Caliper
Corporation

LIRR ACCESS MODE/PARKING DEMAND STUDY
FINAL REPORT

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CHAPTER 1

INTRODUCTION AND EXECUTIVE SUMMARY

This report presents the results of the LIRR Access Mode/Parking Demand Study. The purpose of this project was to provide the LIRR with a modeling capability to forecast the impacts of changes in parking supply, price, and other commuter rail service characteristics on LIRR ridership and on the access mode choice, station choice, and parking lot utilization of LIRR riders.

In this project, Caliper Corporation developed a microcomputer model of the LIRR network and competing modes that uses a modified stochastic user equilibrium assignment approach to determine the number of LIRR riders and the characteristics of their trips based on specified input data. This microcomputer model was implemented in a user-friendly software package.

STUDY APPROACH AND METHODOLOGY

The technical approach integrated significant technical efforts in market research, travel demand modeling, network equilibrium analysis, and software development. Existing LIRR data were supplemented by a parking inventory that obtained base data on parking supply and utilization at LIRR commuter stations. An on-board survey containing a stated preference experiment was conducted to provide data so that travelers' behavioral responses to changes in parking conditions could be quantified with choice models. Extensive analysis and reconciliation of data from multiple sources was required to obtain base case aggregate data on passenger utilization of the LIRR by origin zone and on passenger flows on the various rail network links.

A unified travel demand forecasting model was developed and applied within the framework of stochastic user equilibrium on a network. In this framework, the various choices open to commuters (including choice of mode, access mode, LIRR station, and parking lot) were jointly analyzed in terms of a supernetwork comprised of links representing these alternative travel paths. Estimated monetary values of level of service attributes from prior and new traveler preference models were used as the basis for the perceived generalized costs of rail network links of the various types.

A stochastic user equilibrium assignment methodology, modified to incorporate capacity constraints, was used to assign travelers to the various modes, access modes, LIRR stations, and parking facilities. The equilibrium formulation ensures that consistency is achieved between forecast demand and level of service despite the flow dependence of the latter.

In stochastic user equilibrium, travelers vary in their perceptions of link costs and no user believes that he can unilaterally reduce his disutility of travel by selecting an alternative travel path. Because perceptions of link costs vary among travelers, stochastic user equilibrium provides much more realistic assignments than deterministic user equilibrium, in which only the least cost paths are utilized. The basic feasibility of the stochastic user equilibrium approach in building an empirical rail demand model had been established in prior internal research and development by Caliper and in a small scale application to the problem of forecasting LIRR riders' destination terminal choices under alternative scenarios.

THE RAILRIDER FORECASTING MODEL

The methodology described above was employed in the development of RailRider, a comprehensive ridership forecasting system that was implemented in microcomputer software. In RailRider, AM peak commutation trips are generated at 50 origin zones that cover Queens, Nassau, and Suffolk counties. These trips are all destined to a single destination node representing New York City. The RailRider network includes access subnetworks representing connections between origin zones and stations, parking subnetworks representing parking facilities at stations and their connections to station platforms, and the LIRR subnetwork that consists of LIRR stations and links representing express and local service between stations. The base case network has 1930 links and 846 nodes. Calibration of the model to reflect base case conditions was achieved within close tolerances.

THE RAILRIDER SOFTWARE

The RailRider software package provides LIRR staff with the capability to change parking supply and price, rail service schedules and fares, and total corridor demand, and then produce new forecasts based on these new assumptions. The software has extensive capabilities to produce both on-screen and printed reports in a variety of useful formats. The computer software has been licensed to the LIRR and the MTA for its exclusive use. Documentation for using the software appears in a separate report, "User's Guide to RAILRIDER - The LIRR Planning and Forecasting System."

The forecasting software allows the following input parameters to be changed:

* LIRR local and express service schedules, including inter-station travel times and the number of peak passenger cars providing service;

* LIRR monthly ticket prices in each fare zone;

* The number, size, location, and price of parking lots serving each LIRR commuter station, and the type of restrictions that apply to each lot;

* Overall travel demand in the Long Island-Manhattan corridor; and

* Characteristics of each station, including the fare zone in which it resides and whether electric or diesel service is provided.

Based on the specified inputs, the forecasting software produces the following outputs for the AM peak period:

* LIRR ridership, mode share, and access mode share for 50 residential zones in Queens, Nassau, and Suffolk counties;

* Ridership by station, branch, town, and county, also classified by mode of access (park versus other);

* Branch loading information that indicates the number of riders arriving and leaving each and every commuter station;

* Complete parking statistics, including lot-by-lot forecasts of parking demand and revenue, as well as aggregate reports at the station, branch, town, or county level summarizing parking in both restricted and unrestricted facilities; and

* Summary system performance measures, including the time spent by LIRR riders in various portions of their trip, the total cost of travel, revenue to the LIRR and to parking facilities themselves, and numerous other statistics.

BASE LIRR RIDERSHIP AND PARKING CONDITIONS

Spring, 1986 AM peak ridership on the LIRR was 112,733, of which 49.1 percent access the LIRR by driving and parking at the station. Nassau County represents the largest share of LIRR ridership (63.1 percent), followed by Suffolk County (25.2 percent) and Queens County (11.7 percent). Park access represents 22.6 percent of LIRR riders in Queens, 46.5 percent in Nassau County, and 67.7 percent in Suffolk County. The towns of Hempstead and Oyster Bay represent over 50 percent of AM peak ridership. Brookhaven, Huntington, Smithtown, and Southampton have the highest park access shares, of 80.4 percent, 77.9 percent, 75.8 percent, and 70.5 percent, respectively.

The Babylon, Port Jefferson, and Port Washington Branches dominate LIRR ridership with 28.4 percent, 22.6 percent, and 15.4 percent of AM peak riders, respectively. The Montauk, Oyster Bay, and West Hempstead Branches carry the fewest riders, with 3.0 percent, 2.3 percent, and 1.5 percent, respectively. The highest park access shares are on the Montauk (81.9 percent), Port Jefferson (64.4 percent), and Ronkonkoma (61.0 percent) Branches, respectively. The lowest park access shares are in the City Terminal Zone (10.0 percent) and on the Port Washington Branch (25.8 percent).

There are 55,573 parking spaces available for LIRR commuters, of which an average of 46,406 (83.5 percent) are occupied. Of the total parking capacity, 36,434 spaces (65.6 percent) are unrestricted. Restricted lots are defined to be ones in which use by some individuals is prohibited based on where they live. Permit requirements are not necessarily considered to be restrictions, unless there are residency requirements for purchasing the permit. Also, it should be noted that incomplete data on parking restrictions led to the classification of some lots that may in fact be restricted as unrestricted.

Nassau County has 31,801 spaces (18,205 unrestricted; 13,596 restricted), of which 27,538 are filled. Suffolk County has 19,699 spaces (14,156 unrestricted; 5543 restricted), of which 16,467 are filled. Queens County has 4073 unrestricted spaces, of which 2400 are occupied. Hempstead and Oyster Bay have more parking spaces than any other town, with 19,153 and 8859 spaces, respectively. In Queens, Babylon, Islip, and Brookhaven almost all spaces are unrestricted; Huntington and North Hempstead have the highest proportion of restricted spaces. Huntington and Smithtown have the highest levels of parking congestion, with available spaces filled to 95 percent of capacity in both towns. Congestion is least severe in Queens, Brookhaven, and Islip. Restricted parking lots are generally somewhat more congested than unrestricted lots at the same stations; this is probably a result of the fact that restrictions are often placed on the more desirable lots.

The Babylon and Port Jefferson Branches have by far the greatest number of parking spaces with almost 15,000 each; the West Hempstead and Oyster Bay Branches have the fewest. The Port Jefferson Branch has the highest proportion of restricted parking (52.5 percent). The City Terminal, Port Jefferson, and Babylon Branches have the highest parking occupancy rates, while occupancy is lowest along the Ronkonkoma and Oyster Bay Branches.

DEMAND FORECASTS FOR SELECTED SCENARIOS

In order to test the capabilities of the RailRider model, forecasts were developed for fifteen different scenarios specified by the LIRR. Most of these scenarios are hypothetical and do not represent actual service changes currently being considered by the LIRR.

Based upon RailRider forecasts, electrification of the Main Line will increase AM peak LIRR ridership by more than 3000 riders, with Ronkonkoma Branch ridership increasing by more than 5400 riders. Ridership drops on the Port Jefferson Branch (down 396), the Montauk Branch (down 1070), and the Babylon Branch (down 957). The largest ridership impacts are in the towns of Islip (up 1505) and Brookhaven (up 572). The new riders attracted by this capital project predominantly use park access, taking advantage of new parking capacity at Ronkonkoma Branch stations. Many of the new Ronkonkoma Branch riders come from the diesel portions of the Port Jefferson and Montauk Branches, while a significant number are drawn from the eastern end of the Babylon Branch. It appears that demand on the electrified Ronkonkoma Branch is constrained by parking supply, and that additional capacity would result in a larger increase in branch ridership.

Subsequent electrification of the eastern end of the Port Jefferson Branch is forecast to have relatively small impacts on LIRR ridership, yielding an additional 1104 AM peak riders. The increase is limited by parking constraints at the newly electrified stations. Demand on other branches is not significantly affected by the Port Jefferson electrification.

Introduction of the proposed new Landia Station (between Hicksville and Syosset) would increase total AM peak ridership by only 200. Most of the forecast 2000 AM peak riders at Landia would be drawn away from Syosset (down 441) and Hicksville (down 469), although some riders would be drawn from Ronkonkoma or Oyster Bay diesel territory as well. The net impact on the Port Jefferson Branch is an increase of 742 riders. The impacts of Landia would be significantly greater in the post-electrification phase, when parking capacity constraints become more severe.

Closing of the West Hempstead Branch is forecast to reduce LIRR ridership by 723, with the Hempstead, Babylon, Long Beach, and Far Rockaway Branches picking up the remainder of the former 1729 West Hempstead riders. Closing the Oyster Bay Branch (currently serving 2544 riders) would decrease total LIRR ridership by 1156, with most of the other riders picking up the Port Washington or Port Jefferson Branch.

RailRider was used to forecast the impacts of nine different station closing scenarios; all were found to have relatively localized impacts and only slight effects on systemwide demand. The RailRider model has an implied systemwide fare elasticity of -0.15 and a travel time elasticity of -0.20.

CONCLUDING REMARKS

The RailRider model breaks ground in the implementation of a new generation of travel demand forecasting procedures based upon theoretical advances of the last decade. The model appears to perform quite well in providing answers to questions that cannot be meaningfully addressed by alternative methods. Experience with the model and its forecasts will, of course, be needed to judge its merits and relative performance.

The model accuracy and usefulness can be significantly enhanced if better data is obtained to support future calibration and application efforts. The recommended enhancements to the forecasting system include integration of the model with the destination terminal choice model developed in the East Side Access study, and explicit treatment of alternative commutation modes for which a much improved mode split model would be required.

OUTLINE OF THE REPORT

The remainder of this report is organized as follows. Chapter 2 presents an overview of the study approach and methodology. Chapter 3 describes in detail the data collection and analysis efforts that were conducted over the course of the project. Chapter 4 outlines the structure and operation of the RailRider forecasting model, while Chapter 5 describes the RailRider software. Chapter 6 discusses the current condition of the LIRR with respect to ridership, access mode choice, and parking conditions. Chapter 7 presents RailRider forecasts that were produced for a variety of scenarios specified by the LIRR. Concluding remarks are presented in Chapter 8. Finally, the Appendix to this report contains a printout of the RailRider model output for the Spring, 1986 Base Case. Additional detail and documentation of specific project tasks and the RailRider software are contained in other project reports and technical memoranda that are listed among the Technical References.

CHAPTER 2

STUDY APPROACH AND METHODOLOGY

This chapter presents a summary of the study approach and methodology used in the Access Mode/Parking Demand Study. The chapter is organized as follows. The first section describes the LIRR's objectives for this study. The second section presents an overview of the study approach. The third section discusses some of the key technical issues posed in the project and the rationale for selection of the modeling strategy.

OBJECTIVES OF THE STUDY

The LIRR's principal objective was to obtain a forecasting capability that would enable them to predict the impacts of changes in service levels, schedules, fares, and characteristics of parking at commuter stations (supply, price, and restrictions). A major requirement of the forecasting procedure was that it produce results that were consistent with LIRR system operations and capacity. Specifically, the forecasting methodology had to accurately reflect the capacity constraints that exist in various portions of the LIRR network. Most significant in this regard are limitations in the availability of parking at many LIRR stations. Prior forecasting methodologies developed for the LIRR could not reflect these capacity constraints and therefore produced forecasts that were unrealistic.

Another concern in designing the forecasting capability was to make it durable so that it would not become outdated or unusable as services, fares, or other operating characteristics changed. This was particularly important with respect to anticipated changes in the LIRR's rail network - especially the electrification of the Main Line along with its new station configuration and associated service changes. As a result, the model to be developed was to be flexible enough to incorporate these other changes and still provide a meaningful forecasting capability.

Finally, the forecasting model had to account for the multiplicity of travel choices entailed in predicting traveler response to changes in parking supply and price. These include the choices of whether or not to ride the LIRR and, for those who do, choices of station, access mode, and parking lots (for LIRR riders who use park access only). Travelers do not consider these decisions to be independent of one another. The access mode a rail traveler will select depends greatly upon the station that he uses; the decision to commute by automobile is often motivated (in the LIRR's case) by unavailability of parking at a traveler's preferred station. This interdependence of choice is something that is ignored by many forecasting procedures and results in unrealistic forecasts.

To meet these requirements, Caliper developed a comprehensive network equilibrium ridership forecasting model that explicitly treats the interdependence of these choices made by travelers, physical constraints upon parking lot and system utilization, and consistency between demand levels and level of service supplied.

OVERVIEW OF THE TECHNICAL APPROACH

Our approach to the Access Mode/Parking Demand Study integrated significant technical efforts in market research, travel demand modeling, and network equilibrium analysis. There were four major components of the project.

1. Data Collection and Analysis

While our charter for the project was to develop the forecasting system making use of prior data and models, two separate data collection efforts were required and were performed early in the project. First, a parking inventory was conducted to obtain base data on parking supply and utilization at LIRR commuter stations. Second, survey research was conducted of LIRR riders to collect data that would permit estimation of the importance of parking characteristics upon the key behavioral decisions of station choice, access mode, and parking facility utilization.
In the survey research, data were also collected on current patterns with respect to these travel choices.

In addition to survey research, extensive analysis was performed on LIRR ridership data to establish origin-destination patterns of LIRR riders. A detailed discussion of these data collection and analysis activities is given in Chapter 3.

2. Traveler Preference Analysis

Prior work in analyzing the preferences of LIRR riders (Slavin, et. al., 1982; Caliper Corporation, 1986) was supplemented by estimation of models of the effects of parking fees upon access mode choice and choice of commuter rail versus other modes. Feeder bus utilization models and parking lot choice models were also constructed. The latter model was motivated by the need to estimate the tradeoff between walk times from lots to stations and parking fees. These models were based upon a hybrid of stated preference and revealed preference data and were estimated with discrete choice models of the logit type.

3. Demand Forecasting Model Development and Application using Stochastic User Equilibrium Network Assignment

A unified travel demand forecasting model was developed and applied within the framework of stochastic user equilibrium on a network. In the model, the various choices open to travelers including rail/non-rail mode choice, access mode choice, station choice, and parking lot choice were jointly analyzed in terms of a supernetwork comprised of links representing these alternative travel paths. Values of level of service attributes from traveler preference analysis were used as the basis for determining the perceived disutility or cost of rail network link alternatives.

A stochastic user equilibrium formulation, modified to incorporate capacity constraints, was used to assign travelers to various modes, access modes, and LIRR stations under scenarios specified by the LIRR. The network equilibrium formulation is needed to deal with the fact that in transportation networks, link costs are often dependent upon levels of flow. In particular, congestion makes many links less attractive than they are if utilized well below capacity. The equilibrium solution identifies demand levels that are consistent with level of service at the assigned link travel volumes, greatly enhancing forecast accuracy.

In stochastic user equilibrium, travelers vary in their perceptions of link costs and no user believes that he can unilaterally reduce his disutility of travel by selecting an alternative travel path. For the former reason, stochastic user equilibrium provides much more realistic network assignments than if all travelers perceive link costs to be identical and only the least cost paths are utilized.

This methodology produces forecasts that take account of the effects of congestion and capacity constraints on level of service. Output from the network model provides the LIRR with estimates of parking demand under various scenarios, as well as estimates of the impacts of parking constraints or changes in service on other access modes on LIRR ridership. Because of its general formulation, the model should be useful in addressing a wide range of system planning and evaluation needs over and above those examined in this project.

4. RailRider Microcomputer Applications Software

The equilibrium assignment forecasting methodology was implemented for the LIRR in a custom version of Caliper's RailRider software package. RailRider is a user-friendly microcomputer program that runs on IBM Personal Computers and compatible machines. This software will enable LIRR planning staff to evaluate a broad range of planning scenarios quickly and easily. Despite the fact that the models are much more complex and computationally demanding than those in UTPS and other forecasting systems, we believe that RailRider sets a new standard of ease of use for urban transportation planning software.

DISCUSSION OF TECHNICAL ISSUES AND MODELING STRATEGY

Foremost among the key technical issues to be addressed in this study are the changes that travelers will make in their utilization of the LIRR, LIRR stations, access modes and available parking facilities under alternative service levels, parking capacities, and parking prices. Changes in parking conditions at stations are likely to lead to changes in overall LIRR patronage, station choice by patrons, and the utilization of access modes. Expansion of parking capacity at one or more LIRR stations, for example, may induce some commuters to use the LIRR instead of driving to Manhattan. Current riders whose station choice has been influenced by parking availability may adjust their choice of station to take advantage of the increased capacity. Further, individuals who currently do not drive and park, such as those who are currently dropped off, may choose to switch their mode of access when parking spaces are more readily available. Similar but opposite effects are likely to be observed if parking prices are substantially increased. Current riders may choose to shift to non-LIRR modes, use different stations, or select an access mode that does not require paying the new parking charges. In the event that both capacity is increased and parking charges are instituted it is likely that all of the behavioral changes noted above will apply to some subset of travelers in the LIRR's market. As should be evident, a major difficulty in analyzing responses to parking changes are the myriad and interrelated dimensions of the relevant travel choices.

Another important issue complicating the analysis of parking supply are changes in ridership patterns that will result from implementation of the capital improvement program currently being pursued by the LIRR. These changes, such as electrification of the Main Line to Ronkonkoma, will have large impacts relative to changes in parking fees and include modifications to station locations. Clearly, the capital program will affect the demand for parking at LIRR stations and attempts to model the impacts of parking in isolation from other, stronger influences upon demand would be futile. A comprehensive forecasting system that could predict responses to the broad array of service offerings was required.

One of the major questions motivating this project was an interest in the effects of parking supply expansion upon increasing LIRR ridership. Currently, many parking lots at stations are full to capacity, a fact that makes it difficult to infer the level of utilization that would result if supply were increased. This had two major implications for the modeling effort. First, it was felt that it was necessary to represent capacities explicitly in the forecasting system both for parking lots and also for service supplied to stations. Second, it suggested that inferring traveler preferences from their actual station, access mode, and parking lot choice behavior would be undesirably biased.

Based upon the discussion above, it is important to note that both the disaggregate behavior of travelers and also the aggregate effects of congestion and capacity limitations needed to be addressed in forecasting. Accordingly, a two step approach of quantifying traveler preferences and incorporating these choice determinants in a network equilibrium modeling framework was adopted.

Quantification of Travel Choice Determinants

The network models required estimates of the importance of level of service attributes in influencing the various choices made in traveling to work. In prior work, considerable progress had been made in the application of conjoint analysis of LIRR rider preferences to provide many of the needed inputs.

The methodology by which travel choice determinants were quantified in prior work and in the additional data collection in this project entailed estimation of various species of logit choice models from stated preferences for hypothetical alternatives.

The advantages of utilizing stated preference measurements were several. First, this approach makes it possible to identify responses to new products, services, or conditions that do not presently exist. Second, even when revealed preference data exist, lack of variation in alternatives may make it impossible to quantify accurately the effects of travel determinants. Third, eliciting of responses on likely behavior in response to hypothetical alternatives made it possible to explore linkages among the various travel choices. Fourth, in empirical work, it is often difficult to obtain data on characteristics of unchosen alternatives. In contrast, attributes of alternatives are clearly stated in conjoint/tradeoff experiments. Lastly, budget constraints dictated making the fullest use of available data, much of which had been derived from stated preference analysis.

Several of the measures were taken from data obtained on station choice during the first two weeks of December 1982 (Slavin et. al., 1982). This study, which was based on an onboard survey, contained a component in which commuters ranked in order of preference alternative stations that differed in terms of parking availability/price, proximity to home, electric or diesel service, line haul travel time, fare and seat availability. Ordered logit models were then estimated which provide measures of the dollar value/utility of increments and decrements in these attributes as well as choice probabilities for alternative stations.

Most of the values of level of service attributes used in this study were taken from work performed as part of market research and analysis in the East Side Access study (Caliper Corporation, 1986). In that study, a metric conjoint analysis was conducted of choice of destination terminal on the LIRR. Marginal rates of substitution were estimated between LIRR fare and travel time, egress time, and a transfer at Jamaica. The values from that study were thought to be more pertinent because they were more recent, were based on a more representative sampling plan, and were more accurate than the earlier measurements.

Despite these available results, there was little guidance from prior work with respect to the effects of parking availability and price upon LIRR patronage and access. Transferring these measures from elsewhere, even if it were feasible, seemed highly undesirable and would have been inaccurate as the elasticities would not reflect the preferences of individuals in the LIRR market area. While elasticities could possibly have been inferred from cross-sectional zonal models that contain data on variation of current parking availability and prices, this would have been difficult due to the fact that most lots are at capacity and that there is extremely little price variation among station parking lots. Also the responses to the low level of parking charges currently in place might not be indicative of the behavior in response to much higher parking fees.

For these reasons, a survey was conducted to develop estimates of the effects of parking supply and price upon parking lot utilization, access mode choice, and LIRR mode choice. LIRR riders enjoyed the survey exercise, resulting both in a very high rate of participation (and therefore virtually no response bias) and in a very high completion rate for the information on the survey form itself. Data on both current behavior and stated responses to new alternatives from the survey were analyzed using logit models. The survey research and preference modeling is described in Chapter 3.

Only system-wide values for level-of-service variables were used in the forecasting system due to data limitations. The use of more disaggregate measures specific to geographic zones and a structural model of mode choice are among the logical enhancements to the model that can easily be accommodated within the modeling framework and software.

Demand Forecasting Within an Equilibrium Framework

As indicated previously, a unified demand forecasting model was developed within the framework of network equilibrium analysis. Below we explain some of the fundamentals of this approach and discuss its advantages for forecasting ridership.

In this context, equilibrium forecasting refers to procedures that explicitly account for interrelationships between the level of service on a facility and the volume of persons using that facility. In the following discussion, there are two terms which need to be clearly defined and understood. A path is defined as a set of movements connecting an origin to a destination. In the context of this study, a path is the manner in which an individual travels from Long Island to Manhattan or vice versa. Therefore, a path refers to the combination of choices of mode (LIRR, auto, express bus, etc.), access mode (drive alone/park, carpool/park, Kiss and Ride, Bus, etc.), parking lots (for relevant access modes) and station. The cost of using a particular path is a generalized cost or disutility, and refers to a combination of all of the factors relevant to using that path. In this case, these factors include out-of-pocket expense (for parking, riding the LIRR, paying auto tolls, etc.), access time, line-haul travel time, and numerous other measures of service levels.

The equilibrium approach to forecasting generally requires an iterative solution, according to the following general procedure:

1. Make an initial estimate of the cost of all available travel paths (including modes, access modes, and stations).

2. Based on the estimate of costs from Step 1, assign travelers to the various paths on the basis of the relative generalized cost of each path.

2. Based on the results of the assignment of passengers in Step 2, re-evaluate the costs on the various paths available to travelers. It is very likely that these will be different from the initial estimates, because of congestion or capacity constraint effects. As an example, in Step 1 a parking lot may have been characterized as having many spaces available for LIRR riders. As a result, many travelers were assigned to this parking lot in Step 2. However, this number may be sufficient to cause congestion at this lot, resulting in inconvenience to parkers in the form of longer search times (or increased risk of parking tickets if riders choose to park in illegal or marginally legal spaces). This results in a higher cost on this path.

4. Based on the revised estimates of cost from Step 3, reassign travelers to the various paths on the basis of the relative generalized cost of each path.

5. Repeat steps 3 and 4 until the level of demand and the level of service and cost reach equilibrium.

Figure 2-1 illustrates how an iterative procedure such as that described above reaches an equilibrium solution. In the initial assignment, enough persons are assigned to the facility in question to result in significant congestion. In the second iteration (based on the revised estimate of generalized cost), demand at the facility drops, as travelers find other lower cost paths. In subsequent iterations, demand at the facility levels off to reach an equilibrium point.

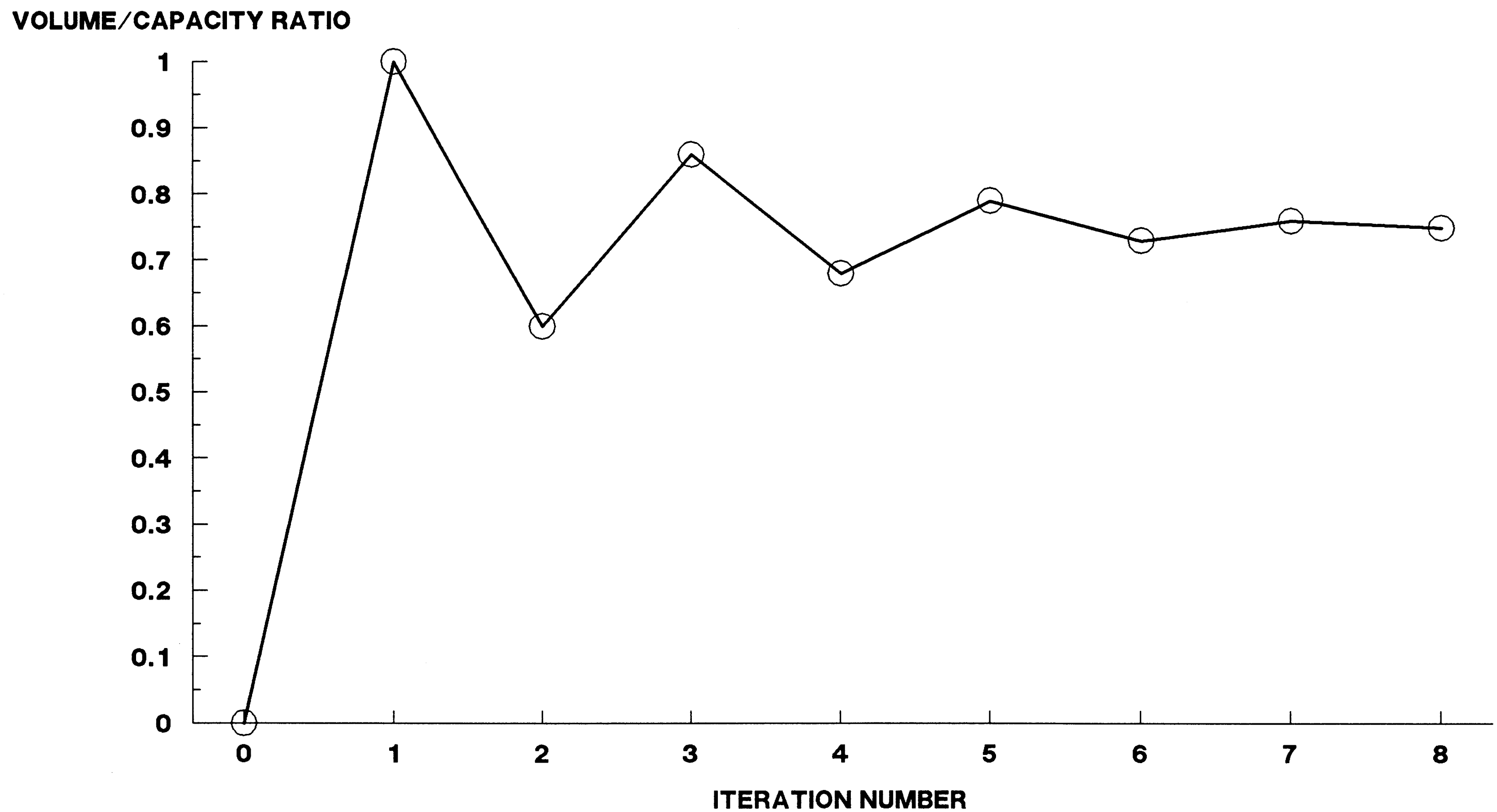
Equilibrium solutions in forecasting are consistent in the fundamental sense that the resultant demand forecasts pertain to supply conditions that would actually exist for the forecast pattern of demand. In contrast, non-equilibrium methods may result in highly inaccurate forecasts when level of service is flow dependent.

A second major advantage of the network modeling approach comes from the joint analysis of choices involved in selection of travel paths. Traditional methods of demand forecasting often split mode choice, access mode choice, and station choice into completely distinct steps, applying separate models in one sequence or another to generate estimates of travel demand. This "sequential" forecasting procedure, while appropriate for certain types of problems, may suffer from a variety of serious flaws. One is that this sequential forecasting method is not appropriate if the actual decision process used by travelers is simultaneous or joint. For example, many LIRR riders jointly choose an access mode and a station at which to board. Applying an access mode choice model followed in sequence by a station choice model (or vice versa) will not accurately reflect the traveler's decision process, and could result in inaccurate or biased forecasts. The network analysis approach does not require this type of arbitrary simplification.

Sequential model application also typically ignores or fails to capture the interaction between level of service and demand. For example, suppose that three separate models are applied in forecasting in the following sequence: mode choice, station choice, and access mode choice. Once the mode choice model is applied, mode choice (under this sequential application) is considered to be fixed and unchanging regardless of the results of the station or access mode choice models. As a result, even if the station choice model predicts extremely high levels of congestion or crowding at certain stations or on certain lines, no shift of riders away from the LIRR will be forecast. This lack of feedback between level of service and demand is a serious deficiency of many commonly used forecasting approaches.

FIGURE 2-1

CONVERGENCE TOWARDS EQUILIBRIUM ON A NETWORK LINK



The joint analysis of the various travel choices was accomplished through the inclusion of different types of links to represent options for the various travel choices commuters make in utilizing the LIRR. This network formulation is sometimes referred to as a "supernetwork" model (Sheffi, 1985). The travel preference analysis results were incorporated by formulating separate generalized cost functions for each type of link utilizing monetary values (i.e. marginal rates of substitution) of the relevant level of service variables.

There is one other key reason for predicting ridership using a network approach rather than direct application of disaggregate demand models. Multinomial logit demand models are technically appropriate when the alternative routes available to travelers are independent of each other. Route alternatives for most travelers are not, however, independent because alternative routes to their ultimate destinations may have significant overlap in their constituent links. These overlaps result in correlations among the route alternatives faced by many individual travelers and can bias the prediction process. The network approach, by explicitly computing the attractiveness (utility) of alternative paths from the LIRR network links, takes into account important correlations among alternative routes. The network approach is also a natural framework within which to take account of residential restrictions on parking. This is done by prohibiting certain network connections between trip origins and restricted parking lots.

For these reasons, Caliper chose to base the forecasting system on network equilibrium analysis. The specific approach selected is known in the technical literature as "stochastic user equilibrium" (Daganzo and Sheffi, 1977).

There are two types of network equilibrium analysis that might have been utilized - <u>deterministic</u> user equilibrium and <u>stochastic</u> user equilibrium. The traditional, deterministic approach is based on three key assumptions, all of which imply that travelers are perfectly rational in their decisionmaking. First, it assumes that link travel times do not vary. Second, it assumes that all travelers have perfect information concerning the characteristics of alternative routes. Finally, it assumes that all travelers choose the least cost route to their destination. These assumptions lead to the following property of the flows assigned to the network: all <u>used</u> paths between a given origin and a given destination have identical costs, and all <u>unused</u> paths have a higher cost. This property is, however, unrealistic both conceptually and empirically. Paths with different costs are commonly utilized by travelers. This may be the result of imperfect knowledge of alternatives, varying perceptions, or varying level of service experienced by different travelers. Stochastic user equilibrium more closely matches these real world phenomena.

Finally, stochastic user equilibrium is the technically correct joint solution to aggregation and equilibrium problems when demand is specified by disaggregate demand models based on discrete choice models such as logit and probit. In this respect, it permits us to achieve complete integration of the travel choice models and network analysis.

Algorithmic solutions for stochastic user equilibrium have only recently been developed and there has been only limited empirical experience with these models. However, application of a small scale stochastic equilibrium model for predicting destination terminal utilization on the LIRR was performed successfully by Caliper as part of the East Side Access study and provided an indication of the feasibility of the network approach. A detailed description of the implementation of the the network equilibrium model appears in Chapter 4 of this report.

CHAPTER 3

DATA COLLECTION AND ANALYSIS

This chapter describes the principal data collection and analysis activities performed in the course of the project. These activities included:

* An inventory of parking supply and utilization at commuter stations,

* An on-board survey to collect information on rider response to variations in parking supply and price,

* Analysis of traveler preferences based on the on-board survey data,

* Analysis of LIRR Passenger Census survey data, and

* Analysis of LIRR Tick Sheet passenger count data.

These data collection and analysis efforts were undertaken to provide input data and Base Case ridership and system performance information required for the development and calibration of the RailRider forecasting model. Separate reports and technical memoranda presented the detailed methodology and results of these data collection and analysis efforts; the sections that follow present a summary of these reports.

THE PARKING INVENTORY

In order to provide base data on parking capacity and utilization for the forecasting model, this study included a comprehensive parking inventory data collection task. The LIRR had previously conducted a systemwide parking inventory in 1980, and additional data on parking supply and utilization were available for some stations as a result of work done by the New York State DOT in 1982. These prior data, however, did not reflect the large number of changes that have taken place in parking supply and price and in LIRR travel demand levels and patterns. As a result, the LIRR elected to conduct a comprehensive new parking inventory to replace the old inventory information and provide a new and consistent database on which the forecasting model could be constructed.

This new parking inventory (referred to below as the 1985 parking inventory to distinguish it from the 1980 effort) was conducted by a data collection team that was specially trained for this purpose. The inventory covered each of the 110 commuter stations that were studied in the 1980 LIRR Parking Inventory, and collected the following data:

* Lot Type (paved lot, unpaved lot, garage, on-street)
* Markings (marked, partially marked, unmarked)
* Capacity (restricted and unrestricted, nominal and actual)
* Utilization (restricted and unrestricted)
* Distances to the station platform
* Estimated time to park
* Safety and handicapped access ratings
* Cost of Parking (daily and hourly, restricted and unrestricted, weekday and weekend, peak and offpeak)
* Methods of parking fee collection

Unlike the 1980 inventory, an attempt was made to collect detailed capacity and use information for on-street parking spaces at stations where these represented a significant parking resource. In addition, the following supplemental information was collected at key parking facilities at selected stations:

* Utilization at several time points
* Auto occupancy
* Portion of usage due to LIRR
* Time of day at which the lots fill
* Peak arrival time

Fieldwork staff also noted other characteristics, conditions, and points of interest at parking facilities and at stations to assist in later interpretation of the inventory data. In particular, detailed notes were made of unusual types of restrictions that applied at the various facilities. A complete description of the parking inventory methodology appears in the Parking Inventory Project Plan (Caliper Corporation, 1985).

All of the parking inventory data were compiled into a microcomputer database using dBase III, and delivered to the LIRR for review and comments. In reviewing these data, LIRR staff noted several instances in which there appeared to be significant inconsistencies between the 1985 inventory and previously available data. As a result, project staff re-inspected 24 stations at which large discrepancies had been identified. Lot capacities at these stations were verified, and attempts were made to identify lots that may have been missed or erroneously included in the 1985 inventory.

For the most part, the discrepancies between the 1985 Caliper Corporation inventory counts and prior data were attributable to one of several sources. First, Caliper's inventory included on-street parking, which was omitted from previous lot inventory efforts. Second, there were several cases in which lots had closed, been expanded, or restrictions changed since the prior data collection efforts. Third, there were instances in which the 1985 inventory failed to identify the existence of valid commuter parking areas. Finally, determination of the number of parking spaces located beneath elevated LIRR tracks or in unpaved and/or unmarked lots often involved a good deal of judgment and interpretation, and was found to be a major contributing factor to discrepancies between different sets of counts.

As an additional step in completing the parking inventory database, telephone conversations were held with representatives of towns and townships in the LIRR service area. These efforts were directed principally at discerning the types of restrictions in effect at parking facilities that were not clearly marked. While the database was enhanced significantly through this effort, there were numerous parking facilities for which no detailed information was obtained.

After the lot re-inspection and telephone research, a revised final version of the parking inventory database was delivered to the LIRR. This database continues to be used by the LIRR for general planning purposes, and was also used in the model development process as the basis for developing parking lot input files. As a further note, the parking lot files used by the final version of the RailRider software incorporate changes to LIRR parking facilities that are more recent than the final version of the parking inventory database.

