zone in response to changes in:

1) In-vehicle travel time
2) Out-of-vehicle travel time
3) Trip costs

Each of the three classes of variables involves a travel impedance or disutility assuming all trips require time and cost which is desirably minimized. The first, in-vehicle travel time, has a one-to-one correspondence with impedance to travel, and both automobile and transit travel times are weighted equally. Out-of-vehicle travel time is weighted by a factor of 2.5 to convert the value to an impedance quantity. In effect, the travelling individual perceives a walking or waiting minute as (2.5) x (travelling minutes in vehicle).

Trip costs in cents must be converted to equivalent minutes in order to be additive with the other components of total travel impedance. Travel costs include auto operating cost, parking cost, and transit fare. The assumption in this model is that the value of an individuals' own time is equal to one-third of the value associated an equivalent amount of working time. The transformation equation is:

$$\text{Cost in minutes} = \frac{\text{Cost (\$)}}{1/3 \times \text{Annual Income (\$)}/120{,}000}$$

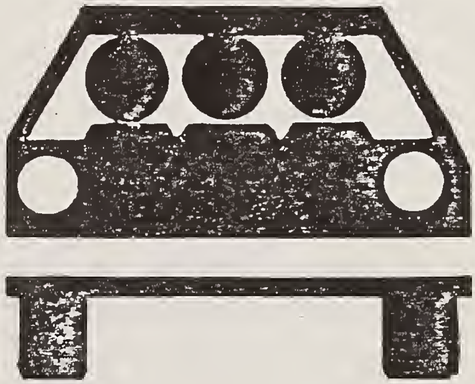
where 120,000 is a constant to convert \$/year to ¢/minute.

A model developed for the analysis of a proposed interstate highway extension in Seattle (35) was believed to be directly transferable to the Portland area because downtown mode splits in the two cities are similar, the cities are of similar size, have similar population characteristics and have similar transit systems and fare schedules. The reference describing the model developed for the Seattle study follows. Pages 46 and 47 show the printout of the computer program on a sample problem which illustrates the input and ouput characteristics of the model. The model application for the Traffic Effects Analysis was reprogrammed for the HP-67 calculator, so printed output is not available.

THE POTENTIAL FOR

CARPOOLING

IN THE I-90 CORRIDOR



DANIEL I RILEY & ASSOC.

The Blue Streak model development is based on the theory of marginal disutility as advanced by Shunk and Bouchard (6) in 1970. The use of the econometric jargon "utility" in this application may be argued by some, however, to be stretching the definition of utility beyond appropriate limits. A more useful term might be "generalized cost" to indicate the level of inconvenience of travel by a mode.

Thus, the Blue Streak model is a generalized cost model which relates modal split (the proportion of trip by transit) to the difference in generalized cost between transit and auto. This difference in cost is often labeled the marginal cost.

The form of the definition of marginal cost was taken from the work of Alan M. Voorhees and Associates in model development in several cities across the U.S. and abroad. This form is given by:

$$MC = 2.5(Ta + Tw - At) + (Tr - Ar) + (F - 0.5P - 0.057D)/Ct$$

where:

Ta = Walk time to/from Transit
Tw = Wait time for Transit
Tr = Transit run time
F = Transit Fare
At = Auto terminal time
Ar = Auto run time
P = Parking cost
D = Highway distance
MC = Marginal generalized cost
Ct = Cost of time = $\frac{499200}{\text{Income}}$

The form of the Blue Streak model was developed from consideration of the curves that had been developed in other cities. Figure B-1 illustrates a typical plot of modal split vs. marginal cost and the shape of the elasticity curve which produces this kind of relationship. As high levels of mode choice are achieved, the mode choice curves flatten considerably. This is due to many reasons: some people require their automobile at their destination; many others do not have transit connections to their destinations, and still others are committed to the auto mode for any of an infinite variety of reasons. Yet at the other end of the scale the mode split approaches zero rapidly as high cost differences are incurred. This is intuitively logical because it is easy to drop mode choice to zero simply by discontinuing service.

