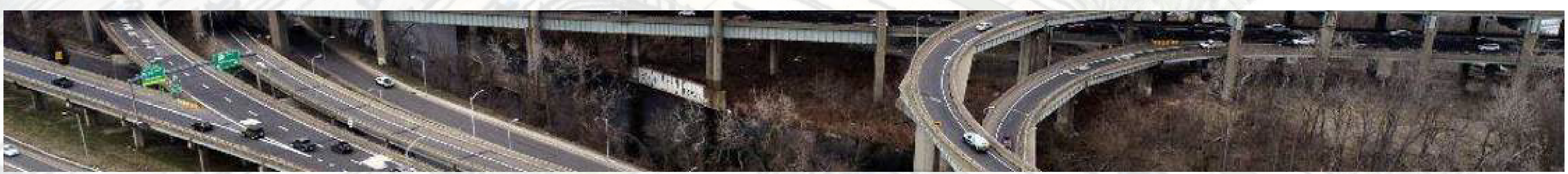
Interstate 84 / Route 8

"MIXMASTER" INTERCHANGE

ANALYSIS, NEEDS AND DEFICIENCIES REPORT

AUGUST 2023

84 new mix | HNTB



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CT DEEP Northern Long-Eared Bat Areas of Concern

1 Introduction

1.1 PURPOSE

This report summarizes the details and results of various studies which have been performed as part of the Connecticut Department of Transportation's (CTDOT) planning process for the Reconstruction of Interstate 84/CT Route 8 Interchange Project (the I-84 Mixmaster Reconstruction Project, the Project). The Project has been initiated by the CTDOT to enhance safety, improve structural conditions, and correct operational and geometric deficiencies of the Interstate 84 (I-84) and Route 8 "Mixmaster" interchange and larger transportation network in the Waterbury area.

The studies that are summarized in this report consist of data collection efforts and engineering analyses for transportation and context (or environmental) features within the Project study area. These studies have collectively been performed to identify the existing (2017) transportation network's deficiencies and to predict its future (2045) deficiencies in a hypothetical "no build" scenario.

The content of this *Analysis, Needs, and Deficiencies Report* is primarily intended to guide the development of conceptual Project improvements. The future "no build" scenario will be used as a benchmark condition for comparison and evaluation of improvement concepts. This report purposefully does not discuss or consider Project improvement concepts.

This report will also serve as a source of information to develop the Project's Draft Purpose and Need Statement as part of the Planning and Environmental Linkages (PEL) process that the CTDOT is undertaking. The Draft Purpose and Need Statement will also be used in the subsequent National Environmental Policy Act (NEPA) process that the CTDOT will follow.

1.2 STUDY AREAS

The City of Waterbury is a major employment center in Connecticut and the governmental, institutional, and cultural center of the Naugatuck River Valley. Waterbury is a formerly renowned capital of general manufacturing and is nicknamed "The Brass City" for its dominance of the U.S. brass industry during the 20th century. In this century, the City is managing a change from industrial roots to a service-sector economy. The City of Waterbury today is home to about 65,000 jobs and is currently implementing a comprehensive strategic plan to reclaim its position as a regional employment center and commercial hub (refer to the *City of Waterbury Downtown Strategic Plan*, available on the City's website, for additional detail).

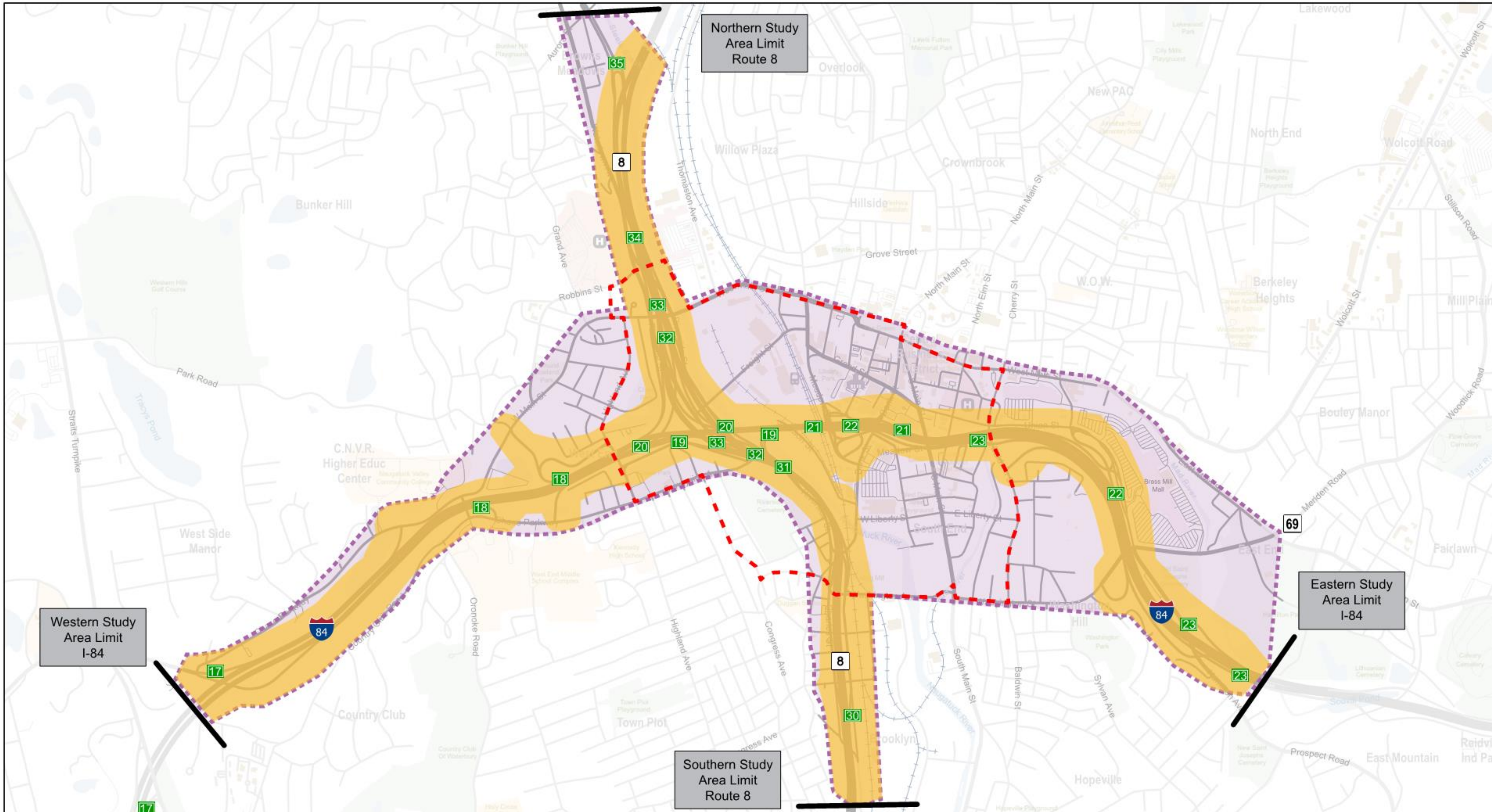
Within Connecticut, I-84 serves as a critical east-west transportation link between New York and Massachusetts. In Waterbury, I-84 is located just south of the City's greater downtown area. Route 8 is a north-south state highway that follows the Naugatuck River and connects Waterbury to the I-95 corridor. Nearly 29,000 people use these highways to commute into the City each day[1].

The general study areas for this report are shown in **Figure 1-1** that follows. These areas include the Project Study Corridor; the Traffic Data Collection Area; and the Key Area Boundary that was used to identify key community resources proximate to the interchange. Each area boundary is unique and was deliberately defined for the purposes of evaluating the deficiencies of the transportation network and the needs of natural and human environments within the Project vicinity. The Project Study Corridor was used to evaluate the deficiencies of the transportation network and for evaluation of the natural environment. The Key Area Boundary was used during analyses of the built human environment. Resource-specific project study areas, such as for Environmental Justice presented in Section 4.1, also were developed.

The Project Study Corridor limits are roughly defined by numbered exits on the I-84 and Route 8 highways. On I-84, the corridor limits run from Exit 17 to 23; on Route 8 they extend just outside Exits 30 and 35. The Mixmaster interchange is located where I-84 and Route 8 cross. It is an elevated, full system, diamond interchange that was designed and constructed to fit within challenging topographical and site constraints. As a result, the interchange has four vertical levels, contains two stacked structures, and has a large number of left-handed entrance and exit ramps.

The study area includes more than 5-miles of highway, 65 studied intersections, 62 bridges (including culverts), and over 100,000 square feet of retaining walls. Significant features within the study area include the Naugatuck and Mad Rivers, several brooks and unnamed tributaries, ten neighborhoods, five parks, three historic districts, many historic places/properties (including Riverside Cemetery), the Metro North Railroad (MNR) Waterbury Branch Line, ten major employers, and the proposed (future) Freight Street District.

[1] From City of Waterbury Downtown Strategic Plan August 2015



Traffic Data Collection Area

Project Study Corridor

Key Area Boundary

Railroad

Open Space

Schools

20 Exit

Hospital

Train Station

City Hall

N

0 1,000 2,000 3,000 Feet

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I-84 Waterbury Mixmaster Reconstruction Project

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Study Areas Map

Date: 11/22/2019 | Figure No: 1-1

1.3 PRIOR REPORTS AND STUDIES

The CTDOT, City of Waterbury, and the former Naugatuck Valley Council of Governments have contemplated a means to address the long-term transportation needs of the I-84 and Route 8 corridors through Waterbury since at least 1995. Initialized as part of the CTDOT's vision, the I-84 Mixmaster Reconstruction Project is the most recent effort to address these transportation needs. Prior reports and studies which are pertinent to the Project include:

- CTDOT Needs and Deficiencies Analysis in the I-84 Corridor Waterbury to Southington, 1995
- Central Naugatuck Valley Regional Plan of Conservation and Development, 1998
- CTDOT I-84 West of Waterbury (WOW) Needs and Deficiencies Study, 2001
- CTDOT Waterbury Interchange Needs Study (WINS), 2010
- City of Waterbury Downtown Strategic Plan, 2015
- City of Waterbury Plan of Conservation and Development (POCD) 2015-2025
- The POCD outlines policy priorities for the physical, economic, and social future of Waterbury and establishes goals for future land use, development, and natural resources. Elements from the POCD that are most pertinent to the Project are discussed in **Section 1.4 Ongoing and Recent Projects**.
- City of Waterbury Freight Street Redevelopment Strategy, 2018

1.4 ONGOING AND RECENT PROJECTS

Ongoing and recent projects that are pertinent to the I-84 Mixmaster Reconstruction Project and discussion in this report are described in this section for general reference. See **Figure 1-2** for the general location of City planning projects. Additional details on previous and programmed bridge rehabilitation projects can be found in **Section 2.6 Existing Structural Conditions**.

1.4.1 CTDOT I-84 Waterbury Widening

The completed I-84 Waterbury Project (State Project No. 151-273) involved upgrades to a 2.7-mile segment of I-84 that is located between the I-84 Mixmaster Reconstruction Project's eastern study limit and Pierpont Road. Upgrades from the I-84 Waterbury Project included addition of a third travel lane and full width shoulders (in each direction), safety improvements, and elimination of an existing substandard "S" curve alignment, among others.

In the interest of time, a project-level decision was made to collect traffic data during the I-84 Waterbury Widening's construction rather than waiting for its eventual completion. Consequently, this collected data may not precisely represent transportation conditions in the study area pre- or post-project construction. This data was then used in several subsequent engineering analyses which are summarized in this report. How this aspect of the data collection was accounted for during the affected analyses is described in the respective report sections.

1.4.2 CTDOT Route 8/I-84 Mixmaster Rehabilitation

The ongoing CTDOT Route 8/I-84 Mixmaster Rehabilitation Project (State Project Nos. 151-326/151-312/151-313) began construction in June 2018. The project involves rehabilitations to several major bridges (including the four stacked mainline bridges) that are located within the Project Study Corridor. The purpose of the rehabilitation project is to preserve the bridges' structural integrity and extend their service lives by 25-years.

The rehabilitation project is a stop-gap measure that is distinct from the I-84 Mixmaster Reconstruction Project. This rehabilitation project is necessary to maintain the safety of the traveling public for the duration of the I-84 Mixmaster Reconstruction Project's design phase. How the ongoing rehabilitation project was considered during analyses of existing and future structural conditions is explained in the respective sections of this report.

1.4.3 Naugatuck River Greenway (NRG)

The Naugatuck River Greenway (NRG) is an ongoing greenway project to construct a 44-mile long multi-use trail which will connect eleven municipalities along the Naugatuck River. Geographically, the City of Waterbury is located in the middle of the proposed greenway, and 7.1 miles of the greenway is within the City boundary. A 2010 study of potential greenway developments within Waterbury anticipated the future Mixmaster reconstruction and understood that it would include connections along the greenway in addition to realignments of roads and highway ramps. As a result, the proposed NRG developments in Waterbury include planned phases and interim connections through the study area to accommodate the I-84 Mixmaster Reconstruction Project.

1.4.4 W.A.T.E.R. Project

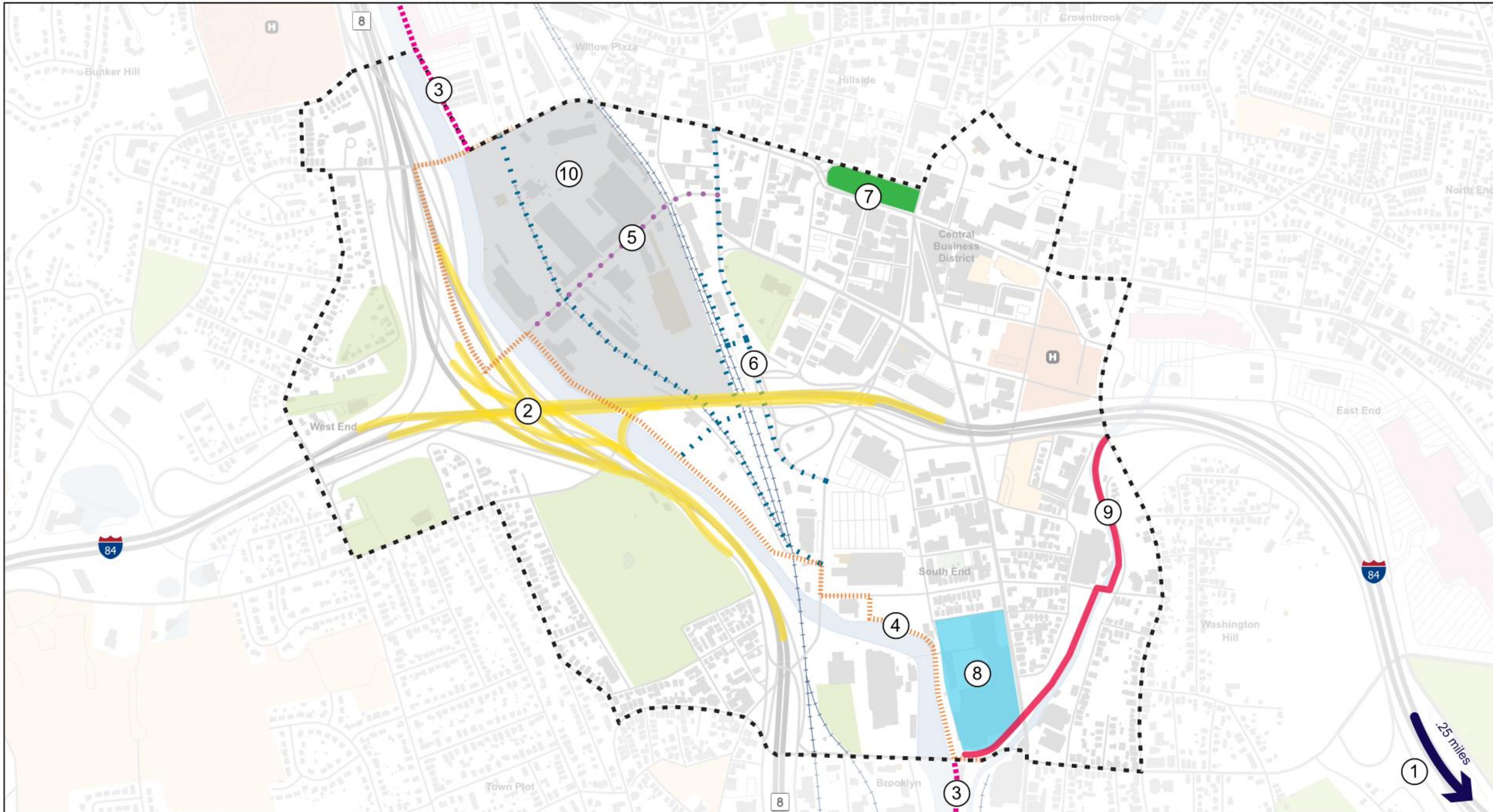
The W.A.T.E.R. project (Waterbury Active Transportation and Economic Resurgence) is a complete street project that is being funded through a TIGER VI Grant. This project intends to improve transportation infrastructure (local roads, shared use paths, and gathering places) in the Waterbury downtown to better integrate areas of the City and to provide connectivity and recreation opportunities. W.A.T.E.R Project components within the study area include:

- Waterbury Naugatuck River Greenway Phase 1 Extension.
- Freight Street Reconstruction, a completed improvement to the deteriorated main street which added an urban side path trail, bicycle, and pedestrian lanes.
- Meadow Street Bicycle and Pedestrian Improvements.
- Jackson Street Reconstruction and Extension, a planned north-south connection between Brooklyn and the future Freight Street District.
- Library-Station-Riverfront Connector, a planned pedestrian bridge to connect Library Park to the riverfront and train station.

1.4.5 Waterbury POCD Projects

The following initiatives and projects as described in the Waterbury Plan of Conservation and Development (POCD) are part of the vision and the revitalization of the City's urban core which is located within the study area:

- Waterbury Next, an ongoing initiative to revitalize downtown Waterbury that includes funding for streetscapes, drainage improvements, and upgrades to the Waterbury Green.
- Downtown Gateways, a planned project to develop six downtown gateways throughout the Central Business District. These gateways would serve as entry points into downtown Waterbury.
- Planned brownfield developments include a former industrial property near the Mixmaster (the Anamet site at 698 South Main Street) which has received funding for demolition and remediation.
- The Mad River Greenway extension and construction in Waterbury is envisioned to be a future component to the City's development strategy.
- Other downtown developments including renovations to the historic train station, retrofitting single-use buildings into mixed-used buildings, developing vacant land and surface parking, and redevelopment of the Freight Street District through a strategic master plan



1. CTDOT I-84 Waterbury Widening
2. CTDOT Mixmaster Rehabilitation
3. Naugatuck River Greenway

W.A.T.E.R. Project

4. Naugatuck River Greenway Phase 1 Extension
5. Freight Street Reconstruction
6. Ongoing Improvements

Waterbury POCD Projects

7. Waterbury Next
8. Brownfield Development
9. Mad River Greenway
10. Freight Street District

N

0 500 1,000 Feet

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I-84 Waterbury Mixmaster Reconstruction Project

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Current Planning Projects Map

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1.5 PROJECT GOALS

A Draft Purpose and Need Statement is being developed for the Project as part of the PEL process. Presently, the Project has the following general goals and considerations:

- Replace structurally and operationally deficient bridges
- Correct highway geometric deficiencies
- Address deficiencies with traffic operations and improve access to highways
- Improve safety and reduce the high crash rate throughout the study area
- Improve the local roadway network, encourage residents to use local roads for traversing the City
- Minimize construction impacts to the City and traveling public
- Provide for multimodal opportunities in the study area
- Support long-term economic opportunities by considering planned developments

The Draft Purpose and Need Statement will be advanced as the Project progresses. The Project goals and objectives to address current and future needs of the I-84 and Route 8 corridors in Waterbury will be further defined in this statement.

2 Existing (2017) Transportation Conditions

2.1 DESCRIPTION OF TRANSPORTATION NETWORK

Along the I-84 corridor from the western study limit, the existing topography slopes up to the east. Near Highland Avenue, there is a ridge line and the ground descends very rapidly to the Naugatuck River valley. On the narrow west side of the valley, Riverside Street is a local collector road; on the wider east side, are former factory sites and a railyard. There are high embankments containing the river on both banks.

I-84 continues easterly, descending to the south of the city center, reaching its lowest point at the South Elm Street overpass near the Mad River crossing. The topography then begins to climb as it progresses to the east following the Mad River valley, turning to the southeast around Holy Land before heading east at the eastern study limit.

Route 8 is a north-south oriented limited access highway that parallels the Naugatuck River on its west side through the study limits. South of I-84, Route 8 is a stacked viaduct (northbound over southbound) due to the narrow width between the historic Riverside Cemetery and the Naugatuck River.

At the center of the study area is the Mixmaster, an elevated, full system interchange. It is a full diamond configuration with four vertical levels. The stacked I-84 viaduct structure exists as the top two levels (Levels 3 and 4) and crosses over Route 8, a railyard, local roads, and the Naugatuck River. Route 8 is located at Level 2, and the local road network is defined as Level 1. The railroad is located vertically between Levels 1 and 2, and the Naugatuck River is located below Level 1.

The system interchange has four left and four right exit ramps but has five left-handed and three right-handed entrance ramps. The system ramps within the Mixmaster are I-84 Exits 19 and 20 and Route 8 Exits 31 and 33. The service ramps within the study area are I-84 Exits 17, 18, 21, 22 and 23 and Route 8 Exits 30, 32, 34 and 35.

System vs. Service Ramps

System ramps are roadways that connect "limited access" highway to another (e.g. Route 8 NB to I-84 EB)

Service ramps are roadways that connect the local roadway network to a limited access

The City of Waterbury does not have an extensive roadway network near the core of the interchange, which limits options for detours for the mainlines. Starting north and moving south, Waterbury has four local street crossings of the Naugatuck River. These local crossings are: West Main Street, Freight Street, Bank Street, and Washington Avenue. The rail line that crosses each of these roadways also restricts the vertical clearance, ranging from 13'-7" to 12'-2".

There are two major local north-south roadways through Waterbury on the west side of the Naugatuck River: Riverside Street and Highland Avenue to the west. Charles Street/South Leonard Street, Riverside Street, and Watertown Avenue are the local streets that run along and under the Route 8 viaduct through the study area.

2.2 EXISTING TRAFFIC DATA

Traffic data was collected to assess existing traffic conditions (or operations) that would eventually be used as a benchmark for future conditions. The collected data was used to calibrate traffic simulation models that were developed for the analyses described in **Section 2.3 Existing Traffic Operations** and **Section 3.4 Future Traffic Operations**.

Data was gathered for segments of I-84, Route 8, and the local street network to develop a full understanding of traffic conditions in the Project Study Corridor. Data collection was generally limited to the Traffic Data Collection Area shown in the **Figure 1-1 Study Areas Map** (See **Appendix 2.2** for detailed maps of data collection locations; refer to **Analysis Location Figures**). The local street network extents in the study area were chosen to include all nearby roads that are critical to travel in the Waterbury downtown. Note, critical roads are referred to as "arterials" throughout this report. The various types of data collected included:

- Highway traffic volumes for I-84 between Exits 17 and 23 and Route 8 between Exits 30 and 35
- Arterial traffic volumes at 65 intersections
- Heavy vehicle volumes at continuous count stations along I-84 and Route 8
- Origin and destination data along I-84, Route 8, and through the study area
- Travel speed data along I-84, Route 8, and major arterials
- Traffic signal data
- Mainline existing queue length observations for I-84 and Route 8

It should be noted that construction associated with the I-84 Waterbury Widening Project was ongoing at Project Study Corridor's eastern limit throughout the traffic data collection efforts (see **Section 1.4 Ongoing and Recent Projects**). The effects of this construction cannot be separated from the data and are therefore inherently reflected in the volumes, origin and destination patterns, travel speeds, and queues that were recorded. However, the project's change to lane configurations was ultimately reflected in the future 2045 "no build" modeling efforts.

2.2.1 Highway Traffic Volumes

Highway traffic volume data was obtained in 2017 for I-84 and Route 8 by placing automated traffic recorders and 24-hour video cameras at select highway ramp and mainline locations within the Project Study Corridor. Raw data and detailed data collection locations are shown in **Appendix 2.2** (refer to **Raw Automated Traffic Recorder (ATR) Data** and **Analysis Location Figures**).

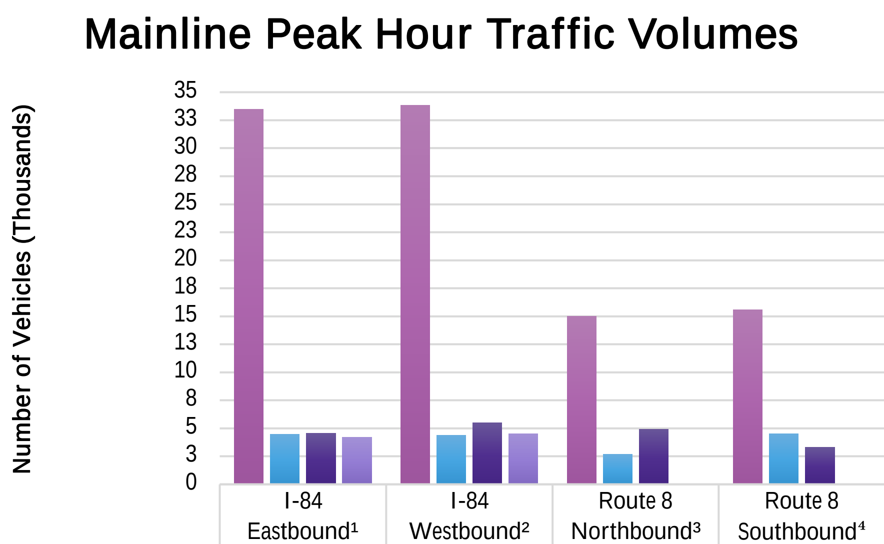
The raw data from automatic traffic recorders and 24-hour video cameras was summarized to determine that the peak hours for weekday highway traffic analysis are 7:30 to 8:30 AM and 4:30 to 5:30 PM. In addition, it was determined that Saturday analysis between 12:00 and 1:00 PM would be warranted along I-84. Further information on these determinations can be found in **Appendix 2.2** (refer to **Peak Hour Selection Memo**).

Figure 2-1 shows the calibrated (or balanced) traffic volumes for each corridor during the selected peak hours along and their corresponding 2017 average daily traffic (ADT). Additional detailed volume maps can be found in **Appendix 2.2** (refer to **Highway Volume Maps**).

Technical Information on Traffic Calibration

For calibration, all counts were factored to 2016 average weekday equivalents using two CTDOT continuous count stations: Continuous Count Station 54, located west of the Study Area in Middlebury between Interchange 16 and 17 on I-84, and Continuous Count Station 23 in Watertown, located at Interchange 37 on Route 8. Combined with 24-hour ramp counts taken every three years, these count stations provide a reliable overview of weekday traffic patterns along

Figure 2-1 Mainline Peak Hour Traffic Volumes



	I-84 Eastbound[1]	I-84 Westbound[2]	Route 8 Northbound[3]	Route 8 Southbound[4]
ADT (2017)	33,490	33,837	15,001	15,591
AM Volume	4,470	4,390	2,700	4,500
PM Volume	4,540	5,480	4,930	3,310
Saturday Volume	4,190	4,520		

[1] I-84 Eastbound between Exits 19 & 20
[2] I-84 Westbound at various locations
[3] Route 8 Northbound between Exits 34 & 35
[4] Route 8 Southbound between Exits 35 & 34

Figure 2-2 through **Figure 2-7** show the daily and weekly traffic volume variation for I-84 and Route 8.

Figure 2-2 I-84 Daily Traffic Volume Variation

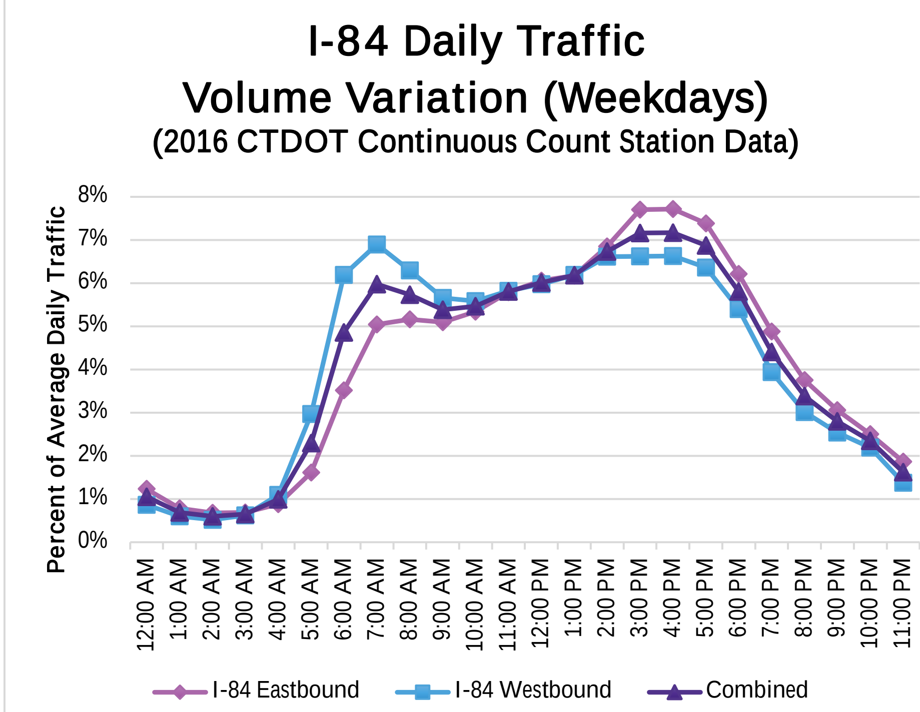


Figure 2-3 I-84 Weekly Traffic Volume Variation

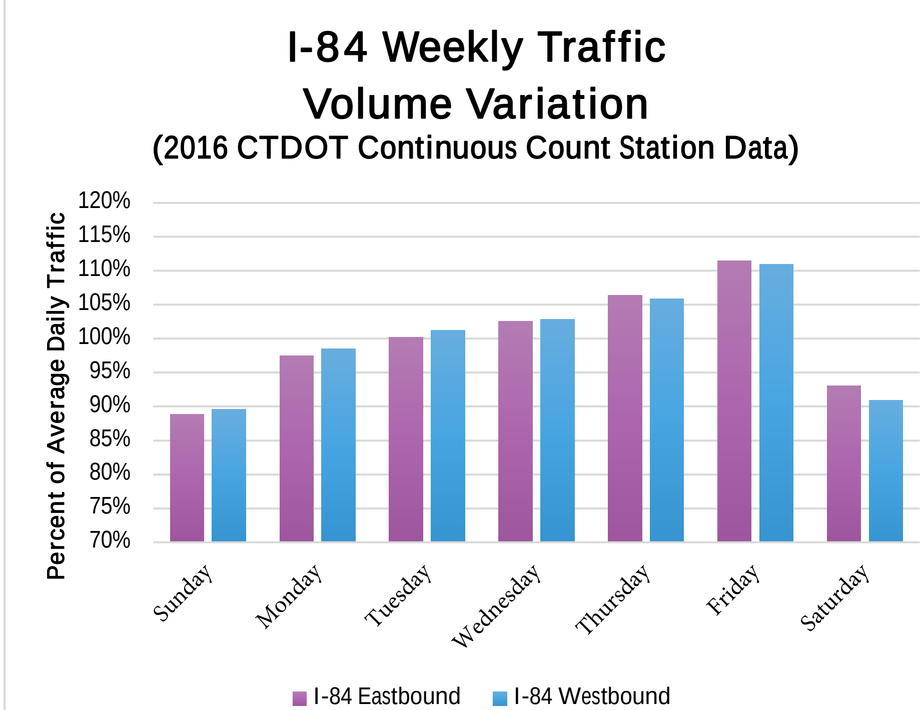


Figure 2-4 I-84 Yearly Traffic Volume Variation

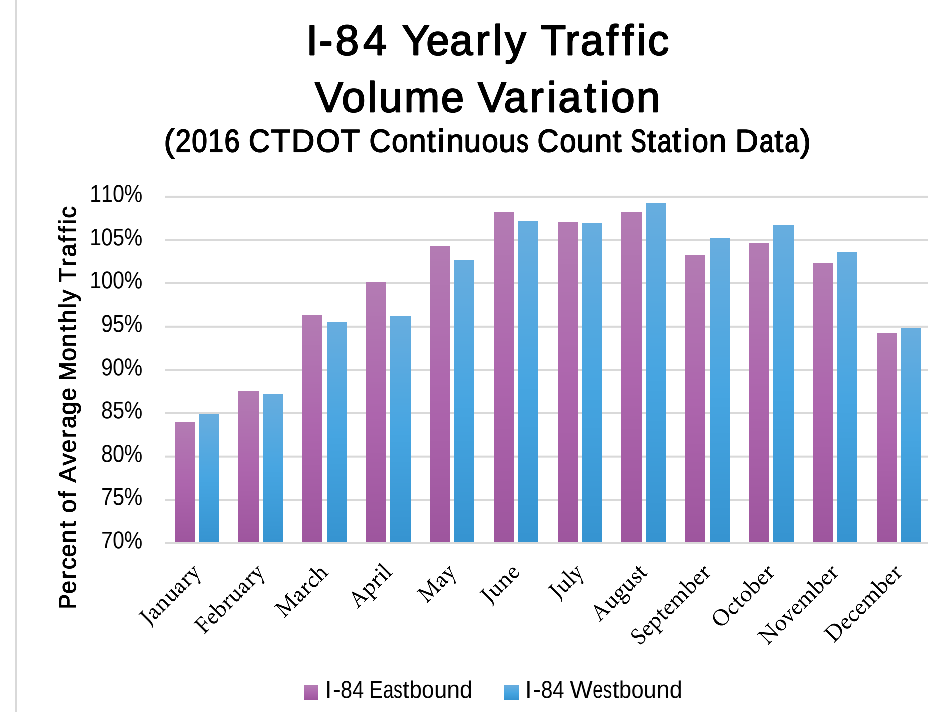


Figure 2-5 Route 8 Daily Traffic Volume Variation

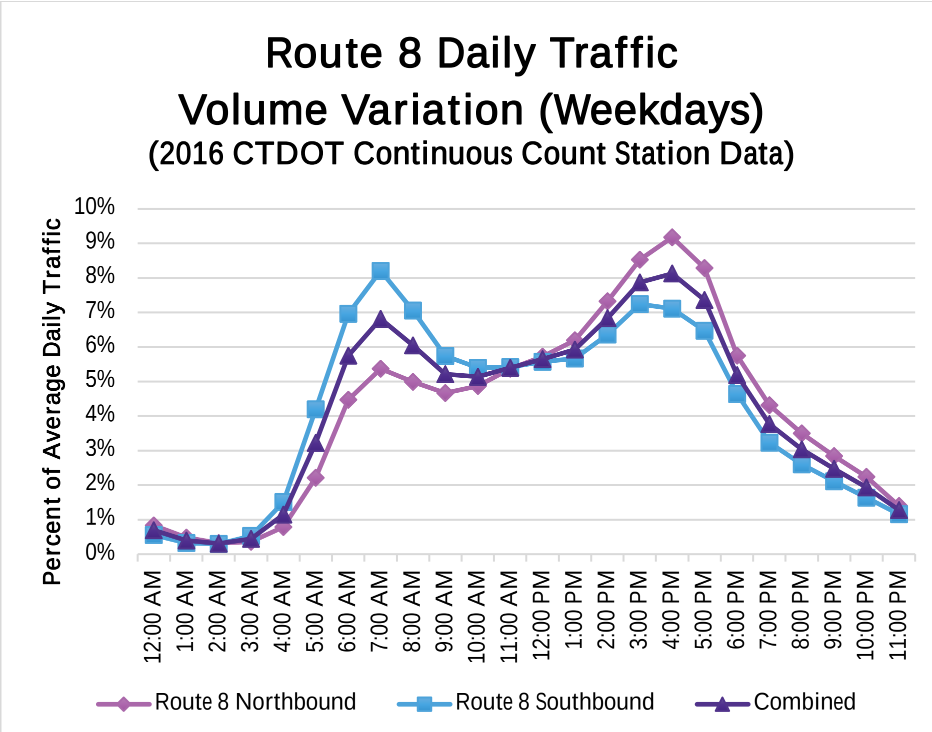


Figure 2-6 Route 8 Weekly Traffic Volume Variation

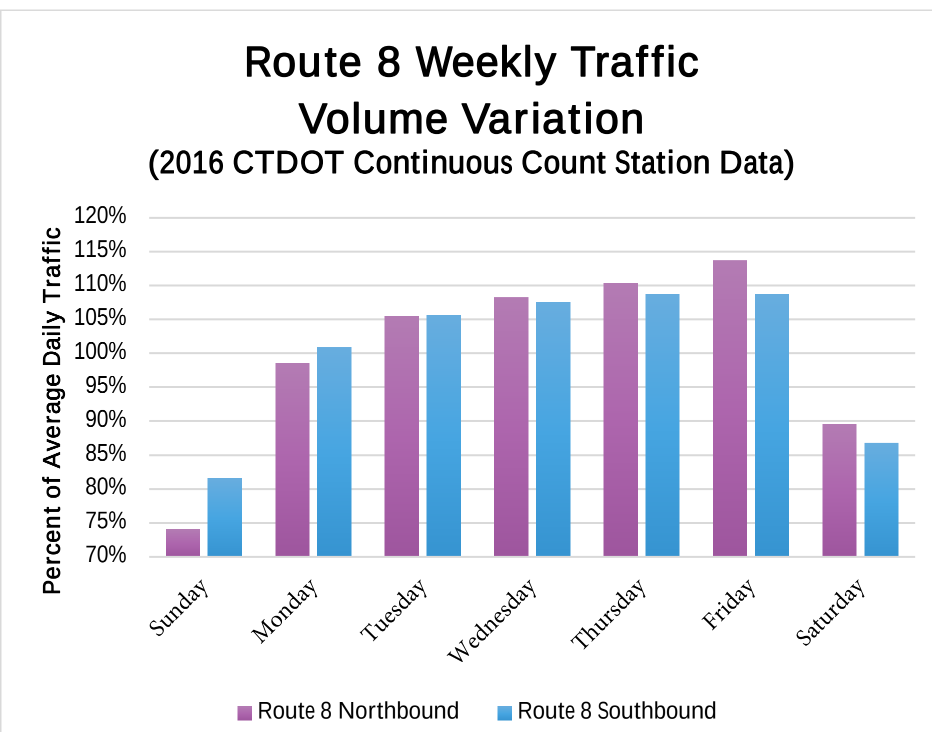
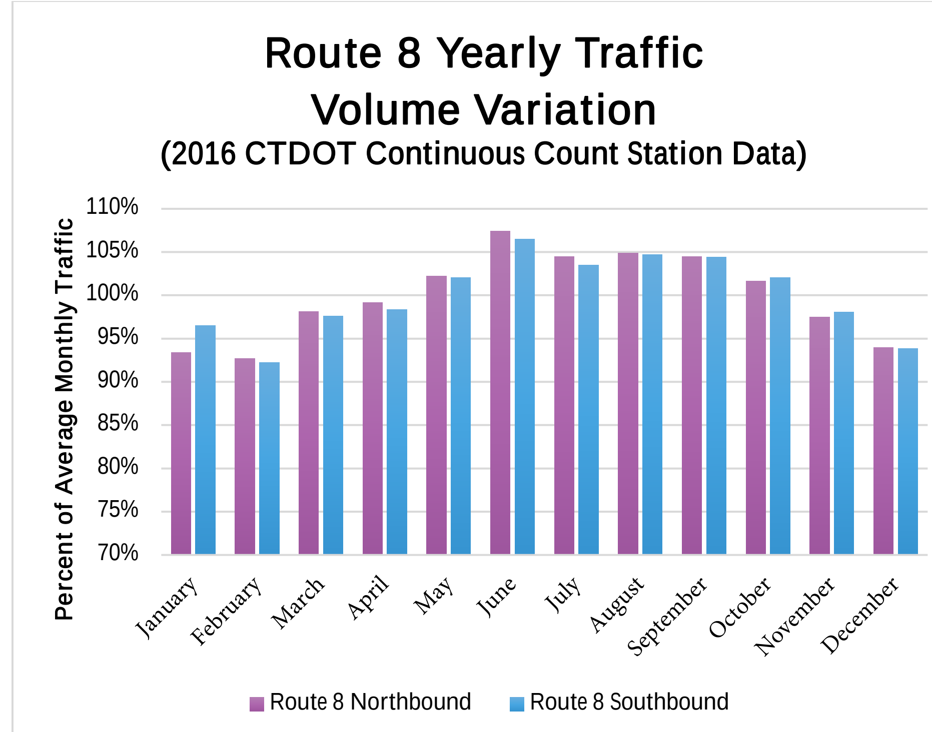


Figure 2-7 Route 8 Yearly Traffic Volume Variation



2.2.2 Arterial and Intersection Traffic Volumes

Arterial and intersection traffic volume data was obtained in 2017 for 65 intersections (see **Figure 2-31**) using manual turning movement counts that included conflicting pedestrians and vehicle classifications. These counts were conducted on weekdays from 6:00 to 9:00 AM, from 3:00 to 6:00 PM, and from 12:00 to 4:00 PM on Saturday. Raw turning movement count data is provided in **Appendix 2.2**.

Turning movement counts were supplemented by automatic traffic recorders placed for a period of seven days at 30 locations along the arterials. Raw automatic traffic recorder (ATR) data and collection locations are shown in **Appendix 2.2** (refer to **Raw ATR Data** and **Analysis Location Figures**).

The raw data from turning movement counts and automatic traffic recorders was summarized to determine that the peak hours for weekday arterial and intersection traffic analysis are 7:30 to 8:30 AM and 4:30 to 5:30 PM. In addition, it was determined that Saturday analysis between 12:00 and 1:00 PM would be warranted at thirteen intersections. Further information on these determinations can be found in the **Peak Hour Selection Memo** in **Appendix 2.2**.

Table 2-1 shows calibrated (or balanced) traffic volumes for a selection of high-volume arterials on major corridors and their corresponding 2017 average daily traffic (ADT). Balanced traffic volumes were used for further intersection analyses and for calibration and validation of traffic models (see **Section 2.3 Existing Traffic Operations** for more on traffic models). Additional detailed volume maps can be found in **Appendix 2.2** (refer to **Arterial Volume Maps**).

Figure 2-8 Arterial Peak Hour Traffic Volumes

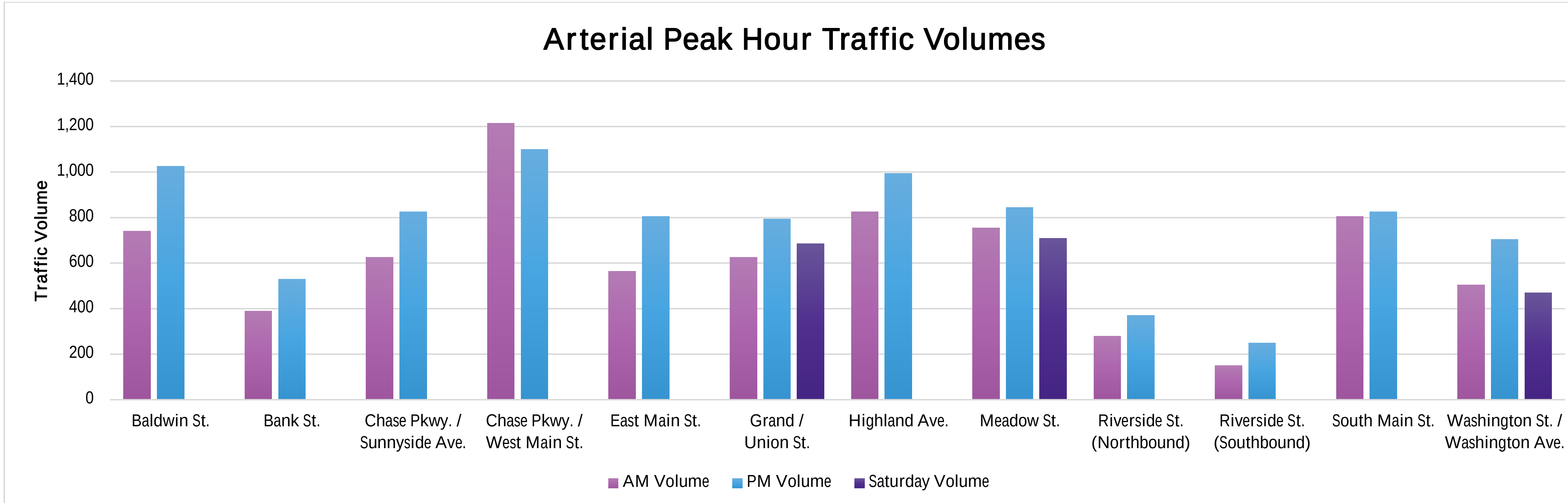


Table 2-1 Arterial Peak Hour Traffic Volumes

Corridor	Direction	AM	PM	Saturday	ADT (2017)	Location
Baldwin St.	Two-way	740	1,025		12,645	Between McMahon and Scovill / Mill St.
Bank St.	Two-way	390	530		6,720	Between Meadow and Jackson St.
Chase Pkwy. / Sunnyside Ave.	Two-way	625	825		8,905	Between Chase Collegiate School Dr. and I-84 EB On-Ramp (Exit 18)
Chase Pkwy. / West Main St.	Two-way	1,215	1,100		17,900	Between Riverside St. and Thomaston Ave.
East Main St.	Two-way	565	805		11,010	Between Maple and Baldwin St.
Grand / Union St.	Two-way	625	795	685	10,020	Between South Main and Bank St.
Highland Ave.	Two-way	825	995		13,740	Between Chase Pkwy. and Birchwood St.
Meadow St.	Two-way	755	845	710	10,605	Between Field and Grand St.
Riverside St.	Northbound	280	370		3,685	North of Sunnyside Ave.
	Southbound	150	250		2,735	
South Main St.	Two-way	805	825		7,225	Between Washington Ave. and Mill St.
Washington St. / Washington Ave.	Two-way	505	705	470	7,885	Between South Leonard and Lafayette St.
Watertown Ave.	Two-way					**No ATR along Watertown Ave.**

2.2.3 Heavy Vehicle Volumes

Data was collected at continuous count stations that are west of Exit 17 on I-84 and south of Exit 30 on Route 8 to determine the weekday vehicle classifications along the highway mainlines. Weekend vehicle classifications were taken from the data collected in 2017 at Exit 17 on I-84. The percent heavy vehicles (vehicles with six or more tires, three or more axles, and/or buses) in each peak hour are shown in **Table 2-2** below and detailed information is provided in **Appendix 2.2** (refer to **Raw CC Class Counts**).

Table 2-2 Mainline Percent Heavy Vehicles

Corridor	AM	PM	Saturday
I-84 Eastbound	9.7%	7.1%	5.5%
I-84 Westbound	10.2%	11.2%	5.6%
Rt. 8 Northbound	6.1%	4.0%	
Rt. 8 Southbound	5.0%	2.6%	

2.2.4 Origins and Destinations

Study Area O/D Data

Origin and destination (O/D) traffic data was obtained in 2017 for I-84 and Route 8 from time-lapse aerial photographic (TLAP) surveys of highway traffic flows. O/D points were identified at the study area boundaries and at all interchange on and off ramps through the study area. **Table 2-3** and **Table 2-4** show an O/D summary for the weekday AM and PM peak hours. **Figure 2-9** through **Figure 2-16** that follow are graphical depictions of these O/D summaries. Detailed O/D matrices and charts are shown in **Appendix 2.2**.

As discussed previously, the CTDOT I-84 Waterbury Widening project was ongoing during collection of this O/D data. As a result of construction related congestion, certain travel pattern "irregularities" were reflected in the data. One irregular travel pattern that was observed was a strong tendency for through traffic to avoid congestion on I-84 Eastbound by using a local road bypass from Exit 23 to a temporary ramp at Hamilton Avenue. The O/D data showed that about 24 percent of I-84 Eastbound through traffic used this bypass route in the AM peak hour and 13 percent used it in the PM peak hour. Because this pattern was a temporary condition attributed to construction, data summaries and subsequent analyses that relied on the O/D data considered all bypass traffic as "through traffic" (rather than traffic entering the local road network). **Table 2-3** and **Table 2-4** reflect the adjusted O/D data.

Table 2-3 Origin and Destination Summary (AM Peak Hour)

Corridor	I-84 EB	I-84 WB	Route 8 NB	Route 8 SB	Local Streets
I-84 Eastbound	52%		16%	4%	28%
I-84 Westbound		39%	18%	12%	31%
Rt. 8 Northbound	14%	11%	34%		41%
Rt. 8 Southbound	21%	20%		29%	30%
Local Roads	17%	14%	12%	22%	35%

Note: EB = Eastbound, WB = Westbound, NB = Northbound, SB = Southbound

Table 2-4 Origin and Destination Summary (PM Peak Hour)

Corridor	I-84 EB	I-84 WB	Route 8 NB	Route 8 SB	Local Streets
I-84 Eastbound	50%		21%	5%	24%
I-84 Westbound		42%	25%	12%	21%
Rt. 8 Northbound	12%	7%	53%		28%
Rt. 8 Southbound	16%	14%		33%	37%
Local Roads	17%	9%	16%	23%	35%

Note: EB = Eastbound, WB = Westbound, NB = Northbound, SB = Southbound

Regional O/D Data

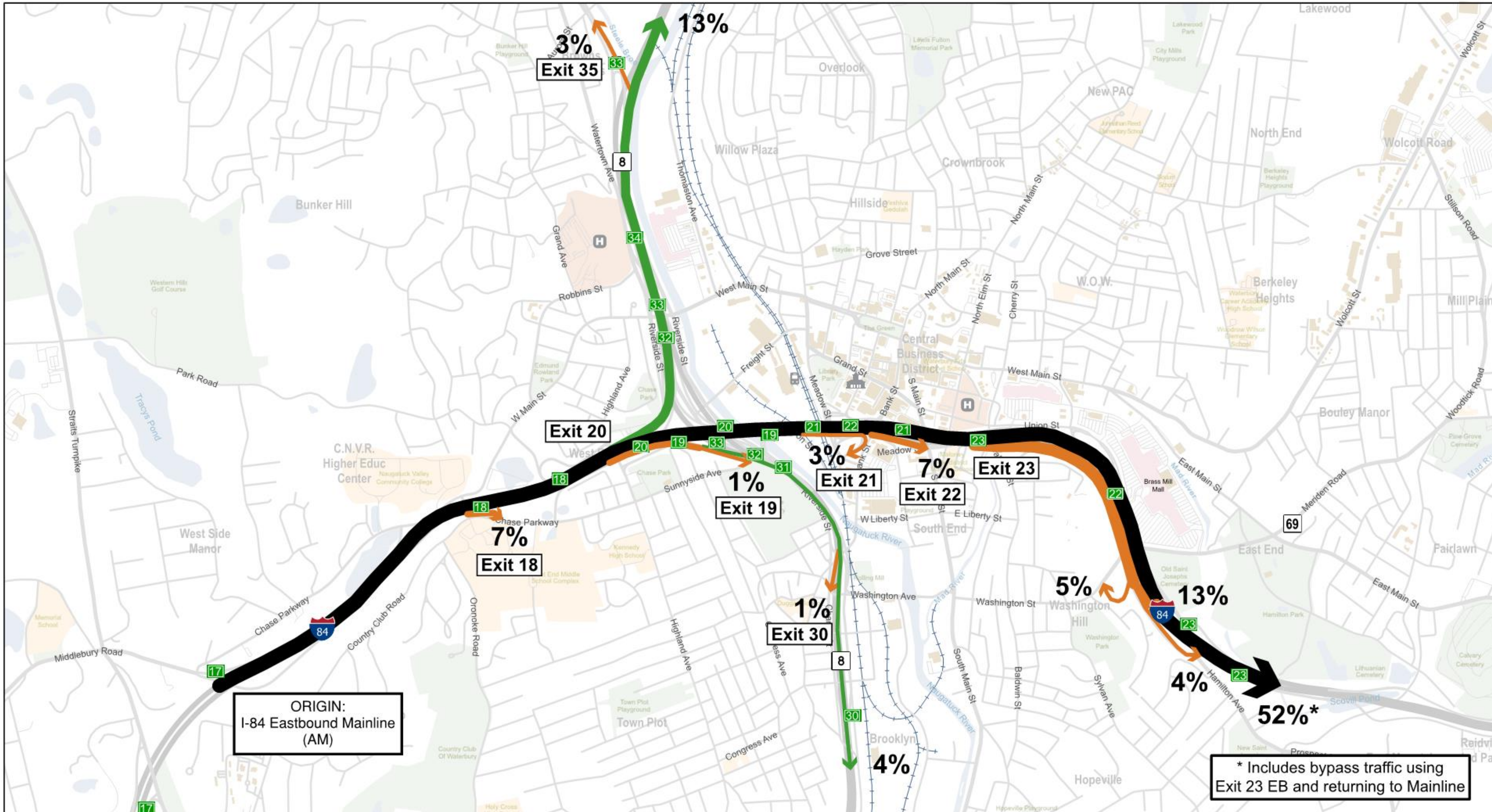
O/D traffic data at a regional level was developed based on INRIX trip records for automobiles and trucks. INRIX operates the largest crowd-sourced data network in the world, tapping into 30 million anonymous GPS and smartphone devices worldwide. GPS pings from trucks, delivery vans, fleet vehicles, and everyday smart phone users are gathered and processed by INRIX to generate distinct vehicle trip records.

INRIX records were evaluated for two data sets: a 2017 full study area data set (approximate 20-mile radius from the Mixmaster) and a 2014 reduced study area data set (approximate 5-mile radius from the Mixmaster). The 2014 data set was reviewed to investigate potential differences between pre-, mid- and post-construction travel patterns for State Project No. 151-273 which was completed in 2018 and widened I-84 east of Waterbury from two to three lanes. The 2017 data set was summarized for Tuesday-Thursday between 7:00 to 9:00 AM and 4:00 to 6:00 PM and in included in **Appendix 2.2** along with figures showing both INRIX study areas (refer to **Analysis Location Figures**).

Summary statistics for the INRIX 2017 full study area data set follow:

- During the weekday AM peak hour 78,159 trips were observed with an average trip length of 35 miles and average travel speed of 34 MPH
- During the weekday PM peak hour 64,805 trips were observed with an average trip length of 40 miles and average travel speed of 33 MPH

The INRIX O/D data was summarized for use in the validation of network modeling.



- I-84 Through Traffic
- I-84 to Route 8 Through Traffic
- Traffic Entering Local Road Network
- X% Percentage of Vehicles Traveling in the X Direction
- Railroad
- Open Space
- Schools
- 20 Exit
- Hospital
- Train Station
- City Hall

N

0 1,000 2,000 3,000 Feet

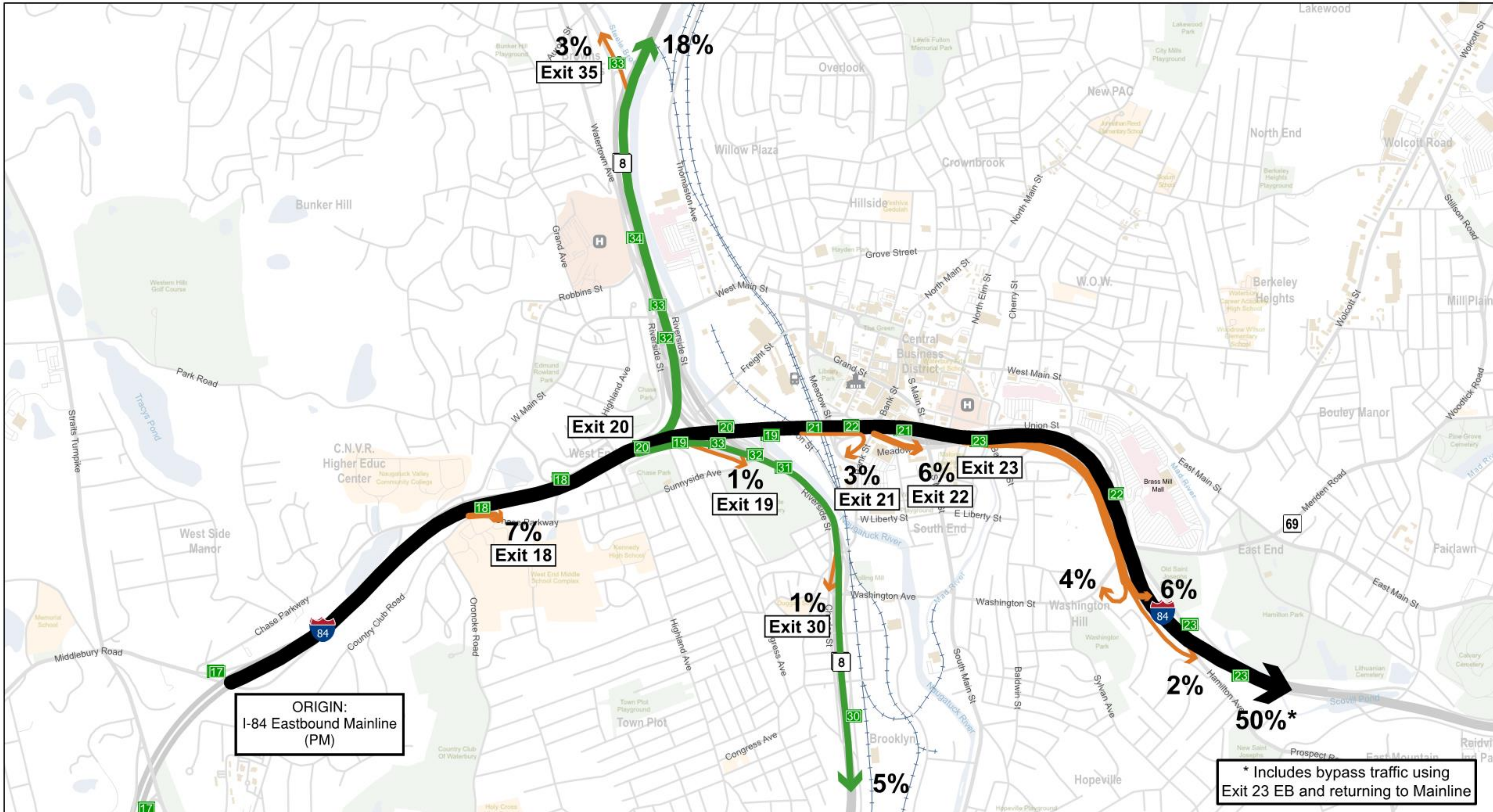
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Origin and Destination Map
I-84 Eastbound AM Peak Hour

Date: 11/22/2019 Figure No: 2-9



I-84 Through Traffic
I-84 to Route 8 Through Traffic
Traffic Entering Local Road Network
X% Percentage of Vehicles Traveling in the X Direction

Railroad
Open Space
Schools
Exit
Hospital
Train Station
City Hall

0 1,000 2,000 3,000 Feet

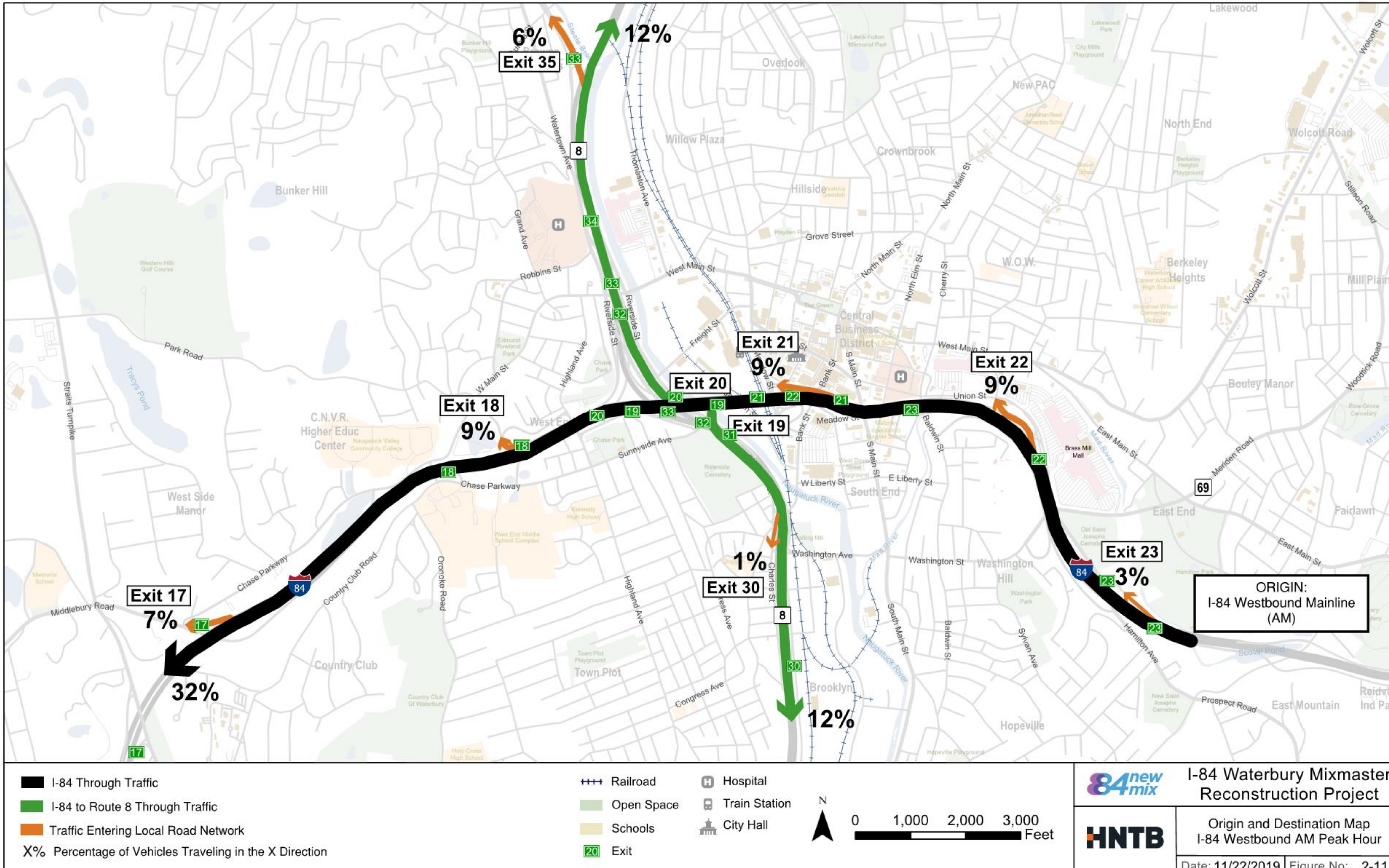
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

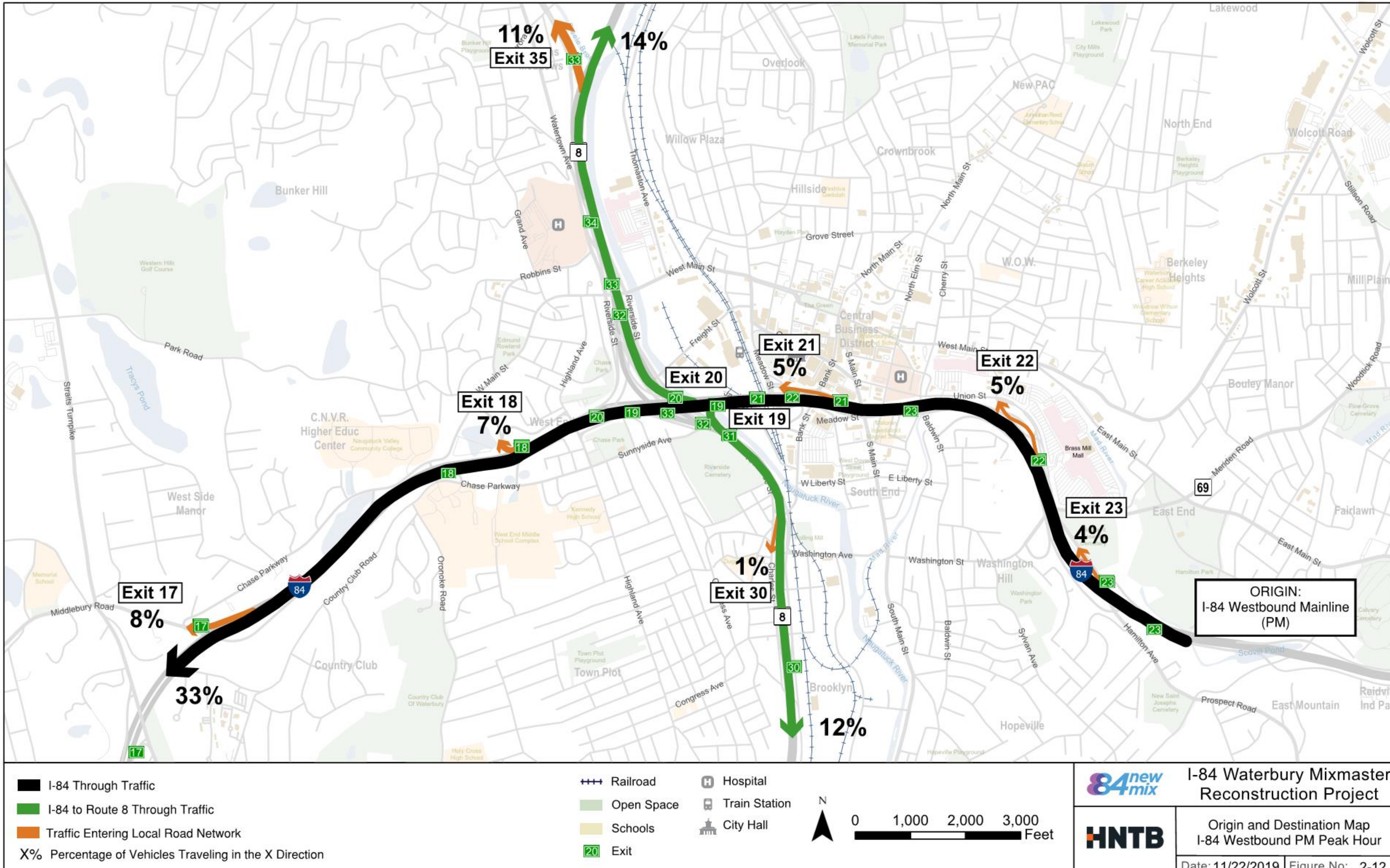
HNTB

Origin and Destination Map
I-84 Eastbound PM Peak Hour

Date: 11/22/2019 Figure No: 2-10



Exit 35
6%
12%
Exit 21
9%
Exit 22
9%
Exit 20
Exit 18
9%
Exit 19
1%
Exit 30
12%
Exit 23
3%
ORIGIN:
I-84 Westbound Mainline
(AM)
Exit 17
7%
32%
Overlook
Willow Plaza
Crownbrook
New PAC
North End
Wolcott Road
Bunker Hill
Hillside
W.O.W.
Berkeley Heights
Mill Plain
Central Business District
Bouley Manor
C.N.V.R. Higher Educ Center
West Side Manor
South End
East End
Fairlawn
Washington Hill
Country Club
Town Plot
Brooklyn
Hopeville
East Mountain
Reidville Ind Park
Lakewood
I-84 Through Traffic
I-84 to Route 8 Through Traffic
Traffic Entering Local Road Network
X% Percentage of Vehicles Traveling in the X Direction
Railroad
Open Space
Schools
Exit
Hospital
Train Station
City Hall
N
0 1,000 2,000 3,000 Feet
84 new mix
I-84 Waterbury Mixmaster Reconstruction Project
HNTB
Origin and Destination Map
I-84 Westbound AM Peak Hour
Date: 11/22/2019 Figure No: 2-11



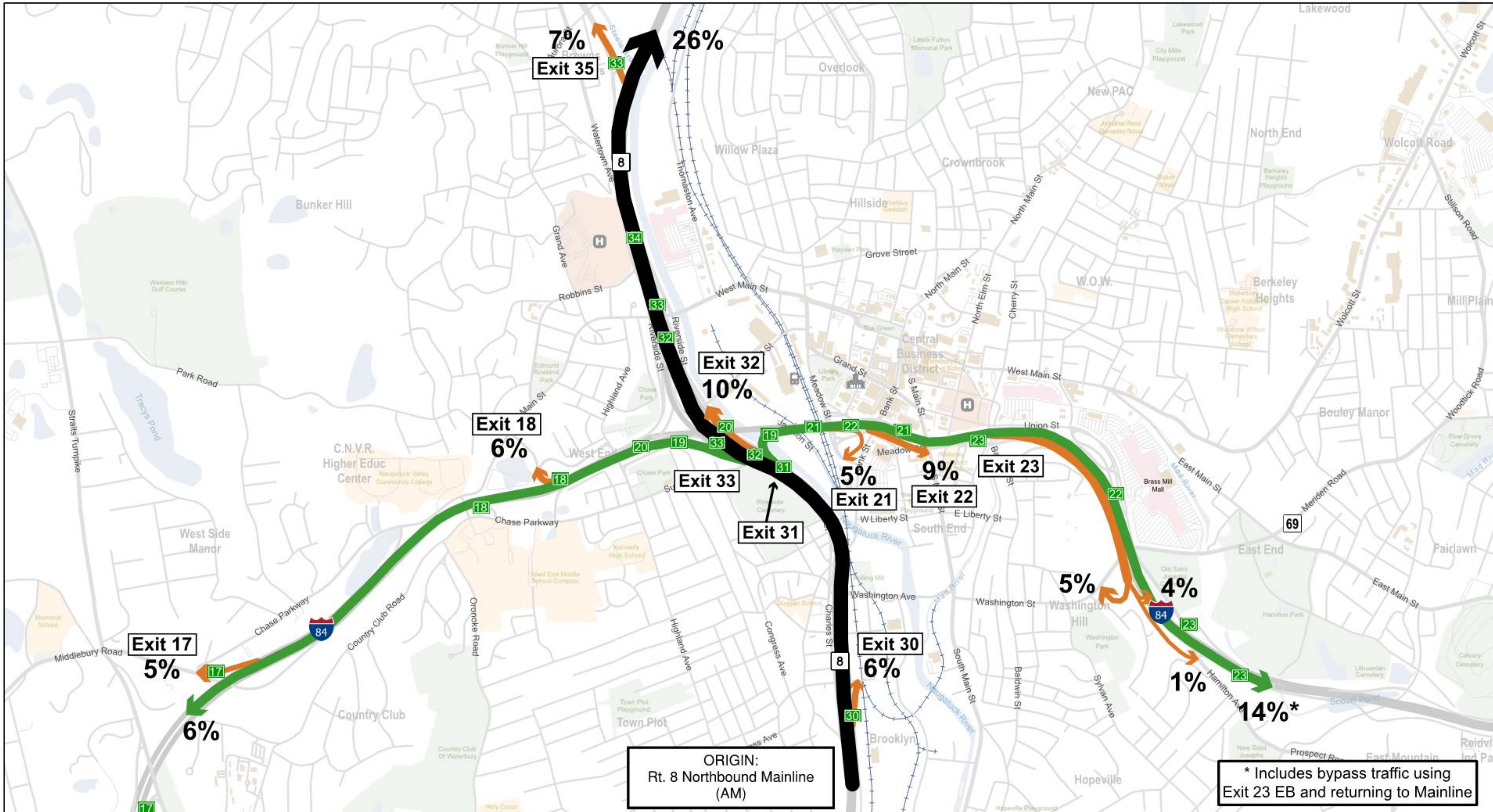
84 new mix

HNTB

I-84 Waterbury Mixmaster Reconstruction Project

Origin and Destination Map
I-84 Westbound PM Peak Hour

Date: 11/22/2019 Figure No: 2-12



Route 8 Through Traffic	Railroad
Route 8 to I-84 Through Traffic	Open Space
Traffic Entering Local Road Network	Schools
X% Percentage of Vehicles Traveling in the X Direction	Exit
	Hospital
	Train Station
	City Hall

N

0 1,000 2,000 3,000 Feet

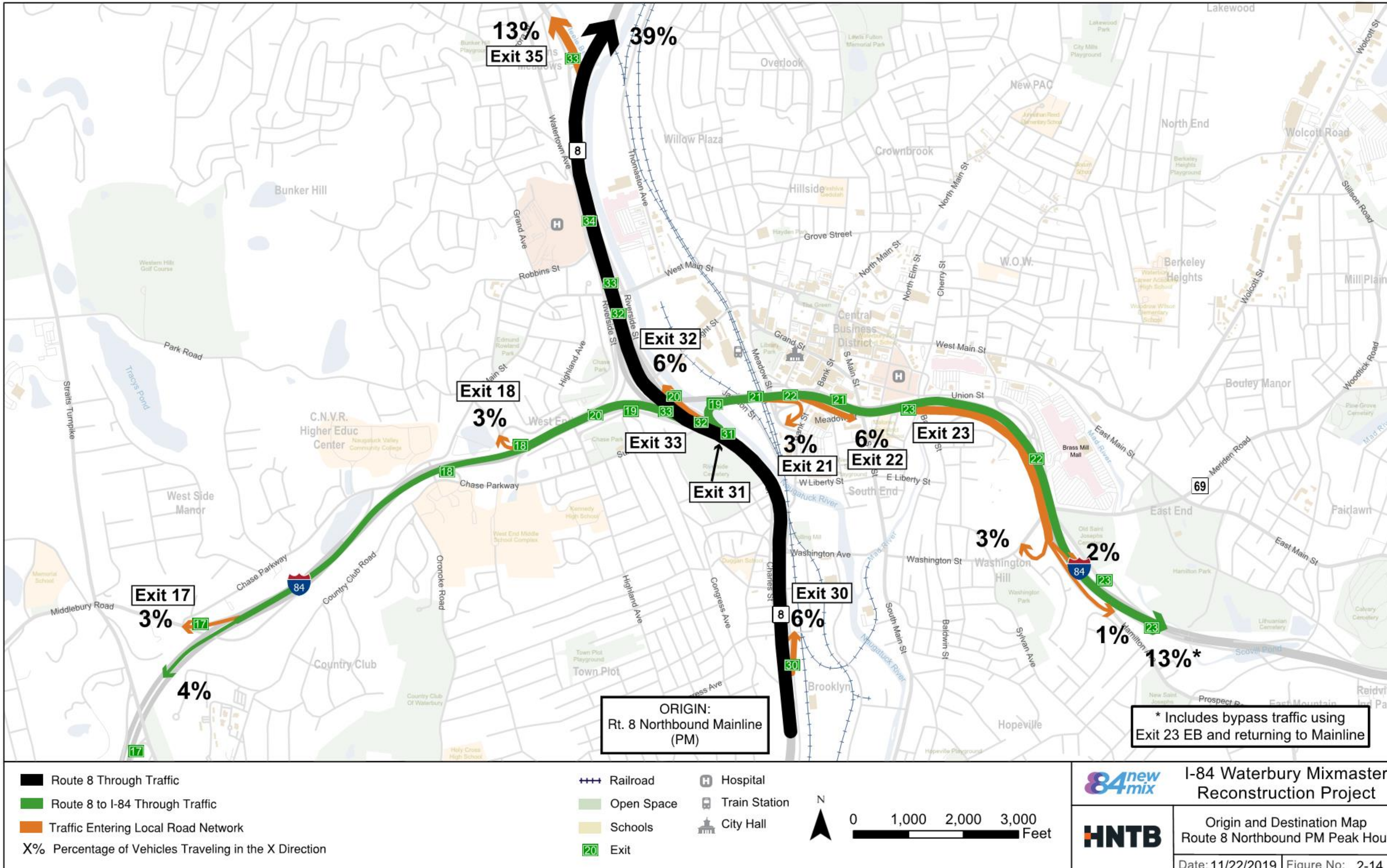
84 new mix

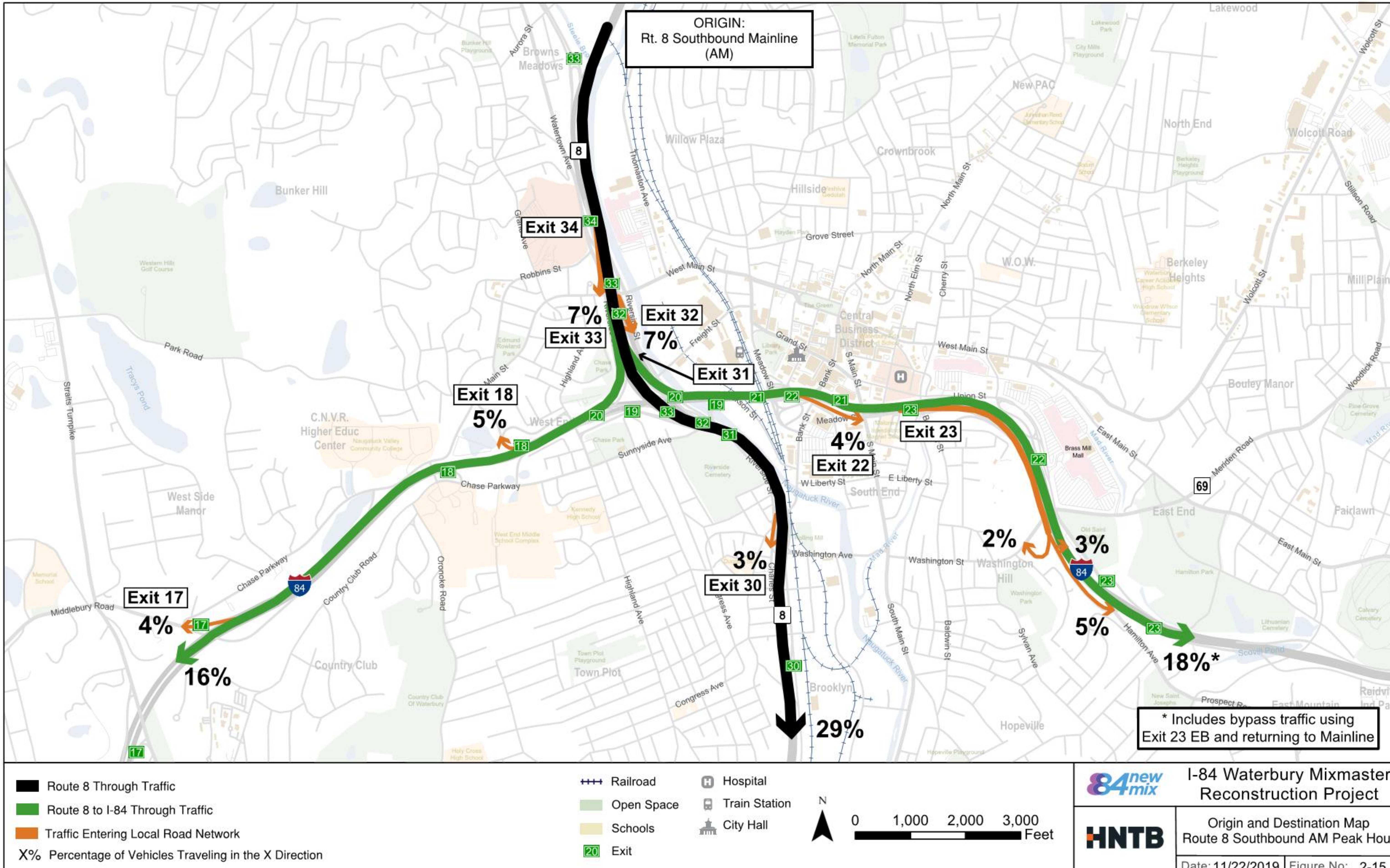
I-84 Waterbury Mixmaster Reconstruction Project

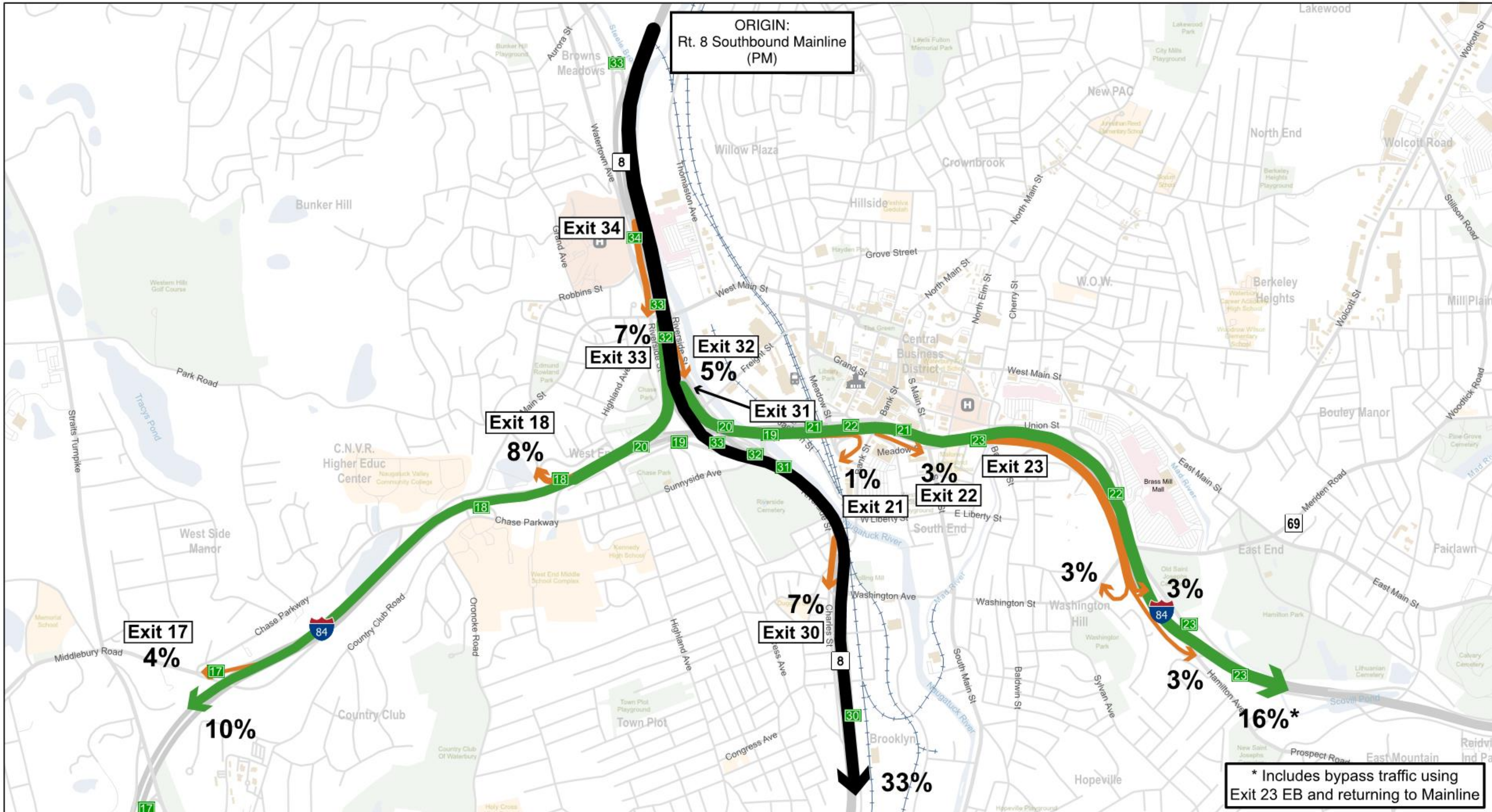
HNTB

Origin and Destination Map
Route 8 Northbound AM Peak Hour

Date: 11/22/2019 Figure No: 2-13


ORIGIN:
Rt. 8 Northbound Mainline
(PM)
Exit 35
13%
39%
Exit 32
6%
Exit 18
3%
Exit 33
Exit 31
Exit 21
3%
Exit 22
6%
Exit 23
3%
2%
1%
13%*
Exit 17
3%
4%
Exit 30
6%
* Includes bypass traffic using
Exit 23 EB and returning to Mainline
Route 8 Through Traffic
Route 8 to I-84 Through Traffic
Traffic Entering Local Road Network
X% Percentage of Vehicles Traveling in the X Direction
Railroad
Open Space
Schools
Exit
Hospital
Train Station
City Hall
0
1,000
2,000
3,000
Feet
I-84 Waterbury Mixmaster
Reconstruction Project
HNTB
Origin and Destination Map
Route 8 Northbound PM Peak Hour
Date: 11/22/2019
Figure No: 2-14


ORIGIN:
Rt. 8 Southbound Mainline
(AM)
Exit 34
Exit 33
Exit 32
Exit 31
Exit 30
Exit 22
Exit 23
Exit 18
Exit 17
7%
7%
5%
4%
3%
2%
3%
5%
4%
16%
29%
18%*
* Includes bypass traffic using
Exit 23 EB and returning to Mainline
Route 8 Through Traffic
Route 8 to I-84 Through Traffic
Traffic Entering Local Road Network
X% Percentage of Vehicles Traveling in the X Direction
Railroad
Open Space
Schools
Exit
Hospital
Train Station
City Hall
N
0 1,000 2,000 3,000 Feet
I-84 Waterbury Mixmaster
Reconstruction Project
HNTB
Origin and Destination Map
Route 8 Southbound AM Peak Hour
Date: 11/22/2019 Figure No: 2-15



Route 8 Through Traffic
Route 8 to I-84 Through Traffic
Traffic Entering Local Road Network
X% Percentage of Vehicles Traveling in the X Direction

Railroad
Open Space
Schools
20 Exit
Hospital
Train Station
City Hall

N

0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Origin and Destination Map
Route 8 Southbound PM Peak Hour

Date: 11/22/2019 Figure No: 2-16

2.2.5 Travel Speeds

Highways

Highway speed data was obtained through travel time runs conducted in 2017 on the I-84 and Route 8 mainlines. Travel time runs were performed for each origin and destination pair on I-84 and Route 8 using the "floating car" driving style. Total travel time and delay data from these runs was used to compute an average travel speed which was then used for calibration and validation of traffic models (see **Section 2.3 Existing Traffic Operations** for more on traffic models). **Figure 2-17** through **Figure 2-20** show average travel speed on the I-84 and Route 8 mainline and system ramps for the weekday AM and PM peak hours. Raw data and additional summaries can be found in **Appendix 2.2** (refer to **Raw Highway Speed Run Data**).

Arterials

Arterial speed data was obtained through travel time runs conducted in 2017 on 12 major arterial corridors. A minimum of five runs were conducted for each arterial using the "floating car" driving style. Total travel time and delay data from these runs was used to compute an average travel speed which was then used for calibration and validation of traffic models (see **Section 2.3 Existing Traffic Operations** for more on traffic models). **Table 2-5** shows the average travel speed on each arterial corridor. Raw data and additional summaries can be found in **Appendix 2.2** (refer to **Raw Arterial Speed Run Data**).

