National Capital Region Transportation Planning Board
777 North Capitol Street, N.E., Suite 300, Washington, D.C. 20002-4290 (202) 962-3310 Fax: (202) 962-3202 TDD: (202) 962-3213

Memorandum

Date: March 15, 2013

To: Subrat Mahapatra (MD SHA)

From: Wenjing Pu (COG/TPB)

Re: INRIX Data Analysis for the Intercounty Connector (ICC) Before and After Study

CC: Elena Constantine, Ronald Kirby, Andrew Meese, Dusan Vuksan (COG/TPB)

The purpose of this memorandum is to summarize the results of the INRIX data analysis for the Intercounty Connector (ICC) Before and After Study and document the technical process used by this analysis.

Key Findings

Significant congestion reduction and travel time reliability improvement were observed in the Intercounty Connector (ICC) Study Area from 2010 (before) and 2012 (after). Although the entire Modeled Area of the National Capital Region Transportation Planning Board generally experienced better traffic conditions in 2012 than 2010, **the ICC Study Area experienced a greater magnitude of improvement in congestion reduction and travel time reliability than did the region overall, by a margin of about 3-4 percentage points**. More specifically, during the AM (8:00-9:00 am) and PM (5:00-6:00 pm) peak hours:

- The Percentage of Congested Route-Miles in the ICC Study Area decreased by 13-19 percentage points (pp); the regional average decrease was 9 pp.
- The Percentage of severely congested route-miles in the ICC Study Area decreased by 3-6 pp; the regional average decrease was only 1 pp.
- The Travel Time Index in the ICC Study Area decreased by 9-10%; the regional average decrease was 6-7%.
- The 80th percentile travel time-based Planning Time Index (PTI80) in the ICC Study Area decreased by 6-9%; the regional average decrease was 5-7%.
- The 95th percentile travel time-based Planning Time Index (PTI95) in the ICC Study Area decreased by 11-12%; the regional average decrease was 7-8%.

Changes from the "Before" Study

In December 2011, COG/TPB staff was requested by SHA to conduct a traffic congestion and reliability analysis in the ICC study area for the "Before" scenario using COG/TPB procured INRIX data. In September 2012, the I-95 Corridor Coalition Vehicle Probe Project (VPP) was expanded to cover all TMC-coded roads in Maryland. As a result, COG/TPB staff was able to download 5-minute

raw data for 2010 and 2012 from the I-95 Traffic Monitoring website (www.i95.inrix.com). Since there were differences and inconsistencies between the COG/TPB procured data and the VPP data, it was highly desirable to use the same raw data to conduct the before and after analysis. Therefore, the current analysis was all based on the 5-minute raw data retrieved from the VPP.

Network Preparation

ICC Study Area (ICC Area)

A total of 790 TMCs or 422 directional route-miles of highways, including 340 route-miles of arterials and 82 route-miles of freeways, were covered in the ICC Study Area (FIGURE 1).

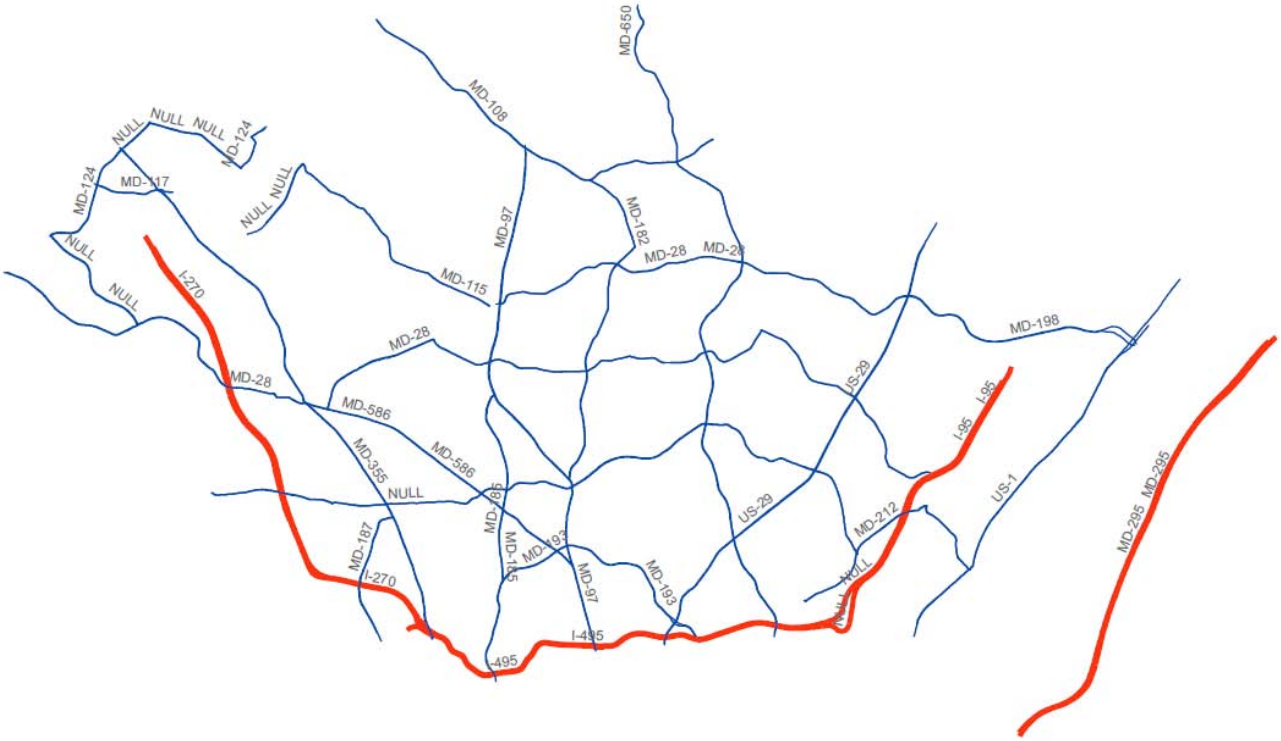

FIGURE 1 ICC Study Area

The version 3.6 TMC table was edited to reflect the corridors, sections and segments defined by SHA. The resulting TMC table was provided in "TMCs.csv", in which:

- The "corridors" were defined by the "Overall Study Area" map provided by SHA (Appendix 1). This map provided 19 corridors and SHA requested two additional freeway corridors to be added in this study: a) MD-295 from MD-198 to I-495, and b) I-270 from I-370 to I-495 + I-495 from I-270 to I-95 + I-95 from I-495 to ICC. This resulted in 21 corridors and each corridor had two directions.

- The "segments" were defined by the "Control Points" map provided by SHA (Appendix 2). Staff of COG/TPB and SHA collaboratively identified the control points along the two freeway corridors added above, and appropriately adjusted the control points along the 19 arterial corridors.

- The "sections" were initially defined by SHA and then slightly adjusted by COG/TPB staff at start/end points where the TMC definitions did not match the section definitions (Appendix 3). A section is larger than a segment but shorter than a corridor. It met SHA's desire of reporting performance measures at an appropriate geographical level.

Regional Contexts

According to the INRIX National Traffic Scorecard[1], the United States including the Washington metropolitan area experienced decreasing traffic congestion from 2010 to 2012. During the same period, the FHWA Traffic Volume Trends[2] reports also showed declining vehicle volumes in the entire states of Maryland, Virginia, and the District of Columbia. In an effort trying to determine the net impact of the ICC on traffic congestion and reliability, the following regional background areas were used to establish relevant regional contexts:

- Maryland portion of the TPB Modeled Area excluding the ICC Study Area (MD w/o ICC Area)
- Maryland portion of the TPB Modeled Area including the ICC Study Area (MD w/ ICC Area)
- The entire TPB Modeled Area (TPB Mod)

Performance Measures

Percentage of Congested Route-Miles

24-Hour Profile

The Percentage of Congested Route-Miles reflects the spatial extent of congestion from a system perspective. FIGURE 2-5 show the Percentage of Congested Route-Miles by time of day during a typical weekday (Tuesdays, Wednesdays and Thursdays) in 2010 and 2012 for the ICC Study Area and three regional background areas (i.e., MD w/o ICC, MD w/ ICC, and TPB Mod).

Congestion was considered when Travel Time Index (TTI), the ratio of actual travel time to free flow travel time, was equal to or above 1.3[3]. The following steps were used to calculate the Percentage of Congested Route-Miles:

1) Calculate the annual average speed for each TMC by 5-minute increments (the harmonic mean[4] was used to average the speeds);
2) Calculate the Travel Time Index (TTI) = Reference Speed / Speed by 5-minute increments;
3) Calculate the total miles of TMCs with TTI >= 1.30 by 5-minute increments;
4) Calculate the Percentage of Congested Route-Miles by dividing the results from step 3) by the total number of miles for each 5-minute increments.

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1 INRIX, Inc., National Traffic Scorecard, http://scorecard.inrix.com
2 FHWA Office of Highway Policy Information, Travel Monitoring, Traffic Volume Trends https://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm
3 National Transportation Operations Coalition (NTOC) Performance Measurement Initiative, 2005 http://www.ntoctalks.com/ntoc/ntoc_final_report.pdf
4 The harmonic mean will ensure the true average of space mean speed is calculated; the commonly used arithmetic mean will usually yield higher average speed than the ground truth.

