BOSTON REGION METROPOLITAN PLANNING ORGANIZATION
Richard A. Davey, MassDOT Secretary and CEO and MPO Chairman
Karl H. Quackenbush, Executive Director, MPO Staff

MEMORANDUM

Date: **January 12, 2012**

To: **Congestion Management Process Files**

From: **Seth Asante, Ryan Hicks, and Efi Pagitsas**
MPO Staff

Re: **Historical Trends: Travel Times and Vehicle Occupancy Levels for I-93 North and Southeast Expressway HOV and General-Purpose Lanes**

INTRODUCTION

This memorandum presents the historical trends of travel times and vehicle occupancy levels identified in an analysis performed as part of the MPO's ongoing monitoring program of the I-93 North and Southeast Expressway high-occupancy-vehicle (HOV) lanes.[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 travel-time data from the HOV and general-purpose lanes 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 data are collected and reported on in the fall and spring, and are used to measure and compare the number of person-trips in the HOV and general-purpose lanes.

The results of the analysis are provided in the Summary.

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 miles south of Exit 31 (Mystic Avenue) in Somerville to a point 0.2 miles south of the Route 1 merge on the Zakim Bridge over the Charles River.[2]

[1] For a description of a typical work program for this monitoring, refer to: Work Program for *2011–2012 HOV Monitoring on I-93 North and the Southeast* Expressway, Boston Region MPO, November, 2011.

[2] On March 5, 2005, the HOV lane on I-93 North 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 CA/T Project southbound lanes and tunnel.

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 miles north of the I-93/Route 3 merge in Quincy to a point 0.9 miles south of the Columbia Road exit in Dorchester. The Southeast Expressway southbound HOV lane currently operates between 3:00 PM and 7:00 PM. Due to its contraflow 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.

DATA COLLECTION

Since 2002, MPO staff has 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 routes at a speed that approximates the experience of the average driver at the time of data collection.

For 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

For 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

Given this mandatory travel time saving rate of one minute per mile and the length of the HOV facilities, the following minimum travel time savings should be achieved:

- I-93 North HOV lane, southbound 2.6 minutes
- Southeast Expressway HOV lane, northbound 5.5 minutes
- Southeast Expressway HOV lane, southbound 5.5 minutes

MPO staff also collects vehicle-occupancy data by lane. This effort takes place during the spring and fall and is carried out only for the AM hours of HOV lane operation. 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, police, fire, and emergency-medical-services vehicles is hard to accurately count, data collectors simply tally the number of vehicles in each of these categories without counting passengers.

ANALYSIS

Figures 1, 2, and 3 present historical travel-time trends from 2002 to 2010 for HOV and general-purpose lanes on I-93 North and the Southeast Expressway. In each of these figures, average travel times for each 30-minute monitoring interval were plotted successively for each season

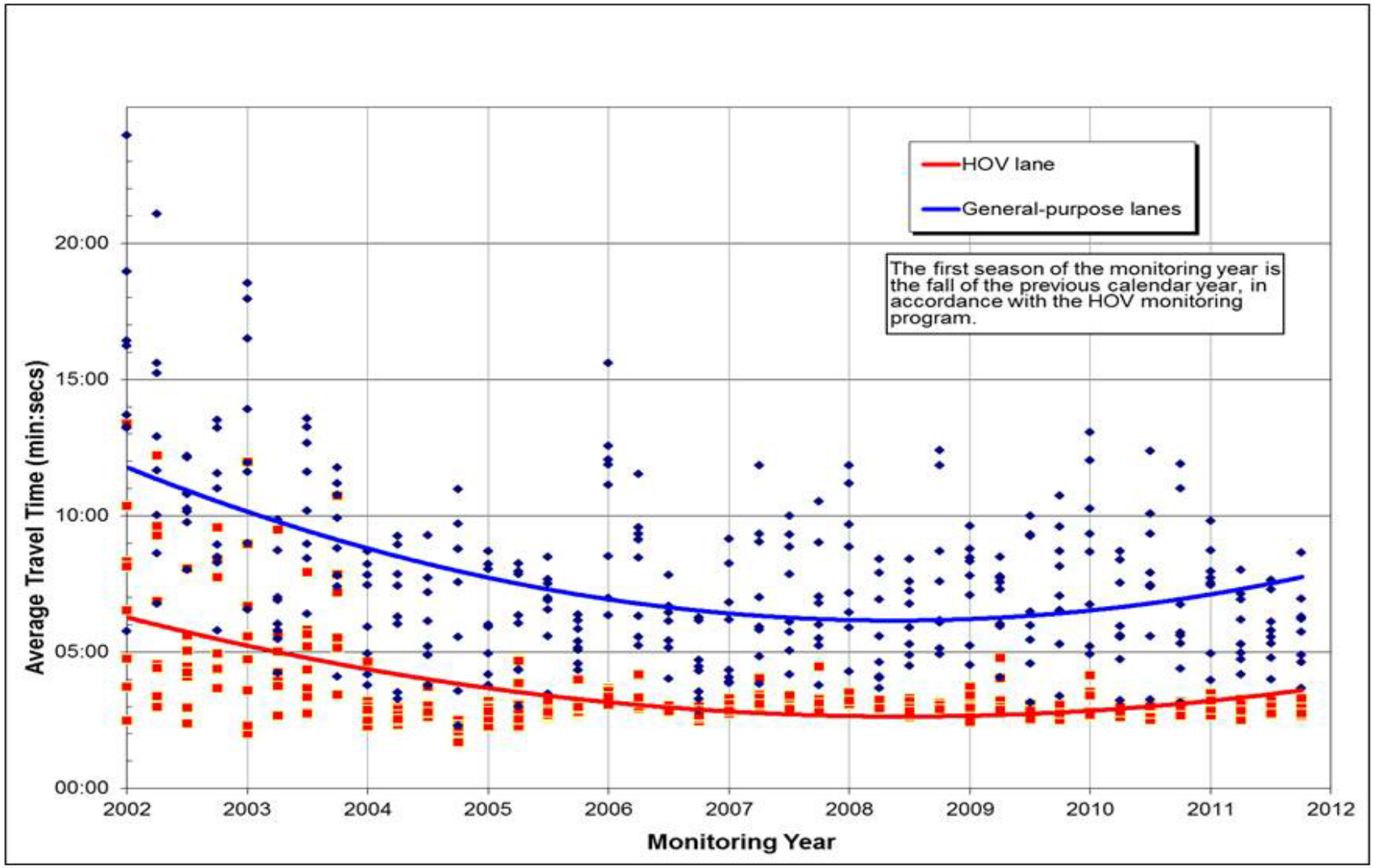

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FIGURE 1
I-93 North Travel Times: Southbound Travel Lanes, AM Peak Period, 2002-11

