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INFORM Evaluation

Volume I: Technical Report

U.S. Department of Transportation
Federal Highway Administration

Research and Development
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, Virginia 22101-2296

FOREWORD

This report is intended for transportation professionals who are implementing or otherwise involved in traffic management and control strategies.

INFORM (INformation FOR Motorists), formerly known as the Integrated Motorist Information System (IMIS), is a corridor traffic management system designed to optimize the existing highway facilities in a 40-mile highway corridor on Long Island, New York. INFORM represents the most advanced variable message sign-based motorist information system in the United States.

The guide documents the use of integrated electronic traffic monitoring, variable message signing, closed-circuit cameras, and ramp metering to optimize traffic flow. In addition, it addresses general design and construction issues, operation and management issues, and provides insight on the public's perception of the system.

This report is being distributed to each Region, Division, and State highway agency.

R. J. Betsold
Director, Office of Safety and Traffic
Operations Research and Development

NOTICE

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16. Abstract

INFORM (INformation FOR Motorists, formerly known as the Integrated Motorist Information System--IMIS) is a corridor traffic management system designed to obtain better utilization of existing highway facilities in a 40-mile (64.4-km) long highway corridor on Long Island, New York. The system includes integrated electronic traffic monitoring, variable message signing, ramp metering, and related strategies to optimize traffic flow through a heavily congested corridor.

The evaluation of INFORM was conducted using extensive field data, surveys, and data collected through the system. The Technical Report presents the overall results of the evaluation, including comparisons of vehicle miles of travel, vehicle hours of travel, speed, occupancy, ramp delays, and equipment failures, motorist perceptions, and other congestion-related measures for the a.m. and p.m. peak periods. Incident case studies were used to evaluate motorist response to and effectiveness of variable message signing strategies. In addition to presenting the quantitative results, the Technical Report documents the many lessons learned in the design, implementation, operation, and evaluation of INFORM.

This volume is one of two reports on the INFORM Evaluation. The other volume is:

FHWA-RD-91-076 Volume II: Executive Summary

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VOLUME I: TECHNICAL REPORT
TABLE OF CONTENTS

CHAPTER PAGE

VOLUME I: TECHNICAL REPORT
TABLE OF CONTENTS (continued)

VOLUME II: EXECUTIVE SUMMARY
TABLE OF CONTENTS

VOLUME I: TECHNICAL REPORT
LIST OF FIGURES

VOLUME I: TECHNICAL REPORT
LIST OF FIGURES (continued)

VOLUME II: EXECUTIVE SUMMARY
LIST OF FIGURES

Figure No. | Page No.

VOLUME I: TECHNICAL REPORT
LIST OF TABLES

LIST OF TABLES (continued)

LIST OF ABBREVIATIONS

AWDT	Average weekday daily traffic
CB	Citizen's band
CCTV	Closed-circuit TV
CO	Carbon monoxide
DOT	Department of Transportation
EB	Eastbound
FHWA	Federal Highway Administration
GCP	Grand Central Parkway
IMIS	Integrated Motorist Information System
INFORM	INformation FOR Motorists
LIE	Long Island Expressway
MOE	Measure of effectiveness
NB	Northbound
NSP	Northern State Parkway
NYSDOT	New York State Department of Transportation
RCU	Remote communications unit
SB	Southbound
SR	State route
UTCS	Urban Traffic Control System
VHT	Vehicle hours of travel
VMS	Variable message sign
VMT	Vehicle miles of travel
VPH	Vehicles per hour
WB	Westbound

1. INTRODUCTION

INFORM (INformation FOR Motorists, formerly known as the Integrated Motorist Information System--IMIS) is a corridor traffic management system designed to obtain better use of existing highway facilities in a 40-mi (64.4 km) long highway corridor on Long Island, New York. Figure 1 shows the general location of the corridor. This operational demonstration was developed in accordance with a cooperative agreement between the Federal Highway Administration (FHWA), the New York State Department of Transportation (NYSDOT), and the transportation agencies of local governments on Long Island.

The INFORM corridor contains two major freeway facilities, the Long Island Expressway, (LIE-Interstate 495), the Northern State Parkway/Grand Central Parkway (NSP/GCP), and a number of parallel and crossing arterial streets and freeways, a total of 128 mi (206.1 km) of controlled roadways. The corridor extends east from the Queens Borough of New York City, through Nassau County, and into Suffolk County. The system consists of electronic surveillance, communications, signing, and control components, providing motorist information for warning and route diversion, ramp control, and signal control. Figure 2 shows the detailed INFORM network, indicating specific ramp meter and variable message sign (VMS) locations. This figure will be referred to frequently in other parts of the report.

The primary commuting directions on the LIE and NSP/GCP are westbound in the morning and eastbound in the evening, although significant reverse direction commuting also occurs. Substantial travel also takes place on holidays, weekends, and summer weekdays, during which there is a large percentage of recreational traffic that may not be completely familiar with the highway system. Much of this traffic is bound for or returning from the resort areas of eastern Long Island.

The busiest facility is the east-west LIE. The 40-mi (64.4 km) section of the LIE on INFORM is a six-lane divided urban freeway, 26.5 mi (42.7 km) of which have adjacent two-lane and three-lane, one-way, surface arterial street frontage roads. The average weekday daily traffic (AWDT) on the LIE ranges between 130,000 and 180,000 vehicles per day. The east-west, limited-access, auto-only NSP is a four- to six-lane divided roadway with grass shoulders, 39 mi (62.8 km) long. The AWDT on the NSP/GCP ranges between 50,000 and 150,000 vehicles per day. Additional east-west highway capacity is provided by 29.5 mi (42.7 km) of six- and seven-lane urban surface arterial streets. At five locations along the east-west corridor, north-south, auto-only, limited-access parkways enable auto drivers to switch between the alternative east-west limited-access and arterial street routes. These north-south parkways are four- and six-lane divided limited-access highways totaling 13.6 mi (21.9 km) length. At four locations along the east-west corridor, four- and six-lane, north-south, surface arterial streets, totaling 5.5 mi (8.9 km) in length, enable all classes of vehicles to switch between the alternative east-west routes.

The various INFORM control elements and their functions are as follows:

- Overall supervision is provided by operators in a control facility at the State Office Building in Hauppauge, NY. Three minicomputers assist with traffic flow monitoring, traffic control, and response to traffic incidents.

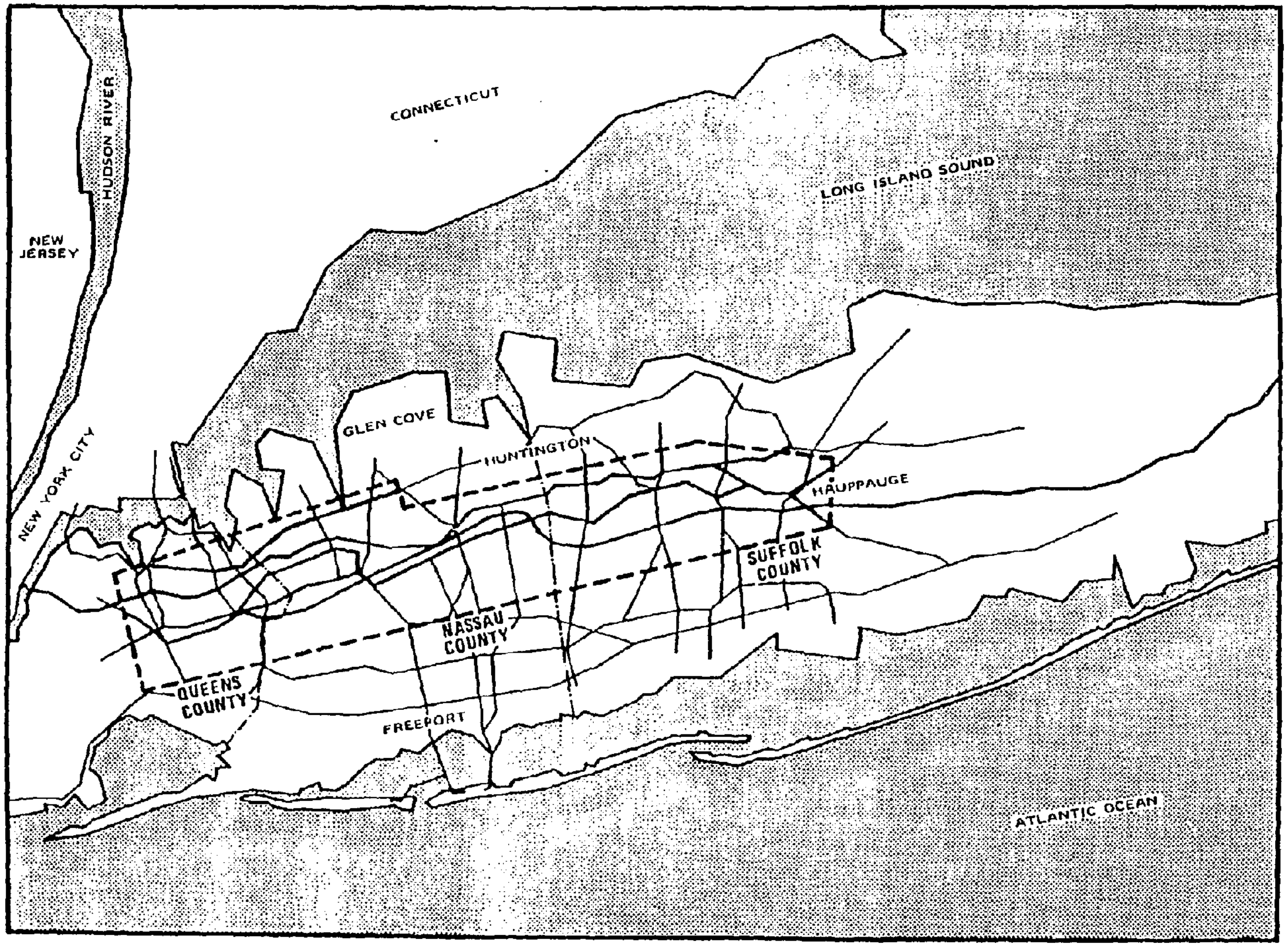


Figure 1. INFORM corridor.

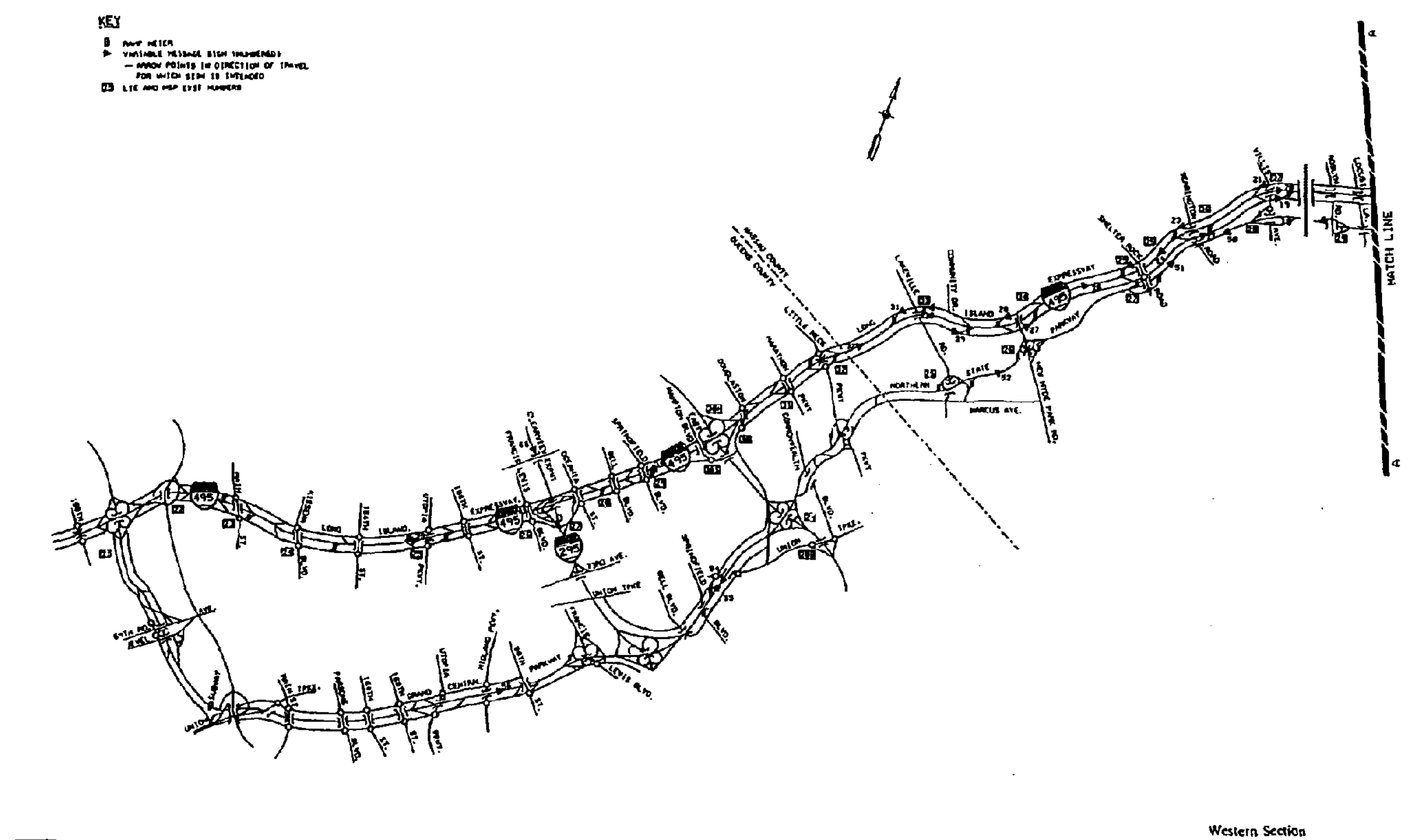
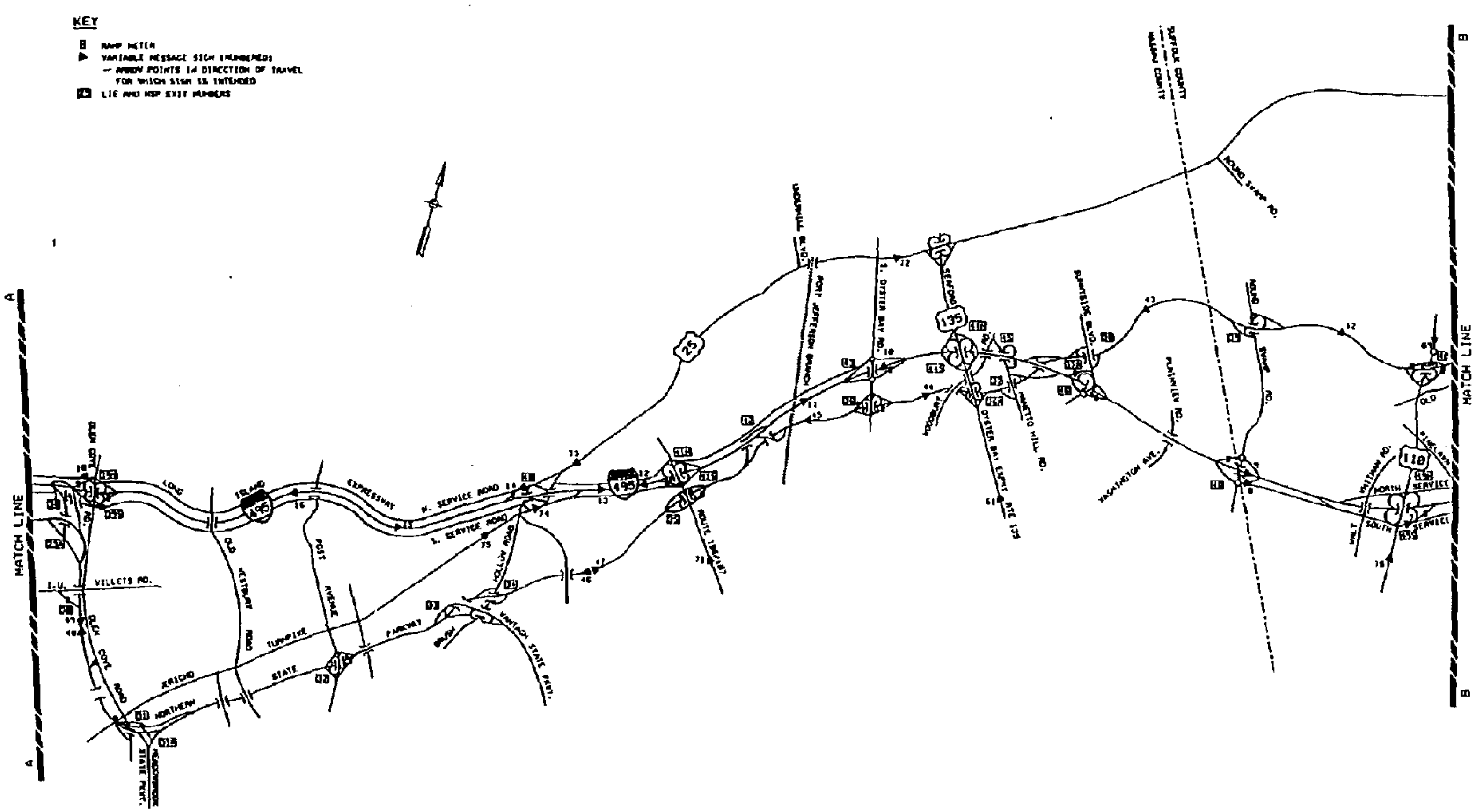


Figure 2. INFORM network.



Central Section

Figure 2. INFORM network (continued).

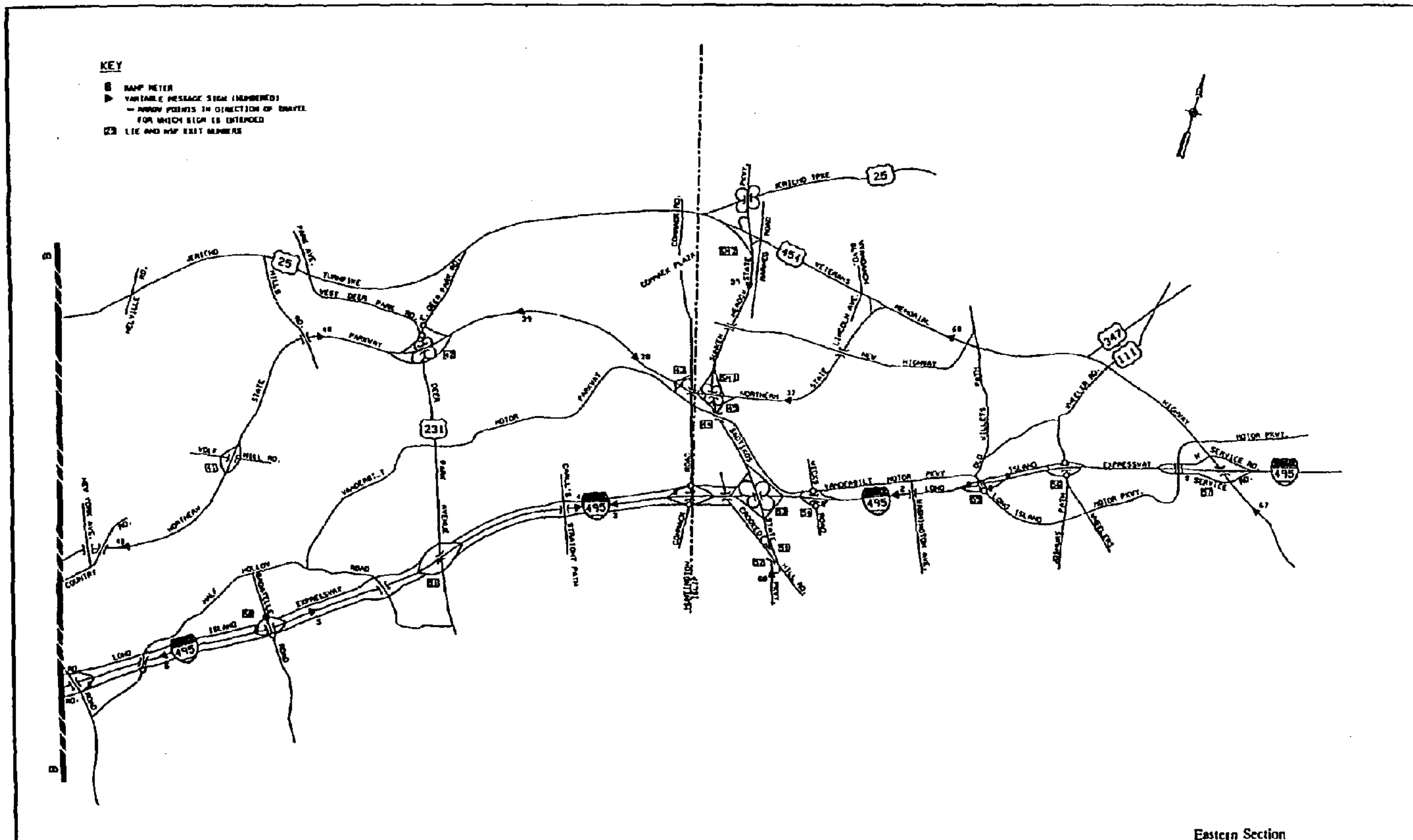


Figure 2. INFORM network (continued).

- Traffic monitoring consists of 2,100 in roadway vehicle presence detectors and 21 roadside citizens band radio monitor units. A limited number of closed-circuit TV (CCTV) cameras have been installed since late 1989 to monitor traffic in construction areas. A 160-mi (257.6-km) coaxial cable communications network connects equipment at more than 400 roadside locations with the control facility.

- At ramps, traffic entering freeways is metered by traffic signals. Roadside hard-wired digital controllers operate these ramp traffic signals, under the supervision of one of the control center computers, or independently in case of communications failure.

- VMS's at 72 locations provide information to motorists on congestion and delays. The controllers for these signs are roadside microcomputers, operating under the supervision of a control center minicomputer.

- The traffic signal indications at 104 arterial street intersections are under INFORM control. New York's Model 170 controllers are used at these intersections, with supervision of coordinated signal indications by one of the INFORM control center computers.

The original INFORM concept also called for information to be transmitted to and displayed at six sites remote from the State's control center to coordinate traffic control efforts between INFORM and other agencies. The following is a list of remote sites and locations:

- New York City Traffic Control Center in Long Island City, N.Y.
- Nassau County Traffic Control Center in Mineola, N.Y.
- Suffolk County Police in Yaphank, N.Y.
- Nassau County Police in Westbury, N.Y.
- New York State Police in Bethpage State Park, N.Y.
- Shadow Traffic Network Headquarters in Union, N.J.

The terminals in these locations are not currently active.

HISTORY OF INFORM

The history of INFORM extends back to the early 1970's, when the Integrated Motorist Information System concept was first conceived. The Long Island corridor was selected as the location for the demonstration from among several candidate sites. The availability of parallel freeways that were close to each other was a significant factor in its selection, because it provided an opportunity for traffic diversion and optimizing corridor traffic flow.

In 1975, the FHWA initiated a major feasibility study. This study was completed in 1977 and resulted in a recommendation and preliminary design for a freeway and arterial system comprising some 200 mi (322 km) of roadway. The system was to include VMS's, ramp metering, highway advisory radio, and various incident management strategies. A comprehensive evaluation plan was formulated in 1980. Final design of the system was completed in 1981, and bids were let in January, 1982.

Construction and implementation of the system took place in stages. The VMS's were the first visible evidence to the motorists that the system was being installed. According to NYSDOT, the decision to install the signs before implementing much of the rest of the system was driven primarily by the way in which the pay items were structured in the contract. This decision resulted in the signs being visible to the motorist for a long period (approximately 2 years) before they were being used actively. Ramp metering signals were installed in 1986 and 1987 and, like the signs, were inactive for a relatively long period.

The first evaluation data were collected in spring 1987. The original evaluation plan called for a 5-week intensive data collection period before the implementation of INFORM, with a second intensive 5-week data collection period after the full implementation of INFORM. It became clear in the latter part of 1988 that INFORM's implementation would be taking place over a longer period of time than first envisioned. Over this period, numerous other factors in addition to INFORM were having an influence on traffic. Construction projects, ramp modifications, and changing traffic patterns brought on by development in the corridor had the potential for confounding the evaluation results if only a single before and a single after period of data were available. Therefore, the course of the evaluation was altered to structure the evaluation in more of a time series analysis in contrast to the original plan, which embodied a single "snapshot" before and a single "snapshot" after INFORM implementation. The modified evaluation methodology placed emphasis on the collection of data through the INFORM surveillance system, with more selective use of field data collection. A full description of the evaluation methodology and data collection program is described later in this chapter.

PURPOSE AND SCOPE OF THE INFORM EVALUATION

This report presents preliminary information on the results of various aspects of the INFORM evaluation. The report emphasizes the overall evaluation of INFORM, lessons that have been learned, and guidance that can be provided in the design, operation, and evaluation of traffic surveillance and control systems like INFORM. The report also presents specific information on the evaluation of the VMS's and the ramp metering subsystem. In addition, the report documents perceptions of INFORM by the public and by those responsible for its planning and implementation.

As with other surveillance and control systems, INFORM is in a constant process of improvement and upgrading. The evaluation provides a series of snapshots of INFORM operation, and it is desirable that additional monitoring on its performance be conducted even after the completion of this evaluation. Nevertheless, the lessons learned up to this point are significant and should be of valuable to both the operation of INFORM itself and to the operation of similar systems in other locations.

Those familiar with INFORM's history understand that INFORM has had its share of difficulties. The INFORM Evaluation brings out the difficulties, as well as its achievements to document the lessons learned so that future systems will not fall into the same pitfalls. The remainder of this chapter discusses the operation of the INFORM components in detail.

OPERATION OF INFORM COMPONENTS

To fully understand the results of the evaluation, one must first understand how INFORM operates. There are several major components of INFORM operation:

- VMS subsystem.
- Ramp metering subsystem.
- Arterial subsystem.
- Surveillance and incident detection.
- Coordination with other agencies.

A private contractor is charged with the day-to-day operational responsibility of INFORM. A maintenance contractor provides maintenance on all INFORM field components. These activities are overseen by NYSDOT staff with responsibilities for specific areas of INFORM.

Operation of the Variable Message Signing Subsystem

Physical Characteristics and Location of the Signs

There are currently 74 disk matrix type VMS's in the INFORM system. The locations of these signs are shown by the triangles in figure 2, presented previously. The triangle points in the travel direction of drivers who will be reading the signs.

The majority of signs consist of 3 message lines, each line having 16 characters. Each character is 16 in (40.64 cm) high, made up of seven rows and five columns of reversible yellow reflective disks 1.5 in (3.81 cm) in diameter. There are 2 4-line signs with 20 18-in (45.72-cm) characters. The remaining 48 mainline freeway signs are 3 lines each. In addition, there are 8 2-line, 16-character-per-line signs; 15 single-line, 11-character signs; and 1 3-line sign on the arterial system.

The mainline freeway signs are mounted on overhead spans. The three-line signs have six plexiglass panels designed for a wind speed loading of at least 90 mi/h (144.9 km/h). The signs are externally illuminated with photocell-switched luminaires mounted on brackets below the sign. Equipment cabinets housing sign controllers are ground-mounted near the sign and may also contain data communication, vehicle detector and radio monitoring equipment.

The two four-line signs are placed at the freeway-to-freeway direct connector diversion points where it is desirable to disseminate information simultaneously about multiple routes. Nine three-line signs are located on north/south freeway routes that intersect with the two major east/west parallel freeway routes. These signs are placed in advance of the first east/west freeway interchange, and display traffic information for the route bearing the sign, as well as both directions on both the LIE and NSP. The 37 signs on LIE/NSP freeway mainlines are located in advance of exits to arterial (or freeway) routes which serve as diversion routes to the parallel freeway. The eight two-line signs are placed on arterial approaches that intersect with freeways on a major arterial diversion route. Figure 3 shows one of these signs, a combination fixed and VMS sign located on westbound Jericho Turnpike approaching the LIE. The 15 single signs are located on service roads parallel to the LIE in advance of entrance ramps. Finally, the one three-line arterial sign is on the eastbound side of Jericho Turnpike. This sign provides information about the arterial and both parallel freeway routes. "Trailblazer" type fixed message guide signs have been installed on all diversion routes to guide diverted traffic.

Figure 3. Variable message sign on westbound Jericho Turnpike approaching LIE.

VMS Operation

The strategy behind the INFORM VMS's is to provide as much accurate and timely information to the motorists as possible. The information reflects the current conditions on the roadway system and does not provide any prediction of traffic conditions. The processing time for automated data gathering and information dissemination tasks is 1 minute. The current operational procedures for signing are based on the human factors research that preceded the system design, with refinements and changes based on the resolution of many technical and social issues that have arisen during actual operation.

The mechanism for development of the operational procedures has consisted of engineering staff presenting problems, issues, and possible solutions to a standing "VMS Committee" formed by NYSDOT. The type of information displayed on the signs is limited to that which is approved in advance by the committee. The committee consists of the NYSDOT Regional Director, Regional Traffic Engineer, INFORM Project Director, a Traffic & Safety Division representative from the headquarters office in Albany, N.Y., and a representative of the system operations contractor. Specific sign texts are discussed in this forum only if they are deemed to be controversial. Otherwise, general operational policies are reviewed and revised if necessary. It is the responsibility of the operations contractor both to advise the committee and carry out the decisions made.

Operating within the established limits, the operations contractor determines the appropriate strategies for system operation. Presently, information disseminated is limited to the following types:

- Delays due to recurring congestion.
- Delays due to non-recurring congestion (accidents or roadwork).
- Absence of delays (Average speed ahead in excess of 30 mi/h (48.3 km/h)).
- Weather conditions that may impact traffic flow.
- Future construction activities involving lane closures.
- Implementation of new devices (ramp meters).
- Catastrophic events requiring evacuation or severely limited access to certain areas (i.e., bridge failure, fires, hazardous material clean-ups.).

Use of descriptors such as "TRUCK ACCIDENT" or "CAR FIRE" are not used. Although the system operators generally have this type of infomation, the committee was split between the view that such information would provide motorists with a better basis for judgement of estimated delays and the view that the incident was being made too interesting and that many motorists would choose to see it rather than divert. In the absence of unanimous opinion, a conservative approach was retained, and the information is withheld from the signs (although it is shared with the media).

Some of the public perception issues dealt with by the committee have resulted in decisions that have further shaped operational strategies. An example is the decision that "Normal Traffic Ahead" be displayed on signs when no delays exist between the sign and the next downstream sign. Complaints that the signs "don't work" ceased after the implementation of that strategy. The media and the public have struggled with the definition of "Normal Traffic," but have not complained about its use.

A similar decision involved use of the word "Delays" rather than "Congestion" and "Long Delays" rather than "Heavy Congestion." The rationale for this decision was that the word "Delays" is more meaningful to Long Island motorists than "Congestion," because it is used more frequently in conversation. A decision that resulted in a major software development effort was that exit numbers, rather than distances in miles, should be used when possible to identify the geographical location and extent of delays. The change is typified as follows:

Original:	Revised:
CONGESTION NEXT 3 MILES	DELAYS EXITS 50-54

The rationale was that flexibility in describing delays is increased, and serious delays far downstream can be described on a sign that might otherwise be blank. As a result, motorists familiar with the roadways can effectively plan diversions to alternate routes, and the point at which to return to the freeway, if appropriate.

Individual Sign Message Creation

Each VMS is exercised for 15 minutes every morning at 5:00 a.m. in order to loosen up any "stuck" dots. After the exercise, the operator downloads an approved sign message library to the field controller. If the sign fails during the day, it must be initialized, in which case its library is again downloaded. The sign library can be accessed by the system software automatically or by manually creating a unique message and sending it to the sign. As a general rule, the first line is a problem statement, the second is a location, and the third, if used, suggests a diversion route.

Delay Analysis. The INFORM system operator performs delay analysis by keeping an eye on the system wall map during off-peak hours and watching it continually during peak hours. The operator can quickly scan the wall map and evaluate which red indications (system detector zones with speeds under 30 mi/h (48.3 km/h) are normally recurring delays, and which are unusual for that period and may represent an incident. Each system operator has learned what recurring delays can be expected in various parts of the system during a given shift. The operator is trained to investigate unusual conditions, and may call up additional information from the system on a video display terminal regarding the delays.

As a rule, the operator will take remedial action when two or more consecutive indications on the map are illuminated. The operator can mentally process the severity of the delays by watching how quickly the delays propagate upstream of the incident. An experienced operator can usually predict:

- The nature of delays (recurring or non-recurring).
- Severity of capacity reduction.
- Rubbernecking.
- The potential extent of delays involved, based on location, time of day and severity of the incident.

The experienced operator will quickly determine the appropriate measure of response based on:

- The location of the incident.
- The temporal proximity to the peak hour.
- The direction of travel.
- The geographical proximity to alternates.
- Weather conditions.
- The day of the week, time of day, season.
- Any special conditions.

The operator will act on this mental roadway delay analysis by keeping certain signs under automatic control and controlling others manually.

<u>Automated Signing.</u> One of the important features of the INFORM system is the use of automatic sign message generation, display, update, and removal. A good deal of operational testing was needed to arrive at proper operation, and the need to maintain system credibility limited the amount of testing employed. After a year of operational experience, the original design philosophy was reevaluated. The software was rewritten to mimic what the system operators were doing manually with the signs on a repetitive basis. This first involved basing sign message decisions on speeds rather than lane occupancies. Starting in mid-1988, limited use of automated VMS text production was incorporated into the operation. Initially, only about one third of the automated sign messages generated were accurate compared to human sign message generation based on the same data. This accuracy level has been increased by software improvements and operational testing.

The four automated modes of operation are as follows:

- Intervention: In this mode, the operator receives an audible and visual prompt that the system has detected a need to place a sign message for a specific sign on the system. The system will display the proposed sign message. The operator may then accept or reject the prompt. If the prompt is accepted, the message is sent out to the sign, after which all updates then occur automatically. This mode is frequently used for mainline signs in areas where delays are complex and difficult to analyze, and the system is less likely to generate an accurate message. The mode can be specified for any of the signs on the system.

- Semi-Automatic: In this mode, the system automatically sends the problem statement line and the problem location line (i.e., Line 1: "DELAYS" Line 2: "EXITS 50 TO 54"). Updates are automatic. No diversion statements are processed.

- Use: In this mode, lines one and two are handled identically as in Semi-Automatic, however diversions are processed and prompted for line three (i.e., Line 3: "CARS USE N. PKWY" alternated with "VIA EXIT 44").

- Automatic: In this mode, all sign messages are sent and updated automatically for all lines with no prompting.

The system is presently operated in a combination of Semi-Automatic and Intervention modes for those signs not under manual control. Each sign in the system can be placed in any of the modes, providing a mixed mode operation. Operation of all signs simultaneously in the Intervention mode was attempted but was not possible with only two operators. The automated modes do not distinguish between recurring and nonrecurring congestion.

While in any of the automated modes, the system will display a message reading "NORMAL TRAFFIC AHEAD" if the following conditions are met:

- There are no delays between the sign in question and the next downstream sign.
- At least 60 percent of the zones on the path are reporting valid data.

The INFORM system has a fixed data base of travel times for each zone by time of day and day of week. The system continually calculates travel times and compares them with the fixed data base values to determine delays for each zone. The delays calculated are presently used by the automated sign message algorithm to quantify the degree of delay.

The automatic signing algorithm is keyed to speeds at each detector station (zone). Once delay signing is activated based on low speeds, calculated delay information is then used to determine the sign message that corresponds with the length of delays. This information is also processed further to evaluate possible diversion paths.

Sections of highway that are influenced by a VMS are called sign paths. Each sign in the system has a unique set of sign paths, called the sphere of influence. Motorists move out of a sign path when they reach the system boundary or enter the sphere of influence of another sign. Criteria that are evaluated for all sign paths are:

- Average speed of zones in the section.
- Percentage of failed zones in the section.
- What delays are greatest on the path.

Presently, INFORM defines delays as mainline speeds below 30 mi/h (48.3 km/h). If cumulative calculated delays on a path exceed 15 minutes longer than the historical travel time, the delays become "long" delays.

Manual Signing. In manual mode, any sign message can be typed in and displayed. This gives the operator flexibility for broadcasting any type of specific traffic information that any situation requires. In order to broadcast a specialized sign message, an operator is encouraged to have concurrence from another operator on the shift. Manual signing is used for:

- Accidents.
- Specific diversion information.
- Road closures.
- Lane closures.
- Road work.
- Special events.
- Special conditions.
- Improvement of automated messages.
- Police requested signing.

One disadvantage of manual signing is that no automatic updating or sign message removal is possible. The system operators on duty must keep the manual messages current and remove them at the appropriate time.

Manual sign message construction follows the following prioritized rules:

- No sign shall divert trucks to a parkway.
- Only approved words are used. First precedents require supervisory approval.
- Line one is a problem statement.
- Line two is a location statement.
- Line three is a diversion statement.
- Alternating messages are not used unless necessary.

A specific diversion is one where the appropriate exit number, alternate route name, and type of vehicle (if necessary) is broadcast. Three types of specific diversions are employed:

- Direct freeway to freeway.
- Freeway to freeway via arterial.
- Freeway to service road.

A general diversion is one where no specific route can be recommended. Two types of general diversions are used:

- "Use Alternate"; Alternates are congested, yet diversion is justified.
- "Avoid Area"; Used for gridlock conditions.

A third type of diversion used tells motorists to stay on the route they are on because of problems on an alternate.

The following general rules apply to use of diversion texts:

- A road closure justifies a specific diversion.
- Diversions should be used when alternate freeway capacity exists.
- When alternates have delays yet a diversion is justified, a general diversion is used.
- Truck routes should be provided when possible. (i.e., "CARS USE N. PKWY"/"TRUCKS USE SVCE RD").

Operation of the Ramp Metering Subsystem

Ramp Meter Location

The ramp metering subsystem has been an integral part of the INFORM system from its original conception. The IMIS Feasibility and Design Study (1977) indicated that metering was expected to have the following effects:

- Reduction of traffic turbulence at ramp merge areas.
- Diversion of traffic from the freeway.
- Reduction in overall delay in the corridor.

A comprehensive set of criteria was established during the feasibility study to identify ramps that could be metered. The primary criteria included:

- Mainline link affected by ramp vehicles experiences level of service D or worse during most days.
- Accident rate at the ramp merge exceeds the average rate by a factor of 2.
- Minimum ramp volume of 240 VPH.
- Maximum ramp volume of 900 VPH.
- Safe stopping and merging geometry on the ramp and merge area.
- Adequate queue storage to avoid interference with local traffic at the ramp entrance.

Figure 2, presented previously, shows the location of ramp meters on the INFORM network. There are currently 50 operating ramp meters on the system, approximately one third of the on-ramps on the INFORM network. The original system conceptual design included 72 meters. Three of these were to have been located on the Cross Island Parkway but were later dropped from the design. Other meters have been dropped in the design stage or due to construction projects. Table 1 presents a listing of all the on-ramp locations with metered ramps identified, along with a.m. and p.m. peak hour volumes. Throughout the report, volumes are specified as an hourly rate (vehicles per hour), including volumes indicated for 15-minute time periods to aid in interpretation of the relative magnitude of volumes. Volumes on the system itself are also expressed as an hourly rate. Also indicated on table 1 is the percent of entrance ramp traffic metered, excluding the mainline entries at either end of the corridor. The percent of entering traffic metered by roadway and direction is:

- LIE westbound a.m. metering - 36.5 percent.
- LIE eastbound p.m. metering - 50.9 percent.
- NSP/GCP westbound a.m. metering - 20.6 percent.
- NSP/GCP eastbound p.m. metering - 16.1 percent.

Table 1. Summary of INFORM on-ramp control and ramp volume.

ZONE NO.	ON-RAMP NAME	METERED?	PEAK AM VOL. 15 MIN.VOL.(VPH)	PEAK PM VOL. 15 MIN.VOL.(VPH)
		LIE EASTBOUND RAMPS (PM METERING)		
	QUEENS			
5	GCP N&S	No		
6	College Pt.	No	798	759
9	Main	Yes	462	618
12	161 St.	Yes	582	642
15	Utopia	Yes	692	706
18	Clearview SB	No	33	28
19	Clearview NB	No	221	193
20	Oceania	Yes	337	361
22	Springfield	Yes	293	296
24	Cross Island	No	1646	1871
26	Douglaston	No	1219	1571
	% Traffic Metered			37.2%
	NASSAU			
29	L. Neck	Yes	695	583
34	Community	Yes	774	987
36	New Hyde	Yes	377	715
42	Searingtown	Yes	796	808
45	Willis	Yes	404	594
49	Glen Cove	No	169	250
51	Glen Cove	Yes	327	461
61	Jericho Tpk.	No	729	1222
63	Rt. 106/107 S	No	644	892
65	Rt. 106/107 N	No	294	738
71	S.O. Bay Rd.	Yes	450	903
73	Seaf. O.B. Exp.	No	277	373
75	Seaf. O.B. Exp.	No	1044	461
79	N. State Pkwy.	No	1604	822
82	Sunnyside	No	223	422
	% Traffic Metered			49.4%
	SUFFOLK			
85	Round Swamp	No	283	438
88	Rt. 110 S	No	54	151
90	Rt. 110	Yes	293	727
91	Pinelawn	Yes	358	1022
95	Bagatelle	No	305	509
99	Deer Park Ave.	No	554	530
115	Vanderbilt	Yes	695	1469
118	Rt. 111	Yes	259	832
	% Traffic Metered			71.3%
	% All LIE Eastbound			51.1%

Table 1. Summary of INFORM on-ramp control and ramp volume (continued).

ZONE NO.	ON-RAMP NAME	METERED?	PEAK AM VOL. 15 MIN.VOL.(VPH)	PEAK PM VOL. 15 MIN.VOL.(VPH)
	LIE WESTBOUND RAMPS (AM METERING)			
	SUFFOLK			
126	Veterans Hwy.	No	1492	1380
130	Rt. 111	Yes	534	700
131	Vanderbilt	Yes	426	754
142	Commack	Yes	818	587
147	Deer Park Ave.	No	989	588
151	Bagatelle	Yes	957	221
155	Rt. 110 North	No	291	989
157	Rt. 110 South	No	740	1217
	% Traffic Metered		43.8%	
	NASSAU			
160	Round Swamp	Yes	266	370
164	Sunnyside	Yes	128	536
165	N. State Pkwy.	No	1082	742
166	Manetto Hill	No	528	839
169	Sea OB Exp N	No	1453	663
171	Sea OB Exp S	No	557	310
178	Rt. 106/107 N	No	707	444
183	Jericho Tpk.	Yes	521	848
192	Glen Cove	No	103	129
194	Glen Cove	Yes	594	683
195	N. State Pkwy.	No	1170	782
198	Willis	No	290	291
201	Searingtown	Yes	331	367
203	Shelter Rock	Yes	243	242
206	New Hyde Park	Yes	479	430
209	Community	Yes	404	698
211	Lakeville	Yes	313	404
	% Traffic Metered		35.8%	
	QUEENS			
214	L. Neck	Yes	547	738
217	Cross Island	No	1431	1492
221	Springfield	No	621	527
224	Clearview N	No	680	550
225	Clearview S	No	406	493
226	Fr. Lewis	No	508	409
229	Utopia	Yes	999	527
232	Kissena	No	477	647
235	Main St.	Yes	239	426
238	Van Wyck	No	65	94
	% Traffic Metered		29.9%	
	% All LIE Westbound		36.5%	

Table 1. Summary of INFORM on-ramp control and ramp volume (continued).

ZONE NO.	ON-RAMP NAME	METERED?	PEAK AM VOL. 15 MIN.VOL.(VPH)	PEAK PM VOL. 15 MIN.VOL.(VPH)
	NSP/GCP EASTBOUND RAMPS (PM METERING)			
	QUEENS			
243	LIE E & W	No	1864	1719
246	Peartree	No	991	778
250	Interboro EB	No	1559	1355
251	Union Tpk. E	No	1199	1673
255	Utopia	No	1129	1163
258	188	No	801	838
260	Fr. Lewis SB	No	148	84
262	Fr. Lewis NB	No	69	55
264	Clearview	No	1758	1595
268	Cross Is. S	No	1118	889
269	Cross Is. N	No	1915	1846
	% Traffic Metered			0.0%
	NASSAU			
273	North Shore Towers	No	338	219
275	Marcus	Yes	396	1132
278	N. Hyde Park	No	463	1522
280	Shelter Rock S.	No	119	344
282	Shelter Rock	Yes	123	105
286	Willis	Yes	244	326
288	Roslyn	No	190	231
289	LIE	No	640	679
291	IU Willets	Yes	554	438
300	Post Ave. S	No	128	406
302	Post Ave.	Yes	575	1223
305	Wantagh N	No	2017	837
307	Brush Hollow	No	200	296
311	Rt. 106 SB	No	181	377
313	Rt. 106 NB	Yes	316	416
314	LIE	No	478	849
317	S.O. Bay Rd. S	No	42	114
319	S.O. Bay Rd NB	Yes	196	277
321	Sea O.B. Exp. S	No	38	117
323	Sea O.B. Exp. N	No	1150	1010
325	Manetto Hill	No	69	159
328	Sunnyside	No	81	763
	% Traffic Metered			33.1%
	SUFFOLK			
331	Round Swamp	No	110	239
335	Rt. 110 SB	No	137	218
337	Rt. 110 NB	Yes	89	677
341	Wolf Hill	No	303	458
347	Deer Park Rd.	No	643	643
353	Commack	No	327	327
355	Sagtikos SB	No	255	87
357	Sagtikos N	No	893	881
362	Veterans Hwy	No	1121	1084
	% Traffic Metered			14.7%
	% All NSP/GCP Eastbound			16.1%

Table 1. Summary of INFORM on-ramp control and ramp volume (continued).

ZONE NO.	ON-RAMP NAME	METERED?	PEAK AM VOL. 15 MIN.VOL.(VPH)	PEAK PM VOL. 15 MIN.VOL.(VPH)
	NSP/GCP WESTBOUND RAMPS (AM METERING)			
	SUFFOLK			
364	Veterans Hwy	No	107	124
368	Sagtikos N	No	736	864
370	Sagtikos S	No	773	738
372	Commack	No	345	275
378	Deer Park NB	No	112	76
380	Deer Park SB	No	696	416
385	Wolf Hill	No	636	202
390	Rt. 110 NB	No	204	340
392	Rt. 110 SB	Yes	604	459
395	Round Swamp	No	368	230
	% Traffic Metered		13.2%	
	NASSAU			
399	Sunnyside	No	391	541
402	Manetto Hill	No	206	241
403	Sea OB Exp	No	1024	456
405	SO Bay N	No	192	195
407	SO Bay SB	Yes	89	136
410	LIE	No	586	947
412	Rt. 106 NB	No	173	335
414	Rt. 106 SB	No	171	411
418	Brush Hollow	No	200	302
420	Wantagh	No	1437	1118
422	Post Ave. NB	No	58	121
424	Post Ave. SB	No	227	148
437	Roslyn Rd	Yes	886	477
439	Willis	Yes	619	629
442	Shelter Rock	Yes	798	594
446	New Hyde Park	Yes	487	633
448	Lakeville NB	No	372	1248
	% Traffic Metered		54.3%	
	QUEENS			
450	Lakeville SB	Yes	191	255
453	L. Neck	Yes	606	914
455	Cross Is. N	No	1980	1757
456	Cross Is. S	No	689	387
457	Union Tpk.	Yes	364	224
459	Clearview	No	1379	881
461	Fr. Lewis NB	No	477	235
463	Fr. Lewis SB	Yes	323	129
465	188	No	576	339
467	Utopia	No	354	223
471	Union Tpk.	No	702	711
472	VW & Interboro	No	3110	2798
475	Jewel Ave.	No	344	283
476	Van Wyck	No	444	179
477	Flush Park	No	20	103
480	LIE E & W	No	1654	1310
	% Traffic Metered		13.8%	
	% All NSP/GCP Westbound		20.6%	

Freeway-to-freeway connectors represent approximately 40 ramps. These are among the highest volume locations that were not selected for metering. One noteworthy observation is that significant changes occurred in many of the ramp volumes between the time of the design and 1990, particularly in the eastern sections of the corridor. Several major office parks were developed during that period which have added many vehicles to the peak hour volumes. One case in point is Vanderbilt Motor Parkway as it enters the LIE eastbound. The p.m. volume on that ramp is nearly 1500 VPH, nearly triple the volume indicated in the 1977 IMIS Feasibility Study. With single lane metering, it is extremely difficult to maintain metering operation at such a high-volume location without seriously impacting arterial traffic. The later discussion will point out the importance of anticipating future volumes in the design of a ramp metering system.

Ramp Meter Configuration

Figure 4 shows a typical ramp metering installation. Each installation contains a ramp meter, an advance warning sign activated prior to the meter turn-on, signs at the ramp meter location stating "STOP HERE ON RED" and "ONE VEHICLE PER GREEN", input and output detectors, and a queue detector. Input/output detectors control the release of vehicles entering on the ramp and also provide volume and occupancy information to the central computer. The queue detector measures occupancy only and serves to warn the central computer of queues backing into the arterial from the on-ramp traffic.

The location of the queue detector was determined in the design stage, based on the locations to which it was felt queue development would be tolerable. On portions of the network with service roads, the queue detector is sometimes located on the left-most service road lane, permitting the queue to back up onto the service road itself. At locations without service roads, the queue detector is virtually always within 100 ft (30.5 m) of the arterial which feeds the ramp. The metering equipment consists of a two-colored traffic signal (red and green indications), cycling between red and green. Flashing warning devices in advance of each ramp meter warn vehicles that the ramp meter is on. Although the ramp metering installations were designed as single lane operation, two-lane metering is in an experimental stage on one ramp.

Ramp Metering Operation

Ramp meters can be operated in manual, time of day, or traffic responsive modes. These are described below:

- Manual operations - system operators may select any individual or group of ramp meters to operate at a specific metering rate. Meters can be turned on and off, or the metering rate changed by the operator in the control center. This mode has been primarily used during the testing stage of ramp metering when each meter was being brought on line.

- Time of day mode - In time of day mode, the operator specifies individual turn-on time, turn-off time and metering rate for each individual ramp. The system then initiates operation and ceases operation at specified times. There is no opportunity for varying time-of-day metering rate within a given metering period (turn-on time to turn-off time). Metering rates would have to be changed by turning metering off, then turn metering back on again. Time-of-day was the primary mode of operation through

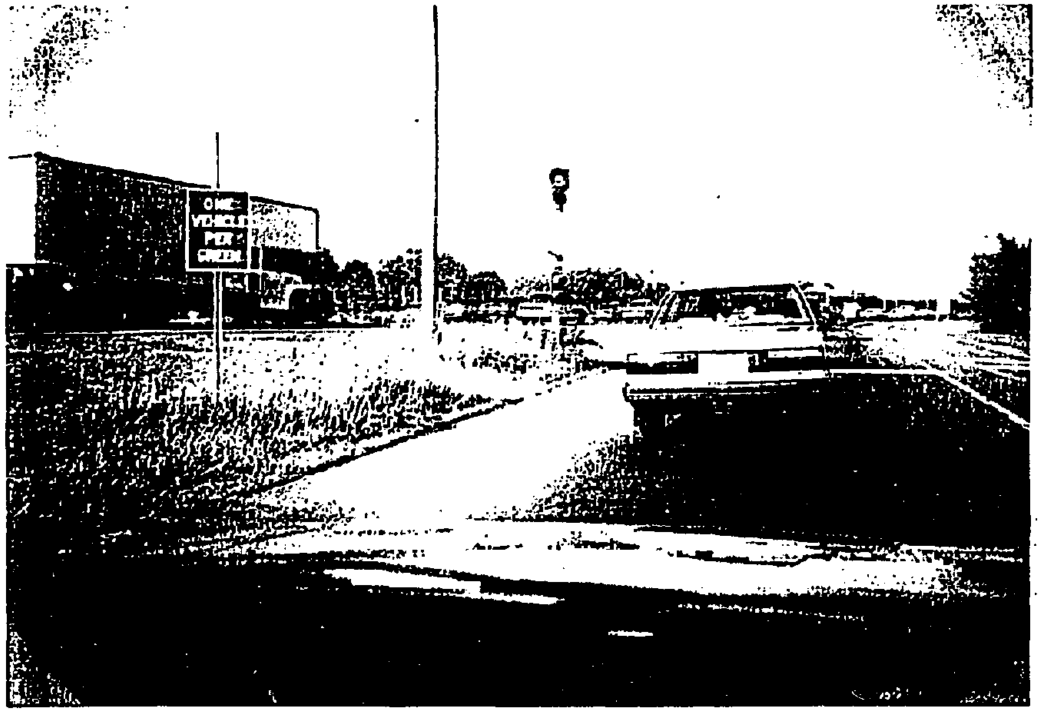


Figure 4. Typical ramp metering installation.

April, 1990. Time-of-day mode also contains a provision for automatic metering shut-off and turn-on in the event that a queue extends back to a queue detector. An occupancy threshold is established individually for each metering location, both for the threshold over which metering would be shut off, and under which metering would be turned back on. Typical turn-off occupancy thresholds have been between 15 and 25 percent. The turn-on threshold is only used for re-initiating ramp metering after it has been turned off within a metering period. It is not used to sense when metering should be initially turned on.

- Traffic responsive mode - Traffic responsive mode adjusts the metering rate in response to mainline and ramp traffic conditions. Traffic responsive mode adds an additional dimension to the management of queues on metered ramps. As the occupancy of the queue detector increases, the traffic responsive metering algorithm increases the metering rate (limited to the maximum metering rate) to avoid or forestall shutdown of the metering operation on that ramp. On the mainline, the traffic-responsive algorithm examines both the upstream and downstream detector stations. Degradation of speed on the mainline will result in a reduction of the metering rate. However, this action will be overridden by excessive queuing on the ramp itself. Thus, the entire metering operation is ultimately controlled by the ability of the ramps to store traffic.

The minimum and maximum metering rates used for any mode are 300 VPH and 800 VPH, respectively. A maximum rate of 900 VPH was originally planned for and tested in the field but produced inconsistent operation. It was determined that the 900 VPH rate provided insufficient red time for a driver to come to a complete stop. INFORM operations staff believe that it was unwise to use an aid that would not condition people to come to a complete stop. Thus, the 800 VPH rate was selected. The 900 VPH rate was tested several additional times in the course implementation and was believed not to produced a consistent and safe operation, as motorists only came to a rolling stop.

Initial Metering Operations

Several types of modifications needed to be made to certain ramp meter installations so that they would provide safe operation. Most of these involved minor modifications, such as moving of the meter, signs, fences, and foliage to provide for safe sight distance. Relocation of the devices was undertaken for certain metering signals as well as for the advanced warning signs. In a few cases, the operations staff have chosen not to turn meters on until major ramp reconstruction can be done to alleviate a potential safety hazard.

A staged process was involved in initiating ramp metering operations at a given site. The first stage involved an electrical engineer going to the site to determine what needed to be repaired or modified prior to the ramp metering turn-on. This was necessary since the ramp metering equipment had been standing dormant for over 2 years.