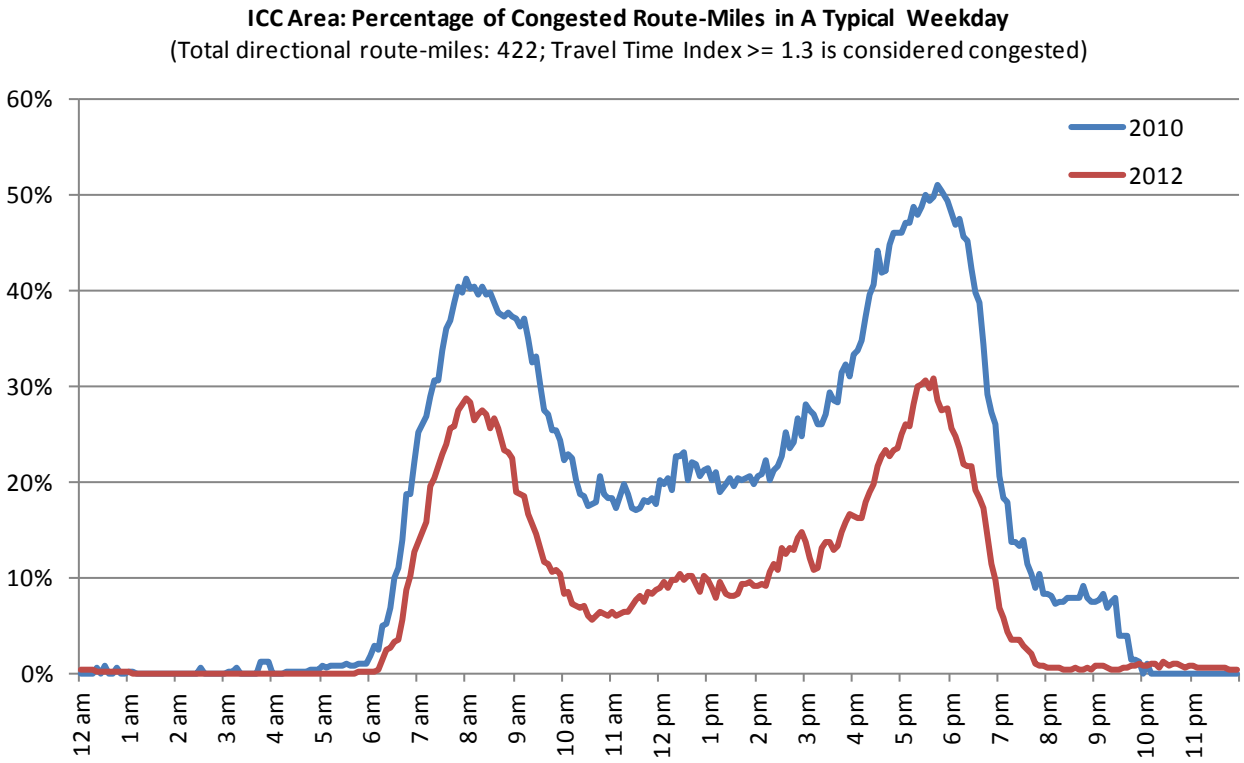


FIGURE 2 Percentage of Congested Route-Miles: ICC Study Area

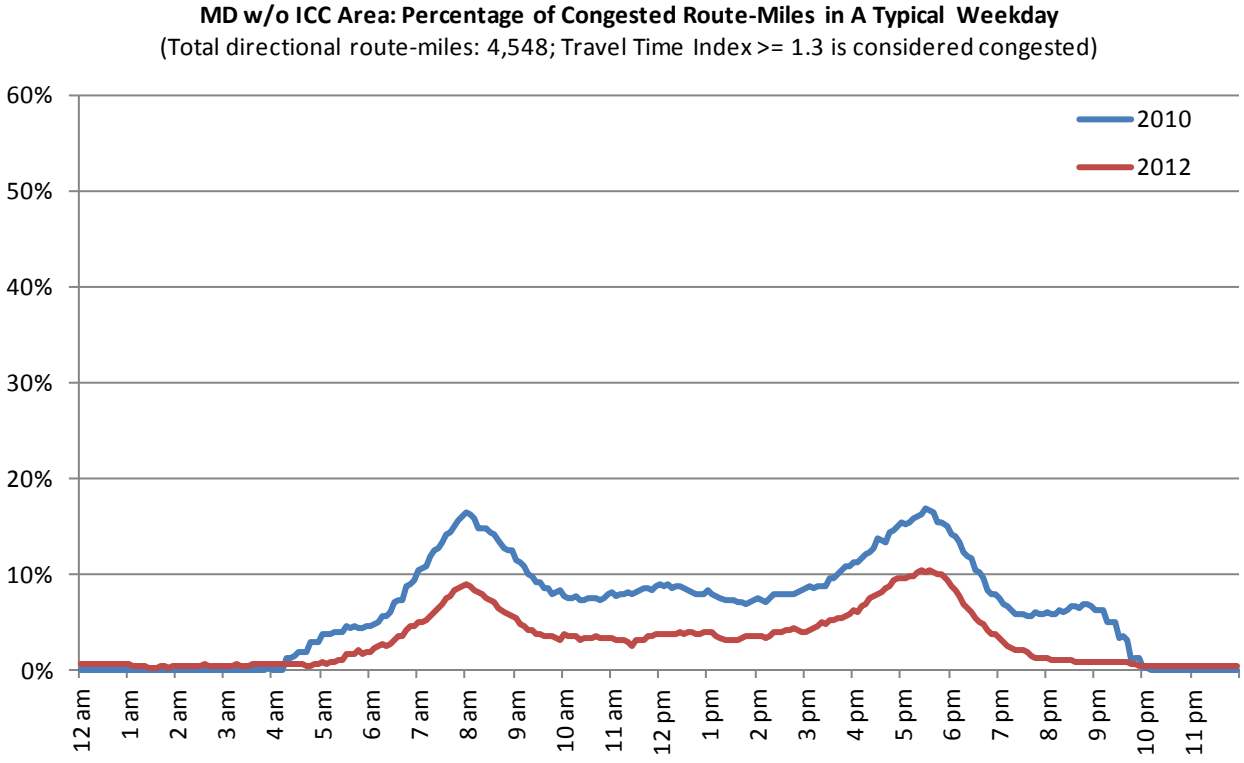


FIGURE 3 Percentage of Congested Route-Miles: MD w/o ICC Area

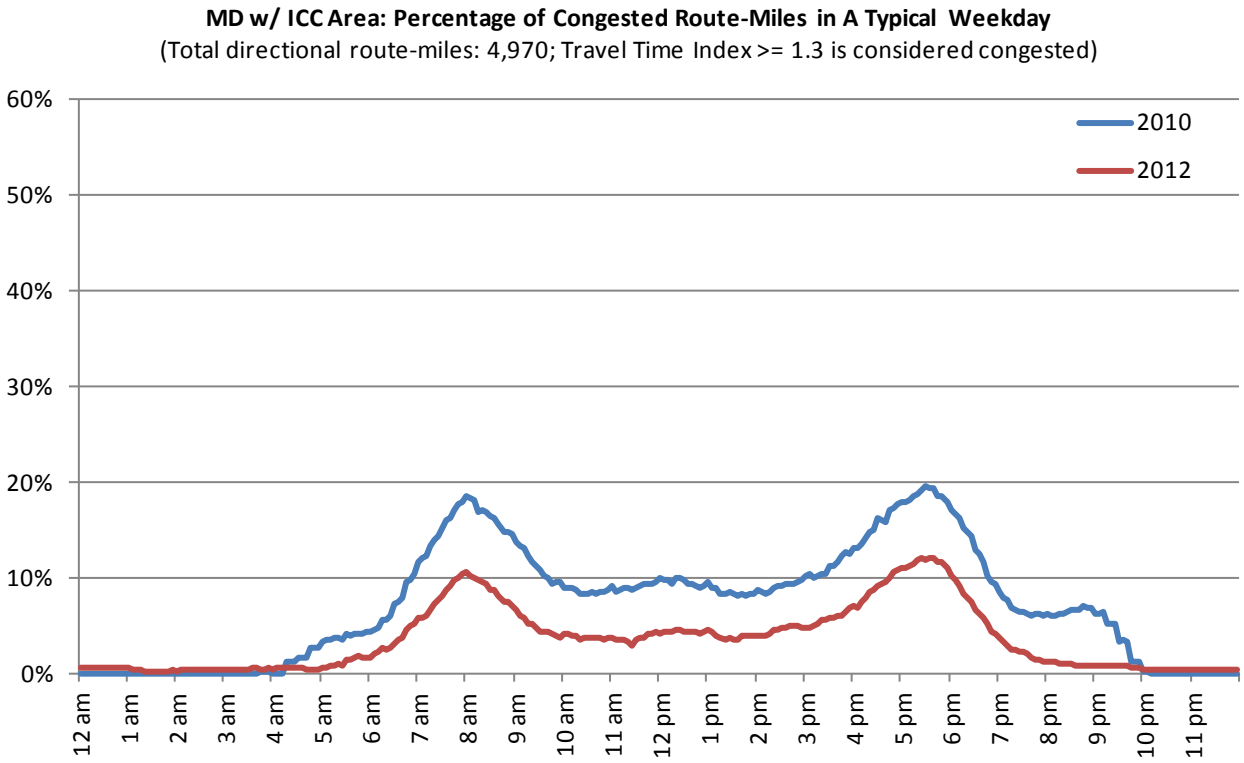


FIGURE 4 Percentage of Congested Route-Miles: MD w/ ICC Area

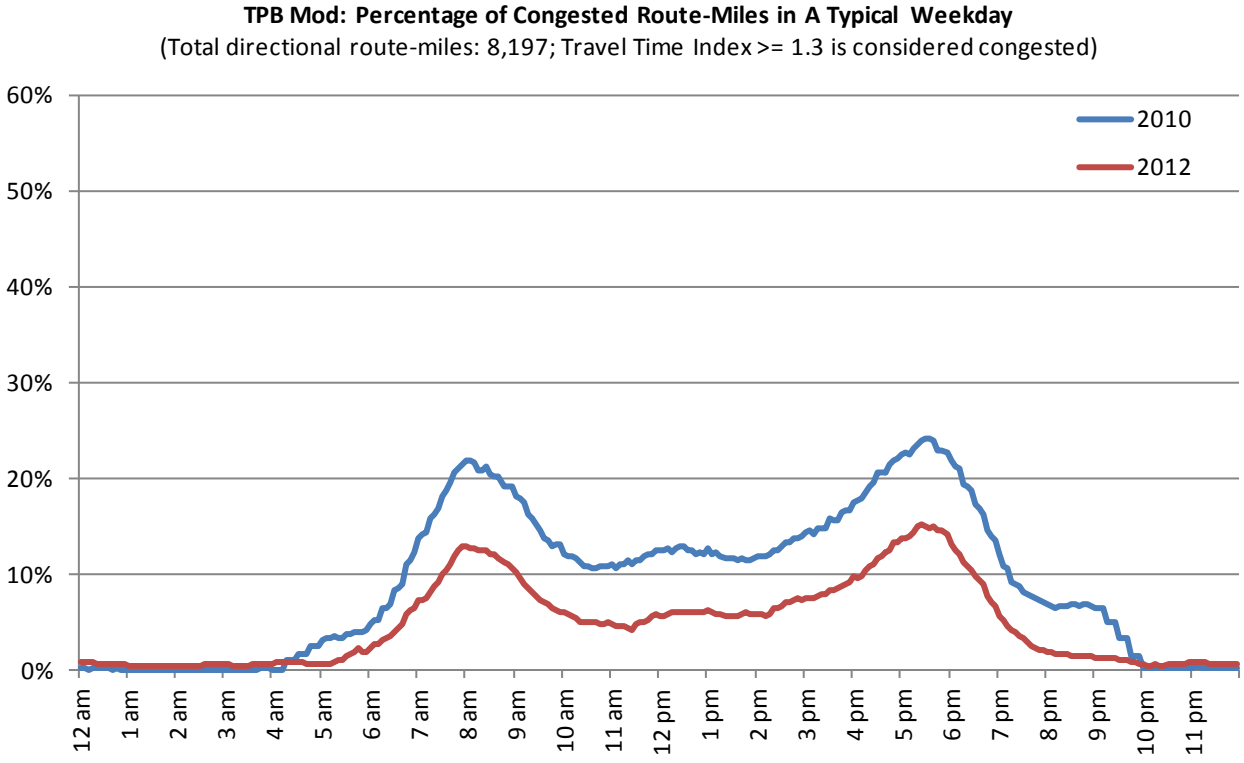


FIGURE 5 Percentage of Congested Route-Miles: TPB Mod

Peak Hour

The Percentage of Congested Route-Miles during AM (8:00-9:00 am) and PM (5:00-6:00 pm) peak hours are provided in FIGURE 6. Compared to the regional averages, the ICC Study Area experienced more widespread peak hour congestion in both 2010 and 2012. This spatial extent of congestion shrank in all areas from 2010 to 2012, but the biggest shrinkage came from the ICC Study Area (FIGURE 7):

- In the AM peak hour, the ICC Study Area had 40% of route-miles congested in 2010, and this number decreased to 27% in 2012, a 13 percentage point (pp) drop. During the same period, the background areas experienced only a 7-9 percentage point drop.

