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Cost Effectiveness of Park-and-Ride Lots in the Puget Sound Area

Final Report

October 1986

Washington State Department of Transportation
in cooperation with
United States Department of Transportation
Federal Highway Administration

COST EFFECTIVENESS OF PARK-AND-RIDE LOTS IN THE PUGET SOUND AREA

by

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16. Abstract

A cost effectiveness evaluation and a cost-benefit analysis was performed on a park-and-ride system consisting of 26 park-and-ride lots in the Seattle metropolitan area. Costs and benefits of the system were examined with respect to the user, the community at large, and the public agencies responsible for providing for the community's transportation needs. A user survey was conducted at the 26 lots. Using the survey data and other data as input, a model was developed to calculate the total incurred trip costs of both the park-and-ride trip and the corresponding trip not involving the park-and-ride lot. These trip costs were compared in a "before" and "after" analysis. In addition, the park-and-ride system was analyzed for its effect on the following transportation system measures of effectiveness: travel time, person miles traveled (PMT), vehicle miles traveled (VMT), traffic volumes, vehicle emissions, accidents, and energy consumption. General results indicated that the park-and-ride system in the Seattle area is cost effective. The average park-and-ride trip was estimated to be 11.6 percent less expensive than the corresponding average previous trip by another mode. Results also indicate that the lots have had a slightly negative impact on travel time and PMT (i.e., these measures have increased), but VMT, traffic volumes, accidents, vehicle emissions, and energy consumption have all been reduced.

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ACRONYMS USED IN THIS REPORT

AAA	-	Automobile Association of America
ARFC	-	Average Relative Fuel Consumption
CBD	-	Central Business District
FHWA	-	Federal Highway Administration
HCM	-	Highway Capacity Manual
HOV	-	High Occupancy Vehicle
METRO	-	Municipality of Metropolitan Seattle
MPH	-	Miles per Hour
P&R	-	Park-and-Ride
PMT	-	Person Miles Traveled
PSCOG	-	Puget Sound Council of Governments
SMSA	-	Standard Metropolitan Statistical Area
TAZ	-	Traffic Analysis Zone
TRAC	-	Washington State Transportation Center
TSM	-	Transportation System Management
TSMC	-	Traffic Systems Management Center
VMT	-	Vehicle Miles Traveled
VPH	-	Vehicles per Hour
WSDOT	-	Washington State Department of Transportation

ABSTRACT

A cost effectiveness evaluation and a cost-benefit analysis was performed on a park-and-ride system consisting of 26 park-and-ride lots in the Seattle metropolitan area. Costs and benefits of the system were examined with respect to the user, the community at large, and the public agencies responsible for providing for the community's transportation needs. A user survey was conducted at the 26 lots. Using the survey data and other data as input, a model was developed to calculate the total incurred trip costs of both the park-and-ride trip and the corresponding trip not involving the park-and-ride lot. These trip costs were compared in a "before" and "after" analysis. In addition, the park-and-ride system was analyzed for its effect on the following transportation system measures of effectiveness: travel time, person miles traveled (PMT), vehicle miles traveled (VMT), traffic volumes, vehicle emissions, accidents, and energy consumption. General results indicated that the park-and-ride system in the Seattle area is cost effective. The average park-and-ride trip was estimated to be 11.6 percent less expensive than the corresponding average previous trip by another mode. Results also indicated that the lots have had a slightly negative impact on travel time and PMT (i.e., these measures have increased), but VMT, traffic volumes, accidents, vehicle emissions, and energy consumption have all been reduced.

EXECUTIVE SUMMARY

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BACKGROUND

Park-and-ride lots are parking facilities, typically located some distance from the central business district (CBD), where the commuter changes from an automobile to some form of public transportation or ridesharing. In major urban areas throughout the United States such lots have been established to provide more efficient transportation and to assist in the conservation of energy. As such, they have become an integral part of the nation's urban transportation system framework. Nowhere is this more true than in the Seattle metropolitan area.

The agency responsible for providing transit service in the Seattle/King County area is the Municipality of Metropolitan Seattle (METRO). The first park-and-ride lot in the Seattle area was established in 1970 by METRO's predecessor, Seattle Transit, in the Northgate vicinity. Encouraged by the high utilization of this lot, the Washington State Department of Transportation (WSDOT) coordinated planning efforts with METRO to provide additional park-and-ride lots in the Seattle metropolitan area. Under a memorandum of understanding between the two agencies, WSDOT was to construct a number of lots using appropriate funds (Interstate, state motor vehicle funds, and METRO matching dollars), and METRO was to maintain them. METRO constructed other lots.

As of March, 1984, the Seattle/King County area had 26 permanent, 8 semi-permanent and 16 interim park-and-ride lots. Lots are classified due to their funding and long-range planning considerations. These 50 lots in total represented 12,520 automobile parking spaces To date, WSDOT has spent approximately $47 million for construction of the 26 permanent lots.

Planned additions to the existing park-and-ride system are extensive. Both METRO and the Puget Sound Council of Governments (PSCOG), the regional planning agency, recommend plans which would double the number of park-and-ride lots in the Seattle/King County region (1) (2).

Despite the substantial sums of money that have been invested and are planned for investment in park-and-ride lots, little has been done to evaluate the total effectiveness of these lots. The initial goal of park-and-ride lots was to entice automobile commuters into express buses to alleviate freeway traffic congestion. Energy conservation became an additional objective with the advent of the Arab oil embargo in the early 1970s. To entice commuters from their cars to transit the benefit to them had to be clearly outlined. Consequently, previous analyses of this topic have focused on benefits to the users through economic savings and energy conservation. However, a need exists to take a more comprehensive and detailed look at the costs and benefits of park-and-ride lots, not only with respect to the user, but with respect to the community at large and to the public agencies responsible for providing for the community's transportation needs. In short, do the benefits park-and-ride lots provide sufficiently justify their expense? This study was undertaken to answer this question for the Seattle area.

The basic goal of this study was to determine the cost effectiveness of existing park-and-ride lots with respect to the total transportation system in the Seattle metropolitan area. Results from this study may also be of use in the development of guidelines and tools for assessing the effectiveness of proposed park-and-ride facilities.

In meeting this goal, the basic objective was to provide a total cost effectiveness evaluation of the existing park-and-ride lot system which included looking at costs, benefits and other measures of effectiveness as they related to each of the following groups:

- the community at large,
- the public agencies involved,
- the park-and-ride lot user.

In developing this study, the question arose of whether highway capital costs, being "sunk" costs (i.e., the investment in them has already been made), should be included in the cost analysis. Depending upon the purpose of the study and the application of its results, arguments can be made both for and against including these costs in the analysis.

The basic purpose of this study was to determine the cost effectiveness of the existing park-and-ride system in terms of the entire transportation system, i.e., have the lots been a worthwhile investment? Since all the capital costs considered in this analysis -- including those for both freeways and park-and-ride lots -- have been "sunk" costs, it is legitimate to include capital costs, including those for freeways, in the cost analysis.

Another strong argument for the inclusion of highway capital costs is that, with respect to the park-and-ride system, WSDOT's "participation with gas tax money is based on the premise that the construction of the park-and-ride lot system will relieve the need for the construction of additional highway lanes" (3).

Another instance in which highway capital costs should be included is that in which the transportation system of the given area is in its infancy. In other words, the construction of either freeway lanes or a park-and-ride system are both viable alternatives (neither are "sunk" costs in this case). In this instance, the trading off of the cost of freeway capacity with that of the park-and-ride system is an appropriate strategy.

However, there are also scenarios in which including high way capital costs is not necessarily appropriate. One such case involves analyzing the cost effectiveness of a single proposed park-and-ride lot. For this case, highway capital costs are "sunk" but the cost of the lot is not. Given a situation in which it is highly unlikely that many additional freeway lanes will be built (which is the case for most major urban areas in the U.S., including Seattle), the trade-off between the cost of the park-and-ride lot would not be with the cost of additional freeway construction, but rather with the cost associated either with the increased freeway congestion which would result if the lot were not built, with the cost of implementing an alternative TSM tactic of equivalent effectiveness, or with the cost of implementing some other form of mass transportation.

Since a sidelight of this study is to provide a base which may be used in developing general guidelines for evaluating the effectiveness of park-and-ride lots, the above scenario was considered. For this, general estimates of congestion costs were developed for inclusion in the cost analysis. Due to limited resources, costs of alternative TSM tactics or mass transit options were not developed.

METHODOLOGY

A lot of the data needed for this study were available through traditional sources. However, certain types of data regarding the park-and-ride lot user were not available and had to be obtained with a special survey. For this purpose, a windshield-placed mail-back business-reply survey form was used. The study consisted of the 26 permanent park-and-ride lots in the Seattle metropolitan area sponsored by the WSDOT. These lots were divided into four corridors, as shown in Figure 1. In the course of the survey, 6,138 forms were distributed among the 26 lots, and 2,402 were returned, for an overall return rate of 39.1 percent.

For the purposes of the cost effectiveness evaluation, the primary information obtained from the survey dealt with what mode patrons used prior to using the park-and-ride lot. With this information, estimates of previous mode trip costs could be made and compared to the costs of the corresponding trips involving park-and-ride lots in a

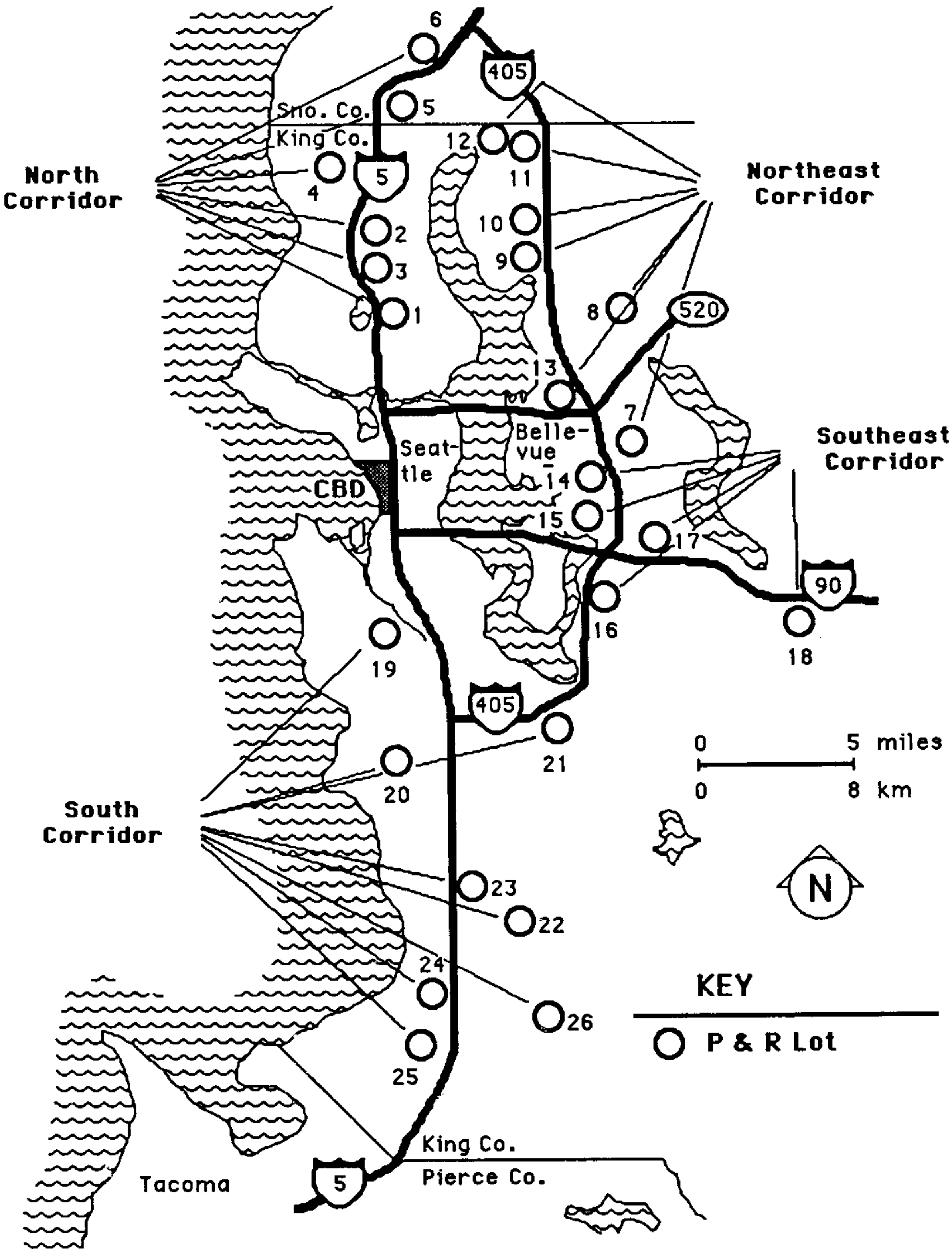


Figure 1. Park-and-Ride Lot Study Area Map

"before and after" trip cost analysis. Trip costs, as referred to here, include much more than just out-of-pocket expenses. The full cost of a trip includes every identifiable cost incurred while providing for that trip. Among those considered in this study are the user costs of time, vehicle operation and parking; public agency costs of roadway provision and maintenance, and transit service provision; the costs to roadway users due to traffic congestion; and other publicly incurred costs such as city planning and police services, and noise and air pollution. These cost components are outlined in Table 1.

In addition to the total public and private cost comparison, separate before and after analyses were made for "user incurred" trip costs and for "public agency incurred" trip costs. Comparing costs from these three different perspectives enabled a clearer view as to how costs and benefits of park-and-ride lots were distributed among the respective groups concerned.

For the purposes of the before and after trip cost analysis, the study area was narrowed down to the north and southeast corridors, consisting of 11 lots in total, because they represented the relative extremes as far as park-and-ride lot utilization was concerned. The north corridor lots had the highest combined utilization rate while the southeast lots had the lowest. The north corridor is in a relatively mature stage while the southeast corridor is still young and developing. Encompassing these two corridors in the analysis enveloped both ends of the spectrum of park-and-ride lots in the Seattle area.

Park-and-ride lots in the Seattle area were designed primarily to serve the suburban commuter trip to downtown Seattle. This is reflected in the survey results showing that 95% of park-and-ride trips are work trips, and 70% of those from the north and southeast corridors go downtown. This study focuses on this primary park-and-ride trip -- the work trip to downtown Seattle -- in its before and after analysis.

Table 1. Total Public and Private Trip Cost Components

Component	Study Value	Reference
Time Costs		
• In-vehicle time	1/3 wage rate	(5) (6) (7)
• Out-of-vehicle time	2.5 x in-vehicle cost	(5) (6) (7)
Public Costs		
• Provision and maintenance of roadway	Peak Period; Bus 2.49 x auto	(5) (8)
• Traffic congestion impact on road users	Time, Fuel, Main.	(5)
• Other government provided services (planning, police, etc.)	Keeler-Small	(4)
• Environmental (noise and air pollution)	Keeler-Small	(4)
Automobile Costs		
• Ownership and operating (less fuel and accident)	FHWA, AAA, Hertz	(9) (10) (11)
• Fuel	" " "	" " "
• Accident	" " "	" " "
Parking Costs		
• Provision of P&R lot parking	Actual Construction & O/M Costs	(12)
• Parking at destination	Reported on survey	(5)
Transit Costs		
• All costs involved in providing transit service (less user fare)	Metro model	(13)
• User fare	Actual fare	(5)

For the north and southeast corridor cases analyzed, the percentage breakdown of previous mode trip types was as follows:

Walk to transit	22.5%
Drive to transit	32.1%
Drive alone (auto)	34.3%
Car/vanpool	11.1%

The corresponding park-and-ride trip breakdown was:

Park-and-ride transit	96.8%
Park-and-ride car/vanpool	3.2%

TRIP COST MODEL

Given the basic analysis needs, a model was required which would reasonably estimate all identifiable costs of a commuter trip. The model needed to be theoretically consistent in estimating costs for each of the four previous mode and the two park-and-ride trip types.

Following a literature search and review, a study by Keeler, Small and Associates (4) was chosen as a base from which to develop the trip cost model. The Keeler-Small study was chosen primarily because 1) it encompassed all of the basic types of costs desired for this study, and 2) it was a very thorough and highly regarded study which remains today a principal work on the subject of urban transport costs.

The Keeler-Small study estimated trip costs for the major urban transportation modes -- auto, bus and rail -- in the San Francisco Bay area. With such inclusions as travel time costs, public services, pollution and accident costs, it accounted for more costs than most previous studies.

To fulfill the needs of this study, some general modifications needed to be made in regards to the Keeler-Small study. These modifications are described in detail in reference (5).

Time Costs

A review of studies on the value of travel time indicated a range of values (6) (7). For the purposes of this study, a middle range estimate of one-third the commuter's hourly wage rate was used for the value of in-vehicle time, and 2.5 times that value was used for the value of out-of-vehicle time. While these values are generally accepted as representative, sensitivity analysis was done to see the impact of altering these assumptions.

RESULTS

Total Costs

The total cost comparison for the average previous mode trip versus the average park-and-ride trip based on a total of 467 cases analyzed is presented in Figure 2. The Figure also lists the component costs for each trip. Keep in mind that these costs are averages of individual observations for all trip types in each category, i.e., the average previous mode trip represents a combination of walk to transit, drive to transit, car/vanpool and auto trips, while the park-and-ride average trip incorporates both park-and-ride transit and park-and-ride car/ vanpool trips.

The results show that on the average, the park-and-ride trip is 7 to 12 percent less expensive than the previous mode trip depending on how sunk costs are handled. The park-and-ride trip is more expensive with respect to time, transit, and parking costs. The latter may seem a little surprising until it is realized that the 55% of previous mode trips involving transit have no parking costs. The only previous mode trip with significant parking costs is the auto drive alone trip. Conversely, every park-and-ride trip incurs the cost of parking at the park-and-ride lot (this is an agency cost, not a user cost).

Figure 3 presents the trip cost for each individual previous mode trip as compared to the average park-and-ride trip. The only previous mode trip more

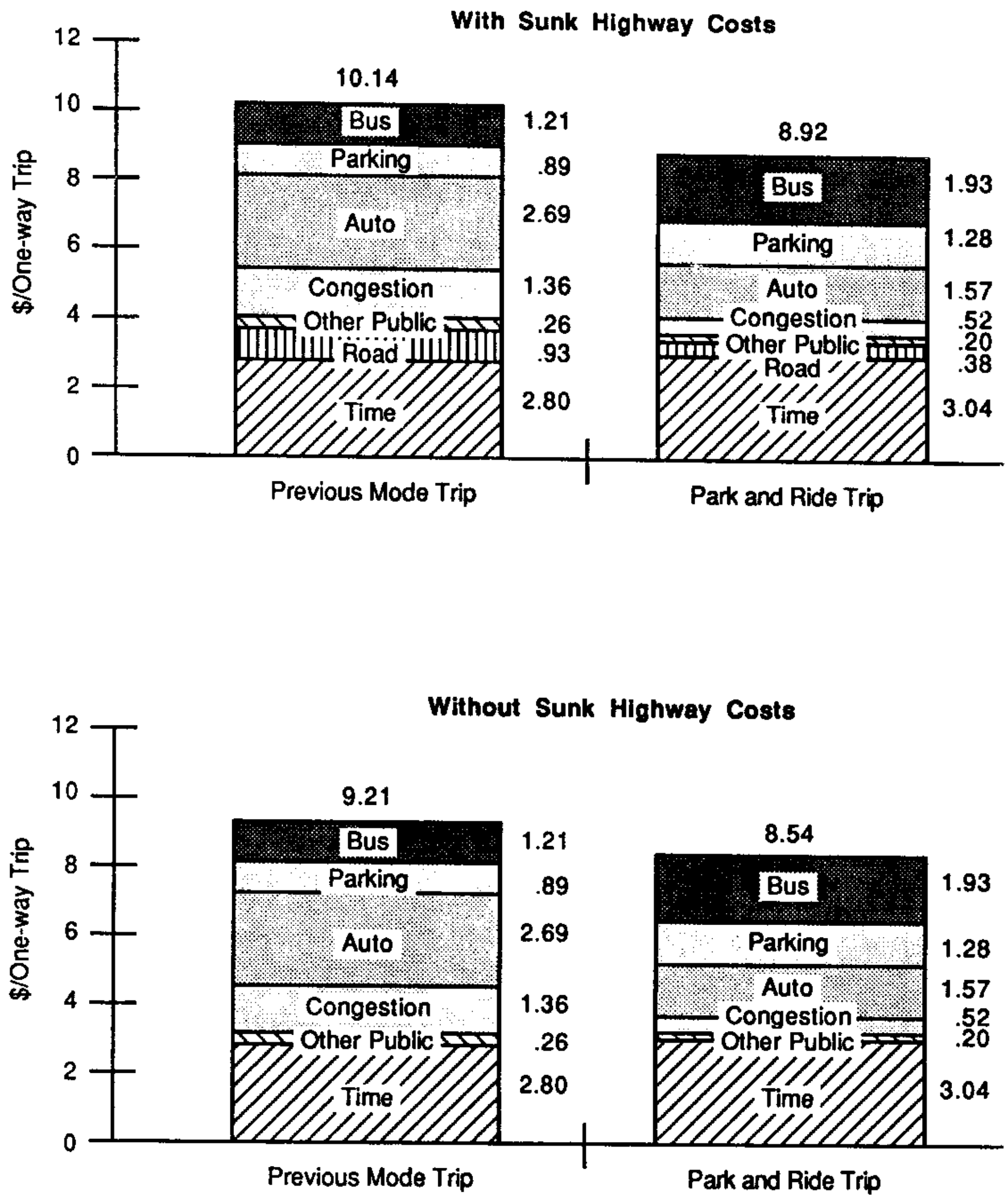


Figure 2. Total Incurred Cost Comparison: Combined Average Previous Mode Trip vs. Combined Average Park-and-Ride Trip (Highway Costs Included).

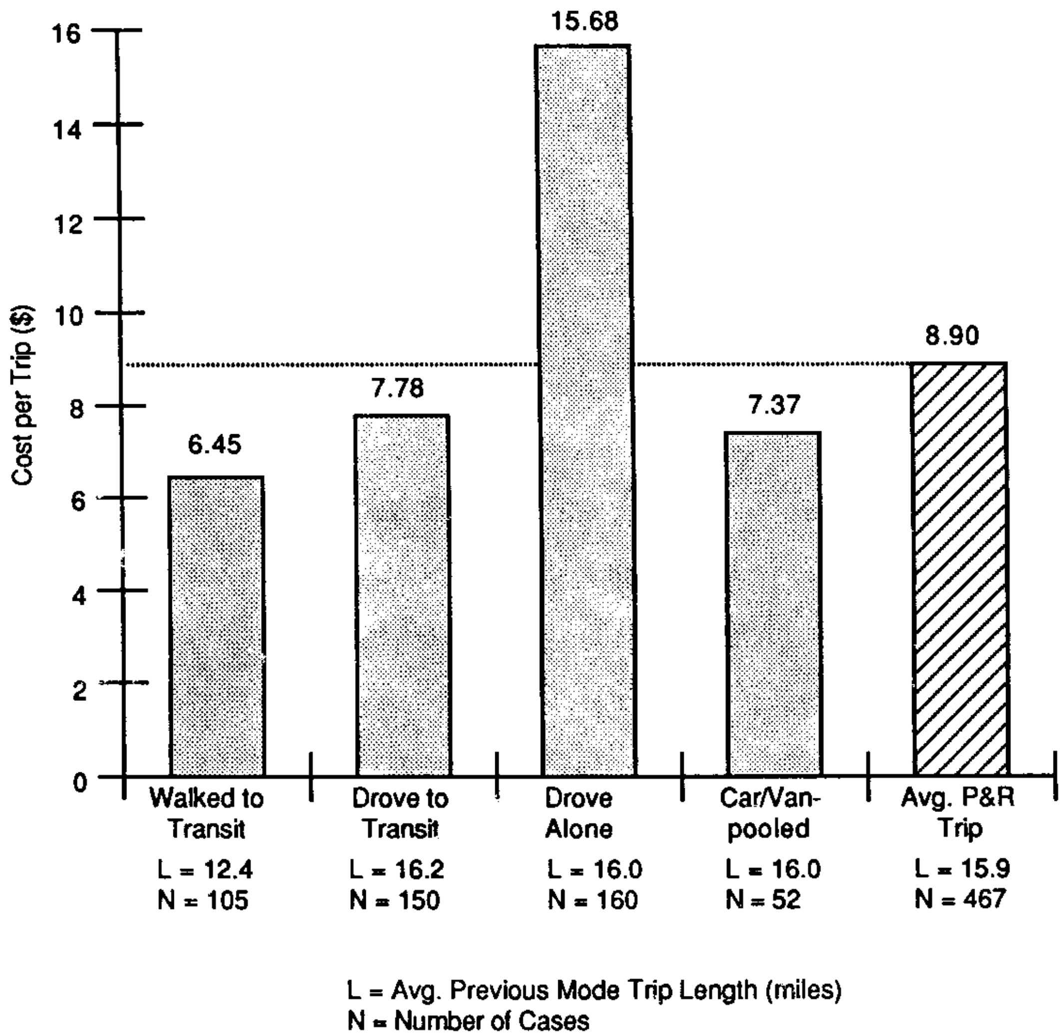


Figure 3 Previous Mode Total Trip Cost by Mode Type vs. Average Park-and-Ride Total Trip Cost (Highway Costs Included).

expensive than the park-and-ride trip is the auto drive alone trip. The drive alone trip represents a large enough portion of previous mode trips and its cost is high enough that it causes the combined average previous mode trip cost to be greater than that of the park-and-ride trip.

Agency and User Costs

When considering total costs -- i.e., those as they affect users, agencies and the general community combined -- results indicate park-and-ride lots to be cost effective. But how do agencies and users fare when considered separately? Figure 4 presents before and after (previous mode vs. park-and-ride) costs per person trip (including highway costs) as incurred by WSDOT, METRO, and the individual user. The agency "after" costs are shown for both existing and 100% lot utilization levels. With respect to WSDOT, park-and-ride trips reduce roadway costs, but the added expense of providing the lot overrides these savings. The net result is that WSDOT spends $0.61 per park-and-ride person trip. However, since WSDOT's primary function is to serve the transportation needs of the public -- which in this case includes both the park-and-ride lot user and the general roadway user -- net costs to WSDOT must be weighed against benefits both to the park-and-ride and general roadway user. The savings to the park-and-ride lot user as shown in Figure 4 is $1.48, or 22.9 percent, per trip. This in itself more than makes up for WSDOT's expenses.

In considering costs incurred by METRO, previous mode trips involving transit (55 percent of all previous mode trips) are compared to park-and-ride transit trips (96.8 percent of all park-and-ride trips). Metro's costs are reduced by $0.11, or 5.0 percent, per transit rider trip when park-and-ride lots are involved (if the lots were 100 percent utilized this would rise to $0.16, or 7.2 percent). In addition, among the data population analyzed, the introduction of park-and-ride lots contributed to a 77 percent increase in transit ridership.

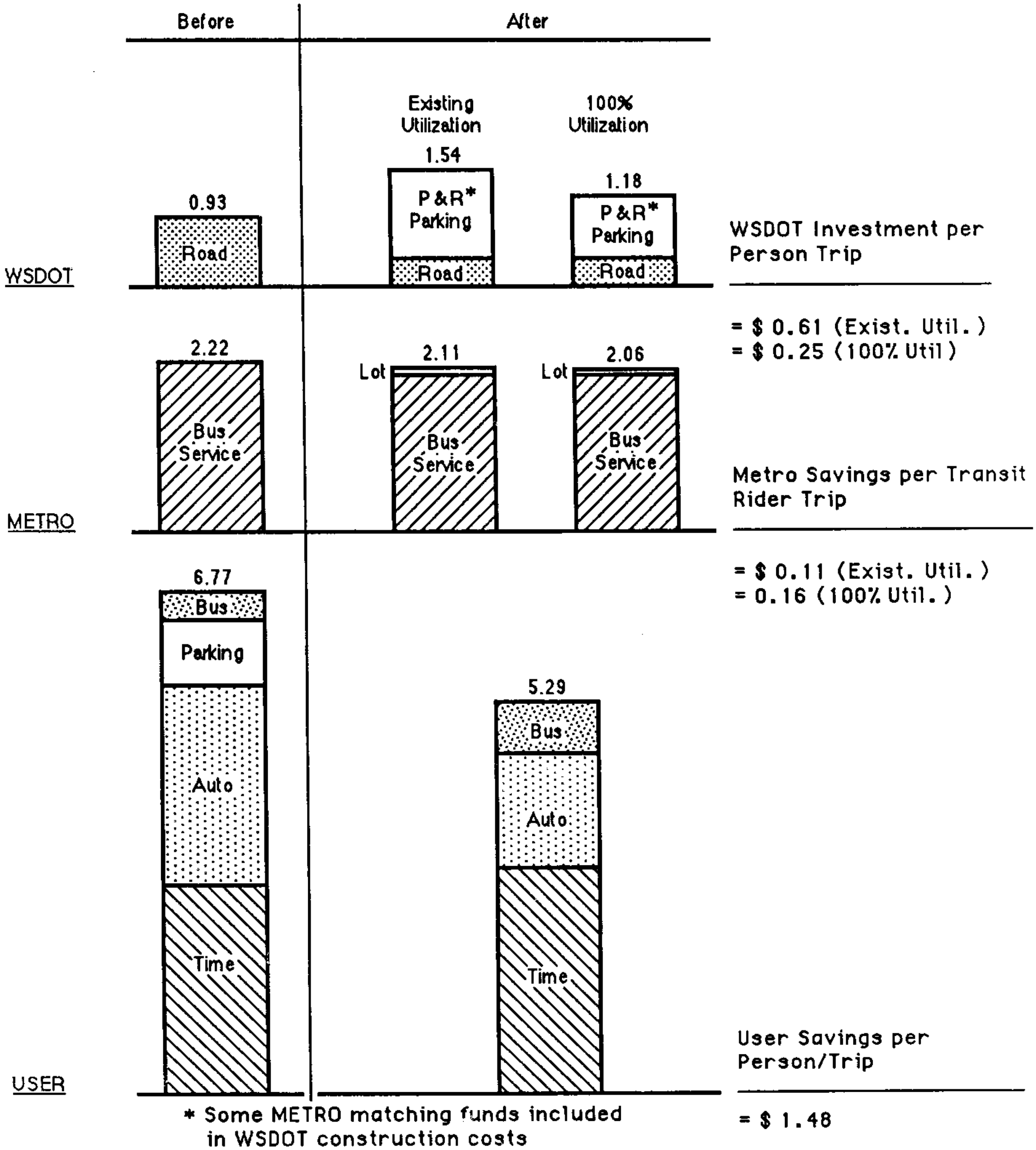


Figure 4. Agency and User Incurred Trip Cost Comparison (Highway Capital Costs Included, Congestion Costs Excluded).

Corridor Comparison

Figure 5 presents the percent of savings due to park-and-ride lots along with utilization rates for each of the north and southeast corridors as well as for two individual lots, Northgate and Eastgate. These costs include highway capital costs. With respect to trip cost savings, park-and-ride lots are more effective in the southeast corridor than in the north. This is somewhat surprising in light of the fact that the south east corridor has a much lower utilization rate (44.9 percent to 79.2 percent for the North). In fact, since its current utilization is so much lower, the southeast corridor has a higher potential for improvement. If the lots were fully utilized, the percent savings per park-and-ride trip would increase to 21.9 percent for the southeast corridor as opposed to 13.4 percent for the north. This contrast in cost effectiveness is even more evident if two selected lots from each of the corridors -- Northgate from the north corridor and Eastgate from the south east (numbers 3 and 17, respectively, in Figure 1, are compared. The Northgate lot, even when fully utilized, experiences an average loss of 3.5 percent per trip, while Eastgate shows an impressive savings of 23.3 percent when fully utilized.

Several factors are involved in producing this discrepancy between the two corridors. One is that southeast corridor trips must travel along I-90, which was a much more costly road to build than was I-5 in the north corridor. Hence, replacing auto with transit trips results in greater savings in the southeast corridor than in the north.

Perhaps a more significant reason, however, is found by comparing the percentage breakdown of previous mode trips between the two corridors (see Figure 6). Both corridors are fairly similar in their percentages of drive to transit and car/vanpool trips. However, a significant difference exists between their walk to transit and auto drive alone trips. Park-and-ride lots in the southeast corridor drew a significantly greater proportion of auto drive alone trips from the roadway than did those in the

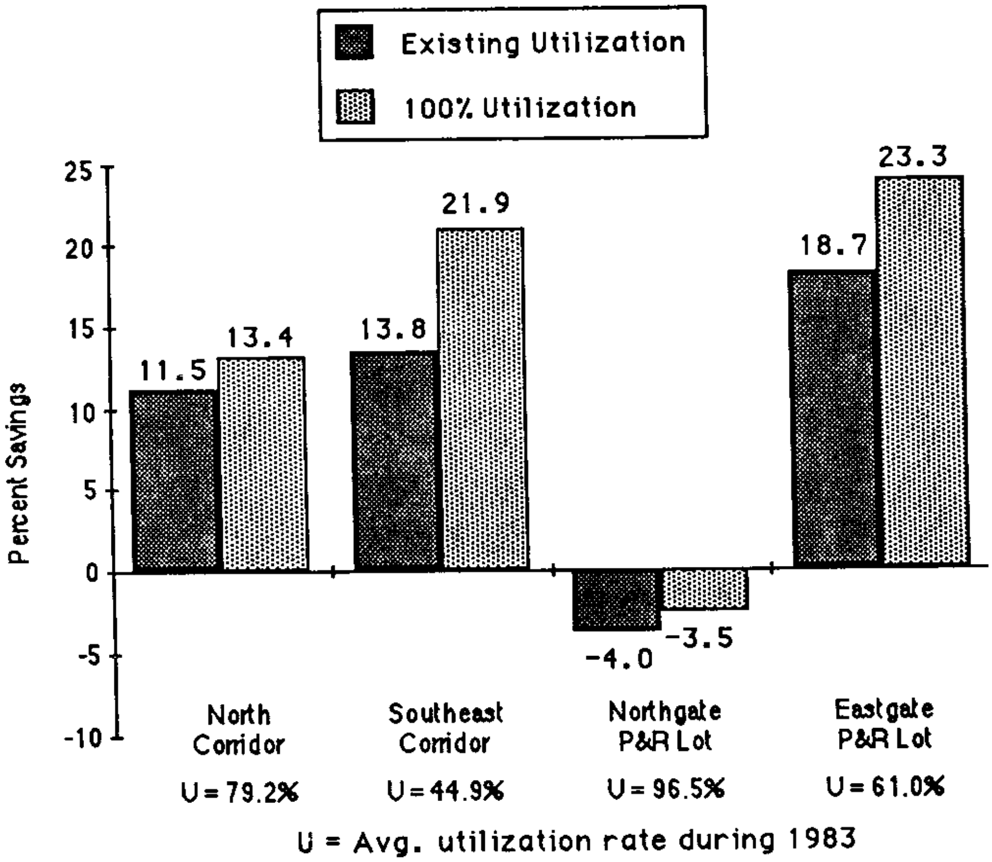


Figure 5. Total Trip Cost Savings Due to Park-and-Ride Lots by Corridor and by Selected Lots (Highway Capital Costs Included).

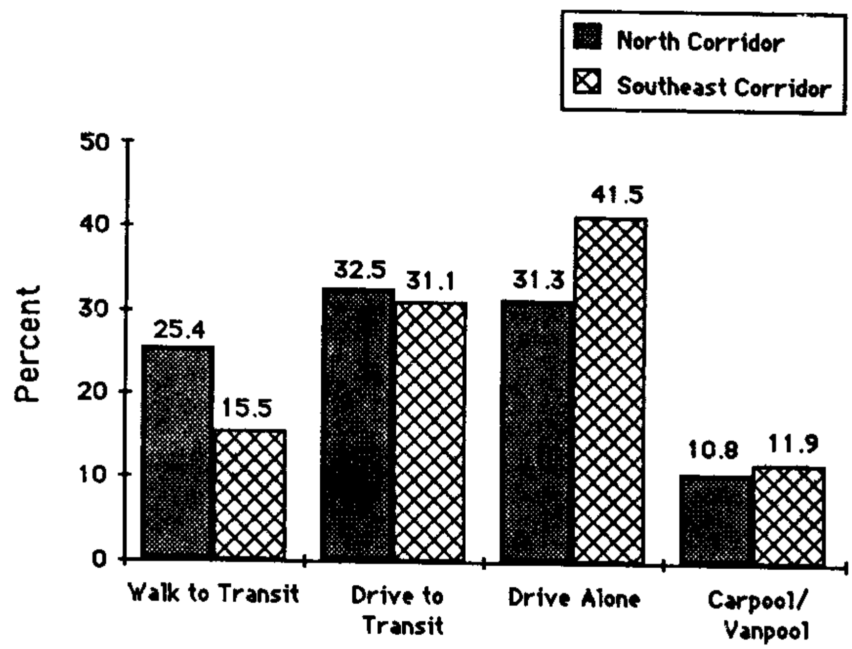


Figure 6. Previous Mode Percentage Breakdowns by Corridor.

north. At the same time, fewer southeast park-and-riders had previously walked to transit. When compared to the park-and-ride trip, the auto drive alone trip is far costlier while the walk to transit trip is less expensive (see Figure 3). Thus, the southeast corridor experiences a greater savings in overall trip costs than does the north corridor.

Figure 7 shows the general cost comparison results by corridor for the case in which highway capital costs are excluded from the cost analysis. In this case, the north corridor appears to fare better than the southeast (8.7 percent savings to 4.3). This is because estimated congestion costs are higher in the north corridor than in the southeast, while highway costs are much greater in the southeast than the north corridor. Thus, excluding highway costs from the analysis causes a greater reduction in park-and-ride trip savings in the southeast than it does in the north corridor.

An interesting note here is that for both situations discussed (with and without the inclusion of highway capital costs) the southeast corridor fares better than the north corridor when the lots are 100 percent utilized.

<u>**Sensitivity Analysis for Various Input Parameter Values**</u>

In determining the values for various input parameters, the researchers considered several values based on varying assumptions and sources. Most significant among these were those used for the value of time, highway costs, congestion costs, and auto owning and operating costs. Several values could be used for each of these parameters. Those used in the cost analysis just presented were those determined most reasonable for use in this study. However, for comparison purposes it was desirable to see how the cost analysis might change if different values were used for these parameters. In the course of the study, the general results of the model were found to be relatively insensitive to changes in estimates used for the value of time; however, they were sensitive to changes in highway, congestion, and auto costs.

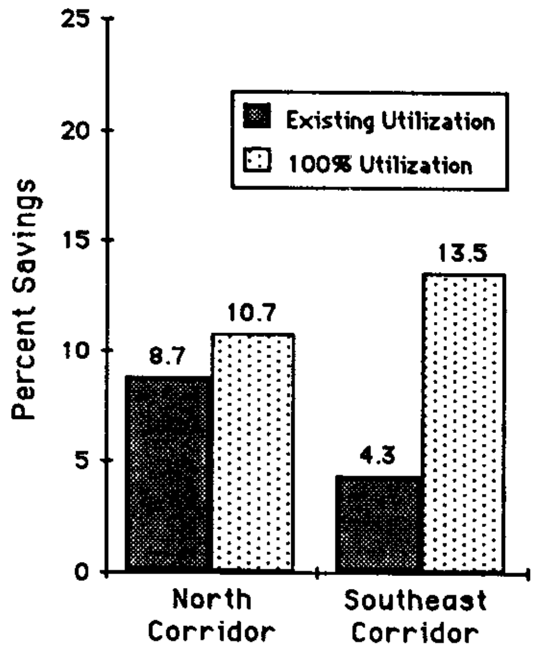


Figure 7. Trip Cost Savings Due to Park-and-Ride Lots by Corridor, Highway Costs Excluded.

General results of trip cost model runs for cases representing several different combinations of three primary input parameters (highway costs, congestion costs, and auto costs are presented in Figure 8). In this sensitivity analysis, highway costs ("peak period") were either included or not included and congestion costs were varied between low, medium, and high estimates. Auto costs were varied between FHWA (the most conservative), AAA (middle range), and Hertz (the highest cost estimates.) When considering these varying input combinations, park-and-ride lots proved to be cost effective for all but the most conservative situations (i.e., when highway capital costs were excluded, congestion costs were either excluded or the lowest estimate for them is used, and the lower range auto cost estimates were used).

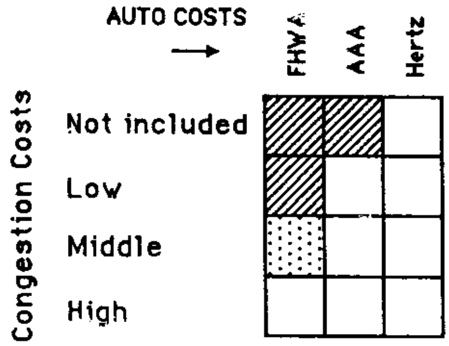
In a further sensitivity analysis, the trip cost comparison was conducted based on the most "extreme" sets of parameter value combinations. Of all the parameter values identified, those which would be most favorable to the previous mode trip (i.e., lower the cost of the previous mode trip more than that of the park-and-ride trip) were outlined as follows as extreme case #1:

- highway capital costs excluded,
- congestion costs excluded
- auto costs based on FHWA and P&R second car values (the park-and-ride second car concept and the Keeler-Small highway cost method are explained in detail in reference (5)),
- value of in-vehicle time is one-half the hourly wage rate, and
- the value of out-of-vehicle time is 3.33 times that of in-vehicle time.

Extreme case #2, that which was most favorable to the park-and-ride trip, was identified by the following parameter values:

- highway costs based on the Keeler-Small method,
- congestion costs based on the high estimates,

A)



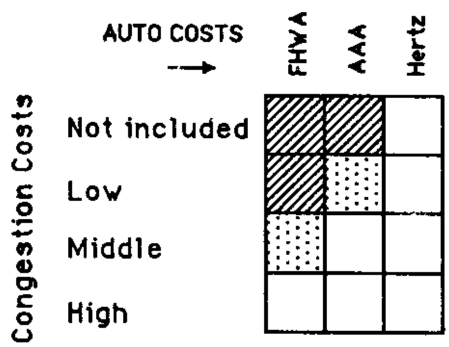
Other Parameter Assumptions

V = 1/3 x Hrly Wage

Vw = 2.5 x V

Highway Capital Costs not Included

B)



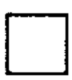
Other Parameter Assumptions

V = 1/3 x Hrly Wage

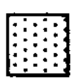
Vw = 2.5 x V

Peak Period Highway Costs

KEY



a. System is cost effective with this set of parameter values (i.e., the park-and-ride trip is less expensive than the previous mode trip).



b. Cost comparison breaks even (i.e., cost of the park-and-ride trip equals that of the previous mode trip).

c. System is not cost effective (i.e., the park-and-ride trip is more expensive than the previous mode trip).

V = Value of In-Vehicle Time

Vw = Value of Out-of-Vehicle Time (Excess Time)

Figure 8. Trip Cost Comparison Sensitivity Analysis for Various Input Parameter Values.

- auto costs based on Hertz estimates,
- in-vehicle value of time is equal to one-fourth the hourly wage rate, and
- the value of out-of-vehicle time is 1.5 times that of in-vehicle time.

The results of the first extreme case show the previous mode trip to be 7.2 percent less expensive than the park-and-ride trip ($8.50 to $9.16). The results of the other extreme case, however, indicated the previous mode trip to be 35.4 percent less expensive than the park-and-ride trip ($12.33 to $9.17). These extremes encompass a very broad range of possibilities as far as the trip cost analysis is concerned, and indicate that park-and-ride lots are highly likely to be cost effective for the situation analyzed in the preceding cost analysis.

Measures of Effectiveness

In order to provide a more comprehensive analysis, it was desirable to evaluate several measures of effectiveness independently, and in as much as possible, in terms of their own units rather than dollars. This was done for the following measures: travel time, person miles traveled, vehicle miles traveled, traffic volumes, vehicle emissions, accidents, and energy consumption. Table 2 presents a general summary of the evaluation of these individual measures of effectiveness.

For the most part, park-and-ride lots have had a small, yet positive impact with regard to individual measures of effectiveness. Although travel time and person miles traveled have slightly increased, the other measures -- vehicle miles traveled (VMT), traffic volumes, accidents, vehicle emissions, and energy consumption -- have experienced reductions. In other words, the negative impacts of slightly longer trip lengths and travel times for the commuter is offset by the positive effects of a more efficient transportation system (fewer VMT), fewer vehicle accidents, better air quality, and more efficient use of energy.

TABLE 2.
MEASURE OF EFFECTIVENESS EVALUATION SUMMARY

Measure of Effectiveness	Units	Estimated Percent Change: Park-and-Ride Trip vs. Previous Mode Trip
Travel Time	minutes/person trip	+13.3%
Person Miles Traveled	miles/person trip	+3.9%
Accidents	$ equivalent/person trip	-35.5%
Energy Consumption	gallon of gas/person trip	-21.3%

Measure of Effectiveness	Units	Estimated Net Percent Effect of Park-and-Ride Lots with Respect to Total Regional Values
Vehicle Miles Traveled	miles/day	-0.5%[1]
Traffic Volumes	vehicle trips/day	-1.3%[2]
Vehicle Emissions	grams/day	
carbon monoxide	grams/day	-0.09%[3]
hydrocarbons	grams/day	-0.12%[3]
nitrogen oxide	grams/day	-0.16%[3]
total suspended particles	grams/day	+0.08%[3]

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[1]Represents percent change with respect to total VMT on Interstate and principal arterials in King County.

[2]Indicates percent change due to park-and-ride lots on the I-5 segment immediately north of downtown Seattle.

[3]Represents percent change with respect to total air pollutants in King County.

CONCLUSIONS

General

The basic conclusion of this study is that park-and-ride lots in the Seattle metropolitan area, as a system, are cost effective. The benefits they provide to the general community justify their expense. Park-and-ride lots provide considerable savings to the user with respect to automobile and parking expenses and they also prove beneficial to both WSDOT and METRO -- the agencies directly involved. The investment WSDOT has made in the park-and-ride system has been significantly out weighed by user savings. With respect to METRO, park-and-ride trips have proven less costly to provide than other transit trips and in addition, the lots have contributed to an increase in transit ridership.

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CONCLUSIONS AND RECOMMENDATIONS

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General

The basic conclusion of this study is that park-and-ride lots in the Seattle metropolitan area, as a system, are cost effective. The benefits they provide to the general community justify their expense. Park-and-ride lots provide considerable savings to the user with respect to automobile and parking expenses and they also prove beneficial to the agencies directly involved.

As Figure 4-4 and the discussion in the "Agency and User Cost" section of Chapter Four indicate, the investment WSDOT has made in the park-and-ride system is outweighed by user savings. A study on park-and-ride lots in Texas (15) has shown that lot utilization increases as highway congestion increases. Given the fact that the Seattle area continues to grow, and that it is unlikely that any new freeway capacity in the area will be built, freeway congestion will undoubtedly increase unless alternative measures are taken. The park-and-ride system is among these alternative measures and is a moderately effective means which WSDOT can pursue to help alleviate the increasing congestion on Seattle area freeways. As for METRO, park-and-ride trips are less costly to provide than other transit trips. This is because lots are typically provided with express routes which have shorter transit run times and relatively high bus occupancies.

Another benefit of park-and-ride lots is that they play a significant role in increasing transit ridership. This is evidenced by the fact that only 55 percent of park-and-ride patrons previously used transit, while 85 percent currently use it. Park-and-ride lots make transit an attractive alternative to commuters living in areas in which, without such lots, transit would not be a feasible option.

In analyzing individual corridors, both the north and the southeast corridors, given their current utilization rates, appear to be good investments. The north corridor currently experiences relatively high lot utilization rates, while the southeast corridor is under-utilized. Thus, the southeast corridor has the potential to be an even better investment in the long run as the development continues and more commuters from that corridor make the trip to downtown Seattle.

The lots in the two corridors not analyzed, the northeast and the south, may prove to be even better investments than those in the corridors analyzed. This observation is based on a number of reasons. First of all, congestion costs in these two corridors are 2 to 12 times greater than those in the other corridors (see Table 3-8, Chapter Three). Second, lots in these corridors have diverted a higher amount of VMT from the roadways than those in the north and southeast corridors (see Table 4-1 and Figures 4-13 and 4-14, Chapter Four). And third, the distances between lots in these corridors and downtown Seattle are generally longer than those for the north and southeast corridor lots (the significance of this point will be explained in a later section of this chapter: "General Guidelines for Locating Park-and-Ride Lots"). These factors combined indicate that the lots in the northeast and south corridors are most probably more cost effective than those in the north and southeast corridors. In light of this, it is apparent that a detailed cost analysis based on all four corridors would provide an even stronger case for the basic conclusion of this study -- that park-and-ride lots in the Seattle metropolitan area are cost effective.

Another factor which, if considered, might provide an even stronger argument for park-and-ride lots has to do with "park-and-pool" use of the lots. As indicated in the "park-and-pool" section of Chapter Four, park-and-pool trips are more cost effective than "park-and-ride transit" trips. The cost analysis for this study included only park-and-ride trips destined for downtown Seattle -- of which only a small fraction (3.2 percent) were park-and-pool trips. Thirty percent of all park-and-ride trips go to destinations other than downtown Seattle, and 88 percent of these are park-and-pool trips (See Chapter Two, Figures 2-10 and 2-11). These trips represent a significant portion of park-and-ride trips and, if the entire park-and-ride system is to be evaluated, they should be considered. Doing so would provide an even stronger case for the conclusion that park-and-ride lots are cost effective.

The bases for these general conclusions include several assumptions regarding the value of various costs inherent in a commuter's trip. Most significant among these are the values for time costs, highway costs, congestion costs and auto costs. These are based, respectively, on the value of in-vehicle time being equal to one-third the commuter's hourly wage rate, and the value of out-of vehicle time being 2.5 times that of in-vehicle time; "peak period highway costs; middle range congestion costs; and AAA auto costs. Each of these is outlined in detail in Chapter Three. However, the majority of the other possible inputs discussed in Chapter Three, if used, would also yield the general result that park-and-ride lots are cost effective (see Figures 4-9 and 4-10, Chapter Four). Only with the use of the most conservative highway and auto cost inputs and the highest value of time do the lots become uneconomical.

As part of the sensitivity analysis (see Chapter Four), the most extreme cases of possible parameter combinations were identified and input into the trip cost model. The result indicated that for the parameter combination most favorable to the previous mode trip, the previous mode trip was only 7.2 percent less costly than the park-and-ride trip. However, when the other extreme was considered, the park-and-ride trip was found to be 34.5 percent less expensive than the previous mode trip. The most reasonable of the input parameter combinations lay somewhere between these two extremes. The large majority of the area between these two extremes represents cases in which park-and-ride lots are cost effective. This study has considered both ends of the spectrum with respect to time, highway, congestion and auto cost inputs and for the most reasonable of these, park-and-ride lots have proven cost-effective.

Individual Measures of Effectiveness

For the most part, park-and-ride lots have had a small yet positive impact with regard to individual measures of effectiveness. Although travel time and person-miles traveled have slightly increased, the other measures -- vehicle miles traveled (VMT), accidents, vehicle emissions, and energy consumption -- have experienced reductions. In other words, the negative impacts of slightly longer trip lengths and travel times for the commuter is offset by the positive effects of a more efficient transportation system (fewer VMT), fewer vehicle accidents, better air quality, and more efficient use of energy.

In 1976, when the majority of the lots in the park-and-ride system had been planned but not yet constructed, one study (3) estimated that the lots would save the equivalent of 73 lane- miles of freeway construction on various segments of I-5, I-90, I-405, and SR-520. However, results from the current research indicate that while this may not necessarily be the case, lots are having an impact in reducing traffic congestion. For instance, on I-5 between downtown Seattle and SR-520 -- where park-and-ride lots have the largest impact on traffic volumes -- 750 to 800 vehicles are diverted from the roadway during the peak hour. Spread across the 8 lanes operating in the peak direction (including the 4 reversible express lanes), this corresponds to a reduction of about 100 peak hour vehicles per lane.

An investigation of peak hour traffic on this segment of I-5 revealed typical peak hour lane volumes of around 1700 vehicles per hour (vph). Peak period traffic at this location is regularly congested. Data from the Traffic Systems Management Center

(TSMC) indicate peak hour speeds ranging from 25 to 45 mph.[1] Adding another 100 vph per lane would significantly contribute to the existing congestion and slow traffic down even further.

At this point it cannot be said that additional freeway lanes would need to be built if the park-and-ride system did not exist; however, park-and-ride lots do contribute to alleviating freeway traffic congestion, and, in doing so, are successful in the TSM sense of making existing transportation facilities more efficient.

General Guidelines for Locating Park-and-Ride Lots

By providing some insight into what makes a lot cost effective, this analysis can serve as a base for developing general guidelines for this purpose.

The lots that fare best are those for which a large percentage of users previously drove alone. Areas in which the use of local transit is not a viable option (i.e., local service is either sparse or nonexistent), and/or areas in which residents have a relatively high propensity for driving, have the highest potential for being a cost effective park-and-ride lot location. Conversely, areas which have reasonably good transit service (such as Northgate) are not necessarily good candidates for park-and-ride lots because, even though they may prove to be well utilized, lots in these areas would draw a large number of users away from local transit.

Based on the trip cost model results (see Appendix D: Trip Cost Model Output Tables), it also appears that lots located farther from downtown Seattle are more effective than those located closer to the CBD. A value of 12.9 miles was found to be the weighted average distance between the CBD and park-and-ride lots for which the average park-and-ride trip was calculated to be less expensive than the average previous

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1 During the course of the peak period, 5 minute interval speeds range between 15 and 50 mph, but predominantly fall into the 25 to 45 mph range.

mode trip. However, for lots for which the park-and-ride trip was more costly than the previous mode trip, the average weighted distance to the CBD was only 8.6 miles.

One reason for this result is that, in general, lots in denser areas closer to the CBD (such as the Northgate area where existing local transit service is relatively extensive) divert a higher proportion of walk-to-transit riders to the park-and-ride trip, whereas lots located farther out in the suburbs (where a high level of local transit service does not exist) divert more auto commuters to the park-and-ride trip.

RECOMMENDATIONS

Based on this study's conclusions, it is recommended that the park-and-ride program in the Seattle metropolitan area continue. The researchers recognize that the park-and-ride program in itself is not the complete answer to this area's problems of urban congestion, pollution, energy consumption, and vehicle accidents; however, it does aid in reducing the severity of these problems and should be continued as part of a package of TSM tactics focusing on these problems. Another TSM tactic which effectively complements the park-and-ride program is the high occupancy vehicle (HOV) lane priority program. HOV lanes are lanes reserved during peak periods for transit and car/vanpool vehicles. By avoiding general traffic congestion in the other lanes, HOV vehicles can travel faster than the general traffic. Such a program helps reduce the travel time of the park-and-ride trip and in doing so increases the attractiveness and cost effectiveness of the park-and-ride trip.

It is also recognized that in order for the park-and-ride program to be most effective, it has to be well managed. Locating park-and-ride lots is very important in this regard. Lot utilization rates have often been used to measure the successfulness of a lot. This study however, defines "successfulness" in slightly different terms. Although utilization rates are important, they are not a valid single measure of success. As this study has shown, a lot can be heavily utilized (e.g. Northgate at 96.5 percent) and still not be cost effective (the incurred cost of the park-and-ride trip from Northgate to downtown Seattle is 4.0 percent greater than that of the corresponding previous mode trip).

Thus, the researchers recommend that the general guidelines for cost effective park-and-ride lot location as outlined in this report be considered when locating future park-and-ride lots. However, they also recognize that these general guidelines can and should be further refined to provide a more valuable set of park-and-ride lot location guidelines.

AREAS FOR FURTHER RESEARCH

Several possibilities exist for further research related to this project. One is to expand this analysis to include the lots in the northeast and south corridors as well. The researchers assume that these corridors would also prove cost effective -- in fact, probably even more so than those already analyzed (see text). Research here could validate this.

Another possibility is to analyze the 30 percent of park-and-ride trips that go to destinations other than downtown Seattle. Among other things, this could provide considerable insight into the nature of park-and-pool trips, which comprise 88 percent of the park-and-ride trips destined outside of downtown Seattle. The indications of this study are that park-and-pool lots are more cost effective than park-and-ride transit trips. Park-and-pool trips represent a substantial portion of park-and-ride trips and need to be considered when evaluating the entire park-and-ride program.

Another idea for future research is to modify the model developed for the trip cost analysis and use it as a tool in testing and identifying locations for future park-and-ride lots. The primary task involved here would be to acquire information or develop assumptions regarding the previous modes of the would-be "park-and-riders."

Something which has been done to a limited extent in this study is an analysis of park-and-ride lot market areas (See Chapter Two). For lots in the southeast corridor, park-and-ride lot users addresses (from the park-and-ride lot survey) were plotted so that the "catchment area" for each park-and-ride lot was graphically portrayed. Some interesting observations can be made from these plots. For instance, the catchment area for one southeast corridor lot (which had a very low utilization rate) was located entirely within that of another. Performing this analysis for lots in the other three corridors may yield additional insight into successful park-and-ride lot locations.

Another related issue which needs further research involves the social costs of roadway congestion -- particularly in the Seattle area. This cost is a significant factor in determining park-and-ride system benefits. Prior work in this area is scarce and a need exists to identify and more accurately quantify the various components of congestion costs.

This study recommends the continuation of the park-and-ride program and suggests that locations farther from the central business district are best for future park-and-ride lots. Before such a policy is implemented, however, the issue of equity must be examined. Further research should be conducted related to the "fairness" of spending scarce transit funds on a system which appears to benefit only persons in the suburban areas. Perhaps research could identify if and how much park-and-ride lots indirectly benefit inner urban areas. If it is found that they do not then perhaps a fair proportion of transit funds can be identified for expenditures which would equally upgrade transit service in the more central urban areas.

Another implication of a policy which would encourage locating park-and-ride lots farther from the CBD is that, by providing better and more efficient service to outlying areas, this policy would encourage and induce longer trips -- thereby supporting urban sprawl. Before actively implementing such a policy, this issue should be more closely examined.

COST EFFECTIVENESS OF PARK-AND-RIDE LOTS IN THE PUGET SOUND REGION

CHAPTER ONE: INTRODUCTION

BACKGROUND AND STUDY PURPOSE

Park-and-ride lots have become an integral part of the nation's urban transportation system framework. In major urban areas throughout the United States such lots have been established to provide more efficient transportation and to assist in the conservation of energy. These lots are parking facilities, typically located some distance from the central business district (CBD), where the commuter changes from an automobile to some form of public transportation or ride sharing.

Implementing a park-and-ride lot program is considered a viable transportation system management (TSM) tactic (37). TSM basically involves making the most productive use of existing transportation resources through coordinated operations and improved management -- i.e., improving the efficiency of the existing system rather than expanding or replacing it. In these times of scarce resources, extensive capital improvements to the urban transportation framework are proving both economically and environmentally unfeasible. Thus, TSM is playing an ever increasing role in urban transportation improvement decisions.

As a TSM tactic, a park-and-ride program is expected to influence travelers in changing modes from single occupancy vehicles to either transit or ridesharing. Although the extent and/or significance of this modal change has seldom been quantified, it has been assumed that it has resulted in the positive effects of reduced VMT, congestion, accidents, vehicle emissions and energy consumption.

The Washington State Department of Transportation (WSDOT) worked with the Seattle Transit System between 1966 and 1970 to plan and implement a demonstration project to provide express bus services (Blue Streak) on Interstate 5. The project proved to be so successful that in 1970 Seattle Transit constructed the first permanent park-and-ride lot in the Northgate vicinity. Subsequently, METRO, which was formed originally to provide metropolitan regional sewage collection, treatment, and disposal facilities, was em powered to also provide metropolitan regional transit service. It acquired Seattle Transit and extended transit service to the King County boundaries.

WSDOT continued its planning involvement with METRO by providing additional park-and-ride lots in the Seattle metropolitan area. This culminated in the execution of a memorandum of understanding (MOU) between the two agencies in 1974. Under the terms of the MOU, the Department was to construct a number of park-and-ride lots near or adjacent to various state highway routes within the metropolitan area, utilizing appropriate funds (Interstate, state MVF and METRO matching dollars). METRO constructed other lots.

As of March, 1984, the Seattle/King County area had 26 permanent, 8 semi-permanent and 16 interim park-and-ride lots. These 50 lots contained a total of 12,520 automobile parking spaces. To date, WSDOT has spent approximately $47 million to construct the 26 permanent lots.

Planned additions to the existing park-and-ride system are extensive. Both METRO and the Puget Sound Council of Governments (PSCOG), the regional planning agency, recommend plans which would double the number of park-and-ride lots in the Seattle/King County region (1) (2).

Despite the substantial sums of money that have been invested and are planned for investment in park-and-ride lots, prior to this study little had been done to evaluate the total effectiveness of these lots. The initial goal of park-and-ride lots was to entice automobile commuters into express buses to alleviate freeway traffic congestion. Energy conservation became an additional objective with the advent of the Arab oil embargo in the early 1970s. To entice commuters from their cars to transit, the benefit to commuters has to be clear. Consequently, previous analyses of this topic have focused on benefits to the users through economic savings and energy conservation.

However, a need exists to take a more comprehensive and detailed look at the costs and benefits of park-and-ride lots, not only with respect to the user, but with respect to the community at large and to the public agencies responsible for providing for the community's transportation needs.

The purpose of this study is to make a significant contribution toward fulfilling that need.

GOALS AND OBJECTIVES

The basic goal of this study was to determine the cost effectiveness of existing park-and-ride lots with respect to the total transportation system in the Seattle metropolitan area. Results from this study may also be of use in the development of guidelines and tools for assessing the effectiveness of proposed park-and-ride facilities.

In meeting this goal, the basic objective was to provide a total cost effectiveness evaluation of the existing park-and-ride lot system which included looking at costs, benefits and other measures of effectiveness as they related to each of the following groups:

- the community at large,
- the public agencies involved,
- the park-and-ride lot user.

A "before" and "after" cost analysis was made to determine the effect park-and-ride lots have on overall trip costs. Trip costs, as referred to throughout this report unless otherwise stated, include much more than just out-of-pocket trip expenses. The full cost of a trip includes every conceivable cost incurred to provide for that trip. This involves the users' costs of time, vehicle operation and parking; public agencies' of roadway provision and maintenance, and transit service provision; the cost to roadway users due to traffic congestion; and other publicly incurred costs such as city planning and police services, and noise and air pollution. These trip cost components were quantified in terms of dollars and aggregated so that a "before" and "after" total cost comparison could be made.

In addition to the total public and private cost comparison, a "before" and "after" analysis was made for "user incurred" trip costs and for "public agency incurred" trip costs. Comparing costs from these three different perspectives gave a clearer view of how the benefits and costs of park-and-ride lots were distributed among the groups concerned.

To provide a more comprehensive assessment, park-and-ride lots were also evaluated on the basis of the following measures of effectiveness:

- travel time,
- person miles traveled (PMT),
- vehicle miles traveled (VMT),
- highway volumes,
- vehicle emissions,
- accidents,
- and energy consumption.

In developing this study, the question arose of whether highway capital costs, being "sunk" costs (i.e., the investment in them has already been made), should be included in the cost analysis. Arguments can be made both for and against including these costs in the analysis, depending upon the purpose of the study and the application of its results.

However, the basic purpose of this study was to determine the cost-effectiveness of the existing park-and-ride system in terms of the entire transportation system. Have the lots been a worthwhile investment? Since all the capital costs considered in this analysis -- including those for both freeways and park-and-ride lots -- are "sunk" costs, it is legitimate to include capital costs, including those for freeways, in the cost analysis.

Another strong argument for the inclusion of highway capital costs is that, with respect to the park-and-ride system, WSDOT's "participation with gas tax money is based on the premise that the construction of the park-and-ride lot system will relieve the need for the construction of additional highway lanes" (28). Whether this is true or not will be analyzed and discussed in this report.

Another instance in which highway capital costs should be included is that in which the transportation system of the given area is in its infancy. In other words, the construction of either freeway lanes or a park-and-ride system are both viable alternatives (neither are "sunk" costs in this case). In this instance, the trading off of the cost of freeway capacity with that of the park-and-ride system is an appropriate strategy.

However, there are also scenarios in which including highway capital costs is not necessarily appropriate. One such case involves analyzing the cost effectiveness of a single proposed park-and-ride lot. For this case, highway capital costs are "sunk" but the cost of the lot is not. Given a situation in which it is highly unlikely that many additional freeway lanes will be built (which is the case for most major urban areas in the U.S., including Seattle), the trade-off between the cost of the park-and-ride lot would not be the cost of additional freeway construction, but rather the cost associated either with the increased freeway congestion which would result if the lot were not built, or with the cost of implementing an alternative TSM tactic of equivalent effectiveness, or else with the cost of implementing some other form of mass transportation.

Since a sidelight of this study is to provide a base which may be used in developing general guidelines for evaluating the effectiveness of future park-and-ride lots, the above scenario was considered. For this, general estimates of congestion costs were developed for inclusion in the cost analysis. Due to limited resources, costs of alternative TSM tactics or mass transit options were not developed.

STUDY NOTES AND SCOPE

This study included a survey of park-and-ride lot users which provided much of the information used in the cost effectiveness and benefit cost evaluations. The survey covered 26 lots in the Seattle metropolitan area. These 26 lots were divided into four corridors as shown on the study area map in Figure 1-1. For this study, some measures of effectiveness were evaluated over the entire 26 lots, but due to limited resources, the majority of the analysis was performed on just two corridors -- the north and the southeast -- consisting of 11 lots. These two corridors were chosen because they exhibit the relative extremes of Seattle area park-and-ride lot utilization. The north corridor lots had the highest combined utilization rate while the southeast lots had the lowest. The north corridor is in a relatively mature stage while the southeast corridor is still young and growing. Encompassing these two corridors in the analysis enveloped both ends of the spectrum of park-and-ride lots in the Seattle area.