Secondly, a traffic engineer was sent to each site to develop an individual metering operations plan. This activity identified anything that might have been unique about the ramp that should be taken into consideration in its operation. This included a review of such items as ramp geometry, ramp location with respect to arterial streets or service roads, sight distance problems, average speed of traffic, and average volume on the ramp. Staff of the INFORM operations contractor believed that one of the things that made the metering implementation proceed smoothly was developing an individual plan for each ramp meter location, similar to what a traffic engineer would do at a new intersection signal location. A significant amount of software work was also needed to create individual data bases so that central software could operate each individual meter in response to specific conditions at that site. A ramp in Suffolk County may require entirely different operation from one in Queens.

The ramp metering system was turned on in stages. An implementation plan was prepared by the operations contractor in April, 1988. The implementation plan identified groupings of ramps according their status of readiness for implementation. A rating scheme was then devised to prioritize the implementation of the meters. The prioritization criteria were based on the original criteria in the feasibility study for selection of ramps to meter.

The initial turn-on of a ramp meter involved between 1 day and 1 week of careful observation in the field. Temporary signing was installed in advance of the metering date, identifying the date on which the metering was to be initiated at that site. The signing called to attention the fact that something different would be happening. This was particularly important in light of how long the meters had been visible to the public without being operated. If operation proceeded well on the first day, occasionally the ramp meter would be operated normally without field observation the next day. If the operations staff was uncomfortable with initial day, the staff would be kept on site at the meter until the necessary modifications were made to provide a high level confidence in the operation. Once the operations staff were comfortable with the operation, they obtained sign-off from the State's Project Director indicating that it would be operated without any special warning devices from thereon.

Ramp metering implementation took place over a period of approximately 1 year, as indicated in figure 5. This was a longer period then first envisioned, due to hardware problems and to modifications believed necessary to provide for safe operation. The implementation of ramp metering was preceded by an extensive public relations campaign that officially began on December 13, 1988 with a media event in the control center. Local politicians and the media were brought into the control center to be shown how the meters operated and what the general utilization strategy was to be. There were numerous press releases during the ramp metering implementation, created by the public relations consultant. Information was also conveyed through monthly incident management meetings, which were attended by most of the affected police agencies in the INFORM corridor. Generally, the police were more concerned about the enforcement and safety aspects of the system than about the potential benefits of the system. The reception of the ramp metering system on the part of the police was mixed. The operations staff have had to be very sensitive to the safety-related concerns of the police. A policy has remained in force that if a patrolman requests a specific ramp meter to be shut down, regardless of the reason, the operations staff will shut it down without question. Thus, the police have ultimate control over the ramp metering operation. However, such requests have rarely been generated.

In the initial 3 months of ramp metering operation there were six minor rear-end collisions on metered on-ramps. While it was uncertain whether this was a particularly high rate of accident occurrence, it was determined that experimentation should begin with using a high-intensity strobe light in a ring on the red signal head. This device was to call the existence of the ramp meter to the drivers' attention. The installation of the strobe light essentially eliminated rear-end collisions during the implementation stage. Because of the effectiveness of the simple installation of the strobe, they have now been installed on all ramp meters within the system.

AVG. NO. OPERATING RAMPS

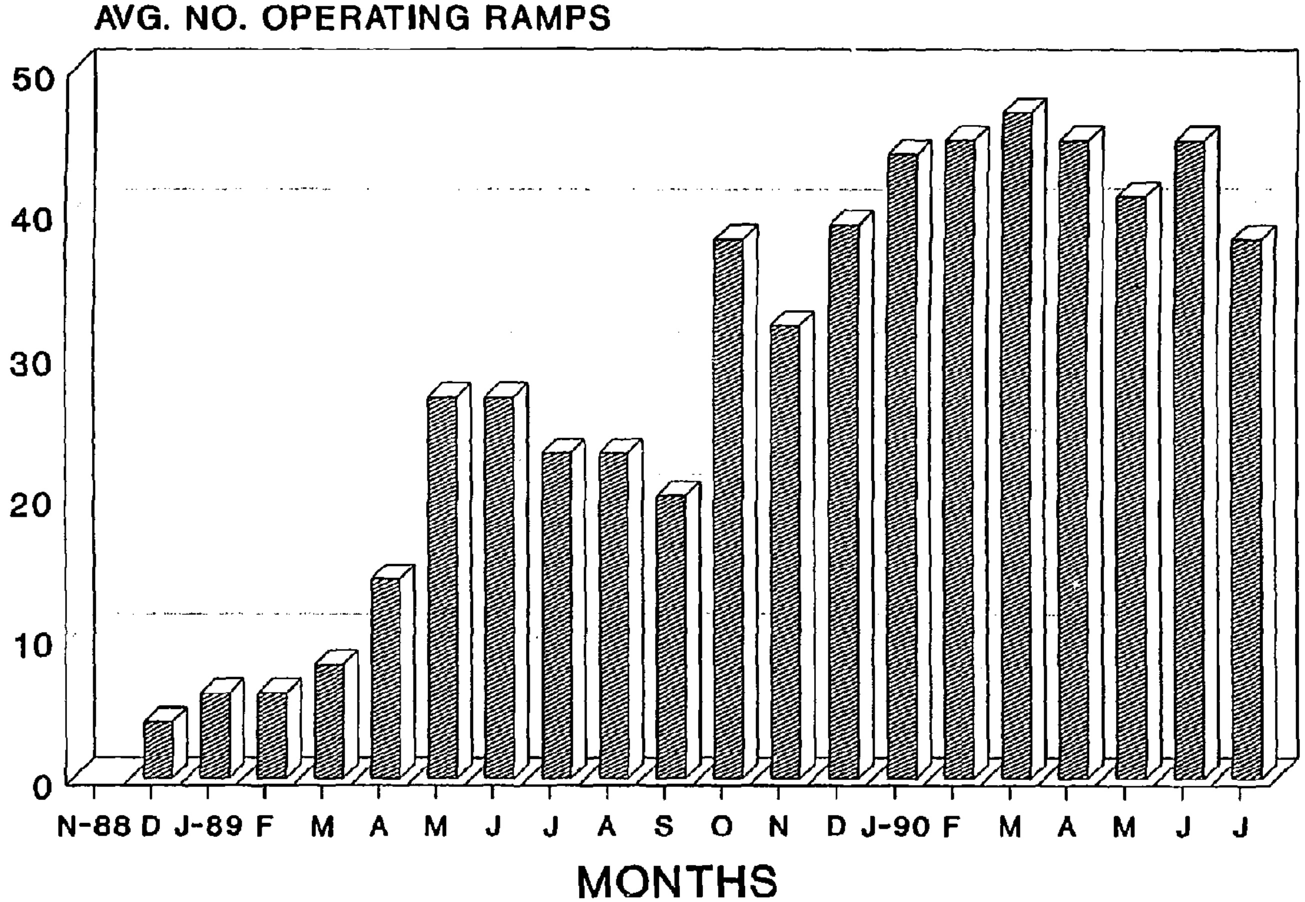


Figure 5. Average number of operating ramps, by month.

Arterial Subsystem

INFORM controls 110 intersections in the corridor, including intersections on LIE service roads and several key arterial routes such as Jericho Turnpike and Veterans Memorial Highway. Most of the routes are State highways. Intersections not on State highways are governed by a legal contract between Nassau County and the State of New York. INFORM does not control any intersections in New York City.

INFORM uses FHWA's Urban Traffic Control System (UTCS) Extended software for intersection control. Local intersections are equipped with a Model 170 type microprocessor and a remote communications unit. The intersections controlled are primarily semi-actuated and run on one of three basic time-of-day timing plans. In the absence of communications from central, the 170s revert to one of three local timing plans, based on time of day, with offsets provided through time-based coordination. Operators can select a diversion timing plan based on their decision to divert traffic from a freeway using VMS's. The system was designed to automatically enact diversion timing plans based on a diversion algorithm. However, this feature is as yet unproven.

Surveillance and Incident Detection

The surveillance component of INFORM consists of the inductive loop detector stations on the mainline and ramps and at selected locations on the arterials plus 20 citizen's band (CB) radio monitors. A police radio scanner was added as part of the initiation of formal operations in early 1988. Limited closed circuit TV (CCTV) capability was added in mid-1989 to cover areas where detection was interrupted due to construction.

Traffic status, generated by detector volume, occupancy and speed data, can be displayed on the wall map in the control center. A real-time computer graphics display has been installed as a supplement to the wall map. The display normally shows speed in three levels on the LIE and NSP/GCP. The computer graphics display has been made available to cable TV networks.

The freeway surveillance system is comprised of approximately 2400 individual inductive loops, grouped into approximately 500 detector stations or zones. A typical detector zone on the LIE consists of a detector in each lane, plus one at a nearby exit or entry ramp. Mainline stations are typically located at half-mile intervals, but the distance can vary depending on the exact location of the ramp. There are some ramps without mainline detector stations and some mainline detector stations between ramps (i.e., no associated ramp detector). Paired "speed trap" detector stations are located at approximately 3-mi (4.83-km) intervals. Vehicle length data derived from the speed trap stations are used to compute speeds at nearby single detector stations. Detector data are processed locally and transmitted to the freeway computer in the control center at 1-minute intervals.

Incident detection is performed through the processing of surveillance data by the freeway computer. A modified California incident detection algorithm is used. The software is designed to trigger an audible alarm on the control panel once the system detects an incident. Early use of the incident alarm function resulted in a high frequency of false alarms. False alarms can be created when certain nonincident traffic circumstances (such as a slow truck or some types of recurring congestion) are interpreted by the incident detection algorithm to be an incident. The alarm function is currently disabled. Although system operators believe the false alarm problem can be reduced through better calibration of the detection algorithm, little additional work has been done on the system to improve the incident detection function. Operators believe they can do a more effective job at detecting incidents by monitoring speeds on the wall map. One of the other difficulties with the algorithm is that only system-wide thresholds are available for a large system on which occupancy characteristics can vary widely among individual subsections of roadway.

Experienced operators can distinguish incident-induced congestion from recurring congestion and can usually readily identify congestion-causing incidents. Those incidents that cause little or no congestion would not normally be detected by INFORM unless they fall within the view of one of the cameras or are identified over the police scanner.

Surveillance on the UTCS-based arterial system consists of single lane system detectors at selected locations. However, many of the arterial detectors have not been providing valid data, as priority has been placed on the freeway operation. Arterial control is performed by a computer dedicated to the arterial system. Although some experimentation has been conducted with traffic responsive control of the arterials, time-of-day operation has been used from the outset of arterial signal control in early 1987.

The CB radio system was instituted as a low-cost method of verification of a "suspected" incident. Operators in the control center can use the CB system to monitor conversations in the vicinity of the 20 remote stations. Informal rules of CB discipline on Long Island have instituted separate frequencies for the LIE and the NSP. While operators indicate that they can usually tell the general nature of an event from the CB conversations, it is not thought to be convenient. The CCTV cameras are highly preferred in areas where cameras are located, and the police scanner is judged to be a much better source of information where the incidents are already known to the police. There are currently 12 color CCTV cameras with full pan, tilt, and zoom capability. The CCTV cameras were typically installed as part of a construction contract. Camera signals are sent over the coaxial cable network to a bank of four CCTV monitors in the control room. The cameras are switch-selectable and are primarily used for incident verification.

Coordination with Other Agencies

INFORM is not comprised of a physical plant only. It also consists of a network of agencies and individuals that monitor and control traffic on Long Island. The coordination of and communications among these agencies is an important part of the total INFORM concept. In addition to the New York State DOT, the agencies include:

- New York State Police.
- New York City Police.
- Nassau County Police.
- Suffolk County Police.
- New York City Traffic Division.
- Nassau County Traffic Division.
- Suffolk County Traffic Division.
- Shadow Traffic Network, Metro Traffic Control, and other radio and TV traffic reporting services.

Communications occur both at the operational level and at the planning level. The operational communications consist of the frequent communications that take place between the INFORM control center operators and police dispatchers, field units, radio traffic reporting services and related agencies as each incident takes place or other traffic circumstance occurs. The planning communication takes place in monthly traffic management meetings and other correspondence and conversations between individuals in management positions with transportation and emergency service agencies. The monthly meetings have been the primary method by which operational plans have been disseminated and concurrence reached on operational coordination strategies. Debriefings of the more significant incidents are a major topic of discussion as well. The meetings are chaired by the INFORM Project Director and attended by most of the local transportation and emergency service agencies within the corridor.

2. DATA COLLECTION AND EVALUATION METHODOLOGY

OVERVIEW OF THE EVALUATION

An extensive plan was developed in 1980 for the evaluation of INFORM. This plan was documented in the FHWA report "IMIS Evaluation Plan: Technical Report," dated April, 1980. The foundation of the original evaluation was a set of measures of effectiveness (MOE's) to be used in evaluating the extent to which the goals and objectives of INFORM were achieved. Table 2 indicates the interrelationship between the original goals and objectives of INFORM. While the evaluation methodology used in the actual evaluation was modified from the original methodology, the goals and objectives have, for the most part, remained intact.

The most significant departure of the actual evaluation from the original evaluation plan was the collection of data in time-series fashion as opposed to the single 5-week before and single 5-week after periods in the original plan. This was made necessary due to the extended time period over which INFORM was implemented and the many factors (other than INFORM) potentially influencing traffic flow during that time. Each sample in the time series represents an approximate 2-week period. There were seven samples within the time series, with the most concentrated sampling taking place in spring 1990 after the full implementation of ramp metering. Two of the samples were actually conducted in one 3-week period using a strategy of alternating days of active and inactive ramp metering. The sampling periods and the conditions they represent are as follows:

- March 23 to April 3, 1987 - This represented 2 weeks out of 5 weeks of actual data collection conducted between March 15 and April 24, 1987. It involved the collection of system data (volume, occupancy and speed), moving car travel time data, incident data, ramp delay data, and related traffic performance data. This 5-week period was to represent the period before the active use of the VMS's and ramp metering capabilities of INFORM, but with the surveillance system available to record traffic performance data.

- November 28 to December 12, 1988 - This period represented a time prior to any ramp metering activity and with signs being operated primarily in the manual mode.

- September 9 to 29, 1989 - This period represented partial metering implementation (approximately 20 ramps) and automated control of the signs. All periods after this point included automated sign control.

- March 3 to 27, 1990 - During this period, both metering and non-metering strategies were employed. Metering was conducted in the time-of-day mode. Metering was conducted in the a.m. peak period westbound on alternate days.

  On the off days for a.m. metering, p.m. metering was conducted in the eastbound direction. Thus, each day included either a.m. westbound or p.m. eastbound metering, but not both. This strategy provided a direct comparison between metering and non-metering operation over the same time period. One of the reasons for adopting this strategy was to attempt to eliminate, to the extent possible, the effect of seasonality and season-related volume changes.

Table 2. System goals and objectives.

GOALS	OBJECTIVES
1. Improved throughput	1. Increase corridor throughput during peak periods 2. Increase person travel
2. Decreased and more predictable travel time	1. Decrease average travel time 2. Reduce variability of average travel time
3. Rapid detection and removal of capacity reducing incidents	1. Reduce incident detection time 2. Reduce incident response time 3. Reduce incident clearance time
4. Timely assistance to stranded motorists	1. Reduce time between breakdown or stop and contact with authorities 2. Decrease response time to provide assistance
5. Reduction in accidents and incidents	1. Reduce number of accidents 2. Reduce number of secondary accidents 3. Reduce severity of accidents
6. Reduced air pollution	1. Reduce undesirable vehicle emissions 2. Reduce corridor CO hot spots
7. Reduced energy consumption	1. Reduce fuel usage
8. Reduced vehicle operating costs	1. Reduce average vehicle operating cost
9. Improved trip information	1. Increase number of motorists given advisory information 2. Reduce number of lost motorists 3. Increase accuracy and timeliness of advisory information
10. Improved comfort and security of motorists	1. Improve comfort and convenience of system 2. Improve security within the system
11. Improved management of highway facilities	1. Increase effectiveness of highway system
12. Increased knowledge and experience with IMIS projects	1. Assess total system and subsystems

- April 24 to May 11, 1990 - This period included metering in the traffic responsive mode.

- June 14 to June 29, 1990 - This period included metering in the traffic responsive mode with software modifications to better manage queue formation at the metered ramps.

Both the April/May and June periods were influenced by construction activities that were not present in other periods. This included service road reconstruction in Suffolk County (with barriers located at the edge of the right lane), reconstruction of the LIE/Sagtikos Parkway interchange, and bridge center pier reconstruction at two bridges over the LIE near the Queens/Nassau County border (in which lanes were narrowed to approximately 10 ft (3.05 m) to accommodate construction in the median). With the exception of spring 1987, all periods were influenced (approximately equally) by the major reconstruction of the Meadowbrook Parkway/Northern State Parkway interchange.

It is important to note that the comparison between the March 1990 metering and non-metering cases may not truly reflect the comparison of conditions with and without metering in the same way as a pure before and after study. One of the observations of INFORM personnel (also evidenced through the surveys of motorists) is that drivers may make wholesale changes to their commuting patterns based on the presence of ramp metering. Since metering had already been operating on some ramps for at least 6 months prior to March 1990, some drivers may have already adjusted their travel patterns in response to the metering. Turning the metering off on alternate days would not likely have induced those drivers to return to their premetering commuting pattern. Thus, the March metering/nonmetering comparison would reflect only the traffic restraint effects of metering, not the long-term diversion effects. The total effect of metering would have to be determined from a comparison with data collected prior to any implementation of metering (such as the 1987 data).

One of the difficulties of conducting a time-series type evaluation is determining which time segments to compare. In the evaluation of time periods for INFORM, it was determined that two comparisons would be of most value: March 1990 metering versus March 1990 nonmetering and March 1990 metering versus spring 1987. The comparison of the two March 1990 data sets should reflect the traffic restraint impacts of metering. Review of the data and impact of construction activities for the April/May 1990 and June 1990 data sets indicated that they would not make good comparisons to other nonmetering data sets. The comparison of March 1990 metering with spring 1987 reflects more of the long-term change. These changes could have been brought about by a number of factors, including change and redistribution of volume, possible change in commuting patterns due to metering, and motorist response to VMS information.

One of the major strategies in the original evaluation plan was a separate evaluation of non-incident conditions and incident conditions. This was necessary both to isolate the effects of INFORM and to associate, to the extent possible, the effectiveness of the individual INFORM components under both conditions. A third condition, termed "average condition" was defined as a combination of incident and nonincident conditions.

The frequency and duration of traffic incidents varies dramatically from day to day and month to month. Incident occurrences and their impact on traffic is often completely unrelated to the traffic control system. Twice as many traffic-impacting incidents could occur in 1 month as in the previous month (or as in the same month in the previous year), and their occurrence could completely skew the apparent results of the evaluation. If INFORM produced significant improvements in traffic flow but the after period included significantly more incidents, then the actual effect of INFORM could be masked or negated, if the effect of those incidents was not screened out. This is why the screening of incident-related data from the data set is important for producing a fair evaluation.

The actual evaluation did not assemble the incident and non-incident conditions into an average condition. After observing the patterns of incident occurrence, it was concluded that the randomness in incident frequency and severity could cause one of the 2-week evaluation periods to be adversely affected without any relationship to the effect of INFORM. For example, the occurrence of two or three major incidents (by chance) within one 2-week period, could cause average traffic performance within that period to be seriously deteriorated in comparison with other periods that had little incident activity. These incidents could have just as easily occurred in one time period as another. The approach taken in the evaluation was therefore to first make a basic comparison of nonincident conditions and then add the incremental benefits of the incident-related strategies. The evaluation of metering was conducted only for nonincident conditions. The evaluation of the signing system was conducted for both incident and nonincident conditions, with emphasis on incident conditions.

DATA COLLECTION

Several types of data were collected for the evaluation:

- System-generated traffic performance data for the freeway. This included traffic volume, occupancy and speed at each mainline detector station and volume and occupancy at each on-ramp and off-ramp. A large percentage of the detector stations were operating during all the evaluation periods.

- System-generated traffic performance data for the arterials. A small percentage of arterial detectors were providing reliable data during the evaluation periods. In addition, few detector stations were located on the LIE service roads, even though this was the primary alternate route for mainline LIE traffic. Detectorization of the service roads was one of the INFORM program areas that was significantly cut back in the early phases of the project to control costs.

- System performance data. This represents operational data on components of INFORM, such as sign and detector failures. It also includes data on system-related decisions, such as changes in VMS sign messages, decisions to shut off metering and records of ramp metering rates.

- Manual data maintained by INFORM operators. This primarily includes incident-related information such as detection time, source, location and duration.

- Field data collected by evaluation contractor staff. This includes:
    - Moving car travel time runs (collected for the spring 1987 and April/May, 1990 periods only).
    - Ramp delay counts (collected for the spring 1987 and April/May 1990 periods only).
    - Vehicle occupancy counts (collected for the spring 1987 only).

- 15-minute automatic machine volume counts at selected nonfreeway locations (collected for four of the seven periods).
- Supplemental incident data collected by the Long Island police agencies (collected in spring 1987 only).
- Travel time logging by regular commuters within the corridor.

• A survey of travel habits and opinions related to INFORM. The primary survey was conducted in June 1990, and an earlier survey was available from fall 1988, conducted for public relations purposes.

System-Generated Data

Detector Data Processing

The data gathered from the INFORM detectors comprised the largest body of information available to the evaluation. Over 500 detector stations continuously monitor traffic and transmit that information to the central computer in Hauppauge. The freeway detector stations are spaced at approximately half-mi (0.8 km) intervals. All mainline stations consist of a single 6- by 6- ft (1.97- by 1.97 m) inductive loop detector in each lane. Paired "speed trap" detectors are located approximately every 3 mi (4.8 km).

Three weekday time periods were established for collection and analysis of the data:

- 6:00 to 9:30 a.m. (a.m. peak period).
- 9:30 a.m. to 3:30 p.m. (mid-day period).
- 3:30 to 7:00 p.m. (p.m. peak period).

Data was collected on magnetic tape in 15-minute increments for both the freeway and arterial system. Each 13-hour data collection period required nearly 100 percent of a 2400 ft (732 m) 1600 bpi 9-track tape for recording the freeway data. The arterial data required approximately one fourth to one third the storage. Data was collected on one weekend per 2-week data collection period. Some of the 2-week data collection periods were longer, due to days during which data could not be recorded (e.g., holidays, bad weather days, or days on which software work or system maintenance was necessary).

Each record of freeway data contained the following information: zone number, date, time, source of mainline data (actual, reconstructed or historic data), mainline volume, mainline occupancy, mainline speed, source of ramp data, ramp volume, and ramp occupancy. This resulted in well over 2 million 15-minute data records for the freeway data alone. Zone correspondence tables and section lengths were obtained from the INFORM data base for accumulating data by INFORM subsections.

Volume and occupancy data from INFORM are produced directly. Speed is a derived value at single detector stations, based on an average vehicle length. Average vehicle lengths are computed at the paired detector stations and the values used for calculation of speed at nearby single detector stations. If one or two detectors are failed in a three-lane detector configuration, the data is reconstructed based on the available data at the one or two remaining functional detectors. If the entire station is failed, the system reverts to historic data. No historic data was used in the evaluation. Reconstructed data was used, but comprised a small percentage of the data collected.

Several steps were involved in the analysis of the system-generated data. Adjustments were needed in the volume and speed data to better represent actual conditions. These adjustments were based on earlier research conducted on INFORM and documented in the FHWA report entitled *Reliability of System Detector Data in Replicating Field Conditions for the Integrated Motorist Information System* (FHWA-RD-88-92, August 1988). The research conducted as part of this report tested a variety of methods for improving the detector-based estimates of volume and speed. As a result, relationships were selected for the processing of raw detector data to develop the best possible estimates of volume and speed. The factored volume was derived by multiplying the raw volume by the constant 1.007. The factored 15-minute speed for each detector station was derived using a regression equation involving the raw speed, lane occupancy and volume/capacity ratio. Separate equations were used for the LIE and the NSP/GCP.

Further processing of the data indicated that the speed relationship was generally appropriate for detector speeds over 30 mi/h (48.3 km/h). For detector speeds of less than 30 mi/h (48.3 km/h) the relationship tended to underestimate speeds and occasionally produce negative speeds when the raw speeds were very low. The relationship had been calibrated based primarily on speeds over 30 mi/h (48.3 km/h). As a result, it was determined that a two-fold relationship should be developed. At detector speeds over 30 mi/h (48.3 km/h), the above relationship was used to adjust the raw data. At speeds less than or equal to 30 mi/h (48.3 km/h), the actual detector speeds were used. Comparisons of detector speed with travel time data indicate that this formulation produces reasonable speeds for evaluation purposes. Each data set in the time series was treated identically, so that even if there is systematic error in the absolute volumes and speeds, the relative differences would be highly reliable. Comparisons of speeds against the travel time runs indicates that the factored system-generated speeds are good estimates of actual speeds. The volume factoring resulted in relatively small changes in volume.

To deal with failed detector stations, the data for the nearest functional detector station was used as replacement data for any stations that were failed. As an additional precaution against spurious data, the allowable speed was capped at 70 mi/h (112.7 km/h).

Estimates of fuel consumption and emissions were also generated as part of the evaluation. The relationships used in making these estimates were based on research conducted in 1988 by Lindley, documented in the report *Development of Fuel Consumption and Vehicle Emissions Relationships for Congested Freeway Flow Conditions.*

<u>**Incident Screening**</u>

The screening of incidents represented the most important element of the data editing process. A record of incident occurrences was maintained by INFORM operations staff. For the spring 1987 data set, this record was maintained by staff of the evaluation contractor, with supplemental information drawn from police incident reports and incident records from a major radio traffic reporting service.

Each day and time period was defined as either an incident or nonincident time period. Incident time periods were used only for incident-related evaluations; they were completely excluded from the summary statistics of vehicle miles, vehicle hours, average speeds and related MOE's. Some consideration had been given to excluding only those regions of INFORM that were in the immediate vicinity of the incident and accepting the data outside that region as nonincident data. Unfortunately, the effect of incidents is quite pervasive. Incidents have the effect not only of deteriorating upstream traffic flow but improving downstream traffic flow. Eliminating only the region immediately surrounding the incident could actually create a better impression of operations than if the incident had not occurred. In a system the size of INFORM, it is unusual for any peak period to be completely incident-free. To eliminate all peak periods with any type of incident would have reduced the nonincident data set to near zero. Thus, the occurrence of minor incidents (either those of very short duration or those having only a small capacity-reducing effect) did not permit a time period to be qualified as an incident time period.

In general, a minor incident included any incident of less than one-half hour duration and blocking one lane or less. Rainy time periods were also defined as incident time periods and were not included in the nonincident summaries. As an additional check against incident bias within the sample, individual days of processed data were screened for the presence of incidents. This process occasionally identified incidents that had been overlooked in the manual incident identification process and sometimes even revealed that the incident was minor enough for the data to be accepted as nonincident data. Typically, the elimination of incident time periods reduced the number of valid nonincident samples from the original 10 weekdays to 6 or 7 days (i.e., 3 to 4 days had to be eliminated due to incidents).

There were four primary outputs from the analysis of system-generated performance data:

- Contours and profiles of average volume for each 2-week time period by time of day and zone.
- Contours and profiles of average speed for each 2-week time period by time of day and zone.
- Contours and profiles of average occupancy for each 2-week time period by time of day and zone.
- Standard deviations for each 15-minute time period and zone.
- Summary MOE's for each 2-week time period. These MOE's were averaged across days and included vehicle miles of travel (VMT), vehicle hours of travel (VHT), average speed computed as the ratio of VMT to VHT, gallons of fuel consumed, grams of emissions (carbon monoxide, hydrocarbons, and oxides of nitrogen).

Figure 6 shows a sample computer output of a contour and profile of speed data for one 2-week sample (April/May 1990). The upper half shows the average speeds; the lower half shows the corresponding standard deviations. The area and time period represented are indicated at the upper left of the diagram. Five subsections were used as the basis for developing subregional summaries of the data: Queens, Western Nassau County, Eastern Nassau County, Western Suffolk County and Eastern Suffolk County. The horizontal axis shows the zones by facility and direction within the defined geographic area (e.g., LIE eastbound, western Nassau County). The vertical axis defines the time period examined. For each zone, a peak period summary is provided, showing average volume, speed or occupancy and sample size.

0MAIN LINE SPEED CONTOUR NON-INCIDENT
LIE WB NASSAU WEST
1990 APRIL/MAY AM PEAK (0600-0915)

BEGIN TIME	ZONE NUMBER 187	188	189	190	191	193	194	195	196	197	198	199	200	201	202	203	204	205	207	208	209	210	211
600	70	53	70	70	55	64	47	63	58	66	68	63	65	69	65	62	68	50	49	51	49	51	46
615	70	50	70	70	51	57	41	56	53	59	61	53	54	55	47	50	56	42	41	41	40	40	38
630	69	48	70	69	39	38	29	38	38	41	41	34	35	38	35	48	57	43	42	42	42	42	38
645	62	40	64	57	31	27	22	34	35	40	39	32	35	35	33	45	52	38	37	34	37	37	34
700	59	41	62	53	30	30	22	40	40	46	46	38	37	34	34	47	53	35	35	32	37	38	35
715	67	51	70	68	36	35	24	41	42	42	43	35	35	31	32	49	54	35	33	32	33	33	32
730	70	55	70	61	36	35	22	39	40	39	43	37	40	35	35	51	56	36	35	32	32	32	30
745	64	48	64	52	31	27	18	36	39	38	38	33	33	32	32	50	52	35	34	32	34	35	33
800	63	44	59	51	27	21	13	35	35	34	36	31	32	33	32	48	54	36	34	31	32	32	30
815	67	49	63	55	32	27	17	38	39	34	37	33	31	31	32	47	56	38	35	32	33	30	29
830	67	49	67	59	41	41	27	43	40	35	37	32	29	31	31	46	55	39	38	34	32	31	29
845	67	49	68	61	39	36	23	43	43	41	40	34	28	30	30	48	56	39	40	38	37	37	34
900	65	48	66	60	36	32	20	43	45	39	38	34	31	30	31	46	55	40	43	44	41	42	42
915	69	48	70	60	37	37	26	45	44	40	40	36	35	36	35	43	52	38	41	45	45	46	43
AVG.SPD	66	48	66	60	37	36	25	42	42	42	43	37	37	37	36	48	55	38	38	37	37	37	35
STD. DEV.	3.4	4.1	3.7	6.6	7.8	11.7	9.1	8.0	6.4	9.2	9.5	9.1	10.2	11.1	9.3	4.4	4.0	4.1	4.5	6.4	5.3	6.1	5.5
ROW AVG.	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
TOT. OBS.	110	110	110	110	110	110	110	110	109	110	110	110	109	109	109	109	108	108	109	109	84	84	84

STANDARD DEVIATION WITHIN EACH CELL

BEGIN TIME	ZONE NUMBER 187	188	189	190	191	193	194	195	196	197	198	199	200	201	202	203	204	205	207	208	209	210	211
600	0.0	2.2	0.0	0.0	1.5	3.2	2.5	3.6	3.2	3.8	2.3	3.0	2.9	0.4	3.4	3.1	1.5	2.3	1.0	2.0	3.2	6.1	10.5
615	0.0	2.2	0.0	0.0	1.7	2.8	2.8	3.0	2.2	2.7	3.2	1.7	3.1	6.8	5.1	4.9	6.3	4.2	4.7	6.8	9.4	11.5	10.7
630	1.1	2.9	0.0	1.1	6.4	6.2	3.6	4.0	4.4	3.5	5.0	4.8	4.6	12.9	7.7	3.2	4.5	2.1	2.8	2.9	5.8	6.2	6.9
645	12.6	9.8	11.3	14.7	9.1	5.7	2.9	3.9	5.0	6.5	7.3	7.4	10.3	13.9	10.3	8.3	13.3	9.8	9.3	8.3	11.6	12.3	11.6
700	15.7	12.4	12.7	12.6	5.5	9.9	6.9	7.0	7.8	9.4	11.0	11.3	9.8	9.6	6.5	8.8	13.1	10.3	10.4	10.0	12.3	13.4	11.7
715	5.6	6.5	0.0	3.5	8.9	14.3	11.3	10.5	10.9	14.4	15.1	13.6	9.0	5.8	4.4	7.7	13.3	11.1	11.5	12.2	13.6	14.4	12.9
730	0.0	1.4	0.0	11.6	13.8	17.4	11.3	7.4	8.9	13.1	12.6	12.9	12.6	14.7	11.0	9.4	14.2	13.6	13.1	15.2	15.2	16.4	14.2
745	10.6	11.3	10.1	18.3	12.3	9.4	6.6	3.4	5.5	6.9	6.3	5.3	9.4	5.5	2.9	6.3	15.7	14.3	14.4	15.8	18.3	18.9	17.0
800	12.8	13.9	17.8	20.0	9.4	4.9	3.0	3.3	5.6	9.3	9.8	9.6	12.3	9.4	3.8	5.1	12.7	12.2	13.6	16.5	18.0	17.5	16.1
815	6.4	9.0	12.4	20.8	13.7	11.8	6.1	5.8	6.5	8.4	6.0	3.4	4.2	1.8	2.1	8.2	12.6	11.7	13.0	15.8	17.2	17.0	15.6
830	6.3	9.1	6.0	17.5	15.1	20.0	14.7	10.4	8.3	4.5	3.8	3.0	3.5	2.4	2.0	8.7	13.1	13.0	12.7	14.4	16.6	16.4	15.0
845	5.2	7.9	4.6	16.7	14.8	16.6	11.5	6.9	9.1	10.7	7.7	2.5	3.8	2.1	1.2	7.3	11.7	11.7	12.5	14.1	16.6	16.6	14.4
900	12.0	9.8	11.3	17.0	12.3	16.5	10.0	6.8	7.4	11.1	7.8	4.6	4.9	3.5	1.8	5.3	11.8	10.6	5.6	8.9	12.3	12.2	7.0
915	0.4	3.2	0.0	15.7	14.0	19.4	13.1	10.5	7.8	12.4	9.8	7.9	11.2	13.4	8.5	9.5	10.7	10.1	5.8	3.3	2.3	2.8	2.7

1 mi/h = 1.61 km/h

Figure 6. Sample speed contour and profile with standard deviations April/May 1990.

System Performance Data

A number of reports produced by INFORM are useful for tracking system decisions. These reports were used to tabulate the performance of INFORM and to correlate traffic performance with system responses. Some of the commonly used reports include:

- VMS report (sample shown in figure 7). The VMS report provides a record of each change in message displayed by a sign and the time of that change. The report was primarily used for reconstructing incidents and is continuously generated as new sign messages are displayed.

- Hourly volume report (figure 8). This report was used to track changes in mainline and ramp volume in response to incidents and changes in sign message displays.

- Ramp metering report (figure 9). This report documents ramp metering status throughout the course of a metering period. It records ramp metering rate for time-of-day metering, times that ramp metering was turned on and off for individual ramps, and lane occupancy at the queue detector that prompted the turn-on or turn-off.

Failures of various system components were reported in the monthly progress reports of the operations contractor. Failure summaries for signs, remote communications units (RCU's), detectors and CB radios were produced from the monthly reports.

Incident Data

Incident data are collected and tabulated on an ongoing basis by INFORM operations staff. A standard form is used to manually tabulate the basic information on the incident, based on a review of traffic data on the system map, monitoring of the police radio scanner, monitoring of CB radio, communications with radio traffic reporters and communications with individual police agencies, as necessary. The basic information includes incident occurrence time, location, type, nature of blockage, detection source, and clear time. The incident data were used both as an overall tabulation of frequency and for reference when reconstructing selected incidents. The incident summaries reflect any incidents that had a noticeable impact on traffic, as determined by the INFORM operator. Normally, the congestion from these incidents covered at least two detector stations and produced different congestion patterns from recurring congestion. Shoulder incidents that were deemed to have had an impact on traffic were included. Disabled vehicles on the shoulder were not included in the incident report, and reported shoulder incidents were virtually always accidents.

Undoubtedly, traffic-impacting incidents occurred that were not actually recorded by the INFORM operators. However, these were generally incidents of lesser severity and duration and would typically not have affected any of the data analysis. Peak periods with steady rainfall were excluded from the nonincident data.

```
17:44 SIGN VMS066 MESSAGE 01-14-00 DISPLAYED, REQUESTED BY COMPUTER
 -          $120B
 -                DELAYS
            ON 495 EAST
 -
 -          $A2B   ON GCP EAST
17:45 SIGN VMS009 MESSAGE 01-12-30 DISPLAYED, REQUESTED BY COMPUTER
            $0000
 -                DELAYS
 -           EXITS 54 - 56
 -
17:46 SIGN VMS052 MESSAGE IMMEDIATE DISPLAYED, REQUESTED BY CENTRAL-MID
 -          $0000
 -                DELAYS
 -                AHEAD
             EXITS 30 TO 32
17:46 SIGN VMS051 MESSAGE IMMEDIATE DISPLAYED, REQUESTED BY CENTRAL-MID
 -          $0000
 -                DELAYS
 -                AHEAD
 -           EXITS 30 TO 32
17:46 SIGN VMS049 MESSAGE IMMEDIATE DISPLAYED, REQUESTED BY CENTRAL-MID
 -          $0000

 -
 -
17:46 SIGN VMS049 MESSAGE IMMEDIATE DISPLAYED, REQUESTED BY CENTRAL-MID
 -          $0000
 -                DELAYS
 -                  TO
 -               EXIT 32
17:47 SIGN VMS009 MESSAGE 01-04-26-DISPLAYED, REQUESTED BY COMPUTER
 -          $0000
 -                DELAYS
 -           EXITS 49 - 50
17:50 SIGN VMS071 MESSAGE 15-00-00 DISPLAYED, REQUESTED BY COMPUTER
 -          $0000
 -
17:51 SIGN VMS007 MESSAGE 15-00-00 DISPLAYED, REQUESTED BY COMPUTER
 -          $0000
 -
17:51 SIGN VMS020 MESSAGE 15-00-00 DISPLAYED, REQUESTED BY COMPUTER
 -          $0000
 -
 -
17:51 SIGN VMS010 MESSAGE 15-00-00 DISPLAYED, REQUESTED BY COMPUTER
 -          $0000
 -

 -
 -
17:51 SIGN VMS008 MESSAGE 15-00-00 DISPLAYED, REQUESTED BY COMPUTER
            $0000
 -
```

Figure 7. Sample variable message sign activity report.

TIME 1800

HOURLY VOLUME REPORT
MONDAY 1700-1800
NSP EB SUFFOLK

DATE 6/19/89

RAMP NAME	RAMP TYPE	RAMP VOLUMES 0-15	15-30	30-45	45-60	HOUR	EXIT FRACTIONS 0-15	15-30	30-45	45-60	HOUR
ROUND SWAMP	EXIT	38	55	43	65	201	0.040	0.055	0.065	0.066	0.057
ROUND SWAMP	ENT.	65	45	41	29	184					
RTE 110 SB	EXIT	20	16	21	16	73	0.022	0.017	0.026	0.018	0.021
RTE 110 SB	ENT.	72	49	40	33	194					
RTE 110 NB	EXIT	107	103	103	101	414	0.114	0.104	0.120	0.105	0.112
RTE 110 NB	ENT.	197	105	130	133	565					
WOLF HILL RD	EXIT	83	83	91	72	315	0.100	0.095	0.082	0.075	0.08[illegible]
WOLF HILL RD	ENT.	121	93	75	74	364					
DEER PARK SB	EXIT	22	24	27	18	91	0.021	0.023	0.025	0.021	0.023
DEER PARK NB	EXIT	159	144	197	142	642	0.151	0.145	0.195	0.173	0.171
DEER PARK RD	ENT.	147	191	150	114	502					
COMMACK RD	EXIT	65	65	73	60	264	0.065	0.063	0.073	0.077	0.071
COMMACK RD	ENT.	91	83	50	74	295					
SAGTIKOS SB	EXIT	230	257	214	131	882	0.250	0.246	0.212	0.189	0.225
SAGTIKOS SB	ENT.	11	11	10	10	42					
SAGTIKOS N	EXIT	328	365	251	244	1199	0.542	0.515	0.474	0.450	0.553
SAGTIKOS N	ENT.	108	107	111	142	469					
VETERANS HWY	ENT.	1495	161	134	159	703M					

MAINLINE VOLUMES 0-15	15-30	30-45	45-60	HOUR
906	943	623	915	3393
970	938	655	533	3577
943	954	691	922	3550
755	879	334	521	2491
903	926	784	951	3504
845	837	752	825	3311
1355	971	[illegible]	947	3872
1059	934	945	943	3951
1091	1002	970	928	3981
745	735	901	941	3280
[illegible]	950	[illegible]	921	3949
946	932	996	854	3770
908	895	1035	867	3706
946	912	1080	858	3806
1009	1034	1034	838	3894
842	902	1000	744	3490
862	852	930	756	3432
859	875	930	727	3501
977	1046	1007	786	3816
1002	1016	917	592	3129
903	973	933	736	3525
750	819	797	645	3015
447	493	532	407	1879
340M	492	505	466	1795M
304M	498	522	474	1785M
316M	478	511	467	1772M
338M	474	510	459	1781M

Figure 8. Sample hourly volume report.

RAMP METERING ACTIVITY REPORT PAGE 2
RMA06251.RPT

DATE 6/25/90 TIME 0928

DATE	TIME	RAMP NUMBER	RAMP LOCATION	MODE	ACTIVITY DESCRIPTION
6/25	0751	61	NEW HYDE PK	A	METER ON. RATE 0 VOL 559
6/25	0755	59	WILLIS AVE	A	RAMP SAVED 0 VOL 595
6/25	0756	55	RTE 110 SB	A	Q ON. OCC 20 VOL 431
6/25	0759	58	ROSLYN RD	A	RAMP SAVED 0 VOL 581
6/25	0800	24	RT 111	A	METER OFF. OCC 8 VOL 464
6/25	0800	25	VANDERBILT	A	METER OFF. OCC 2 VOL 339
6/25	0800	26	COMMACK RD	A	RAMP SAVED 0 VOL 679
6/25	0800	30	ROUND SWAMP	T	METER OFF. OCC 2 VOL 185
6/25	0800	31	SUNNYSIDE	A	METER ON. RATE 0 VOL 70
6/25	0805	26	COMMACK RD	A	RAMP SAVED 0 VOL 633
6/25	0807	55	RTE 110 SB	A	METER ON. RATE 0 VOL 542
6/25	0809	26	COMMACK RD	A	Q ON. OCC 24 VOL 605
6/25	0810	58	ROSLYN RD	A	Q ON. OCC 22 VOL 563
6/25	0811	59	WILLIS AVE	A	Q ON. OCC 26 VOL 499
6/25	0814	55	RTE 110 SB	A	RAMP SAVED 0 VOL 644
6/25	0815	26	COMMACK RD	A	METER ON. RATE 0 VOL 700
6/25	0816	59	WILLIS AVE	A	METER ON. RATE 0 VOL 538
6/25	0819	59	WILLIS AVE	A	RAMP SAVED 0 VOL 477
6/25	0820	58	ROSLYN RD	A	METER ON. RATE 0 VOL 784
6/25	0822	44	UTOPIA PKWY	A	RAMP SAVED 0 VOL 563
6/25	0827	55	RTE 110 SB	A	RAMP SAVED 0 VOL 606
6/25	0828	58	ROSLYN RD	A	RAMP SAVED 0 VOL 687
6/25	0830	58	ROSLYN RD	A	RAMP SAVED 0 VOL 686
6/25	0834	55	RTE 110 SB	A	RAMP SAVED 0 VOL 575
6/25	0837	59	WILLIS AVE	A	RAMP SAVED 0 VOL 625
6/25	0840	58	ROSLYN RD	A	RAMP SAVED 0 VOL 754
6/25	0843	34	GLEN COVE RD	A	RAMP SAVED 0 VOL 526
6/25	0846	34	GLEN COVE RD	A	RAMP SAVED 0 VOL 473
6/25	0847	59	WILLIS AVE	A	RAMP SAVED 0 VOL 577
6/25	0849	58	ROSLYN RD	A	RAMP SAVED 0 VOL 782
6/25	0852	58	ROSLYN RD	A	RAMP SAVED 0 VOL 716
6/25	0855	58	ROSLYN RD	A	RAMP SAVED 0 VOL 684
6/25	0900	26	COMMACK RD	A	METER OFF. OCC 8 VOL 584
6/25	0900	31	SUNNYSIDE	A	METER OFF. OCC 2 VOL 128
6/25	0900	34	GLEN COVE RD	A	METER OFF. OCC 10 VOL 410
6/25	0900	36	SEARINGTOWN	A	METER OFF. OCC 9 VOL 295
6/25	0900	37	SHELTER ROCK	A	METER OFF. OCC 3 VOL 123
6/25	0900	38	NEW HYDE PK	A	METER OFF. OCC 5 VOL 270
6/25	0900	39	COMMUNITY DR	A	METER OFF. OCC 9 VOL 330
6/25	0900	40	LAKEVILLE	A	METER OFF. OCC 4 VOL 315
6/25	0900	41	L. NECK PKWY	A	METER OFF. OCC 3 VOL 447
6/25	0900	44	UTOPIA PKWY	A	METER OFF. OCC 5 VOL 494
6/25	0900	46	MAIN ST	A	METER OFF. OCC 3 VOL 299
6/25	0900	55	RTE 110 SB	A	METER OFF. OCC 3 VOL 381
6/25	0900	58	ROSLYN RD	A	METER OFF. OCC 16 VOL 800
6/25	0900	59	WILLIS AVE	A	METER OFF. OCC 10 VOL 588
6/25	0900	61	NEW HYDE PK	A	METER OFF. OCC 3 VOL 317
6/25	0900	62	LAKEVILLE SB	A	METER OFF. OCC 2 VOL 221
6/25	0900	63	L. NECK PKWY	A	METER OFF. OCC 6 VOL 557
6/25	0901	59	WILLIS AVE	A	METER ON. RATE 0 VOL 561
6/25	0902	59	WILLIS AVE	A	METER OFF. OCC 7 VOL 496
6/25	0907	58	ROSLYN RD	A	METER ON. RATE 0 VOL 670
6/25	0908	58	ROSLYN RD	A	METER OFF. OCC 7 VOL 743
6/25	0909	58	ROSLYN RD	A	METER ON. RATE 0 VOL 767
6/25	0910	58	ROSLYN RD	A	METER OFF. OCC 6 VOL 620

Figure 9. Sample ramp metering activity report.

Field Data

An extensive amount of field data were collected for the evaluation. As indicated earlier, the original evaluation plan entailed two intensive 5-week evaluation periods, both of which involved extensive field data collection. The modified evaluation plan placed more reliance on system-generated data, as sufficient research had been conducted by that time to place confidence in that data to produce valid measures of freeway performance. Thus, in the modified plan, the field data were used as supplemental data and to fill gaps in the system data. A description of the field data collection methodology is presented below.

Moving Car Runs

Moving car runs were conducted for a 5-week period in spring 1987 for the LIE, LIE service roads in Queens and Nassau Counties, the NSP/GCP, and selected arterial roadways on the INFORM network. Additional moving car runs were conducted on the LIE service roads only in April/May 1990, to provide improved traffic performance information on the service roads. In the spring 1987 data collection, 12 moving car routes were developed to cover over 200 1-way mi (322 1-way km) of roadway. In the April/May 1990 period only two routes were needed to cover the designated lengths of service roads. These routes were identical to the service road routes covered in the 1987 data collection.

Runs were conducted for both the a.m. and p.m. peak periods. Each route was timed to take approximately 30 minutes for the round trip. Under poor traffic conditions, the runs could take longer. Under very good traffic conditions, the trip could take less than 30 minutes. Allowing a brief rest and reorientation each run, most drivers could make at least four round trips each peak period. An automated system was established for the collection of the travel time data. This consisted of a Canon HT 5000 hand-held microcomputer and transmission sensor. The transmission sensor generated pulses which were fed into the computer via a bar-code reader. The pulses were translated to distance through the software in the hand-held unit, based on a distance calibration of the unit for each individual moving car. The data generated by the unit consisted of the distance travelled each second, with identifiers for user-specified checkpoints. Checkpoints were established as the exit signs within the gore area of each exit ramp. These were easily identifiable by the moving car drivers. A backup system, consisting of reading times and checkpoints into a tape recorder, was employed in the event the automated system failed.

Following the completion of the runs for each peak period, the data stored in the hand-held unit was downloaded to an IBM-compatible microcomputer in the office. This information was checked for completeness and set aside for later processing. The processing of the data involved the assembly of the second-by-second data into the sections between each exit ramp. Further summarization was conducted to aggregate the travel time data into lengths of 6 to 10 mi (9.7 to 16.1 km). The primary MOE developed from the travel time data was average speed.

Additional travel time runs were available from a limited before and after study of ramp metering conducted by the INFORM operations contractor in the p.m. peak period at the eastern end of the corridor. The results of these runs will be reported separately.

Travel Time Logging by Regular Commuters

Travel time information was collected by commuters within the INFORM corridor in both spring 1987 and spring 1990. Two weeks of supplemental data were collected in November 1990. The commuters were recruited through fliers at park-and-ride lots in the eastern end of the corridors. The primary requirements for participation included at least two persons in the vehicle (one to drive and one to record), and a consistent peak period commuting pattern with substantial length of the trip on the LIE and/or NSP. Participants were paid a nominal fee for each trip ($2.00 each way). The drivers were recruited with the intent to continue each weekday for approximately 3 months. While only a handful of drivers continued with the program for the entire 3 months, the results provide some interesting additional information on the performance of INFORM. Particularly interesting is the comparison of this travel time data with messages being displayed by the VMS's. Sign messages seen by the commuters were recorded in the spring 1990 and November 1990 periods, concurrently with the travel time data. This enabled a direct comparison of sign information with actual congestion experienced by the driver.

Ramp Delay Counts

Ramp delay counts were conducted at metered entrance ramps in the April/May 1990 period. While delay counts were not conducted for the other metering periods, observation of metering operations suggests that the ramp delays experienced in the March and June 1990 periods were similar to those experienced in the April/May period. Ramp delay counts were conducted by recording the number of vehicles waiting in queue at the ramp meter at 30-second intervals. These counts were conducted for 10 minutes at pre-scheduled times at each ramp, after which the observer would move to a new ramp and count for another 10 minutes and to a third ramp for a third 10-minute count. A second count would be conducted at the original ramp after the count at the third ramp was completed. Two full cycles at three different ramps were typically conducted each two-hour peak metering period by a single observer. Counts at each set of ramps were typically repeated every third day. Vehicle hours of delay at metered ramps could be computed from the average queue length multiplied by the period of time metering was in effect.

Ramp delay counts were also conducted in spring 1987, but without metering in operation. Observers used the same approach for recording the number of queued vehicles each 30 seconds. However, queuing was measured from the merge point of the ramp and mainline edgelines, since no metering position and stop bar location had been established. Actually, very little ramp queuing was documented in 1987. Most ramp drivers were able to merge into congested mainline traffic.

Vehicle Occupancy Counts

Vehicle occupancy counts were conducted in spring 1987 at three mainline locations. This information served as basic background information for conversion of VMT and VHT to person miles and person hours of travel, where desired. INFORM was not expected to influence vehicle occupancy in the corridor, as no incentives for high occupancy vehicles are provided in the INFORM corridors.

Automatic Machine Counts

Automatic machine counts were used to supplement the system-generated volume counts at up to 10 locations. Six of these locations were on the LIE service roads and four were on other arterials. The counts were conducted for spring 1987, fall 1989 and April/May 1990.

Motorist Surveys

A home-based survey was conducted of travel habits and opinions related to INFORM. The survey was carried out in conjunction with the opinion survey conducted by the INFORM public relations consultant. The public relations consultant conducted an initial survey in fall 1988 to gauge the perceptions of Long Island residents prior to the public relations campaign. This was done to establish the baseline perceptions of residents so that the effectiveness of the public relations campaign could be measured. Since many of the objectives of the public relations survey were similar to those of the INFORM evaluation, it was determined that the two efforts should be consolidated into one survey effort.

The survey was targeted toward the driving population of households within the INFORM corridor. The INFORM corridor area previously identified in figure 1 delimits the general area encompassed by the survey. By sampling residents within the INFORM corridor the survey sampled those that should be most familiar with the INFORM operation, but yet included a wide range of driving and commuting behavior. Thus, the survey included both individuals that traveled the INFORM facilities extensively as well as those that traveled the facilities very little.

An array of questions was designed to determine how the commuting habits of respondents vary according to the extent to which the INFORM roadways were actually used. Figure 10 shows the questionnaire that was developed for use in sampling public opinion. The survey questions were extensive, covering four pages on legal sized paper. The survey form was distributed with a cover letter to Long Island residents within the defined area who are part of the national network of the market research firm National Family Opinion Research (NFO). NFO maintains a national network of some 400,000 households who are called upon, from time to time, to render their opinions on various products, services, political candidates, and a variety of other information items of local and national significance. The households in NFO's network are scientifically selected to be representative of income levels, household size, race, and a variety of other characteristics. A stratified random sample was selected by zip code area within the INFORM corridor. All drivers in the household were asked to respond, and 800 questionnaires were distributed. The questionnaires were distributed in June 1990. This ensured that all respondents had at least the possibility of exposure to all the INFORM components, including signs and ramp metering, depending on their frequency and location of driving through the INFORM corridor.

A 65-percent return rate was achieved on the residential questionnaire. This is substantially higher than response rates for surveys not done through a formal market research network. Participants in the NFO network have made a prior commitment to be responsive to the questionnaires distributed through the network. The response rate is slightly lower than the normal NFO response rate (75-percent) largely due to the length of the questionnaire. However, the overall high response rate helps to minimize the potential effects of nonresponse bias that can plague any survey effort. The returned questionnaires were processed using a microcomputer statistical analysis package.

MALE AGE 67
COUNTY 059
ZIP 11530

05
Group No.

EACH DRIVER IN THE HOUSEHOLD SHOULD ANSWER IN HIS/HER OWN COLUMN ONLY!

