

MEMORANDUM

TO: Transportation Planning and Programming Committee December 20, 2007
of the Boston Region Metropolitan Planning Organization

FROM: Seth Asante, Jared Fijalkowski, and Efi Pagitsas

RE: Historical Trends: Travel Times and Vehicle Occupancies for I-93 North and
Southeast Expressway HOV and General-Purpose Lanes

1 INTRODUCTION

This memorandum presents the historical trends of travel times and vehicle occupancy identified in an analysis performed as part of the ongoing I-93 North and Southeast Expressway high-occupancy-vehicle (HOV) lane monitoring program.¹ The program is carried out in accordance with Massachusetts Department of Environmental Protection (DEP) regulation 310 CMR 7.37, which calls for samples of HOV and general-purpose lane travel time data to be collected and reported quarterly. The data are used to monitor compliance with a set threshold for the time savings afforded by the HOV lanes compared to travel in the general-purpose lanes. The DEP time-savings threshold was established at one minute per mile. The vehicle occupancy data are collected and reported on in fall and spring, and are used to measure and compare the number of person-trips in the HOV and general-purpose lanes.

A summary of the analysis results is provided in section 5 of this memo.

2 GENERAL DESCRIPTION

The I-93 North HOV lane currently operates between 6:00 AM and 10:00 AM, Monday through Friday, and extends southbound 2.6 miles from a point 0.3 mile south of Exit 31 (Mystic Ave.) in Somerville to a point 0.2 mile south of the Route 1 merge on the Zakim Bridge over the Charles River.² The Southeast Expressway northbound HOV lane currently operates between 6:00 AM and 10:00 AM. It extends northbound 5.5 miles from a point 0.24 mile north of the I-93/Route 3 merge in Quincy to a point 0.9 mile south of Columbia Road in Dorchester. The Southeast Expressway southbound HOV lane currently operates between 3:00 PM and 7:00 PM. Due to its

¹ For a description of a typical work program for this monitoring, refer to: *Work Program for 2006–2007 HOV Monitoring on I-93 North and the Southeast Expressway*, Boston Region MPO, September 7, 2006.

² On March 5, 2005, the HOV lane on I-93 was extended more than half a mile from the lower deck onto the Leonard P. Zakim Bunker Hill Bridge, coinciding with the full opening of the southbound lanes and tunnel.

contra-flow design, it is identical in length and location to its northbound counterpart. A brief description of the historical background of both HOV lanes is provided in the appendix.

3 DATA COLLECTION

Since 2002, CTPS staff have collected, on a quarterly basis, travel times in both the HOV lanes and general-purpose lanes over the course of each four-hour period of HOV lane operation, on non-holiday weekdays. The data-collecting drivers travel the route at a speed that approximates the experience of the average driver at the time of data collection. Other HOV lane users (such as express bus commuters and *MassRIDES* vanpoolers) also volunteer to collect travel-time data as part of their daily commute on non-holiday weekdays.

On the following facilities, travel time data are collected between 6:00 and 10:00 AM:

- I-93 North HOV lane, southbound
- I-93 North general-purpose lanes, southbound
- Southeast Expressway HOV lane, northbound
- Southeast Expressway general-purpose lanes, northbound

On the following facilities, travel time data are collected between 3:00 and 7:00 PM:

- Southeast Expressway HOV lane, southbound
- Southeast Expressway general-purpose lanes, southbound

CTPS and MassHighway staff also collect vehicle occupancy data by lane. This effort takes place during spring and fall and is carried out only for the AM hours of operation. In other words, the vehicle occupancy counts are not conducted for the Southeast Expressway's southbound HOV lane or for its general-purpose lanes during the PM hours of operation. For most vehicles smaller than a microbus, data collectors count persons, up to five. Since occupancy of large buses, microbuses, and police/fire/EMT vehicles is hard to accurately count, data collectors simply tally the number of vehicles in each of these categories without counting passengers.

4 ANALYSIS

Figures 1, 2, and 3 present historical travel time trends from 2002 to 2007 for the I-93 North and Southeast Expressway HOV and general-purpose lanes. In each of these figures, average travel times for each 30-minute monitoring interval were plotted successively for each season from 2002 to 2007. The first season of each monitoring year is fall, in accordance with the HOV monitoring program.³ There are eight data points per season for each facility, each of which represents an average travel time for a 30-minute monitoring interval between 6:00 AM and 10:00 AM or 3:00

³ The first season in each monitoring year is the fall of the previous calendar year. For example, the data shown for the fall of monitoring year 2002 was collected in the fall of calendar year 2001.

FIGURE 1
I-93 North Travel Times
Southbound Travel Lanes (6:00 AM–10:00 AM)