Park-and-ride lots in the Seattle area were designed primarily to serve the suburban commuter trip to downtown Seattle. This is reflected in the fact that 95 percent of park-and-ride trips are work trips, and 70 percent of those from the north and southeast corridors go downtown. This study focuses on this primary park-and-ride trip -- the work trip to downtown Seattle -- in its before and after analysis. In addition, all cases in which the mode used before using the park-and-ride lot (i.e., the "previous mode") was unknown -- or in which no previous trip was made -- were discarded, leaving a total of 467 cases from which the detailed cost analysis was performed. This case selection process is summarized in Table 1-1.

Various component costs comprise the full incurred cost of a commuter trip. For many of these cost components there is not one single value which can be assigned to it

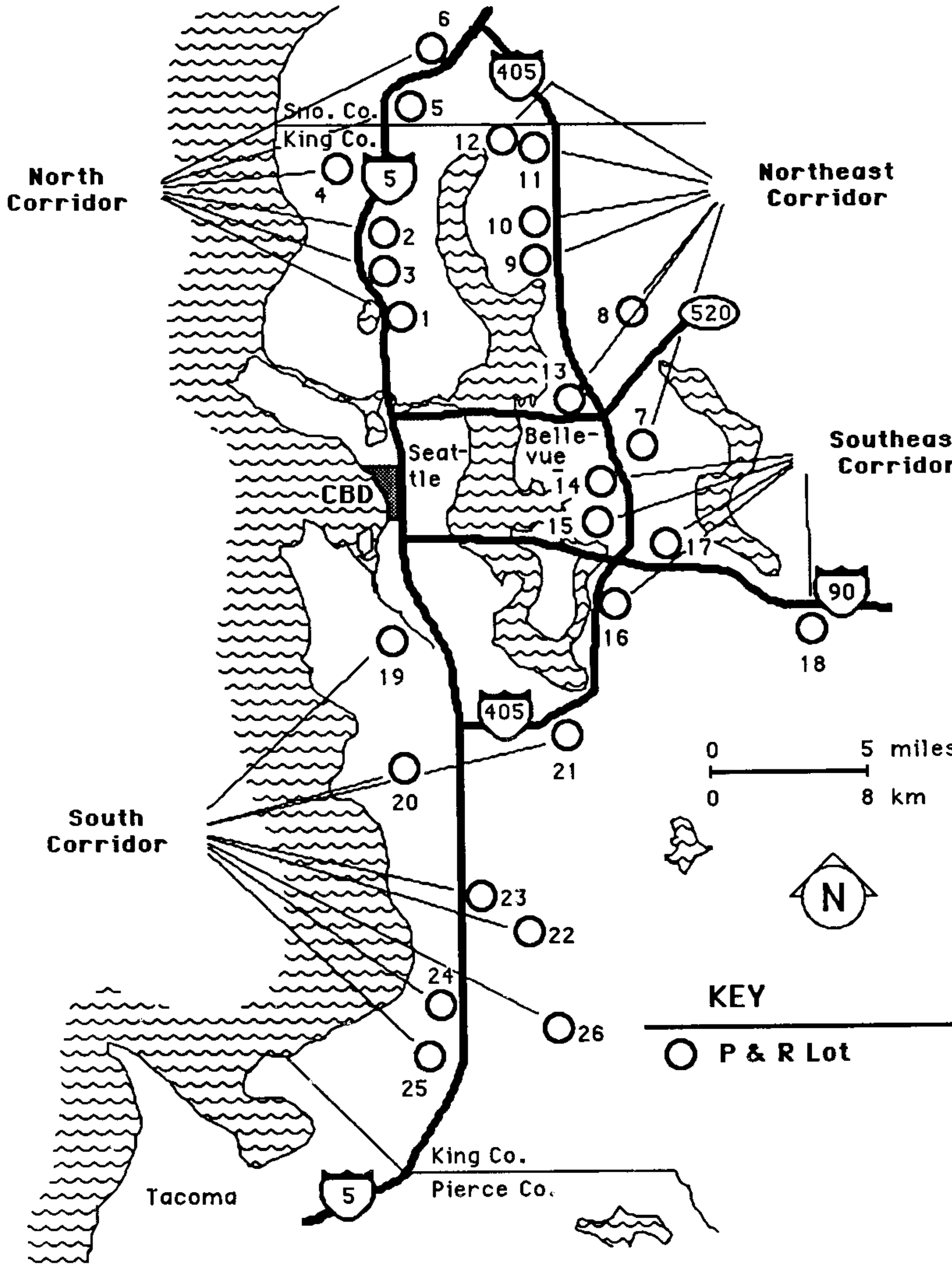

Figure 1-1. Park-and-Ride Lot Study Area Map.

KEY TO PARK-AND-RIDE LOT NUMBERS

Number on Map	Lot Name
North Corridor	
1	Greenlake
2	North Seattle
3	Northgage
4	Shoreline
5	Mountlake Terrace
6	Lynnwood
Northeast Corridor	
7	Overlake
8	Redmond
9	Kingsgate
10	Brickyard
11	Bothell
12	Kenmore
13	South Kirkland
Southeast Corridor	
14	Wilburton
15	South Bellevue
16	Newport Hills
17	Eastgate
18	Issaquah
South Corridor	
19	Olsen-Meyers
20	Burien 362
21	South Renton
22	Kent
23	Kent-Des Moines
24	Star Lake
25	Federal Way
26	Auburn

Figure 1-1. Park-and-Ride Lot Study Area Map (Continued)

TABLE 1-1.
CASES FOR WHICH IN-DEPTH TRIP COST ANALYSIS WAS PERFORMED

In-depth trip cost analysis was perofrmed for cases which represented only

- north and southeast corridors,
- work trips, and
- Seattle CBD destined trips.

Cases were discarded for which the previous mode listed was

- "did not make trip," or
- "other."

In total, 467 cases were analyzed in the two corridor area.

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which will satisfy all points of view. For instance, based on information from the Federal Highways Administration (FHWA), the cost per freeway mile of owning and operating an intermediate size automobile is $0.240. Many would consider this to be too conservative and believe that the $0.339 based on American Automobile Association (AAA) data is more realistic. Where differences such as this existed total trip costs using each of the possible values for the cost component in question were calculated. This naturally resulted in different trip costs and different trip cost comparisons. When several cost components were varied in different combinations, a wide range of trip costs and comparisons resulted. These costs are all presented along with clear notation defining the assigned value of each cost component involved. A recommendation is made as to which complete set of assumptions is considered most reasonable. The recommended set was used in the detailed trip cost analysis.

REPORT ORGANIZATION

This introductory chapter is followed by "Chapter Two: Park-and-Ride Lot Survey," which briefly describes the development and conduction of the park-and-ride lot survey and discusses its results. "Chapter Three: Analytical Methods" outlines the development of the commuter trip cost model. "Chapter Four" presents the results from the trip cost model and the effectiveness evaluation along with an analysis of these of each. "Chapter Five" summarizes a separate but related study on the energy intensity of the Seattle area park-and-ride system. Significant conclusions and recommendations are put forth in the sixth and final chapter, "Practical Implications." The list of references and the appendices comprise the remainder of the report.

CHAPTER TWO:
PARK-AND-RIDE LOT SURVEY

DEVELOPMENT AND CONDUCTION OF SURVEY

A lot of the data needed for this study were available through traditional sources. However, certain types of data regarding the park-and-ride lot user were not available and had to be obtained with a special survey. What follows is a brief overview of the development and conduction of this survey. A more detailed description is contained in Appendix A.

The following list of required information was developed which could be obtained from park-and-ride lot users:

- travel modes:
  - mode before using park-and-ride lot (previous mode)
  - mode from origin to park-and-ride lot
  - mode from park-and-ride lot to destination
- vehicle occupancies:
  - park-and-ride lot access trips
  - park-and-ride lot to destination trips and for park and pool trips
- trip origin and destination (to nearest street intersection)
- trip purpose
- park-and-ride lot use frequency
- access trip and carpool vehicle data such as vehicle make, model, and year
- vehicle ownership information
- transit routes and runs used
- parking fee at destination for poolers.

Based on this information, survey questions were developed which would provide a composite yet still anonymous picture of the park-and-ride lot user. It was decided that a windshield-placed, mail-back, business-reply survey was the most cost-effective means of acquiring the necessary data.

The survey questionnaire was drawn up, reviewed and revised, and then used in a pilot survey at two large park- and-ride lots (Federal Way and Kingsgate). One hundred cars within each lot were chosen for the pilot survey. The pilot survey produced a return rate of 29 percent with a good quality of response. It was determined that approximately 2,000 survey responses would give adequate statistical significance to the survey results. It was estimated that 6,500 stalls in the 26 lots were currently used. Given this, and the 29 percent pilot survey return rate, it followed that all lots and all used stalls would have to be surveyed to attain the desired level of response.

The final revision of the questionnaire resulted in the 16 question form shown in Figure 2-1. The bulk of the survey (24 lots) was conducted on Thursday, June 2, 1983. Two additional lots were surveyed on the following day.

In all, 6,138 forms were distributed and 2,402 were returned for an overall return rate of 39.1 percent. Table 2-1 gives the general survey information by lot and by corridor.

The survey forms were sorted, edited and coded by TRAC survey staff. Origin and destination census tracts and traffic analysis zones (TAZ's) were determined individually for each case from questions 4 and 5 on the survey form. All the coded survey data were then entered into a computer data file to be analyzed and used in a number of ways.

SURVEY RESULTS

Simple tabulations of the survey are indicated on the survey form in Figure 2-1. Initial analysis of the edited and validated survey data were presented in a separate

0597

Dear Park-and-Ride user:

This survey is being conducted by the Washington State Transportation Center to determine the cost effectiveness of Park-and-Ride lots in the Seattle Metropolitan area. This study is funded under a contract with the Washington State Department of Transportation.

Your cooperation in filling out this questionnaire and mailing it to the Transportation Center will provide data from which savings and benefits to users and the community can be calculated. If you experience difficulty in completing the questionnaire, please call 543-7331 in Seattle.

Please mail as soon as possible so that your comments can be incorporated in the final study results. Thank you for your assistance.

1a HOW DID YOU TRAVEL TO THE PARK-AND-RIDE LOT THIS MORNING? (Check only one box)

5☐ Drove alone 94.7%
6☐ Carpooled with others 7.2%
7☐ Vanpooled with others 0.0%
8☐ Other ______ 0.1% (Please specify)

1b TOTAL NUMBER OF PEOPLE IN VEHICLE, INCLUDING DRIVER: 9 10 ☐☐ 1.081 (Avg.)

2 HOW DID YOU TRAVEL FROM THE PARK-AND-RIDE LOT TO YOUR DESTINATION TODAY? (Check only one box)

11☐ Public transit 84.7%
12☐ Carpooled with others 10.0%
13☐ Vanpooled with others 4.8%
14☐ Other ______ 0.4% (Please specify)

3 BEFORE USING THIS PARK-AND-RIDE LOT, HOW DID YOU USUALLY TRAVEL TO YOUR DESTINATION? (Check one box only)

15☐ Walked to public transit 14.0%
16☐ Drove to public transit 19.7%
17☐ Drove alone 33.9%
18☐ Vanpooled with others 1.0%
19☐ Carpooled with others 12.5%
20☐ Didn't make the trip before 17.7%
21☐ Other ______ 1.3% (Please specify)

4 WHERE DID YOU START YOUR TRIP THIS MORNING? (eg. HOME)

The nearest intersection is ______ and ______

and the zip code is 9 8 ☐☐☐ (22 23 24) ☐☐☐☐☐ (25 26 27 28 29) ☐☐☐ (30 31 32)

5 WHERE DID YOU END YOUR TRIP THIS MORNING? (eg. WORK)

The nearest intersection is ______ and ______

and the zip code is 9 8 ☐☐☐ (33 34 35) ☐☐☐☐☐ (36 37 38 39 40) ☐☐☐ (41 42 43)

6 THE PURPOSE OF THIS TRIP WAS: (Check one box only)

44☐ Work 94.6%
45☐ College or Trade School 3.7%
46☐ Shopping 0.4%
47☐ Other ______ 1.3% (Please specify)

7 WHAT TYPE OF VEHICLE DID YOU DRIVE TO THE PARK-AND-RIDE LOT?

Make ______ ☐☐☐☐☐ (48 49 50 51 52) Model ______ ☐☐☐☐☐ (53 54 55 56 57)

Year: 1 9 ☐☐ (58 59) 8.2% Number of Cylinders ☐ (60) 5.6 (Avg.)

Type of Transmission: (Check one) 61☐ Automatic 56.3% 62☐ Manual 43.7%

8 HOW MANY LICENSED MOTOR VEHICLES ARE KEPT IN YOUR HOUSEHOLD? (Check one box only)

63☐ One 23.7% 64☐ Two 48.8% 65☐ Three 19.5% 66☐ Four or more 8.1%

9 HOW LONG DID IT TAKE YOU TO TRAVEL FROM YOUR HOME TO WORK, COLLEGE OR OTHER DESTINATION TODAY?

67 ☐ Hour 0 68 69 ☐☐ Minutes 4 8 (Avg.)

10 HOW MANY TIMES DO YOU USE THIS PARK-AND-RIDE LOT IN AN AVERAGE WEEK? (Check one box only)

70☐ Five 74.9% 71☐ Four 14.4% 72☐ Two or three 7.1% 73☐ One or less 3.5%

IF YOU USED PUBLIC TRANSIT FROM THE PARK-AND-RIDE LOT TO YOUR DESTINATION TODAY, PLEASE ANSWER QUESTIONS 11 AND 12 ONLY.

IF YOU JOINED A CARPOOL OR VANPOOL AT THE PARK-AND-RIDE LOT TODAY, PLEASE ANSWER QUESTIONS 13 THROUGH 16 ON BACK PAGE.

11 WHICH TRANSIT ROUTE(S) DID YOU TAKE TO YOUR DESTINATION THIS MORNING?

Route number ______ ☐☐☐☐ (74 75 76 77) Departure time: ☐☐:☐☐ (78 79 80 81)

If you transferred: Route number ______ ☐☐☐☐ (82 83 84 85) making your bus

transfer at intersection of ______ and ______ ☐☐☐ (86 87 88)

12 WHICH TRANSIT ROUTE(S) DID YOU TAKE TO THE PARK-AND-RIDE LOT THIS AFTERNOON?

Route number ______ ☐☐☐☐ (89 90 91 92) Departure time: ☐☐:☐☐ (93 94 95 96)

If you transferred: Route number ______ ☐☐☐☐ (97 98 99 100) making your bus

transfer at intersection of ______ and ______ ☐☐☐ (101 102 103)

End of Survey. Thank You Very Much. Please Mail Promptly.

Carpool/Vanpool Questions on Back Page.

Figure 2-1.
Survey Form with General Tabulated Results.

13 HOW MANY PERSONS WERE IN YOUR CARPOOL OR VANPOOL TODAY, INCLUDING DRIVER?

104 105
5.27 (Avg.) ☐☐ (Please specify number)

14 IS YOUR VEHICLE EVER USED AS THE CARPOOL/VANPOOL FROM THE PARK-AND-RIDE LOT TO YOUR DESTINATION?

106☐ Yes, ☐☐ % of the time. 109☐ No
107 108

15 HOW MUCH IS THE PARKING FEE AT YOUR DESTINATION?

110 111 112 113
$☐☐.☐☐ per 114☐ Day 115☐ Week 116☐ Month (Check one)
.59 NA 22.20 (Avgs.)

16 WHAT TYPE OF VEHICLE DID YOU CARPOOL/VANPOOL IN TODAY?

Make ______ Model ______

117 118 119 120 121 ☐☐☐☐☐ 122 123 124 125 126 ☐☐☐☐☐

Year: 1 9 ☐☐ (127 128) 5.6 (Avg. Age) Number of Cylinders 129☐ 6.2 (Avg.)

Type of Transmission: (Check one) 130☐ Automatic 67.3% 131☐ Manual 32.7%

End of Survey. Thank You Very Much. Please Mail Promptly.

OFFICIAL PARK AND RIDE SURVEY

63-1198

OFFICIAL
PARK and RIDE
SURVEY

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 429, SEATTLE, WASHINGTON

POSTAGE WILL BE PAID BY ADDRESSEE

WASHINGTON STATE TRANSPORTATION CENTER
121 MORE HALL, FX-10
UNIVERSITY OF WASHINGTON
SEATTLE, WA 98105

Figure 2-1.
Survey Form with General Tabulated Results (Continued)

TABLE 2-1.
SURVEY DISTRIBUTION SUMMARY

Corridor and Lot Name	Number of Stalls	Surveys Distributed	Percent. Utilization	Surveys Returned Number	Surveys Returned Percent
North					
1st NE & NE 100	99	72	72.7	30	41.7
Northgate	515	80	93.2	186	38.8
Shoreline	378	210	55.6	69	32.9
Lynnwood	808	735	91.0	207	28.2
Mountlake Terrace	337	62	18.4	32	51.6
NE 65th at I-5	185	119	64.3	49	41.2
Corridor Totals	2322	1678	72.3	573	34.1
Southeast					
Wilburton	190	121	63.7	47	38.8
South Bellevue	362	46	12.7	18	39.1
Eastgate	626	342	54.6	163	47.7
Issaquah	358	243	67.9	93	38.3
Newport Hills	284	60	21.1	28	32.1
Corridor Totals	1820	812	44.6	349	43.0
Northeast					
Overlake*	NA	NA	NA	NA	NA
Redmond	344	213	61.9	101	47.4
Kingsgate	502	326	64.9	122	37.4
Brickyard Road	207	159	76.8	46	28.
Bothell	163	125	76.7	57	45.6
Kenmore	432	330	76.4	144	43.3
South Kirkland	603	457	75.8	204	44.4
Corridor Totals	2251	1610	71.5	674	41.9
South					
Olson Meyers	562	91	16.2	44	48.4
Burien	362	211	58.3	90	42.7
Kent-Des Moines	235	163	69.4	75	46.0
Star Lake	499	177	35.5	74	62.2
Federal Way	789	651	97.0**	232	35.6
Auburn	367	216	58.9	74	34.3
Kent	729	298	40.9	125	41.9
South Renton	370	231	62.4	81	35.1
Corridor Totals	3913	2038	52.1	795	39.0
System Totals	10306	6138	60.7	2402	39.1

* Due to circumstances, this lot was not surveyed.

** Utilization percentage incorporates 114 surveys distributed in the Federal Way lot in a test survey. Surveys returned from this test are not included in the final survey.

report which has been included as Appendix B of this report. A more in-depth analysis of selected survey results is included in the following section.

ANALYSIS OF SURVEY RESULTS

Comparison of Corridor Results

An investigation of the survey results reveals strong similarities among corridors, but also some unique characteristics. The categories "Percent Utilization" and "Mode from Lot" are most immediately revealing for determining effectiveness. The average annual utilization rates (provided by Metro) show the changes in lot utilization and capacity for the years 1979 - 1984 (see Figure 2-2) and give a more accurate picture of utilization then one day surveys. Comparing the corridors, the Southeast and South corridors have low utilization rates when compared to the North and Northeast corridors.

The lower utilization of the Southeast corridor is a result of two lots within the corridor which greatly upset the corridor average (see Figure 2-3 for utilization at time of TRAC survey). Eliminating the effects of these two lots and two other low utilization lots which upset the averages of the two other corridors (one each in the north and south corridors) brings the percent utilization for each of the corridors into line with the overall percent utilization.

Utilization by Lot

The South Bellevue lot opened in February 1981 and has since experienced extremely low utilization (down to 12.7 percent in 1982, see Figure 2-4). As the second largest lot in the Southeast corridor, its 362 stalls reflect 19.9 percent of the corridor capacity. It is the closest to the Seattle CBD of three lots located along I-90. By 1984 its utilization had risen to only 18.0 percent.

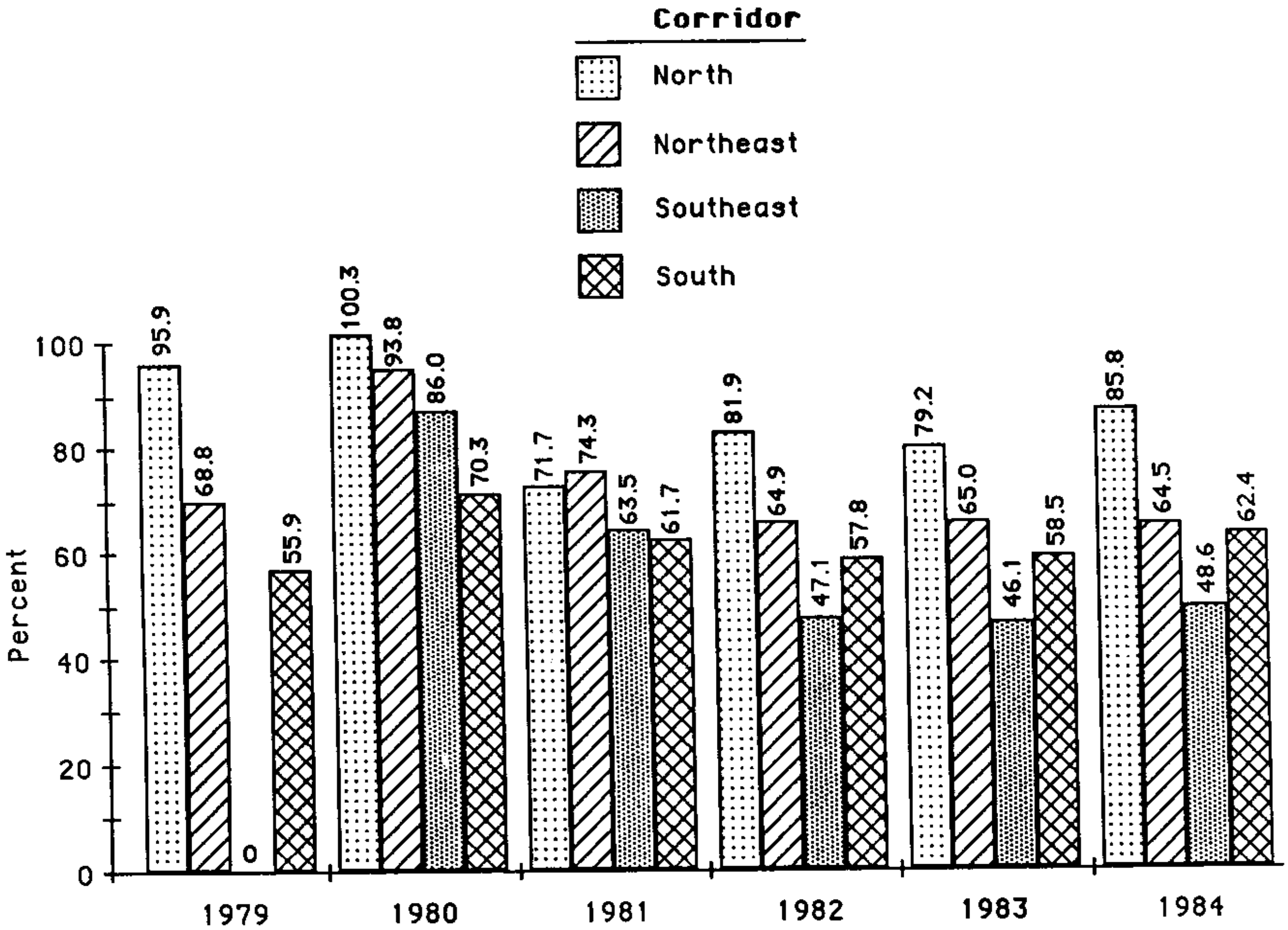
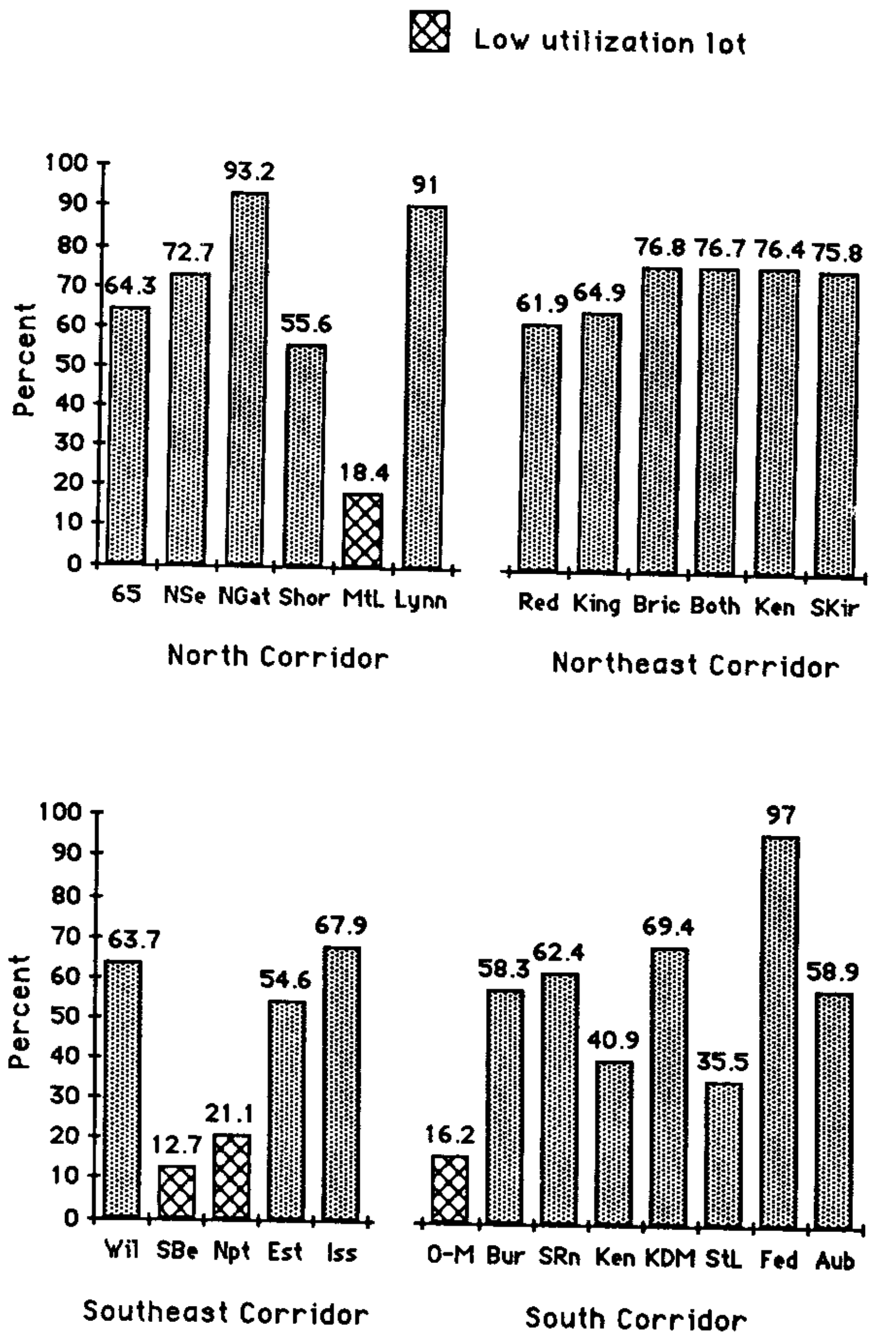


Figure 2-2. Annual Average Utilization of Park and Ride Lots - Corridor Comparisons.



Note: See Table 2-1 for key to lot names.

Figure 2-3. Utilization Rates of Park-and-Ride Lots at Time of TRAC Survey.

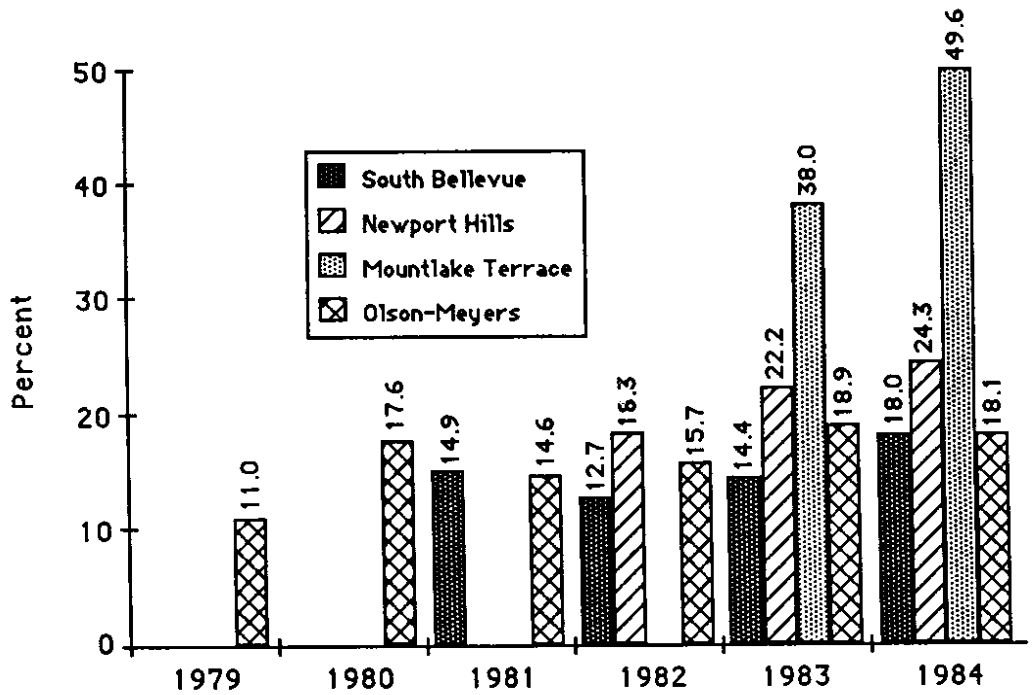


Figure 2-4. Average Annual Utilization Rate of Lots with Low Utilization.

The Newport Hills lot, also in the southeast corridor, opened in June, 1982. Since then its utilization has only increased to 24.3 percent.

In the Northeast corridor, the Mountlake Terrace lot is the only one with a seriously low occupancy, 18.4 percent. It had been opened just prior to the TRAC survey, in April, 1983. Metro's figures show that the average annual utilization for 1984 was 49.6 percent. The low utilization noted by the TRAC survey can be attributed to the lot's recent implementation.

In the South corridor the Olson-Meyers lot has had its average annual utilization increase from 11.0 percent (1979) to only 18.1 percent (1984). At 562 stalls, it has the sixth largest capacity of any of the lots in the survey. The lot opened in September, 1979, and its low utilization rate is quite firmly established.

A common factor of the three lots still reflecting serious under-utilization in 1984, is their proximity to the Seattle CBD, as shown in Figure 2-5. Figure 2-6 gives a closer look at the two lots in the southeast corridor and suggests explanations for their low utilization rates. The catchment area of the trip origins of users of any given lot is a tear-drop shape. The narrow end of the tear drop is located at the park-and-ride lot and the wide end fans out from it, in a direction away from the Seattle CBD. As might be expected the origin densities relate strongly to the lots' utilization rates. Users tend to select the lot closest to their origin which is located between their origin and the CBD.

The South Bellevue lot is the closest to the Seattle CBD of the Southeast corridor lots. The lot is removed from concentrated trip origin densities of park-and-ride lot users. Its catchment area is very small and the majority of users within this catchment prefer the Wilburton lot.

A possible problem with respect to the Newport Hills lot is its proximity to the division between the Southeast corridor catchment area and the South corridor

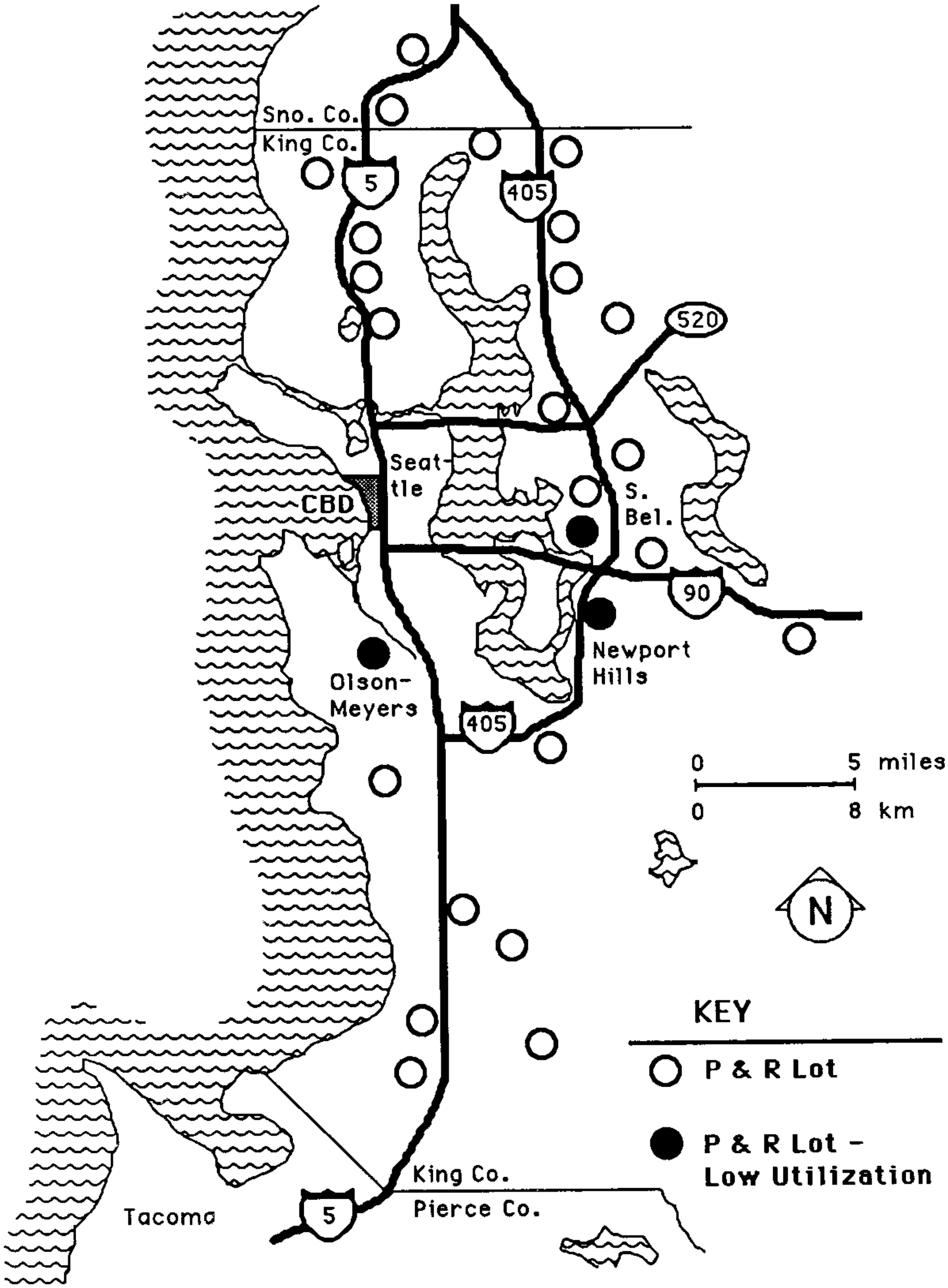


Figure 2-5. Location of Park-and-Ride Lots with Low Utilization.

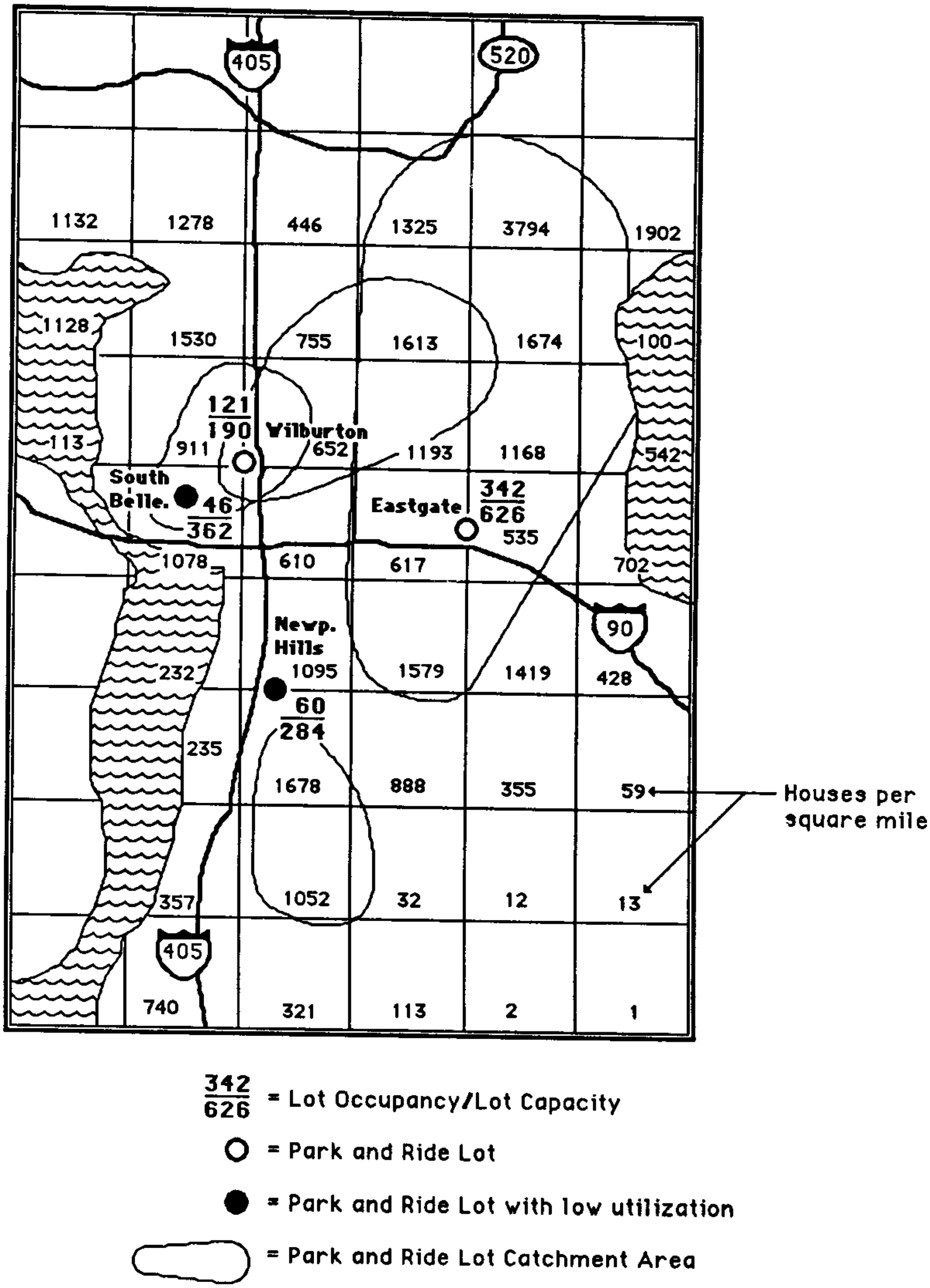


Figure 2-6. Relationship between Location and Population Density for Several Southeast Corridor Lots.

catchment area. With its location relative to the three other South east corridor lots, it must draw users from the area to the south. A user whose origin is more than two or three miles south of the Newport Hills lot may well choose to use a park-and-ride lot from which the bus routes travel around the south end of Lake Washington to avoid the congestion of the I-90 bridge (if destined for the Seattle CBD). This would preclude use of the Newport Hills lot.

The South Bellevue and Newport Hills lots face serious utilization difficulties. Figure 2-6 shows the number of households in each square mile. The Wilburton and Eastgate lots are further from the Seattle CBD than are the South Bellevue and Newport Hills lots, but household density is higher in their catchment areas. If the population densities of the South Bellevue and Newport Hills lots' catchment areas increase to become more in line with densities just several miles further out (from the Seattle CBD), their utilization rates may improve.

The Olson-Meyers lot has different site characteristics than the two above-mentioned lots. It is located in the Duwamish industrial area to the south of the Seattle CBD. While other lots are located in the user's neighborhood, the immediate surrounding area of the Olson-Meyers lot does not include residences. This indicates that most users would have to travel a greater distance to arrive at this lot than would users of other lots. Since this lot is among the lots closest to the CBD (in terms of driving time), it may well be that the transfer to public transit here is less desirable than either connecting to transit at a point closer to one's origin or simply driving into the CBD.

Several lots have very high average annual utilization and appear to be examples of successful locations. Later in this report (Chapters 4 and 6), the term "successfulness" as it pertains to this cost effectiveness study is qualified. Certainly, utilization plays an important role, but it is not the only indicator of a successful park-and-ride lot. In the North corridor two lots have very high utilization: Northgate, at 96.1 percent (1984), and

Lynnwood, at 104.7 percent (1984). In the south corridor the Federal Way lot has an average annual utilization of 104.7 percent (1984). When rates are this high there can be uncertainty on the part of the user as to the availability of parking space. Clearly, in these areas the demand exceeds the supply.

<u>Mode from Lot</u>

Each corridor has one lot with a rate of carpooling and/or vanpooling significantly higher than the overall rate (10.2 percent carpooling, 4.7 percent vanpooling). Car and vanpooling rates for these lots are presented in Figure 2-7, and their relative locations are indicated in Figure 2-8.

In the North corridor the Northeast 65th and I-5 lot has a vanpool rate of 44.9 percent and a carpool rate of 22.4 percent. A majority of these car/vanpoolers (59.2 percent) had Everett-Mukilteo as a destination. An additional 22.2 percent car/vanpooled to Auburn, while none car/vanpooled to the Seattle CBD (see Figure 2-9).

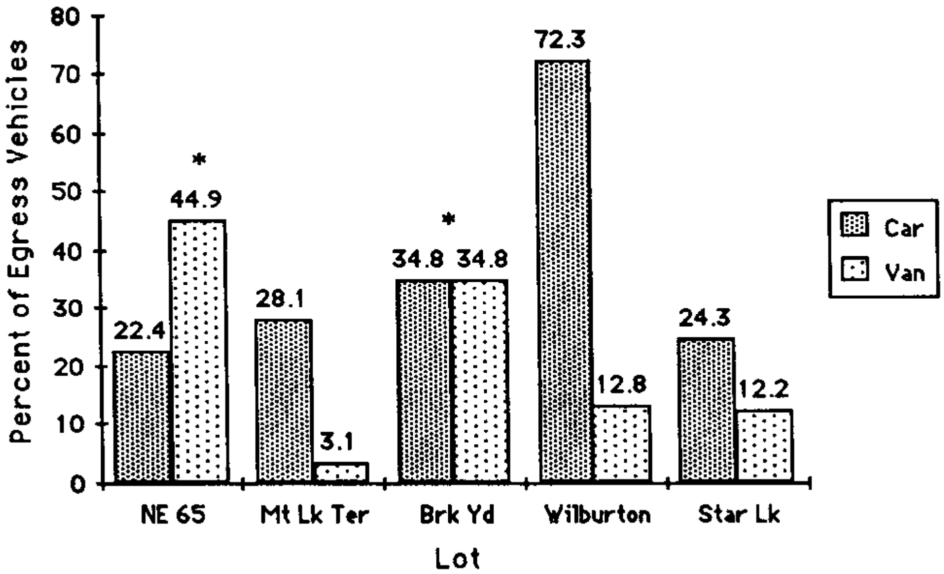
The Mountlake Terrace lot has a 28.1 percent carpool rate but this reflects only nine respondents. The most popular destinations are the Seattle CBD and the Boeing-Duwamish area.

In the Northeast corridor the Brickyard lot has a 34.8 percent carpool rate and an identical (34.8 percent) vanpool rate.

In the Southeast corridor the Wilburton lot has a carpool rate of 72.3 percent. One third of these are destined for Mukilteo, 23.3 percent for Bellevue, and 20.0 percent for the South Center area. None is destined for the Seattle CBD.

In the South corridor the Star Lake lot has a 24.3 percent carpool rate and a 12.2 percent vanpool rate.

Analysis of destinations from all lots in the North and Southeast corridors shows only 12.0 percent of car/vanpoolers were destined for the Seattle CBD. This destination ranked third, with the South Center area and Boeing-Mukilteo destinations



* Lots began as Park-n-Pool lots.

Figure 2-7. Car/vanpooling from Lots with High Car/vanpooling Rates.

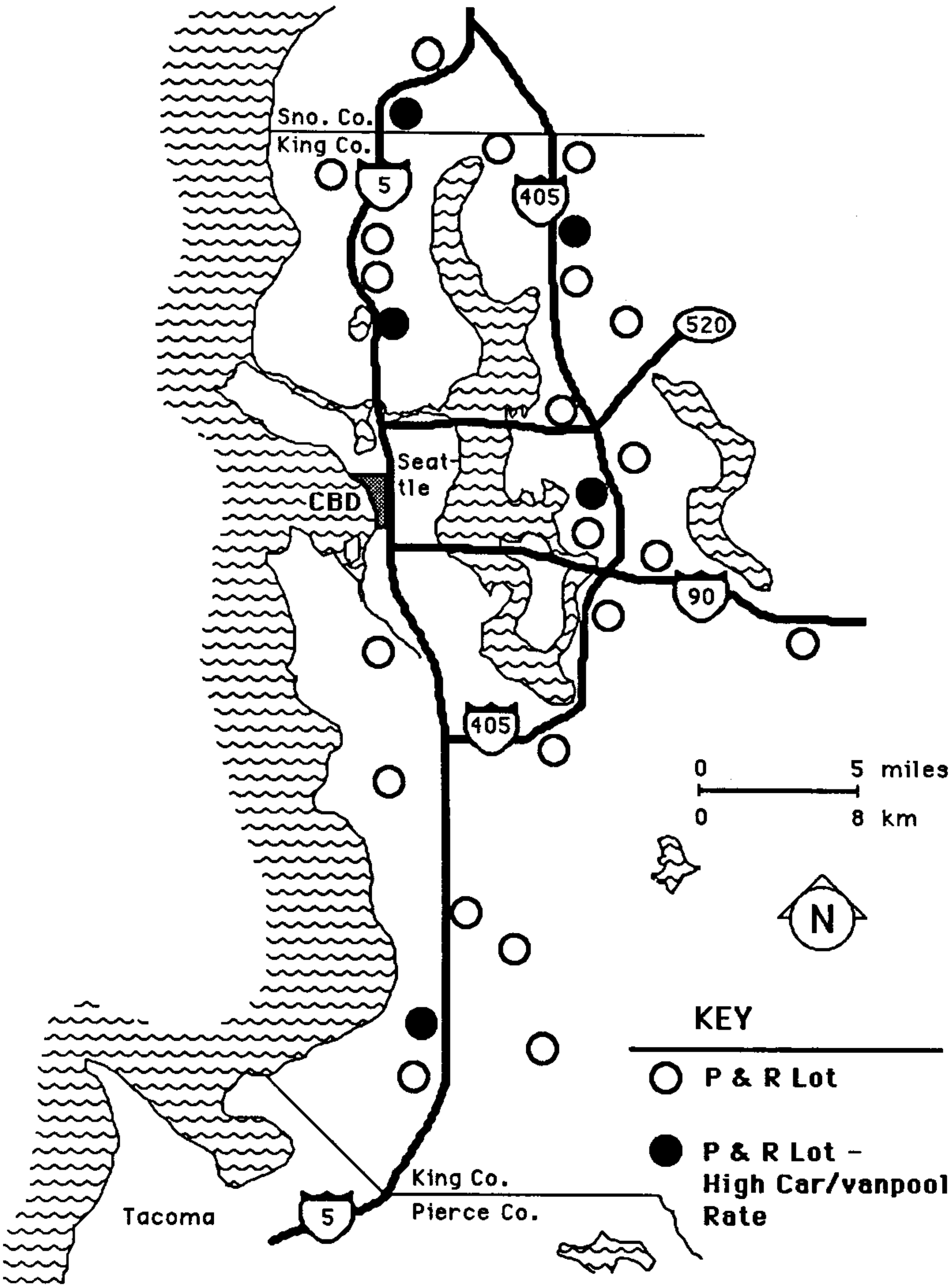


Figure 2-8. Location of Park-and-Ride Lots with High Car/Vanpooling Rates.

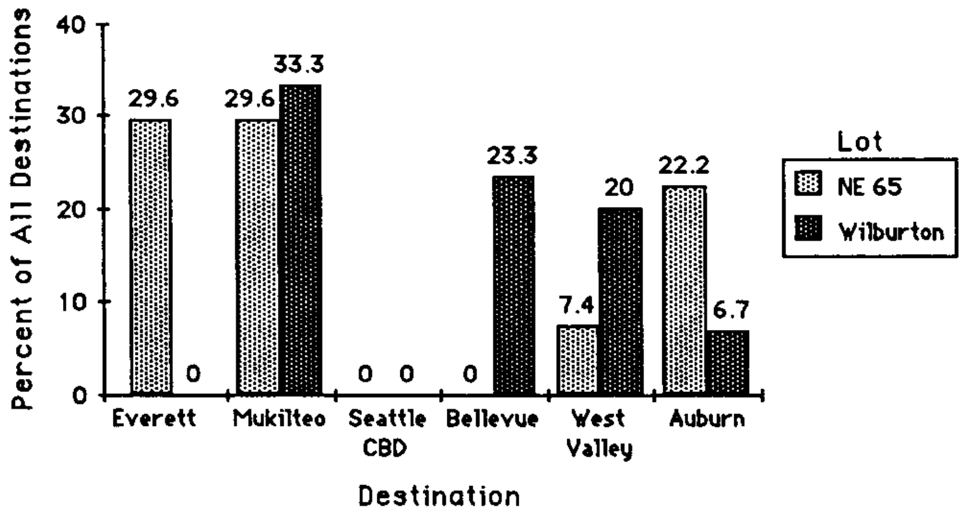


Figure 2-9. Non-transit Trips from Two Selected Lots with High Car/vanpooling Rates.

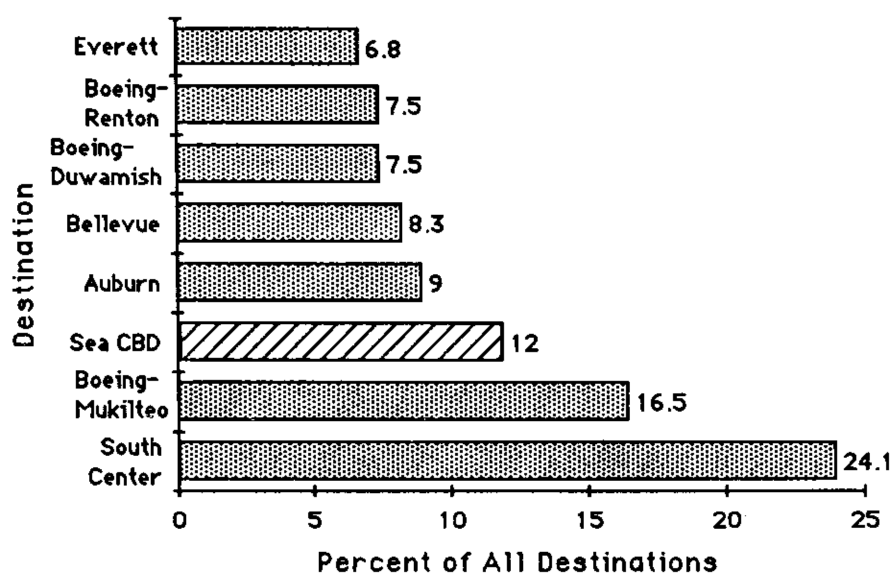


Figure 2-10. Car/Vanpool Destinations from All Lots in the North and Southeast Corridors.

ranking first and second, respectively, at 24.1 percent and 16.5 percent (see Figure 2-10). The low percentage of non-transit destinations to the Seattle CBD is in sharp contrast to the transit Seattle CBD destinations (12.0 percent versus 83.0 percent) (see Figure 2-11). Most of the vanpooling present in the Seattle metropolitan area receives support from employers. Participants in any given van are generally from the same work place. Car/vanpooling occurs for trips that are not well served by public transit. Taking transit into the CBD is easier than taking it to the outlying destinations, so the rate of car/vanpooling from park-and-ride lots to the CBD is low in comparison. Hence, major car/vanpooling destinations from park-and-ride lots are widespread throughout the region (see Figure 2-12). Four of the five lots with high car/vanpooling rates are located north of I-90. Most of the non-urban car/vanpool destinations (i.e., not Seattle and Bellevue) occur south of I-90.

Large employers who promote vanpooling are located primarily outside the CBD. These include Boeing, the Todd and Lockheed shipyards, Honeywell, and Virginia Mason and Swedish hospitals. It should be noted, however, that the two major employers within the Seattle CBD, the Federal Building and Pacific Northwest Bell, also support vanpooling.

<u>Previous Mode</u>

Of the respondents, 92.7 percent drove alone to the park-and-ride lots (see Figure 2-13). 13.8 percent of these had previously (i.e., before using the park-and-ride lot) walked to transit but are now driving to the lots (see Figure 2-14); thus, while some automobile traffic has been created by the lots, some automobile traffic has been eliminated (35.1 percent had previously driven alone the entire distance to their destination but are now only driving as far as the park-and-ride lot). For some users the lots are merely a convenience (19.8 percent of those who drove alone to the lots had previously driven to transit) and their present use of the park-and-ride lot has no major

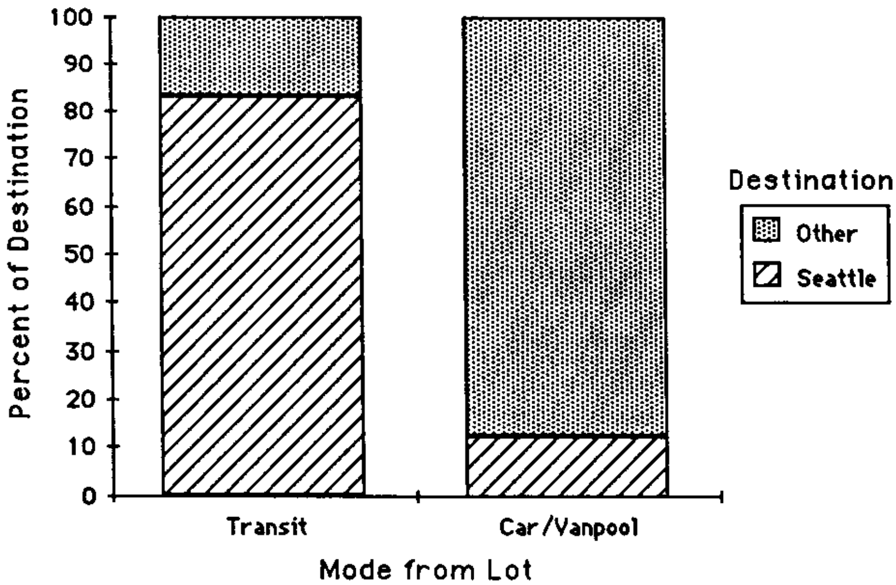


Figure 2-11. Destinations from All Lots in the North and Southeast Corridors - Transit vs. Non-transit.

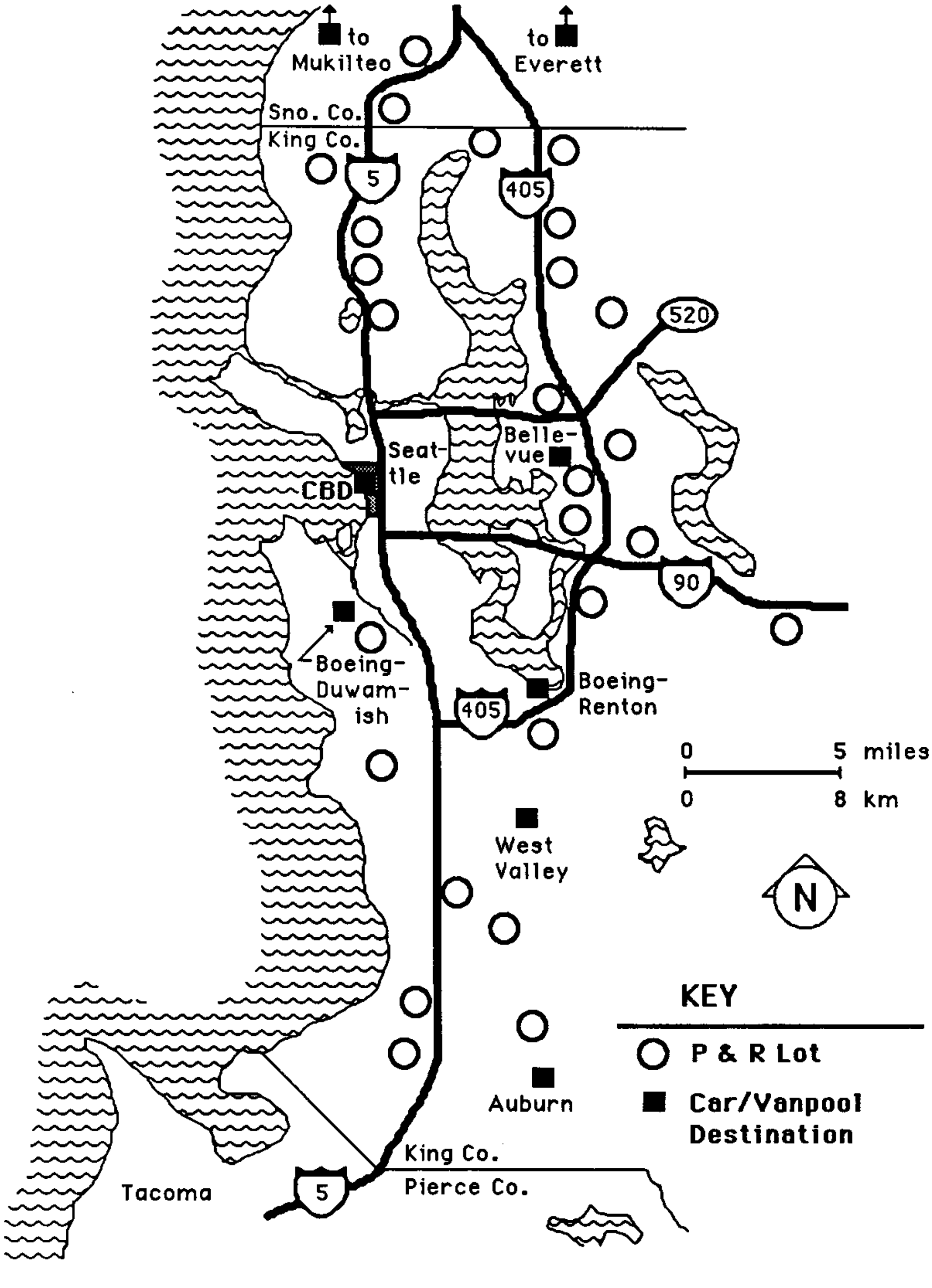


Figure 2-12. Locations of Destinations for Car/Vanpooling.

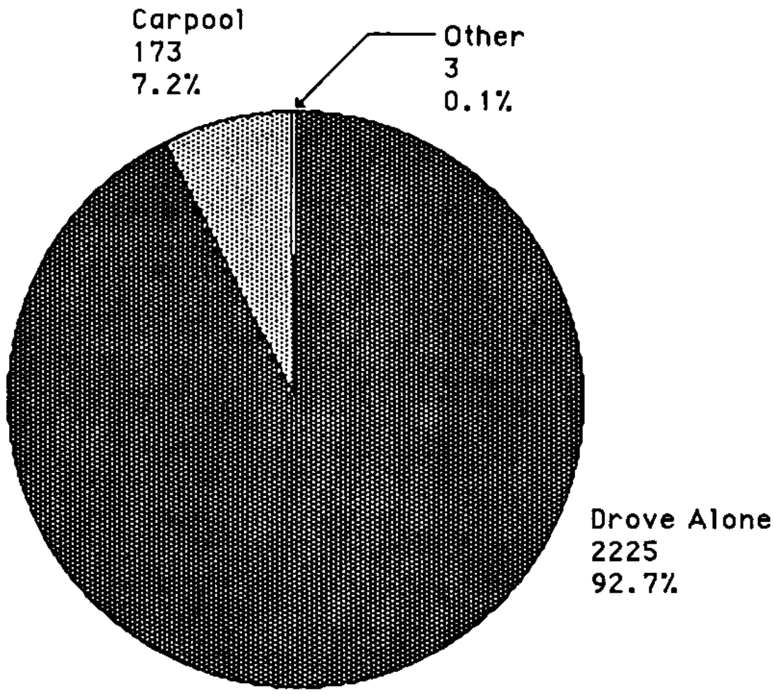


Figure 2-13. Mode to Lot.

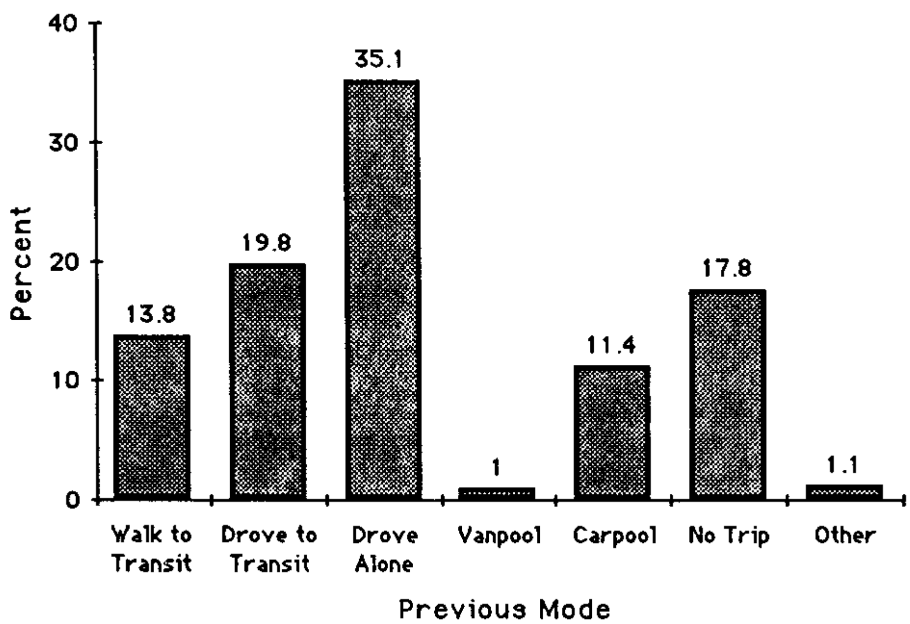


Figure 2-14. Previous Mode of Those Who Drove Alone to Lot.

effect on highway congestion. The mode from the lot was 84.7 percent transit and 14.8 percent car/vanpool, as shown in Figure 2-15. Figure 2-16 presents the mode from lot breakdowns by corridor. The Southeast corridor has a lower use of transit from lot than the norm (72.5 percent versus an 83.5 percent average for all lots). This difference is made up by increased carpooling (20.9 percent versus 10.2 percent over all). Park-and-ride trips are categorized by trip purpose in Figure 2-17. At 94.6 percent of all trips, travel to work was by far the dominant trip purpose.

Comparing the mode from lot by trip purpose reveals that 10.0 percent of users who were going to work did so by carpooling.

Frequency

Respondents tended to be frequent users, with 89.3 per cent of them using the lot at least four times per week (see Figure 2-18). Comparing frequency to mode from lot yields the following results (among those using the lot at least four times per week): transit 89.0 percent, carpool 88.3 percent, vanpool 99.2 percent. Vanpoolers are extremely consistent in their daily use of the lots (see Figure 2-19).

Vehicle Ownership

As a group, park-and-ride users come from households owning more vehicles than the average. Figure 2-20 compares the TRAC survey results with 1980 census data for King County and for suburban areas east of Lake Washington. King County has 15.8 percent households without cars and the suburbs have 7.3 percent households without cars. It is assumed that persons driving to the park-and-ride lots did not come from households which do not own any automobiles. While park-and-ride lot users appear to have significantly higher auto ownership than the county average, they do not appear to have auto ownership which is much higher than the east side suburban average.

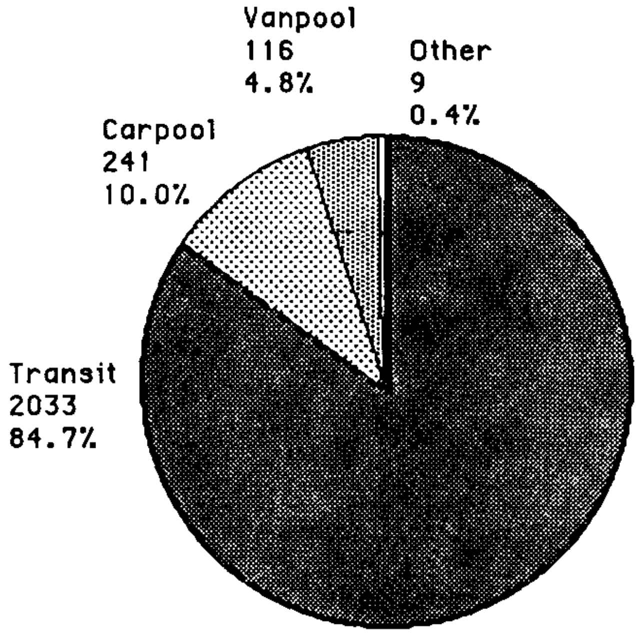


Figure 2-15. Mode from Lot - All Lots.

