I-84 Danbury Project
Needs and Deficiencies Report
Technical Memorandum No. 1

I-84 Danbury Project

State Project Number 34-349

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CONNECTICUT DEPARTMENT OF TRANSPORTATION

CDM Smith

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Section 1

Introduction

This section discusses the study background, goals and objectives, study area, process, and the project team.

1.1 Study Background

The I-84 Exit 3-8 Danbury project came out as a high-priority project from the findings of the Let's GO CT Plan prepared by the Connecticut Department of Transportation (CTDOT). Prior to the Let's GO CT Plan, this segment of I-84 was studied as part of the I-84 Corridor Deficiencies/Needs Study, Exits 1-11 in June **2000**[1].

Following the completion of the I-84 Corridor Deficiencies/Needs Study, CTDOT initiated the Draft Environmental Impact Statement (DEIS) in **2009-11** which included the I-84 segments from the New York line to Waterbury. The DEIS was never published and no further action was taken due to lack of funding.

In **2015**, the segment between Exits 3-8 was deemed as an independent utility by the Federal Highway Administration (FHWA) i.e. this project has a merit of its own and can be pursued independently of other segments in the I-84 corridor. In the same year, the Governor initiated the Let's GO CT Plan and the I-84 Exit 3-8 Danbury project was deemed as a high priority project.

1.2 Study Area

The limits of the project are I-84 between Exits 3 and 8 approximately 6.5 miles in length. In addition, the project extends on U.S. Route 7 between Exits 7 and 9 (west portion) and from I-84 to Exit 11 (east portion) approximately 1.5 miles in length. **Figure 1-1** shows a study area map highlighting the project limits in "red".

I-84 is an interstate expressway oriented in an east-west direction between Exits 3 and 8. Within the study corridor, I-84 has three lanes in each direction between Exits 3 and 7 and east of Exit 7, it transitions into a two-lane highway in each direction. I-84 meets U.S. Route 7 at two interchanges – on the west side at Exit 3 and on the east side at Exit 7.

U.S. Route 7 is classified as an expressway within the study corridor. *For the purposes of this report, U.S. Route 7 is referred as Route 7*. Within the corridor, Route 7 has primarily two lanes in each direction. The study area on Route 7 on the west side extends to Worcester Heights Rd./Miry Brook Road interchange (Exit 7) to the I-84 merge and on the east side from the I-84 split to about White Turkey Road Extension (Exit 11). I-84 and Route 7 are combined between Exits 3 and 7.

Other key roadways within the study area include U.S. Route 6 (Mill Plain Road on the west), Route 37 (North Street), Route 39 (Main Street), Route 53 (Main Street), Route 805 (Federal Road), and Route 806 (Newtown Road).

[1] I-84 Corridor Deficiencies/Needs Study, Exits 1-11, VHB, June 2000.

1.3 Study Goals and Objectives

The project is currently developing a ***Purpose and Need Statement*** as part of the National Environmental Policy Act (NEPA) process. However, the project, in general, has the following goals and considerations:

- Increase highway capacity
- Improve highway access, safety and operations
- Enhance mobility
- Connect City with regional destinations
- Improve multimodal connections
    - Commuter parking
    - Bicycle and pedestrian travel
    - Transit connections
- Improve local and regional commerce and freight mobility

As the study progresses, a Final Purpose and Need Statement will be prepared for review by several agencies and key stakeholders. In addition, the study goals and objectives will be identified to address the current and future needs of the I-84 Danbury corridor.

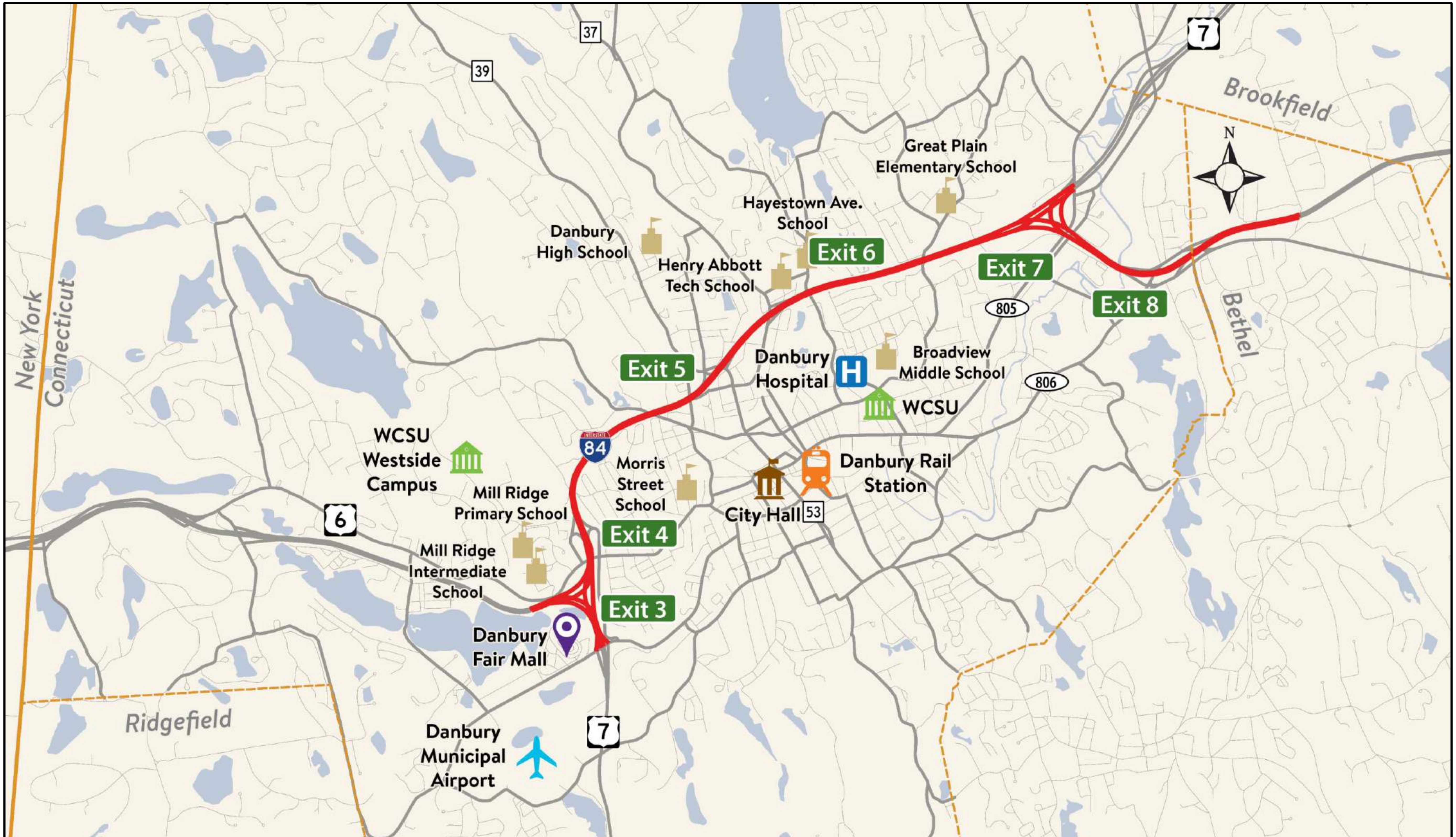
1.4 Study Process

The study process has three integral components – Planning Phase, Environmental Phase, and the Community Engagement Phase. The Planning phase is the study portion and includes the technical analysis and documentation leading to the preliminary engineering. Key elements include the deficiencies/needs identification, development of alternatives, alternatives analysis, and selection of a preferred alternative.

The Environmental phase is the preparation of environmental documentation associated with NEPA and Connecticut Environmental Policy Act (CEPA) processes. The Environmental Process is tied into the Planning Phase as many of the elements of the Planning Phase are included as part of the environmental documentation. Key elements include preparation of the Purpose and Need Statement, identification of environmental constraints, assessment of alternatives, and notification of a Finding of No Significant Impact (FONSI) or Record of Decision (ROD).

The Community Engagement process is critical to both the Planning and Environmental Phase. Under this process, public input and consensus is sought towards the identification of a preferred alternative. Key elements of this process include identification of stakeholders, preparation of a Project Advisory Committee (PAC), and various forms of engagement with neighborhoods and stakeholders.

Figure 1-1 Study Area Map



Section 2

Existing Transportation Conditions

This section discusses the existing transportation conditions in the I-84 study corridor and is broken into the following focus areas:

- **Traffic Conditions** – Section 2.1 and 2.2 discuss existing traffic conditions
- **Geometrics** – Section 2.3 discusses existing highway geometry
- **Structural Conditions** – Section 2.4 discusses existing structural conditions
- **Geotechnical Review** – Section 2.5 discusses geotechnical conditions
- **Safety Analysis** – Section 2.6 discusses safety analysis
- **Multimodal Conditions** – Section 2.7 discusses multimodal conditions i.e. pedestrian, bicycle, transit, and rail modes

2.1 Existing Traffic Data

This section summarizes the existing traffic data collected in the field along I-84, Route 7, and other key roadways within the project area. The traffic data was collected in the months of October and November in 2016.

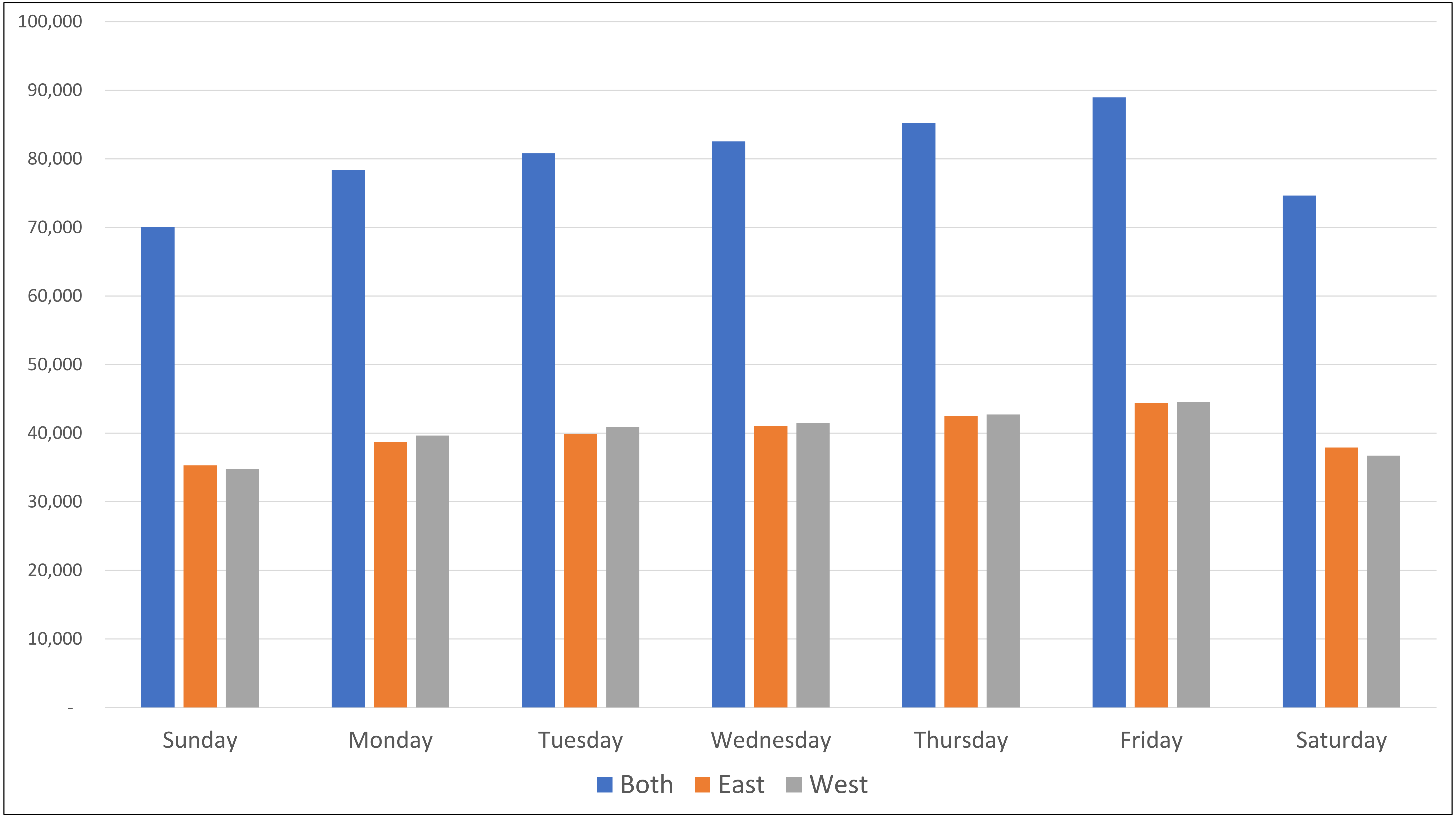
2.1.1 Mainline Traffic Counts

Weekday traffic volumes in 2016 were reviewed during a typical week at the permanent count station on I-84 at the Old Hawleyville Road underpass (between Exits 8 and 9) in Newtown. **Figure 2-1** shows the weekday variation in daily traffic volumes along I-84 in eastbound, westbound, and both directions. Based on the traffic count volumes, Thursday is about 3 percent and Friday is about 8 percent higher than an average weekday daily traffic volume.

Therefore, traffic counts were collected along I-84 and Route 7 mainlines and ramps using MioVision equipment on two separate days – Thursday, October 13 and Friday, October 14, 2016:

- I-84 Westbound between Exits 2 and 3
- I-84 Eastbound Off Ramp to Route 7 Southbound
- Route 7 Northbound to I-84 Westbound
- I-84 Westbound Off Ramp to Route 7 Southbound
- Route 7 Northbound to I-84 Eastbound
- I-84 Eastbound between Exits 5 and 6
- I-84 Westbound between Exits 5 and 6
- I-84 Eastbound Off Ramp to Route 7 Northbound
- Route 7 Southbound Off Ramp to I-84 Eastbound
- I-84 Westbound Off Ramp to Route 7 Northbound
- Route 7 Southbound Off Ramp to I-84 Westbound
- Route 7 Northbound north of I-84
- Route 7 Southbound north of I-84
- I-84 Eastbound between Exits 8 and 9
- I-84 Westbound between Exits 8 and 9
- Route 7 Northbound south of Backus Avenue
- Route 7 Southbound south of Backus Avenue

Figure 2-1 Weekday Variation in Daily Traffic Volumes



The above traffic counts were conducted for a 12-hour period between 6 A.M. and 6 P.M. and extrapolated to develop a daily count profile for the corridor. **Table 2-1** shows the existing (2016) weekday daily, A.M., and P.M. peak hour volumes at three (3) locations in the study corridor.

Table 2-1 Existing (2016) Traffic Volumes – I-84

Location	Weekday Daily Traffic Volume (vehicles per day)		
	East	West	Total
West of Route 7	39,600	40,900	80,500
Between 7s	53,470	55,750	109,220
East of Route 7	40,800	41,500	82,300
	Weekday AM Peak Hour Volume (vehicles per hour)		
West of Route 7	1,820	3,750	5,570
Between 7s	2,810	4,970	7,780
East of Route 7	2,260	4,050	6,310
	Weekday PM Peak Hour Volume (vehicles per hour)		
West of Route 7	3,510	2,650	6,160
Between 7s	4,980	3,700	8,680
East of Route 7	3,710	2,900	6,610

SOURCE: CDM Smith based on MioVision count data.

A historical comparison of hourly variation in traffic volumes was made using the permanent count station on I-84. In 1998, a planning study was conducted along I-84 between Exits 1 and 11[1]. A comparison of 1998 and 2016 daily volumes indicate that the traffic volumes jumped up significantly during the peak periods in 1998 while in 2016 the volumes showed some "flattening" effect. This trend indicates that in 2016, motorists are choosing to travel outside of the typical peak hours to avoid congestion in the corridor. **Figure 2-2** shows a comparison of 1998 and 2016 hourly traffic volumes over the course of a typical weekday.

2.1.2 Ramp Traffic Counts

In addition to mainline counts on I-84 and Route 7, automatic traffic recorder (ATR) counts were conducted on forty (40) ramps in the study area. Thirty-three (33) ramps were along I-84 and the remaining seven (7) on Route 7 in both directions. These traffic counts were conducted over a five-day period including weekends. **Figure 2-3** shows ramp locations categorized as high (red), medium (yellow), and low (green) impact based on the combined peak hour volumes in the weekday A.M. and P.M. peak hour periods.

2.1.3 Intersection Peak Hour Traffic Volumes

Turning movement counts (TMCs) were conducted at fifty (50) intersections in the study corridor. Of the 50 locations, thirty-nine (39) were on I-84 and the remaining eleven (11) on Route 7. TMCs were conducted for a 12-hour duration at twelve (12) locations and during the weekday morning and evening peak periods at the remaining thirty-eight (38) locations. Weekday morning peak period counts were conducted between 6:00 and 9:00 A.M. and the weekday evening peak period counts were conducted between 3:00 and 6:00 P.M. at the 38 locations in October 2016.

Figure 2-4 shows intersection locations categorized as high (red), medium (yellow), and low (green) impact depending on the peak hour volume. A balanced profile of the study corridor showing mainline and ramp volumes along I-84 and Route 7 and intersection flow diagrams is included in the appendix.

2.1.4 Truck Volumes

Truck counts on I-84 were obtained through vehicle classification counts collected using MioVision. The Miovision data classifies vehicles based on the Federal Highway Administration (FHWA) classification system which consists of 13 vehicle classifications. The Single Unit and "Articulated" Truck classifications in Miovision mimic FHWA Classes 5-13. The percentages calculated below are based on those classifications in Miovision. **Table 2-2** shows the weekday daily, A.M., and P.M. truck percentages at three (3) locations in the study corridor.

Table 2-2 Existing (2016) Truck Percentages – I-84

Location	Weekday Daily	
	East	West
West of Route 7	6%	11%
Between 7s	9%	7%
East of Route 7	11%	12%
	Weekday AM Peak	
West of Route 7	10%	8%
Between 7s	11%	7%
East of Route 7	14%	9%
	Weekday PM Peak	
West of Route 7	5%	9%
Between 7s	5%	7%
East of Route 7	7%	10%

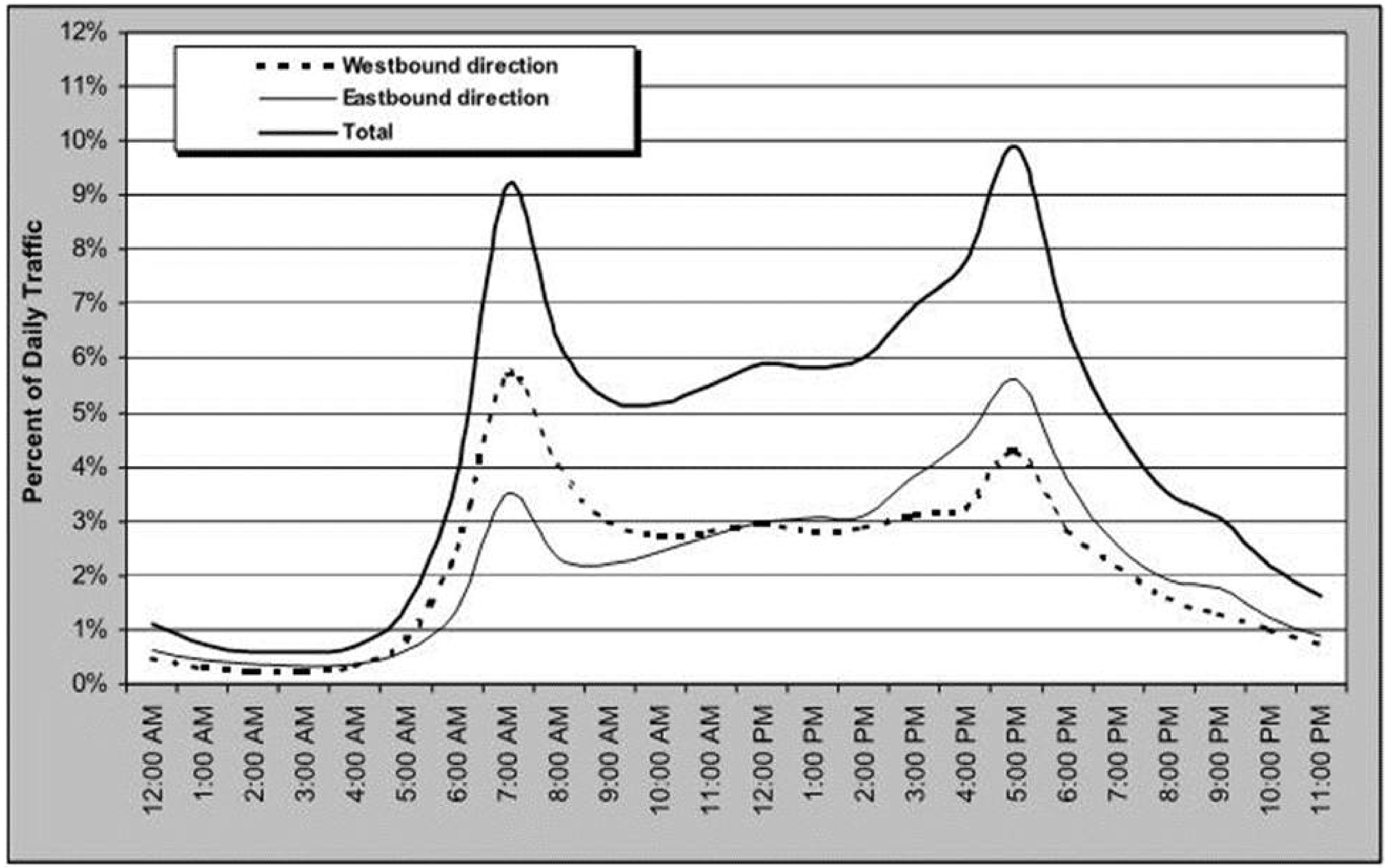
SOURCE: CDM Smith based on MioVision count data.

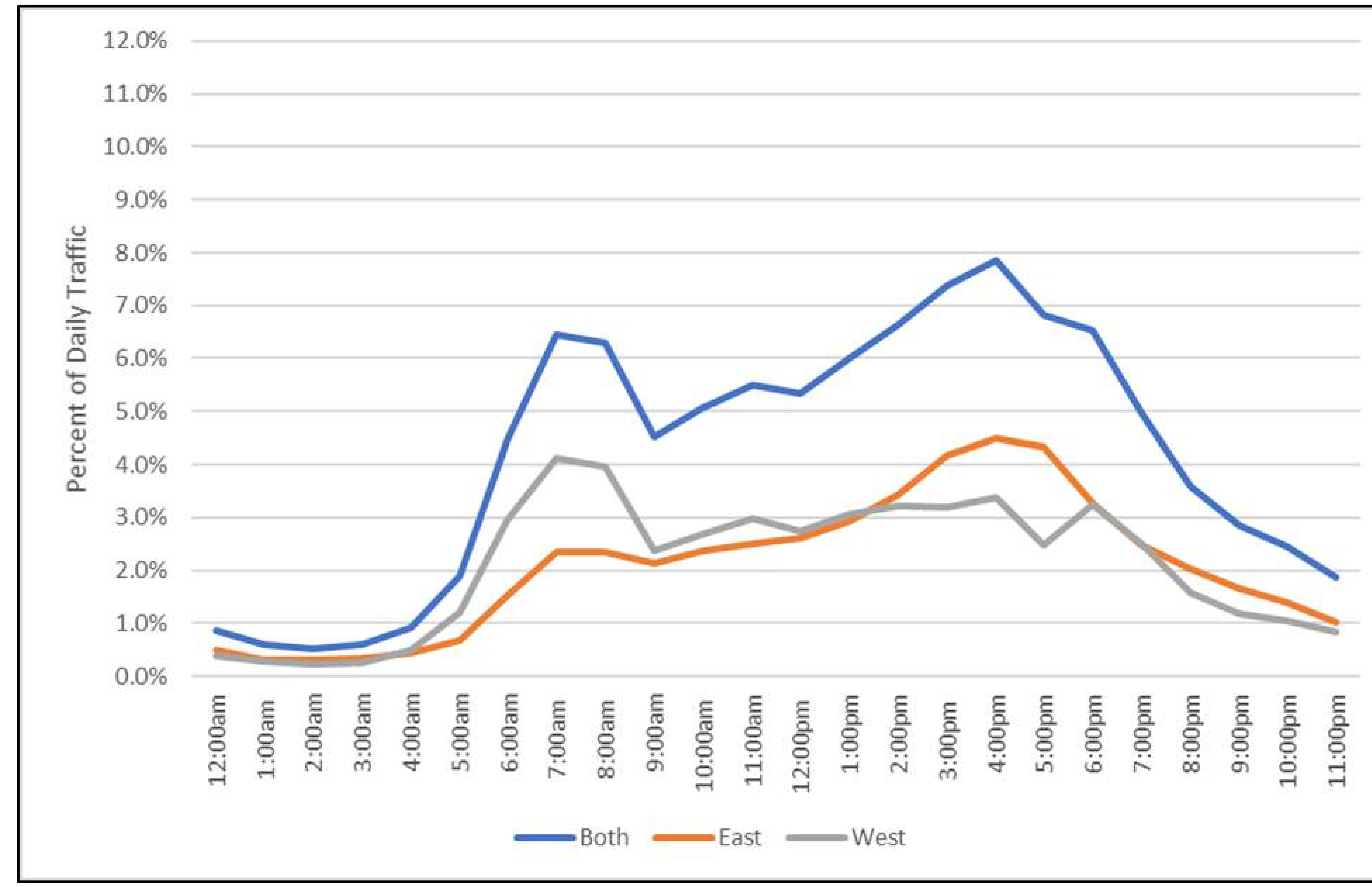
2.1.5 Travel Time and Speed Surveys

Travel time and speed data was gathered using three sources – Global Positioning System (GPS) recorder, National Performance Management Research Data Set (NPMRDS), and INRIX data.

[1] I-84 Planning Study, Exits 1-11, Vanasse Hangen Brustlin, Inc., 2000.

Figure 2-2 Historical Comparison of Weekday Hourly Volumes – I-84





2016

__Source:__ (1) 1998 traffic volume data, I-84 Planning Study, Exits 1-11, Vanasse Hangen Brustlin, Inc., 2000.
(2) 2016 traffic volume data, Connecticut Department of Transportation.

Figure 2-3 I-84 Existing (2016) Ramp Traffic Volume Data

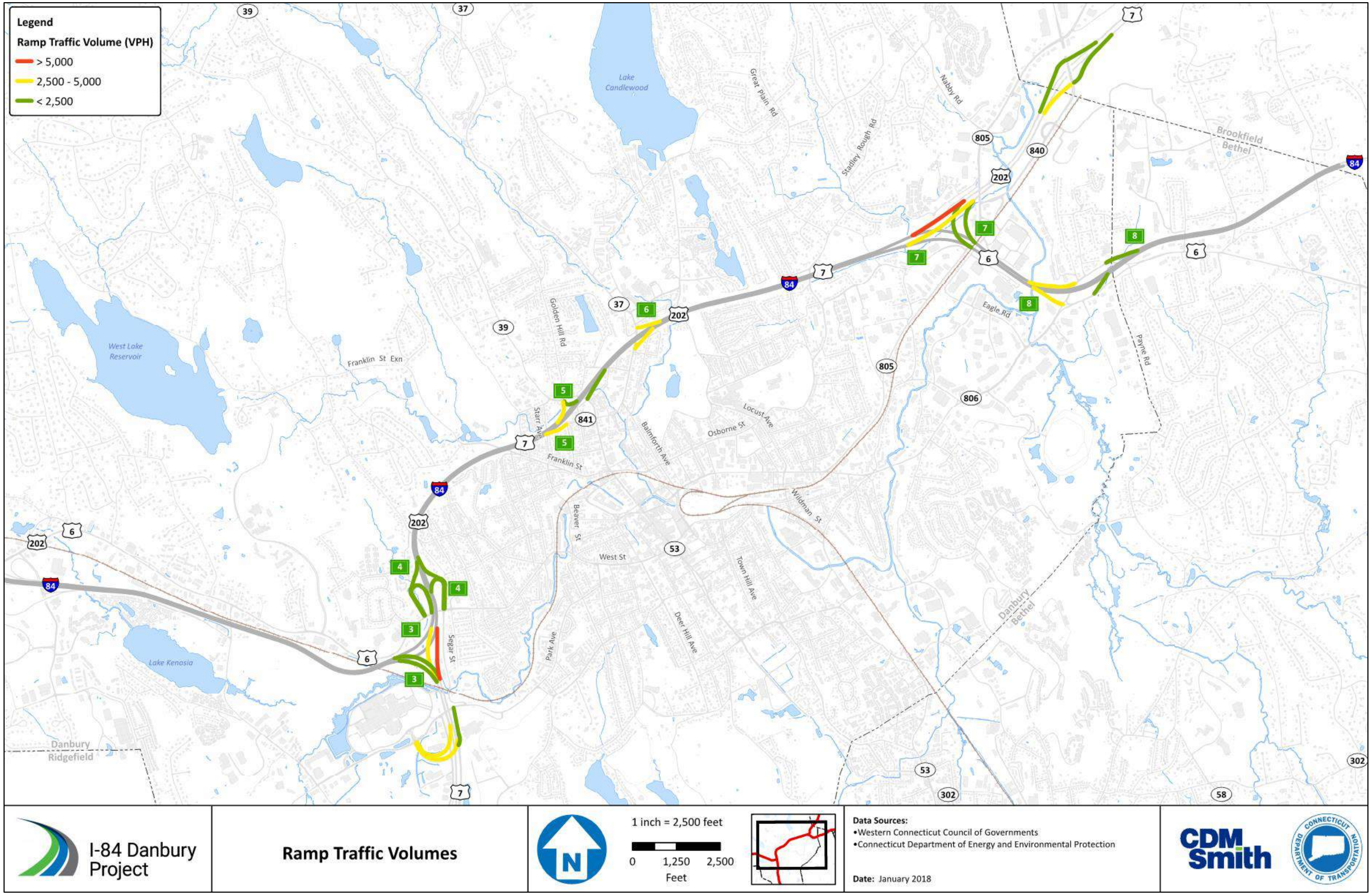
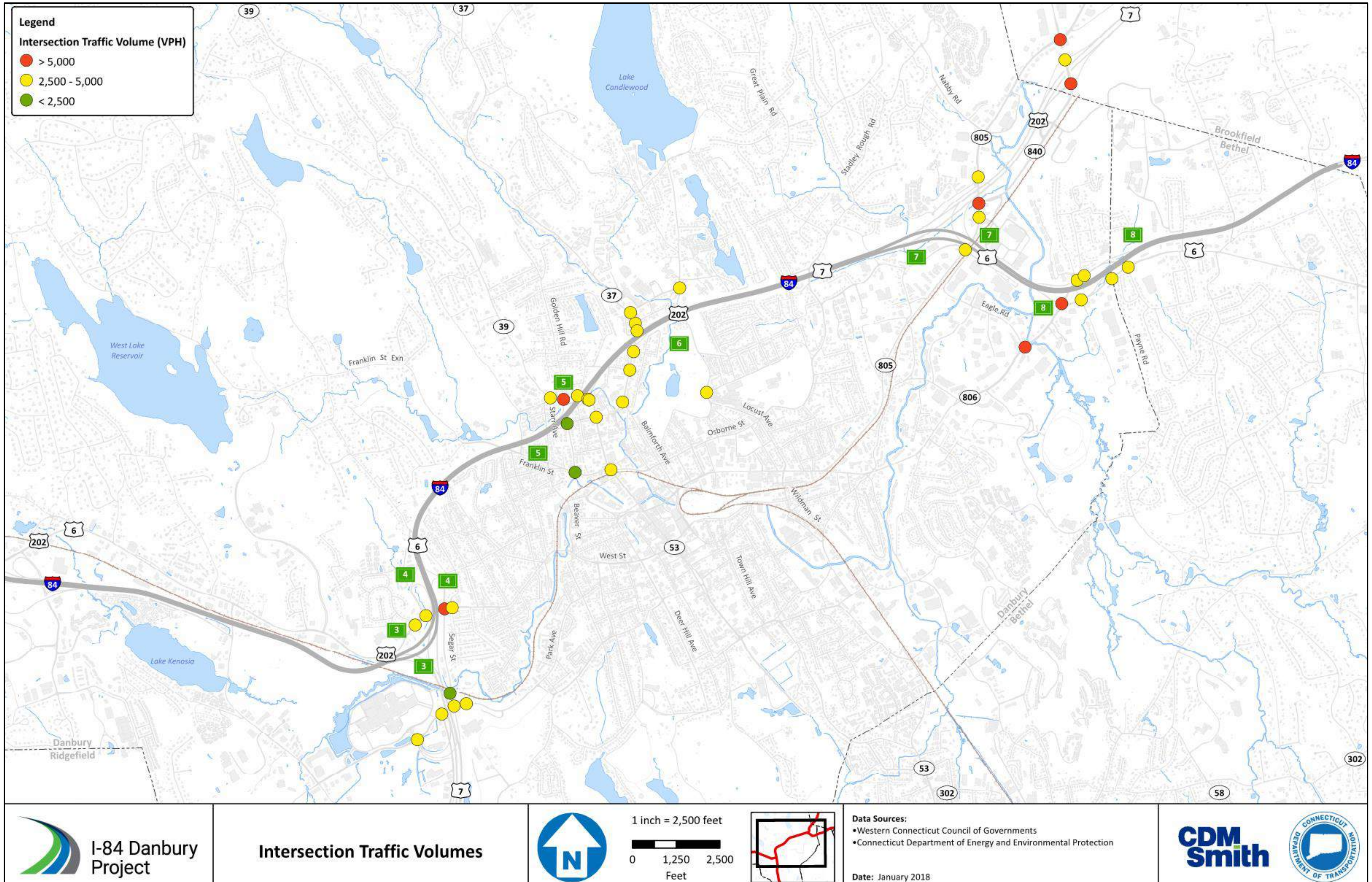


Figure 2-4 I-84 Existing (2016) Intersection Traffic Volume Data



The **GPS recorder data** was obtained by conducting field travel time runs using GPS equipment during the weekday morning (7-9 AM) and evening peak periods (4-6 PM). A minimum of three (3) travel time runs were conducted in each direction during those peak periods in November 2016. The following travel paths were used in the travel time runs:

I-84 Eastbound Runs

- Start at Exit 2 (Old Ridgebury Road) and end at Exit 9 (Route 25 underpass)
- Start at Exit 2 (Old Ridgebury Road) and end at Route 7 southbound (Wooster Heights underpass)

I-84 Westbound Runs

- Start at Exit 9 (Route 25 underpass) and end at Exit 2 (Old Ridgebury Road)
- Start at Exit 9 (Route 25 underpass) and end at Route 7 northbound (White Turkey Road - Exit 11)

Route 7 Northbound Runs

- Start at Wooster Heights underpass and end at I-84 westbound Exit 2 (Old Ridgebury Road)

Route 7 Southbound Runs

- Start at White Turkey Road (Exit 11) and end at I-84 eastbound Exit 9 (Route 25 underpass)

NPMRDS stands for the National Performance Management Research Data Set. It is essentially a repository of vehicle probe data set for average travel times in 5-minute increments obtained by the Federal Highway Administration (FHWA). The travel time data is provided by HERE traffic. For the subject I-84 corridor, HERE travel time data was obtained during the weekday A.M. and P.M. peak periods based on the entire 2016 dataset.

INRIX is a repository of information about roadway speeds and vehicle counts collected via mobile phones and other sources equipped with GPS devices. This information is processed to get vehicle travel times, vehicle delays, congestion hot spots, origin-destinations, and a variety of other performance measures. For the subject I-84 corridor, INRIX travel time data was obtained during the weekday A.M. and P.M. peak periods based on 2016 data.

Table 2-3 summarizes travel times on I-84 between Exits 3 and 8 in the eastbound and westbound directions based on the three (3) methods.

Table 2-3 Existing (2016) Travel Times – I-84

	Weekday AM Peak Period				
		NPRMDS		INRIX	
Direction	GPS (1)	11-Nov	Average (3)	11-Nov	Average (3)
Eastbound	05:11	07:07	07:17	05:29	05:30
Westbound	05:27	08:10	10:07	05:56	06:47
	Weekday Off Peak Period				
	GPS	NPRMDS (Average)		INRIX (Average)	
Eastbound	-	07:27		05:38	
Westbound	-	08:27		05:56	
	Weekday PM Peak Period				
		NPRMDS		INRIX	
Direction	GPS (2)	10-Nov	Average (3)	10-Nov	Average (3)
Eastbound	08:34	19:39	15:18	09:37	10:50
Westbound	06:18	08:58	08:50	06:15	06:12

Note: (1) Weekday A.M. travel time runs were conducted on November 11, 2016.
(2) Weekday P.M. travel time runs were conducted on November 10, 2016.
(3) Average weekday travel times in 2016.

Based on the three (3) methods of travel time data collection, the following observations were made:

- GPS travel times were conducted on a single day of runs in November and therefore, they may not representative of an average condition. When comparing the travel times on the same day in the three methods of collection, GPS and INRIX travel times were close to each other; however, the NPMRDS travel times were significantly higher. This discrepancy could be attributed to the longer TMC segment lengths in NPMRDS compared to the INRIX. TMC is a location in the travel network over which vehicle probe data is collected to obtain speed and travel times.
- When comparing the average weekday travel times in INRIX and NPMRDS, the travel times are higher by 2 minutes or more in NPMRDS than the INRIX. When incidents occur during peak periods, the NPMRDS data tends to report much longer time travel times than INRIX because the congestion backups affect the calculations in NPMRDS with longer segment lengths.
- In summary, weekday A.M. peak period travel time between Exits 3 and 8 is about **6-10** minutes in the westbound direction based on the three data sources.
- In summary, weekday P.M. peak period travel times between Exits 3 and 8 is about **8-11** minutes in the eastbound directions based on INRIX and GPS data.
- Weekday off-peak travel times between Exits 3 and 8 is about **6** minutes based on INRIX and about **7-8** minutes based on NPMRDS data.

Travel time and heat maps based on the three sources of data are included in the **Technical Appendix**.

2.1.6 Origin and Destination Surveys

Origin and destination (O-D) surveys were conducted by SkyComp using time lapse aerial photography (TLAP) supplemented with INRIX analytics. Using the photos collected using TLAP, a sample of vehicles at selected origin points were tracked until they exited the study area at either an off-ramp or the I-84 mainline. A more detailed description of the origin destination survey methodology is provided in the Appendix. TLAP survey flights were conducted on the morning and evening of Friday, October 14, 2016 during the weekday morning and afternoon peak hour period respectively. TLAP data was obtained by vehicle class i.e. light, medium, and heavy vehicles. TLAP results were compiled in the peak direction only. For the off-peak direction, INRIX data was utilized to determine the origin-destination patterns. INRIX data was also used to obtain weekday (Tuesday through Thursday) peak period origin and destination patterns.

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/Route 7 merge between 4:15 and 5:45 p.m.
3. Route 7 northbound at I-84/Route 7 merge between 4:15 and 5:45 p.m.
4. I-84 westbound at I-84/Route 7 merge between 7:15 and 8:45 a.m.
5. Route 7 southbound at I-84/Route 7 merge between 7:15 and 8:45 a.m.

Following the review of the Friday data collected on October 14, 2016, supplemental data for all working Fridays in 2016 were gathered from INRIX to confirm travel patterns. A comparison of O-D data from an average Friday with the data from an interior weekday (Tuesday through Thursday) indicated that Friday patterns are quite different than the interior weekday conditions, in that a lot more of the trips on this portion of I-84 are local trips.

In addition, weekday off-peak O-D data was also obtained to understand travel behavior in the off-peak periods. The results of the O-D surveys for the weekday (Tuesday through Thursday) are described in the following sections by time periods. **The results of the Friday O-D surveys are included in the Technical Appendix.**

2.1.6.1 I-84 Origin-Destination Patterns

Figures 2-5 through 2-7 show O-D patterns derived from the TLAP survey for an average weekday for all traffic entering and exiting I-84 between Exits 3 and 8. These graphics show the O-D patterns for all vehicle classes (auto, trucks) combined. **Individual O-D patterns are presented in the Technical Appendix.**

Weekday A.M. Peak Period – As shown in Figure 2-6, during the A.M. peak period, in the eastbound direction, approximately *44 percent* of the traffic using I-84 within the study area is going through on I-84 and the remaining *56 percent* of the traffic is locally oriented, entering or exiting I-84 via Route 7 or local streets. In the westbound direction, approximately *43 percent* of the traffic is traveling through on I-84 and the remaining *57 percent* of the traffic is entering and exiting I-84 via Route 7 or local streets.

Weekday Off-Peak Period – As shown in Figure 2-7, during the off-peak period, in the eastbound direction, approximately *28 percent* of the traffic using I-84 within the study area is going through on I-84 and the remaining *72 percent* of the traffic is entering and exiting I-84 via Route 7 or local streets. In the westbound direction, approximately *36 percent* of the traffic is going through on I-84 and the remaining *64 percent* of the traffic is entering and exiting I-84 via Route 7 or local streets.

Weekday P.M. Peak Period - As shown in Figure 2-8, during the P.M. peak period, in the eastbound direction, approximately *53 percent* of the traffic using I-84 within the study area is traveling through on I-84 and the remaining *47 percent* of the traffic is entering and exiting I-84 via Route 7 or local streets. In the westbound direction, approximately *51 percent* of the traffic is going through on I-84 and the remaining *49 percent* of the traffic is entering and exiting I-84 via Route 7 or local streets.

In summary, the current travel patterns on I-84 indicate that a significant portion of the traffic using I-84 within the study corridor is local (about 50 percent or more) during peak and off-peak periods.

2.1.6.2 Route 7 Origin-Destination Patterns

Figures 2-8 through 2-10 show the O-D patters for traffic using Route 7 in the Danbury area.

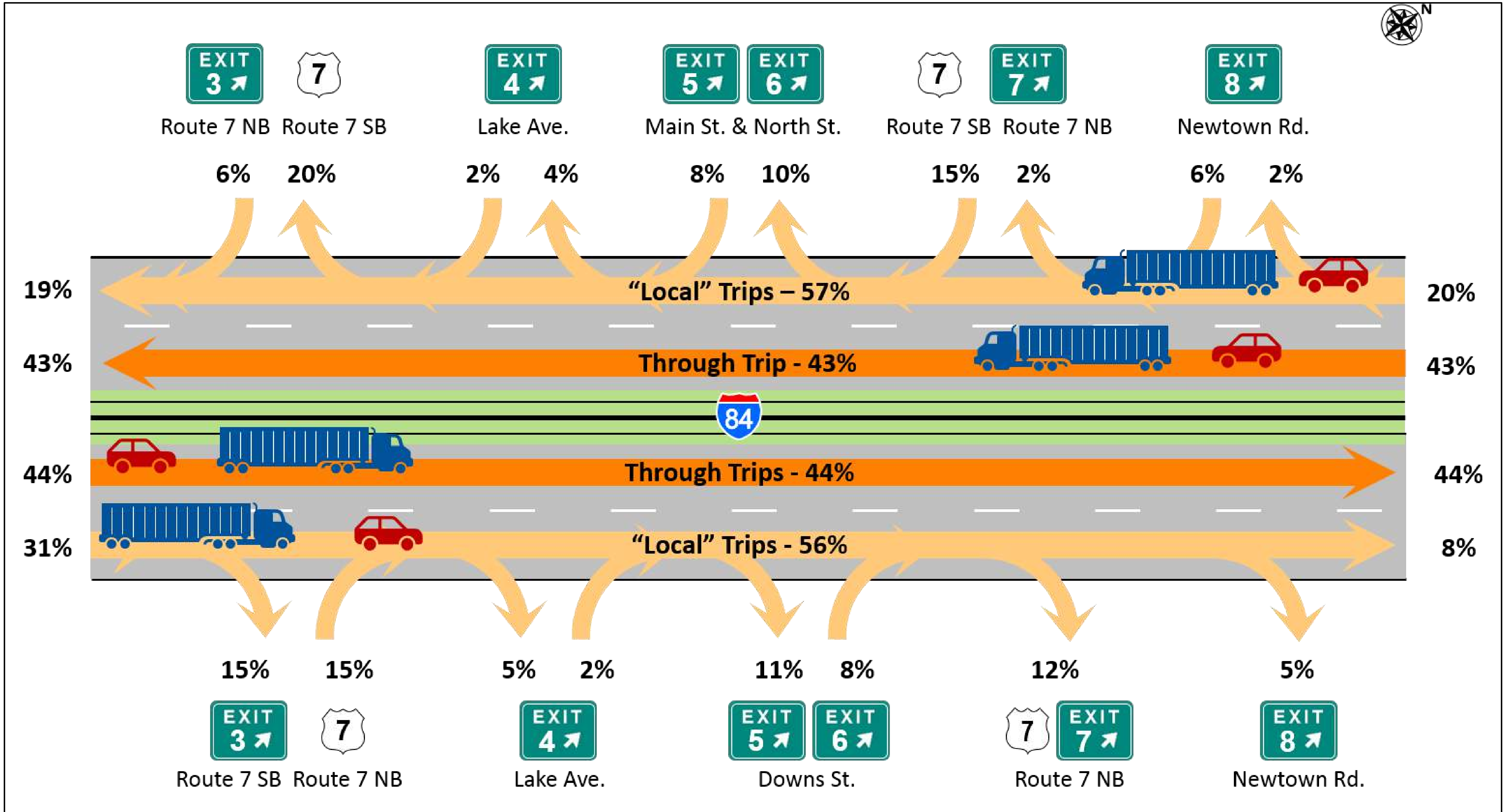
Weekday A.M. Peak Period - As shown in Figure 2-9, during the A.M. peak period, in the eastbound direction, approximately *26 percent* of the traffic entering I-84 at Exit 3 is going through on Route 7, approximately *24 percent* of the traffic continues on I-84 to the east and remaining the *50 percent* of the traffic is oriented towards local interchanges. In the westbound direction, approximately *36 percent* of the traffic entering I-84 from Route 7 at Exit 7 is going through on Route 7, while approximately *40 percent* of the traffic continues on I-84 to the west, and the remaining *24 percent* of the traffic is oriented towards local streets.

Weekday Off-Peak Period - As shown in Figure 2-10, during the off-peak period, in the eastbound direction, approximately *24 percent* of the traffic entering I-84 at Exit 3 is going through on Route 7, approximately *59 percent* of the traffic continues on I-84 to the east, and the remaining *17 percent* of the traffic is oriented towards local streets. In the westbound direction, approximately *44 percent* of the traffic entering I-84 from Route 7 at Exit 7 is going through on Route 7, approximately *34 percent* of the traffic continues on I-84 to the west, and the remaining *22 percent* of the traffic exits to local streets.

Weekday P.M. Peak Period - As shown in Figure 2-11, during the P.M. peak period, in the eastbound direction, approximately *26 percent* of the traffic entering I-84 at Exit 3 is going through on Route 7, approximately *19 percent* of the traffic continues on I-84 to the east, and the remaining *55 percent* of the traffic is oriented towards local streets. In the westbound direction, approximately *32 percent* of the traffic entering I-84 from Route 7 is going through on Route 7, approximately *34 percent* of the traffic continues on I-84 to the west, and the remaining *34 percent* of the traffic is oriented towards local streets.

In summary, the current travel patterns indicate that a significant portion of the traffic entering Route 7 from the west is oriented towards local street exits while the Route 7 traffic entering from the east is oriented towards Route 7 and I-84.

Figure 2-5 I-84 Average Weekday Origin and Destination Data – Weekday A.M. Peak Period



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

Figure 2-6 I-84 Average Weekday Origin and Destination Data – Weekday Off Peak Period

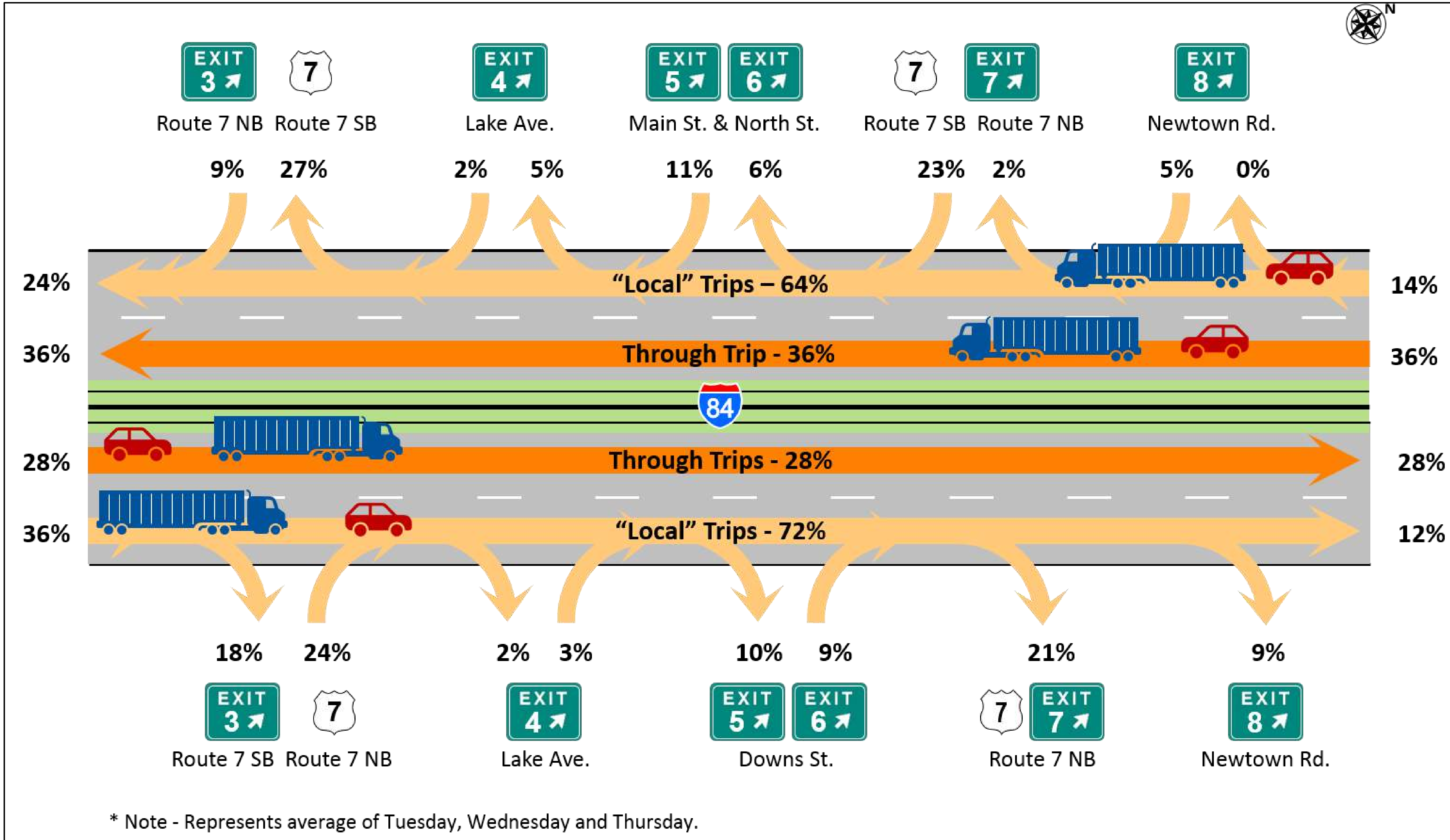
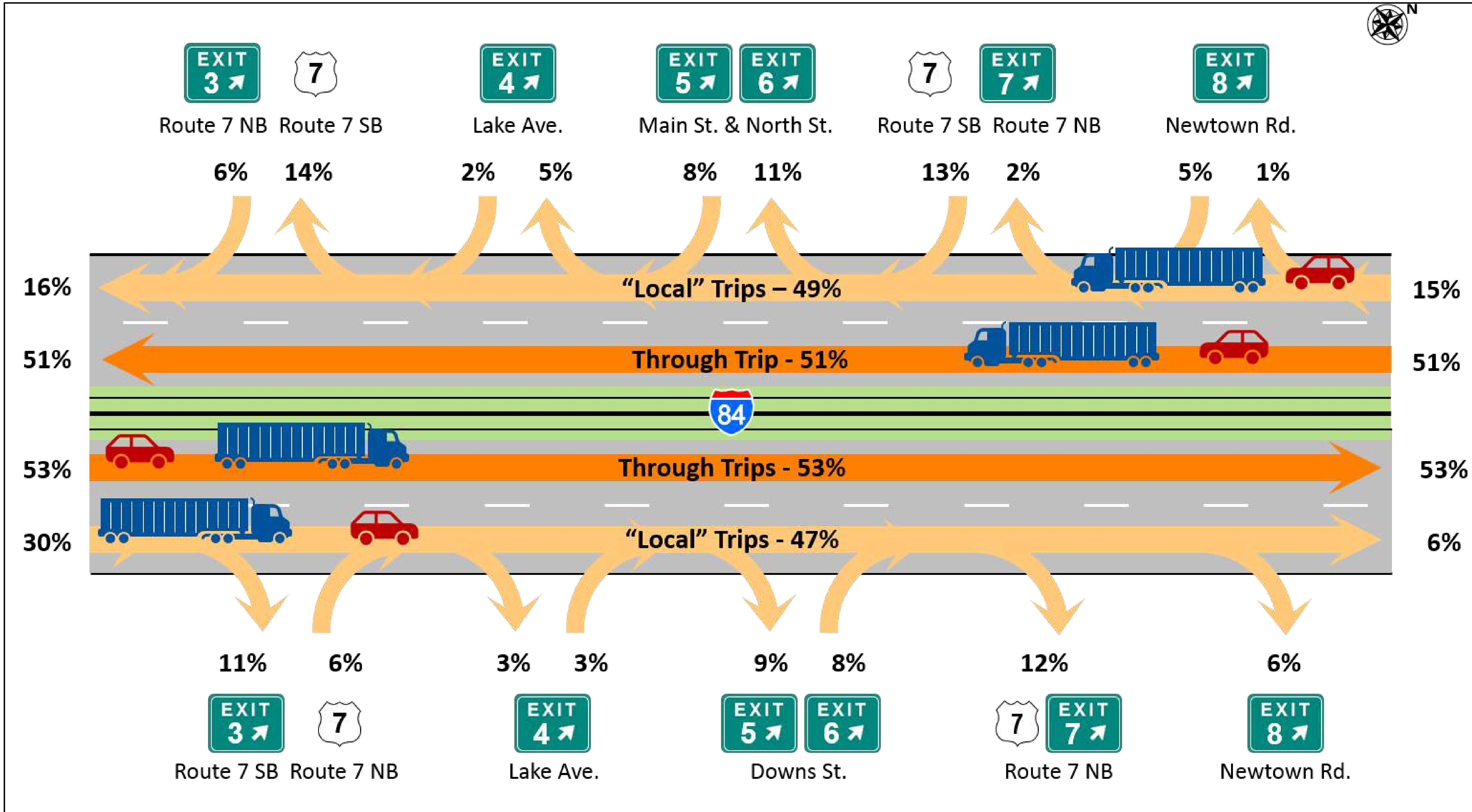
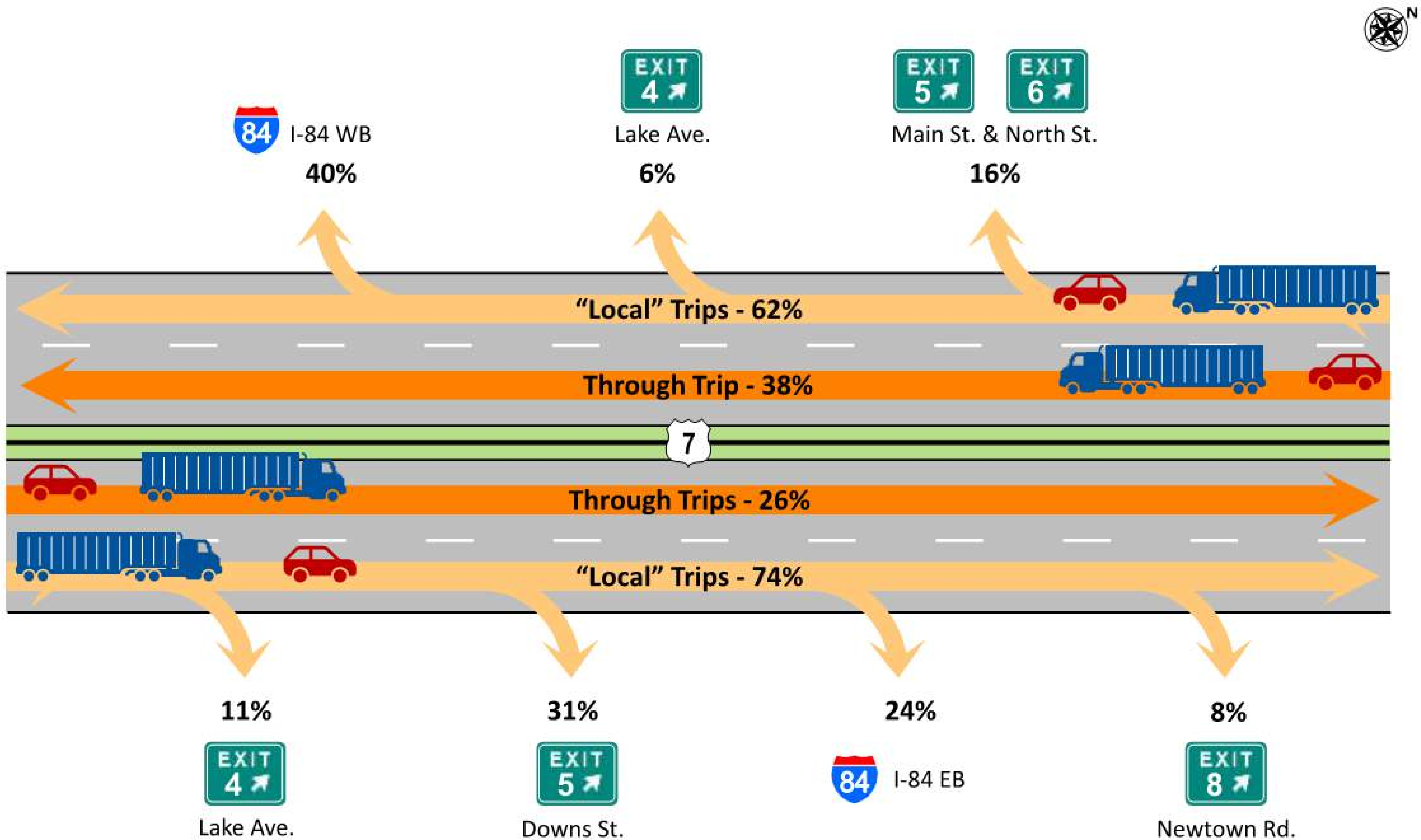


Figure 2-7 I-84 Average Weekday Origin and Destination Data – Weekday P.M. Peak Period



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

Figure 2-8 Route 7 Average Weekday Origin and Destination Data – Weekday A.M. Peak Period



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

Figure 2-9 Route 7 Average Weekday Origin and Destination Data – Weekday Off Peak Period

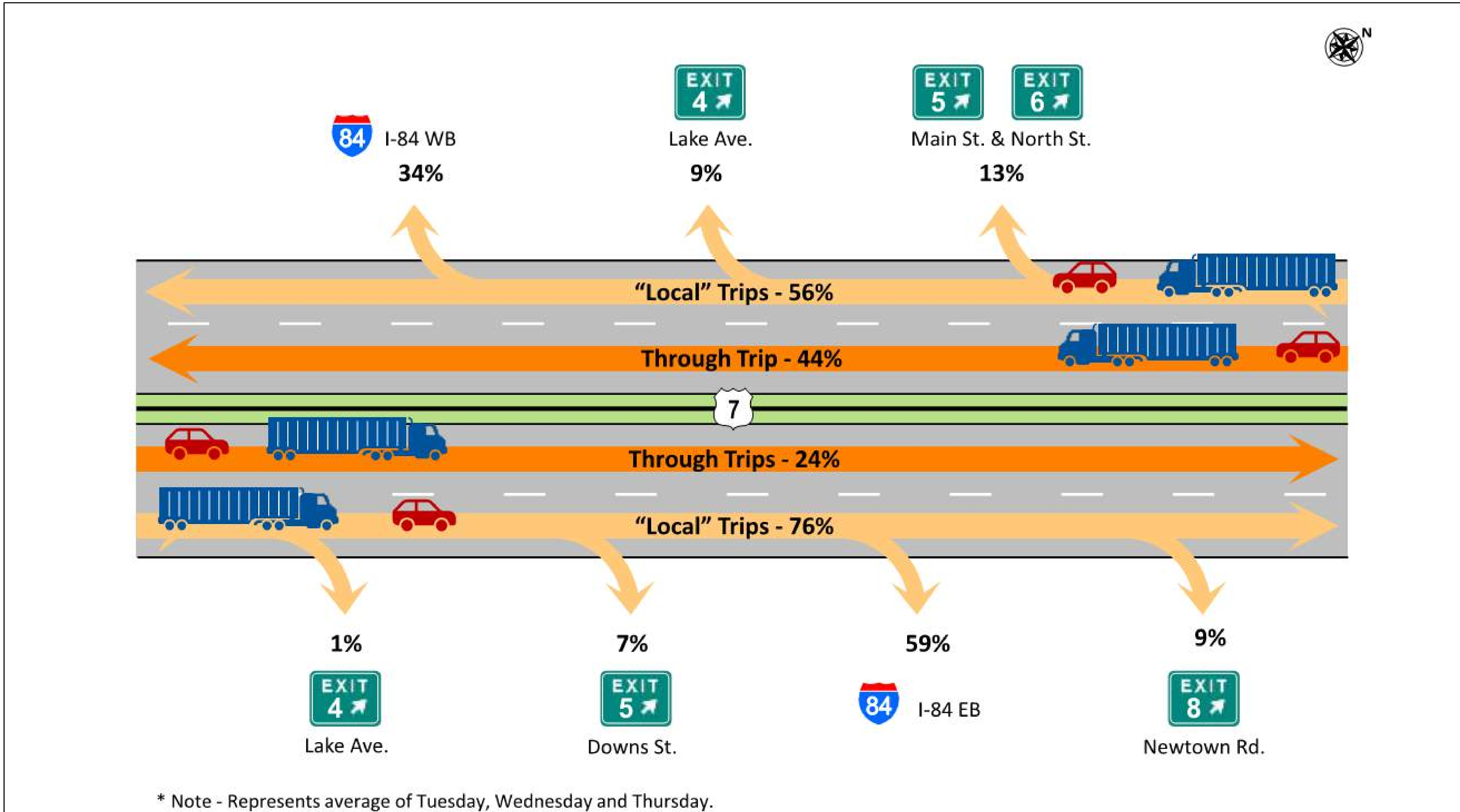
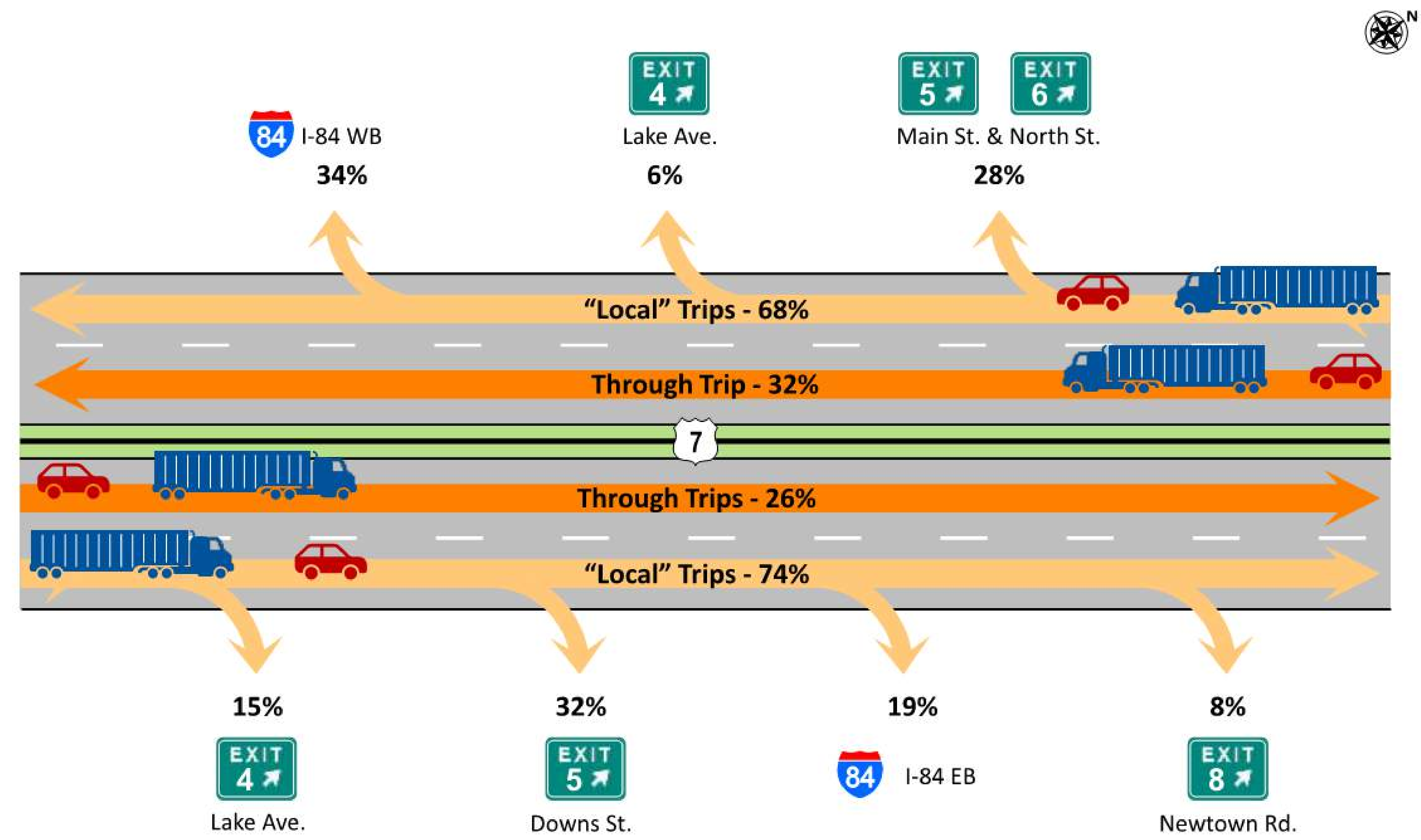


Figure 2-10 Route 7 Average Weekday Origin and Destination Data – Weekday P.M. Peak Period



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

2.1.7 Vehicle Occupancy Counts

Vehicle occupancy counts on I-84 were conducted on Thursday, November 3, 2016 during the weekday A.M peak. mid-day, and P.M. peak periods. *Vehicle occupancy data was obtained by lane in each direction of travel and is only a representative sample of the traffic in each direction. It should be noted that the total count is not the actual traffic volume in that time period.* **Table 2-4** summarizes the vehicle occupancy data based on the data collected in the field in the eastbound direction.

Table 2-4 Vehicle Occupancy Data – I-84 Eastbound Data

Occupancy	AM Peak		Mid-day		PM Peak	
	Count	Percent	Count	Percent	Count	Percent
1	144	86%	136	83%	195	89%
2	22	13%	24	15%	22	10%
3 or more	1	1%	3	2%	1	1%
TOTAL	167	100%	163	100%	218	100%

Note: Based on field data collected on November 3, 2016.

Single occupant vehicles constitute about **89** percent of the traffic during the P.M. peak period in the eastbound direction (commuter peak direction), while two-occupant vehicles constitute about **10** percent of eastbound traffic, and the remaining **1** percent of traffic contains 3 or more occupants.

Table 2-5 summarizes the vehicle occupancy data based on the data collected in the field in the westbound direction.

Table 2-5 Vehicle Occupancy Data – I-84 Westbound Data

Occupancy	AM Peak		Mid-day		PM Peak	
	Count	Percent	Count	Percent	Count	Percent
1	161	91%	161	81%	202	87%
2	12	7%	31	16%	27	11%
3 or more	3	2%	6	3%	4	2%
TOTAL	176	100%	198	100%	233	100%

Note: Based on field data collected on November 3, 2016.

In the A.M. commuter peak period, single occupant vehicles constitute about **91** percent of the westbound traffic, two-occupant vehicles constitute about **7** percent, and the remaining **2** percent of traffic are vehicles with 3 or more occupants. It is generally expected that the mid-day and P.M. peak periods have higher shares of carpools since the most non-commute trips (such as shopping and personal business trips) occur outside the A.M. peak period.

Once the model network and the TAZs were established, the model was validated for accuracy by confirming cutline volumes along I-84 and different portions of the study area. The cutline volume comparison is between the TDM volumes vs. actual field counts. A detailed explanation of the TDM development process and validation along with supporting documentation is provided in the **Technical Appendix**.

2.2 Existing Traffic Operations

This section discusses the development of the traffic simulation model using VISSIM and the results of the traffic operations analysis for the mainline segments, ramps, and intersections.

2.2.1 Existing Travel Demand Model

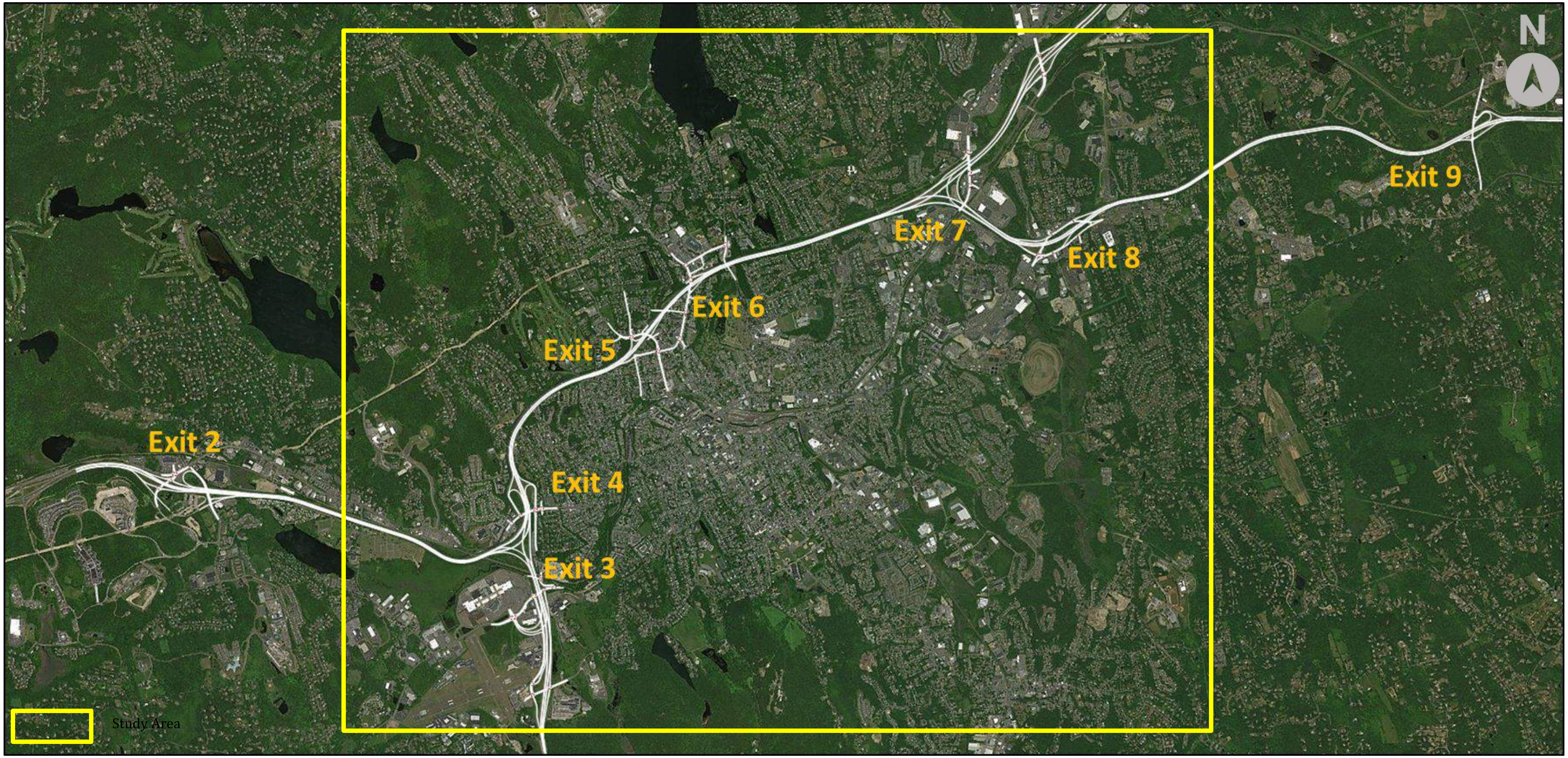
A study area Travel Demand Model (TDM) was developed using the Citilabs Cube modeling platform for the purposes of forecasting future traffic volumes. Data from the latest version of the statewide travel demand model maintained by CTDOT was obtained for this study. The model represents the roadway network as links, which are connected by nodes, which represent intersections. Traffic analysis zones (TAZ), which generally share geographic boundaries with census blocks in Danbury, are used to estimate and forecast population, households, and employment within each TAZ. These socioeconomic variables are used to estimate the number of trips generated each day from each TAZ and used to estimate the level of travel interaction between zones. In addition to incorporating CTDOT's next generation highway network, we reviewed and refined of how TAZ were connected to the local street system, and disaggregated TAZ within the Danbury area to better reflect local development patterns and local street access.

2.2.2 Traffic Simulation Model (VISSIM)

VISSIM is a microscopic traffic simulation software used to model and simulate traffic flow of vehicles within a given network. A microscopic model simulates individual vehicles in a traffic stream by assigning specific characteristics to each vehicle. This allows the model the ability to individually track vehicle movements and represent congested or bottleneck conditions. The purpose of this tool is to provide a representation of future conditions based on future traffic volumes anticipated in the study area. Before this model can be used for evaluating future conditions, the model was calibrated and validated based on accepted guidance by FHWA. A detailed explanation of the model development, calibration, and validation is provided in the Traffic Operations Technical Appendix.

VISSIM models were developed for the weekday A.M. and P.M. peak hour periods. The weekday A.M. model was developed for the 6:00-9:00 A.M. period and the weekday P.M. model was developed for the 3:00-6:00 P.M. period. The model was developed for three-hour periods to accurately represent build-up and dissipation of congestion on I-84. **Figure 2-11** shows the limits of the study area included in the VISSIM model. As described in the Traffic Operations Technical Appendix, the model met the traffic volume and the travel time criteria established by the FHWA to satisfy calibration requirements.

Figure 2-11 VISSIM Model Area



2.2.3 Mainline Segment Operations

This section focusses on the mainline segment operations along I-84 and Route 7.

2.2.3.1 Methodology/Criteria

The VISSIM model was used to determine levels of service along I-84 and Route 7 segments during weekday A.M. and P.M. peak hour periods. **Table 2-6** highlights the level of service (LOS) criteria for freeway mainline segments. The level of service criteria for freeway segments is based on maximum density defined in terms of passenger cars per mile per lane (pc/mi/lane).

Table 2-6 LOS Criteria for Freeway Segments

Level of Service	Maximum Density (pc/mi/lane)
A	11
B	18
C	26
D	35
E	45
F	>45

Source: 2010 Highway Capacity Manual

2.2.3.2 I-84 Mainline Operations

Tables 2-7 and **2-8** show LOS analysis results for I-84 mainline segments in the eastbound and westbound directions respectively under existing (2016) conditions. The LOS tables are broken down by weekday A.M. and P.M. peak hour periods. The following segments show LOS E or F under existing conditions:

Eastbound Direction

The eastbound direction has heavy traffic volumes entering the study area from I-84 and Route 7 during the weekday P.M. peak hour period. The congestion is caused by through and weaving (entering and exiting) traffic between Exits 3 and 8. Therefore, several mainline segments noted below operate at LOS F:

- Between Exit 4 On and Off Ramps
- Between Exit 4 On and Exit 5 Off Ramps
- Between Exit 5 On and Off Ramps
- Between Exit 5 On and Exit 6 On Ramps
- Between Exit 6 On and Exit 7 Off Ramps

The segment between the Exit 8 on-ramp and the Exit 9 off-ramp operates at LOS F due to reduction in number of lanes on the mainline (three to two) east of Exit 8.

Westbound Direction

The westbound direction has heavy traffic volumes entering the study area from I-84 and Route 7 during the weekday A.M. peak hour period. The congestion is caused by weaving (entering and exiting) traffic between Exits 3 and 8. Therefore, the following two (2) mainline segments noted below operate at LOS E or F:

- Between Exit 5 On and Exit 4 Off Ramps
- Between Exit 5 On and Exit 4 Off Ramps
- Between Exit 7 On and Exit 6 Off Ramps

In addition, the following segments operate at LOS E or F due to high traffic demand and a two-lane mainline section on I-84:

- Between Exit 7 On and Off Ramps
- Between Exit 8 On and Off Ramps
- Between Exit 8 Off and 9 On Ramps

Table 2-7 Existing (2016) I-84 Segment Levels of Service – Eastbound Direction

Location			Weekday A.M. Peak			Weekday P.M. Peak		
Start	End	Length (ft)	Volume	Density (pc/mi/ln)	LOS	Volume	Density (pc/mi/ln)	LOS
Exit 3 Off **To Route 7 Southbound**	Exit 03 On **From Route 7 Northbound**	2,433	1290	11.0	A	2580	24.3	C
Exit 4 Off **To Lake Avenue**	Exit 04 On **From Lake Avenue**	856	2290	11.7	B	4840	93.8	F
Exit 4 On **From Lake Avenue**	Exit 05 Off **To Downs Street**	5,817	2840	15.5	B	5650	59.4	F
Exit 5 Off **To Downs Street**	Exit 05 On **From Main Street**	2,318	2140	11.8	B	4400	53.6	F
Exit 5 On **From Main Street**	Exit 06 On **From North Street**	1,964	2810	14.0	B	4980	74.6	F
Exit 6 On **From North Street**	Exit 07 Off **To Route 7 Northbound**	7,232	3580	18.7	C	5730	56.3	F
Exit 7 Off **To Route 7 Northbound**	Exit 07 On **From Route 7 Southbound**	2,279	2730	20.7	C	3680	34.0	D
Exit 8 Off **To Newtown Road East**	Exit 08 On **From Newtown Road East**	2,406	1960	10.9	A	3110	18.0	C
Exit 8 On **From Newtown Road East**	Exit 09 Off **To Hawleyville Road**	14,272	2260	16.0	B	3710	60.9	F

Table 2-8 Existing (2016) I-84 Segment Levels of Service – Westbound Direction

Location			Weekday A.M. Peak			Weekday P.M. Peak		
Start	End	Length (ft)	Volume	Density (pc/mi/ln)	LOS	Volume	Density (pc/mi/ln)	LOS
Exit 04 On **From Lake Avenue**	Exit 03 On **From Route 7 Northbound**	736	3290	22.7	C	1890	11.8	B
Exit 3 Off **To Route 7 Southbound**	Exit 04 On **From Lake Avenue**	950	2990	26.0	C	1710	15.0	B
Exit 4 Off **To Lake Avenue**	Exit 03 Off **To Route 7 Southbound**	1,850	5200	28.0	D	2970	15.6	B
Exit 5 On **From Main Street**	Exit 04 Off **To Lake Avenue**	6,000	5840	35.3	E	3680	21.1	C
Exit 5 Off **To Downs Street**	Exit 05 On **From Main Street**	1,000	4440	25.6	C	2750	16.3	B
Exit 6 Off **To North Street**	Exit 05 Off **To Main Street**	3,350	4970	28.2	D	3700	22.1	C
Exit 7 On **From Route 7 Southbound**	Exit 06 Off **To North Street**	7,450	5720	35.5	E	4570	28.3	D
Exit 7 Off **To Route 7 Northbound**	Exit 07 On **From Route 7 Southbound**	2,050	3730	35.3	E	2860	21.1	C
Exit 8 Off **To Newtown Road**	Exit 08 On **From Newtown Road**	3,650	3190	74.6	F	2430	20.1	C
Exit 9 On **From Hawleyville Road**	Exit 08 Off **to Newtown Road**	14,114	4050	35.2	E	2900	21.9	C

2.2.3.3 Route 7 Mainline Operations

Tables 2-9 and **2-10** show LOS analysis results for Route 7 mainline segments in the northbound and southbound directions respectively under existing (2016) conditions. The LOS tables are broken down by weekday A.M. and P.M. peak hour periods. The following segments show LOS E or F under existing conditions:

Northbound Direction

No mainline segments to report.

Southbound Direction

- **Exit 11 On and Exit 10E Off Ramps** – This segment is between the ramp merge from White Turkey Road extension and the split to the I-84 eastbound ramp. During the A.M. peak hour period, this Route 7 segment is severely congested, and the vehicle queues extend past the White Turkey Road Extension overpass. Further, this segment is affected by the merge between the I-84 westbound ramp and the Federal Road on-ramp.

- **Exit 10E Off and 10 On Ramps** – This segment is between the split to the I-84 eastbound ramp and the ramp merge from Federal Road. During the A.M. peak hour period, this Route 7 segment is severely congested due to the merge between the I-84 westbound ramp and the Federal Road on-ramp.

- **Exit 10 On and Exit 10W Off Ramps** – This segment is between the ramp merge from Federal Road and the merge into I-84 westbound mainline. During the A.M. peak hour periods, this segment Figures severe congestion with almost stopped condition due to the lane drop after the merge with Federal Road. During the P.M. peak hour period, there is some congestion at the merge with I-84 westbound.

2.2.3.4 Summary of Mainline Segment Operations

- Six (6) segments on I-84 operate at LOS F in the eastbound direction due to congestion or mainline capacity in the P.M. peak hour period.

- Five (5) segments on I-84 operate at LOS E or F in the westbound direction due to congestion or mainline capacity in the A.M. peak hour period.

- Three (3) segments on Route 7 operates at LOS F in the southbound direction due to downstream congestion in the A.M. peak hour period.

Figures 2-12 and **2-13** show the mainline segment level of service during the weekday A.M. and P.M. peak hour periods under existing conditions respectively.

Table 2-9 Existing (2016) Route 7 Segment Levels of Service – Northbound Direction

Location			Weekday A.M. Peak			Weekday P.M. Peak		
Start	End	Length (ft)	Volume	Density (pc/mi/ln)	LOS	Volume	Density (pc/mi/ln)	LOS
Exit 7 Off **To Wooster Hghts Rd.**	Exit 7 On **From Wooster Hghts Rd.**	2,379	1060	10.0	A	1890	18.0	C
Exit 10 On **From I-84 Westbound**	Exit 11 Off **To White Turkey Rd. Ext.**	3,172	1790	13.3	B	2730	21.6	C
Exit 11 On **To White Turkey Rd. Ext.**	Exit 11 On **From White Turkey Rd. Ext.**	2,696	600	4.7	A	1130	8.1	A

Table 2-10 Existing (2016) Route 7 Segment Levels of Service – Southbound Direction

Location			Weekday A.M. Peak			Weekday P.M. Peak		
Start	End	Length (ft)	Volume	Density (pc/mi/ln)	LOS	Volume	Density (pc/mi/ln)	LOS
Exit 7 Off **To Sugar Hollow Rd.**	Exit 07 On **From Miry Brook Rd.**	2,802	1410	12.7	B	710	7.7	A
Exit 8 Off **To Backus Ave./Park Ave.**	Exit 07 Off **To Sugar Hollow Rd.**	1,850	1940	11.3	B	1050	6.8	A
Exit 10 On **From Federal Road**	Exit 10W Off **Begin I-84 WB Overlap**	940	1990	65.7	F	1710	45.2	F
Exit 10E Off **To I-84 Eastbound**	Exit 10 On **From Federal Road**	740	1000	160.9	F	890	16.7	B
Exit 11 On **From White Turkey Road Ext.**	Exit 10E Off **To I-84 Eastbound**	3,640	1660	115.2	F	1500	12.4	B
Exit 11 Off **To White Turkey Road Ext.**	Exit 11 On **From White Turkey Road Ext.**	2,590	1180	22.8	C	620	5.1	A

Figure 2-12 Existing (2016) Highway Mainline and Ramp Levels of Service – Weekday A.M. Peak Hour Period

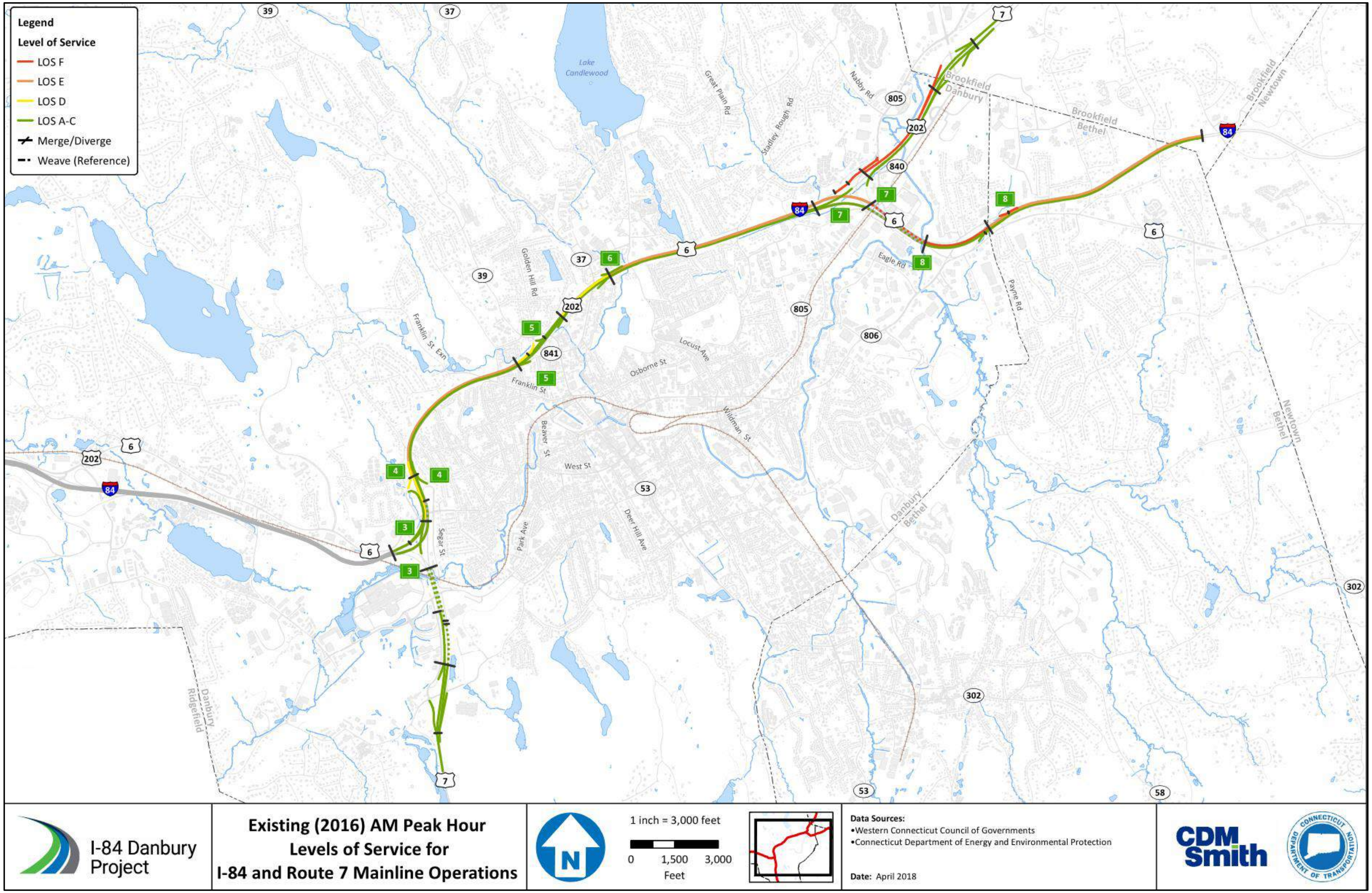
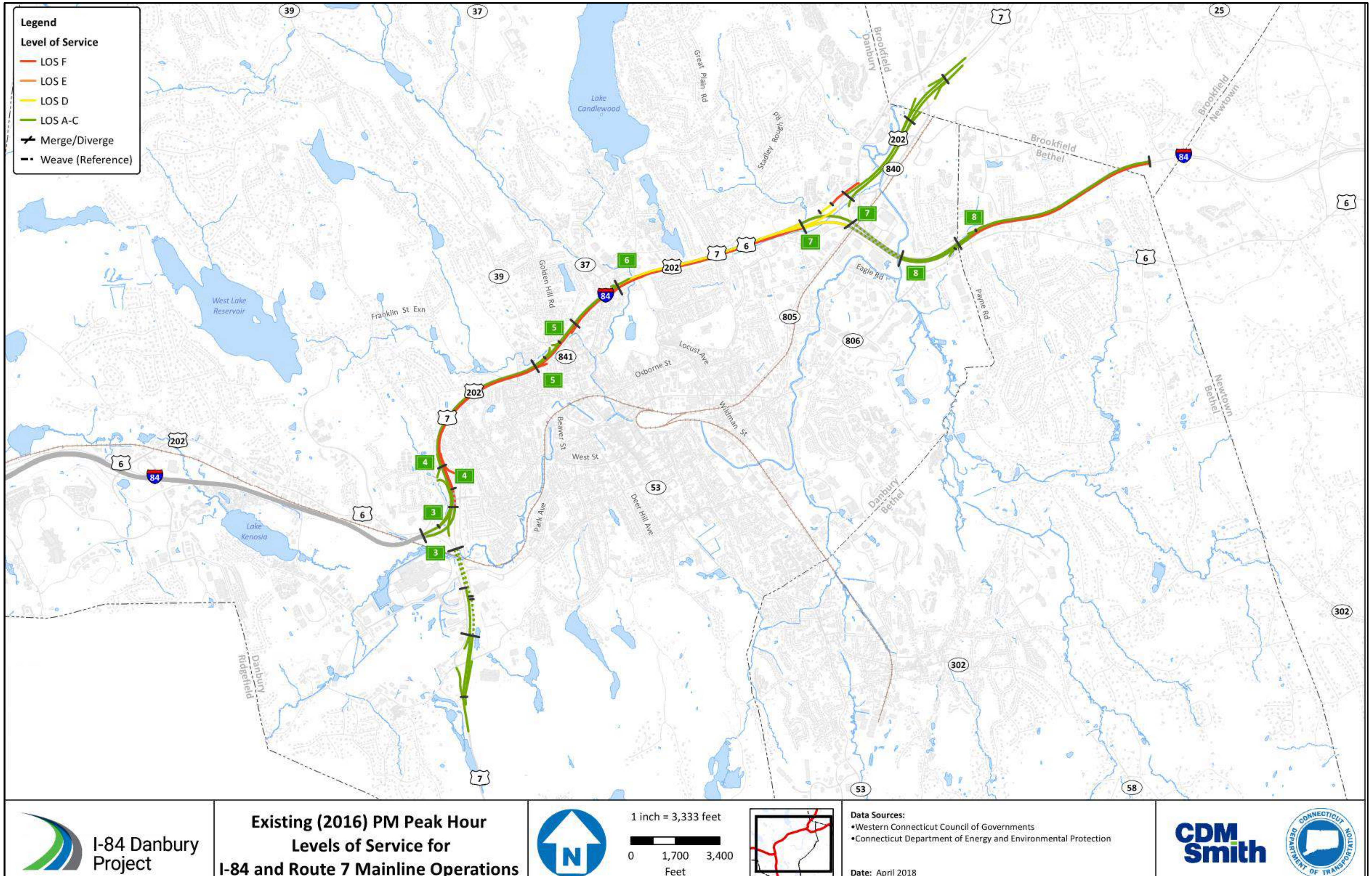


Figure 2-13 Existing (2016) Highway Mainline and Ramp Levels of Service – Weekday P.M. Peak Hour Period



2.2.4 Mainline-Ramp Junction Operations

This section focusses on the mainline and ramp junction operations along I-84 and Route 7.

2.2.4.1 Methodology/Criteria

The VISSIM model was used to determine levels of service along I-84 and Route 7 during the weekday A.M. and P.M. peak hour periods. **Table 2-11** highlights the LOS criteria for freeway-ramp junctions. The level of service criteria for mainline-ramp junctions is based on maximum density defined in terms of passenger cars per mile per lane (pc/mi/lane).

Table 2-11 LOS Criteria for Freeway-Ramp Junctions

Level of Service	Maximum Density (pc/mi/lane)
A	10
B	20
C	28
D	35
E	>35
F	Demand exceeds capacity

2.2.4.2 I-84 Ramp Levels of Service

Tables 2-12 and **2-13** show LOS analysis results for I-84 merge and diverge ramp junctions in the eastbound and westbound directions respectively under existing (2016) conditions. The LOS tables are broken down by weekday A.M. and P.M. peak hour periods. The following ramp junctions show LOS E or F under existing conditions

Eastbound Direction

- **Exit 4 On Ramp from Lake Avenue (merge)** – This merge junction operates at LOS F due to peak hour congestion during the P.M. peak hour period and inadequate acceleration length to merge onto I-84.
- **Exit 5 Off Ramp to Downs Street (diverge)** – This diverge junction operates at LOS F due to peak hour congestion and high off-ramp volume during the P.M. peak hour period
- **Exit 5 On Ramp from Main Street (merge)** – This merge junction operates at LOS F due to peak hour congestion during the P.M. peak hour period and inadequate acceleration length to merge onto I-84.
- **Exit 6 On Ramp from North Street (merge)** – This merge junction operates at LOS F due to peak hour congestion during the P.M. peak hour period and inadequate acceleration length to merge onto I-84.

Westbound Direction

- **Exit 8 Off Ramp to Newtown Road/U.S. 6 (diverge)** – This diverge junction operates at LOS F due to peak hour congestion during the A.M. peak hour period and two-lane section of I-84.

2.2.4.3 Route 7 Ramp Levels of Service

Tables 2-14 and **2-15** show LOS analysis results for Route 7 merge and diverge ramp junctions in the northbound and southbound directions respectively under existing (2016) conditions. The LOS tables are broken down by weekday A.M. and P.M. peak hour periods. The following ramp junctions show LOS F under existing conditions:

Northbound Direction

No ramps to report.

Southbound Direction

The following ramp merges operate at LOS F during the weekday A.M. peak hour period resulting from congestion at the Route 7 merge with I-84 westbound:

- Exit 10 On Ramp from Federal Road
- Exit 11 On Ramp from White Turkey Road Extension

2.2.4.4 Summary of Ramp Levels of Service

- Three (3) ramp merge junctions on I-84 operate at LOS F in the eastbound direction due to congestion and inadequate merging distances in the P.M. peak hour period.
- One (1) ramp diverge junction on I-84 operates at LOS F in the eastbound direction due to congestion and high off-ramp volume in the P.M. peak hour period.
- One (1) ramp diverge junction on I-84 operates at LOS F in the eastbound direction due to congestion and inadequate capacity in the P.M. peak hour period.
- One (1) ramp diverge junction on I-84 operates at LOS F in the westbound direction due to congestion and inadequate capacity in the A.M. peak hour period.
- Two (2) ramp merge junctions on Route 7 operate at LOS F in the southbound direction due to downstream congestion in the A.M.. peak hour period.

Figures 2-13 and **2-14** show the ramp junction level of service during the weekday A.M. and P.M. peak hour periods under existing conditions respectively.

Table 2-12 Existing (2016) I-84 Ramp Levels of Service – Eastbound Direction

Location	Weekday AM Peak				Weekday PM Peak			
	Volume				Volume			
	Mainline	Ramp	Density (pc/mi/ln)	LOS	Mainline	Ramp	Density (pc/mi/ln)	LOS
Exit 4 – Lake Avenue								
On Ramp	2290	550	12.2	B	4840	810	81.5	F
Exit 5 – Downs Street/Main Street								
Off Ramp	2840	700	12.8	B	5650	1250	43.4	F
On Ramp	2140	670	11.8	B	4400	580	64.1	F
Exit 6 – North Street								
On Ramp	2810	770	11.8	B	4980	750	64.1	F
Exit 7 – Route 7								
Off Ramp	3580	1210	15.6	B	5730	2050	31.9	D
Exit 8 – Newtown Road/U.S. 6								
On Ramp	1960	300	9.1	A	3110	600	14.7	B

Table 2-13 Existing (2016) I-84 Ramp Levels of Service – Westbound Direction

Location	Weekday AM Peak				Weekday PM Peak			
	Volume				Volume			
	Mainline	Ramp	Density (pc/mi/ln)	LOS	Mainline	Ramp	Density (pc/mi/ln)	LOS
Exit 3 – Route 7								
Off Ramp	5200	2210	22.8	C	2970	1260	12.9	B
Exit 4 – Lake Avenue								
On Ramp	2990	300	21.2	C	1710	180	11.1	B
Off Ramp	5840	640	28.6	D	3680	710	17.1	B
Exit 5 – Downs Street/Main Street								
On Ramp	4440	1400	28.9	D	2750	930	16.1	B
Off Ramp	4970	530	22.4	C	3700	950	25.7	C
Exit 6 – North Street								
Off Ramp	5720	750	25.4	C	4570	870	20.1	C
Exit 8 – Newtown Road/U.S. 6								
Off Ramp	4050	860	36.2	F	2900	470	20.2	C

Table 2-14 Existing (2016) Route 7 Ramp Levels of Service – Northbound Direction

Location	Weekday AM Peak				Weekday PM Peak			
	Volume				Volume			
	Mainline	Ramp	Density (pc/mi/ln)	LOS	Mainline	Ramp	Density (pc/mi/ln)	LOS
Exit 7 – Wooster Heights Road								
Off Ramp	1290	230	8.5	A	2200	310	14.1	B
Exit 10 – I-84 EB								
On Ramp	1210	580	9.9	A	2050	680	15.1	B
Exit 11 – White Turkey Road Ext.								
Off Ramp	1790	1190	10.7	B	2730	1600	20.1	C
On Ramp	600	270	4.8	A	1130	650	9.2	A

Table 2-15 Existing (2016) Route 7 Ramp Levels of Service – Southbound Direction

Location	Weekday AM Peak				Weekday PM Peak			
	Volume				Volume			
	Mainline	Ramp	Density (pc/mi/ln)	LOS	Mainline	Ramp	Density (pc/mi/ln)	LOS
Exit 7 – Miry Brook Road/Sugar Hollow Road								
On Ramp	1410	660	11.6	B	710	540	7.3	A
Off Ramp	1940	530	11.3	B	1050	340	6.7	A
Exit 10 – Federal Road								
On Ramp	1000	990	92.5	F	890	820	50.8	F
Exit 11 – White Turkey Road Ext.								
On Ramp	1180	480	106.7	F	620	8.4	8.4	A
Off Ramp	1790	610	10.5	B	930	5.4	5.4	A

2.2.5 Weaving Operations

This section focusses on the operational analysis of weaving areas along I-84 and Route 7.