Congestion Management Process

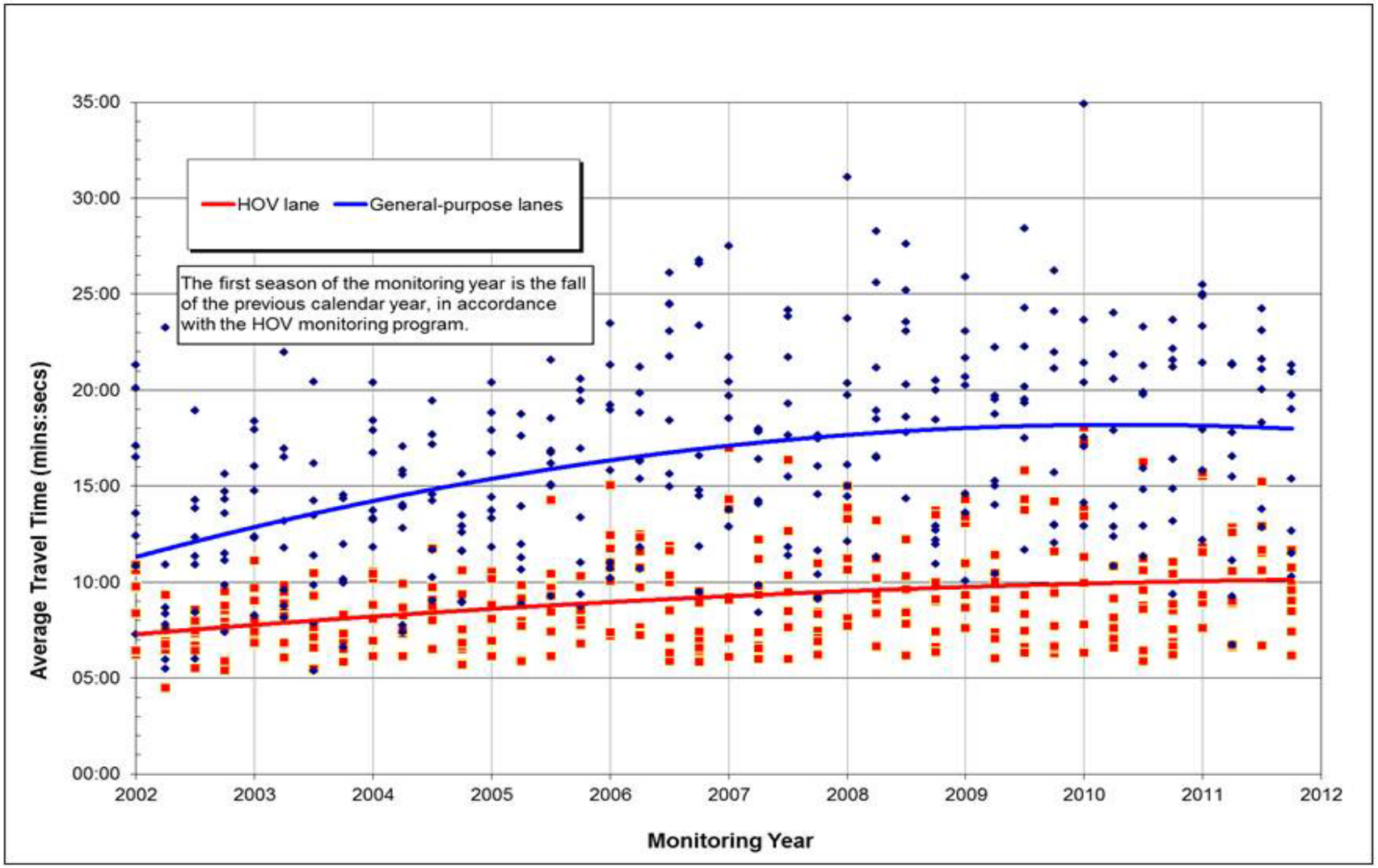

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FIGURE 2
Southeast Expressway Travel Times: Northbound Travel Lanes, AM Peak Period, 2002-11

Congestion Management Process

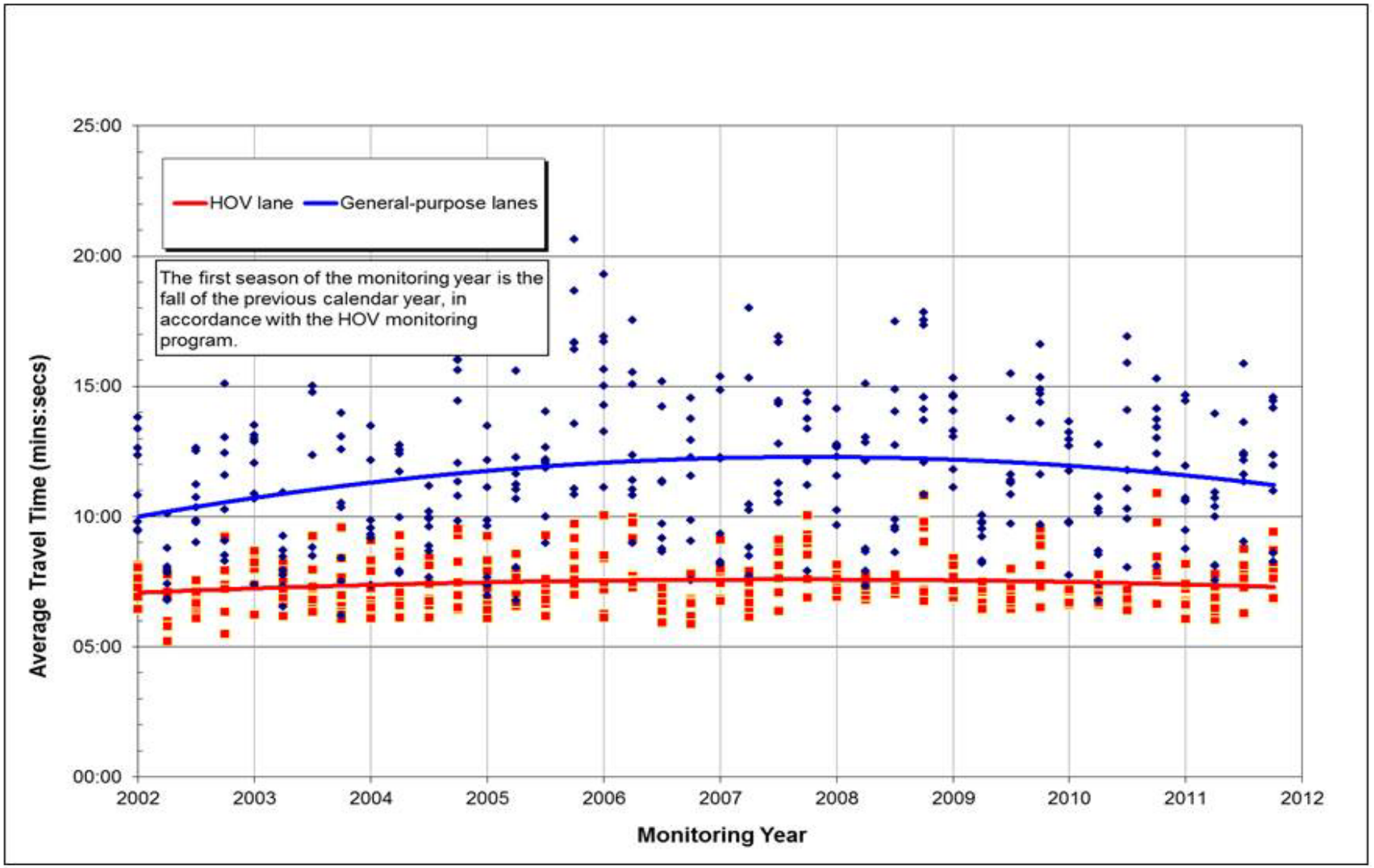

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FIGURE 3
Southeast Expressway Travel Times: Southbound Travel Lanes, PM Peak Period, 2002-11