	DRIVER #1	DRIVER #2	DRIVER #3	DRIVER #4
1. Check your sex:	(14)	(29)	(44)	(59)
Male	1☐	1☐	1☐	1☐
Female	2☐	2☐	2☐	2☐
2. Check your age group:	(15)	(30)	(45)	(60)
17 – 24	1☐	1☐	1☐	1☐
25 – 34	2☐	2☐	2☐	2☐
35 – 49	3☐	3☐	3☐	3☐
50 – 54	4☐	4☐	4☐	4☐
55 & over	5☐	5☐	5☐	5☐

3. a. In Column "A", altogether, during an average week, how many miles do you drive?

b. In Column "B", during an average week, how many miles do you drive one way during your job commute? (WRITE IN NUMBER IN COLUMNS "A" AND "B")

	#1 "A"	#1 "B"	#2 "A"	#2 "B"	#3 "A"	#3 "B"	#4 "A"	#4 "B"
	(16-18)	(19-21)	(31-33)	(34-36)	(46-48)	(49-51)	(61-63)	(64-66)
Miles	___	___	___	___	___	___	___	___
(Check If Do Not Commute To Work By Car)		4☐ (22)		4☐ (37)		4☐ (52)		4☐ (67)

4. a. In Column "A", during an average week, when do you usually drive?

b. In Column "B", during an average week, when do you usually drive during your job commute? (CHECK ALL THAT APPLY IN COLUMNS "A" & "B")

	#1 "A"	#1 "B"	#2 "A"	#2 "B"	#3 "A"	#3 "B"	#4 "A"	#4 "B"
	(23)	(25)	(38)	(40)	(53)	(55)	(68)	(70)
Monday through Friday:								
6 a.m. to 9 a.m.	1☐	1☐	1☐	1☐	1☐	1☐	1☐	1☐
9 a.m. to Noon	2☐	2☐	2☐	2☐	2☐	2☐	2☐	2☐
Noon to 3 p.m.	3☐	3☐	3☐	3☐	3☐	3☐	3☐	3☐
3 p.m. to 6 p.m.	4☐	4☐	4☐	4☐	4☐	4☐	4☐	4☐
6 p.m. to 9 p.m.	5☐	5☐	5☐	5☐	5☐	5☐	5☐	5☐
9 p.m. to Midnight	6☐	6☐	6☐	6☐	6☐	6☐	6☐	6☐
Midnight to 3 a.m.	7☐	7☐	7☐	7☐	7☐	7☐	7☐	7☐
3 a.m. to 6 a.m.	8☐	8☐	8☐	8☐	8☐	8☐	8☐	8☐
Saturday:	(24)	(26)	(39)	(41)	(54)	(56)	(69)	(71)
6 a.m. to Noon	1☐	1☐	1☐	1☐	1☐	1☐	1☐	1☐
Noon to 6 p.m.	2☐	2☐	2☐	2☐	2☐	2☐	2☐	2☐
6 p.m. to Midnight	3☐	3☐	3☐	3☐	3☐	3☐	3☐	3☐
Midnight to 6 a.m.	4☐	4☐	4☐	4☐	4☐	4☐	4☐	4☐
Sunday:								
6 a.m. to Noon	5☐	5☐	5☐	5☐	5☐	5☐	5☐	5☐
Noon to 6 p.m.	6☐	6☐	6☐	6☐	6☐	6☐	6☐	6☐
6 p.m. to Midnight	7☐	7☐	7☐	7☐	7☐	7☐	7☐	7☐
Midnight to 6 a.m.	8☐	8☐	8☐	8☐	8☐	8☐	8☐	8☐
(Check If Do Not Commute To Work By Car)		9☐		9☐		9☐		9☐

5. a. In Column "A", what roads do you drive during an average month?

b. In Column "B", during an average month, what roads do you drive during your job commute? (CHECK ALL THAT APPLY IN COLUMNS "A" & "B")

	#1 "A"	#1 "B"	#2 "A"	#2 "B"	#3 "A"	#3 "B"	#4 "A"	#4 "B"
	(27)	(28)	(42)	(43)	(57)	(58)	(72)	(73)
Long Island Expressway – Suffolk	1☐	1☐	1☐	1☐	1☐	1☐	1☐	1☐
Long Island Expressway – Nassau	2☐	2☐	2☐	2☐	2☐	2☐	2☐	2☐
Long Island Expressway – Queens	3☐	3☐	3☐	3☐	3☐	3☐	3☐	3☐
Northern State Parkway – Suffolk	4☐	4☐	4☐	4☐	4☐	4☐	4☐	4☐
Northern State Parkway – Nassau	5☐	5☐	5☐	5☐	5☐	5☐	5☐	5☐
Grand Central Parkway – Queens	6☐	6☐	6☐	6☐	6☐	6☐	6☐	6☐
(Check If Do Not Commute To Work By Car)		7☐		7☐		7☐		7☐

13837

Figure 10. Survey form.

	DRIVER #1	DRIVER #2	DRIVER #3	DRIVER #4
6. Have you heard about a computerized traffic information system on Long Island?	(74)	(24)	(41)	(58)
Yes – (CONTINUE)	1☐	1☐	1☐	1☐
No – (SKIP TO QU. 9)	2☐	2☐	2☐	2☐
7. What is the name of the system? (CHECK *ONE* BOX)	(75)	(25)	(42)	(59)
MOTRIL	1☐	1☐	1☐	1☐
IMIS	2☐	2☐	2☐	2☐
INFORM	3☐	3☐	3☐	3☐
ROADNET	4☐	4☐	4☐	4☐
Don't know	5☐	5☐	5☐	5☐
8. Where did you hear about the system? (CHECK *ONE* BOX)	(76)	(26)	(43)	(60)
On radio	1☐	1☐	1☐	1☐
In newspaper	2☐	2☐	2☐	2☐
On television	3☐	3☐	3☐	3☐
Saw brochure	4☐	4☐	4☐	4☐
Was told about it	5☐	5☐	5☐	5☐
Don't know	6☐	6☐	6☐	6☐
9. On some highways there are changeable overhead message signs that describe the traffic ahead. For example: *"Normal Traffic Conditions Ahead"*. Have you seen these traffic advisory signs over any highways that you use?	(77)	(27)	(44)	(61)
Yes – (CONTINUE)	1☐	1☐	1☐	1☐
No – (SKIP TO QU. 15)	2☐	2☐	2☐	2☐
10. Based on your experience, how useful is the information on the traffic message signs? (CHECK *ONE* BOX)	(78)	(28)	(45)	(62)
Very useful	1☐	1☐	1☐	1☐
Moderately useful	2☐	2☐	2☐	2☐
Seldom useful	3☐	3☐	3☐	3☐
Never useful	4☐	4☐	4☐	4☐
11. Based on your experience, how accurate is the information on the message signs? (CHECK *ONE* BOX)	(79)	(29)	(46)	(63)
Always accurate	1☐	1☐	1☐	1☐
Usually accurate	2☐	2☐	2☐	2☐
Sometimes accurate	3☐	3☐	3☐	3☐
Almost never accurate	4☐	4☐	4☐	4☐
12. Have you ever changed your route in response to a sign message? (CHECK *ONE* BOX)	(80-2)	(30)	(47)	(64)
Yes, sometimes	1☐	1☐	1☐	1☐
Yes, but rarely	2☐	2☐	2☐	2☐
No, never	3☐	3☐	3☐	3☐
13. Based on your driving experience, what are the two most important benefits of these signs? (WRITE IN A "1" NEXT TO THE *MOST* IMPORTANT BENEFIT AND A "2" NEXT TO THE *SECOND MOST* IMPORTANT BENEFIT)				
Provide timely information to avoid delays	____ (14)	____ (31)	____ (48)	____ (65)
Provide accurate information about traffic ahead	____ (15)	____ (32)	____ (49)	____ (66)
Suggest alternate routes to reach my destination	____ (16)	____ (33)	____ (50)	____ (67)
Warn about tie-ups far in advance	____ (17)	____ (34)	____ (51)	____ (68)
Easy to read at highway speeds	____ (18)	____ (35)	____ (52)	____ (69)
Other (Specify): ____________	____ (19)	____ (36)	____ (53)	____ (70)
14. What changes would you make in the signs or the sign messages? (WRITE IN)	____ (120-22)	____ 37-39	____ (54-56)	____ (71-73)
15. Traffic lights called "merge lights" have been installed on Long Island Expressway and Northern State Parkway *(Grand Central Parkway in Queens)* entrance ramps. They control the flow of cars onto the highways to minimize traffic jams. They let one car at a time merge onto the highway. What is your opinion of these merge lights? (CHECK *ONE* BOX)	(23)	(40)	(57)	(74)
A good idea	1☐	1☐	1☐	1☐
Not a good idea	2☐	2☐	2☐	2☐
No opinion	3☐	3☐	3☐	3☐

Figure 10. Survey form (continued).

13837

		DRIVER #1	DRIVER #2	DRIVER #3	DRIVER #4
16.	Following are statements about the "merge lights". (CHECK ALL THAT APPLY)	(75)	(31)	(54)	(77)
	They keep the highway traffic moving	1☐	1☐	1☐	1☐
	They help reduce merge accidents	2☐	2☐	2☐	2☐
	They make merging easier	3☐	3☐	3☐	3☐
	They slow down my travel time	4☐	4☐	4☐	4☐
	Too long a wait on ramps	5☐	5☐	5☐	5☐
	Difficult to merge from a stop	6☐	6☐	6☐	6☐
	They back up traffic at ramps	7☐	7☐	7☐	7☐
	No opinion	8☐	8☐	8☐	8☐
	Other Statements (Specify):	______	______	______	______
		(76)	(32)	(55)	(78)
17.a.	Have you ever encountered a red merge light as you entered the Long Island Expressway *(LIE)* or the Northern State Parkway *(NSP) (Grand Central Parkway in Queens–GCP)*?	(77)	(33)	(56)	(79) [80-4]
	Yes – (CONTINUE)	1☐	1☐	1☐	1☐
	No – (SKIP TO QU. 20)	2☐	2☐	2☐	2☐
b.	Which ramps? (WRITE IN THE CLOSEST EXIT NUMBER) *Example: LIE Exit 36; NSP Exit 27N.* If exit number not known, write in street name. *Example: LIE Searingtown Road.*	(cc) [3]	(cc)	(cc)	(cc)
	LIE – Exit Number	______(78-80)	______(34-36)	______(57-59)	______(14-16)
	LIE – Exit Number	______(14-16)	______(37-39)	______(60-62)	______(17-19)
	NSP *(GCP)* – Exit Number	______(17-19)	______(40-42)	______(63-65)	______(20-22)
	NSP *(GCP)* – Exit Number	______(20-22)	______(43-45)	______(66-68)	______(23-25)
18.	How long do you typically wait in line at the ramps with merge lights? (CHECK *ONE* BOX)	(23)	(46)	(69)	(26)
	Less than 10 seconds	1☐	1☐	1☐	1☐
	10 to 30 seconds	2☐	2☐	2☐	2☐
	31 to 60 seconds	3☐	3☐	3☐	3☐
	1 to 2 minutes	4☐	4☐	4☐	4☐
	2 to 4 minutes	5☐	5☐	5☐	5☐
	4 to 6 minutes	6☐	6☐	6☐	6☐
	Over 6 minutes	7☐	7☐	7☐	7☐
19.	Do you ever use the service road or another roadway in order to avoid waiting at the merge lights? (CHECK *ONE* BOX)	(24)	(47)	(70)	(27)
	Yes, frequently *(once a week or more)*	1☐	1☐	1☐	1☐
	Yes, occasionally	2☐	2☐	2☐	2☐
	No, never	3☐	3☐	3☐	3☐
20.	Merge lights currently operate only on weekdays, and only during the morning peak hours westbound and evening peak hours eastbound. Beyond that, how should they be operated? (CHECK *ALL* THAT APPLY)	(25)	(48)	(71)	(28)
	Weekdays, eastbound during peak morning hours	1☐	1☐	1☐	1☐
	Weekdays, westbound during peak morning hours	2☐	2☐	2☐	2☐
	For longer periods during the peak hours	3☐	3☐	3☐	3☐
	Just before and just after the peak hours	4☐	4☐	4☐	4☐
	On weekends whenever traffic is heavy	5☐	5☐	5☐	5☐
	At any hour when traffic is heavy	6☐	6☐	6☐	6☐
	Let the computer decide when merge lights will improve traffic flow	7☐	7☐	7☐	7☐
21.	Would an entrance ramp merge light be regarded as:				
a.	A traffic light that must be obeyed?	(26)	(49)	(72)	(29)
	Yes	1☐	1☐	1☐	1☐
	No	2☐	2☐	2☐	2☐
b.	Having no authority to stop cars?	(27)	(50)	(73)	(30)
	Yes	1☐	1☐	1☐	1☐
	No	2☐	2☐	2☐	2☐
c.	Not having any penalty if go through a red light?	(28)	(51)	(74)	(31)
	Yes	1☐	1☐	1☐	1☐
	No	2☐	2☐	2☐	2☐
22.	What do you think will happen if drivers ignore the merge lights? (CHECK *ALL* THAT APPLY)	(29)	(52)	(75)	(32)
	Will get a ticket	1☐	1☐	1☐	1☐
	Slows highway traffic	2☐	2☐	2☐	2☐
	Cause merge accidents	3☐	3☐	3☐	3☐
	Nothing	4☐	4☐	4☐	4☐
23.	If a ramp merge light is not on, what should a driver do? (CHECK *ONE* BOX)	(30)	(53)	(76)	(33)
	Don't stop — merge right into traffic	1☐	1☐	1☐	1☐
	Stop — wait to see if the light comes on	2☐	2☐	2☐	2☐
	Stop briefly, then enter the highway	3☐	3☐	3☐	3☐

Figure 10. Survey form (continued)

13837

		DRIVER #1	DRIVER #2	DRIVER #3	DRIVER #4
24.	What overall effect is the computerized traffic information system having? (CHECK *ONE* BOX)	(34)	(61)	(22)	(49)
	It's quite helpful	1☐	1☐	1☐	1☐
	It helps once in a while	2☐	2☐	2☐	2☐
	It has had no noticeable effect	3☐	3☐	3☐	3☐
	It has made the problems worse	4☐	4☐	4☐	4☐
25.	What specific effects do you think the system is having? (CHECK *ALL* THAT APPLY)	(35)	(62)	(23)	(50)
	Keeps traffic moving	1☐	1☐	1☐	1☐
	Helps drivers avoid delays	2☐	2☐	2☐	2☐
	Helps cut down on merge accidents	3☐	3☐	3☐	3☐
	Smoothes out highway traffic flow	4☐	4☐	4☐	4☐
	Helps drivers save gas	5☐	5☐	5☐	5☐
	Helps during peak hours	6☐	6☐	6☐	6☐
	Speeds up my trip	7☐	7☐	7☐	7☐
	Slows down my trip	8☐	8☐	8☐	8☐
	Causes backups on local access roads	9☐	9☐	9☐	9☐
	Other (Specify):	______ (36)	______ (63)	______ (24)	______ (51)
26.	What do you think is the best source of traffic information while you're driving? (CHECK *ONE* BOX)	(37)	(64)	(25)	(52)
	Radio station	1☐	1☐	1☐	1☐
	Message signs	2☐	2☐	2☐	2☐
	CB radio	3☐	3☐	3☐	3☐
	Other (Specify):	______ (38)	______ (65)	______ (26)	______ (53)
27.	When driving which one radio station do you listen to most often?				
	Call Letters (Specify):	______ (39-40)	______ (66-67)	______ (27-28)	______ (54-55)
	Dial Numbers (Specify):	______ (41-42)	______ (68-69)	______ (29-30)	______ (56-57)
	AM or FM (Circle One)	AM (43-1) FM (2)	AM (70-1) FM (2)	AM (31-1) FM (2)	AM (58-1) FM (2)
28.	What radio station do you listen to most often for traffic information?				
	Call Letters (Specify):	______ (44-45)	______ (71-72)	______ (32-33)	______ (59-60)
	Dial Numbers (Specify):	______ (46-47)	______ (73-74)	______ (34-35)	______ (61-62)
	AM or FM (Circle One)	AM (48-1) FM (2)	AM (75-1) FM (2)	AM (36-1) FM (2)	AM (63-1) FM (2)
29.	What improvements would you like to have in radio traffic reports? (WRITE IN)	(49) ______	(76) ______	(37) ______	(64) ______
30.	Who operates the traffic information system? (CHECK *ONE* BOX)	(50)	(77)	(38)	(65)
	Nassau Department of Traffic	1☐	1☐	1☐	1☐
	Suffolk Department of Traffic	2☐	2☐	2☐	2☐
	New York City Traffic Department	3☐	3☐	3☐	3☐
	New York State Department of Transportation	4☐	4☐	4☐	4☐
	New York State Police	5☐	5☐	5☐	5☐
	Don't know	6☐	6☐	6☐	6☐

		#1 LIE (51)	#1 NSP (52)	#2 LIE (78)	#2 NSP (79)	#3 LIE (39)	#3 NSP (40)	#4 LIE (66)	#4 NSP (67)
31.	Compared with two years ago, how would you say traffic is moving on the Long Island Expressway (*LIE*) and the Northern State Parkway (*NSP*) (*Grand Central Parkway in Queens*)? (CHECK *ONE* BOX FOR *LIE* AND *ONE* BOX FOR *NSP*)								
	Much better	1☐	1☐	1☐	1☐	1☐	1☐	1☐	1☐
	Somewhat better	2☐	2☐	2☐	2☐	2☐	2☐	2☐	2☐
	About the same	3☐	3☐	3☐	3☐	3☐	3☐	3☐	3☐
	Somewhat worse	4☐	4☐	4☐	4☐	4☐	4☐	4☐	4☐
	Must worse	5☐	5☐	5☐	5☐	5☐	5☐	5☐	5☐

		DRIVER #1	DRIVER #2	DRIVER #3	DRIVER #4
32.	Apart from the traffic information system, what do you think are the the most important things that can be done to improve Long Island traffic? (Rank each statement from "1" to "5" in order of importance, with "1" being most important, "2" next in importance, and so on with "5" being least important).		80-5		
	Complete the LIE service road network	______ (53)	______ (14)	______ (41)	______ (68)
	Add a fourth lane on the LIE	______ (54)	______ (15)	______ (42)	______ (69)
	Add a fourth lane on the LIE for high occupancy vehicles	______ (55)	______ (16)	______ (43)	______ (70)
	Widen Northern State Parkway	______ (56)	______ (17)	______ (44)	______ (71)
	Extend the traffic information system farther east	______ (57)	______ (18)	______ (45)	______ (72)
	Extend the traffic information system to Southern Parkway	______ (58)	______ (19)	______ (46)	______ (73)
	Synchronize traffic lights on major east-west and north-south arterials	______ (59)	______ (20)	______ (47)	______ (74)
	Other (Specify): ______	______ (60)	______ (21)	______ (48)	______ (75)
					80-6

13837

Figure 10. Survey form (continued).

Accident Data

Accident data were obtained from New York State DOT computer files. Since the availability of data in the accident record systems lags considerably behind the time of actual occurrence, accident data were not available for the entire range of time periods for which operational data were collected. One of the important considerations in the analysis of accident data is the effect of extraneous factors on accident frequency and severity. A number of other factors could have affected accident frequency other than INFORM. Examples of such factors include: education and enforcement of drunk driving laws, changes in seat belt use, differences in weather patterns from year to year (e.g., some years could have had more slippery roads than others), or even changes in criteria by police departments for reporting accidents. To account for these possible non-INFORM effects, a control section was established on State Route 135 (Seaford-Oyster Bay Expressway). While some of Route 135 is located within the INFORM corridor, it is not under ramp metering control and would not likely have been significantly influenced by INFORM itself.

3. OVERALL CHANGES IN TRAFFIC PERFORMANCE

Chapter 3 provides an examination of overall changes in traffic performance for the freeway and arterial systems. It presents comparisons of volume, speed, occupancy, and other congestion-related measures for the a.m. and p.m. peak periods. It also provides information on general accident trends related to INFORM. This discussion of overall results is followed in chapters 4 and 5 by specific results for the variable message signing system and for ramp metering.

Many interesting observations can be made from the summary data, and significant conclusions can be drawn from these trends. Freeway traffic volume data are discussed first, to provide an appropriate context for the presentation of speeds and other related data. Freeway accident data and arterial results are presented at the end of this chapter.

TRAFFIC VOLUME

Assessment of traffic volume is important for at least two reasons in the evaluation of a freeway traffic control system. First, it indicates whether any increases in throughput have been achieved because of the traffic control strategies. Second, it provides a form of experimental control on the evaluation of other factors, such as speeds and occupancies. If volume is relatively constant over the different evaluation periods, then a direct comparison of other MOE's (such as speeds) among the periods is possible. If volume significantly changes, this would need to be accounted for in the evaluation of these other MOE's.

Figures 11 and 12 indicate the trends in average daily VMT for the a.m. peak period for the LIE and the NSP/GCP over each of the seven 2-week evaluation periods listed in chapter 2. These evaluation periods represented two-week "snapshots" of operations at specific points in time, as described at the beginning of chapter 2. The evaluation periods are arranged chronologically from left to right. In general, the amount of freeway travel stayed relatively constant over the seven periods. The primary exception was the fall 1988 data set, which may have been influenced by seasonal changes in travel, having been collected in late November and early December. Figures 13 and 14 show the VMT data for the p.m. peak period, indicating similar trends to the a.m. peak period.

It was stated in chapter 2 that the most relevant comparisons were likely to be between March 1990 metered and nonmetered and between March 1990 metered and spring 1987. The March-to-March comparison shows essentially the same amount of travel with perhaps a slightly higher level of travel in the metered case.

The primary metering/nonmetering comparisons are for the LIE and NSP/GCP westbound in the a.m. peak period and the LIE and NSP/GCP eastbound in the p.m. peak period. In all of these comparisons, vehicle miles of travel are slightly higher for the March 1990 metered case than for the March 1990 nonmetered and spring 1987 cases.

Tables 3 and 4 provide more detailed VMT summary data for the LIE, NSP/GCP and the North/South Expressways. The tables also express the March-to-March and March 1990 to spring 1987 comparisons in terms of a ratio between the two primary metered and nonmetered cases. The letters above the columns indicate how the ratios were determined. VMT for the March 1990 metered case is between 1 and 5 percent higher than the two nonmetered cases being compared, depending on

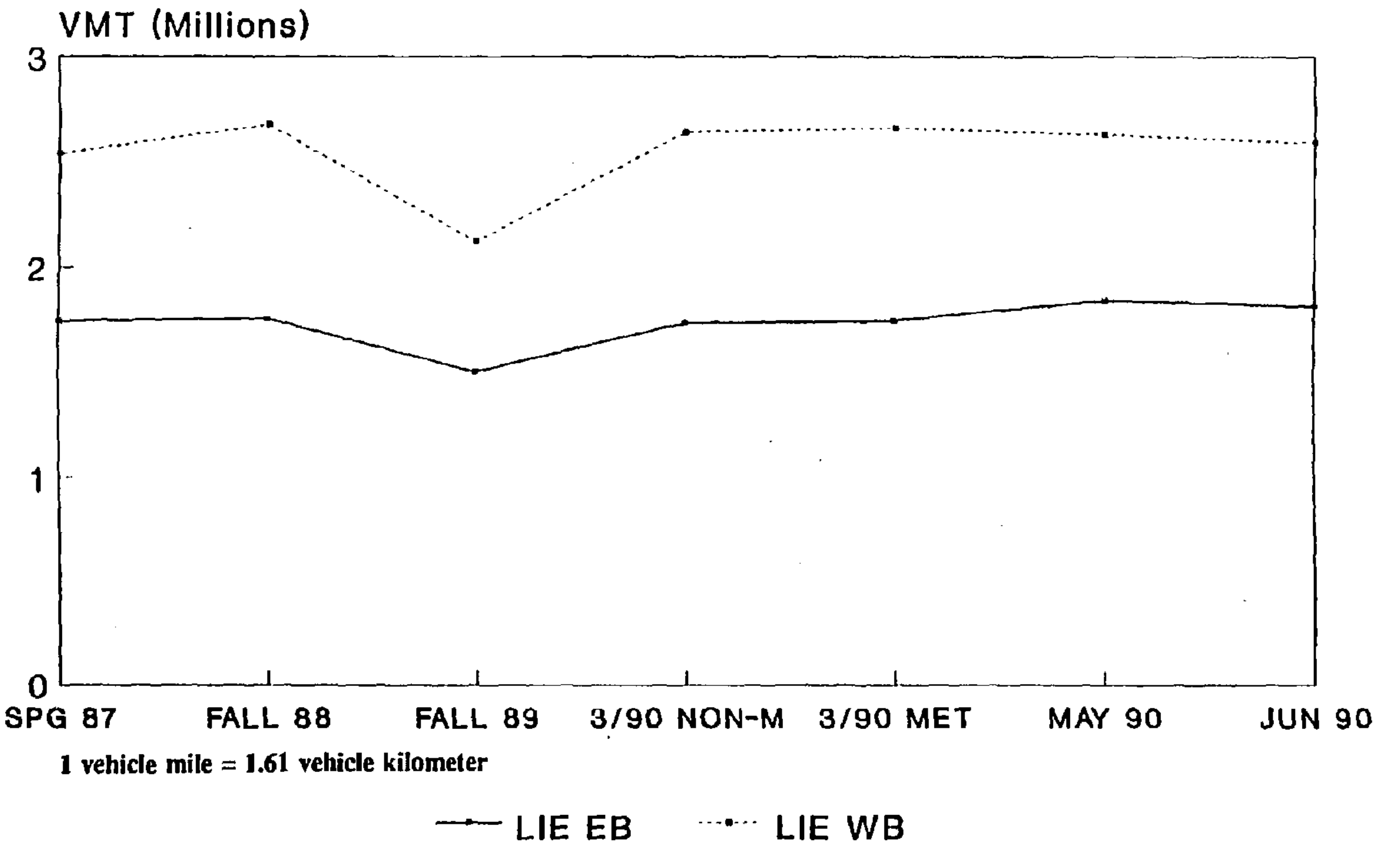


Figure 11. Average daily vehicle miles of travel on the LIE, a.m. peak period (0600-0930).

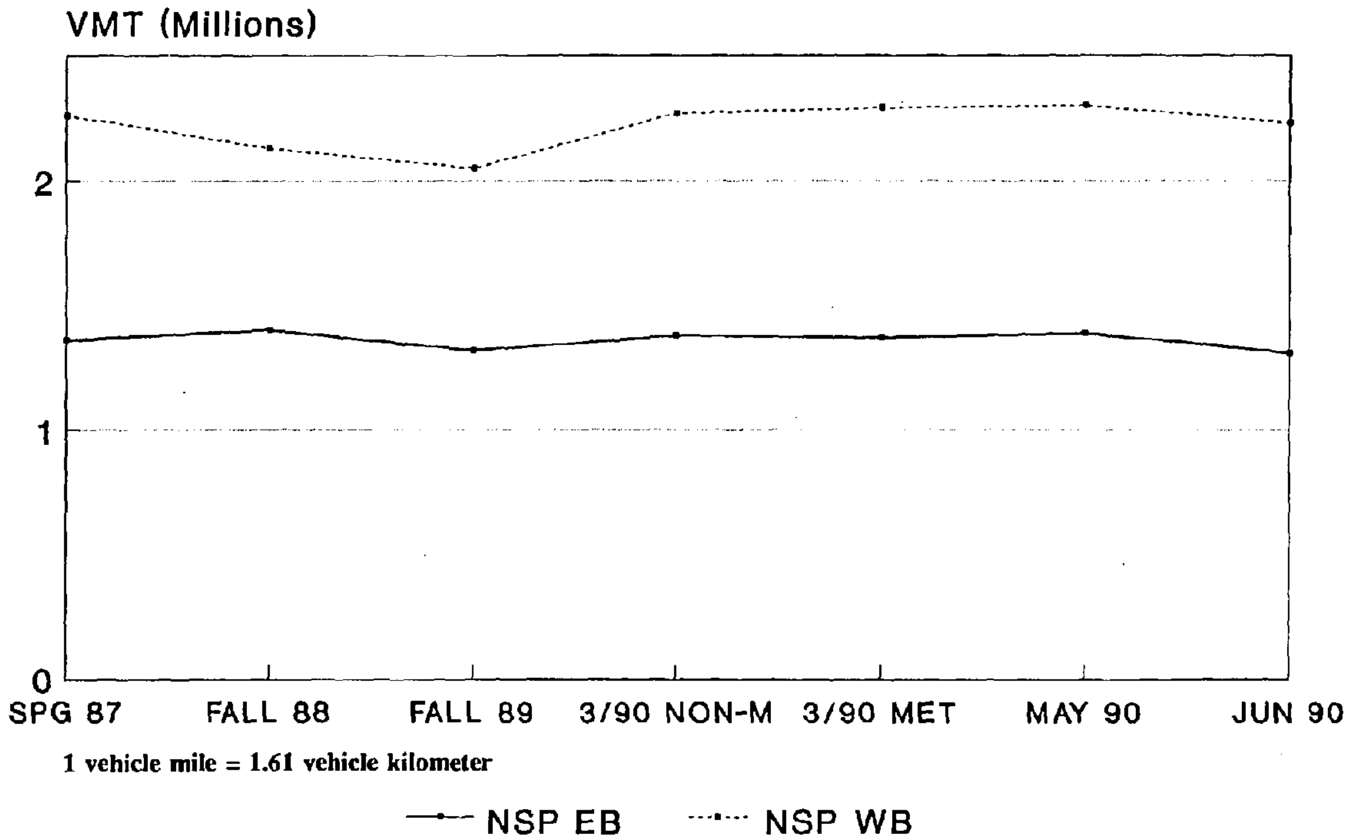


Figure 12. Average daily vehicle miles of travel on the NSP/GCP, a.m. peak period (0600-0930).

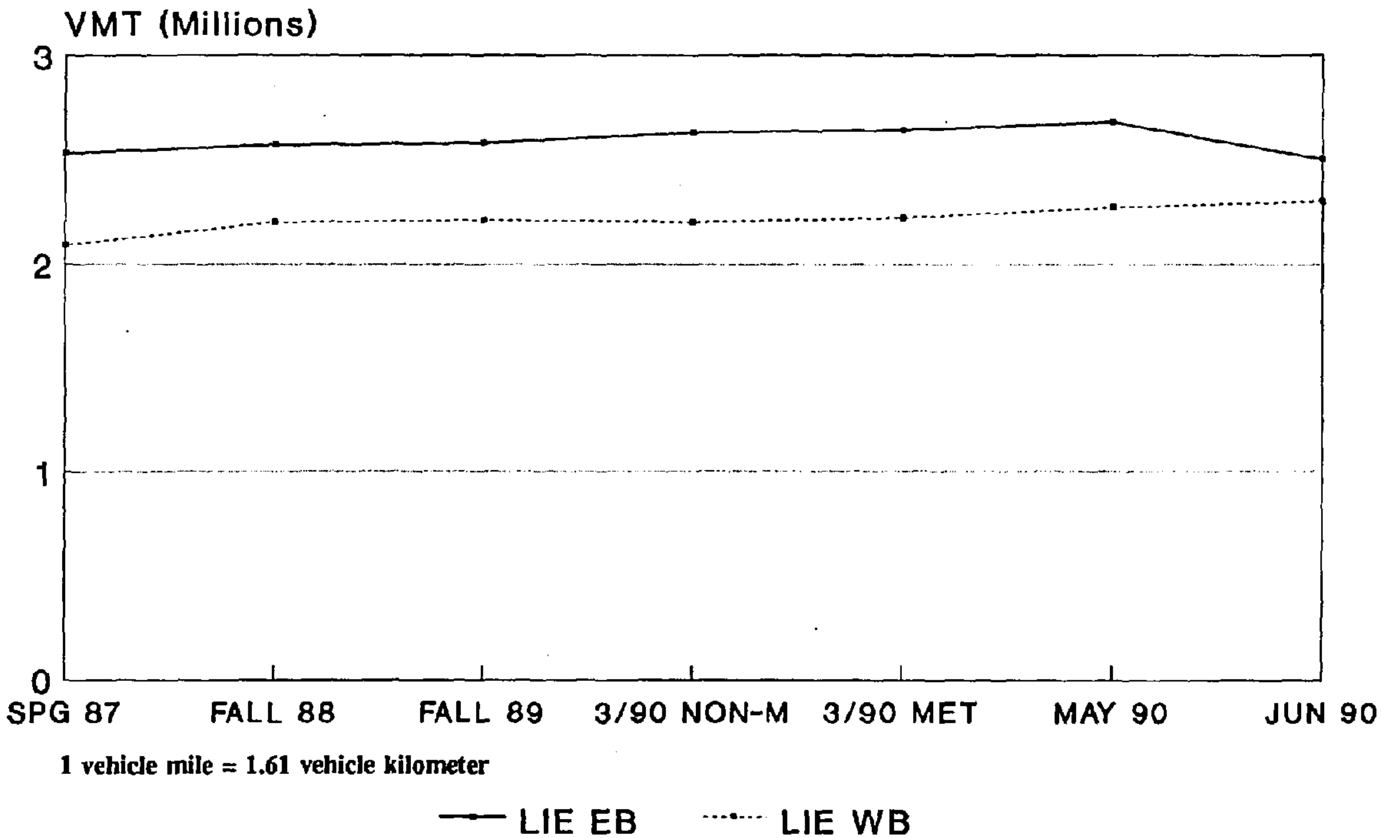


Figure 13. Average daily vehicle miles of travel on the LIE, p.m. peak period (1530-1900).

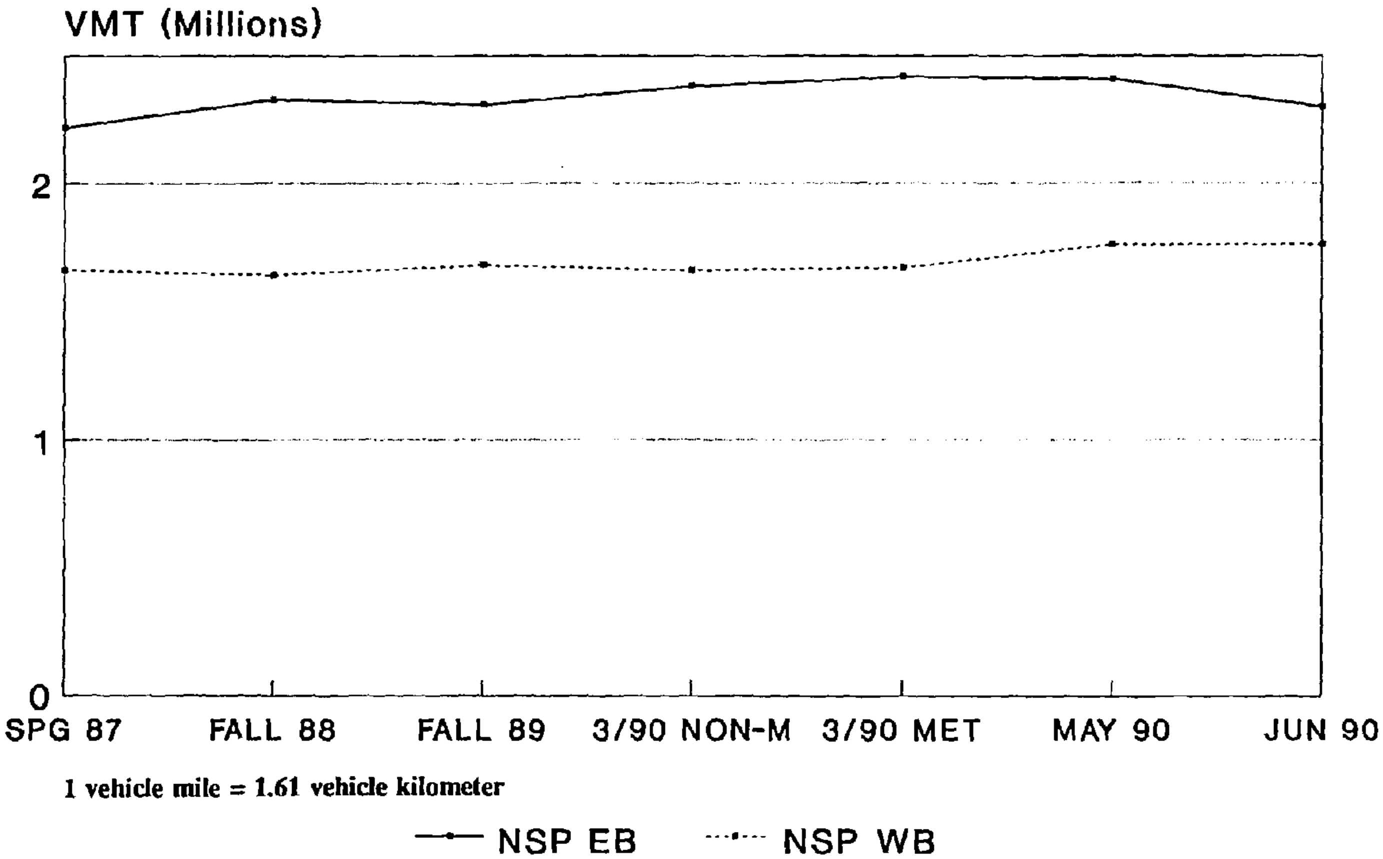


Figure 14. Average daily vehicle miles of travel on the LIE, p.m. peak period (1530-1900).

Table 3. Average daily vehicle miles of travel, a.m. peak (0600-0930).

SECTION	NO.	1987 SPRING	1988 FALL	1989 FALL	1990 MARCH N-METER	METER	1990 APR/MAY	1990 JUNE	RATIOS E/A	E/D
		A	B	C	D	E	F	G		
LIE EB QUEENS	1	404,016	423,709	298,180	351,738	368,040	414,216	394,109	0.91	1.05
LIE EB NASSAU WE	2	426,962	422,182	383,846	450,153	454,768	464,998	466,068	1.07	1.01
LIE EB NASSAU EAS	3	337,580	319,113	288,491	322,377	324,310	335,453	330,408	0.96	1.01
LIE EB SUFFOLK WE	4	302,469	306,261	289,699	327,904	315,981	338,329	344,872	1.04	0.96
LIE EB SUFFOLK EA	5	269,775	283,196	242,110	272,983	276,896	289,753	278,560	1.03	1.01
SUBTOTAL LIE EB	1-5	1,740,802	1,754,461	1,502,326	1,725,155	1,739,995	1,842,749	1,814,017	1.00	1.01
LIE WB SUFFOLK EA	6	499,234	528,133	368,036	505,133	507,911	505,610	483,861	1.02	1.01
LIE WB SUFFOLK W	7	548,011	579,358	493,034	603,072	597,649	586,399	578,442	1.09	0.99
LIE WB NASSAU EA	8	564,077	583,333	469,526	570,534	578,707	568,138	569,665	1.03	1.01
LIE WB NASSAU WE	9	469,627	502,009	420,309	519,172	519,786	507,112	504,401	1.11	1.00
LIE WB QUEENS	10	460,791	485,114	373,935	441,723	456,950	465,134	458,258	0.99	1.03
SUBTOTAL LIE WB	6-10	2,541,740	2,677,947	2,124,840	2,639,634	2,661,003	2,632,393	2,594,627	1.05	1.01
GCP EB QUEENS	11	550,999	555,652	483,108	579,864	581,328	588,683	510,271	1.06	1.00
NSP EB NASSAU W	12	408,946	429,406	329,945	407,159	400,779	404,510	402,439	0.98	0.98
NSP EB NASSAU EA	13	213,207	211,473	209,040	203,442	201,694	205,330	205,523	0.95	0.99
NSP EB SUFFOLK	14	185,115	203,941	210,197	193,213	189,798	192,496	191,726	1.03	0.98
SUBTOTAL NSP EB	11-14	1,358,267	1,400,472	1,232,290	1,383,678	1,373,599	1,391,019	1,309,959	1.01	0.99
NSP WB SUFFOLK	15	541,340	512,419	518,394	537,166	538,480	538,004	532,207	0.99	1.00
NSP WB NASSAU E	16	385,108	380,849	379,261	402,913	401,804	401,786	399,999	1.04	1.00
NSP WB NASSAU W	17	592,669	578,642	528,406	628,097	623,127	623,010	614,851	1.05	0.99
GCP WB QUEENS	18	739,290	661,595	620,876	702,758	727,382	732,225	684,907	0.98	1.04
SUBTOTAL NSP W	15-18	2,258,407	2,133,505	2,046,937	2,270,934	2,290,793	2,295,025	2,231,964	1.01	1.01
SUBTOTAL LIE/NSP EB		3,099,069	3,154,933	2,734,616	3,108,833	3,113,594	3,233,768	3,123,976	1.00	1.00
SUBTOTAL LIE/NSP WB		4,800,147	4,811,452	4,171,777	4,910,568	4,951,796	4,927,418	4,826,591	1.03	1.01
SUBTOTAL LIE/NSP EB/W		7,899,216	7,966,385	6,906,393	8,019,401	8,065,390	8,161,186	7,950,567	1.02	1.01
CLEARVIEW NB	19	59,477	99,887	123,636	138,286	153,497	160,941	126,729	2.58	1.11
CLEARVIEW SB	20	39,105	107,328	113,261	166,593	167,535	169,220	152,733	4.28	1.01
CROSS ISLAND NB	21	76,598	118,283	110,038	145,146	149,909	143,507	133,023	1.96	1.03
CROSS ISLAND SB	22	54,336	74,637	68,071	62,833	61,966	66,991	62,420	1.14	0.99
MEADOWBROOK NB	23	34,377	20,895	45,682	49,110	48,919	48,064	43,751	1.42	1.00
MEADOWBROOK SB	24	20,885	33,679	45,265	47,502	49,155	49,374	45,809	2.35	1.03
WANTAGH PKWY N	25	67,102	69,155	68,665	74,542	73,688	74,947	72,105	1.10	0.99
WANTAGH PKWY S	26	31,558	29,170	39,146	31,426	31,881	31,520	30,534	1.01	1.01
SEAFORD-OYS NB	27	100,232	106,517	98,074	99,349	97,341	100,421	98,557	0.97	0.98
SEAFORD-OYS SB	28	23,866	28,537	24,728	23,326	23,540	26,684	24,416	0.99	1.01
SAGTIKOS NB	29	35,636	59,576	51,049	53,955	53,326	51,981	52,999	1.50	0.99
SAGTIKOS SB	30	105,603	105,727	110,537	109,796	107,356	101,875	95,713	1.02	0.98
SUBTOTAL OTHER	19-30	648,775	853,391	898,152	1,001,864	1,018,113	1,025,525	938,789	1.57	1.02
TOTAL		8,547,991	8,819,776	7,804,545	9,021,265	9,083,503	9,186,711	8,889,356	1.06	1.01

1 mi = 1.61 km

1 vehicle mile = 1.61 vehicle kilometer

Table 4. Average daily vehicle miles of travel, p.m. peak (1530-1900).

SECTION	SEC.NO	1987 SPRING	1988 FALL	1989 FALL	1990 MARCH N-METER	METER	APR/MAY NON-INC	JUNE NON-INC.	RATIO E/A	E/D
		A	B	C	D	E	F	G		
LIE EB QUEENS	1	543,720	544,453	515,059	498,857	488,769	564,181	510,103	0.90	0.98
LIE EB NASSAU WEST	2	595,772	594,525	606,689	641,778	652,853	632,502	587,625	1.10	1.02
LIE EB NASSAU EAST	3	480,920	464,774	479,278	495,892	501,694	489,213	468,743	1.04	1.01
LIE EB SUFFOLK WEST	4	515,692	533,361	558,825	564,310	572,205	575,122	540,794	1.11	1.01
LIE EB SUFFOLK EAST	5	396,461	429,764	418,624	425,266	425,809	420,810	391,370	1.07	1.00
SUBTOTAL LIE EB	1-5	2,532,565	2,566,877	2,578,475	2,626,103	2,641,330	2,681,828	2,498,635	1.04	1.01
LIE WB SUFFOLK EAST	6	379,057	397,463	398,703	397,686	408,438	388,001	404,293	1.08	1.03
LIE WB SUFFOLK WEST	7	402,357	419,029	439,201	427,946	435,759	448,515	469,601	1.08	1.02
LIE WB NASSAU EAST	8	476,825	497,722	500,029	501,665	508,992	515,839	539,035	1.07	1.01
LIE WB NASSAU WEST	9	412,946	428,109	440,042	452,220	451,982	470,012	460,806	1.09	1.00
LIE WB QUEENS	10	417,189	457,889	432,397	419,432	412,952	447,163	422,782	0.99	0.98
SUBTOTAL LIE WB	6-10	2,088,374	2,200,212	2,210,372	2,198,949	2,218,123	2,269,530	2,295,517	1.06	1.01
GCP EB QUEENS	11	750,386	761,593	768,793	804,033	813,304	820,354	712,794	1.08	1.01
NSP EB NASSAU WEST	12	595,775	668,754	623,064	657,364	671,892	641,564	653,768	1.13	1.02
NSP EB NASSAU EAST	13	342,256	362,089	364,726	371,584	383,862	385,488	376,035	1.12	1.03
NSP EB SUFFOLK	14	532,717	540,009	552,032	542,330	553,549	566,107	560,572	1.04	1.02
SUBTOTAL NSP EB	11-14	2,221,134	2,332,445	2,308,615	2,375,311	2,422,607	2,413,513	2,303,169	1.09	1.02
NSP WB SUFFOLK	15	295,903	286,792	305,084	301,979	305,777	339,043	328,175	1.03	1.01
NSP WB NASSAU EAST	16	293,608	278,295	280,972	283,707	285,980	300,145	306,253	0.97	1.01
NSP WB NASSAU WEST	17	451,726	458,703	453,118	468,672	477,241	475,277	493,973	1.06	1.02
GCP WB QUEENS	18	620,089	612,415	644,253	609,349	604,586	648,626	634,624	0.97	0.99
SUBTOTAL NSP WB	15-18	1,661,326	1,636,205	1,683,427	1,663,707	1,673,584	1,763,091	1,763,025	1.01	1.01
SUBTOTAL LIE/NSP EB		4,753,699	4,899,322	4,887,090	5,001,414	5,063,937	5,095,341	4,801,804	1.07	1.01
SUBTOTAL LIE/NSP WB		3,749,700	3,836,417	3,893,799	3,862,656	3,891,707	4,032,621	4,059,542	1.04	1.01
SUBTOTAL LIE/NSP EB/WB		8,503,399	8,735,739	8,780,889	8,864,070	8,955,644	9,127,962	8,861,346	1.05	1.01
CLEARVIEW NB	19	56,927	70,157	138,571	130,445	137,925	139,446	118,302	2.42	1.06
CLEARVIEW SB	20	62,058	74,631	130,810	133,922	134,041	120,868	132,861	2.16	1.00
CROSS ISLAND NB	21	76,337	107,232	118,347	119,614	118,115	111,138	114,938	1.55	0.99
CROSS ISLAND SB	22	94,936	72,148	98,217	112,389	107,154	113,422	98,897	1.13	0.95
MEADOWBROOK NB	23	42,494	23,735	40,363	41,463	44,299	47,695	49,489	1.04	1.07
MEADOWBROOK SB	24	49,785	25,270	36,267	34,349	35,704	31,691	29,991	0.72	1.04
WANTAGH PKWY NB	25	51,733	44,071	48,469	47,455	47,489	50,981	51,389	0.92	1.00
WANTAGH PKWY SB	26	79,600	77,712	71,860	76,726	77,707	75,448	75,085	0.98	1.01
SEAFORD-OYS NB	27	73,260	72,413	73,327	62,904	63,128	66,129	66,401	0.86	1.00
SEAFORD-OYS SB	28	51,370	56,585	52,323	48,156	48,104	52,439	53,885	0.94	1.00
SAGTIKOS NB	29	64,312	86,146	78,123	74,415	79,829	78,502	79,090	1.24	1.07
SAGTIKOS SB	30	81,243	73,964	82,801	72,218	74,373	67,550	70,201	0.92	1.03
SUBTOTAL OTHER	19-30	784,055	784,064	969,478	954,056	967,868	955,309	940,529	1.23	1.01
TOTAL		9,287,454	9,519,803	9,750,367	9,818,126	9,923,512	10,083,271	9,801,875	1.07	1.01

1 mi/h = 1.61 km/h

1 vehicle mile = 1.61 vehicle kilometer

direction and time period. This makes the evaluation somewhat easier, as the differences are not large and no elaborate measures need to be taken to factor speeds and other data that have a relationship to volume. If anything, the slightly higher volume levels in the March 1990 metered case suggest that any benefits of metering identified will be conservative. However,the differences reflected in VMT are not likely to produce a significant understatement of benefits either. Changes in volume throughput are discussed in chapter 5 on ramp metering.

VEHICLE HOURS OF TRAVEL

Figures 15 and 16 indicate average daily vehicle hours of travel for the LIE and NSP/GCP, respectively, for the a.m. peak period. Figures 17 and 18 present similar data for the p.m. peak period. In the two primary comparisons, VHT for the metered case is lower than for the unmetered cases. Note that the VHT for the May and June 1990 metered cases were both higher than either metered or unmetered cases in March. This is largely attributable to the impacts of significant construction activity during that period. Tables 5 and 6 provide more detailed backup data for the VHT statistic, showing the ratios between the comparison cases in the right-hand column.

AVERAGE SPEEDS

Average vehicle speeds can be computed as the ratio of VMT to VHT. This is one of the best measures of differences in system performance and one input into determining user benefits. A higher VMT and a lower VHT for the March 1990 metered case produces noticeable differences in speeds for both comparisons, particularly the comparison of March 1990 metered to spring 1987. Figures 19 and 20 present graphic summaries for the a.m. peak period. Figures 21 and 22 present summaries for the p.m. peak period. Tables 7 and 8 present the more detailed data.

Speed for the peak directions increased by between 1.5 and 3.5 mi/h (2.4 and 5.6 km/h) for the comparison to March 1990 nonmetered for facility subtotals in tables 9 and 10. The differences are as high as 5 mi/h (8.1 km/h) for the comparison to spring 1987 for facility subtotals. For individual subsections, greater increases in speed are noted, but these are countered by decreases or lower increases in other sections. For example, LIE EB Queens and LIE EB Suffolk East have increases in speed in the March 1990 metered versus spring 1987 comparison of 5 to 8 mi/h (8.1 to 12.9 km/h). At the same time, however, the LIE EB Nassau East decreased in speed 5 mi/h (8.1 km/h). There are definite interactions between upstream and downstream sections on freeways, and it is suspected that this interaction may be present here and in other comparisons. It should be noted that the peak periods include some nonmetering time as well as approximately 2 hours of metering time. The differences in speed within the metering period are addressed in chapter 5. In general, however, the increases in speed are less than would have been expected under ramp metering. There are reasons for this, from which lessons can be drawn regarding the design and operation of INFORM and other corridor traffic control systems.

STATISTICAL SIGNIFICANCE

Table 9 presents a statistical analysis of the overall differences in VMT, VHT and average speeds for the LIE and NSP/GCP combined. There is no significant difference in a.m. VMT. There is a significant difference in p.m. VMT, indicating that any VHT and speed improvements are likely conservative.

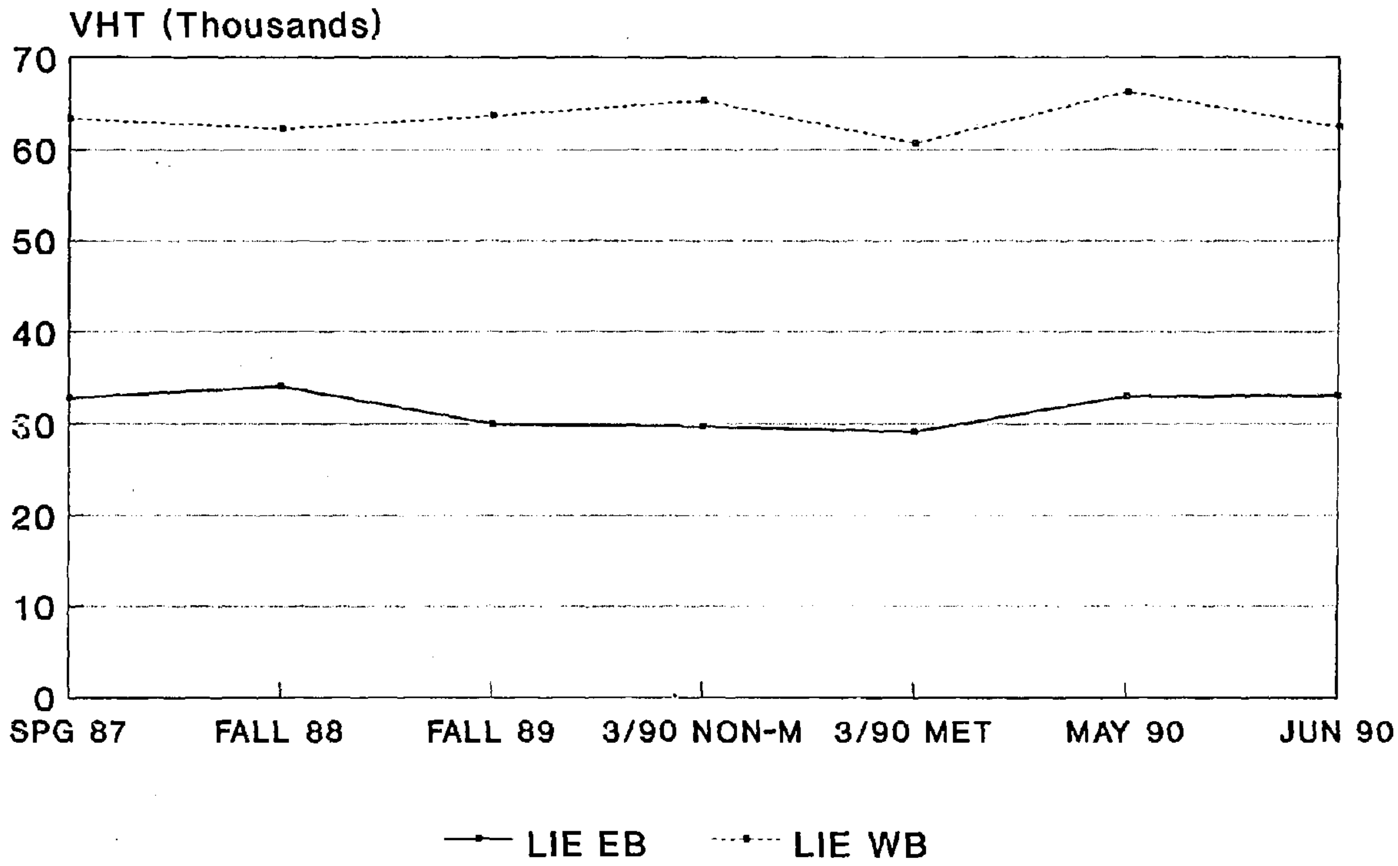


Figure 15. Average daily vehicle hours of travel on the LIE, a.m. peak period (0600-0930).

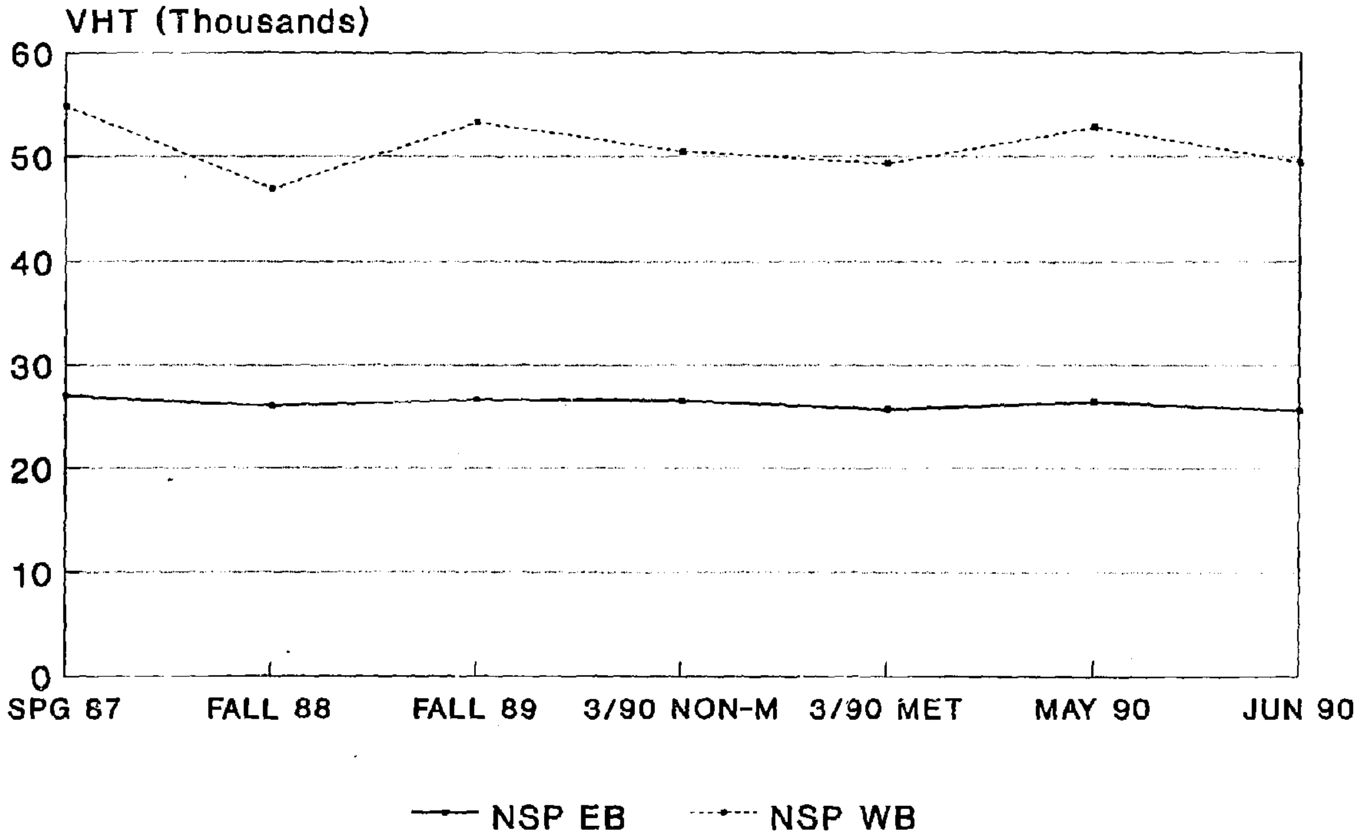


Figure 16. Average daily vehicle hours of travel on the NSP/GCP, a.m. peak period (0600-0930).