2.2.5.1 Methodology/Criteria

The VISSIM model was used to determine levels of service associated with weaving area along I-84 and Route 7 during the weekday A.M. and P.M. peak hour periods. **Table 2-16** highlights the LOS criteria for weaving areas. The level of service criteria for weaving areas is based on maximum density defined in terms of passenger cars per mile per lane (pc/mi/lane).

Table 2-16 LOS Criteria for Weaving Areas

Level of Service	Maximum Density (pc/mi/lane)
A	10
B	20
C	28
D	35
E	>35
F	Demand exceeds capacity

2.2.5.2 I-84 Weaving Areas Levels of Service

Tables 2-17 and **2-18** show LOS analysis results for I-84 weaving areas in the eastbound and westbound directions respectively under existing (2016) conditions. The LOS tables are broken down by weekday A.M. and P.M. peak hour periods. The following weaving areas show LOS E or F under existing conditions:

Eastbound Direction

- **Exit 3 On Ramp (Route 7) and Exit 4 off-ramp (Lake Avenue)** – This weaving area is 806 feet long and consists of a lane drop between the on and off-ramps. During the P.M. peak period, with high traffic volumes crossing each other, this weave area operates at LOS F.

Westbound Direction

- **Exit 8 On Ramp (Newtown Road) and Exit 7 off-ramp (Route 7)** – This weaving area is 1,715 feet long. During the A.M. peak period, with high traffic volumes crossing each other, this weave area operates at LOS F.

2.2.5.3 Route 7 Weaving Areas Levels of Service

Tables 2-19 and **2-20** show LOS analysis results for Route 7 weaving areas in the northbound and southbound directions respectively under existing (2016) conditions. The LOS tables are broken down by weekday A.M. and P.M. peak hour periods. There are no deficient weaving areas along Route 7 under existing (2016) conditions.

2.2.5.4 Summary of Weaving Area Levels of Service

- Two (2) weaving areas are deficient along I-84. One in the eastbound direction between Exits 3 and 4 and the other in the westbound direction between Exits 7 and 8.

Figures 2-12 and **2-13** show the weaving area levels of service during the weekday A.M. and P.M. peak hour periods under existing conditions respectively.

Table 2-17 Existing (2016) I-84 Weaving Levels of Service – Eastbound Direction

Location			Weekday AM Peak				Weekday PM Peak			
Start	End	Length (ft)	Weaving Volume	Non-Weaving Volume	Density (pc/mi/ln)	LOS	Weaving Volume	Non-Weaving Volume	Density (pc/mi/ln)	LOS
Exit 3 On **From Route 7 Northbound**	Exit 4 Off **To Lake Avenue**	806	1,208	1,322	10.3	B	2,400	2,800	85.5	F
Exit 7 On **From Route 7 Southbound**	Exit 8 Off **To Newtown Road**	2,026	300	2,730	18.6	B	470	3,820	27.1	C

Table 2-18 Existing (2016) I-84 Weaving Levels of Service – Westbound Direction

Location			Weekday AM Peak				Weekday PM Peak			
Start	End	Length (ft)	Weaving Volume	Non-Weaving Volume	Density (pc/mi/ln)	LOS	Weaving Volume	Non-Weaving Volume	Density (pc/mi/ln)	LOS
Exit 8 On **From Newtown Road**	Exit 7 Off **To Route 7 Northbound**	1,715	1,588	2,722	67.8	F	1,746	1,794	21.1	C

Table 2-19 Existing (2016) Route 7 Weaving Levels of Service – Northbound Direction

Location			Weekday AM Peak				Weekday PM Peak			
Start	End	Length (ft)	Weaving Volume	Non-Weaving Volume	Density (pc/mi/ln)	LOS	Weaving Volume	Non-Weaving Volume	Density (pc/mi/ln)	LOS
Exit 7 On **From Wooster Hghts. Rd.**	Exit 8 Off **To Park Avenue**	1,005	510	970	8.8	A	980	1,540	15.2	B
Exit 8 On **From Backus Ave./Park Ave.**	Exit 9 Off **To I-84**	1,427	446	1,254	9.9	B	1,698	1,682	18.6	B

Table 2-20 Existing (2016) Route 7 Weaving Levels of Service – Southbound Direction

Location			Weekday AM Peak				Weekday PM Peak			
Start	End	Length (ft)	Weaving Volume	Non-Weaving Volume	Density (pc/mi/ln)	LOS	Weaving Volume	Non-Weaving Volume	Density (pc/mi/ln)	LOS
Exit 9 On **From I--84**	Exit 8 Off **To Backus Ave./Park Ave.**	1,269	994	1,746	14.6	B	1,614	576	12.4	B

2.2.6 Intersection Operations

This section focusses on the operational analysis of intersection located within the study area.

2.2.6.1 Methodology/Criteria

A SYNCHRO model was built for the entire study area corridor which includes the study area intersections identified earlier. This model provides the ability to evaluate intersection operations along the I-84 and Route 7 corridors. LOS was determined for signalized and un-signalized intersections during the weekday A.M. and P.M. peak hour periods.

Table 2-21 highlights the level of service criteria for signalized intersections. The level of service criteria for signalized intersections is based on control delay per vehicle measured in seconds.

Table 2-21 - LOS Criteria for Signalized Intersections

Level of Service	Control Delay per Vehicle (seconds)
A	≤10
B	>10 and ≤20
C	>20 and ≤35
D	>35 and ≤55
E	>55 and ≤80
F	> 80

Source: 2010 Highway Capacity Manual

Table 2-22 highlights the level of service criteria for un-signalized intersections. The level of service criteria for un-signalized intersections is based on control delay per vehicle measured in seconds.

Table 2-22 - LOS Criteria for Un-Signalized Intersections

Level of Service	Control Delay per Vehicle (seconds)
A	≤10
B	>10 and ≤15
C	>15 and ≤25
D	>25 and ≤35
E	>35 and ≤50
F	> 50

Source: 2010 Highway Capacity Manual

2.2.6.2 Level of Service – Signalized Intersections

Tables 2-23 and 2-24 show LOS analysis results for signalized intersections along the I-84 and Route 7 interchanges under existing (2016) conditions. The LOS tables are broken down by weekday A.M. and P.M. peak hour periods. The existing signal phasing and operation was confirmed in the field and timings were obtained from the City or CTDOT for use in the SYNCHRO analysis, *The following is a list of intersections where a specific movement operates at a volume to capacity (v/c) ratio greater than 1.0 and a LOS E or F under existing conditions:*

- **Lake Avenue at I-84 Eastbound Ramps/Segar Street** – This intersection operates at an overall LOS B and D during the weekday A.M. and P.M. peak hour periods respectively. During the P.M. peak hour period, several movements operate at LOS E or worse i.e. Lake Avenue eastbound left turn, Segar Street northbound through, and I-84 eastbound off-ramp left turn movement. This intersection is coordinated and operates on the same controller with the Lake Avenue/Shannon Ridge Road/Ridge Road intersection and signal phasing creates additional delay on the movements leading to poor operating conditions.
- **Lake Avenue at Shannon Ridge Road** – This intersection operates at an overall LOS B and D during the weekday A.M. and P.M. peak hour periods respectively. During the P.M. peak hour period, several movements operate at LOS E or worse i.e. Lake Avenue eastbound left turn, Lake Avenue westbound approach, Ridge Road northbound, and Shannon Ridge Road southbound left-through movements, The Lake Avenue eastbound left turn movement has a v/c ratio of over 1.0.
- **Main Street at I-84 Westbound Ramps/Golden Hill Road** – This intersection operates at an overall LOS F during the weekday A.M. and P.M. peak hour periods. During both peak hour periods, several movements operate at v/c ratios greater than 1.0 and LOS E or F. The reason is the high traffic volumes at this intersection with inadequate capacity to handle the volume during peak periods. Without a westbound on-ramp at Exit 6, this intersection experiences high traffic volume conditions.

The remaining intersections did not consist of any movements with a high v/c ratio and a LOS E or F.

Table 2-23 Existing (2016) Signalized Intersection Levels of Service – I-84 Interchanges

Location			Weekday A.M. Peak			Weekday P.M. Peak		
			V/C	Delay	LOS	V/C	Delay	LOS
Interchange 4								
Lake Avenue at I-84 EB Ramps & Segar Street [1] (Int. #034-217)			**--**	**19.9**	**B**	**--**	**46.7**	**D**
Lake Avenue (Route 6)	EB	L	0.78	37.1	D	1.03	95.3	F
		TR	0.37	19.4	B	0.67	43.2	D
	WB	L	0.50	10.0	A	0.71	42.6	D
		TR	0.59	6.8	A	0.67	10.4	B
Segar Street	NB	L	0.62	51.0	D	0.56	47.1	D
		T	0.45	58.9	E	0.79	85.0	F
		R	0.07	0.4	A	0.60	13.1	B
I-84 EB Exit Ramp	SB	L	0.50	46.8	D	0.75	90.8	F
		TR	0.35	1.9	A	0.41	14.7	B
Lake Avenue at Shannon Ridge Road[1] (Int. #034-217)			**--**	**18.5**	**B**	**--**	**41.7**	**D**
Lake Avenue	EB	LTR	0.24	1.8	A	--	--	--
		Def. L	--	--	--	1.05	95.4	F
		TR	--	--	--	0.55	3.1	A
	WB	LTR	0.50	36.6	D	0.77	65.1	E
Ridge Road	NB	LTR	0.33	57.1	E	0.21	68.5	E
Shannon Ridge Road	SB	LT	0.00	0.0	A	0.09	65.3	E
		R	0.48	2.4	A	0.59	15.9	B
Lake Avenue Ext. at I-84 WB Ramps[1] (Int. #034-203)			**--**	**15.9**	**B**	**--**	**14.6**	**B**
Lake Avenue Ext. (Route 6 and Route 202)	EB	L	0.33	9.5	A	0.19	7.6	A
		T	0.35	7.9	A	0.60	10.5	B
	WB	TR	0.70	18.7	B	0.64	17.6	B
I-84 WB Exit Ramp	SB	L	0.29	19.7	B	0.49	22.6	C
		R	0.80	20.6	C	0.69	16.3	B

<u>Note</u>: (1) City Owned
(2) State Owned

Table 2-23 Existing (2016) Signalized Intersection Levels of Service – I-84 Interchanges (continued)

Location			Weekday A.M. Peak			Weekday P.M. Peak		
			V/C	Delay	LOS	V/C	Delay	LOS
Lake Avenue Ext. at Mill Ridge Road[1] (Int. #034-202)			--	**25.8**	**C**	--	**22.4**	**C**
Lake Avenue Extension (Route 6 and Route 202)	EB	L	0.29	11.3	B	0.31	10.7	B
		TR	0.34	16.6	B	0.58	18.5	B
	WB	L	0.21	9.2	A	0.22	9.2	A
		TR	0.73	24.4	C	0.70	21.4	C
Restaurant Driveway	NB	LT	0.15	23.7	C	0.09	22.4	C
		R	0.19	5.8	A	0.18	6.1	A
Mill Ridge Road	SB	LTR	0.90	54.4	D	0.85	47.9	D
Interchange 5								
Main Street at I-84 WB Ramps & Golden Hill Road[2] (Int. #034-206)			--	**84.9**	**F**	--	**76.5**	**E**
I-84 WB Exit Ramp	NB	L	1.02	96.8	F	1.02	80.6	F
		TR	0.55	18.6	B	0.81	38.6	D
Golden Hill Road	SB	L	0.28	25.9	C	0.61	39.0	D
		TR	1.13	122.0	F	1.05	105.3	F
Main Street (Route 39)	NW.	L	1.13	113.1	F	1.05	87.2	F
		TR	0.48	23.3	C	1.02	73.5	E
	SE.	L	0.15	18.7	B	0.95	93.9	F
		TR	1.11	100.8	F	1.02	86.1	F
Main Street at Downs Street & North Street[1] (Int. #034-205)			--	**32.1**	**C**	--	**52.8**	**D**
Downs Street (S.R. 841)	EB	L	0.73	39.8	D	0.93	54.6	D
		TR	0.81	38.3	D	0.81	36.9	D
North Street (Route 37)	WB	L	0.51	48.2	D	0.77	79.5	E
		TR	0.62	12.2	B	0.93	58.5	E
Main Street (Route 39/53)	NB	L	0.00	0.0	A	0.18	44.7	D
		TR	0.73	32.8	C	0.89	54.5	D
	SB	L	0.23	20.2	C	0.61	49.4	D
		TR	0.71	28.9	C	0.91	57.3	E

__Note__: (1) City Owned
(2) State Owned

Table 2-23 Existing (2016) Signalized Intersection Levels of Service – I-84 Interchanges (continued)

Location			Weekday A.M. Peak			Weekday P.M. Peak		
			V/C	Delay	LOS	V/C	Delay	LOS
Interchange 6								
North Street at Hayestown Avenue[2] (Int. #034-207)			--	**11.3**	**B**	--	**12.7**	**B**
Hayestown Avenue	WB	L	0.75	41.0	D	0.86	56.3	E
		R	0.24	2.9	A	0.33	9.5	A
North Street (Route 37)	NB	T	0.29	11.8	B	0.44	8.9	A
		R	0.49	1.9	A	0.40	1.4	A
	SB	L	0.36	9.1	A	0.59	10.9	B
		T	0.35	8.4	A	0.31	6.1	A
North Street at I-84 WB Exit Ramp[2] (Int. #034-235)			--	**10.6**	**B**	--	**14.1**	**B**
Padanaram Avenue	EB	L	0.12	42.1	D	0.11	42.0	D
		R	0.39	7.0	A	0.25	2.6	A
I-84 WB Exit Ramp	WB	LT	0.59	43.5	D	0.68	40.6	D
		R	0.56	3.9	A	0.50	2.9	A
North Street (Route 37)	NB	LT	0.33	14.7	B	0.42	19.3	B
	SB	TR	0.49	8.2	A	0.52	12.1	B
North Street at Madison Avenue[1] (Int. #034-263)			--	**12.2**	**B**	--	**12.6**	**B**
Madison Avenue	EB	LTR	0.69	23.2	C	0.75	29.8	C
North Court Driveway	WB	LTR	0.00	0.0	A	0.12	14.8	B
North Street (Route 37)	NB	LTR	0.37	6.6	A	0.62	8.4	A
	SB	LTR	0.68	11.7	B	0.69	11.0	B

Note: (1) City Owned
(2) State Owned

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Table 2-23 Existing (2016) Signalized Intersection Levels of Service – I-84 Interchanges (continued)

Location			Weekday A.M. Peak			Weekday P.M. Peak		
			V/C	Delay	LOS	V/C	Delay	LOS
North Street at Balmforth Avenue[2] (Int. #034-227)			--	**19.3**	**B**	--	**36.0**	**D**
Grocery Store Driveway	EB	L	0.12	25.9	C	0.14	32.6	C
		TR	0.13	16.3	B	0.29	26.3	C
Balmforth Avenue	NW	LT	0.70	41.2	D	0.91	72.7	E
		R	0.43	3.3	A	0.50	9.8	A
North Street (Route 37)	NB	L	0.03	6.6	A	0.13	10.1	B
		TR	0.78	28.5	C	0.92	50.7	D
	SB	L	0.76	20.1	C	0.89	45.0	D
		TR	0.28	8.7	A	0.33	11.8	B
Tamarack Avenue at Hayestown Avenue[1]			--	**16.0**	**B**	--	**20.7**	**C**
Hayestown Avenue	EB	LT	0.59	26.6	C	0.86	42.2	D
		R	0.69	7.7	A	0.49	4.7	A
Gas Station Driveway	WB	L	0.15	19.0	B	0.16	19.1	B
		TR	0.11	17.7	B	0.07	16.4	B
Tamarack Avenue	NB	L	0.69	18.0	B	0.84	26.4	C
		TR	0.14	7.3	A	0.39	10.6	B
	SB	LT	0.79	31.7	C	0.67	31.4	C
		R	0.28	1.3	A	0.20	1.6	A
Interchange 8								
Newtown Road at I-84 EB Exit-Ramp[2] (Int. #034-218)			--	**34.9**	**C**	--	**26.7**	**C**
I-84 EB Exit Ramp	EB	T	0.62	29.7	C	0.69	31.5	C
		R	0.68	19.7	B	0.64	18.9	B
Newtown Road (Route 6)	NE	T	0.44	22.6	C	0.72	27.0	C
	SW	L	0.42	40.4	D	0.36	39.8	D
		T	0.95	44.3	D	0.68	27.4	C

Note: (1) City Owned
(2) State Owned

Table 2-23 Existing (2016) Signalized Intersection Levels of Service – I-84 Interchanges (continued)

Location			Weekday A.M. Peak			Weekday P.M. Peak		
			V/C	Delay	LOS	V/C	Delay	LOS
Newtown Road at Old Sherman Turnpike[2] (Int. #034-232)			--	**5.0**	**A**	--	**5.2**	**A**
Newtown Road (Route 6)	EB	TR	0.37	4.2	A	0.59	3.4	A
Old Sherman Turnpike	NB	R	0.15	40.0	D	0.42	41.7	D
Newtown Road at Payne Road[2] (Int. #009-222)			--	**11.3**	**B**	--	**9.9**	**A**
Newtown Road (Route 6)	EB	TR	0.44	7.1	A	0.68	6.1	A
Payne Road	NB	R	0.75	29.1	C	0.74	41.2	D
Newtown Road at I-84 WB Exit Ramp[2] (Int. #034-245)			--	**26.8**	**C**	--	**15.4**	**B**
Newtown Road (Route 6)	WB	TR	0.82	26.6	C	0.63	13.5	B
I-84 WB Exit Ramp	SW	T	0.87	27.8	C	0.68	23.5	C
Newtown Road at I-84 WB On Ramp[2] (Int. #034-239)			--	**21.4**	**C**	--	**16.0**	**B**
Newtown Road (Route 6)	WB	L	0.50	8.1	A	0.34	4.1	A
		T	0.99	38.2	D	0.91	26.8	C
		R	0.04	3.8	A	0.04	2.4	A
Mountainview Terrace	SB	R	0.47	18.6	B	0.35	16.7	B
Eagle Road at Newtown Road[2] (Int. #034-223)			--	**28.5**	**C**	--	**35.2**	**D**
Newtown Road	EB	L	0.64	27.1	C	0.85	47.4	D
		TR	0.39	14.1	B	0.73	25.2	C
	WB	L	0.20	7.3	A	0.63	20.6	C
		TR	0.95	34.1	C	0.82	28.7	C
Shopping Plaza	NB	L	0.28	43.7	D	0.47	46.2	D
		T	0.16	40.5	D	0.58	49.2	D
		R	0.22	31.9	C	0.52	34.8	C
Eagle Road	SB	L	0.45	44.0	D	0.93	79.1	E
		LT	0.41	41.7	D	0.84	62.1	E
		R	0.37	25.0	C	0.67	30.5	C

Note: (1) City Owned
(2) State Owned

Table 2-24 Existing (2016) Signalized Intersection Levels of Service – Route 7 Interchanges

			Weekday A.M. Peak			Weekday P.M. Peak		
Location			V/C	Delay	LOS	V/C	Delay	LOS
Interchange 7								
Wooster Heights at Route 7 NB Ramps[1] (Int. #034-253)			**--**	**5.9**	**A**	**--**	**7.2**	**A**
Wooster Heights Road	EB	LT	0.37	5.5	A	0.60	8.1	A
	WB	TR	0.39	3.5	A	0.27	2.2	A
Rt-7 NB Exit Ramp	NB	LT	0.36	22.3	C	0.39	23.4	C
		R	0.33	6.8	A	0.45	6.6	A
Sugar Hollow Rd at Route 7 SB Off Ramp[1] (Int. #034-252)			**--**	**9.4**	**A**	**--**	**8.2**	**A**
Rt-7 SB Off Ramp	WB	LR	0.52	11.5	B	0.43	11.9	B
Sugar Hollow Road	NB	T	0.03	6.0	A	0.11	5.4	A
	SB	T	0.27	6.9	A	0.34	6.5	A
Wooster Heights at Route 7 SB On Ramp[1] (Int. #034-251)			**--**	**13.6**	**B**	**--**	**16.3**	**B**
Miry Brook Road	EB	LTR	0.49	16.4	B	0.63	18.3	B
Wooster Heights Road	WB	L	0.56	14.2	B	0.28	9.4	A
		TR	0.37	11.0	B	0.32	8.2	A
Sugar Hollow Road	SB	L	0.59	19.5	B	0.57	23.5	C
		TR	0.42	8.9	A	0.45	14.7	B

Note: (1) City Owned
(2) State Owned

Table 2-24 Existing (2016) Signalized Intersection Levels of Service – Route 7 Interchanges (continued)

Location			Weekday A.M. Peak			Weekday P.M. Peak		
			V/C	Delay	LOS	V/C	Delay	LOS
Interchange 8								
Backus Avenue at Sugar Hollow Road[1]			**--**	**5.3**	**A**	**--**	**12.9**	**B**
Backus Avenue	EB	LTR	0.22	10.1	B	0.57	14.5	B
	WB	L	0.42	4.3	A	0.45	8.0	A
		TR	0.17	2.3	A	0.23	4.7	A
Sugar Hollow Road	NB	LT	0.09	16.2	B	0.61	38.0	D
		R	0.03	0.1	A	0.29	7.9	A
Plaza Driveway	SB	LTR	0.00	0.0	A	0.00	0.0	A
Backus Avenue at Route 7 Ramps & Mall Driveway[1] (Int. #034-254)			**--**	**21.9**	**C**	**--**	**24.6**	**C**
Backus Avenue	EB	L	0.00	0.0	A	0.17	44.3	D
		T	0.29	36.8	D	0.60	38.1	D
	WB	L	0.46	43.9	D	0.66	51.4	D
		TR	0.42	24.4	C	0.68	31.1	C
Rt-7 SB Exit Ramp	NB	L	0.82	29.7	C	0.74	39.5	D
		TR	0.10	2.6	A	0.62	18.5	B
Mall Main Driveway	SB	L	0.00	0.0	A	0.49	46.7	D
		TR	0.08	30.4	C	0.60	37.2	D
Backus Avenue at Route 7 NB Exit Ramp[1] (Int. #034-255)			**--**	**6.6**	**A**	**--**	**10.1**	**B**
Backus Avenue	EB	T	0.16	5.4	A	0.58	8.9	A
Park Avenue	WB	T	0.37	6.4	A	0.29	6.6	A
Rt-7 NB Exit Ramp	NB	L	0.19	14.0	B	0.40	19.2	B
		R	0.10	6.1	A	0.45	18.3	B

Note: (1) City Owned
(2) State Owned

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Table 2-24 Existing (2016) Signalized Intersection Levels of Service – Route 7 Interchanges (continued)

Location			Weekday A.M. Peak			Weekday P.M. Peak		
			V/C	Delay	LOS	V/C	Delay	LOS
Park Avenue at Segar Street[1]			**--**	**7.3**	**A**	**--**	**12.2**	**B**
Park Avenue	EB	L	0.04	3.9	A	0.47	7.5	A
		T	0.35	5.8	A	0.68	11.7	B
	WB	T	0.53	10.8	B	0.47	16.6	B
		R	0.12	0.4	A	0.18	0.8	A
Segar Street	SB	L	0.20	16.5	B	0.55	29.2	C
		R	0.49	5.9	A	0.33	6.6	A
Segar Street at Mall East Driveway[1]			**--**	**11.5**	**B**	**--**	**28.6**	**C**
Mall East Driveway	EB	LR	0.24	33.4	C	0.95	77.9	E
Segar Street	NB	L	0.05	9.3	A	0.12	14.8	B
		T	0.23	11.3	B	0.49	20.1	C
	SB	T	0.33	17.6	B	0.32	22.5	C
		R	0.08	0.2	A	0.17	0.4	A
Interchange 11								
Federal Road at Old Brookfield Road[2] (Int. #034-302)			**--**	**12.3**	**B**	**--**	**7.1**	**A**
Old Brookfield Road	EB	LTR	0.64	42.8	D	0.52	47.7	D
Commuter Parking Lot	WB	LTR	0.02	0.1	A	0.19	1.3	A
Federal Road	NB	L	0.08	6.5	A	0.12	3.2	A
		TR	0.17	5.6	A	0.31	2.7	A
	SB	L	0.02	8.3	A	0.03	6.8	A
		TR	0.57	11.1	B	0.40	8.0	A

Note: (1) City Owned
(2) State Owned

Table 2-24 Existing (2016) Signalized Intersection Levels of Service – Route 7 Interchanges (continued)

Location			Weekday A.M. Peak			Weekday P.M. Peak		
			V/C	Delay	LOS	V/C	Delay	LOS
Federal Road at White Turkey Road Ext. [2] (Int. #034-211)			**--**	**17.4**	**B**	**--**	**13.3**	**B**
White Turkey Road Ext. (S.R. 840)	WB	L	0.87	42.0	D	0.69	39.3	D
		R	0.26	17.7	B	0.51	26.1	C
Federal Road (S.R. 805)	NB	T	0.29	1.9	A	0.48	5.2	A
		R	0.31	1.7	A	0.49	2.7	A
	SB	L	0.17	11.2	B	0.36	11.5	B
		T	0.24	10.2	B	0.24	7.8	A
Federal Road at International Drive[2] (Int. #034-211)			**--**	**13.2**	**B**	**--**	**26.1**	**C**
International Drive	WB	L	0.27	39.1	D	0.57	56.9	E
		R	0.07	6.0	A	0.36	16.7	B
Federal Road (S.R. 805)	NB	TR	0.74	27.1	C	0.96	42.0	D
	SB	LT	0.46	1.7	A	0.46	2.0	A
Route 7 NB Ramps at White Turkey Road Ext. [2] (Int. #018-207)			**--**	**18.4**	**B**	**--**	**24.3**	**C**
Rt-7 NB Exit Ramp	EB	L	0.70	26.2	C	0.89	42.7	D
		LT	0.70	26.3	C	0.89	42.7	D
		R	0.76	22.5	C	0.31	2.4	A
White Turkey Road Ext. (Route 202)	NB	T	0.20	17.5	B	0.54	28.0	C
		R	0.33	4.7	A	0.60	5.3	A
	SB	L	0.16	11.1	B	0.36	15.0	B
		T	0.52	13.2	B	0.26	12.7	B
Route 7 SB Ramps at White Turkey Road Ext. [2] (Int. #018-206)			**--**	**20.3**	**C**	**--**	**12.6**	**B**
Rt-7 SB Exit Ramp	WB	LT	0.91	47.5	D	0.75	58.6	E
		R	0.29	7.4	A	0.47	24.6	C
White Turkey Road Ext. (Route 202)	NB	L	0.10	12.2	B	0.44	7.8	A
		T	0.45	14.1	B	0.68	10.7	B
	SB	T	0.53	11.7	B	0.54	7.2	A

Note: (1) City Owned
(2) State Owned

2.2.6.3 Level of Service – Un-signalized Intersections

Tables 2-25 shows LOS analysis results for un-signalized or stop controlled intersections along the I-84 interchanges under existing (2016) conditions. The LOS tables are broken down by weekday A.M. and P.M. peak hour periods. The following is a list of intersections where the side-street or minor street movement operates at a LOS E or F under existing conditions:

- **Cowperthwaite Road at Main Street (Route 39)** – The Cowperthwaite Road left turn movement operates at LOS F during the weekday A.M. and P.M. peak hour periods. This is caused by high traffic volumes on Main Street and inability of left turning vehicles to exit Cowperthwaite Road.
- **I-84 Eastbound Off-Ramp at Fairview & Downs Street** – The I-84 eastbound off-ramp approach operates at LOS F during the weekday P.M. peak hour period. At this location, all three legs of the intersection are stop controlled. During the P.M. peak hour period, the eastbound off-ramp has high traffic volumes exiting to Downs Street since there is no eastbound off-ramp at Exit 6. This causes delay at the stop sign at this intersection with vehicle queues at times backing up to the I-84 mainline.
- **Walnut Street at North Street (Route 37)** – The Walnut Street left turn movement operates at LOS F during the weekday A.M. and P.M. peak hour periods. This is caused by high traffic volumes on North Street and inability of left turning vehicles to exit Walnut Street.

2.2.6.4 Summary of Intersection Levels of Service

- Three (3) signalized intersections in the study area operate at a volume to capacity (v/c) ratio greater than 1.0 and a LOS E or F under existing conditions.
- Three (3) un-signalized or stop controlled intersections show a LOS F on the side street approach under existing conditions.

Figures 2-14 and **2-15** show the intersection levels of service during the weekday A.M. and P.M. peak hour periods respectively.

Table 2-25 Existing (2016) Un-signalized Intersection Levels of Service – I-84 Interchanges

Location			Weekday A.M. Peak Hour			Weekday P.M. Peak Hour		
			V/C	Delay	LOS	V/C	Delay	LOS
Interchange 5								
Cowperthwaite Rd at Main St (Rt-39)								
Cowperthwaite Road	EB	L	1.19	219.8	F	2.63	908.1	F
		R	0.91	59.6	F	0.66	23.8	C
Main Street	NB	L	0.21	10.9	B	0.37	10.9	B
Hillside Ave at Main St (Rt-39)								
Hillside Avenue	WB	LR	0.15	12.4	B	0.15	14.9	B
Main Street	SB	L	0.01	9.7	A	0.02	11.8	B
Water St at Main St (Rt-39)/I-84 EB On Ramp								
Water Street	EB	LTR	0.03	9.9	A	0.02	10.2	B
Main Street	SB	L	0.58	19.0	C	0.69	30.3	D
Tooley Ln at Main St (Rt-39)								
Tooley Lane	WB	LR	0.15	14.0	B	0.19	17.2	C
Main Street	SB	L	0.00	0.0	A	0.00	0.0	A
I-84 EB Off Ramp at Fairview Ave & Downs St								
I-84 EB Off Ramp	EB	T	0.57	14.7	B	1.05	72.8	F
		TR	0.49	12.2	B	0.79	23.8	C
Fairview Avenue	NB	R	0.26	9.7	A	0.21	10.0	A
Downs Street	SB	T	0.08	9.3	A	0.18	10.5	B

Table 2-25 Existing (2016) Un-signalized Intersection Levels of Service – I-84 Interchanges (continued)

Location			Weekday A.M. Peak Hour			Weekday P.M. Peak Hour		
			V/C	Delay	LOS	V/C	Delay	LOS
Interchange 6								
2nd Ave at North St (Rt-37)								
2nd Avenue	WB	LR	0.19	16.5	C	0.23	21.1	C
North Street	SB	L	0.01	9.2	A	0.06	10.7	B
Walnut St at North St (Rt-37)								
Walnut Street	WB	LR	0.19	38.0	E	0.41	53.6	F
North Street	SB	L	0.00	0.0	A	0.00	0.0	A
Interchange 8								
Sky Edge Dr at Newtown Rd								
Sky Edge Drive	NB	R	0.27	15.8	C	0.14	16.0	C

Figure 2-14 Existing (2016) Intersection Levels of Service – Weekday A.M. Peak Hour Period

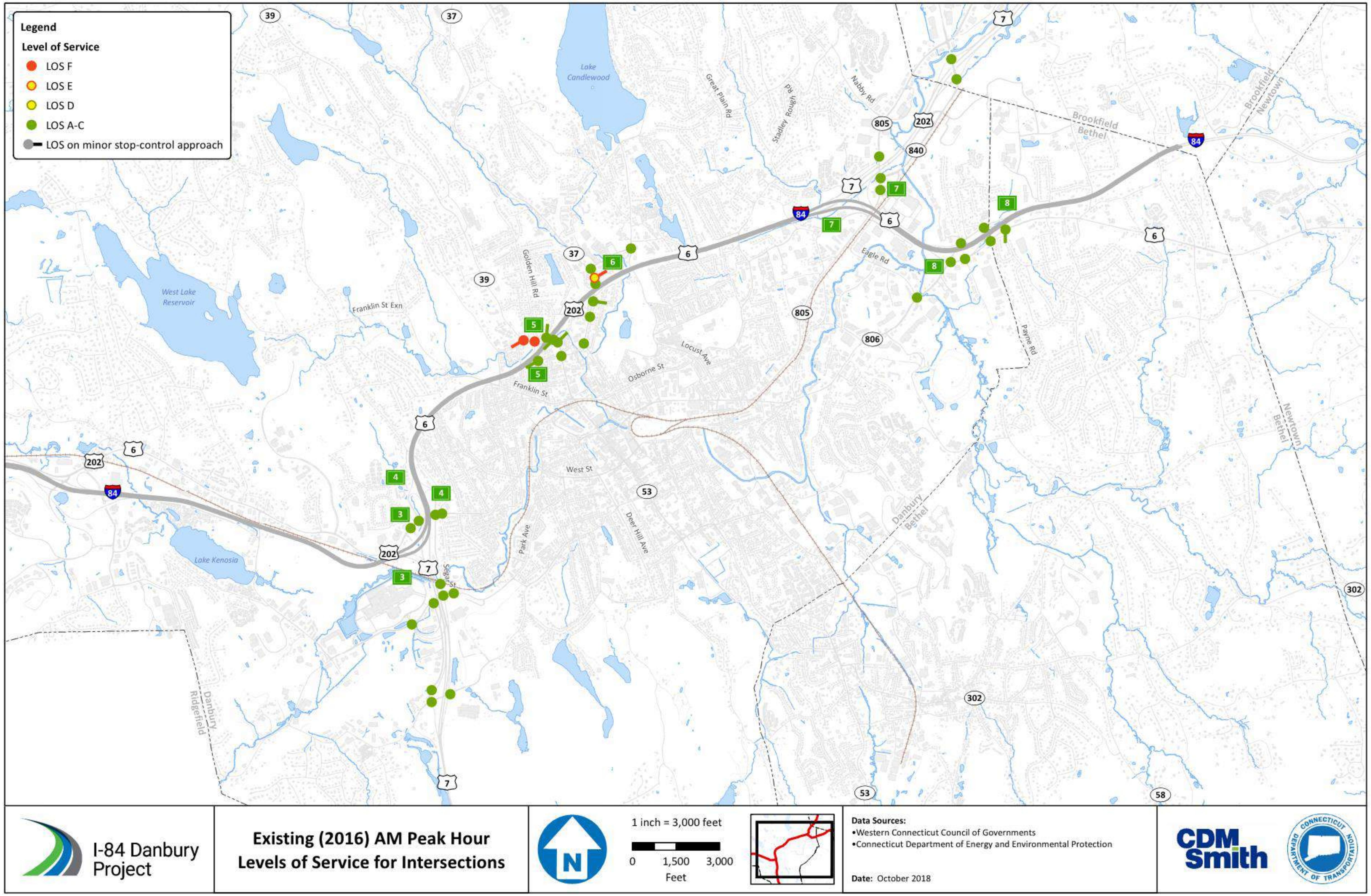
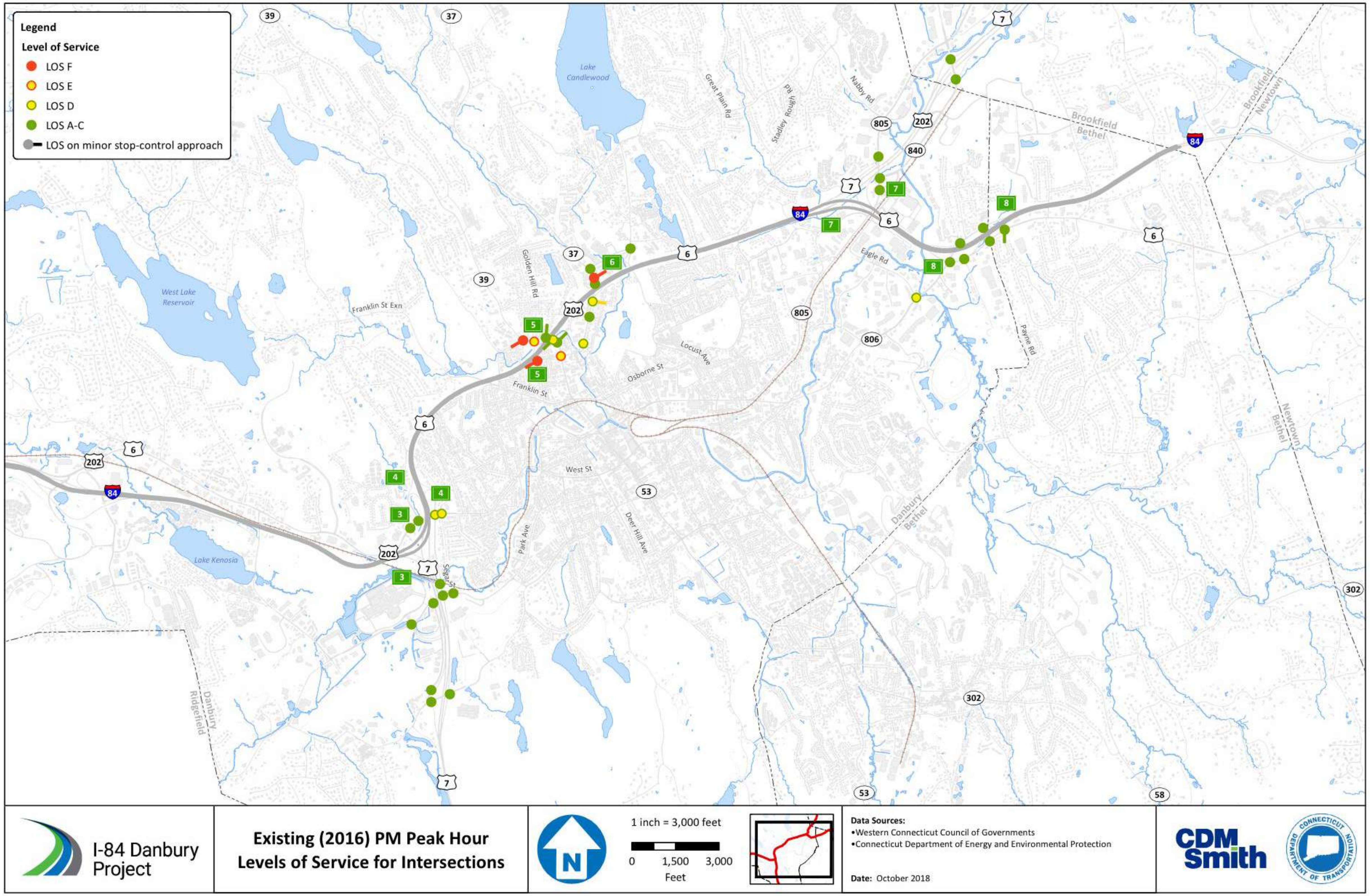


Figure 2-15 Existing (2016) Intersection Levels of Service – Weekday P.M. Peak Hour Period



2.3 Geometrics

This section of the Needs and Deficiencies Report provides a summary of the existing geometric conditions along the I-84 and US Route 7 corridor, noting the areas where there are existing design deficiencies in the highway geometrics. The existing on and off-ramps, as well as bridge structures carrying I-84 and US Route 7 and structures over I-84 are also analyzed, and the existing design deficiencies summarized herein.

2.3.1 Existing Highway Geometry Analysis Methodology

The methodology used to define deficiencies in the existing highway geometrics on I-84 and US Route 7 was determined based on the fifteen (15) controlling design criteria that require design exceptions from the Connecticut Department of Transportation (CTDOT) and the Federal Highway Administration (FHWA). The controlling design criteria are the highway design elements that are determined to be the most critical indicators of a highway's safety and overall serviceability. Any existing geometric condition of I-84 or US Route 7 that do not meet the minimum design requirements of the fifteen (15) controlling design criteria is considered a deficiency in the existing highway. The controlling design criteria used in the deficiency analysis is outlined in Section 6-6.02 of the CTDOT's Highway Design Manual (HDM), 2003 Edition, including revisions to February 2013. The following design elements are the fifteen (15) controlling criteria for the design exception process used to determine deficiencies within the project area:

1. Design Speed
2. Travel Lane and Shoulder Widths
3. * Auxiliary Lane and Shoulder Widths
4. Bridge Widths
5. Structural Capacity
6. Horizontal Alignment
    a. Minimum Radii, and
    b. Compound Curves Which Do Not Meet the 1.5:1 Ratio
7. Vertical Curvature Based On:
    a. Level Stopping Sight Distance at Crest Vertical Curves, and
    b. Level Stopping Sight Distance at Sag Vertical Curves
8. Maximum Grades
9. Stopping Sight Distance (Based on Level Grades)
10. Cross Slopes
11. * Superelevation:
    a. * Rate Based on emax = 6.0%, and
    b. * Superelevation Transition Lengths
12. Vertical Clearances for Bridge Structures
13. Accessibility Requirements for Disabled Individuals
14. Roadside Clear Zones
15. Intersection Sight Distance

*Denotes criteria that was not analyzed in the deficiency analysis

The geometric design criteria for which I-84 and US Route 7 is measured against is determined from Chapter 5 of the CTDOT HDM, which sets the minimum required design criteria values based on new/major reconstruction projects. The auxiliary lane and shoulder widths criteria are not analyzed for the deficiency analysis since turn lanes are not present on the section of I-84 and US Route 7 within the project limits. Additionally, the superelevation and superelevation transition lengths are not analyzed for the deficiency analysis since detailed survey is not available at the time of this study to measure the current superelevation rate constructed in the field. Since there has been several pavement preservation projects completed within this segment of I-84, it is unknown if the current superelevation rate within the study corridor matches the original design of I-84 and US Route 7.

The minimum design criteria are set based on the functional classification of the roadway/highway. I-84 has a functional classification of Urban Interstate Principal Arterial (Urban Freeway), while US Route 7 has a functional classification of Urban Expressway Principal Arterial (Urban Freeway). As such, Figure 5A, Urban Freeways, in Chapter 5 of the CTDOT HDM is used to set the minimum design criteria for both I-84 and US Route 7. Refer to the Highway Appendix for the criteria outlined in Figure 5A of the CTDOT HDM. Refer to the appendix for the controlling design criteria for I-84 and US Route 7.

2.3.2 Existing Ramp Geometry Analysis Methodology

The methodology used to define the deficiencies in the existing on/off-ramp geometrics on I-84 and US Route 7 is determined based on critical ramp design criteria outlined in Section 12-3.03, Critical Design Elements, of the CTDOT HDM. The four (4) critical design elements outlined in this section of the CTDOT HDM are considered important to the safety and proper operation of the ramp junctions. In addition to the four (4) critical design elements, four (4) additional ramp design elements are chosen from various sections of Chapter 12 of the CTDOT HDM to determine design deficiencies in the existing on/off-ramps within the study area. Criteria for the four (4) additional ramp design elements are supplemented by Chapter 10 of the AASHTO Greenbook.

The following design elements are the criteria used to determine deficiencies of the existing on/off-ramps:

Section 12-3.03:

1. Minimum Length of Deceleration for an Exit Ramp
2. Deflection (Taper) Angle for a Taper Exit Ramp
3. Minimum Length of Acceleration for an Entrance Ramp

4. Parallel Portion of the Acceleration Lane for an Entrance Ramp (300’ minimum)

Section 12-1.01.01, 12-2.04, and 12-4.01, and supplemented by Chapter 10 of the AASHTO Greenbook:

5. On/Off-Ramp Terminal Side of Freeway
6. Interchange Spacing
7. Ramp Design Speed
8. Capacity

2.3.3 Data Collection Methods

Several methods were used to measure the existing geometric conditions of I-84 and US Route 7, within the project area, to determine deficiencies along the corridor.

Historical Projects:

Geometric information from historical construction plans of I-84 and US Route 7 were used to re-create the existing horizontal and vertical alignments utilizing Bentley InRoads V8i, SELECTseries 2. The following is a list of the historical construction plans, obtained from CTDOT records, used in the existing geometric conditions data collection:

- Project No. 34-58, Relocation of Route No. 6 at Mill Plain, 1949
- Project No. 34-93, Relocation of Route U.S. 6, 1958
- Project No. 34-94 and 96-85, Relocation of Route U.S. 6 & Route 25, 1958
- Project No. 34-103 and 34-105, Relocation of Route U.S. 6 and Relocation of Route U.S. 7, 1958
- Project No. 34-84 and 34-106, Relocation of Route U.S. 6 and Relocation of Route U.S. 7, 1959
- Project No. 34-124, Relocation of U.S. Route 7, 1973
- Project No. 34-162, 34-164, and 34-176, Improvements to Route I-84, 1981
- Project No. 34-160 and 34-172, Interchange Improvements and Resurfacing on Interstate Route 84 and Route U.S. 7, 1982
- Project No. 34-190, Relocation of U.S. Route 7, 1984
- Project No. 34-189, Widening of I-84, 1986
- Project No. 34-197, Intersection Realignment at I-84 E.B. Exit 8, 1989
- Project No. 34-313, I-84 Interchanges 5 & 6 Improvements, 2014

Electronic Data:

LIDAR data with 2-foot contours and geospatial aerial photography, obtained from the Western Connecticut Council of Governments (WESTCOG), was also used in the analysis of the existing geometric conditions. LIDAR data allowed for a digital terrain model to be produced, which accurately allowed for replication of the existing vertical alignments and aided in the horizontal sight distance calculations.

Surveys:

CTDOT provided historic survey from several areas from existing projects along I-84, which was combined with the LIDAR data from WESTCOG, to create a digital terrain model which is approximate to the existing conditions of the corridor. This digital terrain model was utilized to measure various geometric conditions along the corridor, including vertical geometry and sight distance calculations.

2.3.4 Presentation of Highway, Ramp, and Structure Deficiencies

To aid in the analysis of the deficiencies along the project corridor and to pinpoint the exact areas of I-84 having existing geometric deficiencies, the I-84 eastbound corridor within the study area is broken out into seven (7) segments. The segments run west to east along I-84 Eastbound, and are as follows:

- Segment 1: Kenosia Avenue Overpass to Exit 3 Off-Ramp
- Segment 2: Exit 3 Off-Ramp to Exit 4 Off-Ramp
- Segment 3: Exit 4 Off-Ramp to Kohanza Street Underpass
- Segment 4: Kohanza Street Underpass to Tamarack Avenue Underpass
- Segment 5: Tamarack Avenue Underpass to Exit 7 Off-Ramp
- Segment 6: Exit 7 Off-Ramp to Exit 8 Off-Ramp
- Segment 7: Exit 8 Off-Ramp to Vale Road Overpass

Similarly, the I-84 Westbound corridor within the study area is broken out into seven (7) segments. The segments run west to east along I-84 Westbound and are as follows:

- Segment 1: Kenosia Avenue Overpass to Exit 3 On-Ramp
- Segment 2: Exit 3 On-Ramp to Exit 4 On-Ramp
- Segment 3: Exit 4 On-Ramp to Kohanza Street Underpass
- Segment 4: Kohanza Street Underpass to Tamarack Avenue Underpass
- Segment 5: Tamarack Avenue Underpass to Exit 7 On-Ramp
- Segment 6: Exit 7 On-Ramp to Exit 8 On-Ramp
- Segment 7: Exit 8 On-Ramp to Vale Road Overpass

The US Route 7 Northbound corridor within the study area, is broken out into two (2) segments. The segments run south to north along US Route 7, and are as follows:

- Segment 8: Backus Avenue Overpass to I-84 Merge
- Segment 9: I-84 Diverge to Exit 11 Off-Ramp

The US Route 7 Southbound corridor, within the study area, is broken out into two (2) segments. The segments run south to north along US Route 7, and are as follows:

- Segment 8: Backus Avenue overpass to I-84 Diverge
- Segment 9: I-84 Merge to Exit 11 On-Ramp

2.3.5 I-84 Mainline Geometry Review

Each of the seven (7) segments along both Eastbound and Westbound I-84 were analyzed based on the controlling design criteria from the CTDOT HDM. This section summarizes the results of the analysis and highlights all geometric deficiencies along the I-84 corridor.

Design Speed:

The design speed of an urban freeway is determined by the classification of the area type, either Suburban/Intermediate or Built-up. Section 6-1.03.02 of the CTDOT HDM outlines the descriptions of each area type for Urban Highways and Streets. Along I-84, Segments 1, 2, 6, and 7 are classified as Intermediate, since these segments of I-84 are surrounded by commercial development but feature a wide right-of-way width between the edge of the highway and surrounding properties. Segments 3,4, and 5 are classified as Built-up, since both commercial and residential properties directly about the highway, and there is minimal available right-of-way width between the edge of the highway and surrounding properties. I-84 could not be widened in these segments without significant impacts to surrounding properties and complete right-of-way takes. Based on the area type classification for each segment, the design speed value is determined from Figure 5A of the CTDOT HDM, located in the Highway Appendix. The required design speed was then compared to the posted speed limit within each segment of I-84 (refer to the Highway Appendix. **Table 2-26** summarizes the segments of I-84 Eastbound which do not meet the required design speed. **Table 2-27** summarizes the segments of I-84 Westbound which do not meet the required design speed.

Table 2-26 I-84 Eastbound Design Speed Deficiencies

Segment No.	Segment	Freeway Area Type	CTDOT HDM Design Speed Value for Area Type (mph)	Posted Speed Limit
1	Kenosia Avenue Overpass to Exit 3 Off-Ramp	Intermediate	65-70 mph	50 mph
2	Exit 3 Off-Ramp to Exit 4 Off-Ramp	Intermediate	65-70 mph	50 mph
6	Exit 7 Off-Ramp to Exit 8 Off-Ramp	Intermediate	65-70 mph	55 mph

Table 2-27 I-84 Westbound Design Speed Deficiencies

Segment No.	Segment	Freeway Area Type	CTDOT HDM Design Speed Value for Area Type (mph)	Posted Speed Limit
1	Kenosia Avenue Overpass to Exit 3 On-Ramp	Intermediate	65-70 mph	50 mph
2	Exit 3 On-Ramp to Exit 4 On-Ramp	Intermediate	65-70 mph	50 mph
6	Exit 7 On-Ramp to Exit 8 On-Ramp	Intermediate	65-70 mph	55 mph

Table 2-26 and Table 2-27 indicate three segments for both I-84 Eastbound and Westbound which are considered deficient for design speed, as the actual posted speed limit falls below the minimum design criteria for design speed. These areas fall within the two interchanges with US Route 7, on either end of the project limits (refer to the Highway Appendix).

Travel Lane and Shoulder Widths:

Based on Figure 5A of the CTDOT HDM (refer to the Highway Appendix), the required travel lane width for Urban Freeways is 12 ft. The required right shoulder width is 10 ft. and the required left shoulder width is 8' (4' paved + 4' graded). However, when truck volumes exceed 250 in the Directional Design Hourly Volume (DDHV), both the left and right shoulders should be 12 ft. wide. The truck DDHV was calculated for both the Eastbound and Westbound direction on I-84, and it exceeded 250 in every segment, except within Segment 1 in the Westbound direction. Due to truck DDHV's exceeding 250 in every other segment of I-84, the minimum criteria for left and right shoulder widths is considered 12 ft.

Along with mainline I-84 travel and shoulder lane widths, the on/off-ramp lane and shoulder widths were also analyzed and included in the mainline deficiency analysis. For the on/off-ramps along I-84, the required travel lane width is 12 ft., a 4 ft. left shoulder width, and a 10 ft. right shoulder width. Exit and entrance ramp travel lane and shoulder widths are determined from Section 12-4.02 of the CTDOT HDM (refer to the Highway Appendix).

The travel lane widths along both Eastbound and Westbound I-84 within the project area are all 12 ft. in width and meet the minimum required travel lane width. However, the left and right shoulder widths along I-84 mainline and the I-84 on/off-ramps within the project area vary (refer to the Highway Appendix). **Table 2-28** summarizes the segments of I-84 Eastbound which do not meet the required left shoulder widths, while **Table 2-29** summarizes the segments of I-84 Eastbound which do not meet the required right shoulder widths.

Table 2-28 I-84 Eastbound Left Shoulder Width Deficiencies

Segment No.	Segment	Required Left Shoulder Width (ft)	Actual Left Shoulder Width (ft)
1	Kenosia Avenue Overpass to Exit 3 Off-Ramp	12	10
2	Exit 3 Off-Ramp to Exit 4 Off-Ramp	12	4
4	Exit 6 On-Ramp	4	3
6	Exit 7 Off-Ramp to Exit 8 Off-Ramp	12	6
7	Exit 8 Off-Ramp to Vale Road Overpass	12	8

Table 2-29 I-84 Eastbound Right Shoulder Width Deficiencies

Segment No.	Segment	Required Right Shoulder Width (ft)	Actual Right Shoulder Width (ft)
2	Exit 3 Off-Ramp	10	7
	Exit 3 On-Ramp	10	5
3	Exit 4 Off-Ramp Kohanza Street Underpass	12	10
	Exit 4 On-Ramp	10	8
4	Kohanza Street Underpass to Tamarack Avenue Underpass	12	10
5	Tamarack Avenue Underpass to Exit 7 Off-Ramp	12	10
6	Exit 7 Off-Ramp to Exit 8 Off-Ramp	12	10
7	Exit 8 Off-Ramp	10	7

Table 2-28 and Table 2-29 indicate several segments within I-84 Eastbound where the existing shoulder widths are considered deficient, as the actual shoulder widths fall below the minimum design criteria for shoulder width.

Table 2-30 summarizes the segments of I-84 Westbound which do not meet the required left shoulder widths, while **Table 2-31** summarizes the segments of I-84 Westbound which do not meet the required right shoulder widths.

Table 2-30 I-84 Westbound Left Shoulder Width Deficiencies

Segment No.	Segment	Required Left Shoulder Width (ft)	Actual Left Shoulder Width (ft)
1	Kenosia Avenue Overpass to Exit 3 On-Ramp	12	10
2	Exit 3 On-Ramp to Exit 4 On-Ramp	12	4
3	Exit 4 Off-Ramp	4	1
	Exit 4 On-Ramp	4	3
6	Exit 7 On-Ramp to Exit 8 On-Ramp	12	6
7	Exit 8 On-Ramp to Vale Road Overpass	12	4
	Exit 8 Off-Ramp	4	2

Table 2-31 I-84 Westbound Right Shoulder Width Deficiencies

Segment No.	Segment	Required Right Shoulder Width (ft)	Actual Right Shoulder Width (ft)
2	Exit 3 On-Ramp to Exit 4 On-Ramp	12	10
3	Exit 4 On-Ramp to Kohanza Street Underpass	12	10
	Exit 4 Off-Ramp	10	8
	Exit 4 On-Ramp	10	8
4	Kohanza Street Underpass to Tamarack Avenue Underpass	12	10
	Exit 5 On-Ramp	10	8
5	Tamarack Avenue Underpass to Exit 7 On-Ramp	12	10
6	Exit 7 On-Ramp to Exit 8 On-Ramp	12	10
7	Exit 8 Off-Ramp	10	2

Table 2-30 and Table 2-31 indicate several segments within I-84 Westbound where the existing shoulder widths are considered deficient, as the actual shoulder widths fall below the minimum design criteria for shoulder width (refer to the Highway Appendix).

Bridge Widths and Cross Slopes:

Based on Figure 5A of the CTDOT HDM (refer to the Highway Appendix), the required bridge shoulder widths must match the approach roadway width and cross slope. From the previous section, the required travel lane width for Urban Freeways is 12 ft., and shoulder width for both left and right shoulders is 12 ft.

Table 2-32 summarizes the bridges within segments of I-84 Eastbound which do not meet the required left shoulder widths, while **Table 2-33** summarizes the bridges within the segments of I-84 Eastbound which do not meet the required right shoulder widths.

Table 2-32 I-84 Eastbound Bridges with Left Shoulder Width Deficiencies

Segment No.	Structure No.	Carries	Crossing	Required Left Shoulder Width (ft)	Actual Left Shoulder Width (ft)
1	01182	I-84 EB	Housatonic Railroad	12	10
2	00458	I-84 EB	Lake Avenue (Route 202/Route 6)	12	4
3	01184	I-84 EB/WB	Franklin Street	12	10
4	01185	I-84 EB/WB	Kohanza Street	12	10
	01186	I-84 EB/WB	Starr Avenue	12	9
	00961	I-84 EB/WB	Main Street (Route 39)	12	10
	00956	I-84 EB/WB	North Street (Route 37)	12	10
	01190	I-84 EB/WB	Tamarack Avenue	12	10
6	01195	I-84 EB	Federal Road/ Eagle Road/ Housatonic Railroad	12	6
7	01198	I-84 EB	Still River	12	5

Table 2-33 I-84 Eastbound Bridges with Right Shoulder Width Deficiencies

Segment No.	Structure No.	Carries	Crossing	Required Right Shoulder Width (ft)	Actual Right Shoulder Width (ft)
1	01182	I-84 EB	Housatonic Railroad	12	10
4	01186	I-84 EB/WB	Starr Avenue	12	8 +/-
5	01191	I-84 EB/WB	Great Plain Road	12	10
6	01195	I-84 EB	Federal Road/ Eagle Road/ Housatonic Railroad	12	10
7	01198	I-84 EB	Still River	12	3

Table 2-32 and Table 2-33 indicate several bridges carrying the I-84 Eastbound travel lanes with existing shoulder widths are deficient, as the actual shoulder widths do not match the approach roadway minimum design criteria for shoulder width.

Table 2-34 summarizes the bridges within segments of I-84 Westbound which do not meet the required left shoulder widths, while **Table 2-35** summarizes the bridges within the segments of I-84 Westbound which do not meet the required right shoulder widths.

Table 2-34 I-84 Westbound Bridges with Left Shoulder Width Deficiencies

Segment No.	Structure No.	Carries	Crossing	Required Left Shoulder Width (ft)	Actual Left Shoulder Width (ft)
1	01181	I-84 WB	Housatonic Railroad	12	8
2	00457	I-84 WB	Lake Avenue (Route 202/ Route 6)	12	8
4	00961	I-84 EB/WB	Main Street (Route 39)	12	8
6	00547	I-84 WB	Route 7 NB	12	8
	01196	I-84 WB	Federal Road/ Eagle Road/ Housatonic Railroad	12	5
7	01197	I-84 WB	Still River	12	5

Table 2-35 I-84 Westbound Bridges with Right Shoulder Width Deficiencies

Segment No.	Structure No.	Carries	Crossing	Required Right Shoulder Width (ft)	Actual Right Shoulder Width (ft)
1	01181	I-84 WB	Housatonic Railroad	12	10
2	00457	I-84 WB	Lake Avenue (Route 202/ Route 6)	12	8
3	01184	I-84 EB/WB	Franklin Street	12	10
4	01185	I-84 EB/WB	Kohanza Street	12	10
	01186	I-84 EB/WB	Starr Avenue	12	10
	00961	I-84 EB/WB	Main Street (Route 39)	12	10
	00956	I-84 EB/WB	North Street (Route 37)	12	10
6	00547	I-84 WB	Route 7 NB	12	10
	01196	I-84 WB	Federal Road/ Eagle Road/ Housatonic Railroad	12	10
7	01197	I-84 WB	Still River	12	7

Table 2-34 and Table 2-35 indicate several bridges carrying the I-84 Westbound travel lanes where the existing shoulder widths are considered deficient, as the actual shoulder widths do not match the approach roadway minimum design criteria for shoulder width.

The cross slopes of the travel lanes over the bridge structures along both Eastbound and Westbound I-84 were not analyzed for the deficiency analysis since detailed survey was not available at the time of this study to measure the current cross slopes constructed in the field. However, from field inspection, the cross slopes of the travel lanes and shoulders over bridge structures appear to match the roadway approach cross slopes (refer to the Highway Appendix).

Bridge Condition Rating and Bridge Vertical Clearances:

The condition rating and structural capacity of each bridge structure either carrying I-84 or crossing over I-84 was analyzed based on current inspection reports. Additionally, bridge structures crossing over I-84 were analyzed for vertical clearances. Based on Figure 5A of the CTDOT HDM, located in the Highway Appendix, bridges must adhere to the following minimum vertical clearances:

- Existing Highway Bridge = 16'-0"
- Freeway over Railroad= 23'-0"

Refer to Section 2.4 of this report for a detailed analysis of the bridge structures both carrying I-84 and US Route 7 as well as structures over I-84 and US Route 7.

Minimum Radius and Compound Curves Not Meeting 1.5:1 Ratio:

The horizontal radius of each curve along Eastbound and Westbound I-84 was analyzed to determine which curves meet/do not meet the minimum radius based on design speed. Figure 8-2A in Section 8-2.02.02 in the CTDOT HDM (refer to the Highway Appendix) was used to determine the minimum horizontal radius, based on design speed and a maximum superelevation rate of 6%. The design speed is determined based on the freeway area type. Refer to the Design Speed section of this report, under Section 2.3.5 I-84 Mainline Geometry Review.

Table 2-36 summarizes the segments of I-84 Eastbound in which the horizontal curves do not meet the minimum radius based on design speed, while **Table 2-37** summarizes the segments of I-84 Westbound in which the horizontal curves do not meet the minimum radius based on design speed.

Table 2-36 I-84 Eastbound Minimum Radius Deficiencies

Segment No.	Horizontal Curve No.	Radius of Curve (ft)	Design Speed Based on Radius (mph)	CTDOT HDM Design Speed Value for Area Type (mph)
1	2	1,454	61 mph	65-70 mph
2	3	1,466	62 mph	65-70 mph
	4	1,000	54 mph	65-70 mph
	5	1,432	53 mph	65-70 mph

Table 2-37 I-84 Westbound Minimum Radius Deficiencies

Segment No.	Horizontal Curve No.	Radius of Curve (ft)	Design Speed Based on Radius (mph)	CTDOT HDM Design Speed Value for Area Type (mph)
1	2	1,410	61 mph	65-70 mph
2	3	1,194	57 mph	65-70 mph
	4	1,200	57 mph	65-70 mph

Table 2-36 and Table 2-37 indicate the horizontal curves along segments 1 and 2 fall below the minimum radius for design speed. The deficiencies in horizontal curves through this section I-84 is apparent, as the speed limit drops to 50 mph in this area, due to the deficiencies in the existing horizontal alignment of I-84.

In addition to determining the radii of the existing horizontal curves along I-84, all compound horizontal curves are analyzed to determine if they meet design requirements. From Section 8-2.02.03 of the CTDOT HDM, for compound curves that are used on a mainline freeway section, the radius of the flatter circular arc should not be more than 50% greater than that of the sharper arc. There is one compound curve located on the Eastbound I-84 alignment, and two compound curves located on the Westbound I-84 alignment. **Table 2-38** summarizes the segment of I-84 Eastbound in which the horizontal compound curve does not meet the maximum 1.5:1 ratio. **Table 2-39** summarizes the segment of I-84 Westbound in which the horizontal compound curve does not meet the maximum 1.5:1 ratio.

Table 2-38 I-84 Eastbound Compound Curve Deficiencies

Segment No.	Horizontal Curve No.	Radius of Curve (ft)	Ratio (Should Not Exceed 1.5)
3	6	1,611	2.38
	7	3,828	

Table 2-39 I-84 Westbound Compound Curve Deficiencies

Segment No.	Horizontal Curve No.	Radius of Curve (ft)	Ratio (Should Not Exceed 1.5)
3	5	1,663	2.33
	6	3,880	

Table 2-38 and Table 2-39 indicate there is one horizontal curve, located in segment 3 in both the Eastbound and Westbound direction of I-84, which does not conform to the maximum 1.5:1 ratio. These compound curves are located along the same section of I-84 Eastbound and Westbound, just east of the Exit 4 interchange (refer to the Highway Appendix).

Stopping Sight Distance on Vertical Curves and Maximum Grades:

The minimum required stopping sight distance for both sag and crest vertical curves is determined from Chapter 3 of the AASHTO A Policy on Geometric Design of Highways and Streets (AASHTO Greenbook), 2011 6th Edition. Table 3-34, Design Controls for Crest Vertical Curves Based on Stopping Sight Distance, is used to determine the minimum stopping sight distance and rate of vertical curvature (K value) based on design speed for crest vertical curves. Table 3-36, Design Control for Sag Vertical Curves, is used to determine minimum stopping sight distance and rate of vertical curvature (K value) based on design speed for sag vertical curves (refer to the Highway Appendix). The design speed is determined based on the freeway area type. Refer to the Design Speed section of this report, under Section 2.3.5 I-84 Mainline Geometry Review.

Table 2-40 summarizes the segments of I-84 Eastbound in which the vertical curves do not meet minimum stopping sight distance requirements. **Table 2-41** summarizes the segments of I-84 Westbound in which the vertical curves do not meet minimum stopping sight distance requirements.

Table 2-40 I-84 Eastbound Vertical Curve Stopping Sight Distance Deficiencies

Segment No.	Vertical Curve No.	Crest/Sag Vertical Curve	Measured Stopping Sight Distance (ft)	AASHTO Greenbook Required Stopping Sight Distance (ft)	Design Speed Based on Existing Vertical Alignment (mph)	Required Design Speed for Corridor Segment (mph)
1	1	Sag	634	645	64	65 - 70
2	2	Crest	470	645	53	65 - 70
	3	Sag	440	645	51	65 - 70
	4	Crest	637	645	64	65 - 70
4	10	Sag	356	495	44	50 -55
6	12	Sag	441	645	51	65 - 70
	13	Crest	569	645	59	65 - 70

Table 2-41 I-84 Westbound Vertical Curve Stopping Sight Distance Deficiencies

Segment No.	Vertical Curve No.	Crest/Sag Vertical Curve	Measured Stopping Sight Distance (ft)	AASHTO Greenbook Required Stopping Sight Distance (ft)	Design Speed Based on Existing Vertical Alignment (mph)	Required Design Speed for Corridor Segment (mph)
2	4	Crest	637	645	64	65 - 70
	5	Sag	548	645	58	65 - 70
	6	Crest	641	645	64	65 - 70
6	15	Sag	603	645	62	65 - 70
	16	Crest	630	645	64	65 - 70

Table 2-40 and Table 2-41 indicate there are several vertical curves along the I-84 alignment where the minimum required stopping sight distance on sag and crest vertical curves are not met. In most instances, the location of the deficient vertical curves along the Eastbound and Westbound travel lanes are in the same location along the alignment. Most deficiencies occur at the two interchanges with US Route 7, as this is currently where there are design speed deficiencies.

In addition to stopping sight distance on vertical curves, the maximum vertical grades were analyzed along the I-84 corridor within the project area. From Figure 5A of the CTDOT HDM (refer to the Highway Appendix), the maximum vertical grade is based on the design speed of the freeway. A maximum vertical grade of 4% is used for a design speed between 60mph and 70 mph, while a maximum vertical grade of 5% is used for a design speed between 50 mph and 55 mph.

There was one segment within the I-84 corridor where the maximum allowable grade was exceeded. Refer to **Table 2-42** for a summary of the segment which exceeds the maximum allowable vertical grade, in the Eastbound direction of I-84 (refer to the Highway Appendix).

Table 2-42 I-84 Eastbound Maximum Vertical Grade Deficiencies

Segment No.	Measured Vertical Grade (%)	Maximum Allowable Vertical Grade (%)
2	4.22%	4.00%

Stopping Sight Distance Based on Level Grades:

In addition to calculating stopping sight distance on crest and sag vertical curves, the stopping sight distance on level grades was also analyzed along the I-84 corridor within the project area. A 3-D model of the existing highway was created using Inroads with a combination of LIDAR data and existing historical design plans. From the model, the sight distance around fixed objects (concrete median barrier, bridge abutments, guide rail, etc.) was analyzed.

Table 2-43 summarizes the locations along I-84 Eastbound where the stopping sight distance does not meet the minimum required sight distance based on design speed. **Table 2-44** summarizes the locations along I-84 Westbound where the stopping sight distance does not meet the minimum required sight distance based on design speed. The design speed was determined based on the freeway area type. Refer to the Design Speed section of this report, under Section 2.3.5 I-84 Mainline Geometry Review.

Table 2-43 I-84 Eastbound Level Grade Stopping Sight Distance Deficiencies

Segment No.	Controlling Geometric Feature	Obstructed Stopping Sight Distance Location	Measured Stopping Sight Distance (ft)	AASHTO Greenbook Required Stopping Sight Distance (ft)	Design Speed Based on SSD (mph)	Required Design Speed for Corridor Classification (mph)
1	Concrete Barrier	Starting 850' before the Exit 3 off-ramp diverge	378	645	46	65 - 70
2	Concrete Barrier	Starting 850' before the Exit 3 on-ramp converge	344	360	43	65 - 70
	Guide Rail	Starting 2250' after the Exit 3 off-ramp diverge	342	645	43	65 - 70
6	Guide Rail	Starting 1375' before the Exit 7 on-ramp converge	236	360	34	65 - 70
	Concrete Barrier	Starting 950' after the Exit 7 off-ramp diverge	476	645	53	65 - 70
7	Bridge Pier	Starting 600' after the Exit 8 off-ramp diverge	508	645	56	65 - 70

Table 2-44 I-84 Westbound Level Grade Stopping Sight Distance Deficiencies

Segment No.	Controlling Geometric Feature	Obstructed Stopping Sight Distance Location	Measured Stopping Sight Distance (ft)	AASHTO Greenbook Required Stopping Sight Distance (ft)	Design Speed Based on SSD (mph)	Required Design Speed for Corridor Classification (mph)
2	Concrete Barrier	Starting 1600' before the Exit 4 on-ramp converge	436	645	50	65 - 70
	Concrete Barrier	Starting 2200' before the Exit 3 on-ramp converge	276	360	37	65 - 70
6	Guide Rail	Starting 100' before the Exit 7 off-ramp diverge	327	360	42	65 – 70
	Guide Rail	Starting 400' before the Exit 7 off-ramp diverge	414	645	49	65 – 70
7	Bridge Pier	Starting 2000' before the Exit 8 on-ramp converge	527	645	57	65 – 70

Table 2-43 and 2-44 indicate several locations along Eastbound and Westbound I-84 where the stopping sight distance is below the minimum design criteria due to roadside objects obstructing the view for motorists (refer to Appendix A for the Deficiency Plans).

Travel Lane and Shoulder Cross Slopes:

From Figure 5A of the CTDOT HDM (refer to the Highway Appendix), the travel lane cross slopes in tangent sections should be 1.5% - 2.0% for travel lanes adjacent to the crown of the roadway, and 2.0% for travel lanes away from the crown line. Additionally, the shoulder cross slopes should be 4% where concrete median barrier is present. On highway segments without curbing, the typical shoulder cross slope is 4%. Where curbs are present, the typical shoulder cross slope is 6%.

From visual inspection of Eastbound and Westbound I-84, there does not appear to be any segment within the project limits that does not meet the travel lane and shoulder cross slope minimum design criteria. Therefore, all segments within the I-84 project area meet the minimum requirements for travel lane and shoulder cross slopes.

Accessibility Requirements for Disabled Individuals:

From Section 6-6.02 of the CTDOT HDM, no design exceptions are permitted which do not meet Connecticut General Statute Sections 7-118a and 14-253a, or which do not meet the Americans with Disabilities Act, Public Law 101-336. While accessibility requirements for disabled individuals is a criterion set in the CTDOT HDM, there are currently no accessible areas for pedestrians within mainline I-84 in the project area.

Roadside Clear Zones:

From Section 13-2.02 of the CTDOT HDM (refer to the Highway Appendix), the roadside clear zone is based on design speed, Average Daily Traffic (ADT) and the slopes of the cut/fill areas. Within the I-84 Eastbound and Westbound project limits, the clear zone ranges from 26' to 30' from the edge of shoulder line, based on Figure 13-2A, Recommended Clear Zone Distances.

From visual inspection of Eastbound and Westbound I-84, there does not appear to be any segment within the project limits where a slope off the edge of shoulder is steeper than 4:1 that is not protected by guide rail. Therefore, all segments within the I-84 project limits meet the minimum requirements for roadside clear zones.

Intersection Sight Distance:

From Section 11-2.0 of the CTDOT HDM, the intersection sight distance for at-grade intersections is based on the design speed of the major road and the type of traffic control device at the intersection. Intersections were analyzed for passenger cars (P), single unit trucks (SU), and tractor/semi-trailers with considerations for horizontal obstructions and apparent high points in the road that could obstruct sight.

Table 2-45 I-84 Eastbound Intersection Sight Distance Deficiencies

Segment No.	Exit No.	Turning Movement	Required ISD (feet)			Measured ISD (feet)	Controlling Geometric Feature
			P	SU	Semi-Trailer		
3	4 (Lake Ave.)	Left-turn	530	675	810	767	Bridge Wall

Table 2-46 I-84 Westbound Intersection Sight Distance Deficiencies

Segment No.	Exit No.	Turning Movement	Required ISD (feet)			Measured ISD (feet)	Controlling Geometric Feature
			P	SU	Semi-Trailer		
4	5 (Main St.)	Left-turn	575	600	720	444	Vegetation
4	5 (Main St.)	Right-turn	445	560	680	436	Cut Slope
4	6 (North St.)	Right-Turn	390	490	595	488	Bridge Wall

Table 2-45 and **Table 2-46** indicate that there are four (4) locations in the built-up area where the intersection sight distance is deficient.

2.3.6 US Route 7 Mainline Geometry Review

Each of the two (2) segments along both Northbound and Southbound US Route 7 were analyzed based on the controlling design criteria from the CTDOT HDM. This section summarizes the results of the analysis and highlights all geometric deficiencies along the US Route 7 corridor.

Design Speed:

The design speed of an urban freeway is determined by the classification of the area type, either Suburban/Intermediate or Built-up. Section 6-1.03.02 of the CTDOT HDM outlines the descriptions of each area type. Since, I-84 was classified as an Intermediate area around the two interchanges with US Route 7 at Exit 3 and Exit 7, US Route 7 is also classified as an Intermediate area at these interchange locations. These interchanges are considered Intermediate areas because they are surrounded by commercial development but feature a wide right-of-way width between the edge of the highway and surrounding properties. The interchange of US Route 7 and I-84 can be widened/realigned in these segments with minimal impacts to surrounding properties.

Based on the area type classification for each segment, the required design speed is determined from Figure 5A of the CTDOT HDM (refer to the Highway Appendix). The required design speed was then compared to the posted speed limit within each segment of US Route 7.

Table 2-47 summarizes the segments of US Route 7 Northbound which do not meet the required design speed. **Table 2-48** summarizes the segments of US Route 7 Southbound which do not meet the required design speed.

Table 2-47 US Route 7 Northbound Design Speed Deficiencies

Segment No.	Segment	Freeway Area Type	Required Design Speed	Posted Speed Limit
8	Backus Avenue Overpass to I-84 Merge	Intermediate	65-70 mph	50 mph
9	I-84 Diverge to Exit 11 Off-Ramp	Intermediate	65-70 mph	55 mph

CDM Smith

Table 2-48 US Route 7 Southbound Design Speed Deficiencies

Segment No.	Segment	Freeway Area Type	Required Design Speed	Posted Speed Limit
8	Backus Avenue Overpass to I-84 Diverge	Intermediate	65-70 mph	50 mph
9	I-84 Merge to Exit 11 On-Ramp	Intermediate	65-70 mph	50 mph

Table 2-47 and Table 2-48 indicate segments of US Route 7 Northbound and Southbound considered deficient for design speed, as the actual posted speed limit falls below the minimum design criteria for design speed.

Travel Lane and Shoulder Widths:

Based on Figure 5A of the CTDOT HDM (refer to the Highway Appendix), the required travel lane width for Urban Freeways is 12 ft. The required right shoulder width is 10 ft. and the required left shoulder width is 8' (4' paved + 4' graded). However, when truck volumes exceed 250 in the Directional Design Hourly Volume (DDHV), both the left and right shoulders should be 12 ft. wide. The truck DDHV was calculated for both the Northbound and Southbound direction on US Route 7, and the DDHV did not exceed 250 in any segment.

The travel lane widths along both Northbound and Southbound US Route 7 are all 12 ft. in width and meet the minimum required travel lane width. Additionally, the right shoulder widths along both Northbound and Southbound US Route 7 are all 10' and greater, which meets the minimum required right shoulder width. However, the left shoulder widths along US Route 7, within the project area, vary.

Table 2-49 summarizes the segments US Route 7 Northbound which do not meet the required left shoulder widths, while **Table 2-50** summarizes the segments of US Route 7 Southbound which do not meet the required left shoulder widths.

Table 2-49 US Route 7 Northbound Left Shoulder Width Deficiencies

Segment No.	Segment	Required Left Shoulder Width (ft)	Actual Left Shoulder Width (ft)
8	Backus Avenue Overpass to I-84 Merge	8	6
9	I-84 Diverge to Exit 11 Off-Ramp	8	6

Table 2-50 US Route 7 Southbound Left Shoulder Width Deficiencies

Segment No.	Segment	Required Left Shoulder Width (ft)	Actual Left Shoulder Width (ft)
8	Backus Avenue Overpass to I-84 Diverge	8	4
9	I-84 Merge to Exit 11 On-Ramp	8	4

Table 2-48 and Table 2-49 indicate four (4) segments within US Route 7 Northbound and Southbound where the existing left shoulder widths are considered deficient, as the actual left shoulder widths fall below the minimum design criteria (refer to the Highway Appendix).

Bridge Widths and Cross Slopes:

Based on Figure 5A of the CTDOT HDM (refer to the Highway Appendix), the required bridge shoulder widths must match the approach roadway width and cross slope. From the previous section, the required travel lane width for Urban Freeways is 12 ft., left shoulder width 8', and right shoulder width 10'.

There were several structures along US Route 7 Northbound and Southbound where there are deficiencies in the left shoulder widths. **Table 2-51** summarizes the bridges within segments of US Route 7 Northbound which do not meet the required left shoulder widths. **Table 2-52** summarizes the bridges within segments of US Route 7 Southbound which do not meet the required left shoulder widths.

Table 2-51 US Route 7 Northbound Bridges with Left Shoulder Width Deficiencies

Segment No.	Structure No.	Carries	Crossing	Required Left Shoulder Width (ft)	Actual Left Shoulder Width (ft)
8	00541	US Route 7 NB	Still River & Danbury Mall Connector Overpass	8	7
9	00550	US Route 7 NB	Federal Road Overpass	8	6

Table 2-52 US Route 7 Southbound Bridges with Left Shoulder Width Deficiencies

Segment No.	Structure No.	Carries	Crossing	Required Left Shoulder Width (ft)	Actual Left Shoulder Width (ft)
8	00548	US Route 7 SB	I-84 WB Overpass	8	6
9	00551	US Route 7 SB	Federal Road Overpass	8	6

Table 2-51 and Table 2-52 indicate several bridges carrying the US Route 7 Northbound and Southbound travel lanes where the existing left shoulder widths are considered deficient, as the actual left shoulder widths do not match the approach roadway minimum design criteria for shoulder width.

The cross slopes of the travel lanes over the bridge structures along both Northbound and Southbound US Route 7 were not analyzed for the deficiency analysis since detailed survey is not available at the time of this study to measure the current cross slopes constructed in the field. However, from field inspection, the cross slopes of the travel lanes and shoulders over bridge structures seemed to match the roadway approach cross slopes (refer to the Highway Appendix).

Bridge Condition Rating and Bridge Vertical Clearances:

The condition rating and structural capacity of each bridge structure either carrying US Route 7 or crossing over US Route 7 was analyzed based on current inspection reports. Additionally, bridge structures crossing over US Route 7 were analyzed for vertical clearances. Based on Figure 5A of the CTDOT HDM (refer to the Highway Appendix), bridges must adhere to the following minimum vertical clearances:

- Existing Highway Bridge = 16’-0”
- Freeway over Railroad= 23’-0”

Refer to Section 2.4 of this report for a detailed analysis of the bridge structures both carrying I-84 and US Route 7 as well as structures over I-84 and US Route 7.

Minimum Radius and Compound Curves Not Meeting 1.5:1 Ratio:

The horizontal radius of each curve along Northbound and Southbound US Route 7 was analyzed to determine which curves meet/do not meet the minimum radius based on design speed. Figure 8-2A in Section 8-2.02.02 in the CTDOT HDM is utilized to determine the minimum horizontal radius, based on design speed and a maximum superelevation rate of 6%. The design speed is determined based on the freeway area type. Refer to the Design Speed section of this report, under Section 2.3.6 US Route 7 Mainline Geometry Review.

Table 2-53 summarizes the segments of US Route 7 Southbound in which the horizontal curves do not meet the minimum radius based on design speed.

Table 2-53 US Route 7 Southbound Minimum Radius Deficiencies

Segment No.	Horizontal Curve No.	Radius of Curve (ft)	Design Speed Based on Radius (mph)	Required Design Speed for Corridor Classification (mph)
8	1	1,100	55 mph	65-70 mph
	2	1,160	56 mph	65-70 mph

Table 2-53 indicates the horizontal curves along segments 8 on Southbound US Route 7 fall below the minimum radius for design speed (refer to Appendix A for the Deficiency Plans).

There were no existing compound horizontal curves within the US Route 7 corridor.

Stopping Sight Distance on Vertical Curves and Maximum Grades:

The minimum required stopping sight distance for both sag and crest vertical curves is determined from Chapter 3 of the AASHTO A Policy on Geometric Design of Highways and Streets (AASHTO Greenbook), 2011 6th Edition. Table 3-34 of the Greenbook, Design Controls for Crest Vertical Curves Based on Stopping Sight Distance, is used to determine the minimum stopping sight distance and rate of vertical curvature (K value) based on design speed for crest vertical curves. Table 3-36, Design Control for Sag Vertical Curves, is used to determine minimum stopping sight distance and rate of vertical curvature (K value) based on design speed for sag vertical curves. The design speed is determined based on the freeway area type. Refer to the Design Speed section of this report, under Section 2.3.6 US Route 7 Mainline Geometry Review.

Table 2-54 summarizes the segments of US Route 7 Northbound in which the vertical curves do not meet minimum stopping sight distance requirements. **Table 2-55** summarizes the segments of US Route 7 Southbound in which the vertical curves do not meet minimum stopping sight distance requirements.

Table 2-54 US Route 7 Northbound Vertical Curve Stopping Sight Distance Deficiencies

Segment No.	Vertical Curve No.	Crest/Sag Vertical Curve	Measured Stopping Sight Distance (ft)	AASHTO Greenbook Required Stopping Sight Distance (ft)	Design Speed Based on Existing Vertical Alignment (mph)	Required Design Speed for Corridor Segment (mph)
8	1	Sag	452	645	51	65 - 70
	2	Sag	568	645	59	65 - 70

Table 2-55 US Route 7 Southbound Vertical Curve Stopping Sight Distance Deficiencies

Segment No.	Vertical Curve No.	Crest/Sag Vertical Curve	Measured Stopping Sight Distance (ft)	AASHTO Greenbook Required Stopping Sight Distance (ft)	Design Speed Based on Existing Vertical Alignment (mph)	Required Design Speed for Corridor Segment (mph)
8	2	Crest	578	645	60	65 - 70
9	6	Crest	561	645	59	65 - 70

Table 2-54 and Table 2-55 indicate four (4) vertical curves along the US Route 7 alignment where the minimum required stopping sight distance on sag and crest vertical curves are not met.

In addition to stopping sight distance on vertical curves, the maximum vertical grades were also analyzed along the US Route 7 corridor within the project area. From Figure 5A of the CTDOT HDM, the maximum vertical grade is based on the design speed of the freeway. A maximum vertical grade of 4% is used for a design speed between 60 mph and 70 mph, while a maximum vertical grade of 5% is used for a design speed between 50 mph and 55 mph.

There was one segment within the US Route 7 corridor in which the maximum allowable grade was exceeded. Refer to **Table 2-56** for a summary of the segment which exceeds the maximum allowable vertical grade, in the Northbound direction of US Route 7 (refer to the Highway Appendix).

Table 2-56 US Route 7 Northbound Maximum Vertical Grade Deficiencies

Segment No.	Measured Vertical Grade (%)	Maximum Allowable Vertical Grade (%)
2	4.22%	4.00%

Stopping Sight Distance Based on Level Grades:

In addition to calculating stopping sight distance on crest and sag vertical curves, the stopping sight distance on level grades was analyzed along the US Route 7 corridor within the project area. A 3-D model of the existing highway was created using Inroads with a combination of LIDAR data and existing historical design plans. From the model, the sight distance around fixed objects (concrete median barrier, bridge abutments, guide rail, etc.) was analyzed.

There were no locations along US Route 7 where there is a stopping sight distance on level grade deficiency.

Travel Lane and Shoulder Cross Slopes:

From Figure 5A of the CTDOT HDM (refer to the Highway Appendix), the travel lane cross slopes in tangent sections should be 1.5% - 2.0% for travel lanes adjacent to the crown of the roadway, and 2.0% for travel lanes away from the crown line. Additionally, the shoulder cross slopes should be 4% where concrete median barrier is present. On highway segments without curbing, the typical shoulder cross slope is 4%. Where curbs are present, the typical shoulder cross slope is 6%.

From visual inspection of Northbound and Southbound US Route 7, there does not appear to be any segment within the project limits that does not meet the travel lane and shoulder cross slope minimum design criteria. Therefore, all segments within the US Route 7 project area meet the minimum requirements for travel lane and shoulder cross slopes.

Accessibility Requirements for Disabled Individuals:

From Section 6-6.02 of the CTDOT HDM, no design exceptions are permitted which do not meet Connecticut General Statute Sections 7-118a and 14-253a, or which do not meet the Americans with Disabilities Act, Public Law 101-336. While accessibility requirements for disabled individuals is a criterion set in the CTDOT HDM, there are currently no accessible areas for pedestrians within mainline US Route 7 in the project area.

Roadside Clear Zones:

From Section 13-2.02 of the CTDOT HDM (refer to Appendix B), the roadside clear zone is based on design speed, Average Daily Traffic (ADT) and the slopes of the cut/fill areas. Within the I-84 Eastbound and Westbound project limits, the clear zone ranges from 26' to 30' from the edge of shoulder line, based on Figure 13-2A, Recommended Clear Zone Distances.

From visual inspection of Northbound and Southbound US Route 7, there does not appear to be any segment within the project limits where a slope off the edge of shoulder is steeper than 4:1 that is not protected by guide rail. Therefore, all segments within the US Route 7 project limits meet the minimum requirements for roadside clear zones.

Intersection Sight Distance:

Intersections at the terminus of off-ramps within the US Route 7 corridor were not analyzed, as any off-ramp interchange from US Route 7 is outside of the project limits.

2.3.7 I-84 Ramp Geometry Review

There are twenty-two (22) ramps along both eastbound and westbound I-84 analyzed based on the critical design elements and other design criteria outlined in the CTDOT HDM. This section summarizes the results of the analysis and highlight all geometric deficiencies of the ramps along the I-84 corridor.

Site specific mainline design speeds are determined for ramp evaluation. The mainline design speed is chosen as the lesser of the design speed of the closest governing geometric control or 70 mph. If the closest governing geometric control is deemed far enough away, a design speed of 70 mph is chosen.

Minimum Length of Deceleration for an Exit Ramp:

The minimum length of deceleration for an exit ramp is determined from Section 12-3.01.01 of the CTDOT HDM. The minimum length is determined by the mainline design speed and the design speed of the ramp's first governing geometric control from Figure 12-3A of the CTDOT HDM as adjusted by Figure 12-3B (refer to the Highway Appendix); subsequent curves must also have sufficient deceleration length to safely maneuver the exit ramp. Exit ramps with insufficient deceleration length cause drivers to begin deceleration on the mainline, impeding traffic passing the ramp.

Table 2-57 I-84 Eastbound Minimum Length of Deceleration for Exit Ramp Deficiencies

Exit No.	Ramp Type	Measured Deceleration Length (ft)	Required Deceleration Length (ft)
4	Parallel	139	314
8	Taper	9	394

Table 2-58 I-84 Westbound Minimum Length of Deceleration for Exit Ramp Deficiencies

Exit No.	Ramp Type	Measured Deceleration Length (ft)	Required Deceleration Length (ft)
4	Parallel	98	724
8	Taper	113	535

Tables 2-57 and **2-58** indicate four (4) of the eleven (11) exit ramps do not meet the minimum length of deceleration requirements. Exits 4 and 8 have deficient deceleration lengths for exit ramps on both sides of the highway. These deficiencies are due to sharp horizontal curves entrance ramps in close proximity to the mainline. In the case of the Exit 8 eastbound exit ramp, the exit ramp leaves the mainline on a curve without providing a significant distance for the driver to decelerate (refer to the Highway Appendix).

Deflection (Taper) Angle for a Taper Exit Ramp:

The CTDOT HDM requires the deflection angle for a taper exit ramp be between 2 and 5 degrees (preferably 3 degrees). This deflection angle is measured from the point where the outside edge of an exit ramp starts to deviate from the mainline to where it reaches a width of twelve (12) feet. Taper exit ramps are preferred over parallel ramps as the deflection angle defines the start of the ramp and prevents driver confusion over it being an additional through lane. Parallel ramps were counted as deficiencies, but lane drops for the Route 7 interchanges at Exits 3 and 7, are not considered taper or parallel ramps and are not considered deficiencies.

Table 2-59 I-84 Eastbound Deflection (Taper) Angle for a Taper Exit Deficiencies

Exit No.	Ramp Type	Measured Deflection Angle (degrees)
4	Parallel	N/A
5	Parallel	N/A

Table 2-60 I-84 Westbound Deflection (Taper) Angle for a Taper Exit Deficiencies

Exit No.	Ramp Type	Measured Deflection Angle (degrees)
4	Taper	1
5	Parallel	N/A
8	Parallel	N/A

Tables 2-59 and **2-60** indicate there is one (1) deficient taper exit ramp and four (4) parallel exit ramps out of the eleven (11) total exit ramps along I-84. The parallel ramps and deficient taper angle are largely influenced by the tight urban corridor between exits 3 and 7 which limits the room for a proper taper. A parallel ramp is used at Exit 5 to increase ramp capacity.

Minimum Length of Acceleration for an Entrance Ramp:

The minimum length of acceleration for an entrance ramp is determined from Section 12-3.02.01 of the CTDOT HDM. The minimum length is calculated using the mainline design speed and the ramp's final curve or controlling curve design speed from Figure 12-3D of the CTDOT HDM as adjusted by Figure 12-3E. Entrance ramps with insufficient acceleration lengths results in traffic merging at different speeds. Acceleration lengths are measured from the point of tangency with the mainline or when ramp geometry allows travel speeds equal to that of the mainline to the point when a twelve (12) foot lane is tapered back to the mainline.

Table 2-61 I-84 Eastbound Minimum Length of Acceleration for an Entrance Ramp Deficiencies

Exit No.	Measured Acceleration Length (ft)	Required Acceleration Length (ft)
4	525	1031
5	397	473
6	385	639

Table 2-62 I-84 Westbound Minimum Length of Acceleration for an Entrance Ramp Deficiencies

Exit No.	Measured Acceleration Length (ft)	Required Acceleration Length (ft)
5	745	1000

Tables 2-61 and **2-62** indicate four (4) of the eleven (11) ramps in the project area have deficient acceleration lengths. All four (4) of these ramps are in the built-up area between Exits 3 and 7 (refer to the Highway Appendix).

Parallel Portion of the Acceleration Lane for an Entrance Ramp:

The CTDOT HDM requires the end of an acceleration lane to be parallel to the mainline for no shorter than 300 feet and no longer than 1,200 feet in Section 12-3.02.01. Longer parallel lengths may be necessary with larger traffic volumes on the ramp and mainline but may be confused for additional travel lanes. The minimum length is necessary for all ramps to allow entering traffic to safely merge with the mainline.

The parallel length is measured from the point the ramp becomes tangent or parallel to the mainline and a vehicle is allowed to merge. All ramps meet the minimal 300 feet of parallel acceleration length and less than 1,200 feet maximum.

The parallel length necessary for merging is discussed under the capacity criteria for ramps.

Entrance and Exit Ramp Side of Road:

In order to conform with driver expectancy, all lane drops, entrance ramps, and exit ramps should be on the driver's right, as detailed in CTDOT HDM Section 12-2.04. These changes in the roadway can be a source of confusion for drivers and limiting them promotes safety and improves highway operations.

Table 2-63 I-84 Entrance and Exit Ramp Side Deficiencies

Exit No.	Direction	Type
7	Eastbound	Left hand exit
7	Eastbound	Left hand entrance
3	Westbound	Left hand entrance
3	Westbound	Left hand exit

Table 2-63 indicates the interchanges with Route 7 at Exits 3 and 7 violate driver expectations. This alignment of exits reduces the number of structures, however increases the potential for weaving movements by drivers trained to expect an exit on their right. Also eliminates lane continuity in most cases (refer to the Highway Appendix).

Interchange Spacing:

Frequent access points may be beneficial to a freeway's accessibility, but tight spacing has the potential to impair freeway operations. The CTDOT HDM recommends an interchange spacing of no less than a mile in urban areas per Section 12-1.01.01.

Interchange spacing was measured for the eastbound and westbound directions of I-84 separately, measuring the distance along the mainline between the centroids of the entrance and exit ramp gore areas for each pair of ramps.

Table 2-64 I-84 Interchange Spacing Deficiencies

From Exit No.	To Exit No.	Distance (EB/WB) (miles)
3	4	0.53 EB / 0.51 WB
5	6	0.59 EB / 0.78 WB
7	8	0.85 EB / 0.90 WB

Table 2-64 indicates three (3) of the five (5) interchange spacings are less than one mile. This concentration of interchanges inhibits spacing for advance exit signage, reduces the time available for drivers to become adjusted to the freeway, and limits the available space for weaving maneuvers. The limited space for weaving maneuvers is particularly clear between Exits 3 and 4 eastbound where the lane drop from the branch connection at the Exit 3 entrance ramp occurs after the Exit 4 exit ramp. In the westbound direction between Exits 3 and 4, a concrete barrier is used to prevent Exit 4 entrance ramp traffic from weaving across to the left exit ramp for Exit 3. The spacing between Exits 7 and 8 results in weaving maneuvers for vehicles entering at Exit 7 from Route 7 southbound, exiting at Exit 8 westbound as they cross from a left entrance to a right exit.

Terminal spacing is a subcomponent of interchange spacing and is outlined in CTDOT HDM Section 12-2.01 and Figure 10-68 of the AASHTO Greenbook. Terminal spacing is measured as the distance between gore areas of successive terminals. The Exit 4 westbound entrance ramp terminal is an exception to the on-off-on-off terminal layout as a concrete barrier separates it from the mainline such that it enters the mainline between the Exit 3 westbound exit ramp and Exit 3 westbound entrance ramp; this separation results in an off-off-on-on layout.

Table 2-65 I-84 Eastbound Terminal Spacing Deficiencies

From Exit No.	Terminal Type	To Exit No.	Terminal Type	Measured Distance (feet)	Required Distance (feet)
3	Entrance	4	Exit	806	2000

Table 2-66 I-84 Westbound Terminal Spacing Deficiencies

From Exit No.	Terminal Type	To Exit No.	Terminal Type	Measured Distance (feet)	Required Distance (feet)
4	Entrance	3	Entrance	736	1000
3	Exit	4	Entrance	950	1000
8	Entrance	7	Exit	1715	2000

Table 2-65 and **Table 2-66** indicate four (4) of the twenty (20) terminals are spaced too closely. Terminal spacing deficiencies are concentrated near the Route 7 interchanges. Three (3) of the six (6) terminal spacings between the Exit 3 and 4 interchanges have deficient spacing even with the concrete barrier separating the westbound Exit 4 entrance ramp and Exit 3 exit ramp (refer to the Highway Appendix).

Ramp Design Speed:

Appropriate ramp design speed is a function of the mainline design speed and ramp type as explained in CTDOT HDM Section 12-4.01. Direct connections between high speed facilities require similarly high-speed connections, while loop ramps require lower design speeds and a safe transition in design speeds from the mainline to the ramp proper. Ramps were classified as ramps for right turns, loop ramps, semidirect connections, and direct connections to determine the appropriate range of design speeds.

Table 2-67 I-84 Eastbound Ramp Design Speed Deficiencies

Exit No.	Exit or Entrance	Ramp Type	Design Speed (mph)	Required Design Speed Range per CTDOT HDM (mph)
4	Entrance	Semidirect Connection	32	45 to 55
5	Exit	Ramp for Right Turn	29	50 to 60
5	Entrance	Direct Connection	30	35 to 45
6	Entrance	Direct Connection	21	35 to 45
8	Exit	Ramp for Right Turn	36	50 to 60
8	Entrance	Semidirect Connection	36	40 to 50

Table 2-68 I-84 Westbound Ramp Design Speed Deficiencies

Exit No.	Exit or Entrance	Ramp Type	Design Speed (mph)	Required Design Speed Range per CTDOT HDM (mph)
4	Exit	Ramp for Right Turn	34	45 to 55
8	Exit	Ramp for Right Turn	18	50 to 60

Table 2-67 and **Table 2-68** indicate the ramps in this corridor which require large changes in speed between the ramp proper and mainline (refer to the Highway Appendix).

Capacity:

An interchange's capacity can impact freeway operations if insufficient and promote unsafe speeds and increase construction and maintenance costs if too large. Three methods of increasing interchange capacity used in the project area are additional lanes, parallel exit ramps, and directional or semi-directional interchanges.

These methods of increasing capacity are often used in conjunction with each other, giving a ramp the ability to physically hold more vehicles and increase vehicle speed. All ramps at Exits 3 and 7 are direct or semidirect and three out of the four ramps carrying mainline Route 7 use two lanes. Exits 5 and 6 utilize extended parallel exit ramps to increase ramp capacity to increase ramp capacity, mitigating the effect of queuing at the ramp terminus. All ramps ending at intersections have at least two lanes to increase signal capacity and subsequently ramp capacity. A detailed traffic analysis is provided under Section 2.2.