ON-BOARD SURVEY OF LIRR RIDERS

Extensive information concerning the travel behavior of LIRR riders was available prior to this study. Previous travel behavior survey research conducted by the LIRR focused on origin station choice and destination terminal choice, and provided the LIRR with information and quantitative measures of the importance of a variety of characteristics of LIRR service, including fare, travel time, access and egress time, diesel versus electric service, transfers, etc.

For this study, however, better information was required on traveler response to specific characteristics of parking facilities. In particular, there was little or no available information on the effects of parking at LIRR stations on mode choice, access mode choice, and parking lot choice. The purpose of this on-board survey of LIRR riders was to collect this additional information in a manner suitable for model estimation and application in the RailRider forecasting model.

Accordingly, an on-board survey was conducted with over 900 LIRR riders. Two different survey forms were distributed, one for riders who accessed the LIRR in a car that was parked at or near the station, and one for riders who accessed the LIRR on foot, by Kiss & Ride, or by any other access mode. A summary of the results of this on-board survey appears below. A detailed description of the survey methodology and results appears in the Phase I Technical Memorandum (Caliper Corporation, 1986).

Almost three-fourths (73.6 percent) of LIRR riders who use park access use the LIRR station closest to their home. The most common reasons for using a station other than the closest one to home were shortage of parking spaces and poor train service. Among riders using other access modes, 89.5 percent boarded the LIRR at the station closest to home. Nine out of ten respondents make all of their LIRR trips through the same station; very few use more than one station on a regular basis.

Survey respondents were asked to predict the impact of several changes in station and parking characteristics on their choice of station and access mode. If their current station were permanently closed, a small percentage of commuters would no longer use the railroad and would instead commute via other modes of transportation. Of the remainder, most would switch to a nearby station on the same branch. Most LIRR riders would continue to use the same access mode.

Riders who currently park at LIRR stations were asked how they would respond if parking were no longer available at their usual station. Over half would continue to use the same station, while one-third would switch stations, and about 5 percent would switch to some other mode of transportation. Of those who would continue to use the same station, most would use Kiss & Ride or walk access or would park illegally near the station.

Riders who currently use park access are sensitive to changes in parking price. If parking cost $1.00 per day at all station lots, only about half would continue to park at LIRR stations, while the remainder would change access modes or use a different travel mode altogether. At daily rates of $2.50 and $4.00, only 15 percent and 5 percent, respectively, would continue to park at the station.

Among LIRR riders who use other access modes, 23.4 percent said that they used these other modes because no parking spaces were available at their preferred station, while another 6.2 percent said they wished to avoid paying parking fees. If free parking spaces were available at all LIRR stations, almost one-third of these riders (mostly those who currently access via Kiss & Ride) would elect to drive and park at the station instead.

Only one in four LIRR riders have feeder bus service available. Eighteen percent of respondents said they would use feeder bus service if it were available at a cost of $1.00 per ride; 28 percent would use it at a cost of $0.50 per ride. Kiss & ride access was feasible for only a relatively small proportion of

LIRR riders. Very few riders found carpooling an attractive access mode option; most riders said that it would be difficult or impossible to arrange a convenient carpool, even if preferential parking for carpools was provided as an incentive.

ANALYSIS OF TRAVELER PREFERENCES

This section of the chapter presents the results of estimation of demand models based on the on-board survey data. These demand models were estimated for the principal purpose of obtaining measures of the value of the various components of generalized cost associated with travelers' overall decisions to use alternative stations, access modes, and parking lots.

Because of the requirements of this specific application, a number of conditions and restrictions were placed on model specifications. First, because the interdependence of these travel decisions is explicitly accounted for by the network formulation of the forecasting system, separate (i.e. independent) demand models were estimated for each of the travel decisions mentioned above. Second, demographic variables were omitted from the choice models that were estimated solely to obtain values of service characteristics for network modeling. Demographic variables were, however, incorporated in demand equations where they were both relevant on theoretical grounds and of practical import in model application.

Response to Parking Charges

Because parking is free at most LIRR stations, institution of significant parking charges has the potential to induce LIRR riders to change their travel behavior in terms of stations and/or access modes utilized and may also induce some riders to travel to their destinations by non-railroad modes. To quantify changes in access mode and overall travel mode, a model of these shifts was estimated as a function of the price of parking. The demand relationship for station choice was modeled previously (Slavin, et. al., 1982).

In the survey, travelers who currently park at LIRR stations were asked what they would do if parking fees were $1.00, $2.00, and $4.00 at all stations. Based upon these responses, we developed a model of the choice between the options of continuing to pay-to-park at an LIRR station and that of either changing access mode or changing to a non-LIRR travel mode. The functional form that was used was a binary logit model estimated on the observations of the survey responses for travelers who now drive and park. Current behavior was included in the model as an additional observation per individual with currently paid fee entered as the price of the parking alternative. The results of the model estimation are shown in Table 3-1.

TABLE 3-1

PARKING FEE MODE CHOICE DEMAND MODEL

Parameter	Estimate	Std. Error	t-Statistic
Constant	1.960	0.126	15.56
Parking Fee	-1.383	0.070	-19.72

Observations: 1459
Asymptotic R-Squared: 0.365

Due to the requirements of the network analysis, a sparse model specification with an alternative specific constant was utilized along with the parking price variable. Calculation of the marginal rate of substitution between parking fee and changing access mode revealed that at a parking fee of $1.42 per day, travelers would be as likely to pay the fee as to change access mode.

Table 3-2 utilizes this model to compute the estimated probability or (sample) market share of parkers as a function of the parking price. The table also includes the estimated elasticity of parking choice with respect to price. As is indicated, parking is elastic in the region above $1.50. This may be in part a reflection of the fact that both peak and off-peak travelers were included. These results are also similar to the arc elasticities, also shown in Table 3-2, that were computed directly from the survey responses.

Feeder Bus Access Mode Choice

An exploratory model was made of respondents' projected utilization of feeder bus service if it were to become available. The estimated model parameters for this binary logit model are provided in Table 3-3. The probability of feeder bus use is negatively influenced by having a car available, use of walking or car travel as a current means of access, high income, and parking price. Both longer access distances and current bus availability and use are associated with higher probabilities of utilization of feeder bus. The model indicates that among those who currently access the railroad by car or on foot, less than one-fifth would use convenient feeder bus service if it were made available at a fee of $1.00.

Parking Lot Choice Model

Customer preferences for parking lot choices differing in price and walking time to the station were analyzed by means of a model based on the tradeoff questions in the on-board survey. Because of the discrete binary nature of the response variable, a binary logit functional form was utilized. The explanatory variables were a constant, walking time in minutes, and daily parking cost in dollars.

The estimation results for the parking lot choice model are reproduced in Table 3-4. As is indicated there, the time and cost variables are highly significant. The implicit tradeoff or marginal rate of substitution between parking price and walk time from the lot to the station is $0.10 a minute. This means that parkers are indifferent between a lot that is 2 minutes from the station and costs $1.00 and a lot that is 8 minutes from the station, but has a daily fee of $0.40. This valuation of $6.00 per hour of walking time from one's car to station is reasonable in light of similar measurements Caliper and others have made of

TABLE 3-2

PARKING ACCESS MODE SHARES AND ELASTICITIES

As Estimated From the Logit Model

Fee Level	Share	Elasticity
$0.00	87.7 percent	0.00
$0.25	83.4 percent	-0.06
$0.50	78.1 percent	-0.15
$0.75	71.6 percent	-0.30
$1.00	64.0 percent	-0.50
$1.25	55.8 percent	-0.77
$1.50	47.2 percent	-1.10
$1.75	38.7 percent	-1.50
$2.00	30.9 percent	-1.91
$2.25	24.0 percent	-2.36
$2.50	18.3 percent	-2.82
$2.75	13.7 percent	-3.28
$3.00	10.1 percent	-3.73
$3.25	7.4 percent	-4.16
$3.50	5.3 percent	-4.58
$3.75	3.8 percent	-4.99
$4.00	2.7 percent	-5.38

As Estimated From the Survey Data

Fee Level	Elasticity
$1.75	-1.29
$3.25	-2.12

TABLE 3-3

FEEDER BUS ACCESS MODE DEMAND MODEL

Parameter	Estimate	Std. Error	t-Statistic
Constant	1.040	0.411	2.53
Have Car Avail.	-0.672	0.194	-3.46
Distance	0.116	0.024	4.90
Walk	-0.613	0.394	-1.56
Drive	-0.744	0.351	-2.12
Have Bus Avail.	0.261	0.150	1.74
Income	-0.008	0.003	-2.75
Male	-0.098	0.147	-0.67
Bus Fare	-1.097	0.284	-3.87

Observations: 645
Asymptotic R-Squared: 0.090

TABLE 3-4

PARKING LOT CHOICE DEMAND MODEL

Parameter	Estimate	Std. Error	t-Statistic
Constant	0.458	0.186	2.46
Time	-0.127	0.027	-4.70
Cost	-1.244	0.093	-13.38

Observations: 1466
Asymptotic R-Squared: 0.107

the value of access time. The positive intercept reflects the fact that if faced with only two choices, a majority of individuals would rather park free and walk ten minutes than pay a considerable fee to park at the station.

In the course of the analysis, we also examined whether the value of walk time from parking lots to stations differed as a function of individuals' access times. This was done by estimating the same model as described above for two separate groups of parkers--those with access times greater than and less than eight minutes. As expected those with the shorter access times had a higher value of walk time to the station. However, the two values of time, which were $0.11 and $0.09 per minute, respectively, were nearly identical.

The coefficients of these models and implied marginal rates of substitution between various service characteristics were applied in the RailRider model by their inclusion in the calculation of generalized cost. The complete set of marginal rates of substitution (model coefficients) used in the RailRider model is described in Chapter 4 of this report.

LIRR PASSENGER CENSUS DATA ANALYSIS

In Fall, 1985, the LIRR conducted an on-board survey with over 10,000 AM peak period riders. This survey, known as the Fall 1985 Passenger Census, was designed in part to provide access mode information to supplement other Parking Study data collection efforts. In addition, the survey contained a great deal of information that was potentially valuable in the development of a complete description of current (Base Case) conditions. As a result, the keypunching and preliminary analysis of Passenger Census data were incorporated into this study.

A key motivation for processing the Passenger Census data was to use some of the survey information in developing a current origin-destination station to station demand matrix that could provide a basis for model calibration. Additionally, it was hoped that access mode distributions on a station by station basis could also be derived. Originally, these were to be derived using both the Passenger Census data <u>and</u> the so-called "Tick Sheet" data (described in more detail below). The tick sheet data analysis was to be performed by LIRR staff while the project team processed the Passenger Census data; this work was unfortunately delayed, and the tick sheet data analysis was later incorporated into this study as well (see the following section).

The Passenger Census Data were coded, keypunched, and cleaned, and finally placed into SAS datasets and delivered to the LIRR. Included in these datasets were survey weights that were intended to expand the survey sample to represent the entire LIRR population. Because the tick sheet data were not yet available in processed form, these weights were considered preliminary and were, in fact, discarded later in the course of the project. Complete SAS file specifications, coding conventions, and preliminary unweighted and weighted tabulations and univariate statistics were presented in the Fall 1985 Passenger Census Technical Memorandum (Caliper Corporation, 1985). This technical memorandum also presented a preliminary station-to-station demand matrix.

Review of the preliminary matrix by LIRR staff indicated that there were significant biases in the Passenger Census data, with westernmost stations significantly underrepresented. This is likely explained by the small amount of time that was available for boarders at these western stations to complete the survey before alighting.

TICK SHEET DATA ANALYSIS

The Fall 1985 Passenger Census data were collected from riders traveling in specific cars on AM Peak trains. Riders in all other cars on these trains were the subject of a related data collection effort. LIRR representatives traveling in these cars asked each rider to report their origin station, destination station, and the type of ticket used for the trip. These data were recorded by tick marks on appropriate data collection forms; hence, these data are referred to as the "tick sheet" data. These data were collected on over 80 percent of AM peak period trains, and were invaluable in the development of an improved origin-destination matrix.

The tick sheet data consisted of a series of data records, each containing a train number, a car number, an origin station, a destination station, and the number of persons traveling between those two stations on that car of that train by each of four ticket types - monthly tickets, weekly tickets, one-way full fare tickets, and employee passes. These data were delivered to the project team in a set of microcomputer data files, and were analyzed as follows.

First, a single large spreadsheet was created aggregating all of the individual tick sheet files. Second, validity checks were performed on the data to identify and, where possible, correct for obvious errors or irregularities (these are discussed in the paragraphs that follow). Third, tick sheet data were aggregated across ticket types and across the individual cars of a particular train, because analysis at the ticket type or passenger car level was not required for this project.

Next, tick sheet data records were synthesized for those trains on which data were not collected. This was done by matching trains for which no data were available to trains for which data were available. This matching was based upon similarity of train destination and stop/transfer patterns. Often, manual adjustments were made to the synthesized tick sheet records to correct for slight variations in stop patterns, or for the likely effects of other scheduling variations. Presence of high-speed flyer service at a particular station shortly before or shortly after a particular local train, for example, was assumed to affect the origin station distribution on the local train. The identification of trains containing passengers who had transferred from diesel scoots also required manual corrections to the data.

Finally, after tick sheet data records existed for all peak period trains through Jamaica, the raw tick sheet data were weighted to reflect total train by train ridership as per the LIRR Transportation Department Ridership Book. This weighting was performed for two time periods -- Fall, 1985, and Spring, 1986. This resulted in detailed train by train breakdowns of trip origins and destinations. From this, station-to-station origin-destination matrices were derived. These matrices were delivered to the LIRR in Caliper Corporation (1987). This memorandum also contained revised weighted Passenger Census tabulations based on a new set of survey weights that were, in turn, based upon the new O-D matrices, and also contained reports of detailed train-by-train ridership composition for Fall, 1985 and Spring, 1986.

Several types of irregularities were noted in the tick sheet data. First, there were strong indications that many of the data collection staff were not sufficiently clear in wording the questions that were asked of LIRR passengers. The raw data indicated that an unexpectedly large number of riders reported Jamaica as their ultimate destination. This indicated that riders were responding to the question, "At what station are you getting off this train" rather than the question, "At what station are you finishing your LIRR trip." As a correction, it was assumed in the analysis that the only valid Jamaica destinations were those reported by LIRR employees (those with LIRR pass as a ticket type); all other passengers with Jamaica reported as a final destination were omitted from the analysis.

There were also problems in the reporting of origin stations. Unusually high reported passenger volumes at intermediate transfer points indicated that many riders who had boarded in diesel territory and transferred to electric trains reported as their origin the transfer point rather than their original boarding station. This indicated that riders were responding to the question, "At what station did you board this train" rather than "At what station did you begin this trip." This problem resulted in an overestimate of boarders at certain origin stations (Hicksville, and perhaps Babylon and Huntington to a smaller extent), and an underestimate along the corresponding diesel service areas. The tick sheet sampling plan included no data collection on diesel trains that terminate East of Jamaica and connect with electric trains, because riders on these trains would be surveyed on the corresponding electric train. Therefore, there was no basis for evaluating the extent of the distortion that results from this problem. The train counts and O-D matrices derived from the tick sheet data therefore did not incorporate any correction.

Finally, it appeared that many trip destinations were systematically excluded from the tick sheet data collection. The only reported destinations in the data were Penn Station, Flatbush, Hunterspoint Avenue, Flushing, Woodside, Forest Hills, and Jamaica. No trip destinations were reported for Long Island City branch stations, for intermediate Flatbush Branch stations (E. New York; Nostrand Avenue), or for any stations located east of Jamaica. This was a clear bias in the data for which no correction could be made.

The Spring, 1986 station to station origin-destination matrix developed from the tick sheet data was incorporated into the Base Case RailRider model calibration with several adjustments. First, since the RailRider model was designed only for Manhattan-bound travel, trips with Jamaica destinations (which represent LIRR employees traveling on passes) were excluded. Second, adjustments were made to the boarding counts at several stations (most notably Hicksville and Ronkonkoma) to attempt to correct for bias resulting from incorrect reporting of origin stations, as described above.

CHAPTER 4

THE RAILRIDER FORECASTING MODEL

This chapter describes the structure, operation, and computational methods used by the RailRider forecasting model. The RailRider model is a forecasting system that generates estimates of the travel choices that will be made by commuters in the Long Island to New York City travel market. These forecasts are based on characteristics of the LIRR system and associated parking facilities. RailRider is designed to forecast demand for the AM peak commutation period, and therefore models only inbound commutation trips. The scope of the model includes all trips bound for New York City, ignoring trips with final destinations in Eastern Queens, Nassau, and Suffolk County. The model encompasses all modes of travel, although all non-LIRR travel modes are aggregated within the model. The LIRR system is modeled in great detail, with individual stations and parking facilities included at the most disaggregate level.

The RailRider model represents the region as a network, which in its most basic form consists of two types of elements: <u>nodes</u>, which are points in the network, and <u>links</u>, each of which connects two nodes. Travel flows can occur between any two points in the network along any sequence of links (a <u>path</u>) connecting them. The movement between any pair of nodes along a link may have some impedance or generalized cost associated with it. Nodes, on the other hand, do not have any costs associated with them.

In RailRider, commutation trips are generated at 50 origin zone nodes covering the counties of Queens, Nassau and Suffolk. These trips are all destined for a single destination zone node representing New York City. Commuters have a large number of alternative paths to complete a trip from an origin node to the destination node. These paths traverse nodes and links of several types, representing various paths through the LIRR system and alternate paths using non-LIRR modes of travel. Certain links represent facilities with a limited capacity. These capacity constraints are modeled explicitly in the system.

RailRider evaluates the various paths available to travelers by estimating the total cost of each path. This cost is computed by summing the costs over all the individual links which make up that path. Based on the total cost of the available paths, RailRider assigns the demand between any two points in the network to appropriate paths.

RailRider is an equilibrium model. This means that the cost of traversing a link may depend upon the volume of travelers using that link. Therefore, the model is designed to re-evaluate the costs of alternative paths on an iterative basis, and re-assign some portion of travelers based on the revised estimate of path costs.

In addition, RailRider is a stochastic model. It represents the cost associated with traversing a link as a sample from a distribution of costs. At each iteration, RailRider adds a random component to the cost of certain types of links to simulate the stochastic effect. For a detailed discussion and theoretical justification of the stochastic user equilibrium approach, see Chapter 2 of this report.

The remainder of this chapter presents details on the RailRider network structure, the link cost functions and marginal rates of substitution incorporated in the model, the computational methods that are used by RailRider, and the process through which the RailRider model was calibrated to base case conditions.

THE RAILRIDER NETWORK

The RailRider system contains 6 types of nodes and 9 types of links connecting them. For simplicity of presentation, the RailRider network can be subdivided into three subnetworks:

* An LIRR subnetwork, representing train service provided by the LIRR;

* Parking lot subnetworks, representing parking lots serving LIRR stations; and

* Access subnetworks, representing major LIRR service areas and accessibility to LIRR stations and to New York City by other modes.

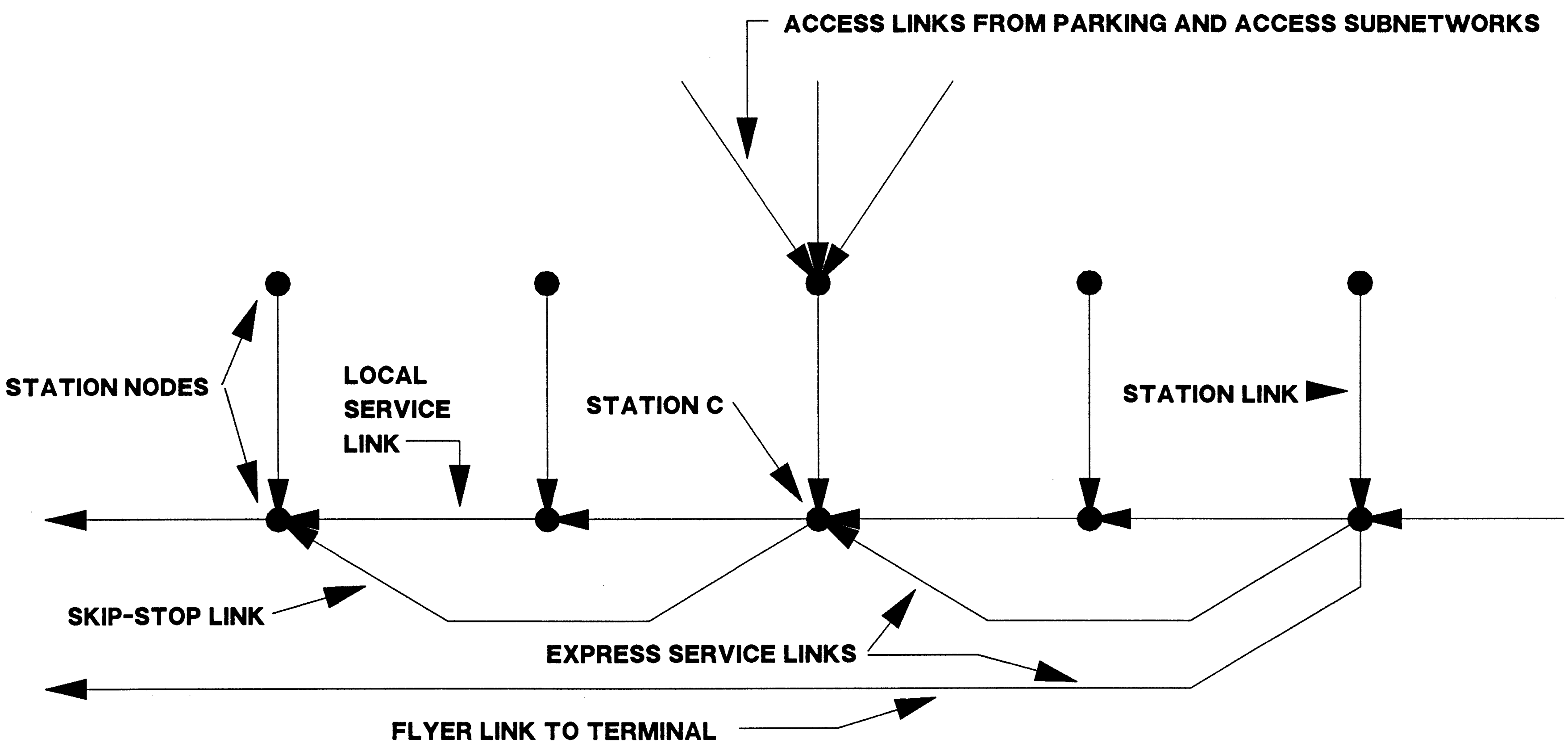
Each of these subnetworks is described below.

The LIRR Subnetwork

The LIRR subnetwork consists of nodes representing LIRR stations and links representing train service between these stations. An illustrative schematic of the LIRR subnetwork is shown in Figure 4-1. Each station is represented by two nodes with a link connecting them. Service links are of two types: local and "express." Because the availability of express or flyer train service is a significant factor in a traveler's perception of the quality of service, local and express links have been modeled explicitly. As a result, many stations in the LIRR subnetwork have more than one inbound and/or outbound connection to other

FIGURE 4-1

THE LIRR SUBNETWORK



stations. The existence of express service links at any station node depends upon whether or not the LIRR provides skip stop or flyer service into or out of that station. In the figure, station C is the destination of one express link, and the origin of another (in this case, a skip stop link).

LIRR station links have the following costs associated with them:

* LIRR Fare
* Wait time at the station platform

Local and express service links have the following only one component of cost associated with them:

* Travel Time (including station dwell time)

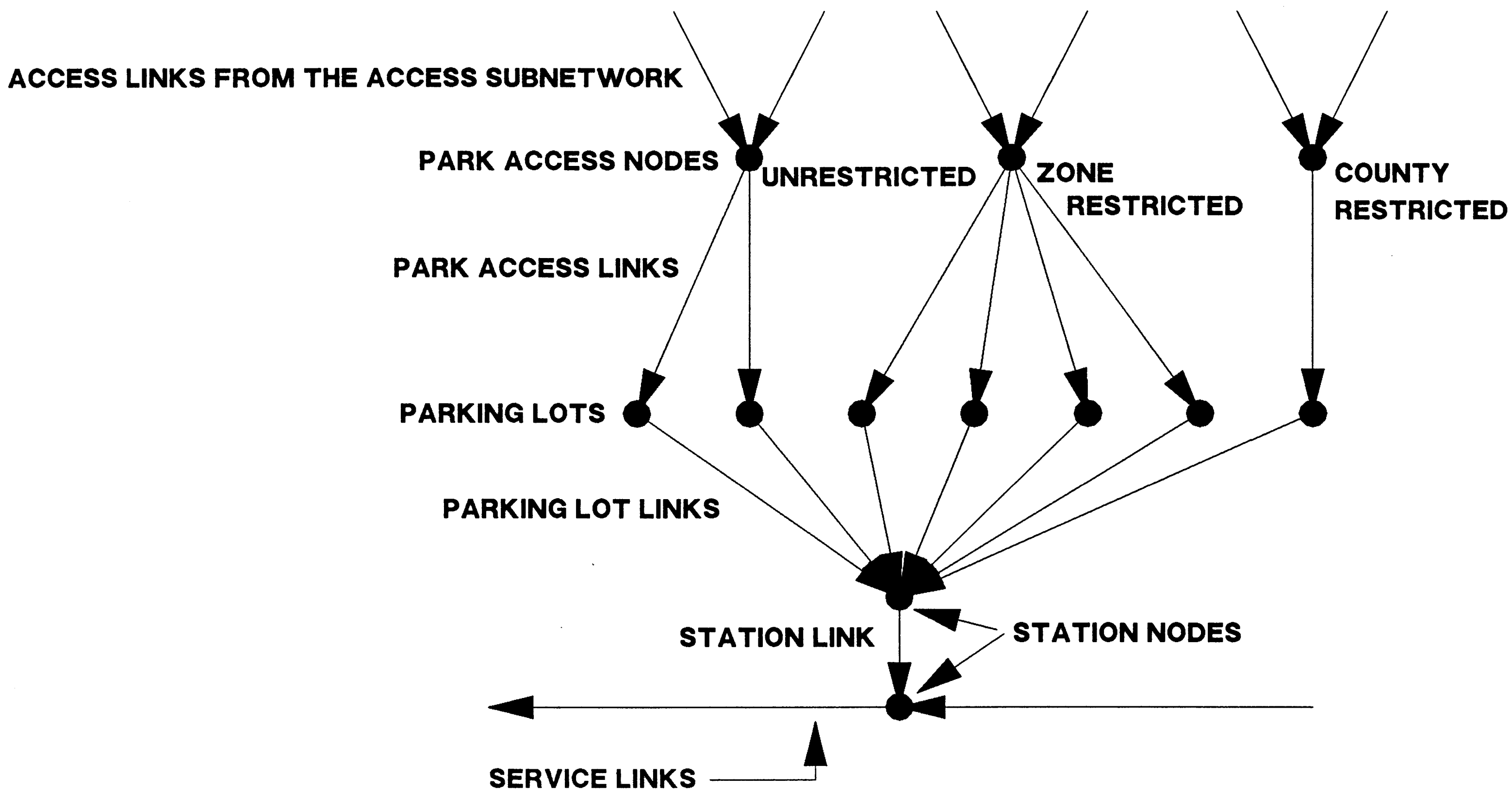
Local and Express service links also have capacity constraints associated with them. Service links located East of Jamaica station have a capacity equal to the number of AM peak seats serving that link. This constraint effectively implements the LIRR's stated service goal of providing a seat to all LIRR riders East of Jamaica. West of Jamaica, service links have a capacity of 130 percent of the number of seats serving that link. This is considered to be crush load capacity by the LIRR.

The Parking Lot Subnetwork

Each LIRR station has associated with it a parking subnetwork that connects the station platform with any available parking facilities. An illustrative schematic of a parking subnetwork appears in Figure 4-2. It consists of one or more nodes representing the various types of parking available at that station (called "park access" nodes), and an additional node representing each parking lot. Links connect each parking access node to each lot and each lot to the LIRR station. Parking access nodes are of four types - unrestricted, zone restricted (representing village resident only lots), county restricted, and non-zone restricted (representing non-village resident only lots). The number of park access nodes at any given station depends on the variety of parking restrictions in effect at the lots serving that station.

Every individual parking facility is represented by a single node and link connecting it to the station. In addition, all available on-street parking at a station is represented by a similar structure. In some cases, where a single parking facility contains spaces with different types of restrictions (e.g., 150 unrestricted parking spaces and 250 spaces reserved for village residents) or with different prices (e.g., 150 free and 250 metered spaces) the lot has been represented in the network as two separate lots within the structure of the model.

FIGURE 4-2
THE PARKING LOT SUBNETWORK



Links between parking lots and stations have the following costs:

* Daily parking cost
* Walk time from the lot to the station platform

In addition, these links have a capacity equal to the maximum number of riders who can park at the lot. This is usually the product of the capacity of the parking lot (in units of cars) and the average occupancy of autos parking at that station (in units of passengers per automobile).

Links connecting the park access nodes to the individual parking lots are pure connectors, and have no impedance or other characteristics.

<u>The Access Subnetworks and Zone Structure</u>

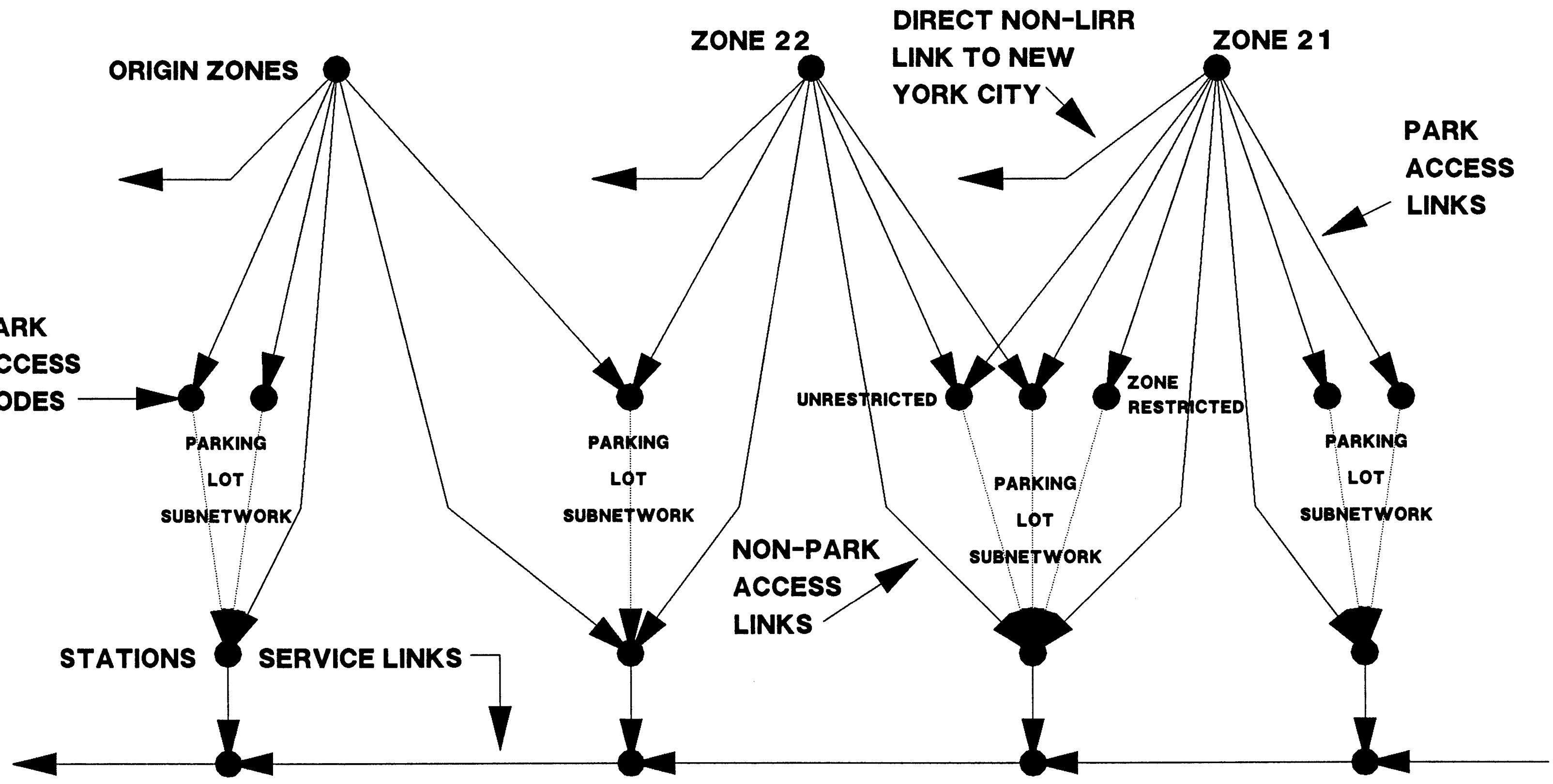
All trips in RailRider begin and end in <u>zones</u>, which are special nodes representing geographical areas. The final part of the network, then, is the set of access subnetworks which define the zones and connect them to the LIRR stations. There is one access subnetwork for each zone. Each one contains one node (the zone) and three or more links: one link connecting the zone directly to the destination (New York City) zone, representing the service provided by non-LIRR modes (subway, express bus, and automobile), and two or more links for each LIRR station used by residents of the zone. These links represent the accessibility of the station by park access and other access modes. This structure is displayed in Figure 4-3.

The link representing the non-LIRR connection between each zone and New York City has the following costs:

* Composite non-LIRR path cost, which is computed as a weighted average of auto travel time and cost (including parking and tolls) and subway travel time and fare

The number of links connecting zones to parking access nodes depends upon the number of park access nodes at the station and on the restrictions that apply to the zone and station in question. Stations that have only unrestricted parking will have only one park access node that is connected to eligible zones. If a station has both unrestricted and restricted parking, all zones served by the station will have a connection to the unrestricted parking access node; only zones which are eligible to use restricted parking facilities at that station will be connected to the restricted parking access node. In Figure 4-3, travelers from origin zone 21 are eligible to use the zone restricted parking facilities at station B, while those from zone 22 are not. Zone to park access node links have the following costs:

FIGURE 4-3
THE ACCESS/ZONE SUBNETWORK



* Travel time from the zone centroid to the station
* Travel cost of driving from the zone centroid to the station

Each zone and eligible station are also connected by one non-park access link that represents the aggregate of all other access modes. The non-park access links have the following cost:

* composite cost and time involved in traveling from the zone centroid to the station on foot, by Kiss & Ride, or by feeder bus

The access subnetwork has one final component -- a set of three links which connect the three LIRR terminal stations to the New York City destination. These links represent egress from the LIRR to the commuter's final destination. As indicated earlier, the network representation of the portion of the LIRR network located West of Jamaica station is a very simple one; a very detailed representation of this portion of the network (including zip code destination zones in Manhattan and relevant NYCTA subway connections) was constructed as part of the LIRR's East Side Access Study (Caliper Corporation, 1986) and incorporated into the Terminal Choice Forecasting Model.

Size of the Base Network

The Base Case network has a total of 1930 links, as follows:

Local Service links	113
Express Service links	59
Station links	107
Parking Lot to Station links	444
Park Access Node to Parking Lot links	445
Origin Zone to Park Access Node links	369
Origin Zone to Station (Non-Park) links	340
Origin Zone to New York City (non-LIRR) links	50
Egress links	3
Total links	1930

The base case network has a total of 846 nodes, as follows:

Origin zone nodes	50
Destination zone nodes	1
Station entry nodes	107
Station service nodes	107
Parking lot nodes	444
Park access nodes	137
Total nodes	846

Note that the size of the network is not fixed by the RailRider model. Changes in LIRR stations, service, and parking facilities can result in a change in the number of links or nodes required to represent the system. The RailRider network builder (described in the following Chapter) automatically accommodates this variability in network size.

LINK COSTS AND MARGINAL RATES OF SUBSTITUTION

Each link in the RailRider network has certain costs associated with it, as described previously. More generically, four types of costs can apply to a network link, as follows:

* Out-of-pocket cost (in dollars);
* Time (in minutes);
* Congestion penalties, which depend upon the ratio of link loading to link capacity; and
* A random cost element, which simulates the stochastic nature of link costs (discussed below).

While some of these costs are expressed in dollars and others in terms of units of time, RailRider requires that all costs be converted into dollar equivalents. Therefore, all costs dimensioned in units of time must be converted into dollar cost equivalents. This is accomplished using marginal rates of substitution as derived from travel demand models. The applicable marginal rates of substitution used by RailRider are as follows:

LIRR and Other Mode Travel Time and Wait Time at LIRR Stations.......	$4.50/hour
Access Time to LIRR Stations.............	$5.22/hour
Walk Time From Lots to LIRR Stations......	$6.00/hour
Egress Time From LIRR Terminals...........	$2.94/hour
Diesel Service Penalty....................	$0.48

The third component of link cost described above is congestion cost, which represents the deterioration in service quality experienced by users of certain facilities as they become more heavily utilized. Congestion cost applies only to a few types of links in the RailRider system. Service links have a congestion cost penalty that increases as the number of riders approaches the link capacity. This simulates the increasing probability of riders having to stand as the number of AM peak riders approaches the number of AM peak seats in service, and is based on the cost penalty function derived for the East Side Access Study. Parking lot links also have a small congestion penalty that simulates the travel time associated with searching for a space in a lot that is nearly full.