- In the PM peak hour, the ICC Study Area had 49% of route-miles congested in 2010, and this number decreased to 30% in 2012, a 19 percentage point (pp) drop. During the same period, the background areas experienced only a 6-9 percentage point drop.

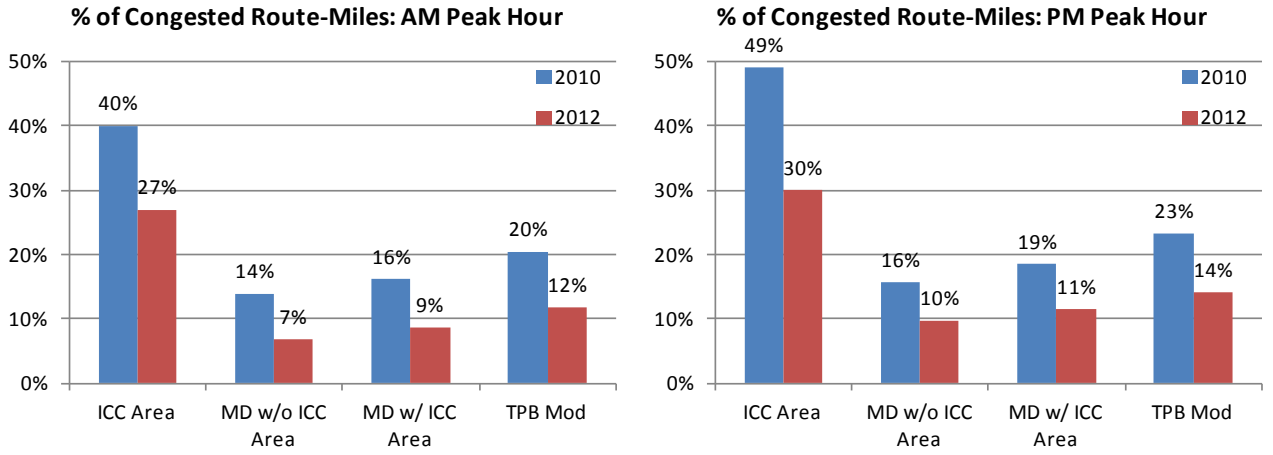


FIGURE 6 Percentage of Congested Route-Miles in AM and PM Peak Hours

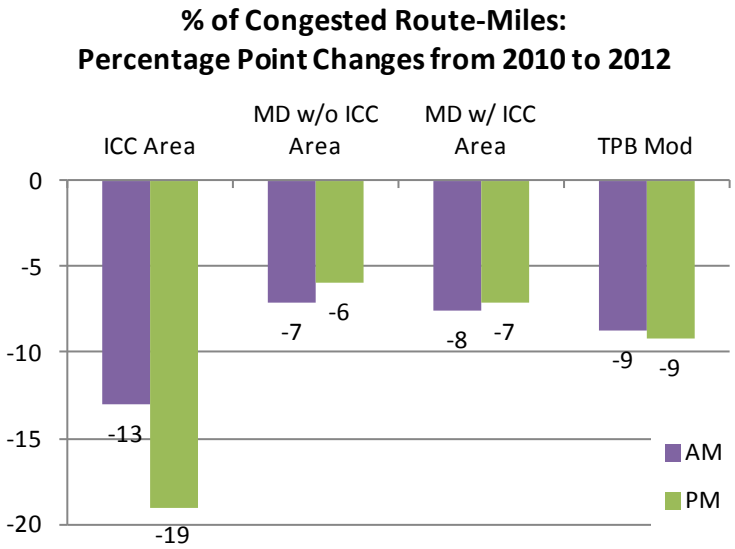


FIGURE 7 Changes of Percentage of Congested Route-Miles from 2010 to 2012

Percentages of Route-Miles by Congestion Level

Congestion Pie in ICC Study Area

The Percentages of Route-Miles by Congestion Level is also a system-wide measure of the extent of congestion. Compare to the previous measure – Percentage of Congested Route-Miles, this measure provides more detailed information about different congestion levels, i.e., uncongested (TTI < 1.15), light (1.15 <= TTI <1.3), moderate (1.3 <= TTI < 2), and severe (TTI > 2). FIGURE 8 provides the Percentage of Route-Miles by Congestion Level during peak hours for the ICC Study Area.

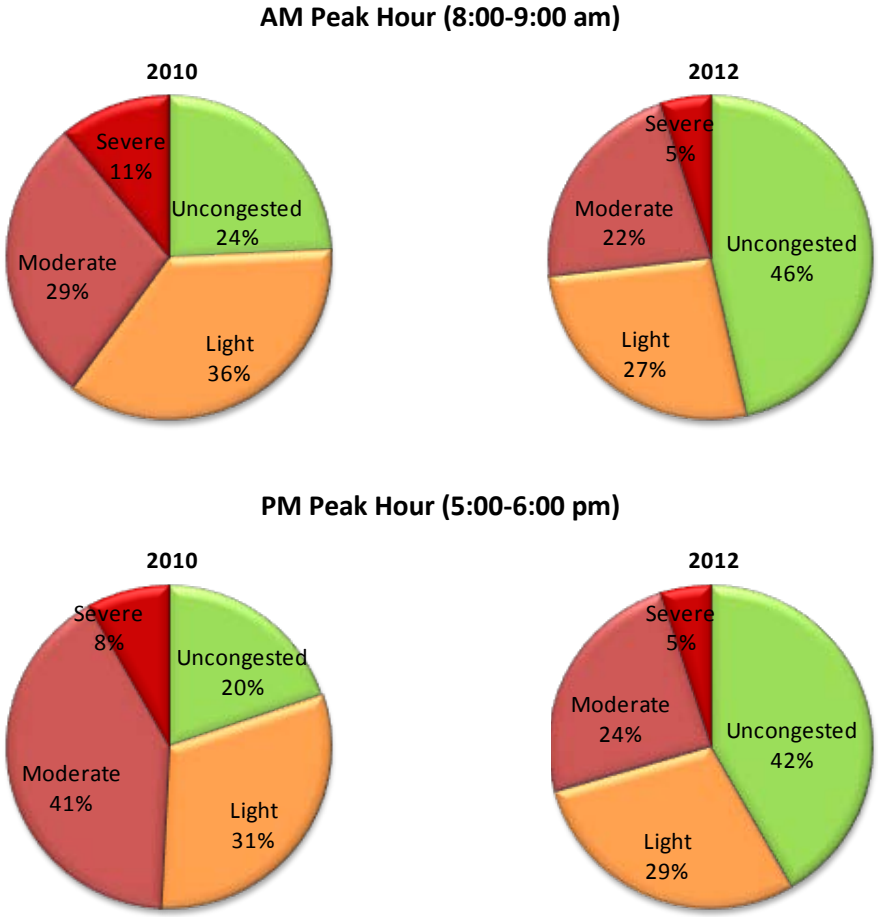


FIGURE 8 Percentages of Route-Miles by Congestion Level in the ICC Study Area

The following steps were used to calculate the Percentages of Route-Miles by Congestion Level:

1) Calculate the annual average speed for each TMC by 5-minute increments (the harmonic mean was used to average the speeds);
2) Calculate the Travel Time Index (TTI) = Reference Speed / Speed by 5-minute increments;
3) Calculate the average TTI for the AM and PM peak hour, respectively;
4) Calculate the route-miles by congestion level for the AM and PM peak hour, respectively;
5) Calculate the Percentage of Route-Miles by Congestion Level by dividing the results from step 4) by the total number of miles.

Severe Congestion

The Percentage of Severely Congested Route-Miles in the AM and PM peak hours are provided in FIGURE 9 for the ICC Study Area and the three regional comparison areas. The changes from 2010 to 2012 of this percentage are provided in FIGURE 10. It is clear that the ICC Study Area had a larger decline in the category of severe congestion than the comparison areas, especially in the AM peak hour.

- In the AM peak hour, the ICC Study Area had 11% of route-miles severely congested in 2010, and this number decreased to 5% in 2012, a 6 percentage point (pp) drop. During the same period, the background areas experienced up to a 1 percentage point drop.

- In the PM peak hour, the ICC Study Area had 8% of route-miles severely congested in 2010, and this number decreased to 5% in 2012, a 3 percentage point (pp) drop. During the same period, the background areas experienced up to a 1 percentage point drop.

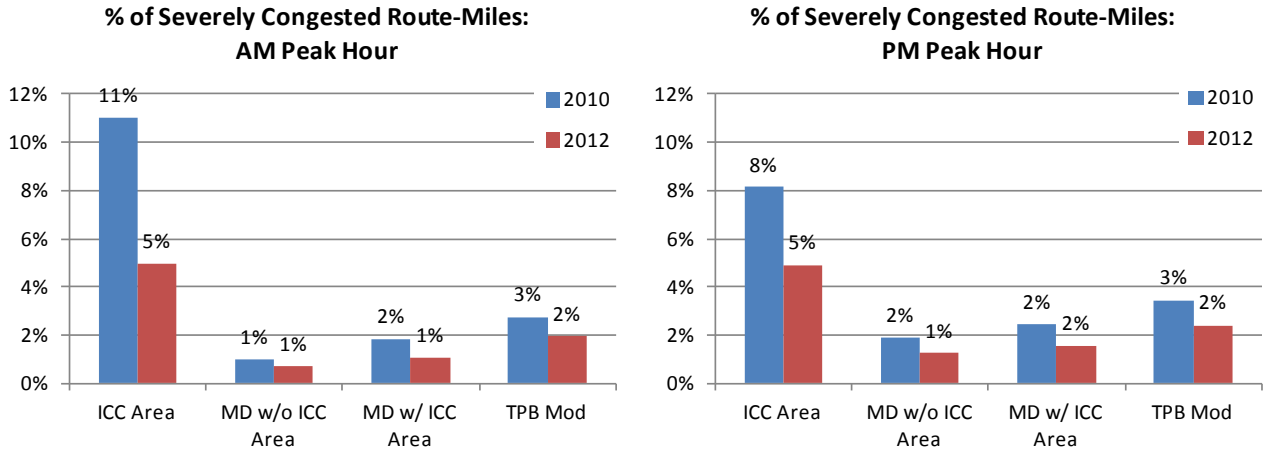


FIGURE 9 Percentages of Severely Congested Route-Miles in AM and PM Peak Hours

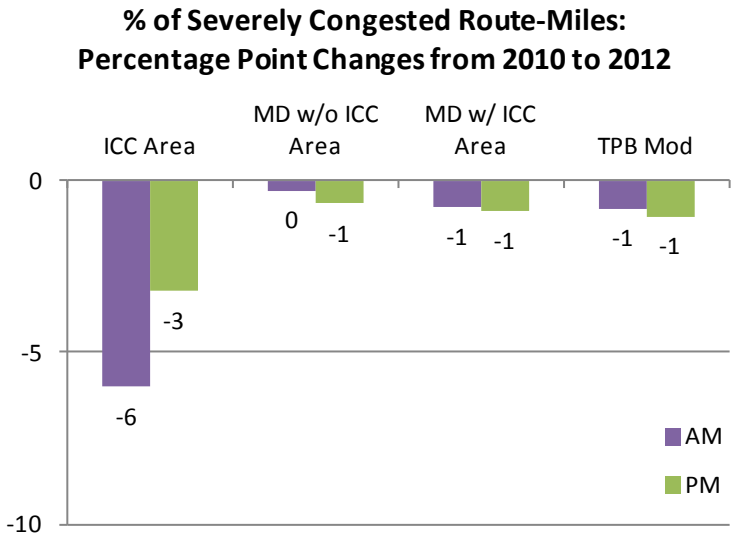


FIGURE 10 Changes of Percentage of Severely Congested Route-Miles from 2010 to 2012

Moderate Congestion

The Percentage of Moderately Congested Route-Miles in the AM and PM peak hours are provided in FIGURE 11 for the ICC Study Area and the three regional areas. The changes from 2010 to 2012 of this percentage are provided in FIGURE 12. The ICC Study Area had a similar decrease to regional areas in the category of moderate congestion in the AM peak hour. In the PM peak hour, the ICC Study Area doubled the decrease of the regional averages.