2.3.8 US Route 7 Ramp Geometry Review

Nine (9) ramps along both northbound and southbound Route 7 connecting the Route 7 mainline to I-84 and Federal Road were analyzed based on the critical design elements and other design criteria outlined in the CTDOT HDM.

Route 7 Mainline:

- Route 7 Northbound merges with I-84 Eastbound at I-84 Interchange 3 (equivalent to Route 7 Interchange 9)
- Route 7 Northbound Exit 9 Exit Ramp: Route 7 Northbound connects to I-84 westbound at Interchange 3
- Route 7 Southbound Exit 9 Entrance Ramp: I-84 Eastbound connects to Route 7 Southbound
- Route 7 Southbound diverges with I-84 Westbound at I-84 Interchange 3 (equivalent to Route 7 Interchange 9)

Route 7 Ramps:

- Route 7 Northbound Exit 10 Entrance Ramp: I-84 Westbound connects to Route 7 Northbound at Interchange 7
- Route 7 Northbound diverges with I-84 Eastbound at I-84 Interchange 7 (equivalent to Route 7 Interchange 10)

- Route 7 Southbound merges with I-84 Westbound at I-84 Interchange 7 (equivalent to Route 7 Interchange 10)
- Route 7 Southbound Exit 10 Exit Ramp: Route 7 Southbound connects to I-84 Eastbound at Interchange 7
- Route 7 Southbound Exit 10 Federal Road Entrance Ramp: Federal Road connects to Route 7 Southbound

This section summarizes the results of the analysis and highlight all geometric deficiencies of the ramps along the Route 7 corridor.

Minimum Length of Deceleration for an Exit Ramp:

Since, a lane is dropped at both exit ramps from Route 7 there were no deficiencies in deceleration length as the necessary deceleration can be achieved on the mainline.

Deflection (Taper) Angle for a Taper Exit Ramp:

The exit ramps from Route 7 to I-84 are direct connections between freeways, so the lane drop and parallel style ramps used are not considered deficiencies and no deflection angle is necessary.

Minimum Length of Acceleration for an Entrance Ramp:

All entrance ramps in the project area have sufficient length of acceleration or add a lane to the mainline.

Parallel Portion of the Acceleration Lane for an Entrance Ramp:

All entrance ramps in the project area are in the acceptable range of length parallel to the mainline for merging with mainline traffic.

Entrance and Exit Ramp Side of Road:

The interchanges between Route 7 and I-84 use left side terminals to minimize the number of structures as summarized in **Table 2-69**. These two (2) left side terminals are replicated on I-84 as the left side Route 7 Exit 9 northbound exit leads to the left side I-84 Exit 3 westbound entrance and the left side Route 7 Exit 10 southbound exit leads to the left side I-84 Exit 7 eastbound entrance.

Table 2-69 Route 7 Entrance and Exit Ramp Side Deficiencies

Exit No.	Direction	Type
9 (Route 7)	Route 7 Northbound to I-84 Westbound	Exit
10 (Route 7)	Route 7 Southbound to I-84 Eastbound	Exit

Interchange Spacing:

Interchange spacing was measured for the northbound and southbound directions of Route 7 separately, taking the distance along the mainline between the centroids of the entrance and exit ramp gore areas for each exit pairing. The centroid of the Route 7 Exit 9 northbound interchange was taken as the gore area of the Route 7 Exit 9 northbound exit ramp and the I-84 Exit 3 eastbound entrance ramp.

Table 2-70 Route 7 Interchange Spacing Deficiencies

From Exit No.	To Exit No.	Distance (NB/SB) (miles)
8 (Route 7)	9 (Route 7)	0.50 NB / 0.47 SB
9 (Route 7)	4 (I-84)	0.49 NB / 0.34 SB

Table 2-70 indicates the interchange spacing of Route 7 Exit 9 and I-84 Exit 4 impact operations coming from Route 7 as well as where the next exit southbound (Route 7 Exit 8) is also substandard (refer to the Highway Appendix).

Terminal spacing along the Route 7 mainline is also considered as summarized in **Tables 2-71** and **2-72**.

Table 2-71 Route 7 Northbound Terminal Spacing Deficiencies

From Exit No.	Terminal Type	To Exit No.	Terminal Type	Measured Distance (feet)	Required Distance (feet)
8 (Route 7)	Entrance	9 (Route 7)	Exit	1280	2000

Table 2-72 Route 7 Southbound Terminal Spacing Deficiencies

From Exit No.	Terminal Type	To Exit No.	Terminal Type	Measured Distance (feet)	Required Distance (feet)
9 (Route 7 to I-84)	Exit	8 (Route 7)	Entrance	1147	2000
10 (Federal Road to Route 7)	Entrance	7 (I-84)	Entrance	940	1000

A lane is added and subsequently dropped at Route 7 Exits 8 and 9 northbound resulting in weaving conflicts for the southwestern I-84 branch connection compounding the deficient terminal spacing. Successive entrance ramps for I-84 and Federal Road at the northeastern branch connection also have deficient spacing (refer to the Highway Appendix).

Ramp Design Speed:

Direct connections between freeways maintain similar design speeds to that of the freeway proper to promote a smooth transition between the two flows of traffic.

Table 2-73 Route 7 Southbound Ramp Design Speed Deficiencies

Exit No.	Exit or Entrance	Ramp Type	Design Speed (mph)	Required Design Speed Range per CTDOT HDM (mph)
10	Entrance (Federal Road to Route 7)	Direct Connection	41	50 to 60
10	Exit (Route 7 to I-84)	Direct Connection	46	50 to 60

Table 2-73 indicates the final two (2) ramps before Route 7 southbound merges with I-84 westbound have significantly slower design speeds than the mainline (refer to Appendix A for the Deficiency Plans).

Capacity:

All ramps to and from Route 7 are single lane direct connections. The direct connections allow for higher design speeds to match the high speeds of the freeway. A detailed traffic analysis is provided under Section 2.2

2.3.9 Existing Highway Geometric Deficiency Conclusions

In summary, this report illustrates the following highway characteristics which contribute to the deficiencies of the corridor:

- Substandard horizontal curves which lower Design Speeds
- Substandard shoulder widths (left and right)
- Substandard Stopping Sight Distance (SSD)
- Substandard exit deceleration and acceleration lane lengths
- Left hand exit ramps which violate driver expectations
- Substandard interchange spacing (> 1 mile)
- Substandard ramp terminal spacing
- Short weave lengths at the 2 interchanges with US Route 7

Correcting these deficiencies will have a significant impact of the operation improvement of the I-84 corridor. **Table 2-74** summarizes the deficiencies in each segment along the Eastbound and Westbound I-84 travel lanes. **Table 2-75** summarizes the deficiencies in each segment along Northbound and Southbound US Route 7. **Table 2-76** summarizes the deficiencies for the on and off ramps along I-84 in the eastbound and westbound directions. **Table 2-77** summarizes the deficiencies for the on and off ramps along U.S. Route 7 in the northbound and southbound directions. Within these figures, the controlling geometric design criteria are listed across the top of the criteria matrix, with the individual segments of the corridor listed along the left column. A red dot denotes that either a portion or the entire length of a segment does not meet the minimum controlling design criteria, a yellow dot denotes that either a portion or the entire length of a segment marginally meets the minimum controlling design criteria, and a green dot denotes that the entire length of a segment meets the minimum controlling design criteria.

Figures 2-16 to **2-33** depict geometric deficiencies associated with horizontal and vertical curvature and interchange spacing. The Highway Appendix includes detailed calculations noting geometric measurements in comparison to minimum design criteria. The I-84 and Route 7 mainline and ramp geometry backup calculations are also included in the Highway Appendix.

Table 2-74 I-84 Eastbound and Westbound Geometric Criteria Matrix

I-84 EASTBOUND HIGHWAY GEOMETRICS

Segment No.	Segment	Design Speed	Travel Lane Widths	Shoulder Widths	Structures				Horizontal Alignment		Vertical Curvature			Stopping Sight Distance (Based on Level Grades)	Travel Lane & Shoulder Cross Slopes	Accessibility Requirements for Disabled Individuals	Roadside Clear Zones	Intersection Sight Distance
					Bridge Widths & Cross Slopes	Bridge Structural Capacity	Bridge Condition Rating	Bridge Vertical Clearances	Minimum Radius	Compound Curves Not Meeting 1.5:1 Ratio	Stopping Sight Distance at Crest Vertical Curves	Stopping Sight Distance at Sag Vertical Curves	Maximum Grades					
1	Kenosia Avenue Overpass to Exit 3 Off-Ramp	Red	Green	Red	Red	Green	Yellow	Green	Red	N/A	N/A	Red	Green	Red	Green	Green	Green	N/A
2	Exit 3 Off-Ramp to Exit 4 Off-Ramp	Red	Green	Red	Red	Green	Green	Green	Red	N/A	Red	Red	Red	Red	Green	Green	Green	N/A
3	Exit 4 Off-Ramp to Kohanza Street Underpass	Green	Green	Red	Red	Green	Green	Yellow	Green	Red	Green	Green	Green	Green	Green	Green	Green	Red
4	Kohanza Street Underpass to Tamarack Avenue Underpass	Green	Green	Red	Red	Green	Green	Red	Green	N/A	Green	Red	Green	Green	Green	Green	Green	Green
5	Tamarack Avenue Underpass to Exit 7 Off-Ramp	Green	Green	Red	Red	Green	Green	Red	Green	N/A	Green	N/A	Green	N/A	Green	Green	Green	N/A
6	Exit 7 Off-Ramp to Exit 8 Off-Ramp	Red	Green	Red	Red	Green	Yellow	Red	Yellow	N/A	Red	Red	Green	Red	Green	Green	Green	N/A
7	Exit 8 Off-Ramp to Vale Road Overpass	Green	Green	Red	Red	Green	Green	N/A	Yellow	N/A	Yellow	Green	Green	Red	Green	Green	Green	Green

I-84 WESTBOUND HIGHWAY GEOMETRICS

Segment No.	Segment	Design Speed	Travel Lane Widths	Shoulder Widths	Structures				Horizontal Alignment		Vertical Curvature			Stopping Sight Distance (Based on Level Grades)	Travel Lane & Shoulder Cross Slopes	Accessibility Requirements for Disabled Individuals	Roadside Clear Zones	Intersection Sight Distance
					Bridge Widths & Cross Slopes	Bridge Structural Capacity	Bridge Condition	Bridge Vertical Clearances	Minimum Radius	Compound Curves Not Meeting 1.5:1 Ratio	Stopping Sight Distance at Crest Vertical Curves	Stopping Sight Distance at Sag Vertical Curves	Maximum Grades					
1	Kenosia Avenue Overpass to Exit 3 On-Ramp	Red	Green	Red	Red	Green	Green	Red	Red	N/A	Green	Green	Green	Yellow	Green	Green	Green	N/A
2	Exit 3 On-Ramp to Exit 4 On-Ramp	Red	Green	Red	Red	Green	Green	Green	Red	Green	Red	Red	Green	Red	Green	Green	Green	N/A
3	Exit 4 On-Ramp to Kohanza Street Underpass	Green	Green	Red	Red	Green	Green	Yellow	Green	Red	Green	Green	Green	Yellow	Green	Green	Green	Green
4	Kohanza Street Underpass to Tamarack Avenue Underpass	Green	Green	Red	Red	Green	Green	Red	Green	N/A	Green	Yellow	Green	N/A	Green	Green	Green	Red
5	Tamarack Avenue Underpass to Exit 7 On-Ramp	Green	Green	Red	Green	Green	Green	Red	Green	N/A	Green	N/A	Green	N/A	Green	Green	Green	N/A
6	Exit 7 On-Ramp to Exit 8 On-Ramp	Red	Green	Red	Red	Green	Yellow	Red	Yellow	N/A	Red	Red	Green	Red	Green	Green	Green	N/A
7	Exit 8 On-Ramp to Vale Road Overpass	Green	Green	Red	Red	Green	Green	N/A	Yellow	N/A	Yellow	Yellow	Green	Red	Green	Green	Green	N/A

Green ● = Meets Controlling Design Criteria
Yellow ● = Marginally Meets Controlling Design Criteria
Red ● = Does Not Meet Controlling Design Criteria

Table 2-75 US Route 7 Northbound and Southbound Criteria Deficiency Matrix

ROUTE 7 NORTHBOUND HIGHWAY GEOMETRICS																			
Segment No.	Segment	Design Speed	Travel Lane Widths	Shoulder Widths	Auxiliary Lane & Shoulder Widths	Structures				Horizontal Alignment		Vertical Curvature			Stopping Sight Distance (Based on Level Grades)	Travel Lane & Shoulder Cross Slopes	Accessibility Requirements for Disabled Individuals	Roadside Clear Zones	Intersection Sight Distance
						Bridge Widths & Cross Slopes	Bridge Structural Capacity	Bridge Condition Rating	Bridge Vertical Clearances	Minimum Radius	Compound Curves Not Meeting 1.5:1 Ratio	Stopping Sight Distance at Crest Vertical	Stopping Sight Distance at Sag Vertical Curves	Maximum Grades					
8	Backus Avenue Overpass to I-84 Merge	● (red)	● (green)	● (red)	N/A	● (red)	● (green)	● (green)	N/A	● (green)	N/A	N/A	● (red)	● (red)	N/A	● (green)	N/A	● (green)	N/A
9	I-84 Diverge to Exit 11 Off-Ramp	● (red)	● (green)	● (red)	N/A	● (red)	● (green)	● (green)	N/A	● (green)	N/A	● (green)	● (yellow)	● (green)	N/A	● (green)	N/A	● (green)	N/A

ROUTE 7 SOUTHBOUND HIGHWAY GEOMETRICS																			
Segment No.	Segment	Design Speed	Travel Lane Widths	Shoulder Widths	Auxiliary Lane & Shoulder Widths	Structures				Horizontal Alignment		Vertical Curvature			Stopping Sight Distance (Based on Level Grades)	Travel Lane & Shoulder Cross Slopes	Accessibility Requirements for Disabled Individuals	Roadside Clear Zones	Intersection Sight Distance
						Bridge Widths & Cross Slopes	Bridge Structural Capacity	Bridge Condition Rating	Bridge Vertical Clearances	Minimum Radius	Compound Curves Not Meeting 1.5:1 Ratio	Stopping Sight Distance at Crest Vertical	Stopping Sight Distance at Sag Vertical Curves	Maximum Grades					
8	Backus Avenue Overpass to I-84 Diverge	● (red)	● (green)	● (red)	N/A	● (red)	● (green)	● (green)	N/A	● (red)	N/A	● (red)	● (green)	● (green)	N/A	● (green)	N/A	● (green)	N/A
9	I-84 Merge to Exit 11 On-Ramp	● (red)	● (green)	● (red)	N/A	● (red)	● (green)	● (green)	N/A	● (green)	N/A	● (red)	● (green)	● (green)	N/A	● (green)	N/A	● (green)	N/A

● (green) = Meets Controlling Design Criteria

● (yellow) = Marginally Meets Controlling Design Criteria

● (red) = Does Not Meet Controlling Design Criteria

Table 2-76 I-84 Eastbound and Westbound Ramp Criteria Matrix

I-84 EASTBOUND RAMPS

Exit	Direction	On/ Off	Ramp Type	Critical Design Elements				Other Design Criteria					
				Length of Deceleration	Deflection (Taper) Angle for Taper Exit Ramp (2 to 5 degrees)	Length of Acceleration	Parallel Portion of Acceleration Lane (>300 ft)	Side	Terminal Spacing		Interchange Spacing (>1 mile)		Ramp Design Speed
									Backward	Forward	Backward	Forward	
3	EB	Off	Direct Connection	🟢	🟢	N/A	N/A	🟢	🟢	🟢	🟢	🔴	🟢
3	EB	On	Direct Connection	N/A	N/A	🟢	🟢	🟢	🟢	🔴	🟢	🔴	🟢
4	EB	Off	Loop Ramp	🔴	🔴	N/A	N/A	🟢	🔴	🟢	🔴	🟢	🟢
4	EB	On	Semidirect Connection	N/A	N/A	🔴	🟢	🟢	🟢	🟢	🔴	🟢	🔴
5	EB	Off	Ramp for Right Turn	🟢	🔴	N/A	N/A	🟢	🟢	🟢	🟢	🔴	🔴
5	EB	On	Direct Connection	N/A	N/A	🔴	🟢	🟢	🟢	🟢	🟢	🔴	🔴
6	EB	On	Direct Connection	N/A	N/A	🔴	🟢	🟢	🟢	🟢	🔴	🟢	🔴
7	EB	Off	Direct Connection	🟢	🟢	N/A	N/A	🔴	🟢	🟢	🟢	🔴	🟢
7	EB	On	Direct Connection	N/A	N/A	🟢	🟢	🔴	🟢	🟢	🟢	🔴	🟢
8	EB	Off	Ramp for Right Turn	🔴	🟢	N/A	N/A	🟢	🟢	🟢	🔴	🟢	🔴
8	EB	On	Semidirect Connection	N/A	N/A	🟢	🟢	🟢	🟢	🟢	🔴	🟢	🔴

I-84 WESTBOUND RAMPS

Exit	Direction	On/ Off	Ramp Type	Critical Design Elements				Other Design Criteria					
				Length of Deceleration	Deflection (Taper) Angle for Taper Exit Ramp (2 to 5 degrees)	Length of Acceleration	Parallel Portion of Acceleration Lane (>300 ft)	Side	Terminal Spacing		Interchange Spacing (>1 mile)		Ramp Design Speed
									Backward	Forward	Backward	Forward	
3	WB	On	Direct Connection	N/A	N/A	🟢	🟢	🔴	🔴	🟢	🔴	🟢	🟢
3	WB	Off	Direct Connection	🟢	🟢	N/A	N/A	🔴	🟢	🔴	🔴	🟢	🟢
4	WB	On	Loop Ramp	N/A	N/A	🟢	🟢	🟢	🔴	🔴	🟢	🔴	🟢
4	WB	Off	Ramp for Right Turn	🔴	🔴	N/A	N/A	🟢	🟢	🟢	🟢	🔴	🔴
5	WB	On	Direct Connection	N/A	N/A	🔴	🟢	🟢	🟢	🟢	🔴	🟢	🟢
5	WB	Off	Loop Ramp	🟢	🔴	N/A	N/A	🟢	🟢	🟢	🔴	🟢	🟢
6	WB	Off	Ramp for Right Turn	🟢	🟢	N/A	N/A	🟢	🟢	🟢	🟢	🔴	🟢
7	WB	On	Direct Connection	N/A	N/A	🟢	🟢	🟢	🟢	🟢	🔴	🟢	🟢
7	WB	Off	Direct Connection	🟢	🟢	N/A	N/A	🟢	🔴	🟢	🔴	🟢	🟢
8	WB	On	Direct Connection	N/A	N/A	🟢	🟢	🟢	🟢	🔴	🟢	🔴	🟢
8	WB	Off	Ramp for Right Turn	🔴	🔴	N/A	N/A	🟢	🟢	🟢	🟢	🔴	🔴

🟢 = Meets Controlling Design Criteria

🔴 = Does Not Meet Controlling Design Criteria

Table 2-77 US Route 7 Ramp Criteria Matrix

ROUTE 7 RAMPS														
				Critical Design Elements				Other Design Criteria						
									Terminal Spacing		Interchange Spacing (>1 mile)		
Exit	Direction	On/ Off	Ramp Type	Length of Deceleration	Deflection (Taper) Angle for Taper Exit Ramp (2 to 5 degrees)	Length of Acceleration	Parallel Portion of Acceleration Lane (>300 ft)	Side	Backward	Forward	Backward	Forward	Ramp Design Speed
9	NB	Off-84W	Direct Connection	🟢	🟢	N/A	N/A	🔴	🔴	🟢	🔴	🔴	🟢
10	NB	On-84W	Direct Connection	N/A	N/A	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
9	SB	On-84E	Direct Connection	N/A	N/A	🟢	🟢	🟢	🟢	🔴	🔴	🔴	🟢
10	SB	On	Direct Connection	N/A	N/A	🟢	🟢	🟢	🟢	🔴	🟢	🟢	🔴
10	SB	Off	Direct Connection	🟢	🟢	N/A	N/A	🔴	🟢	🟢	🟢	🟢	🔴

🟢 = Meets Controlling Design Criteria

🔴 = Does Not Meet Controlling Design Criteria

Figure 2-16 Roadway Design Curvature Deficiencies– Map 1

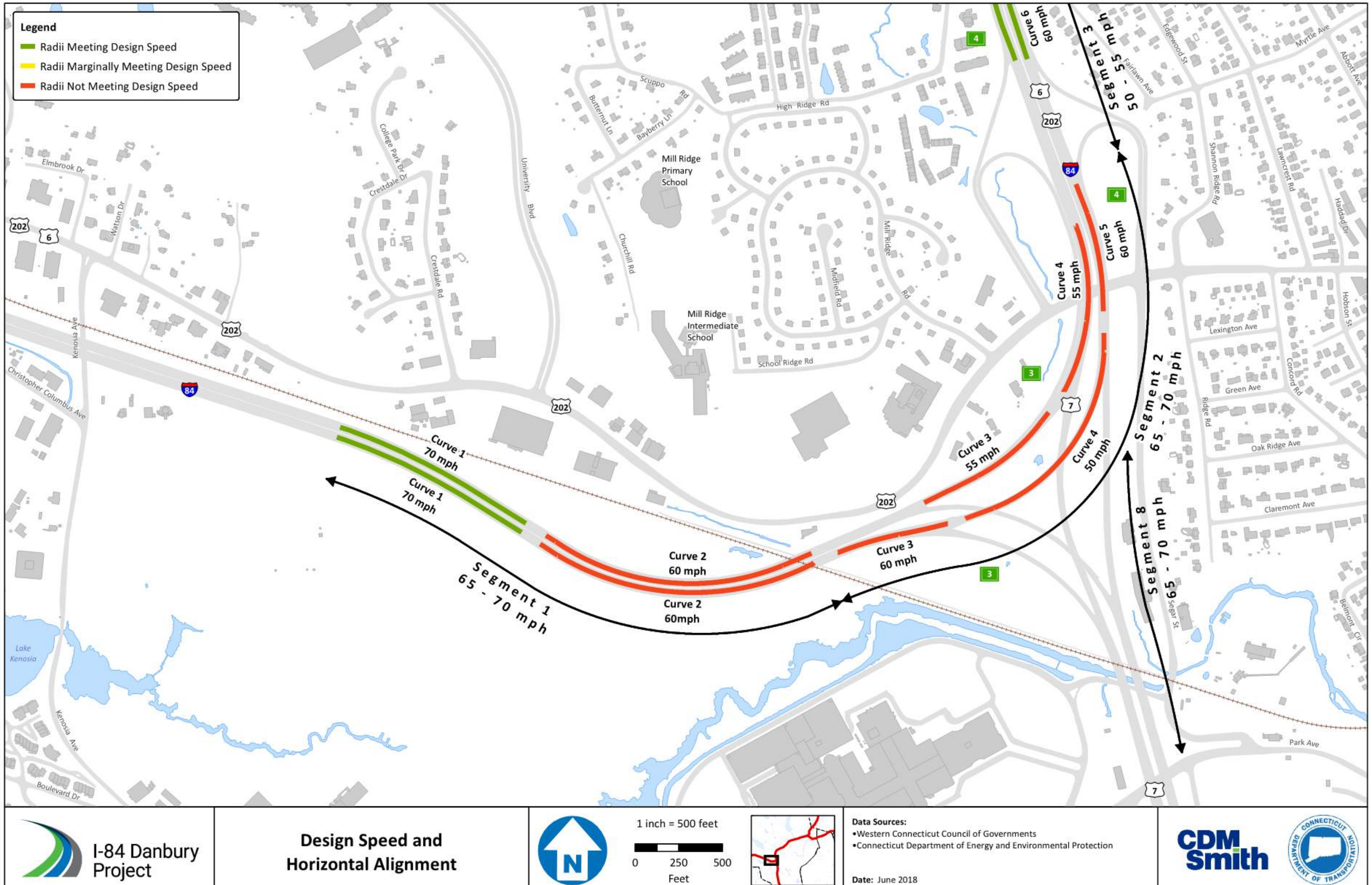


Figure 2-17 Roadway Design Curvature Deficiencies – Map 2

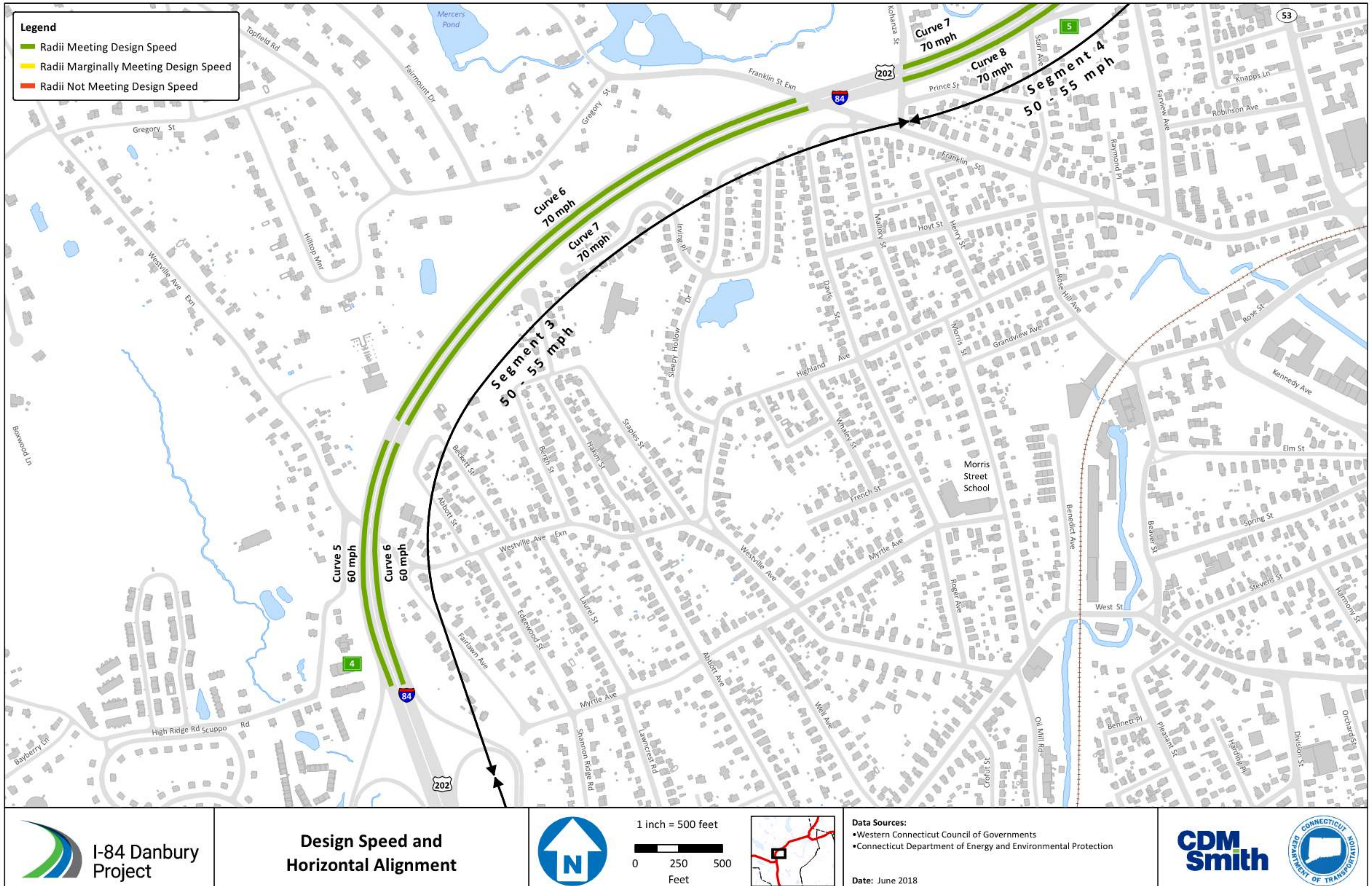


Figure 2-18 Roadway Design Curvature Deficiencies – Map 3

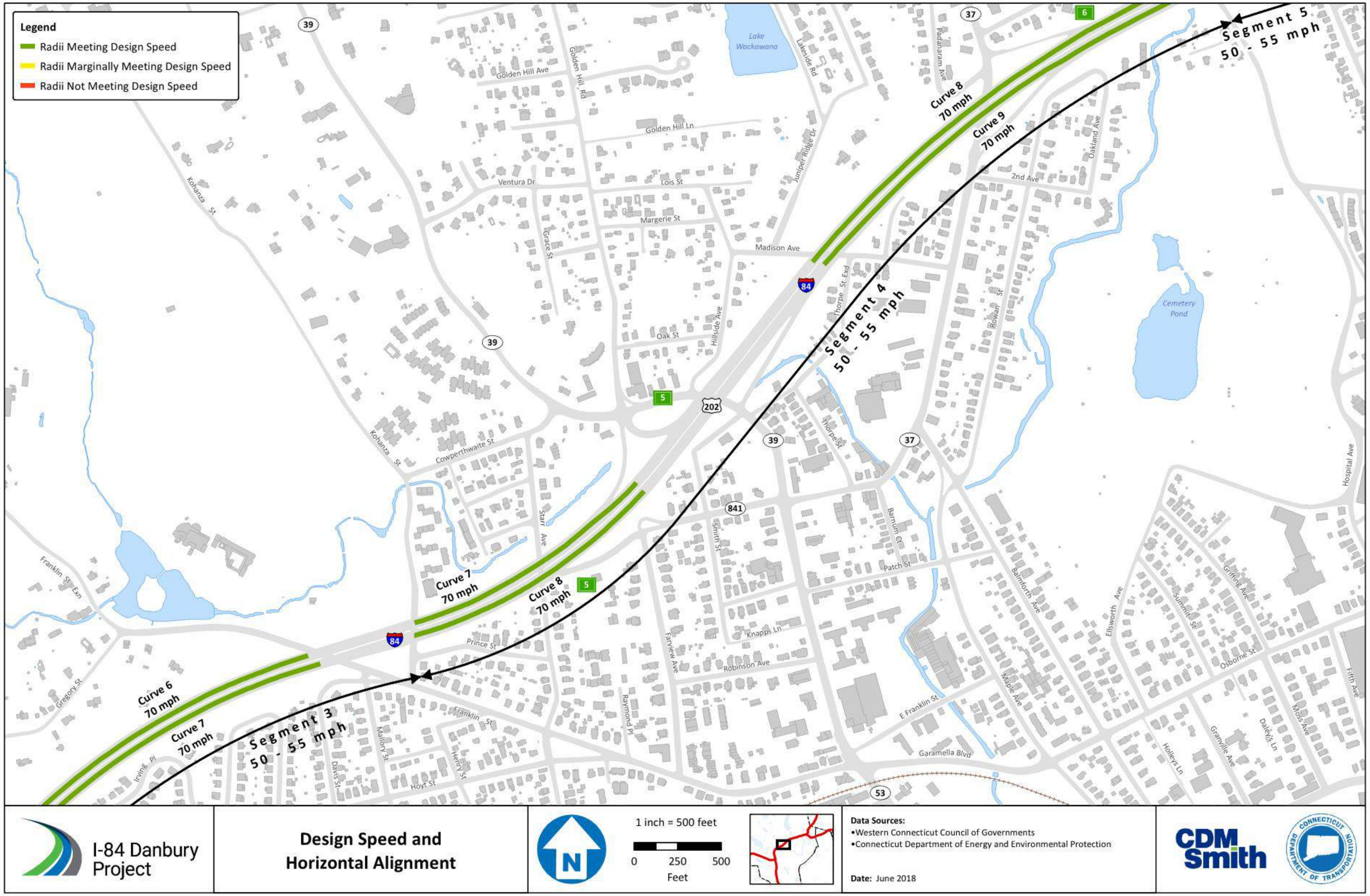


Figure 2-19 Roadway Design Curvature Deficiencies – Map 4

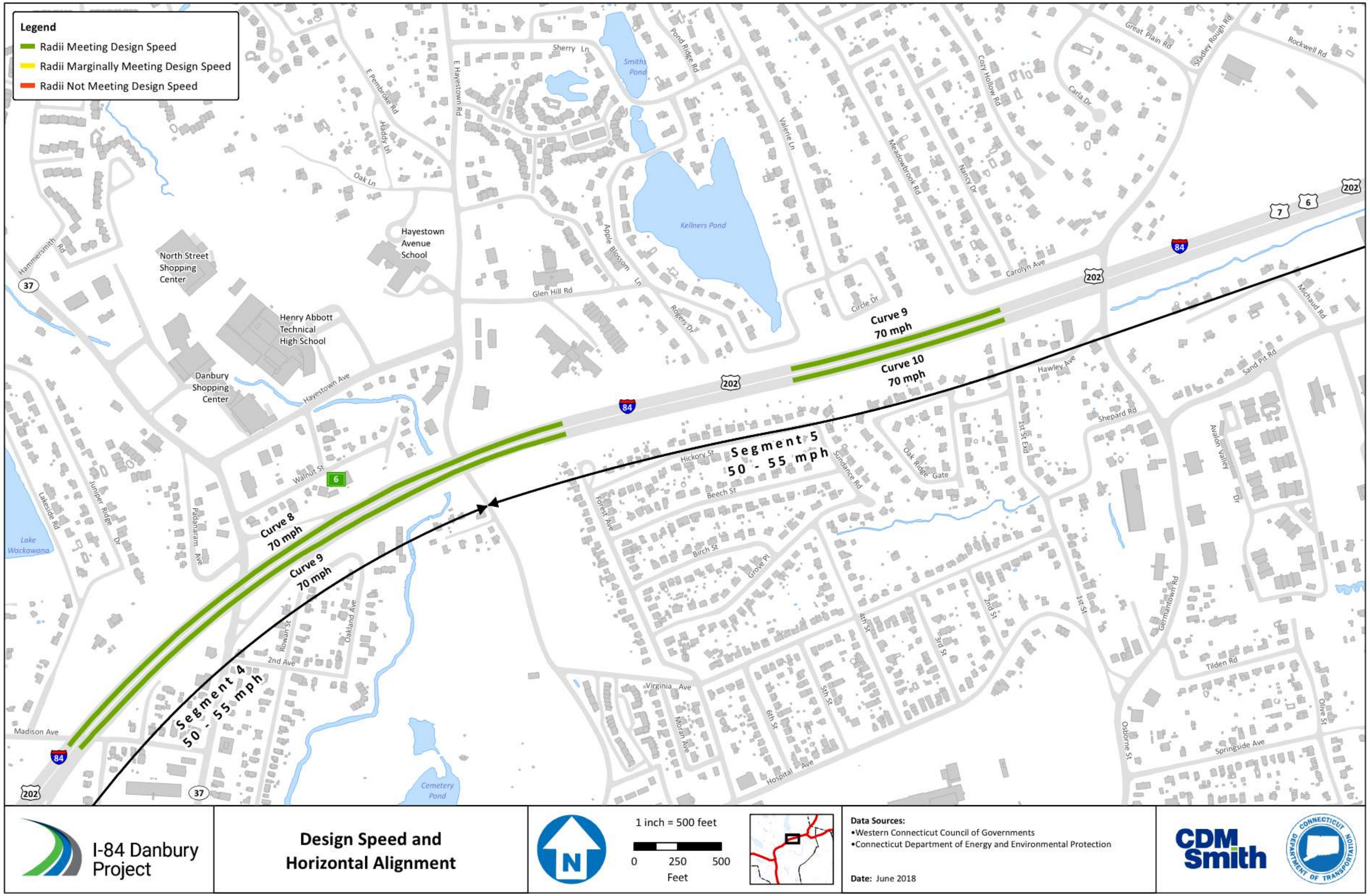


Figure 2-20 Roadway Design Curvature Deficiencies – Map 5

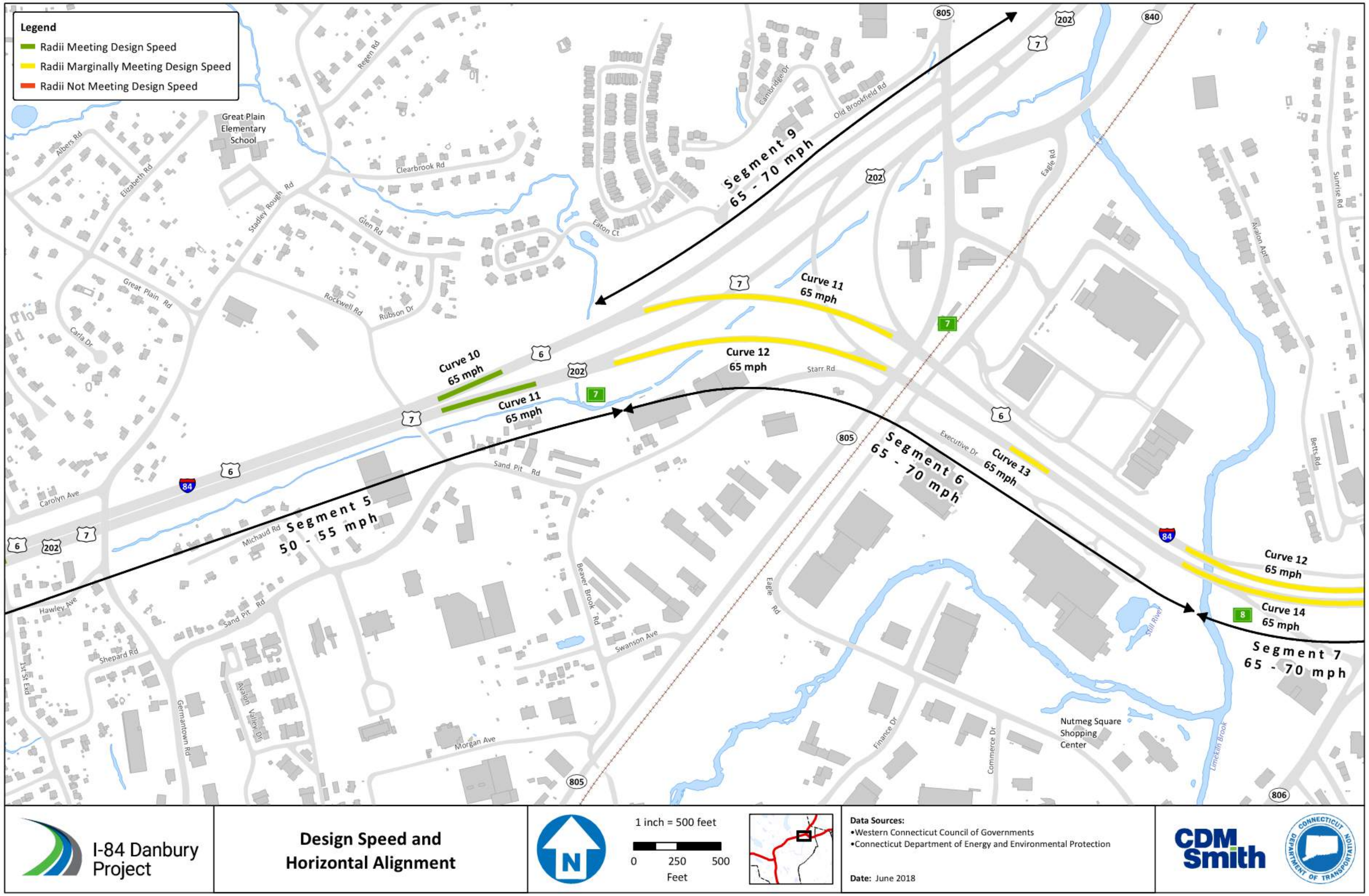


Figure 2-21 Roadway Design Curvature Deficiencies – Map 6

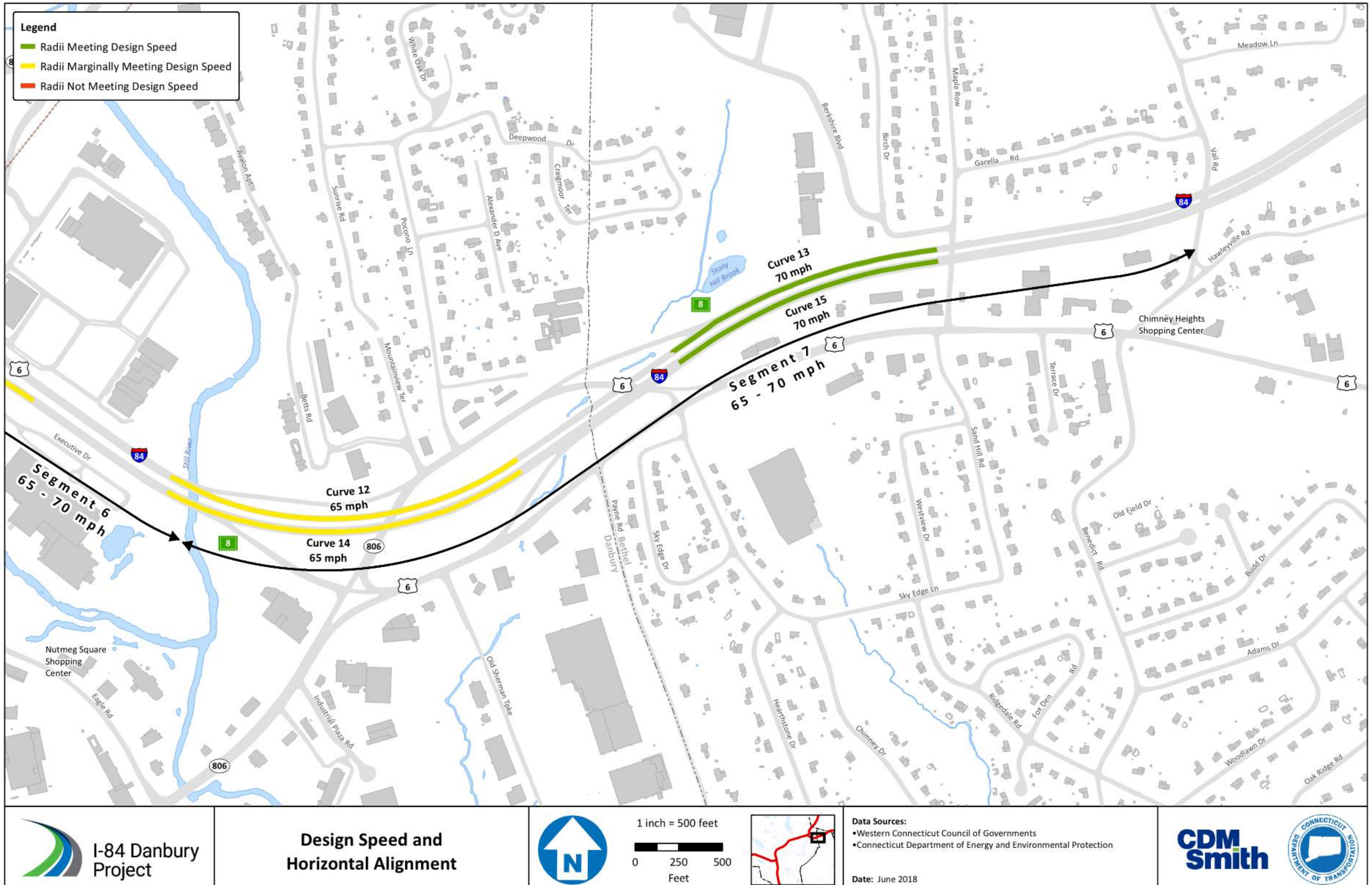


Figure 2-22 Roadway Vertical Curvature Deficiencies – Map 1

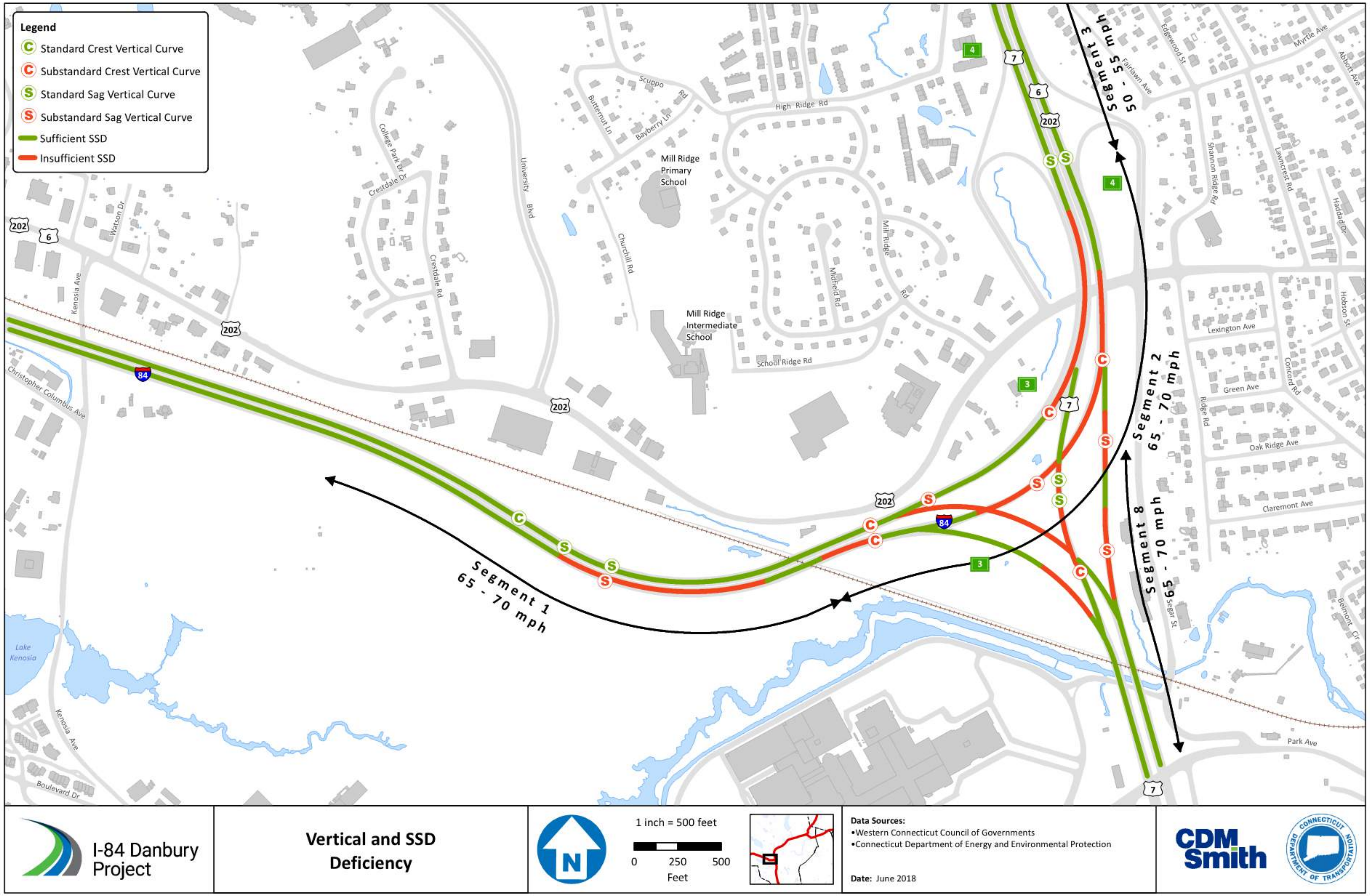


Figure 2-23 Roadway Vertical Curvature Deficiencies – Map 2

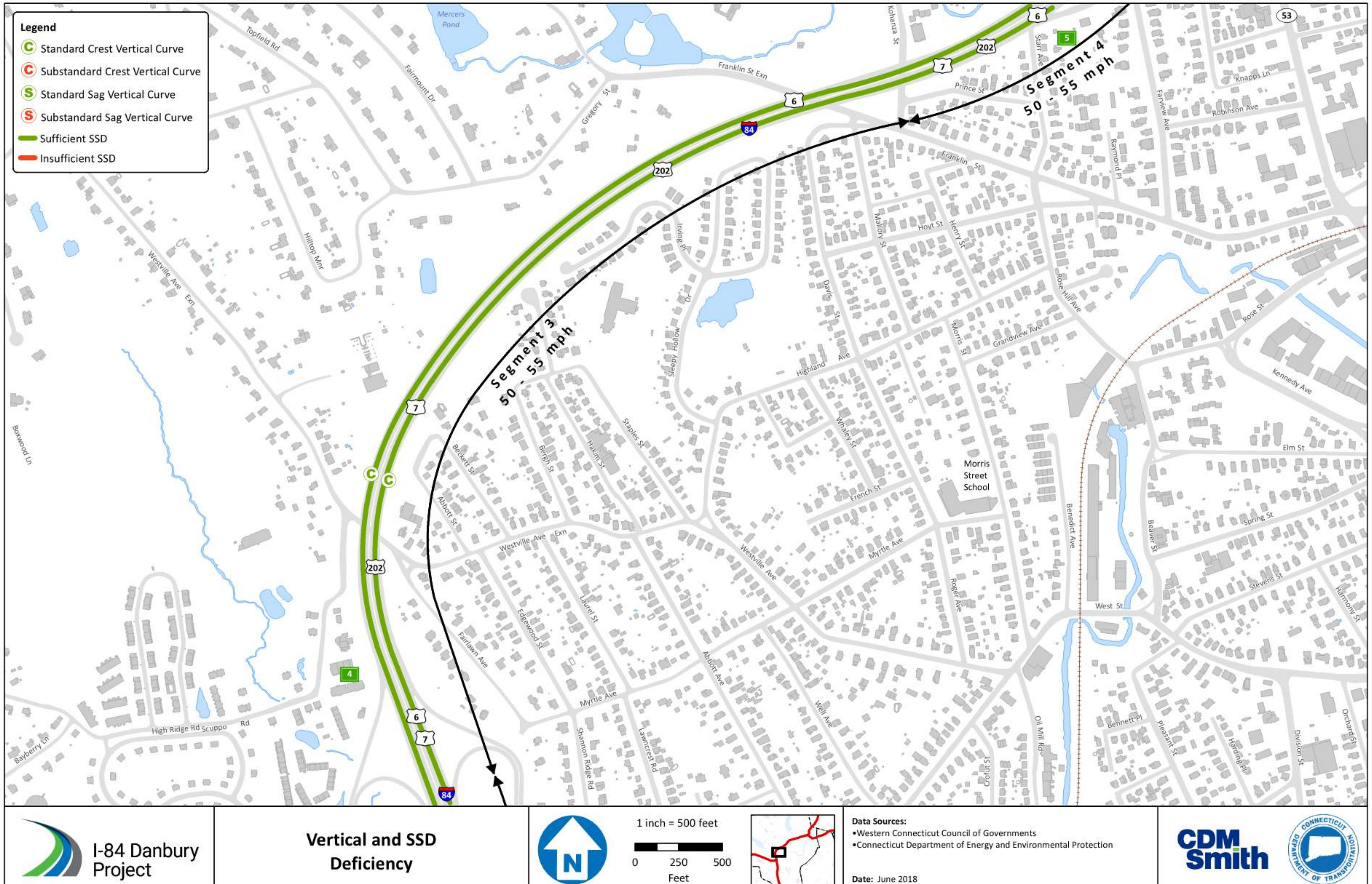


Figure 2-24 Roadway Vertical Curvature Deficiencies – Map 3

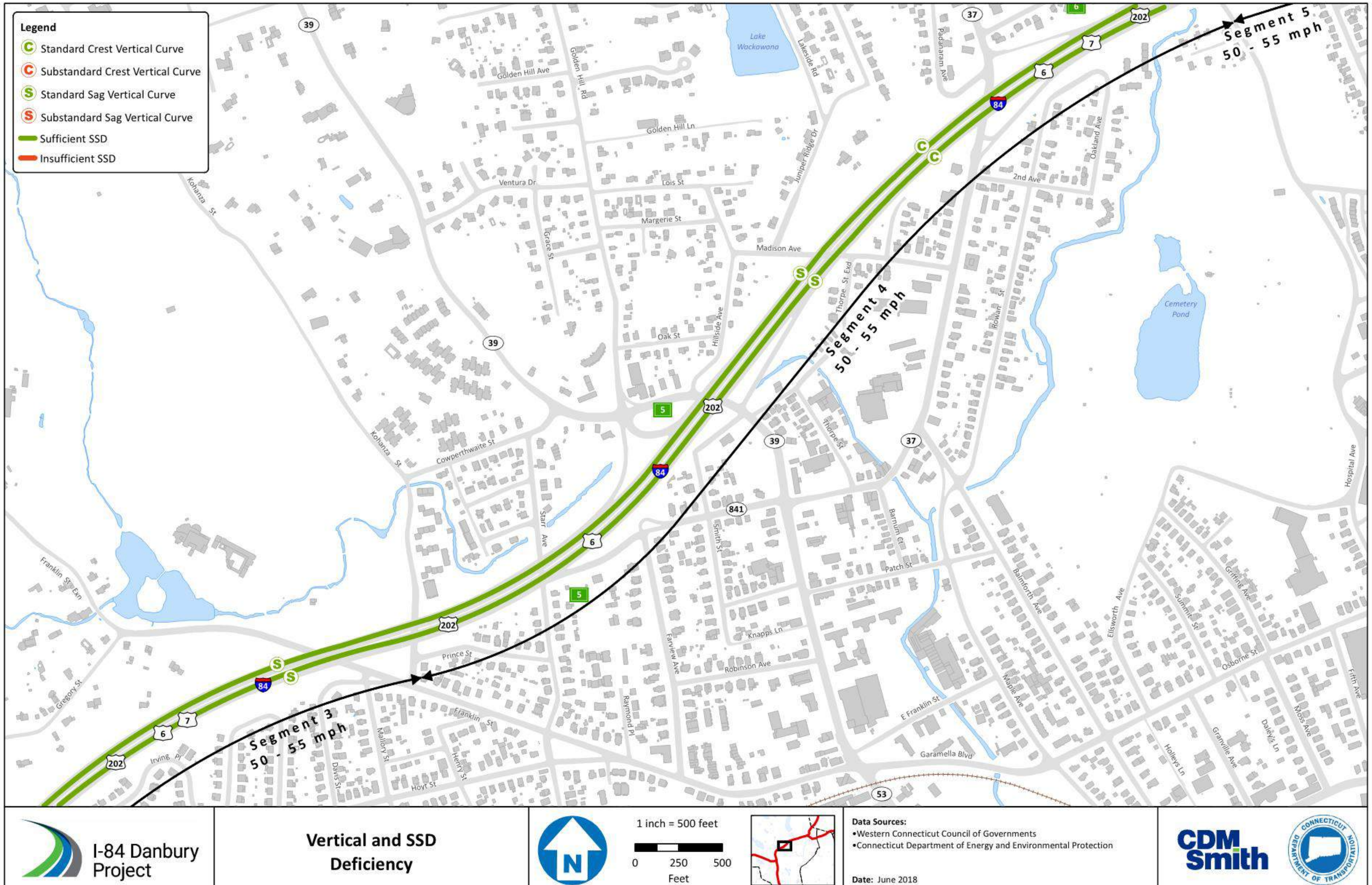


Figure 2-25 Roadway Vertical Curvature Deficiencies – Map 4

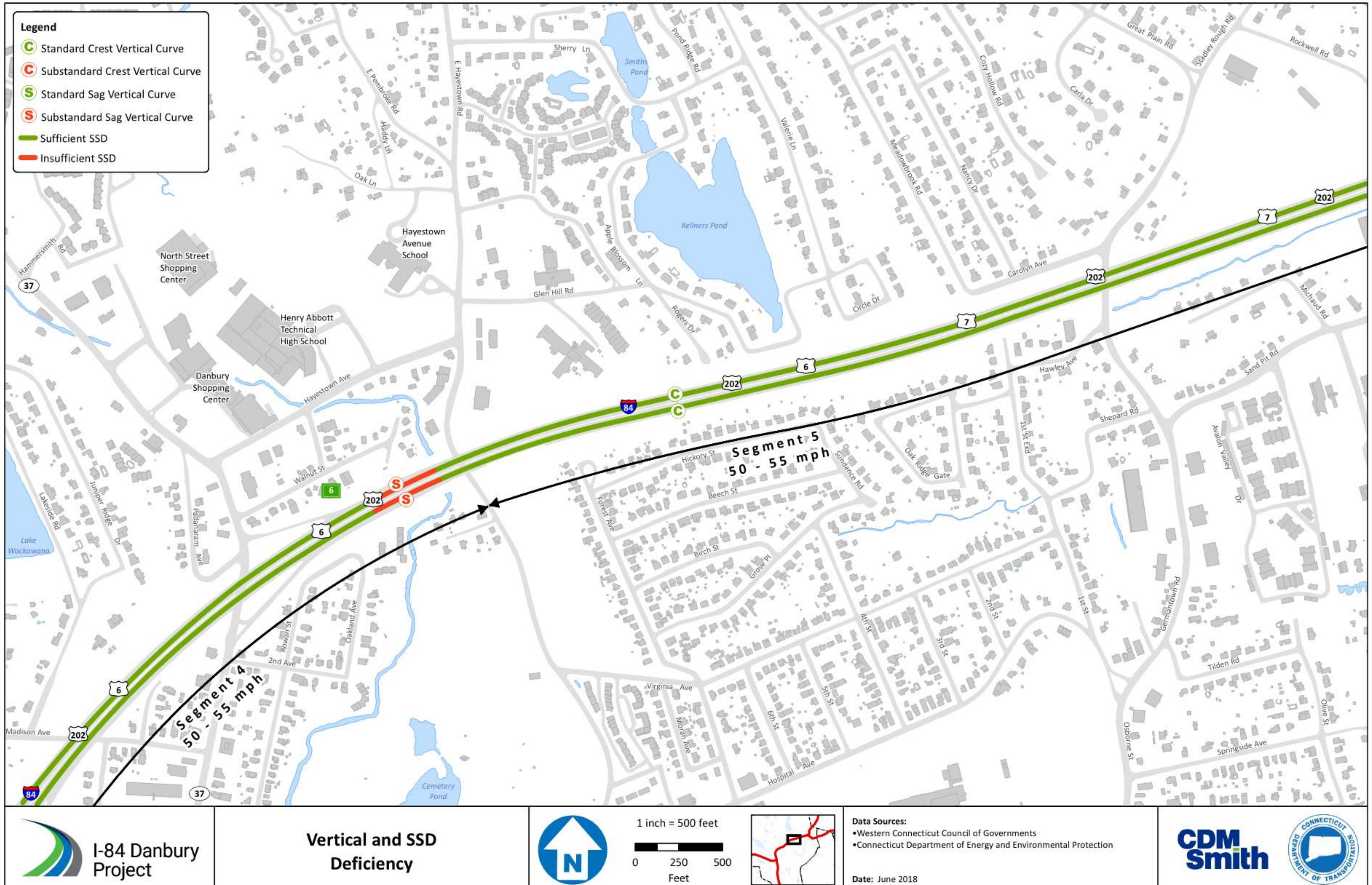


Figure 2-26 Roadway Vertical Curvature Deficiencies – Map 5

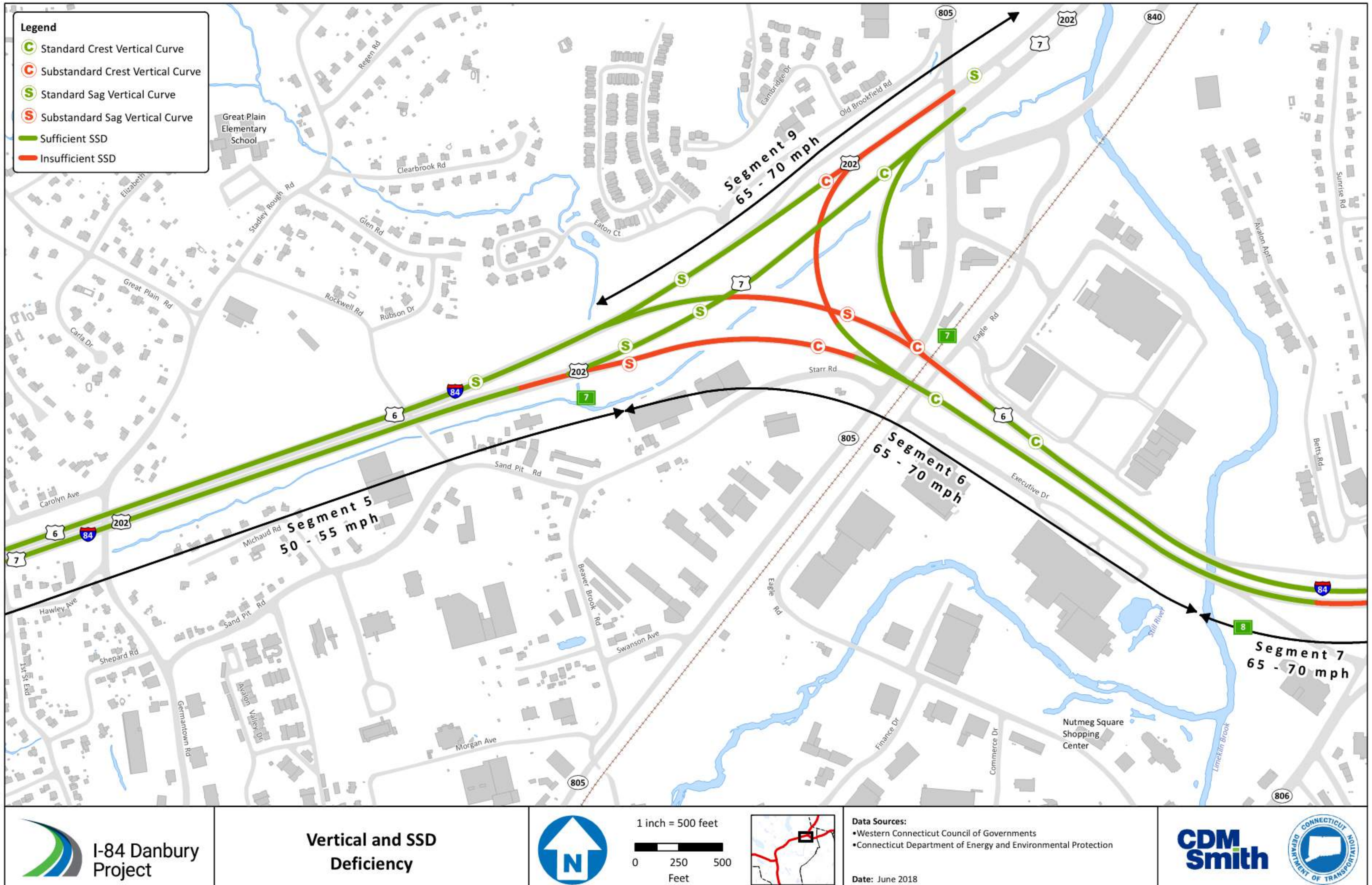


Figure 2-27 Roadway Vertical Curvature Deficiencies – Map 6

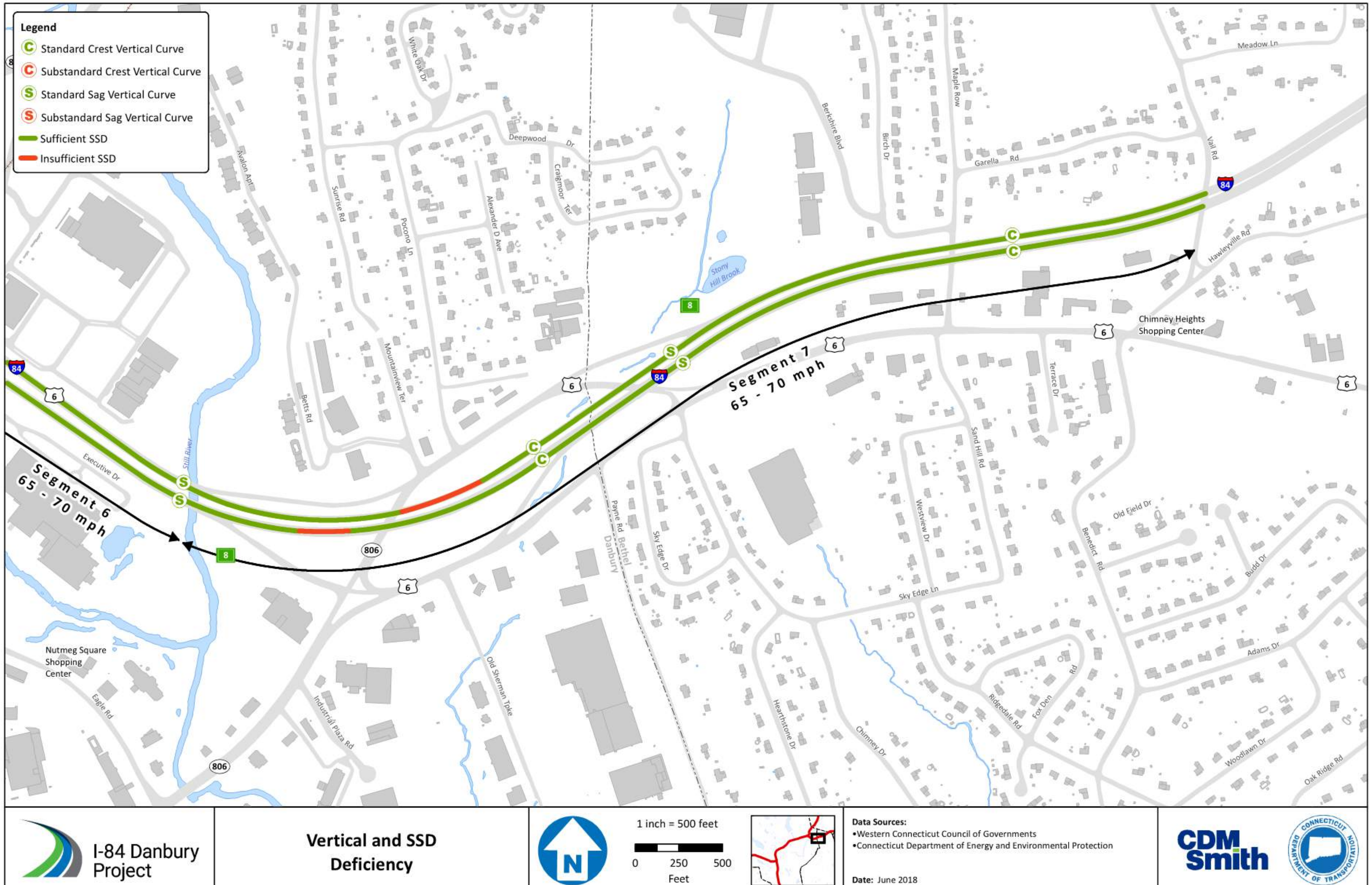


Figure 2-28 Ramp and Interchange Deficiencies – Map 1

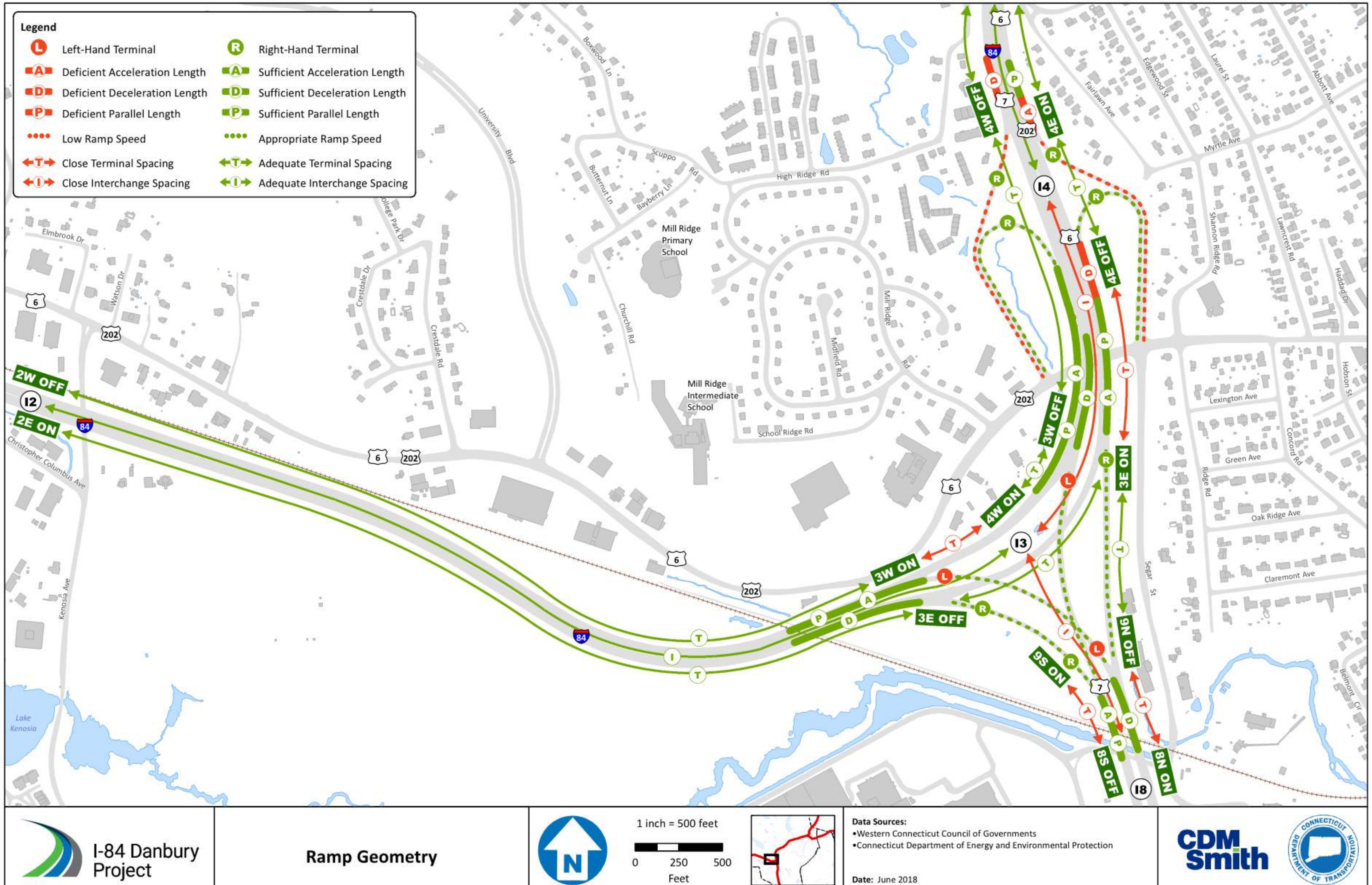


Figure 2-29 Ramp and Interchange Deficiencies – Map 2

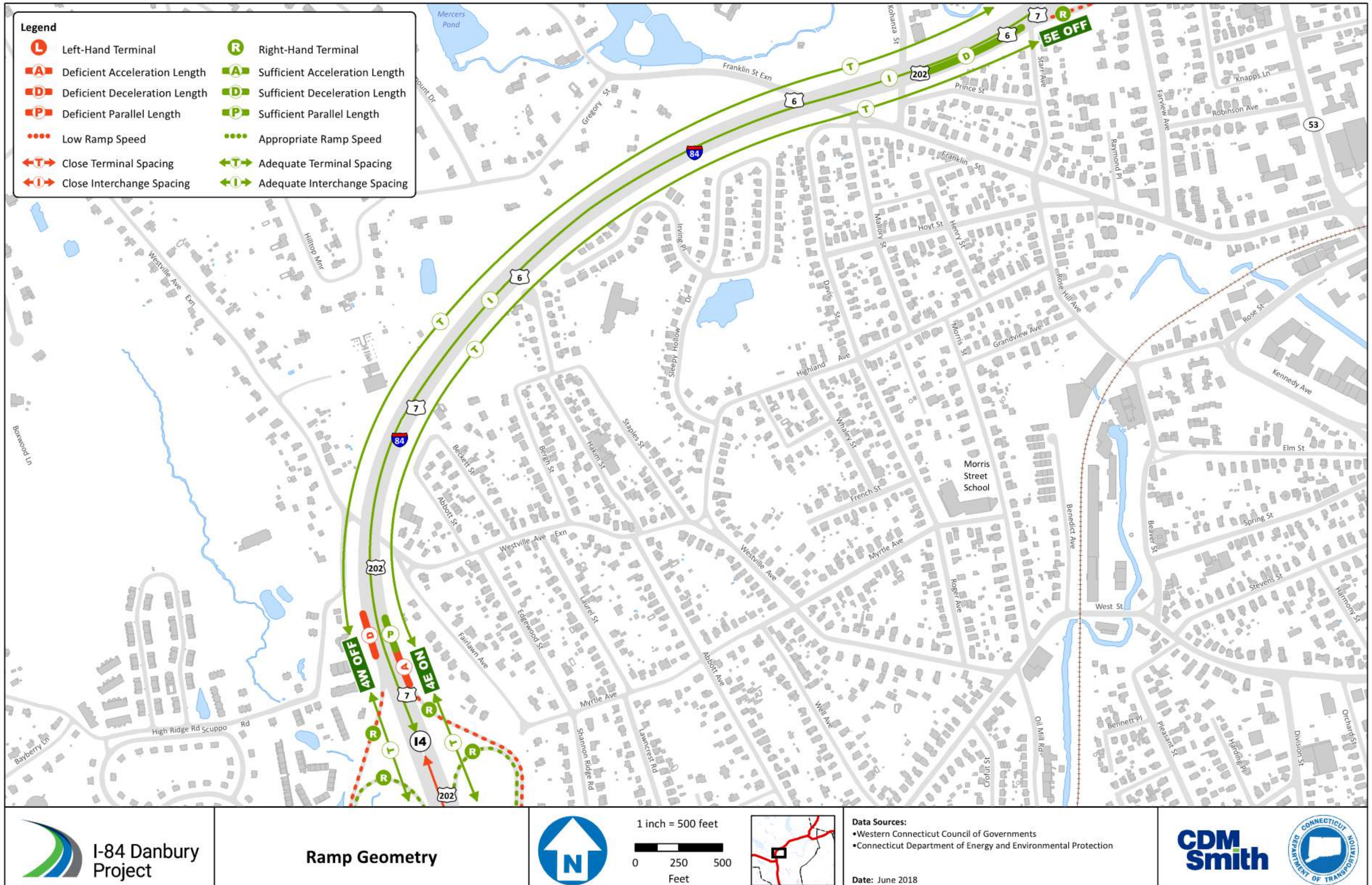


Figure 2-30 Ramp and Interchange Deficiencies – Map 3

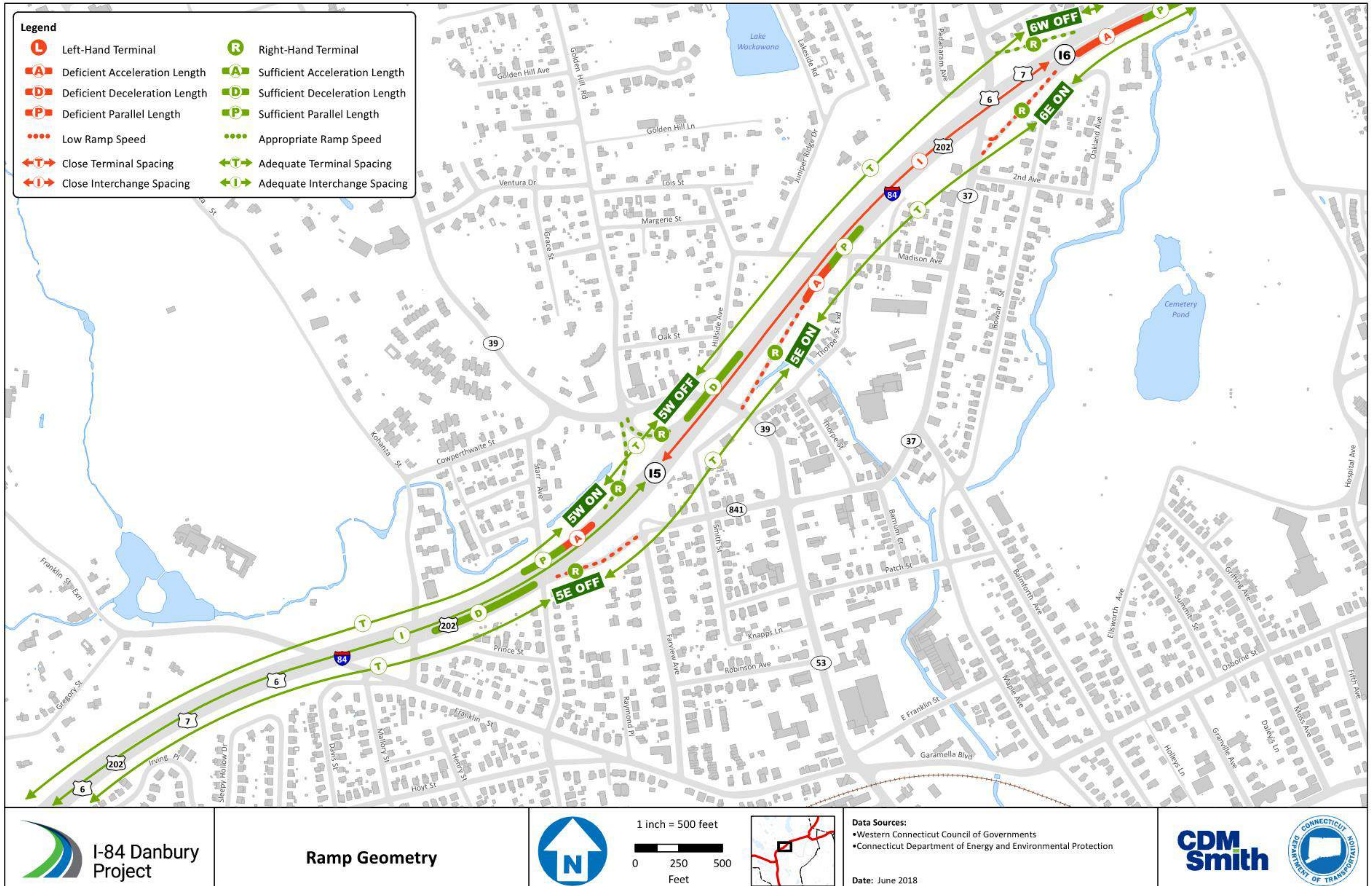


Figure 2-31 Ramp and Interchange Deficiencies – Map 4

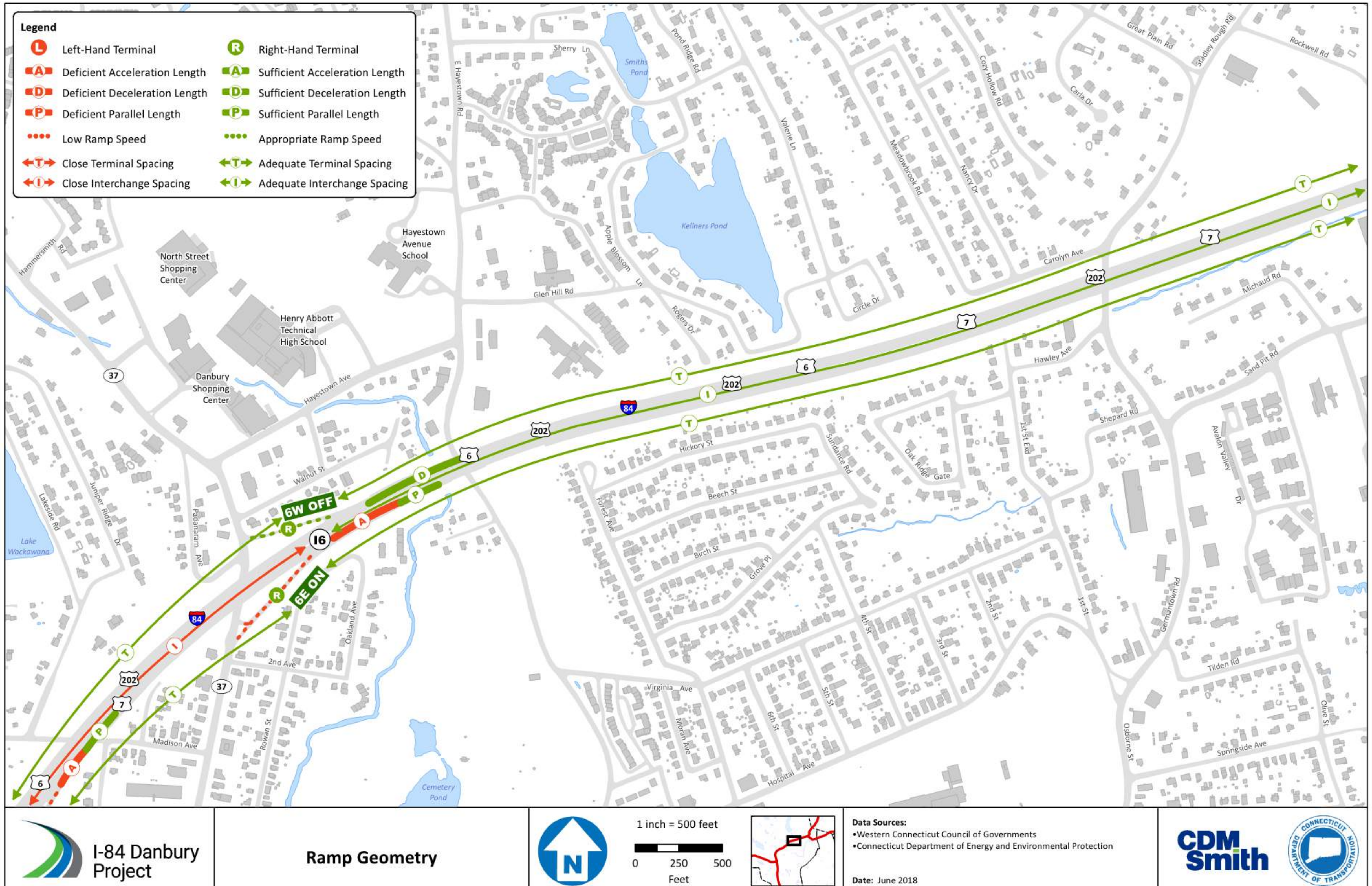


Figure 2-32 Ramp and Interchange Deficiencies – Map 5

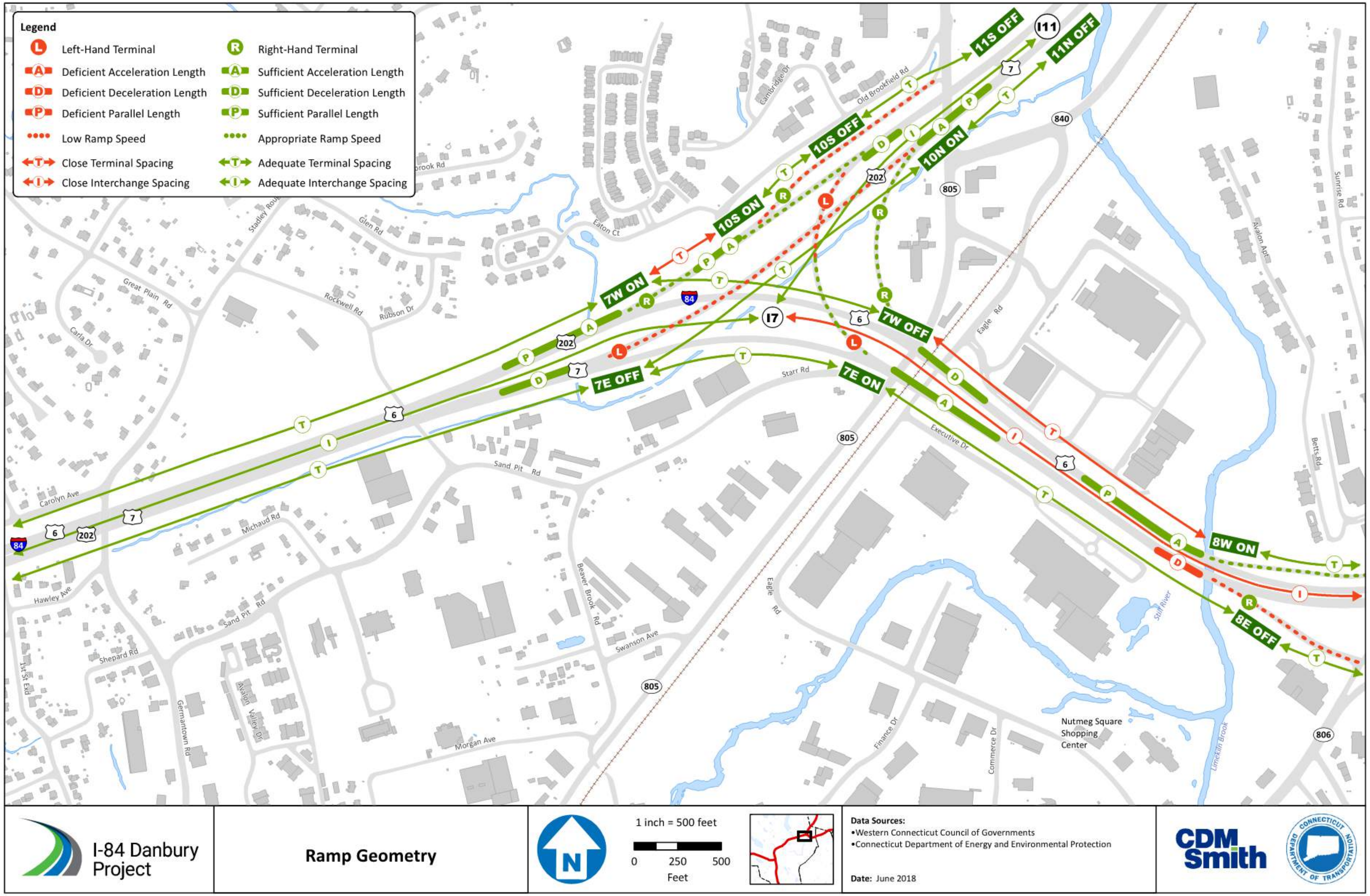
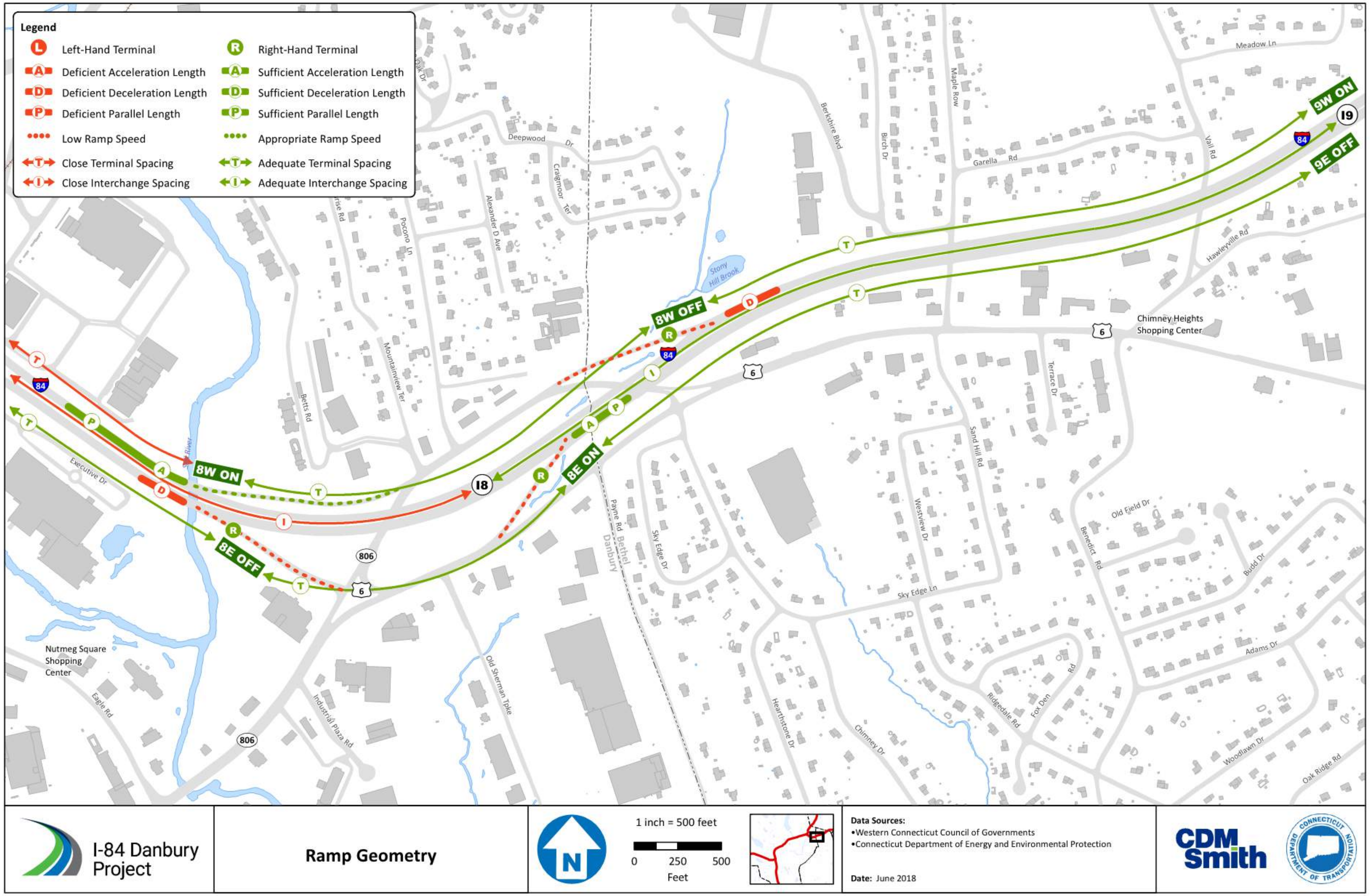


Figure 2-33 Ramp and Interchange Deficiencies – Map 6



2.4 Structural Conditions Review

2.4.1 Structural Overview

The purpose of this report is to describe the current conditions of the structures in the I-84 corridor between Exits 3 and 8 in the towns of Danbury, Newtown, Bethel and Brookfield, Connecticut, and any additional structures that could be impacted by this project. Inspection reports from January 2015 to November 2016 were utilized as the basis for current conditions. The corridor contains forty-eight bridges and nine culverts. The total length of the project limits along I-84 is approximately 4.5 miles.

The structures in the project corridor are classified by the following functional groups:

- Bridges carrying I-84 (I-84)
- Bridges carrying Route 7 (Route 7)
- Bridges carrying local roads over I-84 (Over I-84) *
- Culverts carrying I-84 or State Routes (Culvert)

* The Route 7 over I-84 structures are included in the "Route 7" group

Forty-six (81%) of the bridges and culverts are located in the Town of Danbury, four (7%) in Bethel, four (7%) in Newtown and three (5%) in Brookfield. The I-84 interstate within the project limits and the structures carrying roads over it were built in the early 1960's, which accounts for about 81% of the bridges. The remaining 19% account for the portions of Route 7 that are south and north of the I-84 Interchange, which were built between 1975 and 1986. Seven of the bridges also cross the Housatonic Railroad, which has been in operation since the early 1850's.

Overall, 30% of the bridges are in fair condition by deck area, but only four of the bridges have substandard load ratings. Almost half of the bridges within the corridor have substandard bridge railing. While there is a large percentage of structures with fracture critical and fatigue prone details, all of them are well maintained and had no notable deficiencies.

Table 2-78 below lists the major deficiencies found within the corridor, and the percentage of the bridges by count and deck area that had those deficiencies. The evaluation of this criteria will assist in understanding the replacement versus rehabilitation needs within the corridor, which will be used to evaluate life cycle cost and alternatives analysis.

Table 2-78 Overview of Bridge Deficiencies

Deficiency	% by Count	% by Deck Area
CONDITION		
Structures without Rehabilitation	21%	20%
Fair Condition	21%	30%
Substandard Load Rating	7%	7%
SAFETY		
Substandard Bridge Width	84%	88%
Substandard Vertical Clearance	26%	25%
Horizontal Underclearance Requiring Corrective Action	25%	28%
Substandard Underpass Width	61%	64%
Substandard Bridge Railing	46%	42%
STRUCTURE		
Fracture Critical/Fatigue Prone Details	65%	64%
Structure within FEMA	26%	24%
Skew Angle >30%	40%	42%

Historical inspections and rehabilitation projects were evaluated to understand the current condition and maintenance needs of the existing structures. This information was used to estimate the future component condition ratings and assess maintenance, rehabilitation or replacement required by the year 2037. Section 5.2.3 will further outline the methods and results of the future condition analysis.

The following figures display the bridge and culvert locations throughout the project corridor. The following sections outline the evaluation criteria and provide existing bridge conditions considering the selected deficiency criteria.

CDM Smith

2.4.2 Structural Criteria

2.4.2.1 Condition

2.4.2.1.1 History of Rehabilitation

The historical original plans and rehabilitation plans for the corridor were tabulated to determine what has been done over the corridor's life span, the age of all components of the bridge, and what improvements will be needed in the future. This information, in conjunction with historical inspection data, was used to determine the future bridge conditions in the year 2037.

2.4.2.1.2 Structure Condition

As part of the biennial inspections, condition assessments are made to each of the major components of the bridge using the scale as defined by FHWA in **Table 2-79** below:

Table 2-79 FHWA Coding Guide - Condition

Code	Description
N	NOT APPLICABLE
9	EXCELLENT CONDITION
8	VERY GOOD CONDITION – no problems noted.
7	GOOD CONDITION – some minor problems.
6	SATISFACTORY CONDITION – structural elements show some minor deterioration.
5	FAIR CONDITION – all primary structural elements are sound but may have minor section loss, cracking, spalling or scour.
4	POOR CONDITION – advanced section loss, deterioration, spalling or scour.
3	SERIOUS CONDITION – loss of section, deterioration, spalling, or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.
2	CRITICAL CONDITION – advanced deterioration of primary elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
1	"IMMENENT" FAILURE CONDITION – major deterioration or section loss present in critical structural components, or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic, but corrective action may put bridge back in light service.
0	FAILED CONDITION – out of service; beyond corrective action.

2.4.2.1.3 Load Rating

The CTDOT Bridge Load Rating Manual, in conjunction with American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Manual for Bridge Evaluation, provides guidelines for bridge load ratings. Load ratings are on file for each structure to determine each bridge's capacity to safely carry live loads in its current condition.

2.4.2.2 Safety

2.4.2.2.1 Bridge Width

Based on the figures in Chapter 5 of the CTDOT Highway Design Manual (HDM), the required bridge lane and shoulder widths must match the approach roadway width. Each bridge was examined with Google Earth and the as-built plans to determine if the current lane and shoulder widths were adequate. For any bridges carrying two-way traffic, only right shoulders were evaluated. Any overpasses west of Exit 3 and east of Tamarack Avenue were considered intermediate areas, which are defined as residential or moderate commercial or industrial areas having moderate amounts of roadside development. Any overpasses between Exits 3 and Tamarack Avenue were considered built-up areas, which consist of urbanized areas with a high density of roadside development. During alternatives analysis, the bridge widths will need to be evaluated individually for site specific requirements. **Table 2-80** below displays the required lane and shoulder widths for the various functional classifications.

Table 2-80 Required Lane and Shoulder Widths

Functional Classification	Lane Width	Left Shoulder Width	Right Shoulder Width
Urban Freeway			
DDHV > 250	12'	12'	12'
DDHV < 250	12'	8'	10'
Multi-Lane Principal Arterial			
Intermediate	12'	2' – 4'	2' – 4'
Built-up	11'	2' – 4'	2' – 4'
Minor Arterial			
Intermediate	11' – 12'	2' – 4'	4' – 8'
Built-up	10' – 12'	2' – 4'	4' – 8'
Urban Collector			
Intermediate	11' – 12'	4' – 8'	4' – 8'
Built-up	10' – 12'	2' – 8'	2' – 8'
Local	10' – 11'	2' – 4'	2' – 4'

DDHV = Directional Design Hourly Volume

2.4.2.2.2 Underclearance Geometry

NBI Appraisal Item No. 69 is based on the vertical and horizontal underclearances at the structure location. The vertical and horizontal underclearances are measured from the through roadway to the superstructure or substructure units, respectively. The underclearances are evaluated using Tables 3A and 3B within the FHWA Coding Guide and the minimum of the two ratings is chosen for the appraisal rating. Both vertical and horizontal are based on the functional classification of the underpassing route.

The HDM outlines the minimum vertical clearance requirements based on the functional classification of the under passing roadway. See **Table 2-81** below which outlines the required minimum vertical clearance for full replacement and rehabilitation projects.

Table 2-81 Required Minimum Vertical Clearance

Underpass Classification	Full Replacement	Rehabilitation
Urban Freeway	16'-3"	16'-0"
Principal Arterial	16'-3"	14'-3"
Minor Arterial	16'-3"	14'-3"
Urban Collector	14'-6"	14'-3"
Local	14'-6"	14'-3"

NBI Item Nos. 55 and 56 measure the horizontal under-clearance on the right and left, respectively. This dimension is measured from the edge of roadway (excluding shoulders) or the centerline of the railroad tracks to the nearest obstruction (substructure unit, concrete bridge rail or toe of slope steeper than 1 to 3) on both the left and right side clearance in both directions of travel. A minimum lateral underclearance rating less than a 4 indicates that the underclearance requires corrective action. HDM Section 13-3.04 states that structures should be placed outside of the clear zone; however; many piers and abutments are within the design clear zone and cannot be relocated. In these cases, guiderail or concrete barrier protection is warranted. The available lateral underclearance is important for the site distance requirements, which will need to be evaluated on a case by case basis during alternatives analysis.

2.4.2.2.3 Roadway Width

Chapter 5 of the CTDOT HDM outlines the requirements for lane, left shoulder and right shoulder widths. Similar to the methodology used to determine bridge width, each bridge's crossing roadway was examined with Google Earth to determine if the widths were adequate. For any roadways carrying two-way traffic, only right shoulders were evaluated. Reference Table 2-81 for the required lane and shoulder widths for the various functional classifications. The lane and shoulder widths of the crossing roadways will drive the insufficient horizontal clearance to obstructions.

2.4.2.2.4 Traffic Safety Features

The latest inspection reports were reviewed to determine if the traffic safety features at the bridge locations are up to current standards. The following four traffic safety features were identified:

Bridge Railings: Factors affecting the proper functionality of bridge railings are height, material, strength and geometry. Railings must be capable of smoothly redirecting an impacting vehicle.