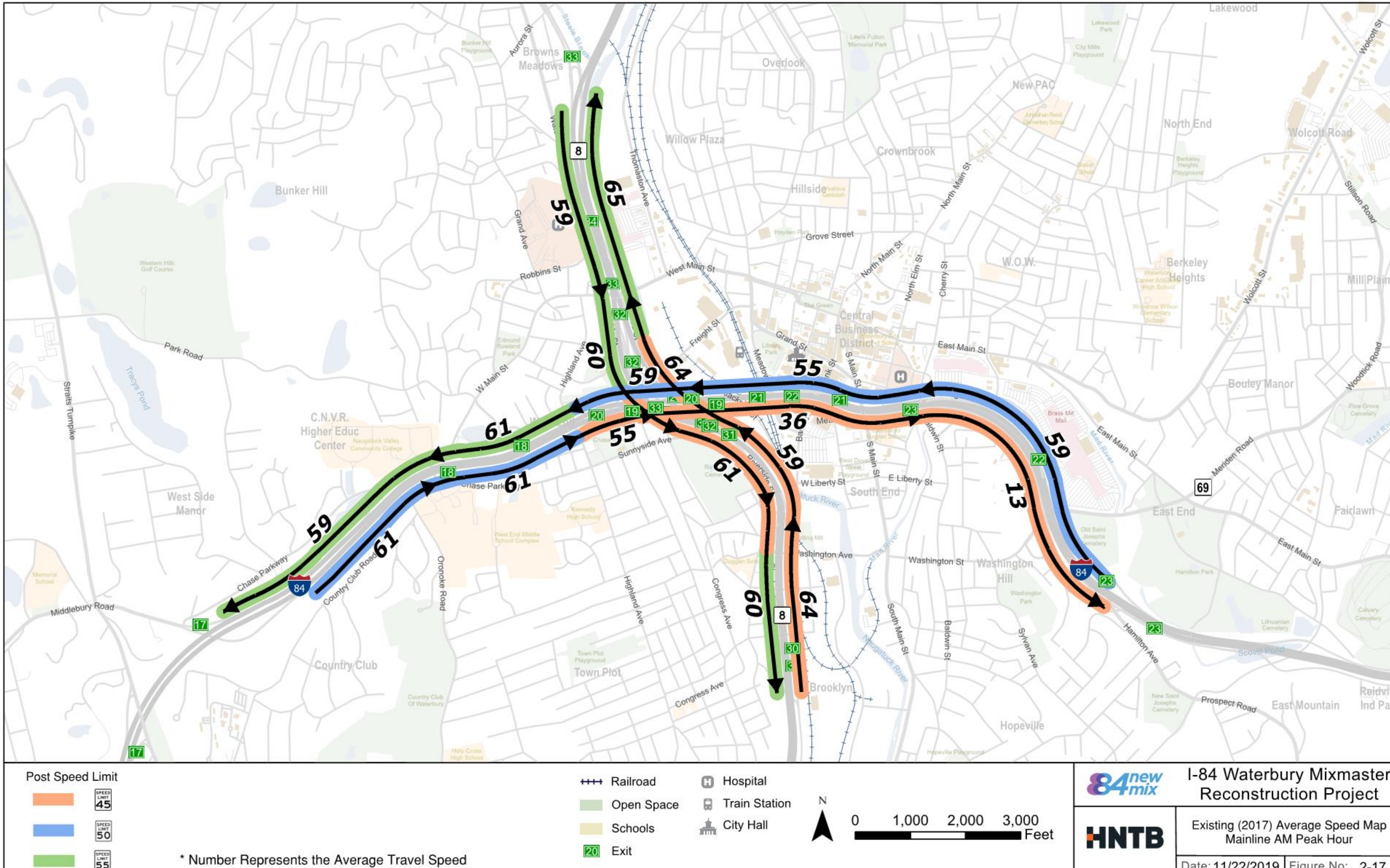
Table 2-5 Existing (2017) Average Speeds, Major Arterials

Corridor	Direction	AM	PM	Saturday	Speed Limit
Baldwin St.	Northbound	18.1	16.6		25
	Southbound	23.3	20.6		25
Bank St.	Northbound	15.2	19.7		25
	Southbound	12.7	13.0		25
Chase Pkwy. / Sunnyside Ave.	Eastbound	18.6	19.2		25-35
	Westbound	22.7	21.3		25-35
Chase Pkwy. / West Main St.	Eastbound	22.4	15.7	20.7	25-35
	Westbound	26.4	15.7	22.6	25-35
East Main St.	Eastbound	18.9	13.3		25
	Westbound	22.4	14.1		25
Grand / Union St.	Eastbound	16.3	15.8	15.3	25-35
	Westbound	20.2	15.7	17.0	25-35
Highland Ave.	Northbound	29.8	29.3		25
	Southbound	22.8	13.3		25
Meadow St.	Northbound	11.4	12.4	15.3	25
	Southbound	12.4	16.5	14.6	25
Riverside St.	Northbound	18.8	16.4		25-35
	Southbound	25.5	24.7		25-35
South Main St.	Northbound	13.0	11.4		25
	Southbound	11.0	13.5		25
Washington St. / Washington Ave.	Eastbound	16.9	10.2	14.9	25-35
	Westbound	22.0	17.1	18.9	25-35
Watertown Ave.	Northbound	30.0	22.7		25-35
	Southbound	24.4	15.9		25-35

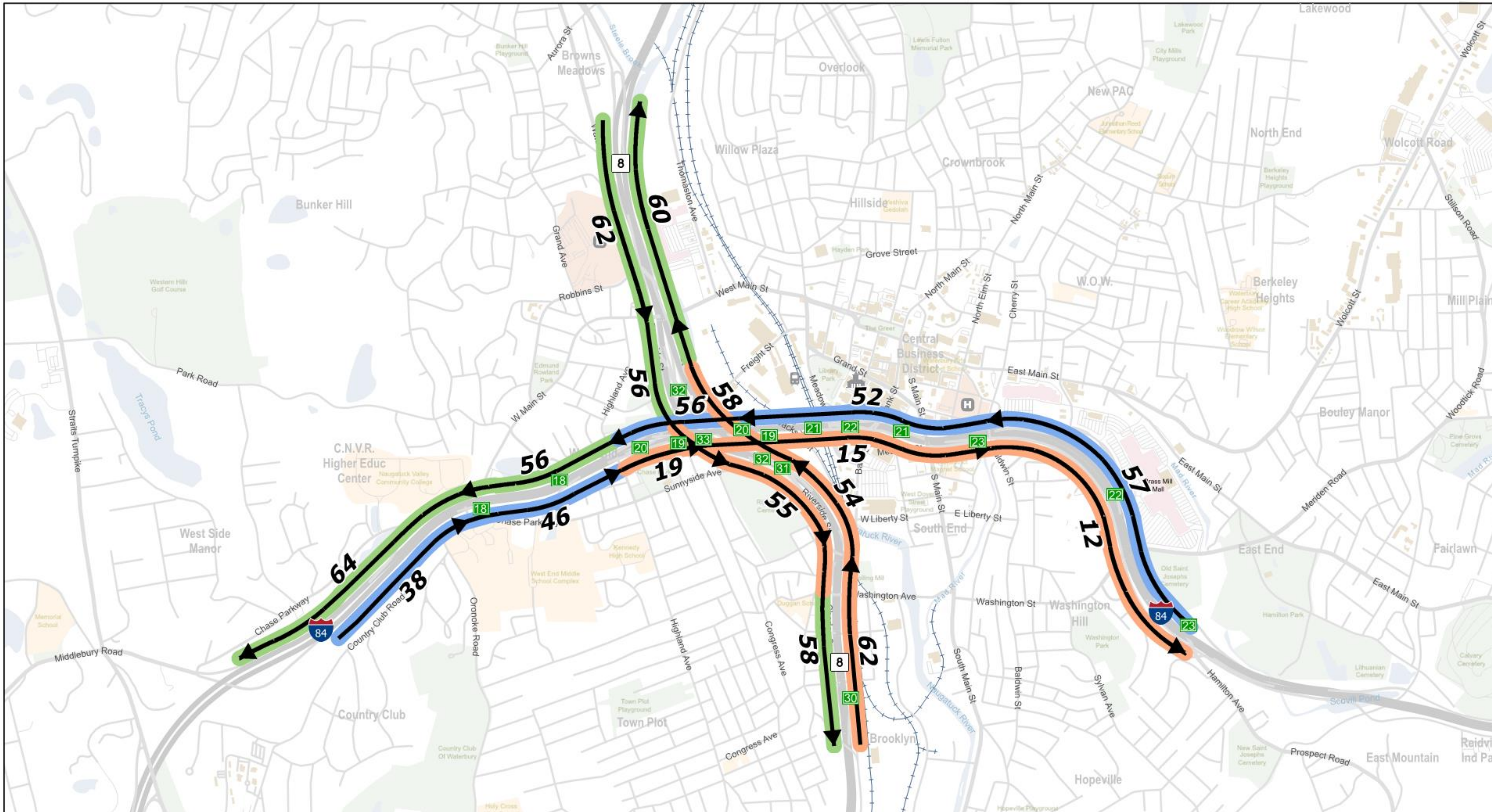
How to Float a Car with Style

Travel time runs are one of the oldest methods of collecting traffic data or information. The method relies on a member from the data collection team (a test driver) operating a test vehicle in live traffic. One major benefit to travel time runs over modern techniques is the test driver's ability to control their driving behavior (or style) which allows consistency of data collection.

The floating car style is the most common driving style employed by test drivers during a travel time run. The driver "floats" with the traffic by traveling at the prevailing speed and



59
65
60
59
64
55
61
55
36
61
61
59
61
59
59
13
60
64
Bunker Hill
Browns Meadows
Willow Plaza
Overlook
Hillside
Crownbrook
New PAC
North End
Wolcott Road
W.O.W.
Berkeley Heights
Mill Plain
Central Business District
Bouley Manor
C.N.V.R. Higher Educ Center
West Side Manor
South End
East End
Fairlawn
Washington Hill
Country Club
Town Plot
Brooklyn
Hopeville
East Mountain
Reidville Ind Park
Lakewood
Post Speed Limit
* Number Represents the Average Travel Speed
Railroad
Open Space
Schools
Exit
Hospital
Train Station
City Hall
N
0 1,000 2,000 3,000 Feet
84 new mix
HNTB
I-84 Waterbury Mixmaster Reconstruction Project
Existing (2017) Average Speed Map Mainline AM Peak Hour
Date: 11/22/2019
Figure No: 2-17



Post Speed Limit

	Speed Limit
Orange	45
Blue	50
Green	55

* Number Represents the Average Travel Speed

Railroad
Open Space
Schools
20 Exit
Hospital
Train Station
City Hall

N

0 1,000 2,000 3,000 Feet

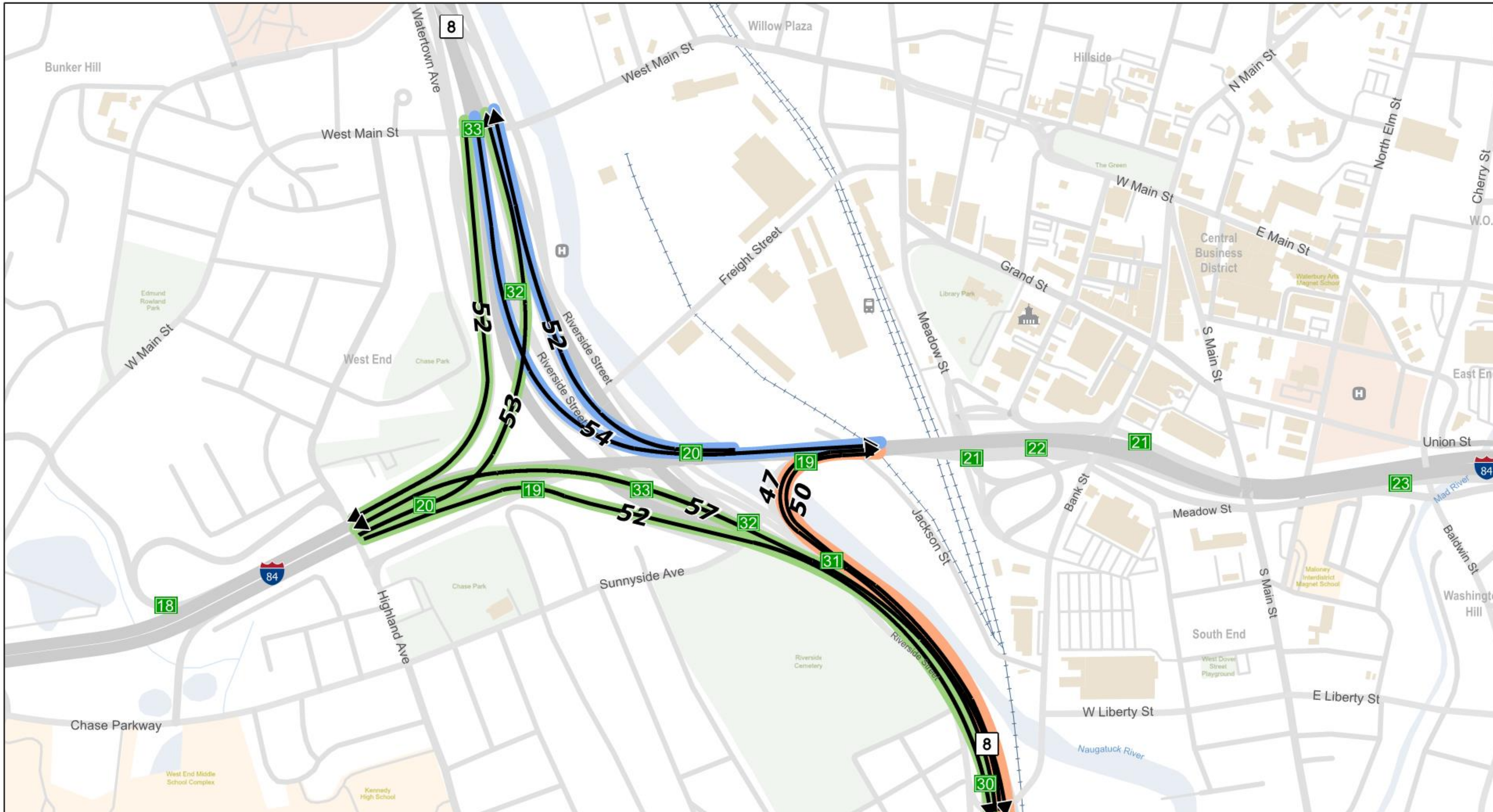
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Existing (2017) Average Speed Map Mainline PM Peak Hour

Date: 11/22/2019 Figure No: 2-18



Post Advisory Ramp Speed

Orange	SPEED LIMIT 25
Blue	SPEED LIMIT 30
Green	SPEED LIMIT 35

* Number Represents the Average Travel Speed

Railroad
Open Space
Schools
Exit
Hospital
Train Station
City Hall

N
0 275 550 1,100 Feet

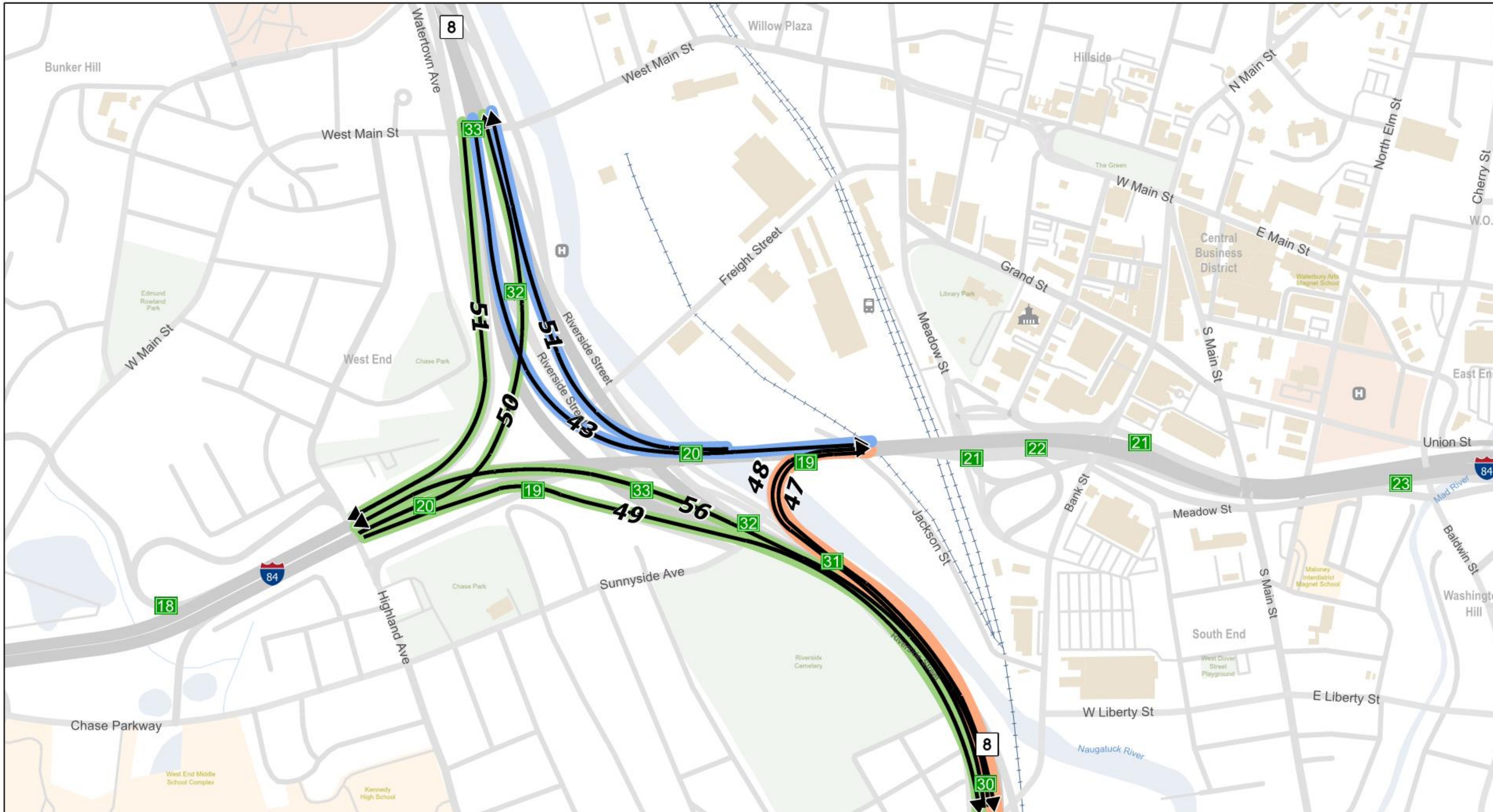
84 new mix

HNTB

I-84 Waterbury Mixmaster Reconstruction Project

Existing (2017) Average Speed Map System Ramp AM Peak Hour

Date: 11/22/2019 Figure No: 2-19



Post Advisory Ramp Speed

- SPEED LIMIT 25
- SPEED LIMIT 30
- SPEED LIMIT 35

* Number Represents the Average Travel Speed

- Railroad
- Open Space
- Schools
- 20 Exit
- Hospital
- Train Station
- City Hall

N

0 275 550 1,100 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Existing (2017) Average Speed Map
System Ramp PM Peak Hour

Date: 11/22/2019 | Figure No: 2-20

2.2.6 Traffic Signal Data

Traffic signal timing plans were obtained from the CTDOT and the City of Waterbury for use in calibration and validation of traffic models (see **Section 2.3 Existing Traffic Operations** for more on traffic models). This data was field verified using the turning movement count video recordings described in the previous **Section 2.2.2** Arterial and Intersection Traffic Volumes. The compiled data can be found in **Appendix 2.2** (refer to Traffic Signal Timing Plans).

2.2.7 Queue Length Observations

Queue length observations were made in 2017 for the I-84 and Route 8 mainlines for calibration and validation of traffic models (see **Section 2.3 Existing Traffic Operations** for more on traffic models). These observations were made in 15-minute intervals for the weekday AM and PM peak hours using aerial surveillance data.

Weekday AM peak hour queuing was observed at the lane drop between Exits 20 and 23 and east of Exit 23 at the temporary ramp to Hamilton Avenue. Peak queue lengths were 4,830 feet and 1,040 feet respectively.

Queueing vs Congestion

For this report, queues were characterized and identified by stop-and-go conditions where vehicles were stopped (or at a rolling stop) and there was less than a car length gap (25 feet) between vehicles.

Congestion was defined as stop-and-go conditions

Weekday PM peak hour queuing was observed at the lane drop between Exits 20 and 23, at the lane drop between Exits 17 and 18, and at the Exit 19 gore area. Peak queue lengths were 4,070 feet, 2,870 feet, and 1,420 feet respectively. Detailed images for both AM and PM peak hour queues are provided in **Appendix 2.2** (refer to **Queuing Aerials**).

2.3 EXISTING TRAFFIC OPERATIONS

The Interstate 84 (I-84) and Route 8 "Mixmaster" interchange and surrounding Waterbury street network within the study area function as a highly complex transportation system. I-84 and Route 8 serve as the primary regional transportation access means configured with weaving sections, right and left-hand highway exits, as well as closely spaced service and system ramps. The City of Waterbury street network is effectively split into quadrants due to the Naugatuck River and Route 8 aligned in the north-south direction and I-84 aligned in the east-west direction. Few roadways provide local access across these major features which encourages intracity trip access via I-84 and Route 8.

To most accurately understand travel patterns and traffic operations within and surrounding the complex study area a series of modeling tools and methodologies are used to identify travel demands, poorly operating intersections, safety and mobility hot spots, and general deficiencies. Having an established baseline of existing traffic operations will be a catalyst for understanding future focus areas and mitigation measures as design concepts advance.

The following sections describe the development of the hierarchical traffic models and traffic analysis tools.

Modeling tools and methodologies refer to nationally accepted mathematical formulas and software programs that assist in representing real-time conditions and operational characteristics.

These tools and methodologies account for existing conditions such as lane geometry, travel speed, traffic volumes, and land use

2.3.1 Modeling Overview

There are several modeling tools used in analyzing complex transportation systems that assist in understanding travel behaviors, travel patterns, vehicle queue lengths, and future traffic conditions. Travel speeds, number of lanes, facility types (e.g. limited access freeway), land use, household vehicle ownership, and employment characteristics are a few of the modeling elements taken into consideration. For this project, the following types of models were developed:

- Travel Demand Model: Evaluates traffic flow as a whole, taking trip generation, trip distribution, mode choice and travel assignment into consideration to forecast future population, employment and land use changes over large regions
- Hybrid Simulation Model: Simulates the movement of individual vehicles based on traffic flow equations to further refine forecasted travel patterns and travel time compared to a travel demand model
- Traffic Simulation Model: Assists in representing the behavior of individual vehicles in a network, simulating interactions of real-world traffic such as weaving, lane use, and queuing using complex algorithms

The project's models were developed, calibrated, and validated using traffic data detailed in previous sections. Following validation, the models were used to analyze and identify deficiencies in the transportation network's conditions (or operations). Finally, the performance of freeway, ramps, weave sections and intersections within the study area was measured and documented from the analysis results. The sections that follow discuss the development and performance results from the project models.

2.3.2 Travel Demand Model

Travel demand models are "big picture" models which focus on regional and statewide travel patterns based on forecasted population, employment and land use changes. The CTDOT statewide travel demand forecasting model was provided to the project team who made refinements and reran the model to forecast trips within and outside of defined areas, truck trips, single occupant vehicles, and high occupancy vehicles.

This updated travel demand model replicates existing conditions and will serve as the technical foundation for evaluating likely changes in the future 2045 travel patterns associated with new Mixmaster interchange concepts.

2.3.3 Hybrid Simulation Model

A Hybrid Simulation Model was developed to further refine the understanding of the traffic patterns for the study transportation network established within the Travel Demand Model.

Hybrid Simulation Models incorporate the simulation of individual vehicle movement based on industry standard formulas to dynamically update travel routes based on delay and roadway capacity constraints. Specifically, the Hybrid Simulation Model iteratively routes trips to develop balanced and optimized travel paths based on volume and delay and further optimizes routes and traffic data by simulating vehicle behavior considering the impacts of traffic controls, queuing, merging and lane changing on traffic operations and travel times.

2.3.4 Traffic Simulation Model

In an effort to simulate and evaluate detailed traffic conditions within the study area, a Simulation Model (using VISSIM software) was developed and calibrated to existing conditions (2017) for the Interstate 84/Route 8 Mixmaster interchange. The Simulation Model uses driver behavior characteristics to simulate individual vehicles interacting with other vehicles in the network. Real-world traffic interactions such as weaving, lane use, and queuing are modeled using complex algorithms. The movements of individually modeled vehicles are tracked by the software and aggregated to produce a record of vehicle performance for the entire network. The existing conditions model will become the foundation of all subsequent simulation modeling analyses and will provide a baseline for comparison with future "no build" and build concepts. Additionally, the VISSIM model allows for 3D animations, assisting in visualizing traffic patterns and presenting planned infrastructure improvements.

The highway mainline segments were modeled beyond the study area limits as a conservative measure, to capture any potential spillback of vehicle queuing that originates within the study area. Local service ramps within the study area were modeled up to the off-ramp intersections. Termini and local intersections were not modeled in VISSIM. Operations analysis at termini and local intersections are summarized in a subsequent section.

Traffic data collected and summarized in the Existing Traffic Data section provide the basis for the vehicle input data along with the calibrated demand and travel pattern data developed with the Hybrid Simulation Model. The Simulation Model was calibrated using FHWA standard methodology. The results of the simulation model analysis are summarized in the next section.

2.3.5 Traffic Analysis Tools

Traffic Analysis Tools are designed to implement the procedures of the Highway Capacity Manual (HCM) for analyzing the performance of isolated or minor transportation facilities. Analysis tools estimate traffic operational performance on a variety of transportation facilities but have limited ability to analyze network or system characteristics.

This study uses Highway Capacity Software (HCS) 2010 to analyze highway mainline, weave, merge and diverge segments and Synchro 9.0 software to analyze ramp termini and local intersections within the study area.

2.3.6 Freeway Operations Overview

"Level of Service" (LOS) is an important metric to understand as it relates to operations and performance. LOS is a qualitative measure of driver satisfaction that consists of several factors which are heavily influenced by the degree of traffic congestion. The factors include speed, travel time, traffic interruption, freedom of maneuverability, safety, driving comfort and convenience, and delay. LOS is measured using the letters A through F, with A being the best or optimal condition and F being the worst.

Analyses to understand the performance of Interstate 84 and Route 8 mainline, merge/diverge and weave sections were conducted, focusing on LOS and the density of sections (or passenger cars per mile per lane – pc/mi/ln). The following table defines general LOS criteria for each of these sections:

Table 2-6 Freeway Level of Service Criteria

Level of Service	Merge or Diverge Density (pc/mi/ln)	Weave Density (pc/mi/ln)	Mainline Density (pc/mi/ln)
A	≤10	≤10	≤11
B	>10-20	>10-20	>11-18
C	>20-28	>20-28	>18-26
D	>28-35	>28-35	>26-35
E	>35	>35	>35-45
F	Demand Exceeds Capacity	Demand Exceeds Capacity	>45 or Demand Exceeds Capacity

2.3.7 Freeway Operation (Mainline, Weave, and Diverge Segments)

Operational analyses for the mainline, weave, merge and diverge segments, and system ramps to/from one highway to another highway were performed using the VISSIM model, defined previously in this section. As a check, operational analyses for the mainline, weave, and merge and diverge segments were also performed using methods outlined in the Transportation Research Board's Highway Capacity Manual (HCM) 2010 and Highway Capacity Software (HCS) 2010.

Table 2-7 and **Table 2-8** summarize the operations for I-84 and Route 8 based on HCS analysis, respectively.

Interstate 84

Table 2-7 I-84 Traffic Operations

Segment	Level of Service A	B	C	D	E	F	Acceptable	Deficient	Total
AM PEAK									
Mainline	0	2	5	4	1	0	11	1	12
Weaves	0	3	4	5	0	0	12	0	12
Merge/Diverge	0	0	3	4	1	1	7	2	9
PM PEAK									
Mainline	0	1	7	3	1	0	11	1	12
Weaves	0	0	6	6	0	0	12	0	12
Merge/Diverge	0	0	1	7	0	1	8	1	9
SAT PEAK									
Mainline	0	2	6	4	0	0	12	0	12
Weaves	0	4	8	0	0	0	12	0	12
Merge/Diverge	0	0	3	6	0	0	9	0	9

As shown above, according to HCS analysis, one mainline facility segment along I-84 operates at an unacceptable LOS during the AM and PM Peak Hours and is considered operationally deficient:

- I-84 Westbound between Exit 23 Off-Ramp and Exit 22 Off-Ramp.

HCS analysis also identified two merge/diverge areas as operationally deficient:

- Exit 22 Off-Ramp during the AM and PM Peak Hours
- Exit 17 Off-Ramp during the AM Peak Hour

Route 8

As shown below, according to HCS analysis, there are no facilities along Route 8 within the study area operating at an unacceptable level of service.

Table 2-8 Route 8 Traffic Operations

Segment	Level of Service A	B	C	D	E	F	Acceptable	Deficient	Total
AM PEAK									
Mainline	1	4	4	1	0	0	10	0	10
Weaves	0	2	4	0	0	0	6	0	6
Merge/Diverge	0	3	4	0	0	0	7	0	7
PM PEAK									
Mainline	1	3	4	2	0	0	10	0	10
Weaves	0	4	0	2	0	0	6	0	6
Merge/Diverge	0	1	4	2	0	0	7	0	7

What Level of Service is it?

- ***Level of Service A****: Free flow. Low traffic volumes, high degree of freedom to maneuver and select speed.*
- ***Level of Service B:*** *Reasonably free flow. High degree of freedom to select speed with some influence from other users.*
- ***Level of Service C:*** *Stable flow. Moderately restricted maneuverability characterized by frequent interactions with other users. Convenience declines but traffic conditions are not typically perceived as uncomfortable.*
- ***Level of Service D:*** *Approaching unstable flow. High traffic density with severely restricted maneuverability. Comfort and convenience have declined. LOS D is generally considered to be a marginally acceptable level of service.*
- ***Level of Service E:*** *Unstable flow. Traffic volume is nearing network capacity. Low freedom to maneuver. Delays are frequent and driver comfort level is low. LOS E is generally considered to be an unacceptable level of service.*
- ***Level of Service F:*** *Forced or breakdown traffic flow. Traffic volumes are exceeding network capacity. Characterized by frequent slowing, delays, low comfort and convenience, and increased crash exposure. LOS F is considered an unacceptable level of service.*

Both HCS and VISSIM analysis findings are reported as each has value in interpreting the traffic operations along the study highways. The HCS estimated traffic operations reflect expected traffic operations at an isolated facility without interaction from upstream or downstream conditions. VISSIM analysis estimates traffic operations throughout the network including the impact of congestion and complex geometric configurations at upstream and downstream facilities.

Figure 2-21 through **Figure 2-30** illustrate the VISSIM and HCS analysis results for the mainline, weave, and merge and diverge segments.

Figure 2-21 and **Figure 2-22** show that the VISSIM analysis estimates higher vehicle density and worse levels of service along the I-84 Eastbound facilities relative to the HCS analysis and lower vehicle density and better levels of service along the westbound I-84 facilities. This is likely due to the construction project operations to the east of the study area. The construction operations constrain eastbound I-84 traffic flow through the study area as traffic slows but meter westbound I-84 flow, thereby reducing mainline density and simultaneously improving the ability of vehicles in merge/diverge and weave areas to navigate the facility.

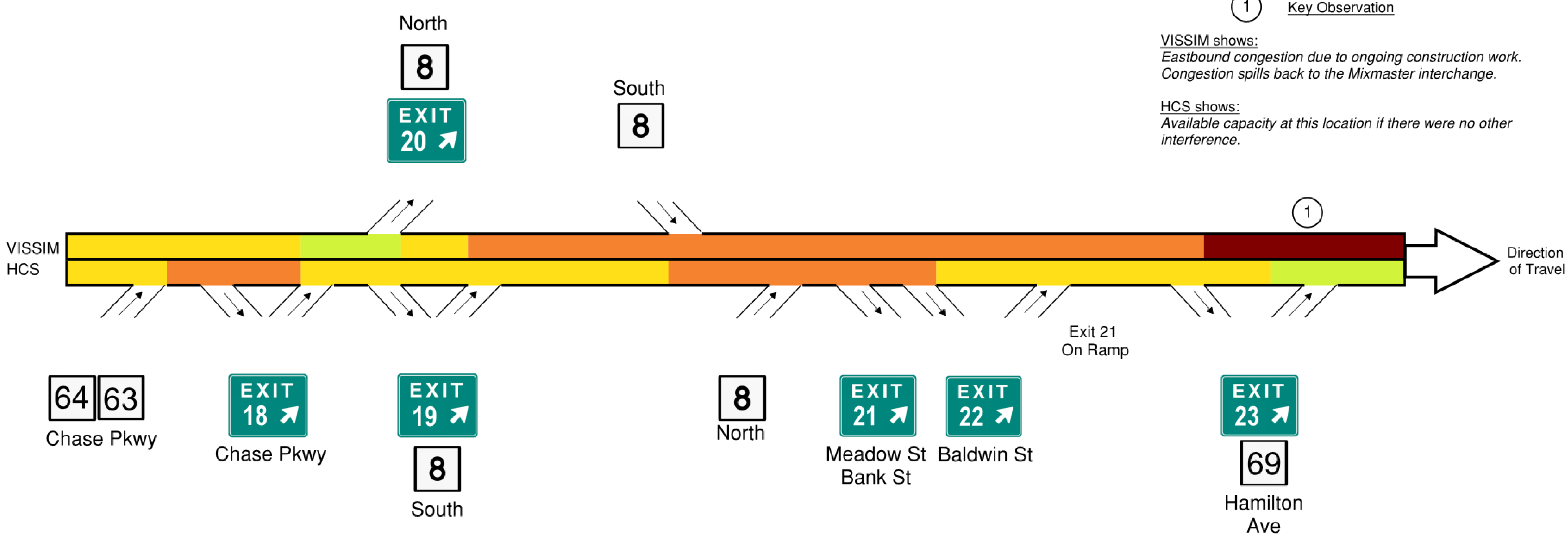
Figure 2-25 and **Figure 2-26** show that the VISSIM and HCS operational analysis findings for Route 8 Northbound are very similar. VISSIM estimates only marginally higher vehicle density along the corridor which indicates that the interference of upstream or downstream traffic conditions is minimal along the corridor. **Figure 2-27** and **Figure 2-28** show that the VISSIM analysis estimates slightly higher vehicle density and worse levels of service along southbound Route 8 facilities relative to the HCS analysis. This indicates that interference of upstream or downstream traffic conditions has a greater effect on travel along this corridor.

I-84 EASTBOUND

(1) Key Observation

VISSIM shows:
Eastbound congestion due to ongoing construction work. Congestion spills back to the Mixmaster interchange.

HCS shows:
Available capacity at this location if there were no other interference.



LEGEND

Best ← Mainline Level of Service (LOS) → Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

VISSIM ANALYSIS FOR I-84 EASTBOUND
HCS ANALYSIS FOR I-84 EASTBOUND

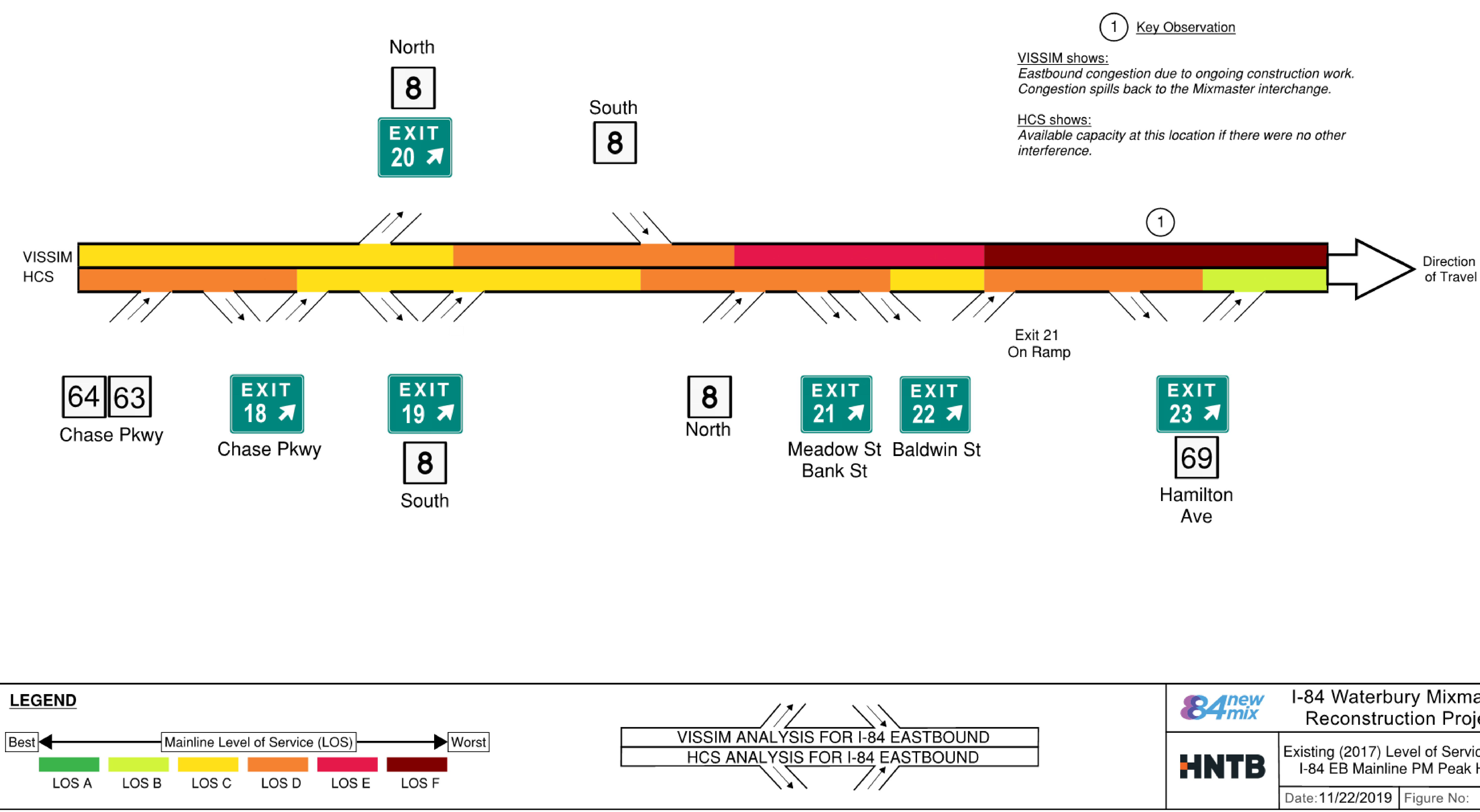
I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Existing (2017) Level of Service Map
I-84 EB Mainline AM Peak Hour

Date: 11/22/2019 | Figure No: 2-21

I-84 EASTBOUND



I-84 Waterbury Mixmaster Reconstruction Project

Existing (2017) Level of Service Map
I-84 EB Mainline PM Peak Hour

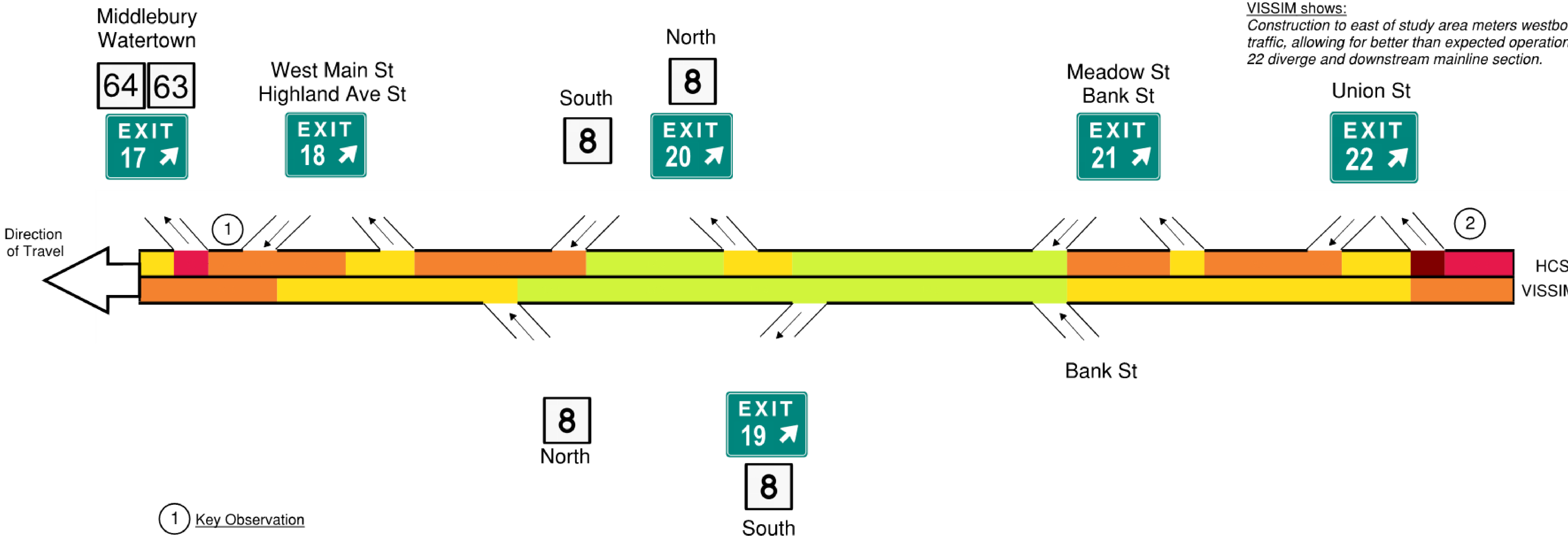
Date: 11/22/2019 Figure No: 2-22

I-84 WESTBOUND

2 Key Observation

HCS shows:
Westbound congestion at Exit 22 diverge and downstream mainline section.

VISSIM shows:
Construction to east of study area meters westbound traffic, allowing for better than expected operations at Exit 22 diverge and downstream mainline section.



1 Key Observation

HCS shows:
Westbound congestion at Exit 17 diverge and downstream freeway segments.

VISSIM shows:
Construction to east of study area meters westbound traffic, allowing for better than expected operations at Exit 17 diverge.

LEGEND

Best ← Mainline Level of Service (LOS) → Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

HCS ANALYSIS FOR I-84 WESTBOUND
VISSIM ANALYSIS FOR I-84 WESTBOUND

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Existing (2017) Level of Service Map
I-84 WB Mainline AM Peak Hour

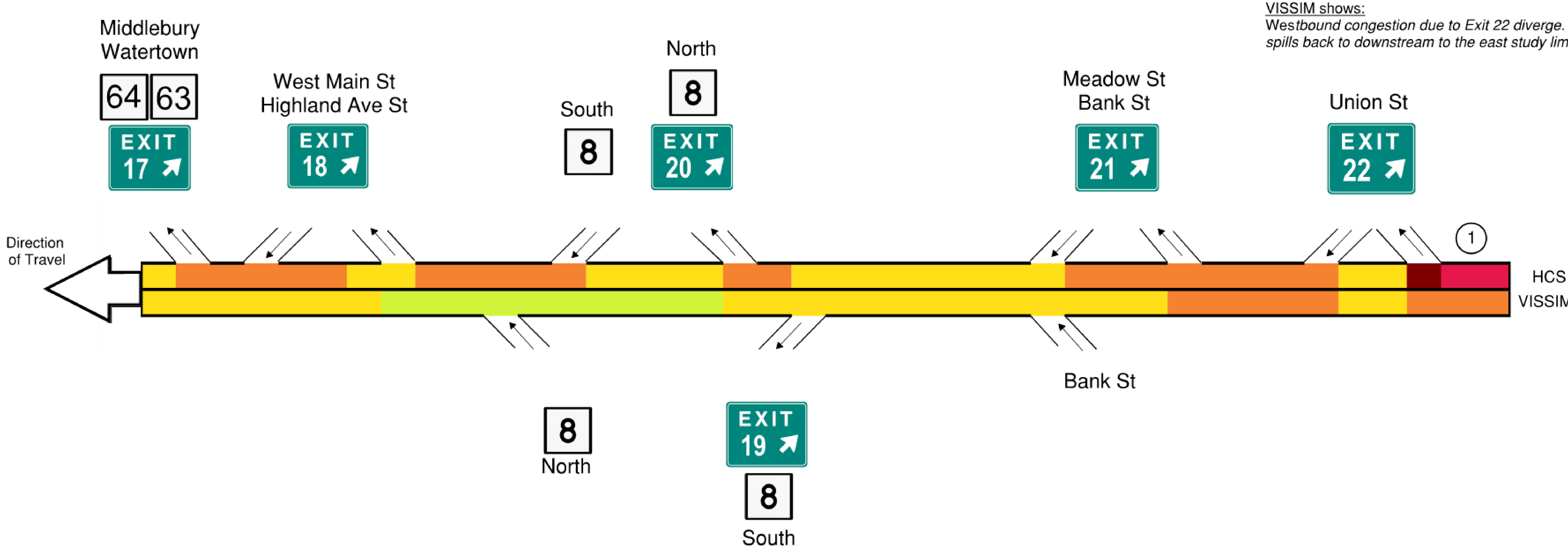
Date: 11/22/2019 | Figure No: 2-23

I-84 WESTBOUND

(1) Key Observation

HCS shows:
Available capacity at this location if there were no other interference.

VISSIM shows:
Westbound congestion due to Exit 22 diverge. Congestion spills back to downstream to the east study limit.



LEGEND

Best ← Mainline Level of Service (LOS) → Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

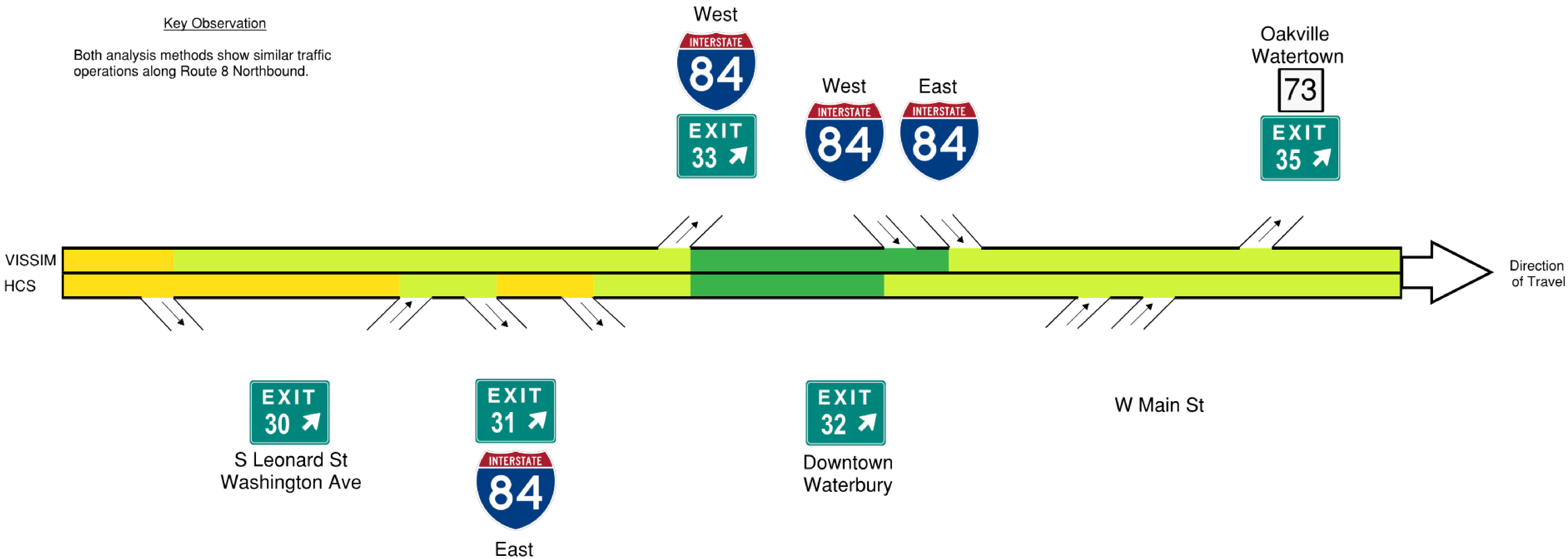
HCS ANALYSIS FOR I-84 WESTBOUND
VISSIM ANALYSIS FOR I-84 WESTBOUND

84 new mix	I-84 Waterbury Mixmaster Reconstruction Project
HNTB	Existing (2017) Level of Service Map I-84 WB Mainline PM Peak Hour
Date: 11/22/2019	Figure No: 2-24

ROUTE 8 NORTHBOUND

Key Observation

Both analysis methods show similar traffic operations along Route 8 Northbound.



LEGEND

Best ← Mainline Level of Service (LOS) → Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

VISSIM ANALYSIS FOR ROUTE 8 NORTHBOUND

HCM ANALYSIS FOR ROUTE 8 NORTHBOUND

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

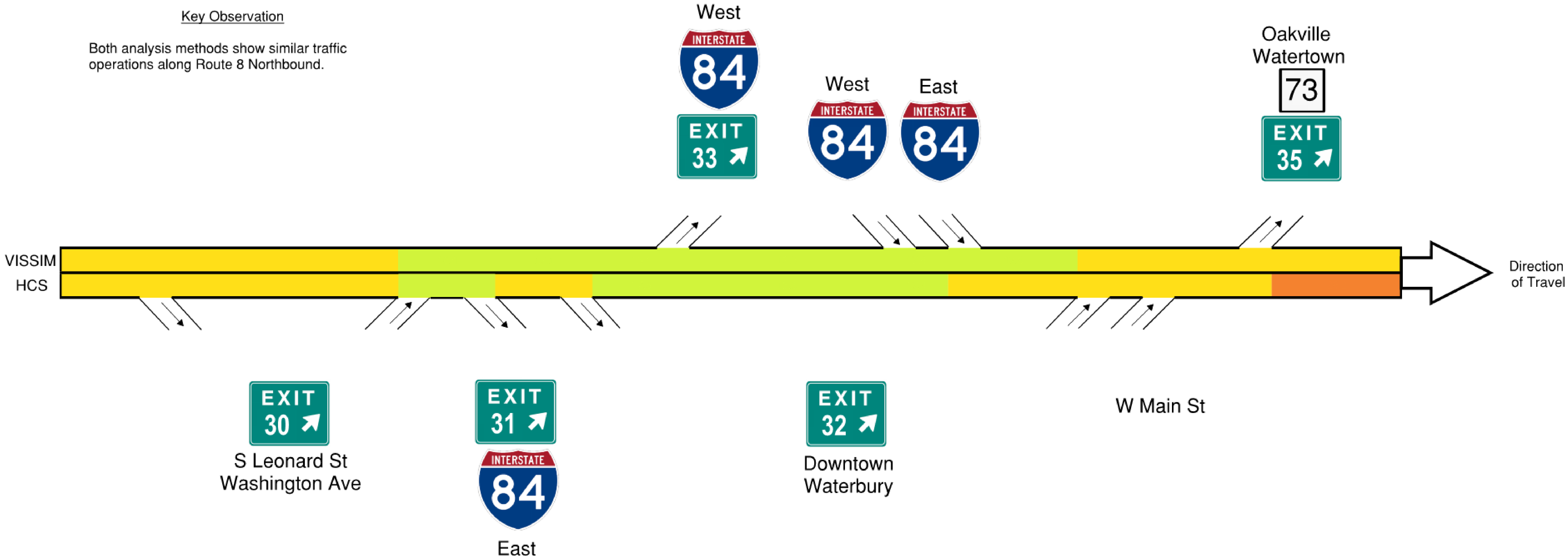
Existing (2017) Level of Service Map
Route 8 NB Mainline AM Peak Hour

Date: 11/22/2019 | Figure No: 2-25

ROUTE 8 NORTHBOUND

Key Observation

Both analysis methods show similar traffic operations along Route 8 Northbound.



LEGEND

Best ← Mainline Level of Service (LOS) → Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

VISSIM ANALYSIS FOR ROUTE 8 NORTHBOUND

HCM ANALYSIS FOR ROUTE 8 NORTHBOUND

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Existing (2017) Level of Service Map
Route 8 NB Mainline PM Peak Hour

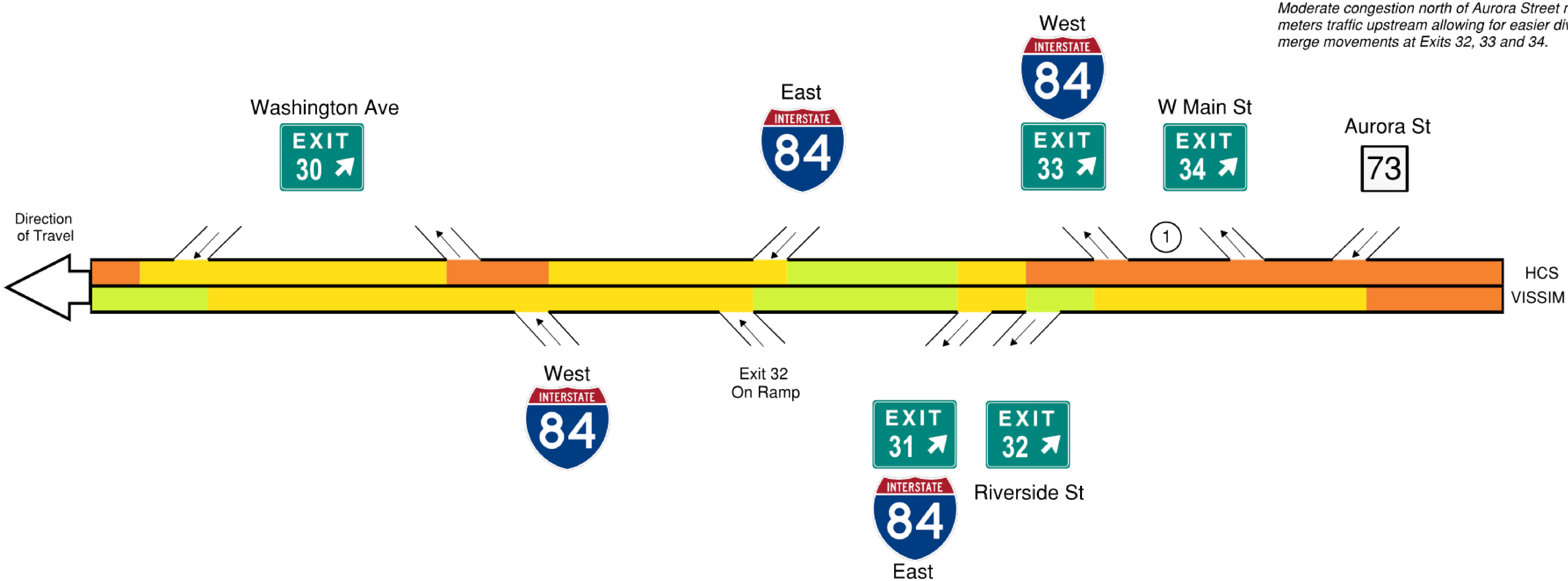
Date: 11/22/2019 | Figure No: 2-26

ROUTE 8 SOUTHBOUND

(1) Key Observation

HCS shows:
Moderate southbound congestion at Exits 32, 33 and 34.

VISSIM shows:
Moderate congestion north of Aurora Street merge meters traffic upstream allowing for easier diverge and merge movements at Exits 32, 33 and 34.



LEGEND

Best ◄— Mainline Level of Service (LOS) —► Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

HCS ANALYSIS FOR ROUTE 8 SOUTHBOUND
VISSIM ANALYSIS FOR ROUTE 8 SOUTHBOUND

84 new mix — I-84 Waterbury Mixmaster Reconstruction Project

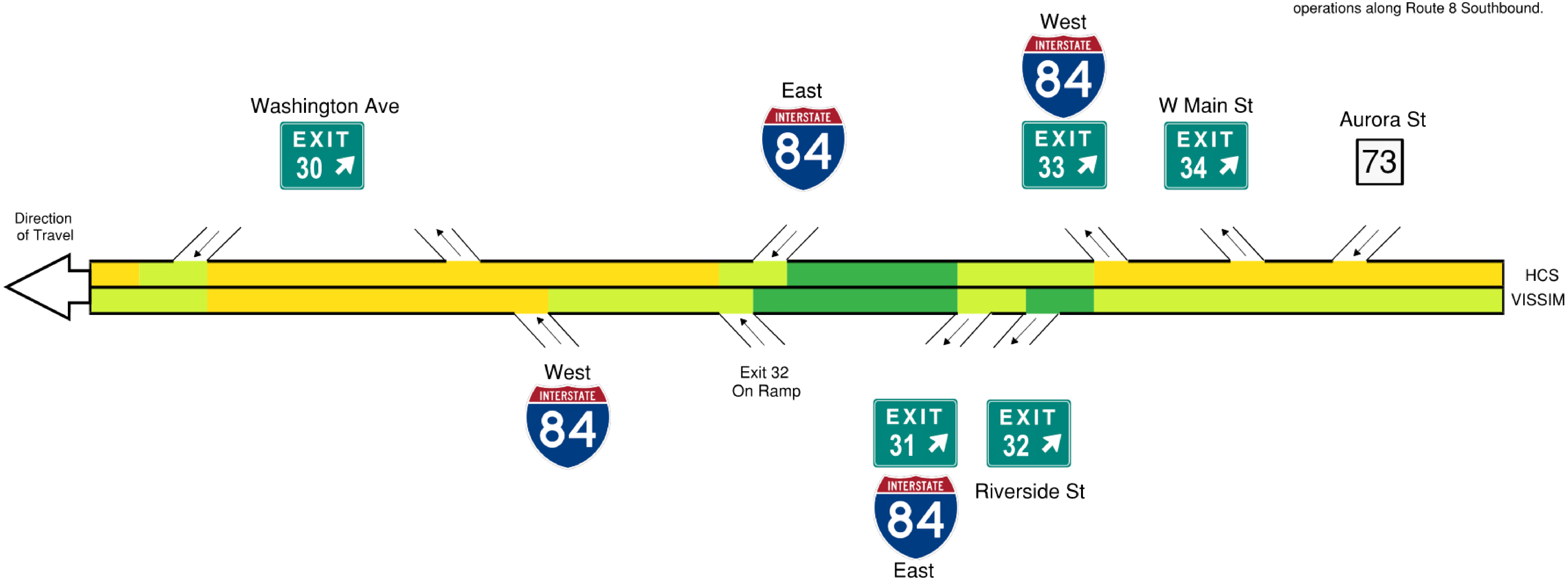
HNTB — Existing (2017) Level of Service Map
Route 8 SB Mainline AM Peak Hour

Date: 11/22/2019 | Figure No: 2-27

ROUTE 8 SOUTHBOUND

Key Observation

Both analysis methods show similar traffic operations along Route 8 Southbound.



LEGEND

Best ◄ Mainline Level of Service (LOS) ► Worst

LOS A LOS B LOS C LOS D LOS E LOS F

HCS ANALYSIS FOR ROUTE 8 SOUTHBOUND

VISSIM ANALYSIS FOR ROUTE 8 SOUTHBOUND

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Existing (2017) Level of Service Map

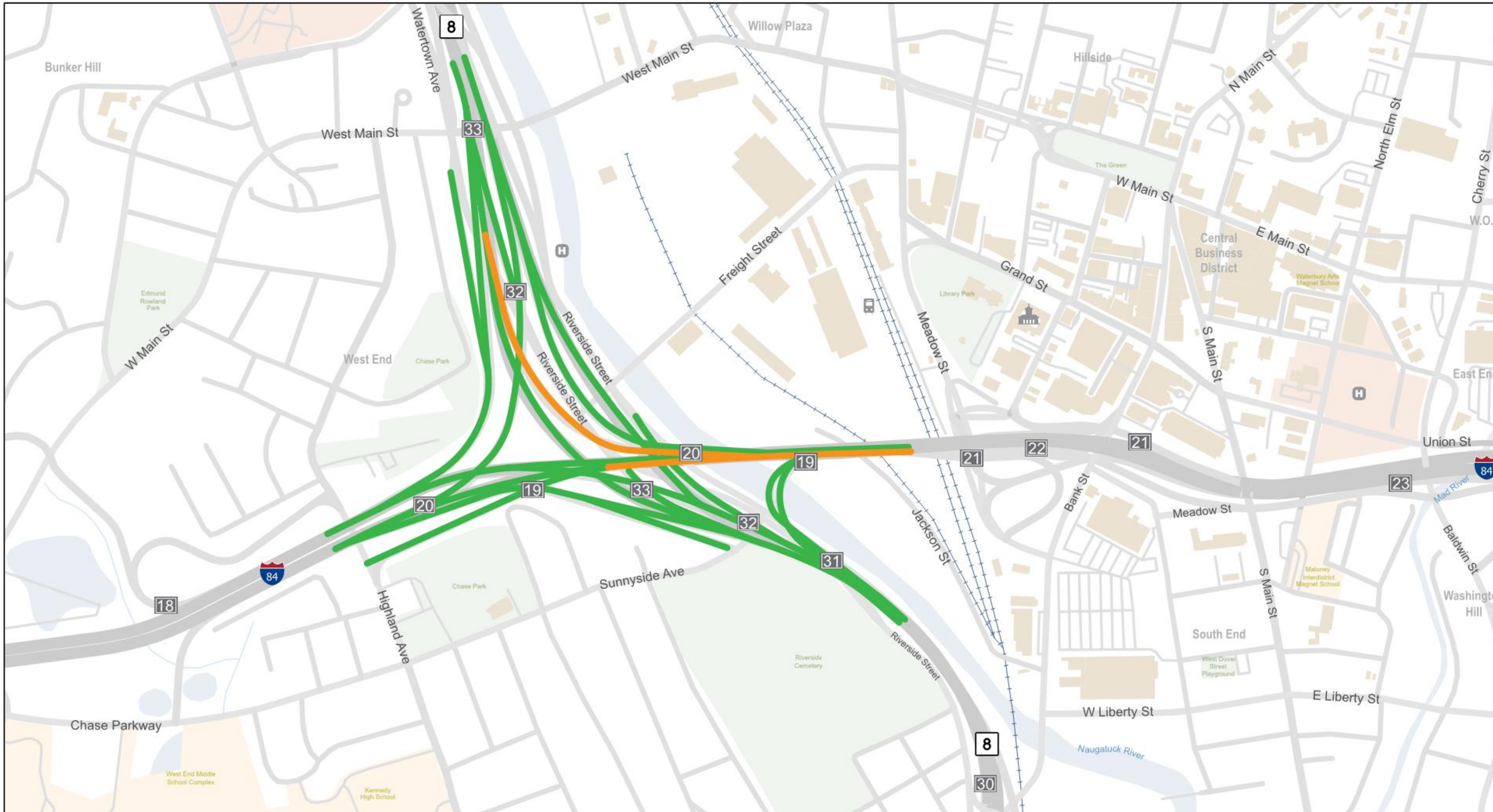
Route 8 SB Mainline PM Peak Hour

Date: 11/22/2019 Figure No: 2-28

Figure 2-29 and **Figure 2-30** represent the LOS results for system ramps.

As shown in **Figure 2-29**, all system ramps are estimated to operate at acceptable levels of service during the AM Peak Hour. **Figure 2-30** shows that all system ramps are estimated to operate at acceptable levels of service except for the I-84 Westbound System Ramp to Route 8 Northbound which experiences a higher than acceptable density, operating at LOS E.

Assumptions, calculations, and detailed output results can be found in Appendix 2.3 (refer to **Weave Calculations and Volumes, Expressway Free Flow Speeds, Expressway Peak Hour Factors,** and **Highway Capacity Software Outputs**).



LEGEND

Best ← Level of Service (LOS) → Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

Railroad
Open Space
Schools
20 Exit
Hospital
Train Station
City Hall

N

0 275 550 1,100 Feet

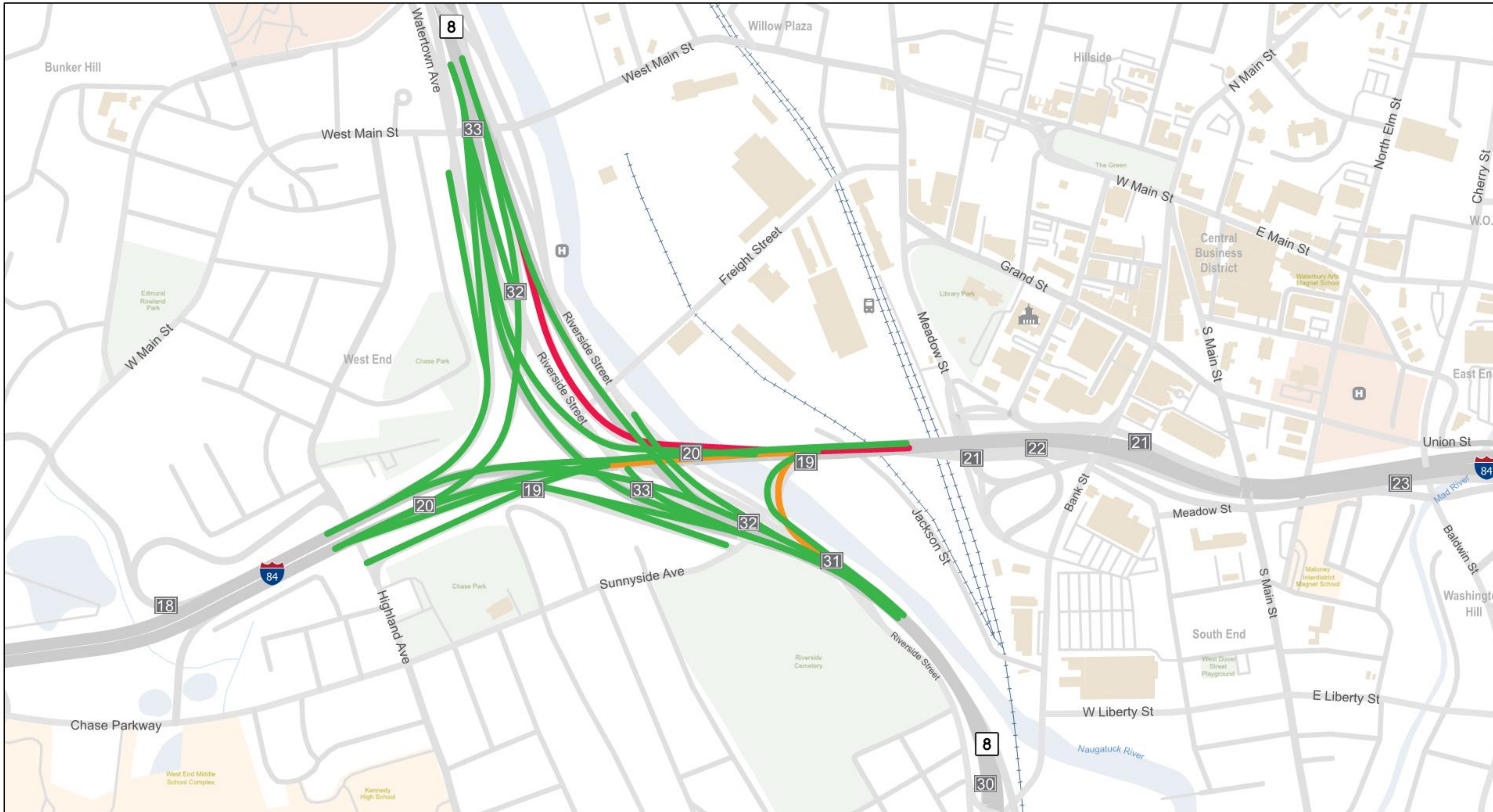
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Existing (2017) Level of Service Map
System Ramps AM Peak Hour

Date: 11/22/2019 Figure No: 2-29



LEGEND

Best ← Level of Service (LOS) → Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

Railroad
Open Space
Schools
Exit

Hospital
Train Station
City Hall

N

0 275 550 1,100 Feet

84 new mix

HNTB

I-84 Waterbury Mixmaster Reconstruction Project

Existing (2017) Level of Service Map
System Ramps PM Peak Hour

Date: 11/22/2019 | Figure No: 2-30

2.3.8 Intersection Operations Overview

As discussed earlier, LOS is a qualitative measure of traffic operations. LOS for intersections are rated differently than highway features. Instead of density, intersection LOS is based on control delay per vehicle in seconds. Control delay per vehicle is a measure of how long it takes to get through the intersection due to the traffic control in place. LOS for signalized and unsignalized intersections are shown in **Table 2-9.**

Table 2-9 Level of Service Criteria for Signalized and Unsignalized Intersections

Level of Service	Signalized Intersections Control Delay per Vehicle (seconds)	Unsignalized Intersections Control Delay per Vehicle (seconds)
A	≤ 10	≤ 10
B	> 10 and ≤ 20	> 10 and ≤ 15
C	> 20 and ≤ 35	> 15 and ≤ 25
D	> 35 and ≤ 55	>25 and ≤ 35
E	> 55 and ≤ 80	> 35 and ≤ 50
F	> 80	> 50

2.3.9 Intersection Operations

Surface street analyses were performed using methods outlined in the HCM 2010 and Synchro 9.0 traffic modeling software.

A total of 65 intersections were analyzed in the AM and PM peak hours. A limited Saturday mid-day (SAT) analysis was performed on 12 intersections around the Brass Mill Center Shopping Mall and at the intersection of West Main Street and Thomaston Avenue. The peak traffic conditions identified for analysis were determined to be 7:30 AM – 8:30 AM, 4:30 – 5:30 PM, and 12:00 PM – 1:00 PM, for the AM, PM and SAT peak hours, respectively. A map of the intersections analyzed is shown in **Figure 2-31** (a detailed map of analysis locations can be found in **Appendix 2.3** (refer to **Intersection Analysis Location Figures**). The intersections with state-owned traffic signals that were studied include:

1. Highland Avenue at Chase Parkway and Sunnyside Avenue
2. Washington Street at Interstate 84 Eastbound Off Ramp (Exit 23)
3. Watertown Avenue at Aurora Street
4. Route 73 at Watertown Avenue and Huntingdon Avenue
5. Route 73 at Aurora Street and East Aurora Street

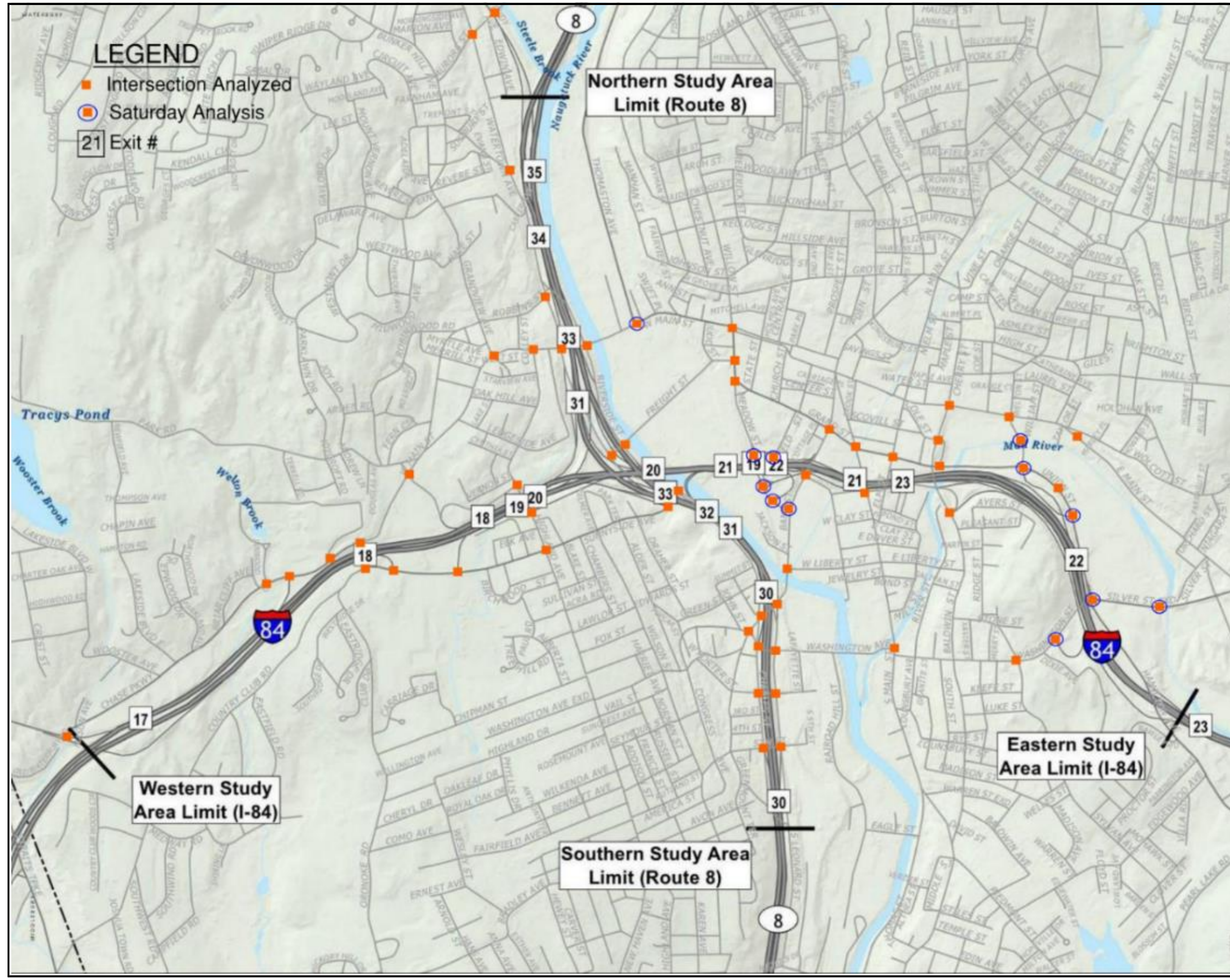


Figure 2-31 Analyzed Arterials and Intersections Map

Traffic signal timings found on current signal plans for State Maintained intersections were used for analysis. Traffic signal field timings were collected for all city-maintained signals within the study area and these timings were compared with the signal plans to match the cycle lengths on the plans. Engineering judgment was used in many cases throughout the study area as the cycle length did not match field timings.

Out of the 65 study intersections, HCM evaluation methods were not applicable to 5 locations due to unconventional controls or configurations. Out of the limited Saturday analysis network, 1 intersection out of 12 was not supported for analysis by HCM methods due to unconventional control or configurations.

The following intersections were therefore omitted from analysis:

- Chase Parkway at Interstate 84 EB On-Ramp (Exit 18)
- Charles Street at Fifth Street and CT Route 8 SB On-Ramp (Exit 30)
- Market Square at Bank Street
- Field Street at Meadow Street #2 and Interstate 84 WB Off-Ramp (Exit 21)
- Highland Avenue at Interstate 84 EB On-Ramp (Exit 18)

Table 2-10 summarizes the capacity analysis findings for the study intersections.

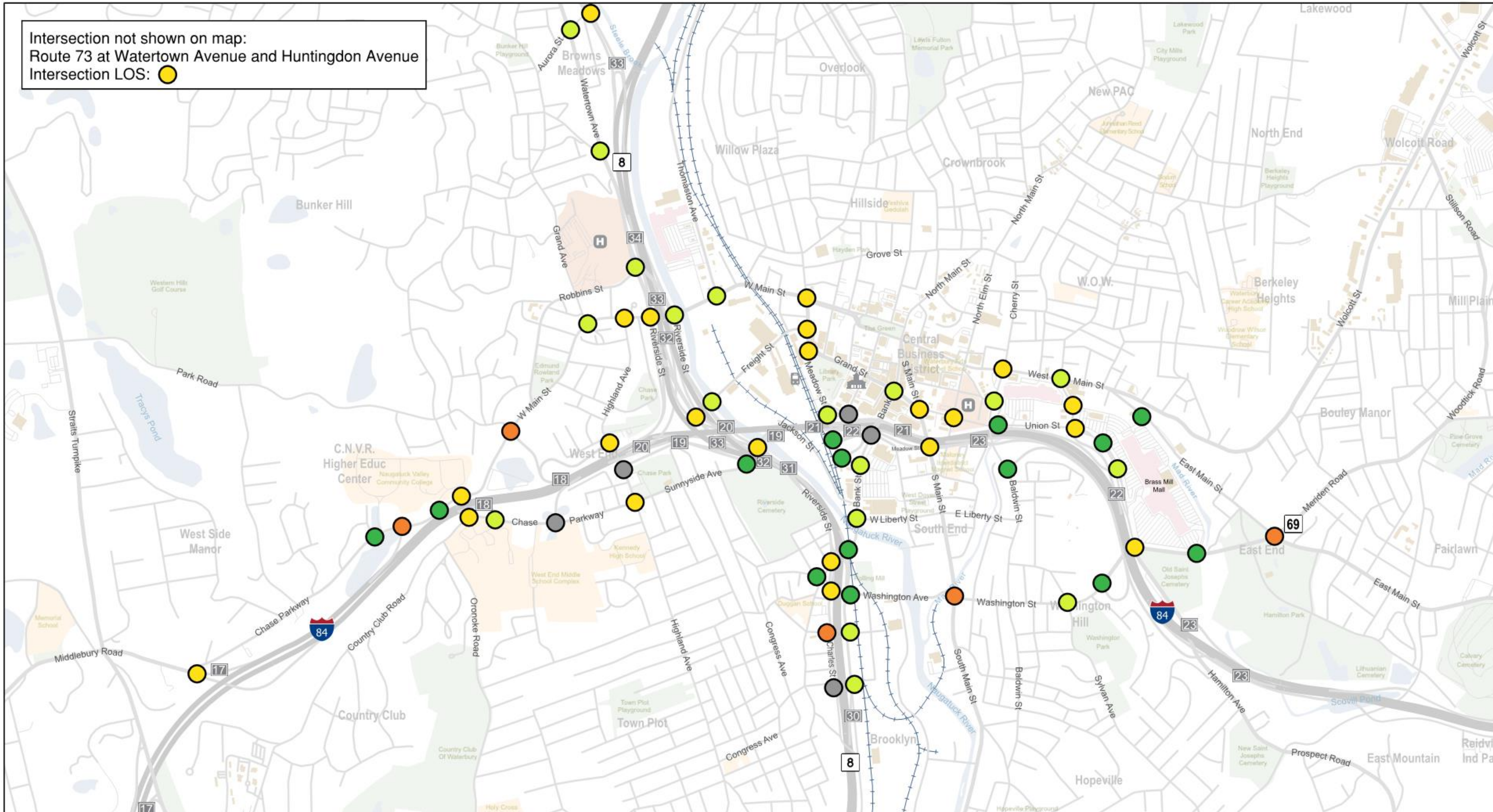
Table 2-10 Signalized and Unsignalized Intersection Capacity Analysis Results

	Level of Service								
	A	B	C	D	E	F	Acceptable	Deficient	Total
AM PEAK	13	20	20	7	0	0	60	0	60
PM PEAK	12	14	20	6	6	2	52	8	60
SAT PEAK	3	5	2	1	0	0	11	0	11

As shown in **Table 2-10,** all study intersections analyzed are estimated to operate at acceptable levels of service during the AM and Saturday Peak Hours. During the PM Peak Hour, 8 out of 60 intersections (approximately 13%) operate at unacceptable levels of service and are considered operationally deficient.

Figure 2-32, Figure 2-33 and **Figure 2-34** illustrates the LOS at the subject intersections for the AM, PM and Saturday Midday peak hours. More detailed information is provided in **Appendix 2.3** (refer to **Existing (2017) Peak Hour Traffic Operation Summary**, **Existing (2017) Level of Service Maps**, and **Existing (2017) Synchro Printouts**).

Intersection not shown on map:
Route 73 at Watertown Avenue and Huntingdon Avenue
Intersection LOS: (LOS C)



LEGEND

Best ← Intersection Level of Service (LOS) → Worst

Intersection	LOS A	LOS B	LOS C	LOS D	LOS E	LOS F	NOT APPLICABLE
No. of intersections:	*14*	*18*	*23*	*5*	*0*	*0*	*5*

Hospital
Train Station
City Hall
Exit

N

0 1,000 2,000 3,000 Feet

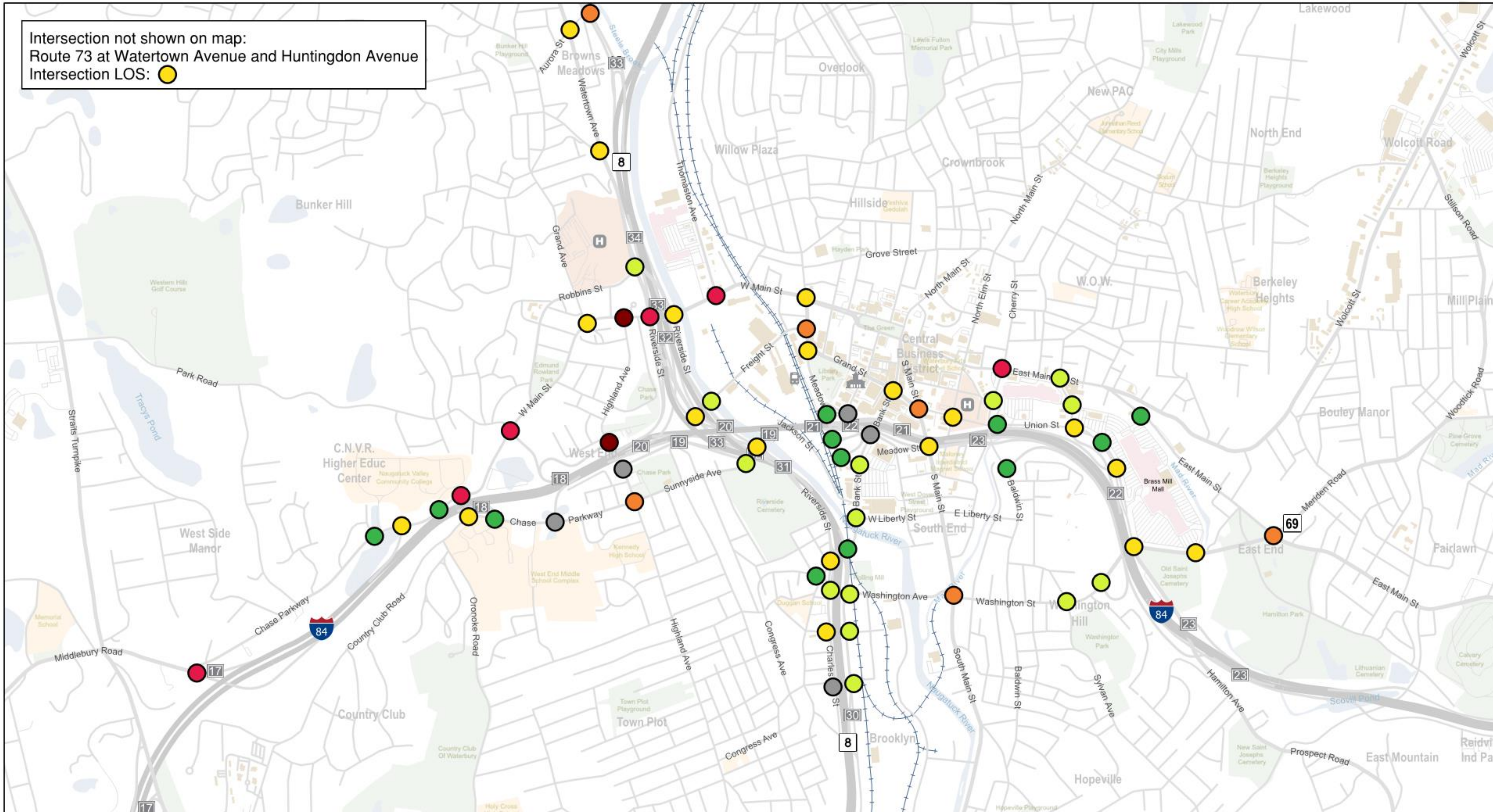
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Existing (2017) Level of Service Map Intersections AM Peak Hour

Date: 11/22/2019 Figure No: 2-32



LEGEND

Best ← Intersection Level of Service (LOS) → Worst

	LOS A	LOS B	LOS C	LOS D	LOS E	LOS F	NOT APPLICABLE
○ Intersection							
No. of intersections:	*14*	*18*	*23*	*5*	*0*	*0*	*5*

Hospital
Train Station
City Hall
Exit

N

0 1,000 2,000 3,000 Feet

84 new mix

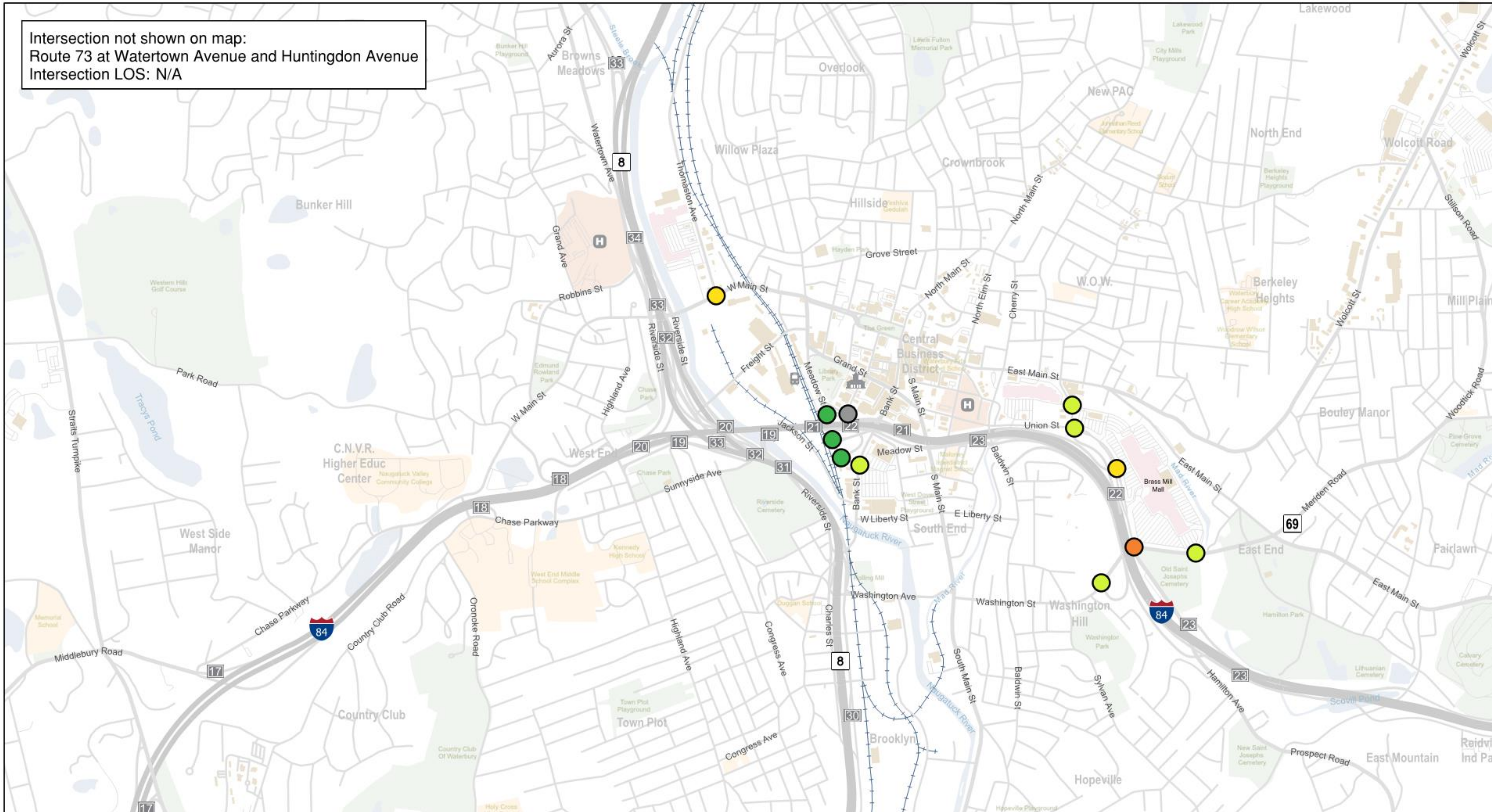
I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Existing (2017) Synchro Intersection Level of Service Map PM Peak

Date: 11/22/2019 Figure No: 2-33

Intersection not shown on map:
Route 73 at Watertown Avenue and Huntingdon Avenue
Intersection LOS: N/A



LEGEND

Best ◄ Intersection Level of Service (LOS) ► Worst

○ Intersection	LOS A	LOS B	LOS C	LOS D	LOS E	LOS F	NOT APPLICABLE
No. of intersections:	*14*	*18*	*23*	*5*	*0*	*0*	*5*

Hospital
Train Station
City Hall
Exit

N

0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Existing (2017) Synchro Intersection Level of Service Map SAT Peak

Date: 11/22/2019 Figure No: 2-34

2.4 ROADWAY GEOMETRICS

This section of the Analysis, Needs and Deficiencies Report, serves to document existing geometric conditions and identify roadway and geometric deficiencies for Interstate 84 (I-84), Connecticut Route 8 (Route 8), System Ramps and Service ramps at the "Mixmaster" interchange and surrounding areas within the study limits based on current design standards. The original project was designed in accordance with the 1958 Geometric Highway Design Standards. Vehicle speeds and projected design traffic volumes were much less than current day.

2.4.1 Methodology

The criteria used to define roadway geometric deficiencies within the study area was derived from the standards established in the Connecticut Department of Transportation, *Highway Design Manual, (2003 Edition Including Revisions to February 2013)* and American Associate of State Highway and Transportation Officials (AASHTO), *A Policy on Geometric Design of Highways and Streets,* (7th Edition, 2018). Controlling design criteria, highway design elements that require a design exception if values are not met, are established within these resources. The following are the controlling design criteria that are included in this report:

a. Design Speed
b. Travel Lane and Shoulder Widths
c. Horizontal Alignment
    a. Minimum Radii, and
    b. Compound Curve Ratio
d. Vertical Curvature
    a. K-Value at Crests/Sags
    b. Maximum/Minimum Grades
e. Stopping Sight Distance
f. Cross Slopes
g. Superelevation
    a. Maximum Rate
    b. Transition Lengths
h. Vertical Clearances
i. Intersection Sight Distances

In addition to the controlling design criteria, the following operational factors were included in this analysis:

- Interchange Spacing
- Ramp Acceleration and Deceleration Lengths
- Highway/Ramp Weaving

The minimum Design Criteria, listed above, are based on the functional classification of the highway. I-84 is classified as an Urban Interstate Principal Arterial (Urban Freeway) and Route 8 is classified as Urban Expressway Principal Arterial (Urban Freeway).

Existing geometric data within the study area was collected using original construction documents and rehabilitation plans, including current State Project #151-312/313/326 (Rehabilitation of Interstate 84 Eastbound, 84 Westbound and Route 8 Bridges). In addition to these sources, ground survey mapping, digital terrain models, and aerial imaging was used to aid in the data collection process.

2.4.2 Interstate 84

Interstate 84 is an east-west roadway, classified as an Urban Interstate Principal Arterial (Urban Freeway) with varying design speeds through the Study Area Limits. Through the core of the Mixmaster, I-84 is an elevated, stacked structure that drops elevation from west to east. These structures span local roadway networks, Route 8, the Naugatuck River and the railyard. The upper level is I-84 Eastbound (Bridge 03191A) while the lower level is I-84 Westbound (Bridge 03191B).

The posted speed limits vary in each direction. In the Eastbound direction, the posted speed limit is 50 mph from the western study area limit through the core of the Mixmaster before increasing to 55 mph at the South Main Street structure. In the Westbound direction, the posted speed limit is 55 mph from the eastern study area limit to the Union Street Ramp where it decreases to 50 mph. The posted 50 mph speed limit is continuous through the core of the Mixmaster to the Highland Avenue Underpass where it increases to 55 mph through the western study area limit.