Congestion Management Process

from 2002 to 2011. The first season of each monitoring year is the fall, in accordance with the MPO's HOV monitoring program.[3] There are eight data points per season for each facility, each of which represents the average travel time for a 30-minute monitoring interval between 6:00 AM and 10:00 AM or between 3:00 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 are the best fit for 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 the HOV and general-purpose lanes of I-93 North and the Southeast Expressway. In each of these figures, the average travel time for each 30-minute monitoring interval between 6:00 AM and 10:00 AM and between 3:00 PM and 7:00 PM were plotted and fitted to polynomial curves, one for the years 2002–03, another for 2004–08, and another for 2009–11 observations. These figures show how the HOV and general-purpose lanes performed during the time that the HOV facility operated from 2002 to 2011. The milestones of the Central Artery Tunnel (CA/T) Project and the economic crisis of 2008 were considered in the selection of the time intervals, as they affected volumes of traffic on the facilities that we monitor. Table A-1, in the appendix, gives the milestones of the Central Artery/Tunnel (CA/T) Project.[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.

Table 1 presents the total number of vehicles and persons, average vehicle occupancy levels, persons per hour per lane, and other data for the HOV and general-purpose lanes of I-93 North, and Table 2 presents the same categories of data for the Southeast Expressway.

FINDINGS

The following sections describe the historical trends of travel times and vehicle occupancy levels for the HOV and general-purpose lanes of I-93 North and the Southeast Expressway.

[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 were collected in the fall of calendar year 2001.

[4] As reported on the former Massachusetts Turnpike Authority's website on October 16, 2007.

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

Historical Trends of Travel Times

Historically, travel times on the I-93 North HOV and general-purpose lanes exhibit interesting characteristics.

- Figure 1 indicates that travel times for both the HOV and general-purpose lanes were highest in 2002 and began decreasing as several milestones of the CA/T Project were accomplished. The opening of the Leonard P. Zakim Bunker Hill Bridge and the completed opening of all the CA/T Project southbound lanes and tunnel contributed greatly to the reductions in travel times (see Table A-1, in the appendix).

TABLE 1
Historical Vehicle Counts: I-93 North, Southbound,
AM Peak Period (6:00 AM–10:00 AM)

Year	Facility	Total Vehicles	Total Persons	Vehicles per Hour per Lane	Persons per Lane	HOV Lane Efficiency Rate*	Persons per Vehicle
	HOV	2,300	7,015	575	1,754	1.21	3.05
2004	General	10,291	11,556	1,286	1,445		1.12
	All	12,591	18,571	1,049	1,548		1.47
	HOV	2,669	8,017	667	2,004	1.24	3
2005	General	11,746	12,888	1,468	1,611		1.1
	All	14,415	20,905	1,201	1,742		1.45
	HOV	2,820	8,022	705	2,005	1.1	2.84
2006	General	13,007	14,568	1,626	1,821		1.12
	All	15,827	22,589	1,319	1,882		1.43
	HOV	2,989	8,372	747	2,093	1.14	2.8
2007	General	12,934	14,640	1,617	1,830		1.13
	All	15,923	23,012	1,327	1,918		1.45
	HOV	3,090	8,545	772	2,136	1.13	2.77
2008	General	13,512	15,164	1,689	1,896		1.12
	All	16,602	23,709	1,383	1,976		1.43
	HOV	2,982	8,347	745	2,087	1.19	2.8
2009	General	12,980	14,062	1,623	1,758		1.08
	All	15,962	22,409	1,330	1,867		1.4
	HOV	2,920	7,599	730	1,900	1.23	2.6
2010	General	11,066	12,403	1,383	1,550		1.12
	All	13,986	20,002	1,166	1,667		1.43
	HOV	3,192	8,876	798	2,219	1.16	2.78
2011	General	13,410	15,255	1,676	1,907		1.14
	All	16,602	24,131	1,383	2,011		1.45

* HOV lane efficiency rate = Persons per hour per HOV lane divided by persons per hour per general-purpose lane, multiplied by 100.

TABLE 2
Historical Vehicle Counts: Southeast Expressway, Northbound, AM Peak Period (6:00 AM–10:00 AM)

Year	Facility	Total Vehicles	Total Persons	Vehicles per Hour per Lane	Persons per Lane	HOV Lane Efficiency Rate*	Persons per Vehicle
	HOV	3,898	10,769	975	2,692	1.7	2.76
2005	General	22,688	25,367	1,418	1,585		1.12
	All	26,586	36,135	1,329	1,807		1.36
	HOV	4,156	10,954	1,039	2,738	2.28	2.64
2006	General	18,237	19,215	1,140	1,201		1.05
	All	22,393	29,937	1,120	1,497		1.34
	HOV	4,104	11,229	1,026	2,807	2.02	2.74
2007	General	20,301	22,204	1,269	1,388		1.09
	All	24,405	33,432	1,220	1,672		1.37
	HOV	3,559	9,855	890	2,464	1.73	2.77
2008	General	21,004	22,751	1,313	1,422		1.08
	All	24,563	32,606	1,228	1,630		1.33
	HOV	3,925	10,630	981	2,658	1.81	2.71
2009	General	21,779	23,515	1,361	1,470		1.08
	All	25,704	34,145	1,285	1,707		1.33
	HOV	4,030	11,455	1,008	2,864	2.16	2.84
2010	General	19,383	21,169	1,211	1,323		1.09
	All	23,413	32,623	1,171	1,631		1.39
	HOV	4,568	12,420	1,142	3,105	2.42	2.72
2011	General	18,528	20,547	1,158	1,284		1.11
	All	23,096	32,967	1,155	1,648		1.43

* HOV lane efficiency rate = Persons per hour per HOV lane divided by persons per hour per general-purpose lane, multiplied by 100.

- Figure 1 indicates that the lowest travel times were observed between 2007 and 2008, and that travel times in both the HOV and general-purpose lanes have been increasing gradually since 2009.
- Figure 1 shows that in 2011, the average time saved by using the HOV lane was about 4.4 minutes. This met the DEP time-savings threshold, which was established at one minute per mile.
- Another trend illustrated in Figure 1 is that the travel-time difference between the HOV lane and general-purpose lanes steadily decreased between 2002 and 2007, and that this trend was reversed in 2008. The travel-time difference between the HOV lane and general-purpose lanes gradually increased between 2008 and 2011. This finding is indicative of increasing congestion at points downstream: from traffic queuing on the Leverett Circle Connector (serving Storrow Drive and points west) that spills onto the I-93 main travel lanes and from traffic queuing in the southbound tunnel during the morning peak period.

Travel-Time Trends during the Four-Hour Monitoring Period

Figures 4 and 5, in the appendix, present travel-time data and associated curves for the four-hour PM monitoring period for I-93 North HOV and general-purpose lanes, respectively.