- In the AM peak hour, the ICC Study Area had 29% of route-miles moderately congested in 2010, and this number decreased to 22% in 2012, a 7 percentage point (pp) drop. During the same period, the background areas experienced a 7-8 percentage point drop.

- In the PM peak hour, the ICC Study Area had 41% of route-miles moderately congested in 2010, and this number decreased to 25% in 2012, a 16 percentage point (pp) drop. During the same period, the background areas experienced only a 5-8 percentage point drop.

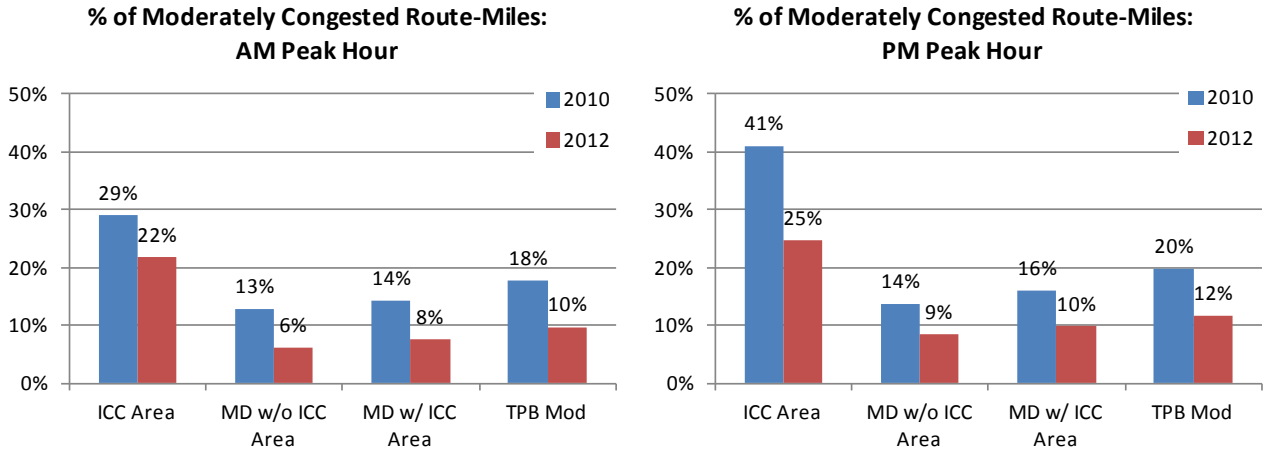


FIGURE 11 Percentages of Moderately Congested Route-Miles in AM and PM Peak Hours

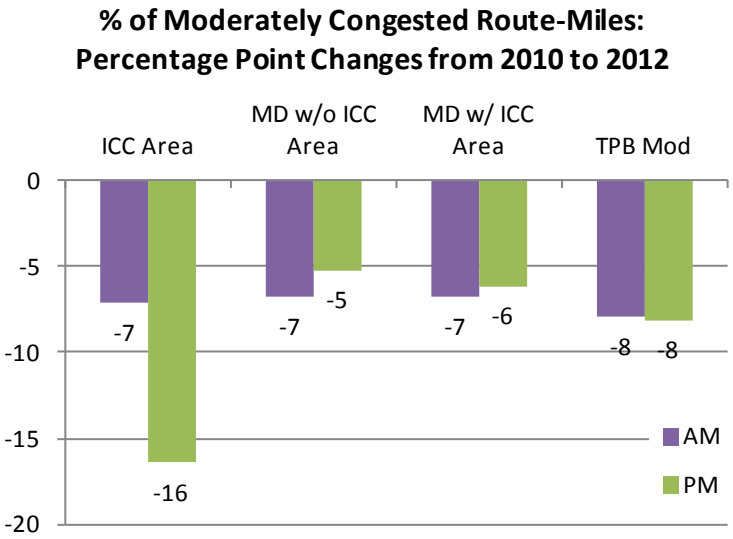


FIGURE 12 Changes of Percentage of Moderately Congested Route-Miles from 2010 to 2012

Travel Time Index

Regional Summaries

Travel Time Index (TTI) is a measure of congestion intensity. It is calculated as the ratio of actual travel time to free flow travel time, or the ratio of reference (free flow) speed to actual speed. The average Travel Time Index of the ICC Study Area and three regional background areas are provided in FIGURE 13. FIGURE 14 shows the changes from 2010 to 2012.

- In the AM peak hour, the ICC Study Area average Travel Time Index was 1.45 in 2010, and this index decreased to 1.30 in 2012, a 10% drop. During the same period, the background areas experienced only a 6-7% drop.

- In the PM peak hour, the ICC Study Area average Travel Time Index was 1.43 in 2010, and this index decreased to 1.29 in 2012, a 9% drop. During the same period, the background areas experienced only a 5-6% drop.

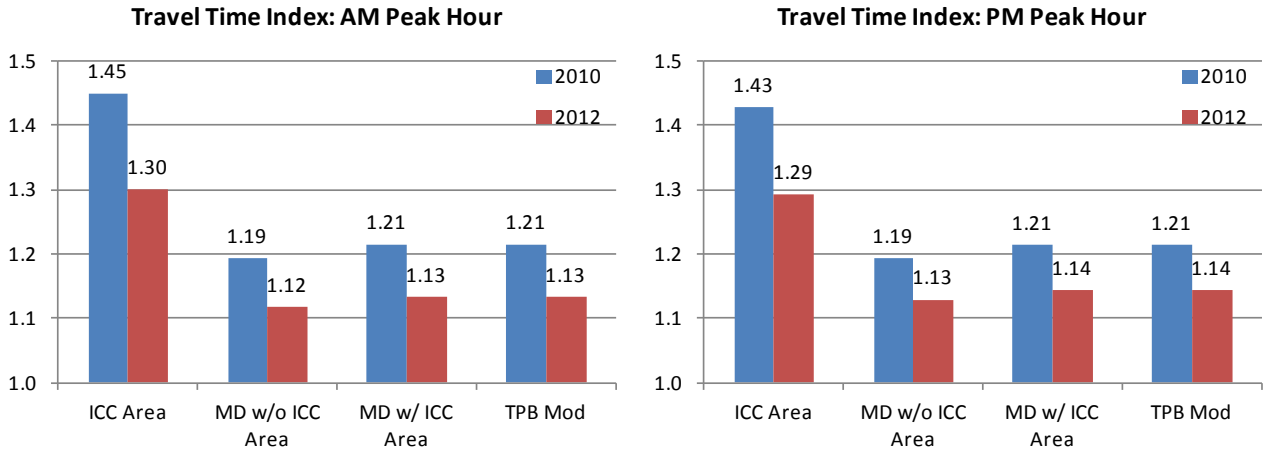


FIGURE 13 Travel Time Index in AM and PM Peak Hours

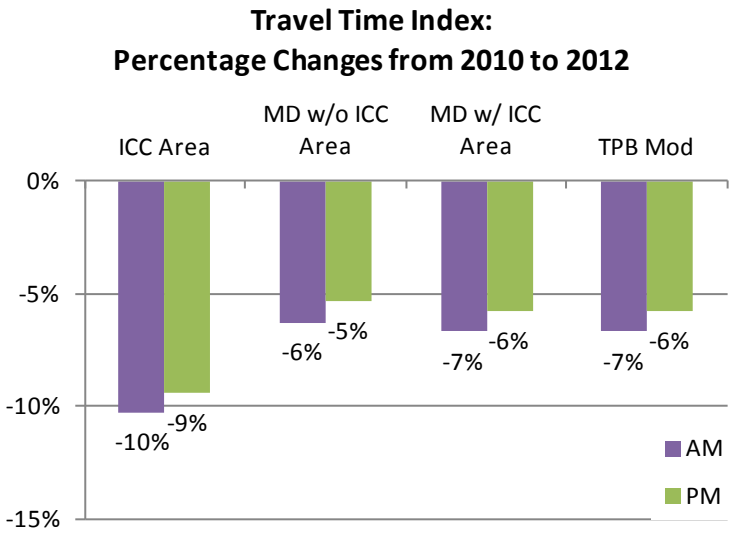


FIGURE 14 Changes of Travel Time Index from 2010 to 2012

Files and Methodology

In this study, TTI was reported at four segmentation levels for the ICC Study Area: TMC, segment, section, and corridor. For each level, a separate file is prepared for the AM and PM peak hours (as listed in Appendix 4): TTIpeak_TMC.csv, TTIpeak_Segment.csv, TTIpeak_Section.csv, and TTIpeak_Corridor.csv

The variables in the files are:

TMC	TMC code as given in "TMCs.csv"
Segment	Segment name as defined in "TMCs.csv"
Section	Section name as defined in "TMCs.csv"
Corridor	Corridor name as defined in "TMCs.csv"
Hour	"8" = AM peak hour 8:00-9:00 am; "17" = PM peak hour 5:00-6:00 pm
Year	2010 (before) or 2012 (after)
TT	Travel time in minutes
FFTT	Free flow travel time in minutes
Miles	TMC/Segment/Section/Corridor length in miles
TT80	80^{th} percentile travel time in minutes
TT95	95^{th} percentile travel time in minutes
TTI	Travel time index = TT/FFTT
PTI80	Planning time index = TT80/FFTT
PTI90	Planning time index = TT95/FFTT

The following steps were used to calculate the TTI at different segmentation levels and for regional averages:

1) Convert speed to travel time in the 5-minute raw data by TMC length divided by speed; the raw 5-minute TMC travel time was added up to obtain segment, section and corridor level travel time;
2) Calculate annual average travel time at TMC, segment, section, and corridor levels by 5-minute increments;
3) Calculate TTI by 5-minute increments;
4) Calculate peak hour TTI by averaging the TTI from step 3).
5) The TMC level TTI calculated from step 4) was averaged to obtain the regional average TTI by using TMC length as a weight.

