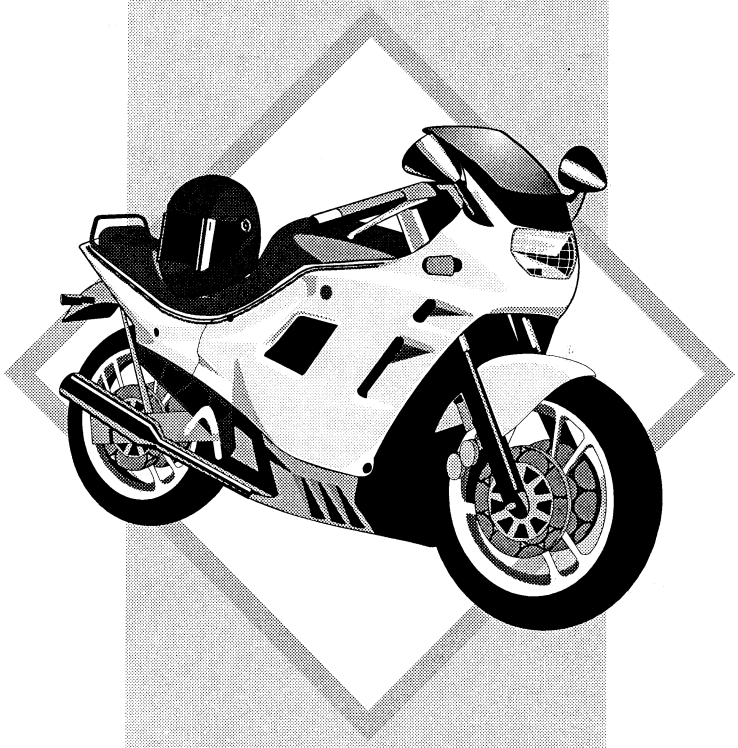
FINAL REPORT

THE EFFECT OF MOTORCYCLE TRAVEL ON THE SAFETY AND OPERATIONS OF HOV FACILITIES IN VIRGINIA



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16. Abstract

The Intermodal Surface Transportation Efficiency Act of 1991 mandated that motorcycles be permitted to travel on federally funded high-occupancy vehicle (HOV) facilities unless they created a safety hazard or adversely affected HOV operations. Although motorcycles had previously been banned from traveling on Virginia's HOV lanes, the Commonwealth Transportation Board (CTB) authorized motorcycle travel on HOV facilities in Virginia as of September 21, 1992, for a 2-year trial period. However, out of concern over whether this policy should continue, the CTB resolved that the Virginia Department of Transportation conduct a study to determine whether motorcycles presented a safety risk on HOV lanes.

This study found that motorcycles account for as much as 3% of the annual traffic on some HOV lanes. However, in the 2 years after the CTB authorized their travel, there were only five motorcycle crashes on HOV lanes. The study recommends that the CTB allow motorcycles to continue to travel on HOV lanes and that VDOT continue to monitor their travel and crashes.

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

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ABSTRACT

The Intermodal Surface Transportation Efficiency Act of 1991 mandated that motorcycles be permitted to travel on federally funded high-occupancy vehicle (HOV) facilities unless they created a safety hazard or adversely affected HOV operations. Although motorcycles had previously been banned from traveling on Virginia's HOV lanes, the Commonwealth Transportation Board (CTB) authorized motorcycle travel on HOV facilities in Virginia as of September 21, 1992, for a 2-year trial period. However, out of concern over whether this policy should continue, the CTB resolved that the Virginia Department of Transportation conduct a study to determine whether motorcycles presented a safety risk on HOV lanes.

This study found that motorcycles account for as much as 3% of the annual traffic on some HOV lanes. However, in the 2 years after the CTB authorized their travel, there were only five motorcycle crashes on HOV lanes. The study recommends that the CTB allow motorcycles to continue to travel on HOV lanes and that VDOT continue to monitor their travel and crashes.

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INTRODUCTION

Over the last 20 years, a transformation in the philosophy of highway transportation has occurred in the United States. This transformation began in the late 1960s when state, federal, and local governments began examining ways of making travel on existing roadways more efficient rather than constructing new ones.[1] During the late 1960s, the volume of traffic on interstate roadways increased dramatically. Construction costs also increased, so a priority was placed on increasing the carrying capacity of existing lanes.[2] The energy crisis of 1973 provided more impetus for implementing these plans. Additionally, drivers became increasingly more concerned about escalating gasoline prices and were open to more cost-effective and energy-efficient ways of traveling. As one response to this concern, high-occupancy vehicle (HOV) facilities were initiated to maximize the person-carrying capacity of roadways and provide reliable savings in travel time. This was to be achieved by tailoring the design or operation of a facility to give preferential treatment to vehicles carrying multiple occupants.[3]

The first HOV facility in North America, the Shirley Highway in Northern Virginia, was opened in 1969. Originally, it was a bus-only facility running from Springfield, Virginia, to the Pentagon. However, in 1973, as a result of increased traffic on the mainline, other vehicles carrying four or more persons were allowed access.[4] Eventually, the number of persons required dropped to three.[5] This initial attempt at improving transportation efficiency proved successful as evidenced by the steady increase in ridership and the development of other HOV facilities throughout the country.[4]

As of 1990, there were 43 HOV facilities in operation in 20 metropolitan areas of North America. Vehicles allowed on these facilities carry a specified minimum number of occupants, typically two, three, or four.[3] The majority of the facilities operate during the peak weekday travel hours, but some remain open 24 hours a day. There are three major types of HOV facilities: those with concurrent-flow lanes, those with contraflow lanes, and those with exclusive lanes. Concurrent-flow lanes are used in the peak direction, that is, parallel to the peak traffic flow. In the contraflow configuration, one lane in the off-peak direction is used as an HOV lane running in the peak direction. These lanes are set off from the off-peak traffic by cones or movable barriers. Exclusive lanes are physically separated from the rest of the

roadway.[6] Some exclusive lanes are reversible in that they provide for the flow of traffic in one direction during the morning peak hours and in the other direction during the evening peak hours. Several other features of HOV systems, such as priority parking and reduced tolls, add to their appeal.[1]

PROBLEM STATEMENT

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) mandated that motorcycles be permitted to travel on federally funded HOV facilities unless they created a safety hazard or adversely affected HOV operations.[7] Motorcycles were prohibited on HOV lanes in Virginia prior to the passage of ISTEA. The Virginia Department of Transportation (VDOT) contended that motorcycle travel was at odds with the principal purpose of an HOV facility, which is to improve the movement of people rather than vehicles.[2] The fact that a motorcycle typically has only one occupant but requires almost as much roadway space as a passenger vehicle is one reason VDOT cited for prohibiting motorcycle travel on HOV lanes.

Motorcycles are generally known to present a risk to safety, being associated with much higher crash, injury, and death rates than other types of vehicles.[7] Thus, it has been hypothesized that safety risks will increase if motorcycles are allowed to travel on HOV facilities. In addition, since motorcycles have a higher crash rate than other vehicles, it has been thought that travel delays will be more frequent if motorcycles are permitted on HOV facilities.

PURPOSE AND SCOPE

In compliance with ISTEA, Virginia's Commonwealth Transportation Board (CTB) authorized motorcycle travel on HOV facilities in Virginia as of September 21, 1992, for a 2-year trial period. However, out of concern over whether this policy should continue, the CTB resolved that VDOT conduct a study to determine whether motorcycles presented a safety risk on HOV lanes (see Appendix A). In keeping with the language of ISTEA and the interests of the CTB, the purpose of this study was to determine whether motorcycle travel on HOV lanes constitutes a safety hazard. The study also sought to determine whether motorcycle travel increased congestion on HOV facilities and whether incidents involving motorcycles increased travel delays on these facilities.

The study was limited to motorcycle travel on HOV facilities in Virginia in the peak direction during the times HOV restrictions were in effect.

DESCRIPTION OF SITES STUDIED

There are eight HOV facilities in Virginia, four in Northern Virginia and four in Hampton Roads. All were chosen for study.

Northern Virginia

1. *Interstate 66 (I-66),* inside the Capital Beltway between Exits 64 and 75, has a two-lane exclusive facility that is restricted to HOV traffic eastbound from 6:30 to 9:00 A.M. and westbound from 4:00 to 6:30 P.M. The HOV facility was open throughout the entire study period.

2. *I-66,* outside the Beltway between Exits 57 and 64, has a concurrent lane that is restricted to HOV traffic eastbound from 5:30 to 9:30 A.M. and westbound from 3:00 to 7:00 P.M. The HOV lane opened on April 27, 1993.

3. *I-95,* between Exits 161 and 170, has a concurrent lane that is restricted to HOV traffic northbound from 6:00 to 9:00 A.M. and southbound from 3:30 to 6:30 P.M. The HOV lane was open throughout the entire study period.

4. *I-395* has a two-lane reversible HOV facility, which runs the entire length of the roadway segment, that is restricted to HOV traffic northbound from 6:00 to 9:00 A.M. and southbound from 3:30 to 6:30 P.M. The HOV facility was open throughout the entire study period.

Hampton Roads

1. *I-64,* between Exits 276 and 284, has a two-lane reversible HOV facility that is restricted to HOV traffic westbound from 5:00 to 8:30 A.M. and eastbound from 3:00 to 6:00 P.M. The HOV facility opened on September 15, 1992.

2. *I-64,* between Exits 284 and 286, has a concurrent lane that is restricted to HOV traffic westbound from 5:00 to 8:30 A.M. and eastbound from 3:00 to 6:00 P.M. The HOV lane opened on November 15, 1993.

