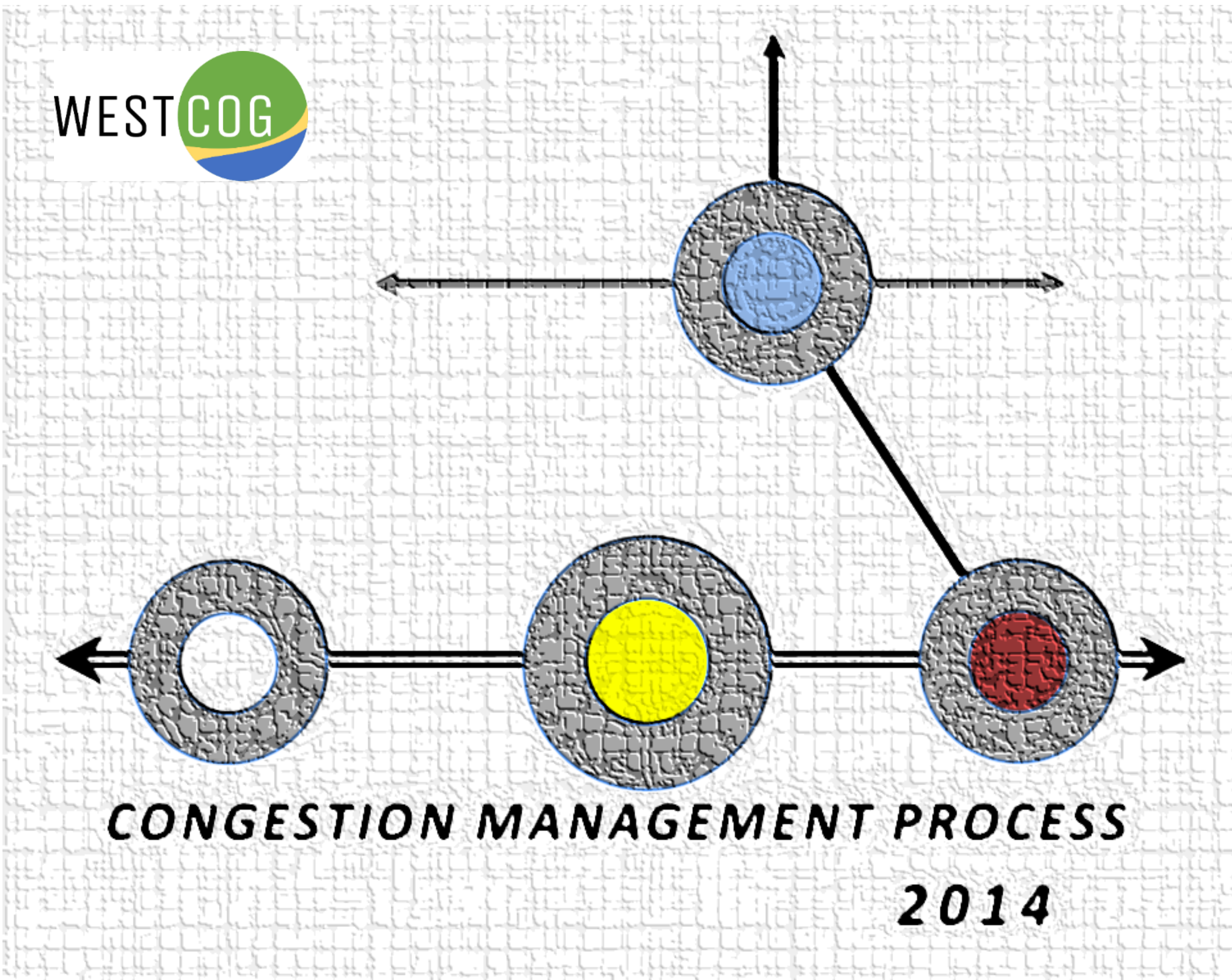

Western Connecticut
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Abstract

The 2014 Congestion Management Process (CMP) report evaluates travel patterns and traffic congestion on highways in Western Connecticut. The CMP is a federal requirement of South Western Region Metropolitan Planning Organization (SWRMPO) by virtue of its status as a Transportation Management Area with a population greater than 200,000[1]. As part of the ongoing efforts to find efficiencies from the merger of South Western Regional Planning Agency and the Housatonic Valley Council of Elected Officials and creation of the Western Connecticut Council of Governments, and to promote cooperation and inter-regional coordination, the CMP reports includes highways within the boundaries of the SWRMPO and Housatonic Valley Metropolitan Planning Organization (HVMPO).

Several different types of information, including Average Daily Traffic (ADT) counts from the Connecticut Department of Transportation, the Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics (LODES) from the United States Census Bureau, and the National Performance Management Research Data Set (NPMRDS) from the Federal Highway Administration, are utilized in this report to describe the extent of and suggest factors contributing to recurring congestion on the region's major highways in 2014. The report focuses on weekday, peak period, peak direction congestion but also includes data for other time periods and directions for comparison. The analyses performed focused on high-resolution and high-density speed information derived and aggregated into five daily time periods. In order to represent typical travel conditions, data was selected for two months (April and October) during which primary and secondary schools are in session, there are no major holidays, and there is a low likelihood of extreme weather, like snow, that would disrupt normal highway operations. The four highways analyzed were I-95, I-84, CT 15, and US 7.

[1] 23 C.F.R. §450.320(a).

Introduction

The Western Connecticut Council of Government (WestCOG) is a new governmental entity formed from the merger of the South Western Regional Planning Agency (SWRPA) and the Housatonic Valley Council of Elected Officials (HVCEO). Created in 2014, WestCOG represents eighteen municipalities in western Connecticut (the region).[2] In addition, WestCOG provides staff to the South Western Region Metropolitan Planning Organization (SWRMPO) and the Housatonic Valley Metropolitan Planning Organization (HVMPO). WestCOG prepared the 2014 Congestion Management Process (CMP) report in its role supporting SWRMPO. Previously, SWRPA had prepared an annual CMP report on behalf of SWRMPO for the purpose of evaluating the effectiveness of the transportation system. Because the region's congestion is not limited to its boundaries, past CMP reports included data for nearby areas. The 2014 CMP report will present congestion information for both the SWRMPO and HVMPO metropolitan areas (collectively, the region).

Traffic congestion is widely recognized as a preeminent quality of life issue in western Connecticut. Recurring highway congestion, slow speeds, delays are a common complaint and have been repeatedly recognized as a drag on the region's economy. Responding to these complaints, the State of Connecticut has proposed a 30 year, $100 billion investment in transportation, known as Let's GO CT, which would add significant new capacity to the region's highway system for the first time in more than a generation.

'Congestion' has been defined as "the level at which transportation system performance is no longer acceptable due to traffic interference."[3] More simply, congestion means a condition where there are more vehicles using a section of highway than it was designed for, resulting in slower speeds and delays. The CMP is primarily concerned with recurring congestion created by peak period demand rather than non-recurring congestion created by crashes or other incidents. The CMP serves as a tool for evaluating deficiencies within the system and the effectiveness of transportation improvement projects over time. The CMP can inform and help in the development of priorities for the Long Range Transportation Plan. The CMP is a required part of the transportation planning process in Transportation Management Areas.[4]

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[2] The eighteen municipal members of WestCOG are: Bethel, Bridgewater, Brookfield, Danbury, Darien, Greenwich, New Canaan, New Fairfield, New Milford, Newtown, Norwalk, Redding, Ridgefield, Sherman, Stamford, Weston, Westport, and Wilton.

[3] 23 C.F.R. § 970.214(a).

[4] 23 C.F.R. § 450.320(a). Transportation Management Areas are Census designated urbanized areas with populations over 200,000. 23 C.F.R. §450.104.

Figure 1: Traffic congestion builds on I-95.

In the recent past, SWRPA prepared its CMP report utilizing a combination of acquired and collected data sets. SWRPA's travel time monitoring program, for instance, utilized the "floating car method" where individual Global Position Satellite (GPS) devices were placed in cars traveling fixed routes along principal highways. While this method provided a great deal of control for specific data collection, it was extremely labor intensive and was incapable of producing a large sample size of events. In 2013, SWRPA obtained access to *Inrix* travel data from the I-95 Corridor Coalition Vehicle Probe Project 2 (I-95 CC VPP). This data was limited to I-95 but covered all hours of the day and all days of the week. The I-95 Corridor Coalition and its partner, the Center for Advanced Transportation Technology (CATT) Laboratory at University of Maryland, provided a series of analytic tools known as the Vehicle Probe Project Suite[5] along with the data.

This report relies heavily on a new data set recently made available to State Departments of Transportation and Metropolitan Planning Organizations by the Federal Highway Administration

[5] See I-95 Corridor Coalition, Beyond Boundaries. Found at http://www.i95coalition.org/projects/vehicle-probe-project-suite/

(FHWA) through a license agreement with *Here*[6]. This data set, which is produced monthly for the entire United States, is known as the National Performance Management Research Data Set (NPMRDS). This data set builds off the basic "floating car method" but uses more advanced data collection and aggregation methods to provide a large sample dataset of high temporal and spatial granularity. Data is obtained from vehicle probes such as mobile phones, commercial vehicle GPS devices, and personal navigation devices. The NPMRDS provides comprehensive temporal and spatial coverage of national highway system routes with large numbers of records for both passenger and commercial vehicle traffic. The NPMRDS data in this report is supplemented by average daily traffic (ADT) data obtained from the Connecticut Department of Transportation (CTDOT). For I-95, data from *Inrix* [7]and the I-95 Corridor Coalition Vehicle Probe Project, analyzed using tools from The Center for Advanced Transportation Technology Laboratory at the University of Maryland, supplements the analysis.

Objectives

Spatial and temporal travel time information extracted for this report is presented with the intent of better understanding congestion along major highways and supporting planning and cost-effective mitigation strategies. By examining the findings in this report, a better understanding of transportation program efficacy and implementation may be possible. The primary objectives of the Congestion Management report are to:

- Obtain and analyze detailed travel time and speed data for the major highways in western Connecticut; and
- Identify patterns and locations of traffic congestion within the Region.

[6] *Here,* which was formed from NAVTEQ and Nokia Maps, has engineering capabilities in mobile mapping and phone technology) For more information, see https://company.here.com/here/

[7] *Inrix.* For more information, see http://inrix.com/

The Region:

The Western Connecticut Planning Region (the region) includes portions of the Census-designated Bridgeport-Stamford and Danbury urbanized areas. Located northwest of New York City, the region is highly urbanized in the southern third and generally becomes more rural as one proceeds north. The regions is traversed by I-95 and I-84, which are critical passenger and freight corridors both regionally and nationally. Figure 1 provides an overview of the Region's highway system.