- Figure 4 shows that in 2002 and 2003, travel times in the HOV lane during each daily period of operation were significantly higher and show considerable peaking. However, from 2004 through 2011, the travel times in the HOV lane showed no peaking at all, as the congestion at the point where it merges with the general-purpose lanes was eliminated when the Zakim Bridge and the southbound tunnel opened.
- Figure 5 shows that in 2002 and 2003, travel times in the general-purpose lanes were significantly higher. However, from 2004 through 2011, the travel times in the general-purpose lanes were reduced significantly.
- In general, the travel times in the general-purpose lanes from 2004 through 2011 were significantly lower than those observed in 2002 and 2003, because the major cause of congestion at the point where the general-purpose lanes merge with the HOV lane was eliminated when the Zakim Bridge and southbound tunnel opened.

Vehicle Volumes and Occupancy Levels

Table 1 presents the total number of vehicles and persons, average vehicle occupancy levels, number of persons per hour per lane, and other data for the I-93 North HOV and general-purpose lanes.

- The HOV-lane volumes appear to have been stabilized; between 2006 and 2011, the average HOV-lane volumes were 705 to 798 vehicles per hour per lane. In that same period, the number of persons per hour per lane in the HOV lane was

1,900 to 2,219. The average vehicle occupancy level in the HOV lane for those years also did not change much; it ranged from 2.60 to 2.84 persons per vehicle.
- Between 2006 and 2011, the average volume of vehicles in the general-purpose lanes was generally between 1,617 and 1,689 vehicles per hour per lane. The average vehicle occupancy level in the general-purpose lanes for those years also did not change much; it ranged from 1.08 to 1.14 persons per vehicle.
- The HOV lane is more efficient than the general-purpose lanes, as it carries more persons per hour per lane (16 percent more persons per hour per lane than the general-purpose lanes in 2011, as shown in Table 1).

Southeast Expressway: Northbound HOV and General-Purpose Lanes

Historical Trends of Travel Times

A summary of a review of the historical trends of travel times on the Southeast Expressway northbound HOV and general-purpose lanes is shown in Figure 2:

- Travel times in both the HOV and general-purpose lanes were lowest in 2002, when data collection began, and since then they have gradually increased.
- The average travel times from 2008 through 2011 for the general-purpose lanes appear to have leveled off. This situation is expected, as the average traffic queue in the general-purpose lanes extends into and beyond the points of observation (the start of the HOV lane in Quincy, and end of the HOV lane in Dorchester) for a substantial portion of the period of operation.
- The HOV lane is faster and more attractive than the general-purpose lanes, as the travel times in the general-purpose lanes have been significantly slower than travel times in the HOV lane, resulting in increased travel-time savings for the HOV lane. Since 2009, the average amount of time saved by using the HOV lane is about eight minutes, which meets the threshold set by DEP. The DEP threshold calls for travel-time savings of 5.5-minutes over the 5.5-mile-long HOV lane.

Travel-Time Trend during the Four-Hour Monitoring Period

Figures 6 and 7, in the appendix, present travel-time data and associated curves for the four-hour monitoring period for the northbound Southeast Expressway HOV and general-purpose lanes. The key findings are:

- Figure 6 indicates that there were significant increases in travel times from 2002 to 2011 for the HOV lane. The figure shows that travel times in the HOV lane have been increasing over a substantial portion of the four-hour monitoring period for each year of observation. The gradual increase in travel times for the HOV lane might be attributable to several factors. One possible factor is that the merging of HOV traffic with general-purpose-lane traffic at the north end of the HOV lane may be a cause of delay in the HOV lane.

- Figure 7 indicates that there were significant increases in travel times from 2002 to 2011 for the general-purpose lanes. The smaller gap between the curves for the periods 2004 – 08 and 2009 – 11, is an indication that travel times have not been increasing over a substantial portion of the four-hour monitoring period. Figure 7 confirms the findings from Figure 2 about the leveling off of travel times from 2008 to 2011 for the general-purpose lanes. The stable travel times from 2008 to 2011 for the general-purpose lanes apply only to the HOV monitoring area and do not account for any of the traffic queues on the Southeast Expressway that extend onto Route 3 and I-93 in Braintree, or between the end of the HOV lane and the Columbia Road on-ramp.

Vehicle Volumes and Occupancy Levels

The total number of vehicles and persons, vehicles and persons per hour per lane, HOV lane efficiency rate, and vehicle occupancy levels for the HOV and general-purpose lanes of the Southeast Expressway are presented in Table 2:

- The HOV lane is more efficient than the general-purpose lanes, as it carries more persons per lane. The HOV lane carries about twice the number of persons per hour per lane than are carried by the general-purpose lanes. Also, in terms of persons per hour per lane, the Southeast Expressway HOV lane is more efficient than the I-93 North HOV lane.
- From 2005 through 2011, the average vehicle occupancy levels for the HOV lane were 2.71 to 2.76 persons per vehicle, and there was not any trend among these values. For the same period, the average vehicle occupancy level for the general-purpose lanes was 1.05 to 1.12 persons per vehicle.
- Between 2005 and 2010, the HOV lane processed an average of 890 to 1,142 vehicles per hour during the four-hour monitoring period. The HOV lane is operating near capacity during the peak hour, given the geometry of the HOV lane merge with the general-purpose traffic at the north end of the lane and increasing traffic demand to use the HOV lane. During 2006 and 2010, it processed approximately 1,300 vehicles during the peak hour.

Southeast Expressway: Southbound HOV and General-Purpose Lanes

Historical Trends of Travel Times

The Southeast Expressway's southbound HOV and general-purpose lanes display characteristics similar to those of their northbound counterparts, though the trends are less marked, as shown in Figure 3:

- Average travel times for both the HOV and general-purpose lanes show less marked trends compared to their northbound counterparts, shown in Figure 2.
- Since 2002, average travel times in the southbound HOV lane remained flat, averaging seven to eight minutes. Similarly, for the general-purpose lanes, the

average travel times have ranged between 11 and 13 minutes since 2003. Figure 3 also shows slight reduction in travel times for the general-purpose lanes since 2008

- The difference in average travel times between the HOV and general-purpose lanes is four to five minutes. Although the average travel times in the HOV lane are faster than the average travel times in the general-purpose lanes, the time savings in the HOV lane on some occasions do not meet the thresholds established by DEP. The DEP threshold calls for travel-time savings of 5.5-minutes over the 5.5-mile-long southbound HOV lane.

One of the reasons for this situation is that during the PM peak period, the traffic merging onto the Southeast Expressway at the Savin Hill/South Bay ramp creates a bottleneck that essentially meters traffic heading southbound on the Southeast Expressway toward the HOV lane entrance. Consequently, traffic in the general-purpose lanes downstream of this bottleneck is faster (comparable to the speed in the HOV lane) until Exits 9 and 10, in East Milton.

Travel-Time Trend during the Four-Hour Monitoring Period

Figures 8 and 9, in the appendix, present travel-time data and associated curves over the four-hour monitoring period for the Southeast Expressway's southbound HOV and general-purpose lanes.

- According to Figure 8, the HOV lane's average travel-time curve for 2009–2011 period appear to be slightly lower than average travel-time curve for 2003–2008 period.
- According to Figure 9, the general-purpose lane's average travel-time curve for 2009–2011 period slightly lower than average travel-time curve for 2003–2008 period for most part of the four-hour monitoring period.

Vehicle Volumes and Occupancy Levels

Vehicle occupancy counts are not conducted for the PM hours of operations on the Southeast Expressway. It is assumed to be identical to that observed for its northbound counterpart during the AM hours of operations. Therefore vehicle occupancy analysis could not be performed for the Southeast Expressway southbound HOV and general-purpose lanes.