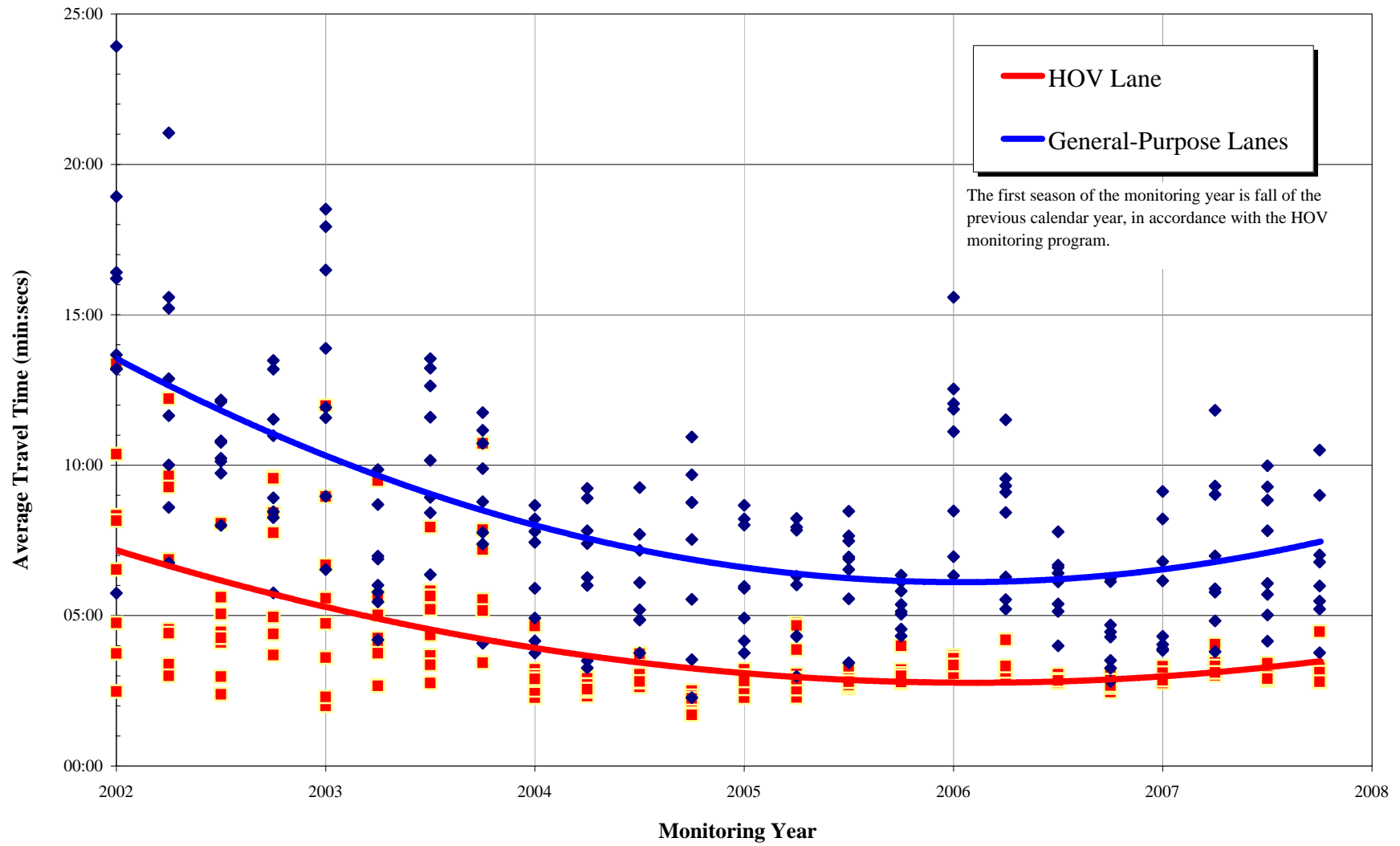


FIGURE 2
Southeast Expressway Travel Times
Northbound Travel Lanes (6:00 AM–10:00 AM)

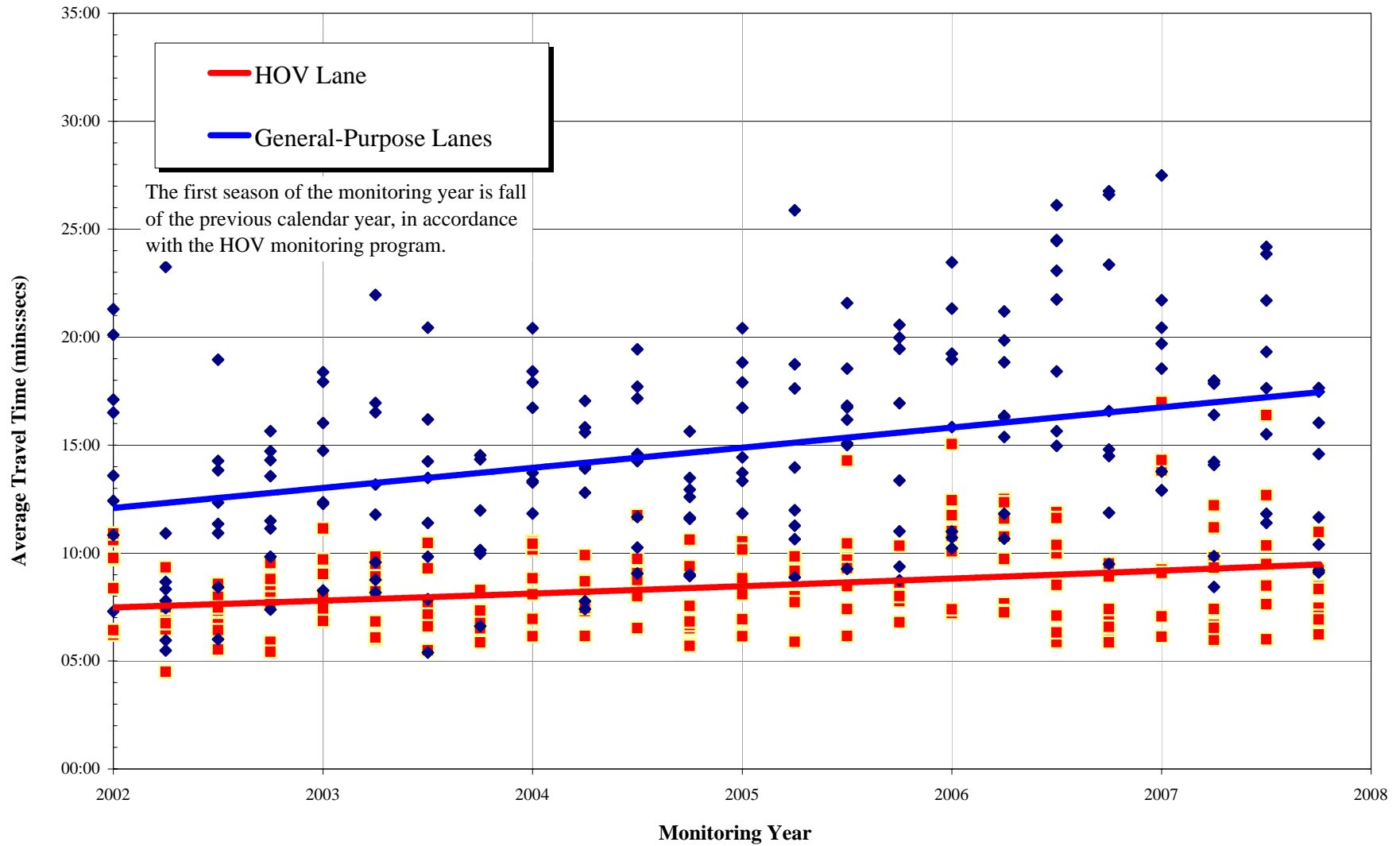
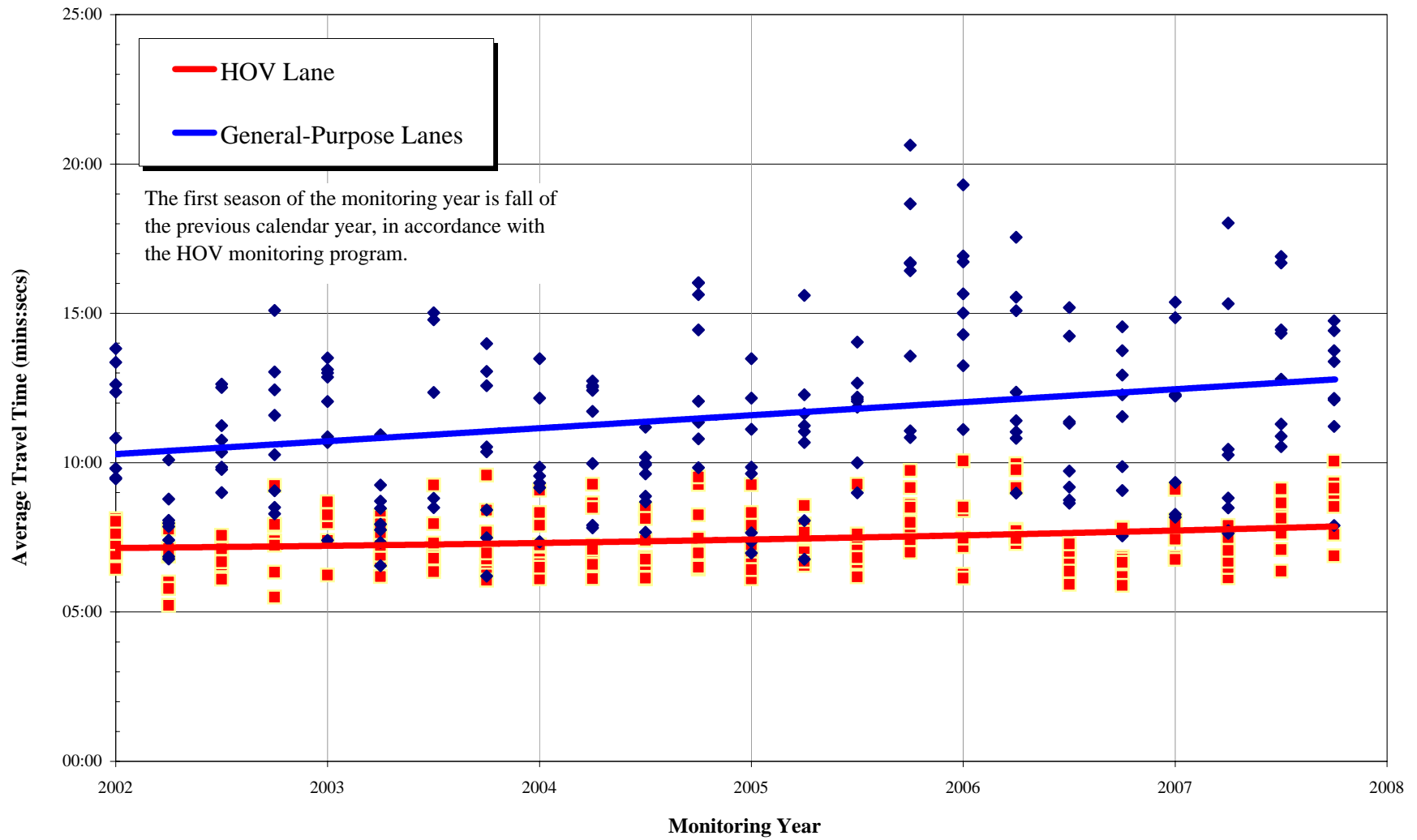


