Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/VA-87/R34		

4. Title and Subtitle	5. Report Date
Changes in Travel in the Shirley Highway Corridor 1983-1986	June 1987
	6. Performing Organization Code
	8. Performing Organization Report No.
7. Author(s)	
E. D. Arnold, Jr.	VTRC 87-R34
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Va. Transportation Research Council Box 3817 University Station Charlottesville, VA 22903	11. Contract or Grant No. 67 T066 967 101 PE101 619
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	Final Report
Virginia Department of Transportation 1221 E. Broad Street Richmond, VA 23219	14. Sponsoring Agency Code

15. Supplementary Notes

In cooperation with the U.S. Department of Transportation, Federal Highway Administration

16. Abstract

On June 5, 1985, a comprehensive, computer-controlled traffic management system (TMS) was implemented on a section of I-95 and I-395 in Northern Virginia. The roadway is a major commuter route into the District of Columbia. A before-and-after evaluation of the TMS was initiated by the Virginia Department of Transportation in the spring of 1983 in anticipation of a summer 1983 implementation. Due to a series of events, the TMS was two years late in being implemented, and data were not collected after its implementation until the spring of 1986. Accordingly, this study describes changes in travel characteristics between these two periods; it recognizes that several major events occurred that likely caused the changes.

Changes in travel on local streets as well as on the interstate are described. Changes in traffic volumes, speeds, travel times, delays, vehicle miles of travel, vehicle hours of travel, and accidents are reviewed. Finally, information on incident detection and management is presented.

17. Key Words	18. Distribution Statement
traffic management; ramp metering; incident management; traffic surveillance; variable message signs	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	53	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

CHANGES IN TRAVEL IN THE SHIRLEY HIGHWAY CORRIDOR 1983-1986

by

E. D. Arnold, Jr.
Research Scientist

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

Virginia Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the Virginia Department of Transportation and the University of Virginia)

In Cooperation with the U.S. Department of Transportation
Federal Highway Administration

Charlottesville, Virginia

June 1987
VTRC 87-R34

TRANSPORTATION PLANNING RESEARCH ADVISORY COMMITTEE

D. W. BERG, Chairman, Assistant Division Administrator, Rail & Public Transportation, VDOT

E. D. ARNOLD, JR., Research Scientist, VTRC

B. R. CLARKE, Assistant Transportation Planning Engineer, VDOT

G. R. CONNER, Assistant Division Administrator, Rail & Public Transportation, VDOT

R. A. DRUMWRIGHT, Transit Manager, James City County Transit

T. F. FARLEY, Assistant District Engineer, VDOT

D. L. FARMER, Chief Transportation Planner, Southeastern Virginia Planning District Commission

J. N. HUMMEL, Chief, Planning & Engineering Division, County of Arlington

A. F. LAUBE, Assistant State Urban Engineer, VDOT

A. H. MOORE, Planning Engineer, County of Henrico

A. J. SOLURY, Division Planning & Research Engineer, FHWA

G. R. STILL, Associate Planner, City of Danville

M. S. TOWNES, Assistant to the Executive Director, Peninsula Transportation District Commission

TABLE OF CONTENTS

ABSTRACT

On June 5, 1985, a comprehensive, computer-controlled traffic management system (TMS) was implemented on a section of I-95 and I-395 in Northern Virginia. The roadway is a major commuter route into the District of Columbia. A before-and-after evaluation of the TMS was initiated by the Virginia Department of Transportation in the spring of 1983 in anticipation of a summer 1983 implementation. Due to a series of events, the TMS was two years late in being implemented, and data were not collected after its implementation until the spring of 1986. Accordingly, this study describes changes in travel characteristics between these two periods; it recognizes that several major events occurred that likely caused the changes.

Changes in travel on local streets as well as on the interstate are described. Changes in traffic volumes, speeds, travel times, delays, vehicle miles of travel, vehicle hours of travel, and accidents are reviewed. Finally, information on incident detection and management is presented.

EXECUTIVE SUMMARY AND CONCLUSIONS

The Virginia Department of Transportation implemented three major construction projects on the Shirley Highway between the spring of 1983 and the spring of 1986. A fourth conventional lane was added in the northbound direction between King Street and Glebe Road and southbound between Shirlington and Duke Street. Also, a comprehensive traffic management system (TMS) was implemented. Finally, a temporary high occupancy vehicle (HOV) lane was added northbound between Woodbridge and Springfield, which is south of the Capital Beltway. Further, the hours of restriction on the highway's reversible HOV lanes were modified to allow all traffic outside of the peak periods to use the roadway. Other major events in the corridor included the start-up of the Alexandria Transit System and the opening of Metrorail to Huntington. To some extent all of these events affected the traffic flow and travel characteristics in the corridor. Unfortunately, it is impossible to isolate the impacts of individual events. The following general conclusions regarding changes in travel in the corridor between 1983 and 1986 can be made. The conclusions are stratified by morning and afternoon peak periods.

Morning Peak Period

Despite a small overall increase in volume, northbound travel on the Shirley Highway conventional lanes generally improved. Overall travel speed between Springfield and the District of Columbia increased by 3 mph, from 19 mph to 22 mph, resulting in a 5.2-minute decrease in travel time. The increase between the Capital Beltway and the George Washington Parkway was 7 mph, from 18 mph to 25 mph. Travel time decreased by 8.9 minutes. Speeds generally decreased to the south of Seminary Road and increased to the north. The result of this change was more uniform speeds than in 1983. Stopped delay increased only by about 4%. The vehicle miles of travel (VMT) increased by about 1%, which corresponded approximately with the change in volume. On the other hand, the vehicle hours of travel (VHT) decreased by 1,530 hours (27%), which is indicative of the decreased travel time along the route.

Travel on the northbound on-ramps to I-395 worsened between 1983 and 1986. Volumes increased by varying percentages (some quite large) at 13 of 20 ramps. Increases were more prevalent on the unmetered ramps than on the metered ramps; however, 8 of the 14 metered ramps had increases in volume. Accordingly, ramp metering did not always reduce traffic flow on the ramps, nor was there an obvious pattern of diversion to unmetered ramps. Generally, volumes on ramps south of Glebe Road increased, and volumes to the north remained the same or decreased. Overall speeds decreased on 19 of 21 ramps by an average of 10 mph. As expected, decreases on the metered ramps tended to be greater than the decreases on the unmetered ramps. Travel times generally increased; however, the average increase was only about 27 seconds. Only three ramps had an increase of a minute or more.

Both VMT and VHT increased greatly, which reflects the increased volumes and decreased speeds. An increase of 270 hours of VHT on the ramps combined with a decrease of 1,530 hours on the conventional lanes resulted in a net decrease of 1,260 hours along the roadway.

Motorists entering I-395 at various interchanges with destinations in Washington generally experienced a decrease in travel time. The only exceptions were motorists entering from the George Washington Parkway and Route 1, who experienced an increase. However, the maximum increase was only 1.4 minutes in a trip taking a total of approximately 6 minutes. Motorists on long trips, however, saved up to 10 minutes of travel time.

Travel on the HOV lanes remained about the same despite a fairly large overall increase in volume. The overall speed decreased slightly, but was still close to 50 mph. There was no stopped delay in 1983 or 1986. Both VMT and VHT increased slightly as a result of the increase in volume and travel time along the facility.

The accident rate during the 12 months after the TMS was implemented increased by 17%; however, the rate during the off-peak hours when the TMS was not operational increased by 15%. Since the increases are so close, it is suggested that the TMS did not cause an increase in accidents. There are no data to prove, however, that the TMS resulted in a decrease in accidents.

In general, there was little negative impact on other roadways in the corridor that are aligned approximately parallel to I-395. Volume changes at various stations located on the other major commuter routes--Route 1, George Washington Parkway, Columbia Pike--and on minor commuter routes varied considerably; however, there was a general tendency for volumes to decrease. Some diversion from I-395 likely occurred since sections of Van Dorn Street, Backlick Road, and the George Washington Parkway had large increases in volume. Changes in speed along these routes also varied considerably; however, most changes were very small and most speeds increased. Speed increases greater than 4 mph occurred on Columbia Pike, Van Dorn Street (despite an increase in volume), Chowan Avenue, and Russell Road/Arlington Ridge Road. Stopped delay most often decreased: there was an average net decrease along all the routes of 96 seconds.

Although there were shifts in traffic flow, the corridor served more traffic in 1986 than in 1983. Volumes increased by 6% and 9% at screenlines located in the southern and northern sections of the corridor, respectively. The VMT on the other major commuter routes and on I-395 decreased by about 5%. Since volumes increased in the corridor, the fact that the VMT decreased on the major commuter routes again indicates likely diversion of traffic to some of the minor commuter routes. The VHT along these same routes decreased; this is indicative of the overall decrease in travel time in the corridor.

Despite increases in volume on practically all of the roadways running across the corridor and interchanging with the Shirley Highway, travel

generally did not worsen. Speeds almost always remained the same or increased slightly. Average stopped delay decreased by 149 seconds.

Afternoon Peak Period

In general, travel changes in the afternoon were not as positive as in the morning. This can be explained to some extent by the fact that the TMS is not as efficient in the afternoon. That is, the majority of the traffic on I-395 enters the roadway at its northern terminus in D.C. Accordingly, there is less opportunity for ramp metering to impact the flow than in the morning when traffic can be metered onto the roadway at points throughout its length.

Traffic volumes along the southbound conventional lanes of the Shirley Highway increased between 14% and 19%. Overall travel speed between Washington and Springfield decreased by 5 mph, from 33 mph to 28 mph, resulting in a 4-minute increase in travel time. This overall decrease in speed was attributable to the extreme congestion that occurred between I-495 and the end of the HOV lanes south of Springfield. Average speeds on that section ranged from 37 mph to 43 mph in 1983 and 13 mph to 17 mph in 1986. Accordingly, if the section of I-395 between I-495 and the George Washington Parkway is considered, the overall travel speed remained constant at 34 mph between 1983 and 1986. This is a very positive impact in light of the 14% to 19% increase in volume. As implied above, average speeds north of Turkeycock generally increased or remained the same, whereas they decreased greatly to the south. Average stopped delay increased from 51 seconds to 180 seconds between D.C. and Springfield, but only from 27 seconds to 61 seconds between the Capital Beltway and George Washington Parkway. A minute of stopped delay is minimal considering the length of the facility. That both VMT and VHT increased significantly is a reflection of the increased volume and unchanged travel time.

Just under half of the southbound on-ramps had decreases in volume, with approximately the same proportion holding for both metered and unmetered ramps. There were no discernible patterns to the location of the increases and decreases in the corridor. Average speeds decreased on 15 of the 20 ramps; there was an overall decrease of 6 mph. As expected, decreases on the metered ramps tended to be greater than the decreases on the unmetered ramps. Travel times generally increased an average of 25 seconds, and no ramps had an increase of a minute or more. The VMT decreased by 14% due to the overall decrease in volume on the ramps. On the other hand, the VHT increased by 80 hours (73%) due to the large increase in travel time which was not offset by the decrease in volume.