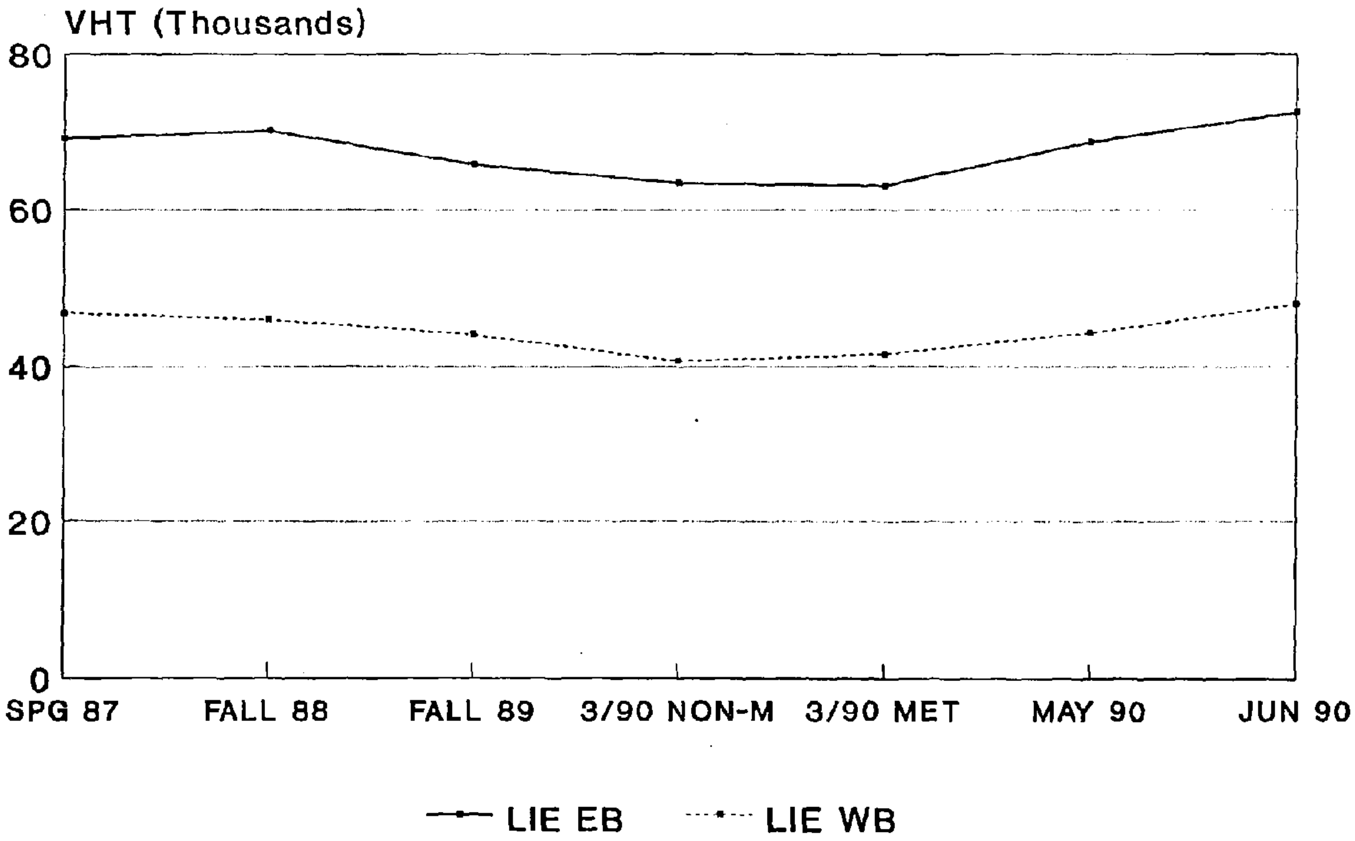


Figure 17. Average daily vehicle hours of travel on the LIE, p.m. peak period (1530-1900).

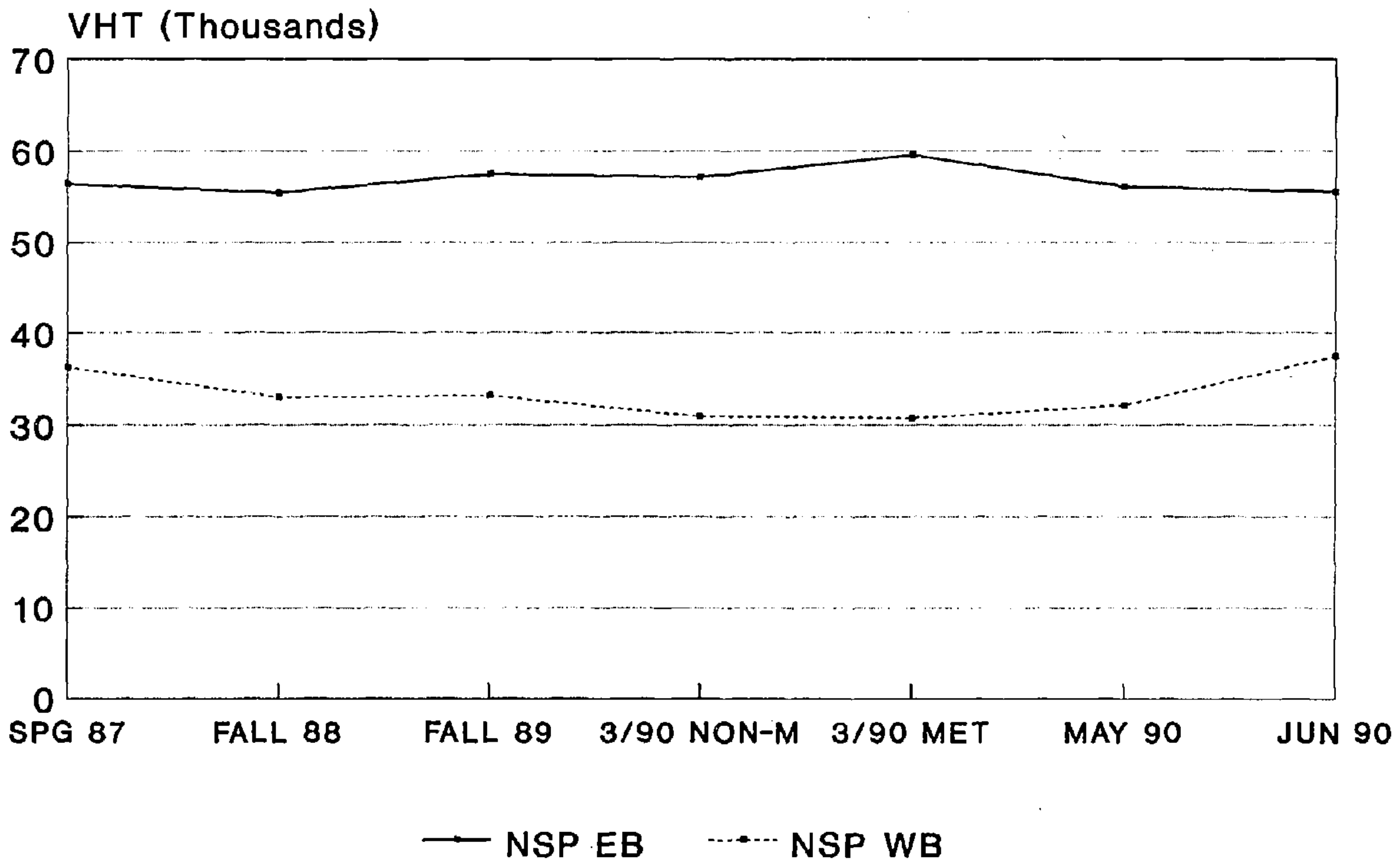


Figure 18. Average daily vehicle hours of travel on the LIE, p.m. peak period (1530-1900).

Table 5. Average vehicle hours of travel, a.m. peak (0600-0930).

SECTION	SEC.NO	1987 SPRING	1988 FALL	1989 FALL	1990 MARCH N-METER	1990 MARCH METER	APR/MAY NON-INC	JUNE NON-INC	RATIOS E/A	RATIOS E/D
		A	B	C	D	E	F	G		
LIE EB QUEENS	1	10,238	11,633	9,169	8,290	7,961	10,273	10,035	0.78	0.96
LIE EB NASSAU WEST	2	7,610	7,247	6,524	6,603	6,658	7,054	7,464	0.87	1.01
LIE EB NASSAU EAST	3	5,398	5,832	4,827	5,146	5,062	5,405	5,389	0.94	0.98
LIE EB SUFFOLK WEST	4	4,944	4,794	4,781	5,050	4,888	5,349	5,288	0.99	0.97
LIE EB SUFFOLK EAST	5	4,628	4,627	4,734	4,595	4,528	4,947	4,911	0.98	0.99
SUBTOTAL LIE EB	1-5	32,818	34,133	30,035	29,684	29,097	33,028	33,087	0.89	0.98
LIE WB SUFFOLK EAST	6	13,214	10,470	13,318	12,220	11,535	12,209	11,623	0.87	0.94
LIE WB SUFFOLK WEST	7	12,810	11,956	13,247	13,287	11,898	12,909	11,742	0.93	0.90
LIE WB NASSAU EAST	8	13,461	10,911	12,600	12,352	10,819	11,750	11,616	0.80	0.88
LIE WB NASSAU WEST	9	12,332	12,947	13,104	12,391	12,138	13,385	12,678	0.98	0.98
LIE WB QUEENS	10	11,566	15,968	11,421	15,072	14,314	16,051	14,812	1.24	0.95
SUBTOTAL LIE WB	6-10	63,383	62,252	63,690	65,322	60,704	66,304	62,471	0.96	0.93
GCP EB QUEENS	11	12,669	11,672	12,694	12,957	12,462	12,755	11,754	0.98	0.96
NSP EB NASSAU WEST	12	7,324	7,602	6,414	6,969	6,770	7,027	7,135	0.92	0.97
NSP EB NASSAU EAST	13	3,732	3,241	3,956	3,490	3,423	3,539	3,529	0.92	0.98
NSP EB SUFFOLK	14	3,244	3,473	3,514	3,072	3,023	3,066	3,077	0.93	0.98
SUBTOTAL NSP EB	11-14	26,969	25,988	26,578	26,488	25,678	26,387	25,495	0.95	0.97
NSP WB SUFFOLK	15	12,464	10,110	13,578	11,925	11,347	12,244	11,190	0.91	0.95
NSP WB NASSAU EAST	16	9,132	7,786	9,358	9,664	8,865	9,198	9,038	0.97	0.92
NSP WB NASSAU WEST	17	13,750	12,179	13,660	12,117	11,811	12,702	12,405	0.86	0.97
GCP WB QUEENS	18	19.496	16,861	16,693	16,792	17,313	18,685	16,769	0.89	1.03
SUBTOTAL NSP WB	15-18	54,842	46,936	53,289	50,498	49,336	52,829	49,402	0.90	0.98
SUBTOTAL LIE/NSP EB		59,787	60,121	56,613	56,172	54,775	59,415	58,582	0.92	0.98
SUBTOTAL LIE/NSP WB		118,225	109,188	116,979	115,820	110,040	119,133	111,873	0.93	0.95
SUBTOTAL LIE/NSP EB/WB		178,012	169,309	173,592	171,992	164,815	178,548	170,455	0.93	0.96
CLEARVIEW NB	19	1,339	2,124	3,005	2,648	2,883	3,240	2,741	2.15	1.09
CLEARVIEW SB	20	730	1,929	2,121	2,587	2,463	2,759	3,110	3.37	0.95
CROSS ISLAND NB	21	1,831	2,124	2,130	2,569	2,523	2,948	2,957	1.38	0.98
CROSS ISLAND SB	22	1,162	1,409	1,414	1,147	1,055	1,286	1,203	0.91	0.92
MEADOWBROOK NB	23	652	309	1,146	1,147	1,255	1,378	1,009	1.92	1.09
MEADOWBROOK SB	24	394	594	1,077	1,064	1,205	1,290	1,031	3.06	1.13
WANTAGH PKWY NB	25	1,769	1,403	1,636	1,609	1,607	1,608	1,569	0.91	1.00
WANTAGH PKWY SB	26	602	441	719	489	490	511	521	0.81	1.00
SEAFORD-OYS NB	27	2,067	1,636	2,048	1,754	1,734	1,714	1,588	0.84	0.99
SEAFORD-OYS SB	28	343	531	384	337	344	390	355	1.00	1.02
SAGTIKOS NB	29	664	1,128	921	896	885	857	875	1.33	0.99
SAGTIKOS SB	30	1,967	1,860	2,111	1,848	1,789	1,752	1,669	0.91	0.97
SUBTOTAL OTHER	19-30	13,520	15,488	18,712	18,095	18,233	19,733	18,628	1.35	1.01
TOTAL		191,532	184,797	192,304	190,087	183,048	198,281	189,083	0.96	0.96

Table 6. Average vehicle hours of travel, p.m. peak (1530-1900).

	SEC.NO.	1987 SPRING	1988 FALL	1989 FALL	1990 MARCH N-METER	METER	APR/MAY NON-INC	JUNE NON-IN	RATIOS E/A	E/D
		A	B	C	D	E	F	G		
LIE EB QUEENS	1	19,910	17,806	19,021	15,264	15,001	18,559	21,484	0.75	0.98
LIE EB NASSAU WEST	2	13,491	15,427	14,946	13,814	13,978	15,314	16,576	1.04	1.01
LIE EB NASSAU EAST	3	8,653	11,137	10,171	9,742	10,041	10,856	10,013	1.16	1.03
LIE EB SUFFOLK WEST	4	12,436	11,588	10,263	13,021	12,095	11,965	12,728	0.97	0.93
LIE EB SUFFOLK EAST	5	14,659	14,190	11,398	11,565	11,944	12,034	11,734	0.81	1.03
SUBTOTAL LIE EB	1-5	69,149	70,148	65,799	63,406	63,059	68,728	72,535	0.91	0.99
LIE WB SUFFOLK EAST	6	7,766	6,660	6,721	6,349	6,565	6,321	6,946	0.85	1.03
LIE WB SUFFOLK WEST	7	7,373	6,607	6,978	6,673	6,828	7,231	7,357	0.93	1.02
LIE WB NASSAU EAST	8	10,426	9,165	8,303	7,856	7,856	8,072	8,998	0.75	1.00
LIE WB NASSAU WEST	9	11,459	10,944	10,415	8,911	9,517	9,923	12,152	0.83	1.07
LIE WB QUEENS	10	9,764	12,630	11,755	10,881	10,873	12,865	12,617	1.11	1.00
SUBTOTAL LIE WB	6-10	46,788	46,006	44,172	40,670	41,639	44,412	48,070	0.89	1.02
GCP EB QUEENS	11	23,130	22,317	23,396	22,513	24,600	21,418	20,870	1.06	1.09
NSP EB NASSAU WEST	12	14,335	14,707	15,011	14,954	15,838	14,941	15,975	1.10	1.06
NSP EB NASSAU EAST	13	7,459	7,616	8,208	8,332	8,660	8,745	8,061	1.18	1.04
NSP EB SUFFOLK	14	11,496	10,790	10,830	11,357	10,457	10,996	10,649	0.91	0.92
SUBTOTAL NSP EB	11-14	56,420	55,430	57,445	57,156	59,555	56,100	55,555	1.06	1.04
NSP WB SUFFOLK	15	5,409	4,873	5,158	5,105	5,158	5,707	5,562	0.95	1.01
NSP WB NASSAU EAST	16	5,948	5,257	5,117	4,886	4,919	5,184	5,526	0.83	1.01
NSP WB NASSAU WEST	17	11,216	9,602	8,778	8,584	8,602	8,583	11,150	0.77	1.00
GCP WB QUEENS	18	13,659	13,323	14,194	12,352	12,064	12,672	15,250	0.88	0.98
SUBTOTAL NSP WB	15-18	36,232	33,055	33,247	30,927	30,743	32,146	37,488	0.85	0.99
SUBTOTAL LIE/NSP EB		125,569	125,578	123,244	120,562	122,614	124,828	128,090	0.98	1.02
SUBTOTAL LIE/NSP WB		83,020	79,061	77,419	71,597	72,382	76,558	85,558	0.87	1.01
SUBTOTAL LIE/NSP EB/WB		208,589	204,639	200,663	192,159	194,996	201,386	213,648	0.93	1.01
CLEARVIEW NB	19	1,314	1,455	3,018	2,298	2,395	2,399	2,519	1.82	1.04
CLEARVIEW SB	20	1,200	1,182	2,092	1,913	1,945	1,828	2,490	1.62	1.02
CROSS ISLAND NB	21	1,701	1,881	2,163	1,859	1,897	1,943	2,237	1.12	1.02
CROSS ISLAND SB	22	2,320	1,333	2,669	2,572	2,548	2,804	3,147	1.10	0.99
MEADOWBROOK NB	23	884	347	737	768	836	1,041	1,160	0.95	1.09
MEADOWBROOK SB	24	982	394	648	619	651	620	577	0.66	1.05
WANTAGH PKWY NB	25	1,117	776	790	773	764	831	869	0.68	0.99
WANTAGH PKWY SB	26	1,944	1,446	1,337	1,299	1,343	1,353	1,481	0.69	1.03
SEAFORD-OYS NB	27	1,307	1,043	1,192	942	932	989	966	0.71	0.99
SEAFORD-OYS SB	28	762	1,084	803	720	725	796	825	0.95	1.01
SAGTIKOS NB	29	1,199	1,614	1,388	1,255	1,365	1,315	1,340	1.14	1.09
SAGTIKOS SB	30	1,553	1,348	1,475	1,256	1,277	1,214	1,273	0.82	1.02
SUBTOTAL OTHER	19-30	16,283	13,903	18,312	16,274	16,675	17,133	18,913	1.02	1.02
TOTAL		224,872	218,542	218,975	208,433	211,671	218,519	232,561	0.94	1.02

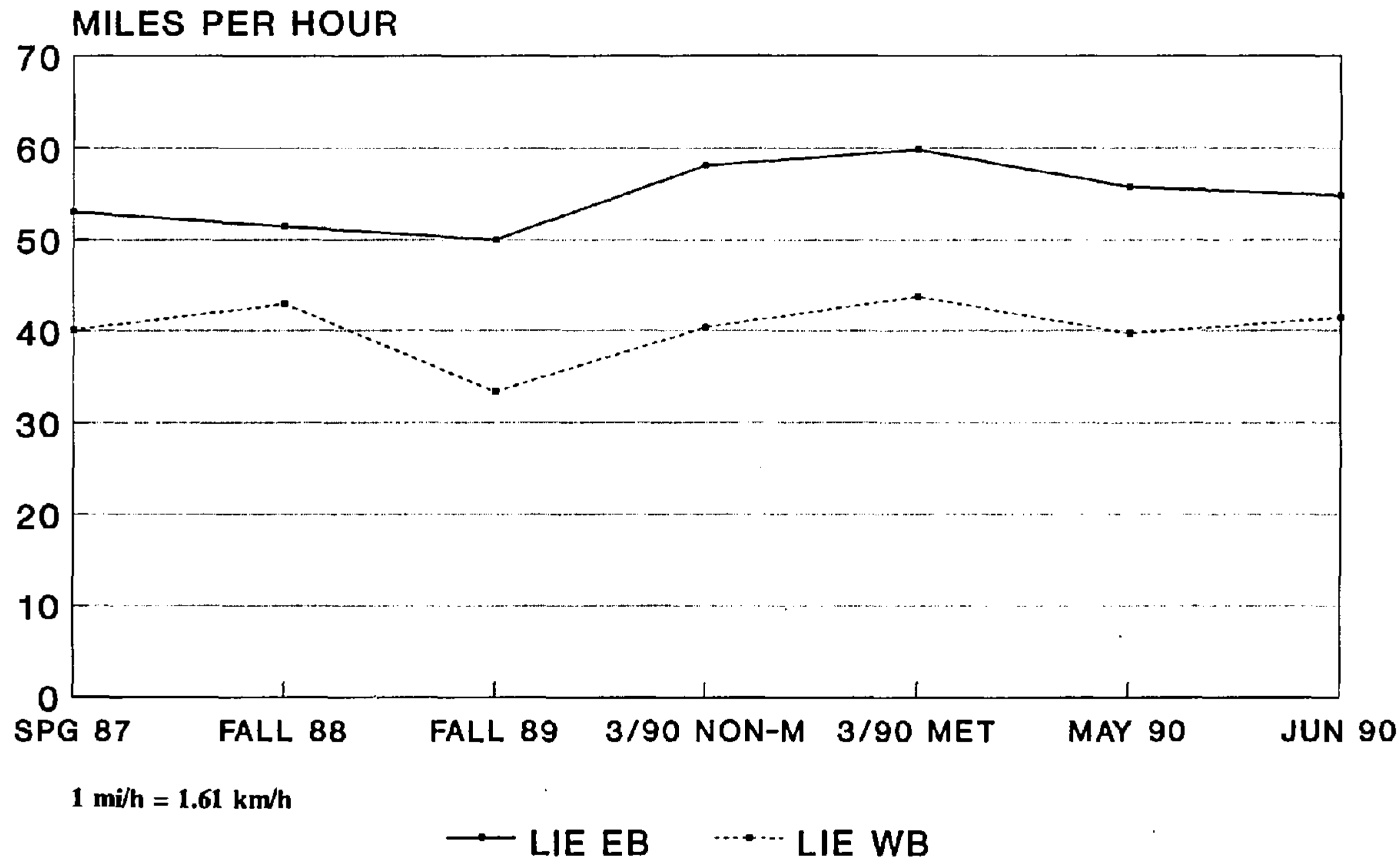


Figure 19. Average speed on the LIE, a.m. peak period (0600-0930).

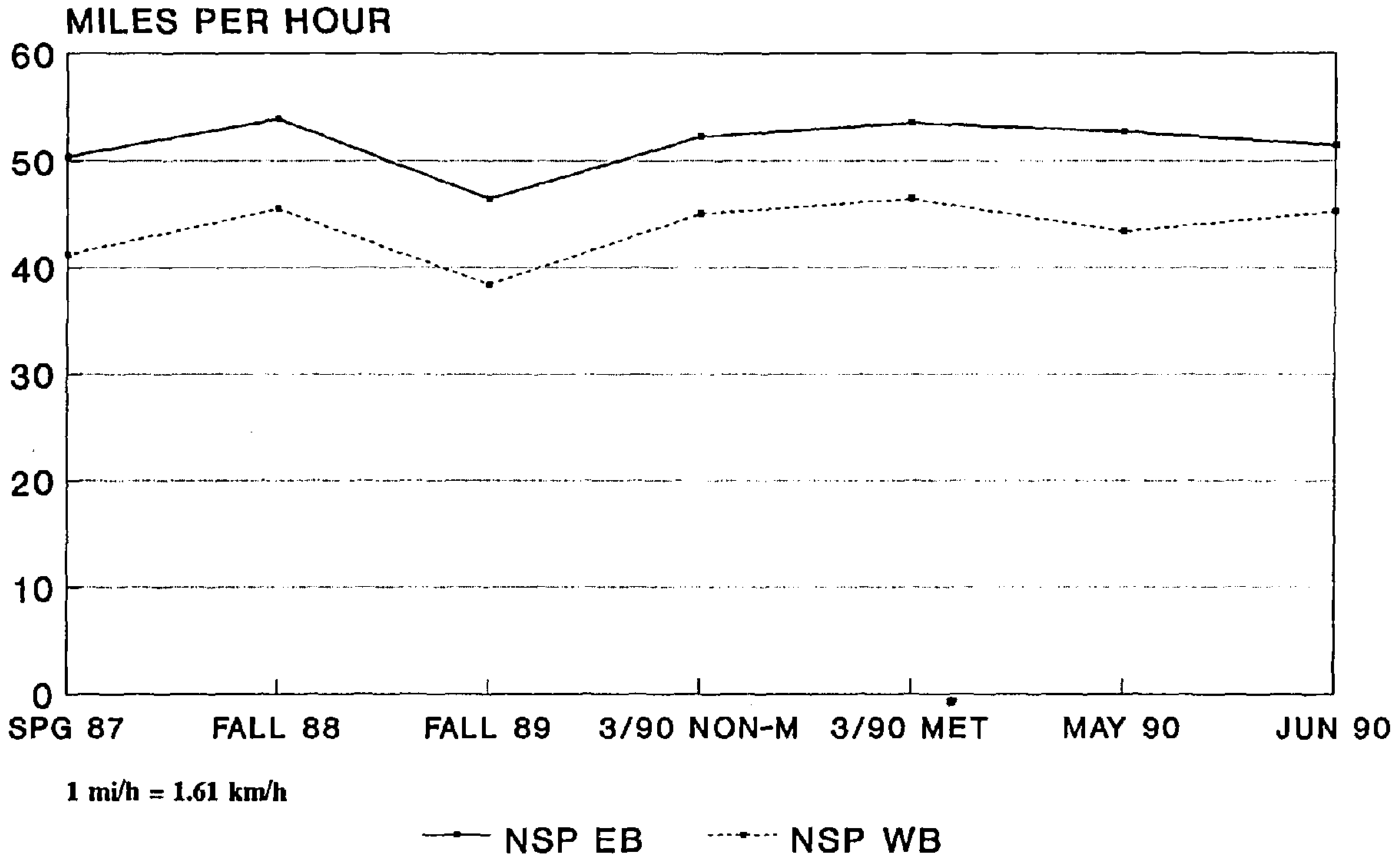


Figure 20. Average speed on the NSP/GCP, a.m. peak period (0600-0930).

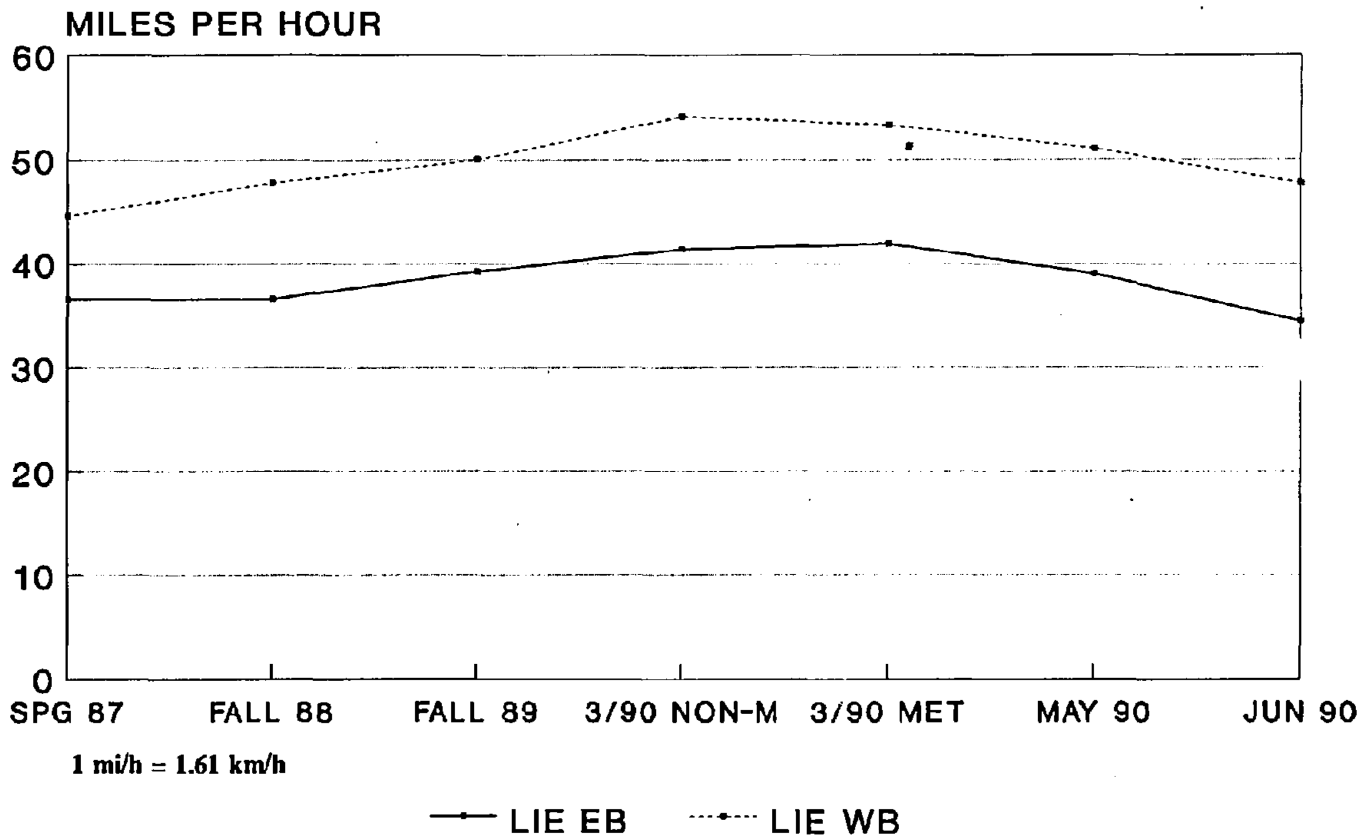


Figure 21. Average speed on the LIE, p.m. peak period (1530-1900).

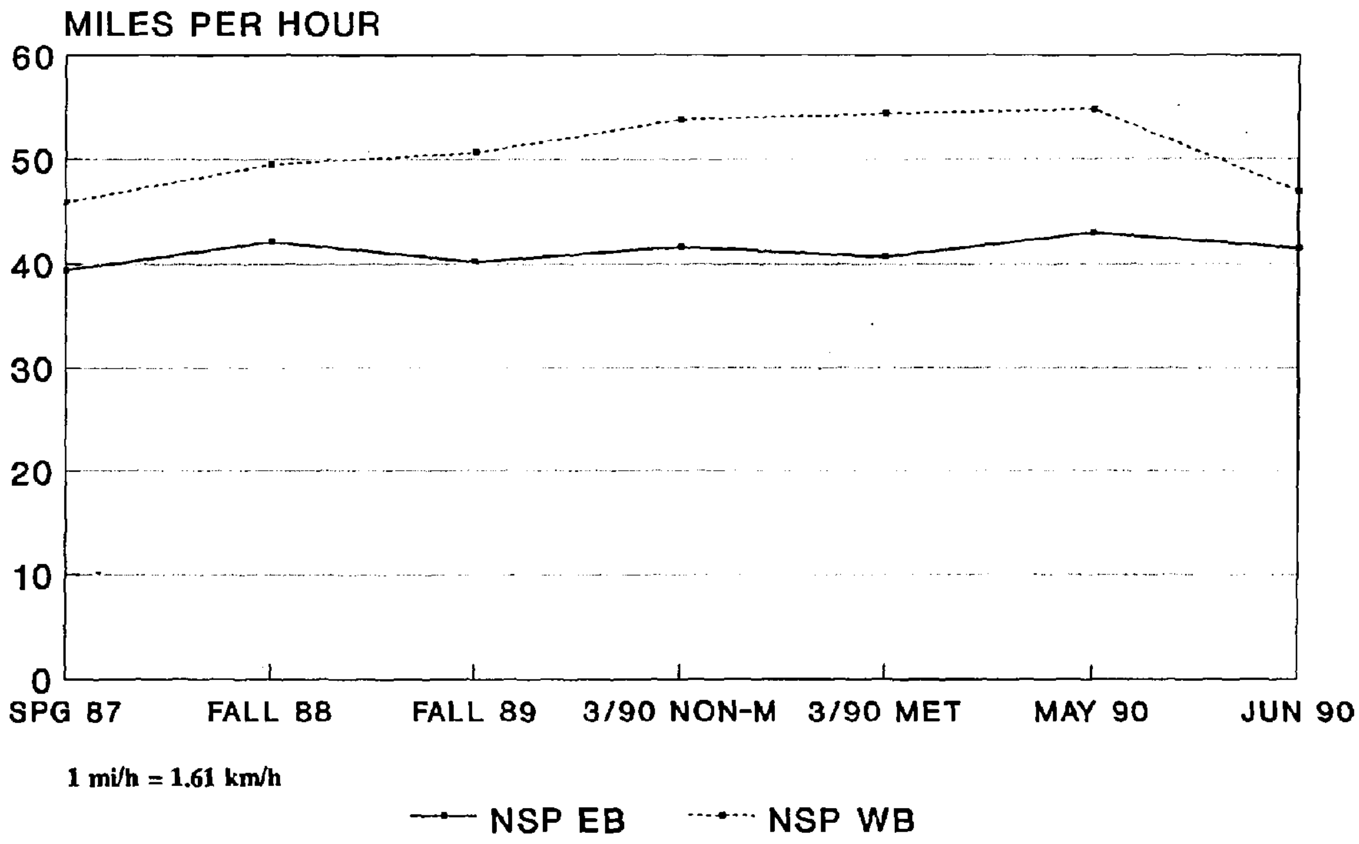


Figure 22. Average speed on the NSP/GCP, p.m. peak period (1530-1900).

Table 7. Average vehicle speeds, a.m. peak (0600-0930).

SECTION	SEC.NO	1987 SPRING	1988 FALL	1989 FALL	1990 MARCH N-METER	1990 MARCH METER	1990 APR/MAY	1990 JUNE	RATIOS E/A	RATIOS E/D
		A	B	C	D	E	F	G		
LIE EB QUEENS	1	39.5	36.4	32.5	42.4	46.2	40.3	39.3	1.17	1.09
LIE EB NASSAU WEST	2	56.1	58.3	58.8	68.2	68.3	65.9	62.4	1.22	1.00
LIE EB NASSAU EAST	3	62.5	54.7	59.8	62.6	64.1	62.1	61.3	1.03	1.02
LIE EB SUFFOLK WEST	4	61.2	63.9	60.6	64.9	64.6	63.3	65.2	1.06	1.00
LIE EB SUFFOLK EAST	5	58.3	61.2	51.1	59.4	61.1	58.6	56.7	1.05	1.03
SUBTOTAL LIE EB	1–5	53.0	51.4	50.0	58.1	59.8	55.8	54.8	1.13	1.03
LIE WB SUFFOLK EAST	6	37.8	50.4	27.6	41.3	44.0	41.4	41.6	1.16	1.07
LIE WB SUFFOLK WEST	7	42.8	48.5	37.2	45.4	50.2	45.4	49.3	1.17	1.11
LIE WB NASSAU EAST	8	41.9	53.5	37.3	46.2	53.5	48.4	49.0	1.28	1.16
LIE WB NASSAU WEST	9	38.1	38.8	32.1	41.9	42.8	37.9	39.8	1.12	1.02
LIE WB QUEENS	10	39.8	30.4	32.7	29.3	31.9	29.0	30.9	0.80	1.09
SUBTOTAL LIE WB	6–10	40.1	43.0	33.4	40.4	43.8	39.7	41.5	1.09	1.08
GCP EB QUEENS	11	43.5	47.6	38.1	44.8	46.6	46.1	43.4	1.07	1.04
NSP EB NASSAU WEST	12	55.8	56.5	51.4	58.4	59.2	57.6	56.4	1.06	1.01
NSP EB NASSAU EAST	13	57.1	65.2	52.8	58.3	58.9	58.0	58.2	1.03	1.01
NSP EB SUFFOLK	14	57.1	58.7	59.8	62.9	62.8	62.8	62.3	1.10	1.00
SUBTOTAL NSP EB	11–14	50.4	53.9	46.4	52.2	53.5	52.7	51.4	1.06	1.02
NSP WB SUFFOLK	15	43.4	50.7	38.2	45.0	47.5	43.9	47.6	1.09	1.06
NSP WB NASSAU EAST	16	42.2	48.9	40.5	41.7	45.3	43.7	44.3	1.07	1.09
NSP WB NASSAU WEST	17	43.1	47.5	38.7	51.8	52.8	49.0	49.6	1.23	1.02
GCP WB QUEENS	18	37.9	39.2	37.2	41.8	42.0	39.2	40.8	1.11	1.00
SUBTOTAL NSP WB	15–18	41.2	45.5	38.4	45.0	46.4	43.4	45.2	1.13	1.03
SUBTOTAL LIE/NSP EB		51.8	52.5	48.3	55.3	56.8	54.4	53.3	1.10	1.03
SUBTOTAL LIE/NSP WB		40.6	44.1	35.7	42.4	45.0	41.4	43.1	1.11	1.06
SUBTOTAL LIE/NSP EB/WB		44.4	47.0	39.8	46.6	48.9	45.7	46.6	1.10	1.05
CLEARVIEW NB	19	44.4	47.0	41.1	52.2	53.2	49.7	46.2	1.20	1.02
CLEARVIEW SB	20	53.5	55.6	53.4	64.4	68.0	61.3	49.1	1.27	1.06
CROSS ISLAND NB	21	41.8	55.7	51.7	56.5	59.4	48.7	45.0	1.42	1.05
CROSS ISLAND SB	22	46.7	53.0	48.1	54.8	58.7	52.1	51.9	1.26	1.07
MEADOWBROOK NB	23	52.6	67.4	39.9	42.8	39.0	34.9	43.3	0.74	0.91
MEADOWBROOK SB	24	52.9	56.7	42.0	44.6	40.8	38.3	44.4	0.77	0.91
WANTAGH PKWY NB	25	37.9	49.3	41.9	46.3	45.8	46.6	45.9	1.21	0.99
WANTAGH PKWY SB	26	52.4	66.1	54.4	64.1	65.0	61.7	58.6	1.24	1.01
SEAFORD-OYS NB	27	48.5	65.1	47.9	56.6	56.1	58.6	62.0	1.16	0.99
SEAFORD-OYS SB	28	69.5	53.6	64.2	69.2	68.4	68.2	68.7	0.98	0.99
SAGTIKOS NB	29	53.6	52.8	55.4	60.2	60.2	60.6	60.5	1.12	1.00
SAGTIKOS SB	30	53.7	56.8	52.4	59.4	60.0	58.1	57.3	1.12	1.01
SUBTOTAL OTHER	19–30	48.0	55.1	48.0	55.4	55.8	52.0	50.4	1.16	1.01
TOTAL		44.6	47.7	40.6	47.5	49.6	46.3	47.0	1.11	1.04

1 mi/h = 1.61 km/h

Table 8. Average vehicle speeds, p.m. peak (1530-1900).

SECTION	NO.	1987 SPRING	1988 FALL	1989 FALL	1990 MARCH -METER	METER	1990 PR/MAY	1990 JUNE	RATIOS E/A	E/D
		A	B	C	D	E	F	G		
LIE EB QUEENS	1	27.3	30.6	27.1	32.7	32.6	30.4	23.7	1.19	1.00
LIE EB NASSAU WEST	2	44.2	38.5	40.6	46.5	46.7	41.3	35.5	1.06	1.00
LIE EB NASSAU EAST	3	55.6	41.7	47.1	50.9	50.0	45.1	46.8	0.90	0.98
LIE EB SUFFOLK WEST	4	41.5	46.0	54.4	43.3	47.3	48.1	42.5	1.14	1.09
LIE EB SUFFOLK EAST	5	27.0	30.3	36.7	36.8	35.6	35.0	33.4	1.32	0.97
SUBTOTAL LIE EB	1-5	36.6	36.6	39.2	41.4	41.9	39.0	34.4	1.14	1.01
LIE WB SUFFOLK EAST	6	48.8	59.7	59.3	62.6	62.2	61.4	58.2	1.27	0.99
LIE WB SUFFOLK WEST	7	54.6	63.4	62.9	64.1	63.8	62.0	63.8	1.17	1.00
LIE WB NASSAU EAST	8	45.7	54.3	60.2	63.9	64.8	63.9	59.9	1.42	1.01
LIE WB NASSAU WEST	9	36.0	39.1	42.2	50.7	47.5	47.4	37.9	1.32	0.94
LIE WB QUEENS	10	42.7	36.3	36.8	38.5	38.0	34.8	33.5	0.89	0.99
SUBTOTAL LIE WB	6-10	44.6	47.8	50.0	54.1	53.3	51.1	47.8	1.20	0.99
GCP EB QUEENS	11	32.4	34.1	32.9	35.7	33.1	38.3	34.2	1.02	0.93
NSP EB NASSAU WEST	12	41.6	45.5	41.5	44.0	42.4	42.9	40.9	1.02	0.96
NSP EB NASSAU EAST	13	45.9	47.5	44.4	44.6	44.3	44.1	46.6	0.97	0.99
NSP EB SUFFOLK	14	46.3	50.0	51.0	47.8	52.9	51.5	52.6	1.14	1.11
SUBTOTAL NSP EB	11-14	39.4	42.1	40.2	41.6	40.7	43.0	41.5	1.03	0.98
NSP WB SUFFOLK	15	54.7	58.8	59.1	59.1	59.3	59.4	59.0	1.08	1.00
NSP WB NASSAU EAST	16	49.4	52.9	54.9	58.1	58.1	57.9	55.4	1.18	1.00
NSP WB NASSAU WEST	17	40.3	47.8	51.6	54.6	55.5	55.4	44.3	1.38	1.02
GCP WB QUEENS	18	45.4	46.0	45.4	49.3	50.1	51.2	41.6	1.10	1.02
SUBTOTAL NSP WB	15-18	45.9	49.5	50.6	53.8	54.4	54.8	47.0	1.19	1.01
SUBTOTAL LIE/NSP EB		37.9	39.0	39.7	41.5	41.3	40.8	37.5	1.09	1.00
SUBTOTAL LIE/NSP WB		45.2	48.5	50.3	53.9	53.8	52.7	47.4	1.19	1.00
SUBTOTAL LIE/NSP EB/WB		40.8	42.7	43.8	46.1	45.9	45.3	41.5	1.13	1.00
CLEARVIEW NB	19	43.3	48.2	45.9	56.7	57.6	58.1	46.9	1.33	1.02
CLEARVIEW SB	20	51.7	63.1	62.5	70.0	68.9	66.1	53.1	1.33	0.98
CROSS ISLAND NB	21	44.9	57.0	54.7	64.3	62.2	57.2	51.4	1.39	0.97
CROSS ISLAND SB	22	40.9	54.1	36.8	43.7	42.0	40.4	31.4	1.03	0.96
MEADOWBROOK NB	23	48.1	68.2	54.7	54.0	52.9	45.8	42.6	1.10	0.98
MEADOWBROOK SB	24	50.7	64.1	55.9	55.4	54.8	51.1	51.9	1.08	0.99
WANTAGH PKWY NB	25	46.3	56.8	61.3	61.4	62.1	61.3	59.1	1.34	1.01
WANTAGH PKWY SB	26	40.9	53.7	53.7	59.1	58.0	55.7	50.7	1.42	0.98
SEAFORD-OYS NB	27	56.0	69.4	61.5	66.8	67.7	66.8	67.3	1.21	1.01
SEAFORD-OYS SB	28	67.4	52.2	65.1	66.8	66.3	65.8	65.3	0.98	0.99
SAGTIKOS NB	29	53.6	53.4	56.3	59.3	58.5	59.7	59.0	1.09	0.99
SAGTIKOS SB	30	52.3	54.9	56.1	57.5	58.2	55.6	55.1	1.11	1.01
SUBTOTAL OTHER	19-30	48.2	56.4	52.9	58.6	58.0	55.8	49.7	1.20	0.99
TOTAL		41.3	43.6	44.5	47.1	46.9	46.1	42.1	1.14	1.00

1 mi/h = 1.61 km/h

Table 9. Summary of significance tests of combined LIE and NSP/GCP measures.

PERIOD	MEASURE	VALUE MARCH 1990 METERED	MARCH 1990 NON-MET	SPRING 1987	t-VALUE	SIGNIFICANCE LEVEL
AM	VMT	8065390		7899216	1.50	NS
AM	VMT	8065390	8019401		0.58	NS
PM	VMT	8955644		8503399	3.65	95%
PM	VMT	8955644	8864070		2.55	95%
AM	VHT	164815		178012	2.99	95%
AM	VHT	164815	171992		4.48	95%
PM	VHT	194966		208589	1.91	90%
PM	VHT	194966	192159		1.19	NS
AM	SPEED	48.9		44.4	4.12	95%
AM	SPEED	48.9	46.6		4.15	95%
PM	SPEED	45.9		40.8	3.89	95%
PM	SPEED	45.9	46.1		0	NS

KEY

NS = Not Significant

90% = Significant at 90% Confidence (Critical t-value = 1.74)

95% = Significant at 95% Confidence (Critical t-value = 2.11)

1 mi = 1.61 km

1 vehicle mile = 1.61 vehicle kilometer

The a.m. VHT is significantly different between the March metered condition and the March nonmetered and spring 1987 condition. The p.m. VHT is significantly lower for the March metered condition compared with the spring 1987 condition. The p.m. VHT is actually lower for the March nonmetered condition than for the March metered condition, but the difference is not significant. Average speeds are significantly different for all but the p.m. comparison between the March metered and March nonmetered conditions.

OVERVIEW OF SYSTEM HARDWARE PERFORMANCE

One of the evaluation parameters involves the extent to which the system is operational over time. Systematic records of failures of various components were first kept in fall 1988. Figures 23 through 27 indicate the number of daily failures of the various components. For the most part, the numbers represent how many signs, detectors, etc., were inoperable on the average day during that month. It is interesting to note that the number of failures tends to increase during the summer. This is partly attributed to increased summer construction activity, which results in more frequent interruptions of communications.

It is also noteworthy that, except for signs, significant progress has been made in keeping the system in working order. Particularly critical are the detector failures, which dropped significantly in August 1989. This was largely the result of a concerted effort by the operations contractor and maintenance contractor. This highlights the importance of system maintenance in running a functional traffic control system. The number of daily failures includes those pieces of hardware that were nonfunctional for extended periods of time due to waiting for parts or maintenance attention. There are still a number of signs in need of restoration to full service. The next chapter provides an evaluation of the effectiveness of the variable message signing subsystem.

ARTERIAL SYSTEM PERFORMANCE

Arterial and Ramp Volume

Sparse detectorization on the LIE service road made the determination of volume differences difficult. However, comprehensive data from the ramps provide a sense of volume changes on the arterials, and other limited information from machine counts on the LIE service road are available. Tables 10 and 11 provide an example of the a.m. peak period volume (nonincident conditions, expressed in vehicles per hour over the peak period) for the 3 primary comparison periods for the on-ramps from the arterials feeding the LIE and NSP/GCP. The western half of the LIE on-ramps represent ramps from the service roads. Tables 10 and 11 also present ratios of the March 1990 metered condition to the spring 1987 and March 1990 nonmetered condition. These ratios are represented by the letters designating the columns.

Table 10 indicates that the March 1990 on-ramp volume is slightly higher than the corresponding 1987 on-ramp volume for the a.m. peak period on the LIE. The section in Queens sustained the largest increase in volume, while there was little change for Nassau and Suffolk County ramp volumes. There was a slight (1-percent) decrease in total on-ramp volume for the March 1990 metered case compared to the March 1990 nonmetered case. However, the entire increase came from the section in Queens. On-ramp volume in Nassau and Suffolk Counties actually decreased for the March 1990 metered case, and the volume for metered ramps decreased at a slightly higher rate than for the overall volume.

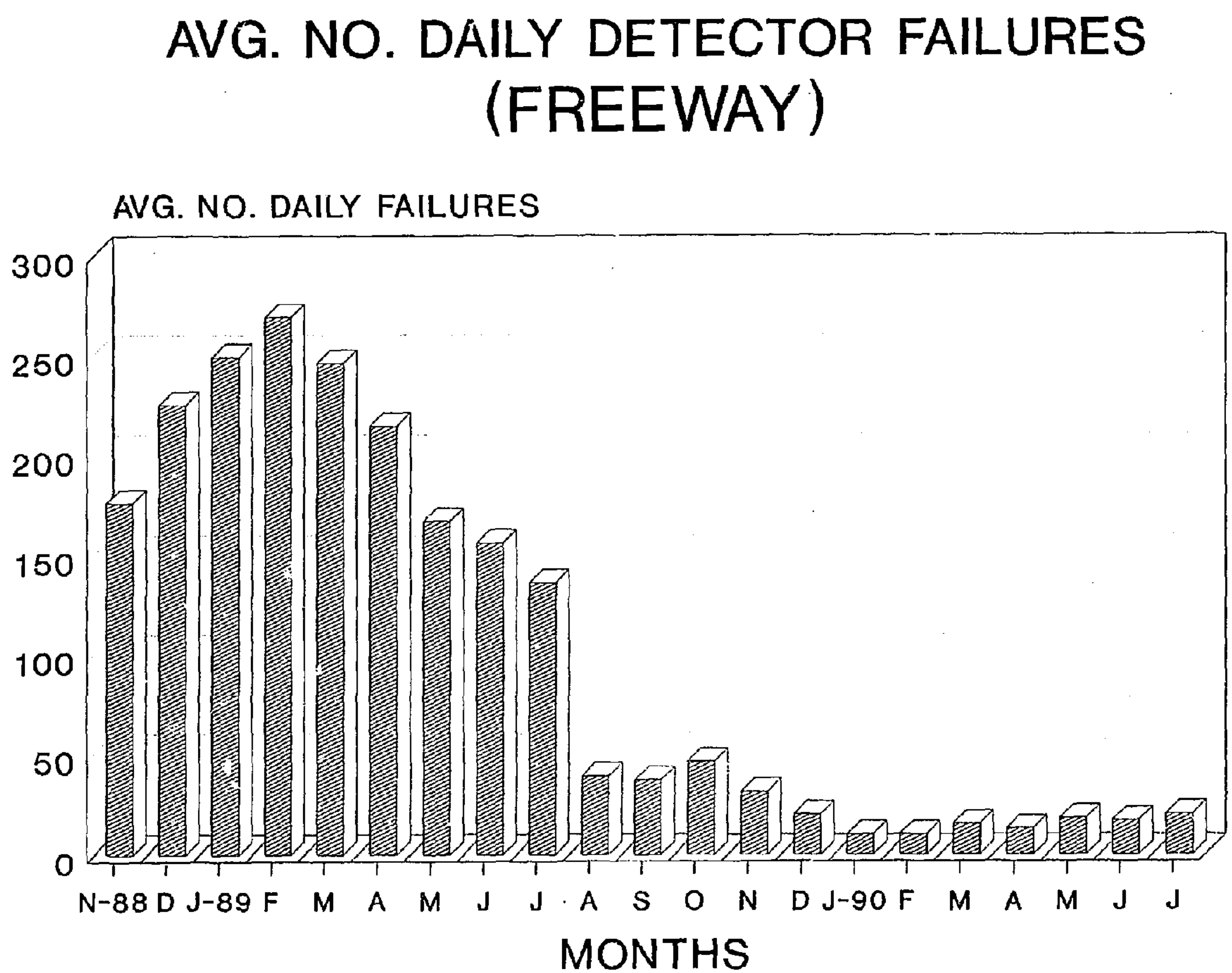


Figure 23. Average number of daily detector failures (freeway).

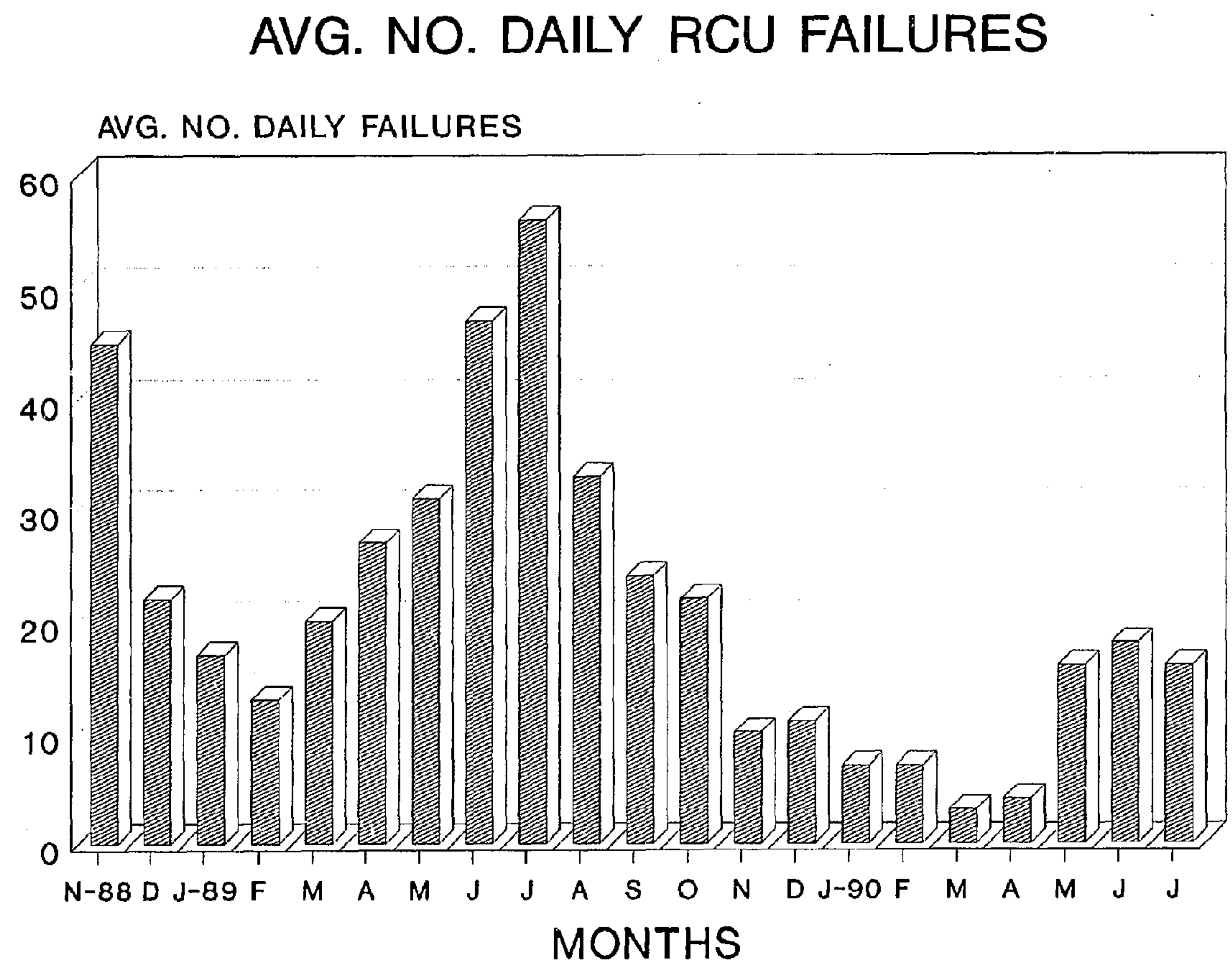


Figure 24. Average number of daily RCU failures.