FIGURE 3
Southeast Expressway Travel Times
Southbound Lanes (3:00 PM–7:00 PM)



PM and 7:00 PM. The data points were then fitted to polynomial curves: one for the HOV lane and one for the general-purpose lanes. Polynomial curves were used because they fit the travel time patterns of the HOV and general lanes.

Figures 4, 5, 6, 7, 8, and 9, included in the appendix, present travel time data and associated curves over the course of the four-hour monitoring period for I-93 North and Southeast Expressway HOV and general-purpose lanes. In each of these figures, the average travel time for each 30-minute monitoring interval between 6:00 AM and 10:00 AM or 3:00 PM and 7:00 PM were plotted and fitted to polynomial curves, one for each year of observation. These figures show how the HOV and general-purpose lanes performed during the time that the HOV facility is operating for each year from 2002 to 2007.

Table A-1, in the appendix, gives the milestones of the Central Artery/Tunnel (CA/T) Project, which is about 99% complete.⁴ This table is included in the memorandum because the CA/T project, as it has progressed through various stages, has had impacts on the operations of the HOV and general-purpose lanes. Total vehicles and persons, average vehicle occupancy, persons per hour per lane, and other data are given for the HOV and general-purpose lanes of I-93 North in Table 1 and for those of the Southeast Expressway in Table 2.

I-93 North: Southbound HOV and General-Purpose Lanes

Historical trends of travel times on the I-93 North HOV and general-purpose lanes show interesting characteristics. Figure 1 indicates that travel times for both the HOV and general-purpose lane were highest in 2002 and began decreasing as several milestones of the CA/T Project were accomplished. The figure also indicates that the lowest travel times were observed in 2006 and that travel times in both the HOV and general-purpose lane are beginning to increase slightly, although the time frame is too short for establishing any meaningful trend. Another trend is that the travel time difference between the HOV lane and general-purpose lanes steadily decreased between 2002 and 2006.

Figures 4 and 5 in the appendix confirm the significantly higher travel times on I-93 North during 2002 and 2003 for both the HOV and general-purpose lanes. Also, Figure 4 shows that during 2002 and 2003, travel times in the HOV lane during each daily period of operation rose gradually from 6:00 AM to a maximum around 8:00 AM and then decreased until the end of operations at 10:00 AM. However, from 2004 through 2007, the travel times in the HOV lane showed no peaking, as the congestion at the point where it merges with the general-purpose lanes was removed upon the opening of the Zakim Bridge and the southbound tunnel. Figure 5 shows that travel times in the general-purpose lanes increased gradually from 6:00 AM to a maximum around 8:30 AM and then decreased gradually until the end of the morning peak period for each year of observation. The travel times in the general-purpose lanes from 2004 through 2007 were significantly lower than those observed in 2002 and 2003, because the congestion at the point where the general-purpose lanes merge with the HOV lane was removed upon opening of the Zakim Bridge and the southbound tunnel.

⁴ According to the website of the Massachusetts Turnpike Authority, October 16, 2007.

