I-84 Danbury Project
Needs and Deficiencies Study
Traffic Operations
Appendix

I-84 Danbury Project

State Project Number 34-349

November 2018

CONNECTICUT DEPARTMENT OF TRANSPORTATION

CDM Smith

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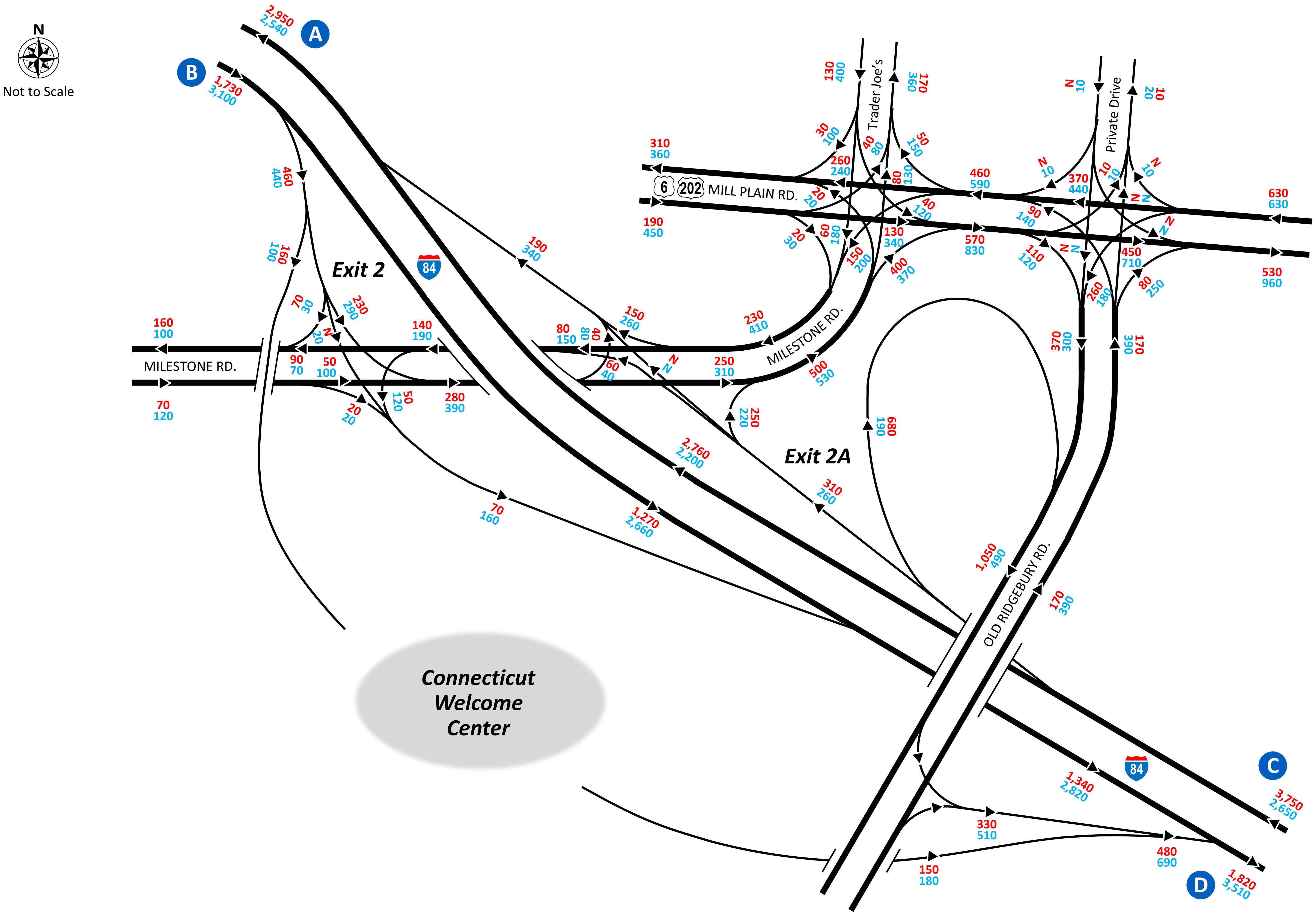


LEGEND

N - Negligible

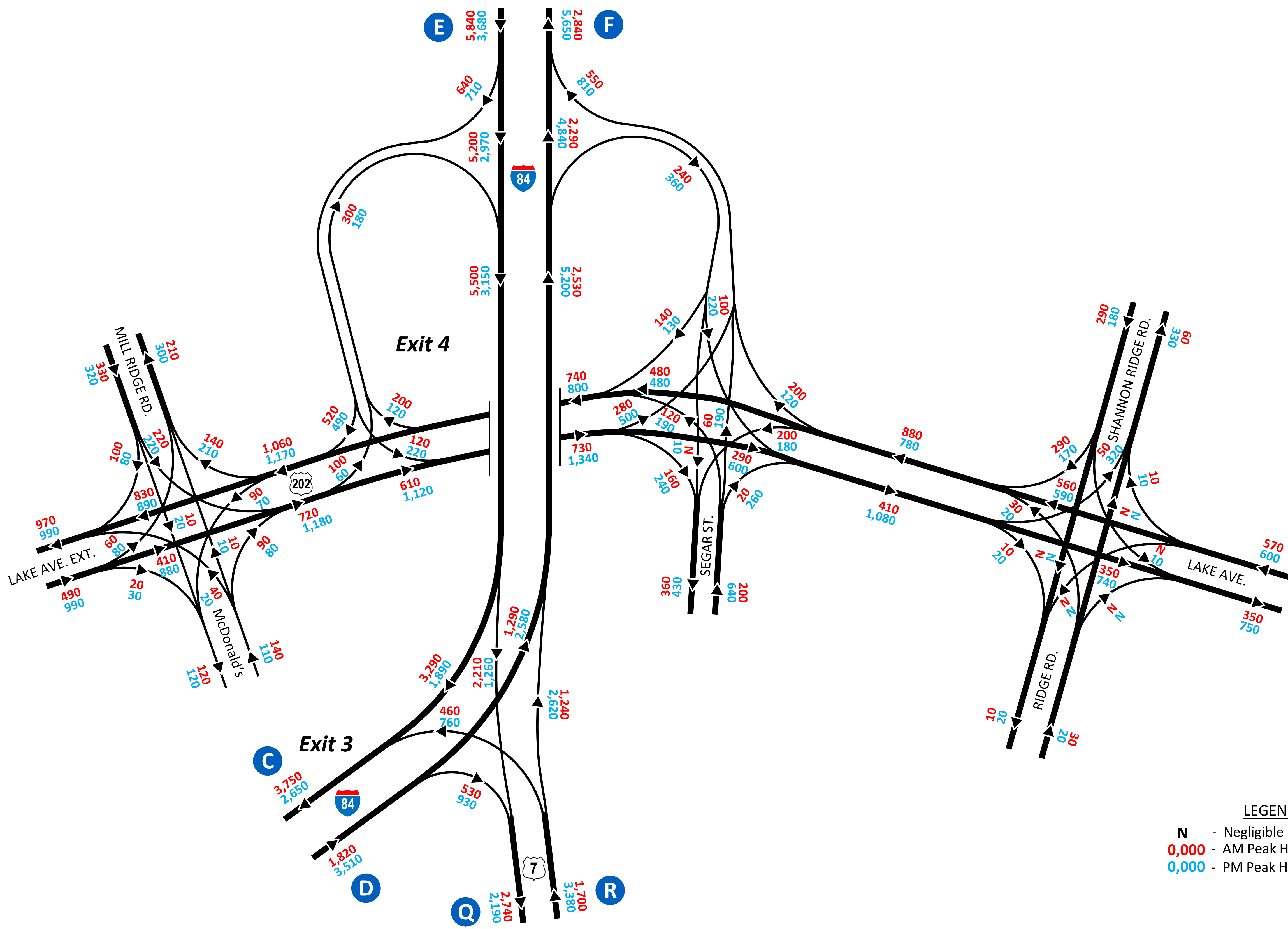
0,000 - AM Peak Hour Traffic Volume

0,000 - PM Peak Hour Traffic Volume

EXISTING (2016)
PEAK HOUR TRAFFIC VOLUMES - EXITS 2 AND 2A

N

Not to Scale



LEGEND

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0,000 - AM Peak Hour Traffic Volume

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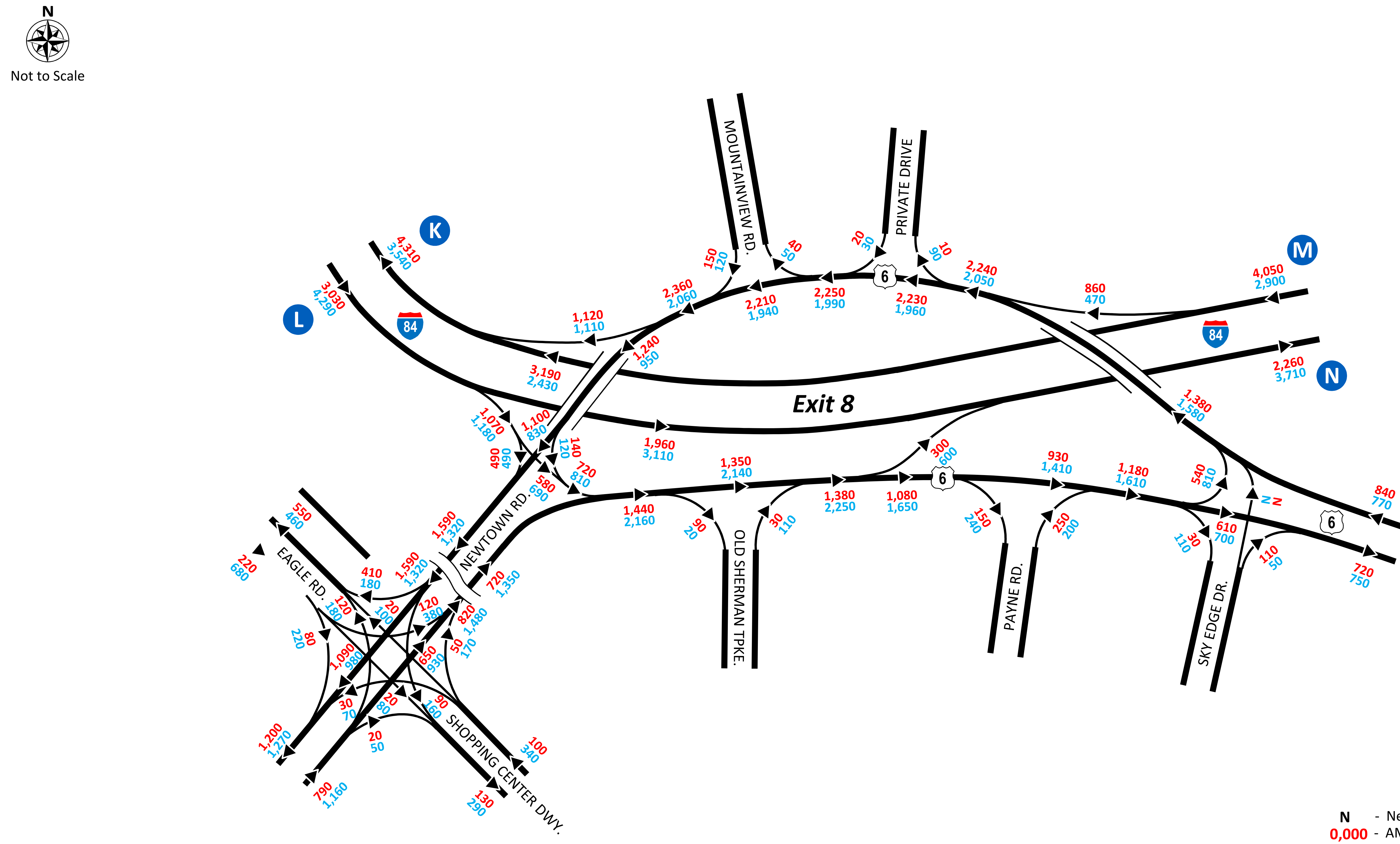
EXISTING (2016)
PEAK HOUR TRAFFIC VOLUMES - EXITS 3 AND 4



LEGEND

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0,000 - AM Peak Hour Traffic Volume
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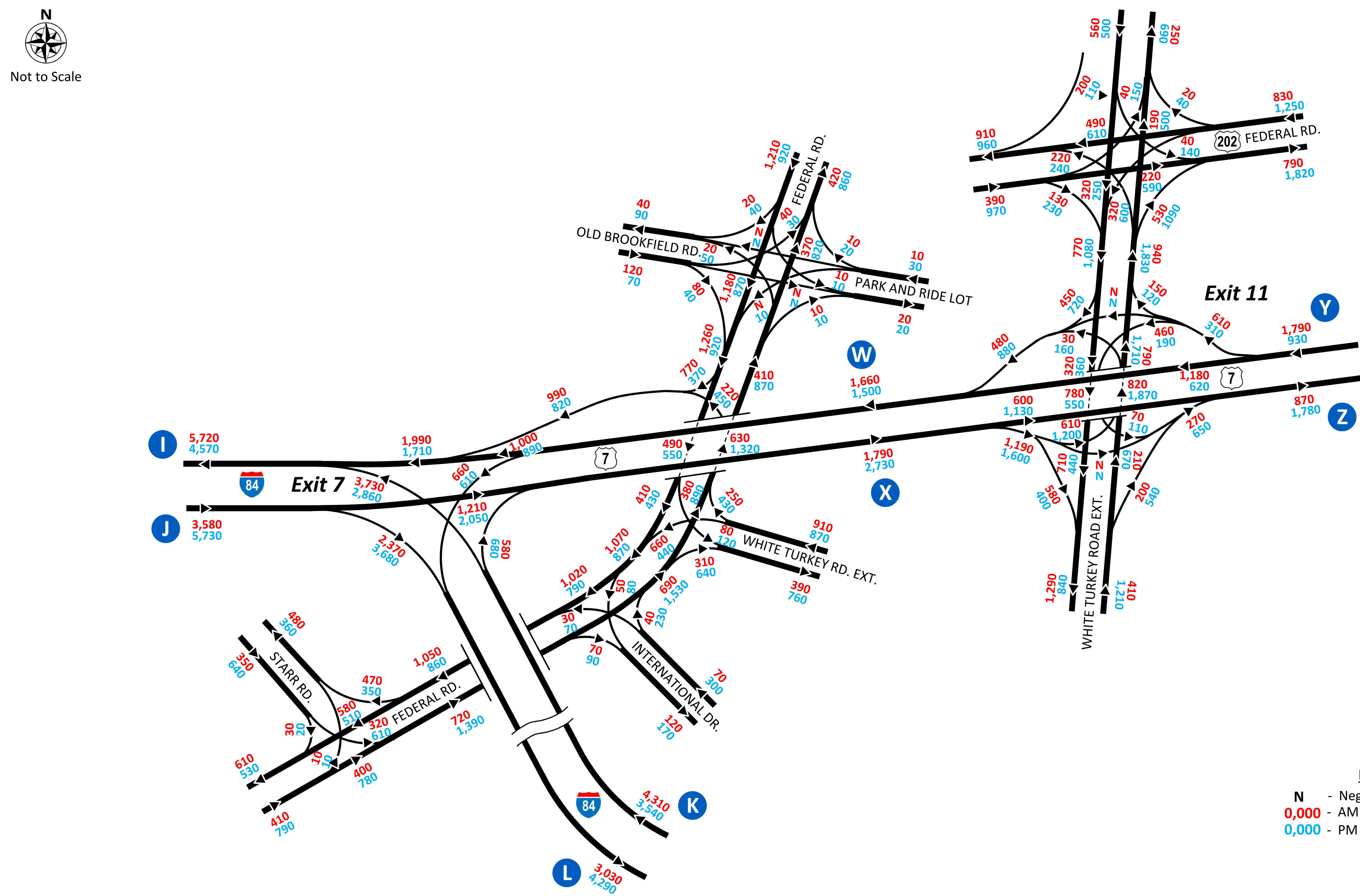
EXISTING (2016)
PEAK HOUR TRAFFIC VOLUMES - EXIT 8



LEGEND

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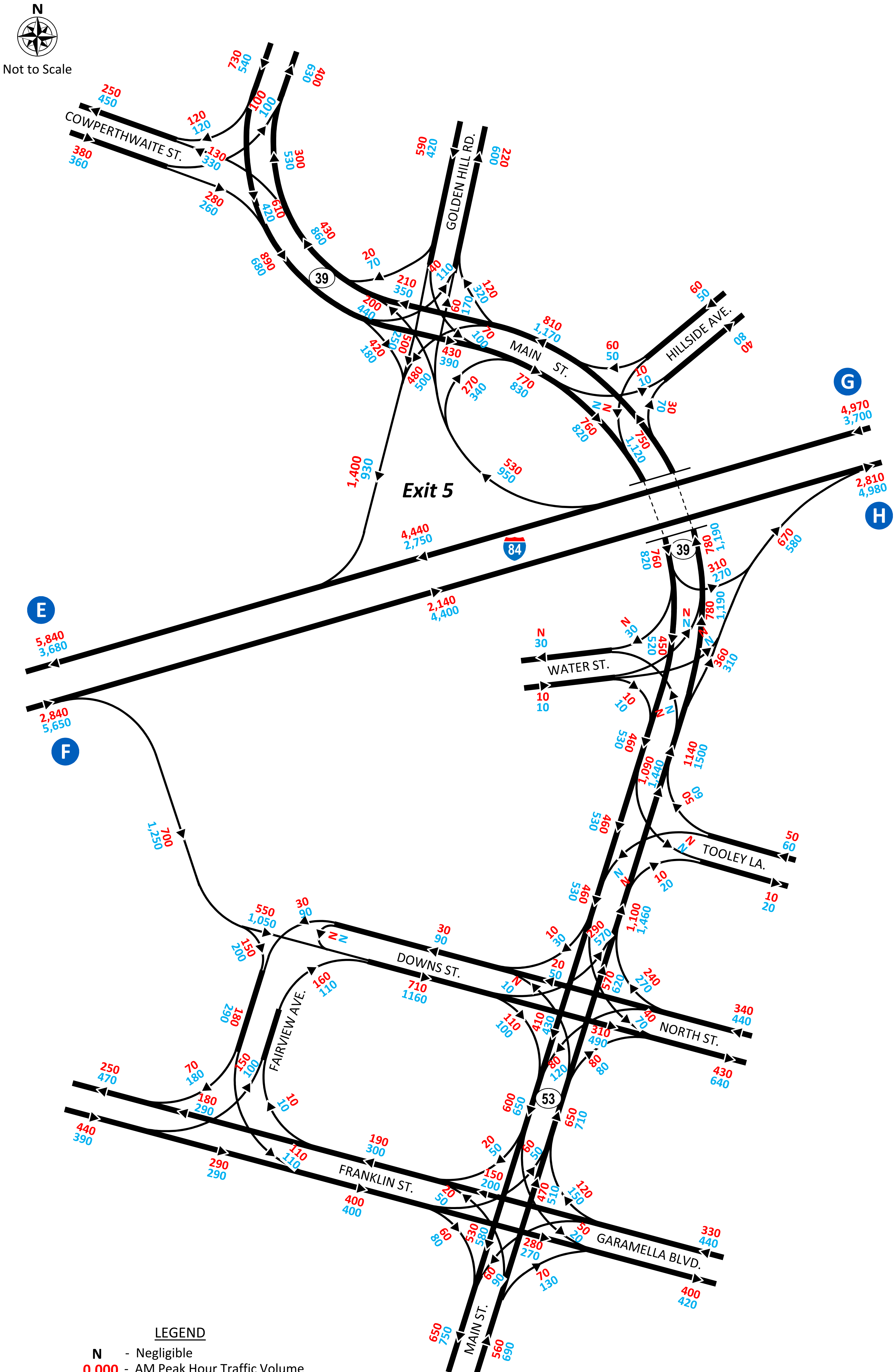
0,000 - PM Peak Hour Traffic Volume

EXISTING (2016)
PEAK HOUR TRAFFIC VOLUMES - EXITS 7 AND 11



LEGEND

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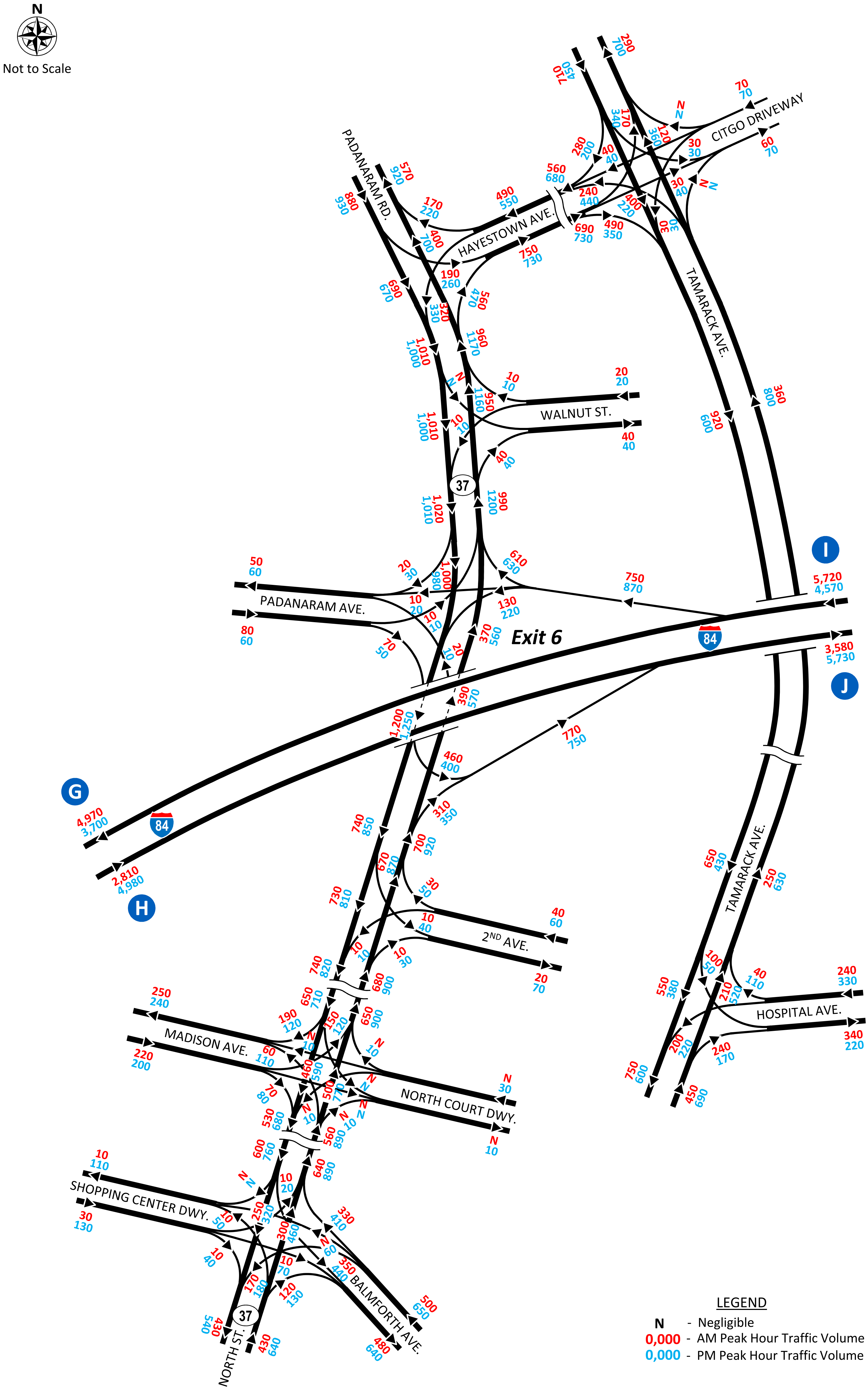
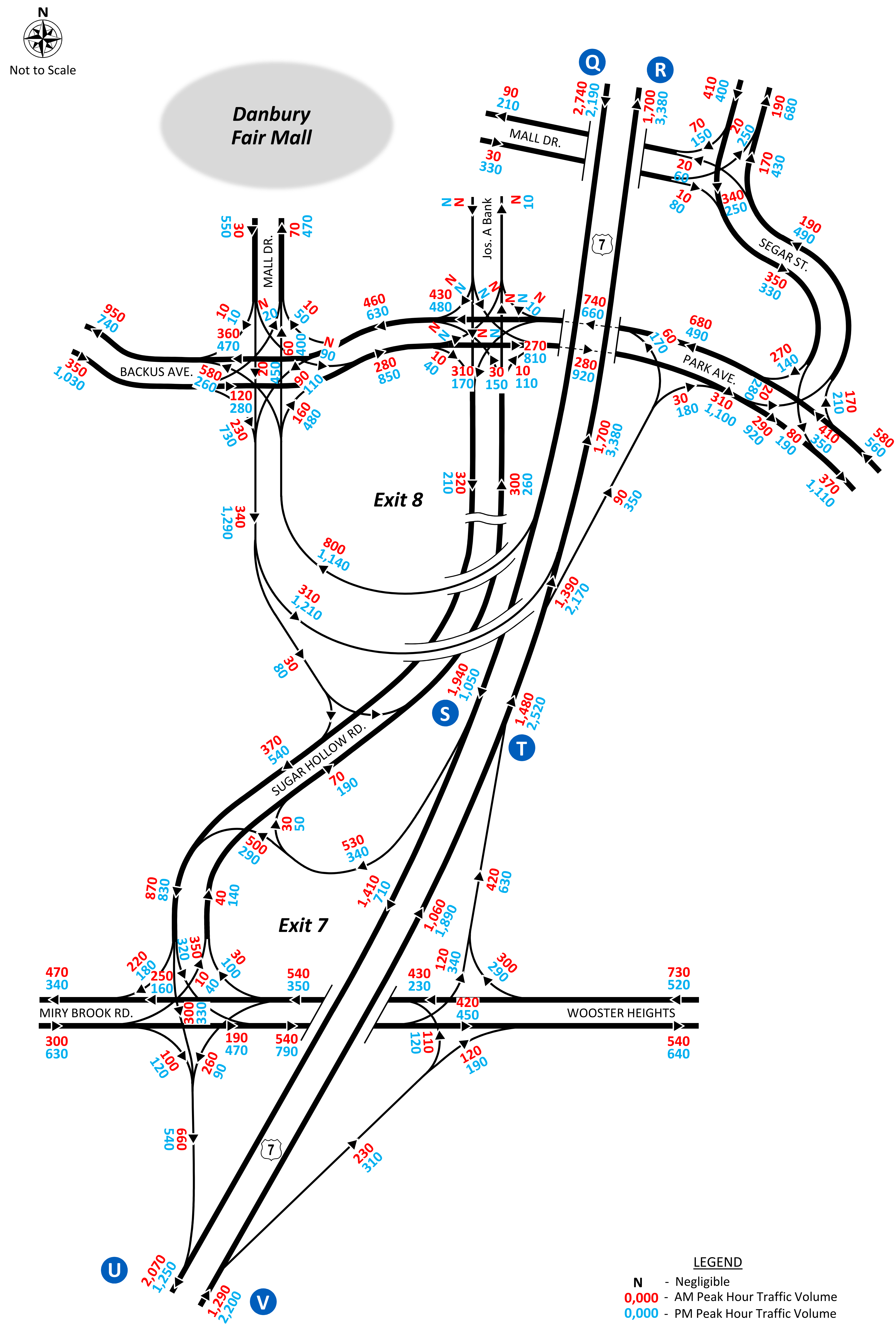
0,000 - AM Peak Hour Traffic Volume

0,000 - PM Peak Hour Traffic Volume

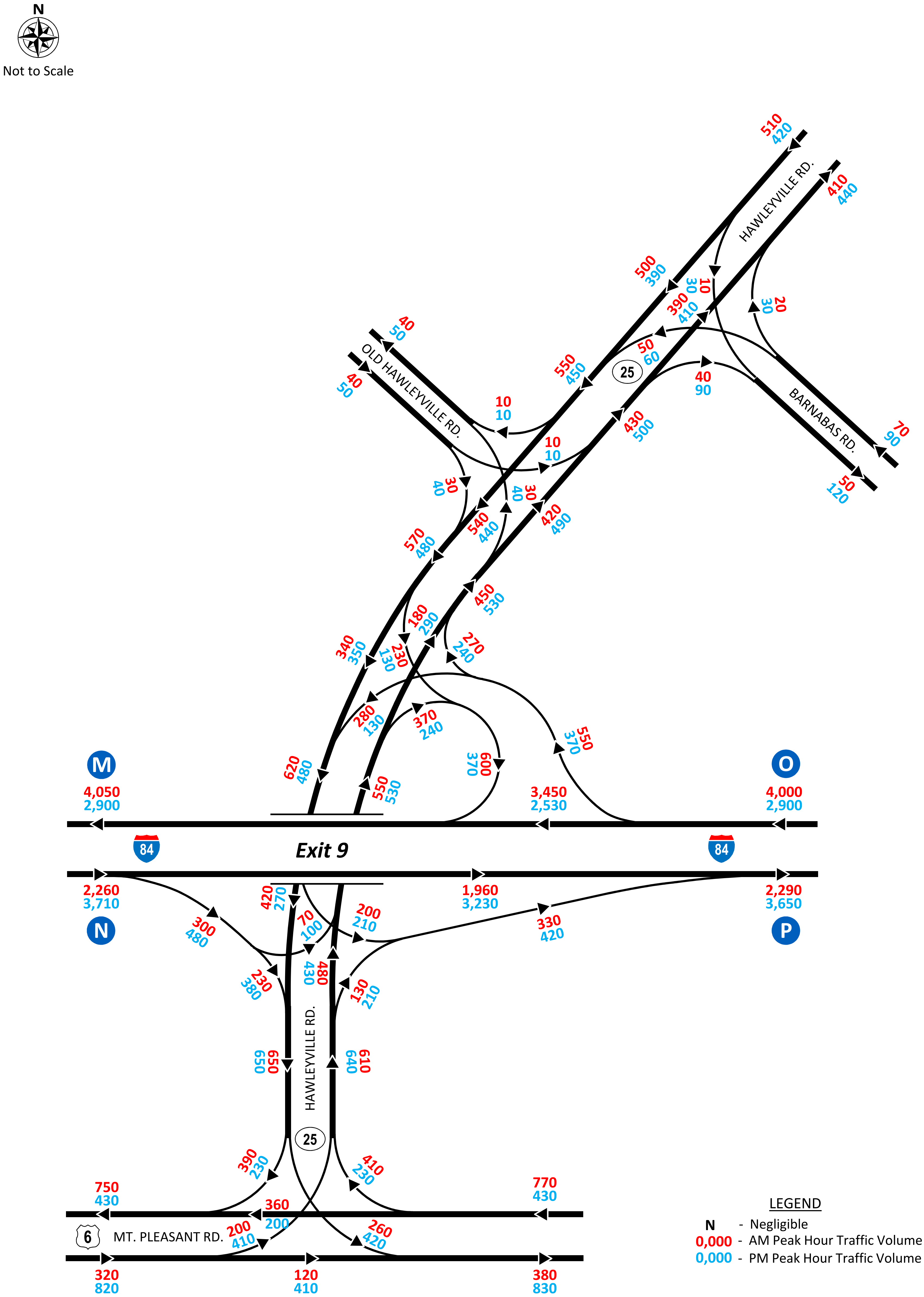
EXISTING (2016)
PEAK HOUR TRAFFIC VOLUMES - EXIT 5



EXISTING (2016)
PEAK HOUR TRAFFIC VOLUMES - EXIT 6

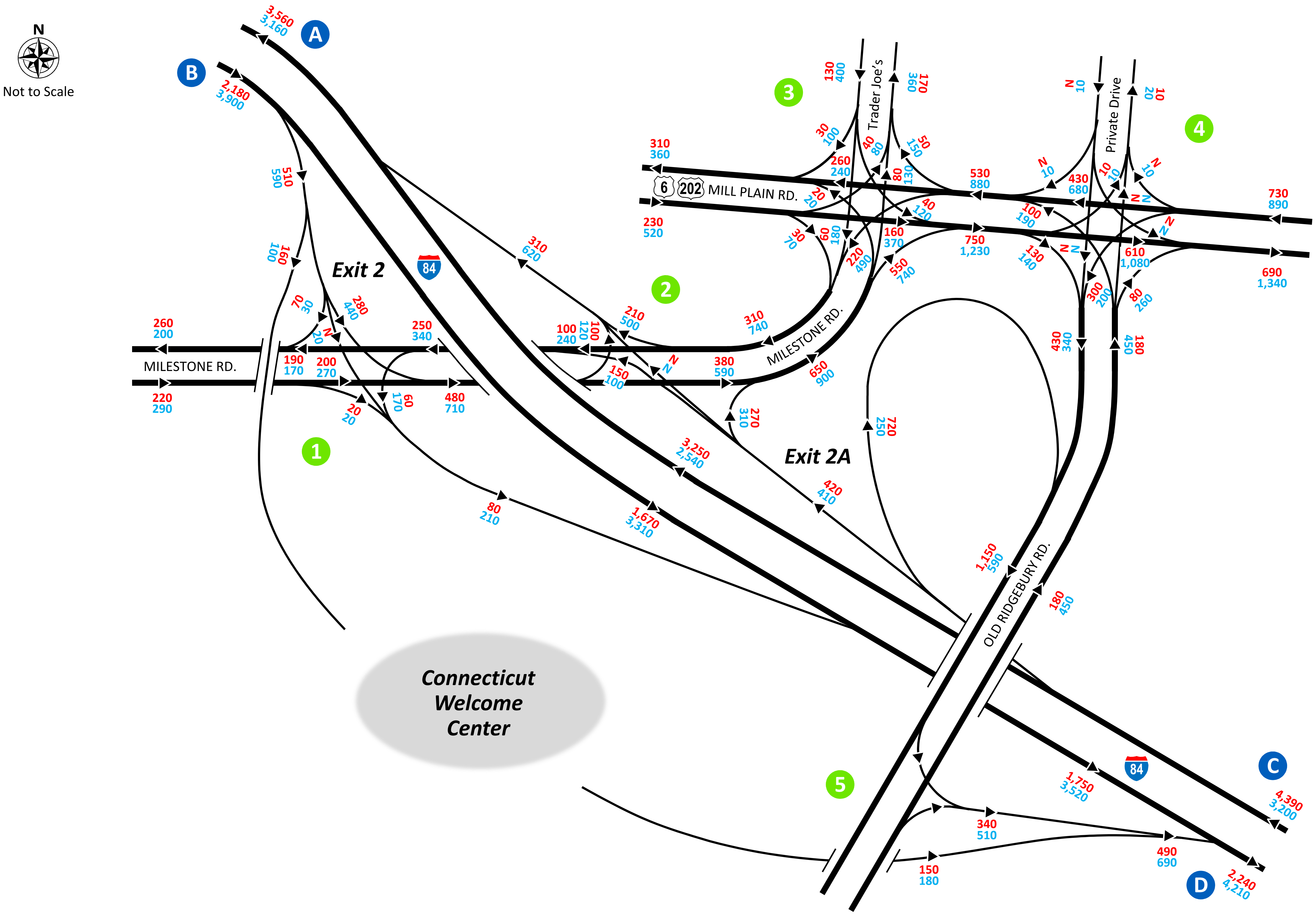


EXISTING (2016)
PEAK HOUR TRAFFIC VOLUMES - EXITS 7 AND 8 (US 7)



EXISTING (2016)
PEAK HOUR TRAFFIC VOLUMES - EXIT 9

CDM Smith



LEGEND

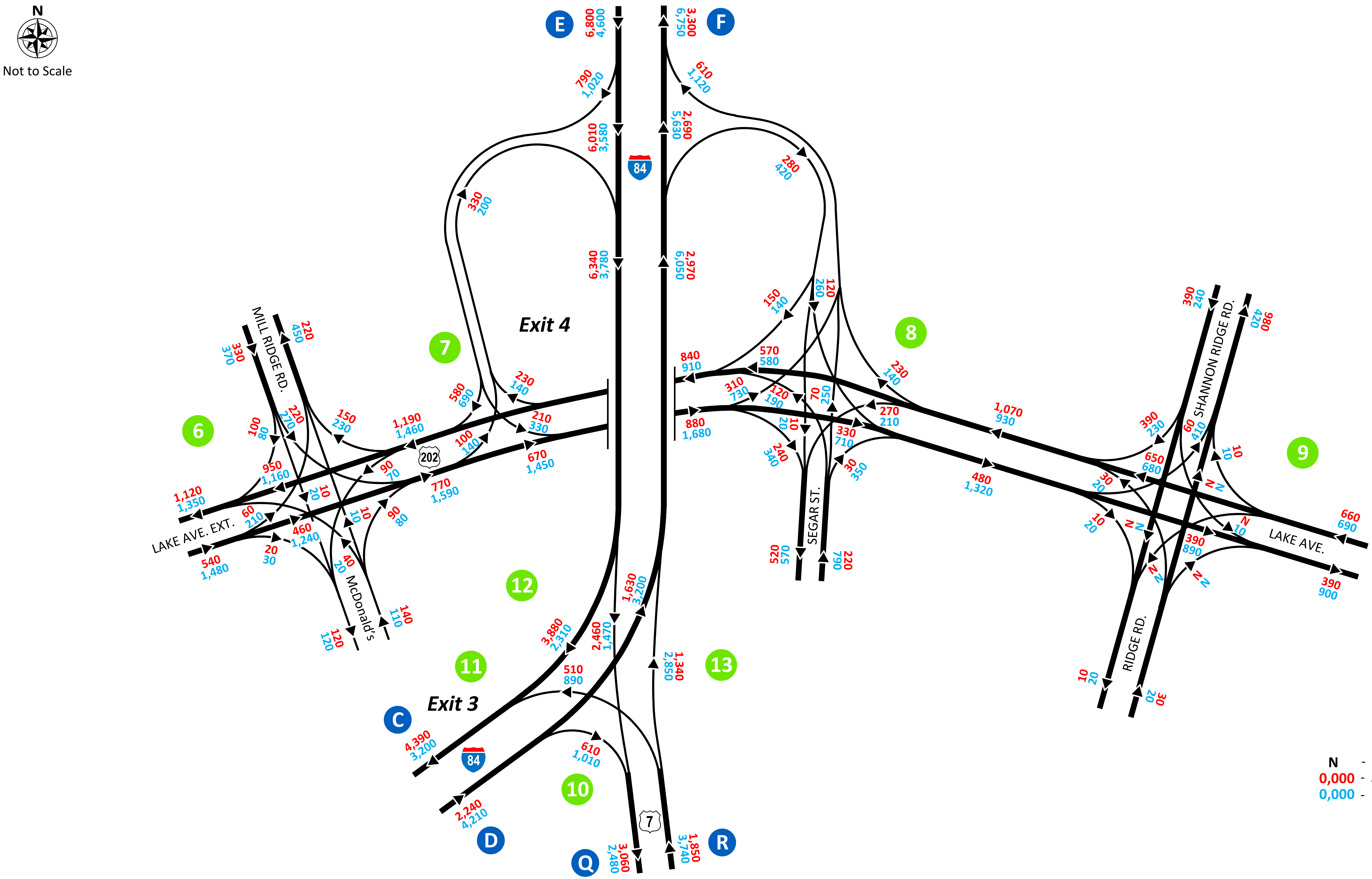
N - Negligible

0,000 - AM Peak Hour Traffic Volume

0,000 - PM Peak Hour Traffic Volume

FUTURE 2040 NO BUILD
PEAK HOUR TRAFFIC VOLUMES - EXITS 2 AND 2A

CDM Smith



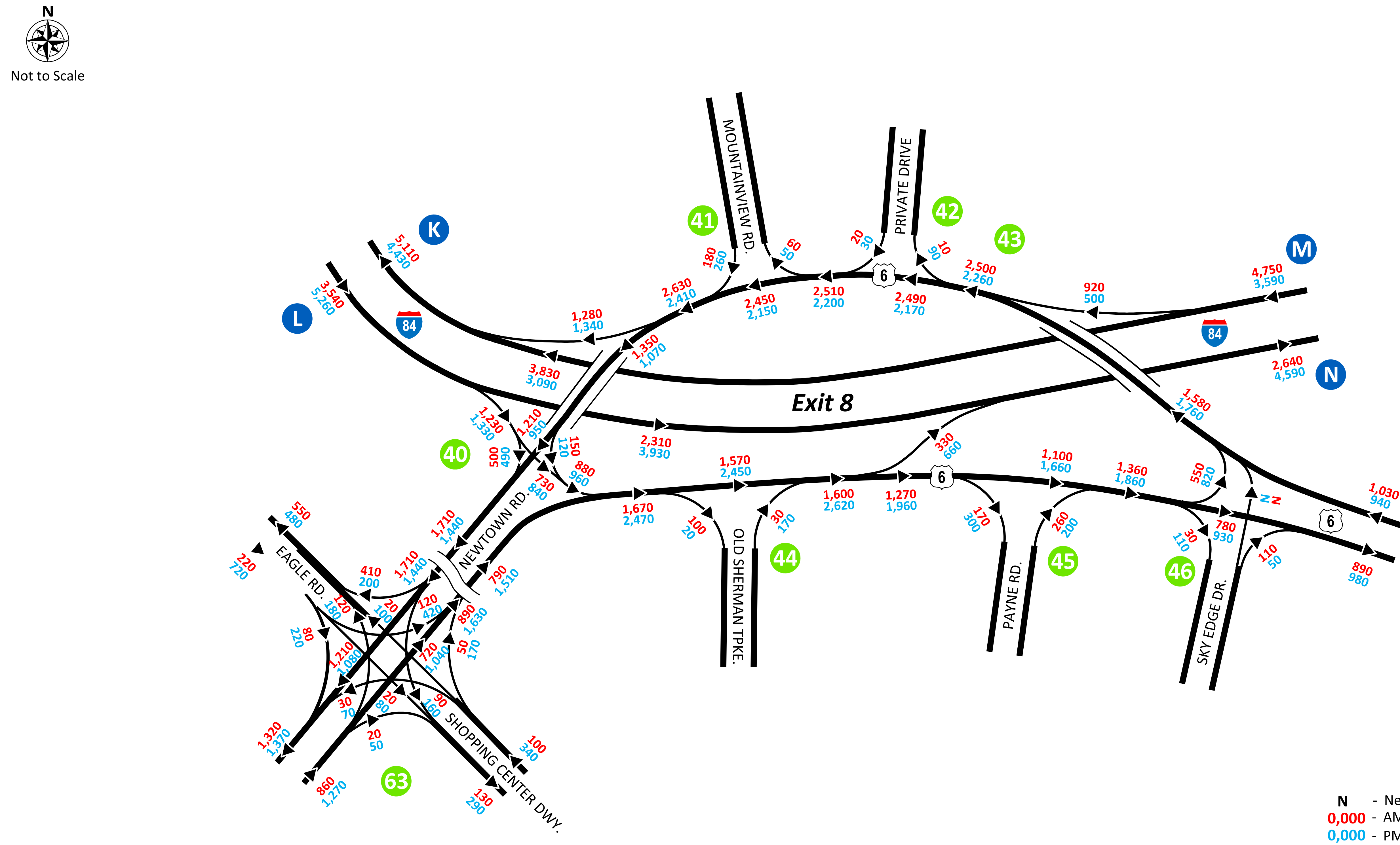
LEGEND

N - Negligible

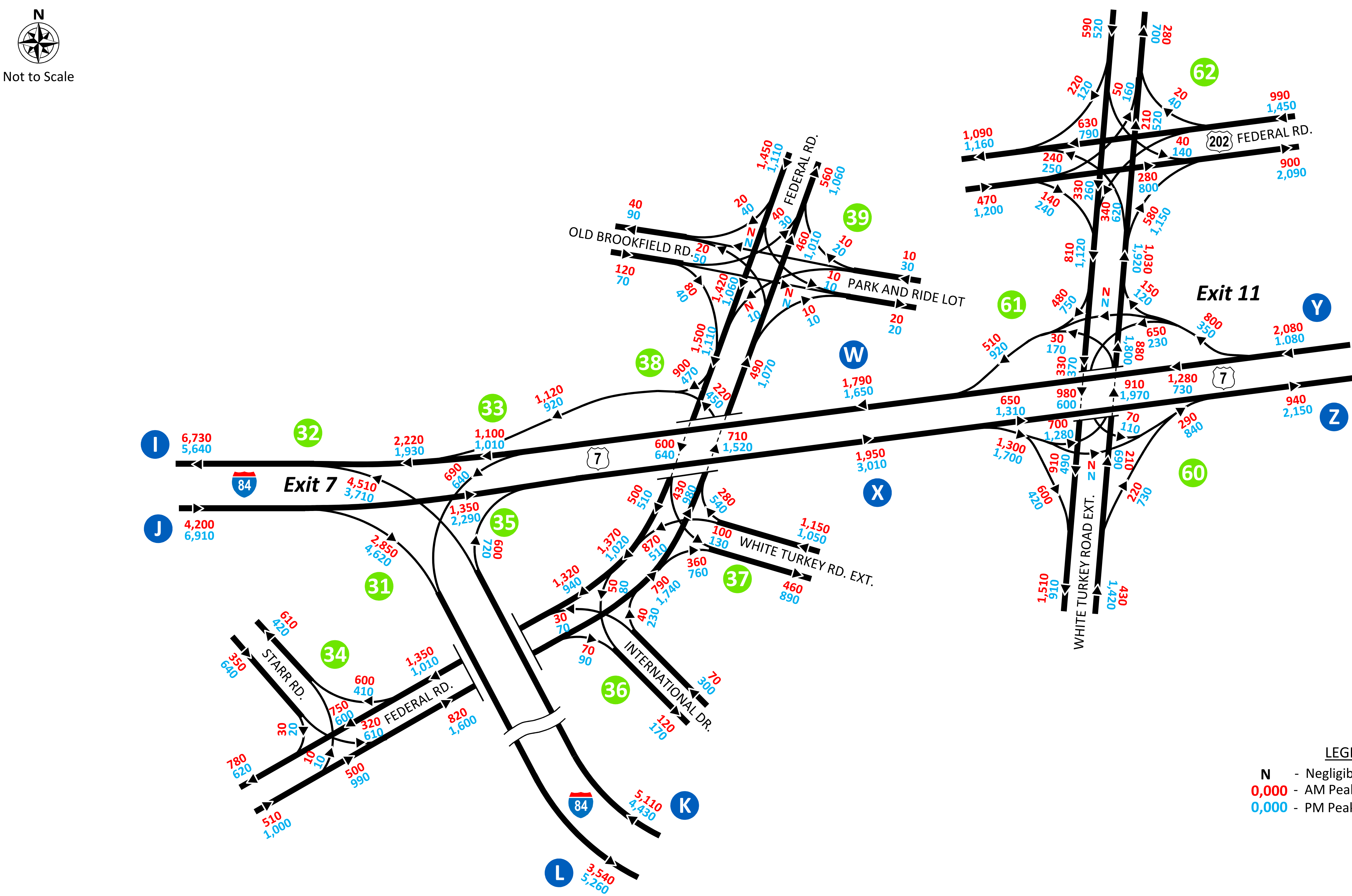
0,000 - AM Peak Hour Traffic Volume

0,000 - PM Peak Hour Traffic Volume

FUTURE 2040 NO BUILD
PEAK HOUR TRAFFIC VOLUMES - EXITS 3 AND 4



FUTURE 2040 NO BUILD
PEAK HOUR TRAFFIC VOLUMES - EXIT 8



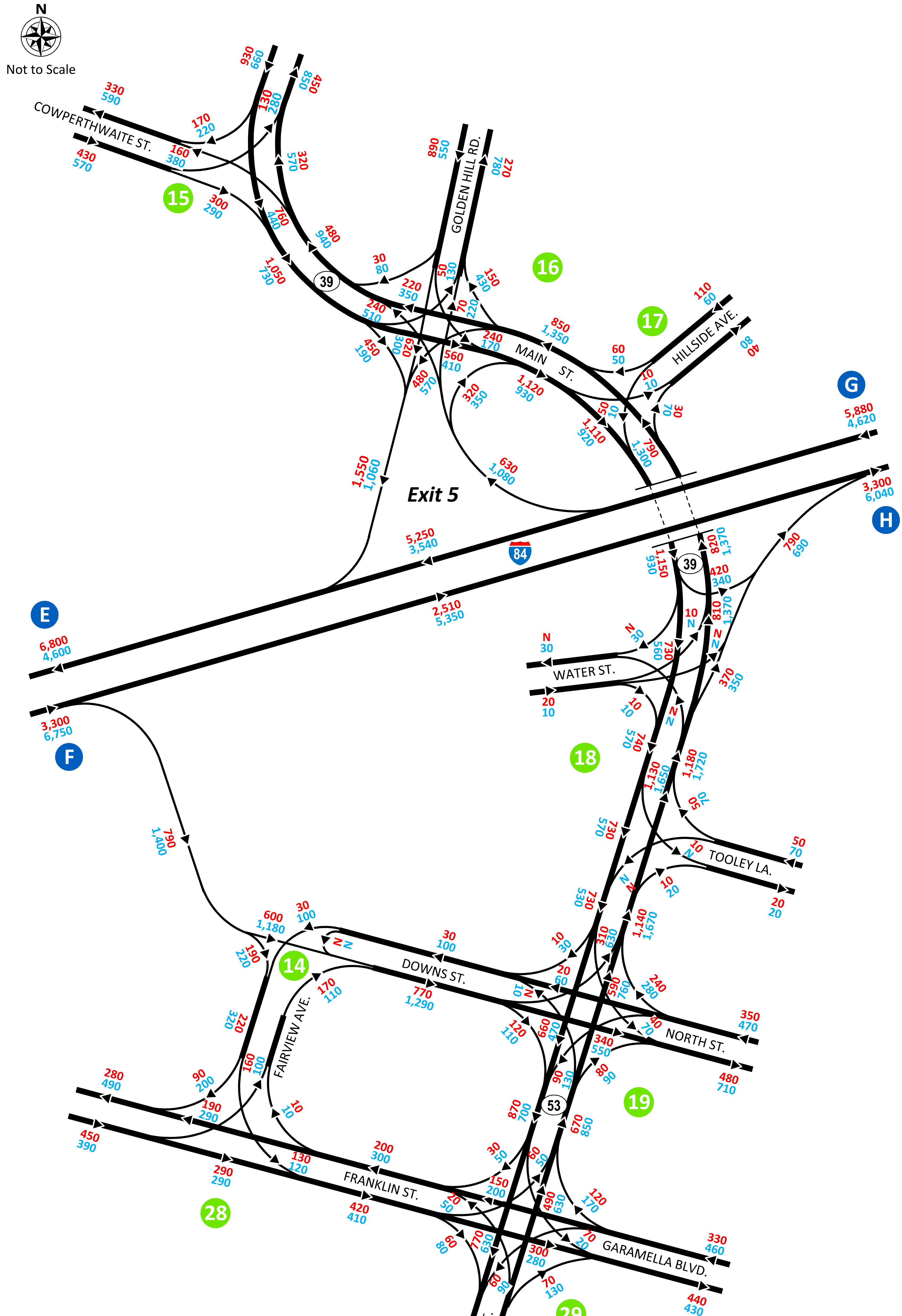
LEGEND

N - Negligible

0,000 - AM Peak Hour Traffic Volume

0,000 - PM Peak Hour Traffic Volume

FUTURE 2040 NO BUILD
PEAK HOUR TRAFFIC VOLUMES - EXITS 7 AND 11



LEGEND

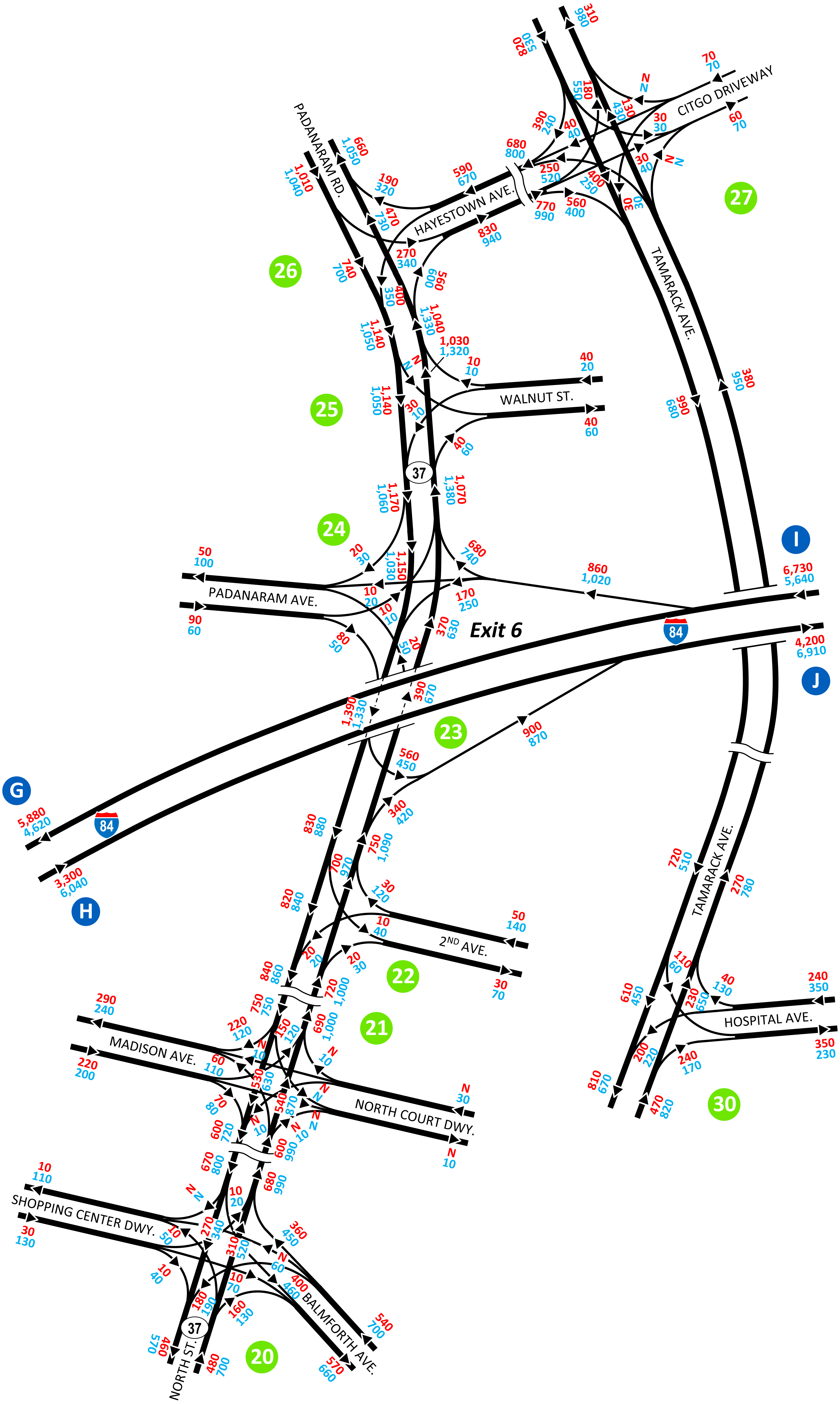
N - Negligible

0,000 - AM Peak Hour Traffic Volume

0,000 - PM Peak Hour Traffic Volume

FUTURE 2040 NO BUILD
PEAK HOUR TRAFFIC VOLUMES - EXIT 5

CDM Smith



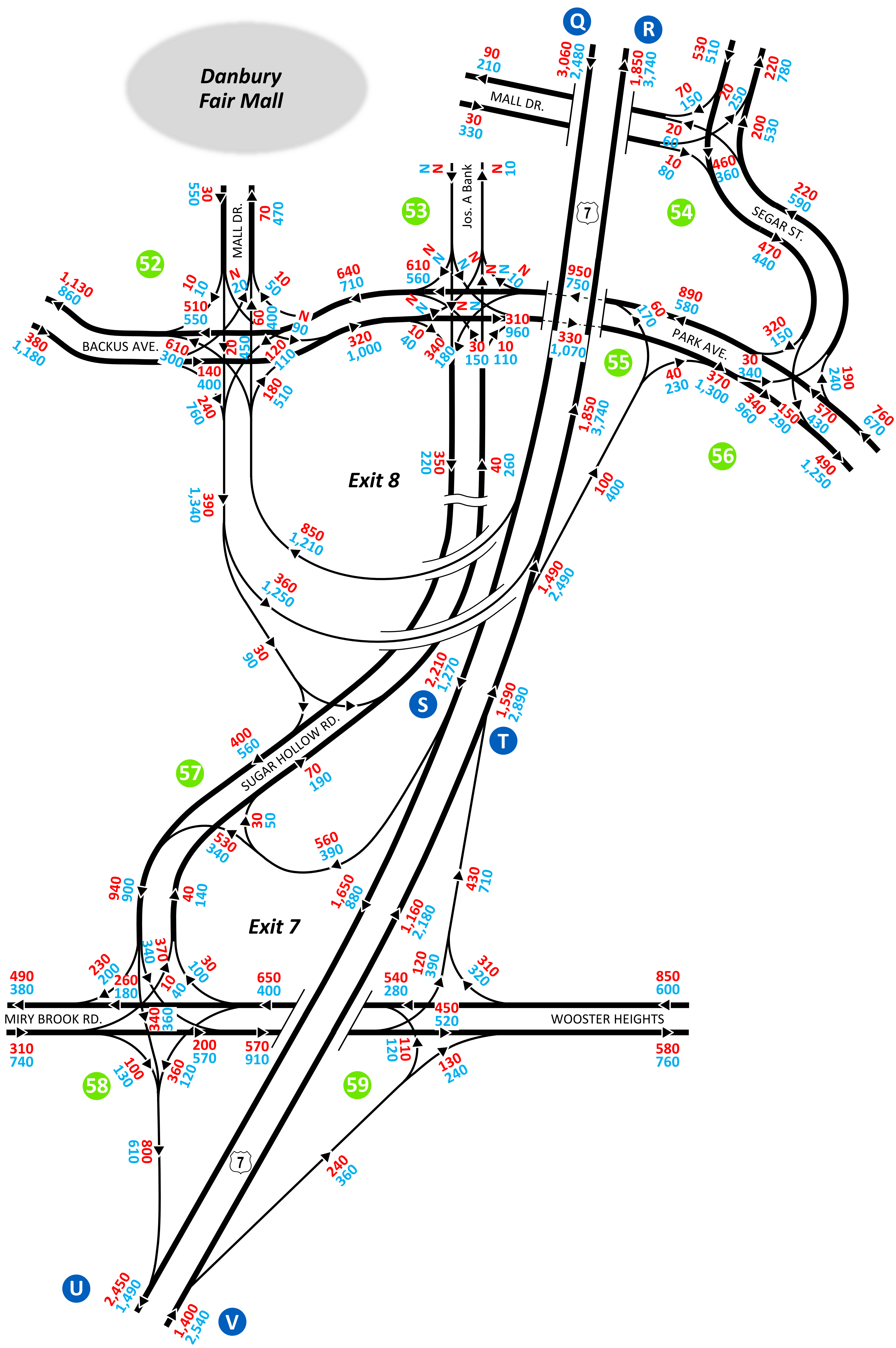
LEGEND

N - Negligible

0,000 - AM Peak Hour Traffic Volume

0,000 - PM Peak Hour Traffic Volume

FUTURE (2040) NO BUILD PEAK HOUR TRAFFIC VOLUMES - EXIT 6



LEGEND

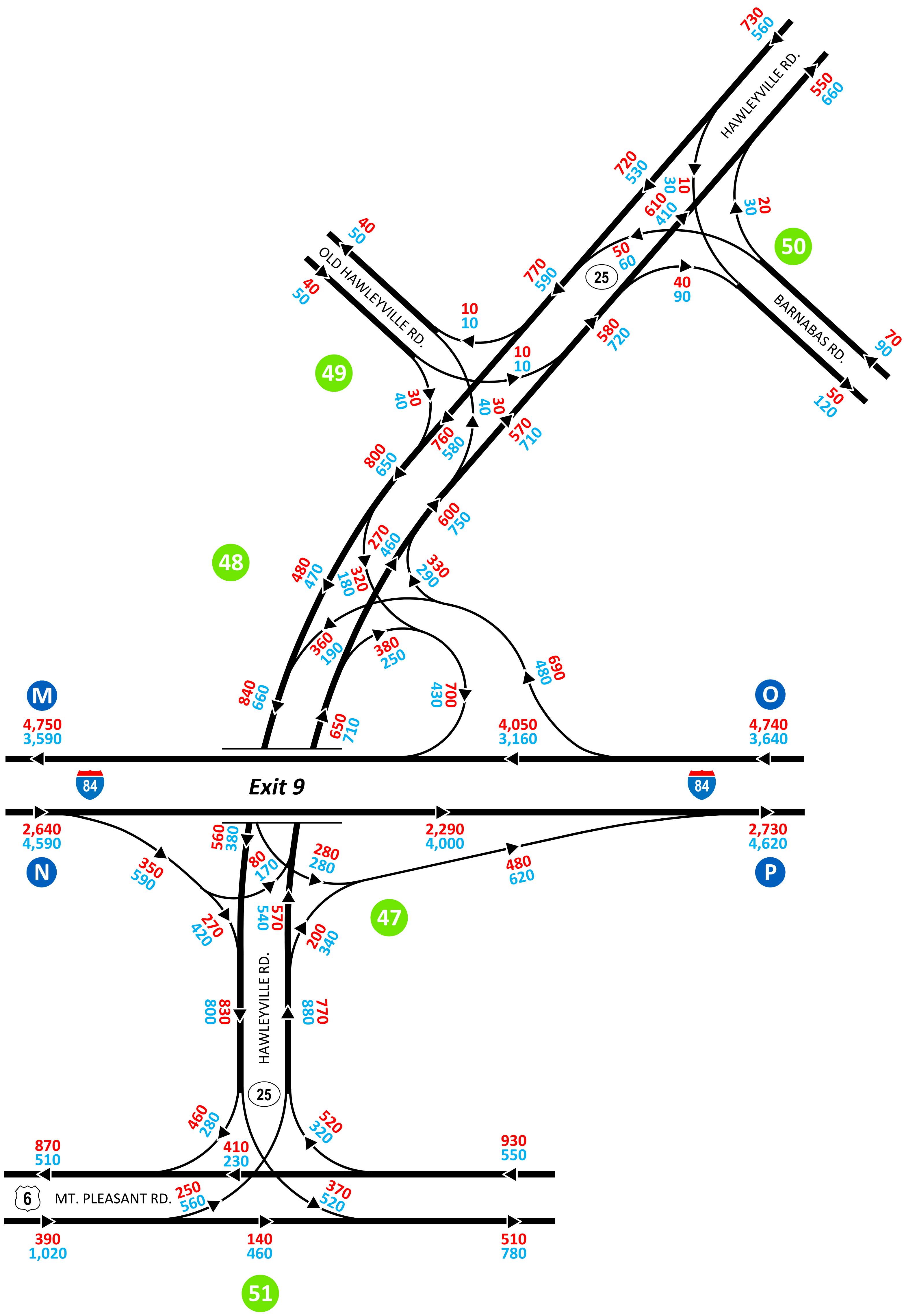
N - Negligible

0,000 - AM Peak Hour Traffic Volume

0,000 - PM Peak Hour Traffic Volume

FUTURE (2040) NO BUILD PEAK HOUR TRAFFIC VOLUMES - EXITS 7 & 8 (US 7)

N
Not to Scale



FUTURE 2040 NO BUILD
PEAK HOUR TRAFFIC VOLUMES - EXIT 9

ORIGIN AND DESTINATION PATTERNS

- SKYCOMP METHODOLOGY
- AVERAGE WEEKDAY PEAK HOUR O-D DATA
- AVERAGE WEEKDAY OFF-PEAK O-D DATA
- FRIDAY O-D DATA

Methodology Documentation

Danbury, CT I-84 Origin-Destination Study

Analysis of the INRIX Analytics TRIPS database product

with local validation using time-lapse aerial photography (TLAP)

October 2016

Prepared for the Connecticut Department of Transportation

By Skycomp Inc., Columbia, Maryland

In association with CDM Smith

Introduction

This report was prepared by Skycomp pursuant to surveys intended to study origin-destination behavior along I-84 in Danbury, Connecticut. New data gathering methods have recently come onto the market that promise to help planners understand complex vehicle movements. Two of these methods were selected for this study: use of the *INRIX Analytics: TRIPS* database product; and overlapping coverage using time-lapse aerial photography to capture a subset of the movements for validation of the former.

This document provides step-by-step descriptions of the procedures that were used and the underlying reasons for choices that were made; it also discusses the products that were delivered and how they were formatted.

Background: Overview of the INRIX "TRIPS" database product and Skycomp validation

INRIX is a nationwide probe data vendor that receives real-time feeds of the GPS "ping" data from a subset of vehicles using the highway system. Wherever these vehicles travel, on-board GPS devices report each vehicle's latitude/longitude coordinates with time stamps, at frequencies that vary by vehicle from every second to once every 3-5 minutes. Traditionally, INRIX's core business has been to synthesize these inputs into segment-specific speed and delay calculations in near real-time, and provide these as information streams back to drivers. While INRIX began this business by aggregating GPS feeds from trucking fleets, today more vehicles of all types have built-in GPS reporting capabilities. Also, drivers using smart phone apps also serve as probes on the highway system, further adding to INRIX's supply of vehicle trajectories.

In 2016 INRIX offered a new product to transportation planning agencies and other urban planners: its archive of the original GPS "ping" database files from which its speed databases have been derived, archived and available for purchase back to January 2014. INRIX did not claim that this product was suitable for any particular purpose; it was left to users to make those determinations.

This new source was attractive for many transportation planning applications. Because the databases contain remotely captured traffic flow metrics 24/7/365 wherever vehicles have traveled, the INRIX coverage areas would not be spatially or temporally constrained, nor affected by daylight. Furthermore, data collection surveys would not need to be ordered in advance, since the archives date continuously back through 2014, and because all new data are automatically added to the archives.

A fundamental question, however, is whether the trajectories in these archives are representative of the overall flow of vehicles within each traffic stream. On behalf of a client base primarily interested in highway facility operations and planning, *Skycomp* looked closely at this question. In 2012 Skycomp had previously introduced a new method of sampling vehicle travel routes, O-D's and travel times across relatively small study areas: by tracing vehicle movements within sets of tightly-aligned time-lapse aerial photography (TLAP), supplemented as needed by carefully-placed ground cameras where lines -of-sight were blocked. Camera clusters aboard stationary helicopters hovering one mile high acquired these very large sets of imagery. (Typical frame rates for each camera were one frame per second, captured continuously for up to two hours.) Later, almost any traffic flow metric could be extracted from the imagery, including travel times along all routes, quantification of signal cycle failures, queue avoidance behavior, and flow rates / turning movement counts anywhere.

While the TLAP method was inherently limited both temporally and spatially, an important strength was that it enabled truly random selections of vehicles (up to a 100% sample if desired), and enabled selected vehicles to be traced by whatever routes were taken across a survey area. Recognizing that the strengths and weaknesses of the new INRIX and TLAP methods were complementary (one was strong where the other was not, and vice versa), Skycomp decided to perform a test of the new INRIX product. Skycomp requested fall 2014 Trips data from INRIX that covered the I-95 approach in New Jersey to the George Washington Bridge. Because this overlapped an O-D study for the Port Authority of NY and NJ that Skycomp had previously completed using TLAP, it would be suitable for an apples-to-apples comparison. Working blindly using only the INRIX data, Skycomp was able to produce O-D tables that were very close to those that had been produced earlier using TLAP.

These results were encouraging to Skycomp because the new tool could provide answers to clients needing data across survey zones much larger than could be recorded by hovering helicopters. At the same time, the TLAP method could be applied as part of a hybrid survey design, to provide validation of INRIX-derived findings across a large survey area by evaluating just a part of that survey area. Accordingly, a business relationship was established between Skycomp and INRIX by which Skycomp would procure and analyze INRIX Trips data for single-study clients, and provide validation of that source using an independent methodology for client agencies wanting it.

Survey Plan: Hybrid INRIX "TRIPS" database product with Skycomp TLAP validation

The survey plan for this O-D study was that Skycomp would use two data sources to provide CDM Smith with the information it would need to conduct its analysis. These sources would be: 1) time-lapse aerial photography at a one-second frame rate (TLAP) for validation of the INRIX product; and 2) raw database records of single heavy vehicle trips produced by INRIX (for the "meat" of the analysis).

