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Memorandum

Date: December 16, 2015

From: Liren Zhou (AECOM) and David Roden (AECOM)

To: Bill Cashman (AECOM)

Re: I-264 Corridor Study – Toll Impact Analysis

Overview

The objective of this task was to develop a tool within the Hampton Roads Regional travel demand model framework to model and analyze the traffic characteristics of the proposed Managed Lanes (ML) in Hampton Road area. A time saving based toll diversion algorithm was designed to estimate the traffic split between the Managed Lanes and General Purpose Lanes (GP). A sub application was developed to set the managed lane toll rates with the objective to maintain the speed on managed lanes to 45 miles per hour or greater. The toll diversion algorithm and the toll setting sub application were incorporated into the Hampton Roads Regional travel demand model. Traffic Analysis Zone (TAZ) based value-of-time (VoT) was estimated from the 2010 Census data and is applied to covert the tolls on managed lanes to equivalent travel time. 2034 Managed Lanes were coded based on the HOV lanes defined in the original network. Model results with the new algorithm were summarized and analyzed and compared with that from the original Hampton Roads Regional model.

Basic Assumptions

Network Coding

2034 Managed Lanes were coded based on the HOV lanes defined in the original Hampton Roads regional model. The HOV lane on and off ramp locations and configurations were maintained to be consistent with the original assumptions. Figure 1 presents the proposed managed lanes in Hampton Roads area in 2034.

Figure 1: Hampton Road 2034 managed lanes system
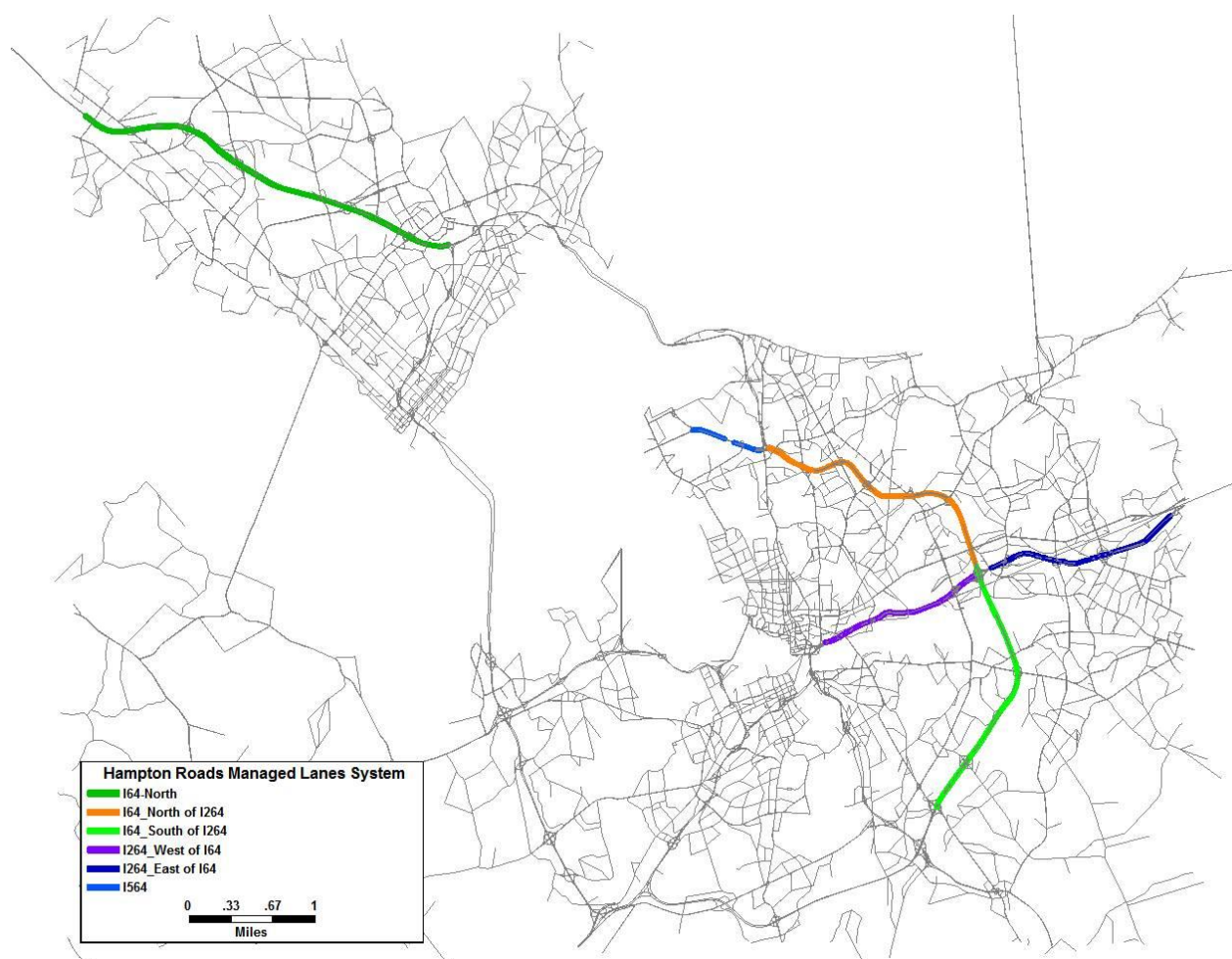
Toll Policy