Geometric Deficiencies Interstate 84

The Design Criteria Tables for I-84 are contained in **Appendix 2.4** (refer to **Interstate 84 Design Criteria Tables**).

Table 2-14 summarizes the geometric deficiencies along Interstate 84 Eastbound and Westbound as analyzed using the controlling design criteria from the CTDOT Highway Design Manual. Within the table, the mainlines are evaluated separately by on-structure and off-structure segments. A green dot indicates that the entire length of the roadway meets the controlling design criteria. A red dot indicates that either a portion or the entire length of roadway does not meet the controlling design criteria.

<u>*Design Speed and Minimum Radius:*</u>

The current CTDOT standards for a roadway classified as an Urban Freeway in a Suburban/Intermediate type area, requires a 65-70 mph design speed. I-84 through the project study area has 2 existing marginally deficient horizontal curves.

Table 2-11 I-84 Mainline Horizontal Curve Deficiencies

Location	Req'd Design Speed¹	Actual Speed²	Minimum Radius for 65 - 70 mph	Existing Radius
I-84 EB from area west of Chase Parkway to an area west of the Highland Ave. overpass	65-70 mph	64 mph	1,665 ft. – 2,050 ft	1,600 ft.
I-84 WB from area west of Chase Parkway to an area west of the Highland Ave. overpass	65-70 mph	63 mph	1,665 ft. – 2,050 ft	1,531 ft.

¹Required Design Speed for Roadway Classification
²Actual Speed Based on Horizontal Alignment

Travel Lane and Shoulder Widths:

Based on the roadway classification, the Design Criteria requires lane widths for I-84 to be 12 feet wide. The required right shoulder width is 10 feet and the required left shoulder width 8 feet. However, based on the heavy truck volumes through the I-84 corridor, the Design Criteria requires that both the left and right shoulders be increased to 12' to meet minimum design standards.

All existing through lanes and auxiliary lanes through the corridor meet the minimum design standard of 12 feet. The shoulder widths, however, are substandard in all locations through the I-84 corridor.

Right Shoulder Width Deficiencies:

Table 2-12 I-84 Mainline Right Shoulder Width Deficiencies

Location	On or Off Bridge	Req'd Right Shoulder Width	Actual Right Shoulder Width
I-84 (EB/WB) from the Chase Parkway Overpass to the area west of the Highland Avenue overpass	Off	12 ft.	10 ft.
I-84 (EB/WB) from the overpass at South Main Street to the area of the Hamilton Avenue overpass	Off	12 ft.	10 ft.
I-84 (EB/WB) from the area west of the Highland Avenue overpass to the overpass at South Main Street	On	12 ft.	3 ft.-11 in.
I-84 (EB/WB) from the area west of the Highland Avenue overpass to the overpass at South Main Street	Off	12 ft.	10 in.

Left Shoulder Width Deficiencies:

Table 2-13 I-84 Mainline Left Shoulder Width Deficiencies

Location	On or Off Bridge	Req'd Left Shoulder Width	Actual Left Shoulder Width
I-84 (EB/WB) from the Chase Parkway Overpass to the area west of the Highland Avenue overpass	On	12 ft.	5 ft.
I-84 (EB/WB) from the Chase Parkway Overpass to the area west of the Highland Avenue overpass	Off	12 ft.	4 ft.
I-84 (EB/WB) from the area west of the Highland Avenue overpass to the overpass at South Main Street	On	12 ft.	3 ft.-11 in.
I-84 (EB/WB) from the area west of the Highland Avenue overpass to the overpass at South Main Street	Off	12 ft.	4 in.

Stopping Sight Distance on Vertical Curves:

The minimum stopping sight distance (SSD), or the sum of the distance traveled during a driver's brake reaction and the distance traveled while decelerating to a complete stop, was determined from Chapter 7 of the CTDOT Highway Design Manual. For a 65-70 mph Design Speed, a minimum SSD of 645' must be achieved. There are seven vertical curves on I-84 Eastbound and nine vertical curves on I-84 Westbound that do not meet the minimum standard.

Operational Deficiencies (I-84):

Per CTDOT Highway Design Manual Section 12-2.04, it is desirable to avoid left hand exits and entrances to the freeway. It becomes a safety issue to merge or exit to/from a low speed ramp onto/off from the high-speed lane of a freeway. Interstate 84 Eastbound has two left-hand ramps.

- Exit 20 off-ramp to Route 8 Northbound (TR 806)
- Route 8 Southbound on-ramp (TR 809) lane add

Interstate 84 Westbound has two left-hand ramps.

- Exit 19 off-ramp to Route 8 Southbound (TR 812)
- Route 8 Northbound on-ramp (TR 808) parallel style

On Interstate 84 Eastbound, the movement from the Exit 18 on-ramp, which is a right-hand on-ramp, can cross two through lanes to reach the left-hand Exit 20 off-ramp to Route 8 Northbound. This creates a short weave with a distance of approximately 1,200 feet.

On Interstate 84 Eastbound, the movement from the Route 8 Southbound on-ramp (TR 809), which is a left-hand lane add, can cross two through lanes to reach the Exit 21 and/or Exit 22 off-ramps.

On Interstate 84 Westbound, the movement from the Route 8 Northbound on-ramp (TR 808) can cross three through lanes to reach the Exit 18 off-ramp.

The Interstate 84 Eastbound auxiliary lane that exists between the Route 8 Northbound on-ramp (TR 811) and the Exit 21 off-ramp has a very short weave distance.

Table 2-14 I-84 Mainline Geometric Deficiencies Matrix

I-84 HIGHWAY GEOMETRICS															
					Horizontal Alignment		Vertical Curvature								
Roadway	Design Speed	Travel Lane Widths	Shoulder Widths	Auxiliary Lane Widths	Minimum Radius	Compound Curvature Ratio	K Value CREST	K Value SAG	Maximum Grade	Minimum Grade	Stopping Sight Distance	Travel Lane & Shoulder Cross Slopes	Superelevation	Superelevation Transition Lengths	Vertical Clearance
I-84 Eastbound (On-Structure)	● (green)	● (green)	● (red)	● (green)	● (green)	N/A	● (green)	● (green)	● (green)	● (green)	● (green)	● (green)	● (green)	● (green)	● (green)
I-84 Eastbound (Off-Structure)	● (yellow)	● (green)	● (red)	● (green)	● (red)	N/A	● (red)	● (red)	● (red)	● (green)	● (red)	● (red)	● (red)	● (green)	● (red)
I-84 Westbound (On-Structure)	● (green)	● (green)	● (red)	● (green)	● (green)	N/A	● (green)	● (red)	● (green)	● (green)	● (green)	● (green)	● (green)	● (green)	● (green)
I-84 Westbound (Off-Structure)	● (yellow)	● (green)	● (red)	● (red)	● (red)	N/A	● (red)	● (red)	● (green)	● (green)	● (red)	● (red)	● (red)	● (green)	● (red)
Eastbound Collector Distributor Road (On-Structure)	● (green)	● (green)	● (green)	N/A	N/A	N/A	● (green)	N/A	● (green)	● (green)	● (green)	● (green)	N/A	N/A	● (green)
Eastbound Collector Distributor Road (Off-Structure)	● (green)	● (green)	● (red)	● (green)	● (green)	● (green)	● (green)	N/A	● (green)	● (green)	● (green)	● (green)	● (red)	● (green)	● (green)

● (green) = ENTIRE LENGTH OF ROADWAY MEETS CONTROLLING DESIGN CRITERIA

● (red) = EITHER A PORTION OR ENTIRE LENGTH OF ROADWAY DOES NOT MEET CONTROLLING DESIGN CRITERIA

● (yellow) = EITHER A PORTION OR ENTIRE LENGTH OF ROADWAY MARGINALLY MEETS CONTROLLING DESIGN CRITERIA

2.4.3 Route 8

CT Route 8 is a north-south roadway, classified as an Urban Expressway Principal Arterial (Urban Freeway) with a design speed of 50-55 mph through the core of the Mixmaster. Route 8 is an elevated, stacked structure south of I-84. The upper level is Route 8 Northbound (Bridge No. 03190A) while the lower level is Route 8 Southbound (Bridge No. 03190B). These structures span local roadway networks.

The posted speed limit is 45 mph from the southerly limit through the Mixmaster. The posted speed limit increases to 55 mph in the Northbound direction at the Freight Street overpass, while in the Southbound direction, the posted speed limit is 55 mph approaching the Mixmaster with the decrease just north of Interstate 84.

Geometric Deficiencies Route 8

The **Route 8 Design Criteria Tables** are contained in **Appendix 2.4.** Summarized below are deficiencies found along Route 8. as analyzed using the controlling design criteria from the CTDOT Highway Design Manual.

Table 2-15 summarizes the geometric deficiencies along Route 8 Northbound and Southbound. Within the table, the mainlines are evaluated separately by on-structure and off-structure segments. A green dot indicates that the entire length of the roadway meets the controlling design criteria. A red dot indicates that either a portion or the entire length of roadway does not meet the controlling design criteria.

Travel Lane and Shoulder Widths:

Based on the roadway classification, the Design Criteria requires lane widths for Route 8 to be 12 feet wide. The required right shoulder width is 10 feet and the required left shoulder width 8 feet.

All existing through lanes and auxiliary lanes through the corridor meet the minimum design standard of 12-foot widths. The shoulder widths, however, are substandard in all locations through the Route 8 corridor. These structures have 12-foot lanes with 3-foot 11-inch shoulders. The structures are stacked in this location due to site constraints with the steep topography and historic cemetery on the west and the Naugatuck River to the east.

The segment of Route 8 north of the interchange has a Direction Design Hourly Volume (DDHV) that exceeds 250 trucks. This requires the shoulders to be 12 feet on both the right and the left. The truck volumes exceed the 250 DDHV threshold after the I-84 Eastbound and Westbound system ramps merge into Route 8.

Stopping Sight Distance on Vertical Curves:

The minimum stopping sight distance (SSD), or the sum of the distance traveled during a driver's brake reaction and the distance traveled while decelerating to a complete stop, was determined from Chapter 7 of the CTDOT Highway Design Manual. For a 55 mph Design Speed, a minimum SSD of 495 feet must be achieved. There is one vertical curve on Route 8 Northbound and one vertical curve on Route 8 Southbound that do not meet the minimum standard.

Compound Curves:

A compound curve is a horizontal curve made up of two (2) or more adjacent curves in the same direction. Section 12-4.03 of the CTDOT Highway Design Manual describes the minimum standards required when using compound curves. The design standard states that the ratio between the radius of the flatter curve and the larger curve should not exceed 2:1. See **Appendix 2.4** for locations (refer to **Route 8 Design Criteria Tables**).

Operational Deficiencies (Route 8):

Route 8 Northbound has four left-hand ramps.

- Exit 33 off-ramp to Interstate 84 Westbound (TR 808)
- Interstate 84 Westbound on-ramp (TR 810) lane add
- Interstate 84 Eastbound on-ramp (TR 806)
- Exit 35 off-ramp to CT Route 73 lane drop

Route 8 Southbound has four left-hand ramps.

- Exit 32 off-ramp
- Exit 31 off-ramp to Interstate 84 Eastbound (TR 809) lane drop
- Exit 32 on-ramp
- Interstate 84 Westbound on-ramp (TR 812)

On Route 8 Northbound, while on Bridge 03190A there is short spacing between the Exit 31, 32 and 33 off-ramps.

Route 8 Northbound - The Interstate 84 Westbound on-ramp (TR 810) is a left lane add to Route 8 Northbound which is followed simultaneously by the left lane ramp from Interstate 84 Eastbound on-ramp (TR 806). It is not clear to the drivers from TR 810 that this is a lane add (not a lane drop) and might be inclined to merge right. This is occurring simultaneously while drivers from TR 806 are required to merge right because TR-806 is a lane drop.

On Route 8 Southbound, the lane striping/configuration is confusing in the vicinity of the Exit 34 off-ramp.

On Route 8 Southbound, the Interstate 84 Westbound on-ramp (TR 812) that ties into the lower level of the Route 8 stacked bridge is extended for the structure's length and effectively serves as a third lane. However, this lane terminates abruptly at the structure's end and forces traffic to merge within a short distance.

Table 2-15 Route 8 Mainline Geometric Deficiencies Matrix

ROUTE 8 GEOMETRICS															
					Horizontal Alignment		Vertical Curvature								
Roadway	Design Speed	Travel Lane Widths	Shoulder Widths	Auxiliary Lane Widths	Minimum Radius	Compound Curvature Ratio	K Value CREST	K Value SAG	Maximum Grade	Minimum Grade	Stopping Sight Distance	Travel Lane & Shoulder Cross Slopes	Superelevation	Superelevation Transition Lengths	Vertical Clearance
Route 8 Northbound (On-Structure)	🟢	🟢	🔴	🟢	🟢	🔴	🟢	🔴	🟢	🟢	🟢	🟢	🟢	N/A	🟢
Route 8 Northbound (Off-Structure)	🟢	🟢	🔴	N/A	🟢	🔴	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🔴
Route 8 Southbound (On-Structure)	🟢	🟢	🔴	🟢	🟢	🔴	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🔴
Route 8 Southbound (Off-Structure)	🟢	🟢	🔴	🟢	🟢	🔴	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🔴

🟢 = ENTIRE LENGTH OF ROADWAY MEETS CONTROLLING DESIGN CRITERIA

🔴 = EITHER A PORTION OR ENTIRE LENGTH OF ROADWAY DOES NOT MEET CONTROLLING DESIGN CRITERIA

2.4.4 Ramps

System Ramps

The Mixmaster is a full system interchange with an equal number of left and right-hand ramps exiting the mainlines and with five left and three right-hand ramps entering the mainlines. The interchange covers four levels, as Route 8 Northbound and Southbound are at level 2 above the local roadways (level 1), with Interstate 84 Westbound at level 3 of the stacked viaduct and Interstate 84 Eastbound at level 4. Route 8 is a stacked viaduct to the south of Interstate 84 with Route 8 Southbound at level 2 and Route 8 Northbound at level 3. With the difference in levels, seven of the System Ramps, also known as Turning Roadways (TR number), are partially or completely on structure. For the purposes of this report, they will only be referred to as System Ramps, but the TR number will remain.

The system ramps within the Mixmaster are, on I-84 – Exits 19 and 20 and on Route 8 – Exits 31 and 33. Descriptions of each are listed below:

Exit 19 - Interstate 84 Eastbound to Route 8 Southbound (TR 805) – on embankment

Exit 20 - Interstate 84 Eastbound to Route 8 Northbound (TR 806) – Left Exit, Structures #03209 and #03200 and on embankment

Exit 33 – Route 8 Southbound to Interstate 84 Westbound (TR 807) – Structure #03206 and on embankment

Exit 33 – Route 8 Northbound to Interstate 84 Westbound (TR 808) – Left Exit, Structure #03190F

Exit 31 – Route 8 Southbound to Interstate 84 Eastbound (TR 809) – Left Exit, Structure #03191D and on embankment

Exit 20 – Interstate 84 Westbound to Route 8 Northbound (TR 810) – Structure #03191E and on embankment

Exit 31 – Route 8 Northbound to Interstate 84 Eastbound (TR 811) – Structure #03190C

Exit 19 – Interstate 84 Westbound to Route 8 Southbound (TR 812) – Left Exit, Structure #03190D

Geometric Deficiencies - System Ramps

The Design Criteria Tables for the System Ramps are contained in **Appendix 2.4** (refer to **System Interchange- Turning Roadways Design Criteria Tables**). Summarized below are deficiencies found on the System Ramps.

Design Speed:

The current CTDOT design standards for Design Speeds are a function of the Mainline Design Speed which results in a 40mph minimum design speed on System Ramps. All the existing System Ramps are posted with advisory speeds ranging from 25mph to 35mph therefore not meeting design standards.

Minimum Radii:

The horizontal radii of the system ramps were analyzed to determine which ramp radii did not meet the minimum requirements based on design speed. All the radii design requirements were determined assuming a 6% superelevation rate.

Minimum Radius Deficiencies:

Table 2-16 System Ramp Horizontal Curve Deficiencies

Location	Minimum Radius based on a 40 mph Design Speed	Existing Radius
Route 8 NB Exit 31 (TR 811)	510 ft.	202 ft.
I-84 WB Exit 19 (TR 812)	510 ft.	240 ft.
I-84 EB Exit 19 (TR 805)	510 ft.	500 ft.

Ramp Travel Lane and Shoulder Widths:

Per CTDOT design standards, the minimum width of a one lane ramp is 26 feet (A 4-foot left shoulder, 12-foot travel way, and a 10-foot right shoulder). The minimum width for a 2-lane ramp is 38 feet (4-foot left shoulder, 2 – 12-foot travel lanes and a 10-foot right shoulder).

All single lane ramps listed above and summarized below have a curb to curb width of 23-foot 10-inch and therefore do not meet the standard.

Multi-lane Turning Roadways on structure have twelve (12) foot lanes with 3-foot 11-inch left and right shoulders. When used as a single lane Turning Roadway, these have adequate width.

Table 2-17 System Ramp Right Shoulder Width Deficiencies

Location	Description	On or Off Bridge	Required Shoulder Width	Existing Right Shoulder Width
Exit 19 (TR 805)	I-84 EB to Route 8 SB	Off	10 ft.	8 ft.
Exit 19 (TR 812)	I-84 WB to Route 8 SB	On	10 ft.	8 ft.
Exit 20 (TR 806)	I-84 EB to Route 8 NB	On	10 ft.	8 ft.
Exit 20 (TR 806)	I-84 EB to Route 8 NB	Off	10 ft.	8 ft.
Exit 31 (TR 809)	Route 8 SB to I-84 EB	On	10 ft.	4 ft. (Bridge No. 03205)
Exit 31 (TR 811)	Route 8 NB to I-84 EB	On	10 ft.	9 ft.-10 in.
Exit 33 (TR 807)	Route 8 SB to I-84 WB	On	10 ft.	8 ft.
Exit 33 (TR 807)	Route 8 SB to I-84 WB	Off	10 ft.	3 ft.
Exit 33 (TR 808)	Route 8 NB to I-84 WB	On	10 ft.	8 ft.-10 in.
Exit 33 (TR 808)	Route 8 NB to I-84 WB	Off	10 ft.	8 ft.

Table 2-18 System Ramp Left Shoulder Width Deficiencies

Location	Description	On or Off Bridge	Required Shoulder Width	Existing Left Shoulder Width
Exit 19 (TR 812)	I-84 WB to Route 8 SB	On	4 ft.	3 ft.-10 in.
Exit 20 (TR 806)	I-84 EB to Route 8 NB	Off	4 ft.	1 ft.-6 in.
Exit 31 (TR 811)	Route 8 NB to I-84 EB	On	4 ft.	2 ft.
Exit 33 (TR 808)	Route 8 NB to I-84 WB	On	4 ft.	3 ft.-11 in.

Compound Curves:

A compound curve is a horizontal curve made up of two (2) or more adjacent curves in the same direction. Section 12-4.03 of the CTDOT Highway Design Manual describes the minimum standards required when using compound curves. The design standard states that the ratio between the radius of the flatter curve and the larger curve should not exceed 2:1. Exit 31 (TR 811) has nine (9) consecutive compound curves which affects rideability. For location, see **Appendix 2.4** (refer to **System Interchange- Turning Roadways Design Criteria Tables**)

Vertical Grades and Stopping Sight Distance:

Highway grades have a major impact on safety and operations of the ramps. The CTDOT Highway Design Manual has established maximum and minimum grades for roadways. Maximum grades are established in order to provide adequate stopping sight distance. These are based on roadway classification. Minimum grades are established in order to provide proper drainage of the roadway and avoid ponding of storm water. All roadway classifications have a minimum vertical grade of 0.50%.

The minimum stopping sight distance (SSD), or the sum of the distance traveled during a driver brake reaction and the distance traveled while decelerating to a complete stop, was determined from Chapter 7 of the CTDOT Highway Design Manual. Exit 31 (TR 811) and Exit 19 (TR 812) have stopping sight distance less than the required 305' for a 40 mph Design Speed.

There are four system ramps that do not meet the minimum roadway grade. They are Exit Ramp 31 (TR 809), Exit 20 (TR 811) and Exit 19 (TR 812). Portions of these ramps are relatively flat and therefore do not meet the minimum vertical grade standard.

Table 2-19 summarizes the geometric deficiencies of the system interchange. Within the table, the system ramps are evaluated separately by on-structure and off-structure segments. A green dot indicates that the entire length of the roadway meets the controlling design criteria. A red dot indicates that either a portion or the entire length of roadway does not meet the controlling design criteria.

Table 2-19 System Ramp Geometric Deficiencies Matrix

SYSTEM RAMPS GEOMETRICS																	
					Horizontal Alignment		Vertical Curvature										
Roadway	Design Speed	Travel Lane Widths	Shoulder Widths	Auxiliary Lane Widths	Minimum Radius	Compound Curvature Ratio	K Value CREST	K Value SAG	Maximum Grade	Minimum Grade	Stopping Sight Distance	Travel Lane & Shoulder Cross Slopes	Superelevation	Superelevation Transition Lengths	Vertical Clearance	Intersection Sight Distance	Acceleration Length
Exit 19 Off-Ramp: I-84 Eastbound to Route 8 Southbound (Off-Structure Only)	🔴	🟢	🟢	N/A	🔴	🔴	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🔴	🟢	N/A
Exit 20 Off-Ramp: I-84 Eastbound to Route 8 Northbound (On-Structure)	🔴	🟢	🔴	N/A	🟢	🟢	🟢	N/A	🟢	🟢	🟢	N/A	🟢	🟢	N/A	N/A	N/A
Exit 20 Off-Ramp: I-84 Eastbound to Route 8 Northbound (Off-Structure)	🔴	🟢	🟢	N/A	🟢	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Exit 33 Off-Ramp: Route 8 Southbound to I-84 Westbound (On-Structure)	🔴	🟢	🟢	N/A	N/A	N/A	N/A	🟢	🟢	🟢	🟢	🟢	N/A	N/A	N/A	N/A	N/A
Exit 33 Off-Ramp: Route 8 Southbound to I-84 Westbound (Off-Structure)	🔴	🟢	🔴	N/A	🟢	N/A	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	N/A	N/A	🟢
Exit 33 Off-Ramp: Route 8 Northbound to I-84 Westbound (On-Structure)	🔴	🟢	🔴	N/A	🟢	N/A	🟢	🔴	🟢	🟢	🟢	🟢	N/A	N/A	🟢	N/A	N/A
Exit 33 Off-Ramp: Route 8 Northbound to I-84 Westbound (Off-Structure)	🔴	🟢	🟢	N/A	🟢	N/A	🟢	N/A	🟢	🟢	🟢	🟢	🟢	🔴	🟢	N/A	N/A
Exit 31 Off-Ramp: Route 8 Southbound to I-84 Eastbound (On-Structure)	🔴	🟢	🔴	N/A	🟢	🟢	🟢	🟢	🟢	🔴	🟢	N/A	🟢	🟢	N/A	N/A	N/A
Exit 31 Off-Ramp: Route 8 Southbound to I-84 Eastbound (Off-Structure)	🔴	🟢	🟢	N/A	🟢	🟢	🟢	🟢	🟢	🟢	🟢	N/A	🟢	🟢	🟢	N/A	N/A
Exit 20 Off-Ramp: I-84 Westbound to Route 8 Northbound (On-Structure)	🔴	🟢	🟢	N/A	🟢	🟢	🟢	🔴	🟢	🟢	🟢	N/A	🟢	🟢	🟢	N/A	N/A
Exit 20 Off-Ramp: I-84 Westbound to Route 8 Northbound (Off-Structure)	🔴	🟢	🟢	N/A	🟢	N/A	🟢	🔴	🟢	🔴	🟢	🟢	🟢	🟢	N/A	N/A	N/A
Exit 31 Off-Ramp: Route 8 Northbound to I-84 Eastbound (On-Structure Only)	🔴	🟢	🔴	N/A	🔴	🟢	🟢	🔴	🟢	🟢	🔴	🟢	🟢	🟢	🟢	N/A	N/A
Exit 19 Off-Ramp: I-84 Westbound to Route 8 Southbound (On-Structure Only)	🔴	🟢	🔴	N/A	🔴	N/A	🟢	🔴	🟢	🔴	🔴	🟢	🟢	🟢	🟢	🟢	N/A

🟢 = ENTIRE LENGTH OF ROADWAY MEETS CONTROLLING DESIGN CRITERIA

🔴 = EITHER A PORTION OR ENTIRE LENGTH OF ROADWAY DOES NOT MEET CONTROLLING DESIGN CRITERIA

Service Ramp Interchanges

There are five service ramp interchanges providing access to I-84 and four providing access to Route 8 within the study area. A service ramp is defined as a ramp that has a terminus on the limited access highway and another terminus at a local roadway network.

- Along Interstate 84, the service ramp interchanges are listed below:

  Exit 17 – Half interchange (Westbound off, Eastbound on)
  Exit 18 – Full interchange with additional Eastbound on-ramp
  Exit 21 – Full interchange
  Exit 22 – 3/4 interchange (no Eastbound on)
  Exit 23 – 3/4 interchange (no Westbound on) Eastbound becomes a Collector Distributor (CD) Roadway

- Along Route 8, the service ramp interchanges are listed below:

  Exit 30 – Full interchange
  Exit 32 – Full interchange
  Exit 34 – Half interchange (Southbound off, Northbound on)
  Exit 35 – Half interchange (Northbound off, Southbound on)

Geometric Deficiencies - Service Ramps

The **Service Ramps Design Criteria Tables** are contained in **Appendix 2.4**. Summarized below are deficiencies found on the Service Ramps.

Interstate 84 Service Ramps

Minimum Radius:

Exit 17 on I-84 Eastbound does not meet the minimum requirement for horizontal radius (curvature).

Table 2-20 I-84 Service Ramp Horizontal Curve Deficiencies

Location	On or Off Bridge	Minimum Radius based on Design Speed	Existing Radius
Exit 17 EB On-Ramp	On	665 ft.	650 ft.
Exit 17 EB On-Ramp	Off	665 ft.	363.36 ft.

Minimum/Maximum Grades:

I-84 has five service ramps that have vertical grades that exceed maximum standards and one ramp that does not meet the minimum grade standard.

Table 2-21 I-84 Service Ramp Grade Deficiencies

Location	On or Off Bridge	Maximum Grade based on Design Speed	Existing Grade
Exit 17 EB On-Ramp	Off	4%	8%
Exit 18 EB On-Ramp	On	6.5%	-7%
Exit 18 EB On-Ramp	Off	6.5%	-7%
Exit 19 EB Off-Ramp	Off	6.5%	-8.44%
Exit 21 EB Off-Ramp	On	6.5%	-7%
Exit 21 EB Off-Ramp	Off	6.5%	-7%
Exit 22 EB Off-Ramp	On	6.5%	-7%
Exit 22 EB Off-Ramp	Off	6.5%	-7%

Lane widths:

I-84 has one service ramp serving as a Collector Distributor (CD) Roadway having a substandard lane width.

Table 2-22 I-84 Service Ramp Lane Width Deficiencies

Location	On or Off Bridge	Required Lane Width	Existing Lane Width
Ramp 2 Baldwin Street to EB CD Road	Off	12 ft.	11 ft.

Right Shoulder Widths:

I-84 has four service ramps that have right shoulder widths that do not meet the minimum standards.

Table 2-23 I-84 Service Ramp Right Shoulder Width Deficiencies

Location	On or Off Bridge	Required Right Shoulder Width	Existing Right Shoulder Width
Exit 22 EB Off-Ramp	On	10 ft.	7 ft.
Exit 22 EB Off-Ramp	Off	10 ft.	8 ft.
Ramp 2 Baldwin Street to EB CD Road	Off	10 ft.	3 ft.
Exit 22 WB Off-Ramp	On	10 ft.	8 ft.
Exit 22 WB Off-Ramp	Off	10 ft.	6 ft.
Exit 18 WB Off-Ramp	Off	10 ft.	8 ft.

Left Shoulder Widths:

I-84 has seven service ramps that have left shoulder widths that do not meet the minimum standards.

Table 2-24 I-84 Service Ramp Left Shoulder Width Deficiencies

Location	On or Off Bridge	Required Left Shoulder Width	Existing Left Shoulder Width
Exit 21 EB Off-Ramp	On	4 ft.	1.5 ft.
Exit 22 EB Off-Ramp	On	4 ft.	2 ft.
Ramp 1 McMahon Street to EB CD Road	Off	4 ft.	2 ft.
Ramp 2 Baldwin Street to EB CD Road	Off	4 ft.	2 ft.
Exit 22 WB On-Ramp	Off	4 ft.	2 in.
Exit 21 WB Off-Ramp	On	4 ft.	0 ft.
	Off	4 ft.	0 ft.
Exit 21 WB On-Ramp	On	4 ft.	3 ft.
	Off	4 ft.	0 ft.

Deceleration Lane Length:

I-84 has one exit ramp that does not have adequate deceleration lane length. Sufficient deceleration lane length is required for a vehicle to safely exit a limited access, high speed roadway.

Table 2-25 I-84 Service Ramp Deceleration Lane Length Deficiencies

Location	On or Off Bridge	Required Deceleration Length	Existing Deceleration Length
Exit 18 EB Off-Ramp	Off	300 ft.	219 ft.

Compound Curve Ratio:

I-84 has three exit ramps that do not meet the requirements for compound curves.

Table 2-26 I-84 Service Ramp Compound Curve Deficiencies

Location	On or Off Bridge	Required Compound Curve Ratio	Existing Compound Curve Ratio
Exit 21 EB On-Ramp	Off	1.5:1, 2:1 Max	4.1, 4:1
Exit 22 EB On-Ramp	Off	1.5:1, 2:1 Max	4:1
Ramp 2 Baldwin Street to EB CD Road	Off	1.5:1, 2:1 Max	2.6, 7:1

Stopping Sight Distance (SSD):

I-84 has one exit ramp that does not have the adequate SSD of 250'. Exit 18 EB On-Ramp (Highland Avenue) has an SSD of 209-feet.

Superelevation Rate and Transition Length:

The superelevation rate, or the rate at which a curve is banked, exceeds the maximum design standard at the Eastbound CD Roadway. The superelevation transition length (affects rideability driving into a banked curve) is below the design standard.

Intersection Sight distance (ISD):

There is one off-ramp that has an ISD at a local road that is below design standard.

Table 2-27 I-84 Service Ramp Intersection Sight Distance Deficiencies

Location	On or Off Bridge	Required ISD	Existing ISD
Exit 19 EB Off-Ramp (Sunnyside Avenue)	Off	390 ft.	197 ft.

Route 8 Service Ramps

Minimum/Maximum Grades:

Route 8 has one service ramp that have vertical grades that exceed maximum standards.

Table 2-28 Route 8 Service Ramp Maximum Grade Deficiencies

Location	On or Off Bridge	Maximum Grade based on Design Speed	Existing Grade
Exit 30 NB On-Ramp	Off	6.5%	9.7%

Route 8 has six ramps that do not meet the minimum grade standard.

Table 2-29 Route 8 Service Ramp Minimum Grade Deficiencies

Location	On or Off Bridge	Minimum Grade based on Design Speed	Existing Grade
Exit 30 NB On-Ramp	Off	0.5%	-0.40%
Exit 30 SB Off-Ramp	Off	0.5%	0.39%
Exit 32 NB Off-Ramp	Off	0.5%	-0.35%
Exit 34 NB On-Ramp	Off	0.5%	-0.08%
Exit 34 SB Off-Ramp	Off	0.5%	-0.43%
Exit 30 NB Off-Ramp	Off	0.5%	0.24%

Right Shoulder Widths:

Route 8 has three service ramps that have right shoulder widths that do not meet the minimum standards.

Table 2-30 Route 8 Service Ramp Right Shoulder Width Deficiencies

Location	On or Off Bridge	Required Right Shoulder Width	Existing Right Shoulder Width
Exit 30 NB On-Ramp	On	10 ft.	8 ft.
	Off	10 ft.	8 ft.
Exit 30 NB Off-Ramp	Off	10 ft.	6 ft.
Exit 32 NB Off-Ramp	On	10 ft.	8 ft.-10 in.
	Off	10 ft.	8 ft.

Left Shoulder Widths:

Route 8 has three service ramp that have left shoulder widths that do not meet the minimum standards.

Table 2-31 Route 8 Service Ramp Left Shoulder Width Deficiencies

Location	On or Off Bridge	Required Right Shoulder Width	Existing Left Shoulder Width
Exit 30 NB On-Ramp	On	4 ft.	0 ft.
	Off	4 ft.	0 ft.
Exit 32 NB Off-Ramp	On	4 ft.	2 ft.
Exit 30 SB Off-Ramp	On	4 ft.	0 ft.
	Off	4 ft.	2 ft.

Deceleration Lane Length:

There is one off ramp that does not have adequate deceleration lane length. Sufficient deceleration lane length is required for a vehicle to safely exit a freeway.

Table 2-32 Route 8 Service Ramp Deceleration Lane Length Deficiencies

Location	On or Off Bridge	Required Deceleration Length	Existing Deceleration Length
Exit 30 NB Off-Ramp	Off	285 ft.	151 ft.

Acceleration Lane Length:

Route 8 has one on ramp that does not have adequate acceleration lane length. The acceleration lane length is critical for vehicle acceleration as it enters the freeway.

Table 2-33 Route 8 Service Ramp Acceleration Lane Length Deficiencies

Location	On or Off Bridge	Required Acceleration Length	Existing Acceleration Length
Exit 32 NB On-Ramp	On	350 ft.	301 ft.

Compound Curve Ratio:

Route 8 has two exit ramps that do not meet the requirements for compound curves.

Table 2-34 Route 8 Service Ramp Compound Curve Deficiencies

Location	On or Off Bridge	Required Compound Curve Ratio	Existing Compound Curve Ratio
Exit 35 SB On-Ramp	Off	1.5:1, 2:1 Max	2.25:1
Exit 30 SB Off-Ramp	Off	1.5:1, 2:1 Max	2.5:1

Superelevation Rate and Transition Length:

Route 8 has two ramps that that have a superelevation transition length that are substandard.

Table 2-35 Route 8 Superelevation Rate and Transition Length Deficiencies

Location	On or Off Bridge	Required Superelevation Transition Length	Existing Superelevation Transition Length
Exit 32 SB Off-Ramp	Off	101.6	100
Exit 30 SB Off-Ramp	On	132	130

Table 2-36 thorough

Table 2-39 summarize the geometric deficiencies along the service ramps Within the tables, the ramps are evaluated separately by on-structure and off-structure segments. A green dot indicates that the entire length of the roadway meets the controlling design criteria. A red dot indicates that either a portion or the entire length of roadway does not meet the controlling design criteria.

Table 2-36 I-84 Eastbound Service Ramp Geometric Deficiencies Matrix

I-84 EASTBOUND SERVICE RAMPS GEOMETRICS																		
					Horizontal Alignment		Vertical Curvature											
Roadway	Design Speed	Travel Lane Widths	Shoulder Widths	Auxiliary Lane Widths	Minimum Radius	Compound Curvature Ratio	K Value CREST	K Value SAG	Maximum Grade	Minimum Grade	Stopping Sight Distance	Travel Lane & Shoulder Cross Slopes	Superelevation	Superelevation Transition Lengths	Vertical Clearance	Intersection Sight Distance	Acceleration Length	Deceleration Length
Exit 17 On-Ramp: Route 64 to I-84 Eastbound (On-Structure)	🟢	🟢	🟢	N/A	🔴	N/A	🟢	N/A	🟢	🟢	🟢	🟢	🟢	🟢	N/A	N/A	N/A	N/A
Exit 17 On-Ramp: Route 64 to I-84 Eastbound (Off-Structure)	🟢	🟢	🟢	N/A	🔴	N/A	🟢	🔴	🔴	🟢	🟢	🟢	🟢	🟢	N/A	N/A	🟢	N/A
Exit 18 Off-Ramp: I-84 Eastbound to Chase Parkway (Off-Structure Only)	🔴	🟢	🟢	N/A	🔴	🟢	🔴	🔴	🟢	🟢	🟢	🟢	🟢	🟢	N/A	🟢	N/A	🔴
Exit 18 On-Ramp: Chase Parkway to I-84 Eastbound (Off-Structure Only)	🟢	🟢	🟢	N/A	🟢	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	N/A	N/A	N/A	N/A
Exit 18 On-Ramp: Highland Avenue to I-84 Eastbound (On-Structure)	🟢	🟢	🔴	N/A	🟢	🟢	N/A	🔴	🔴	🟢	🟢	🟢	🟢	🟢	N/A	N/A	🟢	N/A
Exit 18 On-Ramp: Highland Avenue to I-84 Eastbound (Off-Structure)	🟢	🟢	🟢	N/A	N/A	N/A	🟢	N/A	🔴	🟢	🔴	🟢	N/A	N/A	N/A	N/A	N/A	N/A
Exit 19 Off-Ramp: I-84 Eastbound to Sunnyside Avenue (Off-Structure Only)	🟢	🟢	🟢	N/A	🟢	N/A	🟢	🔴	🔴	🟢	🟢	🟢	🟢	🔴	🔴	🔴	N/A	🟢
Exit 21 On-Ramp: Bank Street to I-84 Eastbound (On-Structure)	🟢	🟢	🔴	N/A	🟢	N/A	N/A	🟢	🟢	🟢	🟢	N/A	🟢	🟢	🟢	N/A	N/A	N/A
Exit 21 On-Ramp: Bank Street to I-84 Eastbound (Off-Structure)	🟢	🟢	🟢	N/A	🔴	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	N/A	N/A	N/A
Exit 21 Off-Ramp: I-84 Eastbound to Meadow Street (On-Structure)	🔴	🟢	🔴	N/A	🔴	🟢	🟢	N/A	🔴	🟢	🟢	N/A	🟢	🟢	N/A	🟢	N/A	N/A
Exit 21 Off-Ramp: I-84 Eastbound to Meadow Street (Off-Structure)	🔴	🟢	🔴	N/A	🔴	🟢	N/A	🔴	🔴	🟢	🟢	🟢	🟢	🟢	N/A	🟢	N/A	N/A
Exit 22 Off-Ramp: I-84 Eastbound to McMahon Street (On-Structure)	🔴	🟢	🔴	N/A	🟢	N/A	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🔴	N/A	N/A	N/A	🟢
Exit 22 Off-Ramp: I-84 Eastbound to McMahon Street (Off-Structure)	🔴	🟢	🔴	N/A	🟢	🔴	🟢	🔴	🔴	🟢	🟢	N/A	🟢	🟢	N/A	🟢	N/A	N/A
Exit 23 Off-Ramp: I-84 Eastbound to Eastbound Collector Distributor Road (Off-Structure Only)	🟢	🟢	🟢	N/A	🟢	🟢	N/A	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	N/A	N/A	N/A
On-Ramp 1: McMahon Street to Eastbound Collector Distributor Road (Off-Structure Only)	🟢	🟢	🔴	N/A	🟢	N/A	🟢	🟢	🟢	🟢	🟢	🔴	🟢	🟢	N/A	N/A	N/A	N/A
On-Ramp 2: Baldwin Street to Eastbound Collector Distributor Road (Off-Structure Only)	🟢	🟢	🔴	🔴	🟢	🔴	N/A	🔴	🟢	🟢	🟢	🟢	🟢	🟢	N/A	N/A	N/A	N/A
Off-Ramp 4: Eastbound Collector Distributor Road to Washington Street (Off-Structure Only)	🟢	🟢	🟢	N/A	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	N/A	🟢

🟢 = ENTIRE LENGTH OF ROADWAY MEETS CONTROLLING DESIGN CRITERIA

🔴 = EITHER A PORTION OR ENTIRE LENGTH OF ROADWAY DOES NOT MEET CONTROLLING DESIGN CRITERIA

Table 2-37 I-84 Westbound Service Ramp Geometric Deficiencies Matrix

I-84 WESTBOUND SERVICE RAMPS GEOMETRICS					Horizontal Alignment		Vertical Curvature											
Roadway	Design Speed	Travel Lane Widths	Shoulder Widths	Auxiliary Lane Widths	Minimum Radius	Compound Curvature Ratio	K Value CREST	K Value SAG	Maximum Grade	Minimum Grade	Stopping Sight Distance	Travel Lane & Shoulder Cross Slopes	Superelevation	Superelevation Transition Lengths	Vertical Clearance	Intersection Sight Distance	Acceleration Length	Deceleration Length
Exit 22 Off-Ramp: I-84 Westbound to Union Street (On-Structure)	🟢	🟢	🔴	N/A	🔴	N/A	🟢	N/A	🟢	🟢	🟢	🔴	🟢	🟢	N/A	N/A	N/A	N/A
Exit 22 Off-Ramp: I-84 Westbound to Union Street (Off-Structure)	🟢	🟢	🔴	N/A	🔴	N/A	🟢	N/A	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	N/A	🟢
Exit 22 On-Ramp: Union Street to I-84 Westbound (Off-Structure Only)	🟢	🟢	🔴	N/A	🔴	N/A	N/A	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	N/A	🟢	N/A
Exit 21 Off-Ramp: I-84 Westbound to Field Street (On-Structure)	🔴	🟢	🔴	N/A	🟢	N/A	🟢	N/A	🔴	🟢	🟢	N/A	🟢	🟢	N/A	N/A	N/A	N/A
Exit 21 Off-Ramp: I-84 Westbound to Field Street (Off-Structure)	🔴	🟢	🔴	N/A	🔴	N/A	🟢	🔴	🔴	🔴	🟢	🟢	🟢	🟢	N/A	N/A	N/A	🟢
Exit 21 On-Ramp (Right): Bank Street to I-84 Westbound (On-Structure)	🟢	🟢	🔴	N/A	🟢	N/A	🟢	N/A	🟢	🟢	🟢	🟢	N/A	N/A	🟢	N/A	N/A	N/A
Exit 21 On-Ramp (Right): Bank Street to I-84 Westbound (Off-Structure)	🟢	🟢	🔴	N/A	🔴	N/A	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	N/A	N/A	N/A
Exit 21 On-Ramp (Left): Bank Street to I-84 Westbound (On-Structure)	🟢	🟢	🔴	N/A	🟢	N/A	🟢	N/A	🟢	🟢	🟢	🔴	N/A	N/A	🟢	N/A	N/A	N/A
Exit 21 On-Ramp (Left): Bank Street to I-84 Westbound (Off-Structure)	🟢	🟢	🔴	N/A	🔴	N/A	N/A	🔴	🟢	🟢	🟢	N/A	🟢	🟢	🟢	N/A	N/A	N/A
Exit 18 Off-Ramp: I-84 Westbound to Highland Avenue (Off-Structure Only)	🟢	🟢	🔴	N/A	🔴	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🔴	🟢	🟢	N/A	N/A
Exit 18 On-Ramp: Route 64 to I-84 Westbound (Off-Structure Only)	🟢	🟢	🟢	N/A	🟢	N/A	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	N/A	N/A	🟢	N/A
Exit 17 Off-Ramp: I-84 Westbound to Route 64 (Off-Structure Only)	🟢	🟢	🟢	N/A	🟢	N/A	🟢	🔴	🔴	🟢	🟢	🟢	🟢	🟢	N/A	N/A	N/A	🟢

🟢 = ENTIRE LENGTH OF ROADWAY MEETS CONTROLLING DESIGN CRITERIA

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Table 2-38 Route 8 Northbound Service Ramp Geometric Deficiencies Matrix

ROUTE 8 NORTHBOUND SERVICE RAMPS GEOMETRICS																		
Roadway	Design Speed	Travel Lane Widths	Shoulder Widths	Auxiliary Lane Widths	Horizontal Alignment		Vertical Curvature				Stopping Sight Distance	Travel Lane & Shoulder Cross Slopes	Superelevation	Superelevation Transition Lengths	Vertical Clearance	Intersection Sight Distance	Acceleration Length	Deceleration Length
					Minimum Radius	Compound Curvature Ratio	K Value CREST	K Value SAG	Maximum Grade	Minimum Grade								
Exit 30 Off-Ramp: Route 8 Northbound to South Leonard Street (Off-Structure Only)	🔴	🟢	🔴	N/A	🟢	N/A	🟢	🟢	🟢	🔴	🟢	🔴	N/A	N/A	N/A	N/A	N/A	🔴
Exit 30 On-Ramp: Washington Street to Route 8 Northbound (On-Structure)	🟢	🟢	🔴	N/A	🟢	🟢	🟢	N/A	🟢	🔴	🟢	🟢	🟢	🔴	🟢	N/A	N/A	N/A
Exit 30 On-Ramp: Washington Street to Route 8 Northbound (Off-Structure)	🟢	🟢	🔴	N/A	🟢	🟢	🔴	🔴	🔴	🔴	🔴	🟢	🟢	🟢	🟢	N/A	N/A	N/A
Exit 32 Off-Ramp: Route 8 Northbound to Northbound Riverside Street (On-Structure)	🔴	🟢	🔴	N/A	🟢	N/A	🟢	N/A	🟢	🔴	🟢	N/A	🟢	🟢	🟢	N/A	N/A	🟢
Exit 32 Off-Ramp: Route 8 Northbound to Northbound Riverside Street (Off-Structure)	🔴	🟢	🟢	N/A	🟢	N/A	🟢	🔴	🟢	🟢	🟢	🟢	N/A	N/A	🟢	🟢	N/A	N/A
Exit 32 On-Ramp: Northbound Riverside Street to Route 8 Northbound (On-Structure)	🟢	🟢	🟢	N/A	N/A	N/A	🟢	N/A	🟢	🟢	🟢	🟢	N/A	N/A	N/A	N/A	🔴	N/A
Exit 32 On-Ramp: Northbound Riverside Street to Route 8 Northbound (Off-Structure)	🟢	🟢	🟢	N/A	🟢	N/A	🟢	🟢	🟢	🟢	🟢	🟢	N/A	N/A	N/A	N/A	N/A	N/A
Exit 34 On-Ramp: Northbound Watertown Avenue to Route 8 Northbound (Off-Structure Only)	🟢	🟢	🟢	N/A	🟢	N/A	🟢	🔴	🟢	🔴	🟢	🟢	N/A	N/A	N/A	N/A	🟢	N/A
Exit 35 Off-Ramp: Route 8 Northbound to Route 73 Northbound (Off-Structure Only)	🟢	🟢	🟢	N/A	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🔴	🟢	N/A	N/A

🟢 = ENTIRE LENGTH OF ROADWAY MEETS CONTROLLING DESIGN CRITERIA

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Table 2-39 Route 8 Southbound Service Ramp Geometric Deficiencies Matrix

ROUTE 8 SOUTHBOUND SERVICE RAMPS GEOMETRICS																		
Roadway	Design Speed	Travel Lane Widths	Shoulder Widths	Auxiliary Lane Widths	Horizontal Alignment		Vertical Curvature				Stopping Sight Distance	Travel Lane & Shoulder Cross Slopes	Superelevation	Superelevation Transition Lengths	Vertical Clearance	Intersection Sight Distance	Acceleration Length	Deceleration Length
					Minimum Radius	Compound Curvature Ratio	K Value CREST	K Value SAG	Maximum Grade	Minimum Grade								
Exit 35 On-Ramp: Route 73 Southbound to Route 8 Southbound (Off-Structure Only)	🟢	🟢	🟢	N/A	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	N/A	N/A	N/A	N/A
Exit 34 Off-Ramp: Route 8 Southbound to West Main Street (On-Structure)	🟢	🟢	🟢	N/A	N/A	N/A	🟢	N/A	🟢	🟢	🟢	🟢	N/A	N/A	N/A	N/A	N/A	N/A
Exit 34 Off-Ramp: Route 8 Southbound to West Main Street (Off-Structure)	🟢	🟢	🟢	N/A	🟢	N/A	🟢	🔴	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	N/A	N/A
Exit 32 Off-Ramp: Route 8 Southbound to Southbound Riverside Street (Off-Structure Only)	🔴	🟢	🟢	N/A	🟢	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🔴	🟢	N/A	N/A	🟢
Exit 32 On-Ramp: Southbound Riverside Street to Route 8 Southbound (Off-Structure Only)	🟢	🟢	🟢	N/A	🟢	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	N/A	🟢	N/A
Exit 30 Off-Ramp: Route 8 Southbound to Charles Street (On-Structure)	🔴	🟢	🔴	N/A	🟢	N/A	🔴	N/A	🟢	🟢	🔴	N/A	🟢	🔴	N/A	N/A	N/A	N/A
Exit 30 Off-Ramp: Route 8 Southbound to Charles Street (Off-Structure)	🔴	🔴	🔴	N/A	🟢	🔴	🔴	🔴	🟢	🔴	🔴	🟢	🟢	🟢	🟢	🟢	N/A	🟢
Exit 30 On-Ramp: Charles Street to Route 8 Southbound (Off-Structure Only)	🟢	🟢	🔴	N/A	🟢	N/A	🟢	N/A	🟢	🟢	🟢	🔴	N/A	N/A	N/A	N/A	N/A	N/A

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🔴 = EITHER A PORTION OR ENTIRE LENGTH OF ROADWAY DOES NOT MEET CONTROLLING DESIGN CRITERIA

Interchange Spacing

The National Cooperative Highway Research Program (NCHRP) Report 687 *"Guidelines for Ramp and Interchange Spacing"* provided guidance for this section. There are no set standards for interchange spacing, however, there is the historic rule of thumb "one mile spacing" in urban areas. The distance between interchanges did vary within urban areas to provide access. Interchange Spacing is defined as the distance measured between the respective centerlines of freeway cross streets that include ramps to or from that freeway. Ramp Spacing is defined as the distance measured from painted tip to painted tip or physical gore to physical gore of the ramp. CTDOT measures from physical gore to physical gore.

There are four major components when assessing these spacings: Traffic Operations, Signing, Safety and Geometric Design.

The Traffic Operations analysis that was performed includes Level of Service analyses for each Weaving Influence Area (auxiliary lane), Merge Influence Area (on-ramp) & Diverge Influence Area (off-ramp) and Mainline sections for the AM, PM and Saturday peak hours. See the Reconstruction of Interstate 84/Route 8 Interchange "Mixmaster" – Level of Service Analysis Existing Conditions (Expressways) Report.

The Signing throughout the study area limits is currently being upgraded with all new signs under CTDOT Projects #151-312/313/326 and #151-273.

The Safety component is part of the Crash Analysis Report. This report has been summarized in **Section 2.5 Crash Data and Safety Analysis**. Further detail can be found in the complete report titled Reconstruction of Interstate 84/Route 8 Interchange "Mixmaster" – Crash Analysis Mainline (Interstate 84, Route 8, Turning Roadways and Ramps) and Local Roadways (Arterials) Report.

The Geometric component analyzes the ramp elements for horizontal and vertical alignment to account for appropriate speed change and sight distance as well as the cross-section elements (see Sections 12-3.02 and 12-4.0 of the CTDOT Highway Design Manual). Additionally, the measured distances for the following four conditions must be analyzed when ramps are in close proximity to each other:

- Exit Ramp to Entrance Ramp (EX-EN) – AASHTO 2018 Green Book
- Entrance Ramp to Exit Ramp (EN-EX) – Auxiliary Lane – AASHTO 2018 Green Book
- Exit Ramp to Exit Ramp (EX-EX) – CTDOT Highway Design Manual Figure 12-2E
- Entrance Ramp to Entrance Ramp (EN-EN) - CTDOT Highway Design Manual Figure 12-2FBelow are the results from the geometric analysis of the ramps.

Interstate 84 Eastbound Ramp Spacing

Interstate 84 Eastbound has the following ramps within the study area limits that do not meet design standards. See **Appendix 2.4** (refer to **Ramp and Interchange Spacing**) for more information.

Table 2-40 I-84 Eastbound Ramp Spacing Deficiencies

Ramp Description	Ramp Spacing Required	Actual Ramp Spacing
Exit 18 on-ramp to Exit 19 off-ramp	2000 ft.	1024 ft.
Exit 19 off-ramp to Exit 20 off-ramp	1500 ft.	370 ft.
Exit 18 on-ramp to Exit 20 on-ramp	800 ft.	610 ft.
Exit 20 on-ramp to Exit 19 on-ramp	800 ft.	635 ft.
Exit 19 on-ramp to Exit 21 off-ramp	2000 ft.	349 ft.
Exit 21 off-ramp to Exit 22 off-ramp	1500 ft.	670 ft.
Exit 21 on-Ramp to Exit 23 off-ramp	1600 ft.	1012 ft.
CD Roadway on-Ramp 1 to CD Roadway on-Ramp 2	800 ft.	584 ft.

Interstate 84 Westbound Ramp Spacing

Interstate 84 Westbound has the following ramps within the study area limits that do not meet ramp spacing design standards. See **Appendix 2.4** (refer to **Ramp and Interchange Spacing**) for more information.

Table 2-41 I-84 Westbound Ramp Spacing Deficiencies

Ramp Description	Ramp Spacing Required	Actual Ramp Spacing
Exit 21 on-ramp (to Rte 8 SB) to Exit 21 on-ramp (to I-84 WB) from Bank Street	800 ft.	151 ft.
Exit 21 on-ramp to Exit 19 off-ramp	2000 ft.	561 ft.
Exit 19 off-ramp to Exit 20 off-ramp	1500 ft.	791 ft.
Exit 21 on-ramp to Exit 20 off-ramp	2000 ft.	1427 ft.
Exit 19 on-ramp to Exit 20 on-ramp	800 ft.	678 ft.
Exit 20 on-ramp to Exit 18 off-ramp	2000 ft.	1394 ft.

Route 8 Northbound Ramp Spacing

Route 8 Northbound has the following ramps within the study area limits that do not meet design standards. See **Appendix 2.4** (refer to **Ramp and Interchange Spacing**) for more information.

Table 2-42 Route 8 Northbound Ramp Spacing Deficiencies

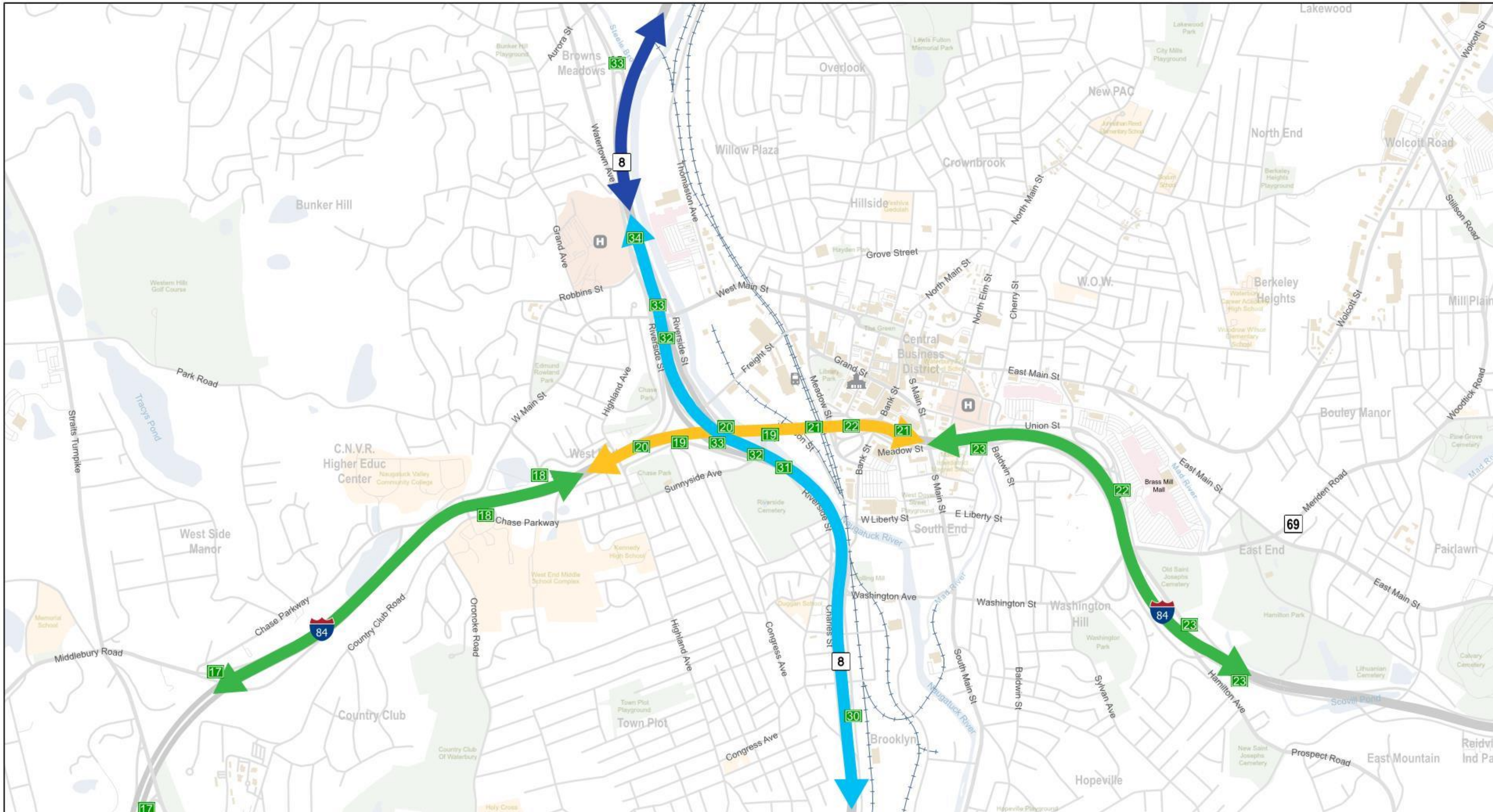
Ramp Description	Ramp Spacing Required	Actual Ramp Spacing
Exit 30 on-ramp to Exit 31 off-ramp	2000 ft.	808 ft.
Exit 31 off-ramp to Exit 32 off-ramp	1500 ft.	594 ft.
Exit 32 off-ramp to Exit 33 off-ramp	1500 ft.	400 ft.
Exit 31 on-ramp to Exit 33 on-ramp	800 ft.	436 ft.
Exit 33 on-ramp to Exit 32 on-ramp	800 ft.	526 ft.

Route 8 Southbound Ramp Spacing

Route 8 Southbound has the following ramps within the study area limits that do not meet design standards. See **Appendix 2.4** (refer to **Ramp and Interchange Spacing**) for more information.

Table 2-43 Route 8 Southbound Spacing Deficiencies

Ramp Description	Ramp Spacing Required	Actual Ramp Spacing
Exit 35 on-ramp to Exit 34 off-ramp	1600 ft.	1535 ft.
Exit 33 off-ramp (right) to Exit 32 off-ramp (left)	1500 ft.	67 ft.
Exit 32 off-ramp to Exit 31 off-ramp	1500 ft.	517 ft.
Exit 32 on-ramp (left) to Exit 33 on-ramp (right)	800 ft.	25 ft.
Exit 32 on-ramp to Exit 31 on-ramp	800 ft.	600 ft.
Exit 31 on-ramp to Exit 30 off-ramp	2000 ft.	1361 ft.



ROADWAY CLASSIFICATION: | AREA TYPE: | DESIGN SPEED:

ROADWAY CLASSIFICATION:	AREA TYPE:	DESIGN SPEED:
URBAN INTERSTATE PRINCIPAL ARTERIAL (URBAN FREEWAY)	SUBURBAN/INTERMEDIATE	65-70 MPH
URBAN INTERSTATE PRINCIPAL ARTERIAL (URBAN FREEWAY)	BUILT-UP	50-55 MPH
URBAN EXPRESSWAY PRINCIPAL ARTERIAL (URBAN FREEWAY)	BUILT-UP	50-55 MPH
URBAN EXPRESSWAY PRINCIPAL ARTERIAL (URBAN FREEWAY)	SUBURBAN/INTERMEDIATE	65-70 MPH

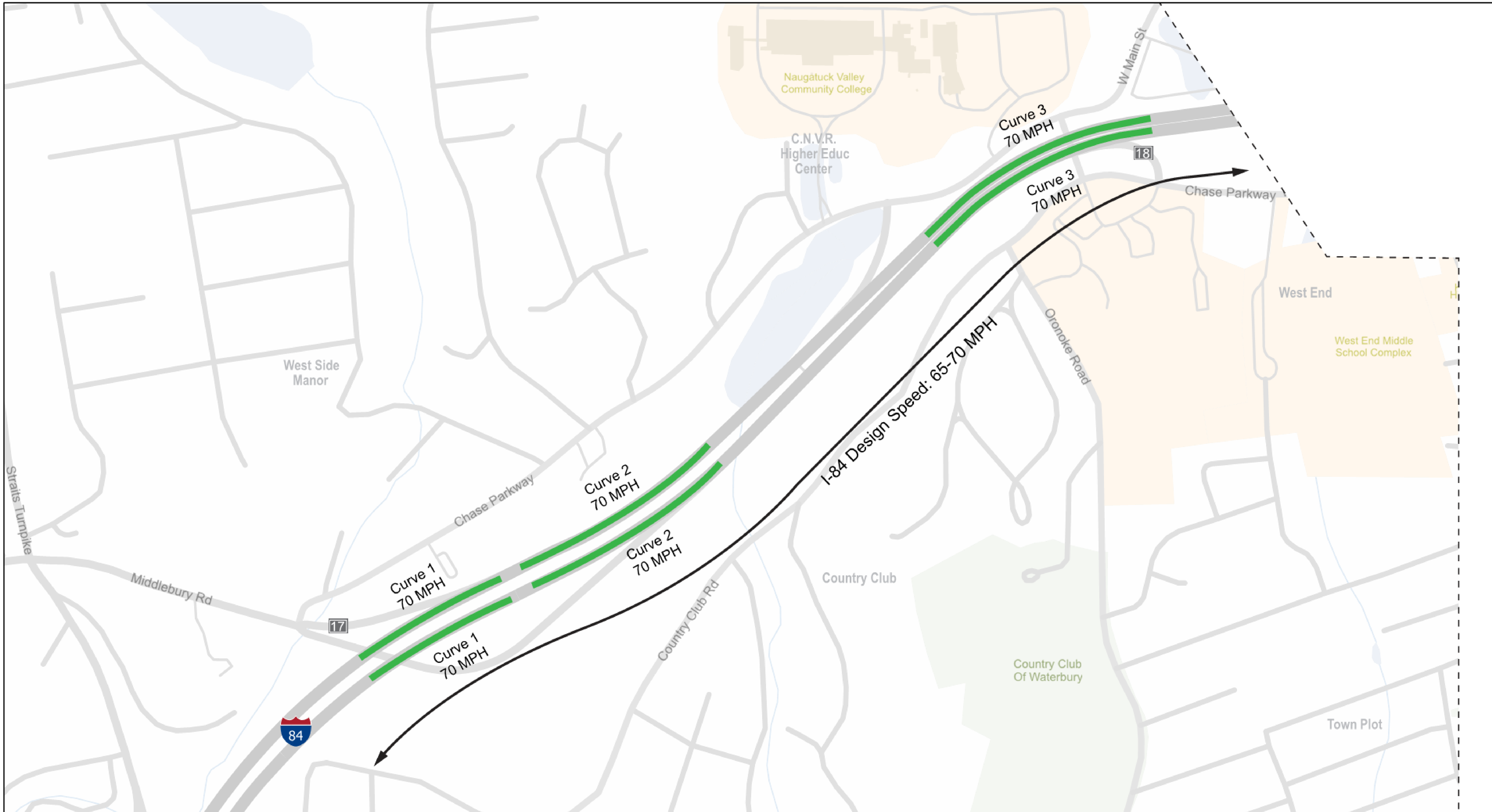
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Geometric Deficiencies Map Design Speed By Classification

Date: 4/28/2020 | Figure No: 2-35



Radii Meeting Design Speed

Radii Marginally Meeting Design Speed

Radii Not Meeting Design Speed

Railroad

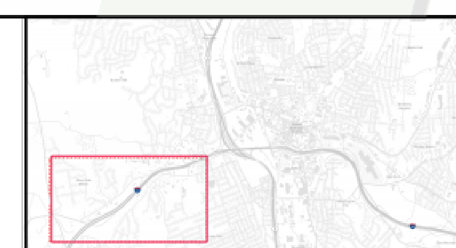
Open Space

Schools

17 Exit

N

0 275 550 1,100 Feet



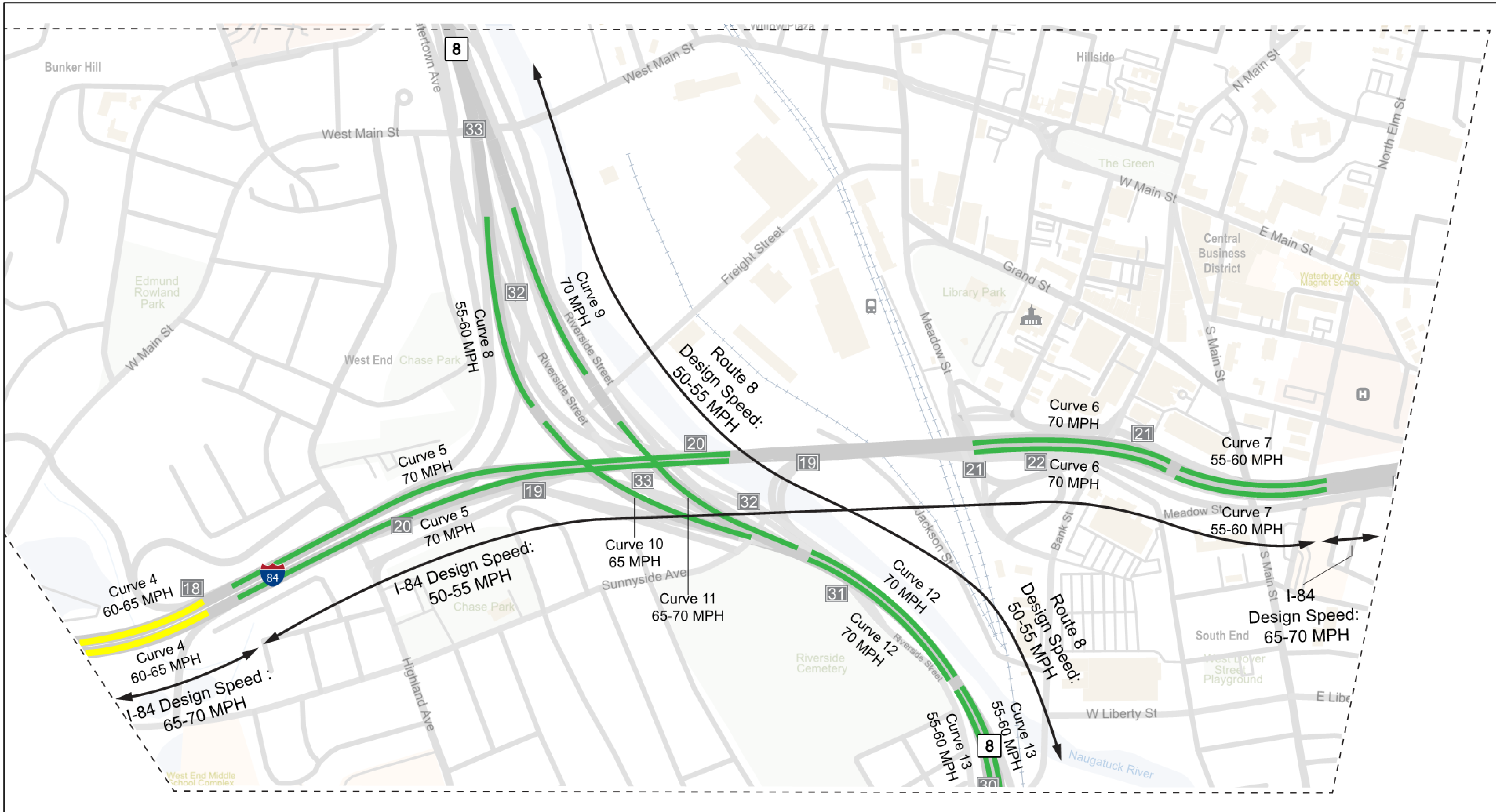
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Design Speed and Horizontal Alignment Map 1 of 5

Date: 11/22/2019 Figure No: 2-36



- Radii Meeting Design Speed
- Radii Marginally Meeting Design Speed
- Radii Not Meeting Design Speed

Railroad | Open Space | Schools | Exit | Train Station | City Hall

N

0 275 550 1,100 Feet

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Design Speed and Horizontal Alignment Map 2 of 5

Date: 11/22/2019 Figure No: 2-37

Radii Meeting Design Speed
Radii Marginally Meeting Design Speed
Radii Not Meeting Design Speed

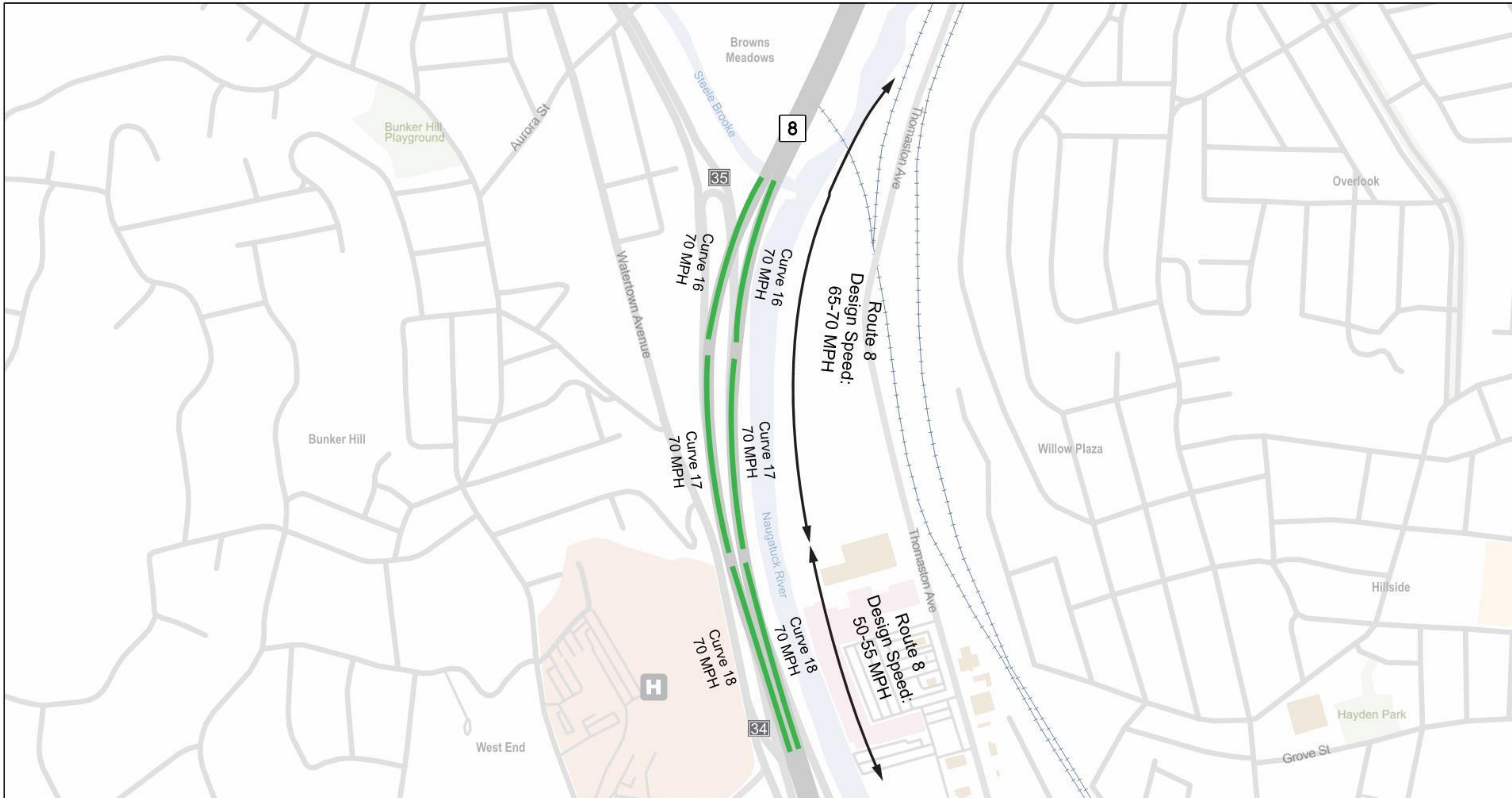
Railroad
Open Space
Schools
17 Exit

N
0 275 550 1,100 Feet

I-84 Waterbury Mixmaster Reconstruction Project

Design Speed and Horizontal Alignment Map 3 of 5

Date: 11/22/2019 Figure No: 2-38



Radii Meeting Design Speed

Radii Marginally Meeting Design Speed

Radii Not Meeting Design Speed

Railroad

Open Space

Schools

Hospital

Exit

N

0 275 550 1,100 Feet

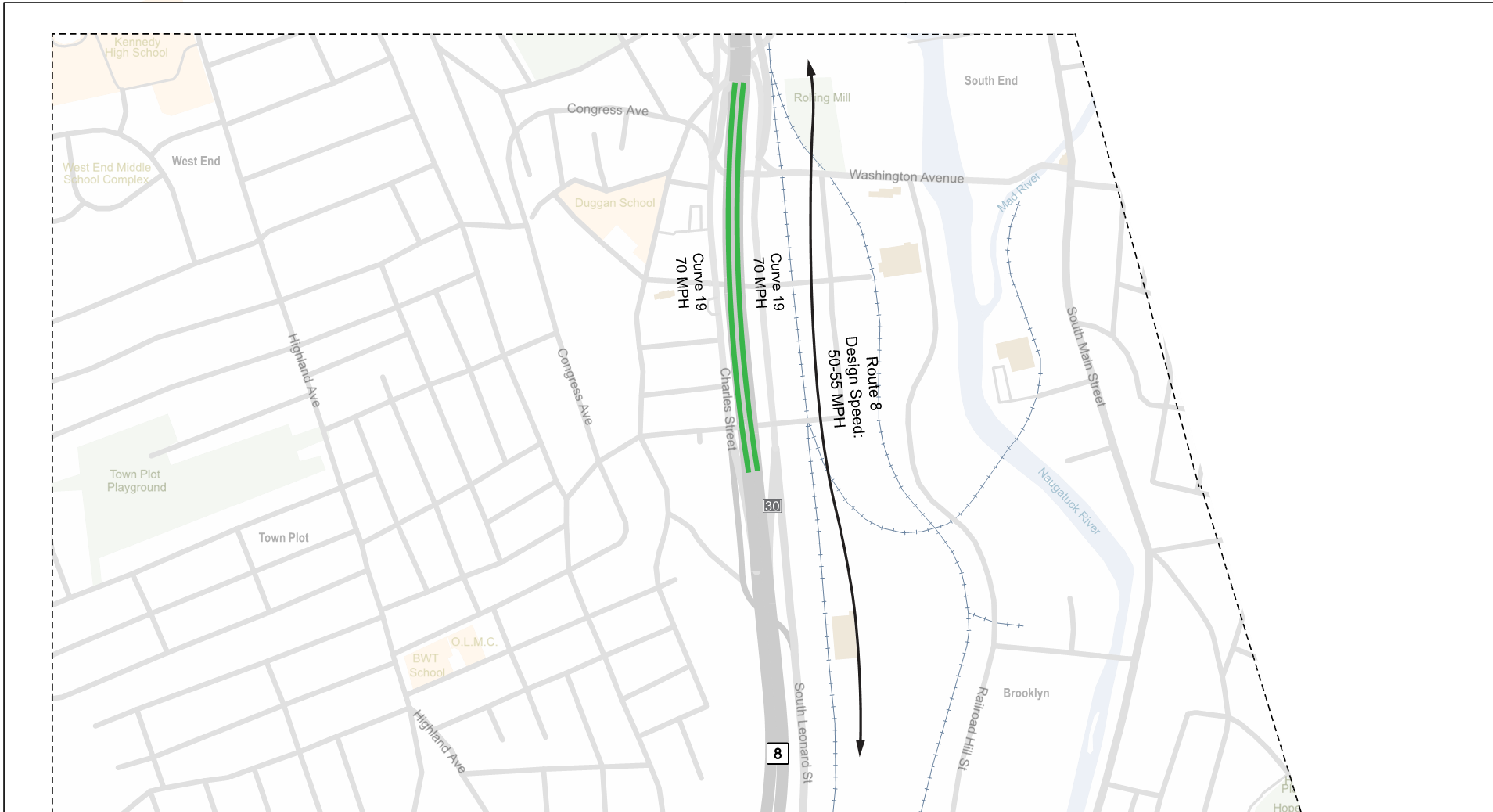
84 new mix

HNTB

I-84 Waterbury Mixmaster Reconstruction Project

Design Speed and Horizontal Alignment Map 4 of 5

Date: 4/29/2020 | Figure No: 2-39

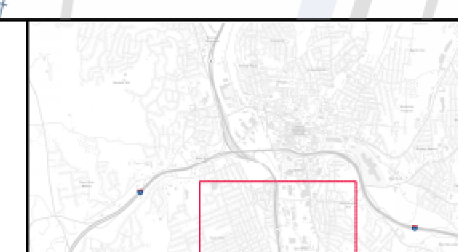


Green	Radii Meeting Design Speed
Yellow	Radii Marginally Meeting Design Speed
Red	Radii Not Meeting Design Speed

- Railroad
- Open Space
- Schools
- 17 Exit

N

0 275 550 1,100 Feet



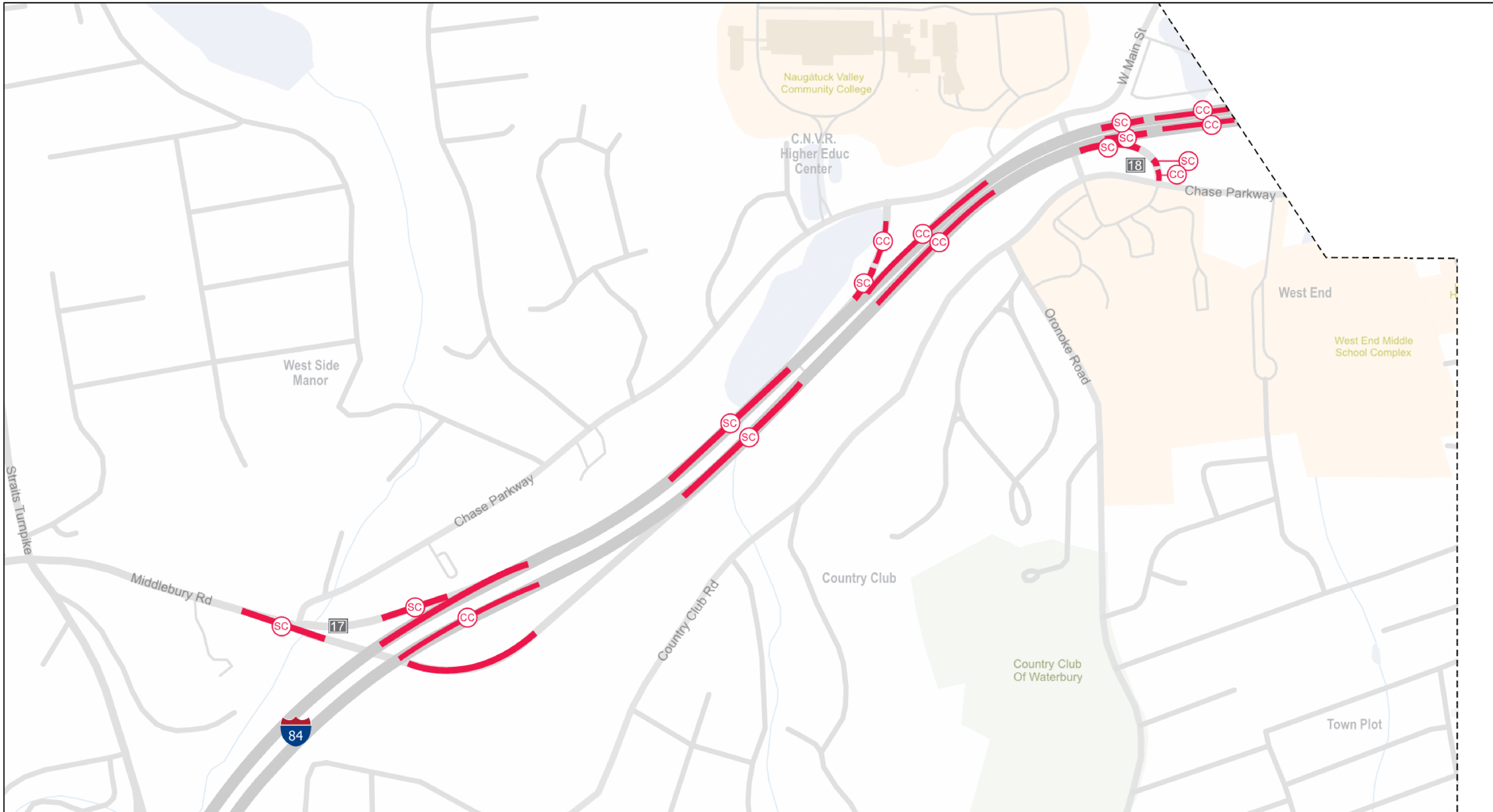
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Design Speed and Horizontal Alignment Map 5 of 5

Date: 11/22/2019 | Figure No: 2-40



Deficient Stopping Sight Distance
CC Deficient Crest Vertical Curve
SC Deficient Sag Vertical Curve

Railroad
Open Space
Schools
17 Exit

N

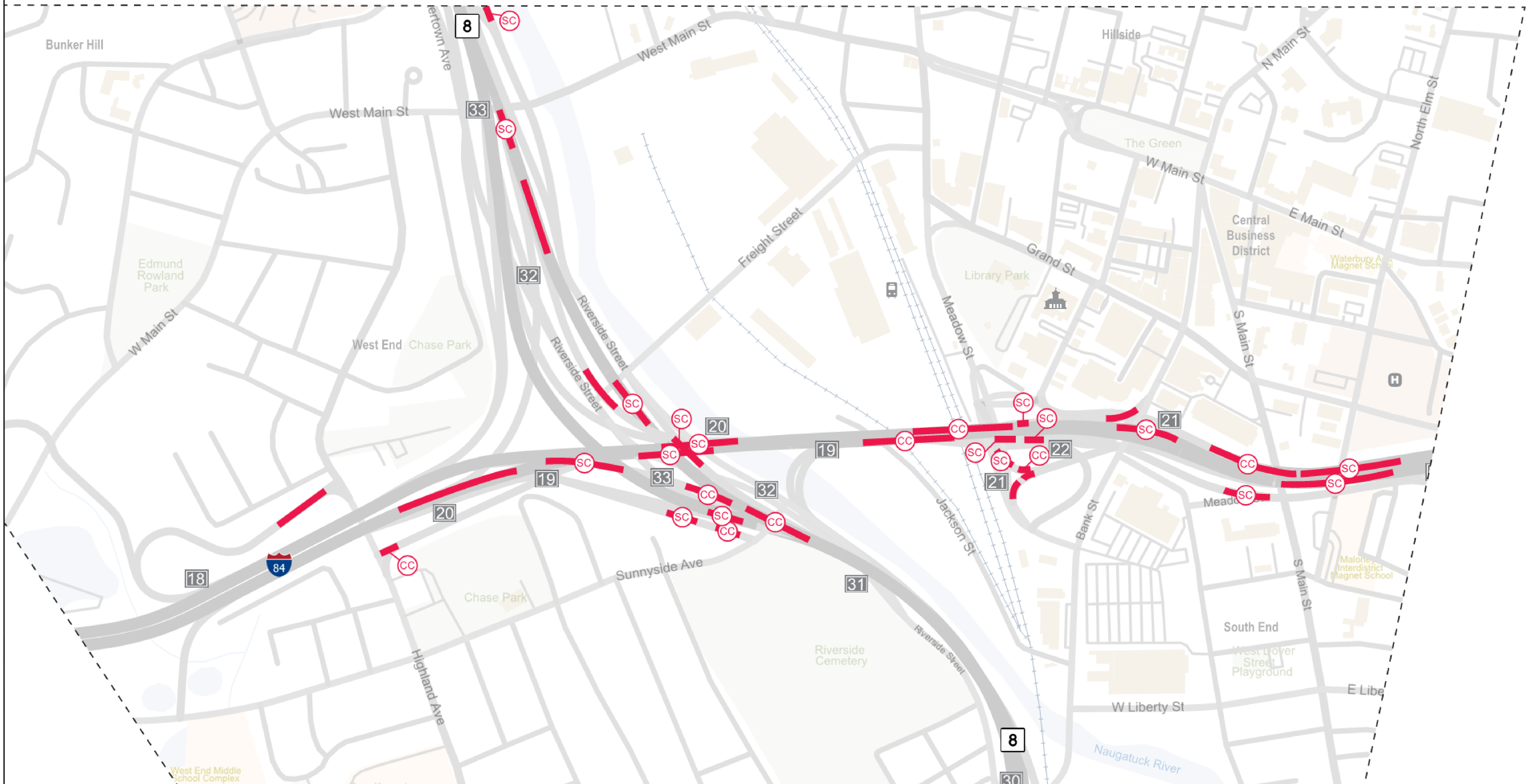
0 275 550 1,100 Feet

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Stopping Sight Distance and Vertical Geometry Map 1 of 5

Date: 11/22/2019 | Figure No: 2-41



Deficient Stopping Sight Distance
Deficient Crest Vertical Curve
Deficient Sag Vertical Curve

Railroad
Open Space
Schools
Exit
Train Station
City Hall

N

0 275 550 1,100 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Stopping Sight Distance and Vertical Geometry Map 2 of 5

Date: 11/22/2019 Figure No: 2-42

Deficient Stopping Sight Distance

CC Deficient Crest Vertical Curve

SC Deficient Sag Vertical Curve

Railroad

Open Space

Schools

17 Exit

N

0 275 550 1,100 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

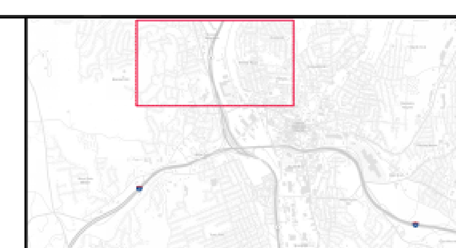
Stopping Sight Distance and Vertical Geometry Map 3 of 5

Date: 11/22/2019 | Figure No: 2-43

Deficient Stopping Sight Distance
CC Deficient Crest Vertical Curve
SC Deficient Sag Vertical Curve

Railroad
Open Space
Schools
Hospital
20 Exit

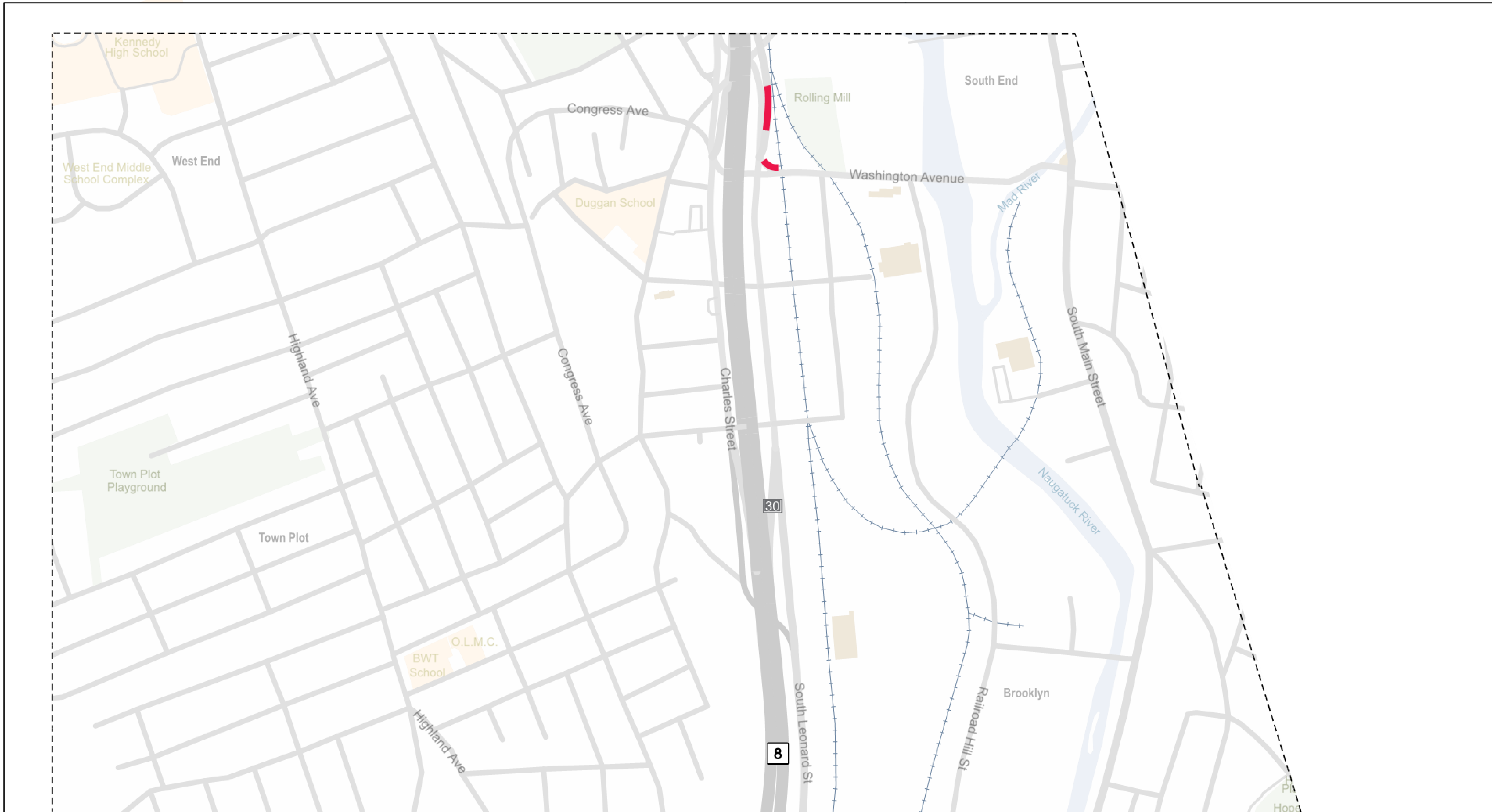
N
0 275 550 1,100 Feet



84 new mix
I-84 Waterbury Mixmaster Reconstruction Project

HNTB
Stopping Sight Distance and Vertical Geometry Map 4 of 5

Date: 11/22/2019 Figure No: 2-44

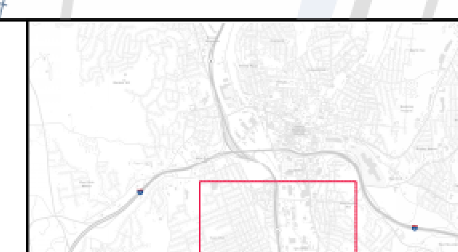


Deficient Stopping Sight Distance
CC Deficient Crest Vertical Curve
SC Deficient Sag Vertical Curve