Utilization of the HOV lanes increased substantially. There was a 49% increase in volume at the station between King Street and Seminary Road. Overall speed between the District and Springfield decreased by 19 mph, from 55 mph to 36 mph. Again, the major problem occurred at the southern termini where the lanes merged with the conventional lanes. The average speed on the HOV lanes just prior to the merge point decreased from 56 mph in 1983 to 8 mph in 1986. The only stopped delay occurred in 1986 at the merge point, and it averaged over 2 minutes. Both VMT and VHT increased considerably due to the large increase in volume.

The accident rate during the 12 months after the TMS was implemented decreased by 8%. When compared to the 15% increase in rate during the off-peak hours when the TMS was not operational, a net reduction of 23% is suggested.

In general, there was little negative impact on other parallel commuter routes in the corridor. Volume changes varied considerably; however, there was a general tendency for them to be negative. The increases were not as great as in the morning, especially when compared to the increases on the Shirley Highway. Average speeds along the routes most often decreased; however, all changes were relatively small. Speed changes greater than 4 mph occurred outbound on Chowan Avenue, Van Dorn Street, and Backlick Road. The latter two routes had decreases of 5 mph and 7 mph, respectively. Average stopped delay on all the routes increased over 800 seconds.

Corridor travel increased considerably since the volume crossing the northern screenline was 18% higher. The increase at the southern screenline was only 7%. Both VMT and VHT along the major commuting routes and I-395 increased. This was indicative of both an increase in volume and in travel time.

Volumes on practically all roads interchanging with I-395 increased. Speed changes were about equally divided between increases and decreases; however, none of the changes was greater than 4 mph. Average stopped delay increased by over 400 seconds on the interchanging roadways.

Incident Detection and Management

Although a before-and-after analysis of the incident detection and management system was not performed, it is intuitively obvious that the CCTV surveillance has improved flow on the Shirley Highway. Accidents and vehicle breakdowns are known to cause significant bottlenecks and congestion on heavily traveled routes. The implementation of a formal program of actions designed to immediately detect an incident and then immediately dispatch the proper response vehicle to the scene will certainly shorten the time needed to clear the incident and its resulting congestion. This fact has been subjectively confirmed for the Shirley Highway through discussions with the Virginia State Police. The Traffic Control Center handled over 1,100 incidents in its first 14 months of operation. Slightly over half (53%) involved disabled vehicles, and 43% involved accidents. Police were notified approximately 70% of the time. Public relations were enhanced as Metro Traffic Control, radio stations, and the Department's Safety Service Patrol were contacted regarding approximately 76% of the incidents. The time between the detection and final clearing of an accident or a disabled vehicle averaged 27 minutes and 38 minutes, respectively.

CHANGES IN TRAVEL IN THE SHIRLEY HIGHWAY CORRIDOR 1983-1986

by

E. D. Arnold, Jr.
Research Scientist

INTRODUCTION

In June 1985, a comprehensive traffic management system (TMS) was implemented in Northern Virginia on the Shirley Highway (I-95/395) between Springfield and the District of Columbia (See Figure 1). This is the same section of roadway that contains the separated, reversible high occupancy vehicle (HOV) lanes in the median. Elements of the TMS include ramp metering, closed circuit television (CCTV) surveillance, variable message signs, and incident detection and management. The system is under computer control in a remote TMS Traffic Control Center.

In the spring of 1983, the Virginia Department of Transportation (VDOT) initiated a before-and-after study of the Shirley Highway corridor to evaluate the impact of the proposed TMS. Due to a series of events and mishaps, the implementation of the system was delayed from the summer of 1983 to June 1985. Accordingly, before-and-after data were collected in the spring of 1983 and the spring 1986, respectively. This report documents and compares traffic patterns in these two time periods; it recognizes that the implementation of the TMS was one of several events occurring during the three-year period that could have affected traffic patterns. Therefore, this study represents an evaluation of a series of improvements and other transportation events that took place in the corridor.

The TMS was also implemented on a section of I-66 in Northern Virginia. A companion report documents an evaluation of that facility.

DESCRIPTION OF THE TMS

The TMS is a computerized freeway surveillance and control system that monitors and regulates traffic flow along an 11.5-mile section of I-95/395. Its goal is to effectively move the greatest number of vehicles in the most efficient manner with the least delay. Components of the system include pavement sensors, CCTV cameras, variable message signs, and ramp meters. These are described in the remainder of this section. The entire system cost approximately $26 million.

Approximately 300 sensors, or inductive loop detectors, are imbedded in the pavement and constantly detect the number of vehicles passing over them as well as their speed. This continuous supply of data is transmitted to the computer at the Traffic Control Center, where it can be visually depicted on a color-coded system map. The data are used in conjunction with other components of the system.

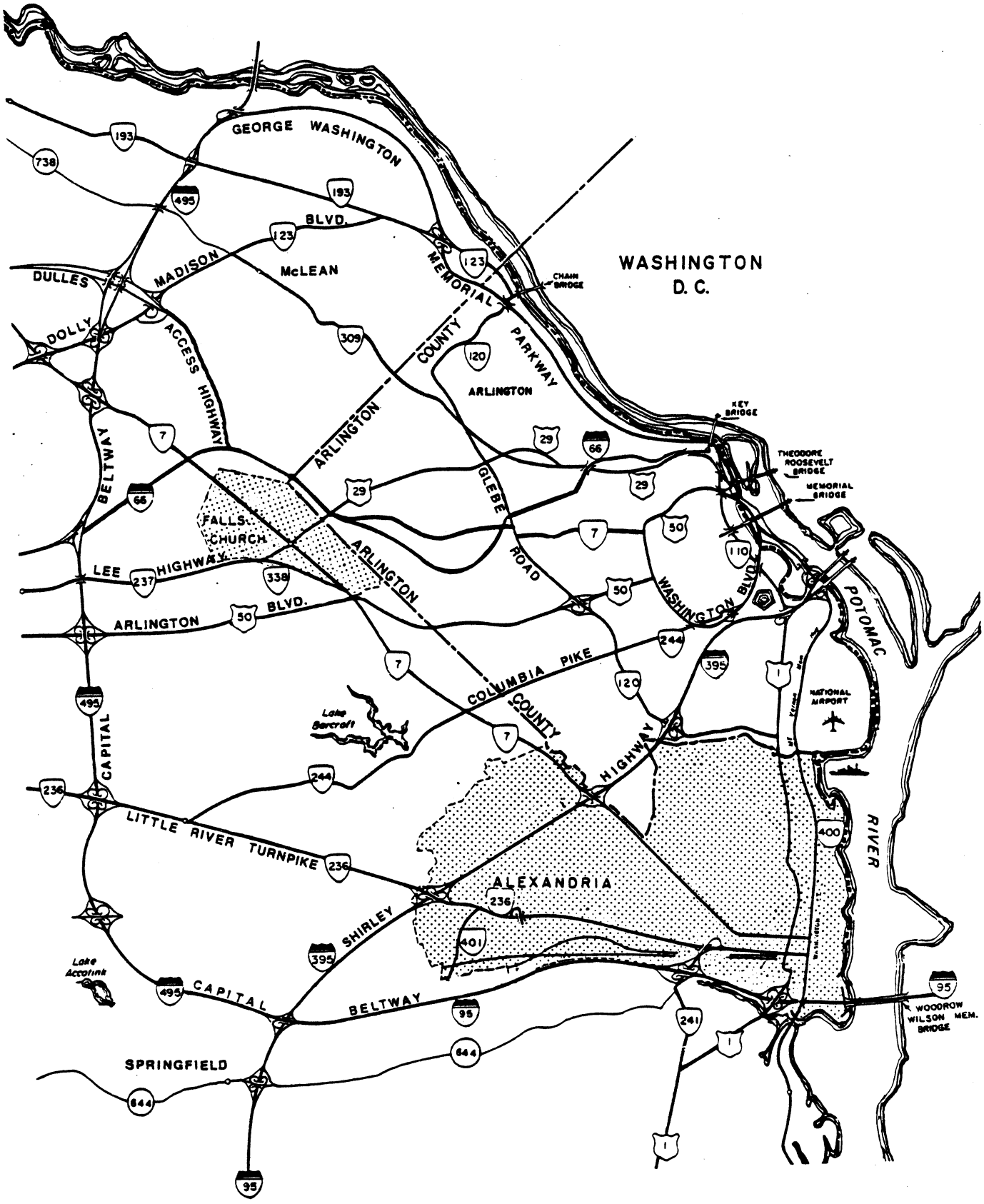

Figure 1. Location map.

Vehicles at 19 on-ramps are metered onto the mainline by traffic signals at the end of the ramps at a rate governed by the existing traffic flow on the mainline. The goal is to allow entering vehicles to join the mainline at a rate which can be accommodated without creating congestion and causing a breakdown in freeway flow. The signals begin operation automatically once a certain threshold volume on the mainline is reached. Spill-over detectors at the beginning of these ramps alert the operators when queues back up to the local streets, and then the meters can be operated at a faster cycle or shut off completely. The locations of the metered ramps are shown schematically in Figure 2.

If the loop detectors sense a build-up of traffic, the TMS operators can view the entire roadway on 26 monitors located in the Traffic Control Center. These monitors receive input from CCTVs located at half-mile intervals. Cameras are mounted high atop poles along the roadway and have both zoom and pan capabilities. Once the cause of the traffic build-up (most often general congestion, an accident, or a disabled vehicle) has been determined, an appropriate response can be initiated. Typically, the Department's Safety Service Patrol or the Virginia State Police are contacted.

Finally, 21 variable message signs located along the interstate and connecting roads are used to relay information to motorists. Messages can be changed by remote control from the Traffic Control Center. They relay both regulatory information (e.g., hours and levels of restriction) and advisory information (e.g., the occurrence of an accident or congestion ahead).

The Traffic Control Center is located on Columbia Pike in Arlington and houses the master computer and other equipment. It operates Monday through Friday, 16 hours per day, from 5:30 a.m. to 9:30 p.m. The TMS is shut off the rest of the time.

PURPOSE AND SCOPE

As indicated, the primary purpose of the study as initiated was to evaluate the impact of the TMS on the traffic in the Shirley Highway corridor. Due to the timing of the implementation of the system and resulting data collection, however, it is impossible to isolate the impact of the TMS. Rather, by comparing travel characteristics in the spring of 1983 and spring of 1986, conclusions were developed regarding the impact of several major transportation events that occurred in the period. The primary events that occurred in the corridor include the following.

1. Metrorail Yellow Line to Huntington opened (late 1983).
2. Fourth conventional lane added to I-395; northbound between King Street and Glebe Road, southbound between Shirlington and Duke Street (early 1984).
3. Alexandria Transit System started (mid 1984).
4. Shirley Highway HOV lanes opened with no restrictions outside of peak periods (early 1985).