Non-rail links that directly connect origin zones to the New York City destination also have associated congestion penalties.

These penalties reflect (albeit somewhat crudely) the delays that result from increased highway congestion and the discomfort that results from increased subway crowding.

Finally, non-park access links connecting origin zones to stations have a flow-dependent penalty associated with them. Most non-park access is on foot, attributable to residents of the area immediately surrounding LIRR stations. As the number of travelers walking to LIRR stations increases, these additional riders come from locations further away from the station, increasing the average access time. The flow-dependent penalty on non-park access links simulates this effect.

All of the congestion cost functions used by RailRider are exponential in form, with different exponents and scalar multipliers for each link type. On service links, these coefficients were determined based on the value of seat availability, just as they were in the East Side Access Study. For non-LIRR and non-park access links, the cost functions were selected and modified in the calibration/validation phase to produce appropriate levels of sensitivity as measured in the on-board survey.

The fourth and final component of link cost is the random (stochastic) cost element. As described earlier, commuters are unable to measure precisely all elements of cost associated with individual network links. Instead, their perceptions of the individual link costs vary. There is also variability in the sensitivity of travelers to the various components of generalized cost. Third, there are other unmeasured characteristics of links that affect the perceived cost of a link to an individual traveler.

To simulate these variations, the link costs are modeled as <u>stochastic</u>. That is, the link costs are assumed to be samples from a <u>distribution</u> rather than being fixed and known. Therefore, after the other three components of cost (dollars, time, congestion) have been computed, a stochastic component is added. The magnitude of the stochastic element, which is referred to here as the "error term", was set differently for each link type, initially based on theoretical considerations. Several of these error terms were modified in the process of calibrating the RailRider model.

COMPUTATIONAL METHODS FOR NETWORK ASSIGNMENT

The basis for the network assignment is the stochastic user equilibrium (SUE) assignment procedure described by Sheffi (1985), which uses the method of successive averages. The mathematical approach presented in this paper is proved to converge at a true SUE solution. The variant used here assumes that the path flows are logit distributed based on the differences in path costs. This formulation leads to a Gumbel distribution of the stochastic link cost component.

The initial implementation of the SUE algorithm identified several practical complications. First and most significant, the original SUE algorithm did not lend itself well to networks in which a large number of links have fixed capacities. In the LIRR case, where all parking lots and service links do have fixed capacity, this problem proved to be a major stumbling block. Initial attempts to simulate fixed link capacities through exponentially increasing congestion penalty functions yielded a model that was terribly unstable and would require countless iterations before reaching a true equilibrium solution in which capacity constraints were not violated. Since one of the major attractions of the network modeling approach was its ability to capture the effects of hard capacity constraints, this problem led us to reconsider the desirability of the stochastic user equilibrium formulation. Indeed, we felt for a time that stochastic user equilibrium could not be made to work on real world problems of this scale.

As an alternative, we attempted to use a deterministic user equilibrium approach with fixed capacity constraints. A mathematical programming formulation was used, which avoids the problems of capacity restraint and incremental assignment in converging or in reaching true user equilibrium (Sheffi 1985, p.116). This approach yielded a model that did not violate capacity constraints, but the solutions were patently unrealistic. In particular, many of the possible paths through the network (which were known to be used by travelers on the real LIRR network) were not utilized in the model solution. This undesirable characteristic of deterministic equilibrium solutions is well-known and was, in fact, a principal motivation for the development of the stochastic user equilibrium approach. Other ad-hoc procedures for multi-path assignment were also considered but rejected based on their unsound theoretical and empirical properties.

As a result, the SUE algorithm was modified to accommodate links with absolute capacity constraints. While the modified algorithm performed well, it also increased the computational burden of producing a network assignment. This resulted in severe complications during model calibration, which are described in the following section.

A second problem that was identified in practical application of SUE was based on high levels of instability on networks that have links with flows that are different by several orders of magnitude. This was the case in the RailRider network, where some links (non-LIRR links between origin zones and New York City) carry tens of thousands of travelers and others (small parking lots) carry fewer than ten travelers. Very small percentage changes in the demand on the high-volume links could overwhelm many smaller links, resulting in high volatility on these smaller links. The adoption of a modified SUE with capacity constraints reduced this instability to a great extent, but one additional modification was required.

This involved a minor modification to the Queens portion of the LIRR network. The non-LIRR links connecting eight of the ten Queens zones to Manhattan were among the highest volume links in the network, with flows in the tens or hundreds of thousands. These links were in effect removed from the network, eliminating the source of much of the model instability. This action effectively prohibits the model from forecasting mode choice effects in these specified portions of Queens. However, the LIRR mode share in these areas is currently well under 5 percent and is unlikely to be realistically affected by any fare or service strategies. Note that the Queens zones covering the Port Washington Branch were not affected by this network modification.

DEVELOPMENT OF BASE CASE NETWORK FLOWS

In order to provide a basis for evaluating the performance of the RailRider model, it was necessary to develop a set of consistent data indicating the current level of demand on all portions of the network. These flow levels, referred to as the "Base Case", were developed from a wide variety of sources, including U.S. Census Journey to Work Data (1980), the LIRR 1985 Passenger Census and Tick Sheet dataset, and the LIRR 1985 Parking Inventory and subsequent updates. This section describes the manner in which base case flows on the network links were determined.

Station link flows were taken from the Spring, 1986 origin-destination matrix produced as part of the Tick Sheet data analysis (see Chapter 3). Link flows on parking lot links were calculated by taking the product of the corresponding parking inventory counts and average auto occupancy for cars parking at the station. The number of LIRR riders using non-park access modes was determined by subtracting park access riders from the total number of riders at that station. In the few cases in which station flows and total parking lot link flows proved to be inconsistent, parking inventory data were verified and modified as necessary, or revised estimates of average auto occupancy were used.

The number of LIRR riders in each origin zone was estimated using data from the 1985 Passenger Census. A correspondence table was developed of travelers' Home Zip codes (which were collected in the survey) onto the 50 origin zones. Then, an appropriately weighted tally of origin zone of riders was generated directly from the survey dataset. This yielded a set of 50 numbers representing total AM peak LIRR ridership from each origin zone. A description of the 50 origin zones and LIRR stations that are contained in each one appears in Table 4-1.

TABLE 4-1

RAILRIDER ORIGIN ZONES

Zone	Zone Name	Town	Stations
1	Western Queens	Queens	Woodside Penn. Station Hunterspoint Ave. Flatbush Ave.
2	Forest Hills-Kew Gardens	Queens	Kew Gardens Forest Hills
3	Jamaica	Queens	Jamaica
4	Rosedale-Locust Manor	Queens	Rosedale Laurelton Locust Manor
5	St. Albans/Hollis	Queens	Hollis St. Albans
6	Jamaica Estates	Queens	None
7	Queens Village	Queens	Queens Village
8	Flushing-Auburndale	Queens	Auburndale Broadway Murray Hill Flushing
9	Bayside-Douglaston	Queens	Little Neck Douglaston Bayside
10	The Rockaways	Queens	Far Rockaway
11	Pt. Washington Peninsula	N. Hempstead	Port Washington Plandome
12	Great Neck Peninsula	N. Hempstead	Manhasset Great Neck
13	Roslyn-Albertson	N. Hempstead	Roslyn Albertson

Table continued on following page...

TABLE 4-1

RAILRIDER ORIGIN ZONES (Continued)

Zone	Zone Name	Town	Stations
14	Floral Park-Merillon Ave	N. Hempstead	None
15	Mineola-Westbury	N. Hempstead	Mineola E. Williston Westbury Carle Place
16	Levittown/East Meadow	Hempstead	None
17	Hempstead	Hempstead	Hempstead
18	Valley Stream	Hempstead	Valley Stream Gibson
19	W. Hemp. Br/Lynbrook/RVC	Hempstead	West Hempstead Hempstead Gardens Lakeview Malverne Westwood Lynbrook Rockville Centre
20	Baldwin-Freeport	Hempstead	Freeport Baldwin
21	Merrick-Wantagh	Hempstead	Wantagh Bellmore Merrick Seaford
22	Cedarhurst-Hewlett	Hempstead	Cedarhurst Woodmere Hewlett
23	Lawrence-Inwood	Hempstead	Inwood Lawrence
24	Centre Ave-Long Beach	Hempstead	Long Beach Island Park Oceanside East Rockaway Centre Ave.

Table continued on following page...

TABLE 4-1

RAILRIDER ORIGIN ZONES (Continued)

Zone	Zone Name	Town	Stations
25	Seaford-Massapequa Park	Oyster Bay	Massapequa Park Massapequa
26	Bethpage-Farmingdale	Oyster Bay	Farmingdale Bethpage
27	Hicksville	Oyster Bay	Hicksville
28	Brookville-Muttontown	Oyster Bay	None
29	Syosset	Oyster Bay	Syosset
30	Sea Cliff-Locust Valley	Oyster Bay	Locust Valley Glen Cove Glen Street Sea Cliff
31	Mill Neck-Oyster Bay	Oyster Bay	Oyster Bay Mill Neck
32	Elmont/Franklin Square	Hempstead	Bellerose Floral Park New Hyde Park
33	Garden City	Hempstead	Country Life Press Garden City Nassau Blvd. Stewart Manor Merillon Ave.
34	Greenvale-Glen Head	Oyster Bay	Glen Head Greenvale
35	CSH-Huntington	Huntington	Cold Spring Harbor Huntington
36	Greenlawn-Northport	Huntington	Greenlawn Northport
37	Dix Hills	Huntington	None

Table continued on following page...

TABLE 4-1

RAILRIDER ORIGIN ZONES (Concluded)

Zone	Zone Name	Town	Stations
38	Amity-Lind/Repub-Pineln	Babylon	Lindenhurst Copiague Amityville
39	Babylon	Babylon	Deer Park Wyandanch Babylon
40	Kings Park-St. James	Smithtown	Kings Park Smithtown St. James
41	Pine Aire-Central Islip	Islip	Central Islip Brentwood
42	Bay Shore-Great River	Islip	Great River Islip Bay Shore
43	Oakdale-Sayville/Ronk	Islip	Ronkonkoma Sayville Oakdale
44	Stony Brook-Pt Jefferson	Brookhaven	Port Jefferson Stony Brook
45	Patchogue/Medfrd-Yaphank	Brookhaven	Patchogue Bellport
46	Mast Shir-Cent Moriches	Brookhaven	Center Moriches Mastic-Shirley
47	Riverhead	Riverhead	None
48	Speonk-Hampton Bays	Southampton	Speonk
49	North Fork	Southold	None
50	South Fork	Southampton	None

Estimation of Non-LIRR flows from each origin zone to New York City was somewhat more complicated. Using a Census tract to origin zone correspondence table, the 1980 Journey to Work data were processed to produce a table showing the flows between each zone and New York City by rail and by all other modes combined. In many cases, these data were inconsistent with the LIRR origin zone flows as calculated above. In Queens, it was apparent that many travelers who reported using rail as their travel mode actually used the subway. Therefore, in this geographic area, the total Journey to Work flows were retained, and the non-LIRR flows were calculated by subtracting the LIRR zone ridership (as calculated previously) from the total Journey to Work flow.

In Nassau and Suffolk counties, the LIRR mode shares that resulted from the Journey to Work data analysis were retained, and combined with the zonal LIRR flows computed earlier to yield estimates of non-LIRR flows from each zone.

The final set of link flows to be determined for the Base Case were the distribution of flows from origin zones to LIRR stations, given that the total flow was known at each origin and that the total flow was known (by access mode) at each station. On-board survey data from the 1985 Passenger Census proved to be inadequate for developing this distribution. Instead, iterative proportional fitting of the individual link flows to their known marginals was used.

The result of all these efforts was a vector of flows on the 1930 links that made up the Base Case network. This "Target Flow" vector was the basis of most of the calibration work described in the following section.

MODEL CALIBRATION

Model calibration is the process of setting model parameters such that the forecasting model accurately reproduces base case conditions on the network. The calibration process entailed finding constants to be added to (or subtracted from) link costs such that the network link flows that result from a model forecast were within a close tolerance of the base case flows. Conceptually, these constants may be thought of as reflecting the contribution of variables that influence perceived cost but are not accounted for explicitly in the cost function. Also, the constants correct for aggregation errors embodied in any geographic zoning system such as those from the use of average travel distances from zone centroids to stations.

Unlike the problem of calibrating traditional traffic assignment models, the problem of calibrating the LIRR network was greatly complicated by the multiplicity of travel choices (i.e. link types) involved and the high degree of interdependence among flows on alternative paths. Changing the constant on one link, for example, might have drastic effects on flows elsewhere in the network. Other nontrivial complications were introduced by the stochastic nature of the equilibrium solution being sought and the simulation method by which the model is solved. Since random drawings are made in determining the stochastic component of link costs, changes in the calibration constants may result in unpredictable and non-continuous changes in link flows.

The mathematical problem of directly solving for the constants appears to be computationally intractable, and thus our first attempts at calibration employed an informed trial and error approach that had proven successful in our prior small scale network equilibrium models. The method was informed in the sense that knowledge of the logit-like behavior of the system helped us avoid some obvious pitfalls and suggested some back-of-the-envelope calculations that could be used to develop preliminary estimates of the appropriate constants for intersecting links of identical type. These first attempts provided little more than insight into the formidable difficulties that lay ahead.

A major problem in calibration was the enormous computational burden involved. Every run with a revised set of calibration constants required roughly one-half hour to get close enough to equilibrium to permit an evaluation of the closeness of the calibration. This coupled with the fact that hundreds or thousands of trials would obviously be required made the calibration problem appear nearly insurmountable.

A man-machine approach has ultimately evolved that proved to be extremely effective, although time consuming, in achieving calibration. Utilizing extremely fast 80386-based microcomputers, the trial and error method of determining constants was replaced by an iterative search procedure. Not all of the logic for the procedure could have been or was specified in software, rendering the human calibrator an essential part of the process. To give some feeling for the level of effort involved, one microcomputer ran continuously 24 hours a day for several weeks as part of the calibration effort. A first generation PC would probably have required more than one year of CPU time for calibration to be achieved.

Interestingly, calibration would probably not have been feasible using a mainframe computer. While it is true that evaluating the equilibrium solution for a particular set of calibration constants would have been much faster, the costs would be prohibitive. Of equal import, the software aids that were developed to allow human intervention would have been much more restricted in their capabilities, making the calibration process much more difficult and time consuming.

A second calibration was performed in the project with updated data that became available from LIRR system counts. In the second calibration, a variety of improvements were made to the calibration procedure. The most notable of these entailed a method of attempting to utilize the minimum number of constants. This is extremely desirable as it reduces the need to generate constants for new links that may be added to the network in evaluating new scenarios. A second improvement entailed breaking the calibration problem up into a set of sub-problems. This increased the accuracy of the calibration and reduced the computational burden.

Calibration was ultimately achieved to quite close tolerances with most links within one percent of the base case flows. For links with very small flows, errors of less than one or two riders were achieved. While we think that even greater accuracy should be possible in the future, the calibration achieved was quite good for the purposes at hand and dramatically better than is typically achieved in large scale urban transportation planning studies in which link volumes may be off by more than one hundred percent. Based upon this experience, similar methods should be able to yield significant improvements in other modeling efforts. We also would like to stress that further enhancements and advances in the area of network calibration are an interesting and important research topic.

Model Validation

While forecasting the effects of system changes with the model will provide the most compelling evidence of validation, available data and external evidence were used to judge model performance and to assess appropriate values for the magnitude of the error terms and cost function coefficients for the various link types. External measures taken from the traveler preference analysis and prior demand models were used to judge the need for corrections in the magnitude of these variables.

Test runs of the model in its final calibrated form provide substantial evidence that the model performs well. It yields results that are consistent with expectations and external measurements. For example, the fare elasticity exhibited by the model is between -0.13 and -0.18, depending upon the level of fare change. These values are certainly consistent with prior measurements. Additional tests with the model indicate a travel time elasticity of -0.20. While this is somewhat lower than the norm for the transit industry as a whole, it may be reasonable due to the large mode share held by the LIRR and the relatively long travel times experienced by commuters on all modes within the Long Island travel market.

CHAPTER 5

THE RAILRIDER FORECASTING SOFTWARE

The RailRider network equilibrium forecasting model described in the previous chapters of this report has been delivered to the LIRR and is available for use as a forecasting tool by LIRR staff. The first section of this chapter describes the architecture and features of the RailRider software. The second section describes how RailRider is used to produce demand forecasts. The third section briefly summarizes RailRider's hardware requirements and technical specifications, while the fourth and final section presents technical notes on interpreting the results of the RailRider model.

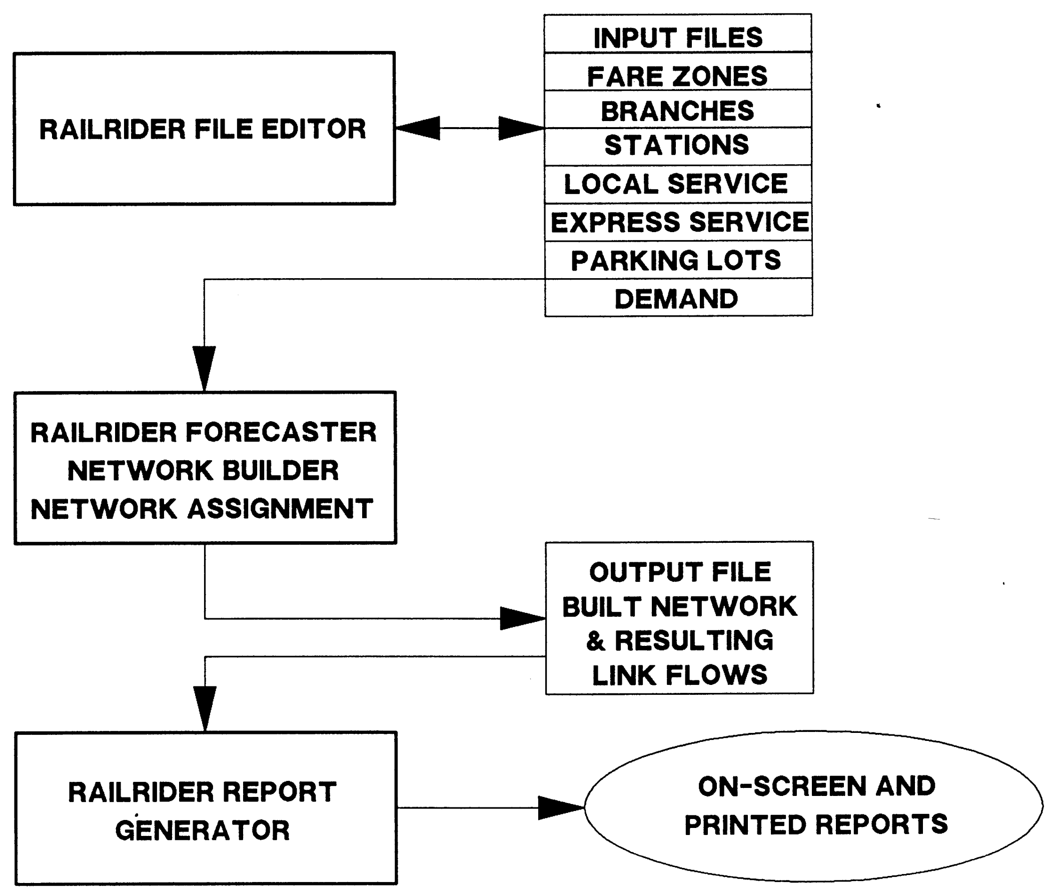
OVERVIEW OF THE RAILRIDER FORECASTING SOFTWARE

RailRider is a proprietary microcomputer software product that implements Caliper Corporation's network-based demand forecasting methodology. The software, which runs under MS-DOS on 80286 or 80386-based microcomputers, has been designed to make it possible for users to apply complex network-based forecasting methods entirely within a menu-driven, user-friendly software environment. The RailRider forecasting system has three major components: a file editor, a forecasting module, and a report generator. Each of these is described below. A schematic of the RailRider model appears in Figure 5-1.

The File Editor

The file editor allows the user to edit seven different types of files which contain information on LIRR service, fares, and parking facilities and on overall commutation demand in the Long Island-New York City travel market. The file editor is designed to manage large numbers of input files effectively, and provides the user with the ability to give each file an alphanumeric label to assist in tracking scenario development and forecast generation. The editor functions in a fashion similar to a spreadsheet program, with special functions for adding and deleting records and for producing formatted printed copies of each file. Editing of alphanumeric fields is simplified by the incorporation of "pop-up" menus, and range checks are automatically performed on all numeric fields.

FIGURE 5-1
SCHEMATIC OF THE RAILRIDER MODEL



The Forecasting Module

The forecasting module has two major components -- a network builder, and the assignment routine. The network builder is a powerful program module that translates 19 types of input files into an internal representation of an appropriate network. The network builder by itself is an innovation in the application of network forecasting methods to transportation problems, because it permits the user to specify the structure and parameters of a network by editing easily understandable files. The network builder also saves time and reduces errors in developing analysis scenarios.

Networks that are used in transportation analysis typically differ from the physical networks that they represent. Invariably, they include additional nodes and links that represent internal connectivity among system components, but have no physical parallel. Individual LIRR stations, for example, must be represented in the internal network as two distinct nodes with a link between them. To model accurately the parking restrictions that apply to lots at LIRR stations, RailRider must construct an internal subnetwork of dummy nodes and links that connect origin zones with individual parking facilities.

In traditional transportation network forecasting applications, users are required to manually construct the internal network. RailRider's network builder makes it possible for the user to edit a set of simple input files, each of which is organized in a manner familiar to the user, and to have these files automatically converted into the complex internal representation required to produce an accurate forecast. The network builder takes input from 19 different input files, 7 of which are accessible to the user through the file editor, and 12 of which are fixed.

The other major component of the forecasting module is the assignment routine itself. As described in Chapter 4 of this report, the assignment routine is a stochastic user equilibrium assignment algorithm that has been modified to accommodate fixed capacity constraints.

The Report Generator

The report generator takes the results of an assignment and produces a variety of on-screen and printed reports. The information that can be abstracted from a RailRider network forecast is very extensive, and the report generator is designed to allow the user to compile desired results efficiently and quickly, and with appropriate documentation.

When the forecasting module completes an assignment, it produces an output file that contains all of the information required to produce and fully document sets of on-screen and printed reports. The output file contains the names, dates, creation times, and descriptions of all of the input files that were used to generate that particular forecast, the data and time that the output file was created, and a user-defined label which describes the run. The output file also contains a reproduction of the internal network representation, all of the text labels required for producing output reports, and the resulting network flows. As a result, reports can be produced from the output file without requiring that the original input files also be available. This alleviates a host of file management problems.

The following types of reports are produced by the report generator:

* Summary Reports
  - System Summary Report
  - Origin Zone Summary Report
  - County and Town Summary Report
  - Branch Summary Report

* Branch Detail Reports
  - Branch Passenger Loading Reports
  - Branch Parking Summary Reports

* Station Detail Reports
  - Station Parking Detail Reports

All reports come in both on-screen and printed formats, with the printed versions supplying slightly more detail than their on-screen counterparts. On-screen reports are selected through a series of simple on-screen menus. For printed reports, the user can select any combination of reports through on-screen menus, specifying the branches and stations for which detailed reports are required. All printed reports are automatically accompanied by a header page that describes the run and the input files that were used in preparing the forecast.

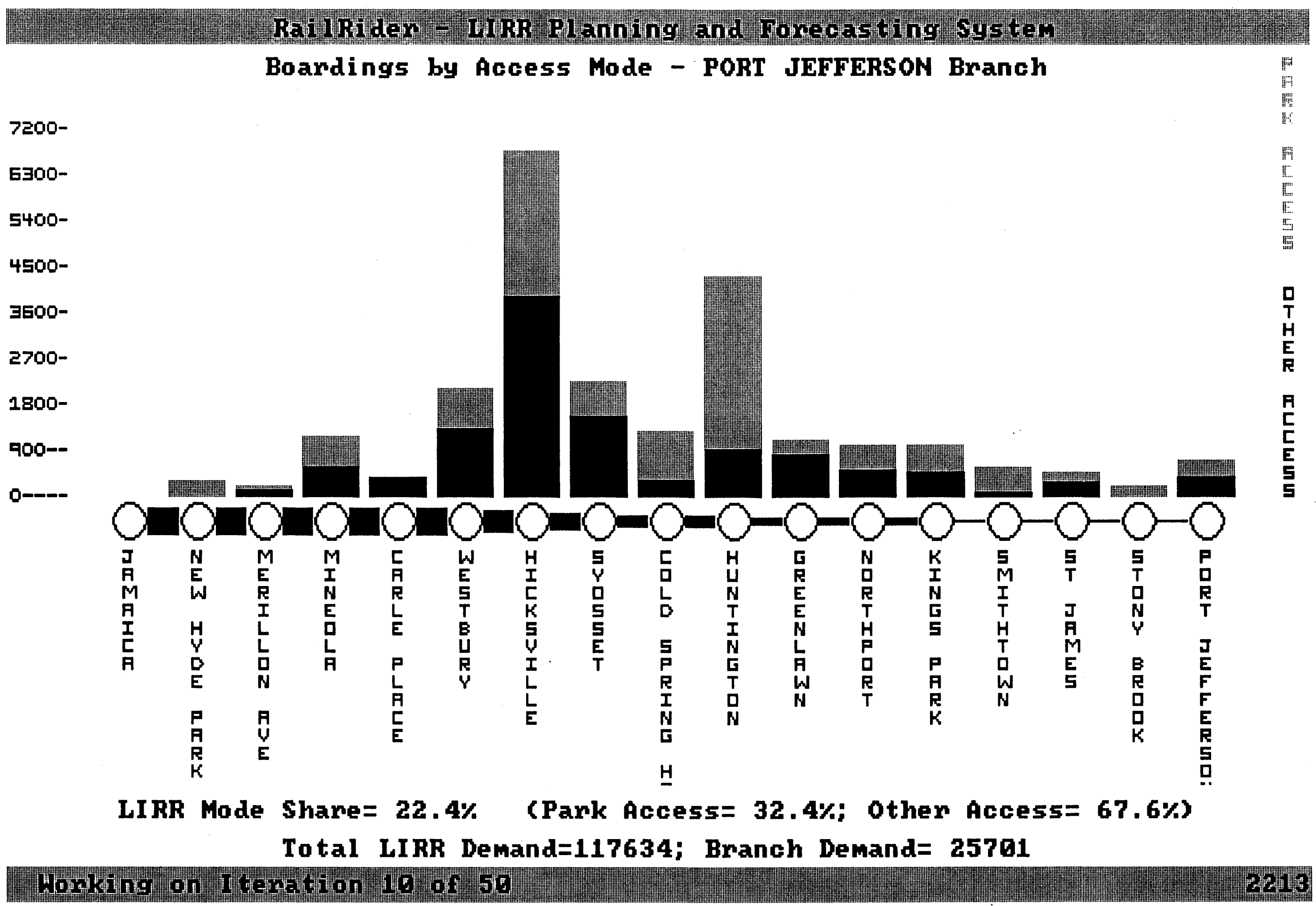
The practical benefit of the report generator lies in the fact that a user can produce a forecast and examine some of the "top-line" results on the screen, and then return to that forecast several days (or weeks or months) later and generate more detailed reports. Even if the input files used to generate the forecast have been edited or deleted, the complete forecast results are still accessible.

RailRider also generates graphic output of forecast results. The user can select a branch to observe while a forecast is in progress. A reproduction of the graphic display appears in Figure 5-2.

<u>The User Interface</u>

The RailRider software is designed with a sophisticated user interface that simplifies the use of the various program modules.

FIGURE 5-2
RAILRIDER GRAPHICS SCREEN DISPLAY



The entire system is menu-driven, with on-screen menus and prompts to help the user select an appropriate course of action. All user keystrokes are automatically screened to prevent illegal entries, and all numeric inputs are checked to insure that they are within a valid numeric range.

RailRider has an integrated, context-sensitive Help facility, similar to that provided in many microcomputer software products. At any point in the program, pressing the "Help" key accesses the on-line Help Manual, which contains over 50 screens of information on how to use the RailRider system. The on-line Help facility can be used, for example, while editing a file to clarify the definition of a particular data file, or while in the report generator to remind the user of the contents of a particular type of report.

Because of this advanced user interface, model users do not need to be experienced microcomputer users to apply the RailRider forecasting models, although rudimentary familiarity with MS-DOS and the microcomputer keyboard can be helpful.

HOW THE RAILRIDER FORECASTING SOFTWARE IS USED

The RailRider forecasting software produces demand forecasts based on a particular "scenario", which consists of a designated set of seven input files. These files are as follows:

* Fare zone files, which contain monthly ticket prices in each fare zone;
* Branch files, which provide information about service on LIRR Branches;
* Station files, which provide information about the characteristics of individual stations;
* Parking lot files, which contain data on parking capacities, restrictions, and prices;
* Local service files, which indicate local service connections on each branch;
* Express service files, which indicate skip-stop, express, or flyer connections between non-adjacent stations; and
* Demand files, which contain information on the total size of the Long Island to New York travel market.

There may be several files of each of these types available to the user. For example, there may be a base fare file, and two other fare files which represent fare increases of 3.5 and 7.0

percent. Additional input files of each type can be created by the user using the RailRider file editor module.

To create a scenario, the user must specify one file of each type to be used as input to the model. Because the input files can be used in a variety of combinations, a large number of scenarios can be generated from a limited number of input file types. With two files of each type, for example, 93 different scenarios can be created by mixing and matching the files in all their possible combinations.

After the user specifies a single file of each type, RailRider processes the input files, generates the appropriate internal representation of the network, produces the demand forecast, and creates the output file. All of these actions are performed automatically, without requiring user intervention.

After a forecast is complete, the user has complete freedom to access the results using only the RailRider report generator module.

HARDWARE REQUIREMENTS/TECHNICAL SPECIFICATIONS

RailRider has been designed to operate on an IBM AT or compatible microcomputer, and requires an 80287 floating point co-processor. Because the forecasting process is computationally intensive, it is recommended that a microcomputer based on the 80386 microprocessor be used in place of the IBM AT or compatible 80286-based machine. The software also requires 640kB of memory, an IBM Enhanced Graphics Adapter with 256kB of memory, and Enhanced Color Display, and a printer capable of producing 132 column output. The software operates under MS-DOS 2.0 or any more recent operating system. The software has been written in the C language, with some portions of the code written in 8088/8086 assembly language. All files used by the forecasting software are in ASCII format for ease of processing.

CHAPTER 6

LIRR RIDERSHIP AND PARKING

This chapter presents a summary description of base case conditions on the LIRR, describing the current levels of ridership and ridership by access mode, and presenting parking supply and utilization statistics. All of the results reported in this chapter are for Spring, 1986, the "Base Case" time period for the study. Detailed tables containing the results reported in this chapter appear in the Appendix to this report. The estimates contained in this chapter are based on data derived from a wide variety of sources, and readers are cautioned that in many cases the level of accuracy of the results is unknown.

LIRR RIDERSHIP AND ACCESS MODE CHOICE

Systemwide Statistics

LIRR AM peak period ridership in the base case is 112,733 riders. This represents approximately 22.1 percent of the total commutation market of 525,479. This total commutation market represents the total number of daily work trips between Queens, Nassau, and Suffolk Counties and Manhattan, and was estimated using data from the 1980 U.S. Census Journey-To-Work data and from base LIRR ridership data. Figure 6-1 shows the distribution of the Long Island commutation market, and also indicates the breakdown of LIRR ridership by access mode. As indicated, 55,305 AM peak riders (49.1 percent) access the LIRR by parking at the station, while the remaining 57,428 (50.9 percent) use other forms of access.

County/Town Statistics

Figure 6-2 shows LIRR ridership by County and by Town. Not surprisingly, Nassau County represents the largest share of LIRR ridership, with 71,160 AM peak riders (63.1 percent). Queens and Suffolk counties represent 11.7 percent and 25.2 percent of LIRR ridership, respectively. On a town by town basis, Hempstead (36.3 percent) and Oyster Bay (15.1 percent) together represent over half of LIRR ridership. North Hempstead (11.7 percent), Queens (11.7 percent), and Huntington (7.2 percent) follow, with Babylon (5.9 percent), Islip (5.5 percent), Brookhaven (3.9 percent), and Smithtown (2.3 percent) each contributing significant numbers of AM peak riders.

FIGURE 6-1
DISTRIBUTION OF THE LONG ISLAND COMMUTATION TRAVEL MARKET

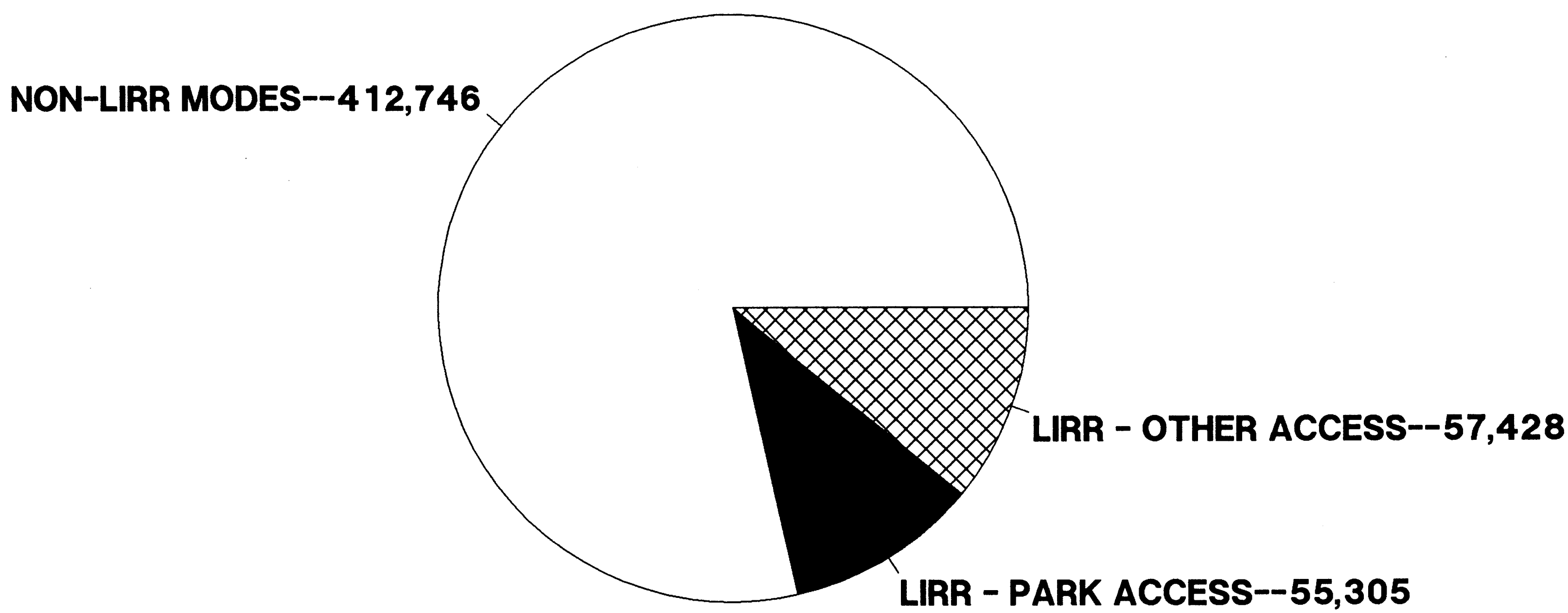
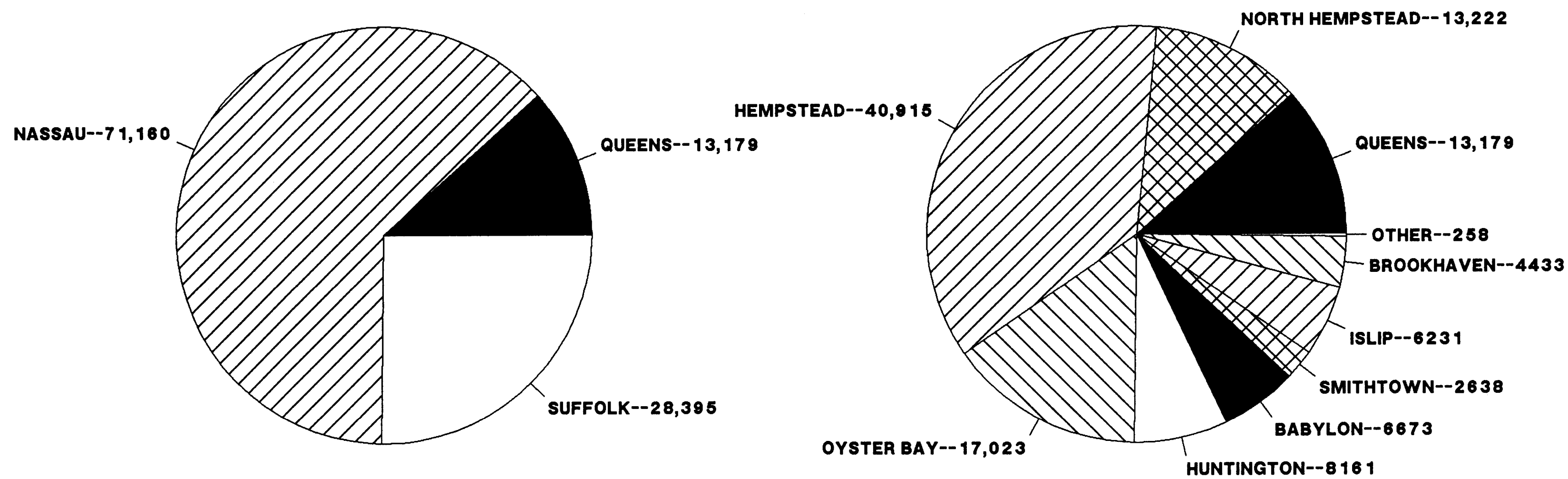


FIGURE 6-2

LIRR RIDERSHIP BY COUNTY AND BY TOWN



RIDERSHIP BY COUNTY

RIDERSHIP BY TOWN

The access mode choice of LIRR riders is shown by County and by Town in Figure 6-3. As expected, the share of riders using park access is much lower in Queens (22.6 percent) than in Nassau County (46.5 percent), and is highest in Suffolk County (67.7 percent). There is similar large variation in access mode choice among the various towns, with the largest park access shares in Brookhaven (80.4 percent), Huntington (77.9 percent), Smithtown (75.8 percent), and Southampton (70.5 percent). Islip (56.6 percent), Babylon (53.8 percent) and Oyster Bay (52.3 percent) also had park access shares of over 50 percent. Hempstead, which represents the largest single town of residence of LIRR riders, had a park access share of 48.6 percent, while North Hempstead and Queens rely least on park access, with shares of 32.5 percent and 22.6 percent, respectively.