Railroad
Open Space
Schools
17 Exit

N

0 275 550 1,100 Feet



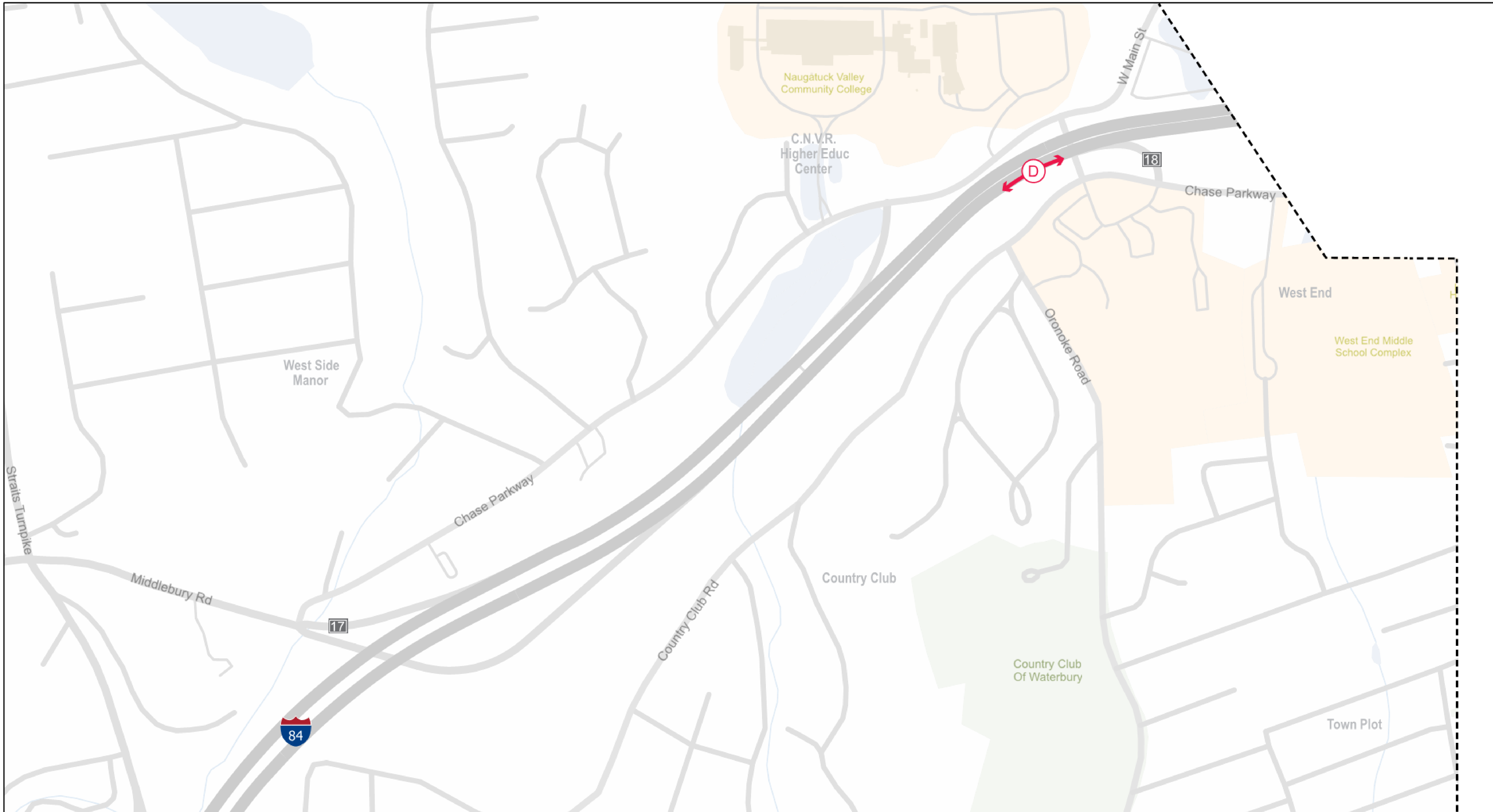
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

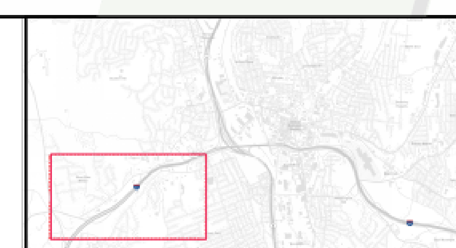
Stopping Sight Distance and Vertical Geometry Map 5 of 5

Date: 11/22/2019 | Figure No: 2-45



L Left Hand Ramp
T Deficient Terminal Spacing
Low Ramp Speed
D Deficient Deceleration Lane
A Deficient Acceleration Lane
Railroad
Open Space
Schools
17 Exit

N
0 275 550 1,100 Feet



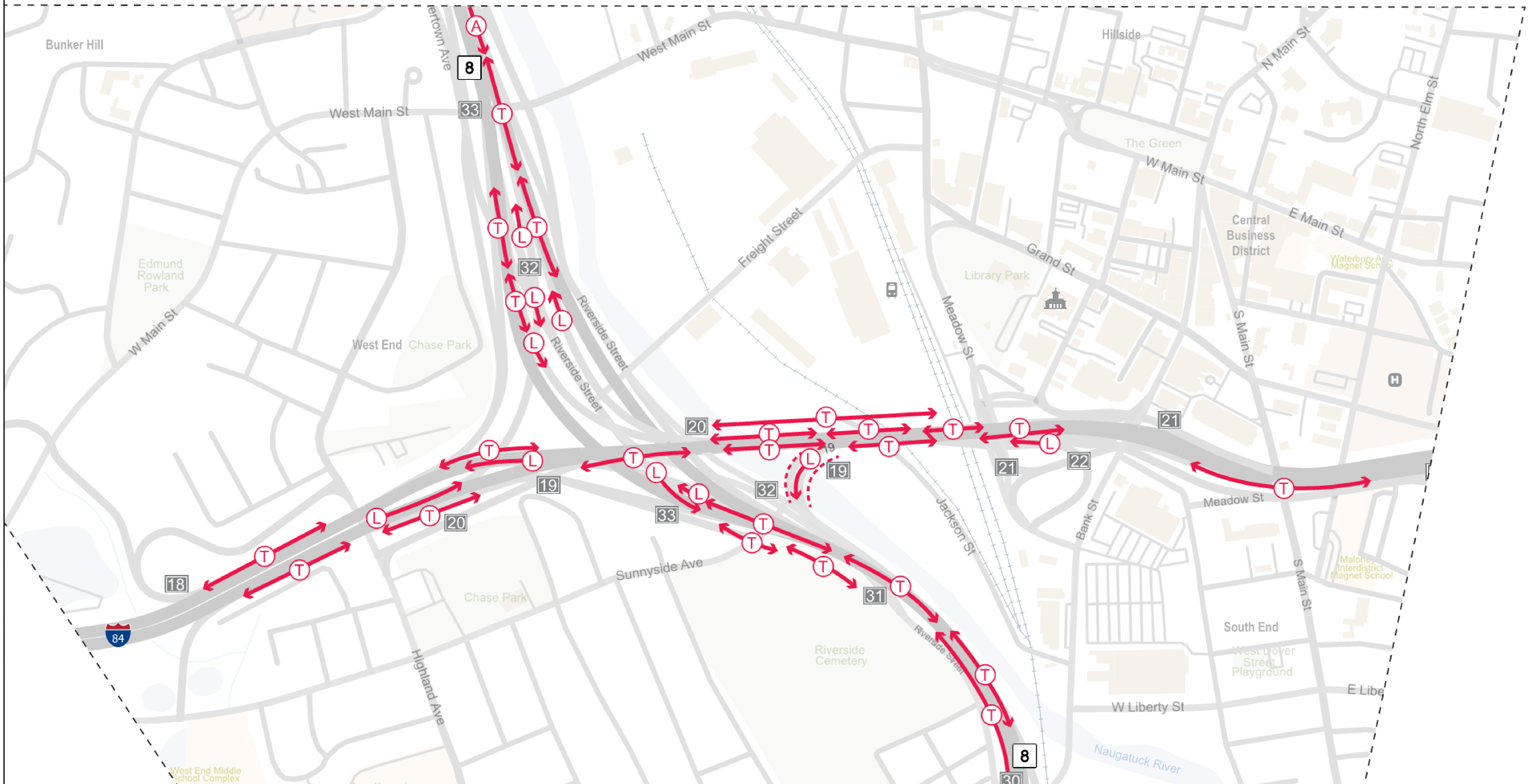
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Ramp Deficiencies Map 1 of 5

Date: 11/22/2019 | Figure No: 2-46



Left Hand Ramp
Deficient Terminal Spacing
Low Ramp Speed
Deficient Deceleration Lane
Deficient Acceleration Lane
Railroad
Open Space
Schools
Exit
Train Station
City Hall

N
0 275 550 1,100 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Ramp Deficiencies Map 2 of 5

Date: 11/22/2019 Figure No: 2-47

L Left Hand Ramp

T Deficient Terminal Spacing

Low Ramp Speed

D Deficient Deceleration Lane

A Deficient Acceleration Lane

Railroad

Open Space

Schools

17 Exit

N

0 275 550 1,100 Feet

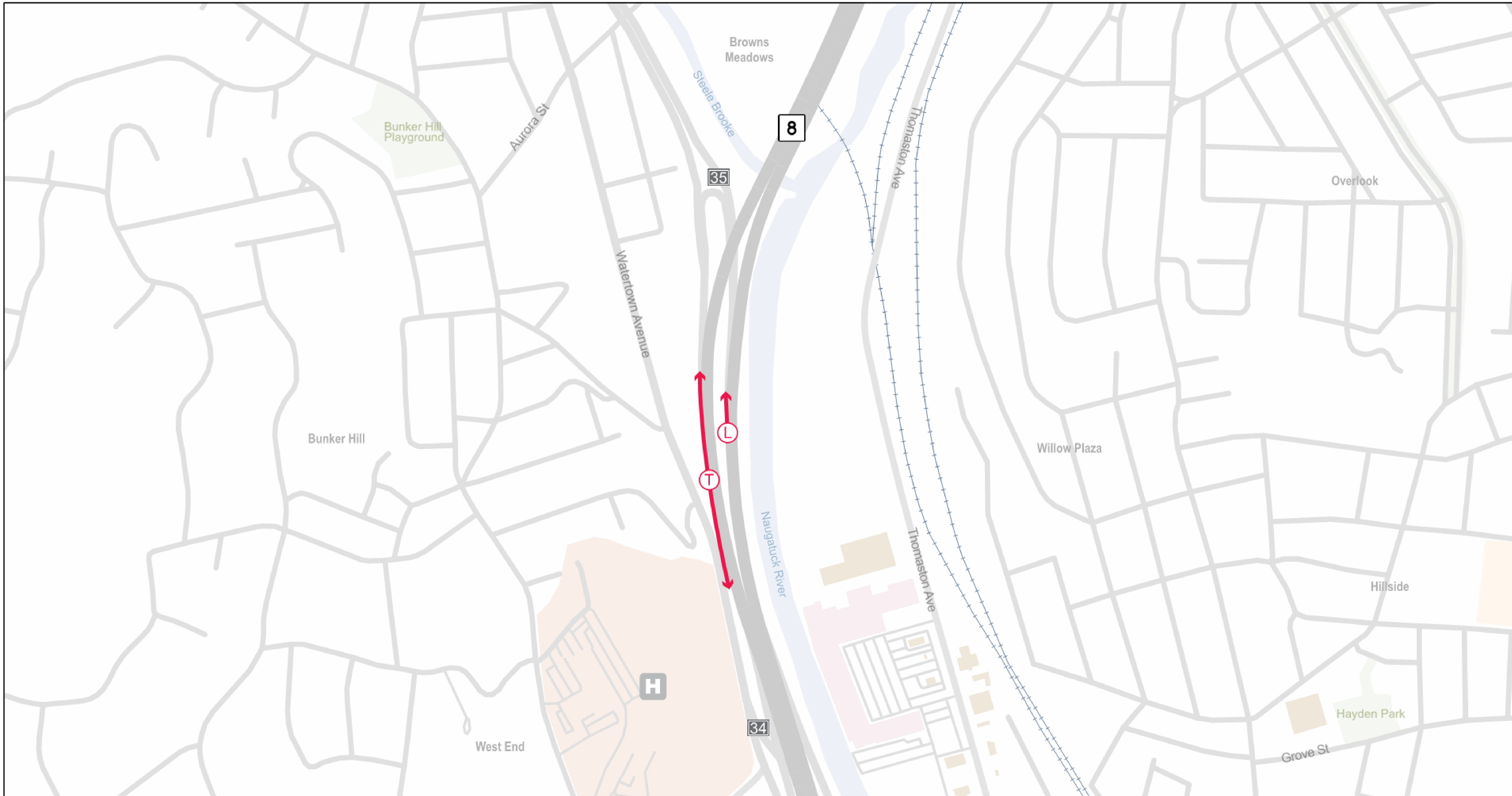
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Ramp Deficiencies Map 3 of 5

Date: 11/22/2019 | Figure No: 2-48



Left Hand Ramp

Deficient Terminal Spacing

Low Ramp Speed

Deficient Deceleration Lane

Deficient Acceleration Lane

Railroad

Open Space

Schools

17 Exit

N

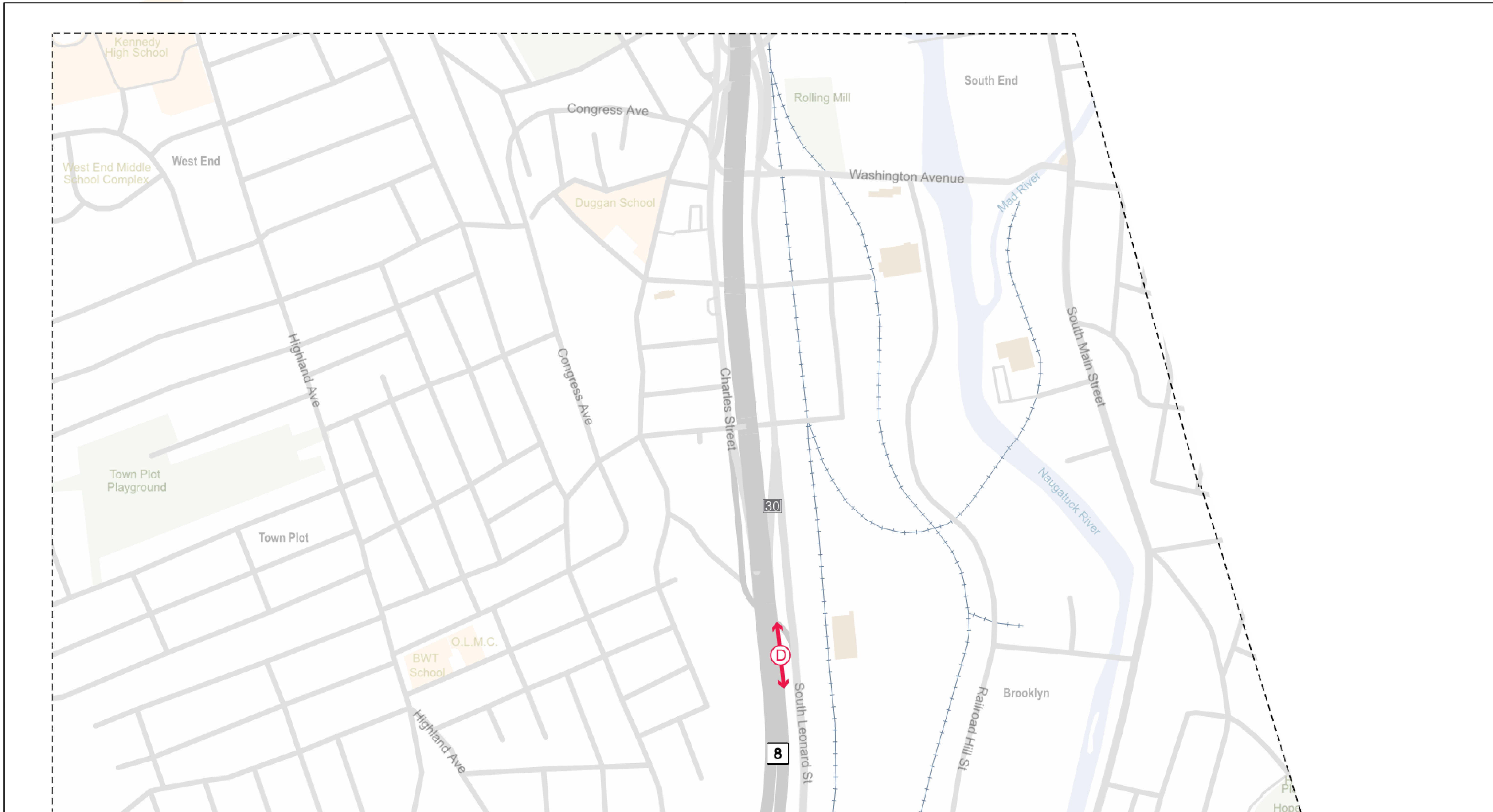
0 275 550 1,100 Feet

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Ramp Deficiencies Map 4 of 5

Date: 11/22/2019 Figure No: 2-49



Left Hand Ramp

Deficient Terminal Spacing

Low Ramp Speed

Deficient Deceleration Lane

Deficient Acceleration Lane

Railroad

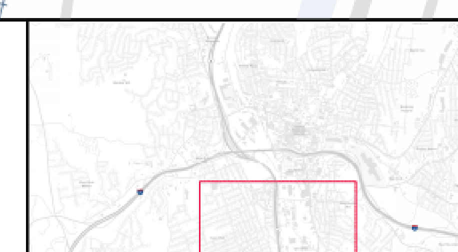
Open Space

Schools

17 Exit

N

0 275 550 1,100 Feet



I-84 Waterbury Mixmaster Reconstruction Project

Ramp Deficiencies Map 5 of 5

Date: 11/22/2019 Figure No: 2-50

2.5 CRASH DATA AND SAFETY ANALYSIS

Crash data for the I-84 and Route 8 interchange system within the Project Study Corridor was obtained for a three-year period (January 1, 2015 to December 31, 2017) from the Connecticut Crash Data Repository (CTCDR). The CTCDR is a source of crash information which is compiled from reports that have been filed by state or local law enforcement officials at the scene of a crash. Crash data is listed by date and includes information about the location, crash type, light, pavement and weather conditions, vehicles involved, direction of travel, severity of injuries, and reason for each incident.

Crash data for 65 local road intersections within the study area was obtained for this same period from the CTCDR and a combination of other data sources. The intersection crash data also included crashes involving cyclists and pedestrians.

These data were compiled, analyzed, then reviewed to summarize crash trends and patterns and to identify potential safety related deficiencies within the study area. The analysis results for crashes occurring on the I-84 and Route 8 mainlines and crashes occurring at intersections are provided in the sections that follow.

2.5.1 I-84 and Route 8 Interchange System

A total of 1,365 crashes along I-84 and Route 8 were reported in the study area during the analyzed three-year period (about one crash per day). A total of 861 crashes occurred on I-84, 189 crashes occurred on Route 8, and 315 crashes occurred on interchange ramps.

The frequency of crashes on I-84 was computed to be 4.5 crashes per million daily vehicle miles traveled (DVMT). This is substantially higher than the average statewide crash rate for all roads of 3.5 crashes per million DVMT. This is significant since crash rates for freeways are typically expected to be lower than the average rate for all roads. The frequency of crashes on this segment of I-84 contributes to non-recurring traffic delays in the Project Study Corridor.

The frequency of crashes on Route 8 was computed to be 3.0 crashes DVMT.

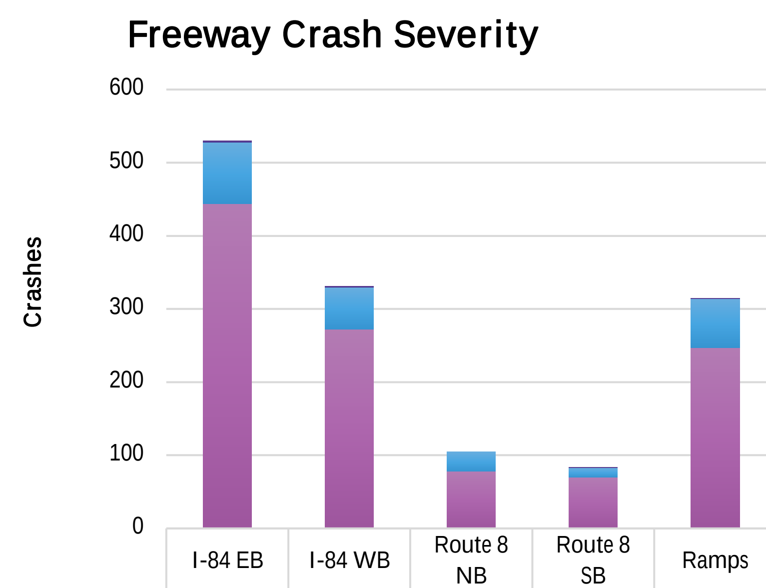
Crash Severity and Crash Types

Overall, the distribution of crash rates by severity and type are generally consistent with expectations given the existing geometry, queueing, and speeds through the study area.

A total of 249 crashes (approximately 18 percent of all crashes) resulted in injury during the study period. A total of 5 fatalities (<1 percent of all crashes) occurred during the study period. Crashes attributed to congestion also typically occur at lower speeds and the high percentage (81 percent) of crashes with no apparent injuries supports this finding. A total of 1,111 crashes resulted in property damage only.

A summary of mainline crash statistics by severity is provided in the following figure.

Figure 2-51 Freeway Crash Severity



	I-84 EB	I-84 WB	Route 8 NB	Route 8 SB	Ramps
Fatality	2	1	0	1	1
Injury	84	58	27	13	67
Property Damage Only	444	272	78	70	247

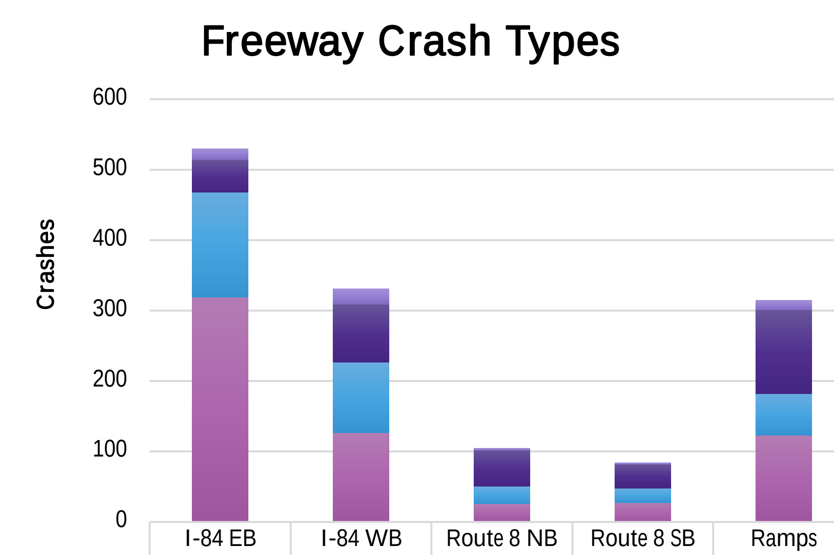
The overall proportion of rear-end crashes (46 percent) seems consistent with observed congested flow conditions where vehicles may need to stop suddenly. Specifically, approximately 60% of I-84 eastbound crashes were rear-end type which corresponds to the higher vehicle density and worse capacity performance observed for eastbound I-84 noted in **Section 2.3 Existing Traffic Operations**.

Similarly, the fixed object crashes that involved no secondary vehicle highlight potential geometric and/or speeding concerns. Fixed object crashes represented a large portion of crashes (45 percent) along Route 8 which can be primarily attributed to existing shoulder widths and compound curve features that do not meet current design standards.

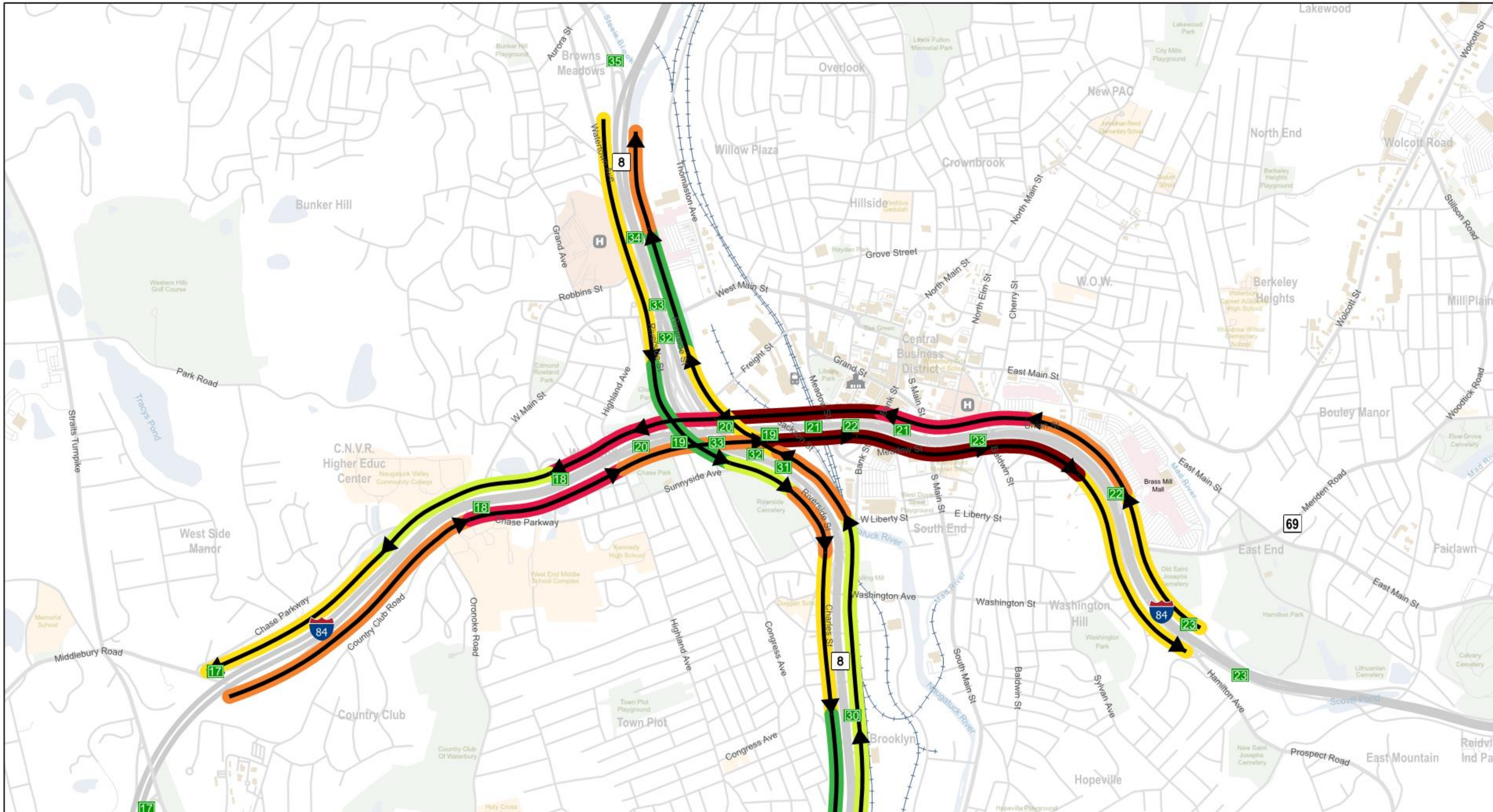
Lastly, sideswipe crashes (25 percent) on limited access highway facilities are usually associated with merging and weaving maneuvers, or attempted avoidance maneuvers attributed to sudden braking for congestion, all of which are prevalent throughout the study area.

A summary of mainline crash statistics by type is provided in the following figure.

Figure 2-52 Crash Type



	I-84 EB	I-84 WB	Route 8 NB	Route 8 SB	Ramps
Other	16	22	3	2	14
Fixed Object	46	82	51	34	119
Sideswipe	149	100	25	21	59
Front to Rear	319	127	26	27	123



LEGEND

Crashes Per Mile

- < 15
- 16 - 30
- 31 - 50
- 51 - 100
- 101 - 200
- > 200

- Railroad
- Open Space
- Schools
- 20 Exit
- Hospital
- Train Station
- City Hall

N

0 1,000 2,000 3,000 Feet

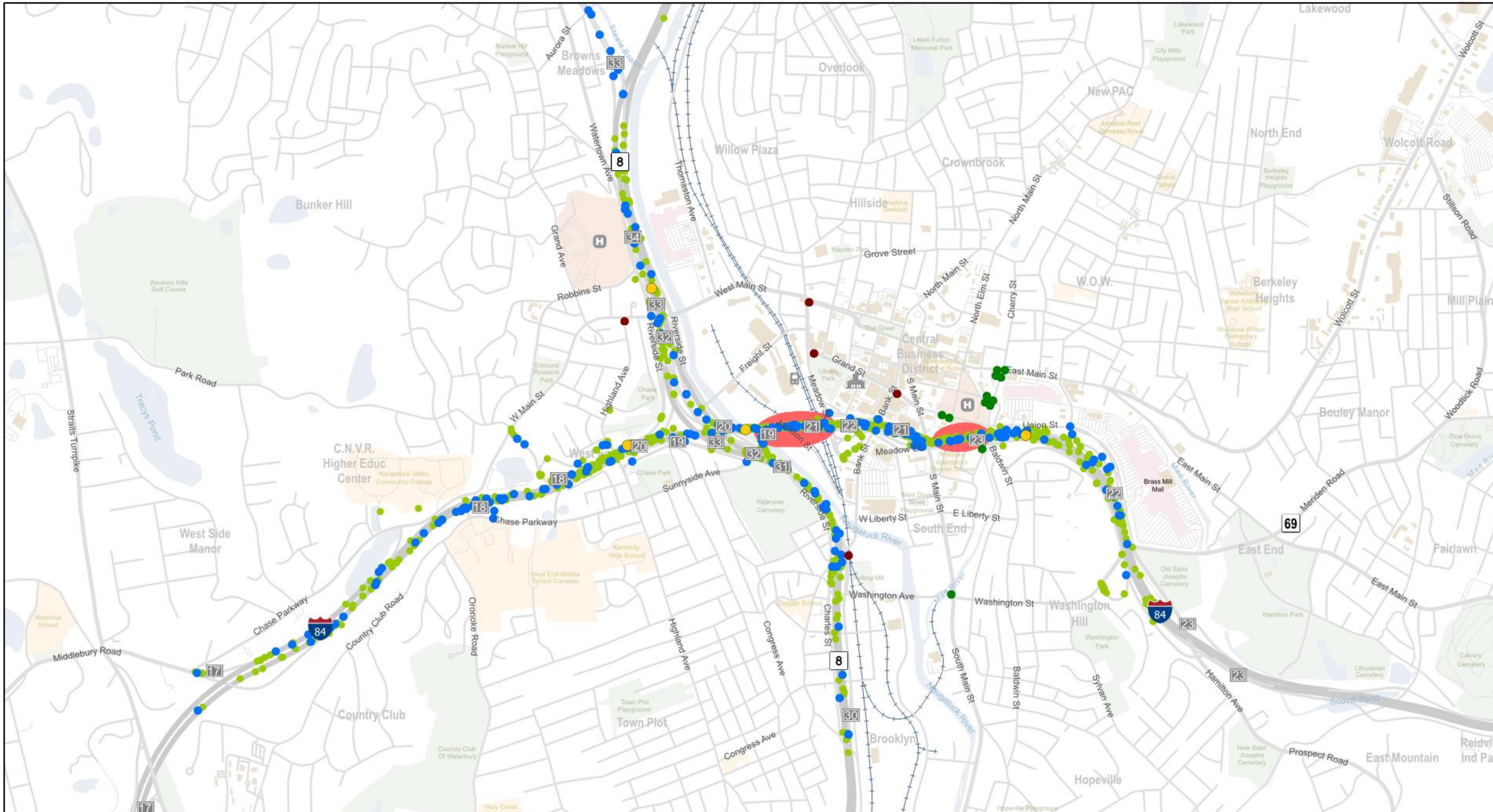
84 new mix

HNTB

I-84 Waterbury Mixmaster Reconstruction Project

Mainline Crash Density Map

Date: 11/22/2019 Figure No: 2-53



- Fatal Injury
- Injury of any type (Serious, Minor, Possible)
- Property Damage Only
- Cyclist Collisions (2015-2017)
- Pedestrian Collisions (2015-2017)
- Crash Hot Spot
- Railroad
- Open Space
- Schools
- 20 Exit
- Hospital
- Train Station
- City Hall

N

0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Crash Severity and Cyclist/Pedestrian Collisions Map

Date: 11/22/2019 Figure No: 2-54

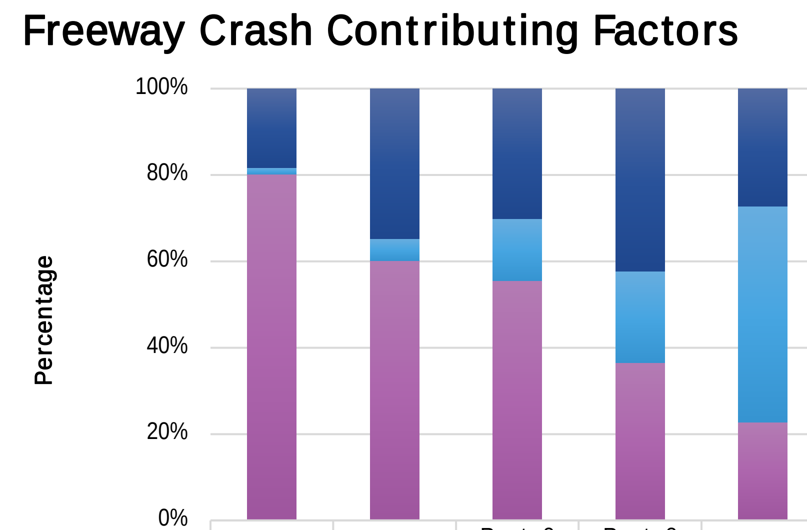
Crash Contributing Factors

A detailed review of incident reports from the crash data set was performed to ascertain the underlying contributing factors to the crash. Documentation of this detailed crash analysis can be found in **Appendix 2.5**. The main conclusions from the analysis are summarized below:

1. The primary contributing factors to crashes on I-84 Eastbound were road geometry (1.57%), traffic congestion (80.11%), and driver behavior and other factors (18.32%). Congestion was generally attributed to the steep grades at the Mixmaster's approach and queuing conditions after the interchange. Geometry and driving behavior related crashes were observed more frequently near the core of the Mixmaster interchange where service ramps become closely spaced.
2. The primary contributing factors to crashes on I-84 Westbound are road geometry (5.08%), traffic congestion (60.17%), and driver behavior and other factors (34.75%). Congestion appeared to be influenced by the presence of a work-zone during the analyzed period. Geometry and driver behavior related crashes became more prevalent as travel speeds increased through and after the interchange.
3. The primary contributing factors to crashes on Route 8 southbound were congestion (55.55%), geometry (14.29%) and driver behavior (30.16%). Geometry and driver behavior influenced crashes were generally explained by observed merging and diverging traffic, lane drops, and weaving conditions.
4. The primary contributing factors to crashes on Route 8 northbound were congestion (36.47%), geometry (21.18%) and driver behavior (42.35%). Geometry and driver behavior influenced crashes can be attributed to merging and diverging traffic, lane drops, and weaving conditions at higher speeds.
5. The primary contributing factors to crashes on the Mixmaster interchange ramps were geometry (50.00%) and driver behavior (27.27%) that was generally attributed to the presence of left hand exits and sharp roadway curvature. Congestion related crashes made up the remainder (22.73%).

A summary of mainline crash statistics by contributing factors is provided in the following figure.

Figure 2-55 Freeway Crash Contributing Factors



	I-84 EB	I-84 WB	Route 8 NB	Route 8 SB	Ramps
Driver Behavior/Other	18%	35%	30%	42%	27%
Geometry	2%	5%	14%	21%	50%
Traffic Congestion	80%	60%	56%	36%	23%

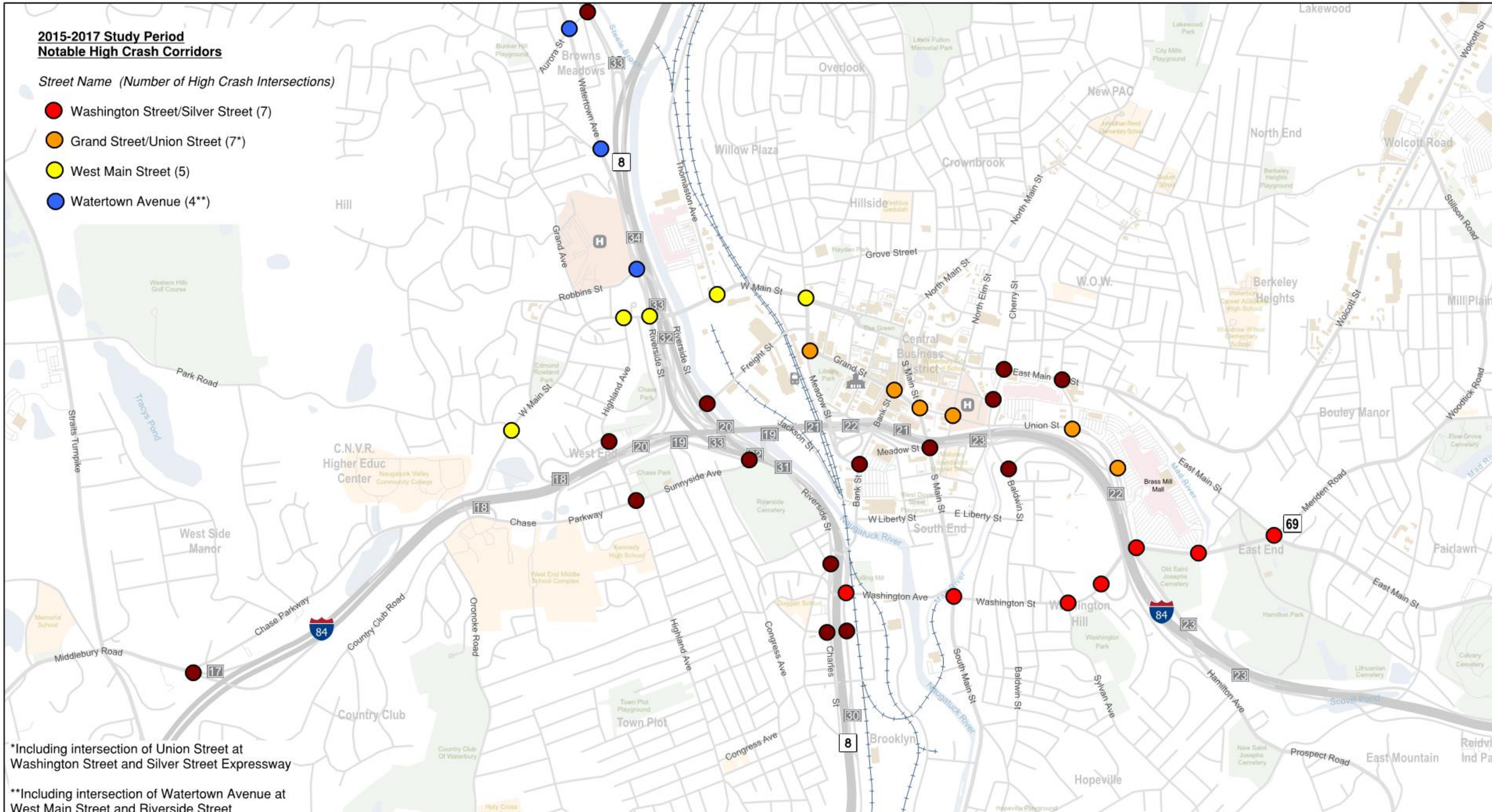
2.5.2 Intersections

A total of 1,715 crashes at 65 intersections were reported in the study area during the analyzed three-year period. This equates to an average of 1.6 crashes per day occurring at a location within the study area. The highest number of reported incidences at a single location was 142 crashes at the intersection of Route 69 (Meriden Road/Silver Street) with East Main Street.

Review of the study area crash data shows that about 69 percent of reported crashes resulted in property damage alone, while the remaining 31 percent involved an injury or fatality. The crash data included 1 fatal crash and 528 crashes that resulted in a potential or confirmed injury. The single fatal crash in the three-year period occurred at the intersection of Route 73 at Aurora Street and East Aurora Street. The crash type was angle, involved two fatalities, and occurred on June 23, 2017 at 7:55 AM.

High crash locations were identified through a two-step screening process. This screening process includes an evaluation of each intersection against a crash quantity threshold along with a critical index threshold which is a measure of the relative crash frequency at each location. The crash quantity threshold is met at any intersection with more than 15 crashes. The critical index measure is a ratio of actual crashes to the intersection's critical crash rate and is met for ratio values equal to or over 1.00. A value greater than 1.00 indicates that the site experiences more crashes than other similar locations in the State. The critical index for each location was calculated using crash rates determined for each study intersection and unofficial critical crash rates previously developed by CTDOT. Of the 65 intersections analyzed, 36 (55%) of the intersections were found to be high crash locations.

High crash intersections are depicted in **Figure 2-56.**



LEGEND

- High Crash Intersection
- High Crash Corridor Intersection (Colors Vary)

2015-2017 Study Period
High Crash Intersection Criteria

Crashes Observed > 15
Actual Crash Rate > Critical Crash Rate

- Hospital
- Train Station
- City Hall
- 20 Exit

N

0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Existing (2017) High Crash Intersection Locations

Date: 11/22/2019 Figure No: 2-56

2.5.3 Bicyclists and Pedestrians

Cyclist and pedestrian crashes were also summarized. There was a total of 27 pedestrian crashes and 3 cyclist collisions in the study area during the analyzed three-year period. There are no existing bicycle facilities at any of the locations where a crash involving a bicycle occurred.

The cyclist collisions occurred at the following intersections:

Table 2-44 Cyclist Collisions (2015 – 2017)

Intersection
Bank Street at Grand Street
Riverside Street at North Leonard Street, Washington Avenue, and CT Route 8 NB On-Ramp
South Main Street at Market Square and I-84 EB Off-Ramp

Intersections with pedestrian collisions are listed below:

Table 2-45 Pedestrian Collisions (2015 – 2017)

Intersection	Number of Collisions
West Main Street at Highland Avenue	1
West Main Street at Meadow and Willow Streets	1
Chase Parkway at I-84 EB On Ramp	1
Meadow Street at Grand Street	1
Bank Street at Grand Street	1
Union Street at Elm Street	2
Union Street at I-84 WB Off Ramp/Brass Mill Drive	1
South Main Street at Washington Avenue	1
Route 69 (Silver Street/Meriden Road) at East Main Street	4
East Main Street at Brass Mill Drive and Welton Street	4
Watertown Avenue at Aurora Street	1
Highland Avenue at I-84 EB On Ramp	1
Baldwin Street at Mill Street	4
Baldwin Street at East Main Street	4

Cyclist and pedestrian collisions are shown on the individual intersection Crash Data Analysis Sheets in **Appendix 2.5.**

2.6 EXISTING STRUCTURAL CONDITIONS

2.6.1 Background

A total of 62 bridges[2] in the study area were identified as being pertinent to the existing (and future) needs of I-84, Route 8, or the Project's constructability. Bridge inspection reports, load ratings, and plans were studied for these bridges to assess their existing structural conditions[3].

Most of the studied bridges carry I-84 and Route 8 mainlines or ramps (system and service); others are overpasses which carry local roads over the highway. Many were built in the 1960s as part of the original "Mixmaster" interchange construction. Deficiencies in these bridges' existing structural conditions were identified through a series of evaluations:

- Physical condition (a condition rating)
- Load carrying capacity (a load rating)
- Functional adequacy (an appraisal rating)
- Sufficiency rating
- Fracture critical bridges and fatigue cracking
- Pile corrosion (where applicable)

Details and results of these evaluations are provided in the following sections.

Note, the results of these evaluations must be understood within the context that this is only a snapshot in time. The original Mixmaster was constructed and opened to traffic in 1968. Since then, at least seven rehabilitation projects have been administered to improve and maintain bridge structural conditions in the Project Study Corridor (see **Figure 2-57)** At least 10 of the 62 bridges studied has planned rehabilitation work in an ongoing or programmed project (see **Table 2-46**). Weighted by deck area, more than 60 percent of these bridges are scheduled for rehabilitation. Furthermore, after a bridge's initial rehabilitation, regular rehabilitation projects are typically required every 20 to 25 years. How rehabilitation projects were accounted for when forecasting future structural conditions is explained further under **Section 3.5 Future Structural Conditions**.

Figure 2-57 Previous Bridge Rehabilitation Projects

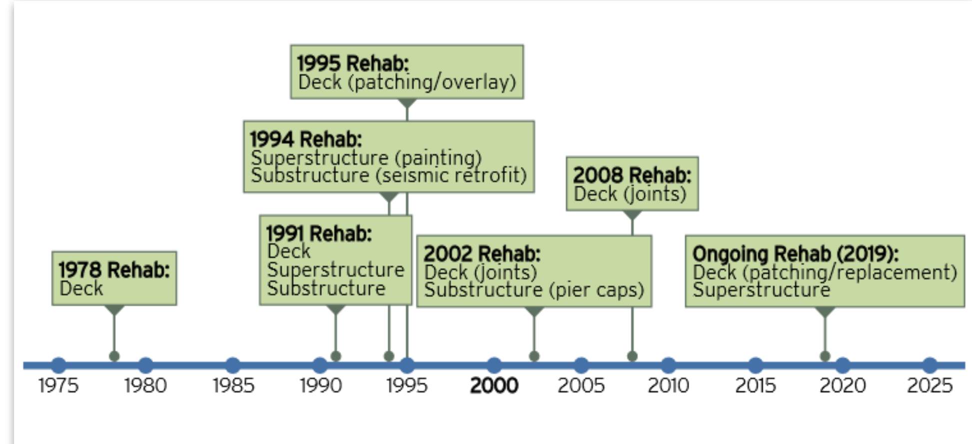


Table 2-46 Current and Planned (2018 through 2022) Bridge Rehabilitation Projects

		Deck						Superstructure					
Bridge No.	**Feature Carried**	**Waterproofing Membrane**	**Deck Joints**	**Deck Repairs**	**Deck Replacement**	**Parapet Replacement**	**Parapet Modifications**	**Steel Repairs**	**Superstructure Strengthening**	**Bearing Replacement**	**Crack Repairs**	**Beam End Repairs and Painting**	**Substructure Repairs**
03190A	RTE 8 NB	✔	✔		✔	✔		✔	✔			✔	✔
03190B	RTE 8 SB	✔	✔		✔	✔	✔	✔	✔			✔	✔
03190C	System Ramp	✔	✔	✔			✔	✔		✔		✔	✔
03190D	System Ramp	✔	✔	✔			✔	✔		✔		✔	✔
03190E	Service Ramp	✔	✔	✔			✔	✔				✔	✔
03190F	System Ramp	✔	✔	✔			✔	✔	✔			✔	✔
03191A	I-84 EB	✔	✔	✔			✔	✔	✔		✔	✔	✔
03191B	I-84 WB	✔	✔	✔			✔	✔	✔		✔	✔	✔
03191D	System Ramp	✔	✔	✔			✔	✔	✔			✔	✔
03191E	System Ramp		✔	✔			✔	✔	✔			✔	✔

[2] Eight out of the 62 studied bridges would be more commonly referred to as culverts based on their structure type. When used in this section the term bridge is meant to include culverts as well.

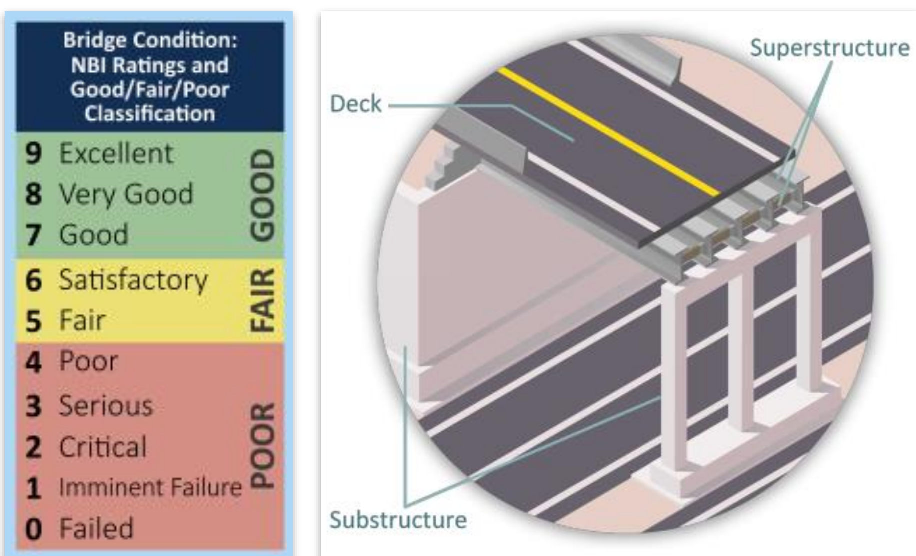
[3] Source information was generally taken from the CTDOT's ProjectWise database. The volume of studied information did not lend to its inclusion as an appendix to this report.

2.6.2 Evaluations and Results

Physical Condition

The CTDOT follows the Federal Highway Administration (FHWA) National Bridge Inspection Standards (NBIS) to inspect and assess the physical condition of the state-owned bridge inventory. Inspectors record NBIS "condition ratings" for major bridge components using a scale from 0 (failed) to 9 (excellent). The condition ratings are assigned during regular inspections to track each components' physical deterioration over time. For a typical bridge, there are three major components which are assigned condition ratings: deck, superstructure, and substructure (see **Figure 2-58**). The lowest of the three component ratings determines the overall condition rating of the bridge. Three ranges of NBIS condition ratings are defined that broadly classify a bridge (and its components) as being in good, fair, or poor condition (see **Figure 2-58**).

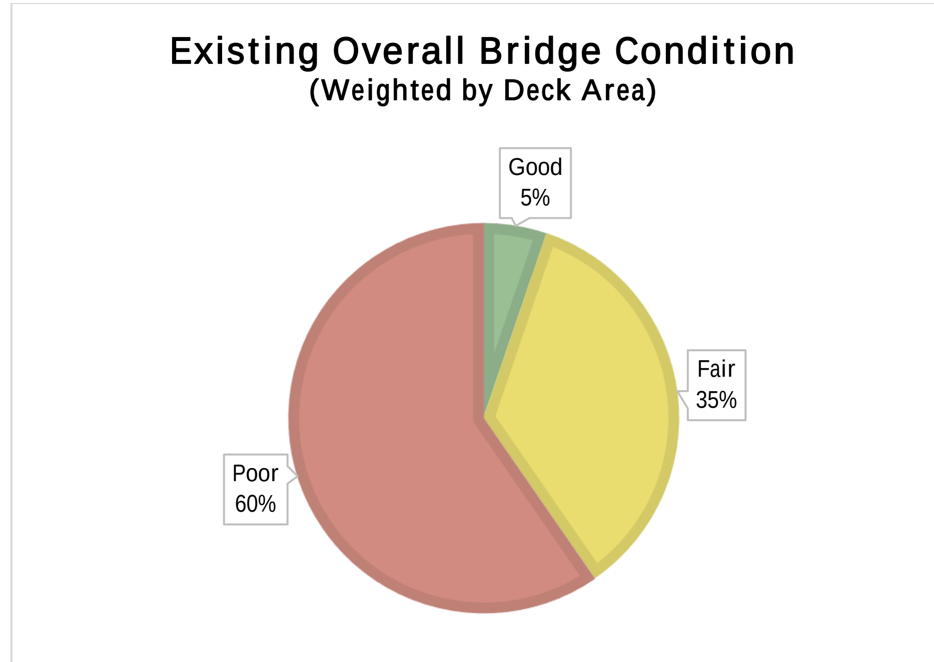
Figure 2-58 NBIS Condition Rating Scale and Example of Major Bridge Components



A bridge that is in poor condition is also considered "structurally deficient." Thus, if any major component is classified as being in poor condition, the overall bridge will be considered structurally deficient. Note that the fact that a bridge is classified as structurally deficient does not imply that the bridge is unsafe, just that deficiencies have been identified that require maintenance,

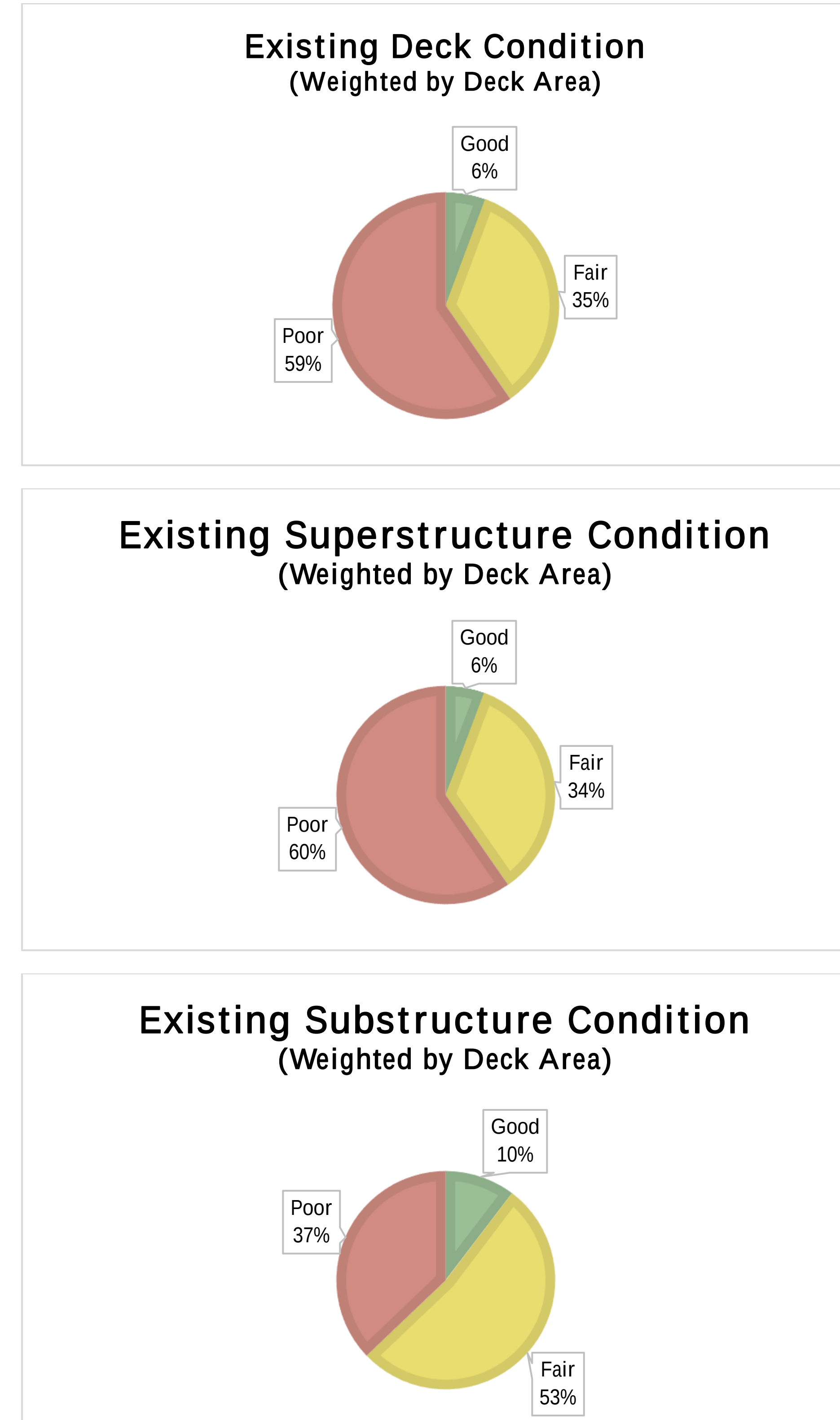
The existing physical conditions of bridges in the project study area were investigated by reviewing current CTDOT bridge inspection reports. Most of these bridges are in overall poor condition and structurally deficient; about 60 percent when weighted by total deck area (see **Figure 2-59**). By this same measure they account for around 17 percent of all structurally deficient bridges in the State's National Highway System (NHS) NBI bridge inventory:

Figure 2-59 Existing Overall Bridge Condition



Existing physical conditions of the studied bridges are also summarized by major components in **Figure 2-60**.

Figure 2-60 Existing Major Bridge Component Conditions



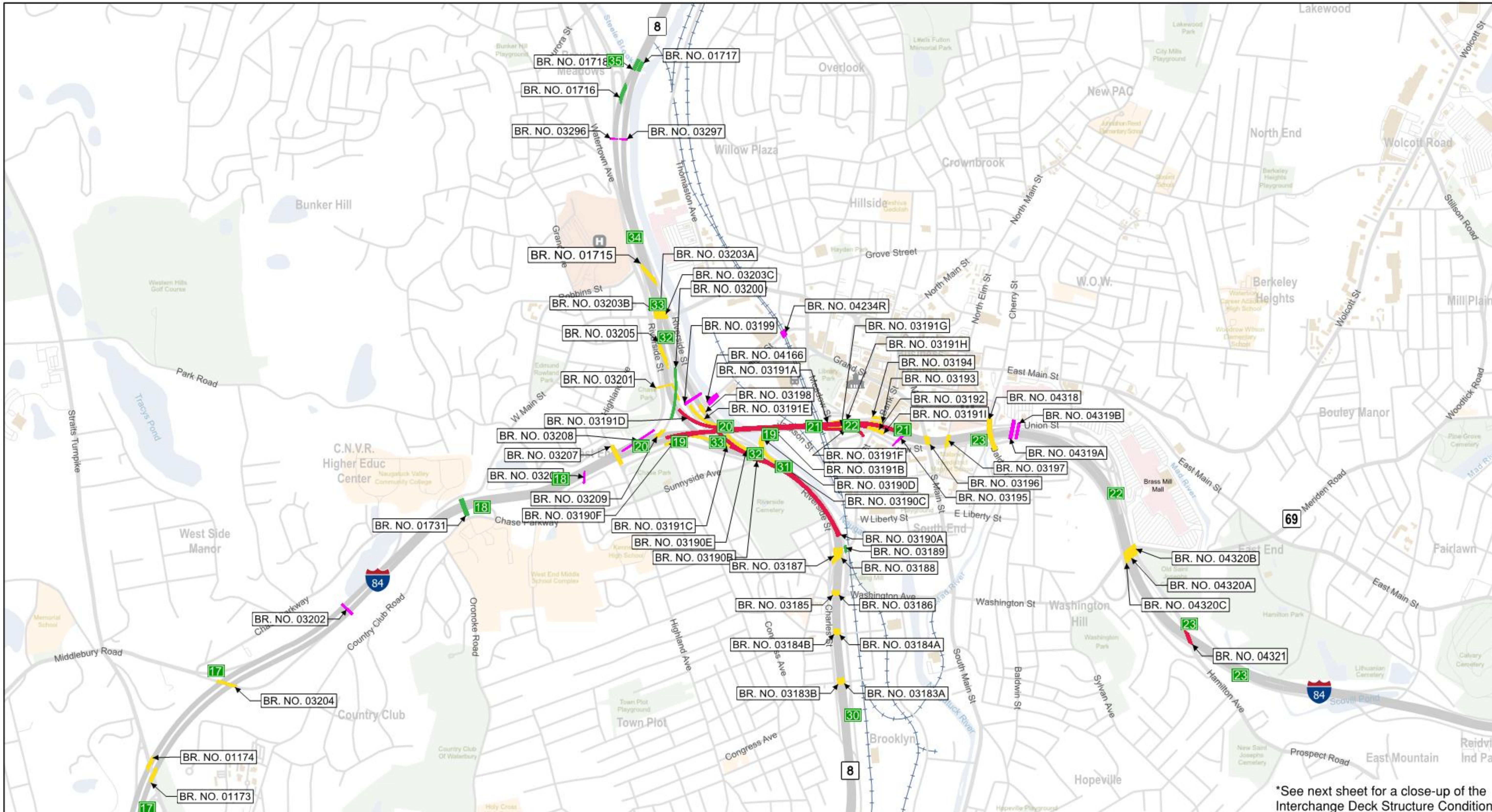
The poor condition of the decks on the stacked I-84 mainline bridges over the Naugatuck River are notable deficiencies among the studied bridges. Continued degradation of the upper bridge deck's concrete is an ongoing safety concern for motorists who travel on the lower deck. Because of this concern, core samples were taken in 2015 at various bridge deck locations and tests were performed to measure the chloride concentrations within these decks. Bridge waterproofing membranes naturally break down over time, commonly resulting in chloride (or salt) contamination of deck concrete from repeated winter applications of deicing agents. These chlorides will accelerate deterioration in a bridge deck when they exceed a certain concentration.

The results of the 2015 sampling and testing were reviewed to supplement condition rating data from inspection reports. Testing results showed that about 40 percent of the 81 sampled locations exceed the acceptable chloride concentration threshold.

Table 2-47 details several geometric characteristics of the studied bridges and shows deck, superstructure, substructure, and culvert (where applicable) condition ratings for each. **Figure 2-61** and **Figure 2-62** that follow show the studied bridge locations and graphically depict their overall physical conditions and deficiencies.

Table 2-47 Characteristics and Existing Conditions of Studied Bridges

					Bridge Condition Rating			
Bridge No.	**Feature Carried/ Crossed**	**No. of Spans**	**Length (Feet)**	**Deck Area (Sq. Feet)**	**Deck**	**Superstructure**	**Substructure**	**Culverts**
01173	I-84 EB over RTE 63 (Middlebury)	3	209	9,222	6	5	7	N/A
01174	I-84 WB over RTE 63 (Middlebury)	3	198	8,657	6	6	6	N/A
01715	RTE 8 over SR 846 NB	1	96	12,048	6	5	6	N/A
01716	RTE 8 SB over RTE 73 WB	3	261	11,432	7	5	6	N/A
01717	RTE 8 SB over Steele Brook	2	183	8,016	7	6	6	N/A
01718	RTE NB over Steele Brook	2	150	6,570	7	7	6	N/A
01731	SR 845 Chase Parkway over I-84 & Ramp 053	2	230	13,271	7	6	6	N/A
03183A	RTE 8 NB over Fifth Street	1	94	4,089	6	7	7	N/A
03183B	RTE 8 SB over Fifth Street	1	94	4,089	5	7	7	N/A
03184A	RTE 8 NB over Porter Street	1	95	4,132	6	7	7	N/A
03184B	RTE 8 SB over Porter Street	1	95	4,133	6	7	7	N/A
03185	RTE 8 NS over Washington Ave	1	73	3,176	6	7	6	N/A
03186	RTE 8 SB over Washington Ave	1	77	3,350	6	7	6	N/A
03187	RTE 8 SB over Bank Street & S. Leonard Street	3	199	11,681	6	6	6	N/A
03188	RTE 8 NB over Bank Street & S. Leonard Street	2	165	7,210	6	6	6	N/A
03189	RTE 8 Ramp 077 over Bank Street	1	106	2,915	7	6	7	N/A
03190A	RTE 8 NB over RTE 8 SB & Local Roads	36	2,634	131,987	3	4	4	N/A
03190B	RTE 8 SB over Riverside Street and Sunnyside Avenue	21	1,589	75,312	4	4	6	N/A
03190C	I-84 TR 811 over I-84 TR 812 & Naugatuck River	9	877	24,188	5	5	5	N/A
03190D	I-84 TR 812 over Riverside Street and Naugatuck River	9	778	21,395	5	5	5	N/A
03190E	RTE 8 Ramp 128 over Riverside Street SB	7	495	13,613	6	6	7	N/A
03190F	I-84 TR 808 over RTE-8 SB & RAMP 129	10	652	17,930	5	4	4	N/A
03191A	I-84 EB over I-84 WB, RTE 8 and Naugatuck River	46	3,766	231,227	4	4	4	N/A
03191B	I-84 WB over RTE 8 and Naugatuck River	30	2,461	154,873	4	4	4	N/A
03191C	I-84 Ramp 169 over I-84 TR 805 & 808	4	408	11,220	5	6	5	N/A
03191D	I-84 TR 809 over RTE 8 NB & Riverside Street	10	781	27,726	4	4	4	N/A
03191E	I-84 TR 810 over RTE 8 NB & Ramp 128	8	630	22,365	6	4	6	N/A
03191F	I-84 Ramp 197 over RAMP 202 Meadow Street	11	672	18,480	4	5	6	N/A
03191G	I-84 Ramp 199 over Meadow Street	3	228	6,316	5	5	6	N/A
03191H	I-84 Ramp 198 over No Notable Feature	1	70	1,890	6	6	5	N/A
03191I	I-84 Ramp 200 over I-84 Ramps 199&202, Bank Street	3	296	10,508	5	6	6	N/A
03192	I-84 Ramp 202 over Bank Street	1	81	2,729	6	7	6	N/A
03193	I-84 WB over Bank Street & Ramp 198	2	133	6,344	6	6	6	N/A
03194	I-84 Ramp 201 over I-84 Ramp 198 & Bank Street	3	195	5,402	5	6	6	N/A
03195	I-84 over Great Brook	1	10	3,500	N/A	N/A	N/A	6
03196	I-84 over SR 847 (South Main St.)	1	64	8,480	6	5	6	N/A
03197	South Elm St. over I-84 & Mcmahon St.	3	201	8,547	6	6	6	N/A
03198	RTE 8 NB over Freight Street	3	138	6,030	5	6	6	N/A
03199	RTE 8 over Sled Haul Brook	1	5	3,725	N/A	N/A	N/A	7
03200	I-84 TR 806 over I-84 TR 808, 809, Riverside	6	703	19,332	7	5	6	N/A
03201	Pedestrian Walk over RTE 8 SB	4	362	3,620	6	7	7	N/A
03202	I-84 over Welton Brook	2	24	6,480	N/A	N/A	N/A	6
03203A	RTE 8 NB over West Main Street No. 1	1	134	9,058	6	6	6	N/A
03203B	RTE 8 SB over Main Street No. 1	1	134	8,589	6	6	6	N/A
03203C	RTE 8 Ramp 131 over West Main Street #1	1	134	4,234	6	6	7	N/A
03204	RTE 94 EB/ I-84 Ramp over I-84	5	387	12,191	6	5	6	N/A
03205	RTE 8 SB over Riverside Street	1	117	12,648	6	6	6	N/A
03206	I-84 EB over Sled Haul Brook	1	10	2,250	N/A	N/A	N/A	6
03207	Highland Ave over I-84	3	288	15,120	6	6	7	N/A
03208	I-84 WB over Sled Haul Brook	1	10	6,000	N/A	N/A	N/A	6
03209	I-84 EB TR 806 over I-84 WB	1	141	5,798	6	7	6	N/A
03296	RTE 8 NB over Dye Shop Brook	1	6	720	N/A	N/A	N/A	7
03297	RTE 8 SB over Dye Shop Brook	1	6	688	N/A	N/A	N/A	7
04166	Freight Street over Naugatuck River	2	178	11,178	N/A	6	6	N/A
04234R	Torrington Secondary over Freight Street	4	95	6,717	N/A	4	4	N/A
04318	Baldwin Street #1 over I-84, Ramps & Local Roads	3	545	37,333	5	6	7	N/A
04319A	I-84, Ramps & Local Roads over Mad River	2	67	24,297	N/A	N/A	N/A	6
04319B	I-84, Ramp, EB Coll over No Notable Feature	1	35	13,152	N/A	7	7	N/A
04320A	I-84 EB over Washington Street	1	164	10,961	6	6	6	N/A
04320B	I-84 WB over Washing Street	1	164	10,783	6	6	6	N/A
04320C	I-84 EB Collector over Washington	1	165	9,059	6	7	6	N/A
04321	RTE 69 over I-84	2	180	9,450	4	5	6	N/A



Overall Condition Rating*

- Condition Rating Is 7 Or Above (Good)
- Condition Rating Is 5 Or 6 (Fair)
- Condition Rating Is 4 Or Below (Poor)
- Condition Rating Not Applicable For this Element

- Railroad
- Open Space
- Schools
- Exit
- Hospital
- Train Station
- City Hall

N

0 1,000 2,000 3,000 Feet

Project Number: 151-331 *Condition Ratings Based on 2016-2018 CTDOT Bridge Inspection Reports

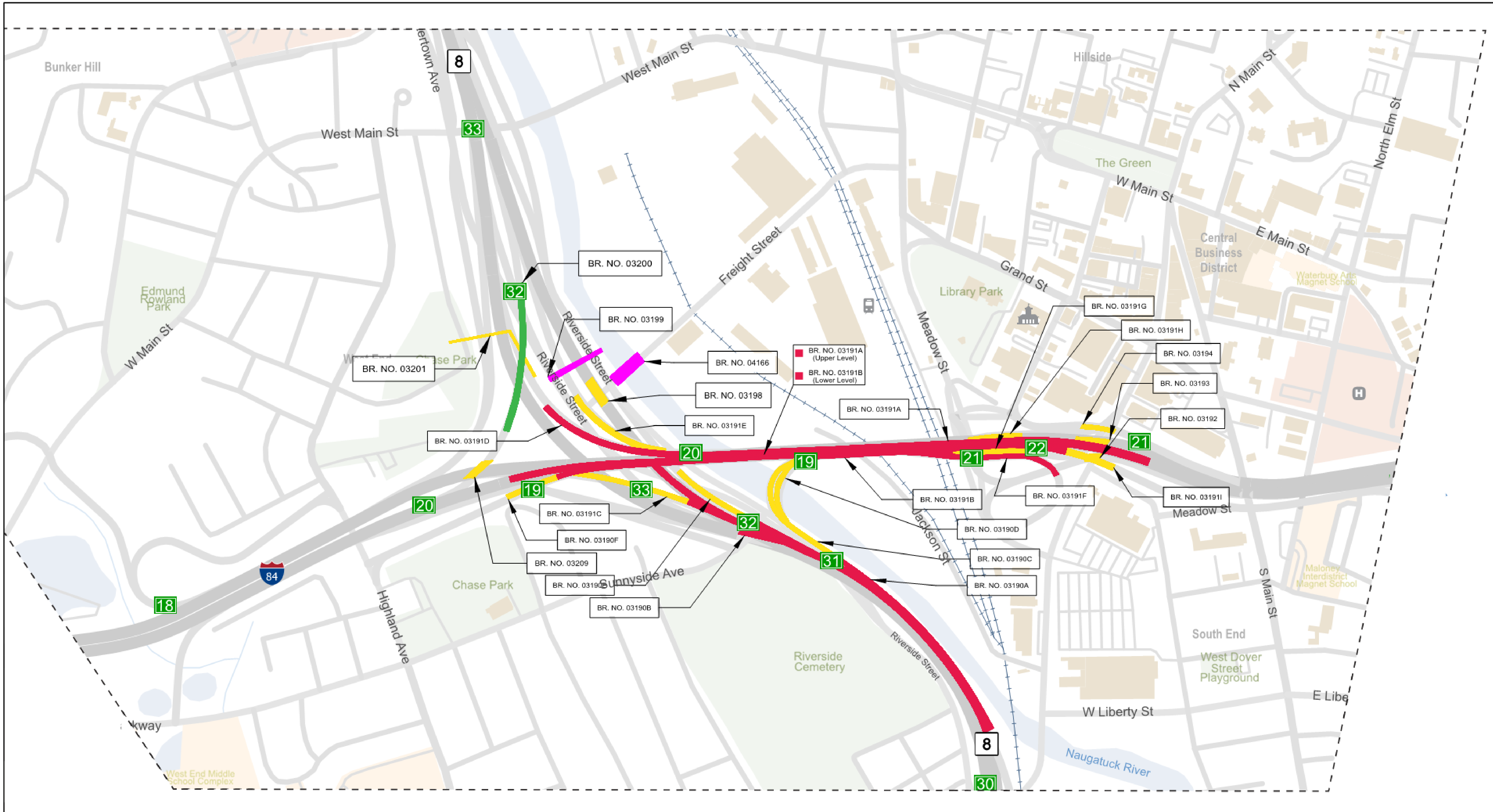
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Existing Physical Conditions Map (Overall Bridge) Study Area Bridges

Date: 11/22/2019 | Figure No: 2-61



Overall Condition Rating*

- Condition Rating Is 7 Or Above (Good)
- Condition Rating Is 5 Or 6 (Fair)
- Condition Rating Is 4 Or Below (Poor)
- Condition Rating Not Applicable For this Element

N

0 275 550 1,100 Feet

Project Number: 151-331 *Condition Ratings Based on 2016-2018 CTDOT Bridge Inspection Reports

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Existing Physical Conditions Map (Overall Bridge) Core Interchange Bridges

Date: 11/22/2019 | Figure No: 2-62

Load Carrying Capacity

Before a bridge is constructed, an engineer designs its structural elements to have a capacity that meets (or exceeds) the anticipated demand from vehicular loading. After construction, bridge inspections are generally performed once every two years to assess physical condition and note any deterioration or damage to structural elements that could reduce load carrying capacity. Based on the observed physical condition, the CTDOT may choose to perform an engineering analysis that will produce a "load rating" for the bridge.

Load rating analyses are performed to assess an in-service bridge's safe load carrying capacity by considering various vehicle loading patterns, physical deterioration, and other uncertainties. Load ratings are developed for vehicular loads that the bridge can carry safely on a regular basis (a legal load rating) and the maximum allowable loads for permitted vehicles that periodically use the bridge (a permit load rating).

The load carrying capacity of the studied bridges was evaluated by reviewing current CTDOT bridge inspection and load rating reports. Load ratings of all 62 bridges within the study area were satisfactory for legal vehicles. In addition, at the completion of the ongoing rehabilitation project (State Project Nos. 151-312/313/326) the Mixmaster will have satisfactory ratings for all permit vehicles which regularly operate in Connecticut.

Functional Adequacy

The CTDOT monitors the functional adequacy of the state-owned bridge inventory using "appraisal ratings" that are defined by the NBIS. Appraisal ratings are used to establish a bridge's relative level of service by comparing details of its construction to current standards for new construction. The functionality of the bridge is appraised by assessing the following criteria:

- Traffic safety features
- Structural evaluation
- Deck geometry
- Underclearance
- Bridge posting
- Waterway adequacy
- Approach roadway alignment

The functional adequacy of the studied bridges was evaluated by reviewing current CTDOT bridge inspection reports. Bridges that would qualify as "functionally obsolete" by the CTDOT's criteria were identified. Functionally obsolete bridges are generally those that do not have adequate lane widths, shoulder widths, vertical clearances, or those that occasionally flood. Over 40 percent of the studied bridges qualify as deficient due to the functional obsolescence.

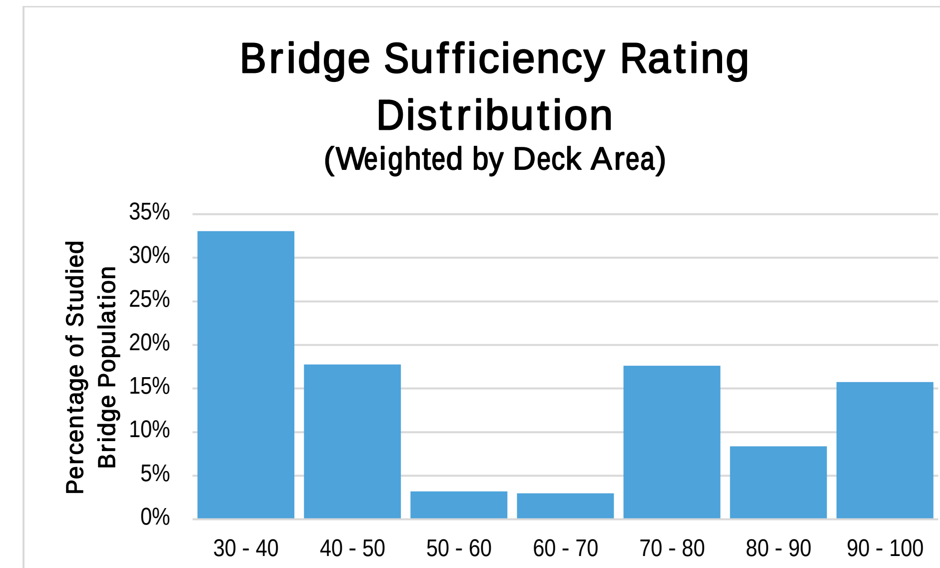
For detailed information on appraisal ratings refer to the FHWA's Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges.

Sufficiency Rating

A sufficiency rating is a value from 0 to 100 percent which indicates a bridge's sufficiency to remain in service. It is calculated with an FHWA prescribed formula that considers "essentiality for public use" in addition to condition rating, load rating, and appraisal rating data (see previous sections). Sufficiency ratings are used primarily as a planning tool for prioritization of bridge projects.

The sufficiency ratings of the studied bridges were summarized from current CTDOT bridge inspection reports and weighted by deck area (see **Figure 2-63** below). More than 50 percent of the studied bridges have a sufficiency rating of less than 50.

Figure 2-63 Bridge Sufficiency Rating Distribution



Fracture Critical Bridges and Fatigue Cracking

Most steel bridges are designed to be redundant, meaning their structural system is capable of carrying loads after localized damage or the failure of one or more of its members. Some bridges lack this desirable redundancy because one or more of its primary load carrying members are considered "fracture critical." Fracture critical bridges per the NBIS definition are steel bridges having primary members whose individual failure would probably cause a portion of, or the entire bridge, to collapse.

Fatigue cracks (with respect to bridges) are cracks in steel members that initiate and are propagated by cyclic loading in regions of concentrated tensile stress. Put more simply, fatigue cracking and fracture is what happens when you repeatedly bend a wire hanger or the tab on an aluminum can. Modern bridge design codes have made provisions to prevent in-service fatigue cracking. However, there are many bridges still in service which have details that would be considered "fatigue prone" by modern standards.

Fracture critical bridges and spans in the study area were identified by reviewing current CTDOT bridge inspection reports. When weighted by deck area, about 19 percent of the studied bridges (43 spans) contain members or details that classify them as fracture critical. The overwhelming majority of these fracture critical spans are located on mainline bridges. Many of these spans have also experienced active fatigue related cracking for decades.

The existing condition of these fracture critical spans is a notable deficiency among the studied bridges. Rehabilitation projects have been performed regularly (and are ongoing) to stop the propagation of cracks in fracture critical members. However, these existing fatigue prone details cannot be fully addressed through rehabilitation work. Consequently, it is anticipated that crack formation and propagation will continue at many of the studied bridges until they are completely replaced.

Pile Corrosion

As part of the Interstate 84/Route 8 Interchange (Mixmaster) project in Waterbury, the HNTB Team was requested by Connecticut Department of Transportation (CTDOT) to perform a subsurface exploration program to investigate the fill material and subsurface composition at substructure locations within the Mixmaster. The intent of the subsurface exploration program was to determine if the fill material below specific foundations presented a potential to cause accelerated corrosion of the steel H-piles supporting those foundations. Waterbury, being an older industrial city with many former industries along the Naugatuck River including brass factories, has fill materials that contain cinders, ash, and other acidic materials that, when combined with groundwater, can cause corrosion of metals at the interface with the groundwater level. The Mixmaster was constructed in the mid to late 1960s as a series of bridges that were built upon manufactured fills at various locations throughout the interchange. Many of the Mixmaster superstructure spans were constructed on steel h-pile supported foundations. H-pile supported foundations have been found to be susceptible to accelerated corrosion if the underlying fill material provides a favorable environment for a corrosion cell to occur. The basis of this study was to determine if the underlying materials and subsurface environment within the interchange produced this excessively corrosive environment for the H pile foundations supporting the Mixmaster interchange.

Seven (7) pile supported pier locations were selected for the investigation. Field borings were completed in May of 2019 and one hundred and two (102) split spoon samples were obtained for testing from the seven (7) locations. The borings varied in depth from 17' to 44'. The samples were tested for Chlorides, Electrical Resistivity, Oxidation-Reduction Potential, pH, Sulfates, and Sulfides.

The results from both the field exploration and lab testing showed very few and localized locations with borderline corrosivity potential due to the in-situ fills. There is no large scale or consistent pattern of factors that would indicate an environment that could cause accelerated corrosion rates of the existing steel H-piles that support the bridge foundations; therefore, the conclusion was that field results and lab data support a finding of minor concern regarding the potential accelerated corrosion of the existing steel H-piles. Based on these findings, additional investigations were not considered warranted.

2.6.3 Summary

There are 62 bridges in the study area which have a combined total deck area of about 1.1 million square feet. During the last 50 years there have been at least seven rehabilitation projects to address structural deficiencies and extend the service life of these bridges. About 60 percent of the studied bridges are presently in poor condition when weighted by total deck area, however, all have satisfactory ratings for legal vehicles. Weighted by deck area, over 40 percent of the studied bridges are functionally obsolete and over 50 percent have a sufficiency rating that make their complete replacement eligible for federal funding.

The decks of the stacked I-84 mainline bridge over the Naugatuck River are in poor physical condition. Recent testing performed on these decks has shown that the concrete has been contaminated with an unacceptable amount of chlorides which will continue to accelerate its deterioration. Continued degradation of top deck concrete is an ongoing safety concern for motorists who travel on the lower deck.

About 19 percent of the studied bridges are considered fracture critical. Some of these fracture critical bridges have fatigue prone details which have caused reoccurring problems with crack formation in steel members. Crack propagation has been managed over the past 30 years, but it is expected that cracks will continue to develop and propagate at multiple fatigue prone locations for the remainder of the structures' service lives.

Finally, the corrosion potential for existing steel pile bridge foundations was investigated. The investigation concluded that the corrosion potential of soils in the study are low.

3 Future (2045) Transportation Conditions

Traffic and structural conditions have been forecasted for the year 2045 and analyzed to identify future needs and deficiencies in the Project Study Corridor. The results from these analyses represent a future "no build" scenario that will be used during the Project's development as a benchmark condition for comparing Project improvement concepts.

Analyses of future traffic operations and future structural conditions are provided in the sections that follow. These analyses build upon the data, models, discussion, and conclusions from the previous **Section 2.0 Existing (2017) Transportation Conditions**.

3.1 FORECASTING TRAFFIC GROWTH

The study developed 2045 trip information by using the Travel Demand Model developed under Existing Conditions along with CTDOT's 2045 Travel Demand Model to establish a new 2045 Travel Demand Forecasting Model. A detailed explanation of this process and supporting documentation is provided in **Appendix 3.1** (refer to **Macroscopic Model Development and Calibration**)

Table 3-1 illustrates the daily change in vehicle miles traveled (VMT) in the subarea network from 2017 to 2045. VMT is calculated by taking the daily traffic for a roadway segment multiplying that by the length of a segment and summing all the segments for a geographic area of concern. In general, the total VMT in the network increased by about 8.6% between 2017 and 2045.

Table 3-1 2017 and 2045 VMT Comparison

Facility Type	2045 VMT	2017 VMT	Difference	
			VMT	%
Freeway	2,893,226	2,747,498	145,728	5.3
Major	1,432,198	1,309,118	123,080	9.4
Minor	3,234,191	2,968,148	266,043	9.0
Collector	3,216,702	2,904,025	312,677	10.8
Ramp	411,626	369,135	42,491	11.5
Total	11,187,943	10,297,924	890,019	8.6

3.2 FUTURE TRAFFIC VOLUMES

Traffic volumes were projected to the year 2045 based on the Travel Demand Model developed by the HNTB Team. The volumes produced by the model were used as a basis for the 2045 volumes, which were balanced and reflected trends in the existing 2017 volumes. To maintain consistency with the expressway analysis, the arterial street network was balanced based on the ramp termini volumes.Daily and Peak Hour traffic volumes for the study area are depicted in **Appendix 3.2** (refer to **Future (2045) Peak Hour Travel Volume Figures**).

Figure 3-1 through **Figure 3-4** provide a comparison between existing (2017) and future (2045) "no build" traffic volumes for the freeway mainlines.