Part One would involve two test periods of about 120 minutes each (Friday morning and evening peak demand periods), during which one-second TLAP would be acquired by Skycomp from a helicopter hovering at high altitude over I-84 in Danbury. The targeted area would be Old Ridgebury Rd to the west and Newtown Rd to the east, and would include US 7 North and South. Vehicles would then be traced through the imagery to establish base line O-D for the corridor. Matching tables would then be produced from the raw INRIX trip records, and O-D percentages would be compared to establish the validity of the INRIX data source.

Provided validity was established as expected, *Part Two* would follow. This would involve steps to fully exploit the INRIX database of GPS pings to understand the O-D patterns on weekdays and Fridays, for all vehicle classes and directions, to inform the analysis by CDM Smith. This would include:

1. O-D tables produced for both peak and off-peak directions and time periods, by weekdays and Fridays, for three vehicle classifications (Heavy, Medium, and Light)
2. Expansion factor template tables for the O-D tables, so that ramp volumes could easily be applied to O-D percentages, which could then be reliably converted to volumes.

Part One: Survey execution and O-D table generation

TLAP Survey flights and image processing

TLAP survey flights were conducted on the morning and evening of Friday, October 14, 2016. Traffic was not affected by significant traffic incidents. The assigned area for TLAP coverage is shown below.

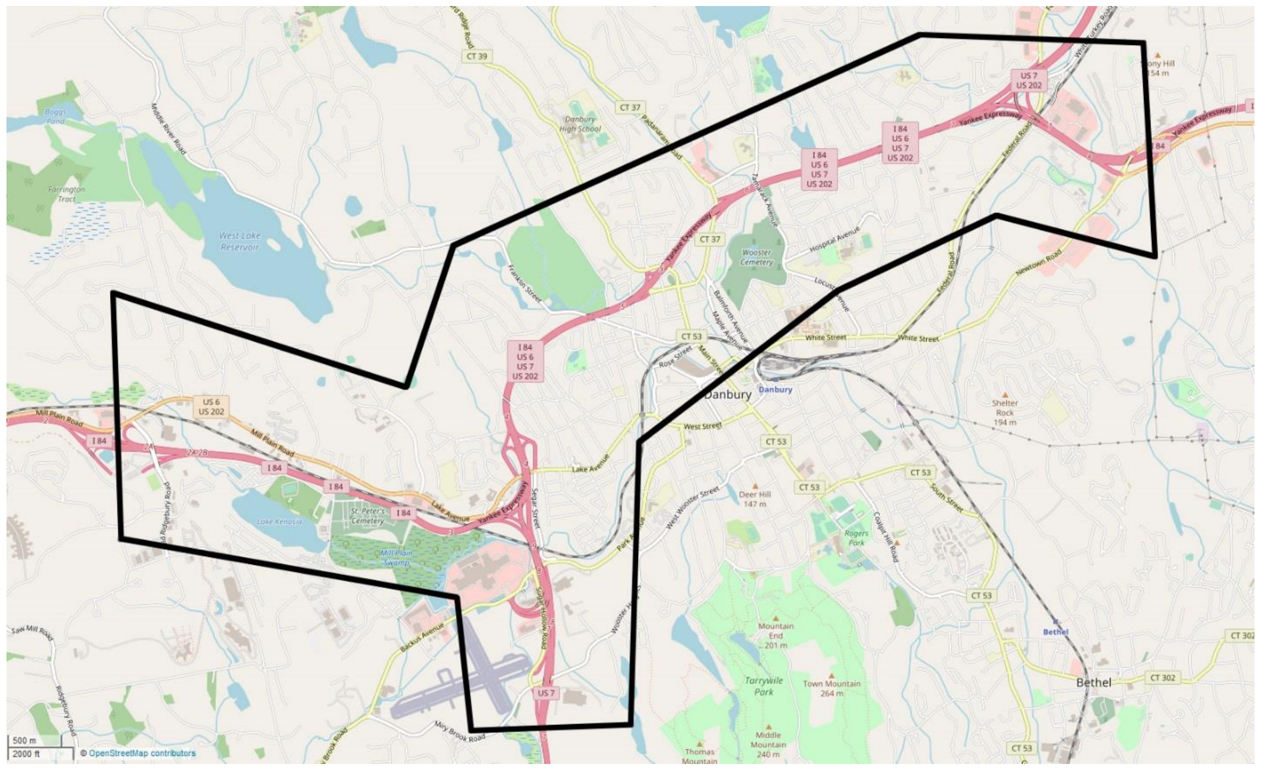
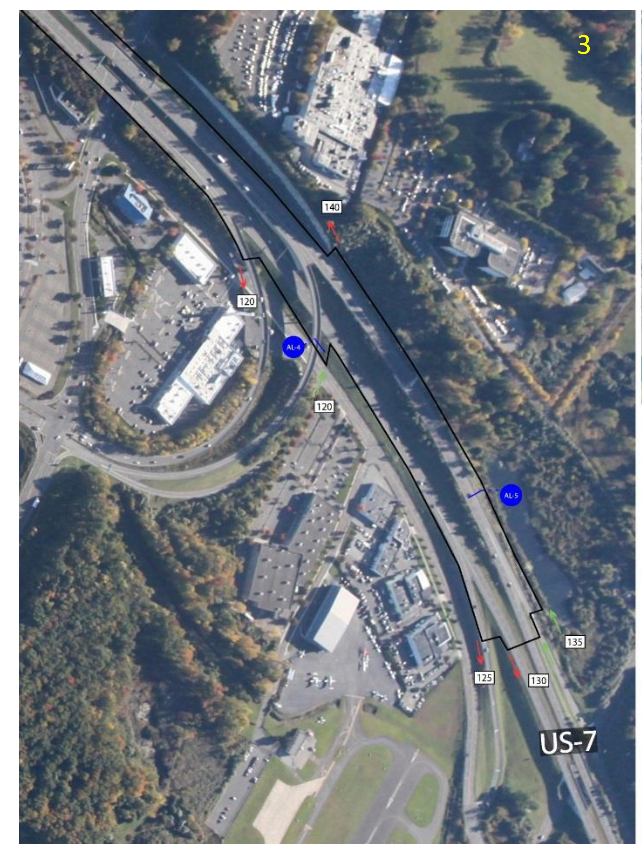


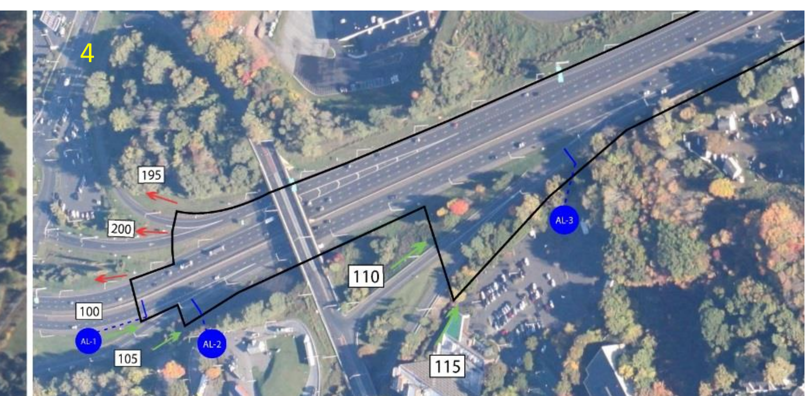
Figure 1: Portion of I-84 designated for coverage by the aerial TLAP cameras.

The dates and approximate times of the imaging periods were:
October 14, 2016 from 7:00 to 9:00 a.m.
October 14, 2016 from 4:00 to 6:00 p.m.

During each flight, each of the cameras operated at one frame per second, generating about 7,500 high-resolution digital images per camera. When the flights were done, all images from each camera were tightly aligned and trimmed, and then assembled onto digital photoboards such that each board showed the entire survey area at a single instant of time. Tight photo alignment was maintained for all copies of each photoboard, such that a digital overlay of origin, destination and route marker codes could be laid over each copy; this overlay also included survey tracing boundaries and other notes to control the process of tracing vehicles and recording the results.

Figure 2 (above) and Figures 3 and 4 (below): One copy of the 7,500 morning photoboards is shown above. The yellow rectangles indicate where the zoomed crop below shows the overlay detail; the blue dots are where vehicles were selected for sampling (at origin points); the white rectangles have origin and destination codes.





TLAP data extraction and O-D table assembly

Sampling points of origin for vehicles were the ramps or main line travel lanes where they crossed into the area shown by the black outline in Figure 1. All samples were traced forward until leaving the survey area; the ramp or main line crossing points out of the survey area defined each vehicle's destination. Each traced vehicle was given a unique vehicle ID number, and its route was documented with tags approximately every 5-10 seconds. (For certainty of vehicle re-identification, this was done using a manual / computer-assisted methodology, with a human applying the tags and the computer compiling the information.)

The results of this tracing process were output into two database tables: the "A" File (see Table 1, below) contains one record for each vehicle traced; the fields are:

1. Unique vehicle ID number;
2. Basic class (only heavy trucks this survey);
3. Elapsed time (seconds) between earliest and latest tag (travel time);
4. Symbol (for tagging photos; not unique);
5. Origin code;
6. Destination code;
7. Notes, if any.

'ID'	Type	Total Time (sec)	Symbol	Origin	Destination	Notes
2001	Car	243	1	160	130	071520 WH CAR
2002	Car	222	2	160	130	071529 WH CAR
2003	Car	112	3	160	180	071541 WH CAR
2004	Car	268	4	160	130	071556 WH CAR
2005	Car	240	5	160	100	071611 WH CAR
2006	Car	233	6	160	190	071630 WH CAR
2007	Car	239	7	160	190	071646 WH CAR
2008	Car	218	8	160	130	071659 WH CAR
2009	Car	139	9	160	185	071715 WH CAR
2010	Car	243	10	160	130	071741 R CAR

Table 1 (above): a partial "A" file is shown, with one record for each traced vehicle. Once an "A" File was created for any particular set of vehicles (say, only those that entered I-84 via US 7 South), the associated O-D table could easily be assembled.

The second database is the "B" File format; this contains one record for every tag placed on each vehicle being traced (see Table 2, below). The fields are:

1. Vehicle ID number (cross references to A File);
2. Origin code;
3. Destination code (recorded only in the last record of each ID);
4. Photo tagged -- each filename is comprised of the photo's date and precise time;
5. Pixel "X" value of tag (X = 0 of all photoboards is the left edge);
6. Pixel "Y" value of tag (Y = 0 of all photoboards is the top edge);
7. Field One (used to record sampling lines / at the origins for this survey);
8. Field Two (used to record any additional data as needed).

'ID'	Origin	Destination	Lane	Photo	X	Y	Field 1	Field 2
2001	160			r_01a_20161014-071514.ecw	15562	2586		
2001	160			r_01a_20161014-071520.ecw	15270	2859	AL11A	
2001	160			r_01a_20161014-071542.ecw	13041	1928		
2001	160			r_01a_20161014-071600.ecw	12168	1936		
2001	160			r_01a_20161014-071623.ecw	10984	1934		
2001	160			r_01a_20161014-071644.ecw	9895	1828		
2001	160			r_01a_20161014-071704.ecw	7616	2747		
2001	160			r_01a_20161014-071724.ecw	6303	2919		
2001	160			r_01a_20161014-071746.ecw	5265	3169		
2001	160			r_01a_20161014-071807.ecw	4575	2715		
2001	160			r_01a_20161014-071822.ecw	3210	408		
2001	160			r_01a_20161014-071838.ecw	2638	614		
2001	160			r_01a_20161014-071856.ecw	2267	1567		
2001	160	130		r_01a_20161014-071917.ecw	1572	2830		

Table 2 (above): a partial "B" file is shown, with one record for each tag placed on a sample. The time of the tag is part of the photo / file name; in this case, Vehicle #2001 traveled from Origin 160 to Destination 130; the travel time was 4 minutes and 3 seconds (from 07:15:14 to 07:19:17). Tracing began near Assignment Line 11A (AL11A).

O-D Tables from TLAP

In consultation with the client, the following sites were sampled for O-D validation:

1. I-84 eastbound mainline (from points west of the survey area) between 7:15 and 8:45 a.m.
2. I-84 eastbound at I-84/Rt 7 merge between 4:15 and 5:45 p.m.
3. Rt 7 northbound at I-84/Rt 7 merge between 4:15 and 5:45 p.m.
4. I-84 westbound at I-84/Rt 7 merge between 7:15 and 8:45 a.m
5. Rt 7 southbound at I-84/Rt 7 merge between 7:15 and 8:45 a.m

The next task was to assemble O-D tables for the sampled sites using the “A” and “B” files. Complete O-D tables for all TLAP sampling are provided for validation comparison.

	Destinations					
Origin: EB I-84, from points west of the survey area	Rt 7 SB	Lake Ave	North St	Rt 7 NB	I-84 EB to points east	Grand Total
TLAP I-84 Count	49	14	20	40.7	91.3	215
TLAP I-84 Percentages	23%	7%	9%	19%	42%	100%

Table 3 (above): The O-D data from I-84 eastbound mainline, morning period, is shown. Data is presented as both raw vehicle tracing data (top), and then converted to percentages of total originating volume (bottom).

INRIX *TRIPS* data processing and analysis

To begin the process, Skycomp ordered a complete set of "trip" files from the INRIX database for vehicles that traveled in the vicinity of the survey area between October 4 and October 20, 2016. The product received was a master database of time-stamped "ping" data (lat/long) of the actual trajectories of a sample (subset) of the vehicle trips in the survey area; an approximate weight classification rating was provided for each trip (light, medium or heavy, with the latter two indicating a truck trip). Skycomp started the analysis by parsing this dataset to retain only the trips that took the routes designated for comparison (see *Figure 5*).

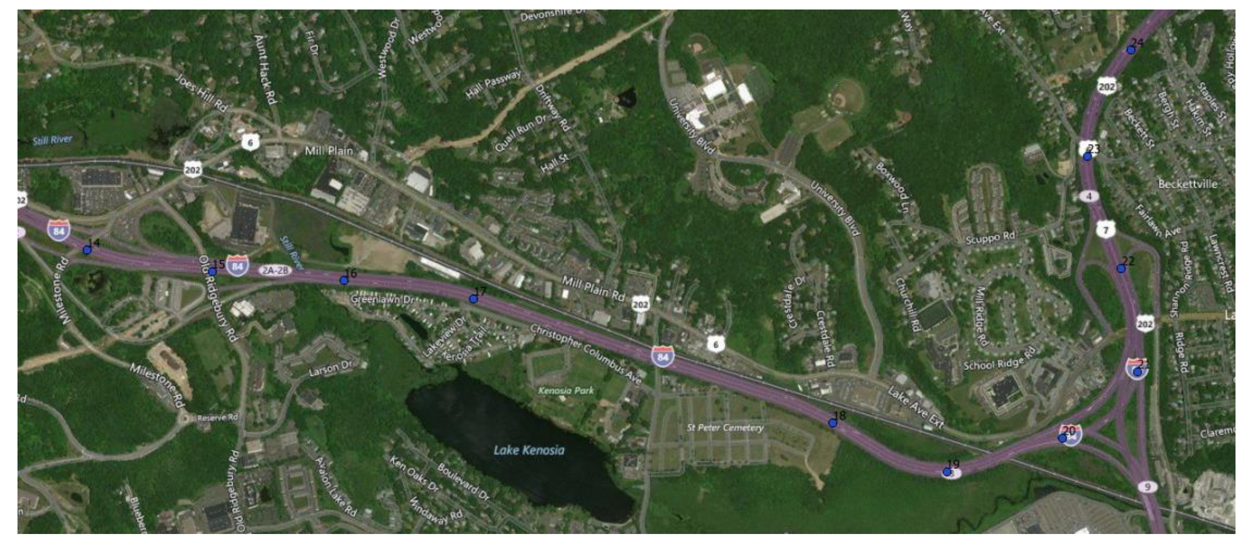


Figure 5: Sequential pings are shown for an eastbound trip on I-84 in the morning. The location of the trip pings indicate that the vehicle began its trip west of the survey area in the eastbound direction.

These trips were then filtered to separate trips made during midweek periods and Friday trips, and then further filtered to retain just the peak periods of travel (two analysis sets were produced: 6:45 to 9:15 a.m. and 3:30 to 6:30 p.m.). Only light vehicles were compared to the TLAP samples, however medium and heavy vehicles were also processed and presented.

Then, for each vehicle that remained in the analysis sets, the survey zones for each entry and exit point were determined, using GIS tools that analyzed the ping trails of each trip (see example in *Figure 6*).

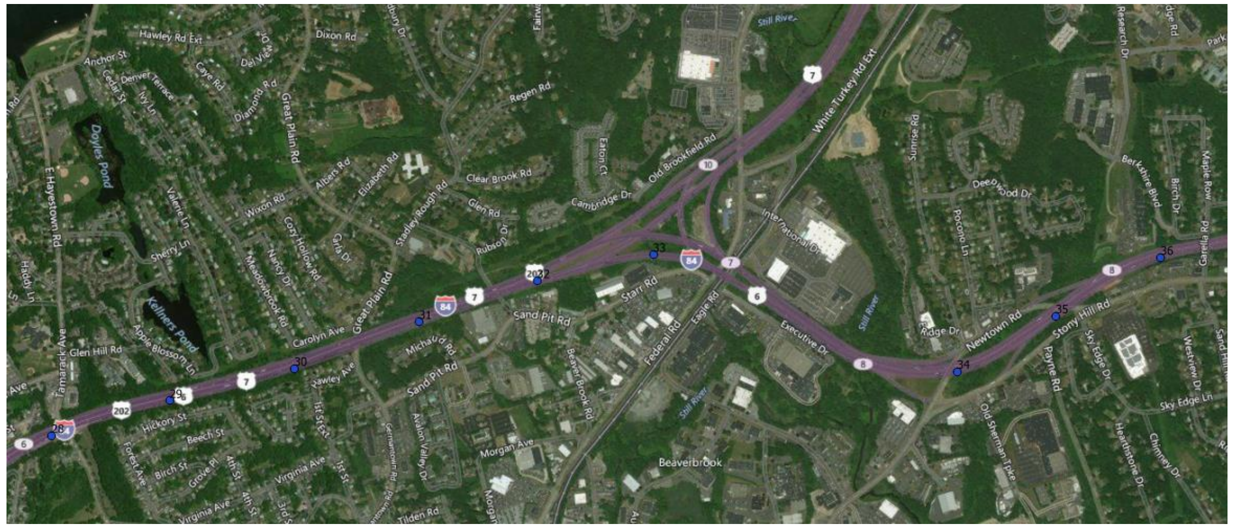


Figure 6: This shows the rest of the trip shown at I-84 in the preceding figure. The ping trail shows that this sample traveled east and exited the survey area on the mainline.

Two tables were generated for each comparative sample set: the raw number of samples from or to each origin or destination, and then those numbers converted to percentages (see *Figure 7* for mainline eastbound flow during the morning period).

	Destinations					
Origin: EB I-84, from points west of the survey area	**Rt 7 SB**	**Lake Ave**	**North St**	**Rt 7 NB**	**I-84 EB to points east**	Grand Total
INRIX I-84 Sample (10-14)	5	2	5	4	20	36
INRIX I-84 Percentages (10-14)	14%	6%	14%	11%	56%	100%
INRIX I-84 Sample (Fridays)	20	5	13	11	46	95
INRIX I-84 Percentages (Fridays)	21%	5%	14%	12%	48%	100%
INRIX I-84 Sample (Tues-Weds-Thurs)	152	26	101	64	673	1016
INRIX I-84 Percentages (Tues-Weds-Thurs)	15%	3%	10%	6%	66%	100%

Table 4: INRIX O-D tables for the eastbound direction / morning period, separated by dates – 10-14, the date TLAP samples were taken, all Fridays in the three-week INRIX sample period, and all Tuesdays, Wednesdays, and Thursdays in the same three-week period.

Validation findings

When the O-D percentage tables are compared between the two methods, close correlations are found. Based on the tables shown below as well as tables for further time periods and directions, a determination was made that the INRIX method would be regarded as "validated" for the purposes of this survey project.

Table 5: Morning Survey Period

	Destinations					
Origin: EB I-84, from points west of the survey area	Rt 7 SB	Lake Ave	North St	Rt 7 NB	I-84 EB to points east	Grand Total
TLAP I-84 Percentages	23%	7%	9%	19%	42%	100%
INRIX I-84 Percentages (10-14)	14%	6%	14%	11%	56%	100%
INRIX I-84 Percentages (Fridays)	21%	5%	14%	12%	48%	100%
INRIX I-84 Percentages (Tues-Weds-Thurs)	15%	3%	10%	6%	66%	100%
Difference TLAP - INRIX (10-14)	9%	1%	-5%	8%	-13%	
Difference TLAP - INRIX (FRIDAYS)	2%	1%	-4%	7%	-6%	
Difference TLAP - INRIX (Tues-Weds-Thurs)	8%	4%	-1%	13%	-24%	

Table 6: Evening Survey Period

	Destinations				
Origin: Eastbound I-84 at I-84/RT 7 merge	Lake Ave	North St	Rt 7 NB	I-84 EB to points east	Grand Total
TLAP I-84 Percentages	5%	9%	22%	65%	100%
INRIX I-84 Percentages (10-14)	8%	6%	22%	64%	100%
INRIX I-84 Percentages (Fridays)	10%	7%	19%	64%	100%
INRIX I-84 Percentages (Tues-Weds-Thurs)	3%	9%	10%	78%	100%
Difference TLAP - INRIX (10-14)	-3%	3%	0%	1%	
Difference TLAP - INRIX (FRIDAYS)	-5%	2%	3%	0%	
Difference TLAP - INRIX (Tues-Weds-Thurs)	2%	0%	12%	-13%	

Tables 5 (top) and 6 (bottom): The correlation between the results of the two methods for cars (light vehicles as named by INRIX) is shown for the morning and evening survey periods.

Part Two: INRIX analysis and O-D tables

INRIX database description and general processing steps

The INRIX TRIPS database is comprised of GPS ping trails of individual trips; each trip has a unique Trip ID number. Furthermore, each trip is associated with a specific device, so that if a vehicle makes three trips in one day, it is possible to understand that the trips are related. Other fields also provided are the time that each trip began and ended; the geographical coordinates of its approximate beginning and ending points (origins and destinations); and the coordinates of all route "pings" which are contained in the database, with precise time stamps. The ping rates vary widely from one trip to the next, ranging from one second to around five minutes (latter is rare). Most vehicles ping at a rate between 30 seconds and two minutes.

To perform this study, the following trips were ordered from and provided by INRIX: for three weeks from October 2 through October 20, 2016; for the year 2016, 38 non-holiday Fridays.

The general processing steps were as follows:

1. Because the INRIX TRIPS database contains three types of vehicle classification (light, medium and heavy vehicles), all vehicle records were segregated and retained for analysis.

2. The next step was to create subsets of the database, each of which contained only the trips that entered the survey area during a specific time period and in a specific direction. First, analysis zones were created on both sides of each entry and exit point, so that a trip with consecutive pings on either side of a site would indicate that the trip crossed the site and would reveal its direction.

3. The geographic coordinates of each origin and destination of each trip was part of the record of each trip provided by INRIX. These points were plotted against a traffic analysis zone (TAZ) map created by Skycomp to identify origins and destinations.

4. Once all trips had been identified that crossed a particular location, those trips were then further divided by day of week, time period and direction. The trips were then assembled into groups that related to each desired O-D table. Just as the TLAP "A" files were used to generate the TLAP O-D tables, it was a straightforward process to assemble the origin and destination codes of each final group into the output matrices.

In this manner, the following O-D tables were generated for each site:

1. Weekday (Tuesday, Wednesday, and Thursday) O-D matrices were provided, by direction, for each of the following time periods: 6:45 to 9:15 am; 9:00 am to 1:00 pm; 1:00 to 4:00 pm; and 3:30 to 6:30 pm

2. Friday O-D matrices were provided, by direction, for the AM and PM peak periods only (6:45 to 9:15 am, 3:30 to 6:30 pm)

For all O-D tables, three versions were prepared: first, the raw counts of trips in each O-D cell; second, the same table but showing percentages in each cell; and third, volume-ready tables in which O-D percentages can be multiplied by origin volumes to produce estimated destination volumes (outside source for volumes needed).

I-84 Danbury CT - LIGHT VEHICLES / AUTOS

Eastbound Origin-Destination Data / Midweek

6:45 - 9:15 AM, October 4 - October 20, 2016,**Tuesdays, Wednesdays, and Thursdays**

WEEKDAYS				Destinations	
Origins	Total INRIX Samples	Rt 7 SB - Danbury Fair Mall	Rt 7 SB - Wooster Heights	Rt 7 SB - To points south	Lake Ave
I-84 EB from points west of the survey area	1213	53	52	137	30
I-84 EB from Old Ridgebury Rd	483	36	14	56	44
I-84 EB from Lake Ave	56				
I-84 EB from Main St or North St	181				
Rt 7 NB to I-84 EB Total	356				37
	Destination Totals	89	66	193	111
Breakdown of Rt 7 NB to I-84 EB Total					
Rt 7 NB from Danbury Fair Mall	43				16
Rt 7 NB from Wooster Heights	23				2
Rt 7 NB from points south of the survey area	290				19

I-84 Danbury CT - LIGHT VEHICLES / AUTOS

Eastbound Origin-Destination Data / Midweek

6:45 - 9:15 AM, October 4 - October 20, 2016, **Tuesdays, Wednesdays, and Thursdays**

WEEKDAYS				Destinations	
Origins	Total INRIX Percentages	Rt 7 SB - Danbury Fair Mall	Rt 7 SB - Wooster Heights	Rt 7 SB - To points south	Lake Ave
I-84 EB from points west of the survey area	100%	4%	4%	11%	2%
I-84 EB from Old Ridgebury Rd	100%	7%	3%	12%	9%
I-84 EB from Lake Ave	100%				
I-84 EB from Main St or North St	100%				
Rt 7 NB to I-84 EB Total	100%				10%
Breakout of Rt 7 NB to I-84 EB Total					
Rt 7 NB from Danbury Fair Mall	12%				4%
Rt 7 NB from Wooster Heights	6%				1%
Rt 7 NB from points south of the survey area	81%				5%

I-84 Danbury CT - LIGHT VEHICLES / AUTOS

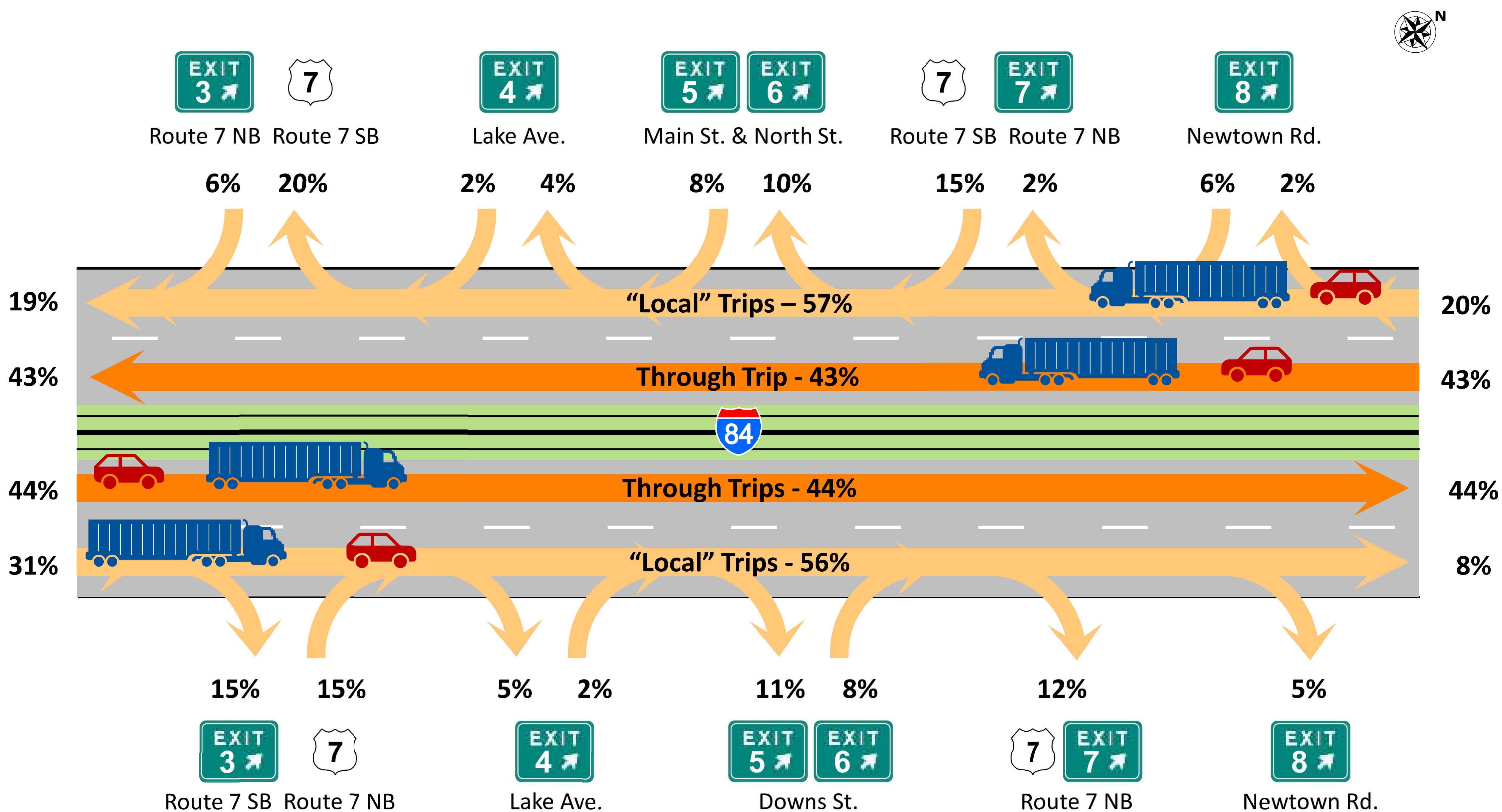
Eastbound Origin-Destination Data / Midweek

Peak Hour, October 4 - October 20 2016, **Tuesdays, Wednesdays, and Thursdays**

WEEKDAYS				Destinations	
Origins	Enter volumes here:	Rt 7 SB - Danbury Fair Mall	Rt 7 SB - Wooster Heights	Rt 7 SB - To points south	Lake Ave
I-84 EB from points west of the survey area	0	0	0	0	0
I-84 EB from Old Ridgebury Rd	0	0	0	0	0
I-84 EB from Lake Ave	0				
I-84 EB from Main St or North St	0				
Rt 7 NB to I-84 EB Total	0				0
	Destination Totals	0	0	0	0
Breakdown of Rt 7 NB to I-84 EB Total					
Rt 7 NB from Danbury Fair Mall					0
Rt 7 NB from Wooster Heights					0
Rt 7 NB from points south of the survey area					0

Tables 7A, B and C (above): From 6:30 to 9:30 a.m. average weekdays, in the eastbound direction, raw partial O-D table (7A), corresponding percentages O-D table (7B), and corresponding volume-ready table (7C).

SKYCOMP TRAFFIC DISTRIBUTION DATA
TOTAL VEHICLE COUNTS

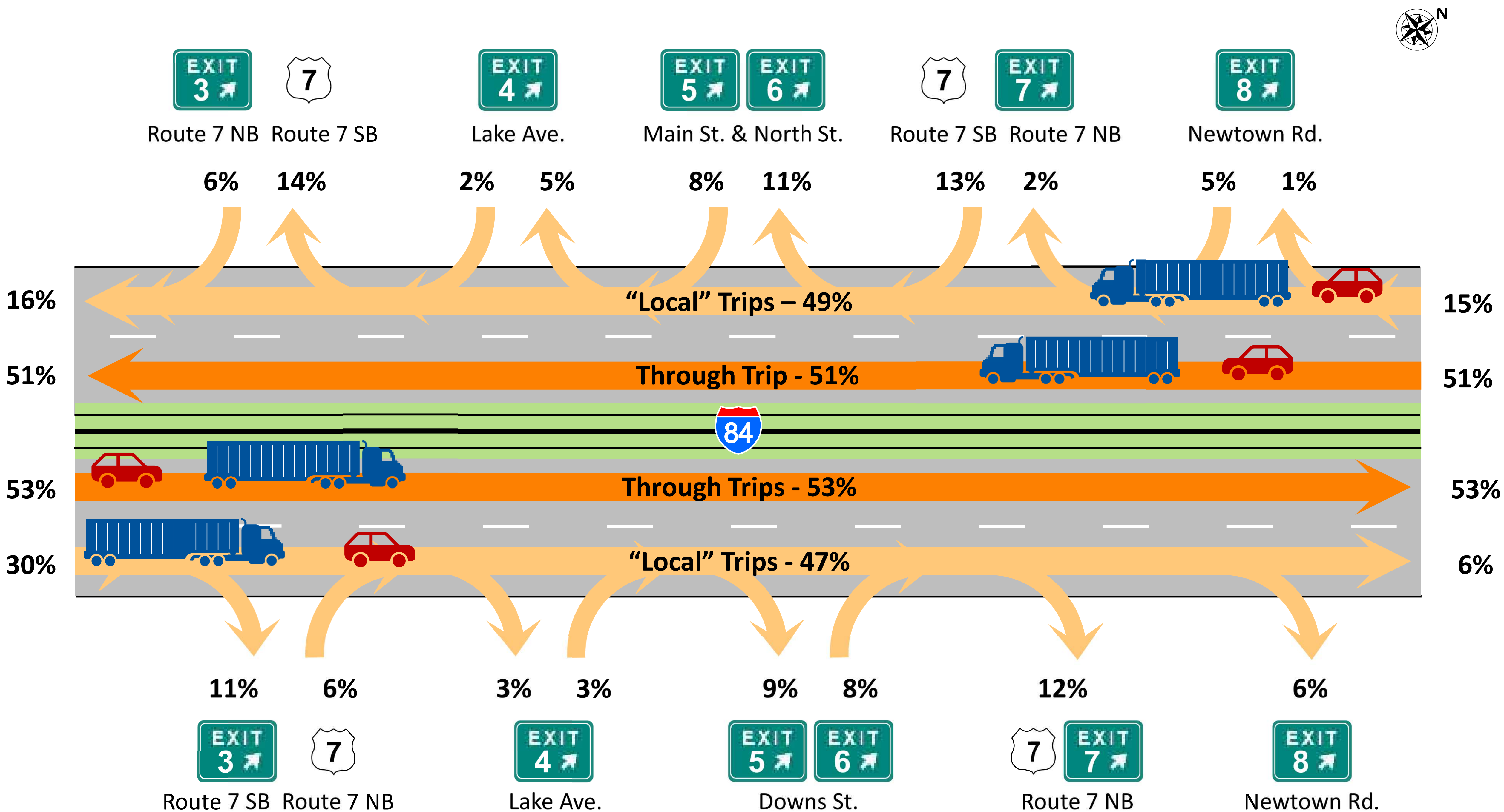


* Note - Represents average of Tuesday, Wednesday and Thursday.

SKYCOMP RAMP TO RAMP DATA
I-84 AVERAGE WEEKDAY* - AM PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
TOTAL VEHICLE COUNTS



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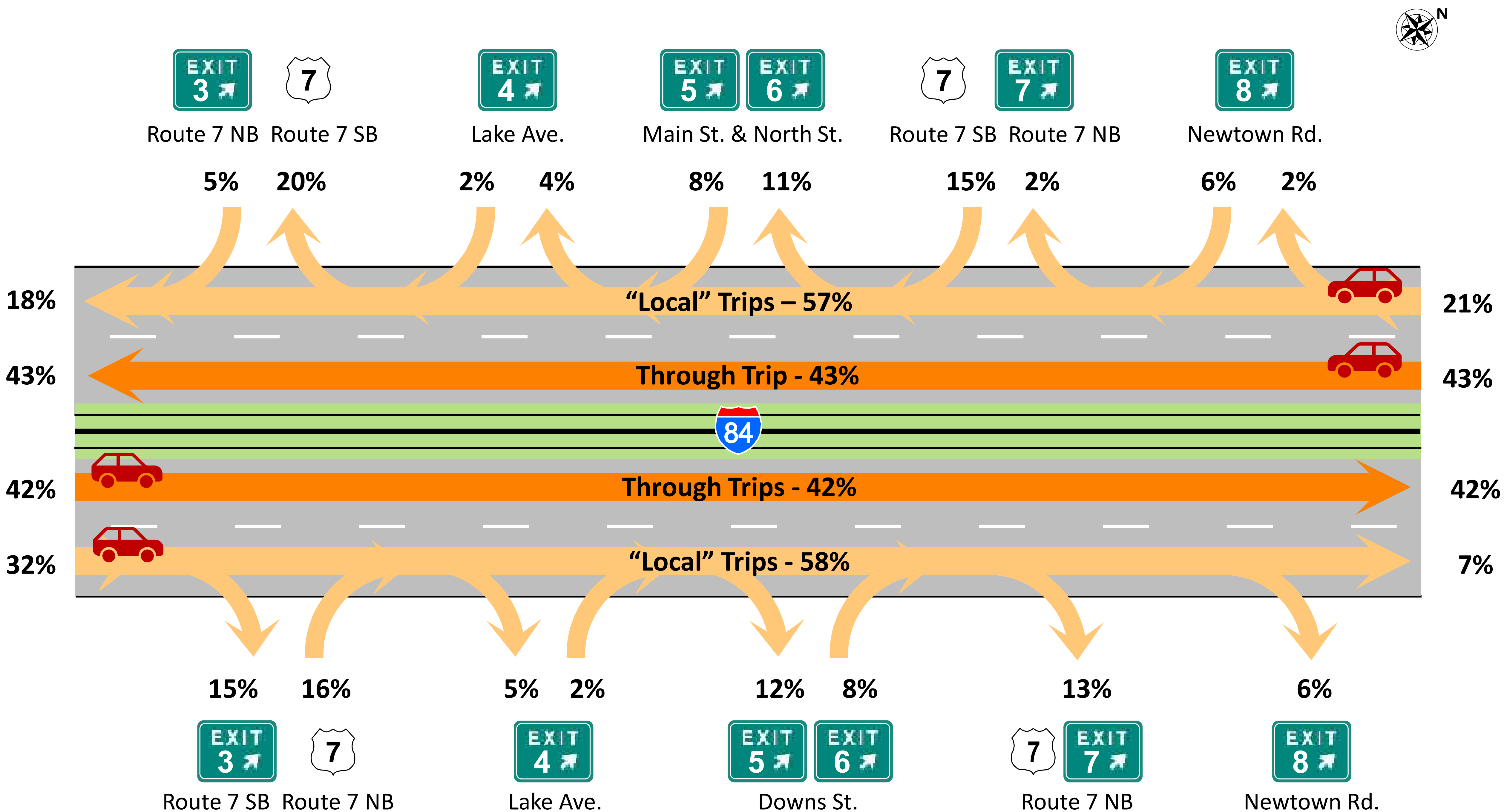
SKYCOMP RAMP TO RAMP DATA
I-84 AVERAGE WEEKDAY* - PM PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
LIGHT TRAFFIC (AUTOS/SMALL TRUCKS)



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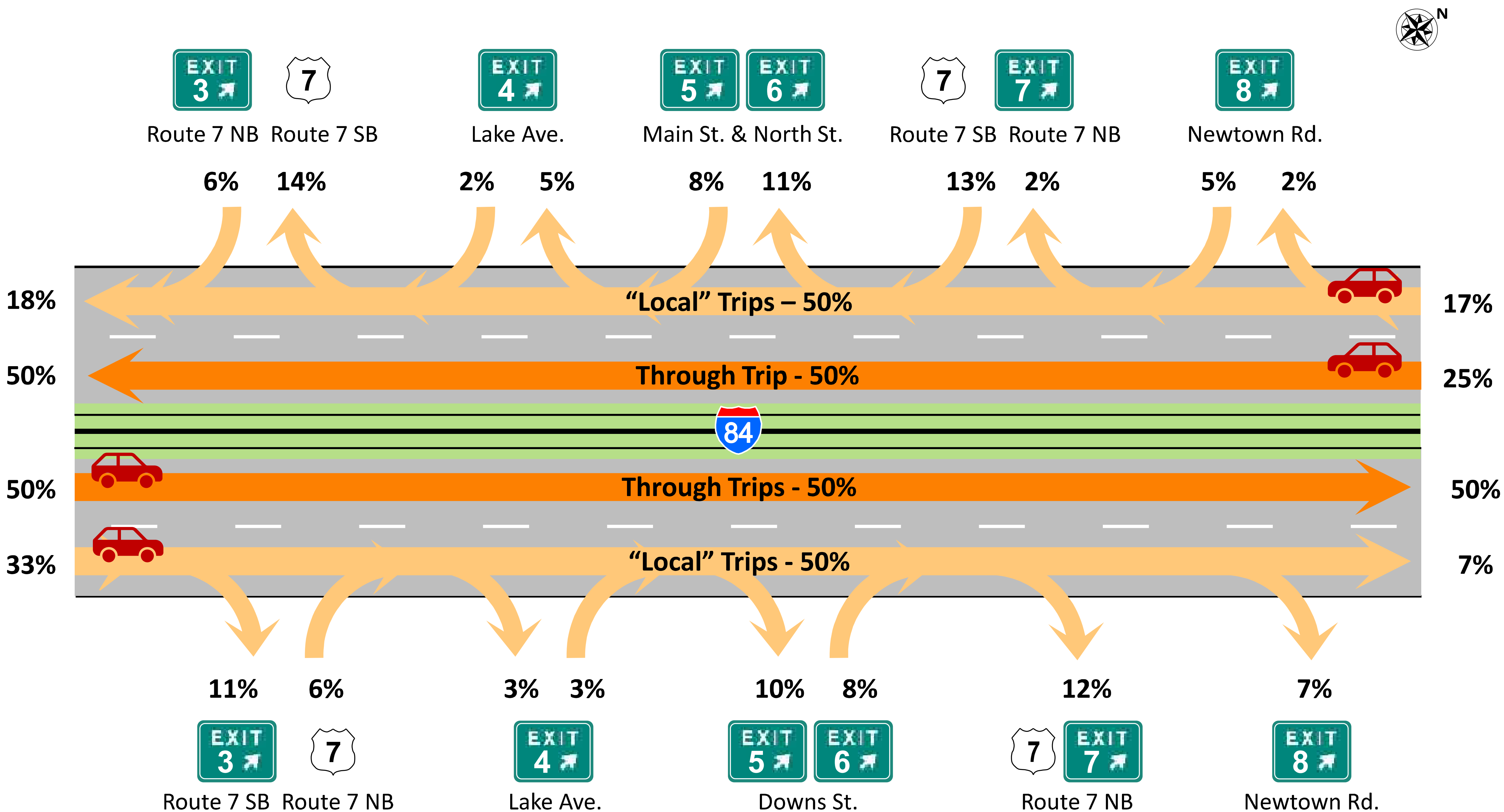
SKYCOMP RAMP TO RAMP DATA
I-84 AVERAGE WEEKDAY* - AM PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
LIGHT TRAFFIC (AUTOS/SMALL TRUCKS)



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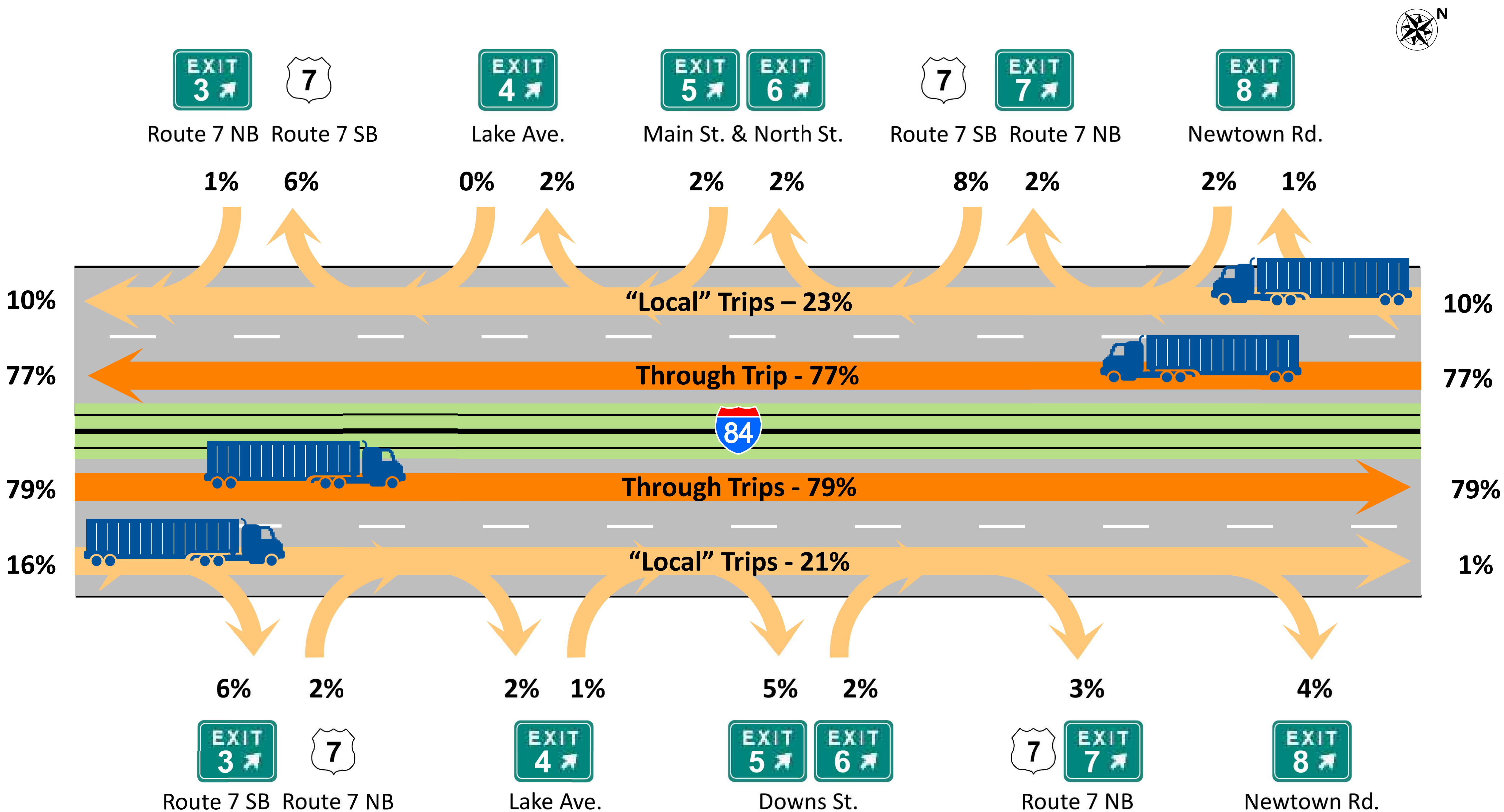
SKYCOMP RAMP TO RAMP DATA
I-84 AVERAGE WEEKDAY* - PM PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
HEAVY TRAFFIC (LARGE TRUCKS)



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SKYCOMP RAMP TO RAMP DATA
I-84 AVERAGE WEEKDAY* - AM PEAK PERIOD

CDM Smith

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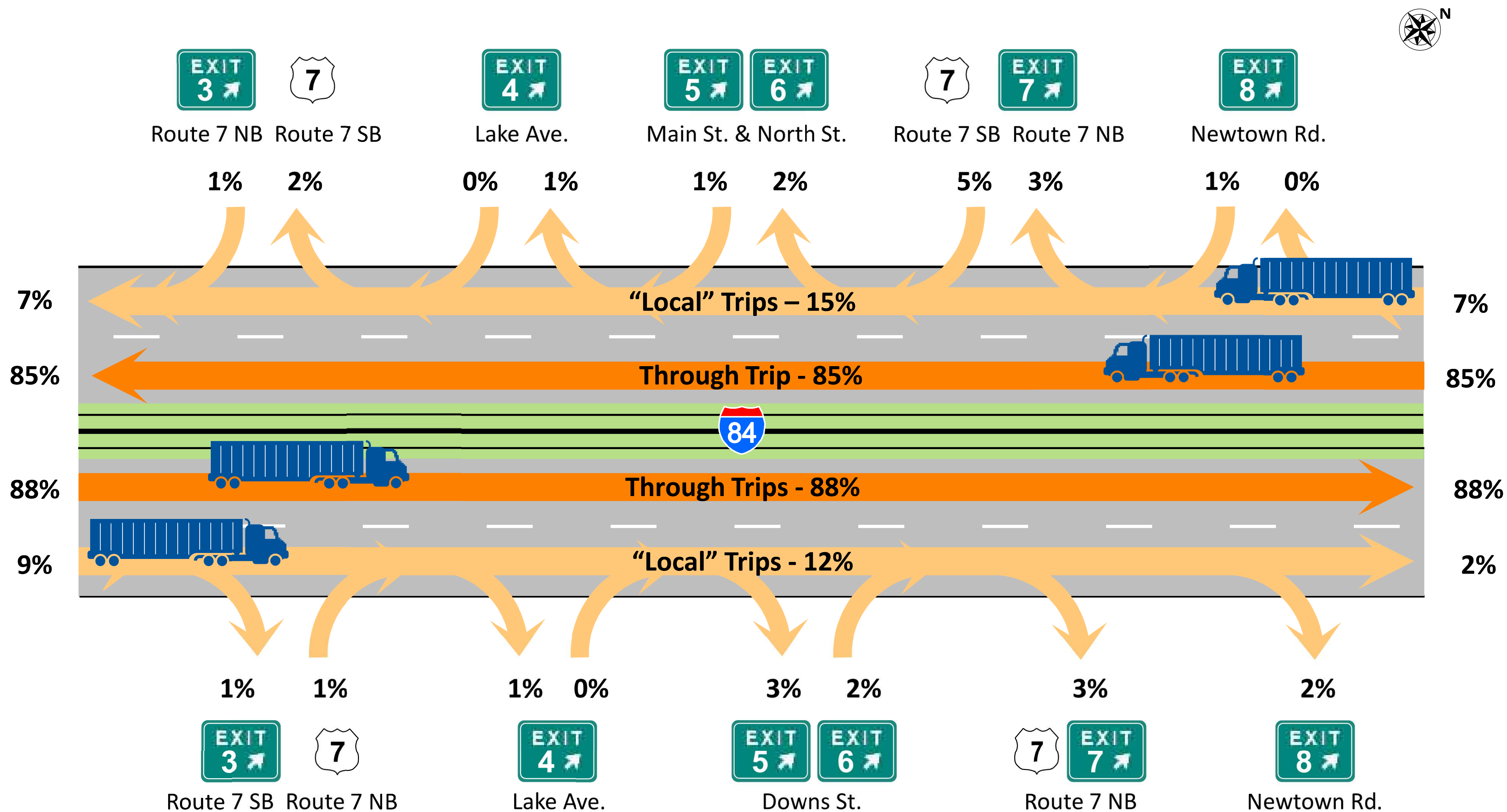

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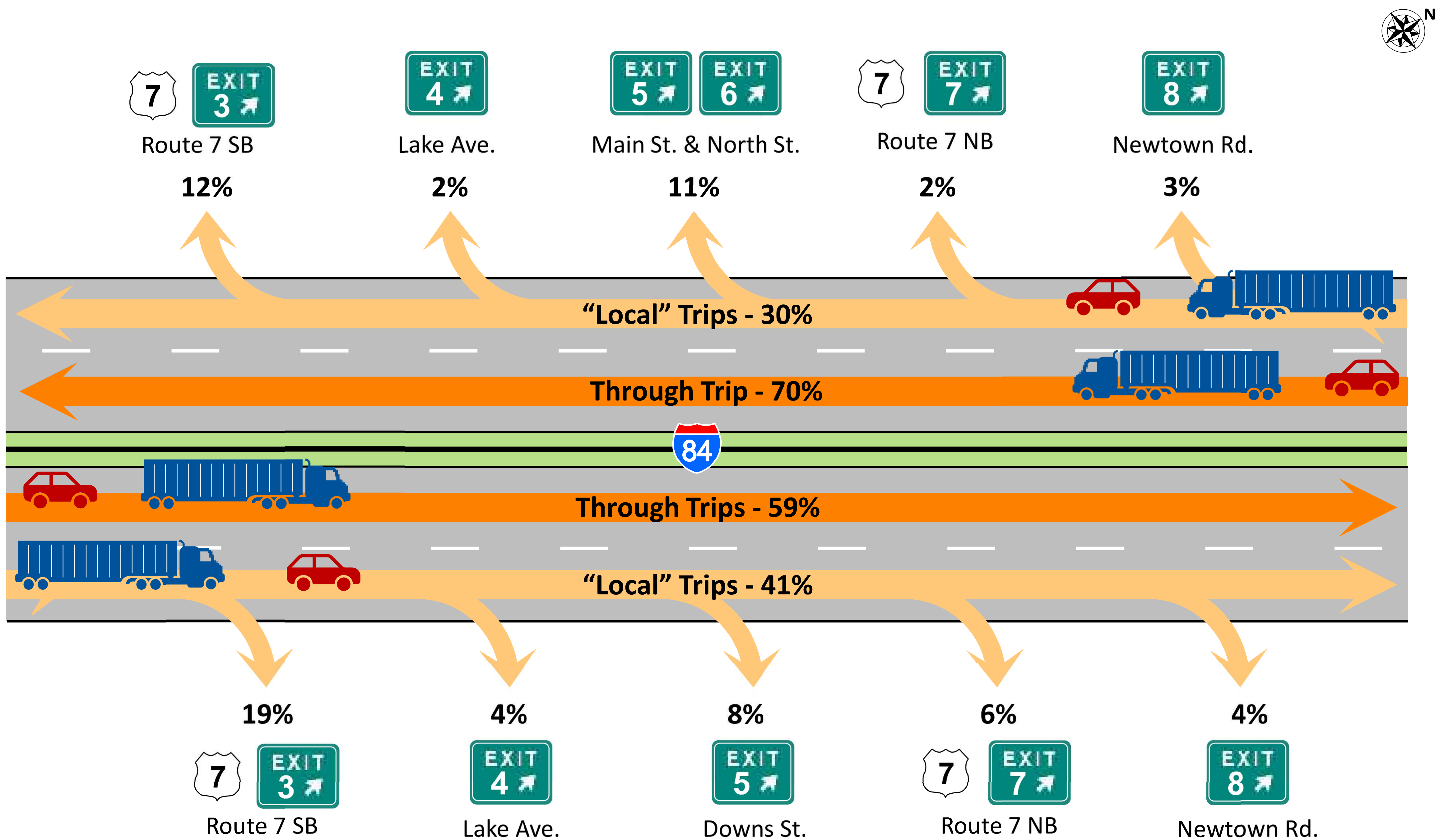
SKYCOMP RAMP TO RAMP DATA
I-84 AVERAGE WEEKDAY* - PM PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
TOTAL TRAFFIC



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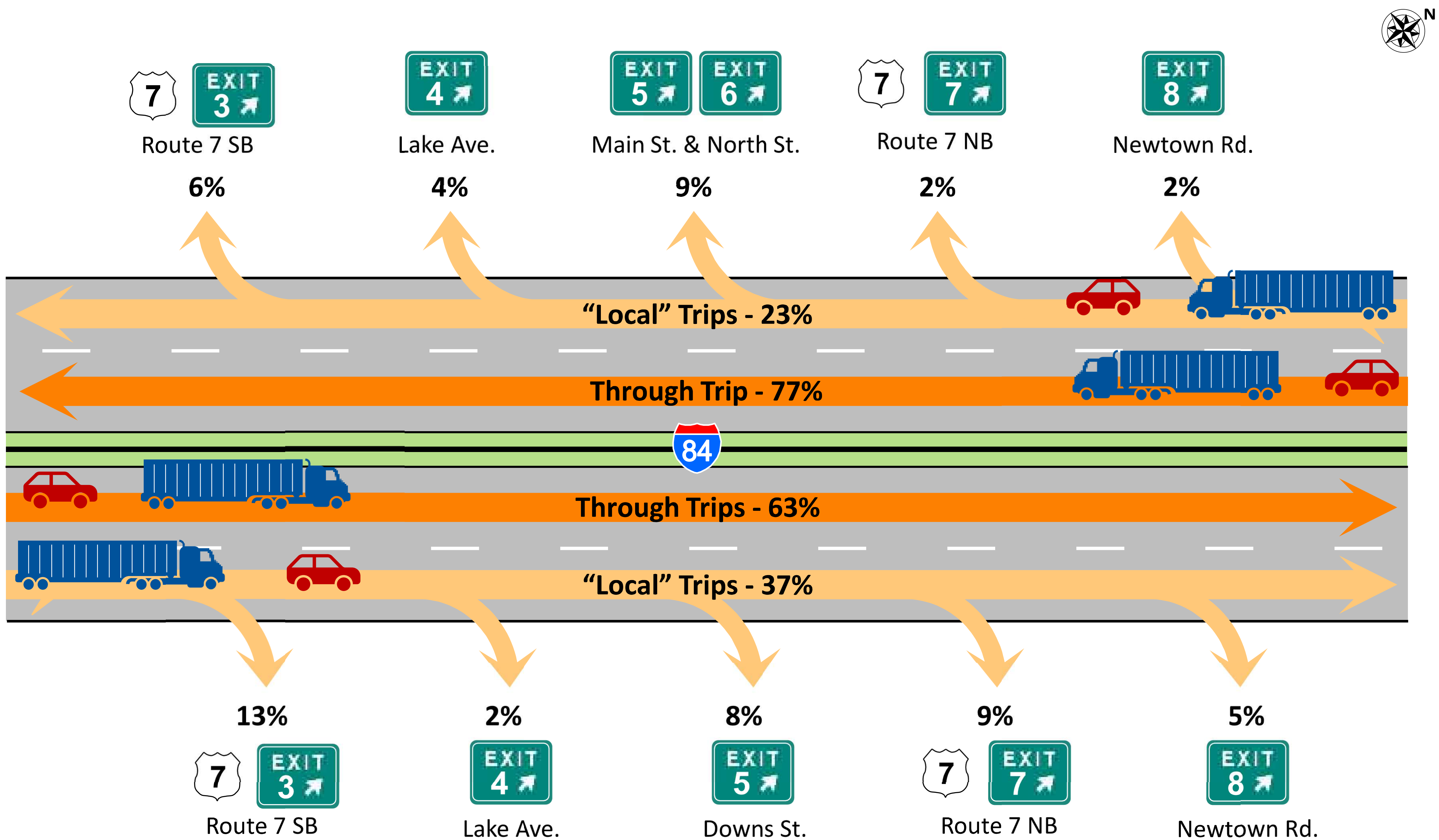
SKYCOMP MAINLINE DESTINATION DATA
I-84 AVERAGE WEEKDAY* - AM PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
TOTAL TRAFFIC



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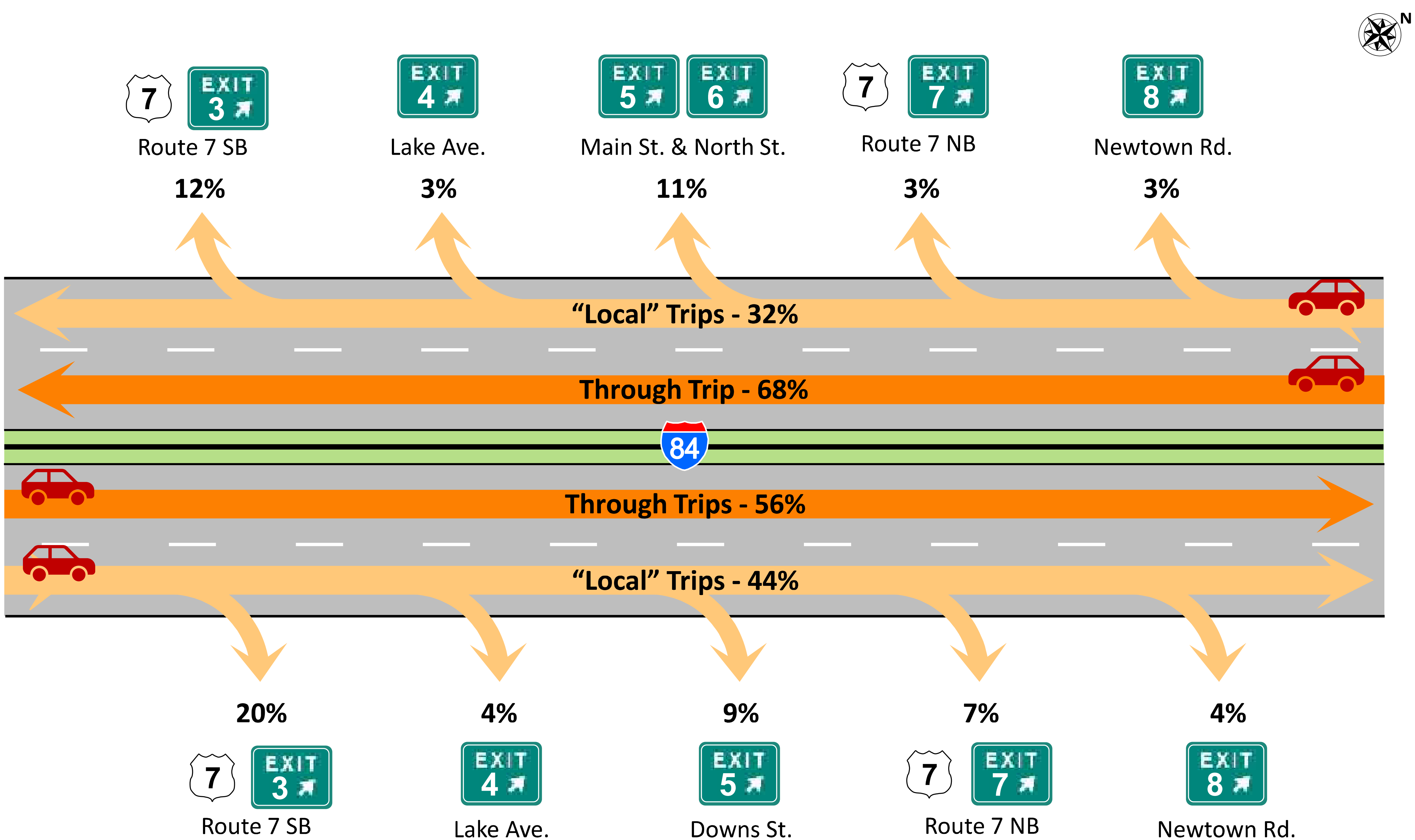
SKYCOMP MAINLINE DESTINATION DATA
I-84 AVERAGE WEEKDAY* - PM PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
LIGHT TRAFFIC (AUTOS/SMALL TRUCKS)



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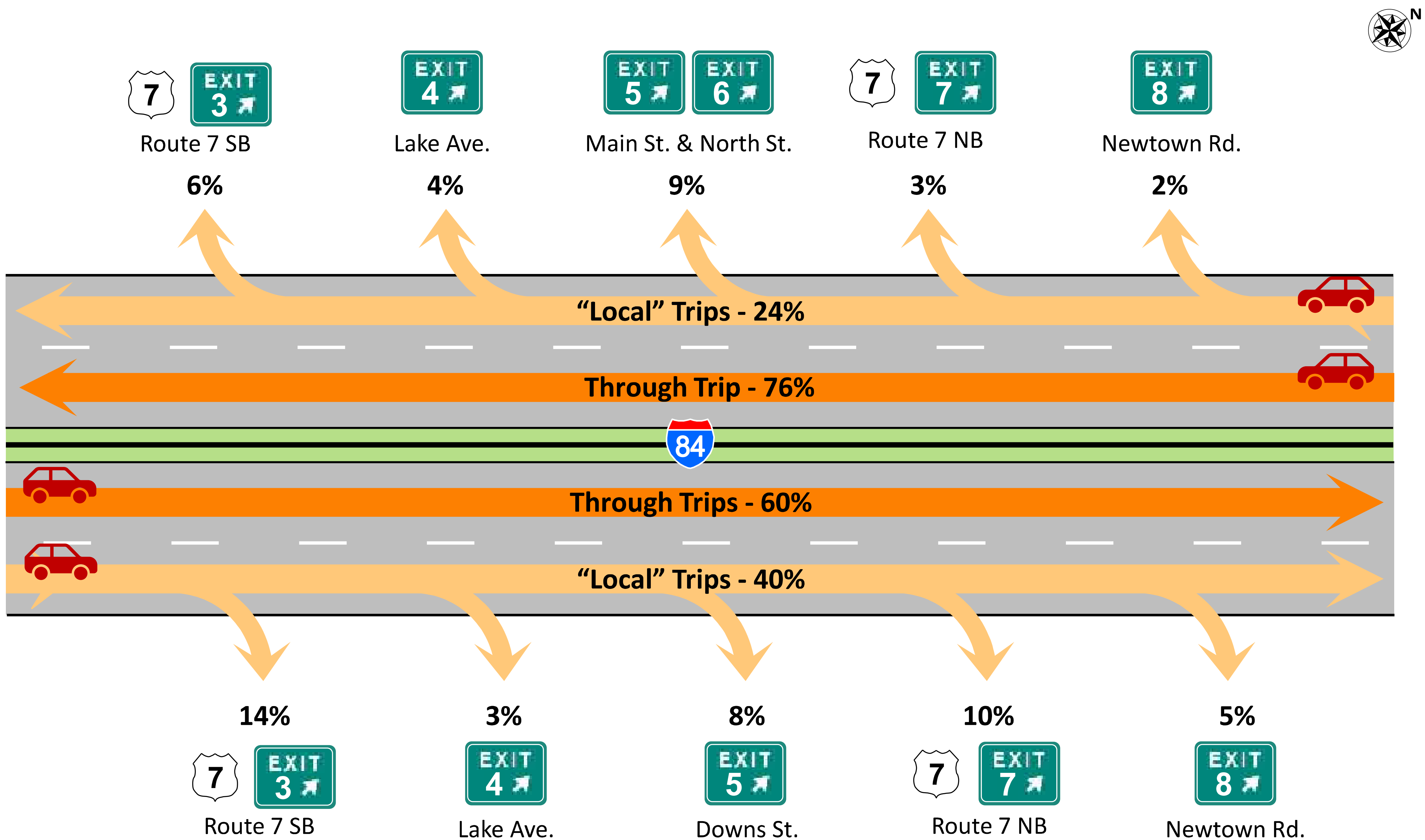
SKYCOMP MAINLINE DESTINATION DATA
I-84 AVERAGE WEEKDAY* - AM PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
LIGHT TRAFFIC (AUTOS/SMALL TRUCKS)