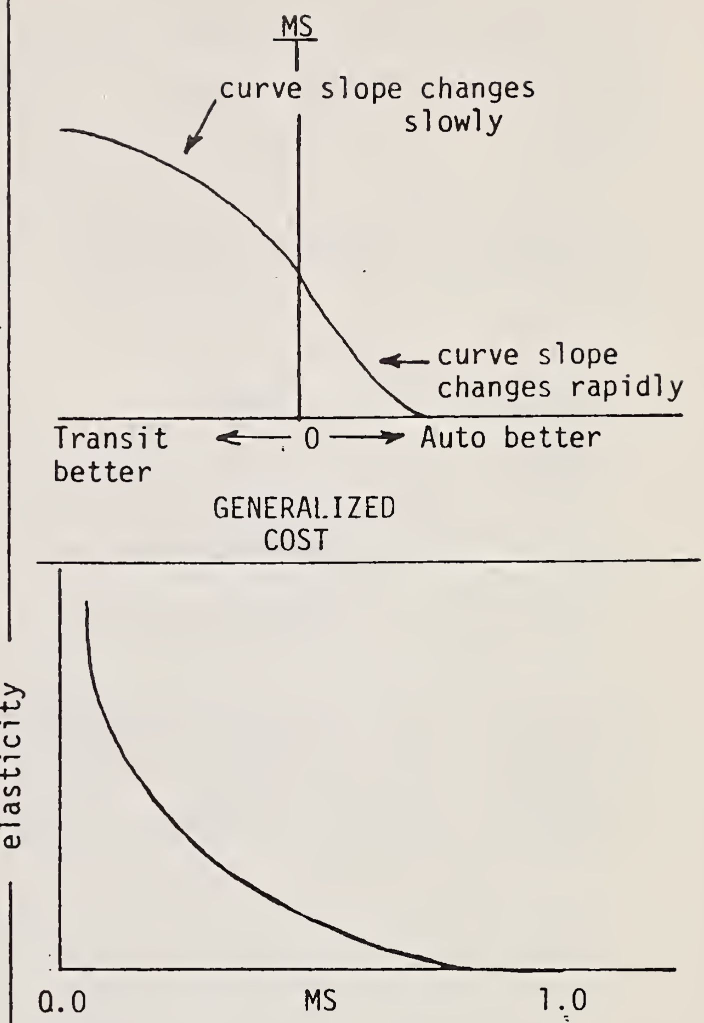


FIGURE B-1

Several curve forms would produce the desired elasticity. One consideration was the log normal curve. Another was the common Gompertz formulation:

$$y = k\, a^{bx}$$

It was decided, however, that the simplest curve to work with (both in calibration and in daily use) that gave the correct elasticity pattern was the Extreme Values Distribution. This has the form:

$$y = e^{-e^{\alpha(X + \mu)}}$$

where, in our case;

y	=	Mode choice probability
X	=	Marginal cost
e	=	Natural logarithm base
α, μ	=	Model constants

Figure B-2 is a plot of the freehand curves from four cities on an extreme values distribution grid. Curves which follow this distribution will plot as straight lines on this grid. It can be readily be seen that all of the plots (except Philadelphia) plot as reasonably straight lines. Philadelphia also is somewhat linear for marginal costs less then zero and the points greater than zero were based on a relatively small sample.