The TMC level TTI of the AM peak hour was visualized in FIGURE 15-16, the changes in TTI were shown in FIGURE 17. The TMC level TTI of the PM peak hour was visualized in FIGURE 18-19, the changes in TTI were shown in FIGURE 20. Similar maps were generated for the entire TPB Modeled Area, which are provided in separate files because of the large sizes (as listed in Appendix 4): Y2010am8.pdf, Y2012am8.pdf, TTIpeak_DiffAM_TPBMod.pdf, Y2010pm5.pdf, Y2012pm5.pdf, TTIpeak_DiffPM_TPBMod.pdf

FIGURE 15 Congestion in the ICC Study Area: 2010 AM Peak Hour (8:00-9:00 am)

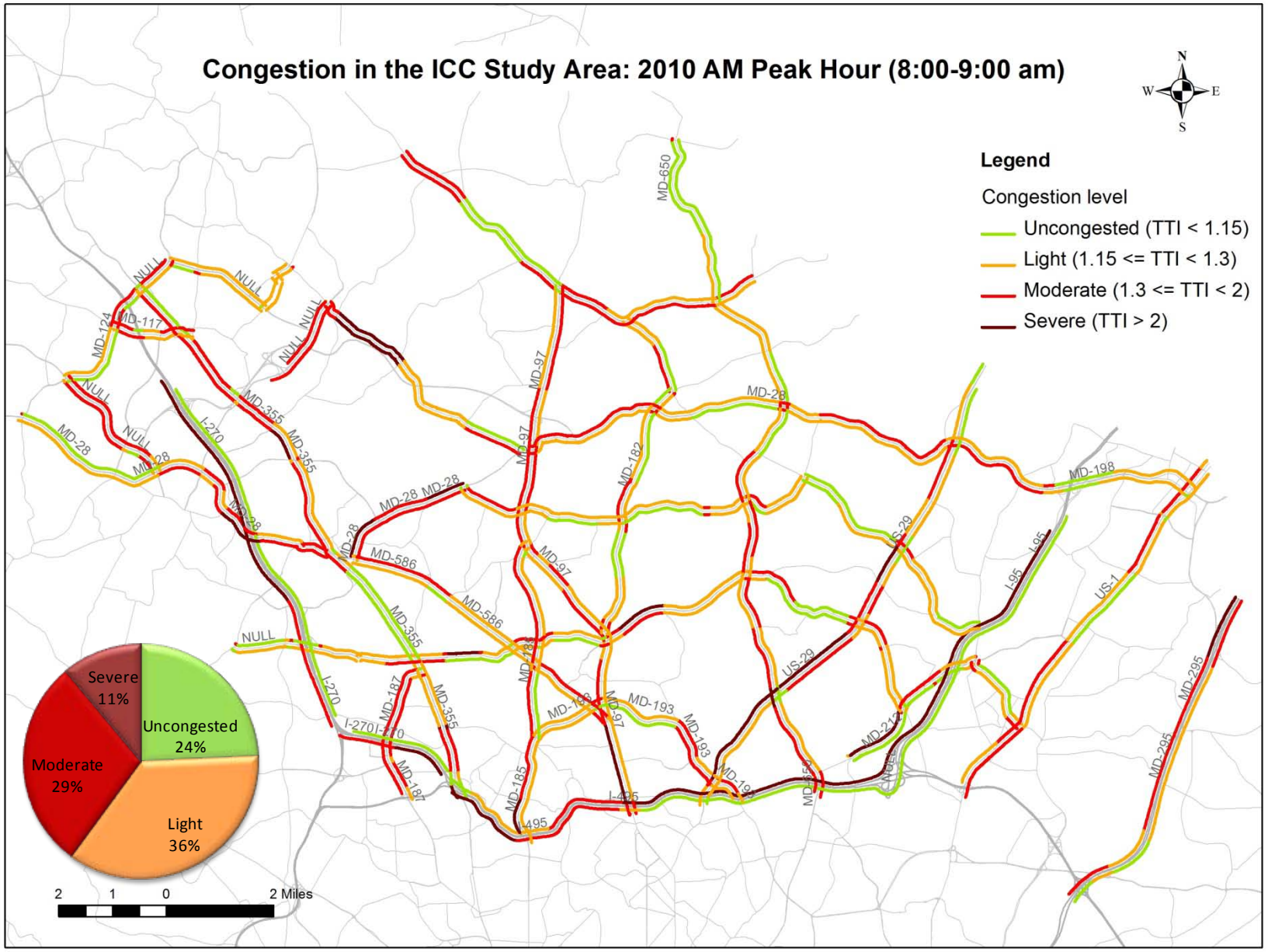


FIGURE 16 Congestion in the ICC Study Area: 2012 AM Peak Hour (8:00-9:00 am)

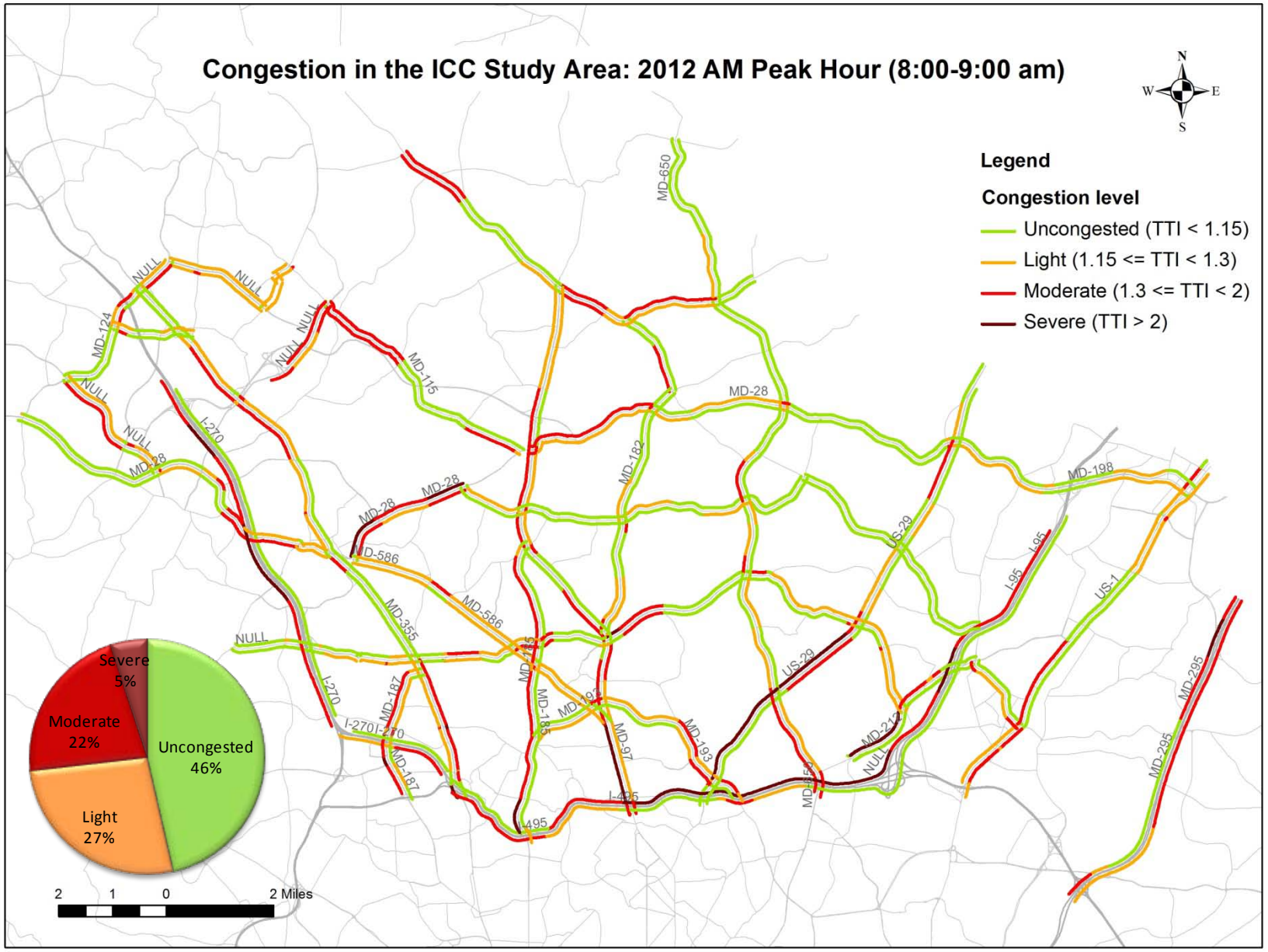


FIGURE 17 Before and After Comparison of Congestion in the ICC Study Area: AM Peak Hour

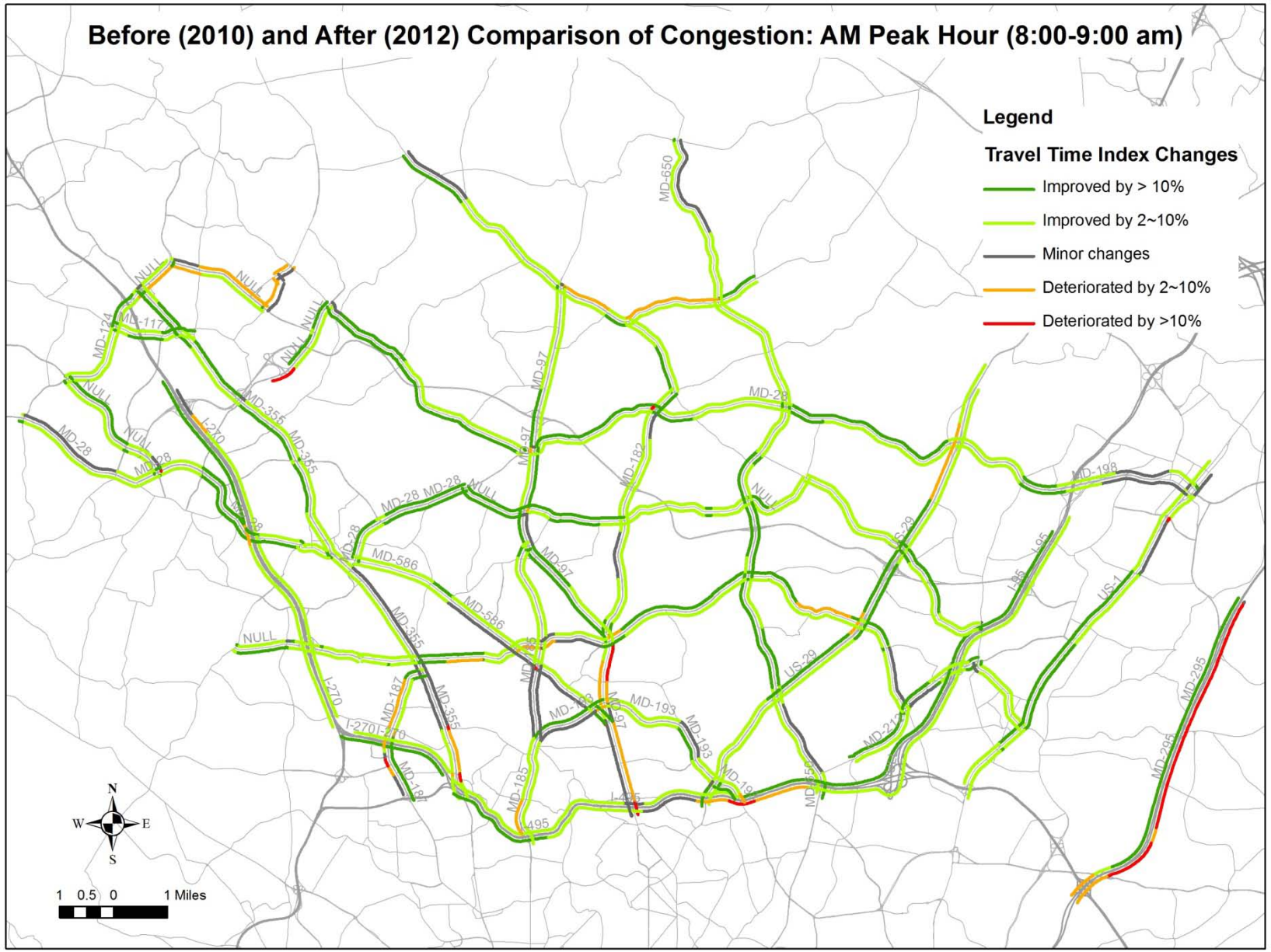


FIGURE 18 Congestion in the ICC Study Area: 2010 PM Peak Hour (5:00-6:00 pm)