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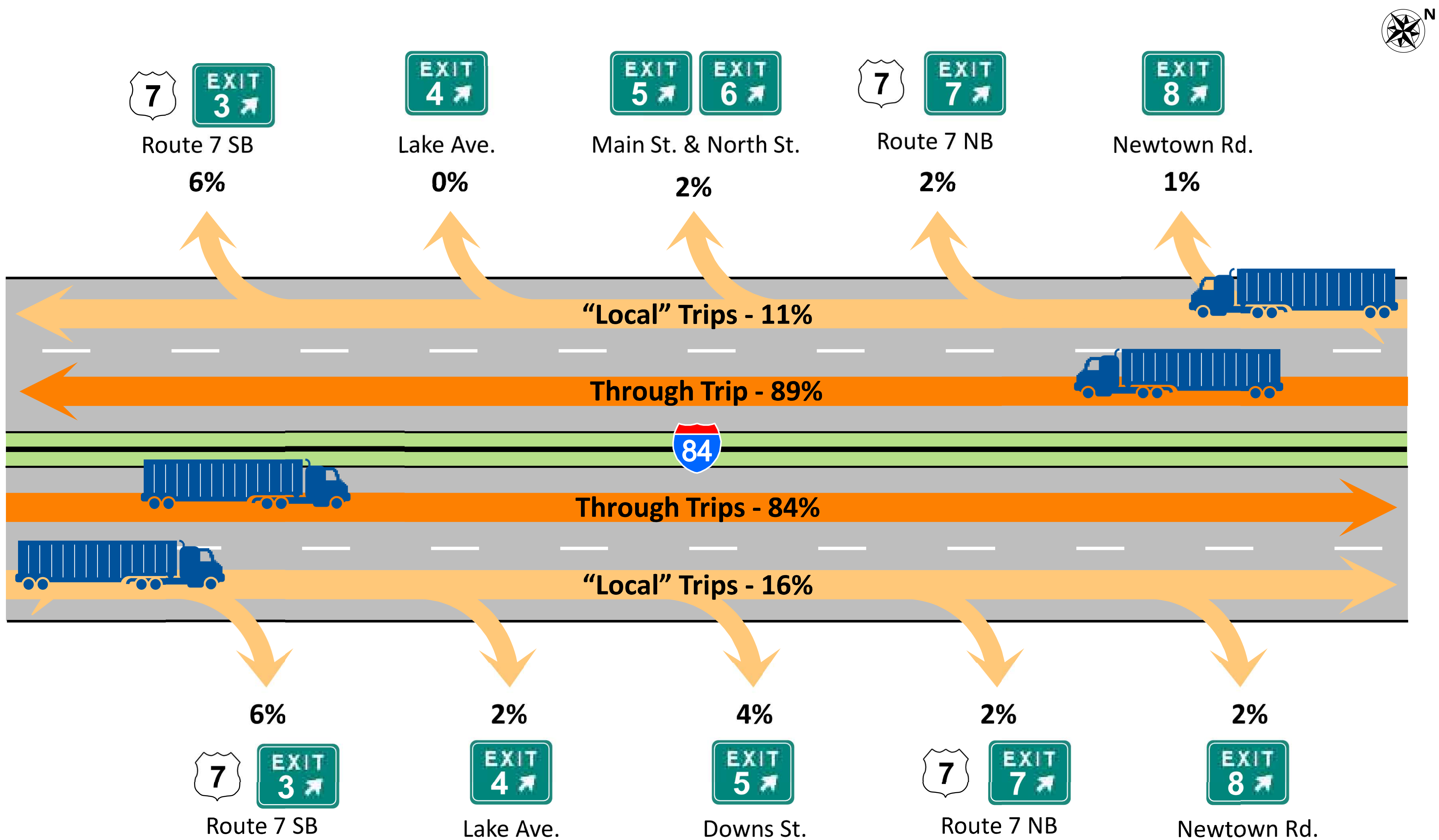
SKYCOMP MAINLINE DESTINATION DATA
I-84 AVERAGE WEEKDAY* - PM PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
HEAVY TRAFFIC (LARGE TRUCKS)



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I-84 AVERAGE WEEKDAY* - AM PEAK PERIOD

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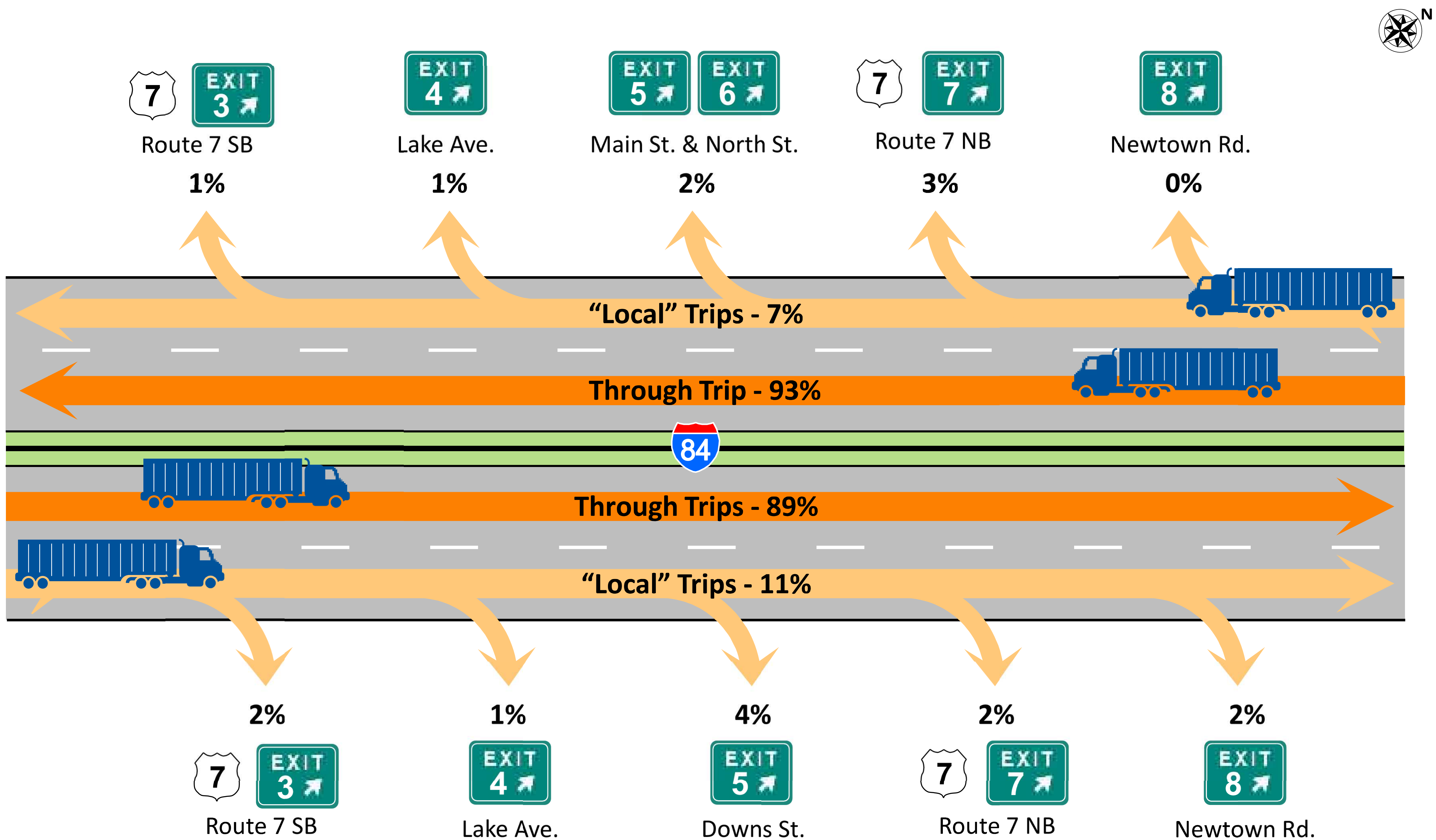

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SKYCOMP MAINLINE DESTINATION DATA
I-84 AVERAGE WEEKDAY* - PM PEAK PERIOD

CDM Smith

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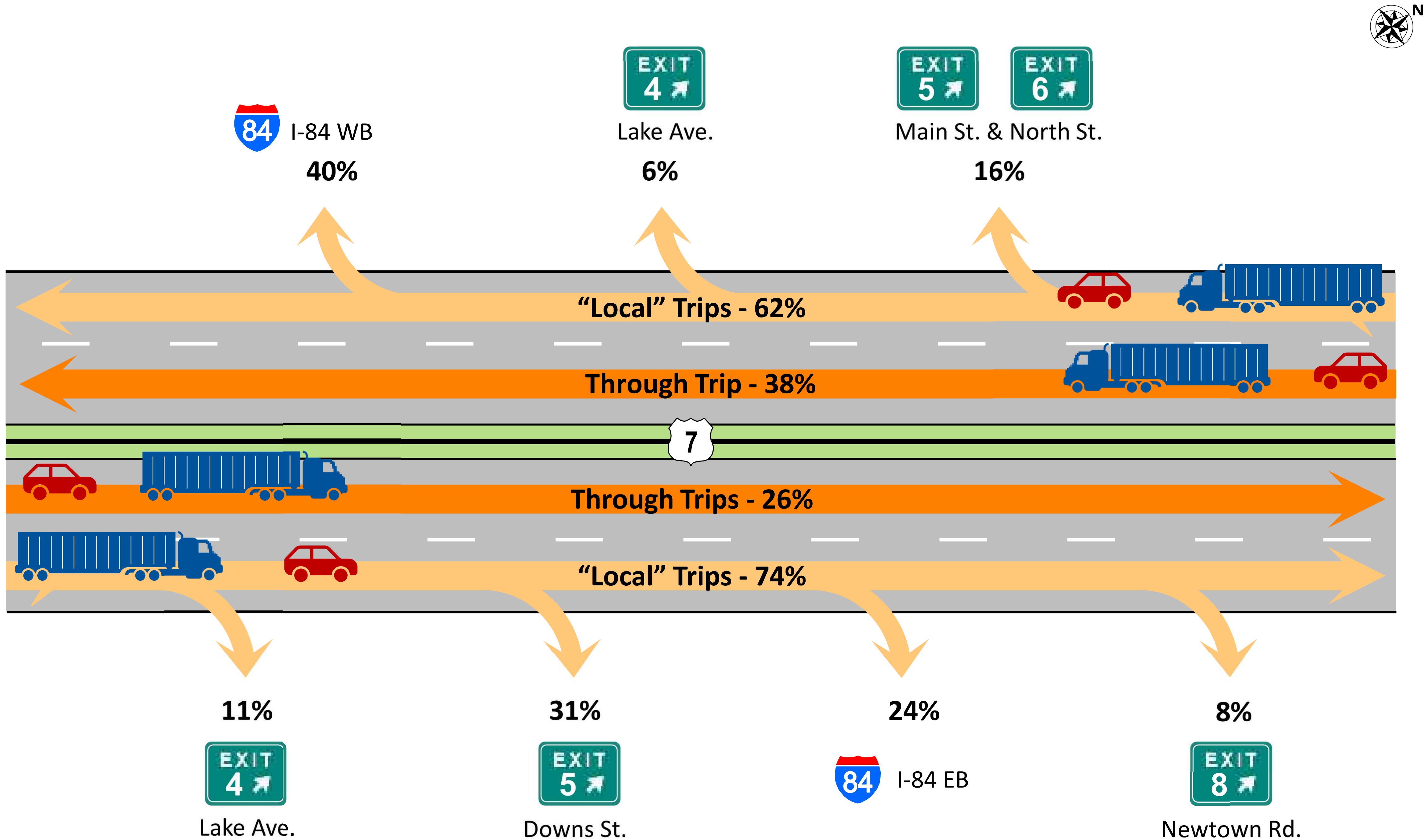

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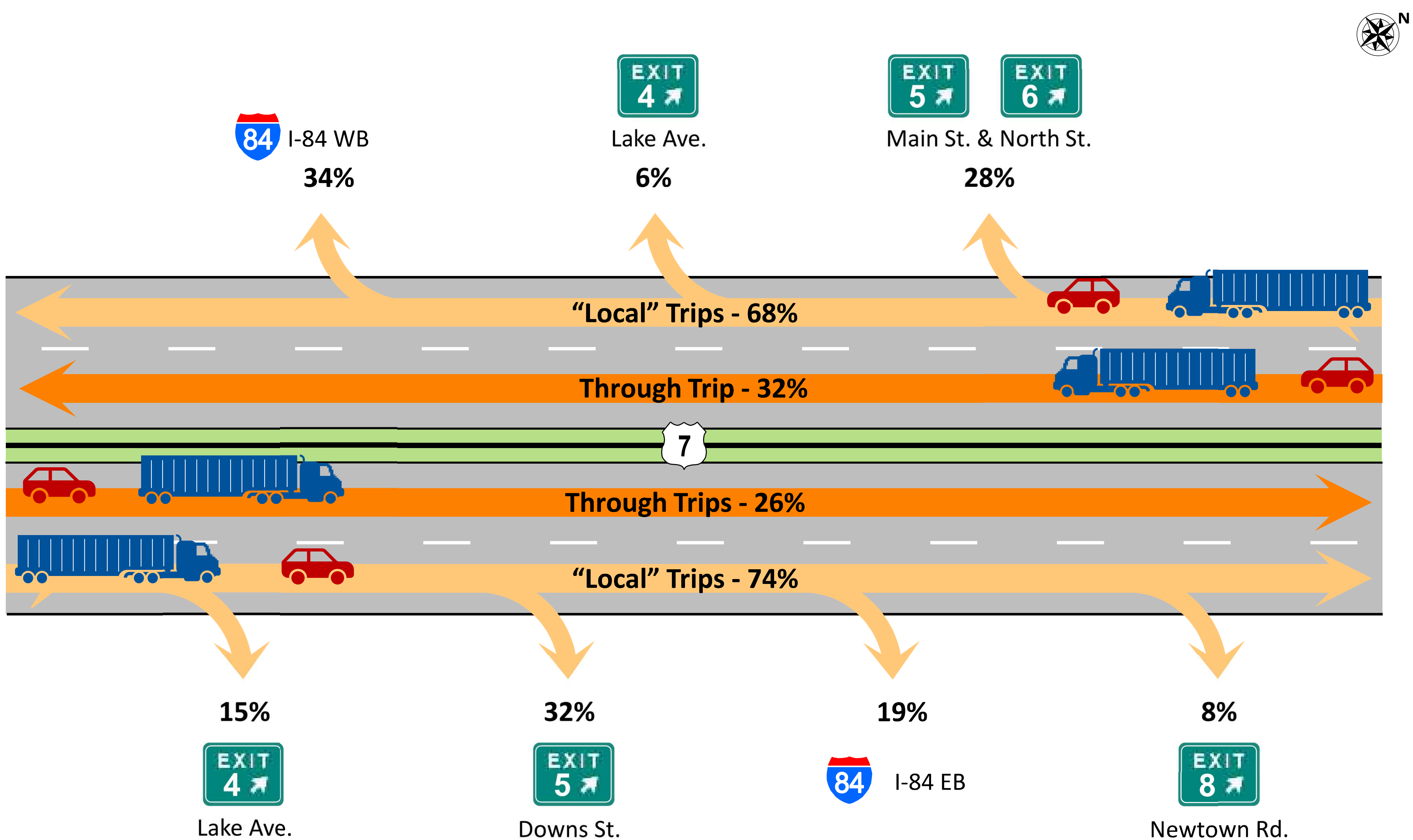
SKYCOMP DESTINATION DATA
ROUTE 7 AVERAGE WEEKDAY* - AM PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
TOTAL TRAFFIC



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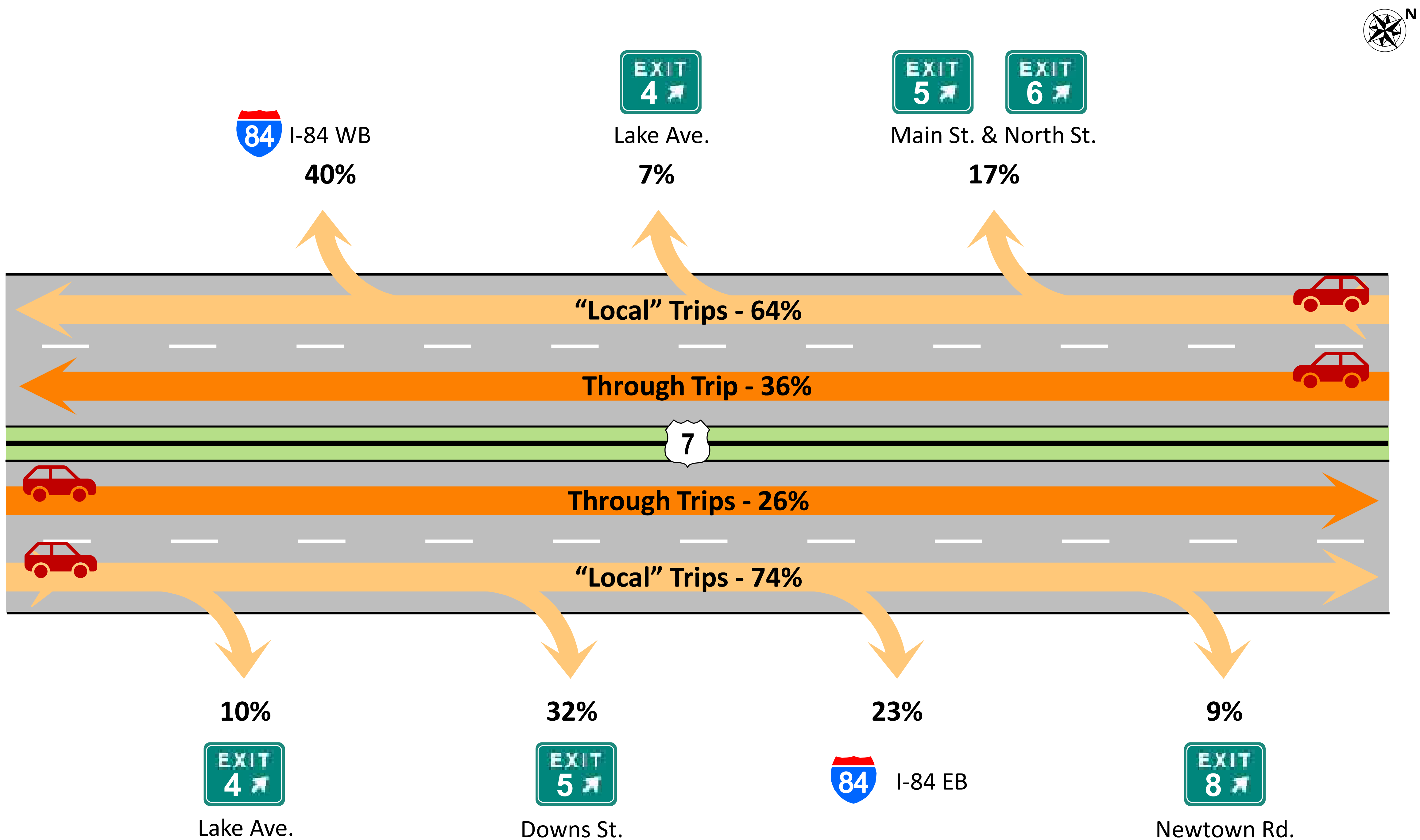
SKYCOMP DESTINATION DATA
ROUTE 7 AVERAGE WEEKDAY* - PM PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
LIGHT TRAFFIC (AUTOS/SMALL TRUCKS)



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ROUTE 7 AVERAGE WEEKDAY* - AM PEAK PERIOD

CDM Smith

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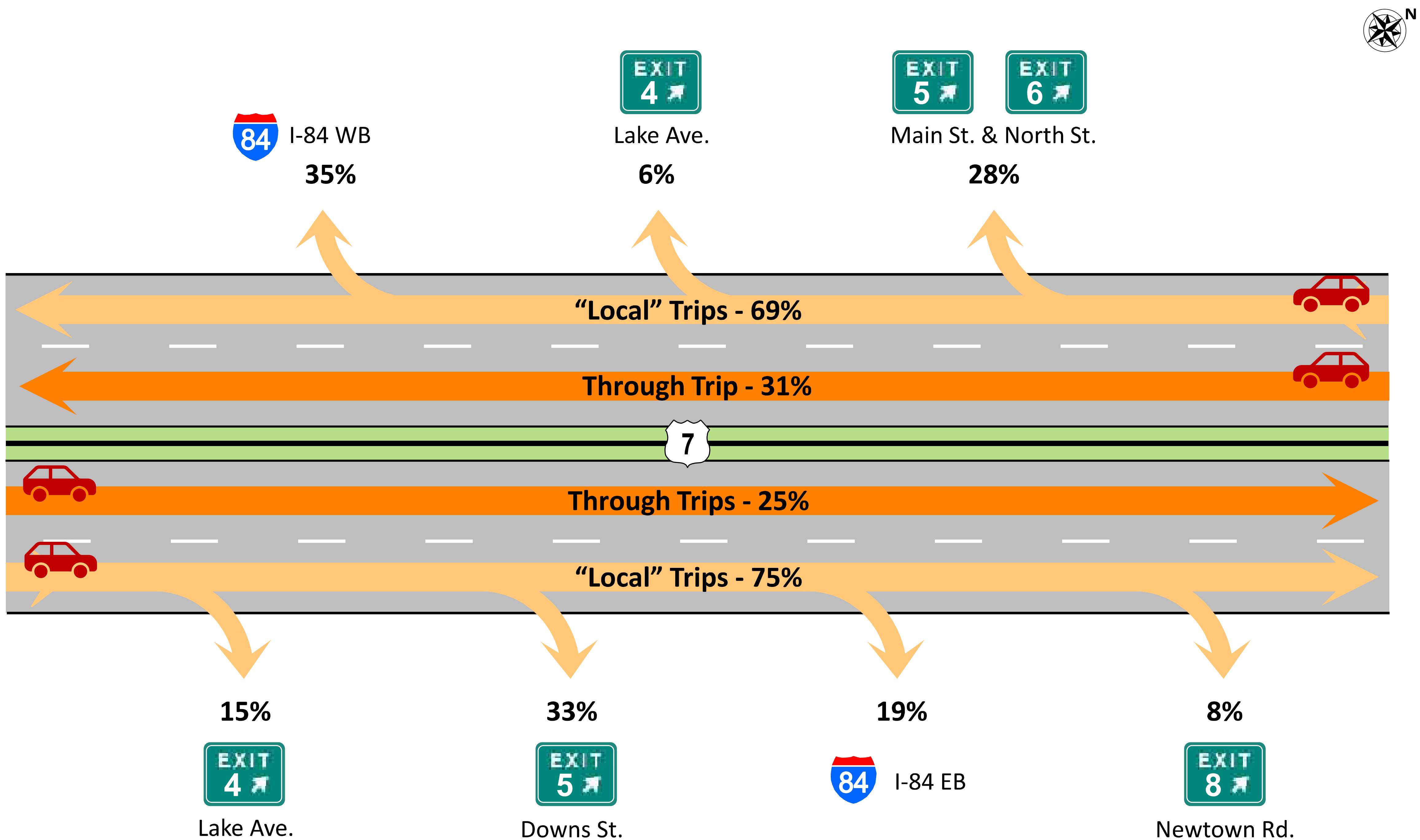

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SKYCOMP DESTINATION DATA
ROUTE 7 AVERAGE WEEKDAY* - PM PEAK PERIOD

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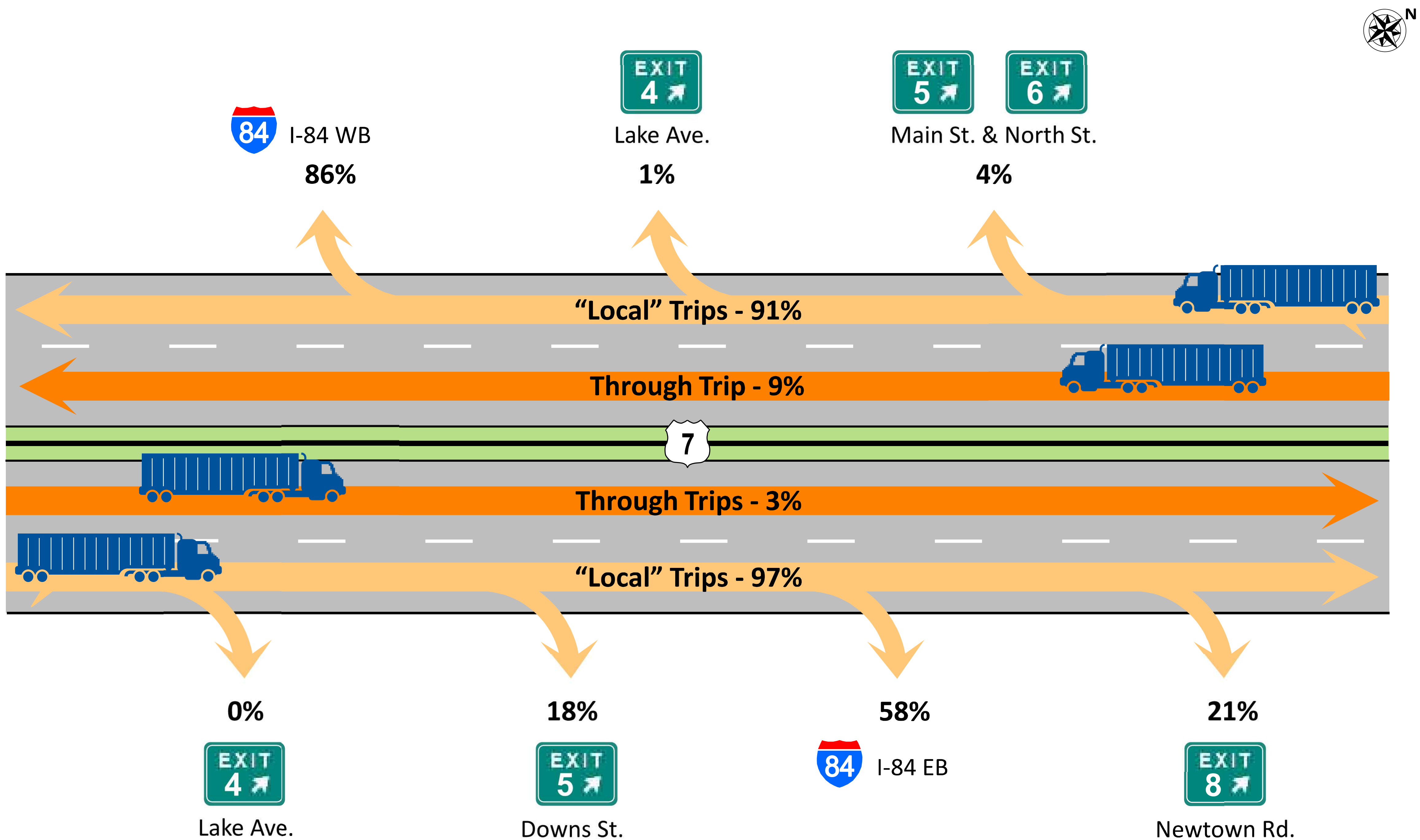
HEAVY TRAFFIC (LARGE TRUCKS)



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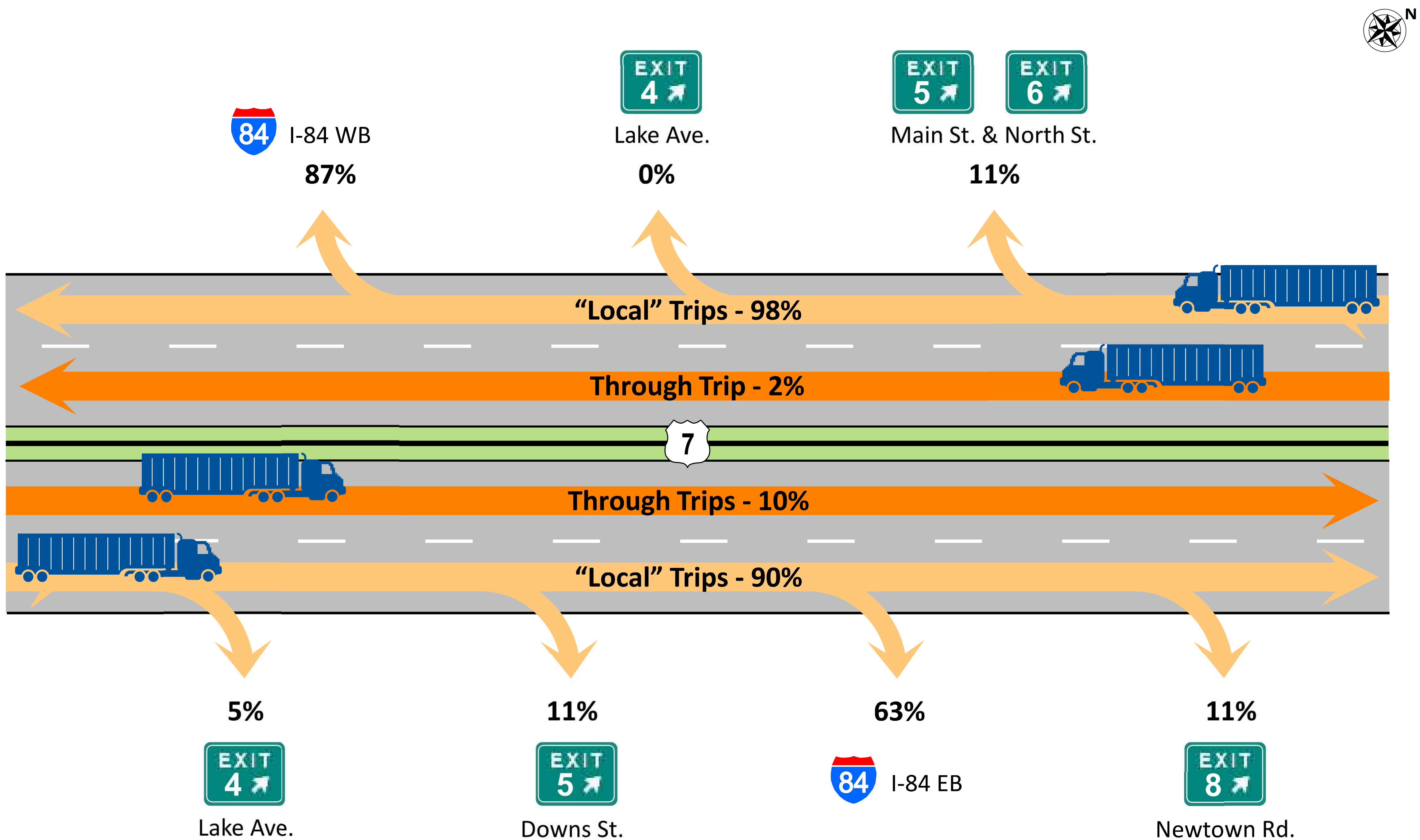

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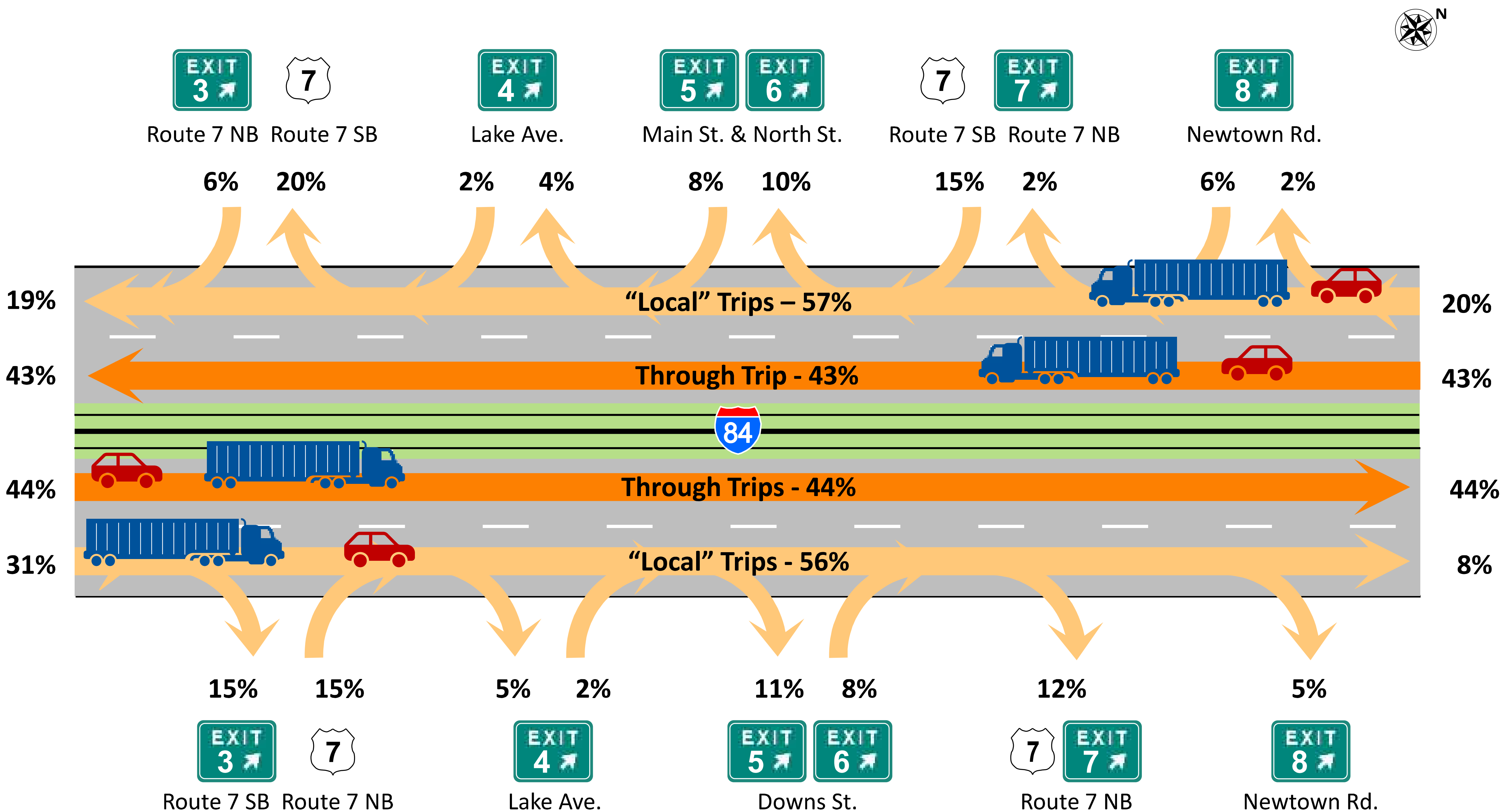
SKYCOMP DESTINATION DATA
ROUTE 7 AVERAGE WEEKDAY* - PM PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
TOTAL VEHICLE COUNTS



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SKYCOMP RAMP TO RAMP DATA
I-84 AVERAGE WEEKDAY* - AM PEAK PERIOD

CDM Smith

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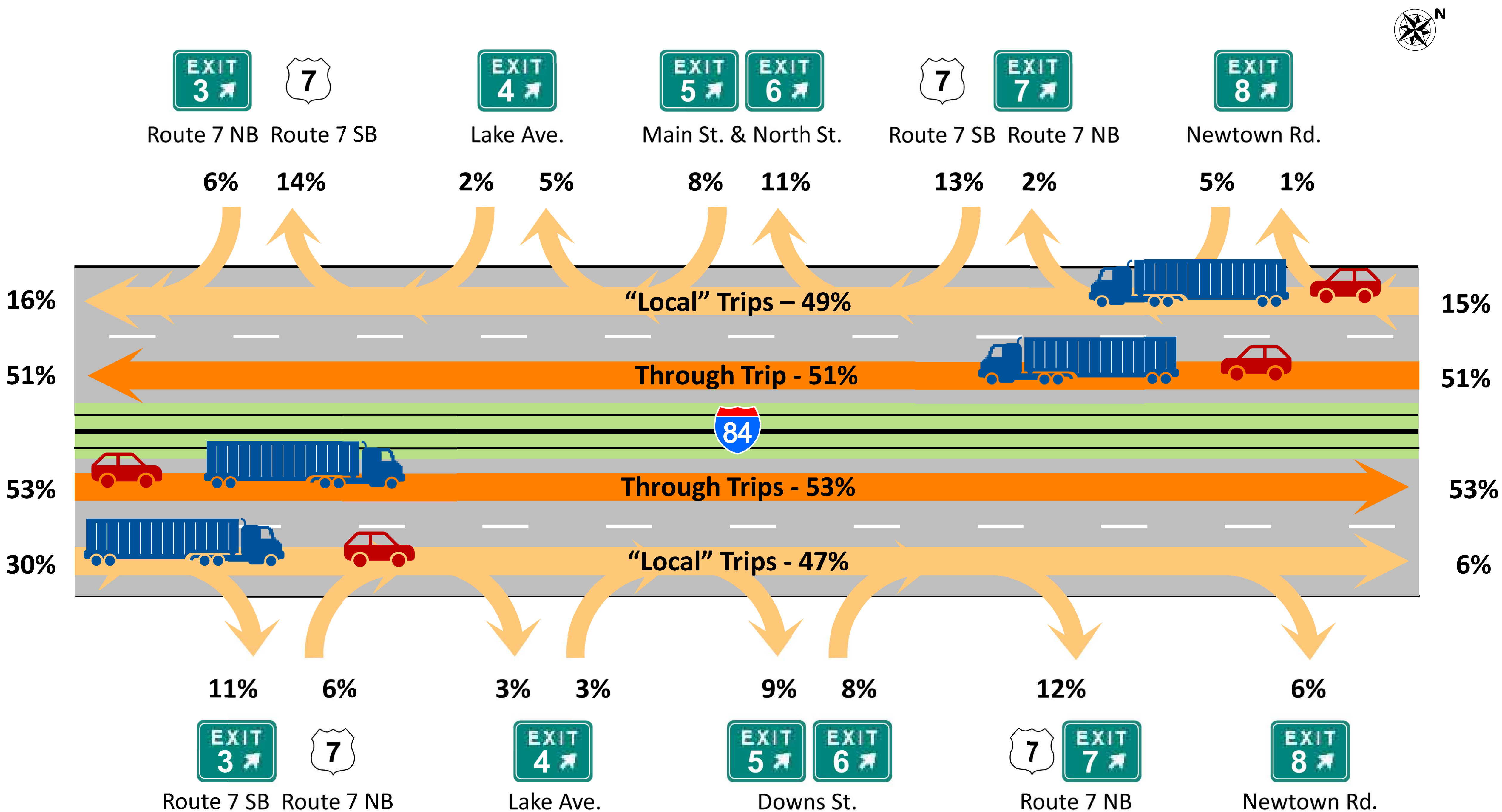

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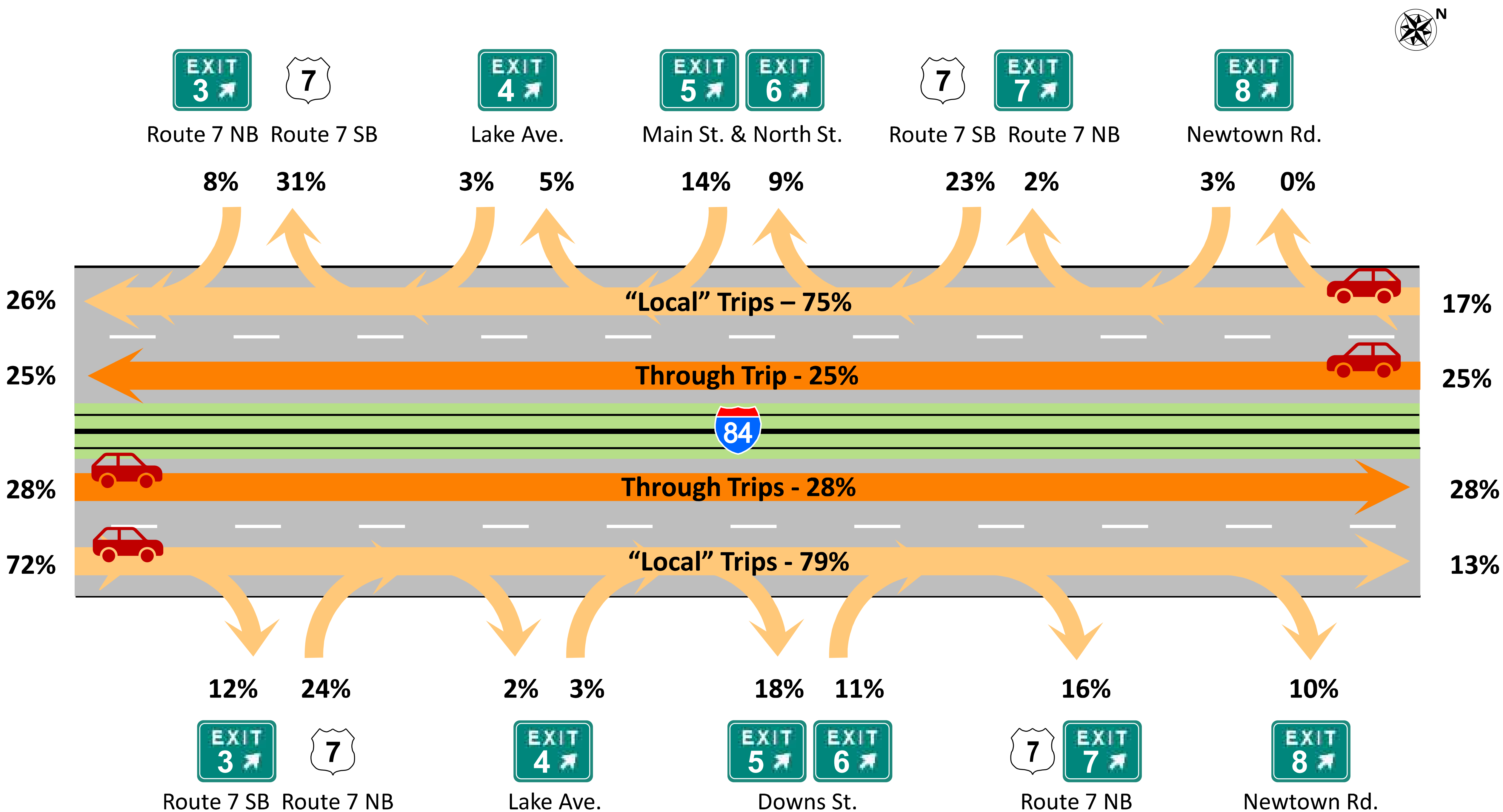
SKYCOMP RAMP TO RAMP DATA
I-84 AVERAGE WEEKDAY* - PM PEAK PERIOD

CDM Smith

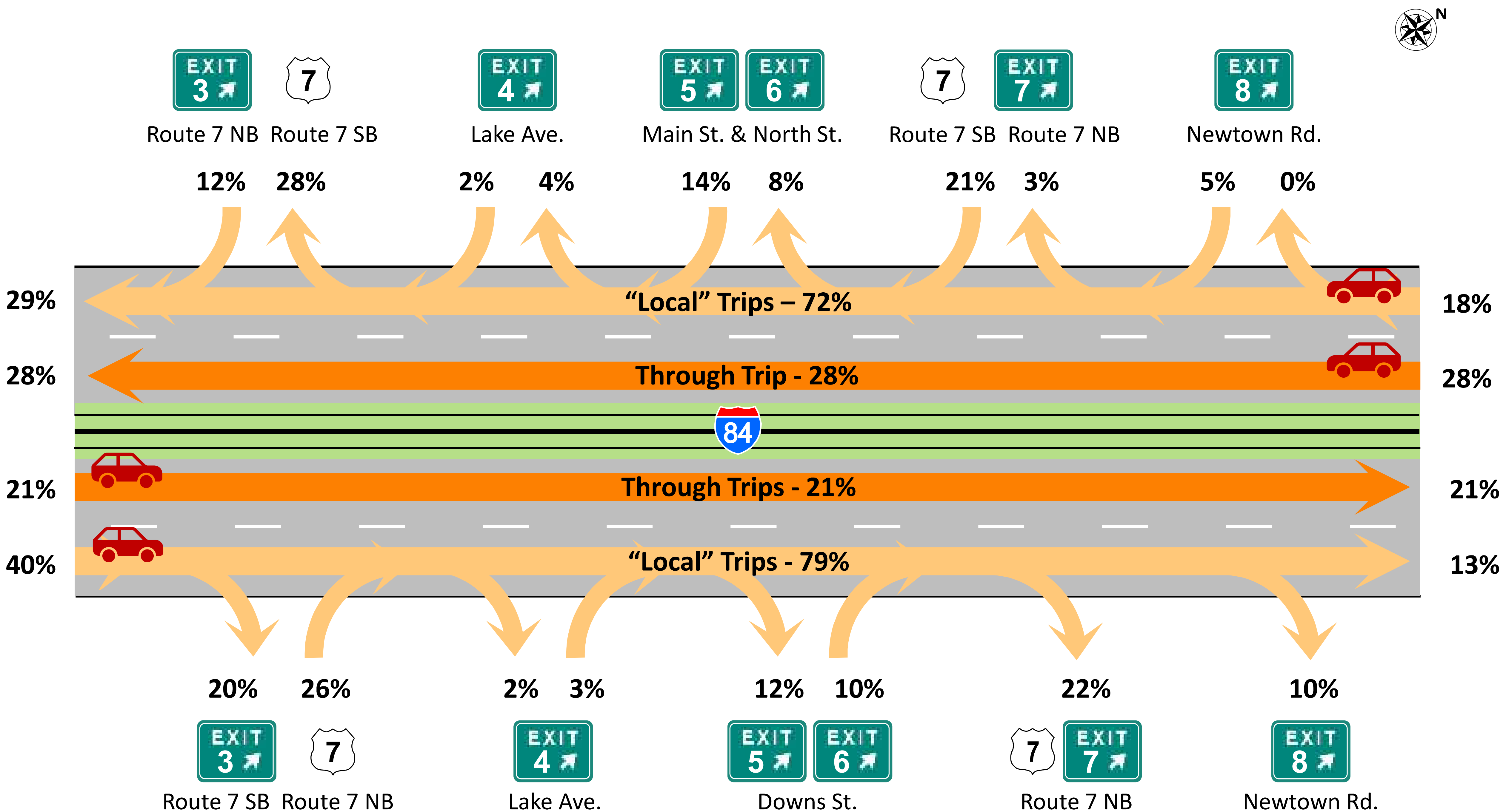
SKYCOMP TRAFFIC DISTRIBUTION DATA
LIGHT TRAFFIC (AUTOS/SMALL TRUCKS)



SKYCOMP RAMP TO RAMP DATA
I-84 AVERAGE FRIDAY – AM PEAK PERIOD

CDM Smith

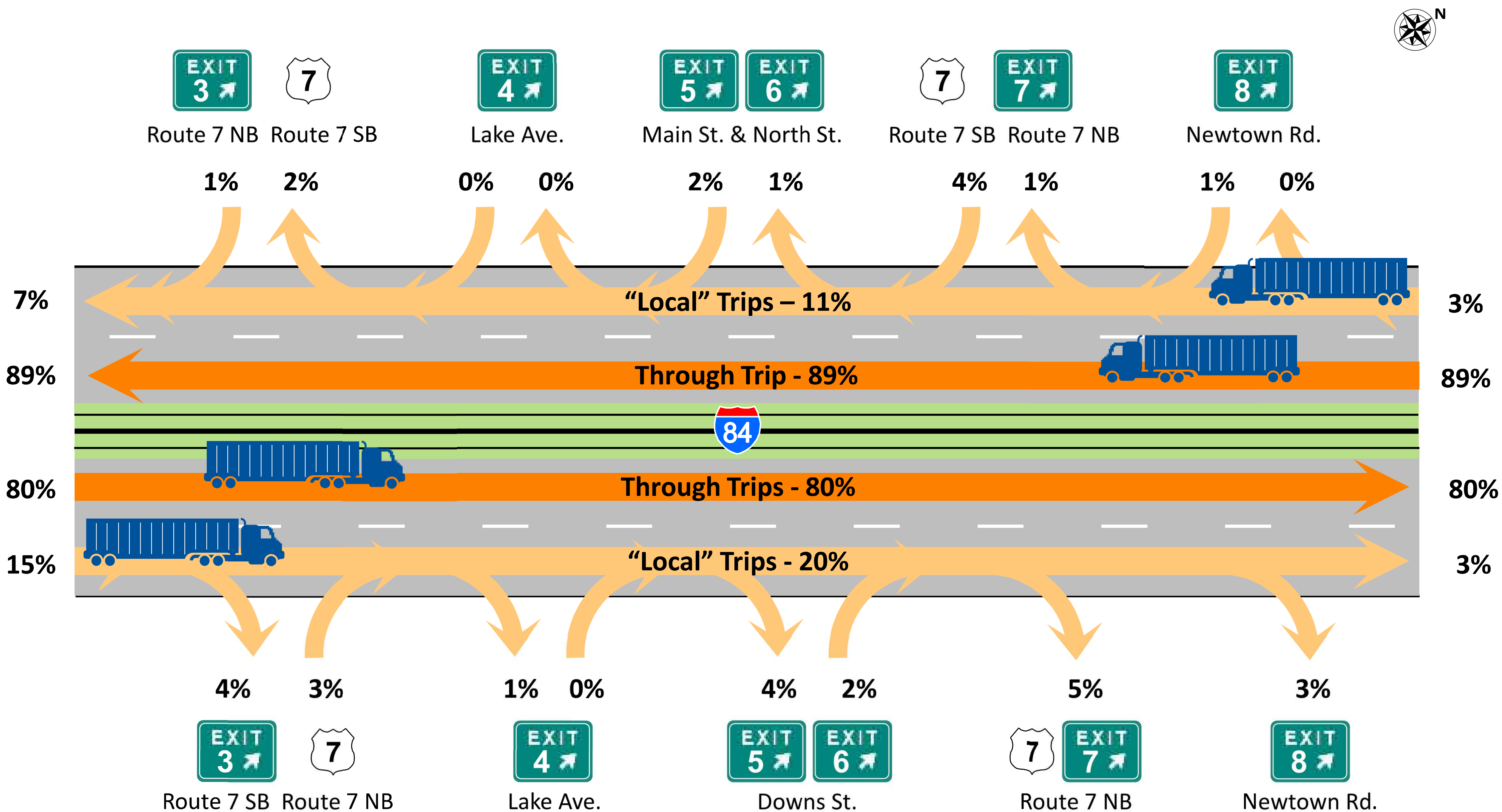
SKYCOMP TRAFFIC DISTRIBUTION DATA
LIGHT TRAFFIC (AUTOS/SMALL TRUCKS)



SKYCOMP RAMP TO RAMP DATA
I-84 AVERAGE FRIDAY – PM PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
HEAVY TRAFFIC (LARGE TRUCKS)



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I-84 AVERAGE FRIDAY – AM PEAK PERIOD

CDM Smith

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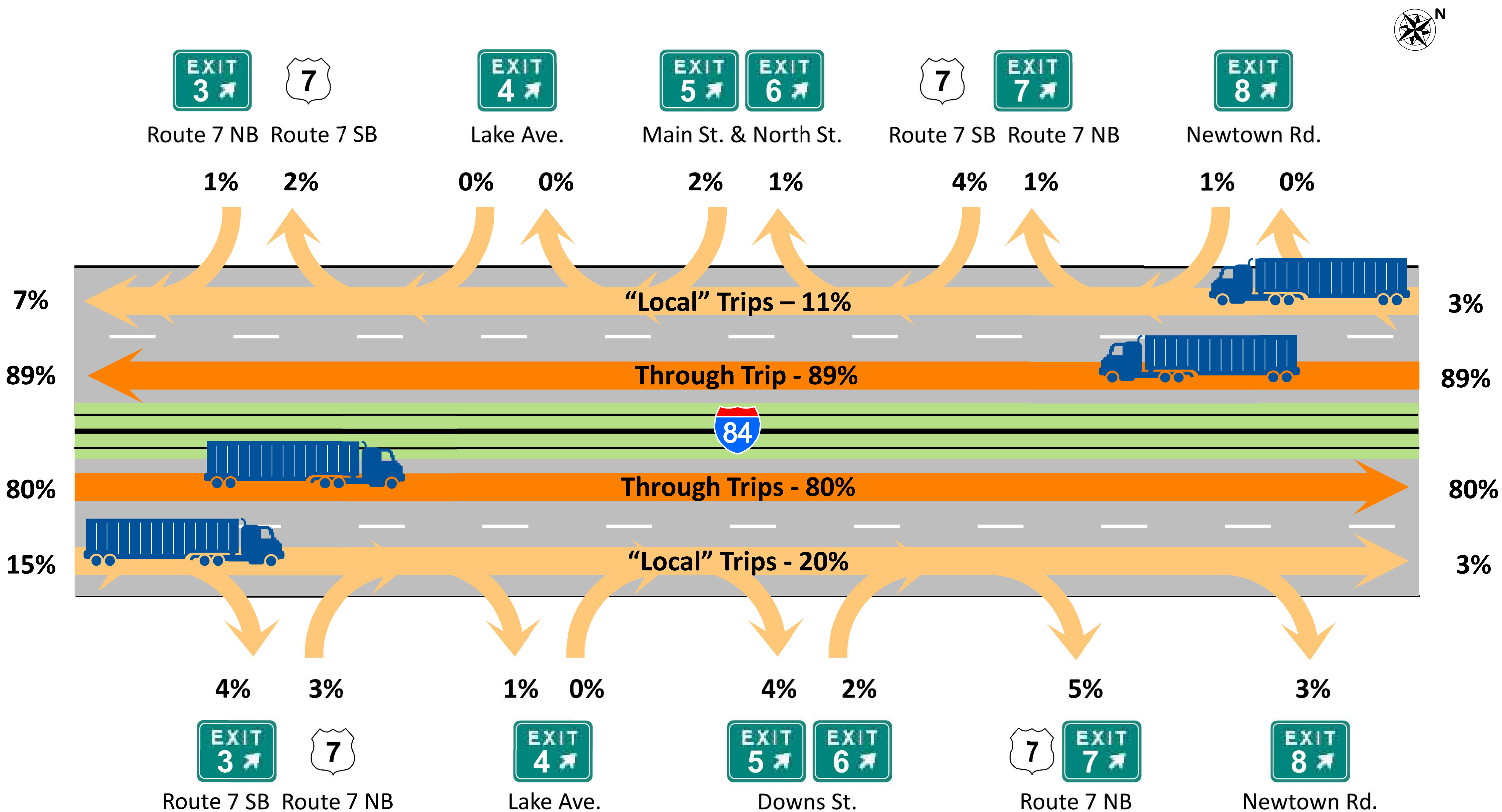
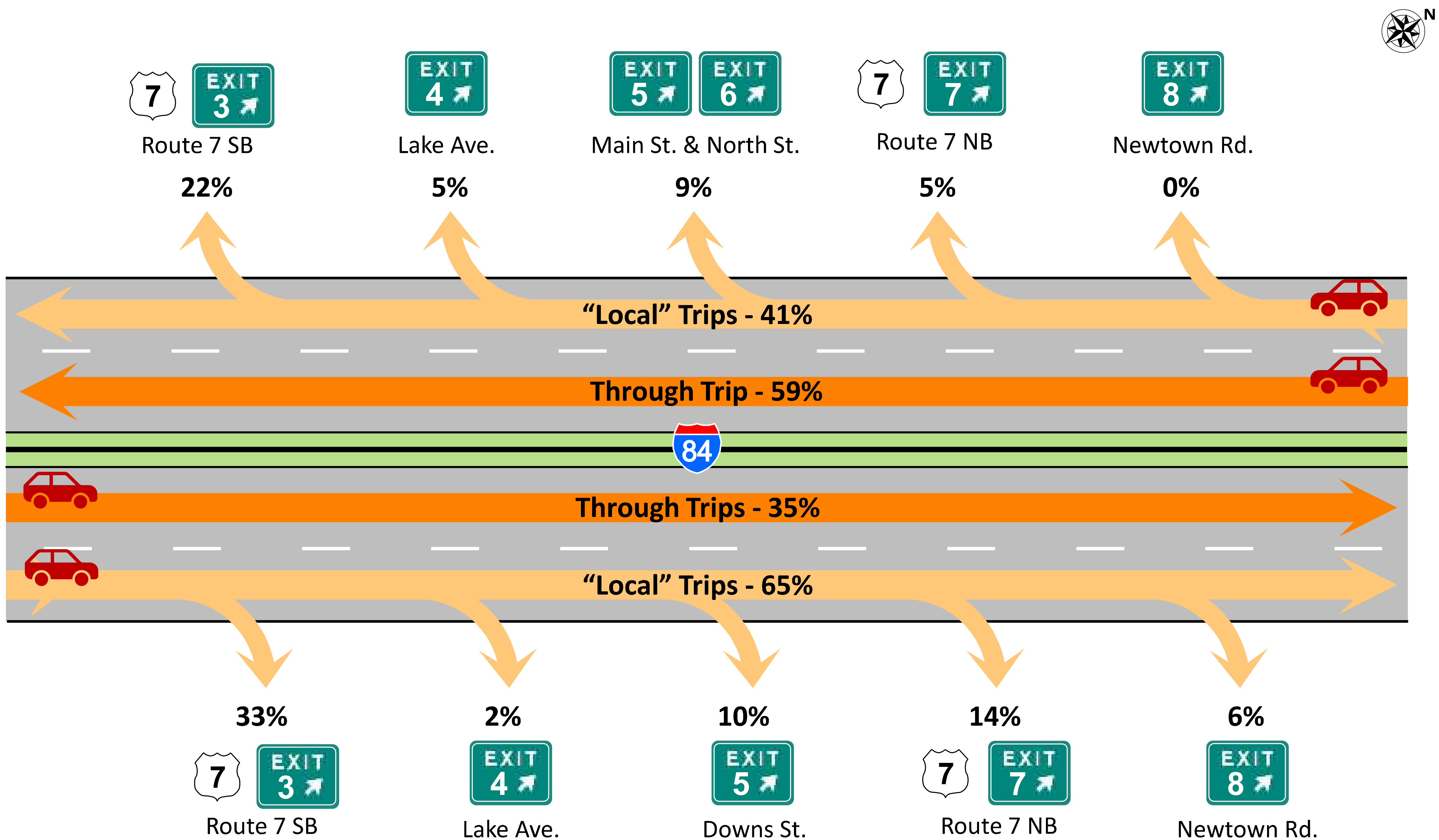


SKYCOMP RAMP TO RAMP DATA
I-84 AVERAGE FRIDAY – PM PEAK PERIOD

CDM Smith

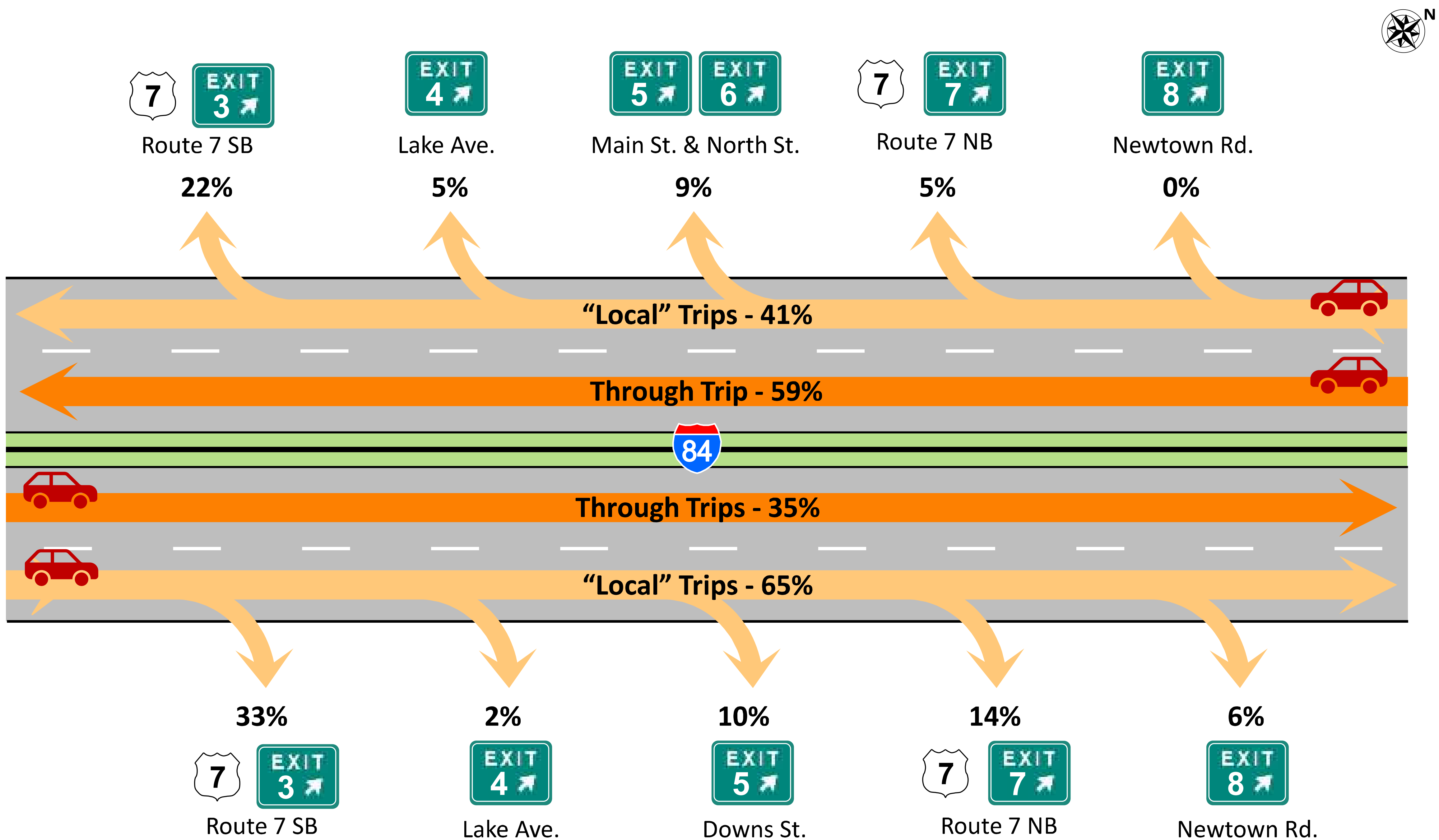
SKYCOMP TRAFFIC DISTRIBUTION DATA
LIGHT TRAFFIC (AUTOS/SMALL TRUCKS)



SKYCOMP MAINLINE DESTINATION DATA
I-84 AVERAGE FRIDAY - AM PEAK PERIOD

CDM Smith

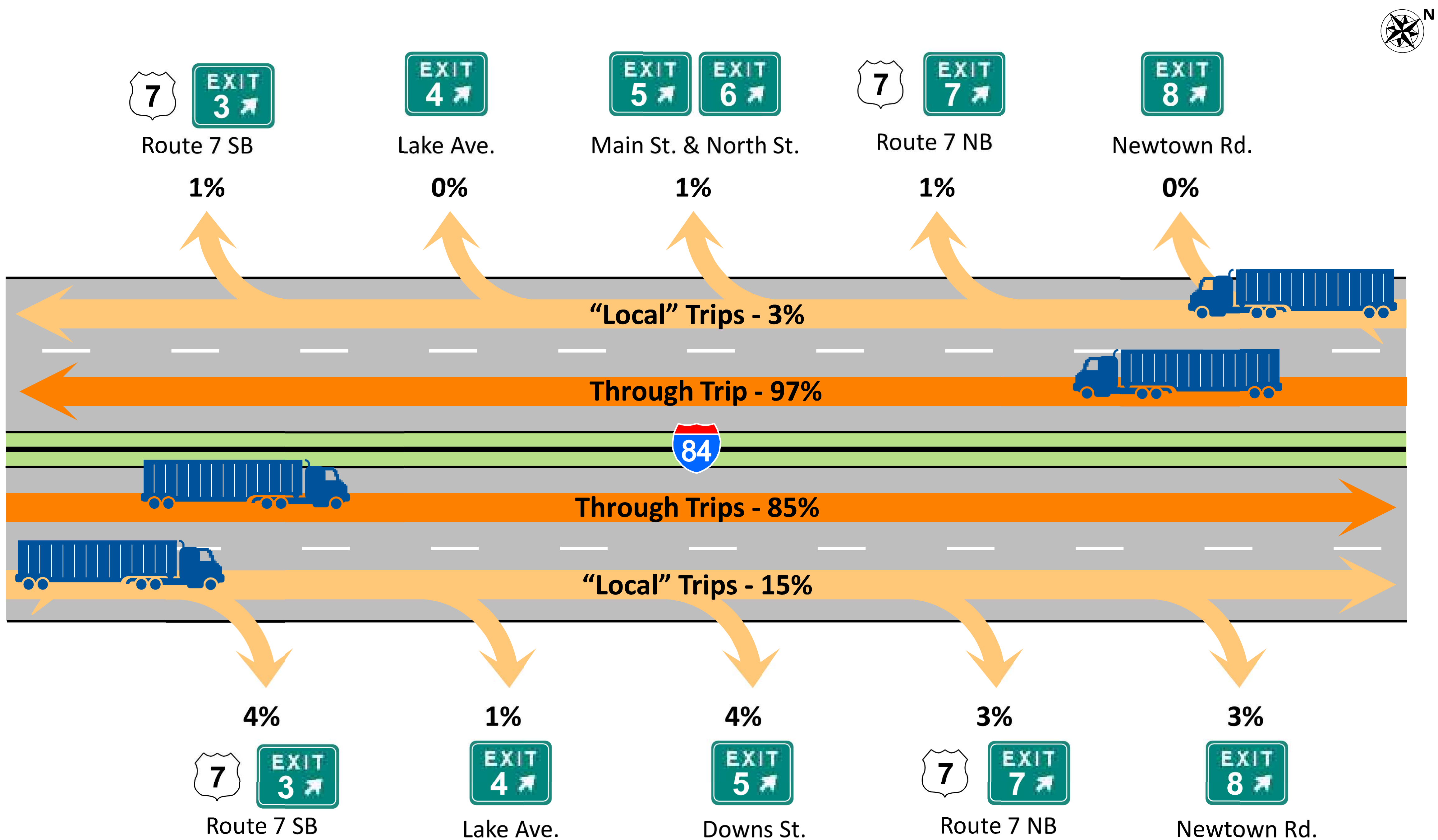
SKYCOMP TRAFFIC DISTRIBUTION DATA
LIGHT TRAFFIC (AUTOS/SMALL TRUCKS)



SKYCOMP MAINLINE DESTINATION DATA
I-84 AVERAGE FRIDAY - PM PEAK PERIOD

CDM Smith

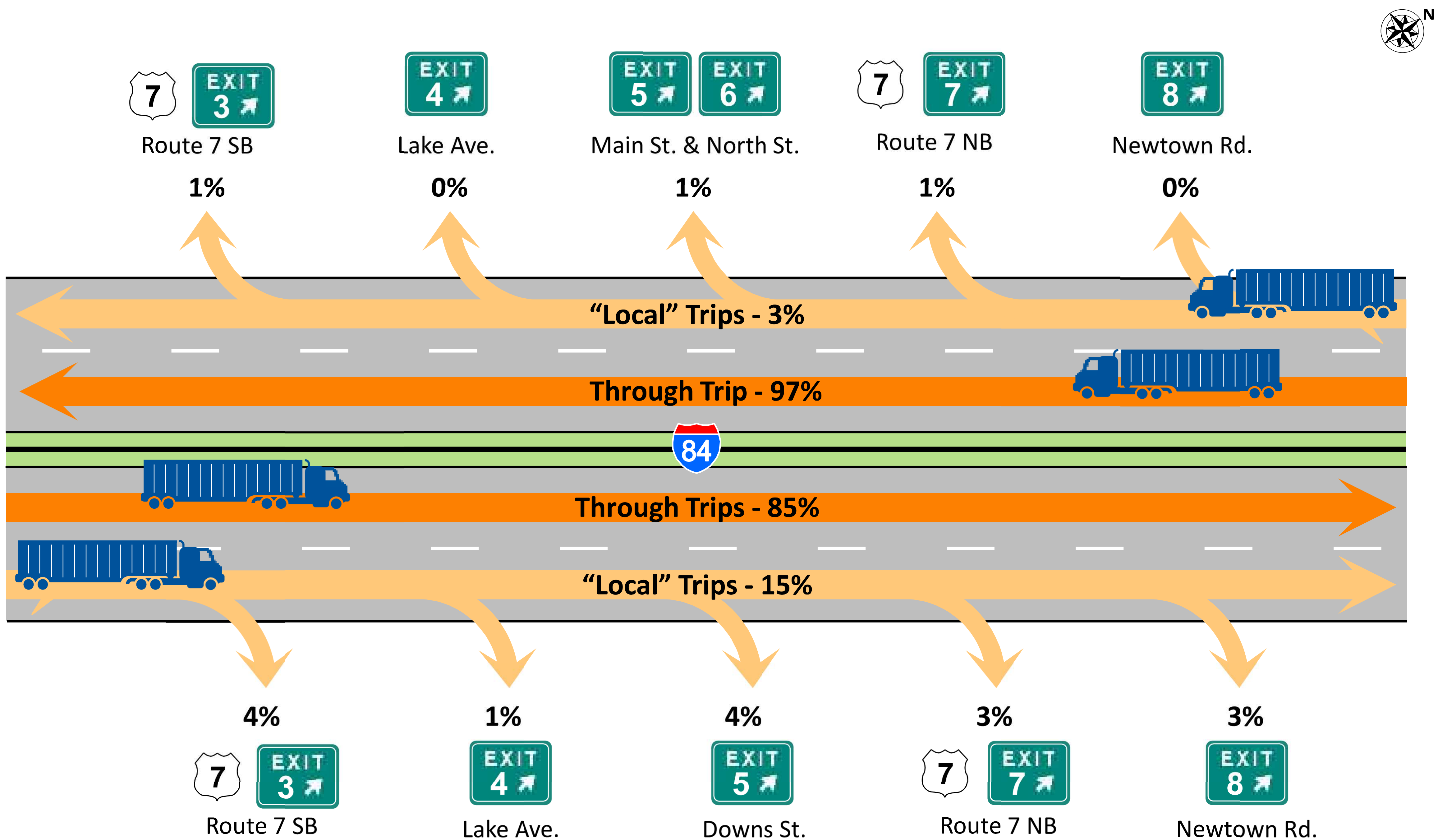
SKYCOMP TRAFFIC DISTRIBUTION DATA
HEAVY TRAFFIC (LARGE TRUCKS)