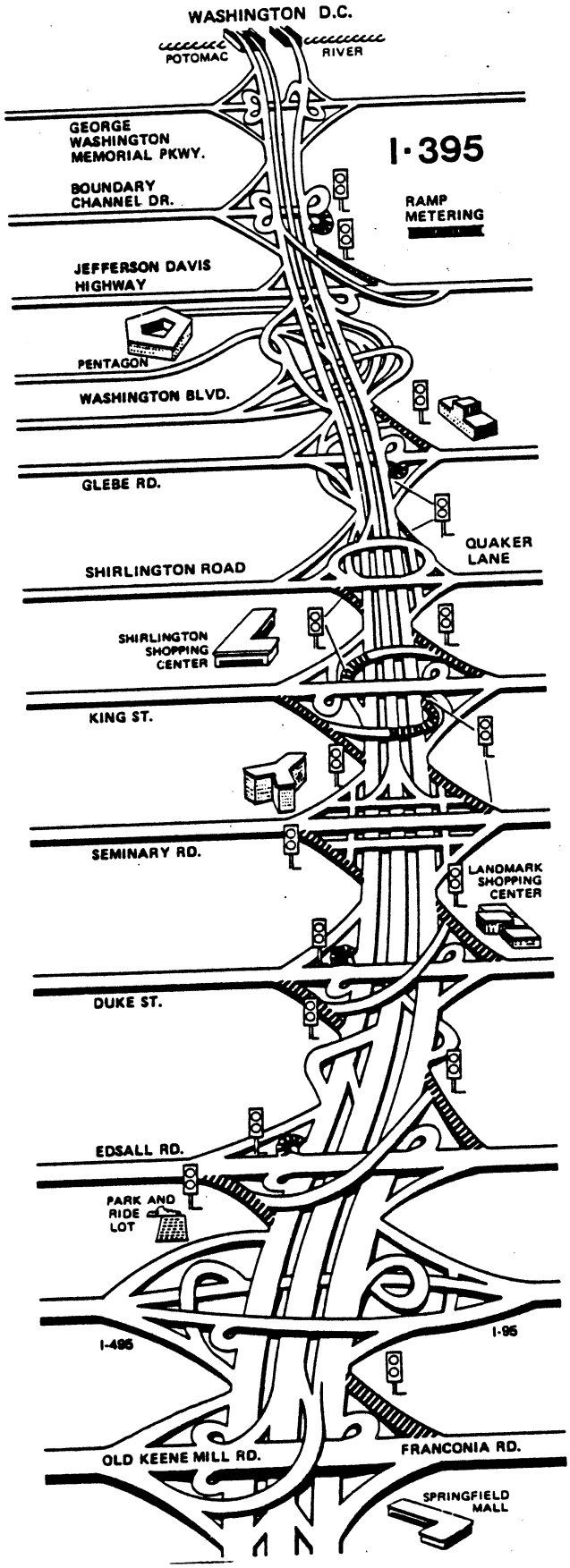

Figure 2. Schematic of I-95/395.

5. TMS implemented (mid 1985).
6. Temporary HOV lane opened northbound between Woodbridge and Springfield (late 1985).

The Shirley Highway corridor, as defined for this study, is bounded by Route 644 on the south, the Potomac River on the north and east, and Columbia Pike on the west. The study focused on the morning and afternoon peak periods in the peak travel direction: northbound in the morning and southbound in the afternoon.

METHODOLOGY

The design of the study was based on the measurement of changes that occurred in traffic characteristics within the corridor. To rationally measure these changes, the corridor was systematically stratified. As a first step, alternative parallel commuter routes were defined. These included Columbia Pike, I-95/395 conventional lanes, I-95/395 HOV lanes, Route 1, and the George Washington Parkway (See Figure 1). Secondly, screenlines were drawn across the width of the corridor to divide the corridor longitudinally. Three screenlines were utilized: one each near the northern and southern termini of the corridor and one approximately in the middle of the corridor. Additionally, two other elements within the corridor were defined: the I-95/395 on-ramps and other local streets that may be impacted.

Data Collection

Data collection consisted of the four major tasks described below, the first three were undertaken in the spring of 1983 and again in the spring of 1986. The fourth was undertaken after the TMS was implemented.

Task 1: Traffic Volume Counts

Peak-period and directional or nondirectional traffic volume counts were obtained at all screenline stations, I-95/395 on-ramps, and other local street locations. Volumes at the stations on the I-395 conventional lanes were obtained manually, whereas all other volumes were collected for a week's period with automatic traffic recorders. Recorders were placed on Monday and picked up on Friday, with the Tuesday, Wednesday, and Thursday data being averaged for the analyses.

Task 2: Speed and Delay Studies

Peak-period speed and delay runs using the floating-car technique were made along the parallel commuter routes and local street travel routes. The number of runs were governed by the procedure for determining sample size described in the Institute of Transportation Engineers' Manual of Traffic Engineering Studies (Fourth Edition, 1976). Seconds of stopped delay were recorded.

Speeds on all on-ramps to I-95/395 were obtained during the peak period and in the peak direction. License plate numbers and times were obtained by observers on each end of the ramp and then matched to determine travel time and resulting speed.

Task 3: Accidents

Accident data for I-95/395 were obtained for a year prior to and then after the TMS was implemented.

Task 4: Incident Detection and Management

Staff at the TMS Traffic Control Center have routinely completed an Incident Detection form since the system was implemented. Copies of these forms were obtained.

FINDINGS

The results of analyzing the data collected are presented in this section of the report. The analyses consisted of a comparison of before-and-after peak-period volumes and speeds on the Shirley Highway (the mainline, HOV lanes, and on-ramps), other parallel commuter routes, and local streets. Travel times on I-395, screenline volumes, VMT, and VHT were determined. Before-and-after accident data were also compared. Finally, data on incident detection and management were analyzed.

Shirley Highway Mainline

Mainline volumes and speed and delay data are shown in Tables 1 through 3.

Volumes

Volumes during the peak period generally increased between 1983 and 1986; they ranged between 4% and 19%. The exception occurred at the northbound station between I-495 and Edsall Road, which experienced a decrease of 7%.

Table 1

Shirley Highway Mainline Volumes

Location	Direction/ Time	Peak Period Volumes[1]		
		1983	1986	% Change from 1983
Bet. I-495 & Edsall	NB/AM	17,200	16,000	- 7%
Bet. I-495 & Edsall	SB/PM	14,300	17,100	+19%
Bet. King & Seminary	NB/AM	17,400	18,100	+ 4%
Bet. King & Seminary	SB/PM	19,500	22,900	+17%
Bet. Glebe & Wash. Blvd.	NB/AM	23,200	24,200	+ 4%
Bet. Glebe & Wash. Blvd.	SB/PM	19,400	22,200	+14%

[1]AM Peak 6:00 to 9:00; PM Peak 3:30 to 6:30

Table 2

Shirley Highway Mainline Speed and Delay
Northbound Peak Period

Location Between	Avg. Speed (MPH) 1983	1986	% Change	Avg. Stopped Delay (Sec.) 1983	1986
Entr. HOV Lanes & Rte. 644	22	19	-14%	0	1
Rte. 644 & I-495	35	16	-54%	0	54
I-495 & Edsall	46	38	-17%	0	6
Edsall & Entr. HOV at Turkeycock	56	41	-27%	0	2
Entr. HOV Turkeycock & Duke	53	34	-36%	0	3
Duke & Seminary	28	16	-43%	16	113
Seminary & King	9	33	+267%	83	8
King & Shirlington	11	45	+309%	44	0
Shirlington & Glebe	19	36	+89%	1	1
Glebe & Rte. 1	16	24	+50%	189	104
Rte. 1 & G.W. Pkwy.	8	10	+25%	51	52
G.W. Pkwy. & Independence	18	14	-22%	70	128
OVERALL	19	22	+16%	454	472
I-495 & G.W. Pkwy.	18	25	+39%	384	289

Table 3

Shirley Highway Mainline Speed and Delay
Southbound Peak Period

Location Between	Avg. Speed (MPH) 1983	1986	% Change	Avg. Stopped Delay (Sec.) 1983	1986
Independence & G.W. Pkwy.	25	29	+16%	22	11
G.W. Pkwy. & Rte. 1	47	47	0%	0	0
Rte. 1 & Glebe	33	32	- 3%	16	7
Glebe & King	21	38	+81%	8	2
King & Seminary	35	42	+20%	0	2
Seminary & Duke	33	41	+24%	0	6
Duke & Entr. HOV Turkeycock	46	47	+ 2%	0	0
Entr. HOV Turkeycock & Edsall	51	40	-22%	0	0
Edsall & I-495	37	17	-54%	3	44
I-495 & Rte. 644	39	16	-59%	2	71
Rte. 644 & Exit HOV Lanes	43	13	-70%	0	37
OVERALL	33	28	-15%	51	180
G.W. Pkwy. & I-495	34	34	0%	27	61

Speed, Delay and Travel Time

After the TMS was implemented, bottlenecks (arbitrarily defined as locations with speeds less than 20 mph) occurred in the northbound lanes in the Springfield area, between Duke Street and Seminary Road, and just before crossing into the District. In 1983, bottlenecks existed from Seminary Road northward to the District. Five links had an increase in speed between 1983 and 1986, whereas the remaining seven had a decrease. All links south of Seminary Road had a decrease in speed; whereas, with the exception of the final link across the 14th Street Bridge, all links north of Seminary Road had an increase. In 1986, the overall speed of 22 mph for the trip between Springfield and the District represented an increase of 3 mph (16%) over the 1983 speed of 19 mph. The increase in speed resulted in a 5.2-minute decrease in travel time. If the section between I-495 and the George Washington Parkway is considered, the overall speed increased from 18 mph to 25 mph (39%). Travel time decreased by 8.9 minutes.

Bottlenecks in the southbound lanes occurred between Edsall Road and southward to the end of the HOV lanes in 1986, whereas no links experienced an average speed less than 20 mph in 1983. The speed increased on five links and decreased on five between 1983 and 1986. One link remained the same. With the exception of a 1-mph decrease in speed between Route 1 and Glebe Road and no change in speed between the George Washington Parkway and Route 1, all links north of the Turkeycock Run area had an increase in speed. All links southward had a decrease. In 1986 the average speed for the trip between the District and Springfield was 28 mph, a decrease of 15% from the 1983 speed. The decrease in speed resulted in a 4-minute increase in travel time. Between the George Washington Parkway and I-495, however, the speed and travel time remained approximately the same.

Stopped delay northbound between Springfield and the District averaged approximately the same in 1983 and 1986, 454 seconds and 472 seconds, respectively. Stopped delay decreased by 95 seconds (25%) between I-495 and the George Washington Parkway.

The stopped delay southbound between the District and Springfield increased over 250% between 1983 and 1986; however, the total delay of 180 seconds in 1986 was relatively small considering the length of the trip. The delay between the George Washington Parkway and I-495 increased from 27 seconds to 61 seconds (126%).

Shirley Highway HOV Lanes

Volumes on the HOV lanes are given in Table 4, and the results of the speed and delay analyses are provided in Table 5.

Volumes

With only one exception, volumes increased on the HOV lanes during the peak period after the implementation of the TMS. The percentage of increase ranged from 8% to 49%; the largest percentages generally occurred north of Glebe Road.