TABLE 1
I-93 North, Southbound Vehicle Occupancy
6:00 AM to 10:00 AM

Year	Facility	Total Vehicles	Total Persons	Vehicles per Hour per Lane	Persons per Hour per Lane	Percent Difference in Persons per Hour per Lane*	Persons per Vehicle
2004	HOV	2,300	7,015	575	1,754		3.05
	General	10,291	11,556	1,286	1,445		1.12
	All	12,591	18,571	1,049	1,548	21%	1.48
2005	HOV	2,669	8,017	667	2,004		3.00
	General	11,746	12,888	1,468	1,611		1.10
	All	14,415	20,905	1,201	1,742	24%	1.45
2006	HOV	2,820	8,022	705	2,005		2.85
	General	13,007	14,568	1,626	1,821		1.12
	All	15,827	22,589	1,319	1,882	10%	1.43
2007	HOV	2,986	8,389	747	2,097		2.81
	General	13,663	15,540	1,708	1,942		1.14
	All	16,649	23,929	1,387	1,994	8%	1.44

Vehicle occupancy monitoring began in 2004.

*Persons per hour per HOV lane minus persons per hour per general-purpose lane divided by persons per hour per general-purpose lane, multiplied by 100

TABLE 2
Southeast Expressway, Northbound Vehicle Occupancy
6:00 AM to 10:00 AM

Year	Facility	Total Vehicles	Total Persons	Vehicles per Hour per Lane	Persons per Hour per Lane	Percent Difference in Persons per Hour per Lane*	Persons per Vehicle
2005	HOV	3,898	10,769	975	2,692		2.76
	General	22,688	25,367	1,418	1,585		1.12
	All	26,586	36,135	1,329	1,807	70%	1.36
2006	HOV	4,156	10,954	1,039	2,738		2.64
	General	18,237	19,215	1,140	1,201		1.05
	All	22,393	29,937	1,120	1,497	128%	1.33
2007	HOV	4,468	12,012	1,117	3,003		2.69
	General	20,534	22,018	1,283	1,376		1.07
	All	25,002	34,030	1,250	1,701	118%	1.36

Vehicle occupancy monitoring for the Southeast Expressway began in 2005.

*Persons per hour per HOV lane minus persons per hour per general-purpose lane divided by persons per hour per general-purpose lane, multiplied by 100

As may be seen in Table 1, the HOV-lane volumes have been increasing steadily, from an average of 575 vehicles per hour per lane in 2004 to about 750 vehicles per hour per lane in 2007 (a 30% increase in four years). The volume of vehicles per hour per lane for the general-purpose lanes has also been increasing, from a volume of 1,286 vehicles per hour per lane in 2004 to 1,708 vehicles per hour per lane in 2007 (33% increase in four years). The increase in the HOV-lane volumes has occurred despite the opening of the Leverett Circle connector in 1999, when access from the HOV lane to the Leverett Circle connector (serving Storrow Drive and points west) was eliminated. Hence, carpools and vanpools heading to Leverett Circle could no longer take advantage of the HOV lane. Thus, more vehicles, including carpools and vanpools, are using the general-purpose lanes and increasing those lanes' person-carrying effectiveness. Still, the HOV lane is more efficient than the general-purpose lanes, as it carries more persons per hour per lane.

Southeast Expressway: Northbound HOV and General-Purpose Lanes

Historical trends of travel times on the Southeast Expressway northbound HOV and general-purpose lanes also show interesting characteristics. Figure 2 shows that travel times in both the HOV and general-purpose lanes were lowest in 2002 and have been increasing since. However, the HOV lane is becoming more attractive, as the travel times in the general-purpose lanes have been increasing at a faster rate than travel times in the HOV lane, resulting in increased travel-time savings for the HOV lane. Figures 6 and 7 in the appendix indicate significant increases in travel times from 2006 to 2007 for the HOV lane and from 2005 to 2007 for the general-purpose lanes.

In addition, Figures 6 and 7 show that travel times in both the HOV and the general-purpose lanes during each daily period of operation increase from 6:00 AM to a peak around 8:00 AM and then decrease until the end of HOV operations at 10:00 AM. The gradual increase in travel times for both the HOV and general-purpose lanes in recent years might be attributable to several factors that may influence the operations of both. These factors include increases in the volume of vehicles that use the HOV lane. Another possible factor is that the HOV merge with general-purpose-lane traffic at the northerly end of the HOV lane may be a cause of delay for both the general-purpose lanes and the HOV lane. However, analysis of such factors would be outside of the scope of this document. Further study would be needed to determine the main causes of the increasing travel times.

As may be seen in Table 2, the HOV lane is more efficient than the general-purpose lanes, as it carries more persons per lane. During 2006 and 2007, it processed on average between 1,000 and 1,100 vehicles per hour per lane during the four hours of operation; 1,400 vehicles during the peak hour. The number of persons per hour per lane carried by the HOV lane is more than twice that carried by the general-purpose lanes.

Southeast Expressway: Southbound HOV and General-Purpose Lanes

The Southeast Expressway southbound HOV and general-purpose lanes display characteristics similar to those of their northbound counterparts, though the trends are less marked. Figure 3 shows that travel times for both the HOV and general-purpose lanes were lowest in 2002 and

have been increasing gradually. However, the HOV lane is becoming more attractive, as the time savings it offers over the general-purpose lanes have been increasing, due to the fact that travel times in the general-purpose lanes are increasing at a faster rate than travel times in the HOV lane.

According to Figure 8, the 2006 and 2007 HOV travel time curves were not significantly different from those of the years 2003 to 2005. Figure 9 in the appendix indicates higher travel times from 2005 to 2007 for the general-purpose lanes. Again, there may be several reasons for these observations, including but not limited to the volume of vehicles that use the HOV lane as well as the HOV merge with general-purpose traffic at the southerly end of the lane. Further study would be needed to identify the main causes. Figures 8 and 9 also show that travel times in both the HOV and the general-purpose lanes during each daily period of operation increase gradually from 3:00 PM to a maximum around 5:00 PM and then decrease until the end of HOV operations at 7:00 PM.

Vehicle occupancy counts are not conducted for the PM hours of operations on the Southeast Expressway. Therefore vehicle occupancy analysis could not be performed for the Southeast Expressway southbound HOV and general-purpose lanes.

5 SUMMARY

The HOV monitoring data are collected in accordance with Massachusetts Department of Environmental Protection (DEP) regulation 310 CMR 7.37. This regulation calls for samples of HOV and general-purpose lanes travel time data to be collected and reported quarterly. The following findings are based on the analysis of the HOV monitoring data:

I-93 North: Southbound HOV and General-Purpose Lanes

1. Travel times for both the HOV and general-purpose lanes were higher in 2002 and 2003. As several milestones of the CA/T Project were achieved, the travel times in the HOV lane decreased dramatically.
2. The opening of the CA/T Project increased the traffic-carrying capacity of the HOV lane in 2004, and since then it has had the ability to handle additional growth in HOV volumes.
3. The HOV lane has been 8–24% more efficient than the general-purpose lanes, as it carries more persons per hour per lane. However, the efficiency of the HOV lane has been decreasing over time as more vehicles, including HOVs, have been using the general-purpose lanes.