SOV and HOV2 vehicles were allowed to use the Managed Lanes for a toll and the HOV3+ traffic could use the facility for free. Trucks were banned from using the Managed Lanes.

The Managed Lanes policy was only applied during the peak periods (i.e., 6 AM to 9 AM and 3 PM to 6 PM). During the off peak periods, the original HOV policy was applied.
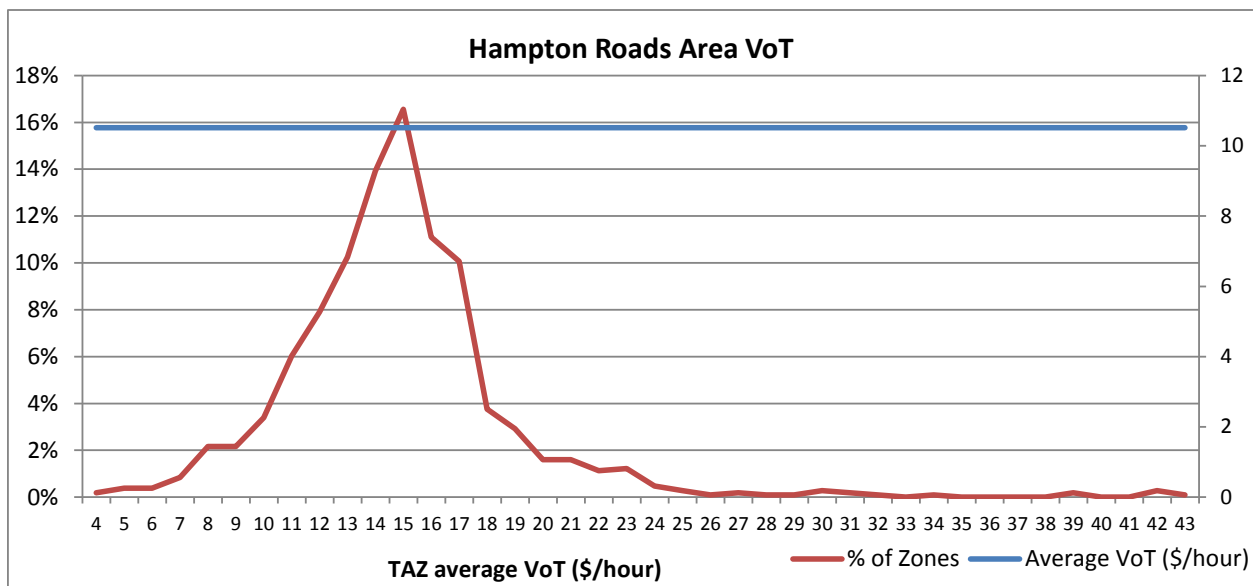
Managed lane toll rates were set through an iterative process with the objective that managed lane speeds should be maintained at 45 miles per hour or greater.