The region consists of 18 municipalities in the west and southwest part of Connecticut, mostly within Fairfield County as well as Litchfield County. Eight municipalities including the cities of Norwalk and Stamford make up the SWRMPO area. Ten municipalities including the city of Danbury make up the HVMPO area (Figure 1).[8] The most urbanized land uses are found along the I-95 corridor along with three of the region's major employment centers (Greenwich, Norwalk, and Stamford). In the northern part of the region, the most urbanized land uses are found around Danbury and the US 7 corridor. The land use in the remainder of the region varies from suburban to rural, and includes several small towns with limited commercial and industrial development.

This report will focus on three major highways that run roughly parallel east-west (I-95, CT 15, and I-84[9]) and one major road running north-south (i.e. US 7) within the region. According to 2014 CTDOT ADT data, the highway sections with the highest traffic volume in the region are found on I-95 and on I-84 near each highway's interchange with US 7.

[8]The SWRPO includes eight municipalities: Darien, Greenwich, New Canaan, Norwalk, Stamford, Weston, Westport, and Wilton. The HVMPO includes 10 towns: Bethel, Bridgewater, Brookfield, Danbury, New Fairfield, New Milford, Newtown, Redding, Ridgefield, and Sherman.

[9] Though these highways are essentially parallel to one another, I-84 officially runs east-west while CT 15 and I-95 officially run north-south. This report will refer to the official directions of each highway.

WestCOG Region

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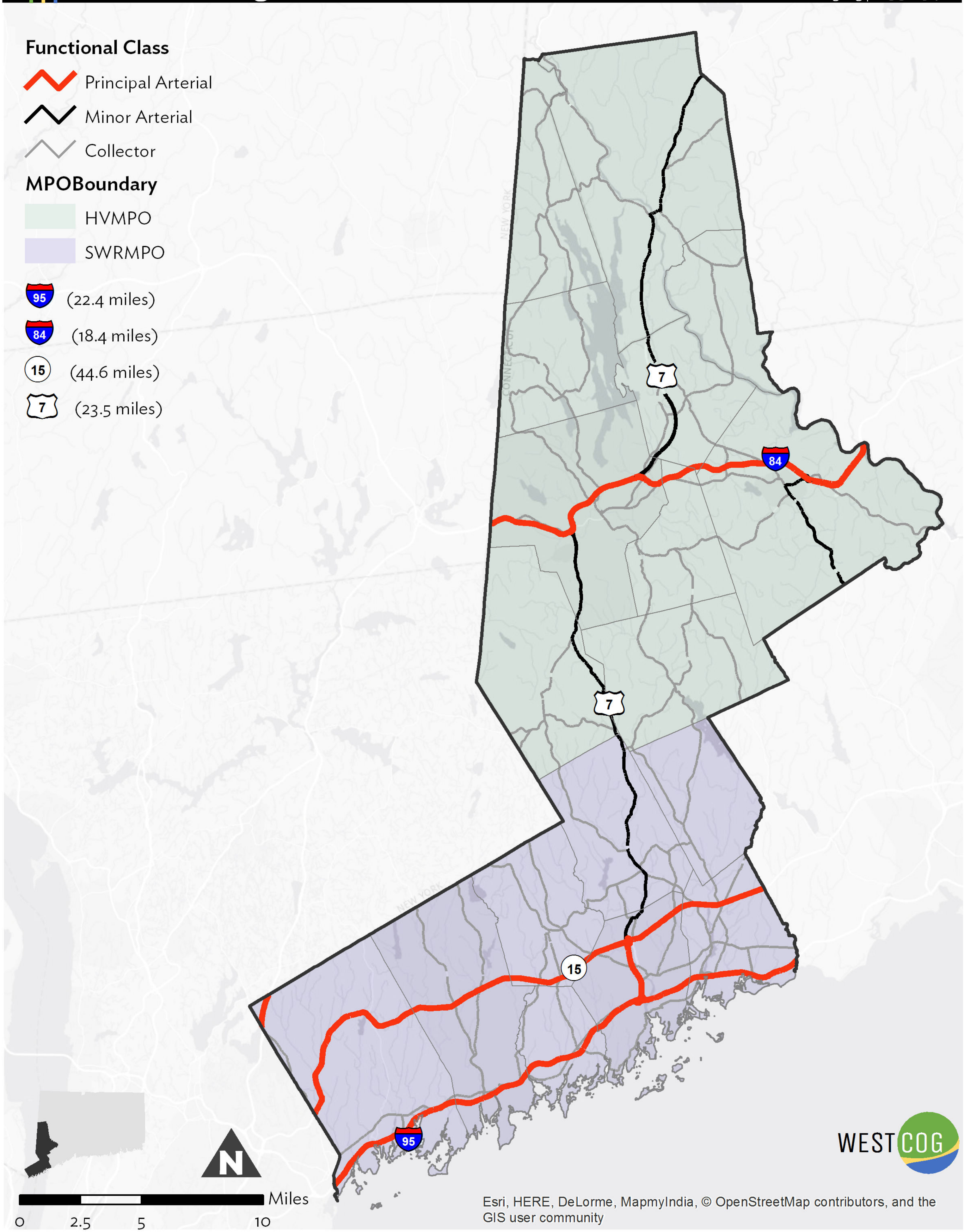


Discussion

The Inflow and Outflow of Workers to and from the Region

The Western Connecticut region is an important economic engine for the state of Connecticut. The region contributes 38% of the total personal income tax revenue to the state of Connecticut, well in excess of its 16.5% share of Connecticut's population.[10] The presence of high paying jobs makes the region an attractive location for job seekers while high housing prices often lead workers to seek housing in less expensive areas outside the region. These two factors together result in long commute trips and congested highways.

The region has four major employment centers and is within commuting distance of New York City and its large metropolitan area. Three employment centers, Greenwich, Norwalk, and Stamford are located along the I-95 corridor in the southern part of the region while one employment center, Danbury, anchors the northern part of the region at the intersection of I-84 and US 7. All four of these communities are major employment destinations with significant net inflows of workers. At the same time, four times as many workers in the region travel outside their town of residence to work than work in the town in which they reside (Table 1).[11]

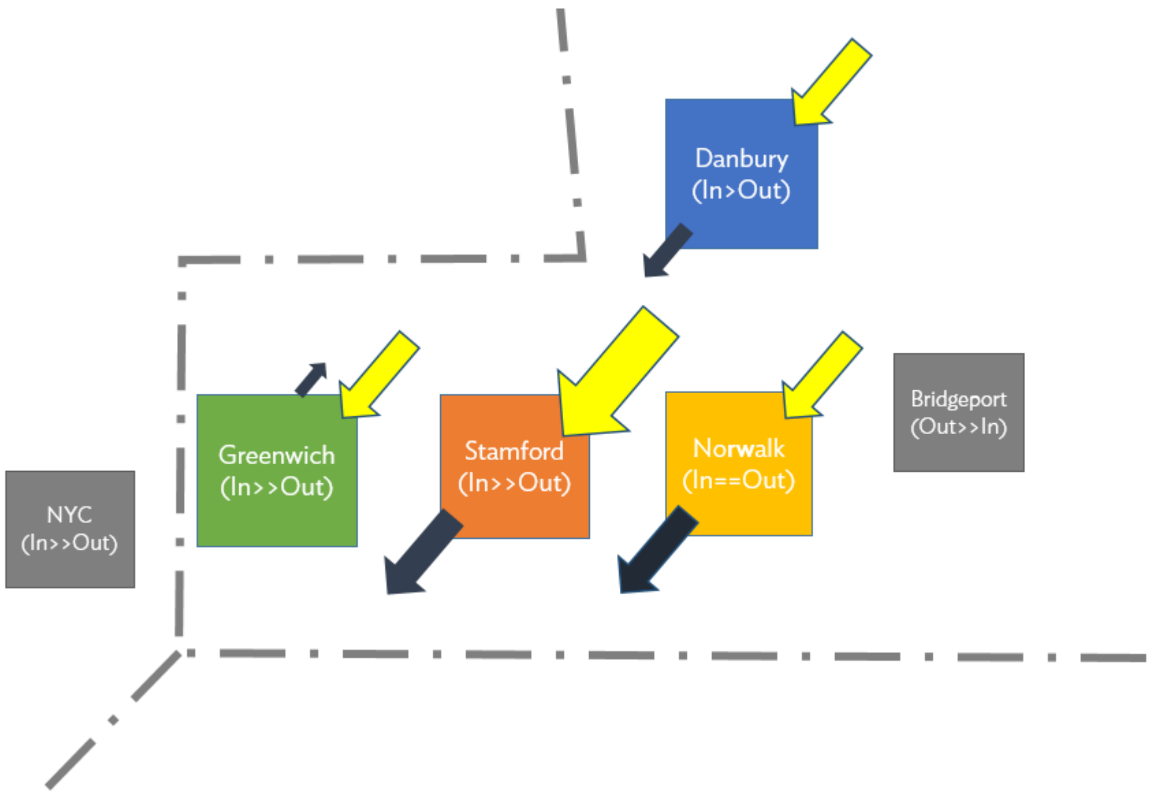
The predominant direction of morning commuter travel is from northeast to southwest. Consequently, many workers who work in Greenwich, Norwalk, and Stamford travel south along I-95 and CT 15 during the morning commute. Danbury also receives an inflow of workers traveling west on I-84 in the morning as well as commuters from the bedroom communities to the north. Residents of Norwalk and Stamford also tend to commute south and west to places of employment. The predominant flow of home-to-work travel suggest a southbound morning peak along with a corresponding northbound afternoon peak for work-to-home travel. As the reader will shortly see, average travel speeds are suppressed according to this pattern. Though some residents of the region commute to jobs in New York City, this route is a secondary contributor source for worker inflows and outflows, much of which is accommodated by other travel modes.

[10] CT Open Data, 2012 Personal Income Tax by Town. See https://data.ct.gov/

[11] Data obtained from OnTheMap Text Only Tool. See http://onthemap.ces.census.gov/tot/ for 2011, Distance/Direction, Work area information.

	Greenwich	Stamford	Norwalk	Danbury
Living in the Selection Area*	19,944	52,365	41,564	31,260
Living and Employed in the Selection Area	6,049	20,235	10,168	11,425
Living in the Selection Area but Employed Outside	13,895	32,130	31,396	19,835
Employed in the Selection Area*	31,933	71,040	40,939	39,849
Employed and Living in the Selection Area	6,049	20,235	10,168	11,425
Employed in the Selection Area but Living Outside	25,884	50,805	30,771	28,424
Net Job Inflow (+) or Outflow (-)	**11,989**	**18,675**	**-625**	**8,589**

Table 1 Inflow outflow of WestCOG working population; major employment centers.



$$[\boldsymbol{Net\ job\ inflow\ or\ outflow}] = [Employed\ in\ selection\ area] - [Living\ in\ selection\ area]$$

Figure 3: Inflow and outflow of workers in the WestCOG Region.