Transitions: The transition from approach guardrail to bridge railing requires that the approach guardrail be firmly attached to the bridge railing.

Approach Guardrail: The approach guardrail system must have adequate length and structural qualities to shield motorists from the hazards at the bridge site and be capable of safely redirecting an impacting vehicle. The system must also act as a smooth transition to the bridge railing that does not cause snagging or pocketing of an impacting vehicle.

Approach Guardrail Ends: The ends of approach rail should be flared, buried, made breakaway or shielded. They are to be designed per the AASHTO Roadside Design Guide.

2.4.2.3 Structure

2.4.2.3.1 Seismic Retrofit

The rehabilitation plans for the structures in the corridor were examined and previously completed seismic retrofit rehabilitations were identified. Additionally, as-built plans were examined to determine if all supports meet minimum seat width requirements per AASHTO 4.7.4.4.

2.4.2.3.2 Fractural Critical and Fatigue Prone

As part of the reporting requirements for the NBIS, CTDOT has a fracture critical members and fatigue prone details inspection data sheet (BRI12). This form is filled out for each different Fracture Critical Member and/or Fatigue Prone Details that are present in the structure. The inspection reports were examined to determine which bridges had fracture critical or fatigue prone details.

2.4.2.3.3 Flooding, Waterway and Scour

Using the Federal Emergency Management Agency (FEMA) flood mapping, bridges within flood areas were identified. It is important to determine which bridges are within a flood zone to perform hydraulic analysis and determine potential environmental impacts due to construction. The mapping within our corridor identifies flood areas with the definitions in **Table 2-82** below.

Table 2-82 FEMA Zone Definitions

Zone	Definition
Zone A	Special flood hazard area subject to inundation by the 1% annual chance of flood with no base flood elevations determined.
Zone AE	Special flood hazard area subject to inundation by the 1% annual chance of flood with base flood elevations determined.
Zone X	Areas of 0.2% annual chance of flood; areas of 1% annual chance of flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance of flood.

The inspection reports and plans were used to identify bridges that are carried over waterways, and what the condition of the waterways were. The three major inspection ratings identified were: waterway adequacy, scour critical structures, and channel/channel protection.

2.4.2.3.4 Structure Geometry

The existing bridge geometry could have a factor in the design and construction of new bridges. Additional design considerations are required for high skew structures. Per the CTDOT Bridge Rating Manual, refined analysis and load rating of diaphragms and cross frames for curved structures and structures with a support skewed greater than thirty degrees is required. Additionally, the CTDOT Bridge Design Manual provides guidance on providing a thickened deck slab and additional deck reinforcement at acute corners for skew angles greater than twenty degrees. For the purposes of this report, a structure with a skew angle greater than thirty degrees is considered to be a high skew structure.

2.4.3 Structural Conditions

2.4.3.1 Condition

2.4.3.1.1 History of Rehabilitation

Within the corridor, most of the bridges have been rehabilitated at least once. Of the forty-seven bridges that were built in the 1960's, twenty-six of them had rehabilitation projects in the 1980's, thirteen in the 1990's, and two most recently in 2017. Twelve bridges, eight of which are culverts, have not been rehabilitated since their original construction. Twenty-one of the steel girder bridges have been painted since 1990. About 77% of bridges have received deck patching and/or deck replacement in the last 30 years. See **Table 2-83** below for summary of the typical bridge rehabilitations within the corridor.

Table 2-83 Rehabilitation Summary

Type of Work	No. Bridges	%
Deck Replacement	21	44%
Deck Rehabilitation	23	48%
Widening	8	17%
Full Replacement	1	2%
Joint Replacement	42	88%
Bearing Replacement	22	46%
Painting	21	44%
Substructure Repair	28	58%

There are twenty-one bridge structures that carry I-84 in the corridor. The average minimum condition rating between the major components of each structure is approximately six. Based on this information, it can be determined that the overall maintenance and up-keep of the bridges carrying I-84 in this corridor has been satisfactory. All bridges in this category underwent at least one rehabilitation project with improvements to the deck, substructure and bearings. **Table 2-84** below displays the rehabilitation projects associated with the bridges carrying I-84.

Table 2-84 Rehabilitation of Bridges Carrying I-84

Plan Year	Proj. No.	Project Description	Bridges
1980	0034-0162	Widening - median girders	01181, 01182
1982	0034-0172	Deck repairs, remove/replace bituminous overlay, install weepholes, clean/reseal expansion joints, curb repair	00956, 00961, 01184, 01185, 01186, 01190, 01191
	0034-0160	Deck repairs, remove/replace bituminous overlay, install weepholes, clean/reseal expansion joints	00457, 00458, 01192
1983	0034-0153	Safety improvements (protective fence)	01185, 01186, 01190, 01191, 01192
1984	0034-0204	Deck replacement, repairs to end cover plates, bearing repair, steel painting, pier cap support	01195, 01196
1985	0034-0206	Deck replacement, new shear studs, new parapet/MBR, wingwall reconstruction, substructure repair, expansion bearings keeper device, performed expansion joints, bolted splices with end cover plate welds	00548
1986	0034-0189	Br. 00457 to be widened by 4 girders on the west side, clean/paint existing steel, remove/replace bituminous overlay, reconstruct parapets/curbing	00457, 00458, 00956, 00961, 01184, 01185, 01186, 01190, 01191, 01192
1987	0174-0122	Replace parapet/sidewalk, MBR and fence, wingwall modification, install weepholes, substructure repairs, deck replacement and cut cross frames to remove concrete, replace expansion bearings, bearing pad replacement	00897
1991	0034-0235	Deck repairs, repair joints, substructure repair, expansion bearing keeper device	00544, 01181, 01182, 01198
	0034-0250	Bridge widening on south side	01186
	0034-0252	Deck repairs, replace deck joints, substructure repairs, expansion bearing keeper device	00547, 00898, 01197
1994	0034-0262	Deck replacement except in mid 36' area, shear studs, bearing replacement, new parapet/MBR	01192
	0034-0266	Bridge widening and abutment drilling and grouting modifications, deck patching and resurfacing, new expansion bearings, keeper blocks	01198
2001	0174-0293	Bridge painting	01186, 01192
2008	0174-0339	Remove/repair existing joints, replace with asphaltic plug expansion joint systems	00457, 00458, 00547, 00548, 00956, 00961, 01181, 01184, 01186, 01191, 01192, 01195, 01196, 01198
2012	0174-0357	Asphaltic plug expansion joint system (installed joint with bridging plate when pavement on both sides of joint are concrete (approach slab), no bridging plate when one side is bituminous)	00544, 01182, 01197
2016	0174-0370	Substructure repairs	01195, 01196
	0034-0334	Substructure repairs, cleaning and painting, bearing replacement, deck resurfacing	00548
2017	0034-0313	I-84 EB widening of superstructure and substructure, deck patching	01185, 01190

The eleven structures carrying local roads or state routes over I-84 were built in the early 1960's when I-84 was constructed. All structures over I-84 have had either extensive deck repair or full deck replacement. Of the eleven structures over I-84, only one of the structures has not had joint replacements, and five have not had substructure repairs in the last thirty years. **Table 2-85** displays the displays the rehabilitation projects associated with the bridges over I-84.

Table 2-85 Rehabilitation of Bridges Over I-84

Plan Year	Proj. No.	Project Description	Bridges
1967	0034-0126	MBR treatment	01183, 01188, 01200, 01202, 01203, 01204
1976	0034-0155	New elastomeric bearing pads, new steel pedestal and braces, new keeper angles	00459, 01199
1980	0034-0162	Full bridge replacement	05261
1983	0034-0153	Safety improvements (protective fence)	00459, 01183, 01188, 01199, 01200, 01201, 01202
1984	0034-0198	Deck replacement, new shear connectors, new sidewalks/MBR, substructure repairs. Br. 01204 clean and paint steel, deck repairs, joints	01183, 01188, 01204
	0034-0199	Deck replacement, new shear connectors, new sidewalks/MBR, substructure repairs, expansion bearing keeper device, trough installed at joints, bolted splice with end cover plate welds.	01180
1987	0009-0077	Replace parapet/sidewalk, MBR and fence, wingwall modifications, install weepholes, substructure repairs, deck replacement and cut cross frames to remove concrete, bridge scuppers	00459
1993	0174-0208	Bridge painting	01200, 01201, 01202, 01203
1994	0034-0263	Bridge widening, deck replacement, new shear connectors, substructure repair/modifications, keeper blocks at abutments, pier 2 and 3, new elastomeric bearing pads	01199
	0034-0266	Deck patching and resurfacing, new expansion bearings, keeper blocks	01200, 01201, 01202, 01203
1995	0174-0244	Bridge painting	01183
2001	0174-0293	Bridge painting	01199
2014	0174-0364	Installation of asphaltic plug expansion joints	00459

There are sixteen structures that carry Route 7 in the corridor. The south side of Route 7 connects into I-84 around Exit 3, and the north side of Route 7 connects into I-84 around Exit 7. Six of these bridges have had deck repairs or full replacements in the last thirty years, and eleven of them have had their joints replaced. Only six bridges have had notable substructure repair projects. **Table 2-86** displays the rehabilitation projects associated with the bridges carrying Route 7.

Table 2-86 Rehabilitation of Bridges Carrying Route 7

Plan Year	Proj. No.	Project Description	Bridges
1984	0034-0202	Deck replacement, new shear connectors, chain link fence added to span 2 only, substructure repairs, concrete bearing pad extension, concrete keeper blocks at fascias, performed expansion joints	00541
	0174-0098	Deck replacement, new shear connectors, new parapet/MBR, substructure repairs, expansion bearing keeper device, bolted splice with end cover plate welds, trough at joints	00550, 00551
1986	0174-0112	Bridge painting	00542
1991	0034-0235	Deck repairs, repair joints, substructure repair, expansion bearing keeper device	00545
	0034-0252	Deck repairs, replace deck joints, substructure repairs, expansion bearing keeper device	00543
1992	0034-0254	Remove top 1.5" of existing slab, add 2.5" min Class F and 1.5" latex modified concrete layers to top of deck, replace MBR, new chain link fence, substructure repairs, keeper blocks, new elastomeric bearings	00542
2008	0034-0260	Original Plans	06569
2011	0174-0357	Asphaltic plug expansion joint system (installed joint with bridging plate when pavement on both sides of joint are concrete (approach slab), no bridging plate when one side is bituminous)	00550, 00551, 03915, 03916, 03919, 03920
2014	0174-0364	Installation of asphaltic plug expansion joints	05462, 05909
2016	0174-0370	Substructure repairs	00541, 00542

Only one culvert has been rehabilitated. Bridge No. 05437, which carries I-84 over Brook, was extended to the north with Project No. 0034-0162 in the early 1980's.

2.4.3.1.2 Structure Condition

Overall, the condition of the bridges is satisfactory. The majority of the structures in fair condition are the structures carrying local roads over I-84. This could be due to the large amount of traffic that travels on I-84 and the salt spray that occurs, which leads to deterioration over time. Additionally, maintenance is focused on the bridges carrying highway due to their importance. About 64% of the bridges carrying I-84 have superstructures and substrucutres in satisfactory condition. The majority of the structures carrying Route 7 have all components in good condition. Only two of the Route 7 structures have deck and superstructures in fair condition. None of the bridges or culverts within the corridor have sufficiency ratings less than 50%.

The majority of the bridges within the corridor have superstructures in satisfactory condition. They exhibit light to medium rusting on most of the superstructure, and minor section loss, which may require cleaning and painting. Approximately 21% of them are in fair condition, which exhibit severe rust and up to 5% of total flange area section loss and up to 25% section loss in the web. For bridges in fair condition, potential exists for minor rehabilitation. **Table 2-87** outlines the overall condition for deck, superstructure and substructure for the forty-eight bridges within the corridor.

Table 2-87 Bridge Condition Summary

Rating		Deck		Superstructure		Substructure	
		No.	%	No.	%	No.	%
5	Fair	6	13%	10	21%	2	4%
6	Satisfactory	24	50%	22	46%	27	56%
7	Good	18	38%	15	31%	19	40%
8	Very Good	0	0%	1	2%	0	0%
Totals		48	100%	48	100%	48	100%

Table 2-88 contains the breakdown of the structural condition of the culverts within the corridor. Of the nine culverts in the corridor, only one was considered fair. Bridge No. 01189, a culvert carrying I-84 over the Padanaram Brook, has small spalls, pop-outs and cracks with efflorescence, and random joint misalignment with active leakage on the ceilings and walls of the cells. All other culverts were satisfactory or better.

Table 2-88 Culvert Condition Summary

Culvert Condition			
Rating		No.	%
5	Fair	1	11%
6	Satisfactory	7	78%
7	Good	1	11%
Totals		9	100%

2.4.3.1.3 Load Rating

The majority of the bridges were load rated using BAR7 with HS-20 vehicular loading between the years 1995 and 2011. Bridge Nos. 01185 and 01190 were the only two bridge structures that were rated using LRFR methods with HL-93 vehicular load due to their recent rehabilitation under Project No. 0034-0313.

Of the bridges within the corridor, only four had a load rating less than 1, two of which were culverts and two were steel bridges. Bridge Nos. 00553 and 05437, both of which are culverts, have inventory rating factor of 0.97 based on field evaluation and documented engineering judgement. Bridge Nos. 05261 and 01183 had substandard load ratings based on load factor design. **Table 2-89** lists these bridges with their rating factors.

Table 2-89 Substandard Load Ratings

Bridge No.	Carries	Crossing	Report Year	Rating Method	Design Truck	Rating Factor
00553	SR 805	Beaver Brook	2001	LFD	HS20	0.97
01183	Westville Ave	I-84	2001	LFD	HS20	0.86
05261	Old Ridgebury Rd	I-84 and Exit Ramps	1997	LFD	HS20	0.78
05437	I-84	Brook	2000	LFD	HS20	0.94

2.4.3.2 Safety

2.4.3.2.1 Bridge Width

Overall, the corridor has adequate lane widths. However, the majority of the left and right shoulders are substandard. Forty-eight (84%) of the bridges within the corridor have at least one substandard element. **Table 2-90** displays the number of bridges that have standard versus substandard lanes and shoulders.

Table 2-90 Standard and Substandard Lane and Shoulder Widths (Bridge)

Element	Standard		Substandard		Total	
	No.	%	No.	%	No.	%
Lane	57	100%	0	0%	57	100%
Left Shoulder	5	11%	40	89%	45	100%
Right Shoulder	28	49%	30	51%	57	100%

2.4.3.2.2 Underclearance Geometry

Overall, about 23% of the structures have substandard minimum vertical clearance for the full replacement condition per HDM standards. If the structures warrant rehabilitation only, fifteen bridges (approximately 34%) have substandard vertical clearance per the HDM. Currently, only six of these bridges are posted. See **Table 2-91** below for posted bridges.

Table 2-91 Bridges Posted for Vertical Clearance

Bridge No.	Crossing Functional Class	Required Clearance per HDM	Posted Clearance
00550	Principal Arterial	14'-3"	13'-9"
00961	Minor Arterial	14'-3"	13'-8"
01185	Local	14'-3"	13'-11"
01186	Urban Collector	14'-3"	13'-10"
01190	Urban Collector	14'-3"	13'-11"
01191	Minor Arterial	14'-3"	13'-8"

Thirteen bridges have lateral underclearances that are driving the NBI No. 69 rating to be three, requiring corrective action. Eight of these bridges have at least one side with a clearance less than two feet. For example, Bridge Nos. 00541 and 00542, which carry I-84 over the Housatonic Railroad, Still River and Mall Access Road, have piers directly adjacent to both sides of the Mall Access Road. In the event that the underpasses need to be widened as a result of the project, substructure elements may need to be relocated, which would be a major structural adjustment.

2.4.3.2.3 Roadway Width

Forty-two of the bridges were evaluated for the underpass roadway width criteria. The remaining fifteen were bridges over waterways and railroads, or culverts. Overall, the lane widths were adequate. Only seven (17%) of the crossing roadways have substandard lane widths. The majority of the right shoulder widths are inadequate. Of the bridges that are crossing roadways, thirty-five (83%) have at least one substandard element. **Table 2-92** below displays the number of crossing roadways that have standard versus substandard lanes and shoulders.

Table 2-92 Standard and Substandard Lane and Shoulder Widths (Crossing Roadway)

Element	Standard		Substandard		Total	
	No.	%	No.	%	No.	%
Lane	35	83%	7	17%	42	100%
Left Shoulder	2	12%	15	88%	17	100%
Right Shoulder	18	43%	24	57%	42	100%

2.4.3.4 Traffic Safety Features

Eight of the fifty-seven bridges and culverts within the corridor have all four traffic safety features that are substandard. The six structures built after 1980 (Bridge Nos. 05462, 05463, 05772, 05773, 05909 and 06569) all have standard features. In the late 1980's to early 1990's, rehabilitation Project No. 0034-0189 reconstructed the parapets, metal beam rail, and curbing of ten bridges (Bridge Nos. 00457, 00458, 00956, 00961, 01184, 01185, 01186, 01190, 01191, and 01192), bringing the features up to current standards. Additionally, in the mid 1980's, Project No. 0034-0204 upgraded the bridge rail and approach systems for Bridge Nos. 01195 and 01196. As part of this project, the replacement of all substandard guardrail systems will be evaluated.

Bridge Railings: Approximately 46% of the bridges within the corridor have substandard bridge railings.

Transitions: 47% of the bridges within the corridor have substandard transitions. All of the bridges carrying local roads over I-84 have guardrail transitions that are substandard.

Approach Guiderail: 46% of the bridges within the corridor have substandard approach guardrail. All of the bridges carrying local roads over I-84 have approach guardrail that is substandard. During the field inspection, it was identified that the majority of these bridges have wood posts with wire rail.

Approach Guiderail Ends: Overall, 18% of the bridges within the corridor have substandard approach guardrail ends. Of the twelve bridges carrying local roads over I-84 that have substandard approach guardrail and transitions, seven of them also have substandard approach guardrail ends.

2.4.3.3 Structure

2.4.3.3.1 Seismic Retrofit

Of the bridge structures within the project, twelve of the bridges (approximately 21%) have undergone a seismic retrofit rehabilitation. The most common seismic retrofit was the addition of concrete keeper blocks or steel keeper angles at the expansion bearings. See **Table 2-93** below for bridges with seismic retrofits.

Table 2-93 Bridges with Seismic Retrofits

Bridge No.	Carries	Crossing	Project No. Installed	Project Year	Notes
00459	US Route 6	I-84	0034-0155	1976	New elastomeric bearing pads, new steel pedestal and braces, new keeper plates
00541	US Route 7 NB	HRRC, STILL RV, MALL ACC.	0034-0202	1984	Concrete bearing pad extension at interior girders, concrete keeper blocks at fascias
00542	US Route 7 SB	HRRC, STILL RV, MALL ACC.	0034-0254	1992	New concrete keeper blocks
01192	I-84	Rockwell Road	0034-0262	1994	Concrete keeper blocks installed
01199	Route 911	I-84	0034-0155	1976	New elastomeric bearing pads, new steel pedestal and braces, new keeper plates
01200	Garella Rd	I-84	0034-0266	1994	Keeper blocks at piers and abutments
01201	Vail Rd	I-84	0034-0266	1994	Keeper blocks at piers and abutments
01202	Old Hawleyville Rd	I-84	0034-0266	1994	Keeper blocks at piers and abutments
01203	Secor Rd	I-84	0034-0266	1994	Keeper blocks at piers and abutments
03915	US Route 7 SB	Still River	0034-0124	1973	Relocation of Route 7 - keeper blocks installed
03916	US Route 7 NB	Still River	0034-0124	1973	Relocation of Route 7 - keeper blocks installed
06569	US Route 7 SB	Wooster Heights Rd	0034-0260	2008	New construction - concrete keeper blocks

Per AASHTO 4.7.4.4, none of the bridges in the corridor have inadequate seat widths.

2.4.3.4.2 Fractural Critical and Fatigue Prone

Only two structures have fracture critical members, which are comprised of horizontally curved multicell steel box girders that are continuous over their piers. The majority of the structures had Fatigue Category E and E' details, most of which consisted of partial length welded cover plates. Some additional fatigue prone details that were present in the structures along the corridor were plug welds, groove welds for flange transitions and web splices, fillet welded gusset plates and rivets at diaphragm connections. **Table 2-94** displays the number of bridges with fracture critical and fatigue details based on their function.

Table 2-94 Fracture Critical and Fatigue Details

Bridge Function	No. Bridges	Fracture Critical		Fatigue Prone	
		No.	%	No.	%
I-84	21	0	0%	17	81%
Over I-84	11	0	0%	9	82%
Route 7	16	2	13%	11	69%
Culvert	9	0	0%	0	0%
Total	57	2	13%	37	65%

2.4.3.4.3 Flooding, Waterway and Scour

There are sixteen bridges that pass over waterways within the corridor. Within the corridor, there are fifteen bridges and culverts that are located within a FEMA flood zone, four of which do not pass over water. **Table 2-95** counts the number of bridges within the different FEMA flood zones.

Table 2-95 Bridges within FEMA Flood Zones

Zone	No. Bridges	%
A	5	33%
AE	4	27%
X	4	27%
AE/X	2	13%
Total	15	100%

The waterway adequacy of the structures had a minimum rating of 7, which indicates for that roadway classification, that there is a slight (frequency of every 11 to 100 years per the FHWA Inspection Coding Guide) chance of overtopping bridge deck and roadway approaches.

None of the structures are deemed to be scour critical. Bridge No. 01197, a two-span steel girder bridge, received a 5, which indicates that the bridge foundations are stable for the calculated scour conditions, but the scour is within the limits of the footing or piles. For this structure, a foundation structural analysis will be required to determine the adequacy of the existing foundation. The remainder of the waterway structures received a rating of 8, which indicates that the foundations are determined to be stable for assessed or calculated scour conditions and that calculated scour is above top of the footing. Three of the culverts exhibited channel and channel protection ratings of 5, which indicates that there is erosion at the embankments with major damage and trees and brush restricting the channel.

2.4.3.4.4 Structure Geometry

Twenty-three bridges within the project limits have skew angles greater than 30 degrees. See **Table 2-96** below for a breakdown of the structures with high skew angles by bridge function.

Table 2-96 Bridges with Skew Angles > 30 Degrees

Bridge Function	No. Bridges	Skew > 30 deg.	
		No.	%
I-84	21	7	33%
Over I-84	11	6	55%
Route 7	16	10	63%
Total	48	23	48%

Figures 2-34 to **2-37** represent the existing structural condition ratings of bridges within the study area.

Table 2-97 Summary of Structural Conditions by Bridge Number

Segment No.	Bridge No.	Carries	Crossing	Bridge Condition	Bridge Capacity	Minimum Vertical Clearance	Bridge Lane/Shoulder Adequacy	Underpass Lane/Shoulder Adequacy	Seismic Retrofit	Adequate Seat Width	Fracture Critical/ Fatigue Prone Details	Scour Critical	Bridge Railing	Approach Rail/ Transitions	Skew
2	00457	I-84	US Route 6	6	1.73	18.75	N	N	N	Y	Y	N	Y	Y	22.15
2	00458	I-84	US Route 6	6	1.33	16.83	N	N	N	Y	Y	N	Y	Y	15.66
7	00459	US Route 6	I-84	5	1.45	16.33	N	N	Y	Y	Y	N	N	N	50.00
8	00541	US Route 7 NB	HRRC, STILL RV, MALL ACC.	5	1.56	23.50	N	N	Y	Y	N	8	Y	Y	34.42
8	00542	US Route 7 SB	HRRC, STILL RV, MALL ACC.	5	1.60	24.92	N	N	Y	Y	N	8	N	N	34.42
8	00543	US Route 7	I-84	7	1.38	15.92	N	N	N	Y	N	N	N	N	63.05
8	00544	I-84 Ramp	I-84 EB	6	1.46	16.00	N	N	N	Y	N	N	N	N	59.07
8	00545	US Route 7	I-84 EB	6	1.70	15.83	Y	N	N	Y	N	N	N	Y	55.42
6	00546	I-84	Beaver Brook	6	999.00	N/A	N	N/A	N	Y	N	8	N/A	N/A	25.14
6	00547	I-84 WB	US Route 7 NB	6	1.29	14.25	N	N	N	Y	Y	N	N	N	59.38
9	00548	I-84 TR 803	I-84 WB, Route 7 NB and Beaver Brook	5	1.55	16.00	N	N	N	Y	Y	8	Y	Y	43.84
9	00549	I-84 TR 804	Beaver Brook	6	999.00	N/A	N	N/A	N	Y	N	8	N/A	N/A	0.00
9	00550	US Route 7 NB	SR 805	6	1.29	13.75	N	N	N	Y	Y	N	N	N	37.91
9	00551	US Route 7 SB	SR 805	6	1.18	16.33	Y	N	N	Y	Y	N	N	N	34.30
9	00553	SR 805	Beaver Brook	6	0.97	N/A	N	N/A	N	Y	N	8	N	N	37.90
N	00897	I-84 EB	Route 25	6	1.20	14.58	N	Y	N	Y	Y	N	N	N	29.89
N	00898	I-84 WB	Route 25	6	1.66	16.17	N	Y	N	Y	Y	N	N	N	29.89
4	00956	I-84	Route 37	6	1.97	14.75	N	N	N	Y	N	N	Y	Y	47.36
4	00961	I-84	Route 39	6	1.74	13.67	Y	N	N	Y	Y	N	Y	Y	24.73
1	01180	Kenosia Avenue	I-84 and Housatonic RR	5	1.42	15.92	N	N	N	Y	Y	N	Y	N	20.57
1	01181	I-84 WB	Housatonic RR	6	1.54	19.67	N	N/A	N	Y	Y	N	N	N	48.80
1	01182	I-84 EB	Housatonic RR	5	1.54	22.58	N	N/A	N	Y	Y	N	N	N	48.80
3	01183	Westville Ave	I-84	6	0.86	16.00	N	N	N	Y	Y	N	Y	N	33.34
3	01184	I-84	Franklin St	6	1.56	14.42	N	Y	N	Y	Y	N	Y	Y	53.97
4	01185	I-84	Kohanza St	6	1.61	13.92	N	Y	N	Y	Y	N	Y	Y	19.04
4	01186	I-84	Starr Ave	6	1.56	13.83	N	Y	N	Y	Y	N	Y	Y	26.70
4	01187	I-84	Kohanza Brook	7	999.00	N/A	N	N/A	N	Y	N	8	N	N	57.81
4	01188	Madison Ave	I-84	7	1.22	17.17	N	N	N	Y	N	N	N	N	38.98
4	01189	I-84	Padanaram Brook	5	999.00	N/A	N	N/A	N	Y	N	8	N/A	N/A	0.00
4	01190	I-84	Tamarack Ave	6	1.69	13.92	Y	N	N	Y	Y	N	Y	Y	12.22
5	01191	I-84	Great Plain Rd	6	1.58	13.67	Y	Y	N	Y	N	N	Y	Y	19.14

LEGEND

MEETS STANDARD

MODERATELY MEETS STANDARD

SUBSTANDARD

NOT APPLICABLE

Segment No.	Bridge No.	Carries	Crossing	Bridge Condition	Bridge Capacity	Minimum Vertical Clearance	Lane/Shoulder Adequacy	Underpass Lane/Shoulder Adequacy	Seismic Retrofit	Adequate Seat Width	Fracture Critical/ Fatigue Prone Details	Scour Critical	Bridge Railing	Approach Rail/ Transitions	Skew
5	01192	I-84	Rockwell Road	7	2.11	14.83	Y	N	Y	Y	N	N	N	Y	18.55
6	01193	I-84 EB	Beaver Brook	7	999.00	N/A	Y	N/A	N	Y	N	8	N/A	N/A	56.69
6	01194	I-84 WB	Beaver Brook	6	999.00	N/A	Y	N/A	N	Y	N	8	N/A	N/A	46.04
6	01195	I-84 EB	Federal/SR 805 Eagle Rd/Housatonic RR	5	1.31	19.42	N	N	N	Y	Y	N	Y	Y	5.81
6	01196	I-84 WB	Federal/SR 805 Eagle Rd/Housatonic RR	5	1.26	19.25	N	N	N	Y	Y	N	Y	Y	-0.07
7	01197	I-84 WB	Still River	6	1.58	N/A	N	N/A	N	Y	Y	5	N	N	23.00
7	01198	I-84 EB	Still River	6	1.52	N/A	N	N/A	N	Y	Y	8	N	Y	23.00
7	01199	Route 911	I-84	5	1.41	16.25	N	N	Y	Y	Y	N	Y	N	40.70
7	01200	Garella Rd	I-84	6	1.20	16.00	N	N	Y	Y	Y	N	Y	N	12.48
7	01201	Vail Rd	I-84	6	1.16	15.75	N	N	Y	Y	Y	N	N	N	31.35
N	01202	Old Hawleyville Rd	I-84	5	1.17	16.33	N	N	Y	Y	Y	N	N	N	19.00
N	01203	Secor Rd	I-84	6	1.39	16.08	N	N	Y	Y	Y	N	N	N	27.75
N	01204	Old Hawleyville Rd	I-84	5	1.26	15.83	N	N	N	Y	Y	N	N	N	31.50
N	01205	I-84	Pond Brook	6	999.00	N/A	Y	N/A	N	Y	N	8	N/A	N/A	23.00
9	03915	US Route 7 SB	Still River	7	1.75	N/A	N	N/A	Y	Y	Y	8	N	N	0.00
9	03916	US Route 7 NB	Still River	7	1.92	N/A	N	N/A	Y	Y	Y	8	N	N	0.00
N	03919	US Route 7 SB	US Route 202	7	2.11	17.08	N	N	N	Y	Y	N	N	N	33.40
N	03920	US Route 7 NB	US Route 202	7	2.18	16.33	N	N	N	Y	Y	N	N	N	33.97
N	05261	Old Ridgebury Rd	I-84 and Exit Ramps	6	0.78	16.67	N	N	N	Y	N	N	Y	N	20.98
N	05437	I-84	Brook	6	0.94	N/A	N	N/A	N	Y	N	8	N/A	N/A	0.00
N	05462	US Route 7 Ramp 47	Sugar Hollow Rd	7	1.43	16.42	N	N	N	Y	Y	N	Y	Y	0.00
8	05463	US Route 7 SB	Park Avenue	7	1.75	16.17	N	N	N	Y	Y	N	Y	Y	18.19
8	05772	US Route 7 NB	Park Avenue	6	1.46	20.92	N	N	N	Y	Y	N	Y	Y	18.19
N	05773	US Route 7 NB	Wooster Heights Rd	7	1.45	17.00	N	N	N	Y	Y	N	Y	Y	30.99
N	05909	US Route 7 Ramp 48	Sugar Hollow Rd	6	2.24	16.67	N	N	N	Y	Y	N	Y	Y	0.00
N	06569	US Route 7 SB	Wooster Heights Rd	7	1.72	22.11	N	N	Y	Y	N	N	Y	Y	30.99

LEGEND

MEETS STANDARD

MODERATELY MEETS STANDARD

SUBSTANDARD

NOT APPLICABLE

Figure 2-34 – Existing Overall Structural Condition Rating – Map 1

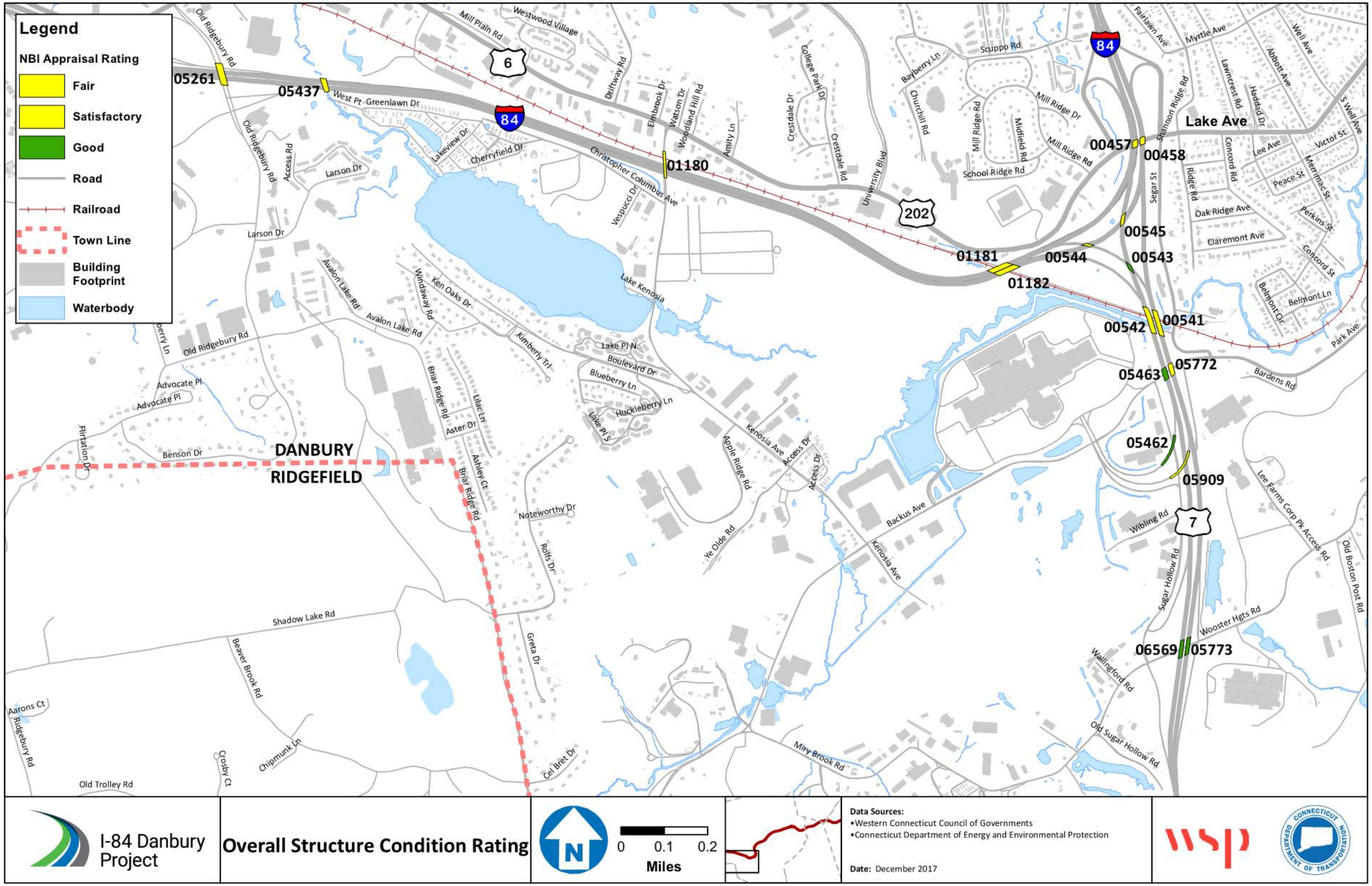


Figure 2-35 – Existing Overall Structural Condition Rating – Map 2

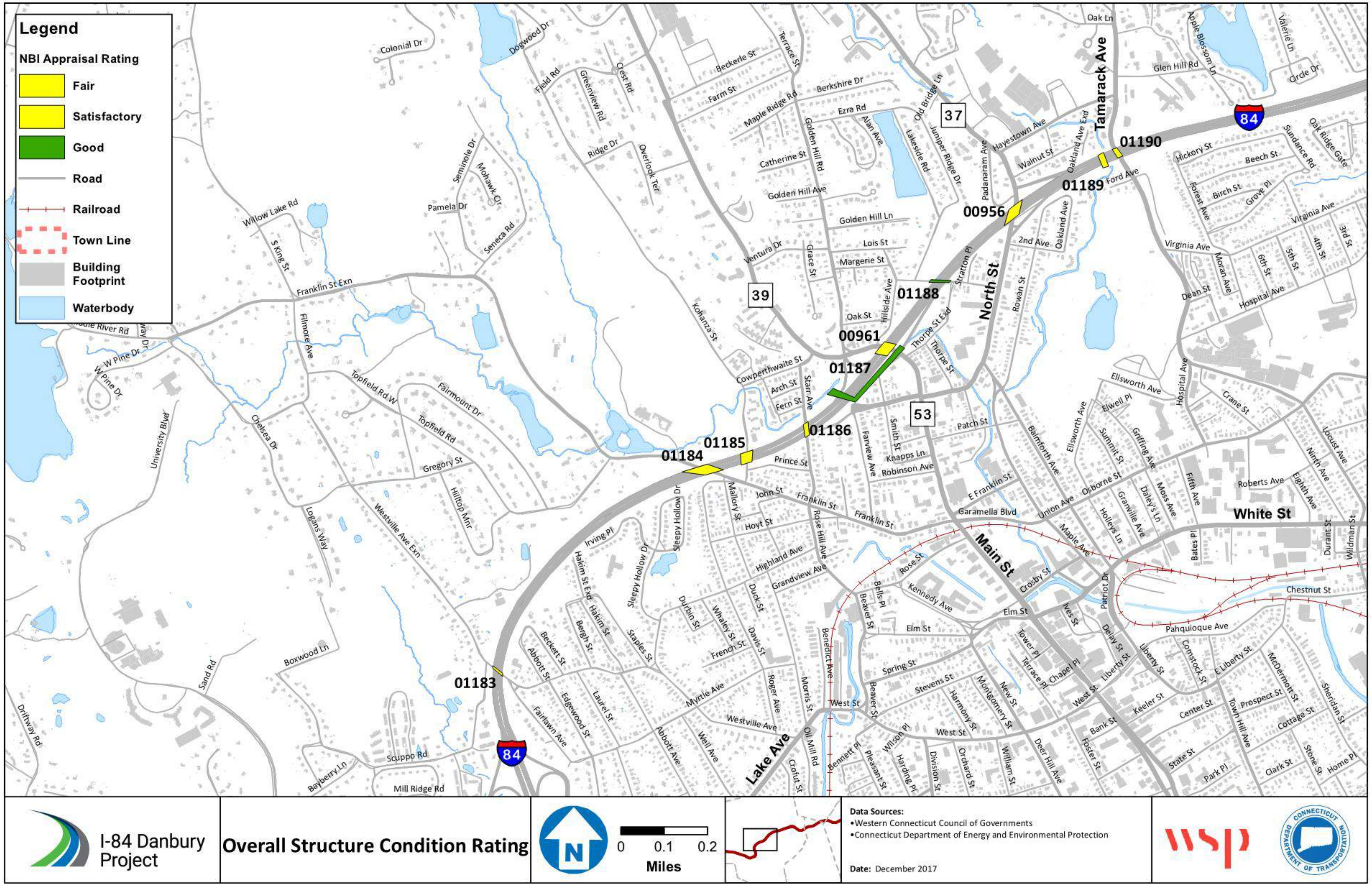


Figure 2-36 – Existing Overall Structural Condition Rating – Map 3

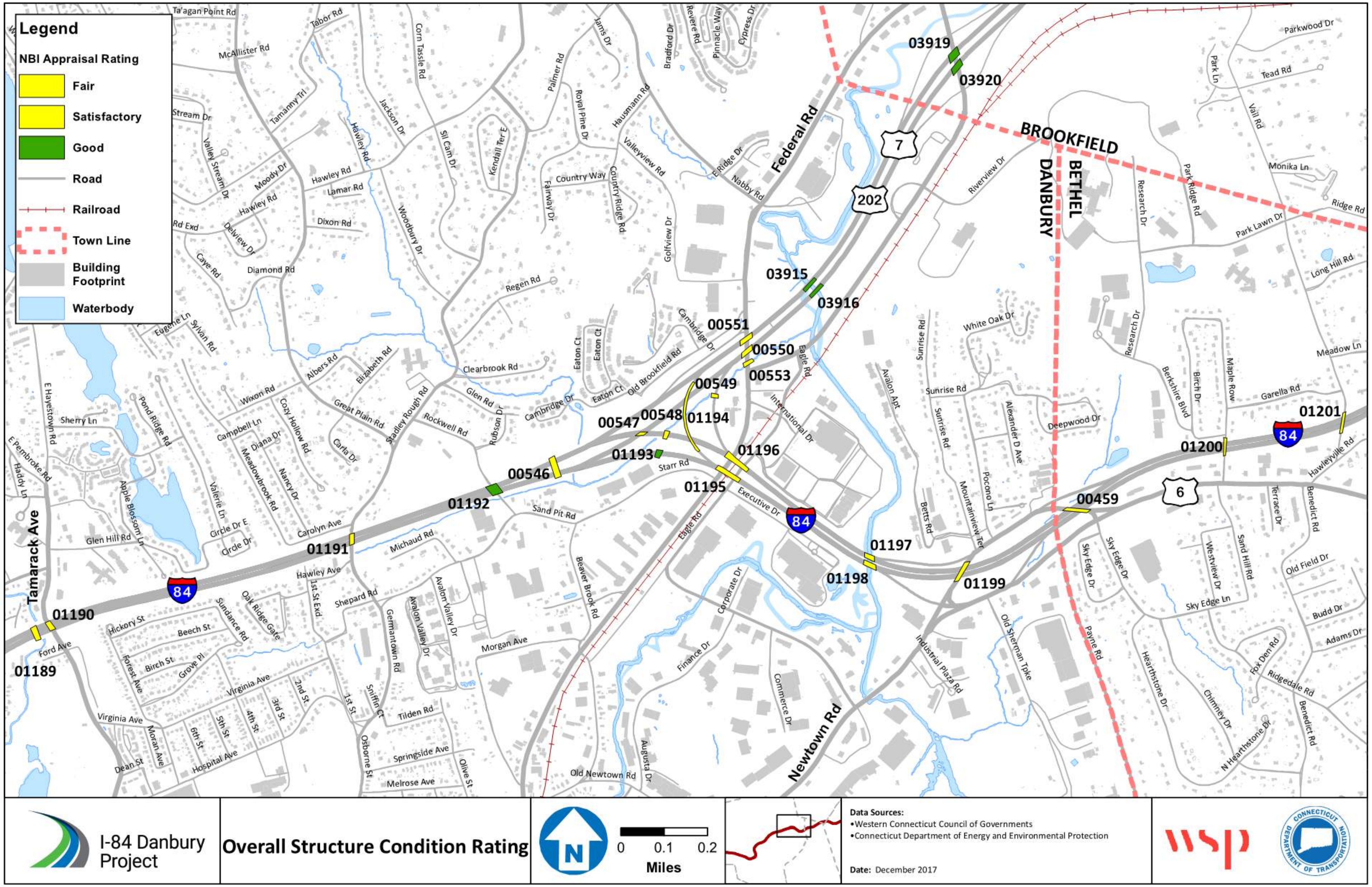
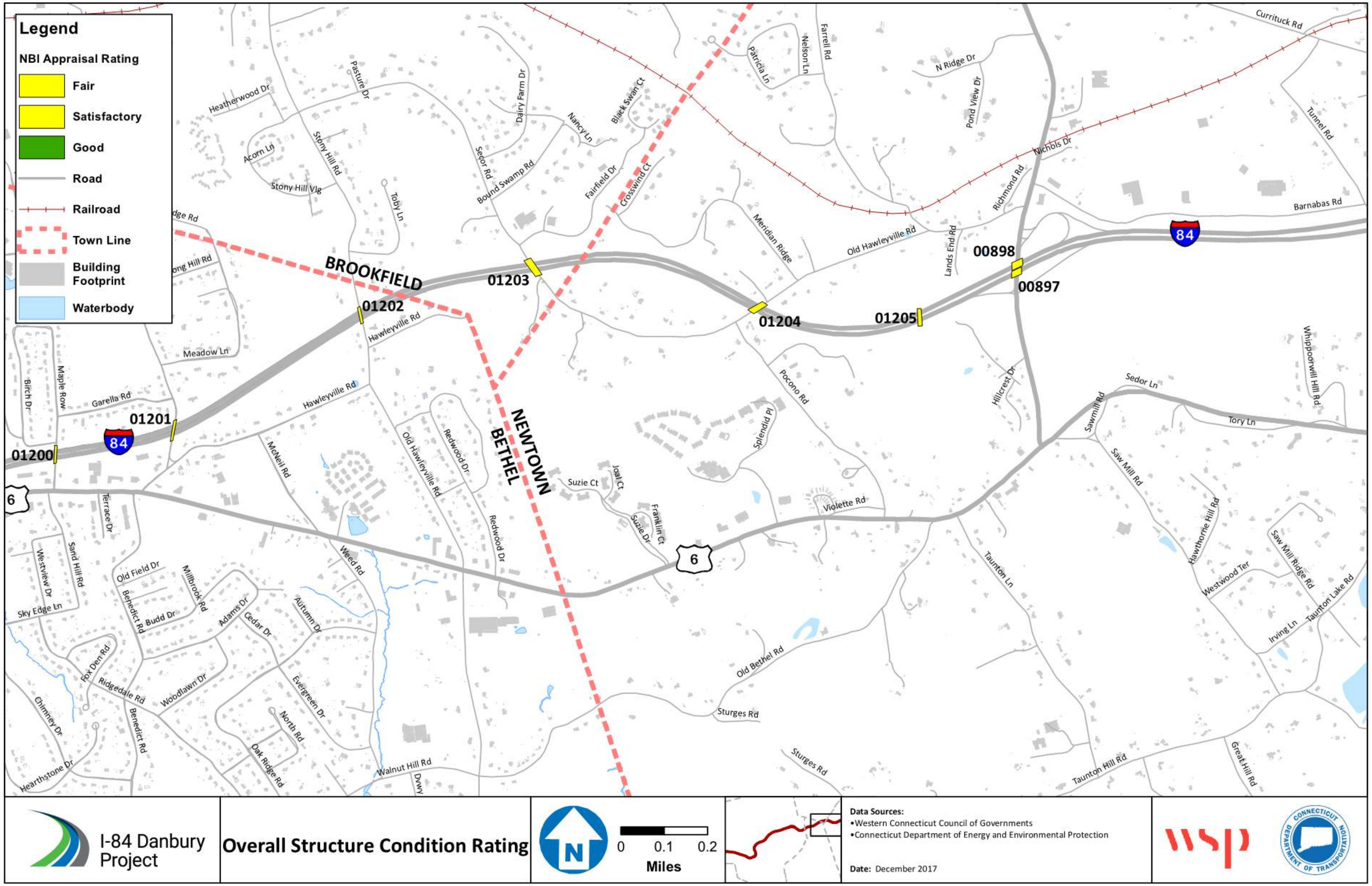


Figure 2-37 – Existing Overall Structural Condition Rating – Map 4



2.5 Geotechnical Conditions Review

The general bedrock geology of the project area is characterized by Gneiss and Granite Gneiss -controlled ridges interrupted by lower valleys of Marble as shown in **Figure 2-38**. Surficial geology as shown in **Figure 2-39** consists largely of glacial deposits including dense Glacial Till in the uplands and overlying Bedrock to softer Glacial and Lacustrine Sands, Silts and Clays in the lower areas above the Till and Bedrock. More recent Swamp Deposits are also present in some areas above the Glacial Deposits.

We have organized the project into four general geologic areas based on available subsurface and structure information:

- Area 1 – Bridges and culverts located within exits 2 and 3 on I-84, and south of Route 7 over Wooster Heights Road in Danbury.
- Area 2 – Bridges and culverts located from exit 3 on I-84 up to structure 01911 that spans I-84 over Great Plain Road in Danbury.
- Area 3 – Bridges and culverts located from structure 01912 that spans I-84 over Great Plain to exit 8 on I-84 in Danbury, and structure 03919 that span Route 7 over Route 202 in Brookfield.
- Area 4 – Bridges and culverts located within exits 8 and 9 on I-84 in Danbury, Bethel, Brookfield and Newtown.

Areas 1 and 3 are areas that generally consist of very loose to medium dense Glacial Meltwater (e.g. Gravel, Sand, and Fines) Deposits overlying medium dense to very dense Glacial Till and relatively deep Bedrock. As is the case for over 50% of the existing structures in these areas, we anticipate the majority of structures will be supported on pile foundations (e.g. H-piles) bearing in Glacial Till and Bedrock. Groundwater levels were recorded as shallow in these areas; thus, we anticipate local dewatering will be required for future construction.

Areas 2 and 4 are areas that generally consist of medium to very dense Glacial Till over relatively shallow Bedrock. As is the case for approximately 70% of the existing structures in these areas, we anticipate the majority of proposed structures can be supported on normal shallow foundations (e.g. Spread footing bearing on soil and/or bedrock). Bedrock removal will likely be required to reach foundation subgrade levels and for roadway widening in some areas. Groundwater levels were recorded as shallow in these areas; local dewatering will be required to construct new foundations.

Please refer to the Geotechnical Appendix for specific area maps. **Tables 2-98 to 2-101** provide conditions at each structure by area and structure number (refer to Tables 1-1,1-2,1-3 and 1-4 in the Geotechnical Appendix).

Table 2-98 Existing Structure Foundation and Geotechnical Data (Area 1)

Location	Structure #	Substructure Description	Foundation Type	Groundwater Depth (ft)	Bedrock Depth (ft)
Area 1	00457	Abutments and wingwalls bearing on 12 in precast-prestressed concrete piles and HP12x53 piles (H-piles installed when bridge at widening and driven to bedrock)	Deep	27.5 to 30	Not encountered
Area 1	00458	Abutments and wingwalls bearing on 12 in precast prestressed concrete piles and HP12x53 piles (H-piles installed when bridge at widening and driven to bedrock)	Deep	27.5 to 30	Not encountered
Area 1	00541	No info on piles properties other than length (50 feet long) and design load of 39 to 40 tons. Piers on 12BP53 piles driven to bedrock (45 to 60 feet long) with design capacity of 47 tons.	Deep	0 to 5	34 to 54
Area 1	00542	No info on piles properties other than length (50 feet long) and design load of 39 to 40 tons. Piers on 12BP53 piles driven to bedrock (45 to 60 feet long) with design capacity of 47 tons.	Deep	0 to 5	34 to 54
Area 1	00543	Abutments and wingwalls bearing on 12 in diameter concrete filled shell piles. Piles at Avg length of 50 feet & axial load of 39 tons.	Deep	4 to 12	49 to 57
Area 1	00544	Abutments and wingwalls are supported on shallow foundations bearing on soil. Maximum pressure of 5000 psf.	Shallow	7 to 12	30
Area 1	00545	Abutments and wingwalls bearing on H steel piles (HP12x53) driven to bedrock. Design to be 45 and 70 feet long with design capacity of 45 tons.	Deep	5 to 7	28 to 37

Figure 2-38 Bedrock Geology

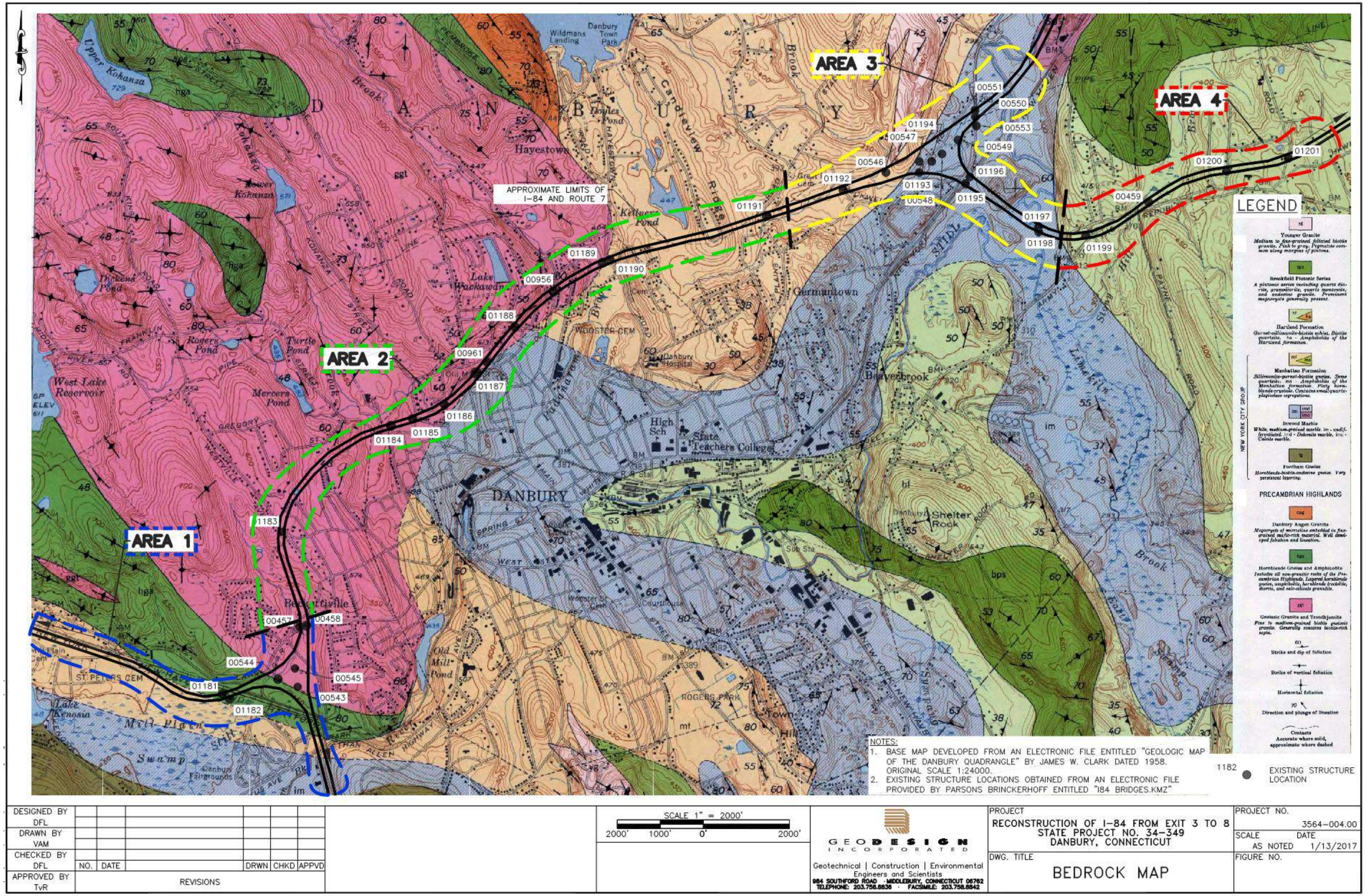


Figure 2-39 Surficial Geology

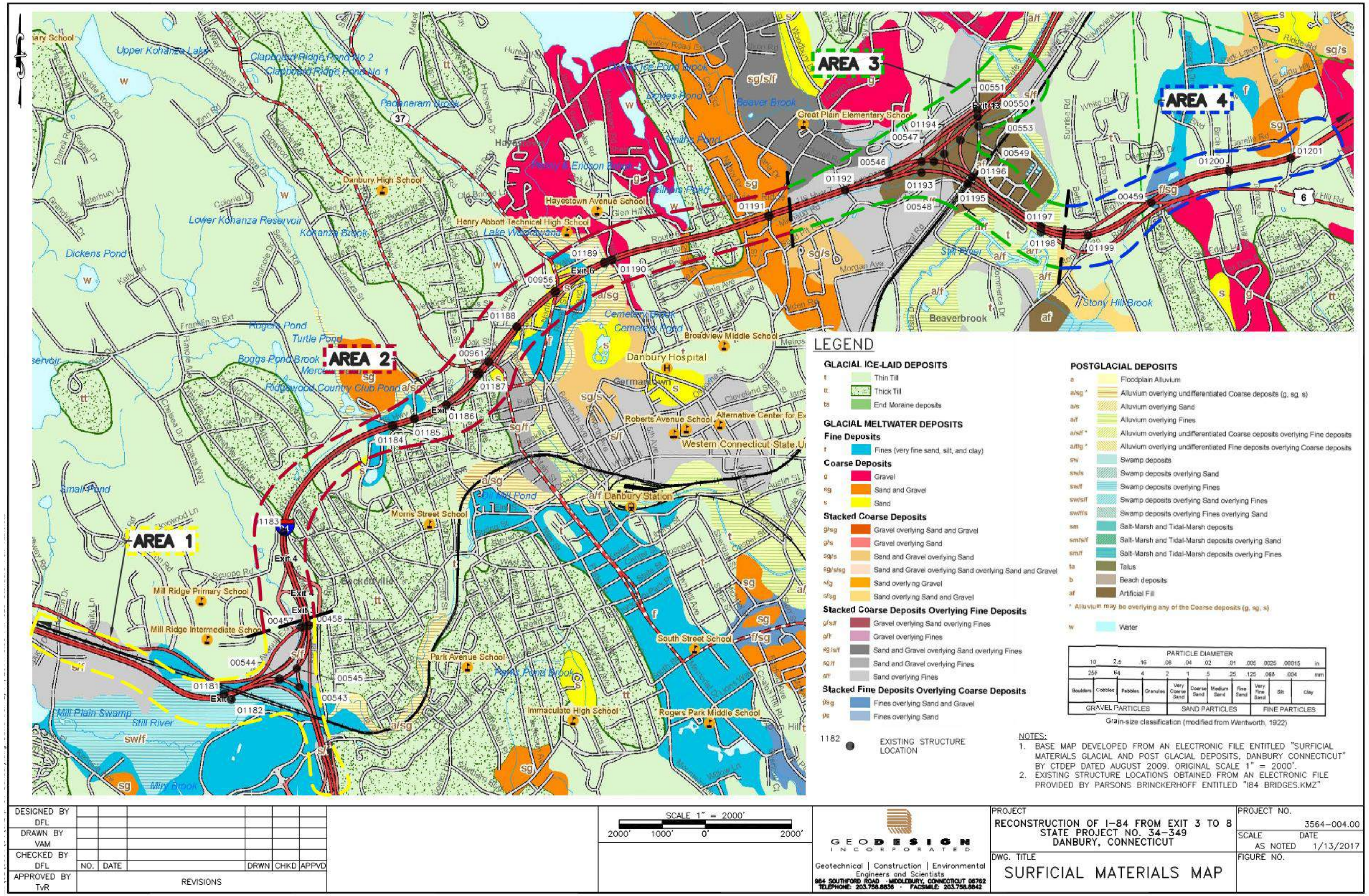


Table 2-98 Existing Structure Foundation and Geotechnical Data (Area 1) (continued)

Location		Structure #	Substructure Description	Foundation Type	Groundwater Depth (ft)	Bedrock Depth (ft)
Area 1		01180	Abutments, wingwalls, and piers are supported on 12BP53 H-piles driven to bedrock with a maximum design load capacity of 46 to 47 tons. The piles are estimated to be 20 to 57 feet long.	Deep	0 to 3	7 to 40
Area 1		01181	Abutments, wingwalls, and piers bearing on H-piles(12BP53) driven to bedrock.	Deep	0 to 7.5	30 to 50
Area 1		01182	Abutments, wingwalls, and piers bearing on H-piles(12BP53) driven to bedrock.	Deep	0 to 7.5	30 to 50
Area 1		05261	Abutments, wingwalls and piers are supported on shallow foundations bearings on soil. Maximum design soil pressure ranged from 3.2 to 3.9 tsf.	Shallow	7 to 17	43 to 64
Area 1		05437	No information	No available information	No available information	No available information
Area 1		05462	Abutments, wingwalls, and piers are supported on shallow foundations bearing on soil. The maximum soil bearing pressure ranged from 0.8 to 3.5 tsf.	Shallow	1 to 29	54 to 80
Area 1		05463	Abutments and wingwall are supported by shallow foundations bearing on soil. The maximum soil bearing pressure is 3.0 tsf.	Shallow	6 to 30	67 to 81
Area 1		05772	Abutments and wingwall are supported by shallow foundations bearing on soil. The maximum soil bearing pressure is 3.0 tsf.	Shallow	6 to 30	67 to 81
Area 1		05909	Abutments, wingwalls, and piers are supported on shallow foundations bearing on soil. The maximum soil bearing pressure ranged from 2.22 to 2.96 tsf.	Shallow	3 to 25	62 to 73
Area 1		05773	Abutments and wingwalls are supported on shallow foundations bearing on soil. Maximum soil bearing pressure of 3.0 tsf.	Shallow	5 to 15	35 to 46
Area 1		06569	Abutments and wingwalls are supported on shallow foundations bearing on soil. Maximum soil bearing pressure of 3.0 tsf.	Shallow	5 to 15	35 to 46

Notes:
1. Groundwater and Bedrock depths is an approximation based on Connecticut State Highway Department and Connecticut Department of Transportation (CTDOT) plans dated from 1958 to 2004.
2. Bearing pressures are noted as pounds per square foot (psf), kips per square foot (ksf), and tons per square foot. (tsf).

Table 2-99 Existing Structure Foundation and Geotechnical Data (Area 2)

Location	Structure #	Substructure Description	Foundation Type	Groundwater Depth (ft)	Bedrock Depth (ft)
Area 2	00956	Limited information about bridge foundations. It seems to be supported on shallow foundations.	Shallow	No available information	No available information
Area 2	00961	Abutments and wingwalls bearings on H-piles (12BP53) driven to bedrock with maximum axial design load of 40 to 45 tons. And shallow footings. (2.6 to 3 tsf)	Deep & Shallow	3 to 8	10 to 30
Area 2	01183	Abutments, wingwalls and piers are supported on shallow foundations bearing on Bedrock. Maximum bedrock pressure ranged from 2.1 to 2.8 tsf.	Shallow	2 to 10	6 to 10
Area 2	01184	12 in diameter concrete shell piles, axial load of 35 tons and lengths that ranged from 45 to 90 feet. The rest of the structures on shallow foundations with a maximum design soil pressure of 2.6 to 3 tsf	Deep & Shallow	2 to 6	Not encountered
Area 2	01185	Abutments and wingwalls are supported on shallow foundations bearing on soil. Maximum design pressure of 2 tsf.	Shallow	1 to 10	Not encountered
Area 2	01186	Abutments and wingwalls are supported on shallow foundations bearing on soil. Maximum pressure of 2.2 to 2.8 tsf	Shallow	3.5 to 5.5	Not encountered
Area 2	01187	Culvert and wingwalls are supported on shallow foundations bearing on soil and/or bedrock. Maximum design bearing pressure ranged from 0.7 to 2.5 tsf.	Shallow	0 to 17	7 to 30
Area 2	01188	Abutments, wingwalls and piers are supported on shallow foundations bearing on Bedrock. Maximum bedrock pressure ranged from 1 to 4.5 tsf.	Shallow	No available information	0 to 10
Area 2	01189	Culvert and wingwalls are supported on shallow foundations bearing on soil. Maximum bearing pressure not provided.	Shallow	1.5 to 3.5	Not encountered
Area 2	01190	Abutments and wingwalls bearing on 12 in diameter concrete filled shell piles. Piles design for and axial load of 35 tons and estimated to be 50 to 60 feet long.	Deep	6 to 19	Not encountered
Area 2	01191	Abutments, wingwalls and piers are supported on shallow foundations bearing on soil. Maximum design soil pressure of 2.5 tsf.	Shallow	2 to 5	31 to 53

Notes:
1. Groundwater and Bedrock depths is an approximation based on Connecticut State Highway Department and Connecticut Department of Transportation (CTDOT) plans dated from 1958 to 2004.
2. Bearing pressures are noted as pounds per square foot (psf), kips per square foot (ksf), and tons per square foot. (tsf).

Table 2-100 Existing Structure Foundation and Geotechnical Data (Area 3)

Location	Structure #	Substructure Description	Foundation Type	Groundwater Depth (ft)	Bedrock Depth (ft)
Area 3	00547	Abutments and wingwalls supported on H piles (12BP53) driven to Bedrock. Estimated length of 33 to 42 feet. Design axial load of 46 tons.	Deep	4 to 9	37 to 59
Area 3	00548	Abutments, wingwalls, and piers bearing on H piles (12BP53) with maximum axial design loads ranged from 27 to 46.2 tons. Maximum pressure from 2.9 to 3.5 tsf.	Deep	2 to 9.5	17 to 36
Area 3	00549	Culvert and wingwalls are supported on shallow foundations bearing on soil. With maximum pressure ranged from 1.5 to 1.8 tsf.	Shallow	Not recorded	61 feet.
Area 3	00550	Wingwalls, and piers bearing on 12 in diameter concrete filled shell piles. Estimated to be 45 feet long and design to a maximum axial load ranged from 32 to 33 tons.	Deep	3 to 9	Not encountered
Area 3	00551	Wingwalls, and piers bearing on 12 in diameter concrete filled shell piles. Estimated to be 45 feet long and design to a maximum axial load ranged from 32 to 33 tons.	Deep	3 to 9	Not encountered
Area 3	00553	Culvert and wingwalls are supported on 12 in diameter concrete filled shell piles. With a maximum axial pile load ranged from 28.8 to 34.4 tons.	Deep	10.5	Not encountered
Area 3	00546	Culvert is supported on shallow foundations. With maximum design soil pressure of 0.9 to 1.4 tsf.	Shallow	6 to 8	32 to 40
Area 3	01192	Abutments, and wingwalls bearing on H-piles(12BP53) driven to bedrock. Piles were design for and axial load of 39 to 45 tons, with an estimated length of 33 to 38 feet.	Deep	0 to 2	19 to 32
Area 3	01193	Culvert and wingwalls are supported on shallow foundations bearing on soil. Maximum design bearing pressure ranged from 1.5 to 2.5 tsf.	Shallow	5	Not encountered
Area 3	01194	Culvert and wingwalls are supported on shallow foundations bearing on soil. Maximum design bearing pressure ranged from 1.5 to 1.6 tsf.	Shallow	3	37
Area 3	01195	Abutments, wingwalls and piers bearing on 12 in diameter concrete filled shell piles. Estimated to be 45 feet longs and design for a maximum axial load of 35 tons.	Deep	6 to 30	83
Area 3	01196	Abutments, wingwalls and piers bearing on 12 in diameter concrete filled shell piles. Estimated to be 45 feet longs and design for a maximum axial load of 35 tons.	Deep	6 to 30	83
Area 3	01197	H-piles (12BP53) driven to bedrock. Piles are estimated to be 15 to 31 feet with 85 kips of design capacity. Bridge piers are supported on shallow foundations bearing on bedrock (4 to 16.7 ksf)	Deep & Shallow	0 to 9	10 to 25

Table 2-100 Existing Structure Foundation and Geotechnical Data (Area 3) (continued)

Location	Structure #	Substructure Description	Foundation Type	Groundwater Depth (ft)	Bedrock Depth (ft)
Area 3	01198	H-piles (12BP53) driven to bedrock. Piles are estimated to be 15 to 31 feet with 85 kips of design capacity. Bridge piers are supported on shallow foundations bearing on bedrock (4 to 16.7 ksf)	Deep & Shallow	0 to 9	10 to 25
Area 3	03915	Abutments and wingwalls are bearing on concrete piles. No info on piles properties other than length (55 to 60 feet long) and design load of 36 tons.	Deep	0 to 5	61 to 105
Area 3	03916	Abutments and wingwalls are bearing on concrete piles. No info on piles properties other than length (55 to 60 feet long) and design load of 36 tons.	Deep	0 to 5	61 to 105
Area 3	03919	Abutments and wingwalls are supported by shallow foundations bearing on soil. Maximum design bearing pressure of 3.2 tsf.	Shallow	0	16 to 32
Area 3	03920	Abutments and wingwalls are supported by shallow foundations bearing on soil. Maximum design bearing pressure of 3.2 tsf.	Shallow	0	16 to 32

__Notes__:
1. Groundwater and Bedrock depths is an approximation based on Connecticut State Highway Department and Connecticut Department of Transportation (CTDOT) plans dated from 1958 to 2004.
2. Bearing pressures are noted as pounds per square foot (psf), kips per square foot (ksf), and tons per square foot. (tsf).

Table 2-101 Existing Structure Foundation and Geotechnical Data (Area 4)

Location	Structure #	Substructure Description	Foundation Type	Groundwater Depth (ft)	Bedrock Depth (ft)
Area 4	00897	10BP42 H-piles driven to bedrock with maximum design load of 36.5 tons. Piers are supported on shallow foundations bearing on soil with a maximum pressure of 2.3 to 2.9 tsf.	Deep & Shallow	0 to 6	0 to 26
Area 4	00898	10BP42 H-piles driven to bedrock with maximum design load of 36.5 tons. The piers are supported on shallow foundations bearing on soil with a maximum pressure of 2.3 to 2.9 tsf.	Deep & Shallow	0 to 6	0 to 26
Area 4	01199	Abutments, wingwalls and piers are supported on shallow foundations bearing on Bedrock. Maximum bedrock pressure ranged from 4.6 to 9 ksf.	Shallow	9 to 12	12 to 25
Area 4	01200	Abutments and wingwalls are supported by shallow foundations bearing on soil with a design bearing pressure of 5,000 psf. Piers on shallow foundations bearing on soil (80,000 psf).	Shallow	3 to 9	22 to 46
Area 4	01201	Abutments, wingwalls and piers are supported on shallow foundations bearing on Bedrock. Maximum bedrock pressure ranged from 47.4 to 12.6 ksf.	Shallow	3 to 13	12 to 22
Area 4	01202	Abutments, wingwalls, and piers are supported on shallow foundations bearings on soil. The maximum design soil pressure ranged from 3.6 to 4.8 ksf.	Shallow	3 to 10	Not encountered

Table 2-101 Existing Structure Foundation and Geotechnical Data (Area 4)(continued)

Location	Structure #	Substructure Description	Foundation Type	Groundwater Depth (ft)	Bedrock Depth (ft)
Area 4	01203	Abutments, wingwalls, and piers are supported on shallow foundations bearings on soil and/or bedrock and piles.	Deep & Shallow	10 to 12	5 to 17
Area 4	01204	Abutments, wingwalls, and piers are supported on shallow foundations bearings on soil and/or bedrock. The maximum pressure ranged from 2.6 to 11.0 ksf.	Shallow	0 to 12	10 to 20
Area 4	01205	Culvert and wingwalls are supported on shallow foundations bearing on soil. The maximum design soil pressure is 2.24 ksf.	Shallow	0	Not encountered

Notes:
1. Groundwater and Bedrock depths is an approximation based on Connecticut State Highway Department and Connecticut Department of Transportation (CTDOT) plans dated from 1958 to 2004.
2. Bearing pressures are noted as pounds per square foot (psf), kips per square foot (ksf), and tons per square foot. (tsf).

2.6 Safety Analysis

Crash data for I-84 Eastbound (EB) and Westbound (WB), Route 7 Northbound (NB) and Southbound (SB), and their respective termini locations within the study area were summarized from January 1, 2014 to December 31, 2016. The crash data was obtained from the University of Connecticut (UCONN) Crash Data Repository and was summarized by direction, location, type, contributing factor, severity, lighting conditions, and pavement conditions. During this period, a total of 1,834 crashes were reported, including three (3) fatalities and 347 crashes that resulted in injuries. The crash data was broken down by route (I-84 or Rte. 7), direction (EB/WB or NB/SB), on/off-ramps or segments, and termini intersections, each with a crash rate expressed in crashes per million vehicle miles traveled (Crashes per MVMT).

2.6.1 I-84 Crashes

There was a total of 1,299 crashes on I-84 in both the eastbound and westbound directions between Exits 2 and 8 including segments and ramps. Of the 1,299 crashes on I-84, 796 crashes (approximately 61 percent) occurred on I-84 EB and the remaining 503 crashes (approximately 39 percent) occurred on I-84 WB. **Table 2-102** shows a breakdown of crashes by year between 2014 and 2016.

Table 2-102 I-84 – Crashes by Year

Direction	2014	2015	2016	Total
Eastbound	264	271	261	**796**
Westbound	154	189	160	**503**
Total	**418**	**460**	**421**	**1299**

The above table shows that the number of crashes per year is generally consistent. More recently, the number of total crashes on I-84 showed approximately 9 percent decline between 2015 and 2016.

2.6.1.1 Eastbound Direction

Of the 796 crashes on I-84 EB, 658 (approximately 83 percent) occurred on mainline segments and the remaining 138 (approximately 17 percent) occurred at an on/off ramp (entrance and exit ramp). Two (2) fatalities occurred in the eastbound direction within the study area between 2014 and 2016.

2.6.1.1.1 Eastbound Mainline

For the I-84 EB segments, majority of the crashes occurred between Exits 4-5 (182 crashes), Exits 6-7 (129 crashes), and Exits 2-3 (122 crashes).

2.6.1.1.1.1 Crash Rates

Table 2-103 shows the I-84 eastbound crashes on the mainline segments.

Table 2-103 I-84 Eastbound - Mainline Crash Rates

Segment From	Segment To	Number of Crashes	Crash Rate (MVMT)
Exit 2	Exit 3	122	1.11
Exit 3	**Exit 4**	**71**	**2.21**
Exit 4	**Exit 5**	**182**	**2.40**
Exit 5	**Exit 6**	**92**	**2.07**
Exit 6	Exit 7	129	1.41
Exit 7	Exit 8	62	1.51

Note: MVMT = Million Vehicle Miles of Travel

The highest crash rates occurred between Exits 4 – 5 (2.40), Exits 3 – 4 (2.21), and Exits 5 – 6 (2.07) as shown in Table 2-105, due to a variety of contributing factors. The segment crash rate scale is based on the CTDOT

Unofficial 2015 Crash Rate for a classified road type, which is 1.54 for the urban interstate. Given this reference point as an average, three (3) of the 6 segments are above this average crash rate.

CTDOT's 2018 Highway Safety Plan published statewide injury and fatality crash rates for 2015 expressed in hundred million vehicle miles of travel. Based on a million vehicles miles of travel, the statewide injury rate is 1.14 and the fatality rate is 0.008. **Table 2-104** shows the injury and fatality crash rate for the I-84 eastbound mainline segments.

Table 2-104 I-84 Eastbound - Mainline Injury and Fatality Crash Rates

Segment From	Segment To	Number of Injuries	Number of Fatalities	Injury Crash Rate (MVMT)	Fatality Crash Rate (MVMT)
Exit 2	Exit 3	18	0	0.2	0.0
Exit 3	Exit 4	10	0	0.3	0.0
Exit 4	Exit 5	36	0	0.5	0.0
Exit 5	Exit 6	12	0	0.3	0.0
Exit 6	Exit 7	21	0	0.2	0.0
Exit 7	Exit 8	12	1	0.3	0.0

Note: MVMT = Million Vehicle Miles of Travel

As shown in Table 2-106, the injury and fatality crash rates on the I-84 segments are well below the statewide injury and fatality crash rates.

2.6.1.1.1.2 Severity

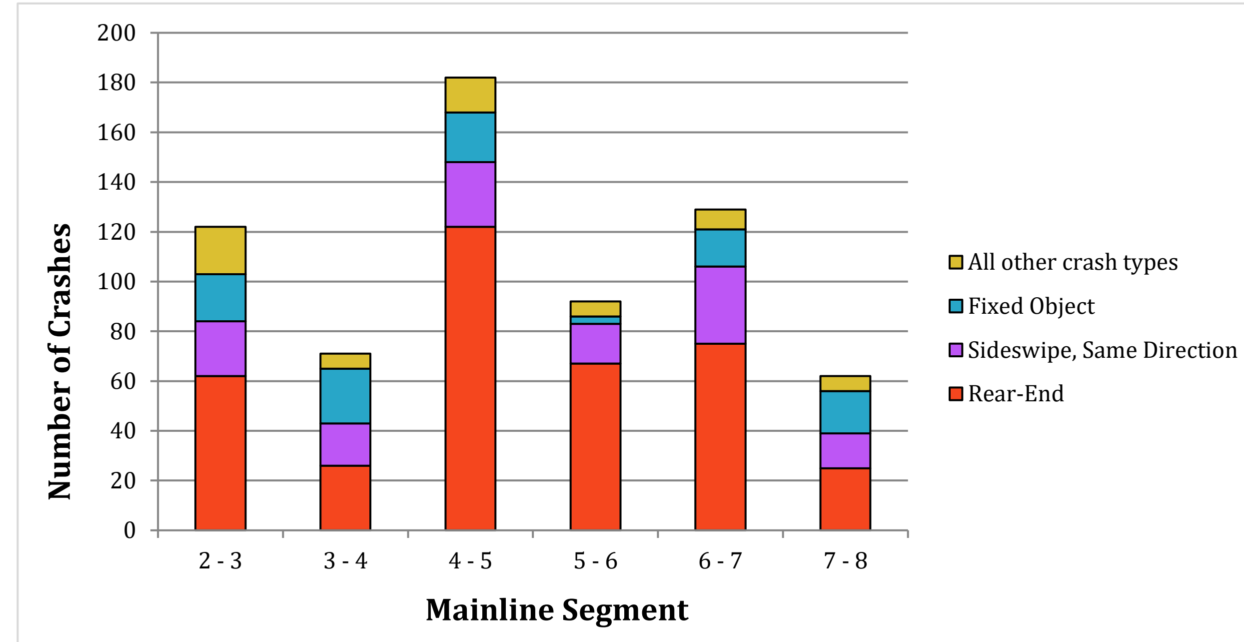
A fatality occurred on December 22, 2016, when a pedestrian was struck and killed by an SUV between Exits 7 and 8 on I-84 EB at 5:30 PM. Given the dark-lighted conditions, the person was likely exiting or entering their vehicle on the side of the road and was likely not visible to driver at fault.

Of the 658 crashes reported, 548 (approximately 83 percent) were property damage only, 109 (approximately 16 percent) were injury related, and the remaining one (1 percent) was a fatality.

2.6.1.1.1.3 Types and Contributing Factors

As shown in **Figure 2-40,** the predominant crash type was rear-end crashes, followed by sideswipes and fixed objects. Of the 658 crashes reported, 377 (approximately 57 percent) were rear-end, 126 (approximately 19 percent) were sideswipes, 96 (approximately 14 percent) were fixed object and the remaining 59 (approximately 10 percent) were other types. Most of the rear-end crashes were reported between Exits 4-5 and 6-7 due to vehicles following too closely and making quick decisions on braking.

Figure 2-40 I-84 Eastbound – Mainline Crash Types



2.6.1.1.1.4 Trucks

Of the 658 crashes reported, medium to heavy trucks contributed to 32 crashes (approximately 5 percent). This is similar in percentage of medium to heavy trucks traveling this corridor in the eastbound direction during peak periods.

2.6.1.1.1.5 Other Factors

Lighting is a concern at many of the segments as 240 of the 658 crashes (approximately 36 percent) occurred during non-daylight hours. Another factor is the wet pavement condition which was a cause of approximately 37 percent of the crashes between Exits 3 and 4.

2.6.1.1.2 Eastbound Ramps

2.6.1.1.2.1 Crash Rates

A ramp crash rate scale was developed to compare individual crash rate at each ramp location with the average ramp crash rate that occurred within the study area. Based on this scale, ramp crash rates less than 6.25 were deemed satisfactory and crash rates above that were considered unsatisfactory. **Table 2-105** shows the I-84 eastbound ramp crash rates.

Table 2-105 I-84 Eastbound – Ramp Crash Rates

Ramp Location	Number of Crashes	Crash Rate (MVMT)
Exit 3 Off-ramp to Rte. 7 SB	11	2.81
Exit 3 On-ramp from Rte. 7 NB	6	0.76
Exit 4 Off-ramp	**9**	**7.81**
Exit 4 On-ramp	5	1.61
Exit 5 Off-ramp	**28**	**15.55**
Exit 5 On-ramp	8	5.78
Exit 6 On-ramp	**19**	**16.60**
Exit 7 Off-ramp to Rte. 7 NB	10	0.83
Exit 7 On-ramp from Rte. 7 SB	12	4.16
Exit 8 Off-ramp	**24**	**7.49**
Exit 8 On-ramp	6	4.35

For the I-84 EB ramp locations, majority of the crashes occurred at the Exit 5 off-ramp with 28 crashes, the Exit 8 Off-ramp with 24 crashes, and the Exit 6 On-ramp with 19 crashes. However, the Exit 5 off-ramp and Exit 6 on-ramp locations had higher crash rates (15.55 and 16.60 respectively) than other ramps. This is mainly due to high traffic volumes traversing the short ramp segments. Exit 4 and 8 off-ramps also had unsatisfactory rates but much lower than the ones at Exit 5 and 6.

2.6.1.1.2.2 Severity

Of the 138 crashes reported, 99 (approximately 72 percent) were property damage only, 38 (approximately 27 percent) were injury related, and the remaining one (1 percent) was a fatality. On March 17, 2016, a fixed object crash occurred resulting in a fatality as an SUV struck a concrete traffic barrier on the Exit 5 Off-ramp while exiting I-84 EB during late morning. This crash could be attributed to the poor curvature approaching the exit ramp.

2.6.1.1.2.3 Types and Contributing Factors

Of the 138 crashes reported, 71 (approximately 52 percent) were rear-end, 37 (approximately 27 percent) were sideswipes, 25 (approximately 18 percent) were fixed object and the remaining 5 (approximately 3 percent) were other types.

Rear-end crashes were predominant at most of the ramp locations. However, fixed object type was predominant at the Exit 3 on-ramp from Route 7 mainly due to vehicle not staying in the lane and striking a fixed object. Sideswipe crashes were predominant at the Exit 5 off ramp to Downs Street due to traffic weaving into the exit when traffic is backed up on the off-ramp. **Figure 2-41** shows the crash types for the ramp locations along I-84 eastbound.

2.6.1.1.2.4 Trucks

At the Exit 5 off-ramp, a total of 3 truck related crashes were reported out of the 28 crashes (approximately 11 percent of the total). This was the most predominant location for truck crashes. Other ramps had very few or no truck related crashes.

2.6.1.1.2.5 Other Factors

A significant number of ramp crashes (approximately 75 percent or more) occurred during daylight and dry pavement conditions. Overall, poor lighting and pavement conditions was not a significant contributor to ramp crashes. However, key locations where dark lighting conditions is a significant issue are the Exit 3 on-ramp, Exit 4 on-ramp, and the Exit 7 on and off ramps. Relative to pavement condition, the Exit 3 on-ramp had significant number of crashes under wet pavement condition.

2.6.1.1.3 Eastbound Ramps Termini

2.6.1.1.3.1 Crash Rates

The termini crash rate scale is based on the average termini crash rate for the corridor and it was determined that a crash rate over 0.99 is unsatisfactory.

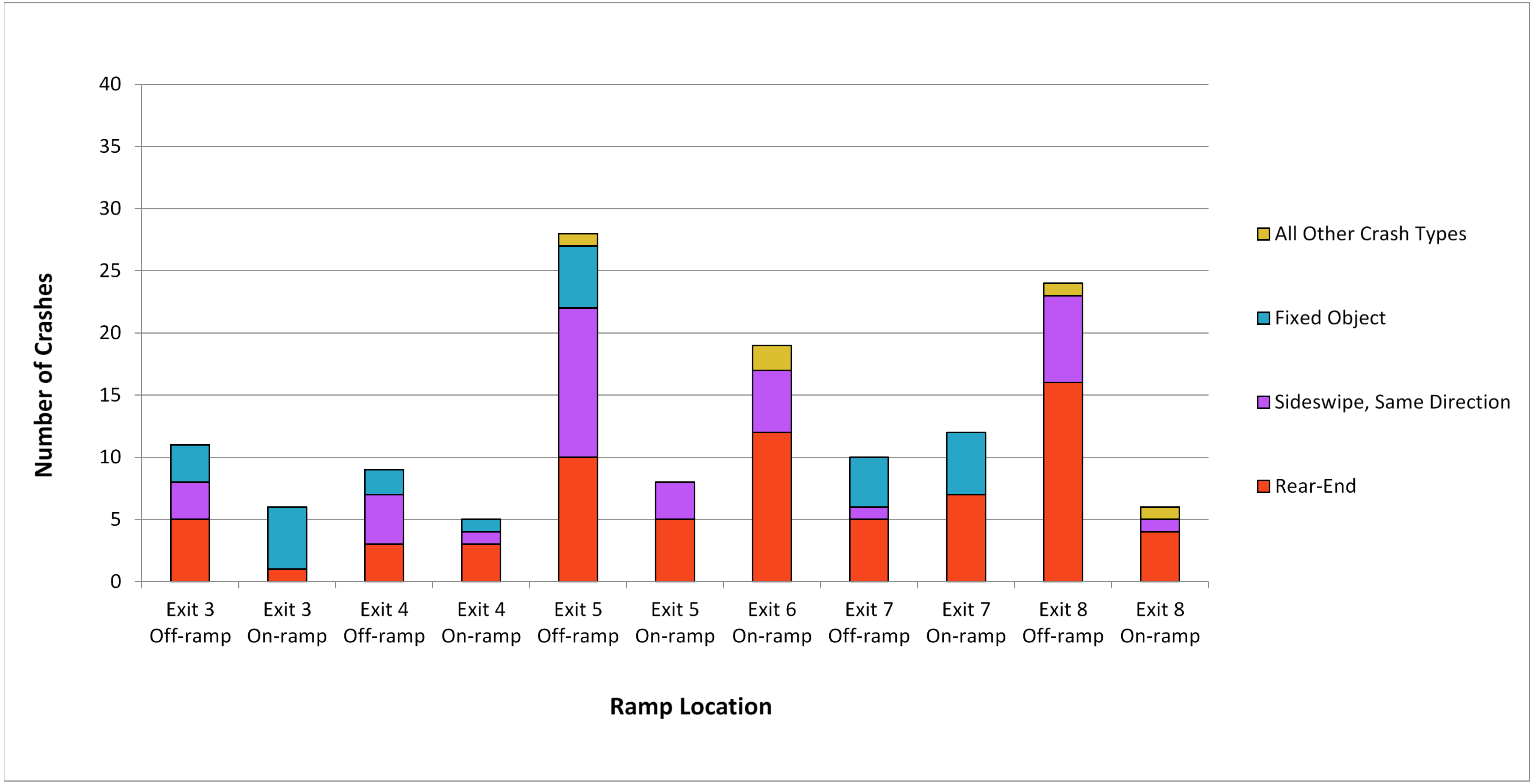
Table 2-106 below shows crash rates for the six (6) ramp termini locations associated with ramps in the eastbound direction. The Exit 4 on/off ramp termini with Route 6/Lake Avenue is the predominant location among others relative to the number of crashes and the crash rate. This is mainly due to short ramp length and sharp curve on the ramps combined with the amount of traffic during peak periods.

The Exit 5 on-ramp intersection with Main Street/Tooley Lane was also above the threshold rate of 0.99 but reported less than half the number of crashes at the Exit 4 ramps.

Table 2-106 I-84 Eastbound – Ramp Termini Crash Rates

Intersection / Ramp Termini	Number of Crashes	Crash Rate (MEV)
Exit 4 On/Off-ramp at Rte. 6 & Lake Ave	**55**	**2.47**
Exit 5 On-ramp at Main St & Tooley Ln	**27**	**1.37**
Exit 5 Off-ramp at Fairview Ave/Downs St	0	0.00
Exit 6 On-ramp at North St.	20	0.71
Exit 8 On-ramp at Newtown Rd/Rte. 6	0	0.00
Exit 8 Off-ramp at Newtown Rd/Rte. 6	5	0.37

Figure 2-41 I-84 Eastbound – Ramp Crash Types



2.6.1.1.3.2 Severity

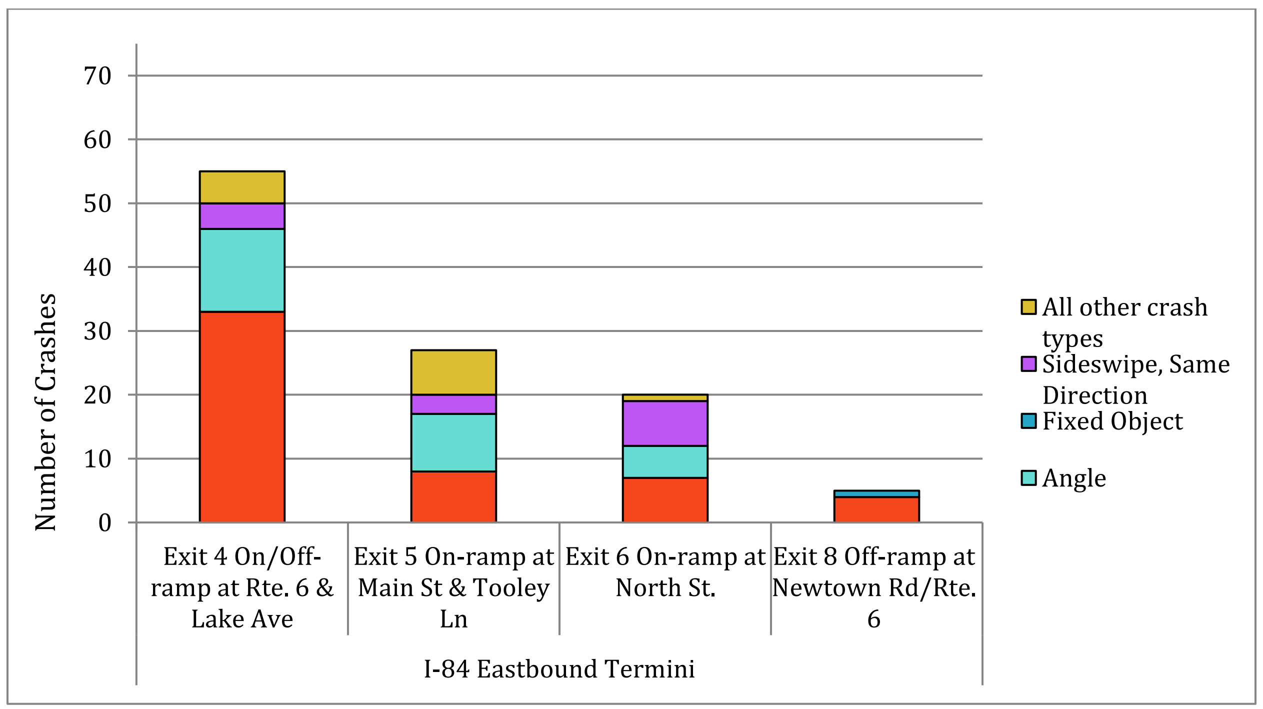
Of the 107 crashes reported at the eastbound termini locations, 86 crashes (approximately 80 percent) were property damage only and the remaining 21 crashes (approximately 20 percent) were personal injury crashes. There were no fatalities reported at the ramp termini locations.

2.6.1.1.3.3 Types and Contributing Factors

Of the 55 crashes reported at the Exit 4 ramp termini with Route 6 and Lake Avenue, 33 (60 percent) were rear-end, 13 (approximately 24 percent) were angle, and the remaining 9 (approximately 16 percent) were other types. Rear-end crashes were predominant due to traffic signal control at this location.

Of the 27 crashes reported at the Exit 5 on-ramp termini with Main Street and Tooley Lane, 9 (approximately 33 percent) were angle, 8 (approximately 30 percent) were angle, 3 (approximately 11 percent) were sideswipes, and the remaining 7 (approximately 26 percent) were other types. Angle and rear-end crashes were predominant due to the poor roadway curvature on Main Street approaching the intersection from the north.

Figure 2-42 I-84 Eastbound – Ramp Termini Crash Types



2.6.1.1.3.4 Trucks

Of the 55 crashes reported at the Exit 4 ramps at Route 6 and Lake Avenue, large trucks were involved in 5 crashes (approximately 9 percent).

2.6.1.1.3.5 Other Factors

Dark lighting condition was a significant factor at the Exit 6 on-ramp and North Street intersection where 12 out of the 12 crashes (approximately 60 percent) were caused due to poor lighting.

2.6.1.2 Westbound Direction

Of the 503 crashes on I-84 WB, 328 (approximately 65 percent) occurred on mainline segments and the remaining 175 (approximately 35 percent) occurred at an on/off ramp (entrance and exit ramp) location. One fatality occurred within the study area between 2014 and 2016.

2.6.1.2.1 Westbound Mainline

For the I-84 WB mainline segments, majority of the crashes occurred between Exits 6-7 (97 crashes), Exits 4-5 (69 crashes), and Exits 2-3 (62 crashes).

2.6.1.2.1.1 Crash Rates

Table 2-107 shows the mainline crash rates in the westbound direction.

Table 2-107 I-84 Westbound – Mainline Crash Rates

Segment From	Segment To	Number of Crashes	Crash Rate (MVMT)
Exit 2	Exit 3	62	0.64
Exit 3	**Exit 4**	**32**	**2.09**
Exit 4	Exit 5	69	0.83
Exit 5	Exit 6	31	0.89
Exit 6	Exit 7	97	0.80
Exit 7	Exit 8	37	0.92

The highest crash rate in the westbound direction was noted between Exit 3 and 4 as shown in Table 2-109, due to a variety of contributing factors. The segment crash rate scale is based on the CTDOT Unofficial 2015 Crash Rate for a classified road type, which is 1.54 for the urban interstate. Given this reference point as an average, one (1) of the 6 segments is above this average crash rate.

Table 2-108 shows the injury and fatality crash rate for the I-84 westbound mainline segments.

Table 2-108 I-84 Westbound - Mainline Injury and Fatality Crash Rates

Segment From	Segment To	Number of Injuries	Number of Fatalities	Injury Crash Rate (MVMT)	Fatality Crash Rate (MVMT)
Exit 2	Exit 3	7	0	0.1	0.0
Exit 3	Exit 4	5	0	0.3	0.0
Exit 4	Exit 5	15	0	0.2	0.0
Exit 5	Exit 6	3	0	0.1	0.0
Exit 6	Exit 7	24	1	0.2	0.0
Exit 7	Exit 8	8	0	0.2	0.0

Note: MVMT = Million Vehicle Miles of Travel

As shown in **Table 2-109**, the injury and fatality crash rates on the I-84 segments are well below the statewide injury and fatality crash rates.

2.6.1.2.1.2 Severity

Of the 328 crashes reported, 265 (approximately 80 percent) were property damage only, 62 (approximately 19 percent) were injury related, and the remaining one (1 percent) was a fatality.

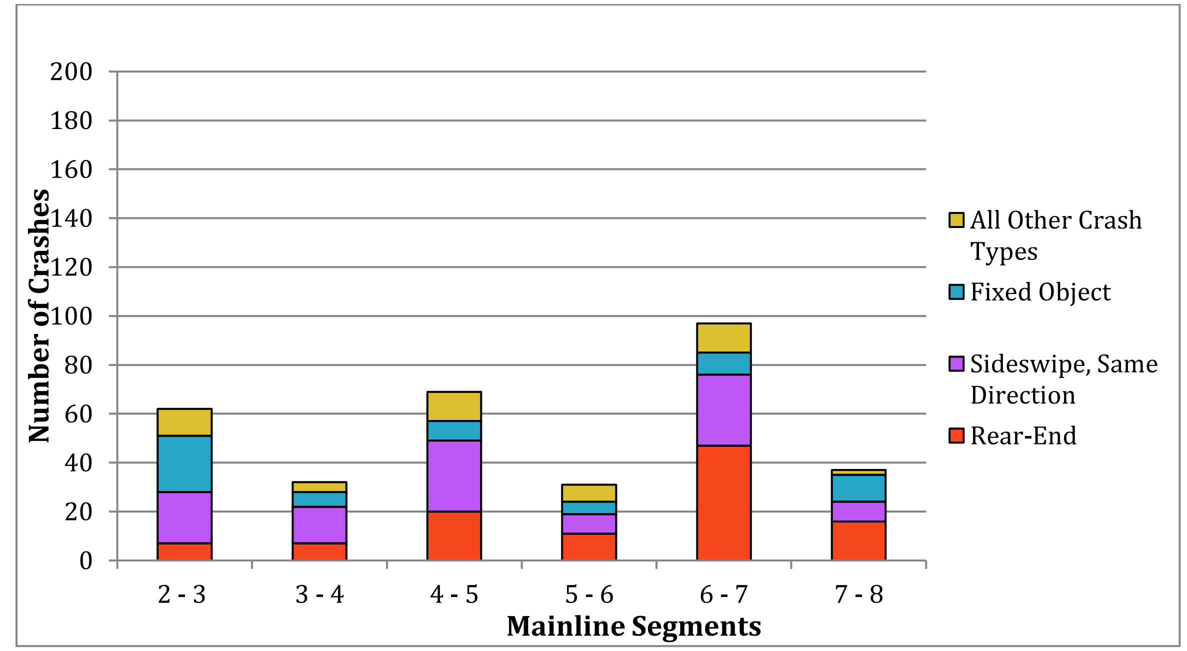
This fatality occurred on December 2, 2014, when a pedestrian was struck between Exits 6 and 7 on I-84 WB at 7:30 PM. Given the dark night conditions, the person was likely exiting or entering their vehicle on the side of the road and was not visible to driver at fault.

2.6.1.2.1.3 Types and Contributing Factors

Of the 328 crashes reported, 110 (approximately 34 percent) were sideswipes, 108 (approximately 33 percent) were rear-end, 62 (approximately 19 percent) were fixed object and the remaining 48 (approximately 14 percent) were other types.

Majority of the crashes occurring at segment Exit 2 -3, 3- 4, 4- 5, and 5-6 were sideswipe and fixed/moving objects, which had a common contributing factor of failing to stay in proper lane. At Interchange Exit 6-7, the predominant crash type was rear-end mostly caused by following too closely. **Figure 2-43** shows the crash types for each of the mainline segment locations along I-84 in the westbound direction.

Figure 2-43 I-84 Westbound – Mainline Crash Types



2.6.1.2.1.4 Trucks

Of the 328 crashes reported, medium to heavy trucks contributed to 25 crashes (approximately 8 percent). This is similar in percentage of medium to heavy trucks traveling this corridor in the westbound direction.

2.6.1.2.1.5 Other Factors

Lighting and pavement conditions were not significant factors to crashes on the westbound mainline segments.

2.6.1.2.2 Westbound Ramps

2.6.1.2.2.1 Crash Rates

Table 2-109 shows the ramp crash rates along I-84 in the westbound direction.