<u>Branch Statistics</u>

Figure 6-4 illustrates base case AM peak LIRR ridership by Branch and by access mode. The Babylon, Port Jefferson, and Port Washington Branches dominate LIRR ridership, with 28.4 percent, 22.6 percent, and 15.4 percent of riders, respectively. The "second tier" of LIRR Branches includes Far Rockaway (7.6 percent), Long Beach (6.4 percent), Hempstead (6.3 percent), and Ronkonkoma (5.7 percent). The Montauk Branch carries 3.0 percent of peak riders, while the Oyster Bay (2.3 percent) and West Hempstead (1.5 percent) Branches represent the smallest shares of LIRR ridership.

Mode of access varies quite a bit, as indicated in the Figure. The highest park access share is on the Montauk Branch (81.9 percent), with the Port Jefferson and Ronkonkoma Branches following with 64.4 percent and 61.0 percent, respectively. The Babylon Branch and Oyster Bay Branch are closest to a fifty-fifty split, with 52.2 percent and 47.7 percent using park access, respectively. These are followed in turn by the Long Beach Branch (43.0 percent), the Far Rockaway Branch (39.7 percent), and the Hempstead Branch (37.7 percent). The <u>lowest</u> park access are on the West Hempstead Branch (27.2 percent), the Port Washington Branch (25.8 percent), and in the City Terminal Zone (10.0 percent).

Figure 6-5 shows the average access times for LIRR riders using park and non-park access for each of the eleven Branches. As the figure indicates, average park access time is in most cases less than half of the non-park access time. The longest park access times are on the Montauk, Ronkonkoma, and City Terminal Branches, while the longest non-park access times are on the Montauk, Port Jefferson, and Ronkonkoma Branches.

FIGURE 6-3
LIRR ACCESS MODE CHOICE BY COUNTY AND BY TOWN

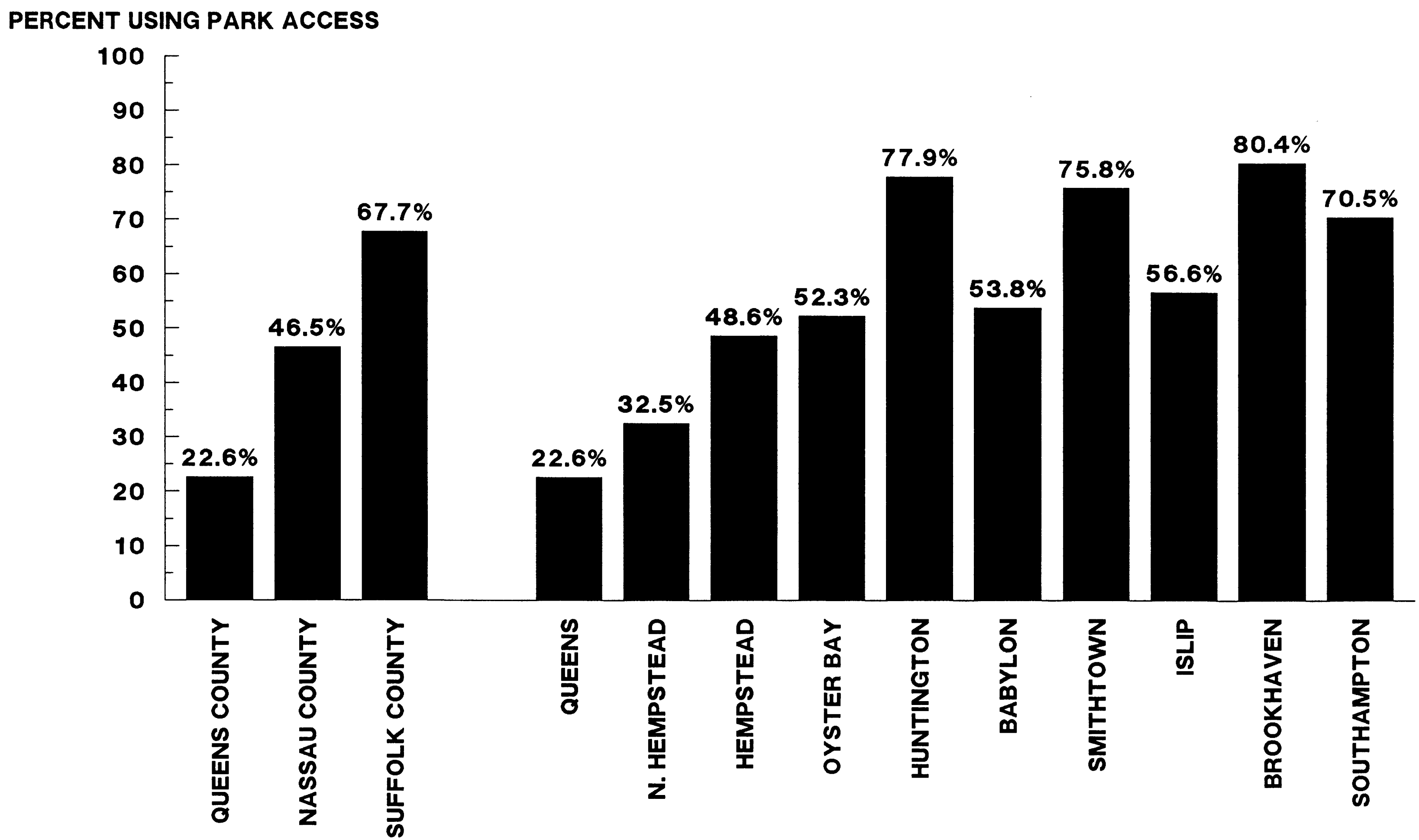


FIGURE 6-4

BASE CASE LIRR RIDERSHIP BY BRANCH AND MODE OF ACCESS

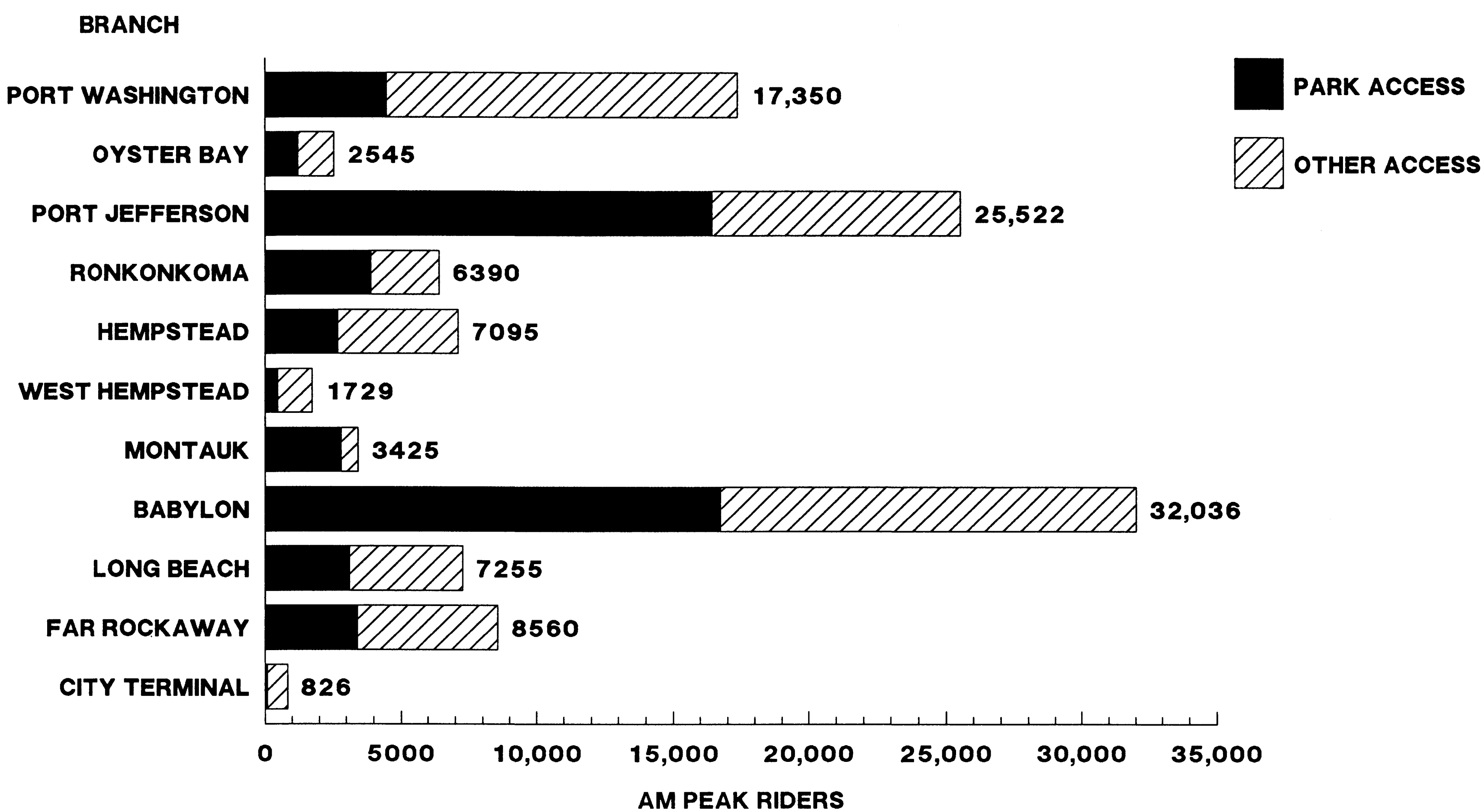
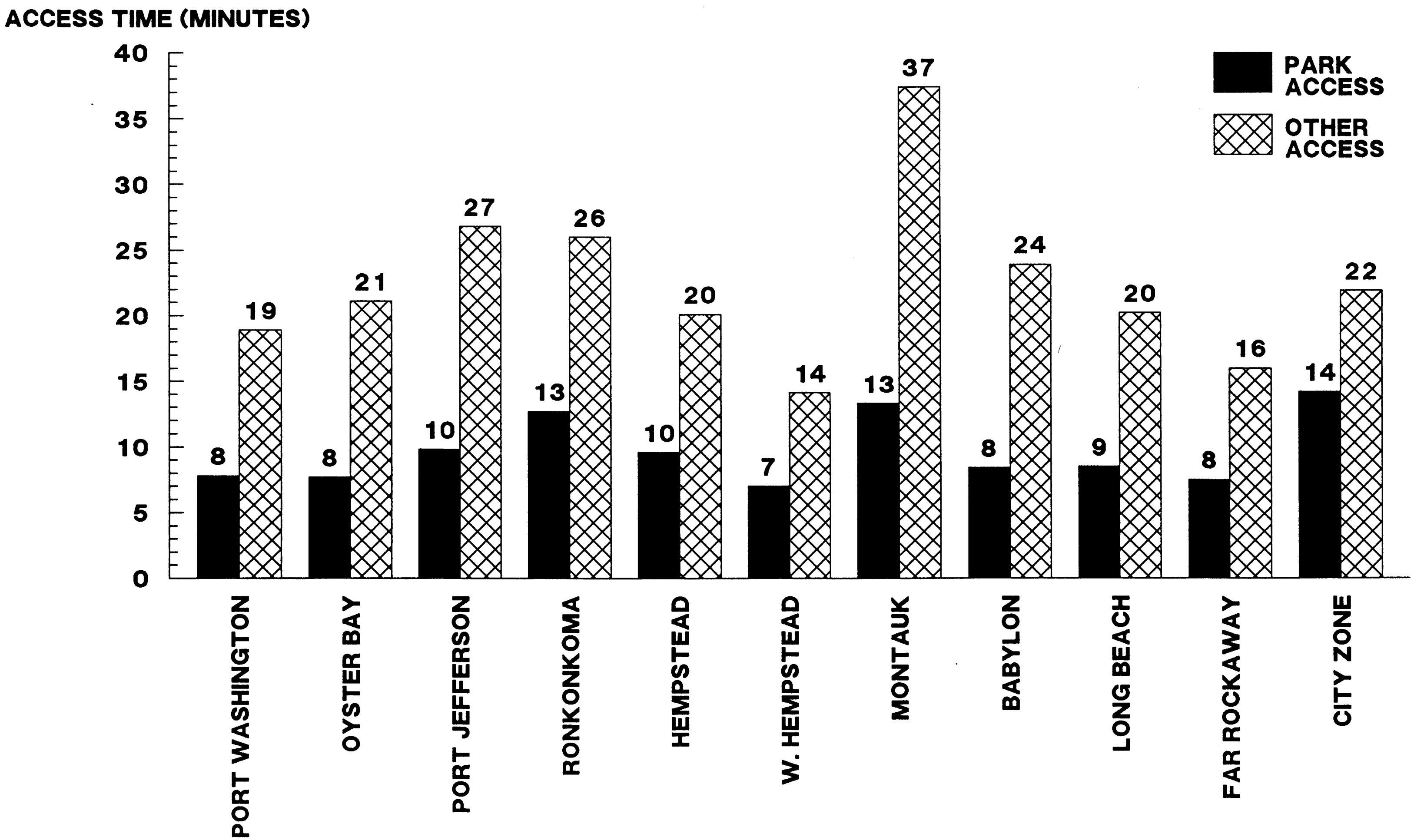


FIGURE 6-5
AVERAGE ACCESS TIME FOR LIRR RIDERS



PARKING SUPPLY AND UTILIZATION

Systemwide, there are 55,573 parking spaces available for LIRR commuters, of which 46,406 are occupied, for an occupancy rate of 83.5 percent. Figure 6-6 summarizes parking conditions by County and by Town, and shows the distribution of unrestricted and restricted parking spaces. As indicated there, the bulk of the 55,573 parking spaces are in Nassau County (31,801), with 4073 spaces in Queens and 19,699 in Suffolk County. On a town by town basis, Hempstead and Oyster Bay hold the largest share of parking spaces, with 19,153 and 8859 spaces, respectively. These two towns are followed in capacity by Huntington (5580), Babylon (4715), Queens (4073), Islip (4054), North Hempstead (3789), Brookhaven (3382), and Smithtown (1773).

There is significant variation among the counties and towns in the proportion of parking spaces that have usage restrictions. In this context (and throughout this report), a restricted lot is one in which use by some individuals is prohibited based on where they live. Permit requirements are not necessarily considered to be restrictions, unless there are residency requirements for purchasing the permit. In addition, as noted in Chapter 3 of this report, data on parking restrictions were known to be incomplete in some cases, resulting in classification of some lots as unrestricted when in fact some restrictions probably apply.

Taking these caveats into account, the majority of parking spaces are unrestricted in Queens County and in the towns of Babylon, Islip, and Brookhaven. In almost all other towns, a majority of parking spaces are restricted to village or town residents. Restrictions affect the largest proportion of parking spaces in Huntington (74.4 percent), North Hempstead (59.4 percent), and Oyster Bay (51.0 percent).

Systemwide, 46,406 of the 55,573 parking spaces available for LIRR commuters are occupied, for an occupancy rate of 83.5 percent. Unrestricted spaces represent 36,434 spaces; these are 79.9 percent full. The remaining 19,139 restricted spaces have an average occupancy of 90.5 percent. Figure 6-7 shows parking lot occupancy by County and by Town for both unrestricted and restricted parking facilities. As a general rule, regions with both unrestricted and restricted facilities exhibit a higher occupancy rate among the restricted facilities. This may simply be an indication of the fact that the more desirable parking facilities are the ones on which restrictions have been placed.

Parking occupancy rates are lowest in Queens (58.9 percent), and approximately equal in Nassau (86.6 percent) and Suffolk (83.6 percent). Within Nassau and Suffolk counties, congestion is more severe in restricted spaces. On a town by town basis, Huntington and Smithtown appear to have the most severe parking congestion, with both unrestricted and restricted spaces

FIGURE 6-6

PARKING CAPACITY BY COUNTY AND TOWN

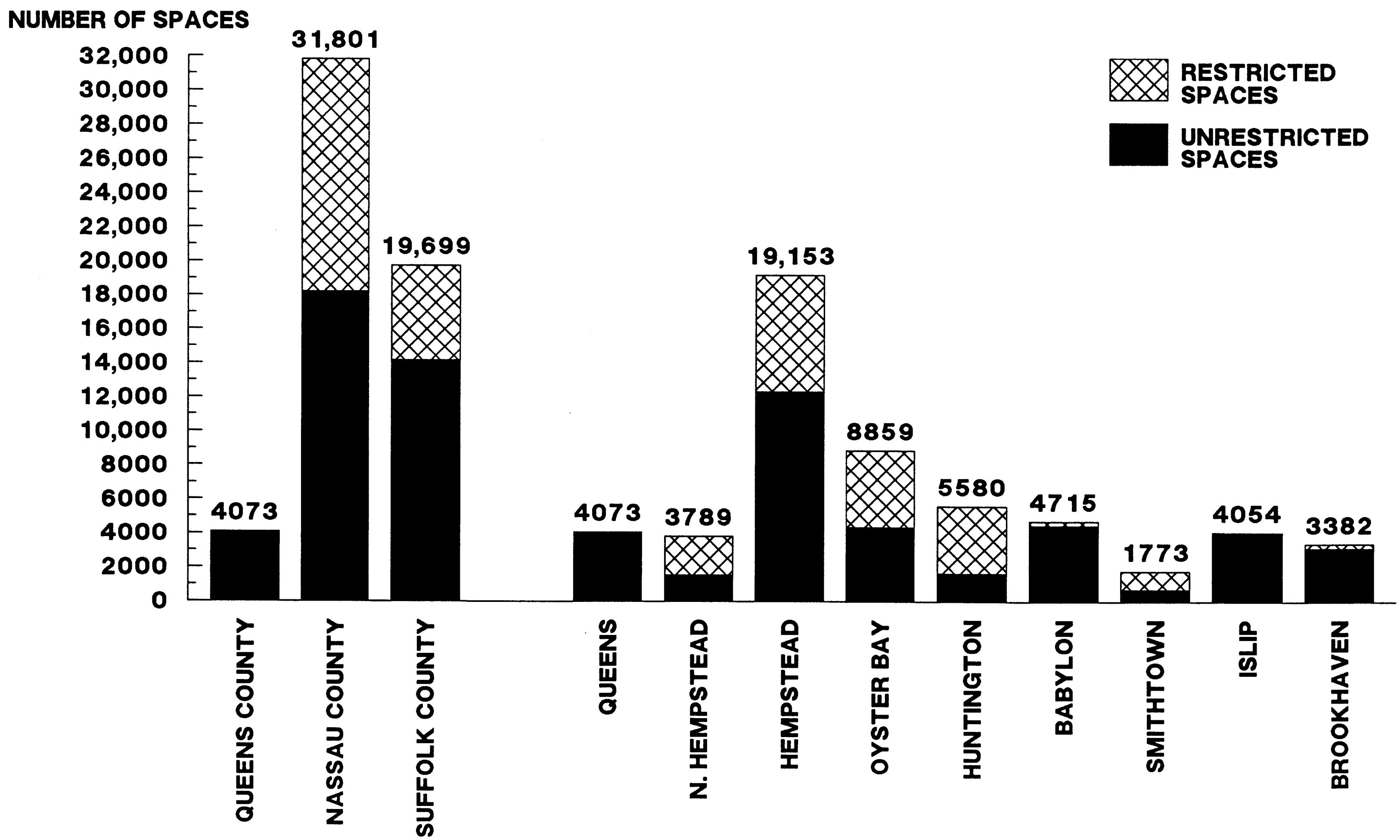
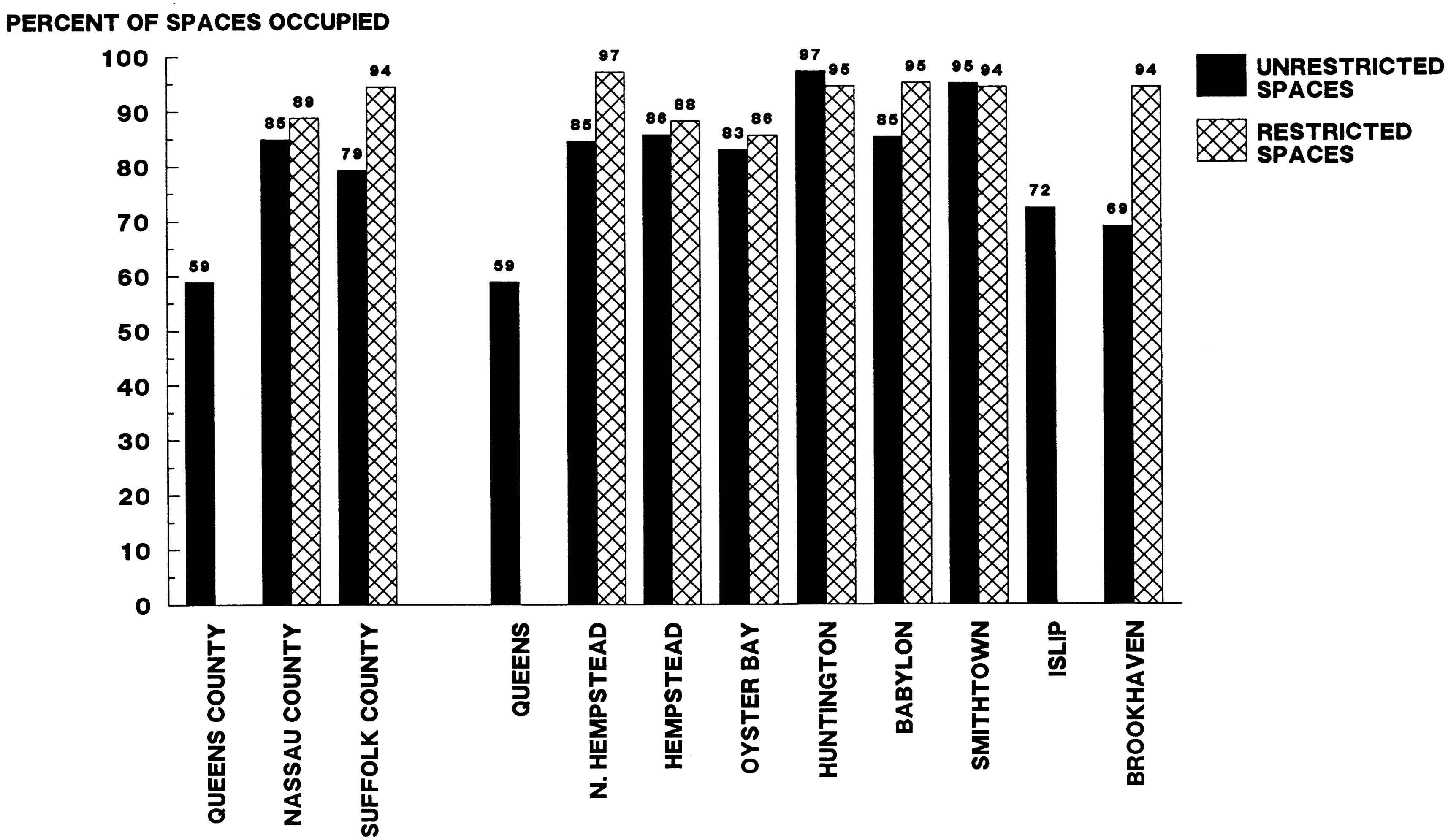


FIGURE 6-7

PARKING UTILIZATION BY COUNTY AND TOWN



occupied at a rate of 94 percent or more. In North Hempstead, Babylon, and Brookhaven, the restricted parking spaces are 97 percent, 95 percent, and 94 percent occupied, respectively. There is some slack in unrestricted lots in these towns -- unrestricted spaces are only 85 percent, 85 percent, and 69 percent full, respectively. The parking congestion is somewhat less severe in Hempstead (86 percent and 88 percent of unrestricted and restricted spaces are full, respectively); in Oyster Bay (unrestricted--83 percent; restricted--86 percent); and in Islip (72 percent occupancy of unrestricted spaces).

The distribution of parking capacity by Branch is shown in Figure 6-8. The Babylon and Port Jefferson Branches have by far the largest number of available parking spaces, with close to 15,000 each. At the other end of the spectrum, the West Hempstead and Oyster Bay Branches have only 480 and 1607 parking spaces, respectively. The Ronkonkoma and Montauk Branches have relatively few parking restrictions, while the Port Jefferson Branch, on the other hand, has restrictions on 7830 of its 14,908 spaces. The Babylon Branch also has a significant number of spaces with parking restrictions, although the 4929 spaces on that Branch represent only 32.9 percent of its total parking capacity, compared to the 52.5 percent ratio on the Port Jefferson Branch.

Parking utilization rates by Branch are shown in Figure 6-9. As indicated, parking spaces on the City Terminal Zone are filled to capacity. The Port Jefferson and Babylon Branches are very close to capacity, with 93 percent of spaces occupied. The Port Washington and Montauk Branches both have very high utilization in restricted lots (97 percent and 94 percent, respectively) but have excess unrestricted capacity (73 percent and 65 percent occupancy, respectively). The West Hempstead and Far Rockaway Branches exhibit similar trends, though the congestion of restricted facilities is somewhat less severe on these two branches. This is once again an indication of the relatively less desirable location and other characteristics of the unrestricted parking facilities. Generally speaking, the largest proportion of excess capacity is along the Oyster Bay and Ronkonkoma Branches, where the level of train service is relatively inferior.

Within the various branches, there is significant variability among individual stations in their level of parking utilization. Even on the most congested branches, several stations still have significant numbers of parking spaces available. On the Port Jefferson Branch, for example, parking lots at Smithtown, Kings Park, Greenlawn, Huntington, Cold Spring Harbor, Westbury, Mineola, and Merillon Ave are virtually at capacity. Northport and Syosset, on the other hand, are filled to only 83.7 percent and 87.4 percent of capacity, respectively, with a total of 299 parking spaces available. New Hyde Park also has 74 of its 584 spaces open and available.

FIGURE 6-8
PARKING CAPACITY BY BRANCH

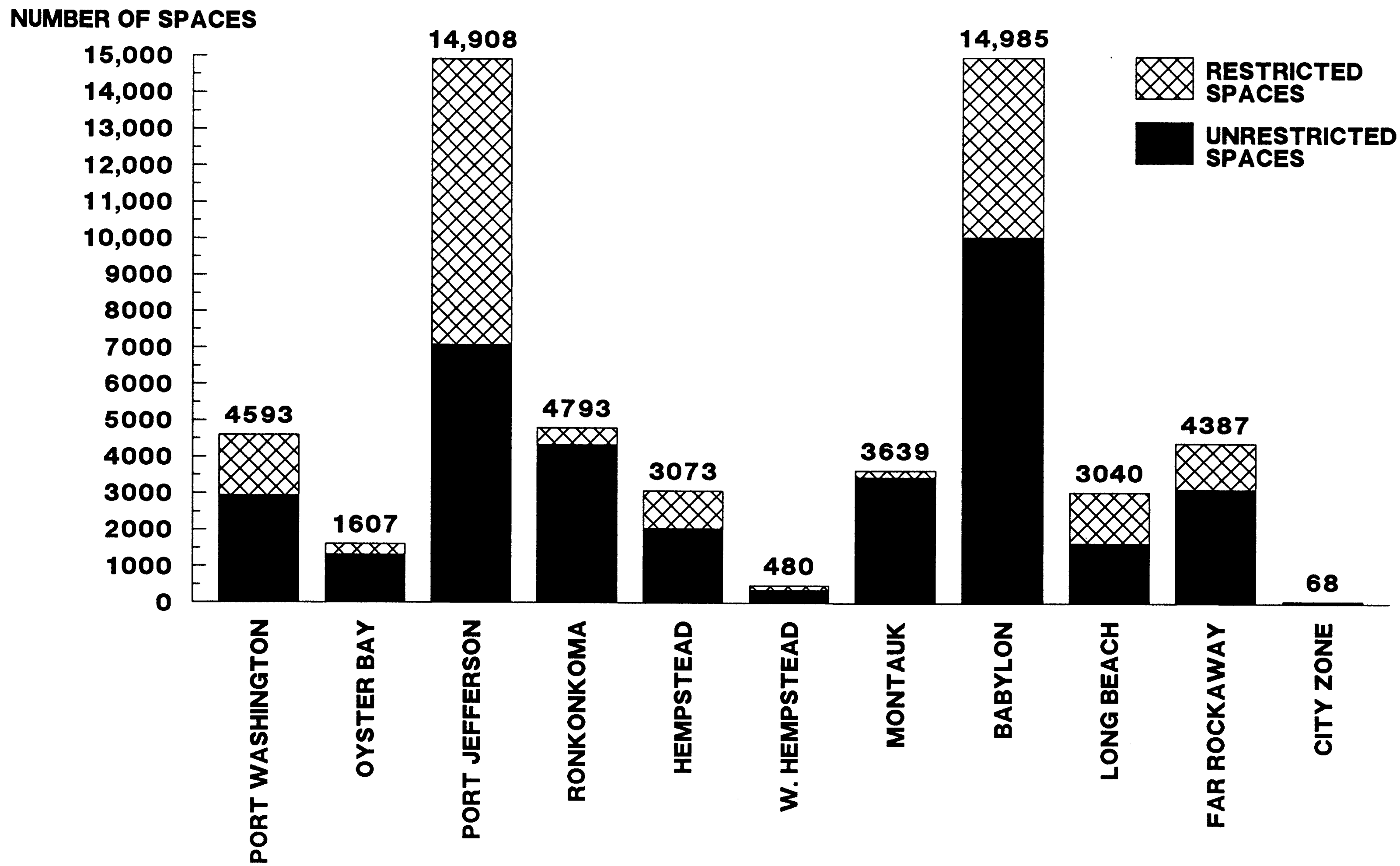
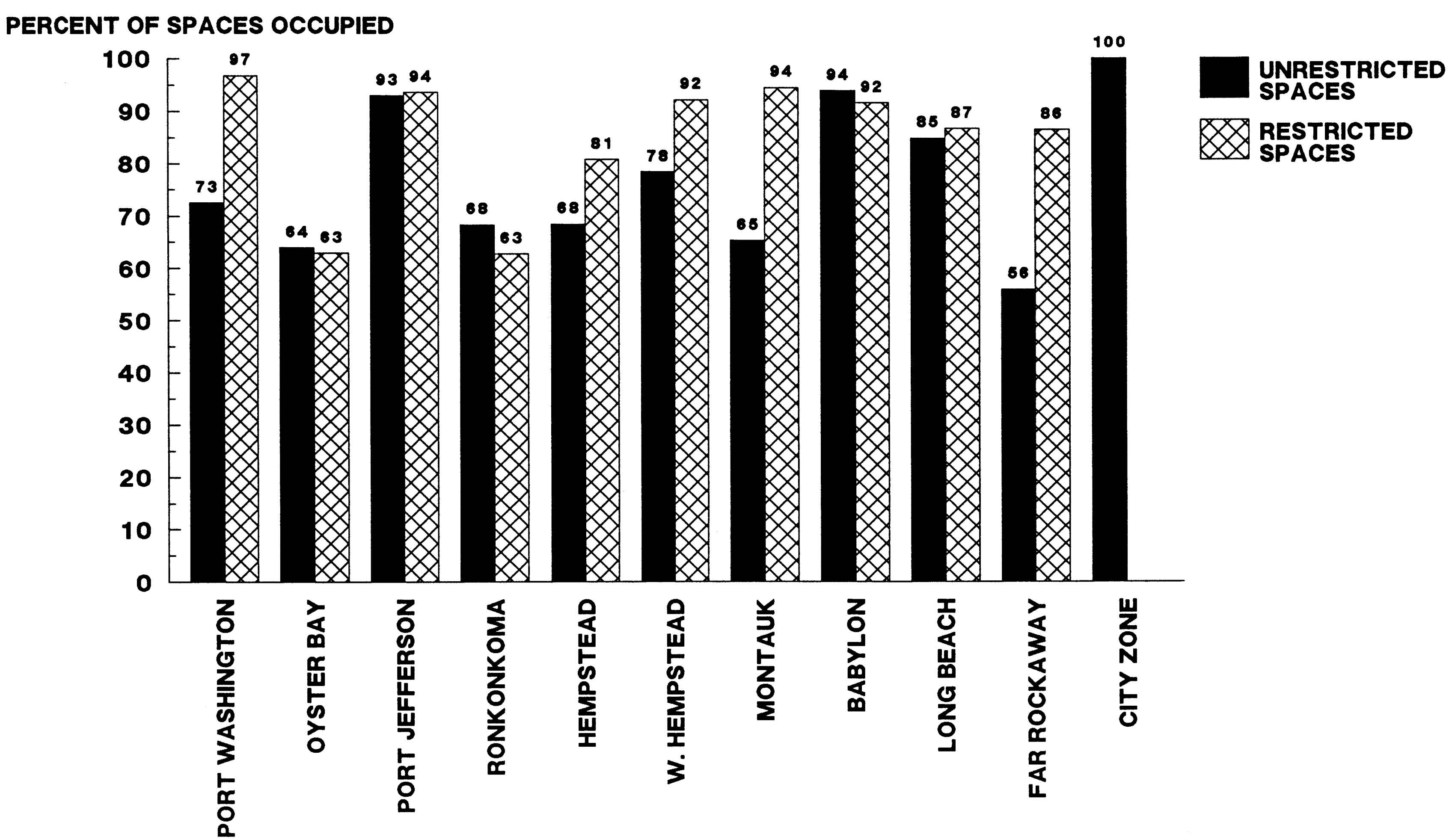


FIGURE 6-9
PARKING UTILIZATION BY BRANCH



On the Babylon Branch, Lindenhurst, Massapequa Park, Seaford, Wantagh, Bellmore, Merrick, and Baldwin are all filled practically to capacity, while some spaces are available at Babylon, Copiague, Amityville, Massapequa, Freeport, and Rockville Centre. The Port Washington Branch also displays variability in parking utilization, with lots at Port Washington, Manhasset, and Great Neck filled to capacity, while limited parking capacity remains at most other stations. A summary of ridership, parking supply, and parking utilization for each LIRR commuter station appears in Table 6-1.