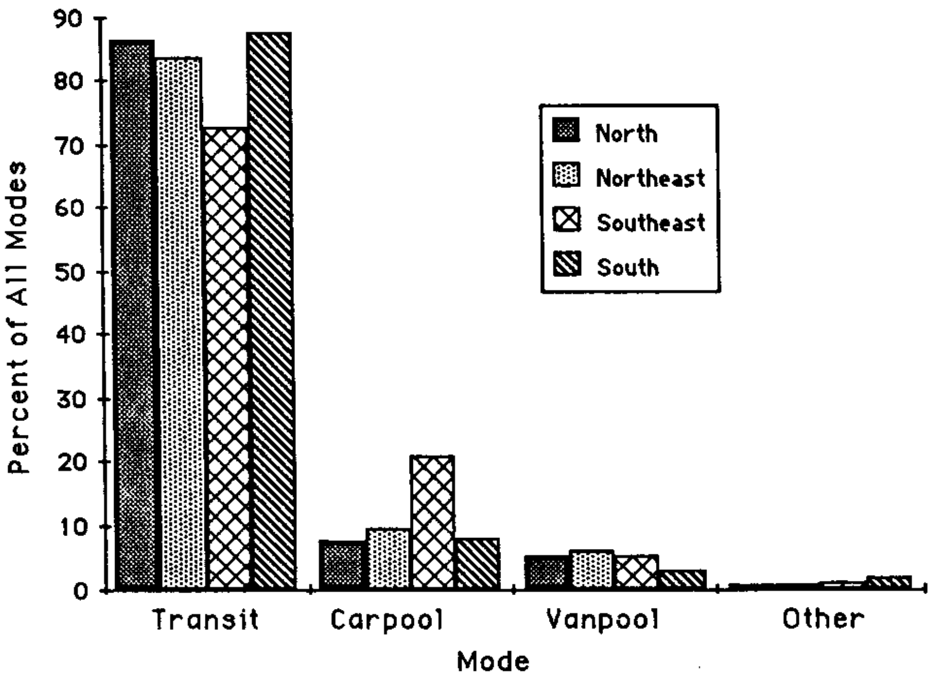


Figure 2-16. Mode from Lot - by Corridor.

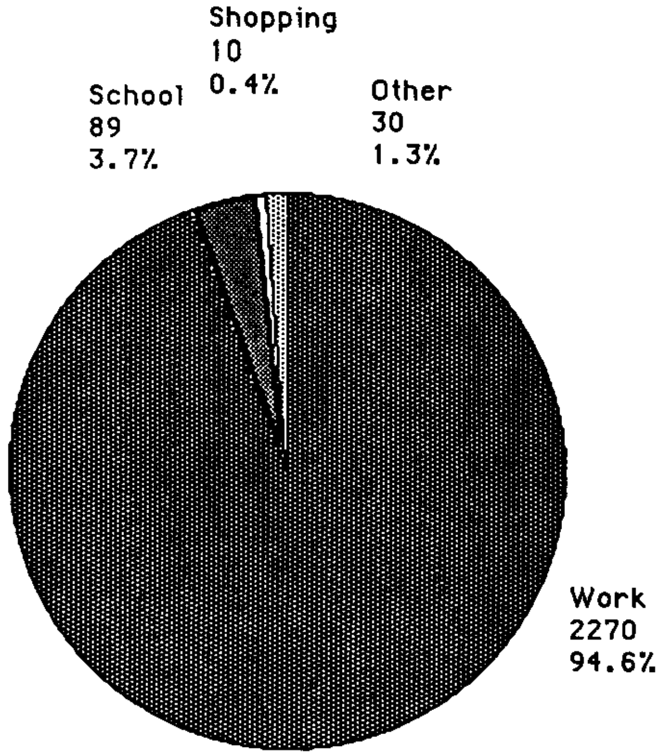


Figure 2-17. Trip Purpose.

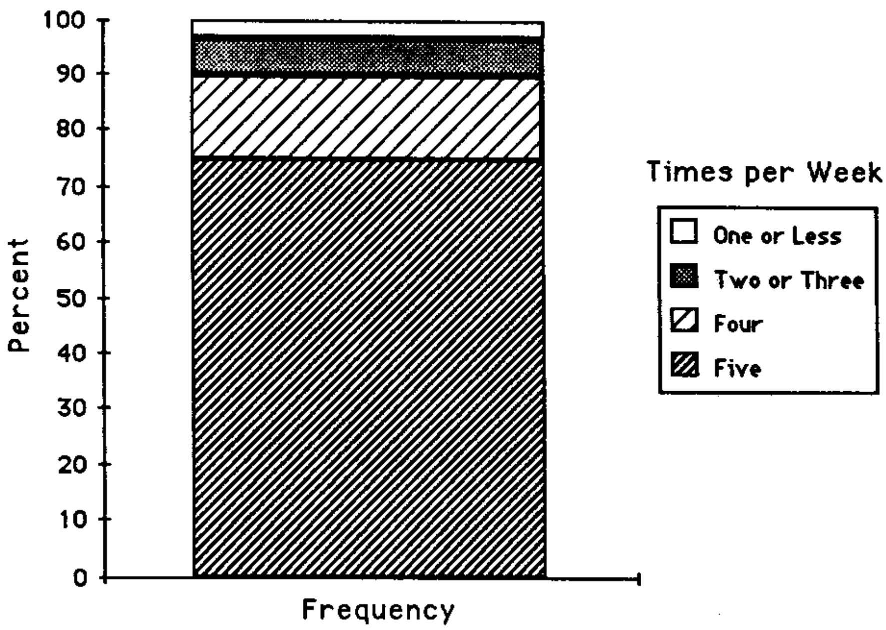


Figure 2-18. Frequency of Lot Use.

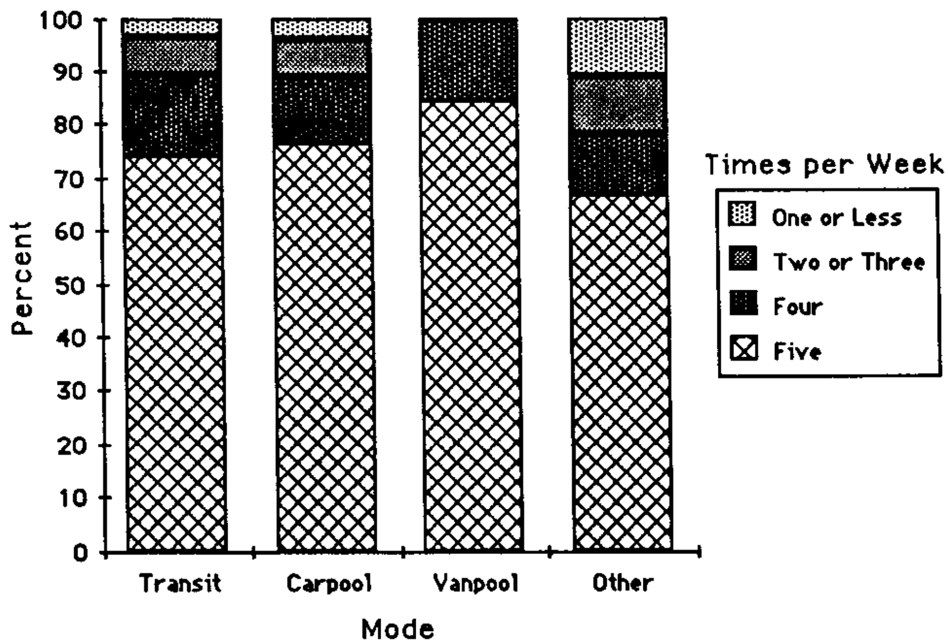


Figure 2-19. Frequency by Mode from Lot.

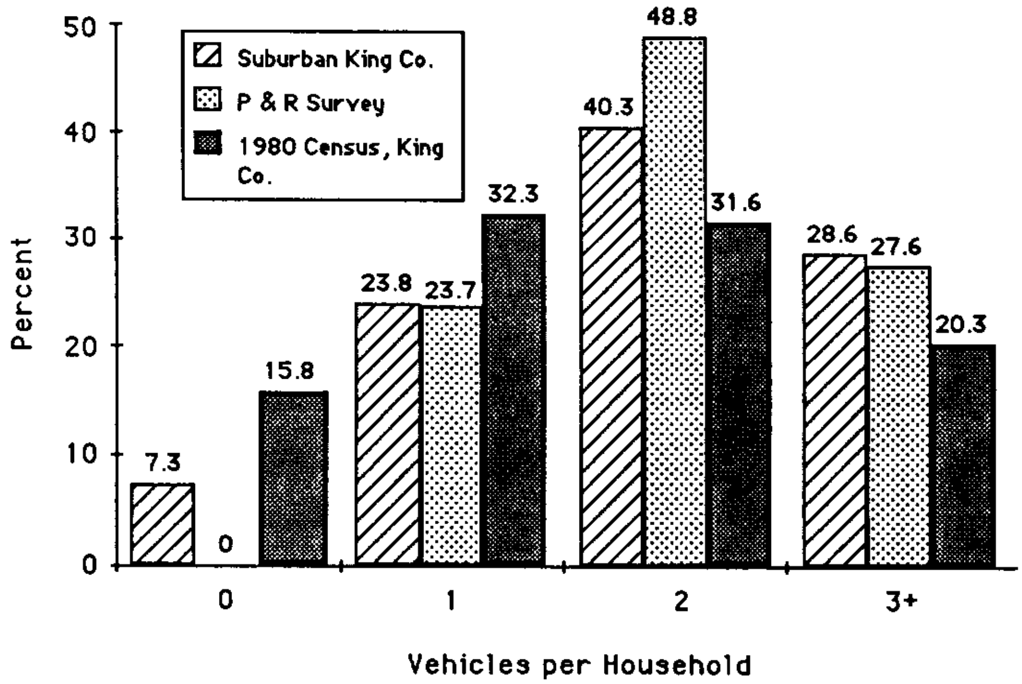


Figure 2-20. Vehicle Ownership Comparison - Suburban Communities, P & R Survey and 1980 Census, King County.

Vehicle Size/Age

Private vehicles used from the lot to the destination (i.e., for carpooling and vanpooling) tend to be larger than those used to access the lot (see Figure 2-21). Eight cylinder engines account for 46.4 percent of egress vehicles and 29.5 percent of access vehicles. Egress vehicles also tend to be newer with 60.4 percent of them being 0-5 years of age versus 30.6 percent of the access vehicles.

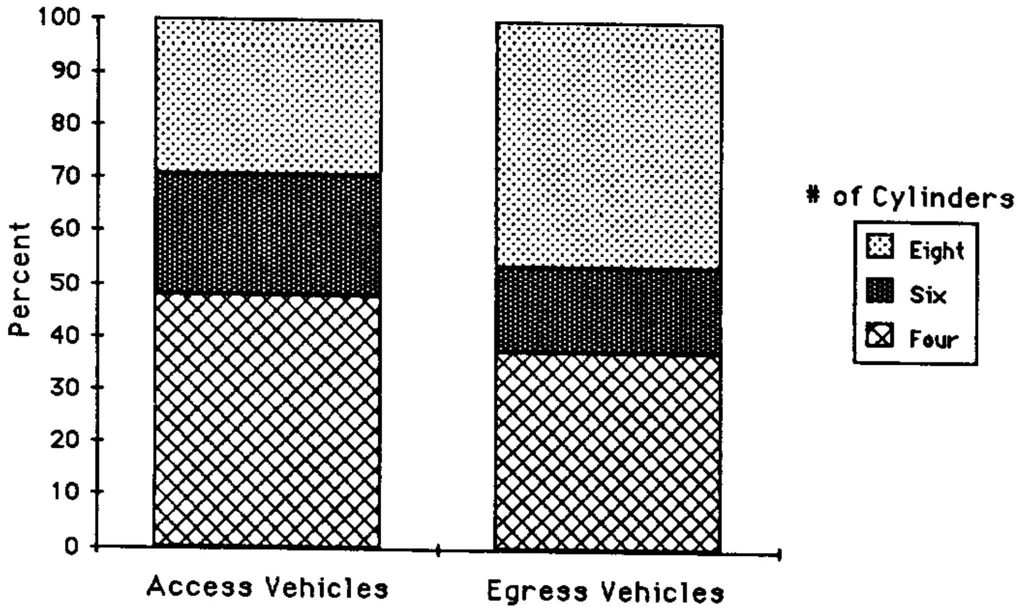
Survey Results Summary

Of the 25 lots covered in the survey, only three are presently experiencing significantly low utilization. Transit is taken to destinations by 83.5 percent of the lot users, 10.2 percent carpool and 4.7 percent vanpool. Very little car/vanpooling is destined for the Seattle CBD (only 12 percent in the two corridors which received detailed analysis). The lots have reduced automobile traffic -- 35.1 percent of the users had previously driven alone to their destination. Vehicle ownership data indicate that lot users are of average income for their neighborhood but above average for King County.

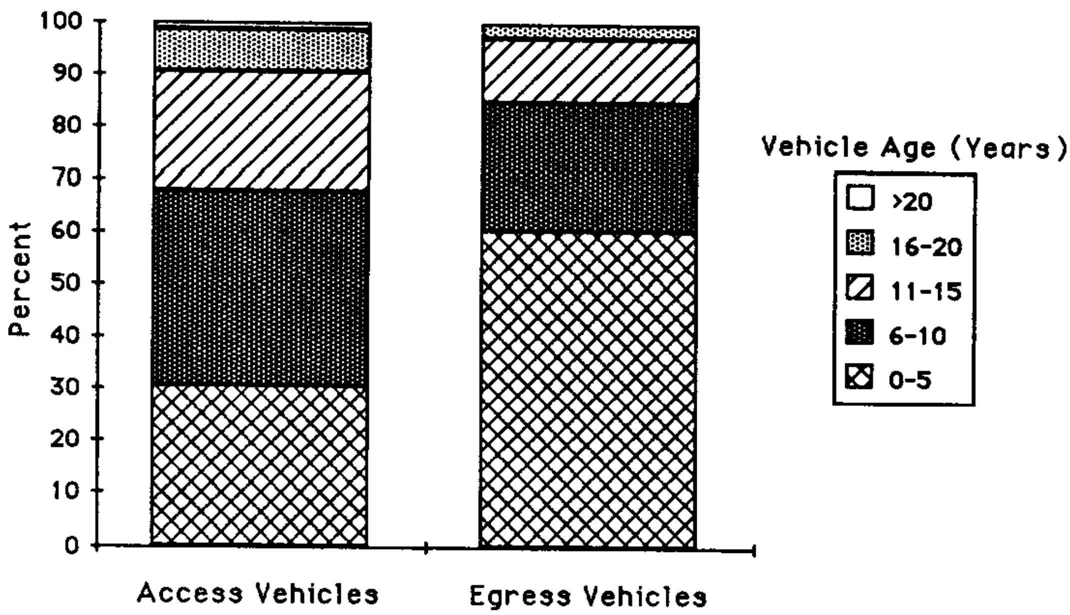
COMPARISON WITH OTHER PARK-AND-RIDE SURVEYS

METRO Average Annual Utilization Counts

Utilization data for permanent lots (in the Metro service area) are available for the years 1979-1984. Figure 2-22 shows total utilization and capacity for the lots. The years 1980 and 1981 show significant utilization and capacity increases over the previous year. In 1981 the utilization again increased significantly (28.3 percent) but the capacity jumped 57.7 percent, resulting in a utilization rate of 66.9 percent. For the next three years (1982-1984) utilization and capacity only increased slightly, and the gap between them did not noticeably change.



Engine Size



Age

Figure 2-21. Access/Egress Vehicle Characteristics.

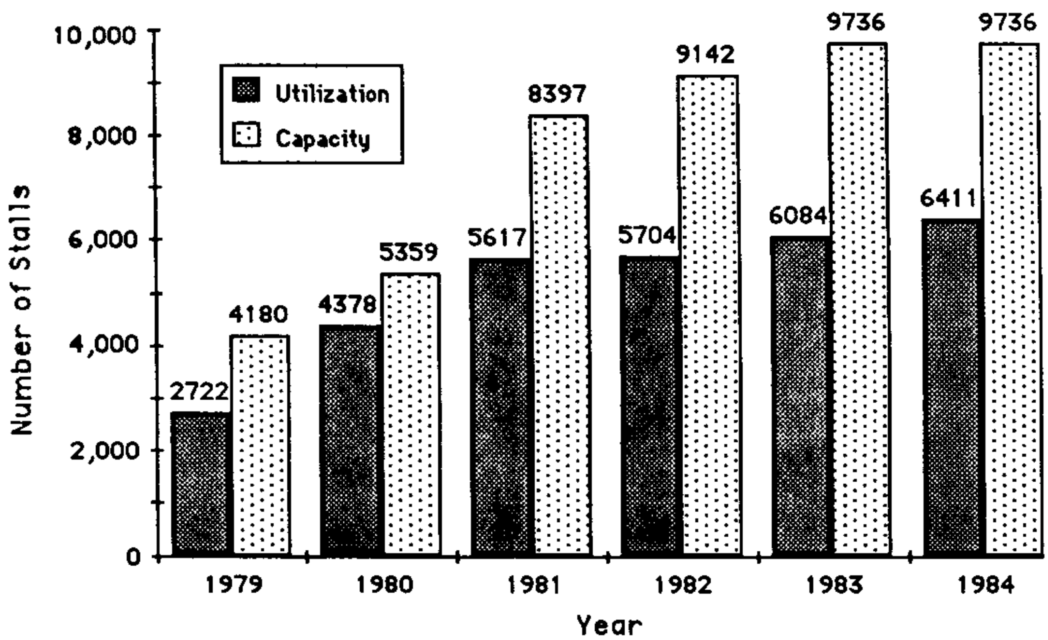


Figure 2-22. Annual Average Utilization of Park and Ride Lots - Permanent Lot Totals (Source: Metro Transit).

Utilization and capacity by corridor are shown in Figures 2-23 through 2-26. The North Corridor (Figure 2-23) shows the healthiest response of utilization to capacity. In 1979 and 1980 the utilization was roughly 100 percent. Major expansion in 1981 was met by a major increase in utilization. Capacity increased gradually, through 1984, and utilization increased accordingly.

The Northeast corridor (Figure 2-24) experienced a steady increase in capacity from 1979-1982. Utilization stabilized in 1981, remaining unchanged through 1984. The capacity remained unchanged from 1982 - 1984, with utilization staying at only 65 percent.

The Southeast corridor (Figure 2-25) had good utilization in 1980. Utilization increased only slightly in 1981, and then remained unchanged through 1984. Major expansion occurred in 1981, and then remained unchanged through 1984, giving low utilization rates (48.6 percent by 1984).

The South corridor (Figure 2-26) followed a pattern similar to that of the Southeast corridor. Utilization had stabilized by 1981, at which time capacity was increased by 62.1 percent. For the years 1981 - 1984 utilization remained at around 60 percent.

The expansion in overall capacity, which occurred in 1981, has not been met by the anticipated increase in utilization.

<u>TRANSPO Study</u>

The "Park-Ride Sizing and Prioritization Study" was prepared for the Municipality of Metropolitan Seattle (Metro) in 1982, by the TRANSPO Group, Inc. (16). Part of the study focused on the existing Park-and-Ride program. This study reviewed results from two previous surveys, some of which can be compared to the results of the 1983 TRAC survey. Figure 2-27 shows comparisons of previous modes. Results of the three surveys are very similar. Two-thirds to three-quarters of the users had previously

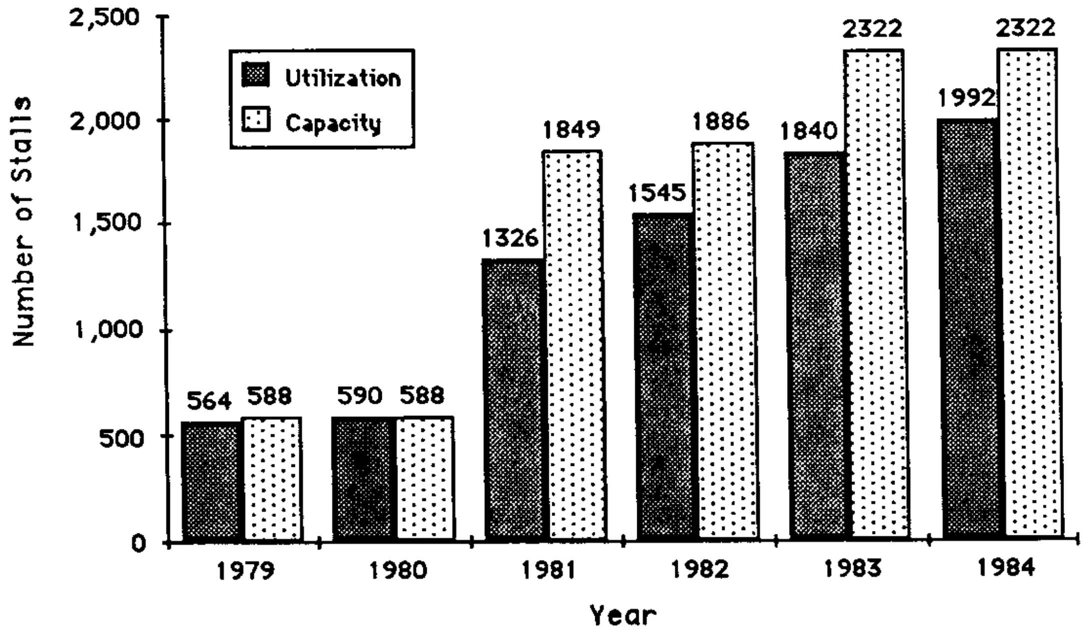


Figure 2-23. Average Annual Utilization of Park-and-Ride Lots - North Corridor (Source: Metro Transit).

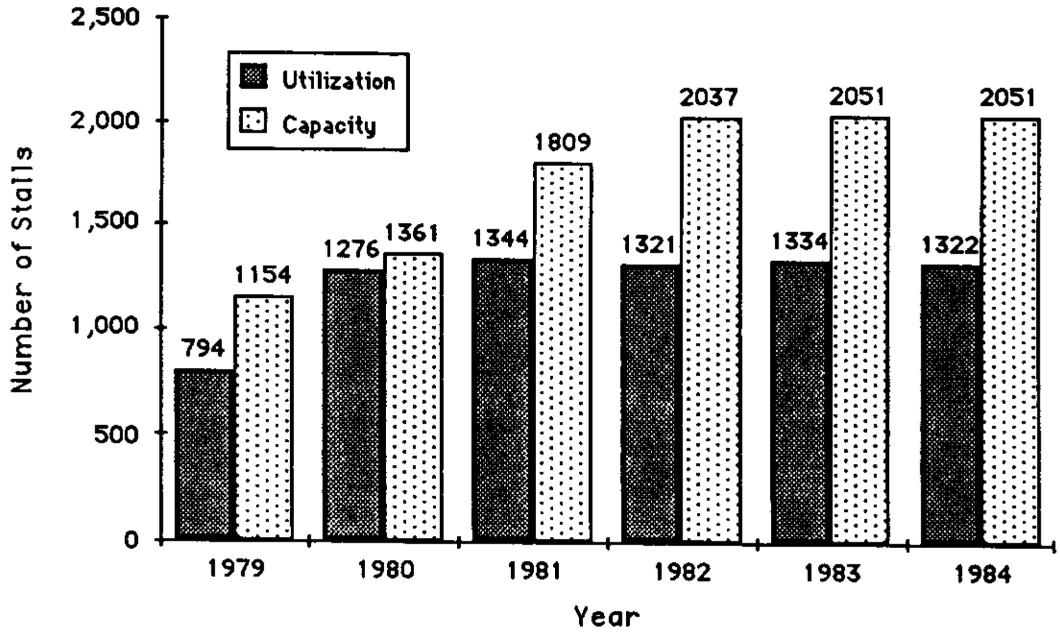


Figure 2-24. Average Annual Utilization of Park-and-Ride Lots - Northeast Corridor (Source: Metro Transit).

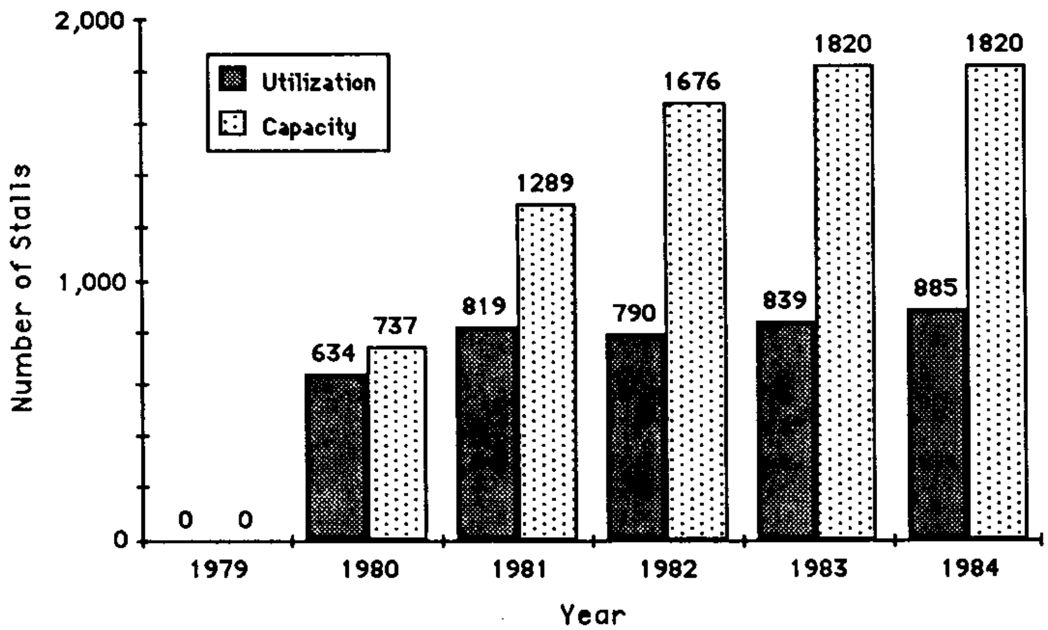


Figure 2-25. Average Annual Utilization of Park-and-Ride Lots - Southeast Corridor (Source: Metro Transit).

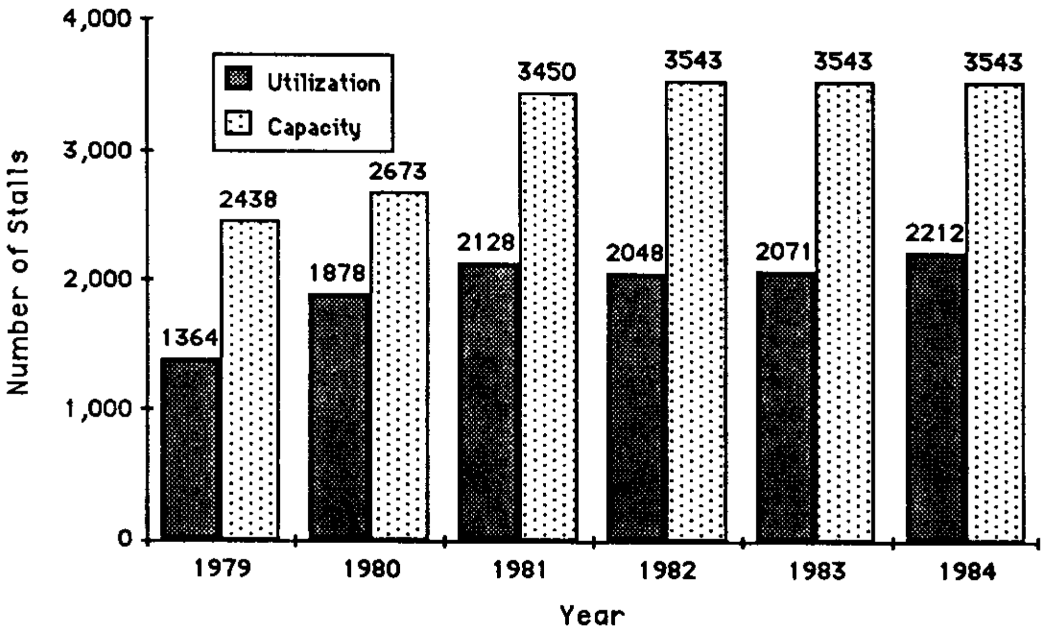
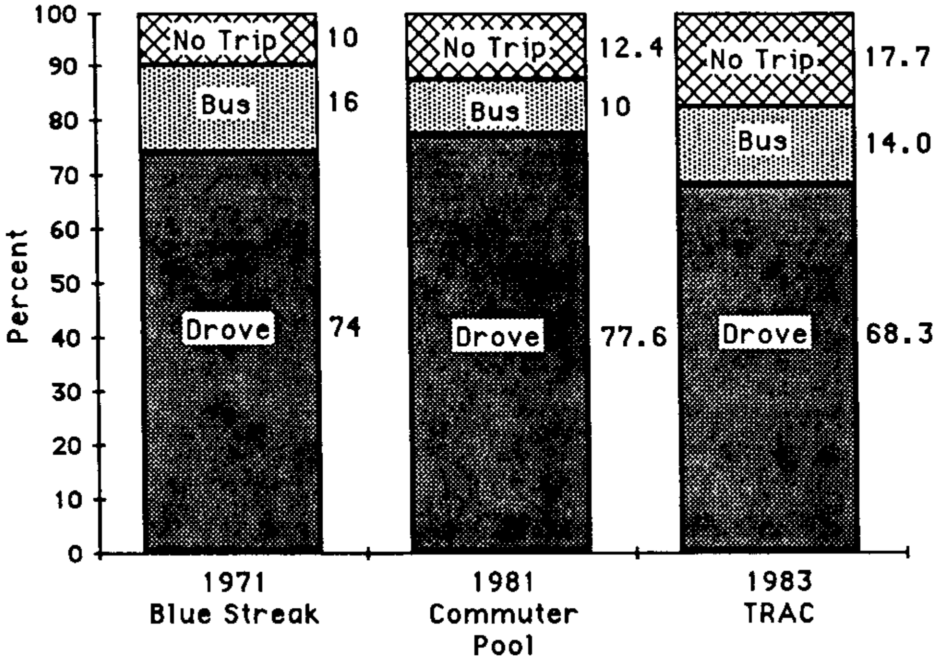


Figure 2-26. Average Annual Utilization of Park-and-Ride Lots - South Corridor (Source: Metro Transit).



Note: "Drove" includes driver or passenger (including car/vanpooling), to transit or to final destination. A more detailed breakdown was not available.

Figure 2-27. Previous Mode of Park-and-Ride Lot Users as Determined by Several Studies.

used automobiles, in some fashion, to reach their destinations. Those who had previously used transit ranged from 10 to 20 percent. The TRANSPO study comments on this by pointing out that the park-and-ride lots are not relying on patronage from persons who have previously walked to transit.

CHAPTER THREE: ANALYTICAL METHODS

ANALYSIS NEEDS

"Total" trip costs consist of total incurred system costs -- including public costs and both user (including the costs of time) and agency costs where they do not overlap. Besides looking at total costs, it was of interest to look at user costs and agency costs individually. Thus, a convenient means had to exist for separating these costs from total costs. In addition, for a more complete cost-effectiveness analysis, it was desirable to make separate "before" and "after" evaluations of the measures of effectiveness outlined in Chapter One.

With these basic analysis needs in mind, a model was required which would reasonably estimate all identifiable costs of the commuter trip.

The model had to be theoretically consistent in estimating costs for each of the four previous mode and the two park-and-ride trip types. For the cases analyzed by the trip cost model, the percentage breakdown of previous mode trip types was as follows:

Walk to transit	22.5%
Drive to transit	32.1%
Drive alone (auto)	34.3%
Car/vanpool	11.1%

The corresponding park-and-ride trip breakdown was as follows:

Park-and-ride transit	96.8%
Park-and-ride car/vanpool	3.2%

Across these six trip types, the model had to be consistent in estimating the following types of costs:

- Private costs associated with owning and operating an automobile
- Agency costs associated with providing transit service

- Cost of providing and maintaining the roadways (termed "highway cost")
- Congestion costs incurred by all roadway users
- Public cost for commuter related services (police, planning, etc.)
- Public cost associated with noise and air pollution.

KEELER-SMALL MODEL

Following a literature search and review, a model developed by Keeler, Small and Associates (4) was chosen as a base from which to develop the trip cost model in this study. The Keeler-Small model was chosen primarily because 1) it encompassed all of the basic types of costs desired for this study, and 2) it was developed as part of a very thorough and highly regarded study which remains today a principal work on the subject of urban transport costs.

What follows here is a brief general description of the Keeler-Small Model. For a more detailed account the reader is referred to the original source.

The Keeler-Small Model was developed to estimate trip costs for the major urban transportation modes -- auto, bus, and rail -- in the San Francisco Bay area. By including travel time costs, public services, and pollution and accident costs, it accounted for more costs than most previous studies.

In addition, expanding upon the economic theory of optimal highway pricing and investment, the Keeler-Small Model was developed with the capability to determine capacity related costs, optimal tolls (congestion tolls), and optimal service levels (volumes and speeds) for freeway service over five different periods of the day. As such, it provided a theoretical way of allocating freeway costs between peak and off-peak users. Keeler and Small's treatment of allocating highway costs was adapted to this study; however, for reasons outlined later in this chapter, the results of this highway cost treatment were not determined appropriate for this study.

The following lists the cost components included in a Keeler-Small calculation of the full cost of a peak hour auto work trip:

- Public costs (including costs of highway use, local government services associated with roadway provision and maintenance, and noise and air pollution) in $/vehicle-mile.
- Travel time costs (both in-vehicle and out-of-vehicle) in $/person-hour.
- Direct automobile operating costs in $/vehicle-mile.
- Auto capital costs (including interest and depreciation costs) in $/vehicle-mile
- Accident costs in $/vehicle-mile.
- Parking costs in $/vehicle-trip.

The costs included in a Keeler-Small calculation of the full cost of a transit work trip are as follows:

- Public costs in $/vehicle-mile.
- Travel time costs (in-vehicle and out-of-vehicle) in $/person-hour
- Total transit operating costs (including bus capital, bus operation, highway capital, highway maintenance, environmental and associated government agency costs) in $/vehicle-hour.

GENERAL ADAPTATIONS AND ADDITIONS

To fulfill the needs of this study, some general modifications needed to be made to the Keeler-Small Model. The first and most obvious was to modify the parameters reflecting the Bay area in 1972 so that they represented 1983 Seattle area values.

Second, the Keeler-Small Model calculated costs for auto, bus, and rail modes. However, the trip cost model for this study had to be capable of calculating not only auto and bus trip costs, but those reflective of park-and-ride trips as well. This was accomplished by simply combining the appropriate auto and bus mode costs with park-and-ride lot associated costs.

Third, a method of reasonably allocating highway costs to highway users had to either be determined or developed. Four methods -- including the Keeler-Small method -- were considered and are discussed later in this chapter.

Fourth, the Keeler-Small study did not explicitly account for the costs that traffic congestion imposed on all highway users. Since a primary argument for park-and-ride lots is that they help alleviate freeway traffic congestion, a method for quantifying this benefit was developed and incorporated into the trip cost calculations.

Fifth, the objective of the Keeler-Small study was to estimate the full cost of a "typical" Bay area work trip. It used average Bay area data to calculate an average Bay area trip. For this study, actual individual trip case data with which to estimate the full cost of each individual trip was available. Wherever possible, empirical parameters and data specific to the case being processed were used.

To further refine the model, a "cold start" factor was incorporated into the auto trip cost calculation for this study. A recent study (5) indicates that auto engines are not fully warmed up until they have traveled five miles. Consequently, automobiles are less fuel efficient over the initial five miles of a trip. Since the majority of park-and-ride lot access trips are of a relatively short distance, the cold start factor was a significant consideration in calculating park-and-ride trip costs.

The assumptions used to obtain the values for individual cost components are outlined in detail in the following section. Major deviations from the assumptions that the Keeler-Small study used will be noted.

TRIP COST MODEL OUTLINE

Table 3-1 lists the total public and private cost components which comprise the trip cost model. Each of these components -- time, public, automobile, parking and

Table 3-1.
PARK & RIDE PROJECT TRIP MODEL COST COMPONENTS
**** TOTAL PUBLIC AND PRIVATE COSTS ****

Time Costs:

- In Vehicle Time (1/3 x hourly wage rate)
- Out of Vehicle Time (1/3 x 2.5 x hourly wage rate)

Public Costs:

- Provision & Maintenance of Roadway
- Other Government Provided Services (Planning, Police, etc.)
- Environmental (Noise & Pollution)

Automobile Costs:

- Ownership and Operating (Not Including Fuel & Accident)
- Fuel
- Accident

Parking Costs:

- Provision of P&R Lot Parking
- Parking at Destination

Transit Costs:

- Total Transit Costs

transit costs -- and their subcomponents will be discussed in detail in the following sections. The components which comprise user incurred costs and agency incurred costs are outlined in Tables 3-2 and 3-3, respectively. Basically, user costs consist of automobile related costs, user parking fees, transit user fares, and the cost of the users' time. The model was designed so that the inclusion of time costs would be optional. Agency costs include primarily services provided by two agencies: the highway agency and the transit agency. Highway agency costs consist of roadway provision and maintenance costs and the cost of constructing park-and-ride lots (METRO provided 10 percent matching funds; this is included). Transit agency costs include the total costs of providing transit service (less the users' fare) and the cost of maintaining the park-and-ride lot. A minor portion of agency costs is incurred by other agencies. These costs include city planning, police and fire agency costs.

A complete listing of the Fortran coding of the trip cost model is contained in Appendix C.

TIME COSTS

Studies on the values people place on their travel time to work indicate a range of values. For in-vehicle time, this range is typically from one-fourth to one-half their hourly wage rate (7), while out-of-vehicle time, (walking and waiting time) ranges from 1 to 4.5 times that of their in-vehicle time (8). For the purposes of the detailed cost analysis of this study, a middle range value of one-third the commuter's hourly wage rate was used for the value of in-vehicle time, and 2.5 times that value was used for the value of out-of-vehicle time.

The model was designed so that these assumed values could be easily changed. For the sensitivity analysis, a range of values for travel time was considered in

Table 3-2.
PARK & RIDE PROJECT TRIP MODEL COST COMPONENTS
**** USER COSTS ****

Time Costs: (Optional)

- In Vehicle Time
- Out of Vehicle Time

Public Costs: (Not Included)

Automobile Costs: (Not Included)

- Ownership and Operating (Not Including Fuel & Accident)
- Fuel
- Accident

Parking Costs:

- Parking at Destination
- (P&R Lot Parking Is Free to User)

Transit Costs:

- Transit User Fare

Table 3-3.
PARK & RIDE PROJECT TRIP MODEL COST COMPONENTS
**** AGENCY COSTS ****

Time Costs: (Not Included)

Public Costs:

- Provision & Maintenance of Roadway (Highway)
- Other Government Provided Services (Various)
- Environmental (Not Included)

Automobile Costs: (Not Included)

Parking Costs:

- Provision of P&R Lot Parking (Highway)*
- Maintenance of P&R Lot Parking (Transit)
- Parking at Destination (Not Included)

Transit Costs:

- Total Transit Costs (Transit)

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*METRO provided 10 percent matching funds on construction costs. This is included in this cost estimate.

calculating the "before" and "after" trip costs. The results of this sensitivity analysis are discussed in Chapter Four.

The question of income was not included in the park-and-ride lot user survey due to the sensitive nature of the question and its expected negative effect on the rate of survey returns. However, users' addresses were known and it was thus possible to match a park-and-ride user living in a given area with the typical average income for that area. The finest breakdown of income information available was from the U.S. Census Bureau's 1980 Urban Transportation Planning Package (UTPP), or Journey to Work File. Workers' earnings by census tract were acquired from this. This information was updated to July 1983 values by means of consumer price indices and integrated into the individual data case records. For the case data analyzed, the mean hourly wage was $10.17 in July 1983 dollars. This corresponded to an average of $3.39 per hour for in-vehicle time and an average of $8.48 per hour for out-of-vehicle time.

PUBLIC COSTS

Highway Costs

A significant cost associated with a vehicle trip is the cost of providing and maintaining the roadway upon which that trip is made. In order to estimate the "total" incurred costs of a trip this cost must be considered. The main difficulty with this is determining how to assign the appropriate portion of the aggregate highway costs to an individual vehicle trip. Depending on one's point of view any number of methods may be used for this purpose. Four different methods were considered for this study and one was chosen for use in the "in-depth" analysis. At the root of all these methods were total annual highway costs.

Total annual highway costs include all costs associated with acquiring the roadway right of way, and constructing and maintaining the roadway. Land acquisition and construction costs for Seattle area freeways were compiled in terms of dollars per lane-mile from historical records provided by WSDOT. Historical costs were converted to 1983 dollars by means of the Washington State Highway Construction Costs Index (17). Using a discount rate of 8 percent, land acquisition and construction costs were annualized -- the former over an infinite lifespan and the latter over a lifespan of 25 years for Portland concrete pavements and 12 years for asphalt pavements.

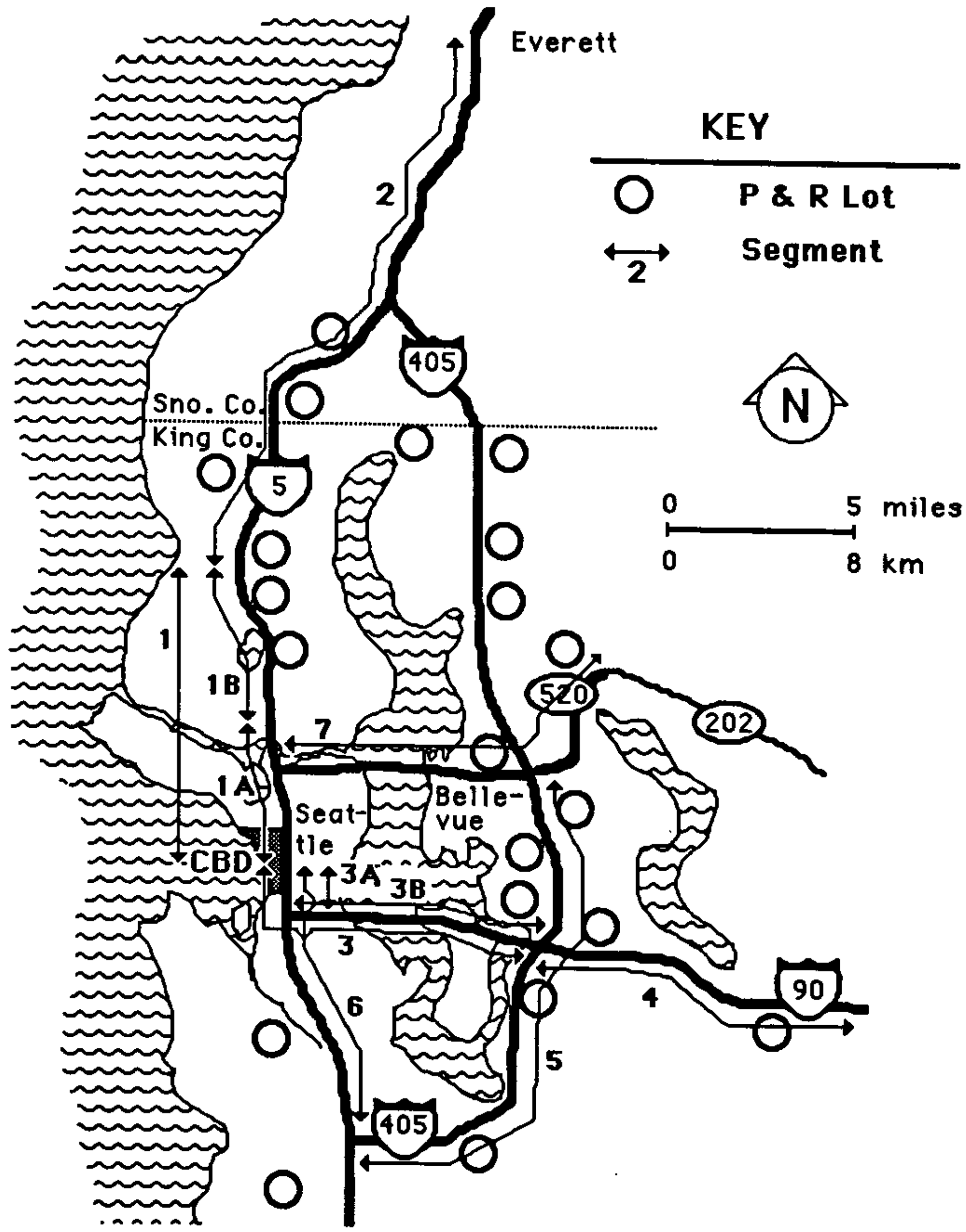
The choice of discount rate is important in the determination of annual highway costs. When applied to government investments, the discount rate should reflect the return which the investment could command in alternative uses. Most economists agree this rate lies somewhere between 6 percent and 12 percent (4). The choice of 8 percent for this study reflects a typical value used by many government agencies including the Army Corps of Engineers, which updates it regularly. This choice is further supported by a National Cooperative Highway Research Council (NCHRP) report which states that "appropriate interest rates applicable to transportation system investments should be somewhere between 7 and 10 percent", and "it appears that 8 percent is a satisfactory approximation of the appropriate social rate of discount" (18).

Before arriving at the final highway costs, another important consideration had to be made. This study is concerned only with passenger vehicle trips. Thus, to the extent possible, it is appropriate to include only costs necessary for the construction of roads for only passenger vehicles. According to a recent U.S. Department of Transportation (USDOT) study (9), approximately 59 percent of urban roadway costs can be attributed to passenger vehicles (i.e., autos, pick-up trucks, passenger vans and buses).Highway construction and maintenance costs were thus multiplied by 0.59 before being added to land acquisition costs. Average annual maintenance costs were arrived at by compiling and averaging actual maintenance costs over a recent five year period from records obtained from WSDOT for the respective freeway segments. Freeway segments for which total annual highway costs were calculated are shown in Figure 3-1. Total annual highway costs for these freeway segments are presented in Table 3-4.

Calculation of highway user costs for each of the four methodologies required traffic volume information ranging from aggregate yearly volumes for one methodology to specific peak hour volumes over each of the freeway segments for another. WSDOT has established the Traffic Systems Management Center (TSMC) which continuously monitors and gathers traffic information from the Seattle area freeways. The traffic data obtained from TSMC was used to determine hourly traffic distribution. Figure 3-2 portrays the typical traffic distribution at a selected freeway location over an average weekday. This distribution, which is representative of distributions over the other freeway segments as well, indicates that the significant traffic peaks occur over a three hour period both in the morning (6 to 9 AM) and evening (3 to 6 PM). In order to more easily work with this traffic data in the highway cost models, the hours of the week were grouped into six periods, each of which contained relatively constant volumes. These periods are outlined in Table 3-5. Figure 3-3 gives an example of how those six period traffic distributions compare to the corresponding hourly distributions.

Figure 3-4 indicates the four methods considered for estimating highway user costs. For convenience these methods are termed "system average," "segment average,""peak period," and "Keeler-Small." For each of these methods, the highway costs per vehicle-mile by segment are presented in Table 3-6. A brief description of these four methods follows.

System Average. This method involved determining the system average annual highway cost ($220,570 per lane-mile) and dividing it by the average annual traffic volume per lane over all the freeway segments considered (4,946,788). This resulted in a value of $.045 per mile for a vehicle trip on any segment during any time of day.



SEGMENT

1A	I-5: Madison/NE 42nd	4	I-90: I-405/E. Issaquah
1B	I-5: NE 42nd/Northgate Way	5	I-405: SR 169/SR 522
1	I-5: Madison/Northgate Way	6	I-5: Madison/I-405 S
2	I-5: Northgate Way/Everett	7	SR-520: I-5/SR 202
3A	I-5: Madison/I-90		
3B	I-90: I-5/I-405		
3	I-5/I-90: Madison/I-405		

Figure 3-1. Seattle Area Freeway Segments

TABLE 3-4.
ESTIMATED ANNUAL HIGHWAY COSTS* FOR SEATTLE ARE FREEWAYS

Segment		Lane	Capital	Right-of-	Maintenance	Total Annual
Number	Description	Miles	Costs	Way Costs	Costs	Costs
1A	I-5: Madison/N.E. 42nd Street	48.4	290,500	150,250	6,300	447,000
1B	I-5: N.E. 42nd/Northgate Way	41.3	81,600	75,500	6,300	161,400
1	I-5: Madison/Northage Way	89.7	194,300	114,900	6,300	315,500
2	I-5: Northgate Way/Everett	147.8	51,300	38,100	3,000	92,300
3A	I-5: Madison/I-90	11.3	204,400	169,100	6,300	380,200
3B	I-90: I-5/I-405	31.8	1,030,700	67,200	11,700	1,109,600
3	I-5 & I-90: Madison/I-405	43.1	876,500	86,200	10,700	973,400
4	I-90: I-405/Issaquah	52.6	84,300	17,300	2,000	103,600
5	I-405: SR-169/SR-522	123.5	84,300	17,300	3,800	105,400
6	I-5: Madison/I-405 (S)	107.9	110,700	50,800	6,300	167,800
7	SR-520: I-5/SR-202	51.0	267,110	29,300	3,600	300,000
	System Average:					213,635

* All costs are in 1983 dollars per lane mile.

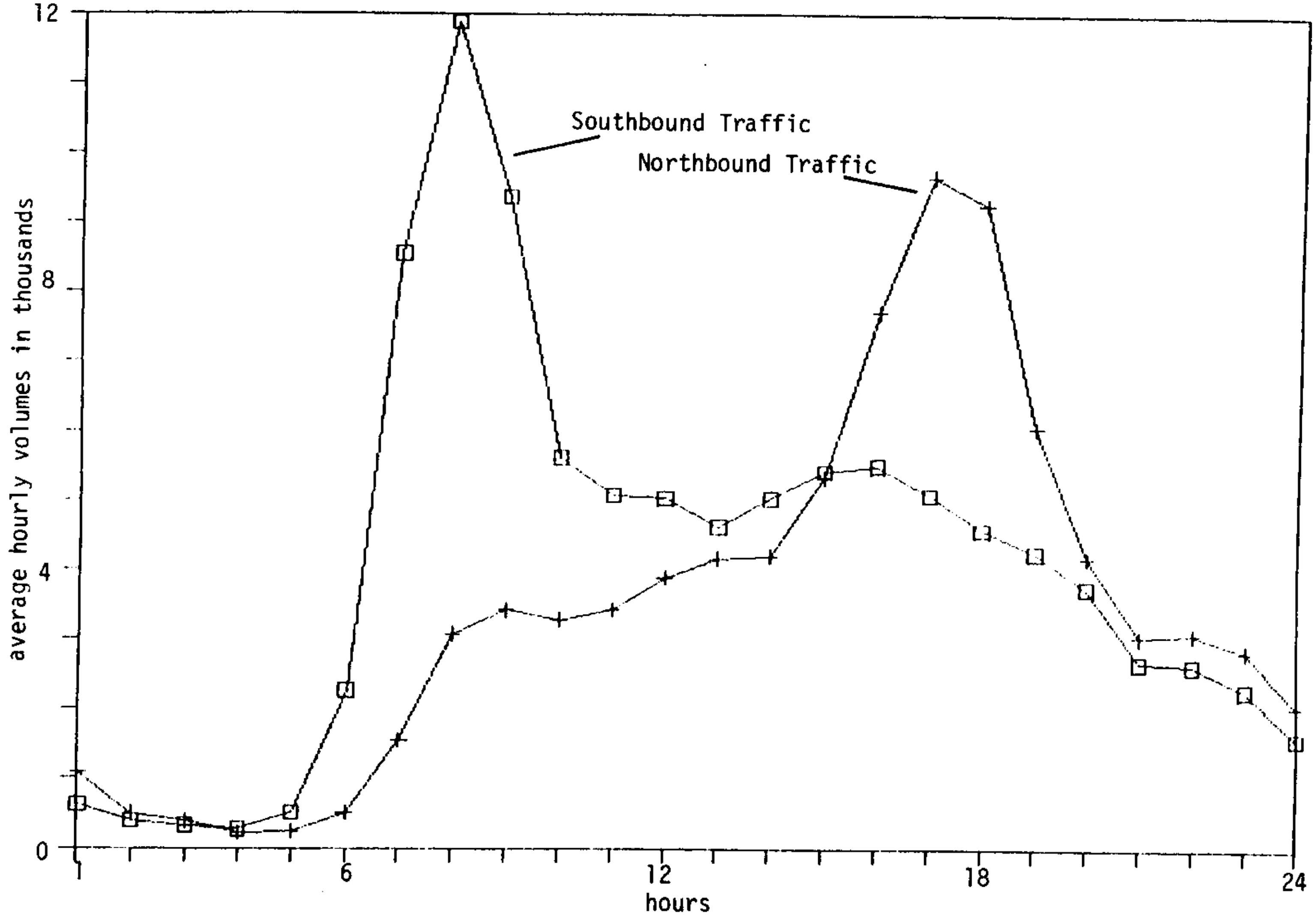


Figure 3-2. Weekday Traffic Volumes: I-5 at Ship Canal Bridge

TABLE 3-5.
WEEKLY TRAFFIC PERIODS FOR THE SEATTLE AREA
I-5 North of Downtown Seattle

	Period	Number of Weekly Hours in Each Direction	Time Period: Inbound	Time Period: Outbound
1.	Peak	5	7-8 AM (M-F)	4-5 PM (M-F)
2.	Near Peak	10	6-7 AM (M-F) 8-9 AM (M-F)	3-4 PM (M-F) 5-6 PM (M-F)
3.	Daytime	20	9-11 AM (M-F) 2-4 PM (M-F)	12-3 PM (M-F) 6-7 PM (M-F)
4.	Off-Peak Weekday/ Weekend Peak	33	11 AM-2 PM (M-F) 4-5 PM (M-F) 10 AM-7 PM (Sat) 12-4 PM (Sun)	7-12 AM (M-F) 12-5 PM (Sat) 11 AM-2 PM (Sun)
5.	Evening/ Weekend Off-Peak	40	5-10 PM (M-F) 8-10 AM (Sat) 7-10 PM (Sat) 8-12 AM (Sun) 4-10 PM (Sun)	7-11 PM (M-F) 9 AM-12 PM (Sat) 5-11 PM (Sat) 9-11 AM (Sun) 2-11 PM (Sun)
6.	Nighttime	60	10 PM-6 AM (Monday-Sunday) 6-8 AM (Sat-Sun)	11 PM-7 AM (Monday-Sunday) 7-9 AM (Sat-Sun)
	Total Weekly Directional Hours	168		

TABLE 3-5.
WEEKLY TRAFFIC PERIODS FOR THE SEATTLE AREA (Continued)
I-90 East of Seattle

	Period	Number of Weekly Hours in Each Direction	Time Period: Inbound	Time Period: Outbound
1.	Peak	5	7-8 AM (M-F)	5-6 PM (M-F)
2.	Near Peak	10	6-7 AM (M-F) 8-9 AM (M-F)	3-5 PM (M-F)
3.	Daytime	20	9-10 AM (M-F) 3-6 PM (M-F)	12-3 PM (M-F) 6-7 PM (M-F)
4.	Off-Peak Weekday/ Weekend Peak	33	10-11 AM (M-F) 1-3 PM (M-F) 6-7PM (M-F) 12-7 PM (Sat) 1-7 PM (Sun)	10 AM-12 PM (M-F) 7-8 PM (M-F) 8 AM-6 PM (Sat)
5.	Evening/ Weekend Off-Peak	40	11 AM-1 PM (M-F) 7-10 PM (M-F)) 8 AM-12 PM (Sun) 7-10 PM (Sat-Sun) 8 AM-1 PM (Sun)	7-10 AM (M-F) 8-11 PM (M-F) 7-8 AM (Sat) 6-9 PM (Sat-Sun) 7-10 AM (Sun)
6.	Nighttime	60	10 PM-6 AM (Monday-Sunday) 6-8 AM (Sat-Sun)	11 PM-7 AM (Monday-Sunday) 9-11 PM (Sat-Sun)
	Total Weekly Directional Hours	168		

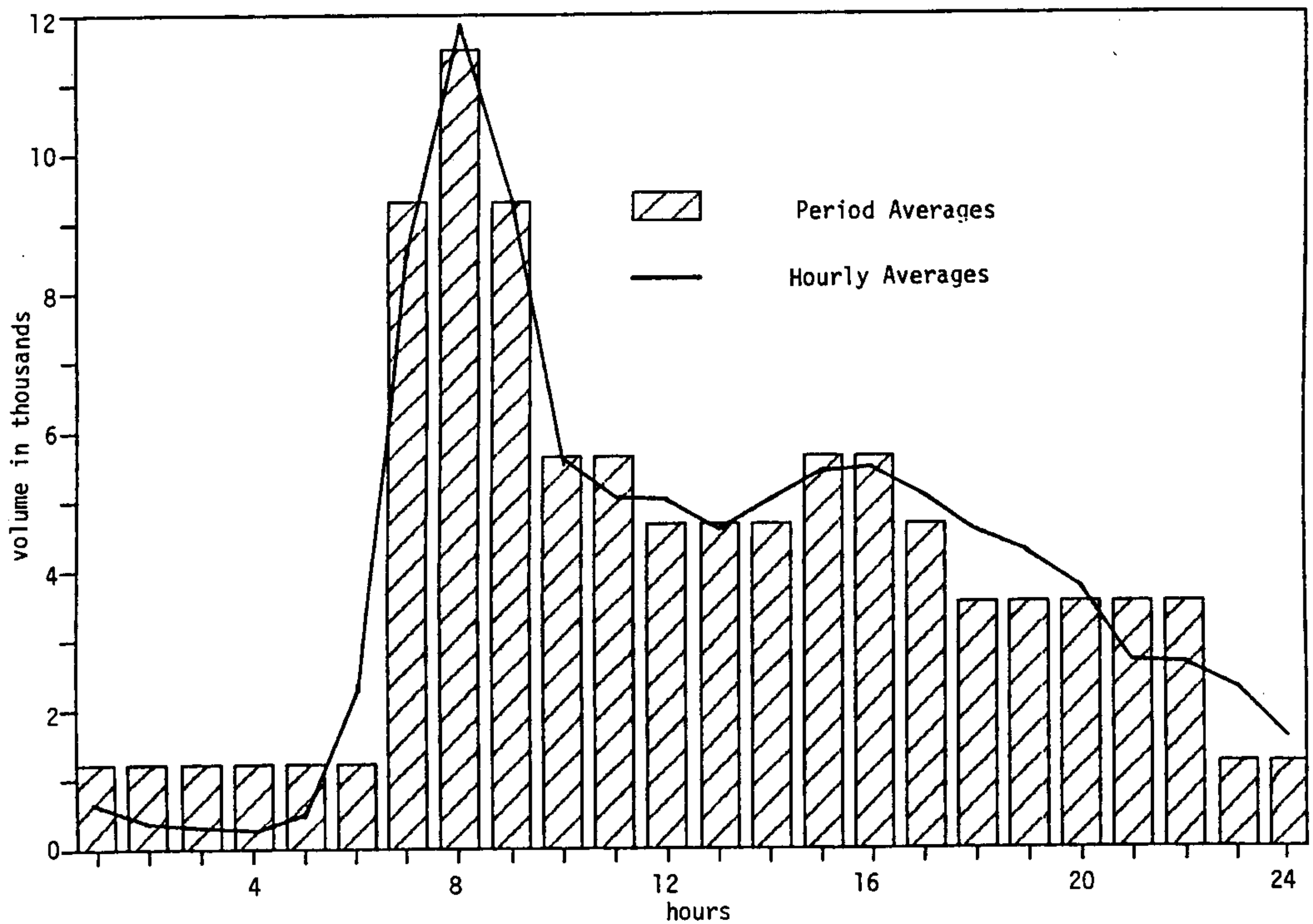


Figure 3-3. Weekday Traffic Volumes: Hourly vs. Period Averages for Southbound Traffic

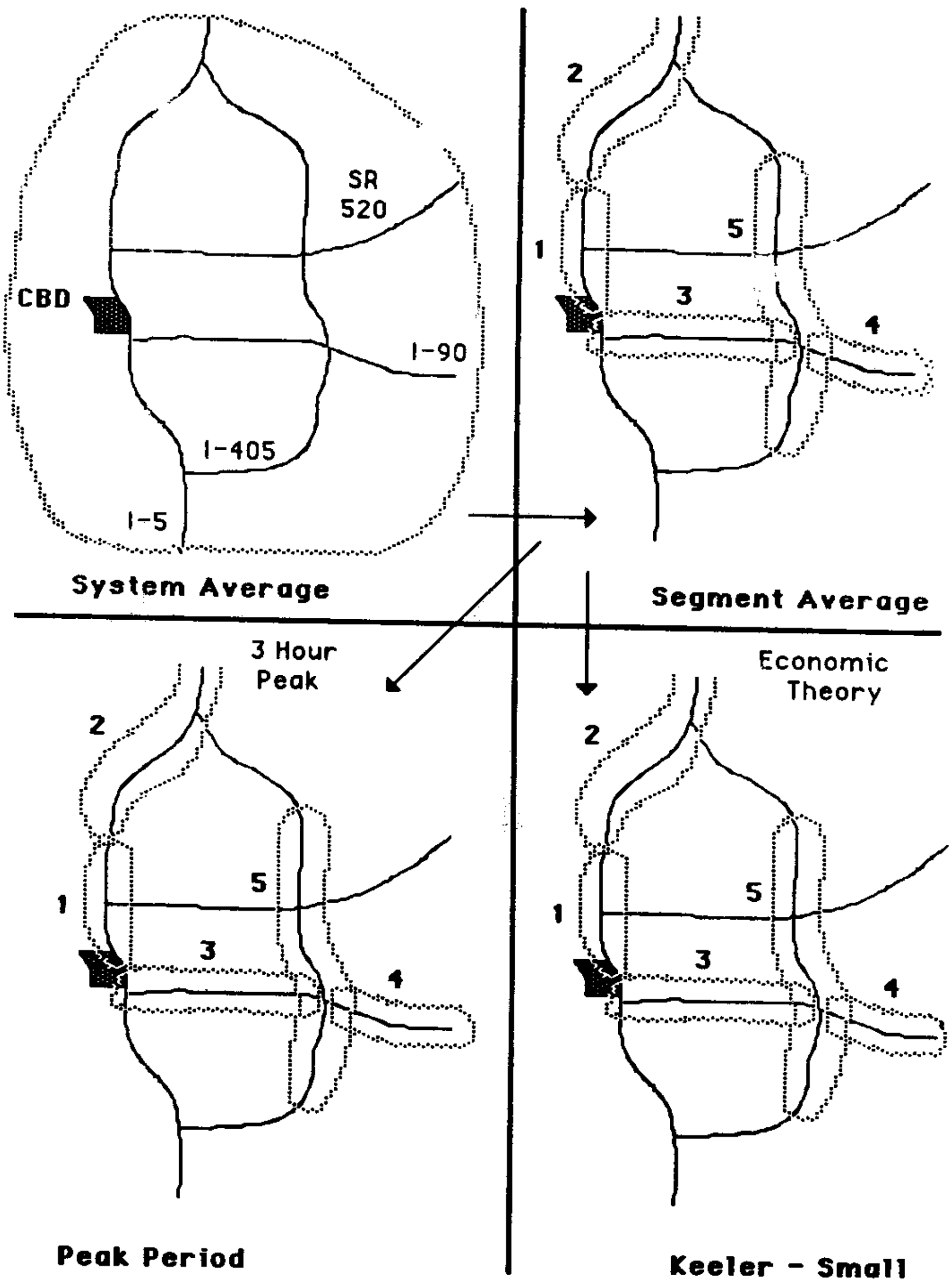


Figure 3-4. Highway Costs: Overview of Four Methodologies

TABLE 3-6.
HIGHWAY COSTS* USING FOUR DIFFERENT METHODS

Freeway Segment	Seattle Freeway System Average	Freeway Segment Average	Peak Period (Peak 3 Hours)	Keeler-Small (Peak 3 Hours)
I-5: CBD/Northgate Way	.042	.058	.124	.189
I-5: Northgate Way/Everett	.042	.020	.041	.051
I-5 and I-90: CBD/I-405	.042	.205	.321	.554
I-90: I-405/Issaquah	.042	.056	.101	.021
I-405: SR-169/SR-522	.042	.019	.039	.021
I-5: CBD/NE 42nd Street (HOV Lane**)	.042	.341	.341	.153

*Costs are in 1983 dollars per vehicle mile.

**HOV = High Occupancy Vehicle lane (lane reserved for transit or vehicles with 3 or more occupants.

__Segment Average__. This method assigned costs to a vehicle trip over a particular segment based on the actual cost of that segment (as shown in Table 3-4) and the average traffic over that segment. With this method, the more costly freeway segments (I-90 between I-5 and I-405, $.205/vehicle-mile) and the segments with relatively light volumes (I-5 High Occupancy Vehicle (HOV) lane, $.341/vehicle-mile) were the most expensive.

__Peak Period__. This method took the segment average method a step further by accounting for the fact that peak period traffic requires more lanes than other periods and consequently should bear the cost of these additional lanes. The basic steps involved in this method are outlined in Figure 3-5. Steps 1 through 4 in the figure were discussed earlier in this section. In step 5, the number of lanes required for each period was determined by dividing the hourly volume during each period by the hourly lane capacity (which in this case was estimated to be 1700 vehicles per hour[1]).