Table 4

Shirley Highway HOV Lane Volumes

Location	Direction/ Time	Peak Period Volume[1]		
		1983	1986	% Change from 1983
Bet. I-495 & Edsall	NB/AM	2,600	2,800	+ 8%
Bet. I-495 & Edsall	SB/PM	5,600	6,500	+16%
Bet. King & Seminary	NB/AM	4,500	4,500	+ 0%
Bet. King & Seminary	SB/PM	3,700	5,500	+49%
Bet. Glebe & Wash. Blvd.	NB/AM	4,600	5,700	+24%
Bet. Glebe & Wash. Blvd.	SB/PM	3,800	5,500	+45%

[1]AM Peak 6:00 to 9:00; PM Peak 3:30 to 6:30

Table 5

Shirley Highway HOV Lane Peak Period Speeds

Location Between	Northbound Avg. Speed (MPH)		Southbound Avg. Speed (MPH)	
	1983	1986	1983	1986
Entrance/Exit & Springfield	56	56	56	8
Springfield & Turkeycock	63	60	61	39
Turkeycock & Seminary	61	55	58	60
Seminary & Shirlington	58	56	54	55
Shirlington & Wash. Blvd.	60	65	65	57
Wash. Blvd. & Eads	54	47	60	50
Eads & Independence	29	25	40	49
OVERALL	50	47	55	36

Speed and Delay

In 1986, average speeds in the morning northbound on the HOV lanes were 55 mph or more up to Washington Boulevard. At that point, speeds began decreasing until at the District line they had dropped to approximately 25 mph. Overall speed from beginning to end was 47 mph, which was only a 3-mph decrease from 1983. The pattern of speeds described above for 1986 was approximately the same in 1983.

In the afternoon, average speeds southbound were generally above 50 mph, except for a slight slowdown at the beginning of the facility in Washington and a significant bottleneck in the Springfield area and southward. This severe congestion at the end of the HOV lanes, which apparently was not occurring in 1983, resulted in a large decrease in overall speed from the District to Springfield from 55 mph to 36 mph (35%).

Stopped delays in 1983 were minimal, occurring only between Eads Street and Independence Avenue in Washington. In 1986 there were again minimal stopped delays at that point; however, as indicated by the average speeds, there were also major delays at the end of the facility, averaging a little over 2 minutes.

Shirley Highway On-Ramps

Volumes, speeds, and travel times on the on-ramps to I-395 are presented in Tables 6 through 9.

Volumes

Most of the northbound on-ramps had an increase in traffic volume during the peak period after the TMS was implemented. Of the 14 ramps that were metered, 8 had an increase in volume ranging from 4% to 287%, 4 had a decrease ranging from 13% to 50%, and 2 had approximately the same volume. Of the 6 ramps not metered, 5 had an increase in volume ranging from 5% to 92% and 1 had an 18% decrease in volume. With the exception of the on-ramps from Seminary Road and westbound Edsall Road, volumes on all ramps south of Glebe Road increased. Volumes on ramps at Glebe Road and northward, except at George Washington Parkway, decreased or remained the same after the TMS was implemented.

Table 6

Shirley Highway On-Ramp Volumes
Northbound

Interchange	Ramp	Metered?	Peak Period Volume [1] 1983	1986	% Change from 1983
Springfield	WB 644 - NB 95	Y	3,600	7,000	+ 94%
	EB 644 - NB 95	N	4,200	7,300	+ 74%
Capital Beltway	WB Beltway - NB 395	N	1,300	2,500	+ 92%
	EB Beltway - NB 395	N	4,500	5,600	+ 24%
Edsall Rd.	WB Edsall - NB 395	Y	700	700	0%
	EB Edsall - NB 395	Y	1,600	1,700	+ 6%
Duke St.	WB Duke - NB 395	Y	1,500	2,800	+ 87%
	EB Duke - NB 395	Y	1,500	5,800	+287%
Seminary Rd.	WB & EB Seminary - NB 395	Y	2,300	2,000	- 13%
	EB Seminary - NB 395	Y	1,400	1,600	+ 14%
King St.	WB King - NB 395	Y	2,400	2,500	+ 4%
	EB King - NB 395	Y	1,000	1,300	+ 30%
Shirlington	Circle - NB 395	Y	4,700	5,300	+ 13%
Glebe Rd.	WB Glebe - NB 395	Y	1,300	900	- 31%
	EB Glebe - NB 395	Y	1,200	800	- 33%
Route 1	NB 1 - NB 395	Y	1,900	1,900	0%
	SB 1 - NB 395	N	1,100	900	- 18%
Boundary Channel	SB B.C. - NB 395	Y	1,200	600	- 50%
G.W. Parkway	NB G.W. - NB 395	N	4,400	4,600	+ 5%
	SB G.W. - NB 395	N	1,700	2,100	+ 24%

[1] 6:00 to 9:00 a.m.

Table 7

Shirley Highway On-Ramp Volumes
Southbound

Interchange	Ramp	Metered?	Peak Period Volume [1] 1983	1986	% Change from 1983
Springfield	WB 644 - SB 95	N	700	400	- 43%
	EB 644 - SB 95	N	400	900	+125%
Capital Beltway	WB Beltway - SB 95	N	5,000	5,400	+ 8%
	EB Beltway - SB 95	N	6,800	6,600	- 3%
Edsall Rd.	WB Edsall - SB 395	Y	2,000	2,000	0%
	EB Edsall - SB 395	Y	1,800	1,800	0%
Duke St.	WB Duke - SB 395	Y	1,800	1,400	- 22%
	EB Duke - SB 395	Y	1,100	1,500	+ 36%
Seminary Rd.	WB Seminary - SB 395	Y	900	900	0%
	EB & WB Seminary - SB 395	Y	2,900	1,800	- 38%
King St.	WB King - SB 395	Y	800	600	- 25%
	EB King - SB 395	Y	900	1,100	+ 22%
Shirlington	Circle - SB 395	Y	2,100	1,600	- 24%
	Collector - SB 395	N	3,400	6,100	+ 79%
Boundary Channel	NB B.C. - SB 395	N	N/A	100	N/A
	SB B.C. - SB 395	N	900	1,000	+ 11%
G.W. Parkway	NB G.W. - SB 395	N	1,000	400	- 60%
	SB G.W. - SB 395	N	400	300	- 25%

[1] 3:30 to 6:30 p.m.

Table 8

Shirley Highway On-Ramp Speeds
Northbound Peak Period[1]

Interchange	Ramp	Avg. Speed (MPH) 1983	Avg. Speed (MPH) 1986	Travel Time (Min.) 1983	Travel Time (Min.) 1986	Metered?
Springfield	WB 644 - NB 95	44	13	0.2	0.8	Y
	EB 644 - NB 95	34	25	0.6	0.8	N
Edsall Rd.	WB Edsall - NB 395	31	23	0.3	0.4	Y
	EB Edsall - NB 395	31	14	0.6	1.0	Y
Duke St.	WB Duke - NB 395	35	17	0.4	0.9	Y
	EB Duke - NB 395	44	20	0.5	1.5	Y
Seminary Road	WB Seminary - NB 395	35	15	0.4	1.3	Y
	EB Seminary - NB 395	21	10	1.2	2.9	Y
King St.	WB King - NB 395	31	28	0.4	0.4	Y
	EB King - NB 395	36	15	0.5	1.6	Y
Shirlington	WB Quaker - NB 395	27	23	0.9	0.8	Y
	EB Shirlington - NB 395	25	23	1.5	1.5	Y
	28th St. - NB 395	23	20	1.3	1.4	Y
	Gunston - NB 395	16	21	0.6	0.5	Y
Glebe Rd.	WB Glebe - NB 395	37	30	0.3	0.4	Y
	EB Glebe - NB 395	28	17	0.2	0.5	Y
Route 1	NB 1 - NB 395	51	26	0.2	0.5	Y
	SB 1 - NB 395	29	29	0.2	0.3	N
Boundary Channel	SB B.C. - NB 395	28	20	0.3	0.4	Y
G.W. Parkway	NB G.W. - NB 395	23	19	0.2	0.3	N
	SB G.W. - NB 395	11	10	0.6	0.7	N

[1]Average speed between 6:00 and 9:00 a.m.

Table 9

Shirley Highway On-Ramp Speeds
Southbound Peak Period[1]

Interchange	Ramp	Avg. Speed (MPH) 1983	Avg. Speed (MPH) 1986	Travel Time (Min.) 1983	Travel Time (Min.) 1986	Metered?
Springfield	WB 644 - SB 95	34	18	0.5	1.2	N
	EB 644 - SB 95	57	37	0.3	0.5	N
Edsall Rd.	WB Edsall - SB 395	33	16	0.3	0.8	Y
	EB Edsall - SB 395	44	20	0.3	1.0	Y
Duke St.	WB Duke - SB 395	25	10	0.3	0.9	Y
	EB Duke - SB 395	42	19	0.2	0.7	Y
Seminary Rd.	WB Seminary - SB 395	19	13	1.2	2.1	Y
	EB Seminary - SB 395	22	13	0.5	1.0	Y
King St.	WB King - SB 395	35	32	0.4	0.4	Y
	EB King - SB 395	38	35	0.4	0.4	Y
Shirlington	WB Quaker - SB 395	29	27	1.4	1.5	Y
	EB Shirlington - SB 395	24	23	0.7	0.8	Y
	28th St. - SB 395	23	20	0.5	0.6	Y
	Gunston - SB 395	24	26	1.2	1.1	Y
Glebe Rd.	WB Glebe - SB 395	33	37	1.3	1.1	N
	EB Glebe - SB 395	32	33	0.9	0.8	N
Boundary Channel	NB B.C. - SB 395	23	23	0.3	0.3	N
	SB B.C. - SB 395	33	29	0.2	0.3	N
G.W. Parkway	NB G.W. - SB 395	22	21	0.2	0.2	N
	SB G.W. - SB 395	34	41	0.2	0.2	N

[1]Average speed between 3:30 and 6:30 p.m.

Most of the southbound on-ramps had no change or a decrease in volume in 1986 as compared to 1983. Of the 9 metered ramps, 4 had decreases ranging from 22% to 38%, 2 had increases of 22% and 36%, and volumes on the ramps from Edsall Road and westbound Seminary Road remained the same. Of the 8 unmetered ramps for which both 1983 and 1986 volumes were known, 4 had decreases and 4 had increases in volumes. Decreases ranged from 3% to 60%, whereas increases ranged from 8% to 125%. There was no tendency for ramps having increases or decreases in volumes to be concentrated in certain sections of the roadway.

Speeds and Travel Times

The average speed of vehicles traversing a northbound on-ramp during the 3-hour period 6:00 a.m. to 9:00 a.m. after the TMS was implemented was 20 mph; it ranged from 10 mph to 29 mph on the 21 individual ramps. Prior to the implementation of the TMS in 1983, the average speed on the same 21 ramps was 30 mph; it ranged from 11 mph to 51 mph. All ramps except two, one metered and one unmetered, had a decrease in speed between the two time periods. The average decrease among the 16 metered ramps was 14 mph, whereas the average decrease among the 3 unmetered was 5 mph. Of course, travel times varied inversely to the speed; the average increase was 0.45 minutes, or 27 seconds. Increases of a minute or more occurred on 3 ramps--Duke Street, Seminary Road, and King Street.