Table 6-1

Summary of LIRR Ridership and Parking Utilization by Branch and Station

Branch	Station	Riders	Spaces	Cars	Occupancy
Port Washington	Port Washington	2,671	731	731	100.0%
	Plandome	606	154	119	77.3%
	Manhasset	2,104	503	485	96.4%
	Great Neck	3,462	460	426	92.6%
	Little Neck	1,583	454	389	85.7%
	Douglaston	891	427	347	81.3%
	Bayside	3,531	1,100	925	84.1%
	Auburndale	892	0	0	
	Broadway	780	127	127	100.0%
	Murray Hill	389	0	0	
	Flushing	441	635	182	28.7%
	BRANCH TOTAL	17,350	4,591	3,731	81.3%
Oyster Bay	Oyster Bay	37	232	18	7.8%
	Mill Neck	24	15	7	46.7%
	Locust Valley	177	108	62	57.4%
	Glen cove	298	155	147	94.8%
	Glen Street	142	119	101	84.9%
	Sea Cliff	237	114	112	98.2%
	Glen Head	295	182	113	62.1%
	Greenvale	110	181	105	58.0%
	Roslyn	337	148	108	73.0%
	Albertson	272	135	73	54.1%
	East Williston	615	217	180	82.9%
	BRANCH TOTAL	2,544	1,606	1,026	63.9%
Port Jefferson	Port Jefferson	696	637	587	92.2%
	Stony Brook	491	516	456	88.4%
	St James	377	275	252	91.6%
	Smithtown	875	761	725	95.3%
	Kings Park	1,139	737	701	95.1%
	Northport	1,471	1,078	902	83.7%
	Greenlawn	567	343	320	93.3%
	Huntington	4,553	3,323	3,257	98.0%
	Cold Spring Harbor	1,196	836	836	100.0%
	Syosset	1,974	978	855	87.4%
	Hicksville	7,742	3,345	3,073	91.9%
	Westbury	1,585	823	783	95.1%
	Carle Place	366	0	0	
	Mineola	1,427	530	527	99.4%
	Merillon Ave	402	140	128	91.4%
	New Hyde Park	662	584	510	87.3%
	BRANCH TOTAL	25,523	14,906	13,912	93.3%

Table 6-1

Summary of LIRR Ridership and Parking Utilization by Branch and Station

Branch	Station	Riders	Spaces	Cars	Occupancy
Ronkonkoma	Ronkonkoma	2,319	2,187	1,377	63.0%
	Central Islip	387	224	192	85.7%
	Brentwood	790	427	393	92.0%
	Deer Park	1,017	443	437	98.6%
	Wyandanch	646	550	266	48.4%
	Farmingdale	626	328	226	68.9%
	Bethpage	605	633	356	56.2%
	BRANCH TOTAL	6,390	4,792	3,247	67.8%
Hempstead	Hempstead	1,509	876	673	76.8%
	Country Life Press	557	428	181	42.3%
	Garden City	770	618	484	78.3%
	Nassau Blvd	969	209	186	89.0%
	Stewart Manor	1,063	152	133	87.5%
	Floral Park	1,249	652	504	77.3%
	Bellerose	464	38	35	92.1%
	Queens Village	415	99	32	32.3%
	Hollis	98	0	0	
	BRANCH TOTAL	7,094	3,072	2,228	72.5%
West Hempstead	West Hempstead	271	150	121	80.7%
	Hempstead Gardens	170	0	0	
	Lakeview	253	41	30	73.2%
	Malverne	602	193	188	97.4%
	Westwood	392	61	53	86.9%
	St Albans	42	35	0	0.0%
	BRANCH TOTAL	1,730	480	392	81.7%
Montauk	Speonk	171	194	98	50.5%
	Center Moriches	59	79	39	49.4%
	Mastic-Shirley	219	213	124	58.2%
	Bellport	7	80	1	1.3%
	Patchougue	829	1,080	588	54.4%
	Sayville	545	684	451	65.9%
	Oakdale	265	250	222	88.8%
	Great River	241	160	118	73.8%
	Islip	544	446	385	86.3%
	Bay Shore	545	451	398	88.2%
	BRANCH TOTAL	3,425	3,637	2,424	66.6%

Table 6-1

Summary of LIRR Ridership and Parking Utilization by Branch and Station

Branch	Station	Riders	Spaces	Cars	Occupancy
Babylon	Babylon	4,311	1,274	1,174	92.2%
	Lindenhurst	1,607	862	833	96.6%
	Copiague	1,039	780	690	88.5%
	Amityville	1,040	804	646	80.3%
	Massapequa Park	2,092	815	763	93.6%
	Massapequa	2,895	1,738	1,589	91.4%
	Seaford	1,587	835	834	99.9%
	Wantagh	3,523	1,244	1,244	100.0%
	Bellmore	3,113	1,547	1,546	99.9%
	Merrick	3,031	1,244	1,231	99.0%
	Freeport	1,960	1,180	977	82.8%
	Baldwin	3,559	1,273	1,258	98.8%
	Rockville Center	2,280	1,386	1,155	83.3%
	BRANCH TOTAL	32,037	14,982	13,940	93.0%
Long Beach	Long Beach	1,815	341	270	79.2%
	Island Park	1,155	528	470	89.0%
	Oceanside	1,595	845	708	83.8%
	East Rockaway	659	192	192	100.0%
	Centre Ave	589	182	160	87.9%
	Lynbrook	1,443	950	802	84.4%
	BRANCH TOTAL	7,256	3,038	2,602	85.6%
Far Rockaway	Far Rockaway	249	300	43	14.3%
	Inwood	248	138	18	13.0%
	Lawrence	484	198	108	54.5%
	Cedarhurst	657	571	483	84.6%
	Woodmere	724	354	347	98.0%
	Hewlett	816	778	483	62.1%
	Gibson	665	125	76	60.8%
	Valley Stream	2,286	1,245	1,111	89.2%
	Rosedale	1,484	368	135	36.7%
	Laurelton	477	52	32	61.5%
	Locust Manor	471	257	0	0.0%
	BRANCH TOTAL	8,561	4,386	2,836	64.7%
City Terminal	Kew Gardens	502	68	68	100.0%
	Forest Hills	260	0	0	
	Woodside	64	0	0	
	Penn Station	0	0	0	
	BRANCH TOTAL	826	68	68	100.0%

CHAPTER 7

DEMAND FORECASTS FOR SELECTED SCENARIOS

In order to test the capabilites and applicability of RailRider, Caliper Corporation utilized the model to produce demand forecasts for fifteen scenarios specified by LIRR staff. These scenarios do not necessarily represent service changes currently being considered by the LIRR. Most of them are hypothetical and intended solely for the purpose of testing the RailRider model.

This chapter presents the results of the fifteen scenario forecasts. The scenarios are organized into several groupings. The first section presents the results of forecasts for electrification and service expansion scenarios. The second section presents the impacts of scenarios in which service to selected branches is eliminated. The third section presents the results of scenarios that involve closing of one or more stations on the LIRR system. Finally, some results pertaining to systemwide changes in fare, service, and parking capacity are presented.

SERVICE EXPANSION SCENARIOS

Four different service improvement/expansion scenarios were studied in this project. The first scenario represented electrification of the Main Line from Bethpage to Ronkonkoma. This electrification project is now under way with completion expected in late 1987. One of the LIRR's major capital improvement projects, this effort involves track reconstruction, significant station relocations and reconstruction, and the construction of greatly expanded parking facilities and improved kiss-and-ride and feeder bus access facilities. This project will have a tremendous impact on service and schedules, with direct electric service to Manhattan reducing travel time by up to 20 minutes. The Main Line electrification scenario is the only one of the fifteen scenarios tested that is intended to reflect planned changes in LIRR service.

A second electrification scenario modeled the effects of electrifying the Port Jefferson Branch from Huntington to Port Jefferson. This hypothetical scenario would take place subsequent to Main Line electrification. This scenario was defined to incorporate revised electric schedules, but no station relocation or changes in parking supply, restrictions, or prices. A minor modification of this hypothetical scenario eliminated all passenger train service to St. James station.

Finally, a scenario was tested that added a station to the Port Jefferson Branch between Syosset and Hicksville. The new station (named Landia) would have a single unrestricted free parking facility with a capacity of 1500 cars. This hypothetical scenario was tested independently of the Main Line electrification. The forecast results for all of these scenarios are presented in the paragraphs that follow.

Main Line Electrification
Port Jefferson Electrification (Hypothetical)

These two scenarios have a major impact on LIRR systemwide ridership, and significant effects on several different branches. Systemwide ridership with Main Line electrification, shown in Figure 7-1, increases by over 3000 AM peak riders, from 112,733 to 115,745. Virtually all of this increase results from riders using park access. The park access mode share rises from 49.1 percent to 50.5 percent; the number of riders who park at LIRR stations increases from 55,305 to 58,491. Electrification of the Port Jefferson Branch increases LIRR ridership to 116,849, or by an additional 1104 AM peak riders. Once again, almost all of the increase is attributable to park access, with the number of riders who park at LIRR stations increasing to 59,555.

Significant travel time savings also result from this scenario. Average total LIRR trip time (including access, wait time, and egress) decreases systemwide from 82.0 minutes to 80.7 minutes, for a net savings among current riders of 2536 person-hours per day or 634,000 person-hours (72.4 person-years) annually. With Port Jefferson electrified, systemwide average trip time drops to 80.4 minutes, with an additional savings of 579 person-hours per day or 145,000 person-hours (16.5 person-years) annually.

The majority of ridership impacts are in Suffolk County, where LIRR ridership increases from 28,395 in the Base Case to 30,920 with Main Line electrification, and to 31,835 with Port Jefferson electrification. The remaining ridership increases occur in Eastern Nassau County. The greatest impacts of Main Line electrification on individual towns are in Islip (LIRR ridership increased by 1505) and Brookhaven (572). Other increases occurred in Hempstead (236), Oyster Bay (229), and Babylon (198). LIRR ridership in the town of Huntington stays relatively constant when the Main Line is electrified. Under Port Jefferson electrification, the subsequent increases are greatest in Brookhaven (354), Islip (282), and Huntington (153).

Impacts of Main Line and Port Jefferson electrification on ridership by branch are shown in Figure 7-2. When the Main Line is electrified, demand increases tremendously, from 6,390 AM peak riders in the Base Case up to 11,848 AM peak riders, an increase of over 5400. Perhaps 40 percent of this increase results from decreases in demand on the Port Jefferson, Montauk, and Babylon

FIGURE 7-1

IMPACTS OF MAIN LINE AND PORT JEFFERSON LINE

ELECTRIFICATION - SYSTEMWIDE DEMAND

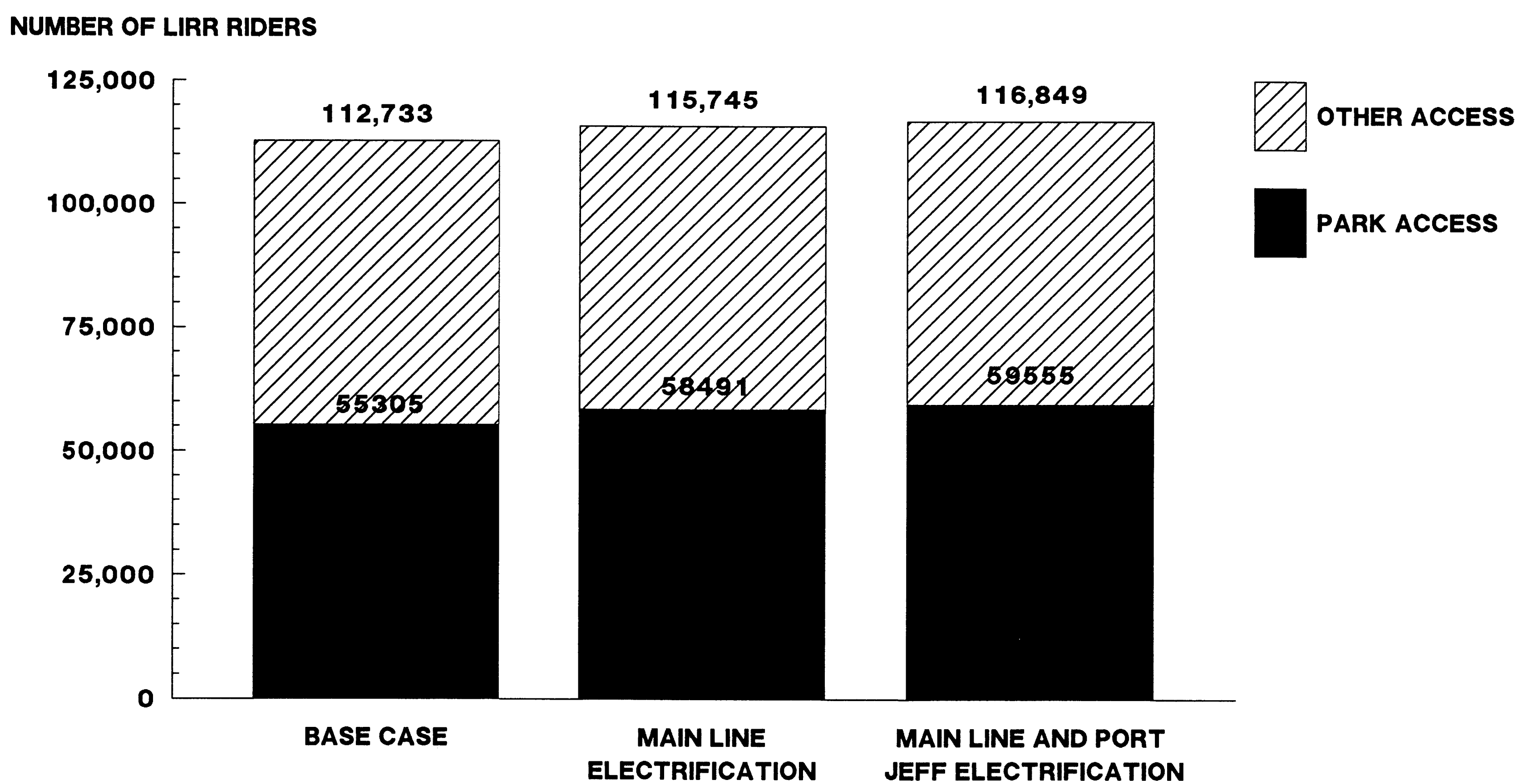
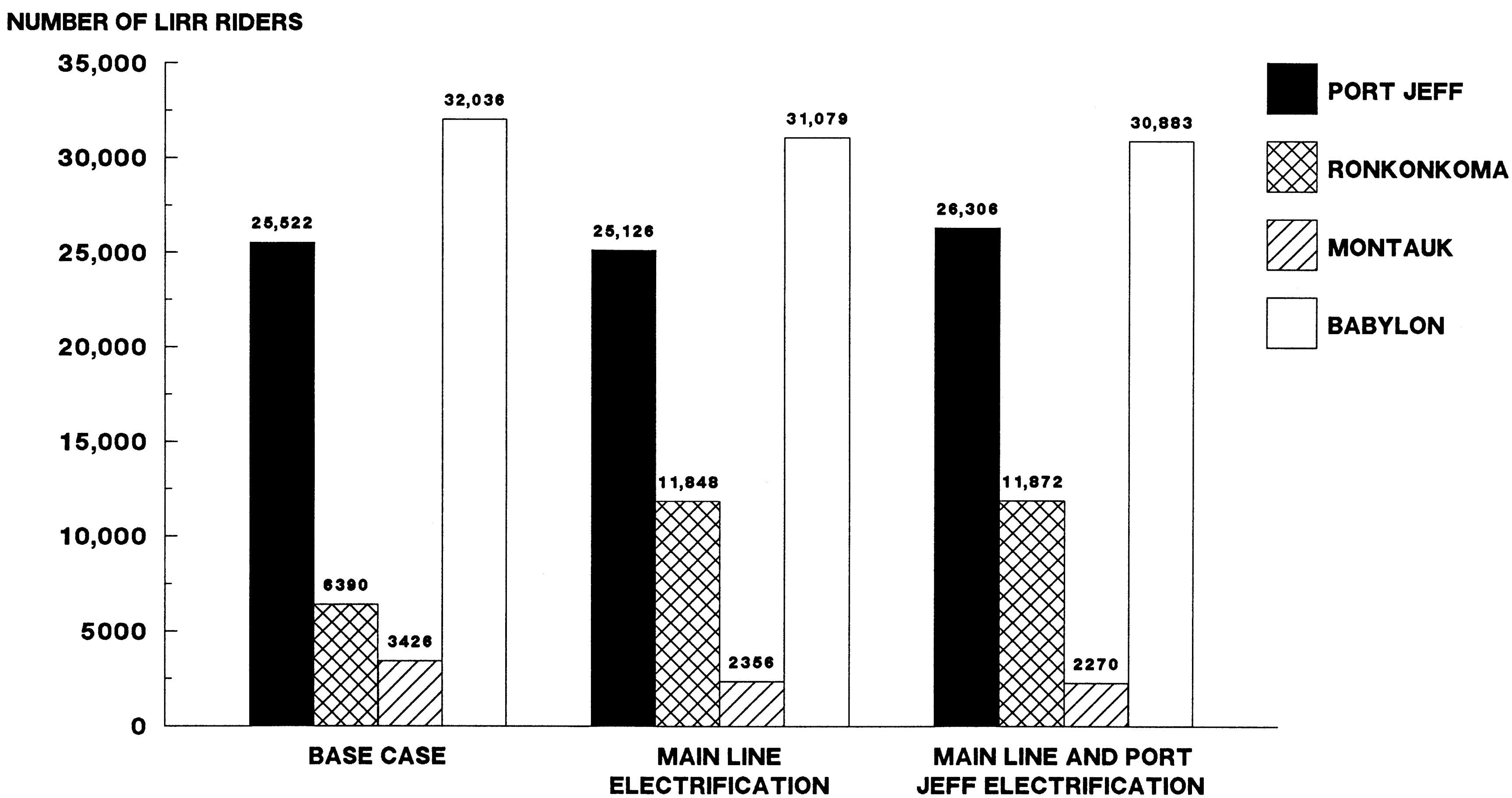


FIGURE 7-2

IMPACTS OF MAIN LINE AND PORT JEFFERSON ELECTRIFICATION - BRANCH DEMAND



branches, on which ridership drops by 396, 1070, and 957 riders respectively.

When the Port Jefferson Branch is electrified, demand on this branch (which had been 25,522 in the base case and was reduced to 25,126 upon Main Line electrification) increases to 26,306, or by 1180 AM peak riders. This is well above the Base Case levels. The effect of Port Jefferson electrification on other branches is very small, as indicated in the Figure.

The new riders generated by Main Line electrification are heavily oriented towards park access, as shown in Figure 7-3. In the base case, 61 percent of Ronkonkoma Branch riders used park access; after electrification the number of riders using park access increases from 3896 to 8807, and the park access mode share increases to 74.3 percent. Whereas Ronkonkoma Branch parking facilities were occupied only at a 67.7 percent rate in the base case, after electrification the occupancy rate increases to a 93.7 percent, higher than any other branch on the LIRR system. This increase in occupancy occurs in spite of (or, perhaps, in association with) an increase in parking capacity from 4793 cars to 7832 cars. Access mode shares on the other branches are relatively unaffected by Main Line electrification, and parking occupancy rates are slightly reduced.

The increase in Port Jefferson Branch demand that results from electrification of Huntington through Port Jefferson is also largely attributable to riders using park access. While the park access share does not increase substantially, the number of riders using park access rises from 16,015 under Main Line electrification to 17,012 under Port Jefferson electrification. This results in parking occupancy of 96.7 percent on the Port Jefferson Branch, even higher than the reconstructed Ronkonkoma Branch.

Station by station ridership impacts are shown in Figures 7-4 through 7-7 for the Port Jefferson, Ronkonkoma, Montauk, and Babylon branches, respectively. As Figure 7-4 indicates, under Main Line electrification the diesel portion of the Port Jefferson Branch loses significant amounts of ridership, as local residents shift their travel to take advantage of the electric service available at nearby Ronkonkoma Branch stations. The electrified portion of the branch remains relatively unaffected. When the remaining diesel portion of the Port Jefferson Branch is electrified, these stations recover all of the ridership they had lost and, in fact, end up with ridership higher than the Base Case. Further increases are prohibited by the parking situation -- parking occupancy is over 95 percent at all of the newly electrified stations between Huntington and Port Jefferson. Port Jefferson Branch electrification also increases ridership slightly at Northport because of related service improvements.

FIGURE 7-3

EFFECT OF MAIN LINE ELECTRIFICATION ON RONKONKOMA BRANCH RIDERSHIP AND ACCESS MODE

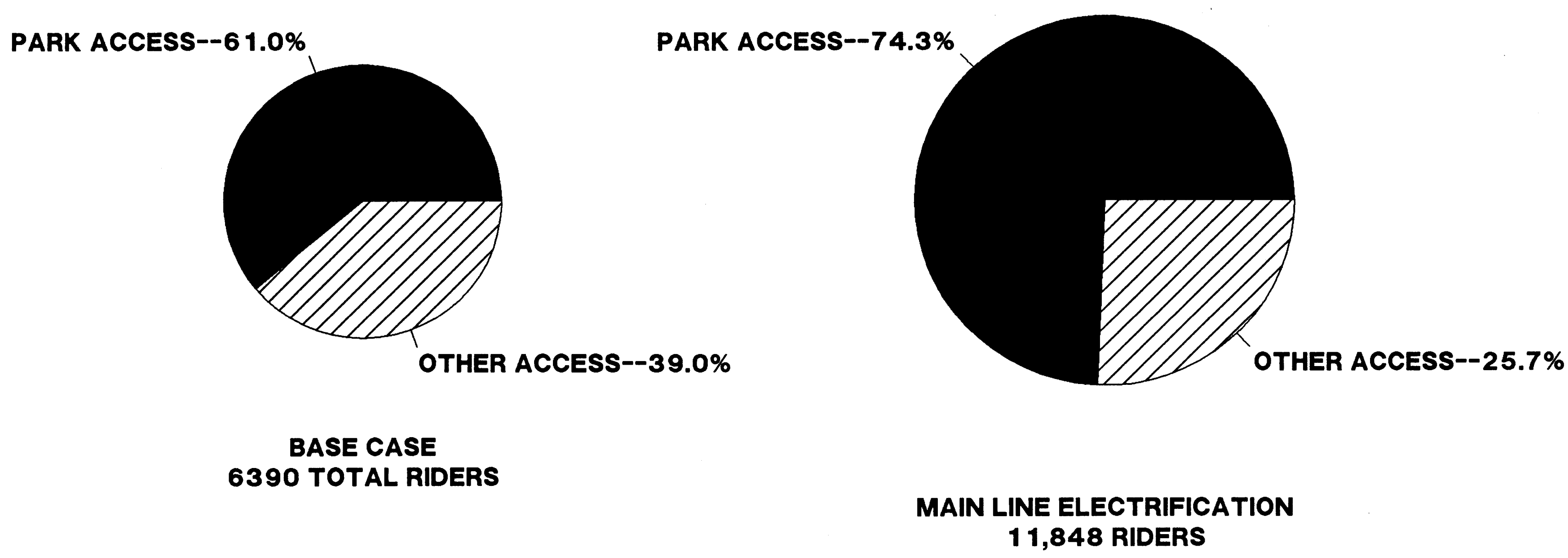
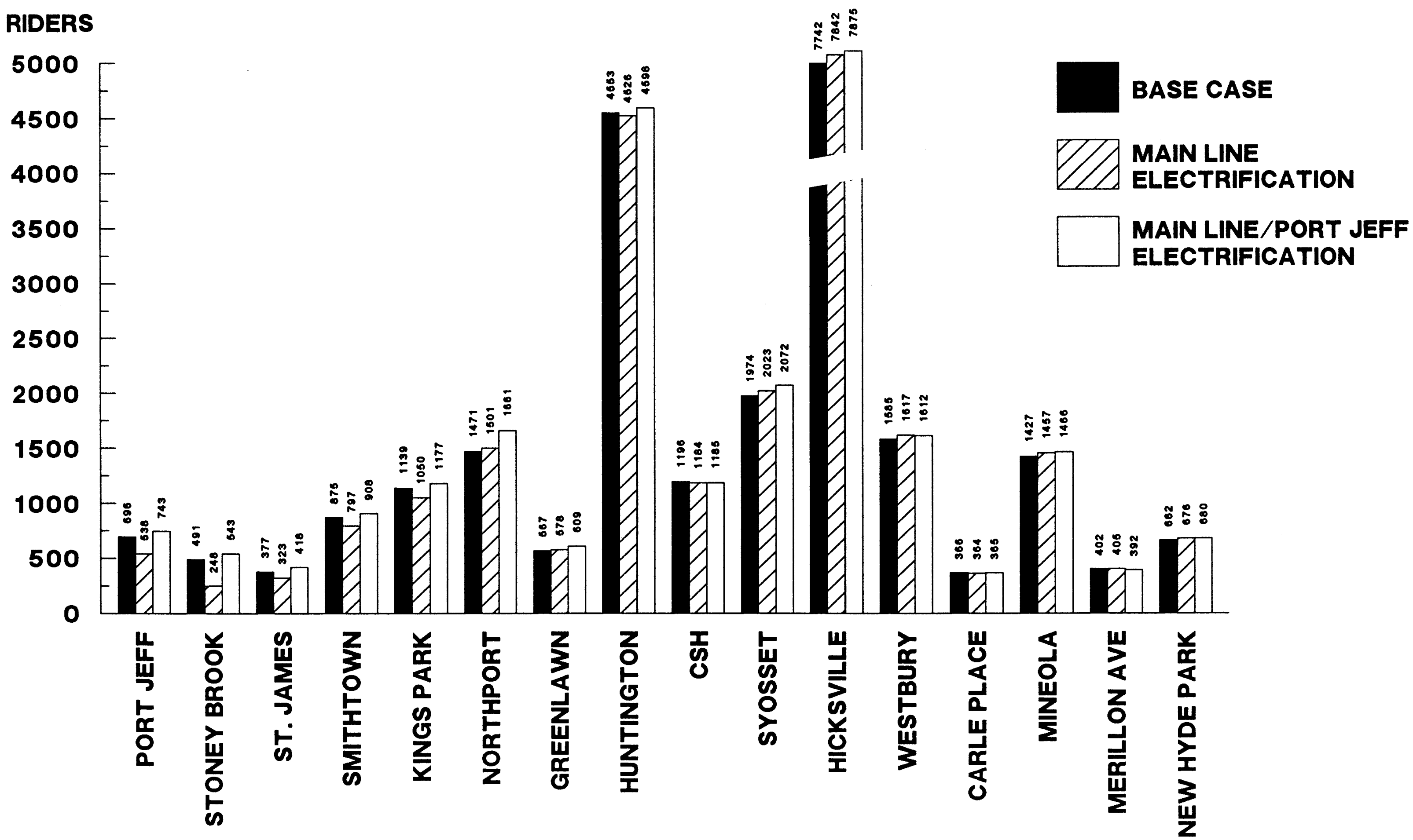


FIGURE 7-4

IMPACTS OF MAIN LINE AND PORT JEFFERSON ELECTRIFICATION - PORT JEFFERSON BRANCH



Ronkonkoma Branch ridership under the Base Case and two electrification scenarios is shown in Figure 7-5. As the Figure indicates, Main Line electrification results in a large increase in ridership at all stations along the branch, with the magnitude of the change greatest at the eastern end of the Branch (where the travel time improvement is greatest). Port Jefferson electrification has virtually no effect on ridership at any of the electrified Main Line stations. There is substantial evidence from the forecast results that demand on the Ronkonkoma Branch under these scenarios is constrained by parking supply -- parking occupancy is 99.6 percent at Deer Park, 97.2 percent at Brentwood, 96.1 percent at Ronkonkoma, 94.5 percent at Farmingdale, and 91.6 percent at Central Islip.

The Montauk Branch is the one whose ridership suffers most as a result of the Main Line electrification project. As indicated in Figure 7-6, demand at every station from Bay Shore to Patchogue is reduced significantly under the Main Line electrification scenario, as passengers who currently use this diesel service drive to electrified Main Line stations instead. When the Port Jefferson Branch is electrified, further decreases in ridership occur at Patchogue and Sayville. While this at first glance seems illogical, it is a result of the interaction of the three branches and capacity constraints. Under Main Line electrification, many Port Jefferson riders in diesel territory abandon the Port Jefferson Branch and use Ronkonkoma station. Because parking facilities at Ronkonkoma are filled to capacity, there is a limit to the number of Montauk branch riders who can switch to this station. <u>After</u> the Port Jefferson electrification is complete, many of the Port Jefferson riders return to their "home" branch, opening up additional capacity at Ronkonkoma station, and allowing additional riders from Sayville and Patchogue to switch over to Ronkonkoma.

Finally, Figure 7-7 shows the impacts of the two electrification scenarios on the easternmost stations of the Babylon Branch. As expected, demand drops at these station under the Main Line scenario, as current riders who live near the Main Line but now choose to drive to the Babylon Branch instead elect to travel via the improved, electrified stations closer to their residence. Port Jefferson electrification has almost no additional effect on Babylon Branch ridership.

An additional scenario that was tested in the project involved eliminating St. James station from the electrified Port Jefferson Branch. This change involved slight schedule modifications and decreases in LIRR travel time from Stony Brook and Port Jefferson. The impacts of this station closing were very slight. There were 418 AM peak riders who would use St. James under the Main Line & Port Jefferson electrification scenario. If St. James were closed, total Port Jefferson Branch demand is projected to drop by 227 riders, from 26,306 to 26,079. There are no other significant impacts in the immediate vicinity of the

FIGURE 7-5

IMPACTS OF MAIN LINE AND PORT JEFFERSON ELECTRIFICATION - RONKONKOMA BRANCH

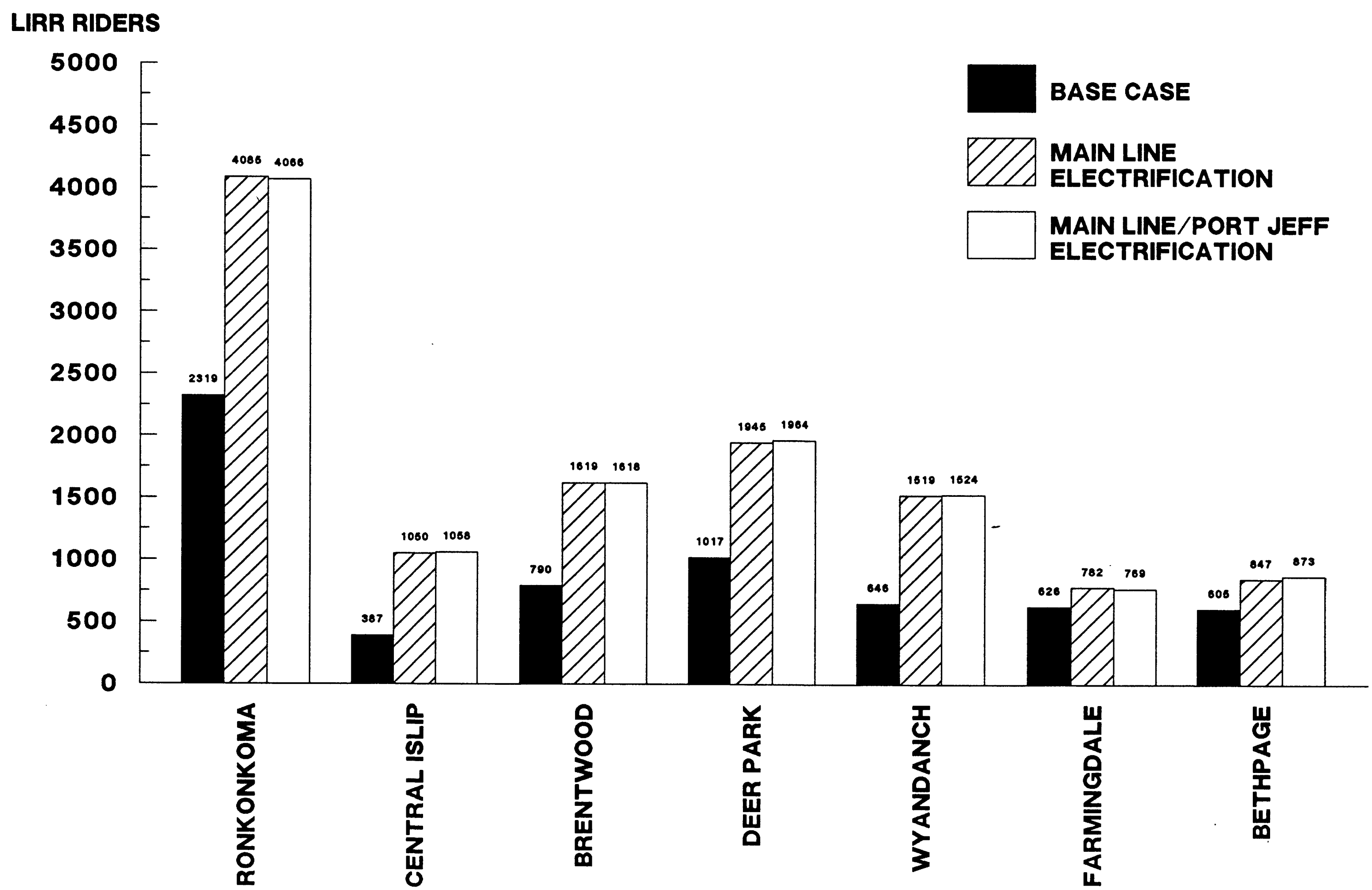


FIGURE 7-6

IMPACTS OF MAIN LINE AND PORT JEFFERSON ELECTRIFICATION - MONTAUK BRANCH

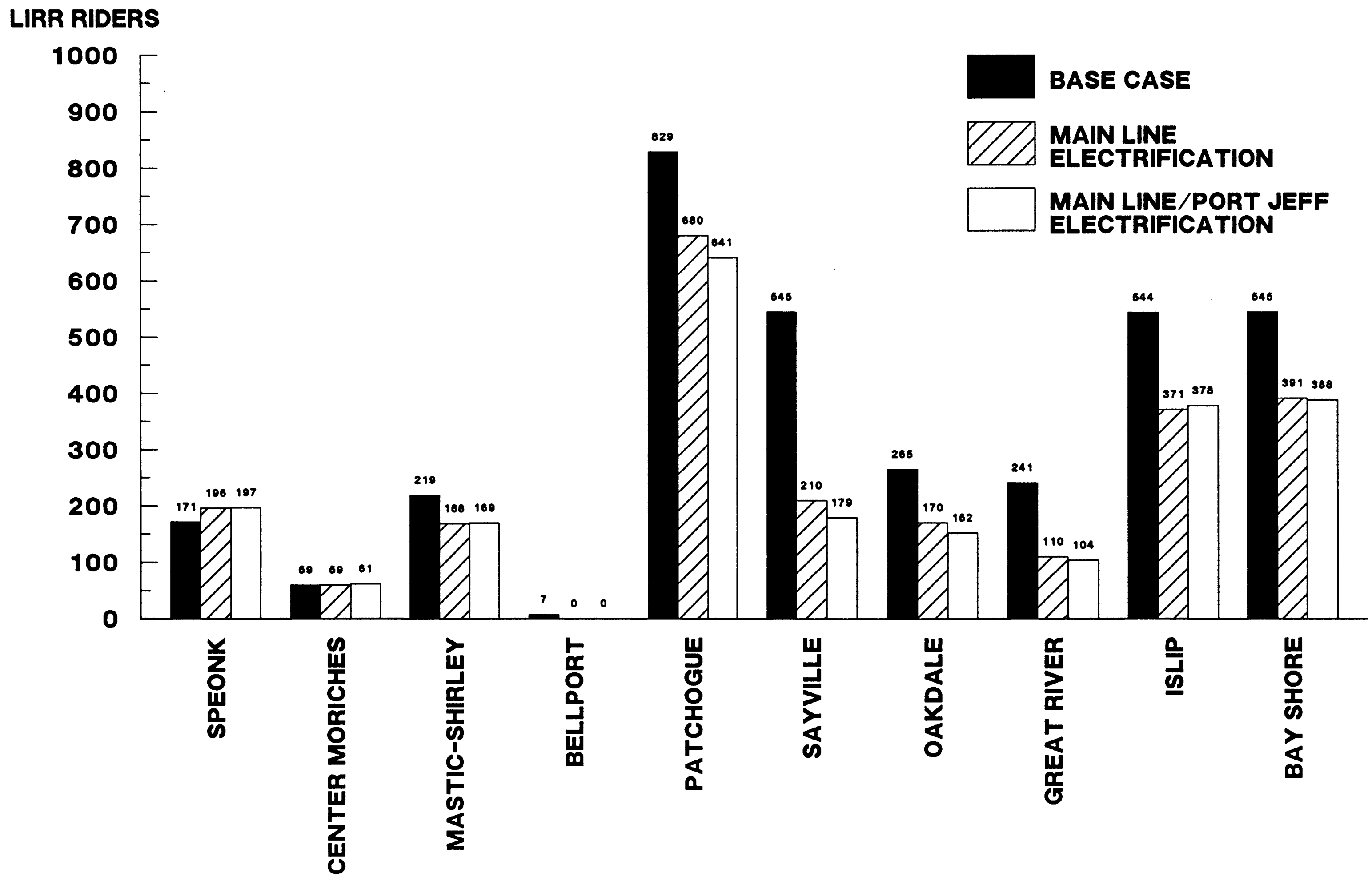
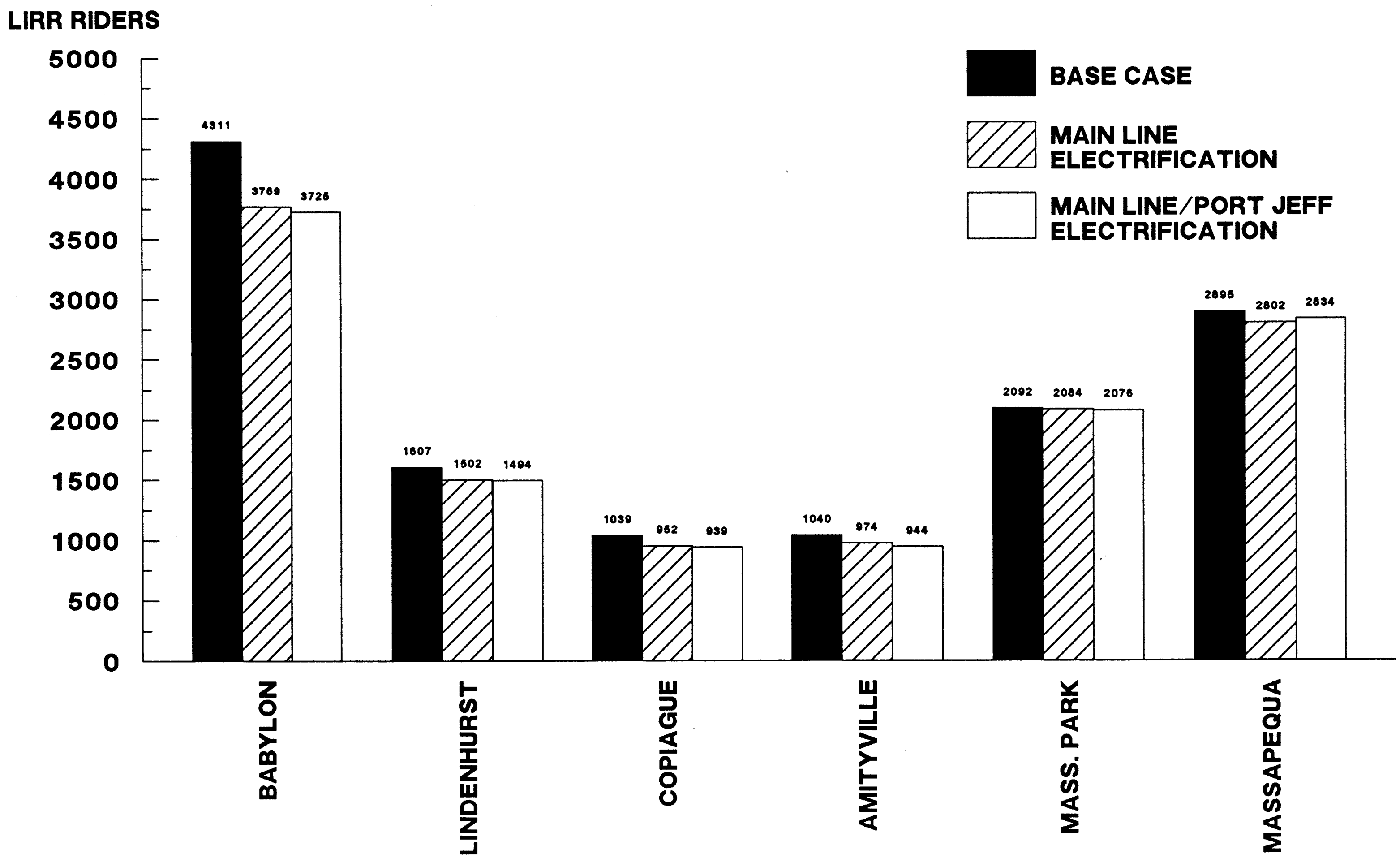


FIGURE 7-7
IMPACTS OF MAIN LINE AND PORT JEFFERSON ELECTRIFICATION - BABYLON BRANCH



former St. James station; that is, no nearby station appears to pick up any substantial portion of the former St. James ridership. This is largely because of the severe capacity constraints that affect almost all of the stations in the vicinity of St. James. In practice, former St. James riders are squeezing into Smithtown and Ronkonkoma stations, and riders there are being forced to other stations by the increased overloading. These effects spread throughout the system, so that no one stations bears a particularly large burden when St. James is closed.