The four major employment center in the region (blue boxes) import large numbers of workers. Yellow arrows represent direction and relative numbers of inbound workers while dark blue arrows represent outbound workers. Stamford is the region’s biggest employment center while Bridgeport (which is outside the region) is largest exporter of workers. Comparatively fewer people commute from the large coastal cities north to Danbury or to New York City for work.

I-95 Corridor

Interstate 95 from the New York State border to New Haven is one of the most heavily travelled highways in Connecticut and has long suffered from severe recurring congestion. The segments within the western Connection region are well known for congestion and slow speed. Within the past five years, the region's section of I-95 has been ranked among the top fifty nationally most congested corridors.[12]

I-95 is the most traveled highway in the SWRMPO area and the larger region. I-95 runs 22.4 miles from the New York state line to the Westport / Fairfield town line. In 2009, daily vehicle miles traveled (VMT) on I-95 in the region exceeded 2.9 million miles. In 2014, the average daily traffic across the entire length of I-95 was 134,000 vehicles with spot locations ranging from 117,000 to 150,000 vehicles per day. The highest traffic volumes on I-95 are found at the Stamford-Darien town line, the Route 7 interchange, and at the Route 136 interchange in Westport. By 2035, the CTDOT travel demand model forecasts ADT on I-95 in excess of 180,000 vehicles per day in Darien and Norwalk.

Recent data obtained from the I-95 Vehicle Probe Project Suite indicate that five of the top ten bottleneck locations on I-95 in Connecticut are found within the region.[13] These bottlenecks are systemic and recurring. For instance, the bottlenecks at Exit 12 on I-95 south had an average backup duration of 2 hours 6 minutes and an average length of 13.5 miles. Further, data suggests that between 2012 and 2014, travel speeds on I-95 in both directions (measured on Tuesdays, Wednesdays, and Thursday) decreased. This downward trend was also marked by greater variability in speeds and a reduction in the slowest speeds. Also of note, the maximum speeds have changed far less than the minimum speeds over the same time period. The associated data and reference maps for the problem sites can be found in appendix 4

Traffic speeds for I-95 were calculated by dividing time of travel (units are in seconds) by length of segment (units in miles). To simplify the analysis, the five-minute epochs were binned into five groups:

---

[12] INRIX. Traffic Scorecard. Congested Corridors 2011. In 2015, INRIX ranked the I-95 corridor between Exit 3 and Exit 21 the 65th most congested corridor in the United States.

[13] Data obtained for October 2014.

- Early Morning (12 to 6 am)
- Morning Peak (6 to 9 am)
- Midday (9 am to 4 pm)
- Afternoon Peak (4 to 7 pm)
- Evening (7 pm to midnight)

The average speed on I-95 in the region for the entire sample period (288 epochs or 24 hours) was 52.8 mph with a minimum of 19.1 mph and a maximum of 61.6 mph.[14] The Early Morning and the Evening periods had the highest average speeds (58.0 mph), with little difference between the southbound and northbound, suggesting free flow conditions. The Midday period had a lower average speed (52.5 mph) but also exhibited little difference between directions.

Unsurprisingly, the combined northbound Afternoon Peak and southbound Morning Peak travel speeds were lower than in other periods and averaged 48.4 mph and 43.5 mph, respectively, for the full extent of I-95 in the region. The average southbound speeds were sensitive to the large volume of commuters travelling south in the morning and were dramatically lower between Westport and Stamford.

In the Morning Peak period, the segment with the lowest speed averaged 24.8 mph while the overall average speed for the full extent of I-95 was 42.1 mph. In contrast, the average northbound speed in the Morning Peak period suggested free flow conditions. The average speed southbound in the Morning Peak is slowest between the Westport-Fairfield town line and Stamford but increases south of Stamford.

Interestingly, I-95 operates slower in both directions during the Afternoon Peak with a southbound average speed of 49.7 mph (east of Stamford) and a northbound average speed of 37.3 mph. This asymmetry of travel speed in the morning and afternoon peaks may suggest that trips for purposes other than work-to-home commutes take place during the Afternoon Peak period. The average speed northbound in the Afternoon Peak period is lowest around downtown Stamford and the US 7 interchange in Norwalk but increases gradually towards the Westport-Fairfield town boundary.

A dip in average speed occurred during all time periods in the vicinity of the I-95 interchange with US 7.   Reduced speeds at this location indicates that construction activity associated with a project[15] to add speed change lanes at this location was negatively impacting travel speed. However, the observed drop in speed at this location also helps to validate the data and methods used in this report as regular drivers of I-95 are doubtless aware of the slow speeds in this location.

[14] Speeds are aggregated across many epoch and segments of between 0.5 and 2 miles in length. Consequently, averages and minimum speeds may not reflect local variations and speed reduction due to congestion.
[15] Project # 102-278

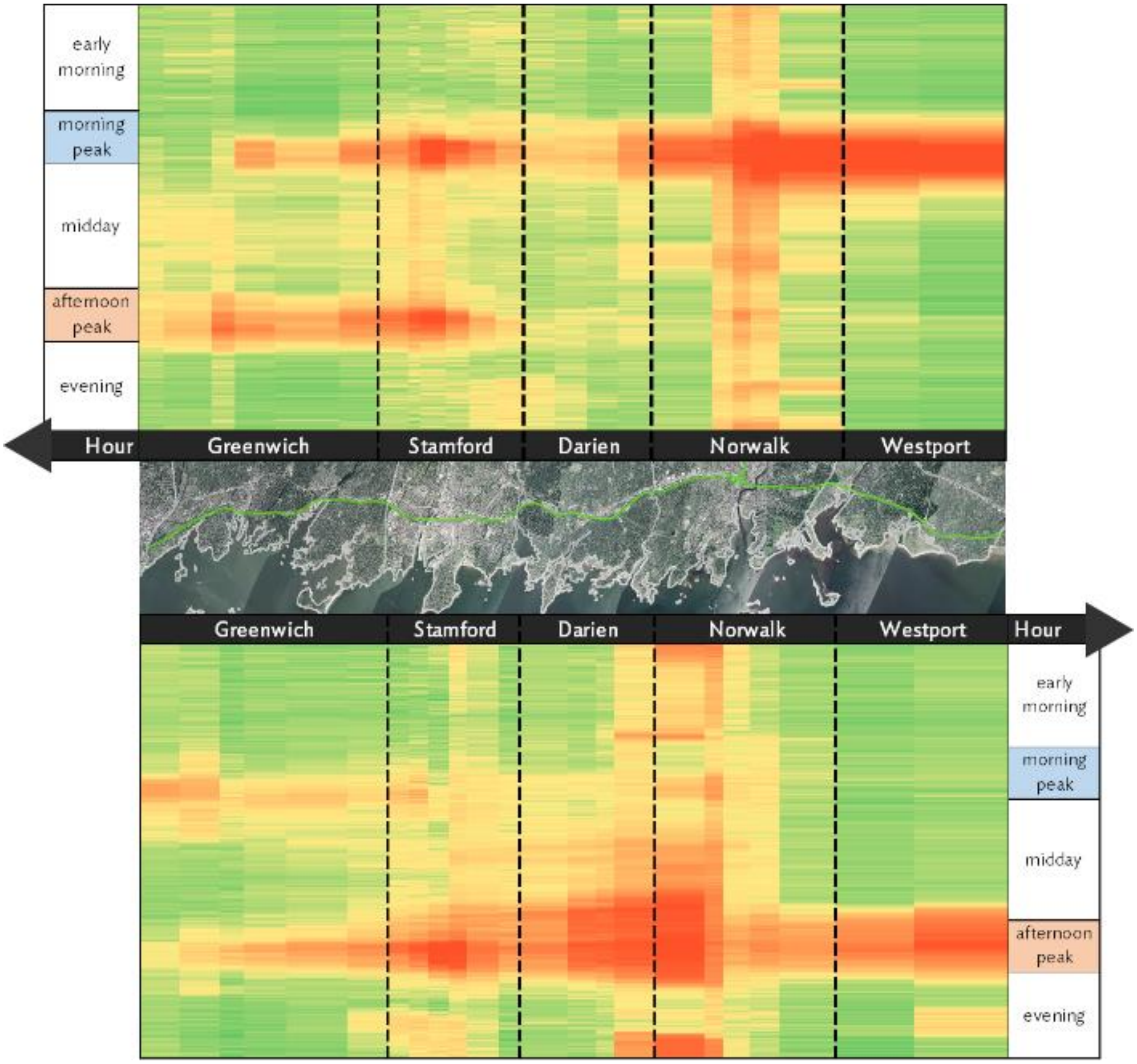
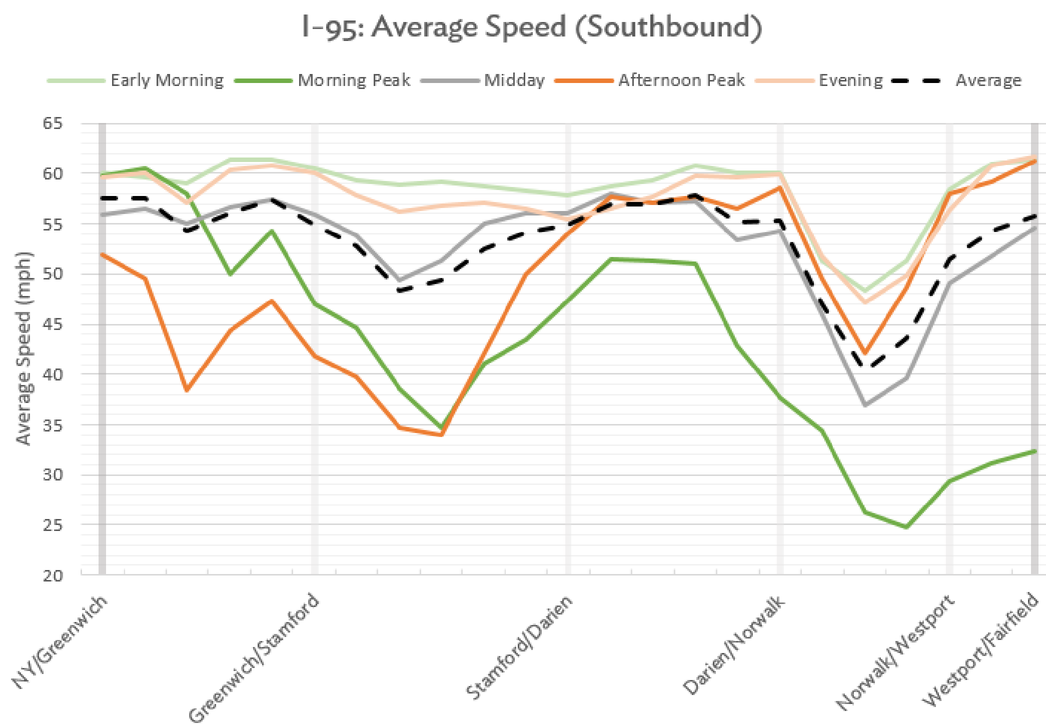


Figure 4: Average speed on I-95 by direction and time of day.