Vehicles traversing the southbound on-ramps between 3:30 p.m. and 6:30 p.m. averaged 31 mph in 1983, ranging from 19 mph to 57 mph on the individual ramps. Corresponding values after the TMS was implemented were 25 mph on average; they varied between 10 mph and 41 mph. Fifteen of the 20 ramps had a decrease in speed between the two time periods. All but one of the 12 metered ramps had a decrease; these decreases averaged 10 mph. Four of the 8 unmetered ramps had a decrease in speed; however, only the decrease of 16 mph and 20 mph on the ramps at Springfield were significant. Speeds in 1986 on the other 6 unmetered ramps were close to being the same as in 1983. Travel times generally increased; the increases averaged 0.42 minutes, or 25 seconds. There were no increases of a minute or more.

Shirley Highway Commuter Travel Times

Since the major commuting pattern in the morning is travel into Washington, travel time from points along I-395 to the District is an important consideration. The previous discussion of speeds on the mainline addressed the issue of traveling the entire length from Springfield to Washington. Table 10 presents data showing travel time on the ramps and on the mainline to D.C. for 1983 and 1986. It is noted that this analysis is not relevant in the afternoon because the major commuting pattern is travel from Washington to various off-ramps, and travel data on off-ramps were not collected. The important consideration in the afternoon is travel on the mainline, and that was discussed previously.

Travel times on the ramps during the morning peak period generally increased after the TMS was implemented. The time on the ramp, however, was a small percentage of the total travel time into the District; therefore, with the exception of those trips originating from the George

Washington Parkway and Route 1, the overall travel times into the District decreased.

Decreases in travel time ranged from 2.4 minutes from Glebe Road to 10.0 minutes from Seminary Road, or 12% to 33%. Although travel time increased for those trips originating from the George Washington Parkway and Route 1, the largest increase was only 1.4 minutes out of a 5.7-minute total trip time.

Table 10

Shirley Highway Ramp Plus Mainline Travel Times
Northbound

	Travel Time (Minutes)					
	1983			1986		
Travel Route	Ramp	Mainline	Total	Ramp	Mainline	Total
WB 644 to D.C.	0.2	37.9	38.1	0.8	32.6	33.4
EB 644 to D.C.	0.6	37.9	38.5	0.8	32.6	33.4
WB Edsall to D.C.	0.3	34.8	35.1	0.4	27.3	27.7
EB Edsall to D.C.	0.6	34.8	35.4	1.0	27.3	28.3
WB Duke to D.C.	0.4	33.0	33.4	0.9	24.7	25.6
EB Duke to D.C.	0.5	33.0	33.5	1.5	24.7	26.2
WB Seminary to D.C.	0.4	29.5	29.9	1.3	18.6	19.9
EB Seminary to D.C.	1.2	29.6	30.8	2.9	18.6	21.5
WB King to D.C.	0.4	24.0	24.4	0.4	17.1	17.5
EB King to D.C.	0.5	24.0	24.5	1.6	17.1	18.7
WB Quaker to D.C.	0.9	19.8	20.7	0.8	16.1	16.9
EB Shirlington to D.C.	1.5	19.8	21.3	1.5	16.1	17.6
WB Glebe to D.C.	0.3	17.7	18.0	0.4	15.0	15.4
EB Glebe to D.C.	0.2	17.7	17.9	0.5	15.0	15.5
NB 1 to D.C.	0.2	8.0	8.2	0.5	8.4	8.9
SB 1 to D.C.	0.2	8.0	8.2	0.3	8.4	8.7
NB G.W. to D.C.	0.2	4.1	4.3	0.3	5.4	5.7
SB G.W. to D.C.	0.6	4.1	4.7	0.7	5.4	6.1

Shirley Highway Accidents

Accident records on I-95/395 between Springfield and D.C. for a 12-month period before and after the implementation of the TMS in June 1985 were analyzed. The findings are summarized in Tables 11 through 13. All

tables report weekday accidents stratified by an A.M. peak period between 6:00 and 10:00, a P.M. peak period between 3:00 and 7:00, and the rest of the day. The direction of travel time for accidents in the A.M. period was north, whereas it was south for the P.M. accidents. The accidents during the rest of the day occurred in both directions. Finally, due to limitations in the data, there was no way to separate accidents occurring on the ramps, the HOV lanes, or the mainline.

Table 11

Shirley Highway Weekday Accidents

Time	BEFORE TMS (12 Months) VMT(10^6)	Accidents	Rate	AFTER TMS (12 months) VMT(10^6)	Accidents	Rate
A.M. (6-10) NB	61.1	84	137	64.2	103	160
P.M. (3-7) SB	68.9	107	155	72.4	103	142
Rest of day NB & SB	164.0	210	128	172.4	253	147

Note: Rate = accidents per 100-million vehicle miles of travel.

Table 12

Shirley Highway Weekday Accident Rates by Type

Type	BEFORE TMS (12 months) NB A.M.	SB P.M.	NB & SB Rest of Day	AFTER TMS (12 months) NB A.M.	SB P.M.	NB & SB Rest of Day
Rear end	105	102	56	103	97	60
Sideswipe	28	39	22	47	28	32
Other	5	15	50	11	18	55

Note: A.M. = 6:00 to 10:00 A.M.
P.M. = 3:00 to 7:00 P.M.
Rate = accidents per 100-million vehicle miles of travel

Table 13

Shirley Highway Weekday Accidents at Interchanges

Time	BEFORE TMS (12 months) Accidents	Rate	AFTER TMS (12 months) Accidents	Rate
A.M. (6-10) NB	80	131	102	159
P.M. (3-7) SB	83	120	101	140
Rest of day NB & SB	180	110	218	126

Note: Rate = accidents per 100-million vehicle miles of travel.

Accident Occurrence

The accident rate outside the eight peak hours increased by 15%, from 128 to 147 accidents per 100 million vehicle miles of travel. The increase in the accident rate during the 6:00 to 10:00 a.m. period was 17%, from 137 to 160. During the P.M. peak period the rate decreased by 8%, from 147 to 128.

Accident Type

Over 90% of the weekday accidents on the Shirley Highway occurring during the peak periods were rear-end collisions and sideswipes. The accident rate for rear-end collisions decreased by 2%, from 105 to 102, in the A.M. peak period and by 5%, from 102 to 97, in the P.M. peak period. The rate during the rest of the day increased by 7%, from 56 to 60.

The rate for sideswipe accidents increased by 45%, from 22 to 32, during the off-peak hours. Sideswipe accidents increased by 68%, from 28 to 47, in the A.M. peak period and decreased by 28%, from 39 to 28, in the P.M. peak period.

Interchange Accidents

The number of accidents in interchange areas increased for all time periods in the 12 months after the TMS was implemented when compared to the 12 months prior to implementation. Accident rates occurring in the off-peak period increased by 15%, from 110 to 126; in the A.M. peak period by 21%, from 131 to 159; and in the P.M. peak by 17%, from 120 to 140.

Other Parallel Commuter Routes

Volumes, speeds, and delays on the George Washington Parkway, Route 1, and Columbia Pike are shown in Tables 14 and 15, respectively.

Volumes

With very few exceptions, peak-period volumes along Route 1, the George Washington Parkway, and Columbia Pike decreased significantly between 1983 and 1986. The exceptions occurred at the southern station on Route 1, where volumes remained close to the same, and at the northern station on the George Washington Parkway, where volumes increased greatly.

Speed and Delay

Between 1983 and 1986, the average speeds in both the morning and afternoon peak period increased on Route 1 and Columbia Pike and decreased on the George Washington Parkway. The largest change, +5 mph, occurred eastbound in the morning on Columbia Pike.

For all but one case, the seconds of stopped delay increased. This was expected on the George Washington Parkway, which experienced a decrease in speed; however, the increase was unexpected for the routes that experienced an increase in average speed.

Local Streets

Volumes, speeds, and delays on local streets in the corridor are presented in Tables 16 through 18.

Volumes

For both the morning and afternoon peak periods, slightly over one-half of the locations had an increase in volume between 1983 and 1986. Most of the sites having an increase in volume were located on routes interchanging with the Shirley Highway. The increase in volume on Glebe Road east of I-395 was particularly large. Other sites having a large increase in volume were Arlington Ridge Road, Van Dorn Street, Cherokee Avenue, Eads Street, Backlick Road, and Commerce Road. All but the last road run approximately north-south in the corridor.

Table 14

Other Parallel Commuter Route Volumes

Location	Direction/ Time	Peak Period Volume[1] 1983	Peak Period Volume[1] 1986	% Change from 1983
Rte. 1 Bet. Green & Jefferson	NB/AM	9,300	9,300	0%
	SB/PM	10,200	11,000	+ 8%
Rte. 1 Bet. Four Mile Run & S. Glebe	Nondir./AM	7,200	6,400	-11%
	Nondir./PM	6,900	6,400	- 7%
Rte. 1 just South of I-395	Nondir./AM	10,600	7,900	-25%
	Nondir./PM	10,600	8,500	-20%
G.W. Pkwy. Bet. I-95 & Church	Nondir./AM	5,400	4,600	-15%
	Nondir./PM	8,300	6,900	-17%
G.W. Pkwy. Bet. Slater's & Alexandria NCL	NB/AM	8,600	5,800	-33%
	SB/PM	8,800	5,100	-42%
G.W. Pkwy. just East of I-395	NB/AM	5,400	10,600	+96%
	SB/PM	6,900	11,300	+64%
Columbia Pike Bet. John Marr & Evergreen	Nondir./AM	5,000	4,000	-20%
	Nondir./PM	7,400	5,800	-22%
Columbia Pike Bet. Rt. 7 & Williams	EB/AM	6,100	1,000	-84%
	WB/PM	5,400	2,700	-50%
Columbia Pike Bet. Rolfe & Wash. Blvd.	Nondir./AM	11,600	6,900	-41%
	Nondir./PM	9,200	6,900	-25%

[1]AM Peak 6:00 to 9:00; PM Peak 3:30 to 6:30

Table 15

Other Parallel Commuter Routes
Peak Period Speed and Delay

Route/Direction	Termini	Avg. Speed (MPH) 1983	1986	% Change	Avg. Stopped Delay (Sec.) 1983	1986
Route 1/NB	I-95 to I-395	18	20	+ 8%	205	237
Route 1/SB	I-395 to I-95	14	15	+ 3%	331	525
G.W. Parkway/NB	Bellview to R.F. & P. Overpass	24	21	-13%	149	307
G.W. Parkway/SB	R.F. & P. Overpass to Bellview	26	22	-13%	101	335
Columbia Pike/EB	Annandale Rd. to Wash. Blvd.	23	28	+22%	232	120
Columbia Pike/WB	Wash. Blvd. to Annandale Rd.	22	24	+ 8%	197	203

Table 16

Local Street Volumes

Location	A.M. Peak Period[1] Dir.	1983	1986	P.M. Peak Period[2] Dir.	1983	1986
Telegraph Rd. North of I-95	NB	5,200	5,100	SB	6,100	6,100
Taylor Run Pkwy. bet. Janney & Dartmouth	Both	1,400	900	Both	1,300	1,000
Woodland Terrace West of Russell	Both	400	500	Both	500	500
Monticello Blvd. bet. Argyle & Underhill	Both	500	500	Both	700	600
Russell Rd. bet. Mansion & Uhler	Both	1,800	1,000	Both	2,200	1,800
Mt. Vernon Ave. bet. Four Mile & Elbert	Both	3,800	3,900	Both	4,300	4,400
Arlington Ridge Rd. North of 19th	Both	2,900	3,500	Both	4,200	4,300
Quaker La. bet. Coventry & Trinity	Both	2,600	3,200	Both	2,900	3,300
Quaker La. bet. Bishop & Woods	Both	3,000	3,900	Both	3,500	3,900
Quaker La. bet. Oakcrest & Crestwood	NB	2,900	2,900	SB	2,700	2,500
Valley Dr. south of Allison	Both	500	400	Both	500	500
Gunston Rd. bet. Custis & Quaker	WB	900	900	N/A	N/A	N/A
Martha Custis Dr. bet. Lyons & Holmes	Both	900	1,100	Both	1,300	1,400
W. Glebe Rd. bet. Valley & Florence	Both	3,000	3,300	Both	3,600	4,100
S. Glebe Rd. bet. W. Glebe & Meade	Both	4,600	4,900	Both	5,900	6,200

[1] 6:00 to 9:00 A.M.
[2] 3:30 to 6:30 P.M.