Southeast Expressway: Northbound HOV and General-Purpose Lanes

1. Travel times in both the HOV and general-purpose lanes have been increasing gradually since 2002.

2. The HOV lane is more efficient than the general-purpose lanes, as it carries 70-128% more persons per lane.
3. The HOV lane is operating near capacity during the peak hour, given the geometry of the HOV merge with the general-purpose traffic at the northerly end of the lane. During 2006 and 2007, it processed approximately 1,400 vehicles during the peak hour.
4. The time savings of using the HOV lane compared to the general-purpose lanes has gradually increased since 2002.

Southeast Expressway: Southbound HOV and General-Purpose Lanes

1. Travel times in both the HOV and general-purpose lanes have been increasing gradually since 2002, but not as much as in the northbound direction.
2. Although vehicle occupancy counts were not conducted for the southbound HOV and general-purpose lanes, it is likely that the HOV lane is more efficient than the general-purpose lanes, as was observed for its northbound counterpart.
3. The HOV lane is becoming more attractive as the time savings of using it compared to the general-purpose lanes increases.

APPENDIX

- **Historical Background of MassHighway HOV Lanes**

- **Tables**

A-1 CA/T Milestones with Potential Effects on I-93 HOV Facilities

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Historical Background of MassHighway HOV Lanes

In February of 1974, a southbound HOV lane was established on I-93 North. In response to ever-increasing queue lengths, this HOV lane was lengthened in August of 1974, and then again in October of 1979, when it stretched a total of 1.07 miles from the beginning of the I-93 double-deck elevated structure near Sullivan Square to a point 900 feet north of the merge between I-93 and Route 1. The lane was later extended further to a length of 2.0 miles, to run from a point just south of Mystic Avenue in Somerville to a point 0.12 mile north of the Route 1 merge in Charlestown. On March 5, 2005, it was extended more than half a mile from the lower deck onto the Leonard P. Zakim Bunker Hill Bridge, coinciding with the full opening of the southbound lanes of the bridge and the Central Artery tunnel. This extension increased the length of the lane to 2.6 miles.

When the I-93 North HOV lane was initially opened, it was made available to buses and carpools having an occupancy of at least three persons. This entry criterion provided acceptable levels of usage in spite of the relatively small numbers of carpools, because the lane was available to all vehicles traveling from I-93 to Route 1 North (including significant numbers of commuters traveling to downtown Boston via the Navy Yard off-ramp and Charlestown Bridge). When the Central Artery North Area project began in 1987, however, the ramp to Route 1 North was closed, and all general traffic was eliminated from the HOV lane. The consequent case of “empty lane syndrome” ultimately led to the 1988 change of the HOV lane entry requirement to the two-plus-persons criterion that has been retained to this date. By 1992 the HOV lane was carrying about 1,100 vehicles during the AM peak hour, which was near its capacity, given the geometry of its merge with general traffic at its southerly end. Access from the HOV lane to the Leverett Circle connector was cut off when the latter was completed in 1999. This reduced the volumes in the HOV lane, which are presently between 700 and 800 vehicles per hour.

The Southeast Expressway HOV lane opened in 1995 as mitigation for the CA/T Project. Entry has been limited to carpools, vanpools, motorcycles, and buses. The occupancy requirement for the lane has changed over the years: first the entry rule was three or more occupants per vehicle; after that there was a sticker program (red and green) that allowed certain numbers of vehicles with two occupants to enter the lane on alternate days. This was later expanded to allow all vehicles with stickers to use the lane on all days. Presently, any vehicle with two or more occupants meets the entry requirements for the HOV lane.

The Southeast Expressway HOV lane’s original three-or-more occupancy rule resulted in maximum volumes of 375 and 400 vehicles per hour for the AM and PM peak periods, respectively. With the introduction of the two-person-occupancy sticker program in 1998, these volumes increased to a maximum of 550 and 525 vehicles per hour for the AM and PM peak periods, respectively. In February 1999, when the two-person-occupancy sticker program was expanded to all days, the maximum volumes increased to 825 vehicles per hour during the AM peak period, and 550 during the PM peak period. In June 1999, when the HOV lane was opened to all vehicles with two or more occupants, with no sticker required, the lane use increased to 1,300 vehicles per hour during the AM peak period and 1,000 during the PM peak period. Presently, the volumes in the HOV lane typically do not exceed 1,300–1,400 vehicles per hour either northbound during the AM peak period or southbound during the PM peak period.

TABLE A-1
CA/T Milestones with Potential Effects on I-93 HOV Facilities

October 1999	Leverett Circle Connector Bridge opens
March 30, 2003	I-93 Northbound tunnel opens
December 20, 2003	I-93 Southbound tunnel opens
April 4–Dec. 19, 2004	I-93 Southbound near South Station reduced from 3 to 2 lanes during reconstruction of Dewey Sq. Tunnel
December 19, 2004	Leverett Circle Bypass Tunnel opens
January 9, 2005	Fourth lane added to I-93 Southbound from Dewey Sq. Tunnel to Southeast Expressway
March 5, 2005	Fourth lane added to I-93 Southbound on Zakim Bridge and in O’Neill Tunnel
July 10, 2006	Portion of ceiling collapses in I-90 Connector Tunnel
August 10, 2006	Ramp A from South Boston Access Rd. to I-90 Connector Tunnel reopens
September 1, 2006	Section of I-90 Connector Eastbound to Exit 25 reopens
November 22, 2006	Ramp D of I-90 Connector Westbound from Exit 24 to I-93 North/South reopens
December 23, 2006	Section of I-90 Connector Westbound reopens
January 14, 2007	Two lanes of I-90 Connector reopen
January 25, 2007	HOV lane from I-93 Northbound to South Station Transportation Center and Kneeland Street reopens
January 26, 2007	Ramp L, linking I-93 Northbound to the I-90 Connector Eastbound, reopens
June 1, 2007	HOV lane to Logan in I-90 Connector Tunnel reopens – end of remediation resulting from July 2006 collapse

FIGURE 4
I-93 North Travel Times
Southbound HOV Lane (6:00 AM–10:00 AM)
By 30-Minute Interval