Observed speeds are represented by colors from green (fast) to red (slow).



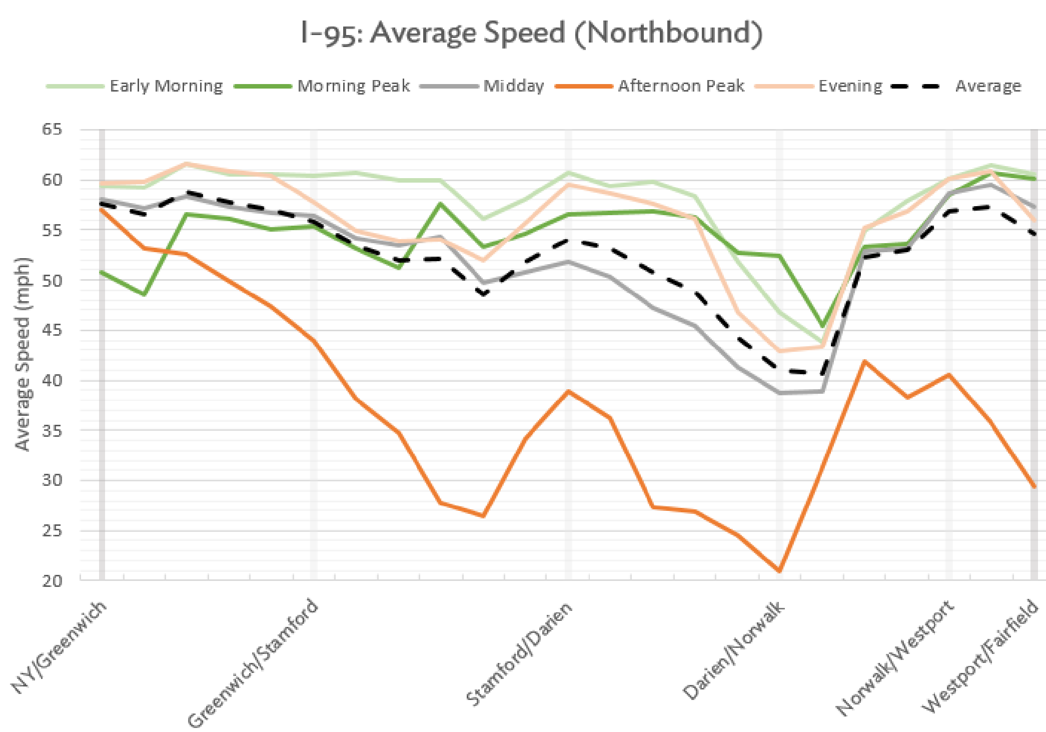


Figure 5: Average speed on I-95 by time of day northbound and southbound.

The Y axis depicts speed while the X axis depicts location on I-95 with town border reference points.

CT 15 (Merritt Parkway) Corridor

CT 15, also known as the Merritt Parkway, is an historic, landscaped parkway that also serves as a major corridor for passenger vehicle travel and daily commuting. All commercial vehicles are prohibited from the Merritt Parkway due to low bridge clearances. A limited access four-lane highway, the Merritt Parkways extends 23.5 miles between the New York state line and the Westport-Fairfield town line. The Merritt Parkway is oriented north of and parallel to I-95. The Merritt Parkway has an ADT of 56,500 vehicles with a minimum of 44,700 and a maximum of 70,100 within the 44 different segments.

The Merritt Parkway has distinct and symmetric patterns of congestion and slow speeds impacting travel in both directions, primarily north of Stamford. During the Morning Peak period, the average speed for the full extent of CT 15 in the region is 50.6 mph. Southbound, travel speeds are about 15 mph lower around Westport but increase towards the New York State line. During the Afternoon Peak period, the average speed northbound is 45.6 mph for the full extent with no observed slow segments around Greenwich. From Stamford north, travel speeds are slowed with a minimum observed speed of 35.5 mph. Travel speeds during the Midday, Evening, and Early Morning periods suggest free flow conditions during those times for the full extent of the Merritt Parkway.

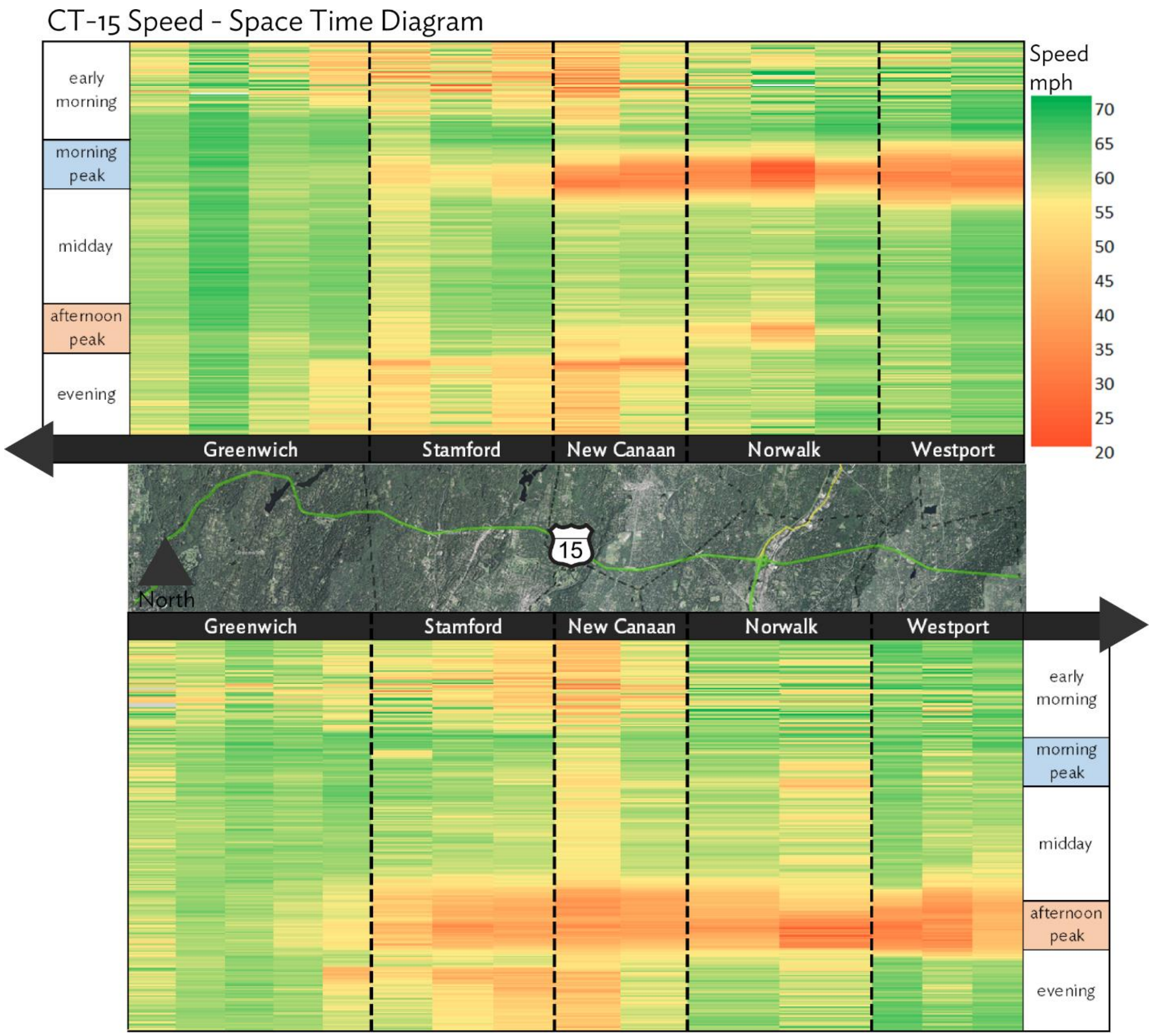
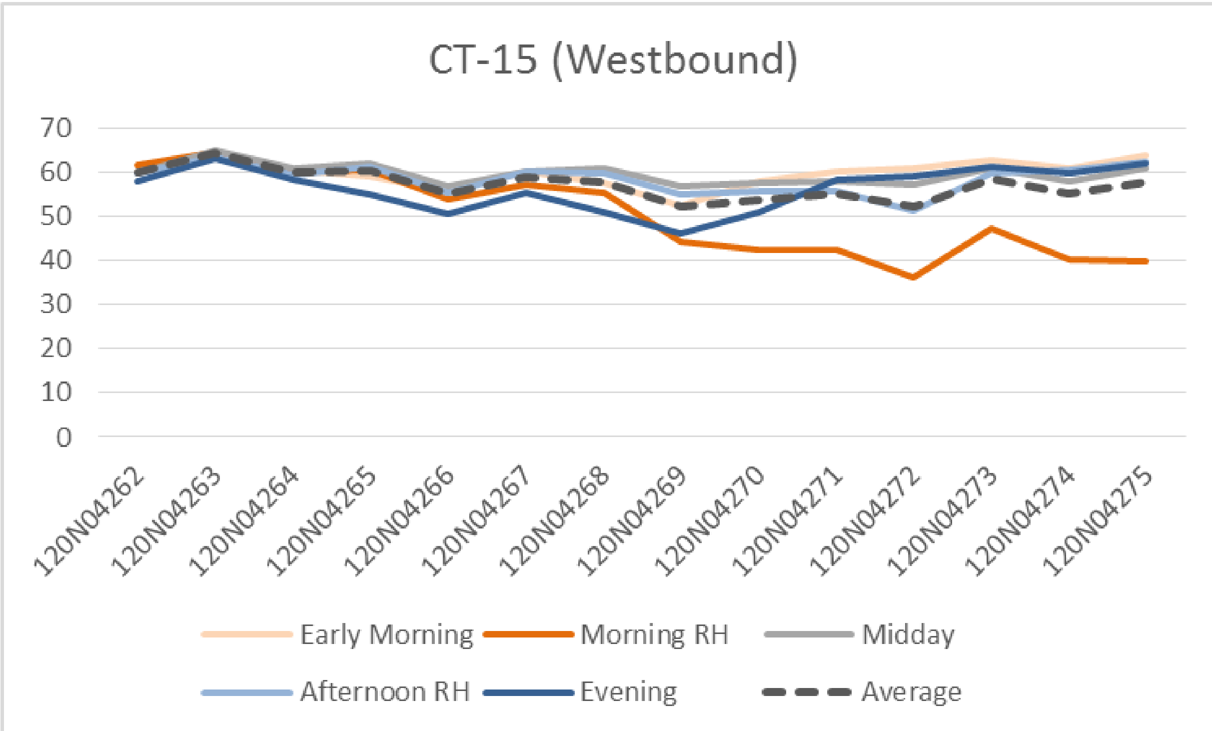


Figure 6: Average speed on CT-15 by direction and time of day.