SKYCOMP MAINLINE DESTINATION DATA
I-84 AVERAGE FRIDAY - AM PEAK PERIOD

CDM Smith

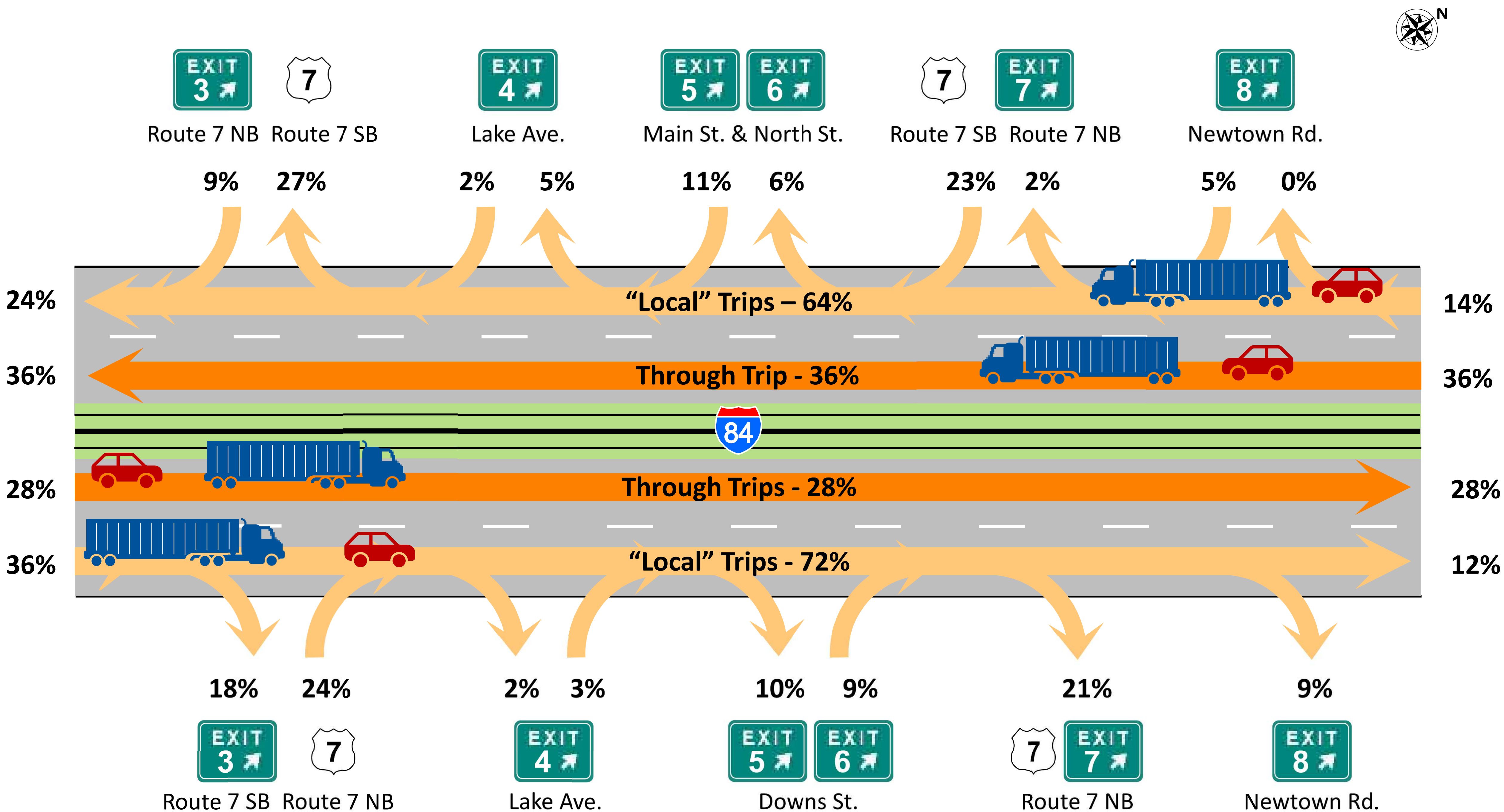
SKYCOMP TRAFFIC DISTRIBUTION DATA
HEAVY TRAFFIC (LARGE TRUCKS)



SKYCOMP MAINLINE DESTINATION DATA
I-84 AVERAGE FRIDAY - PM PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
TOTAL VEHICLE COUNTS



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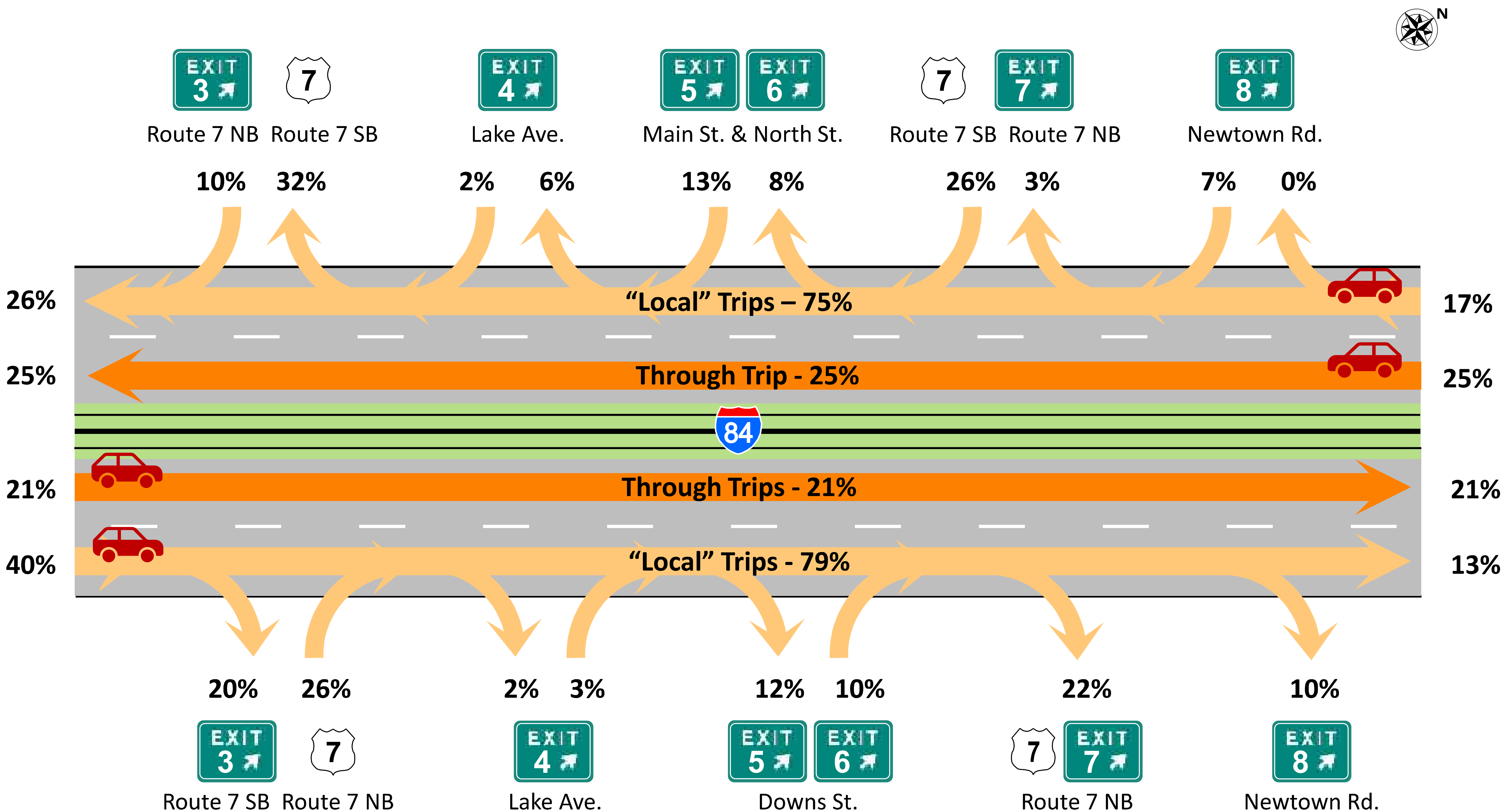
SKYCOMP RAMP TO RAMP DATA
I-84 AVERAGE WEEKDAY* - OFF PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
LIGHT TRAFFIC (AUTOS/SMALL TRUCKS)



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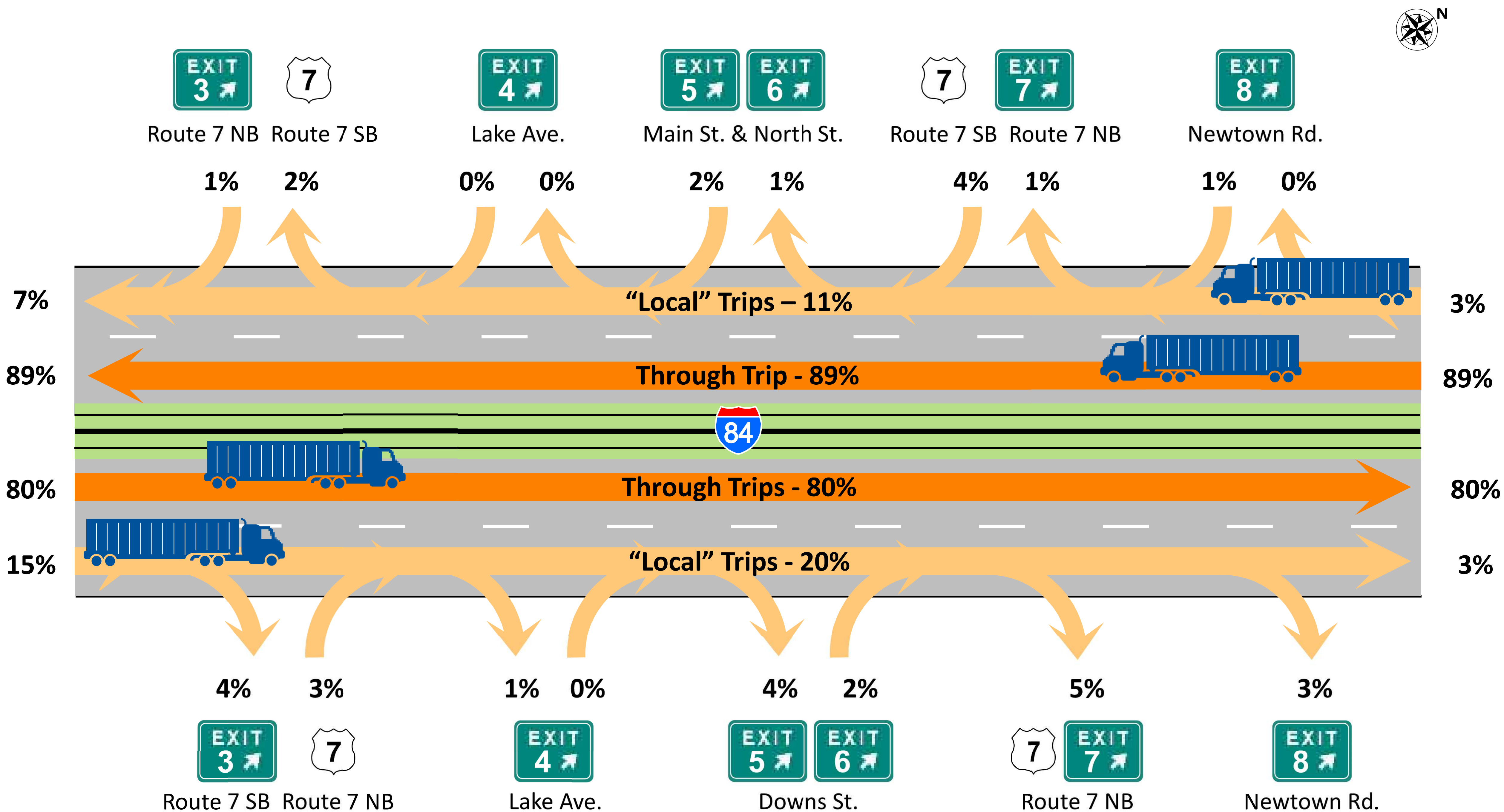
I-84 AVERAGE WEEKDAY* - OFF PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
HEAVY TRAFFIC (LARGE TRUCKS)



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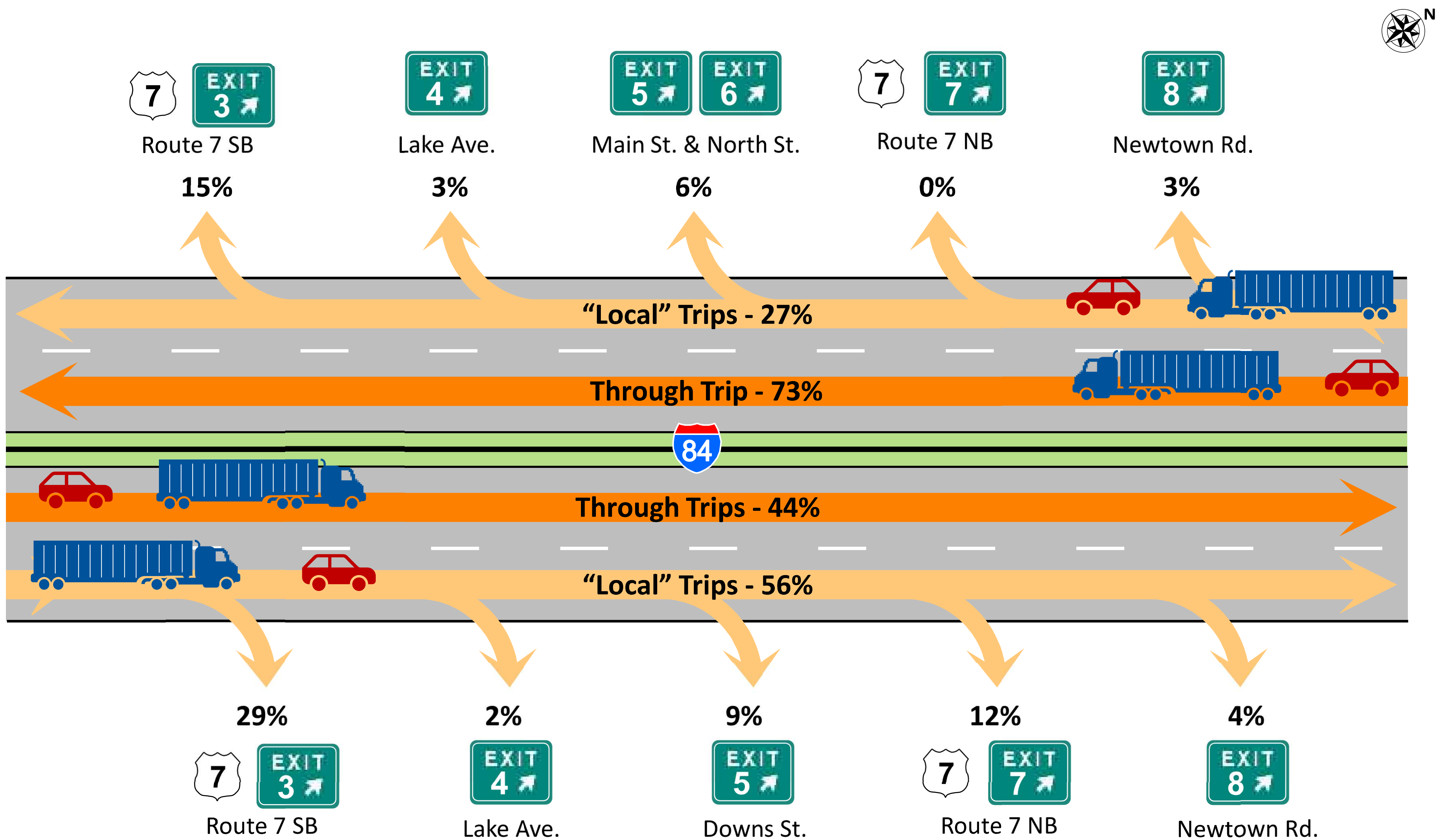
SKYCOMP RAMP TO RAMP DATA
I-84 AVERAGE WEEKDAY* - OFF PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
TOTAL TRAFFIC



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SKYCOMP MAINLINE DESTINATION DATA
I-84 AVERAGE WEEKDAY* - OFF PEAK PERIOD

CDM Smith

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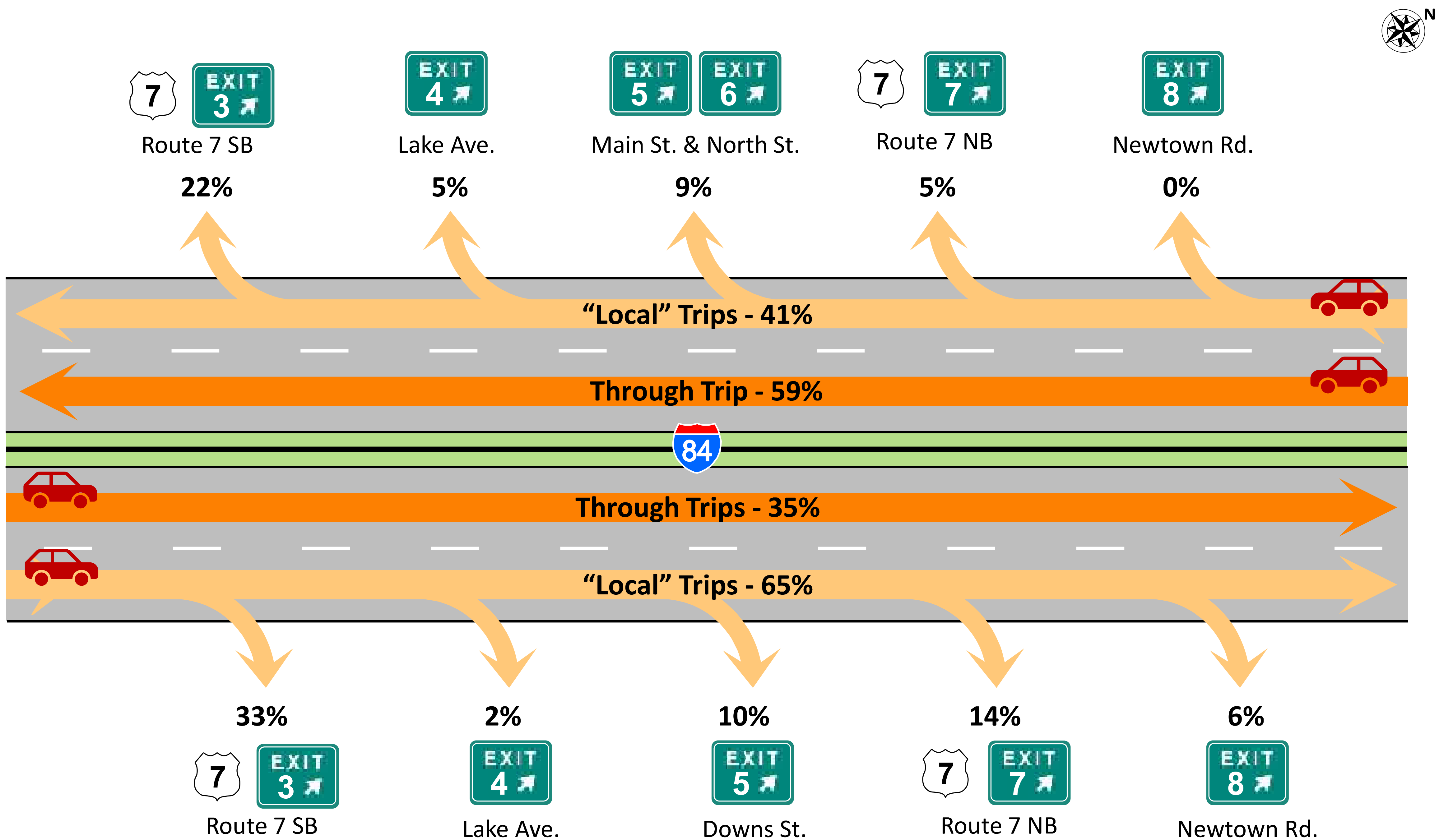
LIGHT TRAFFIC (AUTOS/SMALL TRUCKS)



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SKYCOMP MAINLINE DESTINATION DATA
I-84 AVERAGE WEEKDAY* - OFF PEAK PERIOD

CDM Smith

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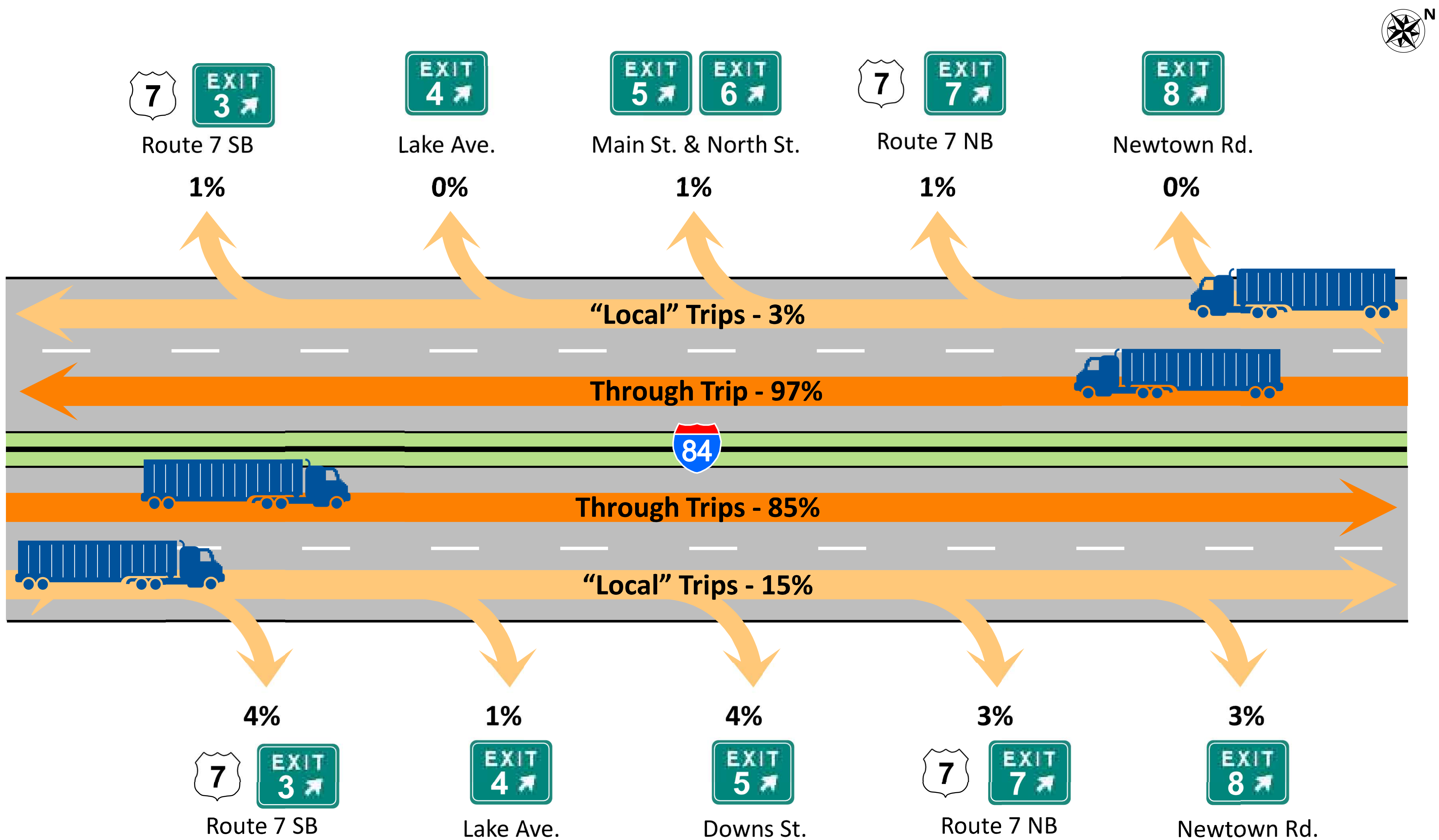
HEAVY TRAFFIC (LARGE TRUCKS)



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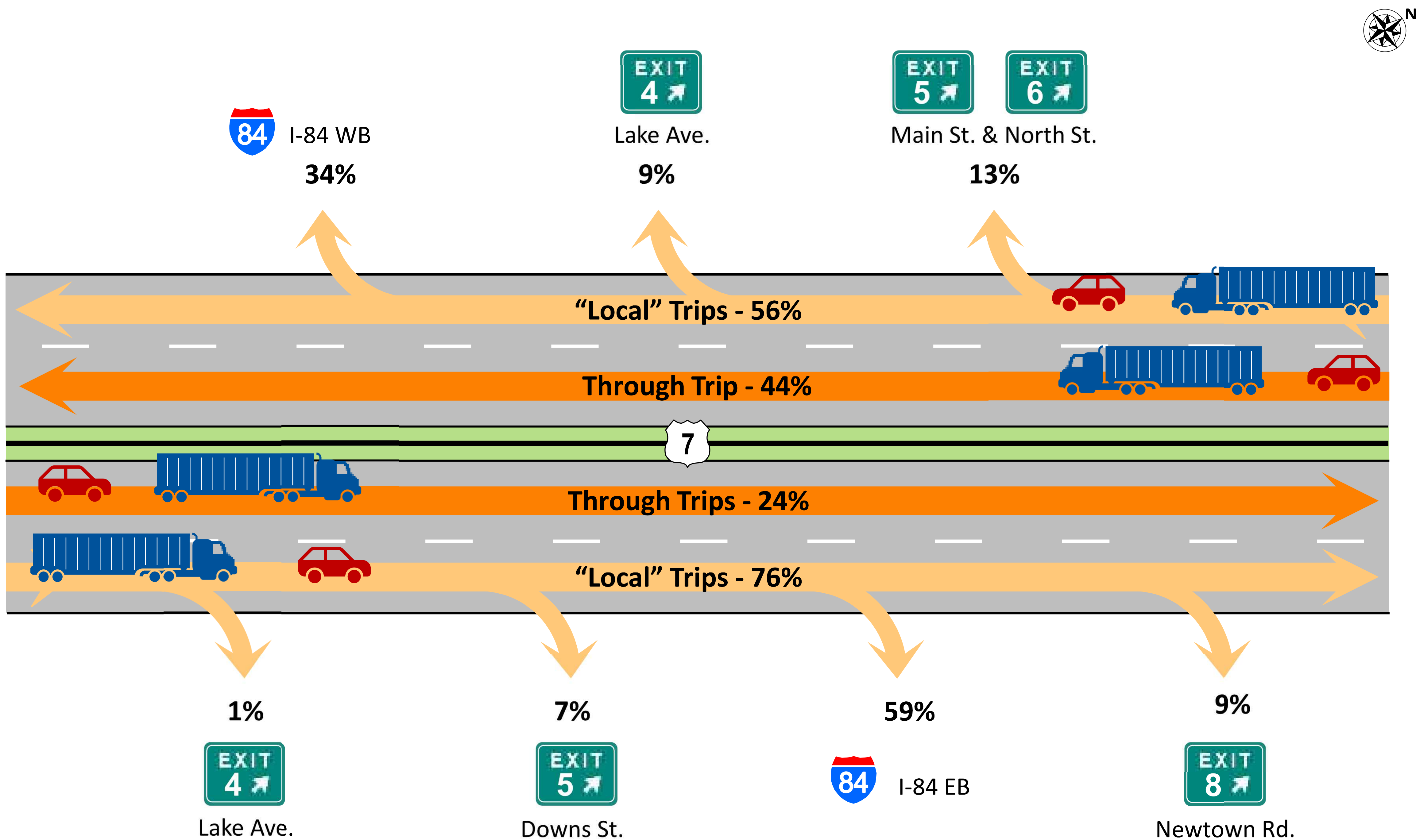
SKYCOMP MAINLINE DESTINATION DATA
I-84 AVERAGE WEEKDAY* - OFF PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
TOTAL TRAFFIC



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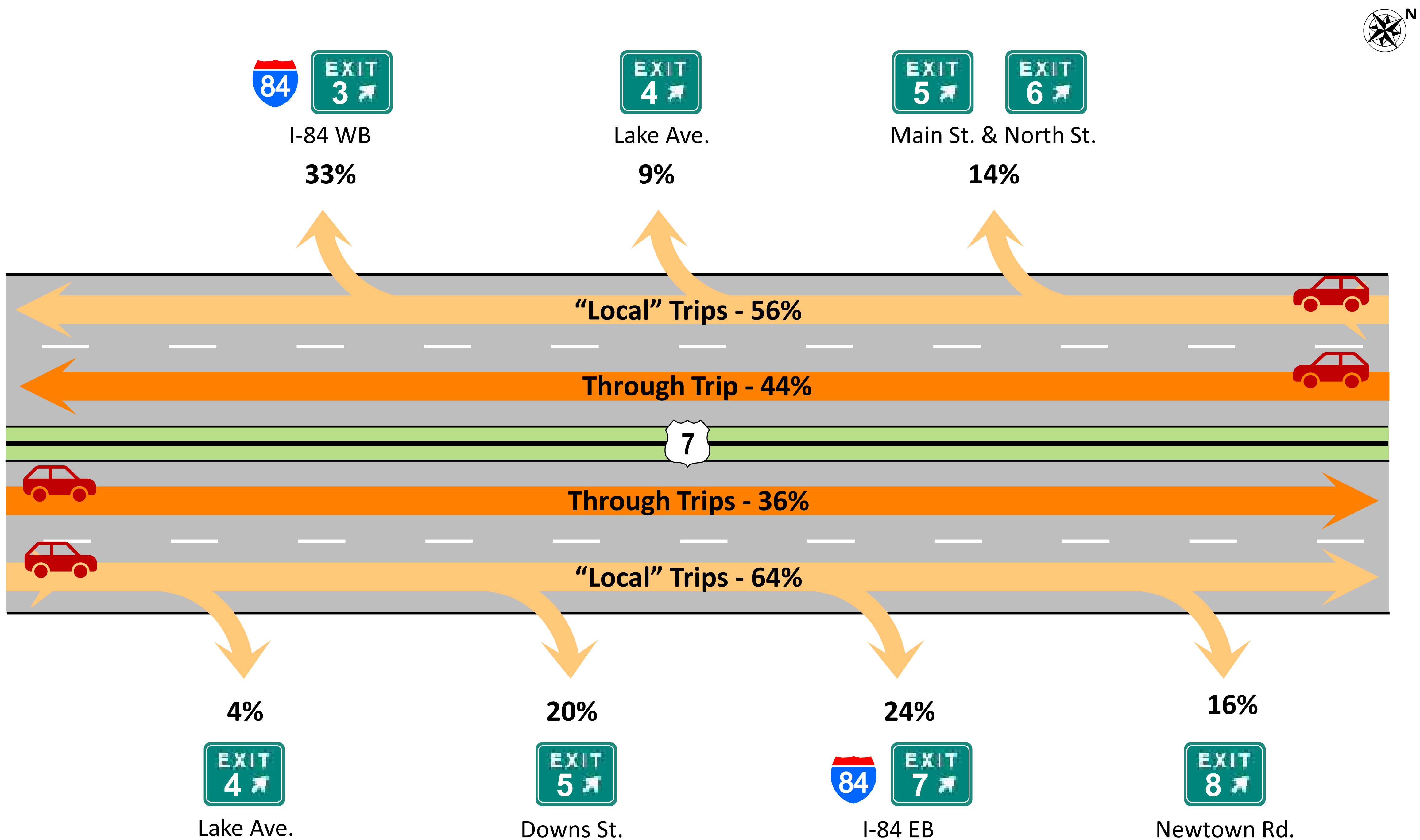
SKYCOMP DESTINATION DATA
ROUTE 7 AVERAGE WEEKDAY* - OFF PEAK PERIOD

CDM Smith

SKYCOMP TRAFFIC DISTRIBUTION DATA
LIGHT TRAFFIC (AUTOS/SMALL TRUCKS)



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SKYCOMP DESTINATION DATA
ROUTE 7 AVERAGE WEEKDAY* - OFF PEAK PERIOD

CDM Smith

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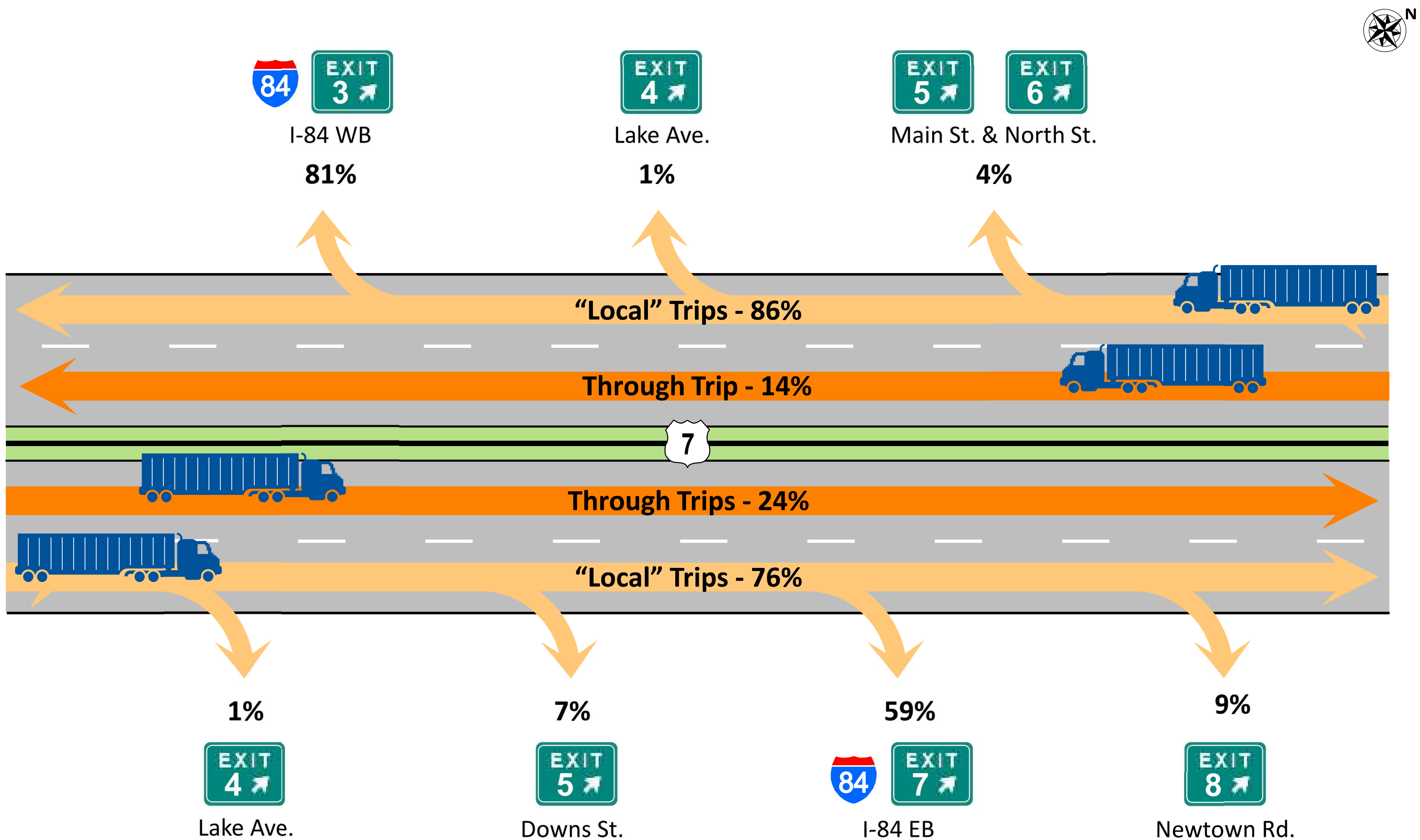
HEAVY TRAFFIC (LARGE TRUCKS)



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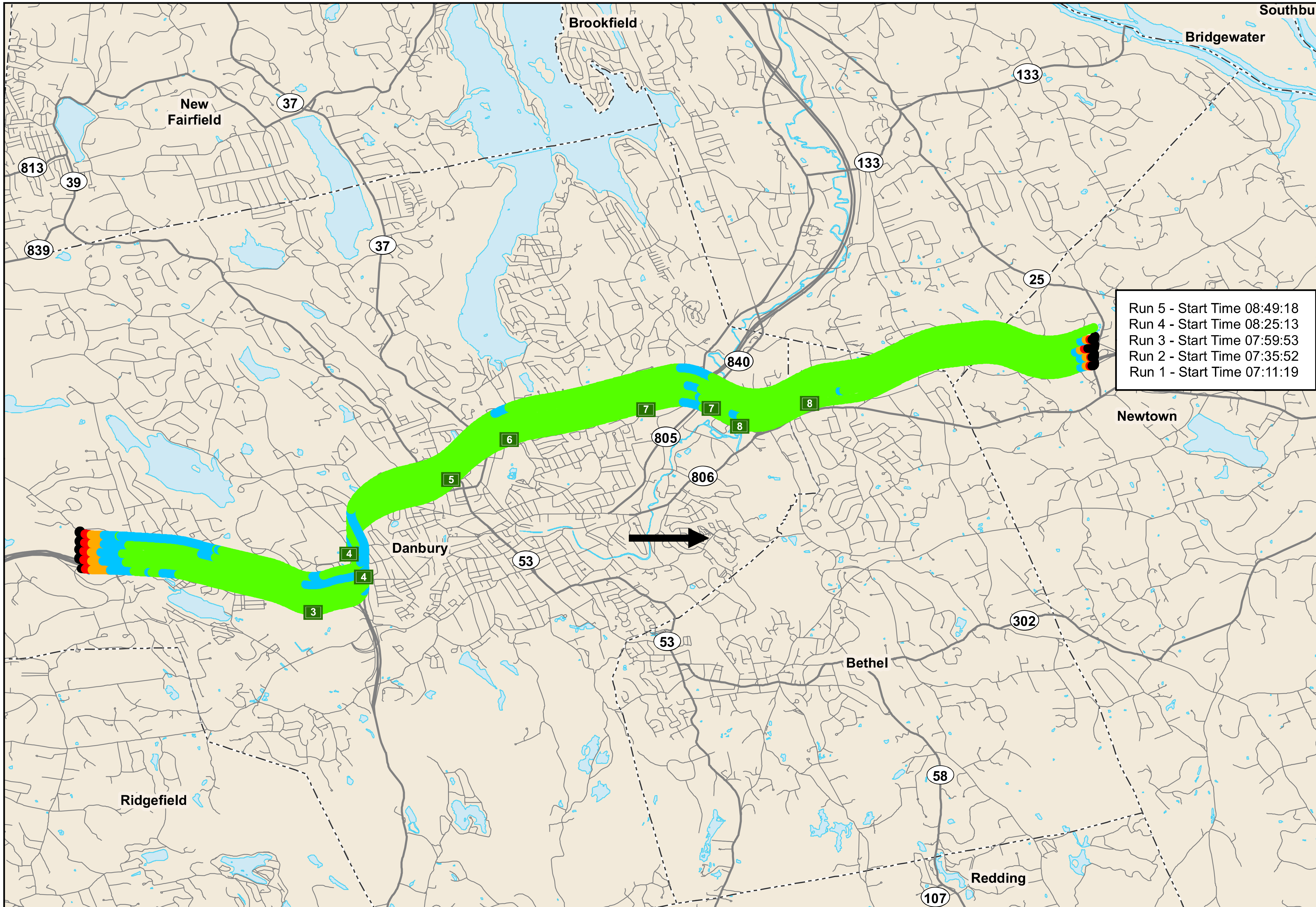
SKYCOMP DESTINATION DATA
ROUTE 7 AVERAGE WEEKDAY* - OFF PEAK PERIOD

CDM Smith

TRAVEL TIME RUNS

- **GPS BASED DATA**
- **INRIX DATA**
- **NPRMDS**



Speed (MPH)
- Under 25.1
- 25.1 - 35.0
- 35.1 - 45.0
- 45.1 - 55.0
- Over 55.0

GPS TRAVEL TIME RUNS

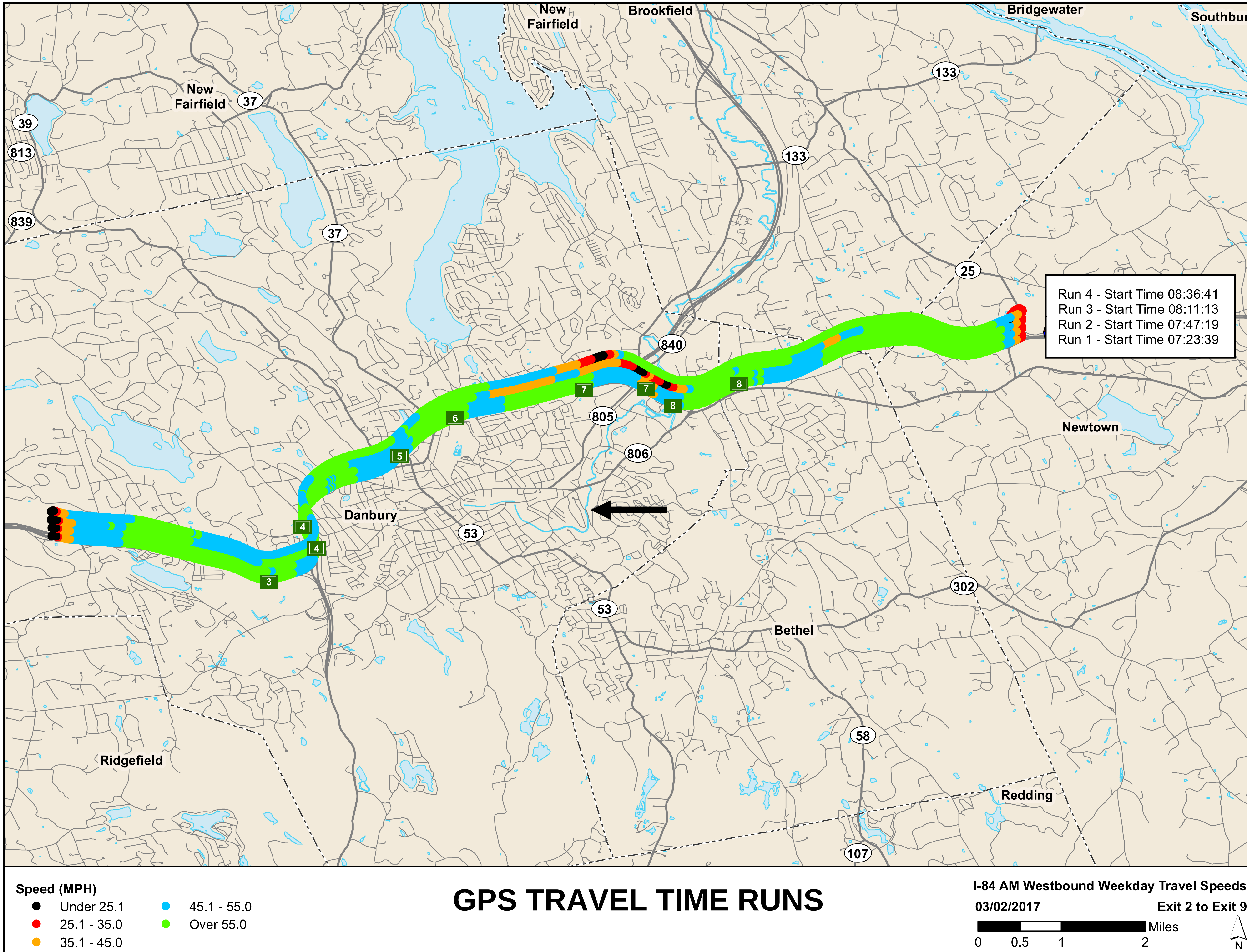
I-84 AM Eastbound Weekday Travel Speeds

03/02/2017

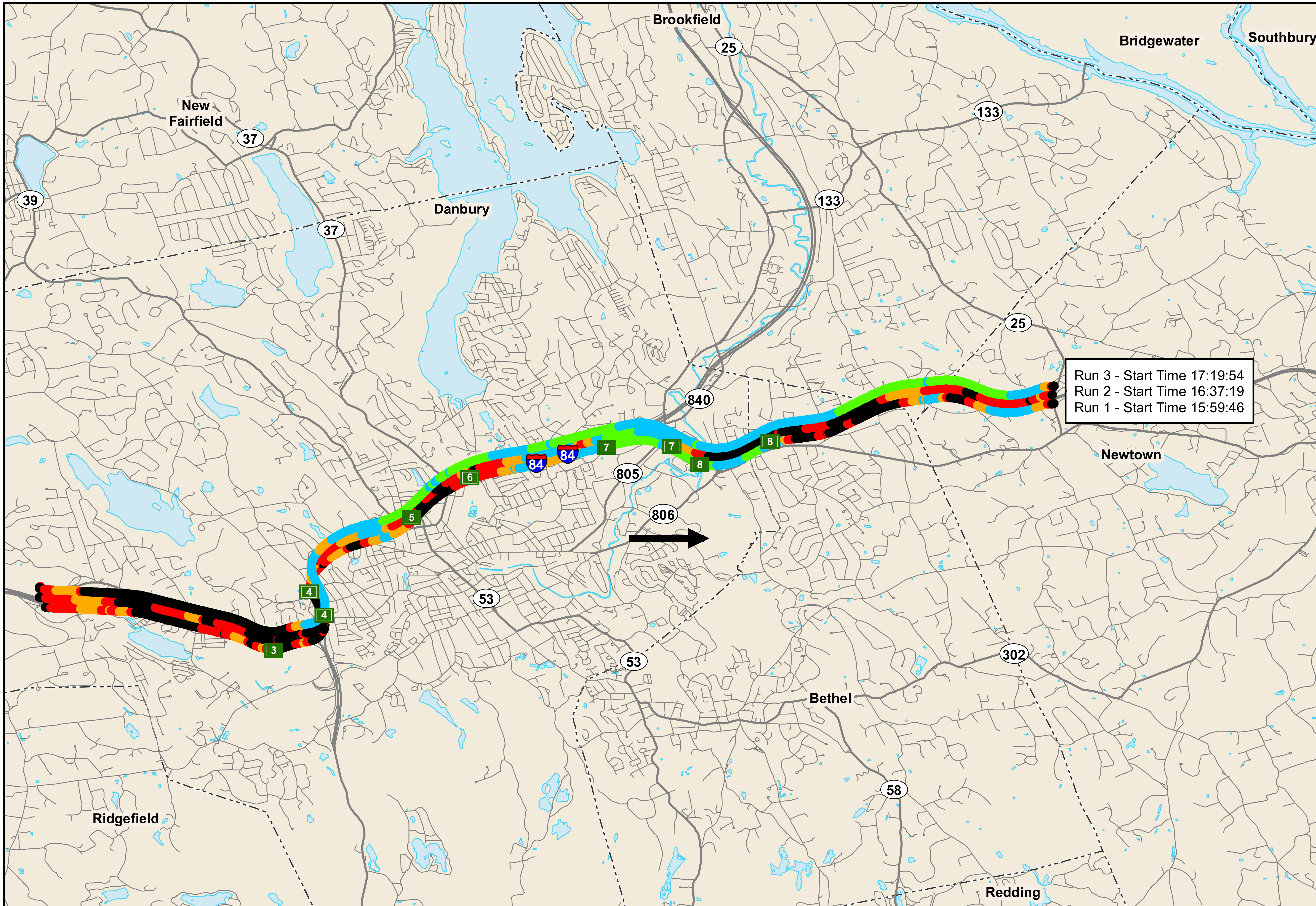
Exit 2 to Exit 9

0 0.5 1 2 Miles

N



GPS TRAVEL TIME RUNS



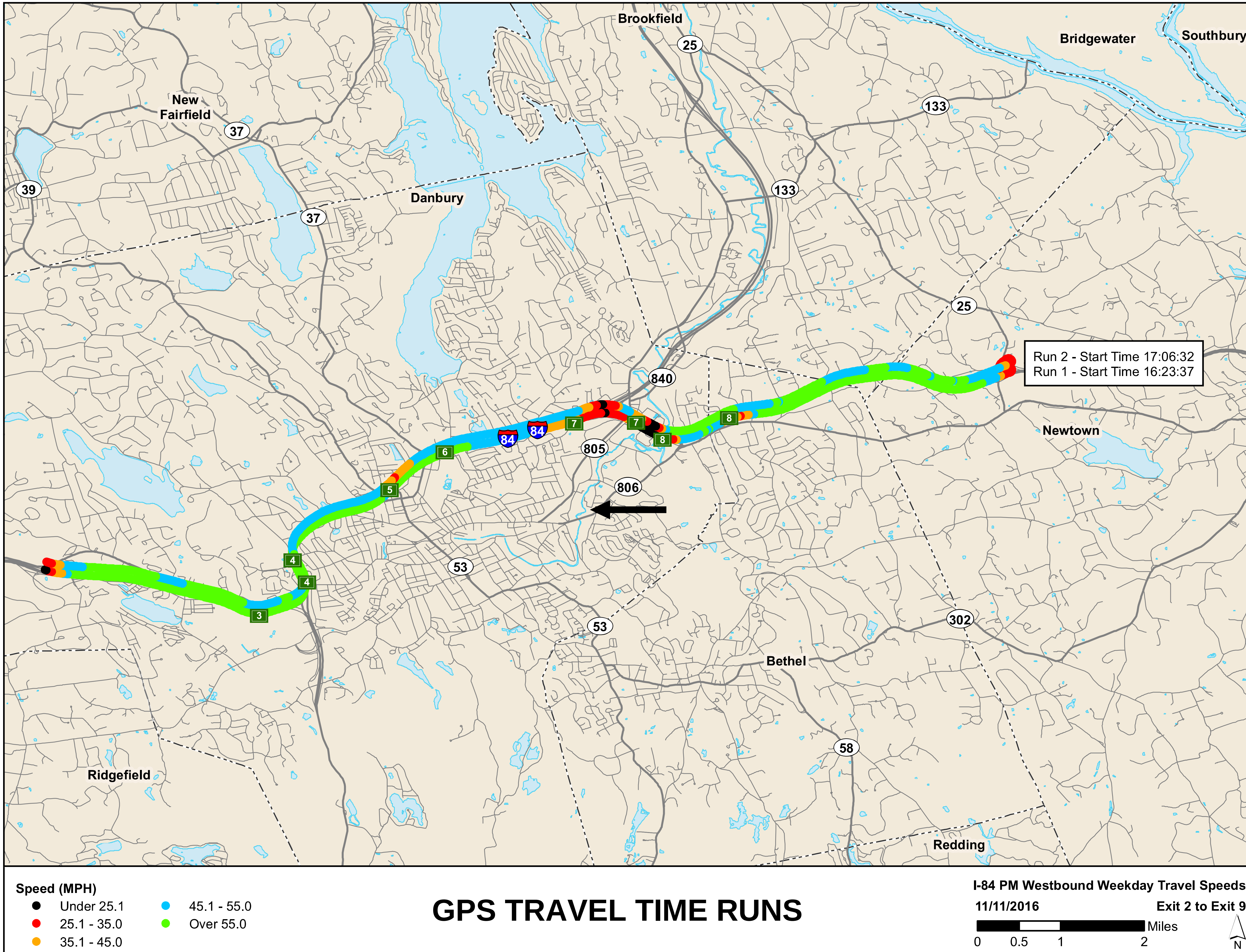
Speed (MPH)
- Under 25.1
- 25.1 - 35.0
- 35.1 - 45.0
- 45.1 - 55.0
- Over 55.0

GPS TRAVEL TIME RUNS

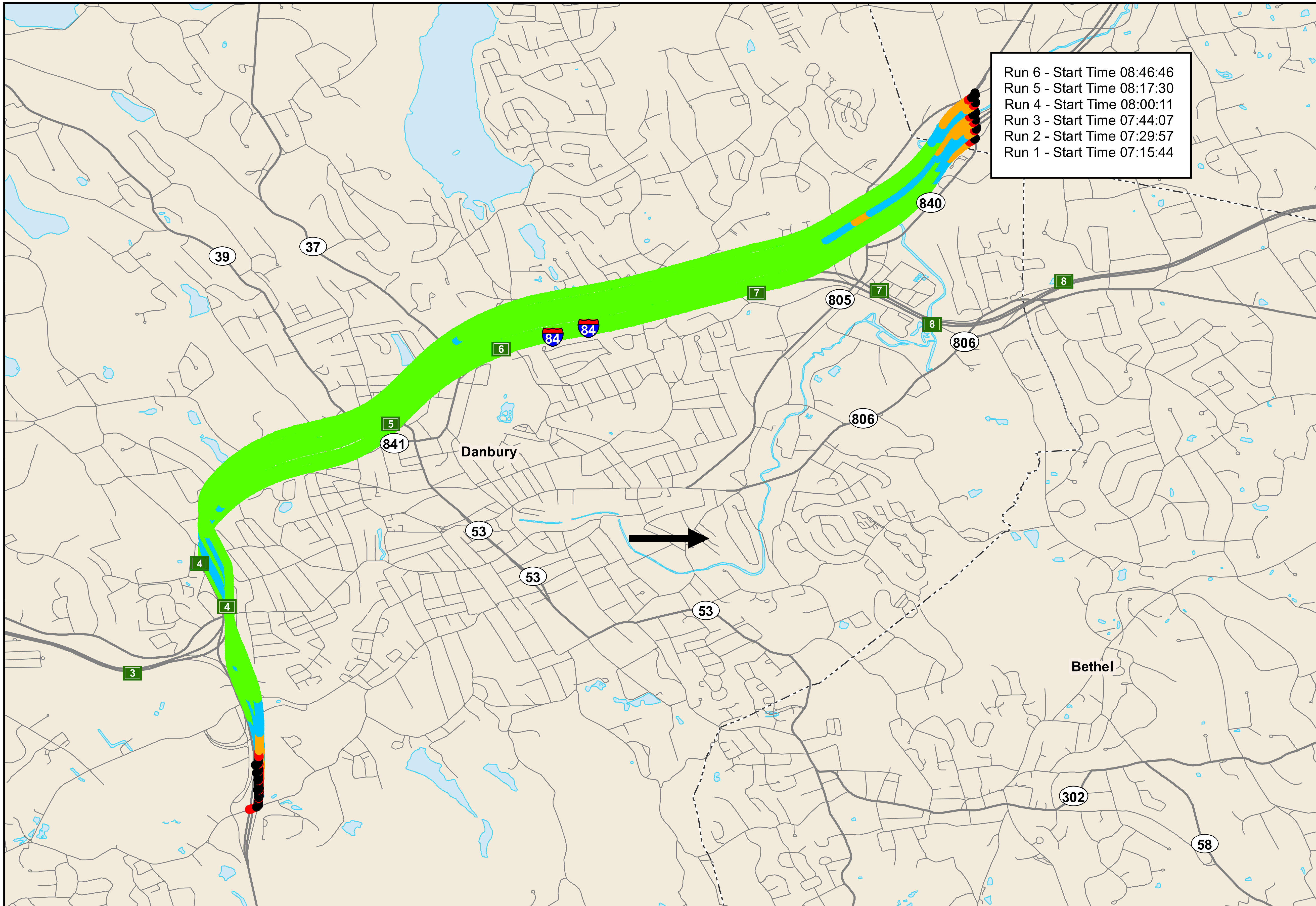
I-84 PM Eastbound Weekday Travel Speeds
11/11/2016 **Exit 2 to Exit 9**

Miles: 0 0.5 1 2

N



GPS TRAVEL TIME RUNS



Speed (MPH)
- Under 25.1
- 25.1 - 35.0
- 35.1 - 45.0
- 45.1 - 55.0
- Over 55.0

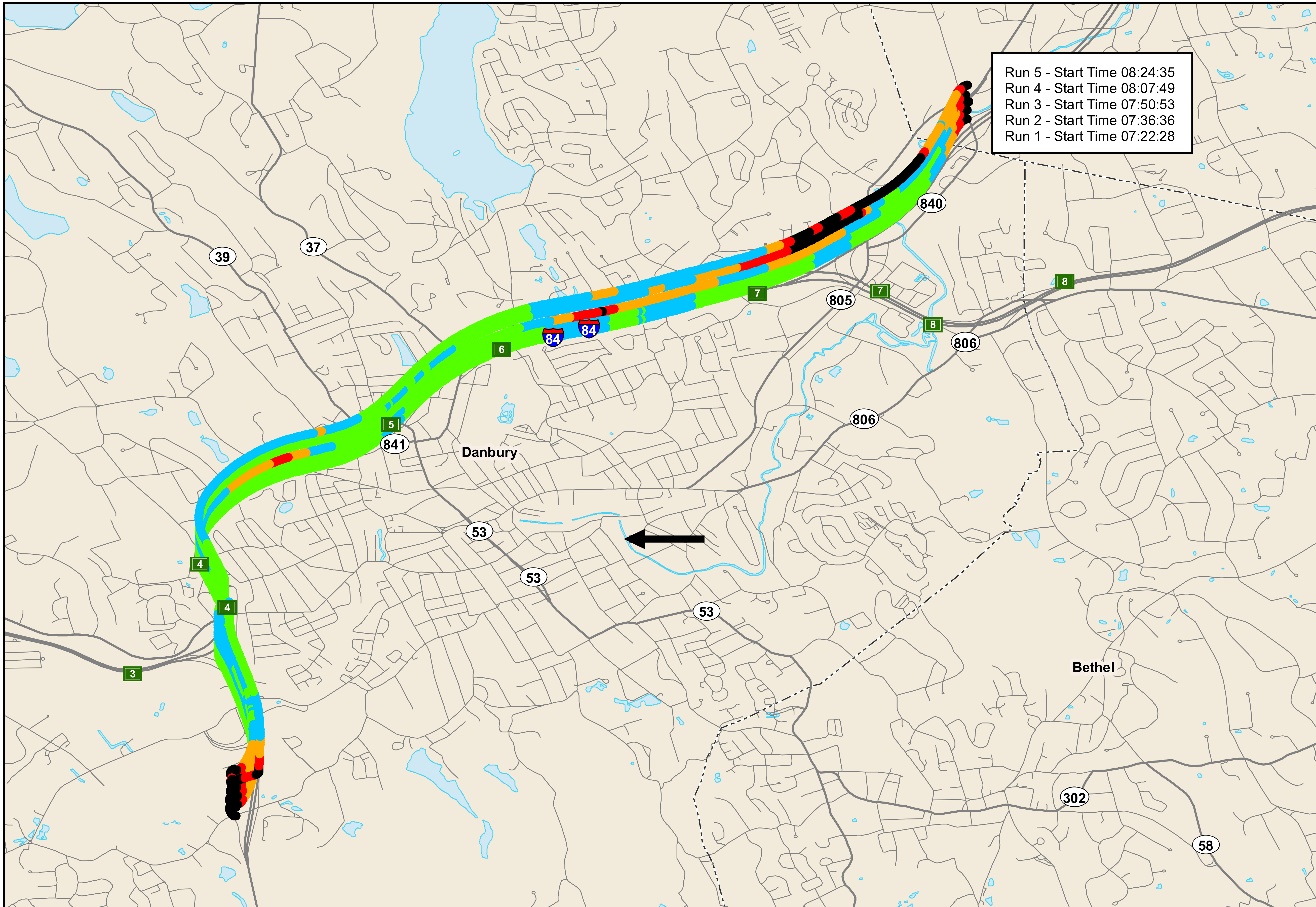
GPS TRAVEL TIME RUNS

I-84 AM Eastbound Weekday Travel Speeds

03/02/2017 Miry Brook Rd to White Turkey Rd

Miles 0 0.25 0.5 1

N



Speed (MPH)

- Under 25.1
- 25.1 - 35.0
- 35.1 - 45.0
- 45.1 - 55.0
- Over 55.0

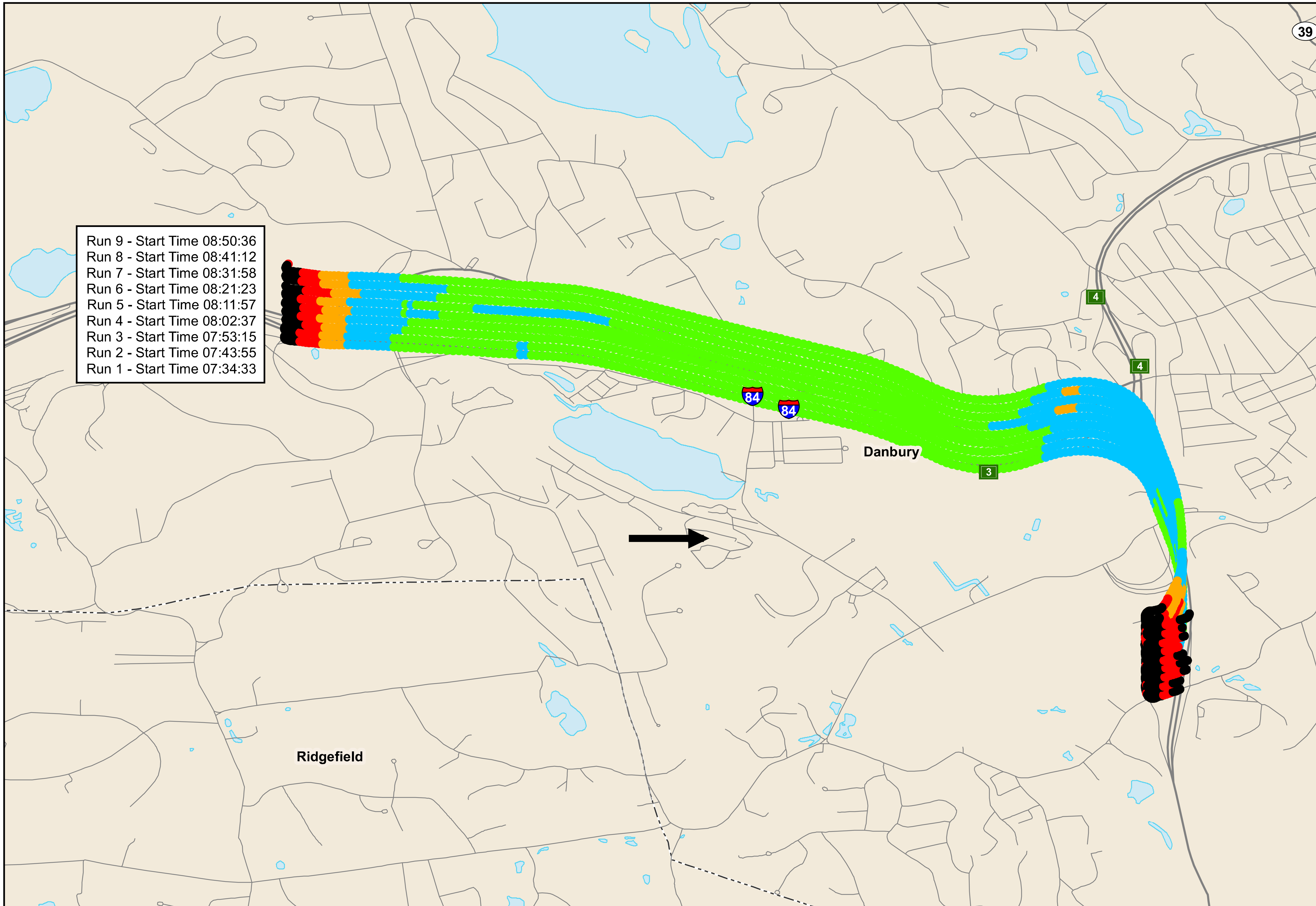
GPS TRAVEL TIME RUNS

I-84 AM Westbound Weekday Travel Speeds

03/02/2017 Miry Brook Rd to White Turkey Rd

0 0.25 0.5 1 Miles

N



Speed (MPH)