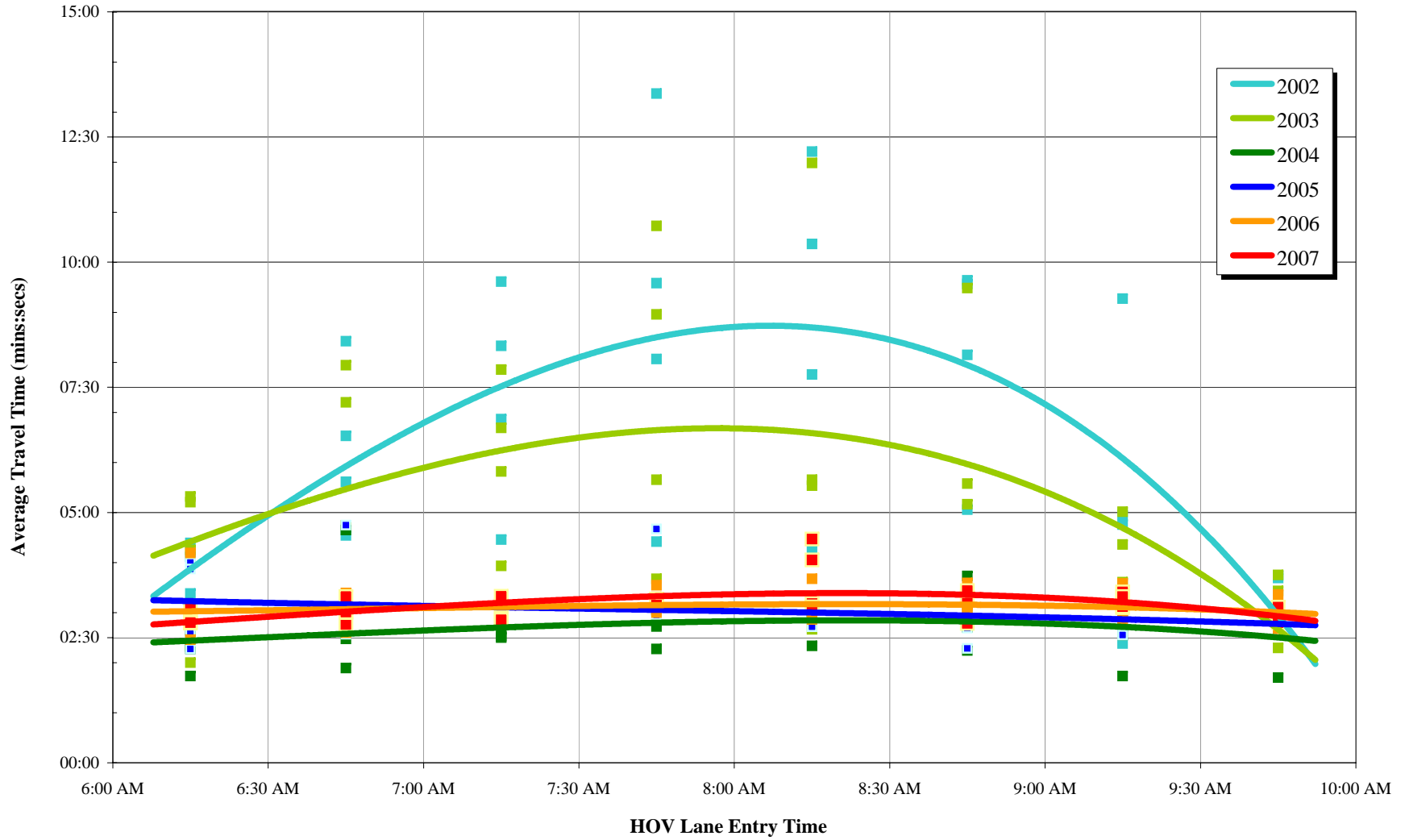


FIGURE 5
I-93 North Travel Times
Southbound General-Purpose Lanes (6:00 AM–10:00 AM)
By 30-Minute Interval