In step 6, the cost of the lanes was allocated to the traffic in the periods requiring them. Everyone must share in the cost of the minimum roadway -- the initial two lanes. The cost of these first two lanes was estimated to be greater than that of subsequent lanes. This was primarily due to "start-up" costs of engineering, design and right of way purchase and to fixed costs associated with such things as landscaping and signing. Unfortunately, data enabling an accurate estimate of the cost of the first two lanes in relation to subsequent ones was not available. For the purposes of this study a rough estimate was made by using a roadway cost estimating model developed by King County (19). With this model the cost of both a four-lane and six-lane roadway was calculated. The difference between these costs was considered to be the cost of the fifth and sixth lanes and was assumed to be roughly equivalent to the cost of the third and

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1 Over the period of a full hour, 1700 vehicles were found to be the most vehicles any freeway lane segment in the study area could support.

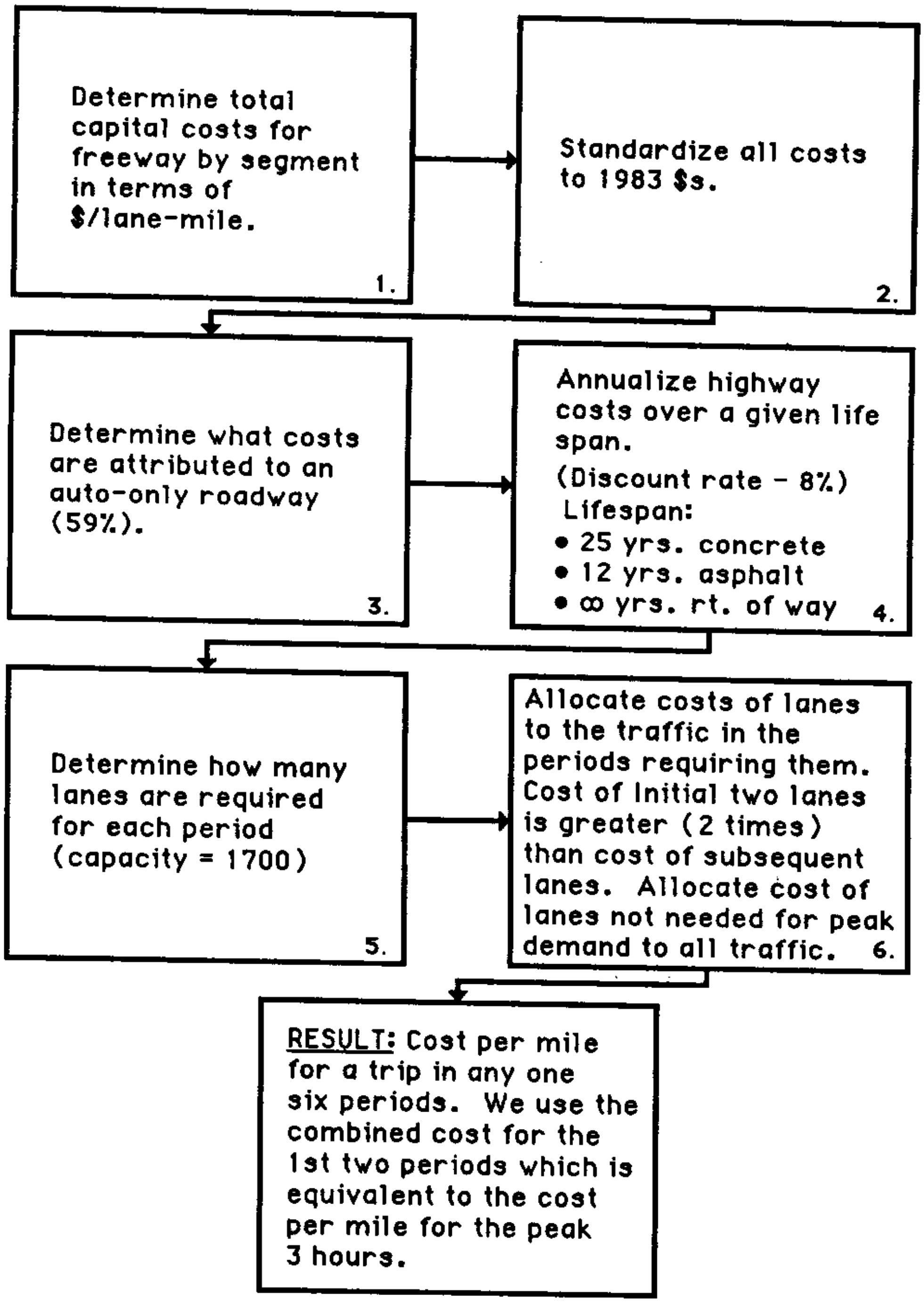

Figure 3-5. Methodology for Estimating Period Highway Costs

fourth lanes. Knowing the cost of these subsequent lanes, the cost of the initial two lanes could be determined. This cost was then compared and found to be 2.3 times greater than that of the subsequent lanes. Allowing for some margin of uncertainty, a general value of 2 was used for this factor.

The night-time period, period 6, typically required only the initial two lanes -- for any lanes more than this, period 6 did not share in the cost. Period 5 traffic may have required 4 lanes, thus it would have shared in the cost for providing the first four lanes only, and so on up to periods 1 and 2. In the case where the freeway was built to a capacity which exceeded even the peak period demand, the cost of the "leftover" lanes was allocated equally to traffic in all periods.

Keeler-Small. In the Keeler-Small study, the cost of autos' use of freeways is estimated using a method based on the theory of optimal highway pricing and investment. This model is concerned with trading off the cost of providing urban freeway capacity against the value of travel time to minimize total capacity related system costs (4). The point at which these costs are minimized represents the optimal level of service for the roadway in question. For the optimal service level, both the short run, marginal cost and the short run, average variable cost can be determined. The difference between these two costs is the marginal congestion cost. More importantly however, assuming investment has been made correctly and returns to scale are constant, these marginal congestion costs are equivalent to user tolls which, if charged, would exactly recover the cost of the road.

This model is complex and theoretical in nature and poses a number of problems if used in a practical framework. First, it treats the highway as a "plant." According to economic theory a plant will naturally adjust itself to its optimum production level. The product in this case is a "unit" of highway capacity. When a plant is at its optimum production level, the price of the product is exactly equal to the marginal cost of that product (20). Hence, in the case of an "optimally adjusted" highway, the marginal costs determined are equivalent to user tolls, which -- if actually charged -- would exactly recover the cost of the road.

One of the problems here is that users do not actually pay a "user toll" equivalent to the marginal cost. Thus, it is unlikely that a highway will ever adjust itself to its "optimum production level." In order for this to actually happen, the state would have to charge appropriate short run, marginal costs during each period, allow demand to change in response, change prices to the new marginal costs, and so on. Since this iterative process is not feasible in this situation, Keeler, Small, et al., decided to "take current demand distributions as given, and base optimal peak tolls on them." They admitted, however, that use of this assumption would "yield upward-biased estimates of long-run optimal tolls for the peak periods and downward biased estimates of optimal tolls for the off-peak periods" (4). This explains why such high highway user costs were obtained when this method was adapted to this study (see Table 3-6).

Of these four highway cost methods just described, the "peak period" method was used for the "in-depth" analysis of this study. However, for comparison purposes, general results of the trip cost model using each of these four methods were computed and will be presented in Chapter Four.

<u>Highway Costs for Buses</u>

Thus far, only the cost of a highway trip as assigned to automobiles has been discussed. The trip cost analysis had to also estimate the highway cost attributable to a transit trip. The USDOT highway cost allocation study gave a cost assignment breakdown by vehicle class for interstate highways. This study assigned autos, passenger trucks and vans 59.38 percent of highway costs, and assigned buses 0.52 percent. Another study showed that on urban interstates and other urban freeways and expressways, autos, passenger trucks and vans represent 88.25 percent of vehicles in the vehicle stream -- while buses account for only 0.31 percent (21). Dividing the percent of costs assigned to each vehicle class by the percentage of that class within the traffic stream yields a value of 0.673 for autos, passenger trucks and vans, and 1.677 for buses. Based on this, the researchers estimated that the highway cost per mile for a bus trip is 1.677/0.673, or 2.49 times that of a freeway auto trip.

Congestion Costs

Traffic congestion imposes a variety of costs upon roadway users. The chief costs include the increased cost of travel time; excessive fuel consumption and increased vehicle maintenance costs due to uneven traffic flow; additional air and noise pollution; and an increase in the probability of traffic accidents. In an attempt to quantify congestion costs, this study draws from several studies in which these costs have been addressed. An argument may be made for the inclusion of other congestion related costs imposed upon the roadway user as well. One study indicated that increased congestion causes increased driving stress, a cost which is difficult to quantify, yet present nonetheless (22). Another study cites the congestion related "increase in the response time to emergency locations by fire and medical units which increases the probability of death and property damage" (23). At this time, however, not enough research has been conducted to enable a reasonable estimate of this cost.

For the purposes of this study, congestion costs will include only the increased costs associated with travel times, automobile operation, traffic accidents, and air and noise pollution. Note, however, that these components comprise a conservative congestion cost since it excludes other congestion related costs which cannot as yet be reasonably estimated.

The first step in developing congestion cost estimates was determining peak traffic volumes for each of the relevant Seattle area freeway segments. Using information from WSDOT's TSMC, average peak hour traffic volumes over each segment were calculated as shown in Table 3-7. Based on these, the marginal impact on the entire traffic stream due to the addition of a given number of vehicles was determined for each freeway segment.

The amount of traffic diverted from each freeway segment due to park-and-ride lots was calculated (see the section on Traffic Volumes, Chapter Four, for details) and added to the existing peak period traffic volumes to estimate what the peak traffic levels might be if the park-and-ride system were not present. It is realized that it is unlikely that all traffic diverted from the roadways due to the park-and-ride lots would return to the roadways if the lots were removed. A certain amount of adjustment would occur as some commuters would find alternative commute means and/or routes by which to avoid the increased congestion. However, since the level of this adjustment is uncertain, and since the cost of any impacts associated with the alter native means and/or routes taken is also unknown, the following congestion costs have been developed based on estimated peak traffic volumes assuming all the diverted traffic would return to the roadway. These volumes are also shown in Table 3-7.

Travel Time. For each freeway segment the decrease in travel speed which would occur if the vehicles currently diverted to the park-and-ride lots were to re-enter the traffic stream, was calculated using the speed-flow curve in Figure 3-6. This curve was developed for the Seattle area based on data obtained from WSDOT for I-5 north of downtown Seattle. Also shown in Figure 3-6 is a theoretical speed-flow for freeways obtained from the Highway Capacity Manual (HCM) (24).

As an example, consider segment 1. Removing park-and-ride lots would increase its volume from 1700 vehicles per hour (vph) per lane to 1800. This results in a reduction of the average traffic stream speed from 53.00 mph to 50.00 mph. For each vehicle to travel 1 mile at this speed requires an extra 0.0679 minutes. However, for all 1800 vehicles, the additional cumulative time spent is 122.264 minutes or 2.038 hours.

**TABLE 3-7.
PEAK HOUR TRAFFIC VOLUMES ON SEATTLE AREA
FREEWAY SEGMENTS: WITH AND WITHOUT PARK-AND-RIDE LOTS**

Segment		Average Peak Hour Lane Volume*	
Number	Description	Existing	P&R Lots
1	I-5: Madison/Northage Way	1700	1800
2	I-5: Northgate Way/Everett	1740	1805
3	I-5 & I-90: Madison/I-405	1685	1645
4	I-90: I-405/Issaquah	570	585
5	I-405: SR-169/SR-522	1780	1800
6	I-5: Madison/I-405 (S)	1870	1870
7a	SR-520: I-5/SR-908	1865	2010

Based on traffic data from WSDOT for Spring 1983

*In vehicles per hour per lane

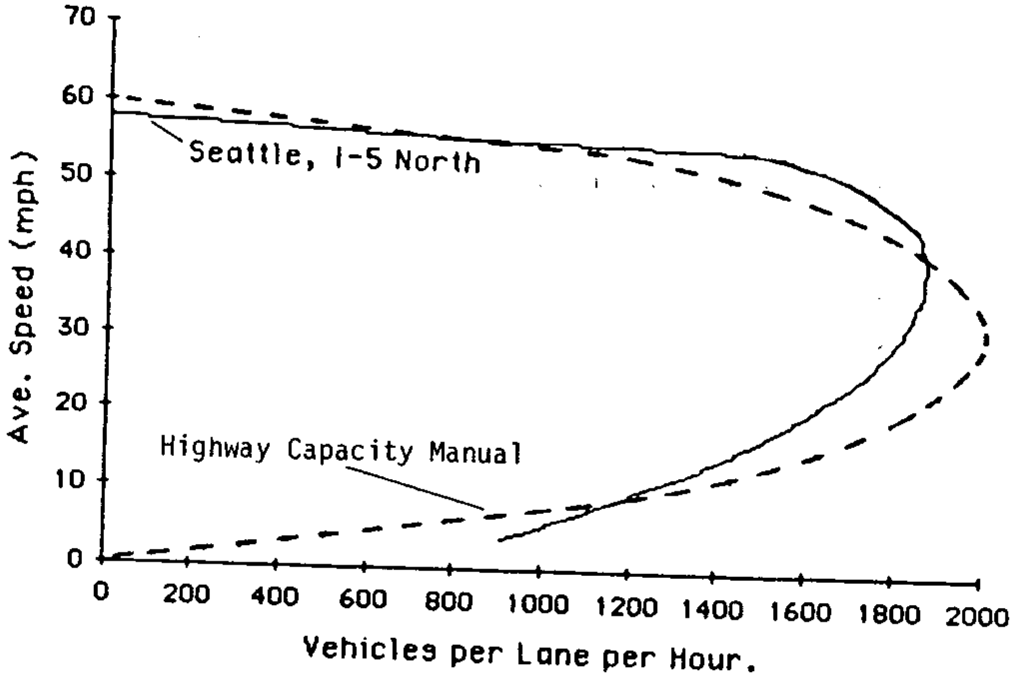

Figure 3-6.
Speed Flow Curves for the Seattle Area and from the Highway Capacity Manual.

One-third the average wage rate for King County workers was found to be $3.70 per hour. Using this as the value of in-vehicle time, the additional cumulative time costs for those 1800 vehicles is $7.54 per mile. This cost is due to 100 vehicles entering the traffic stream. To estimate the cost to be attributed to a single vehicle, the total cost to the traffic stream as caused by 100 cars is divided by 100. The result is a cost of 7.54 cents per vehicle mile. This represents the sum of the additional cost incurred across the entire traffic stream due to the addition of a single vehicle to the stream.

To provide a range for this congestion-related time cost, values of time based on one-fourth the hourly wage rate and one-half the hourly wage rate were used as well. This produced the values of 5.7 and 11.4 cents per vehicle mile respectively, which can be used as the lower and upper limits for this parameter.

Auto Operating Costs. The auto operating costs considered included fuel and variable maintenance costs. Based on the following figures for the U.S. average passenger vehicle fleet mix (23):

Sub compact auto	12%
Compact auto	30%
Standard auto	58%

and the American Automobile Association's (AAA) estimates for auto costs (see next section on Auto Costs for more details), the average auto variable operating cost on freeways was estimated at 8.1 cents per mile. Results from studies attempting to quantify the increase in these costs due to congestion have varied somewhat. One source indicates those costs vary in the same proportion as does travel time (25). Continuing with the example presented in the previous sub-section, the time required to travel a given distance with 1800 vph per lane was 6 percent greater than that required for the same distance with a volume of 1700 vph per lane. Assuming average fuel and maintenance costs of 8.1 cents per mile, each vehicle incurred an additional cost of

0.06 x 8.1, or 0.486 cents per mile. Multiplied by 1800 vehicles in the stream and divided by the 100 additional vehicles yields a cost of 8.75 cents per vehicle mile. This is the additional cost in terms of excessive fuel consumption and maintenance cost that each of the additional 100 vehicles imposes on the entire traffic stream.

Other sources, however, indicate lower costs for this parameter. Rough estimates based on figures from one NCHRP report show that auto running costs increase about 1.4 percent with a change in speed from 50 to 45 mph (26) (corresponding to a lane volume change of 1800 to 1855 vph on the Seattle speed-flow curve, and 1480 to 1740 vph on the Highway Capacity Manual (HCM) curve). Performing calculations similar to those done in the preceding paragraph yields values of 3.82 and 0.76 cents per vehicle-mile respectively. Rough estimates from charts in another NCHRP report indicate an increase in auto running costs of about 3.25 percent for a change in volume to capacity ratio (v/c ratio) of 0.8 to 1.0. This corresponds to a lane volume change of 1495 to 1870 vph based on the Seattle area speed-flow curve, and 1600 to 2000 on the HCM curve. Calculations for these figures produce congestion related auto running costs of 1.33 and 1.32 cents per vehicle-mile respectively. Averaging these yields a value of 1.81 cents per vehicle-mile which may be used as the lower limit for this congestion-related parameter.

Accidents. Accident rates on congested roadways are greater than those for free-flowing roadways. As one study indicates, "it is the differential in speeds that contributes to accidents. Therefore, speed changes in the traffic stream produce accidents" (22). Increased congestion imposes increased accident risks to everyone in the traffic stream. Estimates based on charts in one source indicate that for a speed change from 50 to 45 mph, accident costs on expressways increase by about 13 percent (26). This corresponds to a lane-volume change of 1480 to 1740 vph on the HCM curve and 1800 to 1855 vph on the Seattle area curve. Average accident costs for urban expressways were estimated at 3.22 cents per vehicle-mile (see the sub-section, Accident

Costs, in the next section of this chapter for more details on this). Using this and performing calculations similar to those done for auto running costs, the cost of the imposed accident risk on the traffic system is 2.87 cents and 14.44 cents per vehicle mile based on the HCM curve and the Seattle curve, respectively. These can be used as the lower and upper limits for this parameter.

Environmental Costs. Air and noise pollution due to traffic are impacts imposed not only on roadway users but on the general community as well. Several studies have correlated increased air and noise pollution with traffic congestion. One study states the obvious, that "vehicle emissions are reduced by reducing congestion" (26). With respect to noise pollution, "it is the stop and go traffic characteristic of congestion which is associated with the highest noise levels" (27).

The average cost that one vehicle imposes on society in terms of air and noise pollution was determined to be about 1.5 cents per vehicle-mile (see the following section on "Other Public Costs" for more details on this). Quantifying the increase in these costs due to congestion is difficult. Figures from a study by the Organization for Economic Cooperation and Development (OECD) indicate that vehicle pollutant emissions range from 26 to 530 percent greater for congested versus free flow traffic conditions (27). Kaftansky and Khisty (23) developed values for noise pollution costs which indicated that the costs of commuter traffic noise (0.37 cents/vehicle-mile) is 226 to 711 percent greater than that for the average urban vehicle (ranging from 0.052 to 0.165 cents/vehicle-mile).

The range of estimates for these environmental costs are considerable. As a lower limit, a 26 percent increase may be used since this is the lowest increase cited for either air or noise pollution. An increase of 500 percent was used as a conservative upper limit estimate since the highest figures cited increases of 530 percent and 700 percent for air and noise pollution, respectively.

On the HCM curve, free flow conditions begin to disappear at around 1200 to 1300 vph per lane. Thus, the increases in environmental costs as indicated above occur as lane volumes increase from around 1250 to 2000 vph. Based on this and on the average environmental cost being 1.5 cents per vehicle-mile, calculations for increases of 26 and 500 percent in these environmental costs yield values of 1.04 and 20.0 cents per vehicle-mile, respectively.

Total Congestion Costs. For each congestion cost component a lower and upper limit was estimated. Summing each of the lower limits and higher limits together respectively yields the low and high estimates shown in Table 3-8. Congestion costs for segment 4 are negligible since the peak volumes on that segment are extremely low.

Besides incorporating the lower and upper limit estimates into the trip cost analysis, it was desirable to obtain a middle range value. The estimates for congestion related time costs already provided a middle estimate which is greater than the lower limit by one-third of the difference between the two limits. Since this is less than the average of the two limits, it is a conservative middle estimate. The same proportion was used to arrive at a conservative middle estimate for total congestion costs.

Other Public Costs

Public costs associated with a commuter trip should include not only the capacity related costs of providing and maintaining the roadway, but also the marginal costs of other government provided services to highway users, as well as some measure of the environmental costs that an individual trip invokes. These can be considered the "social overhead" costs. For these, this study relied on the Keeler-Small study, which estimated the total marginal cost of government services to autos in the San Francisco Bay Area in 1972 to be $0.005 per vehicle mile. This included costs for city planning, electricity, public health, coroner, city attorney, district attorney, municipal court, superior court,

TABLE 3-8.
MARGINAL CONGESTION COSTS* IMPOSED ON PEAK PERIOD TRAFFIC BY THE ADDITION OF ONE VEHICLE TO THE TRAFFIC STREAM

Segment Number	Segment Description	Low Estimate	High Estimate	Recommended Value
1	I-5: Madison/Northage Way	11.4	54.6	25.8
1a	I-5: Madison/N.E. 42nd Street (HOV Lane)	--	--	--
2	I-5: Northgate Way/Everett	12.0	56.7	26.9
3	I-5 & I-90: Madison/I-405	6.6	41.1	18.1
4	I-90: I-405/Issaquah	--	--	--
5	I-405: SR-169/SR-522	11.4	54.6	25.8
6	I-5: Madison/I-405 (S)	27.4	110.4	55.1
7a	SR-520: I-5/SR-908	59.9	110.5	61.6

*Costs are in cents per vehicle-mile.

juvenile court, fire department, traffic police, highway patrol, highway administration, and routine road maintenance not varying with capacity.

For environmental costs -- including both noise and air pollution -- the Keeler-Small study estimated a marginal cost of $0.006 per freeway vehicle mile. The portion of this cost attributable to noise pollution is small -- $0.001 -- since the marginal noise cost of an extra vehicle-mile on a freeway is likely to be very low; noise costs are high only on quiet residential streets, where an extra vehicle is likely to be noticed. Pollution costs -- $0.005 per vehicle-mile -- are based on Bay Area estimates for new 1972 pollution controlled autos. Combining the cost of government services with environmental costs gave a total of $0.011 per vehicle-mile for public costs not related to lane capacity. Consumer price indices (13) show that this corresponds to $0.028 per vehicle-mile for the Seattle area in 1983. To calculate these costs for buses, the Keeler-Small model assumed the social overhead cost per bus-mile to be the same as those per auto-mile; however, the environmental costs were estimated to be about 11.5 times greater than those for autos. Based on this, a value of $0.188 per bus-mile is used for this study.

All the public costs thus far outlined have focused on the freeway, or line haul portion of the commute trip. Still to be considered are the line haul feeder portion (i.e., the residential streets and suburban arterials leading to the freeway), and the downtown distribution portion of the trip. Again, following the Keeler-Small study, it is assumed that the roads required for the line haul feeder trip portion are relatively uncongested, and that they would be needed for access to the houses involved, regardless of whether the auto work trip was made or not. Thus, the only public costs considered for this portion of the trip are the $0.028 per auto-mile and $0.188 per bus-mile for environmental, variable maintenance, and social overhead costs of the road system.

As for downtown streets, the Keeler-Small model treats them as a fixed resource and assumes costs are based on the short-run congestions tolls which they would draw in a market equilibrium during the peak period. This cost was found to be directly proportional to the value of time. For a value of time of $3.00 per vehicle-hour, this cost would be about $0.29 per auto-mile and $1.74 per bus mile during the peak period. Adjusting this to an assumed value of $5.15 per vehicle-hour for this study produces a value of $0.498 per auto-mile and $2.987 per bus-mile during rush hour on downtown streets.

AUTOMOBILE COSTS

Automobile Costs: Sources and Methods

The following is a brief outline of the sources, methods, and assumptions used in calculating the various sets of auto costs. Costs per mile by vehicle class are presented for each set in Table 3-9. In general, FHWA costs were the most conservative, Hertz costs the highest, and American Automobile Association (AAA) costs somewhere in between.

One other type of auto cost must be considered here. By their very nature, park-and-ride trips require the use of an automobile. While parked for the day at the park-and-ride lot the auto cannot be used for any other purpose. In light of this, it seems likely that the auto used for the park-and-ride trip would be a "second" car. If this second car was bought and used strictly for this purpose, then it seems reasonable that the cost of that second car should be charged to the park-and-ride trip. This consideration is called the "P&R second car" cost, and is discussed later in more detail. P&R second car costs, when considered, applied only to park-and-ride lot access trips.

FHWA Auto Costs. These costs were taken from an FHWA publication (10) which was based on the typical suburban-based operation of vehicles in the Baltimore, Maryland, area. Vehicle life was assumed to be 12 years with a total lifetime mileage of 120,000 miles. FHWA did not include finance charges in its costs; however, they are relevant to this study and were included based on a 3-year loan and interest rates of

TABLE 3-9.
AUTO COSTS* BY VEHICLE TYPE

	FHWA		AAA		Hertz	
	Arterial	Freeway	Arterial	Freeway	Arterial	Freeway
Large	18.2	16.4	27.7	26.4	44.5	41.7
Intermediate	17.5	14.9	26.1	24.8	43.2	40.8
Compact	13.5	12.1	24.6	23.3	38.8	36.5
Subcompact	12.5	11.0	20.6	19.3	27.5	25.8
Passenger Van	24.2	22.2	38.3	36.8	59.6	56.1

*Costs are in cents per vehicle mile and do not include gasoline or insurance costs.

18 percent for mid-1981 and 11.75 percent for the first quarter of 1984. To determine costs for July, 1983, a straight line curve was drawn between the 1982 and 1984 values and the appropriate costs were picked from the curve.Using the consumer price index for selected cities and SMSA's (28) the values were then transposed to reflect costs in the Seattle/Everett area.

AAA Auto Costs. These costs represented a composite national average and were based on figures published by the American Automobile Association (AAA) for "high-cost" areas (large metropolitan areas) (11). They assumed the vehicle was driven 10,000 miles annually and based depreciation costs on the trade-in value after four years or at 60,000 miles. Insurance costs were based on mainly personal, non-business use of vehicles and no youthful drivers. These costs also did not include outlays for parts, accessories, repairs or other service-station items.

Hertz Auto Costs. Of the three sources typically relied on for estimates of auto driving costs, Hertz Corporation estimates are by far the highest (12). Hertz estimates costs for 20 U.S. cities -- this study used their estimates for Seattle. Estimates were for normally equipped vehicles purchased new, driven for 10,000 miles a year, and kept fully maintained for five years. Hertz costs reflected greater business use of their vehicles than did FHWA or AAA. Insurance costs were based on higher coverage limits and allowed for one or two youthful drivers.

P&R Second Car Costs. The basic methodology for assigning auto owning and operating costs to a commute trip assumes that the commuter owns a vehicle for multiple purposes, only one of which is to commute. Thus, the entire cost of that vehicle is not charged to the commute trip, just the cost per mile for the miles driven while commuting. Some have argued, however, that for a park-and-ride trip, commuters are more likely to purchase a second vehicle specifically for that purpose. If this were truly the case, then auto driving costs for park-and-ride access trips would be higher than those for other purposes.

Auto costs consist of two basic cost types: ownership and operating costs. Operating costs are dependent on the number of miles driven while ownership costs, for the most part, are incurred regardless of mileage driven. If it is assumed that a car is purchased solely for the purpose of getting to and from a park-and-ride lot, then the total miles driven for that car is considerably less than the typical auto. Results from the park-and-ride lot survey indicate that the average park-and-ride lot access trip length was 4.2 miles. Over a period of a year, or 250 working days, this would imply a total of 2,100 miles driven. Using FHWA auto costs as an example, lifetime ownership costs would be divided by 2,100 x 12, or 25,200 miles instead of 12,000 x 12, or 120,000 miles. Operating costs would remain the same per mile. For a new car bought only to be used for park-and-ride lot trips, the auto costs per mile would be 2.67 times greater than that of the typical auto.

However, the park-and-ride lot survey indicates that the average age of vehicles driven to the lot is roughly 8 years. We can thus assume that if a second car were purchased for park-and-ride trips, it would be an older car on the average of 8 years old. This car would have been driven the normal mileage for its first eight years and then driven 2,100 miles a year for the remaining four years. In this case, P&R second car costs would be only 1.08 times that of normal auto costs.

In estimating automobile costs for this study, three separate components were considered: owning and operating (less fuel, insurance and parking) costs, fuel costs, and accident costs. Insurance costs are accounted for in accident costs, while parking costs are considered separately later in this section. Based on a Federal Highway Administration (FHWA) report (10), automobiles were grouped into five classes: large, intermediate, compact, sub-compact, and vans. Auto costs were calculated for each of these classes. There are many other methods and assumptions that can be used in determining these costs. Because of this, auto costs were developed using several different sets of assumptions. The one considered most reasonable was then used for the "in-depth" trip cost analysis.

Before discussing these varying sets of assumptions, some general assumptions that went into the development of the components for all of them should be outlined.

Owning and Operating Costs

Ownership costs considered include depreciation, finance charges, registration and titling fees, scheduled maintenance, and any taxes that apply to these items. For the most part, ownership costs are incurred regardless of how much a vehicle is driven. Operating costs considered include repairs and maintenance, oil, tires, and the taxes applied to these items. In an attempt to reflect the differences between freeway and urban arterial driving costs, the Keeler-Small study makes the assumptions that urban arterial driving is 21 percent more costly than freeway driving in maintenance costs and 300 percent more costly in tire wear. In addition, they assume that typical auto mileage is comprised of 73 percent freeway and 27 percent arterial driving. All owning and operating costs listed later in this section were calculated using these assumptions, which were considered appropriate for the Seattle area.

Gasoline Costs

Gasoline costs were separated from other auto operating costs so that the effects of cold starts could be included in the analysis. Cold starts have the highest impact on short trips; thus it was important to consider them with respect to the short park-and-ride access trip. Figure 3-7 indicates what the typical average relative fuel consumption is for an automobile during the first several miles of its trip. The average relative fuel consumption (ARFC) factor is 3.4 at 0.0 miles and drops linearly to 1.0 at 5.0 miles, at

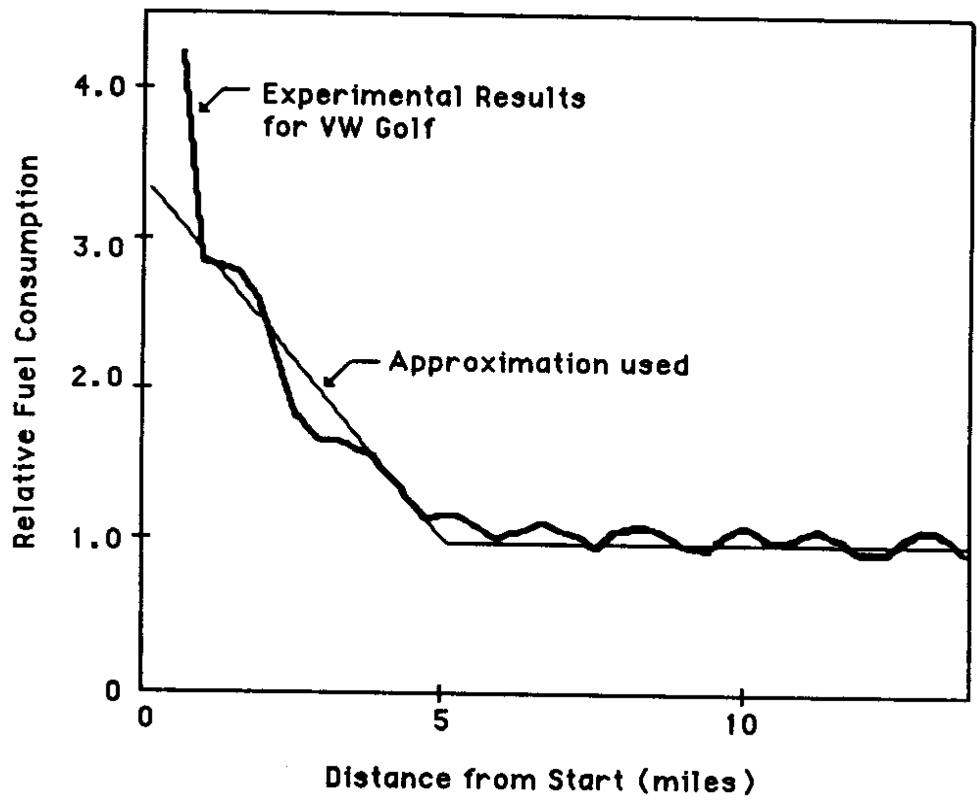

Figure 3-7. Fuel Consumption by Section at 40 mph.
Source: Reference (5).

which point the car is assumed to be fully warmed up (5). Based on this information, the ARFC factor was incorporated into the model.

Also, according to the Keeler-Small study, gasoline consumption is 11 percent greater for arterial driving than for freeway driving. This is due to the frequent stop and go driving that occurs on arterials. For this study's reference date of July, 1983, the average price of gasoline in the Seattle area was $1.273 per gallon (29). Based on these numbers and the assumed mileages listed, gasoline costs for arterial and freeway driving are presented for each of the vehicle classes in Table 3-10.

Accident Costs

Accident costs were determined with the assumption that insurance costs reasonably approximate them. The average insurance cost per mile for all five vehicle classes as estimated by FHWA (10) was used. This value turned out to be $0.050 per mile. However, accident costs can be expected to vary with the degree of congestion. Keeler and Small developed some rough estimates as to how these costs vary between freeway and arterial roads, and between urban and rural areas. The mean ratio of accident rates on uncontrolled to controlled access segments was 2.4. For a ratio of non-rural to rural accident rates a ratio of 1.21 was developed. Using these estimates, the accident costs listed in Table 3-11 were developed. Note that these accident costs are separate from the accident costs incorporated into the congestion costs previously estimated. These accident costs are those normally incurred while traveling on a given type of roadway. Those costs incorporated into the congestion costs represent costs caused by increased congestion and are over and above those incurred normally.

PARKING COSTS

Parking costs considered included the cost of parking in the CBD for all trips driving downtown as well as the cost of providing parking for all park-and-ride trips.

TABLE 3-10
GASOLINE COSTS BY VEHICLE TYPE
CENTS PER MILE

Vehicle Type	Arterial	Freeway
Large	8.1	7.3
Intermediate	6.5	5.9
Compact	5.3	4.8
Subcompact	5.1	4.6
Passenger Van	10.6	9.5

TABLE 3-11.
ACCIDENT COSTS BY ROAD TYPE

Road Type	Accident Costs (cents per vehicle mile)
Rural	
Arterial	6.39
Freeway	2.66
Non-rural	
Arterial	7.73
Freeway	3.22

Average daily parking costs by traffic analysis zone (TAZ) in downtown Seattle were acquired from the Puget Sound Council of Governments (PSCOG) for the summer of 1982 (13). These were updated to 1983 costs using consumer price indices for the Seattle-Everett area.

The cost of park-and-ride lot parking was based on historical cost records for lot construction and land acquisition obtained from WSDOT and annual lot maintenance costs obtained from METRO. Construction and land acquisition costs were annualized over a lifespan of 25 years for construction and an infinite lifespan for land acquisition. The same discount rate used for annualizing highway construction and right of way costs was used here, i.e., 8 percent. Since the lots are used mainly on working days, the total annual construction, right-of-way, and maintenance costs were divided by 250 to get the cost per lot per weekday. These costs were then divided by the number of cars parked in each lot to get the costs per utilized stall per day, which are presented in Table 3-12 for each lot in the two corridor sub-study area. Also presented in Table 3-12 is the cost per stall for each lot. This would be equivalent to the cost per auto parked if the lot were 100 percent utilized.

TRANSIT COSTS

Transit costs were based on a route cost model developed by METRO Transit (14). METRO's model is a fixed/variable cost model and is based on actual reported METRO expenditures. The model assumes that all costs can be cross-classified by the type of system "resource" and the type of cost they represent. This concept is portrayed in Table 3-13. The three resource categories considered were platform hours, platform miles, and block assignment. The basis for these categories is that certain transit costs are most closely related to hours of service while others are more attributable to miles of service. Examples are driver's wages, which are computed hourly, versus fuel usage,

TABLE 3-12
PARK-AND-RIDE LOT COSTS

Lot	Number of Stalls	Number of Stalls Utilized	Cost per Stall	Cost per Auto
Greenlake	185	130	0.51	0.72
North Seattle	99	92	0.46	0.50
Northgate	515	497	1.94	2.01
Shoreline	378	250	2.18	3.30
Mtlake Terrace	337	149	2.13	4.82
Lynnwood	808	720	1.85	2.07
North Corridor	2322	1838	1.80	2.27
Wilburton	190	88	2.28	4.93
South Bellevue	362	49	2.31	17.05
Newport Hills	284	60	2.40	11.36
Eastgate	626	382	1.53	2.51
Issaquah	358	239	1.85	2.78
South Corridor	1820	818	1.96	4.37
Two Corridor Area	4142	2656	1.87	2.92

Notes:

- Costs are in 1983 dollars per day.

- Utilization for all lots save Mountlake Terrace is based on March 1983 figures obtained from METRO. These figures are used because it is believed March is most representative of yearly lot utilization averages. March 1984 figures were used for Mountlake Terrace because it was not open in March 1983.

Table 3-13. Examples of Cross Classification of Transit Agency Costs.

RESOURCE CATEGORIES

COST CATEGORIES	Platform Hours	Platform Miles	Block Assignment
Variable	Drivers	Mechanics, Fuel	
Semi-Variable	Instruction, Service, Supervisors	Maintenance, Foreman, Shop Administration	
Fixed			Operations Management, Debt Service, Planning, Capital

Source: Reference (14).

which is measured in terms of miles. Certain other expenses are not easily correlated with either hours or miles. These may be considered to be overhead costs -- examples of which include the cost of bus maintenance bases and planning and marketing staff. These costs are allocated by block assignment. A block assignment includes the span of operation from the time a bus leaves the base to the time it returns.

The three cost categories include variable, semi-variable and fixed costs. Variable costs are those which fluctuate proportionately with changes in short-run production levels. Conversely, fixed costs are incurred independently of the production level. Semi-variable costs, however, represent something in between in that they do not vary with short-run production levels, yet they do with longer-run levels. An example is wages for service supervisors. When one new driver is hired, no new supervisors are required. However, when the ranks increase by sixty, it may be necessary to add a supervisor.

Costs from METRO's model represented 1982 costs. Price indices were used to update them to 1983 values. Unit costs averaged over the entire Metro route system are shown in Table 3-14. If the coach type or driver type (i.e., full time or part time) was known for a particular route, then the variable cost coefficient could be subdivided further. These refinements are presented in Tables 3-15 and 3-16.

RECOMMENDED VALUES FOR MODEL INPUT PARAMETERS

In order to simplify the "in-depth" cost analysis, the various assumptions and corresponding values of the model input parameters just discussed had to be narrowed to one recommended value for each parameter. For each parameter in which a choice of values existed, the recommended parameter value selected and the reasons for its selection are discussed as follows.

TABLE 3-14
TRANSIT SYSTEM AVERAGE COST COEFFICIENTS

	Per Platform Hour	Per Platform Mile	Per Block Assignment
Variable Costs	$18.98	$0.83	-
Semi Variable Costs	3.09	0.11	-
Fixed Costs	-	0.09	$132.14

TABLE 3-15
TRANSIT VARIABLE COST COEFFICIENT BY DRIVER TYPE

	Cost Per Platform Hour	Additional Cost Per Hour For Artic Assignments
Full-time Driver	$20.87	+ $0.50
Part-time Driver	$11.29	+ $0.50

TABLE 3-16
TRANSIT VARIABLE COST COEFFICIENT BY COACH TYPE

Coach Type	Cost Per Platform Mile
AMG	$0.74
Old Artics	0.77
40' Flyers	0.66
New Artics	1.10

Highway Cost Parameters

When the highway capital costs associated with a vehicle trip are to be included in the trip cost analysis, of the four methods considered for calculating this parameter, the "Peak Period" method was selected for the following reasons:

- It accounts for the differences in freeway segment costs.
- Urban freeways are sized for peak period traffic. This method provides a means to assign the cost of the additional required capacity to the peak period traffic.
- This method is practical, straightforward and models the actual rather than the theoretical situation.

The Keeler-Small method also accounts for differences in freeway segment costs and differences between different time periods; however, due to a variety of reasons, it assigns the vast majority of the highway costs (from 86 percent on I-5 to 99 percent on I-90) to the peak hour traffic. This is neither fair nor realistic. Thus the study team opted not to use the Keeler-Small highway cost method.

A sensitivity analysis was performed using each of these four highway costs. Results are presented in Chapter Three.

Congestion Cost Parameter

The range of estimates for congestion costs is relatively large (see Table 3-8). The lower limit estimate represents the sum of the most conservative estimates for the component values. It is the belief of the researcher that this estimate does not nearly represent the true cost of congestion. Conversely, because the estimate range is so great, using the upper limit (though it is a conservative estimate of the upper limit) may not be justifiable either. Thus, the middle estimate was chosen and is considered to be a relatively conservative estimate for highway congestion costs.

The researchers realize, however, that the reader may have different opinions on this matter and may wish to use one of the other estimates for congestion costs. For this reason trip costs were calculated using each of the estimates. General results of the trip cost comparison based on these calculations are presented in the sensitivity analysis section of Chapter Four.

Auto Cost Parameter

In considering auto costs, an effort was made to encompass a wide range of estimates. The three sources for estimates considered were the Federal Highway Administration (FHWA), the American Automobile Association (AAA), and the Hertz Corporation. Depending upon one's perspective, each of the three estimates could be an acceptable standard. Recognizing this, general results from the trip cost model were computed using each estimate and are presented in the sensitivity analysis section in the next chapter. However, for the more detailed analysis, AAA auto costs were chosen for the following reasons:

- The 12 year lifespan that FHWA assumes produces unrealistically low depreciation costs.
- Hertz estimates are based on the upper extremes of maintenance care, business use, and insurance costs.
- AAA costs represent a fair and realistic compromise between the conservative FHWA and the high Hertz estimates.

Assigning the cost of a second car to park-and-ride access trips was not considered realistic because no evidence exists to warrant it. Park-and-ride lot users, the majority of whom are suburban dwellers, do not have a higher level of vehicle ownership than their suburban neighbors. Hence, the "P&R second car" factor is not significant.

Another consideration worth mentioning here deals with the age of the typical park-and-ride access vehicle versus that of the previous mode auto trip vehicle. From the park-and-ride survey, the average age of the park-and-ride access vehicle was determined to be approximately 8 years. At first glance, this age seemed a little on the high side; however, after considering the average length of the park-and-ride access trip (4.2 miles (6)), it was plain that a newer car was not necessary for that trip. The commuter may opt for a newer more reliable vehicle, however, if the entire commute trip were to be made by auto. Data concerning the age of the typical auto commute vehicle in the Seattle area were not available; however, from the park-and-ride lot survey, age data on carpool vehicles egressing the lots to workplace destinations were available. The average age for these vehicles was about 5.5 years. This indicates that for longer trips commuters tend to employ newer vehicles. If this is indeed the case, then auto costs for the previous mode auto trip would be higher than those for the park-and-ride access trip. Since reliable data were not available to support and/or quantify this assumption, auto costs for both the previous mode and the park-and-ride trip were based on the same AAA estimates.

One other significant assumption in this category deals with accident costs. These costs have been developed for both freeways and arterials, and for both rural and non- rural areas. Accident rates on arterials are higher than those for limited access expressways -- thus, accident costs are also higher. At the time this study was conducted, the majority of the I-90 segment between I-405 and I-5 (segment 3B in Figure 3-1) was a narrow, non-divided, 4-lane roadway. During the morning and afternoon peaks one of the non-peak direction lanes was reversed so as to be used for peak direction traffic. This gave 3 peak direction lanes and 1 non-peak direction lane. Due to these factors, this segment of I-90 had higher accident rates than a typical fully controlled Interstate freeway would have had.[1] Because of this, the trip cost model assigned higher accident costs (equivalent to those for non-rural arterials) to this I-90 segment.

DEFINING AND CALCULATING THE WORK TRIP

Besides the cost component coefficients for time, public, auto, parking and transit costs, several other assumptions and parameters were required for defining and calculating the total trip cost for each trip type considered. These are outlined in the following subsections along with a sample cost calculation for each trip type.

Auto Trip

Basic parameters required for calculating the cost of an auto trip include knowing trip distances and speeds traveled. Trips are assumed to be made over several road segment types. Similar to the Keeler-Small model, these segment types are assumed to include the line haul feeder segment (the portion of the trip on residential streets and suburban arterials leading to the freeway); the line haul or freeway segment; and the downtown distribution segment (which is made over CBD streets). Distances over each of these segments to the Seattle CBD were measured from each census tract which contained a case trip origin. Travel speeds were assumed to be 25 mph for the line haul feeder segment and 20 mph for the downtown distribution portion of the trip. Peak period freeway speeds for each of the freeway segments defined (see Figure 3-1) were obtained from the Traffic Systems Management Center (TSMC). In most instances, in-vehicle travel time was calculated by dividing travel distance by speed. However, in the case of carpools, some additional in-vehicle time was assumed to allow for the pick-up of other riders. Following the Keeler-Small example, a car-pooling delay of 5 minutes

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[1] Based on traffic accident data obtained from WSDOT personnel.

per passenger was used. Out-of-vehicle time for the auto trip consisted of the CBD terminal time, i.e., the time spent parking and walking to the office. Average auto terminal times by downtown TAZs were obtained from PSCOG for this purpose.

Table 3-17 outlines a sample cost calculation for a one-way, peak period, auto work trip.

Park-and-Ride Transit Trip

The park-and-ride transit trip consists of two distinct parts: the lot access trip made by auto, and the transit trip from the lot to downtown. The automobile access trip is calculated in the same manner as the auto work trip. Access distances for cases in the Southeast Corridor were measured from a map. These measured distances were compared with corresponding TAZ centroid to TAZ centroid distances obtained from PSCOG.This provided a reliable "TAZ" distance to "real" distance conversion factor of 0.837 (6). Access trip distances were not measured for the North Corridor, but TAZ to TAZ distances were available. Thus, the conversion factor was applied to North Corridor lot access trip lengths.

Another factor to consider in the park-and-ride trip is the time it takes to circulate the lot looking for an empty stall, park, exit and lock the vehicle, walk to the bus stop area, and wait for the bus. Time spent parking and walking will vary with the size of the lot. 2-1/2 minutes were allotted for circulation, parking and exiting the vehicle; and 2-1/2 minutes were allotted for walking to the bus pickup area (based on a walking speed of 4'/second and an average distance of 600' to walk). Peak period headways for buses serving park-and-ride lots range from 1 to 15 minutes; however, most patrons wait only a few minutes for a CBD-bound bus during peak periods -- a conservative wait time of five minutes, which is one-half of the average headway for most lots, is used here.

TABLE 3-17.
SAMPLE CALCULATION FOR A
ONE-WAY, PEAK PERIOD AUTO WORK TRIP

<u>Input Parameters</u>			
- Value of Time per Person per Hour:			
In-Vehicle		$3.50	
Out-of-Vehicle		$8.75	
- Trip Length and Travel Speed:		<u>Miles</u>	<u>MPH</u>
Line Haul Feeder		5.0	25.0
Freeway Segment 2		5.5	50.0
Freeway Segment 1		7.0	50.0
Downtown Distribution		0.5	20.0
Total		18.0	--
- Vehicle Occupancy	1 Person		
- Vehicle Type	Compact		
<u>Trip Segment</u>		<u>Cost</u>	
- Line Haul Feeder:			
Time costs		0.700	
Public costs[a]		0.056	
Auto costs[b]		2.200	
- Line Haul:			
Time costs		0.875	
Public costs[c]		4.730	
Auto costs[d]		3.913	
- Downtown Distribution:			
Time costs[e]		0.817	
Public costs[f]		0.263	
Auto costs[g]		0.188	
Parking costs[h]		5.00	
Total cost per Person Trip[i]		$18.75	

TABLE 3-17.
SAMPLE CALCULATION FOR A
ONE-WAY, PEAK PERIOD AUTO WORK TRIP (Continued)

Notes:

[a] Includes only non-capital costs (i.e., environmental, social overhead, etc.) -- see text.

b Based on Tables, 3-9, 3-10, and 3-11 (AAA costs) for non-rural arterials. Includes cold start factor (ARFC) of 2.2 applied to Table 6 value.

[c] Based on Table 3-4 peak period costs and Table 3-8 middle range congestion costs for segments 1 and 2 plus other non-capital costs (see text).

[d] Based on Tables 3-9, 3-10, and 3-11 (AAA costs) for non-rural freeways.

[e] Assumes an out-of-vehicle time of 5 minutes for parking and walking to workplace.

[f] Includes non-capital costs plus short-run congestion costs as outlined in text.

[g] Based on Tables 3-9, 3-10, and 3-11 (AAA costs) for non-rural arterials.

[h] Based on downtown parking fee of $5.00.

[i] This cost is for a single occupancy vehicle trip. If this were a carpool trip of 2 persons all costs other than time costs would be divided by 2 to get an overall trip cost of $7.83 per person. (Time costs per person would increase slightly due to an assumed carpooling delay - see text).

For the transit portion of the trip, distances between the lot and downtown were measured from a map. Typically, several routes serve a given park-and-ride lot. Trip times were based on a composite average of bus schedule times for the various routes serving the lot and downtown Seattle. Other route-specific information required included the amount of transit deadhead and layover time to assign to the park-and-ride trip. Deadhead and layover times as well as revenue and block times for relevant routes were acquired from METRO. In cases where routes extended beyond the park-and-ride lot, it was not reasonable to charge the routes' entire deadhead and layover time to the park-and-ride trip. Thus, these values were assigned in a proportion similar to that of the lot-to-downtown run-time to the overall route revenue time. Deadhead miles were assigned in the same way. Also developed from material obtained from METRO were composite averages for the relevant routes involved for driver type (i.e., percentage of part-time vs. full-time drivers) and coach type.

Passenger volume data by route for the spring of 1983 was acquired from METRO as well. From this, average peak period passenger volumes for routes between the park-and-ride lots and downtown Seattle were derived.

One other consideration is the time spent downtown walking between the bus stop and the workplace. An average transit terminal time of 2 minutes was obtained from PSCOG and used in this study.

A sample cost calculation for both a one-way, peak period, park-and-ride transit work trip and a park-and-ride carpool work trip is outlined in Table 3-18.

<u>Park-and-Ride Carpool Trip</u>

Distances for the park-and-ride carpool trip were measured in the same way as those for the park-and-ride transit trip. Calculations for the auto access trip cost and the cost of the trip between the lot and downtown were done in the same manner as those for the park-and-ride transit trip and the auto work trip, respectively. One

TABLE 3-18.
SAMPLE CALCULATION FOR A ONE-WAY, PEAK PERIOD PARK-AND-RIDE WORK TRIP: BOTH TRANSIT AND CARPOOL

Input Parameters

- Value of Time per Person per Hour:

In-Vehicle	$3.50
Out-of-Vehicle	$8.75

- Trip Length, Travel Speed and Time:

	Miles	MPH	Minutes
Park-and-Ride Access Trip	5.0	25.0	12.0
Park-and-Ride to Downtown Trip			
Transit-Line Haul Segment 2	7.5	--	--
Line Haul Segment 1	7.0	--	--
Downtown Distribution	0.7	--	--
Total (Transit)	15.2	--	34.0
Carpool-Line Haul Segment 2	7.5	50.0	9.0
Line Haul Segment 1	7.0	50.0	8.5
Downtown Distribution	0.5	20.0	1.5
Total	15.0	--	19.0

- Vehicle Occupancy

	Number of Persons
Park-and-Ride Access Trip (Auto)	1
Transit Trip	40
Carpool Trip	

- Vehicle Type:

Park-and-Ride Access Trip	Compact Act
Transit Trip	New Artic Coach
Carpool Trip	Intermediate Auto

- Other Transit Trip Characteristics

Driver Type	Part-Time
Route Revenue Minutes	53
Route Deadhead Minutes	48
Route Layover Minutes	6
Block Revenue Minutes	88
Block Platform Hours	2.96
Block Platform Miles	74
1 Person	

TABLE 3-18.
SAMPLE CALCULATION FOR A
ONE-WAY, PEAK PERIOD PARK-AND-RIDE WORK TRIP:
BOTH TRANSIT AND CARPOOL (Continued)

Trip Segment	Cost
- Park-and-Ride Access Trip (Auto):	
Time costs	0.700
Public costs[a]	0.056
Auto costs[b]	2.200
Parking costs[c]	1.035
Segment Total	3.991
- Park-and-Ride to Downtown Trip:	
Transit Trip:	
Time costs[d]	3.733
Public costs[e]	0.435
Transit Costs[f]	2.011
Transit Segment Total per Passenger	6.179
Carpool Trip:	
- Line Haul -	
Time costs [g]	5.233
Public costs[h]	5.406
Auto costs[i]	4.918
- Downtown Distribution -	
Time costs [j]	2.451
Public costs[k]	0.263
Auto costs[l]	0.202
Parking costs[m]	0.500
Carpool Segment Total	19.973
Total per Passenger	6.324
Total Park-and-Ride Transit Trip Cost per Passenger:	$10.17
Total Park-and-Ride Carpool Trip Cost per Passenger	$10.32

TABLE 3-18.
SAMPLE CALCULATION FOR A ONE-WAY, PEAK PERIOD PARK-AND-RIDE WORK TRIP: BOTH TRANSIT AND CARPOOL (Continued)

Notes:

[a] Includes only non-capital costs -- see text.

b Based on Tables, 3-9, 3-10, and 3-11 (AAA costs) for non-rural arterials. Includes cold start factor (ARFC) of 2.2 applied to Table 6 value.

[c] Cost of park-and-ride lot parking for Lynnwood Lot -- see Table 3-12.

[d] Includes 10 minutes' parking and waiting for bus at park-and-ride lot and 2 minutes' walk time in downtown.

[e] Based on Table 3-6 peak period costs and Table 2-8 middle range congestion costs for segments 1 and 2 multiplied by a factor of 2.49 for transit (see text). Also includes non-capital costs for transit road use and transit short-run congestion costs for downtown portion of the trip (see text).

[f] Deadhead and layover time charged is 32 and 4 minutes, respectively. Deadhead miles charged is 13.3. Costs are based on Tables 3-14, 3-15, and 3-16. Since total block time for this route is less than 4 hours, it is assumed the coach can be assigned to another run during the day. Thus the cost per block assignment as shown in Table 3-14 is halved when applied here.

[g] Based on all 3 passengers' time spent. Includes 5 minutes spent parking at park-and-ride lot and waiting for other carpool members.

[h] Based on Table 3-4 peak period costs and Table 3-8 middle range congestion costs for segments 1 and 2 plus other non-capital costs (see text).

[i] Based on Tables 3-9, 3-10, and 3-11 (AAA costs) for non-rural freeways.

[j] Includes 5 minutes spent parking and walking to workplace in downtown.

[k] Includes non-capital costs plus short-run congestion costs as outlined in text.

[l] Based on Tables 3-9, 3-10, and 3-11 (AAA costs) for non-rural arterials.

[m] Assumes a carpool parking fee of $1.00 per day.

consideration unique to this trip is the time spent parking and waiting for the other carpoolers to arrive.

The average vehicle occupancy for park-and-pool egress vehicles was 5.27 persons. For 4 or 5 separate persons to park and congregate at one vehicle takes time. The last pooler to arrive may only spend one minute parking and getting into the car/vanpool vehicle; however, the first person to have arrived may have been waiting ten minutes. As a rough average, five minutes was used for this parameter in this study.

A sample calculation for a one-way, peak period, park-and-ride carpool work trip is included as part of Table 3-18.

Drive to Transit Trip

A significant number of current park-and-ride lot users drove to transit before they used the park-and-ride lot. This trip is similar to the park-and-ride transit trip except that it does not involve the use of the park-and-ride lot. The commuter drives to a convenient bus stop, finds a nearby parking place (usually on the street), and takes transit downtown. Data with respect to the auto access and the transit trip lengths for this type of trip were not available. It was assumed, however, that on the average these trip lengths would be similar to those of the corresponding park-and-ride trip. Hence, cost calculations for this previous mode trip were made in the same manner as those for the corresponding park-and-ride transit trip. The one difference, however, is that the cost of providing park-and-ride lot parking was not included in the drive-to-transit cost calculation. A sample cost calculation is not included here since it is basically the same (less the park-and-ride parking cost) as the one shown for the park-and-ride transit trip in Table 3-18.

Walk to Transit Trip

Average values by TAZ were obtained from PSCOG for transit access walk time, transit wait time, and transit run time to downtown Seattle. Highway distances measured from corresponding Census Tract centroids to the Seattle CBD were used for transit trip lengths. The time spent walking between the bus stop and the workplace was considered to be the same as that for the park-and-ride transit trip -- 2 minutes (obtained from PSCOG).

Since information pertaining to bus driver type or coach type was not available, the average cost coefficients from the METRO route cost model (see Table 3-14) were used. To estimate deadhead and layover time, and deadhead miles, a proportional method was used. For routes serving downtown Seattle from the 11 sub-study area lots, average layover (6 minutes), deadhead (36 minutes), and revenue run (53 minutes) times were determined using METRO data. Given these proportions and the transit run time obtained from PSCOG, layover and deadhead times were calculated. Deadhead miles were estimated to be in the same proportion to revenue miles as deadhead minutes were to revenue minutes. Block revenue time, deadhead time, and miles were also needed for this cost calculation. Approximations for these were obtained by taking averages for routes serving the 11 lots in the sub-study area. The resulting average values were 145 minutes, 98 minutes, and 74 miles for block revenue time, deadhead time, and miles, respectively.

A sample walk-to-transit work trip calculation is presented in Table 3-19.

TABLE 3-19.
SAMPLE CALCULATION FOR A ONE-WAY, PEAK PERIOD TRANSIT WORK TRIP

Input Parameters

- Value of Time per Person per Hour:

In-Vehicle	$3.50	
Out-of-Vehicle	$8.75	

- Trip Length and Travel Speed:

	Miles	Minutes
Line Haul Feeder	3.8	--
Line Haul Segment 2	7.5	--
Line Haul Segment 1	7.0	--
Downtown Distribution	0.7	--
Totals	19.0	52

- Vehicle Occupancy	10 persons
- Walk-to-Transit Time	6 minutes
- Transit Wait Time	10 minutes

Cost Category	Cost
Time Costs	
In-vehicle	2.625
Out-of-vehicle[a]	3.033
Total:	5.658
Public Costs	
Non-capital costs[b]	0.119
Highway capital and congestion costs[c]	0.415
Downtown short-run congestion costs[d]	0.070
Total:	0.604
Transit Costs	
Hour based[e]	1.143
Mileage based[f]	1.095
Block assignment based[g]	0.491
Total	2.729

Total Cost per Passenger Trip $8.99

TABLE 3-19.
SAMPLE CALCULATION FOR A ONE-WAY,
PEAK PERIOD TRANSIT WORK TRIP (Continued)

Notes:

[a] Includes 16 minutes for walk access and wait time plus 2 minutes for walk time between the bus stop and workplace.

b $0.188 per transit mile -- see text.

[c] Based on Table 3-4 peak period costs and Table 3-8 middle range congestion costs for segments 1 and 2 multiplied by a factor of 2.49 for transit -- see text.

[d] $2.987 per transit mile -- see text.

[e] Based on coefficients in Table 3-14. Time charged includes trip run time (52 minutes), deadhead (35 minutes), and layover time (6 minutes).

[f] Based on coefficients in Table 3-14. Miles chrged include trip miles (19.0) and deadhead miles (12.9).

[g] Based on coefficients in Table 3-14. The block assignment coefficient is halved because block time in this case is less than 4 hours -- see text.

CHAPTER FOUR: RESULTS AND ANALYSIS

COST COMPARISONS

The following cost comparisons, unless otherwise stated, are based on the recommended set of assumptions and values for the input parameters described in the previous chapter, which include the following:

- automobile owning and operating costs based on the American Automobile Association (AAA) cost estimates,
- highway costs attributable to a peak hour vehicle trip based on the "peak period" highway cost method,
- middle range estimates for roadway congestion costs.

A full set of trip cost model output tables based on these assumptions and the corresponding input parameters is contained in Appendix D.

Total Costs

The total cost comparison for the average previous mode trip versus the average park-and-ride trip based on the 467 cases analyzed is presented in Figure 4-1. The figure also indicates the component costs (which include both highway and congestion costs) for each trip. Keep in mind that these costs are averages for all trip types in each category, i.e., the average previous mode trip represents a combination of walk to transit, drive to transit, carpool and auto trips, while the park-and-ride average trip incorporates both park-and-ride transit and park-and-ride car/vanpool trips. The results show that on the average, the park-and-ride trip is less expensive than the previous mode trip. The primary savings are in auto, roadway, and congestion costs. The auto costs are less expensive simply because the commuter is driving a shorter distance. The savings in roadway and congestion costs is due primarily to the reduction in the number of autos

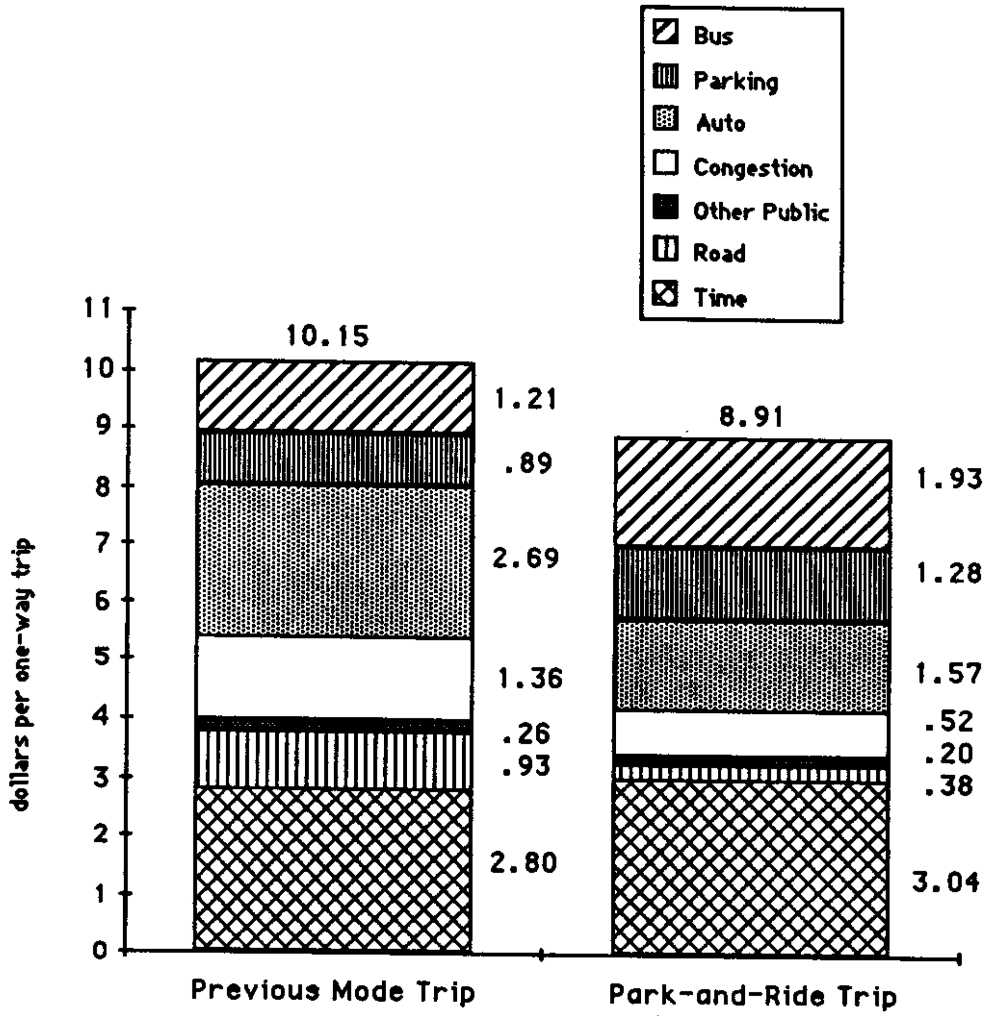


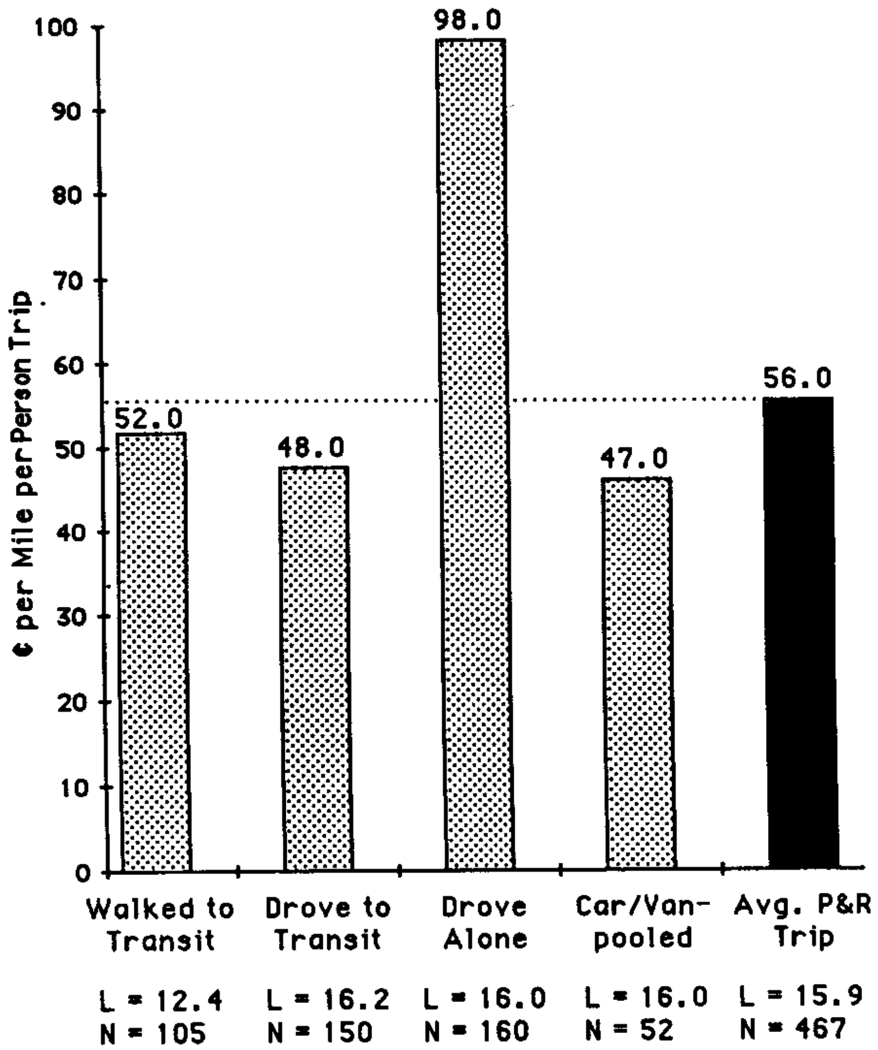
Figure 4-1. Total Incurred Cost Comparison:
Combined Average Previous Mode Trip vs.
Combined Average Park-and-Ride Trip
(Highway Costs Included)

using the freeways -- which are both expensive to provide and relatively congested during the peak periods.