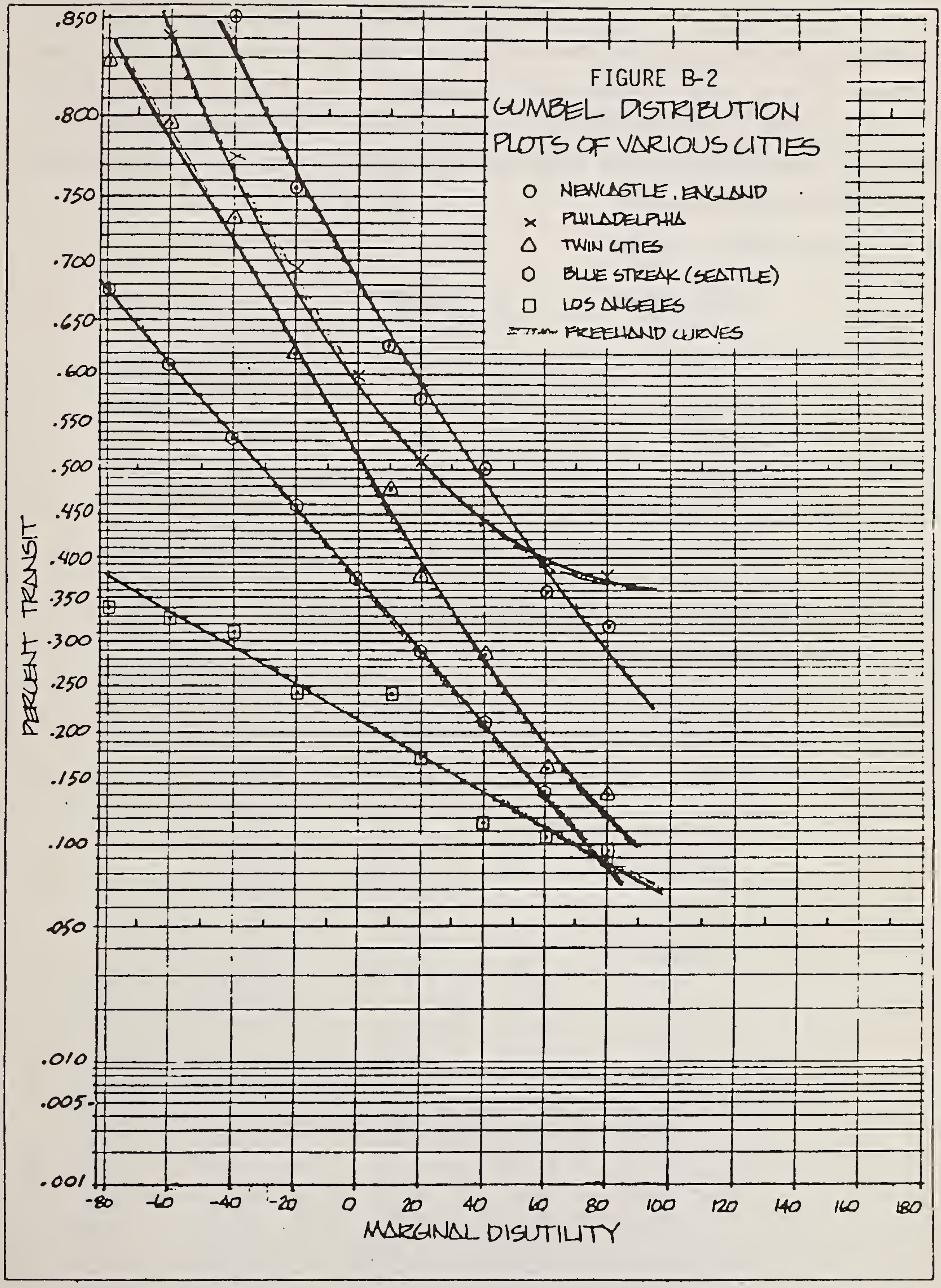
The curve can be easily calibrated from a series of data points by regression using the transformation:

$$\mathrm{Ln}\left|\mathrm{Ln}\ (P_i)\right| = \alpha\ MC_i + \alpha\mu$$

where:

- Ln = Natural logarithm
- P_i, MC_i = Probability of transit mode choice associated with Marginal Cost MC_i
- α, μ = Model parameters

The worth of this curve has been demonstrated several times since the Blue Streak study in other cities. Because it is differentiable it is a valuable tool in the analysis of system parameter optimization.



Source: Blue Streak

The model is applied in two stages. First the model is initialized using known data some base system. In this study the base system is system 4T4. After initialization the model is run for each system alternative. The main function of the model initialization is to detrmine base generalized cost differences in the corridor (x_i). The general flow of the model application process is:

PART I: MODEL INITIALIZATION

STEP	EXOGENOUS INPUT	CALCULATION NUMBER	OUTPUT
1	V ACO, MS	1	p_i, ACO_3+
2	α,μ	2	x_i
3	Demand	6	PD_i
4	Bus Occ.	7	VD_i
	Capacity	8	V_i
		9	Summary

NOTE: A glossary of terms and calculation details follow

PART II: ALTERNATIVES ANALYSIS

STEP	EXOGENOUS INPUT	CALCULATION NUMBER	OUTPUT
1	ΔT_i	3	X_i
2	α,μ	4	$e^{-\omega_i}$
3		5	p_i
4	Demand	6	PD_i
5	Bus Occ.	7	VD_i
	Capacity	8	V_i
7		9	Summary

```
MODEL INITIALIZATION

INPUT VALUES:

MODE SPLIT= 0.400
AVERAGE CAR OCCUPANCY = 1.35
PERSON TRIP DEMAND = 47000.
BUS OCCUPANCY = 38.

BASE PROPORTION OF PERSON TRIPS

TRANSIT=0.400
SINGLE PERSON VEHICLES =0.332
TWO PERSON VEHICLES =0.173
THREE + PERSON VEHICLES =0.095

OCCUPANCY OF 3+ VEHICLES =3.613

 ASE COST-TIME DIFFERENCE

 RANSIT = -6.602
  NGLE PERSON VEHICLES = 0.0 (BY DEFINITION)
TWO PERSON   VEHICLES = 43.981
THREE + PERSON VEHICLES = 70.854

PERSON TRIP DEMAND BY MODE

TRANSIT= 18800.
SINGLE PERSON VEHICLES = 15582.
TWO PERSON VEHICLES =  8128.
THREE + PERSON VEHICLES =  4490.

VEHICLE DEMAND BY MODE

TRANSIT =   495.
SINGLE PERSON VEHICLES = 15582.
TWO PERSON VEHICLES =  4064.
THREE + PERSON VEHICLES =  1243.

TOTAL = 21384.
```