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-lane 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 initially higher in 2002 and 2003 than in subsequent years. 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 the HOV lane has had the ability to handle additional growth in HOV volumes.
3. The HOV lane has been 10 to 24 percent more efficient than the general-purpose lanes, as it carries more persons per hour per lane.

Southeast Expressway: Northbound HOV and General-Purpose Lanes

1. Travel times in the HOV lane have been increasing gradually since 2002.
2. Travel times in the general-purpose lanes have been leveling off gradually since 2008.
3. The HOV lane is more efficient than the general-purpose lanes, as it carries 70 to 128 percent more persons per lane. It is also more efficient than the HOV lane on I-93 North.
4. 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 north end of the lane. From 2006 through 2011, it processed approximately 1,300 vehicles per peak hour.
5. The average time saved by using the HOV lane compared to the general-purpose lanes is about eight minutes, which meets the DEP threshold.

Southeast Expressway: Southbound HOV and General-Purpose Lanes

1. Travel times in both the HOV and general-purpose lanes appear to have leveled off since 2006, and they have decreased slightly since 2009.
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. Although the average travel times in the HOV lane are faster than the average travel times in the general-purpose lanes, the time savings the HOV lane offers do not meet the set of thresholds established by DEP.

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APPENDIX

Historical Background of MassDOT Highway Division's HOV Lanes

Tables

Figures

Historical Background of MassDOT Highway Division's HOV Lanes

In February 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 1974, and then again in October 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 of I-93 and Route 1. The lane was later extended farther, 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 by more than half a mile, from the lower deck onto the Leonard P. Zakim Bunker Hill Bridge, increasing the length of the lane to 2.6 miles. This extension coincided with the full opening of the southbound lanes of the bridge and the Central Artery tunnel.

When the I-93 North HOV lane was initially opened, it was made available to buses, motorcycles, and carpools and vanpools having at least three persons per vehicle. This entry criterion provided acceptable levels of usage, in spite of the relatively small numbers of carpools, because the lane was available to vehicles traveling from I-93 southbound 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, so vehicles could no longer travel directly from I-93 southbound to Route 1 North using the HOV lane or the general purpose lanes. 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 the general-purpose lanes at its southern end. Access from the HOV lane to the Leverett Circle Connector was cut off when the latter was completed in 1999. This led to a reduction of volumes in the HOV lane, which are presently between 700 and 800 vehicles per peak hour.

The Southeast Expressway HOV lane opened in 1995 as mitigation for the CA/T Project. Entry has been limited to carpools, vanpools, buses and other vehicles meeting the occupancy criteria, and motorcycles. The occupancy requirement for the lane has changed over the years: initially the entry rule was three or more occupants per vehicle; after that there was a sticker program (red and green) that allowed 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 requirement 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 hour, 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 hour, 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 hour, and 550 during the PM peak hour. 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 hour and 1,000 during the PM peak hour. Presently, the volume in the HOV lane typically does not exceed 1,300–1,400 vehicles per hour either northbound during the AM peak hour or southbound during the PM peak hour.

TABLE A-1
Central Artery/Tunnel Project Milestones with Potential Effects on I-93 HOV Facilities

Date	Milestone
October 1999	The Leverett Circle Connector viaduct opens.
March 30, 2003	The I-93 northbound tunnel opens.
December 20, 2003	The I-93 southbound tunnel opens.
April 4–December 19, 2004	I-93 southbound near South Station is reduced from three to two lanes during reconstruction of Dewey Square Tunnel.
December 19, 2004	The Leverett Circle eastbound tunnel opens.
January 9, 2005	A fourth lane of I-93 southbound from Dewey Square Tunnel to the Southeast Expressway opens.
March 5, 2005	A fourth lane of I-93 southbound on the Zakim Bridge and in the O'Neill Tunnel opens.
July 10, 2006	A portion of ceiling collapses in the I-90 tunnel in South Boston.
August 10, 2006	Ramp A, from the South Boston Bypass Road to I-90 eastbound, reopens.
September 1, 2006	The section of I-90 eastbound that runs under Fort Point Channel to Exit 25 reopens.

(cont.)

TABLE A-1 (Cont.)
Central Artery/Tunnel Project Milestones with Potential Effects on I-93 HOV Facilities

Date	Milestone
November 22, 2006	Ramp D, from Exit 25 of I-90 westbound under Fort Point Channel to I-93 North/South, reopens.
December 23, 2006	The section of I-90 westbound under Fort Point Channel reopens.
January 14, 2007	The remaining I-90 lanes reopen.
January 25, 2007	The HOV lane from I-93 northbound reopens to South Station Transportation Center and Kneeland Street.
January 26, 2007	Ramp L, linking I-93 northbound to the Seaport District and Ted Williams Tunnel, reopens.
June 1, 2007	The HOV lane from I-93 northbound and Kneeland Street to Logan Airport reopens. This was the final repair and remediation project that resulted from the July 2006 ceiling collapse.