3. *I-564* has a concurrent lane, which runs the entire length of the roadway segment, that is restricted to HOV traffic westbound from 5:00 to 8:30 A.M. and eastbound from 3:00 to 6:00 P.M. The HOV lane opened on September 15, 1992.

4. *Virginia Route 44 (VA 44),* between the toll plaza and Exit 6, has a concurrent lane that is restricted to HOV traffic westbound from 5:00 to 8:30 A.M. and eastbound from 3:00 to 6:00 P.M. The HOV lane opened on September 15, 1992.

METHODS

Overview

Two steps were taken to determine whether motorcycle travel on HOV lanes caused safety or operations problems. The first was to determine the extent of motorcycle traffic on HOV facilities. Such a determination would also provide a basis by which crash and severity rates could be calculated. Further, tracking motorcycle traffic after motorcycles were allowed on HOV facilities in Virginia would provide a basis by which to determine whether opening the facilities to motorcycle traffic increased motorcycle use, thus leading to increased congestion on the facilities.

The second step was to determine the extent of the motorcycle crash problem. In particular, the frequency, rate, and severity of motorcycle crashes on the HOV lanes were compared with those on the mainline. In addition, the crash rates on the entire facility before and after motorcycle traffic was permitted on the HOV lanes were compared. The types of motorcycle crashes were also investigated.

Extent of Motorcycle Traffic

The estimation of traffic and vehicle miles of travel (VMT) for motorcycle travel on HOV and mainline facilities required a special data collection effort and a number of assumptions. Since historical data on motorcycle traffic did not exist, extrapolations from existing data needed to be made. The prevailing assumptions of this method were that motorcycle traffic changed in proportion to the change in passenger vehicle traffic, that the ratio of motorcycle and passenger vehicle traffic was similar on HOV facilities with similar configurations, and that changes in motorcycle traffic were similar on HOV and mainline facilities.

The initial step in generating the database was to extract the traffic volume data from VDOT's annual publication, *Average Daily Traffic Volumes on Interstate, Arterial, and Primary Routes,*[8] for the years 1988 to 1993. The year 1988 was chosen as the initial year for the before period to attenuate the impact of random fluctuations in the data. Each publication contained an estimate of the average daily traffic (ADT) for all vehicle types combined. The 1988 to 1990 publications also included an estimate for passenger vehicle ADT. For each highway segment, passenger vehicle traffic was calculated as a proportion of total ADT for the years 1988 to 1990. This proportion was then multiplied by the full ADT estimates for the years 1991 to 1993 to produce an estimate of the total passenger vehicle traffic.

Estimation of HOV Traffic Volume

Passenger Vehicles

The next step was to estimate passenger vehicle traffic during the hours of HOV restrictions. A special classification count was taken in August 1994 on a segment adjoining and either upstream or downstream of the HOV facility on VA 44, I-64, and I-66 during the hours of HOV restrictions. This count was taken manually. The results were then used to create an estimate for HOV hours in the peak direction. Passenger vehicle traffic during the HOV hours was calculated as a proportion of the total estimate for the segment. For the Northern Virginia routes, the proportion for I-66 was multiplied by the full passenger vehicle traffic volume for each segment for each year. For the Hampton Roads routes, the average of the I-64 and VA 44 proportions were used. The result of this procedure was an estimate of passenger vehicle traffic during HOV hours for each year.

Motorcycles

In order to calculate an estimate of motorcycle traffic during HOV hours, special traffic counts were taken once a month between July 1993 and October 1994 in the morning and evening hours of HOV facility operations at four sites. Data were collected for the two sites in Northern Virginia by videotaping the roadway from VDOT Traffic Management Center cameras placed above the roadway and manually counting the traffic from viewing the videotape. For the two sites in Hampton Roads, the data were collected manually on site. The number of motorcycles and passenger vehicles on the HOV facilities and the number of motorcycles on the mainline were noted for the peak direction for each site. In Northern Virginia, the sites were located on I-395, where there is a reversible two-lane HOV facility, and on I-66 inside the Beltway, where there is no mainline because both peak-direction lanes are HOV lanes. In Hampton Roads, the sites were located on I-64, where there is a reversible two-lane HOV facility, and on VA 44, where the lane adjacent to the median in the peak direction is an HOV lane.

The average of the motorcycle counts from September 1993 to August 1994 was used to determine the average traffic volume for motorcycles at each site during the hours of HOV restrictions. For each segment on which a motorcycle count was taken, the traffic volume was calculated as a proportion of the segment's estimate of passenger vehicle traffic during the hours of HOV restrictions. That proportion for the reversible lanes of I-395 was multiplied by the estimate of passenger vehicle traffic for the calendar year 1993. Likewise, that proportion for the exclusive lanes of I-66 was multiplied by the estimate of passenger vehicle traffic for other segments on I-66. That proportion for VA 44, which had a concurrent HOV lane, was multiplied by the passenger vehicle traffic for the segments including a concurrent lane on VA 44, I-64, I-564, and I-66. Also, that proportion for the counted segment on the reversible HOV lanes of I-64 was multiplied by the passenger vehicle traffic for other segments on the reversible HOV lanes of

I-64. In order to construct an estimate for 1992, the percentage of change that applied to passenger vehicles was applied to the 1993 motorcycle traffic estimate.

Estimation of Mainline Traffic Volume

In the special traffic counts taken to determine motorcycle traffic volume, motorcycles on the mainline were also counted. The 1-year average traffic volume during the hours of HOV restrictions was calculated as the average of the September 1993 through August 1994 counts. For each segment on which a motorcycle count was taken, the motorcycle traffic on the mainline was calculated as a proportion of the motorcycle traffic on the HOV lanes. That proportion for VA 44, which has a concurrent HOV lane, was multiplied by the motorcycle counts on HOV lanes for the segments on VA 44, I-564, I-64, and I-66 that had a concurrent lane. Also, that proportion for the counted segment on the reversible HOV lanes of I-64 was multiplied by the motorcycle counts for HOV lanes for other segments on the reversible HOV lanes of I-64. In order to calculate an estimate for 1992, the percentage of change that applied to passenger vehicles was applied to the 1993 mainline motorcycle estimate. I-66, which has no mainline, obviously had no motorcycle traffic on the mainline.

Estimation of Total Traffic Volume

To calculate total traffic volume, the estimates of HOV and mainline traffic volumes were extrapolated back to 1988 and added for each year.

Estimation of VMT

In order to estimate VMT, which is a critical variable in estimating crash rates, the length of each segment had to be determined. The lengths were calculated from the data provided in VDOT's annual publication, *Average Daily Traffic Volumes on Interstate, Arterial, and Primary Routes,*[8] for the years 1988 to 1993. When the length of a segment was not listed in the publication, the graphic logs, which are maintained by VDOT, were consulted to determine the length.

Motorcycle VMT on the HOV lanes during the hours of HOV restrictions was calculated for 1992 and 1993, the years motorcycles were allowed on HOV lanes, by multiplying the length of each segment by the estimated motorcycle traffic on HOV lanes for the segment during the hours of HOV restrictions by 260 (52 weeks x 5 days).

Motorcycle VMT on the mainline during the hours of HOV restrictions was calculated for the years 1992 and 1993 by multiplying the length of each segment by the estimated motorcycle traffic on the mainline for the segment during the hours of HOV restrictions by 260.

Total motorcycle VMT during the hours of HOV restrictions was calculated for each year, 1988 through 1993, by multiplying the length of each segment by the estimated motorcycle traffic for the segment during the hours of HOV restrictions by 260.

Final calculations were made to adjust the HOV and mainline motorcycle VMT to reflect the fact that the concurrent HOV lanes on I-64 and I-66 were not open part of the time that motorcycles were allowed on HOV facilities. Thus, for the concurrent portion of I-66, deductions were made in VMT for the months in 1992 that the HOV facility was not open. Also, for the concurrent portion of I-64, the VMT for 1992 and part of 1993 was deducted because the facility was not opened until November 15, 1993.

Extent of Motorcycle Crash Problem

Data Normalization

The crash reports for all motorcycle crashes on interstate highways in Northern Virginia and Hampton Roads, as well as on VA 44, for the calendar years 1988 through 1994 were reviewed. The opening date of the HOV facilities to motorcycle traffic is significant in the collection and analysis of crash data. The researchers generated the database such that each year's crash data began on September 21, the day in 1992 that Virginia's HOV facilities were opened to motorcycle traffic. Thus, September 21, 1988, through September 20, 1989, constituted one "motorcycle year" (MY). Using this approach, there were six motorcycle years to be examined—four before motorcycles were allowed to travel on HOV lanes and two after—that stretched from September 21, 1988, to September 20, 1994. It should be noted that the first HOV facilities in Hampton Roads opened on September 15, 1992, only 6 days before motorcycles were allowed, and thus there was little time in Hampton Roads that motorcycles were banned from the HOV lanes. The database was reduced to include only those crashes involving motorcycles in the peak direction on weekdays during the hours in which HOV restrictions would have been in effect. The database was further reduced to include only those crashes that occurred on routes and at locations for which there was an HOV facility during all or part of the study period. Crashes in the database included those that occurred on an HOV facility or on the parallel mainline facility. A description of each crash in the database is given in Appendix B.

The VMT estimates were used to calculate crash rates. Each year's VMT estimates were used to normalize the corresponding MY data, e.g., the 1988 VMT estimates were used to normalize the data for MY 1988/89.

Data Analysis

Crash Incidence and Rate

Three approaches were employed to analyze the crash data. Ideally, a way to examine the impact of a change such as allowing motorcycle travel on HOV lanes would include a before and after comparison. However, such an analysis was complicated in this study because of the fact that motorcycle travel was permitted on HOV lanes virtually simultaneously with the opening of a substantial portion of the HOV miles in Hampton Roads. Thus two of the approaches involved different ways of considering the before and after data.