Observed speeds are represented by colors from green (fast) to red (slow).



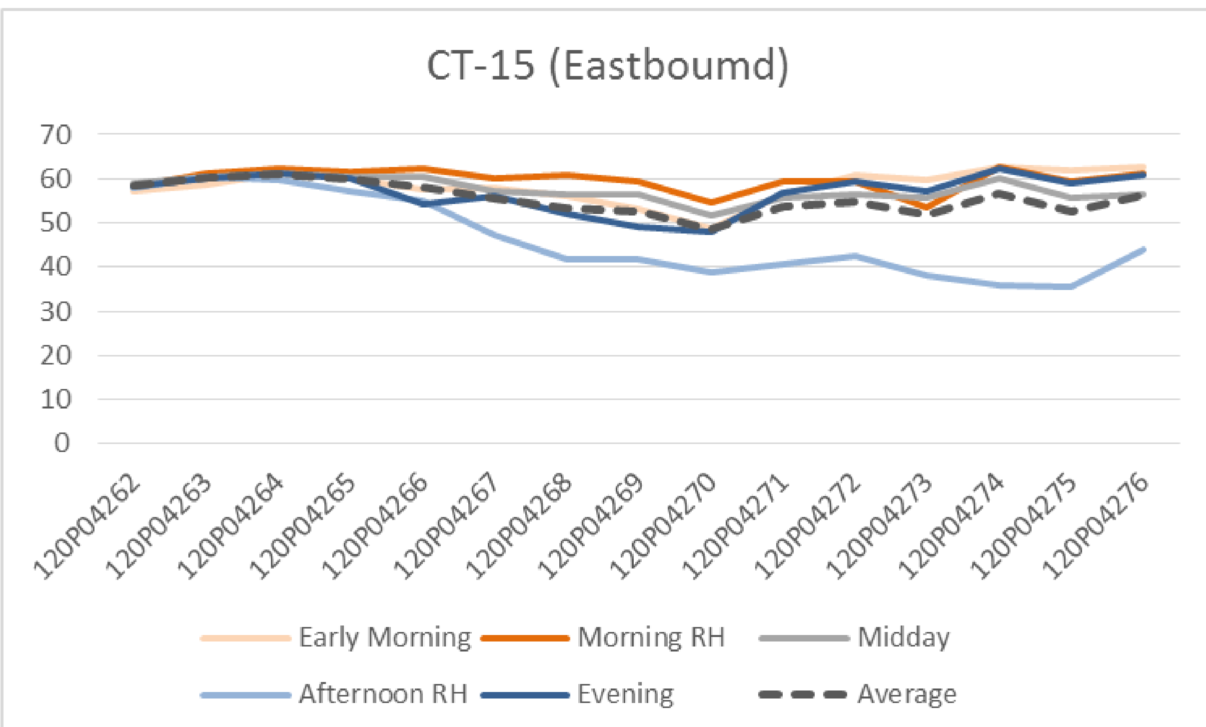
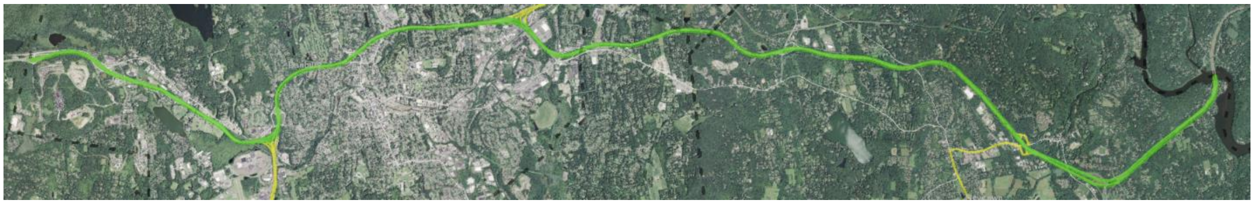


Figure 7: CT 15 travel speeds by time of day.



I-84 Corridor

Interstate 84 is an east-west oriented highway extending 18.5 miles through the northern half of the region from the New York state line to the Newtown-Southbury town boundary at the Rochambeau Bridge over the Housatonic River. I-84 intersects and is concurrently signed with US 7 through Danbury. I-84 is an important freight route that links Connecticut and the other New England states with New York, Pennsylvania, and the transcontinental interstate system. Danbury, a major employment center, is the only large city along I-84 in the region. As a result, travel speed and congestion on I-84 is heavily influenced by commuter travel to and from Danbury by commuters who reside north along Route 7, east towards Waterbury, and west in New York's Hudson Valley.

Unlike the other highways included in this report, the I-84 travel speeds and congestion are asymmetric. While observed westbound travel speeds suggest free flow conditions in all five time periods, eastbound travel speeds are slower throughout nearly the full extent of the highway. During the Morning Peak period, there was only a small decrease in travel speed traveling westbound towards Danbury. However, eastbound travel speeds during the Afternoon Peak period were 5 to 15 mph lower than during other periods. The asymmetric travel patterns are likely symptomatic of Afternoon Peak period traffic being impacted by persons making trips for purposes other than work-to-home.

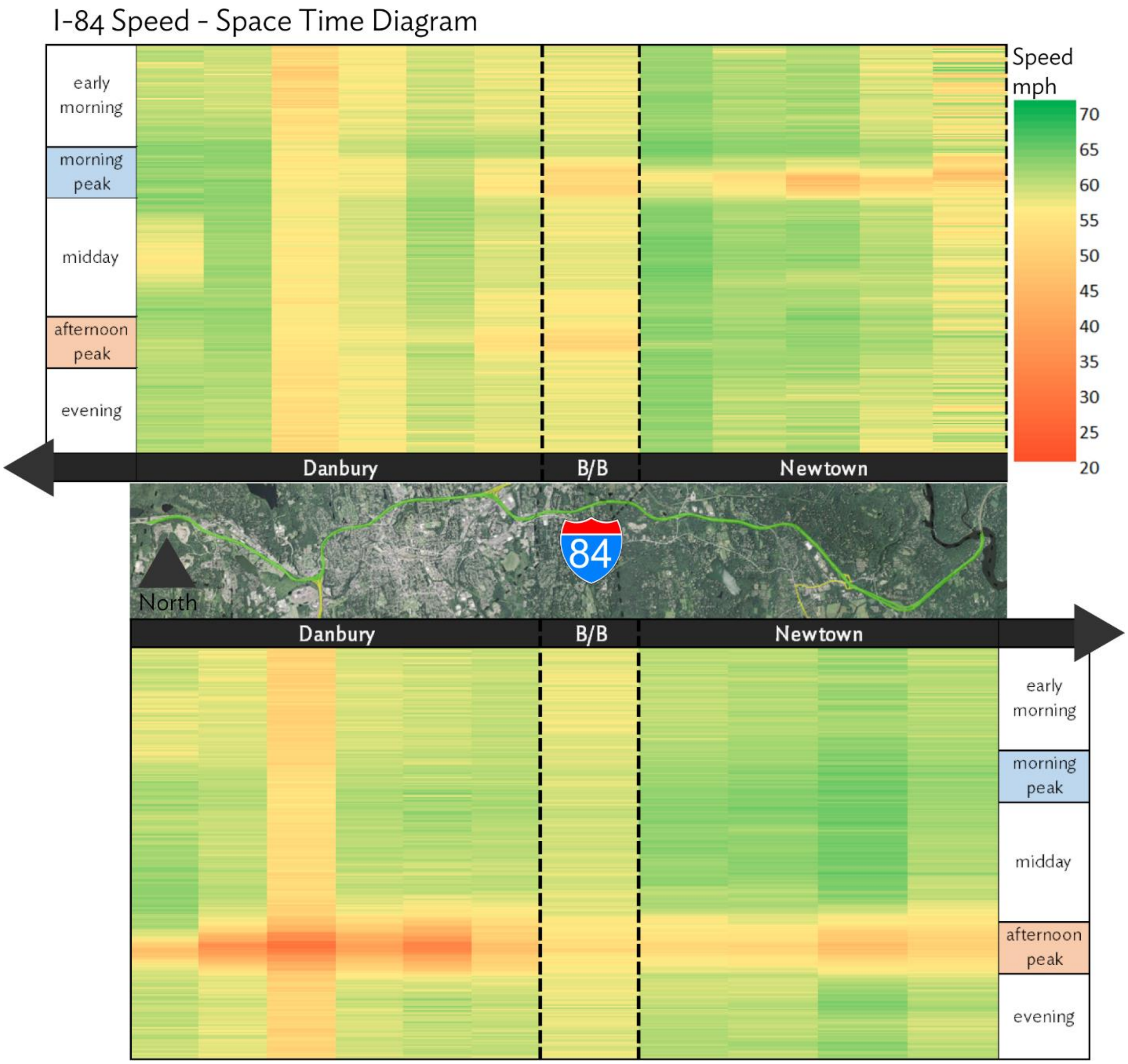
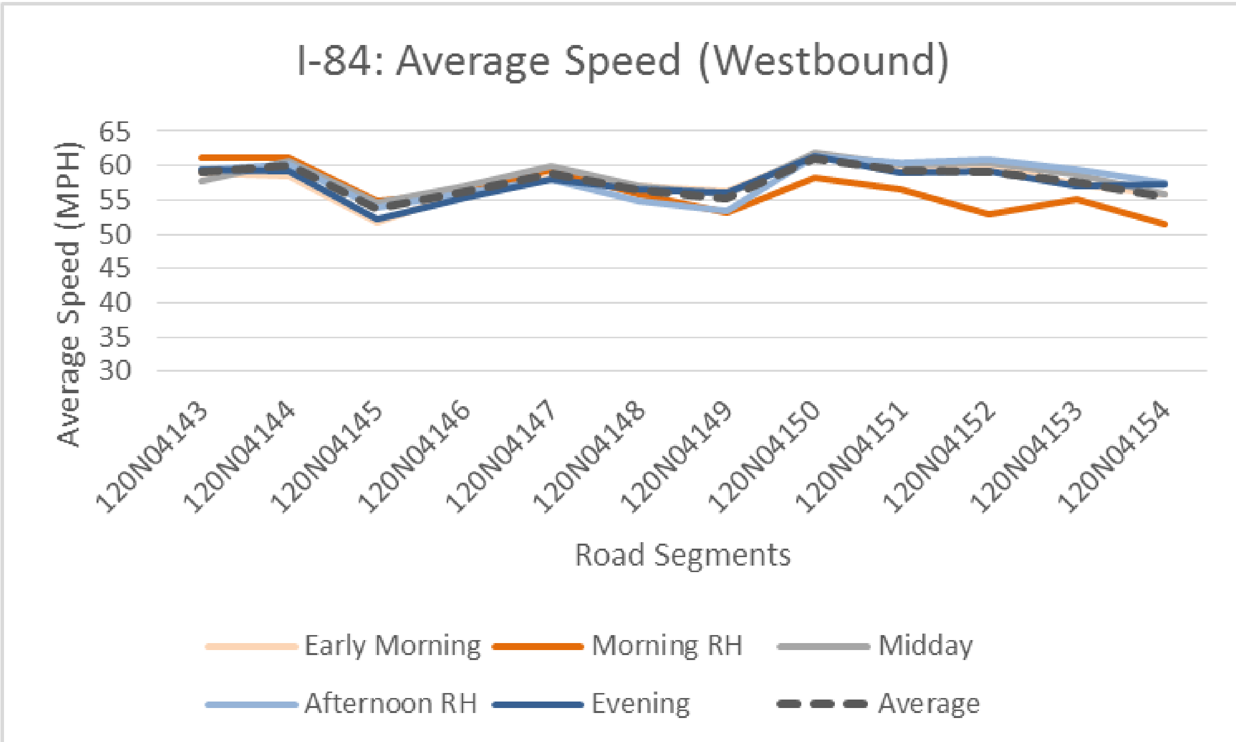