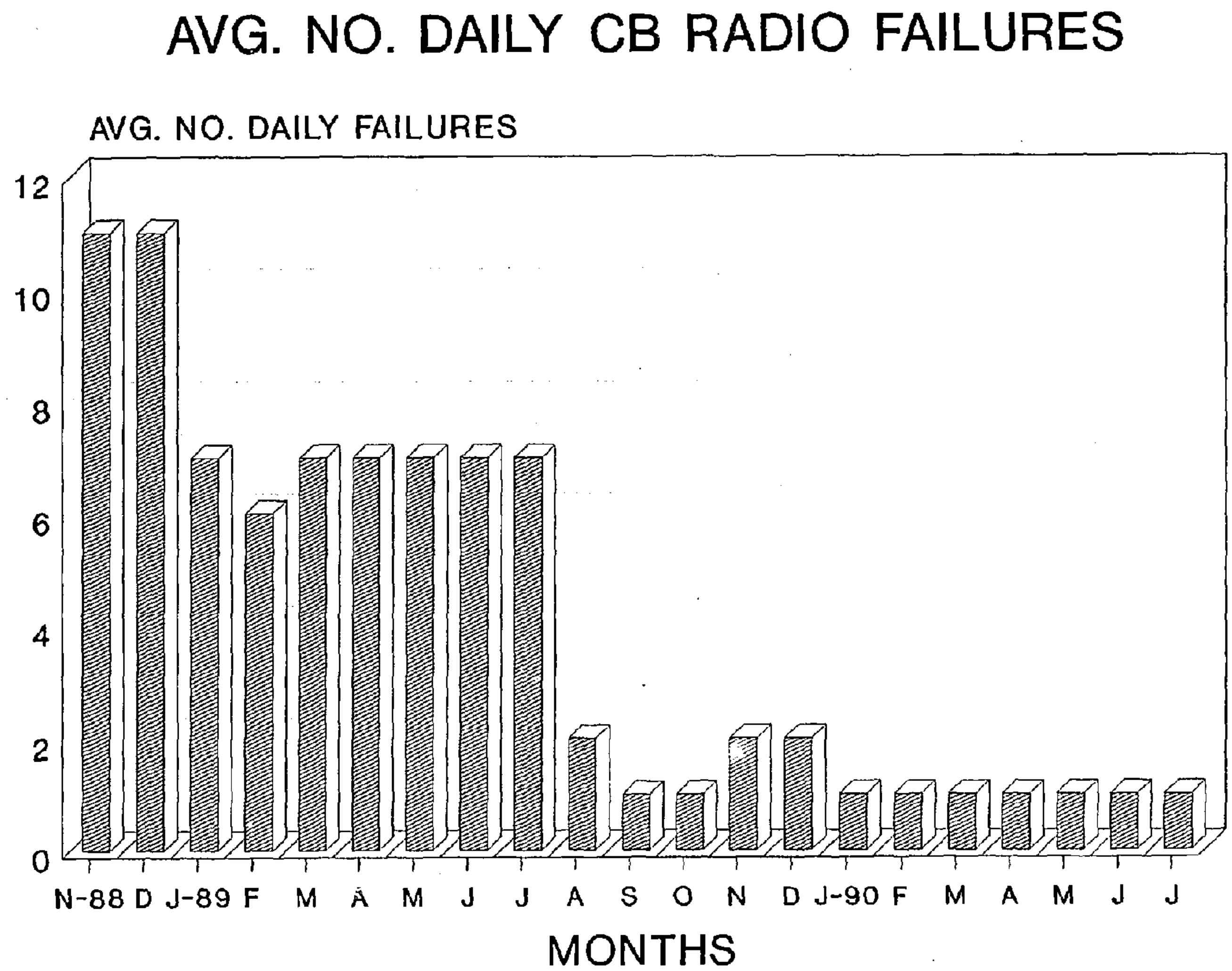


Figure 25. Average number of daily CB radio failures.

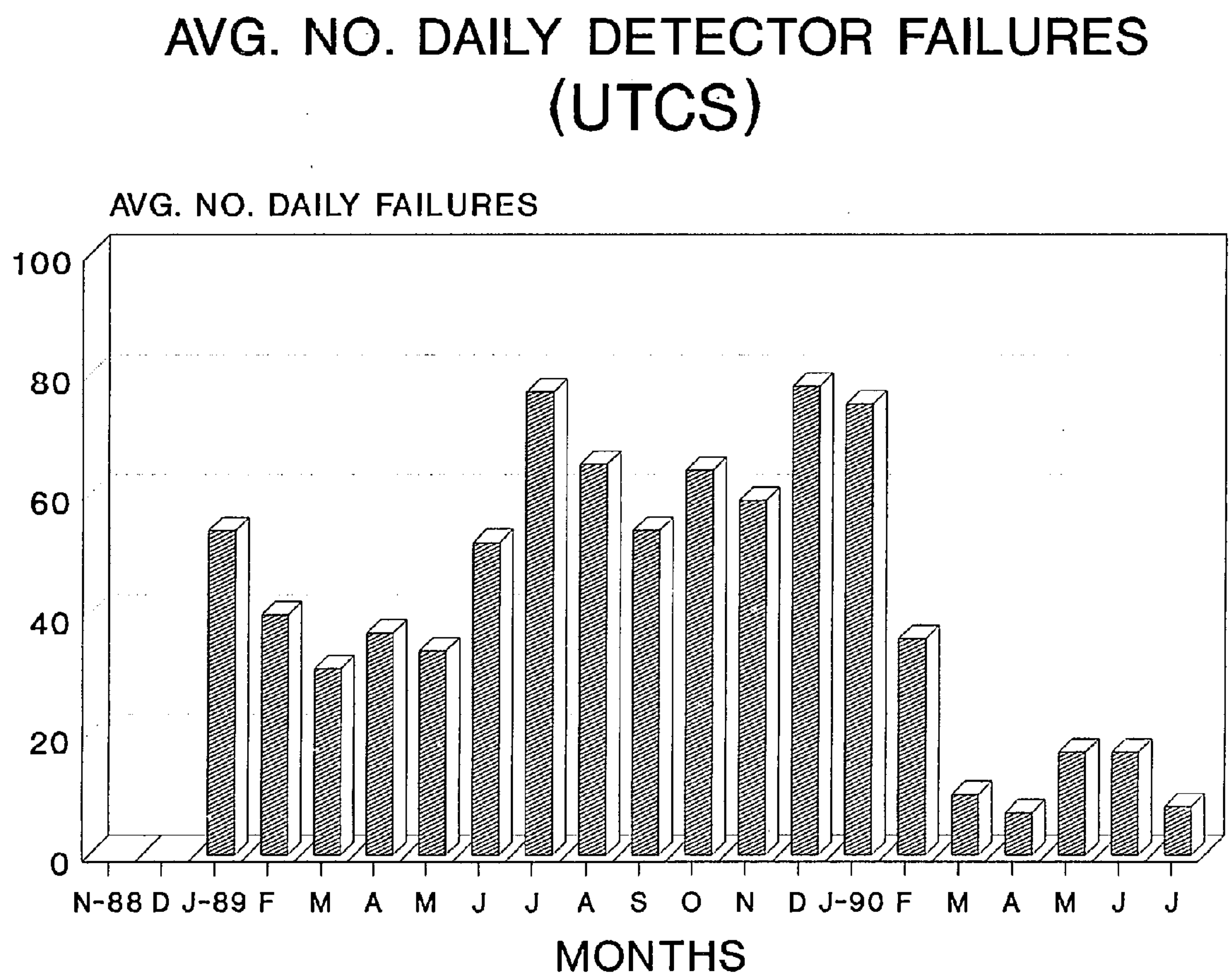


Figure 26. Average number of daily detector failures (UTCS).

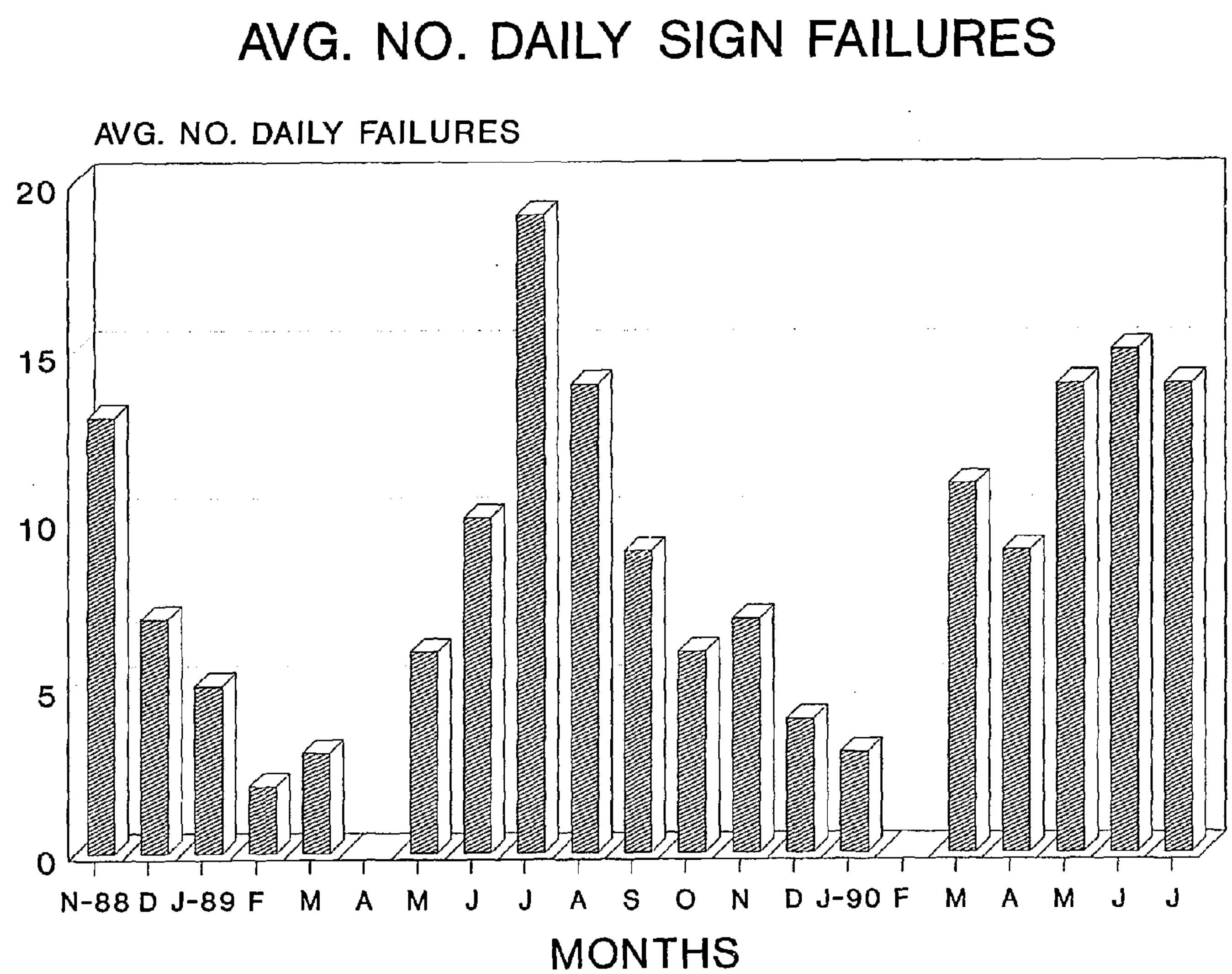


Figure 27. Average number of daily sign failures.

Table 10. Changes in LIE westbound on-ramp volumes (a.m. peak period).

ZONE NO.	ON-RAMP NAME	MTRD?	SPRING 1987 (A)	MARCH 1990 NON-MET (B)	MARCH 1990 METERED (C)	C/A	C/B
	SUFFOLK						
126	Veterans Hwy.	No	1207	1161	1120	0.928	0.965
130	Rt. 111	Yes	475	482	463	0.975	0.961
131	Vanderbilt	Yes	386	393	402	1.041	1.023
142	Commack	Yes	671	705	689	1.027	0.977
147	Deer Park Ave.	No	894	864	862	0.964	0.998
151	Bagatelle	Yes	582	565	562	0.966	0.995
155	Rt. 110 North	No	143	235	241	1.685	1.026
157	Rt. 110 South	No	495	533	548	1.107	1.028
Subtotal (metered)			2114	2145	2116	1.001	0.986
Subtotal			4853	4938	4887	1.007	0.990
	NASSAU						
160	Round Swamp	Yes	195	181	160	0.821	0.884
164	Sunnyside	Yes	86	101	106	1.233	1.050
165	N. State Pkwy.	No	905	933	905	1.000	0.970
166	Manetto Hill	No	336	355	328	0.976	0.924
169	Sea OB Exp N	No	1080	1129	1103	1.021	0.977
171	Sea OB Exp S	No	762	355	354	0.465	0.997
178	Rt. 106/107 N	No	467	545	534	1.143	0.980
183	Jericho Tpk.	Yes	465	448	397	0.854	0.886
192	Glen Cove	No	62	64	65	1.048	1.016
194	Glen Cove	Yes	507	580	475	0.937	0.819
195	N. State Pkwy.	No	932	845	862	0.925	1.020
198	Willis	No	191	282	256	1.340	0.908
201	Searingtown	Yes	241	257	245	1.017	0.953
203	Shelter Rock	Yes	178	193	196	1.101	1.016
206	New Hyde Park	Yes	300	303	303	1.010	1.000
209	Community	Yes	234	300	309	1.321	1.030
211	Lakeville	Yes	205	218	232	1.132	1.064
Subtotal (metered)			2411	2581	2423	1.005	0.939
Subtotal			7146	7089	6830	0.956	0.963
	QUEENS						
214	L.Neck	Yes	393	484	487	1.239	1.006
217	Cross Island	No	1120	1275	1305	1.165	1.024
221	Springfield	No	441	452	407	0.923	0.900
224	Clearview N	No	548	635	637	1.162	1.003
225	Clearview S	No	279	312	321	1.151	1.029
226	Ft. Lewis	No	330	369	380	1.152	1.030
229	Utopia	Yes	415	455	530	1.277	1.165
232	Kissena	No	384	492	479	1.247	0.974
235	Main St.	Yes	179	266	274	1.531	1.030
238	Van Wyck	No	299	53	69	0.231	1.302
Subtotal (metered)			987	1205	1291	1.308	1.071
Subtotal			4388	4793	4889	1.114	1.020
Total			16387	16820	16606	1.013	0.987

Table 11. Changes in NSP/GCP westbound on-ramp volumes (a.m. peak period).

ZONE NO.	ON-RAMP NAME	MTRD?	SPRING 1987 (A)	MARCH 1990 NON-MET (B)	MARCH 1990 METERED (C)	C/A	C/B
	SUFFOLK						
364	Veterans Hwy.	No	101	90	91	0.901	1.011
368	Sagtikos N	No	541	641	611	1.129	0.953
370	Sagtikos S.	No	431	490	499	1.158	1.018
372	Commack	No	324	295	287	0.886	0.973
378	Deer Park NB	No	85	92	82	0.965	0.891
380	Deer Park SB	No	562	609	609	1.084	1.000
385	Wolf Hill	No	452	420	410	0.907	0.976
390	Rt. 110 NB	No	103	127	115	1.117	0.906
392	Rt 110 SB	Yes	430	425	421	0.979	0.991
395	Round Swamp	No	195	229	190	0.974	0.830
Subtotal (metered)			430	425	421	0.979	0.991
Subtotal			3224	3418	3315	1.028	0.970
	NASSAU						
399	Sunnyside	No	215	261	224	1.042	0.858
402	Manetto Hill	No	137	159	159	1.161	1.000
403	Sea OB Exp	No	670	674	668	0.997	0.991
405	SO Bay N	No	145	137	144	0.993	1.051
407	SO Bay SB	Yes	65	62	65	1.000	1.048
410	LIE	No	425	406	406	0.955	1.000
412	Rt. 106 NB	No	153	137	136	0.889	0.993
414	Rt. 106 SB	No	95	106	101	1.063	0.953
418	Brush Hollow	No	124	111	104	0.839	0.937
420	Wantagh	No	1342	1446	1459	1.087	1.009
422	Post Ave. NB	No	44	39	38	0.864	0.974
424	Post Ave. SB	No	154	129	129	0.838	1.000
437	Roslyn Rd	Yes	535	565	553	1.034	0.979
439	Willis	Yes	442	458	452	1.023	0.987
442	Shelter Rock	Yes	569	579	567	0.996	0.979
446	New Hyde Park	Yes	375	384	373	0.995	0.971
448	Lakeville NB	No	272	234	233	0.857	0.996
Subtotal (metered)			1986	2048	2010	1.012	0.981
Subtotal			5762	5887	5811	1.009	0.987
	QUEENS						
450	Lakeville SB	Yes	105	122	122	1.162	1.000
453	L. Neck	Yes	467	486	468	1.002	0.963
455	Cross Is. N	No	1374	1571	1541	1.122	0.981
456	Cross Is. S	No	442	410	381	0.862	0.929
457	Union Tpk.	Yes	203	13	14	0.069	1.077
459	Clearview	No	929	1020	996	1.072	0.976
461	Ft. Lewis NB	No	370	362	372	1.005	1.028
463	Ft. Lewis SB	Yes	127	168	162	1.276	0.964
465	188	No	435	439	430	0.989	0.979
467	Utopia	No	210	209	216	1.029	1.033
471	Union Tpk.	No	550	500	514	0.935	1.028
472	VW & Interboro	No	3335	2725	2718	0.815	0.997
475	Jewel Ave.	No	212	211	210	0.991	0.995
476	Van Wyck	No	215	244	243	1.130	0.996
477	Flush Park	No	7	8	12	1.714	1.500
480	LIE E&W	No	1529	1474	1426	0.933	0.967
Subtotal (metered)			902	789	766	0.849	0.971
Subtotal			10510	9962	9825	0.935	0.986
Total			19496	19267	18951	0.972	0.984

It was indicated earlier in the report that INFORM may have had both long-term effects in altering overall travel patterns as well as short-term effects. The comparison between March 1990 metering and spring 1987 would represent the long-term shifts. The long-term shifts could have been induced by both the metering system and by the VMS system, wherein motorists may have found new travel routes in response to the information provided by INFORM or due to the metering of traffic. One way of interpreting the changes in table 10 is to conclude that the limitations in on-ramp volume on upstream sections (i.e., Nassau and Suffolk) allowed for increases in on-ramp volume on downstream sections (i.e., Queens). Another contributing factor seems to be a shift in volume between the LIE and the NSP/GCP, particularly in Queens. In Queens, the on-ramp volume on the GCP dropped significantly, while the on-ramp volume on the LIE increased significantly. This could have been a long-term response to either the metering or to the improved information generally available. However, the change could also have come from other factors influencing travel patterns in the corridor. For example, a major portion of the decrease on the NSP/GCP was a result of a significant decrease in volume from the Van Wyck Expressway. This decrease could have been caused by a number of other nonINFORM factors.

While the information available on actual arterial volume is scant, the overall trend seems to be one of a slight increase. One of the machine counts indicated up to a 15-percent increase in volume on the LIE service road in Queens between spring 1987 and spring 1990. However, as will be indicated in chapter 4, an incident significantly modifies ramp and arterial volume distributions.

Some diversion of shorter trips to the parallel arterials is typically expected as a byproduct of ramp metering. Some of these short trips would likely not have accessed the freeway at all. If a significant amount of this metering-induced diversion had occurred on INFORM, then the March 1990 metered on-ramp volumes would be generally lower than the March 1990 nonmetered volumes and would possibly be lower than the spring 1987 on-ramp volumes. In addition, one might expect the volumes for nonmetered ramps to increase in volume during periods of metering. Examination of this pattern does not suggest that substantial amounts of meter-induced diversion actually took place.

Nevertheless, the perception surveys (see chapter 6) indicated that some drivers do, in fact, divert to avoid ramp meters. The degree to which these volume shifts take place on INFORM is imperceptible for the metering strategies employed during the course of this evaluation. A more restrictive metering strategy may have resulted in clearly recognizable changes in volume patterns.

Arterial Speed

Average speeds are available from 1987 and 1990 travel time runs on the LIE service roads, which comprise the most significant arterial diversion route in the corridor. Average speed on the LIE service roads decreased by 1 mi/h (1.6 km/h) in the a.m. peak period westbound and increased by 3 mi/h (4.8 km/h) in the p.m. peak period eastbound. These changes are not statistically significant.

Figures 28 and 29 show two plots of arterial speed by time of day for the section of LIE service road between Jericho Turnpike and New Hyde Park Road, 1 for the a.m. peak period westbound and 1 for the p.m. peak period eastbound. Speeds are categorized by half-hour periods and represent nonincident conditions. Speeds in this section of the service road are relatively high for an arterial, as there are a number of long, unsignalized stretches of roadway. Average speeds generally range between 30 and 35 mi/h (48 and 56 km/h). Although the data is not shown, speeds on the

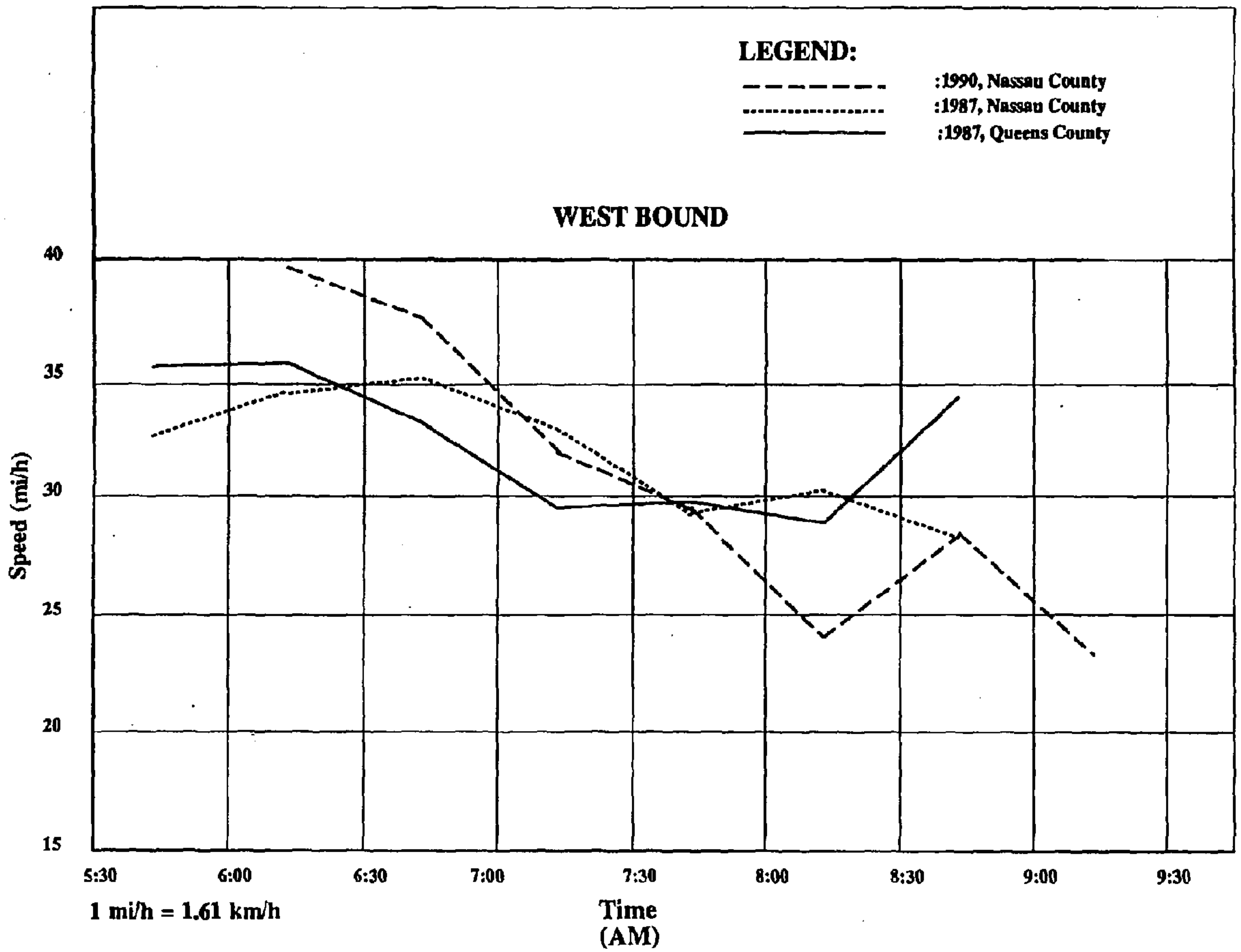


Figure 28. Comparison of average speed on the westbound LIE service road by half-hour period within the a.m. peak period.

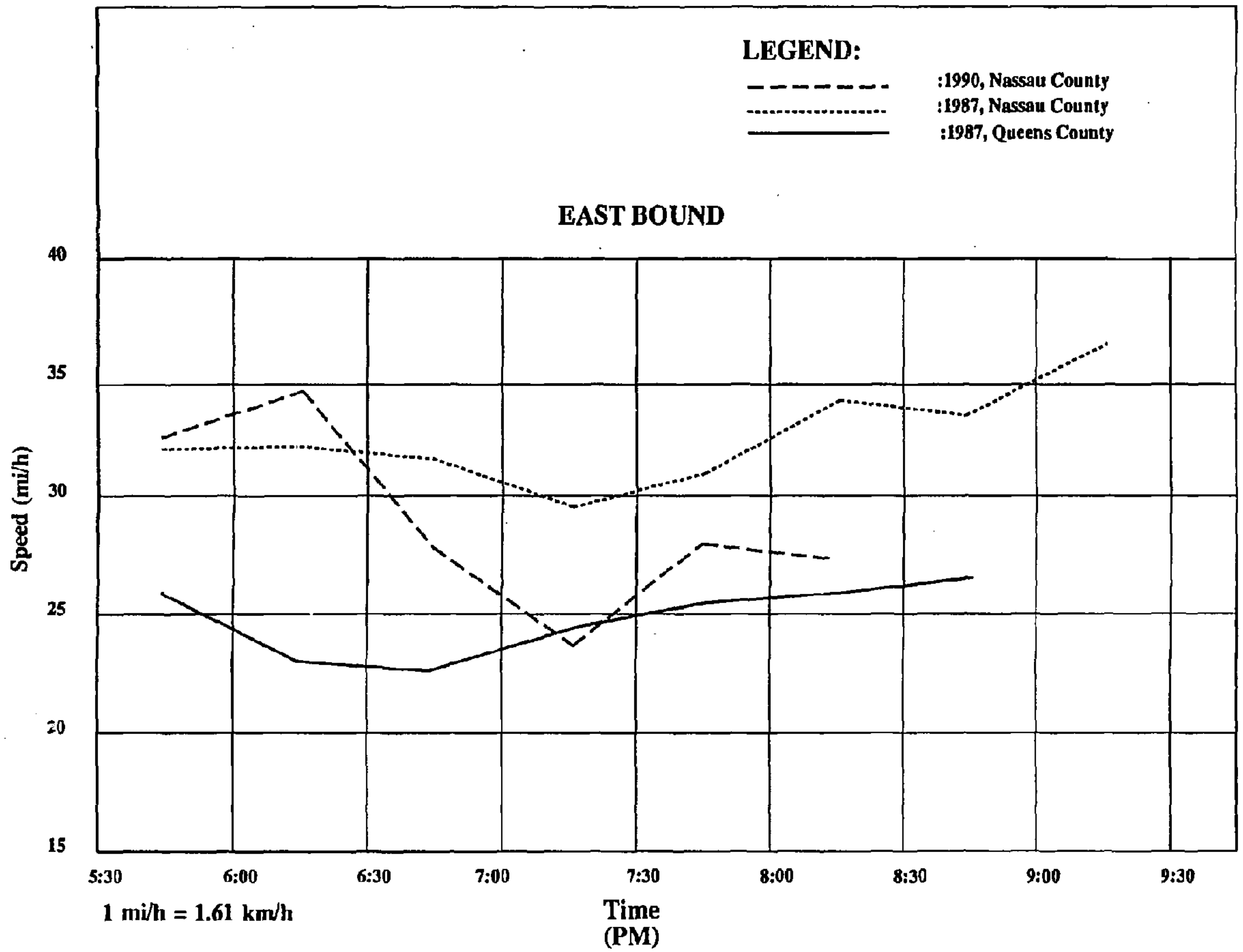


Figure 29. Comparison of average speed on the eastbound LIE service road by half-hour period within the a.m. peak period.

westbound LIE service road in Queens are somewhat slower, particularly in the eastbound p.m., during which average speeds fluctuate between 22 and 27 mi/h (35 and 43 km/h). Figures 28 and 29 indicate that, while the speed over the peak period had little change between 1987 and 1990, the changes within the peak period were more significant. There are no adequate explanations for the changes in speed over the peak period.

ACCIDENT EXPERIENCE

Accident reductions could be expected from both the ramp metering and VMS components of INFORM. While accident warnings are not explicitly provided on the VMS system, the system does identify areas of traffic delay. Motorists can use the delay information not only to consider diversion, but to reduce their speed in anticipation of congestion ahead.

Although insufficient time has elapsed for an adequate evaluation of INFORM accident experience, the available data were compiled and are displayed in table 12 for the LIE and for the control section on SR 135. There are conflicting trends in accident occurrence among the three sections. The total accident frequency on the LIE in Nassau County decreased by 5 percent between 1988 and 1989, while the frequency on the SR 135 control section increased by 13-percent. This is an implied net reduction on the LIE of 18-percent. However, accident frequency on the LIE in Suffolk County remained relatively stable and the injury accidents do not show a similar trend. While the change on the LIE in Nassau County is statistically significant, it is premature to come to any conclusions regarding overall accident trends.

Table 12. Summary of accident data for the LIE and SR 135 control section.

	YEAR			
	1986	1987	1988	1989
SR 135				
TOTAL	348	268	285	323
INJURY	104	100	105	117
LIE NASSAU				
TOTAL	1327	1296	1313	1253
INJURY	566	345	477	455
LIE SUFFOLK				
TOTAL	909	930	908	926
INJURY	313	316	327	281

4. EFFECTIVENESS OF INFORM VARIABLE MESSAGE SIGNING SYSTEM

The purpose of the INFORM variable message signing system is to provide motorists with information to make appropriate route choice decisions. In addition, the information itself is of value insofar as it provides motorists with information on the location and severity of congestion problems. Thus, while the information may not always help motorists to arrive at their destination more quickly, it may allow them to understand reasons for the delay and to better predict when they may arrive.

Several elements of the VMS evaluation are reported here:

- Frequency of VMS displays.
- A VMS case study - an illustration of VMS messages displayed and changes in volume distribution on LIE and NSP ramps and mainline in response to an actual incident and to the VMS system.
- Evaluation of VMS accuracy (comparison with travel time runs).
- Overall changes in traffic patterns in response to VMS system (i.e., To what extent do motorists actually change their routes in response to the sign information?).
- Delay analysis of changes in traffic patterns brought about by the VMS system.

An evaluation in each of these areas is presented in the sections below. Additional information on motorist perceptions of VMS displays is presented in chapter 6.

FREQUENCY OF VMS DISPLAYS

Table 13 shows the number of sign messages displayed on a monthly basis for each of the three 8-hour shifts for operations personnel. September to October 1988 represents the transition period between little reliance on automated sign control to substantial reliance on automated control. The number of sign messages displayed in October was nearly triple the number displayed in September. The number of system-generated sign messages rose from an experimental level of 149 in September to over 10,000 in October.

Another shift in VMS operating strategy can be detected in the June/July 1989 time frame, in which the reliance on manually-generated signing (primarily intervention mode) was increased and reliance on system-generated signing was reduced. This represented a quality control effort on the part of the system operators to monitor and control the system's selection of sign messages. The number of manually-generated messages has stabilized at approximately 8,000 to 9,000 per month, with the total number of monthly messages in the range of 15,000 per month. The 10 p.m. to 6 a.m. shift has a dramatically lower number of monthly messages than the other two shifts.

Table 13. Monthly number of sign messages displayed by INFORM.

		MANUALLY GENERATED				SYSTEM GENERATED				
MONTH	YEAR	6AM-2PM	2PM-10PM	10PM-6AM	SUBTOTAL	6AM-2PM	2PM-10PM	10PM-6AM	SUBTOTAL	TOTAL
SEP	1988	2253	2251	43	4547	7	142	0	149	4696
OCT	1988	1087	1158	330	2575	4028	6622	78	10728	13303
NOV	1988	1733	2469	725	4927	3132	4314	39	7485	12412
DEC	1988	683	615	217	1515	3786	4863	80	8729	10244
JAN	1989	1090	1325	201	2616	3061	3693	0	6754	9370
FEB	1989	1000	1525	454	2979	3190	2697	43	5930	8909
MAR	1989	1321	2789	244	4354	4803	5073	20	9896	14250
APR	1989	1862	2803	122	4787	4230	4124	55	8409	13196
MAY	1989	2075	2966	121	5162	7636	5274	641	13551	18713
JUN	1989	2041	2687	379	5107	4723	3981	111	8815	13922
JUL	1989	1940	3510	0	5450	2224	3371	112	5707	11157
AUG	1989	2414	4058	241	6713	2793	3514	125	6432	13145
SEP	1989	2082	4087	94	6263	3979	3036	116	7131	13394
OCT	1989	4007	5698	82	9787	2369	2445	22	4836	14623
NOV	1989	4727	6603	167	11497	2277	2196	19	4492	15989
DEC	1989	2759	3400	323	6482	1944	2946	78	4968	11450
JAN	1990	4410	2660	29	7099	1370	2374	8	3752	10851
FEB	1990	4789	3194	48	8031	1513	1931	23	3467	11498
MAR	1990	4061	4387	6	8454	3217	2992	21	6230	14684
APR	1990	3635	3896	27	7558	2782	2663	94	5539	13097
MAY	1990	3943	5135	52	9130	3426	2888	35	6349	15479
JUN	1990	3947	4554	138	8639	3243	3746	87	7076	15715
JUL	1990	3663	4499	48	8210	2817	3577	152	6546	14756

To illustrate the load on the INFORM operators, consider the typical number of 4,000 manually-generated signs per month for either the 6 a.m. to 2 p.m. shift or the 2 p.m. to 10 p.m. shift. This represents over 133 sign messages per shift per day (including weekends) or approximately 17 per hour. The number per hour typically increases during the peak periods. At 17 messages per hour, one sign message is being manually-generated each 4 minutes, with a higher frequency during the peak periods. Adding the system-generated messages (nearly equivalent in number to the manually-generated messages) indicates a sign message change once every 2 minutes. Interviews with the system operators have indicated that working with the 72 VMS signs consumes approximately 80-percent of the operators' time on the 2 primary shifts.

The operation of the ramp metering system requires relatively little time. This indicates the large effort which must be dedicated to maintaining the quality of the information that goes out to the motorist, if a pro-active sign use strategy is employed. A less active involvement in sign display would reduce operator workload, but would also likely result in reduced information quality and reduced confidence placed in the information by motorists. This is a key point to be remembered in the design of a VMS system. The motorist expects each sign to produce reliable information. Each additional sign added to the system assumes that there will be operational support available. If one makes the commitment to a large number of signs, one must also make the commitment to providing operational support.

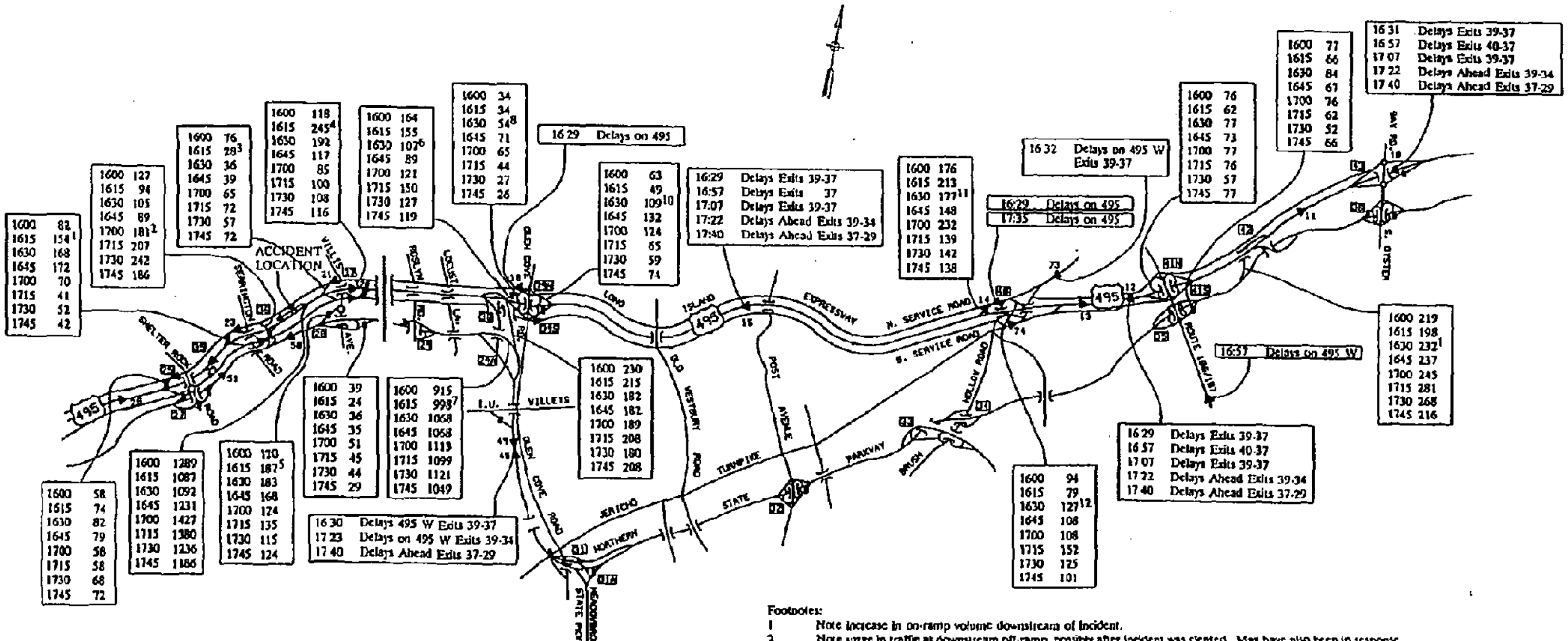
Automated sign algorithms for a system the size of INFORM is essential just for the operator to be able to manage the system, but the system cannot be expected to run itself. While improvement in sign control algorithms may take place over time, human operators are an indispensable part of maintaining the level of information quality that must be present for the system to succeed.

A VMS CASE STUDY

One way to begin to grasp the changes in traffic patterns brought about by the display of traffic condition messages is to illustrate what occurs during a typical incident. Figure 30 shows the sequence of events which occurred on March 15, 1989, when an accident occurred between exits 36 and 37 on the westbound Long Island Expressway between 1615 and 1625 (4:15 and 4:25 p.m.). The incident was not actually detected in the control center until 1628, and the time of occurrence is approximate.

The accident involved a car fire occurring on the westbound shoulder. No lanes were closed, but substantial delays were incurred on both the westbound and eastbound LIE. It should be noted that westbound is the off-peak direction at this time of day, but that westbound volume approaches capacity on the LIE at this time of day on this three-lane section.

The sign messages used during the incident for the westbound LIE are shown on figure 30 by the time at which each message was initially displayed. Sign messages indicating the delays were automatically selected by the central computer, including several signs on the mainline LIE (signs 16, 12 and 10), one sign on the Northern State Parkway (48), and several signs on the approach roadways or LIE service roads (18, 14, 73 and 71).



KEY

- RAMP METER
- VARIABLE MESSAGE SIGN (NUMBERED)
- ARROW POINTS IN DIRECTION OF TRAVEL FOR WHICH SIGN IS INTENDED
- LIE AND NSP EXIT NUMBERS

Footnotes:

1. Note increase in on-ramp volume downstream of incident.
2. Note surge in traffic at downstream off-ramp, possibly after incident was cleared. May have also been in response to additional congestion downstream.
3. Note decrease in volume at upstream on-ramp.
4. Note increase in volume at upstream off-ramp.
5. Note increase in volume at on-ramp to Northern State Parkway, due to diversion from the LIE.
6. Note decrease in volume at upstream on-ramp. Message provided by single line sign on service road at entrance to ramp.
7. Note increase in volume on this alternate route past the incident. Volume may be coming from several locations.
8. Note slight increase in volume from the LIE to southbound Glen Cove Road.
9. Note slight decrease in volume at on-ramp from NSP to LIE.
10. Note increase in volume at off-ramp to Glen Cove Road.
11. Note slight decrease in volume from service road to LIE.
12. Note increase in volume in off ramp from LIE to Jericho Turnpike.
13. Note slight increase in volume diverting from the LIE to the NSP.

Figure 30. Case study incident - volumes and sign messages.

Figure 30. Case study incident - volumes and sign messages.

Other information on figure 30 shows volume for 15-minute periods between 1600 and 1800. The numbers represent actual 15-minute volumes, not the hourly equivalent. Mainline volume counts in the vicinity of the incident indicate a reduction in volume of approximately 200 vehicles in the period between 1630 and 1645. Although the incident was actually identified at 1628, the decrease in volume from 1179 to 1007 between 1615 and 1630 indicates that the incident probably occurred earlier but was not actually detected by the system until 1628. The sharp increase in off-ramp volume between 1615 and 1630 at the Willis Ave. exit ramp supports the contention that the incident occurred early in that quarter-hour period.

One of the primary ways to track the influence of the signs on diversion is to examine changes in volume at the ramps upstream and downstream from the activated signs. An examination of ramp volumes upstream and downstream of the incident location indicates that motorists do, in fact, observe the sign messages. In general, upstream LIE off-ramps increase in volume, upstream on-ramps decrease in volume, and downstream on-ramps increase in volume. The footnotes in figure 30 refer to changes in volume that are worth noting during the course of the incident.

One of the noticeable changes at an upstream on-ramp is the ramp from the westbound NSP to LIE exit 38. The ramp from the NSP to the LIE dropped in volume from 230 to 182, a decrease of approximately 20-percent. At the same time, traffic continuing on the Parkway westbound increased at the time of the incident from approximately 1000 to approximately 1100. Volumes on LIE on-ramps from exits 39 and 40 also decreased, as some motorists sought to divert to the service road once they observed the sign messages approaching the on-ramps.

Several upstream off-ramps exhibited decreases in volume, as shown on figure 30 (observe LIE off-ramps at exits 39, 40 and 42). The LIE on-ramp immediately downstream of the incident dramatically increased in volume between 1615 and 1630, indicating that motorists were using the service road to bypass the incident. The on-ramp at Exit 28 on the NSP also increased, indicating that some of the traffic diverted to the LIE service road was continuing westbound on the NSP. The maximum extent of the queue was approximately 2.5 mi (4 km) upstream of the incident at 1700 (approximately 1 mile (1.6 km) east of LIE Exit 39). After the incident was removed (estimated to be shortly after 1700), congestion downstream of the incident location began to back into this area of the LIE, at which time the area of congestion identified on the signs was lengthened to between exits 37 and 29. Overall, an estimated 1400 vehicles were diverted over the 2-hour period surrounding the incident. These changes were spread over nine upstream on-ramps and off-ramps. As will be discussed in the delay analysis, the extent to which the alternate route delay increased is uncertain.

The value in using exit numbers rather than length of queue as the primary indicator of congestion location is evident from this incident. Most motorists have learned the exit number system. Some may have begun to pay attention to it just because that is the way the information is displayed on the INFORM signs. These motorists can relate exit number displayed on the signs to where they should exit and enter the freeway to circumvent the freeway congestion. However, some motorists have suggested that actual roadway names be used.

Although there are sometimes several miles between interchanges, the use of interchange exit numbers or street names to identify the limits of the congestion location is the only simple method that provides information on both the upstream end and downstream end of congestion. Identifying the upstream end and downstream end of congestion is important in allowing motorists to determine where they should exit the freeway as well as where they should reenter (or whether they should not reenter the freeway at all). The limitation in this method is that the resolution of the information is accurate to within one interchange, and there can be several miles between interchanges in some instances. This was evident in the case study incident, as signs 10 and 12 both referred to delays between exits 40 and 37 between 1657 and 1707. This would have been perceived by motorists as several miles of error in the sign message's description of the congestion location (the queue was only 1 mile (1.6 km) upstream of exit 39). Undoubtedly, the resolution to only the nearest interchange is one of the contributing factors to any perception of inaccuracy by the motorist. However, most interchanges are much closer than between exits 40 and 39. One possibility to provide more resolution is to use names of other cross streets between interchanges as landmarks.

The review of this case study incident indicates the complexity of changes in traffic patterns that can exist in an incident situation. Changes in traffic patterns could be identified as far as 7 miles from the incident. At the same time, some of the changes in traffic patterns at ramps close to the incident may have been brought about by the congestion itself (i.e., motorists diverting due to seeing slow traffic ahead), as exemplified by the early diversion to exit 37 even before the sign messages were displayed. The availability of the service road makes such diversions easy. However, the fact that the volume on the exit 37 off-ramp declined between 1645 and 1700 suggests that the arterial became saturated by 1645. This indicates the importance of traffic responsive arterial traffic control strategies in developing a total corridor traffic control program. Traffic responsive arterial control is a component of the original IMIS program, but has not been implemented, primarily due to its unpredictability and conflicts with major north-south movements. Other incident case studies also indicated the phenomenon of oversaturation on arterial streets due to diversion. The lack of arterial street responsiveness to diverted volumes is a major hindrance to overall corridor traffic flow.

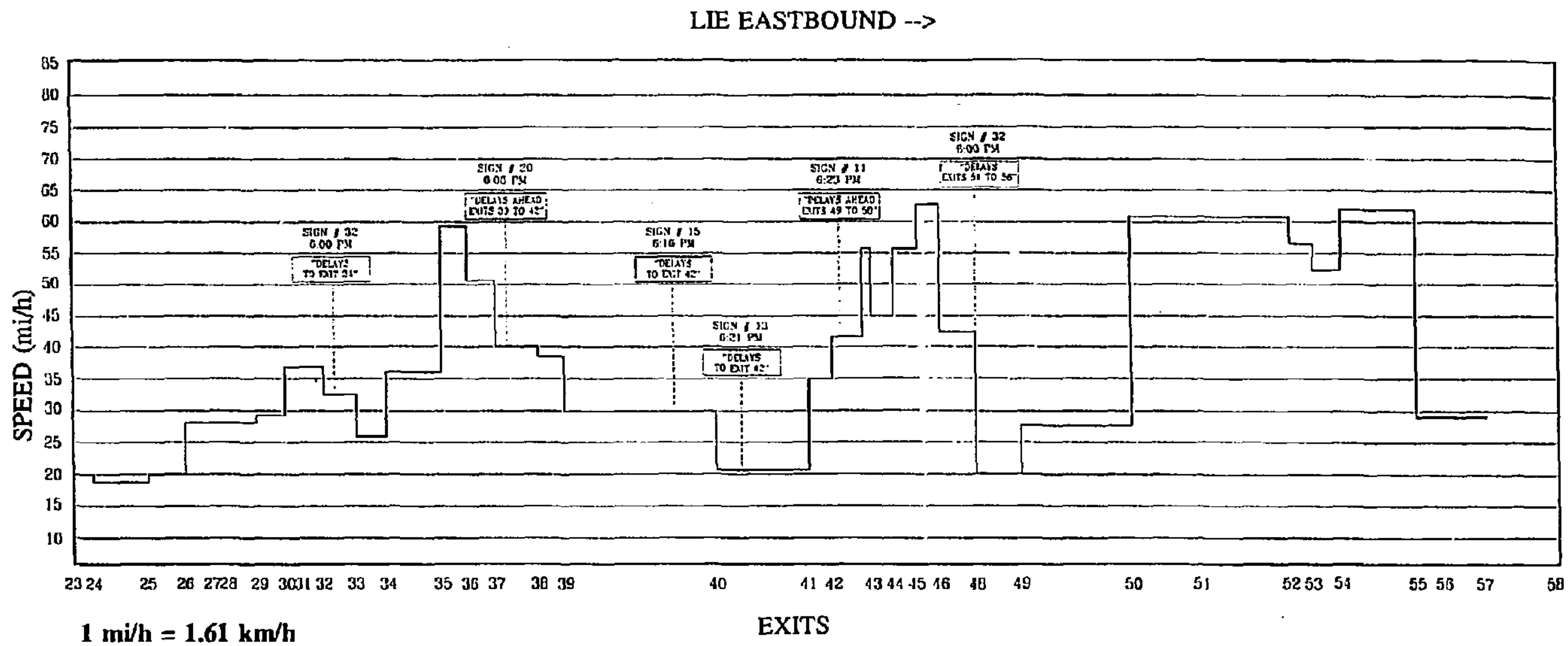
EVALUATION OF VMS INFORMATION ACCURACY

The accuracy of the VMS system was evaluated by comparing the results of a sample of actual travel time runs with information actually displayed on the signs. This was done on a case study basis using a sample of 27 travel time runs made on the Long Island Expressway. Both the interchange-to-interchange travel time and the location and message of each sign were recorded on each run.

Figure 31 graphically displays a comparison of delay areas indicated by the VMS system and the delay areas actually experienced during one travel time run. The results for this particular run shows a high degree of correspondence between the information displayed and the actual locations of congestion as determined by the travel time runs.

However, the VMS system is not without its limitations in accuracy. Even when the VMS system and surveillance components are operating perfectly, inaccuracies can creep into the system through the following:

- Limitations in the spacing of detector stations - the location of the end of a queue could be in error as much as one half mi (0.8 km) even if all the detector stations are working properly. If one detector station is failed, this potential error can increase to 1 mile. Even with the half mile error, motorists can perceive that the message being displayed is not accurate.



1 mi/h = 1.61 km/h

Figure 31. Relationship between vehicle speed and VMS messages for a sample trip on the LIE eastbound.

- Time delays in the display of information - to avoid oscillation in the display of sign message information, a filtering (smoothing) process is used to accumulate traffic information from detector stations. There is a classic dilemma between the provision of traffic data that is stable (i.e., does not oscillate back and forth between congested and uncongested conditions due to the motion of shock waves in traffic) and the responsiveness of the system to actual conditions. The filtering of data increases stability but reduces responsiveness.

- Limitations in being able to communicate location to the motorist. The use of exit numbers (or exit route names) in defining the location of congestion means that the location is accurate (assuming all the detectors are working) to within one interchange. Resolution could be increased by developing other intermediate landmarks that could be displayed by the signs, such as names of streets passing over or under the LIE and NSP.

- Time delays between the point at which the motorist sees the sign and passes through the congested area to which the sign referred. This distance can be up to 10 mi (16 km), depending on the zone of influence of any particular sign, and there could be 20 to 30 minutes between the time that the sign is seen and the time that the situation specified by the sign is experienced. Significant changes in traffic conditions can take place in that amount of time. Typically, however, updates are being provided on other signs as the motorist gets closer to the area to which the sign originally referred.

As a further evaluation of the signing information from the viewpoint of the driver, a comparison was conducted between the delay information provided on the signs and measured travel time for the 27 runs. The results were tabulated on the basis of whether the sign exactly matched the delays that were actually experienced by the moving car driver, were one exit off, two exits off, or were more than two exits off. It is important to indicate that these represent a comparison as the driver sees it. The signs may be more accurate than experienced by the driver, since traffic conditions may change, as described earlier.

The results of this analysis indicate the following for the 110 sign messages analyzed:

- 43 percent agreed exactly with what the moving car driver experienced as the area referred to by the sign was traversed.

- 35 percent were off by one interchange.

- 9 percent were off by two interchanges (upstream, downstream or one on each end).

- 13 percent were off by more than two interchanges.

It is likely that this represents the minimum actual accuracy of the signs, as some of the signs may have been correct at the time that the driver saw them, even though they did not appear to be correct when the driver finally traversed the section referred to by the sign. This points to the difficulty of the task of maintaining current, accurate, credible traffic information over a large area.

OVERALL CHANGES IN TRAVEL PATTERNS IN RESPONSE TO VMS SYSTEM

One of the primary reasons for evaluating the effectiveness of the signing system is to provide other operators of freeway management systems with guidance regarding the extent to which diversion typically takes place. Table 14 summarizes the results of an analysis that was conducted of over 160 different instances of sign messages being displayed in response to the occurrence of 30 separate incidents. The table indicates diversion percentages computed by comparing the volumes (before display and after display) at off-ramps just downstream of VMS signs that displayed delay information during the course of the incident. The last full 15-minute ramp volume prior to display was subtracted from the first full 15-minute volume following display to determine the number of diverted vehicles. The mainline diversion percentage was computed by dividing this difference by the mainline volume at that location. The ramp diversion percentage was computed by dividing this difference by the ramp volume prior to the sign message. While each sign may have had its message changed more than once during the incident, only the first change was analyzed (i.e., from "NORMAL TRAFFIC AHEAD" to the delay message) since it is this initial message that should produce the most noticeable change in diversion activity.

Table 14 categorizes the percentage changes in ramp and mainline volume by the proximity of the off-ramp to the incident (nearest, 2nd nearest and 3rd nearest upstream off-ramps) and by whether the incident occurred in the peak direction or off-peak direction. The vast majority of the incidents analyzed were peak period incidents. The table indicates that the mainline diversion percentages (based on the increase in off-ramp volume divided by mainline volume) are typically between 3 and 4 percent. For individual off-ramps, the percentage is highly variable, but the average percentage increase in off-ramp volume is 40 and 70 percent. The percentages for off-peak directions are generally higher than for peak directions, but this is not universally true. One could reason that the diversion percentages in the off-peak direction may be higher than in the peak direction since greater excess capacity typically exists on alternate routes in the off-peak direction. While there may be a trend in this direction (with the exception of the third nearest upstream off-ramp) it is difficult to say conclusively that this is true.

It is not to be presumed by presenting diversion percentages that diversion is always beneficial. It is conceivable that diversion could actually increase delay, particularly if a sign message causes motorists to over-react to a situation on the freeway. This is one reason for the strategy employed by INFORM of generally refraining from suggesting alternate routes. Suggesting an alternate may imply to the motorist that the alternate will be faster. This is obviously not always the case, and overuse of alternate route messages would likely result in reduced perceptions of the quality of the information provided.

One of the goals of the operation of the signing system is operational balancing across the facilities. This is a delicate task and is only learned from experience on each individual system. Messages that are too strongly worded can be counterproductive and lead to significant credibility problems. The INFORM signing strategy is generally to provide as much information as possible on where delays exist so that each driver can make reasonably intelligent decisions on route choice given his or her current position and ultimate destination.

Table 14. Summary of diversion percentages related to VMS system.

	LOCATION OF UPSTREAM OFF-RAMP WITH RESPECT TO THE SIGN		
	NEAREST	2nd NEAREST	3rd NEAREST
PEAK DIRECTION			
% Ramp Vol. Increase	59.0%	41.0	58.0
% Mainline Diverted	4.2	3.0	4.4
OFF-PEAK DIRECTION			
% Ramp Vol. Increase	69.0	51.0	39.0
% Mainline Diverted	4.8	3.0	4.3

Perhaps the best use of the diversion information in table 16 is in placing bounds on some of the assumptions that are commonly made in feasibility studies for freeway management systems or in planning for actual operations. The diversion percentages shown here are likely to be near the upper bound of the percentages that would occur elsewhere, unless some unique condition exists in which a clear-cut, easily used alternate route is available and for which traffic information is highly accurate and responsive.