The three approaches used were as follows:

1. *Motorcycle crashes and crash rates for the HOV and the mainline facilities were compared for MY 1992/93 and 1993/94, the two after years.* Data for the concurrent sections of I-64 and I-66 included only those crashes that occurred subsequent to the opening of the HOV lanes. This comparison allowed the same-time comparison of the relative motorcycle crash risks on the two types of facilities.

2. *Motorcycle crashes and crash rates for the HOV and mainline facilities were compared for facilities that had operational HOV facilities for the entire before and after periods (i.e., MY 1988/89 through 1993/94).* These facilities included the following:

   - I-395, which has a reversible two-lane HOV facility
   - I-95, which has a concurrent HOV lane
   - I-66, which has exclusive lanes inside the Beltway.

   Generally, the focus of these analyses was whether the crashes and crash rates of the combined HOV and mainline facilities changed after motorcycle traffic was allowed on the HOV lanes.

3. *Motorcycle crashes and crash rates for the HOV and mainline facilities were compared for facilities that had operational HOV facilities for the entire after period (i.e., MY 1992/93 and 1993/94).* This added the following facilities:

   - I-64, which has a two-lane reversible HOV facility
   - I-564, which has a concurrent HOV lane
   - VA 44, which has a concurrent HOV lane.

The concurrent sections of I-64 and I-66 were not included in either before and after comparison because the HOV lanes were not open during the entire after period. This before and after comparison permitted a comparison of the crash experience of motorcycles for the combined facility, but it is less than a complete before and after comparison because the traffic environment in the before period for I-64, I-564, and VA 44 was different than in the after period. Thus, the before and after comparison in the second approach is somewhat confounded by the fact that two events, the opening of the HOV facilities and the opening of these facilities to motorcycle traffic, occurred virtually simultaneously for some of the facilities.

Initially, additional analyses were to be conducted to compare motorcycle and passenger vehicle crashes on the HOV lanes. However, such comparisons proved impossible because there is no place on the crash report form and no data field in the Highway Traffic Information Records System (HTRIS) to capture whether a crash occurred on an HOV facility or on a main-line. Attempts were made to make this determination through special computer programming using the HTRIS data field that indicated the lane number in which a crash occurred. After data manipulations were attempted several times, the resulting database was checked for accuracy by pulling a sample of the crash reports. This sample revealed that the lane number of the crash could not be used as a reliable or valid indicator of whether a crash occurred on an HOV facility. This is mainly because the individuals coding the lane number data have only the diagram a police officer draws to determine the number of the lane in which a crash occurred. In the cases where the investigating officer either (1) drew too many lanes, (2) did not draw all of the lanes, or (3) may not have indicated whether an apparent lane was a shoulder, median, acceleration lane, or deceleration lane, the lane number of the crash may not indicate the true lane of the crash. Because of the large number of crashes on the urban routes with HOV lanes, it was believed to be impractical to manually retrieve and review the crash reports for all crashes. Further, the accuracy of interpreting such a large number of crashes could not be ensured.

The problems in determining whether a crash occurred on the HOV or mainline lane were not due to a lack of diligence on the part of the investigating officers or the coders. The crash report form was developed before HOV lanes existed. Further, the milepost location and travel direction are normally the important data in locating a crash, not the lane in which the crash occurred. Thus, the problems occurred because this type of data request was not anticipated at the time the crash reports were filed, the data coded, and the automated HTRIS fields generated.

Types of Crashes

Types of crashes were examined to determine if there was a difference in the before and after periods and if there was a difference between HOV and mainline lanes. Rear-end, single-motorcycle, congestion-related, and speed-related crashes were believed to be of particular interest for this study. Traveling on the congested mainline was hypothesized to increase rear-end and congestion-related crashes, and travel on the less congested HOV lanes was hypothesized to increase speed-related and single-motorcycle crashes.

RESULTS

NOTE: As stated in the Purpose and Scope Section, these results reflect traffic volumes only for vehicles traveling in the peak direction during the hours of HOV restrictions.

Extent of Motorcycle Traffic

Figure 1 shows the results of the special monthly classification motorcycle counts on VA 44 and compares them for the concurrent HOV lane and the mainline. The counts were similar, with neither facility having more traffic than the other during each month. For MY 1993/94, the traffic volumes were 39.8 on the concurrent HOV lane and 32.7 on the mainline. Thus, only 54.9% of motorcycles used the concurrent HOV lane.

Figure 2 compares the counts for motorcycles and passenger vehicles on the concurrent HOV lane of VA 44. For MY 1993/94, the traffic volume for passenger vehicles was 2,337.8 and that for motorcycles was 39.8. Thus, motorcycle traffic accounted for about 1.7% of the annual traffic on the concurrent HOV lane.

Figure 3 shows the motorcycle classification counts for I-64 and compares them for the two-lane reversible HOV facility and the mainline. At this site, more motorcycles used the HOV lanes. For MY 1993/94, the traffic volume on the two-lane HOV facility was 169.6 and that on the mainline was 36.3. Thus, about 82.4% of the motorcycles used the HOV facility.