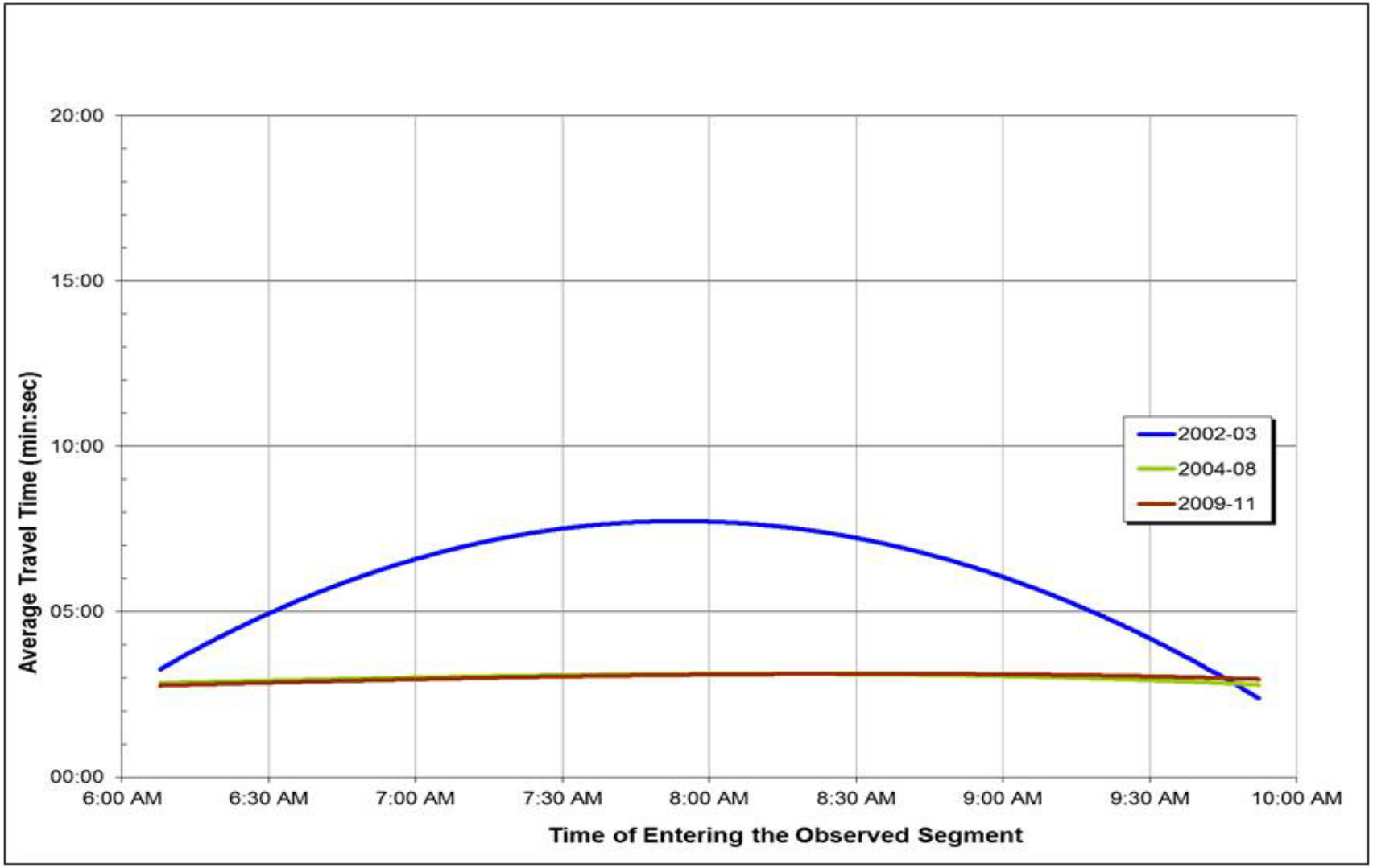

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FIGURE 4
I-93 North Travel Times: Southbound HOV Lane, AM Peak Period, 2002-11

Congestion Management Process

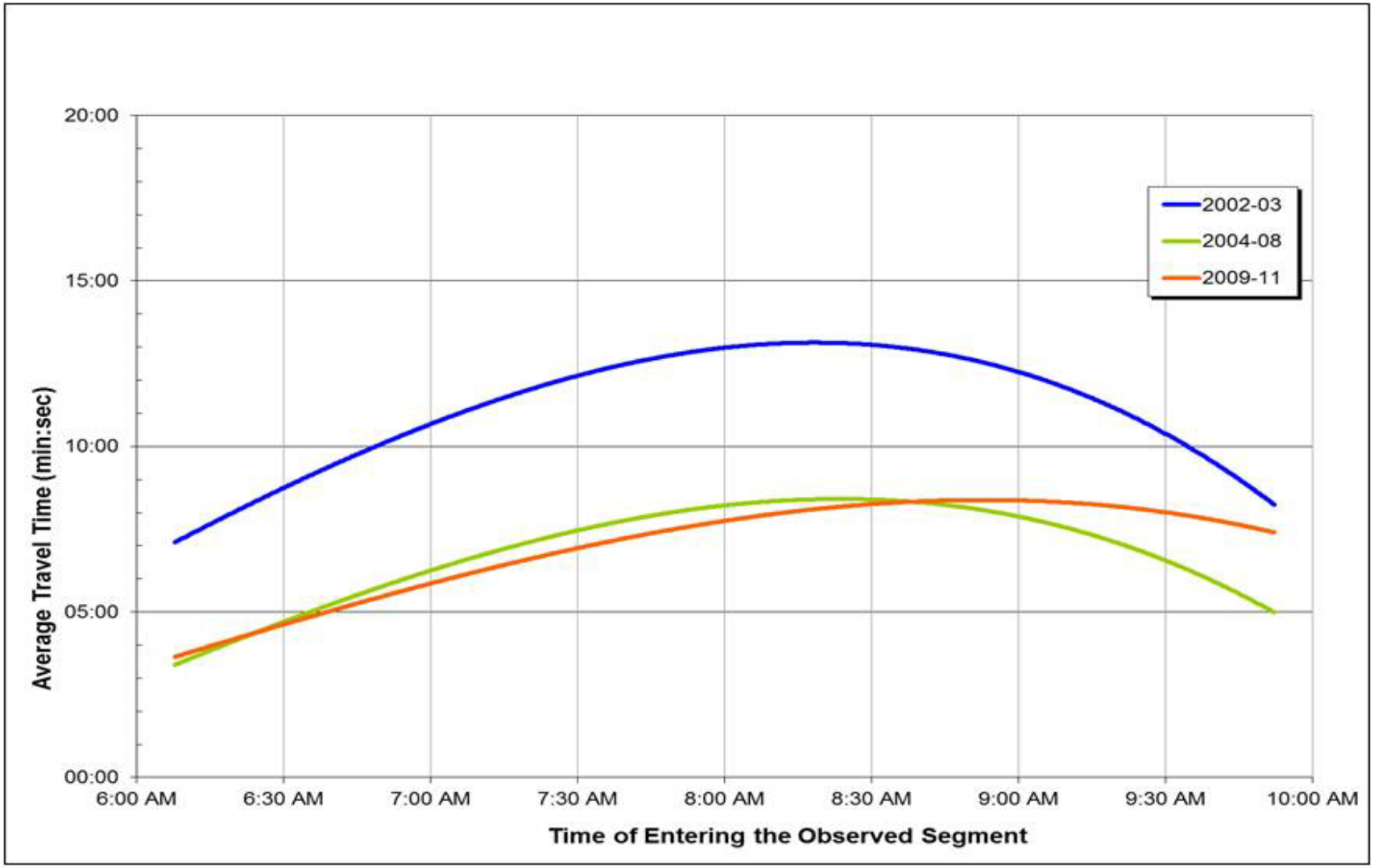

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FIGURE 5
I-93 North Travel Times: Southbound General-Purpose Lanes, AM Peak Period, 2002-11