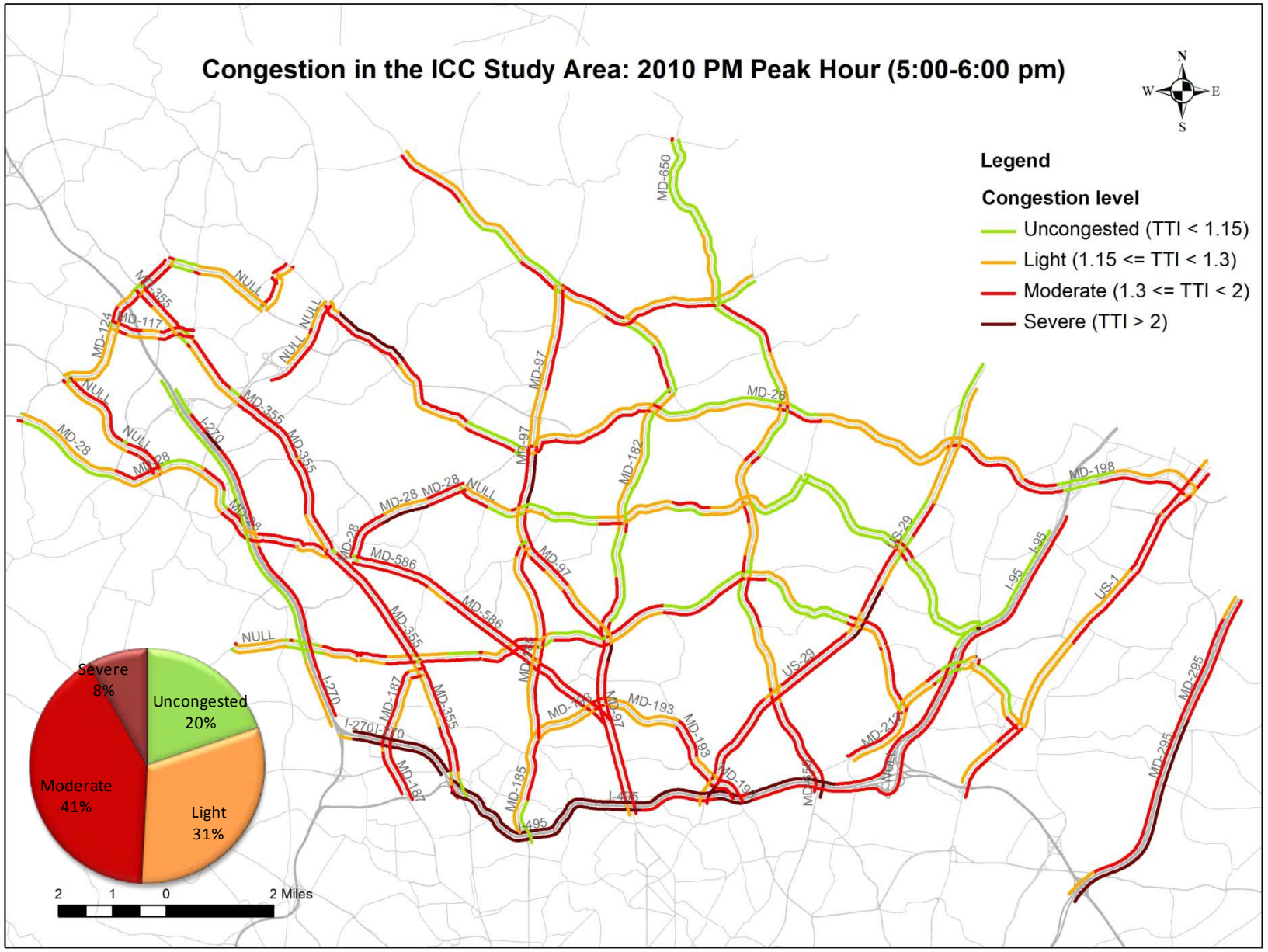


FIGURE 19 Congestion in the ICC Study Area: 2012 PM Peak Hour (5:00-6:00 pm)

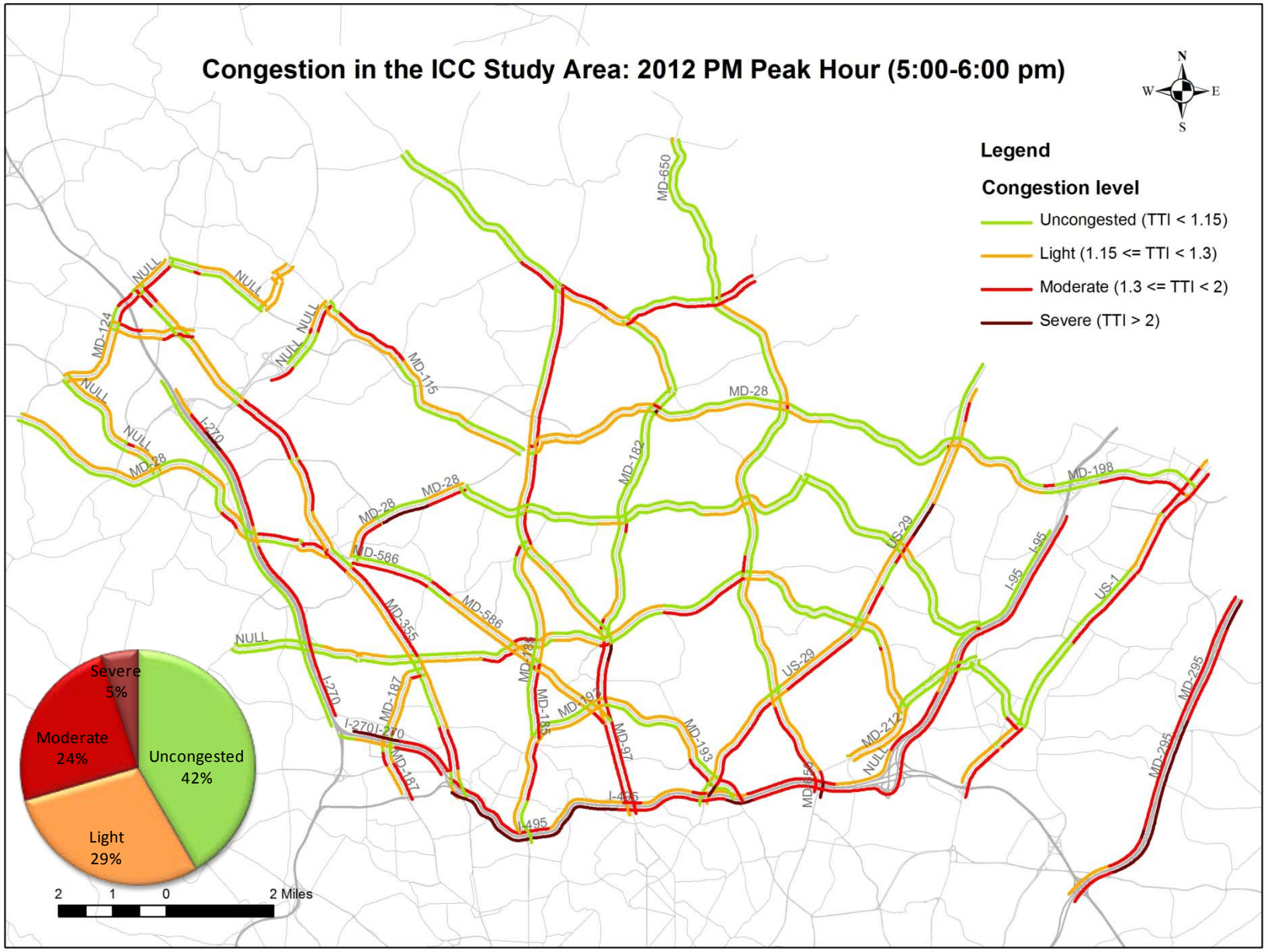
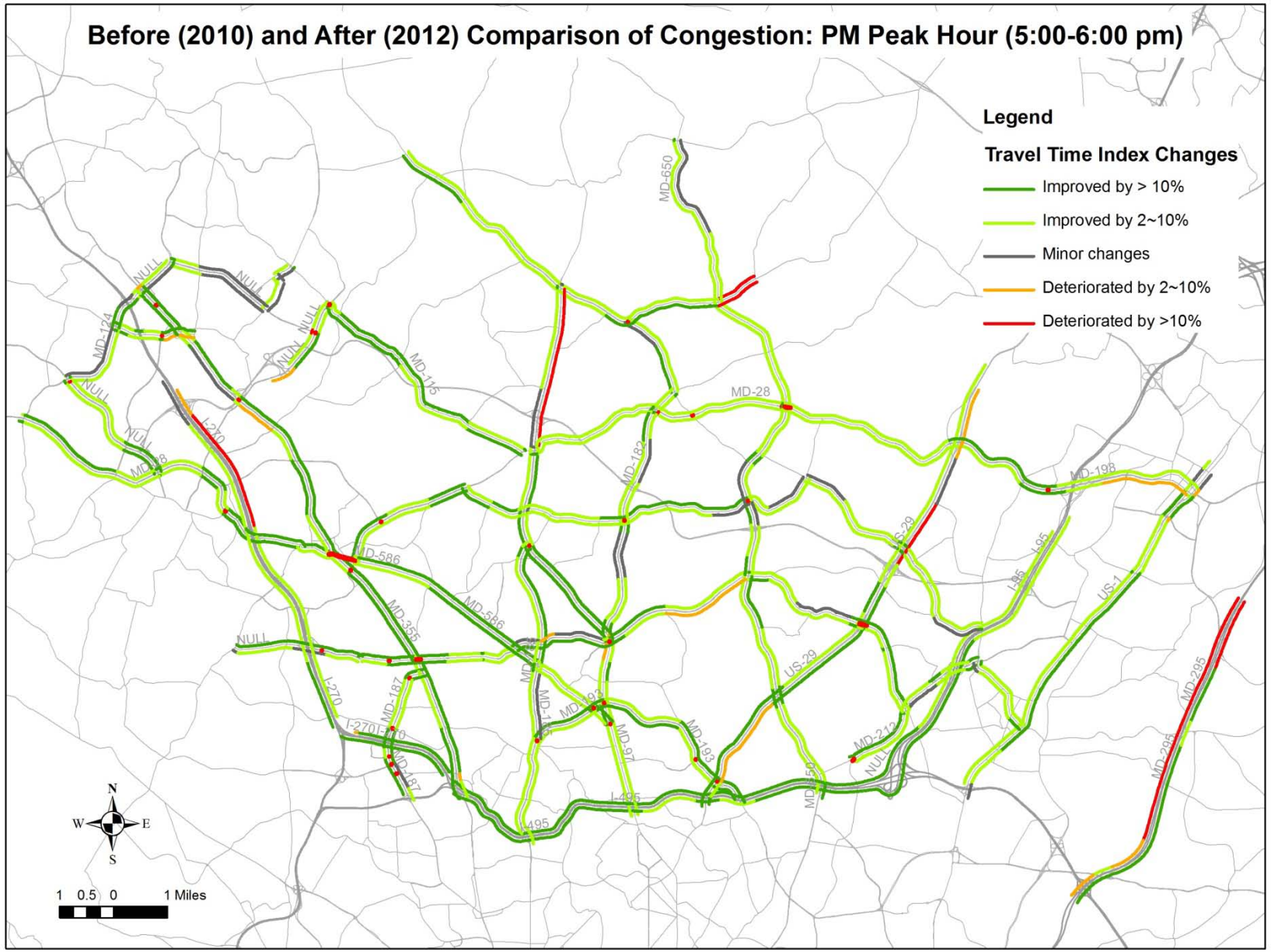