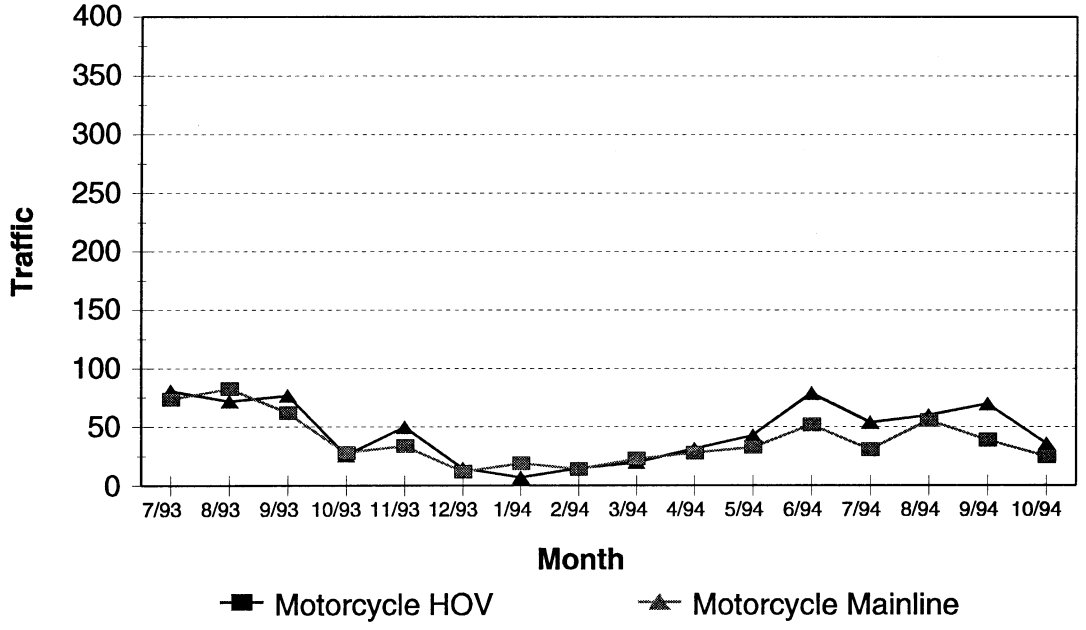

FIGURE 1. MOTORCYCLE TRAFFIC VOLUME ON HOV AND MAINLINE FACILITIES: VA 44

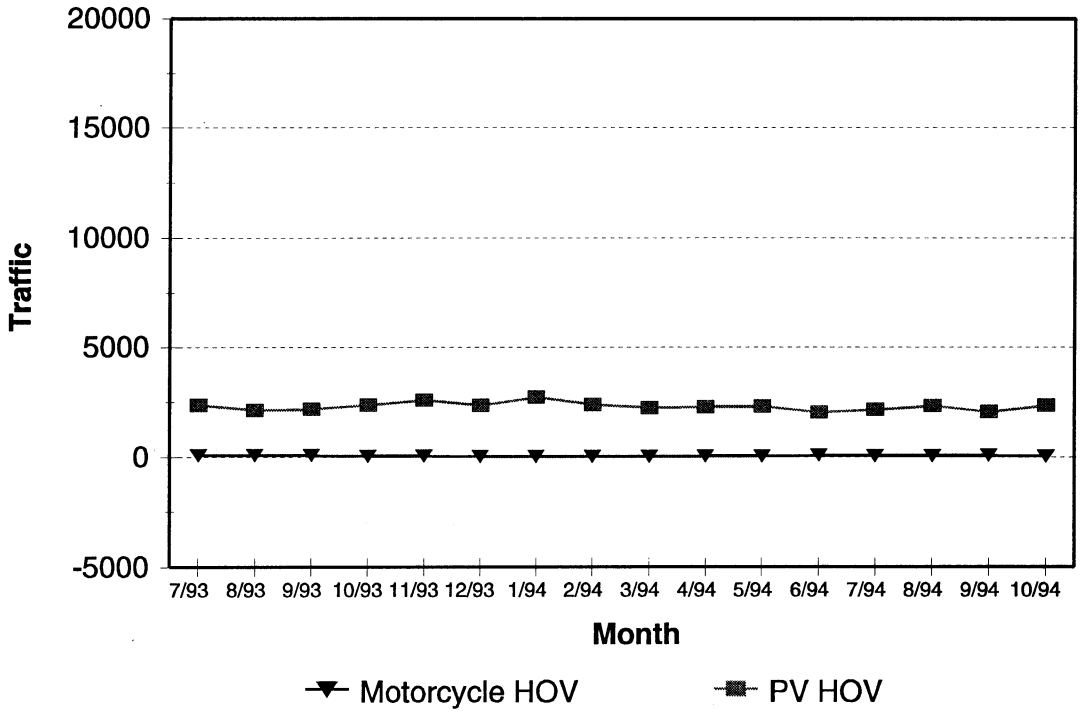

FIGURE 2. MOTORCYCLE AND PASSENGER VEHICLE TRAFFIC VOLUMES ON HOV FACILITY: VA 44

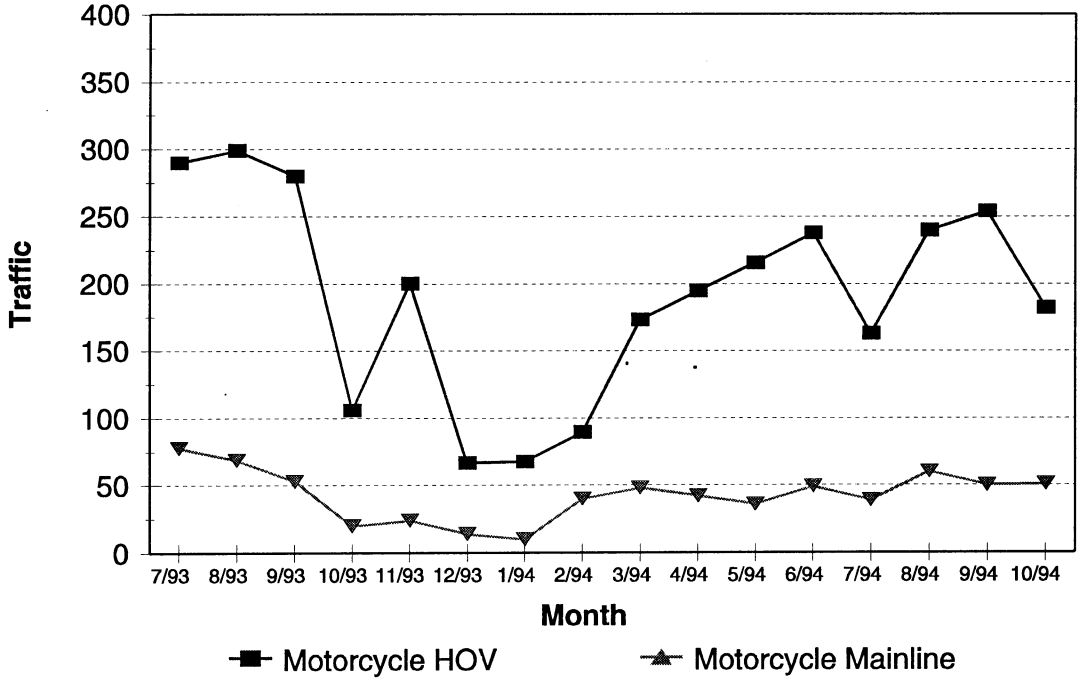

FIGURE 3. MOTORCYCLE TRAFFIC VOLUME ON HOV AND MAINLINE FACILITIES: I-64

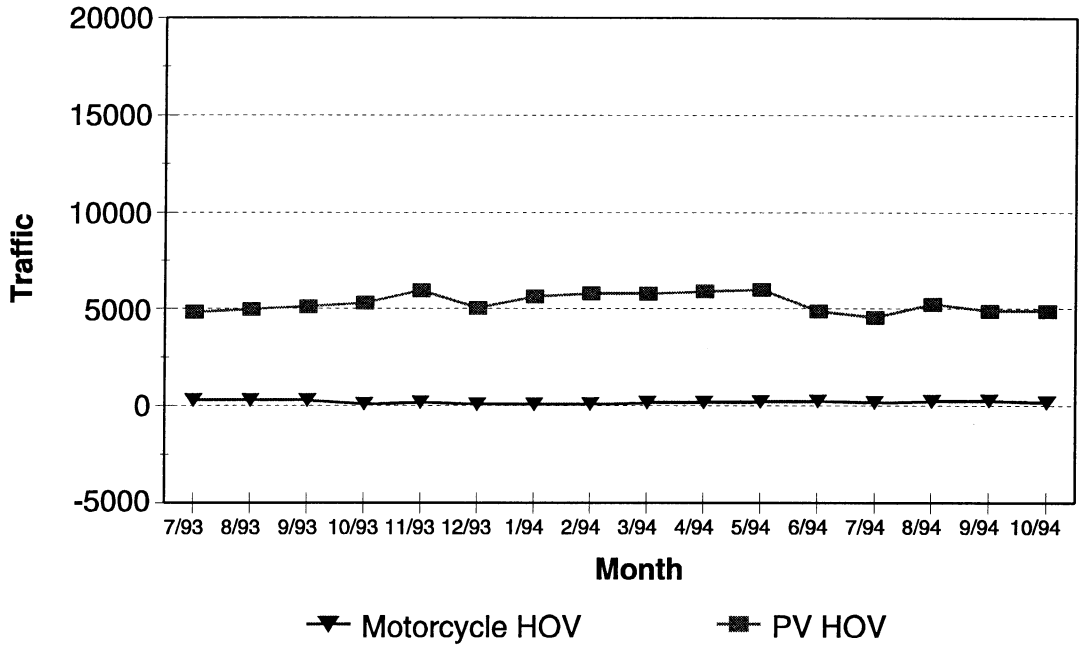

FIGURE 4. MOTORCYCLE AND PASSENGER VEHICLE TRAFFIC VOLUMES ON HOV FACILITY: I-64

Figure 4 compares the results of the special monthly classification counts for passenger vehicles and motorcycles using the two-lane HOV facility on I-64. For MY 1993/94, the traffic volume for passenger vehicles was 5,442.6 and that for motorcycles was 169.6. Thus, motorcycle traffic accounted for about 3.0% of the annual traffic on the HOV facility.

Figure 5 shows the result of the monthly special classification count on the two-lane exclusive HOV facility on I-66 inside the Beltway. There is no mainline to this facility since both lanes in the peak direction are dedicated to HOV traffic during the hours of HOV restrictions. For MY 1993/94, the motorcycle traffic volume on the facility was 157.3.

Figure 6 compares traffic counts for passenger vehicles and motorcycles on I-66, for which both lanes in the peak direction are designated for HOV traffic during the hours of restrictions. For MY 1993/94, the traffic volume for passenger vehicles was 16,829.0 and that for motorcycles was 157.3. Thus, motorcycles comprised about 0.9% of the annual traffic.

Figure 7 compares motorcycle traffic on the two-lane reversible HOV and mainline lanes of I-395. In MY 1993/94, the motorcycle traffic volume was 174.9 on the HOV facility and 12.1 on the mainline. Thus, about 94% of the motorcycle traffic used the reversible HOV facility.

Figure 8 compares motorcycle and passenger vehicle traffic volume on the two-lane reversible HOV facility on I-395. The traffic volume for motorcycles was 174.9, and that for passenger vehicles was 12,234.7. Thus, motorcycles accounted for about 1.4% of the annual traffic on this HOV facility.