Table 2-109 I-84 Westbound – Ramp Crash Rates

Ramp Location	Number of Crashes	Crash Rate (MVMT)
Exit 3 On-ramp from Rte. 7 NB	9	3.43
Exit 3 Off-ramp to Rte. 7 SB	37	4.46
Exit 4 On-ramp	4	2.58
Exit 4 Off-ramp	**27**	**9.15**
Exit 5 On-ramp	2	0.84
Exit 5 Off-ramp	**22**	**27.13**
Exit 6 Off-ramp	**20**	**13.58**
Exit 7 On-ramp from Rte. 7 SB	22	2.30
Exit 7 Off-ramp to Rte. 7 NB	**17**	**6.73**
Exit 8 On-ramp	6	1.25
Exit 8 Off-ramp	9	5.42

For the I-84 WB exit ramp locations, the majority of the 175 crashes occurred at the Exit 3 Off-ramp (37 crashes), the Exit 4 Off-ramp (27 crashes), and the Exit 5 Off-ramp (22 crashes). However, the Exit 5 off-ramp and Exit 6 off-ramp locations had higher crash rates (27.13 and 13.58 respectively) than other ramps. This is mainly due to high traffic volumes traversing the short ramp segments. Exit 4 and 7 off-ramps also showed unsatisfactory rates but were lower than the Exit 5 and 6 ramp locations.

2.6.1.2.2.2 Severity

Of the 175 crashes reported, 151 (approximately 86 percent) were property damage only the remaining 24 (approximately 14 percent) were injury related crashes. No fatalities were reported on any of the westbound ramps.

2.6.1.2.2.3 Types and Contributing Factors

Of the 175 crashes reported, 76 (approximately 43 percent) were rear-end, 40 (approximately 23 percent) were sideswipes, 34 (approximately 19 percent) were fixed object and the remaining 25 (approximately 15 percent) were other types.

The predominant crash type at the Exit 3 and 4 Off-ramp locations were sideswipes and fixed/moving object crashes. Of the 37 crashes at the Exit 3 Off-ramp, 26 were sideswipe and fixed object crashes, where 10 crashes occurred during wet conditions. The higher proportion of sideswipe and fixed object crashes could be attributed to the left-hand exit, horizontal roadway curvature, and short separation between exits 3 and 4. However, the rear-end crashes were still the most common. A similar pattern was observed at the Exit 7 off-ramp where fixed object and sideswipe crashes were proportionally higher. Sideswipes could be attributed to the short weaving section between the Exit 8 on ramp and the Exit 7 off-ramp. The fixed object crashes were associated with the vehicles running off the roadway and hitting fixed objects i.e. guard rail and cable barrier.

Figure 2-44 shows the crash types for each of the ramp locations along I-84 in the westbound direction.

2.6.1.2.2.4 Trucks

The total number of medium to large truck crashes on ramps were 11 out of 175 crashes reported i.e. 6 percent. Truck related crashes were predominant at the Exit 4 off-ramp (19 percent of total crashes) and at the Exit 3 off-ramp (11 percent of total crashes).

2.6.1.2.2.5 Other Factors

A significant number of ramp crashes (approximately 75 percent or more) occurred during daylight and dry pavement conditions. Overall, poor lighting and pavement conditions was not a significant contributor to ramp crashes. However, key locations where dark lighting conditions is a significant issue are Exit 4 on-ramp and the Exit 7 off- ramp. Relative to pavement condition, the Exit 5 off-ramp had significant number of crashes under wet pavement condition.

2.6.1.2.3 Westbound Ramp Termini

2.6.1.2.3.1 Crash Rates

Table 2-110 below shows crash rates for the five (5) ramp termini locations associated with ramps in the westbound direction. The Exit 5 on/off ramp termini with Main Street/Golden Hill Road is the predominant location among others relative to the number of crashes and the crash rate. This is mainly due to the poor ramp curvature approaching and departing the intersection.

The Exit 8 on-ramp intersection with Newtown Road/Mountainview Terrace crash rate was just above the threshold rate of 0.99 but reported half the number of crashes than the Exit 5 ramps intersection with Main Street/Golden Hill Road.

Table 2-110 I-84 Westbound – Ramp Termini Crash Rates

Intersection / Ramp Termini	Crashes	Crash Rate (MEV)
Exit 4 On/Off-ramp at Rte. 6 & Lake Ave	12	0.46
Exit 5 On/Off-ramp at Main St & Golden Hill Rd	**64**	**2.66**
Exit 6 Off-ramp at North St. & Padanaram Rd	27	0.92
Exit 8 On-ramp at Newtown Rd & Mountainview Terrace	**32**	**1.13**
Exit 8 Off-ramp at Newtown Rd/Rte. 6	9	0.44

2.6.1.2.3.2 Severity

Of the 144 crashes reported at the eastbound termini locations, 113 crashes (approximately 78 percent) were property damage only and the remaining 31 crashes (approximately 22 percent) were personal injury crashes. There were no fatalities reported at the ramp termini locations.

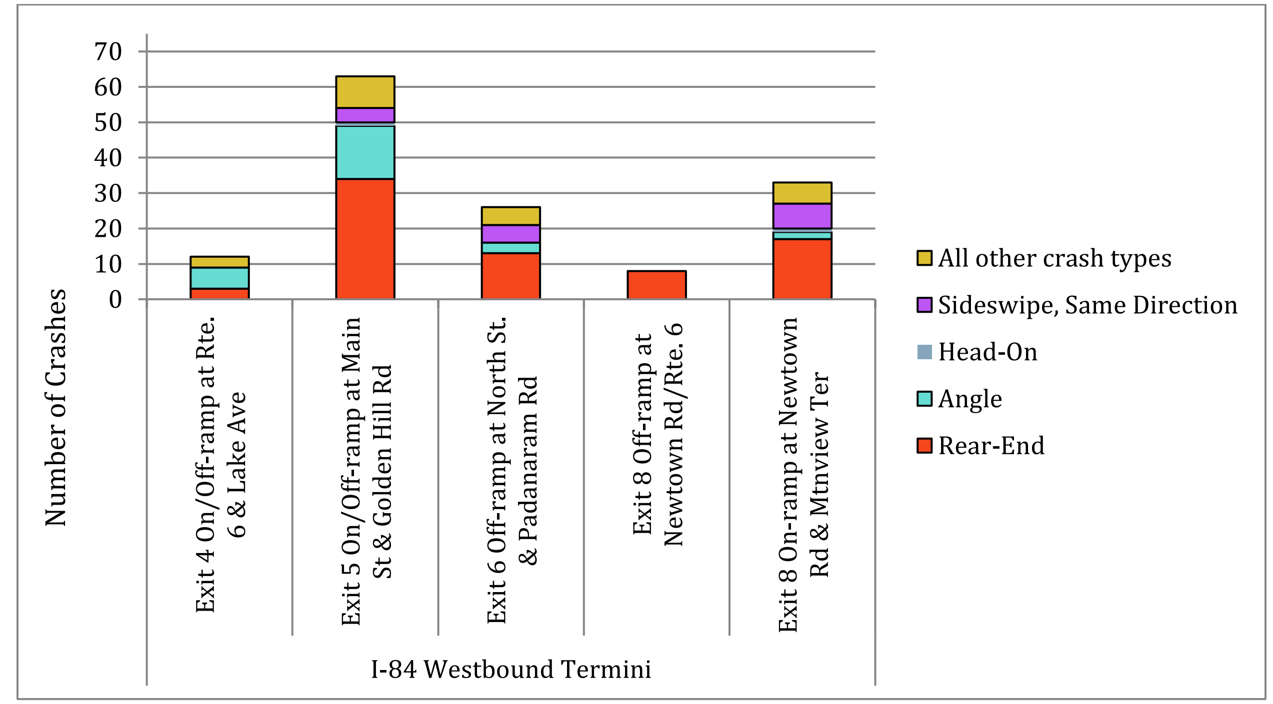
2.6.1.2.3.3 Types and Contributing Factors

Of the 64 crashes reported at the Exit 5 ramp termini with Main Street and Golden Hill Road, 34 (approximately 54 percent) were rear-end, 15 (approximately 23 percent) were angle, and the remaining 15 (approximately 23 percent) were other types. Rear-end crashes were predominant due to traffic signal control at this location.

Of the 32 crashes reported at the Exit 8 on-ramp termini with Newtown Road and Mountainview Terrace, 17 (approximately 53 percent) were sideswipes, 7 (approximately 22 percent) were sideswipes, and the remaining 8 (approximately 25 percent) were other types. Rear-end and sideswipe crashes were predominant due to the weaving operation between the Newtown Road and the I-84 westbound on-ramp movements.

Figure 2-45 shows the ramp termini crash rates along I-84 in the westbound direction.

Figure 2-44 I-84 Westbound – Ramp Termini Crash Types



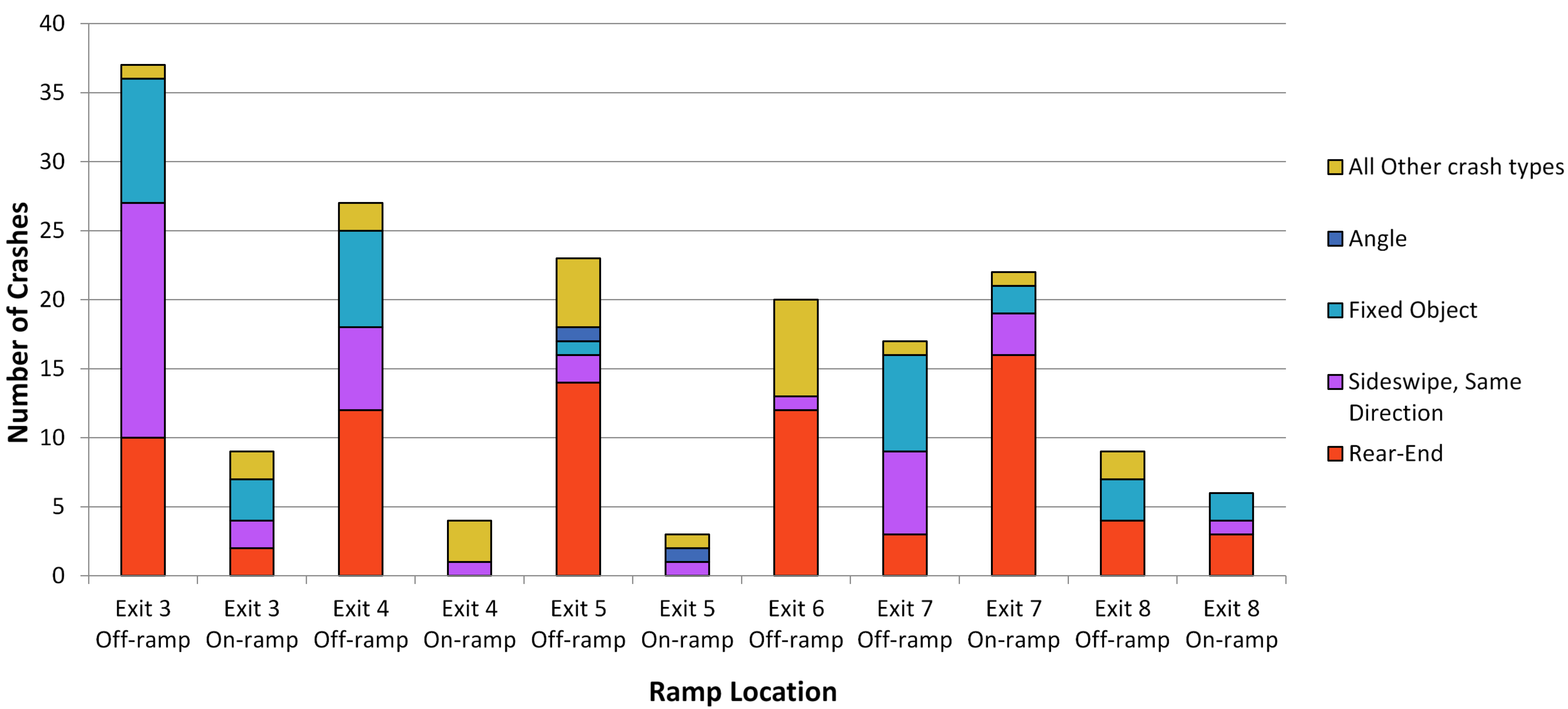
2.6.1.2.3.4 Trucks

Of the 64 crashes reported at the Exit 5 ramps at Main Street and Golden Route 6 and Lake Avenue, large trucks were involved in 4 crashes (approximately 6 percent).

2.6.1.2.3.5 Other Factors

Lighting or pavement condition were not significant factors for cause of crashes at the I-84 westbound ramp termini locations.

Figure 2-45 – I-84 Westbound – Ramp Crash Types



2.6.1.3 Summary of I-84 Crashes

Below is a summary of I-84 crashes based on the data obtained on the most recent three-year period from 2014-16:

General

- Approximately 61 percent of crashes occurred in the eastbound direction.
- More recent crash data shows approximately 9 percent decline in total crashes on I-84 between 2015 and 2016.

Mainline Segments

- High crash rates were between Exits 3 and 6 in the eastbound direction and between Exits 3 and 4 in the westbound direction.
- Two (2) fatalities were reported– one in the eastbound direction and the other in the westbound direction.
- Rear-end crashes were predominant cause on I-84 except between Exits 2 and 4 in the westbound direction fixed object and sideswipe crashes were significant.

Ramps

- High crash rates at the exit 5 off-ramp, the exit 6 on-ramp, and the exit 8 off-ramp in the eastbound direction.
- High crash rates at the exit 4, 5, 6, and 7 off ramps in the westbound direction.
- One (1) fatality reported at the exit 5 off-ramp in the eastbound direction.
- Rear-end crashes were predominant cause at many ramp locations. However, fixed object crashes were predominant at Exit 3 in both directions. Sideswipe crashes were predominant at Exit 5 in the eastbound direction and Exit 7 in the westbound direction.

Termini

- High crash rates at the exit 4 and exit 5 on-ramp termini in the eastbound direction.
- High crash rates at the exit 5 and the exit 8 on-ramp termini in the westbound direction.
- Rear-end crashes were predominant cause at termini locations.

2.6.2 Route 7 Crashes

The study area includes Route 7 NB and SB between Exits 7 to 11, with the southern portion at the Exit 3 off-ramp on I-84 near the Danbury mall and the northern portion at the Exit 7 off-ramp on I-84 near the shopping center. There was a total of 242 crashes on Route 7 northbound and south segments and ramps. With further breakdown by direction, there were 81 crashes (approximately 33 percent) on Route 7 northbound and 161 (approximately 67 percent) crashes on Route 7 southbound. **Table 2-111** shows a breakdown of Route 7 crashes by year.

Table 2-111 Route 7 – Crashes by Year

Direction	2014	2015	2016	**Total**
Northbound	27	31	23	**81**
Southbound	47	67	47	**161**
Total	**74**	**98**	**70**	**242**

The above table shows that the number of total crashes in 2015 is much higher than 2014 and 2016 based on the information obtained from the UCONN repository. More recently, the number of total crashes on Route 7 showed approximately 29 percent decline between 2015 and 2016.

2.6.2.1 Northbound Direction

Of the 81 crashes reported on Route 7 northbound, 65 (approximately 80 percent) occurred on mainline segments and the remaining 16 (approximately 20 percent) occurred at an on/off ramp (entrance and exit ramp). No fatalities were reported on Route 7.

2.6.2.1.1 Northbound Mainline

For the Route 7 NB mainline segments, majority of the 65 crashes reported occurred between the merge from I-84 and the White Turkey Road Extension – Exit 11 (30 crashes) and in the segment prior to the merge between Route 7 and I-84 (24 crashes).

2.6.2.1.1.1 Crash Rates

The highest crash rate segment is the segment prior to merge with I-84. The crash rate is high because it is a short segment with high daily traffic volume on U.S. Route 7 merging with I-84. **Table 2-112** shows the crash rates for each of the segments on Route 7 northbound.

Table 2-112 Route 7 Northbound – Mainline Crash Rates

Segment From (Description)	Segment To (Description)	Number of crashes	Crash Rate (MVMT)
Exit 7	Exit 8 off-ramp	7	0.36
Exit 8 off-ramp	Exit 8 on-ramp	4	1.17
Exit 8 on-ramp	**I-84 EB/WB**	**24**	**3.20**
I-84 EB/WB	Exit 11	30	0.96

Table 2-113 shows the injury and fatality crash rates for each of the segments on Route 7 northbound.

Table 2-113 Route 7 Northbound - Mainline Injury and Fatality Crash Rates

Segment From	Segment To	Number of Injuries	Number of Fatalities	Injury Crash Rate (MVMT)	Fatality Crash Rate (MVMT)
Exit 7	Exit 8 off-ramp	0	0	0.0	0.0
Exit 8 off-ramp	Exit 8 on-ramp	1	0	0.3	0.0
Exit 8 on-ramp	I-84 EB/WB	6	0	0.8	0.0
I-84 EB/WB	Exit 11	5	0	0.2	0.0

Note: MVMT = Million Vehicle Miles of Travel

As shown in Table 2.115, the injury and fatality crash rates on the I-84 segments are well below the statewide injury and fatality crash rates.

2.6.2.1.1.2 Severity

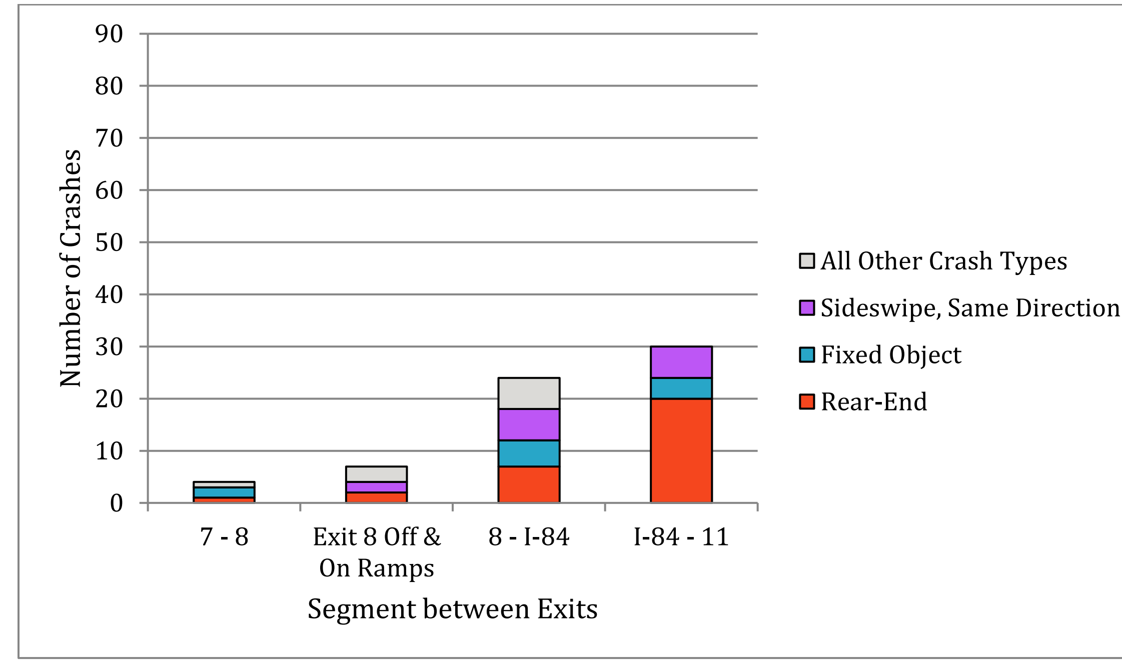
Of the 65 crashes reported, 53 (approximately 81 percent) were property damage only, and the remaining 12 (approximately 19 percent) were injury related. There were no fatalities reported on the Route 7 northbound segments.

2.6.2.1.1.3 Types and Contributing Factors

Of the 65 crashes reported on the Route 7 northbound segments, 30 (approximately 46 percent) were rear-ends, 14 (approximately 22 percent) were sideswipes, 11 (approximately 17 percent) were fixed object and the remaining 10 (approximately 15 percent) were other types.

As shown in **Figure 2-46**, majority of the crashes at the individual mainline segments were rear-end crashes. Specifically, the Route 7 segment between the I-84 ramps and Exit 11 reported 20 rear-end crashes out of 30 total crashes (approximately 67%) with vehicles following too closely.

Figure 2-46 Route 7 Northbound – Mainline Crash Types



2.6.2.1.1.4 Trucks

Of the 65 crashes reported, medium to heavy trucks contributed to 5 crashes (approximately 8 percent). This is similar in percentage of medium to heavy trucks traveling this corridor on Route 7 in the northbound direction.

2.6.2.1.1.5 Other Factors

Dark lighting condition was a cause of all 4 crashes on the segment between the Exit 8 ramps and 16 out of 24 crashes (75 percent) between Exit 8 and the I-84 merge. Wet pavement condition was a cause of 3 out of 4 crashes (75 percent) on the segment between the I-84 ramps. Wet, snow, and icy pavement condition was a cause of 10 out of 24 crashes (approximately 42 percent) on the Route 7 northbound segment between Exit 8 and I-84.

2.6.2.1.2 Northbound Ramps

For the Route 7 NB ramps, a total of 16 crashes were reported in the study corridor.

2.6.2.1.2.1 Crash Rates

Table 2-114 shows crash rates for the two ramps in the study area on Route 7 Northbound. The crash rates were below the threshold rate of 6.25.

Table 2-114 Route 7 Northbound – Ramp Crash Rates

Segment From (Description)	Number of Crashes	Crash Rate (MVMT)
Exit 8 Off-ramp to Park Ave	5	5.77
Exit 8 On-ramp from Backus Ave.	11	2.27

2.6.2.1.2.2 Severity

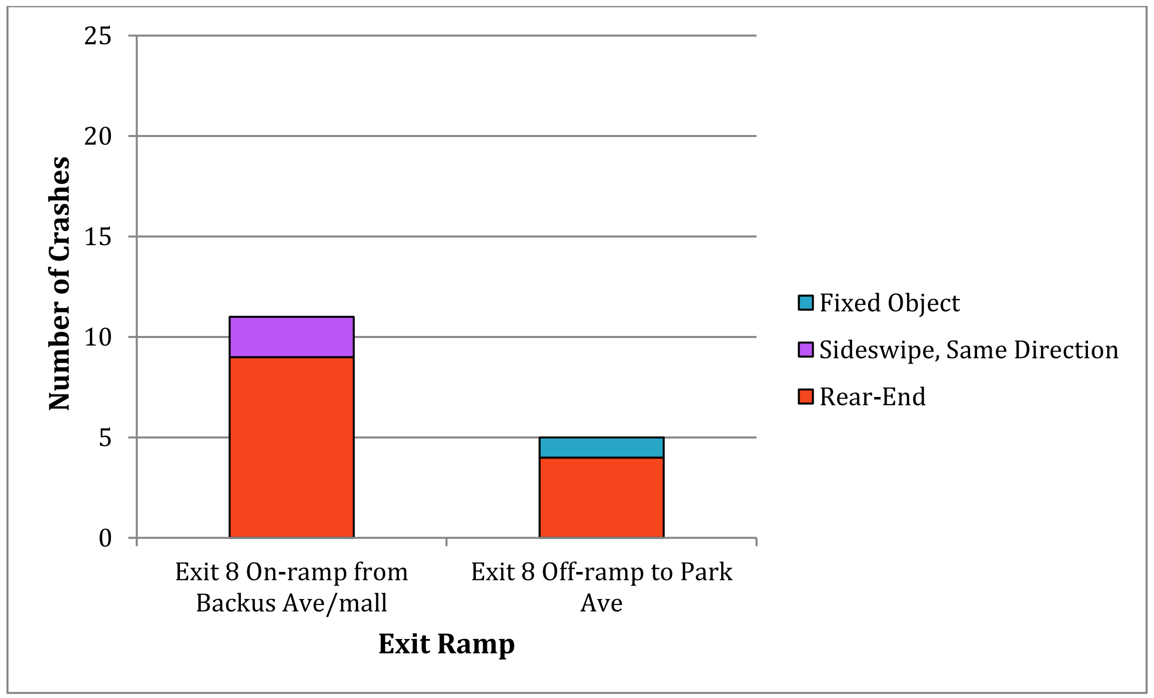
Of the 16 crashes reported, 14 (approximately 88 percent) were property damage only the remaining 2(approximately 12 percent) were injury related crashes. No fatalities were reported on any of the northbound ramps.

2.6.2.1.2.3 Types and Contributing Factors

Of the 16 crashes reported, 13 (approximately 81 percent) were rear-end, 2 (approximately 13 percent) were sideswipes, and 1 (approximately 6 percent) were fixed object.

As shown in **Figure 2-47**, the predominant crash type was rear-end at both ramp locations and in many cases caused by vehicles following too closely.

Figure 2-47 Route 7 Northbound – Ramp Crash Types



2.6.2.1.2.4 Trucks

There were no reported crashes involving medium to heavy trucks at these ramp locations.

2.6.2.1.2.5 Other Factors

Dark lighting condition was a cause for 6 out of 16 crashes (approximately 38 percent). Pavement condition was not a significant factor in crashes at these ramp locations.

2.6.2.1.3 Northbound Ramp Termini

2.6.2.1.3.1 Crash Rates

Table 2-115 below shows crash rates for the two (2) ramp termini locations associated with ramps in the northbound direction. The Exit 8 ramp termini with Backus Avenue shows a crash rate exceeding the threshold rate. This is mainly due to the high number of crashes combined with high traffic volumes.

The Exit 8 off-ramp ramp termini at Backus Avenue and Park Avenue was at the threshold rate of 0.99.

Table 2-115 Route 7 Northbound – Ramp Termini Crash Rates

Intersection / Ramp Termini	Crashes	Crash Rate (MEV)
Exit 8 NB On-ramp/Exit 8 SB Off-ramp at Backus Ave	**22**	**1.79**
Exit 8 NB Off-ramp at Backus & Park Ave	12	0.99

2.6.2.1.3.2 Severity

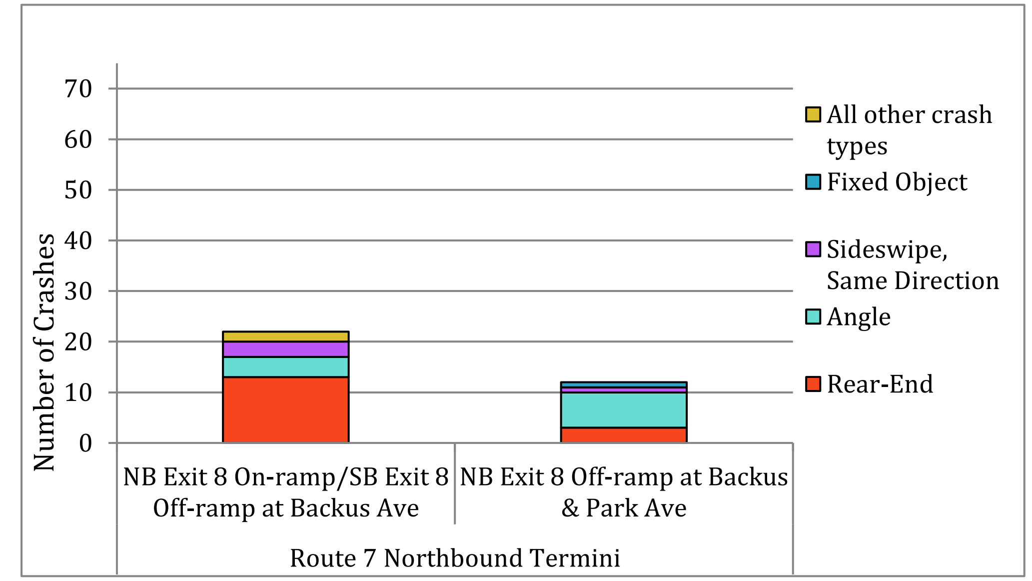
Of the 34 crashes reported, 24 (approximately 71 percent) were property damage only and the remaining 10 (approximately 29 percent) were injury related crashes. No fatalities were reported on any of the northbound ramps.

2.6.2.1.3.3 Types and Contributing Factors

Of the 22 crashes reported at the Exit 8 ramp termini with Backus Avenue, 13 (approximately 59 percent) were rear-end, 4 (approximately 18 percent) were angle, 3 (approximately 14 percent) were sideswipe, and the remaining 2 (approximately 9 percent) were other types.

Of the 12 crashes reported at the Exit 8 off-ramp termini with Backus Avenue/Park Avenue, 7 (approximately 58 percent) were angle, 3 (25 percent) were rear-end, and the remaining 2 (approximately 17 percent) were other types. **Figure 2-48** shows the ramp termini crash types along Route 7 in the northbound direction.

Figure 2-48 Route 7 Northbound – Ramp Termini Crash Types



2.6.2.1.3.4 Trucks

There was only one crash reported at the Exit 8 off-ramp termini with Backus Avenue/Park Avenue involving a medium to large truck.

2.6.2.1.3.5 Other Factors

Dark lighting condition was a high contributor to the crashes at the Exit 8 off-ramp termini with Backus Avenue/Park Avenue i.e. 5 out 12 (approximately 42 percent).

2.6.2.2 Southbound Direction

Of the 161 crashes reported on Route 7 southbound, 127 (approximately 79 percent) occurred on mainline segments and the remaining 34 (approximately 21 percent) occurred at an on/off ramp (entrance and exit ramp). No fatalities were reported on Route 7.

2.6.2.2.1 Southbound Mainline

For the Route 7 southbound mainline segments, majority of the 127 crashes reported occurred between the merge from the White Turkey Road Extension on-ramp and the exit ramp to I-84 eastbound (84 crashes or approximately 66 percent).

2.6.2.2.1.1 Crash Rates

The highest crash rate segment is the segment prior to diverge to the I-84 eastbound off-ramp. The crash rate is high because this segment carries high traffic volumes coupled with weaving movement into I-84 eastbound and westbound.

The segment between the I-84 eastbound ramp and the Federal Road on-ramp also shows a high crash rate mainly due to the merge with I-84 westbound specifically during the morning peak hour congestion.

Table 2-116 shows the crash rates for each of the segments on Route 7 southbound.

Table 2-116 Route 7 Southbound – Mainline Crash Rates

Segment From (Description)	Segment To (Description)	Number of crashes	Crash Rate (MVMT)
Exit 8	Exit 7	16	0.96
Exit 8	I-84 EB/WB	17	1.00
Exit 10 On-ramp (Federal Rd.)	I-84 EB Off Ramp	**10**	**3.68**
I-84 EB Off-Ramp	Exit 11 On-ramp (White Turkey Rd. Ext.)	**84**	**4.98**

Table 2-117 shows the injury and fatality crash rates for each of the segments on Route 7 southbound.

Table 2-117 Route 7 Southbound - Mainline Injury and Fatality Crash Rates

Segment From	Segment To	Number of Injuries	Number of Fatalities	Injury Crash Rate (MVMT)	Fatality Crash Rate (MVMT)
Exit 8	Exit 7	2	0	0.1	0.0
Exit 8	I-84 EB/WB	6	0	0.4	0.0
Exit 10 On-ramp (Federal Rd.)	I-84 EB Off Ramp	2	0	0.7	0.0
I-84 EB Off-Ramp	Exit 11 On-ramp (White Turkey Rd. Ext.)	**25**	**0**	**1.5**	**0.0**

Note: MVMT = Million Vehicle Miles of Travel

As shown in Table 2-119, the injury crash rate on the I-84 segment between the White Turkey Road Extension on-ramp and the I-84 ramps exceeds the statewide injury rate of 1.14.

2.6.2.2.1.2 Severity

Of the 127 crashes reported, 92 (approximately 72 percent) were property damage only, and the remaining 35 (approximately 28 percent) were injury related. There were no fatalities reported on the Route 7 southbound segments.

2.6.2.2.1.3 Types and Contributing Factors

Of the 127 crashes reported on the Route 7 southbound segments, 102 (approximately 80 percent) were rear-ends, 12 (approximately 9 percent) were sideswipes, 5 (approximately 4 percent) were fixed object, and the remaining 8 (approximately 7 percent) were other types.

As shown in **Figure 2-49**, majority of the crashes at the individual mainline segments were rear-end crashes. Specifically, the Route 7 segment between the Exit 11 on-ramp from White Turkey Road Extension and the I-84 split to eastbound ramps reported a total of 73 rear-end crashes (approximately 87%). The main cause of these crashes is the weaving movements coupled with vehicles following too closely.

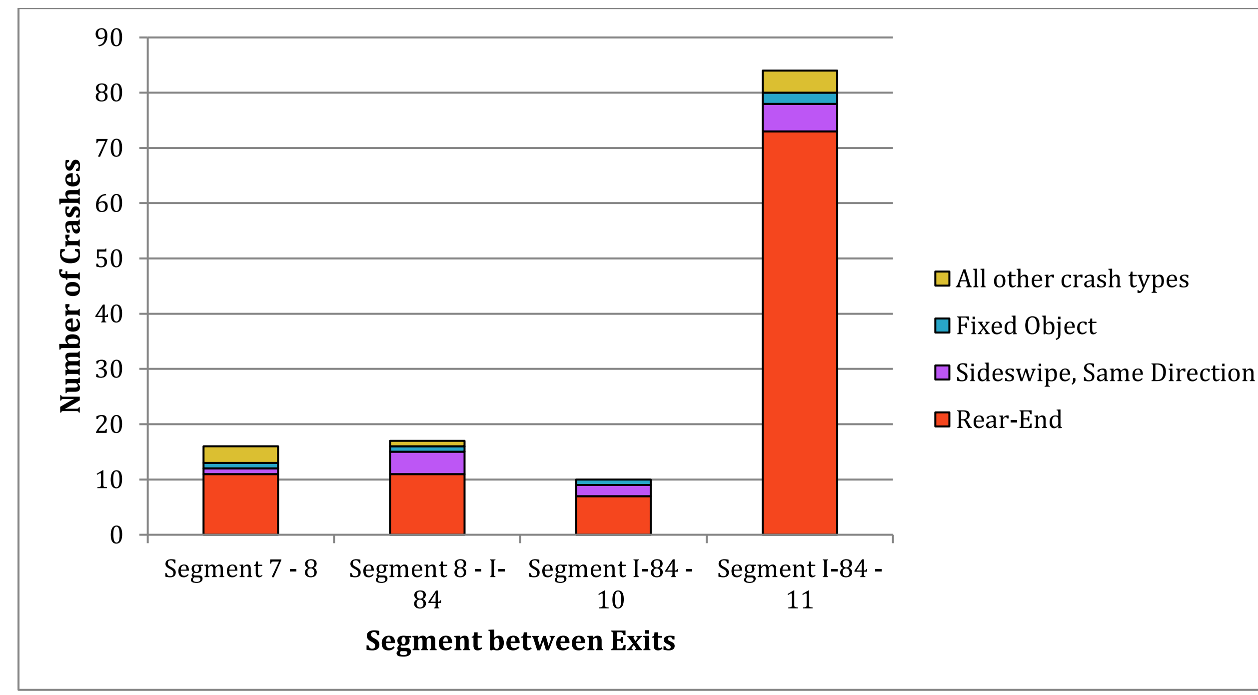
2.6.2.2.1.4 Trucks

Of the 127 crashes reported, medium to heavy trucks contributed to 10 crashes (approximately 8 percent). This is similar in percentage of medium to heavy trucks traveling this corridor on Route 7 in the southbound direction.

2.6.2.2.1.5 Other Factors

A significant number of mainline crashes (approximately 75 percent or more) occurred during daylight and dry pavement conditions. Overall, poor lighting and pavement conditions was not a significant contributor to segment crashes.

Figure 2-49 Route 7 Southbound – Mainline Crash Types



2.6.2.2.2 Southbound Ramps

For the Route 7 SB ramps, a total of 34 crashes were reported in the study corridor.

2.6.2.2.2.1 Crash Rates

Table 2-118 shows crash rates for the two (2) ramps in the study area on Route 7 southbound. The crash rates were below the threshold rate of 6.25.

Table 2-118 Route 7 Southbound – Ramp Crash Rates

Segment From (Description)	Number of Crashes	Crash Rate (MVMT)
Exit 8 Off-ramp to Backus Ave/Park Ave	22	5.31
Exit 10 On-ramp from Federal Road	12	4.24

2.6.2.2.2.2 Severity

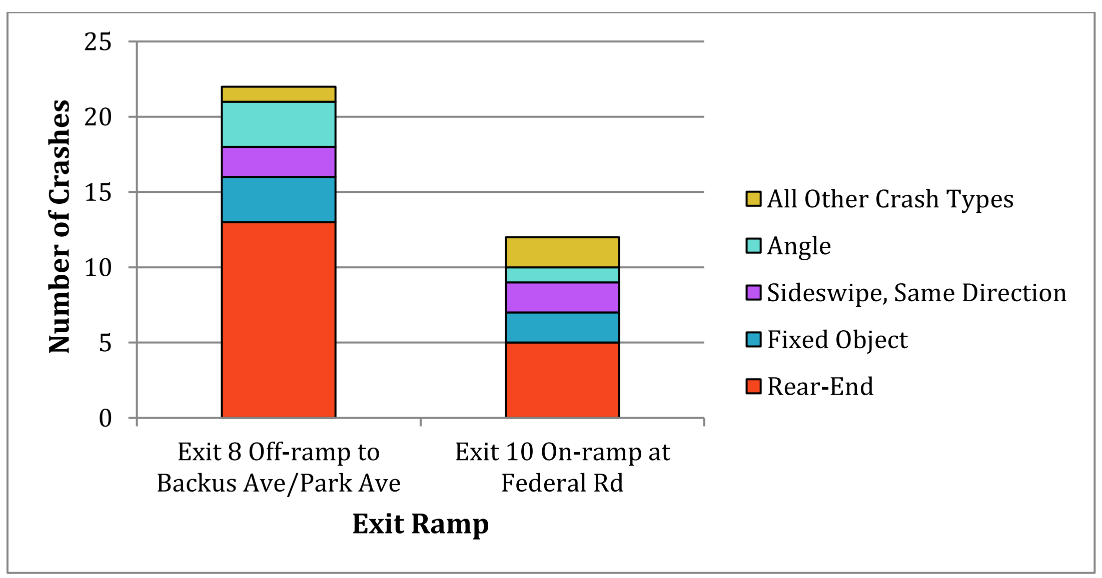
Of the 34 crashes reported, 29 (approximately 86 percent) were property damage only the remaining 5 (approximately 14 percent) were injury related crashes. No fatalities were reported on any of the southbound ramps.

2.6.2.2.2.3 Types and Contributing Factors

Of the 34 crashes reported, 18 (approximately 53 percent) were rear-end, 5 (approximately 15 percent) were fixed object, 4 (approximately 12 percent) were sideswipes, and remaining 7 (approximately 20 percent) were all other types.

As shown in **Figure 2-50**, the predominant crash type was rear-end at both ramp locations and in many cases caused by weaving movements in the short segment between the ramp merge and the exit.

Figure 2-50 Route 7 Southbound – Ramp Crash Types



2.6.2.2.2.4 Trucks

Of the 34 crashes reported, medium to heavy trucks contributed to 2 crashes (approximately 6 percent).

2.6.2.2.2.5 Other Factors

Dark lighting condition was a cause for 6 out of 12 crashes (approximately 50 percent) at the Federal Road on-ramp to Route 7 southbound. Pavement condition was not a significant factor in crashes at these ramp locations.

2.6.2.2.3 Southbound Ramp Termini

2.6.2.2.3.1 Crash Rates

Table 2-119 below shows crash rate for the one ramp termini location in the southbound direction. The crash rate for the Exit 10 on-ramp at Federal Road of 0.32 is well below the threshold rate of 0.99.

Table 2-119 Route 7 Southbound – Ramp Termini Crash Rates

Intersection / Ramp Termini	Crashes	Crash Rate (MEV)
Exit 10 On-Ramp at Federal Road	8	0.32

2.6.2.2.3.2 Severity

Of the 8 crashes reported at the Exit 10 on-ramp termini with Federal Road, 7 (approximately 88 percent) were property damage only and the remaining 1 (approximately 12 percent) was an injury related crash. No fatalities were reported at this termini location.

2.6.2.2.3.3 Types and Contributing Factors

Of the 8 crashes reported at the Exit 8 ramp termini with Federal Road, 5 (approximately 62 percent) were rear-end, 1 (approximately 13 percent) was angle, 1 (approximately 13 percent) was sideswipe, and the remaining 1 (approximately 12 percent) was angle type. Rear-end crashes are caused by vehicles turning into the on-ramp from Federal Road and following closely.

2.6.2.2.3.4 Trucks

There were two crashes (25 percent) reported at the termini with the Exit 10 on-ramp and Federal Road involving a medium to large truck.

2.6.2.2.3.5 Other Factors

Dark lighting or pavement condition was not a significant cause of crashes at the Exit 10 on-ramp termini with Federal Road.

2.6.2.3 Summary of Route 7 Crashes

Below is a summary of Route 7 crashes based on the data obtained on the most recent three-year period from 2014-16:

<u>**General**</u>

- Approximately 67 percent of crashes occurred in the southbound direction.
- More recent crash data shows approximately 29 percent decline in total crashes on Route 7 between 2015 and 2016.

Mainline Segments

- High crash rates were noted in the segment upstream of the merge with I-84 i.e. the Exit 8 on-ramp and I-84 in the northbound direction and the segments between White Turkey Road extension and I-84 eastbound off-ramp, and the Federal Road on-ramp and I-84 westbound in the southbound direction.
- The injury crash rate for the segment between the White Turkey Road extension on-ramp and the I-84 eastbound off-ramp exceeded the statewide average.
- Rear-end crashes were predominant cause on Route 7.

Ramps

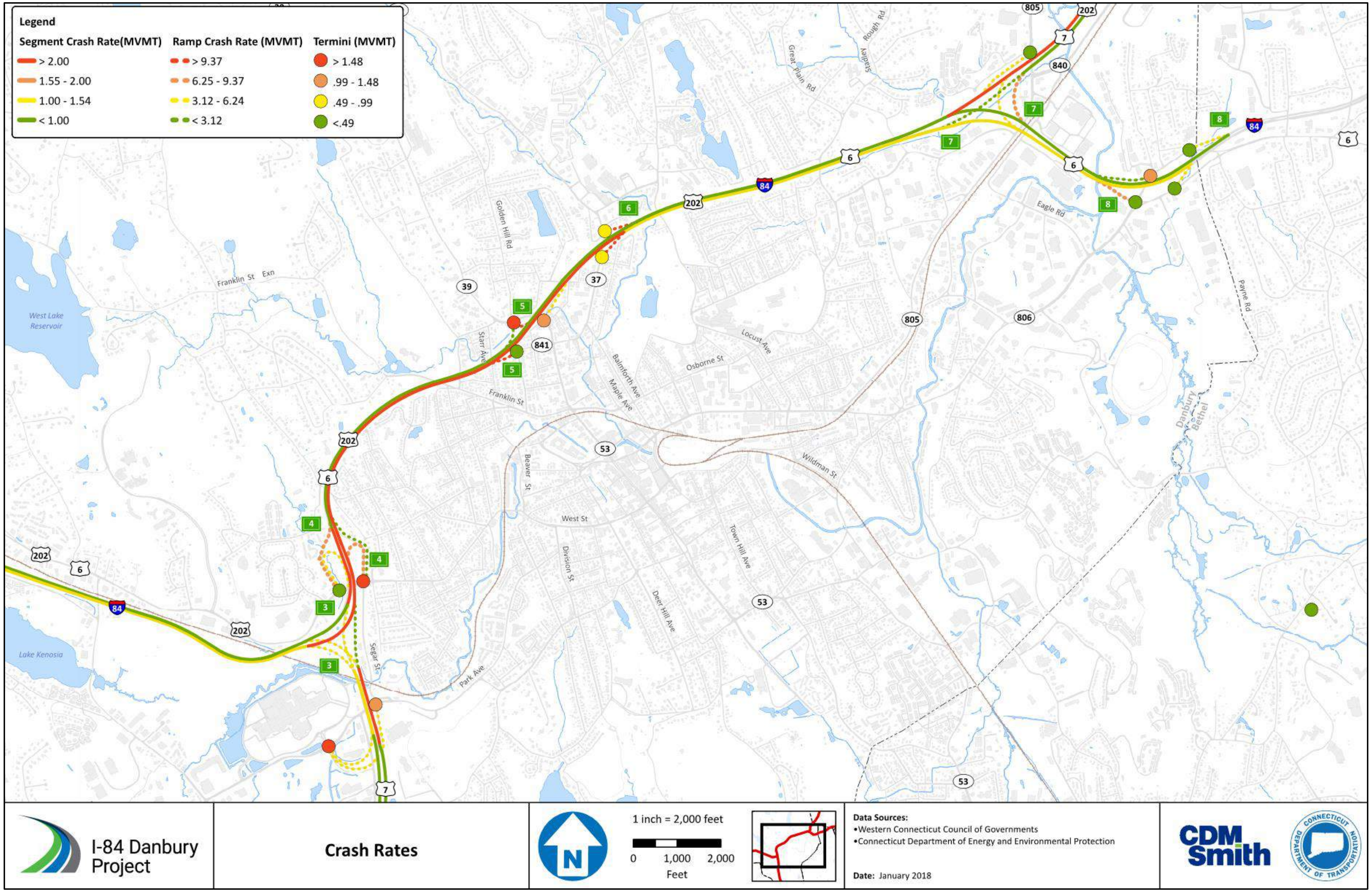
- None of the ramps exceeded the threshold crash rates of 6.25.
- Rear-end crashes were predominant cause at many ramp locations.

Termini

- High crash rates at the Route 7 - Exit 8 northbound/southbound ramp termini with Backus Avenue.
- Rear-end crashes were predominant cause at termini locations.

Figure 2-51 illustrates the crash rates for mainline segments and ramps on I-84 and U.S. Route 7 and ramp termini intersections.

Figure 2-51 Summary of I-84 and Route 7 Crashes



2.7 Multimodal Transportation

Existing Street Network

Interstate 84 and U.S. Route 7 dominate the surface transportation network in Danbury. Built in 1961, the expressways move as many as 110,000 vehicles per day; 50-60% of these vehicles represent “through” trips or vehicles passing through Danbury; 40-50% of these vehicles represent “local” vehicles whose trip begins or ends in Danbury and must therefore utilize I-84 on-and off-ramps to access local streets or arterials. A surprising large amount of this local traffic both begin and end their trips in Danbury, meaning that they use the interstate network for travel purely within the City. One explanation for why there are a large number of intracity travelers using I-84 is that the local street network does not have an efficient layout and does not have adequate capacity for the amount of traffic it carries.

As Danbury evolved from a small industrial city to an important regional center for commerce, it experienced a rapid growth of population[2], and as neighboring towns also experienced suburbanization and growth, the City’s network of urban streets and arterials have been not expanded commensurately. While some improvements have been constructed to increase capacities and to improve the efficiency of intersections, the overall structure of the City’s street network has largely remained unchanged. This is due to a combination of factors and constraints including dense urban development, topography and narrow rights-of-way. It is also due to the pattern of the City’s arterials and collector roads which took shape during the City’s founding and during the peak of the industrial revolution in the 19th century.

These main roads principally followed river valleys and emanated outward from the center of the City in a hub and spoke pattern. The growth and expansion of the City during the automobile era of the 20th century resulted in new, minor, residential streets but, aside from I-84 and US Route 7, few new arterials or major thoroughfares. Consequently, the City does not have a robust grid of streets that can meter and distribute traffic and accommodate the increasing demand for vehicular travel experienced over that last several decades.

While the City’s highway network is complemented by public transit service, including the Housatonic Area Regional Transit (HART) bus system and the Danbury Branch Line commuter rail owned by the Connecticut Department of Transportation (CTDOT) and operated by Metro-North, and while the City has made progress in addressing congestion on its streets and arterials with local capacity improvements, demand management programs, computerized signal systems and Intelligent Transportation System (ITS) upgrades, more can be done to balance transportation.[3]

The objective of this chapter is to identify current needs and deficiencies relative to multimodal travel systems, intermodal connectivity, and community connectivity. Specifically, we will review and assess non-motorized travel networks (walking and bicycling), transit systems, travel demand management tools and intermodal connectivity to:

a) better understand the needs and issues of all travel modes to and through Danbury;

b) assess whether the presence or function of I-84 might contribute to those deficiencies; and,

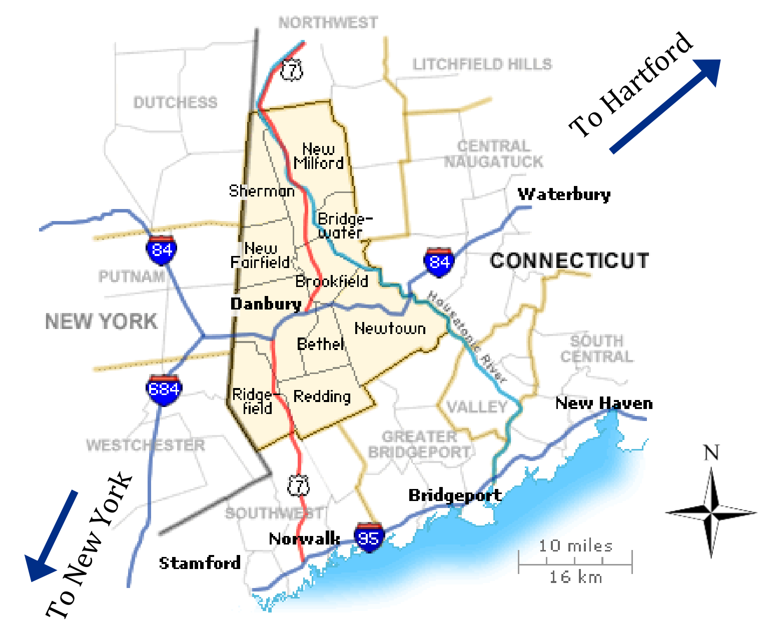
c) identify ways that the improvement of I-84 might address the City’s and the region’s multimodal needs.

2.7.1 Regional Context

Danbury is a city on the western border of Connecticut and lies halfway between Hartford and New York City, as shown in **Figure 2-52**. Interstate and regional travel on I-84 in greater Danbury is influenced by nearby interstate systems including:

- A major interchange between I-84 and I-684 just over the state border in New York that is only 6 miles west of Danbury;
- The interchange of I-84 and State Route 8 in Waterbury which lies 28 miles east of Danbury; and,
- I-95 which travels along the coast of Connecticut and runs through Norwalk, and which lies 18 miles south of Danbury, travelling along Route 7.

Figure 2-52 Greater Danbury Region Map



Source: Wikipedia user AirportExpert, https://en.wikipedia.org/wiki/Greater_Danbury#/media/File:Greater_Danbury_Map.gif

[2] City of Danbury Department of Planning and Zoning, “City of Danbury Transportation Plan 2005”. October, 2005.

[3] Ibid.

Population

The current estimated population of Danbury is 84,000. According to the City's most recent Plan of Conservation and Development (2013), the population of Danbury increased by 23 percent in the 20 years between 1993 and 2013. Also, over that 20-year span, the number of housing units increased by 20 percent and the number jobs grew by 22 percent.[4] This relatively rapid growth of population and development occurred as the City experienced its decline as a manufacturing center and its emergence as a corporate office and retail center, changing the City's physical form in the process.

As indicated in **Table 2-120**, Danbury's population is projected to continue to increase between 2015 and 2025 and at a much higher rate than the surrounding towns and the rest of Connecticut. Surrounding towns within the Greater Danbury area are expected to see stagnation in population growth or a decrease in population.

Table 2-120 – Population Projections

Population Projections for Greater Danbury, 2015-2025			
	2015	2025	% Increase
Danbury	84,147	90,594	7.7%
New Fairfield	13,619	12,910	-5.2%
Brookfield	16,635	16,740	0.6%
Bethel	18,632	18,267	-2.0%
Redding	9,193	9,223	0.3%
Ridgefield	24,618	24,342	-1.1%
Greater Danbury	166,844	172,076	3.1%
State of Connecticut	3,644,546	3,746,184	2.8%
Fairfield County	932,378	954,479	2.4%

Source: Connecticut Population Projections 2015-2025; November 1, 2012 edition; The University of Connecticut State Data Center.

At the same time that the City transitioned its economy to a regional center of corporate commerce, the City experienced an influx of immigrants of various racial and ethnic backgrounds. This diversity of people is evidenced by the 45 different languages that can be heard at City schools and on City streets.[5] The concentration of racial and ethnic diversity is most pronounced in downtown Danbury and in the neighborhoods that lie to the north of downtown and that stretch along I-84. According to data from the U.S. Census Bureau, these racially and ethnically diverse neighborhoods also have among the highest rates of low-income households in the City. These neighborhoods may therefore meet federal and state definitions of Environmental Justice Communities.

[4] City of Danbury Planning Commission, "City of Danbury Plan of Conservation and Development." 2002, as Amended 2013. Page 3.

2.7.2 Environmental Justice Communities

Environmental Justice (EJ) is defined as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin or income, with respect to the development, implementation and enforcement of environmental laws, regulations, and policies."

Federal Executive Order 12898, "*Federal Actions that Address Environmental Justice in Minority Populations and Low-Income Populations*," directs federal agencies to consider EJ when identifying and addressing potential environmental, social and economic impacts. Also, Title VI of the Civil Rights Acts of 1964 requires federal agencies to ensure that all programs or activities that receive federal assistance, and that have the potential to affect human health or the environment, do not discriminate on the basis of race, color, or national origin.

In support of Executive Order 12898, the U.S. Department of Transportation (USDOT) issued Order 5610.2, "*Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (*May 10, 2012), which establishes steps to prevent disproportionately high and adverse effects to minority or low-income populations when constructing or reconstructing transportation systems or in the provision of transportation programs. Accordingly, federal agencies, and state agencies receiving federal funds (such as CTDOT), must avoid, minimize, or mitigate disproportionately high and adverse human health or environmental effects on minority and low-income populations and must ensure the full and fair participation by all potentially affected communities in the transportation decision-making process.

In addition, CTDOT *Title VI Program* (March 31, 2014) provides guidance on performing EJ/Title VI assessments for projects and programs requiring National Environmental Policy Act (NEPA) and Connecticut Environmental Policy Act (CEPA) documentation. It also and defines Title VI to include providing meaningful access for limited English proficiency (LEP) populations.

The identification and engagement of EJ communities is important to the Federal Highway Administration (FHWA) and the CTDOT because it will improve awareness of the needs of EJ populations and enable full and fair participation by potentially affected communities in the planning, development, construction, operation and maintenance of the I-84 Danbury Project.

Low income and minority households and individuals that live within EJ communities are typically more transit-dependent than households and individuals that live in other, more affluent neighborhoods. Households within EJ communities tend to own fewer or no cars; therefore, individuals that live in these households are more reliant on public transit for their daily transportation needs. These households and individuals are traditionally underserved by existing transportation systems and often under-represented in the transportation decision-making process. CTDOT and the project team will seek out and consider the unique needs of residents in EJ communities during every phase of project planning and development. The consideration of EJ will improve mobility options and access to jobs for all residents and result in a project that is more equitable. A detailed Title VI and EJ analysis for this project will be conducted under the NEPA Environmental Assessment (EA) and the CEPA Environmental Impact Statement (EIS) processes. This NEPA/CEPA environmental documentation will include an analysis of current U.S. Census Bureau and American Community Survey (ACS)

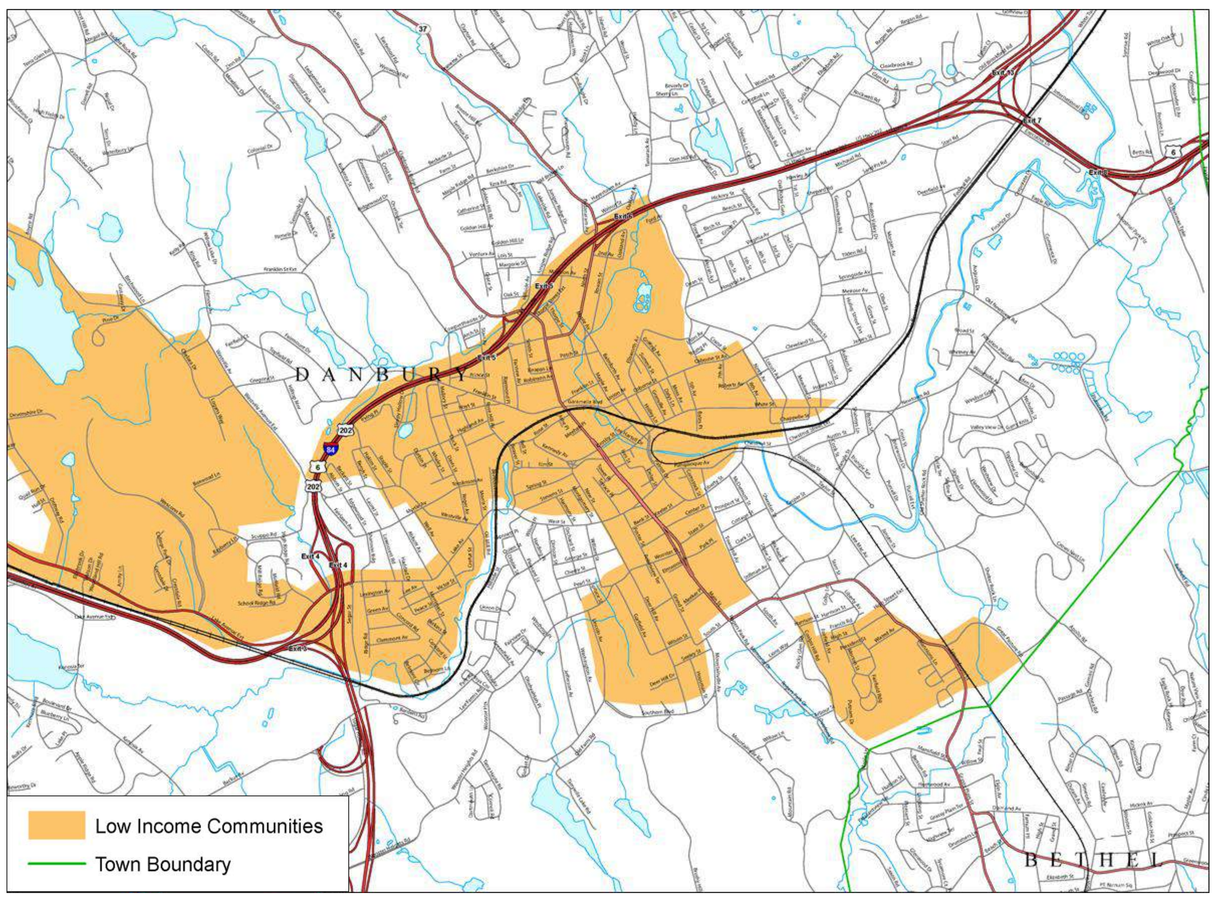
[5] Ibid.

data for census tracts encompassing the project area; including the identification of minority, low-income, and limited English proficiency (LEP) populations.

The NEPA/CEPA processes will also: 1) determine benefits to and potential negative impacts on minority, low-income, and LEP populations for project alternatives; 2) quantify expected effects (total, positive and negative) and disproportionately high and adverse effects on minority, low-income, and LEP populations; and, 3) determine the appropriate course of action, whether avoidance, minimization, or mitigation.

For the purpose of this Needs and Deficiencies Study, the project team preliminarily identified the limits of EJ communities within the project area. These limits were developed from available mapping from the Connecticut Department of Energy and Environmental Protection (CTDEEP) that show EJ communities on a U.S. Census block level. CTDEEP criteria for low income populations are U.S. census blocks where 30% of the population lives below 200% of the federal poverty level. **Figure 2-53** depicts this preliminary mapping of EJ communities in the vicinity of I-84 in Danbury.[6] The map reveals that the EJ neighborhoods in Danbury are clustered in downtown Danbury and along the I-84 corridor.

Figure 2-53 – Environmental Justice Communities Map



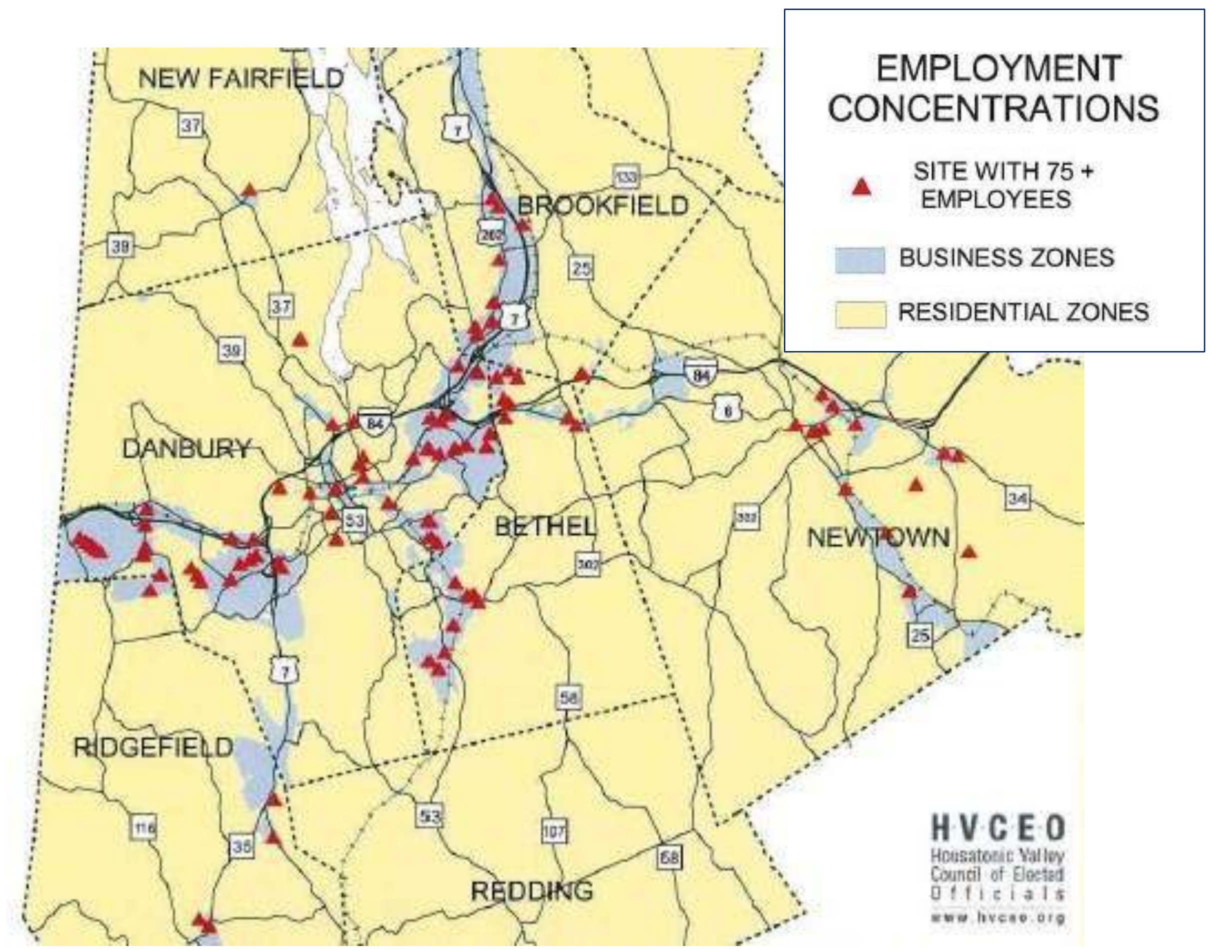
Source: Connecticut Department of Energy and Environmental Protection, January 2009

2.7.3 Land Use and Employment

Within Danbury, there are several major business zones and employment centers. **Figure 2-54** shows sites in the Greater Danbury area that provide more than 75 jobs. Most of these major employers fall along the I-84 and Route 7 corridors. Among these major employers are Western Connecticut State University, which operates two separate campuses in the City, as well as the Danbury Fair Mall, and Danbury Hospital. Other major employers within Danbury are Boehringer-Ingelheim, Cartus, GE Commercial Finance, Pitney Bowes, Praxair, and UTC Aerospace Systems.

As a center of employment, Danbury has many inbound commuters as indicated in **Table 2-121**. Aside from Danbury, the top five cities people commute from are Bethel, Waterbury, Norwalk, Bridgeport and Stamford. Many Danbury residents also commute to other cities within the region, such as Stamford, Norwalk, New York City, Ridgefield and Bethel also as indicated in Table 2-123.

Figure 2-54 – Major Employer Map



Source: Western Connecticut Council of Governments (WestCOG)

[6] http://www.ct.gov/deep/lib/deep/environmental_justice/maps/danbury.pdf

Table 2-121 – Commuter Context

Commuters into City From:		City Residents Commuting To:	
Top Ten Cities			
Danbury, CT	12,721	Danbury, CT	12,721
Bethel, CT	1,170	Stamford, CT	1,338
Waterbury, CT	965	Norwalk, CT	992
Norwalk, CT	920	New York, NY	943
Bridgeport, CT	802	Ridgefield, CT	784
Stamford, CT	655	Bethel, CT	665
New Milford, CT	631	Bridgeport, CT	432
New York, NY	607	Shelton, CT	400
Shelton, CT	464	Hartford, CT	396
Naugatuck, CT	456	Waterbury, CT	365
All Others	25,529	All Others	17,581
County-to-County			
Fairfield County, CT	26,964	Fairfield County, CT	24,693
New Haven County, CT	5,074	New Haven County, CT	2,558
Litchfield County, CT	4,890	Westchester County, NY	2,310
Hartford County, CT	1,751	Hartford County, CT	1,800
Putnam County, NY	1,181	Litchfield County, CT	1,111
Westchester County, NY	1,020	Putnam County, NY	1,025
Dutchess County, NY	963	New York County, NY	607
Middlesex County, CT	340	Dutchess County, NY	309
New London County, CT	337	New London County, CT	201
All Others	2,400	All Others	2,003

Source: U.S. Census Bureau, Center for Economic Studies https://onthemap.ces.census.gov/

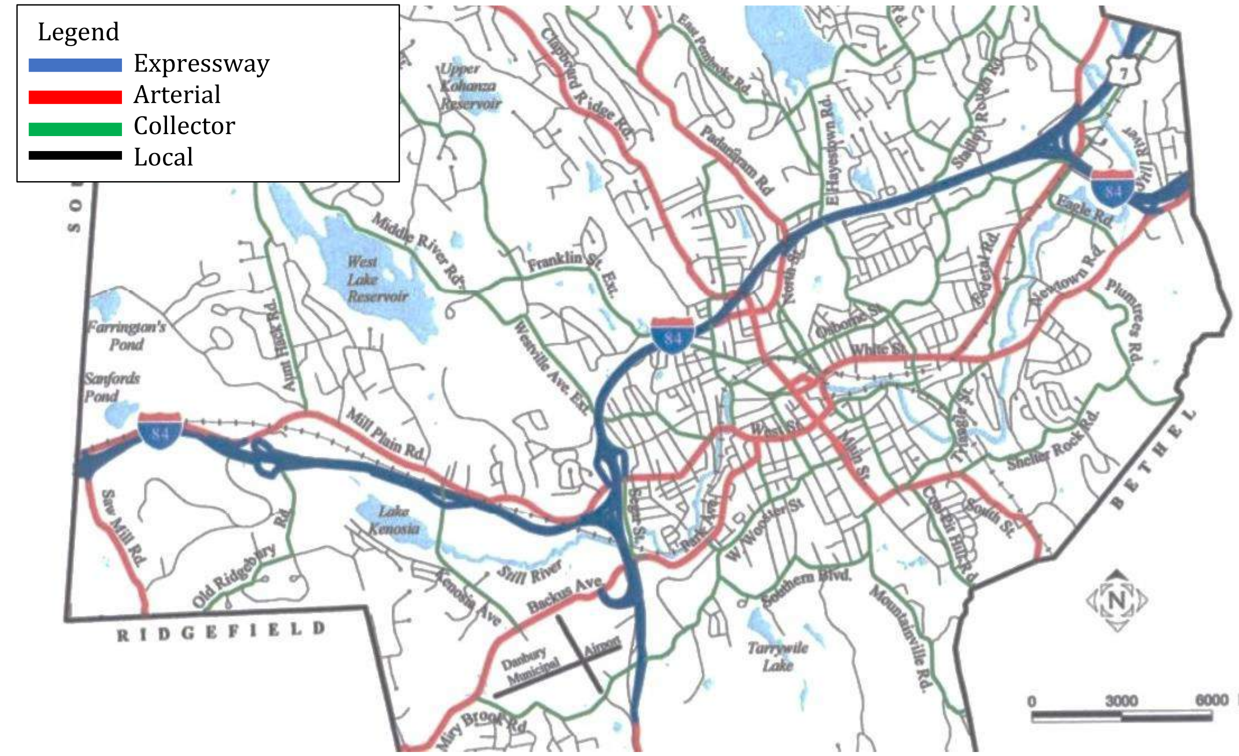
2.7.4 Non-Motorized Transportation

2.7.4.1 Overview of Non-Motorized Travel in Project Area

There are notable deficiencies that affect non-motorized travel – specifically pedestrian and bicycle travel – in the vicinity of the I-84 Danbury corridor. Danbury's existing street network shown in **Figure 2-55**, with its narrow travel lanes and high volume of relatively fast traffic, presents challenges for pedestrian and bicycle connectivity and safety. This is particularly true where the street network intersects the highway and interchanges. These locations experience heavy traffic volumes and relatively fast vehicle speeds, and often consist of multiple travel and turning lanes. With conditions of this nature, these streets are perceived as "impermeable" to pedestrian and bicycle travel.

While the challenges to accommodate pedestrians and bicycles on Danbury's busy and complex streets are many, an analysis of the area presents several opportunities for the development of a pedestrian and bicycle network that would connect people, land uses, and neighborhoods on one side of I-84 to the many nearby and important destinations on the other side of I-84. This would not only improve the safety of non-motorized travel in the project area, but also better connect neighborhoods, improve urban mobility by increasing access to bus stops and other transit facilities, and improve transportation choice - thereby improving access to jobs, education, and other resources.

Figure 2-55 – Functional Classification of Danbury Streets



Source: City of Danbury, Plan of Conservation and Development, 2013. https://www.danbury-ct.gov/government/departments/planning-zoning/

2.7.4.2 Land Uses That Generate or Attract Pedestrians and Bicyclists

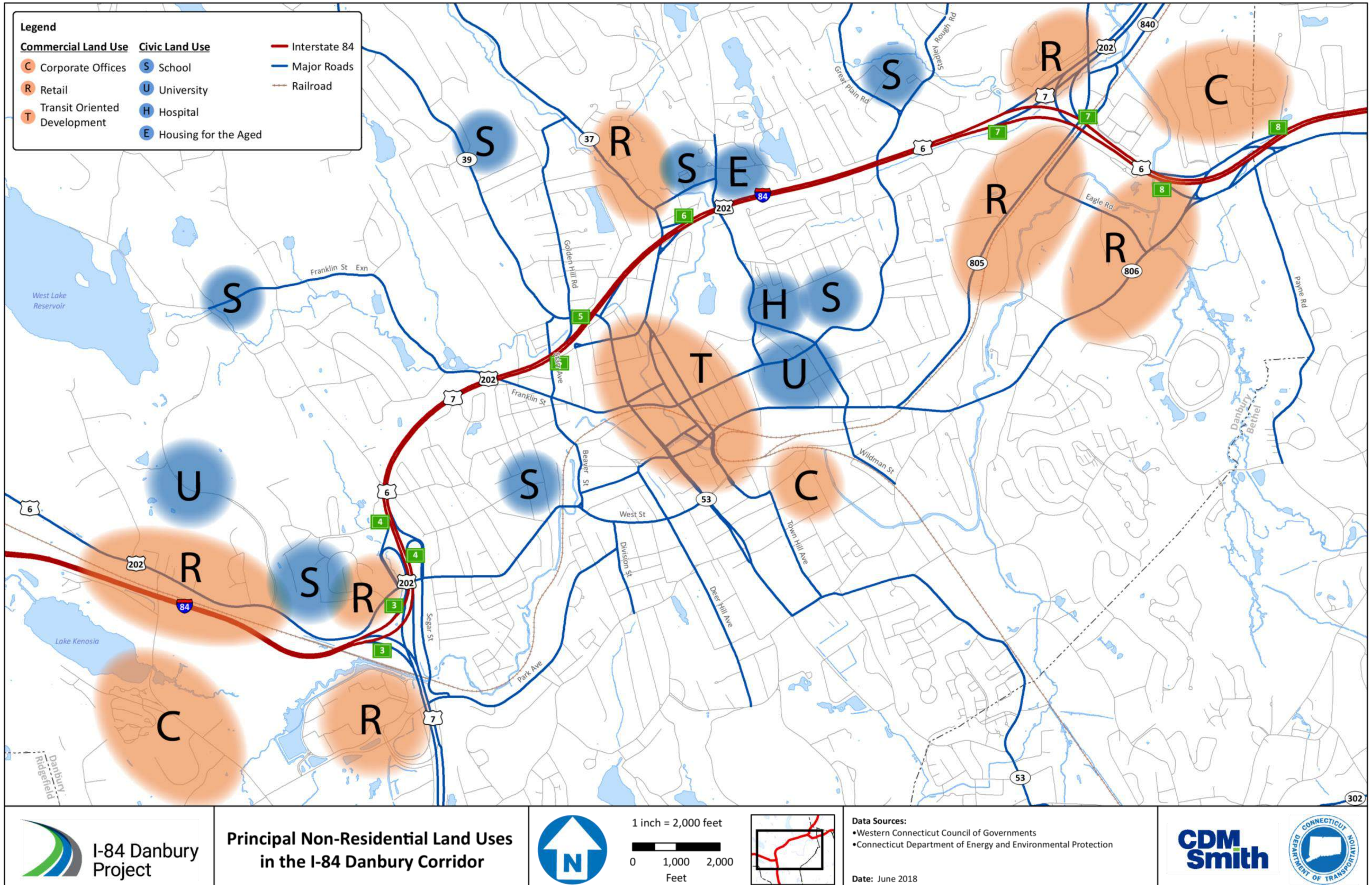
Land use patterns and the street network around the I-84 corridor indicate a potential latent demand for pedestrian travel. Both sides of I-84 are densely developed with various land uses, including retail stores, medical offices and other commercial services, churches and other religious buildings, schools, universities, hospitals, retirement homes and residential development comprised of a mix of single family homes, multi-family homes, condominiums, and apartment buildings. **Figure 2-56** provides an overview of key non-residential land uses in the I-84 Danbury project area.

In addition, many of the residential neighborhoods in the vicinity of I-84 are populated by minority, immigrant, limited English proficiency, and low-income individuals and families. These Environmental Justice (EJ) communities, which are depicted in Figure 2-53, often have few or no cars per household and are therefore more dependent on walking, bicycling, and public transit systems. Residents of EJ neighborhoods are traditionally underserved by existing transportation systems and are more likely to face challenges accessing employment and other services.

These proximate and complimentary land uses, including densely populated neighborhoods, represent generators or attractors of non-motorized travel (origins and destinations of pedestrian and bicycle travel). That is, many of these uses house or accommodate populations that, given appropriate and safe infrastructure for non-motorized travel, would prefer to walk or bicycle among the various land uses, many of which are located on the opposite side of the highway. These population cohorts include young people and older folks who are either too young or too old to drive a motor vehicle or prefer not to drive a motor vehicle, and people from limited economic means who live close to the highway and who may not own or have access to an automobile.

For example, residents of retirement or nursing homes located one-quarter to one-half mile north of I-84 might readily walk or bicycle to the hospital or medical offices located one-half mile south of I-84. Similarly, students of Danbury High School located one-mile north of I-84 and of several elementary schools located within 1,000 feet of the highway, might prefer to walk or bicycle to school from their homes on the opposite side of the highway. In addition, nearly all land uses on the north side of I-84 have residents, workers, patrons, or visitors that might prefer to walk or bicycle to the numerous civic, educational, institutional, and commercial land uses and transportation assets located one-half mile south of I-84 in downtown Danbury.

Figure 2-56 – Principal Non-Residential Land Uses in the I-84 Danbury Corridor



2.7.4.3 Pedestrian and Bicycle Desire Lines and Gaps

The I-84 Danbury project team reviewed and assessed land uses and development patterns on either side of the interstate and identified 12 pedestrian-bicycle "desire lines" across I-84. In the context of this study, a pedestrian-bicycle desire line is the most direct or desirable route between significant pedestrian or bicycle generators and significant pedestrian or bicycle destinations.

These preliminary desire lines, which are depicted in **Figure 2-57**, should be discussed with and reviewed by Danbury residents, area workers, and visitors to confirm travel patterns and non-motorized mobility issues. This will help the project team identify routes most used by pedestrians and bicyclists on a daily basis, as well as routes likely to experience an increased number of pedestrians and bicyclists if pedestrian and bicycle accommodations were provided. The identification of public confirmation of these desired lines will allow the I-84 team to focus safety improvements where there is or will be the highest concentration of pedestrians and bicyclists and where there is the greatest need to connect people to jobs, transit, education and services.

Potential desire lines are mapped by the project team generally located on the 19 streets or arterials that cross I-84 within the project area. These crossing streets were assessed for their ability to safely accommodate pedestrian and bicycle travel, as discussed in sections to follow.

It is important to note that the longest inferred desire line is a potential greenway that runs east-west through the project area. This potential greenway corridor is coincident with the Maybrook Line, currently owned and used for limited freight rail transport by the Housatonic Railroad Company (HRRC). The rail corridor used to have two sets of railroad tracks, however, currently, only one set of tracks remains.

Residents of greater Danbury have expressed a desire for better and safer pedestrian and bicycle travel to and through downtown Danbury from east to west. The Maybrook Line represents an opportunity to provide a continuous, dedicated, east-west pedestrian and bicycle corridor or greenway. This greenway could be constructed within the HRRC right-of-way in the alignment of the set of tracks that were removed; albeit with proper fencing to separate occasional freight rail use from pedestrians and bicyclists.

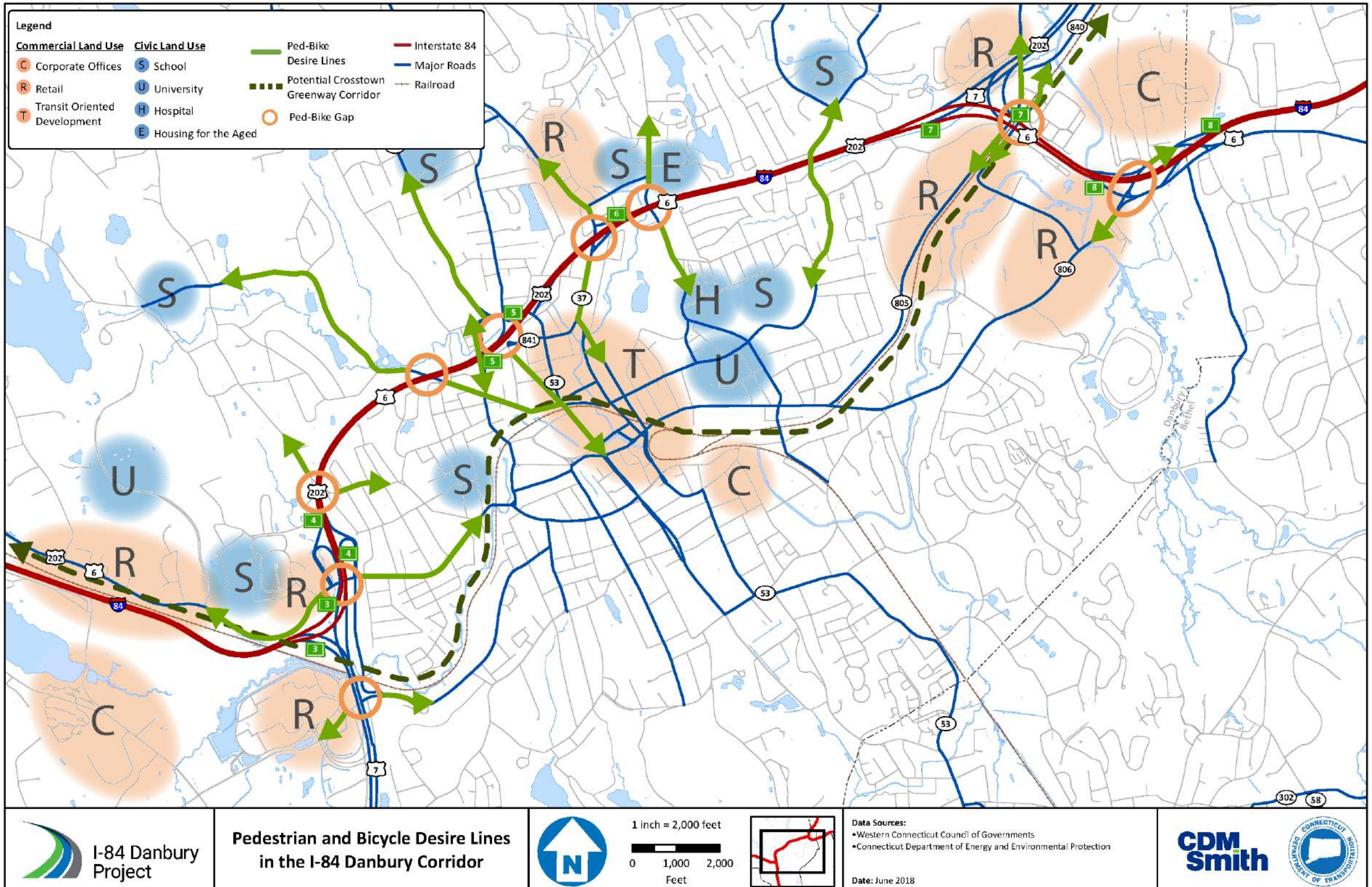
The transportation value of this "crosstown" connection - labeled on Figure 2-57 as "Potential Crosstown Greenway Corridor" - is significant considering the current lack of other east-west bicycle routes across the city due to the hub-and-spoke nature of Danbury's street network. It would connect downtown Danbury to centers of employment, residences, and commerce such as the Danbury Fair Mall, Western Connecticut State University (both the Midtown and Westside Campuses), the numerous corporate office parks on the periphery of the city center, and the vast residential neighborhoods that consist of minority, low-income, and limited English proficiency populations.

This crosstown greenway could also, ultimately, provide a non-motorized commuting pathway between population centers in New York State, just west of the Danbury border, to downtown Danbury and employment centers in greater Danbury. This is because the New York State Department of Transportation (NYDOT) is converting the New York portion of the Maybrook Line to a multi-use trail (pedestrian and bicycle). This new "Maybrook Trailway" will connect the western border of Danbury in the adjacent Putnam County, to Brewster, New York. Currently, the Maybrook Trailway runs from Lake Tonetta in Brewster, New York east to the general vicinity of the I-84 – I-684 interchange.

The technical feasibility of collocating a shared-use path along an active and privately-owned freight railroad and potential future passenger transit line[7] will require much planning and the cooperation of numerous parties including the NYSDOT, CTDOT and HRRC.

[7] Reference to Danbury TOD Study and mention of rail connection between Danbury station and Southeast/Brewster station

Figure 2-57 – Pedestrian and Bicycle Desire Lines in the I-84 Danbury Corridor



2.7.5 Pedestrian Travel

2.7.5.1 Sidewalks and Pedestrian Routes

While downtown Danbury has a fairly cohesive network of sidewalks for pedestrian travel, this network becomes fragmented away from the city center. One-half mile north of downtown Danbury, where I-84 travels through the city, many local streets that cross above and below I-84 lack continuous sidewalks, crosswalks, and other pedestrian accommodations.

As indicated on **Figures 2-58, 2-59, and 2-60**, prominent gaps exist in this sidewalk network, especially where local streets cross above or under I-84. These local streets are characterized by underpass or overpass bridges and streets with limited paved shoulders and generally do not accommodate continuous, connected sidewalks. Further, several of these streets and arterials that cross I-84 intersect with relatively high-speed on-ramps and off-ramps associated with the interchanges of the expressway. Often, these intersections that process traffic from the on- and off-ramps of I-84 to the local streets are designed principally for the fluid movement of vehicles, including, significantly, large vehicles such as semi-trailer trucks that require broad turning radii. Many of these interchange interfaces lack sidewalks and crosswalks entirely and none provide bicycle lanes.

The combination of significant traffic volumes, numerous turning lanes, relatively high-speed traffic, greater volume of large vehicles and lack of pedestrian or bicycle accommodations at the interchanges results in intersections that are not only pedestrian and bicycle un-friendly, but also very intimidating for pedestrians and bicyclists to travel on. Further, many of these ramp interchanges do not intersect the local street at 90 degrees; they intersect the local street at an acute angle. This awkward angle of intersection compromises the safety of pedestrians and bicyclists travelling on the local street because: a) vehicles travelling to or from the I-84 ramps can travel at much higher speeds due to very broad radii; and, b) motorists merging onto the local streets from the ramps have to crane their necks to see on-coming traffic on the local street, which diverts their attention to pedestrians travelling from the opposite direction.

Within the project area, a total of 19 streets, arterials, or state highways cross I-84 and Route 7. Characteristics of these 19 local streets can be found in **Table 2-122**. The I-84 Danbury project team assessed each of these grade-separated crossings to determine the degree to which they safely accommodate pedestrians and bicyclists and to understand the highway's effects on local streets and intra-city mobility. This pedestrian and bicycle compatibility assessment investigated and documented numerous elements that affect the safety and comfort of pedestrians and bicyclists and facilitate non-motorized travel. More on this topic can be found in the following sections and in Appendix A including the location and incidence of crashes between motor vehicles and pedestrians or bicyclists—refer to **Figure 2-61**.

Table 2-122 – Characteristics of Local Streets

Local Street	Functional Classification	HART Bus Routes	Land Uses	Environmental Justice Community
1. Miry Brook Rd - Wooster Heights (at Sugar Hollow Rd)	Collector	-	Retail Jobs	-
2. Backus Ave - Park Ave (at Sugar Hollow Rd)	Arterial	Route 6	Retail	-
3. Segar St (at Mall Access Rd)	Collector	Route 6	Retail	Yes
4. Lake Ave (at Segar St)	Arterial	Route 3 Route 6	Retail School	Yes
5. Westville Ave (at Scuppo Rd)	Collector	-	Residential	Yes
6. Franklin St (at Davis St)	Collector	Route 3	Residential	Yes
7. Starr Ave - Downs St (at Fairview Ave)	Arterial	-	Residential	Yes
8. Main St (at Golden Hill Rd)	Arterial	Route 1	Residential Transit-Oriented Development	Yes
9. Madison Ave (at Juniper Ridge Dr)	Local	-	Residential	Yes
10. North St (at Exit 6)	Arterial	-	Retail School	Yes
11. Tamarack Ave (at Hayestown Ave)	Collector	Route 1	School Housing for the Aged	Yes
12. Great Plain Rd (at Carolyn Ave)	Collector	-	Residential School	-
13. Rockwell Rd (at Sand Pit Rd)	Local	Route 1	Residential	-
14. Federal Rd (at White Turkey Rd)	Arterial	Route 4 Route 7	Retail	-
15. Federal Rd (at Old Brookfield Rd)	Arterial	Route 4 Route 7	Retail	-
16. Federal Rd (at Starr Rd)	Arterial	Route 4 Route 7	Retail	-
17. Eagle Rd (at Executive Dr)	Collector	-	Retail	-
18. Newtown Rd (at Exit 8)	Arterial	Route 2	Retail	-
19. Stony Hill Rd (at Exit 8)	Arterial	Route 2	Retail	-

Figure 2-58– Sidewalk Network – West

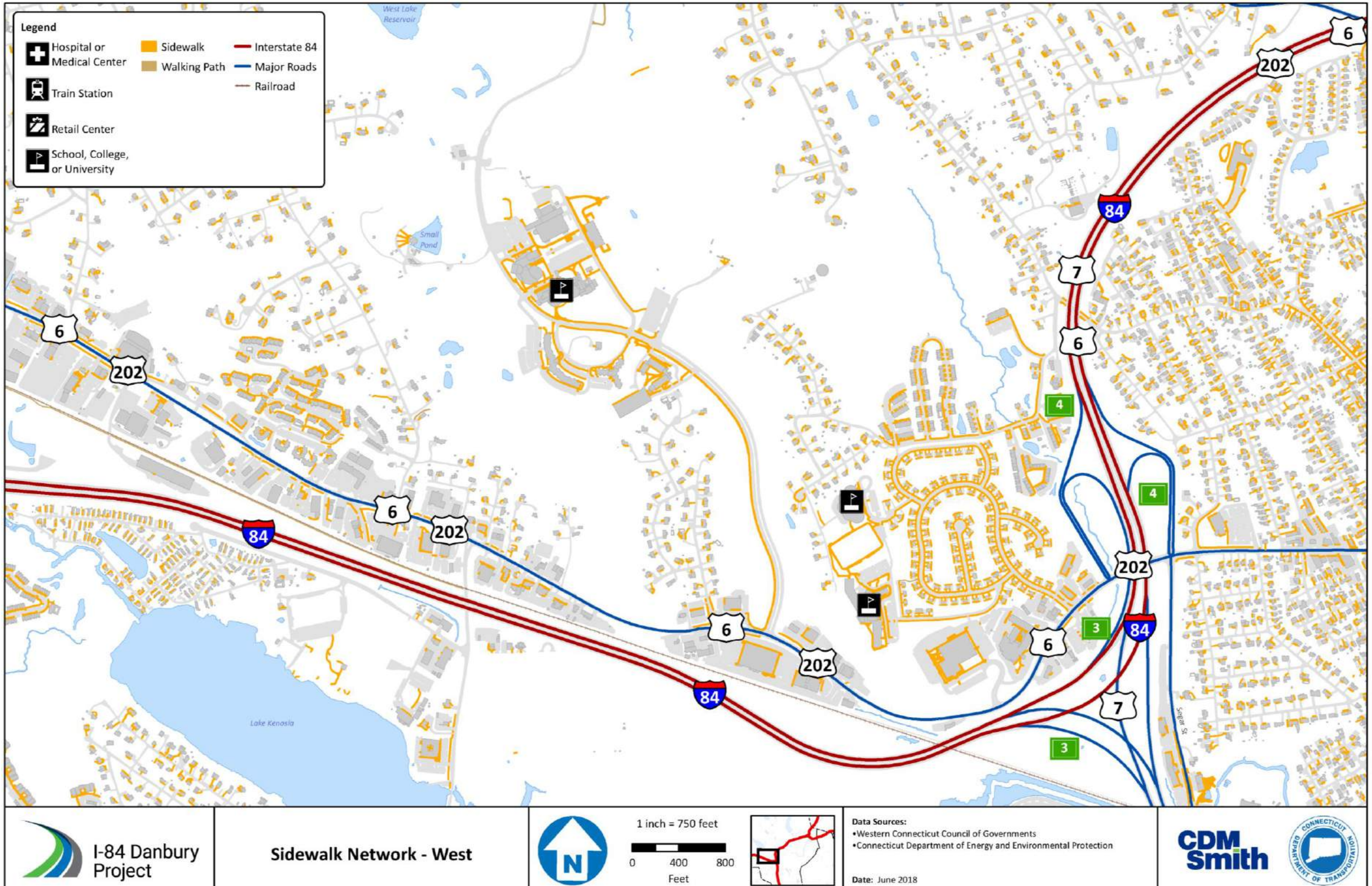


Figure 2-59 – Sidewalk Network – Center

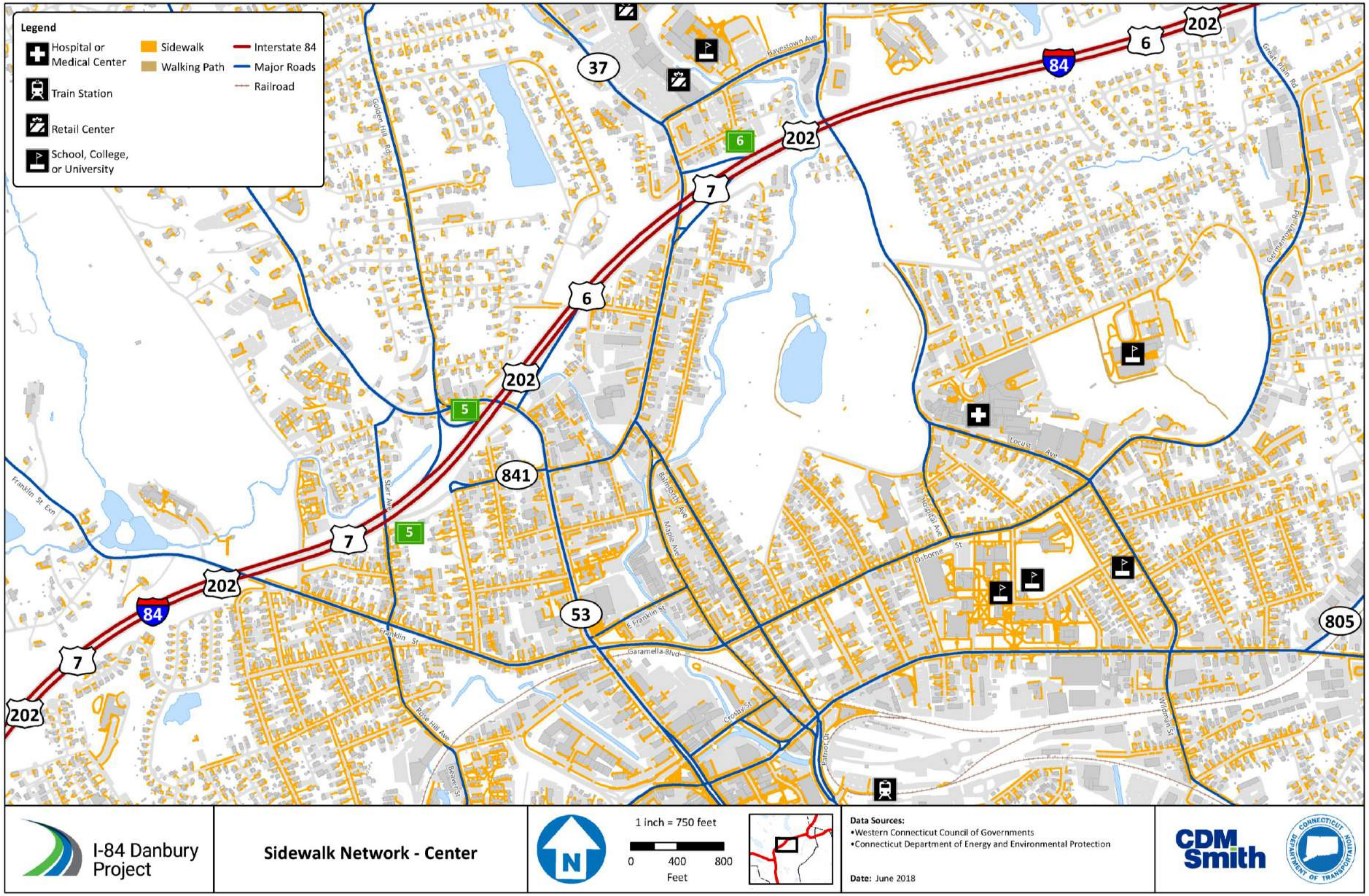


Figure 2-60 – Sidewalk Network – East

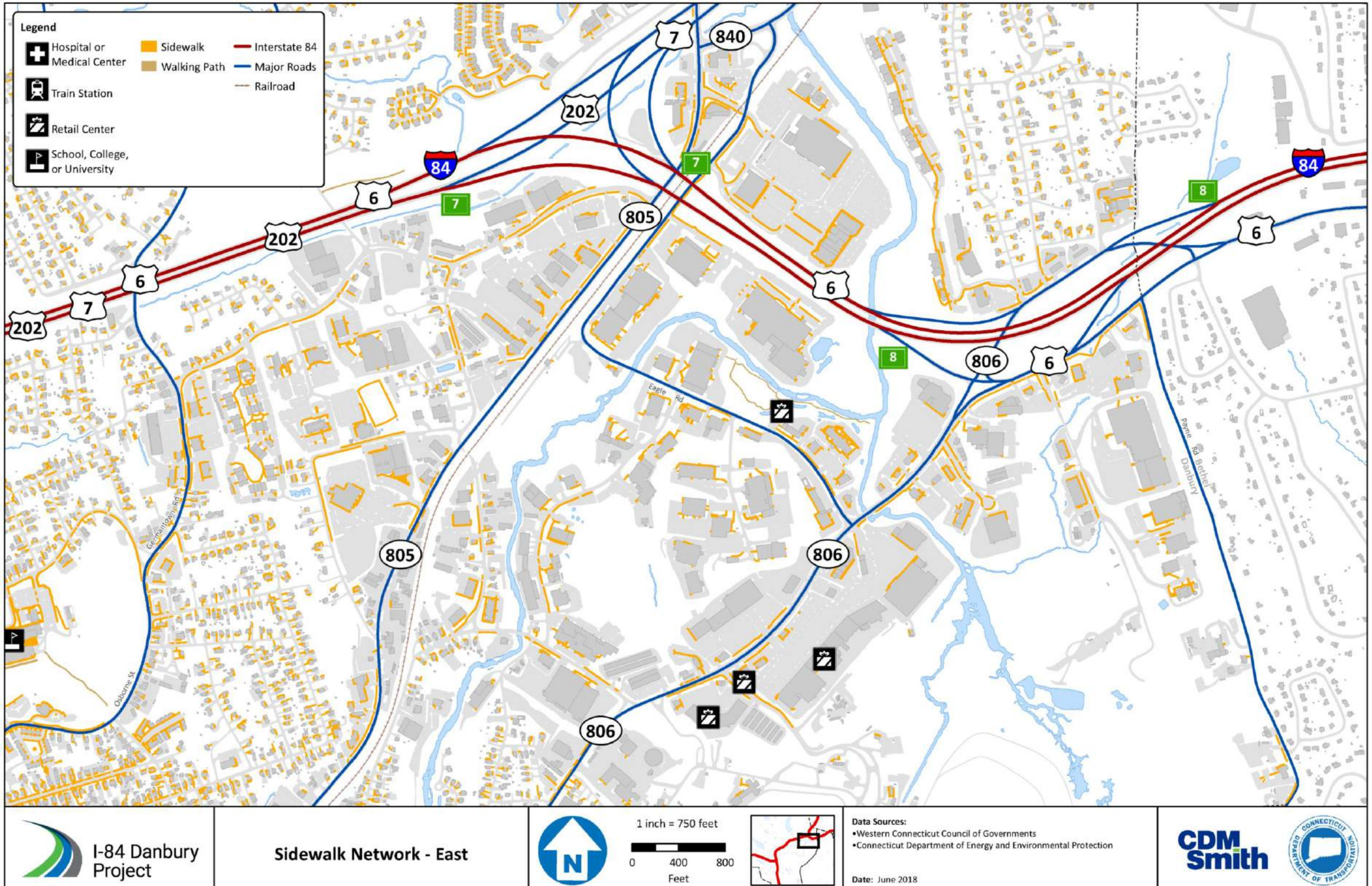
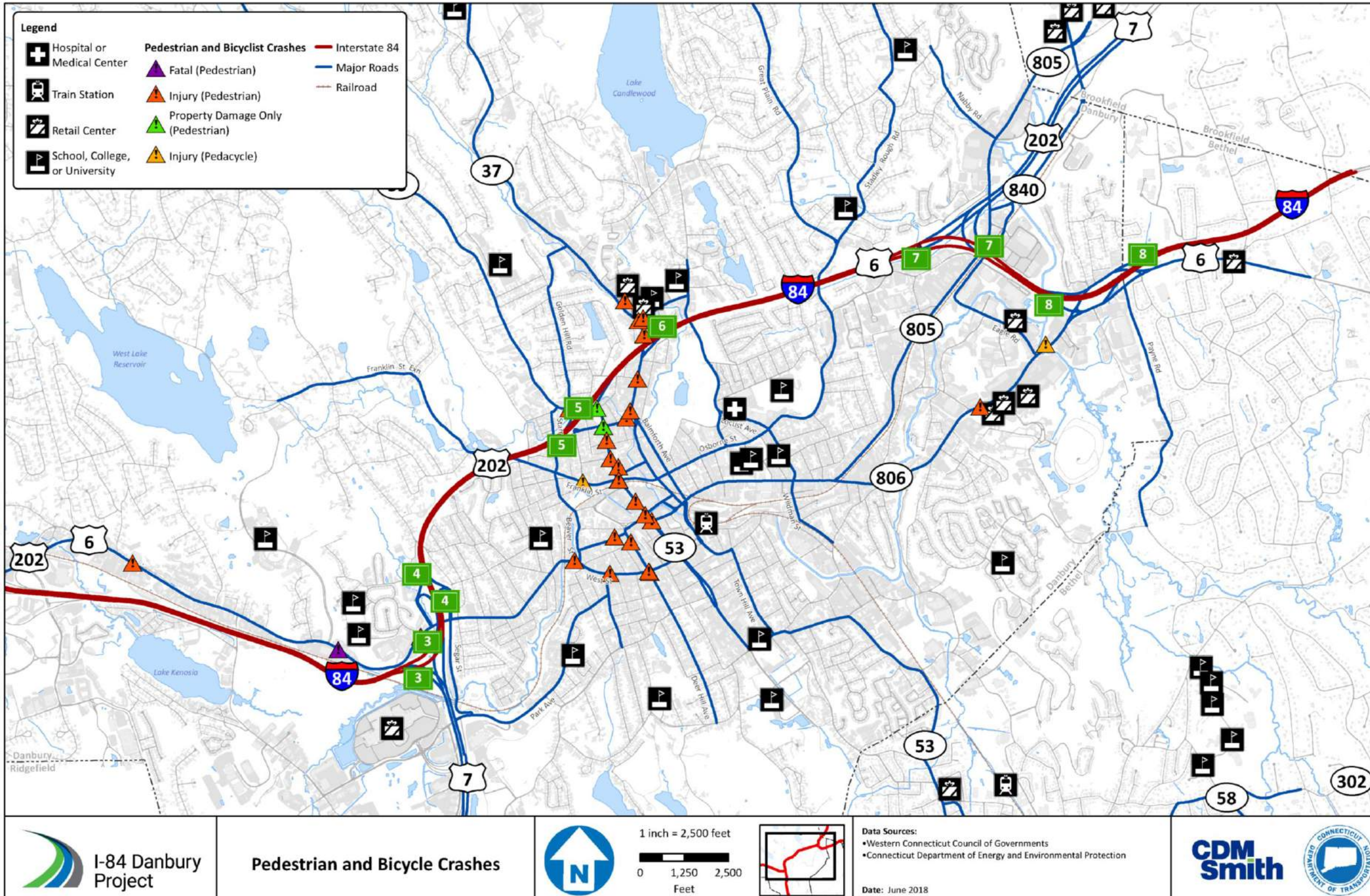


Figure 2-61 – Pedestrian and Bicycle Crashes



2.7.6 Bicycle Travel

Danbury has a notable lack of bicycle accommodations, facilities, and infrastructure. This is principally due to street network constraints, narrow public rights-of-way, and steep road gradients that discourage bicycle use, and also to a perceived lack of demand for bicycle travel.