Figure 8: Average speed on I-84 by direction and time of day.

Observed speeds are represented by colors from green (fast) to red (slow).



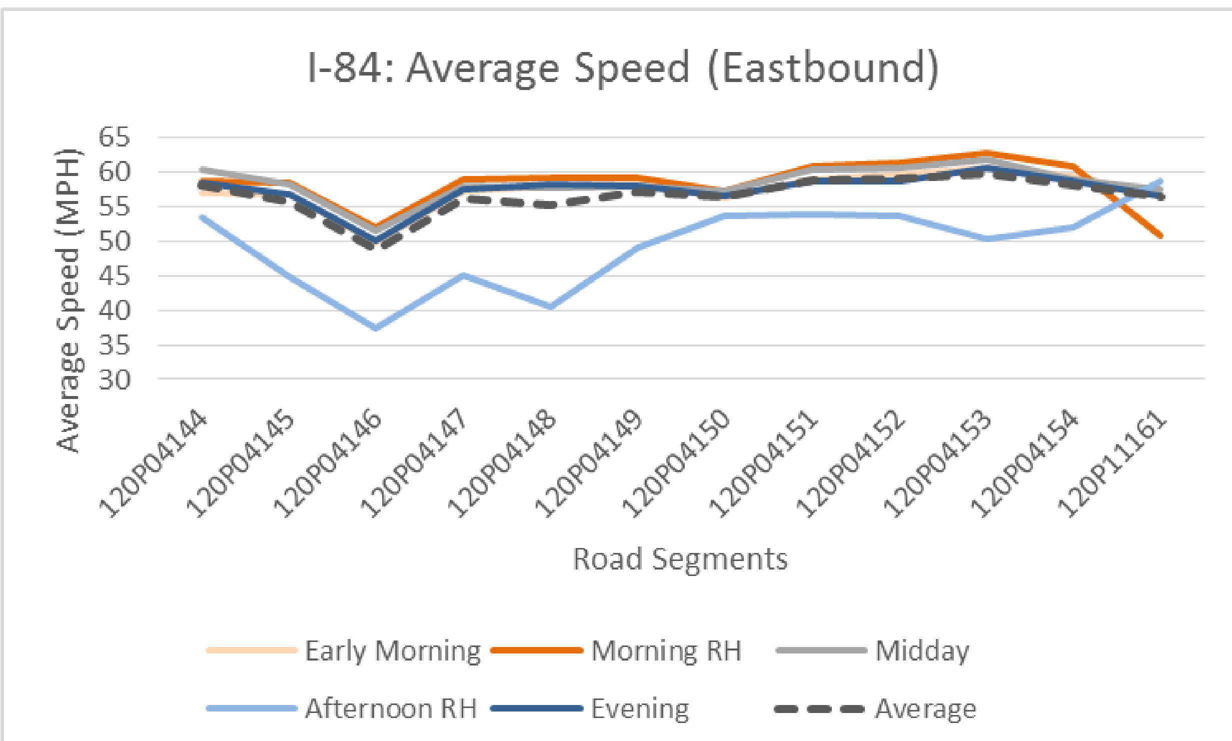


Figure 9: I-84 eastbound travel speeds by time of day.

US 7 Corridor

US Route 7, the primary geographically oriented north-south highway in the region, extends 42.4 miles from I-95 in Norwalk to the New Milford-Kent town boundary. The functional classification and cross section of US 7 varies throughout its extent. In Norwalk, US 7 is a limited access expressway that has interchanges with I-95 and CT 15. From Norwalk to Danbury, US 7 is a surface principal arterial that also provides local access to commercial areas. From Danbury to Brookfield, US 7 is again a limited access expressway, which runs concurrently with I-84 for 3.65 miles. From Brookfield through New Milford, US 7 is again a surface principal arterial.

This report presents data for US 7 in four sections (see Figure 9):

Section A: From I-95 to the Merritt Parkway, US 7 is limited access expressway.[16] The ADT in this sections ranges between 30,000 and 60,000. It is the busiest section of Route 7 and is generally characterized by free flow conditions with an average speed of 53.4 mph. However, southbound travel speeds are lower (26.7 mph average) during the Morning Peak period approaching the I-95 interchange Reduced travel speed in this section are likely due to vehicles merging onto I-95 as well as construction activity associated with a project to add speed change lanes to I-95.

Section B: From the Merritt Parkway north to I-84, US 7 is a surface principal arterial that also provides local access to commercial districts. The land use adjacent to the highway varies, from primarily strip commercial in the south to more rural in the north. The average daily traffic volume general declines as Route 7 goes north and ranges from 32,000 cars on the southern end to about 18,000 on the northern end of this section. The average speed for this segment is 33.3 mph with individual sections ranging from 20.8 mph to 47.9 mph (near I-84).

Along this section of Route 7, traffic trends are complex. Though Danbury is an employment center, the observed travel speeds by direction by time of day suggest that commuters going to destinations other than Danbury and making trips for purposes other than home-to-work and work-to-home are contributing to the congestion. A few key observation stick out:

- Southbound travel speeds are on average 3.3 mph faster across Section B for all five periods of the day than northbound travel speeds. During the Afternoon Peak period, southbound travel speeds are almost 5 mph faster than northbound travel speeds.
- Northbound travel speeds near Grist Mill Road (where the expressway ends) are on average 7.4 mph slower during the Morning Peak and Afternoon Peak periods than southbound travel speeds. The average travel speed northbound is 20.9 mph.
- Southbound travel speeds near Grist Mill Road are most variable during the Morning Peak period, which likely reflects congestion by commuters headed to the CT-15 or I-95.

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[16] Based on a partial segment selection

US-7; Sections A,B,C,D

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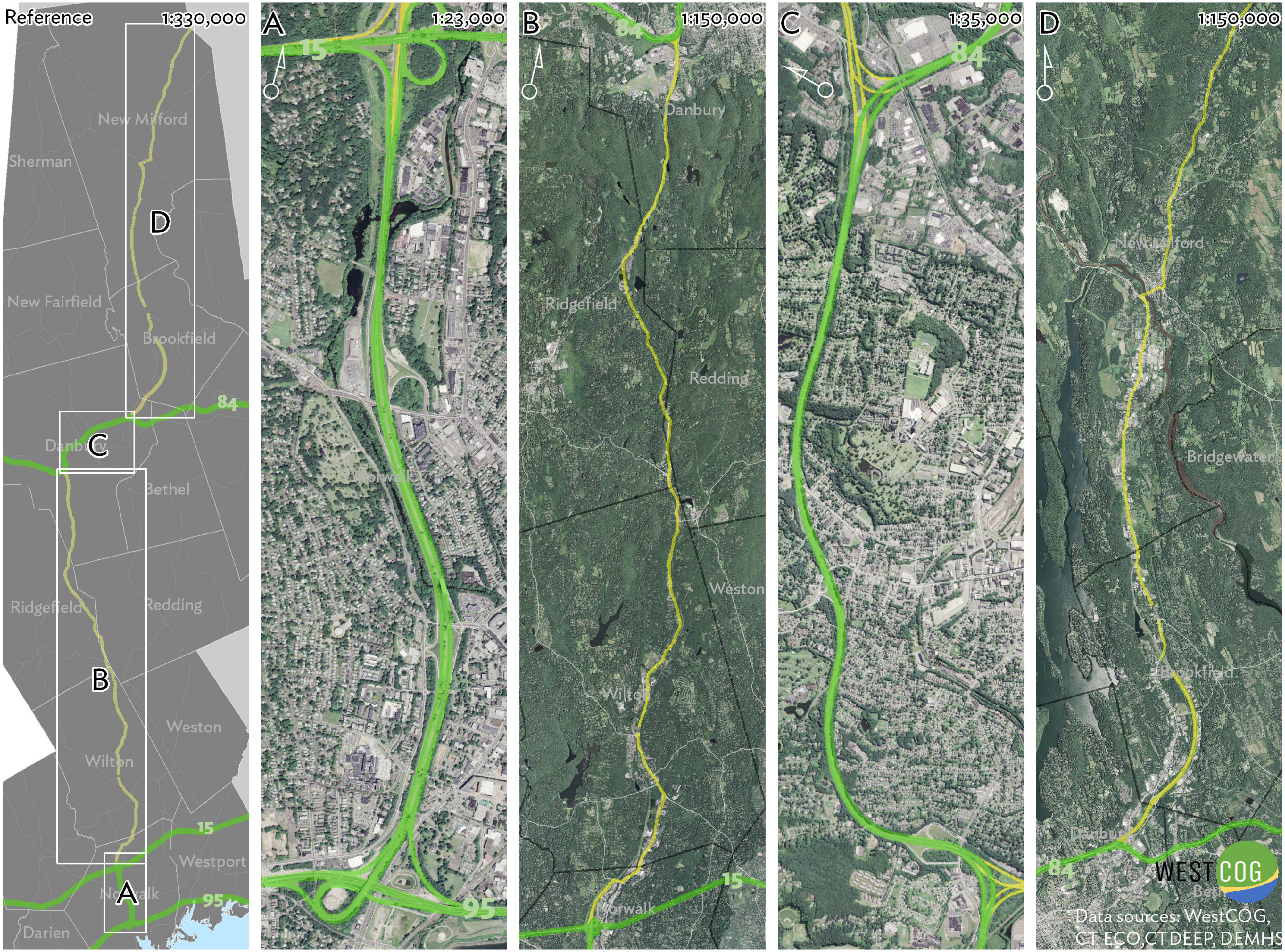

- In the comparatively undeveloped section between Wilton High School and the Route 107 intersection, travel speeds in both the northbound and southbound directions are highly variable based on direction and time period.
- Near the I-84 interchange, there is little variability in southbound travel speeds. Of note, Southbound travel speeds are about 10 mph faster than northbound travel speeds.