Introducing Landia Station

The introduction of Landia Station between Hicksville and Syosset on the Port Jefferson Branch appears to be likely to have major impacts on demand in the immediate vicinity, but relatively insignificant impacts on systemwide demand. According to the scenario forecasts, over 2000 AM peak riders would use Landia Station, but total LIRR AM peak demand would increase by only 200. Figure 7-8 shows the impacts of adding Landia Station on a branch by branch basis. As indicated there, demand on the Port Jefferson Branch would increase by 742 riders, from 25,522 in the Base Case up to 26,264. Small decreases would occur on the Port Washington, Oyster Bay, Ronkonkoma, and Babylon Branches to offset the bulk of this increase. Stations on these other branches carry riders who are conveniently located to the new station. Both the Port Washington and Oyster Bay Branches carry riders living near the diesel service Oyster Bay Branch, and both the Babylon and Ronkonkoma Branches carry riders living near the diesel service Ronkonkoma branch. All of these individuals would have an incentive to drive to the new station.

Figure 7-9 shows the station impacts on the Port Jefferson Branch. As might be expected, the 2077 riders at Landia are drawn largely from Syosset and Hicksville, which lose 441 and 469 AM peak riders, respectively. Further out on the Port Jefferson Branch, many stations lose small percentages of their ridership, as travelers take advantage of the additional parking capacity at stations closer to Manhattan.

Most of the drop in ridership at Hicksville and Syosset is among riders using auto access. At Hicksville, only 173 of the 469 lost riders were using other access modes; at Syosset only 137 of the 441 lost riders were using other access modes. This is consistent with the access mode share at the new Landia Station; 1800 of the 2077 riders use park access, with only 277 using other modes of access. Overall, the addition of 1500 parking spaces at Landia results in an increase in the park access share for the Port Jefferson Branch from 64.4 percent to 65.7 percent, with park access riders increasing from 16,428 to 17,253 and riders using other access dropping from 9,094 to 9,012. Systemwide, the park access share increases from 49.1 percent to 49.5 percent with the introduction of Landia Station.

FIGURE 7-8

IMPACTS OF ADDING LANDIA STATION ON BRANCH DEMAND

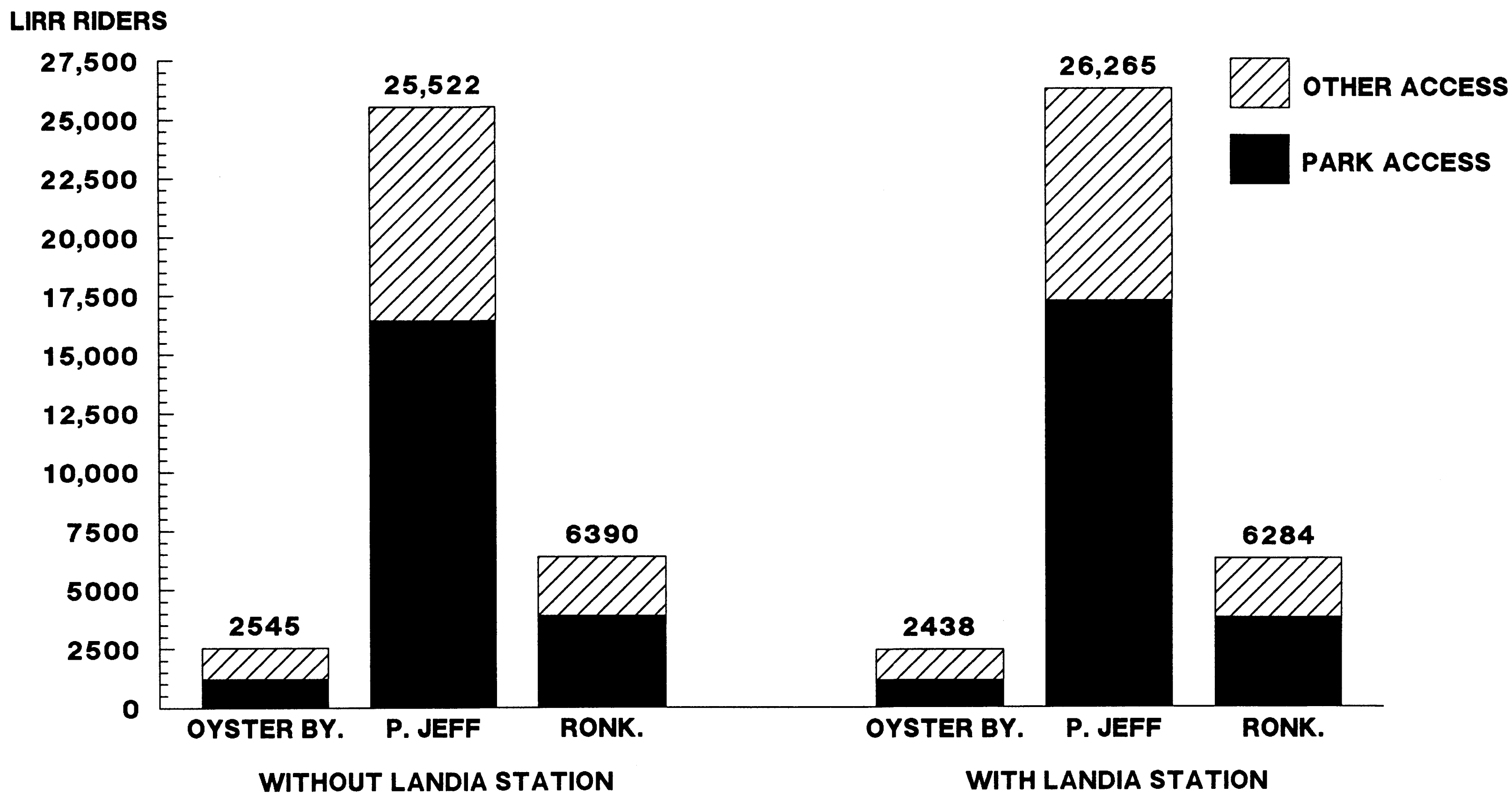
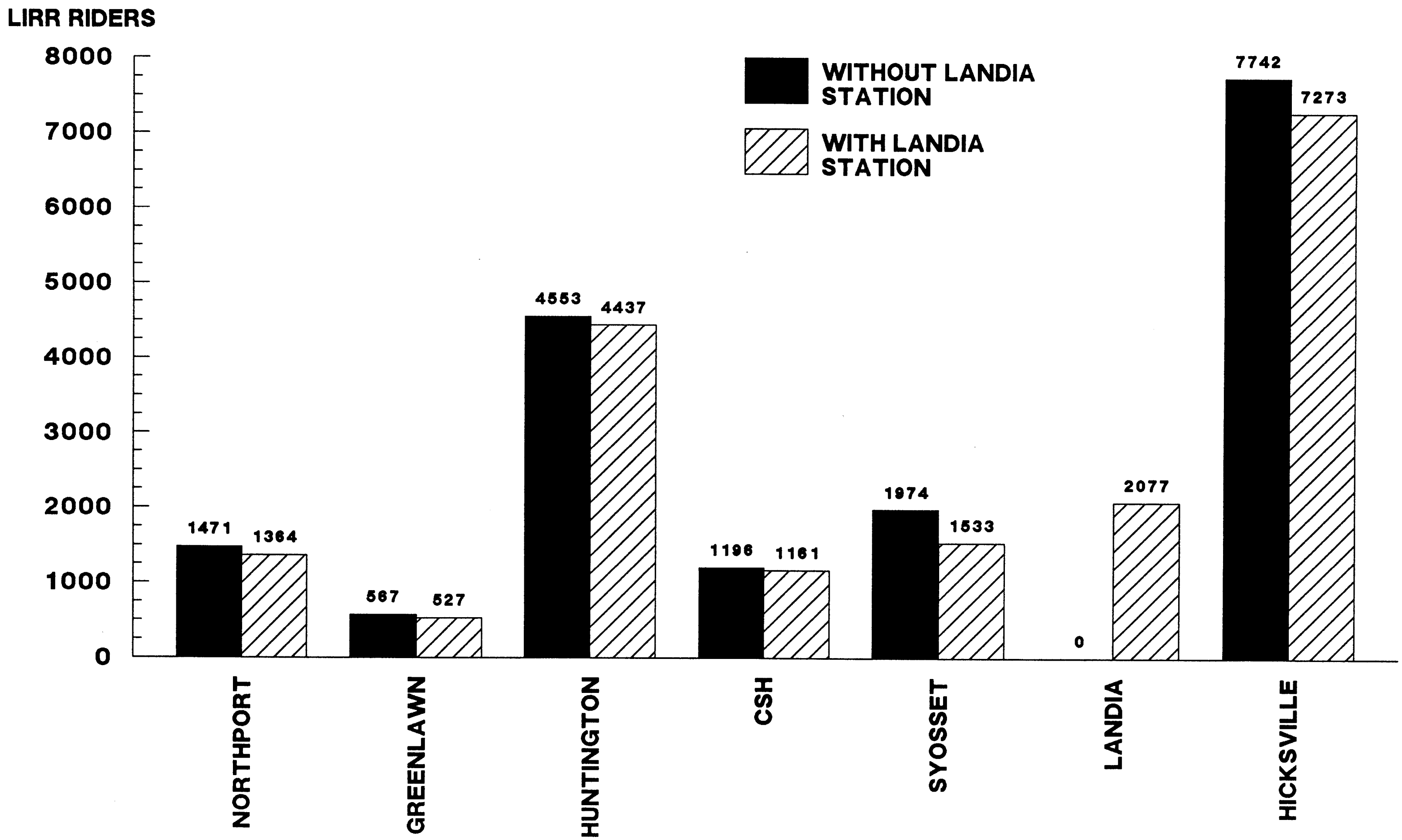


FIGURE 7-9

IMPACTS OF ADDING LANDIA STATION ON DEMAND
AT INDIVIDUAL STATIONS ON THE PORT JEFFERSON BRANCH



It should be noted that the Landia scenario was run independently of the Main Line and Port Jefferson electrification scenarios. If Landia were added post-electrification, the impacts are likely to be somewhat different, because of the severe capacity constraints which result from electrification. Most likely, introduction of Landia Station after electrification of the Main Line and Port Jefferson Branch would have a far greater impact on total LIRR ridership.

BRANCH CLOSING SCENARIOS

Two hypothetical scenarios were specified under which service to all stations on a branch was terminated. Once again, these scenarios were developed solely to test the RailRider model and are not necessarily under consideration by the LIRR. The two scenarios and the corresponding RailRider forecast results are discussed below.

Closing of the West Hempstead Branch

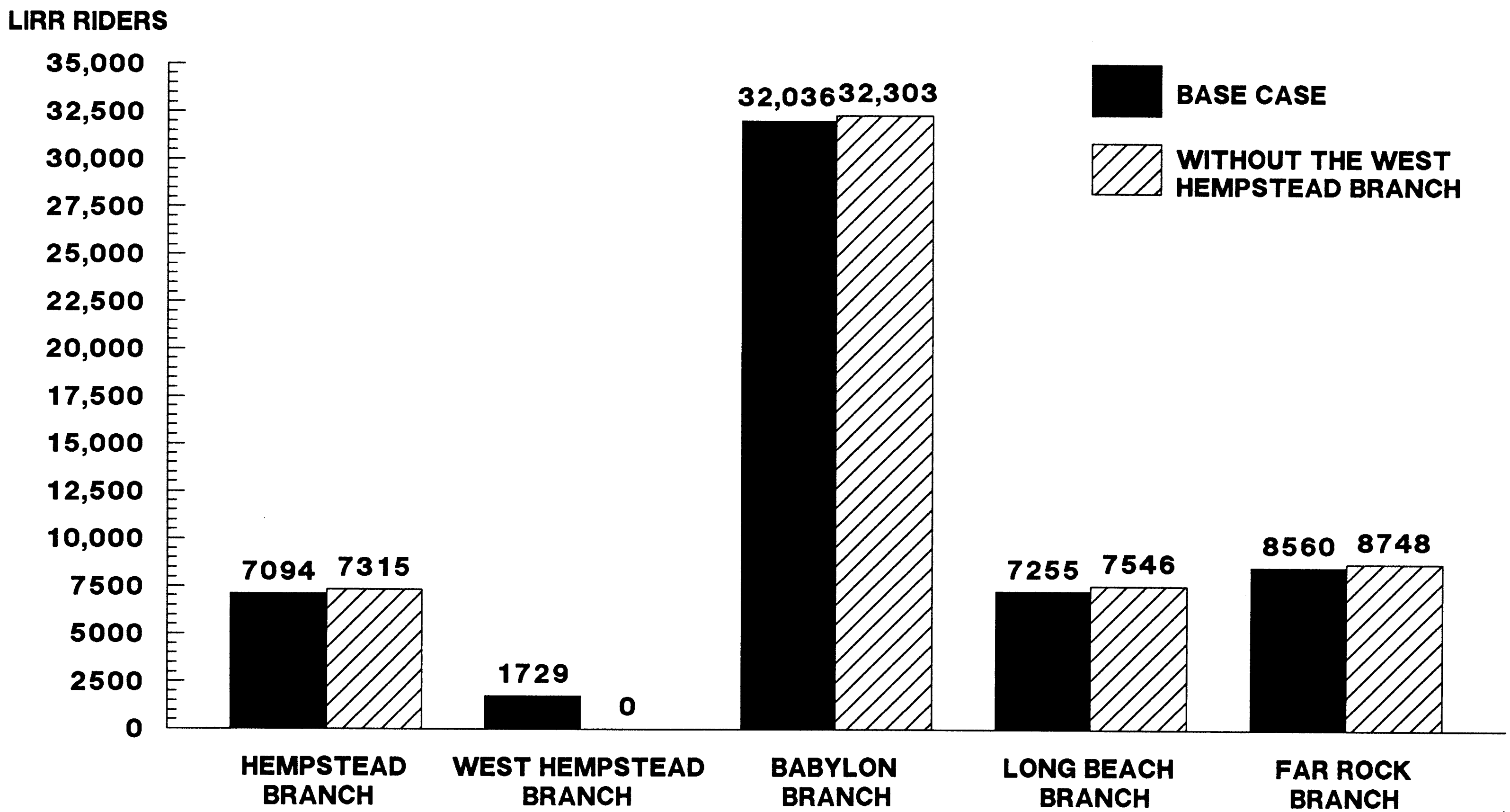
The West Hempstead Branch is the LIRR's most lightly traveled branch, and serves an area that is relatively close to several other branches, including the Hempstead, Babylon, Long Beach, and Far Rockaway branches. As a result, closing this branch, which in the Base Case serves 1729 riders, would not be expected to have a tremendous impact on the LIRR system. The demand forecast for this scenario bears out this expectation, and is shown in Figure 7-10. As indicated there, total LIRR demand drops by 723, with almost all of the remaining riders picked up by the four adjacent branches. Ridership on the Hempstead branch increases by 221, from 7094 in the base case to 7315. Hempstead station ridership increases by 81, Country Life Press by 42, and Garden City by 67. On the Babylon Branch, ridership increases by 267, with most of this increase at Freeport (91) and Rockville Center (175). Demand does not increase at Baldwin because of the already highly congested parking conditions in lots at the station.

Long Beach Branch demand increases by 291 AM peak riders, with the largest increase (110) occurring, as would be expected, at Lynbrook station. Relatively small increases result at the other Long Beach stations. Finally, Far Rockaway Branch ridership increases by 188, with over 100 of these additional riders boarding at Valley Stream.

As might be expected, the branch closing results in a slight increase in the share of LIRR riders who park at the station. The West Hempstead branch is heavily oriented to non-park access, with park access representing only 27 percent of riders (compared to 49.1 percent systemwide). With the West Hempstead Branch closed, most of these riders are forced to drive or to be driven

FIGURE 7-10

IMPACTS ON BRANCH RIDERSHIP OF ELIMINATING SERVICE ON THE WEST HEMPSTEAD BRANCH



TOTAL LIRR DEMAND DROPS FROM 112,733 TO 112,010 (DOWN 723)

to stations that are further away, thereby resulting in increased parking demand at these stations. The branch closing increases the total systemwide number of riders using park access from 55,305 to 55,562, and the park access mode share from 49.1 percent to 49.6 percent.

Closing of the Oyster Bay Branch

The Oyster Bay Branch is the LIRR's second most lightly traveled branch, and because it has a relatively large number of stations, the average passenger demand by station is lower here than anywhere else in the LIRR system. Also, because of the relatively low level of service provided on this branch, many area commuters already go to great lengths to avoid using the Oyster Bay Branch, preferring instead to travel to stations on the Port Washington Branch (which has superior service to Penn Station) or the Port Jefferson Branch.

This branch serves 2544 riders in the Base Case, many of whom are lost to the LIRR when the branch is closed. Overall, systemwide AM peak ridership drops by 1156 according to the forecast. Most of the remainder are picked up by the Port Washington and Port Jefferson branches, as shown in Figure 7-11. On the Port Washington Branch, AM peak demand rises from 17,350 in the Base Case to a forecast level of 17,936, an increase of 586. On a station by station basis, demand at Port Washington increases by 118, at Plandome by 97, at Manhasset by 334, and at Great Neck by 98. On the Port Jefferson Branch, demand increases from 25,522 to 25,999, an increase of 477 riders. This increase is distributed along the branch from New Hyde Park to Syosset, with the increases by station as follows: New Hyde Park - 52; Merillon Ave - 39, Mineola - 46; Carle Place - 18; Westbury - 71; Hicksville - 164; and Syosset - 98.

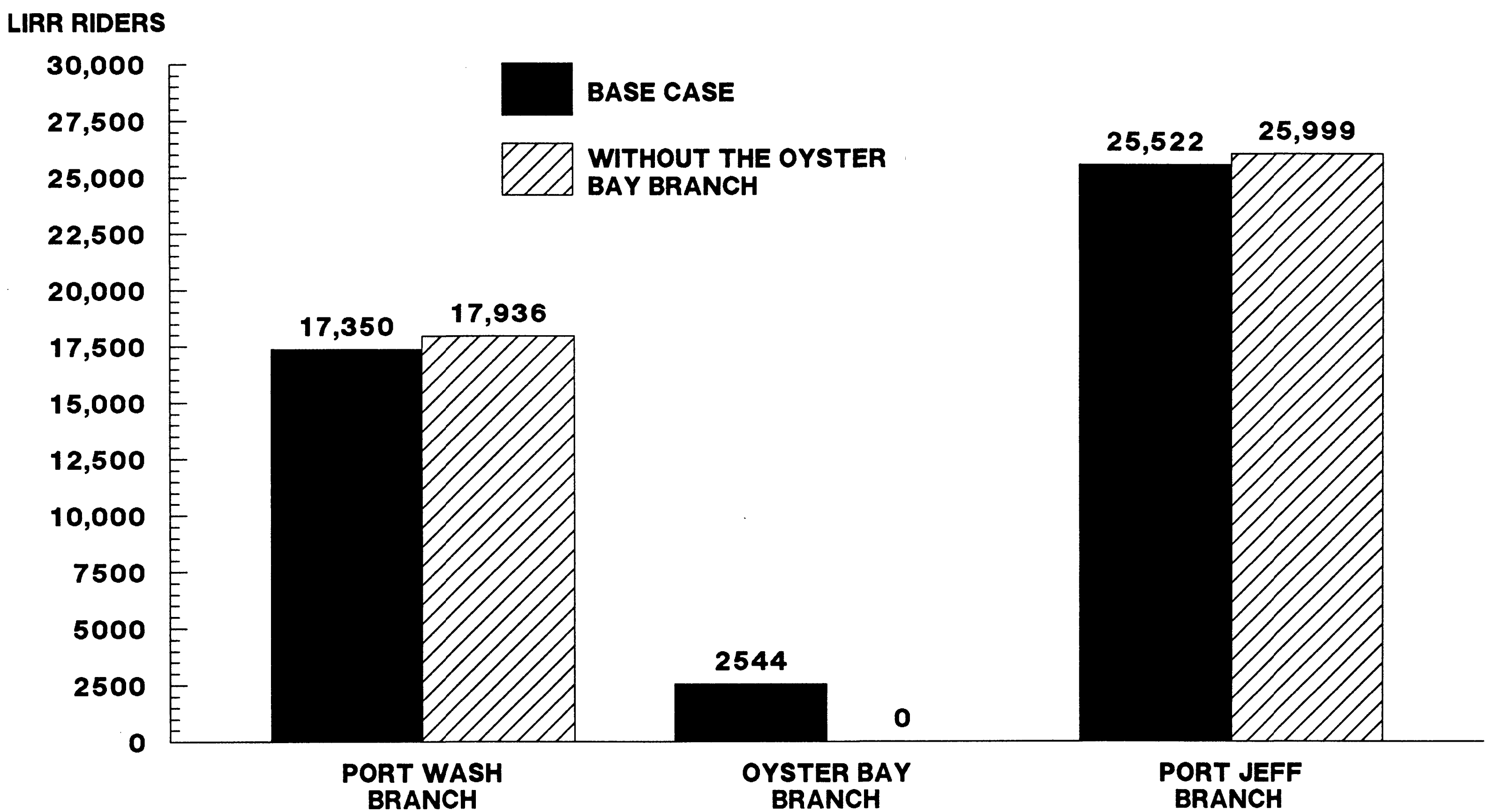
This branch closing results in only a very slight decrease in the share of LIRR riders who park at the station. Unlike the West Hempstead branch, which is heavily oriented to non-park access, the Oyster Bay Branch is currently split about 50-50 with respect to access mode. When the branch is closed, most riders who continue to use the LIRR are switching to stations where parking congestion is already severe, so that the share using other forms of access increases. The branch closing decreases the total systemwide number of riders using park access from 55,305 to 54,431, and decreases the park access mode share from 49.1 percent to 48.8 percent.

STATION CLOSING SCENARIOS

These hypothetical scenarios were designed to test the sensitivity of the RailRider model to relatively small changes in LIRR service. The station closings that were tested were as follows:

FIGURE 7-11

IMPACTS ON BRANCH RIDERSHIP OF ELIMINATING SERVICE ON THE OYSTER BAY BRANCH



TOTAL LIRR DEMAND DROPS FROM 112,733 TO 111,577 (DOWN 1,156)

* Closing of Locust Manor and Laurelton
* Closing of Glen Street, Glen Head, and Sea Cliff
* Closing of Country Life Press
* Closing of Carle Place
* Closing of Albertson Station
* Closing of Inwood
* Closing of Mill Neck Station
* Closing of Hollis
* Closing of Bellport and Center Moriches

The RailRider forecast results are discussed one by one in the paragraphs that follow.

Closing of Locust Manor and Laurelton

This scenario terminates service at stations used by a total of 948 riders. The demand forecast for this scenario indicates that total LIRR demand would stay nearly constant, indicating that most of the affecting passengers would shift to other LIRR stations. Far Rockaway Branch total ridership drops by 235. The largest single change occurs at Rosedale, which picks up 640 additional riders, from a base case of 1484 to a forecast of 2124.

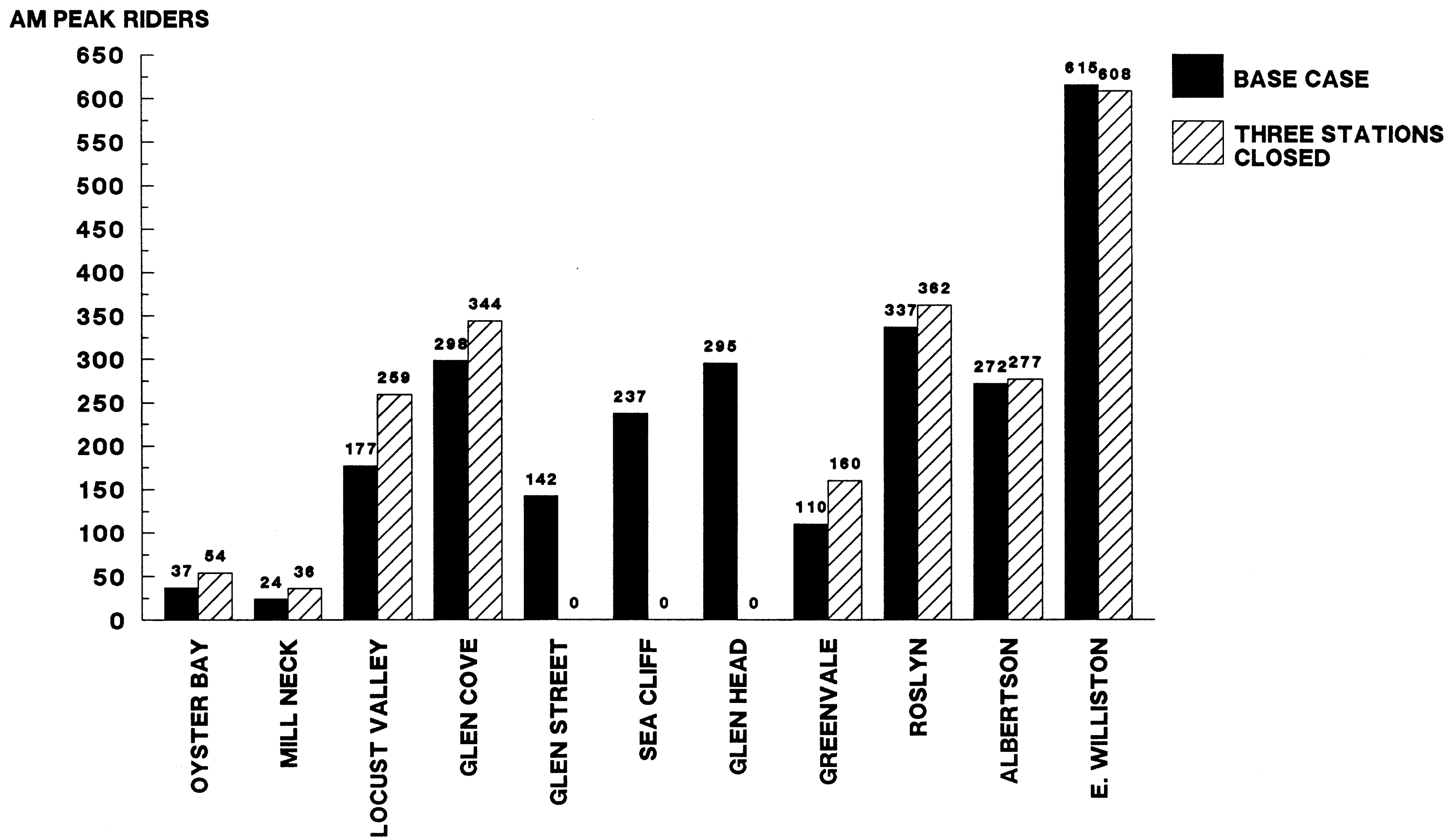
Closing of Glen Street, Glen Head, and Sea Cliff

This scenario terminates service at stations used by a total of 674 riders. The demand forecast for this scenario indicates that total LIRR demand would again stay nearly constant. Oyster Bay Branch total ridership drops by 445, with slight increases in demand on adjacent branches reducing the systemwide ridership loss to only 283. Most of the remaining Oyster Bay Branch Stations pick up additional riders, as shown in Figure 7-12. The biggest changes occur at Locust Valley (from 177 to 259), Glen Cove (298 to 344), Greenvale (110 to 160), and Roslyn (337 to 362). Manhasset station, on the Port Washington line, picks up an additional 46 passengers under this scenario. Other Port Washington Branch stations remain relatively unaffected.

Closing of Country Life Press

This station closing affects 557 AM peak passengers, but has limited impact on total LIRR ridership because of the existence of service at numerous nearby stations. Hempstead Station picks

FIGURE 7-12
EFFECT OF CLOSING GLEN STREET, GLEN HEAD, AND SEA CLIFF STATION ON OYSTER BAY BRANCH RIDERSHIP



up 100 riders, moving from 1509 AM Peak riders in the Base Case up to 1609. Demand at Garden City increases from 770 to 835. Both Merillon and New Hyde Park pick up additional riders (from 402 to 428 and from 662 to 704, respectively), while demand at Mineola remains nearly unchanged (largely due to existing constraints on parking availability).

Closing of Carle Place

This station serves 366 AM Peak riders in the Base Case, virtually all of whom access the station on foot or by being dropped off. Because these riders are not driving and parking at the station, the impact of the station closing is more significant than other station closings. Port Jefferson Branch ridership drops by 309, with only a very small drop among those riders who use park access. Ridership at Westbury, the adjacent station in the Eastbound direction, is unaffected by the closing of Carle Place; ridership at Mineola, the adjacent station in the Westbound direction, increases by only 33 from 1427 to 1460. As noted above, the parking facilities at Mineola are congested in the Base Case, so almost all of this increase is in non-park access. East Williston also appears to pick up a very small number of additional riders.

Closing of Albertson

In the Base Case, Albertson station is used by only 272 AM peak period passengers. Closing this station reduces volume on the Oyster Bay Branch by 136 riders, with slight increases at adjacent stations (Roslyn; E. Williston). No measurable impacts occur on nearby Port Jefferson Branch stations or on other Branches; none could be realistically expected given the small magnitude of the change that was made to the system.

Closing of Inwood

This station closing also affects a relatively small number (248) of AM peak passengers. In this case, total Far Rockaway Branch volume remains nearly constant, with most Inwood riders picked up at Far Rockaway station (249 in the Base Case rising to 360) and Lawrence (484 Base Case rising to 544). No other branches are affected.

Closing of Mill Neck Station
Closing of Hollis
Closing of Bellport and Center Moriches

The remaining three scenarios affect stations with such a small volume of demand that application of a network equilibrium model is truly not required. Mill Neck station on the Oyster Bay Branch, for example, has only 24 riders in the base case. Closing of this particular station could not be expected to have any significant impact on LIRR ridership, or even any impact of great significance on immediately adjacent stations. This is also true of the scenario in which Hollis Station on the Hempstead Branch is closed (98 riders), and the scenario in which Bellport and Center Moriches on the Montauk Branch (66 riders total) are closed.

EFFECTS OF SYSTEMWIDE CHANGES

In addition to the scenario forecasts presented earlier, several other forecasts were made with the RailRider model incorporating carefully specified systemwide changes. These forecasts were made both to provide base case evidence on the sensitivity of LIRR ridership to service and supply variables, and also to confirm that the forecasting model itself would perform reasonably under a normal range of variation in these input parameters. These forecasts provide evidence of fare, parking, and service level elasticities, and are presented below.

Fare Sensitivity

One forecast generated by RailRider incorporated a five percent fare increase over the Base Case conditions. This fare increase resulted in a drop in LIRR ridership of only 0.73 percent, with an implied fare elasticity of -0.15. This fare elasticity is very much in line with that measured in prior LIRR studies. Changes in ridership were relatively consistent among the LIRR branches.

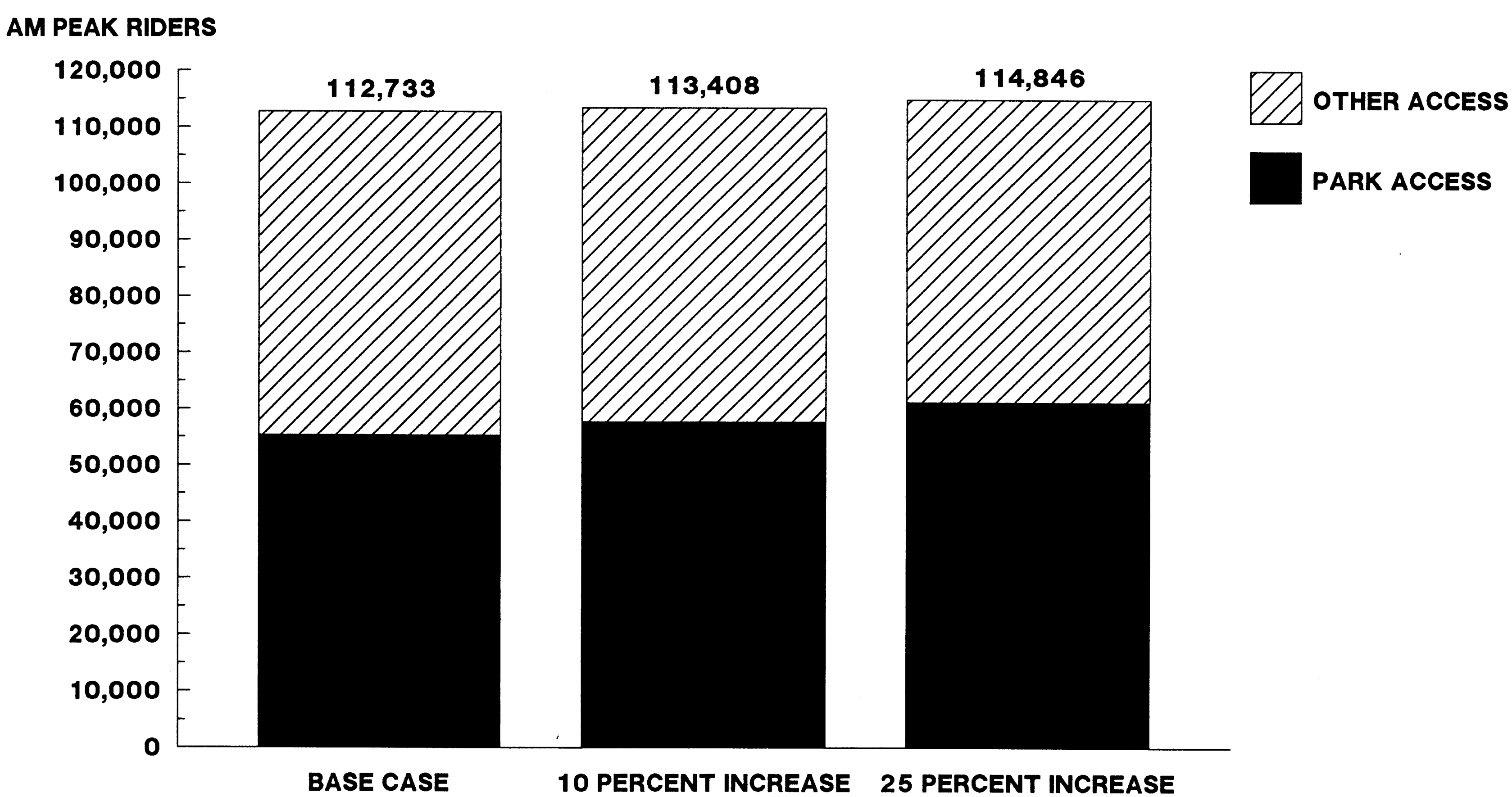
Parking Capacity Sensitivity

Two forecasts were generated using RailRider incorporating increases in parking supply. The first assumed a 10 percent increase in capacity at all parking lots; the second assumed an increase in capacity of 25 percent. While a change of this type would not realistically occur, the exercise of forecasting the impacts of systemwide parking capacity increases is a useful one for identifying overall sensitivity of LIRR ridership to parking capacity, and also for identifying those locations in the LIRR network where increased parking capacity would have the greatest impact.