The park-and-ride trip is more expensive with respect to time, transit, and parking costs. The latter may seem a little surprising but the 55 percent of previous mode trips involving transit have no parking costs. The only previous mode trip with significant parking costs is the auto drive alone trip. Conversely, every park-and-ride trip incurs the cost of parking at the park-and-ride lot (this is an agency cost, not a user cost). Transit costs are more expensive because 96.8 percent of the park-and-ride trips analyzed involved transit. Only 55 percent of previous mode trips involved transit -- thus, when transit costs are averaged over all previous mode trips, the per trip cost is lower. The park-and-ride trip is also more costly in time. One reason for this is that the trip is slightly longer (15.9 miles to 15.3 miles for previous mode), but the primary cause is the time spent transferring from auto to transit at the park-and-ride lot.

Figure 4-2 shows the previous mode, average total trip costs in terms of cost per mile for each individual previous mode and compares them to the average park-and-ride trip cost. Since the average trip length for the previous modes differ, the costs are presented in terms of cost per mile to make them comparable across modes. The most expensive previous mode is by far the auto drive alone trip. In addition, this is the only previous mode trip which is more expensive than its corresponding park-and-ride trip. All of the others are less expensive. The high cost of the auto drive alone trip is what causes the combined average previous mode trip cost to be greater than that of the park-and-ride trip. This obviously suggests that the higher the proportion of auto drive alone trips a park-and-ride system can attract and convert to park-and-ride trips, the more cost effective that system will be.

This total cost comparison includes the cost of both highway capital costs and the costs of congestion and indicates the park-and-ride trip is 11.6 percent less expensive



L = Avg. Previous Mode Trip Length
N = Number of Cases

Figure 4-2. Previous Mode Trip Cost by Mode Type vs. Average Park-and-Ride Total Trip Cost (Highway Costs Included).

than the previous mode trip. As was discussed in Chapter One, arguments may be made for excluding highway costs -- since they may be viewed as "sunk" costs -- from the cost analysis. Hence, throughout this chapter, cost comparisons will be presented both ways -- i.e., once with the inclusion of highway costs, and then again for when highway costs are excluded. If the above total cost comparison were made without the inclusion of highway costs, then the resulting trip cost comparison would be as shown in Figure 4-3. Since highway costs are greater for the previous mode trip, excluding them causes a great reduction in the previous mode trip as compared to the park-and-ride trip. However, the overall result still shows the park-and-ride trip to be less expensive than the previous mode trip by 7.5 percent ($8.59 to $9.29)

Agency and User Costs

In addition to total public and private trip costs, the costs incurred by the principal agencies involved (WSDOT and METRO) and by the individual user are interesting. Figure 4-4 presents these incurred costs in a before and after (previous mode vs. park-and-ride) comparison. The agency "after" costs, which include highway costs, are shown for both existing and 100 percent lot utilization levels.

With respect to WSDOT, park-and-ride trips reduce roadway costs, but the added expense of providing the lot overrides these savings. The net result is that WSDOT spends $0.61 per park-and-ride person trip. However, since WSDOT's primary function is to serve the transportation needs of the public -- which in this case includes the park-and-ride lot user as well as the general roadway user -- net costs to WSDOT must be weighed against benefits to both the park-and-ride and the general roadway user. The savings to the park-and-ride lot user as shown in Figure 4-4 is $1.48, or 22.9 percent, per trip. This in itself more than makes up for WSDOT's expense.

Adding the savings for roadway users due to reduced congestion ($0.84 -- the difference between "before" and "after" congestion costs in Figure 4-1) to user savings

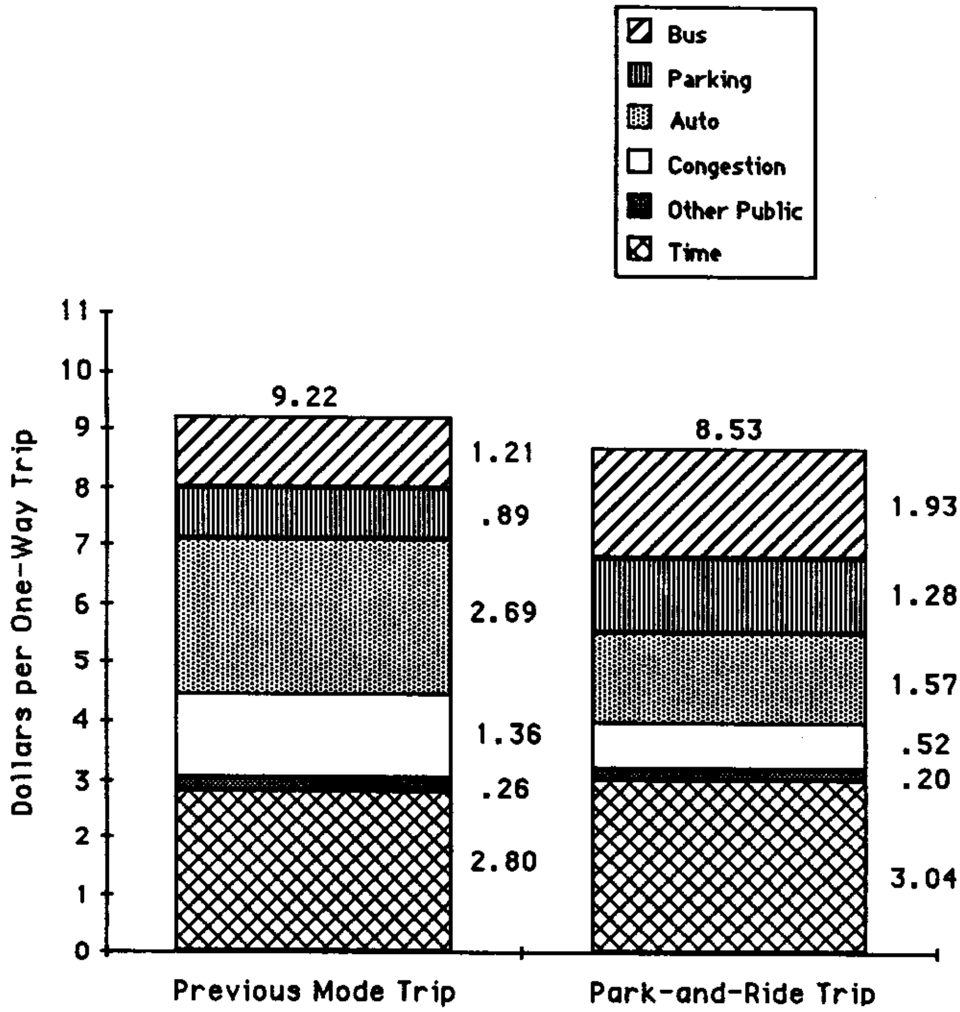


Figure 4-3. Total Incurred Cost Comparison:
Combined Average Previous Mode Trip vs.
Combined Average Park-and-Ride Trip
(Highway Costs Excluded).

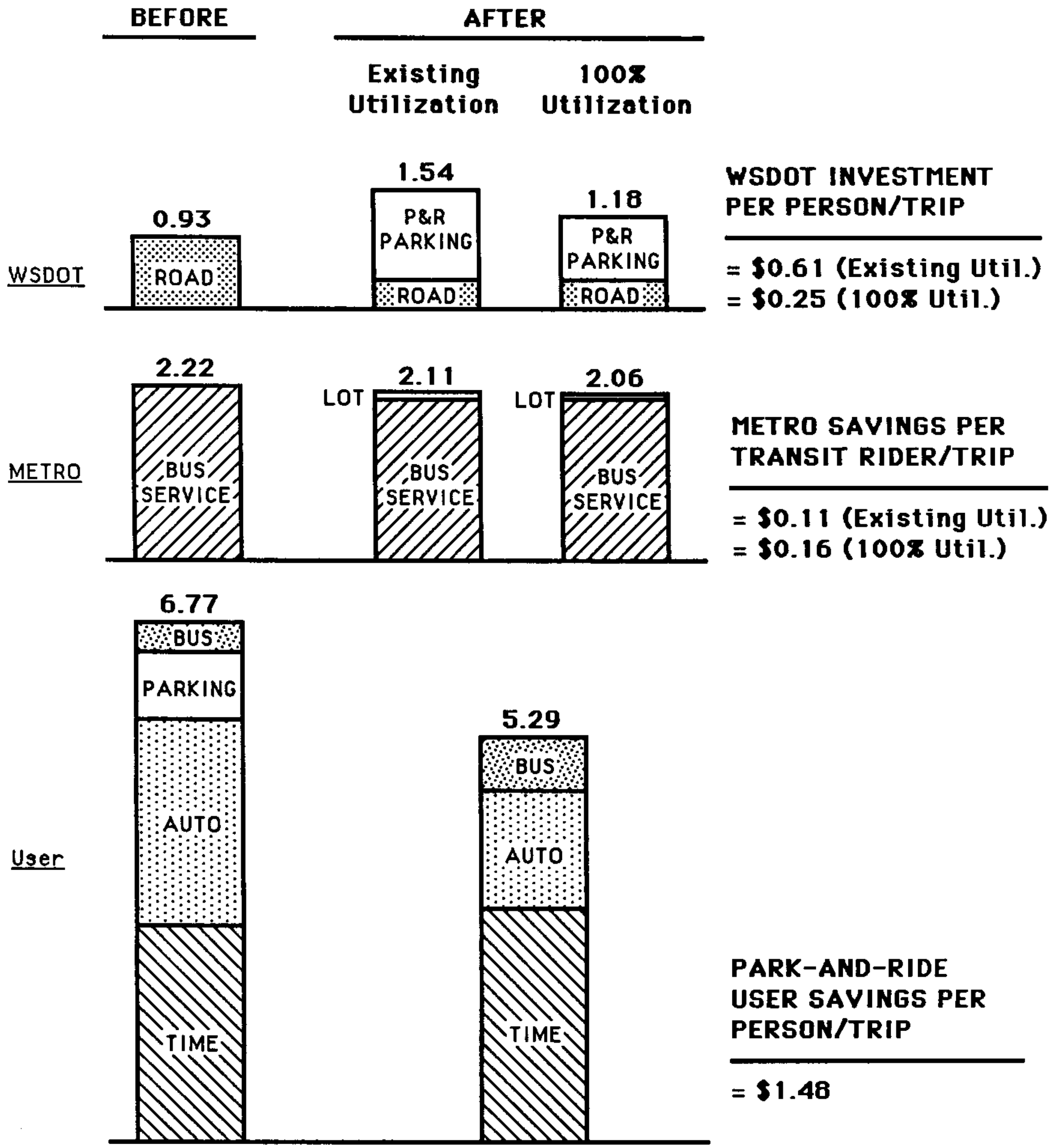


Figure 4-4. Agency and User Incurred Trip Cost Comparison (Highway Capital Costs Included).

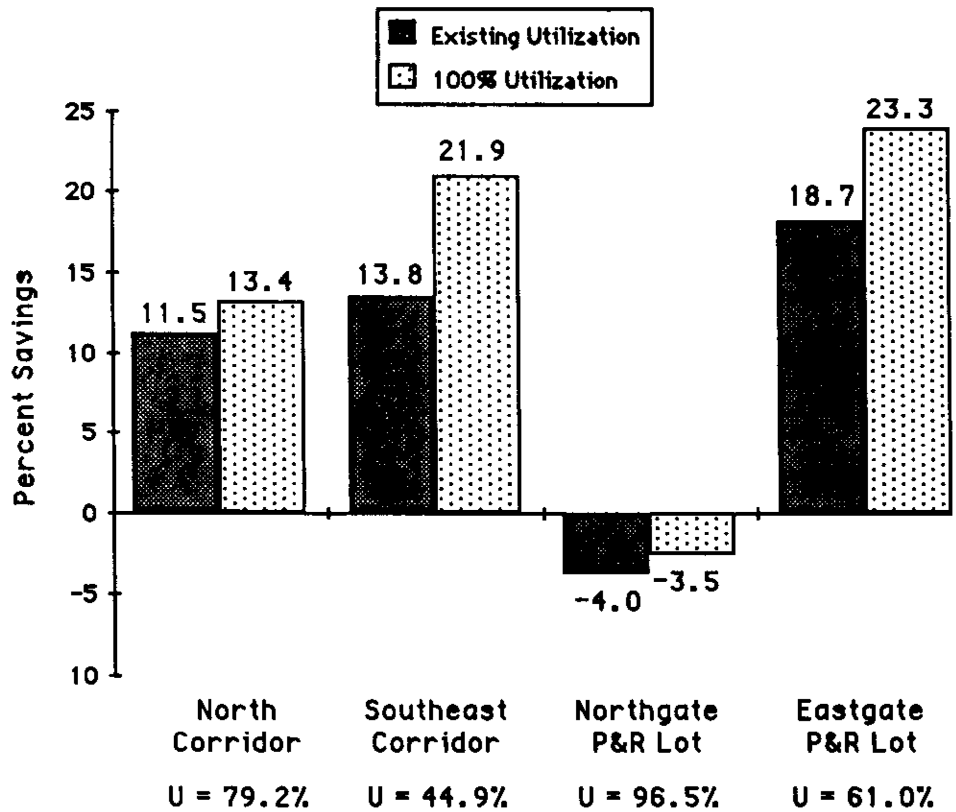
yields a total of $2.37 per person trip as the net savings to the user and general public. Dividing this by WSDOT investments yields a substantial benefit-cost ratio of 3.85. If the lots were used to full capacity, WSDOT's net cost per trip would decrease to $0.25 and the overall benefit-cost ratio would increase significantly to a value of 9.40.

It is also of interest to examine WSDOT's costs versus the transportation system user's benefit when another scenario is considered -- namely, when highway capital costs are excluded from the analysis. For this case WSDOT does not experience any savings in roadway costs (except minimal maintenance costs). Thus, WSDOT's costs for provision of the park-and-ride lots are $1.16 and $0.80 per person trip for the cases reflecting existing and 100 percent lot utilization, respectively. Based on this and on the transportation user's combined savings of $2.34 per person trip, the benefit/cost ratio is calculated at 2.03 and 2.94, respectively, for existing and 100 percent lot utilization levels.

In considering costs incurred by Metro, previous mode trips involving transit (55 percent of all previous mode trips) are compared to park-and-ride transit trips (96.8 percent of all park-and-ride trips). Metro's costs are reduced by $0.11, or 5.0 percent, per transit rider trip when park-and-ride lots are involved (if the lots were 100 percent utilized this would rise to $0.16, or 7.2 percent). In addition, among the data population analyzed, the introduction of park-and-ride lots contributed to a 77 percent increase in transit ridership.

CORRIDOR COMPARISON

Figure 4-5 presents the percent of savings due to park-and-ride lots and utilization rates for each of the north and southeast corridors as well as for two individual lots, Northgate and Eastgate. These costs include highway capital costs. With respect to trip cost savings, park-and-ride lots are more effective in the southeast corridor than in the north. This is somewhat surprising in light of the fact that the southeast corridor has a much lower utilization rate (44.9 percent to 79.2 percent for the



U = Average utilization rate during 1983

Figure 4-5. Total Trip Cost Savings Due to Park-and-Ride Lots by Corridor and by Selected Lots. Highway Capital Costs Included.

North). In fact, since its current utilization is so much lower, the southeast corridor has a higher potential for improvement. If the lots were fully utilized, the percent savings per park-and-ride trip would increase to 21.9 percent for the southeast corridor as opposed to 13.4 percent for the north. This contrast in cost effectiveness is even more evident if two selected lots from each of the corridors -- Northgate from the north corridor and Eastgate from the southeast (#'s 3 and 17, respectively, in Figure 1-1, Chapter I) are compared. The Northgate lot, even when fully utilized, experiences an average loss of 3.5 percent per trip, while Eastgate shows an impressive savings of 23.3 percent when fully utilized.

Several factors are involved in producing this discrepancy between the two corridors. One is that southeast corridor trips must travel along I-90, which was a much more costly road to build than was I-5 in the north corridor (see Table 3-4, Chapter Three). Hence, replacing auto with transit trips results in greater savings in the southeast corridor than in the north.

Perhaps a more significant reason, however, is found by comparing the percentage breakdown of previous mode trips between the two corridors (see Figure 4-6). Both corridors are fairly similar in their percentages of drive to transit and car/vanpool trips. However, a significant difference exists between their walk to transit and auto drive alone trips. Park-and-ride lots in the southeast corridor drew a significantly greater proportion of auto drive alone trips from the roadway than did those in the north. At the same time, fewer southeast park-and-riders had previously walked to transit. When compared to the park-and-ride trip, the auto drive alone trip is far costlier while the walk to transit trip is less expensive (see Figure 4-2). Thus, the southeast corridor experiences a greater savings in overall trip costs than does the north corridor.

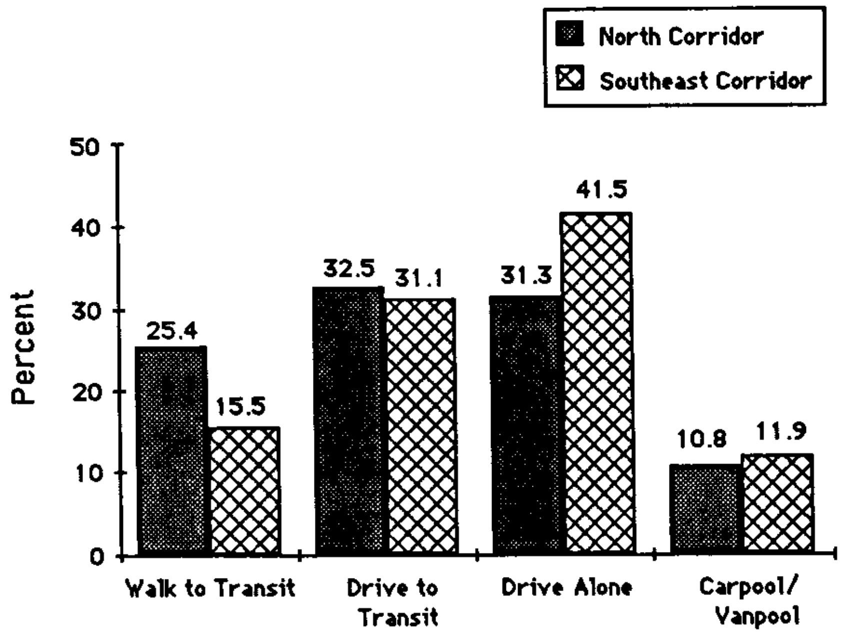


Figure 4-6. Previous Mode Percentage Breakdowns by Corridor.

Figure 4-7 shows the general cost comparison results by corridor for the case in which highway capital costs are excluded from the cost analysis. In this case, the north corridor appears to fare better than the southeast (8.7 percent savings to 4.3). This is because estimated congestion costs are higher in the north corridor than in the southeast (see Table 3-8, Chapter Three) while highway costs are much greater in the Southeast than the North corridor (See Table 3-6, Chapter Three). Thus, excluding highway costs from the analysis causes a greater reduction in park-and-ride trip savings in the southeast than it does in the North corridor.

An interesting note here is that for both situations discussed (with and without the inclusion of highway capital costs) the southeast corridor fares better than the north corridor when the lots are 100 percent utilized.

PARK-AND-POOL

Of the 467 park-and-ride cases analyzed, only 15 (3.2 percent) used carpooling or vanpooling to egress the lot. This percentage is low primarily because only trips to downtown Seattle were analyzed. When considering all cases, the portion of persons who car/vanpooled from the lot was 14.8 percent (See Figure 2-15, Chapter Two).

However, even with this information some general observations can be made. First, it is apparent that car/vanpooling in general is a very cost-effective means of commuting. In the previous mode cost comparison of Figure 4-2 it is the least expensive per mile of all the trip modes considered. Figure 4-8 compares the per mile cost of the park-and-ride transit trip with that of the park-and-ride carpool, or park-and-pool trip. In this comparison, which included highway capital costs, the park-and-pool trip is 20.4 percent less expensive than the park-and-ride transit trip. Even when allowing for some uncertainty due to the low number of cases, it is apparent that the park-and-pool trip is more economical than the conventional park-and-ride transit trip. This can be attributed to the savings in time and transit costs.

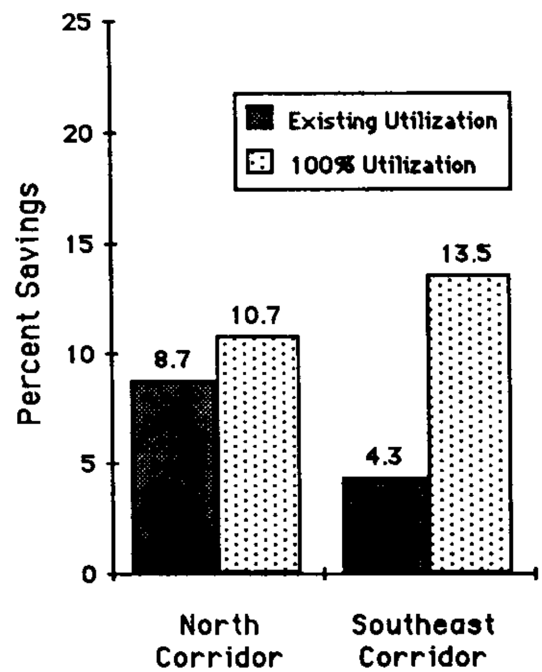
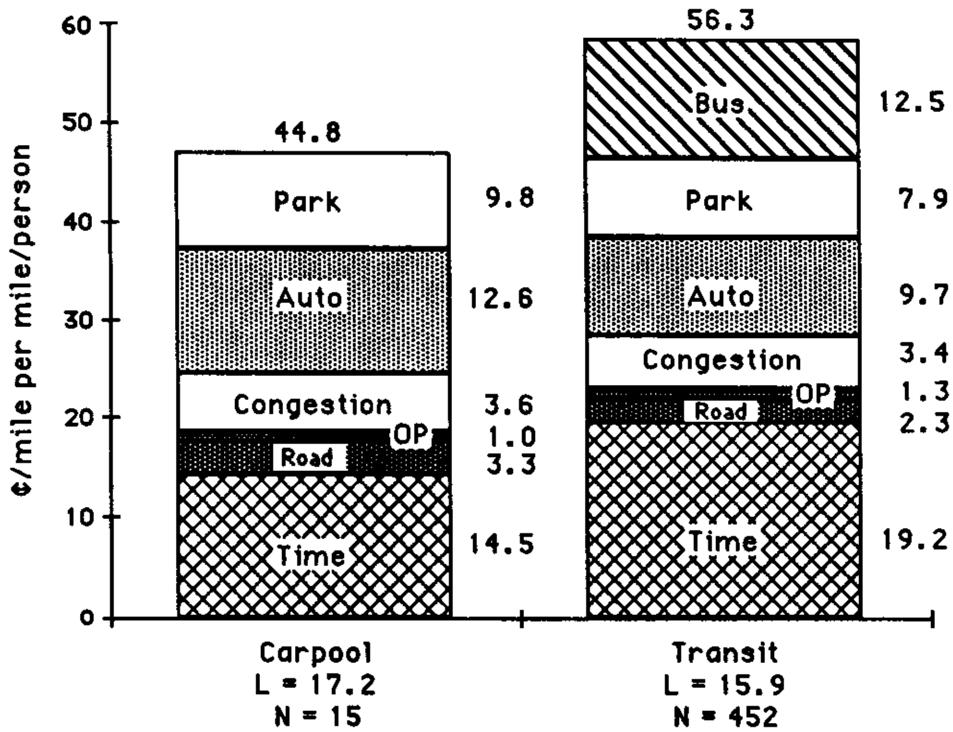


Figure 4-7. Trip Cost Savings Due to Park-and-Ride Lots by Corridor, Highway Costs Excluded.



L = Ave. Trip Length
N = Number of Cases
OP = Other Public Costs

Figure 4-8. Park-and-Ride Trip Cost per Mile by Lot Egress Mode.

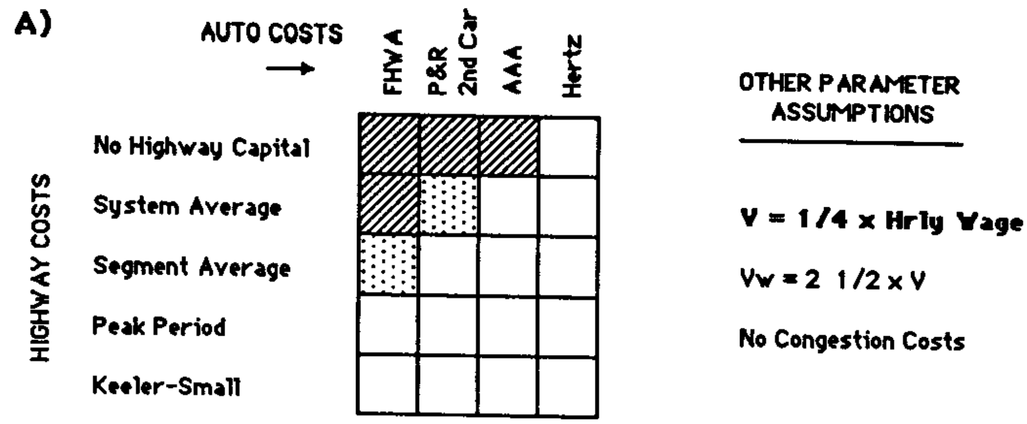
SENSITIVITY ANALYSIS FOR VARIOUS INPUT PARAMETER VALUES

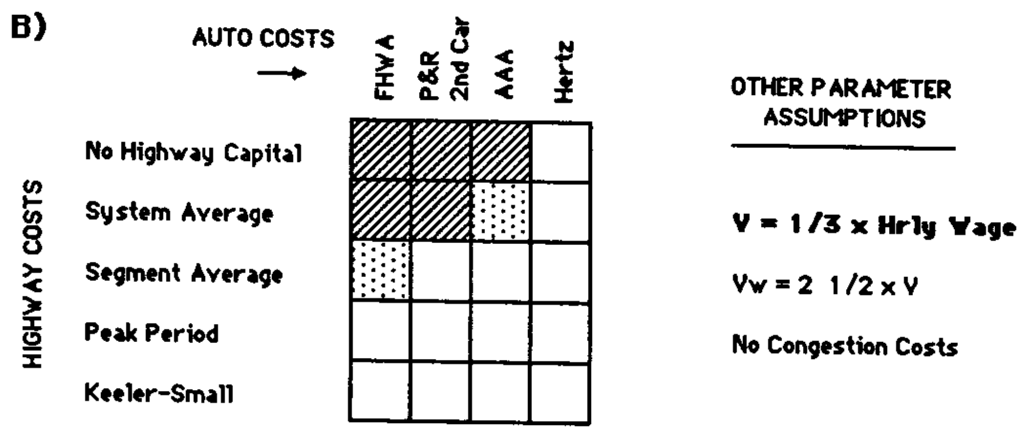
In determining the values for various input parameters, the researchers considered several values based on varying assumptions and sources. Most significant among these were those used for the value of time, highway costs, congestion costs, and auto owning and operating costs (outlined in detail in Chapter Three). The values used for these parameters in the cost analysis just presented were those determined most reasonable for use in this study. However, for comparison purposes it is desirable to see how the cost analysis might change if different values are used for these parameters.

The trip cost model was run for cases representing 132 different combinations of the four primary input parameters: time costs, highway costs, congestion costs, and auto costs. General results of these runs are presented in Figure 4-9 in terms of three basic categories. The results from the runs fell into the three broad categories as follows:

- park-and-ride trip is less expensive than previous mode trip (92 runs),
- cost of each trip is basically equal (11 runs),
- park-and-ride trip is more expensive than previous mode trip (29 runs).

The purpose of this sensitivity analysis is to determine the general results of the trip cost model over a wide range of possible input parameter values. Note that these runs encompass some input parameter combinations which are not necessarily realistic. Most notably, it can be argued that any combination which excludes both highway capital and congestion costs would be unreasonable (this situation is reflected in the top row of boxes in Figure 4-9A through F). Highway capital costs and congestion costs are interrelated. For the most part, they can be traded off for one another -- i.e., given increasing levels in a particular corridor, if additional roadway capacity is not constructed, then congestion and its associated costs will increase. It is recognized that this is a simple view which possibly excludes a number of potentially relevant factors (e.g., a successful TSM tactic may alleviate congestion costs without the aid of additional





KEY

a. System is cost effective with this set of parameter values (i.e., the park-and-ride trip is less expensive than the previous mode trip).

b. Cost comparison breaks even (i.e., cost of the park-and-ride trip equals that of the previous mode trip).

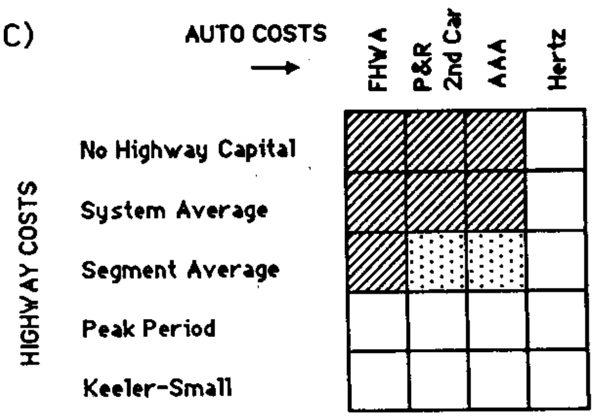
c. System is not cost effective (i.e., the park-and-ride trip is more expensive than the previous mode trip).

V = Value of In-Vehicle Time

Vw = Value of Out-of-Vehicle Time (Excess Time)

Figure 4-9. Trip Cost Comparison Sensitivity Analysis for Various Input Parameter Values.

C)



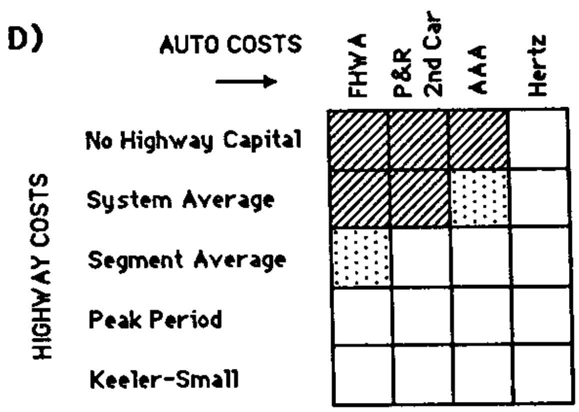
OTHER PARAMETER ASSUMPTIONS

V = 1/2 x Hrly Wage

Vw = 2.5 x V

No Congestion Costs

D)



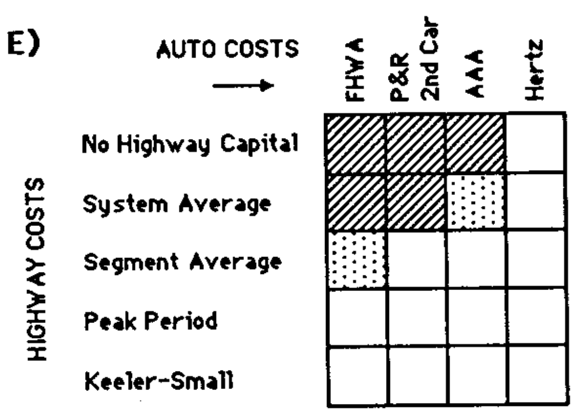
OTHER PARAMETER ASSUMPTIONS

V = 1/3 x Hrly Wage

Vw = 1 1/2 x V

No Congestion Costs

E)



OTHER PARAMETER ASSUMPTIONS

V = 1/3 x Hrly Wage

Vw = 3 1/3 x V

No Congestion Costs

Figure 4-9. (Continued)

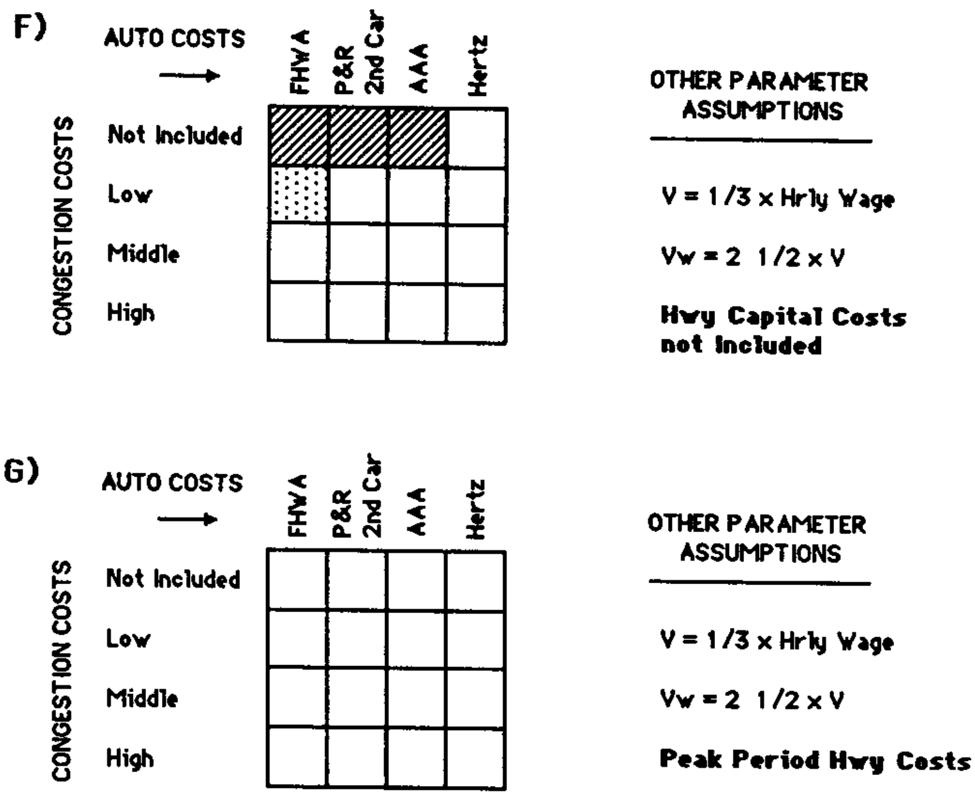


Figure 4-9. (Continued)

roadway construction); however, for the most part, this view holds true. Highway capital costs can be traded off for congestion costs, and one or the other should be included when calculating total trip costs. Hence, it may be argued that the parameter combinations represented by the top row of Figure 16A through F are unreasonable.

In general, the previous mode trip is more intense in highway use and auto use than the park-and-ride trip, and therefore is more sensitive to changes in highway, congestion, and auto costs. Hence, higher values for any of these three parameters will make the previous mode trip proportionally more expensive than the park-and-ride trip. The converse will happen when these costs are decreased (i.e., the previous mode trip will decrease accordingly with respect to the park-and-ride trip.) Thus, in Figure 4-9, only for the most conservative estimates for highway, congestion and auto costs do the runs indicate the lots to be not cost effective.

The park-and-ride trip is more time intensive than the previous mode trip -- particularly with respect to in-vehicle time -- and consequently is more sensitive to changes in the value of time. Thus, in proportion to the previous mode trip, the park-and-ride trip cost is more sensitive to an increase in the value of time. This is indicated in Figure 4-9 when all parameters are held constant save that for in-vehicle time. As the value of in-vehicle time increases from one-fourth the hourly wage rate to one-half the hourly wage rate, cases for which the lots were formerly cost effective became not cost effective.

As a final sensitivity analysis exercise, it was desirable to conduct the trip cost comparison based on the most "extreme" sets of parameter value combinations. Of all the parameter values identified, those which would be most favorable to the previous mode trip (i.e., lower the cost of the previous mode trip to the greatest extent in relation to that of the park-and-ride trip) are outlined as follows as extreme case #1:

- highway capital costs excluded,
- congestion costs excluded,
- auto costs based on FHWA and P&R second car values,
- value of in-vehicle time is one-half the hourly wage rate, and
- the value of out-of-vehicle time is 3.33 times that of in-vehicle time.

Extreme case #2, that which is most favorable to the park-and-ride trip, is identified by the following parameter values:

- highway costs based on the Keeler-Small method,
- congestion costs based on high estimates,
- auto costs based on Hertz estimates,
- in-vehicle value of time is equal to one-fourth the hourly wage rate, and
- the value of out-of-vehicle time is 1.5 times that of in-vehicle time.

The results of the first extreme case show the previous mode trip to be 7.2 percent less expensive than the park-and-ride trip ($8.50 to $9.16). The results of the other extreme case, however, indicate the previous mode trip to be 35.4 percent less expensive than the park-and-ride trip ($12.33 to $9.17). These extremes encompass a very broad range of possibilities as far as the trip cost analysis is concerned, and indicate that the park-and-ride lots are likely to be cost effective for the situation analyzed.

EVALUATION OF VARIOUS MEASURES OF EFFECTIVENESS

In order to provide a more comprehensive analysis, it was desirable to evaluate several measures of effectiveness independently, and as much as possible, in terms of their own units rather than dollars. This has been done for the following measures: travel time, person miles traveled, vehicle miles traveled, traffic volumes, vehicle emissions, and accidents. A brief discussion of these analyses follows. An in-depth analysis of the impact that park-and-ride lots have on energy consumption was conducted as a separate but related study (6). Significant results of that study are discussed in Chapter Five.

Travel Time

Due primarily to the time involved in transferring between modes, the average park-and-ride trip takes longer than the average previous mode trip by 13.3 percent (see Figure 4-10). In general, the use of park-and-ride lots as opposed to the previous modes used means an increase in travel time for the commuter.

Person Miles Traveled

Just as travel time is increased by the use of park-and-ride lots, so is the average trip length. As shown in Figure 4-11, the average park-and-ride trip is 3.9 percent longer (15.9 miles to 15.3 miles) than the previous mode trip. Thus, the use of park-and-ride trips increases the overall number of person-miles traveled.

Vehicle Times Traveled

Perhaps a more significant measure of effectiveness than person miles traveled is vehicle miles traveled (VMT). VMT has a significant effect on energy use, vehicle emissions, accidents, congestion and traffic capacity requirements. In general, a reduction in VMT will cause a reduction in each of these other measures.

The estimated effect that park-and-ride lots have had on daily VMT is presented in Table 4-1. The net decrease in VMT is simply the difference between the estimated auto VMT decrease and the transit VMT increase. The net auto VMT decrease was obtained by determining the total number of autos employed in previous mode trips and subtracting from that the total number employed in the park-and-ride trip between the lot and destination (assumed to be the Seattle CBD for these purposes). This yielded a net reduction in autos used by lot, which in turn was multiplied by the distance between lot and destination to get the estimated net reduction in daily auto VMT. Figure 4-12 graphically portrays the net decrease in total VMT.

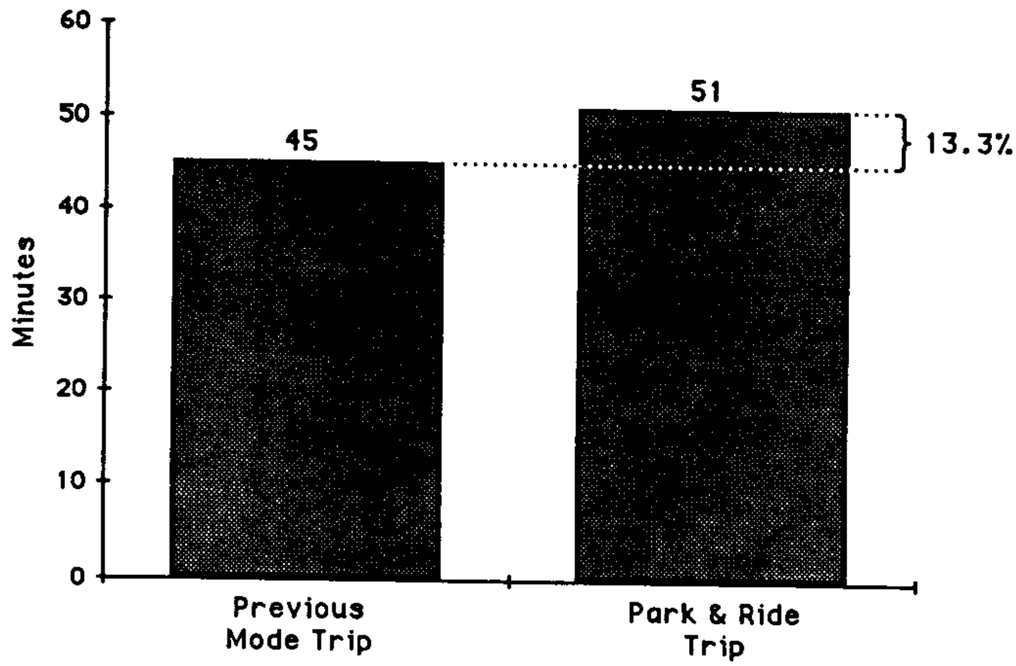


Figure 4-10. Trip Travel Time: Combined Average Previous Mode Trip vs. Combined Average Park & Ride Trip.

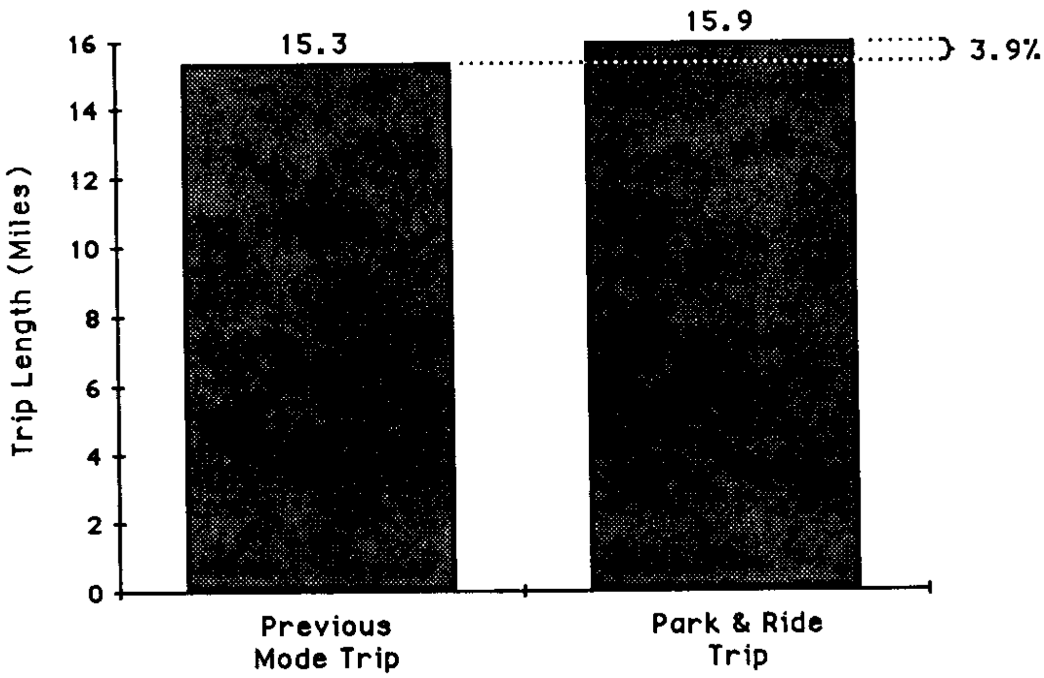


Figure 4-11. Trip Length: Combined Average Previous Mode Trip vs. Combined Average Park & Ride Trip.

TABLE 4-1.
ESTIMATED IMPACT OF PARK-AND-RIDE LOTS ON DAILY VEHICLE MILES TRAVELED (VMT)

	Decrease in Auto VMT	Increase in Transit VMT	Net Decrease in VMT
North Corridor	15,934	1,844	14,090
Northeast Corridor	18,524	1,820	16,704
Southeast Corridor	7,586	712	6,874
South Corridor	31,952	3,708	28,244
Total System	73,996	8,084	65,912*

*This represents 0.5% of total VMT on Interstates and principal arterials in King County (30).

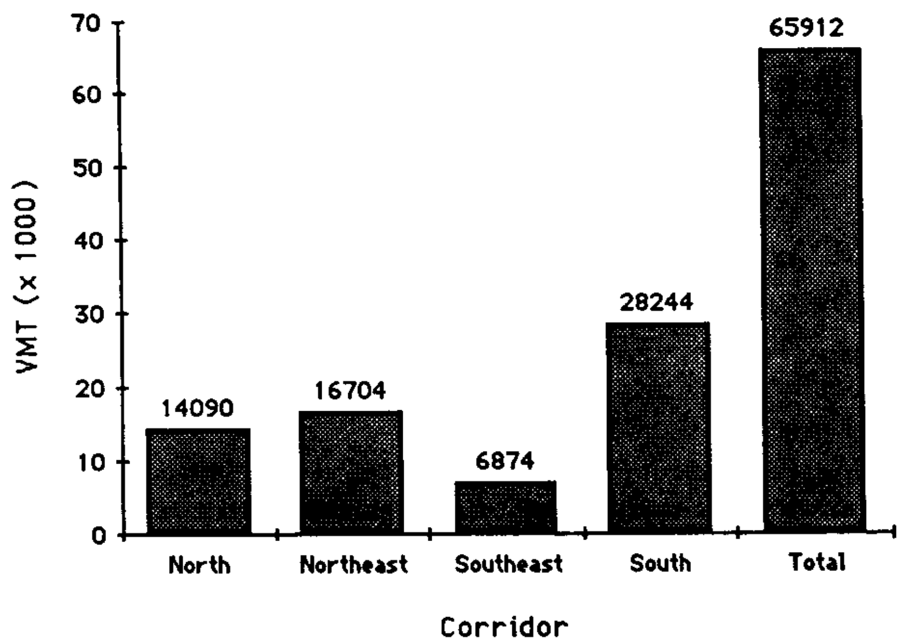


Figure 4-12. Estimated Net Decrease in Daily VMT by Corridor Due to Use of Park-and-Ride Lots.

For the four corridor area, the total estimated VMT diverted from the Seattle area highways is nearly 66,000 VMT per day, which represents 0.5 percent of total VMT on Interstates and principal arterials in King County (30). Looking at the corridors independently, the south corridor makes the largest contribution to the total reduction of VMT, while the southeast corridor contributes the least. In terms of effectiveness, however, this is slightly misleading because the south corridor has the largest number of park-and-ride stalls of the four corridors, while the southeast corridor has the fewest. Therefore, in Figure 4-13, VMT is presented in a different fashion -- in terms of VMT reduced per park-and-ride lot stall built, and VMT reduced per park-and-ride lot stall occupied.

The northeast corridor, due to its relatively high utilization rate (1983 average utilization rate of 75.7 percent) and the longer distances from its lots to downtown Seattle, had the highest reduction in VMT per stall built, at 7.42. However, when looking at VMT reduced per occupied stall, the south corridor is by far the most effective with a rate of 12.24. The high value for the south corridor is due to the relatively long distances between several of its larger lots and downtown Seattle. For the entire system in 1983, the reduction in daily VMT per park-and-ride lot stall was 6.40, while per stall utilized, the daily reduction in VMT was 9.86.

__Traffic Volumes__

A basic argument in support of park-and-ride lots is that they reduce traffic volumes on crowded urban freeways and arterials. Based on information from the park-and-ride lot survey, the estimated number of daily, one-way, vehicle trips diverted from Seattle area freeway segments due to park-and-ride lots is presented in Figure 4-14. These numbers were calculated in a manner similar to that of VMT, i.e., they represent the difference between the total number of park-and-ride vehicles used between the lot and downtown Seattle. I-5 experiences the greatest traffic volume reduction,

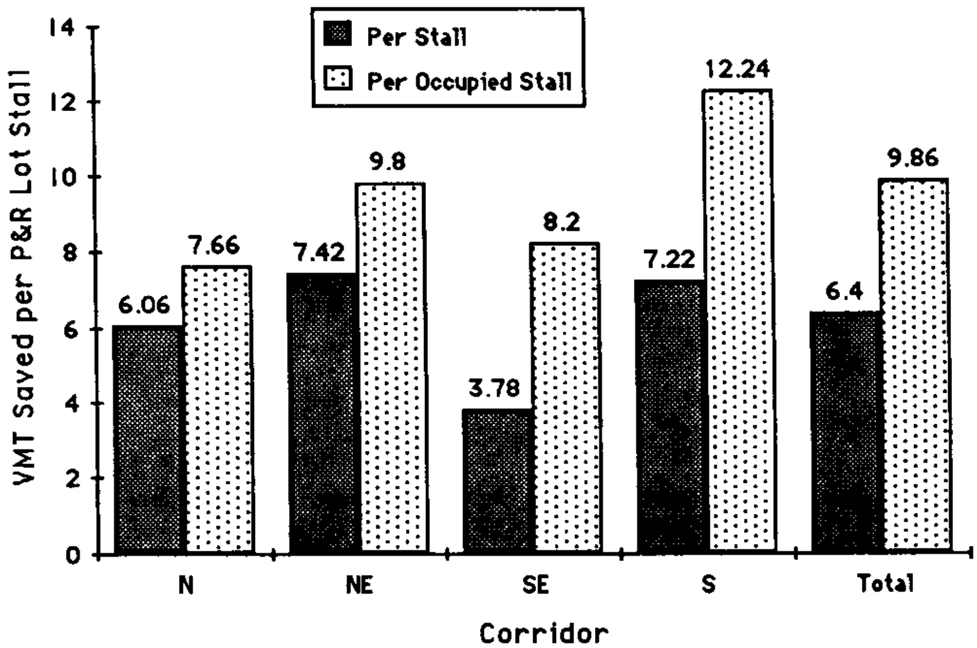


Figure 4-13. Estimated Net Decrease in Daily VMT per Park-and-Ride Lot Stall Due to Use of Park-and-Ride Lots.

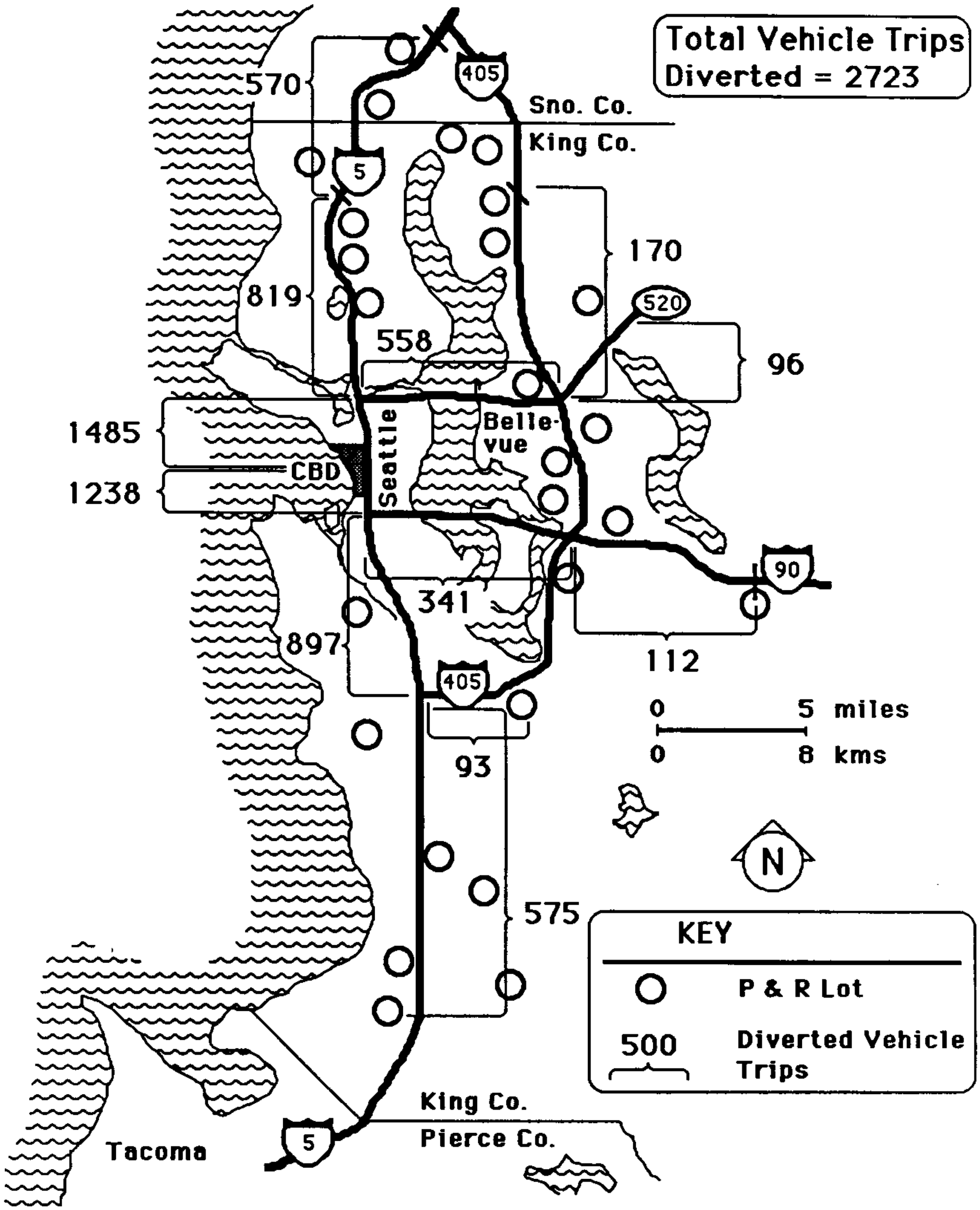


Figure 4-14. Estimated Average Number of One Way Vehicle Trips per Day Diverted from Freeway Segments Due to Park and Ride Lots.

particularly on the segments adjacent to the CBD. Immediately north of the CBD, estimated 1485 one-way trips are diverted. This represents about 1.5 percent of the total average weekday traffic volume at this location (30). The total number of diverted one-way daily vehicle trips was 2723, which corresponds to a total reduction in average weekday traffic volume of 5446 trips (two-way) due to park-and-ride lots.

Based on a frequency distribution of morning trip departure times in the park-and-ride survey data set, it was calculated that 53 percent of the trips occur in the peak hour, and 92 percent in the peak 3 hours. For I-5 just north of downtown Seattle, 1485 vehicle trips are diverted. This corresponds to 787 vehicles in the peak hour. Using a capacity of 1700 vehicles per lane, this is equivalent to 0.46 lanes saved at this freeway location due to park-and-ride lots.

Vehicle Emissions

Based on the vehicle emission rate information in Table 4-2, and information from Table 4-1, the research team estimated that for the total park-and-ride lot system analyzed, the effect on air quality is as outlined in Table 4-3. Daily hydrocarbon and nitrogen oxide emissions have been reduced -- and carbon monoxide emissions have been significantly reduced. Due to the increase in diesel bus VMT, however, emission of total suspended particulates appears to have slightly increased. With respect to total air pollutants in King County, however, the amount of change in air quality due to park-and-ride lots is relatively insignificant, with impacts ranging around 0.1 percent.[1]

Accidents

Since accidents are highly correlated to VMT, and park-and-ride lots have reduced VMT, it is safe to say that park-and-ride lots have reduced accidents. This is

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1 Based on information from Air Pollution Control Puget Sound, a King County Agency.

TABLE 4-2.
VEHICLE POLLUTANT EMISSION RATES

	Auto (Gm/Mile)	Diesel Bus (Gm/Mile)
Carbon Monoxide (CO)	15.60	5.96
Hydrocarbons (HC)	1.90	0.75
Nitrogen Oxides (NOX)	3.80	15.90
Total Suspended Particulates	0.08	1.20

Source: Metro TRANSITion Phase IV Technical Report - Draft, Metro Transit, August 1980.

TABLE 4-3.
AIR QUALITY IMPACT OF PARK-AND-RIDE LOT SYSTEM

	Daily Emission Type Decrease/Increase (Gms in 000's)			
	CO	HC	NOX	TSP
Auto	-1154	-140	-282	-1
Transit	+48	+6	+128	+10
Net	-1106	-134	-154	+9
% of Daily Total (King Co.)[a]	-0.09	-0.12	-0.16	+0.08

[a]Based on information from Air Pollution Control Puget Sound, a King County Agency.

CO = Carbon Monoxide

HC = Hydrocarbons

NOX = Nitrogen Oxides

TSP = Total Suspended Particulates

supported by results from the trip cost model as shown in Figure 4-15. The cost of auto accidents is directly proportional to the rate of auto accidents. Since the accident cost per person trip was reduced from $0.31 for the previous mode trip to $0.20 for the park-and-ride trip (a reduction of 35.5 percent), auto accident rates were reduced accordingly. A slight increase in transit accidents may have occurred due to the increase in bus VMT; however, bus accident rates are much lower on a per passenger basis than those for autos (31), and any increase in bus accidents that may have occurred is considered insignificant in relation to the reduction in auto accidents.

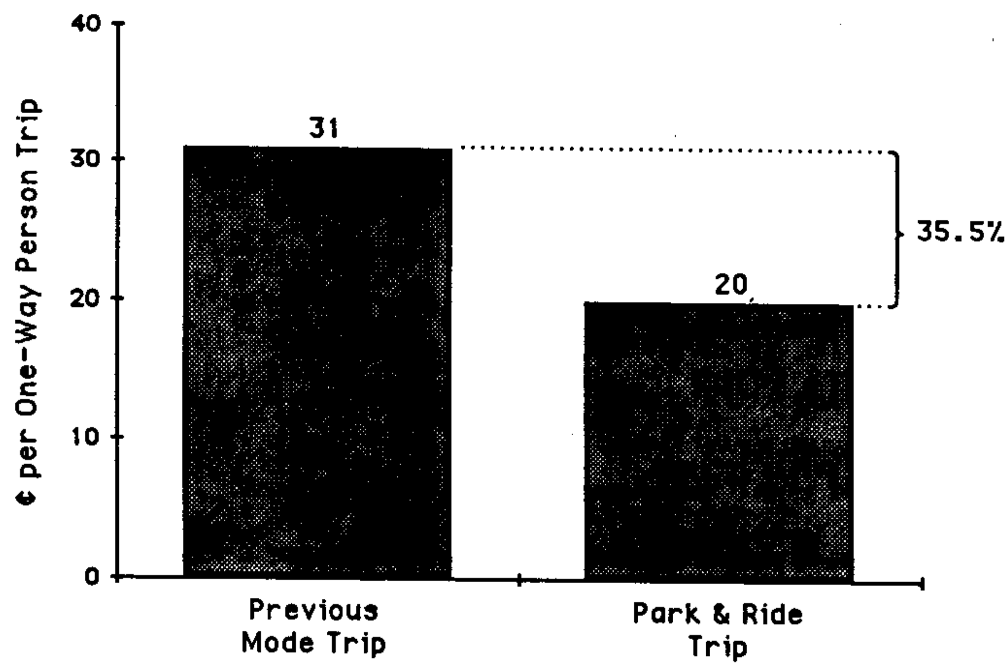

Figure 4-15. Auto Accident Costs: Previous Mode Trip vs. Park-and-Ride Trip.

CHAPTER FIVE: PARK-AND-RIDE SYSTEM ENERGY INTENSITY

INTRODUCTION

This chapter is a summary of an independent but related study on the energy intensity of the Seattle area park-and-ride system. For more details on this study the reader is referred to the original source (6).

Due to the relatively high passenger volumes of the transit vehicle, as compared to average work trip vehicle occupancy, park-and-ride systems are considered to offer significant energy savings and air quality benefits (37). This research quantifies operational energy use of a large scale system and develops an energy intensity for an average trip from each lot, each of four regional travel corridors, and the entire system. The energy intensity of the park-and-ride system, as measured in British thermal units (BTU's) per person-mile of travel, is compared to the energy intensity of system users' previous modes.

The literature reviewed in the course of this project included evaluations of existing and projected passenger car fuel consumption, the adjustment of tested automobile fuel consumption (miles per gallon) to in-use ("road") fuel consumption park-and-ride operations, and park-and-ride lot direct and indirect energy consumption. Details of these reviews are available in reference (6).

METHODS

The measurement of the average energy intensity of trips using park-and-ride lots required data on trip lengths, vehicle occupancy and fuel economy for each vehicle. A survey of park-and-ride system users provided all trip origin and destination data, and automobile, carpool and vanpool occupancies (see Chapter Two). The survey also collected automobile make and model information, which was used to assign automobile fuel economies (miles per gallon) for each automobile trip. Study calculations were largely carried out by several computer programs. The two principal programs, DISTANC and PRFUEL, developed trip length records, and energy use and intensities, respectively.

Highway Distances Computation

Average distances were computed from the following two sources: 1) scaled distances from U.S. Census Bureau 1980 block maps for the Seattle-Everett urbanized area, and 2) regional traffic analysis zone (TAZ) centroid to centroid distances over the 1980 network of freeways and arterials. Distances between trip origins and park-and-ride lots were scaled for the south-east corridor lots and used to adjust origin to park-and-ride lot distances in the other three corridors. All other distances were unadjusted TAZ to TAZ distances.

A Puget Sound Council of Governments (PSCOG) 1980 regional network for 355 TAZ's produced the travel distance skims used for model TAZ to TAZ distances. The DISTANC program read the PSCOG TAZ to TAZ distance file and matched distances to TAZ pairs read from the survey file records. Another input file contained internal travel distances for each of the 355 zones. The following distances (in tenths of miles) were determined for each survey record: 1) origin to destination; 2) origin to park-and-ride lot; 3) park-and-ride to destination; 4) park-and-ride to inbound bus transfer location; 5) inbound bus transfer location to destination; 6) destination to outbound bus transfer location; 7) outbound bus transfer to park-and-ride lot; and 8) origin to park-and-ride lot scaled distance (southeast lots only).

Average Vehicle Occupancy Data

Both the automobile and carpool/vanpool occupancies were obtained directly from the survey data file and tabulated by the PRFUEL program for each lot, corridor, and system-wide. Compilation of transit vehicle occupancies involved the following described tasks.

The METRO bus passenger volume data base contained the average volume per trip at specific route checkpoints during the morning and afternoon peak periods, as well as during the midday. Volumes were reported for both inbound and outbound runs, and the number of passengers boarding and alighting was also given. In order to develop bus passenger volumes for each of the transit park-and-ride to destination trips reported in the park-and-ride survey, it was necessary to weight the Metro-surveyed volumes by the percentage they comprised of the total trip distance. This was accomplished by measuring the total route length and the distances between Metro checkpoint locations (typically park-and-ride lots, major transfer points, and entry locations to the Seattle central business district). An input file containing inbound and outbound passenger volumes on 266 distinct trips was developed. The PRFUEL program read the transit route numbers and times from the survey file and matched them to a passenger volume. For each survey record, an average passenger volume of the inbound and outbound transit trips to the park-and-ride and any transfer trips was computed.

Fuel Consumption and Energy Intensity Calculations

Average person-miles is the product of a trip's respective average distance and average vehicle occupancy. The PRFUEL program computed average and total person-miles for each lot, corridor, and system-wide. Average fuel economy for automobiles, carpools and vanpools was based on EPA "city" mileage guide ratings (32) adjusted to in-use fuel economy by a four variable equation. Direct matches to EPA mileage guide ratings were made to about 600 vehicles in the north and southeast corridors. PRFUEL used model year averages calculated from the 600 vehicles to assign EPA fuel economies to vehicles in the northeast and south corridors.

The fuel economy adjustment equation required both the population of the trip origin's postal zipcode and the average number of miles driven per day. PRFUEL matched the zipcode contained in the survey file to the appropriate population. Miles driven per day was assumed to be twice the origin to park-and-ride or origin to destination trip length. Average adjusted fuel economies for each trip type were calculated for each lot, corridor, and the system. A constant value was used for two climatic variables in the four-variable equation.

Transit vehicle fuel consumption for each of ten Metro bus fleets was obtained from the Metro Vehicle Maintenance Division. The number of available seats on the surveyed routes was used to weight fuel economy between the fuel economies of the regular and articulated coach fleets at the primary assignment base of the route. PRFUEL assigned fuel economies to all survey record transit routes. Assignments were made to both inbound and outbound routes, and to transfer routes if applicable. The energy consumption of electric trolleys was converted to equivalent miles per gallon of diesel fuel in order to be able to use these routes in the PRFUEL analyses.

Total fuel consumption for each park-and-ride lot was computed by dividing the average trip distance by the corresponding average fuel economy. The resulting fuel consumption for the average trip was then expanded to a lot total by multiplying times the number of surveys distributed at the park-and-ride lot.

The energy content of the fuel was expressed in British thermal units (BTU's). Reference (33) gives the BTU content of one gallon of gasoline as 125,000 and one gallon of diesel fuel as 138,700. The energy intensity of the surveyed origin to destination trip using the park-and-ride lot, and an origin to destination trip using the origin to park-and-ride lot vehicle, was expressed as average BTU's per person-mile. The averages were derived by dividing total BTU's by total person-miles.