Table 16, continued

Location	A.M. Peak Period[1] Dir.	1983	1986	P.M. Peak Period[2] Dir.	1983	1986
Army-Navy Dr. South of 28th	Both	600	600	Both	1,500	900
Army-Navy Dr. bet. Nash & Country Club	Both	600	700	Both	1,100	900
N. Jordan St. bet. Taney & Howard	Both	2,000	1,900	Both	2,400	2,600
N. Howard St. bet. Louis & Loyola	Both	1,400	1,200	Both	1,700	1,500
King St. bet. Taylor & Dearing	Both	2,700	2,900	Both	4,000	4,400
28th St. bet. King & Columbus	Both	900	800	Both	1,200	1,100
N. Van Dorn St. bet. Braddock & Menokin	Both	2,800	2,800	Both	1,900	1,900
Seminary Rd. bet. Jordan & Menokin	Both	4,400	4,200	Both	5,700	5,300
N. Van Dorn St. bet. Sanger & Maris	Both	4,200	4,200	Both	4,100	4,400
Duke St. bet. Reynolds & Van Dorn	Both	4,800	5,500	Both	8,000	8,400
S. Van Dorn St. bet. Stevenson & Duke	NB	2,600	2,800	SB	3,100	3,200
S. Van Dorn St. bet. Eisenhower & Southern RR	NB	3,700	7,300	SB	4,100	5,100
Edsall Rd. bet. Turkeycock Run & Yoakum	Both	2,700	3,200	Both	3,900	4,400
Franconia Rd. bet. Frontier & Elder	Both	5,700	6,400	Both	8,200	9,200
Old Keene Mill Rd. bet. Cumberland & Spring	Both	7,200	9,200	Both	10,000	10,300
Edsall Rd. bet. Clifton & Monroe	Both	3,500	3,900	Both	4,000	4,400

[1] 6:00 to 9:00 A.M.
[2] 3:30 to 6:30 P.M.

Table 16, continued

Location	A.M. Peak Period[1] Dir.	1983	1986	P.M. Peak Period[2] Dir.	1983	1986
Edsall Rd. bet. Beryl & Indian Run	Both	3,200	3,200	Both	4,000	4,200
Cherokee Ave. bet. Edsall & Navaho	NB	400	1,000	SB	500	1,100
Cherokee Ave. bet. Fairland & Montrose	NB	100	100	SB	200	200
Little River Tnpk. bet. Brookside & Southland	Both	4,600	5,200	Both	6,800	8,900
Little River Tnpk. bet. Beauregard & Oasis	EB	4,100	6,200	N/A	N/A	N/A
N. Beauregard St. bet. Morgan & Sanger	NB	2,900	2,800	SB	2,600	2,700
Sanger Ave. bet. Knole & Bradford	Both	1,600	1,800	Both	2,400	2,600
N. Beauregard St. South of Seminary	NB	3,100	3,200	SB	3,300	3,700
N. Beauregard St. bet. Seminary & Fillmore	NB	2,000	1,400	SB	2,000	1,600
Seminary Rd. bet. Beauregard & I-395	Both	3,700	5,400	Both	5,900	9,000
N. Beauregard St. bet. Braddock & King	NB	2,700	2,300	SB	2,500	2,400
King St. bet. Dawes & Chesterfield	Both	4,100	4,200	Both	6,500	8,700
Walter Reed Dr. bet. Wakefield & Dinwiddie	N/A	N/A	N/A	SB	3,400	2,600
Walter Reed Dr. bet. Oakland & Pollard	NB	2,800	2,300	SB	2,400	2,300
Arlington Mill Dr. bet. Walter Reed & Taylor	Both	2,300	1,500	Both	3,200	2,000
S. Glebe Rd. bet. 19th & 20th	NB	2,400	2,800	SB	2,900	5,600

[1] 6:00 to 9:00 A.M.
[2] 3:30 to 6:30 P.M.

Table 16, continued

Location	A.M. Peak Period[1] Dir.	1983	1986	P.M. Peak Period[2] Dir.	1983	1986
S. Glebe Rd. bet. 14th & 15th	NB	2,100	5,200	SB	2,900	2,900
Walter Reed Dr. bet. 12th & 13th	N/A	N/A	N/A	SB	2,500	2,300
Columbia Pike bet. Oakland & Monroe	EB	1,000	1,300	WB	2,500	5,100
Columbia Pike bet. Walter Reed & Highland	EB	7,000	4,200	WB	4,200	4,300
Reed Ave. bet. Evans & Rte. 1	Both	1,100	900	Both	1,100	700
Columbia Pike bet. Morey & Spring	EB	5,700	1,300	N/A	N/A	N/A
Leesburg Pike bet. Columbia & Rock Spring	Both	5,400	5,900	Both	8,500	10,000
Seminary Rd. South of Magnolia	Both	2,600	3,000	Both	3,800	4,300
S. Eads St. South of 11th	Both	2,900	6,400	Both	1,700	2,700
Mt. Vernon Ave. bet. Russell & Reed	Both	2,000	2,000	Both	2,800	2,700
Braddock Rd. bet. Spring Valley & Randolph	NB	2,300	2,300	SB	2,000	2,300
Backlick Rd. bet. Bowie & I-395	NB	1,400	5,100	SB	2,900	5,700
Commerce Rd. bet. Bowie & I-395	Both	3,100	5,900	Both	4,700	5,000
Braddock Rd. bet. Verde & Arcadia	N/A	N/A	N/A	SB	1,300	1,000
Columbia Pike bet. Lincolnia & Ashwood	EB	4,000	1,100	N/A	N/A	N/A
Lincolnia Rd. bet. Sand & Summit	NB	900	800	N/A	N/A	N/A
Lincolnia Rd. bet. Pine & Century	NB	900	1,100	SB	1,200	1,200
N. Chambliss St. bet. Beauregard & Lincolnia	N/A	N/A	N/A	SB	1,300	1,300

[1] 6:00 to 9:00 A.M.
[2] 3:30 to 6:30 P.M.

Table 17

Local Street Speed and Delay
A.M. Peak Period

Route	From	To	Avg. Speed (MPH) 1983	Avg. Speed (MPH) 1986	Avg. Stopped Delay (Sec.) 1983	Avg. Stopped Delay (Sec.) 1986
Braddock	Backlick	Columbia Pike	25	27	110	61
Van Dorn/ Menokin	Franconia	Rte. 7	19	24	238	145
Cherokee	Edsall	Rte. 236	29	32	6	0
Chowan	Cherokee	Rte. 236	24	33	18	0
Army-Navy	S. Glebe	Eads	29	26	9	31
Russell/ Arlington Ridge	Braddock	I-395 Ramp	17	23	204	101
Walter Reed/ Beauregard	Rte. 236	Columbia Pike	21	21	193	195
Franconia/ Old Keene Mill	Accotink Ck.	Van Dorn	15	24	338	126
Franconia/ Old Keene Mill	Van Dorn	Accotink Ck.	26	28	101	96
Edsall	Backlick	Van Dorn	24	25	82	78
Edsall	Van Dorn	Backlick	26	30	58	41
Route 236	Columbia Pike	Quaker	27	28	124	108
Route 236	Quaker	Columbia Pike	28	29	129	123
Seminary/ G. Mason	Columbia Pike	Quaker	24	20	149	256
Seminary/ G. Mason	Quaker	Columbia Pike	21	23	222	138
Route 7	Columbia Pike	Quaker	20	20	135	170
Route 7	Quaker	Columbia Pike	24	24	82	89
Shirlington/ Quaker	Glebe	Rte. 236	23	19	89	186

Table 17, continued

Route	From	To	Avg. Speed (MPH) 1983	Avg. Speed (MPH) 1986	Avg. Stopped Delay (Sec.) 1983	Avg. Stopped Delay (Sec.) 1986
Shirlington/ Quaker	Rte. 236	Glebe	23	23	86	107
Glebe/S. Glebe	Columbia Pike	Rte. 1	18	20	202	178
Glebe/S. Glebe	Rte. 1	Columbia Pike	25	27	89	56
Lincolnia/ Chambliss	Columbia Pike	Rte. 236	27	28	27	26
Lincolnia/ Chambliss	Rte. 236	Columbia Pike	22	24	51	37
Backlick	Rte. 236	Old Keene Mill	26	26	94	85
Backlick	Old Keene Mill	Rte. 236	22	19	148	219

Table 18

Local Street Speed and Delay
P.M. Peak Period

Route	From	To	Avg. Speed (MPH) 1983	Avg. Speed (MPH) 1986	Avg. Stopped Delay (Sec.) 1983	Avg. Stopped Delay (Sec.) 1986
Braddock	Columbia Pike	Backlick	20	17	187	251
Van Dorn/ Menokin	Rte. 7	Franconia	21	16	176	264
Cherokee	Rte. 236	Edsall	25	22	12	64
Chowan	Rte. 236	Cherokee	27	33	1	0
Army-Navy	Eads	S. Glebe	26	27	37	34
Russell/ Arlington Ridge	I-395 Ramp	Braddock	19	23	148	103
Walter Reed/ Beauregard	Columbia Pike	Rte. 236	22	20	176	259
Franconia/ Old Keene Mill	Accotink Ck.	Van Dorn	27	24	76	173
Franconia/ Old Keene Mill	Van Dorn	Accotink Ck.	18	17	258	328
Edsall	Backlick	Van Dorn	27	25	59	88
Edsall	Van Dorn	Backlick	21	17	121	245
Route 236	Columbia Pike	Quaker	25	27	134	128
Route 236	Quaker	Columbia Pike	25	22	177	219
Seminary/ G. Mason	Columbia Pike	Quaker	19	19	201	242
Seminary/ G. Mason	Quaker	Columbia Pike	20	20	200	239
Route 7	Columbia Pike	Quaker	18	19	150	149
Route 7	Quaker	Columbia Pike	20	21	100	123
Shirlington/ Quaker	Glebe	Rte. 236	17	18	216	200

Table 18, continued

Route	From	To	Avg. Speed (MPH) 1983	Avg. Speed (MPH) 1986	Avg. Stopped Delay (Sec.) 1983	Avg. Stopped Delay (Sec.) 1986
Shirlington/ Quaker	Rte. 236	Glebe	21	23	119	112
Glebe/S. Glebe	Columbia Pike	Rte. 1	21	21	162	134
Glebe/S. Glebe	Rte. 1	Columbia Pike	19	20	160	165
Lincolnia/ Chambliss	Columbia Pike	Rte. 236	22	21	63	63
Lincolnia/ Chambliss	Rte. 236	Columbia Pike	24	22	35	44
Backlick	Rte. 236	Old Keene Mill	19	12	247	386
Backlick	Old Keene Mill	Rte. 236	22	20	178	160

Volumes at slightly under one-half of the locations remained the same or decreased in the 1983-86 time period. Decreases were generally small; however, large decreases occurred at locations on Columbia Pike, Russell Road, Beauregard Street, Arlington Mill Drive, Reed Avenue, and Taylor Run Parkway.