- Under 25.1
- 25.1 - 35.0
- 35.1 - 45.0
- 45.1 - 55.0
- Over 55.0

GPS TRAVEL TIME RUNS

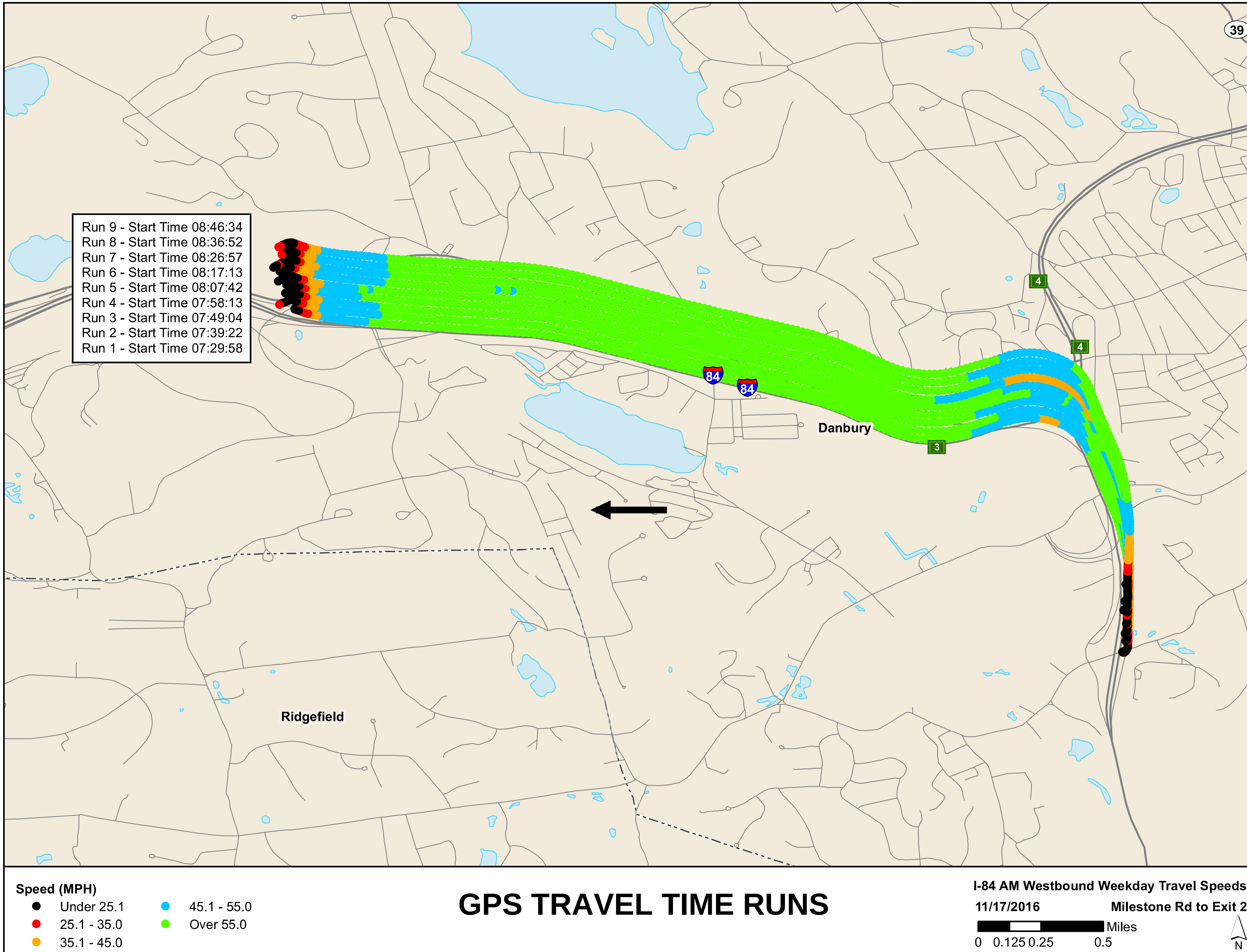
I-84 AM Eastbound Weekday Travel Speeds

11/17/2016 **Milestone Rd to Exit 2**

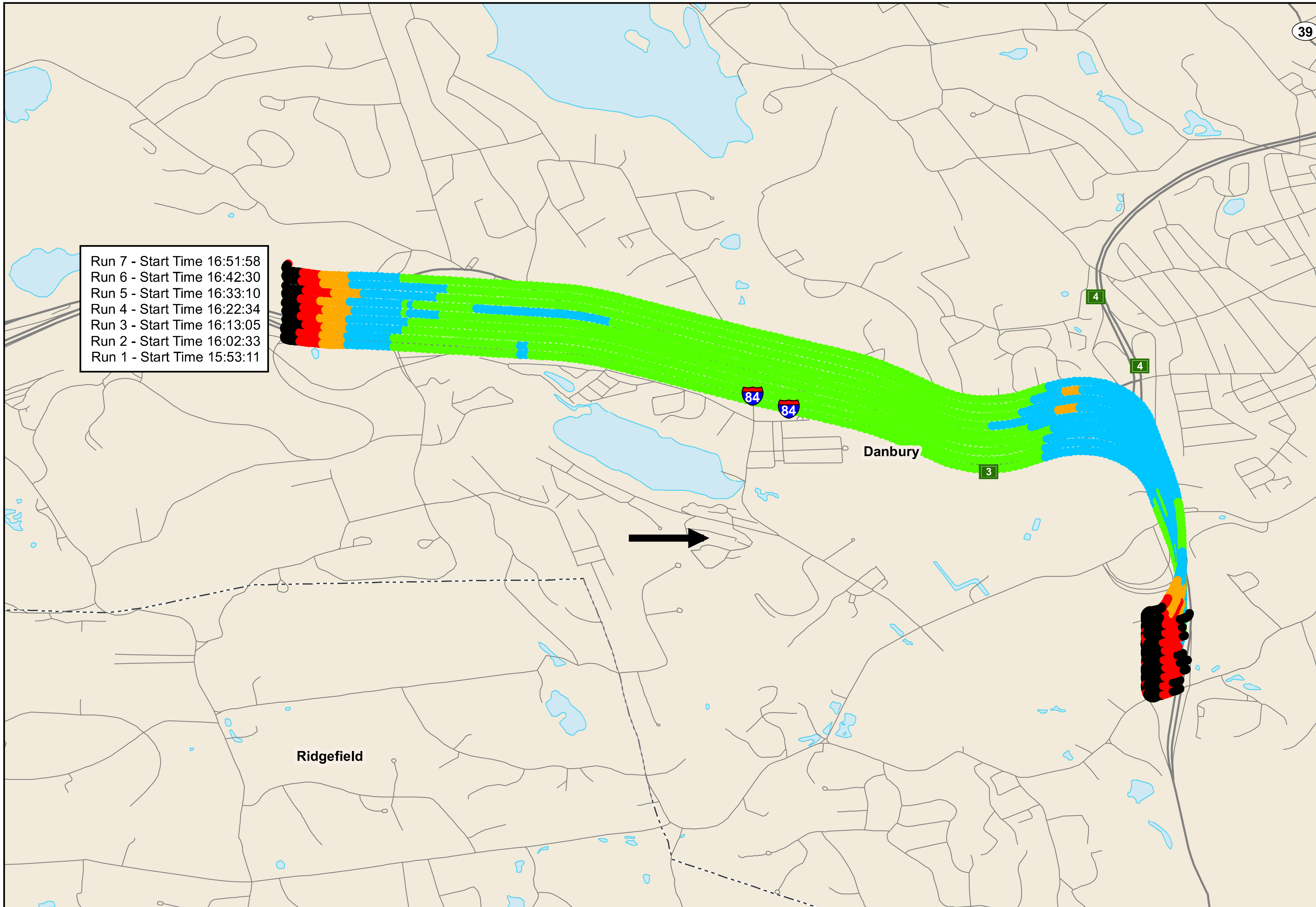
Miles

0 0.125 0.25 0.5

N



GPS TRAVEL TIME RUNS



Speed (MPH)

- Under 25.1
- 25.1 - 35.0
- 35.1 - 45.0
- 45.1 - 55.0
- Over 55.0

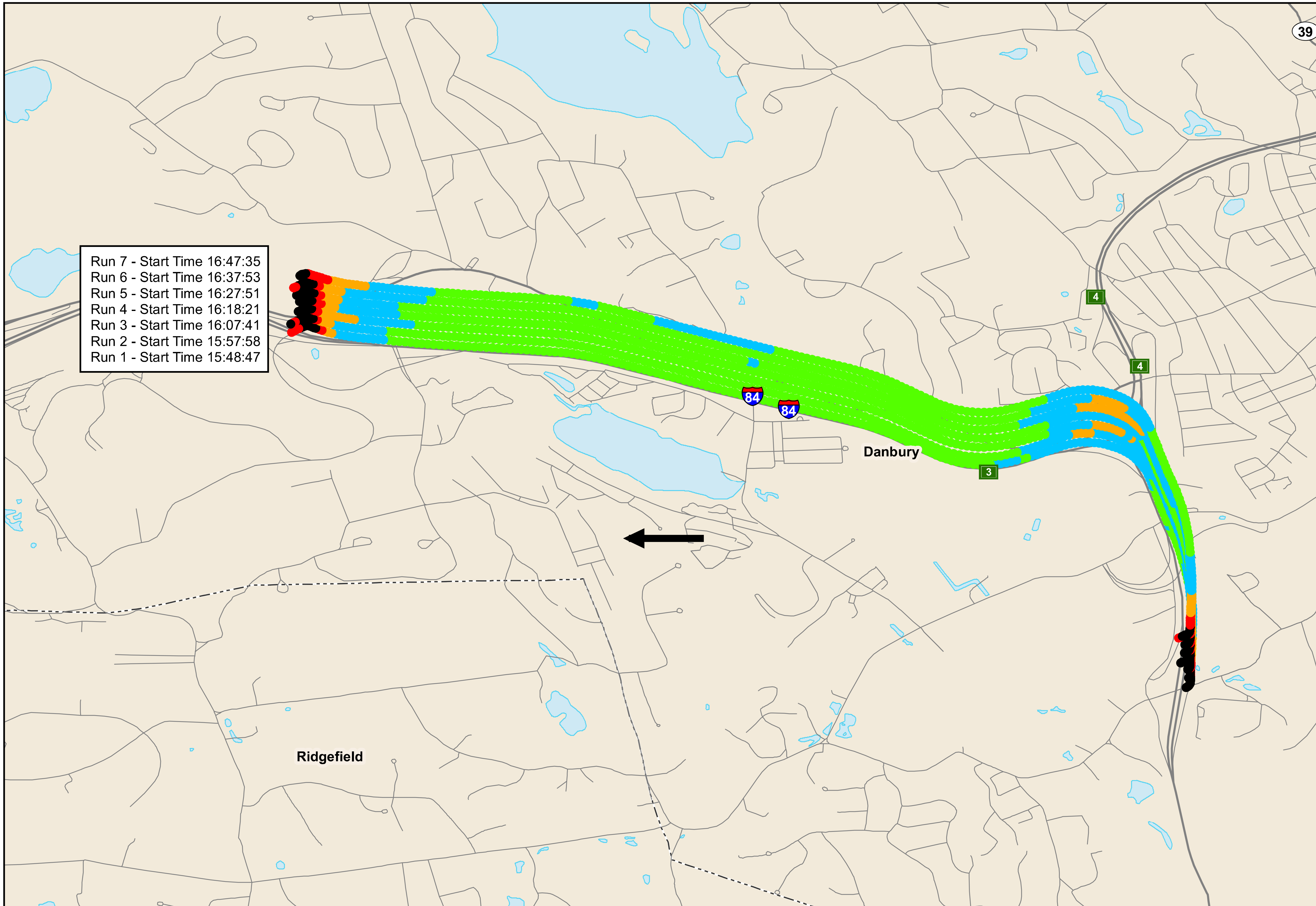
GPS TRAVEL TIME RUNS

I-84 PM Eastbound Weekday Travel Speeds

11/17/2016 **Milestone Road to Exit 2**

Miles
0 0.125 0.25 0.5

N



Speed (MPH)

- Under 25.1
- 25.1 - 35.0
- 35.1 - 45.0
- 45.1 - 55.0
- Over 55.0

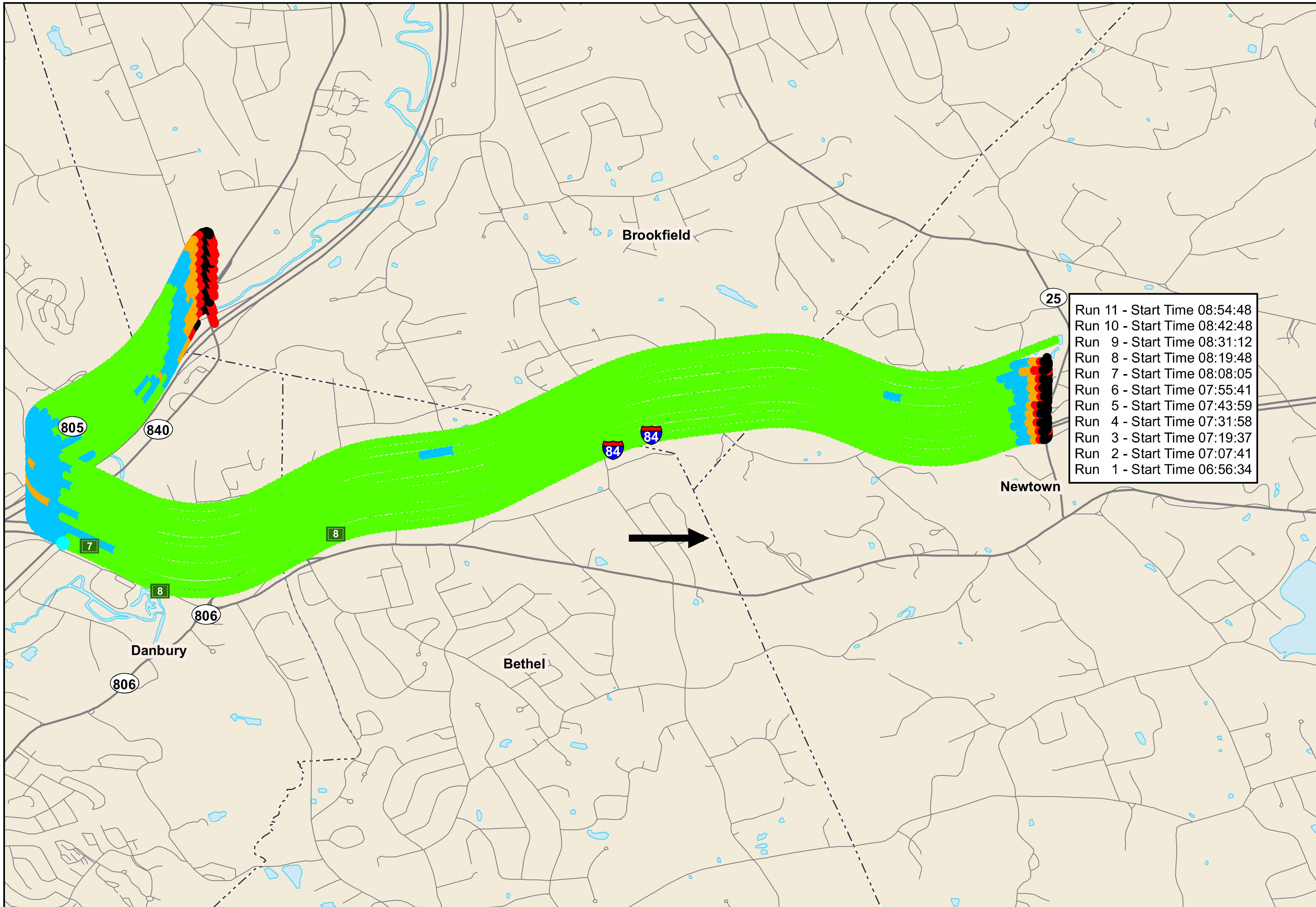
GPS TRAVEL TIME RUNS

I-84 PM Westbound Weekday Travel Speeds

11/17/2016 **Milestone Rd to Exit 2**

Miles
0 0.125 0.25 0.5

N



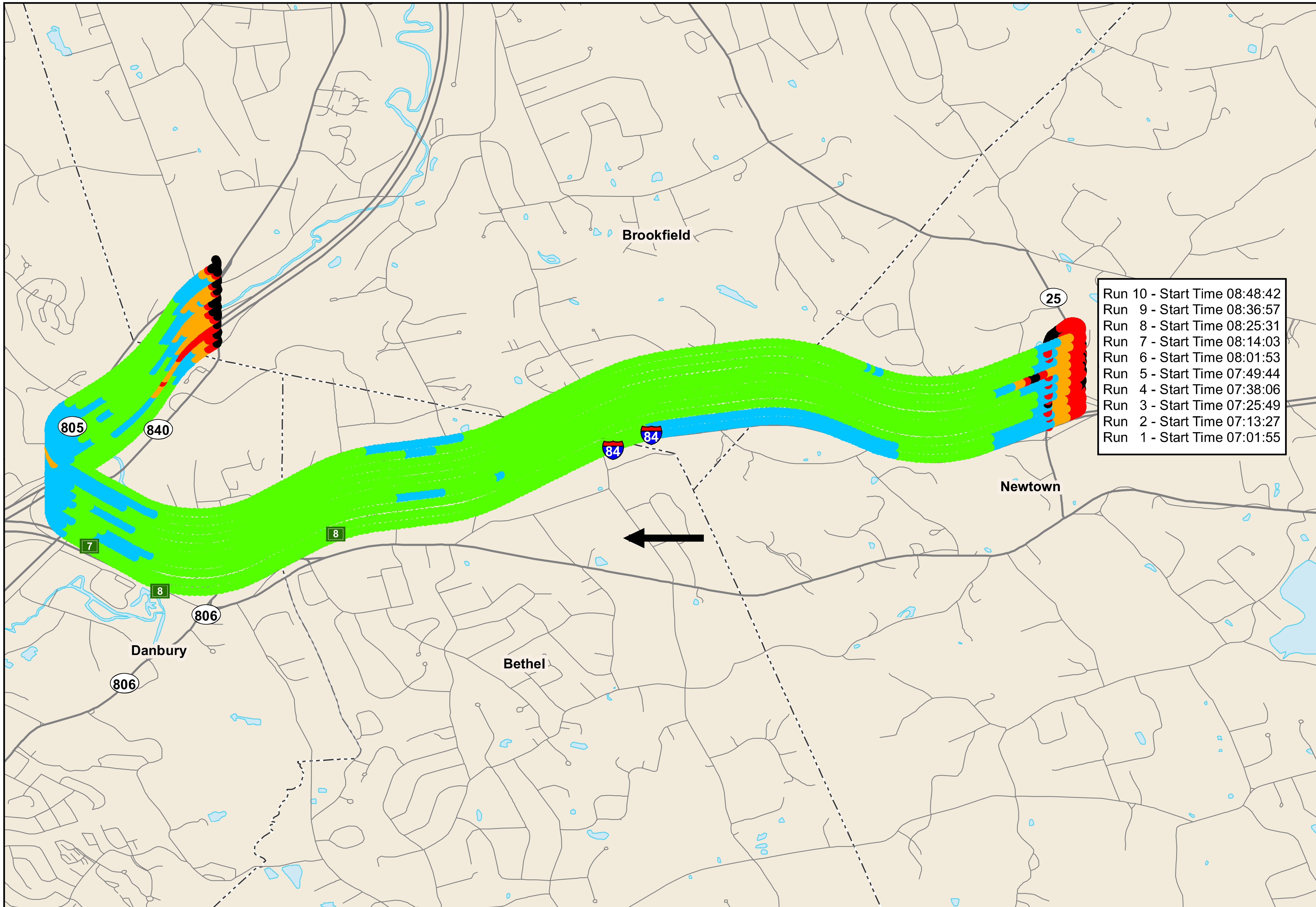
Speed (MPH)
Under 25.1
25.1 - 35.0
35.1 - 45.0
45.1 - 55.0
Over 55.0

GPS TRAVEL TIME RUNS

I-84 AM Eastbound Weekday Travel Speeds

11/18/2016 **White Turkey Rd to Exit 9**

Miles 0 0.25 0.5 1 N



Speed (MPH)

- Under 25.1
- 25.1 - 35.0
- 35.1 - 45.0
- 45.1 - 55.0
- Over 55.0

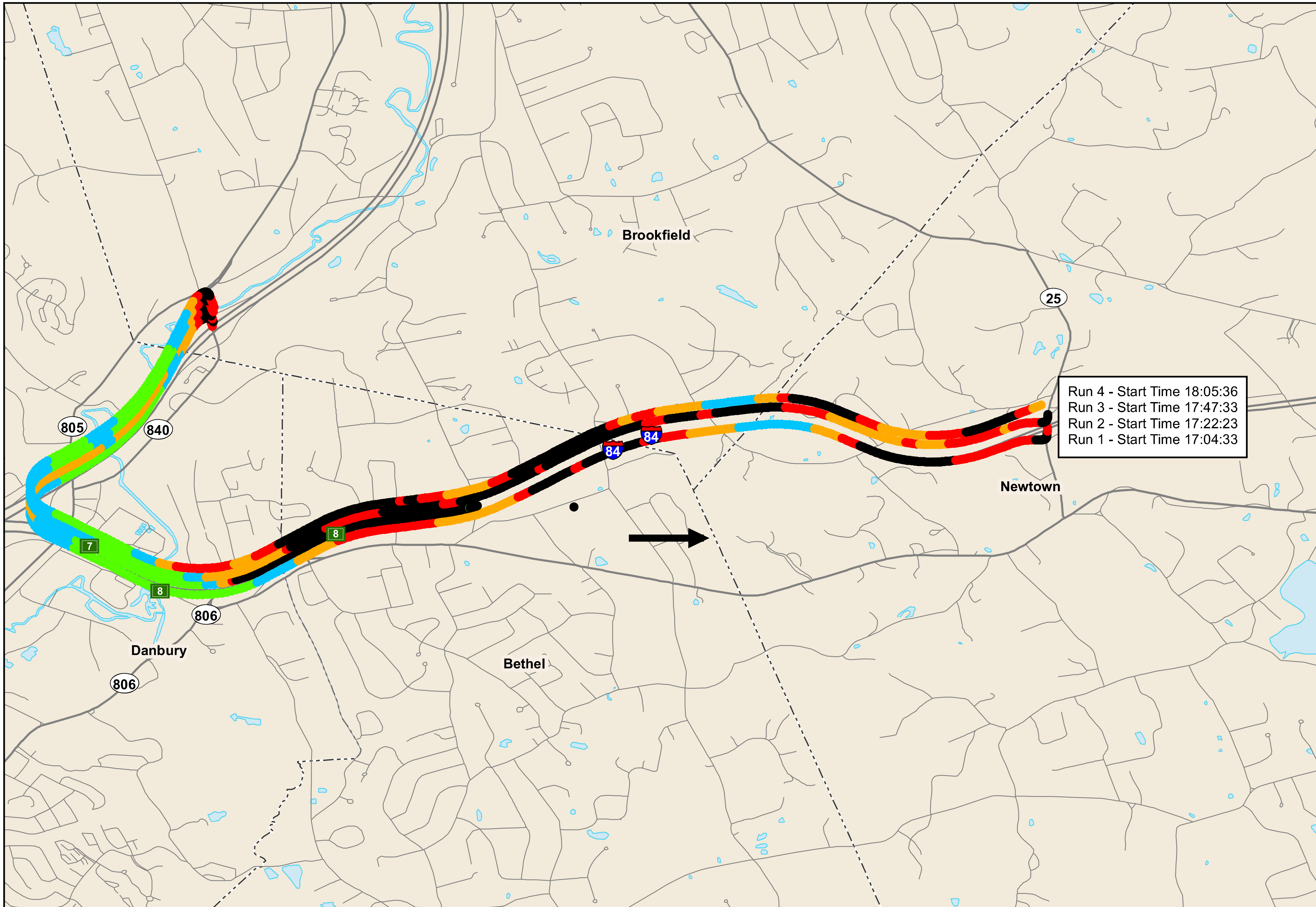
GPS TRAVEL TIME RUNS

I-84 AM Westbound Weekday Travel Speeds

11/18/2016 **White Turkey Rd to Exit 9**

Miles: 0 0.25 0.5 1

N



Speed (MPH)

- Under 25.1
- 25.1 - 35.0
- 35.1 - 45.0
- 45.1 - 55.0
- Over 55.0

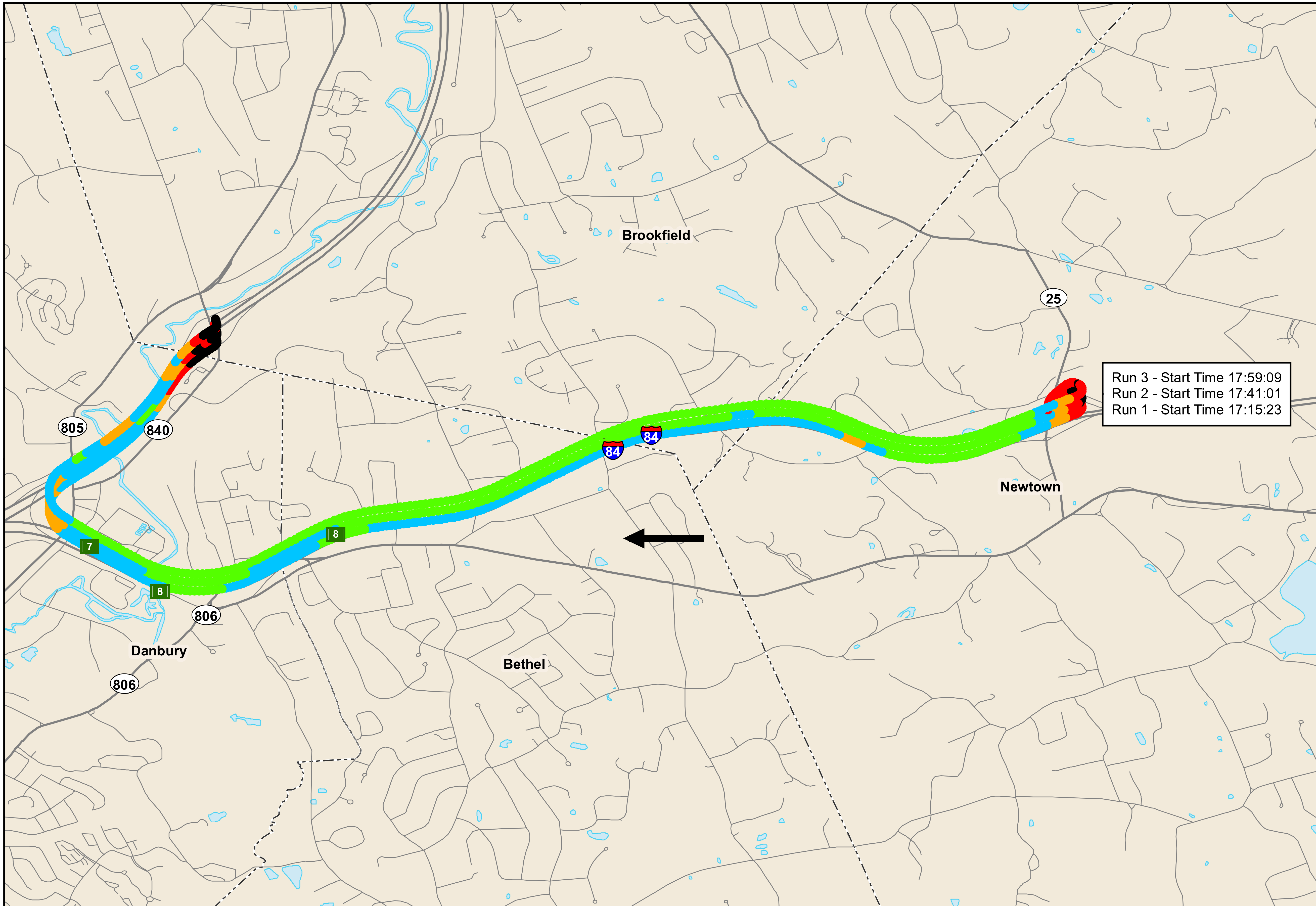
GPS TRAVEL TIME RUNS

I-84 PM Eastbound Weekday Travel Speeds

11/17/2016 **White Turkey Rd to Exit 9**

Miles 0 0.25 0.5 1

N



Speed (MPH)

- Under 25.1
- 25.1 - 35.0
- 35.1 - 45.0
- 45.1 - 55.0
- Over 55.0

GPS TRAVEL TIME RUNS

I-84 PM Westbound Weekday Travel Speeds

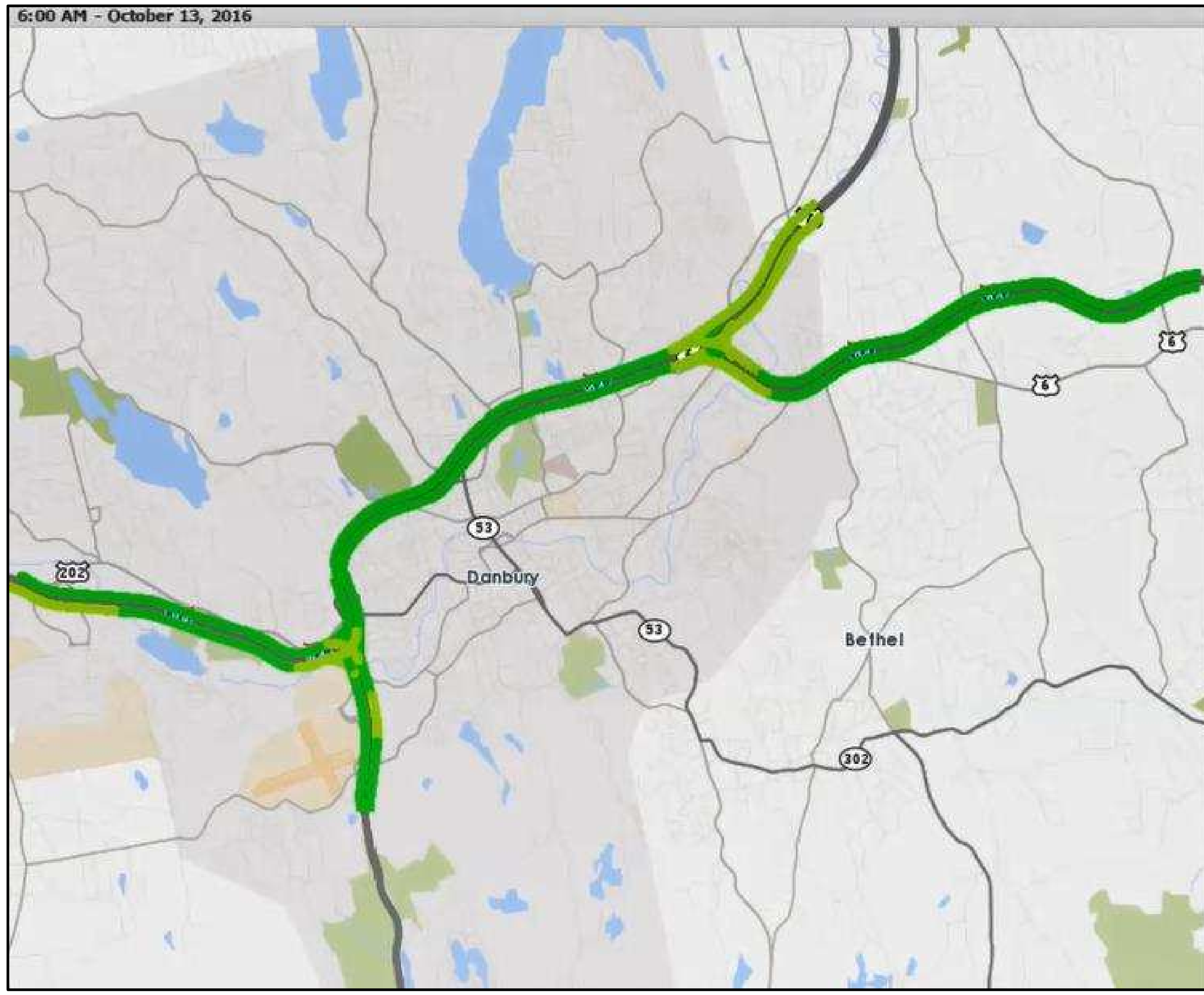
11/17/2016 **White Turkey Rd to Exit 9**

0 0.25 0.5 1 Miles

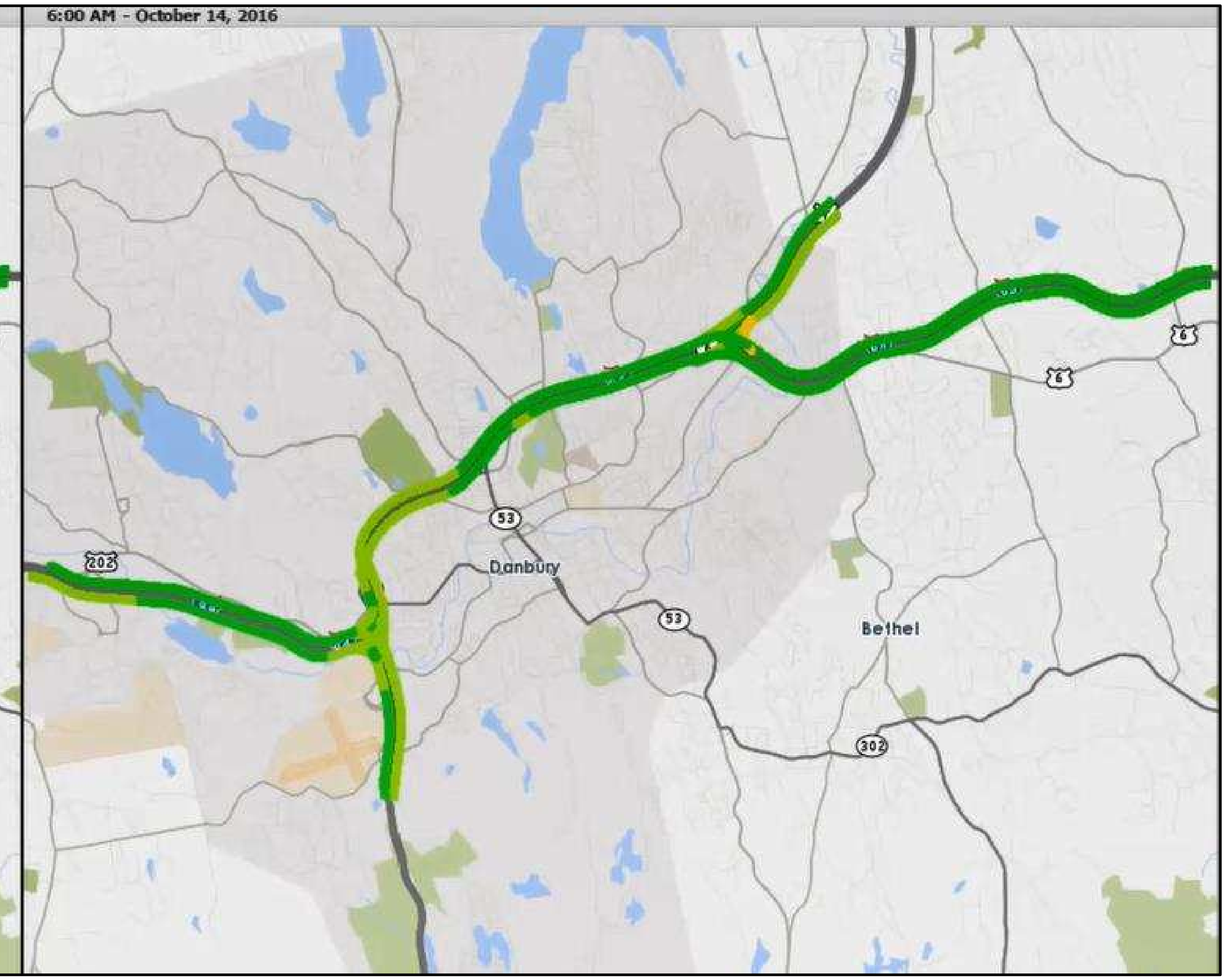
N

Weekday A.M. Peak Period
6:00 A.M.

Thursday



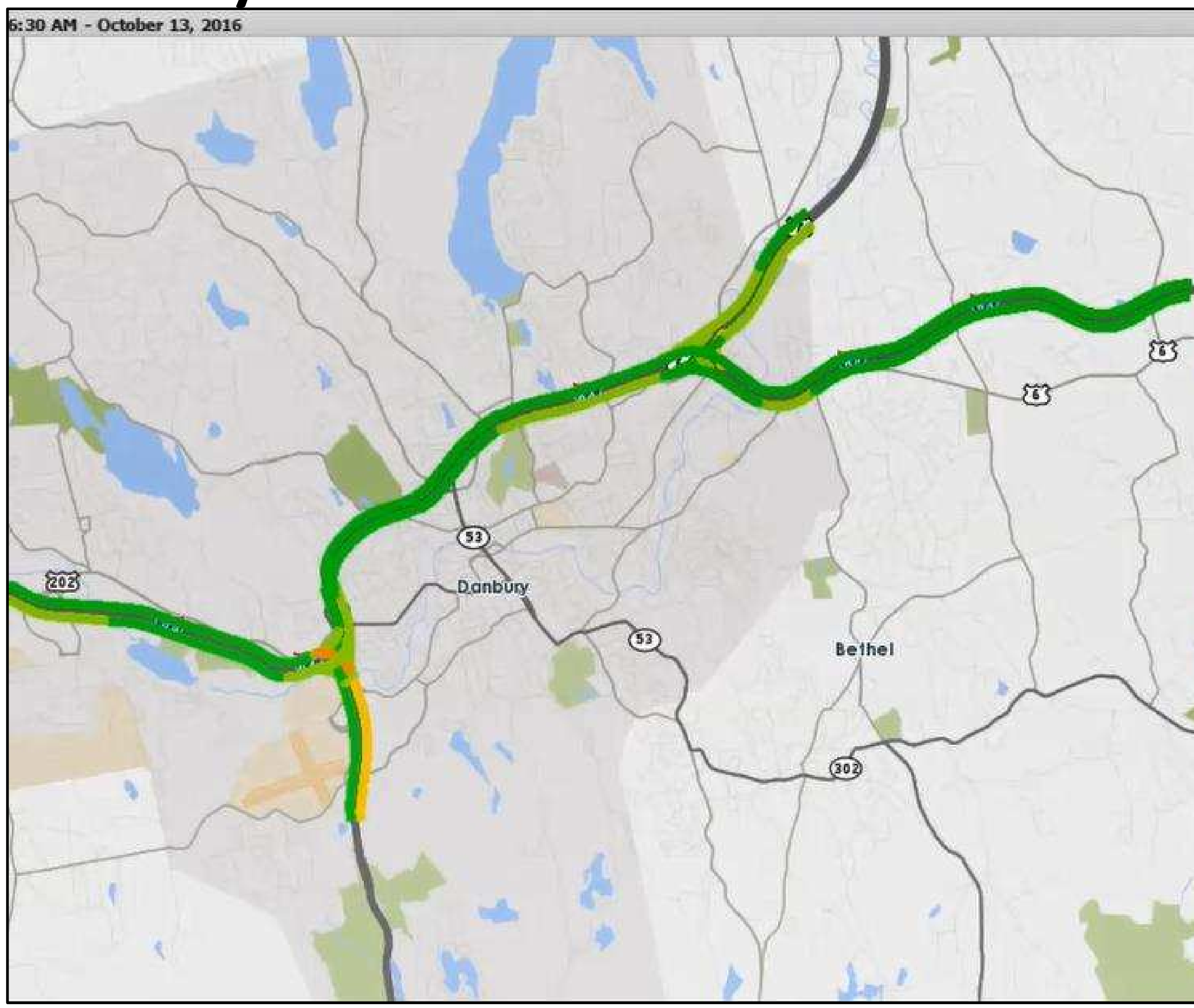
Friday



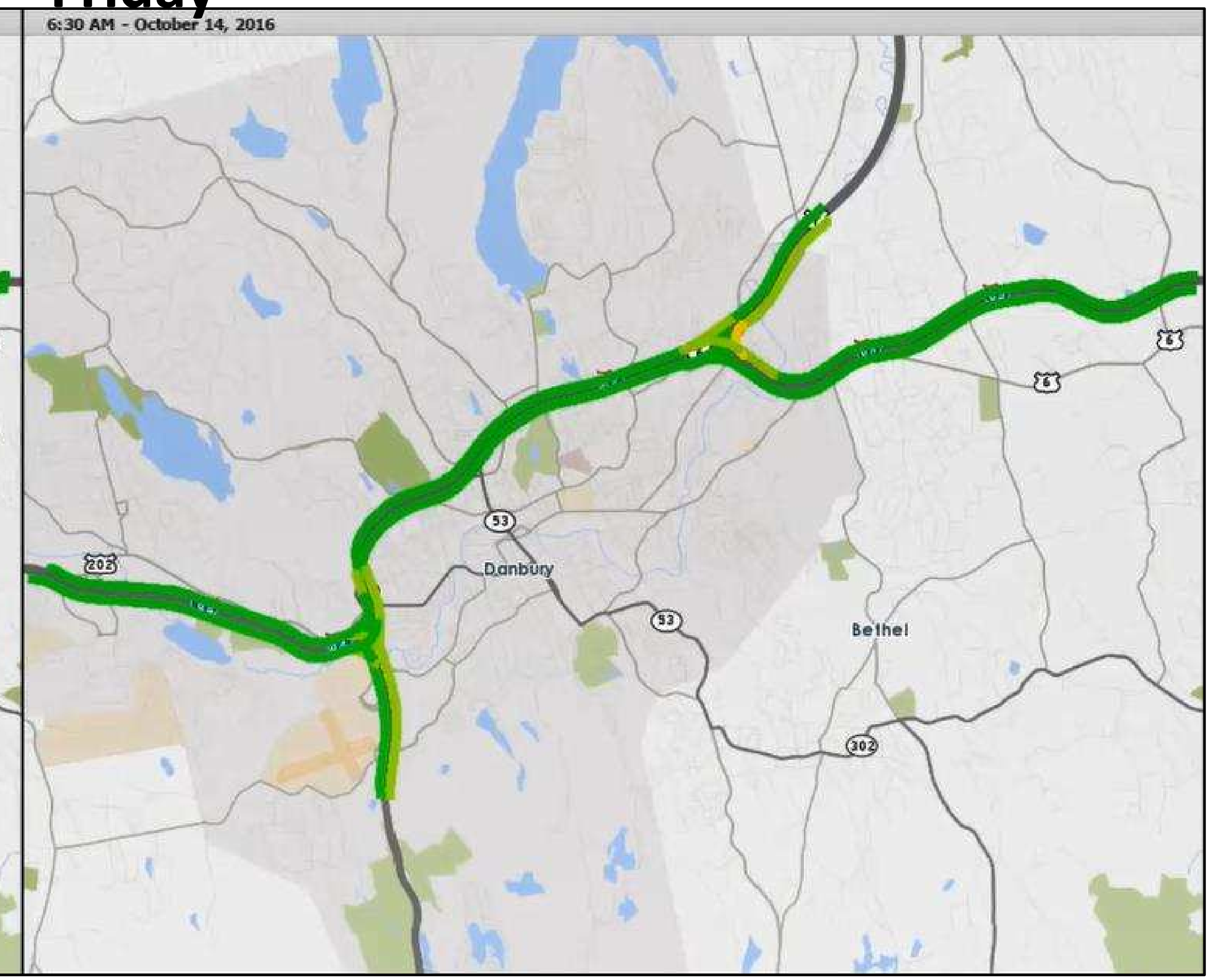
INRIX TRAVEL TIME RUNS

Weekday A.M. Peak Period
6:30 A.M.

Thursday



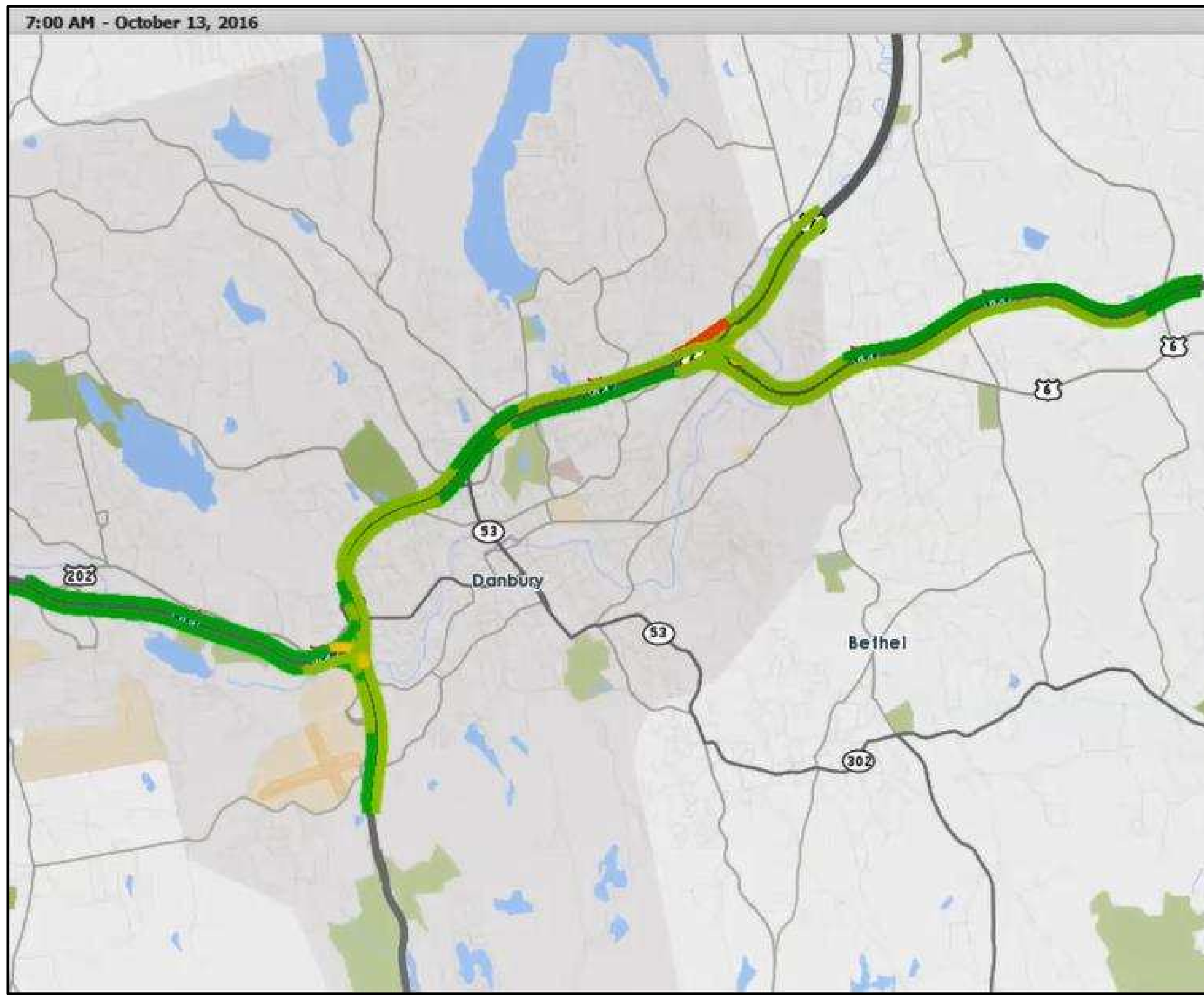
Friday



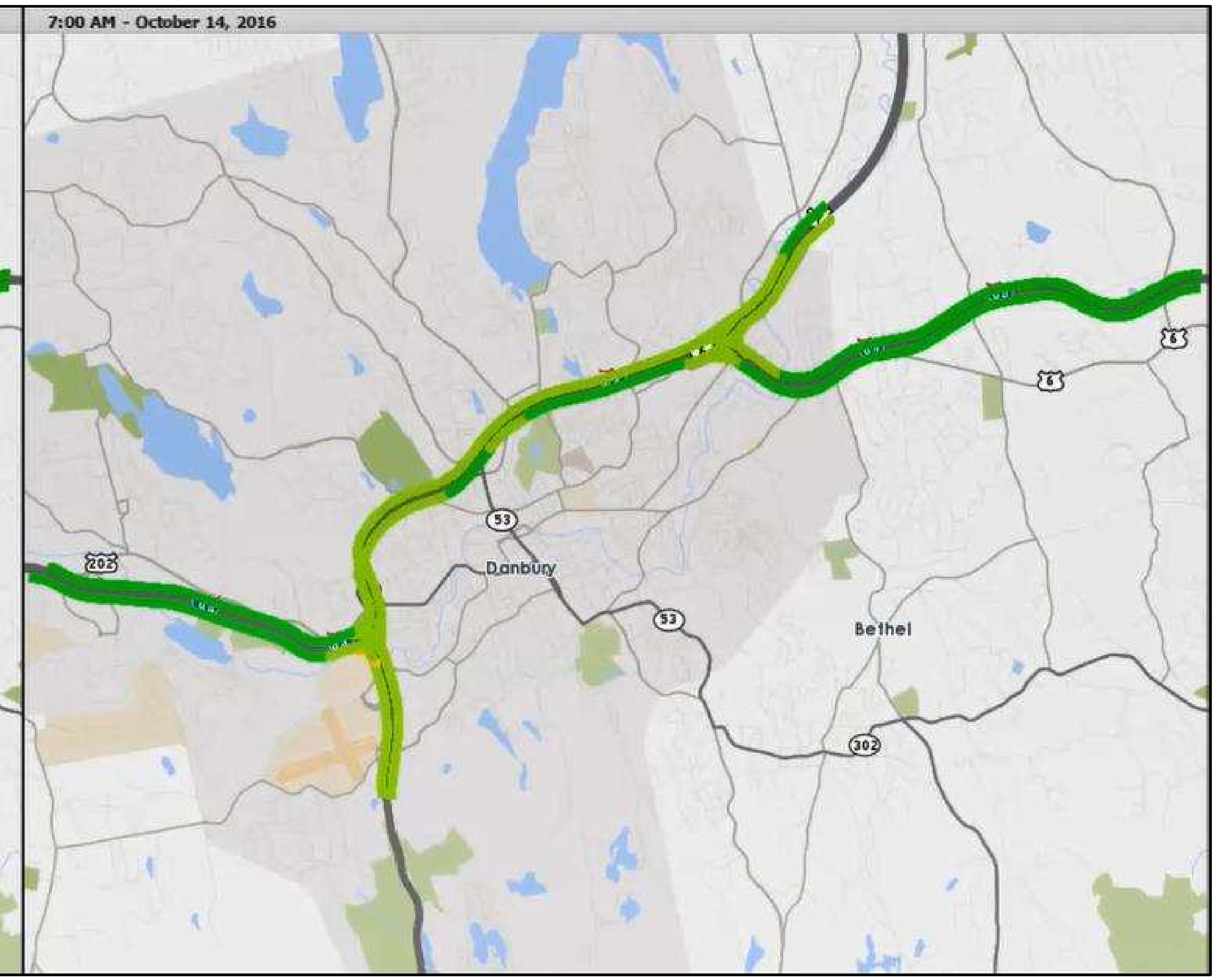
INRIX TRAVEL TIME RUNS

Weekday A.M. Peak Period
7:00 A.M.

Thursday



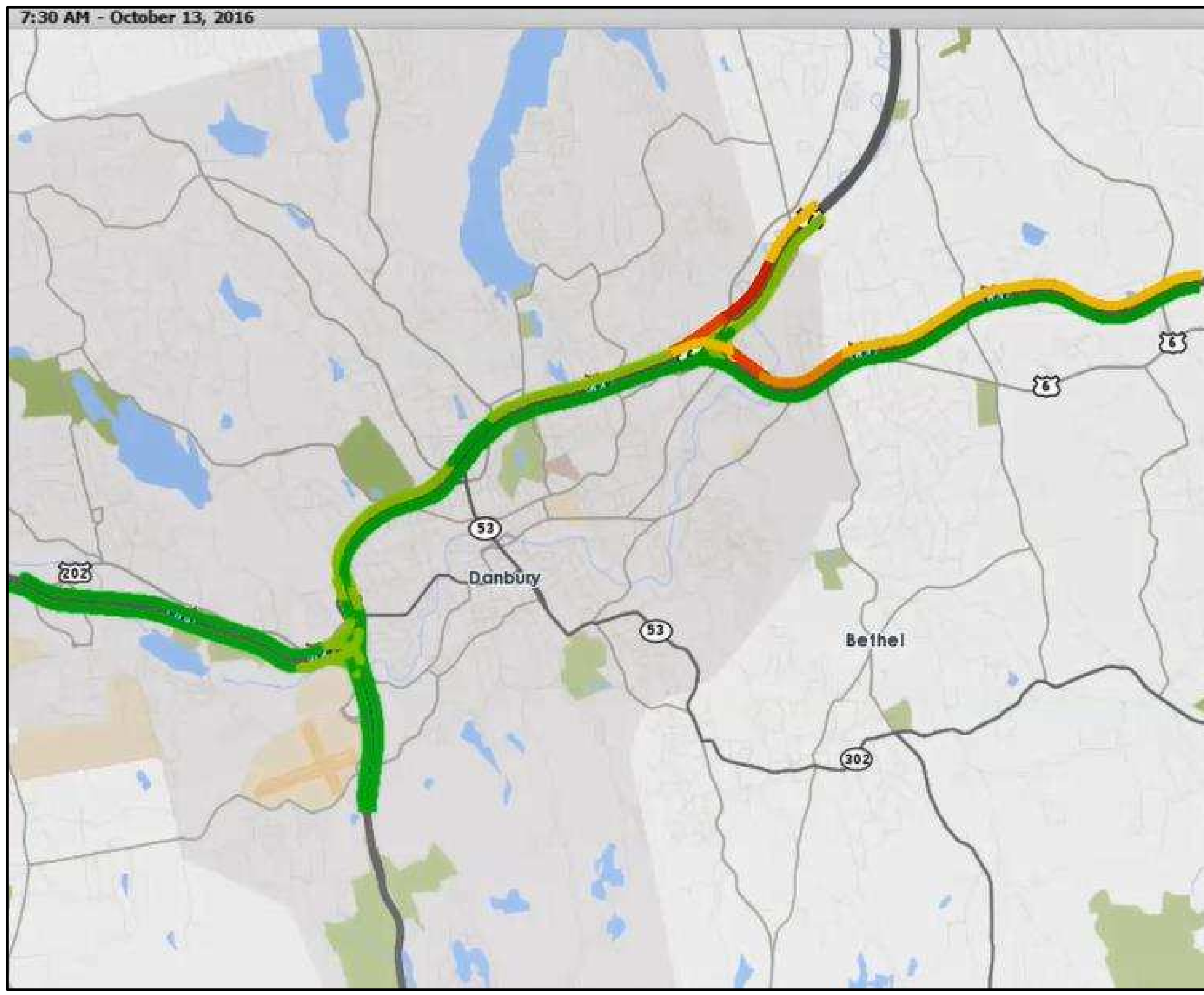
Friday



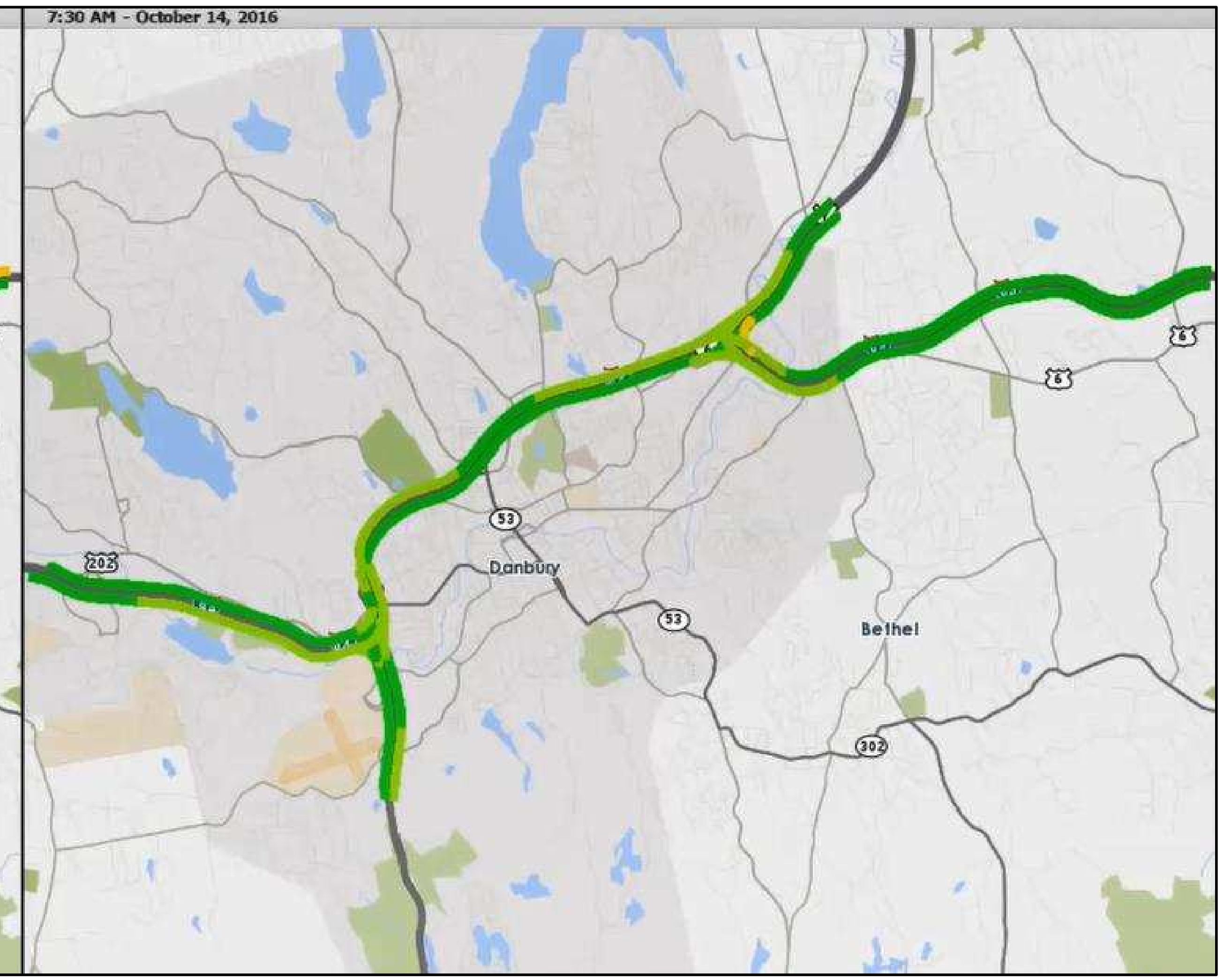
INRIX TRAVEL TIME RUNS

Weekday A.M. Peak Period
7:30 A.M.

Thursday



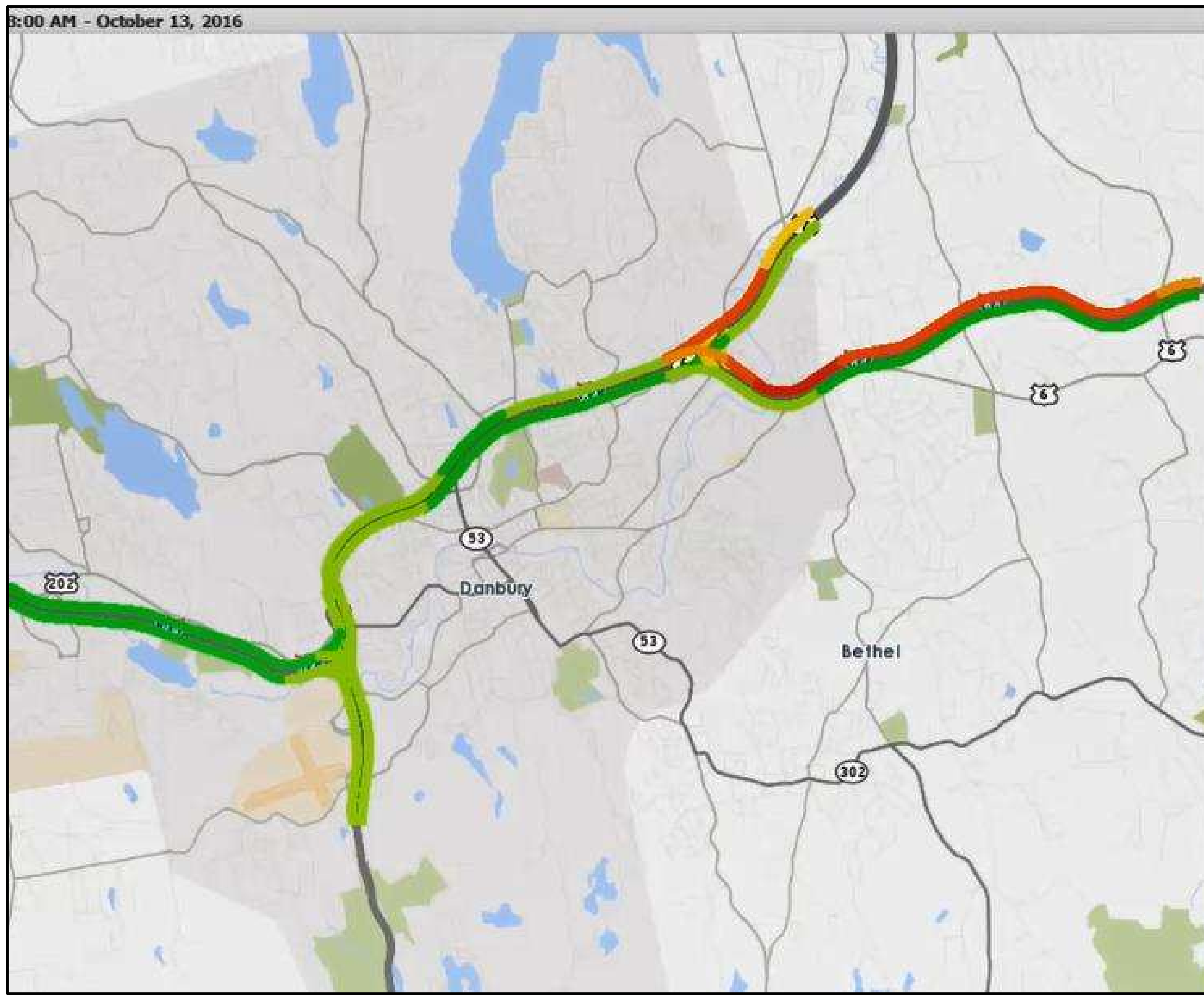
Friday



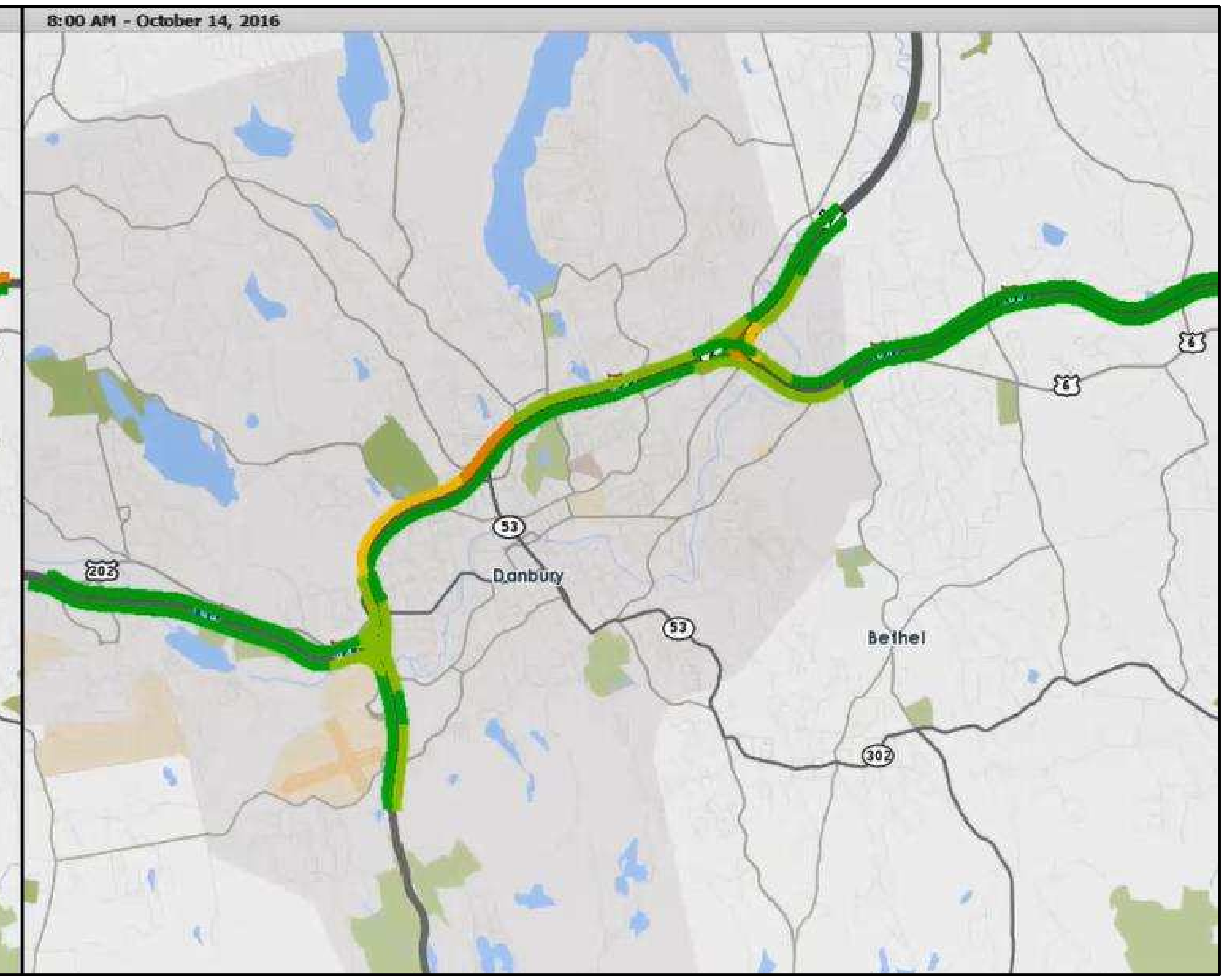
INRIX TRAVEL TIME RUNS

Weekday A.M. Peak Period
8:00 A.M.

Thursday



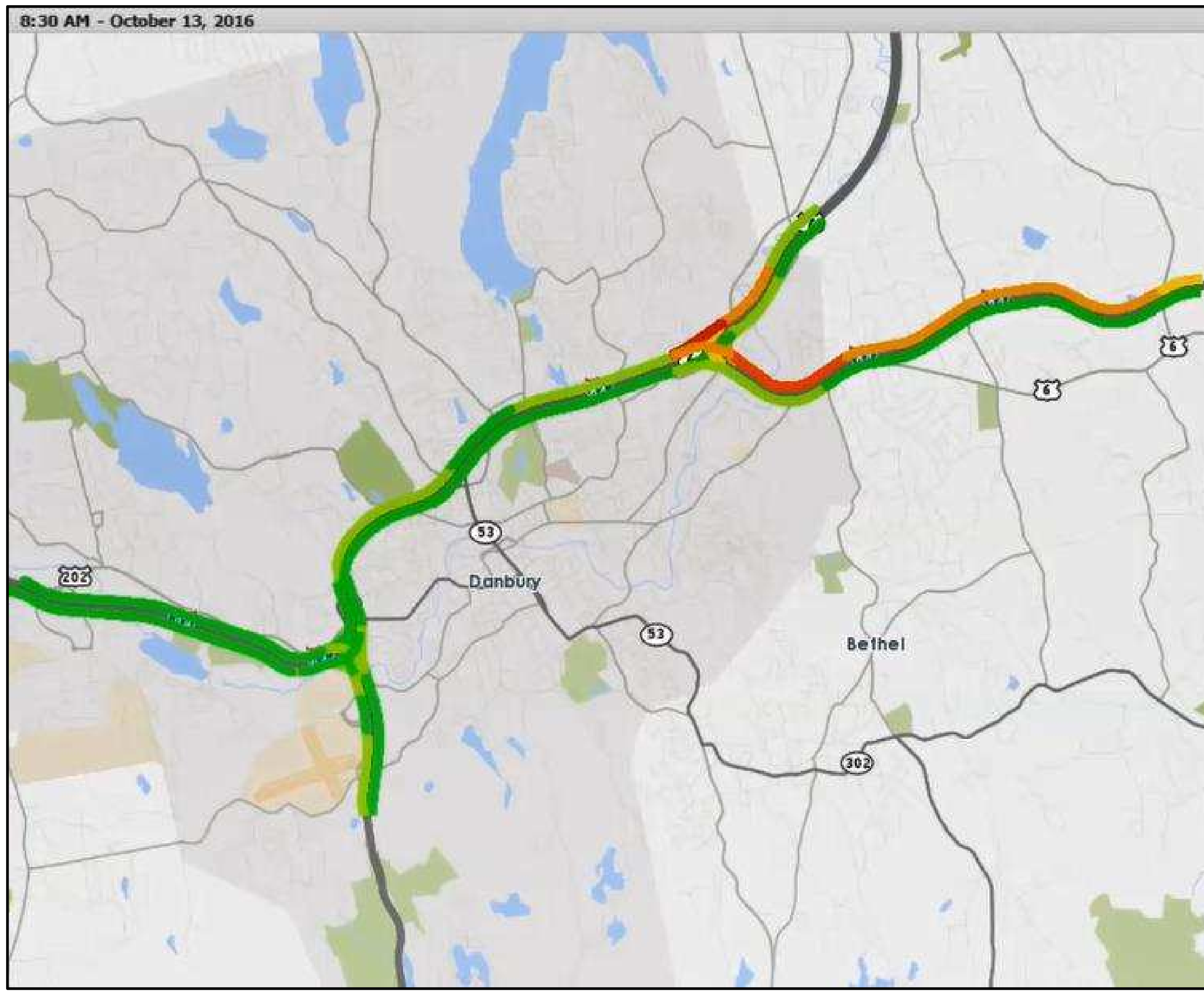
Friday



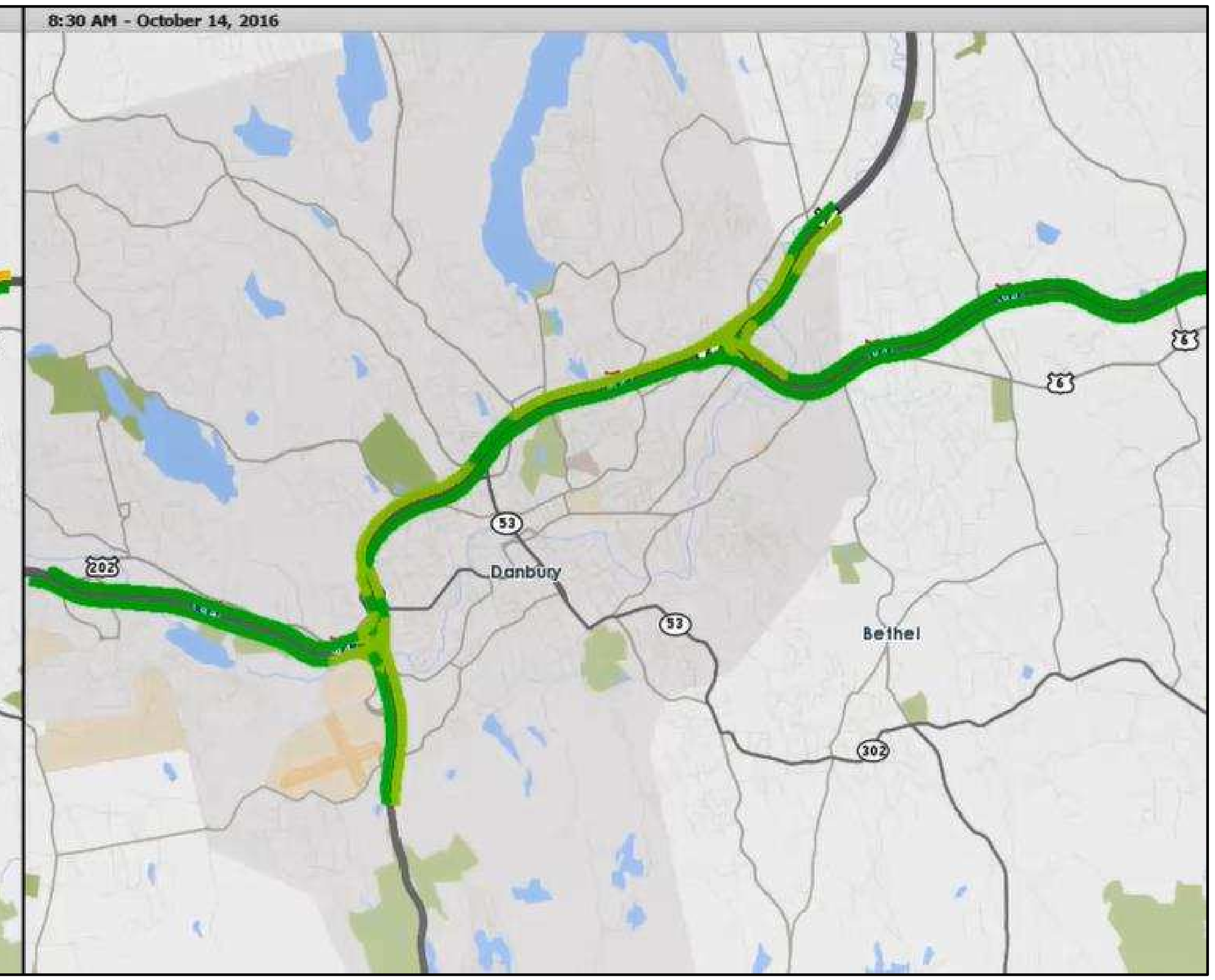
INRIX TRAVEL TIME RUNS

Weekday A.M. Peak Period
8:30 A.M.