Toll Diversion Modeling

The SOV, HOV2, and HOV3+ traffic was split between the toll and toll free path based on the ratio of the generalized costs between the toll and non-toll path and a toll diversion curve borrowed from other studies. The toll path was the path that included the managed lanes and the toll free path was the path using the general purpose lanes. The toll on the managed lanes was converted to travel time through the value-of-time index (VoT) and included in the generalized cost function for the toll path.

The zonal value-of-time index was estimated based on the household income data from the 2010 Census. Average TAZ value-of-time for SOV traveler was estimated as 40 percent of average zonal house income. The value-of-time for HOV 2 and HOV 3+ travelers was set to be 20 and 30 percent higher than that of SOV travelers. Under this approach, the average value-of-time in the Hampton Roads area was $10.51 per hour, close to the global value of $10.01 per hour applied in the original model. The VoT applied to the trips between zone I and zone J was defined as the average of the VoT of zone I and zone J. Figure 2 presents the zonal VoT distribution and the average VoT in the Hampton Roads area estimated from 2010 Census.

*Figure 2: Hampton Roads area zonal value-of-time distribution*

Model Integration

The toll rates on the managed lanes were set through a feedback loop with the objective of maintaining the speeds on the managed lanes at 45 mph or greater. A sub application was developed to implement the toll setting process. It was added to the regional model for AM and PM peak periods, as illustrated in figure 3.
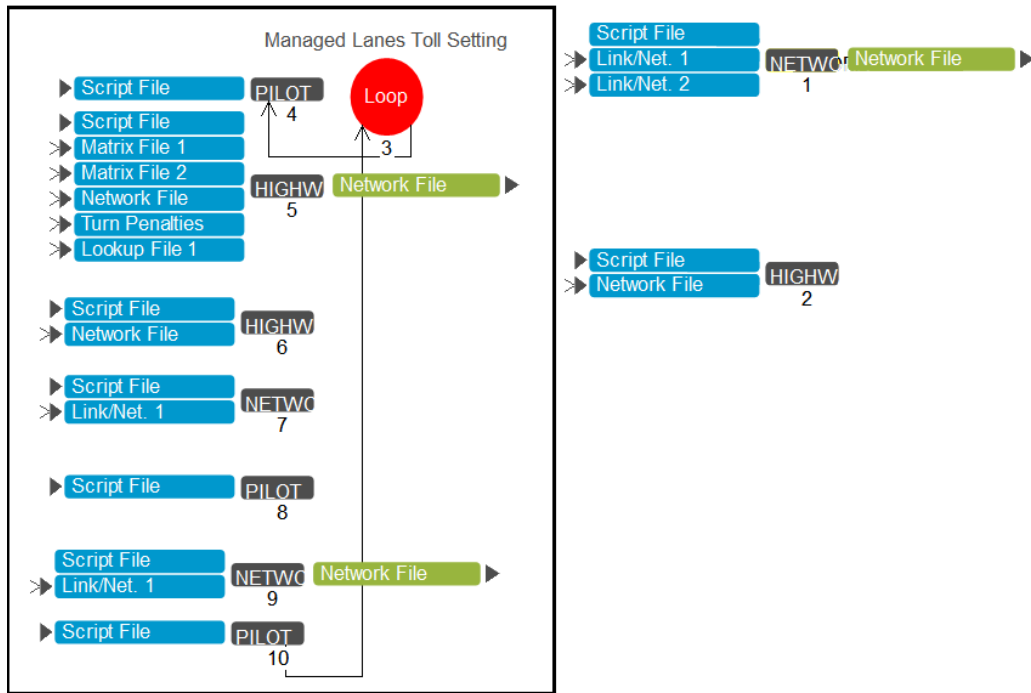
Four additional keys were added to the Regional model for the managed lanes process, as illustrated in figure 4. The "Managed Lanes Process" key is a check box that allows the user to choose whether to implement the managed lane process or continue with the original modeling process. If the check box is checked, the managed lane process will be implemented. If not, the managed lanes process will be bypassed and the original modeling process will be implemented. The "Managed Lanes Minimum Speed" key allows the user to set the managed lane minimum speed for the toll rate setting process. The "Managed lane minimum toll rate" key sets the minimum toll rate for the toll rate setting process as a starting point to find the optimal rate for the minimum speed defined by the minimum speed key. The "Toll Rate Increment" key defines the amount the toll rate will increase in each iteration as the algorithm attempts to adjust the toll to maintain the desired speed.