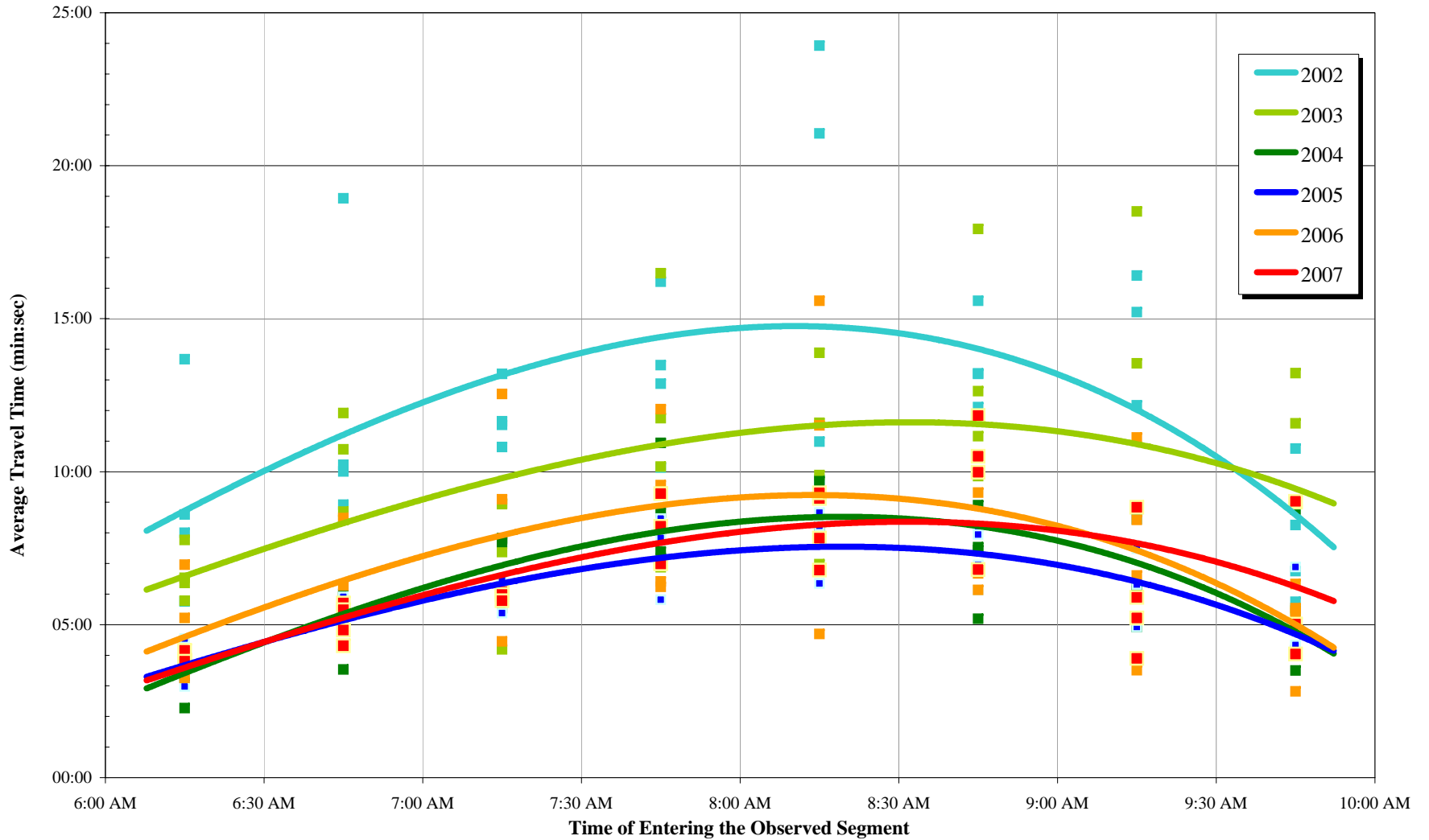


FIGURE 6
Southeast Expressway Travel Times
Northbound HOV Lane (6:00 AM–10:00 AM)
By 30-Minute Interval

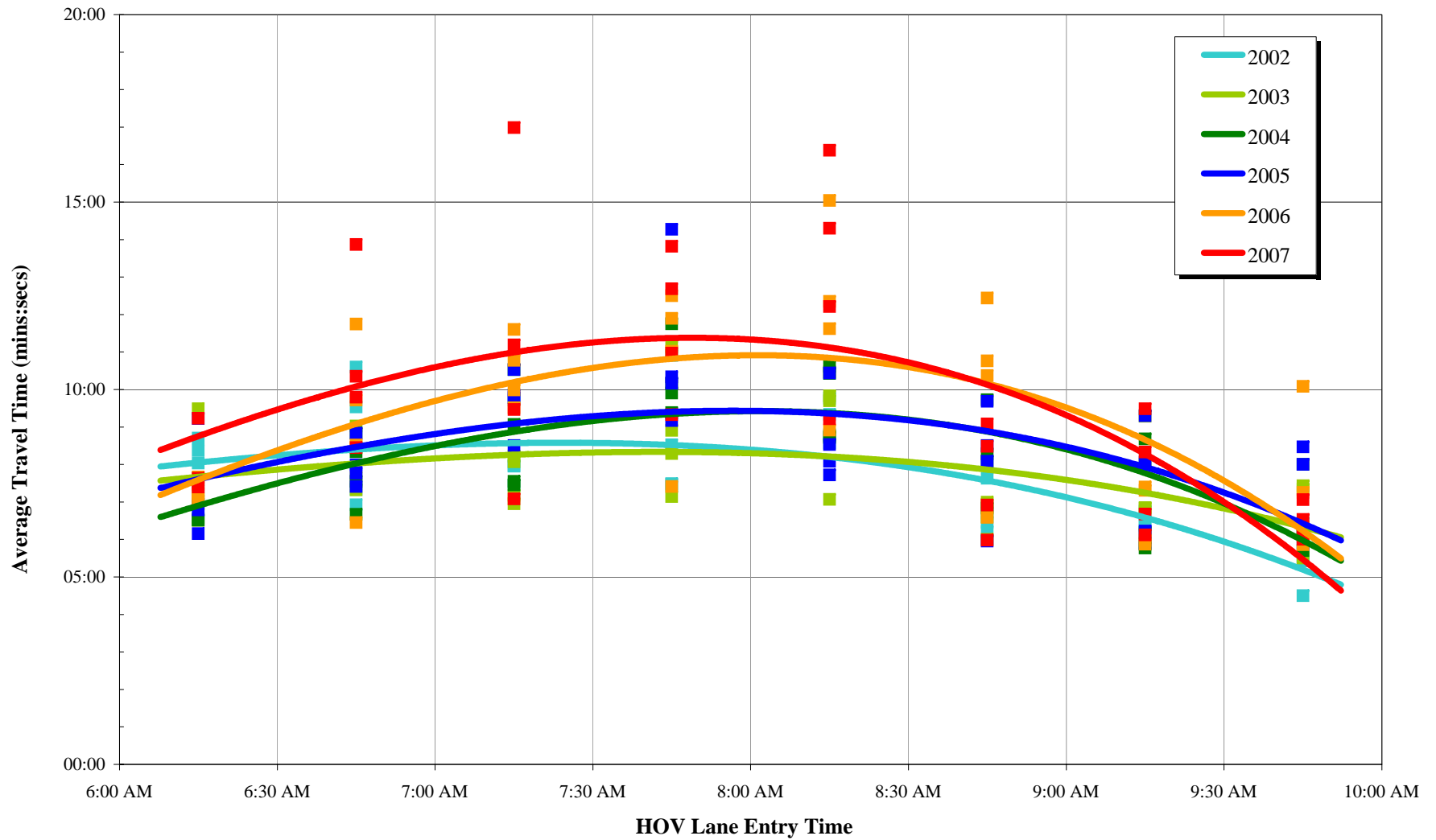


FIGURE 7
Southeast Expressway Travel Times
Northbound General-Purpose Lanes (6:00 AM–10:00 AM)
By 30-Minute Interval