Congestion Management Process

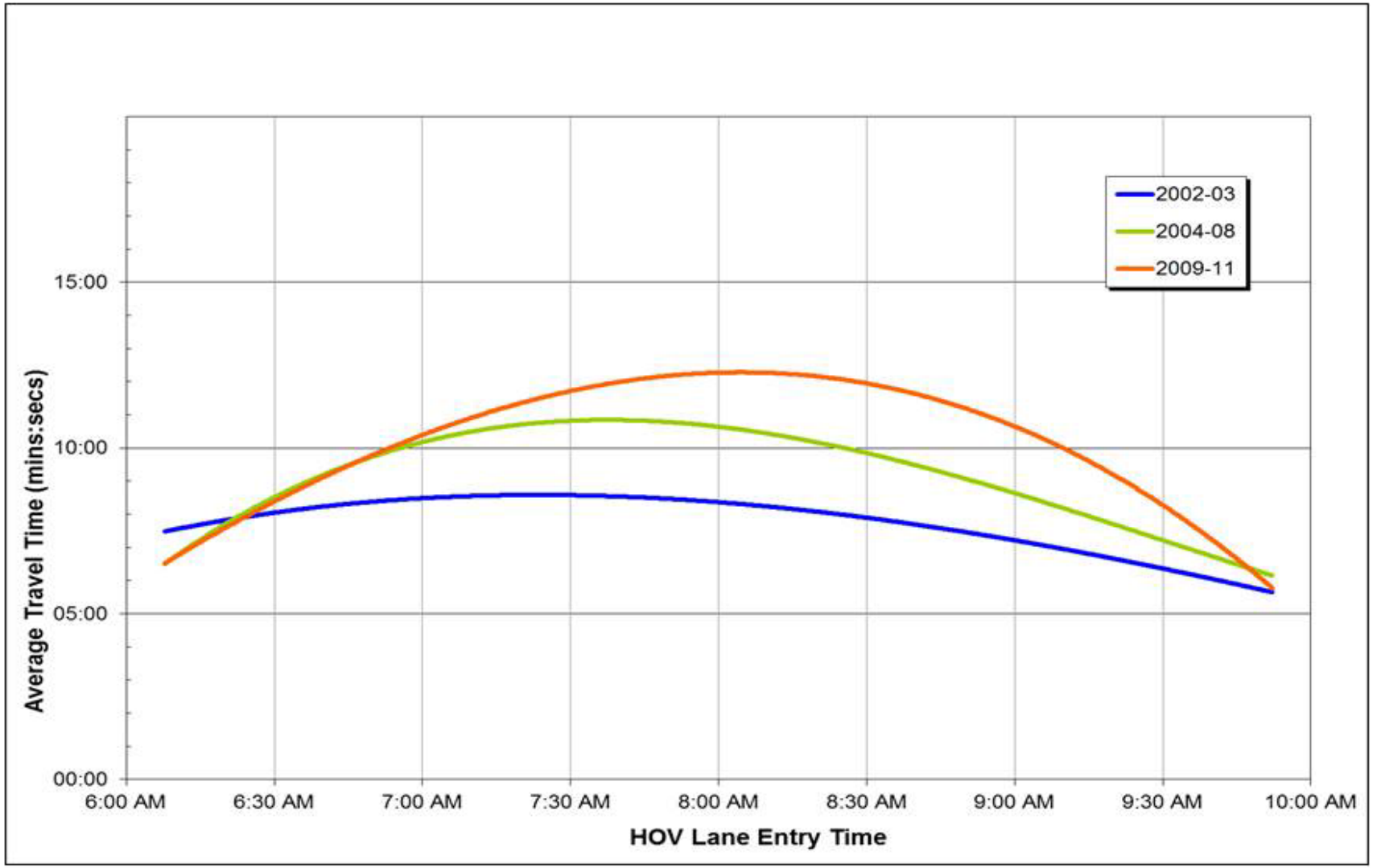

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FIGURE 6
Southeast Expressway Travel Times: Northbound HOV Lane, AM Peak Period, 2002-11

Congestion Management Process

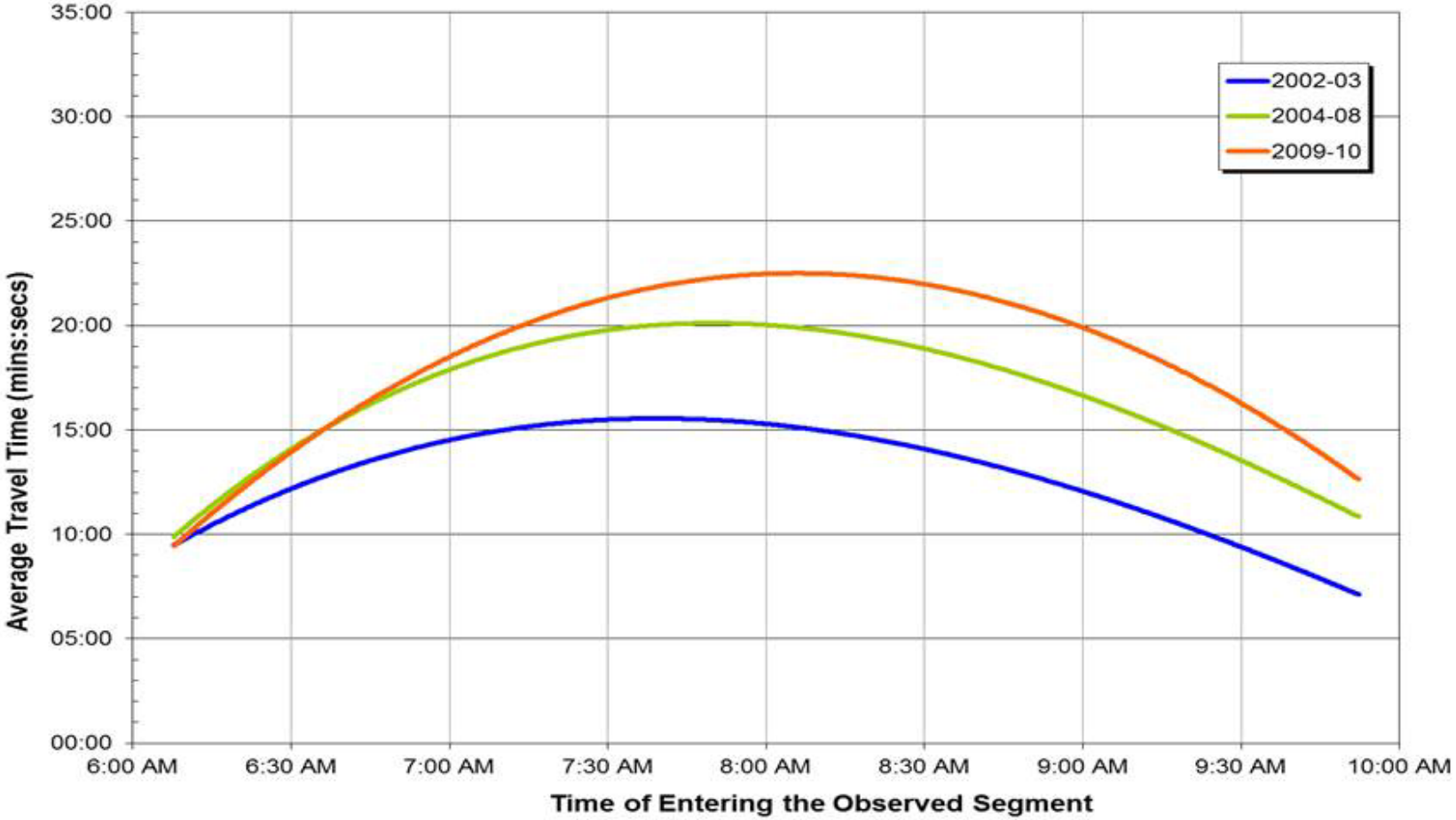

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FIGURE 7
Southeast Expressway Travel Times: Northbound General-Purpose Lanes, AM Peak Period, 2002-11