As Figure 7-13 indicates, the Base AM peak Case LIRR ridership of 112,733 increases to 113,408 with a ten percent parking capacity increase, and up to 114,845 with a 25 percent increase in parking capacity. These increases represent only 0.6 percent and 1.9 percent of systemwide ridership, because much of the expanded parking supply is in portions of the LIRR system where excess capacity already exists. The number of LIRR riders using park access increases from 55,305 in the Base Case to 57,695 (4.3 percent) with a ten percent capacity increase, and to 61,154 (10.6 percent) when capacity is increased 25 percent. While the concept of parking elasticity is not particularly meaningful, the

FIGURE 7-13

EFFECT OF PARKING SUPPLY INCREASE ON LIRR RIDERSHIP



implied elasticities are 0.07 for systemwide ridership or 0.43 for park access ridership.

There are many changes in the distribution of LIRR ridership when parking capacity is changed. However, almost all of these changes represent redistribution of riders among stations on a branch or among access modes, while very few major shifts in branch ridership occur (Figure 7-14). There are numerous cases in which ridership drops at certain stations as riders opt to drive to new parking capacity that is available at previously congested stations. Figure 7-15, for example show the impact on the Babylon Branch of a 25 percent increase in parking supply. As indicated, the number of riders using park access increases at most stations, but drops at Amityville and Freeport as riders shift to stations with more desirable service and fare characteristics. Wantagh, Seaford, and Bellmore experience the largest overall ridership increases.

Speed of Service Sensitivity

A forecast was generated assuming a systemwide ten percent reduction in travel time on all local and express service links. This improvement in travel time resulted in a 2.0 percent increase in systemwide LIRR ridership up to 114,996 AM peak riders, implying a travel time elasticity of -0.20.

FIGURE 7-14
IMPACT OF PARKING CAPACITY INCREASES ON LIRR BRANCH RIDERSHIP

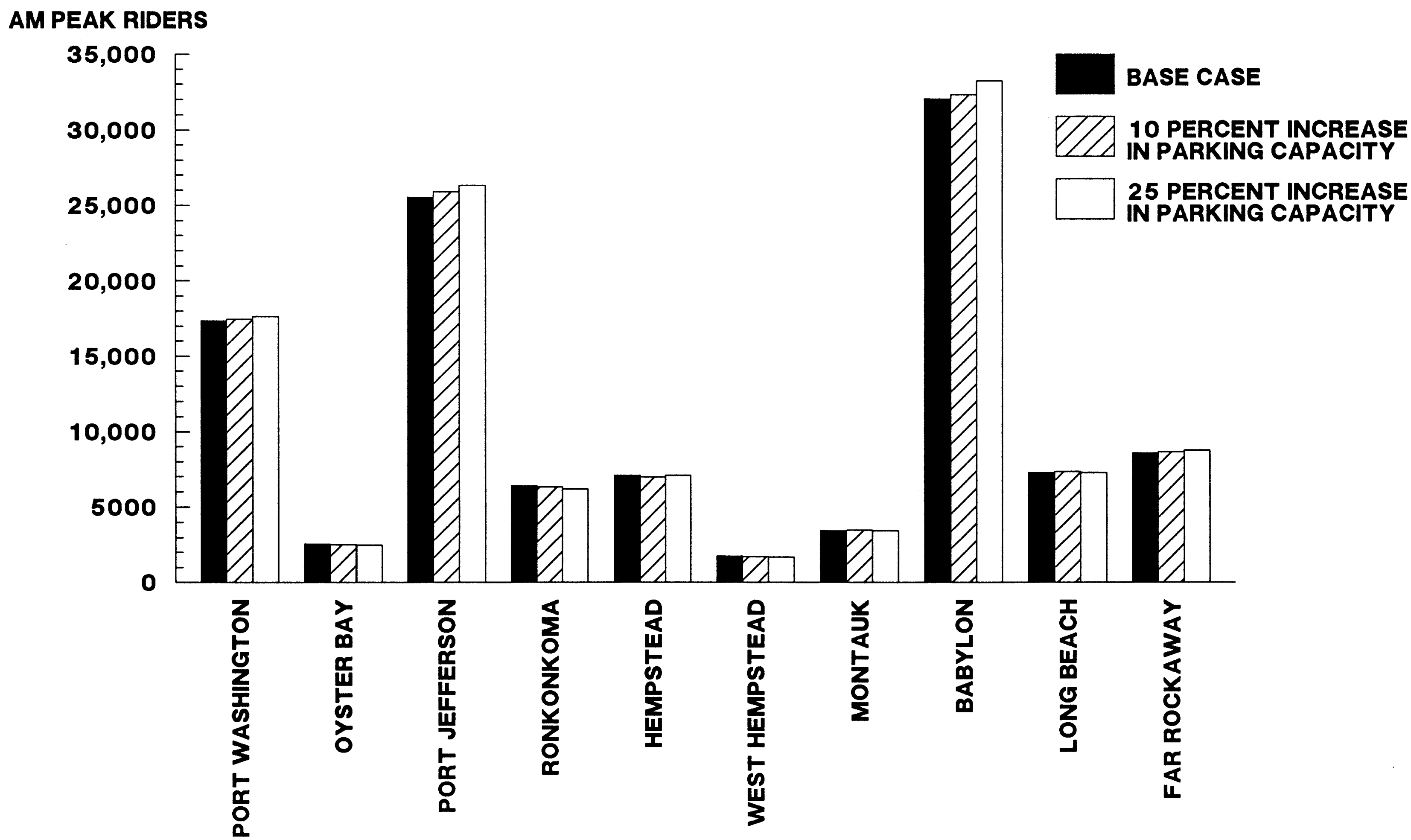
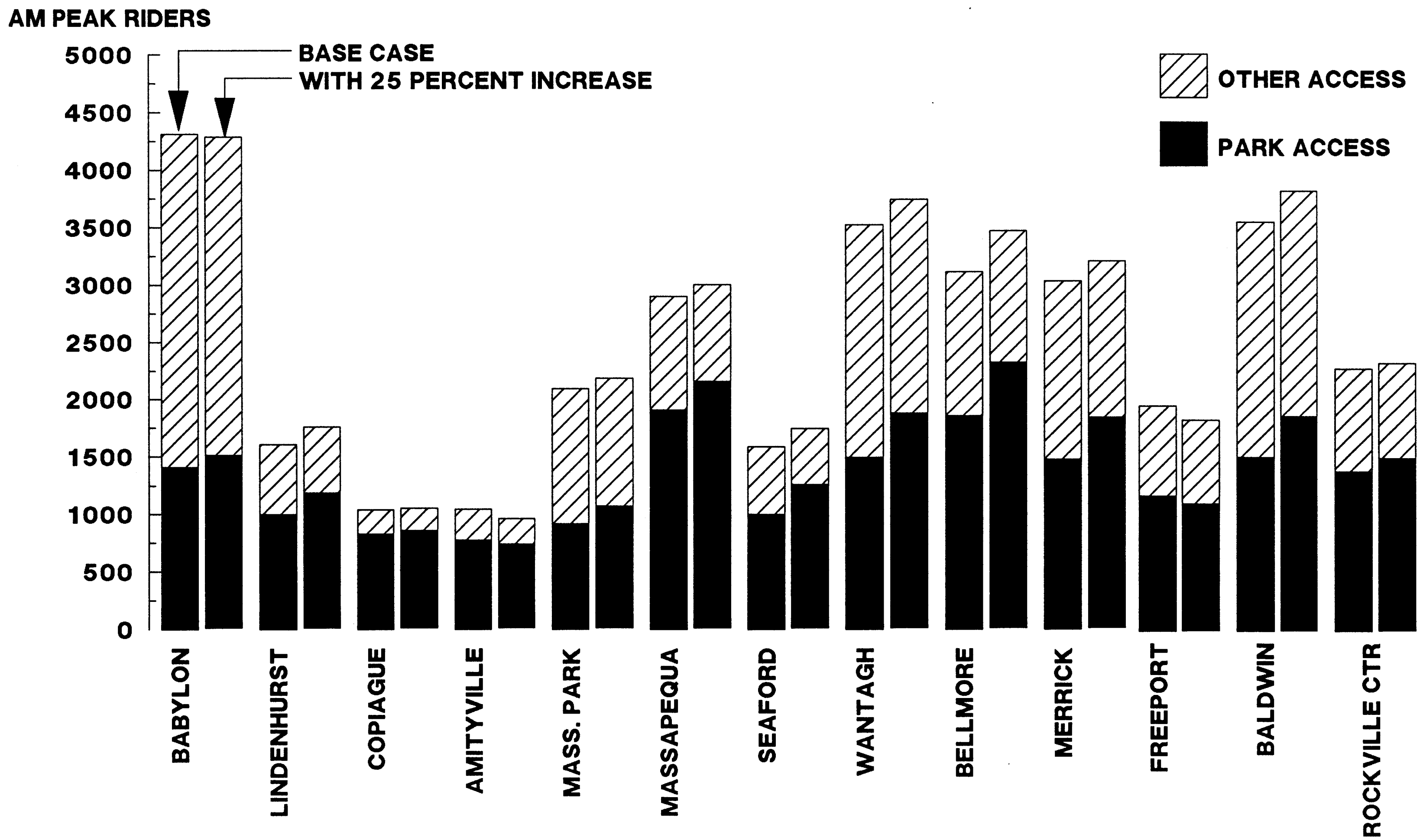


FIGURE 7-15

EFFECTS OF A 25 PERCENT PARKING CAPACITY INCREASE ON THE BABYLON BRANCH



CHAPTER 8

CONCLUDING REMARKS

In this chapter, we offer some additional thoughts and perspectives on the RailRider forecasting model and its predictions. We also describe possible future enhancements and topics for further research.

The RailRider forecasting model breaks ground in the implementation of a new generation of travel demand forecasting procedures based upon theoretical advances of the last decade. From a methodological perspective, the project demonstrates the feasibility of applying demand models within a stochastic user equilibrium framework to a problem of sufficient scale and complexity to warrant consideration of this approach for solving significant transportation planning problems.

Based upon our experience in this project and in the East Side Access study, very different and inherently more plausible forecasts come from a modeling framework that deals explicitly with capacity constraints, flow-dependent costs, and supply-demand equilibration than from traditional four step planning models.

At this juncture the model results appear to be quite reasonable and we look forward to the future availability of measurements that will permit assessment of forecast accuracy. Considerable experience with the model and its forecasts will be needed to judge its merits for the intended purpose and its performance relative to alternative forecasting procedures. Due to the upcoming capital program projects and related changes to the LIRR system, there should be ample opportunity to validate the model against real world behavior. Additional and better data on system ridership would also greatly enhance subsequent calibration and validation of the model. Indeed, calibration to reflect the effects of changes through time should make it possible to fine tune the model considerably.

A number of significant data limitations were encountered in the project, each of which had impacts upon model development. These are discussed below in the hope that these limitations can be surmounted in the future.

Deficiencies were found in many of the data that we used in developing the model inputs. In particular, inconsistencies and likely biases were encountered when ridership data were assembled from different sources. As a result, extensive reconciliation of data was performed using subjective judgments about which data were likely to be most correct. We draw little comfort from the observation that our base case estimates reflect what is probably the best current knowledge about characteristics of LIRR system utilization. Users are cautioned that some of RailRider's inputs are estimates of unknown precision.

As discussed previously, measurements were lacking for flows on some network links making it necessary for us to use synthetic methods to estimate these quantities. In future, actual measurements could be obtained and would certainly be preferable.

The computer implementation of the model differs from other planning models in that it is much more complicated and yet easier to use. One reason it is easier to use is that the software was customized for the LIRR system. While the conceptual approach to the forecasting problem is transferable and could be applied to the Metro North Commuter Railroad or other urban transportation properties, the network structure and the behavioral models that are imbedded in the model are specific to the LIRR. As a result, the model does not require a massive amount of setup work for a given application, and there is no need for specially trained analysts who are familiar with the arcane setup procedures of UTPS and similar packages. Significant automation and simplification of the application process was an essential design goal of the project that we believe has been successfully achieved. It is our hope that through the on-line Help system, the automatic error-checking, and the network builder that RailRider will have made progress in reducing or eliminating user errors in the forecasting process.

Despite the ease with which the model may be applied, users will need to become familiar with the concept of stochastic user equilibrium formulation upon which the model is based. This is necessary for appropriate interpretation of the model output, in general, and particularly for comprehending the interdependencies among network link flows that are manifest. Also, because the simulation method is utilized to calculate equilibria, users will need to distinguish the random variations in flows that are simulation artifacts from the causal effects of system changes.

A concern at the outset of the project was the size of a network equilibrium problem that could be solved on a microcomputer within reasonable running time. What we have found is that a model of this size strains the limits of current microcomputer performance, taking an hour to run on the fastest microcomputer that is widely available. However, the performance is still more than competitive with mainframe models, and the microcomputer implementation permits many sophisticated software features that would not otherwise be possible. Also, the continuing speed increases available in low cost hardware suggest that current limitations on problem size and performance will be short-lived.

While the design of the forecasting system was heavily influenced by the project's focus on assessing the impacts of parking conditions upon LIRR ridership, the model is quite generic and comprehensive and can address the demand effects of an extremely broad array of planning measures and system changes. There are, nevertheless, a number of avenues for further development and enhancement of the LIRR forecasting system that would strengthen its usefulness and accuracy as a corporate planning tool.

First, integration of the model with the destination terminal choice model developed in the East Side Access Study would extend the application of the model to a broader range of system planning issues. In addition to terminal volumes, an integrated model would provide a detailed and accurate portrait of the LIRR principal transfer facility at Jamaica station. Also, issues associated with changes in subway connections from the LIRR to Manhattan could be assessed.

Second, the forecasting model can be significantly enhanced through explicit treatment of alternative commutation modes and through development of a much improved mode split model. This would require an extensive data collection effort including surveys of both riders and non-riders to provide the basis for model estimation.

Other possible extensions include incorporation of a revenue/ticket type/fare payment module to extend the treatment of fares and make the model more useful for examining the revenue implications of pricing strategies. Disaggregation by time of the AM peak and/or inclusion of off-peak and PM travel would also broaden the range of issues that could be studied. Finally, more detailed treatment of LIRR service characteristics would enhance RailRider's utility as a service planning tool.

Operational experience with the model and its application to planning and evaluation problems at the LIRR will be the best evidence on the performance and value of the forecasting system and will undoubtedly suggest some other modifications and enhancements. We encourage and look forward to user feedback on RailRider.

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APPENDIX

RAILRIDER MODEL OUTPUT, SPRING 1986 BASE CASE

RailRider - LIRR Planning and Forecasting System

LIRR Base Case Scenario (Spring 1986)