Section C: From the southern end of the US 7 – I-84 overlap in Danbury to the intersection with US 202 in Brookfield, US 7 is a limited access highway that overlaps I-84 for 3.65 miles.[17] Section C is 5.50 miles long and has an average speed pf 51.5 mph. The ADT on this section is 23,000 vehicles per day, which is similar to the ADT observed on Section B. Travel speeds on Section C vary minimally across all time periods although southbound travel speeds are generally lower than northbound travel speeds. Notably, southbound travel speeds near the US 7 overlap with I-84 are lower by about 15 mph during the Morning Peak period.

Section D: Between Brookfield and New Milford, US-7 is a surface principal arterial. The land use along US 7 in this section is a mix of commercial (large and small retail) and low intensity rural. The ADT in Section D drops precipitously from south (about 28,000 vehicles/day at the Brookfield – New Milford town line) to north (about 3,100 vehicles/day at the New Milford – Kent town line). The average travel speed in Section D is 34.9 mph and varies from a minimum of 18.0 mph near downtown New Milford to a maximum of 45.0 mph. Travel speeds in Section D are highly variable suggesting periodic congestion.

[17] Analysis does not include the I-84 portion

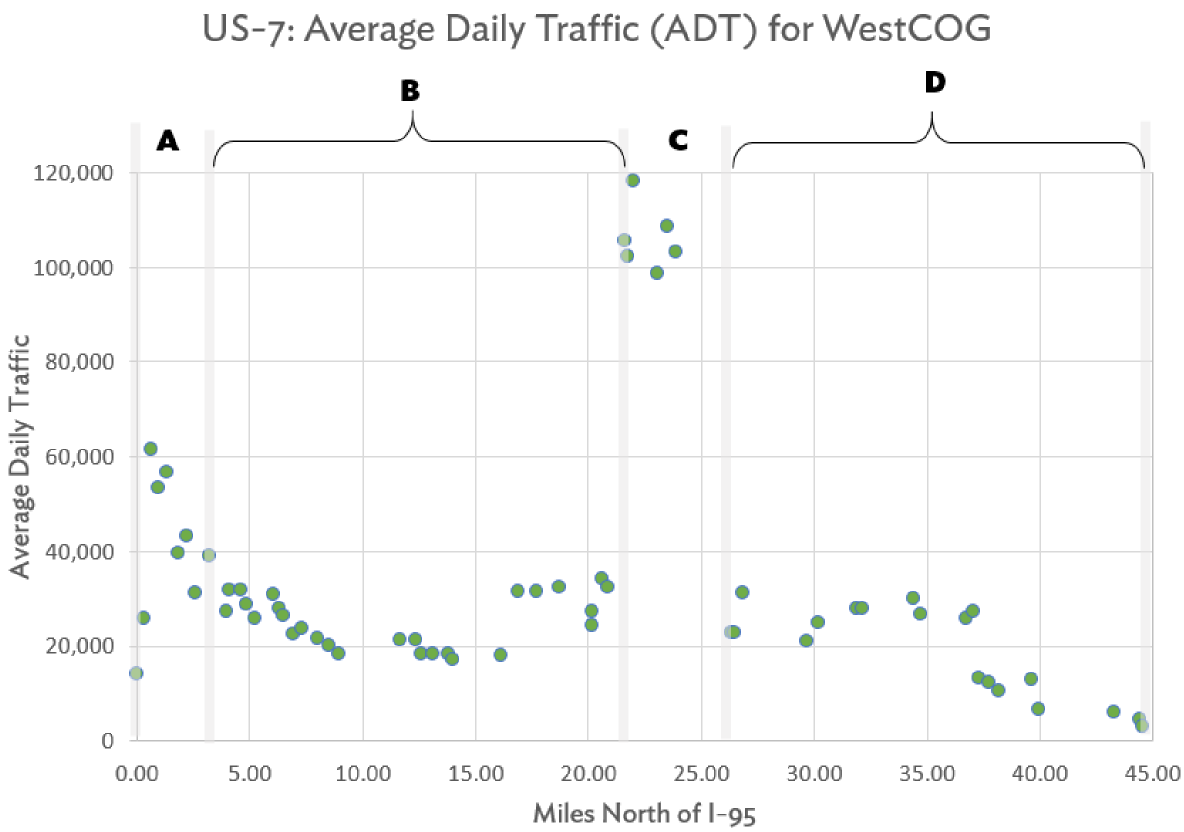

Figure 11: ADT on US-7 by distance north of I-95.

Freight

The I-95 corridor is a critical corridor for freight traffic along the entire East Coast of the United States. For the portion of I-95 within the region, average travel speeds for commercial vehicles was 2.4 mph slower than the average travel speed for passenger vehicles. Commercial vehicles had slower average speeds than passenger vehicles on all but one segment of highway with differences varying from 6.5 mph slower to 1.0 mph faster. Temporally, the difference between commercial and passenger vehicles was smallest (about 1.5 mph) between 7:15 am and 9:35 am largest between 7:50 pm and midnight (about 4.0 mph). This finding suggests that congestion during the morning rush hour impacts all vehicles, including commercial vehicles.

Data Sets and Methodology

NPMRDS

This report relies heavily on the National Performance Management Research Data Set (NPMRDS), which is a vehicle probe based travel time data set. The NPMRDS is produced by the company *Here* and made available for free by the Federal Highway Administration to State Departments of Transportation and Metropolitan Planning Organizations. The travel time data contained in the NPMRDS was obtained from mobile phones, vehicle GPS devices, and portable navigation devices. The data is organized by multi-state regions and published monthly.

The data is divided into five minute increments called epochs which are numbered from 0 to 287 for an entire 24-hour day. Each epoch corresponds to a specific time increment starting at 12:00am and increasing incrementally through the day (Appendix 2). For instance, the time 6:15 am corresponds with epoch #75. All of the data is associated with a specific line segment within the road network, which are typically one mile or less in length and include a directionality component (e.g. east, west, north, south). These segments are called TMCs (traffic message channels) (Appendix 3).

To acquire and process the data, WestCOG staff began by downloading.csv files (comma delimited data) from the *Here* website. The data contained in the .csv files is organized into a hierarchical structure based on geography. The coarsest scale is region (e.g. Northeastern states); at the next level are states (e.g. Connecticut); and within the states are counties (e.g. Fairfield and Litchfield). For each epoch and segment, there is an associated travel time record.

To prepare this report, data was selected for the months of April and October and for the days of Tuesday, Wednesday, and Thursday. These selections were made in order to represent typical travel conditions when primary and secondary schools are in session and when highway travel is less likely to be impacted by winter storms or holidays. This approach is consistent with prior CMP reports prepared by SWRPA. Unlike the small samples produced using the floating car method, the NPMRDS offered huge numbers of records (over 18 million) for this selection.[18] In order to spatially reference this data, a key step was create a spatial join between the speed data and the FHWA Monthly Static File (Q12014) so that the road segment variable called TMC could be linked with the individual speed data. Due to the large files sizes and instability of the software, data was further subset to individual highways.

Graphs and summary statistics were created in MS Excel using the Pivot Tables module. Using Pivot Tables removed the maximum number of row limitations and allowed database like aggregation by category. Epochs were binned into five functional time periods: Early Morning (midnight to 6:00am); Morning Peak (6:00-9:00am); Midday (9:00am-4:00pm); Afternoon Peak (4:00-7:00pm);

[18] These data sets are very large and may need to be loaded into a database for processing and analysis.

Evening (7:00pm-midnight). The data records contained travel time in seconds, which was converted to speed in miles per hour by dividing the length of the line segment by time.

ADT

The Connecticut Department of Transportation provides average daily traffic (ADT) data for specific locations throughout Connecticut for numbered national highway system routes.[19] ADT data is collected on three-year cycles[20] at specific locations and represent running averages. ADT data is useful for transportation planning analyses, such as determining the volume-to-capacity ratio of highways and year-over-year changes in traffic volume.

LODES

The Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics (LODES)[21] are produced by United States Census Bureau's Longitudinal Employer-Household Dynamics program. This information is aggregated by municipality, Census Tract, Zip Code, and other geographies. For this report, the latest available data (2011) was extracted using the OnTheMap text-only analytic tool. The LODES data provides information on the workers' place of work by place of residence as well as the direction and distance workers commute. The OnTheMap tool outputs raw excel data and mapping products. For this report, Distance/Direction, Destination, and Inflow/Outflow information was obtained for the larger towns in the region (Danbury, Greenwich, Norwalk, and Stamford) in order to help understand commuting patterns.

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[19] 2012 ADT data found at State of Connecticut, Department of Transportation. See http://www.ct.gov/dot/cwp/view.asp?a=3532&q=330402

[20] See http://onthemap.ces.census.gov/tot/

[21] LODES data found at United Census Bureau, Longitudinal Employer-Household Dynamics website. See On the Map Text-only Tool, http://onthemap.ces.census.gov/tot/ or http://lehd.ces.census.gov/data/ for data sources.