INFORM represents about as close to an ideal diversion situation as could exist. The Northern State Parkway represents a readily available diversion route to the LIE in many locations, and the LIE service roads are present for a significant length of corridor. It would be only rarely that other corridors have networks that offer situations in which motorists can more readily divert. Therefore, one of the possible conclusions of this research is that the diversion percentages shown in table 16 are quite likely the most that one would expect out of variable message signing systems using a similar signing strategy as used on INFORM. More dramatic incident situations, such as complete roadway closure, would obviously incur higher percentages, but the numbers shown in table 16 represent what would be typical without suggested or mandatory diversion messages.

While the percentage of mainline traffic diverted (3 to 4 percent) may appear rather small, the diversion percentage for the average incident over the three upstream off-ramps exceeds 10 percent. At a mainline volume of 5,000 VPH, this represents 500 vehicles diverted, which is quite likely as much as or more than a signalized alternate route could absorb, at least without significant responsiveness in signal timing on the alternate route.

Several instances of alternate route signing were noted in the incident case studies. On one occasion, a westbound incident on the LIE resulted in a message DELAYS EXITS 39-37 at 4:46 p.m. on sign 10 at Seaford Oyster Bay Road, located approximately 1 mi (1.6 km) upstream of the direct exit ramp from the LIE to the NSP (Exit 42). Ten minutes later, the message "LONG DELAYS EXITS 40 TO 37, CARS USE N. PKWY VIA EXIT 42" was displayed. Between 4:45 and 5:00, traffic volume on the Exit 42 ramp increased only 16 percent as a result of the relatively passive delay message. From 5:00 to 5:15, volume increased an additional 50 percent in response to the stronger message. This represented 140 vehicles that would have otherwise been caught in the queue on the LIE and reduced the queue on the LIE by more than one third of a mile.

The tracking of changes in traffic movement in response to VMS message displays is extremely complex. There are many factors that can influence a motorist's decision to divert or to re-enter a freeway, including such factors as motorist perception of the severity of congestion, perception of the expected duration in congestion, physical length of congestion, availability and knowledge of alternate routes, and anticipated congestion on alternate routes. Although the diversion percentage at any given ramp is relatively simple to compute, the determination of the extent to which the diversions resulted in reduced delay is quite difficult. Furthermore, the transferability of these diversion percentages must be viewed with great caution, since not only is each incident unique but the comparability of the traffic networks between the INFORM corridor and other corridors is quite different. In general, the following rules would apply to the level of diversion:

- The diversion percentage would increase as the directness of the alternate route increases.

- The diversion percentage would increase with increased excess capacity on the alternate route.

- The diversion percentage would increase as the motorists' faith in the signing system increases (i.e., after the initial break-in period when motorists are determining how reliable the information actually is).

The last factor mentioned (credibility of the sign information) is an extremely important factor in influencing motorists' decisions to change their routes. If the sign information cannot be believed, it is highly unlikely that the signs would have much influence on traffic patterns over the long term. Motorists may believe the signs at first, resulting in extensive diversion, but if they discover that the information is often inaccurate, they are unlikely to pay attention to that information and little diversion would likely occur.

Observation of the INFORM signing system and motorist responsiveness to that system indicates that motorists develop a "feel" for what the system means when certain sign messages are displayed and what response has the best chance of saving the motorist time. In a sense, a comprehensive VMS system is interpreted by motorists as if it were another human being with its own personality. This personality is created by the algorithms and control philosophy of the system operators, based on the strength of the messages, consistency of the information, etc.. One's interpretation of the sign information (and how to respond to the sign information) is based on each individual's history of experience with INFORM under similar conditions. A message indicating delay may mean one thing to motorists who have traveled the facility consistently, have a good knowledge of alternate routes, and have found the sign information to be generally accurate. It may mean something entirely different (in terms of how to respond) to a less familiar driver or one who may have had a bad experience concerning wrong information on a sign. This is part of the unique character of each VMS system and makes the transferability of results more difficult to interpret. If another system is known for putting out inaccurate sign information, it would be expected that the diversion percentages shown here do not apply and could, in fact, be zero.

DELAY ANALYSIS OF CHANGES IN TRAVEL PATTERNS BROUGHT ABOUT BY THE VMS SYSTEM

The estimation of VMS-related delay savings is highly complex, due to the many signs, ramps, and alternate routes involved. The VMS case study presented earlier is a relatively minor incident, and yet there were eight signs, nine off-ramps and multiple diversion paths involved. There were 22 message changes associated with the incident over a 70-minute period, not including the changes back to the "NORMAL TRAFFIC AHEAD" message.

Each incident is also unique in terms of its nature, severity, time of occurrence and duration. A true estimate of delay savings from the VMS system for any incident would have to compare vehicle hours under the actual condition with the vehicle hours that would have occurred had the signs not existed. This comparison could be done in one of two ways: (1) comparing actual MOE's for given incidents with identical incidents that did not have the VMS system activated; or (2) estimating delays with and without VMS-induced diversion (through computer simulation or otherwise) for a sample of incidents and extrapolating that result to the total corridor. The first alternative is unworkable, as the likelihood of an identical incident (in severity, location, time of occurrence, etc.) is extremely remote. The simulation of traffic patterns is the most straightforward method of estimating delay savings, but is also highly complex for a corridor of this size. The best that can be done is to estimate some bounds on delay savings could for a typical incident, based on known diversions, and to extrapolate some expected delay savings from that smaller sample. Although more extensive simulation studies of the effect of diversion on alternate route delay could be conducted, such a task is more complex than is possible to accomplish within this project and would only produce a simulated result, not a measure of actual delay.

To begin to establish a measure of the delay savings due to the VMS system, the March 15, 1989 case study incident was used as a basis for estimating the change in delay. An approach to the delay reduction estimate can be established as follows:

- Estimate the mainline delay that actually occurred during the incident. One way of estimating that delay is through procedures established by an earlier FHWA research project entitled "Alternative Surveillance Concepts and Methods for Freeway Incident Management." This estimate represents delay <u>with diversion</u>.

- Estimate the mainline delay that would have occurred had the diversions not taken place. This can be accomplished by adding the diverted traffic back into the mainline volume approaching the incident and reevaluating the delay. The difference between the vehicle hours of travel with diversion and without diversion conditions represents mainline delay reduction, but some of that delay savings must be negated due to slower travel times on the alternate routes.

- Estimate reduction in speed (versus using the freeway) for those vehicles diverting, by virtue of their having to use an alternate route. Speed data are available from nonincident travel time runs on the service road.

- Estimate the further speed deterioration on the alternate routes due to the diverted traffic for that incident. This is the most difficult part of the analysis and can only be approximated.

This estimate of delay is complicated by the many paths that diverted traffic can take. There are many thousands of combinations of origins and destinations for motorists involved in the incident. Some motorists approaching the incident may have a destination nearby and may divert to an earlier north-south arterial street. Other motorists may have a destination well downstream of the incident and may attempt to divert onto a parallel freeway or arterial and reenter the facility from which they diverted at some point downstream of the incident. Simplifying assumptions must be made just to enable the computation to be conducted.

Table 15 presents an analysis of the delay savings expected from the diversions that occurred in response to the sign messages on the March 15, 1989, incident. It indicates the estimates of each step in the calculations. The maximum possible delay savings is represented by the difference in mainline delay that occurred with the diversion versus the mainline delay that would have occurred had no diversion taken place. This represents an upper bound on the delay savings. Any additional delay on the service roads would decrease this estimate of delay savings.

Table 15. Estimate of VMS-induced delay savings for case study incident.

1. Reduction in freeway delay (based on procedures in <u>Alternative Surveillance Concepts and Methods of Freeway Incident Management</u>)

Estimated delay without diversion	2804 veh hr
Estimated delay with diversion	<u>537</u> veh hr
Delay savings	2267
(assumes diversion of 800 vehicles to various ramps)	

2. Estimated additional arterial travel time (diverted vehicles)

Average miles if on freeway	5 miles
Average miles under diversion (1 extra mile)	6 miles
Average speed differential between freeway and service road	35 mi/h (55 vs 20)
No. vehicles diverted	800 veh hr
6 miles x 800 vehicles ÷ 20 mi/h	240 veh hr
5 miles x 800 vehicles ÷ 55 mi/h	<u>73</u>
Additional delay =	167 veh hr

3. Estimated additional arterial travel time (vehicle already on arterial)

Average normal volume on arterial	1000 VPH	
Length impact by diverted traffic	5 miles	
Speed without diverted vehicles	42 mi/h	
Speed with diverted vehicles	20 mi/h	
5 miles x 1000 VPH x 1.5 hr ÷ 20 mi/h		375 veh hr
5 miles x 1000 VPH x 1.5 hr ÷ 42 mi/h		<u>179</u> veh hr
Additional delay	196 veh hr	

4. Summary

VHT saved freeway	2267
Additional arterial delay	
- Diverted vehicles	-167
- Veh already on arterial	<u>-196</u>
TOTAL delay saved	1904

1 mi = 1.61 km
1 mi/h = 1.61 km/h

The analysis period for the delay estimate was 16:00 to 18:00. The key factor was the estimation of the diverted traffic. Table 16 shows the estimate of diverted traffic by ramp for each 15-minute period, rounded to the nearest 10 vehicles. Over the entire period, an estimated 1400 vehicles were diverted from the mainline. Since some of this was likely not due to the VMS information (such as the upstream ramp closest to the incident), a more conservative estimate of diversion was made (800 vehicles over the 2-hour period). These data were input to a computer program replicating the equations in the FHWA study referenced earlier. The results in table 17 show that the estimated maximum mainline delay savings for the diversions on westbound LIE as a result of the signing system is 2267 vehicle hours.

The arterial speeds of diverted traffic were then estimated versus what the speeds would have been on the freeway. The estimated additional arterial delay for diverted traffic due to the VMS information is 167 vehicle hours.

There would also be additional delay for each vehicle normally travelling the alternate route. Based on actual measured nonincident speed and an estimate of speed with diverted traffic overlaid on normal traffic, an estimated additional delay of 196 vehicle hours would be incurred. A sample of four additional incidents were reconstructed using the method described above, based on a range of incident severities. The delay savings estimates for these other incidents were significantly less than for the incident described above, ranging between 55 and 1000 vehicle hours saved. Using an average delay savings estimate of 500 vehicle hours per incident applied to 50 incidents per month, the annual maximum incident-related delay savings for the VMS component of the system is 300,000 vehicle hours annually. Although this number is approximate, based necessarily on a limited sample of incidents, it demonstrates the order of magnitude of the delay savings attributable to the variable message signing system. This excludes the planned incident (i.e., construction and maintenance) and nonincident benefits.

The nonincident benefits are even more difficult to quantify than the incident-related benefits, but they are likely to be less than the incident-related benefits. Reconstruction was conducted of traffic conditions and signing during peak periods for nonincident conditions. Unlike the incident conditions, in which volume shifts could be spotted almost immediately after the VMS sign message was displayed, little discernable shift could be detected for signing which was associated with recurring congestion. Most motorists are already expecting those delays and have generally adjusted their routes to account for those delays.

While the immediate effects of nonincident signing cannot be totally negated, it is likely that the delay savings from nonincident signing is small. The major benefit of nonincident signing is more likely the assurance given to drivers that they have not taken the wrong route. It is also possible that the VMS system has influenced long-term shifts to more efficient commuting patterns. Signing may have persuaded commuters to take or try alternate routes even during nonincident periods. The only way this would be reflected in the evaluation is through differences in VMT and VHT. This effect is quite difficult to isolate and its magnitude is uncertain.

It is also important to note that the sign messages are not the only source of information for motorists. Some drivers may rely on commercial radio station reports more than the signs. Within the INFORM corridor, much of the information broadcast over radio and TV is generated by INFORM.

Table 16. Estimate of diverted traffic from LIE for case study incident.

	TIME								
ENTRANCE/EXIT	1600	1615	1630	1645	1700	1715	1730	1745	TOTALS
NSP EXIT	0	0	-30	-40	-40	-80	-70	0	-260
JERICHO EXIT	0	0	-40	-20	-20	-60	-30	-10	-180
JERICHO ENTRANC	0	0	-20	-50	0	-60	-60	-60	-250
GLEN COVE NB	0	0	-50	-70	-60	0	0	0	-180
GLEN COVE SB	0	0	-20	-40	-40	-10	0	0	-110
NSP ENTRANCE	0	0	-40	-40	-40	0	-40	0	-160
WILLIS OFF	0	-130	-70	0	30	20	10	0	-140
WILLIS ON	0	-50	-40	-40	-10	-10	-20	-10	-180
TOTAL	0	-180	-310	-300	-180	-200	-210	-80	-1460

NEGATIVE NUMBERS = TRAFFIC DIVERTED FROM LIE

Speed summaries are sent via facsimile machine every 30 minutes to approximately 1 dozen radio stations or traffic reporting services, including the two major commercial traffic services in the New York City region. Thus, INFORM is involved in the provision of information both directly and indirectly.

INFORM has a significant role to play in planned construction and maintenance activity. The signs are regularly used for night time construction signing and diversion. They are also used to notify drivers of upcoming construction activities and special events that may impact traffic. The signs have been particularly useful in moving maintenance activities. The field activity is coordinated with the INFORM control center and signing is modified as the maintenance units move through the system. Benefits can accrue in terms of reduced manpower requirements, delay reduction to traffic and possibly in improved safety. However, the benefits are also difficult to quantify.

5. EFFECTIVENESS OF THE RAMP METERING SUBSYSTEM

Ramp metering has been one of the foundational strategies of INFORM from the outset, and significant benefits were expected to be derived from metering. One of the interesting activities of the public relations campaign was to change the term "ramp meter" to "merge light." It was believed by the public relations consultant that the new term conveyed a more acceptable message to the public and was easier for them to understand. However, "ramp meter" will continue to be used in this report.

The following topics are discussed in this chapter:

- Ramp meter performance.
- Motorist compliance.
- Changes in throughput.
- Changes in speed.
- Delay at ramp meters.
- Composite VHT and speed estimates.

RAMP METER PERFORMANCE

As discussed in chapter 1, there are several modes of ramp meter operation. Metering in March 1990 was conducted in time-of-day mode, while the periods in April/May and June 1990 were conducted in traffic responsive mode. In both modes, there is the possibility that excessive queues will force the shut-off of metering. This is referred to as the "queued-off" condition. The amount of time that metering stays on, in combination with the metering rate, defines the degree of restriction in the metering plan.

Table 17 summarizes some of the basic features of metering performance. The time-of-day mode is represented by the March data, and the traffic responsive (automated) mode is represented by the April/May data. Eastbound ramp meters are generally turned on at 4:00 p.m. (1600). Westbound meters are typically turned on at 7:00 a.m., but several are turned on earlier. Metering rates during the evaluation periods typically ranged between 500 and 800 VPH, depending on ramp volume. The meaning of the remaining columns is as follows:

- Average minutes on - The daily average for actual metering time. This was computed from the ramp metering activity report.

- Average times queued off - This represents the average number of times the meter was shut down within a single metering period.

- Average time off - This indicates, for those times the meter did queue off, how many minutes, on average, the meter stayed off before returning to service.

- Peak 15-minute volume is reported on a VPH basis.

- Average queue - This was collected in the field and represents the average number of vehicles in queue waiting at the ramp. This is discussed in a separate section.

Table 17. Summary of ramp metering operation.

RAMP NO	RAMP NAME	TYPE OF METERING	TIME ON	AVG. MINUTES ON	AVG. TIMES QUE'D OFF	AVG. OFF TIME	BASE METERING RATE	PEAK 15_MIN. VOLUME	AVG. QUEUE
LIE EB RAMPS									
1	MAIN ST	TOD	1600	114.8	0.2	26	800	618	
1	MAIN ST	AUTOMATED	1600	120	0	0		618	1.2
2	161ST ST.	TOD	1600	113.2	0.4	17	800	642	
2	161ST ST	AUTOMATED	1600	120	0	0		642	
3	UTOPIA PKWY	TOD	1600	120	0	0	800	706	
3	UTOPIA PKWY	AUTOMATED	1600	118.8	0.1	12		706	4.5
4	OCEANIA ST.	TOD	1600	120	0	0	800	361	
4	OCEANIA ST	AUTOMATED	1600	120	0	0		361	0.6
5	SPRINGFIELD	TOD	1600	120	0	0	500	296	
5	SPRINGFIELD	AUTOMATED	1600	120	0	0		296	0.6
6	L. NECK PKWY	TOD	1600	110	0.2	50	800	583	
6	L. NECK PKWY	AUTOMATED	1600	117	0.1	27		583	1.3
7	COMMUNITY DR	TOD	1600	115.8	0.25	97	800	987	
7	COMMUNITY DR	AUTOMATED	1600	134.1	1.4	31.4		987	
8	NEW HYDE PK	TOD	1600	93.8	0	105	800	715	
8	NEW HYDE PK	AUTOMATED	1600	67.6	1.3	39.3		715	
9	SEARINGTOWN	TOD	1600	120	0	0	800	808	
9	SEARINGTOWN	AUTOMATED	1600	108	0.4	30		808	3.9
10	WILLIS AVE	TOD	1600	120	0	0	800	594	
10	WILLIS AVE	AUTOMATED	1600	120	0	0		594	2.3
11	GLEN COVE RD	TOD	1600	120	0	0	800	461	
11	GLEN COVE RD	AUTOMATED	1600	120	0	0		461	1.8
13	S.O.BAY RD	TOD	1600	55.7	1	64.3	800	903	
13	S.O.BAY RD	AUTOMATED	1600	88.4	1.8	17.6		903	3.4
15	RT 110 NORTH	TOD	1600	120	0	0	800	727	
15	RT 110-NORTH	AUTOMATED	1600	120	0	0		727	5.8
16	PINELAWN RD	TOD	1600	114.5	1	11	800	1022	
16	PINELAWN RD	AUTOMATED	1600	100.1	1.3	17.3		1022	11.1
21	VANDERBILT	AUTOMATED	1600	90.5	0	0		1469	0.7
22	RT 111	TOD	1600	88	3	10.7	800	832	
22	RT 111	AUTOMATED	1600	73.7	4.1	11		832	7.4

Table 17. Summary of ramp metering operation (continued).

RAMP NO.	RAMP NAME	TYPE OF METERING	TIME ON	AVG. MINUTES ON	AVG. TIMES QUE'D OFF	AVG. OFF TIME	BASE METERING RATE	PEAK 15 MIN. VOLUME	AVG. QUEUE
LIE WB RAMPS									
24	RT 111	TOD	700	60	0	0	800	534	
24	RT 111	AUTOMATED	700	60	0	0		534	
25	VANDERBILT	TOD	700	60	0	0	700	426	
25	VANDERBILT	AUTOMATED	700	57	1.25	6		426	
26	COMMACK RD	AUTOMATED	700	57.2	3.4	19.3		818	
28	BAGATELLE RD	TOD	700	20.9	0	0	800	957	
28	BAGATELLE RD	AUTOMATED	700	13.4	1.9	24.2		957	
30	ROUND SWAMP	TOD	718	50.3	0	0	800	266	
30	ROUND SWAMP	AUTOMATED	700	60	0	0		266	
31	SUNNYSIDE	TOD	732	50.3	0.2	0	800	128	
31	SUNNYSIDE	AUTOMATED	800	58.8	0	0		128	
33	JERICHO TPK	TOD	700	118.6	0	0	800	521	
33	JERICHO TPK	AUTOMATED	700	120	0	0		521	0
34	GLEN COVE RD	TOD	700	103	0	0	800	594	
34	GLEN COVE RD	AUTOMATED	700	95.1	1.3	16.6		594	6.5
36	SEARINGTOWN	TOD	700	118.6	0	0	800	331	
36	SEARINGTOWN	AUTOMATED	700	113.1	0	0		331	0.7
37	SHELTER ROCK	TOD	710	118.3	0	0	800	243	
37	SHELTER ROCK	AUTOMATED	700	120	0	0		243	0.6
38	NEW HYDE PK	TOD	600	109.3	0	0	800	479	
38	NEW HYDE PK	AUTOMATED	631	108.4	0	0		479	0
39	COMMUNITY DR	TOD	700	100.1	0.1	32	800	404	
39	COMMUNITY DR	AUTOMATED	700	120	0	0		404	2.2
40	LAKEVILLE	TOD	700	106.6	0	0	800	313	
40	LAKEVILLE	AUTOMATED	700	120	0	0		313	0.3
41	L. NECK PKWY	TOD	700	114.3	0	0	800	547	
41	L. NECK PKWY	AUTOMATED	700	120	0	0		547	5.6
44	UTOPIA PKWY	TOD	810	101.5	0	0	800	999	
44	UTOPIA PKWY	AUTOMATED	702	105	0.1	22		999	1
46	MAIN ST	TOD	700	117.6	0	0	500	239	
46	MAIN ST	AUTOMATED	700	122	0	0		239	0.5

Table 17. Summary of Ramp Metering Operation (continued).

RAMP NO	RAMP NAME	TYPE OF METERING	TIME ON	AVG. MINUTES ON	AVG. TIMES QUE'D OFF	AVG. OFF TIME	BASE METERING RATE	PEAK 15_MIN. VOLUME	AVG. QUEUE
NSP EB RAMPS									
47	MARCUS AVE	TOD	1600	105	1	75	800	1132	
47	MARCUS AVE	AUTOMATED	1600	71	4	25.4		1132	6.1
48	SHELT ROCK N	TOD	1700	60.2	0	0	800	105	
48	SHELT ROCK N	AUTOMATED	1703	45.6	0	0	800	105	0
49	WILLIS AVE	TOD	1731	101.6	0	0	500	326	
49	WILLIS AVE	AUTOMATED	1600	119.5	0	0		326	1.2
50	IU WILLETS	TOD	1600	118.8	0.2	5	600	438	
50	IU WILLETS	AUTOMATED	1600	180	0	0	600	438	
51	POST AVE N	TOD	1600	3	0	0	800	1223	
51	POST AVE N	AUTOMATED	1601	28.6	2.8	47.6		1223	1.1
52	RTE 106 NB	TOD	1600	119.2	0.2	3	800	416	
52	RTE 106 NB	AUTOMATED	1600	99.3	0.8	4.3		416	0.8
53	S.O.BAY RD N	TOD	1600	119.5	0.3	2	600	277	
53	S.O.BAY RD N	AUTOMATED	1600	119.4	0.1	4		277	1.4
54	RTE 110 NB	TOD	1712	87	0.3	12	800	677	
54	RTE 110 NB	AUTOMATED	1600	102.8	1.8	9.7		677	8.9
NSP WB RAMPS									
55	RTE 110 SB	TOD	700	112.7	1	7.3	NA	604	
55	RTE 110 SB	AUTOMATED	700	100.2	2.1	10.1		604	
56	S.O.BAY RD S	TOD	700	44.9	0.1	0	800	89	
58	ROSLYN RD	AUTOMATED	700	67.8	2.3	22.4		886	
59	WILLIS AVE	TOD	710	96.5	2.2	10.8	700	619	
59	WILLIS AVE	AUTOMATED	700	76	4.6	9.6		619	3.6
60	SHELTER ROCK	TOD	600	79.7	2.1	17.3	800	798	
60	SHELTER ROCK	AUTOMATED	600	86.2	2.8	12.1		798	2.5
61	NEW HYDE PK	TOD	700	120	0	0	800	487	
61	NEW HYDE PK	AUTOMATED	700	112.8	1.5	4.8		487	2.3
62	LAKEVILLE SB	TOD	700	120	0	0	800	191	
62	LAKEVILLE SB	AUTOMATED	700	120	0	0		191	0.4
63	L. NECK PKWY	TOD	700	111.9	0.6	8.8	700	606	
63	L. NECK PKWY	AUTOMATED	700	101.8	2.4	7.6		606	4.7
64	UNION TPKE	AUTOMATED	700	121.4	0	0	600	702	
65	FR LEWIS SB	TOD	710	114.6	0.3	6	500	323	
65	FR LEWIS SB	AUTOMATED	700	104.7	0.1	6		323	0.6

One of the observations from the table is that up to half the ramps are susceptible to queuing off and that this occurs for both TOD and traffic responsive (automated) modes. As would be expected, the ramps with heavier volumes are the ones that typically queue off more frequently. Several ramps queue off an average of 4 times per peak period. A number of ramps are queued off for nearly half of their 2-hour target metering period. The Post Avenue on-ramp to eastbound NSP stayed on an average of only 3 minutes in the March, 1990 metering period, due to the heavy volume. The automated ramp metering algorithm turned the meter back on more frequently, but the average time on was still less than 30 minutes for the Post Avenue ramp. This points to the difficulty of sustaining ramp metering under high volume conditions, particularly if only single lane metering is available. Observation in the field and of the 15-minute volumes over the peak period indicates that some ramps have surges within certain time frames. This is particularly true of the eastbound ramps in the p.m. peak period near major employment centers. The surges make metering difficult to maintain, as queues develop rapidly during those periods. Modifications to the software were conducted in June 1990 to try to preserve metering operations for longer periods.

The percentage of traffic that is actually metered is even less than was indicated earlier in chapter 1 (see table 1). There are significant periods when ramp metering is shut down to avoid surface street impacts. Field observation of some of the surface street impacts indicates that the impacts are a very real concern and that the decision to continue to meter would create major surface street traffic problems. The expected impacts and subsequent public outcry are the major incentives given by INFORM operations staff for maintaining the ramp metering policy. As will be seen in subsequent sections, this also limits what can be accomplished on the freeway.

MOTORIST COMPLIANCE

Data on motorist violations of the ramp metering signals are accumulated by the system based on analysis by the input/output detectors. These were field checked for reasonableness. Motorist compliance has been good, despite early fears that Long Island drivers would ignore the signals. Percent compliance ranges from a low of 74 percent to a high of 96 percent. The average compliance on the NSP/GCP ramps is 85 percent. The average on the LIE is 83 percent.

CHANGES IN THROUGHPUT

One of the long-running debates concerning ramp metering has been whether it produces an increase in traffic throughput, particularly through bottleneck sections. One of the arguments for ramp metering is that it can prevent breakdown and thereby achieve higher sustained throughputs within the existing cross section.

Figures 32 through 35 show peak period volumes for each of the three primary comparison periods for the LIE and NSP/GCP metering time periods. The volumes are shown as an hourly rate over the peak period. While both the March 1990 nonmetering and March 1990 metering data sets show slight improvement in throughput over the spring 1987, the best test of the pure effect of metering on throughput is between the March 1990 metering and nonmetering data sets. While the metered throughput is rarely lower than the nonmetered throughput, neither is it significantly higher. Several of the highest volume sections show a 1- to 2- percent increase in throughput (e.g., see LIE eastbound p.m. and NSP/GCP eastbound p.m.) for the metering period.

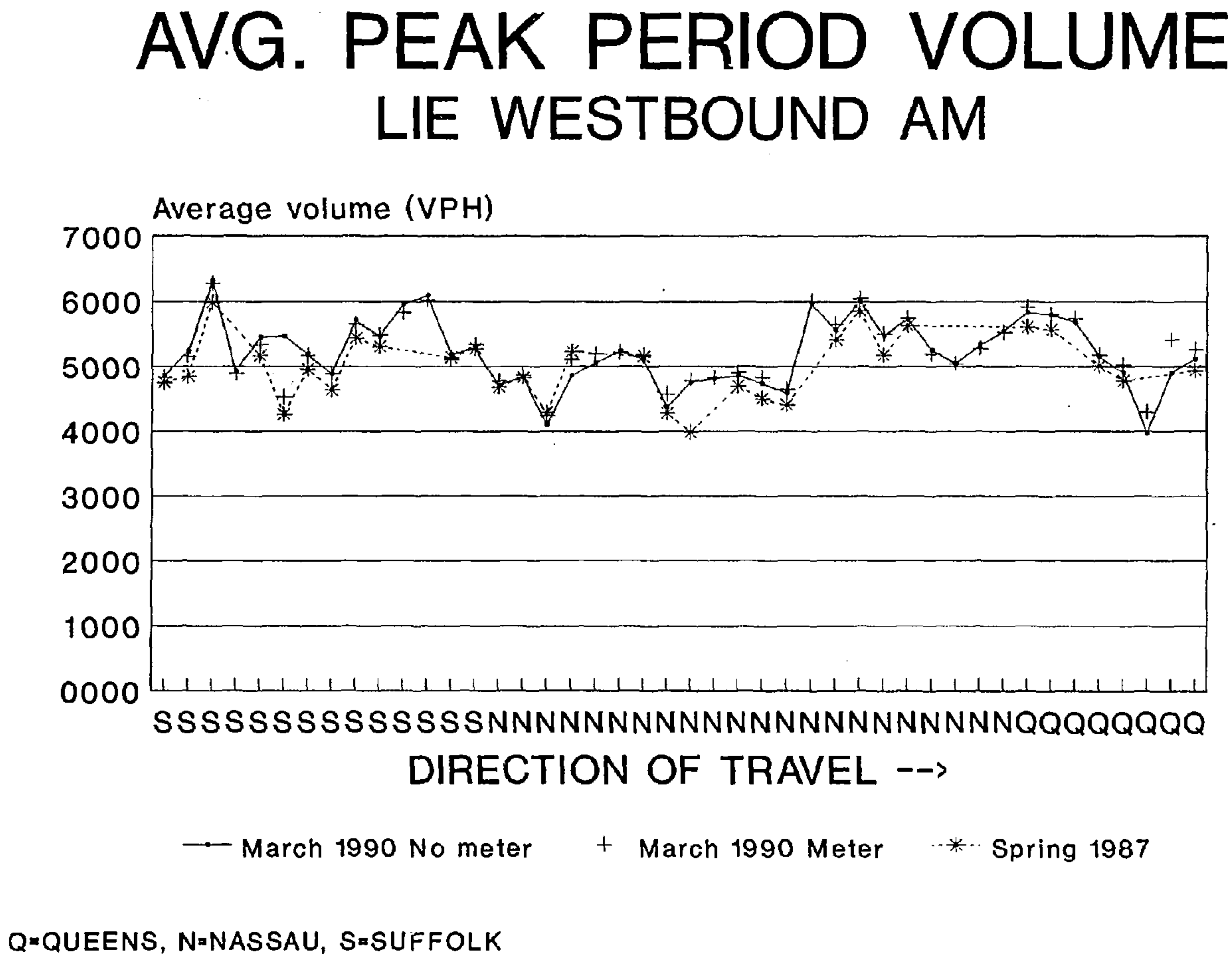


Figure 32. Average peak period volume, LIE westbound a.m.

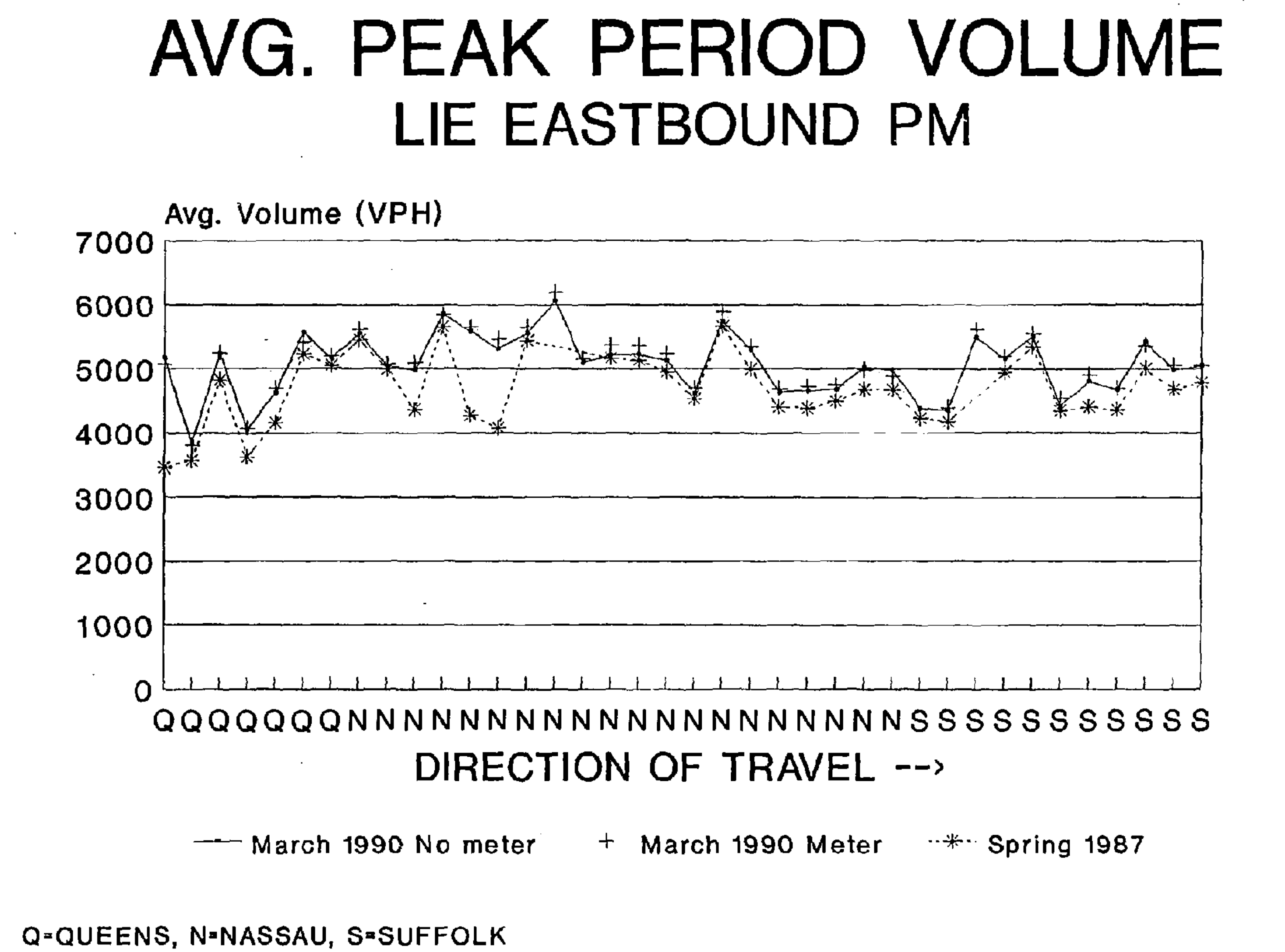


Figure 33. Average peak period volume, LIE eastbound p.m.

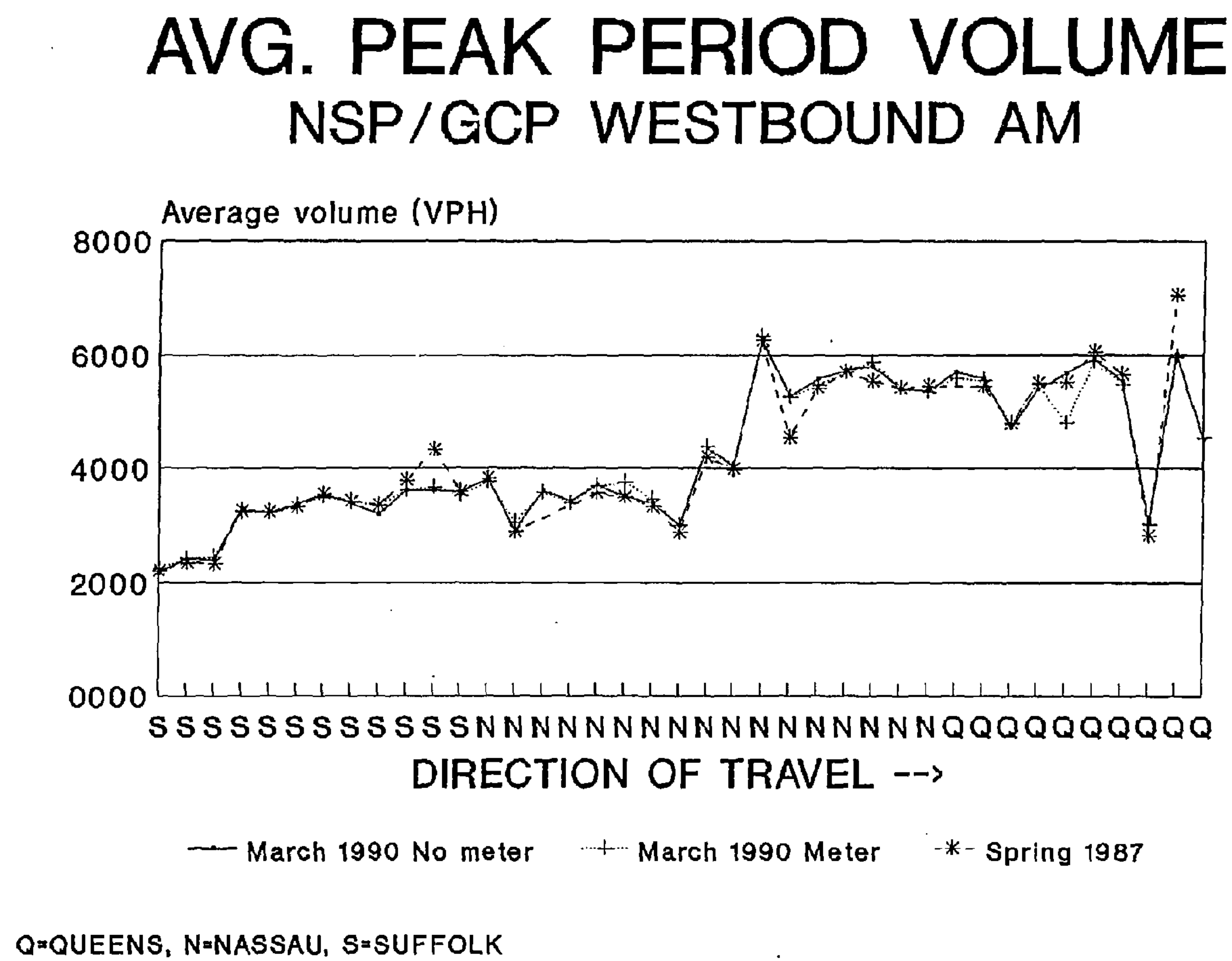


Figure 34. Average peak period volume, NSP/GCP westbound a.m.

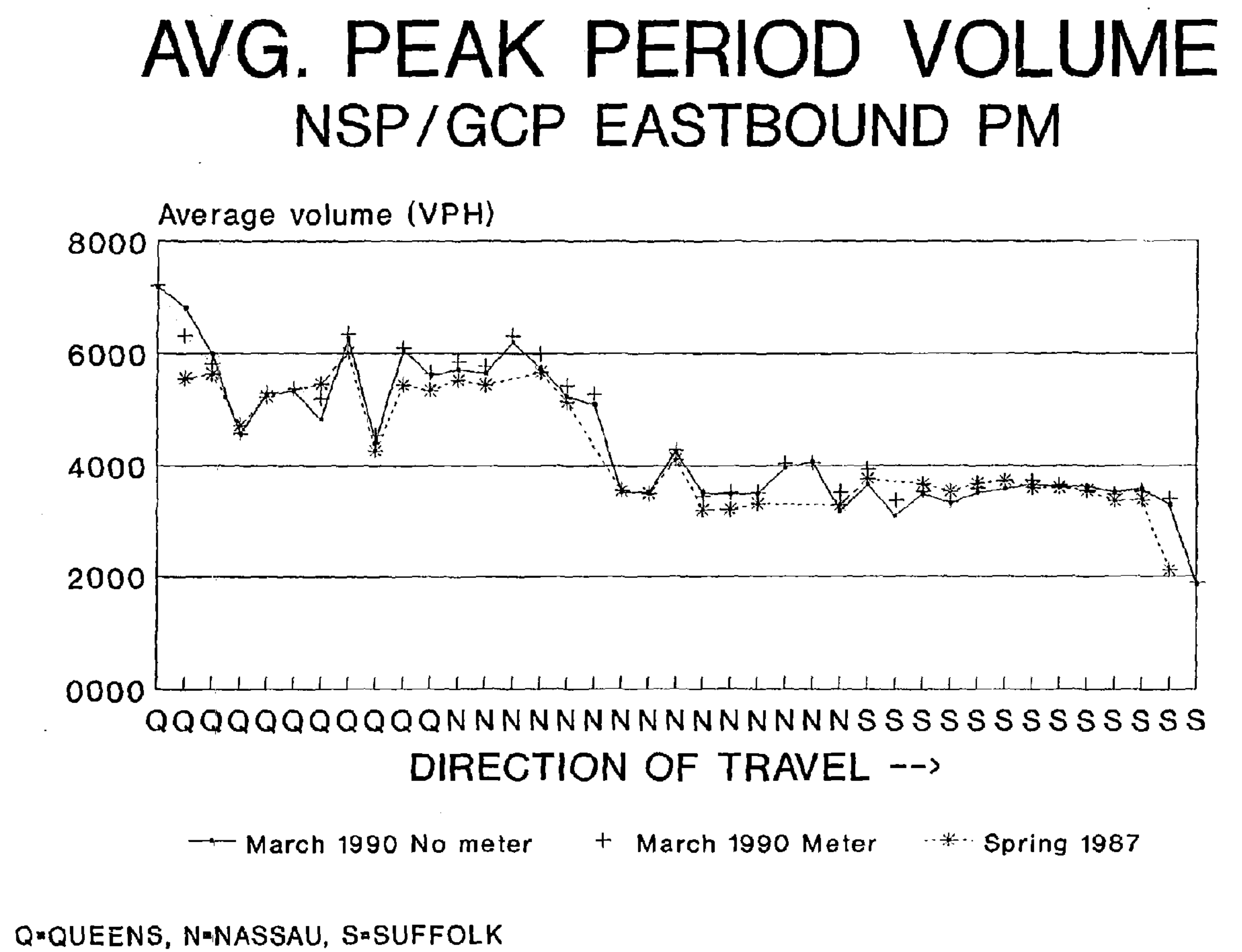


Figure 35. Average peak period volume, NSP/GCP eastbound p.m.

While the peak period shows no major change in throughput, it is possible that higher throughputs are sustained for short periods. This was examined by plotting volumes (an hourly rate) for 15-minute time periods early in the metering period (7:15 to 7:30 a.m. and 4:15 to 4:30 p.m. -- figures 36 through 39). In several cases, the highest metered volumes tend to be slightly higher than the highest nonmetered volumes. The differences are generally greater than the differences between the metering and nonmetering peak period volumes, but the differences are still not large. The largest difference is for the NSP/GCP Eastbound p.m. at 1615 (figure 39), which represents a 7-percent increase. The LIE westbound a.m. at 7:15 also shows some increase in volume at the peak locations, including some increases in Nassau County in the range of 7-percent. This is compared to an approximate 2-percent increase over the entire peak period.

Thus, it is possible that metering is bringing about a short-term improvement in the early part of the peak period, but this increase cannot be sustained, most likely due to the problem of queuing capacity on the ramps. The increases in throughput are inconsistent, even in the early part of the metering period. The data suggest that the increase in throughput is, <u>at most</u>, 7-percent, and is, on average, more likely in the range of 2-percent. Since this improvement could generally not be sustained by INFORM throughout the metering period, the actual sustainable improvement in throughput is difficult to determine.

CHANGES IN SPEED

Changes in speed have already been partly addressed in chapter 3 in the summary figures and tables. Further analysis was conducted by plotting speed profiles for average peak period speeds and for 15-minute speeds for the 7:15 to 7:30 a.m. and 4:15 to 4:30 p.m. periods (figures 40 through 47). The results indicate noticeable but sporadic improvements in speed. For example, the LIE westbound a.m. at 7:15 shows a fairly dramatic improvement in speed at bottlenecks in western Suffolk County and eastern Nassau County (figure 45), from 33 mi/h (53.1 km/h)(March nonmetering) to 52 mi/h (83.7 km/h)(March metering) at one zone in western Suffolk County and 33 mi/h (53.1 km/h) to 55 mi/h (88.6 km/h) at one zone in eastern Nassau County. However, examination of the comparable peak period speeds at the same zones (figure 40) indicates increases in the range of only 4 mi/h (6.44 km/h) (40 mi/h to 44 mi/h (64.4 to 70.8 km/h)). This difference can be at least partly attributed to the lack of storage capacity on the ramps and the subsequent shut down of metering at some ramps.

Tables 18 and 19 present the speed information in a way that changes can be assessed over the course of a peak period. The figures show the proportion of zones on the LIE for which speeds are less than or equal to 30 mi/h (48.3 km/h), the speed value that the INFORM operators use as the threshold of congestion. A higher proportion means greater congestion. This will be referred to as a "congestion index." This is presented for the LIE only.

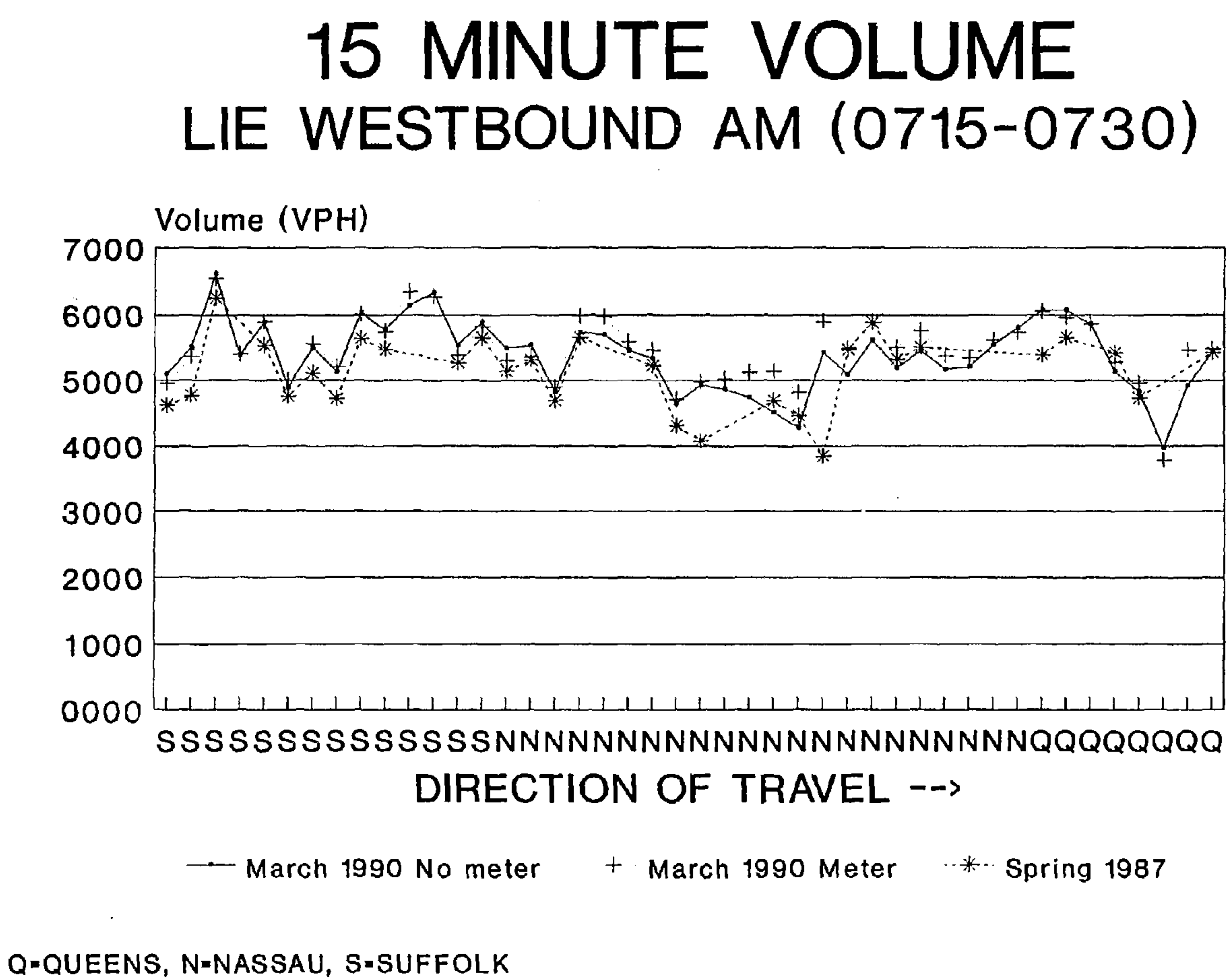


Figure 36. 15 minute volume, LIE westbound a.m. (0715-0730).

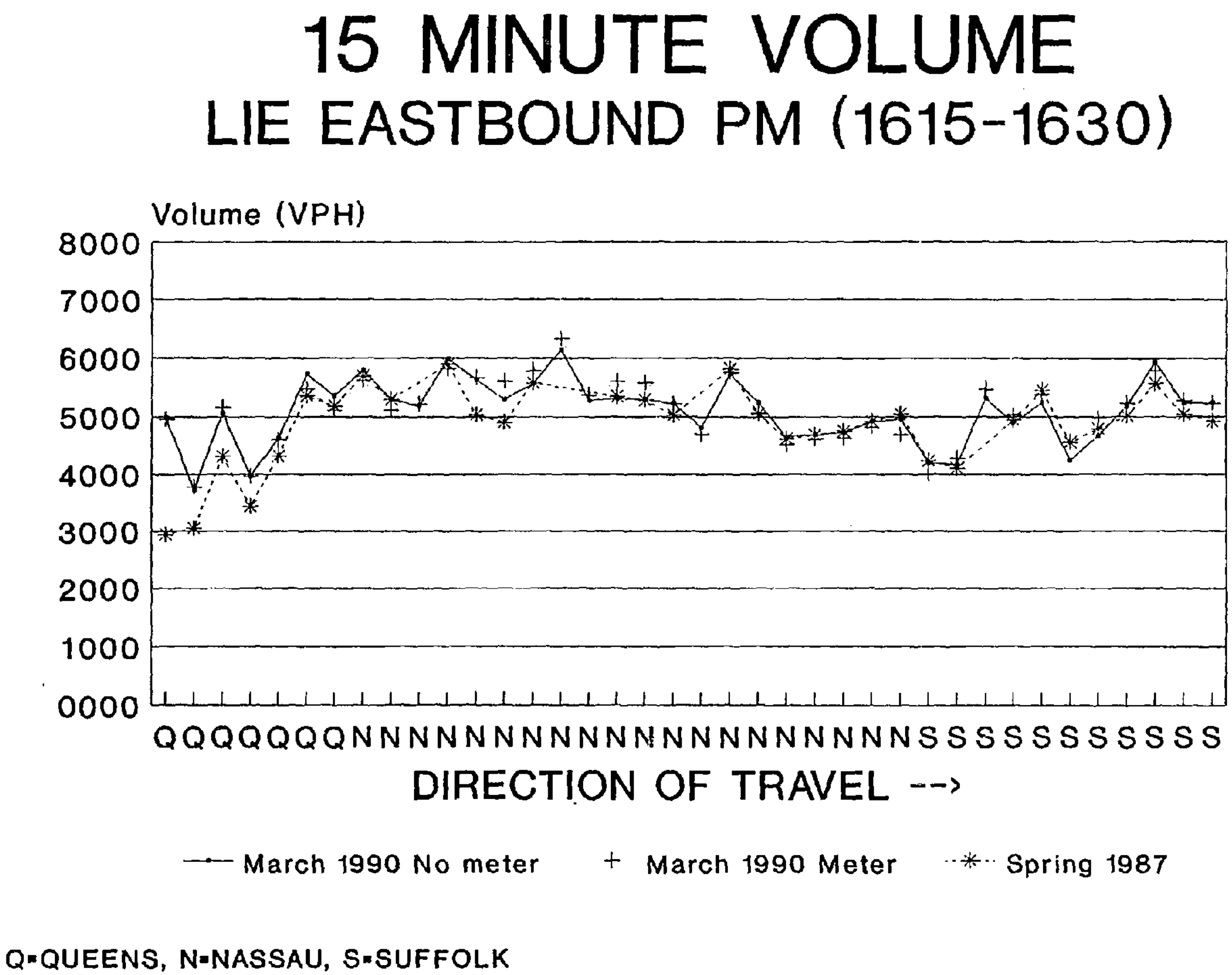


Figure 37. 15 minute volume, LIE eastbound p.m. (1615-1630).

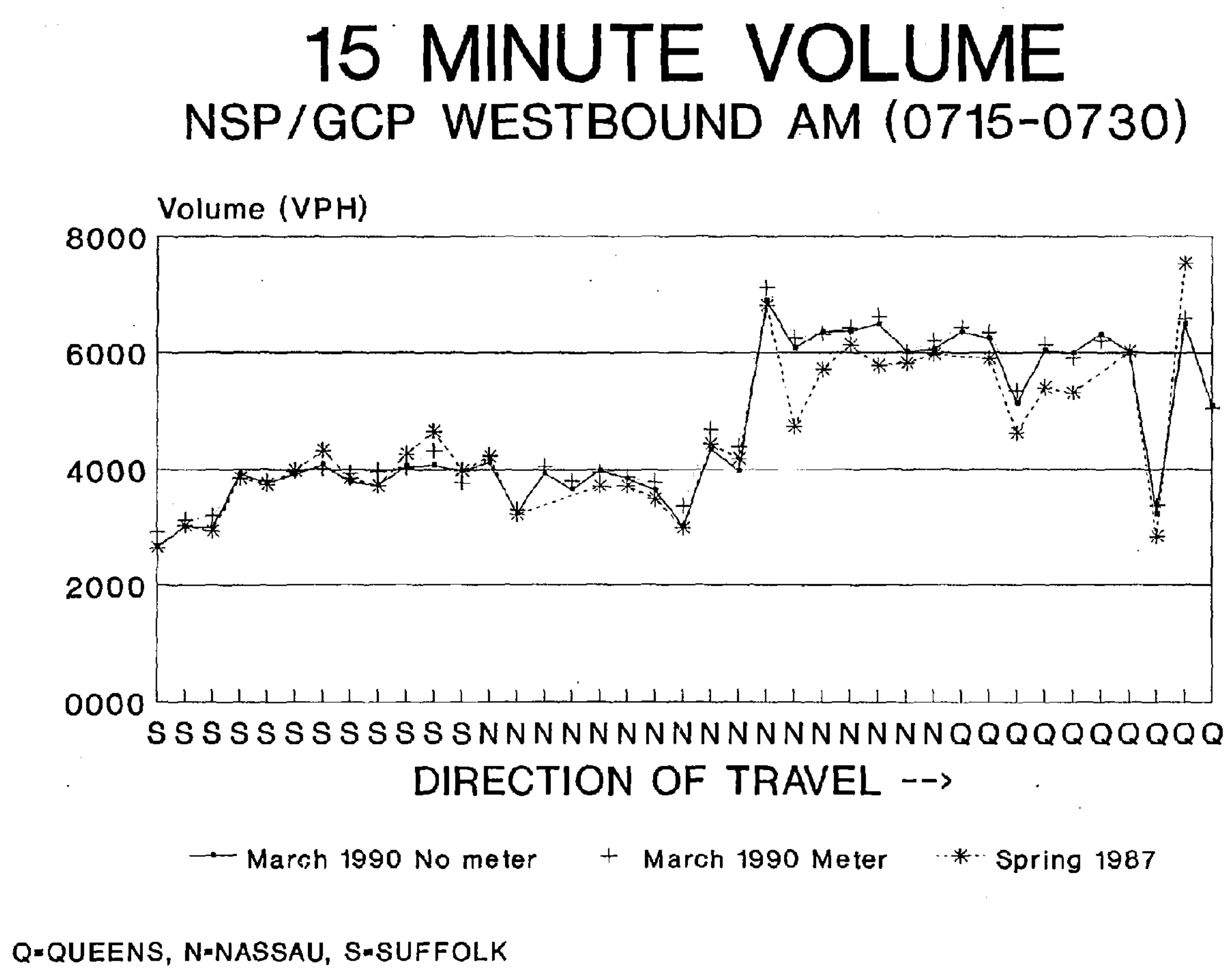


Figure 38. 15 minute volume, NSP/GCP westbound a.m. (0715-0730).