Thursday



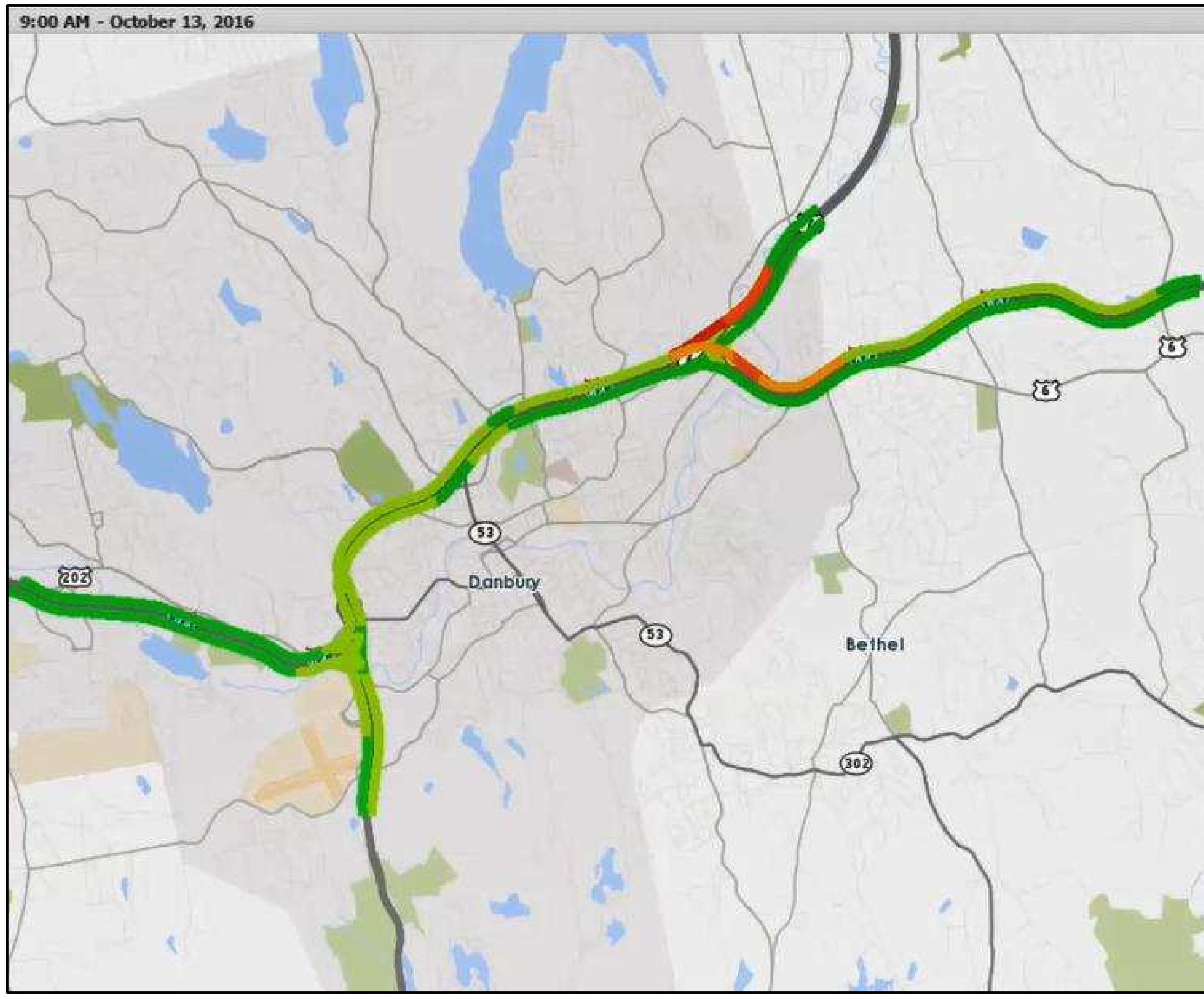
Friday



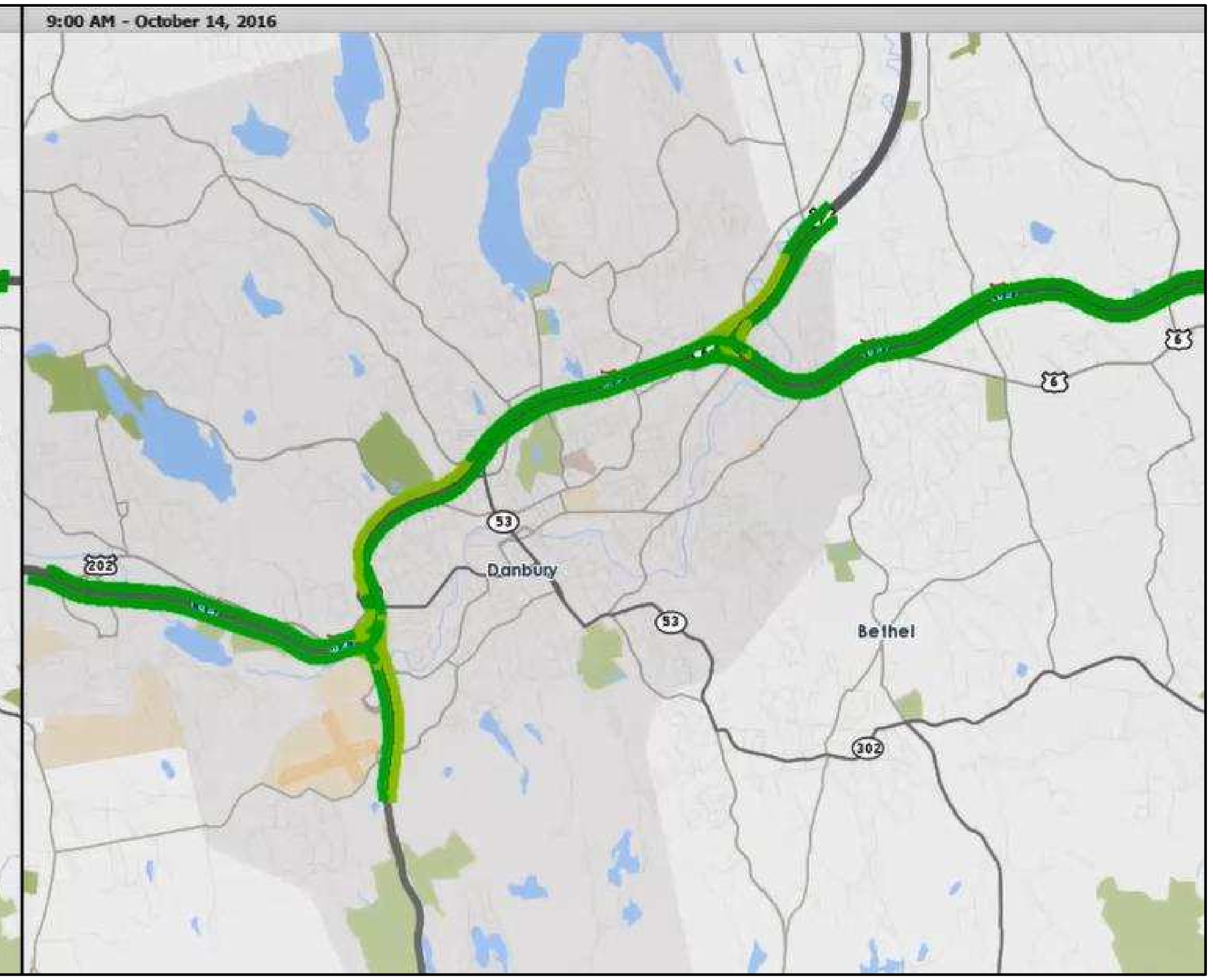
INRIX TRAVEL TIME RUNS

Weekday A.M. Peak Period
9:00 A.M.

Thursday



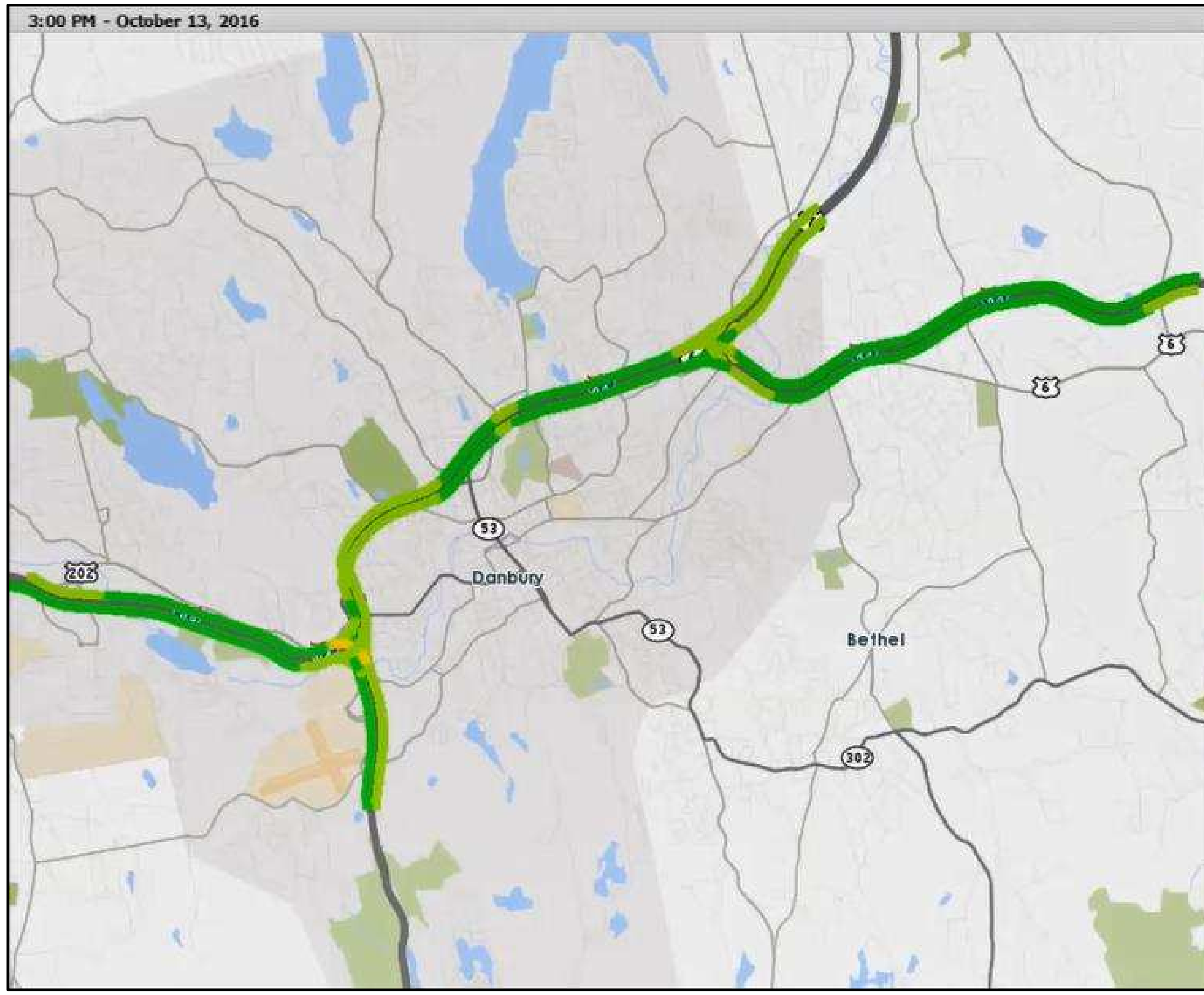
Friday



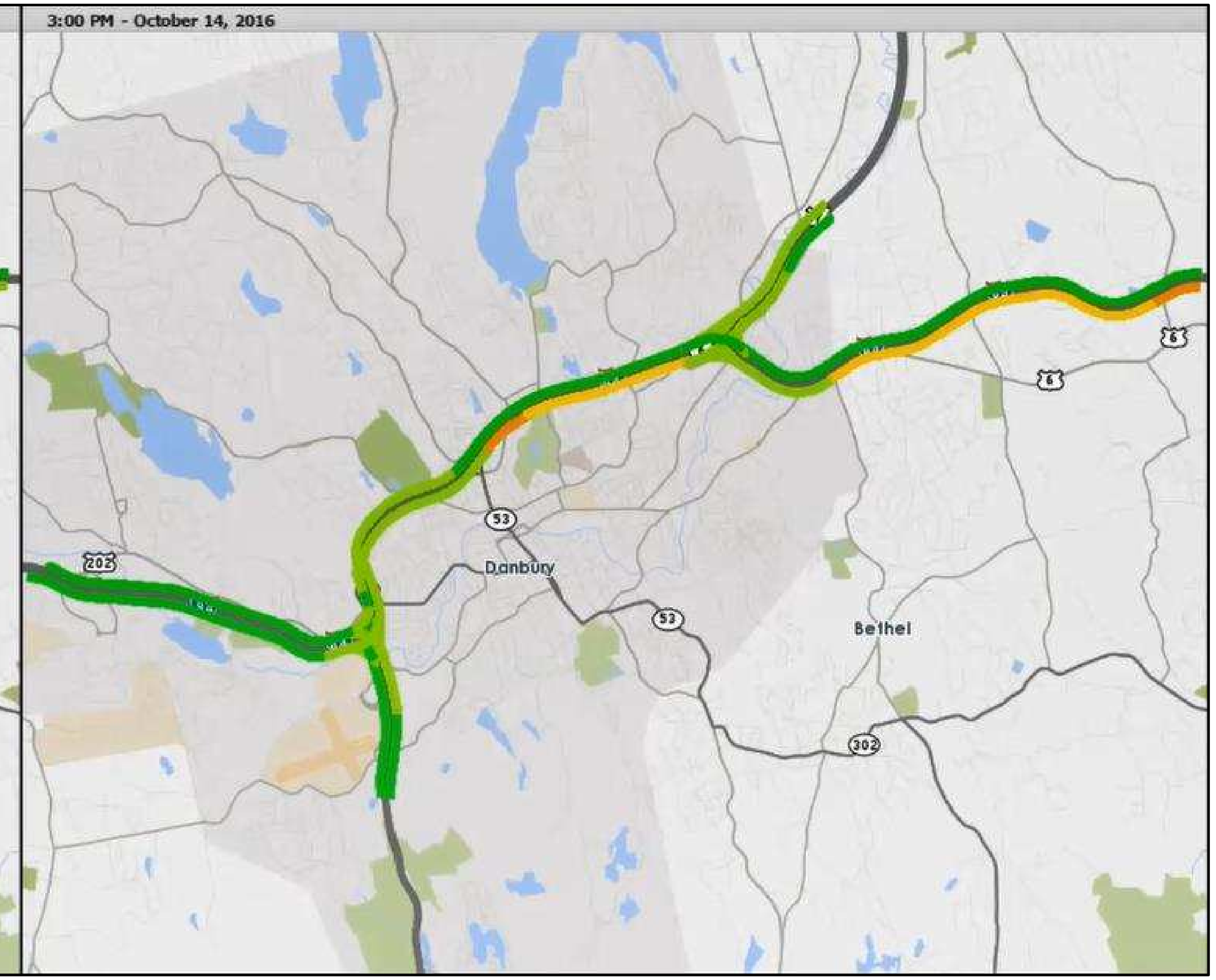
INRIX TRAVEL TIME RUNS

Weekday P.M. Peak Period
3:00 P.M.

Thursday



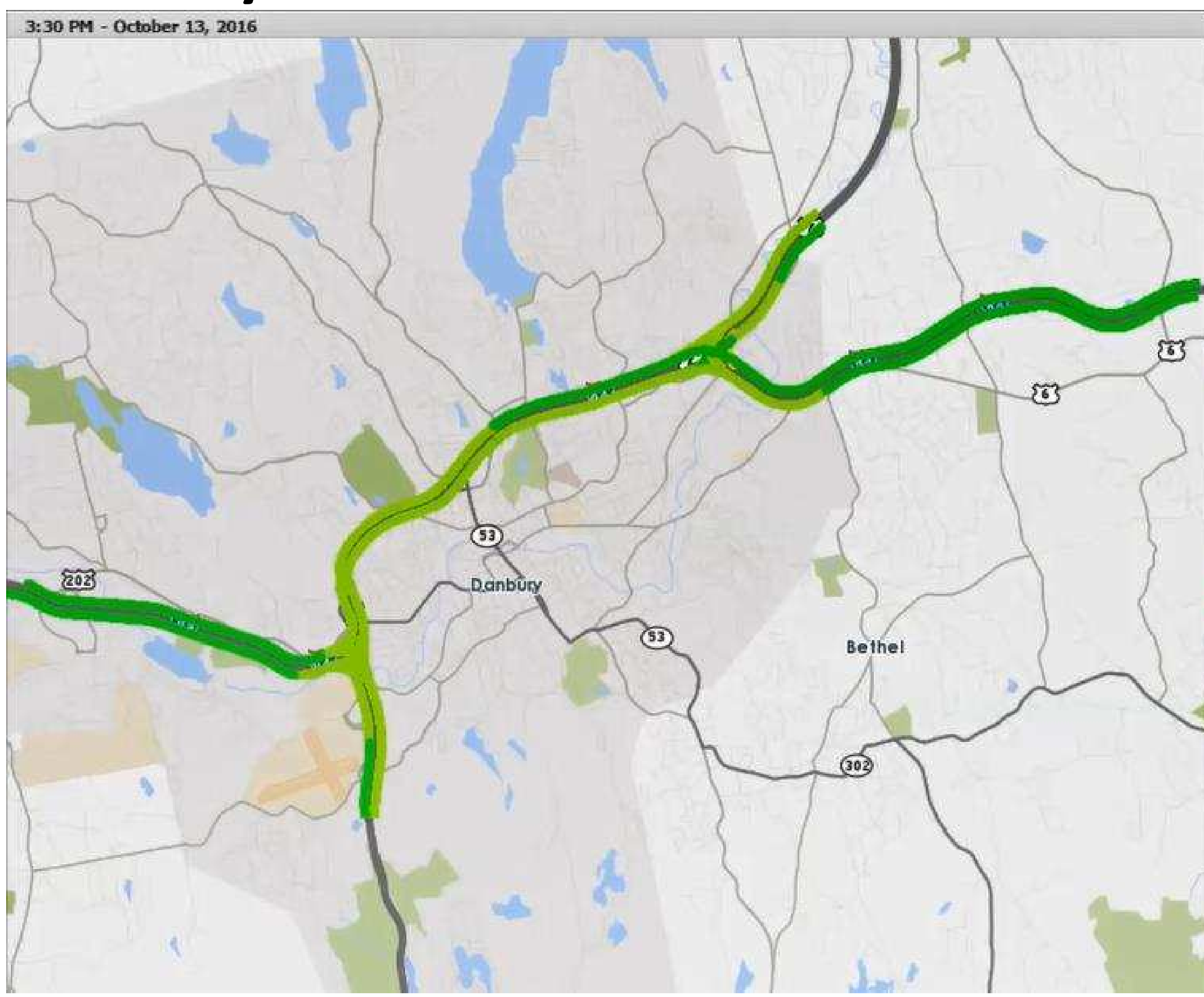
Friday



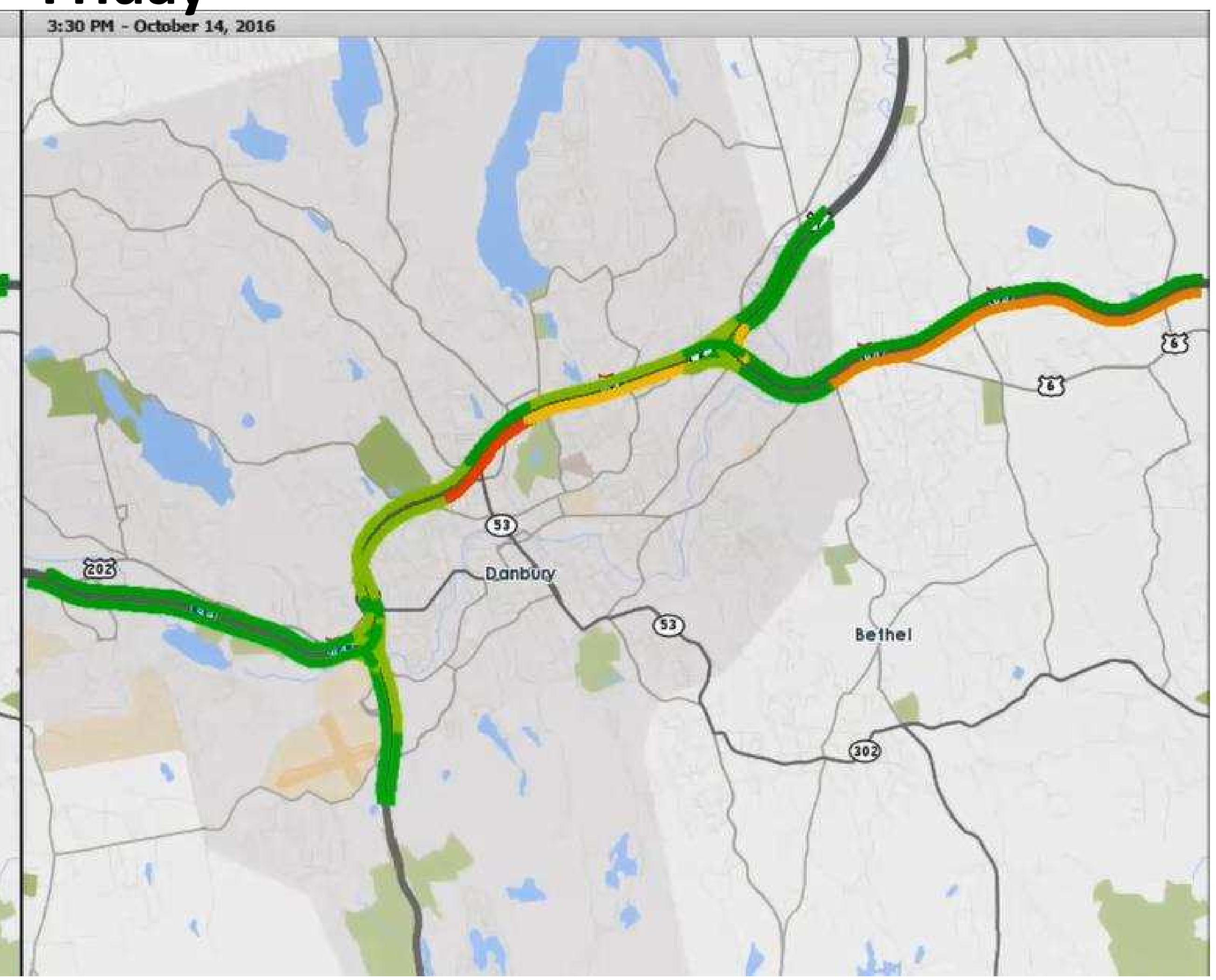
INRIX TRAVEL TIME RUNS

Weekday P.M. Peak Period
3:30 P.M.

Thursday



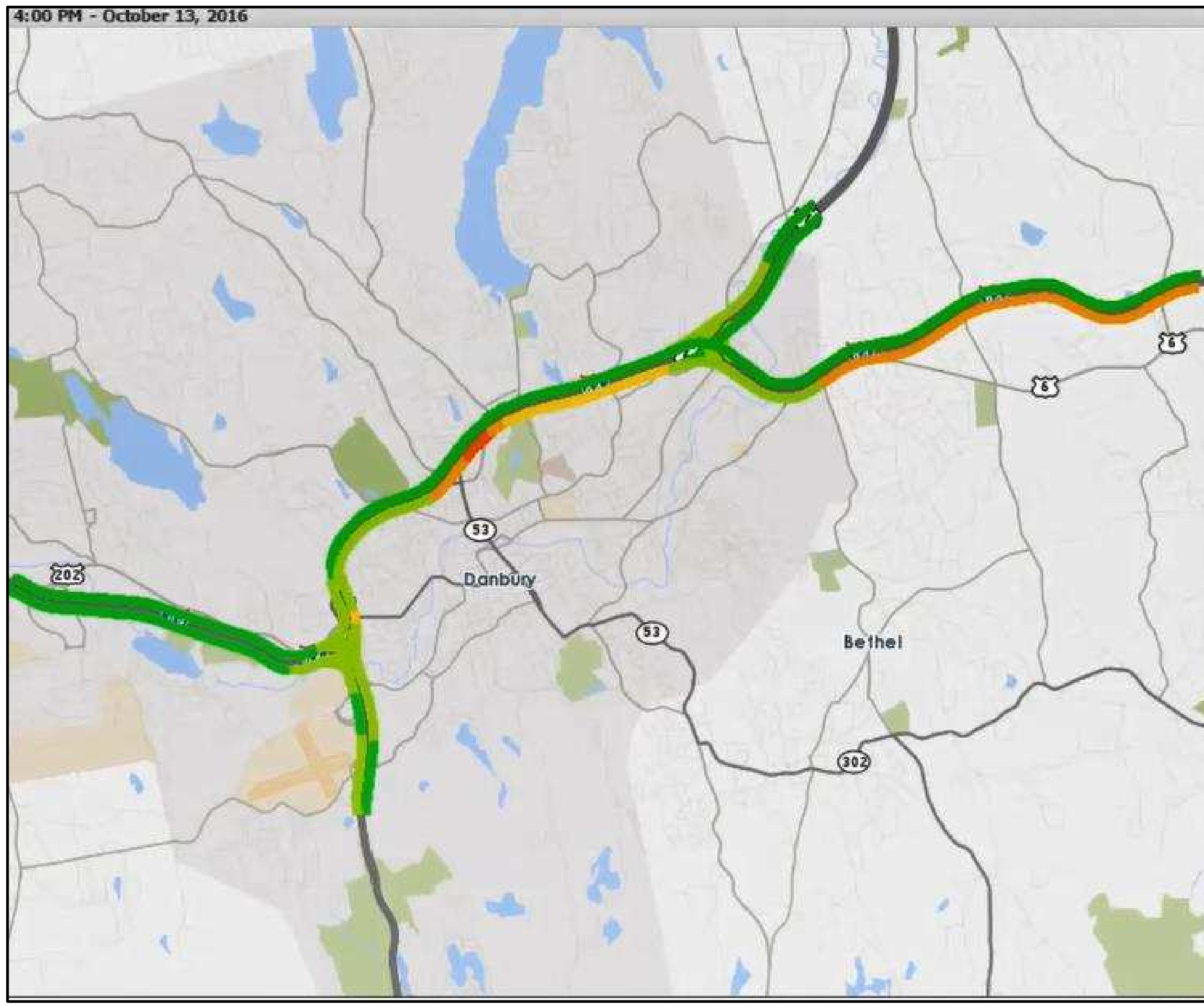
Friday



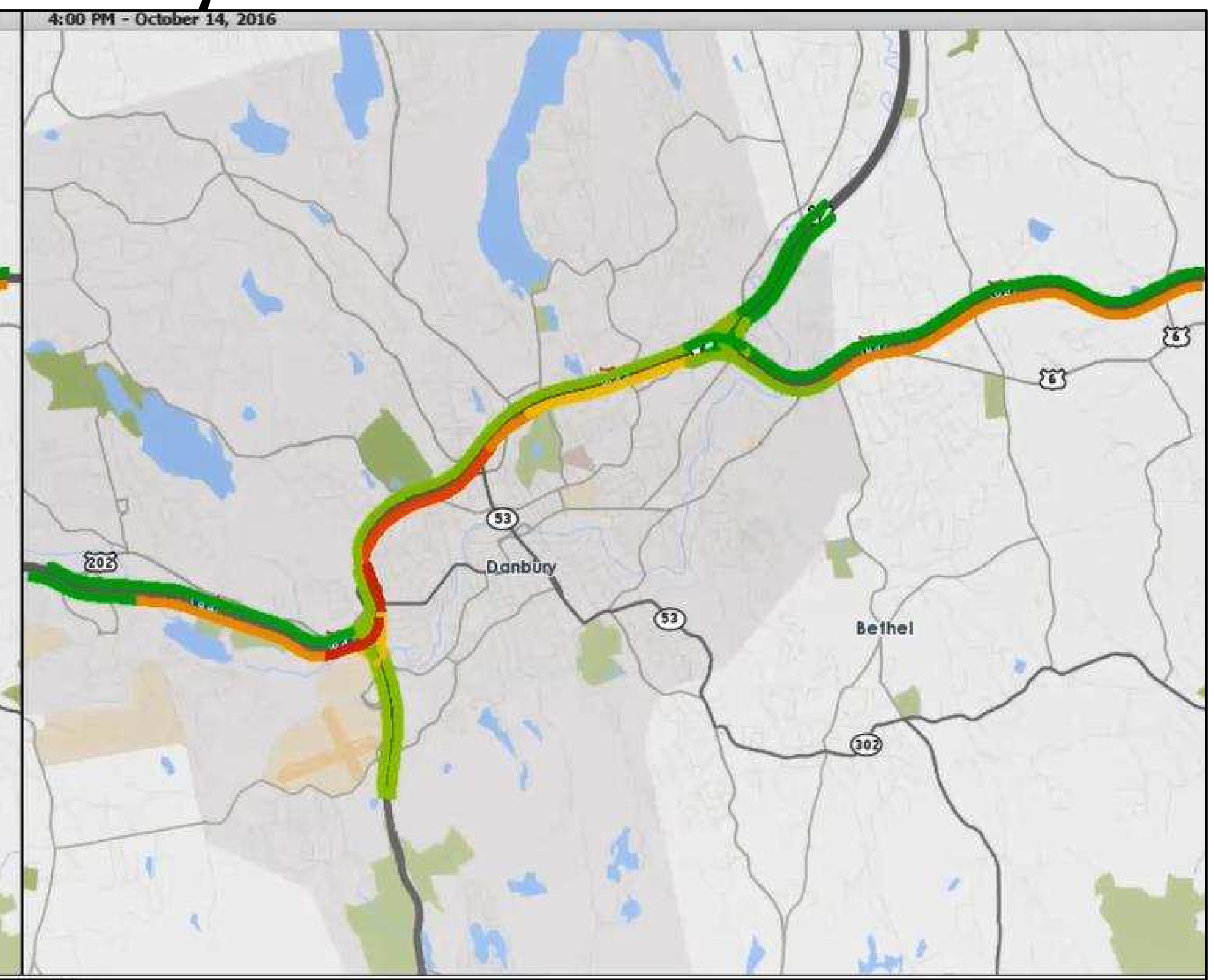
INRIX TRAVEL TIME RUNS

Weekday P.M. Peak Period
4:00 P.M.

Thursday



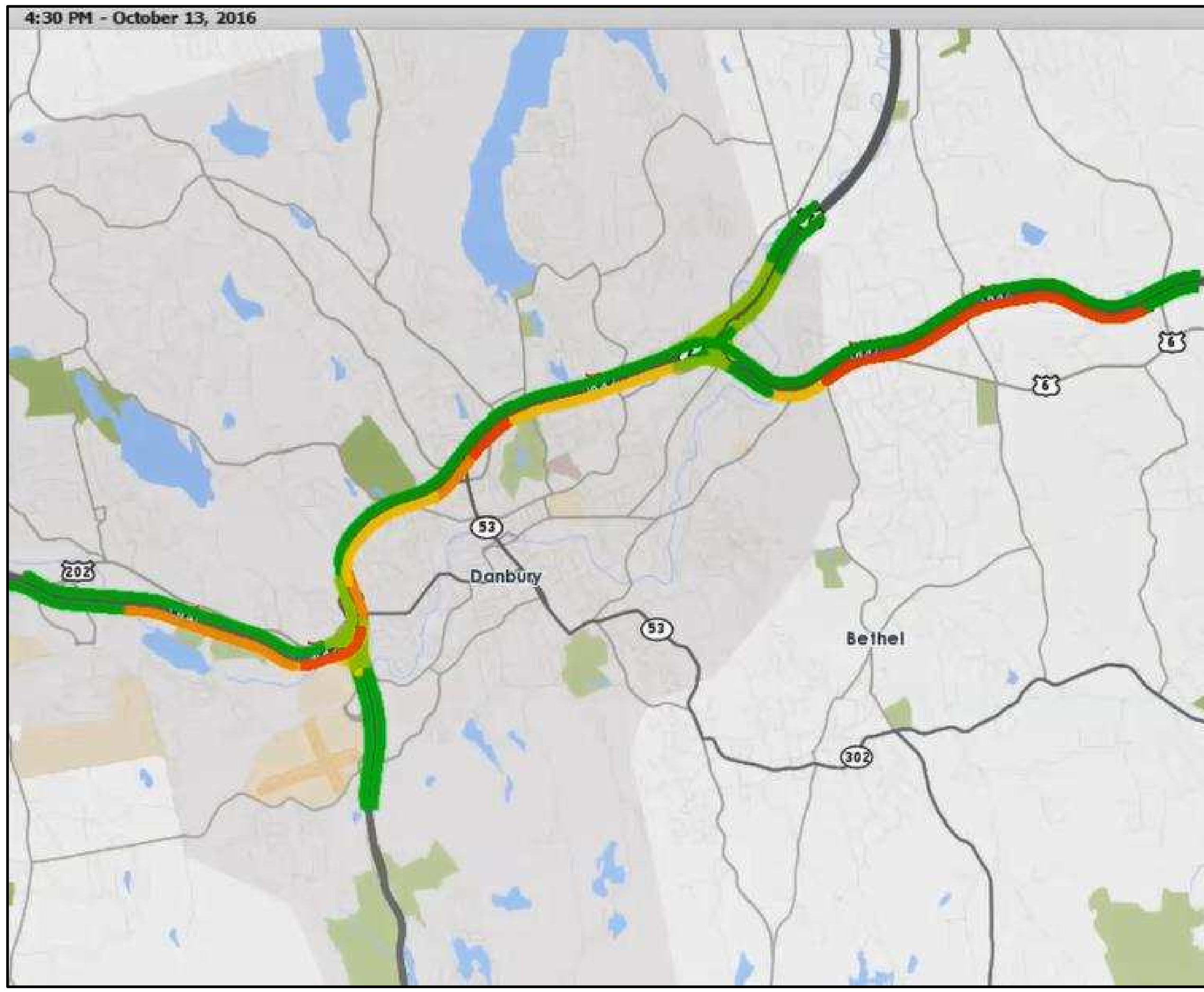
Friday



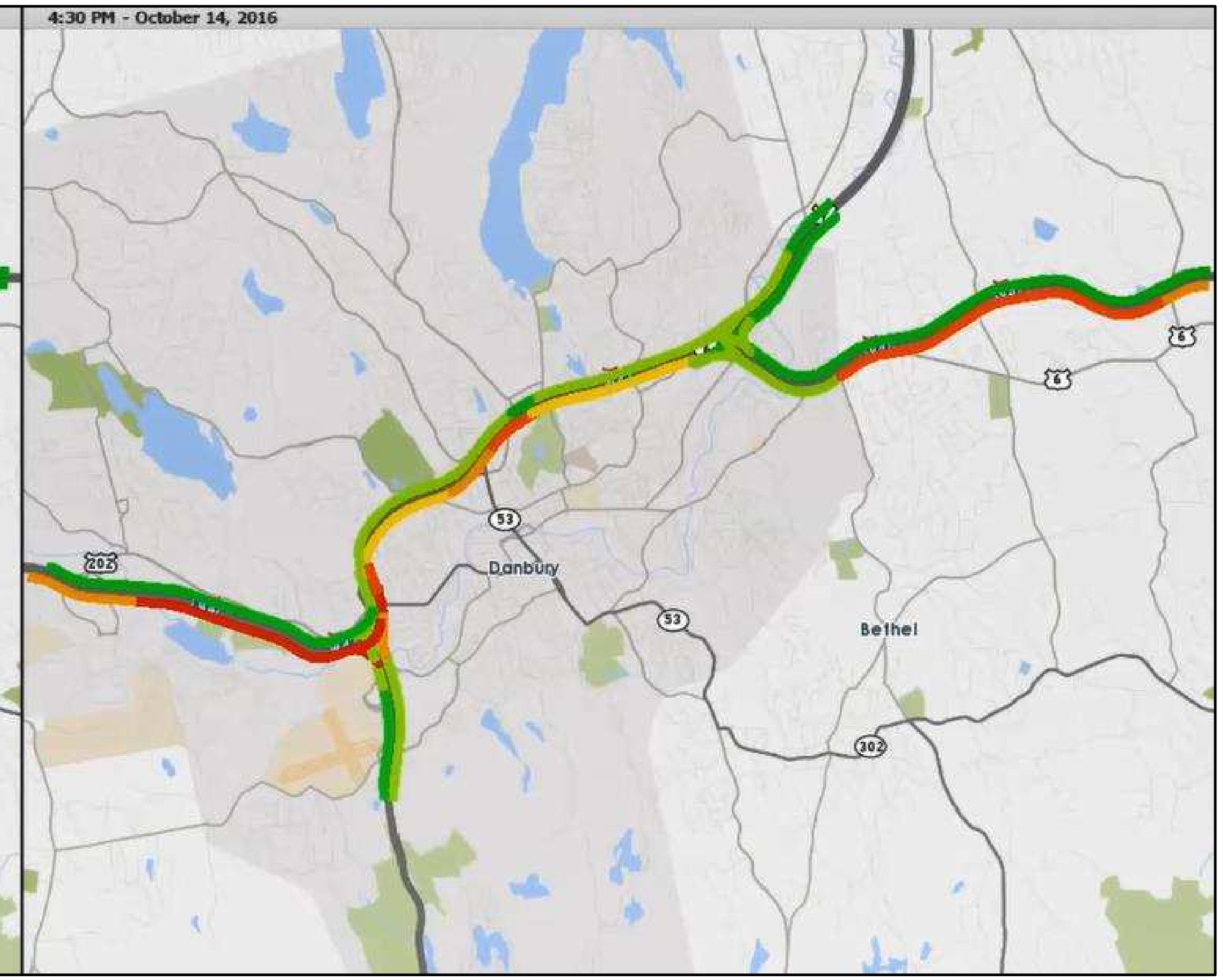
INRIX TRAVEL TIME RUNS

Weekday P.M. Peak Period
4:30 P.M.

Thursday



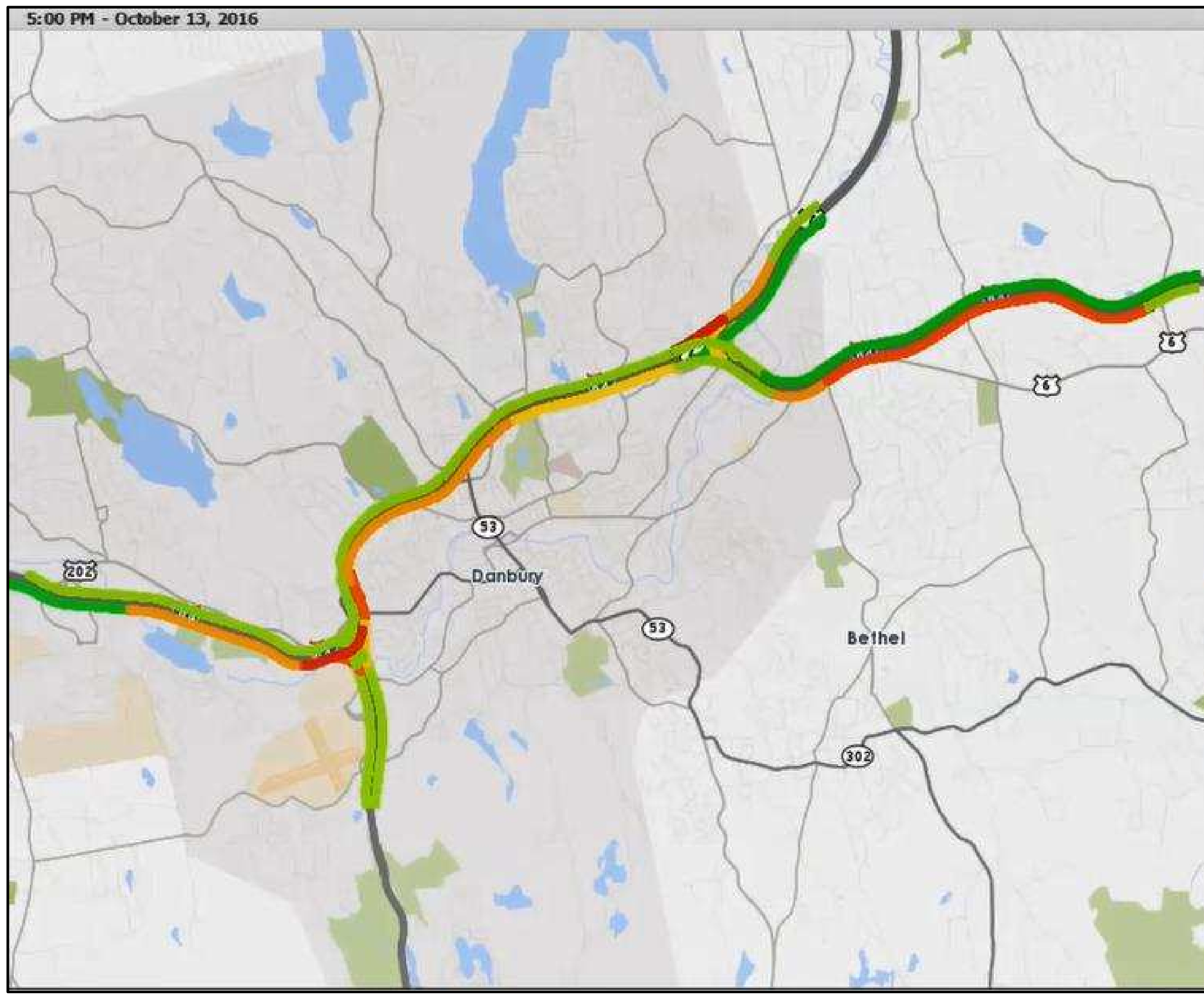
Friday



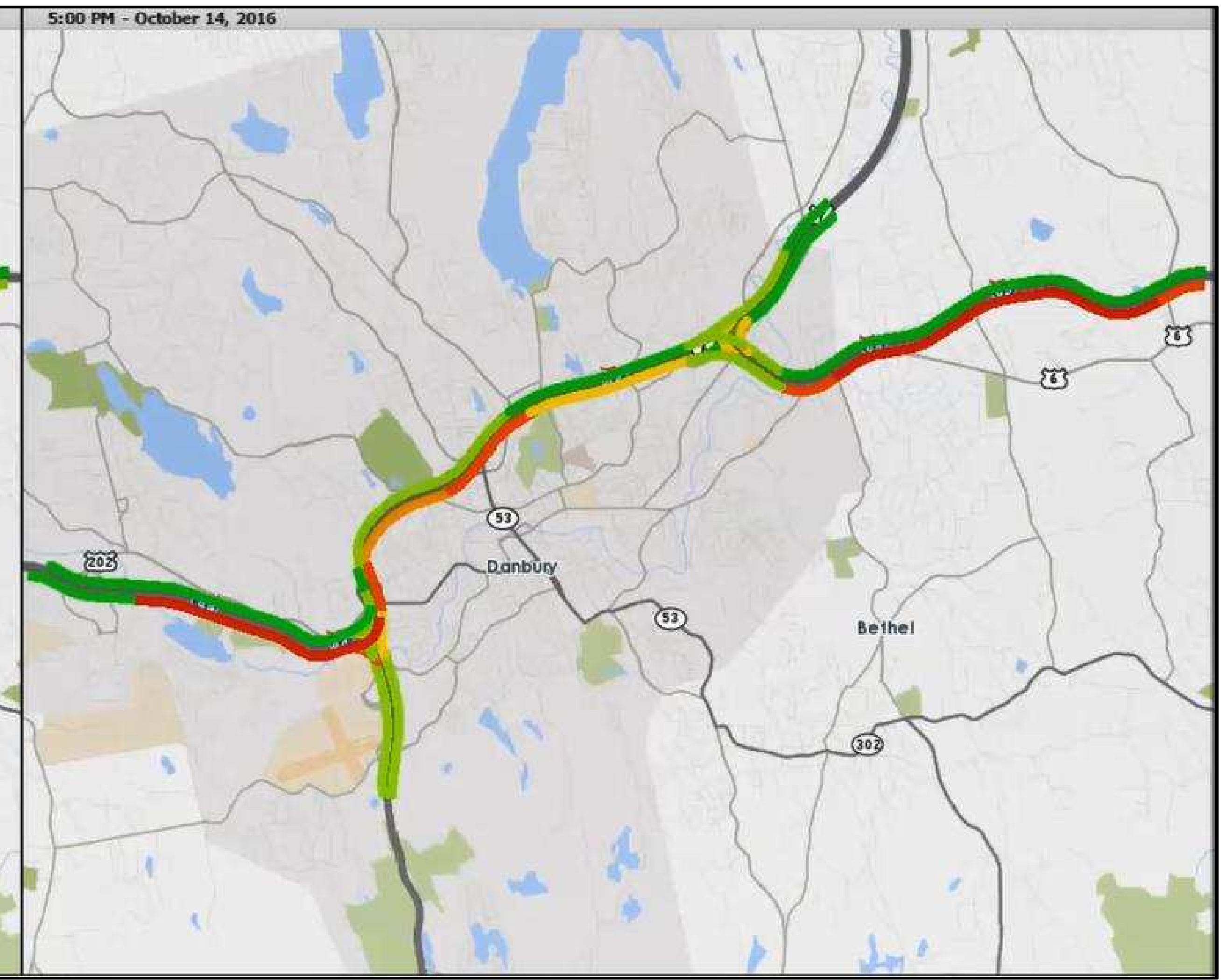
INRIX TRAVEL TIME RUNS

Weekday P.M. Peak Period
5:00 P.M.

Thursday



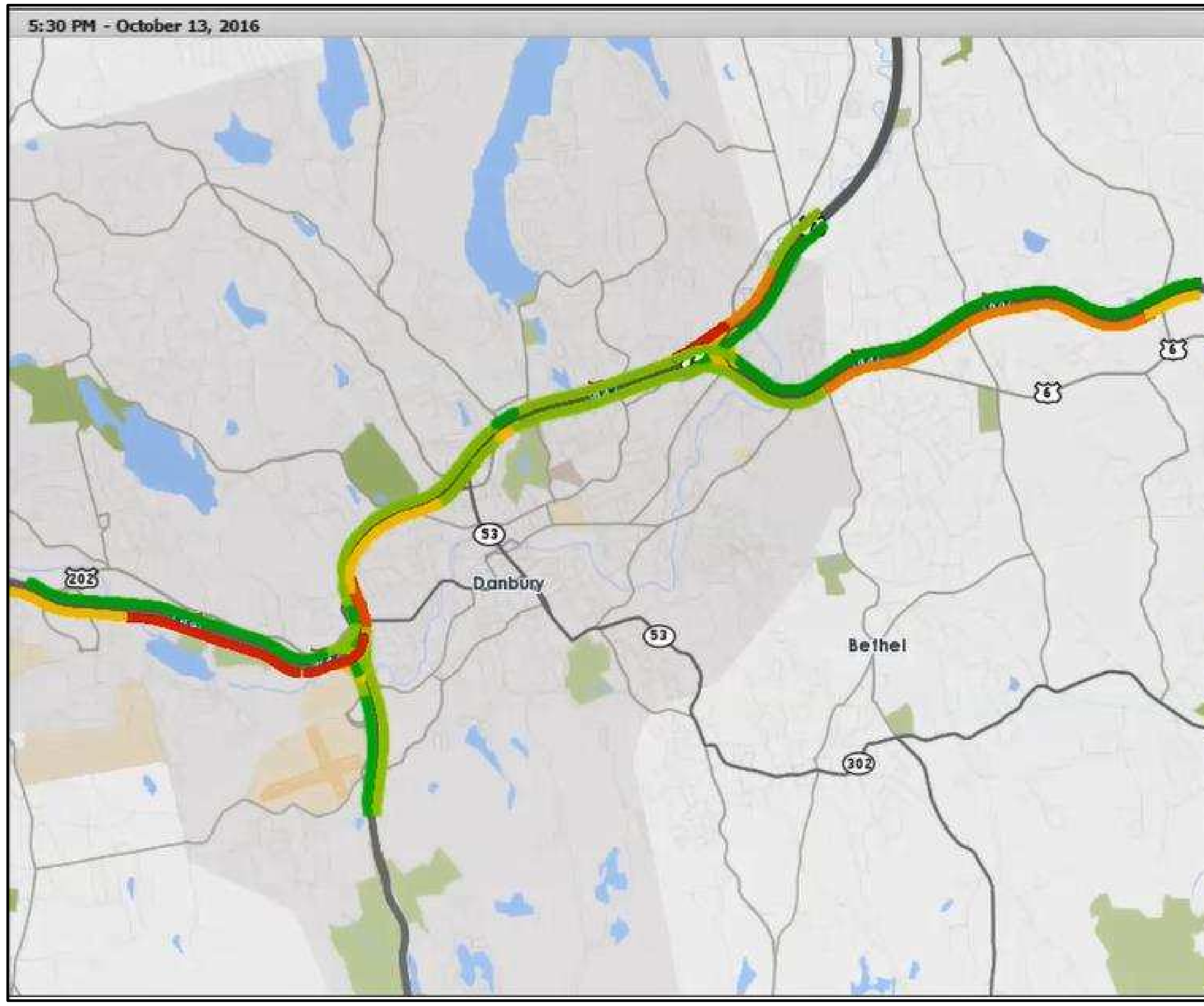
Friday



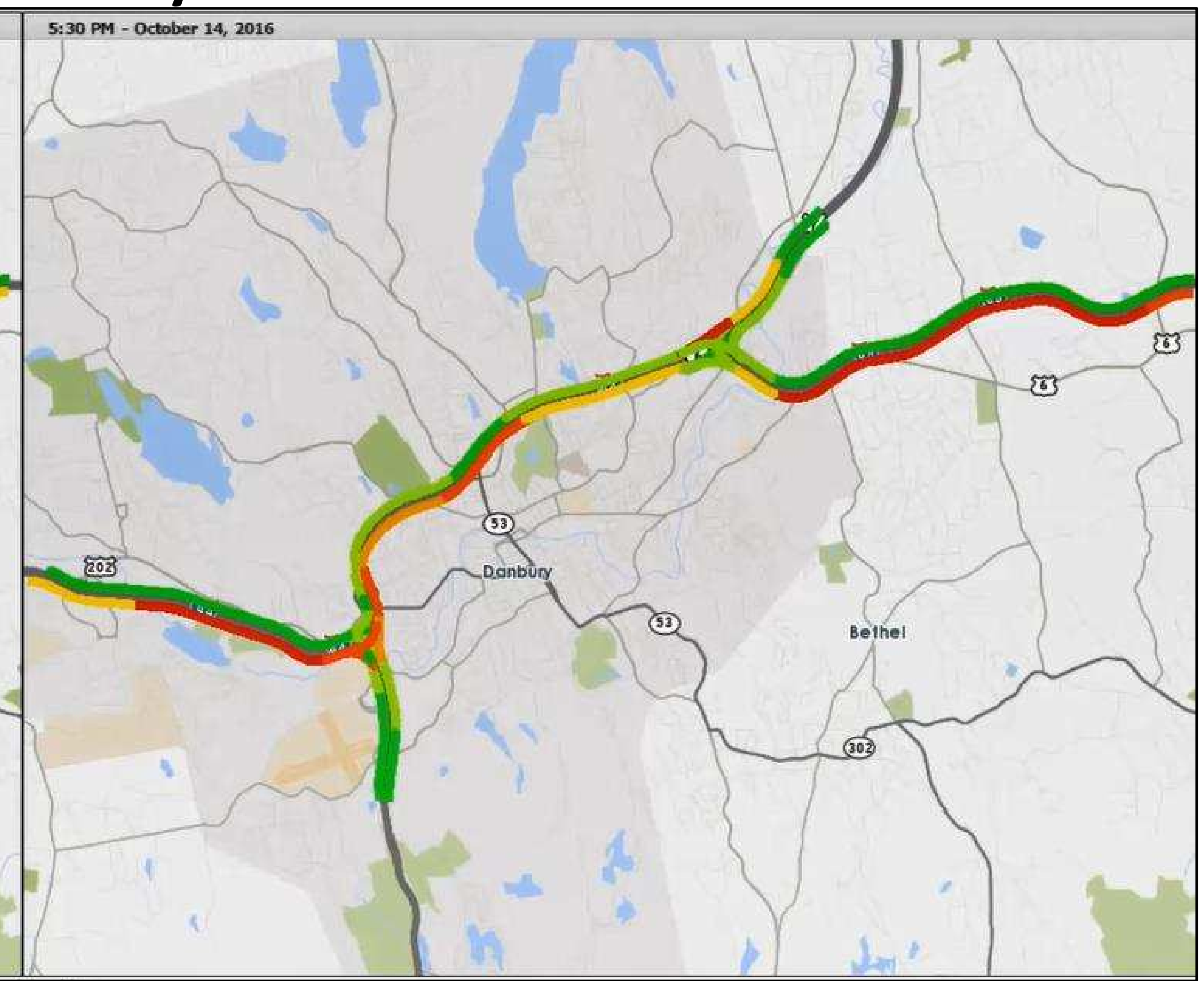
INRIX TRAVEL TIME RUNS

Weekday P.M. Peak Period
5:30 P.M.

Thursday



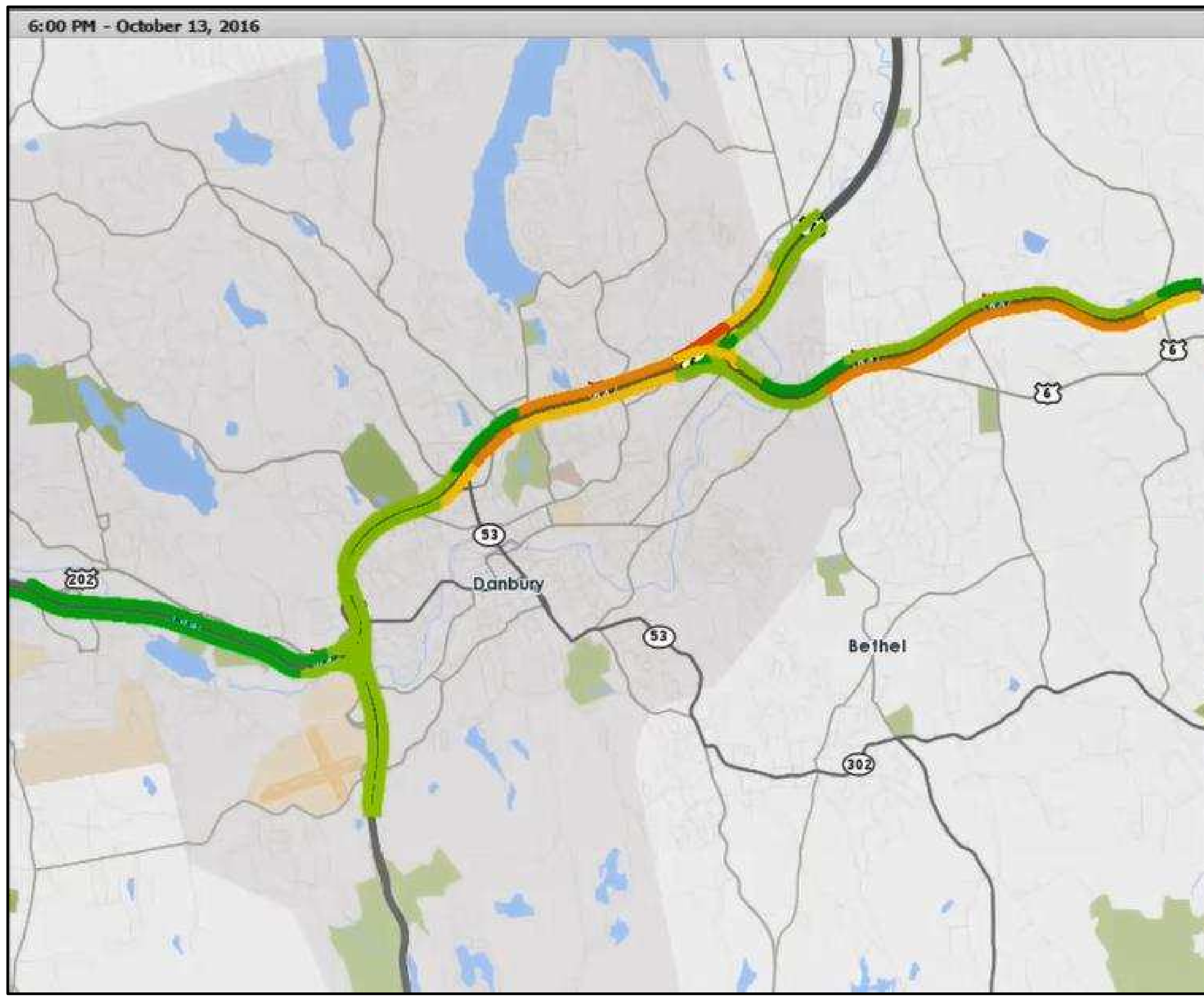
Friday



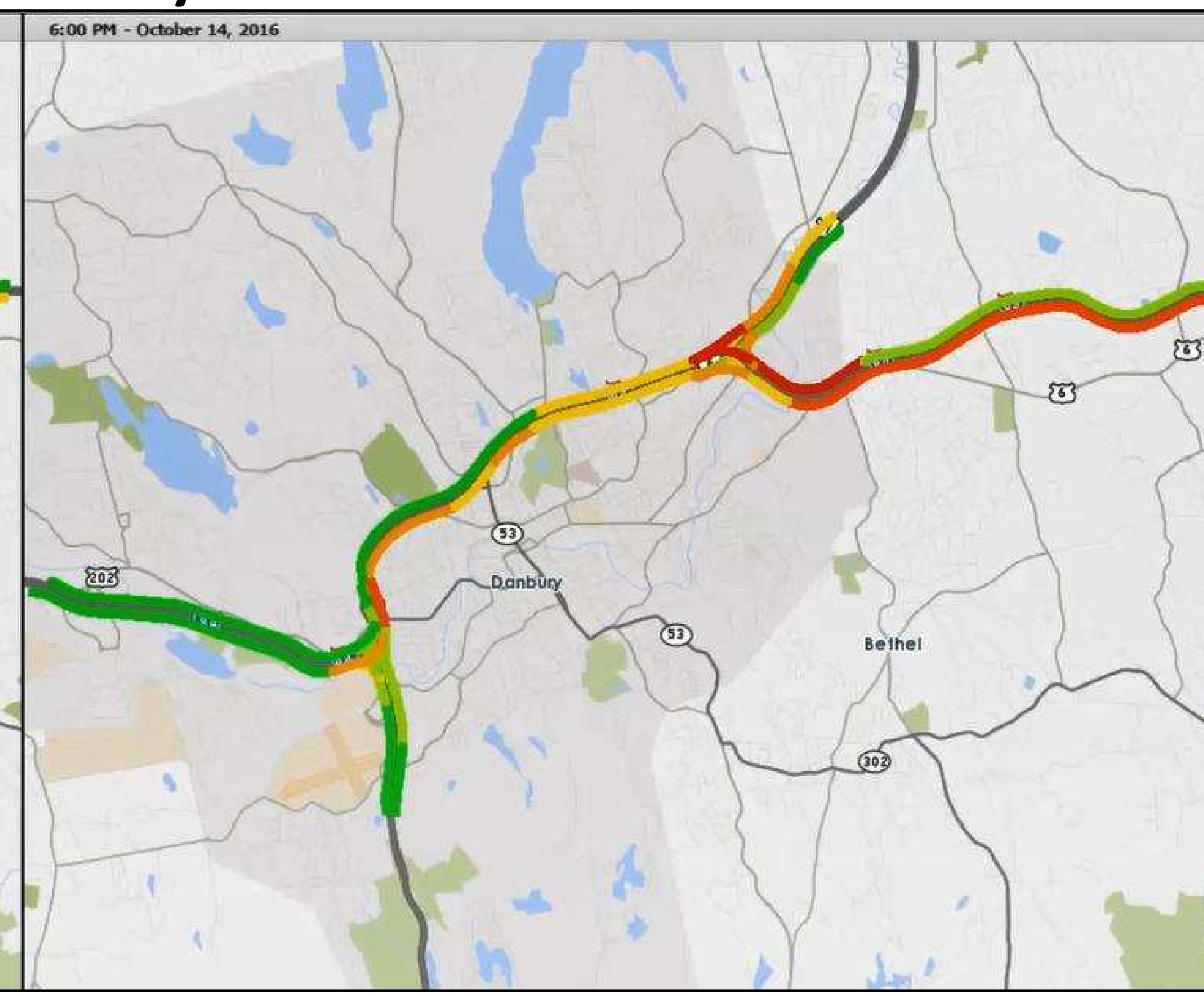
INRIX TRAVEL TIME RUNS

Weekday P.M. Peak Period
6:00 P.M.