RESULTS

Tables 5-1 through 5-5 contain summary statistics for each of the four travel corridors and for the entire system. Data for individual lots are available in Reference (6). Data in the five tables are unweighted corridor and system averages on a lot-by-lot basis (i.e., each lot is counted equally in computing corridor averages rather than weighting by the lot's percentage of all corridor occupied parking spaces).

This research also included a before and after fuel consumption comparison which included consideration for the "car left home." The "car left home" theory states that when a non-auto commute trip is taken, the auto left at home is used to the extent that the energy consumed is equal to 40 percent of what would have been consumed had an auto commute trip been made (34). When considering the park-and-ride trip, the auto that is tied up at the park-and-ride lot has no potential for consuming the fuel beyond what is required for the access trip. Whereas, for walk to transit and carpool/vanpool trips, the auto left at home will most probably be used.

Figure 5-1 indicates the energy savings that the park-and-ride trip experiences when compared to the previous mode trip. The park-and-ride trip is 20.5 percent more fuel efficient when not considering the car left home, and is 32.1 percent more efficient when the car left home factor is considered.

CONCLUSIONS

Park-and-Ride System and Automobile Energy Intensity

Based on this study, the park-and-ride system offers significant operational energy efficiencies over the automobile mode for regional home to work trips. System-wide, the average, one-way park-and-ride trip had an energy intensity of 959 BTU's per person-mile as compared to an average automobile energy intensity of 5,827 BTU's per person-mile for the typical trip at an average automobile occupancy of 1.08 persons (surveyed origin to park-and-ride lot occupancy). Using a regional average automobile

Table 5-1.
SYSTEM-WIDE AND CORRIDOR ENERGY INTENSITY
BTU's Per Person-Mile

Corridor Name	Park-Ride Surveys Returned	Mode of Trip: Via Park-and-Ride	Mode of Trip: Via Auto	Mode of Trip: Auto Ratio
North	573			
Averages		1095	5594	5.19
Std. Deviation		122	400	.81
Minimum		850	5256	4.53
Maximum		1227	5904	6.74
Southeast	349			
Averages		1282	6531	5.23
Std. Deviation		290	987	1.00
Minimum		1012	5529	3.57
Maximum		1549	7835	6.52
Northeast	674			
Averages		1073	5927	5.56
Std. Deviation		71	580	.75
Minimum		945	5234	4.65
Maximum		1142	7026	6.51
South	795			
Averages		987	5775	5.92
Std. Deviation		151	215	.79
Minimum		805	5634	4.99
Maximum		1144	6182	7.16
System-wide	2402			
Averages		1092	5919	5.52
Std. Deviation		167	574	.83
Minimum		805	5234	3.57
Maximum		1549	7835	7.16

[1] Based on surveyed vehicle occupancies of origin to park-and- ride lot trips.

Table 5-2.
SYSTEM-WIDE AND CORRIDOR AVERAGE TRIP LENGTHS
DISTANCES IN MILES

Corridor Name	Origin to P&R	P&R to Destination	Origin to Destination: Via P&R	Origin to Destination: Direct	Origin to Destination: Direct/ P&R
North					
Averages	3.6	13.5	17.0	16.5	0.97
Std. Deviation	1.1	4.8	5.2	4.8	0.03
Minimum	2.1	8.1	11.6	10.9	0.94
Maximum	5.1	19.9	23.5	22.6	1.01
Southeast					
Averages	4.1	15.0	19.4	18.0	0.93
Std. Deviation	1.0	2.5	3.1	3.2	0.05
Minimum	3.0	11.3	15.4	14.0	0.85
Maximum	5.5	18.2	23.5	21.2	0.97
Northeast					
Averages	4.0	16.5	20.5	19.3	0.94
Std. Deviation	0.7	2.9	3.1	2.6	0.05
Minimum	3.4	10.7	14.8	14.5	0.84
Maximum	5.4	19.5	24.9	23.2	1.01
South Corridor					
Averages	4.0	17.4	21.4	20.3	0.95
Std. Deviation	1.1	5.5	6.3	6.2	0.03
Minimum	2.8	7.8	10.8	10.6	0.91
Maximum	6.1	23.8	29.7	29.4	0.99
System-wide					
Averages	4.0	15.8	19.8	18.7	0.95
Std. Deviation	1.0	4.3	4.8	4.5	0.04
Minimum	2.1	7.8	10.8	10.6	0.84
Maximum	6.1	23.8	29.7	29.4	1.01

Table 5-3.
SYSTEM-WIDE AND CORRIDOR AVERAGE VEHICLE OCCUPANICES

Corridor Name	Origin to Park-and-Ride Auto	Origin to Destination Bus	Carpool/ Vanpool
North			
Averages	1.12	32.5	4.32
Std. Deviation	0.08	4.4	2.11
Minimum	1.07	26.7	2.50
Maximum	1.27	40.8	8.28
Southeast			
Averages	1.06	31.5	4.64
Std. Deviation	0.05	4.5	1.07
Minimum	1.00	25.1	2.88
Maximum	1.12	35.9	5.88
Northeast			
Averages	1.08	32.7	5.35
Std. Deviation	0.05	3.4	2.13
Minimum	1.00	29.1	2.75
Maximum	1.15	38.1	8.67
South Corridor			
Averages	1.09	36.9	3.96
Std. Deviation	0.04	5.6	1.27
Minimum	1.04	29.9	2.00
Maximum	1.16	45.8	5.21
System-wide			
Averages	1.09	33.7	4.55
Std. Deviation	0.05	4.6	1.72
Minimum	1.00	25.1	2.00
Maximum	1.27	45.8	8.67

Table 5-4.
SYSTEM-WIDE AND CORRIDOR AVERAGE FUEL ECONOMIES
Miles per Gallon

	(1)	(2)	(3)	(4)	
	Origin to P&R	Park-and-Ride to Destination		Origin to Destination	
Corridor Name	Auto	Bus	Vanpools	Auto	(4)/(1)
North					
Averages	15.7	4.2	18.1	20.1	1.28
Std. Deviation	1.4	.15	5.3	1.0	0.07
Minimum	13.8	4.0	10.8	18.5	1.18
Maximum	17.6	4.4	25.8	21.1	1.37
Southeast					
Averages	14.6	4.2	19.3	18.3	1.26
Std. Deviation	1.4	.13	2.9	2.0	0.03
Minimum	12.8	4.1	14.6	16.0	1.22
Maximum	16.0	4.4	22.9	20.2	1.28
Northeast					
Averages	15.5	4.2	22.4	19.7	1.27
Std. Deviation	1.0	.07	3.6	1.2	0.04
Minimum	14.2	4.1	16.0	17.8	1.21
Maximum	17.1	4.3	25.4	21.4	1.33
South Corridor					
Averages	15.6	4.1	21.1	20.0	1.28
Std. Deviation	0.6	.13	2.7	0.8	0.04
Minimum	14.7	4.0	17.8	18.8	1.21
Maximum	16.6	4.3	24.9	20.9	1.32
System-wide					
Averages	15.4	4.16	20.4	19.6	1.28
Std. Deviation	1.1	0.12	5.4	1.2	0.05
Minimum	12.8	4.0	10.8	16.0	1.18
Maximum	17.6	4.4	25.8	21.4	1.37

Table 5-5.
SYSTEM-WIDE AND CORRIDOR AVERAGE PERSON-MILES

	Origin to P&R	Park-and-Ride to Destination		Origin to Destination
	Auto	Bus	Car/ Vanpools	Auto
Corridor Name				
North				
Averages	4.0	410	62.4	18.5
Std. Deviation	1.1	183	49.1	5.3
Minimum	2.3	240	20.4	11.6
Maximum	5.5	681	164.6	25.9
Southeast				
Averages	4.7	419	69.2	19.1
Std. Deviation	1.1	154	21.2	4.0
Minimum	3.2	244	44.2	14.7
Maximum	6.1	602	106.9	23.7
Northeast				
Averages	4.3	506	89.3	20.8
Std. Deviation	0.7	88	40.9	3.0
Minimum	3.6	358	20.1	15.5
Maximum	5.8	626	143.9	24.8
South Corridor				
Averages	4.3	673	72.3	21.9
Std. Deviation	1.1	307	33.3	6.3
Minimum	2.9	257	15.6	12.0
Maximum	6.3	1091	114.4	30.5
System-wide				
Averages	4.3	518	74.0	20.3
Std. Deviation	1.0	208	37.9	4.9
Minimum	2.3	240	15.6	11.6
Maximum	6.3	1091	164.6	30.5

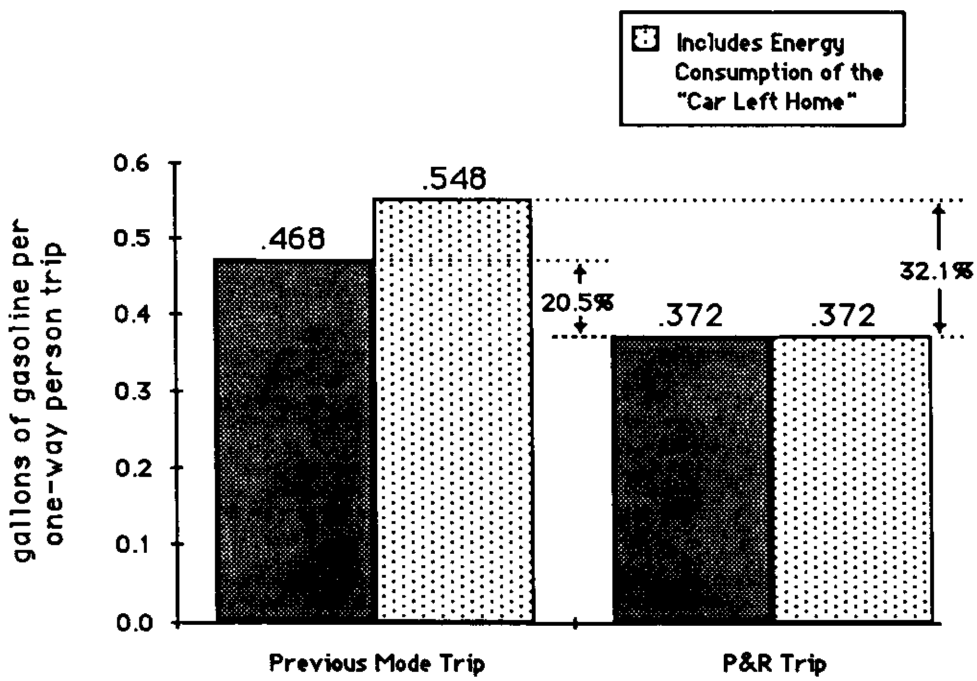

Figure 5-1. Average Energy Consumption Comparison (Averaged Over 25 Lots).

occupancy of 1.20 for work trips, the energy intensity of the automobile trip would be 5,244 BTU's per person-mile for the typical trip at an average automobile occupancy of 1.08 persons (surveyed origin to park-and-ride lot occupancy). Using a regional average automobile occupancy of 1.20 for work trips, the energy intensity of the automobile trip would be 5,244 BTU's per person-mile. Although transit vehicles were found to have a high rate of fuel consumption (4.16 miles per gallon on the average), the park-and-ride trip energy efficiency was due to the high average passenger load of 35.6 persons per surveyed trip.

Fuel Consumption -- Before and After

In the before and after analysis of fuel consumption (gallons of gasoline), previous fuel consumption of the 6,672 system users was estimated as 1,829,000 gallons of gasoline for all modes reported when considering the effect of the "car left home." Neither the 1.3 percent who reported "other" previous modes nor the 18.0 percent who did not make the trip before (see Chapter Two for survey results) were included in the estimate. Park-and-ride system annual fuel use was estimated to be 1,242,500 gallons, resulting in a net reduction of 586,500 gallons or 32.1 percent. Annual operational fuel savings of the system in 1983 was estimated at 94.9 gallons per occupied space.

When the "car left home" factor was discounted, total yearly previous fuel consumption was estimated at only 1,516,500 gallons of gasoline. Yet the annual park-and-ride system fuel use still exhibited a substantial savings (20.5 percent) in comparison.

Capital Energy Payback

Construction energy for a typical 550-space park-and-ride lot has been estimated as 167,000 gallons of gasoline and annual maintenance energy as 630 BTU's per square foot (35). With an estimated energy savings of 94.9 gallons per occupied space, and 60.7 percent utilization of all system parking spaces, the entire Seattle area system has an energy payback period of about six years. This analysis may yield a conservative estimate of energy savings attributable to the system since the construction energy of freeway lanes not required due to the shift to a higher occupancy travel mode has not been considered. The energy payback of individual lots has not been estimated.

__Vehicle Fuel Consumption__

The fleet of surveyed vehicles had an average fuel economy of 15.6 miles per gallon for the origin to park-and-ride lot trip when adjusted from EPA mileage ratings to in-use fuel economy by means of an EPA-developed regression equation. This equation adjusts fuel economy primarily on the basis of average miles driven per day. The origin to park-and-ride trip had a system-wide average distance of 4.2 miles and the origin to destination trip had a 19.2 mile average distance. When the origin to park-and-ride automobile fleet EPA mileage rating was adjusted using the 19.2 miles distance, in-use fuel economy was estimated as 19.8 miles per gallon. The fuel economy penalty for the short trip to the park-and-ride lot appeared to be about 21 percent.

System-wide, carpool and vanpool in-use fuel economy for the park-and-ride to destination trip was calculated to average 21.5 miles per gallon, 8.6 percent higher than the in-use economy of the origin to park-and-ride fleet on the origin to destination trip. Given the high average occupancy of carpools and vanpools (5.25 persons per vehicle system-wide average), carpools and vanpools achieved similar energy intensitites for the park-and-ride to destination trip as transit--1,100 and 813 BTU's per person-mile, respectively.

Reference (36) presents future year passenger car fuel consumption figures of 26.2 in 1990 and 27.5 in the year 2000. The annual increase in fleet average fuel economy is projected to decrease after 1985 since federally mandated, new car fuel economy increases will end with the 1985 model year at a 27.5 miles per gallon new car average. Assuming no significant increases will be made in transit vehicle fuel economy in the next 15 years, the difference between energy intensities of the park-and-ride system and automobile origin to destination trips will decrease to the year 2000. The 1990 and year 2000 passenger car fleets are projected to be 32.8 and 38.9 percent, respectively, more fuel efficient than the 1983 fleet (36). This change in vehicle fuel consumption would lower the 1990 origin to destination automobile trip energy intensity to 3,963 BTU's per person-mile (work trip average automobile occupancy of 1.20). In the year 2000, the energy intensity of this trip would be 3,776 BTU's per person-mile.

Energy intensity of the origin to park-and-ride portion of the park-and-ride system trip would also decrease correspondingly. Calculated 1990 park-and-ride system energy intensity for the average origin to destination trip would be 938 BTU's per person-mile. In terms of energy intensity, the park-and-ride trip will retain a more than 4:1 advantage over all automobile trips through the year 2000. Figure 5-2 shows the calculated energy intensities for the park-and-ride system and automobile (1.20 average car occupancy) modes for 1983, 1990 and 2000.

Previous Travel Modes of Park-and-Ride System Users

Reference (6) presents users' reported previous travel modes from each lot, the four travel corridors, and the entire system. Figure 5-3 shows the previous travel modes of park-and-ride system users. Of all the system users who previously made the trip (82 percent of all surveyed), 41.6 percent used transit (58 percent of these drove to transit), and 56 percent drove alone or carpooled. Assuming that carpools have an average occupancy of 3.0 persons per vehicle, it is the latter 56 percent of the system users that previously made the trip that can definitely be considered to be switching to a more energy efficient mode. There is probably no significant gain in energy efficiency for system users who previously drove to transit. For those who previously walked to transit (17.3 percent of all previously making the trip), there is a probable gain in energy efficiency. Although these users had no automobile trip, average passenger volume of

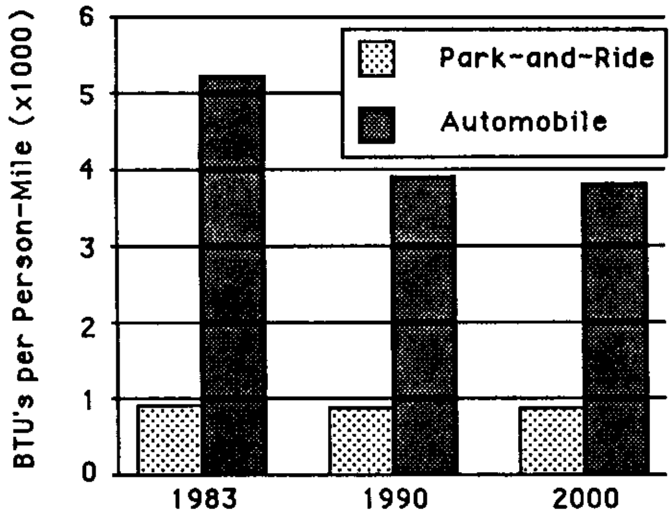

Figure 5.2 Energy Intensity Comparisons, Park-and-Ride vs. Automobile Modes: 1983, 1990, and 2000.

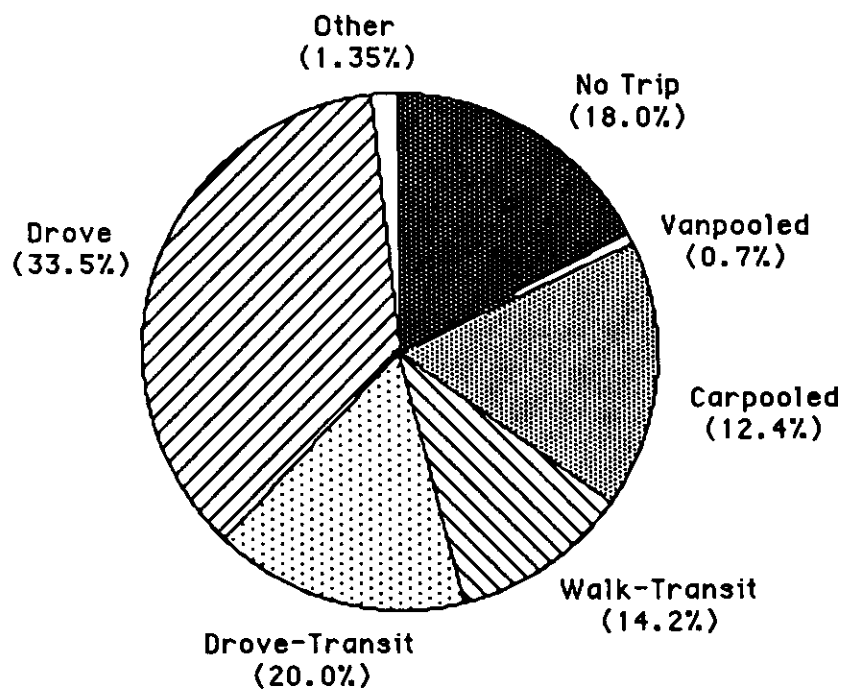

Figure 5-3. Previous Mode to Destination.

their transit trip was likely lower than their present express transit service from the park-and-ride lot. Also to be considered for these users is the vehicle-mile-traveled (VMT) of the car not driven to transit -- estimated in Reference (34) as 40 percent of the work trip VMT.

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APPENDIX A

SURVEY PROCEDURES

APPENDIX A: SURVEY PROCEDURES

IDENTIFY INFORMATION NEEDS

The cost effectiveness analysis of park-and-ride lots required the accumulation of information about the lots (size, location, transit service, maintenance, and capital costs) and about the users of the lots (where, what, when, why, how questions are appropriate). The information about the lots was readily available; however, the information available pertaining to the park-and-ride users did not reflect non-METRO Transit use of the facilities. A goal of this research project was to determine the cost-effectiveness of the use of park-and-ride lots for all users (all those leaving a vehicle in the lot and changing mode for the remainder of their trip) including park-and-riders and park-and-poolers.

The task of the research project team was to develop a survey technique and instrument suited to the information requirements. The original data obtained from the survey of park-and-ride users would be input to subsections of the cost-effectiveness analysis; both the comparison of commuting trip costs with and without park-and-ride lots and comparison of energy consumption with and without park-and-ride lots are subprojects dependent upon the original data obtained through the survey. The survey responses provided a window on the use of park-and-ride lots, in terms of lot utilization areawide and by individual lots, and in terms of change-of-mode options: transit, carpool, or vanpool.

TARGET POPULATION

As inferred above, the target population of the survey was the park-and-ride user: that person who left a vehicle during the day to occupy a stall in the lot, who then made a change of travel mode for the rest of the trip. Those persons who also changed mode at the park-and-ride lot but did not leave a motorized vehicle at the lot were excluded from the survey, as were motorcyclists. The primary lot design criteria involved four-plus wheeled and motorized vehicles with a currently small area requirement for pedestrian shelter and loading, kiss-and-ride operation, or bicycle/motorcycle parking. Thus the survey was focused on those leaving cars, vans, and trucks in the lots.

INFORMATION REQUIRED

Members of the park-and-ride project staff developed a list of required and desired user information in question form. The topics included:

- Trip modes used: from origin to park-and-ride lot and vehicle occupancy, from park-and-ride lot to destination and vehicle occupancy for pool, alternate mode used (if one didn't use park-and-ride lot)
- Trip origin and destination (to nearest street intersection)
- Trip purpose
- Park-and-ride lot use frequency
- Vehicle data make, model, year, ownership
- Transit route and run data
- Parking fee at destination for poolers

The questions were designed to provide a composite, yet still anonymous, picture of the park-and-ride user.

REVIEW AND CHOICE OF SURVEY TYPE

The choice of survey type/method was made by consensus after discussing the attributes and disadvantages of different survey types. Six basic types of surveys were initially (if only briefly) considered and evaluated. Home interviews were quickly discarded as being too costly for this study; although they would provide a very good quality of information, there was no guarantee that those interviewed would have knowledge or experience of park-and-ride lots. The survey results could be biased by time of day, who is home and who isn't, etc., which would complicate any results. Thus, the home interview technique was not acceptable.

A second technique briefly considered was the telephone interview -- it has similar problems to the home interview, along with an advantage that survey personnel would not have to travel. Again, the survey response could easily be biased. The target population consisted of those who left motorized vehicles at the park-and-ride lot, not just anyone in the phone book.

An onboard transit survey was also considered, but rejected because it would ignore those park-and-ride users who car- or vanpooled, who were considered to be important in this study.

The fourth survey type considered was a mail-out survey, to be mailed to residents living in areas served by park-and-ride lots. One big problem with this was that so many forms would have to be sent and processed (the returns) in order to actually survey the park-and-ride user population. This was considered too costly for the project budget.

By recording the license plate number of each vehicle parked in each lot, the survey staff could identify (through access to Washington State Department of Licensing files) owner's registered address and thus the trip origin. This was the fifth survey type considered. This would provide a limited amount of information -- not enough for the study requirements of destination, trip purpose, frequency of use, etc. This technique was rejected due to lack of informational depth.

It was agreed that a windshield-placed, mail-back business-reply survey would adequately provide both information and low cost. The survey form was initially a composite of questions contributed by the research project team, which was reviewed by team members and revised according to comments.

A preliminary draft form was tested using a group of civil engineering students at The University of Washington in spring quarter, 1983. Their responses were quickly analyzed for question comprehension and answer clarity. The form was again refined and revised, with the inclusion of more answer options and more concise questions.

This second draft was then ready to be distributed as a sample survey of park-and-ride lot users in order to determine an expected return rate. Two groups of 100 cars were chosen as the sample, each from large park-and-ride lots (Federal Way and Kingsgate). Areas within the lots were chosen and noted so as not to resurvey those areas during the actual survey. The lots were chosen due to their size and high space utilization. Survey forms were placed on the vehicle windshields (under the left wiper blade, in front of the driver, with the words, "Official Park-and-Ride Survey," in plain view) on Thursday, May 19, 1983, two weeks prior to the scheduled full survey.

The sample survey produced a return rate of 29% with a good quality of response. It was then decided that all lots and all stalls must be surveyed in order to obtain an overall return of approximately 2,000 responses, since utilization was estimated at about 6,500 stalls used.

The final revision of the survey instrument was made after receipt of approximately 95% of the sample survey returns. Coding boxes were screened onto the survey cards, providing space for answers to the survey questions. Most of the survey form was self-coding, meaning the respondents, by checking a box or filling in a blank, provided the necessary code for data entry.

SURVEY IMPLEMENTATION

The final survey form included 16 questions for the park-and-ride user. The survey form, both front and back, is shown as Figure 2-1 in Chapter Two of this report.

It was determined that for statistical significance for all lots' response, we would survey all park-and-ride lot users on the chosen survey date. We thus expected a return of approximately 30%, giving a sample population of approximately 2,000 surveys.

The desired date of survey was in the last week of May or the first week in June 1983, so scheduled to include responses from those destined to The University of Washington for work or school. U.W. spring quarter finals were scheduled to being during the second week in June, and thus a survey during finals week would have reflected an unusual situation for U.W. students and staff commuting patterns.

The full/formal survey was scheduled and took place on Thursday, June 2, 1983, with four groups of three persons each distributing the folded and numerically sequenced forms in four quadrants of the Seattle area:

North:	Northgate, North Seattle, Lynnwood, Shoreline, Kenmore, Bothell
Northeast:	South Kirkland, Overlake, Redmond, Kingsgate, Brickyard
Southeast	Wilburton, South Bellevue, Newport Hills, Eastgate, Issaquah
South:	Olson-Myers, Burien, Kent-Des Moines, Kent, Auburn, Star Lake, Federal Way, South Renton

On the following day, two lots were added and survey -- N.E. 65th and I-5 (an interim lot) and the newly opened Mountlake Terrace lot. In total, 6,189 forms were distributed to automobiles, trucks, and vans in the 26 lots. (The Overlake park-and-pool lot, located in the Sears Overlake parking lot, was surveyed by mistake, yet it ended up being the only pool-only lot surveyed.)

SURVEY CONDITIONS

The survey forms were distributed on a day with overcast skies. The north and south quadrants experienced light rainfall during the survey, while the northeast and southeast quadrants met with only fine mist or dry conditions.

One lot was affected by construction: this was the interim lot at N.E. 65th and I-5 which had eight parking stalls blocked off due to maintenance work taking place directly above on I-5.

Several lots had vehicles parked around the perimeter, outside the lot boundaries. These vehicles were not surveyed; only those parked within the boundaries of the were given survey forms.

SURVEY CODING AND EDITING

The survey responses began arriving at the TRAC office the day following the survey: Friday. The survey forms received were sorted by lot (using the preprinted number on each form). Editing and coding were performed for each response by the TRAC survey staff. The coding and editing consisted of a check for answer consistency (e.g., if a respondent checked "drive alone" for question 1A, answer to question 1B should be "1"), and for form completeness.

The forms were then individually coded by origin and destination for both census tract and traffic analysis zone (TAZ). Block map sets showing census tracts were marked to also shown TAZones so that coders could easily enter origin or destination number codes once origin or destination was located on the map. This step of the coding process was very time consuming, requiring a minimum of two passes of each survey form as the origins were seldom located on the same map as destinations. Forms with uncodable origins or destinations were separated for later review.

Upon completion of the visual editing and coding process, the data from each response card was entered into a computer data file. Keypunching was done by a data-entry group on campus who fit our work into their workload. Both coding and data entry were more time-consuming than anticipated.

A Fortran program was written to check the data file for errors in data entry. Logic checks for each question were identified by the project staff which included acceptable value ranges of responses, a list of which questions had interdependent answers, and which fields should be blank and when. This program provided a consistent editing check for logic errors, response compatibility, and for value ranges.

A series of if...then statements were created and refined to pinpoint error type and flag those cases (each survey response form represented one case) which had an error. Output was a list of case number, error type, and column location of error, which provided a straight-forward correction tool.

Error correction was accomplished by editing the text of the raw data case file. The Fortran check program was again run to check the case file for any omissions.

Those errors in the case file which resulted from blank fields or uncodable responses were left in the file. Although those cases were incomplete or not entirely consistent, some data might prove to be valuable for future studies.

The source documents (survey responses) are maintained by TRAC. It is hoped that this survey case file will provide data for additional research into park-and-ride lots.

APPENDIX B

COST EFFECTIVENESS OF PARK-AND-RIDE LOTS: PRELIMINARY ANALYSIS OF PARK-AND-RIDE LOT USER SURVEY

TABLE OF CONTENTS

1. Introduction

The purpose of this report is to present the results of a preliminary analysis of the Park-and-Ride Lot User Survey data. These data were collected on June 2 and 3, 1983, as an integral part of the project "Cost Effectiveness of Park-and-Ride Lots" being conducted for the Washington State Transportation Center at the University of Washington. The objectives of this study, the role of the survey, and the survey and survey instrument design are described elsewhere (see survey Procedures and Implementation Report). This report focuses on the survey responses.

Data were collected using a prepaid mail-back postcard survey of park-and-ride lot patrons at 26 lots in the Seattle-Everett Standard Metropolitan Statistical Area. To meet the overall study objectives, the survey was designed specifically to gather travel data about park-and-ride lot users, with one survey form distributed and not more than one response expected for each vehicle parked in each lot. The population from which the sample was drawn was therefore expected to represent owners and/or drivers of vehicles parked in the lots. Because the primary access mode to the park-and ride lots surveyed was drive-alone auto (see section 3), the sampling population also represents a very large proportion of all lot users on the survey day, including both drivers and passengers of vehicles. One qualification, though, is that because some travelers use park-and-ride lots more or less frequently than other users, the sample may exhibit a degree of trip frequency bias. This occurs because not all respondents have an equal chance of being included in the survey. Such bias is inevitable in surveys of this type and can only be corrected after the data have been collected and initial analyses performed. Further investigation of this issue is underway and, if found to be significant, will be reported separately. The results presented in this report thus represent preliminary but important and basic analyses of the edited and validated survey dataset, which are necessary before more detailed analyses should be undertaken.

Except for the summary tabulation in the next section, the results presented in this report are for the aggregated survey responses from all park-and-ride lots surveyed. More disaggregate analyses will be performed subsequently as required.

2. Summary of Survey Responses

Of 6138 survey forms distributed, 2402 were returned for an overall survey response rate of 39.1 per cent. The 26 surveyed lots also contained 10,306 parking spaces, of which 6252 or 60.7 per cent were occupied. The survey response rates and lot utilization are summarized for each lot in Exhibit 1.

The 26 lots have also been distinguished by corridor: North (lots 1-6), Northwest (lots 7-13), Southeast (lots 14-18) and South (lots 19-26). The corridor response rates, as a percentage of forms distributed, were:

North	34.1 per cent
Northeast	41.9 per cent
Southeast	43.0 per cent
South	39.0 per cent

Exhibit 1 also summarizes the travel modes used by survey respondents in traveling from each lot. While the majority of respondents clearly used transit (83.5 per cent), significant numbers also used carpool (10.2 per cent) and vanpool (4.7 per cent) as their egress mode from the lot. However, these percentages vary considerably from lot to lot, as Exhibit 1 shows.

Exhibits 2-4 present the same summary information more graphically, for each of the 26 lots surveyed. Exhibit 2 shows the number of parking stalls in each lot and the utilization and response rate (in terms of percentage of surveys returned). Exhibit 3 presents the modal split between transit and carpoool and vanpool for survey respondents at each lot. Finally, Exhibit 3 shows the modal split for carpool and vanpool, separately, for each lot.

Exhibit 1

Survey Summary

LOT	NUMBER OF STALLS	NUMBER OF SURVEYS DISTRIBUTED	PERCENT UTILIZATION	NUMBER OF SURVEYS RETURNED	% RETURNED (OF # DISTRIBUTED)	MODE FROM LOT: % TRANSIT	% CARPOOL	% VANPOOL	% OTHER (WALK, BICYCLE, ETC.)
26 Lot Total	10306	6138	60.7**	2402	39.1	83.5	10.2	4.7	1.1
NORTH CORRIDOR									
1 N.E. 65th @ I-5*	185	119	64.3	49	41.2	28.6	22.4	44.9	4.1
2 North Seattle	99	72	72.7	30	41.7	90.0	10.0	--	--
3 Northgate	515	480	93.2	186	38.8	94.1	2.2	2.7	1.0
4 Shoreline	378	210	55.6	69	32.9	97.1	2.9	--	--
5 Mountlk Terr. (CT)*	337	62	18.4	32	51.6	68.8	28.1	3.1	--
6 Lynnwood (CT)	808	735	91.0	207	28.2	91.8	7.2	1.0	--
N. Corridor TOTAL	2322	1678	72.3	573	34.1	86.4	7.7	5.2	0.7
NORTHEAST CORRIDOR									
7 Overlake P. & P.	NA	NA	NA	NA	NA	NA	NA	NA	NA
8 Redmond	344	213	61.9	101	47.4	89.1	4.0	5.9	1.0
9 Kingsgate	502	326	64.9	122	37.4	73.8	16.4	9.0	0.8
10 Brickyard	207	159	76.8	46	28.9	30.4	34.8	34.8	--
11 Bothell	163	125	76.7	57	45.6	89.5	10.5	--	--
12 Kenmore	432	330	76.4	144	43.3	95.8	2.8	--	1.4
13 S. Kirkland	603	457	75.8	204	44.4	88.7	7.4	3.4	0.5
N.E. Corridor TOTAL	2251	1610	71.5	674	41.9	83.7	9.6	5.9	0.7
SOUTHEAST CORRIDOR									
14 Wilburton	190	121	63.7	47	38.8	12.8	72.3	12.8	2.1
15 S. Bellevue	362	46	12.7	18	39.1	66.7	22.2	11.1	--
16 Newport Hills	284	60	21.1	28	46.7	67.9	32.1	--	--
17 Eastgate	626	342	54.6	163	47.7	86.5	9.2	2.5	1.8
18 Issaquah	358	243	67.9	93	38.3	80.6	11.8	7.5	--
S.E. Corridor TOTAL	1820	812	44.6	349	43.0	72.5	20.9	5.4	1.1
SOUTH CORRIDOR									
19 Olsen-Meyers	562	91	16.2	44	48.4	93.2	4.5		2.3
20 Burien 362	362	211	58.3	90	42.7	87.8	8.9	3.3	
21 South Renton	370	231	62.4	81	35.1	81.5	11.1	6.2	1.2
22 Kent	729	298	40.9	125	41.9	94.4	4.0		1.6
23 Kent-Des Moines	235	163	69.4	75	46.0	90.7	6.7	1.3	1.3
24 Star Lake	499	177	35.5	74	41.8	62.2	24.3	12.2	1.3
25 Federal Way	789	651	97.0**	232	35.6	93.5	3.0	0.9	2.6
26 Auburn	367	216	58.9	74	34.3	79.7	12.2	5.4	2.7
S. Corridor TOTAL	3913	2038	52.1	795	39.0	87.3	7.9	3.0	1.8

*These lots were surveyed on June 3, 1983. They are recently in service.

**Percentage incorporates 114 cars within Federal Way Park-and-Ride Lot pretest area which was not included in the final survey.

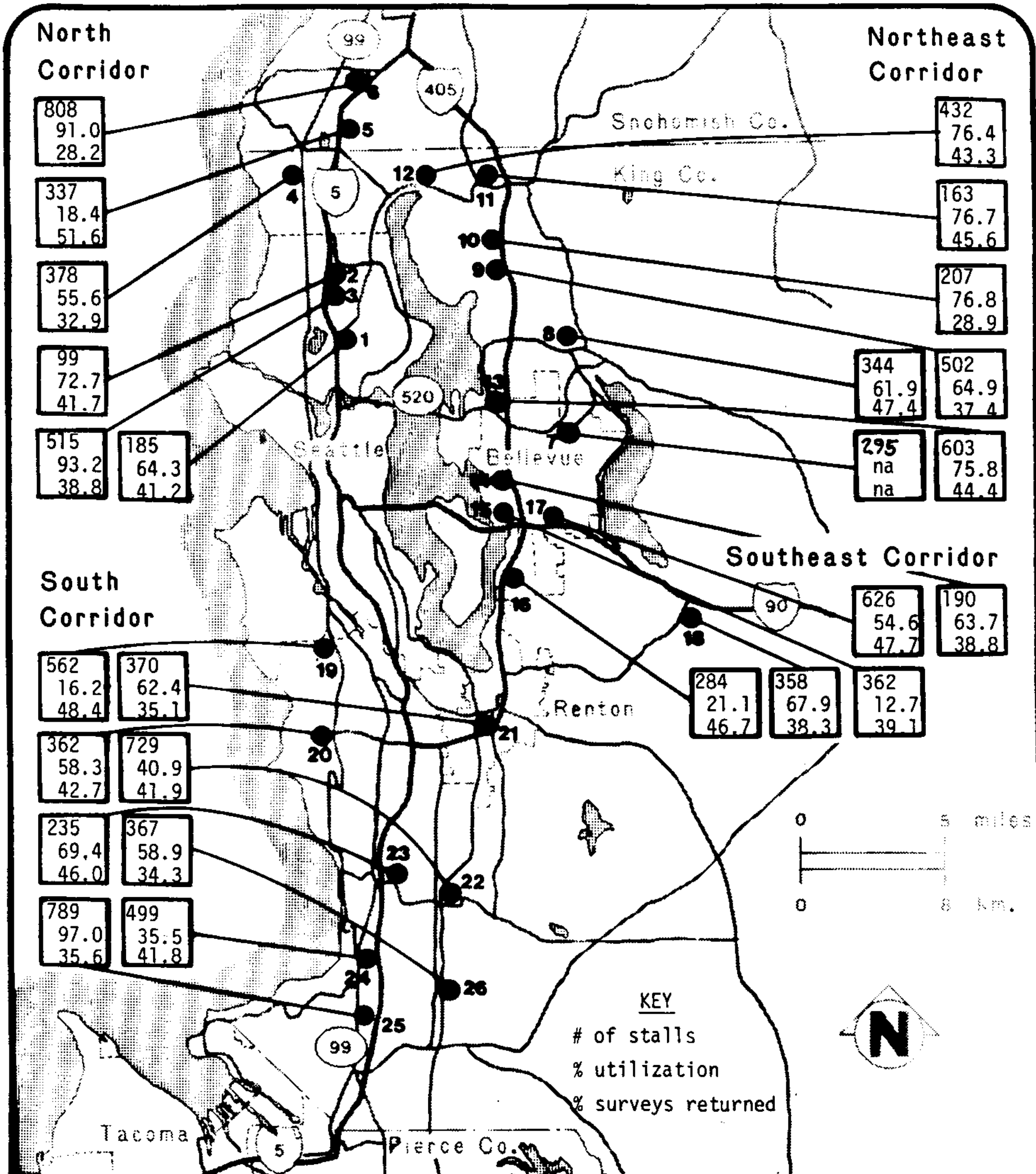


Exhibit 2

Utilization and Response, by Lot

COST EFFECTIVENESS OF PARK & RIDE LOTS

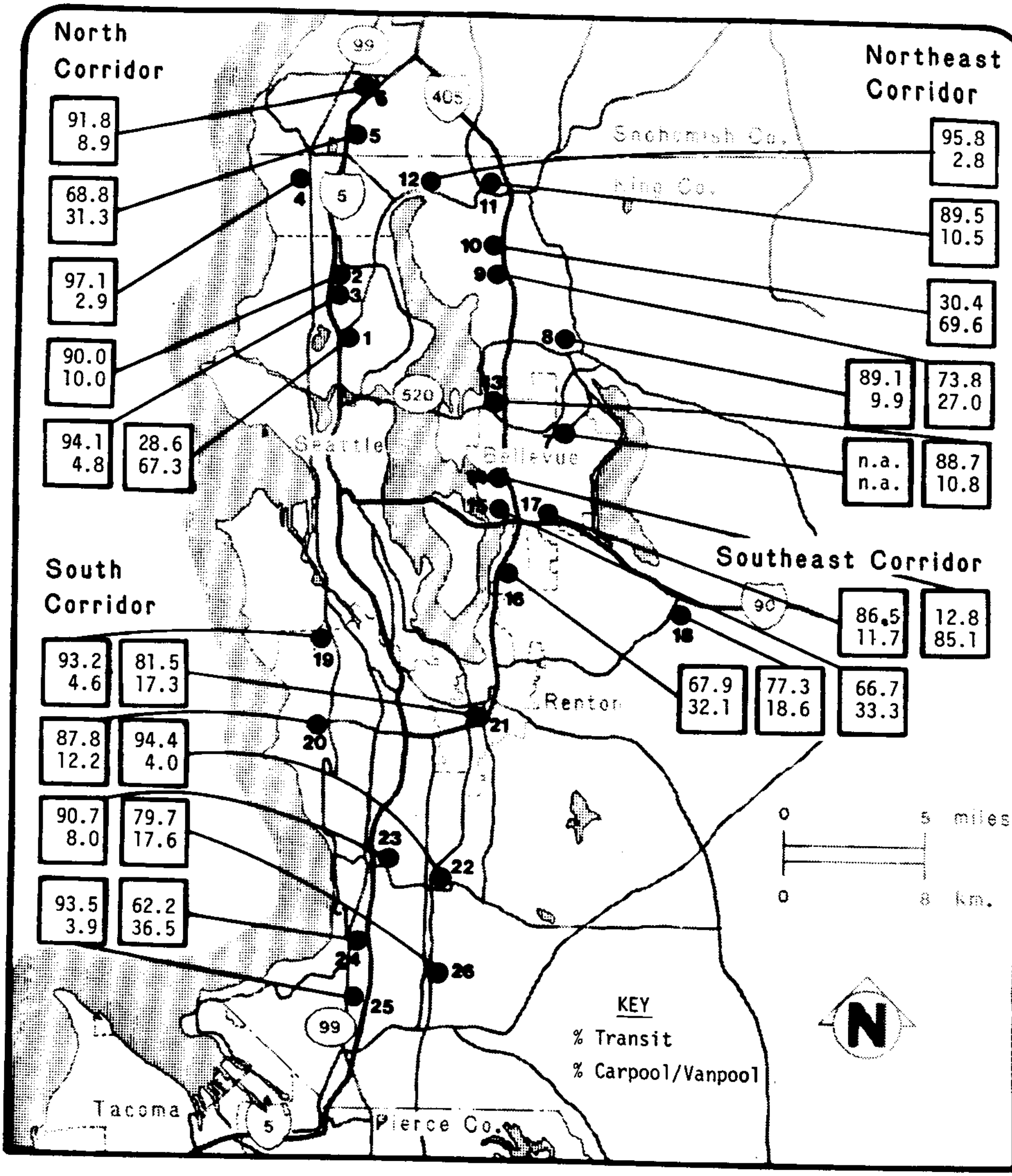


Exhibit 3

Mode from Lot: Transit and Carpool/Vanpool

COST EFFECTIVENESS OF PARK & RIDE LOTS

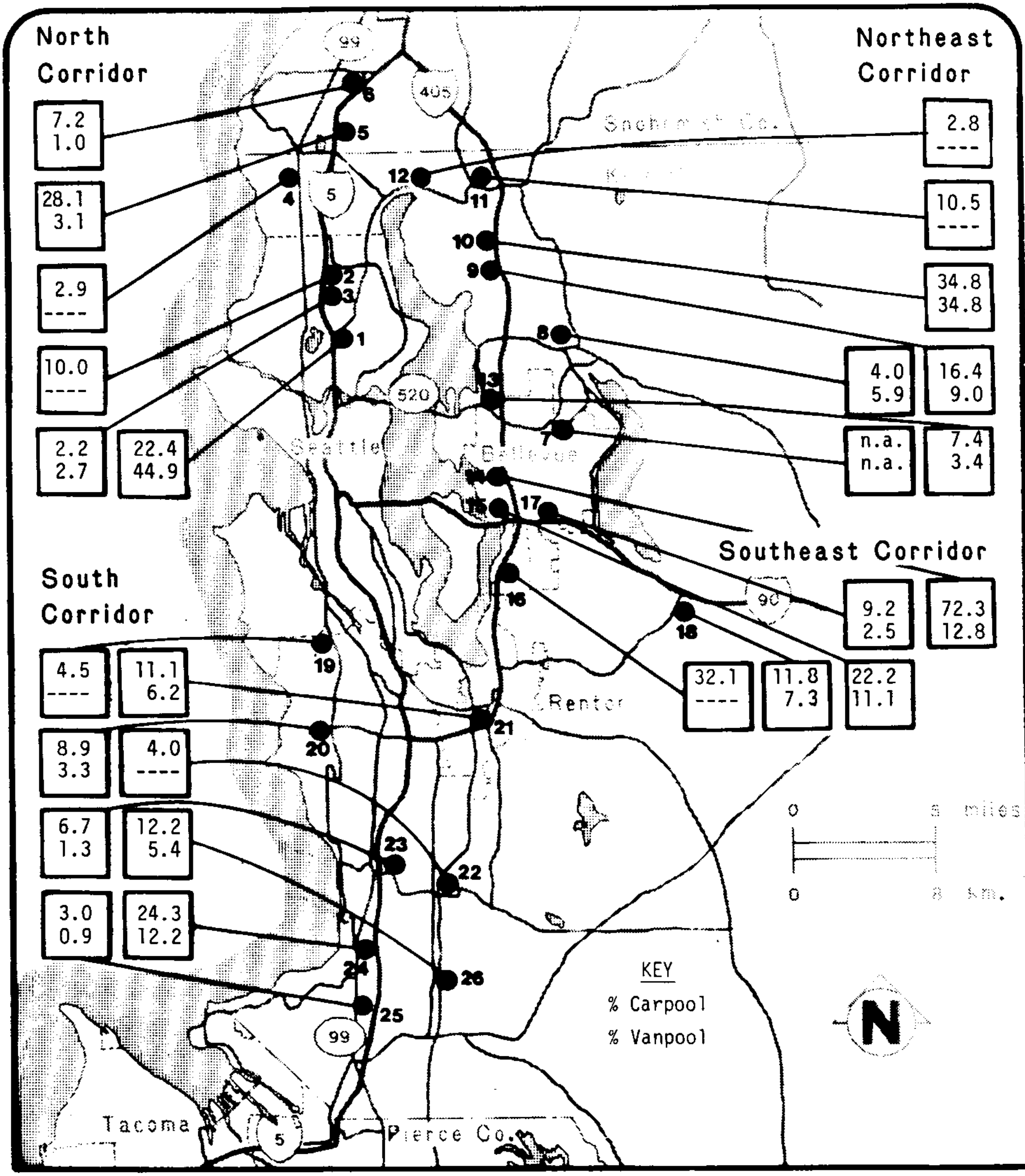


Exhibit 4

Mode from Lot:
Carpool and Vanpool

COST EFFECTIVENESS
OF
PARK & RIDE LOTS

3. Access and Egress Modes

For the sake of convenience, the mode of travel used by respondents in traveling to the park-and-ride lot is here referred to as the access mode. The mode of travel from the lot, and to the destination, is called the egress mode.

Exhibit 5 summarizes the access mode distribution. Clearly, the primary access mode to the lot was drive-alone automobile, with some 92.7 per cent of respondents choosing that mode. Exhibit 6 presents the occupancy distribution for respondent vehicles accessing the lot. The average occupancy was 1.081.

The egress mode distribution for travel from the lot is shown in Exhibit 7. As mentioned earlier, transit was naturally the dominant egress mode (84.7 per cent) although carpool (10.0 per cent) and vanpool (4.8 per cent) comprise a significant share. The egress mode occupancy distribution is shownin Exhibit 8. The average occupancy of vehicles (other than transit) traveling from the lots is 5.268 persons.

Exhibit 9 presents a cross tabulation of access mode by egress mode. Of those who drove alone to the park-and-ride lot, 85.1 per cent took transit to their destination, 9.9 per cent carpooled and 4.5 per cent met a vanpool. Those who carpooled to the park-and-ride lot primarily changed mode and rode transit (80.3 per cent).

Exhibit 5

Travel Mode to Park-and-Ride Lot

Mode	Count	%
Drove Alone	2225	92.7
Carpool	173	7.2
Other	3	0.1

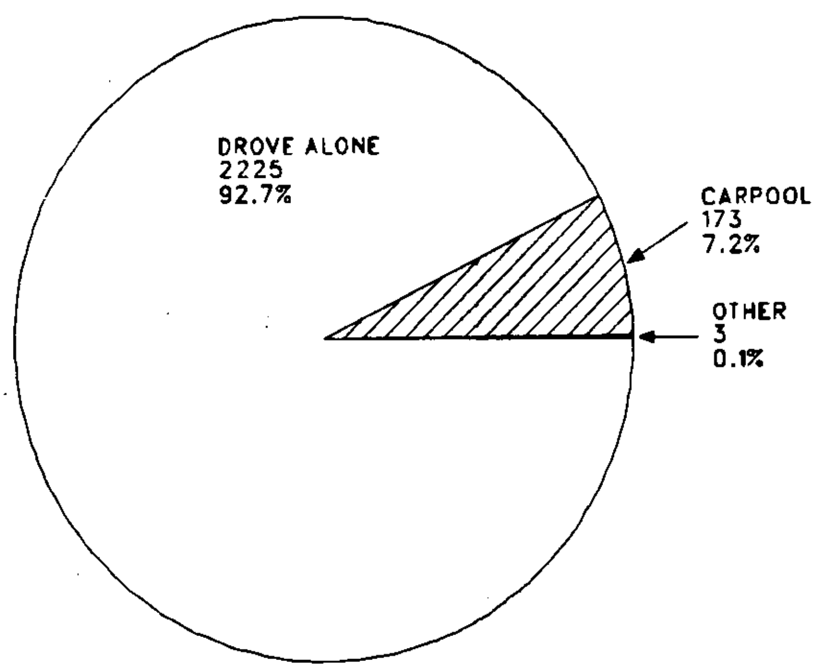


Exhibit 6

Occupancy Distribution of Vehicles Used to Park and Ride Lots

Occupancy	Count	%
1	2227	92.8
2	158	6.6
3	11	0.5
4	5	0.2

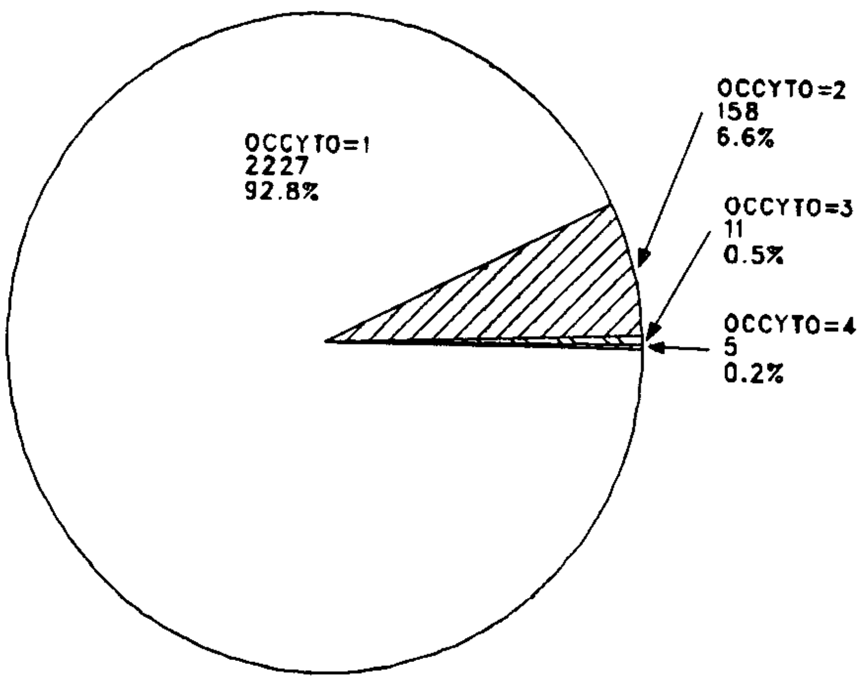


Exhibit 7

Travel Mode from Park-and-Ride Lot

Mode	Count	%
Transit	2033	84.7
Carpool	241	10.0
Vanpool	116	4.8
Other	9	0.4

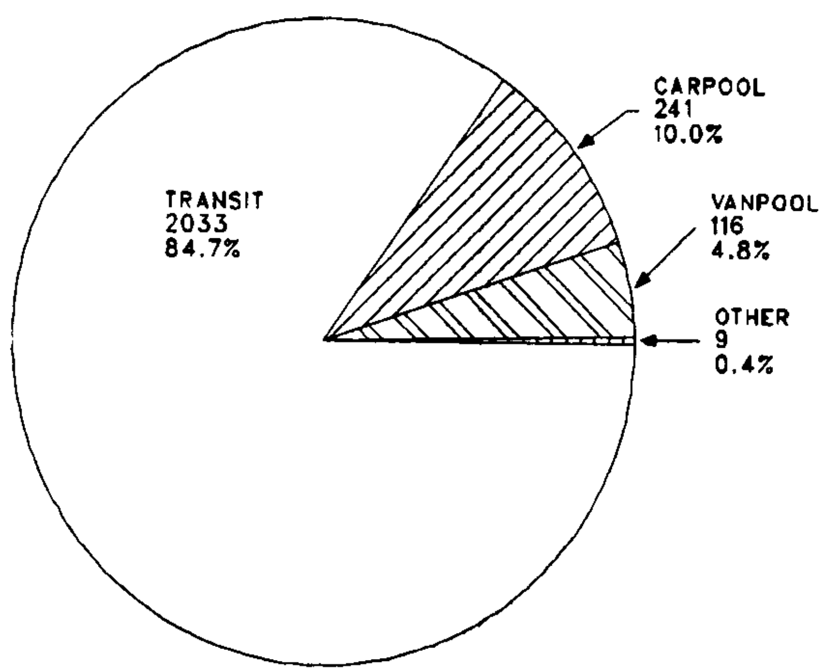


Exhibit 8

Occupancy Distribution of Autos and Vans Used from Park-and-Ride Lots

Occupancy	Count	%
2	69	20.1
3	92	26.8
4	61	17.8
5	8	2.3
6	8	2.3
7	6	1.7
8	13	3.8
9	20	5.8
10	24	7.0
11	18	5.2
12	20	5.8
13	1	0.3
14	2	0.6
16	1	0.3

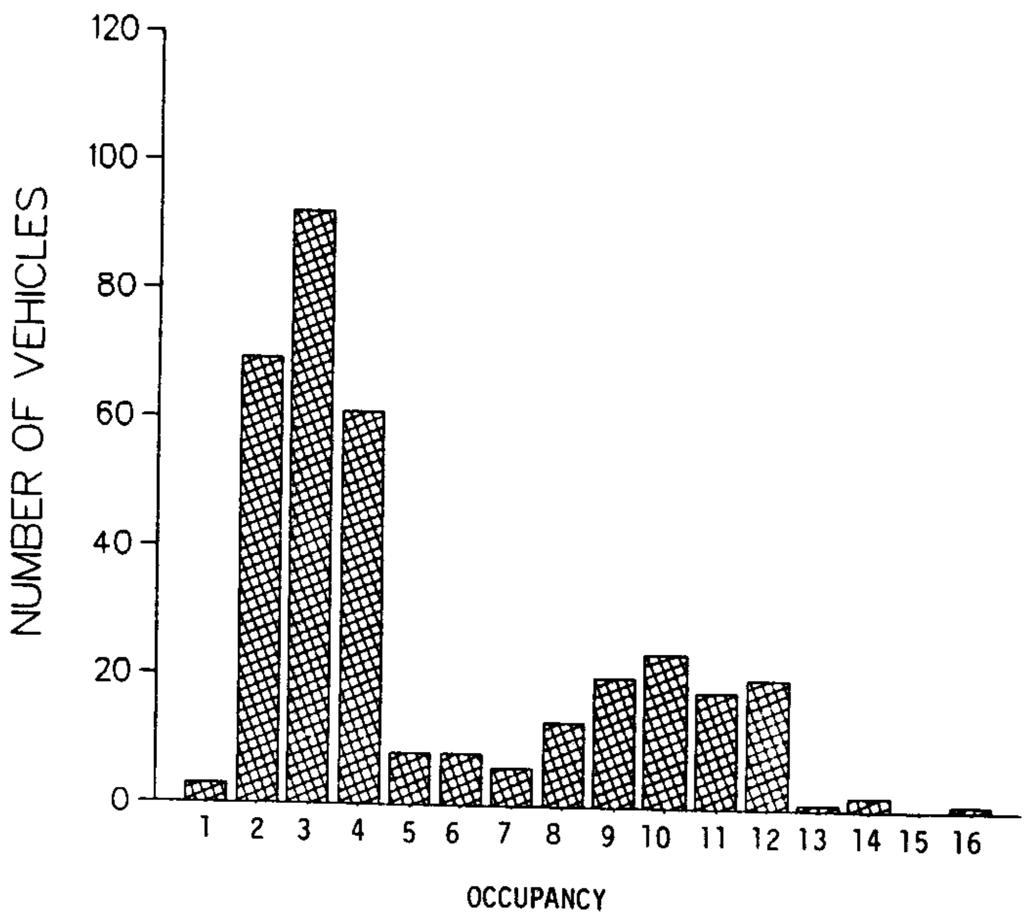


Exhibit 9

Travel Mode to Park-and-Ride Lot

by

Mode from Park-and-Ride Lot

Access Mode		Egress Mode			
		Transit	Carpool	Vanpool	Other
Drove Alone		1892.	222.	101.	9.
		85.1	9.9	4.5	0.4
		93.1	91.3	87.1	100.0
Carpool		139.	21.	13.	0.
		80.3	12.1	7.5	0.
		6.8	8.7	11.2	0.
Other		1.	0.	2.	0.
		33.3	0.	66.7	0.
		0.	0.	1.7	0.

KEY
Count
Row Percentage
Column Percentage

4. Previous Modes of Travel

A respondent's mode of travel used prior to the use or existence of the park-and-ride lot is necessary in analyzing trip costs both with the park-and-ride lot network and without it. In approximately 2 per cent of the cases, respondents noted two previous modes used. The frequency distribution of previous modes is presented in Exhibit 10. The largest group previously drove alone to their destination (33.9 per cent), with an additional 19.7 per cent driving to transit (e.g. travelled to another park-and-ride facility). A total of 13.5 per cent of the respondents previously either carpooled or vanpooled to their destinations. A more detailed look at the previous mode of travel can be obtained from Exhibits 11 and 12, which display the cross tabulations of present egress mode by the previous mode, and present access mode by the previous mode.

Exhibit 10

Mode Before Using Park-and-Ride Lot

Exhibit 10

Mode before Using
Park and Ride Lot

Mode	Count	%
Walked to Transit	336.	14.0
Drove to Transit	471.	19.7
Drove Alone	813.	33.9
Vanpool	23.	1.0
Carpool	300.	12.5
Didn't Make Trip	423.	17.7
Other	30.	1.3

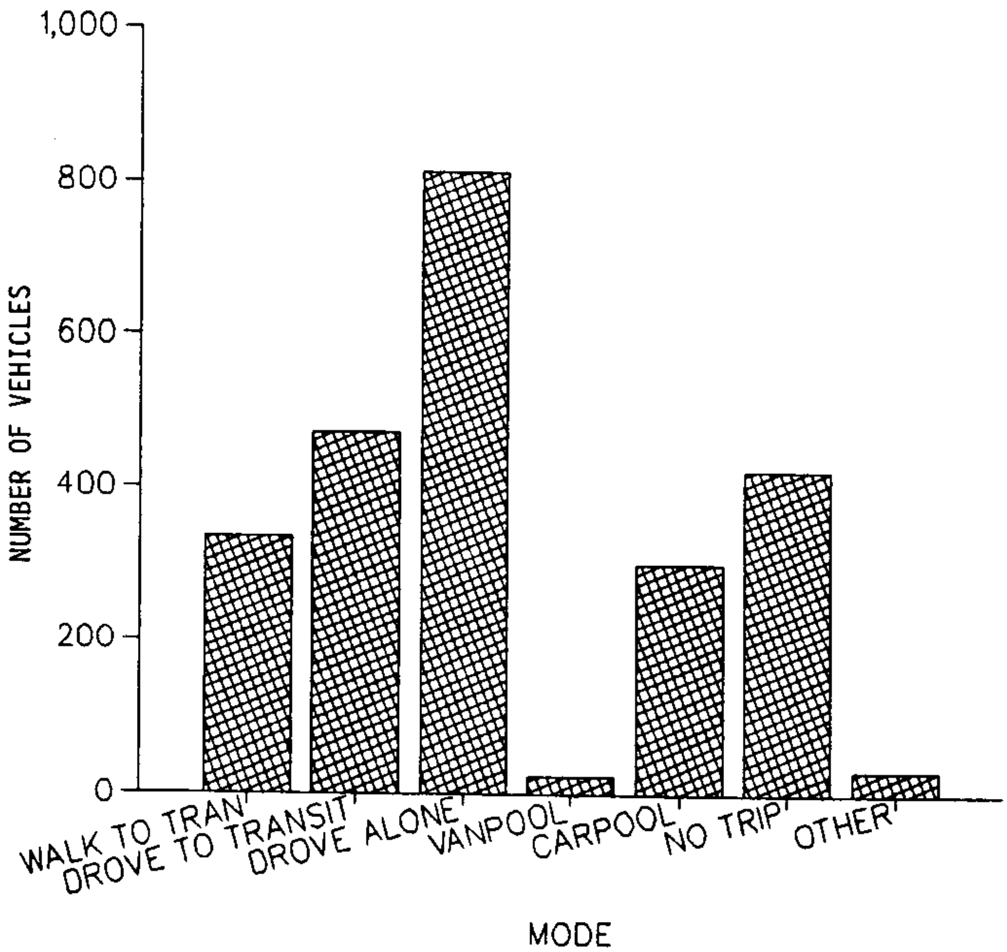


Exhibit 11

Egress Mode Used from Park-and-Ride Lot
by
Previous Mode Used

Mode from Lot	Previous Mode: Walked to Transit	Drove to Transit	Drove Alone	Van-Pool	Car-Pool	Didn't Make Trip	Other
Transit	320. 15.8 95.5	429. 21.2 91.1	667. 32.9 82.1	14. 0.7 60.9	175. 8.6 58.3	394. 19.4 93.4	27. 1.3 90.0
Carpool	11. 4.8 3.3	24. 10.0 5.1	95. 39.4 11.7	0. 0. 0.	92. 38.2 30.7	18. 7.5 4.3	2. 0.8 6.7
Vanpool	4. 3.4 1.2	16. 13.8 3.4	49. 42.2 6.0	9. 7.8 39.1	32. 27.6 10.7	5. 4.3 1.2	1. 0.9 3.3
Other	0. 0. 0.	2. 22.2 0.4	1. 11.1 0.1	0. 0. 0.	1. 11.1 0.3	5. 55.6 1.2	0. 0. 0.

KEY
Count
Row Percentage
Column Percentage

Exhibit 12

Access Mode to Park and Ride Lot by Previous Mode Used

Access Mode		Previous Mode: Walked to Transit	Drove to Transit	Drove Alone	Van-Pool	Car-Pool	Didn't Make Trip	Other
Transit	Count	306.	440.	778.	23.	254.	395.	24.
	Row %	13.8	19.8	35.1	1.0	11.4	17.8	1.1
	Column %	91.1	93.6	95.7	100.0	84.7	93.4	80.0
Carpool	Count	30.	29.	34.	0.	46.	27.	6.
	Row %	17.4	16.9	19.8	0.	26.7	15.7	3.5
	Column %	8.9	6.2	4.2	0.	15.3	6.4	20.0
Other	Count	0.	1.	1.	0.	0.	1.	0.
	Row %	0.	33.3	33.3	0.	0.	33.3	0.
	Column %	0.	.2	.1	0.	0.	.2	0.

KEY
Count
Row Percentage
Column Percentage

5. Trip Purposes

The primary trip purpose of the respondents, as expected, is work, at 94.6 per cent of cases, while 3.7 per cent were for school, 0.4 per cent for shopping and 1.3 per cent for other or miscellaneous purposes. Exhibit 13 shows the trip purpose frequency distribution.

Exhibit 14 is a cross tabulation of access mode by trip purpose, showing that the primary trip purpose was work for all access modes.

Exhibit 15 illustrates the distribution of trip purposes by egress trip modes. The primary trip purpose for all modes was work. Transit provided 84.6 per cent of the work trips, while carpooling provided 10.0 per cent and vanpooling 5.2 per cent of the work trips. Transit also provided the major share of school trips (91.0 per cent). Although the number of shopping trips is small (10), 30 per cent of those trips were carpooled, with the remaining 70 per cent provided by transit.

Exhibit 13

Trip Purpose

Name	Count	%
Work	2270.	94.6
School	89.	3.7
Shopping	10.	0.4
Other	30.	1.3

Exhibit 14

Mode to Park-and-Ride Lot
by
Trip Purpose

Access Mode		Purpose: Work	School	Shopping	Other
A c c e s s	Drove Alone	2111.	77.	9.	25.
		95.0	3.5	0.4	1.1
		93.0	87.5	90.0	83.3
	Carpool	157.	10.	1.	5.
		90.8	5.8	0.6	2.9
M o d e		6.9	11.4	10.0	16.7
	Other	2.	1.	0.	0.
		66.7	33.3	0.	0.
		0.1	1.1	0.	0.

KEY
Count
Row Percentage
Column Percentage

Exhibit 15

Mode from Park-and-Ride Lot
by
Trip Purpose

Egress Mode		Purpose: Work	School	Shopping	Other
	Transit	1917.	81.	7.	26.
		94.4	4.0	0.3	1.3
		84.6	91.0	70.0	86.7
	Carpool	226.	7.	3.	4.
		94.2	2.9	1.2	1.7
		10.0	7.9	30.0	13.3
	Vanpool	116.	0.	0.	0.
		100.0	0.	0.	0.
		5.1	0.	0.	0.
	Other	8.	1.	0.	0.
		88.9	11.1	0.	0.
		0.4	1.1	0.	0.