FIGURE 20 Before and After Comparison of Congestion in the ICC Study Area: PM Peak Hour



Planning Time Index

Definitions and Methodology

Planning Time Index (PTI) is a travel time reliability measure. PTI80 is the ratio of 80th percentile travel time to free flow travel time, and PTI95 is the ratio of 95th percentile travel time to free flow travel time. 80th percentile travel time was thought to be sensitive to transportation management strategies while 95th percentile travel time was likely due to incidents that transportation agencies usually did not have control over, such as extreme weather conditions. Nonetheless, the 95th percentile travel time did reflect travelers' experience. Therefore, both PTI80 and PTI95 were provided in this study.

The following steps were used to calculate the PTI at different segmentation levels:

1) Convert speed to travel time in the 5-minute raw data by TMC length divided by speed; the raw 5-minute TMC travel time was added up to obtain segment, section and corridor level travel time;
2) Calculate the 80th and 95th percentile travel times of the year at TMC, segment, section, and corridor levels by 5-minute increments;
3) Calculate PTI80 and PTI95 by 5-minute increments;
4) Calculate peak hour PTI by averaging the PTI from step 3);
5) The TMC level PTI calculated from step 4) was averaged to obtain the regional average PTI by using TMC length as a weight.

PTI80

The 80th percentile travel time-based Planning Time Index (PTI80) of the ICC Study Area and three regional background areas are provided in FIGURE 21. FIGURE 22 shows the changes from 2010 to 2012.

- In the AM peak hour, the ICC Study Area average Planning Time Index (PTI80) was 1.59 in 2010, and this index decreased to 1.45 in 2012, a 9% drop. During the same period, the background areas experienced only a 6-7% drop.

- In the PM peak hour, the ICC Study Area average Planning Time Index (PTI80) was 1.55 in 2010, and this index decreased to 1.45 in 2012, a 6% drop. During the same period, the background areas experienced only a 5% drop.

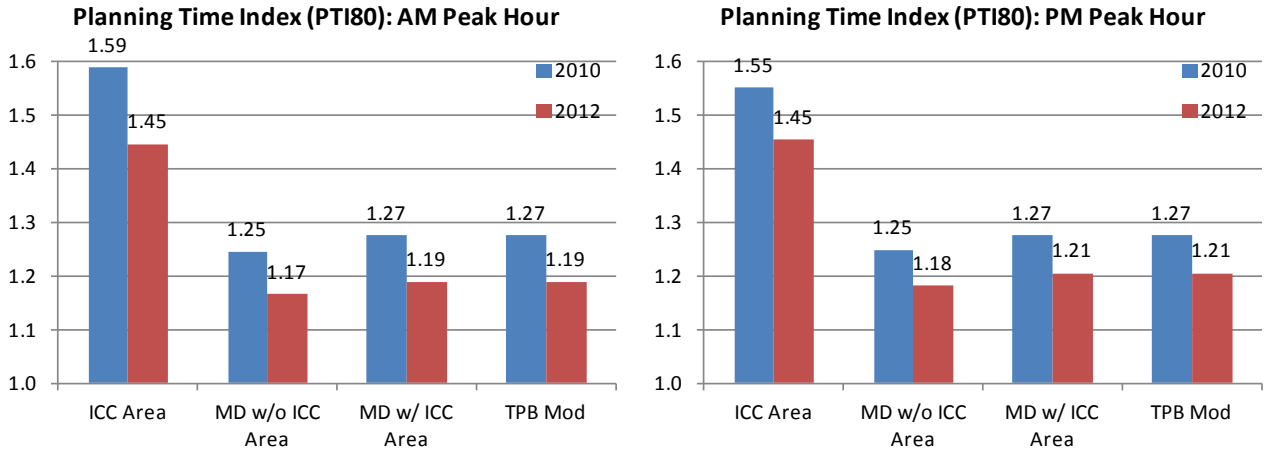


FIGURE 21 Planning Time Index (PTI80) in AM and PM Peak Hours

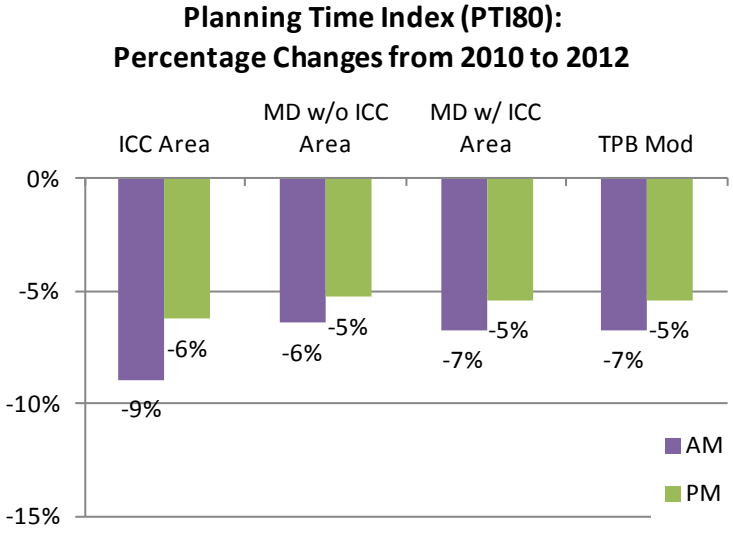


FIGURE 22 Changes of Planning Time Index (PTI80) from 2010 to 2012

PTI95

The 95th percentile travel time-based Planning Time Index (PTI95) of the ICC Study Area and three regional background areas are provided in FIGURE 23. FIGURE 24 shows the changes from 2010 to 2012.

- In the AM peak hour, the ICC Study Area average Planning Time Index (PTI95) was 2.11 in 2010, and this index decreased to 1.85 in 2012, a 12% drop. During the same period, the background areas experienced only an 8% drop.

- In the PM peak hour, the ICC Study Area average Planning Time Index (PTI95) was 2.04 in 2010, and this index decreased to 1.82 in 2012, an 11% drop. During the same period, the background areas experienced only a 7% drop.