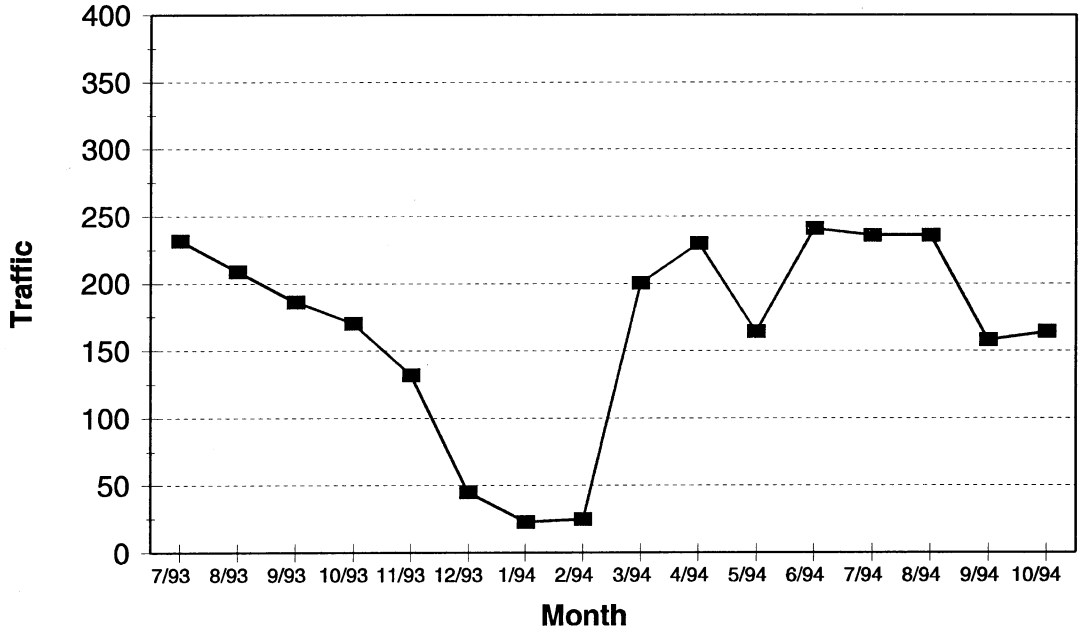

FIGURE 5. MOTORCYCLE TRAFFIC VOLUME ON HOV FACILITY: I-66

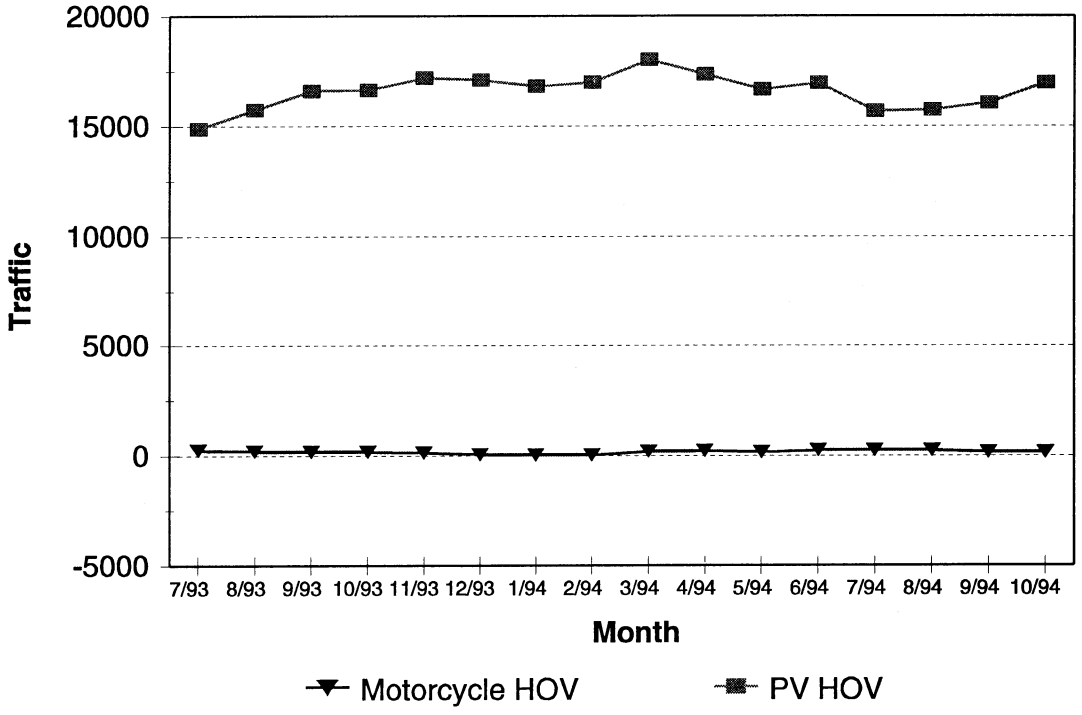

FIGURE 6. MOTORCYCLE AND PASSENGER VEHICLE TRAFFIC VOLUMES ON HOV FACILITY: I-66

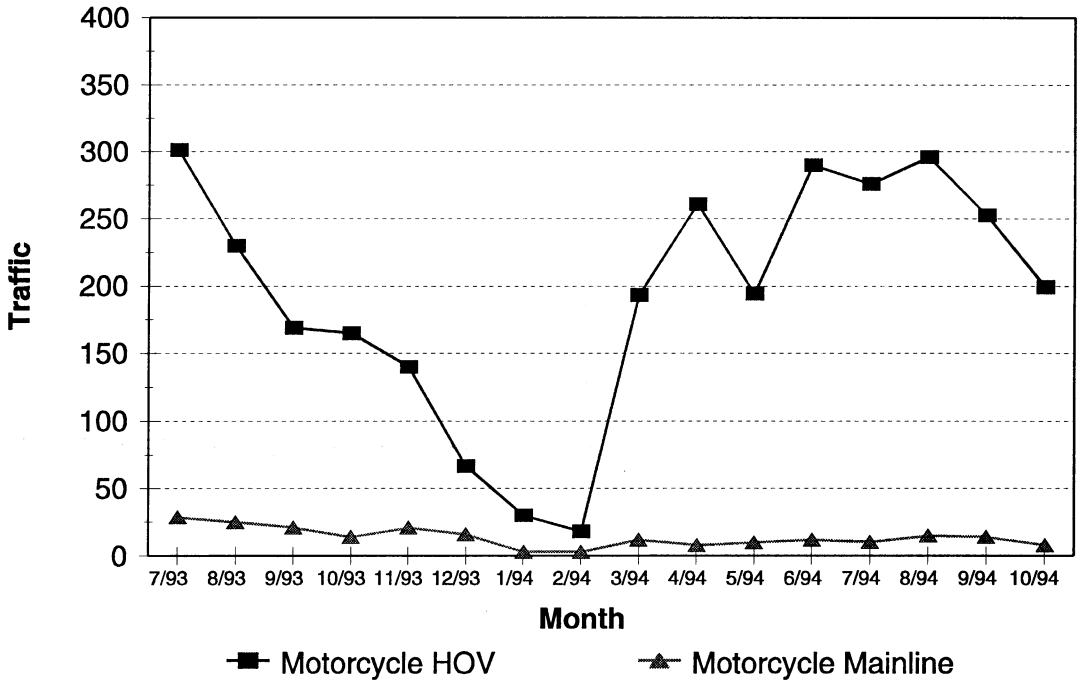

FIGURE 7. MOTORCYCLE TRAFFIC VOLUME ON HOV AND MAINLINE FACILITIES: I-395

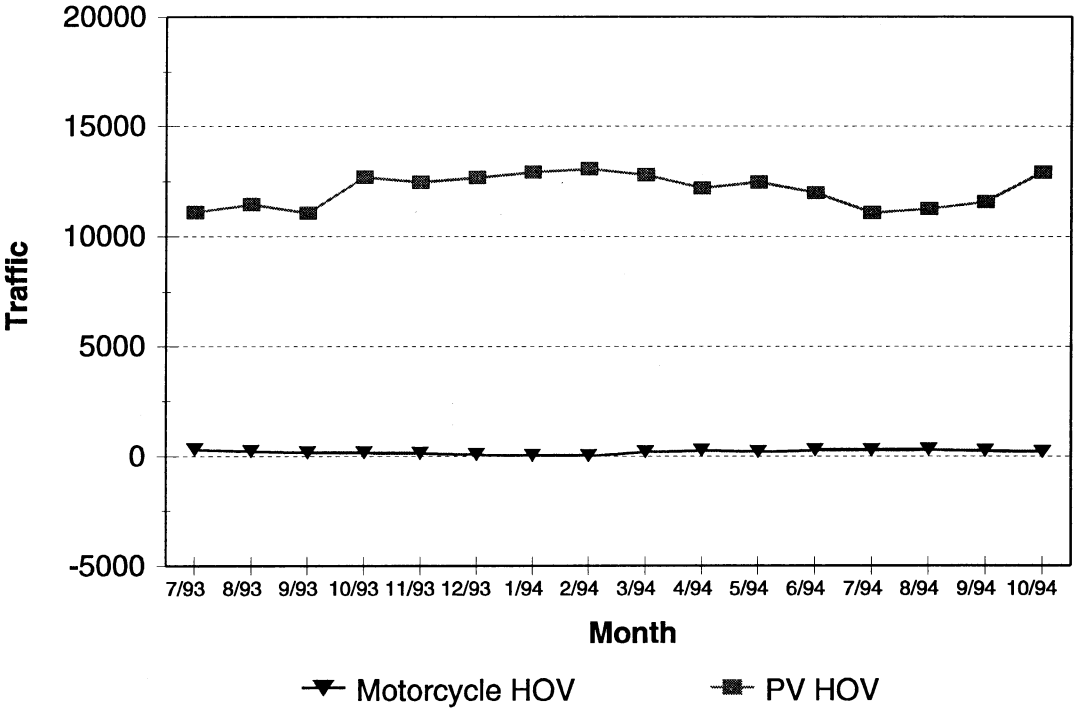

FIGURE 8. MOTORCYCLE AND PASSENGER VEHICLE TRAFFIC VOLUMES ON HOV FACILITY: I-395

Table 1 compares the motorcycle traffic volumes in 1993 and 1994 on HOV lanes for the months of July through October, the months during which a special count was taken for both years. Motorcycle traffic was lower in 1994 than in 1993 at three of the sites and higher at one. Motorcycle traffic decreased modestly from 723.5 in 1993 to 719.2 in 1994.

TABLE 1. MOTORCYCLE TRAFFIC VOLUME ON HOV LANES (7-10/93 VS. 7-10/94)

Route	July-October 1993	July-October 1994	% Change
VA 44	64.0	55.0	-14.1
I-64	243.8	209.8	-13.9
I-66	199.3	198.5	-0.4
I-395	216.4	255.9	+18.3
Total	723.5	719.2	-0.6

Table 2 compares the motorcycle traffic volumes in 1993 and 1994 on the mainline for the months of July through October. Motorcycle traffic decreased at each of the three sites with a mainline. Overall, mainline motorcycle traffic decreased from 139.0 in 1993 to 99.7 in 1994. Even if the decreases noted in Tables 1 and 2 are not substantial, they lend no support to the argument that opening HOV lanes to motorcycle traffic would increase motorcycle use.

TABLE 2. MOTORCYCLE TRAFFIC VOLUME ON MAINLINE LANES (7-10/93 VS. 7-10/94)

Route	July-October 1993	July-October 1994	% Change
VA 44	61.8	37.8	-38.8
I-64	55.0	50.0	-9.1
I-66	NA	NA	NA
I-395	22.2	11.9	-46.4
Total	139.0	99.7	-28.3

Table 3 shows the estimated motorcycle VMT on HOV lanes for MY 1992/93 and 1993/94. The total VMT for motorcycles on HOV lanes was 2,711,593, which is more than 4 times the VMT of 621,478 on the mainline.