Key
Count
Row Percentage
Column Percentage

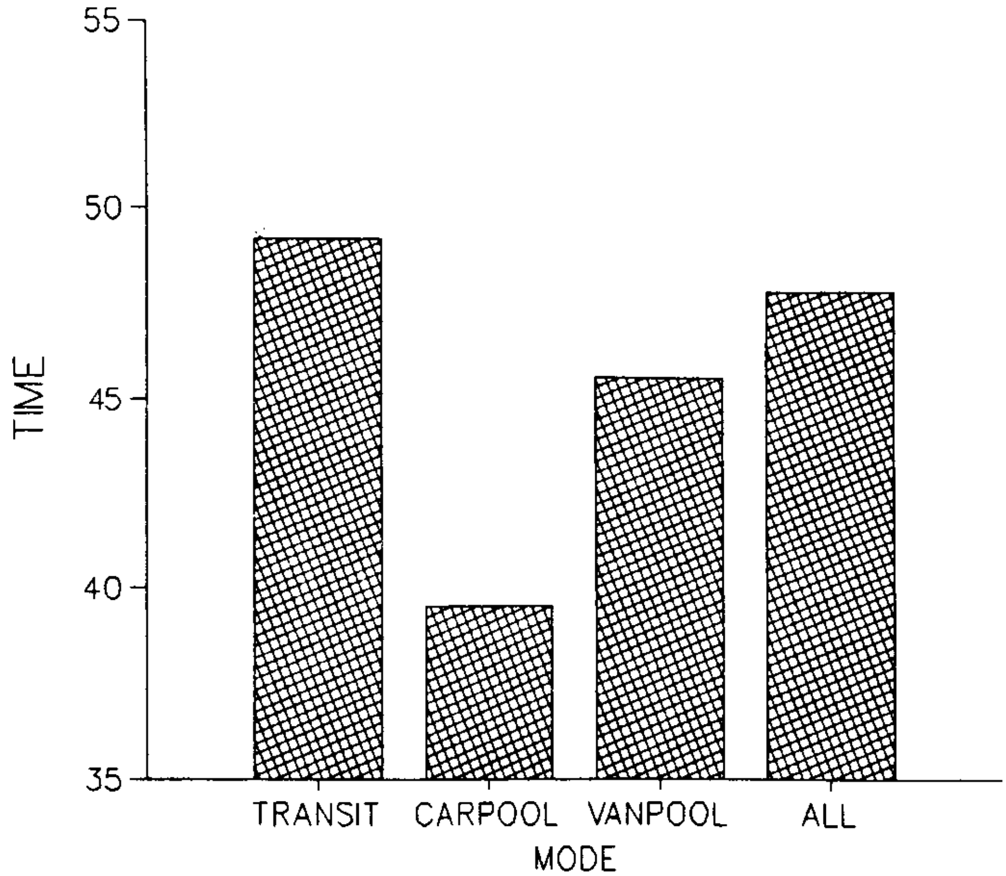
6. Travel Times

The average travel time was computed to be 47.9 minutes for all modes and all respondents (2402), with a standard deviation of 20.3 minutes. By mode, average travel times varied from 39.5 minutes for the carpool trip (Std. Dev. = 19.5 minutes) to 49.2 minues for the transit trip (Std. Dev. = 20.2 minutes), as presented in Exhibit 16.

Exhibit 16

Mean Total Reported Travel Time (Minutes) by Mode, from Origin

Mode		Mean Time	Standard Deviation
	Transit	49.2	20.2
	Carpool	39.5	19.5
	Vanpool	45.6	18.0
	All	47.9	20.3



7. Trip Frequency

Exhibit 17 illustrates the weekly use of the park-and-ride lots in four categories: five times per week (74.9 per cent), four times per week (14.4 per cent), two or three times per week (7.1 per cent) and one or less (3.5 per cent). This distribution of weekly use may have some effect on the expandability of the sample to the whole park-and-ride population. Therefore, as previously noted, the sample will be investigated as to its degree of trip frequency bias.

A cross tabulation of frequency of lot use vs egress mode is presented in Exhibit 18. This shows that 62.5 per cent of the sample population use transit five times per week, and of those who use the park-and-ride lot five times per week, 83.9 per cent ride transit to their destination. 74.3 per cent of the transit riders of the sample use the park-and-ride lot daily. For those respondents who vanpool, 84.5 per cent use the park-and-ride lots daily compared with 76.3 per cent of the carpoolers.

Exhibit 17

Frequency of Lot Use
(Times per Week)

Frequency	Count	%
Five	1797.	74.9
Four	346.	14.4
Two or Three	171.	7.1
One or Less	84.	3.5

Exhibit 18

Frequency of Lot Use
by
Mode from Lot

Weekly Frequency	Mode from Lot: Transit	Carpool	Vanpool	Other
Five	1506.	184.	98.	6.
	83.9	10.3	5.5	0.3
	74.3	76.3	84.5	66.7
Four	299.	29.	17.	1.
	86.4	8.4	4.9	0.3
	14.7	12.0	14.7	11.1
Two or Three	151.	18.	1.	1.
	88.3	10.5	0.6	0.6
	7.4	7.5	0.9	11.1
One or Less	73.	10.	0.	1.
	86.9	11.9	0.	1.2
	3.6	4.1	0.	11.1

Key
Count
Row Percentage
Column Percentage

8. Vehicle Ownership

Vehicle ownership per household for survey respondents is presented in Exhibit 19. Over 75 per cent of respondents have at least two vehicles in their household. A cross-tabulation of egress modes by vehicle ownership (Exhibit 20) illustrates similar distributions of vehicle ownership for all modes of egress from the Park-and-Ride lots. Exhibit 20 displays histograms of vehicle ownership for each of the three identified egress modes. The average vehicle ownership is highest for those respondents who carpooled from the Park-and-Ride lots (2.30 vehicles per household), and lowest for those who used transit (2.09 vehicles per household).

A second cross-tabulation, in Exhibit 21, of access mode by vehicle ownership shows that 76.7 per cent of those respondents who drove alone to the Park-and-Ride lots own two or more vehicles, and 70.9 per cent of those who carpooled to the lots. The average vehicle ownership for those who drove alone to the Park-and-Ride lot is 2.13 vehicles per household, and 2.02 vehicles per household for those who carpooled to the lots.

Exhibit 19

Vehicle Ownership

Licensed Vehicles per Household	Number	Percentage
One	563	23.7
Two	1158	48.8
Three	462	19.5
Four or More	192	8.1

Exhibit 20

Mode from Park-and-Ride Lot by Vehicle Ownership

Mode From Lot	One	Two	Three	Four or More
Transit	498.	986.	371.	155.
	24.8	49.1	18.5	7.7
	88.6	85.2	80.5	80.7
Carpool	40.	113.	58.	26.
	16.9	47.7	24.5	11.0
	7.1	9.8	12.6	13.5
Vanpool	22.	53.	30.	11.
	19.0	45.7	25.9	9.5
	3.9	4.6	6.5	5.7
Other	2.	5.	2.	0.
	22.2	55.6	22.2	0.
	0.4	0.4	0.4	0.

(Column header: Vehicles per Household)

Key
Count
Row Percentage
Column Percentage

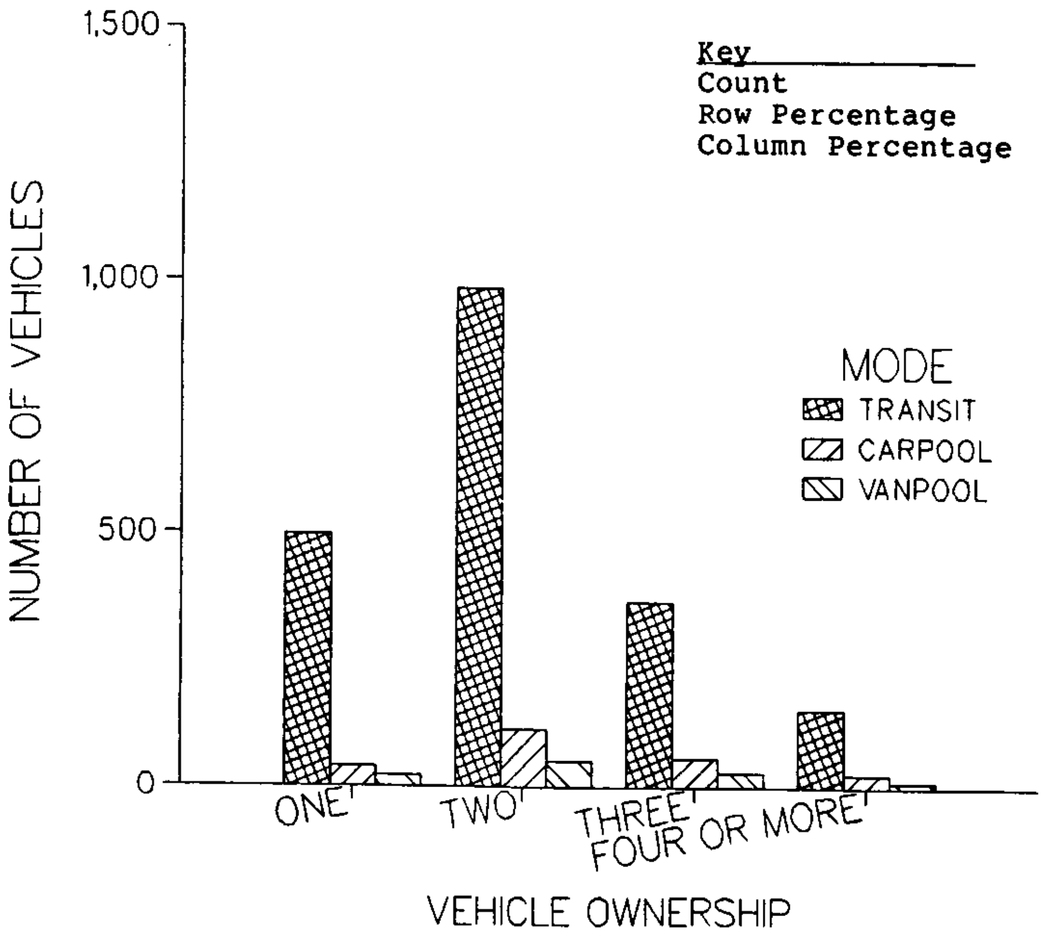
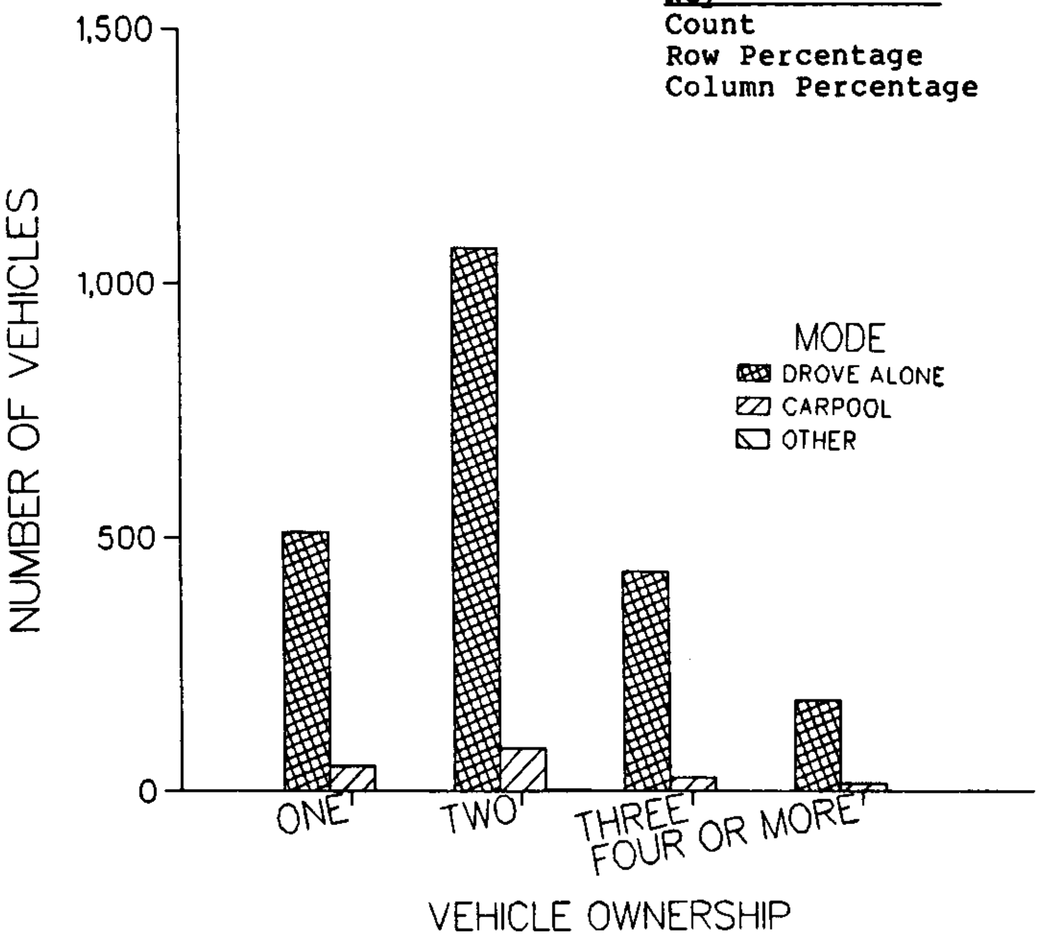


Exhibit 21

Mode to Park-and-Ride Lot by Vehicle Ownership

Mode to Lot		Vehicles per Household: One	Two	Three	Four or More
	Drove Alone	513.	1072.	436.	178.
		23.3	48.8	19.8	8.1
		91.1	92.7	94.4	92.7
	Carpool	50.	82.	26.	14.
		29.1	47.7	15.1	8.1
		8.9	7.1	5.6	7.3
	Other	0.	3.	0.	0.
		0.	100.0	0.	0.
		0.	0.3	0.	0.

Key
Count
Row Percentage
Column Percentage



9. Parking Fees

Parking fee information was gathered from those respondents who either carpooled or vanpooled from the Park-and-Ride lot to their destination. Thus the sample size would be, at most, 357 responses. Of these, only 135 provided parking fee data. Exhibit 22 presents the average parking fees by egress mode. It appears that vanpools may receive a larger parking subsidy, although without further information regarding trip destinations, conclusions cannot as yet be drawn.

Exhibit 22

Average Parking Fee
by
Mode from Park-and-Ride Lot

Mode	Pay Structure: Daily	Weekly	Monthly	# Respondents
Carpool	$0.70	Not Available	$24.16	107
Vanpool	$0.14	Not Available	$10.83	38
# Respond.	82	---	53	135

*For entire sample (includes areas other than CBD)

10. Vehicle Characteristics

The survey responses provide information about the vehicles used for access to and egress from the Park-and-Ride lots. This includes the make, model, year, transmission type, and number of cylinders for each vehicle.

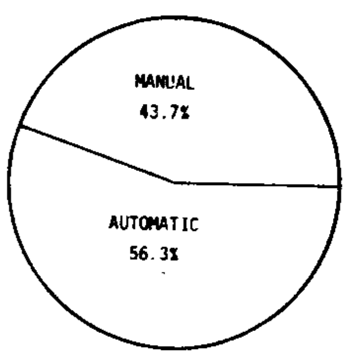
The vehicles used by respondents to access the Park-and-Ride lots are almost evenly split between automatic (56.3%) and manual (43.7%) transmission. (Exhibit 23). The access vehicles primarily have four cylinders (47.7%), with six and eight cylinder vehicles comprising the rest of the group (22.7% and 29.5%, respectively) (Exhibit 24). The egress vehicles, in contrast, consist of 46.4 per cent with eight cylinders and 53.6 per cent with six or fewer cylinders. An average of 5.65 cylinders per access vehicle was determined from the survey responses, with an average of 6.18 cylinders per vehicle for the egress vehicles. The difference between access and egress vehicles is reflected in the average access and egress occupancies of 1.081 and 5.268 persons per vehicle, respectively.

Access and egress vehicles have been classified according to age groups for Exhibits 25 and 26. For all access vehicles, 69.4 per cent are over five years old, whereas for all egress vehicles (ignoring transit vehicles), only 39.6 per cent are older than five years. Vehicle age information is provided also by access and egress mode.

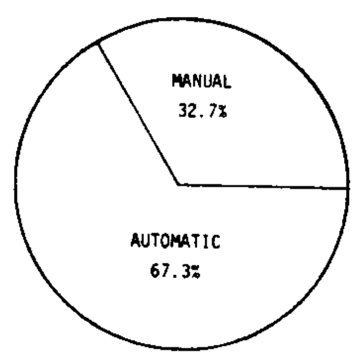
Exhibit 23

Transmission Type for Access and Egress Vehicles

	Vehicle	
Transmission Type	Access to Park-and-Ride	Egress from Park-and-Ride
Automatic	56.3%	67.3%
Manual	43.7%	32.7%
Sample Size	2328	330



Transmission Type of
Park-and-Ride Access Vehicles

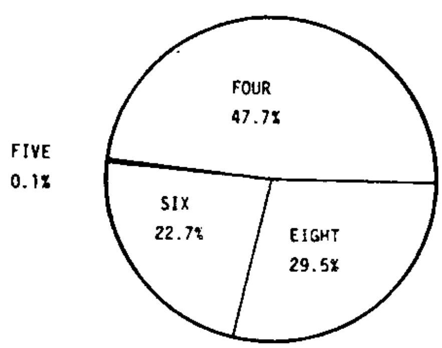


Transmission Type of
Park-and-Ride Egress Vehicles
(excluding Transit)

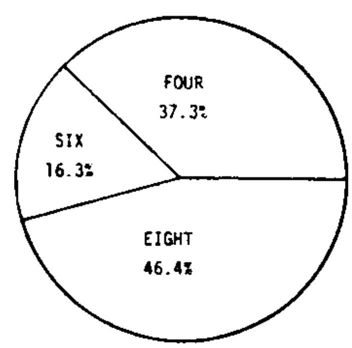
Exhibit 24

Number of Cylinders for Access and Egress Vehicles

	Vehicle	
# Cylinders/ Vehicle	Access to Park-and-Ride	Egress from Park-and-Ride
4	47.7	37.3
5	0.1	--
6	22.7	16.3
8	29.5	46.4
Sample Size	2241	306



Number of Cylinders in Access Vehicle Engines



Number of Cylinders in Egress Vehicle Engines (excluding Transit)

Exhibit 25

Age Distribution of Access Vehicles

Age	All Access Vehicle	SOV (Drove Alone)	HOV (Carpool Vanpool)
0-5 years (1979-1983)	30.6%	30.0%	36.1%
6-10 years (1974-1978)	36.9%	31.8%	42.4%
11-15 years (1969-1973)	22.7%	23.1%	18.0%
16-20 years (1964-1968)	8.3%	8.8%	2.3%
Over 20 years (1963-earlier)	1.5%	6.3%	1.2%
Sample Size	2333	2161	172

Exhibit 26

Age Distribution of Egress Vehicles (Except Transit Vehicles)

Age	All Egress Vehicle	Carpool	Vanpool
0-5 years (1979-1983)	60.4%	46.5%	89.5%
6-10 years (1974-1978)	24.1%	32.0%	7.4%
11-15 years (1969-1973)	12.6%	17.0%	3.1%
16-20 years (1964-1968)	2.6%	3.5%	--
Over 20 years (1963-earlier)	0.3%	1.0%	--
Sample Size	295	200	95

11. Concluding Comments

This report has presented a preliminary analysis of the Park-and-Ride Lot User Survey. The data set was edited and validated prior to analysis. The results presented in this reportare primarily for the aggregated survey responses from all Park-and-Ride lots surveyed, although a summary of responses both by lot and by corridor was reported in Exhibit 1.

On-going work involves stratification of the data set to the level of individual lots, as well as by selected travel corridors, as part of the overall evaluation of the cost-effectiveness of Park-and-Ride lots in Seattle. Further investigation is also being undertaken of the effects, if any, of trip frequency bias in the data. The results of these investigations will be reported separately.

APPENDIX C

FORTRAN CODING FOR TRIP COST MODEL

FORTRAN CODING FOR TRIP COST MODEL

```
c TRIP is a fortran program for analyzing commuter trip costs
c both with and without the Park $ Ride Lot
c
c There are three inputs to the model :
c       1. LOTDATA -- information related to each of the p&r lot.
c       2. PNRDATA -- original survey data.
c       3. VARY ----- contain variables whose value can be changed.
c
c TRIP provides two ways to simulate different situations :
c       1. by changing variable values in the file VARY.
c       2. by prompting you for different view points.
c
c There are two output files generated by TRIP :
c       1. PNROUT -- contains useful information and intermediate
c                    calculations for each survey case.
c       2. COST ANALYSIS TABLEs.
c
c All the variables used in the model are documented in a seperate
c dictionary.
c
      program trip
      real mile1,mile2,lymn,lotcost,lhov,lr,lus,lc,ld
      integer prnum,pmd,mtpr,mfpr,vetp,veyr,cvetp,cveyr,oct,otaz,dtaz
      integer code1,code2,code3,code4,prfrq
      character city(14)*16
      character title(4)*17
      character titl1(5)*20
      character titl2(3)*20
      character titl3(2)*20
      character titl4*20
      character comment*100
      character mssge1(3)*18,mssge2(2)*25,mssge3(2)*25,mssge4(3)*51
      dimension pre(14,5),after(14,4),total(14,2)
      dimension premil(14,5),aftmil(14,4),totmil(14,2)
      dimension kasep(14,5),kasea(14,4),kaset(14,2)
      dimension pbreak(5,14,14),abreak(3,14,14),tbreak(2,14,14)
      dimension utauto(14),stall(14)
      dimension rmtor(6),rmtol(6),rmtod(6),rgr(6),rgl(6),rgd(6)
c
c first dimension 1-6 8-12 correspond to the 11 park and ride lots
c                7 and 13 correspond to the north and southeast corridors
c               14 corresponds to the total 'in-depth' study area
c
      common /sub/ lr,lus,lc,ld,vetp,pmd,avginc,lhtp,att,runtime,wait,
     +          walk1,mfpr,aocc,plrs,plrn,prmile,lotcost,autos,stalls
     +          ,cvetp,prbmin,rvmn,lymn,ddmn,brvmn,bphr,optp1,
     +          p,optp2,bus11,bus14,bus16,bus20,plc,lhov,plus,busocc,
     +          otaz,prnum
      common /various/code1,code2,code3,code4,pclc1,pclc3,pclus1,pclus3,
     +              pclus4,sc1,sc3,sus1,sus3,sus4,pchov,spl1,tv,tw,rpcr
```

```
      common /autocom/ rmtor,rmtol,rmtod,rgr,rgl,rgd,pgr,pmtor,
     +                 sr,sd,rpcd,rar,ral,rad
      data utauto,stall/28*0./
      data pbreak,abreak,tbreak/980*0.,588*0.,392*0./
      data pre,after,total/70*0.0,56*0.0,28*0.0/
      data premil,aftmil,totmil/70*0.0,56*0.0,28*0.0/
      data kasep,kasea,kaset/70*0,56*0,28*0/
      data title/'  Previous Mode','   Park & Ride ','Combined Average',
     +          'Comparision Ratio'/
      data titl1/'Walk to Transit','Drive to Transit','   Drive Alone',
     +          '     Vanpool','    Carpool'/
      data titl2/'Transit from P&R Lot','Carpool from P&R Lot',
     +          'Vanpool from P&R Lot'/
      data titl3/'Previous Mode','Park & Ride'/
      data titl4/'- pmd/p&r -'/
      data mssge1/'TOTAL Perspective','AGENCY Perspective',
     +           'USER Perspective'/
      data mssge2/'time costs included','time costs not included'/
      data mssge3/'public costs included','public costs not included'/
      data mssge4/'cost of p&r lot parking based on actual utilization',
     +           'cost of p&r lot parking based on 100% utilization',
     +           'cost of p&r lot parking free to user'/
      data city/'Green Lake','North Seattle','Northgate',
     +'Shoreline','Mt.Lake Terrace','Lynnwood','N. Corridor',
     +'Wilburton','S. Bellevue','Newport Hills','Eastgate',
     +'Issaquah','S.E. Corridor','Total study area'/
      open(3,file='vary')
      open(4,file='lotdata')
      open(5,file='pnrdata')
      open(6,file='pnrout',status='new')
      read(3,9) pclc1,pclc3,pclus1,pclus3,pclus4,sc1,sc3,sus1,sus3,sus4
     +      ,pchov,spll
9     format(/5f5.3,5f4.1,f5.3,f4.1)
      read(3,7) (rmtor(i),i=1,6),(rmtod(j),j=1,6),(rmtol(k),k=1,6),
     +(rgr(l),l=1,6),(rgl(m),m=1,6),(rgd(n),n=1,6),tv,tw,pgr,pmtor,
     +rar,ral,rad,sr,sd,rpcr,rpcd
7     format(10x,12f5.3/10x,12f5.3/10x,12f5.3/10x,2f3.1/10x,2f5.2/
     +10x,3f6.4/10x,2f4.1,2f6.4)
      write(*,3)
3     format(1x,'please enter a comment to explain your auto cost')
      read(*,4) comment
4     format(a100)
c     write(*,101)
101   format(1x,'enter mode, 1 for single choice,2 for multiple choice')
c     read(*,102) mode
102   format(i1)
c     if(mode.eq.1) then
c     write(*,99)
99    format(1x,'enter code1 --- perspective'/11x,'1 = total costs'/11x,
     +'2 = agency cost, this implies time cost will not be included'/
     +11x,'3 = user cost, implies code3=2 and code4=3')
c     read(*,102) i11
c     write(*,105)
```

```
105   format(1x,'enter code2 --- time cost included?'/11x,'1 = yes'/
     +11x,'2 = no')
c     read(*,102) i21
c     write(*,106)
106   format(1x,'enter code3 --- public cost included?'/11x,'1 = yes'/
     +11x,'2 = no')
c     read(*,102) i31
c     write(*,107)
107   format(1x,'enter code4 --- cost of p&r lot parking'/11x,
     +'1 = based on utilization'/11x,'2 = based on number of spaces'/
     +11x,'3 = no cost, when looking at user costs')
c     read(*,102) i41
c         i12=i11
c         incr1=1
c         i22=i21
c         incr2=1
c         i32=i31
c         incr3=1
c         i42=i41
c         incr4=1
c      elseif (mode.eq.2) then
      write(*,99)
      write(*,108)
108   format(/1x,'note : please enter your selection(s) in ascending '
     +,'order seperating by 1 column')
      read(*,109) i11,i12,incr1
109   format(i1,1x,i1,1x,i1)
      if(i12.eq.0) then
        i12=i11
        incr1=1
      elseif (i12.ne.0.and.incr1.eq.0) then
        incr1=i12-i11
      elseif(incr1.eq.3) then
        i12=3
        incr1=1
      endif
      write(*,105)
      read(*,109) i21,i22
      incr2=1
      if(i22.eq.0) i22=i21
      write(*,106)
      read(*,109) i31,i32
      incr3=1
      if(i32.eq.0) i32=i31
      write(*,107)
      read(*,109) i41,i42,incr4
      if(i42.eq.0) then
        i42=i41
        incr4=1
      elseif (i42.ne.0.and.incr4.eq.0) then
        incr4=i42-i41
      elseif(incr4.eq.3) then
        i42=3
```

```
         incr4=1
       endif
c      endif
       write(*,6)
6      format(1x,'do you need SUMMARY REPORT TABLE ?'/
     +11x,'1 = yes'/11x,'2 = no')
       read(*,102) iock1
        write(*,43)
43      format(1x,'do you need ALL COST COMPONENT TABLE ?'/
     +11x,'1 = yes'/11x,'2 = no')
        read(*,102) iock2
        write(*,47)
47      format(1x,'do you need COST COMPONENT SUMMARY ?'/
     +11x,'1 = yes'/11x,'2 = no')
        read(*,102) iock3
       write(*,16)
16     format(1x,'please wait, I am working for you')
c
c use a four level do loop to process all the combinations of view
c points. 'save' is used to meet the code default.
c
       do 1100 icode1=i11,i12,incr1
          code1=icode1
          if(icode1.eq.2) then
            isav1=i21
             is22=i22
             i22=2
            i21=2
          endif
         do 1200 icode2=i21,i22,incr2
            code2=icode2
            if(icode1.eq.3) then
               isav2=i31
               is32=i32
               i32=2
               i31=2
            endif
          do 1300 icode3=i31,i32,incr3
             code3=icode3
             if(icode1.eq.3) then
                isav3=i41
                is42=i42
                i42=3
                i41=3
             endif
            do 1400 icode4=i41,i42,incr4
               code4=icode4
c
c both lotdata and pnrdata are sorted by lot number(ltnum in lotdata,
c prnum in pnrdata). because of sorted sequence, we can use the
c master file transaction file updating' logic to process the data.
c
c      open(4,file='lotdata')
```

```
c      open(5,file='pnrdata')
       iutil=1
       read(4,1)ltnum,prmile,prbmin,busocc,rvmn,lymn,ddmn,rvml,brvmn,
      +         bphr,bpml,optp1,optp2,bus11,bus14,bus16,bus20,lotcost,
      +         autos,stalls,lhov,plus,plc
1      format(i2,f4.1,f2.0,f4.1,f3.0,f2.0,f3.0,f5.2,f3.0,f5.2,7f3.0,
      +       f7.2,2f4.0,f3.1,f4.1,f3.1)
c
c array utauto and stall between here and statement 15 are used
c to record the capacity and utilization of each p&r lot.
c
       utauto(iutil)=autos
       stall(iutil)=stalls
       utauto(7)=autos
       stall(7)=stalls
       utauto(14)=autos
       stall(14)=stalls
       read(5,2)id,prnum,otaz,dtaz,mtpr,mfpr,pmd,aocc,prfrq,cocc,cppk,
      +         pfee,vetp,veyr,cvetp,cveyr,oct,avginc,lr,lus,lc,ld,
      +         lhtp,plrn,plrs,att,ttt,p,runtime,walk1,wait
2      format(i4,i2,2i3,3i1,f2.0,i1,f2.0,f4.0,f1.0,i1,i2,i1,i2,
      +       i5,f5.0,2f4.1,2f3.1,i1,2f4.1,2f2.0,f5.2,3f2.0)
       goto 15
c
c read and process one record each time
c
10     read(5,2,end=100)id,prnum,otaz,dtaz,mtpr,mfpr,pmd,aocc,prfrq,
      +         cocc,cppk,pfee,vetp,veyr,cvetp,cveyr,oct,avginc,lr,lus,
      +         lc,ld,lhtp,plrn,plrs,att,ttt,p,runtime,walk1,wait
       if (mfpr.eq.4) goto 10
       if (ltnum.eq.prnum) goto 15
       read(4,1)ltnum,prmile,prbmin,busocc,rvmn,lymn,ddmn,rvml,brvmn,
      +         bphr,bpml,optp1,optp2,bus11,bus14,bus16,bus20,lotcost,
      +         autos,stalls,lhov,plus,plc
       iutil=iutil+1
       utauto(iutil)=autos
       stall(iutil)=stalls
       if(iutil.le.6) then
          utauto(7)=utauto(7)+autos
          stall(7)=stall(7)+stalls
       else
          utauto(13)=utauto(13)+autos
          stall(13)=stall(13)+stalls
       endif
       if(iutil.eq.6) iutil=iutil+1
       utauto(14)=utauto(14)+autos
       stall(14)=stall(14)+stalls
c
c modify prnum to make it correspond to the correct row number
c and set corridor index
c
15     icor=7
       if (prnum.gt.6) then
```

```
            icor=13
            prnum=prnum-6
         endif
c
c call subroutines by pmd to calculate previous trip cost then
c transfer control to statement 50
c
      goto (40,30,20,20,20),pmd
20    call auto(cost1,mile1,time1,time2,time,pub1,pub2,pub,auto1,auto2,
     +          auto3,pauto,park,bus,pcost,*50)
c
c 'kode' in the prbus argument allows the sharing of the subroutine
c by both previous and p&r mode.
c
30    kode=pmd
      call prbus(cost1,mile1,kode,plr,time1,time2,time,pub1,pub2,pub,
     +          auto1,auto2,auto3,pauto,park,bus,pcost,*50)
40    call walkbus(cost1,mile1,time1,time2,time,pub1,pub2,pub,auto1,
     +          auto2,auto3,pauto,park,bus,pcost,*50)
c
c call subroutine by mfpr to calculate 'after' cost then transfer to 90
c
50    goto (70,60,60),mfpr
60    call prauto(cost2,mile2,plr,atime1,atime2,atime,apub1,apub2,apub,
     +          aauto1,aauto2,aauto3,aauto,apark,abus,acost,*90)
70    kode=mfpr
      call prbus(cost2,mile2,kode,plr,atime1,atime2,atime,apub1,apub2,
     +          apub,aauto1,aauto2,aauto3,aauto,apark,abus,acost,*90)
c
c  back from cost calculation subroutine --- begin to update the
c  cost array and mile array
c
90    pre(prnum,pmd)=pre(prnum,pmd)+cost1
      pre(icor,pmd)=pre(icor,pmd)+cost1
      after(prnum,mfpr)=after(prnum,mfpr)+cost2
      after(icor,mfpr)=after(icor,mfpr)+cost2
      kasep(prnum,pmd)=kasep(prnum,pmd)+1
      kasep(icor,pmd)=kasep(icor,pmd)+1
      kasea(prnum,mfpr)=kasea(prnum,mfpr)+1
      kasea(icor,mfpr)=kasea(icor,mfpr)+1
      premil(prnum,pmd)=premil(prnum,pmd)+mile1
      premil(icor,pmd)=premil(icor,pmd)+mile1
      aftmil(prnum,mfpr)=aftmil(prnum,mfpr)+mile2
      aftmil(icor,mfpr)=aftmil(icor,mfpr)+mile2
      v=avginc/(2085.0*tv)
      vw=avginc/(2085.0*tw)
      pmin1=time1*60./v
      pmin2=time2*60./vw
      pmin=pmin1+pmin2
      amin1=atime1*60./v
      amin2=atime2*60./vw
      amin=amin1+amin2
      pbreak(pmd,prnum,1)=pbreak(pmd,prnum,1)+time1
```

```
pbreak(pmd,prnum,2)=pbreak(pmd,prnum,2)+time2
pbreak(pmd,prnum,3)=pbreak(pmd,prnum,3)+time
pbreak(pmd,prnum,4)=pbreak(pmd,prnum,4)+pub1
pbreak(pmd,prnum,5)=pbreak(pmd,prnum,5)+pub2
pbreak(pmd,prnum,6)=pbreak(pmd,prnum,6)+pub
pbreak(pmd,prnum,7)=pbreak(pmd,prnum,7)+auto1
pbreak(pmd,prnum,8)=pbreak(pmd,prnum,8)+auto2
pbreak(pmd,prnum,9)=pbreak(pmd,prnum,9)+auto3
pbreak(pmd,prnum,10)=pbreak(pmd,prnum,10)+pauto
pbreak(pmd,prnum,11)=pbreak(pmd,prnum,11)+park
pbreak(pmd,prnum,12)=pbreak(pmd,prnum,12)+bus
pbreak(pmd,prnum,13)=pbreak(pmd,prnum,13)+pcost
pbreak(pmd,prnum,14)=pbreak(pmd,prnum,14)+pmin
pbreak(pmd,icor,1)=pbreak(pmd,icor,1)+time1
pbreak(pmd,icor,2)=pbreak(pmd,icor,2)+time2
pbreak(pmd,icor,3)=pbreak(pmd,icor,3)+time
pbreak(pmd,icor,4)=pbreak(pmd,icor,4)+pub1
pbreak(pmd,icor,5)=pbreak(pmd,icor,5)+pub2
pbreak(pmd,icor,6)=pbreak(pmd,icor,6)+pub
pbreak(pmd,icor,7)=pbreak(pmd,icor,7)+auto1
pbreak(pmd,icor,8)=pbreak(pmd,icor,8)+auto2
pbreak(pmd,icor,9)=pbreak(pmd,icor,9)+auto3
pbreak(pmd,icor,10)=pbreak(pmd,icor,10)+pauto
pbreak(pmd,icor,11)=pbreak(pmd,icor,11)+park
pbreak(pmd,icor,12)=pbreak(pmd,icor,12)+bus
pbreak(pmd,icor,13)=pbreak(pmd,icor,13)+pcost
pbreak(pmd,icor,14)=pbreak(pmd,icor,14)+pmin
abreak(mfpr,prnum,1)=abreak(mfpr,prnum,1)+atime1
abreak(mfpr,prnum,2)=abreak(mfpr,prnum,2)+atime2
abreak(mfpr,prnum,3)=abreak(mfpr,prnum,3)+atime
abreak(mfpr,prnum,4)=abreak(mfpr,prnum,4)+apub1
abreak(mfpr,prnum,5)=abreak(mfpr,prnum,5)+apub2
abreak(mfpr,prnum,6)=abreak(mfpr,prnum,6)+apub
abreak(mfpr,prnum,7)=abreak(mfpr,prnum,7)+aauto1
abreak(mfpr,prnum,8)=abreak(mfpr,prnum,8)+aauto2
abreak(mfpr,prnum,9)=abreak(mfpr,prnum,9)+aauto3
abreak(mfpr,prnum,10)=abreak(mfpr,prnum,10)+aauto
abreak(mfpr,prnum,11)=abreak(mfpr,prnum,11)+apark
abreak(mfpr,prnum,12)=abreak(mfpr,prnum,12)+abus
abreak(mfpr,prnum,13)=abreak(mfpr,prnum,13)+acost
abreak(mfpr,prnum,14)=abreak(mfpr,prnum,14)+amin
abreak(mfpr,icor,1)=abreak(mfpr,icor,1)+atime1
abreak(mfpr,icor,2)=abreak(mfpr,icor,2)+atime2
abreak(mfpr,icor,3)=abreak(mfpr,icor,3)+atime
abreak(mfpr,icor,4)=abreak(mfpr,icor,4)+apub1
abreak(mfpr,icor,5)=abreak(mfpr,icor,5)+apub2
abreak(mfpr,icor,6)=abreak(mfpr,icor,6)+apub
abreak(mfpr,icor,7)=abreak(mfpr,icor,7)+aauto1
abreak(mfpr,icor,8)=abreak(mfpr,icor,8)+aauto2
abreak(mfpr,icor,9)=abreak(mfpr,icor,9)+aauto3
abreak(mfpr,icor,10)=abreak(mfpr,icor,10)+aauto
abreak(mfpr,icor,11)=abreak(mfpr,icor,11)+apark
abreak(mfpr,icor,12)=abreak(mfpr,icor,12)+abus
```

```
      abreak(mfpr,icor,13)=abreak(mfpr,icor,13)+acost
      abreak(mfpr,icor,14)=abreak(mfpr,icor,14)+amin
      write(6,33) code1,code2,code3,code4,id,prnum,mfpr,pmd,prfrq,lr,
     +lus,lc,ld,vetp,cvetp,oct,plr,plus,plc,lhov,cost1,cost2,mile1,
     +mile2,time1,time2,time,pub1,pub2,pub,auto1,auto2,auto3,pauto,
     +park,bus,pcost,atime1,atime2,atime,apub1,apub2,apub,aauto1,aauto2,
     +aauto3,aauto,apark,abus,acost,pmin1,pmin2,pmin,amin1,amin2,amin
 33   format(1x,4i1,i4,i2,2i1,i1,4f4.1,2i1,i5,f4.1,f4.1,2f3.1,2f8.2,
     +2f4.1,26f5.2,6f3.0)
      goto 10
c
c  after  one record is processed, go back to read the next record
c
c  loop 200 220 computes the subtotals of cost,miles and case numbers
c  for each type of trip of both previous and p&r mode.
c
100   do 200 i=1,5
         kasep(14,i)=kasep(7,i)+kasep(13,i)
         premil(14,i)=premil(7,i)+premil(13,i)
         pre(14,i)=pre(7,i)+pre(13,i)
         if (i.eq.5) goto 200
         kasea(14,i)=kasea(7,i)+kasea(13,i)
         aftmil(14,i)=aftmil(7,i)+aftmil(13,i)
         after(14,i)=after(7,i)+after(13,i)
200   continue
      do 220 i=1,5
         do 210 j=1,14
            pbreak(i,14,j)=pbreak(i,7,j)+pbreak(i,13,j)
            if(i.gt.3) goto 210
            abreak(i,14,j)=abreak(i,7,j)+abreak(i,13,j)
210      continue
220   continue
c
c  loop 400 500 computes the total cost,miles and cases for each
c  p&r lot for both previous and p&r mode.
c
      do 400 i=1,14
         do 395 j=1,5
            kaset(i,1)=kaset(i,1)+kasep(i,j)
            total(i,1)=total(i,1)+pre(i,j)
            totmil(i,1)=totmil(i,1)+premil(i,j)
395      continue
400   continue
      do 500 i=1,14
         do 495 j=1,4
            kaset(i,2)=kaset(i,2)+kasea(i,j)
            total(i,2)=total(i,2)+after(i,j)
            totmil(i,2)=totmil(i,2)+aftmil(i,j)
495      continue
500   continue
      do 520 i=1,14
         do 510 j=1,14
            do 505 k=1,5
```

```
              tbreak(1,i,j)=tbreak(1,i,j)+pbreak(k,i,j)
              if(k.gt.3) goto 505
              tbreak(2,i,j)=tbreak(2,i,j)+abreak(k,i,j)
505         continue
510       continue
520     continue
c
c   loop 750 compute the average of cost and miles.
c
        do 750 i=1,14
          do 745 j=1,2
              if (kaset(i,j).eq.0) goto 745
              total(i,j)=total(i,j)/kaset(i,j)
              totmil(i,j)=totmil(i,j)/kaset(i,j)
745       continue
750     continue
        if(iockl.eq.2) goto 9980
c
c   generate SUMMARY REPORT TABLE
c
        write(*,600) mssgel(codel)
600     format('1',36x,'Cost Effectiveness of Park and Ride Lots'/
       +47x,'Summary Report Table'//
       +49x,a18/63x,'difference between avg'/
       +17x,'avg previous mode trip  avg park & ride trip  previous mo',
       +'de trip and'/
       +65x,'  avg p&r trip      pmd   pmd/p&r'/
       +20x,'trip   trip   cost |  trip   trip   cost |',21x,
       +'|cost/   cost    lot   n of'/
       +20x,'cost   miles  per  |  cost   miles  per  |  trip',
       +3x,'trip  cost/ | p&r    per   util  cases'/
       +21x,'($)',10x,'mile |',3x,'($)',10x,'mile |',2x,'cost   miles  ',
       +'mile | cost   mile     (%)'/39x,'|',21x,'|',21x,'|')
        write(*,604)
604     format('+',16x,'---------------------------------------------------',
       +'--------------------------------------------')
608     format('+',16x,'===================================================',
       +'============================================')
        do 800 i=1,14
        if (kaset(i,1).eq.0.or.kaset(i,2).eq.0) goto 780
          diff1=total(i,1)-total(i,2)
          diff2=totmil(i,1)-totmil(i,2)
          diff3=total(i,1)/totmil(i,1)-total(i,2)/totmil(i,2)
          diff4=total(i,1)/total(i,2)
          diff5=total(i,1)*totmil(i,2)/(totmil(i,1)*total(i,2))
        if(i.eq.7.or.i.eq.13) write(*,652)
        if(i.eq.7.or.i.eq.13) write(*,604)
652     format(39x,'|',21x,'|',21x,'|')
650     format(' ')
        write(*,700) city(i),(total(i,j),totmil(i,j),
       +total(i,j)/totmil(i,j),j=1,2),diff1,diff2,diff3,diff4,diff5,
       +utauto(i)/stall(i)*100.,kaset(i,1)
700     format(1x,a16,f7.2,f7.1,f7.2,' |',f6.2,1x,f6.1,f7.2,' |',f6.2,1x
```

```
     +,2x,f4.1,2x,f5.2,' |',1x,f4.2,4x,f4.2,3x,f4.1,3x,i3)
      if(i.eq.7.or.i.eq.13) write(*,652)
      if(i.eq.7) write(*,604)
      if(i.eq.13) write(*,608)
      goto 800
780   write(*,78) city(i)
 78   format(1x,a16,1x,'----there are no cases for this lot----')
800   continue
      write(*,820) mssge2(code2),mssge3(code3),mssge4(code4),comment
820   format('0','note : ',a25/8x,a25/8x,a51//1x,'comment : ',a100)
      write(*,830)
830   format('1')
c
c  loop 900 computes average cost and miles for each trip type
c  (both previous and p&r mode)
c
9980  do 900 i=1,14
         do 895 j=1,5
            if(kasep(i,j).eq.0) then
               pre(i,j)=999999.99
               premil(i,j)=999999.99
               goto 850
            endif
            pre(i,j)=pre(i,j)/kasep(i,j)
            premil(i,j)=premil(i,j)/kasep(i,j)
850         if(j.eq.5) goto 895
            if(kasea(i,j).eq.0) then
               after(i,j)=999999.99
               aftmil(i,j)=999999.99
               goto 895
            endif
            after(i,j)=after(i,j)/kasea(i,j)
            aftmil(i,j)=aftmil(i,j)/kasea(i,j)
895      continue
900   continue
      if(iockl.eq.2) goto 9990
c
c  generate PARK & RIDE TRIP Characteristics
c
      write(*,901) mssgel(codel)
901   format(43x,'Average PARK & RIDE TRIP Characteristics'//
     +        55x,a18//
     +        22x,'transit from p&r lot',8x,'carpool from p&r lot',
     +        8x,'vanpool from p&r lot       combined avg p&r trip'//
     +    20x,'trip  trip  cost  n  % of | trip  trip  cost  n  % of |',
     +        1x,'trip  trip  cost  n  % of | trip  trip  cost total'/
     +     20x,'cost miles  per       all  | cost miles  per       all  |'
     +        ,2x,'cost miles  per       all |  cost miles  per    n'/
     +        21x,'($)',8x,'mile    trips |  ($)',8x,'mile    trips |',
     +        2x,'($)',8x,'mile    trips |  ($)',8x,'mile')
      write(*,612)
612   format(46x,'|',27x,'|',27x,'|')
      write(*,614)
```

```
614     format('+',18x,'--------------------------------------------',
     +'-------------------------------------------------------')
      do 910 i=1,14
        if(i.eq.7.or.i.eq.13) write(*,612)
       if(i.eq.7.or.i.eq.13) write(*,614)
        if(kaset(i,2).eq.0.or.kaset(i,1).eq.0) goto 908
        rkase=kaset(i,2)*.01
        if(kasea(i,1).eq.0) then
          ravg1=999999.99
        else
             ravg1=after(i,1)/aftmil(i,1)
        endif
        if(kasea(i,2).eq.0) then
          ravg2=999999.99
        else
          ravg2=after(i,2)/aftmil(i,2)
        endif
        if(kasea(i,3).eq.0) then
          ravg3=999999.99
        else
          ravg3=after(i,3)/aftmil(i,3)
        endif
      write(*,905) city(i),after(i,1),aftmil(i,1),ravg1,kasea(i,1),
     +kasea(i,1)/rkase,after(i,2),aftmil(i,2),ravg2,kasea(i,2),
     +kasea(i,2)/rkase,after(i,3),aftmil(i,3),ravg3,kasea(i,3),
     +kasea(i,3)/rkase,
     +total(i,2),totmil(i,2),total(i,2)/totmil(i,2),kaset(i,2)
905   format(1x,a16,1x,f5.2,2x,f4.1,1x,f5.2,1x,i3,1x,f5.1,' |',
     +f5.2,2x,f4.1,1x,f5.2,1x,i2,1x,f5.1,' |',
     +f5.2,2x,f4.1,1x,f5.2,1x,i2,1x,f5.1,' |',
     +f5.2,2x,f4.1,1x,f5.2,1x,i3)
        if(i.eq.7.or.i.eq.13) write(*,612)
        if(i.eq.7) write(*,614)
      if(i.eq.13) write(*,618)
618   format('+',18x,'============================================',
     +'=======================================================')
        goto 910
908     write(*,78) city(i)
910   continue
      write(*,820) mssge2(code2),mssge3(code3),mssge4(code4),comment
      write(*,980) mssge1(code1)
c
c  generate PREVIOUS MODE TRIP Characteristics
c
980   format('1',44x,'Average PREVIOUS MODE TRIP Characteristics'//
     +       55x,a18//
     +    29x,'----- walk to transit -----    ---- drive to transit',
     +       ' -----     ------- drive alone -------'//
     +       29x,'trip  trip   cost   n  % of |  trip  trip   cost  ',
     +       'n   % of |  trip  trip   cost  n  % of'/
     +       29x,'cost  miles  per        all |  cost  miles  per',
     +       7x,'all   |  cost  miles  per        all'/
     +       29x,'($)',10x,'mile      trips |  ($)',10x,'mile     ',
```

```
     +        'trips |  ($)',10x,'mile     trips')
      write(*,622)
622   format(57x,'| ',29x,'|')
      write(*,626)
626   format(29x,'------------------------------------------------',
     +'---------------------------------------------')
      do 930 i=1,14
         if(i.eq.7.or.i.eq.13) write(*,626)
         if(kaset(i,1).eq.0) goto 928
         rkase=kaset(i,1)*.01
        if(kasep(i,1).eq.0) then
          ravg1=999999.99
        else
             ravg1=pre(i,1)/premil(i,1)
        endif
        if(kasep(i,2).eq.0) then
          ravg2=999999.99
        else
          ravg2=pre(i,2)/premil(i,2)
        endif
        if(kasep(i,3).eq.0) then
          ravg3=999999.99
        else
          ravg3=pre(i,3)/premil(i,3)
        endif
      write(*,935) city(i),pre(i,1),premil(i,1),ravg1,kasep(i,1),
     +kasep(i,1)/rkase,pre(i,2),premil(i,2),ravg2,kasep(i,2),
     +kasep(i,2)/rkase,pre(i,3),premil(i,3),ravg3,kasep(i,3),
     +kasep(i,3)/rkase
935   format(10x,a16,2x,f5.2,2x,f4.1,2x,f5.2,1x,i3,1x,f5.1,' | ',
     +f5.2,2x,f4.1,2x,f5.2,1x,i3,1x,f5.1,' |',
     +f5.2,2x,f4.1,2x,f5.2,1x,i3,1x,f5.1,2x)
        if(i.eq.7) write(*,626)
      if(i.eq.13) write(*,632)
632   format(29x,'================================================',
     +'=============================================')
        goto 930
928     write(*,78) city(i)
930   continue
      write(*,820) mssge2(code2),mssge3(code3),mssge4(code4),comment
      write(*,986) mssge1(code1)
986   format('1',44x,'Average PREVIOUS MODE TRIP Characteristics'/
     +        59x,'continued'//
     +        55x,a18//
     +        98x,'combined average'/
     +        32x,'---------- vanpool ----------    ---------- carpool',
     +        ' ----------      -- previous mode trip --'//
     +        32x,'trip  trip   cost    n  % of |  trip  trip   cost  ',
     +        'n   % of |  trip  trip   cost  total'/
     +        32x,'cost  miles  per          all |  cost  miles  per',
     +        7x,'all  |  cost  miles  per     n'/
     +        32x,'($)',10x,'mile     trips |  ($)',10x,'mile     ',
     +        'trips |  ($)',10x,'mile')
```

```
      write(*,633)
633   format(60x,'| ',29x,'| ')
      write(*,636)
636   format(31x,'---------------------------------------------',
     +'------------------------------------')
      do 940 i=1,14
         if(i.eq.7.or.i.eq.13) write(*,636)
         if(kaset(i,1).eq.0) goto 938
         rkase=kaset(i,1)*.01
        if(kasep(i,4).eq.0) then
          ravg1=999999.99
        else
             ravg1=pre(i,4)/premil(i,4)
        endif
        if(kasep(i,5).eq.0) then
          ravg2=999999.99
        else
          ravg2=pre(i,5)/premil(i,5)
        endif
      write(*,945) city(i),pre(i,4),premil(i,4),ravg1,kasep(i,4),
     +kasep(i,4)/rkase,pre(i,5),premil(i,5),ravg2,kasep(i,5),
     +kasep(i,5)/rkase,total(i,1),totmil(i,1),
     +total(i,1)/totmil(i,1),kaset(i,1)
945   format(14x,a16,1x,f5.2,2x,f4.1,2x,f5.2,1x,i3,1x,f5.1,' | ',
     +f5.2,2x,f4.1,2x,f5.2,1x,i3,1x,f5.1,' | ',
     +f5.2,2x,f4.1,2x,f5.2,3x,i3)
        if(i.eq.7) write(*,636)
        if(i.eq.13) write(*,632)
        goto 940
938     write(*,78) city(i)
940   continue
      write(*,820) mssge2(code2),mssge3(code3),mssge4(code4),comment
      write(*,830)
c
c  loop 770 computes average cost break down
c
9990  do 770 i=1,5
         do 768 j=1,14
            do 766 k=1,14
               if(kasep(j,i).eq.0) goto 764
               pbreak(i,j,k)=pbreak(i,j,k)/kasep(j,i)
764             if (i.gt.3) goto 766
                if(kasea(j,i).eq.0) goto 762
                abreak(i,j,k)=abreak(i,j,k)/kasea(j,i)
762             if(i.gt.2) goto 766
                if(kaset(j,i).eq.0) goto 766
                tbreak(i,j,k)=tbreak(i,j,k)/kaset(j,i)
766         continue
768       continue
770     continue
       if(iock2.eq.2) goto 9992
c
c  generate tables of TRIP COST BREAKDOWNS
```

```
c
      do 860 i=1,5
         write(*,865) title(1),titl1(i)
 865     format(52x,'Average Trip Cost Breakdowns'//
     +          59x,a17/
     +          58x,a16/
     +          21x,'------ Time ------   ----- Public -----   ',
     +          '--------- Auto ----------  -Park-  -Bus-',
     +          '  Total  Trip  Total  Trip   n '/
     +          105x,'Trip  Miles  Cost  Time  of'/
     +    21x,'In    Out of',36x,'Own $',31x,'Cost',9x,'Per   (min)'/
     +          21x,'Veh    Veh   Total   Road  Other  Total   fuel',
     +    '  Oper  Accdnt  Total  Total  Total',16x,'Mile    cases')
      write(*,853)
 853  format(18x,'-----------------------------------------------------',
     +'-----------------------------------------------------------',
 841  format(18x,'=====================================================')
     +'===========================================================',
     +'===========================================================')
        do 855 j=1,14
           if(j.eq.7.or.j.eq.13) write(*,853)
           if(kasep(j,i).eq.0) goto 858
           if(premil(j,i).eq.0.) then
              rratio=999999.999
           else
              rratio=pre(j,i)/premil(j,i)
           endif
      write(*,866) city(j), (pbreak(i,j,k),k=1,13),premil(j,i),
     +                 rratio,pbreak(i,j,14),kasep(j,i)
 866  format(1x,a16,1x,3f7.2,' |',f5.2,2f7.2,' |',f5.2,3f7.2,
     +' |',f5.2,'| ',f5.2,f7.2,f6.1,f6.2,f7.0,i5)
           if(pbreak(i,j,13).eq.0.) pbreak(i,j,13)=99999999.
      write(*,861) (pbreak(i,j,k)/pbreak(i,j,13)*100.,k=1,12)
 861  format(18x,'%',f6.2,2f7.2,' |',f5.1,2f7.2,' |',f5.1,3f7.2,
     +' |',f5.1,'| ',f5.1)
           if(j.eq.7) write(*,853)
           if(j.eq.13)write(*,841)
           goto 855
 858       write(*,78) city(j)
           if(j.eq.13) write(*,841)
 855    continue
      write(*,863) comment
 863  format(//1x,'comment : ',a100)
      write(*,830)
 860  continue
      do 880 i=1,3
         write(*,865) title(2),titl2(i)
         write(*,853)
         do 874 j=1,14
            if(j.eq.7.or.j.eq.13) write(*,853)
            if(kasea(j,i).eq.0) goto 876
            if(aftmil(j,i).eq.0.) then
              rratio=999999.999
            else
```

```
               rratio=after(j,i)/aftmil(j,i)
            endif
      write(*,866)city(j),(abreak(i,j,k),k=1,13),aftmil(j,i),
     +                  rratio,abreak(i,j,14),kasea(j,i)
            if(abreak(i,j,13).eq.0.) abreak(i,j,13)=99999999.
      write(*,861) (abreak(i,j,k)/abreak(i,j,13)*100.,k=1,12)
            if(j.eq.7) write(*,853)
            if(j.eq.13) write(*,841)
            goto 874
876         write(*,78) city(j)
      if(j.eq.13) write(*,841)
874      continue
      write(*,863) comment
      write(*,830)
880   continue
9992  if(iock3.eq.2) goto 9999
c
c  generate combined comparision tables
c
       do 140 i=1,2
          write(*,865) title(3),titl3(i)
          write(*,853)
         do 120 j=1,14
            if(j.eq.7.or.j.eq.13) write(*,853)
            if(kaset(j,i).eq.0) goto 122
            if(totmil(j,i).eq.0.) then
               rratio=999999.999
            else
               rratio=total(j,i)/totmil(j,i)
            endif
      write(*,866)city(j),(tbreak(i,j,k),k=1,13),totmil(j,i),
     +                  rratio,tbreak(i,j,14),kaset(j,i)
            if(tbreak(i,j,13).eq.0.) tbreak(i,j,13)=99999999.
      write(*,861) (tbreak(i,j,k)/tbreak(i,j,13)*100.,k=1,12)
            if(j.eq.7) write(*,853)
            if(j.eq.13) write(*,841)
            goto 120
122         write(*,78) city(j)
            if(j.eq.13) write(*,841)
120      continue
      write(*,863) comment
      write(*,830)
140   continue
          write(*,865) title(4),titl4
         do 160 j=1,14
            if(j.eq.7.or.j.eq.13) write(*,650)
            if(j.eq.7.or.j.eq.13) write(*,853)
            if(kaset(j,1).eq.0.or.kaset(j,2).eq.0) goto 155
            if(totmil(j,2).eq.0.) then
               rratio=999999.999
            else
               rratio=total(j,1)*totmil(j,2)/(totmil(j,1)*total(j,2))
            endif
```

```
            rkas1=kaset(j,1)
            rkas2=kaset(j,2)
            ratio=rkas1/rkas2
      do 881 k=1,14
         if(tbreak(1,j,k).eq.0.or.tbreak(2,j,k).eq.0) then
            tbreak(1,j,k)=99999999.
            tbreak(2,j,k)=1.
         endif
881   continue
      write(*,867) city(j),(tbreak(1,j,k)/tbreak(2,j,k),k=1,13),
     +totmil(j,1)/totmil(j,2),rratio,tbreak(1,j,14)/tbreak(2,j,14),ratio
867   format(1x,a16,1x,3f7.2,' |',f5.1,2f7.2,' |',f5.1,3f7.2,
     +' |',f5.1,'| ',f5.1,f7.2,2f6.2,f6.2,f6.2)
            if(j.eq.7) write(*,853)
            if(j.eq.13) write(*,841)
            if(j.eq.7.or.j.eq.13) write(*,650)
            goto 160
155         write(*,78) city(j)
160      continue
      write(*,863) comment
      write(*,830)
9999  rewind 4
      rewind 5
c
c  reinitialize arrays to zero
c
      do 899 i=1,14
         utauto(i)=0.
         stall(i)=0.
        do 898 j=1,5
           pre(i,j)=0.
           premil(i,j)=0.
           kasep(i,j)=0
           if(j.eq.5) goto 898
           after(i,j)=0.
           aftmil(i,j)=0.
           kasea(i,j)=0
           if(j.gt.2) goto 898
           total(i,j)=0.
           totmil(i,j)=0.
           kaset(i,j)=0
898    continue
899   continue
      do 999 i=1,5
         do 997 j=1,14
            do 995 k=1,14
               pbreak(i,j,k)=0.
               if(i.gt.3) goto 995
               abreak(i,j,k)=0.
               if(i.gt.2) goto 995
               tbreak(i,j,k)=0.
995         continue
997      continue
```

```
999     continue
1400   continue
        if(icode1.eq.3) then
         i41=isav3
         i42=is42
       endif
1300   continue
        if(icode1.eq.3) then
          i31=isav2
          i32=is32
       endif
1200   continue
        if(icode1.eq.2) then
          i21=isav1
          i22=is22
        endif
1100   continue
       stop
       end


       subroutine auto(cost,mile,time1,time2,time,pub1,pub2,pub,auto1,
     +                auto2,auto3,pauto,park,bus,ac,*)
       real lymn,lotcost,lhov,lr,lus,lc,ld,lc2
       integer prnum,pmd,mtpr,mfpr,vetp,veyr,cvetp,cveyr,oct,otaz,dtaz
       integer code1,code2,code3,code4
       real mile,mtor,mtol,mtod,l1
       dimension rmtor(6),rmtol(6),rmtod(6),rgr(6),rgl(6),rgd(6)
       common /sub/ lr,lus,lc,ld,vetp,pmd,avginc,lhtp,att,runtime,wait,
     +            walk1,mfpr,aocc,plrs,plrn,prmile,lotcost,autos,stalls
     +            ,cvetp,prbmin,rvmn,lymn,ddmn,brvmn,bphr,optp1,
     +            p,optp2,bus11,bus14,bus16,bus20,plc,lhov,plus,busocc,
     +            otaz,prnum
       common /various/code1,code2,code3,code4,pclc1,pclc3,pclus1,pclus3,
     +              pclus4,sc1,sc3,sus1,sus3,sus4,pchov,spl1,tv,tw,rpcr
       common /autocom/ rmtor,rmtol,rmtod,rgr,rgl,rgd,pgr,pmtor,
     +                 sr,sd,rpcd,rar,ral,rad
       pcr=rpcr
       pcd=rpcd
       ar=rar
       ad=rad
       al=ral
       if (pmd.eq.3) then
           dcp=0.0
       elseif (pmd.eq.4.or.pmd.eq.5) then
           dcp=.187
       endif
       mile=lr+lus+lc+ld
       l1=lus+lc
       v=avginc/(2085.0*tv)
       vw=avginc/(2085.0*tw)
       if(code2.eq.2) then
           v=0.
```

```
     vw=0.
 endif
 if (lhtp.eq.1.or.lhtp.eq.2) then
     pclc=pclc1+pcr
     sc=sc1
     pclus=pclus1+pcr
     sus=sus1
 elseif (lhtp.eq.3) then
     pclc=pclc3+pcr
     sc=sc3
     pclus=pclus3+pcr
     sus=sus3
 elseif (lhtp.eq.4) then
     pclc=pclc3+pcr
     sc=sc3
     pclus=pclus4+pcr
     sus=sus4
 endif
 if (vetp.eq.7.or.vetp.eq.0) vetp=3
 mtor=rmtor(vetp)
 mtol=rmtol(vetp)
 mtod=rmtod(vetp)
 gr=rgr(vetp)
 gl=rgl(vetp)
 gd=rgd(vetp)
 if (pmd.eq.3) then
     occ=1.0
 elseif (pmd.eq.4.or.pmd.eq.5) then
     occ=2.24
 endif
 if (pmd.eq.3) pkcost=p
 if (pmd.eq.4) pkcost=.28
 if (pmd.eq.5) pkcost=.86
 if(codel.eq.2) then
    mtor=0.
    mtol=0.
    mtod=0.
    gr=0.
    gl=0.
    gd=0.
    ar=0.
    al=0.
    ad=0.
    pkcost=0.
 endif
 if (lr.gt.5.0) then
     arfcr=6.0/lr+1.0
     arfcl=1.0
     arfcd=1.0
 else
     arfcr=3.4-.24*lr
        if ((lr+ll).gt.5.0) then
           arfcl=(.24*lr**2-2.4*lr+6.0)/ll+1.0
```

```
              arfcd=1.0
           else
             arfcl=3.4-.24*(lr+ll)
               if ((lr+ll+ld).gt.5.0) then
                  arfcd=(.24*(lr+ll)**2-2.4*(lr+ll)+6.0)/ld+1.0
               else
                  arfcd=3.4-.24*(lr+ll+ld)
               endif
           endif
      endif
      lc2=lc-lhov
      if(lc2.lt.0.) lc2=0.
      if(pmd.eq.4.or.pmd.eq.5) pclc=(pclc*lc2+pchov*lhov)/lc
      if(code3.eq.2) then
         pcr=0.
         pclus=0.
         pclc=0.
         pcd=0.
      endif
      acr=(dcp+lr/sr)*v*occ+(pcr+mtor+ar+(gr*arfcr))*lr
      acl=(lus/sus+lc/sc)*v*occ+(mtol+al+(gl*arfcl))*ll+pclus*lus
     c+pclc*lc
      acd=((ld/sd)*v+(att/60.0)*vw)*occ+(pcr+pcd+mtod+ad+gd*arfcd)*ld+
     cpkcost/2.0
      ac=(acr+acl+acd)/occ
      cost=ac
      time1=(dcp+lr/sr+lus/sus+lc/sc+ld/sd)*v
      time2=(att/60.)*vw
      time=time1+time2
      pub1=((pclus-pcr)*lus+(pclc-pcr)*lc+pcd*ld)/occ
      pub2=(pcr*mile)/occ
      pub=pub1+pub2
      auto1=(gr*arfcr*lr+gl*arfcl*ll+gd*arfcd*ld)/occ
      auto2=(mtor*lr+mtol*ll+mtod*ld)/occ
      auto3=(ar*lr+al*ll+ad*ld)/occ
      pauto=auto1+auto2+auto3
      park=pkcost/(2.*occ)
      bus=0.
      ac=time+pub+pauto+park
      return 1
      return
      end


      subroutine prbus(cost2,mile2,kode,plr,time1,time2,time,pub1,pub2,
     +                 pub,auto1,auto2,auto3,aauto,park,bus,prbusc,*)
      real lymn,lotcost,lhov,lr,lus,lc,ld,mile2
      integer prnum,pmd,mtpr,mfpr,vetp,veyr,cvetp,cveyr,oct,otaz,dtaz
      integer code1,code2,code3,code4,optp,bustp,prfrq
      real kr,kl,kd,mtor,mtol
      dimension rmtor(6),rmtol(6),rmtod(6),rgr(6),rgl(6),rgd(6)
      common /sub/ lr,lus,lc,ld,vetp,pmd,avginc,lhtp,att,runtime,wait,
```

```
+             walkl,mfpr,aocc,plrs,plrn,prmile,lotcost,autos,stalls
+             ,cvetp,prbmin,rvmn,lymn,ddmn,brvmn,bphr,optpl,
+             p,optp2,busl1,busl4,busl6,bus20,plc,lhov,plus,busocc,
+             otaz,prnum
 common /various/code1,code2,code3,code4,pclc1,pclc3,pclus1,pclus3,
+               pclus4,sc1,sc3,sus1,sus3,sus4,pchov,spl1,tv,tw,rpcr
 common /autocom/ rmtor,rmtol,rmtod,rgr,rgl,rgd,pgr,pmtor,
+                 sr,sd,rpcd,rar,ral,rad
 data fare1,fare2,fare3/.49,.73,.86/
 data scale/.837/
 data vchft,vchpt,vchart/20.87,11.29,.5/
 data vcml1,vcml4,vcml6,vcm20/.74,.77,.66,1.1/
 data kd,kr/2.99,.188/
 data fcm,fcb,ccb,ttt/.09,70.42,61.72,2.0/
 data prbtpw,pldn,plds,sch,scm/.1667,.7,1.1,3.13,.11/
 pcr=rpcr
 pcd=rpcd
 ar=rar
 al=ral
 ad=rad
 prmil=prmile
 if(prnum.eq.5.or.prnum.eq.6) then
    fare=fare3
 elseif (prnum.le.3) then
    fare=fare1
 else
    fare=fare2
 endif
 if(prnum.le.6) then
    pld=pldn
 else
    pld=plds
 endif
 if(kode.eq.2) prmil=prmile-0.5
 if(code1.eq.1) fare=0.
 v=avginc/(2085.0*tv)
 vw=avginc/(2085.0*tw)
 if(code2.eq.1) then
   v=0.
   vw=0.
 endif
 dcp2=(aocc-1.)*.0833
 if(dcp2.lt.0.) dcp2=0.
 if (plrs.eq.0.0) then
     plr=scale*plrn
 else
     plr=plrs
 endif
 if(plr.eq.0.) plr=0.5
 if(plr.gt.lr) then
   plrr=lr
   plrl=plr-lr
 else
```

```
  plrr=plr
  plrl=0.
endif
mile2=plr+prmil+pld
if (plrr.gt.5.0) then
   arfcr=6.0/plrr+1.0
   arfcl=1.0
else
   arfcr=3.4-.24*lr
   if((plrr+plrl).gt.5.0) then
       arfcl=(.24*plrr**2-2.4*plrr+6.0)/plrl+1.0
   else
       arfcl=3.4-.24*(plrr+plrl)
   endif
endif
if (code4.eq.1) then
    prpk=lotcost/autos
elseif (code4.eq.2) then
    prpk=lotcost/stalls
elseif (code4.eq.3) then
    prpk=0.0
endif
if (lhtp.eq.1.or.lhtp.eq.2) then
    pclc=pclc1+pcr
    pclus=pclus1+pcr
    sus=sus1
elseif (lhtp.eq.3) then
    pclc=pclc3+pcr
    sc=sc3
    pclus=pclus3+pcr
    sus=sus3
elseif (lhtp.eq.4) then
    pclc=pclc3+pcr
    pclus=pclus4+pcr
    sus=sus4
endif
prbtime=((prbmin/rvmn)*(rvmn+lymn+ddmn))/60.
prbmile=prmil*(1.0+ddmn/rvmn)
pll=prmil-pld
pllmile=pll/prmil*prbmile
pldmile=pld/prmil*prbmile
if (bphr.gt.4.0) then
    perblk=prbtime/(brvmn/60.0)
else
    perblk=0.5*prbtime/(brvmn/60.0)
endif
if (vetp.eq.7.or.vetp.eq.0) vetp=3
mtor=rmtor(vetp)
gr=rgr(vetp)
mtol=rmtol(vetp)
gl=rgl(vetp)
if(code1.eq.2) then
   mtor=0
```

```
    ar=0.
    gr=0.
    mtol=0.
    al=0.
    gl=0.
    fare=-fare
 endif
 adj=kr-pcr
 vch= (optp1*vchft+optp2*vchpt+(bus14+bus20)*vchart)/100.0
 vcm=((bus11*vcm11+bus14*vcm14+bus16*vcm16+bus20*vcm20))/100.0
 plc2=plc-lhov
 kl=(2.49/pllmile)*((pclc+adj)*plc2+(pclus+adj)*plus+
+(pchov+adj)*lhov)
 if(code3.eq.2) then
    pcr=0.
    pclus=0.
    kl=0.
    kd=0.
 endif
 if(code1.eq.3) then
     vch=0.
     sch=0.
     vcm=0.
     scm=0.
     fcm=0.
     fcb=0.
     ccb=0.
 endif
 gr=pgr*gr
 mtor=pmtor*mtor
 gl=pgr*gl
 mtol=pmtor*mtol
 prcr=(dcp2+plrr/sr+plrl/sus)*v+(pcr+mtor+ar+(gr*arfcr))*plrr/aocc
++(pclus+mtol+al+(gl*arfcl))*plrl/aocc+0.5*(prpk/aocc)
 prcbus=prbtpw*vw+prbtime*(vch+sch)/busocc+prbmin/60.0*v
c+pllmile*kl/busocc+pldmile*(kr+kd)/busocc
c+prbmile*(vcm+scm+fcm)/busocc+perblk*(fcb+ccb)/busocc
c+ttt/60.0*vw
 prbusc=prcr+prcbus+fare
 cost2=prbusc
 if (kode.eq.2) cost2=prbusc-.5*prpk/aocc
 time1=(dcp2+plrr/sr+plrl/sus+prbmin/60.)*v
 time2=(prbtpw+ttt/60.)*vw
 time=time1+time2
 pub1=(kl-kr)*pllmile/busocc+kd*pldmile/busocc+pclus*plrl/aocc
 pub2=pcr*(plr/aocc)+((pllmile+pldmile)/busocc)*kr
 pub=pub1+pub2
 auto1=gr*arfcr*plrr/aocc+gl*arfcl*plrl/aocc
 auto2=mtor*plrr/aocc+mtol*plrl/aocc
 auto3=ar*plrr/aocc+al*plrl/aocc
 aauto=auto1+auto2+auto3
 park=.5*prpk/aocc
 if(kode.eq.2) park=0.
```

```
 bus=(prbtime*(vch+sch)+prbmile*(vcm+scm+fcm)
++perblk*(fcb+ccb))/busocc+fare
 prbusc=time+pub+aauto+park+bus
 return 1
 return
 end


 subroutine walkbus(cost1,mile1,time1,time2,time,pub1,pub2,pub,
+                   auto1,auto2,auto3,pauto,park,bus,tc,*)
 real lymn,lotcost,lhov,lr,lus,lc,ld
 integer prnum,pmd,mtpr,mfpr,vetp,veyr,cvetp,cveyr,oct,otaz,dtaz
 integer code1,code2,code3,code4
 real l1,l,mile1,kr,kl,kd
 common /sub/ lr,lus,lc,ld,vetp,pmd,avginc,lhtp,att,runtime,wait,
+            walk1,mfpr,aocc,plrs,plrn,prmile,lotcost,autos,stalls
+            ,cvetp,prbmin,rrrr,xxxx,yyyy,zzzzz,bphr,optp1,
+            p,optp2,bus11,bus14,bus16,bus20,plc,lhov,plus,bbbbbb,
+            otaz,prnum
 common /various/code1,code2,code3,code4,pclc1,pclc3,pclus1,pclus3,
+              pclus4,sc1,sc3,sus1,sus3,sus4,pchov,spl1,tv,tw,rpcr
 data fare1,fare2,fare3/.49,.73,.86/
 data vcm,scm,fcm/.83,.11,.09/
 data fcb,ccb,brvmn,busocc/70.42,61.72,145.0,32.4/
 data rvmn,lymn,ddmn,vch,sch/53.0,6.0,36.0,18.73,3.09/
 data ttt,kd,kr/2.0,2.99,.188/
 pcr=rpcr
 if(otaz.ge.180.and.otaz.le.237) then
    fare=fare1
 elseif(otaz.ge.248) then
    fare=fare3
 else
    fare=fare2
 endif
 if(code1.eq.1) fare=0.
 if(code1.eq.2) fare=-fare
 tb=(runtime/brvmn)*(fcb+ccb)
 mile1=lr+lus+lc+ld
 v=avginc/(2085.0*tv)
 vw=avginc/(2085.0*tw)
 if (lhtp.eq.1.or.lhtp.eq.2) then
    pclc=pclc1
    pclus=pclus1
 elseif (lhtp.eq.3) then
    pclc=pclc3
    pclus=pclus3
 elseif (lhtp.eq.4) then
    pclc=pclc3
    pclus=pclus4
 endif
 if (runtime/rvmn.le.1.0) then
     bustime=runtime+(runtime/rvmn)*(lymn+ddmn)
 else
```

```
     bustime=runtime+lymn+(runtime/rvmn)*ddmn
endif
lc2=lc-lhov
kl=2.49*(pchov*lhov+pclc*lc2+pclus*lus)/(lus+lc)
if (code3.eq.2) then
     kr=0.
     kl=0.
     kd=0.
endif
if (code2.eq.2) then
     v=0.
     vw=0.
endif
pct=kl*(lus+lc)+kd*ld+kr*mile1
utc=((walk1+wait+ttt)/60.)*vw+(runtime/60.)*v
l=lr+lus+lc+ld
tm=l*(1.0+ddmn/rvmn)*(vcm+scm+fcm)
trt=(bustime/60.0)*(vch+sch)
if(code1.eq.3) then
   trt=0.
   tm=0.
   tb=0.
endif
ttc=utc+(trt+tm+tb+pct)/busocc+fare
cost1=ttc
time1=(runtime/60.)*v
time2=((walk1+wait+ttt)/60.)*vw
time=time1+time2
pub1=(kl*(lus+lc)+kd*ld)/busocc
pub2=kr*mile1/busocc
pub=pub1+pub2
bus=(trt+tm+tb)/busocc+fare
tc=time+pub+bus
auto1=0.
auto2=0.
auto3=0.
pauto=0.
park=0.
return 1
return
end


subroutine prauto(cost2,mile2,plr,time1,time2,time,pub1,pub2,pub,
+                 auto1,auto2,auto3,aauto,park,bus,prautc,*)
real mtol,mtor,mtod,mtorl
real lymn,lotcost,lhov,lr,lus,lc,ld,mile2
integer prnum,pmd,mtpr,mfpr,vetp,veyr,cvetp,cveyr,oct,otaz,dtaz
integer code1,code2,code3,code4
dimension rmtor(6),rmtol(6),rmtod(6),rgr(6),rgl(6),rgd(6)
common /sub/ lr,lus,lc,ld,vetp,pmd,avginc,lhtp,att,runtime,wait,
+            walk1,mfpr,aocc,plrs,plrn,prmile,lotcost,autos,stalls
+            ,cvetp,prbmin,rvmn,lymn,ddmn,brvmn,bphr,optpl,
```

```
+              p,optp2,bus11,bus14,bus16,bus20,plc,lhov,plus,busocc,
+              otaz,prnum
 common /various/code1,code2,code3,code4,pclc1,pclc3,pclus1,pclus3,
+                 pclus4,sc1,sc3,sus1,sus3,sus4,pchov,spl1,tv,tw,rpcr
 common /autocom/ rmtor,rmtol,rmtod,rgr,rgl,rgd,pgr,pmtor,
+                    sr,sd,rpcd,rar,ral,rad
 data scale/.837/
 data pldn,plds/.7,1.1/
 pcr=rpcr
 pcd=rpcd
 ar=rar
 al=ral
 ad=rad
 if (cocc.eq.0) cocc=5.3
 dcp2=(aocc-1)*.0833
 if(dcp2.lt.0.) dcp2=0.
 if (plrs.eq.0) then
     plr=scale*plrn
 else
      plr=plrs
 endif
 if(plr.eq.0.) plr=0.5
 if(plr.gt.lr) then
   plrr=lr
   plrl=plr-lr
 else
   plrr=plr
   plrl=0.
 endif
 if(prnum.le.6) then
    pld=pldn
 else
    pld=plds
 endif
 mile2=plr+prmile+pld
 v=avginc/(2085.0*tv)
 vw=avginc/(2085.0*tw)
 if(code2.eq.2) then
   v=0.
   vw=0.
 endif
 pratpw=5.0/60.0
 pl1=prmile-pld
 if (mfpr.eq.2) then
     p=0.7
 elseif (mfpr.eq.3) then
     p=.14
 endif
 if (mfpr.eq.3) cvetp=5
 if (mfpr.eq.2.and.cvetp.eq.0) cvetp=1
 if (cvetp.eq.7.or.cvetp.eq.0) cvetp=3
 if (vetp.eq.7.or.vetp.eq.0) vetp=3
 mtol=rmtol(cvetp)
```

```
 mtor=rmtor(vetp)
 mtorl=rmtol(vetp)
 mtod=rmtod(cvetp)
 gl=rgl(cvetp)
 gd=rgd(cvetp)
 gr=rgr(cvetp)
 if(code1.eq.2) then
    mtor=0.
    mtorl=0.
    mtol=0.
    mtod=0.
    gr=0.
    gl=0.
    gd=0.
    ar=0.
    al=0.
    ad=0.
    p=0.
endif
if (lhtp.eq.1.or.lhtp.eq.2) then
     pclc=pclc1+pcr
     pclus=pclus1+pcr
     sus=sus1
 elseif (lhtp.eq.3) then
     pclc=pclc3+pcr
     pclus=pclus3+pcr
     sus=sus3
elseif (lhtp.eq.4) then
      pclc=pclc3+pcr
     pclus=pclus4+pcr
     sus=sus4
endif
plc2=plc-lhov
if (plrr.gt.5.0) then
     arfcr=6.0/plrr+1.0
     arfcl=1.0
     arfcd=1.0
else
     arfcr=3.4-.24*plrr
        if ((plr+pll).gt.5.0) then
           arfcl=(.24*plr**2-2.4*plr+6.0)/pll+1.0
           arfcd=1.0
        else
          arfcl=3.4-.24*(plr+pll)
            if ((plr+pll+ld).gt.5.0) then
                arfcd=(.24*(plr+pll)**2-2.4*(plr+pll)+6.0)/ld+1.0
            else
               arfcd=3.4-.24*(plr+pll+ld)
            endif
        endif
endif
if (code4.eq.1) then
    prpk=lotcost/autos
```

```
 elseif (code4.eq.2) then
     prpk=lotcost/stalls
 elseif (code4.eq.3) then
     prpk=0.0
 endif
 prapcl=(pchov*lhov)+(pclc*plc2)+(pclus*plus)
 if(code3.eq.2) then
    pcr=0.
    prapcl=0.
    pcd=0.
    pclus=0.
 endif
 gr=gr*pgr
 mtor=mtor*pmtor
 gl=gl*pgr
 mtorl=mtorl*pmtor
 prcr=(dcp2+plrr/sr+plrl/sus)*v+(pcr+mtor+ar+gr*arfcr)*plrr/aocc
c+(pclus+mtorl+al+gl*arfcl)*plrl/aocc+.5*(prpk/aocc)
 prautc=pratpw*vw*cocc+(pll/spll)*v*cocc
c+(pcr+mtol+al+(gl*arfcl))*pll+prapcl
c+((ld/sd)*v+((att/60.0)*vw))*cocc
c+(pcr+pcd+mtod+ad+gd*arfcd)*ld+p/2.0
 pratrip=prautc/cocc+prcr
 cost2=pratrip
 time1=(dcp2+plrr/sr+plrl/sus+pll/spll+ld/sd)*v
 time2=(pratpw+att/60.)*vw
 time=time1+time2
 pub1=(prapcl+pcd*ld)/cocc+pclus*plrl/aocc
 pub2=pcr*plr/aocc+pcr*(prmile+ld)/cocc
 pub=pub1+pub2
 auto1=gr*arfcr*plrr/aocc+(gl*arfcl*pll+gd*arfcd*ld)/cocc
+       +(gl*arfcl*plrl)/aocc
 auto2=(mtor*plrr+mtorl*plrl)/aocc+(mtol*pll+mtod*ld)/cocc
 auto3=(ar*plrr+al*plrl)/aocc+(al*pll+ad*ld)/cocc
 aauto=auto1+auto2+auto3
 park=.5*prpk/aocc+.5*p/cocc
 bus=0.
 prautc=time+pub+aauto+park
 return 1
 return
 end
```