Figure 4: Additional keys for the managed lanes process

Highway Assignment RELGAP Parameter	0.01
Year for port trip generation data	2009
otrace	1
dtrace	1
Radius	1
PKVOT	16.67
OPVOT	16.67
IntZones	1-1447,1500-1503
ExtZones	1448-1499
James River Distance Factor	4.2
AM CAPFAC	2.6
MD CAPFAC	5
PM CAPFAC	2.9
NT CAPFAC	4.3
PROCESSLIST	1-24
TrueShpDisp_SHP_FIle	R:\CUBE\Temp_LZ\HR_ver1.2_ML\Base_2009\Future_2034\HR_Highway_TrueShapes_final.shp Browse ... Edit ...
TrueShpDisp_DBF_FIle	R:\CUBE\Temp_LZ\HR_ver1.2_ML\Base_2009\Future_2034\HR_Highway_TrueShapes_final.dbf Browse ... Edit ...
TrueShpDisp_SHX_FIle	R:\CUBE\Temp_LZ\HR_ver1.2_ML\Base_2009\Future_2034\HR_Highway_TrueShapes_final.shx Browse ... Edit ...
Prepare Model Reports and Maps	1
Base Year Run	0

Managed Lanes Process Parameters

☑ Managed Lanes Process (check to apply the managed lanes process)

Managed Lanes Minimum Speed	45
Managed Lanes Minimum Toll Rate (cent/mile)	10
Managed Lanes Toll Rate Increment (cent/mile)	5

[Save] [Close] [Next...] [Back...] [Run]

A file folder named "ML" is manually created under the model input folder (\Base_2009\Future_2034\) to store the input file for the managed lanes process. Three additional input files are needed to run the managed lanes process. The file named "HR_HOT_GRP_2034.csv" contains A node, B node, and a link code that defines the managed lane links. This file also includes the GP lane links for the none-toll path building and the convenience of post processing analysis. The file "VOT_HR.mat" is the value of time matrix and file "HOT_DIV.DBF" is the toll diversion file. After the managed lanes process run is complete, two additional files are created in this folder. The new files, named TOLL_ML_AM.CSV and TOLL_ML_PM.CSV, include the final SOV and HOV2 toll rates for AM and PM peak period.

The output files created by the managed lanes process are in the same format as the original regional model. The only difference is that an additional attribute named "HOT_GRP" is added to the loaded network to identify the managed lane links. The intermediate files from the managed lanes process, mainly the loaded networks for each iteration of the toll rate searching, are stored in "\Output\Base_2009.Future_2034\ML". A command was added to the first pilot application script of the first setup application group to automatically generate the sub folder "ML" for storing the managed lane intermediate output files.

Model Results

Table 1 presents a summary of the AM peak period traffic characteristics for the managed lanes and general purpose lanes separated by facility, segment, and direction. The road segment definitions of the Hampton Roads area managed lanes can be found in Figure 1. Table 2 shows the similar information for the HOV scenario. Tables 3 and 4 present the same information for the PM peak period.

Table 5 and 6 present AM and PM peak period express lanes market shares for the managed lanes and HOV lanes scenarios.

Overall, the converting of HOV lanes to managed lanes increases the express lane road utilization and reduces the congestion on general purpose lanes. The total demand along the corridor was slightly lower after imposing tolls to SOV and HOV2+ traffic to use the express lanes.

In the AM peak period, managed lane speeds stay above 45 mph under the minimum toll rate of 10 cent per mile for most segments, except on eastbound I-64 north and westbound I-264 east of I-64. In the PM peak period, maximum toll rates of 35, 65, and 115 cent per mile were needed to keep the managed lane speeds over 45 miles per hour on eastbound I-64 north, westbound I-64 north, and eastbound I-264 east of I-64.

It is worth noting that the managed lanes traffic estimates were made based on the parameters borrowed from other studies and that used in the regional model. For a higher level study, more traffic and travel behave data are needed to verify the input parameters, including the total demand and mode split along the corridors, the regional traveler's willingness to pay toll, and the traffic peak period characteristics and others.