Appendices

Appendix 1: Correspondence between Periods in the Day and Epoch Range

Time of Day	**Epoch Range**
Early morning (12:00 am - 6:00 am)	0 - 72
Morning Peak (6:00 am - 9:00 am)	73 - 108
Midday (9:00 am - 4:00 pm)	109 - 192
Afternoon Peak (4:00 - 7:00 pm)	192 - 229
Evening (7:00 pm – 12:00 am)	230 - 287

Appendix 2: Example of the Correspondence between Epochs and Time of Day (Five-Minute Increments)

Epoch	***Time***
0	0:00:00
1	0:05:00
2	0:10:00
3	0:15:00
4	0:20:00
5	0:25:00
6	0:30:00
7	0:35:00
8	0:40:00
9	0:45:00
10	0:50:00
11	0:55:00
12	1:00:00
13	1:05:00
14	1:10:00
15	1:15:00
16	1:20:00
17	1:25:00
18	1:30:00
19	1:35:00
20	1:40:00
21	1:45:00
22	1:50:00

Appendix 3: The Variables within the NPMRDS Data Sets

The variables include:

- TMC: Code which identifies the spatial location of a highway segment
- Admin Level 3: Code which identifies the county
- Distance: The length of the highway segment
- Road Number: Categorical tag for the highway name
- Road Direction: Highway direction (e.g. north/south or east/west)
- Epoch: Identifies the time of day
- Travel Time All Vehicles: The length in seconds that the combined sensors took for all vehicles to travel that particular distance. This variable was utilized for all speed calculations because of lack of missing or null value records
- Travel Time Passenger Vehicles: The length in seconds that the combined sensors of passenger vehicles took to travel that particular distance
- Travel Time Freight Vehicles: The length in seconds that the combined sensor for commercial vehicles took to travel that particular distance
- Speed All: A derived value based on the formula:
  *Speed = distance (miles) *60 (seconds) * 60 (minutes)/time (seconds)*

ID	TMC	ADMIN_LEVEL_3	DISTANCE	ROAD_NUMBER	ROAD_DIRECTION	DATE	EPOCH	Travel_TIME_ALL_VEHICLES	Travel_TIME_PASSENGER_VEHICLES	Travel_TIME_FREIGHT_TRUCKS	speed_all
128115	120N041	Fairfield	1.03	I-84	Westbound	4292014	280	61	61		60.78
128116	120N041	Fairfield	1.03	I-84	Westbound	4292014	240	64		64	57.93
128117	120N041	Fairfield	1.03	I-84	Westbound	4012014	2	61		61	60.78
128118	120N041	Fairfield	1.03	I-84	Westbound	4012014	42	60	60	60	61.8
128119	120N041	Fairfield	1.03	I-84	Westbound	4012014	82	59	59		62.84
128120	120N041	Fairfield	1.03	I-84	Westbound	4012014	122	63	61	64	58.85
128121	120N041	Fairfield	1.03	I-84	Westbound	4012014	162	66	77	63	56.18

Figure 12: Example of typical data file for NPMRDS analysis.

Appendix 4: I-95 Corridor Coalition Vehicle Probe Project Bottleneck Rankings.

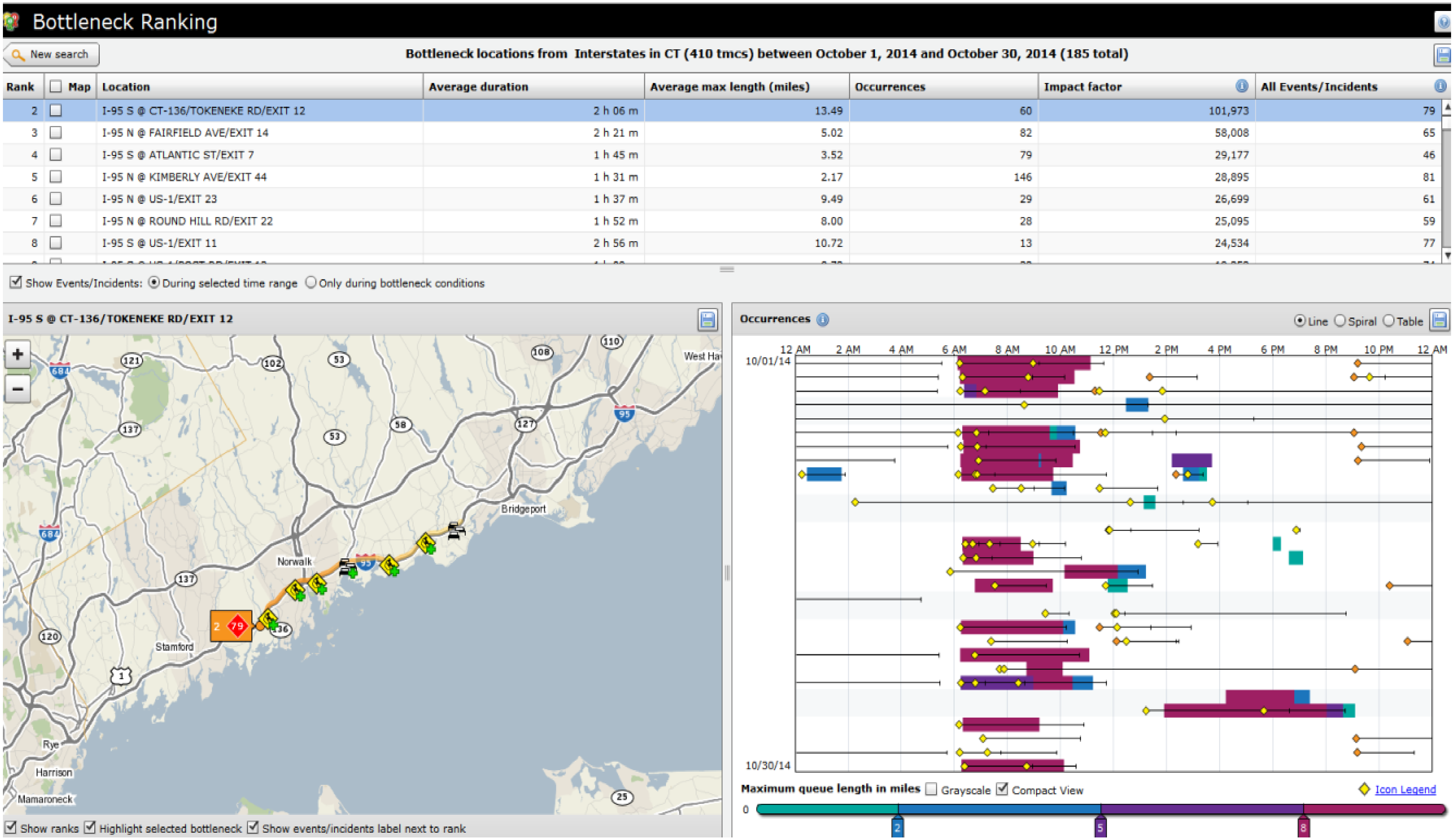

Figure 13: Bottleneck Ranking and Traffic Congestion along I-95.

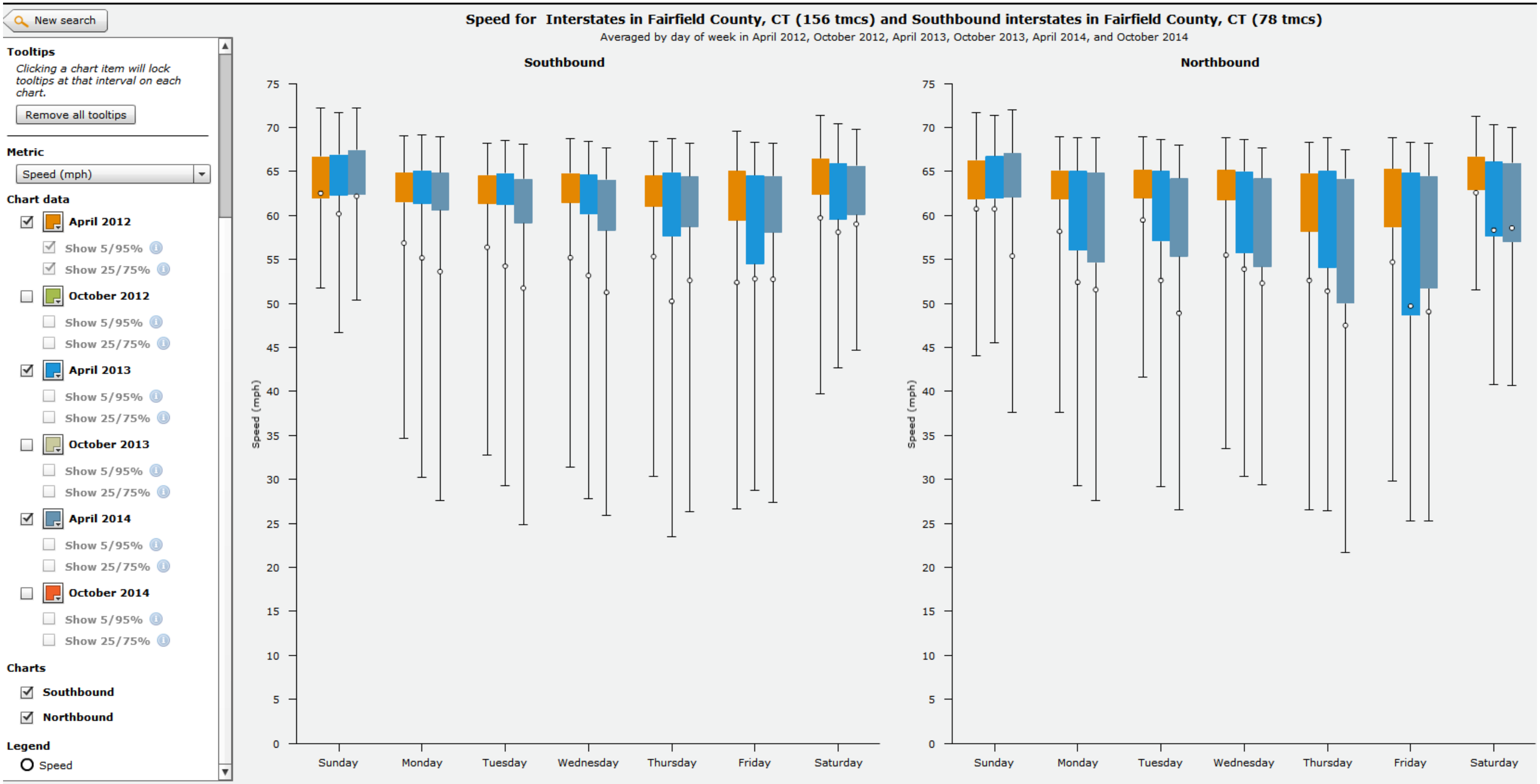

Figure 14: Average travel speed by day for April and October of 2012 – 2014 along the I-95 corridor.