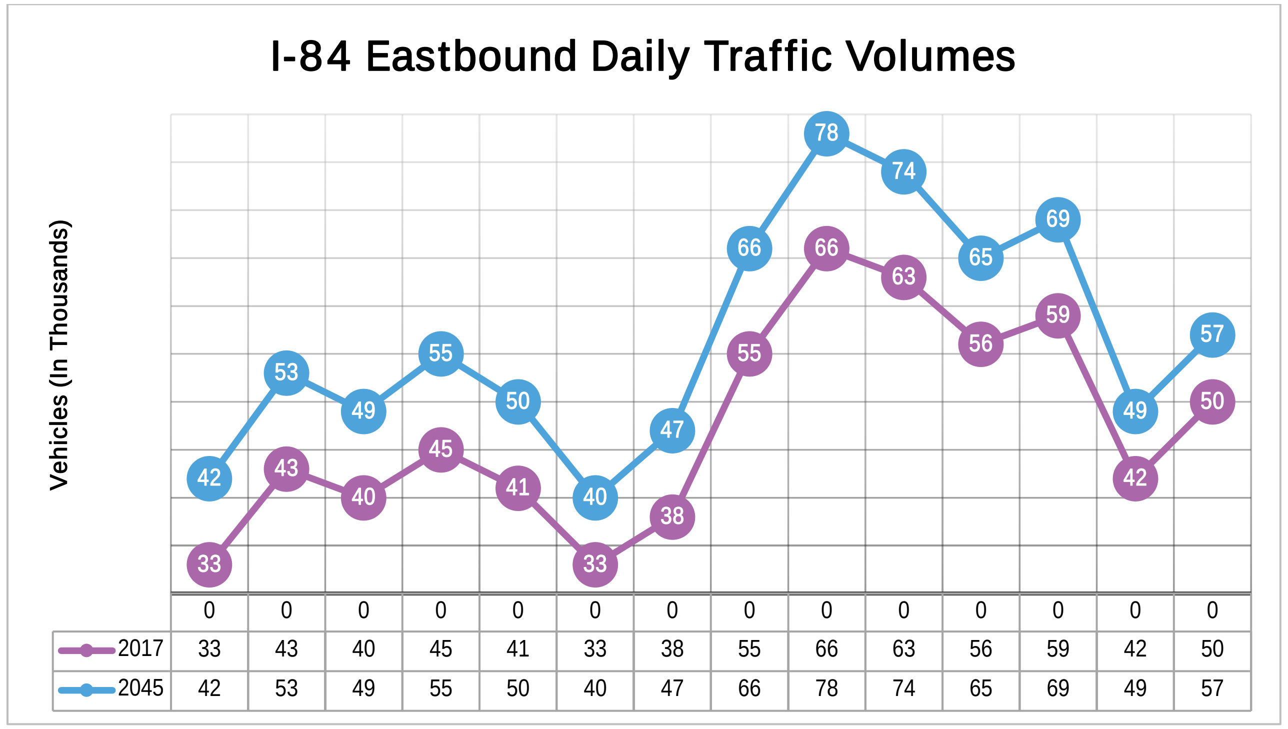
Significant future "no build" traffic volume observations are summarized below:

Table 3-2 2045 Traffic Volume Observations

Facility	Traffic Volume Growth in Percentage		Minimum Volume Location	Maximum Volume Location
	ADT	Peak Hour		
I-84 Eastbound	14%-27%	9%-35%	East of Exit 20 Off-Ramp (40,100 VPD)	East of Exit 19 On-Ramp (77,900 VPD)
I-84 Westbound	8%-18%	2%-19%	West of Exit 17 Off-Ramp (38,700 VPD)	East of Exit 21 Off-Ramp (76,000 VPD)
Route 8 Northbound	7%-20%	13%-32%	South of Exit 33 On-Ramp (18,200 VPD)	South of Exit 35 Off-Ramp (54,600 VPD)
Route 8 Southbound	9%-15%	5%-20%	North of Exit 33 Off-Ramp (16,700 VPD)	North of Exit 34 On-Ramp (53,800 VPD)

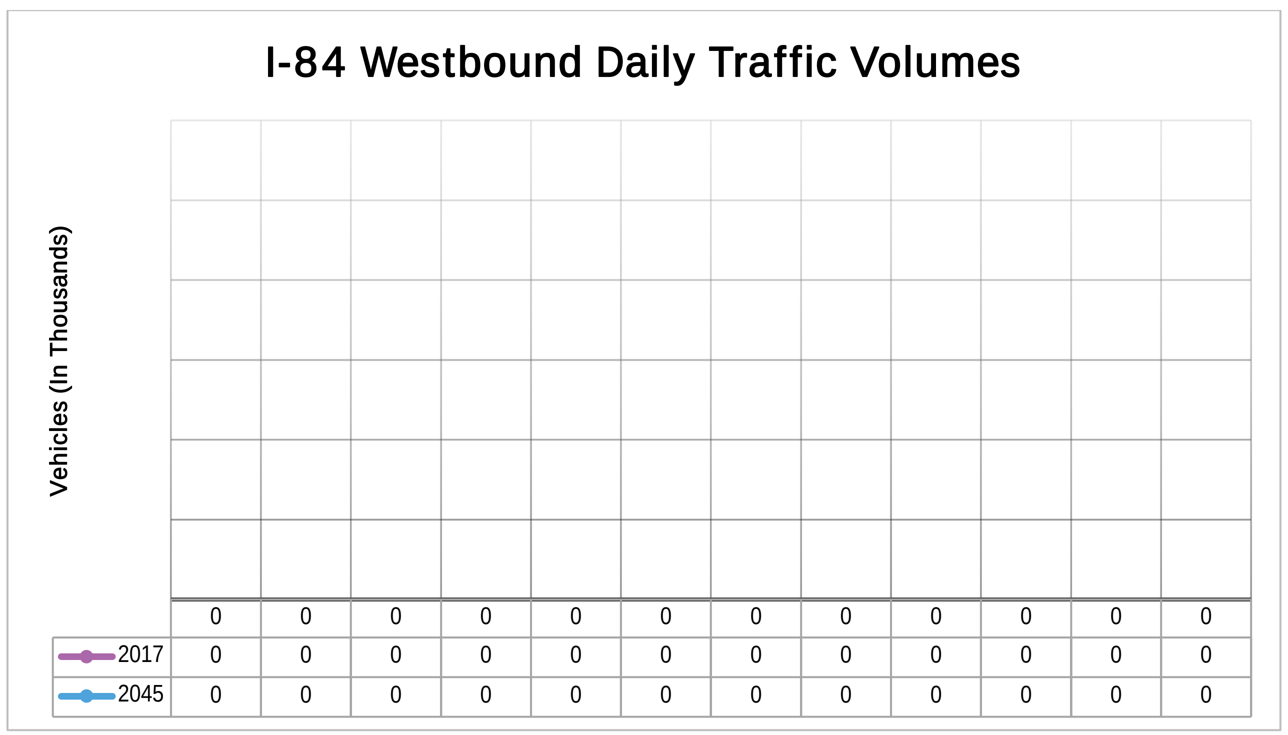
Note: VPD = Vehicles Per Day

Figure 3-1 I-84 Eastbound 2017 vs 2045 Daily Traffic Volumes



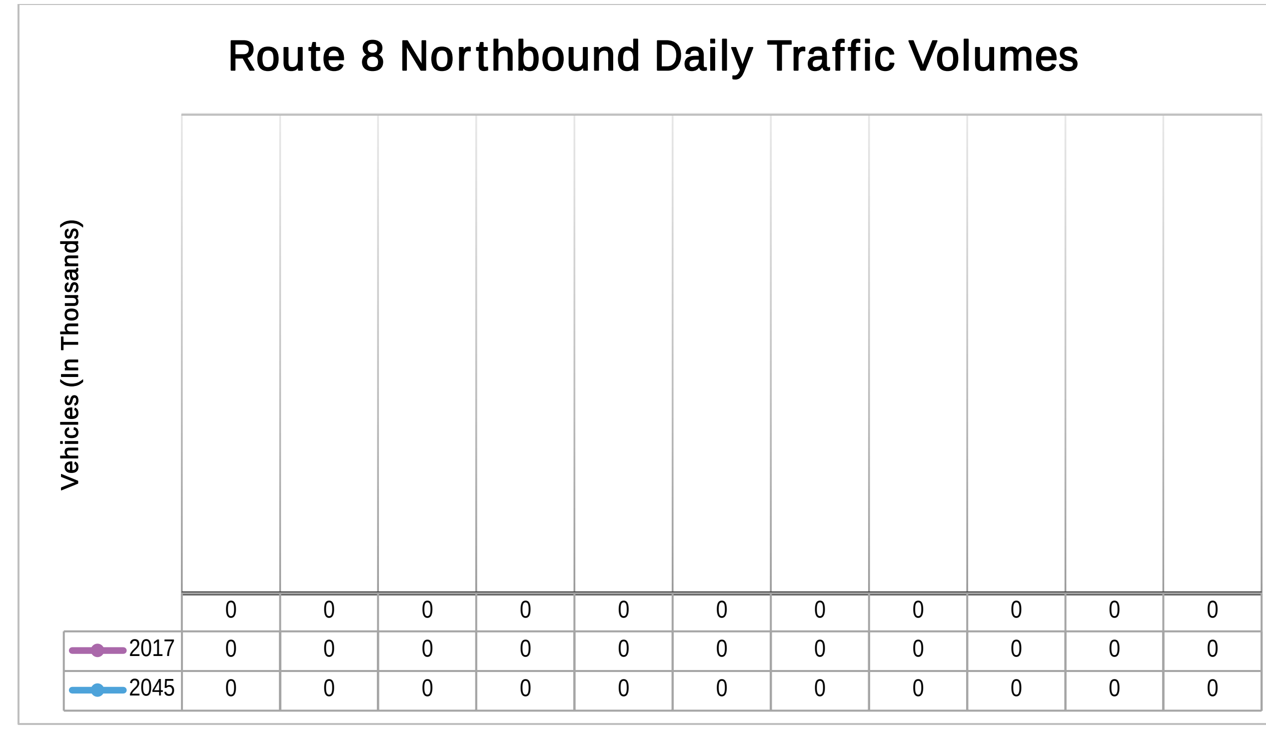
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	33	43	40	45	41	33	38	55	66	63	56	59	42	50
2045	42	53	49	55	50	40	47	66	78	74	65	69	49	57

Figure 3-2 I-84 Westbound 2017 vs 2045 Daily Traffic Volumes



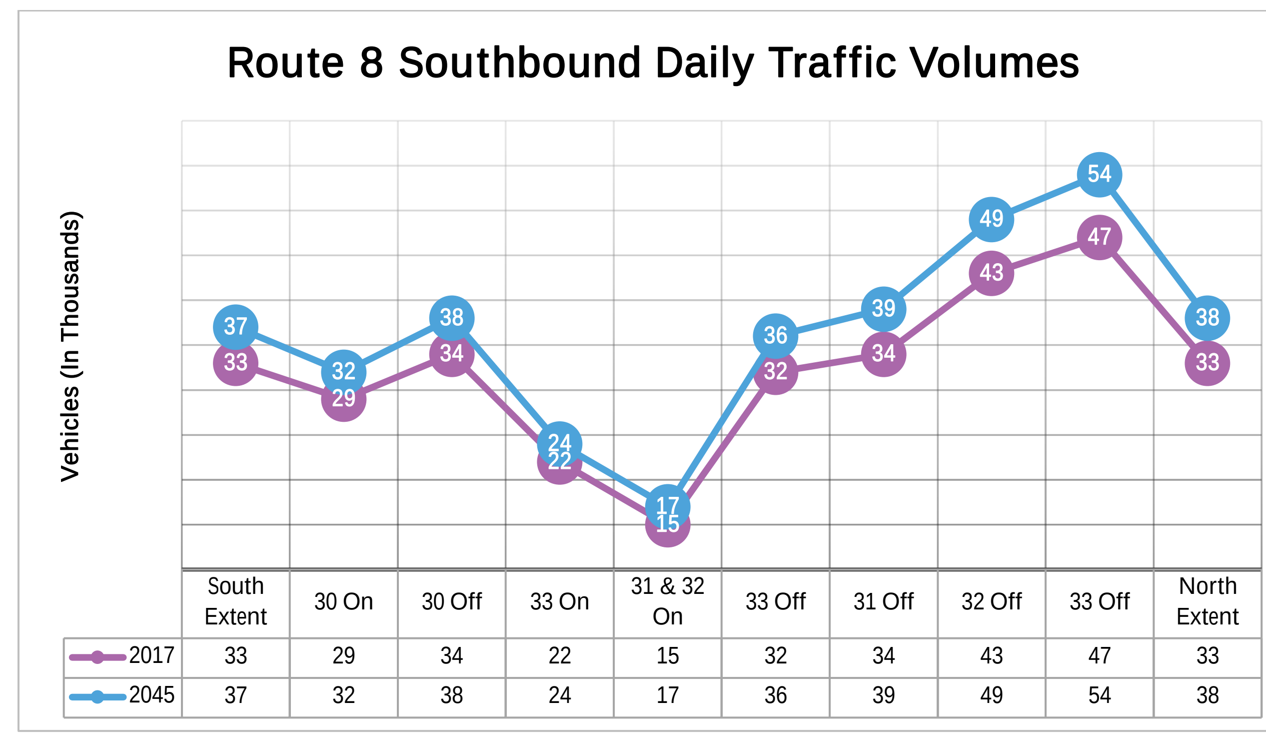
	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0
2045	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3-3 Route 8 Northbound 2017 vs 2045 Daily Traffic Volumes



	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0
2045	0	0	0	0	0	0	0	0	0	0	0

Figure 3-4 Route 8 Southbound 2017 vs 2045 Daily Traffic Volumes



	South Extent	30 On	30 Off	33 On	31 & 32 On	33 Off	31 Off	32 Off	33 Off	North Extent
2017	33	29	34	22	15	32	34	43	47	33
2045	37	32	38	24	17	36	39	49	54	38

3.3 FUTURE (2045) TRAFFIC SIMULATION MODEL

This section has been prepared to summarize the traffic simulation (VISSIM) models that were developed for the future 2045 "no build" condition, presenting the results and findings from the model review and calibration process.

3.3.1 Model Inputs

The 2045 "no build" models were developed by updating the calibrated Existing Conditions models to reflect future conditions. The microsimulation study area remains unchanged from the Existing Conditions models, consisting of the highway mainline and ramp facilities along both Interstate 84 and Route 8 within the City of Waterbury. However, one item that has been modified in the 2045 includes geometry associated with the completion of I-84 widening project, State Project #151-273. Specific items that are reflected in the 2045 future year include:

- Three (3) continuous through lanes for I-84 EB east of Baldwin Street
- Three (3) continuous through lanes for I-84 WB east of Union Street off ramp
- Addition of I-84 EB exit 25 to Harpers Ferry Road, located west of Hamilton Avenue Bridge
- Removal of temporary Hamilton Avenue slip-lane on-ramp to I-84 EB (formerly located west of Hamilton Avenue Bridge)

The 2045 "no build" AM and PM peak hour highway volumes within the study area were obtained from the macroscopic modeling for 2045 "no build" condition.

3.3.2 Model Performance

Traffic simulation model performance is measured by metrics which describe various attributes of traffic operations for individual vehicles as well as the entire network. The following table defines network performance measures used to describe the model traffic operations.

Table 3-3 Traffic Simulation Model Performance Measures

Performance Measure	Definition	Context
Vehicle Miles Traveled (VMT)	The cumulative total distance traveled by all vehicles in the network.	A higher VMT is desirable. This indicates that vehicles were able to travel further during the simulation.
Vehicle Hours Traveled (VHT)	The cumulative total travel time recorded for all vehicles in the network.	A lower VHT is desirable. This indicates that vehicles take less time to arrive at their destination.
Average Speed (in miles per hour)	Travel speed averaged over all vehicles in the network.	A higher speed is desirable (mathematically modeled around the speed limit) This indicates that vehicles travel uninfluenced by congestion or other constraints.
Average Delay Time (in seconds per vehicle)	The averaged additional time experienced by vehicles in the network below the free-flow speed of the facility.	A lower average delay time is desirable. This indicates that vehicles are not forced to reduce speeds.
Number of Stops	The cumulative total number of stops vehicles experience traveling within the network.	Fewer stops are desirable. This indicates that vehicles are not forced to stop by congestion or other constraints.
Total Stopped Delay (in vehicle hours)	The cumulative duration of delay experienced by vehicles under a stopped condition.	A lower stopped delay is desirable. This indicates vehicles incur less waiting time or delay while stopped within the network.

Table 3-4 summarizes the Network Performance Measure findings for the Existing (2017) and Future (2045) Simulation Models.

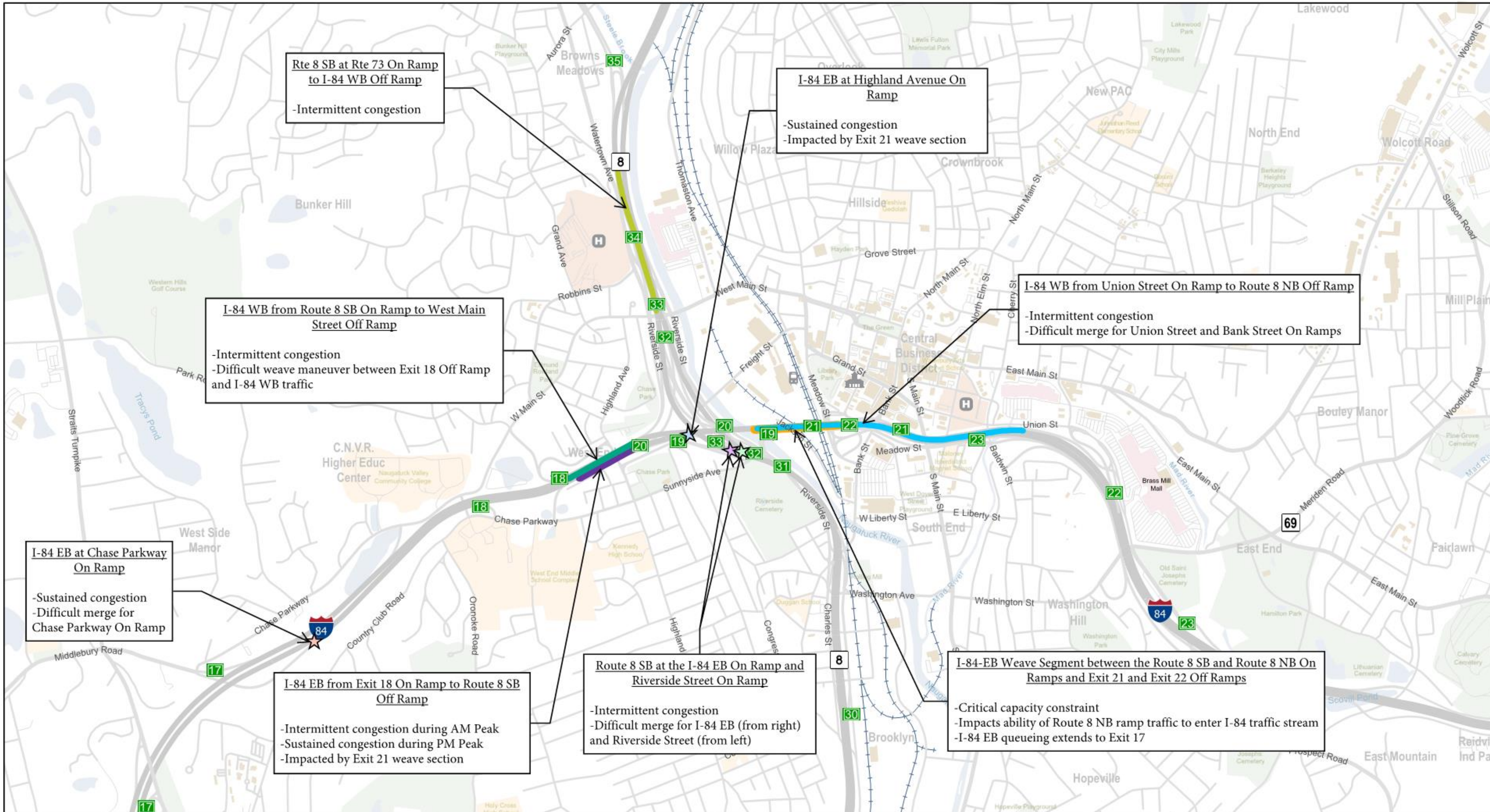
Table 3-4 Traffic Simulation Model Performance Comparison

Performance Measure	Unit	Existing (2017)	Future (2045)	Difference (+/-%)
AM Peak				
VMT	mi	136,039	71,106	-48%
VHT	h	2,702	1,469	-46%
Average Speed	mph	50	49	-2%
Average Delay Time	sec	28	35	25%
Number of Stops	ea.	53,392	29,080	-46%
Total Stopped Delay	h	19	17	-11%
PM Peak				
VMT	mi	75,578	69,786	-8%
VHT	h	1,706	2,217	30%
Average Speed	mph	44	33	-25%
Average Delay Time	sec	63	156	148%
Number of Stops	ea.	148,713	439,755	196%
Total Stopped Delay	h	34	102	200%

Key findings include:

- **VMT:** Despite an increase in traffic volumes, the 2045 Future Conditions models show a decrease in vehicle miles traveled reflecting congestion experienced in both AM and PM Peak networks. The AM Peak model specifically shows a 48% decrease in VMT.
- **VHT:** The AM Peak 2045 Future model shows a 46% reduction in vehicle hours traveled. However, this does not reflect more efficient flow. In this case, the congestion forecasted by the model backs up and does not allow all vehicle demand to enter the network. Despite traffic volumes forecasted to increase in 2045, the 2045 Model processed 37% fewer vehicles (21,622) than the 2017 Model (34,362).
- **Average Speed:** As expected with forecasted congestion increases, average vehicle speeds decrease in future modeled conditions.
- **Average Delay Time:** As expected with forecasted congestion increases, average delay times increase in future modeled conditions.
- **Number of Stops:** As expected with forecasted congestion increases, the number of stops increase in the 2045 PM Peak model compared to the 2017 PM Peak model. The number of stops decreases in the 2045 AM Peak model relative to the 2017 AM Peak model due to severe congestion forecasted which blocked vehicle demand from entering the network.
- **Total Stopped Delay:** As expected with forecasted congestion increases, total stopped delay time increases in the 2045 PM Peak model compared to the 2017 PM Peak model. The duration of total stopped delay decreases in the 2045 AM Peak model relative to the 2017 AM Peak model due to vehicle demand blocked from entering the network.

The notable points of congestion observed in the 2045 "no build" models are depicted on **Figure 3-5**. A summary of the modeled travel speeds for the 2045 "no build" condition along Interstate 84 and Route 8, for the AM and PM peak hours can be found in **Appendix 3.3**.



I-84 EB from Chase Parkway/Country Club Rd to Rte 8 SB off Ramp On Ramp
I-84 EB from Rte 8 SB and NB On Ramps and Meadows St and Main St Off Ramps
I-84 WB from Rte 8 SB On Ramps to West Main St Off Ramp
I-84 WB from Union St On Ramp to Rte 8 NB Off Ramp
Rte 8 SB at Rte 73 On Ramp to I-84 WB Off Ramp

I-84 EB at Chase Parkway On Ramp
I-84 EB at Highland Ave On Ramp
Rte 8 SB at I-84 EB On Ramp
Rte 8 SB at Riverside St SB On Ramp

Railroad
Open Space
Schools
Exit
Hospital
Train Station
City Hall

N
0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Model Performance and Observations

Date: 11/22/2019 Figure No: 3-5

3.4 FUTURE TRAFFIC OPERATIONS

3.4.1 Freeway Operations (Mainline, Weave, and Diverge Segments)

This section summarizes the capacity analysis results for 2045. Operational analyses for the mainline, weave, merge and diverge segments, and system ramps to/from one highway to another highway were performed using the VISSIM model, defined previously in this section, and as a check, also performed using methods outlined in the Transportation Research Board's Highway Capacity Manual (HCM) 2010 using Highway Capacity Software (HCS) 2010.

Interstate analysis sections included Interstate 84 between Exits 17 and 23 and Route 8 between Exits 30 and 35. The analysis peak hours were 7:30 AM – 8:30 AM, 4:30 – 5:30 PM, for the AM and PM peak hours, respectively. A limited Saturday mid-day (SAT) capacity analysis using HCS 2010 was performed on I-84 from 12:00 PM – 1:00 PM.

Free flow speeds and peak hour factors used in this analysis were carried forward from previous analyses. Heavy vehicle percentages used in the analysis were developed from the 2045 Travel Demand Model.

As discussed in the existing conditions section, freeway mainline, weave and diverge sections LOS is measured as it relates to density, measured in passenger cars per mile per line (pc/mi/ln).

It should be noted that construction was completed on the eastern end of the project near Interchange 23, which affected the final lane configuration and geometry of I-84. The analysis for 2045 was adjusted to reflect the final condition after construction.

Table 3-5 and **Table 3-6** illustrate the analysis results for each freeway facility type along both directions of I-84 and Route 8. The Highway Capacity Software output is summarized in **Appendix 3.4**.

Table 3-5 I-84 Future (2045) Traffic Operations (LOS)

	Level of Service								
	A	B	C	D	E	F	Acceptable	Deficient	Total
AM PEAK									
Mainline	0	2	5	4	1	0	11	1	12
Weaves	0	3	4	5	0	0	12	0	12
Merge/Diverge	0	0	3	4	1	1	7	2	9
PM PEAK									
Mainline	0	1	4	4	3	0	9	3	12
Weaves	0	0	4	4	3	1	8	4	12
Merge/Diverge	0	0	1	3	4	1	4	5	9
SAT PEAK									
Mainline	0	1	5	4	2	0	10	2	12
Weaves	0	0	7	5	0	0	12	0	12
Merge/Diverge	0	0	1	3	5	0	4	5	9

Table 3-6 Route 8 Future (2045) Traffic Operations (LOS)

	Level of Service								
	A	B	C	D	E	F	Acceptable	Deficient	Total
AM PEAK									
Mainline	1	3	4	2	0	0	10	0	10
Weaves	0	3	1	0	2	0	4	2	6
Merge/Diverge	0	0	4	3	0	0	7	0	7
PM PEAK									
Mainline	0	2	6	2	0	0	10	0	10
Weaves	0	0	3	3	0	0	6	0	6
Merge/Diverge	0	2	4	1	0	0	7	0	7

Consistent with the Existing Conditions section, both HCS and VISSIM analysis findings are reported as each has value in interpreting the traffic operations along the study highways. The HCS estimated traffic operations reflect expected traffic operations at an isolated facility without interaction from upstream or downstream conditions. VISSIM analysis estimates traffic operations throughout the network including the impact of congestion and complex geometric configurations at upstream and downstream facilities.

Figure 3-6 through Figure 3-13 illustrate the VISSIM and HCS analysis results for the mainline, weave, and merge and diverge segments.

Figure 3-6 and **Figure 3-7** show that the VISSIM analysis estimates higher vehicle density and worse levels of service along the eastbound I-84 facilities relative to the HCS analysis. Unlike the Existing Conditions analysis which reflected ongoing construction operations, the 2045 Future Conditions assume construction has been completed. The worsened operating conditions expected in VISSIM reflect traffic demand exceeding the capacity of the freeway facility in the vicinity of Exit 21 and Exit 22, which causes a projected traffic backup to Exit 20 in the AM Peak Hour and to the western study limit during the PM Peak Hour.

Figure 3-8 and **Figure 3-9** depict the Westbound I-84 VISSIM and HCS capacity analysis findings. During the AM Peak Hour, VISSIM forecasts a significantly lower vehicle density and better levels of service to the west of the Route 8 interchange. VISSIM forecasts a low mainline traffic density entering the complicated Route 8 merge areas, allowing a more efficient merge operation than HCS forecast.

Figure 3-10 and **Figure 3-11** show that the VISSIM and HCS operational analysis findings for Northbound Route 8 are very similar during the AM Peak Hour. During the PM Peak Hour, however, VISSIM forecasts that the weave area between Exit 30 On-Ramp and Exit 31 Off-Ramp will perform at LOS F, causing a downstream traffic backup to the southern extent of the study, but by metering traffic, allowing for more efficient upstream operations than HCS forecasted.

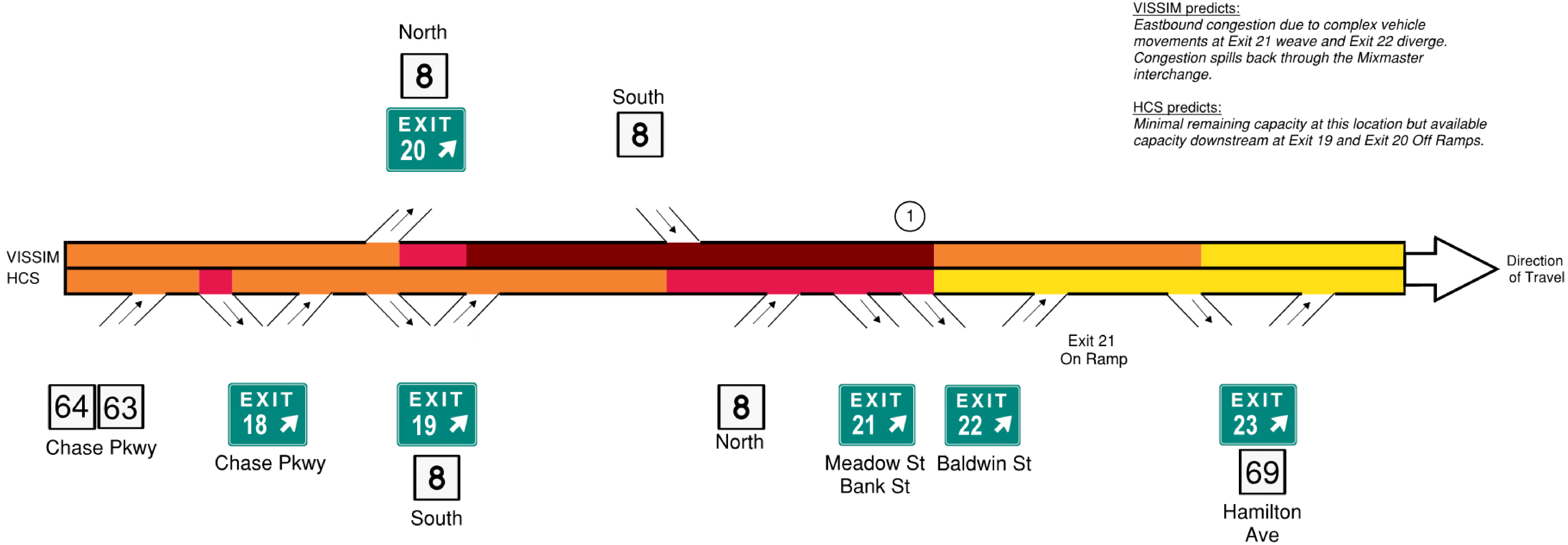
Figure 3-12 and **Figure 3-13** depict the Southbound Route 8 operational analysis findings. VISSIM forecasts slightly more efficient traffic operations along the corridor than HCS. Each analysis method expects the section of freeway between the merge from I-84 Westbound and Exit 30 Off-Ramp to operate an unacceptable LOS E.

I-84 EASTBOUND

(1) Key Observation

VISSIM predicts:
Eastbound congestion due to complex vehicle movements at Exit 21 weave and Exit 22 diverge. Congestion spills back through the Mixmaster interchange.

HCS predicts:
Minimal remaining capacity at this location but available capacity downstream at Exit 19 and Exit 20 Off Ramps.



LEGEND

Best ← Mainline Level of Service (LOS) → Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

VISSIM ANALYSIS FOR I-84 EASTBOUND
HCS ANALYSIS FOR I-84 EASTBOUND

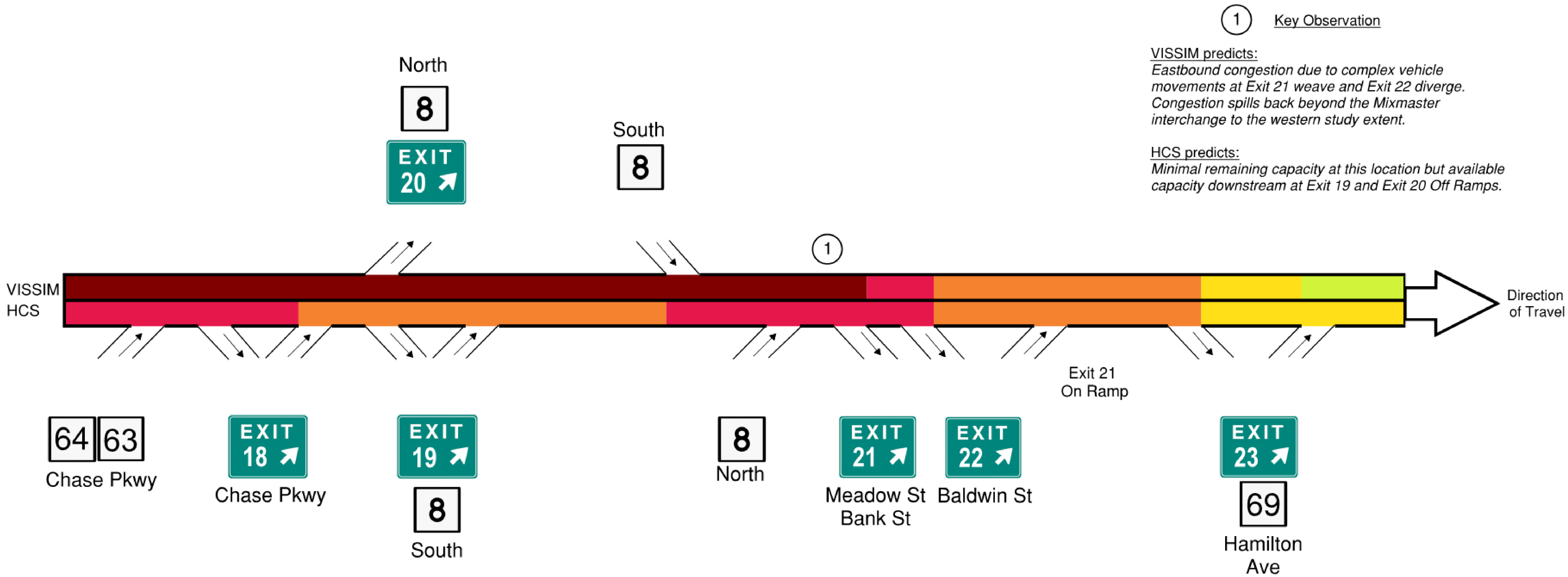
I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Future (2045) Level of Service Map
I-84 EB Mainline AM Peak Hour

Date: 11/22/2019 | Figure No: 3-6

I-84 EASTBOUND



LEGEND

Best ← Mainline Level of Service (LOS) → Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

VISSIM ANALYSIS FOR I-84 EASTBOUND
HCS ANALYSIS FOR I-84 EASTBOUND

84 new mix

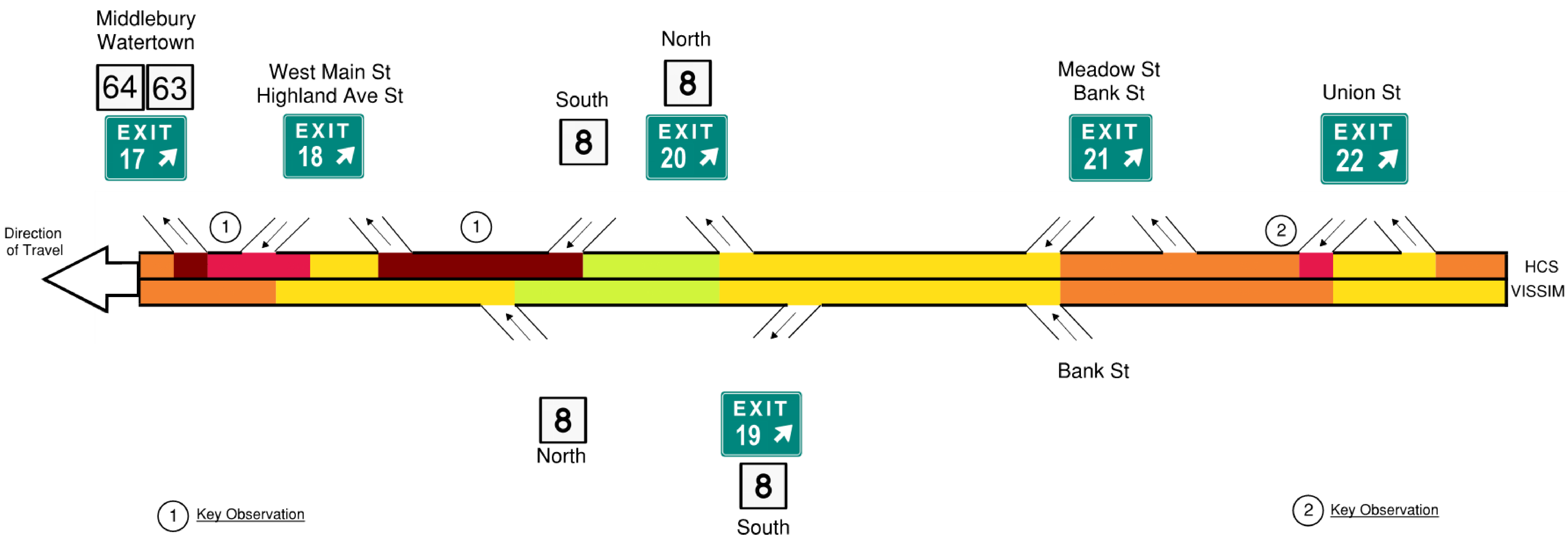
I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Future (2045) Level of Service Map
I-84 EB Mainline PM Peak Hour

Date: 11/22/2019 | Figure No: 3-7

I-84 WESTBOUND



1 Key Observation

HCS predicts:
Deficient LOS at Route 8 and Exit 18 weave area.
Deficient LOS at Exit 18 merge and Exit 17 diverge.

VISSIM predicts:
Less downstream vehicle density allows for better merging and weaving operations at these locations.

2 Key Observation

HCS predicts:
Deficient LOS at Exit 22 merge area.

VISSIM predicts:
Less downstream vehicle density allows for slightly better merge operation at Exit 22.

LEGEND

Best ← Mainline Level of Service (LOS) → Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

HCS ANALYSIS FOR I-84 WESTBOUND
VISSIM ANALYSIS FOR I-84 WESTBOUND

84 new mix

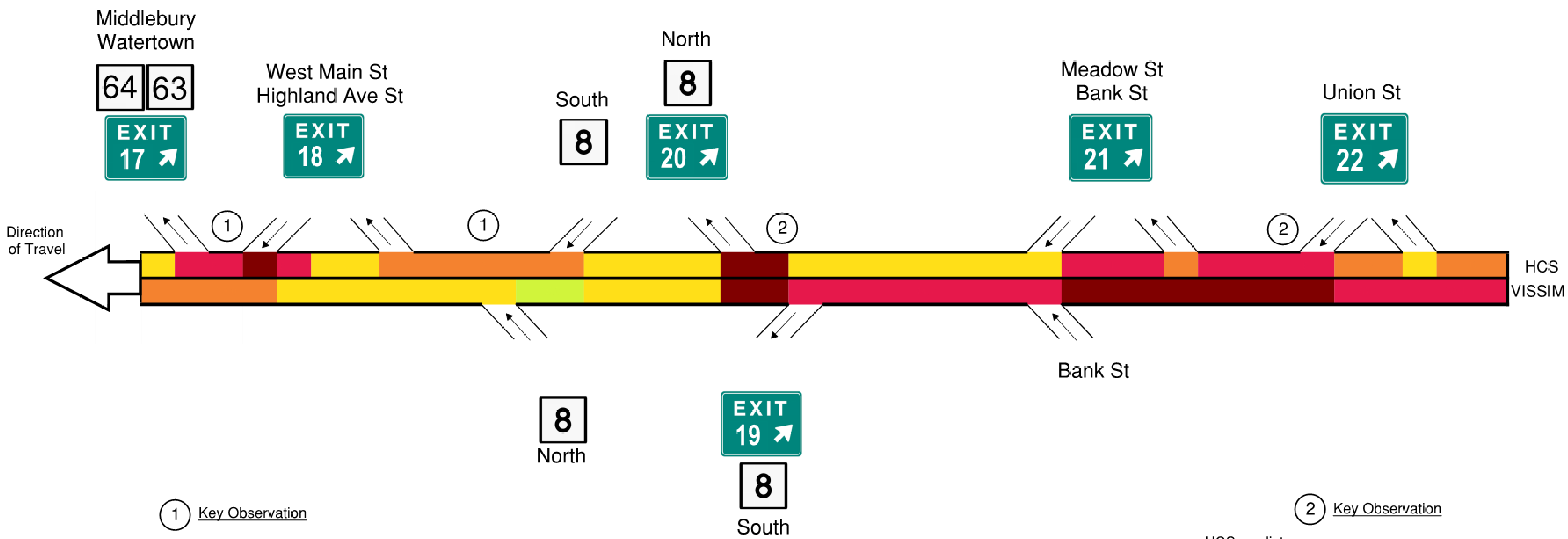
I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Future (2045) Level of Service Map
I-84 WB Mainline AM Peak Hour

Date: 11/22/2019 | Figure No: 3-8

I-84 WESTBOUND



1 Key Observation

HCS predicts:
LOS D at Route 8 and Exit 18 weave area.
Deficient LOS at Exit 18 merge and Exit 17 diverge.

VISSIM predicts:
Less downstream vehicle density at the Route 8 SB merge area allows for better merging and weaving operations at these locations. The lower downstream density is caused by the traffic metering due to congestion at Exit 20, 21, and 22.

2 Key Observation

HCS predicts:
Deficient LOS at Exit 20 diverge.
Deficient LOS at Exit 22 merge area and the freeway segment between Exit 21 merge and diverge areas.

VISSIM predicts:
Congestion at Exit 20 diverge spills back through Exit 19 diverge area, worsening traffic operations downstream through Exit 21 and 22.

LEGEND

Best ← Mainline Level of Service (LOS) → Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

HCS ANALYSIS FOR I-84 WESTBOUND
VISSIM ANALYSIS FOR I-84 WESTBOUND

84 new mix | I-84 Waterbury Mixmaster Reconstruction Project

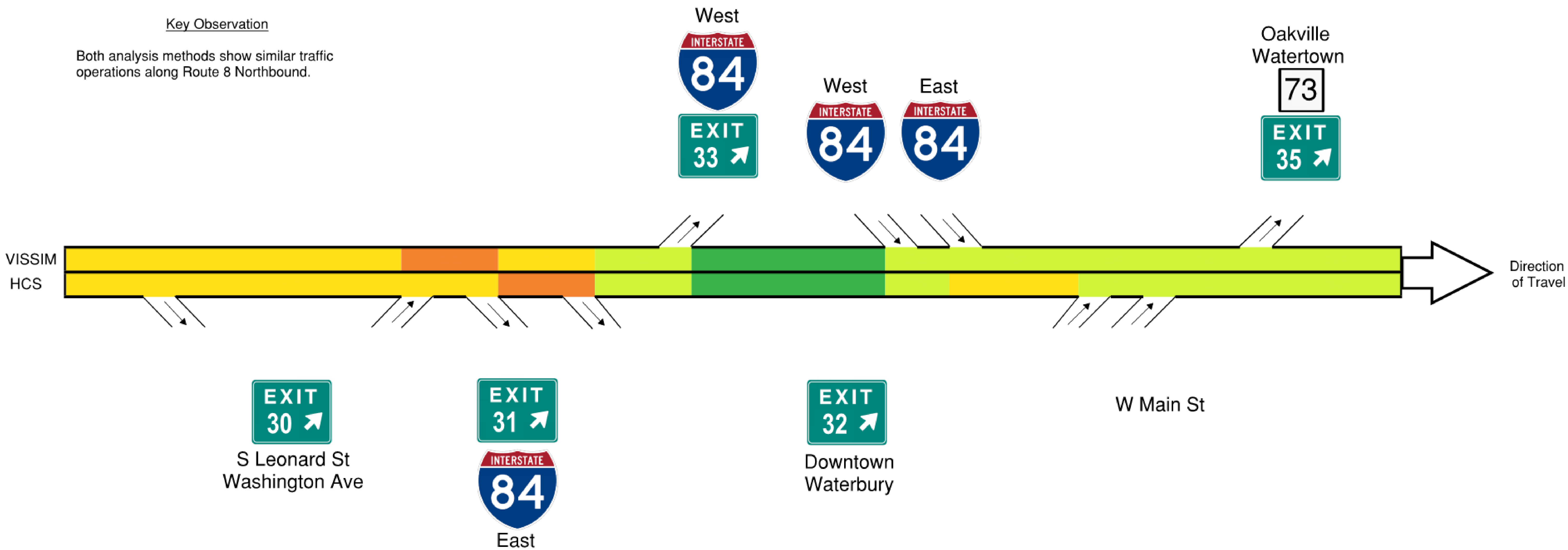
HNTB | Future (2045) Level of Service Map
I-84 WB Mainline PM Peak Hour

Date: 11/22/2019 | Figure No: 3-9

ROUTE 8 NORTHBOUND

Key Observation

Both analysis methods show similar traffic operations along Route 8 Northbound.



LEGEND

Best ← Mainline Level of Service (LOS) → Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

VISSIM ANALYSIS FOR ROUTE 8 NORTHBOUND
HCM ANALYSIS FOR ROUTE 8 NORTHBOUND

84 new mix

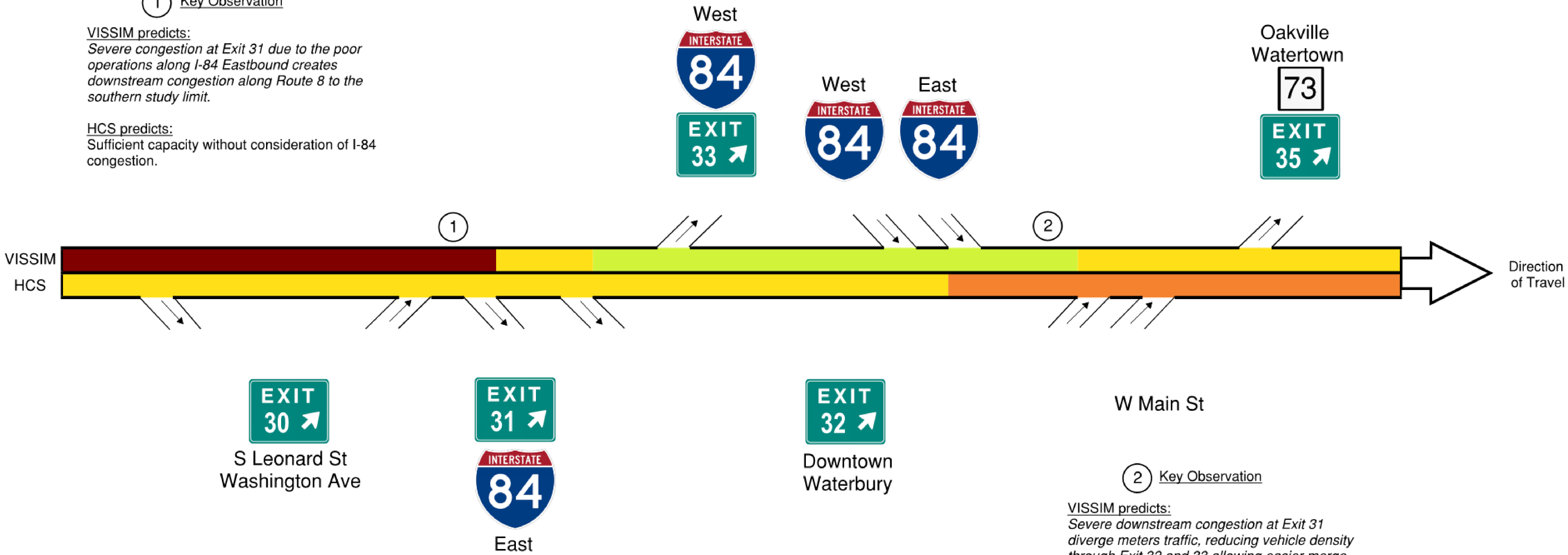
I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Future (2045) Level of Service Map
Route 8 NB Mainline AM Peak Hour

Date: 11/22/2019 | Figure No: 3-10

ROUTE 8 NORTHBOUND



① Key Observation

VISSIM predicts:
Severe congestion at Exit 31 due to the poor operations along I-84 Eastbound creates downstream congestion along Route 8 to the southern study limit.

HCS predicts:
Sufficient capacity without consideration of I-84 congestion.

② Key Observation

VISSIM predicts:
Severe downstream congestion at Exit 31 diverge meters traffic, reducing vehicle density through Exit 32 and 33 allowing easier merge operations.

HCS predicts:
Moderate congestion at I-84 Eastbound merge and all freeway segments upstream.

LEGEND

Best ◄— Mainline Level of Service (LOS) —► Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

VISSIM ANALYSIS FOR ROUTE 8 NORTHBOUND
HCM ANALYSIS FOR ROUTE 8 NORTHBOUND

84 new mix

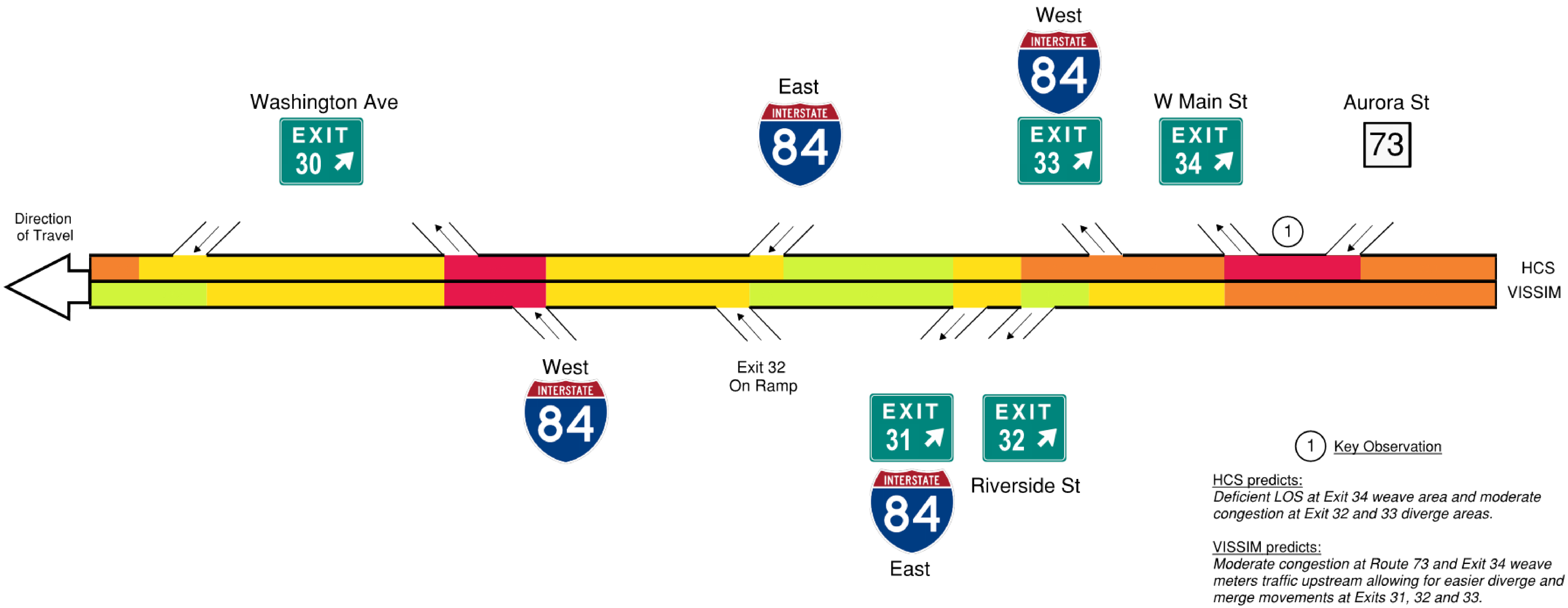
I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Future (2045) Level of Service Map
Route 8 NB Mainline PM Peak Hour

Date: 11/22/2019 | Figure No: 3-11

ROUTE 8 SOUTHBOUND



LEGEND

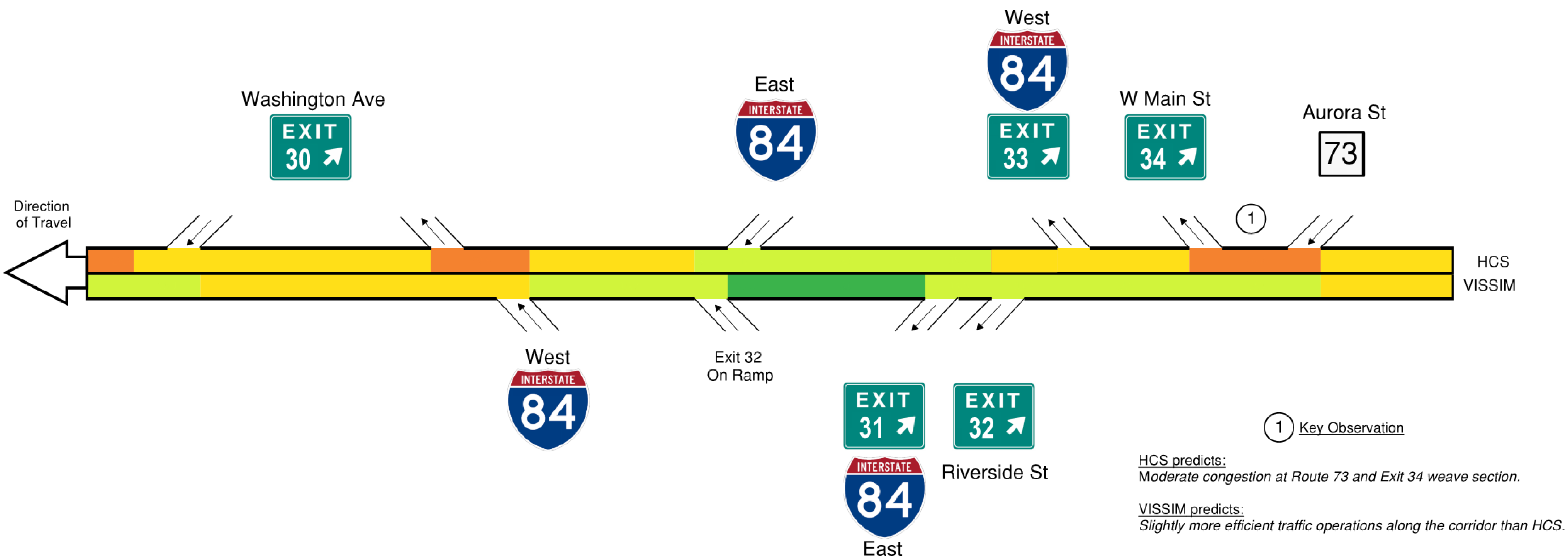
Best ◄ Mainline Level of Service (LOS) ► Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

HCS ANALYSIS FOR ROUTE 8 SOUTHBOUND
VISSIM ANALYSIS FOR ROUTE 8 SOUTHBOUND

84 new mix	I-84 Waterbury Mixmaster Reconstruction Project
HNTB	Future (2045) Level of Service Map Route 8 SB Mainline AM Peak Hour
Date: 11/22/2019	Figure No: 3-12

ROUTE 8 SOUTHBOUND



LEGEND

Best ◄ Mainline Level of Service (LOS) ► Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

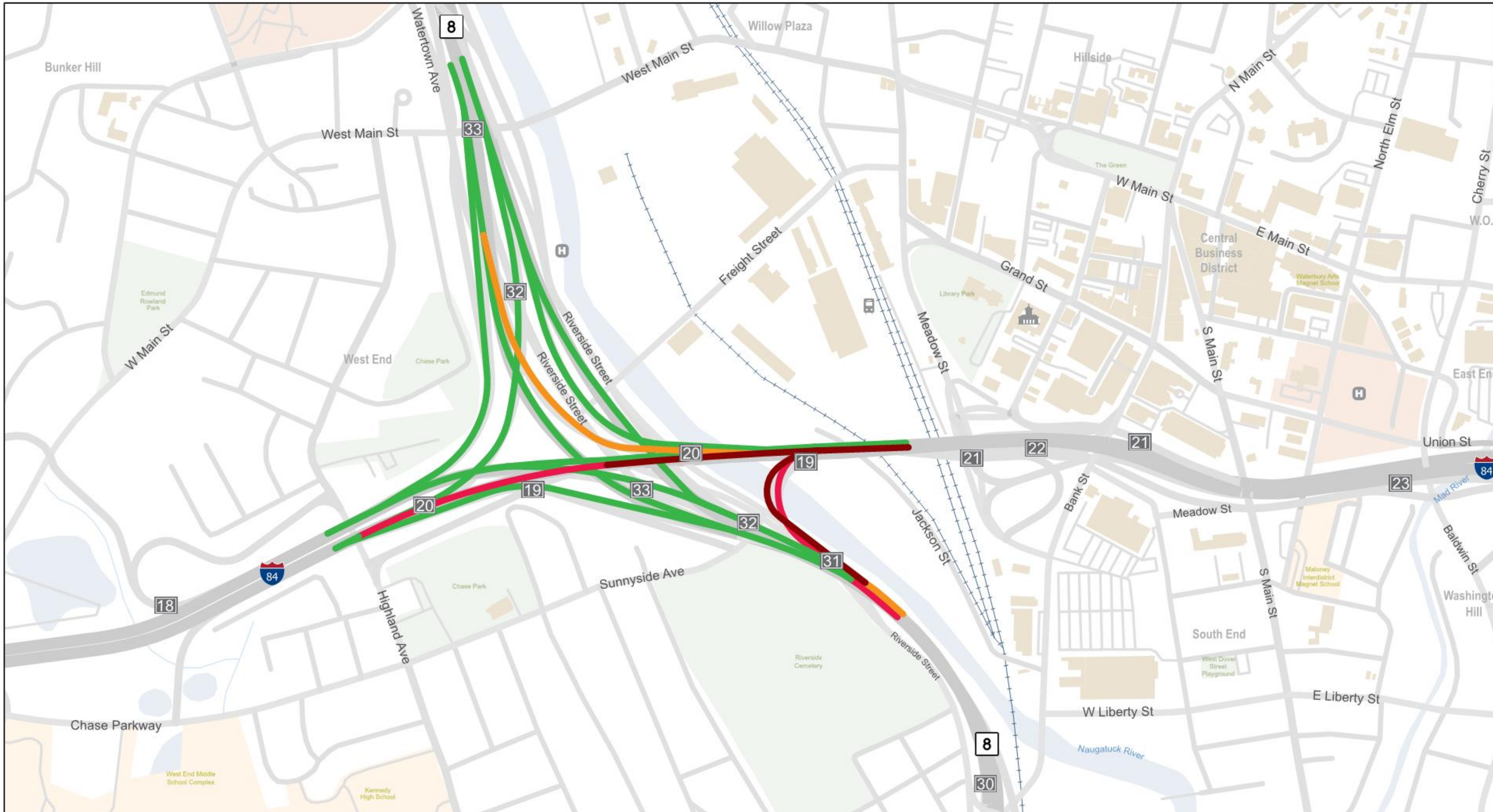
HCS ANALYSIS FOR ROUTE 8 SOUTHBOUND
VISSIM ANALYSIS FOR ROUTE 8 SOUTHBOUND

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Future (2045) Level of Service Map
Route 8 SB Mainline PM Peak Hour

Date: 11/22/2019 Figure No: 3-13



LEGEND

Best ← Level of Service (LOS) → Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

Railroad
Open Space
Schools
Exit
Hospital
Train Station
City Hall

N
0 275 550 1,100 Feet

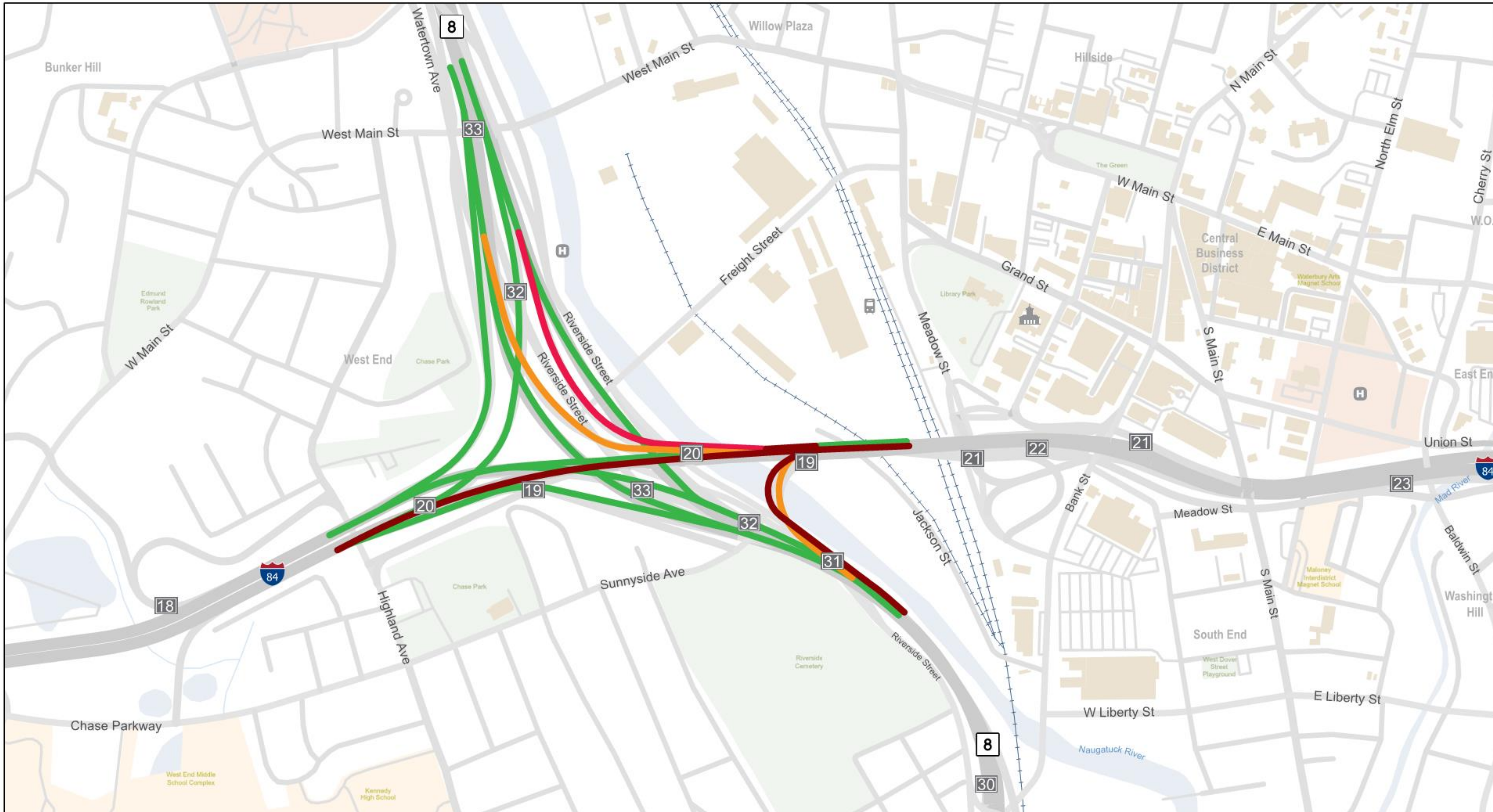
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Future (2045) Level of Service Map
System Ramps AM Peak Hour

Date: 11/22/2019 | Figure No: 3-14



LEGEND

Best ← Level of Service (LOS) → Worst

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

Railroad
Open Space
Schools
Exit
Hospital
Train Station
City Hall

N

0 275 550 1,100 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Future (2045) Level of Service Map System Ramps PM Peak Hour

Date: 11/22/2019 Figure No: 3-15

3.4.2 Intersection Operations

This section summarizes 2045 capacity analyses for intersection operations. Surface street analyses were performed using methods outlined in the Transportation Research Board's Highway Capacity Manual 2010 and Synchro 9.0 traffic modeling software. The results and summaries of those projected models follows.

The same 65 intersections that were analyzed under existing (2017) conditions were analyzed for 2045. Analysis hours include AM and PM peak hours and a limited Saturday mid-day (SAT) peak. Analysis was performed on 12 intersections around the Brass Mill Center Shopping Mall and the intersection of West Main Street and Thomaston Avenue. As previously summarized, the peak traffic conditions identified for analysis were determined to be 7:30 AM – 8:30 AM, 4:30 – 5:30 PM, and 12:00 PM – 1:00 PM, for the AM, PM and SAT peak hours, respectively.

Out of the 65 study intersections, HCM evaluation methods were not applicable to 5 locations due to unconventional controls or configurations. Out of the limited Saturday analysis network, 1 intersection out of 12 was not supported for analysis by HCM methods due to unconventional control or configurations.

The following intersections were therefore omitted from analysis:

1. Chase Parkway at Interstate 84 EB On-Ramp (Exit 18)
2. Charles Street at Fifth Street and CT Route 8 SB On-Ramp (Exit 30)
3. Market Square at Bank Street
4. Field Street at Meadow Street #2 and Interstate 84 WB Off-Ramp (Exit 21)
5. Highland Avenue at Interstate 84 EB On-Ramp (Exit 18)

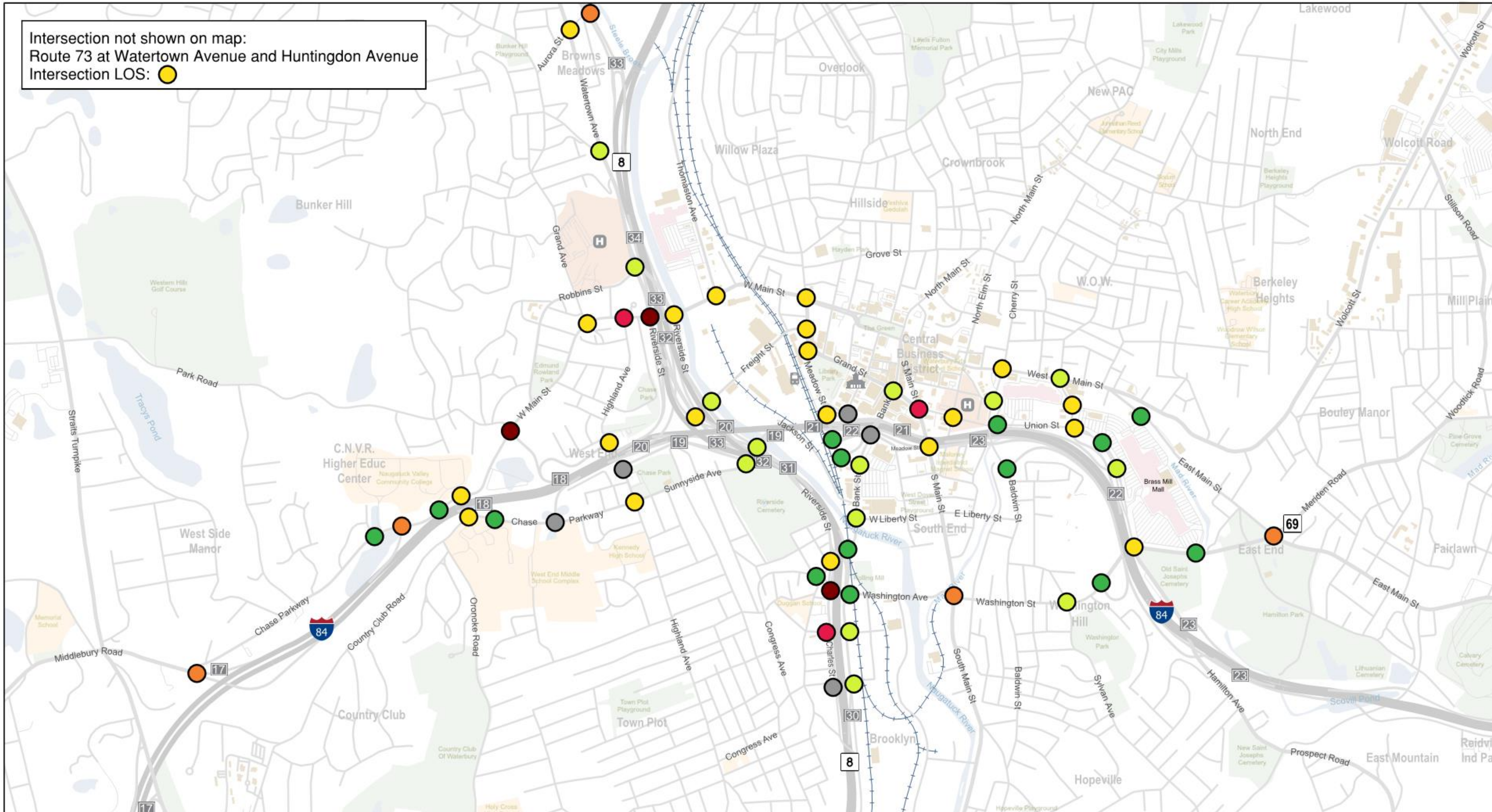
As summarized in the existing conditions section, Levels of Service (LOS) for intersections uses control delay per vehicle to understand operations. **Table 3-7** summarizes the capacity analysis findings for the study intersections. A more detailed table which summarizes 95th percentile queue lengths, control delay, and volume to capacity ratio is provided in **Appendix 3.4** (refer to **Future (2045) No-Build Intersection Peak Hour Traffic Operation Summary**).

Figure 3-16 through **Figure 3-18** illustrate the Levels of Service for each intersection. The detail Synchro printouts are included in **Appendix 3.4** (refer to **Future (2045) No-Build Intersection Synchro Printouts**).

Table 3-7 No Build (2045) Intersection Levels of Service

	Level of Service								
	A	B	C	D	E	F	Acceptable	Deficient	Total
AM PEAK	14	14	21	5	3	3	54	6	60
PM PEAK	9	12	14	9	3	13	44	16	60
SAT PEAK	3	3	4	1	0	0	11	0	11

As shown in **Table 3-7**, all study intersections analyzed are estimated to operate at acceptable levels of service during the Saturday Peak Hour. During the AM Peak Hour and PM Peak Hour, respectively, 6 out of 60 intersections (10%) and 16 out of 60 intersections (approximately 27%) operate at unacceptable levels of service and are considered operationally deficient.



LEGEND

Best ← Intersection Level of Service (LOS) → Worst

	LOS A	LOS B	LOS C	LOS D	LOS E	LOS F	NOT APPLICABLE
No. of intersections:	14	18	23	5	0	0	5

○ Intersection

Hospital
Train Station
City Hall
Exit

N

0 1,000 2,000 3,000 Feet

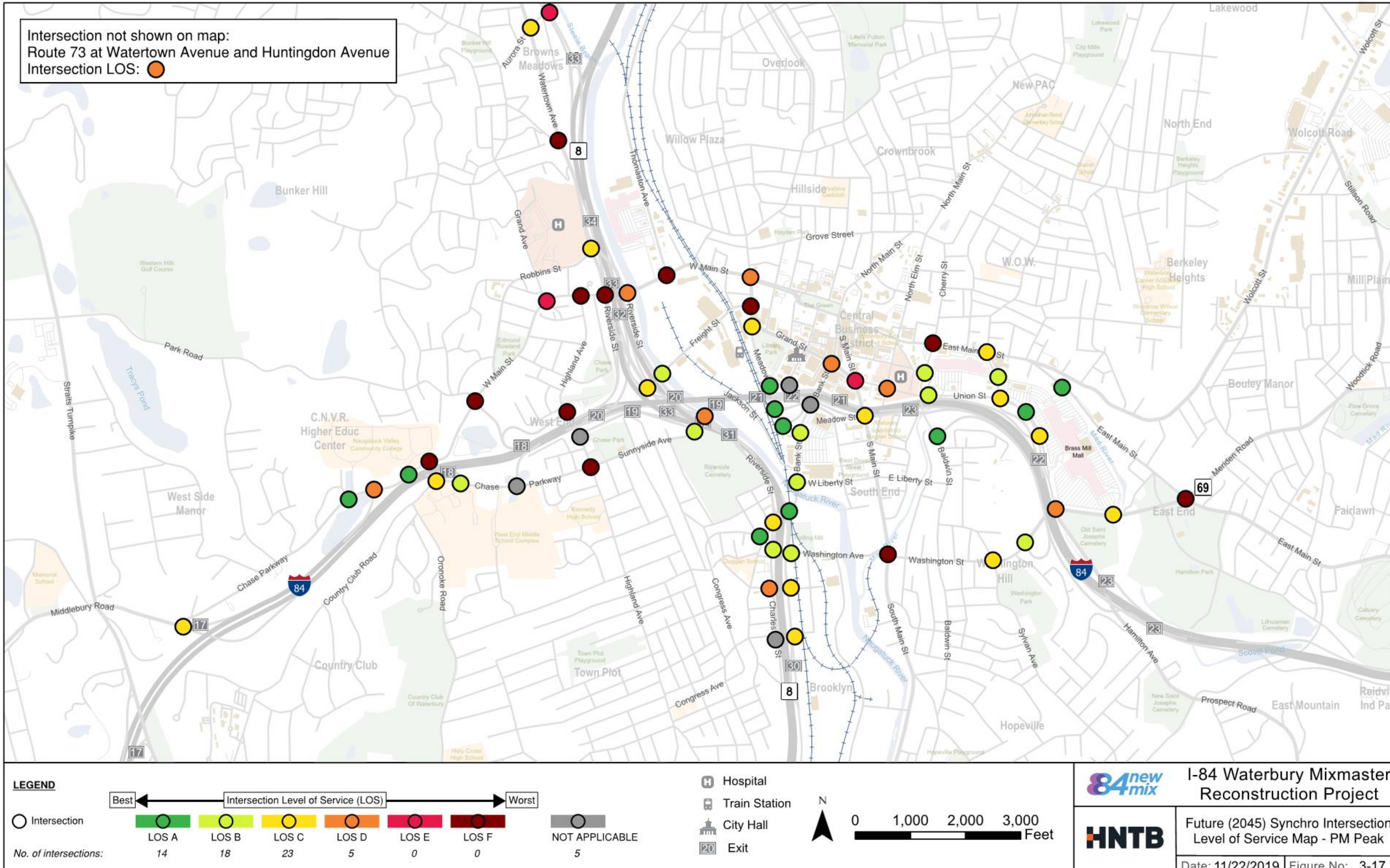
84 new mix

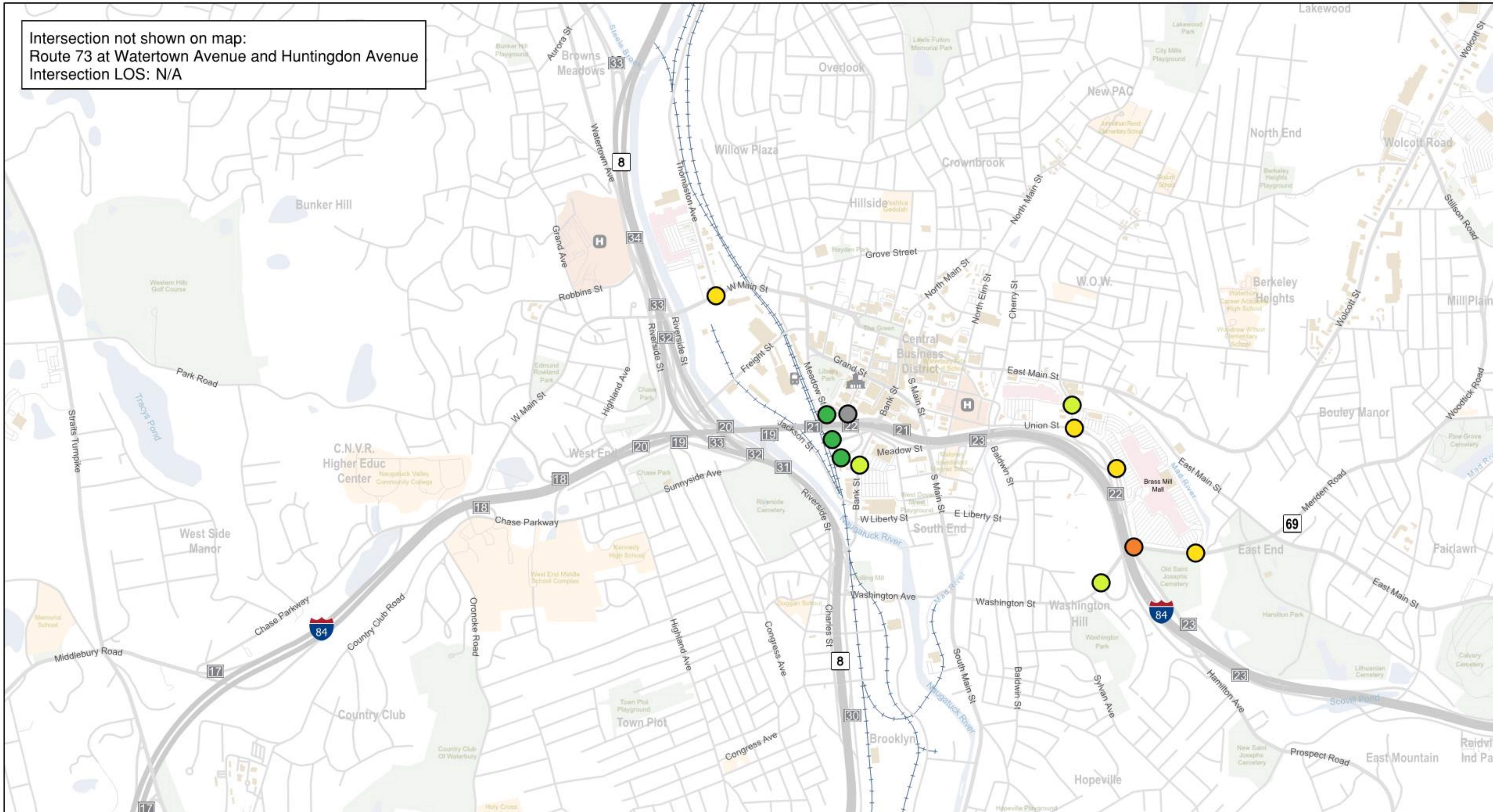
I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Future (2045) Level of Service Map Intersections AM Peak Hour

Date: 11/22/2019 Figure No: 3-16


Intersection not shown on map:
Route 73 at Watertown Avenue and Huntingdon Avenue
Intersection LOS:
Browns Meadows
Overlook
New PAC
North End
Wolcott Road
Lakewood
Willow Plaza
Crownbrook
Bunker Hill
Hillside
Grove Street
W.O.W.
Berkeley Heights
Mill Plain
Central Business District
Bouley Manor
C.N.V.R. Higher Educ Center
West End
West Side Manor
South End
East End
Fairlawn
Washington Hill
Country Club
Town Plot
Brooklyn
Hopeville
East Mountain
Reidville Ind Park
Watertown Ave
Aurora St
Grand Ave
Robbins St
Riverside St
Thomaston Ave
W Main St
Park Road
Straits Turnpike
Highland Ave
Freight St
Grand St
Meadow St
Bank St
S Main St
Jackson St
North Main St
North Elm St
Cherry St
East Main St
Union St
Meadow St
Sunnyside Ave
Chase Parkway
W Liberty St
E Liberty St
Baldwin St
Washington Ave
Washington St
Meriden Road
Wolcott St
Stillson Road
Woodtick Road
Chase Parkway
Country Club Road
Oronoke Road
Middlebury Road
Congress Ave
Charles St
South Main St
Sylvan Ave
Hamilton Ave
Prospect Road
East Main St
Brass Mill Mall
LEGEND
Best
Intersection Level of Service (LOS)
Worst
Intersection
LOS A
LOS B
LOS C
LOS D
LOS E
LOS F
NOT APPLICABLE
No. of intersections:
14
18
23
5
0
0
5
Hospital
Train Station
City Hall
Exit
N
0
1,000
2,000
3,000
Feet
84 new mix
I-84 Waterbury Mixmaster Reconstruction Project
HNTB
Future (2045) Synchro Intersection Level of Service Map - PM Peak
Date: 11/22/2019
Figure No: 3-17



LEGEND

Best ← Intersection Level of Service (LOS) → Worst

	LOS A	LOS B	LOS C	LOS D	LOS E	LOS F	NOT APPLICABLE
○ Intersection							
No. of intersections:	*14*	*18*	*23*	*5*	*0*	*0*	*5*

- Hospital
- Train Station
- City Hall
- Exit

N

0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Future (2045) Synchro Intersection Level of Service Map - SAT Peak

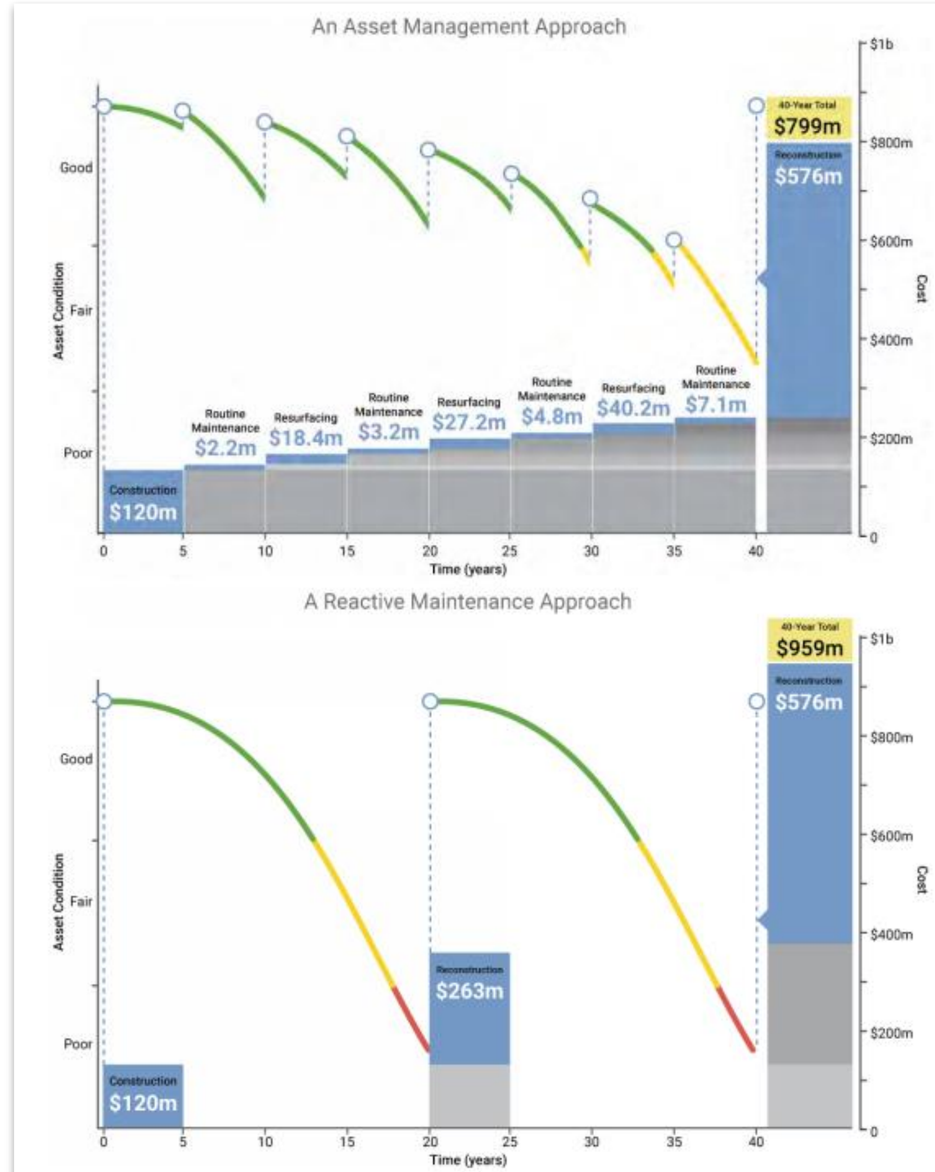
Date: 11/22/2019 Figure No: 3-18

3.5 FUTURE STRUCTURAL CONDITIONS

Forecasts of study area bridge conditions were developed for the year 2045 based on engineering judgment[4], planned rehabilitation projects, and their existing physical condition.

Predicting post-rehabilitation physical condition was a major consideration in these forecasts. The CTDOT administers preventative rehabilitation projects to maintain the condition of state-owned bridges. Rather than restoring a bridge to "like-new" condition in reaction to severe deterioration, this method of asset management uses relatively minor rehabilitation projects to keep each bridge in a "state of good repair" throughout its life. Appreciable savings can be realized over a bridge's life by using this proactive approach to asset management (see **Figure 3-19**). However, a natural trend resulting from this approach is the increased frequency of preservation/rehabilitation projects performed as the bridge ages. Another observed trend is that rehabilitation projects performed later in the asset's life tend to be more substantial and are generally less effective.

Figure 3-19 Proactive Maintenance vs. Reactive Maintenance [5]



4 An analytics-based approach to forecasting future conditions with computer models and deterioration curves, while desirable, would be problematic because of insufficient data (the sample of structures similar to those in the study area is small) and the lack of an established analysis method.

5 Source: Rhode Island DOT, Investing Rhode Island's Future: A 10-Year Plan to Strengthen Our State's Transportation Systems, 2014. Based on an analysis published by TXDOT. Texas DOT, Typical Life Cycle Costs of a Highway, 2014, http://ftp.dot.state.tx.us/pub/txdot-info/tpp/2040/Life Cycle-costs-of-a-highway.pdf

Weighted by deck area, more than 60 percent of the studied bridges are scheduled for rehabilitation before the year 2045 (a subset that includes all major bridges in the study area). Also, by 2045 many of these bridges will be about 80 years old and far beyond their originally intended design life. **Table 3-8** gives the forecasted year 2045 physical conditions for major components of these bridges. These forecasts were made by considering the bridges' age and the trends described in the previous paragraph.

Table 3-8 Major Bridge Forecasted Year 2045 Conditions

Bridge No.	Programmed Rehabilitation Projects	2045 Deck Rating	2045 Superstructure Rating	2045 Substructure Rating
03190A	State Project No. 151-326	6	5	5
03190B		6	5	5
03190C		4	5	5
03190D		4	5	5
03190E		4	5	5
03190F		4	5	5
03191D		4	5	5
03191E		4	5	5
03191A	State Project No. 151-312	4	4	5
03191B	State Project No. 151-313	4	4	5

It was ultimately judged that programmed rehabilitation projects will only be effective at maintaining these bridges in overall "fair" condition through 2045 (the threshold for Structurally Deficient; see **Section 2.6 Existing Structural Conditions**). Even within this subset there are important exceptions:

1. The condition of bridge decks (and other elements) that are being completely replaced during the programmed rehabilitation projects will likely be satisfactory by 2045 (Bridge Nos. 03190A and B).
2. The condition of many mainline bridge decks is a notable deficiency due to measured 2015 chloride contamination exceeding acceptable concentration thresholds. Their deterioration is expected to accelerate through 2045. Due to the lack of a suitable detour, a complete replacement of these decks was determined to be cost prohibitive and infeasible. It is assumed that programmed rehabilitations involving deck patching will only be effective at maintaining these decks in a "poor" condition (Bridge Nos. 03190C thru F and Bridge Nos. 03191A, B, D, and E).
3. Because of ongoing safety concerns, the poor condition of decks on the stacked I-84 mainline bridges over the Naugatuck River (Bridge Nos. 03191A and 03191B) are already notable deficiencies among the studied bridges. These deficiencies will remain unaddressed through 2045 in the "no build" scenario.
4. The condition of fracture critical members and spans experiencing fatigue related cracking is already a notable deficiency among the studied bridges (see **Section 2.6 Existing Structural Conditions**). Rehabilitation projects to stop crack propagation are already programmed for many of these spans, however, there are still fatigue prone locations on several bridges that are not being fully addressed through rehabilitation. It is assumed that programmed rehabilitations will only be effective at maintaining these bridge superstructures in "fair/poor" condition through 2045 (Bridge Nos. 03190A and B and Bridge Nos. 03191A and B).

Finally, the programmed rehabilitation projects are not intended to improve the studied bridge's functional adequacy or eliminate fatigue prone details. Therefore, existing structural and functional deficiencies fracture critical spans will remain unchanged in 2045.

4 Existing Social, Economic, and Environmental Conditions

4.1 KEY CONTEXT FEATURES AND CHARACTERISTICS

This section inventories key context features and characteristics within the I-84 Mixmaster Reconstruction Project's study area. Depending on the social, economic and environmental resource to be evaluated, the Study Area for the Project may be larger or smaller than that shown in **Figure 1-1**.

Project improvement concepts for the transportation network that are proposed during design development will be evaluated within the framework of this "contextual inventory." The Project will use a Context Sensitive Design Solutions (CSS) approach to project development and implementation. This contextual inventory is just one component of the CSS process. Using CSS, the Project will also present opportunities to restore, enhance, and expand local context and economic identifiers through an integrated design solution.

Context Sensitive Design Solutions (CSS)

The Federal Highway Administration (FHWA) describes CSS as "a collaborative, interdisciplinary approach that involves all stakeholders in providing a transportation facility that fits its setting. It is an approach that leads to preserving and enhancing scenic, aesthetic, historic, community, and environmental resources, while improving or maintaining safety, mobility, and infrastructure conditions." According to Context Sensitive Solutions section on the FHWA website, the process is guided by four core principles:

1. *A shared stakeholder vision to provide a basis for decisions.*
2. *A comprehensive understanding of contexts.*
3. *Continuing communication and collaboration to achieve consensus.*
4. *Flexibility and creativity to shape effective transportation solutions, while preserving and enhancing community and natural environments.*

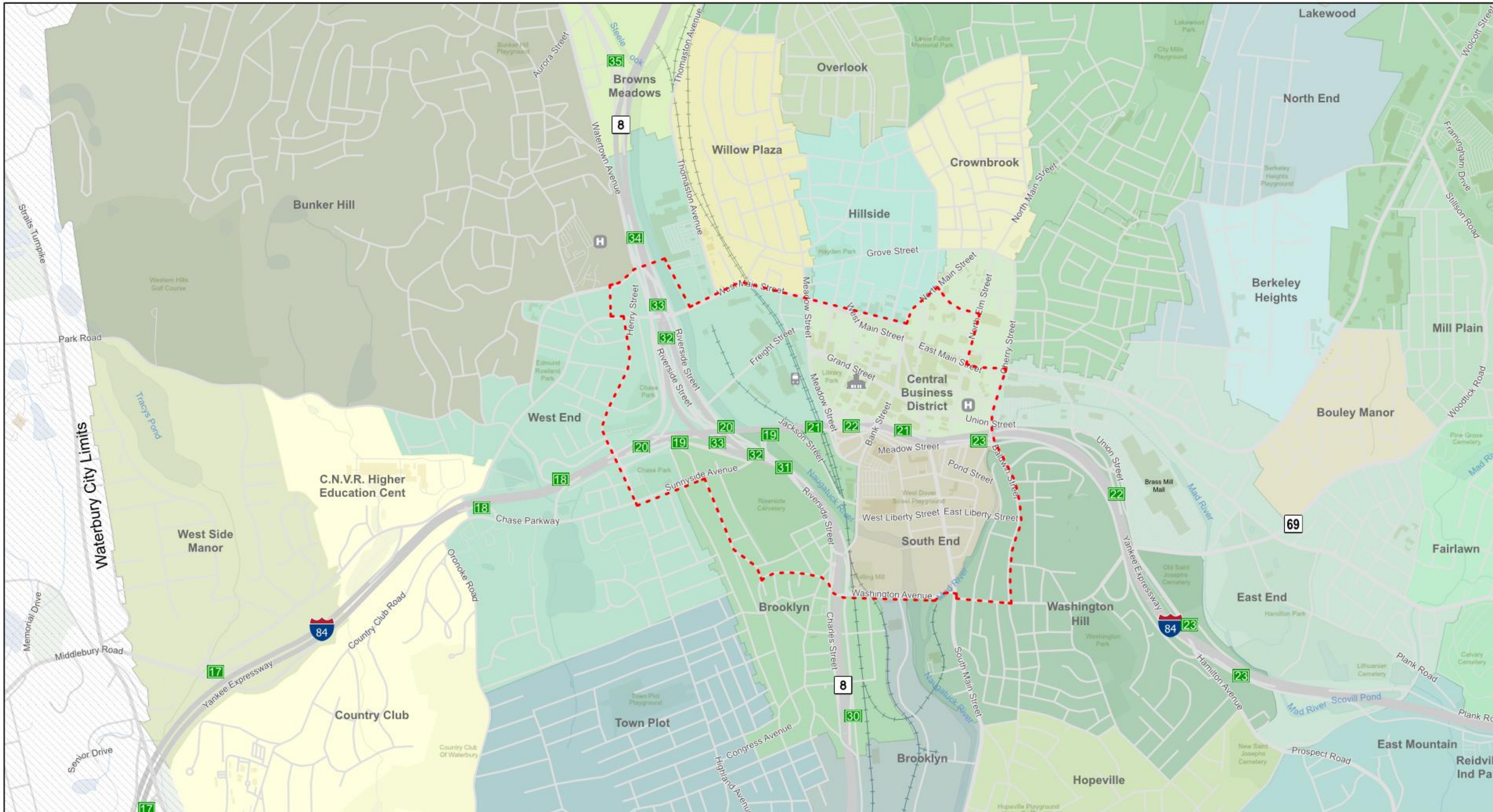
The process allows for identifying a wide range of objectives, including

The contextual inventory was compiled from data sources owned by the State of Connecticut, City of Waterbury, and the Naugatuck Valley Council of Governments, through online research, and through qualitative data collected during site visits. In addition, various state-wide, regional, and city-wide planning studies and projects[6] were reviewed during the development of this inventory including:

- Waterbury Interchange Needs Study (WINS)
- City of Waterbury Adopted Plan of Conservation and Development (POCD) 2015-2025
- Freight Street Redevelopment Strategy Master Plan (2018)
- Waterbury Active Transportation and Economic Resurgence (W.A.T.E.R.) TIGER Capital Project Grant Application
- Naugatuck River Greenway (NRG)

The collected data was inventoried at both a city-wide and community scale. Planning studies and maps were reviewed to identify key elements at the city-wide scale. At the community scale, a key inventory area was delineated to complete a more in-depth neighborhood assessment. The key area includes the Central Business District (CBD) and the neighborhoods of Brooklyn, South End, and West End which are directly adjacent to the Mixmaster (see **Figure 4-1**).