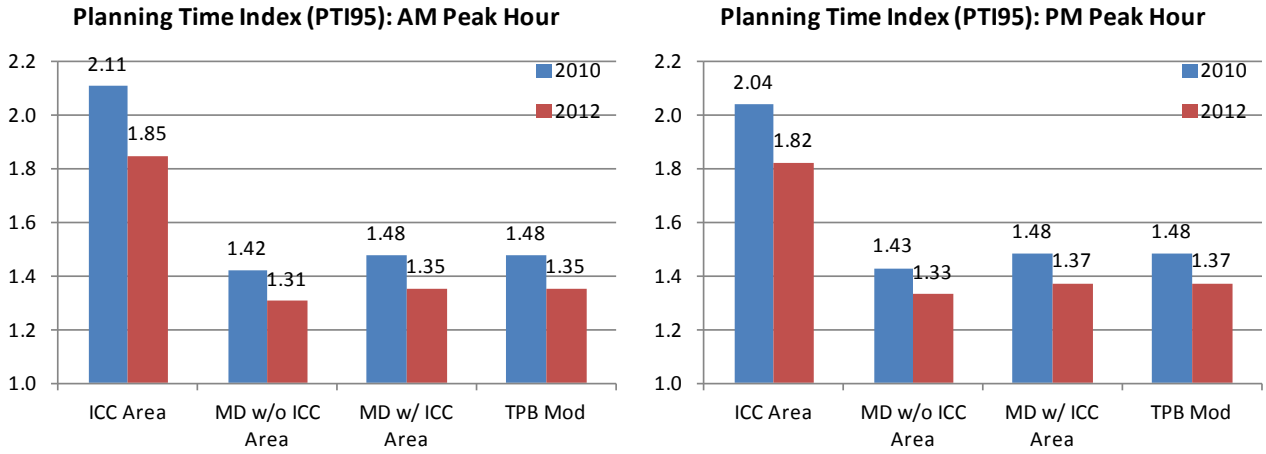


FIGURE 23 Planning Time Index (PTI95) in AM and PM Peak Hours

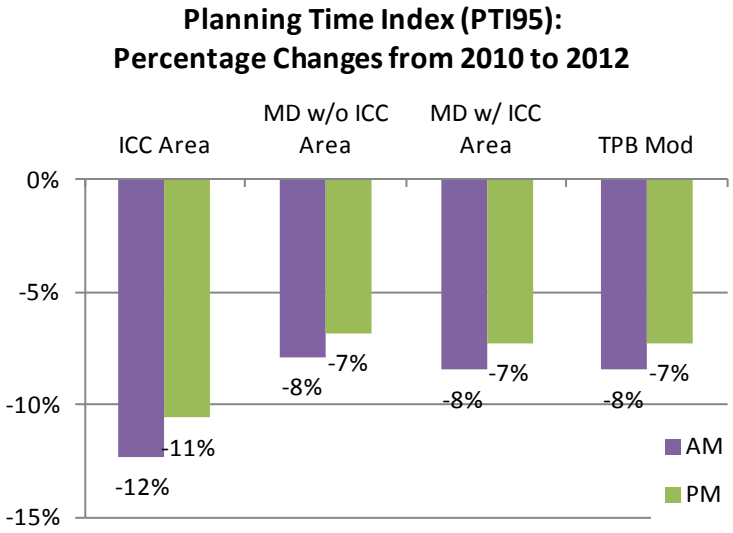
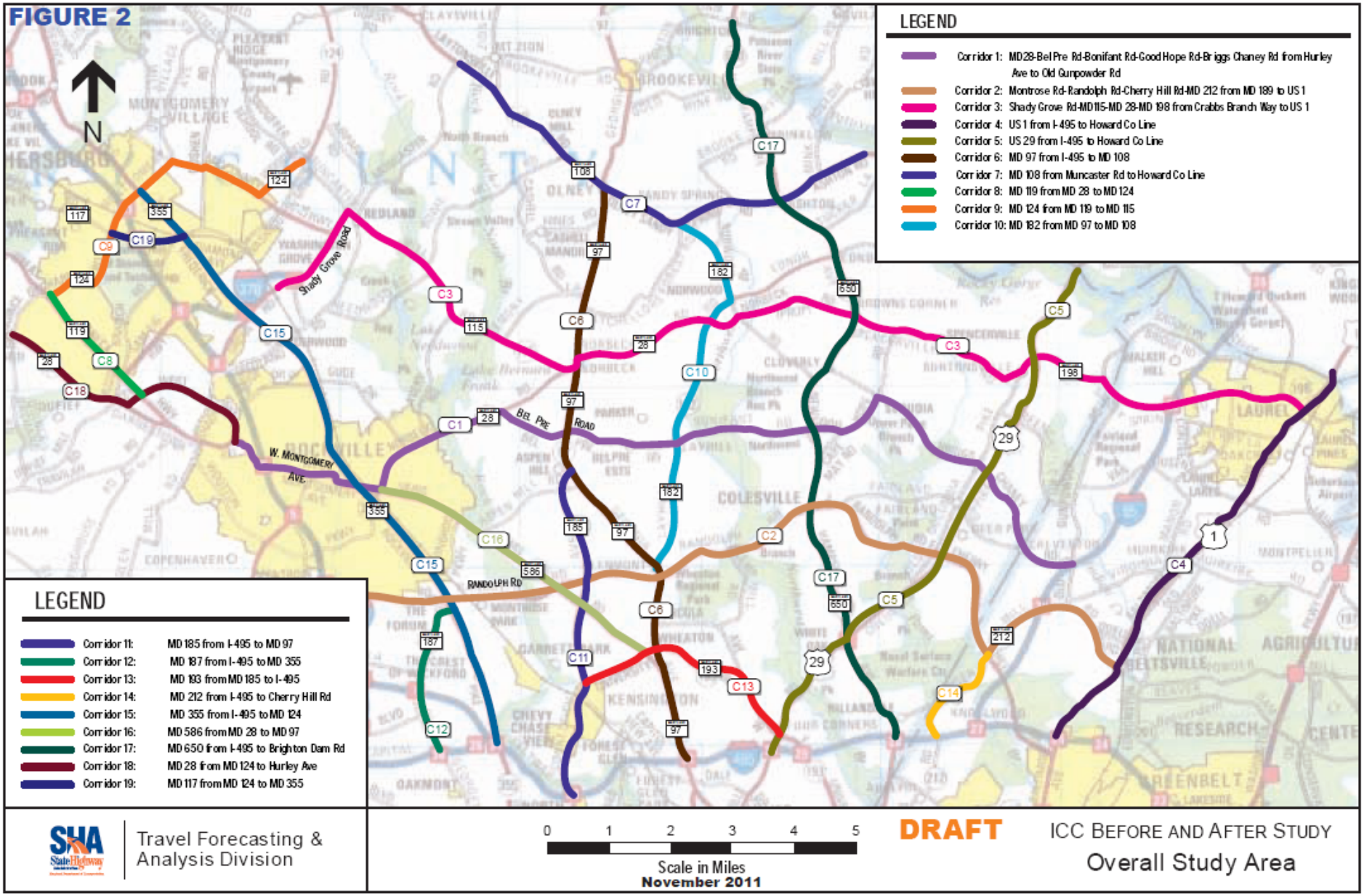


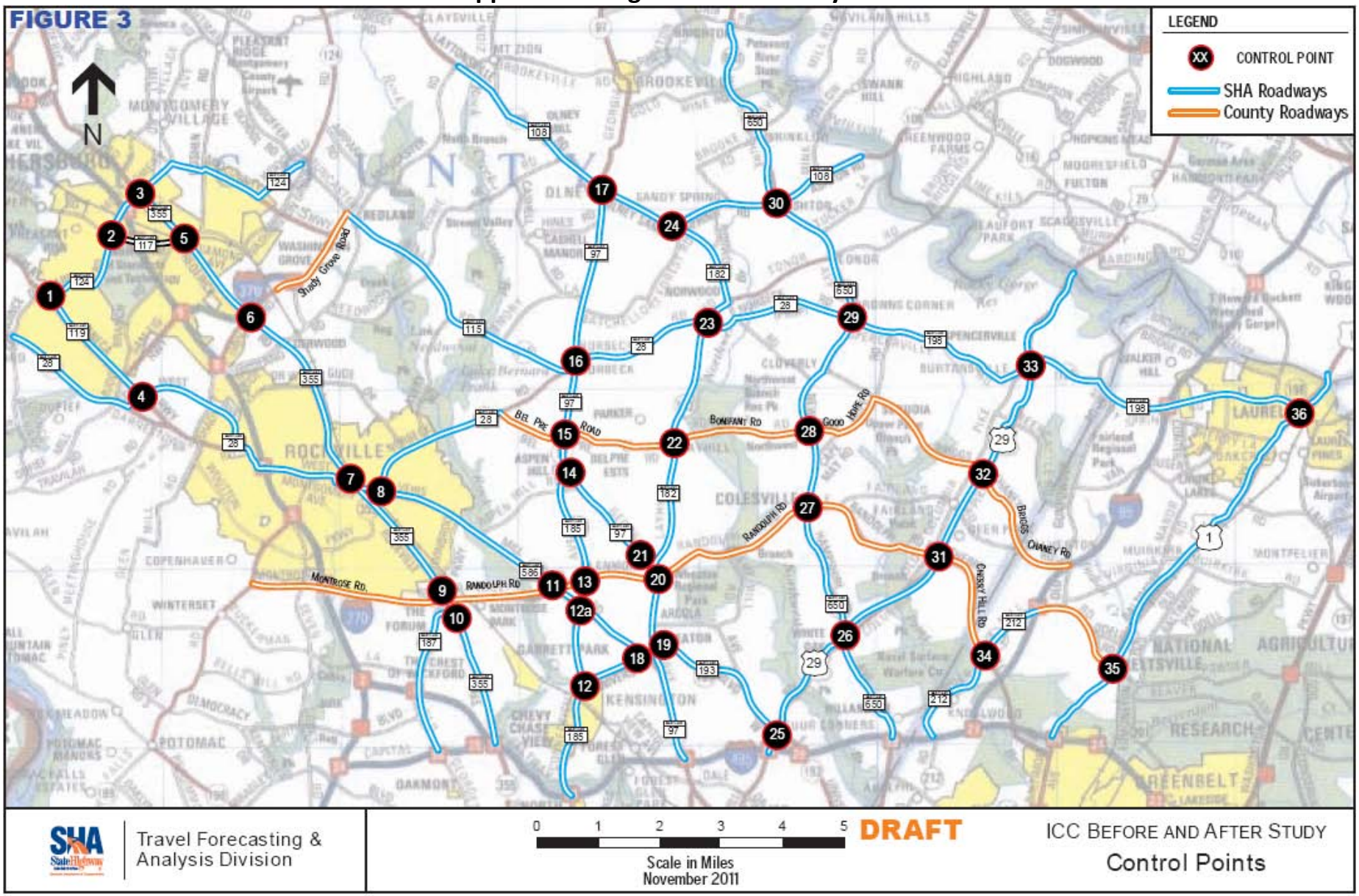
FIGURE 24 Changes of Planning Time Index (PTI95) from 2010 to 2012

Appendices

Appendix 1: Corridors Defined by SHA



Appendix 2: Segments Defined by SHA



Appendix 3: Sections Defined by SHA

Route	Start	End	Revised Start/End due to TMC definition	Section
MD 28/ MD 198	I-270	MD 97		MD28MD198S1
	MD 97	MD 650		MD28MD198S2
	MD 650	I-95		MD28MD198S3
	I-95	MD 295		MD28MD198S4
Montrose Rd/ Randolph Rd	I-270	MD 586		MonRanS1
	MD 586	MD 97		MonRanS2
	MD 97	MD 650		MonRanS3
	MD 650	US 29		MonRanS4
MD 586/ MD 193	MD 28	~~Randolph Road~~	MD-185	MD586MD193S1
	~~Randolph Road~~	~~MD 97~~	MD-193	MD586MD193S2
	MD 97	I-495		MD586MD193S3
MD 108	MD 97	MD 216		MD108
I-495	I-270 Spurs	MD 97		I495S1
	MD 97	I-95		I495S2
	I-95	MD 295		I495S3
I-270	MD 124	MD 28		I270S1
	MD 28	I-270 Spurs		I270S2
MD 355	MD 124	MD 28		MD355S1
	MD 28	I-495		MD355S2
MD 97	MD 108	MD 28		MD97S1
	MD 28	~~MD 182~~	Randolph	MD97S2
	~~MD 182~~	I-495		MD97S3
MD 185	MD 97	I-495		MD185
MD 182	MD 108	MD 97		MD182
MD 650	MD 97	MD 28		MD650S1
	MD 28	I-495		MD650S2
US 29	MD 198	Randolph Rd		US29S1
	Randolph Rd	I-495		US29S2
I-95	MD 198	MD 212		I95S1
	MD 212	I-495		I95S2
US 1	MD 198	Ritz Way		US1S1
	Ritz Way	I-495		US1S2
MD 295	MD 198	MD 197		MD295S1
	MD 197	I-495		MD295S2

Appendix 4: List of Files Attached to this Memorandum

ICC Study Area:

1) TMCs.csv	TMC Table with segment, section and corridor information
2) TTIpeak_TMC.csv	TMC-level Travel Time Index for peak hours
3) TTIpeak_Segment.csv	Segment-level Travel Time Index for peak hours
TTIpeak_Section.csv	Section-level Travel Time Index for peak hours
4) TTIpeak_Corridor.csv	Corridor-level Travel Time Index for peak hours

TPB Modeled Area:

5) Y2010am8.pdf	Colored map of Travel Time Index for AM peak hour in 2010
6) Y2012am8.pdf	Colored map of Travel Time Index for AM peak hour in 2012
7) TTIpeak_DiffAM_TPBMod.pdf	Colored map of Travel Time Index changes for AM peak hour
8) Y2010pm5.pdf	Colored map of Travel Time Index for PM peak hour in 2010
9) Y2012pm5.pdf	Colored map of Travel Time Index for PM peak hour in 2012
10) TTIpeak_DiffPM_TPBMod.pdf	Colored map of Travel Time Index changes for PM peak hour