Speed and Delay

Between 1983 and 1986 the average speed in the morning on 20 of the 25 routes listed in Table 17 either increased or remained the same. The average increase was 3.3 mph, and the average decrease was 3.5 mph. Large increases were observed on Van Dorn Street (5 mph), Chowan Avenue (9 mph), Russell/Arlington Ridge Roads (6 mph), and Franconia/Old Keene Mill Roads eastbound (9 mph). Decreases of 4 mph occurred eastbound on Seminary and Glebe Roads.

A different pattern occurred in the afternoon peak period between 1983 and 1986. Thirteen of the 25 routes listed in Table 18 had a decrease in average speed; the decreases averaged 2.9 mph. Speeds on the other 12 routes either remained the same or increased; the increases averaged 2.1 mph. Decreases of 5 mph and 7 mph occurred on Van Dorn Street and Backlick Road, respectively. A 6-mph increase occurred on Chowan Avenue.

With only a few exceptions, the average stopped delay coincided with the change in speed; i.e., delay increased if speed decreased and vice versa. The net change in average stopped delay totaled over the first 7 routes, which basically run north-south in the corridor, was a decrease of 245 seconds in the morning and an increase of 238 seconds in the afternoon. For the remaining routes, which basically run east-west across the

corridor, the net change totaled over all the routes was a -87 seconds in the morning and a +542 seconds in the afternoon.

Screenline Volumes

Three imaginary screenlines were drawn across the corridor. The stations along these screenlines and the volumes at each are given in Table 19. Between 1983 and 1986, volumes along the southern screenline generally decreased in the morning and increased in the afternoon; however, total volume across the screenline increased by about 6% in the morning and 7% in the afternoon. In the A.M. peak period, the increase of almost 100% on Van Dorn Street offset the general trend of decreases at the other stations. In the P.M. peak period, the large increases on I-395 and Van Dorn Street were partially offset by the 40% decrease on the George Washington Parkway.

Volumes at all stations except the one on Columbia Pike along the northern screenline increased in both the morning and afternoon peak periods. Total screenline volumes increased by about 9% in the morning and by 18% in the afternoon.

The screenline drawn across the middle of the corridor was not as clearly defined as the other two because of the potential for north-south travel on many of the intersecting streets. Diversion to these alternate north-south routes was evident as total volumes at the major stations on the screenline decreased by 19% in the A.M. peak period and 4% in the P.M. peak period, despite increases at both ends of the corridor.

Vehicle Miles of Travel

VMT along the major commuting routes in the corridor are given in Table 20. Due to the locations of the count stations, these statistics represent travel between the screenline stations in Table 19. The VMT was calculated by multiplying the average 3-hour volume between stations by the distance between the stations.

In the morning peak period, the total VMT on the major commuter routes decreased by 5% between 1983 and 1986. The Shirley Highway mainline, HOV lanes, and on-ramps had an increase in VMT; whereas, VMT on the other three parallel routes decreased.

In the afternoon peak period, the total VMT increased by 8%. Decreases occurred on Columbia Pike, George Washington Parkway, and the I-395 on-ramps.

During the combined peak periods, the VMT increased by 10,050 (2%).

Table 19

Screenline Volumes

Route	Location	A.M. Peak Period[1] - NB 1983	A.M. Peak Period[1] - NB 1986	P.M. Peak Period[2] - SB 1983	P.M. Peak Period[2] - SB 1986
I-395	Bet. I-495 & Edsall	17,200	16,000	14,300	17,100
I-395 HOV	Bet. I-495 & Edsall	2,600	2,800	5,600	6,500
Van Dorn St.	Bet. Eisenhower & Southern R.R.	3,700	7,300	4,100	5,100
Route 1	Bet. Green & Jefferson	9,400	9,300	10,200	11,000
G.W. Pkwy.	Bet. I-95 & Church	4,500	4,100	6,800	4,100
	Totals	37,400	39,500	41,000	43,800
Columbia Pike	Bet. Williams & Rte. 7	6,100	1,300	5,400	2,700
I-395	Bet. Seminary & King	17,400	18,100	19,500	22,900
I-395 HOV	Bet. Seminary & King	4,500	4,500	3,700	5,500
Route 1	Bet. Four Mile Run & S. Glebe	5,800	4,500	4,800	4,500
G.W. Pkwy.	Bet. Slaters & Alexandria NCL	8,600	5,800	8,800	5,100
	Totals	42,400	34,200	42,200	40,700
Columbia Pike	Bet. Rolfe & Wash. Blvd.	11,600	6,900	9,200	6,900
I-395	Bet. Glebe & Wash. Blvd.	23,200	24,200	19,400	22,200
I-395 HOV	Bet. Glebe & Wash. Blvd.	4,600	5,700	3,800	5,500
Route 1	South of I-395	3,800	5,600	4,700	5,900
G.W. Pkwy.	East of I-395	5,400	10,600	6,900	11,300
	Totals	48,600	53,000	44,000	51,800

[1] 6:00 to 9:00 A.M.
[2] 3:30 to 6:30 P.M.

Table 20

Vehicle Miles of Travel in the Corridor

Route	A.M. Peak Period[1]-NB 1983	A.M. Peak Period[1]-NB 1986	P.M. Peak Period[2]-SB 1983	P.M. Peak Period[2]-SB 1986
Columbia Pike	28,410	13,160	23,430	15,410
I-395 Mainline	147,400	148,440	142,940	167,860
I-395 HOV	33,050	34,800	39,050	51,660
Route 1	32,840	30,640	32,430	33,860
G.W. Pkwy.	37,330	36,650	43,050	35,740
Subtotal	279,030	263,690	280,900	304,530
I-395 On-ramps	5,370	7,560	3,130	2,700
Total	284,400	271,250	284,030	307,230

[1] 6:00 to 9:00 a.m.
[2] 3:30 to 6:30 p.m.

Vehicle Hours of Travel

VHT along the major commuting routes in the corridor are shown in Table 21. These statistics represent travel between the screenline stations in Table 19. The VHT was calculated by multiplying the average 3-hour volume between stations by the average time it took to traverse that link.

In the morning peak period, the total VHT on the major commuter routes decreased by 19% between 1983 and 1986. The VHT on Columbia Pike, the I-395 mainline, and Route 1 decreased; whereas, the other routes and the ramps had an increase in VHT.

In the afternoon the total VHT increased by 3%. Only Columbia Pike and the George Washington Parkway had decreases in VHT.

During the combined peak periods, the VHT decreased by 1,900 (9%).

Table 21

Vehicle Hours of Travel in the Corridor

Route	A.M. Peak Period[1]-NB		P.M. Peak Period[2]-SB	
	1983	1986	1983	1986
Columbia Pike	1,560	560	1,150	720
I-395 Mainline	5,660	4,130	3,430	3,860
I-395 HOV	550	590	680	1,040
Route 1	1,730	1,550	2,230	2,280
G.W. Pkwy.	1,550	1,770	1,670	1,460
Subtotal	11,050	8,600	9,160	9,360
I-395 On-ramps	210	480	110	190
Total	11,260	9,080	9,270	9,550

[1] 6:00 to 9:00 a.m.
[2] 3:30 to 6:30 p.m.

Incident Detection and Management

Staff at the Traffic Control Center routinely complete an Incident Report form for all incidents detected by the traffic management system. Over 1,100 incidents on the Shirley Highway were logged from June 5, 1985, to July 31, 1986. Fifty-three percent of the incidents involved disabled vehicles and 43% involved accidents.

Police authorities were notified of the incident approximately 70% of the time. Of those incidents requiring police notification, 86% were reported to the Virginia State Police, 6% to the D.C. Police, 6% to the Arlington County Police, and 2% to the Fairfax County Police. Metro Traffic Control, radio stations, and the Department's Safety Service Patrol were also notified of the incidents approximately 76% of the time. The Safety Service Patrol was notified approximately 24% of the time.

The average time between the detection of and final clearing of an incident was 27 minutes for an accident and 38 minutes for a disabled vehicle. The average time from detection of an incident to the arrival of a response vehicle was 9 minutes for an accident and 18 minutes for a disabled vehicle. After arrival of the response vehicle, both types of incidents required an average of 23 minutes before the incident was cleared. The times do not add correctly because the breakdown of total time was not always available.

SUMMARY OF FINDINGS

Following is a summary of the changes in travel characteristics that occurred in the Shirley Highway corridor during the peak periods between 1983 and 1986, accident experience on I-395 for the year immediately preceding and the year immediately following the implementation of the TMS, and incident detection and management activities on I-395 for the period June 5, 1985, through July 30, 1986.

Changes in Travel Characteristics

The base period of time for which the travel characteristics are compared is the peak commuting period, which in the morning is defined as 6:00 to 9:00 and in the afternoon as 3:30 to 6:30. The direction of travel is toward the District of Columbia, or inbound, in the morning, and outbound in the afternoon. Changes are grouped into the categories of I-395 mainline, on-ramps, and HOV lanes; other commuter routes running the length of the corridor, or roughly parallel to I-395; and routes running across the corridor, or roughly perpendicular to I-395.

I-395 Mainline, On-ramps, and HOV Lanes

1. Volumes on the northbound mainline lanes decreased slightly just inside the Capital Beltway and increased slightly at the two stations further north. Southbound volumes increased from 14% to 19% at all three stations.