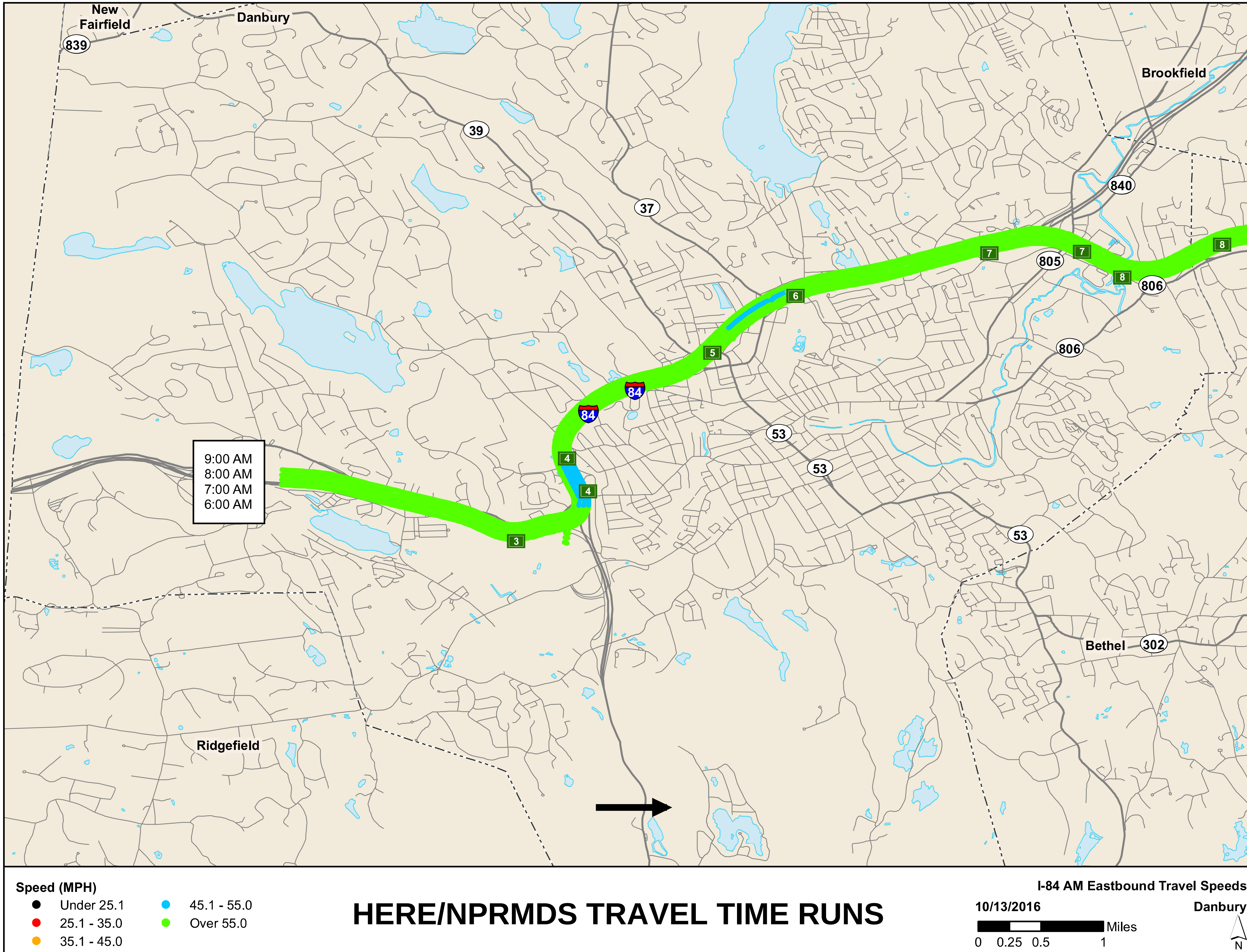
Thursday



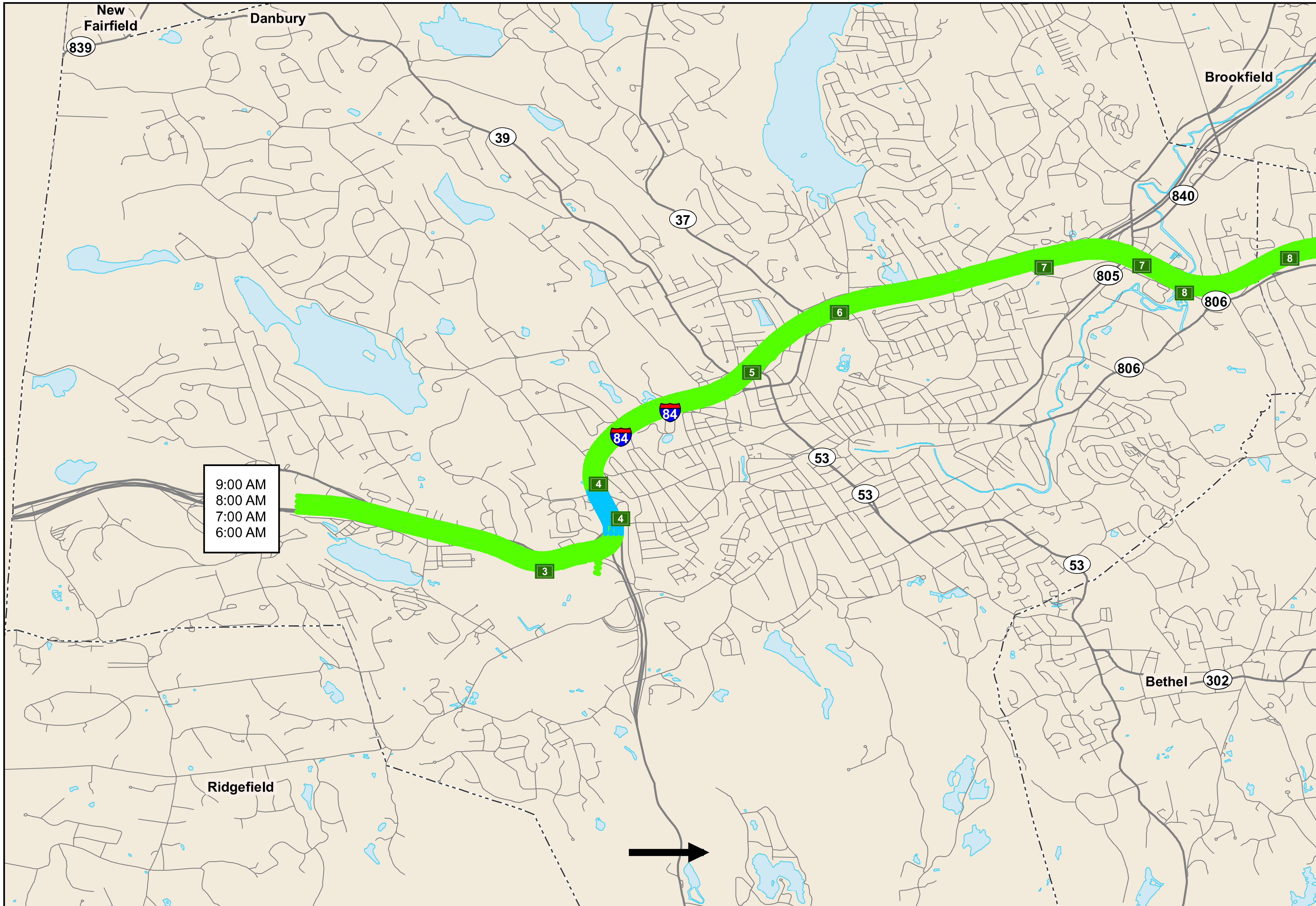
Friday



INRIX TRAVEL TIME RUNS



HERE/NPRMDS TRAVEL TIME RUNS



Speed (MPH)

- Under 25.1
- 25.1 - 35.0
- 35.1 - 45.0
- 45.1 - 55.0
- Over 55.0

HERE/NPRMDS TRAVEL TIME RUNS

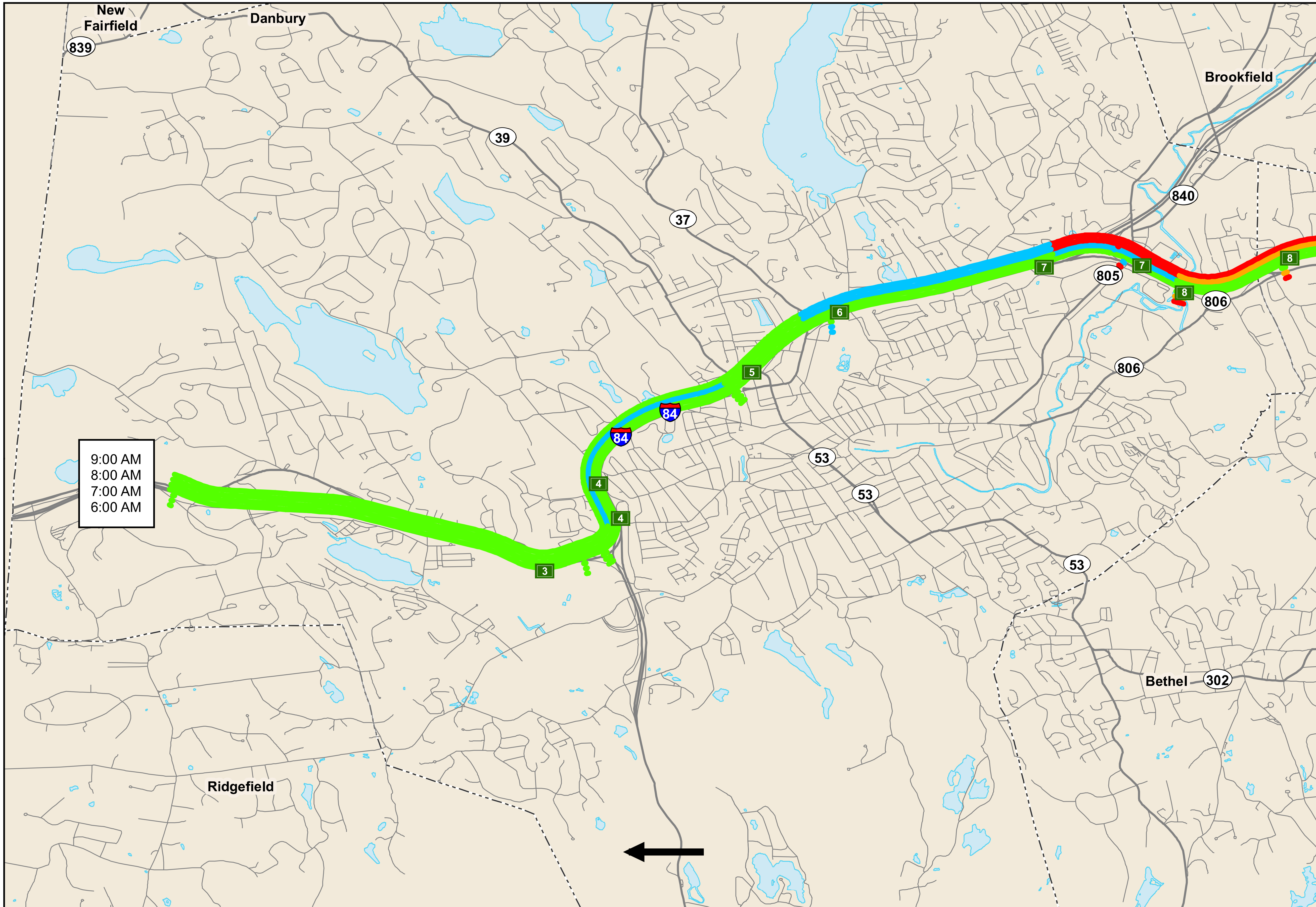
I-84 AM Eastbound Travel Speeds

10/14/2016

Danbury

Miles 0 0.25 0.5 1

N



Speed (MPH)

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- 45.1 - 55.0
- Over 55.0

HERE/NPRMDS TRAVEL TIME RUNS

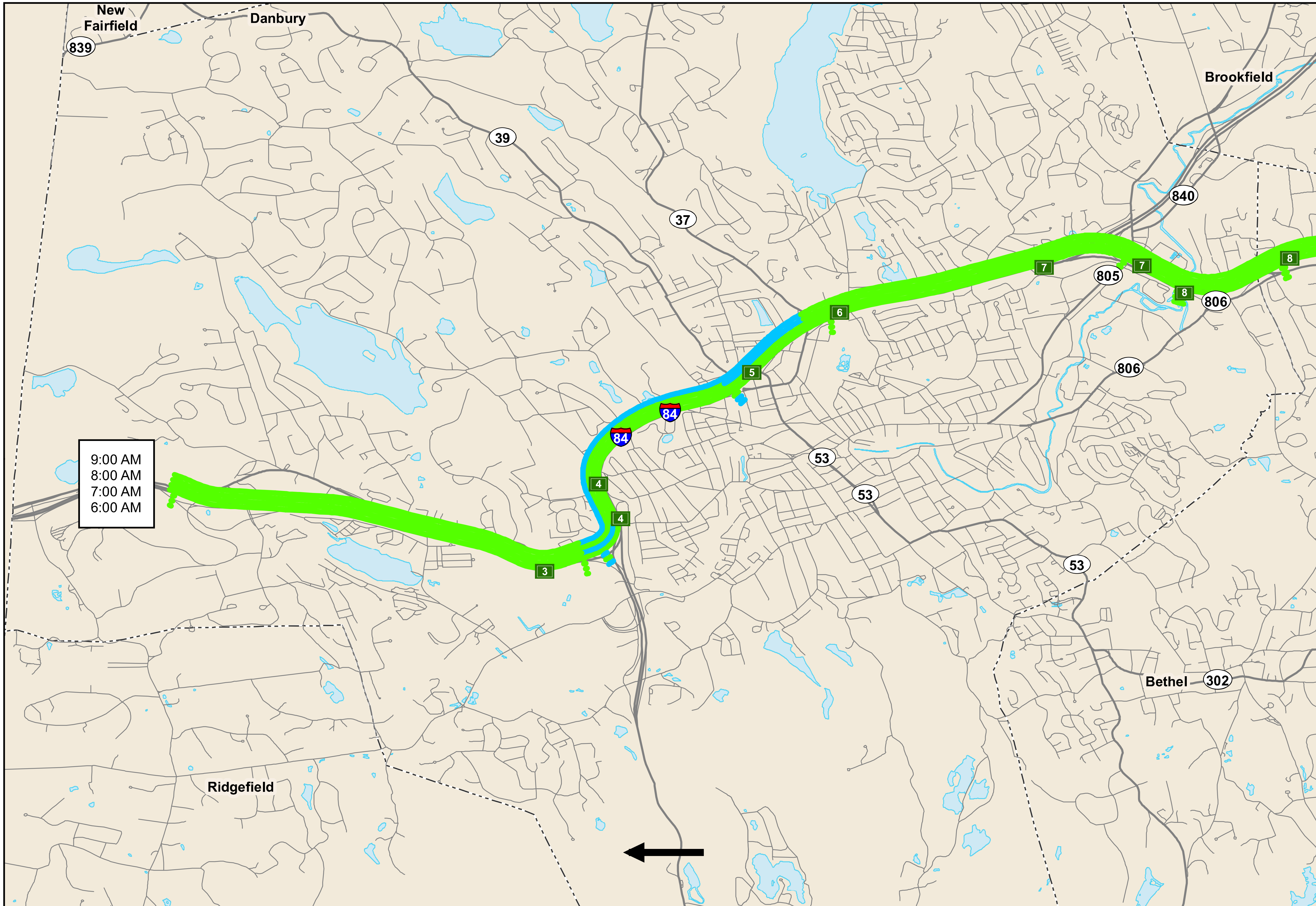
I-84 AM Westbound Travel Speeds

10/13/2016

Danbury

Miles
0 0.25 0.5 1

N



Speed (MPH)

- Under 25.1
- 25.1 - 35.0
- 35.1 - 45.0
- 45.1 - 55.0
- Over 55.0

HERE/NPRMDS TRAVEL TIME RUNS

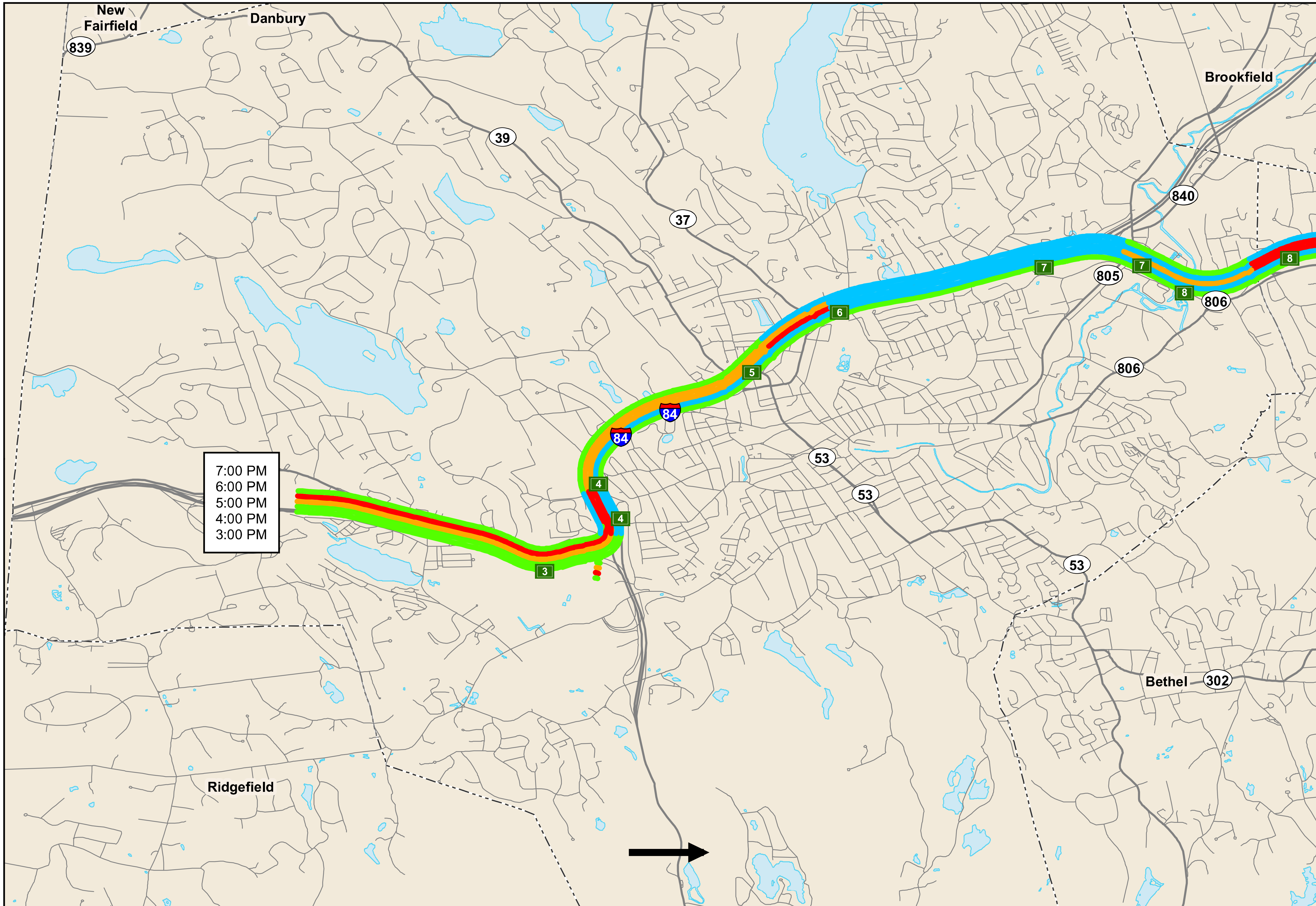
I-84 AM Westbound Travel Speeds

10/14/2016

Danbury

0 0.25 0.5 1 Miles

N



Speed (MPH)
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- 35.1 - 45.0
- 45.1 - 55.0
- Over 55.0

HERE/NPRMDS TRAVEL TIME RUNS

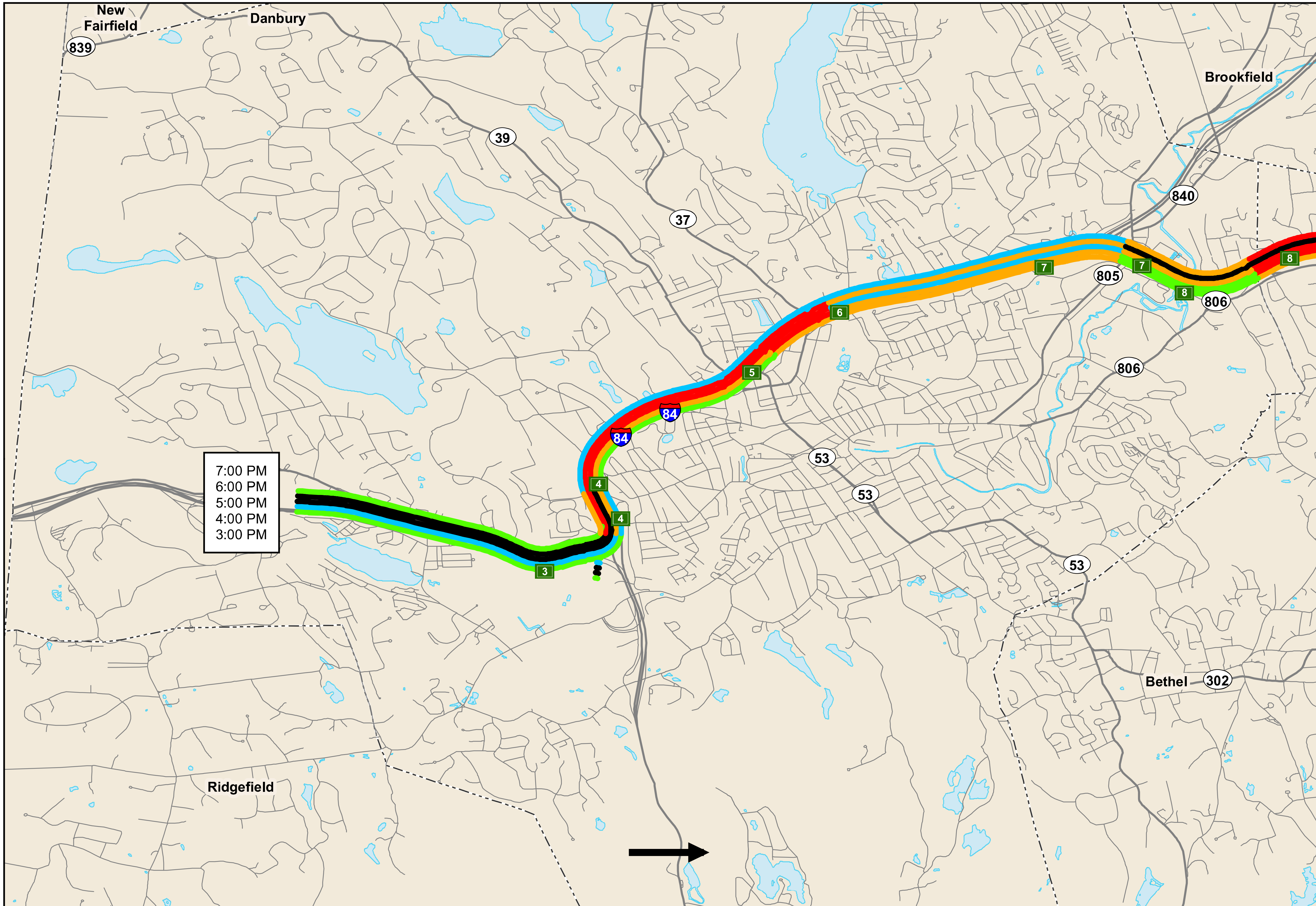
I-84 PM Eastbound Travel Speeds

10/13/2016

Danbury

0 0.25 0.5 1 Miles

N



Speed (MPH)
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- 35.1 - 45.0
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- Over 55.0

HERE/NPRMDS TRAVEL TIME RUNS

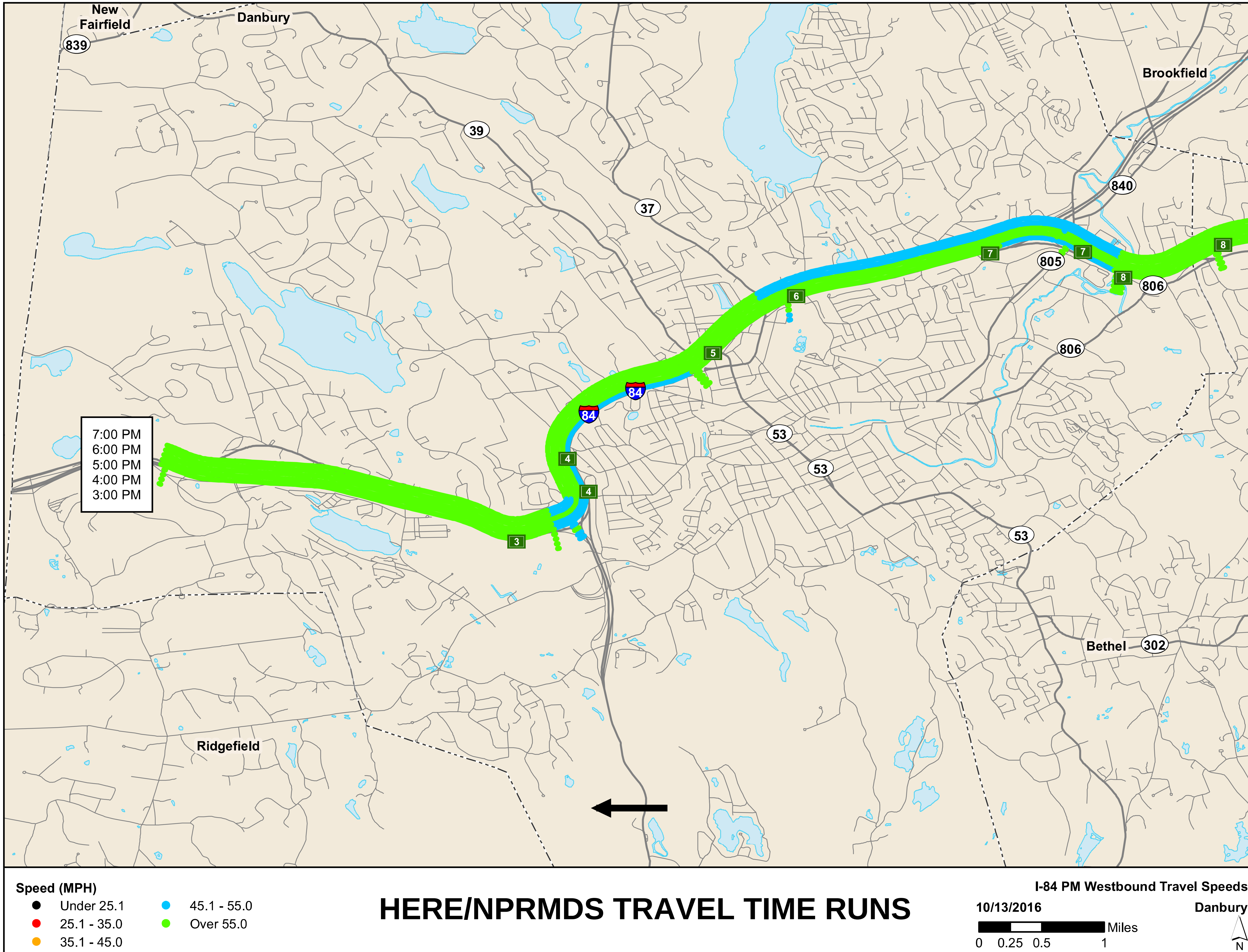
I-84 PM Eastbound Travel Speeds

10/14/2016

Danbury

0 0.25 0.5 1 Miles

N

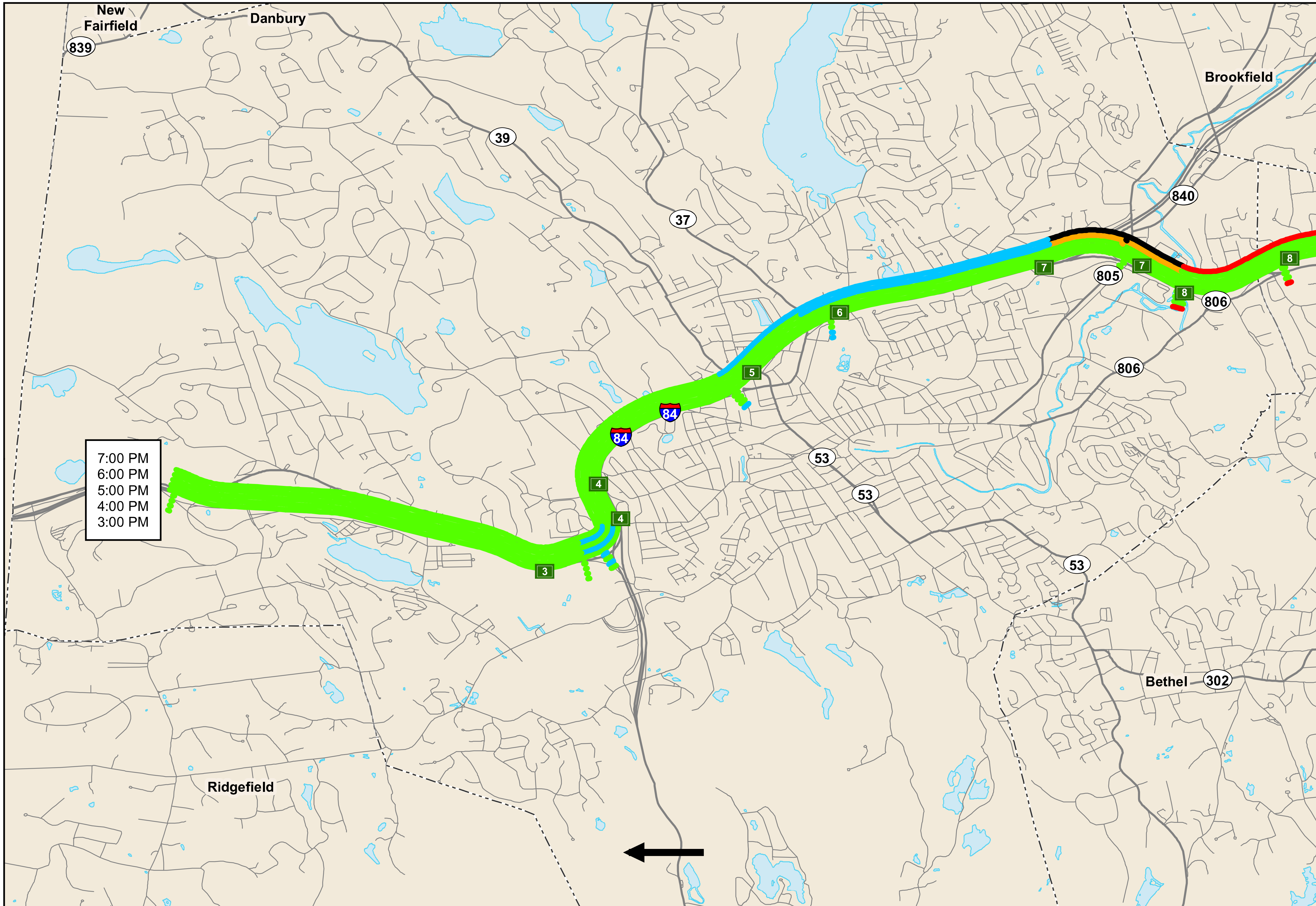


HERE/NPRMDS TRAVEL TIME RUNS

I-84 PM Westbound Travel Speeds

10/13/2016

Danbury



Speed (MPH)

- Under 25.1
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- 35.1 - 45.0
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- Over 55.0

HERE/NPRMDS TRAVEL TIME RUNS

I-84 PM Westbound Travel Speeds

10/14/2016

Danbury

Miles 0 0.25 0.5 1

N

TRAVEL DEMAND MODEL METHDOLOGY DOCUMENT

Model Development

The goal of developing a travel demand model for the study area is twofold: (1) to develop growth rates for I-84 and other local approach roads in Danbury and (2) developing localized travel patterns that can be used within the VISSIM traffic operations model developed for this study. The localized travel patterns within the operations model can be used to assess benefits of potential future improvements, particularly in terms of major weaving movements.

Connecticut Statewide Travel Demand Model

CTDOT maintains a statewide travel demand model that describes travel within the state. Within the currently adopted model, the state is divided into 1,806 traffic analysis zones (TAZ or "zones"). Within each zone, existing and future levels of population, household, and employment forecasts are used to estimate the number of trips generated by activities, and the relative amount of interaction between zones (for example, the number of commuters traveling from one zone to another zone). Travel to points outside of Connecticut are consolidated to 52 points representing access roads at the borders of the state, calibrated to observed traffic counts at these points.

Highway Network

CTDOT is also in the process of developing a new statewide model that covers an expanded area, incorporating parts of New York, Massachusetts, and Rhode Island. The new model uses the original zones within Connecticut from the existing statewide model, and adds zones in the adjacent states, for a total of 2,225 zones (See Figure 1). The expanded highway network allows traffic in the model to choose between the different routes that are available to travelers coming from outside the state, as traffic conditions change within the state. For example, depending on the destination within Connecticut, travelers originating from New York City or points west have the option of using I-95, Route 15(Merritt Parkway), or I-684/I-84.

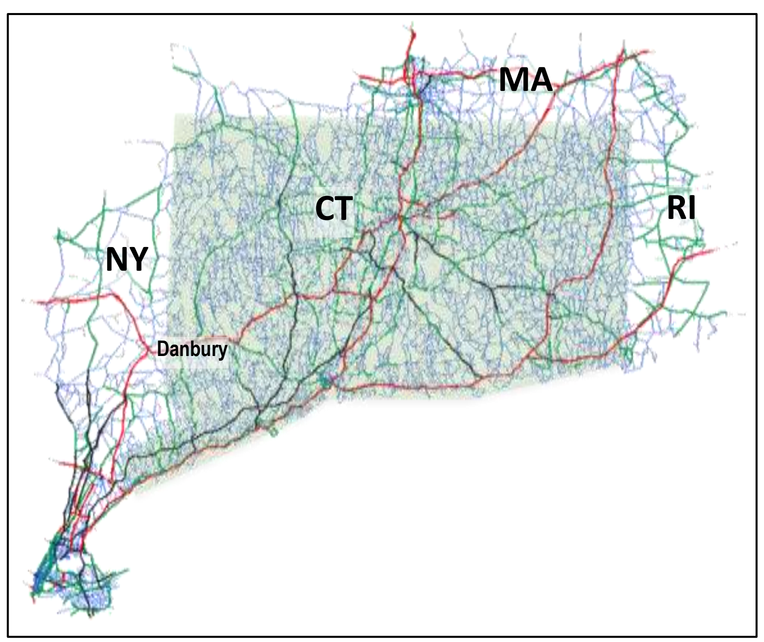

*Figure **Error! No text of specified style in document.**-1: New/Expanded Statewide Model Highway Network Coverage Area*

The new network includes a more detailed representation of the highway and street system, including interchange ramps and more local streets. Since the study area for this project, I-84 from Exit 3 to 8, is very close to the state border with New York, using the new/expanded highway network would provide the ability to assess the impacts of traffic shifting to I-84 with capacity improvements, and traffic shifting away from I-84 with construction. For these reasons, it was decided that the new/expanded highway network would be a good base from which to start for this study.

Adjustments to Trips

Within the travel demand model, the number of trips made on an average weekday by people traveling for work/commute and other purposes (e.g., shopping, personal business, social/recreational, among others), are summarized into trip tables, which are matrices that contain the estimated number of trips between an origin and a destination for all pairs of zones. Trips made by people are separated into trips made within motor vehicles (either alone or in a carpool) and trips made using transit, bicycle, and walk modes. Traffic is assigned to the highway network assuming that drivers prefer to minimize their travel time, and seek to use the fastest route between two zones. In the model, as more traffic uses a road, the speeds on that road decreases, and other routes become the preferred route. Trips are shifted back and forth between routes until an equilibrium is found.

For this study of I-84, the highway network for the new statewide model was available but the rest of the model, including trip tables, were not yet completed. The existing statewide model uses trip tables that represent the entire 24 hours of an average weekday and trips only go as far as the state borders. The new/expanded model will use smaller time periods but was not ready at the time of this study. Since, one of the goals of the model development for this study was to develop origin-destination travel patterns for the I-84 corridor that could be used as input to the traffic operations analysis, better representation of the directional peaking patterns for the AM and PM peak periods was needed. To this end, three levels of adjustments were made: (1) Divide the daily trip tables into small periods; (2) Expand the trip tables to encompass the geography covered by the expanded highway network; and (3) Disaggregate selected zones within the study corridor.

The steps in the process are shown in Figure 2. The green boxes in Figure 2 show the different source elements of the model: the existing statewide model, the expanded statewide model, and trip table data from the NYMTC travel demand model.

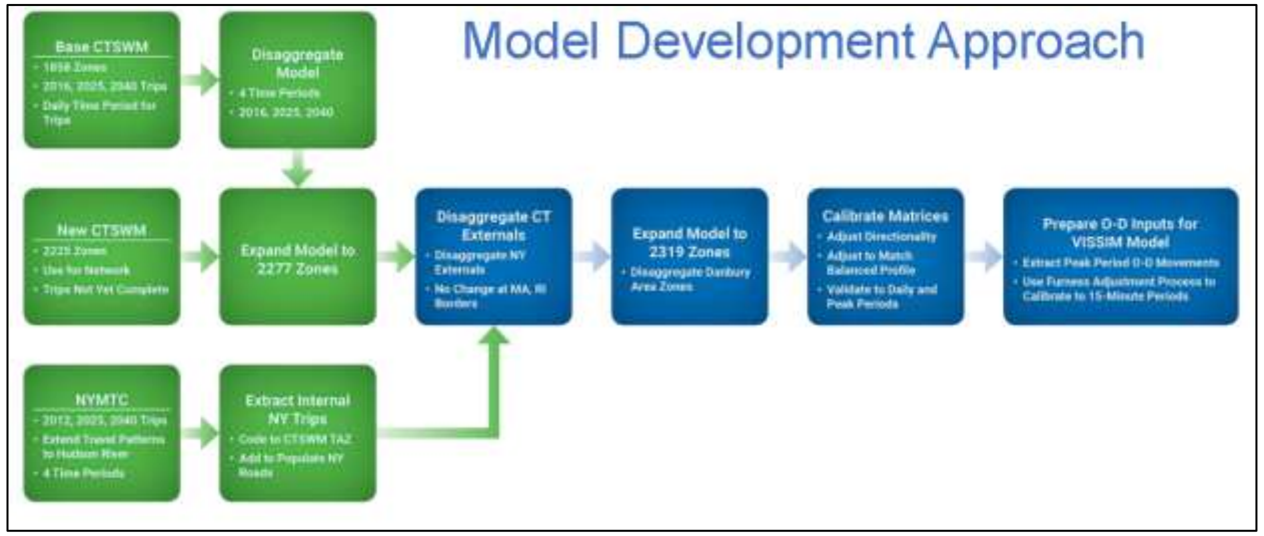

Figure -2: Trip Table Development Approach

Develop Peak Period Vehicle Trip Tables

The 24-hour/weekday trip tables representing motor vehicle travel in Connecticut were split into smaller time periods, representing the AM peak (6-9 AM), PM peak (4-7 PM), Midday (9AM-4PM), and Night (7PM-6AM), to match the periods used in the NYMTC model. Directional factors, or diurnal factors, were applied to each of these components of traffic from the statewide model: work/commute trips, nonwork trips, and non-home-based trips. Table 1 shows the factors that were applied to trips statewide. Since, the existing statewide model did not use diurnal factors, information from other travel demand models in the region, including New York Metropolitan Transportation Council's (NYMTC's) and the Capital Region Council of Governments' (CRCOG's) were reviewed, borrowed, and adjusted. The factors in Table 1 will be different from those that will ultimately be used with the final expanded statewide model when it is completed.

Table 1
Diurnal Factors

		Percent Occuring in Each Period			
Trip Purpose	Direction	AM (6AM-9AM)	Midday (9AM-4PM)	PM (4PM-7PM)	Night (7PM-6AM)
HBW	P-A	40.52	6.88	1.59	1.01
HBW	A-P	0.51	10.28	37.26	1.95
HBNW	P-A	7.93	22.62	12.11	7.34
HBNW	A-P	0.85	13.75	15.22	20.18
NHB	P-A	4.60	24.77	12.85	7.78
NHB	A-P	2.00	25.37	14.15	8.48

Notes:
HBW = Home-based work trips
HBNW = Home-based non-work trips
NHB = Non-home based trips
P-A = Production to attraction direction
A-P = Attraction to production direction

On I-84, the diurnal factors for the external station at the New York State border were developed to match the balanced traffic profile documented in Section 1 of the report. This ensured that the peak direction on I-84 would be westbound in the AM peak period and eastbound in the PM peak period.

Develop Expanded Geography for Trip Tables

The next step was to adapt the existing model's trip tables to the new highway network and expand its geographic coverage. At the Massachusetts and Rhode Island borders, additional stations were added to the network in the same location to replicate the existing external stations.

At the western border with New York, each of the external stations from the original CTDOT trip tables were disaggregated into zones in Westchester, Putnam, Dutchess, and New York City using data from the NYMTC model, which includes detailed representation of these areas. Since the NYMTC model already includes time-of-travel information, this disaggregation was conducted using different factors for the AM, Midday, PM, and Night model periods. This information had been obtained for a previous study of the I-95 corridor. Information for trips that stay entirely within New York State were also extracted from the NYMTC model and renumbered to match the CTDOT zone system within the area covered by the CTDOT expanded statewide model.

Disaggregate Zones in Study Area

Finally, the boundaries of existing zones in the I-84 corridor in Danbury were reviewed to identify large zones that would need to be disaggregated into smaller zones for this study. Zones that straddled both sides of the freeway, zones that were large enough to encompass multiple freeway interchanges, and zones that covered in areas with multiple but distinct approaches to the freeway were split. Finally, the highway network in the travel demand model was compared to the network coded for the VISSIM traffic operations model and zones were disaggregated as needed to ensure that there would be traffic assigned to all the roads included in the VISSIM model. Figure 3 shows the zones in Danbury that were disaggregated for this study, and the boundaries along which they were split. In Figure 3, the thick red lines are the city/town boundaries, and the thinner red lines show the boundaries of the zone system used for this study; zones of the same color show the extent of the original larger CTDOT model zone.

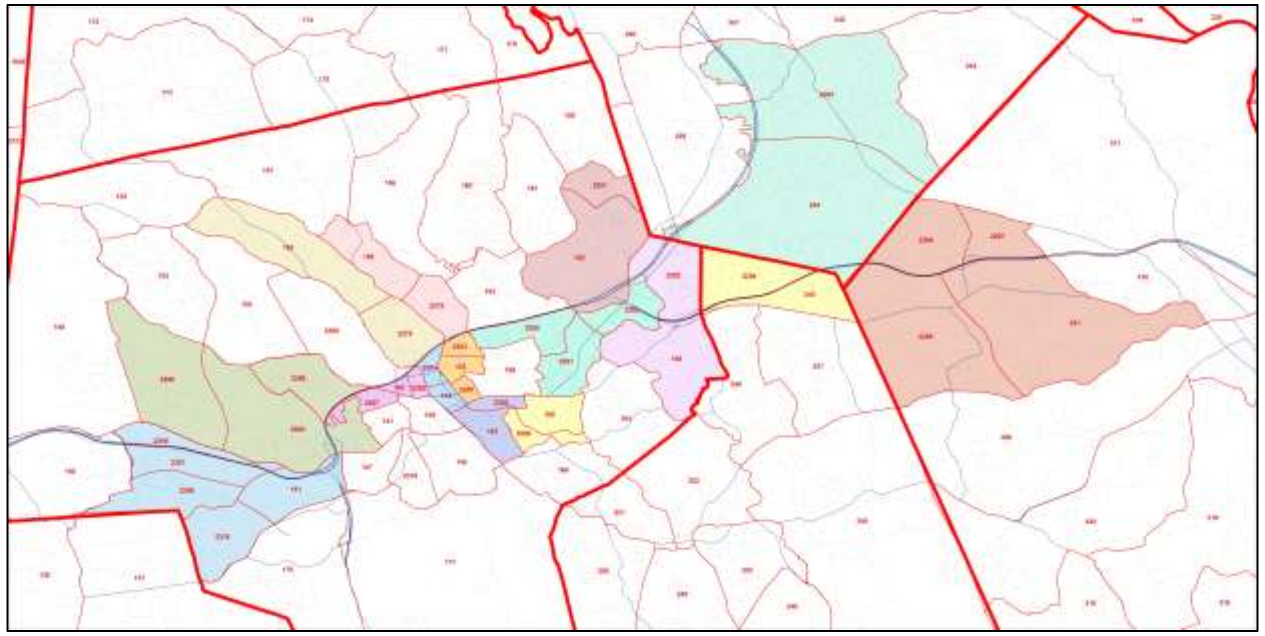

Figure-3: Disaggregated Zones in Danbury Area

Model Validation

The model validation effort was conducted at two levels – first, the daily traffic volumes assigned to links around the I-84 study area were checked to confirm that the changes made to the model did not adversely alter the model performance on these links; second, the peak period traffic volumes assigned to the links on I-84 mainlines and ramps were checked to confirm that the peaking patterns matched the balanced traffic profile.

Figure 4 shows the extent of four traffic cutlines used to compare daily traffic volumes in the study area before and after the model adjustments. A traffic cutline is an imaginary line that intercepts all traffic traveling on parallel roads. For example, in Figure 4, cutlines 1 and 2 cross all roads that carry traffic traveling in a north-south direction, approaching or departing from the I-84 corridor. Cutlines 3 and 4 cross I-84 and parallel roads, generally carry traffic traveling in an east-west direction.

Table 2 compares the daily traffic volumes assigned within the model on the four cutlines, before and after the model adjustments described herein, vs. total daily traffic counts. The results in Table 2 confirm that the daily traffic assigned within the modified model is similar to, or better than, the original model loadings within the CTDOT model. The modified model will be used to estimate growth in the corridor and its surrounding roadways.

Table 2
Model Validation for Cutlines

Cutline	Total Observed Weekday Volume	Original CTDOT Model	Percent Difference	Modified Danbury Model	Percent Difference
1: North of I-84	124,600	163,900	32%	159,500	28%
2: South of I-84	173,382	159,800	-8%	184,400	6%
3: West of Route 7	424,400	381,100	-10%	423,900	0%
4: East of Route 7	408,250	447,200	10%	451,900	11%

Table 3 compares the model assignment vs. the balanced traffic count profile for eastbound I-84 ramps and mainline links for the AM Peak, Midday, PM Peak, and Night analysis periods. Table 4 compares the same information for westbound links on I-84. Figure 5 compare the peak period and off-peak period traffic volumes assigned to I-84 vs. the balanced traffic profile. As shown, the modified model provides a reasonable estimate of the peak period traffic assignments from the basis of the origin-destination travel patterns used within the VISSIM model

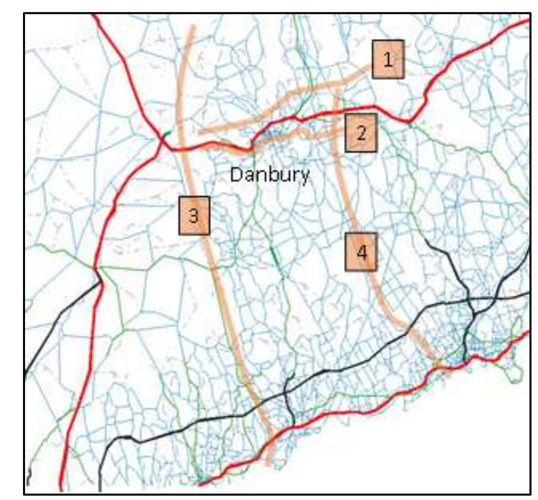

Figure 4: Cutline Locations

Table 3

Model Validation for Ramps and Mainlines - Eastbound I-84 Links

	AM Peak Period (6AM - 9AM)			Midday Period (9AM - 4PM)			PM Peak Period (4PM - 7PM)			Night Period (7PM - 6AM)			Daily		
Eastbound Links	Count	Model	Pct. Diff.	Count	Model	Pct. Diff.	Count	Model	Pct. Diff.	Count	Model	Pct. Diff.	Count	Model	Pct. Diff.
Mainline	**3,592**	**4,165**	**16%**	**10,734**	**11,880**	**11%**	**11,809**	**11,166**	**-5%**	**8,482**	**7,920**	**-7%**	**34,617**	**35,131**	**1%**
Exit 2 Off	607	578	-5%	1,132	1,087	-4%	1,114	1,168	5%	697	661	-5%	3,550	3,494	-2%
Exit 2 On	164	168	3%	841	841	0%	644	421	-35%	351	351	0%	2,000	1,781	-11%
Exit 2 On	1,157	784	-32%	2,290	1,673	-27%	2,197	2,261	3%	806	594	-26%	6,450	5,312	-18%
Mainline	**4,306**	**4,538**	**5%**	**12,733**	**13,307**	**5%**	**13,536**	**12,680**	**-6%**	**8,942**	**8,203**	**-8%**	**39,517**	**38,728**	**-2%**
Exit 3 Off	1,234	1,352	10%	3,067	3,458	13%	3,216	2,999	-7%	1,881	1,957	4%	9,397	9,766	4%
Exit 3 On	2,989	3,193	7%	7,409	8,250	11%	8,696	8,348	-4%	4,055	5,204	28%	23,150	24,995	8%
Mainline	**6,061**	**6,380**	**5%**	**17,076**	**18,099**	**6%**	**19,017**	**18,030**	**-5%**	**11,116**	**11,450**	**3%**	**53,270**	**53,959**	**1%**
Exit 4 Off	491	328	-33%	1,181	1,193	1%	1,340	1,796	34%	838	391	-53%	3,850	3,708	-4%
Exit 4 On	1,404	1,014	-28%	3,256	3,083	-5%	3,033	2,866	-5%	2,107	1,578	-25%	9,800	8,541	-13%
Mainline	**6,975**	**7,066**	**1%**	**19,151**	**19,989**	**4%**	**20,710**	**19,099**	**-8%**	**12,385**	**12,638**	**2%**	**59,220**	**58,792**	**-1%**
Exit 5 Off	1,795	1,874	4%	4,473	4,630	4%	4,685	3,993	-15%	2,697	2,463	-9%	13,650	12,960	-5%
Exit 5 On	1,701	1,892	11%	2,697	2,105	-22%	2,220	2,242	1%	1,282	1,266	-1%	7,900	7,505	-5%
Mainline	**6,881**	**7,084**	**3%**	**17,374**	**17,463**	**1%**	**18,245**	**17,348**	**-5%**	**10,970**	**11,441**	**4%**	**53,470**	**53,336**	**0%**
Exit6 On	1,916	1,870	-2%	3,239	3,688	14%	2,760	2,875	4%	1,586	1,588	0%	9,500	10,021	5%
Mainline	**8,796**	**8,954**	**2%**	**20,613**	**21,152**	**3%**	**21,005**	**20,223**	**-4%**	**12,556**	**13,029**	**4%**	**62,970**	**63,358**	**1%**
Exit 7 Off	2,750	2,759	0%	7,405	6,966	-6%	7,529	6,447	-14%	3,916	3,829	-2%	21,600	20,001	-7%
Exit 7 On	1,551	1,366	-12%	3,086	2,638	-15%	2,405	2,152	-11%	1,458	1,361	-7%	8,500	7,517	-12%
Mainline	**7,598**	**7,561**	**0%**	**16,295**	**16,823**	**3%**	**15,880**	**15,928**	**0%**	**10,097**	**10,561**	**5%**	**49,870**	**50,873**	**2%**
Exit 8 Off	2,815	2,899	3%	5,479	5,738	5%	4,497	4,396	-2%	2,609	3,008	15%	15,400	16,041	4%
Exit 8 On	805	839	4%	2,096	2,097	0%	2,106	2,208	5%	1,243	1,281	3%	6,250	6,425	3%
Mainline	**5,588**	**5,501**	**-2%**	**12,912**	**13,183**	**2%**	**13,489**	**13,740**	**2%**	**8,731**	**8,834**	**1%**	**40,720**	**41,258**	**1%**
Exit 9 Off	730	865	19%	1,439	3,012	109%	1,632	2,224	36%	899	1,928	114%	4,700	8,029	71%
Exit 9 On	819	1,035	26%	1,326	1,872	41%	1,364	1,753	29%	292	565	94%	3,800	5,225	38%
Mainline	**5,676**	**5,671**	**0%**	**12,799**	**12,043**	**-6%**	**13,221**	**13,269**	**0%**	**8,124**	**7,471**	**-8%**	**39,820**	**38,454**	**-3%**

Table 4

Model Validation for Ramps and Mainlines - Westbound I-84 Links

	AM Peak Period (6AM - 9AM)			Midday Period (9AM - 4PM)			PM Peak Period (4PM - 7PM)			Night Period (7PM - 6AM)			Daily		
Westbound Links	Count	Model	Pct. Diff.	Count	Model	Pct. Diff.	Count	Model	Pct. Diff.	Count	Model	Pct. Diff.	Count	Model	Pct. Diff.
Mainline	**10,403**	**11,479**	**10%**	**13,907**	**13,907**	**0%**	**9,828**	**11,462**	**17%**	**7,514**	**7,512**	**0%**	**41,653**	**44,360**	**6%**
Exit 9 Off	1,375	1,458	6%	2,010	2,010	0%	1,209	2,040	69%	628	923	47%	5,222	6,431	23%
Exit 9 On	1,484	1,123	-24%	2,345	2,345	0%	1,231	1,763	43%	652	789	21%	5,712	6,020	5%
Mainline	**10,513**	**11,143**	**6%**	**14,242**	**14,242**	**0%**	**9,851**	**11,185**	**14%**	**7,538**	**7,378**	**-2%**	**42,143**	**43,948**	**4%**
Exit 8 Off	2,115	1,800	-15%	2,693	2,693	0%	1,722	1,651	-4%	1,274	1,259	-1%	7,804	7,403	-5%
Exit 8 On	2,951	2,488	-16%	5,263	5,263	0%	4,355	4,324	-1%	3,432	3,310	-4%	16,001	15,385	-4%
Mainline	**11,348**	**11,831**	**4%**	**16,812**	**16,812**	**0%**	**12,484**	**13,858**	**11%**	**9,696**	**9,428**	**-3%**	**50,340**	**51,929**	**3%**
Exit 7 Off	1,353	1,443	7%	3,337	3,337	0%	2,499	1,748	-30%	1,311	1,218	-7%	8,499	7,746	-9%
Exit 7 On	5,577	5,636	1%	8,459	8,459	0%	6,577	6,271	-5%	3,965	3,857	-3%	24,578	24,223	-1%
Mainline	**15,572**	**16,024**	**3%**	**21,934**	**21,934**	**0%**	**16,562**	**18,381**	**11%**	**12,350**	**12,067**	**-2%**	**66,418**	**68,406**	**3%**
Exit 6 Off	2,042	2,004	-2%	3,873	3,873	0%	2,929	3,225	10%	1,669	1,694	2%	10,512	10,796	3%
Mainline	**13,530**	**14,021**	**4%**	**18,060**	**18,060**	**0%**	**13,633**	**15,156**	**11%**	**10,682**	**10,373**	**-3%**	**55,905**	**57,610**	**3%**
Exit 5 Off	1,571	1,987	26%	3,146	3,146	0%	2,977	3,625	22%	1,923	2,351	22%	9,617	11,109	16%
Exit 5 On	3,801	3,189	-16%	4,764	4,764	0%	3,325	3,492	5%	2,288	3,109	36%	14,178	14,554	3%
Mainline	**15,760**	**15,223**	**-3%**	**19,679**	**19,679**	**0%**	**13,981**	**15,022**	**7%**	**11,047**	**11,131**	**1%**	**60,467**	**61,055**	**1%**
Exit 4 Off	1,572	1,254	-20%	2,666	2,666	0%	2,431	1,982	-18%	1,422	1,355	-5%	8,090	7,257	-10%
Exit 3 Off	5,825	5,919	2%	7,300	7,300	0%	4,910	5,498	12%	3,437	3,479	1%	21,472	22,196	3%
Exit 4 On	1,008	1,294	28%	850	850	0%	592	610	3%	458	366	-20%	2,908	3,120	7%
Mainline	**9,372**	**9,343**	**0%**	**10,562**	**10,562**	**0%**	**7,232**	**8,152**	**13%**	**6,647**	**6,664**	**0%**	**33,812**	**34,721**	**3%**
Exit 3 On	1,110	1,343	21%	3,053	3,053	0%	2,688	1,724	-36%	1,450	1,552	7%	8,301	7,672	-8%
Mainline	**10,482**	**10,686**	**2%**	**13,615**	**13,615**	**0%**	**9,920**	**9,876**	**0%**	**8,097**	**8,216**	**1%**	**42,113**	**42,393**	**1%**
Exit 2 Off SB	1,442	1,380	-4%	1,112	1,112	0%	625	630	1%	463	472	2%	3,642	3,594	-1%
Exit 2 Off NB	749	708	-5%	1,543	1,543	0%	1,082	1,071	-1%	623	627	1%	3,997	3,949	-1%
Exit 2 On	543	529	-3%	1,099	1,099	0%	1,161	1,134	-2%	601	576	-4%	3,403	3,338	-2%
Mainline	**8,834**	**9,128**	**3%**	**12,059**	**12,059**	**0%**	**9,373**	**9,310**	**-1%**	**7,612**	**7,693**	**1%**	**37,878**	**38,190**	**1%**

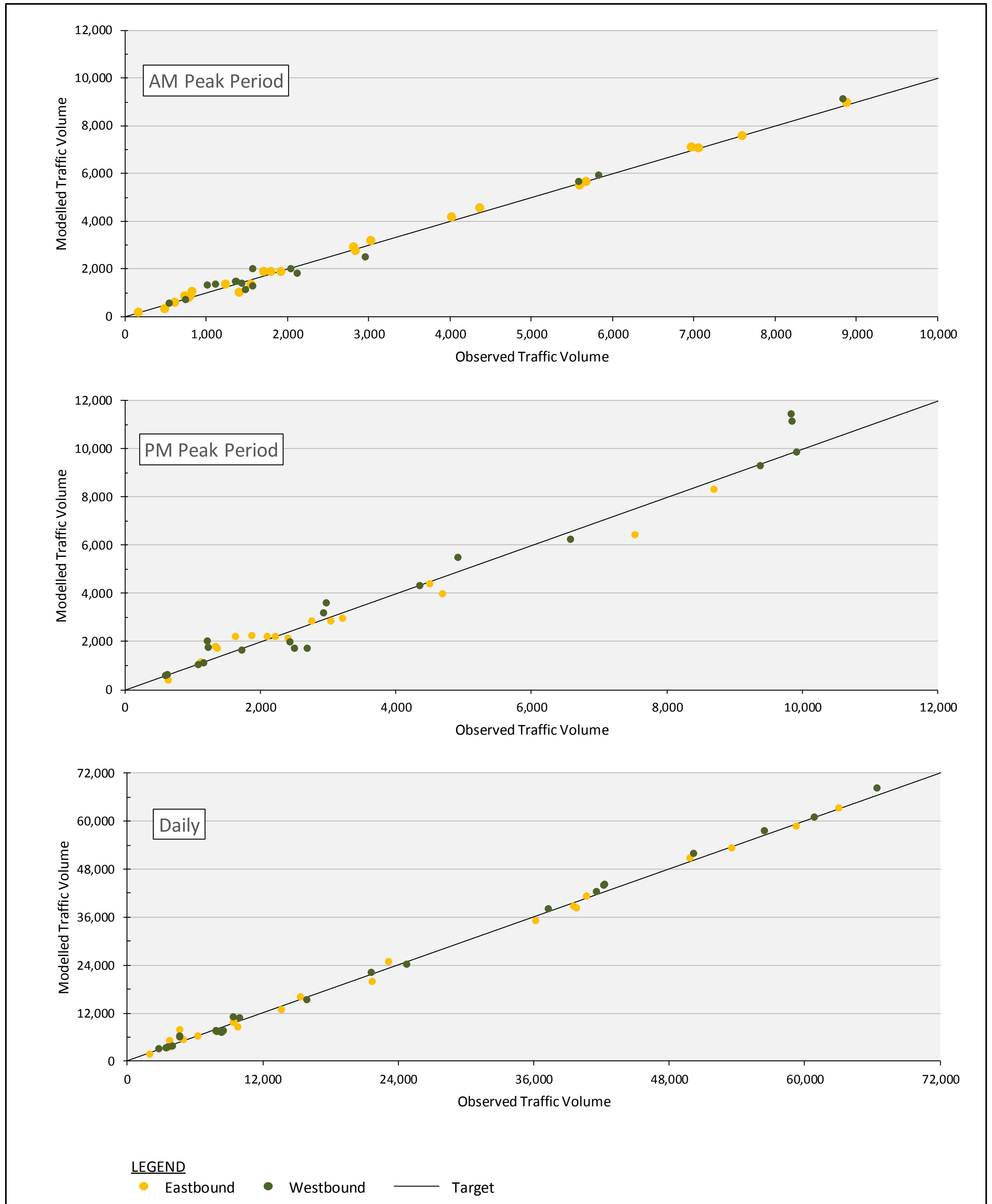

Figure 5: Comparison between Model and Observed Traffic Volume on I-84

Forecasted 2040 Traffic Volumes

Forecasted traffic volumes for the I-84 study area were developed by overlaying growth from the CTDOT statewide regional model on the balanced traffic profile developed for this study. CTDOT maintains a 2040 forecast year for the statewide model for air quality conformity, planning and programming purposes. Trip tables for 2040 are available at weekday levels for cars and trucks; developed in the same way as the base year 2016 trip tables. For this study, the process, described earlier, used to split into smaller time periods and to disaggregate zones into smaller zones, and merge trip information from the NYMTC model was applied at 2040 levels.

Calibration adjustments made to the 2016 trip tables in the I-84 study area were carried forward into 2040. These trip tables were assigned to the regional highway network and compared to similar runs at 2016 levels to estimate the amount of growth at each interchange along I-84. The daily traffic growth was divided into peak and offpeak period growth and then further divided among the different hours that comprise the AM and PM peak periods.

Table 5 shows the growth along four cutlines that cover the study area. As shown, the average annual growth between 2016 and 2040 is in the range of 0.6% to 0.8% per year on roads in the Danbury area leading to/away from I-84 (cutlines 1 and 2) and 0.5% per year or lower on east-west roads that parallel I-84, including, Route 15, and I-95. This is consistent with the development patterns in this part of the state, with more mature development patterns.

Table 5
Daily Traffic Growth at Cutlines

Cutline	AverageWeekday Traffic 2016	2040	Total Growth	Average Annual Percent Growth
1: North of I-84	159,500	191,400	31,900	0.8%
2: South of I-84	184,400	212,900	28,500	0.6%
3: West of Route 7	423,900	458,900	35,000	0.3%
4: East of Route 7	451,900	503,600	51,700	0.5%

The Technical Appendix and the Report show daily and peak hour volumes on I-84 between Exits 3 and 9. On average, the mainline volumes on I-84 are forecasted to increase by about 15 percent between 2016 and 2040, for an average annual percent growth of 0.6% per year, with slightly higher growth occurring at the east end of the project area, where existing volumes are lower, and slightly lower growth occurring at the west end of the project area, where existing volumes are higher and existing development patterns are more dense.

Extract Origin-Destination Patterns and Prepare Inputs for VISSIM Model

In addition to splitting zones, the highway network used in the travel demand model was checked and coded to ensure that links corresponding to the VISSIM model, including links where traffic counts were conducted, were present. Once the peak period models were validated, origin-destination patterns within the I-84 study area were extracted, including freeway ramp-to-ramp movements as well as local street patterns around each interchange. While the model refinements made for this study provide a good estimate of travel patterns on I-84, a travel demand model such as the CT statewide model is not sufficiently detailed to replicate patterns at the local street level.

The origin-destination patterns extracted from the model were used as an initial seed matrix into a matrix calibration process that adjusted movements to match balanced peak hour and peak period traffic volumes at each ramp, ramp termini, and local intersection. The seed matrix from each peak period was factored to an average 15-minute volume and adjusted to match the balanced 15-minute demand estimates for the corridor, creating 12 origin-destination matrices for the AM peak period (3 hours) and 16 matrices for the PM peak period (4 hours). In the adjustment process, priority was given to the turning movements at ramp termini and ramp and mainline volumes on I-84; local street movements were then used to fulfill turning movement targets at local street intersections.

VISSIM SIMULATION MODEL METHDOLOGY DOCUMENT

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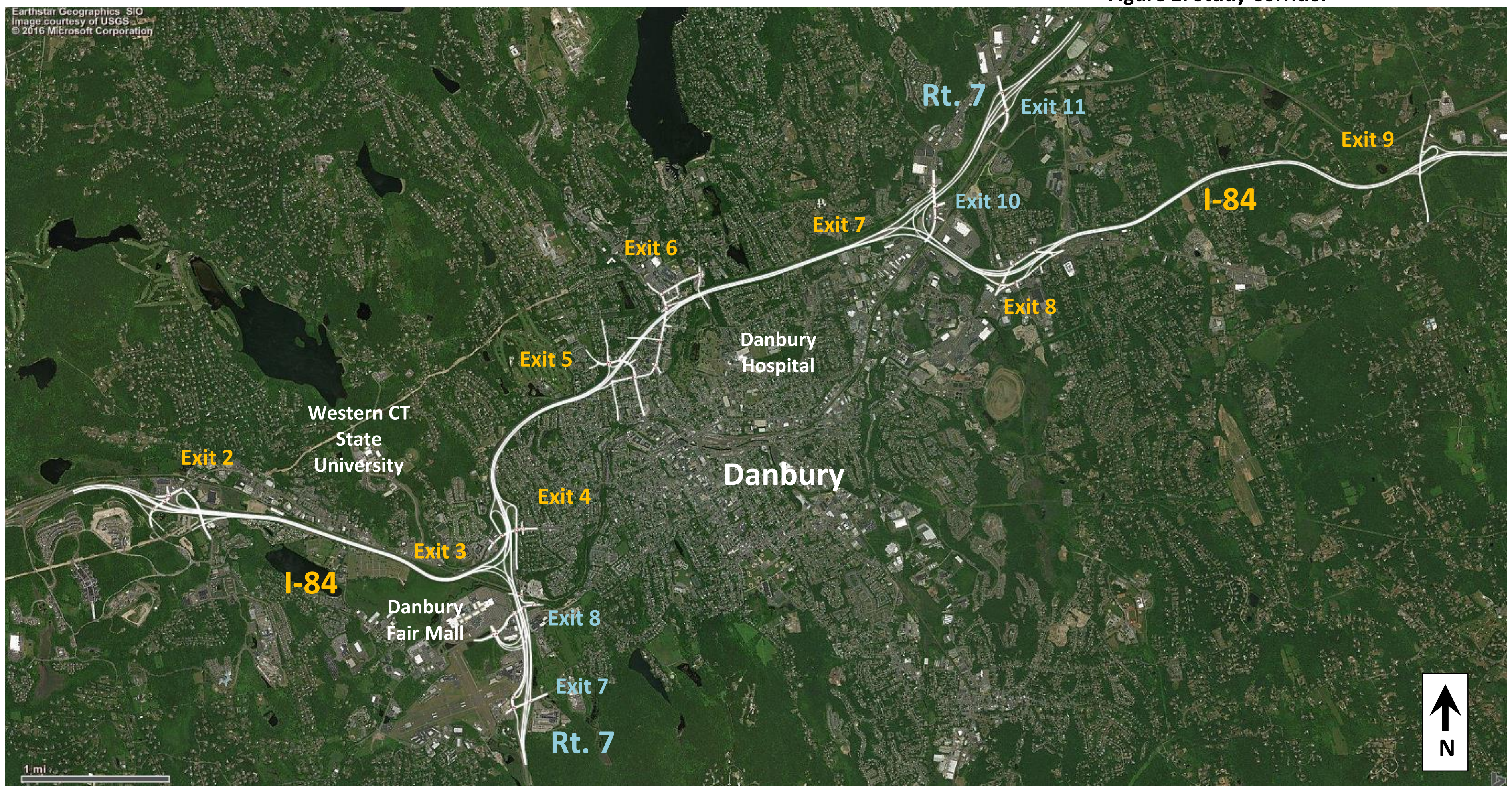
1 Introduction

This report documents the components of the VISSIM model development and calibration process for the I-84 Danbury project and provides a summary of validation results. VISSIM models of the 2016 Existing AM and PM peak period traffic conditions were developed and validated to better understand existing travel patterns and issues along the 5.5-mile I-84 study corridor. The models will also serve as the basis for analyzing 2040 no-build traffic conditions and future traffic improvements needed to meet mobility needs in this corridor.

Extensive data collection was undertaken to calibrate and validate the simulation models to reflect existing traffic conditions. The VISSIM data collection needs for model development are discussed in Section 3.0 below. The procedure for calibrating the peak period traffic simulation models involved comparing the model results to field data that included link traffic volumes, vehicle queue lengths, travel times, and average speed. The calibration goals and how they were achieved are discussed in Sections 4.0 and 5.0.

The project limits begin just beyond the I-84 Exit 3 interchange with Route 7 to the Exit 8 interchange with Newtown Road. This section of I-84 is approximately 5.5 miles in length. The VISSIM model was extended to include west of Exit 2 and east of Exit 9 on I-84 and from Exit 7 to Exit 11 on Route 7 in order to effectively populate the model. Figure 1 illustrates the project study corridor modeled in VISSIM.

Figure 1: Study Corridor



2 Background

Simulation modeling is a useful tool for assessing design improvements to the roadway system. Simulation models enable engineers to evaluate future traffic operations of a proposed roadway redesign/alignment before it is implemented and the model outputs help in evaluating the potential merits and demerits of design options. Models are developed to reasonably estimate the future system response by calibrating to existing traffic conditions. Calibration is a process of adjusting model parameters so that simulated response are representative of measured field conditions.

Traffic simulation may be macroscopic or microscopic. Macroscopic models describe the traffic process with aggregate quantities, such as flow and density. Microscopic models describe the behavior of the individual drivers in response to their perceived environments. The aggregate response in the latter case is the result of interactions among many driver/vehicle entities. Microscopic models are helpful in capturing the more detailed aspects of the system (e.g., traffic congestion operations at a network bottleneck).

VISSIM was selected as the microsimulation modeling tool for the study of the I-84 Danbury project. VISSIM is a stochastic traffic simulator that uses the psycho-physical driver behavior model developed by R. Wiedemann. VISSIM combines a perceptual model of the driver with a vehicle model. Every driver with his/her specific behavior characteristics is assigned to a specific vehicle; as a result, the driver behavior corresponds to the technical capabilities of his vehicle.

The behavior model for the driver involves a classification of reactions in response to the perceived relative speed and distance with respect to the preceding vehicle. Drivers can make the decision to change lanes that can either be forced by a routing requirement, or made by the driver in order to access a faster-moving lane.

Four driving modes are defined: free driving, approaching, following, and braking. In each mode, the driver behaves differently, reacting either to his following distance, or trying to match a prescribed target speed. More detailed descriptions of the VISSIM model are provided in the VISSIM User Manual – Version 8.00.

VISSIM was selected for analysis of the I-84 study corridor due to its modeling capabilities that can simulate unique operational conditions, merging/diverging vehicle movements, and traffic weaving areas. VISSIM also has 3D visualization capabilities, which make it easier to visualize design options for the project team and is a valuable resource for stakeholder engagement during public presentations.

3 Data

The VISSIM model setup requires the input of geometric, traffic control, and traffic flow data for the study corridor. Key VISSIM inputs obtained from the traffic data collection effort and field observations that were used for model development are discussed below.

3.1 Geometric Data

Geometric features that are incorporated in the VISSIM model include the number of lanes, lane additions, lane drops, auxiliary lanes, highway curvature, and intersection geometry. Geometric information for the I-84 Danbury study was obtained from aerial photographs provided in VISSIM by Microsoft Bing Maps, field observations, and available intersection layouts. Lane configurations were initially developed from signal timing sheets or aerial photographs and then confirmed or revised based on field observations.

3.2 Traffic Control Data

Traffic signal timing information was incorporated into the VISSIM model based on information from the traffic signal timing sheets obtained from the Connecticut Department of Transportation and the City of Danbury. The location of intersection controls were identified using aerial photography and confirmed during field visits. The posted speed limits for the study area roadways were also collected during field visits.

3.3 Traffic Flow Data

Traffic flow data relevant to microsimulation model development includes:

- Intersection turning movement counts at signalized intersections and major unsignalized intersections.
- East and westbound I-84 travel time data.
- Observations of congestion along the corridor and queue length observations at signalized intersections.
- Study area Travel Demand Model traffic volumes and origin-destination data (a detailed explanation of the development process and validation is provided in the Technical Appendix).

4 Calibration Goals

The traffic model calibration objective was to reasonably simulate existing traffic operations so that model performance estimates are representative of field measured conditions. There are no universally accepted procedures for conducting calibration and validation for complex transportation networks. The responsibility lies with the modeler to implement a suitable procedure which provides an acceptable level of confidence in the model results. During VISSIM calibration, model outputs were compared against field data to determine if the outputs were within acceptable levels. Validation criteria used for this study were based on suggested calibration targets established by the Federal Highway Administration (FHWA).