[6] For further description of these planning studies and projects refer to **Section 1.4 Ongoing and Recent Projects**



Key Area Boundary

Railroad	Hospital
Open Space	Train Station
Schools	City Hall
Exit	

N

0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Key Area and Neighborhoods Map

Date: 11/22/2019 Figure No: 4-1

4.1.1 City-Wide Inventory

The city-wide inventory is the macro-scale inventory analysis for the City of Waterbury. It is summarized under three major themes – Demographics, Land Use and Zoning, and Economic and Cultural Drivers. Note, environmental, natural, and historical resources are discussed in **Section 4.4 Environmental and Natural Resources**.

Demographics

Population Characteristics

According to the US Census Bureau American Community Survey[7], Waterbury's population in 2017 was 109,250 people, a slight decrease from 110,430 people in 2010. The POCD states that the growth or decline of population varies depending on the geographic location. The fastest growing areas are in the City's outer edges, while neighborhoods close to the Mixmaster, such as South End and Brooklyn saw their populations decline between 2000 and 2010. Population density also varies from neighborhood to neighborhood. **Figure 4-2** shows that neighborhoods surrounding Downtown Waterbury have a higher population density, creating an urban core.

Table 4-1 compares the age distributions in Waterbury and Connecticut. At both the state level and within Waterbury, the primary age groups were 25-44 and 45-64 years of age. The median age in Waterbury was thirty-five, younger than the state median of forty. The age distribution supports the revitalization effort of downtown Waterbury as shifting trends throughout the country show both younger populations and empty-nesters are choosing to live in urban areas with a walkable downtown and less automobile dependency.

Table 4-1 Waterbury Population Age Distribution[8]

Age	Waterbury No. of Persons	Waterbury %	Connecticut No. of Person	Connecticut %
0-4	7,619	7%	186,188	5.20%
5-14	15,655	14.30%	432,367	12%
15-24	15,680	14.30%	495,626	13.70%
25-44	29,751	27.30%	872,640	24.20%
45-64	33,169	24.20%	1,031,900	28.70%
65+	14,077	12.90%	575,757	16%
Total	**109,250**	**100%**	**3,594,478**	**100%**

Population characteristics regarding race and income for Waterbury as of 2017 are summarized below[9]:

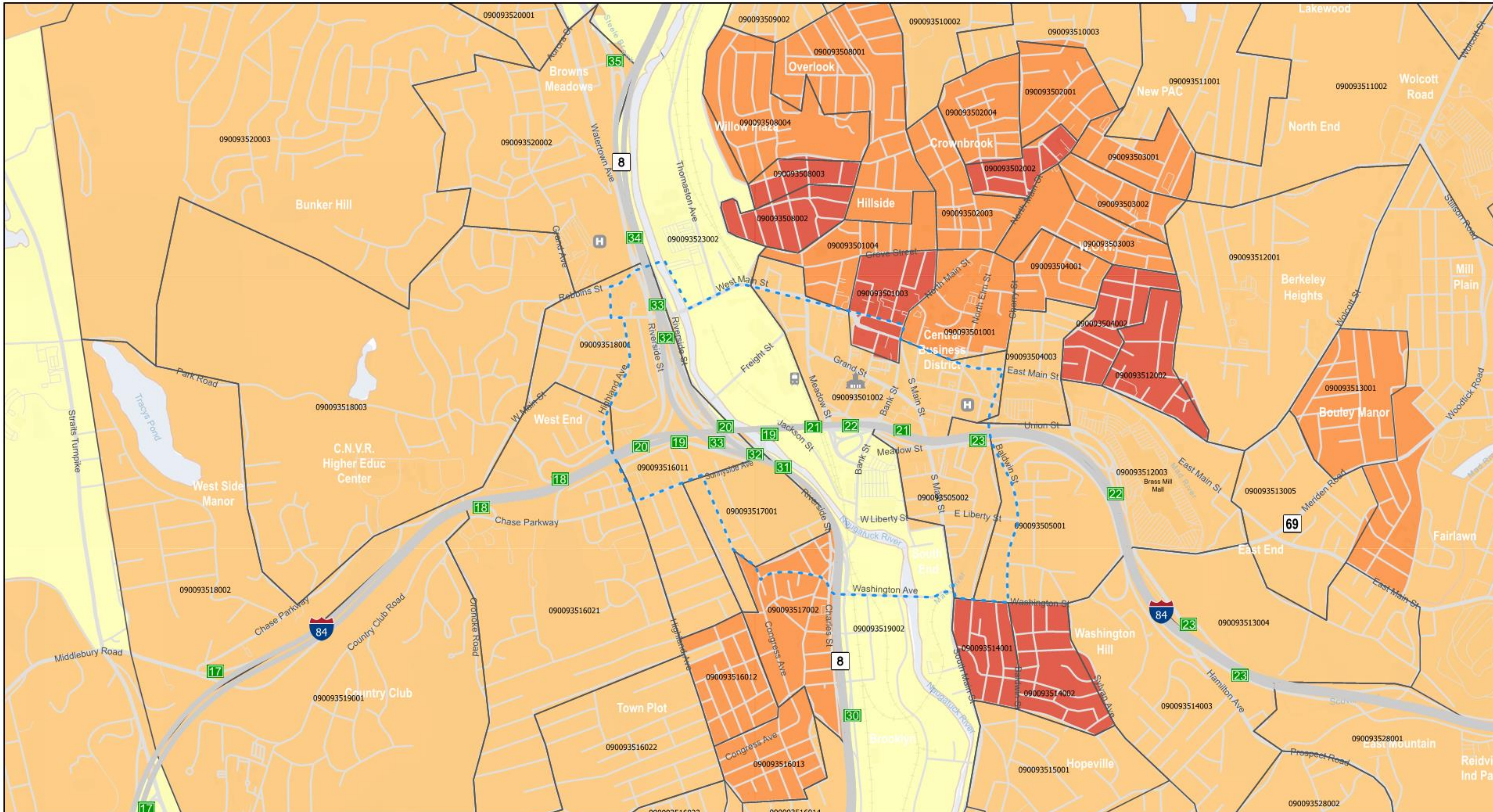
- The largest racial groups are White (38.5%), Hispanic or Latino (37.2%), and Black (17.9%);
- The median household income is $39,681;
- The unemployment rate is 8.1%, higher than the New Haven County average (5.5%) and Connecticut State average (5.1%); and
- The poverty rate is 25.4%, significantly higher than the County (12.8%) and State (10.4%) rates.

Due to the racial composition and poverty rate, the City of Waterbury is considered an "Environmental Justice" community. This is described in more detail in the following section.

[7] U.S. Census Bureau, American Community Survey (ACS), "Age and Sex" 2017: Five-Year Estimates Subject Tables.

[8] U.S. Census Bureau, American Community Survey (ACS), "Age and Sex" 2017: Five-Year Estimates Subject Tables.

[9] U.S. Census Bureau, American Community Survey (ACS), "Income In the Past Twelve Months" and "ACS Demographic and Housing Estimates" 2017: Five-Year Estimates Subject Tables.



2019 USA Population Density Block Group

- 0 - 1,000 people per sq mi
- 1,000 - 8,400 people per sq mi
- 8,400 - 15,800 people per sq mi
- 15,800 - 24,000 people per sq mi
- 24,000 - 629,000 people per sq mi

Key Area

N

0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Population Density Map

Date: 6/23/2020 | Figure No: 4-2

Title VI/Environmental Justice

According to the United States Environmental Protection Agency (EPA), Environmental Justice is "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 protections for Environmental Justice include Executive Order (EO) 12898, *Federal Actions that Address Environmental Justice in Minority Populations and Low-Income Populations,* and Title VI of the Civil Rights Act of 1964. EO 12898 directs federal agencies to "make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations." Title VI of the Civil Rights Act of 1964 requires that no person shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance.

As shown in **Figure 4-2.1** and **Figure 4-2.2**, the EJ Study Area includes the Project Study Corridor, the Traffic Data Collections Area, and the Key Area Boundary-study area limits illustrated in Figure 1-1. To be more inclusive, the EJ Study Area also includes all US Census block groups that touch those study area limits. For block groups with boundaries extending beyond the EJ Study Area limits, the entirety of the block group is included in the analysis. This results in fifty-five block groups that are included in the Environmental Justice assessment.

For this analysis, the threshold definition for racial minority and low-income populations used to identify Environmental Justice populations within the Environmental Justice (EJ) Study Area are as follows:

a. <u>Racial Minority</u>

Federal guidance provided by the Council on Environmental Quality (CEQ) states "minority populations should be identified where either (a) the minority population of the affected area exceeds 50 percent or (b) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis."[10] The term "meaningfully" provides the lead and sponsoring agencies room to exercise discretion in determining the appropriate thresholds. Given an analysis of the local context, demographics and county and state averages, this project will be following part (b) of the CEQ definition. As such, the EJ threshold for racial minority is considered to be anything greater than the State's average minority population of 32%. The unit of geographical analysis used for this study is the census block group.

b. <u>Low-Income Population</u>

According to the US Census Bureau American Community Survey, in the State of Connecticut, the average household size in 2017 was 2.65, making the federal poverty threshold $18,957[11]. The Connecticut General Statutes (CGS) (Chapter 439, Section 22a-20a) defines an EJ community as a United States census block group for which thirty percent or more of the population consists of low income persons who are not institutionalized and have an income below two hundred percent of the federal poverty level. Two hundred percent of the federal threshold is $37,914. Environmental Justice block groups exceed this threshold if 30% or more of the population has a household income of less than $37,914.

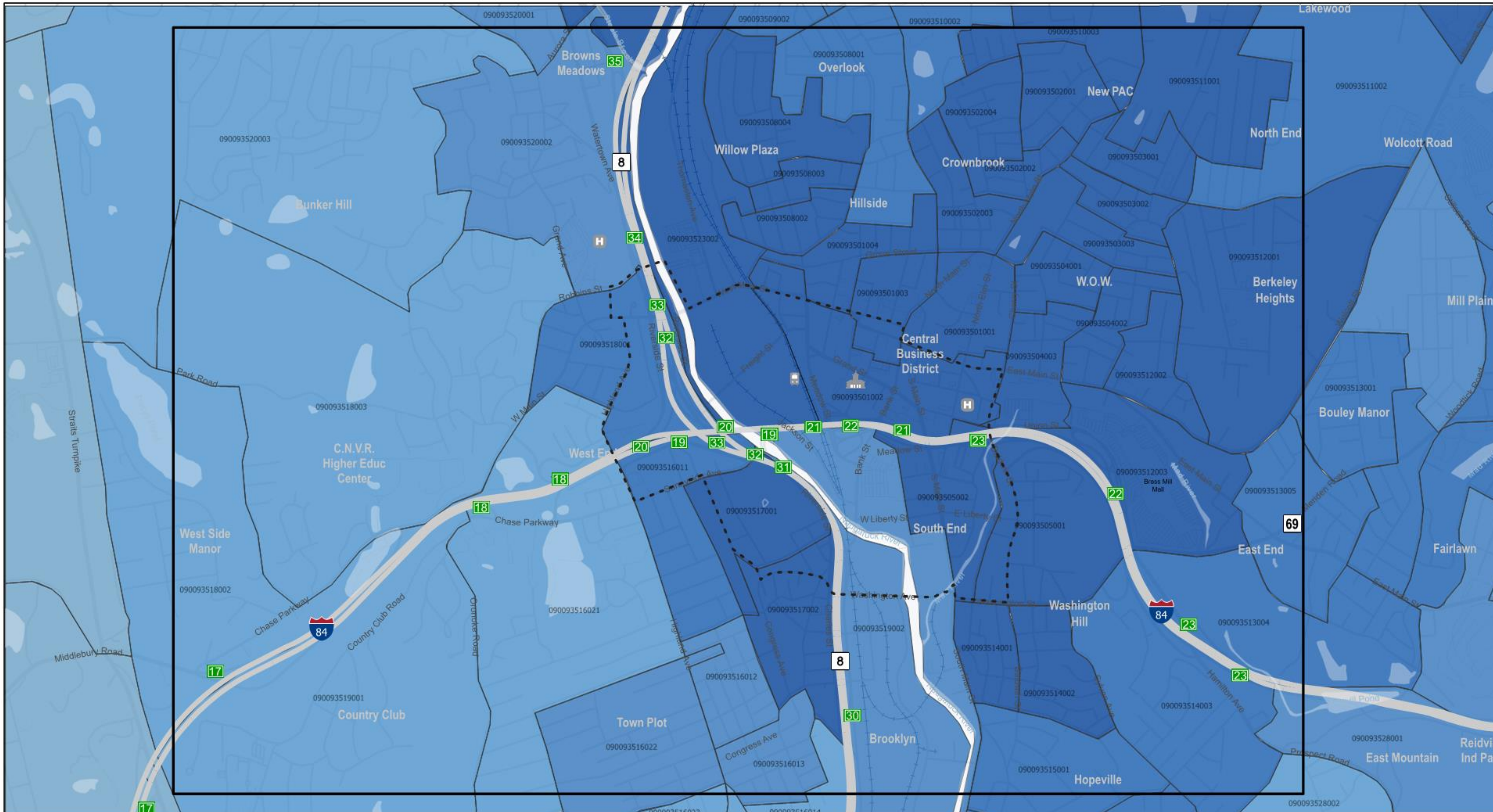
Table 4-2 provides data on the State, County, City, study area and individual block groups racial minority composition and low-income populations, while **Figure 4-3** depicts the location of Environmental Justice block groups. All data used to develop these maps and tables was collected from the 2017 US American Community Survey. Due to the racial composition and/or income findings, forty-eight of the fifty-five EJ Study Area block groups are considered EJ communities. Fourteen of the seventeen of block groups that are immediately adjacent to either Route 8 or I-84 are EJ communities, and all block groups surrounding the immediate interchange are EJ block groups (see **Figure 4-3**).

The City of Waterbury has also been on the Connecticut Distressed Municipalities List[12] since 1999, when the State started to publish the list. The list is determined annually based on indicators that measure the fiscal capacity of each municipality based on its tax base. In 2017, Waterbury was ranked third on the list. As both the EJ findings and Distressed Municipalities list indicate, the needs of the local community will be an important consideration in the development of highway alternatives.

[10] Council on Environmental Quality Executive Office of the President, *Environmental Justice Guidance Under the National Environmental Policy Act,* December 10, 1997. Accessed at https://www.epa.gov/sites/production/files/2015-02/documents/ej_guidance_nepa_ceq1297.pdf

[11] Federal Register by the Department of Health and Human Services (HHS), *Annual Update of the HHS Poverty Guidelines 2017*.

[12] Department of Economic and Community Development, State of Connecticut. Distressed Municipalities. From http://www.ct.gov/ecd/cwp/view.asp?a=1105&q=251248



Percent of Minorities by Block Group

- < 20%
- 21% - 40%
- 41% - 60%
- 61% - 80%
- 81% - 100%

Environmental Justice Study Area

Key Area

Source: U.S. Census Bureau, American Community Survey (ACS), "ACS Demographic and Housing Estimates" 2017: Five-Year Estimates Subject Tables.

Railroad

Open Space

Schools

20 Exit

Hospital

Train Station

City Hall

N

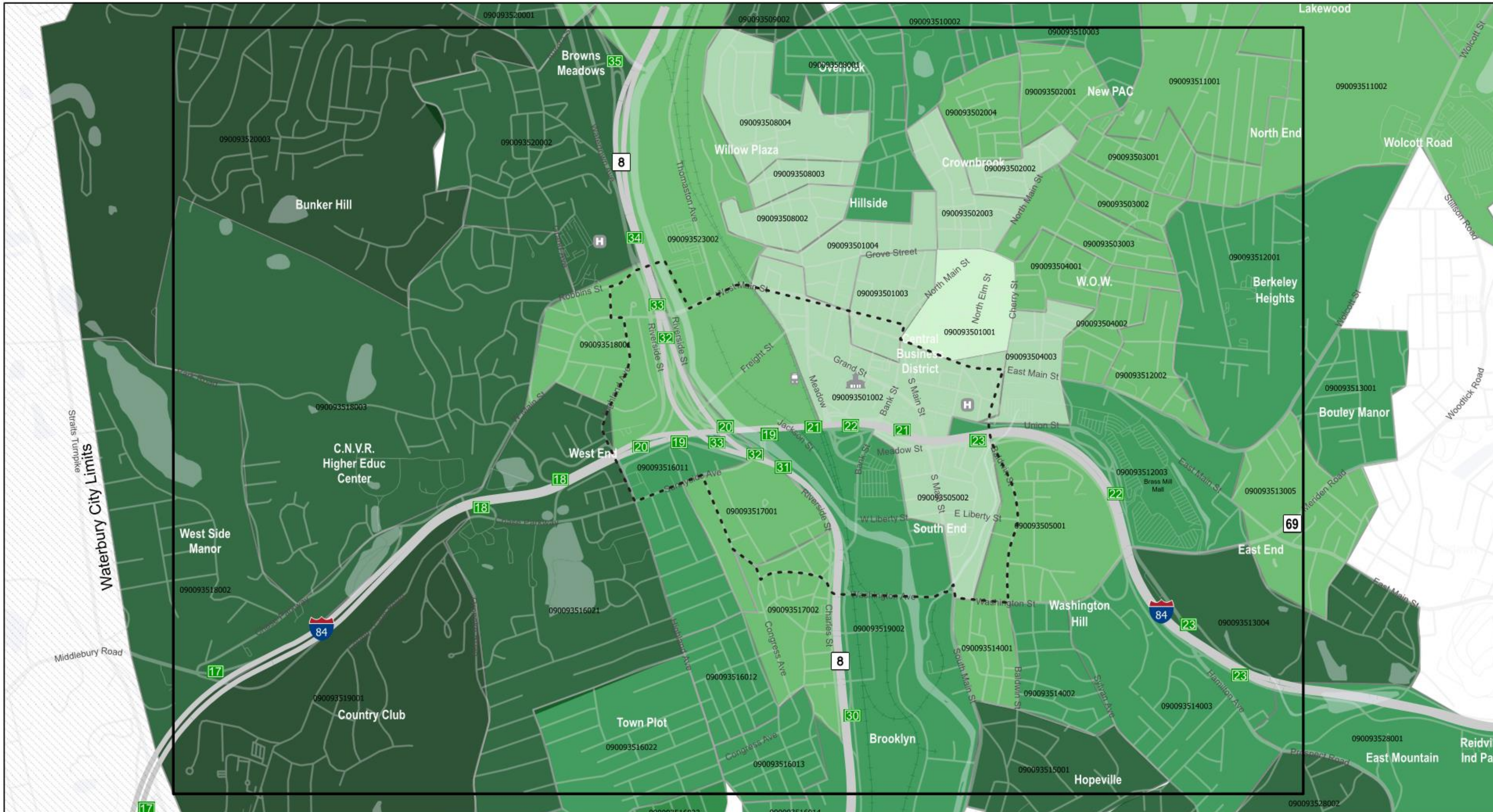
0 1,000 2,000 3,000 Feet

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Percentage of Minorities Map

Date: 8/5/2020 | Figure No: 4-2.1



Average Household Income by Block Group
- < $15,000
- $15,000 - 35,000
- $35,000 - $50,000
- $50,000 - 75,000
- $75,000 - 100,000
- > $100,000

Environmental Justice Study Area
Key Area

Source: U.S. Census Bureau, American Community Survey (ACS), "Income In the Past Twelve Months" 2017: Five-Year Estimates Subject Tables.

Railroad
Open Space
Schools
Exit
Hospital
Train Station
City Hall

N
0 1,000 2,000 3,000 Feet

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Average Household Income Map

Date: 8/5/2020 | Figure No: 4-2.2

Table 4-2 Environmental Justice Populations Matrix

	State of Connecticut		New Haven County		City of Waterbury		Study Area		Census Block Group																			
									90093501001		90093501002		90093501003		90093501004		90093502001		90093502002		90093502003		90093502004		90093503001		90093503002	
Income (by household)	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Households Below Threshold (income less than $37,914)	332084	25%	94890	30%	18448	47%	11764	46%	652	87%	428	94%	670	88%	368	72%	142	42%	151	76%	229	73%	164	54%	99	58%	77	48%
Households Above Threshold (income $37,914 or greater)	1,023,318	75%	232,512	70%	21,409	53%	14,420	54%	101	13%	29	6%	95	12%	145	28%	203	58%	49	24%	89	27%	149	46%	74	42%	92	52%
TOTAL	1355402	100%	327402	100%	39857	100%	26184	100%	753	100%	457	100%	765	100%	513	100%	345	100%	200	100%	318	100%	313	100%	173	100%	169	100%
Race (by individual)																												
Total Minority	1148429	32%	309127	36%	67204	62%	38860	63%	830	72%	325	79%	700	59%	445	84%	955	94%	515	99%	1000	100%	500	80%	430	83%	370	95%
Total Non-Minority	2,446,049	68%	553,000	64%	42,046	39%	22,980	37%	315	27%	85	21%	480	40%	85	15%	60	6%	5	1%	5	1%	125	19%	85	16%	20	5%
TOTAL	3,594,478	100%	862,127	100%	109,250	100%	61840	100%	1145	100%	410	100%	1180	100%	530	100%	1015	100%	520	100%	1005	100%	625	100%	515	100%	390	100%

Exceeds EJ Thresholds
90093501001 EJ Block Group

	Census Block Group																															
	90093503003		90093504001		90093504002		90093504003		90093505001		90093505002		90093508001		90093508002		90093508003		90093508004		90093509002		90093510002		90093510003		90093511001		90093511002		90093512001	
Income (by household)	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Households Below Threshold (income less than $37,914)	169	59%	120	60%	241	61%	132	69%	293	55%	205	69%	167	31%	267	64%	130	66%	459	74%	73	27%	79	24%	243	41%	545	47%	221	43%	320	46%
Households Above Threshold (income $37,914 or greater)	119	41%	82	40%	164	39%	63	31%	247	45%	93	31%	396	69%	161	36%	69	34%	166	26%	202	73%	255	76%	369	59%	636	53%	311	57%	384	54%
TOTAL	288	100%	202	100%	405	100%	195	100%	540	100%	298	100%	563	100%	428	100%	199	100%	625	100%	275	100%	334	100%	612	100%	1181	100%	532	100%	704	100%
Race (by individual)																																
Total Minority	700	92%	690	85%	935	89%	295	65%	1208	84%	620	93%	1449	63%	1004	80%	385	81%	1360	85%	134	42%	940	71%	1060	74%	1570	77%	889	67%	1780	80%
Total Non-Minority	65	8%	115	14%	120	12%	160	35%	227	16%	45	7%	841	37%	246	20%	90	19%	235	15%	186	58%	385	29%	365	26%	470	23%	446	33%	435	20%
TOTAL	765	100%	805	100%	1055	100%	455	100%	1435	100%	665	100%	2290	100%	1250	100%	475	100%	1595	100%	320	100%	1325	100%	1425	100%	2040	100%	1335	100%	2215	100%

Exceeds EJ Thresholds
90093501001 EJ Block Group

Source: U.S. Census Bureau, American Community Survey (ACS), "Income In the Past Twelve Months" and "ACS Demographic and Housing Estimates" 2017: Five-Year Estimates Subject Tables.

Table 4-2 Environmental Justice Populations Matrix (continued)

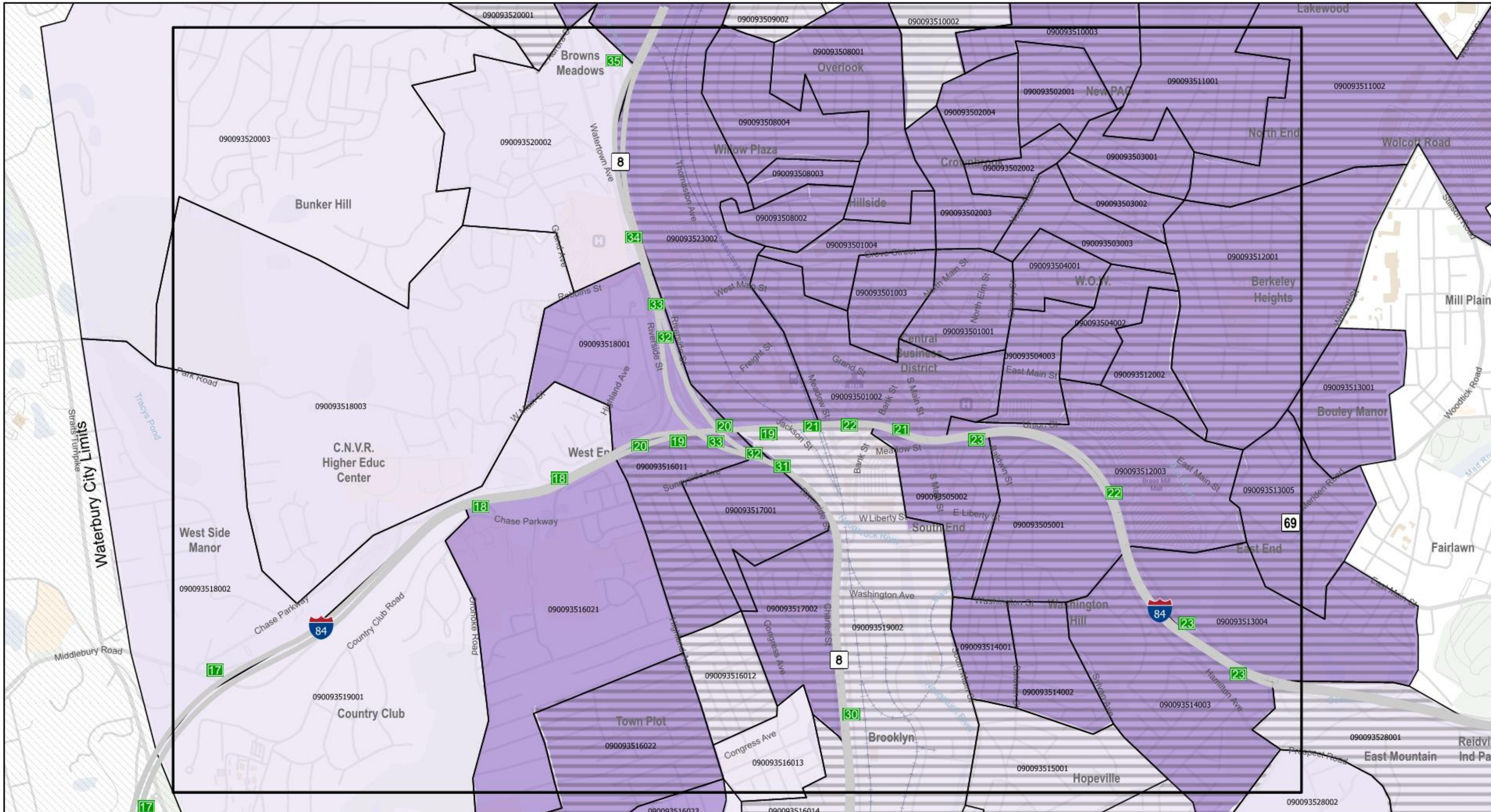
	Census Block Group																													
	90093512002		90093512003		90093513001		90093513004		90093513005		90093514001		90093514002		90093514003		90093515001		90093516011		90093516012		90093516013		90093516014		90093516021		90093516022	
Income (by household)	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Households Below Threshold (income less than $37,914)	228	62%	140	55%	219	43%	70	31%	243	52%	296	68%	168	38%	250	45%	90	21%	133	32%	93	28%	78	27%	78	27%	194	32%	363	44%
Households Above Threshold (income $37,914 or greater)	147	38%	121	45%	303	57%	163	69%	239	48%	139	32%	298	62%	312	55%	348	79%	306	68%	259	72%	225	73%	225	73%	412	68%	482	56%
TOTAL	375	100%	261	100%	522	100%	233	100%	482	100%	435	100%	466	100%	562	100%	438	100%	439	100%	352	100%	303	100%	303	100%	606	100%	845	100%
Race (by individual)																														
Total Minority	1085	76%	325	78%	855	73%	800	86%	480	80%	1054	85%	675	76%	1260	65%	800	65%	435	55%	384	47%	235	24%	165	34%	125	12%	1005	60%
Total Non-Minority	335	24%	90	23%	325	27%	135	14%	120	20%	176	15%	210	24%	685	35%	440	35%	350	45%	431	52%	730	76%	320	66%	945	88%	685	41%
TOTAL	1420	100%	415	100%	1180	100%	935	100%	600	100%	1230	100%	885	100%	1945	100%	1240	100%	785	100%	815	100%	965	100%	485	100%	1070	100%	1690	100%

Exceeds EJ Thresholds
90093501001 EJ Block Group

	Census Block Group																											
	90093516023		90093517001		90093517002		90093518001		90093518002		90093518003		90093519001		90093519002		90093520001		90093520002		90093520003		90093523002		90093528001		90093528002	
Income (by household)	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Households Below Threshold (income less than $37,914)	103	37%	164	55%	369	56%	368	61%	138	21%	149	25%	41	13%	81	19%	39	15%	90	20%	150	15%	136	46%	258	29%	93	15%
Households Above Threshold (income $37,914 or greater)	184	63%	146	45%	304	44%	239	39%	518	79%	472	75%	299	87%	380	81%	239	85%	396	80%	867	85%	173	54%	644	71%	595	85%
TOTAL	287	100%	310	100%	673	100%	607	100%	656	100%	621	100%	340	100%	461	100%	278	100%	486	100%	1017	100%	309	100%	902	100%	688	100%
Race (by individual)																												
Total Minority	50	7%	525	62%	1490	76%	350	43%	135	11%	265	20%	253	21%	454	46%	259	37%	320	27%	670	26%	634	89%	1090	47%	385	27%
Total Non-Minority	640	93%	320	38%	480	24%	460	57%	1,095	89%	1,035	79%	952	79%	541	54%	436	63%	865	73%	1,890	74%	81	11%	1,250	53%	1,035	73%
TOTAL	690	100%	845	100%	1970	100%	810	100%	1230	100%	1300	100%	1205	100%	995	100%	695	100%	1185	100%	2560	100%	715	100%	2340	100%	1420	100%

Exceeds EJ Thresholds
90093501001 EJ Block Group

Source: U.S. Census Bureau, American Community Survey (ACS), "Income In the Past Twelve Months" and "ACS Demographic and Housing Estimates" 2017: Five-Year Estimates Subject Tables.



Environmental Justice (EJ) Populations by Block Group

- EJ Populations (Income)
- EJ Populations (Race)
- EJ Populations (Income + Race)
- Not EJ Populations
- Environmental Justice Study Area

Source: U.S. Census Bureau, American Community Survey (ACS), "Income In the Past Twelve Months" and "ACS Demographic and Housing Estimates" 2017: Five-Year Estimates Subject Tables.

- Railroad
- Open Space
- Schools
- Exit
- Hospital
- Train Station
- City Hall

N

0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Environmental Justice Populations

Date: 8/5/2020 Figure No: 4-3

Limited English Proficiency

Limited English Proficiency (LEP) refers to individuals who do not speak English as their primary language and who have a limited ability to read, speak, write, or understand English.[13] The United States Department of Transportation (USDOT) issued "Policy Guidance Concerning Recipients' Responsibilities to LEP Persons" which is modeled after Department of Justice (DOJ) guidance to ensure "reasonable steps are taken to ensure meaningful access to programs and activities by LEP persons.[13]" These protections are in place to ensure that these individuals are given an equitable chance to be involved in the public outreach and participation activities associated with federally funded transportation projects.

The USDOT "Policy Guidance Concerning Recipients' Responsibilities to LEP Persons" discusses the concept of "safe harbor" with respect to the requirements for translation of written materials. The Safe Harbor Threshold is calculated by dividing the population estimate for a language group that "Speaks English less than very well" by the total population of the county. The LEP Safe Harbor Threshold provision stipulates that for each LEP group that meets the LEP language threshold (5 percent or 1,000 individuals, whichever is less, of the population to be served) the subrecipient of federal funding (local/state governments and transportation organizations and agencies) must provide translation of vital documents (e.g., Notice of Nondiscrimination, Complaint Procedure and Complaint Form) in written format for non-English speaking persons. These safe harbor provisions apply to written documents only. This data has been used to identify where populations have limited English proficiency within the Study Area. The languages that meet the safe harbor threshold in the Study Area are Spanish / Spanish Creole, Portuguese / Portuguese Creole, and other Indo-European languages. The Other Indo-European languages category includes Albanian, Lithuanian, Pashto (Pushto), Romanian, and Swedish-language speakers.

The US Census Bureau compiles 2015 American Community Survey (ACS) data for language groups at the state level for the following language groups:

- Spanish or Spanish Creole
- French (incl. Patois, Cajun)
- French Creole
- Italian
- Hmong
- German
- Yiddish
- Other West Germanic languages
- Scandinavian languages
- Greek
- Russian
- Polish
- Serbo-Croatian
- Other Slavic languages
- Armenian
- Persian
- Gujarati
- Hindi
- Urdu
- Other Indic languages
- Other Indo-European languages
- Chinese
- Japanese
- Korean
- Mon-Khmer, Cambodian
- Portuguese or Portuguese Creole
- Thai
- Laotian
- Vietnamese
- Other Asian languages
- Tagalog
- Other Pacific Island Languages
- Navajo
- Other Native North American languages
- Hungarian
- Arabic
- Hebrew
- African languages
- Other and unspecified languages

The Study Area has Census Tracts that meet the "safe harbor" threshold for "Spanish or Spanish Creole", "Portuguese or Portuguese Creole", and "Other Indo-European languages" presented in **Table 4.1.1-1** and displayed in **Figure 4.1.1-1**. The Other Indo-European languages category include Albanian-, Lithuanian-, Pashto- (Pushto), Romanian-, and Swedish-language speakers.

Additional research and targeted outreach led to the identification of Albanian as a type of "Other Indo-European Languages" spoken, as well as other languages spoken by populations in Waterbury. Albanian and Arabic are the top-two, non-English languages spoken by Waterbury Public School students. Additionally, Waterbury is home to Haitian populations that speak French/French Creole languages.

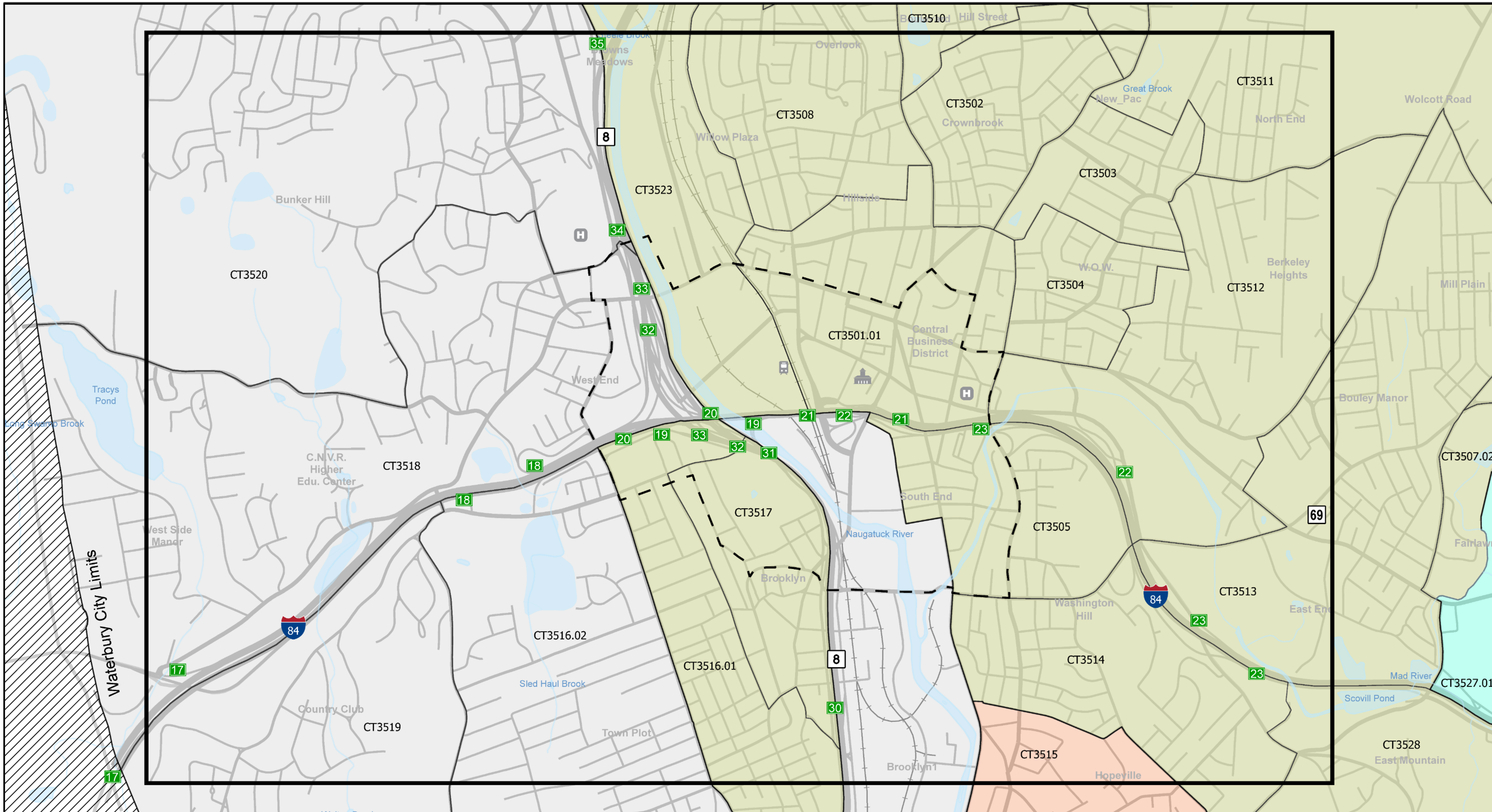
Table 4.1.1-1 Languages Meeting the "Safe Harbor" Threshold

Census Geography	Spanish or Spanish Creole:		Portuguese or Portuguese Creole:		Other Indo-European languages:		Total pop. 5 years and older:
	#	%	#	%	#	%	
CT 3501	813	*24.0*	-	0.0	-	0.0	3,382
CT 3502	661	*20.8*	-	0.0	-	0.0	3,175
CT 3503	364	*22.0*	-	0.0	-	0.0	1,655
CT 3504	370	*15.2*	17	0.7	-	0.0	2,435
CT 3505	579	*23.5*	59	2.4	14	0.6	2,462
CT 3508	741	*15.1*	22	0.4	6	0.1	4,915
CT 3509	114	*6.4*	20	1.1	-	0.0	1,794
CT 3510	289	*7.0*	11	0.3	25	0.6	4,127
CT 3511	284	*7.5*	-	0.0	82	2.2	3,782
CT 3512	621	*15.5*	48	1.2	-	0.0	4,001
CT 3513	425	*7.7*	-	0.0	73	1.3	5,532
CT 3514	830	*22.4*	81	2.2	25	0.7	3,710
CT 3515	369	*7.7*	217	*4.6*	-	0.0	4,765
CT 3516.01	158	*5.1*	24	0.8	18	0.6	3,103
CT 3517	166	*6.9*	-	0.0	-	0.0	2,408
CT 3521	234	*6.4*	32	0.9	26	0.7	3,648
CT 3522	204	*8.5*	-	0.0	7	0.3	2,394
CT 3523	445	*14.4*	11	0.4	-	0.0	3,091
CT 3524	205	*7.1*	21	0.7	-	0.0	2,896
CT 3526	267	*5.2*	-	0.0	202	3.9	5,122
CT 3527.01	130	*5.1*	-	0.0	176	*6.9*	2,559
CT 3527.02	376	*6.7*	79	1.4	-	0.0	5,628
CT 3528	817	*12.4*	19	0.3	63	1.0	6,570

(Shaded) Exceeds "Safe Harbor" threshold

Source: US Census Bureau. Table B16001 - Age by Language Spoken at Home by Ability to Speak English for the Population 5 Years and Over (2015 ACS 5-year estimates).

[13] United States Department of Transportation (USDOT). *LEP Guidance*. From January 2016



Legend

- US Census Tracts
- Spanish/Spanish creole and Other Indo-European Language
- Spanish/Spanish Creole and Portuguese/Potuguese Creole
- Spanish or Spanish Creole

- Hospital
- Train Station
- City Hall
- Railroad
- 20 Exit

- Environmental Justice Study Area
- Key Area

Source:
United States Census Bureau. American Community Survey (ACS) - Age by Language Spoken at Home by Ability to Speak English for the Population 5 years and Over. 2015 ACS 5-year estimates.

N

0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Limited English Proficiency Census Tracts in Waterbury

Date: 2023 | Figure No: 4.1.1-1

Land Use and Zoning

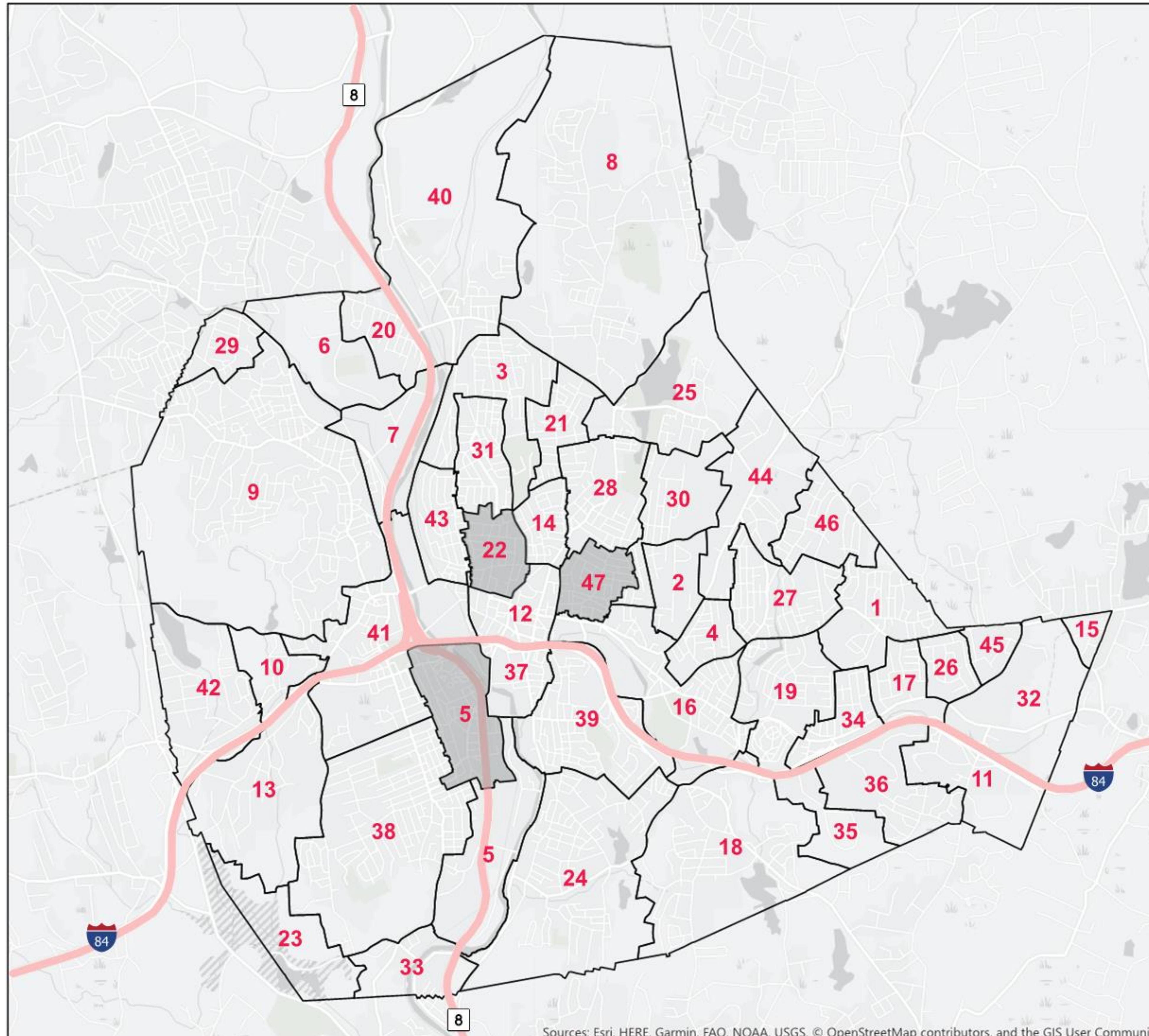
To develop an understanding of the setting in which the Mixmaster is located, land use and zoning information for the City of Waterbury was collected. According to the 2015 POCD, Waterbury has a total land area of approximately 18,640 acres, with a variety of land uses. The land use was comprised of:

- 35.7% Residential
- 17.3% Infrastructure and Right-of-Way
- 18.0% Vacant Land
- 11.3% Open Space
- 6.0% Institutional
- 5.7% Commercial and Office Uses
- 6.0% Industrial Uses

Majority of the commercial and office uses are located within and adjacent to the CBD. The CBD has a range of mixed use residential and commercial buildings. More than half of the industrial land is light industry clustered in industrial parks near I-84 and Route 8. **Figure 4-5** illustrates the existing land use, while **Figure 4-6** illustrates the future land use proposed in the POCD around the key area. The Future Land Use Plan is based upon appropriate locations for and relationships between land uses, existing land use and development patterns, environmental and natural features, physical features, current and potential zoning, planning analysis, public workshops and community survey to reflect the desires and visions of citizens and stakeholders.

The City of Waterbury has three active Neighborhood Revitalization Zones (NRZ) and twenty-one active neighborhood groups. The NRZ Program was established by the State of Connecticut in 1995 to revitalize neighborhoods through the collaborative involvement of residents, business, and government to determine a common vision and set of priorities. Of the four neighborhoods surrounding the Mixmaster, the neighborhood of Brooklyn, on the south side of the Mixmaster, is the only designated NRZ. The other two NRZ neighborhoods, St. Margaret/Willow Plaza and Walnut Orange Walsh, are outside the key area boundary of the Mixmaster, as indicated on the city-wide neighborhood map in **Figure 4-4**.

1 Alexander Avenue
2 Berkeley Heights
3 Boulevard
4 Bouley Manor
-Bouley Manor Neighborhood Assoc.
5 Brooklyn
-Brooklyn Neighborhood Assoc. NRZ
6 Brookside Ind. Park
7 Brown's Meadow
8 Bucks Hill
-Bucks Hill Community Club
9 Bunker Hill
-Bunker Hill Community Club
-Western Hills Neighborhood Assoc.
10 C.N.V.R. Higher Ed. Center
11 Captain Neville Ind. Park
12 Central Business District
-Main Street Waterbury
13 Country Club
-Country Club Neighborhood Assoc.
14 Crown Brook
-Crown Brook Neighborhood Assoc.
15 Deerfield and Sunset
16 East End
-East End Community Club
17 East Farm
18 East Mountain
19 Fairlawn
20 Fairmount
21 Hill Street
22 Hillside
-Hillside Historic District Neighborhood Assoc.
-St. Margaret/Willow Plaza NRZ
23 Hop Brook
24 Hopeville
-Hopeville Neighborhood Assoc.
-Gilmartin Community Club
-South End Neighborhood Assoc.
-Washington Park Neighborhood Assoc.
25 Lakewood
-Lakewood Neighborhood Assoc.
26 Maplewood Manor
27 Mill Plain
28 New PAC
29 Newtown Heights
30 North End
31 Overlook
32 Pierpont Road
33 Platts Mills
34 Reidville
35 Reidville Ind. Park
- Bouley Manor Neighborhood Assoc.
36 Scott Road
37 South End
38 Town Plot
-Town Plot Neighborhood Assoc.
39 Washington Hill
40 Waterville
-Waterville Community Club
-Waterbury Neighborhood Council
41 West End
42 West Side Manor
43 Willow Plaza
44 Wolcott Road
45 Woodhaven
46 Woodtick Road
47 W.O.W.
-Walnut Orange Walsh NRZ

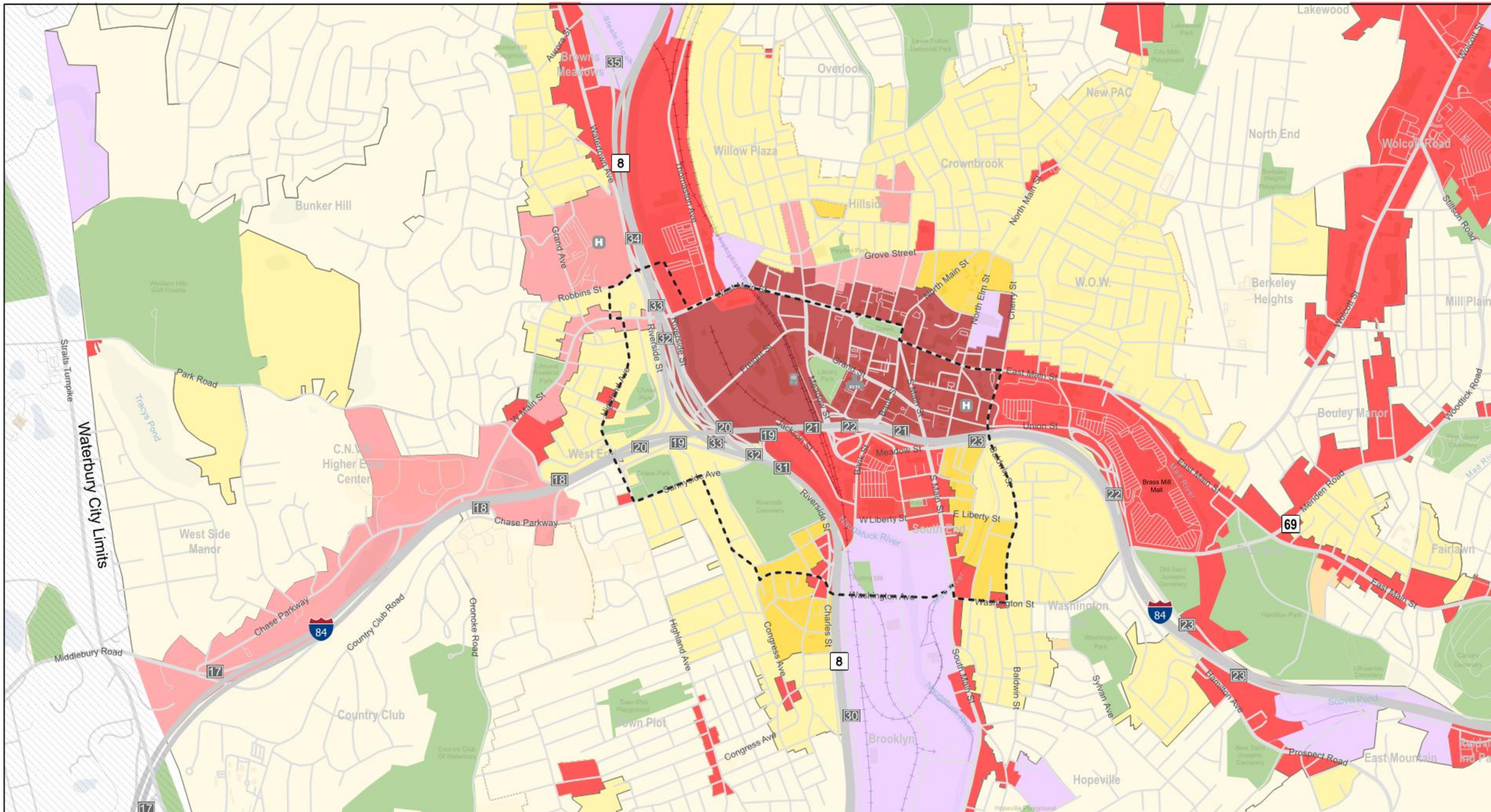


Neighborhood with a Neighborhood Revitalization Zone (NRZ)

84 new mix — I-84 Waterbury Mixmaster Reconstruction Project

HNTB — Neighborhoods and Neighborhood Groups

Date: 4/27/2020 | Figure No: 4-4



Key Area Boundary
Low Density Residential
Medium Density Residential
High Density Residential
Central Business District
Commercial
Mixed Use
Industrial
Open Space
Railroad
Exit
Hospital
Train Station
City Hall

N

0 1,000 2,000 3,000 Feet

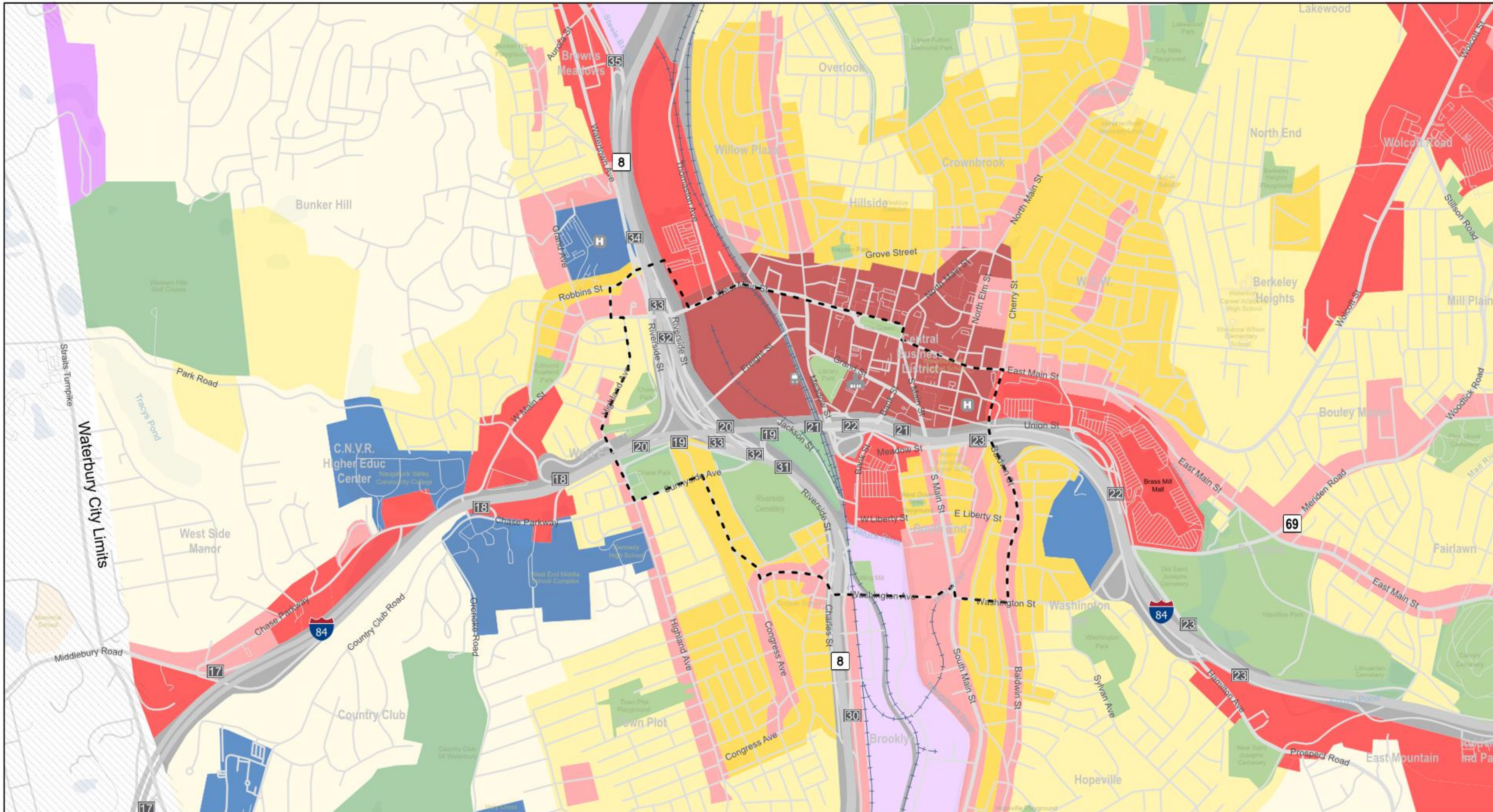
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Land Use Map

Date: 11/22/2019 Figure No: 4-5



Key Area Boundary	Central Business District
Low Density Residential	Commercial
Medium Density Residential	Mixed Use
High Density Residential	Industrial
Open Space	Railroad
Institutional	Open Space
Industrial Park	Schools
Hospital	Exit
Train Station	City Hall

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Future Land Use

Date: 4/28/2020 Figure No: 4-6

Open Space and Public Parks

In 1997, the State of Connecticut added in its General Statutes, a goal of conserving 21%, or 673,210 acres, of State land for open space by year 2023. According to the POCD, the City of Waterbury's current goal is to conserve 21%, a 10% increase from the current state, of its land for open space but a specific strategy has not been proposed. Open spaces are intended to preserve the natural qualities of an area that are tied to environmental features and the wellbeing of regional wildlife. The preservation of open space aims to maintain the aesthetic and cultural character of the region.

Connecticut's public parks are outdoor green spaces set aside by the government for recreational benefits for public use. Parks offer enhancements to urban spaces such as connectivity, sites for gathering, and ecological value.

Currently, the open spaces located in the City of Waterbury and listed in the POCD consist of:

- 7.0% Public Parks and Recreation
- 2.0% Preserved Open Space
- 1.7% Cemeteries

Major public parks in the key area include: (see **Figure 4-7**)

- Waterbury Green
- Library Park
- Chase Park
- Hamilton Park
- Washington Park

Streetscape

Streetscape elements such as street trees and urban planting serve as an environmentally conscience planning precedent that improves water quality, mitigates urban heat island effect, and reduces air pollution. Some of Waterbury's neighborhoods are lined with these streetscape elements which also help enhance the experience of being in the city in addition to the environmental benefits. The newly installed Freight Street Reconstruction also includes green infrastructure to manage stormwater and create a visually attractive buffer between vehicular traffic and bicycle/pedestrian paths.

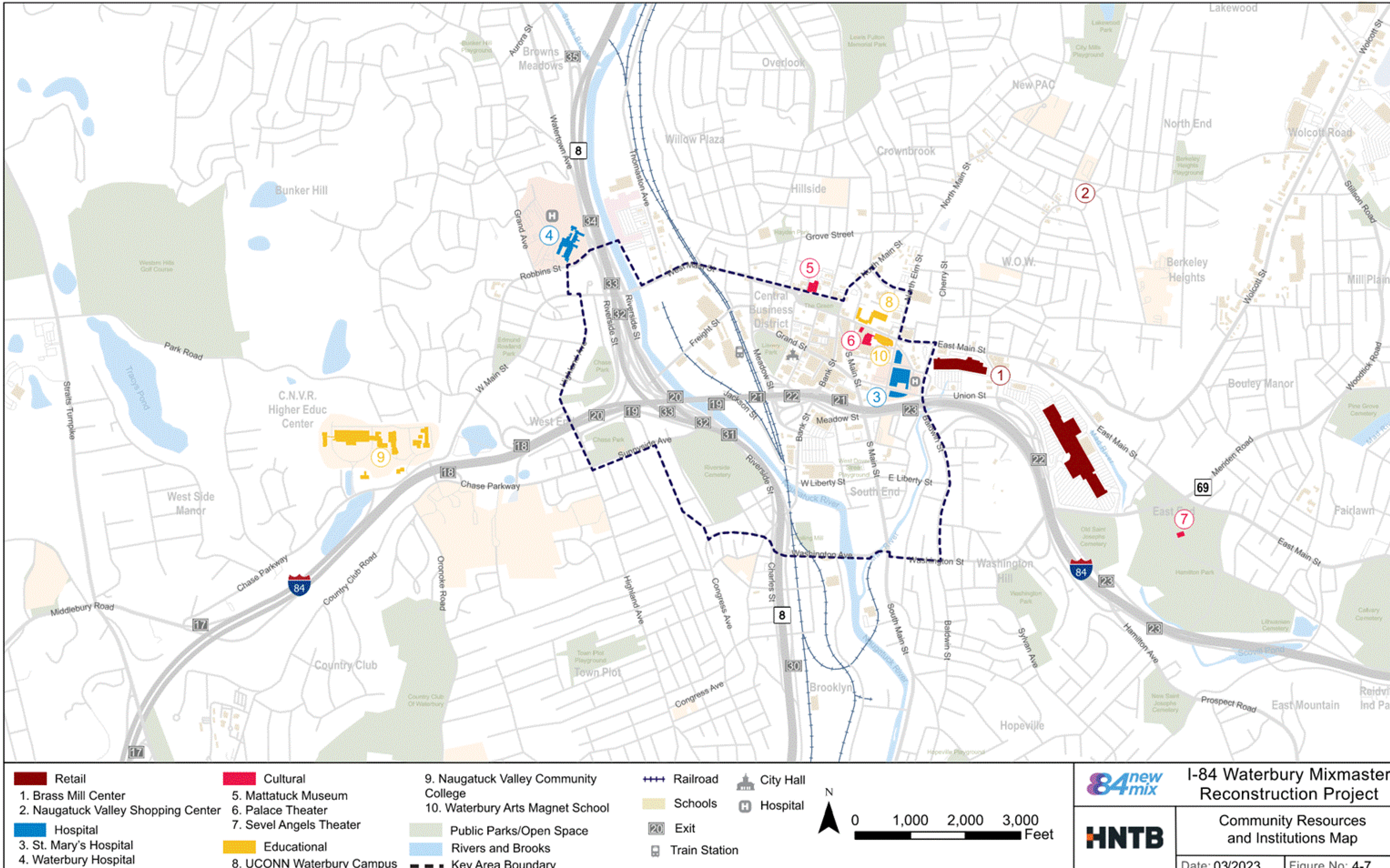
Economic and Cultural Drivers

Economic and cultural drivers for the City of Waterbury were identified to ensure the Project is designed to promote economic and cultural preservation and growth in the city (see **Figure 4-7).** In Waterbury, the largest employer is City government. The largest private-sector employers are St. Mary's Hospital and Waterbury Hospital. St. Mary's Hospital is in downtown Waterbury and Waterbury Hospital is adjacent to Route 8, just north of the interchange. All three employers have 1,000 or more employees.

Waterbury has several major retail centers, in addition to the local shops in the CBD. The major retail centers within the city boundaries are Brass Mill Center, immediately adjacent to downtown on the east, and Naugatuck Valley Shopping Center at the outskirt along Route 69. Downtown Waterbury is currently undergoing revitalization and it is the City of Waterbury's goal to transform the area through mixed-use development.

Mattatuck Museum and the Palace Theater are two examples of major cultural resources located in downtown Waterbury. The Palace Theater was renovated in 2004, alongside the opening of the Waterbury Arts Magnet School. A short distance from the Mixmaster, south of Brass Mill Center, is the Seven Angels Theater at Hamilton Park which is a venue for regional and national touring performances.

In addition to art and cultural venues, Waterbury is home to several educational institutions. Adjacent to the key study area, is the University of Connecticut Waterbury Campus in the CBD. The Naugatuck Valley Community College (NVCC) is located west of the interchange and not included in the key area.



Retail
1. Brass Mill Center
2. Naugatuck Valley Shopping Center
Hospital
3. St. Mary's Hospital
4. Waterbury Hospital
Cultural
5. Mattatuck Museum
6. Palace Theater
7. Sevel Angels Theater
Educational
8. UCONN Waterbury Campus
9. Naugatuck Valley Community College
10. Waterbury Arts Magnet School
Public Parks/Open Space
Rivers and Brooks
Key Area Boundary
Railroad
Schools
Exit
Train Station
City Hall
Hospital
N
0
1,000
2,000
3,000
Feet
84 new mix
I-84 Waterbury Mixmaster Reconstruction Project
HNTB
Community Resources and Institutions Map
Date: 03/2023
Figure No: 4-7
Browns Meadows
Overlook
Willow Plaza
Crownbrook
New PAC
North End
Wolcott Road
Lakewood
Bunker Hill
Hillside
W.O.W.
Berkeley Heights
Mill Plain
Central Business District
C.N.V.R. Higher Educ Center
West Side Manor
Bouley Manor
South End
Fairlawn
Washington Hill
Country Club
Town Plot
Brooklyn
Hopeville
East Mountain
Reidville Ind Park
Grove Street
East Main St
Union St
Meadow St
Chase Parkway
Middlebury Road
Country Club Road
Park Road
Robbins St
W Main St
Sunnyside Ave
Washington Ave
Washington St
Meriden Road
Prospect Road
Hamilton Ave

Historical Resources

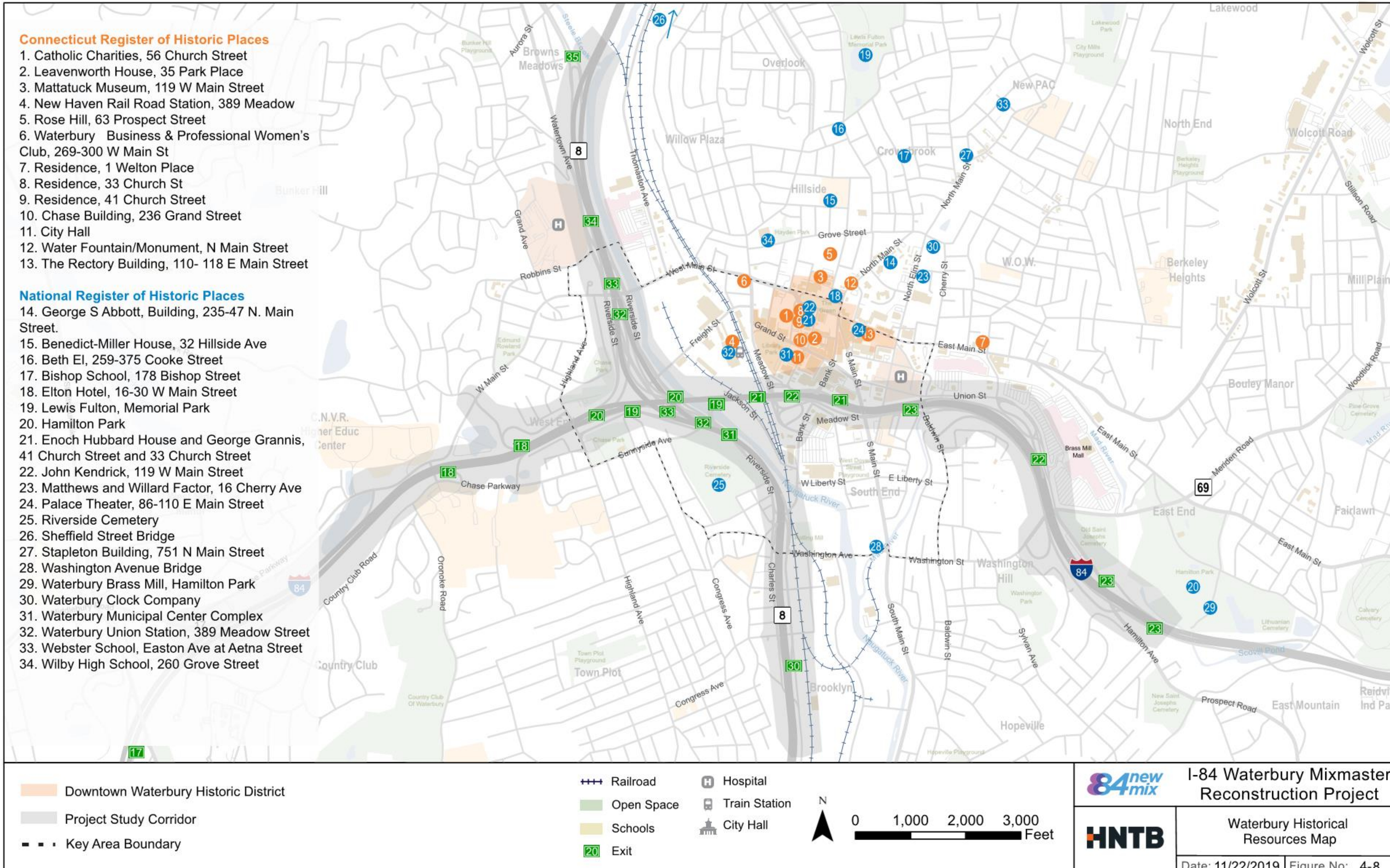
The City of Waterbury has a wealth of historic inventory (see **Figure 4-8**). There are four historic Districts on the Federal and State Register, thirteen properties on the Connecticut Register of Historic Places, thirty-one properties on the National Register of Historic Places, and one known archaeological site (see **Table 4-3**).

Mapping from the NPS National Register of Historic Places' unrestricted database shows three historically significant areas that are partially located within the Project Study Corridor (see **Figure 4-8**). These resources include Riverside Cemetery, a cultural resource site, and Downtown Waterbury Historic District and Hamilton Park, which are both considered cultural resource districts. Other smaller resources including cultural resource buildings, sites, and structures are mapped in the vicinity, but outside of the Project Study Corridor. It should be noted that since this mapping is from unrestricted database, there are potentially additional resources present in or near the existing alignment that may be included in databases which are not available to the public.

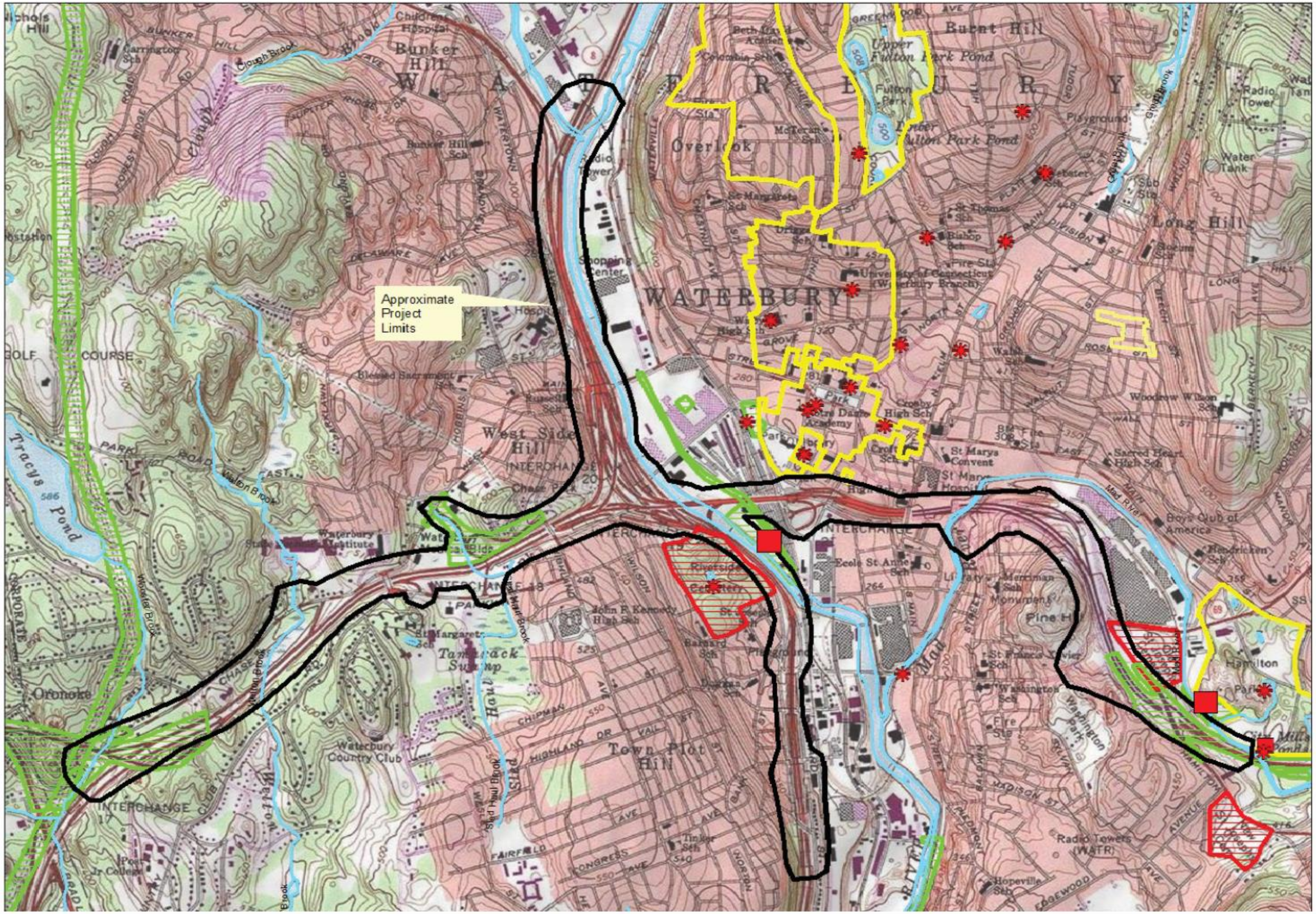
Additional historical and archaeological mapping is provided in **Figure 4-8.1** through **Figure 4-8.9** which show Approximate Project Limits in relation to known cultural resources on file with the CTDOT Office of Environmental Planning. One archaeological site, named Dog's Nest, is located along Jackson Street.

Table 4-3 City of Waterbury Historical Resources

<table>
<tr><th>Connecticut Register of Historic Places</th><th>National Register of Historic Places, Properties</th></tr>
<tr><td>• Catholic Charities, 56 Church Street
• Leavenworth House, 35 Park Place
• Mattatuck Museum, 119 W Main Street
• New Haven Railroad Station (Union Station), 389 Meadow
• Rose Hill, 63 Prospect Street
• Waterbury Business & Professional Women's Club, 269-300 W Main St
• Residence, 1 Welton Place
• Residence, 33 Church St
• Residence, 41 Church Street
• Chase Building, 236 Grand Street
• City Hall
• Water Fountain/Monument, N Main Street
• The Rectory Building (St Patrick's Hall), 110-118 E Main Street</td><td rowspan="5">• George S Abbott, Building, 235-47 N. Main Street.
• Benedict-Miller House, 32 Hillside Ave
• Beth El, 259-375 Cooke Street
• Bishop School, 178 Bishop Street
• Elton Hotel, 16-30 W Main Street
• Lewis Fulton, Memorial Park, bounded by Cook, Pine, Fern and Charlotte Streets
• Hamilton Park, bounded by Silver Street, E Main Street, Idlywood Ave, Plank Rod, the Mad River and I-84
• Enoch Hubbard House and George Grannis, 41 Church Street and 33 Church Street
• John Kendrick, 119 W Main Street
• Matthews and Willard Factor, 16 Cherry Ave
• Palace Theater, 86-110 E Main Street
• Riverside Cemetery, Riverside Street from Sunnyside to Summit Street
• Sheffield Street Bridge, Sheffield Street over Hancock Brook
• Stapleton Building, 751 N Main Street
• Washington Avenue Bridge, Washington Ave over Mad River
• Waterbury Brass Mill, Idlewood Ave in Hamilton Park
• Waterbury Clock Company, N Elm, Cherry Street, and Cherry Ave
• Waterbury Municipal Center Complex, 235, 236 Grand Street; 7, 35, 43 Field Street
• Waterbury Union Station, 389 Meadow Street
• Webster School, Easton Ave at Aetna Street
• Wilby High School, 260 Grove Street</td></tr>
<tr><th>National Register of Historic Places, District</th></tr>
<tr><td>• Bank Street Historic District, 207-231 Bank Street
• Downtown Waterbury Historic District, bounded by Main, Meadow, and Elm Streets
• Hillside Historic District, bounded by Woodlawn Terr., W Main Street, and Willow Street</td></tr>
<tr><th>Archaeological Sites</th></tr>
<tr><td>• Dog's Nest Site, 69-29 Jackson Street</td></tr>
</table>


Connecticut Register of Historic Places
1. Catholic Charities, 56 Church Street
2. Leavenworth House, 35 Park Place
3. Mattatuck Museum, 119 W Main Street
4. New Haven Rail Road Station, 389 Meadow
5. Rose Hill, 63 Prospect Street
6. Waterbury Business & Professional Women's Club, 269-300 W Main St
7. Residence, 1 Welton Place
8. Residence, 33 Church St
9. Residence, 41 Church Street
10. Chase Building, 236 Grand Street
11. City Hall
12. Water Fountain/Monument, N Main Street
13. The Rectory Building, 110- 118 E Main Street
National Register of Historic Places
14. George S Abbott, Building, 235-47 N. Main Street.
15. Benedict-Miller House, 32 Hillside Ave
16. Beth El, 259-375 Cooke Street
17. Bishop School, 178 Bishop Street
18. Elton Hotel, 16-30 W Main Street
19. Lewis Fulton, Memorial Park
20. Hamilton Park
21. Enoch Hubbard House and George Grannis, 41 Church Street and 33 Church Street
22. John Kendrick, 119 W Main Street
23. Matthews and Willard Factor, 16 Cherry Ave
24. Palace Theater, 86-110 E Main Street
25. Riverside Cemetery
26. Sheffield Street Bridge
27. Stapleton Building, 751 N Main Street
28. Washington Avenue Bridge
29. Waterbury Brass Mill, Hamilton Park
30. Waterbury Clock Company
31. Waterbury Municipal Center Complex
32. Waterbury Union Station, 389 Meadow Street
33. Webster School, Easton Ave at Aetna Street
34. Wilby High School, 260 Grove Street
Downtown Waterbury Historic District
Project Study Corridor
Key Area Boundary
Railroad
Open Space
Schools
Exit
Hospital
Train Station
City Hall
N
0 1,000 2,000 3,000 Feet
84 new mix
I-84 Waterbury Mixmaster Reconstruction Project
HNTB
Waterbury Historical Resources Map
Date: 11/22/2019 Figure No: 4-8

Detail of 2013 USGS Topo Map



Office of Environmental Planning
Environmental Review
Historical and Archaeological Resources

State Project No. 151-331
I-84 & Route 8 Intersection
Mixmaster Reconstruction
Waterbury
Map 1 of 9

- Project Area
- Watercourses
- Natl Hist Landmarks
- NRHP Structures
- Historic Districts
- Cemetery
- Previous CR Surveys

Approximate Location of Archaeological Site

- **Historic**
- **Pre-Contact**
- **Unknown**

N

0 950 1,900 3,800 Feet

84 new mix

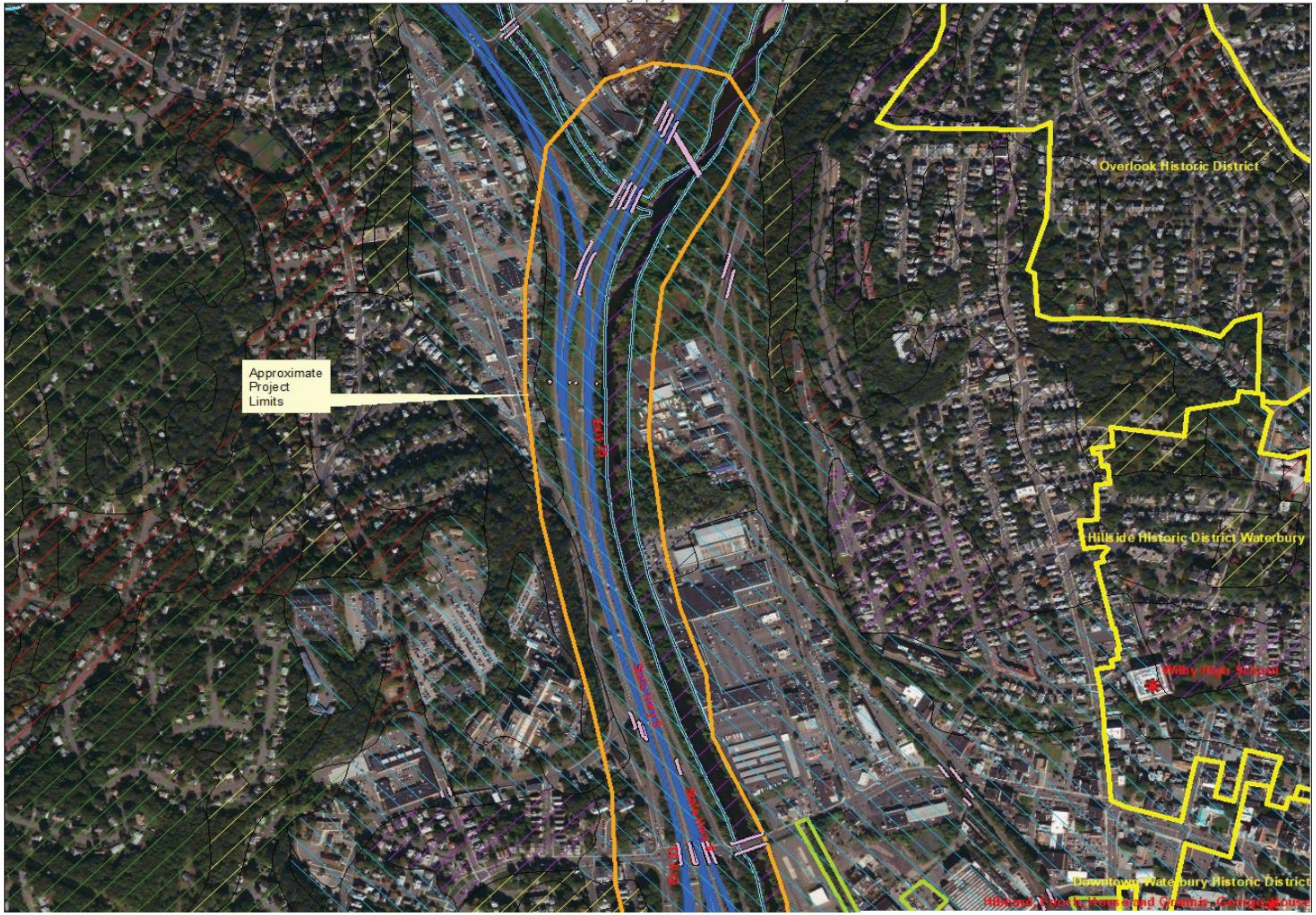
I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Historical and Archaeological Resources Map 1 of 9

Date: 6/2/2020 | Figure No: 4-8.1

Detail of Recent Aerial Photography -- Northernmost Aspect of Project Area



Office of Environmental Planning Environmental Review Historical and Archaeological Resources

State Project No. 151-331
I-84 & Route 8 Intersection
Mixmaster Reconstruction
Map 2 of 9
Waterbury

Project Area
Natl Hist Landmarks
NRHP Structures
Historic Districts
Cemetery
Previous CR Surveys

Approximate Location of Archaeological Site

Historic
Pre-Contact
Unknown

Predicted Archaeological Soil Sensitivity

High	Low
Moderate	Poor
Variable	Unknown

CONNECTICUT DEPARTMENT OF TRANSPORTATION

N

0 300 600 1,200 1,800 2,400 Feet

84 new mix

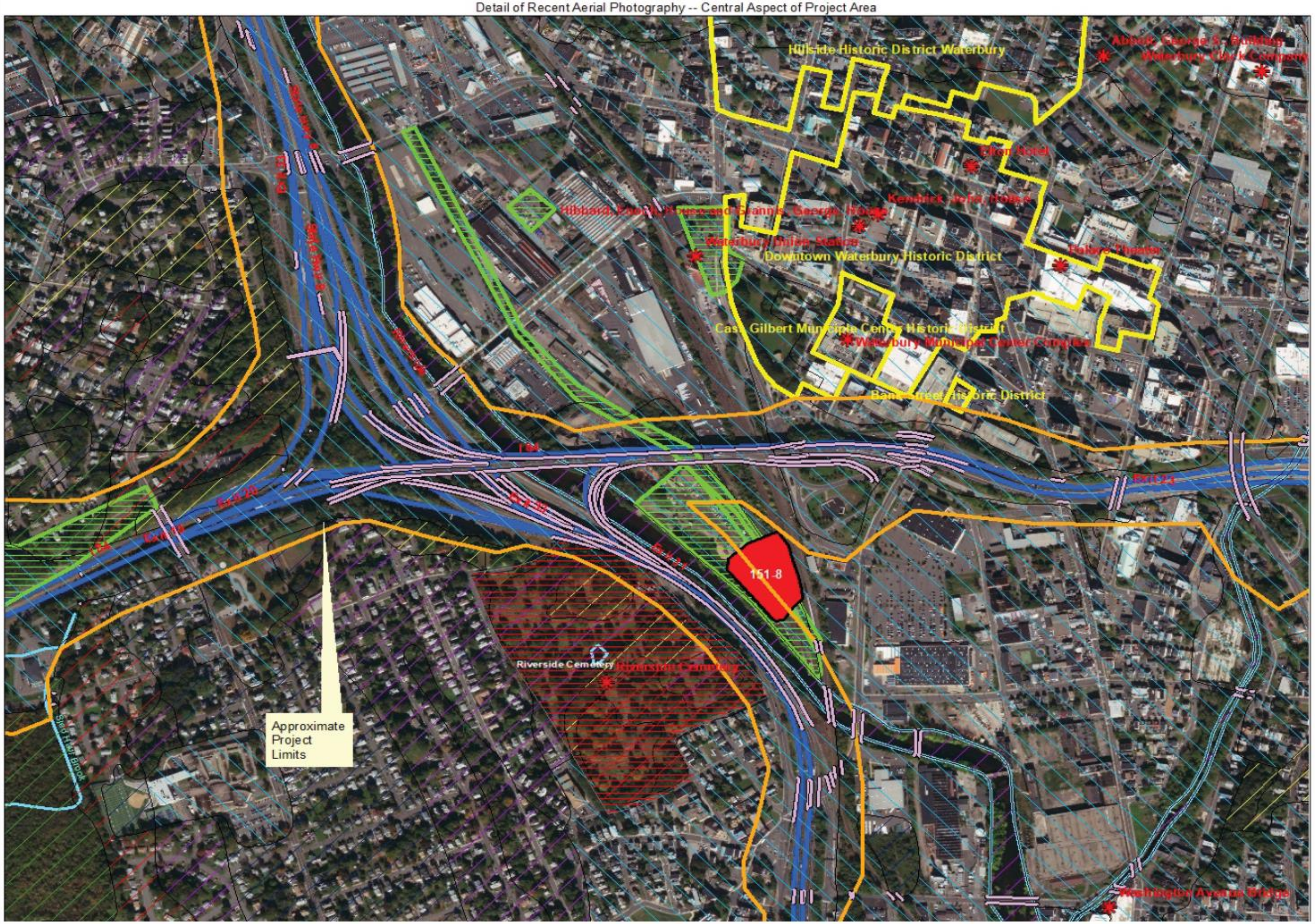
I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Historical and Archaeological Resources Map 2 of 9

Date: 6/2/2020 | Figure No: 4-8.2

Detail of Recent Aerial Photography -- Central Aspect of Project Area



Office of Environmental Planning
Environmental Review
Historical and Archaeological Resources

State Project No. 151-331
I-84 & Route 8 Intersection
Mixmaster Reconstruction
Map 3 of 9
Waterbury

- Project Area
- Natl Hist Landmarks
- NRHP Structures
- Historic Districts
- Archeo Site Bounds
- Cemetery
- Previous CR Surveys