Mon Jul 13 17:31:05 1987

Inputs for this scenario:

```
Scenario       : BASECASE (Mon Jul 13 17:20:04 1987) - LIRR Base Case Scenario (Spring 1986)

Fare Zones     : FAREZONE (Wed Jun  3 09:53:50 1987) - LIRR Fare Zones - Monthly Fares (Spring 1986)

Branches       : BRANCH   (Wed Jun  3 10:00:12 1987) - LIRR Branches (Spring 1986)

Stations       : STATION  (Wed Jun  3 10:00:02 1987) - LIRR Stations (Spring 1986)

Parking Lots   : PARKLOT  (Wed Jun  3 10:00:00 1987) - LIRR Station Parking Lots (Spring 1986)

Local Service  : LIRRLOCL (Mon Jul 13 15:59:38 1987) - LIRR Base Local Service (Spring 1986)

Express Service: LIRREXPR (Mon Jul 13 15:59:48 1987) - LIRR Base Express Service (Spring 1986)

Trips to Manhattan: TOTDEM   (Wed Jun  3 10:00:04 1987) - Zone to Manhattan Travel (Spring 1986)
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TOTAL A.M. PEAK TRAVEL VOLUMES

Long Island Rail Road	112,733	21.5%
Other (Non-LIRR) Travel Modes	412,746	78.5%
TOTAL	525,479	100.0%

LIRR A.M. PEAK VOLUME BY ACCESS MODE

Park Access	55,305	49.1%
Other Access Mode	57,428	50.9%
TOTAL	112,733	100.0%

LIRR A.M. PEAK TRAVEL TIME (Minutes)

Average Park Access Time	9.30		
Average Non-Park Access Time	21.89		
Average Access Time (Combined)	15.71		
Average Platform Wait Time	5.00		
Average On-Board Line-Haul Time	46.23		Non-LIRR
Average Egress Time	15.06		Average
LIRR SYSTEMWIDE AVERAGE	82.01	vs.	61.36

LIRR A.M. PEAK TRAVEL COST

Average Park Access Cost	$0.68		
Average Non-Park Access Cost	$1.03		
Average Access Cost (Combined)	$0.85		
Average Parking Cost	$0.18		
Average Per Trip Ticket Price	$3.11		Non-LIRR
Average Egress Cost	$0.80		Average
LIRR SYSTEMWIDE AVERAGE	$4.76	vs.	$4.40

LIRR SYSTEM REVENUE

Daily Parking Lot Revenue	$10,080
AM Peak LIRR Ticket Revenue	$350,235

County	Total Travel Volume	Travel By Mode				LIRR Travel By Access Mode			
		LIRR		Non-LIRR		Park Access		Non-Park Access	
QUEENS	367,727	13,179	3.6%	354,549	96.4%	2,985	22.6%	10,193	77.3%
NASSAU	113,660	71,160	62.6%	42,500	37.4%	33,096	46.5%	38,063	53.5%
SUFFOLK	44,092	28,395	64.4%	15,697	35.6%	19,223	67.7%	9,171	32.3%
MANHATTAN	0	0	--%	0	--%	0	--%	0	--%
Regional Total	525,479	112,733	21.5%	412,746	78.5%	55,305	49.1%	57,428	50.9%

Town	Total Travel Volume	LIRR		Non-LIRR		Park Access		Non-Park Access	
NORTH HEMPSTEAD	22,995	13,222	57.5%	9,773	42.5%	4,300	32.5%	8,921	67.5%
HEMPSTEAD	66,597	40,915	61.4%	25,682	38.6%	19,886	48.6%	21,029	51.4%
OYSTER BAY	24,068	17,023	70.7%	7,045	29.3%	8,910	52.3%	8,113	47.7%
HUNTINGTON	11,254	8,161	72.5%	3,093	27.5%	6,356	77.9%	1,806	22.1%
BABYLON	9,650	6,673	69.2%	2,977	30.8%	3,587	53.8%	3,087	46.3%
SMITHTOWN	3,887	2,638	67.9%	1,249	32.1%	1,999	75.8%	640	24.3%
NEW YORK CITY	0	0	--%	0	--%	0	--%	0	--%
ISLIP	9,784	6,231	63.7%	3,553	36.3%	3,528	56.6%	2,703	43.4%
BROOKHAVEN	8,141	4,433	54.5%	3,708	45.5%	3,563	80.4%	870	19.6%
RIVERHEAD	40	28	70.0%	12	30.0%	28	100.0%	0	0.0%
SOUTHAMPTON	1,330	224	16.8%	1,106	83.2%	158	70.5%	66	29.5%
SOUTHOLD	6	6	100.0%	0	0.0%	6	100.0%	0	0.0%
QUEENS BOROUGH	367,727	13,179	3.6%	354,549	96.4%	2,985	22.6%	10,193	77.3%
Regional Total	525,479	112,733	21.5%	412,746	78.5%	55,305	49.1%	57,428	50.9%

	Parking Utilization Total for All Facilities			Parking Utilization Unrestricted Lots Only			Parking Utilization Restricted Lots Only			
County	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	Average Parking Fee
QUEENS	4,073	2,400	58.9%	4,073	2,400	58.9%	0	0	--%	$0.56
NASSAU	31,801	27,538	86.6%	18,205	15,462	84.9%	13,596	12,076	88.8%	$0.27
SUFFOLK	19,699	16,467	83.6%	14,156	11,232	79.3%	5,543	5,235	94.4%	$0.08
MANHATTAN	0	0	--%	0	0	--%	0	0	--%	--
Regional Total	55,573	46,406	83.5%	36,434	29,094	79.9%	19,139	17,312	90.5%	$0.22

Town	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	Average Parking Fee
NORTH HEMPSTEAD	3,789	3,485	92.0%	1,540	1,301	84.5%	2,249	2,184	97.1%	$0.67
HEMPSTEAD	19,153	16,580	86.6%	12,323	10,555	85.7%	6,830	6,025	88.2%	$0.12
OYSTER BAY	8,859	7,474	84.4%	4,342	3,606	83.0%	4,517	3,868	85.6%	$0.41
HUNTINGTON	5,580	5,316	95.3%	1,624	1,579	97.2%	3,956	3,737	94.5%	$0.00
BABYLON	4,715	4,046	85.8%	4,448	3,792	85.3%	267	254	95.1%	$0.30
SMITHTOWN	1,773	1,677	94.6%	714	678	95.0%	1,059	999	94.3%	$0.00
NEW YORK CITY	0	0	--%	0	0	--%	0	0	--%	--
ISLIP	4,054	2,932	72.3%	4,054	2,932	72.3%	0	0	--%	$0.00
BROOKHAVEN	3,382	2,398	70.9%	3,121	2,153	69.0%	261	246	94.3%	$0.03
RIVERHEAD	0	0	--%	0	0	--%	0	0	--%	--
SOUTHAMPTON	194	98	50.5%	194	98	50.5%	0	0	--%	$0.00
SOUTHOLD	0	0	--%	0	0	--%	0	0	--%	--
QUEENS BOROUGH	4,073	2,400	58.9%	4,073	2,400	58.9%	0	0	--%	$0.56
Regional Total	55,573	46,406	83.5%	36,434	29,094	79.9%	19,139	17,312	90.5%	$0.22

No.	Zone	Total Travel Volume	Travel By Mode: LIRR		Non-LIRR		LIRR Travel By Access Mode: Park Access		Non-Park Access	
1	Western Queens	188,940	620	0.3%	188,320	99.7%	56	9.0%	564	91.0%
2	Forest Hills-Kew Gardens	25,369	206	0.8%	25,163	99.2%	26	12.6%	180	87.4%
3	Jamaica	15,957	238	1.5%	15,719	98.5%	0	0.0%	238	100.0%
4	Rosedale-Locust Manor	13,148	1,846	14.0%	11,302	86.0%	173	9.4%	1,673	90.6%
5	St. Albans/Hollis	20,626	218	1.1%	20,408	98.9%	11	5.0%	207	95.0%
6	Jamaica Estates	17,147	204	1.2%	16,943	98.8%	43	21.1%	161	78.9%
7	Queens Village	13,841	1,697	12.3%	12,144	87.7%	511	30.1%	1,186	69.9%
8	Flushing-Auburndale	43,652	2,359	5.4%	41,293	94.6%	577	24.5%	1,782	75.5%
9	Bayside-Douglaston	19,101	5,251	27.5%	13,850	72.5%	1,471	28.0%	3,780	72.0%
10	The Rockaways	9,946	539	5.4%	9,407	94.6%	117	21.7%	422	78.3%
11	Pt. Washington Peninsula	4,836	3,814	78.9%	1,022	21.1%	1,179	30.9%	2,635	69.1%
12	Great Neck Peninsula	7,364	4,562	62.0%	2,802	38.0%	1,280	28.1%	3,282	71.9%
13	Roslyn-Albertson	2,310	1,080	46.8%	1,230	53.2%	224	20.7%	856	79.3%
14	Floral Park-Merillon Ave	3,672	1,033	28.1%	2,639	71.9%	228	22.1%	805	77.9%
15	Mineola-Westbury	4,813	2,732	56.8%	2,081	43.2%	1,389	50.8%	1,343	49.2%
16	Levittown/East Meadow	7,354	4,867	66.2%	2,487	33.8%	2,089	42.9%	2,778	57.1%
17	Hempstead	3,626	1,904	52.5%	1,722	47.5%	871	45.7%	1,034	54.3%
18	Valley Stream	6,278	2,824	45.0%	3,454	55.0%	1,392	49.3%	1,433	50.7%
19	W. Hemp. Br/Lynbrook/RVC	7,809	5,412	69.3%	2,397	30.7%	3,069	56.7%	2,344	43.3%
20	Baldwin-Freeport	6,402	4,341	67.8%	2,061	32.2%	1,907	43.9%	2,433	56.0%
21	Merrick-Wantagh	10,634	8,164	76.8%	2,470	23.2%	4,766	58.4%	3,398	41.6%
22	Cedarhurst-Hewlett	3,713	2,177	58.6%	1,536	41.4%	1,221	56.1%	955	43.9%
23	Lawrence-Inwood	2,174	779	35.8%	1,395	64.2%	315	40.4%	464	59.6%
24	Centre Ave-Long Beach	8,111	6,276	77.4%	1,835	22.6%	2,480	39.5%	3,795	60.5%
25	Seaford-Massapequa Park	8,510	6,453	75.8%	2,057	24.2%	3,499	54.2%	2,954	45.8%
26	Bethpage-Farmingdale	2,533	1,822	71.9%	711	28.1%	940	51.6%	883	48.5%
27	Hicksville	7,103	4,833	68.0%	2,270	32.0%	2,560	53.0%	2,272	47.0%
28	Brookville-Muttontown	1,312	969	73.9%	343	26.1%	526	54.3%	444	45.8%
29	Syosset	1,097	770	70.2%	327	29.8%	417	54.2%	353	45.8%
30	Sea Cliff-Locust Valley	1,741	1,141	65.5%	600	34.5%	525	46.0%	616	54.0%
31	Mill Neck-Oyster Bay	756	547	72.4%	209	27.6%	298	54.5%	249	45.5%
32	Elmont/Franklin Square	6,754	1,371	20.3%	5,383	79.7%	309	22.5%	1,062	77.5%
33	Garden City	3,742	2,800	74.8%	942	25.2%	1,468	52.4%	1,332	47.6%
34	Greenvale-Glen Head	1,016	487	47.9%	529	52.1%	146	30.0%	341	70.0%
35	CSH-Huntington	3,726	2,794	75.0%	932	25.0%	2,321	83.1%	474	17.0%
36	Greenlawn-Northport	5,020	3,710	73.9%	1,310	26.1%	2,953	79.6%	758	20.4%
37	Dix Hills	2,508	1,656	66.0%	852	34.0%	1,082	65.3%	574	34.7%
38	Amity-Lind/Repub-Pineln	3,317	2,367	71.4%	950	28.6%	1,489	62.9%	878	37.1%
39	Babylon	6,333	4,306	68.0%	2,027	32.0%	2,098	48.7%	2,208	51.3%
40	Kings Park-St. James	3,887	2,638	67.9%	1,249	32.1%	1,999	75.8%	640	24.3%
41	Pine Aire-Central Islip	4,377	2,543	58.1%	1,834	41.9%	1,376	54.1%	1,167	45.9%
42	Bay Shore-Great River	3,018	2,171	71.9%	847	28.1%	1,159	53.4%	1,011	46.6%
43	Oakdale-Sayville/Ronk	2,389	1,518	63.5%	871	36.5%	993	65.4%	525	34.6%
44	Stony Brook-Pt Jefferson	5,495	3,019	54.9%	2,476	45.1%	2,426	80.4%	594	19.7%
45	Patchogue/Medfrd-Yaphank	1,801	965	53.6%	836	46.4%	792	82.1%	173	17.9%
46	Mast Shir-Cent Moriches	845	449	53.1%	396	46.9%	345	76.8%	104	23.2%
47	Riverhead	40	28	70.0%	12	30.0%	28	100.0%	0	0.0%
48	Speonk-Hampton Bays	117	116	99.1%	1	0.9%	84	72.4%	32	27.6%
49	North Fork	6	6	100.0%	0	0.0%	6	100.0%	0	0.0%
50	South Fork	1,213	108	8.9%	1,105	91.1%	74	68.5%	34	31.5%
	Regional Total	525,479	112,733	21.5%	412,746	78.5%	55,305	49.1%	57,428	50.9%

No.	Zone	Average LIRR Access Time By Access Mode (Minutes)			Average LIRR Access Cost By Access Mode		
		Park	Other	Combined	Park	Other	Combined
1	Western Queens	18.2	25.0	24.4	$0.76	$0.79	$0.79
2	Forest Hills-Kew Gardens	5.2	12.1	11.3	$0.22	$0.28	$0.27
3	Jamaica	--	19.6	19.6	--	$0.55	$0.55
4	Rosedale-Locust Manor	5.2	12.4	11.7	$0.22	$0.31	$0.30
5	St. Albans/Hollis	7.8	14.6	14.2	$0.32	$0.35	$0.35
6	Jamaica Estates	13.4	20.6	19.1	$0.56	$0.55	$0.56
7	Queens Village	7.5	20.1	16.3	$0.31	$0.58	$0.50
8	Flushing-Auburndale	8.3	14.4	12.9	$0.34	$0.30	$0.31
9	Bayside-Douglaston	5.5	14.1	11.7	$0.23	$0.36	$0.33
10	The Rockaways	12.6	26.9	23.8	$0.56	$0.97	$0.88
11	Pt. Washington Peninsula	6.0	19.7	15.5	$0.27	$0.70	$0.57
12	Great Neck Peninsula	5.8	18.2	14.7	$0.24	$0.58	$0.49
13	Roslyn-Albertson	5.8	31.9	26.5	$0.29	$1.38	$1.16
14	Floral Park-Merillon Ave	4.9	21.4	17.8	$0.22	$0.72	$0.61
15	Mineola-Westbury	7.9	24.9	16.3	$0.39	$1.07	$0.73
16	Levittown/East Meadow	14.5	35.1	26.3	$0.81	$1.77	$1.36
17	Hempstead	7.1	26.0	17.3	$0.36	$1.10	$0.76
18	Valley Stream	5.3	13.1	9.3	$0.24	$0.35	$0.29
19	W. Hemp. Br/Lynbrook/RVC	6.3	18.7	11.7	$0.30	$0.64	$0.45
20	Baldwin-Freeport	4.1	15.9	10.7	$0.22	$0.66	$0.47
21	Merrick-Wantagh	5.4	15.1	9.4	$0.30	$0.70	$0.47
22	Cedarhurst-Hewlett	5.8	16.4	10.4	$0.26	$0.50	$0.36
23	Lawrence-Inwood	4.9	17.1	12.2	$0.22	$0.57	$0.43
24	Centre Ave-Long Beach	7.7	20.6	15.5	$0.39	$0.83	$0.65
25	Seaford-Massapequa Park	4.3	15.3	9.3	$0.26	$0.76	$0.49
26	Bethpage-Farmingdale	7.0	32.8	19.5	$0.43	$1.80	$1.09
27	Hicksville	5.6	18.2	11.5	$0.33	$0.94	$0.61
28	Brookville-Muttontown	13.7	36.9	24.3	$0.77	$1.88	$1.28
29	Syosset	3.5	20.9	11.5	$0.22	$1.15	$0.64
30	Sea Cliff-Locust Valley	6.5	34.1	21.4	$0.34	$1.61	$1.03
31	Mill Neck-Oyster Bay	10.4	42.6	25.1	$0.61	$2.30	$1.38
32	Elmont/Franklin Square	8.1	16.6	14.7	$0.36	$0.50	$0.47
33	Garden City	7.2	17.9	12.3	$0.34	$0.65	$0.49
34	Greenvale-Glen Head	5.2	30.8	23.1	$0.27	$1.35	$1.03
35	CSH-Huntington	5.6	21.5	8.3	$0.36	$1.27	$0.51
36	Greenlawn-Northport	7.9	19.9	10.4	$0.57	$1.33	$0.73
37	Dix Hills	14.0	50.4	26.6	$0.94	$3.14	$1.70
38	Amity-Lind/Repub-Pineln	4.2	20.4	10.2	$0.28	$1.17	$0.61
39	Babylon	9.5	23.2	16.5	$0.66	$1.43	$1.05
40	Kings Park-St. James	6.9	36.4	14.0	$0.57	$2.76	$1.10
41	Pine Aire-Central Islip	11.6	39.9	24.6	$0.90	$2.88	$1.81
42	Bay Shore-Great River	10.9	36.1	22.7	$0.88	$2.68	$1.72
43	Oakdale-Sayville/Ronk	7.4	52.1	22.9	$0.67	$4.07	$1.84
44	Stony Brook-Pt Jefferson	15.6	46.7	21.7	$1.36	$3.70	$1.82
45	Patchogue/Medfrd-Yaphank	14.6	46.6	20.3	$1.25	$3.70	$1.69
46	Mast Shir-Cent Moriches	24.0	46.5	29.2	$2.00	$3.66	$2.39
47	Riverhead	45.5	--	45.5	$4.33	--	$4.33
48	Speonk-Hampton Bays	22.7	44.1	28.7	$1.89	$3.38	$2.30
49	North Fork	50.7	--	50.7	$4.22	--	$4.22
50	South Fork	55.9	115.1	74.3	$4.66	$9.06	$6.03
	Regional Total	7.8	21.9	15.0	$0.49	$1.03	$0.77

Branch Name	Total Branch Volume	Branch Volume By Access Mode: Park Access	Other Access	Parking Utilization: Auto Capacity	Cars Parked	Fill %	Daily Parking Revenue	AM Peak Ticket Revenue
PORT WASHINGTON	17,350	4,477	12,873	4,592	3,731	81.3%	$3,080	$43,434
OYSTER BAY	2,544	1,215	1,330	1,607	1,025	63.8%	$150	$8,504
PORT JEFFERSON	25,522	16,428	9,094	14,908	13,911	93.3%	$3,267	$86,409
RONKONKOMA	6,390	3,896	2,494	4,793	3,247	67.7%	$152	$26,003
HEMPSTEAD	7,094	2,674	4,421	3,073	2,228	72.5%	$857	$18,798
WEST HEMPSTEAD	1,729	470	1,259	480	392	81.7%	$68	$4,611
MONTAUK	3,426	2,807	618	3,639	2,423	66.6%	$70	$15,294
BABYLON	32,036	16,730	15,306	14,985	13,942	93.0%	$1,788	$101,709
LONG BEACH	7,255	3,124	4,131	3,039	2,603	85.7%	$351	$21,732
FAR ROCKAWAY	8,560	3,402	5,158	4,387	2,835	64.6%	$298	$22,047
CITY TERMINAL	826	82	744	68	68	100.0%	$0	$1,693
LIRR Total	112,733	55,305	57,428	55,573	46,406	83.5%	$10,080	$350,235

PORT WASHINGTON Branch

Station	Arriving Trains: Number of Seats	Arriving Trains: Number of Passengers	Arriving Trains: Peak Period Occupancy	Passengers Boarding	Departing Trains: Number of Seats	Departing Trains: Number of Passengers	Departing Trains: Peak Period Occupancy
PORT WASHINGTON	0	0	--%	2,671	10,560	2,671	25.3%
PLANDOME	10,560	2,671	25.3%	606	11,760	3,277	27.9%
MANHASSET	11,760	3,277	27.9%	2,104	11,760	5,381	45.8%
GREAT NECK	10,560	3,905	37.0%	3,462	17,280	7,367	42.6%
LITTLE NECK	8,880	130	1.5%	1,583	11,280	1,713	15.2%
DOUGLASTON	11,280	1,713	15.2%	891	11,280	2,604	23.1%
BAYSIDE	11,280	2,604	23.1%	3,531	11,280	6,135	54.4%
AUBURNDALE	9,840	3,212	32.6%	892	9,840	4,104	41.7%
BROADWAY	9,840	4,104	41.7%	780	9,840	4,884	49.6%
MURRAY HILL	9,840	4,884	49.6%	389	9,840	5,273	53.6%
FLUSHING	9,840	5,273	53.6%	441	9,840	5,714	58.1%

Station	Total Station Volume	Station Volume By Access Mode: Park Access	Station Volume By Access Mode: Other Access	Daily Parking Revenue	AM Peak Ticket Revenue	Average Access Time (Min.): Park Access	Average Access Time (Min.): Other Access	Average Access Time (Min.): Combined
PORT WASHINGTON	2,671	877	1,794	$548	$7,146	6.4	20.1	15.6
PLANDOME	606	142	464	$0	$1,622	6.7	19.4	16.4
MANHASSET	2,104	583	1,521	$644	$5,627	8.3	27.6	22.2
GREAT NECK	3,462	511	2,951	$618	$9,261	7.2	20.6	18.6
LITTLE NECK	1,583	467	1,117	$359	$3,681	8.2	18.0	15.2
DOUGLASTON	891	416	475	$265	$2,071	6.8	14.4	10.9
BAYSIDE	3,531	1,110	2,421	$170	$8,209	9.0	15.9	13.7
AUBURNDALE	892	0	892	$0	$2,073	--	15.1	15.1
BROADWAY	780	152	628	$0	$1,814	6.2	11.8	10.7
MURRAY HILL	389	0	389	$0	$905	--	12.8	12.8
FLUSHING	441	219	223	$477	$1,026	10.6	16.4	13.5
Branch Total	17,350	4,477	12,873	$3,080	$43,434	7.8	18.9	16.0

OYSTER BAY Branch

Station	Arriving Trains: Number of Seats	Arriving Trains: Number of Passengers	Arriving Trains: Peak Period Occupancy	Passengers Boarding	Departing Trains: Number of Seats	Departing Trains: Number of Passengers	Departing Trains: Peak Period Occupancy
OYSTER BAY	0	0	--%	37	3,240	37	1.1%
MILL NECK	1,800	13	0.7%	24	1,800	37	2.1%
LOCUST VALLEY	3,240	61	1.9%	177	3,240	238	7.3%
GLEN COVE	3,240	238	7.3%	298	3,240	536	16.5%
GLEN STREET	3,240	536	16.5%	142	3,240	678	20.9%
SEA CLIFF	3,240	678	20.9%	237	3,240	915	28.2%
GLEN HEAD	3,240	915	28.2%	295	3,240	1,210	37.3%
GREENVALE	3,240	1,210	37.3%	110	3,240	1,319	40.7%
ROSLYN	3,240	1,319	40.7%	337	3,240	1,657	51.1%
ALBERTSON	3,240	1,657	51.1%	272	3,240	1,929	59.5%
EAST WILLISTON	3,240	1,929	59.5%	615	4,440	2,544	57.3%

Station	Total Station Volume	Station Volume By Access Mode: Park Access	Station Volume By Access Mode: Other Access	Daily Parking Revenue	AM Peak Ticket Revenue	Average Access Time (Min.): Park Access	Average Access Time (Min.): Other Access	Average Access Time (Min.): Combined
OYSTER BAY	37	21	16	$0	$133	5.1	14.9	9.3
MILL NECK	24	9	15	$0	$85	6.0	21.5	15.7
LOCUST VALLEY	177	75	102	$23	$628	4.5	13.2	9.5
GLEN COVE	298	176	121	$0	$1,058	4.5	10.3	6.8
GLEN STREET	142	121	22	$0	$506	6.6	15.7	8.0
SEA CLIFF	237	135	102	$0	$842	10.3	20.9	14.9
GLEN HEAD	295	135	159	$62	$1,048	8.5	24.4	17.1
GREENVALE	110	110	0	$11	$390	12.6	--	12.6
ROSLYN	337	129	208	$4	$1,199	10.6	28.1	21.4
ALBERTSON	272	88	185	$50	$969	5.5	25.9	19.4
EAST WILLISTON	615	216	399	$0	$1,645	7.0	20.0	15.4
Branch Total	2,544	1,215	1,330	$150	$8,504	7.7	21.1	14.7

PORT JEFFERSON Branch

Station	Arriving Trains: Number of Seats	Arriving Trains: Number of Passengers	Arriving Trains: Peak Period Occupancy	Passengers Boarding	Departing Trains: Number of Seats	Departing Trains: Number of Passengers	Departing Trains: Peak Period Occupancy
PORT JEFFERSON	0	0	--%	696	7,200	696	9.7%
STONY BROOK	7,200	696	9.7%	491	7,200	1,187	16.5%
ST JAMES	7,200	1,187	16.5%	377	7,200	1,564	21.7%
SMITHTOWN	7,200	1,564	21.7%	875	7,200	2,439	33.9%
KINGS PARK	7,200	2,439	33.9%	1,139	7,200	3,578	49.7%
NORTHPORT	7,200	3,578	49.7%	1,471	7,200	5,049	70.1%
GREENLAWN	7,200	5,049	70.1%	567	7,200	5,617	78.0%
HUNTINGTON	3,480	822	23.6%	4,553	14,880	5,375	36.1%
COLD SPRING HARBOR	13,920	4,229	30.4%	1,196	13,920	5,426	39.0%
SYOSSET	13,920	5,426	39.0%	1,974	13,920	7,399	53.2%
HICKSVILLE	14,160	3,439	24.3%	7,742	20,400	11,181	54.8%
WESTBURY	15,840	6,075	38.4%	1,585	15,840	7,660	48.4%
CARLE PLACE	9,120	3,584	39.3%	366	9,120	3,950	43.3%
MINEOLA	17,280	7,425	43.0%	1,427	16,800	8,852	52.7%
MERILLON AVE	8,280	2,856	34.5%	402	8,280	3,258	39.3%
NEW HYDE PARK	8,280	3,258	39.3%	662	8,280	3,920	47.3%

Station	Total Station Volume	Station Volume By Access Mode: Park Access	Station Volume By Access Mode: Other Access	Daily Parking Revenue	AM Peak Ticket Revenue	Average Access Time (Min.): Park Access	Average Access Time (Min.): Other Access	Average Access Time (Min.): Combined
PORT JEFFERSON	696	616	79	$0	$3,186	11.5	19.4	12.4
STONY BROOK	491	479	13	$0	$2,250	15.2	35.5	15.8
ST JAMES	377	302	75	$0	$1,728	12.9	36.8	17.7
SMITHTOWN	875	761	114	$0	$3,766	4.4	38.0	8.7
KINGS PARK	1,139	841	298	$0	$4,904	8.9	21.1	12.1
NORTHPORT	1,471	1,083	388	$17	$5,818	5.3	14.1	7.6
GREENLAWN	567	384	183	$0	$2,244	5.1	22.3	10.7
HUNTINGTON	4,553	3,909	644	$0	$15,820	10.5	30.1	13.3
COLD SPRING HARBOR	1,196	1,003	193	$0	$4,157	13.5	31.2	16.3
SYOSSET	1,974	1,026	947	$427	$6,069	8.9	26.8	17.5
HICKSVILLE	7,742	3,687	4,055	$2,075	$23,806	10.3	28.5	19.8
WESTBURY	1,585	940	645	$361	$4,872	10.4	26.2	16.8
CARLE PLACE	366	0	366	$0	$1,124	--	17.8	17.8
MINEOLA	1,427	632	795	$99	$3,818	11.1	28.0	20.5
MERILLON AVE	402	153	249	$0	$1,075	10.5	24.4	19.1
NEW HYDE PARK	662	612	50	$288	$1,771	6.1	17.4	7.0
Branch Total	25,522	16,428	9,094	$3,267	$86,409	9.8	26.8	15.8

RONKONKOMA Branch

Station	Arriving Trains: Number of Seats	Arriving Trains: Number of Passengers	Arriving Trains: Peak Period Occupancy	Passengers Boarding	Departing Trains: Number of Seats	Departing Trains: Number of Passengers	Departing Trains: Peak Period Occupancy
RONKONKOMA	0	0	--%	2,319	8,280	2,319	28.0%
CENTRAL ISLIP	8,280	2,319	28.0%	387	8,280	2,706	32.7%
BRENTWOOD	8,280	2,706	32.7%	790	8,280	3,496	42.2%
DEER PARK	8,280	3,496	42.2%	1,017	8,880	4,513	50.8%
WYANDANCH	7,560	2,872	38.0%	646	7,560	3,518	46.5%
FARMINGDALE	7,560	3,518	46.5%	626	7,560	4,144	54.8%
BETHPAGE	7,560	4,144	54.8%	605	7,560	4,749	62.8%

Station	Total Station Volume	Station Volume By Access Mode: Park Access	Station Volume By Access Mode: Other Access	Daily Parking Revenue	AM Peak Ticket Revenue	Average Access Time (Min.): Park Access	Average Access Time (Min.): Other Access	Average Access Time (Min.): Combined
RONKONKOMA	2,319	1,653	667	$0	$9,984	19.1	42.2	25.8
CENTRAL ISLIP	387	230	157	$0	$1,666	3.1	14.8	7.8
BRENTWOOD	790	472	318	$0	$3,401	7.6	23.3	13.9
DEER PARK	1,017	524	493	$0	$4,023	13.1	22.6	17.7
WYANDANCH	646	319	327	$0	$2,555	6.2	14.8	10.5
FARMINGDALE	626	271	354	$17	$2,224	6.9	21.0	14.9
BETHPAGE	605	427	178	$136	$2,151	6.4	20.6	10.6
Branch Total	6,390	3,896	2,494	$152	$26,003	12.7	26.0	17.9

HEMPSTEAD Branch

Station	Arriving Trains: Number of Seats	Arriving Trains: Number of Passengers	Arriving Trains: Peak Period Occupancy	Passengers Boarding	Departing Trains: Number of Seats	Departing Trains: Number of Passengers	Departing Trains: Peak Period Occupancy
HEMPSTEAD	0	0	--%	1,509	9,600	1,509	15.7%
COUNTRY LIFE PRESS	9,600	1,509	15.7%	557	9,600	2,066	21.5%
GARDEN CITY	9,600	2,066	21.5%	770	9,600	2,836	29.5%
NASSAU BLVD	9,600	2,836	29.5%	969	9,600	3,805	39.6%
STEWART MANOR	9,600	3,805	39.6%	1,063	9,600	4,869	50.7%
FLORAL PARK	9,840	3,702	37.6%	1,249	9,840	4,950	50.3%
BELLEROSE	8,640	3,576	41.4%	464	8,640	4,040	46.8%
QUEENS VILLAGE	7,440	2,564	34.5%	415	7,440	2,980	40.1%
HOLLIS	6,480	2,138	33.0%	98	6,480	2,236	34.5%

Station	Total Station Volume	Station Volume By Access Mode: Park Access	Station Volume By Access Mode: Other Access	Daily Parking Revenue	AM Peak Ticket Revenue	Average Access Time (Min.): Park Access	Average Access Time (Min.): Other Access	Average Access Time (Min.): Combined
HEMPSTEAD	1,509	808	701	$170	$4,036	9.5	29.9	19.0
COUNTRY LIFE PRESS	557	217	341	$0	$1,491	7.1	17.0	13.2
GARDEN CITY	770	581	189	$0	$2,060	9.9	22.3	12.9
NASSAU BLVD	969	223	746	$0	$2,592	11.9	21.6	19.3
STEWART MANOR	1,063	159	904	$0	$2,844	11.4	17.1	16.2
FLORAL PARK	1,249	605	644	$571	$3,341	9.6	19.0	14.4
BELLEROSE	464	43	422	$53	$1,241	5.5	14.2	13.4
QUEENS VILLAGE	415	38	377	$62	$965	6.4	16.8	15.9
HOLLIS	98	0	98	$0	$227	--	16.5	16.5
Branch Total	7,094	2,674	4,421	$857	$18,798	9.6	20.1	16.1

WEST HEMPSTEAD Branch

Station	Arriving Trains: Number of Seats	Arriving Trains: Number of Passengers	Arriving Trains: Peak Period Occupancy	Passengers Boarding	Departing Trains: Number of Seats	Departing Trains: Number of Passengers	Departing Trains: Peak Period Occupancy
WEST HEMPSTEAD	0	0	--%	271	3,600	271	7.5%
HEMPSTEAD GARDENS	3,600	271	7.5%	170	3,600	441	12.3%
LAKEVIEW	3,600	441	12.3%	253	3,600	694	19.3%
MALVERNE	3,600	694	19.3%	602	3,600	1,296	36.0%
WESTWOOD	3,600	1,296	36.0%	392	3,600	1,687	46.9%
ST ALBANS	2,640	1,394	52.8%	42	2,640	1,436	54.4%

Station	Total Station Volume	Station Volume By Access Mode: Park Access	Station Volume By Access Mode: Other Access	Daily Parking Revenue	AM Peak Ticket Revenue	Average Access Time (Min.): Park Access	Average Access Time (Min.): Other Access	Average Access Time (Min.): Combined
WEST HEMPSTEAD	271	145	126	$0	$725	9.6	20.9	14.9
HEMPSTEAD GARDENS	170	0	170	$0	$455	--	15.4	15.4
LAKEVIEW	253	36	217	$0	$677	4.9	15.4	13.9
MALVERNE	602	225	376	$68	$1,610	5.6	12.9	10.2
WESTWOOD	392	63	328	$0	$1,047	7.3	11.5	10.8
ST ALBANS	42	0	42	$0	$98	5.5	12.5	12.4
Branch Total	1,729	470	1,259	$68	$4,611	7.0	14.1	12.2

MONTAUK Branch

Station	Arriving Trains: Number of Seats	Arriving Trains: Number of Passengers	Arriving Trains: Peak Period Occupancy	Passengers Boarding	Departing Trains: Number of Seats	Departing Trains: Number of Passengers	Departing Trains: Peak Period Occupancy
SPEONK	0	0	--%	171	3,600	171	4.8%
CENTER MORICHES	3,600	171	4.8%	59	3,600	230	6.4%
MASTIC-SHIRLEY	3,600	230	6.4%	219	4,680	449	9.6%
BELLPORT	3,600	74	2.1%	7	3,600	81	2.3%
PATCHOGUE	4,680	456	9.7%	829	5,400	1,285	23.8%
SAYVILLE	5,400	1,285	23.8%	545	5,400	1,829	33.9%
OAKDALE	4,800	1,056	22.0%	265	4,800	1,321	27.5%
GREAT RIVER	4,800	1,321	27.5%	241	4,800	1,562	32.5%
ISLIP	4,800	1,562	32.5%	544	4,800	2,107	43.9%
BAY SHORE	5,400	2,880	53.3%	545	5,400	3,426	63.4%

Station	Total Station Volume	Station Volume By Access Mode: Park Access	Station Volume By Access Mode: Other Access	Daily Parking Revenue	AM Peak Ticket Revenue	Average Access Time (Min.): Park Access	Average Access Time (Min.): Other Access	Average Access Time (Min.): Combined
SPEONK	171	117	54	$0	$856	43.9	85.5	56.9
CENTER MORICHES	59	46	12	$0	$293	27.8	57.2	33.9
MASTIC-SHIRLEY	219	149	70	$0	$1,097	13.3	31.5	19.1
BELLPORT	7	1	6	$0	$35	23.6	23.6	23.6
PATCHOGUE	829	706	123	$70	$3,796	18.1	50.9	22.9
SAYVILLE	545	473	72	$0	$2,345	11.1	50.3	16.2
OAKDALE	265	233	32	$0	$1,141	8.0	18.3	9.3
GREAT RIVER	241	141	100	$0	$1,039	10.6	21.5	15.1
ISLIP	544	462	83	$0	$2,343	4.2	12.5	5.4
BAY SHORE	545	478	67	$0	$2,348	11.9	28.2	13.9
Branch Total	3,426	2,807	618	$70	$15,294	13.3	37.4	17.7

BABYLON Branch

Station	Arriving Trains: Number of Seats	Arriving Trains: Number of Passengers	Arriving Trains: Peak Period Occupancy	Passengers Boarding	Departing Trains: Number of Seats	Departing Trains: Number of Passengers	Departing Trains: Peak Period Occupancy
BABYLON	4,320	2,140	49.5%	4,311	21,600	6,451	29.9%
LINDENHURST	15,360	432	2.8%	1,607	16,560	2,040	12.3%
COPIAGUE	16,560	2,040	12.3%	1,039	16,560	3,079	18.6%
AMITYVILLE	16,560	3,079	18.6%	1,040	16,560	4,118	24.9%
MASSAPEQUA PARK	11,040	1,208	10.9%	2,092	17,040	3,301	19.4%
MASSAPEQUA	17,040	3,301	19.4%	2,895	17,040	6,196	36.4%
SEAFORD	17,040	6,196	36.4%	1,587	18,240	7,782	42.7%
WANTAGH	14,400	3,998	27.8%	3,523	18,480	7,521	40.7%
BELLMORE	17,520	6,776	38.7%	3,113	17,520	9,889	56.4%
MERRICK	17,520	9,889	56.4%	3,031	17,520	12,920	73.7%
FREEPORT	12,720	4,545	35.7%	1,960	18,720	6,504	34.7%
BALDWIN	17,520	5,268	30.1%	3,559	17,520	8,828	50.4%
ROCKVILLE CENTER	17,520	8,828	50.4%	2,280	17,520	11,108	63.4%

Station	Total Station Volume	Station Volume By Access Mode: Park Access	Station Volume By Access Mode: Other Access	Daily Parking Revenue	AM Peak Ticket Revenue	Average Access Time (Min.): Park Access	Average Access Time (Min.): Other Access	Average Access Time (Min.): Combined
BABYLON	4,311	1,409	2,902	$1,073	$14,980	17.5	42.0	34.0
LINDENHURST	1,607	999	608	$0	$5,585	11.2	20.1	14.5
COPIAGUE	1,039	828	211	$0	$3,611	6.4	20.5	9.3
AMITYVILLE	1,040	775	265	$143	$3,612	7.7	22.5	11.4
MASSAPEQUA PARK	2,092	916	1,176	$0	$6,434	4.5	12.5	9.0
MASSAPEQUA	2,895	1,907	988	$308	$8,903	5.0	20.8	10.4
SEAFORD	1,587	1,001	585	$0	$4,879	8.7	22.4	13.7
WANTAGH	3,523	1,493	2,030	$0	$10,833	5.8	20.3	14.2
BELLMORE	3,113	1,855	1,258	$0	$9,573	6.3	15.7	10.1
MERRICK	3,031	1,477	1,553	$0	$9,319	12.4	23.7	18.2
FREEPORT	1,960	1,172	787	$0	$6,026	8.7	27.0	16.1
BALDWIN	3,559	1,510	2,049	$0	$10,945	8.1	17.6	13.6
ROCKVILLE CENTER	2,280	1,386	893	$264	$7,010	7.0	20.0	12.1
Branch Total	32,036	16,730	15,306	$1,788	$101,709	8.4	23.9	15.8

LONG BEACH Branch

Station	Arriving Trains: Number of Seats	Arriving Trains: Number of Passengers	Arriving Trains: Peak Period Occupancy	Passengers Boarding	Departing Trains: Number of Seats	Departing Trains: Number of Passengers	Departing Trains: Peak Period Occupancy
LONG BEACH	0	0	--%	1,815	11,280	1,815	16.1%
ISLAND PARK	9,840	1,318	13.4%	1,155	9,840	2,473	25.1%
OCEANSIDE	11,280	2,969	26.3%	1,595	11,280	4,564	40.5%
EAST ROCKAWAY	11,280	4,564	40.5%	659	11,280	5,223	46.3%
CENTRE AVE	11,280	5,223	46.3%	589	11,280	5,812	51.5%
LYNBROOK	14,160	5,880	41.5%	1,443	14,160	7,323	51.7%

Station	Total Station Volume	Station Volume By Access Mode: Park Access	Station Volume By Access Mode: Other Access	Daily Parking Revenue	AM Peak Ticket Revenue	Average Access Time (Min.): Park Access	Average Access Time (Min.): Other Access	Average Access Time (Min.): Combined
LONG BEACH	1,815	324	1,490	$0	$5,581	14.7	27.2	24.9
ISLAND PARK	1,155	564	590	$107	$3,551	9.1	18.5	13.9
OCEANSIDE	1,595	849	745	$0	$4,903	5.2	11.2	8.0
EAST ROCKAWAY	659	231	428	$10	$2,025	4.8	18.6	13.7
CENTRE AVE	589	192	397	$0	$1,811	10.8	15.0	13.6
LYNBROOK	1,443	963	481	$235	$3,861	9.5	20.7	13.2
Branch Total	7,255	3,124	4,131	$351	$21,732	8.5	20.2	15.2

FAR ROCKAWAY Branch

Station	Arriving Trains: Number of Seats	Arriving Trains: Number of Passengers	Arriving Trains: Peak Period Occupancy	Passengers Boarding	Departing Trains: Number of Seats	Departing Trains: Number of Passengers	Departing Trains: Peak Period Occupancy
FAR ROCKAWAY	0	0	--%	249	8,640	249	2.9%
INWOOD	8,640	249	2.9%	248	8,640	497	5.8%
LAWRENCE	8,640	497	5.8%	484	8,640	981	11.4%
CEDARHURST	8,640	981	11.4%	657	8,640	1,638	19.0%
WOODMERE	8,640	1,638	19.0%	724	8,640	2,362	27.3%
HEWLETT	8,640	2,362	27.3%	816	8,640	3,177	36.8%
GIBSON	8,640	3,177	36.8%	665	8,640	3,842	44.5%
VALLEY STREAM	15,840	5,251	33.2%	2,286	15,120	7,537	49.8%
ROSEDALE	11,040	3,003	27.2%	1,484	11,040	4,487	40.6%
LAURELTON	8,400	2,252	26.8%	477	8,400	2,729	32.5%
LOCUST MANOR	7,200	1,499	20.8%	471	7,200	1,970	27.4%

Station	Total Station Volume	Station Volume By Access Mode: Park Access	Station Volume By Access Mode: Other Access	Daily Parking Revenue	AM Peak Ticket Revenue	Average Access Time (Min.): Park Access	Average Access Time (Min.): Other Access	Average Access Time (Min.): Combined
FAR ROCKAWAY	249	52	197	$0	$665	5.5	13.6	11.9
INWOOD	248	22	227	$0	$664	17.0	22.4	21.9
LAWRENCE	484	130	354	$26	$1,293	10.6	23.9	20.3
CEDARHURST	657	580	78	$253	$1,759	7.9	14.1	8.7
WOODMERE	724	416	307	$0	$1,936	5.5	11.6	8.1
HEWLETT	816	579	237	$0	$2,182	7.5	19.7	11.0
GIBSON	665	91	574	$0	$1,779	5.0	15.3	13.9
VALLEY STREAM	2,286	1,333	953	$0	$6,115	7.9	17.2	11.8
ROSEDALE	1,484	162	1,322	$19	$3,450	6.9	13.7	13.0
LAURELTON	477	38	439	$0	$1,109	6.1	12.5	12.0
LOCUST MANOR	471	0	471	$0	$1,095	--	16.7	16.7
Branch Total	8,560	3,402	5,158	$298	$22,047	7.5	16.0	12.6

CITY TERMINAL Branch

Station	Arriving Trains: Number of Seats	Arriving Trains: Number of Passengers	Arriving Trains: Peak Period Occupancy	Passengers Boarding	Departing Trains: Number of Seats	Departing Trains: Number of Passengers	Departing Trains: Peak Period Occupancy
KEW GARDENS	45,070	40,410	89.7%	502	45,070	40,912	90.8%
FOREST HILLS	45,070	40,912	90.8%	260	45,070	41,172	91.4%
WOODSIDE	56,110	49,558	88.3%	64	56,110	49,622	88.4%
PENN STATION	90,910	89,643	98.6%	0	0	0	--%

Station	Total Station Volume	Station Volume By Access Mode: Park Access	Station Volume By Access Mode: Other Access	Daily Parking Revenue	AM Peak Ticket Revenue	Average Access Time (Min.): Park Access	Average Access Time (Min.): Other Access	Average Access Time (Min.): Combined
KEW GARDENS	502	82	420	$0	$1,029	14.2	24.2	22.5
FOREST HILLS	260	0	260	$0	$532	--	20.6	20.6
WOODSIDE	64	0	64	$0	$132	--	12.1	12.1
PENN STATION	0	0	0	$0	$0	--	--	--
Branch Total	826	82	744	$0	$1,693	14.2	21.9	21.1

PORT WASHINGTON Branch

Station	Parking Utilization Total for All Facilities			Parking Utilization Unrestricted Lots Only			Parking Utilization Restricted Lots Only			Average Parking Fee
	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	
PORT WASHINGTON	731	731	100.0%	0	0	--%	731	731	100.0%	$0.75
PLANDOME	154	119	77.3%	0	0	--%	154	119	77.3%	$0.00
MANHASSET	503	485	96.4%	102	100	98.0%	401	386	96.3%	$1.33
GREAT NECK	460	426	92.6%	97	64	66.0%	363	362	99.7%	$1.45
LITTLE NECK	454	389	85.7%	454	389	85.7%	0	0	--%	$0.92
DOUGLASTON	427	347	81.3%	427	347	81.3%	0	0	--%	$0.77
BAYSIDE	1,100	925	84.1%	1,100	925	84.1%	0	0	--%	$0.18
AUBURNDALE	0	0	--%	0	0	--%	0	0	--%	--
BROADWAY	127	127	100.0%	127	127	100.0%	0	0	--%	$0.00
MURRAY HILL	0	0	--%	0	0	--%	0	0	--%	--
FLUSHING	635	182	28.7%	635	182	28.7%	0	0	--%	$2.62
Branch Total	4,592	3,731	81.3%	2,943	2,133	72.5%	1,650	1,597	96.8%	$0.83

OYSTER BAY Branch

Station	Parking Utilization Total for All Facilities			Parking Utilization Unrestricted Lots Only			Parking Utilization Restricted Lots Only			Average Parking Fee
	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	
OYSTER BAY	232	18	7.8%	232	18	7.8%	0	0	--%	$0.00
MILL NECK	15	7	46.7%	15	7	46.7%	0	0	--%	$0.00
LOCUST VALLEY	108	62	57.4%	24	17	70.8%	84	45	53.6%	$0.36
GLEN COVE	155	147	94.8%	155	147	94.8%	0	0	--%	$0.00
GLEN STREET	119	101	84.9%	119	101	84.9%	0	0	--%	$0.00
SEA CLIFF	114	112	98.2%	114	112	98.2%	0	0	--%	$0.00
GLEN HEAD	182	113	62.1%	29	23	79.3%	153	89	58.2%	$0.55
GREENVALE	181	105	58.0%	181	105	58.0%	0	0	--%	$0.11
ROSLYN	148	108	73.0%	148	108	73.0%	0	0	--%	$0.04
ALBERTSON	135	73	54.1%	135	73	54.1%	0	0	--%	$0.69
EAST WILLISTON	217	180	82.9%	152	124	81.6%	65	56	86.2%	$0.00
Branch Total	1,607	1,025	63.8%	1,305	835	64.0%	302	190	62.9%	$0.15

PORT JEFFERSON Branch

Station	Parking Utilization Total for All Facilities			Parking Utilization Unrestricted Lots Only			Parking Utilization Restricted Lots Only			Average Parking Fee
	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	
PORT JEFFERSON	637	587	92.2%	555	510	91.9%	82	77	93.9%	$0.00
STONY BROOK	516	456	88.4%	516	456	88.4%	0	0	--%	$0.00
ST JAMES	275	252	91.6%	128	122	95.3%	147	130	88.4%	$0.00
SMITHTOWN	761	725	95.3%	461	437	94.8%	300	288	96.0%	$0.00
KINGS PARK	737	701	95.1%	125	119	95.2%	612	581	94.9%	$0.00
NORTHPORT	1,078	902	83.7%	177	133	75.1%	901	770	85.5%	$0.02
GREENLAWN	343	320	93.3%	30	30	100.0%	313	290	92.7%	$0.00
HUNTINGTON	3,323	3,257	98.0%	1,365	1,364	99.9%	1,957	1,893	96.7%	$0.00
COLD SPRING HARBOR	836	836	100.0%	52	52	100.0%	784	784	100.0%	$0.00
SYOSSET	978	855	87.4%	0	0	--%	978	855	87.4%	$0.50
HICKSVILLE	3,345	3,073	91.9%	2,159	1,965	91.0%	1,185	1,107	93.4%	$0.68
WESTBURY	823	783	95.1%	597	557	93.3%	226	226	100.0%	$0.46
CARLE PLACE	0	0	--%	0	0	--%	0	0	--%	--
MINEOLA	530	527	99.4%	222	222	100.0%	308	304	98.7%	$0.19
MERILLON AVE	140	128	91.4%	105	103	98.1%	35	25	71.4%	$0.00
NEW HYDE PARK	584	510	87.3%	584	510	87.3%	0	0	--%	$0.56
Branch Total	14,908	13,911	93.3%	7,078	6,580	93.0%	7,830	7,331	93.6%	$0.23

RONKONKOMA Branch

Station	Parking Utilization Total for All Facilities: Auto Capac.	Cars Parked	Fill %	Parking Utilization Unrestricted Lots Only: Auto Capac.	Cars Parked	Fill %	Parking Utilization Restricted Lots Only: Auto Capac.	Cars Parked	Fill %	Average Parking Fee
RONKONKOMA	2,187	1,377	63.0%	2,187	1,377	63.0%	0	0	--%	$0.00
CENTRAL ISLIP	224	192	85.7%	224	192	85.7%	0	0	--%	$0.00
BRENTWOOD	427	393	92.0%	427	393	92.0%	0	0	--%	$0.00
DEER PARK	443	437	98.6%	443	437	98.6%	0	0	--%	$0.00
WYANDANCH	550	266	48.4%	550	266	48.4%	0	0	--%	$0.00
FARMINGDALE	328	226	68.9%	328	226	68.9%	0	0	--%	$0.07
BETHPAGE	633	356	56.2%	172	67	39.0%	461	289	62.7%	$0.38
Branch Total	4,793	3,247	67.7%	4,332	2,958	68.3%	461	289	62.7%	$0.05

HEMPSTEAD Branch

Station	Parking Utilization Total for All Facilities			Parking Utilization Unrestricted Lots Only			Parking Utilization Restricted Lots Only			Average Parking Fee
	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	
HEMPSTEAD	876	673	76.8%	649	452	69.6%	227	222	97.8%	$0.25
COUNTRY LIFE PRESS	428	181	42.3%	308	157	51.0%	120	23	19.2%	$0.00
GARDEN CITY	618	484	78.3%	399	304	76.2%	219	180	82.2%	$0.00
NASSAU BLVD	209	186	89.0%	0	0	--%	209	186	89.0%	$0.00
STEWART MANOR	152	133	87.5%	43	43	100.0%	109	90	82.6%	$0.00
FLORAL PARK	652	504	77.3%	516	381	73.8%	136	123	90.4%	$1.13
BELLEROSE	38	35	92.1%	38	35	92.1%	0	0	--%	$1.50
QUEENS VILLAGE	99	32	32.3%	99	32	32.3%	0	0	--%	$1.95
HOLLIS	0	0	--%	0	0	--%	0	0	--%	--
Branch Total	3,073	2,228	72.5%	2,053	1,404	68.4%	1,020	824	80.8%	$0.38

WEST HEMPSTEAD Branch

Station	Parking Utilization Total for All Facilities			Parking Utilization Unrestricted Lots Only			Parking Utilization Restricted Lots Only			Average Parking Fee
	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	
WEST HEMPSTEAD	150	121	80.7%	150	121	80.7%	0	0	--%	$0.00
HEMPSTEAD GARDENS	0	0	--%	0	0	--%	0	0	--%	--
LAKEVIEW	41	30	73.2%	41	30	73.2%	0	0	--%	$0.00
MALVERNE	193	188	97.4%	140	135	96.4%	53	52	98.1%	$0.36
WESTWOOD	61	53	86.9%	0	0	--%	61	53	86.9%	$0.00
ST ALBANS	35	0	0.0%	35	0	0.0%	0	0	--%	$0.00
Branch Total	480	392	81.7%	366	287	78.4%	114	105	92.1%	$0.17

MONTAUK Branch

Station	Parking Utilization Total for All Facilities			Parking Utilization Unrestricted Lots Only			Parking Utilization Restricted Lots Only			Average Parking Fee
	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	
SPEONK	194	98	50.5%	194	98	50.5%	0	0	--%	$0.00
CENTER MORICHES	79	39	49.4%	79	39	49.4%	0	0	--%	$0.00
MASTIC-SHIRLEY	213	124	58.2%	213	124	58.2%	0	0	--%	$0.00
BELLPORT	80	1	1.3%	80	1	1.3%	0	0	--%	$0.00
PATCHOGUE	1,080	588	54.4%	901	420	46.6%	179	169	94.4%	$0.12
SAYVILLE	684	451	65.9%	684	451	65.9%	0	0	--%	$0.00
OAKDALE	250	222	88.8%	250	222	88.8%	0	0	--%	$0.00
GREAT RIVER	160	118	73.8%	160	118	73.8%	0	0	--%	$0.00
ISLIP	446	385	86.3%	446	385	86.3%	0	0	--%	$0.00
BAY SHORE	451	398	88.2%	451	398	88.2%	0	0	--%	$0.00
Branch Total	3,639	2,423	66.6%	3,460	2,255	65.2%	179	169	94.4%	$0.03

------------------------------ BABYLON Branch ------------------------------

Station	Parking Utilization Total for All Facilities			Parking Utilization Unrestricted Lots Only			Parking Utilization Restricted Lots Only			Average Parking Fee
	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	
BABYLON	1,274	1,174	92.2%	1,274	1,174	92.2%	0	0	--%	$0.91
LINDENHURST	862	833	96.6%	595	579	97.3%	267	254	95.1%	$0.00
COPIAGUE	780	690	88.5%	780	690	88.5%	0	0	--%	$0.00
AMITYVILLE	804	646	80.3%	804	646	80.3%	0	0	--%	$0.22
MASSAPEQUA PARK	815	763	93.6%	403	385	95.5%	412	378	91.7%	$0.00
MASSAPEQUA	1,738	1,589	91.4%	495	486	98.2%	1,243	1,104	88.8%	$0.19
SEAFORD	835	834	99.9%	416	416	100.0%	419	418	99.8%	$0.00
WANTAGH	1,244	1,244	100.0%	156	156	100.0%	1,088	1,088	100.0%	$0.00
BELLMORE	1,547	1,546	99.9%	1,547	1,546	99.9%	0	0	--%	$0.00
MERRICK	1,244	1,231	99.0%	1,244	1,231	99.0%	0	0	--%	$0.00
FREEPORT	1,180	977	82.8%	1,180	977	82.8%	0	0	--%	$0.00
BALDWIN	1,273	1,258	98.8%	1,059	1,049	99.1%	214	209	97.7%	$0.00
ROCKVILLE CENTER	1,386	1,155	83.3%	100	96	96.0%	1,285	1,059	82.4%	$0.23
Branch Total	14,985	13,942	93.0%	10,056	9,431	93.8%	4,929	4,511	91.5%	$0.13

LONG BEACH Branch

Station	Parking Utilization Total for All Facilities			Parking Utilization Unrestricted Lots Only			Parking Utilization Restricted Lots Only			
	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	Average Parking Fee
LONG BEACH	341	270	79.2%	341	270	79.2%	0	0	--%	$0.00
ISLAND PARK	528	470	89.0%	528	470	89.0%	0	0	--%	$0.23
OCEANSIDE	845	708	83.8%	310	234	75.5%	535	473	88.4%	$0.00
EAST ROCKAWAY	192	192	100.0%	129	129	100.0%	63	63	100.0%	$0.05
CENTRE AVE	182	160	87.9%	104	90	86.5%	78	71	91.0%	$0.00
LYNBROOK	950	802	84.4%	228	197	86.4%	722	605	83.8%	$0.29
Branch Total	3,039	2,603	85.7%	1,641	1,391	84.8%	1,399	1,212	86.6%	$0.13

FAR ROCKAWAY Branch

Station	Parking Utilization Total for All Facilities			Parking Utilization Unrestricted Lots Only			Parking Utilization Restricted Lots Only			Average Parking Fee
	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	Auto Capac.	Cars Parked	Fill %	
FAR ROCKAWAY	300	43	14.3%	300	43	14.3%	0	0	--%	$0.00
INWOOD	138	18	13.0%	138	18	13.0%	0	0	--%	$0.00
LAWRENCE	198	108	54.5%	198	108	54.5%	0	0	--%	$0.24
CEDARHURST	571	483	84.6%	493	410	83.2%	78	73	93.6%	$0.52
WOODMERE	354	347	98.0%	354	347	98.0%	0	0	--%	$0.00
HEWLETT	778	483	62.1%	778	483	62.1%	0	0	--%	$0.00
GIBSON	125	76	60.8%	40	24	60.0%	85	52	61.2%	$0.00
VALLEY STREAM	1,245	1,111	89.2%	153	151	98.7%	1,091	959	87.9%	$0.00
ROSEDALE	368	135	36.7%	368	135	36.7%	0	0	--%	$0.14
LAURELTON	52	32	61.5%	52	32	61.5%	0	0	--%	$0.00
LOCUST MANOR	257	0	0.0%	257	0	0.0%	0	0	--%	--
Branch Total	4,387	2,835	64.6%	3,132	1,751	55.9%	1,255	1,084	86.4%	$0.10

CITY TERMINAL Branch

Station	Parking Utilization Total for All Facilities: Auto Capac.	Cars Parked	Fill %	Parking Utilization Unrestricted Lots Only: Auto Capac.	Cars Parked	Fill %	Parking Utilization Restricted Lots Only: Auto Capac.	Cars Parked	Fill %	Average Parking Fee
KEW GARDENS	68	68	100.0%	68	68	100.0%	0	0	--%	$0.00
FOREST HILLS	0	0	--%	0	0	--%	0	0	--%	--
WOODSIDE	0	0	--%	0	0	--%	0	0	--%	--
PENN STATION	0	0	--%	0	0	--%	0	0	--%	--
Branch Total	68	68	100.0%	68	68	100.0%	0	0	--%	$0.00