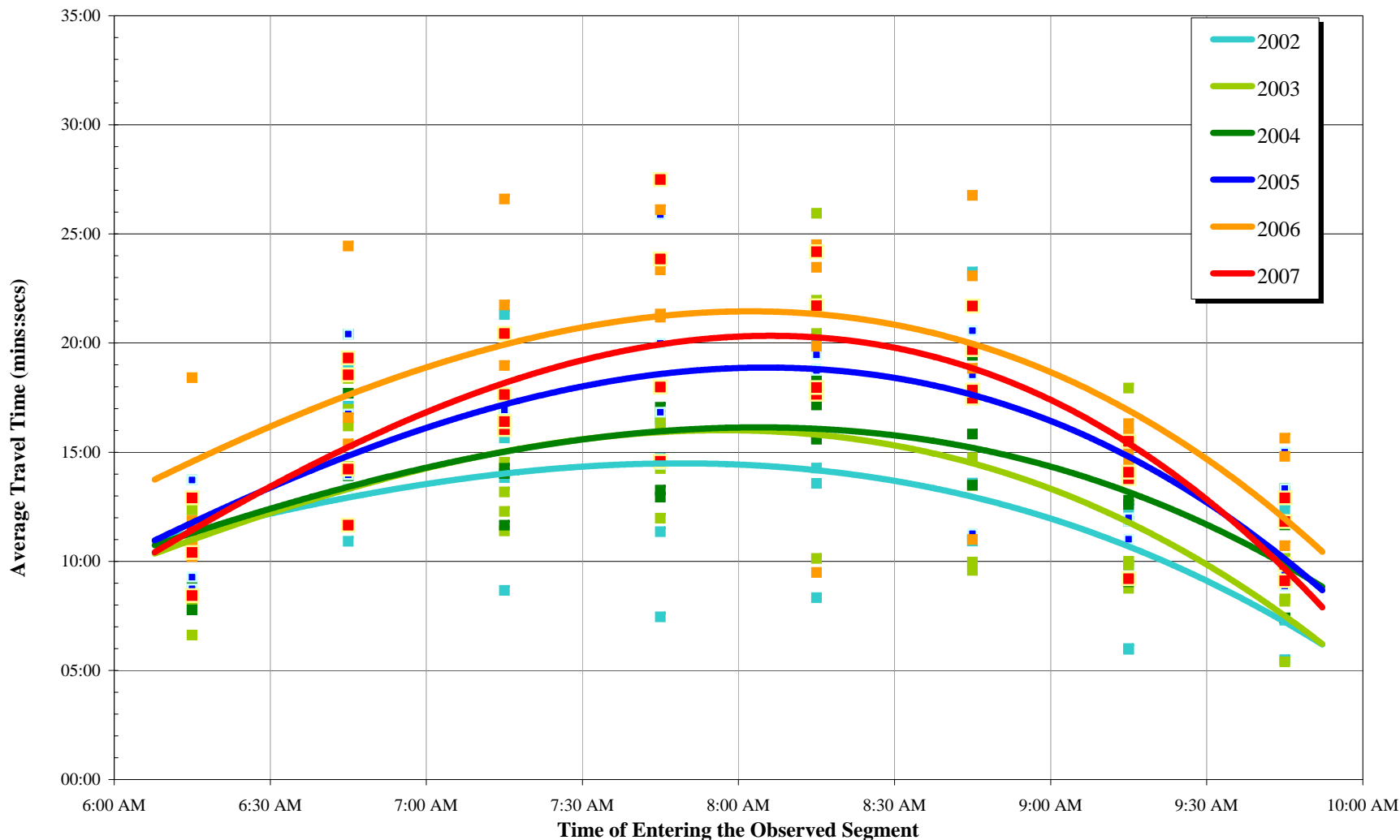


FIGURE 8
Southeast Expressway Travel Times
Southbound HOV Lane (3:00 PM–7:00 PM)
By 30-Minute Interval

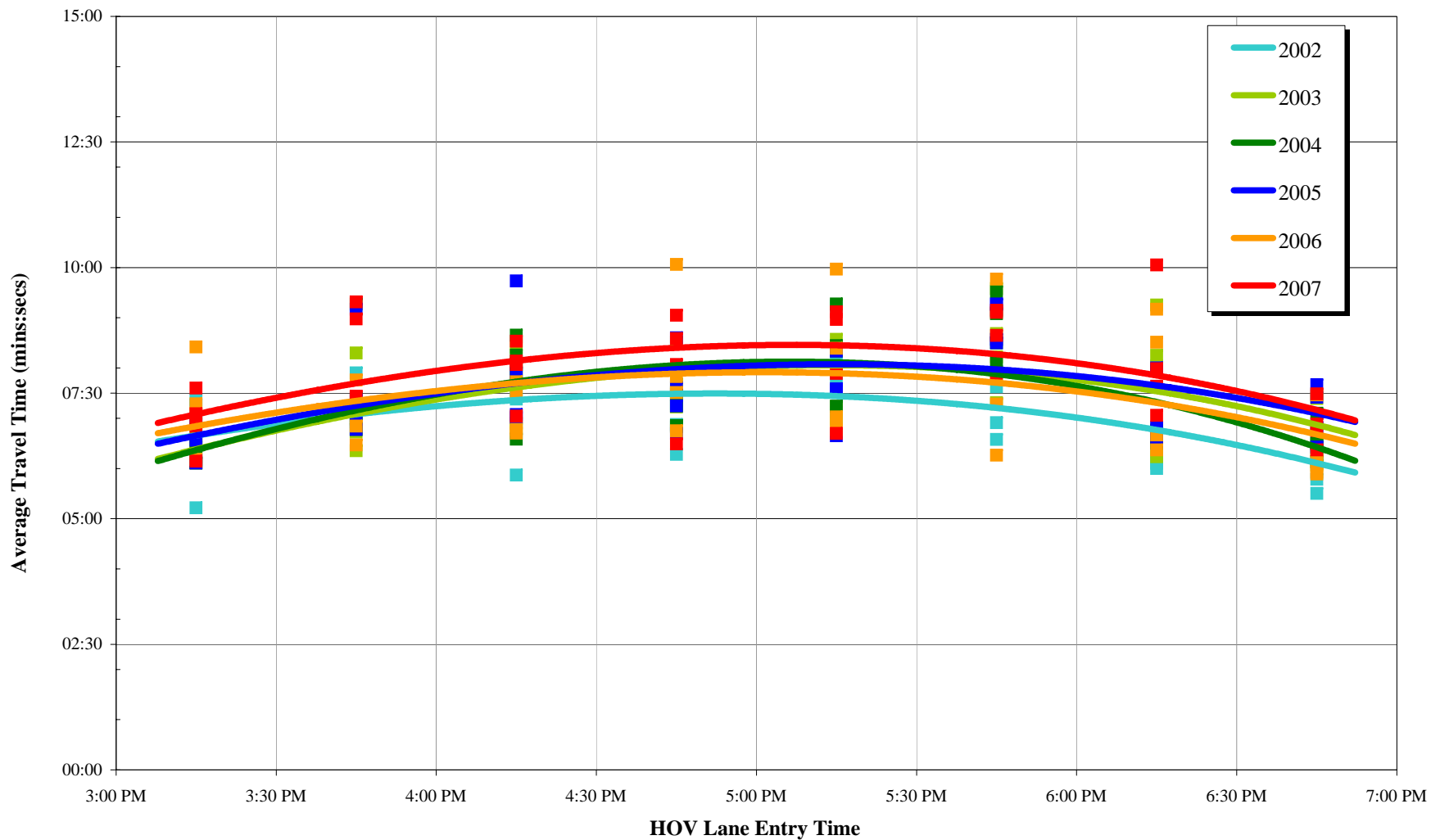


FIGURE 9
Southeast Expressway Travel Times
Southbound General-Purpose Lanes (3:00 PM–7:00 PM)
By 30-Minute Interval