TABLE 3. MOTORCYCLE VMT ON HOV LANES IN AFTER PERIOD

Facility Type	MY 1992/93	MY 1993/94	Total
HOV	1,309,710	1,401,883	2,711,593
Mainline	283,094	338,384	621,478

Extent of Motorcycle Crash Problem

Mainline vs. HOV Lanes in the After Period

Table 4 compares the number of motorcycle crashes on the HOV and mainline lanes in the after period. All crashes involved an injury and property damage, but there were no fatalities. In MY 1992/93, there were more crashes on the mainline, but in MY 1993/94, there were more crashes on the HOV lanes. Overall, there were 14 crashes: 9 occurred on the mainline and 5 on the HOV lanes.

TABLE 4. MOTORCYCLE CRASHES IN AFTER PERIOD

Route Type	MY 1992/93	MY 1993/94	Total
HOV	1	4	5
Mainline	6	3	9

Table 5 compares the motorcycle crash rates on the HOV and mainline lanes in the after period. Even though the rate was higher on the HOV lanes in MY 1993/94 than in MY 1992/93, it was lower for the HOV lanes overall in the after period. Overall, the rate per hundred million VMT (HMVMT) was 184.39 for the HOV lanes and 1448.16 for the mainline lanes. Thus, the motorcycle crash rate was more than 7 times higher on the mainline than on the HOV lanes.

TABLE 5. MOTORCYCLE CRASH RATES PER HMVMT IN AFTER PERIOD

Route Type	MY 1992/93	MY 1993/94	Total
HOV	76.35	285.33	184.39
Mainline	2,119.44	886.57	1,448.16

Table 6 compares the number of injuries in crashes involving motorcycles on HOV lanes with those on the mainline for the after period. In MY 1992/93, there were more injuries on the mainline, but in MY 1993/94, there were more injuries on the HOV lanes. Overall, there was one more injury on the HOV lanes than on the mainline. However, the crash that created 6 injuries on the HOV lanes in MY 1993/94 was caused by a wrong-way driver of a passenger vehicle. The driver, who had Alzheimer's disease, successively struck two cars head on. The motorcyclist was unable to avoid the collision in front of him. Thus, one must be cautious in interpreting the fact that there were more injuries on the HOV lanes than on the mainline in the after period.

TABLE 6. MOTORCYCLE CRASH INJURIES IN AFTER PERIOD

Route Type	MY 1992/93	MY 1993/94	Total
HOV	1	10	11
Mainline	6	4	10

Table 7 compares the motorcycle injury rates for HOV and mainline lanes for the after period. Even in MY 1993/94, in which 6 injuries were caused by one crash involving a wrong-way passenger vehicle, the injury rate was lower on the HOV lanes. Overall, the rate per HMVMT was almost 4 times higher on the mainline than on the HOV lanes.

TABLE 7. MOTORCYCLE CRASH INJURY RATE PER HMVMT IN AFTER PERIOD

Route Type	MY 1992/93	MY 1993/94	Total
HOV	76.35	713.33	405.67
Mainline	2,119.44	1,182.09	1,609.07

Table 8 compares the types of motorcycle crashes on the HOV and mainline lanes. Speed was not a factor in any of the crashes on the HOV lanes and was a factor in only one crash on the mainline. All of the mainline collisions between motorcycles and other vehicles in the after period were rear-end crashes, but only 60% of HOV collisions between motorcycles and other vehicles were rear-end crashes. All single-motorcycle crashes in the after period occurred on the mainline, and each involved the driver losing control. Thus, allowing motorcycle travel on HOV lanes was not associated with speed-related or single-motorcycle crashes.

TABLE 8. TYPES OF MOTORCYCLE CRASHES ON HOV VS. MAINLINE IN AFTER PERIOD

Type	HOV	Mainline
Motorcycle speeding	0	1
Other vehicle speeding	0	0
Motorcycle rear-ends other vehicle	2	1
Other vehicle rear-ends motorcycle	1	3
Single motorcycle	0	5
Congestion related	3	3
Total	5	9

Roadways with an HOV Lane in the Entire Before and After Periods

Tables 9 and 10 show the impact on motorcycle crashes of allowing motorcycle traffic on HOV lanes on those segments of roadways that had an HOV lane in the entire before and after periods. These roadways included I-66, which has two HOV lanes; I-95, which has a concurrent HOV lane; and I-395, which has a reversible two-lane HOV facility. This before and after analysis considered the combined number of motorcycle crashes on both the HOV facility and the mainline.

Table 9 shows a breakdown of the motorcycle crashes in three 2-year intervals so that the reader can compare equal time periods. There are two intervals for the 4 motorcycle years before motorcycle traffic was allowed on HOV lanes, and one for the 2 motorcycle years that motorcycle traffic was allowed. There were no fatal crashes involving motorcycles. There were more motorcycle crashes in the second before interval than in the first before interval or the entire after period, but there were fewer injuries. Overall, little difference can be discerned between the before and after periods outlined by the data in this table. What is most interesting about these data is that of the 3 injury crashes that occurred in the first before interval, 2 occurred in the HOV lanes. Thus, even though it was not legal at the time for motorcycles to travel on HOV lanes, motorcycles were involved in crashes on them.

Table 10 considers the difference in motorcycle crash rates per HMVMT for the entire before and after periods. There is no evidence from this before and after analysis that allowing motorcycle traffic on the HOV lanes increased the crash hazards for motorcycles.

TABLE 9. MOTORCYCLE CRASHES, INJURIES, AND FATALITIES ON SEGMENTS WITH HOV LANES IN ENTIRE BEFORE AND AFTER PERIODS FOR HOV AND MAINLINE COMBINED

Type	MY 1988/89 MY 1989/90	MY 1990/91 MY 1991/92	MY 1992/93 MY 1993/94
Fatal crashes	0	0	0
Fatalities	0	0	0
Injury crashes	3	3	3
Injuries	4	3	4
PDO crashes	0	2	0
Total crashes	3	5	3

TABLE 10: MOTORCYCLE CRASH, INJURY, AND FATALITY RATES PER HMVMT ON SEGMENTS WITH HOV LANES IN ENTIRE BEFORE AND AFTER PERIODS FOR HOV AND MAINLINE COMBINED

Rate	Before	After
Fatal crash	0	0
Fatality	0	0
Injury crash	162.47	147.77
Injury	189.55	197.03
PDO crash	55.11	0
Total crash	216.63	147.77

Table 11 shows the type of motorcycle crashes occurring on these roadways. In collisions between motorcycles and other vehicles, speed was not a factor. However, speed was a factor in 40% of the single-motorcycle crashes. Further, in single-motorcycle crashes, the motorcyclist always lost control. Crashes were about as likely to involve a single motorcycle in the after period as in the before period. All rear-end collisions between motorcycles and other vehicles occurred in the before period, as did all motorcycle crashes related to congestion. Thus, these data suggest that allowing motorcycle travel on HOV lanes was associated with fewer rear-end and congestion-related crashes involving motorcycles.

TABLE 11: TYPES OF MOTORCYCLE CRASHES ON SEGMENTS WITH HOV LANES IN ENTIRE BEFORE AND AFTER PERIODS FOR HOV AND MAINLINE COMBINED

Type	MY 1988/89 MY 1989/90	MY 1990/91 MY 1991/92	MY 1992/93 MY 1993/94
Motorcycle speeding	1	0	1
Other vehicle speeding	0	0	0
Motorcycle rear-ends other vehicle	1	0	0
Other vehicle rear-ends motorcycle	0	3	0
Single motorcycle	2	1	2
Congestion related	1	3	0
Total	3	5	3

Roadways with an HOV Lane in at Least the Entire After Period

Tables 12 and 13 consider the impact on motorcycle crashes of motorcycles being allowed on HOV lanes for the entire segments of roadways that had an HOV lane in at least the entire after period. These roadways included I-66, which has two HOV lanes inside the Beltway; I-95, which has a concurrent HOV lane; I-395, which has a reversible two-lane HOV facility; VA 44, which has a concurrent HOV lane; I-64, which has a two-lane reversible HOV facility; and I-564, which has a concurrent HOV lane. The segments of I-64 and I-66 with concurrent HOV lanes were the only segments with HOV lanes that were not included in this analysis. This was because each opened subsequent to the date that motorcycles were allowed on HOV lanes. Thus, this approach examined the impact of allowing motorcycle traffic on the HOV lanes for the entire facility. This before and after comparison was somewhat confounded by the fact that two events, the opening of the HOV facilities and the opening of these facilities to motorcycle traffic, occurred virtually simultaneously for some of the facilities.

Table 12 shows a breakdown of the motorcycle crashes on these roadways in three 2-year intervals—two for the 4 motorcycle years before motorcycle traffic was allowed on HOV lanes, and one for the 2 motorcycle years that motorcycle traffic was allowed. The only fatal motorcycle crash involved one fatality in the first before interval. There were as many injury crashes involving motorcycles in the first before interval as in the after period, but there were fewer in the second before interval. The greatest number of injuries occurred in the after period, but this finding was complicated by the fact that 6 of the injuries occurred in the unusual crash in which a man with Alzheimer's disease drove his passenger vehicle through the barrier gates and down the wrong way of the reversible HOV facility on I-64.

TABLE 12: MOTORCYCLE CRASHES, INJURIES, AND FATALITIES ON SEGMENTS WITH HOV LANES IN AT LEAST THE ENTIRE AFTER PERIOD FOR HOV AND MAINLINE COMBINED

Type	MY 1988/89 MY 1989/90	MY 1990/91 MY 1991/92	MY 1992/93 MY 1993/94
Fatal crash	1	0	0
Fatalities	1	0	0
Injury crash	11	8	11
Injuries	13	8	18
PDO crash	1	2	0
Total crashes	13	10	11

Table 13 compares the difference in motorcycle crash rates per HMVMT for the before and after periods for these roadways. The only fatal motorcycle crash occurred in the before period; thus, the fatality rate was higher in the before period. However, the motorcycle injury crash and injury rates were higher in the after period. The total motorcycle crash rate was slightly lower in the after period. Overall, however, given that many of the injuries in the after period occurred in a single crash in which the motorcyclist was clearly not at fault, the data in Tables 12 and 13 do not tend to support the notion that motorcycle traffic on HOV lanes increased crashes involving motorcycles.