Approximate Location of Archaeological Site

- Historic
- Pre-Contact
- Unknown

Predicted Archaeological Soil Sensitivity

- High
- Low
- Moderate
- Poor
- Variable
- Unknown

N

0 300 600 1,200 1,800 2,400 Feet

84 new mix

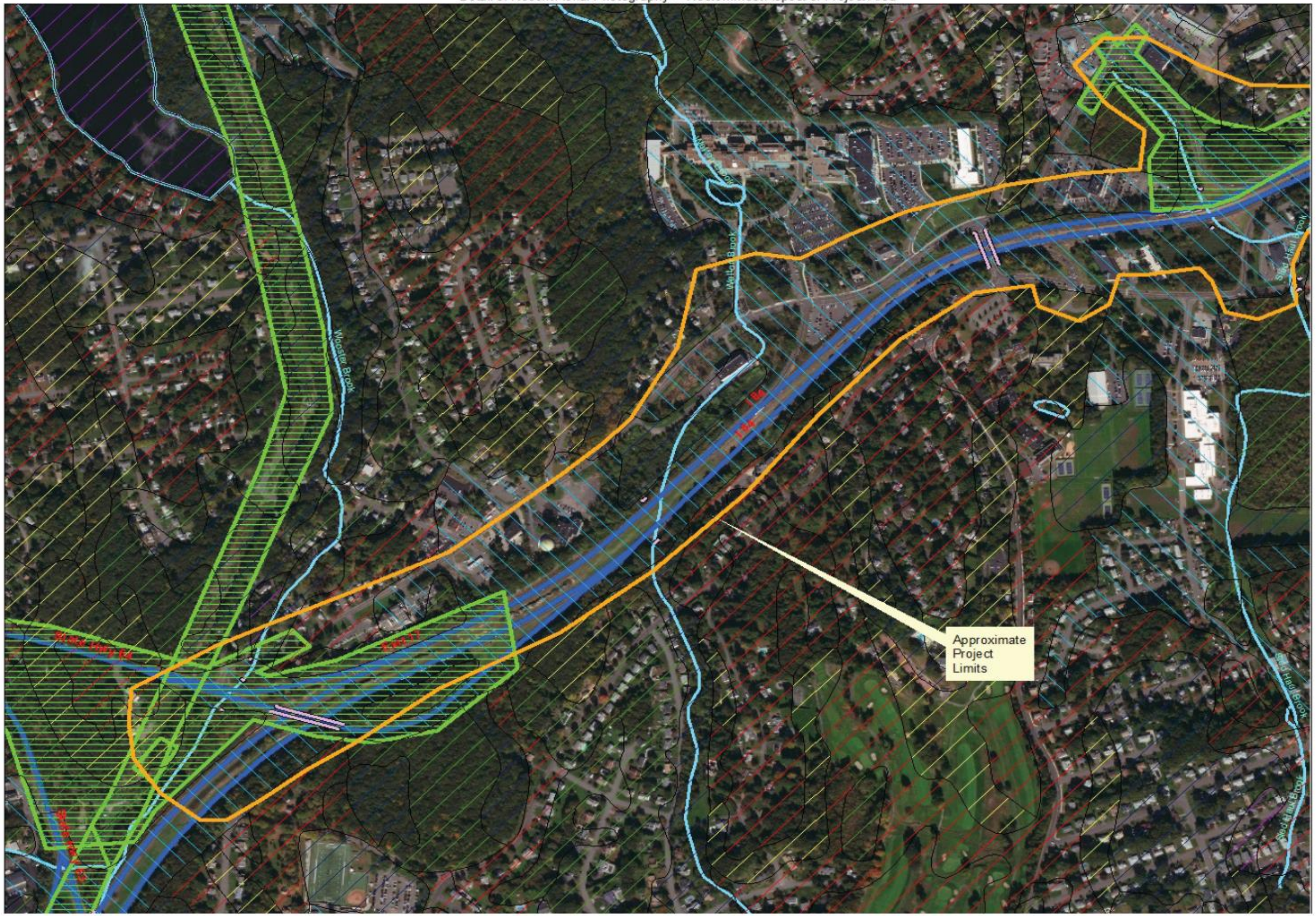
I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Historical and Archaeological Resources Map 3 of 9

Date: 6/2/2020 | Figure No: 4-8.3

Detail of Recent Aerial Photography -- Westernmost Aspect of Project Area



Office of Environmental Planning
Environmental Review
Historical and Archaeological Resources

State Project No. 151-331
I-84 & Route 8 Intersection
Mixmaster Reconstruction
Map 4 of 9
Waterbury

Project Area
Natl Hist Landmarks
NRHP Structures
Historic Districts
Cemetery
Previous CR Surveys

Approximate Location of Archaeological Site

Historic
Pre-Contact
Unknown

Predicted Archaeological Soil Sensitivity

High
Low
Moderate
Poor
Variable
Unknown

N

0 300 600 1,200 1,800 2,400
Feet

84 new mix

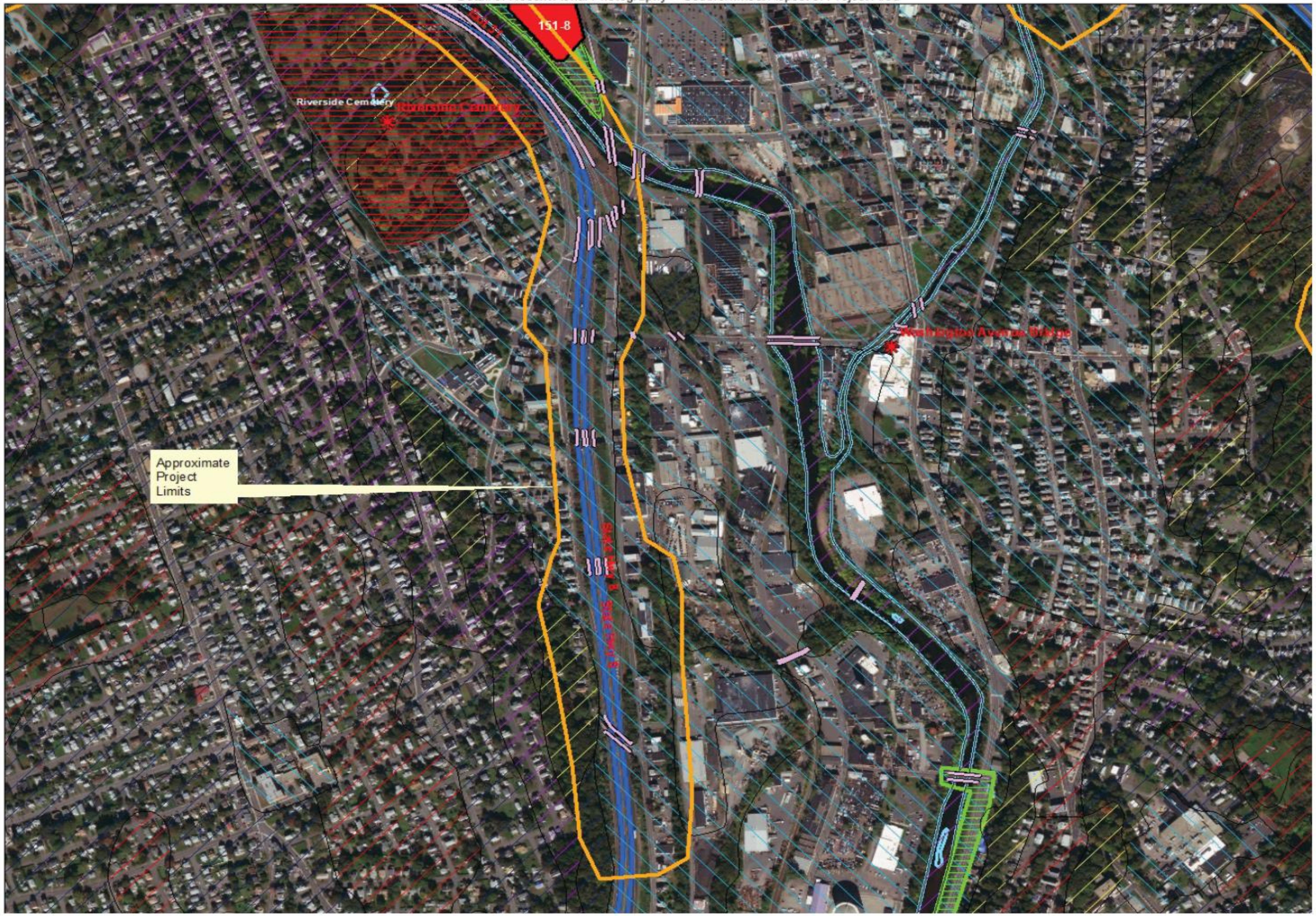
I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Historical and Archaeological Resources Map 4 of 9

Date: 6/2/2020 | Figure No: 4-8.4

Detail of Recent Aerial Photography -- Southernmost Aspect of Project Area



Office of Environmental Planning
Environmental Review
Historical and Archaeological Resources

State Project No. 151-331
I-84 & Route 8 Intersection
Mixmaster Reconstruction
Map 5 of 9
Waterbury

- Project Area
- Natl Hist Landmarks
- NRHP Structures
- Historic Districts
- Archeo Site Bounds
- Cemetery
- Previous CR Surveys

Approximate Location of Archaeological Site

- **Historic**
- **Pre-Contact**
- **Unknown**

Predicted Archaeological Soil Sensitivity

- High
- Low
- Moderate
- Poor
- Variable
- Unknown

N

0 300 600 1,200 1,800 2,400 Feet

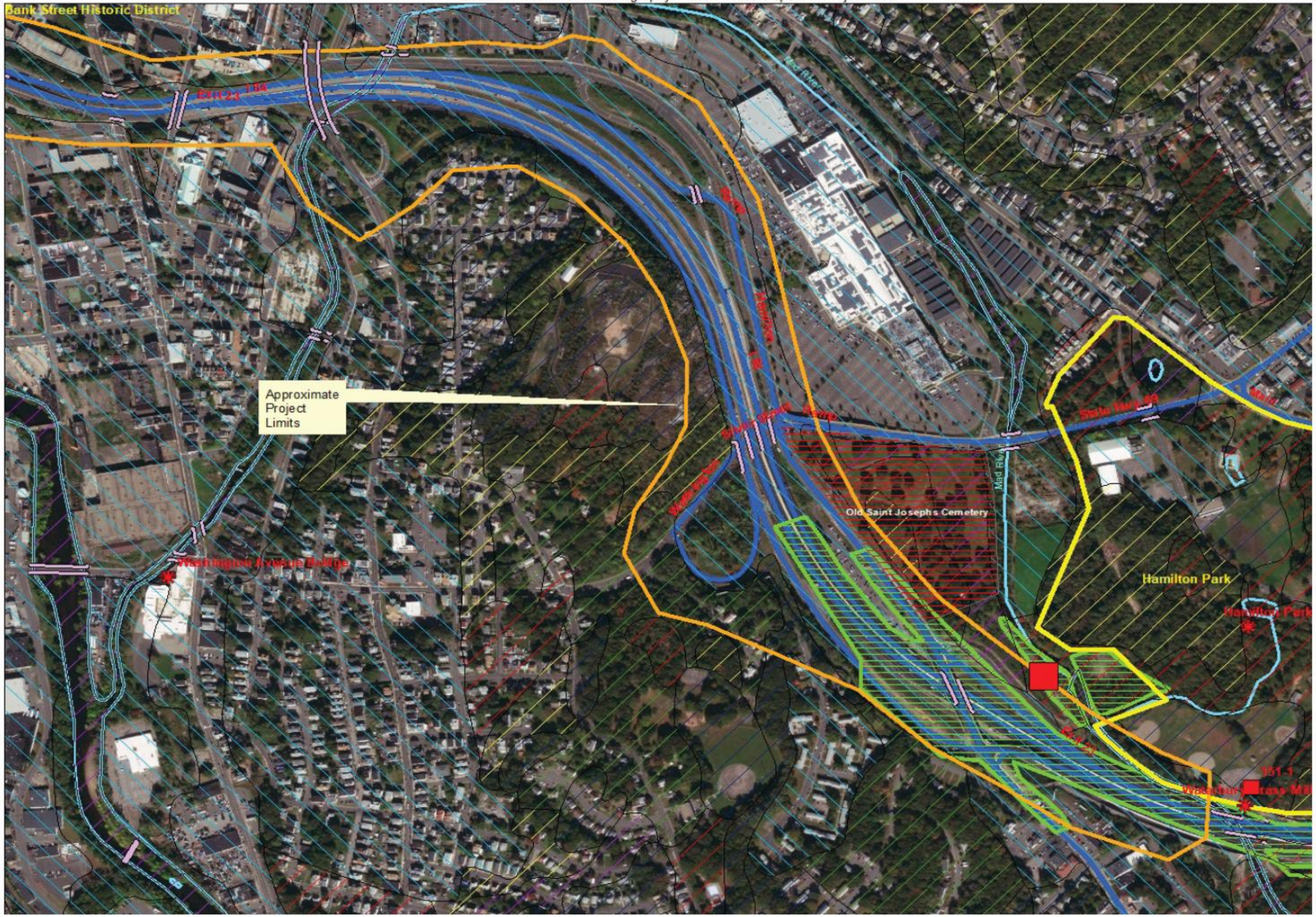
I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Historical and Archaeological Resources Map 5 of 9

Date: 6/2/2020 | Figure No: 4-8.5

Detail of Recent Aerial Photography -- Easternmost Aspect of Project Area



Office of Environmental Planning Environmental Review Historical and Archaeological Resources

State Project No. 151-331
I-84 & Route 8 Intersection
Mixmaster Reconstruction
Map 6 of 9
Waterbury

- Project Area
- Natl Hist Landmarks
- NRHP Structures
- Historic Districts
- Cemetery
- Previous CR Surveys

Approximate Location of Archaeological Site

- Historic
- Pre-Contact
- Unknown

Predicted Archaeological Soil Sensitivity

- High
- Low
- Moderate
- Poor
- Variable
- Unknown

N

0 300 600 1,200 1,800 2,400 Feet

84 new mix

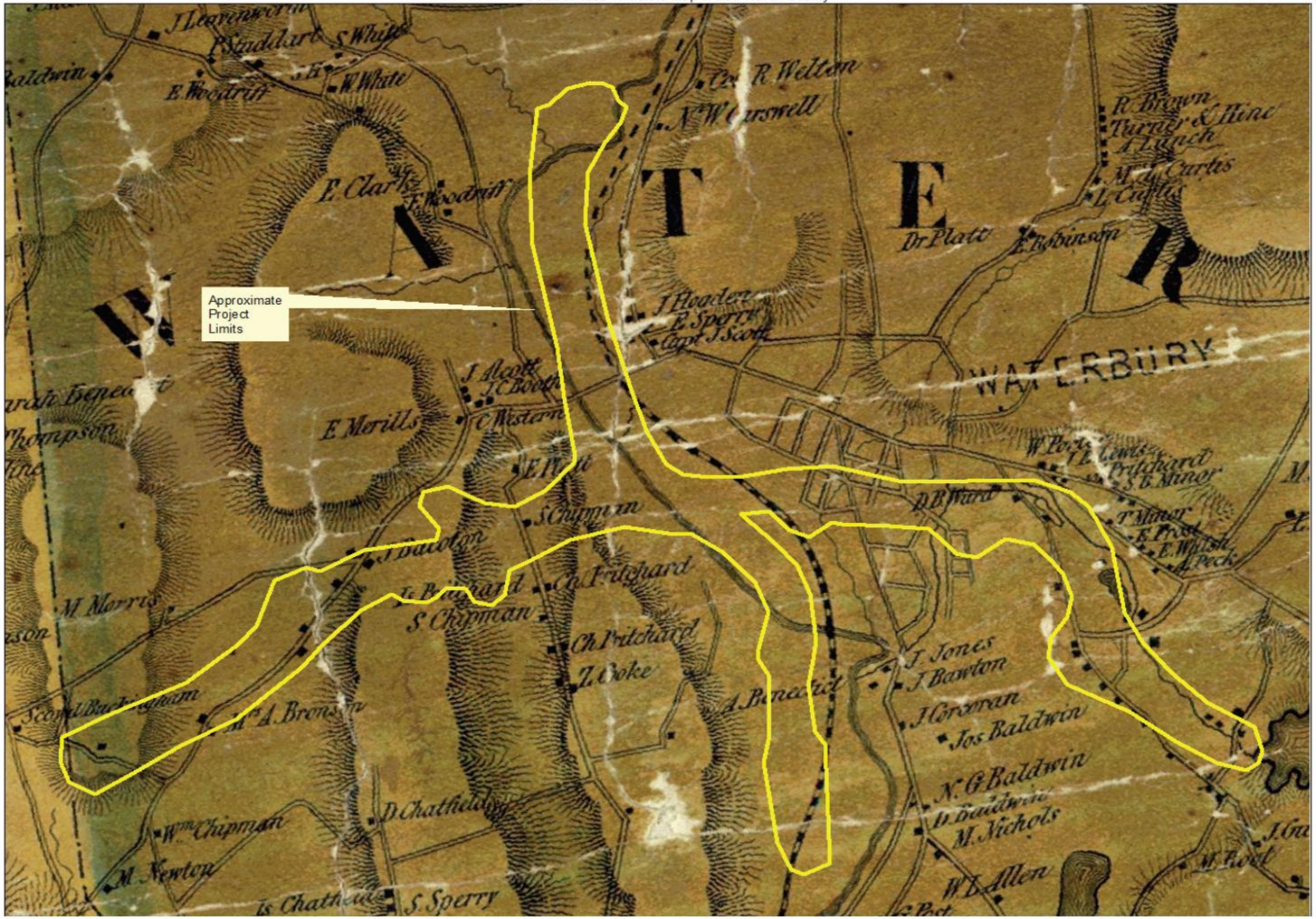
HNTB

I-84 Waterbury Mixmaster Reconstruction Project

Historical and Archaeological Resources Map 6 of 9

Date: 6/2/2020 | Figure No: 4-8.6

Detail of 1852 Whiteford Map of New Haven County



N

0 0.125 0.25 0.5 0.75 1 Miles

Office of Environmental Planning
Environmental Review
Historical and Archaeological Resources

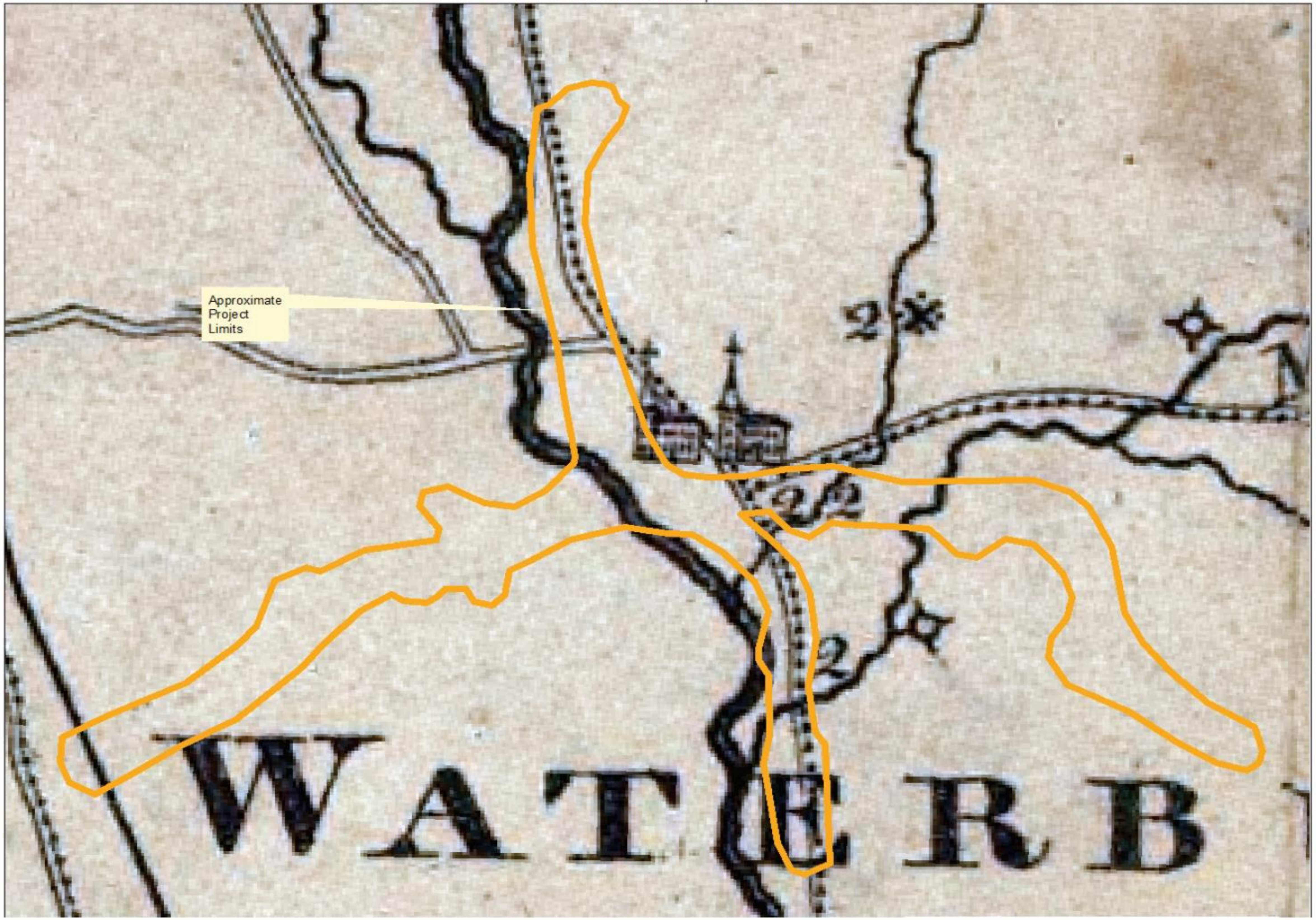
State Project No. 151-331
I-84 & Route 8 Intersection
Mixmaster Reconstruction
Map 7 of 9
Waterbury

I-84 Waterbury Mixmaster Reconstruction Project

Historical and Archaeological Resources Map 7 of 9

Date: 6/2/2020 | Figure No: 4-8.7

Detail of 1811 Warren Map of Connecticut



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Historical and Archaeological Resources

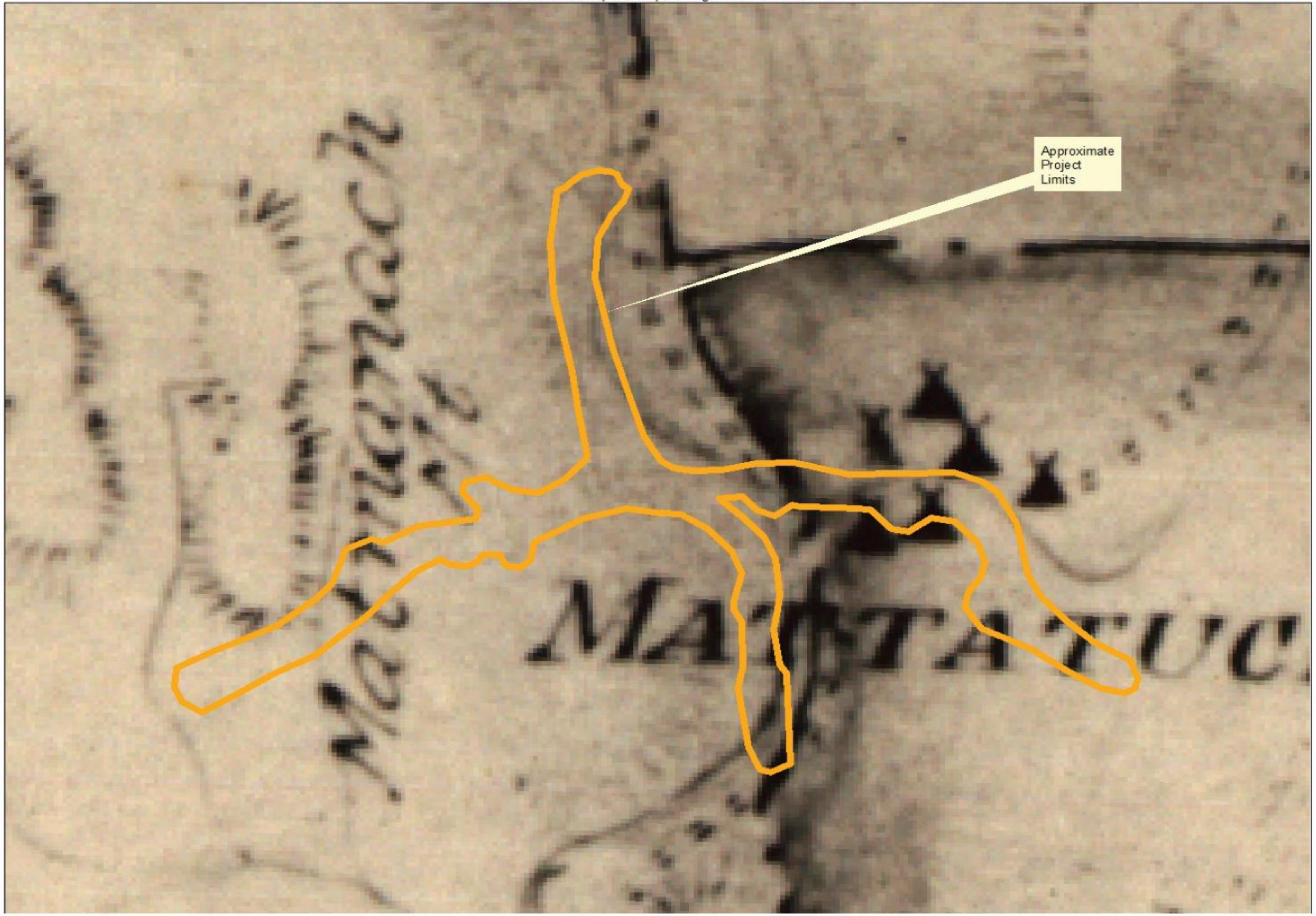
State Project No. 151-331
I-84 & Route 8 Intersection
Mixmaster Reconstruction
Map 8 of 9
Waterbury

I-84 Waterbury Mixmaster Reconstruction Project

Historical and Archaeological Resources Map 8 of 9

Date: 6/2/2020 | Figure No: 4-8.8

Detail of Griswold-Speiss Map of Indigenous Connecticut ca 1620



Office of Environmental Planning
Environmental Review
Historical and Archaeological Resources

State Project No. 151-331
I-84 & Route 8 Intersection
Mixmaster Reconstruction
Map 9 of 9
Waterbury

N

0 0.175 0.35 0.7 1.05 1.4 Miles

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Historical and Archaeological Resources Map 9 of 9

Date: 6/2/2020 | Figure No: 4-8.9

4.1.2 Neighborhood Assessment

The neighborhood assessment looks deeper into the area surrounding the Mixmaster as discussed in the city-wide assessment. The neighborhoods surrounding the Mixmaster are roughly divided into four neighborhood quadrants, due to the intersection of I-84 and Route 8, as shown on **Figure 4-9** through **Figure 4-19**. The four neighborhoods are the Central Business District, South End, Brooklyn, and West End. This micro-scale analysis provides in-depth detail into land uses, cultural and natural resources, and a qualitative assessment of each neighborhood (see **Figure 4-9** through **Figure 4-19** for key elements identified in this section).

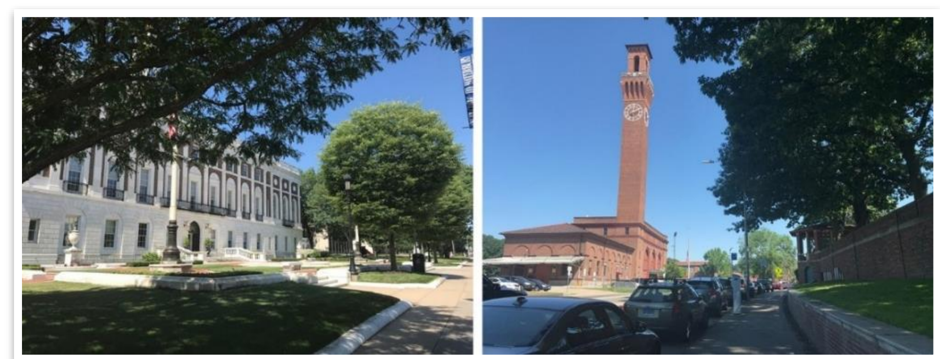
Central Business District (CBD)

Waterbury's CBD is a historical downtown, located north of I-84 and east of the Naugatuck River. Waterbury Green (see **Figure 4-9**, left), a linear open space on West Main Street and Bank Street, serves as the main hub and a central transit stop for many bus lines. During the day, it is a leisurely, well-used public space. During commuting hours, the area is heavily trafficked by pedestrians and public transit. Framing the Waterbury Green are several important civic buildings – Mattatuck Museum, Basilica of the Immaculate Conception, and Greater Waterbury YMCA. The area is lined with street trees and benches and is generally well-maintained.

Figure 4-9 Photos of Waterbury Green (Left) and Library Park (Right)

Another major nexus of the CBD is Library Park (see **Figure 4-9**, right). At the intersection of Meadow Street and Grand Street, the park is framed by notable public buildings – Waterbury Train Station, the Superior Court and Waterbury Courthouse, the Silas Bronson Public Library, and Waterbury City Hall (see **Figure 4-10**). It is important to note that Library Park is at grade on the north along Grand Street while the streets on the south side are at a significantly lower grade. As a result, a tall brick retaining wall was built along three sides of the park with a generous staircase on the south side for access. The W.A.T.E.R. project (Waterbury Active Transportation and Economic Resurgence) aims to address the grade change by implementing a connector between Library Park, Waterbury Train Station, and the Naugatuck River Greenway (NRG) (Library Park-Train-Station-Riverfront) with a pedestrian bridge and improved streetscape.

Figure 4-10 Photos of City Hall (Left) and Train Station/Library Green (Right)



Both Waterbury Green and Library Park are located within the Downtown Waterbury Historic District and listed under the National Register of Historic Places (NRHP). Many buildings within the historic district are also listed as historical properties on the national or state level and are well maintained. Most historical buildings have been renovated to contemporary uses such as public buildings, offices, or mixed-uses. There is also the Bank Street Historic District on Bank Street in the CBD, which consists of four, late 19th Century brick buildings.

Outside of the historic districts, buildings in the CBD are mostly nondescript. Most major streets have a continuous building façade that provide an urban density to the general downtown area. Alongside streets and closer to I-84, there are significant number of surface parking lots and vacant land. Furthermore, there are several large parking garages closer to the I-84 and St. Mary's Hospital in the southern part of the CBD (see **Figure 4-11**). These land uses create unmaintained and unwelcoming spaces in an otherwise walkable downtown.

Figure 4-11 Photos of Bank/Grand (Left) and Meadow/Field Intersections (Right)

Most of the existing planning projects consider improvements and connections to the CBD as major components. The underpasses and overpasses that connect CBD with surrounding neighborhoods are important gateways and special attention should be paid to their physical treatment and design. The Project should also be sensitive to the historical and cultural resources in the neighborhood in order to minimize and mitigate disruptions to the features that make the CBD vibrant.

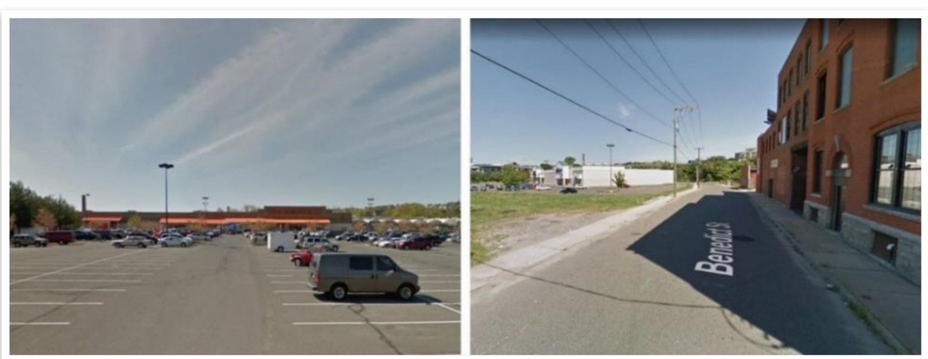
Furthermore, the ongoing Freight Street District redevelopment, directly adjacent to downtown, will be an important consideration for the Project. The proposed strategy for the district would likely introduce mixed-use and high-density residential development to the area, with a strong connection to downtown and Naugatuck River Greenway (NRG). The Project will need to develop concepts that integrate with the goals of the Freight Street District redevelopment.

South End

South of the CBD is the neighborhood of South End. South End is a small neighborhood with a mix of land uses – big box retail, light industry, and single-family residential. On the west side of the neighborhood, Benedict Street and Bank Street are dominated by two big box retail footprints and large surface parking lots. Given the configuration of these large lots, this area is a deterrent for walking and biking. Moreover, the surrounding streets are rarely used on a weekday afternoon (see **Figure 4-12** and **Figure 4-13**).

Figure 4-12 Photos of Benedict Street (Left) and Benedict/West Clay Intersection (Right)

Figure 4-13 Photos of Big Box Retail (Left) and Vacant Land on Benedict Street (Right)



Similarly, the east side of Benedict Street is dotted with large vacant manufacturing buildings, light industrial uses, and surface parking lots. Land uses gradually become more residential toward the east side. Most residential properties are two-story row houses with several three-story apartment buildings along South Main Street. In addition, there are numerous neighborhood retail stores, light industry uses, and vacant lots on and near South Main Street (see **Figure 4-14** and **Figure 4-15**).

Figure 4-14 Photos of W. Dover Street at South End (Left) and S. Main Street (Right)

Figure 4-15 Photos of E. Dover Street (Left) and Mill Street (Right)

Continuing easterly, two civic institutions are located at the intersection of South Main Street, East Clay Street, and South Elm Street – St Anne's Catholic Church and Maloney Elementary School (see **Figure 4-16**). St. Anne's twin steeples have served as a beacon from various viewpoints throughout the city, however they are currently in the process of being removed due to age, repair costs and liability.

Figure 4-16 Photos of St. Anne's Church (Left) and Maloney Elementary School (Right)

Brooklyn

West of the South End, spanning the Naugatuck River is the neighborhood of Brooklyn. Most of the land in Brooklyn is occupied as high- and middle-density, single-family residential, except for the light industrial zoned area between Route 8 and Naugatuck River and an unused area east of Naugatuck River (see **Figure 4-17**).

Located west of Route 8 are two major open spaces in Brooklyn, the historical Riverside Cemetery and Chase Park (see **Figure 4-18**). Connections between Brooklyn, CBD, Naugatuck River Greenway, and other neighborhoods will be a focus for the Project.

Figure 4-17 Photos of Alder Street (Left) and Washington Avenue (Right) in Brooklyn

Figure 4-18 Photos of Riverside Cemetery (Left) and Chase Park (Right)

West End

West of the CBD and north of I-84 is the neighborhood of West End. The area west of the Naugatuck River is mostly single-family residential. Given its lower density, this area also has more green space between buildings (**Figure 4-19**).

Figure 4-19 Photos of Highland Ave (Left) and Wilson Street (Right) in West End

Waterbury Hospital is a major employer and civic institution. The hospital is located immediately north of West End on Robbins Street (see **Figure 4-7 Community Resources and Institutions Map**). The landscaped campus with standard sidewalks blends into the neighborhood. However, access to the hospital will need to be considered in the design of the new interchange.

The area between the Naugatuck River and the CBD is designated as Freight Street District. The District is currently undergoing redevelopment planning as part of the Freight Street Redevelopment Strategy Master Plan, as previously described in **Section 1.4 Ongoing and Recent Projects**. The area is zoned as a Central Business District, though most of the current land uses are light industrial. Given that the redevelopment plan for Freight Street has been proposed recently, the redevelopment effort is at a very early stage and has not yet physically transformed the area.

Similar to Brooklyn, West End, outside of the Freight Street District, is not a focus of potential development area but its connections between Brooklyn, downtown, and other neighborhoods will continue to be a focus for the Project.

4.1.3 Historically Disadvantaged and Environmentally Burdened Communities

Historically disadvantaged and environmentally burdened communities are defined by the USDOT as communities that experience disproportionately high and adverse health, environmental, climate-related, economic, and other cumulative impacts.[14] Overburdened communities are "minority, low-income, tribal, or indigenous populations or geographic locations in the United States that potentially experience disproportionate environmental and/or safety harms and risks. This disproportionality can be a result of greater vulnerability to environmental hazards, heightened safety risks, lack of opportunity for public participation, or other factors."[14] Underserved communities are "populations sharing a particular characteristic, as well as geographic communities that have been systematically denied a full opportunity to participate in aspects of economic, social, and civic life." [14]

This section identifies these communities within Waterbury that are historically disadvantaged and environmentally burdened. The identification of these conditions enhances the Study Team's understanding of the challenges the community may have historically faced, and helps identify the areas within Waterbury where these burdens exist at higher levels. Locating these areas early could help determine areas where project impacts may further intensify these burdens and where mitigation strategies should be focused.

A combination of interactive online mapping tools was used to identify communities facing economic, environmental, and transportation burdens within the Environmental Justice (EJ) Study Area. These tools included the Environmental Justice Screening and Mapping Tool (EJScreen) and the Climate and Economic Justice Screening Tool (CEJST).

EJScreen is a tool developed by the United States Environmental Protection Agency (EPA) that uses national data compiled from several federal agencies to map EJ communities and display environmental and socioeconomic indicators for a specific geographic area. These indicators represent data for specific environmental or community characteristics, such as the level of certain pollutants in the air. Some indicators quantify proximity to sources of exposure of environmental pollutants, or the value of certain types of exposure to environmental pollutants. All the indicators described in the EJScreen section of this report are pollutant indicators.

CEJST is a tool developed by the White House Council on Environmental Quality (CEQ) pursuant to Executive Order (EO) 14008.[15] EO 14008 directs agencies "to make achieving environmental justice part of their missions by developing programs, policies, and activities to address the disproportionately high and adverse human health, environmental, climate-related and other cumulative impacts on disadvantaged communities, as well as the accompanying economic challenges of such impacts." It also directs the CEQ to create a geospatial Climate and Economic Justice Screening Tool to identify these communities and to annually publish interactive maps highlighting disadvantaged communities that have been historically overburdened and underserved."

EJScreen and CEJST differ in how they display the data used in their maps. EJScreen displays the data at the Census Block Group level (the smallest geographic unit tabulated by the Census Bureau), while CEJST displays this data at the Census Tract level (which contains a grouping of Census blocks). This distinction is important when viewing the associated mapping that pairs with the data from these tools. Waterbury contains 28 total Census Tracts; the EJ Study Area focuses on the 23 Census Tracts that fall within the Project Study Area. The 23 Census Tracts within the EJ contain 58 Census Block Groups.

[14] United States Department of Transportation (USDOT), "*Equity Action Plan*." From January 2022

[15] The Federal Register, Executive Office of the President. "*Executive Order 14008 of January 27, 2021, Tackling the Climate Crisis at Home and Abroad.*" Feb. 2021

EJScreen Demographic Characteristics

EJScreen Pollutant Indicators

The EJScreen tool was used to identify communities at the Census Block Group level with disproportionately high levels of five pollutants. These pollutants were selected because they are often associated with transportation, and the effects transportation has on the surrounding environment.[16] The following describes these pollutants in greater detail. The pollutants are as follows:

- Ozone - Potential ozone exposure in terms of summer seasonal daily maximum concentrations in an 8-hour period.[5]
- Particulate Matter (PM) 2.5 - Potential exposure to inhalable particles that are 2.5 micrometers or smaller.[5]
- Diesel PM - Estimated concentration of Diesel PM in the air as provided by the 2017 Air Toxics update.[5]
- Air Toxics Cancer Risk - Estimated lifetime inhalation cancer risk from the analyzed carcinogens in ambient outdoor air.[5]
- Traffic Proximity and Volume - Annual Average Daily Traffic (AADT) at major roads within 500 meters of the Census Block centroid, divided by distance in meters from the Census Block centroid.[5]

The data used in EJScreen is collected at the Census Tract level, the data for that Census Tract is then reassigned to all the Census Block Groups within that Census Tract. This means that all Census Block Groups within a Census Tract will have the same values for a pollutant indicator.[17] Percentiles are used to display pollutant indicator values below which a certain percentage of the data in a data set is found. For example, if an indicator is in the 75th percentile, that means its value is higher than 75 percent of the other values. The percentiles were calculated by the EPA. The data presented in **Table 4.1.3-2** uses percentiles to compare the EJ Study Area to Connecticut (state-level) and national level data.[5]

EJScreen Community Conditions

There are many Census Block Groups within Waterbury that appear to be above the state average for the following pollutant indicators: exposure to ozone levels, PM 2.5, diesel PM, and traffic proximity and volume. Certain Census Block Groups meeting the traffic proximity and volume pollutant indicator threshold were also identified by EJScreen for needing additional consideration, defined as Census Block Groups within the threshold of the 80th – 100th percentile compared to state data. This does not necessarily mean there is a threat to the health within these Census Block Groups, but that further investigation may be warranted.[5]

Table 4.1.3-1 is a broad overview of the pollutant indicator and percentiles represented on the pollutant indicator maps provided in **Figure 4.1.3-1** through **Figure 4.1.3-5**. Detailed pollutant indicator values for each Census Block Group are provided in **Table 4.1.3-2** which displays the pollutant indicator values along with the state and national percentiles for each pollutant.

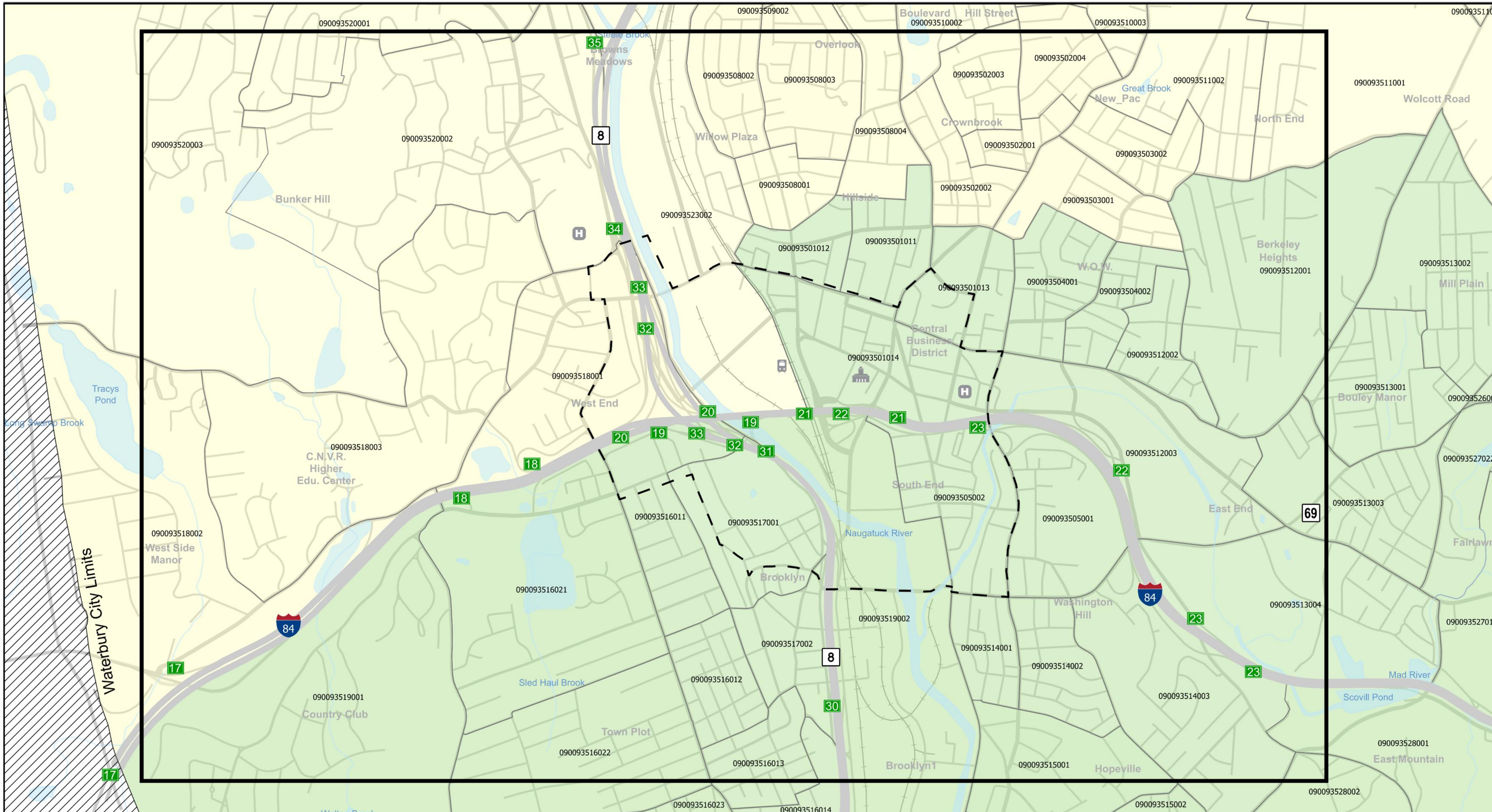
Table 4.1.3-1 EJScreen EJ Study Area State Percentile Conditions by Pollutant Indicator

Pollutant Indicator	Percentile Range (Compared to state average)	Number of Census Block Groups
Ozone *parts per billion (ppb)*	≤49.99%	22
	50.00-59.99%	36
	Total	58
PM 2.5 *micrograms per cubic meter ($\mu g/m^3$)*	≤49.99%	1
	50.00-59.99%	21
	60.00-69.99%	36
	Total	58
Diesel PM *$\mu g/m^3$*	≤49.99%	25
	50.00-59.99%	21
	60.00-69.99%	12
	Total	58
Air Toxics Cancer Risk *Air toxics cancer risk unit (atcru)*	≤49.99%	58
	Total	58
Traffic Proximity and Volume *Proximity score (prx. sc.)*	≤49.99%	13
	50.00-59.99%	3
	60.00-69.99%	10
	70.00-79.99%	8
	80.00-89.99%	13*
	90.00-94.99%	6*
	95.00-100%	5*
	Total	58

*Census Block Groups ≥ 80th percentile may merit additional consideration

United States Environmental Protection Agency. 2023 version. EJScreen. Retrieved: January 10, 2023, from www.ejscreen.epa.gov/mapper/.

[16] U.S. Department of Transportation. *Justice40 Initiative*. Retrieved: [https://www.transportation.gov/equity-Justice40.]
[17] U.S. Environmental Protection Agency (EPA). "*EJScreen Technical Documentation*" 2022.



Ozone Levels (State Percentiles)*

- 0.00% - 49.99%
- 50.00% - 59.99%

*Potential ozone exposure in terms of summer seasonal daily maximum concentrations in an 8-hour period.

The Ozone Level values presented in EJScreen's mapping are derived from 2018 source data from EPA's Office of Air Quality Planning and Standards (OAQPS), Non-attainment Areas (NAA).

- Hospital
- Train Station
- City Hall
- Railroad
- 20 Exit
- Environmental Justice Study Area
- Key Area

Sources: US Environmental Protection Agency. 2023 version. EJScreen.Retrieved: 01/2023 from url https://ejscreen.epa.gov/mapper/

US Environmental Protection Agency. "EJScreen TechnicalDocumentation" 2022.

N

0 1,000 2,000 3,000 Feet

84 new mix

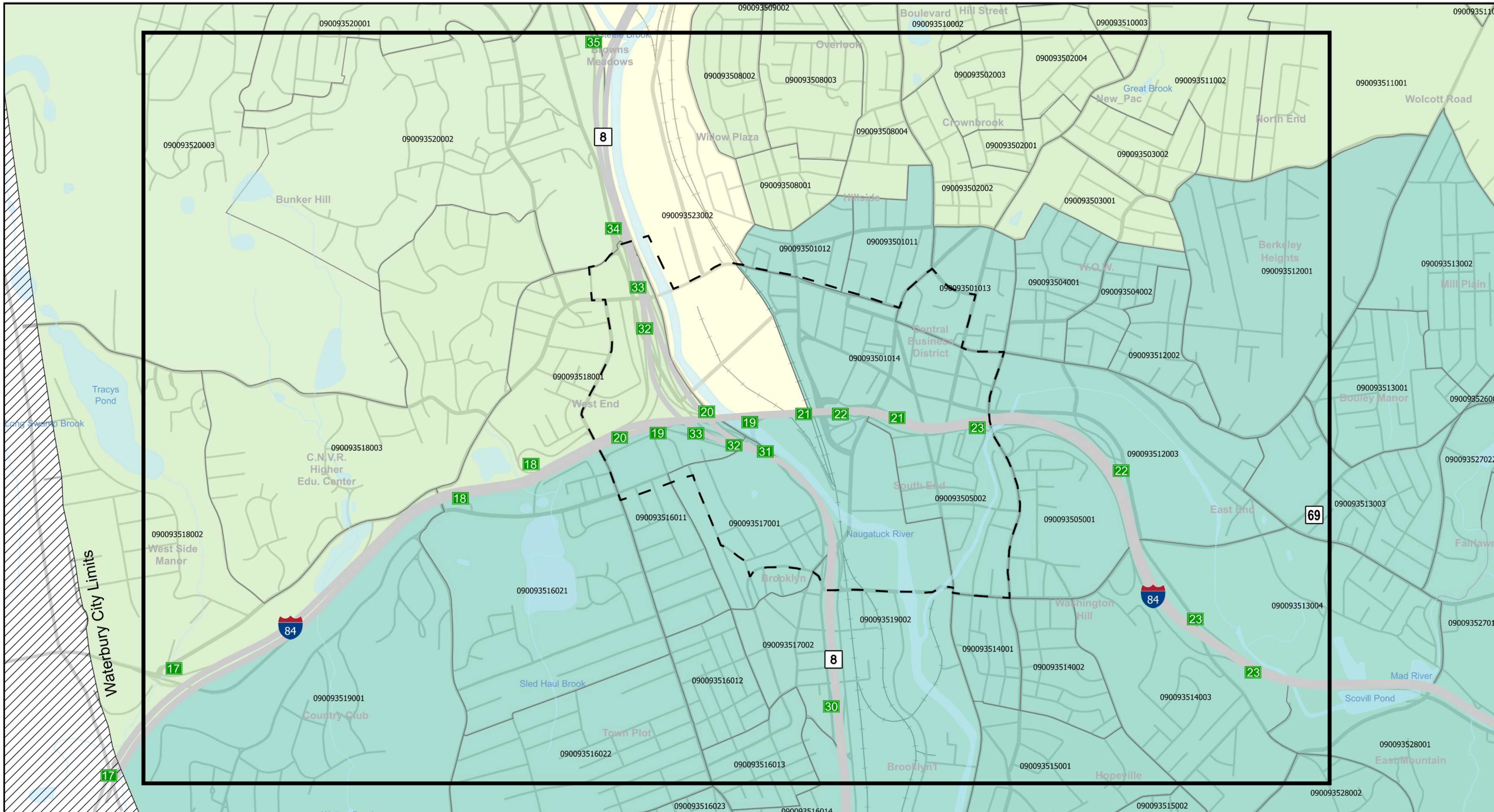
I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Pollutant Indicator Map: Ozone

Date: 2023

Figure No: 4.1.3-1



Particulate Matter 2.5 Levels (State Percentiles)*

- 0.00% - 49.99%
- 50.00% - 59.99%
- 60.00% - 69.99%

*Potential exposure to inhalable particles that are 2.5 micrometers or smaller.

The PM 2.5 values presented in EJScreen's mapping are derived from 2018 source data from EPA's Office of Air Quality Planning and Standards (OAQPS), Non-attainment Areas (NAA).

- Hospital
- Train Station
- City Hall
- Railroad
- 20 Exit
- Environmental Justice Study Area
- Key Area

Sources: US Environmental Protection Agency. 2023 version. EJScreen.Retrieved: 01/2023 from url https://ejscreen.epa.gov/mapper/

US Environmental Protection Agency. "EJScreen TechnicalDocumentation" 2022.

N

0 1,000 2,000 3,000 Feet

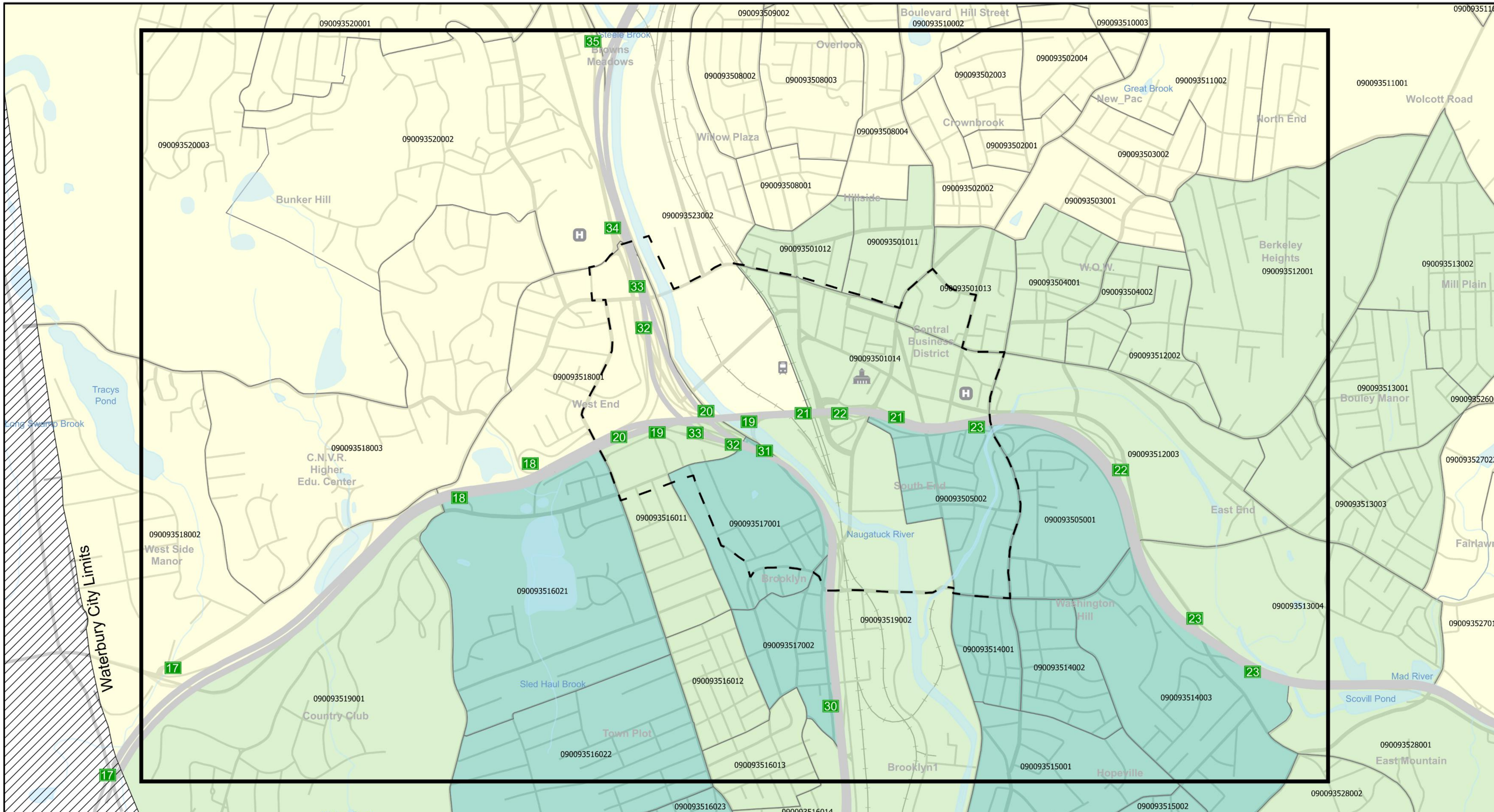
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Pollutant Indicator Map: Particulate Matter 2.5

Date: 2023 | Figure No: 4.1.3-2



Diesel Particulate Matter (State Percentiles)*

- 0.00% - 49.99%
- 50.00% - 59.99%
- 60.00% - 69.99%

*Estimated concentration of Diesel PM in the air as provided by the 2017 Air Toxics update.

The Diesel PM values presented in EJScreen's mapping are derived from 2017 source data from EPA's Office of Air Quality Planning and Standards (OAQPS).

- Hospital
- Train Station
- City Hall
- Railroad
- 20 Exit

- Environmental Justice Study Area
- Key Area

Sources: US Environmental Protection Agency. 2023 version. EJScreen.Retrieved: 01/2023 from url https://ejscreen.epa.gov/mapper/

US Environmental Protection Agency. "EJScreen TechnicalDocumentation" 2022.

N

0 1,000 2,000 3,000 Feet

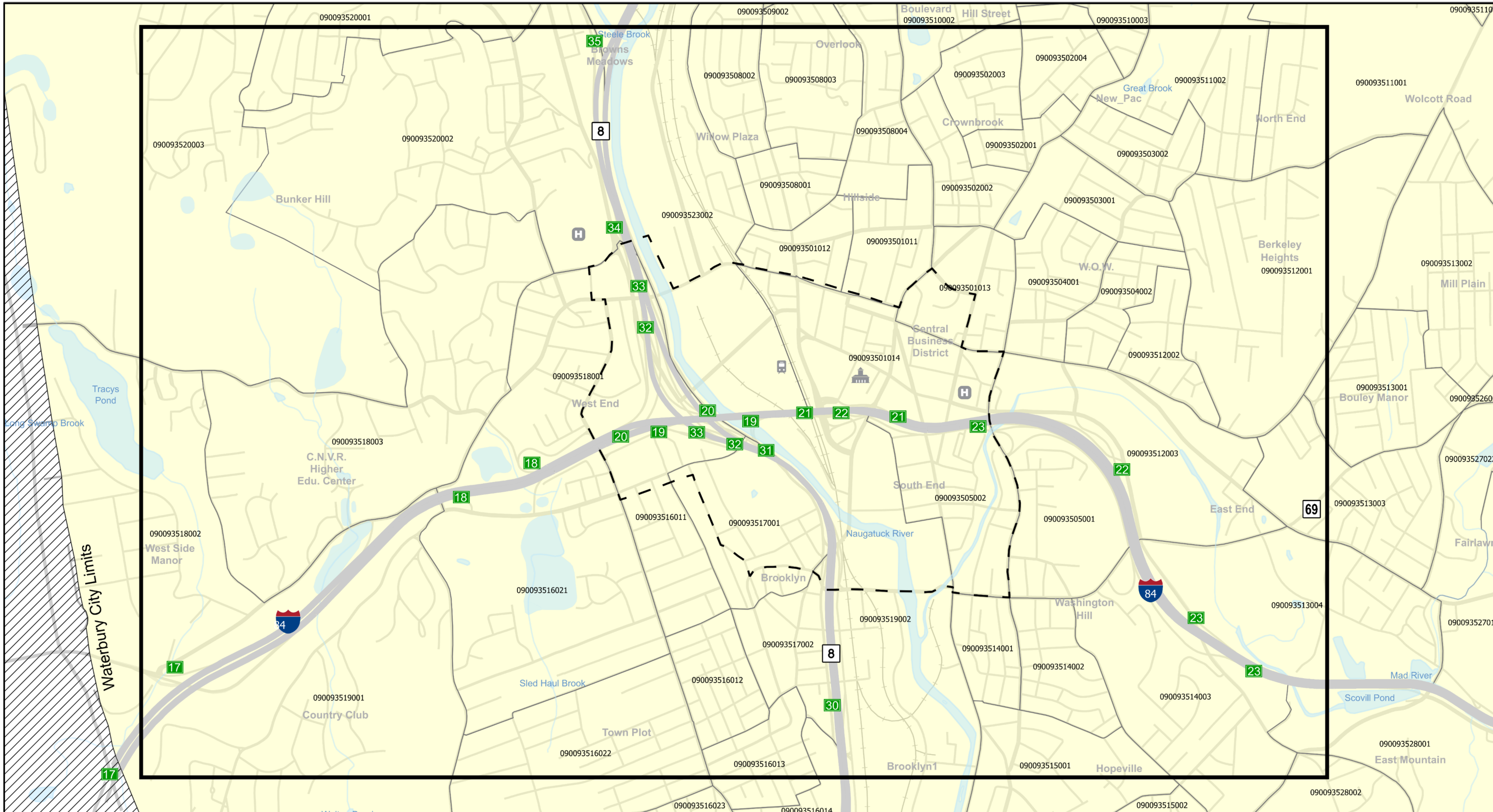
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Pollutant Indicator Map: Diesel Particulate Matter

Date: 2023 | Figure No: 4.1.3-3



Air Toxics Cancer Risk (State Percentiles)*

0.00% - 49.99%

*Estimated lifetime inhalation cancer risk from the analyzed carcinogens in ambient outdoor air.

The Air Toxics Cancer Risk values presented in EJScreen's mapping are derived from 2017 source data from EPA's Office of Air Quality Planning and Standards (OAQPS).

- Hospital
- Train Station
- City Hall
- Railroad
- 20 Exit
- Environmental Justice Study Area
- Key Area

Sources: US Environmental Protection Agency. 2023 version. EJScreen.Retrieved: 01/2023 from url https://ejscreen.epa.gov/mapper/

US Environmental Protection Agency. "EJScreen TechnicalDocumentation" 2022.

N

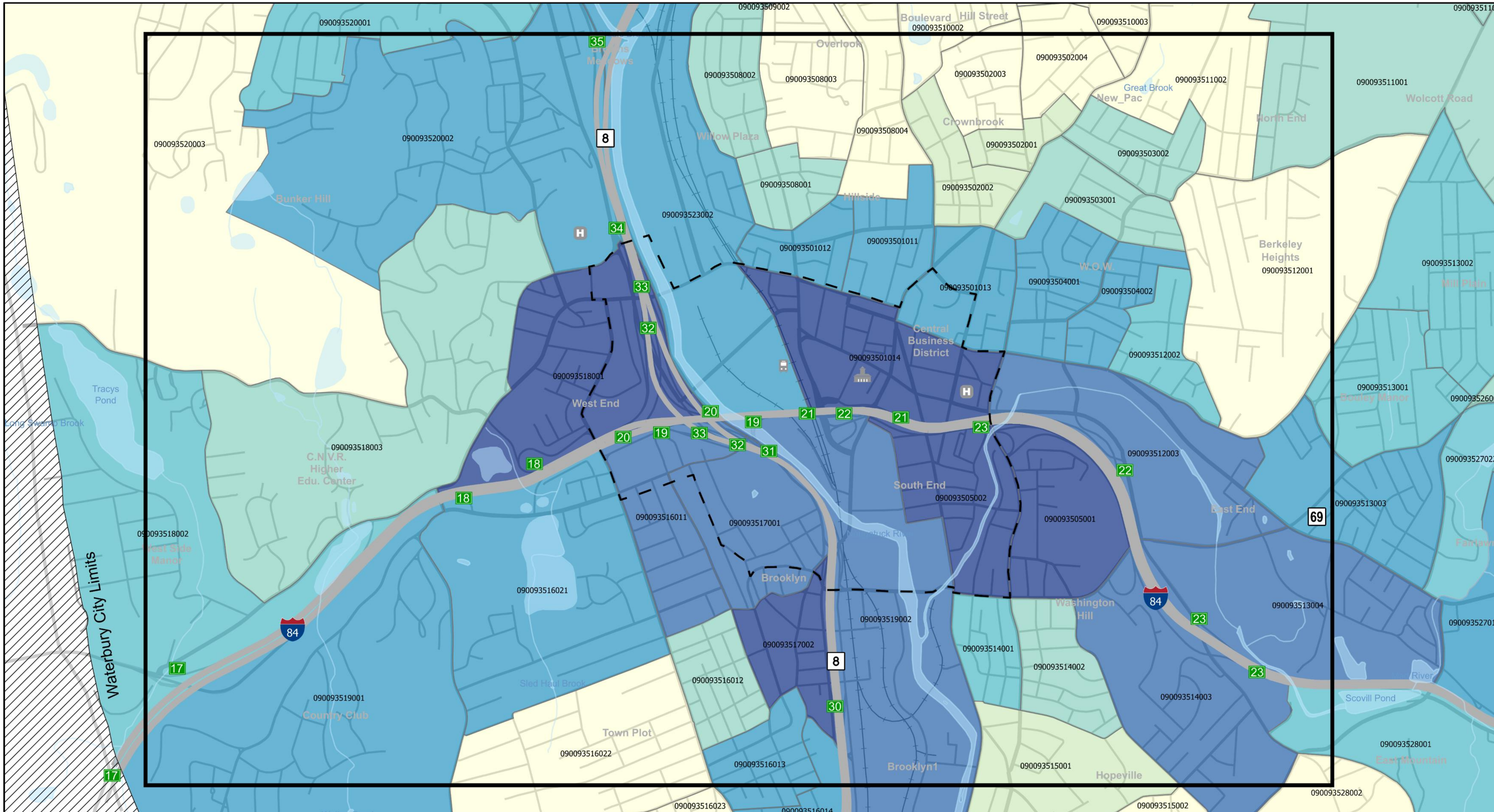
0 1,000 2,000 3,000 Feet

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Pollutant Indicator Map: Air Toxics Cancer Risk

Date: 2023 | Figure No: 4.1.3-4



Traffic Proximity and Volume (State Percentiles)*

- 0.00% - 50.00%
- 50.01% - 60.00%
- 60.01% - 70.00%
- 70.01% - 80.00%
- 80.01% - 90.00%
- 90.01% - 95.00%
- 95.01% - 100.00%

*Annual Average Daily Traffic (AADT) at major roads within 500 meters of the Census Block centroid, divided by distance in meters from the Census Block centroid.

The Traffic Proximity and Volume values presented in EJScreen's mapping are derived 2019 Highway Performance Monitoring System (HPMS).

- Hospital
- Train Station
- City Hall
- Railroad
- 20 Exit

- Environmental Justice Study Area
- Key Area

Sources: US Environmental Protection Agency. 2023 version. EJScreen.Retrieved: 01/2023 from url https://ejscreen.epa.gov/mapper/

US Environmental Protection Agency. "EJScreen TechnicalDocumentation" 2022.

N

0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Pollutant Indicator Map: Traffic Proximity and Volume

Date: 2023 | Figure No: 4.1.3-5

Table 4.1.3-2 EJScreen Pollutant Indicator Data

		Census Block Group														
		090093523002	090093520003	090093520001	090093520002	090093518003	090093518001	090093518002	090093519001	090093516021	090093516022	090093516023	090093516014	090093516013	090093516012	090093501011
Pollutant Indicator	Ozone (ppb)	42.1	42.2	42.2	42.2	42.3	42.3	42.3	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.3
	State (Percentile)	46%	47%	47%	47%	49%	49%	49%	53%	53%	53%	53%	52%	52%	52%	50%
	USA (Percentile)	49%	49%	49%	49%	50%	50%	50%	51%	51%	51%	51%	51%	51%	51%	50%
	PM 2.5 (µg /m^3)	7.49	7.52	7.52	7.52	7.58	7.58	7.58	7.67	7.68	7.68	7.68	7.68	7.68	7.68	7.65
	State	48%	51%	51%	51%	56%	56%	56%	62%	63%	63%	63%	63%	63%	63%	60%
	USA	21%	22%	22%	22%	24%	24%	24%	26%	26%	26%	26%	26%	26%	26%	25%
	Diesel PM (µg /m^3)	0.166	0.181	0.181	0.181	0.186	0.186	0.186	0.197	0.213	0.213	0.213	0.209	0.209	0.209	0.195
	State	35%	43%	43%	43%	46%	46%	46%	52%	60%	60%	60%	58%	58%	58%	51%
	USA	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%
	Air Toxics Cancer Risk (atcru)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	State	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	USA	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%
	Traffic Proximity and Volume (prx. sc.)	1300	31	750	1000	470	4400	580	1100	1200	36	49	1600	1300	330	900
	State	86%	18%	78%	83%	69%	96%	73%	84%	85%	20%	24%	89%	86%	61%	82%
	USA	85%	18%	76%	82%	65%	96%	70%	82%	84%	20%	23%	88%	85%	57%	79%

		Census Block Group														
		090093513003	090093513001	090093513002	090093511001	090093511003	090093512001	090093512003	090093505001	090093505002	090093501014	090093512002	090093504002	090093504001	090093501013	090093513004
Pollutant Indicator	Ozone	42.3	42.3	42.3	42.2	42.2	42.3	42.3	42.3	42.3	42.3	42.3	42.3	42.3	42.3	42.3
	State	51%	51%	51%	48%	48%	50%	50%	51%	51%	50%	50%	50%	50%	50%	51%
	USA	51%	51%	51%	50%	50%	51%	51%	51%	51%	50%	51%	50%	50%	50%	51%
	PM 2.5	7.68	7.68	7.68	7.6	7.6	7.67	7.67	7.68	7.68	7.65	7.67	7.66	7.66	7.65	7.68
	State	63%	63%	63%	57%	57%	62%	62%	63%	63%	60%	62%	61%	61%	60%	63%
	USA	26%	26%	26%	24%	24%	25%	25%	26%	26%	25%	25%	25%	25%	25%	26%
	Diesel PM	0.196	0.196	0.196	0.18	0.18	0.193	0.193	0.217	0.217	0.195	0.193	0.194	0.194	0.195	0.196
	State	51%	51%	51%	42%	42%	50%	50%	63%	63%	51%	50%	50%	50%	51%	51%
	USA	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%
	Air Toxics Cancer Risk	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	State	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	USA	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%
	Traffic Proximity and Volume	1400	680	670	310	370	99	1700	3500	4700	8800	670	950	1200	1500	1700
	State	87%	76%	76%	60%	64%	37%	90%	95%	97%	99%	76%	82%	86%	88%	90%
	USA	86%	73%	73%	56%	60%	33%	89%	95%	97%	99%	73%	80%	85%	87%	89%

United States Environmental Protection Agency. 2023 version. EJScreen. Retrieved: January 10, 2023, from www.ejscreen.epa.gov/mapper/.

Table 4.1.3-2 EJScreen Pollutant Indicator Data (Continued)

		Census Block Group													
		090093516011	090093517001	090093517002	090093519002	090093515001	090093515002	090093514001	090093514002	090093514003	090093528002	090093528001	090093527011	090093527022	090093526003
Pollutant Indicator	Ozone (ppb)	42.4	42.3	42.3	42.4	42.5	42.5	42.4	42.4	42.4	42.4	42.4	42.4	42.4	42.3
	State (Percentile)	52%	51%	51%	53%	54%	54%	52%	52%	52%	53%	53%	53%	52%	50%
	USA (Percentile)	51%	51%	51%	51%	52%	52%	51%	51%	51%	52%	52%	51%	51%	51%
	PM 2.5 (μg /m^3)	7.68	7.67	7.67	7.67	7.72	7.72	7.69	7.69	7.69	7.72	7.72	7.7	7.69	7.66
	State	63%	62%	62%	62%	67%	67%	65%	65%	65%	67%	67%	65%	64%	61%
	USA	26%	25%	25%	26%	27%	27%	26%	26%	26%	27%	27%	26%	26%	25%
	Diesel PM (μg /m^3)	0.209	0.222	0.222	0.197	0.22	0.22	0.225	0.225	0.225	0.201	0.201	0.179	0.179	0.175
	State	58%	66%	66%	52%	65%	65%	68%	68%	68%	54%	54%	42%	42%	40%
	USA	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%
	Air Toxics Cancer Risk (atcru)	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	State	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	USA	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%
	Traffic Proximity and Volume (prx. sc.)	1800	2900	3200	2100	230	120	680	360	2600	170	670	1700	550	390
	State	90%	94%	95%	91%	53%	40%	76%	63%	93%	47%	76%	89%	72%	65%
	USA	90%	94%	95%	91%	49%	37%	73%	59%	93%	43%	73%	89%	69%	61%

		Census Block Group													
		090093501012	090093508001	090093508002	090093508003	090093508004	090093502002	090093503001	090093503002	090093511002	090093502001	090093502003	090093510002	090093502004	090093510003
Pollutant Indicator	Ozone	42.3	42.2	42.2	42.2	42.2	42.3	42.3	42.3	42.2	42.3	42.3	42.2	42.3	42.2
	State	50%	49%	49%	49%	49%	49%	49%	49%	48%	49%	49%	48%	49%	48%
	USA	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
	PM 2.5	7.65	7.6	7.6	7.6	7.6	7.61	7.63	7.63	7.6	7.61	7.61	7.57	7.61	7.57
	State	60%	56%	56%	56%	56%	58%	58%	58%	57%	58%	58%	55%	58%	55%
	USA	25%	24%	24%	24%	24%	24%	25%	25%	24%	24%	24%	23%	24%	23%
	Diesel PM	0.195	0.186	0.186	0.186	0.186	0.187	0.189	0.189	0.18	0.187	0.187	0.181	0.187	0.181
	State	51%	45%	45%	45%	45%	46%	48%	48%	42%	46%	46%	43%	46%	43%
	USA	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%
	Air Toxics Cancer Risk	20	20	20	20	20	20	20	20	20	20	20	20	20	20
	State	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	USA	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%	<50%
	Traffic Proximity and Volume	1500	350	380	34	130	250	440	370	120	230	82	48	110	180
	State	88%	63%	65%	19%	42%	55%	67%	64%	39%	54%	33%	24%	38%	49%
	USA	87%	59%	60%	19%	38%	51%	64%	59%	36%	49%	30%	23%	34%	44%

United States Environmental Protection Agency. 2023 version. EJScreen.
Retrieved: January 10, 2023, from www.ejscreen.epa.gov/mapper/

CEJST Demographic Characteristics

CEJST Indicators and Burdens

The CEJST identifies communities at the Census Tract level that are considered disadvantaged and classifies such disadvantage into categories of burdens. A community is considered disadvantaged if it is in a Census Tract that meets the threshold(s) for at least one of the categories of burdens. A category's threshold is met when its respective environmental indicator meets or exceeds the 90th percentile for one of the environmental indicators and meets or exceeds the threshold of an associated socioeconomic indicator. Thresholds for socioeconomic indicators vary depending on the socioeconomic indicator utilized, however the predominant indicator is low income.[18] **Table 4.1.3-3** identifies the burden categories with additional information regarding the corresponding indicator thresholds. [18]

Table 4.1.3-3 CEJST Categories of Burden

Burden Category	Census Tract Indicator Threshold	
	Percentile	Indicator
Transportation	≥ 90%	**Diesel PM** exposure; OR **Transportation barriers** *(commute time, no vehicle, walkability, and transportation cost as a percentage of income)*; OR **Traffic proximity and volume**
	≥ 65%	**Percent of population that is low-income.** *(Percent of a Census Tract's population in households where household income is at or below 200% of the Federal poverty level)*
Health	≥ 90%	**Asthma** *(Share of people who answer "yes" to both of these questions: "Have you ever been told by a health professional that you have asthma?" and "Do you still have asthma?")*; OR **Diabetes** *(Share of people ages 18 years and older who have been told by a health professional that they have diabetes)*; OR **Heart disease** *(Share of people ages 18 years and older who have been told by a health professional that they had angina or coronary heart disease)*; OR **Low life expectancy** *(Average number of years people have left in their lives)*
	≥ 65%	**Percent of population that is low-income.**
Workforce Development	≥ 90%	**Linguistic isolation** *(Share of households where no one over age 14 speaks English very well)*; OR **Low median income** *(Low median income calculated as a share of the area's median income)*; OR **Poverty** *(Share of people living at or below 100% of the Federal poverty level)*; OR **Unemployment** *(Number of unemployed people as a share of the labor force)*
	≥ 10%	**Percent of people ages 25 years or older whose educational attainment is less than a high school diploma**.
Climate Change	≥ 90%	**Expected agriculture loss rate** *(Expected agricultural value at risk from losses due to natural hazards related to climate change)*; OR **Expected building loss rate** *(Expected building value at risk from losses due to these natural hazards)*; OR **Expected population loss rate** *(Expected fatalities and injuries due to these natural hazards)*; OR **Projected flood risk** *(A high precision, climate-adjusted model that projects flood risk for properties in the future)*; OR **Projected wildfire risk** *(The risk of wildfire is calculated from inputs associated with fire fuels, weather, human influence, and fire movement)*
	≥ 65%	**Percent of population that is low-income.**
Energy	≥ 90%	**Energy Cost** *(Average household annual energy cost in dollars divided by the average household income)*; OR **PM 2.5** exposure
	≥ 65%	**Percent of population that is low-income.**
Housing	≥90%	**Housing cost** *(Share of households that are both earning less than 80% of Housing and Urban Development's Area Median Family Income and are spending more than 30% of their income on housing costs)*; OR **Lack of green space** *(Share of land with developed surfaces covered with artificial materials like concrete or pavement)*; OR **Lack of indoor plumbing** *(Housing without indoor kitchen facilities or complete plumbing facilities)*; OR **Lead paint** *(Share of homes built before 1960, which indicates potential lead paint exposure)* **OR** experienced **Historic underinvestment** *(Census tracts that experienced historic underinvestment based on redlining maps created by the federal government's Homeowners' Loan Corporation (HOLC) between 1935 and 1940)*
	≥ 65%	**Percent of population that is low-income.**
Legacy Pollution	≥ 90%	**Proximity to: hazardous waste facilities** *(Number of hazardous waste facilities within 5 kilometers, each divided by distance in kilometers)*, or **Superfund sites** *(Number of proposed or listed Superfund or National Priorities list sites within 5 kilometers, each divided by distance in kilometers)*, or **risk management plan facilities** *(Count of Risk Management Plan facilities, each divided by distance in kilometers)* **OR** Have at least one **abandoned mine** or **formerly used defense site** within the Census Tract
	≥ 65%	**Percent of population that is low-income.**
Water / Wastewater	≥ 90%	**Underground storage tanks and releases** *(Weighted formula of the density of leaking underground storage tanks and the number of all active underground storage tanks within 1,500 feet of the census tract boundaries)*; OR **Wastewater discharge** *(Risk-Screening Environmental Indicators modeled toxic concentrations at stream segments within 500 meters, divided by distance in kilometers)*
	≥ 65%	**Percent of population that is low-income.**

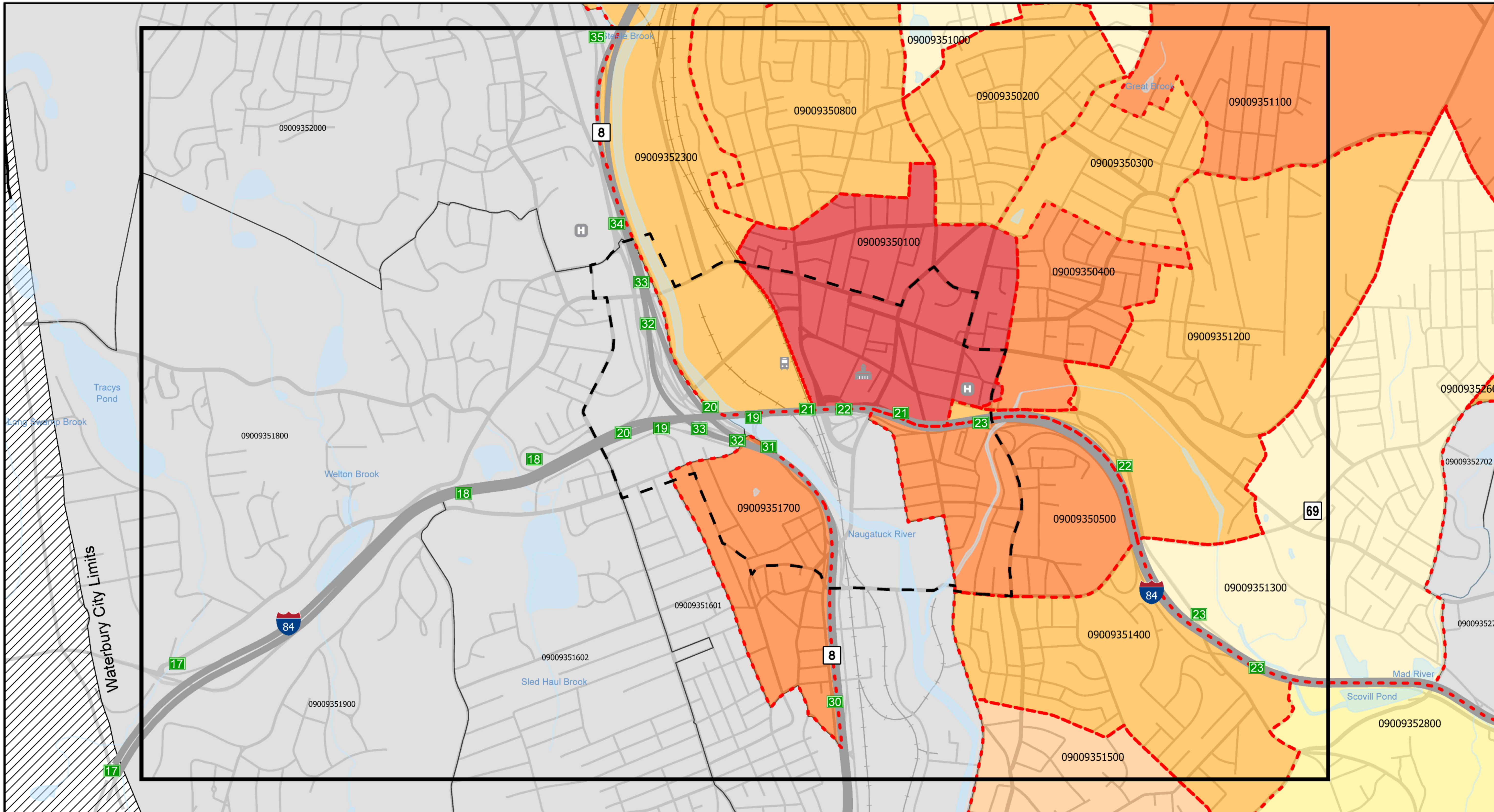
[18] White House CEQ. "*Climate and Economic Justice Screening Tool Technical Support Document.*" 2022

CEJST Community Conditions

The city of Waterbury has a total of 28 Census Tracts, 23 of which make up the EJ Study Area. CEJST indicated that of the 23 Census Tracts within the EJ Study Area, 16 meet the threshold of being disadvantaged, meaning that approximately 70 percent of the Census Tracts within the EJ Study Area are considered disadvantaged. **Table 4.1.3-4** provides an overview of the number of disadvantaged Census Tracts and the burden(s) that exist within them. The locations of burden and Census Tract are displayed in **Figure 4.1.3-6**. More detailed conditions for each Census Tract are displayed in **Table 4.1.3-5.**

Table 4.1.3-4 CEJST EJ Study Area Conditions: Category of Burden for Disadvantaged Census Tracts identified in Waterbury

Burden Category	Number of Census Tracts with Burden (Out of 16 identified as disadvantaged)
Transportation	3
Health	14
Workforce (Economic)	15
Climate Change (Resiliency)	1
Energy	13
Housing	12
Legacy Pollution	14
Water / Wastewater	2



Disadvantaged Census Tracts*

- Disadvantaged
- Not Disadvantaged
- 1 Burden Identified
- 3 Burdens Identified
- 4 Burdens Identified
- 5 Burdens Identified
- 6 Burdens Identified
- 7 Burdens Identified

*A detailed description of the data displayed including methodology, thresholds, and community characteristics is provided in Section 4.1.3 of this report.

Sources:
United States Council on Environmental Quality (CEQ). 2023 version. Climate and Economic Justice Screening Tool (CEJST). Retrieved: 01/2023 from url https://screeningtool.geoplatform.gov/en/#11.32/41.5546/-73.0424

White House CEQ. "Climate and Economic Justice Screening Tool Technical Support Document." 2022

- Hospital
- Train Station
- City Hall
- Railroad
- 20 Exit

- Environmental Justice Study Area
- Key Area Boundry

N

0 1,000 2,000 3,000 Feet

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Disadvantaged Census Tract Map

Date: 2023 | Figure No: 4.1.3-6

Table 4.1.3-5 CEJST Disadvantaged Census Tracts and Associated Burdens Data

Category	Burden	9009352600	9009351100	9009350500	9009351200	9009350400	9009350100	9009350300	9009350200	9009350800	9009351000	9009352300	9009351700	9009351500	9009352800	9009351400	9009351300
Socioeconomic Indicator	Low Income	○	○	○	○	○	○	○	○	○		○	○	○	○	○	
	High School Education	○	○	○	○	○	○	○	○	○	○	○	○		○	○	○
Transportation	Traffic Proximity Volume	○					○						○				
Health	Asthma	○	○	○	○	○	○	○	○	○		○	○	○	○	○	
	Diabetes			○		○	○	○		○							
	Heart Disease						○										
	Low Life Expectancy						○			○							
Energy	Energy Cost	○	○	○	○	○	○	○	○	○		○	○	○		○	
Workforce	Linguistic Isolation	○		○			○	○	○		○				○	○	○
	Unemployment		○	○	○	○	○	○	○	○		○	○				
	Low Median Income		○	○	○	○	○	○	○	○			○			○	
	Poverty			○		○	○	○	○				○				
Climate Change	Expected Agriculture Loss Rate		○														
Housing	Housing Cost	○	○	○	○	○	○	○	○	○		○	○			○	
	Lead Paint			○		○		○	○	○				○			
	Lack of Indoor Plumbing					○	○										
	Historic Underinvestment			○				○									
	Lack of Green Space					○	○	○									
Legacy Pollution	Proximity of Superfund	○	○	○	○	○	○	○	○	○			○	○		○	
	Formerly Used Defense Sites											○					
	Proximity to Hazardous Waste Facilities			○			○						○	○	○	○	
Water / Wastewater	Underground Storage Tanks and Releases					○	○										

Legend and Notes:

○ = Environmental indicator ≥ 90% and associated socioeconomic indicator met or exceeded

A Census Tract is considered disadvantaged if the Census Tract meets the threshold(s) for at least one of the categories of burdens. A category's threshold is met when at least one of the respective environmental indicators meets or exceeds the 90th percentile and the category's associated socioeconomic indicator is met or exceeded. See previous table for socioeconomic indicators.

4.1.4 Hazardous or Contaminated Sites

This section provides an inventory and contextualization for properties affected or potentially affected by hazardous materials within the Project Study Area.

The City of Waterbury has an ample history of industrial manufacturing business. Contrary to the regulatory protections residents are accustomed to today, historically, the manufacturing industry had little or often no health and safety regulations. Unsafe practices resulted in hazardous materials contaminating different sites around the city that require monitoring to manage potential impacts on the current population.

Hazardous sites are often identified by the dangerous or potentially dangerous qualities they exhibit. Broadly, hazardous materials have properties like ignitability, corrosivity, reactivity, and toxicity. In more severe instances, hazardous materials can cause death, disabling injury, or serious illness. Due to their significance, understanding where these contaminated properties exist is critically important for avoidance in future projects and to continue to protect the safety of the community and environment.

Sites

There are four categories of hazardous or potentially hazardous sites included in this report and identified within the project study area:

- Brownfield sites;
- Environmental Use Restrictions sites;
- Superfund sites; and
- Toxic Release Inventory sites.

Brownfield Sites include locations that are affected by or may potentially be affected by a hazardous substance, pollutant, or contaminant. The study team focused on Brownfield Sites identified within CTDEEP's Brownfield Inventory. Twenty-seven (27) sites were identified with this designation.[19]

Environmental Use Restrictions (EUR) sites are areas that have been inspected by hazardous material experts and deemed unsafe for specific activities. The restrictions placed on the properties are to minimize the risk of exposure to toxic materials. CTDEEP's Connecticut Environmental Land Use Restrictions Online Mapper identified Six (6) sites with this designation.[20]

Superfund sites are properties where uncontrolled or abandoned hazardous waste were released into the environment. Superfund sites were identified using the EPA's Superfund Enterprise Management System (SEMS) database. According to the database, all superfund sites identified within the key study area are noted have been removed from the National Priority List (NPL); however, one (1) site, Scoville Industrial Landfill (Store Avenue), remains on the NPL. The NPL is a nationalized list of superfund sites developed to assist the EPA in prioritizing and determining sites that warrant further investigation. Properties that have been removed from the NPL, or non-NPL properties, continue to be monitored with reports of site characterizations. A total of nine (9) sites were identified with these designations.[21]

Toxic Release Inventory (TRI) sites are locations affected by toxic chemicals released by industrial commercial facilities. Identification alone of TRI sites do not indicate health risks, the purpose of the inventory is to identify the presence and quantity of chemical releases. Seven (7) sites were identified using EPA's TRI National Analysis mapper.[22]

The points of interest are detailed in **Table 4.1.4-1** and are presented in **Figure 4.1.4-1**. A total of forty-eight (48) potentially contaminated or hazardous sites were identified within the Study Area.