Table 1: Hampton Roads managed lanes traffic – AM Peak Period

Facility	Segment	Dir	Weighted Lanes	Weighted Capcity	FFSPD	Length	Toll Rate (cent/mile) Min	Toll Rate Max	Toll Rate Avg	Congested Speed Min	Congested Speed Max	Congested Speed Avg	SOV	HOV2	HOV3	TRK	TOTAL	V/C
Managed Lanes																		
I64	I64-North	WB	1.00	5,094	60.5	9.97	10.0	10.0	10.0	51.6	59.6	55.9	1,752	238	766	-	2,756	0.54
I64	I64-North	EB	1.00	5,058	60.5	9.14	10.0	75.0	15.5	45.5	63.6	51.4	2,341	262	830	-	3,433	0.68
I64	I64-North of I264	WB	1.90	9,387	58.7	7.32	10.0	10.0	10.0	55.4	58.5	57.1	2,078	237	649	-	2,964	0.32
I64	I64-South of I264	NB	1.00	5,373	64.6	6.93	10.0	10.0	10.0	55.5	69.8	60.5	1,642	229	784	-	2,655	0.49
I264	I264-West of I64	WB	1.00	4,940	59.7	4.03	10.0	10.0	10.0	53.7	59.5	56.6	1,319	178	675	-	2,172	0.44
I264	I264-East of I64	WB	1.00	5,231	59.8	6.60	10.0	25.0	11.2	45.5	59.5	51.1	2,158	344	984	-	3,486	0.67
General Purpose Lanes																		
I64	I64-North	WB	3.24	16,500	60.7	9.82	0.0	0.0	0.0	49.5	57.8	53.5	8,165	861	-	958	9,984	0.61
I64	I64-North	EB	3.14	15,881	60.4	9.11	0.0	0.0	0.0	29.8	58.1	44.9	10,656	1,034	-	730	12,420	0.78
I64	I64-North of I264	WB	3.21	15,881	59.6	6.47	0.0	0.0	0.0	43.7	53.6	49.9	9,565	1,247	4	552	11,369	0.72
I64	I64-South of I264	NB	2.95	15,851	64.6	6.55	0.0	0.0	0.0	24.3	67.6	48.5	9,407	1,313	65	476	11,261	0.71
I264	I264-West of I64	WB	2.74	13,552	59.7	4.52	0.0	0.0	0.0	39.9	54.5	48.7	8,362	1,061	-	206	9,628	0.71
I264	I264-East of I64	WB	4.50	24,347	63.3	5.59	0.0	0.0	0.0	40.3	58.8	56.1	12,438	1,781	18	573	14,810	0.61
ML + GP Lanes																		
I64	I64-North	WB	4.24	21,595		9.90							9,917	1,099	766	958	12,739	0.59
I64	I64-North	EB	4.14	20,939		9.13							12,997	1,296	830	730	15,853	0.76
I64	I64-North of I264	WB	5.12	25,269		6.90							11,644	1,484	653	552	14,333	0.57
I64	I64-South of I264	NB	3.95	21,224		6.74							11,049	1,542	849	476	13,916	0.66
I264	I264-West of I64	WB	3.74	18,492		4.28							9,681	1,239	675	206	11,800	0.64
I264	I264-East of I64	WB	5.50	29,578		6.10							14,596	2,125	1,002	573	18,296	0.62