2. The average overall northbound speed of travel on the mainline between Springfield and D.C. increased by 3 mph, from 19 mph to 22 mph, which resulted in a 5.2-minute decrease in travel time. The increase between the Capital Beltway and the George Washington Parkway, however, was 7 mph, from 18 mph to 25 mph. Travel time decreased 8.9 minutes. Southbound speeds decreased from 33 mph to 28 mph, and travel time increased by 4 minutes between the District and Springfield. There was significant congestion in the Springfield area, however, and speed on the section between the George Washington Parkway and I-495 remained constant at 34 mph.

3. In 1983, average speeds on the northbound mainline lanes were generally lower on links north of Seminary Road than on links to the south. Between 1983 and 1986, average speeds increased greatly north of Seminary Road and decreased to the south such that conditions were more uniform throughout the length of the facility. On the southbound lanes, the speeds remained about the same or increased on links north of Turkeycock; however, speeds decreased greatly southward. In fact, the decrease was so great that the overall speed between D.C. and Springfield decreased.

4. The average amount of stopped delay on the mainline increased very slightly (4%) northbound between Springfield and the District and decreased greatly (25%) between I-495 and the George Washington Parkway. Average stopped delay increased greatly in the southbound lanes: from 51 seconds to 180 seconds along the entire section and

from 27 seconds to 61 seconds along the section between I-495 and the Parkway.

5. Northbound VMT on the mainline between the Capital Beltway and Washington Boulevard increased by about 1,000 (about 1%). The VMT southbound between the same termini increased by almost 25,000 (about 17%).

6. Northbound VHT on the mainline between I-495 and Washington Boulevard decreased by over 1,500 hours (about 27%). The VHT southbound increased a little over 400 hours (about 13%).

7. On-ramps to the northbound lanes most often increased in volume; 13 of the 20 ramps from Springfield to the George Washington Parkway had increases ranging from 4% to 287%. Volumes on 8 of the 14 metered ramps increased, and volumes on 5 of the 6 unmetered ramps increased. Generally, ramps south of Glebe Road had increases, whereas volumes on ramps at Glebe Road and northward remained the same or decreased. Volumes on the metered ramps from westbound Route 644 and from both directions on Duke Street increased greatly. Large decreases in volume occurred on the metered ramps from eastbound Glebe Road and southbound Boundary Channel Drive. Volumes on the unmetered ramps from the Capital Beltway and from eastbound Route 644 increased greatly.

   Southbound on-ramps most often decreased in volume; the decrease ranged from 3% to 60% and occurred on only 8 of the 17 ramps. Four of the 9 metered ramps and 4 of the 8 unmetered ramps experienced decreases in volume. There was no pattern to the location of the increases and decreases. Large decreases occurred on the metered ramp from eastbound Duke Street and on the unmetered ramps from eastbound Route 644 and the Shirlington Collector Road.

8. Average speeds on the on-ramps generally decreased. The average speed on the 21 northbound ramps dropped 10 mph from an average of 30 mph to 20 mph; all but two ramps had a decrease. Speeds on 15 of the 20 southbound ramps decreased; the average decrease on the 20 ramps was 6 mph, from 31 mph to 25 mph. The average amount of decrease was greater on the metered ramps than on the unmetered ramps. Significant decreases in speed occurred on the northbound ramps from eastbound Route 644 and King Street, and from both directions on Duke Street and Seminary Road. Significant southbound decreases occurred on the ramps from both directions on Edsall Road and Duke Street.

   Since travel time varies inversely with speed, a general increase was observed on both northbound and southbound ramps. The average increase was less than half a minute, and only three ramps had an increase of a minute or more.

9 The VMT on the on-ramps between Edsall Road and Glebe Road increased on those northbound and decreased on those southbound. The northbound increase was from 5,370 to 7,560 (41%), and the southbound decrease from 3,130 to 2,700 (14%).

10. The VHT on the on-ramp movements between Edsall Road and Glebe Road increased greatly both northbound and southbound. Northbound VHT increased from 210 to 480 hours (129%), and southbound VHT increased from 110 to 190 hours (73%).

11. Since travel times on the on-ramps was such a small part of the entire trip, overall travel times for trips into the District generally decreased. The time of travel for trips originating at all interchanges, except at the George Washington Parkway and Route 1, and traveling to Independence Avenue in Washington decreased. These decreases ranged from 2.4 to 10.0 minutes (12% to 33%). The maximum travel time increase on the above two interchanges was 1.4 minutes on about a 6-minute trip.

12. With only one exception, volumes on the HOV lanes increased at all stations both northbound and southbound. Increases tended to be the highest in the southbound direction.

13. Average overall speeds on the HOV lanes northbound between Springfield and D.C. decreased from 50 mph to 47 mph and from 55 mph to 36 mph southbound. The large decrease southbound was directly attributable to the severe congestion that occurred in the Springfield area. The average speed just prior to the merge back to the conventional lanes dropped from 56 mph to 8 mph.

14. The only stopped delay on the HOV lanes occurred in 1986 at the aforementioned merge point. The delay averaged over 2 minutes.

15. The VMT on the HOV lanes increased in both directions (about 5% northbound and 32% southbound).

16. The VHT on the HOV lanes increased in both directions (about 7% northbound and 53% southbound).

17. During the off-peak hours, when the TMS was not operational, the accident rate on I-395 increased by 15%. The morning peak period had a 17% increase in accident rate in the northbound direction; whereas the rate decreased by 8% in the southbound direction in the afternoon peak period.

18. Rear-end and sideswipe collisions accounted for over 90% of the accidents on I-395 in the peak periods. When comparing accident rates before and after the implementation of the TMS, rear-end accident rates decreased by 2% in the A.M. peak period traveling north and 5% in the P.M. peak period traveling south. The off-peak period had a 7% increase.

    After the implementation of the TMS, the accident rate for sideswipes increased by 68% in the morning peak period traveling north, decreased by 28% in the afternoon peak period traveling south, and increased by 45% during the rest of the day.

19. The number of weekday accidents occurring in interchange areas increased in all time periods after the TMS was implemented. Accident

rates increased by 15% in the off peak, 21% in the A.M. peak period traveling north, and 17% in the P.M. peak period traveling south.

Other Commuter Routes

Additional streets in the corridor aligned approximately parallel to I-395 that were considered commuter routes included sections of Columbia Pike, Route 1, George Washington Parkway, Braddock Road, Van Dorn Street, Cherokee Avenue, Chowan Avenue, Army-Navy Drive, Russell Road/Arlington Ridge Road, Walter Reed Drive/Beauregard Street, and Backlick Road. The first three summary statements in this section reflect travel changes specifically on these roadways.

1. Volume changes in both the morning and afternoon varied considerably; however, there was a general tendency for volumes to decrease. Large increases were experienced at stations on Van Dorn Street, Cherokee Avenue, Backlick Road, and the northern section of the George Washington Parkway.

2. Changes in speeds were generally small; only 4 inbound and 3 outbound routes changed by more than 4 mph. Speeds increased on 7 of the 11 routes in the morning, but only on 5 of the 11 in the afternoon. Changes greater than 4 mph occurred inbound on Columbia Pike (+ 5 mph), Van Dorn Street (+ 5 mph), Chowan Avenue (+ 9 mph), and Russell Road/Arlington Ridge Road (+ 6 mph). Outbound changes greater than 4 mph occurred on Chowan Avenue (+ 6 mph), Van Dorn Street (- 5 mph), and Backlick Road (- 7 mph).

3. The amount of stopped delay inbound most often decreased; the average net decrease on all the routes was 96 seconds. Stopped delay outbound, however, greatly increased; the average net increase was 811 seconds.

4. Screenlines were drawn just north of I-495 and just south of the roadway link formed by Washington Boulevard and I-395. In the morning, total volume entering the corridor from the south increased by about 6%. The volume at the northern screenline increased by 9%, indicating that a net gain had occurred in the corridor. The volume of traffic entering the corridor along the northern screenline in the afternoon increased by 18%. This rate of increase dropped to 7% at I-495, indicating a net loss in the corridor.

5. VMT were calculated for the major commuter routes (I-395, Columbia Pike, Route 1, and George Washington Parkway) between the above screenlines. The VMT decreased by 5% inbound in the morning and increased by 8% outbound in the afternoon.

6. VHT were also calculated for those roadways and sections identified in 4 and 5 above. The VHT decreased by 19% inbound in the morning and increased by 3% outbound in the afternoon.

Routes Across the Corridor

Travel data on streets in the corridor aligned approximately perpendicular to I-395 were also collected to determine the impact of changes in the corridor. These streets included Route 644, Edsall Road, Route 236, Seminary Road, Route 7, Quaker Lane, Glebe Road, and Lincolnia Road/Chambliss Street. The first three summary statements in this section reflect travel changes on these roadways.

1. Volumes on essentially all the roads interchanging with I-395 increased in both the morning and afternoon peak periods. The increases ranged from 2% to 148%; however, most were over 10%. The only exception was Lincolnia Road and Chambliss Street, both of which carried about the same volume.

2. In the morning, average speeds in both directions on roads interchanging with I-395 almost always increased or remained the same. The only exceptions were at Shirlington in the north-to-south direction and on Seminary Road in the west-to-east direction. Only one change was greater than 4 mph. Changes in speeds in the afternoon were very small; none were greater than 4 mph. Changes were almost equally distributed between increases and decreases.

3. Average stopped delay decreased by 149 seconds in the morning and increased by 421 seconds in the afternoon.

4. Volumes at 14 stations in the corridor that were not located on any of the previously addressed streets or routes generally experienced very minor changes, which were about equally distributed between increases and decreases. Large increases occurred on Eads Street in Arlington in both the morning and afternoon and on Commerce Road in the morning. Arlington Mill Drive and Taylor Run Parkway had large decreases in both periods, and a large decrease in afternoon volume occurred on Reed Avenue. These stations were included at the request of local jurisdictions in order to measure the impact on key local streets.

Incident Detection and Management

The following summarizes the results of analyzing over 1,100 incidents that occurred on the Shirley Highway from June 5, 1985, to July 31, 1986.

1. Slightly over half (53%) of the incidents involved disabled vehicles, and 43% involved accidents.

2. Police were notified of the incident approximately 70% of the time. Eighty-six percent of these were reported to the Virginia State Police, 6% to the D.C. Police, 6% to the Arlington County Police, and 2% to the Fairfax County Police.

3. Metro Traffic Control, radio stations, and the Department's Safety Service Patrol were notified of the incident approximately 76% of the time. The Safety Patrol was called in for about 24% of the incidents.

4. The average time between the detection of and final clearing of an accident was 27 minutes. It took an average of 9 minutes for the response vehicle to arrive on the scene once notified.

5. The average time between the detection of and final clearing of a disabled vehicle was 38 minutes. The average time for the response vehicle to arrive was 18 minutes.

ACKNOWLEDGEMENTS

Many people assisted in the development of this project. Special recognition and appreciation are extended to Ken Lantz and Phil Hopkins for their help in the design of the project and coordination of the data collection, and to John Joyce and Walter Johnson for their help as the key field contacts for data collection.

Thanks also go to John Shelor, Clyde Giannini, Steve Blackwell, and Gwen Harris for their assistance in analyzing the data, to Jan Kennedy for typing the report, to Roger Howe for editing the report, and to Jean Vanderberry and her staff for preparing the final report.