APPENDIX D

TRIP COST MODEL OUTPUT TABLES

APPENDIX D
TRIP COST MODEL OUTPUT TABLES

The following tables are a sample of the trip cost model output. This particular run included the following values for the primary parameters:

- Value of in-vehicle time = one-third the commuter's hourly wage rate.
- Value of out-of-vehicle time = 2.5 times that of in-vehicle time.
- "Peak period" highway costs.
- No congestion costs.
- AAA auto costs.

Summary Report Table

TOTAL Perspective

	avg previous mode trip			avg park & ride trip			difference between avg previous mode trip and avg p&r trip			pmd	pmd/p&r		
	trip cost ($)	trip miles	cost per mile	trip cost ($)	trip miles	cost per mile	trip cost	trip miles	cost/ mile	cost/ p&r cost	cost per mile	lot util (%)	n of cases
Green Lake	6.49	7.1	.91	5.67	7.2	.79	.81	-.1	.13	1.14	1.16	70.3	4
North Seattle	6.16	10.1	.61	6.31	11.0	.57	-.15	-.9	.04	.98	1.06	92.9	24
Northgate	7.11	11.4	.62	7.69	12.4	.62	-.58	-.9	.00	.92	1.00	96.5	121
Shoreline	8.55	14.7	.58	7.56	15.0	.50	.98	-.4	.08	1.13	1.16	66.1	41
Mt.Lake Terrace	7.82	15.5	.51	8.52	15.9	.54	-.71	-.4	-.03	.92	.94	44.2	19
Lynnwood	9.94	21.0	.47	8.86	21.4	.41	1.08	-.4	.06	1.12	1.14	89.1	123
N. Corridor	8.30	15.4	.54	8.03	16.1	.50	.27	-.6	.04	1.03	1.08	79.2	332
Wilburton	7.82	12.1	.65	10.31	12.6	.82	-2.50	-.5	-.17	.76	.79	46.3	4
S. Bellevue	9.91	12.5	.79	15.03	12.7	1.18	-5.12	-.2	-.39	.66	.67	13.5	4
Newport Hills	7.50	13.4	.56	13.07	13.5	.97	-5.57	-.1	-.41	.57	.58	21.1	7
Eastgate	9.23	12.4	.74	7.99	13.2	.60	1.24	-.8	.14	1.16	1.23	61.0	80
Issaquah	12.15	20.3	.60	10.51	21.2	.49	1.64	-.9	.10	1.16	1.21	66.8	40
S.E. Corridor	9.99	14.8	.67	9.28	15.6	.60	.71	-.8	.08	1.08	1.13	44.9	135
Total study area	8.79	15.3	.58	8.39	15.9	.53	.40	-.7	.05	1.05	1.09	64.1	467

note : time costs included
public costs included
cost of p&r lot parking based on actual utilization

comment : Total Public and Private Costs, 4-17-85
(this table consider higher accident rate for I-90)

Average PREVIOUS MODE TRIP Characteristics

TOTAL Perspective

	walk to transit					drive to transit					drive alone				
	trip cost ($)	trip miles	cost per mile	n	% of all trips	trip cost ($)	trip miles	cost per mile	n	% of all trips	trip cost ($)	trip miles	cost per mile	n	% of all trips
Green Lake	4.64	7.1	.66	2	50.0	*****	****	*****	0	.0	8.33	7.2	1.17	2	50.0
North Seattle	4.79	7.2	.67	5	20.8	6.23	10.8	.58	14	58.3	8.26	10.2	.81	3	12.5
Northgate	5.64	10.7	.53	50	41.3	7.05	12.8	.55	23	19.0	10.20	12.0	.85	35	28.9
Shoreline	6.03	12.8	.47	8	19.5	6.04	15.5	.39	12	29.3	11.64	14.6	.80	18	43.9
Mt.Lake Terrace	5.97	13.7	.44	2	10.5	6.22	15.1	.41	11	57.9	12.46	16.8	.74	5	26.3
Lynnwood	7.90	18.8	.42	17	13.8	7.79	20.7	.38	48	39.0	14.52	22.4	.65	41	33.3
N. Corridor	6.07	12.3	.49	84	25.3	7.08	16.6	.43	108	32.5	12.17	16.6	.73	104	31.3
Wilburton	*****	****	*****	0	.0	7.82	12.1	.65	4	100.0	*****	****	*****	0	.0
S. Bellevue	*****	****	*****	0	.0	8.16	15.9	.51	1	25.0	12.29	11.1	1.10	2	50.0
Newport Hills	7.62	14.8	.51	1	14.3	7.48	13.2	.57	6	85.7	*****	****	*****	0	.0
Eastgate	7.38	12.1	.61	19	23.8	7.11	12.8	.55	17	21.3	11.96	12.4	.97	35	43.8
Issaquah	8.78	17.8	.49	1	2.5	8.71	20.0	.44	14	35.0	16.10	20.2	.80	19	47.5
S.E. Corridor	7.45	12.5	.60	21	15.6	7.79	15.3	.51	42	31.1	13.38	15.0	.89	56	41.5
Total study area	6.34	12.4	.51	105	22.5	7.28	16.2	.45	150	32.1	12.59	16.0	.78	160	34.3

note : time costs included
public costs included
cost of p&r lot parking based on actual utilization

comment : Total Public and Private Costs, 4-17-85

Average PARK & RIDE TRIP Characteristics

TOTAL Perspective

	transit from p&r lot					carpool from p&r lot					vanpool from p&r lot					combined avg p&r trip			
	trip cost ($)	trip miles	cost per mile	n	% of all trips	trip cost ($)	trip miles	cost per mile	n	% of all trips	trip cost ($)	trip miles	cost per mile	n	% of all trips	trip cost ($)	trip miles	cost per mile	total n
Green Lake	5.67	7.2	.79	4	100.0	*****	****	*****	0	.0	*****	****	*****	0	.0	5.67	7.2	.79	4
North Seattle	6.27	10.9	.58	23	95.8	7.29	14.3	.51	1	4.2	*****	****	*****	0	.0	6.31	11.0	.57	24
Northgate	7.69	12.4	.62	121	100.0	*****	****	*****	0	.0	*****	****	*****	0	.0	7.69	12.4	.62	121
Shoreline	7.55	15.0	.50	40	97.6	7.96	17.1	.47	1	2.4	*****	****	*****	0	.0	7.56	15.0	.50	41
Mt.Lake Terrace	8.72	15.8	.55	17	89.5	6.89	17.0	.41	2	10.5	*****	****	*****	0	.0	8.52	15.9	.54	19
Lynnwood	8.99	21.4	.42	117	95.1	6.33	20.2	.31	6	4.9	*****	****	*****	0	.0	8.86	21.4	.41	123
N. Corridor	8.07	16.0	.50	322	97.0	6.70	18.7	.36	10	3.0	*****	****	*****	0	.0	8.03	16.1	.50	332
Wilburton	10.31	12.6	.82	4	100.0	*****	****	*****	0	.0	*****	****	*****	0	.0	10.31	12.6	.82	4
S. Bellevue	15.01	12.3	1.22	3	75.0	15.09	13.9	1.09	1	25.0	*****	****	*****	0	.0	15.03	12.7	1.18	4
Newport Hills	13.07	13.5	.97	7	100.0	*****	****	*****	0	.0	*****	****	*****	0	.0	13.07	13.5	.97	7
Eastgate	8.10	13.2	.61	77	96.3	5.26	12.6	.42	3	3.8	*****	****	*****	0	.0	7.99	13.2	.60	80
Issaquah	10.57	21.3	.50	39	97.5	8.07	19.8	.41	1	2.5	*****	****	*****	0	.0	10.51	21.2	.49	40
S.E. Corridor	9.34	15.6	.60	130	96.3	7.79	14.3	.55	5	3.7	*****	****	*****	0	.0	9.28	15.6	.60	135
Total study area	8.43	15.9	.53	452	96.8	7.06	17.2	.41	15	3.2	*****	****	*****	0	.0	8.39	15.9	.53	467

note : time costs included
public costs included
cost of p&r lot parking based on actual utilization

comment : Total Public and Private Costs, 4-17-85
(this table consider higher accident rate for I-90)

Average PREVIOUS MODE TRIP Characteristics
continued

TOTAL Perspective

	vanpool					carpool					combined average previous mode trip			
	trip cost ($)	trip miles	cost per mile	n	% of all trips	trip cost ($)	trip miles	cost per mile	n	% of all trips	trip cost ($)	trip miles	cost per mile	total n
Green Lake	*****	****	*****	0	.0	*****	****	*****	0	.0	6.49	7.1	.91	4
North Seattle	5.84	12.3	.47	1	4.2	6.19	13.9	.45	1	4.2	6.16	10.1	.61	24
Northgate	3.84	9.2	.42	1	.8	4.61	10.4	.45	12	9.9	7.11	11.4	.62	121
Shoreline	*****	****	*****	0	.0	6.75	16.9	.40	3	7.3	8.55	14.7	.58	41
Mt.Lake Terrace	*****	****	*****	0	.0	5.87	17.1	.34	1	5.3	7.82	15.5	.51	19
Lynnwood	6.57	20.8	.32	2	1.6	7.05	20.6	.34	15	12.2	9.94	21.0	.47	123
N. Corridor	5.71	15.8	.36	4	1.2	6.04	16.1	.38	32	9.6	8.30	15.4	.54	332
Wilburton	*****	****	*****	0	.0	*****	****	*****	0	.0	7.82	12.1	.65	4
S. Bellevue	*****	****	*****	0	.0	6.92	11.8	.59	1	25.0	9.91	12.5	.79	4
Newport Hills	*****	****	*****	0	.0	*****	****	*****	0	.0	7.50	13.4	.56	7
Eastgate	*****	****	*****	0	.0	6.58	12.6	.52	9	11.3	9.23	12.4	.74	80
Issaquah	*****	****	*****	0	.0	8.22	21.6	.38	6	15.0	12.15	20.3	.60	40
S.E. Corridor	*****	****	*****	0	.0	7.22	16.0	.45	16	11.9	9.99	14.8	.67	135
Total study area	5.71	15.8	.36	4	.9	6.43	16.0	.40	48	10.3	8.79	15.3	.58	467

note : time costs included
public costs included
cost of p&r lot parking based on actual utilization

comment : Total Public and Private Costs, 4-17-85
(this table consider higher accident rate for I-90)

Average Trip Cost Breakdowns

Previous Mode

Walk to Transit

	Time: In Veh	Time: Out of Veh	Time: Total	Public: Road	Public: Other	Public: Total	Auto: fuel	Auto: Own $ Oper	Auto: Accdnt	Auto: Total	Park: Total	Bus: Total	Total Trip Cost	Trip Miles	Total Cost Per Mile	Trip Time (min)	n of cases
Green Lake	1.30	1.41	2.70	.14	.04	.18	.00	.00	.00	.00	.00	1.75	4.64	7.1	.66	42.	2
	% 27.94	30.34	58.28	3.1	.88	3.98	.0	.00	.00	.00	.0	37.7					
North Seattle	1.08	1.66	2.74	.15	.04	.19	.00	.00	.00	.00	.00	1.86	4.79	7.2	.67	49.	5
	% 22.48	34.74	57.22	3.1	.87	3.96	.0	.00	.00	.00	.0	38.8					
Northgate	1.44	1.70	3.14	.17	.06	.23	.00	.00	.00	.00	.00	2.27	5.64	10.7	.53	52.	50
	% 25.50	30.12	55.62	3.0	1.10	4.06	.0	.00	.00	.00	.0	40.3					
Shoreline	1.51	1.83	3.34	.17	.07	.25	.00	.00	.00	.00	.00	2.44	6.03	12.8	.47	54.	8
	% 25.06	30.38	55.44	2.9	1.23	4.12	.0	.00	.00	.00	.0	40.4					
Mt.Lake Terrace	1.33	1.97	3.30	.18	.08	.26	.00	.00	.00	.00	.00	2.42	5.97	13.7	.44	56.	2
	% 22.30	32.93	55.22	3.0	1.33	4.32	.0	.00	.00	.00	.0	40.5					
Lynnwood	1.93	2.42	4.35	.19	.11	.30	.00	.00	.00	.00	.00	3.25	7.90	18.8	.42	69.	17
	% 24.43	30.65	55.08	2.4	1.38	3.77	.0	.00	.00	.00	.0	41.2					
N. Corridor	1.52	1.85	3.37	.17	.07	.24	.00	.00	.00	.00	.00	2.45	6.07	12.3	.49	55.	84
	% 25.01	30.57	55.58	2.8	1.18	3.99	.0	.00	.00	.00	.0	40.4					
Wilburton	----there are no cases for this lot --																
S. Bellevue	----there are no cases for this lot----																
Newport Hills	1.84	2.94	4.78	.23	.09	.32	.00	.00	.00	.00	.00	2.53	7.62	14.8	.51	59.	1
	% 24.14	38.55	62.69	3.0	1.13	4.15	.0	.00	.00	.00	.0	33.2					
Eastgate	1.73	2.95	4.68	.23	.07	.30	.00	.00	.00	.00	.00	2.40	7.38	12.1	.61	60.	19
	% 23.52	39.94	63.46	3.1	.95	4.01	.0	.00	.00	.00	.0	32.5					
Issaquah	2.36	2.47	4.83	.25	.10	.36	.00	.00	.00	.00	.00	3.60	8.78	17.8	.49	78.	1
	% 26.86	28.09	54.95	2.9	1.18	4.06	.0	.00	.00	.00	.0	41.0					
S.E. Corridor	1.77	2.92	4.69	.23	.07	.30	.00	.00	.00	.00	.00	2.46	7.45	12.5	.60	61.	21
	% 23.73	39.21	62.95	3.0	.97	4.02	.0	.00	.00	.00	.0	33.0					
Total study area	1.57	2.07	3.64	.18	.07	.25	.00	.00	.00	.00	.00	2.45	6.34	12.4	.51	56.	105
	% 24.71	32.60	57.31	2.9	1.13	3.99	.0	.00	.00	.00	.0	38.7					

comment : Total Public and Private Costs, 4-17-85

(this table consider higher accident rate for I-90)

Average Trip Cost Breakdowns

Previous Mode
Drive to Transit

	Time			Public			Auto				Park	Bus	Total Trip Cost	Trip Miles	Total Cost Per Mile	Trip Time (min)	n of cases
	In Veh	Out of Veh	Total	Road	Other	Total	fuel	Own $ Oper	Accdnt	Total	Total	Total					
Green Lake	----there are no cases for this lot----																
North Seattle	1.32	1.25	2.57	.41	.16	.58	.47	.84	.15	1.46	.00	1.62	6.23	10.8	.58	44.	14
	% 21.27	20.01	41.27	6.6	2.63	9.24	7.5	13.52	2.42	23.42	.0	26.1					
Northgate	1.50	1.21	2.72	.40	.21	.61	.56	1.14	.22	1.91	.00	1.82	7.05	12.8	.55	49.	23
	% 21.28	17.22	38.50	5.7	2.95	8.67	7.9	16.10	3.08	27.08	.0	25.8					
Shoreline	1.50	1.19	2.69	.31	.18	.49	.36	.69	.16	1.22	.00	1.64	6.04	15.5	.39	50.	12
	% 24.87	19.71	44.58	5.1	2.93	8.05	6.0	11.48	2.71	20.18	.0	27.2					
Mt.Lake Terrace	1.48	1.14	2.62	.26	.16	.42	.35	.50	.12	.97	.00	2.21	6.22	15.1	.41	51.	11
	% 23.81	18.30	42.11	4.2	2.63	6.81	5.6	8.08	1.86	15.58	.0	35.5					
Lynnwood	1.88	1.29	3.17	.31	.26	.57	.49	.99	.23	1.71	.00	2.35	7.79	20.7	.38	56.	48
	% 24.12	16.49	40.61	4.0	3.28	7.26	6.3	12.64	2.97	21.95	.0	30.2					
N. Corridor	1.64	1.24	2.88	.34	.22	.55	.47	.92	.20	1.59	.00	2.05	7.08	16.6	.43	52.	108
	% 23.24	17.51	40.75	4.8	3.04	7.82	6.7	12.96	2.80	22.47	.0	29.0					
Wilburton	1.73	1.33	3.06	.68	.17	.86	.22	.35	.08	.65	.00	3.25	7.82	12.1	.65	51.	4
	% 22.10	17.02	39.12	8.8	2.18	10.94	2.9	4.44	1.01	8.31	.0	41.6					
S. Bellevue	1.78	1.21	3.00	.52	.27	.80	.65	1.38	.43	2.46	.00	1.91	8.16	15.9	.51	56.	1
	% 21.86	14.88	36.74	6.4	3.36	9.76	7.9	16.91	5.25	30.10	.0	23.4					
Newport Hills	1.86	1.54	3.39	.50	.16	.66	.45	.73	.15	1.33	.00	2.10	7.48	13.2	.57	48.	6
	% 24.82	20.57	45.39	6.6	2.18	8.83	6.0	9.76	1.98	17.73	.0	28.0					
Eastgate	2.06	1.64	3.70	.44	.15	.59	.41	.64	.15	1.21	.00	1.60	7.11	12.8	.55	50.	17
	% 28.97	23.09	52.06	6.2	2.18	8.34	5.8	9.04	2.18	17.05	.0	22.6					
Issaquah	2.27	1.44	3.71	.46	.25	.71	.58	1.14	.28	2.00	.00	2.28	8.71	20.0	.44	59.	14
	% 26.11	16.54	42.65	5.3	2.87	8.19	6.7	13.12	3.16	22.98	.0	26.2					
S.E. Corridor	2.06	1.52	3.58	.48	.19	.67	.46	.81	.19	1.47	.00	2.06	7.79	15.3	.51	53.	42
	% 26.50	19.52	46.02	6.2	2.47	8.63	5.9	10.42	2.48	18.85	.0	26.5					
Total study area	1.76	1.32	3.08	.38	.21	.59	.47	.89	.20	1.56	.00	2.05	7.28	16.2	.45	52.	150
	% 24.21	18.11	42.33	5.2	2.87	8.06	6.5	12.20	2.71	21.38	.0	28.2					

comment : Total Public and Private Costs, 4-17-85
(this table consider higher accident rate for I-90)

Average Trip Cost Breakdowns

Previous Mode
Drive Alone

		Time			Public			Auto				Park	Bus	Total Trip Cost	Trip Miles	Total Cost Per Mile	Trip Time (min)	n of cases
		In Veh	Out of Veh	Total	Road	Other	Total	fuel	Own $ Oper	Accdnt	Total	Total	Total					
Green Lake		.43	.80	1.23	.84	.20	1.05	.81	1.61	.31	2.72	3.34	.00	8.33	7.2	1.17	21.	2
	%	5.13	9.61	14.74	10.1	2.43	12.56	9.7	19.27	3.74	32.68	40.0	.0					
North Seattle		.58	.63	1.20	1.02	.29	1.31	1.02	2.50	.42	3.94	1.80	.00	8.26	10.2	.81	23.	3
	%	7.00	7.57	14.57	12.3	3.49	15.84	12.4	30.25	5.13	47.74	21.8	.0					
Northgate		.80	.96	1.76	1.17	.34	1.51	.95	2.68	.47	4.10	2.83	.00	10.20	12.0	.85	26.	35
	%	7.86	9.42	17.28	11.5	3.32	14.81	9.3	26.23	4.66	40.19	27.7	.0					
Shoreline		.97	.99	1.95	1.29	.41	1.71	1.18	3.49	.57	5.24	2.73	.00	11.64	14.6	.80	30.	18
	%	8.29	8.47	16.77	11.1	3.55	14.68	10.1	30.01	4.92	45.06	23.5	.0					
Mt.Lake Terrace		.91	.77	1.68	1.41	.47	1.88	1.49	4.52	.62	6.64	2.26	.00	12.46	16.8	.74	31.	5
	%	7.27	6.21	13.49	11.3	3.81	15.12	12.0	36.28	4.99	53.26	18.1	.0					
Lynnwood		1.42	.90	2.31	1.57	.63	2.20	1.56	5.09	.85	7.50	2.50	.00	14.52	22.4	.65	40.	41
	%	9.76	6.17	15.93	10.8	4.36	15.17	10.8	35.05	5.87	51.67	17.2	.0					
N. Corridor		1.06	.92	1.98	1.35	.47	1.82	1.26	3.83	.64	5.73	2.64	.00	12.17	16.6	.73	33.	104
	%	8.74	7.54	16.29	11.1	3.86	14.96	10.3	31.49	5.28	47.09	21.7	.0					
Wilburton	----there are no cases for this lot----																	
S. Bellevue		.71	1.01	1.71	3.00	.32	3.31	1.22	3.10	.40	4.71	2.55	.00	12.29	11.1	1.10	25.	2
	%	5.76	8.20	13.95	24.4	2.57	26.96	9.9	25.20	3.27	38.37	20.7	.0					
Newport Hills	----there are no cases for this lot----																	
Eastgate		.97	1.02	1.99	2.89	.35	3.24	1.07	2.89	.49	4.45	2.28	.00	11.96	12.4	.97	28.	35
	%	8.11	8.51	16.62	24.2	2.93	27.12	9.0	24.13	4.07	37.19	19.1	.0					
Issaquah		1.69	1.00	2.69	3.05	.57	3.63	1.51	4.88	.84	7.24	2.55	.00	16.10	20.2	.80	41.	19
	%	10.49	6.22	16.71	19.0	3.56	22.52	9.4	30.31	5.24	44.96	15.8	.0					
S.E. Corridor		1.20	1.01	2.22	2.95	.42	3.38	1.23	3.57	.61	5.40	2.38	.00	13.38	15.0	.89	32.	56
	%	9.01	7.57	16.57	22.1	3.17	25.23	9.2	26.69	4.52	40.40	17.8	.0					
Total study area		1.11	.95	2.06	1.91	.45	2.36	1.25	3.74	.63	5.62	2.55	.00	12.59	16.0	.78	32.	160
	%	8.84	7.55	16.39	15.2	3.61	18.78	9.9	29.70	5.00	44.60	20.2	.0					

comment : Total Public and Private Costs, 4-17-85
(this table consider higher accident rate for I-90)

Average Trip Cost Breakdowns

Previous Mode
Vanpool

	------ Time ------			----- Public -----			-------- Auto ----------				-Park-	-Bus-	Total Trip Cost	Trip Miles	Total Cost Per Mile	Trip Time (min)	n of cases
	In Veh	Out of Veh	Total	Road	Other	Total	fuel	Own $ Oper	Accdnt	Total	Total	Total					
Green Lake	----there are no cases for this lot----																
North Seattle	1.55	1.14	2.69	.81	.16	.96	.51	1.38	.23	2.12	.06	.00	5.84	12.3	.47	40.	1
	% 26.59	19.55	46.14	13.8	2.66	16.50	8.7	23.68	3.95	36.29	1.1	.0					
Northgate	.83	.77	1.60	.79	.12	.91	.32	.80	.15	1.27	.06	.00	3.84	9.2	.42	33.	1
	% 21.50	20.05	41.55	20.7	3.03	23.68	8.3	20.84	4.00	33.14	1.6	.0					
Shoreline	----there are no cases for this lot----																
Mt.Lake Terrace	----there are no cases for this lot----																
Lynnwood	1.64	.91	2.55	.97	.26	1.23	.57	1.81	.35	2.73	.06	.00	6.57	20.8	.32	49.	2
	% 24.92	13.91	38.83	14.8	4.00	18.77	8.6	27.54	5.28	41.46	1.0	.0					
N. Corridor	1.41	.94	2.35	.89	.20	1.09	.49	1.45	.27	2.21	.06	.00	5.71	15.8	.36	43.	4
	% 24.77	16.39	41.16	15.5	3.49	19.01	8.6	25.43	4.73	38.74	1.1	.0					
Wilburton	----there are no cases for this lot----																
S. Bellevue	----there are no cases for this lot----																
Newport Hills	----there are no cases for this lot----																
Eastgate	----there are no cases for this lot----																
Issaquah	----there are no cases for this lot----																
S.E. Corridor	----there are no cases for this lot----																
Total study area	1.41	.94	2.35	.89	.20	1.09	.49	1.45	.27	2.21	.06	.00	5.71	15.8	.36	43.	4
	% 24.77	16.39	41.16	15.5	3.49	19.01	8.6	25.43	4.73	38.74	1.1	.0					

comment : Total Public and Private Costs, 4-17-85
(this table consider higher accident rate for I-90)

Average Trip Cost Breakdowns

Previous Mode
Carpool

	Time: In Veh	Time: Out of Veh	Time: Total	Public: Road	Public: Other	Public: Total	Auto: fuel	Auto: Own $ Oper	Auto: Accdnt	Auto: Total	Park: Total	Bus: Total	Total Trip Cost	Trip Miles	Total Cost Per Mile	Trip Time (min)	n of cases
Green Lake	----there are no cases for this lot----																
North Seattle	2.01	1.07	3.08	.83	.18	1.01	.43	1.22	.26	1.91	.19	.00	6.19	13.9	.45	40.	1
	% 32.47	17.34	49.81	13.5	2.84	16.31	6.9	19.71	4.15	30.78	3.1	.0					
Northgate	1.07	.90	1.97	.80	.13	.93	.37	.97	.18	1.52	.19	.00	4.61	10.4	.45	35.	12
	% 23.16	19.56	42.72	17.4	2.84	20.20	8.0	21.07	3.87	32.91	4.2	.0					
Shoreline	1.78	1.02	2.80	.89	.21	1.10	.60	1.75	.30	2.65	.19	.00	6.75	16.9	.40	45.	3
	% 26.36	15.12	41.48	13.2	3.17	16.35	8.9	26.00	4.43	39.32	2.8	.0					
Mt.Lake Terrace	1.39	.90	2.29	.92	.22	1.13	.49	1.49	.28	2.26	.19	.00	5.87	17.1	.34	44.	1
	% 23.68	15.26	38.94	15.6	3.68	19.32	8.3	25.34	4.82	38.47	3.3	.0					
Lynnwood	1.80	.82	2.62	.96	.26	1.22	.63	2.04	.35	3.02	.19	.00	7.05	20.6	.34	48.	15
	% 25.52	11.63	37.15	13.6	3.69	17.32	8.9	28.97	4.94	42.81	2.7	.0					
N. Corridor	1.52	.88	2.40	.89	.20	1.09	.52	1.57	.28	2.36	.19	.00	6.04	16.1	.38	42.	32
	% 25.10	14.56	39.66	14.7	3.36	18.07	8.6	25.99	4.55	39.10	3.2	.0					
Wilburton	----there are no cases for this lot----																
S. Bellevue	1.84	1.41	3.25	1.31	.15	1.46	.49	1.32	.21	2.01	.19	.00	6.92	11.8	.59	38.	1
	% 26.66	20.37	47.04	18.9	2.15	21.10	7.0	19.09	2.99	29.08	2.8	.0					
Newport Hills	----there are no cases for this lot----																
Eastgate	1.67	1.05	2.73	1.30	.16	1.46	.52	1.46	.23	2.20	.19	.00	6.58	12.6	.52	39.	9
	% 25.41	15.99	41.40	19.8	2.42	22.21	7.9	22.11	3.49	33.47	2.9	.0					
Issaquah	2.35	.78	3.13	1.36	.27	1.64	.68	2.16	.41	3.26	.19	.00	8.22	21.6	.38	54.	6
	% 28.60	9.48	38.08	16.6	3.33	19.92	8.3	26.33	5.00	39.66	2.3	.0					
S.E. Corridor	1.94	.97	2.91	1.33	.20	1.53	.58	1.71	.30	2.59	.19	.00	7.22	16.0	.45	45.	16
	% 26.85	13.47	40.32	18.4	2.79	21.17	8.0	23.73	4.10	35.85	2.7	.0					
Total study area	1.66	.91	2.57	1.03	.20	1.24	.54	1.62	.28	2.44	.19	.00	6.43	16.0	.40	43.	48
	% 25.75	14.15	39.91	16.1	3.15	19.23	8.4	25.15	4.38	37.88	3.0	.0					

comment : Total Public and Private Costs, 4-17-85
(this table consider higher accident rate for I-90)

Average Trip Cost Breakdowns

Park & Ride
Transit from P&R

	------ Time ------			----- Public -----			-------- Auto ----------				-Park-	-Bus-	Total Trip Cost	Trip Miles	Total Cost Per Mile	Trip Time (min)	n of cases
	In Veh	Out of Veh	Total	Road	Other	Total	fuel	Own $ Oper	Accdnt	Total	Total	Total					
Green Lake	1.08	1.19	2.27	.30	.11	.41	.28	.38	.10	.76	.36	1.87	5.67	7.2	.79	39.	4
	% 19.08	20.99	40.07	5.2	1.94	7.15	4.9	6.70	1.81	13.43	6.4	33.0					
North Seattle	1.25	1.20	2.45	.37	.16	.53	.45	.79	.15	1.40	.24	1.65	6.27	10.9	.58	43.	23
	% 20.00	19.06	39.06	5.9	2.58	8.50	7.3	12.62	2.41	22.28	3.9	26.3					
Northgate	1.48	1.24	2.72	.37	.19	.56	.49	.92	.19	1.59	.97	1.84	7.69	12.4	.62	48.	121
	% 19.32	16.12	35.44	4.9	2.47	7.34	6.3	11.97	2.41	20.70	12.6	24.0					
Shoreline	1.56	1.28	2.85	.28	.15	.43	.32	.52	.12	.97	1.65	1.66	7.55	15.0	.50	49.	40
	% 20.69	16.97	37.66	3.7	2.04	5.69	4.3	6.92	1.65	12.82	21.8	22.0					
Mt.Lake Terrace	1.45	1.12	2.56	.27	.17	.44	.39	.63	.12	1.14	2.34	2.23	8.72	15.8	.55	51.	17
	% 16.59	12.80	29.39	3.1	2.00	5.09	4.5	7.27	1.37	13.12	26.8	25.6					
Lynnwood	1.89	1.28	3.17	.32	.27	.59	.53	1.08	.24	1.84	1.01	2.37	8.99	21.4	.42	56.	117
	% 20.98	14.29	35.27	3.6	3.00	6.57	5.8	11.97	2.70	20.52	11.2	26.4					
N. Corridor	1.62	1.25	2.87	.34	.21	.55	.47	.90	.19	1.56	1.08	2.02	8.07	16.0	.50	50.	322
	% 20.03	15.50	35.53	4.2	2.61	6.77	5.8	11.11	2.38	19.30	13.4	25.0					
Wilburton	1.73	1.33	3.06	.68	.18	.86	.22	.35	.08	.65	2.46	3.29	10.31	12.6	.82	51.	4
	% 16.75	12.90	29.65	6.6	1.72	8.29	2.2	3.37	.77	6.30	23.9	31.9					
S. Bellevue	1.47	1.30	2.77	.53	.16	.69	.33	.59	.17	1.08	8.53	1.94	15.01	12.3	1.22	46.	3
	% 9.80	8.66	18.46	3.5	1.10	4.61	2.2	3.92	1.11	7.21	56.8	12.9					
Newport Hills	1.85	1.54	3.39	.47	.16	.64	.41	.68	.14	1.24	5.68	2.12	13.07	13.5	.97	48.	7
	% 14.16	11.77	25.93	3.6	1.25	4.87	3.2	5.22	1.11	9.49	43.5	16.2					
Eastgate	1.88	1.53	3.42	.44	.16	.60	.43	.66	.15	1.23	1.22	1.63	8.10	13.2	.61	49.	77
	% 23.27	18.93	42.20	5.4	1.96	7.41	5.3	8.13	1.80	15.25	15.1	20.1					
Issaquah	2.44	1.48	3.92	.45	.28	.73	.63	1.31	.32	2.26	1.37	2.30	10.57	21.3	.50	61.	39
	% 23.03	14.00	37.03	4.3	2.60	6.90	5.9	12.40	3.03	21.35	13.0	21.8					
S.E. Corridor	2.03	1.51	3.54	.46	.19	.65	.48	.84	.20	1.52	1.71	1.91	9.34	15.6	.60	53.	130
	% 21.78	16.13	37.91	4.9	2.09	6.97	5.1	9.04	2.10	16.29	18.3	20.5					
Total study area	1.74	1.32	3.06	.37	.21	.58	.47	.88	.19	1.55	1.26	1.99	8.43	15.9	.53	51.	452
	% 20.59	15.70	36.29	4.4	2.44	6.83	5.6	10.45	2.29	18.34	15.0	23.6					

comment : Total Public and Private Costs, 4-17-85
(this table consider higher accident rate for I-90)

Average Trip Cost Breakdowns

Park & Ride
Carpool from P&R

	Time			Public			Auto				Park	Bus	Total	Trip	Total	Trip	n
	In Veh	Out of Veh	Total	Road	Other	Total	fuel	Own $ Oper	Accdnt	Total	Total	Total	Trip Cost	Miles	Cost Per Mile	Time (min)	of cases
Green Lake	----there are no cases for this lot----																
North Seattle	1.24	1.84	3.08	.50	.23	.74	1.10	1.69	.37	3.16	.32	.00	7.29	14.3	.51	32.	1
	% 17.03	25.24	42.26	6.9	3.19	10.11	15.0	23.21	5.07	43.29	4.3	.0					
Northgate	----there are no cases for this lot----																
Shoreline	1.25	1.59	2.84	.45	.19	.64	.97	1.47	.33	2.77	1.71	.00	7.96	17.1	.47	36.	1
	% 15.70	19.95	35.65	5.7	2.36	8.04	12.1	18.43	4.20	34.78	21.5	.0					
Mt.Lake Terrace	1.35	1.62	2.97	.46	.14	.60	.49	1.04	.23	1.76	1.57	.00	6.90	17.0	.41	44.	2
	% 19.50	23.53	43.03	6.6	2.06	8.67	7.2	15.02	3.32	25.51	22.8	.0					
Lynnwood	1.11	1.23	2.34	.51	.18	.69	.59	1.41	.29	2.28	1.02	.00	6.34	20.2	.31	38.	6
	% 17.48	19.46	36.94	8.1	2.88	10.96	9.3	22.18	4.60	36.06	16.0	.0					
N. Corridor	1.18	1.41	2.59	.49	.18	.67	.66	1.37	.29	2.32	1.13	.00	6.71	18.7	.36	39.	10
	% 17.63	20.98	38.62	7.4	2.68	10.05	9.8	20.37	4.34	34.52	16.8	.0					
Wilburton	----there are no cases for this lot----																
S. Bellevue	1.05	2.19	3.24	.81	.17	.98	.59	1.44	.25	2.28	8.59	.00	15.10	13.9	1.09	31.	1
	% 6.95	14.52	21.47	5.4	1.11	6.49	3.9	9.55	1.64	15.12	56.9	.0					
Newport Hills	----there are no cases for this lot----																
Eastgate	.58	1.27	1.85	.66	.11	.77	.37	.80	.16	1.33	1.32	.00	5.26	12.6	.42	27.	3
	% 11.03	24.08	35.11	12.4	2.12	14.56	6.9	15.23	3.10	25.27	25.1	.0					
Issaquah	1.11	1.50	2.61	.73	.19	.92	.99	1.75	.35	3.08	1.45	.00	8.07	19.8	.41	40.	1
	% 13.78	18.60	32.38	9.0	2.41	11.44	12.2	21.64	4.28	38.17	18.0	.0					
S.E. Corridor	.78	1.50	2.28	.70	.14	.84	.54	1.12	.22	1.87	2.80	.00	7.79	14.3	.55	30.	5
	% 10.02	19.24	29.26	9.0	1.79	10.79	6.9	14.36	2.78	24.01	35.9	.0					
Total study area	1.05	1.44	2.49	.56	.17	.73	.62	1.28	.27	2.17	1.68	.00	7.07	17.2	.41	36.	15
	% 14.84	20.34	35.18	8.0	2.35	10.32	8.7	18.16	3.77	30.66	23.8	.0					

comment : Total Public and Private Costs, 4-17-85
(this table consider higher accident rate for I-90)

Average Trip Cost Breakdowns

Park & Ride
Vanpool from P&R

	Time: In Veh	Time: Out of Veh	Time: Total	Public: Road	Public: Other	Public: Total	Auto: fuel	Auto: Own $ Oper	Auto: Accdnt	Auto: Total	-Park- Total	-Bus- Total	Total Trip Cost	Trip Miles	Total Cost Per Mile	Trip Time (min)	n of cases
Green Lake	----there are no cases for this lot----																
North Seattle	----there are no cases for this lot----																
Northgate	----there are no cases for this lot----																
Shoreline	----there are no cases for this lot----																
Mt.Lake Terrace	----there are no cases for this lot----																
Lynnwood	----there are no cases for this lot----																
N. Corridor	----there are no cases for this lot----																
Wilburton	----there are no cases for this lot----																
S. Bellevue	----there are no cases for this lot----																
Newport Hills	----there are no cases for this lot----																
Eastgate	----there are no cases for this lot----																
Issaquah	----there are no cases for this lot----																
S.E. Corridor	----there are no cases for this lot----																
Total study area	----there are no cases for this lot----																

comment : Total Public and Private Costs, 4-17-85
(this table consider higher accident rate for I-90)

Average Trip Cost Breakdowns

Combined Average
Previous Mode

	Time: In Veh	Time: Out of Veh	Time: Total	Public: Road	Public: Other	Public: Total	Auto: fuel	Auto: Own $ Oper	Auto: Accdnt	Auto: Total	Park: Total	Bus: Total	Total Trip Cost	Trip Miles	Total Cost Per Mile	Trip Time (min)	n of cases
Green Lake	.86	1.10	1.97	.49	.12	.62	.40	.80	.16	1.36	1.67	.88	6.49	7.1	.91	31.	4
	% 13.29	17.03	30.32	7.6	1.87	9.49	6.2	12.38	2.40	20.99	25.7	13.5					
North Seattle	1.22	1.24	2.46	.47	.15	.62	.44	.91	.16	1.51	.24	1.33	6.16	10.1	.61	42.	24
	% 19.75	20.18	39.93	7.6	2.50	10.07	7.1	14.79	2.62	24.52	3.8	21.6					
Northgate	1.22	1.31	2.53	.57	.18	.75	.42	1.09	.20	1.71	.84	1.28	7.11	11.4	.62	42.	121
	% 17.22	18.37	35.59	8.0	2.49	10.51	5.9	15.37	2.78	24.05	11.8	18.1					
Shoreline	1.29	1.21	2.50	.76	.26	1.02	.67	1.86	.32	2.85	1.21	.96	8.55	14.7	.58	42.	41
	% 15.08	14.20	29.27	8.9	3.08	11.95	7.8	21.81	3.76	33.38	14.2	11.2					
Mt.Lake Terrace	1.31	1.12	2.43	.59	.24	.83	.62	1.56	.25	2.43	.60	1.53	7.82	15.5	.51	46.	19
	% 16.74	14.29	31.03	7.5	3.06	10.59	8.0	19.95	3.14	31.06	7.7	19.6					
Lynnwood	1.72	1.25	2.97	.80	.36	1.16	.80	2.36	.42	3.58	.86	1.37	9.94	21.0	.47	51.	123
	% 17.29	12.57	29.87	8.1	3.64	11.72	8.0	23.74	4.25	36.03	8.6	13.8					
N. Corridor	1.42	1.26	2.67	.67	.26	.93	.60	1.67	.30	2.57	.84	1.29	8.30	15.4	.54	46.	332
	% 17.05	15.13	32.19	8.1	3.10	11.20	7.3	20.09	3.56	30.92	10.2	15.5					
Wilburton	1.73	1.33	3.06	.68	.17	.86	.22	.35	.08	.65	.00	3.25	7.82	12.1	.65	51.	4
	% 22.18	17.02	39.12	8.8	2.18	10.94	2.9	4.44	1.01	8.31	.0	41.6					
S. Bellevue	1.26	1.16	2.42	1.96	.26	2.22	.89	2.22	.36	3.47	1.32	.48	9.91	12.5	.79	36.	4
	% 12.72	11.78	24.41	19.7	2.66	22.48	9.0	22.43	3.63	35.05	13.3	4.8					
Newport Hills	1.85	1.74	3.59	.46	.15	.61	.38	.63	.13	1.14	.00	2.16	7.50	13.4	.56	50.	7
	% 24.72	23.18	47.91	6.1	2.03	8.15	5.1	8.35	1.70	15.16	.0	28.8					
Eastgate	1.46	1.61	3.07	1.56	.22	1.78	.62	1.56	.27	2.45	1.02	.91	9.23	12.4	.74	41.	80
	% 15.83	17.46	33.29	16.9	2.39	19.27	6.7	16.92	2.94	26.54	11.0	9.9					
Issaquah	2.01	1.16	3.17	1.82	.40	2.23	1.03	3.04	.56	4.63	1.24	.89	12.15	20.3	.60	51.	40
	% 16.54	9.53	26.08	15.0	3.32	18.33	8.4	25.05	4.60	38.10	10.2	7.3					
S.E. Corridor	1.65	1.46	3.11	1.57	.27	1.84	.72	1.94	.35	3.00	1.01	1.03	9.99	14.8	.67	45.	135
	% 16.49	14.65	31.13	15.7	2.71	18.40	7.2	19.39	3.47	30.09	10.1	10.3					
Total study area	1.48	1.32	2.80	.93	.26	1.19	.64	1.75	.31	2.69	.89	1.21	8.79	15.3	.58	45.	467
	% 16.87	14.97	31.84	10.6	2.97	13.57	7.3	19.86	3.53	30.65	10.2	13.8					

comment : Total Public and Private Costs, 4-17-85
(this table consider higher accident rate for I-90)

Average Trip Cost Breakdowns

Combined Average
Park & Ride

	Time: In Veh	Time: Out of Veh	Time: Total	Public: Road	Public: Other	Public: Total	Auto: fuel	Auto: Own $ Oper	Auto: Accdnt	Auto: Total	Park: Total	Bus: Total	Total Trip Cost	Trip Miles	Total Cost Per Mile	Trip Time (min)	n of cases
Green Lake	1.08	1.19	2.27	.30	.11	.41	.28	.38	.10	.76	.36	1.87	5.67	7.2	.79	39.	4
	% 19.08	20.99	40.07	5.2	1.94	7.15	4.9	6.70	1.81	13.43	6.4	33.0					
North Seattle	1.25	1.22	2.48	.38	.16	.54	.48	.83	.16	1.47	.25	1.58	6.31	11.0	.57	43.	24
	% 19.86	19.36	39.22	6.0	2.61	8.58	7.6	13.13	2.54	23.29	3.9	25.0					
Northgate	1.48	1.24	2.72	.37	.19	.56	.49	.92	.19	1.59	.97	1.84	7.69	12.4	.62	48.	121
	% 19.32	16.12	35.44	4.9	2.47	7.34	6.3	11.97	2.41	20.70	12.6	24.0					
Shoreline	1.56	1.29	2.85	.28	.15	.44	.34	.55	.13	1.01	1.65	1.62	7.56	15.0	.50	48.	41
	% 20.56	17.05	37.61	3.7	2.04	5.75	4.5	7.22	1.71	13.39	21.8	21.5					
Mt.Lake Terrace	1.44	1.17	2.60	.29	.17	.46	.40	.68	.13	1.21	2.26	1.99	8.53	15.9	.54	50.	19
	% 16.84	13.71	30.55	3.4	2.01	5.40	4.7	7.93	1.54	14.17	26.5	23.4					
Lynnwood	1.85	1.28	3.13	.33	.27	.60	.53	1.09	.25	1.87	1.01	2.26	8.86	21.4	.41	55.	123
	% 20.86	14.47	35.33	3.7	3.00	6.72	6.0	12.33	2.77	21.06	11.4	25.5					
N. Corridor	1.60	1.26	2.86	.34	.21	.55	.48	.91	.19	1.58	1.08	1.96	8.03	16.1	.50	50.	332
	% 19.97	15.63	35.60	4.2	2.61	6.85	5.9	11.34	2.42	19.69	13.5	24.4					
Wilburton	1.73	1.33	3.06	.68	.18	.86	.22	.35	.08	.65	2.46	3.29	10.31	12.6	.82	51.	4
	% 16.75	12.90	29.65	6.6	1.72	8.29	2.2	3.37	.77	6.30	23.9	31.9					
S. Bellevue	1.36	1.52	2.89	.60	.17	.76	.39	.80	.19	1.38	8.54	1.45	15.03	12.7	1.18	42.	4
	% 9.08	10.13	19.21	4.0	1.10	5.08	2.6	5.34	1.24	9.20	56.8	9.7					
Newport Hills	1.85	1.54	3.39	.47	.16	.64	.41	.68	.14	1.24	5.68	2.12	13.07	13.5	.97	48.	7
	% 14.16	11.77	25.93	3.6	1.25	4.87	3.2	5.22	1.11	9.49	43.5	16.2					
Eastgate	1.84	1.52	3.36	.45	.16	.61	.43	.66	.15	1.24	1.22	1.56	7.99	13.2	.60	48.	80
	% 22.97	19.05	42.03	5.6	1.97	7.58	5.4	8.31	1.83	15.50	15.3	19.6					
Issaquah	2.40	1.48	3.88	.46	.27	.73	.64	1.32	.32	2.28	1.37	2.24	10.51	21.2	.49	61.	40
	% 22.85	14.09	36.94	4.4	2.60	6.99	6.1	12.57	3.05	21.68	13.1	21.3					
S.E. Corridor	1.99	1.51	3.49	.47	.19	.66	.48	.85	.20	1.53	1.75	1.84	9.28	15.6	.60	52.	135
	% 21.42	16.22	37.64	5.0	2.08	7.09	5.2	9.21	2.13	16.53	18.9	19.9					
Total study area	1.71	1.33	3.04	.38	.20	.58	.48	.89	.20	1.57	1.28	1.93	8.39	15.9	.53	51.	467
	% 20.43	15.82	36.26	4.5	2.44	6.93	5.7	10.66	2.33	18.68	15.2	22.9					

comment : Total Public and Private Costs, 4-17-85
(this table consider higher accident rate for I-90)

Average Trip Cost Breakdowns

Comparision Ratio

- pmd/p&r -

	Time			Public			Auto				Park	Bus	Total Trip Cost	Trip Miles	Total Cost Per Mile	Trip Time (min)	n of cases
	In Veh	Out of Veh	Total	Road	Other	Total	fuel	Own $ Oper	Accdnt	Total	Total	Total					
Green Lake	.80	.93	.87	1.7	1.11	1.52	1.4	2.11	1.52	1.79	4.6	.5	1.14	.98	1.16	.81	1.00
North Seattle	.97	1.02	.99	1.2	.94	1.15	.9	1.10	1.01	1.03	1.0	.8	.98	.92	1.06	.98	1.00
Northgate	.82	1.05	.93	1.5	.93	1.32	.9	1.19	1.06	1.07	.9	.7	.92	.92	1.00	.89	1.00
Shoreline	.83	.94	.88	2.7	1.70	2.35	2.0	3.42	2.48	2.82	.7	.6	1.13	.97	1.16	.86	1.00
Mt.Lake Terrace	.91	.96	.93	2.0	1.40	1.80	1.5	2.31	1.87	2.01	.3	.8	.92	.97	.94	.92	1.00
Lynnwood	.93	.97	.95	2.4	1.36	1.96	1.5	2.16	1.72	1.92	.8	.6	1.12	.98	1.14	.94	1.00
N. Corridor	.88	1.00	.93	2.0	1.23	1.69	1.3	1.83	1.52	1.62	.8	.7	1.03	.96	1.08	.91	1.00
Wilburton	1.00	1.00	1.00	1.0	.96	1.00	1.0	1.00	1.00	1.00	*****	1.0	.76	.96	.79	1.00	1.00
S. Bellevue	.92	.76	.84	3.3	1.59	2.91	2.3	2.77	1.93	2.51	.2	.3	.66	.98	.67	.85	1.00
Newport Hills	1.00	1.13	1.06	1.0	.93	.96	.9	.92	.88	.92	*****	1.0	.57	.99	.58	1.03	1.00
Eastgate	.80	1.06	.92	3.5	1.41	2.94	1.4	2.35	1.86	1.98	.8	.6	1.16	.94	1.23	.86	1.00
Issaquah	.84	.78	.82	4.0	1.48	3.03	1.6	2.30	1.74	2.03	.9	.4	1.16	.96	1.21	.83	1.00
S.E. Corridor	.83	.97	.89	3.4	1.41	2.79	1.5	2.27	1.76	1.96	.6	.6	1.08	.95	1.13	.86	1.00
Total study area	.86	.99	.92	2.5	1.28	2.05	1.3	1.95	1.59	1.72	.7	.6	1.05	.96	1.09	.90	1.00

comment : Total Public and Private Costs, 4-17-85
(this table consider higher accident rate for I-90)