TABLE 13: MOTORCYCLE CRASH, INJURY, AND FATALITY RATES PER HMVMT ON SEGMENTS WITH HOV LANES IN AT LEAST THE ENTIRE AFTER PERIOD FOR HOV AND MAINLINE COMBINED

Rate	Before	After
Fatal crash	17.27	0
Fatality	17.27	0
Injury crash	328.06	362.48
Injury	362.59	593.16
PDO crash	51.80	0
Total crash	397.13	362.48

Table 14 shows the types of motorcycle crashes on these roadways. Speed was not a factor in collisions between motorcycles and other vehicles but was a factor in 33% of the single-motorcycle crashes. Further, in single-motorcycle crashes, the motorcyclist always lost control.

There were more rear-end collisions in the before period than in the after period. More motorcycle crashes were congestion related in the before period than in the after period. Thus, these data indicate that allowing motorcycle travel on HOV lanes was associated with fewer rear-end collisions between motorcycles and other vehicles and fewer congestion-related crashes.

TABLE 14: TYPES OF MOTORCYCLE CRASHES ON ROADWAY SEGMENTS WITH HOV LANES IN AT LEAST THE ENTIRE AFTER PERIOD FOR HOV AND MAINLINE COMBINED

Type	MY 1988/89 MY 1989/90	MY 1990/91 MY 1991/92	MY 1992/93 MY 1993/94
Motorcycle speeding	1	0	2
Other vehicle speeding	1	0	0
Motorcycle rear-ends other vehicle	6	1	2
Other vehicle rear-ends motorcycle	1	5	3
Single motorcycle	3	2	4
Congestion related	9	7	4
Total	13	10	11

DISCUSSION

One of the most striking findings of this study was that compared to passenger vehicle traffic, there was little motorcycle traffic on the HOV lanes. Even the high estimate of 3.0% of the annual traffic on the reversible HOV facility on I-64 in Hampton Roads is likely much less than the amount of traffic that travels illegally down the HOV lanes each day. Also, it is interesting to note that there is no evidence that motorcycle traffic is increasing on the commuter routes considered. It is known that motorcycles in general have a higher crash rate than do passenger vehicles, and there was a concern that opening HOV lanes to motorcycle traffic might unleash a latent demand or even create a demand for travel by vehicles that have higher crash risks than do passenger vehicles. However, there was no evidence that this has been the case.

Another prominent finding was the relatively few number of crashes involving motorcycles on the HOV lanes, particularly considering that the vast majority of the motorcycle VMT on the study roadway segments was on the HOV lanes in the after period. In fact, one can conclude from the data that it is safer for a motorcyclist to travel on an HOV lane than on the mainline.

CONCLUSIONS

There is no evidence at this time that allowing motorcycle traffic on HOV lanes has an adverse impact on safety or operations. The current level of motorcycle traffic—a high of 3.0% of the annual traffic on HOV lanes—is not substantial, and the number of crashes involving motorcycles is low. In fact, there is some evidence to indicate that allowing motorcycles to travel on the HOV lanes may even decrease the number of incidents, particularly rear-end and congestion-related crashes, involving motorcycles in the peak direction.

If, in accordance with the provisions of ISTEA, a state may ban motorcycles from HOV lanes only if there is a documented safety or operations problem created by such traffic, then VDOT has no basis on which to institute such a ban at this time. However, VDOT's original point concerning the banning of motorcycle traffic is still valid: motorcycles are not high-occupancy vehicles. If the HOV lanes move toward capacity, if motorcycle traffic becomes a substantial proportion of the HOV traffic, or if crashes involving motorcycles increase, then an operations problem could follow.

RECOMMENDATIONS

1. *The CTB should not institute a ban on motorcycle traffic on HOV lanes at this time.* There were no data revealed in this study to indicate safety or operations problems caused by motorcycle travel.

2. *VDOT should continue to monitor traffic and crash patterns on HOV lanes.* Although there is no evidence that would warrant the banning of motorcycles from HOV facilities at this time, VDOT should remain aware of changing conditions. There is certainly the issue of whether motorcycle traffic may increase in the future. If so, at what point may allowing single-occupant vehicles adversely affect HOV operations? The latter is an issue that should remain a concern of VDOT.

3. *VDOT should investigate the feasibility of adding a field to the HTRIS to note whether a crash occurred on an HOV lane.* There are some nagging questions that could not be answered by this study because of insufficient data. One is that even though there were relatively few motorcycle crashes on the HOV lanes, has there been an overall increase in crashes on HOV lanes as a result of allowing motorcycle traffic? Given that HOV lane mileage and usage are increasing, such a field would benefit VDOT's effort to monitor crashes on these facilities.

ACKNOWLEDGMENTS

This research would not have been possible without the cooperation and, in many cases, great effort on the part of a number of individuals. First, we express our appreciation to Lewis Woodson for his work on the traffic-related data. Not only did Lewis spend many days in the field collecting the data and many hours in the office viewing videotapes and supervising and performing the data reduction, he also coordinated efforts with VDOT's Northern Virginia Traffic Management Center (TMC) on this project.

Thanks also go to James Chu and the TMC staff for allowing us to use their remote video facilities to provide tapes for use in preparing the motorcycle traffic counts. The staff of VDOT's Traffic Engineering Division, and especially R. Robert Rasmussen and Teresa Glass, provided crash data, accident reports, and general consulting on VDOT's computerized crash files and responded to all of our requests for information with good humor and quick turnaround. We also appreciate the work of Peggy Tardy and Ray Haynes of VDOT's Information Systems Division for providing systemwide crash data.

Finally, special thanks go to Linda Evans, whose editing of the paper and review of the study findings helped us make a very complicated topic more understandable.

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APPENDIX A

Commonwealth Transportation Board
Resolution Dealing with Motorcycles on HOV Lanes
September 17, 1992

Moved by Mr. Warner, seconded by M. Hoffler, that

WHEREAS, in 1985, in accordance with Section 163 of the Surface Transportation Act of 1982, Virginia was granted approval by the Federal Highway Administration to restrict the use of motorcycles on the HOV lanes on Routes I-95, I-395, I-66, I-64, and Route 44 based on certification submitted by the Virginia Department of Transportation that motorcycles constituted a safety hazard on the HOV lanes; and

WHEREAS, Section 1056 of the Intermodal Surface Transportation Efficiency Act of 1991 (hereafter referred to as "the Act") amends Section 163 of the Surface Transportation Act of 1982 to read as follows:

> "Notwithstanding any other provision of this Act or any other law, no funds apportioned or allocated to a State for Federal-aid highways shall be obligated for a project for constructing, resurfacing, restoring, rehabilitating, or reconstructing a Federal-aid highway which has a lane designated as a carpool lane unless the use of such lane includes use by motorcycles. Upon certification by the State to the Secretary, after notice in the Federal Register and an opportunity for public comment, and acceptance of such certification by the Secretary, the State may restrict such use by motorcycles if such use would create a safety hazard. Any certification made before the effective date of the enactment of the Intermodal Surface Transportation Efficiency Act of 1991 shall not be recognized by the Secretary until the Secretary publishes notice of such certification in the Federal Register and provides an opportunity for public comment on such language." [Amended language underlined.]

WHEREAS, there are no studies available regarding the safety impacts of allowing motorcycles to use HOV lanes based on actual use of such facilities; and

WHEREAS, the Board has determined that existing data is not sufficient to ascertain those impacts to its satisfaction.

NOW, THEREFORE, BE IT RESOLVED, that effective Monday, September 21, 1992, motorcycles shall be allowed on all HOV lanes within the Commonwealth for a trial period of two years; and

BE IT FURTHER RESOLVED, that the Board hereby directs the Department to design and conduct a study, to be completed no later than December 31, 1994, using data collected during the trial period, to determine if motorcycles present a safety hazard on the HOV lanes; and

BE IT FURTHER RESOLVED, that if, at any time during the trial period, the Commissioner determines that the accident rate for motorcycles exceeds the accident rate for other types of vehicles on the HOV lanes during the restricted periods and/or adversely affects HOV operations compared to other vehicles, the Commissioner is directed to advise the Commonwealth Transportation Board and, with their concurrence, immediately rescind motorcycle use on those HOV lanes where permitted by the Act and initiate the certification procedure to prohibit motorcycles on all HOV lanes as set forth under Section 1056 of the Act. Absent such findings, motorcycles shall be granted continued use of the HOV lanes without additional Board action; and

BE IT FURTHER RESOLVED, that the Board directs the Department to make this resolution known to the public throughout the Commonwealth and to immediately provide a copy of this resolution to the Virginia State Police and seek their assistance in collecting the necessary accident data. The Department shall also be requested to take any other necessary action to implement motorcycle use on the affected roadways by the effective date of this resolution.

Motion carried.