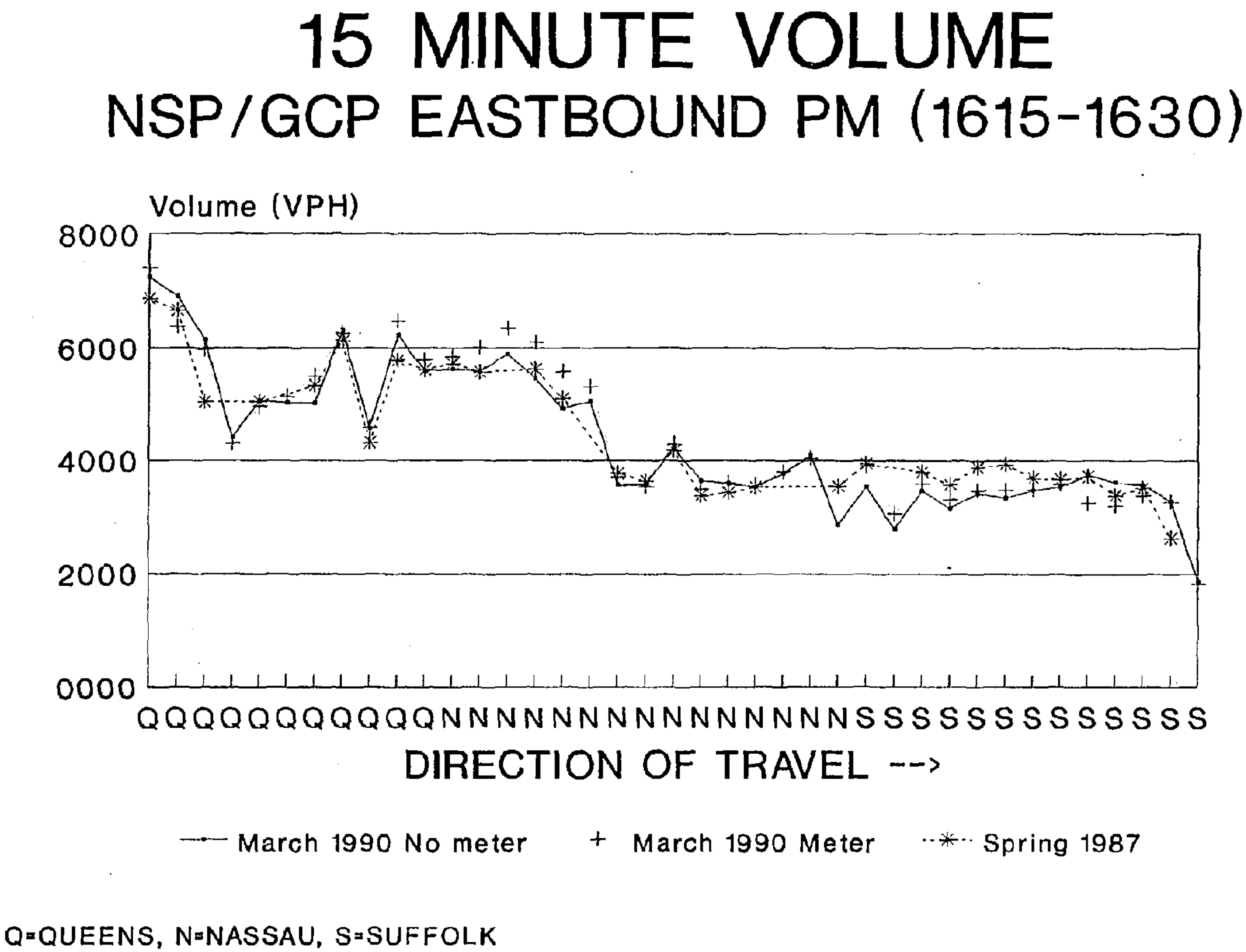
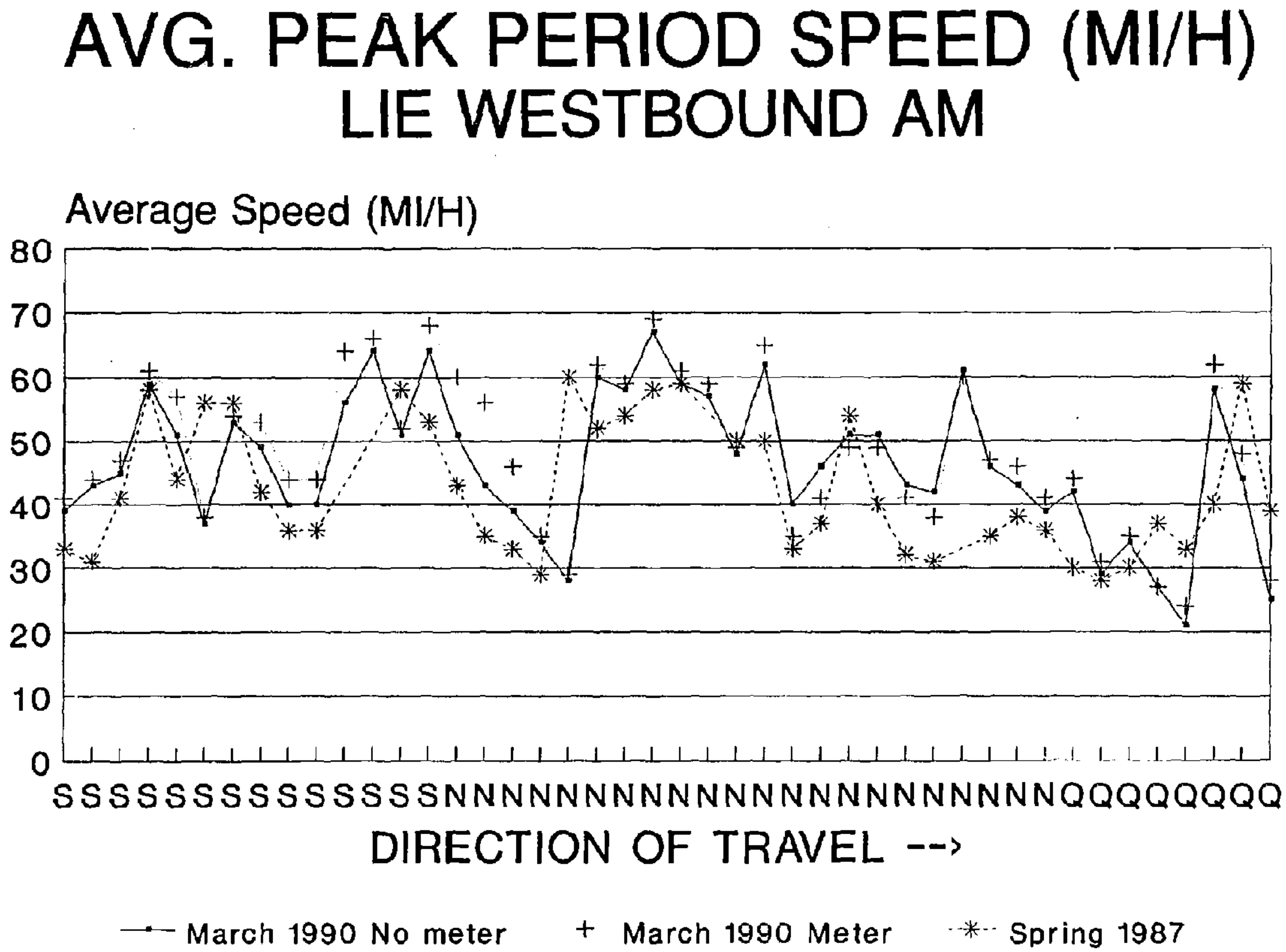


Figure 39. 15 minute volume, NSP/GCP eastbound p.m. (1615-1630).



1 mi/h = 1.61 km/h

Q=QUEENS, N=NASSAU, S=SUFFOLK

Figure 40. Average peak period speed (mi/h), LIE westbound a.m.

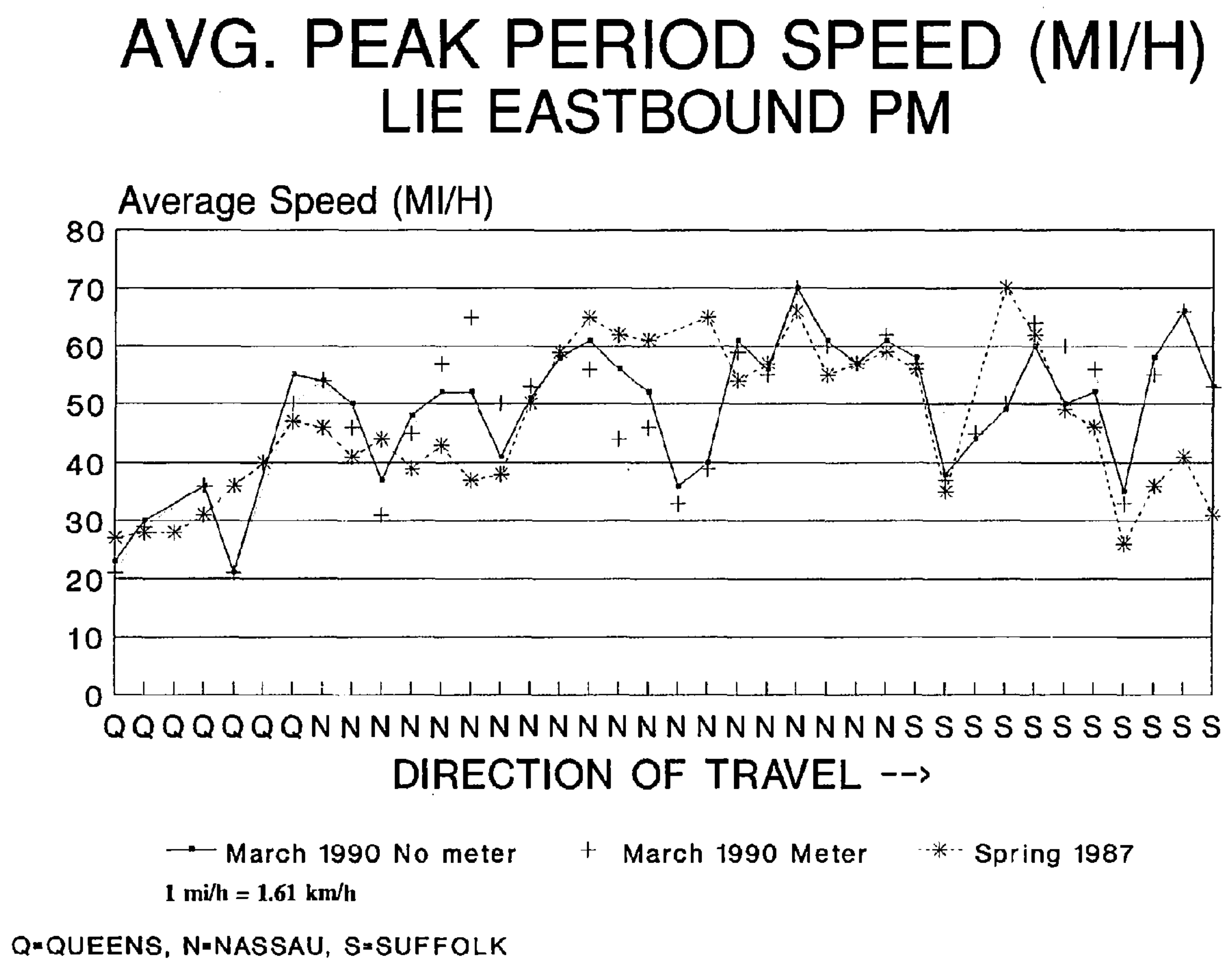


Figure 41. Average peak period speed (mi/h), LIE eastbound p.m.

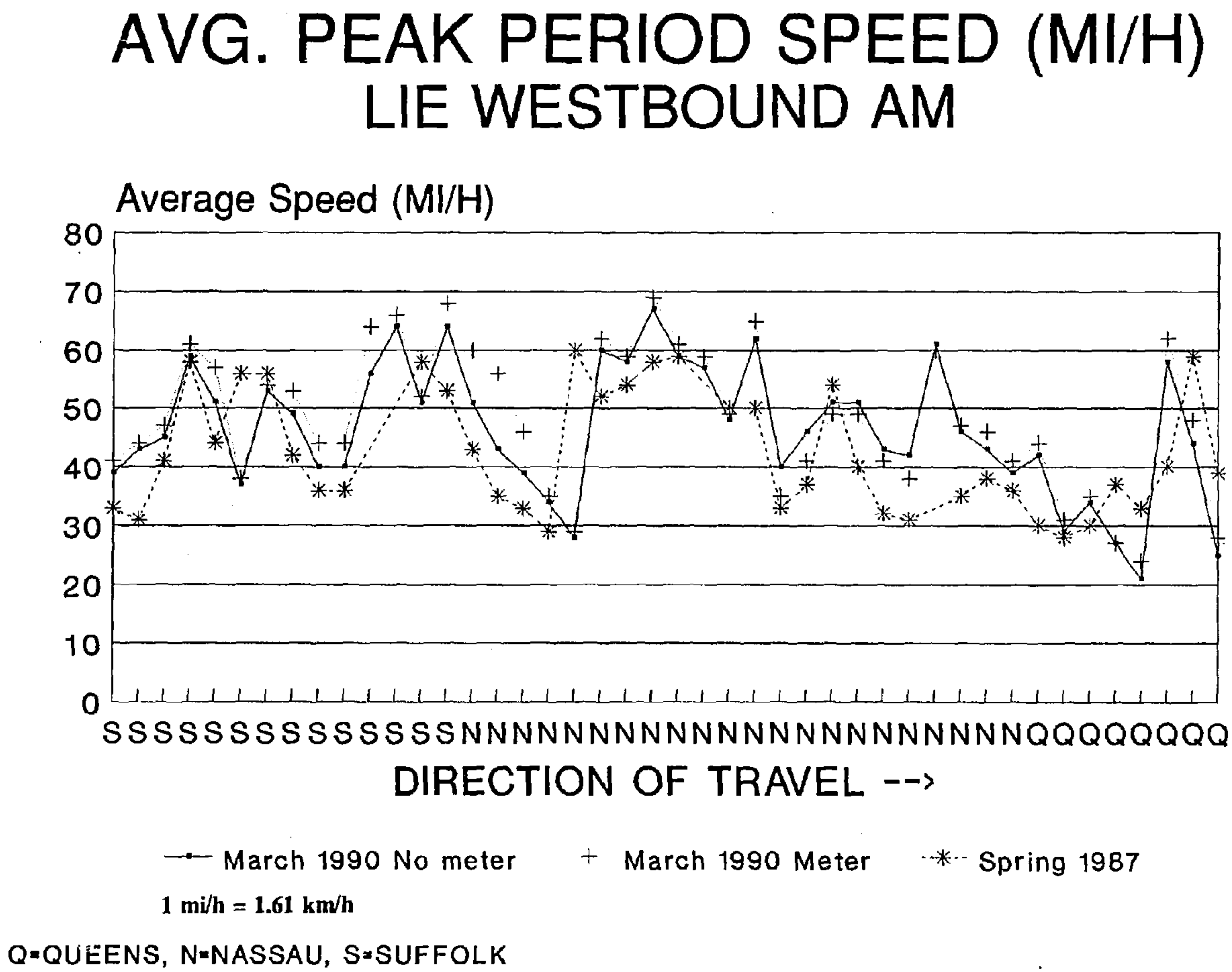


Figure 42. Average peak period speed (mi/h), LIE westbound a.m.

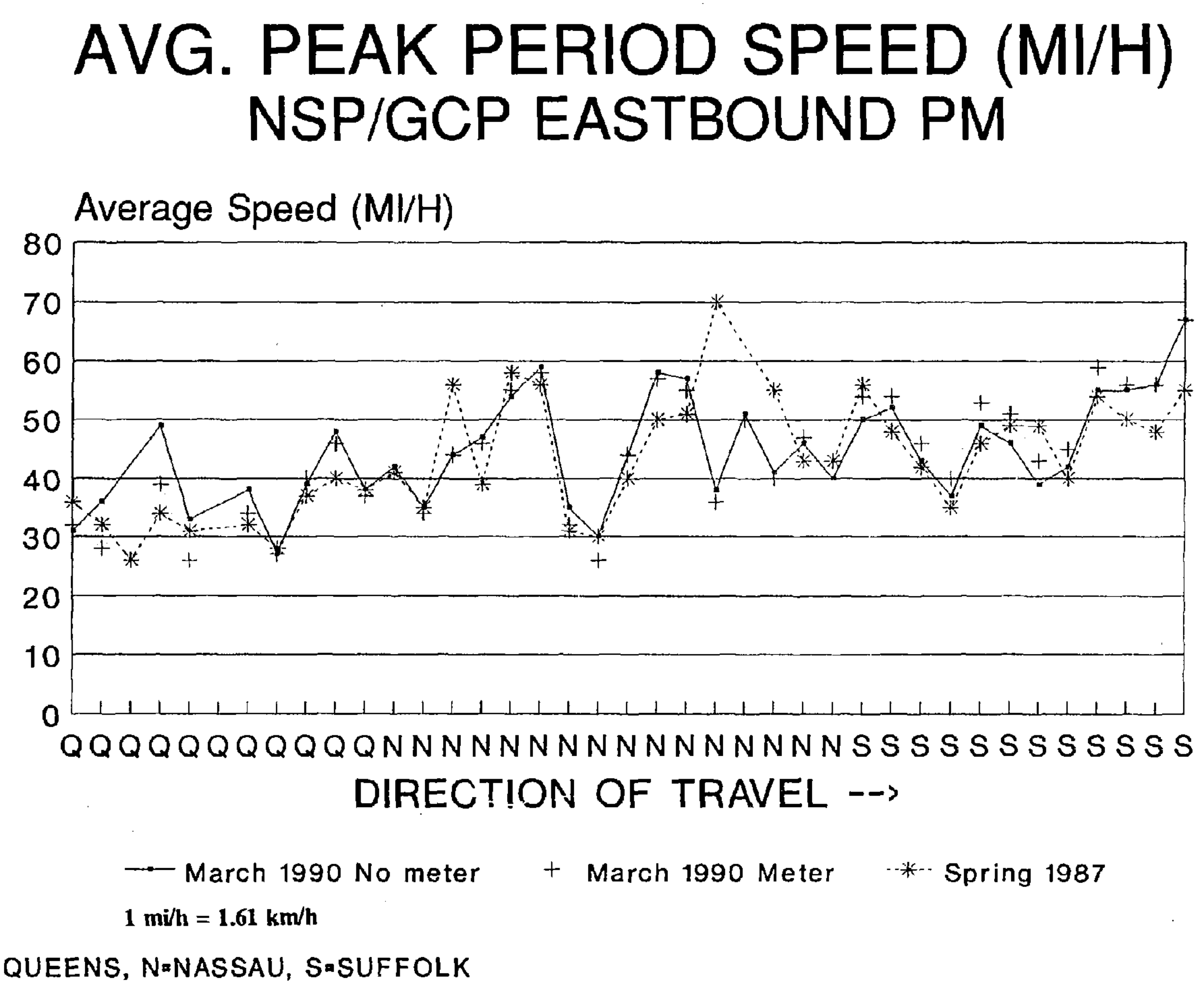


Figure 43. Average peak period speed (mi/h), NSP/GCP eastbound p.m.

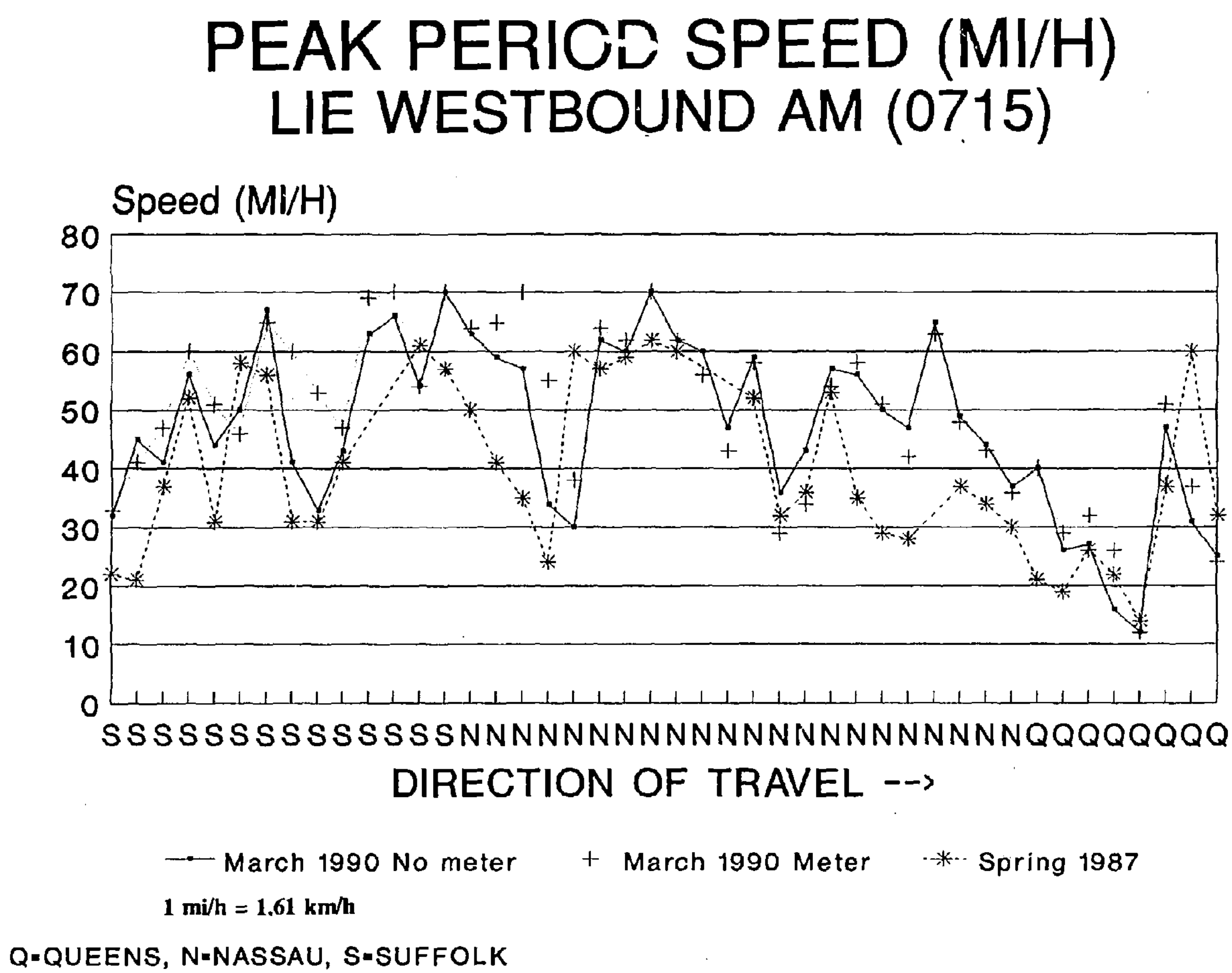
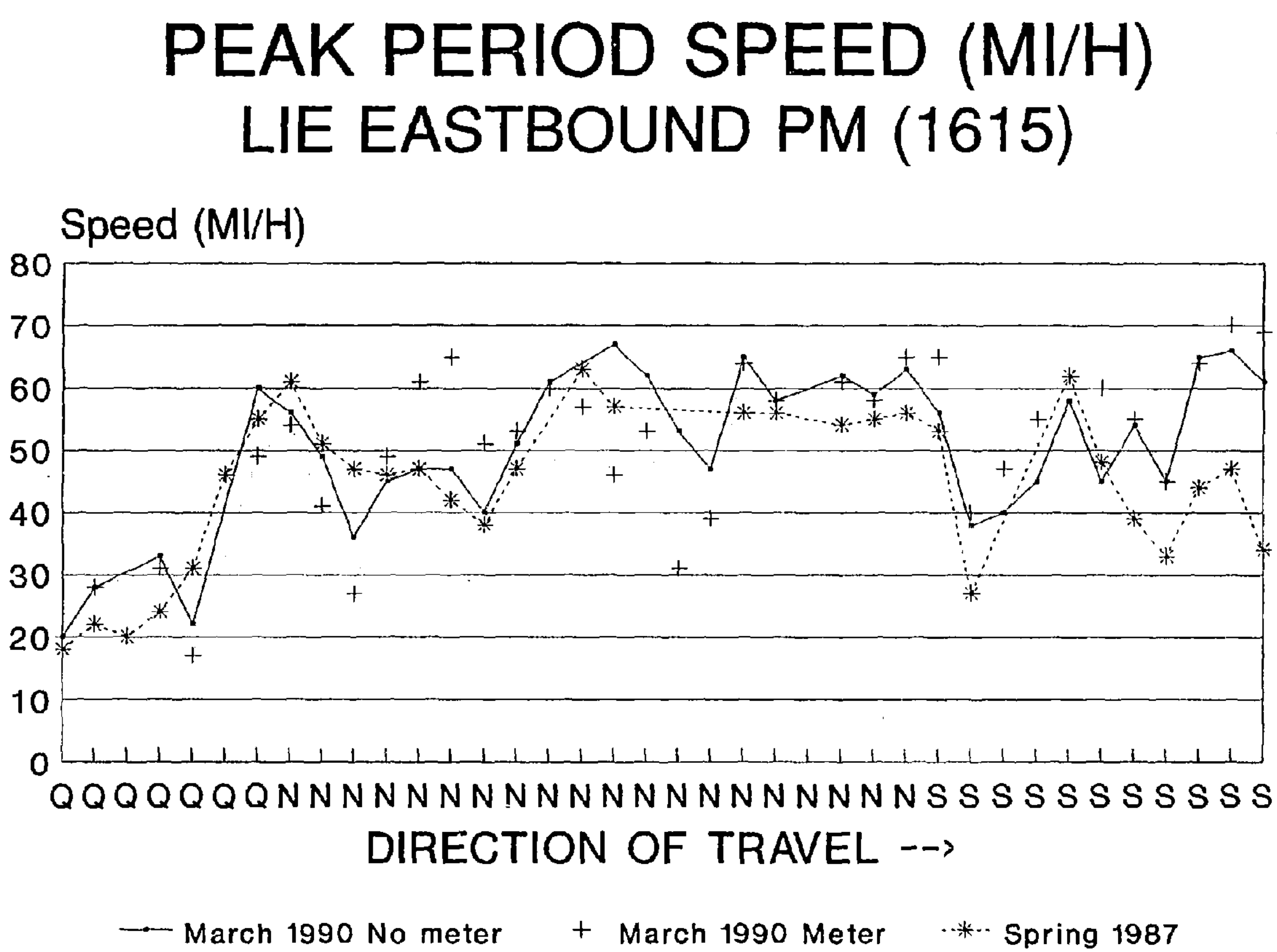


Figure 44. Peak period speed (mi/h), LIE westbound a.m. (0715).



1 mi/h = 1.61 km/h

Q=QUEENS, N=NASSAU, S=SUFFOLK

Figure 45. Peak period speed (mi/h), LIE eastbound p.m. (1615).

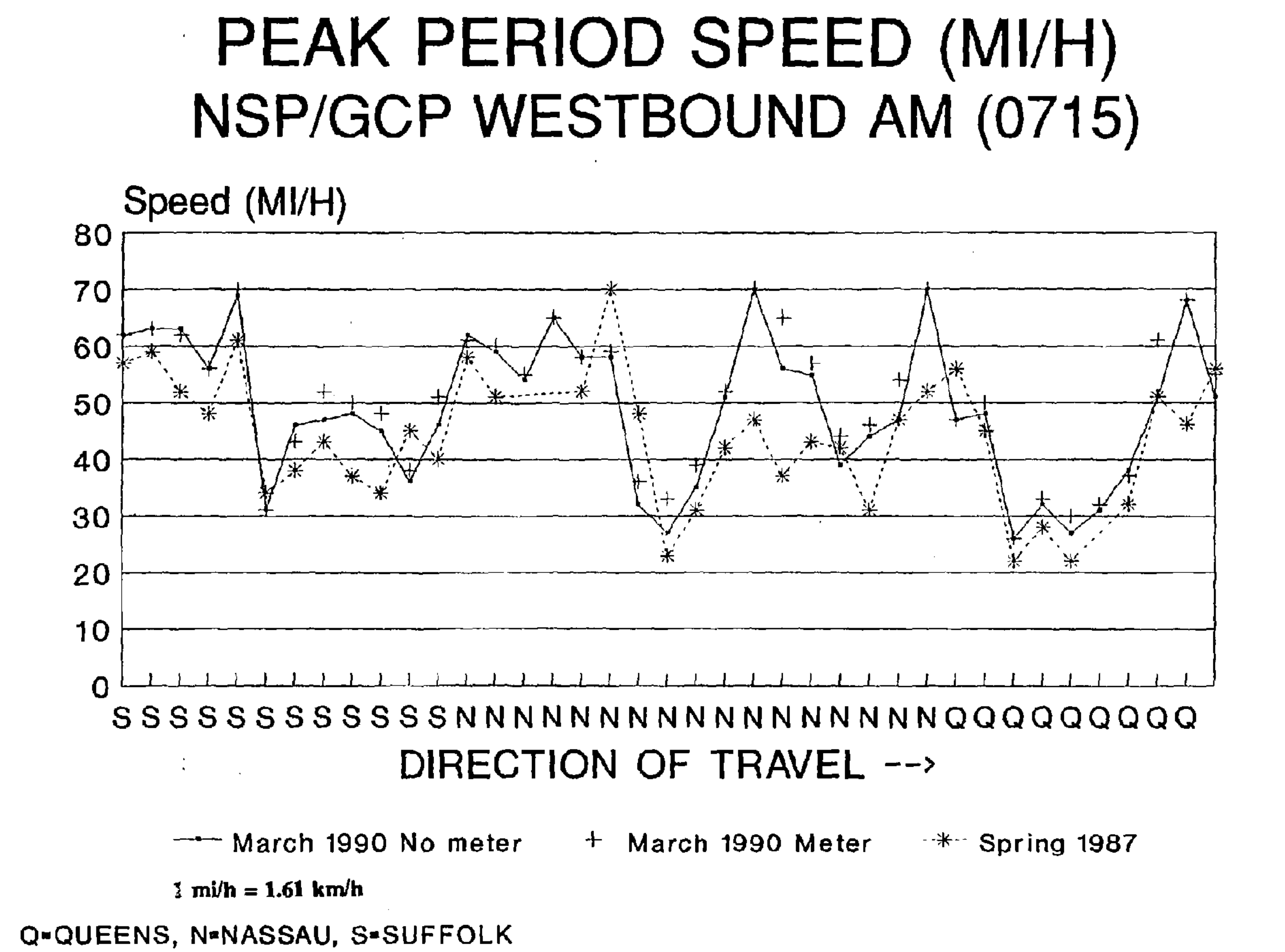


Figure 46. Peak period speed (mi/h), NSP/GCP westbound a.m. (0715).

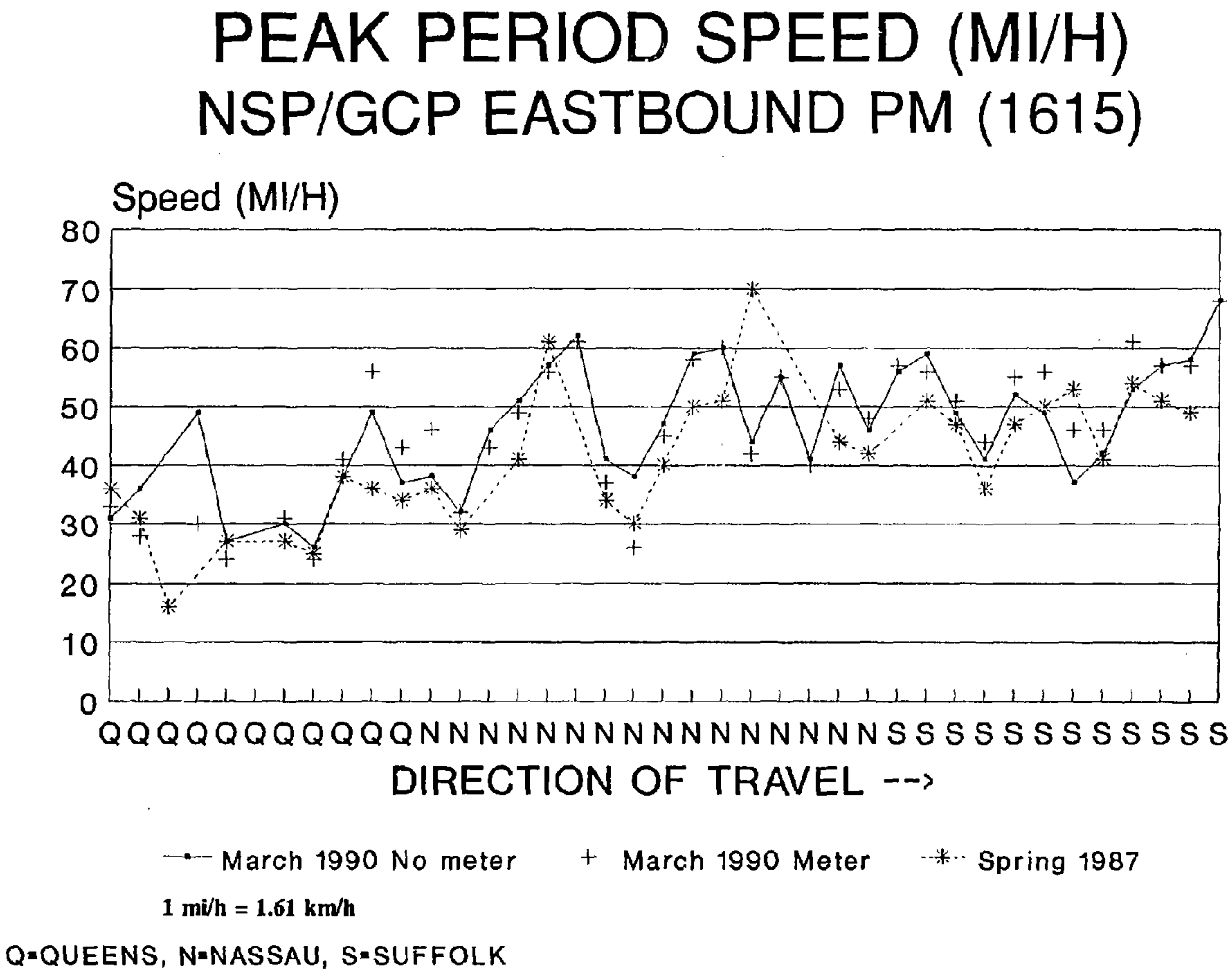


Figure 47. Peak period speed (mi/h) NSP/GSP eastbound p.m. (1615).

Table 18. Proportion of zones with speeds <= 30 mi/h LIE westbound a.m.

A. LIE WB SUFFOLK EAST AM

TIME	1987 SPRING	1988 FALL	1989 FALL	1990 MARCH N-METERD	1990 MARCH METERED	1990 APR/MAY	1990 JUNE
600	0.09	0.00	0.00	0.00	0.00	0.00	0.00
615	0.09	0.00	0.00	0.00	0.00	0.00	0.00
630	0.09	0.09	0.09	0.00	0.00	0.00	0.00
645	0.27	0.09	0.18	0.00	0.00	0.09	0.18
700	0.36	0.00	0.45	0.27	0.09	0.09	0.09
715	0.36	0.00	0.55	0.00	0.18	0.18	0.09
730	0.55	0.00	0.65	0.36	0.09	0.18	0.09
745	0.45	0.09	0.73	0.55	0.27	0.18	0.18
800	0.45	0.09	0.45	0.36	0.18	0.27	0.00
815	0.45	0.09	0.55	0.45	0.36	0.18	0.09
830	0.45	0.09	0.36	0.45	0.18	0.09	0.09
845	0.27	0.09	0.18	0.27	0.18	0.00	0.00
900	0.09	0.09	0.09	0.18	0.09	0.00	0.00
915	0.00	0.00	0.00	0.18	0.00	0.00	0.00
ALL	0.28	0.05	0.30	0.22	0.22	0.12	0.09

B. LIE WB SUFFOLK WEST AM

TIME	1987 SPRING	1988 FALL	1989 FALL	1990 MARCH N-METERD	1990 MARCH METERED	1990 APR/MAY	1990 JUNE
600	0.00	0.00	0.00	0.00	0.00	0.00	0.00
615	0.00	0.00	0.00	0.00	0.00	0.00	0.00
630	0.00	0.00	0.00	0.00	0.00	0.00	0.00
645	0.00	0.00	0.06	0.00	0.00	0.00	0.00
700	0.00	0.00	0.12	0.00	0.00	0.06	0.00
715	0.06	0.00	0.18	0.06	0.00	0.00	0.00
730	0.12	0.00	0.18	0.06	0.06	0.06	0.00
745	0.12	0.00	0.18	0.12	0.12	0.06	0.00
800	0.29	0.00	0.24	0.18	0.12	0.06	0.00
815	0.18	0.00	0.18	0.29	0.18	0.06	0.00
830	0.12	0.00	0.24	0.24	0.12	0.12	0.00
845	0.12	0.00	0.18	0.18	0.06	0.00	0.00
900	0.12	0.00	0.12	0.06	0.00	0.06	0.00
915	0.00	0.00	0.00	0.00	0.00	0.06	0.00
ALL	0.08	0.00	0.12	0.08	0.05	0.04	0.00

C. LIE WB NASSAU EAST AM

TIME	1987 SPRING	1988 FALL	1989 FALL	1990 MARCH N-METERD	1990 MARCH METERED	1990 APR/MAY	1990 JUNE
600	0.00	0.00	0.00	0.00	0.00	0.00	0.00
615	0.00	0.00	0.00	0.00	0.00	0.00	0.00
630	0.00	0.00	0.00	0.00	0.00	0.00	0.05
645	0.00	0.00	0.00	0.00	0.00	0.00	0.05
700	0.10	0.00	0.00	0.00	0.00	0.00	0.00
715	0.10	0.00	0.00	0.05	0.00	0.10	0.05
730	0.00	0.05	0.20	0.15	0.05	0.25	0.05
745	0.35	0.05	0.35	0.25	0.20	0.20	0.05
800	0.35	0.05	0.30	0.35	0.20	0.15	0.05
815	0.30	0.05	0.25	0.25	0.15	0.15	0.00
830	0.30	0.10	0.40	0.40	0.25	0.25	0.15
845	0.45	0.10	0.35	0.45	0.30	0.35	0.25
900	0.60	0.10	0.50	0.45	0.40	0.40	0.25
915	0.50	0.05	0.25	0.40	0.15	0.40	0.05
ALL	0.21	0.04	0.19	0.20	0.12	0.16	0.07

D. LIE WB NASSAU WEST AM

TIME	1987 SPRING	1988 FALL	1989 FALL	1990 MARCH N-METERD	1990 MARCH METERED	1990 APR/MAY	1990 JUNE
600	0.00	0.00	0.00	0.00	0.00	0.00	0.00
615	0.00	0.04	0.00	0.00	0.00	0.00	0.00
630	0.09	0.09	0.04	0.00	0.04	0.04	0.04
645	0.17	0.17	0.04	0.13	0.09	0.09	0.26
700	0.13	0.26	0.17	0.04	0.04	0.13	0.30
715	0.22	0.26	0.22	0.04	0.09	0.04	0.26
730	0.17	0.30	0.35	0.04	0.09	0.09	0.30
745	0.13	0.30	0.52	0.04	0.09	0.09	0.26
800	0.22	0.13	0.57	0.13	0.09	0.13	0.30
815	0.09	0.09	0.61	0.09	0.09	0.17	0.09
830	0.04	0.00	0.17	0.04	0.09	0.13	0.00
845	0.09	0.04	0.13	0.04	0.09	0.17	0.00
900	0.04	0.04	0.13	0.09	0.09	0.09	0.00
915	0.00	0.04	0.09	0.09	0.04	0.04	0.00
ALL	0.10	0.13	0.22	0.06	0.07	0.09	0.13

E. LIE WB QUEENS AM

TIME	1987 SPRING	1988 FALL	1989 FALL	1990 MARCH N-METERD	1990 MARCH METERED	1990 APR/MAY	1990 JUNE
600	0.00	0.00	0.00	0.00	0.06	0.00	0.00
615	0.06	0.22	0.17	0.00	0.06	0.06	0.00
630	0.06	0.17	0.28	0.06	0.11	0.17	0.28
645	0.22	0.22	0.33	0.33	0.28	0.39	0.39
700	0.44	0.44	0.50	0.56	0.44	0.67	0.61
715	0.56	0.33	0.44	0.61	0.50	0.67	0.61
730	0.39	0.39	0.44	0.72	0.50	0.61	0.61
745	0.61	0.50	0.50	0.56	0.50	0.61	0.56
800	0.66	0.44	0.60	0.56	0.44	0.61	0.50
815	0.33	0.28	0.44	0.56	0.39	0.56	0.39
830	0.17	0.33	0.39	0.44	0.17	0.56	0.28
845	0.11	0.22	0.28	0.44	0.17	0.56	0.28
900	0.11	0.22	0.28	0.28	0.06	0.39	0.17
916	0.11	0.17	0.22	0.11	0.00	0.28	0.11
ALL	0.27	0.28	0.34	0.37	0.26	0.44	0.34

1 mi/h = 1.61 km/h

Table 19. Proportion of zones with speeds <= 30 mi/h LIE eastbound p.m.

	A. LIE EB SUFFOLK EAST PM						
				1990	1990		
	1987	1988	1989	MARCH	MARCH	1990	1990
TIME	SPRING	FALL	FALL	N-METER	METERED	APR/MAY	JUNE
1530	0.00	0.00	0.13	0.00	0.13	0.00	0.13
1545	0.00	0.13	0.00	0.13	0.13	0.00	0.00
1600	0.13	0.13	0.00	0.13	0.13	0.13	0.00
1615	0.13	0.13	0.00	0.25	0.25	0.13	0.13
1630	0.50	0.38	0.13	0.25	0.25	0.13	0.38
1645	0.75	0.38	0.13	0.38	0.25	0.25	0.38
1700	0.75	0.63	0.25	0.38	0.25	0.25	0.38
1715	0.88	0.63	0.38	0.38	0.25	0.25	0.38
1730	1.00	0.63	0.63	0.38	0.25	0.25	0.25
1745	1.00	0.75	0.25	0.38	0.25	0.25	0.25
1800	0.88	0.75	0.13	0.25	0.25	0.25	0.38
1815	0.75	0.25	0.13	0.13	0.25	0.13	0.25
1830	0.13	0.25	0.13	0.13	0.25	0.13	0.13
1845	0.00	0.00	0.13	0.13	0.00	0.00	0.13
ALL	0.49	0.36	0.17	0.23	0.21	0.15	0.22

	B. LIE EB SUFFOLK WEST PM						
				1990	1990		
	1987	1988	1989	MARCH	MARCH	1990	1990
TIME	SPRING	FALL	FALL	N-METER	METERED	APR/MAY	JUNE
1530	0.13	0.00	0.00	0.00	0.00	0.00	0.00
1545	0.27	0.00	0.00	0.00	0.00	0.00	0.00
1600	0.33	0.00	0.00	0.00	0.00	0.00	0.07
1615	0.27	0.00	0.00	0.00	0.00	0.00	0.00
1630	0.40	0.00	0.00	0.00	0.00	0.00	0.00
1645	0.40	0.00	0.00	0.00	0.07	0.00	0.07
1700	0.20	0.07	0.00	0.07	0.13	0.00	0.07
1715	0.20	0.07	0.00	0.13	0.13	0.00	0.13
1730	0.27	0.13	0.00	0.20	0.20	0.07	0.13
1745	0.33	0.07	0.00	0.13	0.13	0.07	0.13
1800	0.13	0.00	0.00	0.13	0.13	0.00	0.00
1815	0.13	0.00	0.00	0.00	0.00	0.00	0.00
1830	0.13	0.00	0.00	0.00	0.00	0.00	0.00
1845	0.13	0.00	0.00	0.00	0.00	0.00	0.00
ALL	0.24	0.02	0.00	0.05	0.06	0.01	0.04

	C. LIE EB NASSAU EAST PM						
				1990	1990		
	1987	1988	1989	MARCH	MARCH	1990	1990
TIME	SPRING	FALL	FALL	N-METER	METERED	APR/MAY	JUNE
1530	0.00	0.06	0.00	0.00	0.00	0.00	0.06
1545	0.00	0.12	0.00	0.00	0.00	0.00	0.06
1600	0.00	0.12	0.00	0.00	0.00	0.06	0.06
1615	0.00	0.12	0.00	0.00	0.00	0.12	0.06
1630	0.00	0.12	0.00	0.00	0.12	0.18	0.06
1645	0.00	0.18	0.06	0.00	0.12	0.18	0.12
1700	0.00	0.12	0.12	0.06	0.12	0.24	0.12
1715	0.00	0.12	0.12	0.06	0.12	0.24	0.12
1730	0.06	0.24	0.12	0.12	0.18	0.24	0.18
1745	0.00	0.24	0.18	0.18	0.12	0.24	0.18
1800	0.00	0.24	0.12	0.12	0.12	0.24	0.18
1815	0.00	0.24	0.12	0.12	0.12	0.24	0.12
1830	0.00	0.12	0.00	0.12	0.00	0.18	0.12
1845	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ALL	0.00	0.14	0.06	0.05	0.07	0.15	0.10

	D. LIE EB NASSAU WEST PM						
				1990	1990		
	1987	1988	1989	MARCH	MARCH	1990	1990
TIME	SPRING	FALL	FALL	N-METER	METERED	APR/MAY	JUNE
1530	0.04	0.00	0.00	0.00	0.00	0.00	0.04
1545	0.04	0.00	0.00	0.00	0.07	0.00	0.11
1600	0.04	0.04	0.04	0.00	0.07	0.00	0.19
1615	0.07	0.04	0.04	0.00	0.07	0.00	0.26
1630	0.07	0.04	0.07	0.07	0.07	0.04	0.30
1645	0.04	0.04	0.07	0.11	0.07	0.04	0.41
1700	0.00	0.07	0.19	0.07	0.15	0.07	0.37
1715	0.07	0.15	0.07	0.00	0.04	0.11	0.33
1730	0.07	0.30	0.11	0.04	0.11	0.26	0.33
1745	0.15	0.26	0.11	0.19	0.15	0.22	0.41
1800	0.26	0.19	0.07	0.11	0.07	0.26	0.33
1815	0.19	0.07	0.04	0.04	0.00	0.15	0.26
1830	0.07	0.04	0.00	0.00	0.00	0.04	0.22
1845	0.00	0.00	0.00	0.00	0.00	0.00	0.07
ALL	0.08	0.09	0.06	0.04	0.06	0.08	0.26

	E. LIE EB QUEENS PM						
				1990	1990		
	1987	1988	1989	MARCH	MARCH	1990	1990
TIME	SPRING	FALL	FALL	N-METER	METERED	APR/MAY	JUNE
1530	0.57	0.44	0.44	0.33	0.39	0.33	0.50
1545	0.50	0.44	0.50	0.39	0.39	0.44	0.56
1600	0.50	0.33	0.44	0.44	0.44	0.50	0.50
1615	0.61	0.33	0.50	0.39	0.39	0.50	0.56
1630	0.56	0.39	0.39	0.33	0.44	0.33	0.61
1645	0.50	0.33	0.33	0.22	0.39	0.33	0.61
1700	0.39	0.39	0.39	0.33	0.39	0.33	0.67
1715	0.11	0.33	0.33	0.39	0.39	0.33	0.61
1730	0.22	0.22	0.39	0.39	0.39	0.28	0.61
1745	0.33	0.22	0.44	0.33	0.28	0.33	0.67
1800	0.28	0.17	0.33	0.22	0.28	0.22	0.61
1815	0.33	0.17	0.39	0.17	0.28	0.17	0.50
1830	0.22	0.17	0.33	0.28	0.39	0.33	0.50
1845	0.22	0.06	0.33	0.39	0.28	0.28	0.50
ALL	0.37	0.29	0.40	0.33	0.37	0.34	0.57

1 mi/h = 1.61 km/h

The tables show that the congestion index is low (usually zero) at the beginning of the peak period, increases in the middle of the peak period, and then tapers off. Careful study of the data is required to identify the changes between the 7 samples in the time series over the course of the peak period. The overall changes in the congestion index for the entire LIE for westbound a.m. and eastbound p.m. are as follows:

	CONGESTION INDEX	
	a.m.	p.m.
Spring 1987	.28	.21
March 1990 Nonmetered	.20	.11
March 1990 Metered	.15	.13

The above data is consistent with the overall statistics presented earlier in chapter 3. The a.m. peak period shows general improvement in congestion for the March 1990 a.m., while the p.m. peak period shows no improvement over March 1990 nonmetered but some improvement over spring 1987.

RAMP DELAY

Table 17 previously presented the data available on ramp delay for the April/May metered period. Most of the queues are less than five vehicles. Queues tend to be particularly low at the lower volume ramps. Another reason for some of the small queues, however, is the propensity for the system to shut certain ramp meters down in response to excessive queuing on the ramps. The average queue computation includes those periods when the meter is queued off and there is no queue at the meter.

An average queue was computed by facility and direction and is as follows:

- LIE westbound a.m. - 1.2 vehicles.
- LIE eastbound p.m. - 3.4 vehicles.
- NSP/GCP westbound a.m. - 2.4 vehicles.
- NSP/GCP eastbound p.m. - 2.4 vehicles.

The number of vehicle hours of ramp delay can be computed by multiplying the average number of vehicles in queue for each ramp by the amount of time that metering was to have been active (usually 2 hours). The estimated VHT due to ramp delay is 86 vehicle hours for the a.m. metering period for both the LIE and NSP/GCP and 147 vehicle hours for the p.m. metering period. In each case, this represents only about one tenth of 1-percent (0.1 percent) of the total VHT for the respective peak periods. This is an incidental amount of delay to entering traffic.

However, it should be recognized that the ramp delay is probably less than what it should be with ramp metering. There are low volumes at some ramps, while other ramps experience so much queuing under metering that the meters are queued off, eliminating the ramp delay. Even a doubling or tripling of the ramp queues would result in a relatively insignificant amount of delay on a system-wide basis. If the queues were allowed to interfere with surface street traffic, however, the amount of delay would be spread across many more vehicles and the increased delay would be significant.

The logical conclusion, then, is that queue storage on the ramps is a critical element of system design. The major factors in creation of that storage capacity are ramp length, location with respect to nearby surface streets, and two-lane versus single lane metering. A strong argument could be made that two-lane metering is needed on a number of INFORM ramps to eliminate or forestall the shut-down of the metering. While work has been done on the ramp metering algorithm to reduce the propensity for queued off meters, the ability to meter and the flexibility in metering is seriously compromised by not having the two-lane capability available. Thus, careful consideration of ramp volumes, storage capacities, and operational policy on queue management is essential in system design.

6. PERCEPTION SURVEY OF LONG ISLAND RESIDENTS

One of the important evaluation measures of INFORM is how the system is perceived by those who use the system (i.e., primarily the residents of Long Island). Perceptions of users of INFORM were gauged through a set of surveys of Long Island residents. The survey methodology was described in chapter 2. The results are presented below.

GENERAL CHARACTERISTICS OF RESPONDENTS

Table 20 indicates the distribution of respondents by age and sex. The table indicates that an approximate equivalent number of male and female drivers responded to the survey. Nearly two thirds of the drivers are younger than 50 years old.

DRIVING HABITS

The survey results indicated that, during an average week, Long Island drivers drive approximately 156 mi (251 km). Males tend to drive slightly more miles than females. Questions were asked regarding the typical times of day during which travel takes place as well as the facilities on which that travel occurs. Table 21 indicates the percentage of respondents that drive during specified periods of time for both the "average day" as well as the work commute. The numbers are not intended to be totalled, as respondents could have checked several periods. The table indicates that travel is done throughout the day but that the heaviest periods of travel are during the a.m. and p.m. peak commuting periods. Male and female drivers drive in the same general patterns, but females are slightly less likely to be driving in the peak commuting periods.

Table 22 indicates how the driving is distributed over the INFORM roadways. It indicates that the sections most frequently traveled by respondents are in Nassau County. This is most likely due to Nassau County being in the middle of the corridor and the general commuting direction being toward New York City. Even though the LIE and GCP in Queens have only half the INFORM roadway mileage as Nassau County and Suffolk County, the Queens roadways are travelled as much as the Suffolk County roadways and almost two-thirds as much as the Nassau County roadways. The table indicates that the Long Island Expressway is traveled more frequently than the Northern State Parkway in all of the sections.

DRIVER UNDERSTANDING OF INFORM

One of the survey questions posed was "Have you heard about a computerized information system on Long Island?" Table 23 indicates the results, stratified by sex and by commuting and driving habits. Overall, 60 percent of the respondents had heard about the system. Those that regularly drive the LIE and NSP/GCP were slightly more informed about the system (approximately 65 percent) than those who did not regularly drive these roadways (50 to 55 percent - see LIE non-drivers). As table 24 indicates, however, a very small proportion of respondents actually knew the name of the system (6.2 percent). Approximately 87 percent answered that they did not know the name.

Table 20. Age and sex distribution of respondents

AGE	MALE NO.	MALE PERCENT	FEMALE NO.	FEMALE PERCENT
17-24	38	8.5	50	11.0
25-34	58	12.9	81	18.8
35-49	172	38.3	177	39.3
50-54	35	7.8	34	7.6
55 and over	145	32.3	107	23.8
	448	100.0	449	100.0

Table 21. Time periods driven (percent driving during specified time period).

	MALE		FEMALE		TOTAL	
	Commute	All Trips	Commute	All Trips	Commute	All Trips
<u>WEEKDAY</u>						
6 a.m. to 9 a.m.	65.5	51.2	64.5	49.7	46.1	43.8
9 a.m. to Noon	12.1	32.3	9.6	40.8	36.5	10.9
Noon to 3 p.m.	9.5	34.6	11.1	41.7	38.1	10.3
3 a.m. to 6 p.m.	37.5	47.0	30.0	53.9	50.4	33.8
6 p.m. to 9 p.m.	20.2	43.8	12.2	37.6	40.7	16.2
9 p.m. to Midnight	6.6	21.3	4.7	16.3	18.8	5.7
Midnight to 3 a.m.	2.0	5.5	2.0	4.1	4.8	2.0
3 a.m. to 6 a.m.	3.7	2.6	0.9	1.5	2.0	2.3
<u>SATURDAY</u>						
6 a.m. to Noon	13.0	47.0	11.1	37.6	42.3	12.0
Noon to 6 p.m.	12.1	59.4	11.1	59.2	59.3	11.6
6 p.m. to Midnight	6.9	46.1	5.2	27.4	36.8	6.1
Midnight to 6 a.m.	2.6	6.6	2.0	7.9	7.2	2.3
<u>SUNDAY</u>						
6 a.m. to Noon	9.5	42.1	5.2	30.6	36.4	7.4
Noon to 6 p.m.	7.5	59.7	5.5	55.1	57.4	6.5
6 p.m. to Midnight	5.5	34.3	3.5	24.2	29.3	4.5
Midnight to 6 p.m.	1.2	3.5	0.9	2.3	2.9	1.0

Table 22. Frequency of driving on INFORM roadways (percent regularly driving on specified roadways).