Table 2: Hampton Roads HOV lanes traffic – AM Peak Period

Facility	Segment	Dir	Weighted Average			Length	Toll Rate (cent/mile)			Congested Speed			Weighted Average Volume					V/C
			Lanes	Capcity	FFSPD		Min	Max	Avg	Min	Max	Avg	SOV	HOV2	HOV3	TRK	TOTAL	
HOV Lanes																		
I64	I64-North	WB	1.00	5,094	60.7	9.97	0.0	0.0	0.0	54.4	61.8	58.1	-	1,450	682	-	2,132	0.42
I64	I64-North	EB	1.00	5,058	60.7	9.14	0.0	0.0	0.0	52.6	62.1	56.2	-	1,948	793	-	2,741	0.54
I64	I64-North of I264	WB	1.90	9,387	58.7	7.32	0.0	0.0	0.0	56.1	59.2	57.8	-	1,405	571	-	1,976	0.21
I64	I64-South of I264	NB	1.00	5,373	64.9	6.93	0.0	0.0	0.0	56.0	68.8	61.0	-	1,845	744	-	2,589	0.48
I264	I264-West of I64	WB	1.00	4,940	59.7	4.03	0.0	0.0	0.0	54.8	57.7	56.7	-	1,643	602	-	2,245	0.45
I264	I264-East of I64	WB	1.00	5,231	60.7	6.60	0.0	0.0	0.0	53.9	60.0	55.9	-	2,089	810	-	2,900	0.55
General Purpose Lanes																		
I64	I64-North	WB	3.24	16,500	60.8	9.82	0.00	0.00	0.00	42	56	48.8	10,961	76	36	806	11,879	0.72
I64	I64-North	EB	3.14	15,881	60.5	9.11	0.00	0.00	0.0	23	56	40.5	12,995	92	38	550	13,674	0.86
I64	I64-North of I264	WB	3.21	15,881	59.6	6.47	0.00	0.00	0.00	40	52	40.9	11,304	612	248	408	12,572	0.79
I64	I64-South of I264	NB	2.95	15,851	64.9	6.55	0.00	0.00	0.00	19	66	47.5	11,301	345	140	350	12,137	0.77
I264	I264-West of I64	WB	2.74	13,552	59.7	4.52	0.00	0.00	0.00	42	53	53.6	10,281	54	19	181	10,536	0.78
I264	I264-East of I64	WB	4.50	24,347	63.4	5.59	0.00	0.00	0.00	39	57	46.0	15,786	409	160	510	16,864	0.69
GP + HOV Lanes																		
I64	I64-North	WB	4.24	21,595		9.90							10,961	1,526	719	806	14,012	0.65
I64	I64-North	EB	4.14	20,939		9.13							12,995	2,041	830	550	16,415	0.78
I64	I64-North of I264	WB	5.12	25,269		6.90							11,304	2,017	819	408	14,548	0.58
I64	I64-South of I264	NB	3.95	21,224		6.74							11,301	2,190	885	350	14,726	0.69
I264	I264-West of I64	WB	3.74	18,492		4.28							10,281	1,697	621	181	12,781	0.69
I264	I264-East of I64	WB	5.50	29,578		6.10							15,786	2,498	971	510	19,764	0.67