ALTERNATIVE ANALYSIS

INPUT VALUES:

CHANGE IN TIME-COST DIFFERENCE FOR TRANSIT = 8.000
CHANGE IN TIME-COST DIFFERENCE FOR 3+ PERSON VEHICLES = 0.000
CHANGE IN TIME-COST DIFFERENCE FOR 2 PERSON VEHICLES = 0.000

REVISED GENERALIZED TIME-COST DIFFERENCES:

TRANSIT = *-14.6
3+ OCCUPANT VEHICLES = 70.854
2 OCCUPANT VEHICLES = 43.981

INTERIM CALCULATIONS:

E FOR 1 OCCUPANT VEHICLES = 0.372
E FOR 2 OCCUPANT VEHICLES = 0.194
E FOR 3+ OCCUPANT VEHICLES = 0.107
TOTAL E = 0.673

DEMAND PROPORTION BY MODE:

TRANSIT = 0.434
1 OCCUPANT VEHICLES = 0.313
2 OCCUPANT VEHICLES = 0.163
3+ OCCUPANT VEHICLES = 0.090

PERSON TRIP DEMAND BY MODE

TRANSIT= 20377.
SINGLE PERSON VEHICLES = 14711.
TWO PERSON VEHICLES = 7674.
THREE + PERSON VEHICLES = 4239.

VEHICLE DEMAND BY MODE

TRANSIT = 536.
SINGLE PERSON VEHICLES = 14711.
TWO PERSON VEHICLES = 3837.
THREE + PERSON VEHICLES = 1173.

TOTAL = 20257.

NEW AVERAGE CAR OCCUPANCY = 1.350

NEW MODE SPLIT = 0.434

APPENDIX 3: Method of Calculating Average Walking Distance

The difference in average transit patron walking distance between Mall and non-Mall conditions was estimated by a generalized model which assumed an equal distribution of bus rider origins and destinations in downtown Portland for all bus routes. For example, if 1.98% of all Tri-Met riders in downtown are destined for the Galleria in the block bounded by Adler - Tenth - Morrison - Ninth, the model assumed that 1.98% of the riders on each route serving downtown were bound for that block.

Once the assumption of equal distribution of origins and destinations for each downtown transit route was made, the calculation of average walking distance follows. The average daily patronage on each route was determined by reference to Tri-Met data for 1980.

The calculation of average walking distance then becomes the mean of a frequency distribution which is a function of: (1) the proportion of patrons on each route destined for each of the blocks downtown; (2) the number of patrons on each route; and (3) the distance in feet between the closest approach of each route to each of the blocks in question.

For example, the Galleria block mentioned above was estimated to have 1.98% of all transit patron origins and destinations in downtown (based upon Figure 9, page 33 of the July 25, 1980 draft report, "Downtown Alignments Westside Transit Way: Initial Assessment" by the Portland Bureau of Planning). Figure 9 in that report shows employee and student populations by block, and also shows daily retail shoppers in blocks with significant retail floor space such as the Galleria, Meier & Frank, etc.

The daily patronage by each route was then apportioned to each block and assigned a walking distance based upon the closest approach of each route to each of the blocks in turn. For example, if a route on the Mall has 2,100 patrons on the average weekday, the distance patrons on that route need to walk to reach the Galleria is from the midpoint between 5th and 6th Avenues (assuming half arrive on 6th and half return to 5th Avenue) and the center of the block bounded by Tenth - Morrison - Ninth - Alder, or 800 feet (4 blocks). Therefore, 1.98% of 2,100 people (or 41.58 persons) walk 800 feet between buses and their final origin/destination for the particular route in the example. This computation was made until all 2,100 patrons on that route were accounted for, and then the whole series of calculations was repeated for each route. The completion of this operation results in a frequency distribution of modelled walking distances for the Mall condition, and by finding the mean value of the frequency distribution, the average walking distance of transit patrons is determined.

The average walking distance for non-Mall conditions was determined in the same manner. The mean value for the Mall was determined to be 531 feet, and for the non-Mall the mean is 689 feet, 158 feet farther.

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