APPENDIX B

Summary of Motorcycle Crashes on Selected HOV and Mainline Sections

Interstate 64

Crashes Prior to HOV Opening

2/3/89	4:00 P.M.	A motorcycle traveling eastbound at 20 mph changed lanes to avoid an unknown vehicle and rear-ended a stopped passenger vehicle. Congestion related.
6/8/89	5:45 P.M.	A passenger vehicle traveling eastbound at 60 mph slowed to avoid a stopped vehicle ahead and changed lanes, cutting in front of the motorcycle. The motorcycle struck the passenger vehicle on the left side. The motorcyclist was injured. Congestion related.
1/22/90	6:00 A.M.	A passenger vehicle traveling 5 mph was changing lanes at the same time a motorcycle passing traffic on the shoulder tried to merge into the traffic lane at 30 mph. The car struck the motorcycle. The motorcyclist was injured. Congestion related.
6/21/90	4:50 P.M.	A motorcycle traveling eastbound at 45 mph attempted to stop, laid down the motorcycle, and was ejected. The motorcyclist was injured.
7/17/90	6:50 A.M.	A motorcycle traveling westbound lost control and skidded into the path of a passenger vehicle traveling at 40 mph. The motorcyclist was killed.
7/20/90	8:15 A.M.	A passenger vehicle traveling 40 mph slowed for traffic in the westbound lane and was rear-ended by a motorcycle traveling 45 mph. The motorcyclist was uninjured except for complaint of pain. Congestion related.
9/7/90	3:40 P.M.	A passenger vehicle stopped in eastbound traffic was rear-ended by a motorcycle traveling at 25 mph. The motorcyclist was injured. Congestion related.
9/12/90	7:10 A.M.	A pickup truck was stopped in the westbound traffic lane and was rear-ended by a motorcycle traveling 15 mph. No injuries. Congestion related.

10/9/90	8:15 A.M.	A motorcycle was slowing in heavy westbound traffic and was rear-ended by a passenger vehicle traveling 40 mph. The motorcyclist was uninjured except for complaint of pain. Congestion related.
5/13/91	5:45 A.M.	A passenger vehicle and the motorcycle following it were stopped in traffic and rear-ended by another passenger vehicle traveling westbound at 40 mph. The motorcyclist was injured. Congestion related.
1/27/92	4:43 P.M.	In order to avoid stopped vehicles ahead, the motorcyclist traveling eastbound at 45 mph had to lay down the motorcycle. The motorcyclist was injured. Congestion related.
11/13/92	5:00 P.M.	A motorcycle traveling eastbound exited at 30 mph, lost control on the ramp and overturned. The motorcyclist was ejected and injured.
2/18/93	3:55 P.M.	A stopped passenger vehicle was rear-ended by a motorcycle traveling eastbound at 20 mph. The driver of the passenger vehicle was uninjured except for complaint of pain. Congestion related.

HOV Crashes

12/6/93	5:15 P.M.	In stop-and-go traffic, a motorcycle traveling eastbound at 30 mph was following a passenger vehicle too closely and rear-ended it. The motorcyclist was injured. Congestion related. (Concurrent HOV lane.)
3/23/94	5:46 A.M.	Passenger vehicle 1, traveling eastbound at 55 mph in the wrong direction on the reversible HOV lanes, had a head-on collision with passenger vehicle 2, which was traveling at 55 mph. Passenger vehicle 1 continued in the wrong direction at 45 mph and struck passenger vehicle 3 head on. The motorcyclist attempted to avoid the accident but collided into passenger vehicle 3. The motorcyclist was injured, as were the driver and passenger in passenger vehicles 2 and 3. The driver of the wrong-way vehicle had Alzheimer's disease and was also injured in the crash. (Reversible HOV lanes.)

Mainline Crashes

9/21/92	5:45 A.M.	A motorcycle was stopped in traffic and was rear-ended by a passenger vehicle traveling westbound at 10 mph. The passenger

		vehicle was then rear-ended by a tractor-trailer traveling 15 mph. The motorcyclist was injured. Congestion related. (Mainline to reversible HOV lanes.)
11/20/92	4:00 P.M.	A motorcycle was exiting eastbound at 70 mph, lost control, ran off the road to the right, and struck a guardrail. The motorcyclist was injured. Speed related. (Mainline to reversible HOV lanes.)
1/4/93	6:40 A.M.	A motorcycle was stopped in traffic and was rear-ended by a passenger vehicle traveling westbound at 10 mph. The passenger vehicle was then rear-ended by a passenger vehicle traveling 45 mph. The motorcyclist was uninjured except for complaint of pain. Congestion related. (Mainline to reversible HOV lanes.)
9/9/93	5:00 P.M.	A motorcyclist traveling eastbound at 55 mph pulled onto the shoulder, lost control, and was ejected and injured. (Mainline to reversible HOV lanes.)
7/7/94	4:15 P.M.	As a passenger vehicle slowed to 35 mph, an eastbound motorcycle failed to slow and rear-ended the passenger vehicle. Both the motorcyclist and passenger were injured. Congestion related. (Mainline to reversible HOV lanes.)
9/13/94	4:10 P.M.	While moving from the acceleration lane onto eastbound I-64 at 50 mph, the motorcyclist lost control and overturned. The motorcyclist was injured. (Mainline to concurrent HOV lane.)

Interstate 66

HOV Crashes

4/21/89	4:30 P.M.	A motorcycle traveling east at 70 mph attempted to exit, lost control, and struck the guardrail. The motorcyclist was ejected and injured. Speed related. (Exclusive HOV lanes.)
5/21/93	5:09 P.M.	A passenger vehicle traveling westbound at 10 mph overtook and failed to slow for a motorcycle traveling 5 mph, rear-ending it. The motorcyclist was injured. Congestion related. (Concurrent HOV lane.)
11/09/93	8:40 A.M.	A passenger vehicle traveling eastbound at 55 mph moved into the acceleration lane in front of the motorcycle traveling 40 mph and

was rear-ended. The motorcyclist and his passenger were injured. (Exclusive HOV lanes.)

Interstate 395

HOV Crashes

8/24/90 6:20 P.M. A motorcycle traveling south at 50 mph rear-ended a passenger vehicle that was slowed for traffic and traveling at 40 mph. The motorcyclist was uninjured except for complaint of pain. Congestion related. (Reversible HOV lanes.)

Mainline Crashes

6/18/91 6:55 A.M. A motorcycle traveling northbound at 3 mph was rear-ended by a passenger vehicle traveling 5 mph. The motorcycle rebounded into the guardrail. No injuries. Congestion related. (Mainline to reversible HOV lanes.)

10/22/91 4:40 P.M. A passenger vehicle traveling south at 20 mph changed lanes and struck a motorcycle on the left side. The motorcyclist was uninjured except for complaint of pain. (Mainline to reversible HOV lanes.)

Interstate 95

HOV Crashes

6/25/92 4:50 P.M. A motorcycle was stopped in traffic and was rear-ended by a van traveling southbound at 30 mph. No injuries. Congestion related. (Concurrent HOV lane.)

Mainline Crashes

7/24/90 4:35 P.M. A motorcycle traveling south at 25 mph in the open shoulder lane had a blowout, lost control, and struck an embankment. Both the motorcyclist and passenger were injured. (Mainline to concurrent HOV lane.)

3/12/92 3:35 P.M. A motorcyclist was exiting southbound I-95, traveling 55 mph on the ramp. While trying to avoid debris in the roadway, the motorcyclist lost control and overturned. The motorcyclist was

uninjured except for complaint of pain. (Mainline to concurrent HOV lane.)

8/20/92	5:20 P.M.	A motorcycle was stopped in traffic and was rear-ended by a passenger vehicle traveling southbound at 20 mph. The motorcyclist was uninjured except for complaint of pain. Congestion related. (Mainline to concurrent HOV lane.)
9/30/92	6:10 P.M.	A motorcyclist traveling south at 30 mph changed lanes, ran over a patch of oil, and lost control, overturning. The motorcyclist had no visible injuries outside of complaint of pain. (Mainline to concurrent HOV lane.)
5/30/94	6:20 A.M.	During a high-speed chase (95 mph), a motorcycle lost control and ran off the road to the left on the northbound off-ramp, struck an embankment, and overturned. The motorcyclist left the scene. (Mainline to concurrent HOV lane.)

Interstate 564

Crashes Prior to HOV Opening

5/1/90	6:50 A.M.	A passenger vehicle traveling westbound at 20 mph slowed for traffic and was rear-ended by a motorcycle traveling 25 mph. The motorcyclist was injured. Congestion related.

HOV Crashes

3/21/94	5:50 A.M.	In stop-and-go traffic, a motorcycle changed lanes at 15 mph and rear-ended a passenger vehicle. The motorcyclist was injured. Congestion related. (Concurrent HOV lane.)

Mainline Crashes

6/2/93	6:00 A.M.	A passenger vehicle and a motorcycle following it had stopped in traffic. Another passenger vehicle traveling westbound at 15 mph rear-ended the motorcycle, pushing it into the passenger vehicle ahead. The motorcyclist was injured. Congestion related. (Mainline to concurrent HOV lane.)

State Route 44

Crashes Prior to HOV Opening

12/5/88	7:30 A.M.	A passenger vehicle traveling west at 45 mph lost control and struck another passenger vehicle, which in turn struck a motorcycle traveling 30 mph. The collision caused the motorcycle to rebound into the side of another passenger vehicle. The motorcyclist and one of the passenger vehicle drivers were uninjured except for complaint of pain. Congestion related.
11/2/90	3:35 P.M.	A passenger vehicle changing lanes to avoid other vehicles cut in front of a motorcycle, causing the motorcycle to hit the passenger vehicle near the driver side door. The collision caused the motorcycle to veer to the left into the path of another passenger vehicle, which struck the motorcycle. The motorcyclist was injured.
8/14/91	5:45 A.M.	A passenger vehicle stopped in westbound traffic was rear-ended by a motorcycle changing lanes at 30 mph. The motorcyclist was uninjured except for complaint of pain. Congestion related.

HOV Crashes None.

Mainline Crashes None.