2.7.6.1 On-Street Facilities

Bicyclists may travel on any street in the city of Danbury, with the exception of limited-access roadways and streets with signed prohibitions on non-motorized travel. However, there are no marked bicycle lanes or designated on-street bikeways within Danbury city limits, and many corridors lack safe on-street bicycle routes, signage, and paved shoulders suitable for bicycle travel. Only small, fragmented, and isolated portions of State roads in or around the I-84 Danbury corridor are designated as suitable for bicycle travel by CTDOT. The Route 7 corridor between Ridgefield and Danbury, specifically, is one notable corridor without bicycle routes that parallel the limited-access roadway.

The *Greater Danbury Regional Bike Plan*, published in 2015 by Housatonic Area Regional Transit (HART) for the Housatonic Valley Council of Elected Officials (HVCEO)[8], outlined several recommendations to increase Danbury's bike-friendliness. Other recent mobility-related studies and reports include the *2015 – 2040 Regional Transportation Plan for the Housatonic Region*, Connecticut Bicycle and Pedestrian Advisory Board annual reports, and the *Route 7 Transportation and Land Use Study*. Specific recommendations from these initiatives include:

- Adopt a municipal Complete Streets policy. Complete Streets are streets that are designed and operated to enable safe access for all users, including pedestrians, bicyclists, motorists, and transit riders of all ages and abilities.[9]
- Complete a bicycle and pedestrian access plan which would include the examination of multi-use trails as described in the Danbury Plan of Conservation and Development.
- Seek a study to develop counter measures that would improve safe use of Main Street -Route 53, South Street, Newtown Road, and West Street due to high rates of bicycle collisions on these streets.
- Enhance the accessibility of the Still River Greenway to facilitate travel by bicycle and completing its connection to the Brookfield portion of the trail.
- Support the development of the Norwalk River Valley Trail and Western New England Greenway projects.
- Work with CTDOT to install sheltered bike racks at Park and Ride commuter parking lots, many of which are served by HART bus routes.
- Pursue efforts to make trail connections to Putnam County's Maybrook Trailway at the New York – Connecticut state line.

2.7.6.2 Off-Street Facilities

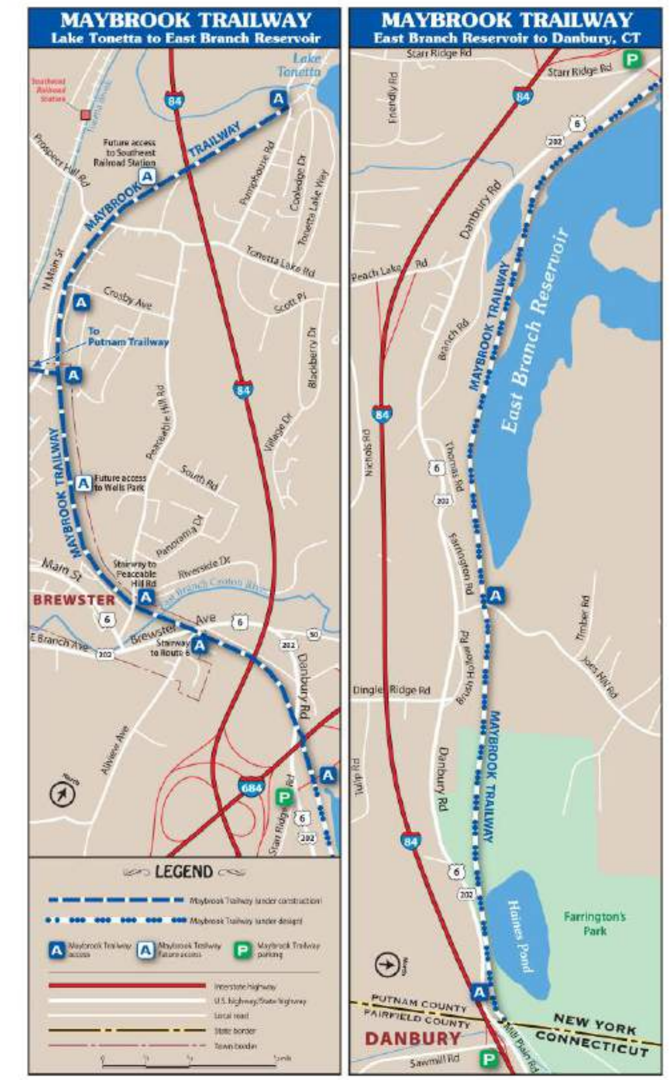
The few bike routes that exist in and around Danbury are off-street and generally intended for recreational purposes, with settings in parks, open spaces, or on separate trails.

Planned Greenways and Multi-Use Trails

There is currently active construction on the Norwalk River Valley Trail, which is a planned network of off-road recreational trails connecting Norwalk, Wilton, Ridgefield, Redding, and Danbury. While there is currently no construction in Danbury, the current vision of the Norwalk River Valley Trail in Danbury, shown in **Figure 2-63**, is to accommodate recreational bicycling, with connections to open spaces south of the I-84 corridor. However, an extension of the planned trail to the north along a route that crosses the I-84 corridor, could expand the availability of recreational bicycling, as well as provide opportunities for commuter bicycle travel between downtown Danbury and residential neighborhoods to the south of the city center.

As discussed in Section 2.7.4.3, west of the city of Danbury, the New York State Department of Transportation is working to convert a portion of freight rail right-of-way associated with the Maybrook Line. The so-called Maybrook Trailway, shown in **Figure 2-62**, will connect the western border of Danbury in the adjacent Putnam County, to Brewster, New York. Currently, the Maybrook Trailway runs from Lake Tonetta in Brewster, New York east to the general vicinity of the I-84 – I-684 interchange.

Figure 2-62 - Maybrook Trailway in New York State



Source: Putnam County Planning Department, Maybrook Trailway Brochure, 2013. http://www.putnamcountyny.com/wordpress/wp-content/uploads/2012/06/Maybrook-Trailway-Brochure.pdf

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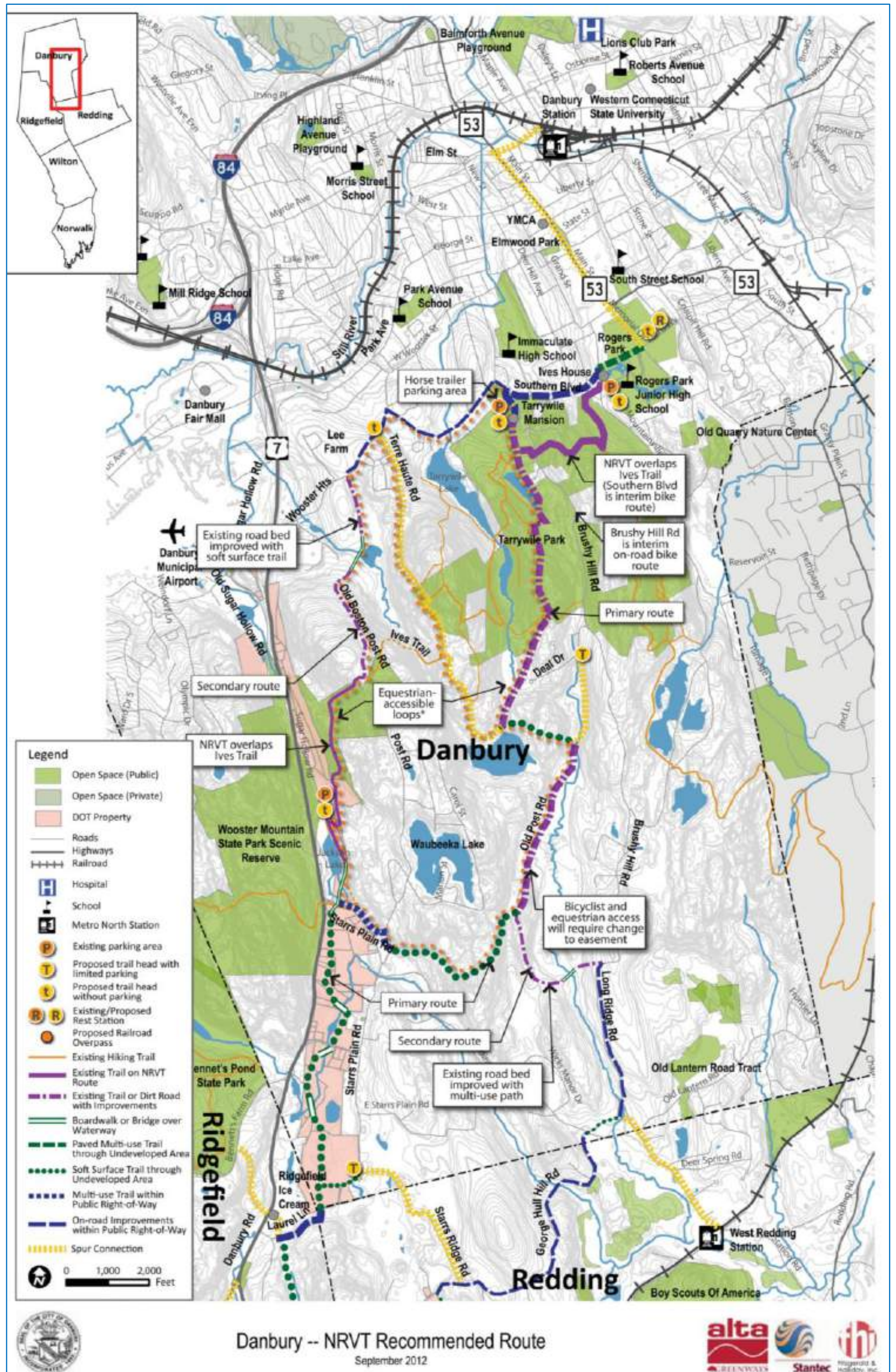
[8] *The Housatonic Valley Council of Elected Officials (HVCEO) is now incorporated into the Western Connecticut Council of Governments (WestCOG).*

[9] Smart Growth America, "What are Complete Streets?"

Figure 2-63 - Planned Future Norwalk River Valley Trail



Source: Friends of the Norwalk River Valley Trail, 2012. http://nrvt-trail.com/maps/danbury/

Some groups in greater Danbury advocate extending New York's Maybrook Trailway east over a portion of the Maybrook Line railroad right-of-way in Danbury. This extension would expand the availability of recreational bicycling regionally, as well as provide opportunities for commuter bicycling between downtown Danbury and Brewster Station in Brewster, New York. It would also connect Downtown Danbury and many residential districts, including Environmental Justice communities, to the Danbury Mall and other commercial neighborhoods and major employers located to the west of the city center.

2.7.7 Pedestrian and Bicycle Compatibility Index (PBCI)

Within the project area, a total of 19 streets, arterials, or state highways cross I-84 and Route 7. The I-84 Danbury project team assessed each of these crossings to determine the degree to which they safely accommodate pedestrians and bicyclists and to understand how the interstate highway affects local streets and mobility. This pedestrian and bicycle travel and safety study investigated and documented numerous factors that contribute to the safety and comfort of pedestrians and bicyclists and that facilitate non-motorized travel.

2.7.7.1 Need for Pedestrian and Bicycle Facilities on Streets that Cross I-84

As discussed in Section 2.7.4.2, I-84 bisects the City of Danbury and separates densely populated neighborhoods and various land uses or destinations. Many of these destinations represent generators or attractors of non-motorized travel (origins and destinations of pedestrian and bicycle travel). Many residents, workers, patrons, or visitors travelling between the dense residential neighborhoods to schools, churches, stores, hospitals, and employment centers might prefer to walk or bicycle a few blocks instead of drive. However, as discussed in Sections 2.7.5 and 2.7.6, many of the local streets that cross or intersect with I-84 or its interchanges are not pedestrian-friendly or bicycle-friendly; in fact, many are very intimidating for pedestrians and bicyclists to travel on due to traffic volumes, traffic speeds, awkward intersection geometry, and multiple travel and turning lanes.

While there is a lack of empirical data that show a correlation between bicycle and pedestrian friendly streets and higher levels of non-motorized travel, there is much anecdotal evidence that indicates that, when provided appropriate and safe infrastructure for non-motorized travel, many people would prefer to walk or bicycle among various, proximate land uses, especially young people and older folks who are either too young or too old to drive a motor vehicle, people who prefer not to drive, and people from limited economic means who live close to the highway and who may not own or have ready access to an automobile.

Measuring this "latent demand" for pedestrian and bicycle travel is an inexact science and is beyond the scope of this study; however, experience in other cities and in other states that address similar barriers to non-motorized travel by providing new, safe and convenient pedestrian and bicycle facilities – such as well-illuminated, ADA accessible, and signalized pedestrian crosswalks, bicycle lanes, protected bicycle lanes (Cycle Tracks), and even bridges dedicated solely to pedestrians and bicyclists – see great increases in the number of pedestrians and bicyclists and significant reductions in crashes between motor vehicles and pedestrians and bicyclists. In other words, investments in pedestrian and bicycle infrastructure in densely populated neighborhoods with mixed land uses yield great benefits in travel safety and in the reduction of travel demand by single-occupant automobiles.

2.7.7.2 Pedestrian and Bicycle Compatibly Index

To facilitate a better understanding of pedestrian and bicycle travel needs, a Pedestrian and Bicycle Compatibly Index (PBCI) was developed by CDM Smith to quantify pedestrian and bicycle safety and non-motorized accessibility of each of the 19 street crossings, shown in **Figure 2-64**, and representative intersections in the vicinity of the I-84 project area. In some cases, the cross street intersected with highway interchange or on- and off-ramps.

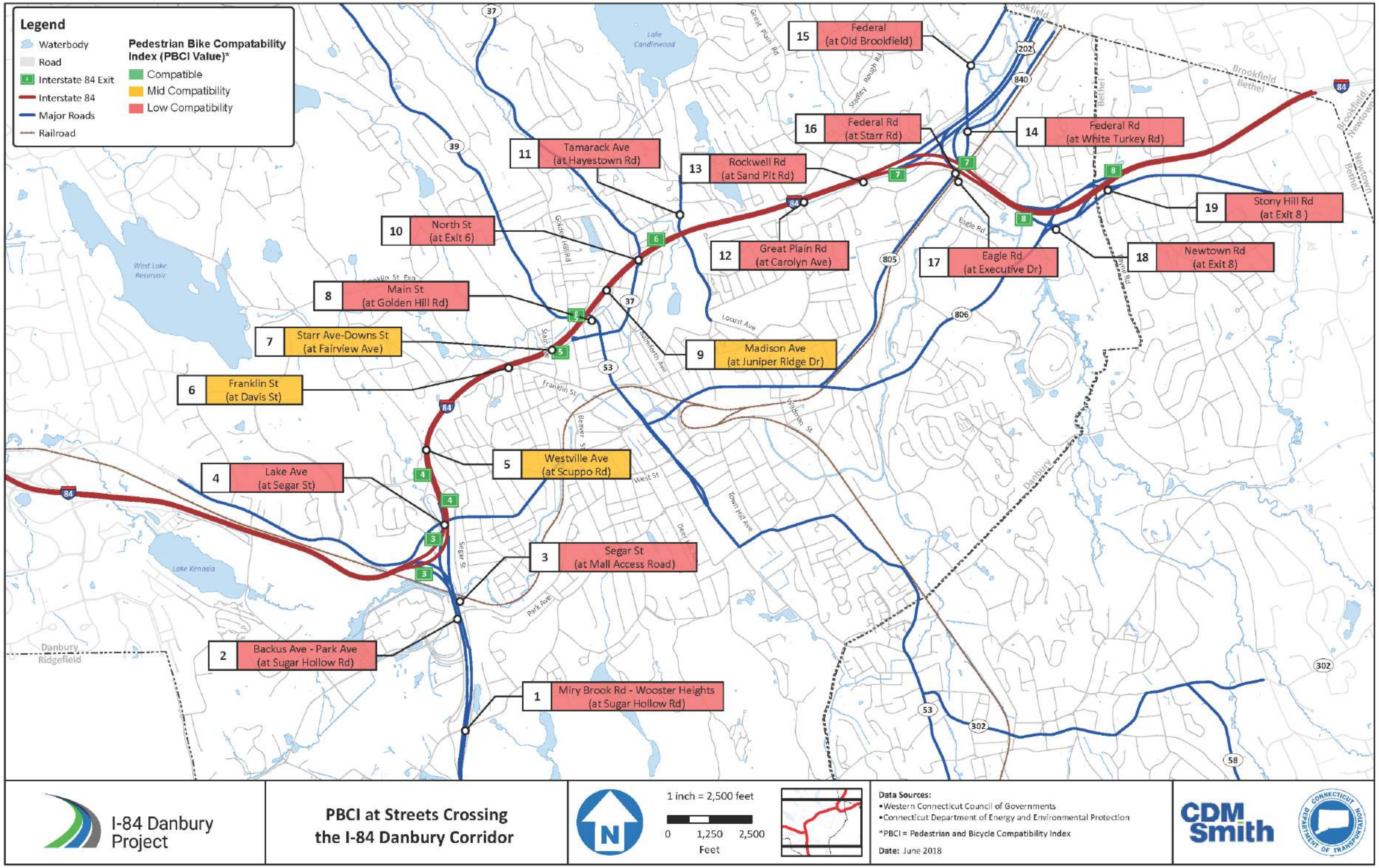
This PBCI factors multiple criteria to identify deficiencies within each of the following three categories:

- Pedestrian safety and accommodations
- Bicycle safety and accommodations
- Vehicular crashes (vehicle-vehicle, vehicle-pedestrian, and vehicle-bicycle)

These categories, and the criteria within each, were designed to identify existing barriers to walkability and bikability – i.e. conditions that may hinder or discourage walking and bicycling due to a lack of safety accommodations, a general sense of discomfort or insecurity, and other conditions that discourage pedestrian travel including high traffic speeds, long or non-existent crosswalks, and poor lighting.

A combination of these factors can transform a roadway or intersection into a veritable barrier for pedestrians or bicyclists. These barriers disrupt desire lines and encourage residents and commuters to drive an automobile or go elsewhere for goods and services. These barriers also affect people's locational decisions on where to live or work and can affect real estate values.

Figure 2-64 – PBCI at Streets Crossing the I-84 Danbury Corridor



2.7.8 Optimal Intersection – Design Principles

To inform the methodology of the PBCI, a hypothetical intersection of optimal design was identified. This optimal intersection, pictured below in **Figure 2-65**, provided guidance for the development of the pedestrian and bicycle safety criteria included in the PBCI.

Figure 2-65 – Example of an Optimally-Designed Intersection

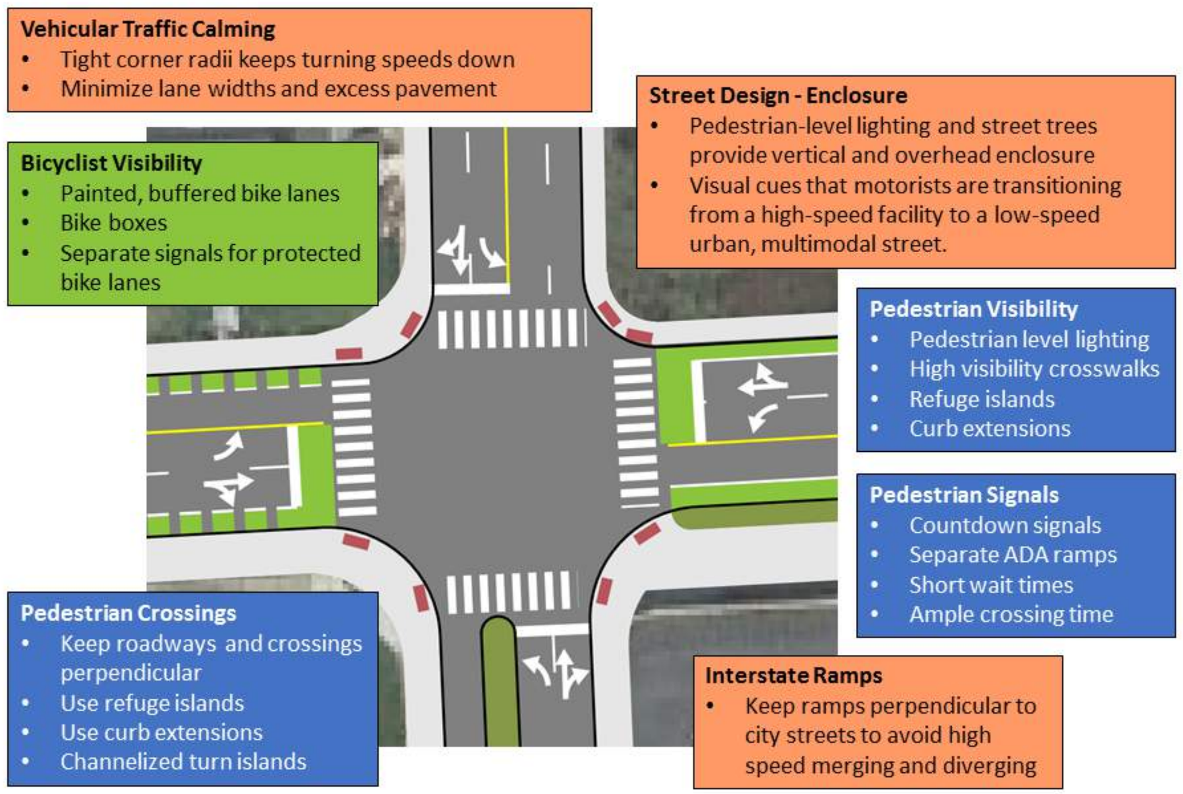


Figure 2-65 depicts several best practice design principles, such as:

Vehicular Traffic Calming

- Tight corner radii keep turning speeds down
- Minimized lane widths and excess pavement

Street Design – Enclosure

- Pedestrian-level lighting and street trees provide vertical and overhead enclosure
- Visual cues that motorists are transitioning from a high-speed facility to a low-speed urban, multimodal street

Interstate Ramps

- Keep ramps perpendicular to city streets to avoid high speed merging and diverging

Pedestrian Visibility

- Pedestrian level lighting
- High visibility crosswalks
- Pedestrian refuge islands
- Curb extensions

Pedestrian Signals

- Countdown signals
- Separate ADA ramps
- Short wait times
- Ample crossing time

Pedestrian Crossings

- Keep roadways and crossings perpendicular
- Pedestrian refuge islands
- Curb extensions
- Channelized turn islands

Bicyclist Visibility

- Painted, buffered bike lanes
- Bike boxes, a designated area at the head of a traffic lane at a signalized intersection that provides bicyclists with a safe and visible way to get ahead of queuing traffic during the red signal phase.[10]
- Separate signals for protected bike lanes

2.7.9 Methodology for Assessing Cross Streets

2.7.9.1 Pedestrian and Bicycle Safety Deficiency Factors

This PBCI evaluated 10 pedestrian and bicycle safety deficiency factors at each of the 19 cross streets. The 10 pedestrian and bicycle safety deficiency factors include:

[10] National Association of City Transportation Officials, "Urban Bikeway Design Guide, Second Edition." 2014.

1. Number of Lanes Entering Intersection
2. Bicycle Facilities
3. Average Daily Traffic (ADT) Volumes
4. Street Lighting
5. Intersection Turning Radii
6. One-way versus Two-Way Operations
7. Sidewalks
8. Crosswalks
9. Travel Lane Widths
10. ADA Pedestrian Crossing Signals

A point value of 10, 5, or 1 was given to each intersection for each factor – 10 being the most ideal condition for a given factor and 1 being the least ideal condition for a given factor. For example, in evaluating the sidewalk deficiency factor, “Sidewalks on Both Sides” was given a value of 10 points, “Sidewalks on One Side” was given a value of 5 points, and “No Sidewalks” was given a value of 1 point.

D7 – Sidewalks		
Sidewalks on Both Sides	10	pts
Sidewalk on One Side	5	pts
No Sidewalks	1	pts

A sum of the 10 above factor scores was then divided by 10 to achieve an average score. For example, if one intersection scored a 10 (most ideal condition) for all ten Pedestrian and Bicycle Deficiency Factors, its sum would be 100 and its average 10, representing the highest possible score.

2.7.9.2 Vehicular Crash Factors

Three vehicular crash factors were also considered in the PBCI. Vehicle crash factors followed the same scoring scale as above for total number of crashes using three-year crash history data for:

1. Total Number of Crashes

2. Number of Crashes Involving Pedestrians

3. Number of Crashes Involving Bikes

C1 - Total Number of Crashes		
0	10	Pts
1 – 9	5	Pts
10 or More	1	Pts
C2 - Number of Crashes Involving Pedestrians		
0	10	Pts
1	5	Pts
2 or More	1	Pts
C3 - Number of Crashes Involving Bikes		
0	10	Pts
1	5	Pts
2 or More	1	Pts

A sum of the 3 above factor scores was then divided by 3 to achieve an average score. Again, if one intersection scored a 10 (most ideal condition) for all 3 Vehicular Crash Factors, its sum would be 30 and its average 10, representing the highest possible score.

2.7.9.3 Pedestrian and Bicycle Compatibility Index Scores

The final Pedestrian and Bicycle Compatibility Index (PBCI) scores were calculated by multiplying the Pedestrian and Bicycle Safety Deficiency Factor scores and the Vehicular Crash Factor scores. The highest possible PBCI score is 100. The below summary of findings compares actual scores of each of the 19 cross streets studied against this highest possible score.

2.7.9.4 Findings

Scores were used to aggregate streets into three categories of compatibility: “Compatible,” “Medium Compatibility,” and “Least Compatible.” Of the 19 cross streets that were evaluated, none were found to be Compatible to pedestrian and bicycle travel; four were found to be of “Medium Compatibility”; and fifteen were found to be “Least Compatible.”

Compatible (Range of Values 67 to 100)

- None

Medium Compatibility (Range of Values 34 to 67)

- Westville Ave (at Scuppo Rd)
- Franklin St (at Davis St)
- Starr Ave – Downs St (at Fairview Ave)
- Madison Ave (at Juniper Ridge Dr)

Least Compatible (Range of Values 1 to 33)

- Miry Brook Rd – Wooster Heights (at Sugar Hollow Rd)
- Backus Ave – Park Ave (at Sugar Hollow Rd)
- Segar St (at Mall Access Road)
- Lake Ave (at Segar St)
- Main St (at Golden Hill Rd)
- North St (at Exit 6)
- Tamarack Ave (at Hayestown Ave)
- Great Plain Rd (at Carolyn Ave)
- Rockwell Rd (at Sand Pit Rd)
- Federal Rd (at White Turkey Rd)
- Federal Rd (at Old Brookfield Rd)
- Federal Rd (at Starr Rd)
- Eagle Rd (at Executive Dr)
- Newtown Rd (at Exit 8)
- Stony Hill Rd (at Exit 8)

The full Pedestrian and Bicycle Compatibility Index, its scores, and detailed results of individual street and intersection assessments can be found in the Multimodal Appendix.

2.7.10 Prioritization of Multimodal Improvements in the I-84 Danbury Corridor

The same 19 local streets that cross I-84 that were the subject of analysis for pedestrian and bicycle compatibility were also assigned priority levels that factor a broad set of criteria, including:

1. The Pedestrian-Bicycle Compatibility Index (PBCI), as a means to pedestrian and bicycle safety;
2. The presence of pedestrian-bicycle "Desire Lines" along the street, as a means to understand the latent demand for pedestrian and bicycle travel;
3. The presence of Environmental Justice communities along the street or near the street, as a means to factor the unique needs of transit-dependent populations and households that own one or no cars; and,
4. Whether the street is served by fixed-route bus transit, as a means to recognize that people who use bus transit likely need to walk or bicycle from their homes, schools or places of employment to a bus stop in order to access public transit.

The ranking of the 19 cross streets using criteria that recognizes pedestrian and bicycle safety, latent demand for non-motorized travel, the needs of transit-dependent populations, and the use of the street as a bus transit route provides a comprehensive methodology to prioritize streets in the project area for multimodal improvements. In this way, future public investments in non-motorized travel (pedestrian and bicycle accommodations) and enhancements to bus transit in the I-84 project area will be targeted to areas of greatest need.

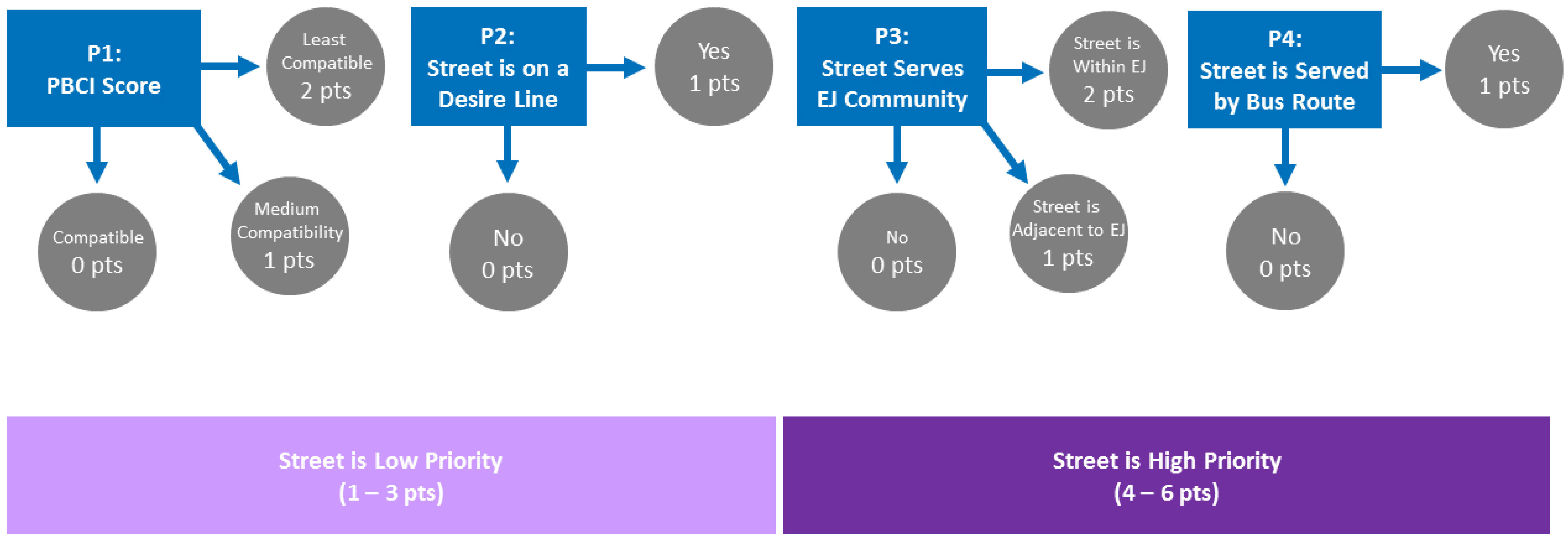
This prioritization methodology provides assurance multimodal travel improvements or investments incorporated into the I-84 Danbury Project will elevate urban mobility in Danbury, especially for residents of Environmental Justice communities and residents with limited mobility, by:

- better connecting neighborhoods proximate to I-84 that are currently isolated by the physical presence of I-84 or are negatively affected by the "barriers" to local travel that results from the influence of I-84 traffic;
- improving residents' access to jobs, schools and services;
- improving transportation choice and residents' access to transit; and,
- expanding social and economic networks; that is, creating more cohesion between neighborhoods to improve social, intergenerational and multi-cultural interaction, and reduce real or perceived isolation of neighborhoods that have less economic status.

The following **Figure 2-66** illustrates this prioritization methodology.

CDM Smith

Figure 2-66 – Determination of Priority for Multimodal Improvements



P1. Pedestrian-Bicycle Compatibility Index (PBCI) Rating

For this critical pedestrian-bicycle safety factor, a point value of 2, 1, or 0 was given to each street based on its total PBCI rating. A score of 2 was given to streets that attained a "Least Compatible" PBCI Score; a score of 1 was given to streets that attained a "Medium Compatibility" PBCI rating; and a score of 0 was given to streets that attained a "Compatible" PBCI rating.

P2. Street is on a Desire Line

For this latent pedestrian-bicycle travel demand factor, a point value of 1 or 0 was given to each street. A value of 1 indicates "Yes," the street is located on a "Desire Line" as depicted in Figure 2-57; and a value of 0 indicates "No," the street is not located on a Desire Line.

P3. Street Serves Environmental Justice (EJ) Communities

For this EJ factor, a point value of 2, 1, or 0 was given to each street. A value of 2 indicates that the street is within an EJ Community; a value of 1 indicates the street connects EJ communities to key services or destinations; and a value of 0 indicates the street is not within or adjacent to an EJ community.

P4. Street is Served by Bus Transit Route

For this factor recognizing the importance of bus transit, a point value of 1 or 0 was given to each street. A value of 1 indicates "Yes," the street serves as a fixed-route for HART buses as depicted in Figure 2-65; and a value if 0 indicates "No," the street does not coincide with a HART bus route.

A sum of the scores for these factors was then calculated for each street, with scores ranging from 0 to 6. Streets with scores that fell between 0 and 3 are classified as "Low Priority," and streets with scores that fell between 4 and 6 are classified as "High Priority." The higher the score indicates the greater the need for pedestrian and bicycle facility improvements to these local city streets. **Table 2-123** provides the values for each factor for each street and the final prioritization rating for each street. **Figure 2-67** depicts the location of each street with its priority rating. In both the table and the figure, a "Low Priority" rating is color-coded lavender and a "High Priority" rating is color-coded deep purple.

Figure 2-67 – Prioritization of Multimodal Improvements in the I-84 Danbury Corridor

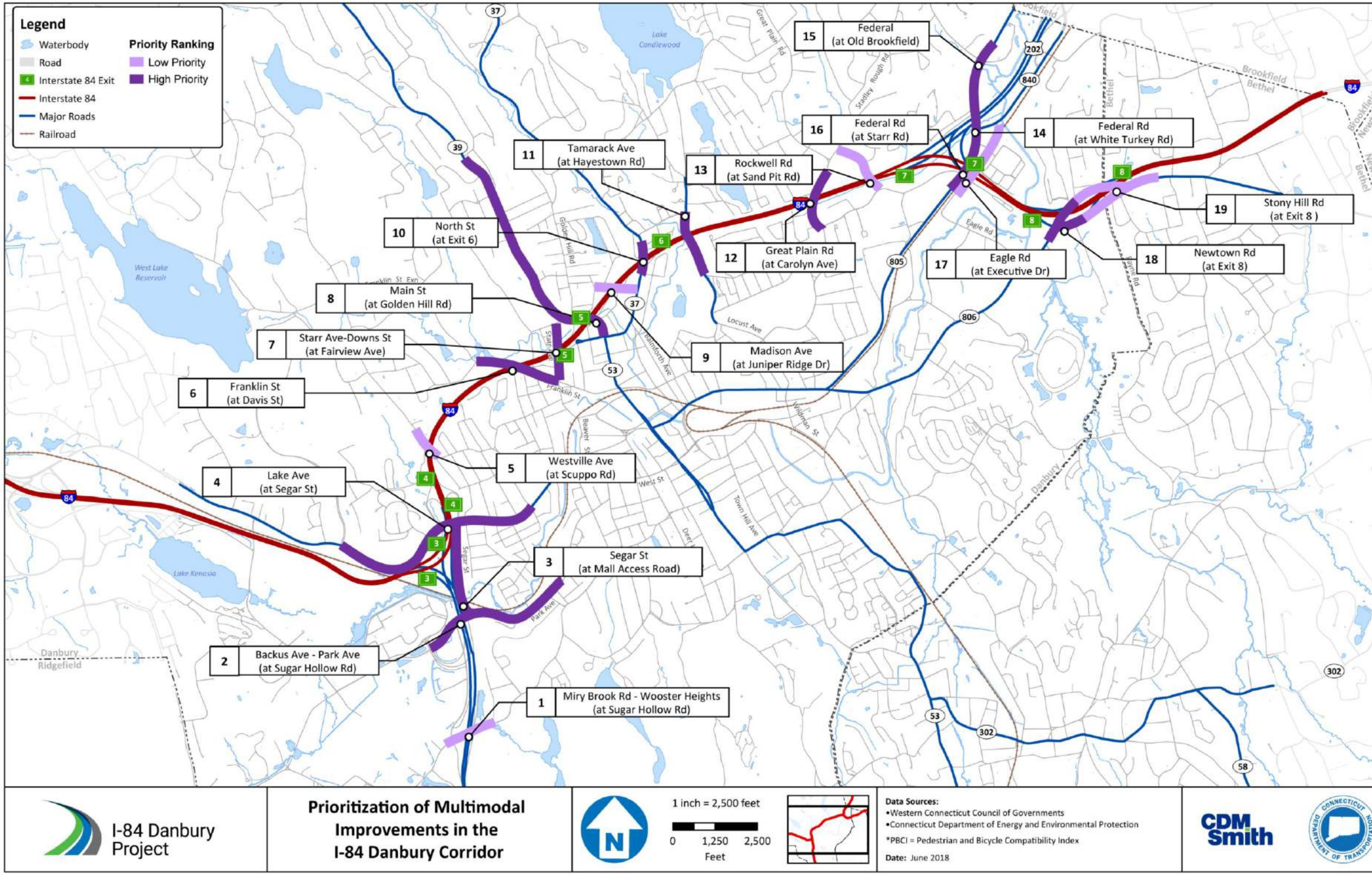


Table 2-123 – Prioritization of Multimodal Improvements in the I-84 Danbury Corridor

I-84 Danbury Project
Prioritization of Non-Motorized Transportation Improvements

Color Codes for PBCI Values:

- **= Compatible** (range of values: 67 to 100)
- **= Medium Compatibility** (range of values: 34 to 67)
- **= Least Compatible** (range of values: 1 to 33)

			Local Intersections Adjacent to I-84																		
			1. Miry Brook Rd - Wooster Heights (at Sugar Hollow Rd)	2. Backus Ave - Park Ave (at Sugar Hollow Rd)	3. Segar St (at Mall Access Rd)	4. Lake Ave (at Segar St)	5. Westville Ave (at Scuppo Rd)	6. Franklin St (at Davis St)	7. Starr Ave - Downs St (at Fairview Ave)	8. Main St (at Golden Hill Rd)	9. Madison Ave (at Juniper Ridge Dr)	10. North St (at Exit 6)	11. Tamarack Ave (at Hayestown Ave)	12. Great Plain Rd (at Carolyn Ave)	13. Rockwell Rd (at Sand Pit Rd)	14. Federal Rd (at White Turkey Rd)	15. Federal Rd (at Old Brookfield Rd)	16. Federal Rd (at Starr Rd)	17. Eagle Rd (at Executive Dr)	18. Newtown Rd (at Exit 8)	19. Stony Hill Rd (at Exit 8)
Prioritization of Non-Motorized Transportation Improvements Factors																					
Pedestrian and Bicycle Compatibility Index (PBCI) Scores:			23.3	19.2	25.0	21.7	35.0	39.2	54.0	26.1	49.0	25.6	30.8	32.0	30.0	16.1	24.5	12.3	29.2	12.6	15.4
P1 - PBCI Factor																					
Least Compatible	2	pts	2	2	2	2	1	1	1	2	1	1	2	2	2	2	2	2	2	2	2
Medium Compatibility	1	pts																			
Compatible	0	pts																			
P2 - Street is on a Desire Line																					
Yes	1	pts	0	1	0	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	0
No	0	pts																			
P3 - Street Serves Environmental Justice (EJ) Communities																					
Street is Within an EJ Community	2	pts	0	1	2	2	1	2	2	2	2	2	1	0	0	0	0	0	0	0	0
Street Connects EJ Communities to Services or Major Destinations	1	pts																			
No	0	pts																			
P4 - Street is Served by Bus Transit Route																					
Yes	1	pts	0	1	1	1	0	1	0	1	0	0	1	1	1	1	1	1	0	1	1
No	0	pts																			
Total = Sum of P1 through P4 (Highest Possible Score = 6)			2	5	5	6	3	5	4	6	3	4	5	4	3	4	4	4	3	4	3

Color Codes for Priority Ranking Values:

- **= Low Priority (1-3)**
- **= High Priority (4-6)**

(Scale of 1 to 6: The higher the score, the greater the need for improvement)

The following section provides a brief description of each street within the two classifications of multimodal priority, Low Priority and High Priority.

Low Priority (Range of Values 1 to 3)

1. Miry Brook Road – Wooster Heights (at Sugar Hollow Road)

Miry Brook Road and Wooster Heights are Collector roads and run east to west in the vicinity of Route 7, Exit 7 at the southwestern end of the project corridor. Land uses along the corridor include residential, commercial, corporate offices, and Danbury Municipal Airport. The vast majority of the corridor lacks sidewalks and crosswalks. Miry Brook Road and Wooster Heights are not served by fixed route bus transit and is not home to Environmental Justice Communities.

2. **Backus Avenue – Park Avenue (at Sugar Hollow Road)**

Backus Avenue and Park Avenue are Arterial roads and run east to west in the vicinity of Route 7, Exit 8, close to the merge with I-84 at the southwestern end of the project corridor. Land uses along the corridor include big box commercial and retail developments, most notably with the Danbury Fair Mall. The vast majority of the corridor lacks sidewalks and crosswalks. Backus Avenue and Park Avenue are served by one HART bus route, the 6 Route (Danbury Mall – Lake Avenue) and is not home to Environmental Justice Communities.

5. Westville Avenue (at Scuppo Road)

Westville Avenue is a Collector road that runs northwest from the city center. The avenue runs between Lake Avenue to the east and Middle River Road / Filmore Avenue to the northwest. The vast majority of land uses along Westville Avenue are residential, with both single- and multi-family homes. With the exception of its easternmost downtown end, Westville Avenue lacks sidewalks along its entire length. East of I-84, the north side of Westville Avenue is home to an Environmental Justice Community. West of I-84, the south side of Westville Avenue is home to an Environmental Justice community. Westville Avenue is also served by one HART bus route; the 3 Route (Mill Plain Road – Brewster).

7. Starr Avenue – Downs Street (at Fairview Avenue)

Starr Avenue is a short, 1/3-mile long Collector road than runs between Franklin Street to the south and Cowperthwaite Street, connecting to Main Street / Route 39. Starr Avenue passes below I-84, over Kohanza Brook, and is fronted entirely by residential, single-family, and multi-family homes and buildings. The southernmost half of Starr Avenue, defined by the I-84 overpass that runs above it, is entirely within an Environmental Justice community. Starr Avenue is not directly served by HART bus routes but is in close proximity to bus routes that serve nearby Franklin Street and Main Street.

9. Madison Avenue (at Juniper Ridge Drive)

Madison Avenue is a short local street that runs between Hillside Avenue to the west and North Street to the east, passing over I-84 on a bridge. Land uses on Madison Avenue are almost entirely residential, and about half of the street has sidewalks. Madison Avenue is not served by any HART bus routes and is entirely within an Environmental Justice Community.

12. Great Plain Road (at Carolyn Avenue)

Great Plain Road is a long Collector road that runs between Sand Pit Road to the south and Candlewood Lake's Driftwood Point to the north. Land uses on Great Plain Road are almost entirely residential, and most of the street lacks sidewalks. The corridor is partially served by HART's 1 Route (Town Park – Hospital) and is adjacent to, but not within, an Environmental Justice Community.

13. Rockwell Road (at Sand Pit Road)

Rockwell Road is a short local street that runs between Stadley Rough Road and Sand Pit Road. I-84 is carried about the street on a bridge, and the entire street lacks sidewalks. The street is home to a mix of residential and industrial land uses. Rockwell Road is served by HART's 1 Route (Town Park – Hospital) and is not within an Environmental Justice Community.

17. Eagle Road (at Executive Drive)

Eagle Road is a Collector road that runs between White Turkey Road and Newtown Road. Land uses on the corridor include commercial buildings, corporate parks, hotels, and big box retail developments. Sidewalks exist on Eagle Road in disconnected segments. The street is partially served by HART's 2 Route (Newtown Road – Stony Hill) and is not within an Environmental Justice Community.

19. Stony Hill Road (at Exit 8)

Stony Hill Road is an Arterial road that makes up the eastern half of the one-way loop "turtleback" street configuration in the vicinity of I-84, Exit 8. Land uses along the street include residential, commercial, and big box retail developments. Stony Hill Road has partial sidewalk coverage and a marked crosswalk exists at the entrance to the Target parking lot. The street is served by HART's 2 Route (Newtown Road – Stony Hill) and is not within an Environmental Justice Community.

High Priority (Range of Values 4 to 6)

3. Segar Street (at Mall Access Road)

Segar Street is a Collector road that runs north to south between Park Avenue and Lake Avenue, roughly parallel to Route 7's approach to I-84 in the vicinity of Exit 9. Segar Street does not cross I-84 but intersects with a Danbury Fair Mall access road that crosses beneath a pair of I-84 bridges. Both Segar Street and the Mall access road lack continuous sidewalks and crosswalks. Segar Street is served by HART's 6 Route (Danbury Mall – Lake Avenue) and about three-quarters of the street is within an Environmental Justice Community.

4. Lake Avenue (at Segar Street)

Lake Avenue is an Arterial road and among the few thoroughfares that connects downtown Danbury to points west, generally paralleling the I-84 right-of-way. Lake Avenue runs between downtown Danbury to the east and Kenosia Avenue to the west, where it becomes Mill Plain Road / Route 202 / Route 6. The easternmost, downtown end of Lake Avenue is comprised of single- and multi-family homes and commercial complexes. The western half of Lake Avenue, defined by the I-84 overpass that carries the highway above it, is comprised of many big-box retail stores, supermarkets, drive-thru eateries, and condominium complexes set back from the main right-of-way. Notable destinations along or near Lake Avenue include the Danbury Housing Authority, Stop & Shop, CVS, Western Connecticut State University's Westside Campus, and Mill Ridge Primary School. Environmental Justice communities are located along the entirety of Lake Avenue on both sides of I-84. Lake Avenue is also served by three HART bus routes; the 3 Route (Mill Plain Road – Brewster), the 6 Route (Danbury Mall – Lake Avenue), and the Loop 1 (Hospital – Danbury Mall).

6. Franklin Street (at Davis Street)

Franklin Street is a Collector road that runs east to west between downtown Danbury and the residential neighborhoods to the north and west. Notable destinations along or near Franklin Street include downtown Danbury, Danbury Station, the HART Pulse Point, the Danbury Police Department, Ridgewood Country Club, and the Mill Plain, Clapboard Ridge Road, and Chambers Road neighborhoods. Environmental Justice communities are also located along Franklin Street, at its downtown end to the east and in the vicinity of the West Lake Reservoir to the west. Franklin Street is also served by two HART bus routes; the 3 Route (Mill Plain Road – Brewster) and the Loop 1 (Hospital – Danbury Mall).

8. Main Street (at Golden Hill Road)

Main Street is an Arterial road that runs directly through the center of downtown Danbury, between South Street to the south and Cowperthwaite Street to the north, where it becomes Clapboard Ridge Road. The land uses fronting Main Street include a wide variety of mixed-use buildings, institutions, commercial and retail, and public space. Notable destinations along or near Main Street include South Street Elementary School, Elmwood Park, Danbury Public Library, Naugatuck Valley Community College, Danbury City Hall, Danbury Station, Danbury City Green, the HART Pulse Point, and Danbury Police Department. The portions of Main Street within the main core of downtown Danbury have sidewalks on both sides of the street and crosswalks at most cross streets. However, as Main Street runs north away from the city center and towards the I-84 corridor, this network of sidewalks and crosswalks becomes fragmented and discontinuous. The southern half of Main Street, defined by the I-84 overpass that carries the highway over it, it entirely within an Environmental Justice community. Main Street is also served by all HART bus routes as they approach the downtown Pulse Point transfer station on Kennedy Avenue, in addition to the Loop 1 (Hospital – Danbury Mall) and the Loop 2 (Bethel – Newtown Road).

10. North Street (at Exit 6)

North Street / Route 37 is an Arterial road that runs between Main Street to the south and Hayestown Avenue to the north, where it becomes Padanaram Road, leading to the Hayestown and Margerie Manor neighborhoods. Notable destinations along or near North Street include a cluster of automobile service and sales outlets, a C-Town supermarket, Henry Abbott Technical High School, the North Street Shopping Center, and many small commercial business establishments such as banks, drive-thru eateries, strip malls, medical offices, and gas stations. The southernmost half of North Street, defined by the I-84 overpass that runs above it, is entirely within an Environmental Justice community. North Street is also served by two HART bus routes; the 1 Route (Town Park – Hospital) and the Loop 1 (Hospital – Danbury Mall).

11. Tamarack Avenue (at Hayestown Road)

Tamarack Avenue is a Collector road that runs between the intersection of Locust and Hospital Avenues to the south to Candlewood Lake to the north, where it becomes East Hayestown Road. Notable destinations along or near Tamarack Avenue include Western Connecticut State University, Ellsworth Avenue School, Danbury Hospital, Hayestown Avenue Elementary School, Henry Abbott Technical High School, the North Street Shopping Center, as well as residential buildings and small commercial business establishments like banks, drive-thru eateries, strip malls, medical offices, and gas stations. The western side of Tamarack Avenue, south of the overpass that carries I-84 over it, is designated as an Environmental Justice community. Tamarack Avenue is also served by two HART bus routes; the 1 Route (Town Park – Hospital) and the Loop 1 (Hospital – Danbury Mall).

14. Federal Road (at White Turkey Road), 15. Federal Road (at Old Brookfield Road, 16. Federal Road (at Starr Road)

Federal Road is an Arterial road that runs from the Danbury city center at White Street north to Brookfield and New Milford as State Route 202. Federal Road is home to a wide array of land uses including commercial, big box retail, industrial, and some multifamily residential complexes set back from the main road. Most of Federal Road lacks sidewalks, and only one crosswalk is present in the project corridor at Old Brookfield Road. Federal Road is served by two HART bus routes; the 4 Route (Brookfield – YMCA) and the 7 Route (New Milford – Route 7) and is not home to an Environmental Justice Community.

18. Newtown Road (at Exit 8)

Newtown Road is an Arterial road and makes up the western half of the one-way loop "turtleback" street configuration in the vicinity of I-84, Exit 8. Land uses along the street include residential, commercial, and big box retail developments. Newtown Road has partial sidewalk coverage and no marked crosswalks. The street is served by HART's2 Route (Newtown Road – Stony Hill) and is not within an Environmental Justice Community.

2.7.11 Bus Transit

2.7.11.1 HART Fixed Route Bus Service

The bus transit in the Danbury area is run by Housatonic Area Regional Transit (HART). This bus system serves the city of Danbury on 7 routes, some extending into neighboring towns like Bethel, Brookfield, and New Milford. The routes also serve major employers, shopping centers, medical centers, schools, the downtown area, and elderly and low-income housing areas. Most major arterials within the city are well served by the HART Fixed Route system. Each bus is equipped with two bike racks, encouraging multi-modal travel.

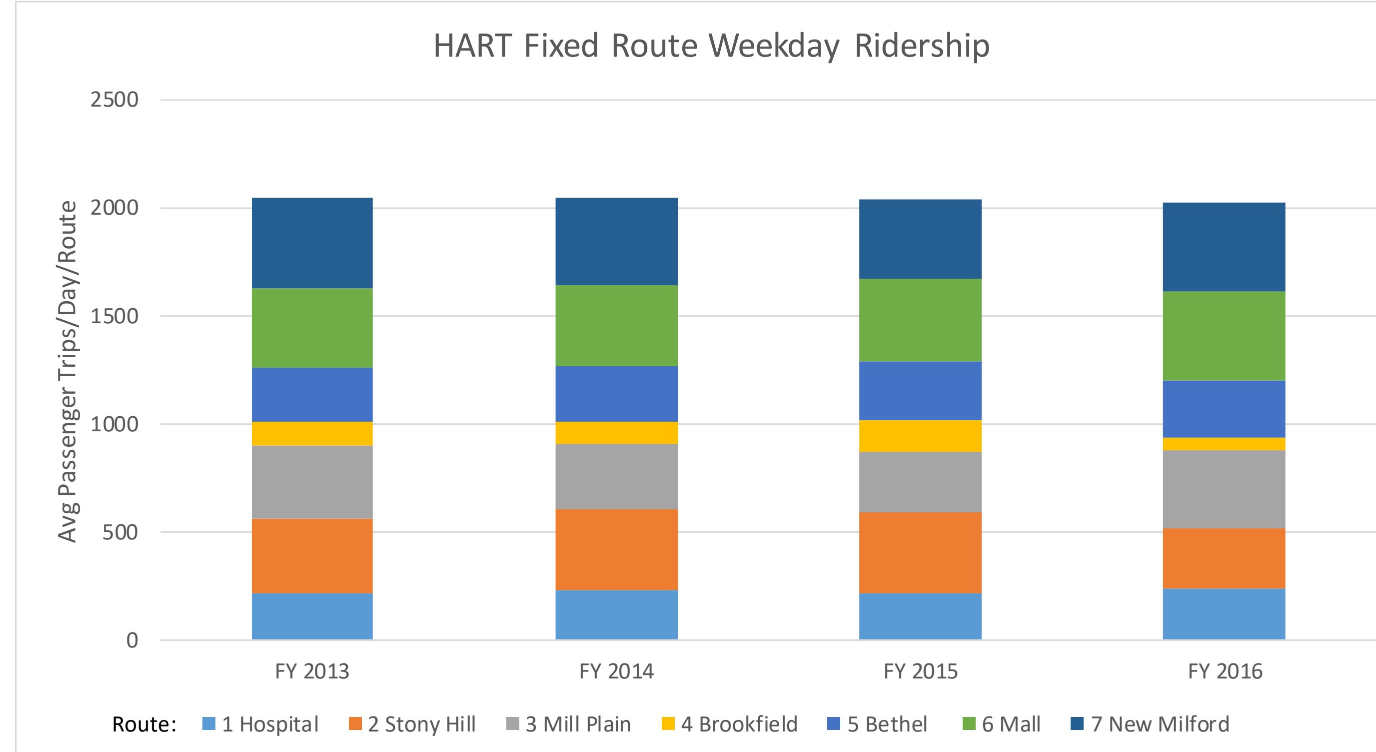
The HART system operates in a timed-transfer "pulse" mode with all routes meeting at a downtown pulse point at Kennedy Park at similar times. Pulse points enable bus passengers to transfer from one bus route to another without delay. The pulse point is located approximately ½ mile away from the Danbury Train Station. During AM and PM peak periods, busses stop at each location every 30 minutes and during non-peak periods, every 60 minutes.

While HART provides adequate transit coverage and headways, general needs and deficiencies exist in the lack of bus stop amenities such as shelters, benches, and level boarding areas. While outside of HART's jurisdiction, deficiencies exist in the lack of uninterrupted sidewalk coverage to facilitate first- and last-mile connections from a transit user's point of alighting from the bus and their final destination of home, work, or school. Final construction of the I-84 Danbury Project can include transit-supportive infrastructure to improve such deficiencies, such as:

- Bus shelters
- Benches
- Level boarding areas
- Bus pull-outs
- Bus queue jump lanes, a dedicated space for transit at an intersection that uses transit signal priority to allow buses to enter traffic flow in a priority position, which can reduce delay and increase reliability of bus service.[11]
- Transit signal priority, a tool that modifies traffic signal timing when transit vehicles are present, which can reduce delay and increase reliability of bus service.[12]
- ADA-accessible sidewalks and crosswalks in the I-84 project area.

The total ridership for all HART fixed route buses averages around 2,000 passengers per weekday and 1,200 passengers per Saturday, with no busses running on Sundays. Information obtained over the last four years has shown ridership to be stable, as shown in Figure 2-68.

Figure 2-68 – HART Fixed Route Ridership



Source: Housatonic Area Regional Transit, 2017

[11] National Association of City Transportation Officials, "Transit Street Design Guide." 2016.

[12] National Association of City Transportation Officials, "Transit Street Design Guide." 2016.

Figure 2-69 – HART Fixed Route Map and Ridership

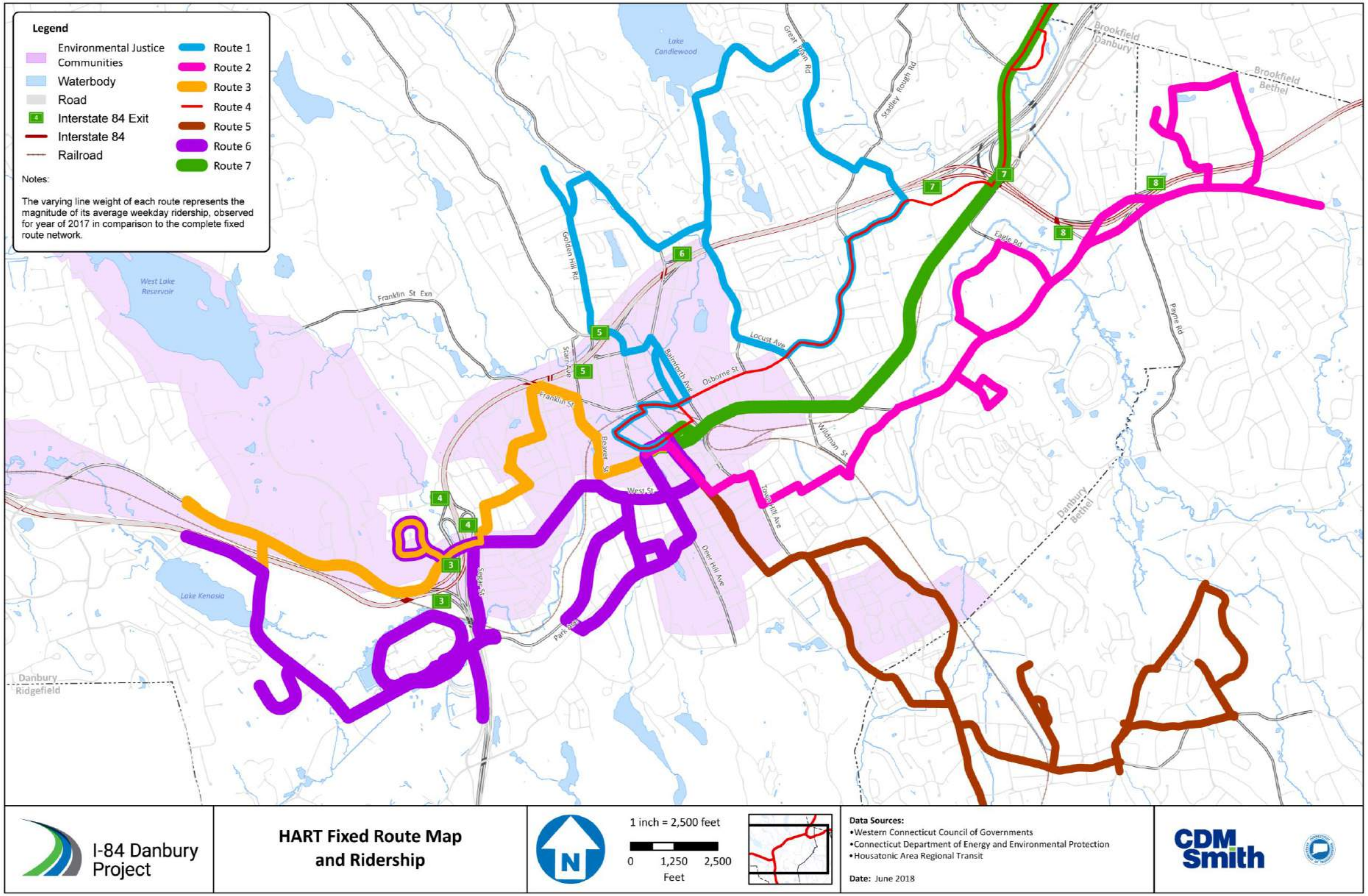


Figure 2-69 shows a map of all the HART Fixed Route services and ridership levels in comparison to the other lines. The thicker the line on the map, the higher the ridership on that route. This map shows high ridership on Routes 6 and 7, which service the Danbury Fair Mall and New Milford, respectively.

2.7.11.2 U-Pass CT Program

Western Connecticut State University in Danbury is among the participating institutions of the U-Pass CT program, which provides free bus and train access to university students in Connecticut. The U-Pass is available to full-time undergraduate students at participating UConn campuses and both full- and part-time credit undergraduate students at participating Connecticut State Colleges and Universities taking at least one class per semester on campus. In Danbury, Housatonic Area Regional Transit (HART) and the CTrail / Metro-North New Haven Line transit systems participate in the U-Pass CT program.

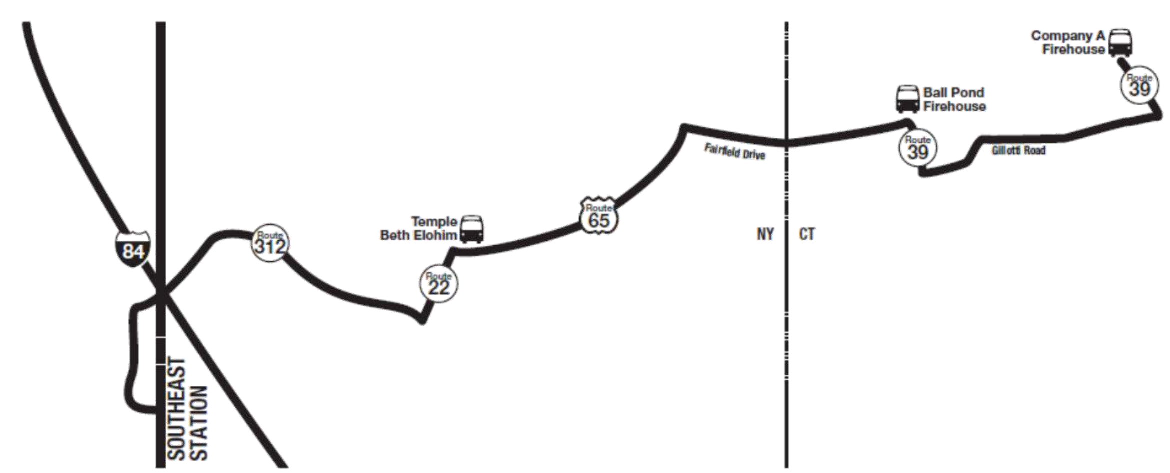
2.7.11.3 Bus Shuttles to Commuter Rail Stations

In addition to fixed routes, HART also provides three shuttle services between park-and-ride lots in various greater Danbury towns and train stations in New York along the MTA Metro-North Railroad Harlem Line, as shown in **Figure 2-73**. These shuttles meet morning southbound departures and afternoon/evening northbound arrivals to and from Grand Central Terminal. In order to increase ridership on these shuttle lines, Metro-North Railroad offers a combined bus-rail UniTicket pass that is accepted on all HART buses. Metro-North also provides a guaranteed ride home program to shuttle users that purchase a UniTicket.

The three HART bus shuttles are: New Fairfield-Southeast Shuttle, Danbury-Brewster Shuttle, and the Ridgefield-Katonah Shuttle.

The New Fairfield-Southeast Shuttle service, shown in **Figure 2-70**, stops at Park-and-Ride lots in New Fairfield; buses also stop in Brewster, NY and then follow Route 312 to Southeast Station. The HART shuttle meets five southbound trains at the Southeast, NY train station between 6:13 and 7:51 AM.

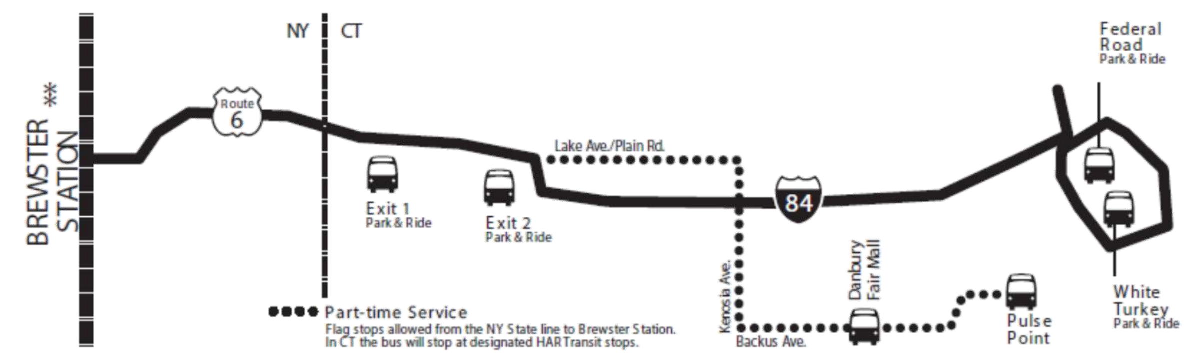
Figure 2-70 – HART New Fairfield-Southeast Shuttle Map



Source: Housatonic Area Regional Transit (HART), 2018. http://www.hartransit.com/routes/shuttles/new-fairfield-southeast

The Danbury-Brewster Shuttle services park-and-ride lots off I-84 at Exits 1,2, and 7 and then travels locally down Route 6 to the Village of Brewster, NY as shown in **Figure 2-71**. This shuttle meets nine morning departures at the Brewster, NY train station between 5:55 and 8:31 AM and 14 arrivals between 4:00 and 9:10 PM. This shuttle also services the reverse commute, from Brewster to Danbury in the morning. When the shuttle is not operating, a HART Fixed Route bus provides hourly service between the HART Pulse Point and Brewster Station.

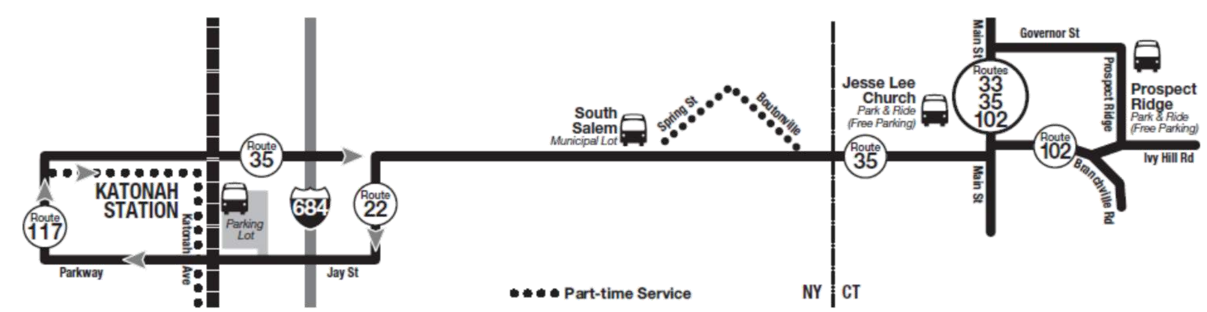
Figure 2-71 – HART Danbury-Brewster Shuttle Map



Source: Housatonic Area Regional Transit (HART), 2018. http://www.hartransit.com/routes/shuttles/danbury-brewster

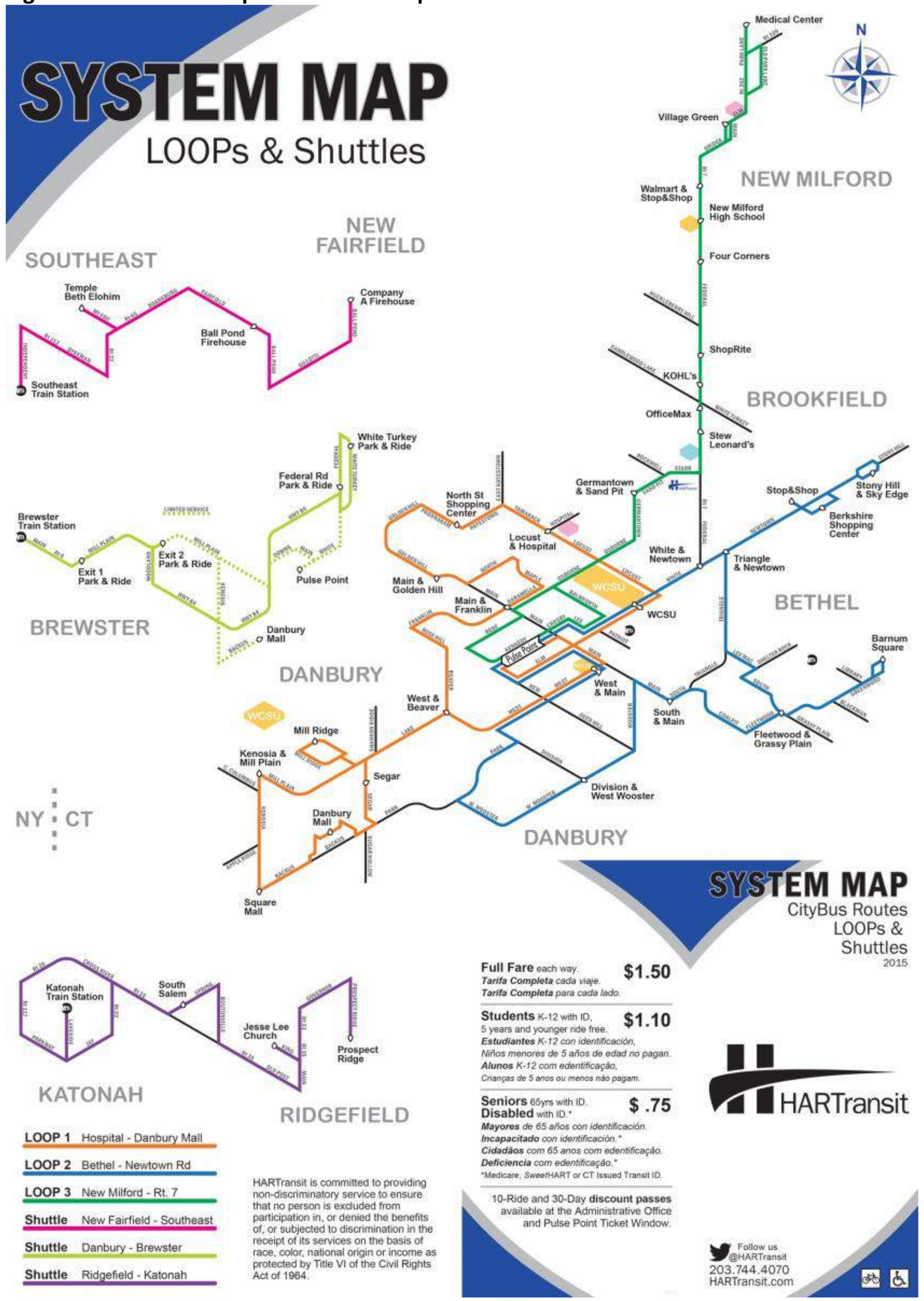
The Ridgefield-Katonah Shuttle, shown in **Figure 2-72**, originates in Ridgefield and follows Route 35 west into NY, stopping in Lewisboro, NY then continuing to Katonah Station via Route 22. This shuttle meets seven southbound trains between 6:20 and 8:30 AM and nine northbound trains between 4:54 and 8:24 PM. This shuttle also provides service on a reverse commute.

Figure 2-72 – HART Ridgefield-Katonah Shuttle Map



Source: Housatonic Area Regional Transit (HART), 2018. http://www.hartransit.com/routes/shuttles/ridgefield-katonah

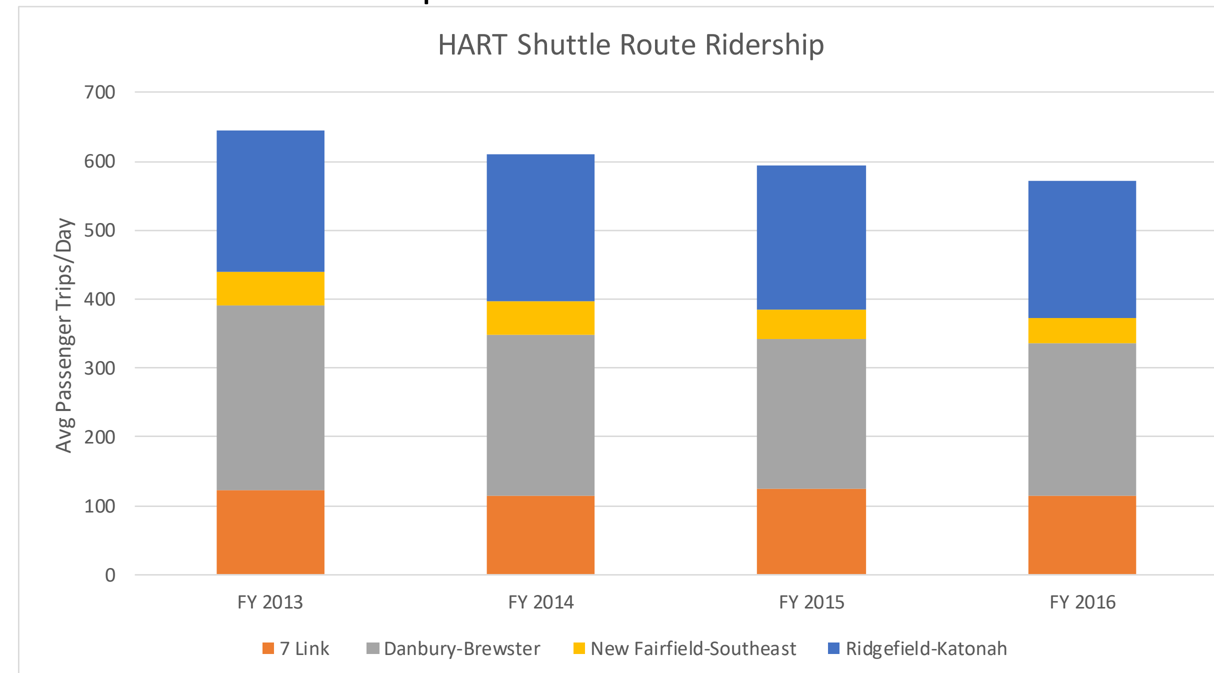
Figure 2-73 – HART Loop and Shuttle Map



Source: Housatonic Area Regional Transit (HART), 2018. http://www.hartransit.com/routes/system-map

Information obtained over the last four years, shown in **Figure 2-74**, shows that on average there are a total of 570 trips made per weekday for all three shuttle routes. Ridership over the last four years has dropped slightly, possibly due to an increase in available parking at the Southeast Station.

Figure 2-74 – HART Shuttle Route Ridership

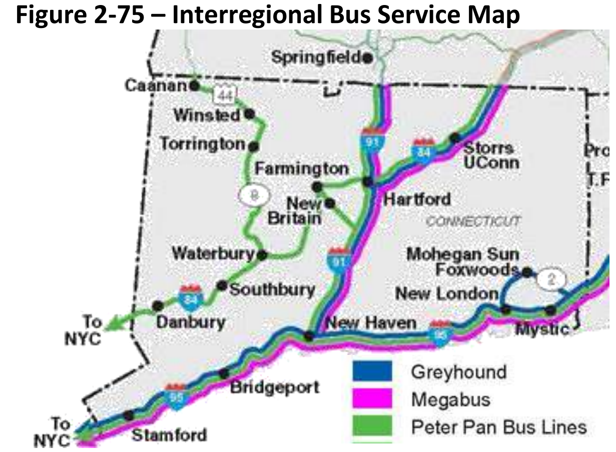


A fourth shuttle is operated jointly by HART and WHEELS (Norwalk Transit District). It is the Route 7 LINK regional bus route between Danbury and Norwalk, which serves employment sites and retail centers along the Route 7 corridor. Busses originate and terminate at the HART Pulse Point in Danbury and the WHEELS Pulse Point in Norwalk. The LINK provides hourly peak period service Monday-Friday.

2.7.11.4 Interregional Bus

Peter Pan operates an interregional bus route from Hartford to New York with stops in Danbury, Southbury and Woodbury. In each direction, the company provides seven daily trips Monday-Thursday and Saturday and eight trips on Fridays and Sundays. Greyhound and Megabus also operate interregional busses in the area, but those busses do not run along the I-84 corridor. Instead those companies travel along the I-91 and I-95 corridors and service cities between Hartford and New York City. These bus services are shown in **Figure 2-75** below.

Figure 2-75 – Interregional Bus Service Map



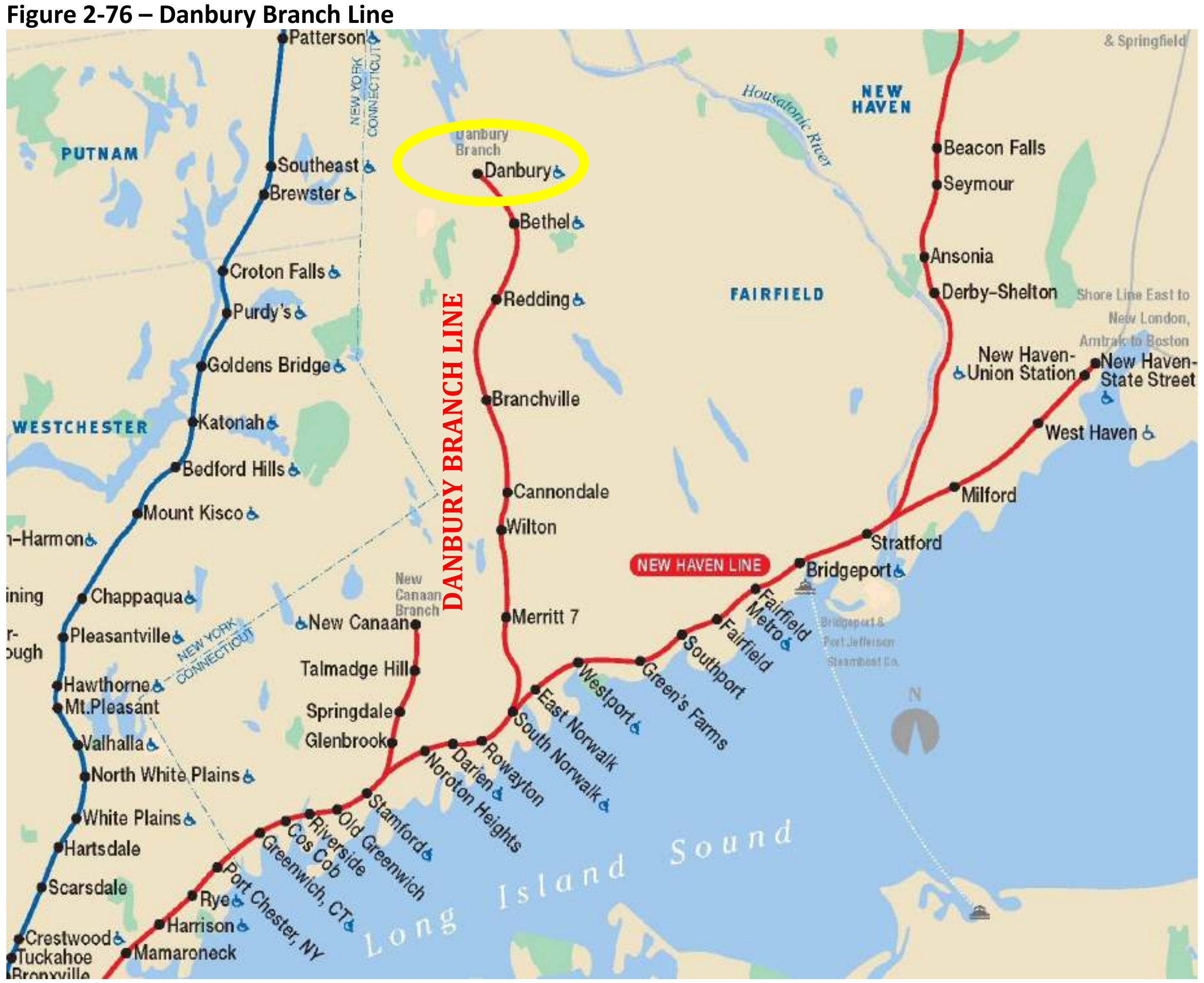
Source: Boston Region Metropolitan Planning Organization, Massachusetts Regional Bus Study, 2013. http://www.ctps.org/2013_mass_bus_study

2.7.12 Rail Transit

2.7.12.1 The Danbury Branch Line

The Danbury Branch Line is a 23.6-mile single track, non-electrified rail line running between Danbury and Norwalk, as shown in **Figure 2-76**. The line has stations in Danbury, Bethel, Redding, Ridgefield (Branchville), Wilton (Cannondale and Wilton), and Norwalk (Merritt 7 and South Norwalk). The current rail service is operated by Metro-North and provides 11 round trips during the weekday and six on Saturdays. The Danbury Branch serves about 1,300 riders daily. The Metro-North New Haven Line, which includes the Danbury Branch Line, participates in the UPass CT program, discussed in Section 2.7.11.2.

Figure 2-76 – Danbury Branch Line



Source: Metropolitan Transportation Authority (MTA), Metro-North Railroad Map, 2011. http://web.mta.info/mnr/html/mnrmap.htm

2.7.12.2 Potential Extension of Commuter Rail Service

A Benefit-Cost Analysis (BCA) of the Danbury Branch Line was performed by CTDOT to determine the best course of action regarding the potential future extension of the Line northward to New Milford. The BCA determined that to attract the largest number of riders and reduce trip times within the region, the electrification of the Danbury Branch Line would be beneficial. This improvement is forecasted to increase ridership along the Danbury Branch Line while also attracting commuters currently using the Route 7 corridor. Ultimately alleviating some freeway congestion.

Prior to 1971, the Danbury Branch Line's passenger service extended 13.6 miles north of Danbury to New Milford. It was not until a contractual change in passenger service from Consolidated Rail Corporation (Conrail) to Metro-North Commuter Railroad, that passenger service north of Danbury ceased in 1983. To date, the region supports restoration of this passenger rail service (approximately 13.6 miles north along the Berkshire Line to New Milford).

Connecticut's long-range transportation plan, "Let's Go CT!," lists improvements to the Danbury Branch Line, including electrification of the line and extension of the line north to New Milford, as a key project. However, after further analysis of costs and forecasted ridership levels, improvements to the Danbury branch line have been "tabled" by CTDOT and will be reconsidered at a future date.

There has also been discussion about extending the Danbury Branch Line not only to New Milford, but also further north into northwestern Connecticut along the Housatonic Line. As depicted in **Figure 2-78**, the service would potentially include stations in the Connecticut towns of Brookfield, New Milford, Kent, Salisbury, and North Canaan. The railroad north of New Milford to the Massachusetts border is currently owned by CTDOT, and the rail from the Massachusetts border to Pittsfield, MA was owned by the HRRC until 2015, when MassDOT purchased the rail from Canaan, CT to Pittsfield, MA. This corridor currently provides limited rail freight activity, however, according to a 2014 study by MassDOT, passenger service could also be extended northward to Pittsfield.

There is also interest, although no formal studies, to improve another rail line in greater Danbury for new passenger rail service – the Maybrook Line. Running from west to east, the Maybrook Line, shown in **Figure 2-77**, is an east-west freight rail line owned by the Housatonic Railroad Co. (HRRC). The rail line connects Maybrook, New York with Derby, CT via Newburgh, NY and Danbury, CT. In the not so distant past, it served as New England's major east to west freight corridor across the Hudson River and had passenger service up until 1974. Today, in the Danbury area, the Maybrook rail line makes local freight trips between Danbury, CT and Derby, CT as most of the regional freight activity has shifted to motorized vehicles or to other freight rail routes.

Figure 2-77 – Potential Commuter Rail

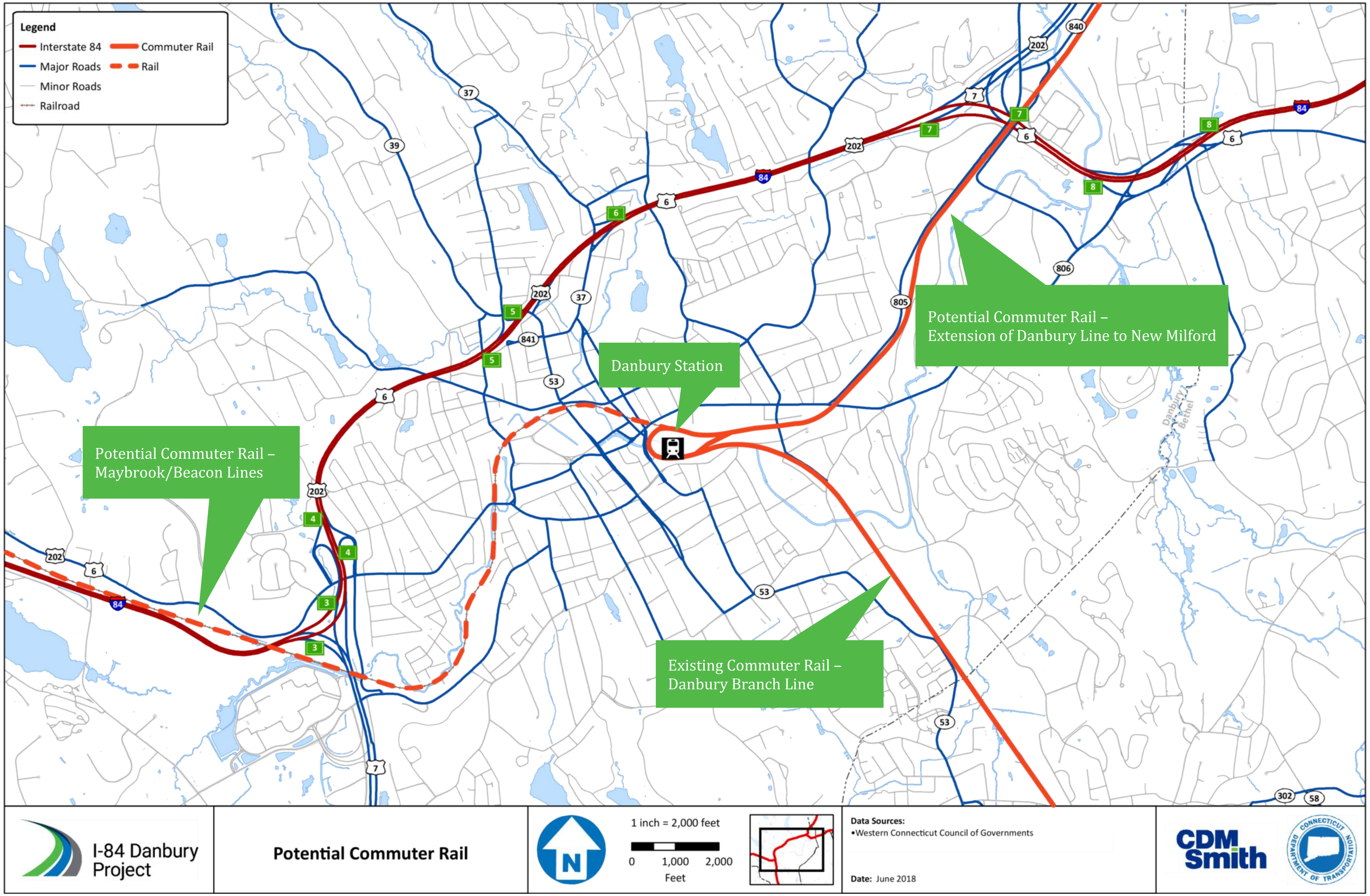
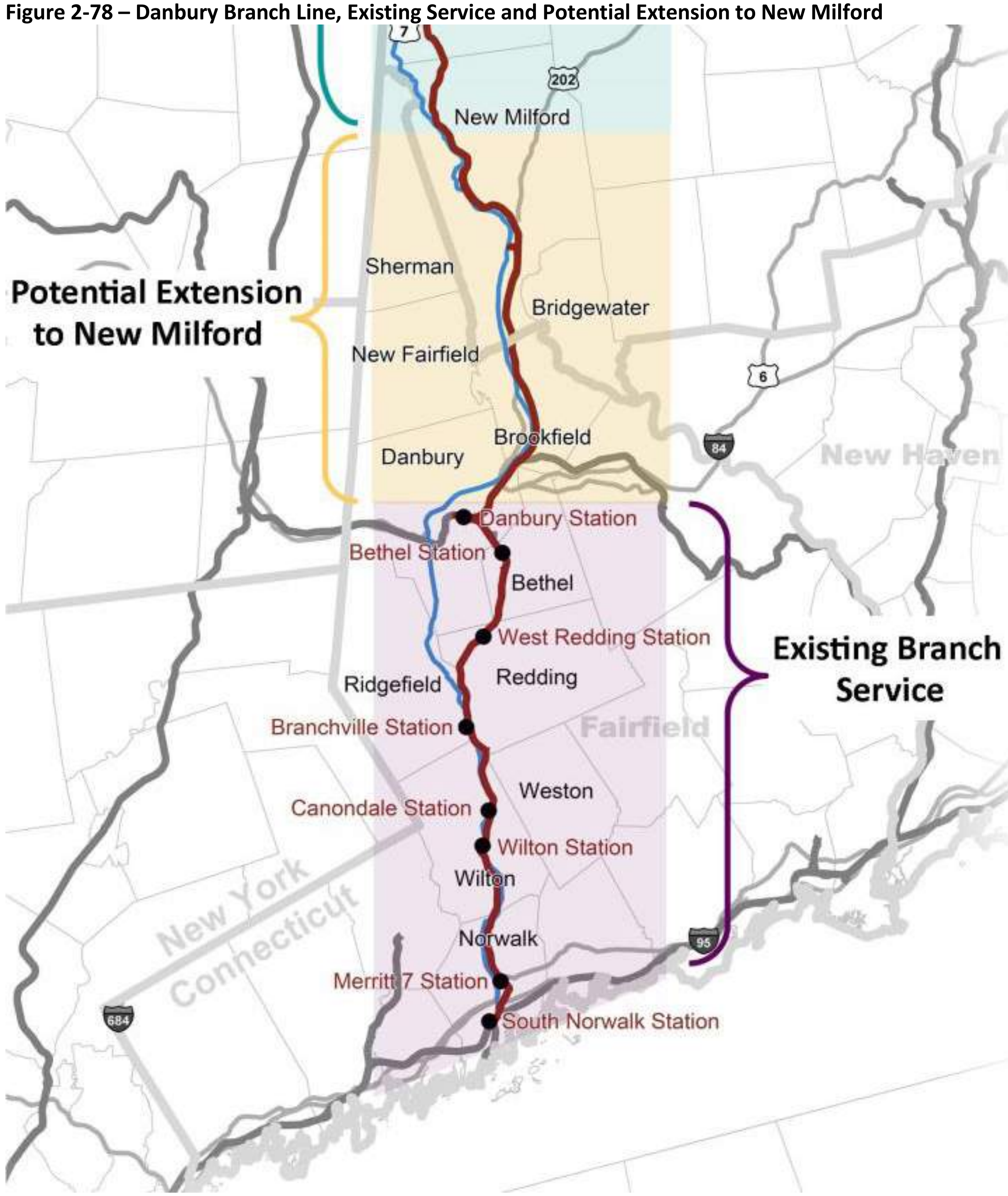


Figure 2-78 – Danbury Branch Line, Existing Service and Potential Extension to New Milford



Source: Connecticut Department of Transportation (CTDOT), Danbury Branch Line Final Implementation Plan, 2016.
http://www.danburybranchstudy.com/Danbury%20RR%20-%20Final%20Report.pdf

2.7.12.3 The Harlem Line

The Harlem Line is owned and operated by the Metropolitan Transit Authority (MTA) and services New York, Westchester, and Putnam Counties. During peak hours, the Harlem Line operates from Southeast Station to Grand Central Terminal on 13-minute headways. Harlem Line ridership greatly outpaces the Danbury Branch Line ridership, with around 4,000 riders boarding from the Southeast, Brewster, and Katonah Stations and about 46,000 riders overall. Danbury and other Connecticut towns are connected to the Harlem Line through the 3 HART transit shuttles that bring commuters to and from the Southeast, Brewster and Katonah Stations (refer to discussion in Section 2.7.11.3). Commuters can also choose to obtain a monthly or yearly parking pass at the stations and utilize their own vehicles for transportation. **Table 2-124** shows average parking availability and utilization based on project team observations of satellite imagery and information from parking operators.

Table 2-124 – MTA Harlem Line Stations Parking Availability

Station	Available Parking	Utilization
Southeast Station	623	89%
Brewster Station	280	96%
Katonah Station	400	74%

During peak hours, the Harlem Line provides more frequent and convenient service to New York City than the Danbury Branch Line. Some commuters who live in the greater Danbury Area and commute to New York City prefer to take the Harlem Line because they can avoid transferring trains at the South Norwalk station. The headways, during peak hours, at the Harlem Line are nearly 3 times as many trips. In **Table 2-125**, a sample commute from New Milford to Grand Central Station in New York City was analyzed using various modes of transportation. Despite the additional cost of Trip 2, which utilizes that Harlem Line, many commuters would opt for Trip 2 in order to save time rather that Trips 4 or 5, which utilize the Danbury Branch Line. These disparities lead commuters from the Danbury area to use the Harlem Line in New York rather than the Danbury Branch Line by driving to stations in Southeast, Brewster or Katonah, New York or by taking a HART bus shuttle to these stations.