Table 3: Hampton Roads managed lanes traffic – PM Peak Period

Facility	Segment	Dir	Weighted Lanes	Weighted Capcity	FFSPD	Length	Toll Rate Min	Toll Rate Max	Toll Rate Avg	Congested Speed Min	Congested Speed Max	Congested Speed Avg	SOV	HOV2	HOV3	TRK	TOTAL	V/C
												Managed Lanes						
I64	I64-North	WB	1.00	5,682	60.5	9.97	10.0	35.0	13.9	45.2	59.4	50.5	2,515	337	1,192	-	4,044	0.71
I64	I64-North	EB	1.00	5,641	60.5	9.14	10.0	65.0	15.5	46.9	63.4	53.5	2,078	330	1,126	-	3,534	0.63
I64	I64-North of I264	EB	1.90	10,471	58.7	7.32	10.0	10.0	10.0	55.2	58.6	56.8	2,343	347	942	-	3,632	0.35
I64	I64-South of I264	SB	1.00	5,978	64.2	6.46	10.0	10.0	10.0	54.1	67.3	58.6	1,907	332	1,161	-	3,400	0.57
I264	I264-West of I64	EB	1.00	5,510	59.9	3.46	10.0	10.0	10.0	51.2	58.9	53.7	1,961	357	1,111	-	3,429	0.62
I264	I264-East of I64	EB	1.00	5,842	60.1	6.75	10.0	115.0	14.3	45.1	58.9	52.0	2,013	388	1,456	-	3,857	0.66
I564	I564	WB	1.21	6,673	60.0	0.90	10.0	10.0	10.0	60.0	60.0	60.0	-	-	-	-	-	0.00
I564	I564	EB	1.00	5,510	60.0	0.75	10.0	10.0	10.0	55.0	57.6	57.3	1,947	185	218	-	2,350	0.43
												General Purpose Lanes						
I64	I64-North	WB	3.24	18,404	60.7	9.82	0.0	0.0	0.0	29.0	56.0	44.2	12,425	1,404	-	725	14,554	0.79
I64	I64-North	EB	3.14	17,714	60.4	9.11	0.0	0.0	0.0	35.1	58.4	48.5	10,541	1,312	-	970	12,823	0.72
I64	I64-North of I264	EB	3.15	17,351	58.9	6.58	0.0	0.0	0.0	39.4	53.6	47.8	10,659	1,707	6	498	12,871	0.74
I64	I64-South of I264	SB	3.09	18,436	64.6	6.32	0.0	0.0	0.0	17.6	66.9	49.8	10,957	1,844	136	500	13,437	0.73
I264	I264-West of I64	EB	3.00	16,530	59.9	3.81	0.0	0.0	0.0	47.9	55.0	50.4	10,075	1,649	-	269	11,992	0.73
I264	I264-East of I64	EB	4.55	27,249	62.6	5.94	0.0	0.0	0.0	40.0	58.5	53.9	14,422	2,521	1	562	17,506	0.64
I564	I564	WB	3.00	16,530	60.0	0.74	0.0	0.0	0.0	59.8	59.8	59.8	763	159	-	70	992	0.06
I564	I564	EB	2.00	11,020	60.0	0.74	0.0	0.0	0.0	55.5	57.7	57.5	3,986	353	-	96	4,435	0.40
												ML + GP Lanes						
I64	I64-North	WB	4.24	24,086		9.90							14,940	1,741	1,192	725	18,598	0.77
I64	I64-North	EB	4.14	23,355		9.13							12,619	1,642	1,126	970	16,357	0.70
I64	I64-North of I264	WB	5.05	27,821		6.95							13,002	2,054	948	498	16,503	0.59
I64	I64-South of I264	NB	4.09	24,415		6.39							12,865	2,175	1,297	500	16,837	0.69
I264	I264-West of I64	WB	4.00	22,040		3.64							12,036	2,006	1,111	269	15,421	0.70
I264	I264-East of I64	WB	5.55	33,092		6.35							16,435	2,910	1,457	562	21,363	0.65
I564	I564	WB	4.21	23,203		0.82							763	159	-	70	992	0.04
I564	I564	EB	3.00	16,530		0.75							5,934	538	218	96	6,785	0.41