The calibration goals included:

- Goal 1: Model link versus observed flows to meet the following criteria:
  - Link volumes for more than 85 percent of cases to be:
    - Within 100 vph, for volumes less than 700 vph
    - Within 15 percent, for volumes between 700 vph and 2,700 vph
    - Within 400 vph, for volumes greater than 2,700 vph
  - GEH statistic[1] to be less than 5 for more than 85 percent of individual link flows
- Goal 2: Model link versus observed travel time to meet the following criteria:
  - Average travel time to be within 15 percent (or one minute, if higher) for I-84 segments

5 VISSIM Model Development

The roadway network was originally traced over a scaled aerial photograph imported into VISSIM. The number of lanes, location of lane additions and drops, intersections, and other roadway geometric features were confirmed by field visits. Additional details were incorporated into the VISSIM network (i.e., posted speed limits, traffic signal timing, etc.) to better reflect field conditions. In addition, driver behavior parameters, such as driver aggressiveness, and saturation flow rates were calibrated based on field observations.

[1] The GEH statistic is a formula used to compare two sets of traffic volumes, frequently used in traffic modelling. The GEH formula is similar to a chi-squared test, but is not a true statistical test. It is an empirical formula to compare the hourly traffic volume from the traffic model versus the hourly traffic volume of actual count data.

Not all default VISSIM input parameters were determined to accurately represent study area conditions and required adjustments to better replicate existing conditions. Therefore, different driver behavior parameters were adjusted in the peak period to achieve realistic queuing and congested traffic conditions.

Model parameters related to the physical attributes of the VISSIM model development are listed in Sections 5.1 and 5.2 and are assigned for each vehicle type. As a standard traffic modeling procedure, once the vehicle population has been defined, the simulation should be tested with the default Driver Behavior Parameters, which defines the global calibration step in microsimulation modeling. This initial calibration is performed to identify the values for capacity adjustment parameters that cause the model to best reproduce field observed traffic capacities and operations.

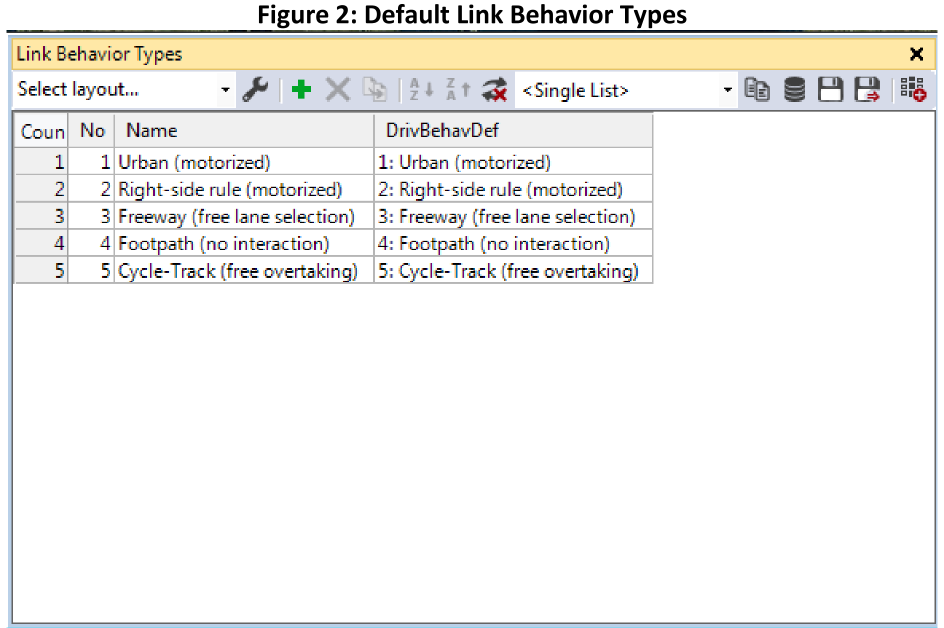
The initial VISSIM model calibration indicated that certain bottleneck locations and congested sections failed to reproduce field observations with default driver behavior settings. Consequently, fine tuning of the model was necessary, which was achieved by modifying Driver Behavior Parameters that influence capacity. Section 5.3 of this reports describes the model fine tuning adjustments.

5.1 Network Coding

VISSIM uses a link-connector network structure. A link cannot have multiple sections with a different number of travel lanes; therefore, multiple links need to be created for each roadway section.

Several link types are defined in VISSIM by default and each link type controls the driving behavior. These default link types are presented in Figure 2 and a detailed discussion of these link types and associated driving behaviors is provided in Section 5.3.

Figure 2: Default Link Behavior Types



Coun	No	Name	DrivBehavDef
1	1	Urban (motorized)	1: Urban (motorized)
2	2	Right-side rule (motorized)	2: Right-side rule (motorized)
3	3	Freeway (free lane selection)	3: Freeway (free lane selection)
4	4	Footpath (no interaction)	4: Footpath (no interaction)
5	5	Cycle-Track (free overtaking)	5: Cycle-Track (free overtaking)

Lane changing behavior of vehicles following their route was modeled using lane change and emergency stop parameters for connectors. For lane changes at intersections, at least 20 feet of emergency stop distance was used. This distance defines the last possible position for a vehicle to change lanes; (i.e., if a vehicle could not change lanes due to high traffic flows but needs to stay on its route, it will stop at this position to wait for an opportunity to change lanes). Also, care was taken that the lane changing distance (distance at which vehicles begin to attempt to change lanes) was greater than the storage length of the turn lane itself to help achieve the correct lane utilization at the approach to these locations.

5.2 Traffic Coding

Default vehicle types (Car, HGV (truck), Bus, Tram (transit), Bike, and Pedestrian) may be used to define traffic composition in VISSIM. A user may also define its own vehicle types. For this project, the default vehicle types of Car and HGV (truck) were utilized.

A single vehicle type shares common vehicle performance attributes. These attributes include model, acceleration/deceleration, weight, power, and length. The functions and distributions of the Car and Heavy Goods Vehicle types are presented in Figure 3 and

Figure 4, respectively. The HGV type was assumed to have a slower acceleration and higher weight than a typical passenger car.

Figure 3: Car Vehicle Type Functions & Distributions

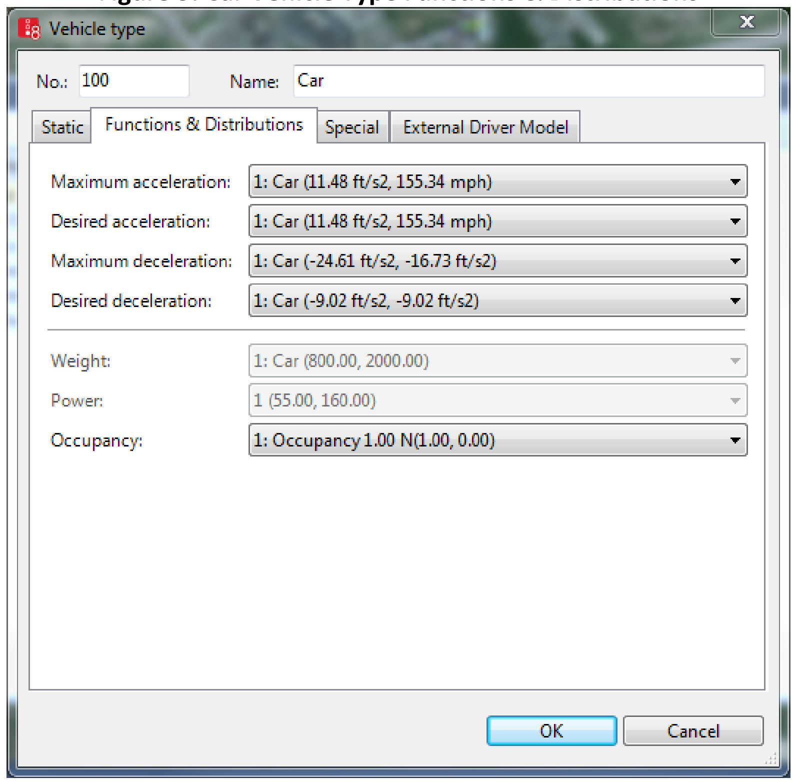
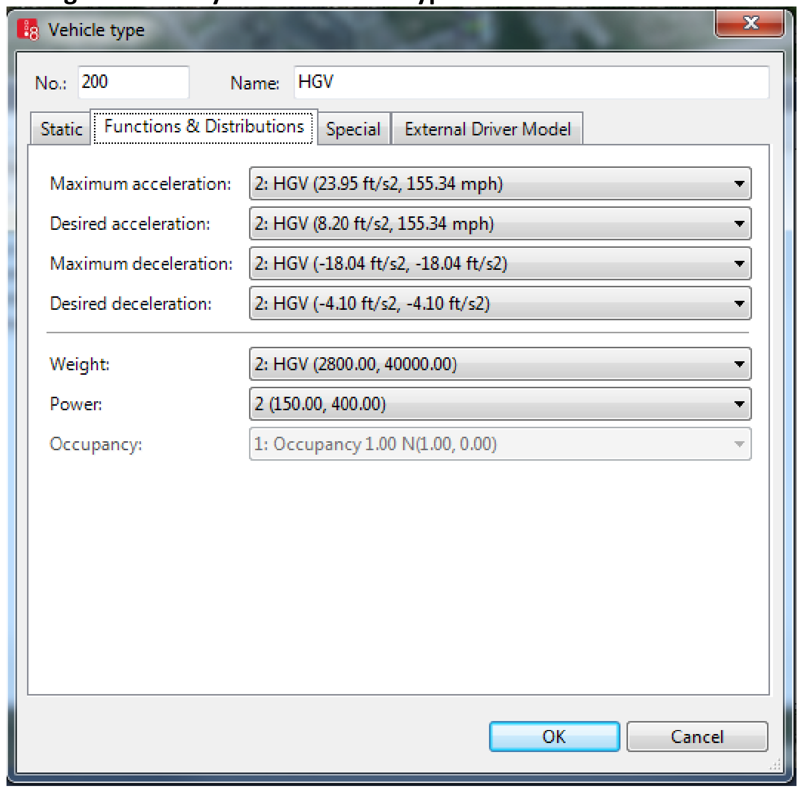


Figure 4: Heavy Goods Vehicle Type Functions & Distributions



Traffic Assignment or Routing

VISSIM traffic assignments use Routing Decisions. A route is a fixed sequence of links and connectors from the routing decision point to one or multiple destinations. Each vehicle input source (e.g., I-84, Route 7, and local streets) has a routing decision point (origin). Routes extend from the origin point to each ultimate destination in the network resembling a “tree and its branches.” No vehicles are taken out or added to the network automatically; therefore, it is important that balanced volume flows are entered. The routing distribution assigned in VISSIM is an output of the Travel Demand Model.

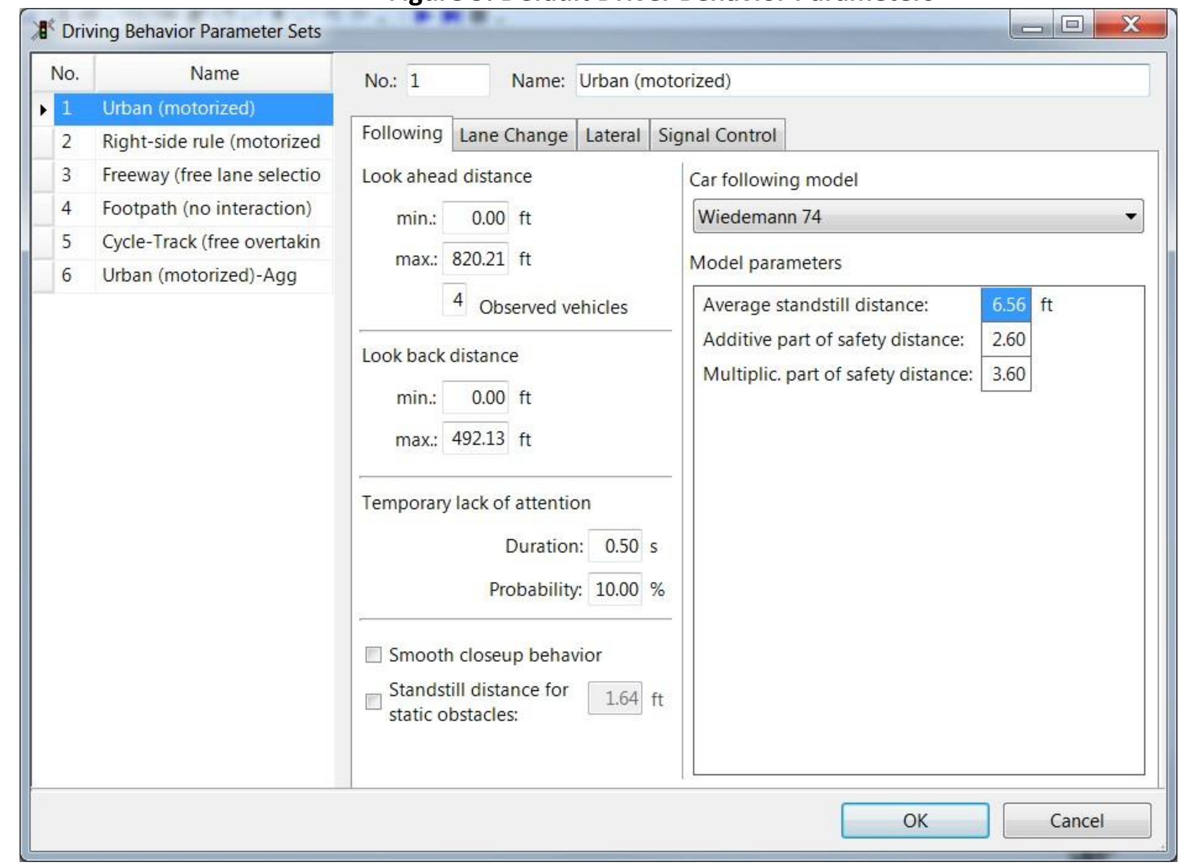
Speed Distributions

The desired speed for a vehicle type at any location in the model network is defined as a distribution rather than a fixed value in order to better reflect the stochastic nature of traffic. The speed distribution is an important parameter that has a significant influence on roadway capacity and achievable travel speeds. Posted speed limits were used as a basis to generate speed distributions.

5.3 Driver Behavior Parameters

The driver behavior in VISSIM is modeled through the car-following and lane-change models. The driving behavior is assigned to each link by its link type. For each vehicle class, a different driving behavior parameter set may be defined. By default, six parameter sets are predefined and are presented in Figure 5 (numbers 1 to 6).

Figure 5: Default Driver Behavior Parameters



Links with modified driver behavior parameters had to be defined to reproduce existing traffic conditions. No correlation was assumed between vehicle type and the driver behavior. Drivers were assumed to behave differently for different roadway geometries, such as for curved sections or sections with inadequate sight distance as compared to straight sections. Thus, the parameters described here apply equally to all vehicle types, but were adjusted for each link type.

Car-Following Model

VISSIM includes two car-following models – urban driver and freeway driver. The car-following model of the urban driver model is named Wiedemann74 with three tunable parameters and the freeway driver is named Wiedmann99 with ten tunable parameters. These parameters can be adjusted as needed to better reflect existing driving behaviors. In addition to other parameters, such as vehicle speed, heavy vehicle percentage, and number of lanes, the car-following parameters effectively change roadway capacity, vehicle spacing, and headways.

The car-following parameters adjusted during the calibration process for freeways were modified based on previous experiences with similar type of networks and operations, engineering judgment, and field observations. These parameters were typically adjusted if a field condition (i.e., poor vertical sight distance, short weaving areas, etc.) warranted a change from VISSIM default parameters. Five of the car-following parameters that are the most sensitive for calibration and modified in this model include:

- CC0 – Standstill Distance is defined as the desired distance between stopped cars. This parameter is typically used to increase or decrease vehicle spacing while vehicles are in queue and is used during calibration to affect queue duration and length.
- CC1 – Headway Time is not a direct measure of headway time but rather a factor that affects the following (minimum desired safety) distance. The higher this value, the more cautious the driver is;

thus reducing capacity. The car-following distance has the strongest influence on capacity for high-volume links and based on the default VISSIM parameters (including CC1), the capacity of an urban freeway link is approximately 1900 vehicles/hour/lane (vphpl). CC1 was adjusted from 0.90 seconds to values ranging from 0.8 to 1.5 seconds.

- CC2 – Following Variation is the longitudinal oscillation and how much more distance than the desired safety distance a driver allows before moving closer to the vehicle in front. CC2 values were adjusted to range from 13.12 to 29.99 ft.
- CC4 – Negative 'Following' Threshold defines the negative speed differential during the following state. Smaller values result in more sensitive reactions to speed changes of preceding vehicles and the vehicles are more tightly coupled. CC4 was adjusted from 0.35 m/s to values ranging from -0.35 to -1.0 m/s.
- CC5 – Positive 'Following' Threshold control speed differential during the following state. Smaller values result in more sensitive reactions to speed changes of preceding vehicles and the vehicles are more tightly coupled. CC5 was adjusted from 0.35 m/s to values ranging from 0.35 to 1.0 m/s (the positive value of CC5 corresponds to the negative value of CC4).

Lane-Change Distance

Lane-change look-back distances is the distance in the VISSIM model where a vehicle will start attempting to make a lane change to a target lane prior to an off-ramp, a lane drop, or change in travel direction. This lane-change distance is a parameter on every connector in the VISSIM network and the default value is 656 feet. This distance is typically acceptable for low speed, intersection turning movements; however, it would provide challenging lane changing behavior for freeway diverges and lane drops. The lane-change distance for diverges and lane drops in the VISSIM model was modified to match the goal of calibrating existing queues, speeds, and travel times within the study area.

Lane-Change Parameters

VISSIM also includes a different set of parameters which govern how vehicles change lanes as they travel between their origins and destinations. VISSIM includes parameters for necessary (in order to make a turning movement) and discretionary lane changes (for more room/higher speed).

The model's lane-change parameters were modified from default values in order to better reflect existing lane-change behavior. Most of the model modifications occurred at high-volume merges or at major freeway diverges. Following are the three main parameters that were adjusted.

- Necessary Lane-Change Decelerations: the maximum deceleration and accepted deceleration (normal) of both the lane-changing vehicle and the trailing vehicle (non-lane changing) can be modified to allow for more aggressive lane changing behavior. By providing higher deceleration values, vehicles have the ability to make more aggressive lane changes. In some cases, if these values are not modified, an unrealistic behavior will occur and vehicles desiring to make a lane change will reach an "emergency stop position." The vehicle will effectively stop in the middle of the facility until an adequate gap appears and they can finish the lane-change maneuver.
- Safety Distance Reduction Factor is used to reduce the safety distance between two vehicles. The default value is 0.60. A smaller value results in a shorter safety distance during a lane change, thus vehicles will merge into smaller gaps compared to default conditions. After the lane change occurs, the original safety distance is taken into account again.
- Maximum Deceleration for Cooperative Braking defines if a trailing vehicle will start cooperative breaking to allow a leading vehicle to change from an adjacent lane. If the trailing vehicle determines that it would have to break with a higher deceleration than this value, it will not start or continue cooperative breaking. A higher value will result in more cooperative breaking and the potential for more discretionary lane changes to occur.

In areas where significant lane-change conditions were identified, default driving behavior was adjusted in the model to account for more aggressive and/or cooperative lane-change-behavior drivers. Adjustments in the lane-change parameters were used to better replicate actual driver behavior under congested and severe weaving conditions in the simulation model.

It is important to note that many of these changes are link specific to account for the variations in geometric and accompanying driver behaviors along the corridor. Furthermore, values may differ between the AM and PM peak hours since motorists will change their lane-change aggressiveness based on prevailing traffic conditions.

6 Random Seed Variations

Once the calibrated model was established, the calibrated parameter set was run with three different random seeds. The random seed affects the realization of the stochastic quantities in VISSIM, such as inlet flows and vehicle capabilities. The three runs were shown to produce similar results that met the calibration targets and the results presented in Section 7.0 were based on the seed "48" run.

7 Results

An iterative process of making adjustments in the model and comparing the VISSIM data outputs to the field collected data was conducted until calibration targets were met. This section describes the results of the calibration process to meet the goals for the I-84 study area.

7.1 Goal 1: Model link versus observed flows to meet criteria

The initial calibration target was to match the modeled hourly flows of the VISSIM model with the observed hourly flows, meeting specific criteria detailed in Section 4 for at least 85% of link flows. A comparison between modeled and observed volumes was also made using the GEH statistic, a calculation similar to a chi-squared test.

The results listed in Table 1 and Table 2 demonstrate that threshold criteria were met for both the AM and PM peak periods, respectively.

Table 1: Calibration Volume Acceptance Targets – AM Peak Period

Criteria and Measures	Calibration Acceptance Targets	Met Target
Hourly Flows – Model vs. Observed		
Within 100 veh/h, for Flow < 700 veh/h	>85% of cases	Yes
Within 15%, for 700 veh/h < Flow < 2,700 veh/h	>85% of cases	Yes
Within 400 veh/h, for Flow > 2,700 veh/h	>85% of cases	Yes
GEH Statistic < 5 for Individual Link Flows	>85% of cases	Yes

Table 2: Calibration Volume Acceptance Targets – PM Peak Period

Criteria and Measures	Calibration Acceptance Targets	Met Target
Hourly Flows – Model vs. Observed		
Within 100 veh/h, for Flow < 700 veh/h	>85% of cases	Yes
Within 15%, for 700 veh/h < Flow < 2,700 veh/h	>85% of cases	Yes
Within 400 veh/h, for Flow > 2,700 veh/h	>85% of cases	Yes
GEH Statistic < 5 for Individual Link Flows	>85% of cases	Yes

7.2 Goal 2: Model link versus observed travel time to meet criteria

The goal of the calibrated VISSIM model was to obtain modeled average travel time on I-84 segments to be within 15 percent or one minute of existing condition measurements. The AM and PM peak direction travel times met this criteria (see Table 3).

Table 3: Calibration Travel Time Acceptance Targets

Criteria and Measures	Calibration Acceptance Targets	Met Target
AM Peak Period – Westbound I-84		
Within 15% (or 1 minute if higher)	>85% of cases	Yes
PM Peak Period – Eastbound I-84		
Within 15% (or 1 minute if higher)	>85% of cases	Yes

8 Conclusion

The Base AM and PM VISSIM models have been acceptably calibrated based on the results obtained from the models and compared with field measured data previously described; therefore, these models will be used as the basis for VISSIM models developed to evaluate future design scenarios.

Volume Calibration Sheet

Time Period	AM Existing 7:00-8:00	**Notes:**	
Route	Interstate 84 and US Route 7	Comparing model results to ConnDOT approved Peak Hour volumes	
City	Danbury, CT		
Simulation Run	Seed_48		
Analyst	MK		
Date	12/27/2017		

Site No.	Site Name	Description	CTDOT	VISSIM	± GEH
			7:00-8:00		
Site No.	**Site Name**	**Eastbound I-84 Mainline**	*CTDOT*	**VISSIM**	**± GEH**
1	**E84_02ex-2Aon**	**To Milestone Road (02 Off)**	*1276*	1267	**-0.3**
2	**E84_2Aon-2Bon**	**From Milestone Road (2A On)**	*1340*	1322	**-0.5**
3	**E84_2Bon-03ex**	**From Old Ridgebury Road (2B On)**	*1820*	1782	**-0.9**
4	**E84_03ex-03on**	**To Route 7 Southbound (03 Off)**	*1290*	1219	**-2.0**
5	**E84_03on-04ex**	**From Route 7 Northbound (03 On)**	*2530*	2387	**-2.9**
6	**E84_04ex-04on**	**To Lake Avenue (04 Off)**	*2290*	2179	**-2.3**
7	**E84_04on-05ex**	**From Lake Avenue (04 On)**	*2840*	2784	**-1.1**
8	**E84_05ex-05on**	**To Downs Street (05 Off)**	*2140*	1954	**-4.1**
9	**E84_05on-06on**	**From Main Street (05 On)**	*2810*	2583	**-4.4**
10	**E84_06on-07ex**	**From North Street (06 On)**	*3580*	3333	**-4.2**
11	**E84_07ex-07on**	**To Route 7 Northbound (07 Off)**	*2730*	2327	**-8.0**
12	**E84_07on-08ex**	**From Route 7 Southbound (07 On)**	*3030*	2884	**-2.7**
13	**E84_08ex-08on**	**To Newtown Road East (08 Off)**	*1960*	1803	**-3.6**
14	**E84_08on-09ex**	**From Newtown Road East (08 On)**	*2260*	2084	**-3.8**
15	**E84_09ex-09on**	**To Hawleyville Road (09 Off)**	*1960*	1792	**-3.9**
--	**--**	***Continue to Exit 10 and Hartford (09 On…)***	--	--	
Site No.	**Site Name**	**Westbound I-84 Mainline**	*CTDOT*	**VISSIM**	**± GEH**
--	**--**	***Continue to Exit 1 and New York (02 On…)***	--	--	
16	**W84_02on-02ex**	**To Milestone & Old Ridgebury (02 Off)**	*2760*	3079	**5.9**
17	**W84_02ex-03on**	**From Route 7 Northbound (03 On)**	*3750*	3869	**1.9**
18	**W84_03on-04on**	**From Lake Avenue Ext. (04 On)**	*3290*	3390	**1.7**
19	**W84_04on-03ex**	**To Route 7 Southbound (03 Off)**	*2990*	3009	**0.3**
20	**W84_03ex-04ex**	**To Lake Avenue Ext. (04 Off)**	*5200*	5247	**0.7**
21	**W84_04ex-05on**	**From Main Street (05 On)**	*5840*	5881	**0.5**
22	**W84_05on-05ex**	**To Main Street (05 Off)**	*4440*	4402	**-0.6**
23	**W84_05ex-06ex**	**To North Street (06 Off)**	*4970*	4931	**-0.6**
24	**W84_06ex-07on**	**From Route 7 Southbound (07 On)**	*5720*	5649	**-0.9**
25	**W84_07on-07ex**	**To Route 7 Northbound (07 Off)**	*3730*	3740	**0.2**
26	**W84_07ex-08on**	**From Newtown Road West (08 On)**	*4310*	4239	**-1.1**
27	**W84_08on-08ex**	**To Newtown Road West (08 Off)**	*3190*	3174	**-0.3**
28	**W84_08ex-09on**	**From Hawleyville Road (09 On)**	*4050*	4109	**0.9**
29	**W84_09on-09ex**	**From Hawleyville Road (09 Off)**	*3450*	3602	**2.6**
Site No.	**Site Name**	**Northbound Rt-7 Mainline**	*CTDOT*	**VISSIM**	**± GEH**
30	**N07_07ex-07on**	**To Wooster Heights Road (07 Off)**	*1060*	1066	**0.2**
31	**N07_07on-08ex**	**From Wooster Heights Road (07 On)**	*1480*	1494	**0.4**
32	**N07_08ex-08on**	**To Backus Avenue & Mall (08 Off)**	*1390*	1373	**-0.5**
33	**N07_08on-09ex**	**From Backus Avenue & Mall (08 On)**	*1700*	1660	**-1.0**
--	**--**	***Ramps to I-84 & Start EB Overlap (09 Off)***	--	--	
34	**N07_10on-11ex**	**Ramps from I-84 & End EB Overlap (10 On)**	*1790*	1472	**-7.9**
35	**N07_11ex-11on**	**To White Turkey Road Ext. (11 Off)**	*600*	520	**-3.4**
--	**--**	***Continue to Brookfield and New Milford (11 On…)***	--	--	
Site No.	**Site Name**	**Southbound Rt-7 Mainline**	*CTDOT*	**VISSIM**	**± GEH**
--	**--**	***Continue to Norwalk & Ridgefield (07 On…)***	--	--	
36	**S07_07on-07ex**	**To Sugar Hallow Road (07 Off)**	*1410*	1603	**5.0**
37	**S07_07ex-08ex**	**To Backus & Park Avenues (08 Off)**	*1940*	2086	**3.3**
38	**S07_08ex-09on**	**Ramps from I-84 & End WB Overlap (09 On)**	*2740*	2774	**0.6**
--	**--**	***I-84 WB Overlap (After Federal Rd. On Ramp)***	--	--	
39	**S07_FdWo-10ex**	**Ramp to I-84 EB (10 Off)**	*1000*	942	**-1.9**
40	**S07_10ex-11on**	**From White Turkey Road Ext. (11 On)**	*1660*	1616	**-1.1**
41	**S07_11on-11ex**	**To White Turkey Road Ext. (11 Off)**	*1180*	1137	**-1.3**

Site No.	Site Name	Eastbound I-84 Ramps	CTDOT	VISSIM	± GEH
42	E84_02ex-RMP	To Milestone Road (02 Off)	*460*	397	-3.0
43	E84_2Aon-RMP	From Milestone Road (2A On)	*70*	62	-1.0
44	E84_2Bon-RMP	From Old Ridgebury Road (2B On)	*480*	483	0.1
45	E84_03ex-RMP	To Route 7 Southbound (03 Off)	*530*	546	0.7
46	E84_03on-RMP	From Route 7 Northbound (03 On)	*1240*	1170	-2.0
47	E84_04ex-RMP	To Lake Avenue (04 Off)	*240*	200	-2.7
48	E84_04on-RMP	From Lake Avenue (04 On)	*550*	627	3.2
49	E84_05ex-RMP	To Downs Street (05 Off)	*700*	808	3.9
50	E84_05on-RMP	From Main Street (05 On)	*670*	635	-1.4
51	E84_06on-RMP	From North Street (06 On)	*770*	768	-0.1
52	E84_07ex-RMP	To Route 7 Northbound (07 Off)	*1210*	982	-6.9
53	E84_07on-RMP	From Route 7 Southbound (07 On)	*660*	575	-3.4
54	E84_08ex-RMP	To Newtown Road East (08 Off)	*1070*	1061	-0.3
55	E84_08on-RMP	From Newtown Road East (08 On)	*300*	297	-0.2
56	E84_09ex-RMP	To Hawleyville Road (09 Off)	*300*	280	-1.2
57	E84_09on-RMP	From Hawleyville Road (09 On)	*330*	343	0.7
Site No.	**Site Name**	**Westbound I-84 Ramps**	***CTDOT***	**VISSIM**	**± GEH**
58	W84_02on-RMP	From Milestone Road (02 On)	*190*	194	0.3
59	W84_02ex-RMP	To Milestone Road (02 Off)	*990*	798	-6.4
60	W84_03on-RMP	From Route 7 Northbound (03 On)	*460*	486	1.2
61	W84_04on-RMP	From Lake Avenue Ext. (04 On)	*300*	371	3.9
62	W84_03ex-RMP	To Route 7 Southbound (03 Off)	*2210*	2235	0.5
63	W84_04ex-RMP	To Lake Avenue Ext. (04 Off)	*640*	615	-1.0
64	W84_05on-RMP	From Main Street (05 On)	*1400*	1466	1.7
65	W84_05ex-RMP	To Main Street (05 Off)	*530*	529	0.0
66	W84_06ex-RMP	To North Street (06 Off)	*750*	712	-1.4
67	W84_07on-RMP	From Rt-7 SB & Federal Rd (07 On)	*1990*	1899	-2.1
68	W84_07ex-RMP	To Route 7 Northbound (07 Off)	*580*	499	-3.5
69	W84_08on-RMP	From Newtown Road West (08 On)	*1120*	1147	0.8
70	W84_08ex-RMP	To Newtown Road West (08 Off)	*860*	872	0.4
71	W84_09on-RMP	From Hawleyville Road (09 On)	*600*	528	-3.0
72	W84_09ex-RMP	To Hawleyville Road (09 Off)	*550*	505	-2.0
Site No.	**Site Name**	**Northbound Rt-7 Ramps**	***CTDOT***	**VISSIM**	**± GEH**
73	N07_07ex-RMP	To Wooster Heights Road (07 Off)	*230*	167	-4.5
74	N07_07on-RMP	From Sugar Hollow Road (07 On)	*420*	434	0.7
75	N07_08ex-RMP	To Backus Avenue (08 Off)	*90*	117	2.7
76	N07_08on-RMP	From Backus Avenue (08 On)	*310*	298	-0.7
77	N07_11ex-RMP	To White Turkey Road Ext. (11 Off)	*1190*	907	-8.7
78	N07_11on-RMP	From White Turkey Road Ext. (11 On)	*270*	300	1.8
Site No.	**Site Name**	**Southbound Rt-7 Ramps**	***CTDOT***	**VISSIM**	**± GEH**
79	S07_07on-RMP	From Wooster Heights Road (07 On)	*660*	645	-0.6
80	S07_07ex-RMP	To Wooster Heights Road (07 Off)	*530*	471	-2.6
81	S07_08ex-RMP	To Backus Avenue (08 Off)	*800*	689	-4.1
82	S07_FdWo-RMP	From Federal Road (Fd On)	*990*	973	-0.5
83	S07_10ex-RMP	From White Turkey Road Ext. (11 On)	*480*	588	4.7
84	S07_11on-RMP	To White Turkey Road Ext. (11 Off)	*610*	656	1.8

Count (Calibration Target)	#CTDOT	#VISSIM	± %
Sum of all link volumes (Within 5% overall)	138826	136099	2%
GEH Goal	#CTDOT	#V@Goal	%V@Goal
Count |GEH|<=5 (85% of Total)	84	78	93%
Hourly Link Volumes	#CTDOT	#V@Goal	%V@Goal
Link Volume < 700 Vehicles (85% within 100)	21	20	95%
700 Vehicles < Link Volume ≥ 2,700 Vehicles (85% within 15	30	26	87%
Link Volume ≤ 2700 Vehicles (85% within 400)	17	16	94%
Overall	68	62	91%

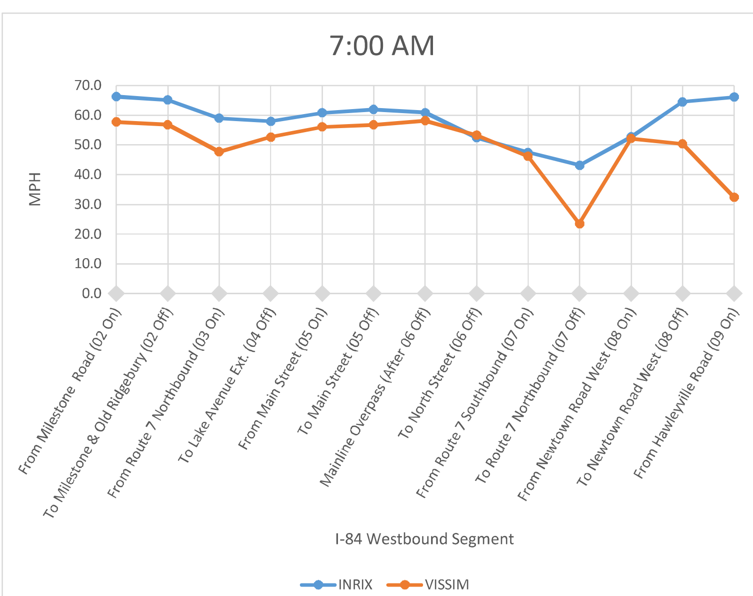
VISSIM Speed Calibriation Results
Interstate 84 in Danbury, CT

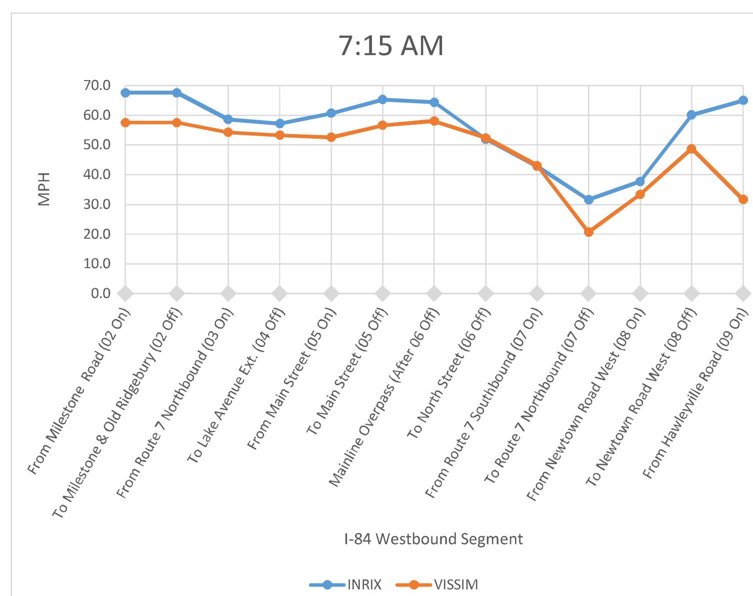
VISSIM/INRIX Speed Comparisons, I-84 Danbury
AM Existing 7:00-8:00 (Seed_48) - Page 1/2

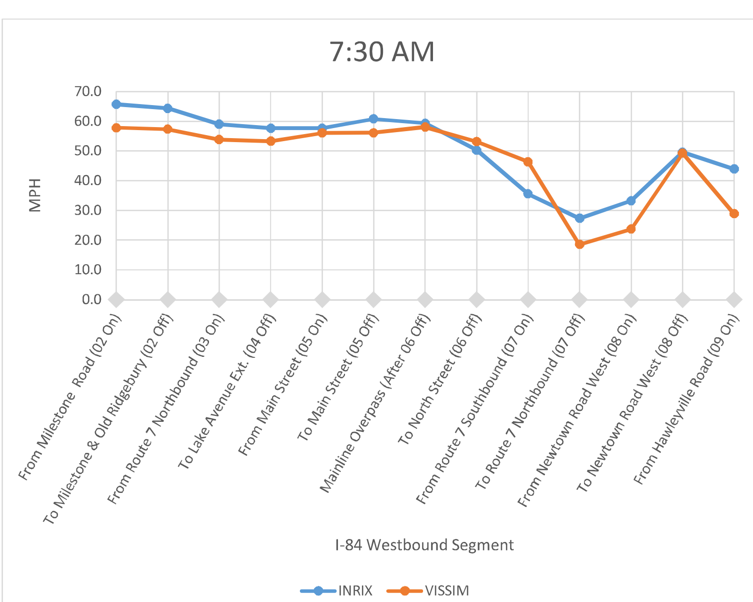
Date: 12/27/2017

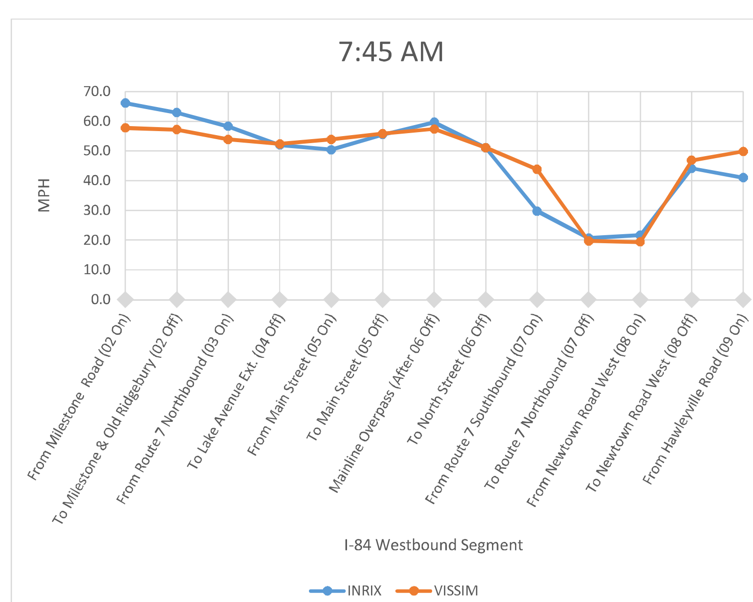
Analyst: MK

Westbound I-84 Mainline (Peak 7:00-8:00 AM)









Westbound I-84 Mainline

Speed from East at Merge/Diverge Point

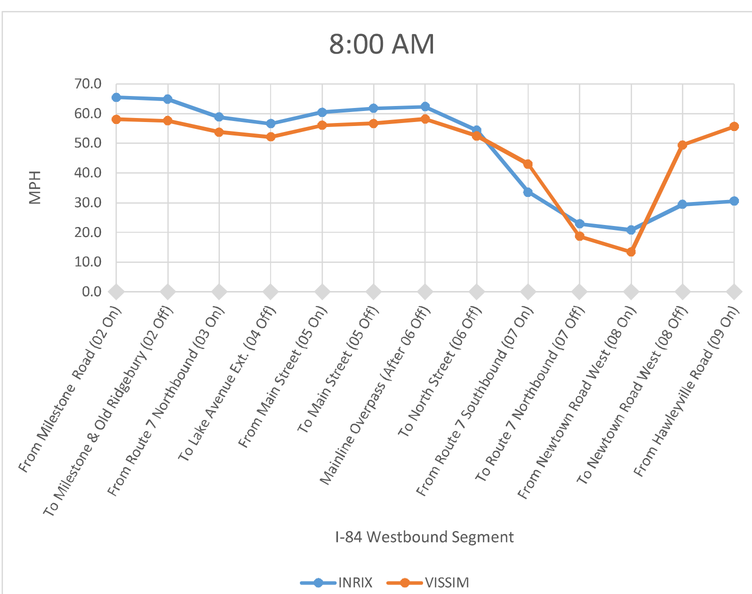
VISSIM Speed Calibriation Results
Interstate 84 in Danbury, CT

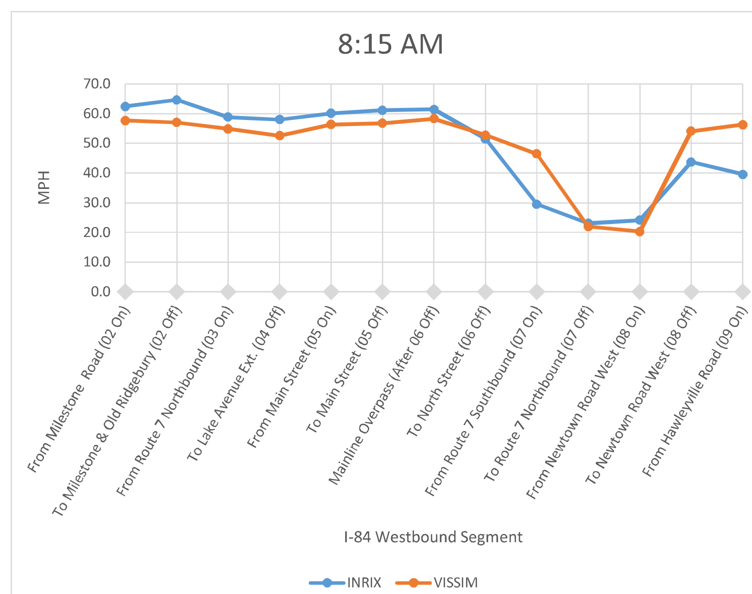
VISSIM/INRIX Speed Comparisons, I-84 Danbury
AM Existing 7:00-8:00 (Seed_48) - Page 2/2

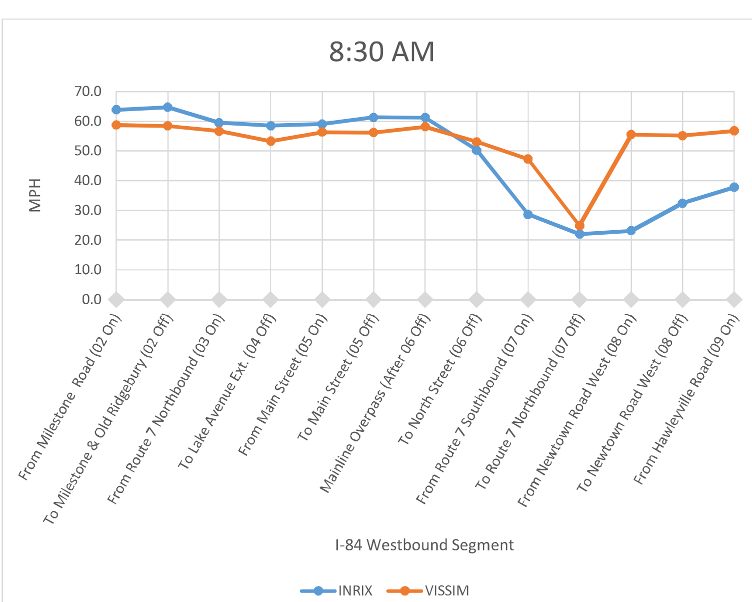
Date: 12/27/2017

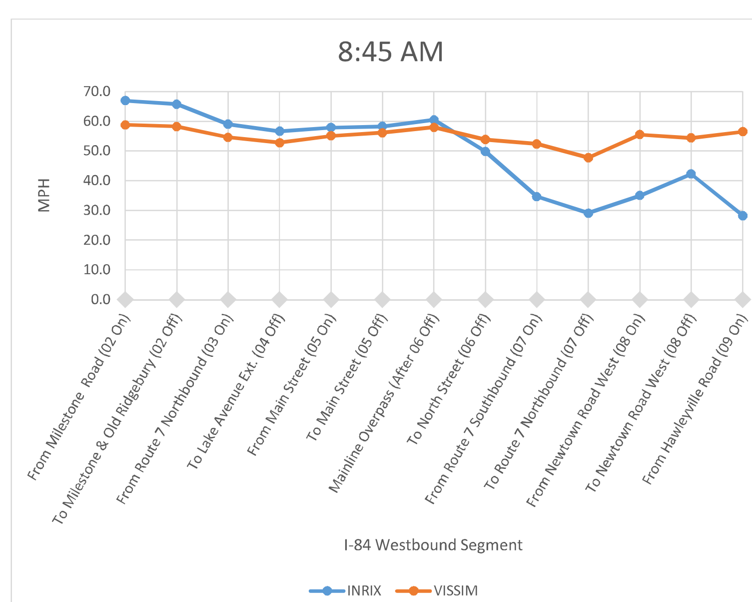
Analyst: MK

Westbound I-84 Mainline (Post 8:00-9:00 AM)









Westbound I-84 Mainline

Speed from East at Merge/Diverge Point

Volume Calibration Sheet

Time Period	PM Existing 4:30-5:30	**Notes:**
Route	Interstate 84 and US Route 7	Comparing model results to ConnDOT approved Peak Hour volumes
City	Danbury, CT	
Simulation Run	Seed_48	
Analyst	MK	
Date	12/27/2017	

Site No.	Site Name	Description	CTDOT	VISSIM	± GEH
				2 T 16:30-17:30	
Site No.	**Site Name**	**Eastbound I-84 Mainline**	*CTDOT*	**VISSIM**	**± GEH**
1	E84_02ex-2Aon	To Milestone Road (02 Off)	2660	2461	-3.9
2	E84_2Aon-2Bon	From Milestone Road (2A On)	2820	2629	-3.7
3	E84_2Bon-03ex	From Old Ridgebury Road (2B On)	3510	3296	-3.7
4	E84_03ex-03on	To Route 7 Southbound (03 Off)	2580	2339	-4.9
5	E84_03on-04ex	From Route 7 Northbound (03 On)	5200	4899	-4.2
6	E84_04ex-04on	To Lake Avenue (04 Off)	4840	4554	-4.2
7	E84_04on-05ex	From Lake Avenue (04 On)	5650	5476	-2.3
8	E84_05ex-05on	To Downs Street (05 Off)	4400	4191	-3.2
9	E84_05on-06on	From Main Street (05 On)	4980	4702	-4.0
10	E84_06on-07ex	From North Street (06 On)	5730	5528	-2.7
11	E84_07ex-07on	To Route 7 Northbound (07 Off)	3680	3590	-1.5
12	E84_07on-08ex	From Route 7 Southbound (07 On)	4290	4177	-1.7
13	E84_08ex-08on	To Newtown Road East (08 Off)	3110	2963	-2.7
14	E84_08on-09ex	From Newtown Road East (08 On)	3710	3505	-3.4
15	E84_09ex-09on	To Hawleyville Road (09 Off)	3230	3063	-3.0
--	--	*Continue to Exit 10 and Hartford (09 On...)*	--	--	
Site No.	**Site Name**	**Westbound I-84 Mainline**	*CTDOT*	**VISSIM**	**± GEH**
--	--	*Continue to Exit 1 and New York (02 On...)*	--	--	
16	W84_02on-02ex	To Milestone & Old Ridgebury (02 Off)	2200	2305	2.2
17	W84_02ex-03on	From Route 7 Northbound (03 On)	2650	2700	1.0
18	W84_03on-04on	From Lake Avenue Ext. (04 On)	1890	1892	0.0
19	W84_04on-03ex	To Route 7 Southbound (03 Off)	1710	1700	-0.2
20	W84_03ex-04ex	To Lake Avenue Ext. (04 Off)	2970	2996	0.5
21	W84_04ex-05on	From Main Street (05 On)	3680	3718	0.6
22	W84_05on-05ex	To Main Street (05 Off)	2750	2746	-0.1
23	W84_05ex-06ex	To North Street (06 Off)	3700	3705	0.1
24	W84_06ex-07on	From Route 7 Southbound (07 On)	4570	4548	-0.3
25	W84_07on-07ex	To Route 7 Northbound (07 Off)	2860	2735	-2.4
26	W84_07ex-08on	From Newtown Road West (08 On)	3540	3410	-2.2
27	W84_08on-08ex	To Newtown Road West (08 Off)	2430	2185	-5.1
28	W84_08ex-09on	From Hawleyville Road (09 On)	2900	2705	-3.7
29	W84_09on-09ex	From Hawleyville Road (09 Off)	2530	2351	-3.6
Site No.	**Site Name**	**Northbound Rt-7 Mainline**	*CTDOT*	**VISSIM**	**± GEH**
30	N07_07ex-07on	To Wooster Heights Road (07 Off)	1890	2126	5.3
31	N07_07on-08ex	From Wooster Heights Road (07 On)	2520	2768	4.8
32	N07_08ex-08on	To Backus Avenue & Mall (08 Off)	2170	2189	0.4
33	N07_08on-09ex	From Backus Avenue & Mall (08 On)	3380	3319	-1.1
--	--	*Ramps to I-84 & Start EB Overlap (09 Off)*	--	--	
34	N07_10on-11ex	Ramps from I-84 & End EB Overlap (10 On)	2730	2605	-2.4
35	N07_11ex-11on	To White Turkey Road Ext. (11 Off)	1130	974	-4.8
--	--	*Continue to Brookfield and New Milford (11 On...)*	--	--	
Site No.	**Site Name**	**Southbound Rt-7 Mainline**	*CTDOT*	**VISSIM**	**± GEH**
--	--	*Continue to Norwalk & Ridgefield (07 On...)*	--	--	
36	S07_07on-07ex	To Sugar Hallow Road (07 Off)	710	898	6.6
37	S07_07ex-08ex	To Backus & Park Avenues (08 Off)	1050	1217	5.0
38	S07_08ex-09on	Ramps from I-84 & End WB Overlap (09 On)	2190	2278	1.9
--	--	*I-84 WB Overlap (After Federal Rd. On Ramp)*	--	--	
39	S07_FdWo-10ex	Ramp to I-84 EB (10 Off)	890	954	2.1
40	S07_10ex-11on	From White Turkey Road Ext. (11 On)	1500	1539	1.0
41	S07_11on-11ex	To White Turkey Road Ext. (11 Off)	620	619	0.0

Site No.	Site Name	Eastbound I-84 Ramps	*CTDOT*	VISSIM	± GEH
42	E84_02ex-RMP	To Milestone Road (02 Off)	*440*	324	-5.9
43	E84_2Aon-RMP	From Milestone Road (2A On)	*160*	169	0.7
44	E84_2Bon-RMP	From Old Ridgebury Road (2B On)	*690*	657	-1.3
45	E84_03ex-RMP	To Route 7 Southbound (03 Off)	*930*	990	1.9
46	E84_03on-RMP	From Route 7 Northbound (03 On)	*2620*	2542	-1.5
47	E84_04ex-RMP	To Lake Avenue (04 Off)	*360*	370	0.5
48	E84_04on-RMP	From Lake Avenue (04 On)	*810*	933	4.2
49	E84_05ex-RMP	To Downs Street (05 Off)	*1250*	1231	-0.5
50	E84_05on-RMP	From Main Street (05 On)	*580*	560	-0.8
51	E84_06on-RMP	From North Street (06 On)	*750*	864	4.0
52	E84_07ex-RMP	To Route 7 Northbound (07 Off)	*2050*	1941	-2.4
53	E84_07on-RMP	From Route 7 Southbound (07 On)	*610*	586	-1.0
54	E84_08ex-RMP	To Newtown Road East (08 Off)	*1180*	1230	1.4
55	E84_08on-RMP	From Newtown Road East (08 On)	*600*	540	-2.5
56	E84_09ex-RMP	To Hawleyville Road (09 Off)	*480*	408	-3.4
57	E84_09on-RMP	From Hawleyville Road (09 On)	*420*	409	-0.5
Site No.	**Site Name**	**Westbound I-84 Ramps**	***CTDOT***	**VISSIM**	**± GEH**
58	W84_02on-RMP	From Milestone Road (02 On)	*340*	382	2.2
59	W84_02ex-RMP	To Milestone Road (02 Off)	*450*	404	-2.2
60	W84_03on-RMP	From Route 7 Northbound (03 On)	*760*	780	0.7
61	W84_04on-RMP	From Lake Avenue Ext. (04 On)	*180*	198	1.3
62	W84_03ex-RMP	To Route 7 Southbound (03 Off)	*1260*	1297	1.0
63	W84_04ex-RMP	To Lake Avenue Ext. (04 Off)	*710*	739	1.1
64	W84_05on-RMP	From Main Street (05 On)	*930*	944	0.5
65	W84_05ex-RMP	To Main Street (05 Off)	*950*	971	0.7
66	W84_06ex-RMP	To North Street (06 Off)	*870*	842	-1.0
67	W84_07on-RMP	From Rt-7 SB & Federal Rd (07 On)	*1710*	1809	2.4
68	W84_07ex-RMP	To Route 7 Northbound (07 Off)	*680*	673	-0.3
69	W84_08on-RMP	From Newtown Road West (08 On)	*1110*	1211	3.0
70	W84_08ex-RMP	To Newtown Road West (08 Off)	*470*	539	3.1
71	W84_09on-RMP	From Hawleyville Road (09 On)	*370*	326	-2.4
72	W84_09ex-RMP	To Hawleyville Road (09 Off)	*370*	311	-3.2
Site No.	**Site Name**	**Northbound Rt-7 Ramps**	***CTDOT***	**VISSIM**	**± GEH**
73	N07_07ex-RMP	To Wooster Heights Road (07 Off)	*310*	239	-4.3
74	N07_07on-RMP	From Sugar Hollow Road (07 On)	*630*	640	0.4
75	N07_08ex-RMP	To Backus Avenue (08 Off)	*350*	576	10.5
76	N07_08on-RMP	From Backus Avenue (08 On)	*1210*	1124	-2.5
77	N07_11ex-RMP	To White Turkey Road Ext. (11 Off)	*1600*	1518	-2.1
78	N07_11on-RMP	From White Turkey Road Ext. (11 On)	*650*	690	1.5
Site No.	**Site Name**	**Southbound Rt-7 Ramps**	***CTDOT***	**VISSIM**	**± GEH**
79	S07_07on-RMP	From Wooster Heights Road (07 On)	*540*	412	-5.9
80	S07_07ex-RMP	To Wooster Heights Road (07 Off)	*340*	324	-0.9
81	S07_08ex-RMP	To Backus Avenue (08 Off)	*1140*	1059	-2.4
82	S07_FdWo-RMP	From Federal Road (Fd On)	*820*	855	1.2
83	S07_10ex-RMP	From White Turkey Road Ext. (11 On)	*880*	918	1.3
84	S07_11on-RMP	To White Turkey Road Ext. (11 Off)	*310*	361	2.8

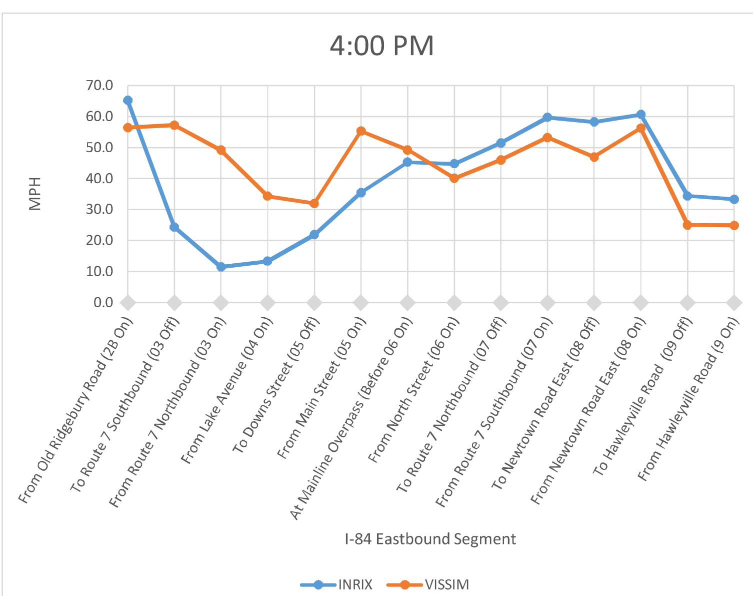
Count (Calibration Target)	#CTDOT	#VISSIM	± %
Sum of all link volumes (Within 5% overall)	155420	152451	2%
GEH Goal	#CTDOT	#V@Goal	%V@Goal
Count |GEH|<=5 (85% of Total)	84	78	93%
Hourly Link Volumes	#CTDOT	#V@Goal	%V@Goal
Link Volume < 700 Vehicles (85% within 100)	15	13	87%
700 Vehicles < Link Volume ≥ 2,700 Vehicles (85% within 15	33	29	88%
Link Volume ≤ 2700 Vehicles (85% within 400)	20	20	100%
Overall	68	62	91%

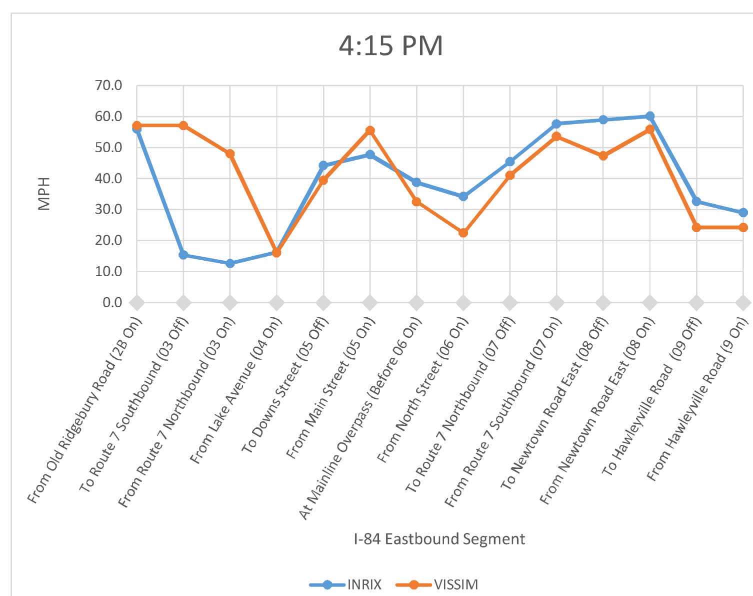
VISSIM Speed Calibration Results
Interstate 84 in Danbury, CT

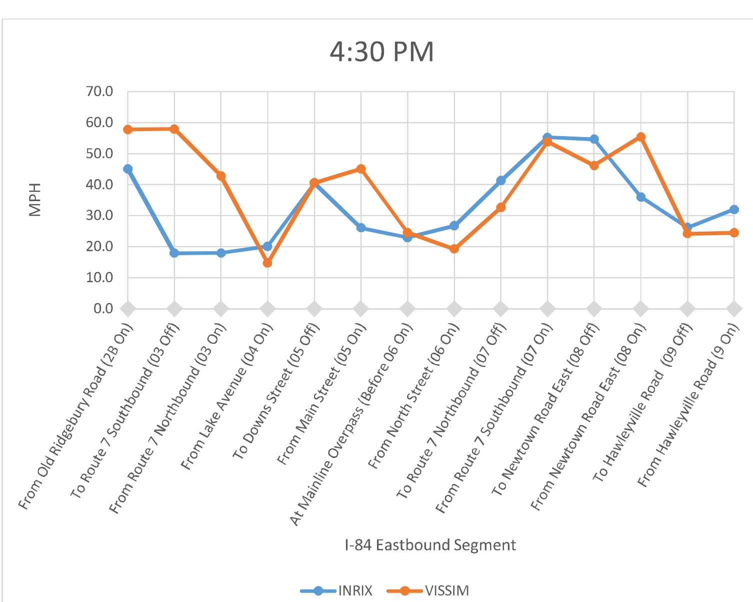
VISSIM/INRIX Speed Comparisons, I-84 Danbury Date: 12/27/2017
PM Existing 4:30-5:30 (Seed_48) - Page 1/2

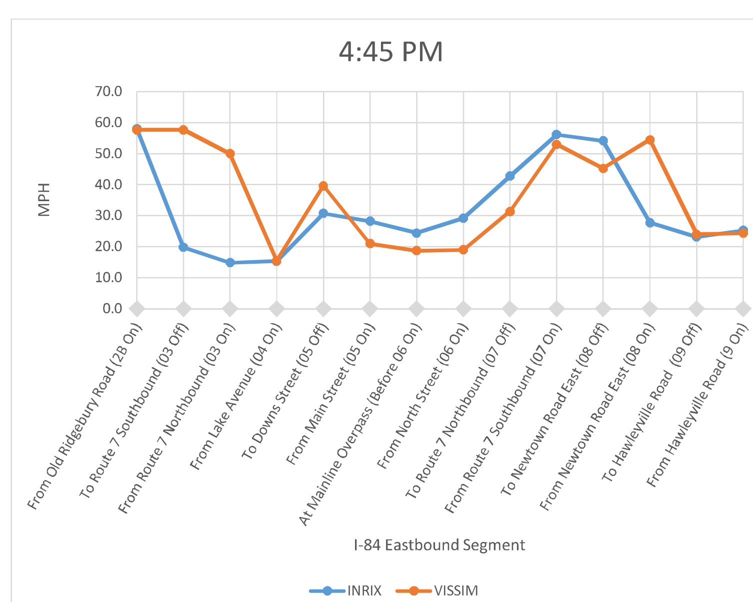
Analyst: MK

Eastbound I-84 Mainline (Peak 4:00-5:00 PM)









Eastbound I-84 Mainline Speed from West at Merge/Diverge Point

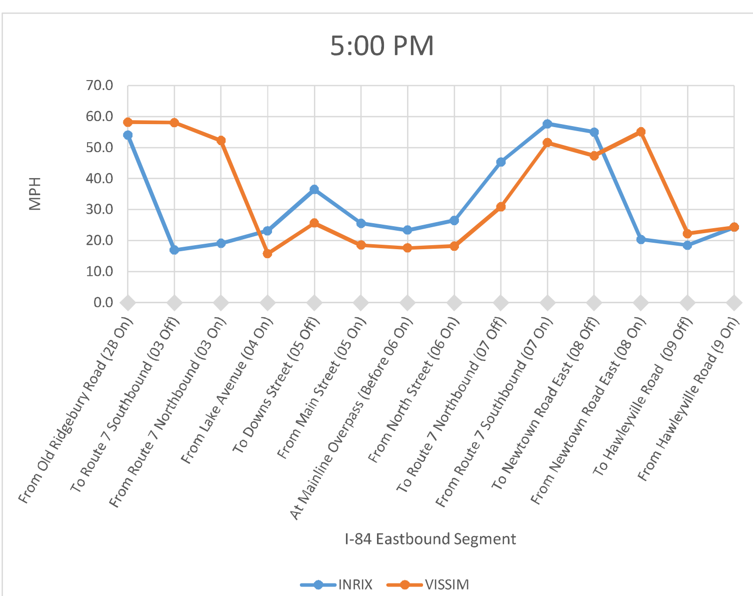
VISSIM Speed Calibration Results
Interstate 84 in Danbury, CT

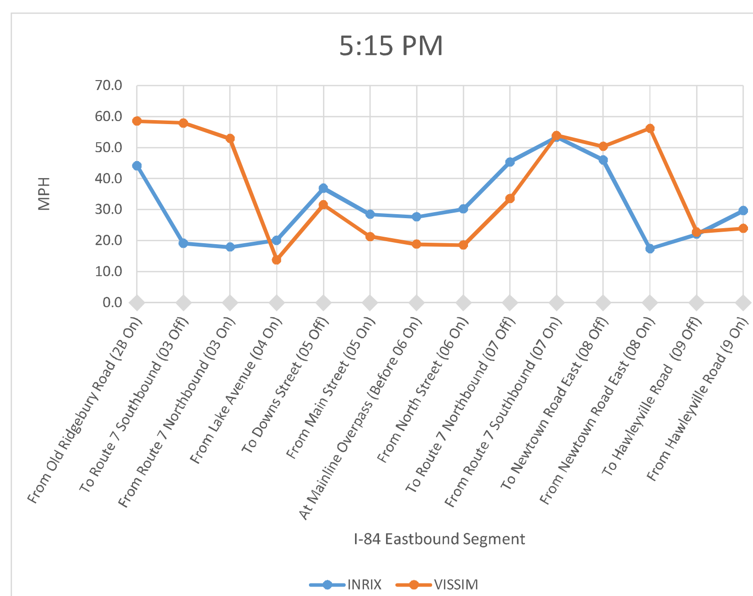
VISSIM/INRIX Speed Comparisons, I-84 Danbury
PM Existing 4:30-5:30 (Seed_48) - Page 2/2

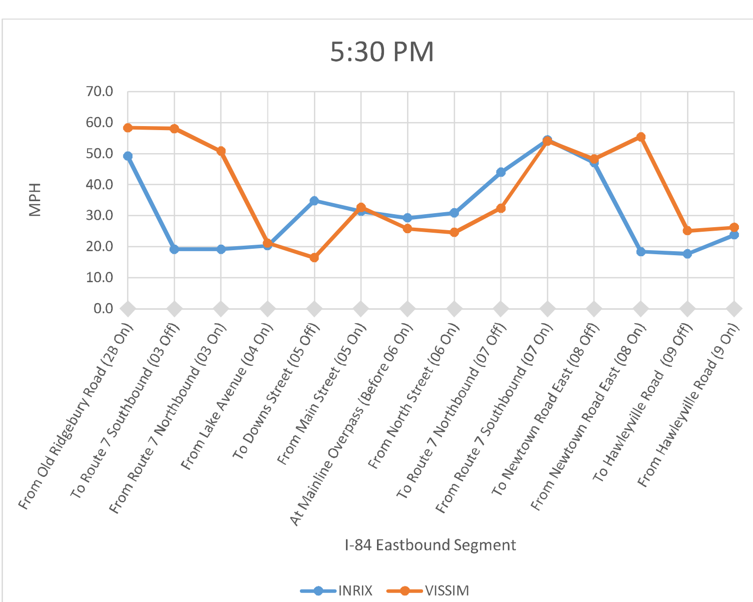
Date: 12/27/2017

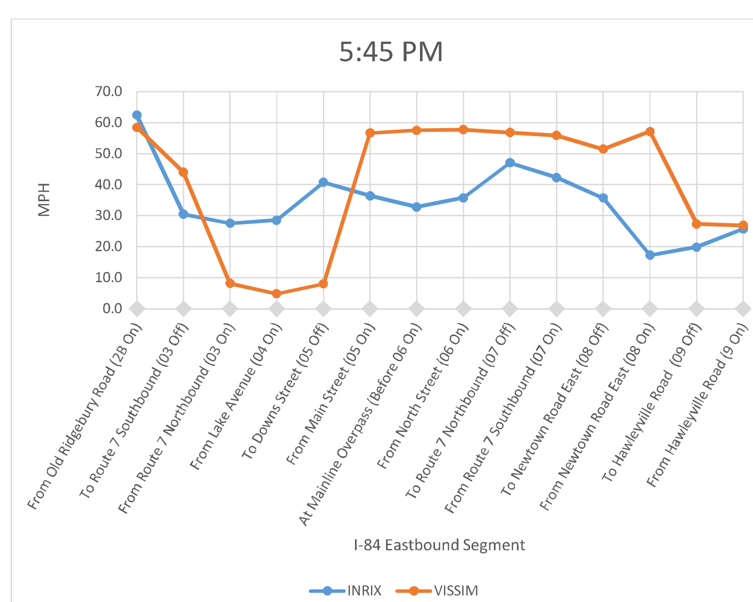
Analyst: MK

Eastbound I-84 Mainline (Post 5:00-6:00 PM)









Eastbound I-84 Mainline

Speed from West at Merge/Diverge Point