	MALE		FEMALE		TOTAL	
	Commute	All Trips	Commute	All Trips	Commute	All Trips
LIE Suffolk	11.8	43.7	6.0	31.0	8.5	35.8
LIE Nassau	21.6	63.5	9.5	45.0	14.9	52.0
LIE Queens	13.8	38.3	7.1	23.7	10.0	29.7
NSP Suffolk	8.7	32.7	4.2	27.1	6.2	28.6
NSP Nassau	15.6	54.3	9.5	45.5	12.0	47.9
GCP Queens	11.6	36.3	6.7	24.8	8.7	29.4

* Numbers do not total to 100 percent

Table 23. Awareness of computerized traffic information system on Long Island.

	Male	Female	LIE Drivers	LIE Non-Drivers	LIE Commuters	NSP/GCP Drivers	NSP/GCP Commuters	TOTAL
Yes, have heard about system	63.5	56.8	64.5	51.5	64.7	67.1	67.0	60.0
No, have not heard about system	36.5	43.2	35.5	48.5	35.3	32.9	33.0	40.0
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 24. Respondent understanding of name of system.

MOTRIL	0.9%
IMIS	3.3
INFORM	6.2
ROADNET	2.4
Don't Know	87.0

Table 25. Source of information about the system.

Radio	7.1%
Newspaper	34.4
TV	6.9
Brochures	0.9
Was Told	18.7
Don't Know	31.9

As indicated in table 25, those who had heard about the system (even though they may not have known the name) had heard from the newspaper, most likely through occasional articles that may have appeared about INFORM. Word of mouth was the next most common source, followed by radio.

Table 26 indicates a high degree of awareness of the overhead traffic advisory signs. The specific wording of the question was "On some highways there are changeable overhead message signs that describe the traffic ahead. For example: NORMAL TRAFFIC CONDITIONS AHEAD. Have you seen these traffic advisory signs over any highways that you use?" Overall, approximately 96 percent of the drivers had seen these signs. Thus, while a high percentage of drivers may recognize individual components of a freeway system, many do not recognize them as part of a unified system. While drivers may not recognize INFORM as a system, this recognition is not likely critical to its success as long as drivers properly accept and respond to the individual components of the system.

Table 26. Awareness of overhead traffic advisory signs.

	Male	Female	LIE Drivers	LIE Commuters	NSP/GCP Drivers	NSP/GCP Commuters	TOTAL
Aware	97.5	95.9	98.4	95.5	98.9	81.8	96.4%
Not Aware	2.5	4.1	1.6	4.5	1.1	18.2	3.6
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0

DRIVER PERCEPTION OF TRAFFIC ADVISORY INFORMATION

One of the survey questions asked was "Based on your experience, how useful is the information on the traffic message signs?" On average, 29-percent of the respondents rated the information as very useful and another 46-percent indicated that the information was moderately useful (table 27). It is possibly significant that a lower percentage of commuters indicated the information to be very useful than the larger group of LIE and NSP/GCP drivers. It is quite likely that the traffic information is less useful during peak commuting periods, since there are fewer uncongested alternate routes during those periods. Although the differences are only 6- to 7-percent, it suggests that drivers are aware of this difference in information usefulness by time of day.

Table 28 indicates the difficulty of the task of maintaining accurate traffic information and the critical reviews that drivers give to the accuracy of the information. Overall, only 7-percent of respondents indicated the information to be always accurate. However, nearly 56-percent indicated the information to be usually accurate. Thus, most drivers appear to be generally content with the information. However, some credibility problems remain with a proportion of drivers in spite of the amount of time and effort invested in keeping the information current. There are several potential causes of inaccurate sign information: limitations in the positional accuracy due to the half-mile detector spacing and/or failed detector stations, limitations in temporal accuracy due to the smoothing of detector data, and human inaccuracies due to possible operator inattention or delays in response.

Table 27. Usefulness of traffic advisory information.

	Male	Female	LIE Drivers	LIE Commuters	NSP/GCP Drivers	NSP/GCP Commuters	TOTAL
Very useful	29.8%	28.7	35.4	28.6	37.9	18.2	29.2%
Moderately useful	46.0	46.1	48.8	57.1	46.3	72.7	46.0
Seldom useful	21.0	21.9	15.0	14.3	14.7	9.1	21.5
Never useful	3.2	3.3	0.8	0.0	1.1	0.0	3.3
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 28. Accuracy of traffic advisory information.

	Male	Female	LIE Drivers	LIE Commuters	NSP/GCP Drivers	NSP/GCP Commuters	TOTAL
Always accurate	6.8%	7.3	2.4	9.5	3.2	18.2	7.0%
Usually accurate	55.1	57.2	55.1	33.3	54.7	9.1	56.2
Sometimes accurate	34.3	32.6	39.4	57.1	37.9	72.7	33.5
Almost never accurate	3.7	2.8	3.1	0.0	4.2	0.0	3.3
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0

A survey question asked "Have you ever changed your route in response to a sign message?' Table 29 indicates that some 45-percent of drivers sometimes change their route in response to the messages. Slightly more than one-quarter have never changed their route. One of the operational strategies of INFORM is to operate the signs in such a way as to maintain a balance in traffic among the facilities. It is pointed out by INFORM staff that achieving this balance requires only a proportion of the drivers to divert. The survey results indicate that there is a pool of drivers who are at least willing to divert and that the percentages of these divertable drivers is significant enough to achieve the desired balance.

Table 30 indicates driver perception of the benefits of the signs. The timeliness of the information and the advance warning provided of traffic congestion are perceived to be the most significant benefits. The provision of alternate route information is perceived as one of the less significant benefits. These results correspond to the general operational philosophy of INFORM, which places less emphasis on recommending alternate routes than on providing information on the location of congestion.

One of the survey questions asked what changes drivers would make in the signs or the sign messages. A compilation of these open-ended responses (table 31) indicated that improved accuracy was the most frequently mentioned request. A significant number listed the provision of information on alternate routes as a preference.

DRIVER PERCEPTION OF RAMP METERING

A number of questions polled driver perception of the operation of the merge lights. The term "merge light" was used in the questionnaire, as this is the name for ramp metering signals used in the public relations campaign. Table 32 indicates that approximately one-fifth of drivers have no opinion about the merge lights, and that the remainder are split approximately 50-50 on whether they are a good idea or not a good idea. The NSP/GCP commuters gave the merge lights a slightly better rating than the LIE commuters.

Table 33 indicates driver perception of the merge light function in several specific areas. Drivers were asked to check all categories that apply. It is interesting that the most frequently checked responses had to do with the negative aspects of ramp metering. Nearly 45 percent refer to the creation of backups at the ramps. This could be interpreted as either an acknowledgement that the merge lights are doing what they were intended to do (store vehicles on the ramps) or a sensitivity to the backups being more significant than they should be. The difficulty of merging into traffic from a stop was checked by over 40 percent of the drivers. The most frequently listed benefit was that the merge lights can help reduce merge accidents (20-percent overall). Overall, approximately 37-percent of survey respondents have encountered a red merge light (table 34). This percentage increases to approximately 48-percent for LIE and NSP/GCP drivers, and to over 60-percent for LIE commuters.

Table 35 indicates the perceived wait time for those drivers who have encountered a red merge light. The waits are perceived to be 1 minute or less by almost 90-percent of the drivers. Almost a third indicated that the waits are less than 10 seconds, indicating that there would usually not be more than 1 vehicle in line as the driver approached the merge light.

Table 29. Frequency of route changes in response to highway advisory signs.

Change route sometimes	45.6%
Rarely change route	27.0
Never change route	27.4
Total	100.0

Table 30. Driver perception of variable message sign benefits.

	#1 Benefit	#2 Benefit
Provide timely information	29.6%	16.1
Provide accurate information	17.8	18.1
Suggest alternate routes	8.9	15.1
Warn of tie-ups in advance	33.6	20.3

*Percentage of respondents rating "provide timely information" as the No. 1 function

Table 31. Changes respondents would like to make in signs or sign messages (open-ended responses).

43	Provide more accurate information
34	Provide information on alternate routes
28	Make signs easier to read
20	Provide more current information
15	Provide more detailed information
14	Show length of delay to be expected
12	Indicate time of report
8	Install more signs
6	Indicate lane conditions (e.g. which ones are blocked)
4	Provide names of exits rather than numbers
4	Indicate speed in incident area
7	Provide more reliable information
7	Provide more advanced notice
9	Make messages more understandable
2	Remove signs
1	Provide larger signs
1	Provide bridge and tunnel information (into Manhattan)

Table 32. Driver perception of value of merge lights.

	Male	Female	LIE Drivers	LIE Commuters	NSP/GCP Drivers	NSP/GCP Commuters	TOTAL
Good idea	43.0%	36.7	49.6	57.1	47.4	63.6	39.8%
Not good idea	39.8	37.9	40.2	33.3	42.1	27.3	38.7
No opinion	17.2	25.3	10.2	9.5	10.5	9.1	21.5
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 33. Driver Perception of merge light effect.

	Male	Female	LIE Drivers	LIE Commuters	NSP/GCP Drivers	NSP/GCP Commuters	TOTAL
Keep traffic running	28.1%	22.2	22.8	23.4	23.7	23.6	24.0%
Reduce accidents	30.5	26.4	26.1	26.7	26.9	26.9	27.3
Make merging easier	26.5	24.2	22.9	23.7	23.6	24.1	24.4
Reduce travel time	21.8	20.6	20.1	20.2	20.0	20.2	20.3
Increase ramp units	28.5	25.1	25.0	26.1	25.3	25.7	25.6
Make merging more difficult	42.3	41.9	39.0	40.3	38.7	40.3	42.1
Cause ramp backups	47.2	43.2	41.7	43.2	43.0	43.3	45.0

Table 34. Percentage of drivers encountering red merge light.

	Male	Female	LIE Driver	LIE Commuter	NSP/GCP Driver	NSP/GCP Commuter	Total
Yes, have encountered	41.6	29.9	58.1	59.1	50.5	63.6	36.7%
No, have not encountered	54.6	64.7	39.5	36.4	48.4	27.3	63.3

Table 35. Perceived typical wait time on a ramp with merge lights.

Less than 10 seconds	33.9%
10 to 30 seconds	38.5
31 to 60 seconds	17.9
1 to 2 minutes	6.4
2 to 4 minutes	3.0
4 to 6 minutes	0.3

One of the phenomena observed by personnel involved in the operation of INFORM was that drivers tend to make a decision of whether to stand in queue at a metered on-ramp or to divert to one of the LIE service roads. In most cases, it is easy to observe the queue at the ramp meter while still on the service road and to continue on the service road if the ramp delay appears to be excessive. Diverting drivers may choose to enter at a downstream on-ramp, or may continue on the service road, particularly if the trip is short. This diversion is, in fact, one of the expected effects of ramp metering, which is more likely to discourage a short trip from entering the freeway than a long trip, since the percentage increase in travel time due to delay at a ramp meter would be greater for a short trip. Table 36 indicates that some of this diversion is, in fact, occurring. Some 15 percent of those encountering a red merge light indicated that they frequently use the service road or another roadway to avoid waiting at the merge lights. Another 27 percent indicate that they do this occasionally. This suggests that ramp metering is, at least in part, having some diversionary effects.

Drivers were asked how the merge light operation should be changed on their current peak period operation. Table 37 indicates the high degree of trust drivers place in the ability of the central computer to make a determination. There appears to be a willingness to tolerate additional ramp meter operation, if it will improve traffic flow.

Table 38 indicates driver understanding of the legal status of merge lights. The vast majority of drivers recognize the merge lights as a legal traffic control device that must be obeyed. However, a sizeable proportion (over 25-percent) perceive that there would be no penalty if they go through a red merge light. In reality, passing through a red ramp metering indication is a ticketable offense. The results in table 39 indicate that approximately one-third of drivers expect that they would get a ticket if they passed through a red merge light. While observed compliance with the ramp meters is quite good, the perception among drivers is that the meters are not backed by significant enforcement power.

Most drivers have the proper understanding of what should be done if a ramp metering signal is not on (table 40). Most recognize that they should not stop but should merge directly into traffic. However, one-third believe that they should stop briefly and then proceed. A review of the driver perceptions of ramp metering indicate that there is still a gap in their understanding of the function of ramp metering and their responsibility toward it. Nevertheless, field reviews of the ramp metering operation indicate that, by and large, motorists are responding to ramp metering in the proper way. Thus, the failure to understand is not necessarily a problem in the operation of the system.

OVERALL PERCEPTION OF INFORM

A survey question asked drivers "What overall effect is the computerized traffic information system having?" Table 41 indicates that approximately one-fourth of drivers viewed the system to be quite helpful. Another 40-percent indicated that the system helps once in a while. Relatively few indicated that it has made the problems worse, although the LIE and NSP/GCP commuters checked that response most often (approximately 8-percent). The slightly more negative commuter response may have to do with the perception of ramp metering.

Table 36. Driver diversion to avoid merge lights.

Frequently	14.7 %
Occasionally	26.7 %
Never	58.6 %

Table 37. What additional times should be considered for operation of merge lights.

Weekdays Eastbound AM	8.5%
Weekdays Westbound PM	9.6%
Longer periods during peak hours	5.2%
Before and after peak hours	3.9%
Weekends whenever traffic is heavy	18.4%
Any hour when traffic is heavy	29.5%
Let computer decide when	39.5%

* Numbers do not total to 100 percent

Table 38. Driver understanding of legal status of merge lights.

	Male	Female	LIE Drivers	LIE Commuter	NSP/GCP Drivers	NSP/GCP Commuter
A traffic light that must be obeyed	82.7	87.5	82.0	85.7	84.8	100.0
Have no authority to stop cars	20.0	14.4	17.8	13.6	14.7	9.1
Have no penalty if go thru red light	28.4	23.6	27.8	40.0	25.8	40.0

* Numbers do not total to 100 percent

Table 39. Driver understanding of outcome if merge light is ignored.

	Male	Female	LIE Drivers	LIE Commuters	NSP/GCP Drivers	NSP/GCP Commuters
Will get a ticket	31.8	32.6	46.5	54.5	44.2	63.6
Slows highway traffic	18.5	14.9	14.8	27.3	18.9	9.1
Cause merge accidents	34.5	35.3	33.3	31.8	36.8	36.4
Nothing	38.5	35.5	34.1	31.8	33.7	18.2

* Numbers do not total to 100 percent

Table 40. Driver understanding of what to do if merge light is not on.

	Male	Female	LIE Drivers	LIE Commuters	NSP Drivers	NSP Commuters
Don't stop--merge right into traffic	61.7	56.0	66.4	52.4	63.8	50.0
Stop..wait to see if light comes on	3.7	3.7	3.9	9.5	4.3	10.0
Stop..then enter the highway	34.6	40.3	29.7	38.1	31.9	40.0
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0

Table 41. Driver perception of overall effect of INFORM.

	Male	Female	LIE Drivers	LIE Commuters	NSP/GCP Drivers	NSP/GCP Commuters
Quite helpful	25.5	23.9	27.0	28.6	12.4	27.3
Helps once in a while	39.6	43.1	38.9	42.9	39.1	54.5
No noticeable effect	28.9	27.9	31.7	19.0	33.7	18.2
Has made problems worse	6.1	5.0	2.4	9.5	0.0	0.0
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0

Table 42 indicates the specific perceived effects of the INFORM system overall. Consistently, the most frequently indicated response is that it helps drivers avoid delays. This suggests that drivers are citing the traffic information component of INFORM as the most significant benefit. The other most frequently recognized benefits are that it keeps traffic moving and smoothes out highway traffic flow. Gasoline savings was the least perceived effect.

Table 43 indicates that, in spite of the positive reception of the traffic information generated by INFORM, drivers still rely on information from radio stations as the best source of traffic information. There is a noteworthy difference between the perceptions of drivers and commuters in this regard. The commuter subgroups on the LIE and NSP/GCP place higher reliance on radio station information than does the overall driver population. It is important to note that INFORM provides regular information to all the major radio traffic reporting networks, so that INFORM is likely responsible for most of the radio information the driver receives within the LIE/NSP/GCP corridor. However, INFORM does not cover all the Long Island roadways, which is likely a significant reason for driver use of radio stations as the primary source.

Table 44 indicates improvements drivers would like to see in radio traffic reports on Long Island. Providing more frequent traffic updates, expanding the area of coverage, and providing more current information were the 3 most frequently mentioned improvements in this open-ended question.

Table 45 indicates that a large majority of drivers do not know who operates INFORM. Of those that did identify a responsible agency, most selected the proper response, New York State DOT.

Table 46 indicates the thinking of Long Island drivers as to the most important actions that can be taken to improve Long Island traffic. The addition of a fourth lane on the Long Island Expressway was the most commonly checked response. The completion of the LIE service roads was also listed frequently. The extension of INFORM eastward or to the Southern State Parkway was significantly lower on the priority list.

Table 42. Specific perceived effects of INFORM.

	Male	Female	LIE Drivers	LIE Commuters	NSP/GCP Drivers	NSP/GCP Commuters
Keeps traffic moving	25.5	26.6	34.9	40.9	32.9	45.5
Helps drivers avoid delays	39.6	43.0	51.2	36.4	52.6	36.4
Helps cut down on merge accidents	21.4	20.4	27.1	27.3	22.1	18.2
Smoothes out highway traffic flow	25.8	20.6	31.02	31.8	27.4	27.3
Helps drivers save gas	4.7	4.2	4.7	4.5	4.2	0.0
Helps during peak hours	22.7	18.2	27.1	36.4	26.3	36.4
Speeds up my trip	10.9	8.0	31.02	18.2	15.8	18.2
Slows down my trip	10.9	11.1	9.3	4.5	7.4	9.1
Causes backup on local access roads	18.3	18.4	16.3	22.7	13.7	9.1

Table 43. Driver perception of best source of traffic information.

	Male	Female	LIE Driver	LIE Commuter	NSP/GCP Driver	NSP/GCP Commuter
Radio Station	58.4%	52.6	58.0	57.1	61.5	63.6
Message Signs	29.9	40.4	29.4	28.6	31.9	27.3
CB Radio	11.6	7.0	12.6	14.3	6.6	9.1
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0

Table 44. Changes respondents would like to make in radio traffic reports (open-ended responses).

No.	Comments
58	Provide more frequent reports
54	Increase area of coverage
41	Provide more current information
31	Provide more accurate information
18	Provide more air time for traffic coverage
15	Provide more detailed reports
14	Provide more frequent reports during peak hours
10	Suggest alternate routes
5	Need more traffic stations
5	Speak more slowly
2	Provide advance notice of construction
1	Indicate type of accident
1	Provide follow-on reports
1	Indicate exit no. of incident
1	Indicate time of incident
1	Indicate speed in incident area

Table 45. Driver perception of who operates INFORM.

	Male	Female	LIE Driver	LIE Commuter	NSP/GCP Driver	NSP/GCP Commuter
Nassau Traffic	3.3	2.9	0.8	0.0	1.1	0.0
Suffolk Traffic	1.0	1.4	0.0	0.0	0.0	0.0
N.Y. City Traffic	3.6	1.4	2.4	4.8	1.1	0.0
N.Y.S. DOT	18.6	11.8	18.1	19.0	18.1	36.4
N.Y. State Police	1.0	1.2	0.0	0.0	0.0	0.0
Don't Know	72.6	81.2	78.7	76.2	79.8	63.6
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0

Table 46. Driver perception of most important traffic improvements needed on Long Island.

(Percent of Drivers Listing Each Strategy)

	#1 PRIORITY	#2 PRIORITY	#3 PRIORITY	#4 PRIORITY	#5 PRIORITY
Complete the LIE service road network	29.1	19.4	16.9	5.5	4.3
Add a fourth lane on the LIE	39.4	15.6	9.4	4.4	3.6
Add a fourth lane on the LIE for HOVs	7.7	9.3	8.9	12.3	12.2
Widen Northern State Parkway	13.5	21.9	16.1	10.0	6.0
Extend the TIS farther east	2.8	3.7	6.5	7.5	12.4
Extend the TIS to Southern Parkway	4.8	4.5	6.6	8.3	14.3
Synchronize traffic lights on east-west and north south arterials	12.6	9.5	10.4	14.0	13.7

* Numbers do not total to 100 percent

7. CONCLUSIONS AND SUMMARY OF LESSONS LEARNED

At the beginning of this report it was stated that INFORM was designed as an operational demonstration of corridor traffic control technology. New ground has been broken by INFORM, but not without a number of difficult encounters with the reality of building a system of this scale. While INFORM continues to undergo change and improvement, experience with INFORM has taught many lessons that are important in designing, constructing and operating corridor traffic control systems. Some of the lessons have been learned the hard way -- through trial and error. INFORM can also lay claim to some legitimate successes.

This summary draws from both sides of the experience. It highlights some of the major findings thus far (additional information will be provided in the final report), and presents a variety of lessons learned in several areas of design, construction and operation of INFORM. Comments are also provided on the evaluation methodology for such systems. The conclusions and lessons are based on evaluation results and are organized into the following categories:

- Motorist information.
- Ramp metering.
- Public perception.
- General design and construction issues.
- General operational issues.
- Evaluation methodology for corridor traffic control systems.

MOTORIST INFORMATION

INFORM represents the most advanced VMS-based motorist information system in the U.S. In addition to the benefits it has provided to the motoring public, it has been and will continue to be a testing ground for further improvement of motorist information strategies. Some of the specific findings and lessons learned include:

- Impact on delay - The VMS's are an effective part of INFORM. The incident case studies have indicated that drivers do, in fact, modify their routes if they are consistently given accurate information. Estimated delay savings for the peak period incidents analyzed ranged up to 1900 vehicle hours. The estimated annual delay savings for the incident-related effects of the VMS's is 300,000 vehicle hours. Delay savings are also attributable to INFORM involvement in recurring traffic congestion, construction activity and special events, but the savings are difficult to quantify. The availability of the signs for certain functions also eliminates the need to perform that same service in another more expensive way (e.g., nighttime closure of the LIE or NSP/GCP for construction and maintenance).

- Automated sign message selection - Automated sign message selection is an important part of INFORM. It is accurate within the limitations of the detector data provided by the surveillance system, and is essential to allowing the operators to keep up with the information demands in a corridor the size of INFORM, particularly in the peak periods.

- Commitment to VMS operation and information quality - A significant investment of operational staff time is made in maintaining the timeliness and accuracy of the INFORM sign information. A commitment to the installation of VMS's must be backed by a significant commitment to their operation. Monitoring and control of the INFORM VMS sign information comprises an estimated 80 percent of operator time (based on operator interviews), even with the assistance of an automated message-selection algorithm. One cannot expect the system to run itself and maintain the quality of information that the motoring public expects. INFORM produces over 14,000 sign messages per month to attempt to maintain the quality of information.

- Level of diversion - Diversion is clearly taking place in response to the sign messages. For a typical incident using passive messages (i.e., no recommended alternate route), 5 to 10 percent of mainline traffic on INFORM could be diverted over several upstream off-ramps (typically 3- to 4- percent at an individual ramp). This can vary widely, however, based on the location and severity of the incident, availability of alternate routes and other factors. This suggests that motorists have some degree of faith that the INFORM information is accurate and that motorists perceive that faster travel can take place on an alternate route. What occurs on the alternate route is difficult to trace due to the many origins and destinations of motorists and to the relative lack of detectorization on the alternate route. Displaying a diversion message (such as "LONG DELAYS ON 495 EAST, USE N. PKWY) typically results in higher diversion percentages, depending on the proximity and capacity of the alternate route. Experience on INFORM indicates that, as a rule of thumb, adding a diversion message will double the normal passive diversion percentage. Numbers could be higher for extremely convenient diversion routes and lower for inconvenient diversion routes. Diversion messages should be used sparingly, as drivers who encounter delays on the diversion route may fault the system for recommending that they be sent that way, even if that route is faster. Passive congestion signing puts the system at less risk of being criticized and tends to avoid the major shifts in volume that can create alternate route congestion, if alternate route capacity is limited.

- Transferability of diversion percentages to other corridors - In general, the following rules would apply to the level of diversion:

  - The diversion percentage would increase as the directness of the alternate route increases.

  - The diversion percentage would increase with increased excess capacity on the alternate route.

  - The diversion percentage would increase as the motorists' faith in the signing system increases (i.e., after the initial break-in period when motorists are determining how reliable the information actually is). INFORM operators recognize the credibility of the sign information to be an extremely important factor in influencing motorists' decisions to change their routes. It is their philosophy that, if the signs cannot be believed, it is highly unlikely that the signs would have much influence on traffic patterns over the long term.

- Diversion and alternate route traffic control schemes - The development of effective corridor diversion schemes is heavily dependent on the ability of alternate routes to absorb traffic from the mainline. Parallel freeways, such as the LIE and NSP/GCP offer an ideal opportunity for such diversion to take place, and such diversion has been identified on INFORM. The lack of traffic-responsive capabilities on parallel arterials is the most significant detriment to the potential overall effectiveness of diversion strategies. Several incident reconstructions indicated a high initial diversion to arterials, followed by arterial breakdown when capacity was exceeded. While INFORM was designed and equipped with traffic-responsive arterial control, this capability was not able to be used during the evaluation. System communications problems during the evaluation created the potential for intersection controllers to drop off-line. The stand-by timing pattern, which would be used in this eventuality, would be significantly different from the traffic responsive pattern. The LIE service road could not be detectorized adequately enough, due to fiscal reasons, to provide the desirable level of information for traffic responsive control. The other primary east-west arterial highway on the INFORM system (Jericho Turnpike) is generally too distant from the LIE and NSP to be a viable diversion route, even if the traffic-responsive feature were operable (although it may come into play during the most severe incidents). Conflicts with north-south traffic under a traffic responsive diversion plan is certainly a deterrent to effective diversion traffic control, but is less of a problem during off-peak periods.

- Use of VMS's in general - The extent to which other highway networks are appropriate for extensive use of VMS's is highly dependent on diversion potential in the corridor. Low diversion potential (i.e., lack of parallel routes with available capacity) means that the information provided will be of less value.

- VMS location - VMS location should be based on logical diversion points. Signs should be associated with specific route choice opportunities, and located far enough in advance of the diversion point to give drivers sufficient time to change lanes. While additional signs could always be used on INFORM, most of the signs have proved to be well located. A recommended strategy for determining sign location is to think through the possible combinations of incident location and associated diversion points, including diversion points on the arterial system. There is greater need for placing signs at logical diversion points which may be farther from the freeway than may have been customarily thought. If motorists are told about congestion only when they reach the freeway, it may be too late to provide them with a convenient alternate route. They must be informed at the location of their diversion point.

- Importance of information quality - Maintaining the quality of the information displayed by the signing system must be a top priority of system operation. Signing is a passive method of control, relying on an informed, voluntary decision by drivers. Motorist confidence in the system is difficult to earn and easy to lose. Providing stale information is one of the quickest ways to lose credibility. For a system the size of

INFORM, and for many smaller systems, automated sign control with human monitoring and refinement is likely to be the most effective combination. Without automated control, operators are not likely to be able to respond quickly enough to changes in traffic conditions and could easily forget to modify sign messages. Without human involvement, the sign information may sometimes lack meaningful detail and may occasionally be wrong.

- Factors in maintaining information credibility - Maintaining credibility is one of the most important tasks in operating a VMS system. While a majority of motorists from the survey viewed the sign information to be useful and accurate, it is evident that some credibility problems remain. Possible factors contributing to the lack of completely accurate information include:

  - Specification of delay areas by exit number. Where longer distances exist between interchanges, there is more likely to be error between what the VMS says and what the motorist perceives. For example, a distance of 2 mi (3.2 km) between interchanges means that the location of the end of the queue could be as much as 1 mi (1.6 km) from the nearest interchange. This can be perceived as erroneous information by the motorist. Cross streets between interchanges could be considered as supplemental landmarks to increase the ability of the system to define congestion location. These cross streets need to be well marked so that drivers can correlate the sign message with physical location. Street names could be used in place of exit numbers, but exit numbers are readily learned, are sequential down the length of the freeway, result in fewer characters per message, and are more easily managed by the system.

  - Time delay between actual conditions and display of the appropriate message on a sign. This can be attributed both to the necessary smoothing/filtering process for detector data and decision algorithms in sign message selection. Consequently, there is a time period (hopefully brief) in which sign messages are not displayed for delay conditions that have developed or in which sign messages remain for delay conditions that no longer exist.

  - Failed detector stations, which significantly reduce the resolution of the data being processed for making sign message decisions. This affects both automated and manual signing.

- Signing philosophy - One of the goals of the operation of the signing system is operational balancing across the facilities. This is a delicate task and is only learned from experience on each individual system. Messages that are too strongly worded can be counterproductive and lead to significant credibility problems. The INFORM signing strategy is generally to provide as much information as possible on the location of delays so that drivers can make reasonably intelligent decisions on route choice given their current positions and ultimate destinations. The signing philosophy described in earlier sections (i.e., bracketing congestion areas by exit numbers, e.g., "DELAYS EXITS 34 TO 37") is an effective method of communicating congestion locations to the motoring public. In most cases, it is superior to identifying the length of congestion (e.g., "DELAYS NEXT 3 MILES"), as it allows motorists to more effectively determine where they should exit the facility and which reentry point will place them downstream of the incident.

- Freeway detectorization strategies - The detector spacing on the freeway portion of INFORM is approximately one station each one-half mi (0.8 km). If all detectors are working, this assures that the location of an incident or back of a queue will be in error no more than one-half mi (0.8 km). While this amount of error can be distinguished by motorists, the detector spacing is in keeping with the sign message strategy of bracketing the delays by interchange location. More frequent detector spacing would, of course, improve resolution and responsiveness.

- Ramp detectorization strategies - Detectorization of all on-ramps and off-ramps is an important part of the signing and diversion strategy. On-ramp and off-ramp volumes are often referred to by operators to determine whether the signing messages are having an effect (or too much of an effect). Even if on-ramps are not metered, they should still be detectorized. Under budgetary constraints, this could be done selectively, with emphasis on important diversion-related ramps.

- Administrative aspects of sign message selection - A committee structure for reviewing sign messages, as done for INFORM, is an effective method of gaining the collective wisdom of agencies with a vested interest in use of the signs and in gaining consensus on how the signs should be used. However, it introduces more pressure to display a wider range of messages, including public service announcements that may not be relevant to traffic management. The sign message selection criteria must be defined well enough to avoid misuse of the capability but be flexible enough for operators to respond to the wide range of conditions.

- Messages during non-delay periods - Experience with INFORM indicates that it is better to continually display messages on the signs rather than to leave the sign blank during noncongested periods. Displaying the "NORMAL TRAFFIC CONDITIONS AHEAD" message greatly reduced the complaints about the signs being inactive.

- Timing of sign installation - Signs should be installed not too far in advance of the date of expected system operation. Signs standing dormant for long periods of time (as occurred with INFORM) results in a longer period for gaining public acceptance. It will take the public longer to be convinced that the signs actually work. In addition, the signing strategy should be tested off-line prior to the time at which the signs are first actively used. Mistakes, oversights and inefficiencies in the early stages make it more difficult to earn the trust of motorists. Signing software should have the capability to examine system sign selection and allows operator sign selection for training purposes without actually displaying the messages in the field.

- Accident frequency - Accident data are available for the corridor through 1989. The VMS system was fully operational for most of 1989, but the ramp metering system was not. There was a 5-percent reduction in accidents (reportable and nonreportable) on the LIE in Nassau County between 1988 and 1989. At the same time, accidents on S.R. 135 on Long Island (used as a control section) increased by 13-percent. This potentially represents a positive influence of the VMS system on accident occurrence, but insufficient time has elapsed to determine if this constitutes a sustained trend. Two more years of accident data should be obtained to verify INFORM's effect on accidents.

RAMP METERING

- Overview of ramp metering results:

  - The a.m. peak period speeds for the March 1990 metering case increased 3- to 8-percent over the March 1990 nonmetering case and 13-percent over the spring 1987 case. Certain subsections showed higher increases and others showed lower increases or no change. VMT was either higher or remained stable for the metering case. Changes were statistically significant at the 95-percent confidence level.

  - The p.m. peak period speeds for the March 1990 metering case were unchanged from the March 1990 nonmetering case and increased 13- percent over the spring 1987 case. VMT increased approximately 1-percent over the March nonmetering case and approximately 5-percent over the spring 1987 case.

  - To provide perspective, an improvement in speed of 10-percent would result in approximately 3 million vehicle hours of delay saved annually for the a.m. and p.m. peak periods in the peak direction of travel alone. Thus, there is potential for substantial reduction in vehicle hours due to ramp metering.

  - The maximum increase in throughput in a bottleneck section for the metering scenario was 7-percent. Other bottleneck sections increased by 2- to 3-percent and others were unchanged. Thus, ramp metering may produce marginal increases in throughput through bottleneck sections, but not likely more than 2- to 3-percent, on average.

  - The congestion index (percentage of detector stations with speeds less than or equal to 30 mi/h (48 km/h)) was reduced by 25-percent for the March 1990 metering versus March 1990 nonmetering cases and 50-percent for the March 1990 metering versus spring 1987 cases for the a.m. peak period. A slight increase was noted for the p.m. March-to-March comparison and 35-percent decrease was noted for the comparison to spring 1987.

  - Average queues at metered ramps throughout the metering periods are relatively short, ranging from 1.2 to 3.4 vehicles. This represents only about 0.1-percent of the total VHT on the LIE and NSP/GCP. Contributing factors to this low number are a number of low-volume ramps as well as the propensity for metering to be shut off on the higher volume ramps to avoid surface street impacts. Later versions of the ramp metering algorithm have enabled the metering operation to be preserved more frequently.

- <u>Limitations in ramp metering effectiveness</u> - The potential effectiveness of ramp metering on INFORM is constrained by the limitations in the number of ramps metered, in the storage areas to manage queues and in the maximum metering rates for single-lane metering. Ramp metering proved not to be as effective as was anticipated in the feasibility study. INFORM does not have sufficient ramp metering control over enough traffic to produce a noticeable, sustained change in freeway speeds. Some of the potential ramp meters were eliminated from the design and others were eliminated by construction projects. Even if these meters had not been eliminated, the capability of the system to restrict entering traffic would still be limited. Significant use of two-lane metering is needed to exercise greater control over high-volume on-ramps. Additional ramps also need to be metered, including selected freeway-to-freeway ramps before adequate control can be established.

- <u>Queue management and two-lane metering</u> - Inability to manage queues so as not to impact cross street traffic is the most serious threat to the success of ramp metering. As traffic demand on the freeway increases, the capability of the system to manage queues will become increasingly important. Two-lane metering must be a serious consideration in a ramp metering system. Major geometric changes in ramp configuration can often be avoided by allowing two-lane peak period metering on ramps that function as single lane during the rest of the day (e.g., Minnesota DOT uses two-lane metering on ramps with minimum 18-ft (5.5-m) pavements). Two-lane metering applied on INFORM could eliminate most queue spillover onto arterial streets.

- <u>Phased turn-on of ramp metering</u> - The phased turn-on of ramp metering worked quite well for INFORM. It allowed for greater attention to specific traffic engineering needs at individual ramps and allowed knowledge to be gained that would improve operations as implementation proceeded.

- <u>Anticipation of future volumes</u> - A number of ramp volumes more than doubled between the time of the feasibility study and the actual operation of INFORM. Future volumes need to be anticipated in the design stage, and flexibility needs to be built in to enable conversion to two-lane metering.

- <u>Improving ramp metering effectiveness</u> - There are a number of items that should be considered in freeway design and operations to make ramp metering more feasible and effective. Some of these include:

    - Providing queuing lanes on service roads. Queuing onto service roads should be acceptable as long as serious interference with nearby cross streets does not occur.

- Providing adequate storage on freeway on-ramps to minimize potential queue interference with arterial street traffic. This can be accomplished by moving the ramp junction at the mainline farther downstream (usually only practical for freeways being newly constructed or reconstructed) or by providing multiple lanes on the on-ramp.

- Queue management at the upstream signalized intersection. This may require special signal phasing, such as prohibiting right turns on an approach to an entrance ramp, even on a permitted through movement. Queue management is one of the primary needs for integration of freeway and arterial systems.

ARTERIAL SYSTEM

- Arterial speed - The results of the arterial evaluation was hampered by the relatively sparse detectorization, particularly on the LIE service roads, where diversion potential is greatest. Average speed on the LIE service road, as measured by travel time runs, decreased by 1 mi/h (1.6 km/h) in the a.m. peak period westbound and increased by 3 mi/h (4.8 km/h) in the p.m. peak period eastbound. These changes are not significant.

- Arterial volume - Sparse and unreliable detectorization on the LIE service road made the determination of volume differences difficult. However, limited information from machine counts on the LIE service road indicated volume increases of up to 15-percent during the a.m. and p.m. peak periods between spring 1987 and spring 1990. These volume changes could have come from a combination of the natural growth in volume, diversion of certain trips from the freeway. Some diversion of shorter trips to the parallel arterials is typically expected as a byproduct of ramp metering. The perception surveys indicated that some drivers do divert to avoid ramp meters. An improvement in signal timing could also induce an increase in volume diverted from the freeway or from other parallel routes. If volume had held constant, more significant increases in speed may have been realized. However, the extent to which the increase was due to meter-induced diversion, improved signal timing or natural traffic growth cannot be determined.

- Freeway/arterial integration - INFORM is not to the point where full integration of freeway and arterial control has been achieved. Arterials have difficulty accommodating significant diversion from the freeway. This was noticed in several incidents in which volume at upstream exit ramps closest to the incident increased (i.e., diverted to the service road) but then decreased after a short period of time due to saturation at the signalized service road intersections. While the LIE service roads offer substantial opportunity to accommodate diversion, their ability to accommodate diversion will be limited until traffic responsive timing is implemented. Substantial work is still needed on traffic responsive control. The arterial and freeway systems do not necessarily need to be integrated for purposes of diversion as long as the arterial can quickly respond to changes in traffic patterns. However, there is a need for integration for purposes of queue management at the ramp meters.

Arterial detectorization strategies - Supplemental arterial detectorization is highly desirable on key diversion routes. INFORM is blind to much of what occurs on key alternate routes, particularly the LIE service road. Two or 3 detectors at quarter-mile spacings in advance of signalized intersections would yield important information concerning the adequacy of the diversion route. These could be single lane detectors if necessary. While computer algorithms can be devised to estimate intersection delay using fewer detectors, the potential for error is large, and actual detectorization is preferred. New technology, such as video image detection, may become appropriate for queue-sensing and delay estimation at such locations, and these applications should be kept in mind.

PUBLIC PERCEPTION

- Driver awareness of the VMS's - 96-percent of the residents surveyed in the INFORM area stated that they had seen the VMS's.

- Usefulness of information - Overall, 29-percent of the respondents rated the sign information very useful, and 46-percent rated it moderately useful.

- Accuracy of the information - 7-percent of the respondents indicated the information to be always accurate, and 56-percent indicated it to be usually accurate.

- Changes in route - Approximately 45-percent of the drivers stated that they "sometimes" change their route in response to the sign messages. Slightly over 25-percent have never changed their route in response to a message.

- Perceived wait time at ramp meters - Waiting time at the ramp meters are perceived to be 1 minute or less by 80-percent of the drivers who have experienced a wait. This seems to correspond to the findings of the ramp delay studies.

- Diversion to avoid ramp meters - Some 15-percent of those encountering a red "merge light" indicated that they frequently use the service road or another roadway to avoid waiting. Another 27-percent indicate that they do this occasionally. Thus, ramp metering does produce some diversion effects.

- Overall perception of ramp metering - Approximately 40-percent of respondents viewed ramp metering to be a good idea and 40-percent viewed it not to be a good idea. The remainder had no opinion.

- Overall perception of INFORM - 25-percent of respondents viewed INFORM to be quite helpful. Another 40-percent indicated that the system helps once in a while. Overall, it can be concluded that drivers view the VMS's positively, but reaction to ramp metering is mixed.

GENERAL DESIGN AND CONSTRUCTION ISSUES

(Based primarily on interviews with staff of NYSDOT, the operations contractor, and local police and transportation personnel)

- Communications - There were some 200 cuts in the direct-bury cable in the first year of operation. A plan did not initially exist to control the cuts. The current procedure involves informing contractors of the location of the cable at the time of their permit application. INFORM inspectors conduct an inspection of the cable both before and after the contractor conducts the work. Contractors who cut the cable are responsible for the cost of its repair, but the repair may only be done by the INFORM maintenance contractor. This has dramatically reduced the number of cable cuts, and cuts are now rare. INFORM has more problem with loss of power, as they do not have control over that particular area.

- Inspection - Careful inspection and quality control in construction is critical to the long term operation of the system. INFORM has hundreds of miles of cable, and many different technicians were involved. A high degree of quality control in the installation of all system components is expensive to provide but is well worthwhile in the long-term operation.

- Access to signs - When designing the variable message signing system, the signs should be designed for easy access without shutting down lanes for sign maintenance. This may require adding catwalks or positioning the signs differently. Shutting down lanes to perform sign maintenance is costly and creates safety hazards. This also argues for the importance of maintenance considerations in selection of sign technology.

- Construction phasing - The sequencing of construction of high-visibility aspects of the system should not be left up to the contractor and to the contractor's payment schedule. Signs and ramp meters should not be installed too long prior to their actual operation. It is the experience of NYSDOT that this causes a public relations problem and exposes the equipment to the elements.

- Awareness of opportunities for improvement and expansion - Reconstruction and new construction of highway projects offer excellent opportunities to build improvements into the system. INFORM has worked with other NYSDOT departments to incorporate the provision of communications, CCTV cameras, and restoration of other system components into construction contracts. INFORM inspectors work with the contractors to insure the proper installation of components and coordination of activities. Particular attention should be paid to opportunities for adding conduit within a construction contract, with large savings possible over installation under a separate contract.

- Impact of construction on INFORM - One of the occurrences that was not forseen was the extent to which other construction activity would have an impact on INFORM. Some of the ramp meters originally installed have been removed for construction work. Other ramps have even been eliminated. INFORM operates within a continually changing set of circumstances. Other systems can be expected to experience the same conditions and operators should anticipate dealing with this.

- Cost control of replacement parts - Some of the components of INFORM were specially designed and manufactured for the system. While the original quantities were sufficient to make this economical in the bidding of the construction contract, the replacement parts are very expensive. The need for and possible cost of replacement parts needs to be anticipated in design, and provisions made to control those costs as part of the bid documents.

- Control center - The location of the control center within the State Office Building minimized control center cost but required radio and data transmission over a much longer distance than if the center had been more centrally located. This has implications in communications construction and maintenance cost and in staff access time to field units. The control center needs to be designed to accommodate more than just the basic system functions. For example, it needs to provide space to accommodate tour groups, engineer workspace, and conference area/lunch area.

GENERAL OPERATIONAL AND MANAGEMENT ISSUES

(Based primarily on INFORM interviews)

- Ongoing traffic engineering involvement in all phases of operations - A corridor traffic control system cannot be expected to run itself. A commitment must be made to traffic engineering involvement in all phases, including ramp metering initiation, VMS operations, refinement and modification of metering operations, tuning of incident detection algorithms, traffic signal operations, communications with emergency services, and communications with the media.

- Differences between a traffic control system and a highway project - There is a tendency to want to make the process of building and maintaining a traffic control system fit into the same process as used for highway construction and maintenance. This is not practical. Two examples of differences that should be taken in approach are:

    - Bidders need to be given greater flexibility in construction than DOT's are normally accustomed to. These are sophisticated traffic control systems with advanced electronics, requiring different approaches to design, operations and maintenance. Mid-course corrections may be needed because of advances in electronics or circumstances arising in the field.

    - Greater consistency and continuity is needed in staff involvement through all phases of the project. The project cannot be merely handed off from design to construction to operations. Someone needs to guide the project from the start and continue with it through the startup and initial operations phase, ideally as a project manager who has responsibility for guiding it through all phases.

- Name of the system - Because of the length of time in implementation, the original name of the system (IMIS) became tarnished. It also did not convey the essential nature of the system to the public. The name INFORM was developed by NYSDOT management both because it better conveyed the nature of the system and because it provided a new image and, in effect, a fresh start.

- Use of private contractors - Interviews with NYSDOT personnel indicate that INFORM has successfully demonstrated the use of private contractors for system maintenance and operations. This route was chosen because of some uncertainty regarding the outcome of INFORM and the State's concern over hiring permanent employees should the system not work out.

- Commitment from top management - Commitment from top management and constant provision of information to them is needed to sustain continuity over time. There were a number of commissioners involved over the course of INFORM implementation, and State personnel had to keep each one of them informed. Transitions in leadership are inevitable, and operators of traffic control systems should have the mechanisms in place to keep upper management and elected officials informed on what the system is, how it operates and the benefits it provides.

- Operations and maintenance plans - Operations and maintenance plans are important to address in the design phase of the project and are now required by the FHWA. This forces the designer to consider the implications of design on operations and may introduce more cost-effective designs overall, rather than just the design that has the lowest construction cost.

- Software - The software drives the system. Understanding the software is a key to operating and improving the system. If the software is developed by a consultant, someone (preferably more than one person) on the DOT staff should have indepth knowledge of the software, understand what modifications are being made, and be able to bridge the gap when new personnel come in. Documentation of the software is critical to smooth transitions. Ongoing software modifications are needed to tailor and tune the system and to more adequately address the needs that arise as the system matures.

- Manuals - Several types of manuals have been developed for use on INFORM: technical manuals, operations manuals, and system administration manuals. Detailed technical manuals were produced during the design and integration stage. The operations contractor pulled the most relevant operational information from these manuals and constructed a quick-reference manual for the daily operational needs and a training manual for giving operators basic familiarity with the system. A cross-reference of system components and relationships was also constructed. These are the documents most frequently referred to by operators.

- Key characteristics of a good system operator - The operations contractor was asked to identify the key characteristics of a good system operator for INFORM. Several characteristics emerged:

- Good powers of concentration and ability to focus on specific tasks without losing perspective of the general picture.

- Ability to focus on a specific incident situation and manage that incident over time, much like air traffic controllers would watch an individual aircraft assigned to them.

- Ability to stick with active operational involvement over 2 or 3 hours, maintaining composure during crises.

- Ability to think on their feet. The good operators have a mental map of the system and are able to do several things in rapid order and keep track of all the situations and priorities. This type of multi-tasking skill is difficult to teach, but an operator with that skill is highly valuable to the operation.

- Ability to pick up other administrative tasks while operational activity slows down.

- Although computer understanding may be helpful, it is not a requirement of the position. The necessary computer skills can be readily taught.

• Importance of networking with other system operators - Traffic control system developments are occurring throughout the U.S., and new lessons are being learned on each one. Taking advantage of the advancements, approaches, mistakes, and lessons learned on each system is an important part of helping the systems to operate more efficiently and successfully.

• Public relations - Agencies should be careful not to oversell the benefits of the system. Decision makers should not be given the impression that a traffic control system will make congestion disappear but that it will allow congestion to be better managed. Benefits are often subtle and receive little praise from motorists. Therefore, the systems have significant risk from a political point of view and some politicians are reluctant to back them because of the subtle benefits and possibility that they will not work. Publishing INFORM's role in major events and managing disasters (such as the Avianca airplane crash on northern Long Island in 1989) has helped in that regard.

• Dissemination of INFORM traffic information - INFORM collects information on traffic flow that has substantial value to other organizations. An estimated 70 radio stations, directly or indirectly, benefit from information provided by INFORM and many people involved in the traffic broadcast business derive their living from disseminating traffic information, part of which is provided by INFORM. INFORM has allowed some of the traffic reporting services to do a better job and to either save resources or invest resources in other areas not as well covered. New York State financial managers have wanted to sell that information rather than give it away. However, INFORM has continued to offer the information free as a public service. This has been an expansion of the system's function beyond its original charge.

- Interagency coordination - Traffic control spans across numerous types of agencies and jurisdictional levels. Coordination and support among those agencies is an obvious need. Regular meetings have been very important for communications and management of INFORM, as has the work of the sign subcommittee.

EVALUATION METHODOLOGY

- Complexity of the evaluation - The evaluation of a corridor traffic control system is one of the more complex types of traffic-related evaluation. There are numerous threats to the validity of such an evaluation, even excluding the statistical and sample size concerns. Some of these include:

  - Occurrence of incidents - The influence of incidents on traffic flow can be pervasive. Inclusion of incident data in the basic comparisons between system/no-system conditions leaves the evaluation highly subject to the chance occurrence of incidents. Even cordoning off subsections of the system and conducting separate "mini-evaluations" is an invalid approach since incidents impact traffic far upstream and downstream of the location of the incident. Incident influences must be screened out, even though the incident may not have occurred in the subsection being evaluated. Unfortunately, the necessary elimination of incident-related data reduces sample size, and some balance must be maintained between accepting and rejecting incident-related data.

  - Construction activity - Timing an evaluation to avoid the impact of construction activity is a major dilemma. In the northern climates, evaluations cannot normally be considered during periods when inclement weather patterns dominate. When these weather patterns give way to weather more conducive to evaluation, construction activity also tends to increase. To the extent possible, evaluation during construction activity needs to be avoided. This was not always possible for the INFORM evaluation.

  - Time-related factors - A long implementation period, such as occurred in INFORM, makes determination of the effect of the system more difficult, and many other effects creep in.

  - Seasonal factors - Seasonal considerations include volume changes, amount of travel occurring during daylight versus darkness, propensity for incidents (e.g., heat-related stalls), and differences in weather conditions.

- Experimental control - The most important controls over the evaluation are the screening of incident-related data and accounting for volume changes. Comprehensive volume data must be available as a basis for judging changes in speed and vehicle hours of travel. Because the volume accommodated in the March 1990 metering case was as high or higher than the comparison cases, no adjustment was conducted.

- Time series evaluations - The status of a traffic control system is frequently changing and hopefully improving over time. An evaluation of such a system can hardly be considered a "final word." A time series approach is quite appropriate for such a system, particularly when data can be economically collected through the system itself.

- Collection of traffic performance data through the system - The original INFORM evaluation was designed with a large amount of field data collection, particularly travel time runs. This form of evaluation is quite costly and difficult to manage. Experience with the INFORM evaluation indicates that data can be successfully collected through the system, included calibrated speed data. These data are not only easier and less costly to collect than the travel time data, but they are also more comprehensive (except for those areas not covered by the system).

- Incident reconstruction and evaluation of incident conditions - Optimizing traffic flow during incident periods is one of the primary benefits originally perceived for INFORM. The evaluation of those benefits, however, is a difficult task, because each incident is unique and the impacts of most incidents are pervasive. Incidents affect many travel patterns over multiple roadways and interchanges. The best method that could be devised for evaluating these impacts was the complete reconstruction of the incident, including incident time/location/duration, sign messages, mainline volumes, and ramp volumes. The reconstruction of each incident is complex and required a considerably longer time to evaluate than it did for the incident to occur. Delay savings estimates are approximate and additional information on arterial delays would improve the evaluation. Nevertheless, it was found to be the most effective method. Consideration should be given to building incident reconstruction capabilities into the system as a long-term need in traffic control software.

- Designing for system evaluation needs - Reference was made earlier to the need for including plans for operation and maintenance in the system design phase. This should be expanded to include provisions for evaluation. In fact, a strong case can be made that surveillance needs for operation and evaluation are highly correlated, if not identical. What the system evaluator knows after-the-fact should also be known by the system operator as input into control decisions. For example, little information was available to the evaluation concerning arterial traffic performance. INFORM operators are also, in effect, blind to what is occurring on the arterial system. This knowledge is essential for obtaining the best use of VMS for diversion, and the lack of detectorization undoubtedly results in the underutilization of INFORM's capabilities. Designing for evaluation needs should cost no more than designing for effective operation and, in the long run, will limit outlays for extensive field evaluation.

- Public opinion - Obtaining an accurate picture of public opinion is another area where evaluation and operation have needs in common. Much can be learned by systematically sampling public opinion. Complaints need to be factored in, but should not be allowed to bring about a change in operation that would not be for the overall good of the corridor. A resident survey approach will obtain a broader cross section of opinion, but a driver-based approach (e.g., questionnaires mailed to drivers of the facilities, identified through license plates) is also valid.

- Use of regular commuters in evaluation - While some coordination, cooperation, and longevity problems were experienced with the use of regular commuters to collect travel time data for this evaluation, this approach should be seriously considered for other evaluations. Several advantages of this approach are:

  - The ultimate evaluation of a system is based on how much time is saved for the driving public. There is no more direct form of evaluation than the measurement of trip times of actual commuters. If a system provides benefits, these benefits should result in measurable time savings for motorists who use the system.

  - Provided the management problems can be overcome, commuters are an inexpensive form of field evaluation. Commuters should record both on-facility travel time as well as door-to-door travel time, with atypical trips thrown out.

  - Eventually, this form of evaluation can also be automated, using in-vehicular navigation instrumentation of commuter vehicles.

INFORM COSTS

The costs associated with the construction and operation of INFORM are as follows:

Construction and System Integration

Communications	$13,440,000
VMS's	6,341,000
Ramp meters	567,000
Traffic signal system	1,381,000
Central equipment	2,348,000
Freeway detectors	1,392,000
Maintenance of traffic, mobilization, and miscellaneous	2,277,000
System integration	5,360,000
Spare parts	1,900,000
Total	35,006,000

Annual Costs

Operations contract	$1,267,000
Maintenance contract	2,650,000
NYSDOT INFORM staff	580,000
	4,497,000

An economic evaluation of the quantifiable benefits of INFORM was conducted using both the March 1990 metering/March 1990 nonmetering and the March 1990 metering/spring 1987 comparisons. There are many uncertainties involved in such an evaluation but the intent was to establish a general range in benefit/cost ratio that could be assigned to INFORM. The March 1990 metering/March 1990 nonmetering should provide an indication of the low end of the range. The March 1990 metering/spring 1987 should provide an indication of the high end of the range. Only operational benefits (not safety benefits) are included in the evaluation.

It is important to understand that there are many considerations that cannot be included in a single benefit/cost value. Examples of items not included on the benefits side of the equation include the additional safety, convenience and time savings of using INFORM to assist in construction and maintenance activity, the provision of information from INFORM to the radio traffic reporting services, INFORM staff taking nighttime calls for signal maintenance for NYSDOT signals on Long Island (not just the INFORM signals), upgrading of arterial signals that would have been needed even without INFORM, and general benefits of improved communications and information to the police (incident response benefits).

The benefit/cost analysis assumed a 10-year life for INFORM construction items and a 10-percent discount rate. This resulted in an annualized cost of $10,192,000. The benefits were computed assuming an economic value of $8.00 per vehicle hour of delay saved. The delay savings were computed for equivalent VMT's for all time periods, thereby controlling for the amount of travel. Only weekday delay savings from the LIE and NSP/GCP were included (i.e., north/south expressways and arterials were excluded). The resulting benefit/cost ratios are:

- March 1990 metering/March 1990 nonmetering - 1.8
- March 1990 metering/spring 1987 - 8.3

It is expected that the actual benefit/cost ratio is between these two values. The above benefit/cost ratios occur with what may be viewed to be relatively small increases in average speed (the maximum difference in average speed is 5 mi/h (8.1 km/h)). However, when this change is applied to the large amount of travel that takes place daily on INFORM, it is apparent that the computed economic benefits are significant.

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