Table 4: Hampton Roads HOV lanes traffic – PM Peak Period

Facility	Segment	Dir	Weighted Average			Length	Toll Rate (cent/mile)			Congested Speed			Weighted Average Volume					V/C
			Lanes	Capcity	FFSPD		Min	Max	Avg	Min	Max	Avg	SOV	HOV2	HOV3	TRK	TOTAL	
HOV Lanes																		
I64	I64-North	WB	1.00	5,682	60.7	9.97	0.0	0.0	0.0	46.5	59.2	52.8	-	2,707	1,163	-	3,869	0.68
I64	I64-North	EB	1.00	5,641	60.7	9.14	0.0	0.0	0.0	51.0	61.7	55.2	-	2,292	1,074	-	3,366	0.60
I64	I64-North of I264	EB	1.90	10,471	58.7	7.32	0.0	0.0	0.0	55.7	59.1	57.4	-	2,067	868	-	2,935	0.28
I64	I64-South of I264	SB	1.00	5,978	64.5	6.46	0.0	0.0	0.0	52.9	67.3	57.4	-	2,604	1,075	-	3,679	0.62
I264	I264-West of I64	EB	1.00	5,510	59.9	3.46	0.0	0.0	0.0	52.6	56.6	53.7	-	2,556	1,006	-	3,561	0.65
I264	I264-East of I64	EB	1.00	5,842	60.9	6.75	0.0	0.0	0.0	38.9	58.4	54.3	-	2,672	1,083	-	3,756	0.64
I564	I564	WB	1.21	6,673	60.0	0.90	0.0	0.0	0.0	60.0	60.0	60.0	-	-	-	-	-	0.00
I564	I564	EB	1.00	5,510	60.0	0.75	0.0	0.0	0.0	58.5	59.4	59.3	-	687	215	-	902	0.16
General Purpose Lanes																		
I64	I64-North	WB	3.24	18,404	60.8	9.82	0.00	0.00	0.00	18	52	38.7	15,465	110	48	556	16,178	0.88
I64	I64-North	EB	3.14	17,714	60.5	9.11	0.00	0.00	0.0	26	56	43.7	13,376	115	51	823	14,365	0.81
I64	I64-North of I264	EB	3.15	17,351	58.9	6.58	0.00	0.00	0.00	30	52	39.2	12,712	762	310	399	14,183	0.82
I64	I64-South of I264	SB	3.09	18,436	64.8	6.32	0.00	0.00	0.00	14	66	49.8	13,236	514	211	398	14,359	0.78
I264	I264-West of I64	EB	3.00	16,530	59.9	3.81	0.00	0.00	0.00	44	55	52.4	12,606	81	31	227	12,944	0.78
I264	I264-East of I64	EB	4.55	27,249	62.7	5.94	0.00	0.00	0.00	38	57	46.1	17,859	798	324	493	19,474	0.71
I564	I564	WB	3.00	16,530	60.0	0.74	0.00	0.00	0.00	60	60	49.0	1,145	239	86	126	1,596	0.10
I564	I564	EB	2.00	11,020	60.0	0.74	0.00	0.00	0.00	51	56	54.7	5,895	4	1	128	6,028	0.55
GP + HOV Lanes																		
I64	I64-North	WB	4.24	24,086		9.90							15,465	2,817	1,210	556	20,048	0.83
I64	I64-North	EB	4.14	23,355		9.13							13,376	2,407	1,125	823	17,730	0.76
I64	I64-North of I264	WB	5.05	27,821		6.95							12,712	2,829	1,178	399	17,118	0.62
I64	I64-South of I264	NB	4.09	24,415		6.39							13,236	3,118	1,286	398	18,038	0.74
I264	I264-West of I64	WB	4.00	22,040		3.64							12,606	2,637	1,036	227	16,505	0.75
I264	I264-East of I64	WB	5.55	33,092		6.35							17,859	3,470	1,407	493	23,229	0.70
I564	I564	WB	4.21	23,203		0.82							1,145	239	86	126	1,596	0.07
I564	I564	EB	3.00	16,530		0.75							5,895	691	216	128	6,931	0.42

Table 5: AM Peak Period express lanes market shares

Express Lanes Traffic Share										
			Managed Lanes				HOV Lanes			
Facility	Segment	Dir	SOV	HOV2+	HOV3+	Total	SOV	HOV2+	HOV3+	Total
I64	I64-North	WB	18%	22%	100%	22%	0%	95%	95%	15%
I64	I64-North	EB	18%	20%	100%	22%	0%	95%	95%	17%
I64	I64-North of I264	EB	18%	16%	99%	21%	0%	70%	70%	14%
I64	I64-South of I264	SB	15%	15%	92%	19%	0%	84%	84%	18%
I264	I264-West of I64	EB	14%	14%	100%	18%	0%	97%	97%	18%
I264	I264-East of I64	EB	15%	16%	98%	19%	0%	84%	83%	15%

Table 6: PM Peak Period express lanes market shares

Express Lanes Traffic Share										
			Managed Lanes				HOV Lanes			
Facility	Segment	Dir	SOV	HOV2+	HOV3+	Total	SOV	HOV2+	HOV3+	Total
I64	I64-North	WB	17%	19%	100%	22%	0%	96%	96%	19%
I64	I64-North	EB	16%	20%	100%	22%	0%	95%	95%	19%
I64	I64-North of I264	EB	18%	17%	99%	22%	0%	73%	74%	17%
I64	I64-South of I264	SB	15%	15%	89%	20%	0%	84%	84%	20%
I264	I264-West of I64	EB	16%	18%	100%	22%	0%	97%	97%	22%
I264	I264-East of I64	EB	12%	13%	100%	18%	0%	77%	77%	16%
I564	I564	WB	0%	0%	0%	0%	0%	0%	0%	0%
I564	I564	EB	33%	34%	100%	35%	0%	99%	99%	13%