Table 2-125 – Sample Commute Costs

Trips	Description	Duration (minutes)	Time	Cost per trip
1	**Automobile Drive** from New Milford Directly to Grand Central	**2:30**	7:00	**$ 64.63**
	80 mile drive to Grand Central (via Rt. 7, I-84, I-684)	2:30	9:30	
2	**Southeast Station**, Harlem Line to Grand Central	**2:15**	7:00	**$ 27.47**
	28 mile drive to Southeast Station	0:42	7:42	
	Layover (14 min. peak headway, ave.)	0:09	7:51	
	MTA Harlem Line to Grand Central	1:24	9:15	
3	**HART shuttle to Southeast Station**, Harlem Line to Grand Central	**2:40**	6:35	**$ 10.05**
	16 mile drive to Company A Firehouse	0:28	7:03	
	Layover (17 min. headway until 7:53)	0:06	7:09	
	HART Danbury-Brewster Shuttle	0:34	7:43	
	Layover (14 min. peak headway average)	0:08	7:51	
	MTA Harlem Line to Grand Central	1:24	9:15	
4	**HART shuttle to Brewster Station**, Harlem Line to Grand Central	**2:25**	7:05	**$ 17.81**
	12 mile drive to White Turkey Road Park-and-Ride lot	0:20	7:25	
	Layover (17 min. headway until 7:53)	0:09	7:34	
	HART Danbury-Brewster Shuttle	0:28	8:02	
	Layover (14 min. peak headway average)	0:08	8:10	
	MTA Harlem Line to Grand Central	1:20	9:30	
5	**Danbury Branch Line** to NH Line to Grand Central	**2:46**	6:50	**$ 21.02**
	16 mile drive to Danbury Station	0:30	7:20	
	Layover (35 min. headway until 7:54)	0:08	7:28	
	Danbury Branch Line to South Norwalk Station	0:50	8:18	
	Layover at South Norwalk Sta. (11 min. headway, ave.)	0:11	8:29	
	MTA New Haven Line to Grand Central	1:07	9:36	
6	**HART Bus to Danbury Branch Line** to NH Line to Grand Central	**3:18**	6:18	**$ 11.52**
	HART Bus (7) to HART Pulse Point (30 min. headway until 9:05)	0:55	7:13	
	Walk from Pulse Point to Danbury Train Station	0:10	7:23	
	Layover at Danbury Sta. (35 min. headway until 7:54)	0:05	7:28	
	Danbury Branch to South Norwalk	0:50	8:18	
	Layover at South Norwalk Sta. (11 min. peak headway average)	0:11	8:29	
	MTA New Haven Line, South Norwalk to Grand Central	1:07	9:36	

Assumptions
All trips depart from the New Milford Town Green, around 7 AM.
All Bus and Rail lines are running on time.
All driving times are Google Maps averages, and therefore factor traffic congestion.

2.7.12.4 Rail Freight

Historically, rail freight frequently traveled through the area via the Maybrook Line, from Maybrook, NY to New Haven, CT. In 1974, a major fire damaged the Poughkeepsie Bridge and the Maybrook Line was forced to close. Freight traffic was rerouted south from Albany then to Hopewell Junction, then finally east to New Haven. In 1993, Conrail sold all the tracks in the Danbury Area, and rail freight traffic had to be re-routed again. Now, rail freight traffic principally travels along the Albany-Boston Line, then turns south towards New Haven once it reaches Springfield, MA.

The Maybrook Line within the Danbury Area is currently owned by the Housatonic Railroad Company, Inc. (HRRC). Reportedly, infrequent rail freight service is provided between Derby Connecticut and Danbury; rail freight service between Danbury and the New York state line is currently inactive. The section of the Maybrook Line in New York is owned by the MTA and is also inactive. The State of New York plans to construct a multi-use trail within the rail right-of-way between the Connecticut State line in Danbury and Brewster, NY.

The HRRC also owns the Housatonic Rail Line that travels north from Danbury to the Massachusetts border. It also operates infrequent rail freight service on that segment. In 2015, the Massachusetts Department of Transportation purchased the Berkshire Line, which is the northward continuation of the Housatonic Rail Line to Pittsfield, MA and beyond.

2.7.13 Travel Demand Management

The Federal Highway Administration (FHWA) defines Travel Demand Management (TDM) as management of both the growth of traffic and the periodic shifts in traffic demand on a given network or system to better manage traffic congestion and improve the performance of the transportation system. Managing travel demand involves use of a variety of tools and strategies that provide travelers, regardless of whether they drive alone, with travel choices - such as work location, route, time, and mode.

Travel Demand Management (TDM) strategies, or solutions that re-distribute or reduce travel demand, can be implemented by both the public sector and the private sector. These strategies or solutions provide more sustainable transportation options to commuters (i.e. alternative to commuting by single-occupant automobile).

In the public sector, a variety of TDM services are available including park-and-ride lots, carpool/vanpool services through CTrides, and bike/transit integration. CTrides, which is subsidized by the State of Connecticut through CDOT, offers two services with its NuRides and vRides programs. NuRides is a service that connects local commuters and incentivizes them to form car pools. This program rewards commuters that track their commute trips and provides additional points to commuters who telecommute, use shared rides, or use transit. vRides is a service offered by Enterprise, in partnership with CTrides and private employers, to set up and operate vanpools.

The private sector can contribute to TDM by allowing their employees to work flexible hours and to telecommute. This enables employee flexibility to avoid commuting during peak hours of travel, or to work from home. These options help in alleviating rush hour congestion. Another TDM strategy offered by the private sector are shared vehicles including taxi services and shared mobility services, like Uber and Lyft.

Additional TDM services that could be offered in the Danbury area are car shares, bike shares, and parking demand management. Car shares services, such as Zip Car, provide cars for customers or subscribers to rent on a short-term basis. Bike share programs, like Citi Bike in NYC and the Lime Bike in Hartford, operate in the same way; customers purchase a pass to ride a shared bike and return the bike to another location near their final destination.

Another way to facilitate TDM and encourage multimodal travel is to implement parking demand management. Danbury does not have parking maximums under the municipal Zoning Code nor requires private companies to manage parking demand. The City does have minimum parking requirements for private companies through its zoning code; such regulations often result in an oversupply of parking spaces which can result in induced demand for single-occupant automobile travel and decreased use of public transportation.

2.7.13.1 Intermodal Connections

Commuter Parking to Commuter Rail

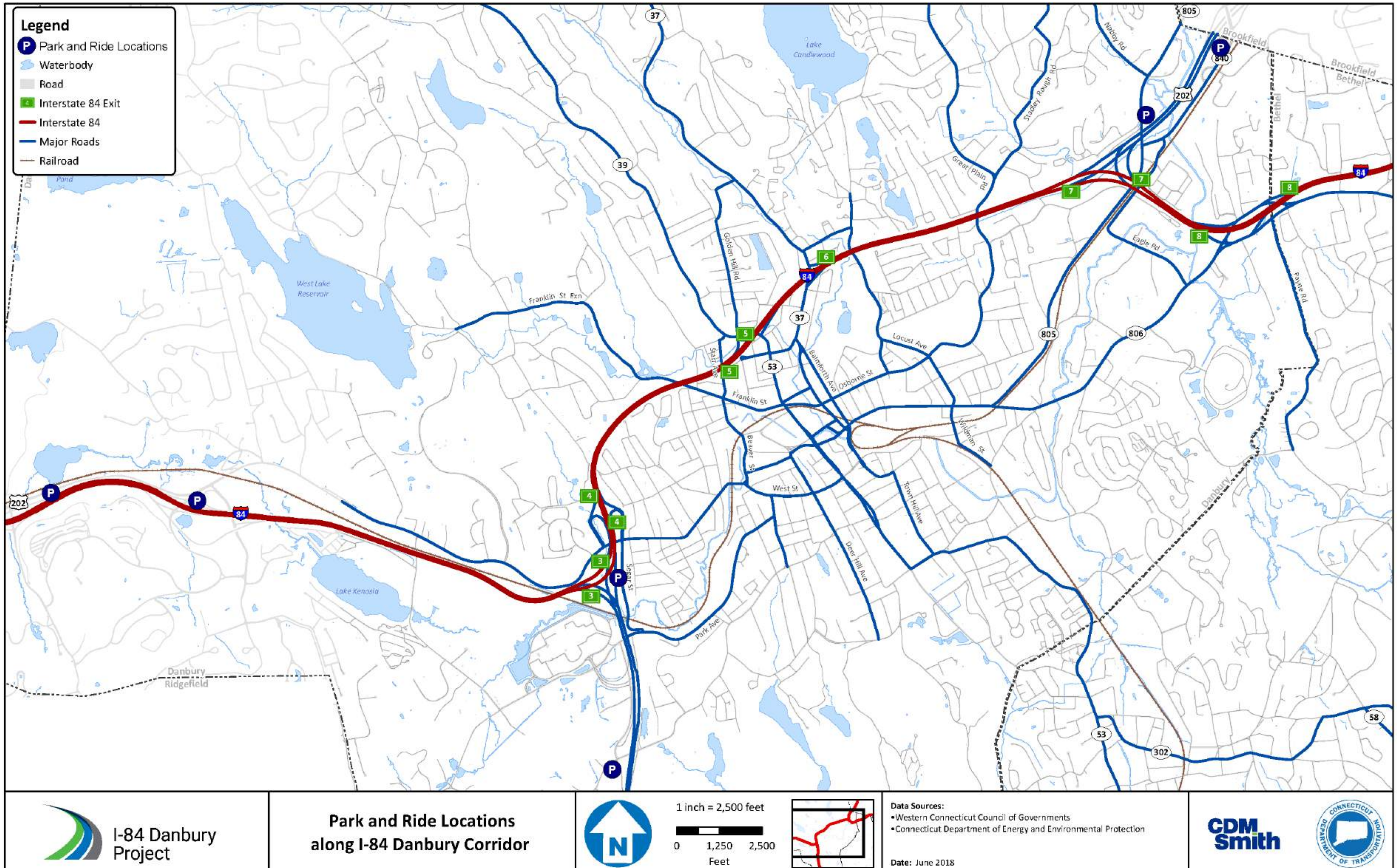
There are seven commuter parking lots along the I-84 and Route 7 corridors within the study area, listed in **Table 2-126**. Six of these lots are served by either a HART Fixed Route bus service or a HART Shuttle bus service. Through these HART services, these commuter parking lots can be linked to either the Danbury Branch line or the MTA Harlem Line for further connections to transit. **Figure 2-79** shows the location of all the park-and-ride lots in relation to I-84 and the Greater Danbury Area as well as the number of parking space and the approximate rate of utilization during peak hours of use.

Table 2-126 – I-84 Commuter Parking Lot Occupancy and Service

#	Park-And-Ride Location	Size	Occupancy	Express Bus	Local Bus
1	I-84 @ Exit 1	160	21%	Brewster Shuttle	#3 Mill Plain Road
2	I-84 @ Exit 2	112	63%	Brewster Shuttle	#3 Mill Plain Road
3	I-84 @ Segar Street	45	11%	N/A	#6 Lake Avenue
4	Route 7 @ Federal Road	115	32%	Brewster Shuttle	#4 Brookfield, #7 New Milford
5	Route 7 at Miry Brook	171	39%	N/A	Route 7 Link
6	Route 7 @White Turkey Road	75	52%	Brewster Shuttle	N/A
7	I-84 @ Exit 9	53	N/A	N/A	N/A

Source: Western Connecticut Council of Governments (WestCOG), Western Connecticut Commuter Parking Inventory, 2018.
https://westcog.org/wp-content/uploads/2018/05/Commuter-Parking-Individual-Lot-Summaries-Update.pdf

Figure 2-79 – Park-And-Ride Locations



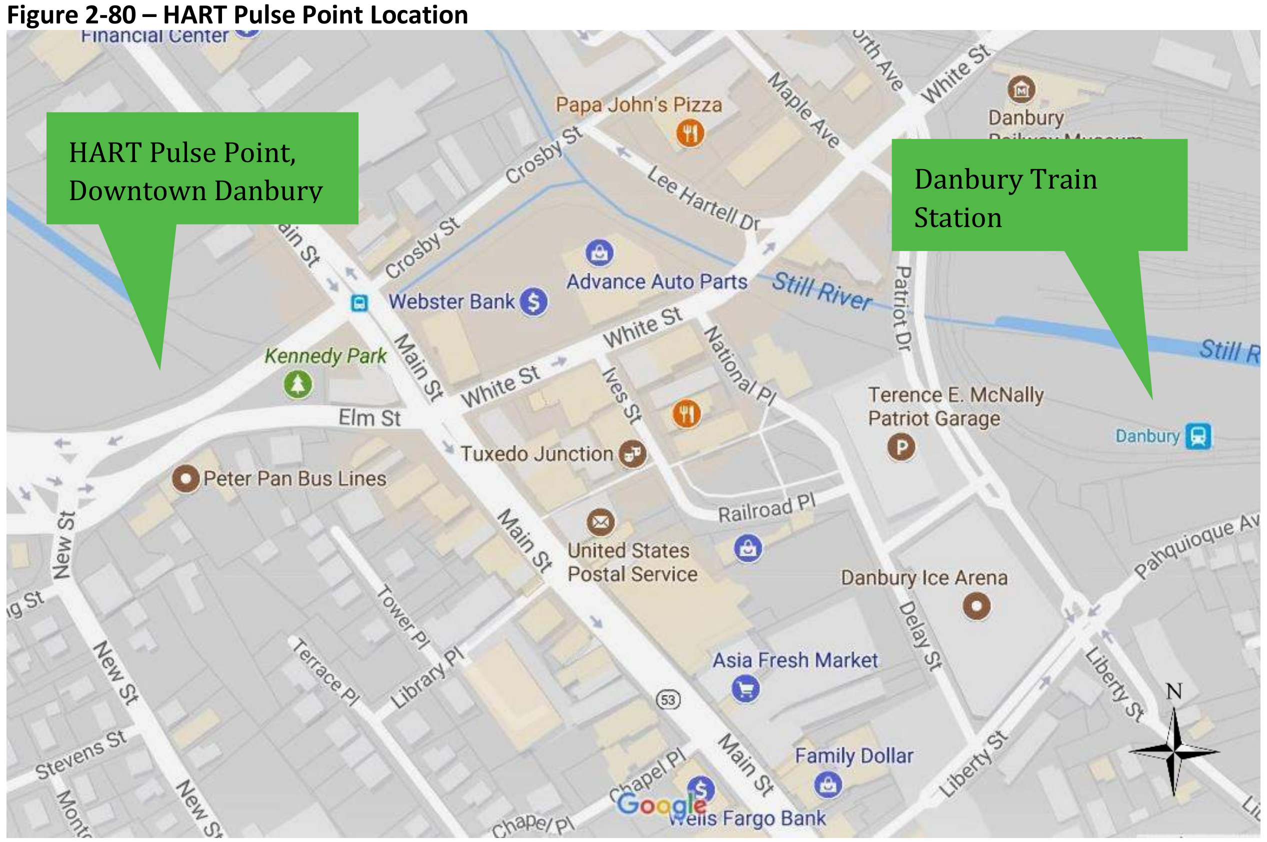
2.7.13.2 Bus Transit to Danbury Station and the Danbury Branch Line

One issue with multimodal transportation in Danbury is the distance between the HART bus pulse point and the Danbury Train Station. The pulse point and the train station are one-half mile apart. **Figure 2-80** shows the location of the HART pulse point relative to the Danbury Train Station. During peak hours, 7 bus routes converge at the pulse point every 30 minutes, while the Danbury Branch rail line operates every 35 minutes during peak hours. During peak hour, there is often a 20-minute layover between buses arriving at the pulse point and departures from the Danbury Branch line.

None of the HART busses directly stop at the Danbury Train Station. Two separate routes, Route 2 and Route 7, both bypass the train station on trips to and from the Pulse Point.

A transit-oriented development study commissioned by the City of Danbury (refer to Section 2.7.13.4) recommends moving the bus pulse point closer to the Danbury train station. If the pulse point were to be closer to, or located at the train station, intermodal transportation – i.e. facilities or systems that facilitate the exchange of travelers among the various modes of travel including automobile, shared vehicles, taxis, Zip Cars, carpool/vanpools, fixed route buses, shuttles, commuter rail, bicycle and pedestrian - would be enhanced.

Figure 2-80 – HART Pulse Point Location



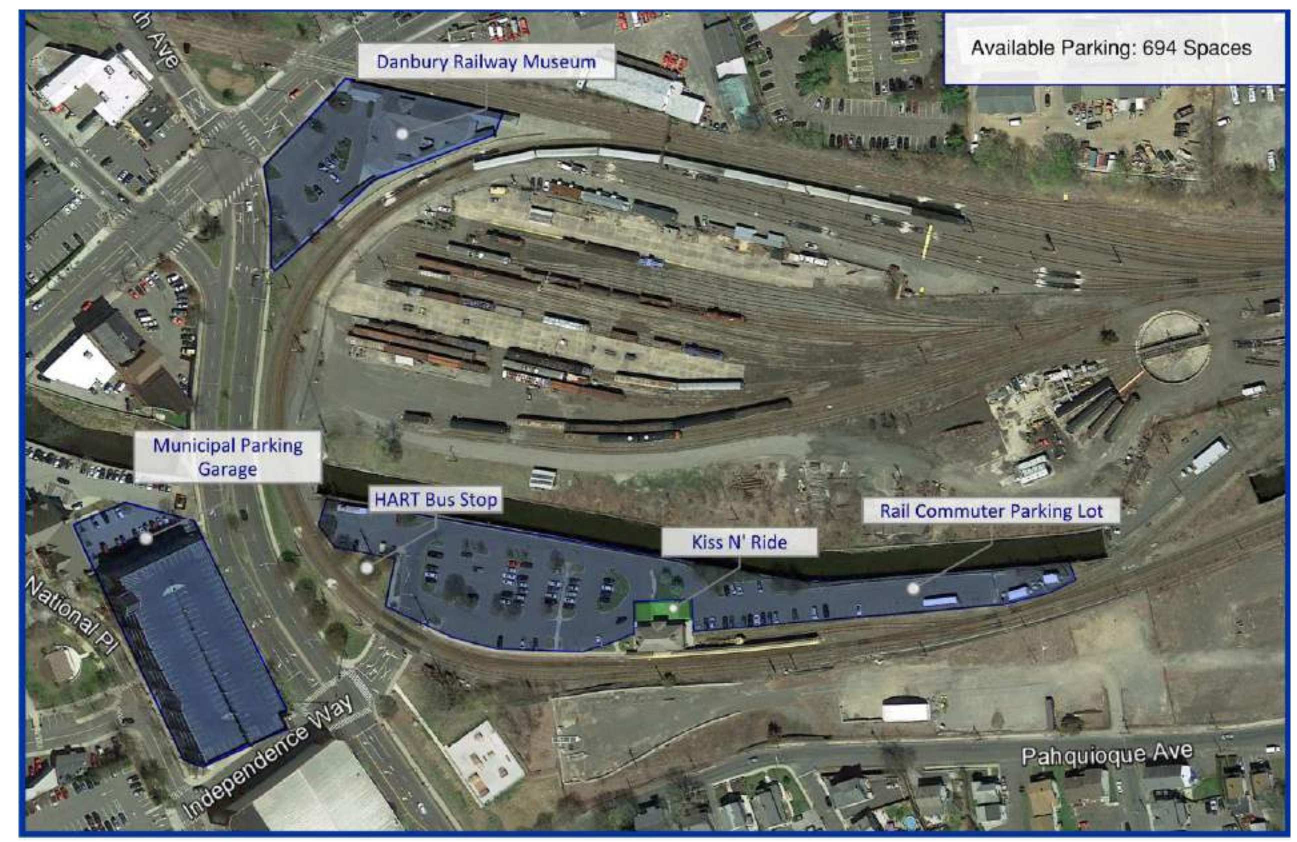
Source: Google Maps

2.7.13.3 Commuter Parking at Danbury Station

The Danbury Train Station, located on Patriot Drive, has a commuter parking lot that is managed by Metro-North. The lot has 146 parking spaces; 12 metered, 5 for persons with disabilities, and 129 permitted.[13] Due to the infrequent use of permitted parking, the facility has sold 120% of their capacity and experiences no issue with accommodating commuters. These parking areas are shown in **Figure 2-81**.

Adjacent to the station is the Terence E. McNally Patriot Garage, owned and operated by the Danbury Parking Authority. This facility maintains 540 permittable spaces and 10 spaces for persons with disabilities, with an average monthly utilization of 255 permitted vehicles per month. Garage parking for students is validated through the Naugatuck Valley Community College allowing 150 students to utilize the garage daily. The hours of operation are between 5am to 2am, Monday through Thursday; 5am to 3 am Friday and Saturday; and 8am – 2am on Sundays, with a restriction on overnight parking.[14]

Figure 2-81 – Danbury Station Map



[13] Source: Western Connecticut Council of Governments (WestCOG), Western Connecticut Commuter Parking Inventory, 2018. https://westcog.org/wp-content/uploads/2018/05/Commuter-Parking-Individual-Lot-Summaries-Update.pdf

[14] Source: Danbury Parking Authority, Parking Locations. https://www.danburyparking.com/locations.php

2.7.13.4 Downtown Danbury Transit-Oriented Development Study (2016 – present)

The City of Danbury is currently undertaking a Transit-Oriented Development (TOD) study to advance the revitalization of downtown Danbury. The TOD boundary, shown in **Figure 2-82,** was based on areas of downtown that are within a ten-minute walk to Danbury Station. The northern edge of the TOD study area lies approximately one-quarter mile south of the I-84 Danbury Project limits. Objectives of the study are to:

- Expand Downtown Danbury's walkable and mixed-use character and unlock market-driven development opportunities.
- Improve multi-modal access and make more effective use of transit service.
- Link Downtown, neighborhoods and transit and design places that attract people.
- Engage community stakeholders to advance the TOD vision.

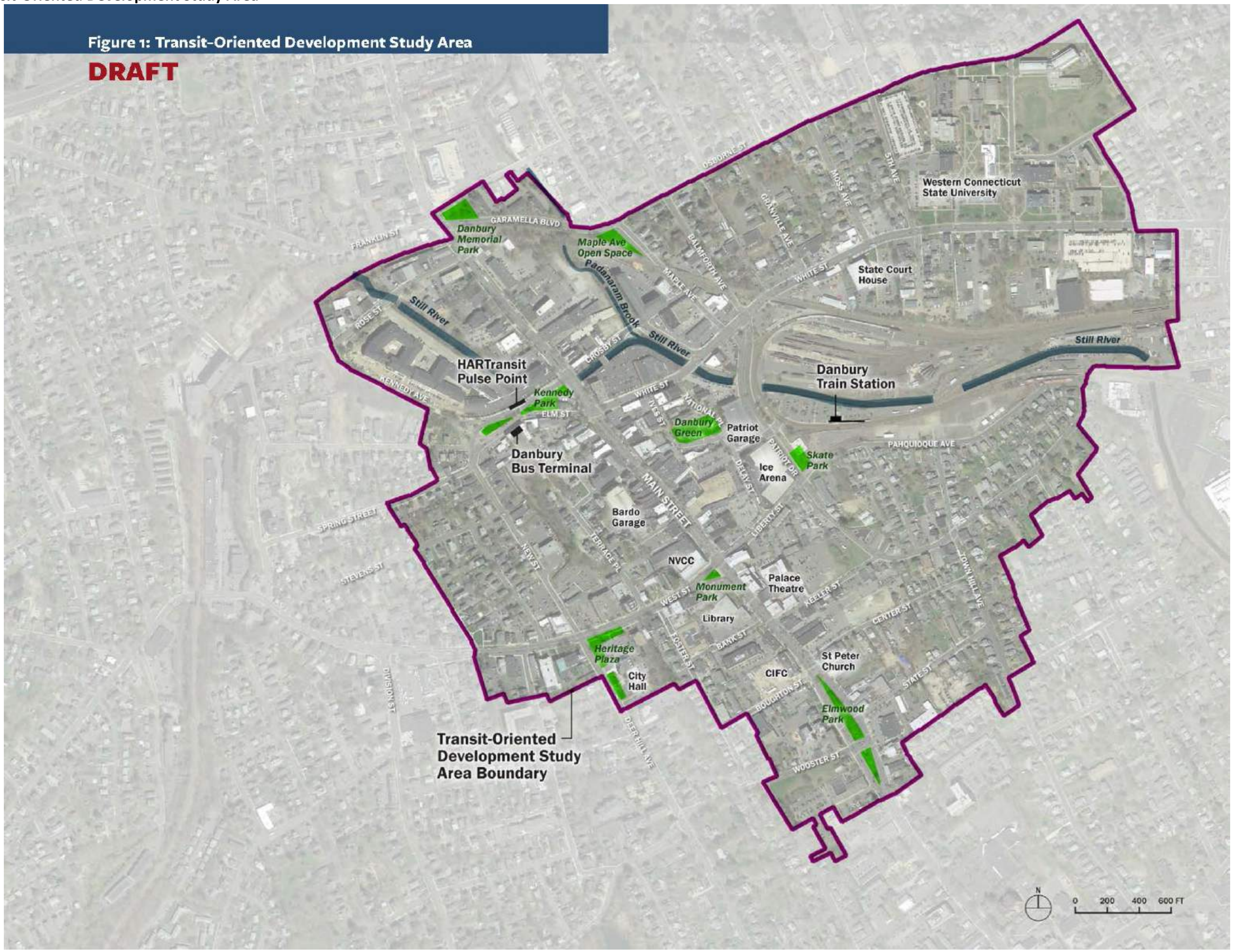
Initial findings of the TOD study - provided in a draft report titled "Downtown Danbury Transit-Oriented Development Study, City of Danbury, CT" dated May 2018 - include:

- There is a strong market for downtown housing, with the potential for 1,200 additional housing units.
- This influx of new residents will bolster the demand for new retail, restaurants and other services.
- Housing and complementary retail services would be constructed as infill development.
- Current zoning is generally conducive to TOD, however, some modifications to parking and building height regulations may be warranted.
- To improve intermodal connectivity and boost transit ridership, the City and HART should relocate the current bus pulse point from Kennedy Park to a site on Pahquique Avenue adjacent to the Danbury Train Station.
- Non-motorized travel is key to TOD; the City should improve pedestrian and bicycle networks throughout downtown and improve connections to neighborhoods. The study established a prioritized network of street improvements to improve pedestrian-bike travel.
- Initiate commuter rail network improvements including a new rail connection between Danbury Station and the Harlem Line in New York.
- Explore opportunities to link Downtown Danbury to pedestrian-bike paths in adjacent communities (Brookfield, Brewster and the Norwalk Valley Regional Trail).

TOD in Downtown Danbury will concentrate new residential, commercial, and employment land uses in a relatively dense, mixed-use district that is within walking and bicycling distance of bus and train services. Therefore, many of these TOD recommendations would improve non-motorized travel (walking and bicycling) and increase transit ridership levels. This shift of travel from cars to more sustainable forms of transportation will benefit operations on I-84 by reducing travel demand by single-occupant automobiles and enabling people to live closer to where they work. Also, since the TOD study area encompasses a large Environmental Justice community in downtown Danbury, TOD has the potential to improve access to jobs for low-income, minority, and limited English proficiency populations in Danbury,

In addition, by capitalizing on the State's and the City's past investments in transit and utility infrastructure, TOD in Danbury has the potential to expand the municipal tax base without requiring extensive new infrastructure.

Figure 2-82 – City of Danbury Transit-Oriented Development Study Area



Source: City of Danbury, Transit-Oriented Development Study, June 2018. https://www.danbury-ct.gov/government/departments/planning-zoning/tod/

2.7.13.5 Potential Commuter Shuttle Routes

An additional deficiency in the Danbury multimodal network is the lack of connections between commuter parking lots along the highway and major centers of employment and transit hubs throughout the city. This presents a need to bridge these "first-mile" and "last-mile" travel gaps to allow for additional travel mode choices, other than arriving to final destinations via single-occupant automobile on I-84 and local streets. A potential future network of public or private express shuttles, depicted below in **Figure 2-83**, could connect inbound commuters with major employment centers, transit hubs, and park-and-ride lots – both existing lots and potential new lots – by intercepting them outside of the city center and removing single-occupant vehicles from the I-84 mainline and local streets. This mode shift will become even more critical during the future construction of the I-84 Danbury Project, which will likely present considerable delays and detours on the mainline.

As discussed in Sec. 2.7.1 – Existing Street Network, the street network in Danbury was established when Downtown Danbury was the center of regional commerce. The street network in Danbury was laid out in response to this hub of activity, including Danbury Station, and a variety of other factors, including physiographic constraints and land use patterns. The result is a hub and spoke network of arterials and streets the radiate outward from downtown Danbury. While this pattern made sense in the 19th century, it is not a terribly efficient network for today's travel needs.

This is because growth and development in greater Danbury since the latter half of the 20th century and the construction of the interstate highway system, and continuing to this day, have not been centered in downtown Danbury; rather, construction of numerous shopping centers, corporate office parks, manufacturing facilities and apartment and condominium complexes has occurred on large tracts of open land in exurban locations near highway interchanges. Consequently, transportation patterns have radically changed. Most travel no long begins or ends in downtown Danbury. Most commuter and commercial traffic begins in suburban or exurban districts and is destined for relatively new uses in other, low-density exurban districts; often and increasingly, an exurban district near other, more remote cities. That is, traffic patterns throughout greater Danbury are now more amorphous, where a high percentage of commuters travel from one exurb to another - through Danbury rather than to Danbury.

Public transit systems generally have not adapted well to this shift, although Housatonic Area Regional Transit (HART) has done an admirable job at recognizing new travel patterns and has tweaked its fixed route bus network to better connect its customers to new, exurban centers of employment. However, in spite of these adaptations, getting the average suburban or exurban resident to forego commuting by single-occupant automobile is difficult, especially when available transit routes are not express routes, and when "first mile" and "last mile" travel gaps exist (first and last mile gaps include lack of service connections or alternative travel modes between a bus stop or a transportation terminal to a commuter's final destination after leaving the transit system).

In recognition of these hurdles to transit solutions that respond to this radical shift of commuting patterns, some jurisdictions are using smaller, more nimble and route-limited shuttle buses. These shuttles can be operated by the public or private sectors. In fact, in greater Danbury, HART currently operates three such shuttles between Danbury area commuter parking lots and train stations on the Harlem Line in New York (refer to discussion in Section 2.7.11.3).

Increasingly, large private employers are operating shuttle busses or even bus fleets; the shuttles have routes and stops like a normal public bus system, however it only has one destination – an employer's place of business. Companies that operate private shuttles find that they are better able to recruit high quality employees. Employees who use the shuttles experience slightly longer commutes, however, the shuttle busses are often outfitted with tables, AC electric outlets, and Wi-Fi so employees can get things done during their commute. They also don't have to deal with the stress of driving in peak hour traffic; therefore, employers find that employees who take advantage of shuttle busses (or company-sponsored van pools – refer to Section 2.7.13 for more information on this TDM approach to ride-sharing) are more productive.

Other private ride-sharing companies are using big data to identify where people are and where they want to go. They have created platforms for smart phone app users to find shuttles or vans with multiple passengers going to the same destination. Riders or customers are assigned to pick-up locations that are on a route chosen by other customers on board the van. Optimization software uses real-time traffic data and passenger inputs to dynamically route shuttles or vans on the quickest path between proximate pick-up locations on high-demand routes and an employment destination (or proximate destinations) that are also common to customers on the shuttle or van. These dynamic, demand-responsive, shared travel solutions will become more commonplace as technology improves (including, in the not too distant future, autonomous shuttles or vans) and as people understand the value and benefits.

To facilitate multimodal travel and improve transportation choice in the I-84 Danbury Project area, CTDOT could partner with HART, major private employers, and/or private, ride-sharing companies to implement new, demand-responsive shuttle routes.

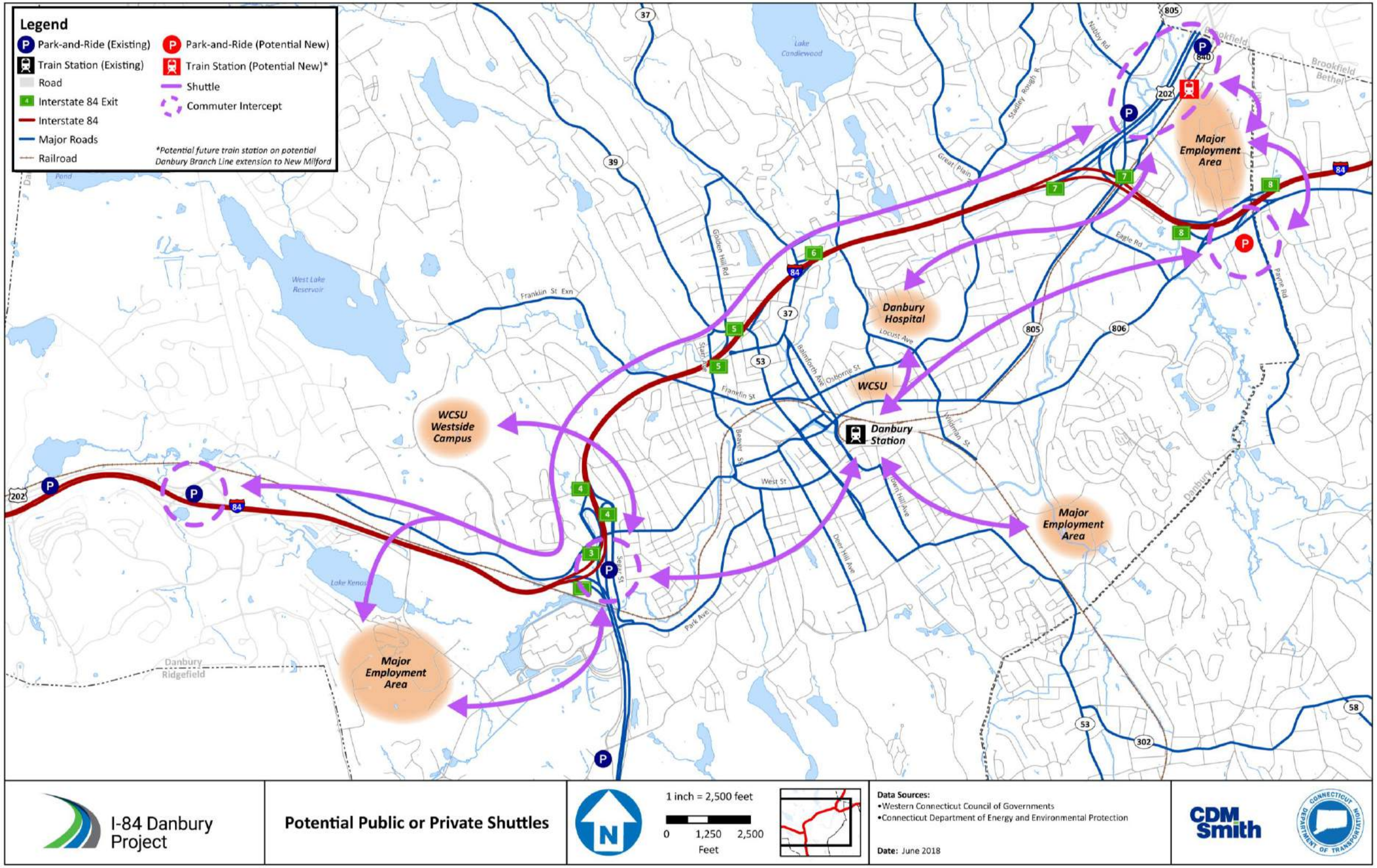
A potential future network of public or private express shuttles is depicted in **Figure 2-83**. These shuttles could connect inbound commuters with major employment centers in greater Danbury. New transit hubs located at existing commuter 'Park-and-Ride' lots, and at potential new commuter lots, could intercept commuters outside of the city center (on Route 7, for example) and provide well-appointed and comfortable facilities to allow commuters to transfer to a public or private shuttle that would take them directly to their final destination, such as a corporate office park, a major employer, or a transit station.

The benefits of this alternate mode of travel include:

- Incentivize commuters to use ride-sharing services.
- Reduce the number of single-occupant vehicles travelling on the most congested sections of I-84 and on over-taxed local streets.
- Provide congestion relief and reduction in peak hour delays for other motorists on the highway network.

This potential mode shift strategy would be particularly beneficial during the future construction phases of the I-84 Danbury Project, which will likely result in significant traffic delays for a multi-year construction duration due to lane shifts and detours on I-84 and on Route 7.

Figure 2-83 – Potential Public or Private Express Shuttles



2.7.14 Summary of Multimodal Transportation Needs and Deficiencies

The consideration of multimodal travel improvements or investments incorporated into the I-84 Danbury Project will elevate urban mobility in greater Danbury, especially for Environmental Justice communities and residents with limited mobility, by:

- better connecting neighborhoods proximate to I-84 that are currently isolated by the physical presence of I-84 or are affected by the "barriers" to local travel that results from the influence of I-84 traffic;
- improving the safety of non-motorized travel in the project area;
- improving residents' access to jobs, schools and services;
- improving transportation choice and residents' access to transit; and,
- expanding social and economic, networks; that is, creating more cohesion between neighborhoods that helps to improve social, intergenerational and multi-cultural interaction, and reduces real or perceived isolation of neighborhoods that have less economic status.

Following is a summary of potential multimodal improvements that could be incorporated into the I-84 Danbury Project to provide these benefits; they are grouped by travel mode or topic.

Non-Motorized Travel (Pedestrian & Bicycle):

There are notable deficiencies that affect pedestrian and bicycle travel (non-motorized travel) in the vicinity of the I-84 Danbury corridor. Danbury's existing street network, with its narrow travel lanes and high volume of relatively fast traffic, presents challenges for pedestrian and bicycle connectivity and safety. This is particularly true where the local street network intersects I-84 on- and off-ramps at highway interchanges. Streets at these locations not only experience heavy and fast traffic volumes, but also often have multiple travel and turning lanes. Traffic flow on these streets can be intimidating for pedestrians and bicyclists and the streets can be perceived as impermeable to pedestrian and bicycle travel.

The I-84 Danbury Project represents an opportunity to repair the local street network in the immediate vicinity of the I-84 corridor to mitigate the degree to which the limited access highway network separates neighborhoods, and the degree to which traffic conditions and street geometry create obstacles for local pedestrian and bicycle travel. Investments in pedestrian and bicycle infrastructure in densely populated neighborhoods with mixed land uses (like the neighborhoods in the I-84 project area) can yield great benefits in travel safety and in the reduction of travel demand by single-occupant automobiles. They can also improve connectivity to transit by making it easier and safer for pedestrians and bicyclists to travel from their homes or places of employment to bus stops. These non-motorized improvements could include:

- Continuity of sidewalks and street lighting on all 19 streets that cross I-84 in the project area.
- Intersection geometry improvements and crosswalks such as those depicted in the "Optimal Intersection" diagram provided in **Figure 2-65**; particularly on the streets identified as High Priority of multimodal improvements within this chapter.
- Marked bicycle lanes or paved shoulders suitable for bicycle travel on prioritized streets that cross I-84 in the project area.
- Sheltered bike racks at Park and Ride commuter parking lots, many of which are served by HART bus routes.
- Enhanced accessibility to the proposed Still River Greenway to facilitate travel by bicycle.
- Bus shelters and lighting at major bus stops in the project area.
- Exploring the feasibility of collocating a shared-use path along the Connecticut segments of the Maybrook Line between Danbury and the NewYork state border. This potential multi-use greenway corridor would connect to New York's proposed Maybrook Trailway to connect downtown Danbury with Brewster Station on the Harlem Line in Brewster, New York. It would also connect Downtown Danbury and many residential districts, including Environmental Justice communities, to the Danbury Mall and other commercial neighborhoods to the west of the city center.

Fixed Route Bus Transit

The bus transit system in the I-84 Danbury Project area is operated by the Housatonic Area Rapid Transit (HART). HART operates seven routes in and around Danbury that effectively serve the City, its downtown, major employment centers, shopping centers, medical centers, and schools. It also serves special populations well including residents of Environmental Justice communities and elderly residents. However, more could be done on the bus routes in the vicinity of the I-84 Danbury Project to make transit use safer and more convenient, including:

- Improving pedestrian and bicycle safety on streets that connect residential neighborhoods with bus routes.
- Improving street lighting levels along walking routes to bus stops and at bus stops.
- Providing bus shelters, at least at high ridership bus stop locations.
- Reducing congestion levels on I-84 to avoid diversion of traffic onto local City streets; such diversions delay bus travel times and make buses miss connections at timed transfer points, which in turn makes bus riders late for work.

Bus Shuttles

While HART's fixed route bus network and three shuttle bus routes between commuter parking lots and commuter rail stations serve local needs, more can be done to facilitate mode shift from single-occupant automobiles to bus transit - especially in light of changing land use and transportation patterns in greater Danbury. The I-84 Danbury Project team should consider expanding the use of smaller shuttle buses to get people to work or to make it easier for commuters to access other forms of transit. This might be done by creating more comfortable and convenient transfer points at existing or new commuter parking lots and by improving vehicular, pedestrian and bicycle access to commuter parking lots. The implementation of publicly- or privately-operated, demand response bus shuttles or jitneys in coordination with HART, private employers, and/or private ride-sharing companies could address several needs, including providing convenient multimodal alternatives for commuters, relieving peak-hour congestion, and improving worker productivity.

Rail Transit

Ridership on the Danbury Branch is stymied by low service levels which may be due, in part, by Danbury Station access challenges, including deficient pedestrian and bicycle networks on local streets and traffic congestion on streets leading to downtown Danbury and Danbury Station from I-84 and Route 7 interchanges. The I-84 Danbury Project might improve vehicular access to downtown Danbury and to Danbury Station (where there is a sufficient supply of commuter parking), as well as improve pedestrian access on streets in the vicinity of I-84 that feed into the existing downtown sidewalk network. Improved access would result in higher levels of commuter rail ridership and fewer highway vehicles miles travelled in the greater Danbury region.

A potential extension of the Danbury Branch Line to New Milford would also reduce single-occupancy-vehicle travel at junction of I-84 and Route 7. However, the Danbury Branch Line extension project is not likely to be funded and prioritized in the near-term. Nonetheless, the potential of better connecting commuter rail commuters to new, future stations north of the I-84 corridor should be considered under the I-84 Danbury Project with the intent of streamlining access to these future station site(s) for travelers on I-84 and on Route 7 – that is, working to set the stage for better access to the stations if and when they are constructed at a future date.

Travel Demand Management

Travel Demand Management (TDM) is the application of multiple transportation strategies and policies to re-distribute or reduce demand in travel, particularly travel by single-occupant automobile. The State of Connecticut, through CTDOT, subsidizes various forms of TDM including car-pooling services though the CTrides program, van-pooling services through the vRides program, and telecommuting incentives to encourage employers to give employees work schedule flexibility to avoid commuting during peak hours of travel. Because TDM helps to reduce overall vehicles miles travelled in a region and alleviate rush hour congestion, CTDOT might consider augmenting its current TDM programs and incentives, especially during the multi-year project construction period where construction activity and detours has the potential to result in excessive traffic congestion. Other states, including Virginia, have enacted similar intensive TDM programs in advance of major construction projects to minimize construction-related delays.

Intermodal Connections

A Transit-Oriented Development (TOD) study commissioned by the City of Danbury recommends moving the HART bus pulse point closer to the Danbury train station, possibly to a site on Pahquioque Avenue, to improve bus access to commuter rail and boost overall transit ridership. Currently, the HART pulse point in Downtown Danbury is a ten-minute walking distance from Danbury Station. Such a move would facilitate the exchange of travelers among the various modes of travel (i.e. improve intermodal connectivity) including automobile, shared vehicles, (taxis, Zip Cars, carpool/vanpools), fixed route buses, shuttles, commuter rail, bicycle and pedestrian modes of travel.

The City of Danbury is currently undertaking a Transit-Oriented Development (TOD) study to advance the revitalization of downtown Danbury. TOD in Downtown Danbury will concentrate new residential, commercial, and employment land uses in a relatively dense, mixed-use district that is within walking and bicycling distance of bus and train services. The northern edge of the TOD study area lies approximately one-quarter mile south of the I-84 Danbury Project limits.

To support TOD, there is need and opportunity to improve intermodal connectivity among transit and transportation systems that serve Downtown Danbury. This might include improving vehicular access between I-84 and downtown Danbury and improving non-motorized and transit connectivity between the I-84 project area and the TOD study area. Such improved connectivity to the proposed TOD district would increase transit ridership levels on HART's fixed-route bus network and on the Danbury Branch Line. This shift of travel from single-occupant automobiles to these more sustainable forms of transportation will benefit operations on I-84 by reducing travel demand by single-occupant automobiles and enabling people to live closer to where they work. Also, since the TOD study area encompasses a large Environmental Justice community in downtown Danbury, TOD has the potential to improve access to jobs for low-income, minority, and limited English proficiency populations in Danbury.

Section 3
Future Transportation Conditions

3.1 Forecasting Traffic Growth

Future traffic growth was obtained from using the existing (2016) validated TDM and the CTDOT trip tables. CTDOT trip tables contain future population and employment data projections. For the future analysis year, 2040 was used to develop projections. Like existing conditions, the future (2040) trip tables were disaggregated into the zone structure developed for this project. Further, the daily trip tables obtained from CTDOT were sliced into peak periods using the hourly distributions. A detailed explanation of process to develop future projections along with supporting documentation is provided in the Technical Appendix. **Table 3-1** provides a representation of future (2040) growth factors at select locations within the study area for the weekday daily, A.M., and P.M. peak hour periods respectively.

Table 3-1 Future (2040) Traffic Growth Factors

Location	Eastbound			Westbound		
	Daily	AM	PM	Daily	AM	PM
I-84 West of Exit 3	0.6%	0.5%	0.6%	0.5%	0.5%	0.5%
I-84 between Exits 4 and 5	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
I-84 between Exits 5 and 6	0.6%	0.5%	0.6%	0.6%	0.5%	0.5%
I-84 between Exits 7 and 8	0.6%	0.5%	0.6%	0.6%	0.6%	0.5%
I-84 East of Exit 8	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%
	Northbound			Southbound		
	Daily	AM	PM	Daily	AM	PM
Route 7 South of Exit 3	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Route 7 North of Exit 7	0.5%	0.3%	0.3%	0.4%	0.4%	0.4%
	Northbound			Southbound		
	Daily	AM	PM	Daily	AM	PM
Lake Avenue	0.6%	1.0%	0.2%	0.5%	0.2%	0.6%
Main Street	0.5%	0.8%	0.2%	0.7%	0.7%	0.7%
North Street	0.3%	1.0%	0.3%	0.4%	0.2%	0.3%
Federal Road	1.0%	0.5%	0.6%	0.8%	0.8%	0.6%
Newtown Road	0.5%	0.6%	0.8%	0.6%	1.0%	0.4%

NOTE: Traffic growth factors shown are per year.

As indicated in the table, the traffic growth factors are around 0.5 to 0.6 percent per year on I-84. On Route 7, the traffic growth factors range between 0.3 to 0.5 percent per year. Along key arterial streets within the corridor such as Lake Avenue, North Street, and Newtown Road, the traffic growth factor is as high as 1.0 percent per year during certain peak hour periods.

To develop future (2040) no build traffic volumes, the future (2040) projected traffic volumes were added to the traffic volumes from key Major Traffic Generators within the study area. Future (2040) no build traffic volumes are provided in the technical appendix.

3.2 Future (2040) No Build Traffic Volumes

This section provides the future (2040) no-build traffic volumes for key roadways in the study area.

3.2.1 I-84 Traffic Volumes – Existing vs. Future

Table 3-2 provides a comparison of existing (2016) and future (2040) no build traffic volumes along I-84.

Table 3-2 I-84 Traffic Volumes – Existing vs. Future

Eastbound	2016			2040		
	Daily	AM	PM	Daily	AM	PM
West of Exit 3	38,800	1,820	3,510	46,000	2,240	4,210
Between Exits 4 and 5	58,800	2,840	5,650	67,200	3,300	6,750
Between Exits 5 and 6	53,400	2,810	4,980	61,800	3,300	6,040
Between Exits 7 and 8	50,900	3,580	5,730	59,300	4,200	6,910
East of Exit 8	41,300	2,260	3,710	48,400	2,640	4,590
Westbound	2016			2040		
	Daily	AM	PM	Daily	AM	PM
West of Exit 3	42,400	3,750	2,650	48,000	4,390	3,200
Between Exits 4 and 5	61,100	5,840	3,680	69,100	6,800	4,600
Between Exits 5 and 6	57,700	4,970	3,700	65,600	5,880	4,620
Between Exits 7 and 8	52,000	5,720	4,570	58,400	6,730	5,640
East of Exit 8	44,000	4,050	2,900	49,800	4,750	3,590

3.2.2 Route 7 Traffic Volumes – Existing vs. Future

Table 3-3 provides a comparison of existing (2016) and future (2040) no-build traffic volumes along Route 7.

Table 3-3 Route 7 Traffic Volumes – Existing vs. Future

Northbound	2016			2040		
	Daily	AM	PM	Daily	AM	PM
South of Exit 3	32,700	1,700	3,380	35,000	1,850	3,740
North of Exit 7	27,800	1,790	2,730	30,100	1,950	3,010
Southbound	**2016**			**2040**		
	Daily	**AM**	**PM**	**Daily**	**AM**	**PM**
South of Exit 3	32,000	2,740	2,190	34,500	3,060	2,480
North of Exit 7	31,800	1,660	1,500	35,600	1,790	1,650

3.2.3 Key Arterials Traffic Volumes – Existing vs. Future

Table 3-4 provides a comparison of existing (2016) and future (2040) no-build traffic volumes along key arterials in the study area.

Table 3-4 Key Arterial Traffic Volumes - Existing vs. Future

Northbound/Eastbound	2016			2040		
	Daily	AM	PM	Daily	AM	PM
Lake Avenue	11,500	730	1,340	13,300	880	1,680
Main Street	12,500	780	1,190	14,300	820	1,370
North Street	5,400	390	570	5,900	390	670
Federal Street	9,500	630	1,320	12,000	710	1,520
Newtown Road	29,400	720	1,350	33,100	790	1,510
Southbound/Westbound	**2016**			**2040**		
	Daily	**AM**	**PM**	**Daily**	**AM**	**PM**
Lake Avenue	10,500	740	800	11,900	840	910
Main Street	10,600	760	820	12,600	1,150	930
North Street	13,400	1,200	1,250	14,900	1,390	1,330
Federal Street	8,200	490	550	10,000	600	640
Newtown Road	31,600	1,590	1,320	34,000	1,710	1,440

3.3 Network Performance Measures

This section discusses the network performance measures which include I-84, Route 7, and other study area roadways. Network performance measures were obtained to understand system wide impacts of the increased traffic growth in the future.

3.3.1 Definitions of Performance Measures

Performance measures are metrics which are used to determine the effectiveness of a specific improvement strategy or alternative. The following is a list and definition of network performance measures used in the VISSIM analysis:

- **Total distance traveled or Vehicle Miles Traveled (VMT)** – The total distance traveled by all vehicles that completed their trips in the designated time period. This is measured for the entire network. A higher VMT is considered good, as it means that drivers are able to travel further within a given period of time.

- **Total travel time or Vehicle Hours Traveled (VHT)** – The total travel time experienced by all vehicles that completed their trips in the designated time period. This is measured for the entire network. A lower VHT is considered good, as it means drivers are spending less time waiting at signals/stop signs and there is less stop-and-go driving.

- **Average speed (in miles per hour)** – Travel speed averaged over all vehicles that completed their trips in the designated time period. This is measured for the entire network (and includes when drivers are stopped at signals and stop signs). A higher speed is considered good, as it means vehicles are moving efficiently through the intersections and along the corridor. In the model, the maximum speed a vehicle can achieve on any portion of the corridor is the desired speed. The desired speed is a function of the posted speed limit and varies for each vehicle based on driver comfort and travel conditions.

- **Average delay time (in seconds per vehicle)** – The delay time is the additional time incurred by a vehicle when the travel speed drops below the free-flow speed of the facility. When the delay time is averaged over the number of vehicles in the roadway system, the average delay time is computed. A lower average delay time is considered as good, as it means the vehicles are not experiencing frequent speed reductions.

- **Number of stops** – The total number of stops experienced by vehicles traveling on a facility. Fewer stops are good as vehicles travel unimpeded.

- **Total stopped delay (in vehicle hours)** – The amount of delay experienced by vehicles under a stopped condition measures in vehicle hours. A lower stopped delay is considered good, as it means drivers are spending less time stopping on a facility and do not incur waiting time or delay.

3.3.2 Quantitative Performance Measures

- **Existing (2016)** – This condition represents current traffic volumes under the current roadway network.

- **Future (2040) No Build** – This condition represents future (2040) no build traffic volumes under the current roadway network.

Table 3-5 presents a comparison of existing and future no build network performance measures during the A.M. and P.M. peak hour periods.

Table 3-5 Network Performance Measures

Description	Unit	Existing (2016)	Future No Build (2040)	Difference (%)
AM Peak Hour				
Total Distance Traveled	mi	106,237	114,281	**+8%**
Total Travel Time	h	2,595	3,795	**+46%**
Average Speed	mph	41	30	**-26%**
Average delay time per vehicle	sec	68	137	**+103%**
Number of Stops	ea	72,664	207,848	**+186%**
Total stopped delay	h	185	466	**+152%**
PM Peak Hour				
Total Distance Traveled	mi	115,954	117,304	**+1%**
Total Travel Time	h	3,289	5,809	**+77%**
Average Speed	mph	35	20	**-42%**
Average delay time per vehicle	sec	79	211	**+168%**
Number of Stops	ea	68,153	443,706	**+551%**
Total stopped delay	h	218	996	**+358%**

The following are some of the key observations:

- **Total distance traveled or Vehicle Miles Traveled (VMT)** – The VMT increases by about 8 percent (106,237 vehicle miles under existing to 114,281 vehicle miles under the future no build condition) during the A.M. peak hour period and by about 1 percent (115,954 vehicle miles under existing to 117,304 miles under the future no build condition) during the P.M. peak hour period. *This shows an improvement in VMT. However, it is important to note that in future (2040) condition, the model shows a reduction in VMT in the post P.M. peak hour period when everything becomes standstill due to congestion.*

- **Total travel time or Vehicle Hours Traveled (VHT)** – The VHT increases by about 46 percent (2,595 vehicle hours under existing to 3,795 vehicle hours under the future no build condition) during the A.M. peak hour period and by about 77 percent (3,289 vehicle hours under existing to 5,809 vehicle hours under the future no build condition) during the P.M. peak hour period. *This shows deterioration in VHT.*

- **Average speed (in miles per hour)** – The average speed decreases by about 26 percent (41 miles per hour under existing to 30 miles per hour under the future no build condition) during the A.M. peak hour period and by about 42 percent (35 miles per hour under existing to 20 miles per hour under the future no build condition) during the P.M. peak hour period. *This shows deterioration in average speed.*

- **Average delay time (in seconds per vehicle)** – The average speed decreases by about 103 percent (68 seconds under existing to 137 seconds under the future no build condition) during the A.M. peak hour period and by about 168 percent (79 seconds under existing to 211 seconds under the future no build condition) during the P.M. peak hour period. *This shows deterioration in average delay. traffic volumes.*

- **Number of stops** – The number of stops increases by about 186 percent (72,664 under existing to 207,848 under the future no build condition) during the A.M. peak hour period and by about 551 percent (68,153 under existing to 443,706 under the future no build condition) during the P.M. peak hour period. *This shows deterioration in number of stops.*

- **Total stopped delay** – The total stopped delay increases by about 152 percent (185 vehicle hours under existing to 466 vehicle hours under the future no build condition) during the A.M. peak hour period and by about 4 percent (218 vehicle hours under existing to 996 vehicle hours under the future no build condition) during the P.M. peak hour period. *This shows deterioration in total stopped delay.*

3.3.3 Model Observations

Specific observations were made from the VISSIM model relative to vehicle delay and queuing in the A.M. and P.M. peak hour periods. The following summarizes those observations.

3.3.3.1 AM Peak Hour Period

During the A.M. peak hour period, the eastbound direction of I-84 is anticipated to operate congestion free in the future (2040) except slight congestion between Exits 7 and 8.

In the westbound direction on I-84, the congestion levels are anticipated to increase drastically near the Exit 8 on-ramp (Newtown Road) due to the weaving movement into Route 7 northbound in the future. The resulting queues from this congestion spill back on I-84 approximately 4 miles upstream of the Exit 8 on-ramp (about 4 miles more than existing). **Figure 3-1** shows a graph depicting the anticipated bottleneck on I-84 and the impact on vehicle speeds approaching the congestion near Exit 7 and 8 during the A.M. peak hour period.

The Route 7 southbound merge with I-84 at Exit 7 is anticipated to increase vehicle delays and queues upstream of the merge point into Route 7 and Federal Road, and other connecting arterial streets. Because of the bottleneck caused by the Route 7 traffic merging into I-84, the vehicle speeds on I-84 are near free-flow heading west of the merge point. The figure shows the higher speeds west of Exit 7 under the future condition.

Based on the vehicle queuing data obtained from the VISSIM model, on Route 7 in the southbound direction, vehicle queues are anticipated to extend approximately 2.5 miles upstream of the merge point with I-84 (about 1.7 miles more than existing conditions). Overall, the roadway network adjacent to Exit 7 breaks down in the future due to inadequate capacity to accommodate the forecasted traffic on I-84, Route 7, and Federal Road.

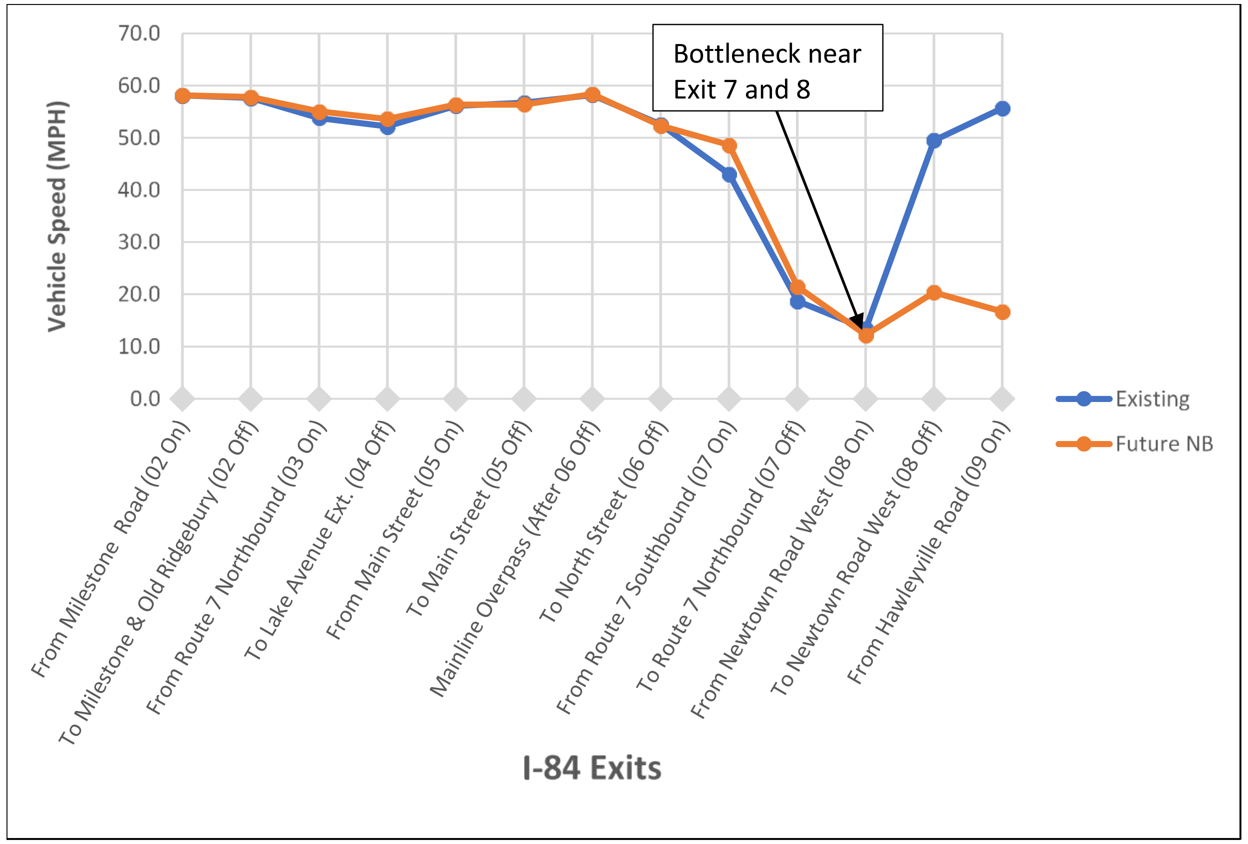


Figure 3-1 I-84 Westbound Speed Curve – AM Peak Hour

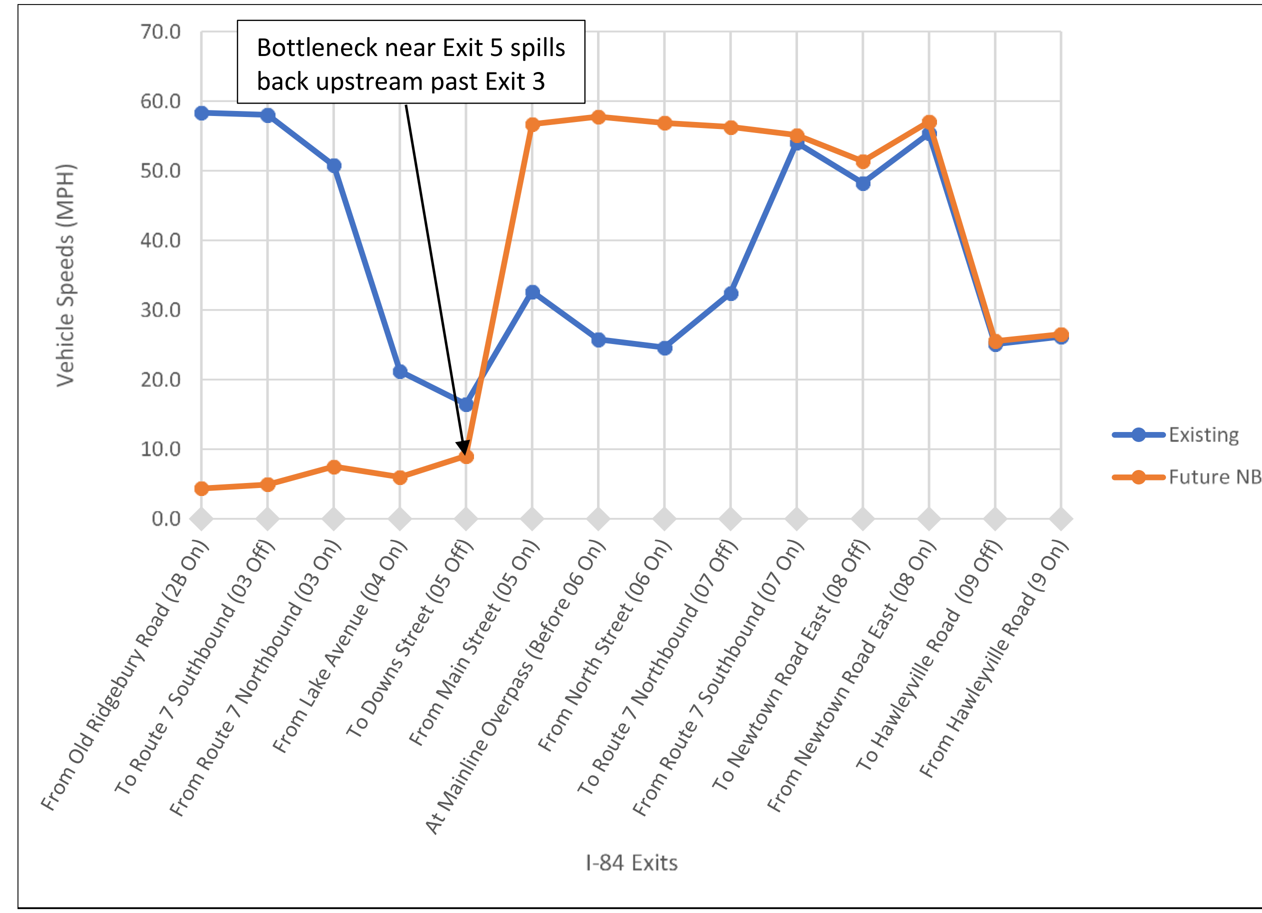


Figure 3-2 I-84 Eastbound Speed Curve – PM Peak Hour

3.3.3.2 PM Peak Hour Period

During the P.M. peak hour period, the eastbound direction of I-84 is anticipated to experience an increase in congestion with higher traffic volumes. Complete breakdown in traffic flow occurs near Exits 3 and 5. At Exit 3, the Route 7 northbound merge with I-84 is anticipated to create merging problems and traffic is anticipated to back-up upstream of the merge on Route 7. Essentially, Route 7 is anticipated to be a complete gridlock in the future. At Exit 5, the Downs Street off-ramp is anticipated to be an operational issue and vehicle queues spillback on I-84 blocking through traffic. The resulting vehicle delays and queues extend approximately 5 miles (about 4 miles more than existing) on I-84. On Route 7, the vehicle queues extend approximately 2.0 miles (about 1.8 miles more than existing). However, downstream of the merge, vehicle speeds on I-84 will increase due to the metering effect at the merge point and these speeds will reach free-flow condition heading east. **Figure 3-2** shows a graph depicting the anticipated bottleneck at the I-84/Route 7 merge and Downs Street exit.

The westbound direction of I-84 is anticipated to operate congestion free in the future (2040). The only exception being the Lake Avenue exit where I-84 is anticipated to experience a slowdown because of traffic spilling over on the highway from Lake Avenue.

3.4 Future (2040) Level of Service Analysis

This section discusses the levels of service analysis under future (2040) conditions for the mainline segments, mainline-ramp junctions, weaving segments, and the intersections.

3.4.1 Mainline Segment Operations

This section focusses on the mainline segment operations along I-84 and Route 7 under future (2040) conditions.

3.4.1.1 I-84 Mainline Operations

This section discusses the I-84 mainline operations under future conditions.

Eastbound Direction

Table 3-6 shows LOS analysis results for I-84 mainline segments in the eastbound direction during the weekday A.M. and P.M. peak hour periods. As discussed earlier in Section 2.3.3.2, the eastbound direction peaks during the weekday P.M. peak hour period and congestion is caused by through and weaving (entering and exiting) traffic between Exits 3 and 8. This condition is anticipated to deteriorate in the future and several mainline segments noted below will continue to operate at LOS E or F:

- Between Exit 3 Off and Exit 3 On Ramps
- Between Exit 4 On and Off Ramps
- Between Exit 4 On and Exit 5 Off Ramps
- Between Exit 5 On and Off Ramps
- Between Exit 5 On and Exit 6 On Ramps
- Between Exit 6 On and Exit 7 Off Ramps
- Between Exit 7 Off and Exit 7 On Ramps
- Between Exit 8 On and Exit 9 Off Ramps

Westbound Direction

Table 3-7 shows LOS analysis results for I-84 mainline segments in the westbound direction during the weekday A.M. and P.M. peak hour periods. As stated earlier in Section 2.3.3.1, traffic conditions are anticipated to deteriorate on both I-84 and Route 7 and the following segments will continue to operate at LOS E or F in the future:

- Between Exit 5 On and Exit 4 Off Ramps
- Between Exit 6 Off and Exit 5 Off Ramps
- Between Exit 7 On and Exit 6 Off Ramps
- Between Exit 7 On and Off Ramps
- Between Exit 8 On and Off Ramps
- Between Exit 9 On and Exit 8 Off Ramps

Table 3-6 Future (2040) I-84 Segment Levels of Service – Eastbound Direction

Location			Weekday AM Peak			Weekday PM Peak		
Start	End	Length (ft)	Volume	Density (pc/mi/ln)	LOS	Volume	Density (pc/mi/ln)	LOS
Exit 3 Off **To Route 7 Southbound**	Exit 03 On **From Route 7 Northbound**	2,433	1,630	13.2	B	3,200	81.7	F
Exit 4 Off **To Lake Avenue**	Exit 04 On **From Lake Avenue**	856	2,690	13.4	B	5,630	107.5	F
Exit 4 On **From Lake Avenue**	Exit 05 Off **To Downs Street**	5,817	3,300	17.6	B	6,750	73.9	F
Exit 5 Off **To Downs Street**	Exit 05 On **From Main Street**	2,318	2,510	13.6	B	5,350	70.3	F
Exit 5 On **From Main Street**	Exit 06 On **From North Street**	1,964	3,300	16.2	B	6,040	86.1	F
Exit 6 On **From North Street**	Exit 07 Off **To Route 7 Northbound**	7,232	4,200	21.5	C	6,910	54.6	F
Exit 7 Off **To Route 7 Northbound**	Exit 07 On **From Route 7 Southbound**	2,279	2,850	24.3	C	4,620	35.9	E
Exit 8 Off **To Newtown Road East**	Exit 08 On **From Newtown Road East**	2,406	2,310	12.2	B	3,930	18.6	C
Exit 8 On **From Newtown Road East**	Exit 09 Off **To Hawleyville Road**	14,272	2,640	17.9	B	4,590	64.4	F

Table 3-7 Future (2040) I-84 Segment Levels of Service – Westbound Direction

Location			Weekday AM Peak			Weekday PM Peak		
Start	End	Length (ft)	Volume	Density (pc/mi/ln)	LOS	Volume	Density (pc/mi/ln)	LOS
Exit 4 On **From Lake Avenue**	Exit 03 On **From Route 7 Northbound**	736	3,880	24.5	C	2,310	13.6	B
Exit 3 Off **To Route 7 Southbound**	Exit 04 On **From Lake Avenue**	950	3,550	27.2	D	2,110	17.6	B
Exit 4 Off **To Lake Avenue**	Exit 03 Off **To Route 7 Southbound**	1,850	6,010	27.7	D	3,580	17.4	B
Exit 5 On **From Main Street**	Exit 04 Off **To Lake Avenue**	6,000	6,800	35.2	E	4,600	24.4	C
Exit 5 Off **To Downs Street**	Exit 05 On **From Main Street**	1,000	5,250	26.1	D	3,540	19.0	C
Exit 6 Off **To North Street**	Exit 05 Off **To Main Street**	3,350	5,880	28.9	D	4,620	38.8	E
Exit 7 On **From Route 7 Southbound**	Exit 06 Off **To North Street**	7,450	6,730	36.3	E	5,640	36.0	E
Exit 7 Off **To Route 7 Northbound**	Exit 07 On **From Route 7 Southbound**	2,050	4,510	35.2	E	3,710	24.4	C
Exit 8 Off **To Newtown Road**	Exit 08 On **From Newtown Road**	3,650	3,830	122.9	F	3,090	23.5	C
Exit 9 On **From Hawleyville Road**	Exit 08 Off **to Newtown Road**	14,114	4,750	85.9	F	3,590	26.2	D

3.4.1.2 Route 7 Mainline Operations

This section discusses the Route 7 mainline operations under future conditions.

Northbound Direction

Table 3-8 shows LOS analysis results for the Route 7 mainline segments in the northbound direction during the weekday A.M. and P.M. peak hour periods. Under the future condition, the mainline segment between Exit 7 On and Off Ramps (Wooster Heights Road) is anticipated to deteriorate to LOS F during the weekday P.M. peak hour period. This is because of the downstream congestion at the Route 7 merge with I-84 eastbound.

Southbound Direction

Table 3-9 shows LOS analysis results for the Route 7 mainline segments in the southbound direction during the weekday A.M. and P.M. peak hour periods. The following segments will continue to operate at LOS E or F:

- Between Exit 11 On and Exit 10E Off Ramps
- Exit 10E Off and 10 On Ramps
- Exit 10 On and Exit 10W Off

In addition to the above segments, the segment of Route 7 between Exit 11 Off and On Ramps (White Turkey Road Extension) is anticipated to operate at LOS F during the weekday A.M. peak hour period. As discussed earlier in Section 2.3.3.1, this is caused by the vehicle delays and queues spilling back upstream of the Route 7 merge with I-84 westbound.

3.4.1.3 Summary of Mainline Segment Operations

- Eight (8) segments on I-84 are anticipated operate at LOS F in the eastbound direction.
- Six (6) segments on I-84 are anticipated to operate at LOS E or F in the westbound direction.
- One (1) segment on Route 7 is anticipated to operate at LOS F in the northbound direction.
- Four (4) segments on Route 7 are anticipated to operate at LOS F in the southbound direction.

Figures 3-3 and **3-4** show the mainline segment level of service during the weekday A.M. and P.M. peak hour periods under future conditions respectively.

Table 3-8 Future (2040) Route 7 Segment Levels of Service – Northbound Direction

Location			Weekday A.M. Peak			Weekday P.M. Peak		
Start	End	Length (ft)	Volume	Density (pc/mi/ln)	LOS	Volume	Density (pc/mi/ln)	LOS
Exit 7 Off **To Wooster Hghts Rd.**	Exit 07 On **From Wooster Hghts Rd.**	2,379	1,160	11.1	B	2,180	178.2	F
Exit 10 On **From I-84 Westbound**	Exit 11 Off **To White Turkey Rd. Ext.**	3,172	1,950	13.9	B	3,010	19.6	C
Exit 11 Off **To White Turkey Road Ext.**	Exit 11 On **From White Turkey Road Ext.**	2,696	700	5.0	A	1,280	8.5	A

Table 3-9 Future (2040) Route 7 Segment Levels of Service – Southbound Direction

Location			Weekday A.M. Peak			Weekday P.M. Peak		
Start	End	Length (ft)	Volume	Density (pc/mi/ln)	LOS	Volume	Density (pc/mi/ln)	LOS
Exit 7 Off **To Sugar Hollow Rd.**	Exit 07 On **From Miry Brook Rd.**	2,802	1,650	13.0	B	880	7.7	A
Exit 8 Off **To Backus Ave./Park Ave.**	Exit 07 Off **To Sugar Hollow Rd.**	1,850	2,210	11.3	B	1,270	6.8	A
Exit 10 On **From Federal Road**	Exit 10W Off **Begin I-84 WB Overlap**	940	2,220	65.8	F	1,930	98.7	F
Exit 10E Off **To I-84 Eastbound**	Exit 10 On **From Federal Road**	740	1,100	163.6	F	1,010	146.7	F
Exit 11 On **From White Turkey Road Ext.**	Exit 10 Off **To I-84 Eastbound**	3,640	1,790	150.4	F	1,650	40.1	E
Exit 11 Off **To White Turkey Road Ext.**	Exit 11 On **From White Turkey Road Ext.**	2,590	1,280	177.6	F	730	6.0	A

Figure 3-3 Future (2040) Highway Mainline and Ramp Levels of Service – Weekday A.M. Peak Hour Period

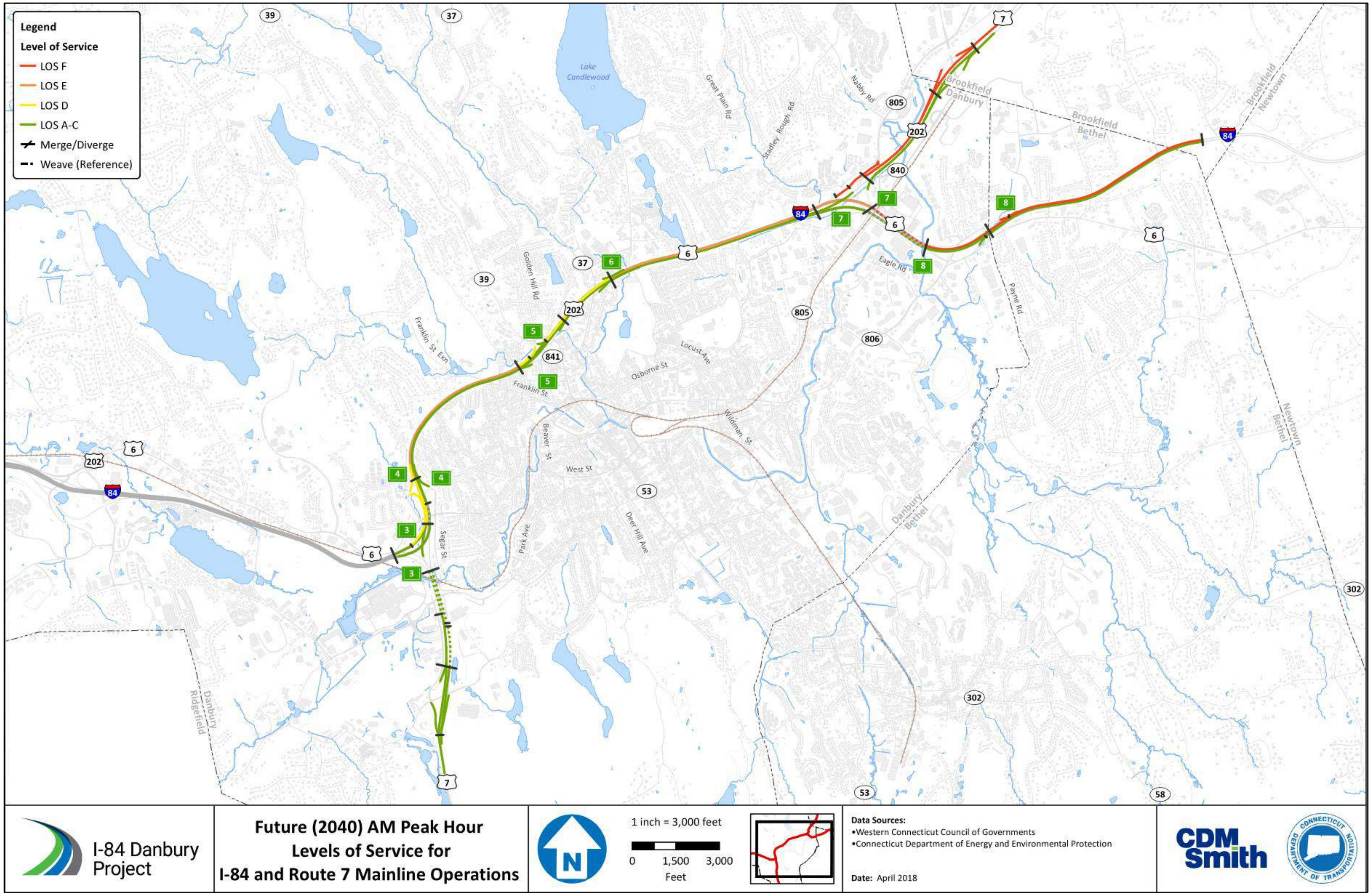
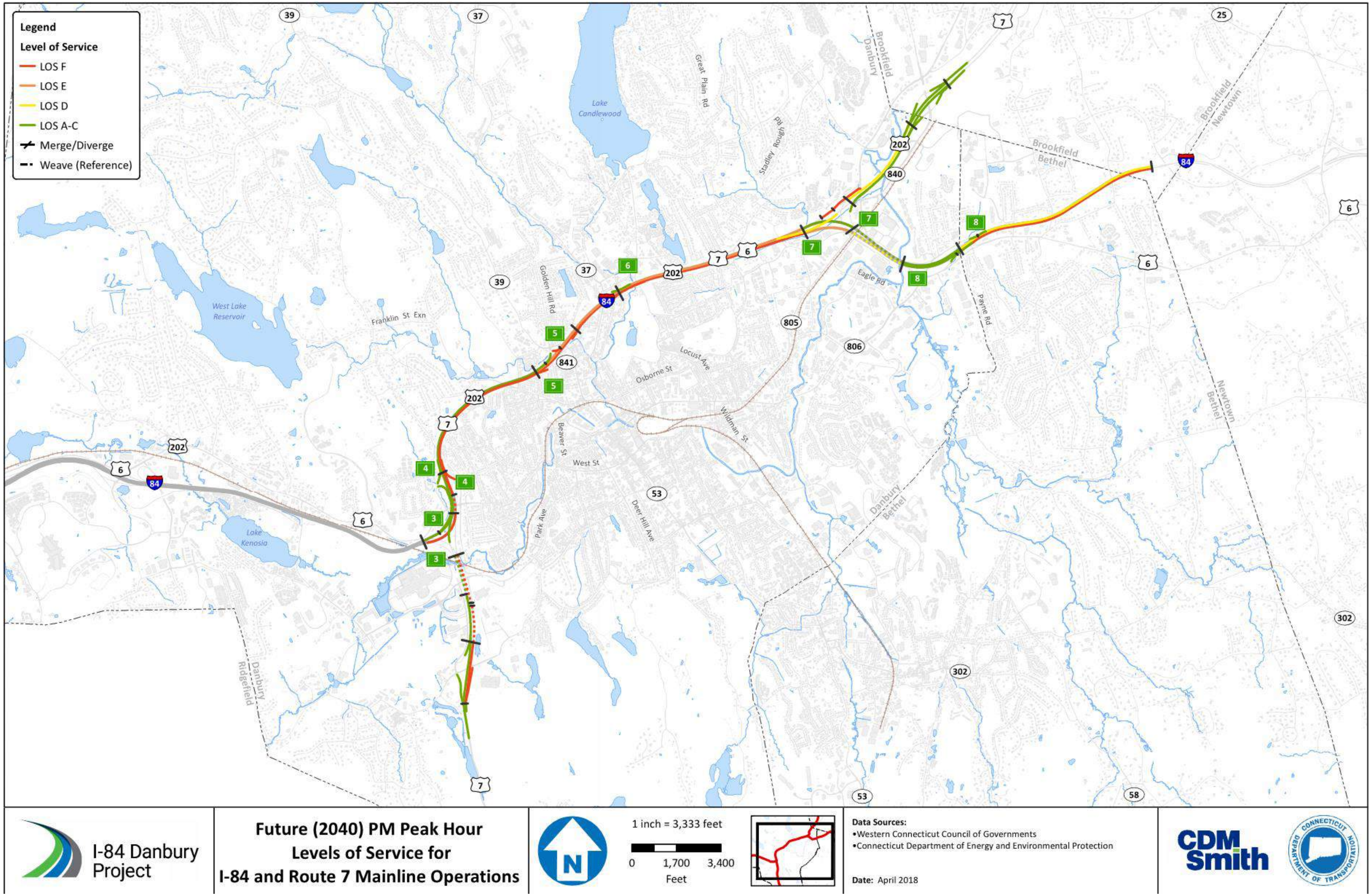


Figure 3-4 Future (2040) Highway Mainline and Ramp Levels of Service – Weekday P.M. Peak Hour Period



3.4.2 Mainline Ramp Junction Operations

This section focusses on the mainline and ramp junction operations along I-84 and Route 7 under future conditions.

3.4.2.1 I-84 Ramp Levels of Service

This section discusses the I-84 mainline and ramp junctions under future (2040) conditions.

Eastbound Direction

Table 3-10 shows LOS analysis results for I-84 merge and diverge ramp junctions in the eastbound direction during the weekday A.M. and P.M. peak hour periods. The following ramp junctions continue to operate at LOS E or F under future conditions with increased traffic volumes:

- Exit 4 On Ramp from Lake Avenue (merge)
- Exit 5 Off Ramp to Downs Street (diverge)
- Exit 5 On Ramp from Main Street (merge)
- Exit 6 On Ramp from North Street (merge)

Westbound Direction

Table 3-11 shows LOS analysis results for I-84 merge and diverge ramp junctions in the westbound direction during weekday A.M. and P.M. peak hour periods. The Exit 8 Off Ramp to Newtown Road/U.S. Route 6 (diverge) continues to operate at LOS F under future conditions. The Exit 5 Off Ramp to Main Street is anticipated to operate at LOS F because of vehicle queues spilling back to the mainline from the Exit 5 Off Ramp/Main Street intersection. This section discusses the existing traffic conditions in the I-84 study corridor. The limits of the project are I-84 between Exits 3 and 8 and Route 7 between Exits 7 and 9 on the west side and to Exit 11 on the east side of the study corridor. This section includes current traffic data, traffic flows, and traffic conditions on the highway mainline, ramps, and the arterial street network adjacent to I-84 and Route 7.

Table 3-10 Future (2040) I-84 Ramp Levels of Service – Eastbound Direction

	Weekday AM Peak				Weekday PM Peak			
	Volume				Volume			
Location	Mainline	Ramp	Density (pc/mi/ln)	LOS	Mainline	Density (pc/mi/ln)	Density (pc/mi/ln)	LOS
Exit 4 - Lake Avenue								
On Ramp	2690	610	14.1	B	5630	1120	104.1	F
Exit 5 - Downs Street/Main Street								
Off Ramp	3300	790	14.4	B	6750	1400	55.0	F
On Ramp	2510	790	13.6	B	5350	690	8.18	F
Exit 6 - North Street								
On Ramp	3300	900	13.6	B	6040	870	81.8	F
Exit 7 - Route 7								
Off Ramp	4200	1350	17.8	B	6910	2290	32.0	D
Exit 8 - Newtown Road/U.S. 6								
On Ramp	2310	330	10.2	B	3930	660	15.5	B

Table 3-11 Future (2040) I-84 Ramp Levels of Service – Westbound Direction

	Weekday AM Peak				Weekday PM Peak			
	Volume				Volume			
Location	Mainline	Ramp	Density (pc/mi/ln)	LOS	Mainline	Density (pc/mi/ln)	Density (pc/mi/ln)	LOS
Exit 3 - Route 7								
Off Ramp	6010	2460	22.8	C	3580	1470	14.3	B
Exit 4 - Lake Avenue								
On Ramp	3550	330	21.2	C	2110	200	12.7	B
Off Ramp	6800	790	28.6	D	4600	1020	19.9	B
Exit 5 - Downs Street/Main Street								
On Ramp	5250	1550	28.9	D	3540	1060	19.5	B
Off Ramp	5880	630	22.4	C	4620	1080	47.1	F
Exit 6 - North Street								
Off Ramp	6730	860	25.4	C	5640	1020	24.5	C
Exit 8 - Newtown Road/U.S. 6								
Off Ramp	4750	920	36.2	F	3590	500	24.7	C

3.4.2.2 Route 7 Ramp Levels of Service

This section discusses the Route 7 mainline and ramp junctions under future (2040) conditions.

Northbound Direction

Table 3-12 shows LOS analysis results for Route 7 merge and diverge ramp junctions in the northbound direction during the weekday A.M. and P.M. peak hour periods under future conditions. The Route 7-Wooster Heights Road intersection is anticipated to operate at LOS F during the P.M. peak period because of resulting congestion downstream at the Route 7 merge with I-84 eastbound.

Southbound Direction

Table 3-13 shows LOS analysis results for Route 7 merge and diverge ramp junctions in the southbound direction during the weekday A.M. and P.M. peak hour periods under future conditions. The following ramp merges continue to operate at LOS F resulting from congestion at the Route 7 merge with I-84 westbound:

- Exit 10 On Ramp from Federal Road
- Exit 11 On Ramp from White Turkey Road Extension

In the future, the congestion and vehicle queues are anticipated to extend further upstream of the Route 7 merge with I-84 westbound and impact the off-ramp at White Turkey Road extension. This results in a LOS F at that ramp diverge during the weekday A.M. peak hour period.

3.4.2.3 Summary of Ramp Levels of Service

- Three (3) ramp merge and one (1) ramp diverge junctions on I-84 are anticipated to operate at LOS F in the eastbound direction.
- Two (2) ramp diverge junctions on I-84 are anticipated to operate at LOS F in the westbound direction.
- One (1) ramp diverge junction on Route 7 is anticipated to operate at LOS F in the northbound direction.
- One (1) ramp diverge and two (2) ramp merge junctions on Route 7 are anticipated to operate at LOS F in the southbound direction.

Figures 3-3 and **3-4** show the ramp junction level of service during the weekday A.M. and P.M. peak hour periods under future conditions respectively.

Table 3-12 Future (2040) Route 7 Ramp Levels of Service – Northbound Direction

	Weekday AM Peak				Weekday PM Peak			
	Volume				Volume			
Location	Mainline	Ramp	Density (pc/mi/ln)	LOS	Mainline	Density (pc/mi/ln)	Density (pc/mi/ln)	LOS
Exit 7 - Wooster Heights Road								
Off Ramp	1400	240	9.3	A	2540	360	120.0	F
Exit 10 - I-84 EB								
On Ramp	1350	600	10.2	B	2290	720	14.1	B
Exit 11 - White Turkey Road Ext.								
Off Ramp	1950	1300	11.1	B	3010	1700	16.1	B
On Ramp	650	290	4.8	A	1280	840	10.7	B

Table 3-13 Future (2040) Route 7 Ramp Levels of Service – Southbound Direction

	Weekday AM Peak				Weekday PM Peak			
	Volume				Volume			
Location	Mainline	Ramp	Density (pc/mi/ln)	LOS	Mainline	Density (pc/mi/ln)	Density (pc/mi/ln)	LOS
Exit 7 - Miry Brook Rd./Sugar Hollow Rd.								
On Ramp	1650	800	12.7	B	880	610	7.8	A
Off Ramp	2210	560	11.3	B	1270	390	6.8	A
Exit 10 - Federal Road								
On Ramp	1100	1120	93.3	F	1010	920	122.9	F
Exit 11 - White Turkey Road Ext.								
On Ramp	1280	510	186.5	F	730	920	9.2	A
Off Ramp	2080	800	116.4	F	1080	350	6.2	A

3.4.3 Weaving Operations

This section focusses on the operational analysis of weaving areas along I-84 and Route 7.

3.4.3.1 I-84 Weaving Areas Levels of Service

This section discusses the I-84 weaving areas under future (2040) conditions.

Eastbound Direction

Table 3-14 shows LOS analysis results for I-84 weaving areas in the eastbound direction during the weekday A.M. and P.M. peak hour periods under future conditions. The following weaving areas continue to operate at LOS F under future conditions:

- Exit 3 On Ramp (Route 7) and Exit 4 off-ramp (Lake Avenue)

Westbound Direction

Table 3-15 shows LOS analysis results for the I-84 weaving area in the westbound direction during the weekday A.M. and P.M. peak hour periods under future conditions. The following weaving areas continue to operate at LOS F under future conditions:

- Exit 8 On Ramp (Newtown Road) and Exit 7 off-ramp (Route 7)

3.4.3.2 Route 7 Weaving Areas Levels of Service

This section discusses the Route 7 weaving areas under future (2040) conditions.

Northbound Direction

Table 3-16 shows LOS analysis results for Route 7 weaving areas in the northbound direction during the weekday A.M. and P.M. peak hour periods under future conditions. The following weaving areas are anticipated to operate at LOS F under future conditions:

- Exit 7 On Ramp (Wooster Heights Road) and Exit 8 off-ramp (Park Avenue)
- Exit 8 On Ramp (Backus Ave./Park Ave.) and Exit 9 off-ramp (I-84)

This is caused by the Route 7 merge with I-84 eastbound during the weekday P.M. peak hour period.

Southbound Direction

Table 3-17 shows LOS analysis results for Route 7 weaving areas in the southbound direction during the weekday A.M. and P.M. peak hour periods under future conditions No deficient weaving areas to report in the southbound direction.

Figures 3-3 and **3-4** show the weaving area level of service during the weekday A.M. and P.M. peak hour periods under future conditions respectively.

Table 3-14 Future (2040) I-84 Weaving Levels of Service – Eastbound Direction

Location			Weekday AM Peak				Weekday PM Peak			
Start	End	Length (ft)	Weaving Volume	Non-Weaving Volume	Density (pc/mi/ln)	LOS	Weaving Volume	Non-Weaving Volume	Density (pc/mi/ln)	LOS
Exit 3 On **From Route 7 Northbound**	Exit 4 Off **To Lake Avenue**	806	1,330	1,640	11.8	B	2,610	3,440	111.6	F
Exit 7 On **From Route 7 Southbound**	Exit 8 Off **To Newtown Road**	2,026	300	3,240	20.8	C	490	4,770	29.2	D

Table 3-15 Future (2040) I-84 Weaving Levels of Service – Westbound Direction

Location			Weekday AM Peak				Weekday PM Peak			
Start	End	Length (ft)	Weaving Volume	Non-Weaving Volume	Density (pc/mi/ln)	LOS	Weaving Volume	Non-Weaving Volume	Density (pc/mi/ln)	LOS
Exit 8 On **From Newtown Road**	Exit 7 Off **To Route 7 Northbound**	1,715	1,760	3,350	67.9	F	2,000	2,430	27.8	C

Table 3-16 Future (2040) Route 7 Weaving Levels of Service – Northbound Direction

Location			Weekday AM Peak				Weekday PM Peak			
Start	End	Length (ft)	Weaving Volume	Non-Weaving Volume	Density (pc/mi/ln)	LOS	Weaving Volume	Non-Weaving Volume	Density (pc/mi/ln)	LOS
Exit 7 On **From Wooster Hghts. Rd.**	Exit 8 Off **To Park Avenue**	1,005	530	1,060	9.4	A	1,110	1,780	155.3	F
Exit 8 On **From Backus Ave./Park Ave.**	Exit 9 Off **To I-84**	1,427	490	1,360	10.7	B	1,800	1,940	148.1	F

Table 3-17 Future (2040) Route 7 Weaving Levels of Service – Southbound Direction

Location			Weekday AM Peak				Weekday PM Peak			
Start	End	Length (ft)	Weaving Volume	Non-Weaving Volume	Density (pc/mi/ln)	LOS	Weaving Volume	Non-Weaving Volume	Density (pc/mi/ln)	LOS
Exit 9 On **From I--84**	Exit 8 Off **To Backus Ave./Park Ave.**	1,269	1,090	1,970	14.3	B	1,736	730	11.9	B

3.4.3.3 Summary of Weaving Area Levels of Service

- Two (2) weaving areas are deficient along I-84. One in the eastbound direction between Exits 3 and 4 and the other in the westbound direction between Exits 7 and 8.

- Two (2) weaving areas are deficient along Route 7 northbound – one between Exits 7 and 8 and the other between Exits 8 and 9.

Figures 3-7 and **3-8** show the weaving area levels of service during the weekday A.M. and P.M. peak hour periods under future conditions respectively.

3.4.4 Intersection Operations

This section focusses on the operational analysis for intersections located within the study area.

3.4.4.1 Level of Service – Signalized Intersections

Tables 3-18 and **3-19** show LOS analysis results for signalized intersections along the I-84 and Route 7 interchanges under future (2040) conditions. The LOS tables are broken down by weekday A.M. and P.M. peak hour periods. *The following is a list of intersections where a specific movement operates at a volume to capacity (v/c) ratio greater than 1.0 and a LOS E or F under future conditions:*

- **Lake Avenue at I-84 Eastbound Ramps/Segar Street** – This intersection is anticipated to operate at an overall LOS C and F during the weekday A.M. and P.M. peak hour periods respectively. During the P.M. peak hour period, several movements operate at LOS E or worse i.e. Lake Avenue eastbound left turn, Segar Street northbound left and through, and I-84 eastbound off-ramp left turn movement.

- **Lake Avenue at Shannon Ridge Road** – This intersection is anticipated to operate at an overall LOS B and F during the weekday A.M. and P.M. peak hour periods respectively. During the P.M. peak hour period, the eastbound approach on Lake Avenue is anticipated to operate at LOS F with a v/c ratio greater than 1.0.

- **Lake Avenue Extension at Mill Ridge Road** – This intersection is anticipated to operate at an overall LOS C and D during the weekday A.M. and P.M. peak hour periods respectively. During the P.M. peak hour period, the westbound through and right movement on Lake Avenue is anticipated to operate at LOS F with a v/c ratio greater than 1.0.

- **Main Street at I-84 Westbound Ramps/Golden Hill Road** – This intersection is anticipated to operate at an overall LOS F and excessive delays during the weekday A.M. and P.M. peak hour periods. During both peak hour periods, several movements would deteriorate with increase in traffic volumes and are anticipated to operate at v/c ratios greater than 1.0 and LOS E or F.

- **Main Street at Downs Street/North Street** – This intersection is anticipated to operate at an overall LOS E during the weekday A.M. and P.M. peak hour periods respectively. During the P.M. peak period, several movements would deteriorate with increase in traffic volumes and are anticipated to operate at v/c ratios greater than 1.0 and LOS E or F.

- **North Street at Hayestown Avenue** – This intersection is anticipated to operate at an overall LOS C during the weekday A.M. and P.M. peak hour periods. During the P.M. peak period, the southbound left turn movement is anticipated to operate at LOS F with an increase in traffic volume.

- **North Street at Balmforth Avenue** – This intersection is anticipated to operate at an overall LOS C and D during the weekday A.M. and P.M. peak hour periods respectively. During the P.M. peak period, the left and through movement on Balmforth Avenue is anticipated to deteriorate in level of service (LOS D to F) and a v/c ratio over 1.0.

- **Tamarack Avenue at Hayestown Avenue** – This intersection is anticipated to operate at an overall LOS B and LOS E during the weekday A.M. and P.M. peak hour periods respectively. During the P.M. peak period, the eastbound left and through movement on Hayestown Avenue is anticipated to deteriorate in level of service (LOS D to E) and show a v/c ratio of 1.42.

- **Newtown Road at I-84 Eastbound Off-Ramp** – This intersection is anticipated to operate at an overall LOS D and LOS C during the weekday A.M. and P.M. peak hour periods respectively. During the A.M. peak hour period, Newtown Road approach through movement is anticipated to operate at LOE D with a v/c ratio greater than 1.0.

- **Newtown Road at I-84 Westbound On-Ramp** – This intersection is anticipated to operate at an overall LOS D and LOS E during the weekday A.M. and P.M. peak hour periods respectively. During both peak hour periods, the traffic headed towards the I-84 westbound on-ramp is anticipated to operate at LOS F with a v/c ratio greater than 1.0.

- **Eagle Road at Newtown Road** – This intersection is anticipated to operate at an overall LOS D during the weekday A.M. and P.M. peak hour periods. During the A.M. peak period, the westbound through and right movement on Newtown Road is anticipated to deteriorate in level of service (LOS D to E) and slightly increase in v/c ratio over 1.0. During the P.M. peak period, the southbound left-through movement on Eagle Road continues to operate at LOS F with v/c ratio over 1.0.

- **Segar Street at Mall Driveway** – This intersection is anticipated to operate at an overall LOS B and LOS C during the weekday A.M. and P.M. peak hour periods respectively. During the PM. peak period, the Mall East driveway is anticipated to operate at LOS F with a v/c ratio greater than 1.0.

- **Federal Road at White Turkey Road Extension** – This intersection is anticipated to operate at an overall LOS C and LOS B during the weekday A.M. and P.M. peak hour periods respectively. During the A.M. peak period, the westbound left turn movement at the White Turkey Road intersection is anticipated operate at LOS E with a v/c ratio greater than 1.0.

- **Federal Road at International Drive** – This intersection is anticipated to operate at an overall LOS B and LOS E during the weekday A.M. and P.M. peak hour periods respectively. During the P.M. peak period, the Federal Road northbound shared through-right movement is anticipated to operate at LOS F with a v/c ratio greater than 1.0.

- **Route 7 Southbound at White Turkey Road Extension** – This intersection is anticipated to operate at an overall LOS D and LOS E during the weekday A.M. and P.M. peak hour periods respectively. During the A.M. peak period, the westbound left and through movement at the Route 7 southbound exit ramp is anticipated to operate at LOS E.

The remaining intersections did not consist of any movements with a high v/c ratio and a LOS E or F.