Congestion Management Process

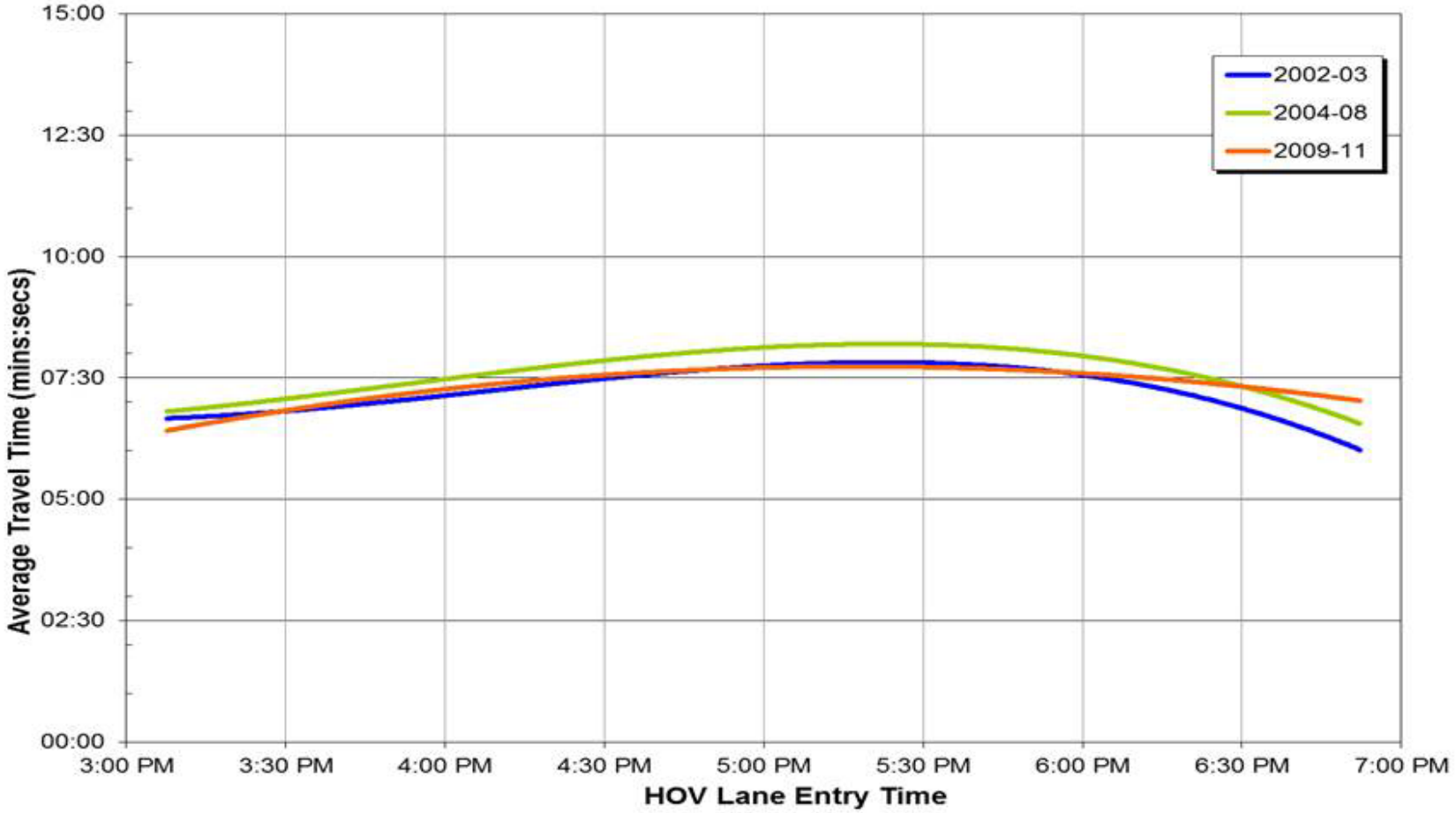

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FIGURE 8
Southeast Expressway Travel Times: Southbound HOV Lane, PM Peak Period, 2002-11

Congestion Management Process

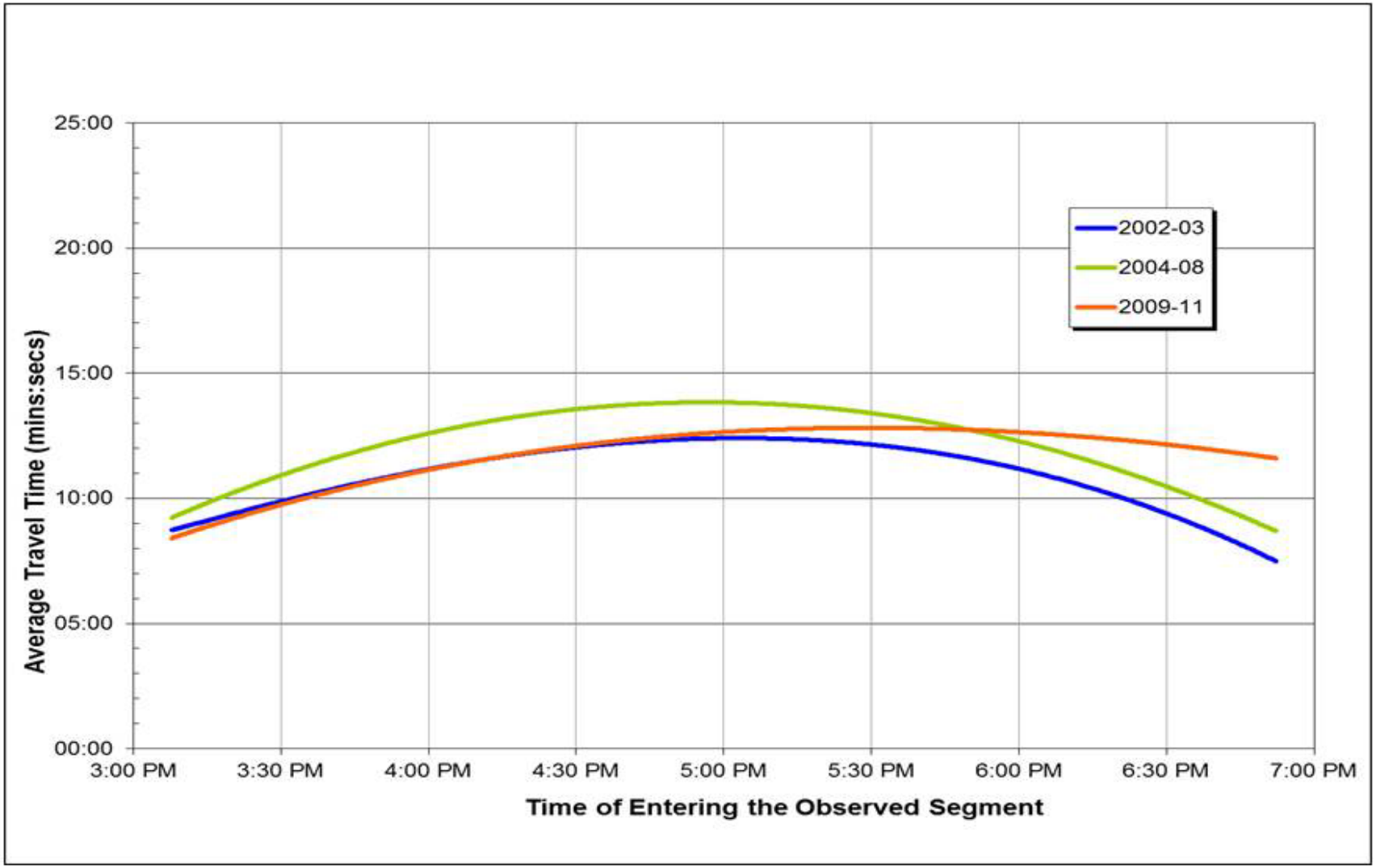

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FIGURE 9
Southeast Expressway Travel Times: Southbound General-Purpose Lanes, PM Peak Period, 2002-11

Congestion Management Process