Table 3-18 Future (2040) Signalized Intersection Levels of Service – I-84 Interchanges

Location			Weekday A.M. Peak			Weekday P.M. Peak		
			V/C	Delay	LOS	V/C	Delay	LOS
Interchange 4								
Lake Avenue at I-84 EB Ramps & Segar Street[1] (Int. #034-217)			**--**	**25.1**	**C**	**--**	**103.4**	**F**
Lake Avenue (Route 6)	EB	L	0.86	51.4	D	1.51	271.8	F
		TR	0.45	19.3	B	0.86	76.8	E
	WB	L	0.69	21.5	C	1.06	111.0	F
		TR	0.69	8.2	A	0.81	18.2	B
Segar Street	NB	L	0.63	53.2	D	0.59	48.4	D
		T	0.53	63.1	E	1.12	153.8	F
		R	0.10	0.6	A	0.74	44.9	D
I-84 EB Exit Ramp	SB	L	0.63	54.2	D	0.89	127.8	F
		TR	0.73	24.9	C	0.46	16.8	B
Lake Avenue at Shannon Ridge Road[1] (Int. #034-217)			**--**	**19.6**	**B**	**--**	**80.8**	**F**
Lake Avenue	EB	LTR	0.29	2.3	A	--	--	--
		Def. L	--	--	--	1.59	296.4	F
		TR	--	--	--	0.65	4.0	A
	WB	LTR	0.55	38.3	D	0.88	77.9	E
Ridge Road	NB	LTR	0.35	58.9	E	0.21	68.9	E
Shannon Ridge Road	SB	LT	0.00	0.0	A	0.09	65.3	E
		R	0.67	5.7	A	0.67	19.5	B
Lake Avenue Ext. at I-84 WB Ramps[1] (Int. #034-203)			**--**	**20.2**	**C**	**--**	**20.6**	**C**
Lake Avenue Ext. (Route 6 and Route 202)	EB	L	0.33	9.5	A	0.46	12.5	B
		T	0.38	8.3	A	0.79	17.3	B
	WB	TR	0.82	23.8	C	0.76	22.0	C
I-84 WB Exit Ramp	SB	L	0.50	23.5	C	0.70	29.2	C
		R	0.88	27.8	C	0.82	23.5	C

<u>Note</u>: (1) City Owned
(2) State Owned

Table 3-18 Future (2040) Signalized Intersection Levels of Service – I-84 Interchanges (continued)

Location			Weekday A.M. Peak			Weekday P.M. Peak		
			V/C	Delay	LOS	V/C	Delay	LOS
Lake Avenue Ext. at Mill Ridge Road[1] (Int. #034-202)			--	**31.2**	**C**	--	**54.7**	**D**
Lake Avenue Extension (Route 6 and Route 202)	EB	L	0.34	13.0	B	0.79	40.2	D
		TR	0.37	17.1	B	0.80	25.1	C
	WB	L	0.22	9.3	A	0.34	13.3	B
		TR	0.82	35.5	D	1.01	87.8	F
Restaurant Driveway	NB	LT	0.15	23.7	C	0.08	24.8	C
		R	0.19	5.8	A	0.18	6.5	A
Mill Ridge Road	SB	LTR	0.90	54.4	D	0.94	64.6	E
Interchange 5								
Main Street at I-84 WB Ramps & Golden Hill Road[2] (Int. #034-206)			--	**146.4**	**F**	--	**124.4**	**F**
I-84 WB Exit Ramp	NB	L	1.22	161.1	F	1.18	133.8	F
		TR	0.67	24.5	C	0.91	50.8	D
Golden Hill Road	SB	L	1.25	176.9	F	1.35	220.1	F
		TR	1.42	232.4	F	1.24	168.4	F
Main Street (Route 39)	NW.	L	1.13	113.1	F	1.20	139.6	F
		TR	0.54	24.5	C	1.19	129.7	F
	SE.	L	0.20	19.3	B	1.12	141.5	F
		TR	1.34	194.7	F	1.08	101.1	F
Main Street at Downs Street & North Street[1] (Int. #034-205)			--	**55.4**	**E**	--	**77.9**	**E**
Downs Street (S.R. 841)	EB	L	0.78	43.5	D	1.00	71.3	E
		TR	0.89	46.2	D	0.90	45.3	D
North Street (Route 37)	WB	L	0.55	48.9	D	0.85	92.0	F
		TR	0.61	11.9	B	1.04	90.9	F
Main Street (Route 39/53)	NB	L	0.00	0.0	A	0.19	45.8	D
		TR	0.76	34.3	C	1.11	108.2	F
	SB	L	0.25	20.9	C	0.64	52.9	D
		TR	1.14	105.2	F	0.97	69.2	E

Note: (1) City Owned
(2) State Owned

Table 3-18 Future (2040) Signalized Intersection Levels of Service – I-84 Interchanges (continued)

			Weekday A.M. Peak			Weekday P.M. Peak		
Location			V/C	Delay	LOS	V/C	Delay	LOS
Interchange 6								
North Street at Hayestown Avenue[2](Int. #034-207)			--	**14.3**	**B**	--	**14.7**	**B**
Hayestown Avenue	WB	L	0.85	47.3	D	0.90	60.2	E
		R	0.25	3.6	A	0.46	14.7	B
North Street (Route 37)	NB	T	0.37	14.0	B	0.48	9.7	A
		R	0.52	2.7	A	0.53	3.2	A
	SB	L	0.57	13.0	B	0.77	19.6	B
		T	0.39	9.6	A	0.32	6.3	A
North Street at I-84 WB Exit Ramp[2] (Int. #034-235)			--	**12.4**	**B**	--	**16.3**	**B**
Padanaram Avenue	EB	L	0.12	41.7	D	0.11	42.0	D
		R	0.45	9.2	A	0.25	2.6	A
I-84 WB Exit Ramp	WB	LT	0.62	41.5	D	0.70	39.2	D
		R	0.57	3.5	A	0.54	2.7	A
North Street (Route 37)	NB	LT	0.36	17.0	B	0.63	25.7	C
	SB	TR	0.59	11.3	B	0.57	14.1	B
North Street at Madison Avenue[1] (Int. #034-263)			--	**13.3**	**B**	--	**13.2**	**B**
Madison Avenue	EB	LTR	0.72	26.7	C	0.78	33.0	C
North Court Driveway	WB	LTR	0.00	0.0	A	0.12	15.4	B
North Street (Route 37)	NB	LTR	0.40	6.5	A	0.67	9.2	A
	SB	LTR	0.74	13.0	B	0.70	11.1	B

Note: (1) City Owned
(2) State Owned

Table 3-18 Future (2040) Signalized Intersection Levels of Service – I-84 Interchanges (continued)

Location			Weekday A.M. Peak			Weekday P.M. Peak		
			V/C	Delay	LOS	V/C	Delay	LOS
North Street at Balmforth Avenue[2] (Int. #034-227)			**--**	**26.2**	**C**	**--**	**42.9**	**D**
Grocery Store Driveway	EB	L	0.12	28.4	C	0.15	33.1	C
		TR	0.13	17.5	B	0.29	26.4	C
Balmforth Avenue	NW	LT	0.73	45.6	D	0.97	85.8	F
		R	0.48	4.9	A	0.56	12.8	B
North Street (Route 37)	NB	L	0.03	6.6	A	0.13	10.1	B
		TR	0.81	29.9	C	0.98	62.2	E
	SB	L	0.94	44.6	D	0.94	54.1	D
		TR	0.29	8.9	A	0.34	11.9	B
Tamarack Avenue at Hayestown Avenue[1]			**--**	**17.2**	**B**	**--**	**67.0**	**E**
Hayestown Avenue	EB	LT	0.61	27.4	C	1.37	205.7	F
		R	0.78	12.4	B	0.54	5.0	A
Gas Station Driveway	WB	L	0.15	19.2	B	0.33	28.7	C
		TR	0.11	17.8	B	0.07	17.1	B
Tamarack Avenue	NB	L	0.72	20.0	B	1.00	56.2	E
		TR	0.16	7.6	A	0.45	11.4	B
	SB	LT	0.80	33.1	C	0.73	33.8	C
		R	0.39	2.6	A	0.25	3.0	A
Interchange 8								
Newtown Road at I-84 EB Exit-Ramp[2] (Int. #034-218)			**--**	**51.5**	**D**	**--**	**30.6**	**C**
I-84 EB Exit Ramp	EB	T	0.76	33.6	C	0.81	35.7	D
		R	0.68	19.4	B	0.63	18.1	B
Newtown Road (Route 6)	NE	T	0.50	23.8	C	0.84	31.6	C
	SW	L	0.44	40.3	D	0.35	39.5	D
		T	1.07	75.5	E	0.81	32.6	C

Note: (1) City Owned
(2) State Owned

Table 3-18 Future (2040) Signalized Intersection Levels of Service – I-84 Interchanges (continued)

			Weekday A.M. Peak			Weekday P.M. Peak		
Location			**V/C**	**Delay**	**LOS**	**V/C**	**Delay**	**LOS**
Newtown Road at Old Sherman Turnpike[2] (Int. #034-232)			**--**	**5.0**	**A**	**--**	**7.2**	**A**
Newtown Road (Route 6)	EB	TR	0.43	4.4	A	0.69	4.8	A
Old Sherman Turnpike	NB	R	0.15	40.0	D	0.53	42.1	D
Newtown Road at Payne Road[2] (Int. #009-222)			**--**	**14.3**	**B**	**--**	**12.9**	**B**
Newtown Road (Route 6)	EB	TR	0.53	9.4	A	0.81	9.4	A
Payne Road	NB	R	0.79	38.0	D	0.76	47.4	D
Newtown Road at I-84 WB Exit Ramp[2] (Int. #034-245)			**--**	**37.3**	**D**	**--**	**17.2**	**B**
Newtown Road (Route 6)	WB	TR	0.98	42.4	D	0.72	15.8	B
I-84 WB Exit Ramp	SW	T	0.90	30.6	C	0.69	23.6	C
Newtown Road at I-84 WB On Ramp[2] (Int. #034-239)			**--**	**47.3**	**D**	**--**	**61.1**	**E**
Newtown Road (Route 6)	WB	L	0.56	10.1	B	0.41	6.9	A
		T	1.15	95.6	F	1.19	114.8	F
		R	0.06	4.6	A	0.05	4.4	A
Mountainview Terrace	SB	R	0.55	23.8	C	0.61	26.0	C
Eagle Road at Newtown Road[2] (Int. #034-223)			**--**	**37.7**	**D**	**--**	**40.9**	**D**
Newtown Road	EB	L	0.64	27.1	C	0.87	51.9	D
		TR	0.43	14.6	B	0.82	28.4	C
	WB	L	0.22	7.5	A	0.72	32.0	C
		TR	1.02	50.3	D	0.90	34.2	C
Shopping Plaza	NB	L	0.28	43.7	D	0.47	46.2	D
		T	0.16	40.5	D	0.57	49.1	D
		R	0.22	31.9	C	0.51	34.6	C
Eagle Road	SB	L	0.45	44.0	D	1.02	102.2	F
		LT	0.41	41.7	D	0.92	75.8	E
		R	0.37	25.0	C	0.68	31.0	C

<u>**Note**</u>: (1) City Owned
(2) State Owned

Table 3-19 Future (2040) Signalized Intersection Levels of Service –Route 7 Interchanges

Location			Weekday A.M. Peak V/C	Weekday A.M. Peak Delay	Weekday A.M. Peak LOS	Weekday P.M. Peak V/C	Weekday P.M. Peak Delay	Weekday P.M. Peak LOS
Interchange 7								
Wooster Heights at Route 7 NB Ramps[1] (Int. #034-253)			**--**	**6.4**	**A**	**--**	**8.4**	**A**
Wooster Heights Road	EB	LT	0.40	5.5	A	0.67	9.5	A
	WB	TR	0.45	4.5	A	0.29	2.3	A
Rt-7 NB Exit Ramp	NB	LT	0.38	23.9	C	0.43	25.2	C
		R	0.36	6.9	A	0.58	10.1	B
Sugar Hollow Rd at Route 7 SB Off Ramp[1] (Int. #034-252)			**--**	**9.8**	**A**	**--**	**8.9**	**A**
Rt-7 SB Off Ramp	WB	LR	0.54	12.0	B	0.49	12.8	B
Sugar Hollow Road	NB	T	0.03	6.2	A	0.11	5.6	A
	SB	T	0.29	7.1	A	0.35	6.8	A
Wooster Heights at Route 7 SB On Ramp[1] (Int. #034-251)			**--**	**16.0**	**B**	**--**	**18.4**	**B**
Miry Brook Road	EB	LTR	0.52	17.8	B	0.70	21.2	C
Wooster Heights Road	WB	L	0.74	21.3	C	0.40	11.5	B
		TR	0.37	11.3	B	0.34	8.9	A
Sugar Hollow Road	SB	L	0.63	21.2	C	0.62	26.0	C
		TR	0.47	10.8	B	0.50	16.4	B

Note: (1) City Owned
(2) State Owned

Table 3-19 Future (2040) Signalized Intersection Levels of Service –Route 7 Interchanges (continued)

			Weekday A.M. Peak			Weekday P.M. Peak		
Location			**V/C**	**Delay**	**LOS**	**V/C**	**Delay**	**LOS**
Interchange 8								
Backus Avenue at Sugar Hollow Road[1]			**--**	**6.1**	**A**	**--**	**13.5**	**B**
Backus Avenue	EB	LTR	0.25	11.1	B	0.60	14.5	B
	WB	L	0.50	5.6	A	0.54	9.9	A
		TR	0.27	3.1	A	0.26	4.7	A
Sugar Hollow Road	NB	LT	0.12	20.3	C	0.66	45.3	D
		R	0.03	0.1	A	0.30	8.5	A
Plaza Driveway	SB	LTR	0.00	0.0	A	0.00	0.0	A
Backus Avenue at Route 7 Ramps & Mall Driveway[1] (Int. #034-254)			**--**	**25.4**	**C**	**--**	**27.5**	**C**
Backus Avenue	EB	L	0.00	0.0	A	0.18	45.5	D
		T	0.37	38.1	D	0.77	44.2	D
	WB	L	0.64	52.0	D	0.69	54.7	D
		TR	0.54	26.6	C	0.76	34.5	C
Rt-7 SB Exit Ramp	NB	L	0.88	35.3	D	0.78	40.7	D
		TR	0.11	2.4	A	0.85	19.1	B
Mall Main Driveway	SB	L	0.00	0.0	A	0.51	48.8	D
		TR	0.09	31.4	C	0.70	43.1	D
Backus Avenue at Route 7 NB Exit Ramp[1] (Int. #034-255)			**--**	**6.4**	**A**	**--**	**11.7**	**B**
Backus Avenue	EB	T	0.16	4.6	A	0.63	10.5	B
Park Avenue	WB	T	0.45	6.1	A	0.33	7.4	A
Rt-7 NB Exit Ramp	NB	L	0.21	18.2	B	0.40	20.1	C
		R	0.14	7.2	A	0.59	23.7	C

Note: (1) City Owned
(2) State Owned

Table 3-19 Future (2040) Signalized Intersection Levels of Service –Route 7 Interchanges (continued)

Location			Weekday A.M. Peak			Weekday P.M. Peak		
			V/C	Delay	LOS	V/C	Delay	LOS
Park Avenue at Segar Street[1]			--	**10.2**	**B**	--	**30.8**	**C**
Park Avenue	EB	L	0.08	4.5	A	0.65	14.3	B
		T	0.35	6.1	A	0.82	50.2	D
	WB	T	0.63	14.6	B	0.59	22.7	C
		R	0.14	0.5	A	0.20	1.3	A
Segar Street	SB	L	0.44	24.3	C	0.72	35.1	D
		R	0.58	6.9	A	0.32	5.4	A
Segar Street at Mall East Driveway[1]			--	**11.9**	**B**	--	**27.8**	**C**
Mall East Driveway	EB	LR	0.26	34.7	C	0.95	79.3	E
Segar Street	NB	L	0.06	9.2	A	0.14	14.9	B
		T	0.25	11.1	B	0.59	23.5	C
	SB	T	0.43	17.5	B	0.40	23.5	C
		R	0.08	0.1	A	0.17	0.3	A
Interchange 11								
Federal Road at Old Brookfield Road[2] (Int. #034-302)			--	**13.6**	**B**	--	**7.4**	**A**
Old Brookfield Road	EB	LTR	0.64	42.8	D	0.52	47.7	D
Commuter Parking Lot	WB	LTR	0.03	0.1	A	0.19	1.3	A
Federal Road	NB	L	0.10	7.2	A	0.15	3.5	A
		TR	0.21	6.3	A	0.39	3.1	A
	SB	L	0.02	8.4	A	0.03	7.0	A
		TR	0.68	13.3	B	0.49	8.9	A

Note: (1) City Owned
(2) State Owned

Table 3-19 Future (2040) Signalized Intersection Levels of Service –Route 7 Interchanges (continued)

Location			Weekday A.M. Peak			Weekday P.M. Peak		
			V/C	Delay	LOS	V/C	Delay	LOS
Federal Road at White Turkey Road Ext. [2] (Int. #034-202)			**--**	**26.2**	**C**	**--**	**14.9**	**B**
White Turkey Road Ext. (S.R. 840)	WB	L	1.01	64.9	E	0.76	41.2	D
		R	0.27	16.7	B	0.61	27.5	C
Federal Road (S.R. 805)	NB	T	0.36	2.1	A	0.54	4.9	A
		R	0.36	2.8	A	0.59	5.9	A
	SB	L	0.24	13.0	B	0.44	15.7	B
		T	0.32	12.2	B	0.29	8.4	A
Federal Road at International Drive[2] (Int. #034-211)			**--**	**19.5**	**B**	**--**	**56.1**	**E**
International Drive	WB	L	0.27	39.1	D	0.57	56.9	E
		R	0.07	7.3	A	0.35	16.3	B
Federal Road (S.R. 805)	NB	TR	0.94	43.1	D	1.14	98.2	F
	SB	LT	0.59	3.0	A	0.55	2.6	A
Route 7 NB Ramps at White Turkey Road Ext. [2] (Int. #018-207)			**--**	**19.9**	**B**	**--**	**25.5**	**C**
Rt-7 NB Exit Ramp	EB	L	0.74	26.9	C	0.93	46.9	D
		LT	0.74	27.0	C	0.93	46.9	D
		R	0.73	20.8	C	0.31	2.3	A
White Turkey Road Ext. (Route 202)	NB	T	0.21	19.4	B	0.58	29.2	C
		R	0.37	5.1	A	0.72	6.6	A
	SB	L	0.17	13.0	B	0.38	15.4	B
		T	0.70	18.1	B	0.30	13.1	B
Route 7 SB Ramps at White Turkey Road Ext. [2] (Int. #018-206)			**--**	**36.8**	**D**	**--**	**14.6**	**B**
Rt-7 SB Exit Ramp	WB	LT	1.10	92.4	F	0.85	68.1	E
		R	0.26	9.7	A	0.44	23.7	C
White Turkey Road Ext. (Route 202)	NB	L	0.12	13.3	B	0.49	8.9	A
		T	0.55	18.2	B	0.72	12.1	B
	SB	T	0.60	13.8	B	0.57	7.9	A

<u>**Note**</u>: (1) City Owned
(2) State Owned

3.4.4.2 Level of Service – Un-signalized Intersections

Tables 3-20 shows LOS analysis results for un-signalized or stop controlled intersections along the I-84 interchanges under future (2040) conditions. The LOS tables are broken down by weekday A.M. and P.M. peak hour periods. *The following is a list of intersections where the side-street or minor street movement operates at a LOS E or F under future conditions:*

- **Cowperthwaite Road at Main Street (Route 39)** – The Cowperthwaite Road left turn movement continues to operate at LOS F during the weekday A.M. and P.M. peak hour periods with increase in traffic volumes.
- **Hillside Avenue at Main Street (Route 39)** – The Hillside Avenue approach is anticipated to operate at LOS F and LOS E during the weekday A.M. and P.M. peak hour periods respectively with increase in traffic volumes.
- **Water Street at Main Street (Route 39)/I-84 Eastbound On-Ramp** – The southbound left turn movement on Main Street is anticipated to operate at LOS F during the weekday P.M. peak hour period as a result of the lack of gaps in the opposing flow of traffic on Main Street.
- **I-84 Eastbound Off-Ramp at Fairview & Downs Street** – The I-84 eastbound off-ramp approach continues to operate at LOS F during the weekday P.M. peak hour period with increase in traffic volumes.
- **2nd Avenue at North Street** – The 2nd Avenue approach is anticipated to operate at LOS E and LOS F during the weekday A.M. and P.M. peak hour periods respectively with increase in traffic volumes.
- **Walnut Street at North Street (Route 37)** – The Walnut Street left turn movement continues to operate at LOS F during the weekday A.M. and P.M. peak hour periods.

Figures 3-5 and **3-6** show the future intersection levels of service during the weekday A.M. and P.M. peak hour periods respectively.

Table 3-20 Future (2040) Un-signalized Intersection Levels of Service – I-84 Interchanges

Location			Weekday A.M. Peak Hour			Weekday P.M. Peak Hour		
			V/C	Delay	LOS	V/C	Delay	LOS
Interchange 5								
Cowperthwaite Rd at Main St (Rt-39)								
Cowperthwaite Road	EB	L	2.74	934.4	F	12.40	5362.3	F
		R	1.29	189.7	F	0.82	38.0	E
Main Street	NB	L	0.32	13.4	B	0.48	13.0	B
Hillside Ave at Main St (Rt-39)								
Hillside Avenue	WB	LR	0.85	80.9	F	0.43	38.8	E
Main Street	SB	L	0.02	9.9	A	0.03	13.1	B
Water St at Main St (Rt-39)/I-84 EB On Ramp								
Water Street	EB	LTR	0.08	11.6	B	0.02	10.3	B
Main Street	SB	L	0.81	32.8	D	1.06	100.4	F
Tooley Ln at Main St (Rt-39)								
Tooley Lane	WB	LR	0.15	14.4	B	0.26	20.7	C
Main Street	SB	L	0.02	11.2	B	0.00	0.0	A
I-84 EB Off Ramp at Fairview Ave & Downs St								
I-84 EB Off Ramp	EB	T	0.63	16.5	C	1.19	122.9	F
		TR	0.57	14.1	B	0.89	34.3	D
Fairview Avenue	NB	R	0.28	10.0	A	0.21	10.0	A
Downs Street	SB	T	0.09	9.5	A	0.20	10.8	B

Table 3-20 Future (2040) Un-signalized Intersection Levels of Service – I-84 Interchanges (continued)

Location			Weekday A.M. Peak Hour			Weekday P.M. Peak Hour		
			V/C	Delay	LOS	V/C	Delay	LOS
Interchange 6								
2nd Ave at North St (Rt-37)								
2nd Avenue	WB	LR	0.33	23.7	C	0.58	35.7	E
North Street	SB	L	0.01	9.4	A	0.07	11.4	B
Walnut St at North St (Rt-37)								
Walnut Street	WB	LR	0.66	115.3	F	0.55	84.8	F
North Street	SB	L	0.00	0.0	A	0.00	0.0	A
Interchange 8								
Sky Edge Dr at Newtown Rd								
Sky Edge Drive	NB	R	0.34	20.3	C	0.20	21.8	C

Figure 3-5 Future (2040) Intersection Levels of Service – Weekday A.M. Peak Hour Period

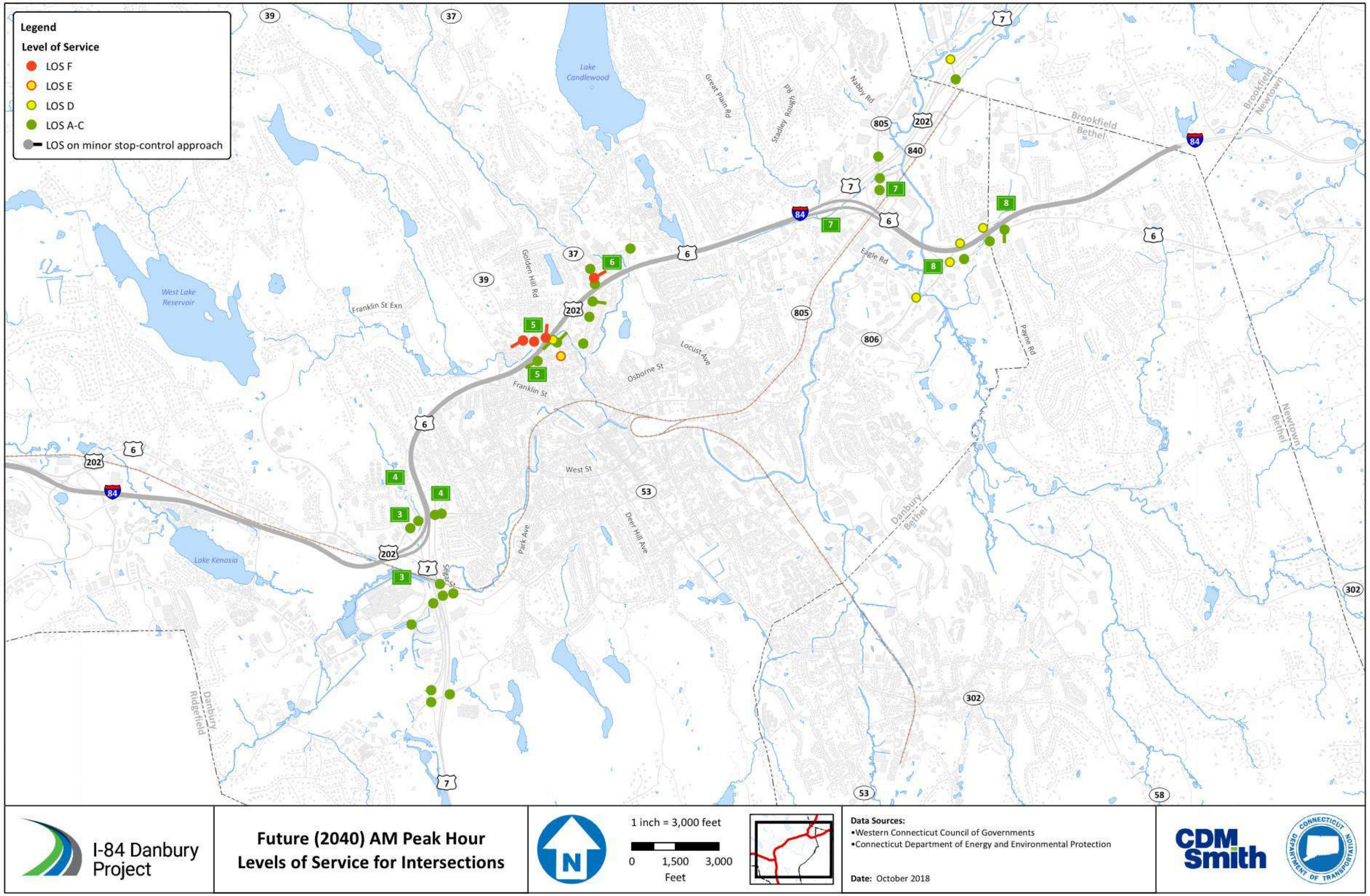
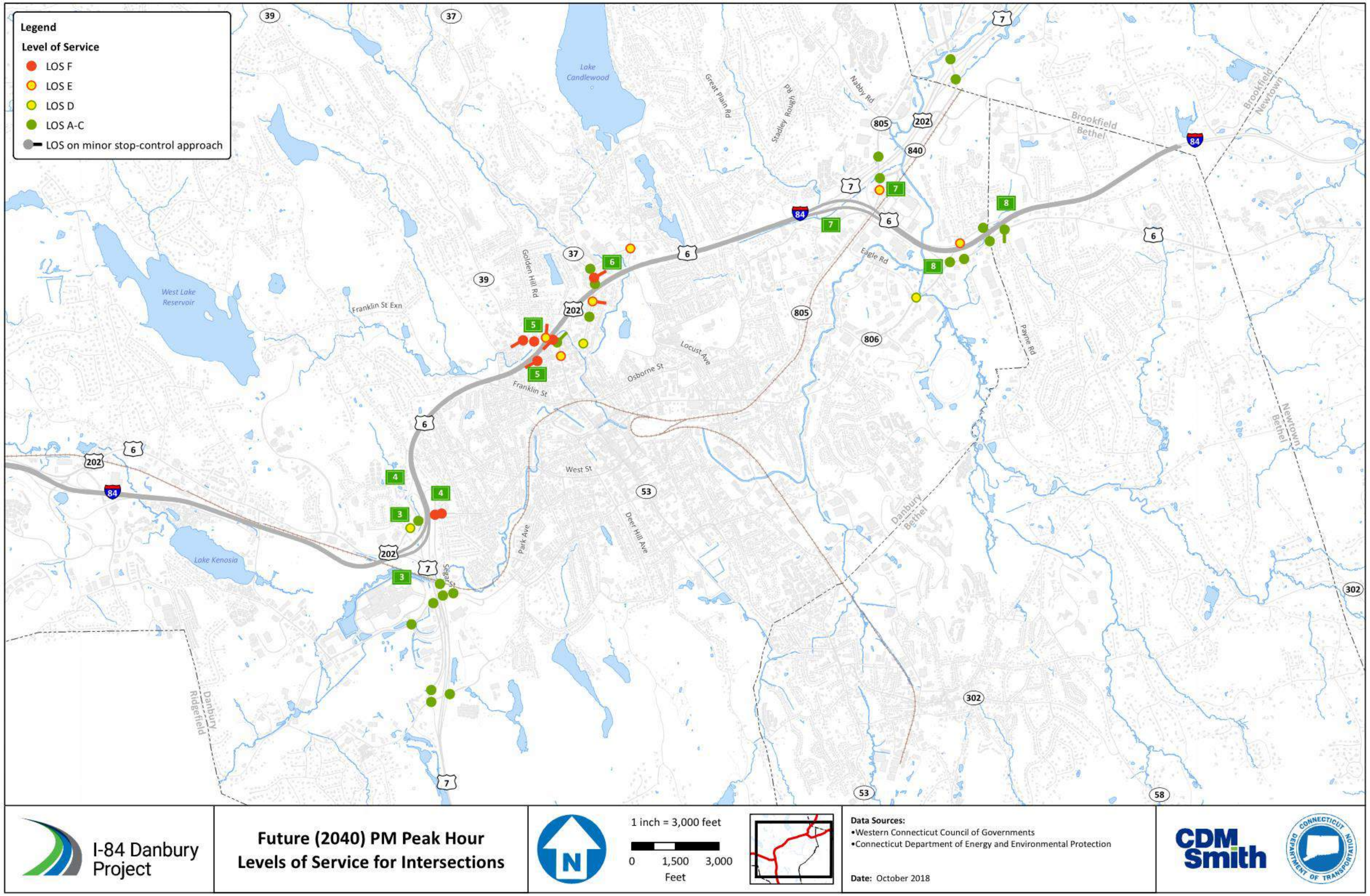


Figure 3-6 Future (2040) Intersection Levels of Service – Weekday P.M. Peak Hour Period



3.4.5 Comparison of Existing and Future Conditions

This section provides a comparison of highway operations (I-84 and Route 7) and intersection operations (signalized and unsignalized) between existing and future conditions.

3.4.5.1 Comparison of Highway Operations

Table 3-21 provides a comparison of noted deficiencies along I-84 between existing and future conditions during the weekday A.M. and P.M. peak hour periods. The number of deficiencies is shown for the mainline segments, ramp junctions, and weaving segments on I-84 and is summarized below:

- About 89 and 50 percent of the mainline segments are anticipated to be deficient by 2040 in the eastbound and westbound directions respectively.
- About 67 percent of the mainline-ramp junctions are anticipated to be deficient by 2040 in the eastbound direction.
- 50 percent of the weaving areas are anticipated to be deficient by 2040 in the eastbound and westbound directions.

Table 3-22 provides a comparison of noted deficiencies along Route 7 between existing and future conditions during the weekday A.M. and P.M. peak hour periods. The number of deficiencies is shown for the mainline segments, ramp junctions, and weaving segments on Route 7 and is summarized below:

- About 67 percent of the mainline segments are anticipated to be deficient by 2040 in the southbound direction.
- About 60 percent of the mainline-ramp junctions are anticipated to be deficient by 2040 in the southbound direction.
- All weaving areas are anticipated to be deficient by 2040 in the northbound direction.

3.4.5.2 Comparison of Intersection Operations

Table 3-23 provides a comparison of noted deficiencies at signalized and un-signalized intersections and is summarized below:

- About 38 percent (an increase of 25 percent over existing) of the signalized intersections are anticipated to be deficient by 2040.
- About 75 percent (an increase of 38 percent over existing) of the un-signalized intersections are anticipated to be deficient by 2040.

Table 3-21 – Comparison of Highway Operations – I-84

	Total		Existing (2016)		Future (2040)	
Weekday A.M. Peak Hour	Eastbound	Westbound	Eastbound	Westbound	Eastbound	Westbound
Mainline Segment	9	10	0	5	0	5
Ramps	6	7	0	1	0	1
Weaving Segments	2	1	0	1	0	1
Weekday P.M. Peak Hour	Eastbound	Westbound	Eastbound	Westbound	Eastbound	Westbound
Mainline Segment	9	10	6	0	8	2
Ramps	6	7	4	0	4	1
Weaving Segments	2	1	1	0	1	0

Table 3-22– Comparison of Highway Operations – Route 7

	Total		Existing (2016)		Future (2040)	
Weekday A.M. Peak Hour	Northbound	Southbound	Northbound	Southbound	Northbound	Southbound
Mainline Segment	3	6	0	3	0	4
Ramps	4	5	0	2	0	3
Weaving Segments	2	1	0	0	0	0
Weekday P.M. Peak Hour	Northbound	Southbound	Northbound	Southbound	Northbound	Southbound
Mainline Segment	3	6	0	1	1	3
Ramps	4	5	0	1	1	1
Weaving Segments	2	1	0	0	2	0

Table 3-23 – Comparison of Intersection Operations

		Existing (2016)		Future (2040)	
Type of Intersection Control	Total	A.M. Peak	P.M. Peak	A.M. Peak	P.M. Peak
Signalized	30	1	3	6	9
Un-signalized (STOP control)	8	2	3	3	6

3.5 Future Structural Conditions

This section provides the estimated future component condition ratings for every structure and any likely maintenance, rehabilitation, or replacement required by 2037. Each bridge's deck, superstructure, and substructure ratings are projected based on historical rating data and other important factors that can affect the rate at which the component deteriorates. The culvert ratings are also predicted in the same manner. The following provides the general framework for the criteria and procedure used to determine the future ratings and summary of the results of the future conditions analysis. Full results for each structure and the methodology for producing the future prediction graphs are in Appendix B of the Existing Conditions Report.

3.5.1 Evaluation Criteria

The condition ratings for the structures, dating back to 1992, are plotted for each year creating a series of points showing the component's state at any point in this historical period. In order to create a larger data set for more realistic and uniform results, the rating data was combined for all the bridges per their functional group established in this report (I-84, Over I-84, etc.), and a best-fit curve was applied for each component rating in relation to time. The functional groups also naturally group structures of similar age together, with the exception of the Route 7 structures, which have variation in year built and slightly different Annual Average Daily Truck Traffic (AADTT). However, the adjustment factors account for the variation and help individualize each base curve. To ensure that the base curves are showing the true or natural deterioration without having spikes in ratings due to rehabilitations, the pre-rehabilitation data for structures was removed.

The adjusted curve is used to project the structure's future component ratings for 2037 by using adjustment factors. See Appendix B of the Existing Conditions Report for a full summary of the methodology of the future condition rating predictions, base curve generation and each adjustment factor used, as well as the group base curves and individual bridge component curves.

Using the information generated from the estimated future condition ratings and engineering judgement, a qualitative approach is used to determine the "Likely Required Action" for each structure within the planning period. Likely required actions were determined assuming the ongoing maintenance program remains in place throughout the duration of this study. This ranges from routine maintenance only to full replacement of the structure.

The general rules for the selection of each Likely Required Action are listed here:

- All Future Condition Ratings (FCR) > 6 – Minor/major maintenance only
- All FCR between 5 and 6 – Maintenance and minor rehabilitation
- Deck FCR < 5, superstructure and substructure FCR > 5 – Deck replacement (maintenance or minor rehabilitation on superstructure and substructure assumed)
- Deck and superstructure FCR < 5, substructure FCR > 5 – Superstructure replacement (maintenance or minor rehabilitation for substructure assumed)
- Superstructure FCR < 5, deck and substructure FCR > 5 – Major superstructure rehabilitation (maintenance or minor rehabilitation for deck and substructure assumed)
- Substructure FCR < 5, deck and superstructure FCR > 5 – Major substructure rehabilitation (routine maintenance or minor rehabilitation for deck and superstructure assumed)
- Superstructure and substructure < 5, deck > 5 – Major superstructure rehabilitation and Major substructure rehabilitation (routine maintenance or minor repairs for the deck assumed)
- All FCR < 5 – Full structure replacement

These are the general rules used to develop the Likely Required Actions; however, engineering judgement is applied in certain cases for more rational and financially feasible results.

Finally, a category for the Likely Required Action of bearing replacement is also included in the table. For this common rehabilitation strategy, the bearing type, current bearing condition rating, and notes from the latest inspection reports are used to determine if bearing replacement is likely to be required within the planning period. This qualitative assessment is unique from the other Likely Required Actions but provides a useful addition to the scope of the potential future rehabilitation evaluation.

3.5.2 Evaluation Results

Table 3-24 below provides a summary of the future predicted condition ratings and likely required action for the bridges in the I-84 group.

Table 3-24 I-84 Predicted Condition Ratings and Likely Required Action

Bridge No.	Current Condition Ratings			2037 Predicted Condition Ratings			Likely Required Action by 2037								Comments from Current Condition Report
	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure	Minor/Major Maintenance Only	Maintenance and Minor Rehabilitation	Deck Replacement	Deck and Beam Replacement	Major Superstructure Rehabilitation	Major Substructure Rehabilitation	Full Bridge Replacement	Bearing Replacement	
00457	6	6	7	4.7	4.7	5.5				X				X	Underside of deck has cracks, spalls, and hollow areas likely required deck replacement. Girders have moderate to heavy rust and pitting. Self-lubricating bronze sliding plate bearings are currently in fair condition. Light to moderate rust and laminar rust; 1/8" rust between plates.
00458	7	6	7	5.4	4.9	5.7					X				Routine maintenance, repairs, and patching of cracks and spalls likely required. Girders have areas of peeling paint, moderate to heavy laminar rust, and pitting.
00544	6	6	7	4.8	5.0	5.1				X				X	Minor cracks, spalls, and hollow areas on deck and parapet. Bituminous overlay has areas of cracking and potholes. Deck underside has map cracking and efflorescence. Painted surfaces have approximately 15% deterioration, spot painting likely required. Self-lubricating bronze sliding plate bearings are currently in fair condition and there is 24% loss of bearing area.
00547	7	6	6	5.4	4.7	5.1					X				Routine maintenance; repair and patch minor cracks and spalls. Girders exhibit light to moderate rust, gouges, scrapes, and pitting.
00548	6	5	6	5.0	3.7	4.5							X		Deck maintenance and weep drainage repairs. Girders have section loss in bottom flange and web; partially repaired and newly painted. The abutments have cracks, hollow areas, and spalls with exposed rebar. Pedestals have isolated spalls.
00897	7	6	6	5.5	4.8	5.1					X				Routine maintenance; repair and patch minor cracks and spalls. Girders exhibit gouges, scrapes, and slight negative camber due to past collision damage. There are large areas of chipped paint with light to moderate rust.
00898	7	6	5	5.5	4.8	4.1						X			Routine maintenance; repair and patch minor cracks and spalls. Superstructure maintenance and repairs, spot painting likely required. Pier caps have numerous stains, hollow areas, spalls, cracks, and areas of exposed rebar. Several cracks and hollow areas in the abutments.
00956	5	6	6	3.0	4.5	4.2							X		Deck underside has numerous cracks, spalls, and hollow areas. Jersey barrier has spalls and hollow areas. Girders have

Bridge No.	Current Condition Ratings			2037 Predicted Condition Ratings			Likely Required Action by 2037								Comments from Current Condition Report
	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure	Minor/Major Maintenance Only	Maintenance and Minor Rehabilitation	Deck Replacement	Deck and Beam Replacement	Major Superstructure Rehabilitation	Major Substructure Rehabilitation	Full Bridge Replacement	Bearing Replacement	
															peeling paint, heavy rust, and gouges due to collision damage. Abutments have stains, cracks, pop-outs, hollow areas, and spalls with exposed rebar. Rocker bearing currently with moderate to heavy rust.
00961	6	6	6	4.5	4.6	4.6							X		Underside of deck has patches that are cracking again and numerous hollow areas and deteriorating full-depth repairs on the underside, deck replacement likely required. Jersey barrier has hollow areas, spalls, and active leakage. Less than 50% of painted surfaces have deterioration. Girders have impact scrapes and gouges due to collision damage. Hairline cracks, hollow areas, and spalls with exposed rebar on abutments. There is active leakage through the deck joint onto backwall.
01181	5	6	6	3.5	4.7	4.7							X		Overlay has areas of light ravelling, cracks, open paving seams, depressed areas, and potholes. Deck underside has map cracking, spalls, hollow areas, and exposed rebar. 50% of painted surfaces are rusting, full girder painting likely required. Cracks and spalls with exposed rebar on abutments, pier caps, and pier columns.
01182	5	5	6	3.4	3.4	4.8							X		Overlay has areas of light to moderate ravelling, cracks, and open paving seams. Deck underside has map cracking, spalls, hollow areas, and exposed rusted rebar. Girders have areas of peeling paint with light to moderate rust. Girders have section loss up to 16.4% loss in web shear and 16.4% loss in web bearing. Less than 50% of painted surfaces are rusting. Cracks and spalls with exposed rebar on abutments, pier caps, and pier columns.
01184	6	6	6	3.9	4.7	4.3							X		Overlay has areas of map cracking, open paving seams, bituminous spalls and bituminous spalls. Deck underside has patches, hollow areas, and cracks. Expansion joints are in fair condition. There is active leakage which is causing peeling paint and heavy rust on the girders. Abutments have cracks, hollow areas, spalls with exposed rebar, and stains from active leakage. Rocker bearings are currently in fair condition with light to heavy rust.
01185	6	6	7	4.6	4.8	5.2			X						Underside of deck has map cracking, hollow areas, spalls, and exposed rebar. Jersey barrier and parapets have spalls and cracks. Routine superstructure maintenance such as spot

Bridge No.	Current Condition Ratings			2037 Predicted Condition Ratings			Likely Required Action by 2037								Comments from Current Condition Report
	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure	Minor/Major Maintenance Only	Maintenance and Minor Rehabilitation	Deck Replacement	Deck and Beam Replacement	Major Superstructure Rehabilitation	Major Substructure Rehabilitation	Full Bridge Replacement	Bearing Replacement	
															painting, repairs, and repairing welds likely required.
01186	6	7	6	4.6	5.6	4.9			X						Deck replacement likely required as useful deck life is coming to an end. Routine maintenance, repairs, patching of cracks and spalls, and spot painting likely required. Repair and patch substructure cracks and spalls in abutments.
01190	7	6	6	5.5	5.0	5.0					X				Girders have areas of peeling paint, laminated rust, and gouges due to collision damage. Past leakage onto abutments as well as concrete patches, cracks, pop-outs, hollow areas, and spalls with exposed rebar.
01191	5	6	6	3.6	4.8	5.0				X					Underside of deck has poor quality patches, map cracking, hollow areas, spalls, and areas of exposed rebar. Less than 50% of the paint has deteriorated. Girders have moderate rust, pitting, and gouges due to collision damage. Abutments have cracks, areas of scale, hollow areas, spalls with exposed rebar, and evidence of past leakage from deck joints.
01192	7	7	7	5.1	5.5	5.5		X							Routine maintenance, repairs, patching of cracks and spalls, and spot painting likely required.
01195	5	5	7	3.8	4.0	5.6				X				X	Underside of deck has map cracking, spalls, hollow areas, and areas of exposed rusted rebar. The drainage and construction joints are in fair condition. Girders have peeling paint, heavy rust, and section loss. There are poor quality welds and areas of deteriorating paint. Self-lubricating bronze sliding plate bearings are currently in fair condition with light to heavy rust and 1/4" rust between plates, likely replaced along with superstructure.
01196	5	5	7	3.9	3.7	5.6				X					Underside of deck has map cracking, spalls, hollow areas, and areas of exposed rebar. The drainage is in fair condition. Girders have peeling paint, heavy rust, and section loss. There are poor quality welds and areas of deteriorating paint.
01197	7	7	6	5.2	5.4	5.1	X								Routine maintenance, repairs, patching of cracks and spalls, and spot painting likely required.
01198	7	6	6	5.3	4.8	5.3					X				Routine maintenance, repairs, patching of cracks and spalls, and spot painting likely required. Girders have moderate rust, pitting, and areas of re-rusting.

Table 3-25 below provides a summary of the future predicted condition ratings and likely required action for the bridges in the Route 7 group.

Table 3-25 Route 7 Predicted Condition Ratings and Likely Required Action

Bridge No.	Current Condition Ratings			2037 Predicted Condition Ratings			Likely Required Action by 2037								Comments from Current Condition Report
	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure	Minor/Major Maintenance Only	Maintenance and Minor Rehabilitation	Deck Replacement	Deck and Beam Replacement	Major Superstructure Rehabilitation	Major Substructure Rehabilitation	Full Bridge Replacement	Bearing Replacement	
00541	6	5	7	4.8	4.2	5.8				X					Deck replacement likely required. The Girders have peeling, heavy rust, and section loss. Bearing and web stiffeners have rusted through holes and section loss. Less than 50% of painted surfaces are deteriorated.
00542	6	5	6	4.8	4.1	4.7							X		Latex modified concrete deck has map cracking and potholes. The deck underside has cracks, honeycombing, hollow areas, and spalls. Poor drainage with clogged scupper grates and abandoned drains. Girders have heavy rust and section loss with repair plates already welded to certain webs. The girder alignment is considered fair. Abutments, pier caps, and pier columns have patches, map cracking, and spalls. Self-lubricating bronze sliding plate bearings are currently in fair condition. Moderate rust with 1/2" rust between plates.
00543	6	7	7	4.5	5.9	5.5			X					X	Underside of deck has hairline cracks, hollow areas, and spalls; likely required deck replacement as useful deck life is coming to an end. Parapet maintenance for cracks, scrapes, and spalls. Four self-lubricating bronze sliding plate bearings show no sign of movement and there is 12.5% loss of bearing - bearing replacement likely required.
00545	6	6	7	4.7	4.7	5.5				X					Underside of deck has hairline cracks, map cracking, hollow areas, and spalls with exposed rebar; likely required deck replacement as useful deck life is coming to an end. Light rust and peeling paint on about 25% of superstructure. Girders have areas of laminated rust, pitting, and localized bows. Girders also have scrapes and gouges from collision damage.
00550	6	6	6	5.1	5.1	4.4						X			Deck and superstructure routine maintenance, repairs, and patching of cracks and spalls. Less than 50% of painted surfaces have deteriorated, spot painting likely required for girders.

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Bridge No.	Current Condition Ratings			2037 Predicted Condition Ratings			Likely Required Action by 2037								Comments from Current Condition Report
	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure	Minor/Major Maintenance Only	Maintenance and Minor Rehabilitation	Deck Replacement	Deck and Beam Replacement	Major Superstructure Rehabilitation	Major Substructure Rehabilitation	Full Bridge Replacement	Bearing Replacement	
00551	6	6	6	4.8	5.2	4.5			X			X			Routine maintenance, repairs, and patching of cracks and spalls. Less than 50% of painted surfaces have deteriorated, spot painting likely required for girders. Deck replacement likely required as useful deck life is coming to an end. Substructure likely required repairs and rehab.
03915	7	7	7	5.9	6.0	6.0		X						X	Routine maintenance, repairs, and patching of cracks and spalls. Weathering steel rocker bearings are currently in fair condition. Heavy and laminar rust. 1/4" thick rust on rockers and masonry plates - at least routine maintenance and/or painting likely required for bearings.
03916	7	7	7	5.9	6.0	5.9		X						X	Routine maintenance, repairs, and patching of cracks and spalls. Spot painting likely required. Weathering steel rocker bearings have heavy and laminar rust. 1/4" thick rust on rockers, masonry plates, and anchor bolts - at least routine maintenance and/or painting likely required for bearings.
03919	7	7	7	6.0	6.0	6.2		X							Routine maintenance, repairs, and patching of cracks and spalls. Spot painting likely required. Pot bearings with neoprene and Teflon are currently in fair condition, with moderate to heavy rust - at least routine maintenance and/or painting likely required for bearings.
03920	7	7	7	6.0	5.7	6.2		X							Routine maintenance, repairs, and patching of cracks and spalls. Spot painting likely required for superstructure. Pot bearings with elastomer and Teflon are currently in fair condition, with moderate to heavy rust - at least routine maintenance and/or painting likely required for bearings.
05462	7	7	7	6.1	6.2	5.9		X							Routine maintenance, repairs, and patching of cracks and spalls. Spot painting likely required for superstructure.
05463	7	7	7	5.9	5.6	5.6		X						X	Routine maintenance, repairs, and patching of cracks and spalls. Expansion joints are in fair condition. Spot painting likely required for superstructure. Rocker bearings have light to heavy rust and laminar rust - painting or replacement likely required for bearings.

Bridge No.	Current Condition Ratings			2037 Predicted Condition Ratings			Likely Required Action by 2037								Comments from Current Condition Report
	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure	Minor/Major Maintenance Only	Maintenance and Minor Rehabilitation	Deck Replacement	Deck and Beam Replacement	Major Superstructure Rehabilitation	Major Substructure Rehabilitation	Full Bridge Replacement	Bearing Replacement	
05772	7	6	6	6.0	4.9	5.0					X	X		X	Routine maintenance, repairs, and patching of cracks and spalls. Expansion joints are in fair condition. Paint in fair condition, painting likely required for superstructure. Girders have heavy rust and section loss. Abutments have hollow areas, areas of scale, cracks, and spalls with exposed rebar. Rocker bearings are currently in fair condition. Light to heavy rust. 3/16" rust between rockers and masonry plates - painting or replacement likely required for bearings.
05773	7	7	6	5.8	6.1	5.0						X		X	Routine maintenance, repairs, and patching of cracks and spalls. Spot painting likely required for superstructure. Abutments have hairline cracks, hollow areas, pop-outs, and spalls with exposed rebar. Rehab and repairs of substructure likely required. Rocker bearings have light to heavy rust and laminar rust - painting or replacement likely required for bearings.
05909	6	7	6	5.2	5.6	5.2		X							Routine maintenance, repairs, and patching of cracks and spalls. Active leakage on to abutments. Spot painting likely required for superstructure.
06569	7	8	7	6.5	7.3	6.3	X								Routine maintenance and spot painting likely required for superstructure.

Table 3-26 below provides a summary of the future predicted condition ratings and likely required action for the bridges in the Over I-84 group.

Table 3-26 Over I-84 Predicted Condition Ratings and Likely Required Action

Bridge No.	Current Condition Ratings			2037 Predicted Condition Ratings			Likely Required Action by 2037								Comments
	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure	Minor/Major Maintenance Only	Maintenance and Minor Rehabilitation	Deck Replacement	Deck and Beam Replacement	Major Superstructure Rehabilitation	Major Substructure Rehabilitation	Full Bridge Replacement	Bearing Replacement	
00459	6	6	5	5.1	4.4	4.2							X		Bituminous concrete overlay has cracks, potholes, and raveling as well as the deck underside having hairline cracks and up to 14% deterioration; likely required deck replacement as useful deck life is coming to an end. Superstructure has girders with peeling paint, heavy rust, section loss, and missing welds. Self-lubricating bronze sliding plate bearings and elastomeric bearings are currently in fair condition. Light to moderate rust and laminar. 3/4" thick rust between sole plate and keeper angles. The piers and abutments have large spalls, cracks, and hollow areas with exposed rebar.
01180	6	5	6	5.2	3.7	5.1					X			X	Deck maintenance, weep drainage repairs, patching, and potential resurfacing. Bottom flange section loss at mid-span on multiple girders. Girders have heavy laminar rust and isolated active corrosion. Severe paint condition of 75% deterioration, address in superstructure rehab. Self-lubricating bronze sliding plate bearings are currently in fair condition; heavy rust and 3/4" laminar rust on plates.
01183	6	6	6	4.7	5.1	5.3			X						Bituminous concrete overlay has hairline map cracks and raveling as well as the deck underside having hairline cracks, hollow areas, and spalls; likely required deck replacement. Routine maintenance; repair and patch minor cracks and spalls. Spot painting likely required.
01188	6	7	7	4.9	6.0	6.1			X					X	Heavy raveling and potholes on bituminous deck overlay as well as hairline map cracking, hollow areas, and spalls with exposed rebar in the underside of the deck. Utility upkeep and maintenance. Patch and repair cracks and spalls. Rocker bearings are currently in fair condition. Light to moderate rust with 1/2" rust between rockers and plates.
01199	6	5	6	4.5	3.9	4.7							X		Deck overlay has light to moderate rutting, raveling, and areas of map cracking. Expansion joints are in fair condition. Spalls, cracks, hollow areas, and areas of exposed rebar in underside of deck, abutments, pier caps, and pier columns. Girders have numerous areas of pitting and section loss in critical areas, up to 10% web loss.

Bridge No.	Current Condition Ratings			2037 Predicted Condition Ratings			Likely Required Action by 2037								Comments
	Deck	Superstructure	Substructure	Deck	Superstructure	Substructure	Minor/Major Maintenance Only	Maintenance and Minor Rehabilitation	Deck Replacement	Deck and Beam Replacement	Major Superstructure Rehabilitation	Major Substructure Rehabilitation	Full Bridge Replacement	Bearing Replacement	
01200	6	6	6	5.0	5.1	5.2			X						Deck joints are paved over and have cracks. There are hairline cracks, hollow areas, and spalls on the underside of the deck with a maximum underside deck deterioration of 17.6%. Routine maintenance for superstructure and substructure; repair and patch minor cracks and spalls. Spot painting likely required.
01201	6	7	6	4.9	6.0	5.3			X						Bituminous overlay has rutting in the wheel lines and cracks covering up to 50% of surface area. The underside of the deck has hairline cracks, hollow areas, and spalls with exposed rebar. Spot painting likely required. Routine maintenance; repair and patch minor cracks and spalls in piers and abutments.
01202	6	5	6	4.9	3.7	5.2				X					Bituminous concrete overlay has areas of map cracking throughout, up to 80% of surface area. The underside of the deck has hairline cracks, concrete patches, hollow areas, and spalls. Girders and diaphragms have light rust with impacted rust up to 1/2" between flanges and deck haunches. Girders have section losses up to 3/16" deep. Random welds missing or of poor quality. Long scrape with rust along a girder due to collision damage.
01203	6	6	6	4.7	5.1	5.2			X						Bituminous overlay has sealed and unsealed cracks. The deck underside has full depth patches, map cracking, hollow areas, shallow rebar, and spalls. Spot painting likely required. Routine maintenance; repair and patch cracks and spalls in piers and abutments.
01204	6	5	6	5.0	3.7	4.5							X		Bituminous concrete overlay has moderate to heavy wear, sealed and unsealed cracks, areas of raveling, and potholes. Underside of deck has hairline cracks and spalls with shallow rebar. Likely required deck overlay resurfacing and routine maintenance. Girders have section loss resulting in 15% shear loss and 84% bearing loss. Girders have peeling paint and heavy rust. 50% of painted surfaces are rusting. Cracks and spalls in pier caps, pedestals, and abutments.
05261	7	7	7	5.8	5.8	5.6		X						X	Deck will likely need at least minor rehab based on inspection report notes - the overlay has numerous potholes and map cracks; extensive deterioration. Rocker bearings have heavy rust; 3/16" rust between rocker and masonry plate - painting or replacement likely required for bearings.

Table 3-27 below provides a summary of the future predicted condition ratings and likely required action for the bridges in the Culvert group.

Table 3-27 Culvert Predicted Condition Ratings and Likely Required Action

	2037 Predicted Condition Ratings	Likely Required Action by 2037			
Bridge No.	Culvert	Minor/Major Maintenance Only	Maintenance and Minor Rehabilitation	Major Rehab or Replace Culvert	Comments
00546	5.4		X		
00549	5.7		X		
00553	5.5		X		
01187	5.3		X		
01189	4.1			X	Spalls, cracks, pop-outs, exposed wires, and leaking joints.
01193	6.3	X			
01194	5.1		X		
01205	5.6		X		
05437	5.6		X		

Figures 3-7 through **3-10** provide a graphical representation of the corridor based on the future overall structure condition, which is taken as the minimum rating of deck, superstructure, substructure and culvert future rating.

Figure 3-7 Future Overall Structure Condition Rating – Map 1

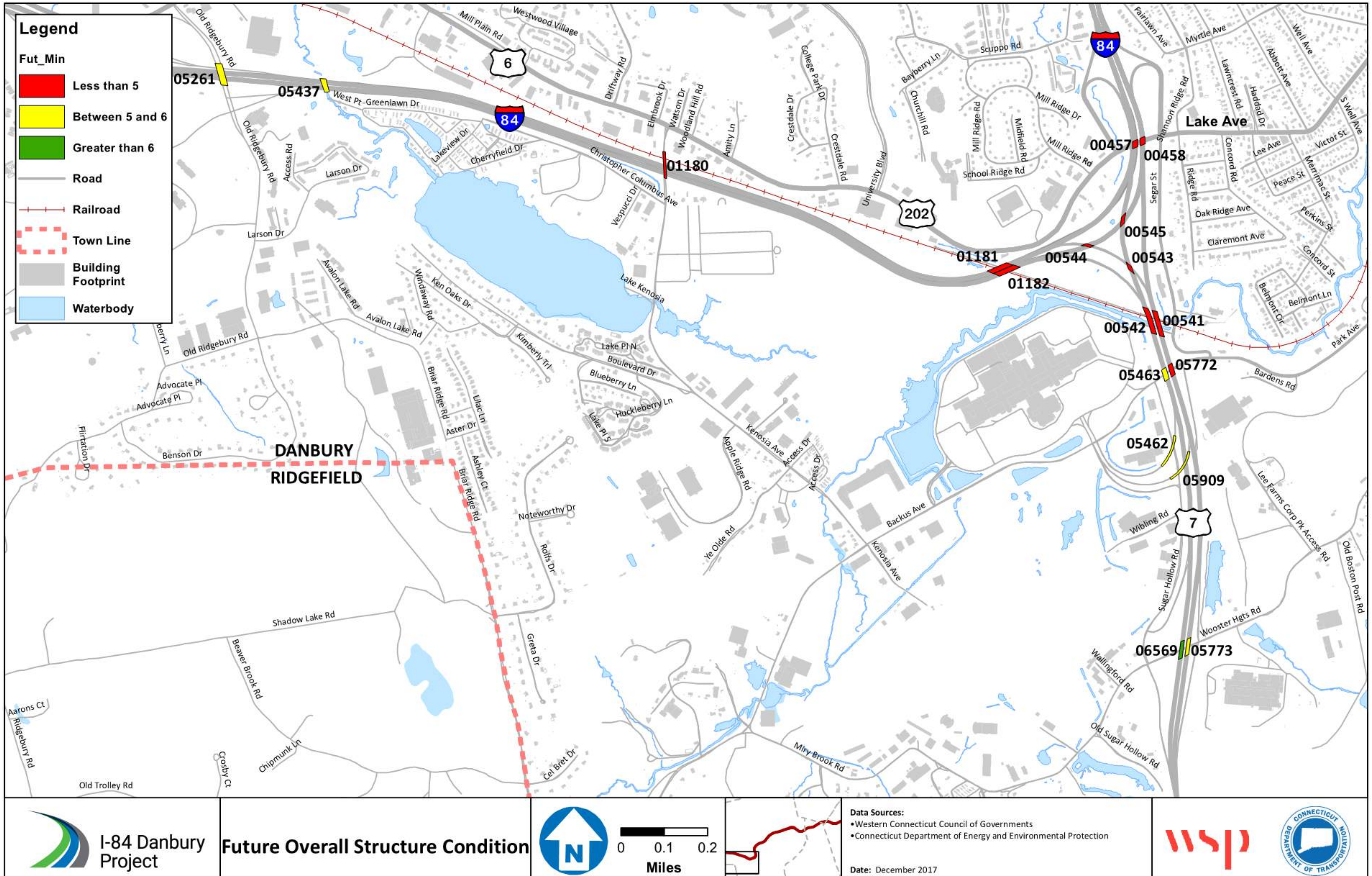


Figure 3-8 Future Overall Structure Condition Rating – Map 2

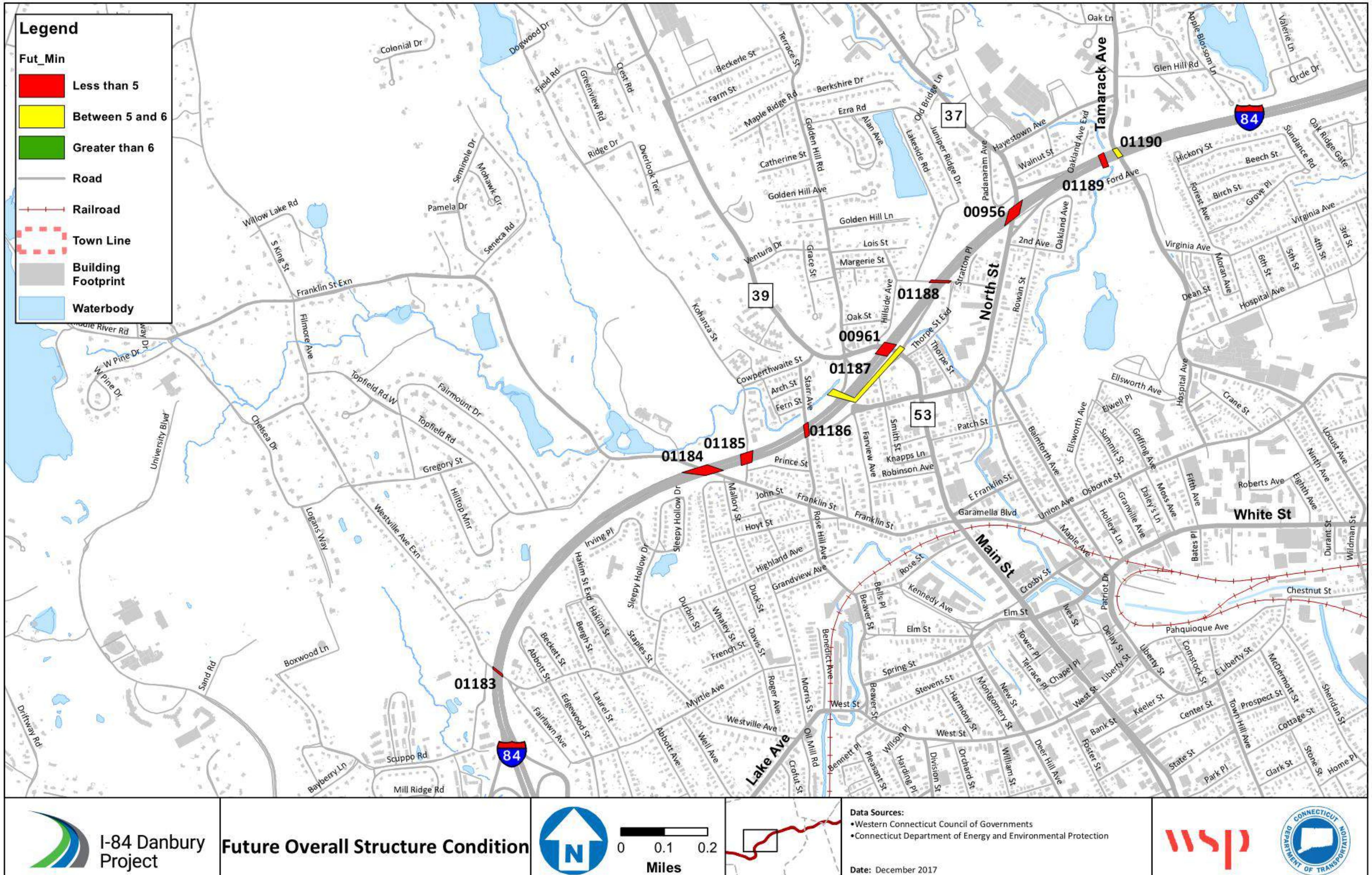


Figure 3-9 Future Overall Structure Condition Rating – Map 3

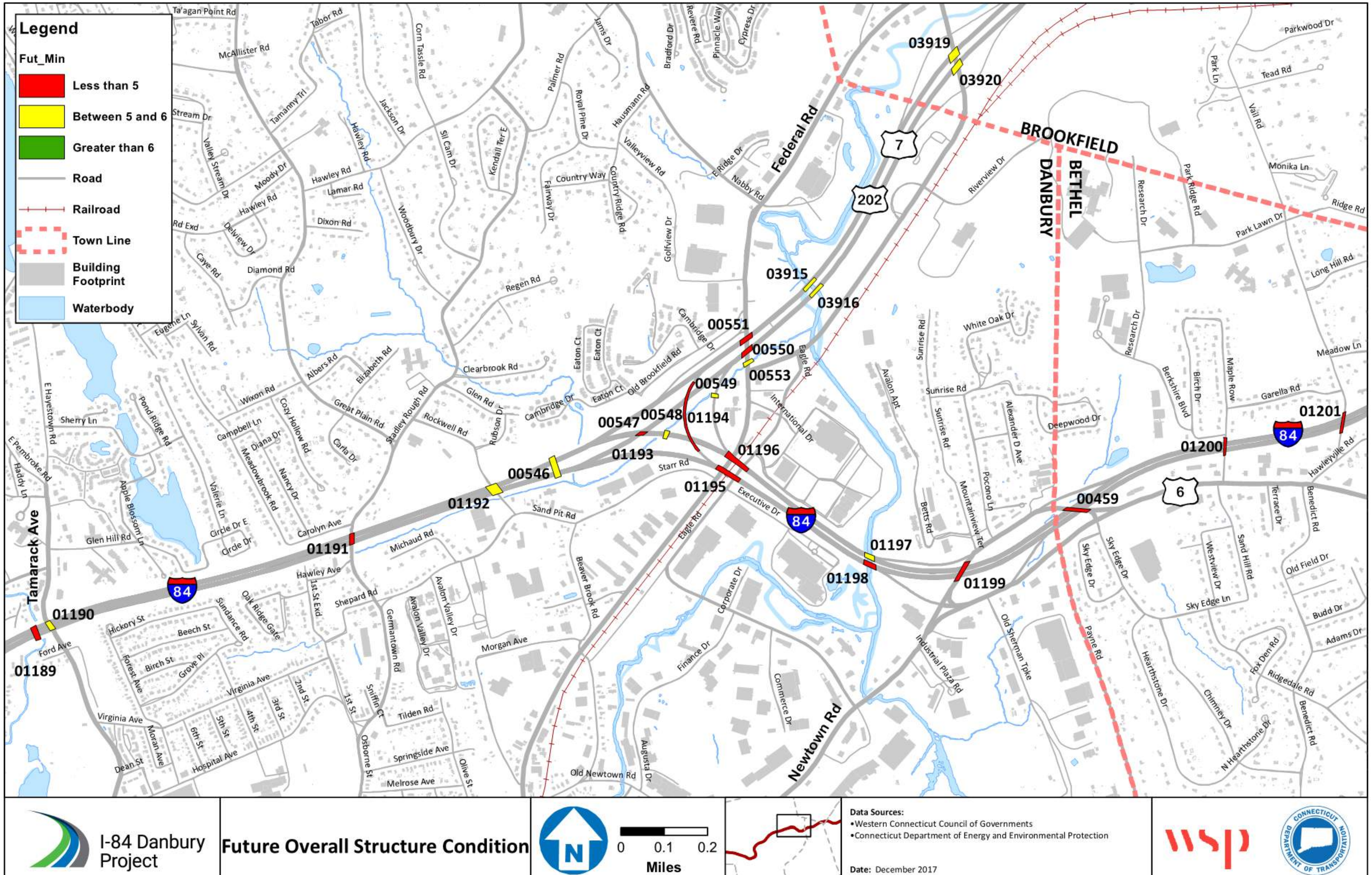
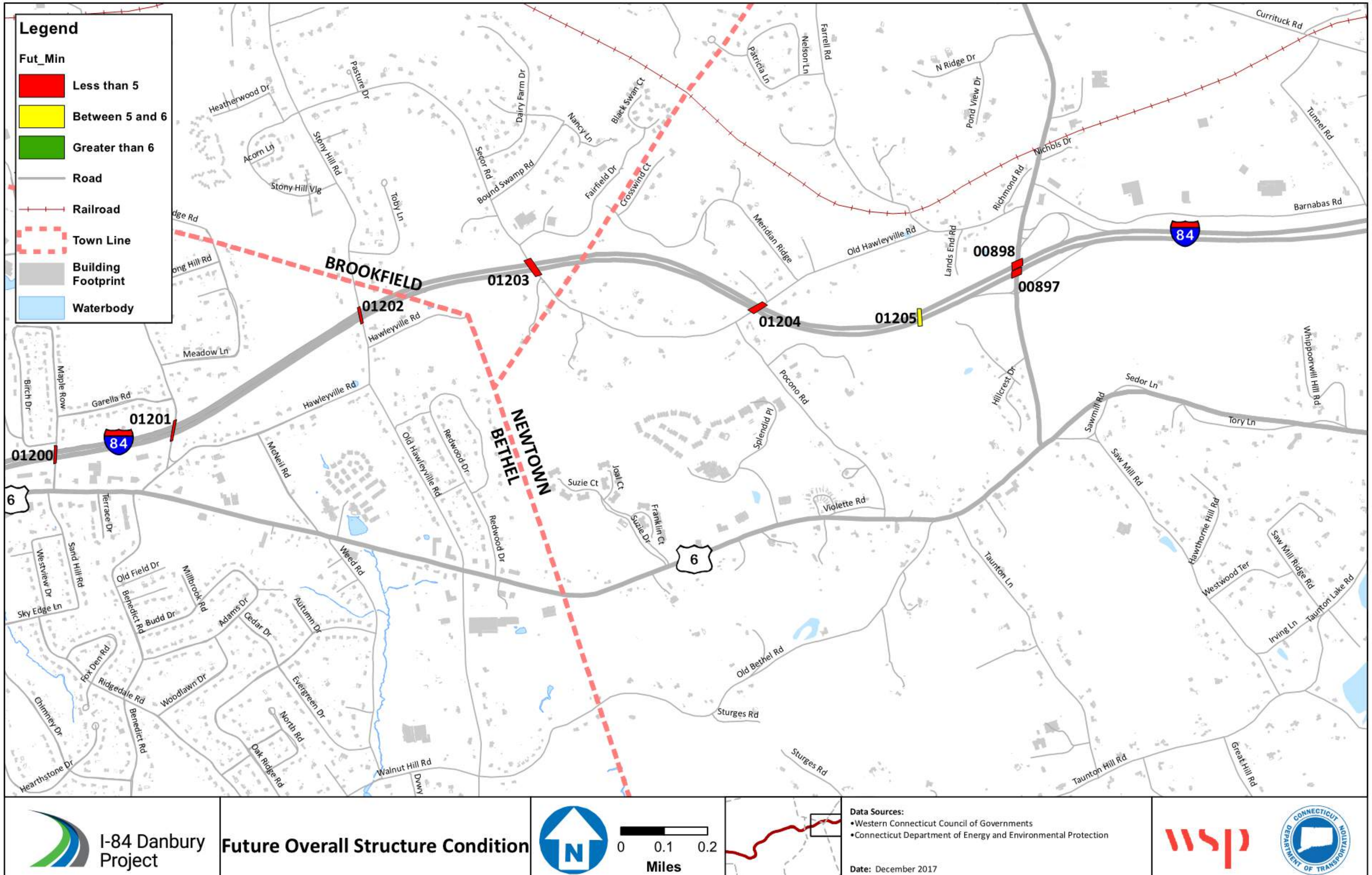


Figure 3-10 Future Overall Structure Condition Rating – Map 4



Section 4
Summary of Findings and Deficiencies

This section summarizes the corridor-wide and interchange-specific findings and deficiencies identified in the technical analysis.

4.1 I-84

This section summarizes the deficiencies for I-84 within the study area.

4.1.1 Mainline Deficiencies

- Substandard horizontal curves near Exits 3 and 4 which lower design speeds
- Substandard shoulder widths throughout the corridor
- Substandard stopping sight distance caused by vertical curves throughout the corridor
- Substandard roadway grades for truck movements
- Substandard interchange spacing requirements i.e. between Exits 3 and 4, Exits 5 and 6, and Exits 7 and 8
- Mainline capacity deficiencies, with a significant portion of local traffic using I-84 during peak periods – Exits 3 to 8 in the eastbound direction and Exits 6 to 8 in the westbound direction
- Mainline crashes attributed to roadway geometry and peak period congestion – Exits 3 to 6 in the eastbound direction and Exits 3 to 4 in the westbound direction
- Several structures on I-84 mainline require replacement

4.1.2 Interchange Deficiencies

4.1.2.1. Exit 3 – Route 7

- Weaving operation between Exits 3 and 4 in the eastbound direction
- Left hand exit and entrance to/from I-84 and Route 7 in the westbound direction does not meet driver expectancy

4.1.2.2 Exit 4 – Lake Avenue

- Substandard deceleration length and exit curvature for off-ramps in the eastbound and westbound direction
- Substandard acceleration length for the on-ramp in the eastbound direction
- Weaving operation between Exits 3 and 4 in the eastbound direction
- Poor traffic merge operation for the on-ramp in the eastbound direction
- High crash rates at the off-ramps in the eastbound and westbound direction – rear-ends and sideswipes
- Insufficient intersection capacity at Lake Avenue/I-84 Eastbound Ramps/Segar Street, Lake Avenue/Shannon Ridge Road, and Lake Avenue/Mill Ridge Road intersections
- High crash rates at Lake Avenue/I-84 Eastbound Ramps/Segar Street intersection attributed to intersection operation.

4.1.2.3 Exit 5 – Main Street (Route 39)

- Substandard exit curvature for off-ramps in the eastbound and westbound direction
- Substandard acceleration lengths for the on-ramps in the eastbound and westbound directions
- Poor traffic diverge operation for the off-ramp in the eastbound and westbound directions
- Poor traffic merge operation for the on-ramp in the eastbound direction
- High crash rates at the off-ramps in the eastbound and westbound direction – rear-ends and sideswipes
- Insufficient intersection capacity at Main Street/I-84 Ramps/Golden Hill Road, Main Street/Downs Street/North Street, Main Street/Cowperthwaite Road, Main Street/Hillside Avenue, Main Street/Water Street/I-84 Eastbound on-ramp, and I-84 Eastbound off-ramp/Farview Street/Downs Street intersections
- High crash rates at the Main Street/I-84 Ramps/Golden Hill Road and Main Street/Water Street/I-84 Eastbound on-ramp intersections attributed to intersection operation.

4.1.2.4 Exit 6 – North Street (Route 37)

- Incomplete interchange on North Street
- Substandard acceleration length for the on-ramp in the eastbound direction
- Poor traffic merge operation for the on-ramp in the eastbound direction
- High crash rates at the on-ramp in the eastbound direction – rear-ends and sideswipes
- Insufficient intersection capacity at North Street/Hayestown Avenue, North Street/I-84 Westbound off-ramp, North Street/Balmforth Avenue, Tamarack Avenue/Hayestown Avenue, North Street/2nd Avenue, and North Street/Walnut Street intersections

4.1.2.5 Exit 7 – Route 7

- Weaving operation between Exits 7 and 8 in the westbound direction

- Left hand exit and entrance to/from I-84 and Route 7 in the eastbound direction does not meet driver expectancy
- High crash rate at the Route 7 exit in the westbound direction

4.1.2.6 Exit 8 – Newtown Road (SR 805)

- Substandard deceleration length for the off-ramps in the eastbound and westbound directions
- Substandard exit curvature for the off-ramp in the westbound direction
- Poor traffic diverge operation for the off-ramp in the westbound direction
- High crash rate at the off-ramp in the eastbound direction – rear-ends and sideswipes
- Insufficient intersection capacity at I-84 Westbound on-ramp/Newtown Road/Mountainview Terrace and Eagle Road/Newtown Road intersections
- High crash rate at the I-84 Westbound on-ramp/Newtown Road/Mountainview Terrace intersection – rear-ends and sideswipes

4.2 Route 7

This section summarizes the needs for Route 7 within the study area.

4.2.1 Mainline Deficiencies

- Substandard horizontal curves on both sections of Route 7 i.e. west and the east section
- Substandard shoulder widths throughout the corridor
- Substandard stopping sight on Route 7 throughout the corridor
- Insufficient interchange spacing between Exits 8 and 9 and Exits 10 and 11
- Insufficient mainline capacity on Route 7 northbound at the merge with I-84 eastbound and on Route 7 southbound between White Turkey Road Extension and the merge with I-84 westbound
- Mainline crashes attributed to roadway geometry and peak period congestion – Route 7 northbound at the merge with I-84 eastbound and on Route 7 southbound between White Turkey Road Extension and the merge with I-84 westbound
- Structures on Route 7 mainline within project area require replacement

4.2.2 Interchange Deficiencies

4.2.2.1 Exit 7 – Wooster Heights Road

- Weaving operation between Exits 7 and 8 in the northbound direction
- Poor traffic diverge operation for the off-ramp to Wooster Heights Road in the northbound direction caused by peak period congestion

4.2.2.2 Exit 8 – Park Avenue/Backus Avenue

- Weaving operation between Exits 8 and 9 in the northbound direction
- High crash rate at the Backus Avenue/Route 7 southbound off-ramp/Route 7 northbound on-ramp intersection

4.2.2.3 Exit 9 – I-84 Ramps (west side)

- Weaving operation between Exits 8 and 9 in the northbound direction

4.2.2.4 Exit 10 – Federal Road/I-84 Ramps (east side)

- Left hand entrance and exit to/from I-84 eastbound and Route 7 does not meet driver expectancy
- Substandard ramp curvature on entrance ramp (Federal Road) and exit ramp (I-84 eastbound).
- Poor traffic merge operation with Route 7 in the southbound direction caused by the lane drop and proximity to the I-84 westbound merge

4.2.2.5 Exit 11 – White Turkey Road Extension

- Poor traffic merge and diverge operation with Route 7 in the southbound direction caused by the queue spillback from the I-84 westbound merge

Figures 4-1 through **4-6** summarize the identified deficiencies along I-84 and Route 7 within the study area.

4.3 Corridor Wide Needs

The following is a list of corridor wide needs:

- Deficiencies in existing transit and rail service in the study area
- Lack of travel demand management (TDM) programs i.e. commuter parking, carpool, vanpool and other employer driven opportunities within the region
- Lack of pedestrian and bicycle travel linkages in the corridor specifically near I-84
- Inefficient freight travel and connectivity within the corridor

Figure 4-1 – Summary of Needs and Deficiencies – Map 1

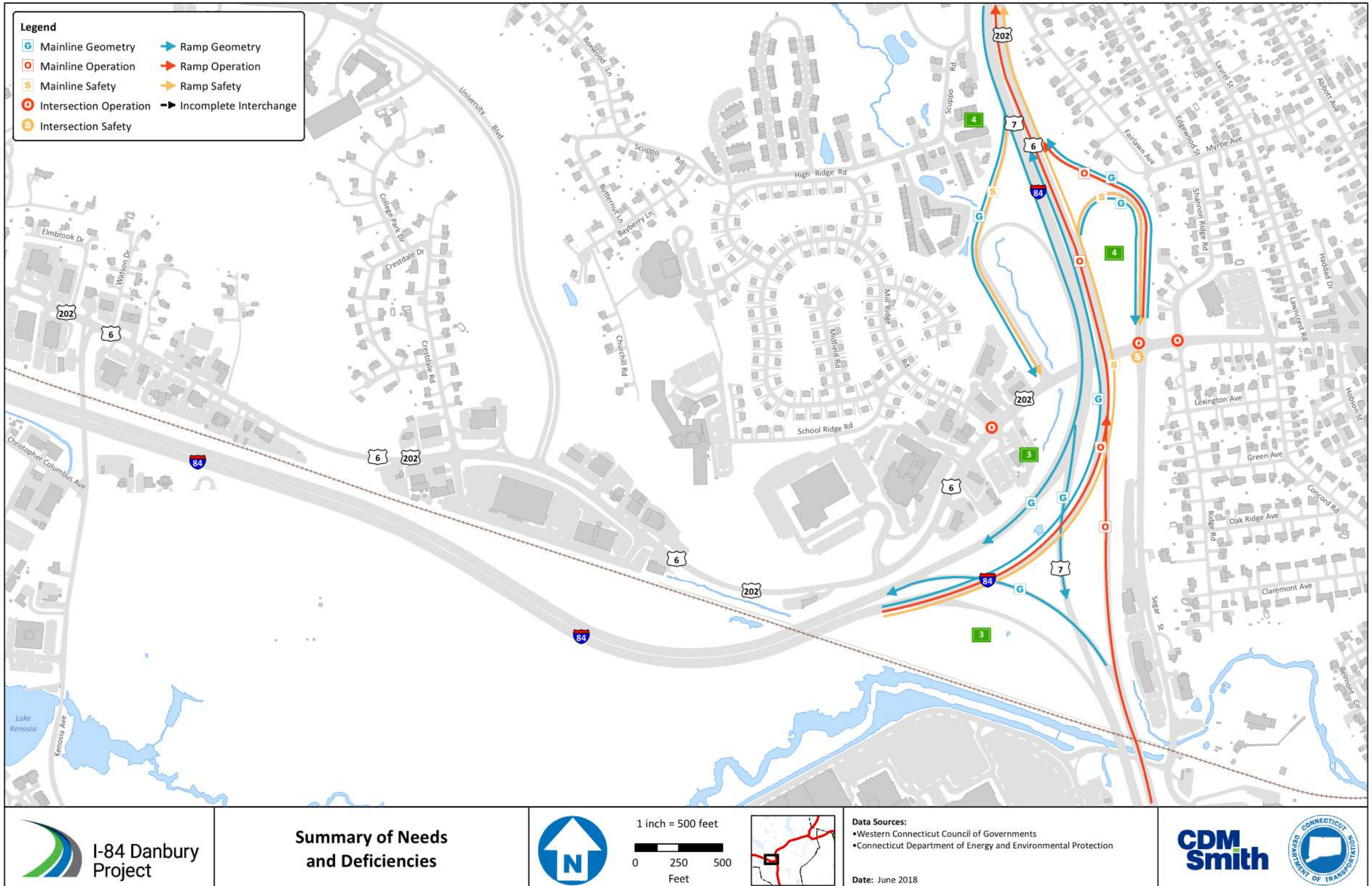


Figure 4-2 – Summary of Needs and Deficiencies – Map 2

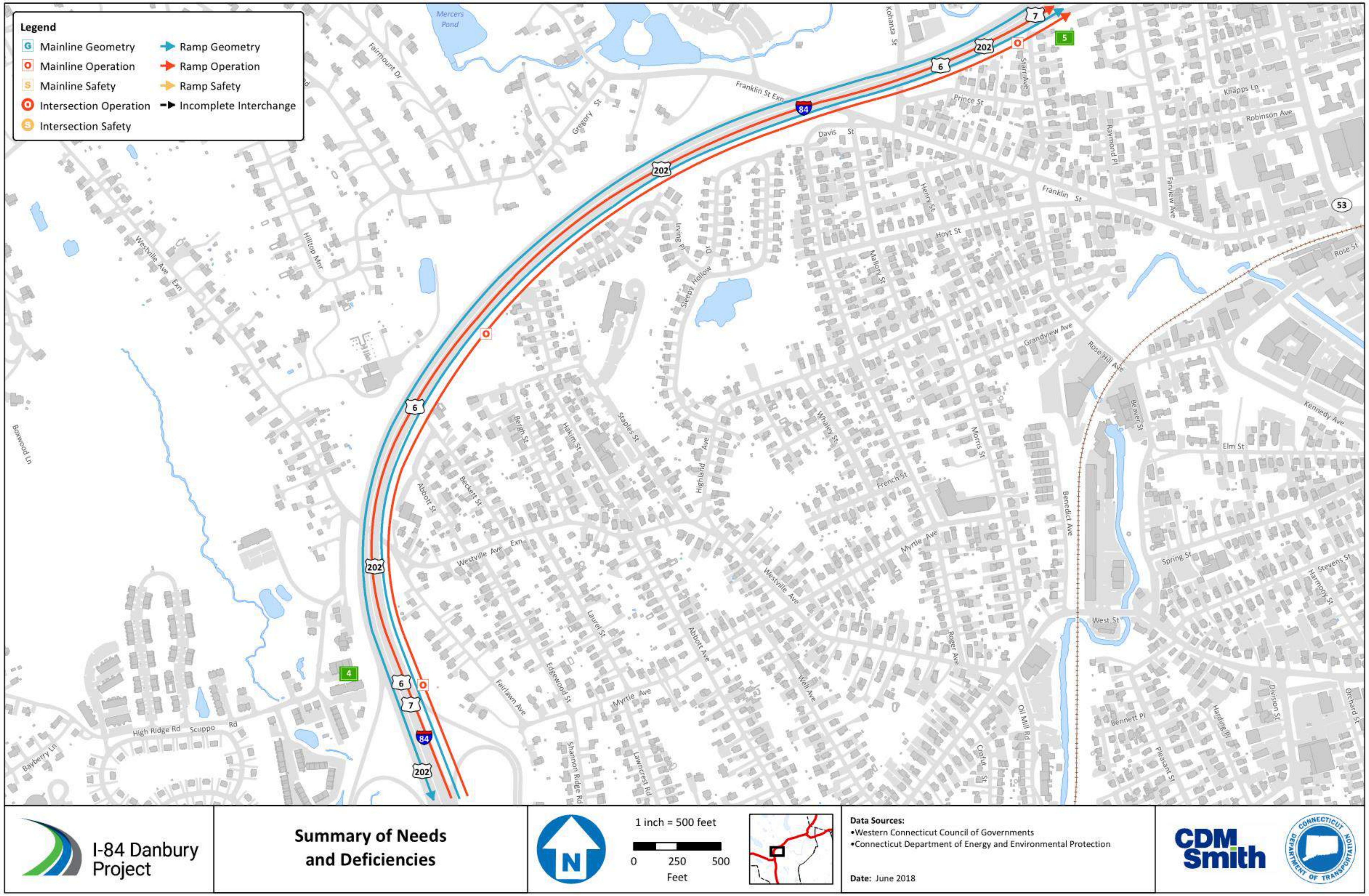


Figure 4-3 – Summary of Needs and Deficiencies – Map 3

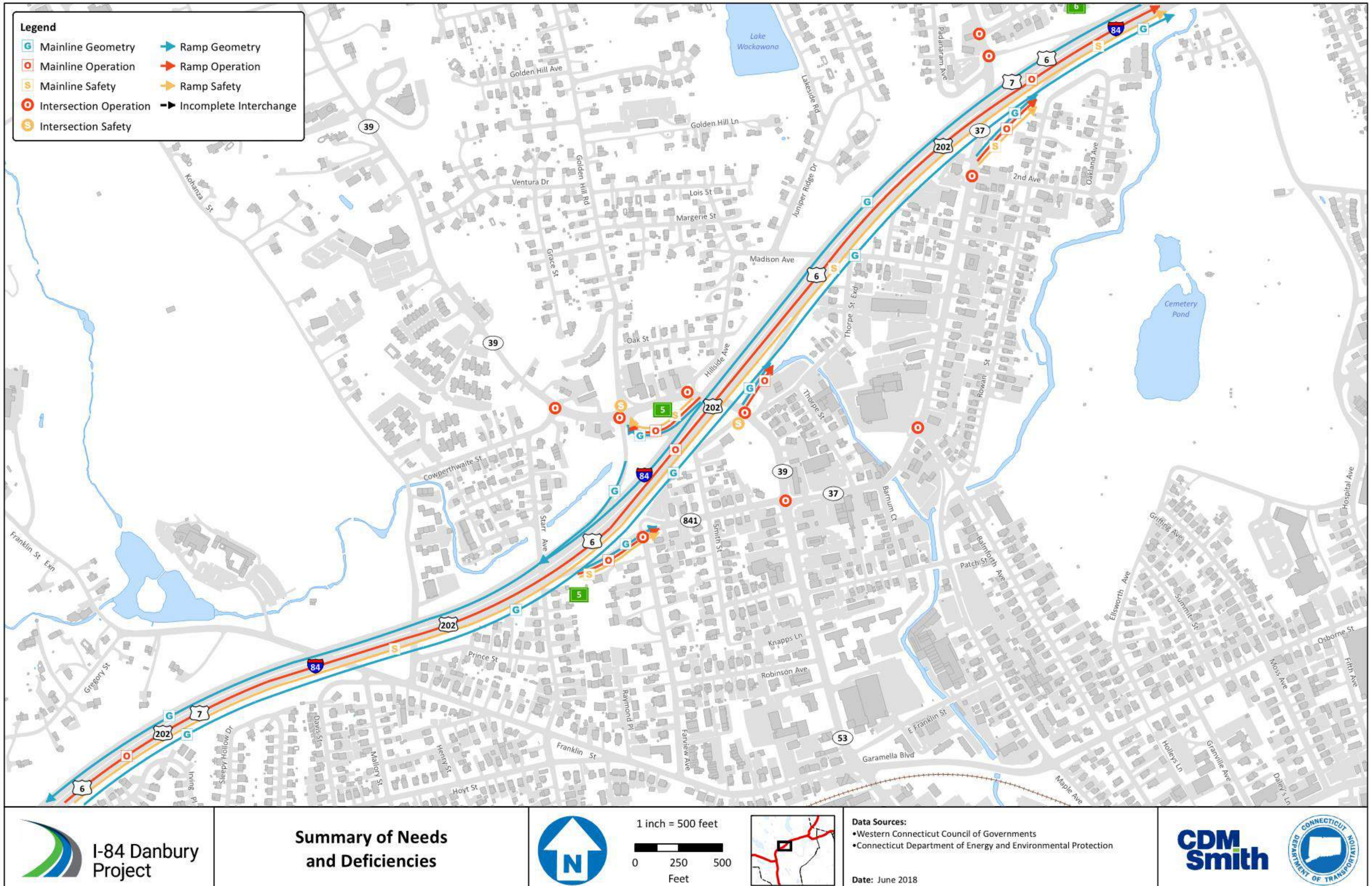


Figure 4-4 – Summary of Needs and Deficiencies – Map 4

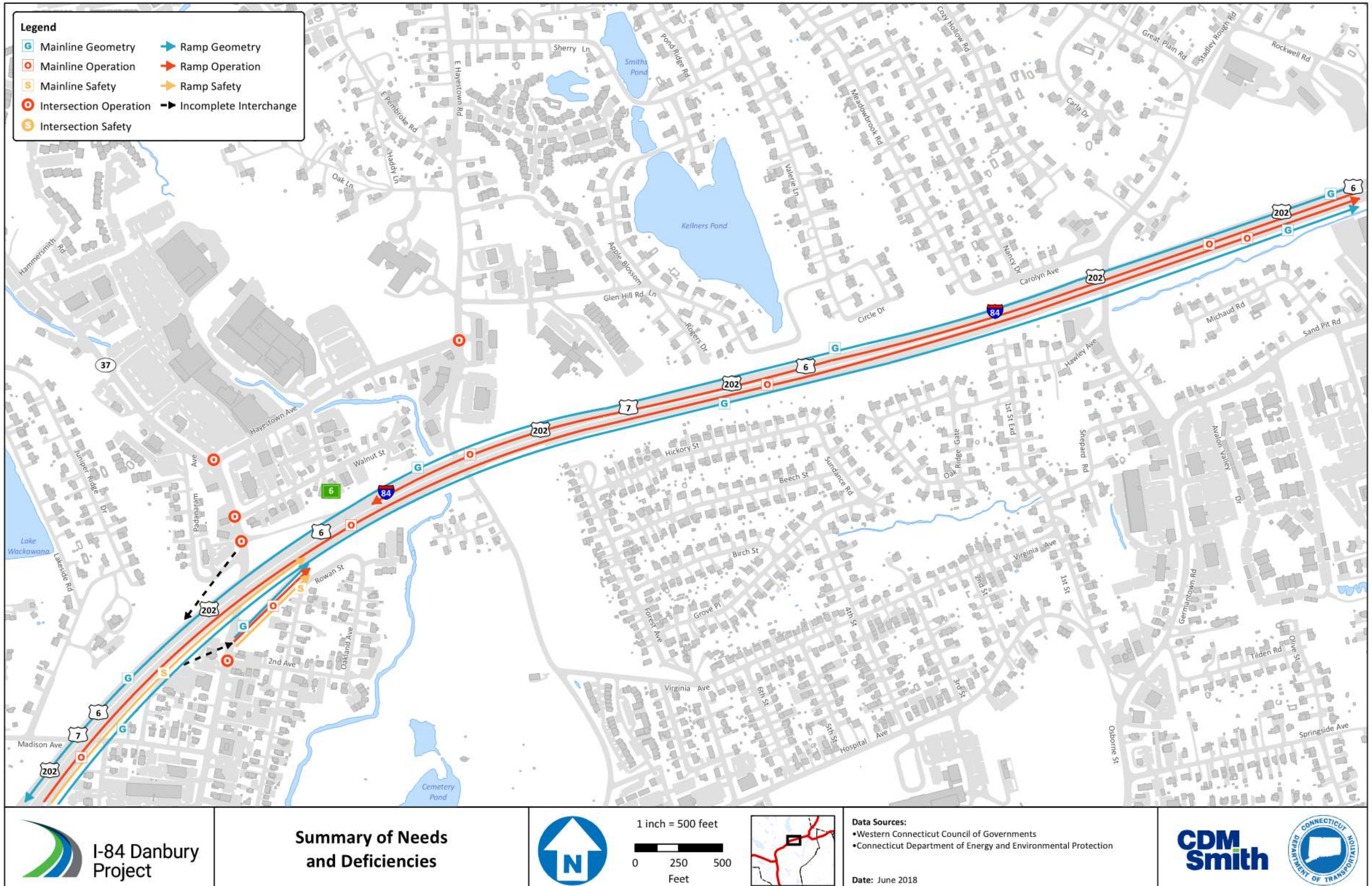


Figure 4-5 – Summary of Needs and Deficiencies – Map 5

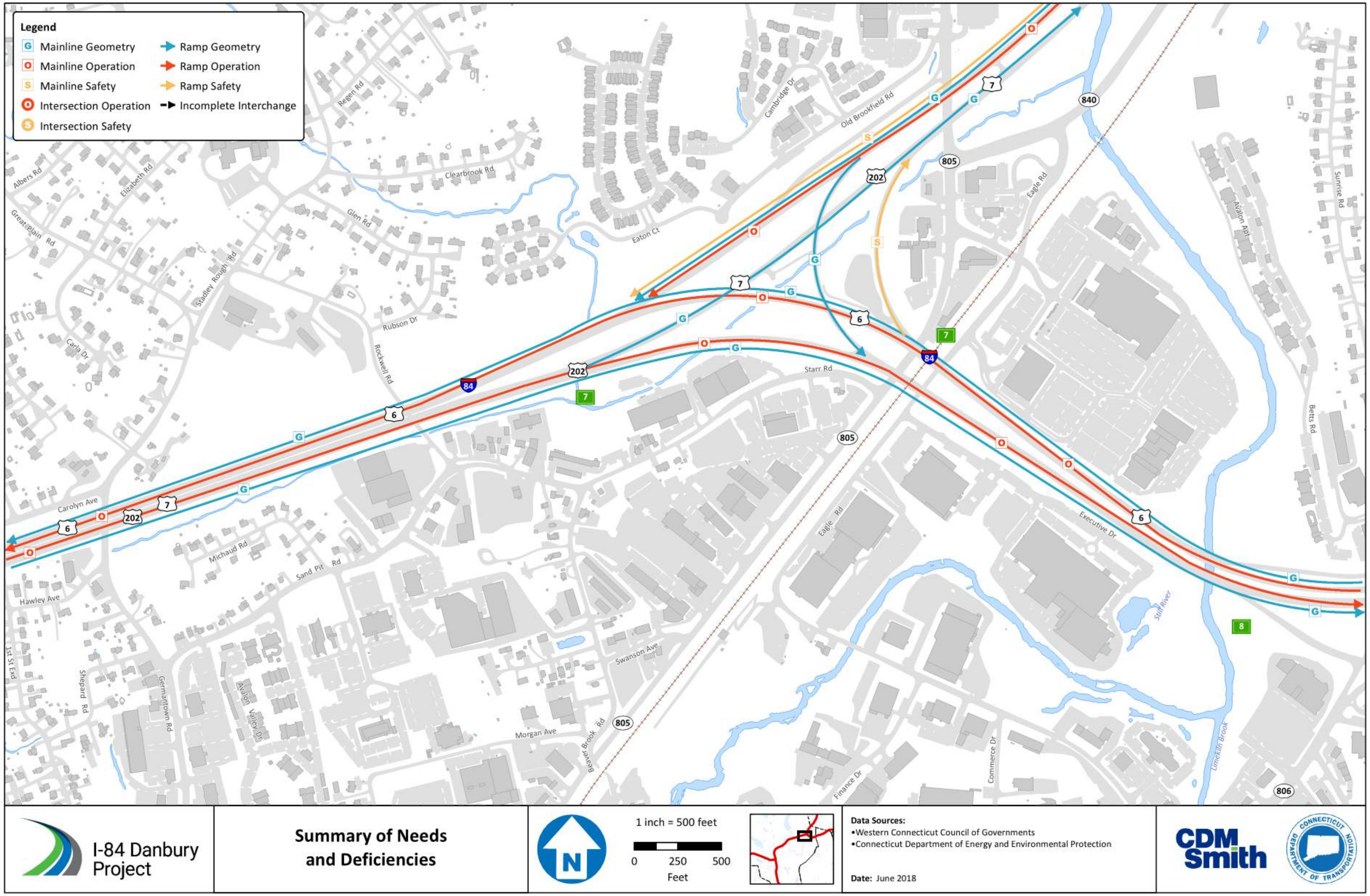


Figure 4-6 – Summary of Needs and Deficiencies – Map 6