Table 4.1.4-1 List of Potentially Contaminated / Hazardous Sites within Study Area

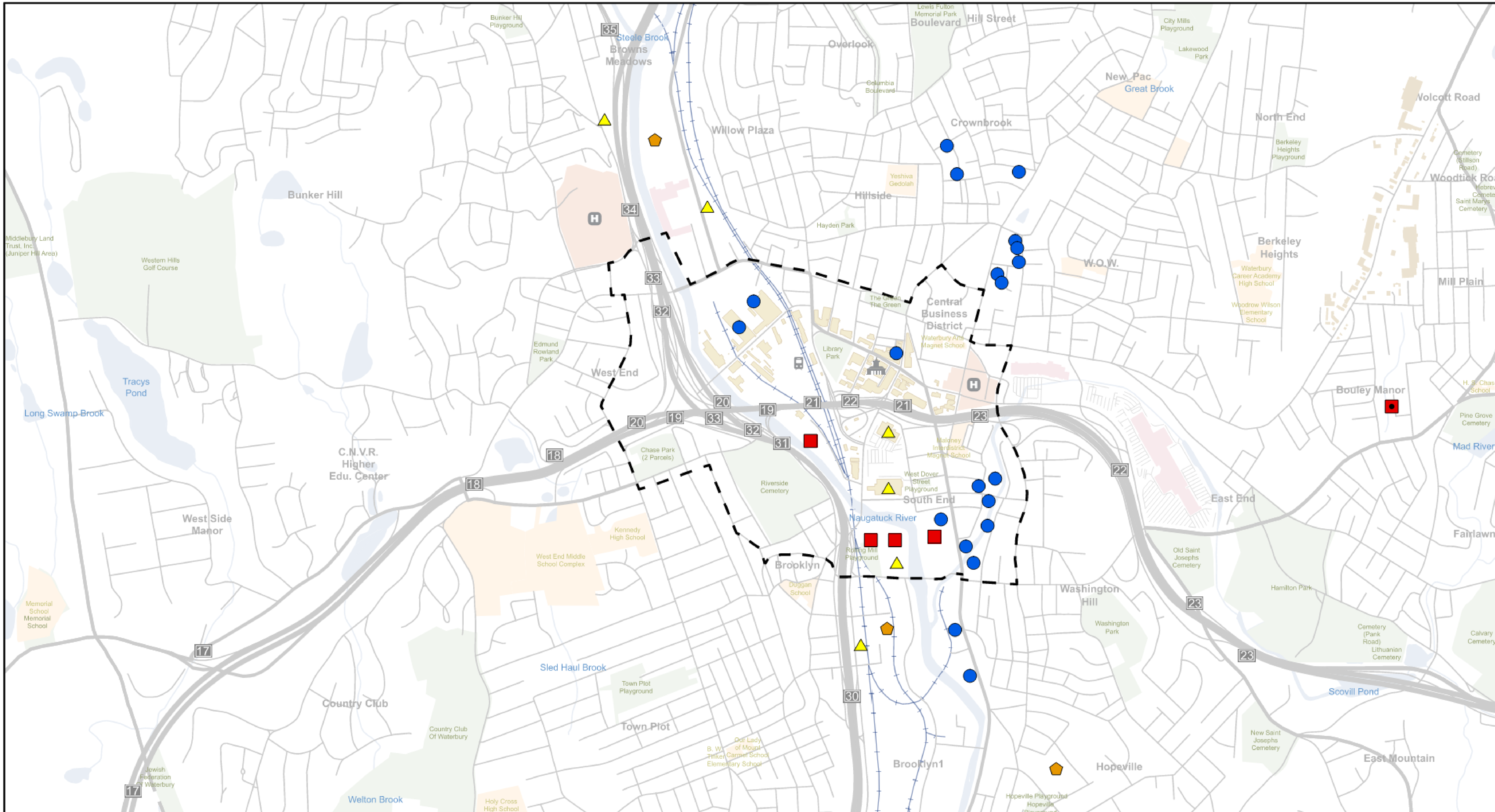
Brownfield Sites[19]	EUR Sites[20]
• 116 Bank Street • 909 Bank Street • 37 Bristol Street • 40 Bristol Street • 31 Burton Street • 39 Cherry Avenue • 16 Cherry Street • 145 Cherry Street • 177 Cherry Street • 215 Cherry Street • 130 Freight Street • 170 Freight Street • 167 Maple Street • 313 Mill Street • 324 Mill Street • 359 Mill Street • 128 North Elm Street • 134 North Elm Street • 47-103 Pearl Street • 99 Pearl Street • 272 River Street • 698 South Main Street • 777 South Main Street • 835 South Main Street • 1046 South Main Street • 1200 South Main Street • 2100 South Main Street	• 425 Bank Street • 575 Bank Street • 155 South Leonard Street • 144 Thomaston Avenue • 160 Washington Avenue • 461 Watertown Avenue
Superfund Sites[21]	**TRI Sites[22]**
• 725 Bank Street • 737 Bank Street • 40 Bristol Street • 29 Jackson Street • 210 Municipal Road • 35 Pearl Lake Road • 563 South Leonard Street • 698 South Main Street • Store Avenue	• 215 (209) Piedmont Avenue • 114 Porter Street • 563 South Leonard Street • 566 South Leonard Street • 567 South Leonard Street • 2712 South Main Street • 311 (-319) Thomaston Avenue

[19] *Brownfields Site Inventory*. Connecticut Department of Energy & Environmental Protection. (2022, July). Retrieved from https://portal.ct.gov/DEEP/Remediation--Site-Clean-Up/Brownfields/Brownfields-Site-Inventory

[20] *Connecticut Environmental Land Use Restrictions Online Mapper*. Connecticut Department of Energy & Environmental Protection. (2022, March). Retrieved from https://portal.ct.gov/DEEP/Remediation--Site-Clean-Up/Environmental-Use-Restrictions/Environmental-Use-Restrictions

[21] Environmental Protection Agency. (2023, March). *Environmental Protection Agency Superfund Enterprise Management System*. EPA. Retrieved from https://www.epa.gov/enviro/sems-overview

[22] Environmental Protection Agency. (2023, March). *Where You Live*. EPA TRI National Analysis. Retrieved from https://www.epa.gov/trinationalanalysis/where-you-live



Legend

- Environmental Use Restrictions
- Toxic Release Inventory Site
- Superfund (Non-NPL) Site
- Superfund (NPL) Site
- Brownfield Site

Sources: Brownfields Site Inventory. Connecticut Department of Energy & Environmental Protection (2022, July); Environmental Protection Agency. Environmental Protection Agency Superfund Enterprise Management System (2023, March); Connecticut Environmental Land Use Restrictions Online Mapper. Connecticut Department of Energy & Environmental Protection (2022, March); Where You Live. EPA TRI National Analysis (2023, March)

- Railroad
- Open Space
- Schools
- 20 Exit
- Hospital
- Train Station
- City Hall
- Key Area Boundry

N

0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Potentially Contaminated / Hazardous Sites

Date: 2023

Figure No: 4.1.4-1

4.2 TRANSIT AND RAIL ASSESSMENT

This section summarizes transit services in the Waterbury area including an evaluation focused on the frequency and type of service provided. An additional focus was placed on programmed improvements to existing services or the infrastructure used in the delivery of those services. The findings of this investigation are summarized in **Section 4.2.2 Transit Service Summary** and outline the impact of the current and future transit services on the study area. Analysis of impacts also includes a discussion of the demographic characteristics that drive the transit needs of the region.

4.2.1 Demographic Characteristics

The City of Waterbury had a population of 118,098 as of the year 2018. The metropolitan area around Waterbury, particularly its urban core, has a relatively large transit dependent population with 20 percent of households not having access to a vehicle and approximately 40 percent only having access to a single vehicle. This means the transit services in the region are a need as opposed to a choice for many residents. **Table 4-4** and **Table 4-5** depict Waterbury's modal split and vehicles available by household. Data is derived from 2016 American Community Survey 5-year estimates.

Table 4-4 City of Waterbury Population Mode Split

Modal Split	Estimate	Margin of Error	% of Working Population
Drove Alone	34,771	+/-1,365	79.53%
Carpooled	4,745	+/-674	10.85%
Public transportation	2,073	+/-360	4.74%
Walked	994	+/-177	2.27%
Other means	455	+/-154	1.04%
Worked at home	685	+/-188	1.57%
Total Working Population	43,723	+/-1,230	100%

Table 4-5 City of Waterbury Vehicles per Household

Vehicles per Household	Estimate	Margin of Error	% of Households
No vehicle available	8,037	+/-611	20.23%
1 vehicle available	16,027	+/-808	40.33%
2 vehicles available	11,044	+/-577	27.79%
3 vehicles available	3,339	+/-350	8.40%
4 or more vehicles available	1,288	+/-246	3.24%
Total Households	39,735	+/-778	100%

4.2.2 Transit Service Summary

The Waterbury area has a robust fixed-route transit network serviced by CTtransit Waterbury for local service; CTtransit New Haven and CTtransit Hartford for express service; Peter Pan, and Greyhound for regularly scheduled intercity service; and North East Transportation (NET) operating paratransit and dial-a-ride services through the Greater Waterbury Transit District. In addition, the Metro North Waterbury Branch Line (WBL) provides commuter rail service from Waterbury to Bridgeport for rail connections to the New Haven Line (NHL) and Grand Central Terminal (GCT) in New York. These services accommodate diverse user groups within the region through weekday and weekend rail and transit services with connections to urban, suburban and rural areas around the Mixmaster.

While the transit and rail services in the Waterbury area are extensive, there is little direct impact of these services on the day-to-day traffic of the Mixmaster Interchange. Moreover, much of the traffic generated on the Mixmaster originates outside of Waterbury and therefore changes in transit dependency in the region are not likely to significantly impact traffic volumes over the Mixmaster. None of the local CTtransit Waterbury buses operating throughout the Waterbury area operate directly through the Mixmaster interchange. Two CT Transit Express bus routes (routes 925, and 928) provide express service from Waterbury to Hartford with all boardings occurring in downtown Waterbury. The routes operate east of the Mixmaster using local roads before merging onto I-84 towards the eastern boundary of the study area. A relatively small number of intercity transit vehicles operate over and through the Mixmaster network itself. These services include over the road coach buses operated by various intercity bus providers (such as Peter Pan, Greyhound, and Mega Bus) and several other smaller bus companies with charter service.

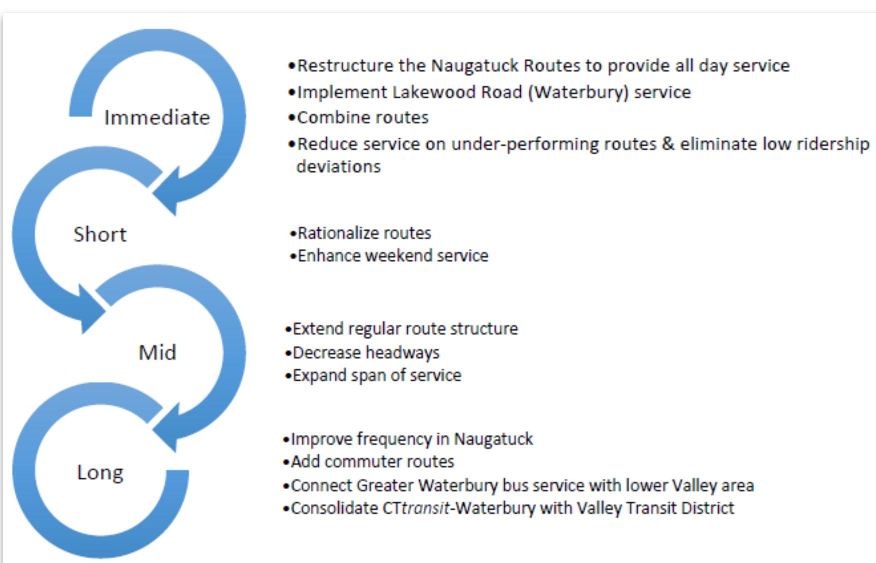
CT*transit* - Waterbury

The CTtransit - Waterbury Division (see **Figure 4-22**) operates seven days a week to provide fixed route service to the Naugatuck Valley. They contract with NET to operate 22 local bus routes in Waterbury. Service usually operates from 6:00 AM to midnight on weekdays, 9:30 AM to midnight on Saturdays, and 9:30 AM to 5:00 PM on Sundays. In addition, three commuter-oriented routes, operating during peak hours only, provide access to suburban employment opportunities in Waterbury and surrounding communities. Specific

The system carried more than 2.72 million passengers in 2015 and 36 vehicles are in operation during peak service. Multiple bus stops are located near the Waterbury Green, on East and West Main Streets. Most routes have coordinated arrivals at the Green, allowing for transfers between routes, then departing in a "pulse" on the half hour or on the hour.

The transit system has undergone and continues to benefit from ongoing capital upgrades and service improvements. More recent improvements include a new maintenance facility in Watertown and a new fare system. The new fareboxes include automatic vehicle location (AVL) and automatic passenger counters (APC).

Figure 4-20 WATS Graphic



The Naugatuck Valley Council of Governments (NVCOG) completed a Waterbury Area Transit Study (WATS) in 2017, identifying immediate, short-term and long-term opportunities for improved service using existing resources and expanding the system to provide high quality, frequent service. **Figure 4-20** represents the general scale and summary of improvements.

CT*transit* – New Haven

The CTtransit – New Haven Division operates seven days a week to provide fixed route service. One route in this system, Route 229, extends from Union Station in New Haven to the downtown Waterbury Green via Hamden and Cheshire. This route operations 7 days a week with 18 round trips daily with weekday headways of 30-minutes during peak hour and 60-minutes in the off-peak hours. Saturday frequency is 60 minutes. The service operates weekdays from 5:00AM to 8:00PM and on the weekends from 5:00AM to 6:00PM. Average daily ridership for this route is approximately 2,139 with a travel time of 73 minutes.

CT*fastrak* and Express Bus Service

CT*fastrak* is Connecticut's first bus rapid transit (BRT) system, featuring a 9.4 mile dedicated, bus-only guideway between downtown New Britain and Hartford with routes that integrate into the larger CT*transit* system. Two routes operate between Hartford and Waterbury, using CT*fastrak* for a portion of the route, the 925 and the 928. The 925 operates during weekday peak hours only while the 928 operates during the off peak and on weekends. The primary difference between the two routes is that the 925 does not stop at the Cheshire Milldale Park & Ride or the Southington Plantsville Park & Ride. In Waterbury, both routes serve the Metro North Waterbury Train Station (stopping on Meadow Street), the Waterbury Green, and St. Mary's Hospital.

The 450 Torrington/Waterbury Flyer is a weekday express bus that serves the Metro North Waterbury Train Station when heading inbound towards the Waterbury Green. Nine trips are provided on weekdays between 5:50 AM and 8:48 PM. There is no weekend service.

Figure 4-21 CT Transit - Hartford Map

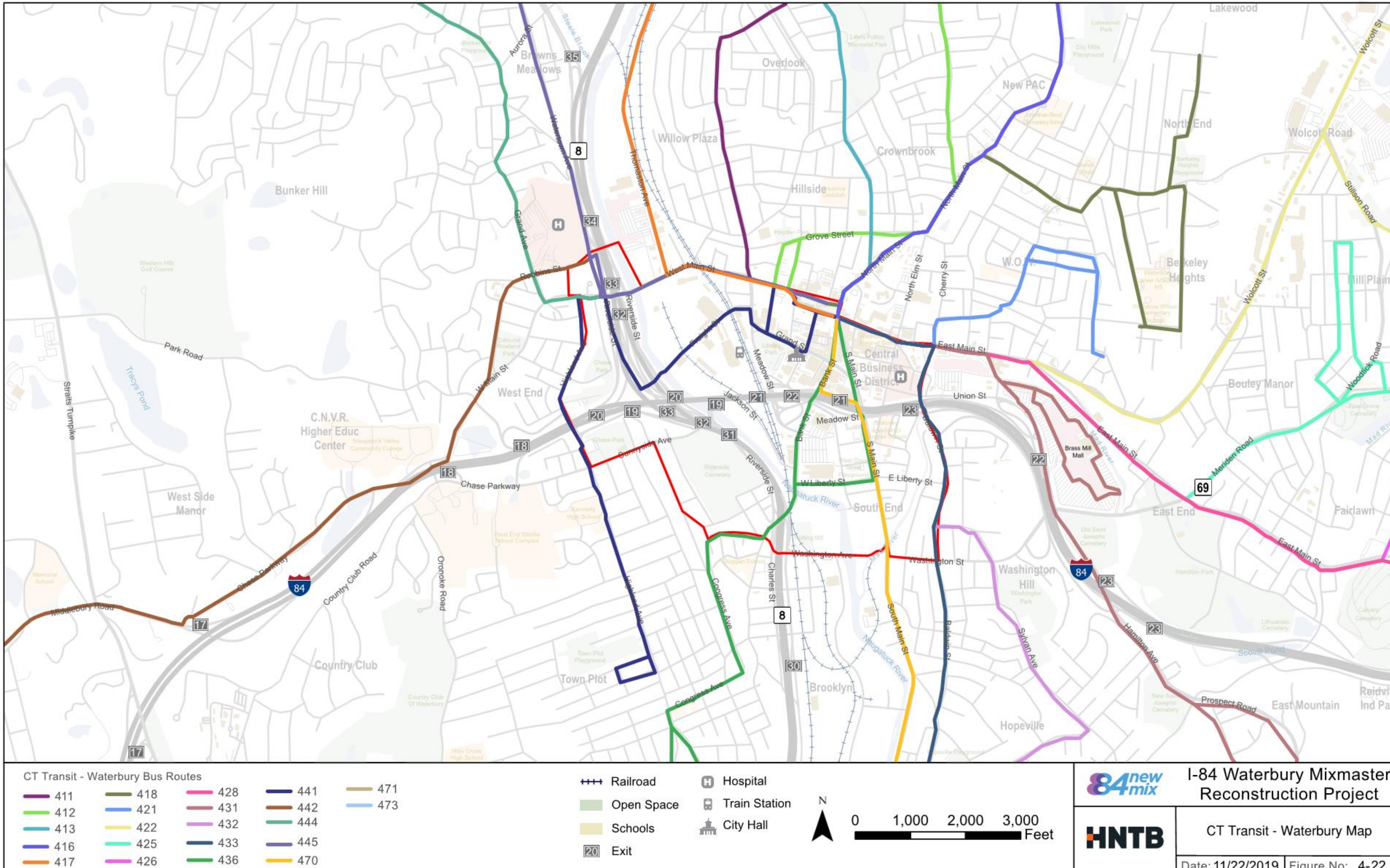
Intercity Bus Service

Intercity bus service for Waterbury is provided by Peter Pan Bus Lines and Greyhound. The Waterbury Travel Center (intercity bus station) is located at 188 Bank Street, approximately 1,000 feet from the Waterbury Green and local bus route pulse point, and 1,800 feet from the Waterbury train station. Peter Pan operates six trips weekdays and five trips on weekends. In addition, Peter Pan operates three trips on weekdays and weekends between Waterbury and New Haven. Greyhound operates a similar service, with six trips on weekdays and four trips on weekends to Hartford and just one trip daily between Waterbury and New Haven.

Paratransit Service and Dial-a-Ride

The Americans with Disabilities Act (ADA) requires operators of regular fixed-route bus service to provide complementary paratransit services to persons that are unable to use regular bus service. This service is available to all ADA eligible residents that have origins and destinations within ¾ of a mile of a local fixed route. Rides must be scheduled one day in advance and the hours of operation mirror local fixed route service.

North East Transportation (NET) operates the ADA paratransit program linked to the CTtransit-Waterbury fixed route service. NET also operates the dial-a-ride program for the Greater Waterbury Transit District (GWTD). GWTD was formed to provide service for elderly and disabled residents in 9 towns, including the City of Waterbury.



Lakewood
Browns Meadows
Overlook
New PAC
Willow Plaza
Crownbrook
North End
Wolcott Road
Bunker Hill
Hillside
W.O.W.
Berkeley Heights
Hill Plain
Central Business District
Bouley Manor
West End
C.N.V.R. Higher Educ Center
West Side Manor
South End
East End
Fairlawn
Washington Hill
Country Club
Town Plot
Brooklyn
Hopeville
East Mountain
Reidville Ind Park
Brass Mill Mall
Grove Street
West Main St
East Main St
North Main St
North Elm St
Cherry St
Union St
Meadow St
S Main St
South Main St
Bank St
Grand St
Jackson St
Riverside St
Thomaston Ave
Grand Ave
Robbins St
Park Road
W Main St
Chase Parkway
Middlebury Road
Country Club Road
Oronoke Road
Straits Turnpike
Congress Ave
Charles St
Washington Ave
Washington St
W Liberty St
E Liberty St
Baldwin St
Sylvan Ave
Hamilton Ave
Prospect Road
Meriden Road
Woodtick Road
Wolcott St
Stillson Road
Naugatuck River
Mad River
Tracy Pond
CT Transit - Waterbury Bus Routes
411
412
413
416
417
418
421
422
425
426
428
431
432
433
436
441
442
444
445
470
471
473
Railroad
Open Space
Schools
Exit
Hospital
Train Station
City Hall
N
0 1,000 2,000 3,000 Feet
84 new mix
HNTB
I-84 Waterbury Mixmaster Reconstruction Project
CT Transit - Waterbury Map
Date: 11/22/2019
Figure No: 4-22

Passenger Rail Service: Waterbury Branch Line (WBL)

The WBL is one of three Metro North Railroad (MNR) branches off the New Haven Line (NHL). The branch is 27.1 miles long and primarily serves 6 stations. The WBL begins at the NHL's Bridgeport station and has stops in Derby, Ansonia, Seymour, Beacon Falls, Naugatuck, and Waterbury. Some weekday trains also stop in Stratford between Bridgeport and Derby-Shelton. Service is operated seven days a week.

The WBL also operates limited through service to Grand Central Terminal (GCT) in New York City which also makes stops in Stamford. The WBL passenger train schedule consists of 15 weekday trains between Waterbury and Bridgeport. There are eight northbound and seven southbound trains daily, Monday through Friday. Except for one AM Peak train, service to GCT requires a transfer at Bridgeport Station; these transfers are synchronized with NHL trains. The AM Peak for the NHL and its branches is defined as trains arriving at GCT between 5:00AM and 10:00AM or departing from GCT between 5:30AM and 9:00AM. There are two southbound and one northbound AM peak trains. The PM Peak is defined as trains that depart GCT between 4:00PM and 8:00PM; there are two northbound and one southbound PM Peak trains.

A weekday trip between Waterbury and GCT takes an average of two hours and 31 minutes in each direction. A trip between Waterbury and Bridgeport takes on average 55 minutes. The average northbound trip on the WBL takes a minute longer than its southbound counterpart. The scheduled transfer wait time in Bridgeport is 5-7 minutes on weekends and 3-10 minutes on weekdays. However, if a transfer is missed heading towards Waterbury, there is a three hour wait for the next train. This is extremely prohibitive in the overall use of the system and is a major factor which limits branch line ridership.

Overall ridership on the WBL is weak with approximately 1,014 daily riders; however, it is reflective of the overall service being provided. The inbound (towards GCT) 7:38 AM and outbound (towards Waterbury) 6:00 PM have the greatest number of riders. Service on the WBL is limited by the lack of signalization and passing sidings, which prevent the operation of more than one trainset on the line at a time. Capital improvements are underway to both signalize the line and add passing sidings. In addition to the new signal system the four passing sidings, one in Devon, Derby, Beacon Falls and Waterbury will allow up to 10 trains to safely operate along the branch line at the same time. When completed, the improvements will lead to better, more consistent service that would likely draw better ridership. However, regardless of the improved ridership realized as a result of better service, it would be unlikely to have any significant impact on traffic volumes over the Mixmaster or through the study area.

The WBL is in the process of receiving major capital improvements that will facilitate expanded service. The branch line is currently un-signalized and lacks passing sidings; this prohibits multiple trains from operating on the line simultaneously. The new signal system will allow more trains to operate, which will likely increase ridership in the coming decades.

4.3 BICYCLE AND PEDESTRIAN ASSESSMENT

The intent of this section is to gain an understanding of the existing bicycle and pedestrian infrastructure and activities within as related to the Mixmaster interchange. The Project provides an opportunity to improve non-vehicular circulation and overall experience across and around I-84 and Route 8. As discussed in the previous **Demographics** section (see **Section 4.2 Demographic Characteristics**), Waterbury residents have limited access to vehicles and would benefit from improved bicycle and pedestrian connections.

Bicycle and pedestrian data have been collected through online research and qualitative data from site visits. In addition, current bicycle and pedestrian initiatives within the area were reviewed for the development of this assessment. Data collection and reviews focused on the local road network within the previously defined Key Area Boundary (see **Figure 1-1 Study Areas Map** and **Figure 4-1 Key Area Boundary and Neighborhoods Map**).

It is not part of this phase of the Project to conduct interviews with community stakeholders nor conduct quantitative research such as pedestrian/bicycle counts. In addition, there are no current studies available to evaluate pedestrian and cyclist safety.

4.3.1 Current Bicycle/Pedestrian Initiatives

The *Statewide Bicycle and Pedestrian Transportation Plan* and *Statewide Bicycle Map* was published in 2009, however, CTDOT began the process of updating the documents in 2015. As a result, the information in this section refers to the *Draft 2017 Connecticut Bicycle and Pedestrian Transportation Plan Update*. The CTDOT vision is to implement an integrated network of on-road facilities and multi-use trails that connect municipalities with key destinations and strengthen links to neighboring states. Three main goals are recommended to achieve this vision:

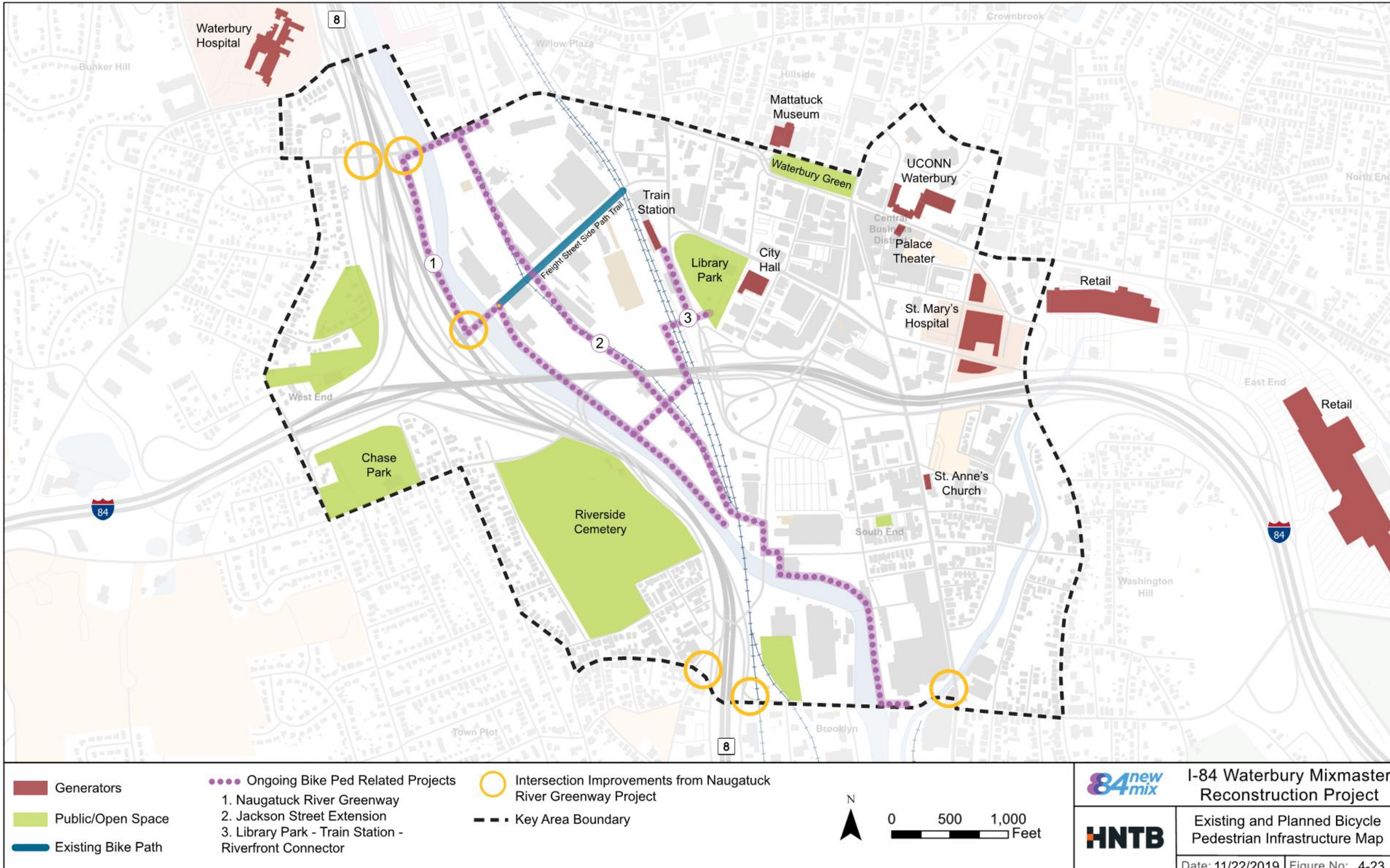
- Improve bicyclist and pedestrian safety;
- Enhance mobility for bicyclists and pedestrians;
- Maximize resources to achieve meaningful improvements

In addition, a statewide Bicycle and Pedestrian Advisory board was established in 2009, to examine and promote bicyclists and pedestrians' programs and facilities. *Let's Go CT*, a transportation plan for the state of Connecticut, laid out action plans for bicycling and pedestrian infrastructure improvements and implemented the Community Connectivity Grant Program to achieve a safer and more reliable multi-modal transportation system.

In Waterbury, the following projects featured significant improvements to the bicycle and pedestrian network within the Key Area Boundary (see **Figure 4-23**):

- Naugatuck River Greenway (NRG)
- Waterbury Active Transportation and Economic Resurgence (W.A.T.E.R.) Project
    - NRG Phase 1 Extension
    - Freight Street Reconstruction
    - Meadow Street Bicycle and Pedestrian Improvements
    - Jackson Street Reconstruction and Extension
    - Library-Station-Riverfront Connector

See **Section 1.4 Ongoing and Recent Projects** for a more detailed description of these projects.



Waterbury Hospital
Mattatuck Museum
Waterbury Green
UCONN Waterbury
Train Station
Freight Street Side Path Trail
Library Park
City Hall
Palace Theater
Retail
St. Mary's Hospital
Chase Park
Riverside Cemetery
St. Anne's Church
Retail
West End
South End
Washington Hill
Town Plot
Brooklyn
East End
North End
Bunker Hill
Willow Plaza
Hillside
Crownbrook
8
84
1
2
3
Generators
Public/Open Space
Existing Bike Path
Ongoing Bike Ped Related Projects
1. Naugatuck River Greenway
2. Jackson Street Extension
3. Library Park - Train Station - Riverfront Connector
Intersection Improvements from Naugatuck River Greenway Project
Key Area Boundary
N
0 500 1,000 Feet
I-84 Waterbury Mixmaster Reconstruction Project
Existing and Planned Bicycle Pedestrian Infrastructure Map
Date: 11/22/2019
Figure No: 4-23

4.3.2 Existing Conditions

To develop an understanding of cyclist and pedestrian needs in Waterbury, a site visit was conducted to collect qualitative data on bicycle paths and sidewalks in the Key Area Boundary.

Bicycle Infrastructure

Mapping data on bicycle infrastructure within the City of Waterbury was not available for use in this analysis. Furthermore, designated bicycle paths were not observed except for the newly reconstructed Freight Street Bike Path. There are a fair number of bicycle racks in the Central Business District area, compared to other neighborhoods. Given the significant amount of proposed bicycle improvements through the NRG and W.A.T.E.R. projects, bicycle infrastructure should be an important part of the Project in order to continue bicycle access improvements in Waterbury.

Sidewalks and Crossings

The existing conditions of sidewalks and crossings in Waterbury vary neighborhood to neighborhood. The following conditions were observed during site visits:

Central Business District (CBD)

The CBD offers a significant amount of pedestrian infrastructure (see **Figure 4-24**), supporting the heavy pedestrian traffic observed in the neighborhood:

- Sidewalks
  - Are present on almost every street
  - Generally, have a standard of 5 feet
  - Have more generous widths within the historic district and on main streets
  - Are well maintained with adequate street lighting
  - Are lined with street trees and street furniture, providing a welcoming and pleasant experience for pedestrians
- Crossings
  - Some but not all key crossings are signalized and have crosswalk striping
  - Crossings near I-84 are wide and difficult to cross in one cycle, creating safety concerns

Figure 4-24 Photos of Waterbury Green (Left) and Grand Street (Right)

South End

Compared to the CBD, the South End does not have strong pedestrian infrastructure (see **Figure 4-25**).

- Most of the neighborhoods have continuous sidewalks along the main roads, but they are not particularly well maintained, especially those that pass by vacant or semi-used lots.
- On side streets, there are either sidewalks on one side of the road or sidewalks without curbs.
- Most sidewalks are on uneven ground and are generally narrow.
- There is a lack of street trees and pedestrian friendly amenities such as pedestrian lights, benches, or trash receptacles.
- Sidewalks along the big box retail parcels and parallel to I-84 have harsh conditions with narrow, exposed sidewalks, and no building frontage.

Figure 4-25 Photos of Market Square (Left) and Jewelry Street (Right)

Brooklyn and West End

Riverside Street Northbound and Southbound span through the neighborhoods of Brooklyn and West End. The previously performed CTDOT Waterbury Interchange Needs Study (WINS) included a field inspection of Riverside Street as part of its evaluation on pedestrian and bicycle needs. The existing sidewalk deficiencies as described in the WINS is summarized below:

- Riverside Street Northbound: The sidewalk on the east side is in poor condition, overgrown with weeds and heavily silted. It is also discontinued between Sunnyside Avenue and Bank Street. There are no sidewalks on the west side.
- Riverside Street Southbound: There are no sidewalks between West Main Street and Sunnyside Avenue.

In West End, the Freight Street Reconstruction (part of the W.A.T.E.R. Project) has been recently and successfully implemented (see **Figure 4-26**). The newly paved street now includes the urban side trail that provides generous bicycle lanes, pedestrian paths, and green infrastructure between the vehicular lanes and trail to manage stormwater and provide an aesthetically pleasing buffer. At the terminus of Freight Street on Riverside Street is a pedestrian ramp and bridge that crosses Route 8 Southbound and continues to the residential area of West End (see **Figure 4-26**).

Figure 4-26 Photos of Recently Constructed Freight Street Multi-Use Path

Overpasses and Underpasses

The current Mixmaster interchange configuration divides the key area and limits connections among neighborhoods. The overpasses and underpasses that serve as connections are primarily for vehicles to cross I-84 and Route 8 (see **Figure 4-30** for locations). Generally, the widths provided are generous for vehicles and narrow for pedestrians. The following conditions were observed during site visits:

Underpasses (Figure 4-27 and Figure 4-28)

- Conditions are generally unwelcoming.
- The large overhead interchange creates a dark and overwhelming environment for pedestrians.
- Sidewalks are not present on both sides of the road and most existing sidewalks are very narrow, with no buffer from vehicular traffic.
- There is a lack of lighting underneath the interchange, creating safety concerns at night or during unfavorable weather.

Figure 4-27 Photos of South Main Street (Left) and Bank Street (Right) Underpasses

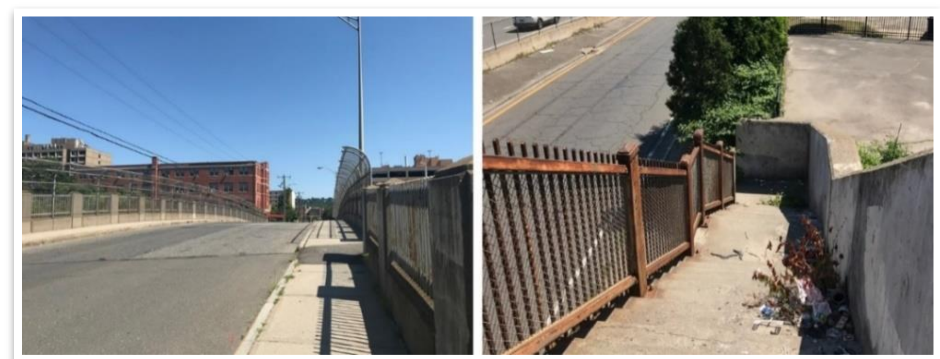
Figure 4-28 Photo of Meadow Street Underpass

Overpasses (Figure 4-29)

- Conditions are generally unwelcoming
- Sidewalks are narrow, with no buffer from heavy vehicular traffic
- Areas are exposed as there are no street planting nor protection from the road
- Often, there is no lighting on the bridge except for at the beginning and end.
- The lack of pedestrian friendly elements creates an unpleasant experience especially at night or during unfavorable weather.

Furthermore, although there is stairway access from the South Elm Street overpass to McMahon Street below, the stairway is poorly maintained and littered with trash (see **Figure 4-29**). This is a notable issue because South Elm Street overpass serves as a major gateway from South End to downtown and St. Mary's Hospital. Overall, these conditions create an unwelcoming environment for walking or bicycling in addition to potential safety issues.

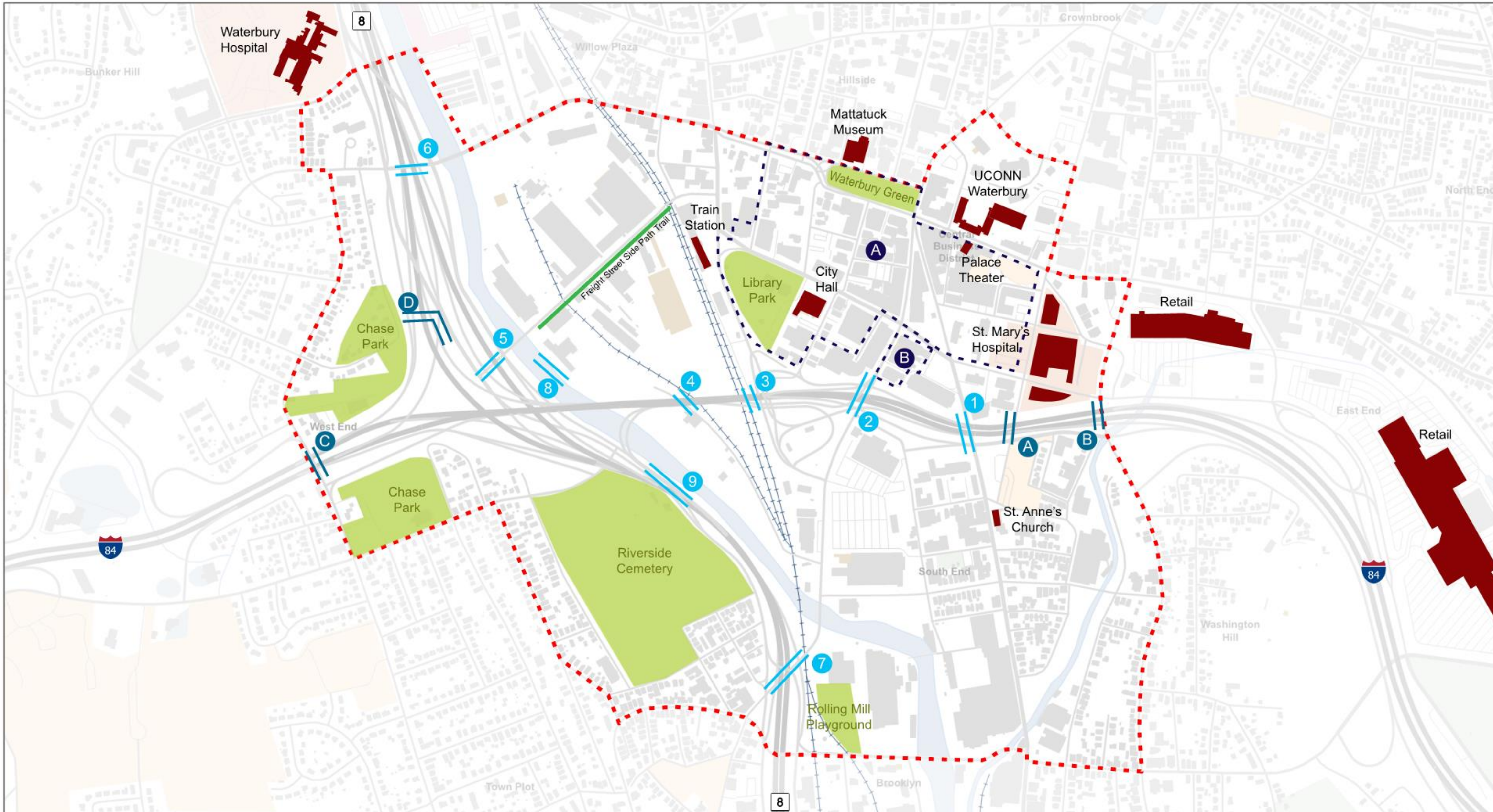
Figure 4-29 Photos of South Elm Street Overpass (Left) and McMahon Street Access (Right)



Although there are a fair number of existing I-84 crossings (albeit in poor condition) there is a lack of Naugatuck River and Route 8 crossings, especially between the neighborhood of South End and Brooklyn. Furthermore, there is no access to the Naugatuck River and the Mad River in the key area.

Cyclist and Pedestrian Collisions

Section 2.5 Crash Data and Safety Analysis documents crash data for the study area. As previously mentioned, there were a total of 27 pedestrian crashes and 3 cyclist collision in the study area (see **Figure 2-54**) between 2015-2017. Notably, the pedestrian and bicycle collisions are located to the far east of the study area, outside of any planned pedestrian and bicycle improvements.



Generators

Public/Open Space

Historic Districts
A. Downtown Waterbury
B. Bank Street

Underpass
1. South Main St
2. Bank St/I-84
3. Meadow St
4. Jackson St
5. Freight St
6. W Main St
7. Bank St/Route 8
8/9. Riverside St/ Route 8

Overpass
A. South Elm St
B. Baldwin St
C. Highland Ave
D. Pedestrian Overpass

N

0 500 1,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Overpasses and Underpasses Map

Date: 11/22/2019 Figure No: 4-30

4.4 ENVIRONMENTAL AND NATURAL RESOURCES

Environmental and natural resources in Waterbury were inventoried to identified.

4.4.1 Environmental Constraints

Waterbury is a host to various natural resources including watercourses, wetlands, soils, and endangered species, in addition to an abundance of historical resources. To determine the existing impacts to natural and historical resources within the study area, the following resources at the state or federal level were consulted:

- Connecticut Department of Energy and Environmental Protection (CT DEEP)
  - Surface Water Quality and Ground Water Quality
  - Atlas of Public Water Supply Sources
  - Aquifer Protection Area (APA)
  - Coastal Area Management (CAM) Zone
  - Natural Diversity Database (NDDB)
  - Critical Habitat
  - Northern Long-Eared Bat Location Map
- United States Environmental Protection Agency (US EPA)
  - Sole Source Aquifer
- United States Fish and Wildlife Service (USFWS)
  - National Wetlands Inventory (NWI)
  - Information for Planning and Conservation (IPaC) tool
- United Stated Department of Homeland Security (US DHS)
  - Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM)
- United States Department of Agriculture (USDA) Natural Resource Service (NRCS)
  - Web Soil Survey
  - Farmland Soils

Field investigations will be scheduled once the design concepts have been identified. For the evaluation of environmental constraints, the study area was limited to 300-feet from the edge of existing roadways. This study area includes Route 8, Interstate 84, on- and off-ramps and is referred to throughout the report as the Project Study Corridor (see **Figure 1-1 Study Areas Map**).

Water Resources

One of Waterbury's most prominent natural resources is the Naugatuck River; however, the highway currently serves as a barrier between the river and the city, leaving no access to the river's edge (see **Figure 4-31**). As discussed in **Section 1.4 Ongoing and Recent Projects**, the Naugatuck River Greenway project is currently under various design stages depending on the geographic location and seeks to address the lack of access to the river. Waterbury also has several small rivers and brooks including Mad River, Sled Haul Brook, Welton Brook, and Wooster Brook that are located near the Mixmaster. Mad River is located on the eastern edge of the South End neighborhood. Similar to the Naugatuck River, the edge is mostly inaccessible, which may be addressed in the long-term as part of the Mad River Greenway.

Figure 4-31 Photos of the Naugatuck River

Water Quality

The protection of surface and ground water sources from contamination is important for cutting water treatment costs, reducing risk to public health, and protecting the habitats of fish and other aquatic life. The CT DEEP Surface Water and Ground Water Quality map categorizes the water sources in Connecticut by quality (see **Figure 4-32**).

Ground water quality for the western portion of the existing alignment is mapped as "GA". Groundwater classified GA is designated as existing private and potential public or private supplies of water suitable for drinking without treatment. It is also baseflow for hydraulically-connected surface water bodies. The central and eastern portion of the existing alignment is classified as "GB". Groundwater classified as GB is designated as industrial process water, cooling waters, and baseflow for hydraulically-connected water bodies. This ground water is presumed not suitable for human consumption without treatment.

Wooster Brook, Welton Brook, and Sled Haul Brook are all classified as "A" surface waters. Class A surface water designated uses include habitat for fish and other aquatic life and wildlife, potential drinking water supplies, recreation, navigation, and water supply for industry and agriculture. The Naugatuck River and Mad River are both classified as "B" surface waters. Class B surface water designated uses include habitat for fish and aquatic life and wildlife, recreation, navigation, and industrial and agricultural water supply.

Water Impacts

To evaluate existing and potential impacts to surface and ground water, public supply watersheds and aquifers in Connecticut were identified. A public supply watershed is an area of land that will drain to a specific waterbody that is used for domestic, commercial, and industrial purposes. An aquifer is defined as an underground layer of water-bearing rock located beneath the water table.

A review of a physical copy of the CT DEEP Atlas of Public Supply Sources indicates that the existing alignment is not located within a public water supply watershed. This resource is not publicly available, and mapping cannot be reproduced, therefore mapping for this resource will not be provided in this report.

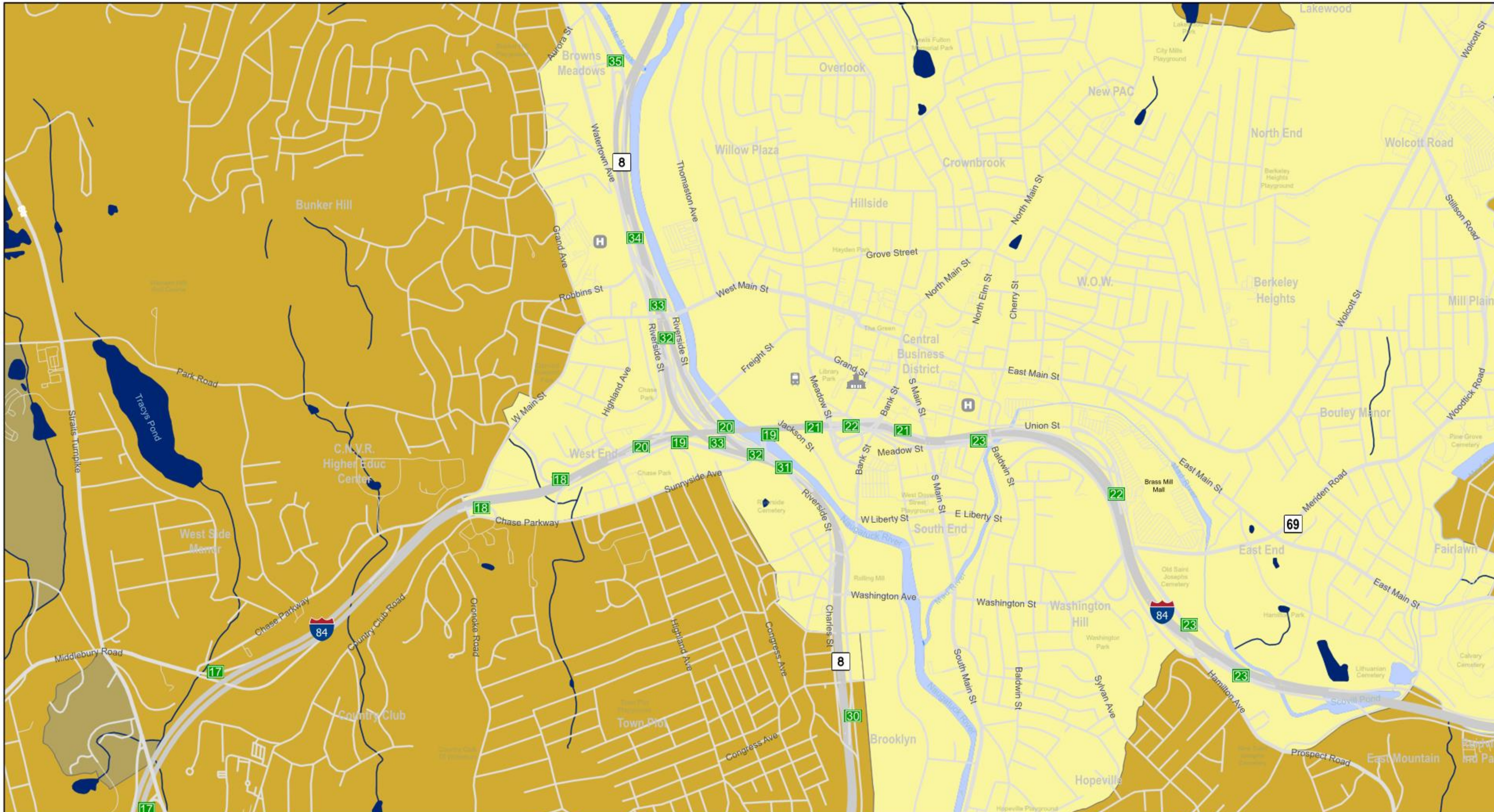
The US EPA classifies a sole source aquifer as one where:

- The aquifer supplies at least 50% of the drinking water for its service area
- There are no reasonably available alternative drinking water sources should the aquifer become contaminated

According to the **US EPA Sole Source Aquifer Map** within **Appendix 4.4**, there are two sole source aquifers within Connecticut – Pootatuck Aquifer in the towns of Newton, Easton, and Monroe, and the Pawcatuck River Aquifer in the towns of Sterling, Voluntown, North Stonington, and Stonington. The Project is located in Waterbury and is therefore not situated within nor in immediate proximity to a sole source aquifer. In addition to sole source aquifers, the **CT DEEP Aquifer Protection Area (APA)** was reviewed, and can be found in **Appendix 4.4**. There are 127 active well fields located within 80 towns in the State of Connecticut. These areas aim to protect sand and gravel aquifers that serve more than 1,000 people. Currently, Waterbury does not have any final or preliminary aquifer protection areas and is not part of the APA program.

In addition to a review of the surface and ground water sources, impacts to coastal areas were also considered. CT DEEP emphasizes the importance of coastal areas with the following statement, "Our coastal area provides myriad opportunities for recreation, public access, commercial fishing, marine trades, and international shipping, as well as habitat for fish, shellfish, birds, wildlife and plants. We all use our coast and we all have to work together to make sure it is available for future generations."[23] An assessment of the CT DEEP Coastal Area Management (CAM) Zones indicates that the City of Waterbury, approximately 18 miles inland, is not located within a CAM Zone. For the **CT DEEP Coastal Area Management (CAM) Zone Map** refer to **Appendix 4.4**

[23] Connecticut Department of Energy and Environmental Protection (CT DEEP). (2019, April 2). Overview of the Connecticut Coastal Management Program. Retrieved from Department of Energy & Environmental Protection: https://www.ct.gov/deep//cwp/view.asp?q=323536&deepNav_GID=1622



Groundwater Classification
- GA
- GB
- To GA, GAA

Surface Water Qualification
- A
- AA
- B
- B*
- SA
- SB

- Railroad
- Open Space
- Schools
- Exit
- Hospital
- Train Station
- City Hall

N

0 1,000 2,000 3,000 Feet

I-84 Waterbury Mixmaster Reconstruction Project

84 new mix

HNTB

Surface and Groundwater Resources Map

Date: 11/22/2019 Figure No: 4-32

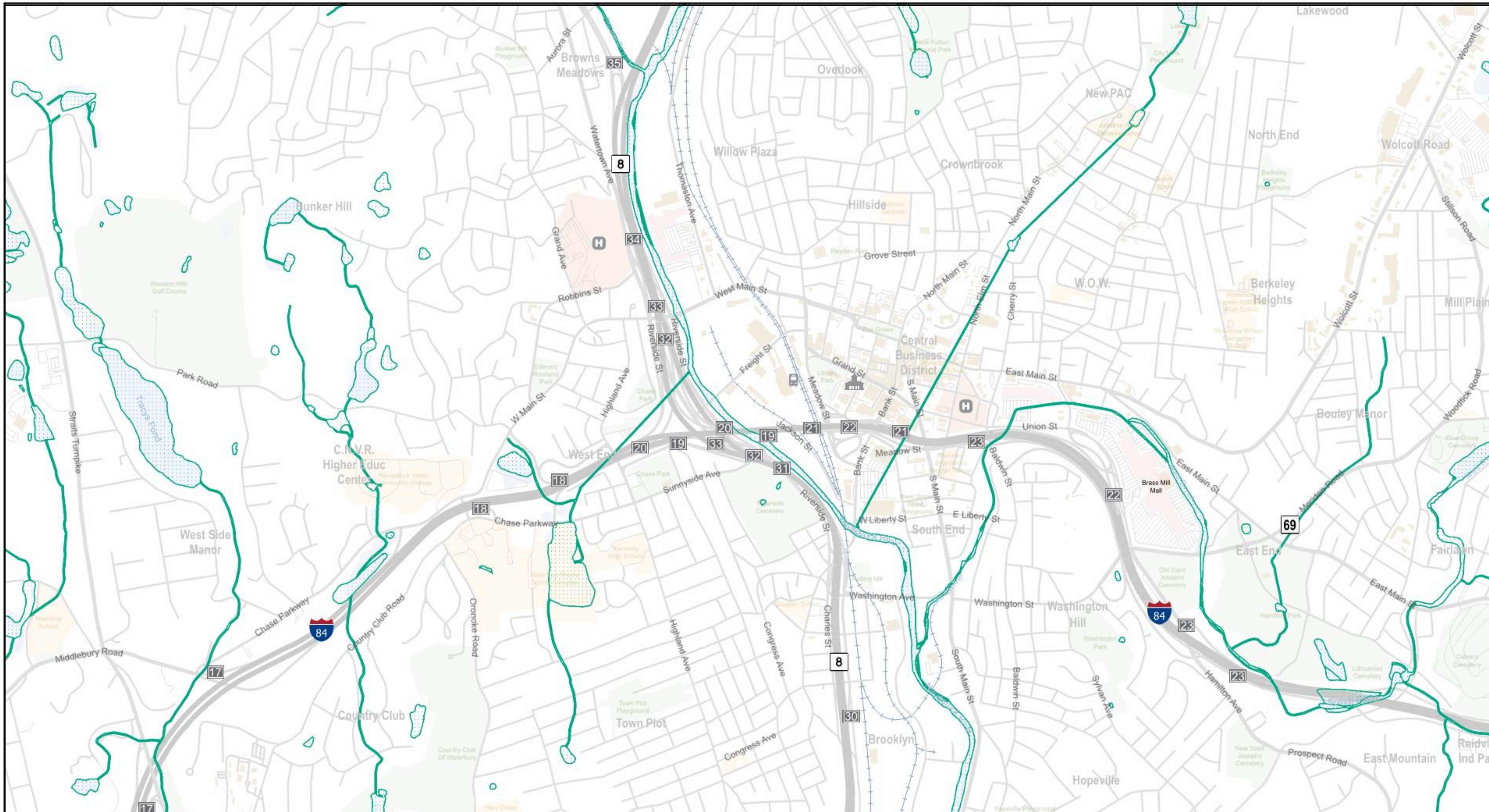
Wetlands

The US EPA defines wetlands as "areas where water covers the soil or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season."[24] Wetlands serve as diverse ecosystems, providing necessary resources for aquatic and terrestrial species.

The USFWS National Wetlands Inventory (NWI) map (see **Figure 4-33**) identifies multiple riverine, freshwater forested/shrub wetlands, and freshwater ponds within the existing alignment. Named perennial watercourses within the existing alignment include Wooster Brook, Welton Brook, Sled Haul Brook, the Naugatuck River, and Mad River. Several other smaller, unnamed tributaries and wetlands or ponds also appear on the mapping. Based on the NWI depiction, several of the watercourses appear to be piped through culverts along the existing alignment.

Utilizing data from NWI, web soil survey, and aerial imagery, several areas through throughout the existing alignments were identified as potential wetlands or watercourses (see **Figure 4-34**). These areas include the named perennial watercourses in addition to potential floodplain wetlands near the Naugatuck River and Mad River. There is also a small wetland and potential vernal pool within the gore area between the I-84 Eastbound Exit 23 off-ramp and Washington Street. A potentially isolated wetland that may also function as a vernal pool in the westernmost portion of the existing alignment, south of the I-84 Eastbound Exit 17 on-ramp.

[24] United States Environmental Protection Agency (US EPA). (2018, July 5). *How do Wetlands Function and Why are they* Valuable? Retrieved from United States Environmental Protection Agency: https://www.epa.gov/wetlands/how-do-wetlands-function-and-why-are-they-valuable



National Wetlands Inventory

Railroad
Open Space
Schools
20 Exit
Hospital
Train Station
City Hall

N

0 1,000 2,000 3,000 Feet

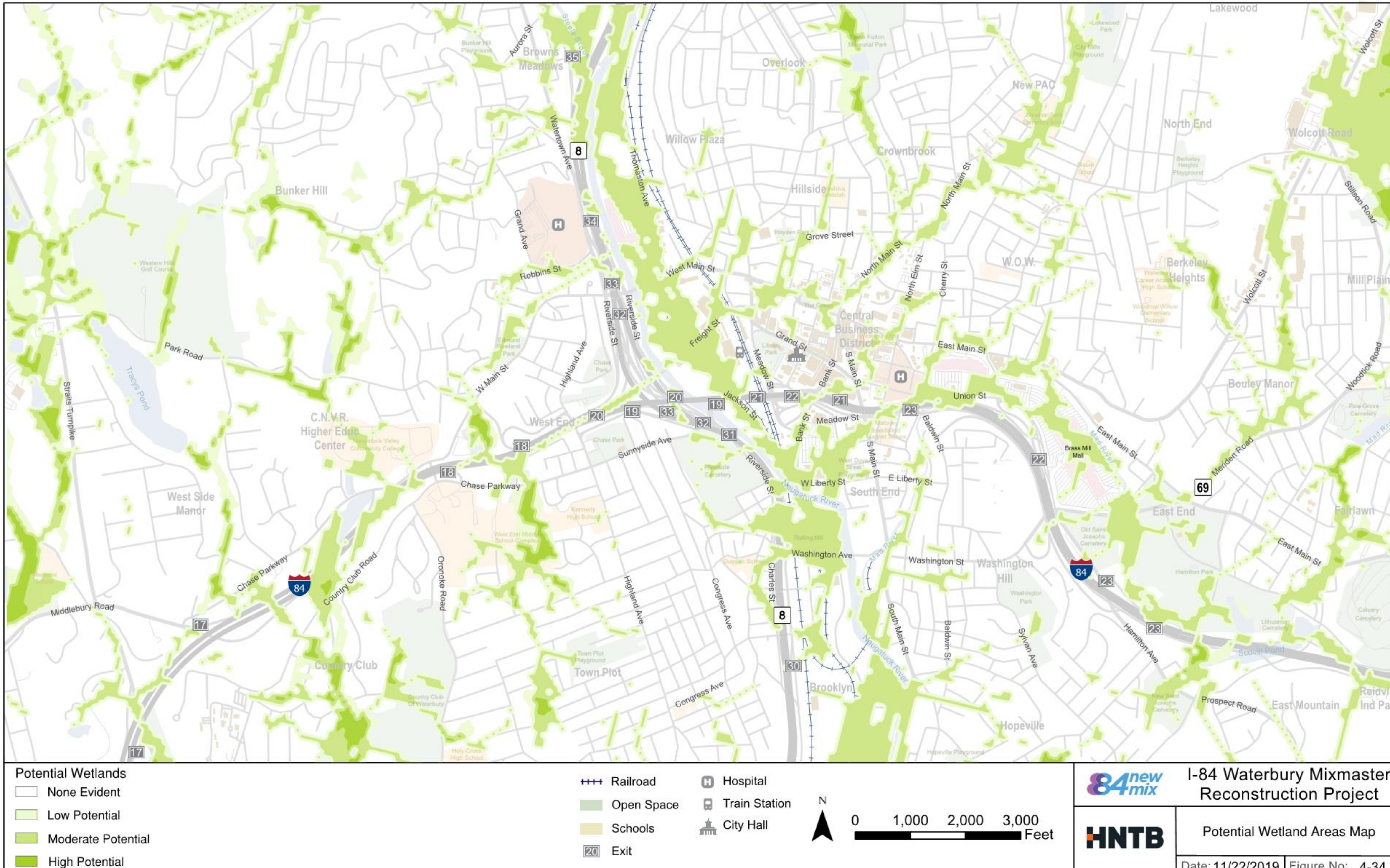
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

National Wetlands Inventory Maps

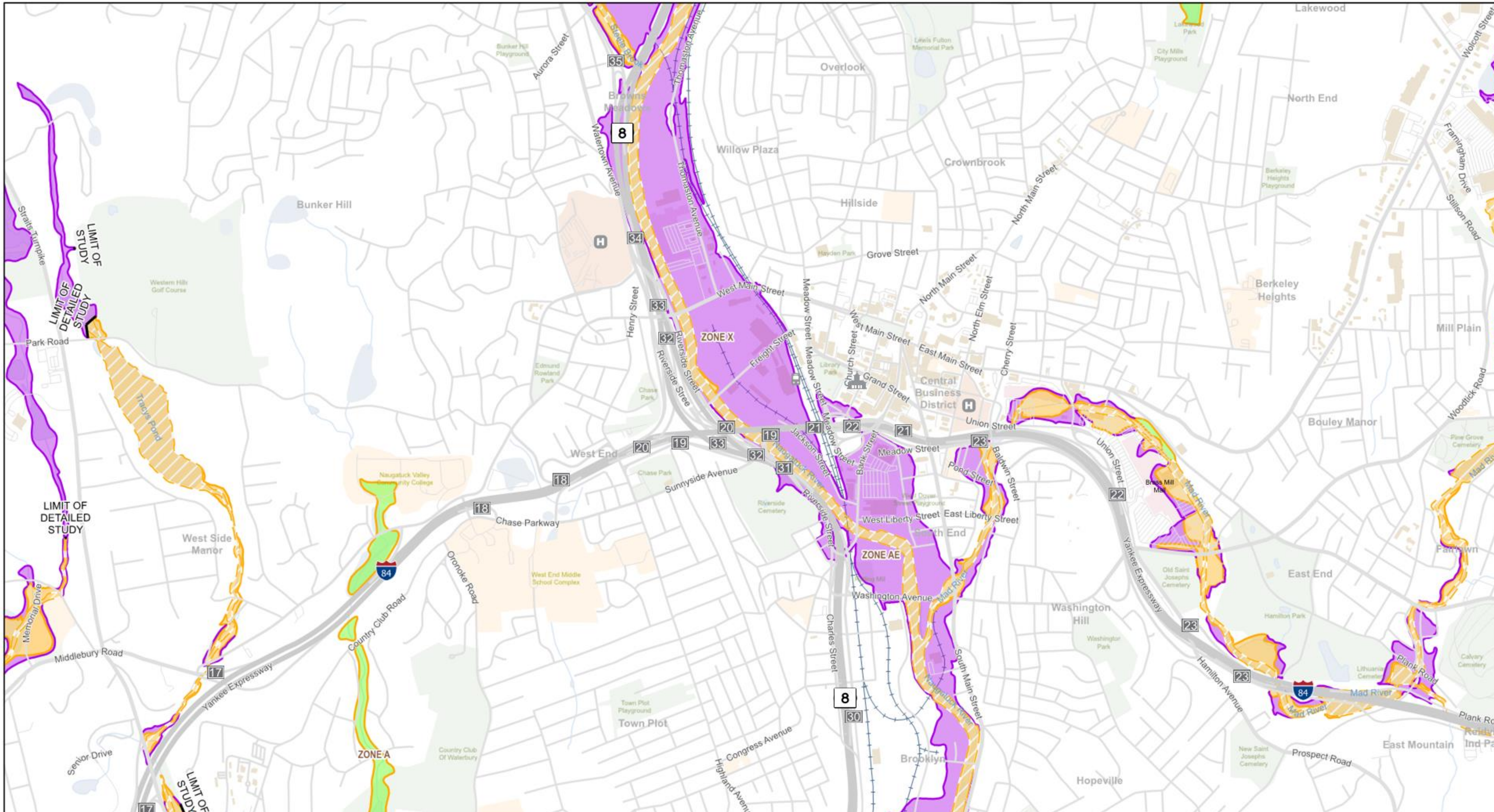
Date: 11/22/2019 Figure No: 4-33


Potential Wetlands
None Evident
Low Potential
Moderate Potential
High Potential
Railroad
Open Space
Schools
Exit
Hospital
Train Station
City Hall
N
0 1,000 2,000 3,000 Feet
84 new mix
I-84 Waterbury Mixmaster Reconstruction Project
HNTB
Potential Wetland Areas Map
Date: 11/22/2019
Figure No: 4-34

Floodplains

Floodplains are defined as an area of land subject to overflow from an adjacent waterbody. Floodways are located within floodplains and are defined as the minimum area of land that must remain free of obstruction to facilitate the discharge of a flood. Mitigating impacts to floodplains are crucial for maintaining public safety and the environmental benefits provided by floodplains such as increased soil moisture and the growth of diverse biological species.

FEMA FIRM maps indicate that both floodway and the 100-year and 500-year floodplains are present within the existing alignment (see **Figure 4-35 Floodplains Map**). The number of years indicates the average frequency of a flood incident of a certain intensity. Specifically, a 100-year floodplain represents the area of land that is likely to be flooded in a storm event that has the probability of occurring once in 100 years. Floodways are associated with Wooster Brook in the western portion of the Mixmaster, the Naugatuck River in the central portion, and the Mad River in the eastern portion. Wooster Brook, Welton Brook, and the Mad River have mapped associated 100-year floodplains and mapped 500-year floodplains are present in the vicinity of Wooster Brook, the Naugatuck River, and the Mad River.



Flood Hazard Boundaries

- 1% annual chance floodplain boundary
- 0.2% annual chance floodplain boundary
- Floodway Boundary
- Zone Break
- Limit of Floodway, Study, or Detailed Study

Flood Hazard Area

- Zone A
- Zone AE
- Zone AH
- Zone AO
- Zone V
- Zone VE
- Floodway Area in Zone AE
- Zone X, area of 0.2% annual chance flood
- Zone X, area protected by levee
- Zone X, area of 1% annual chance flood

- Railroad
- Open Space
- Schools
- 20 Exit
- Hospital
- Train Station
- City Hall

N

0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Floodplains Map

Date: 11/22/2019 Figure No: 4-35

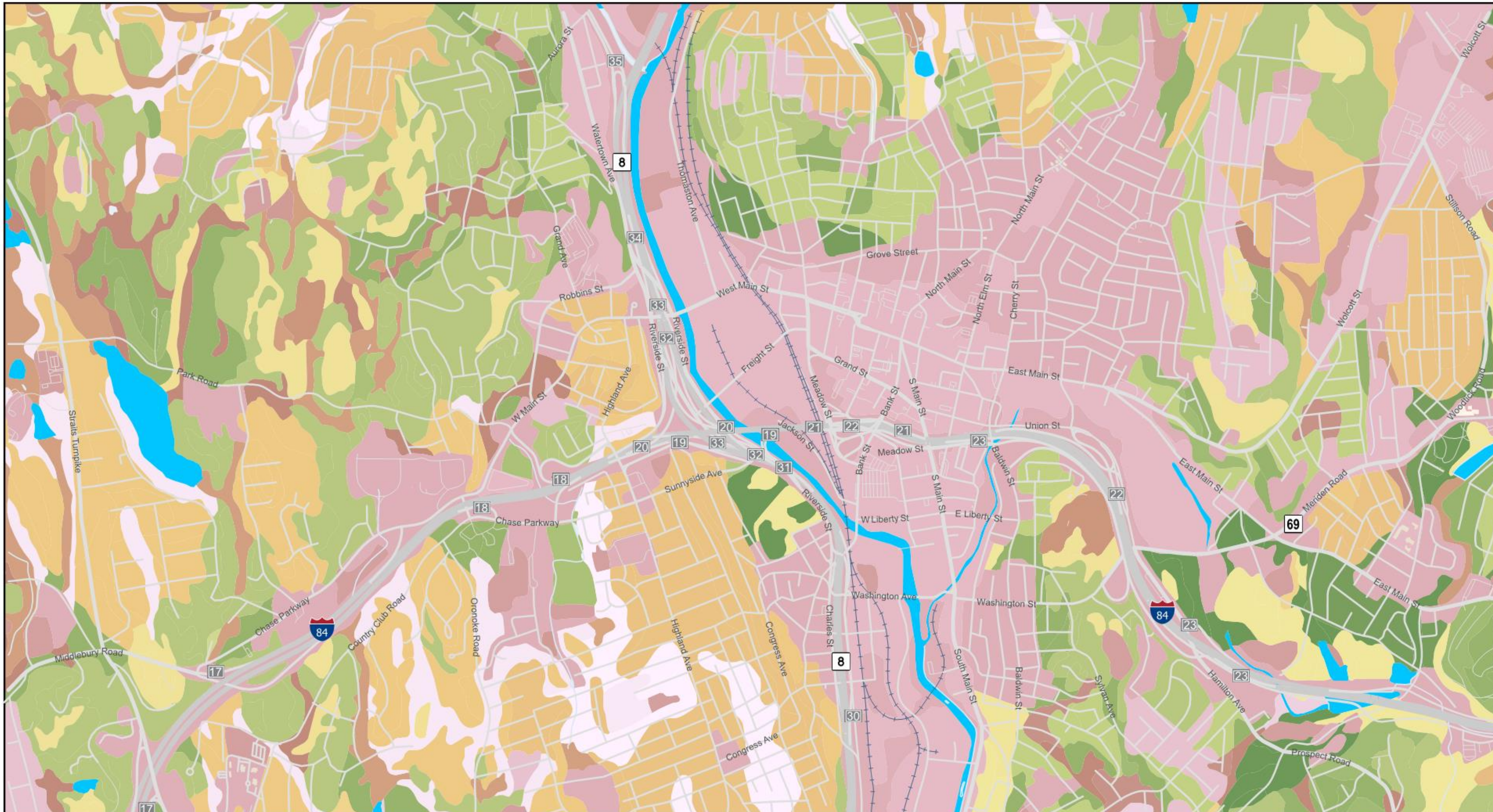
Soils

Soil is one of the most essential natural resources, providing several vital functions needed to sustain life on Earth. As described by the NRCS, "soils sustain biological activity such as plant growth and microbial activity; regulate and partition the flow of water through the landscape; filter, transform, immobilize, buffer, and degrade organic and inorganic materials such as municipal and animal wastes; store and cycle nutrients and other elements such as carbon dioxide; and support buildings and protect archeological treasures."[25]

According to the USDA NRCS Web Soil Survey, most of the land within the existing alignment consists of Udorthent-Urban land complex, urban land, and water. Additionally, two wetland soil series are mapped within the limits; these soils include Ridgebury, Leicester, and Whitman soils (3) and Catden and Freetown Soils (18) (see **Figure 4-36**).

A review of the USDA NRCS Farmland Soils map reveals that both Prime Farmland Soils and Statewide Important Farmland Soils are present within the existing alignment (see **Figure 4-37**). These soils are largely concentrated on the western side of Route 8, north and south of I-84. These soils are also present in the easternmost portion of the existing alignment, north of I-84 westbound Exit 23. No Locally Important Farmland Soils are mapped within the existing alignment.

[25] United States Department of Agriculture (USDA). (1995, November). Soil Quality. Retrieved from USDA Natural Resources Conservation Service: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/rca/?cid=nrcs143_014198



- Agawam fine sandy loam
- Agawam-Urban land complex
- Belgrade silt loam
- Branford silt loam
- Canton and Charton fine sandy loams
- Canton and Charton soils
- Catden and Freetown soils
- Charlton-Chatfield complex
- Charlton-Urban land complex
- Cheshire fine sandy loam
- Dumps
- Fluvaquents-Udifluvents complex, frequently flooded
- Gloucester gravelly sandy loam
- Halsey silt loam
- Haven silt loam
- Hinckley loamy sand
- Hinckley-Urban land complex
- Hollis-Chatfield-Rock outcrop complex
- Leicester fine sandy loam
- Limerick and Lim Soils
- Merrimac fine sandy loam
- Merrimac-Urban land complex
- Ninigret fine sandy loam
- Ninigret-Urban land complex
- Occum fine sandy loam
- Paxton and Montauk fine sandy loams
- Paxton-Urban land complex
- Pits, Quarries
- Pootatuck fine sandy loam
- Rainbow silt loam
- Raypol silt loam
- Ridgebury fine sandy loam
- Ridgebury, Leicester, and Whitman soils
- Rippowam fine sandy loam
- Rock outcrop-Hollis complex
- Saco silt loams
- Scarboro muck
- Sutton fine sandy loam
- Sutton-Urban land complex
- Timakwa and Natchaug soils
- Udorthents, smoothed
- Udorthents-Pits complex
- Udorthents-Urban land complex
- Urban land
- Urban land-Charlton-Chatfield complex
- Urban land-Chatfield-Rock outcrop complex
- Walpole sandy loam
- Woodbridge fine sandy loam
- Woodbridge-Urban land complex
- Water

N

0 1,000 2,000 3,000 Feet

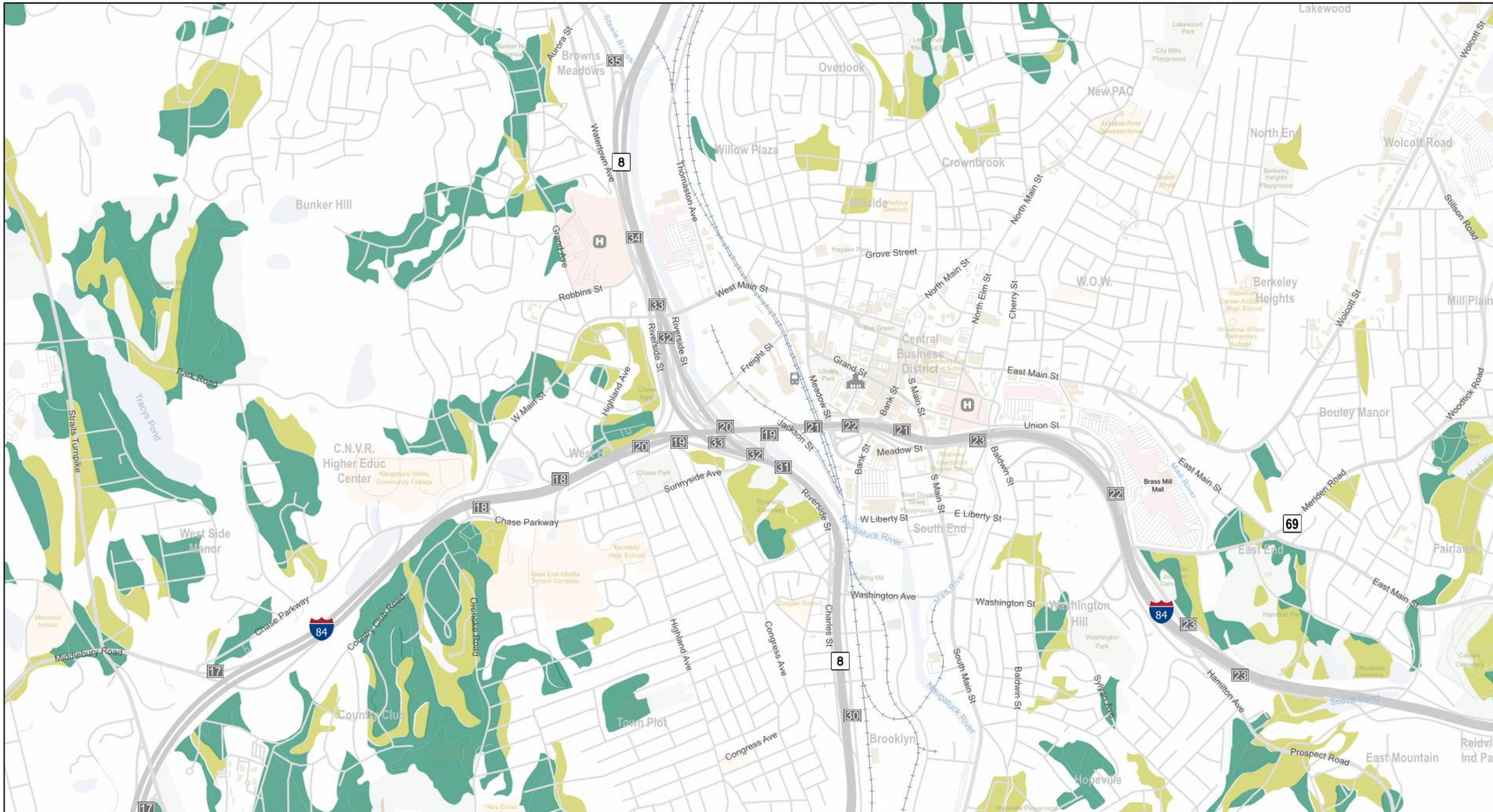
84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

USDA NCRS Web Soil Survey Map

Date: 11/22/2019 Figure No: 4-36



Prime Farmland Soil

Farmland Soil of Statewide Importance

Railroad

Open Space

Schools

20 Exit

Hospital

Train Station

City Hall

N

0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

USDA NCRS Farmland Soils Map

Date: 11/22/2019 Figure No: 4-37

Endangered Species

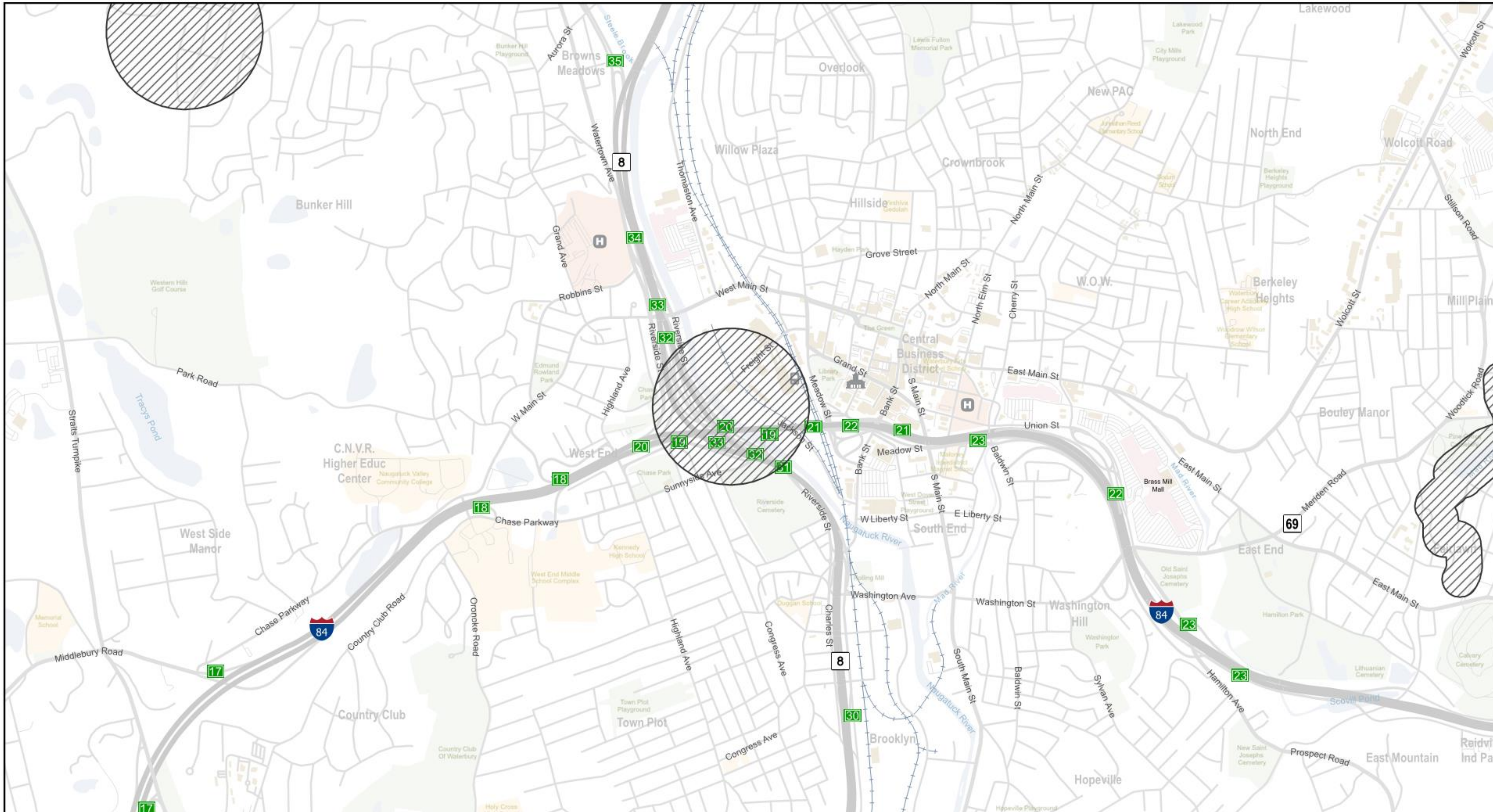
Four different resources were utilized to identify endangered species, species at risk of extinction, within the existing alignment. The USFWS Information for Planning and Conservation (IPaC) tool identifies federally listed species, endangered species at the federal level, and critical habitats, locations identified as containing essential features needed for the survival of endangered species. At the federal level, both classifications are managed under the Endangered Species Act (ESA). Review of the USFWS IPaC tool indicates that there are presently no federally listed species or critical habitats anticipated within the limits of the existing alignment. However, the IPaC review identified fourteen birds protected by the Migratory Birds Treaty Act and the Bald and Golden Eagle Protection Act. These bird species include:

1. Bald eagle (Haliaeetus leucocephalus);
2. Black-billed cuckoo (Coccyzus erythropthalmus);
3. Bobolink (Dolichonyx oryzivorus);
4. Canada warbler (Cardekkuba canadensis);
5. Cerulean warbler (Dendroica cerulea);
6. Eastern whip-poor-will (Antrostomus vociferus);
7. Ggolden-winged warbler (Vermivora chrysoptera);
8. Kentucky warbler (Oporornis formosus);
9. Nelson's sparrow (Ammodramus nelsoni);
10. Prairie warbler (Dendroica discolor);
11. Rred-headed woodpecker (Melanerpes erythrocephalus);
12. Rrusty blackbird (Euphagus carolinus);
13. Semipalmated sandpiper (Calidris pusilla); and
14. Wood thrush (Hylocichla mustelina)

The documents received from the USFWS containing this information can be found in **Appendix 4.4**.

On the state-level, a review of the most recent CT DEEP Natural Diversity Database (NDDB) maps (December 2017) indicates that there is at least one mapped NDDB area, location of endangered, threatened, or special concern species, just east of the Route 8 and Interstate 84 interchange (see **Figure 4-38**). It should be noted that these maps are typically updated every six months, and as a result, there is the potential for additional NDDB areas to be added throughout the Design and Permitting process. No critical habitats at the state-level, as defined by CT DEEP Critical Habitats, are mapped within or adjacent to the existing alignment. Please refer to **Appendix 4.4** for the **CT DEEP Critical Habitat Map**.

The CT DEEP Northern Long-Eared Bat Areas of Concern map indicates towns where there are known hibernacula for the Northern Long-Eared Bat (Myotis septentrionalis) and indicates that there are no known roost trees in the state for this species. Towns with known hibernacula include Salisbury, Winchester, East Granby, Morris, New Milford, Roxbury, Bridgewater, Greenwich, and North Branford (see **CT DEEP Northern Long-Eared Bat Areas of Concern** in the **Appendix 4.4**). No known Northern Long-Eared Bat hibernacula or roost trees are located in or immediately adjacent to the City of Waterbury or the existing alignment.



Natural Diversity Database Areas

Railroad

Open Space

Schools

Exit

Hospital

Train Station

City Hall

N

0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Natural Diversity Database Areas Map

Date: 11/22/2019 Figure No: 4-38

4.5 GEOTECHNICAL CONDITIONS

This section documents and summarizes existing subsurface data for I-84, Route 8, system and service ramps at the "Mixmaster" and surrounding areas. This task consisted of researching and collecting existing subsurface information for the study area. Relevant geologic data was available from geology maps and reports, soil/rock boring logs from bridge and highway plans, and soil/water information from conservation service surveys.

The HNTB team contacted CTDOT Soils and Foundations Section for any available geotechnical reports of structures, pile driving records, load-tests, or other field data. No existing, archived geotechnical reports were located at the Section's office; however, some data was provided regarding potential steel pile corrosion in fill materials, which is discussed in **Section 2.6 Existing Structural Conditions**.

4.5.1 Site Geology

Physical Features

The Waterbury area or quadrangle lies near the eastern edge of the Western Connecticut Highlands, with the City of Waterbury occupying the east-central part. The center of the City is near a topographic low-point at the confluence of the Naugatuck River and its tributary the Mad River. The local topography exhibits numerous hills ranging from 150 to 300 feet in height.

Figure 4-36 shows, at the subject project's area, the soil survey from the map produced by Connecticut Department of Energy and Environmental Protection (CTDEEP) in October 2009 and titled "Connecticut Soils – Waterbury, CT." The soil survey map contains interpretation of land uses which are based on the properties of the shallow soil/rock. Most of the land rating around the project's interchange is "Urban land". The map also shows the two major waterways; the Naugatuck and Mad Rivers.

Surficial Geology

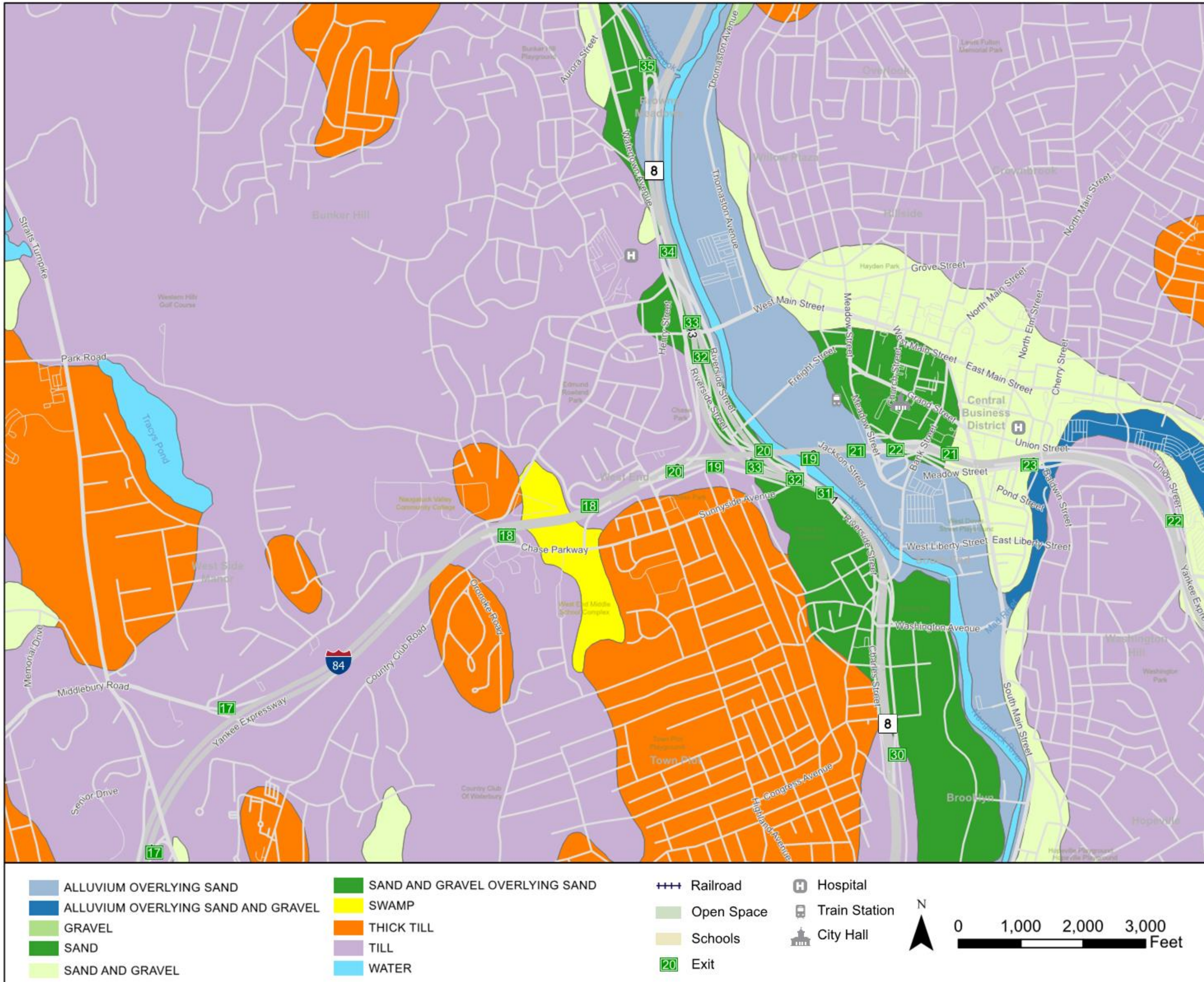
The map produced by CTDEEP in August 2009 and titled "Surficial Materials – Glacial and Postglacial Deposits – Waterbury, Connecticut" shows the extent and texture of surficial deposits, that range from a few feet to several hundred feet in thickness, overlying the bedrock surface. These materials are glacially derived and divided in two broad categories: Glacial Ice-Laid deposits (tills and moraine) which are generally exposed in the uplands; and Glacial Meltwater deposits (stratified fine and/or coarse soils) which are commonly concentrated in valleys and lowlands. There also exists some localized Postglacial sediments (floodplain alluvium and swamp deposits). See **Figure 4-39**.

Glacial Ice-Laid deposits were derived directly from the ice. The matrix of the tills is predominantly sand and silt, with sparse to abundant boulders. Some tills contain lenses of sand and gravel, with occasional masses of laminated fine-grained sediment. Tills blanket the bedrock surface in variable thicknesses and underlie the Meltwater deposits.

Glacial Meltwater deposits were laid down in glacial streams, lakes, and ponds which occupied the lowlands as the last ice-sheet melted away to the north. These deposits are composed of layers of sands, gravels, silts, and clays with few to no boulders. Meltwater deposits are better sorted, more permeable, and are relatively easy to excavate and build highways on.

Postglacial Sediments are less widely distributed and are typically thinner than the glacial deposits that they overlie. Deposits of floodplain alluvium are composed of sands, gravels, and silts that have been reworked and mixed with organic matter.

Similarly, the "Quaternary Geology – Waterbury, Connecticut" map produced by CT DEEP in December 2010 (see **Figure 4-40**) illustrates the geologic features formed during the Quaternary Period, from about 2.6 million years ago to the present time and includes the Pleistocene (glacial) and Holocene (postglacial) Epochs. At least twice in the Pleistocene, continental ice-sheets swept across Connecticut from the north.



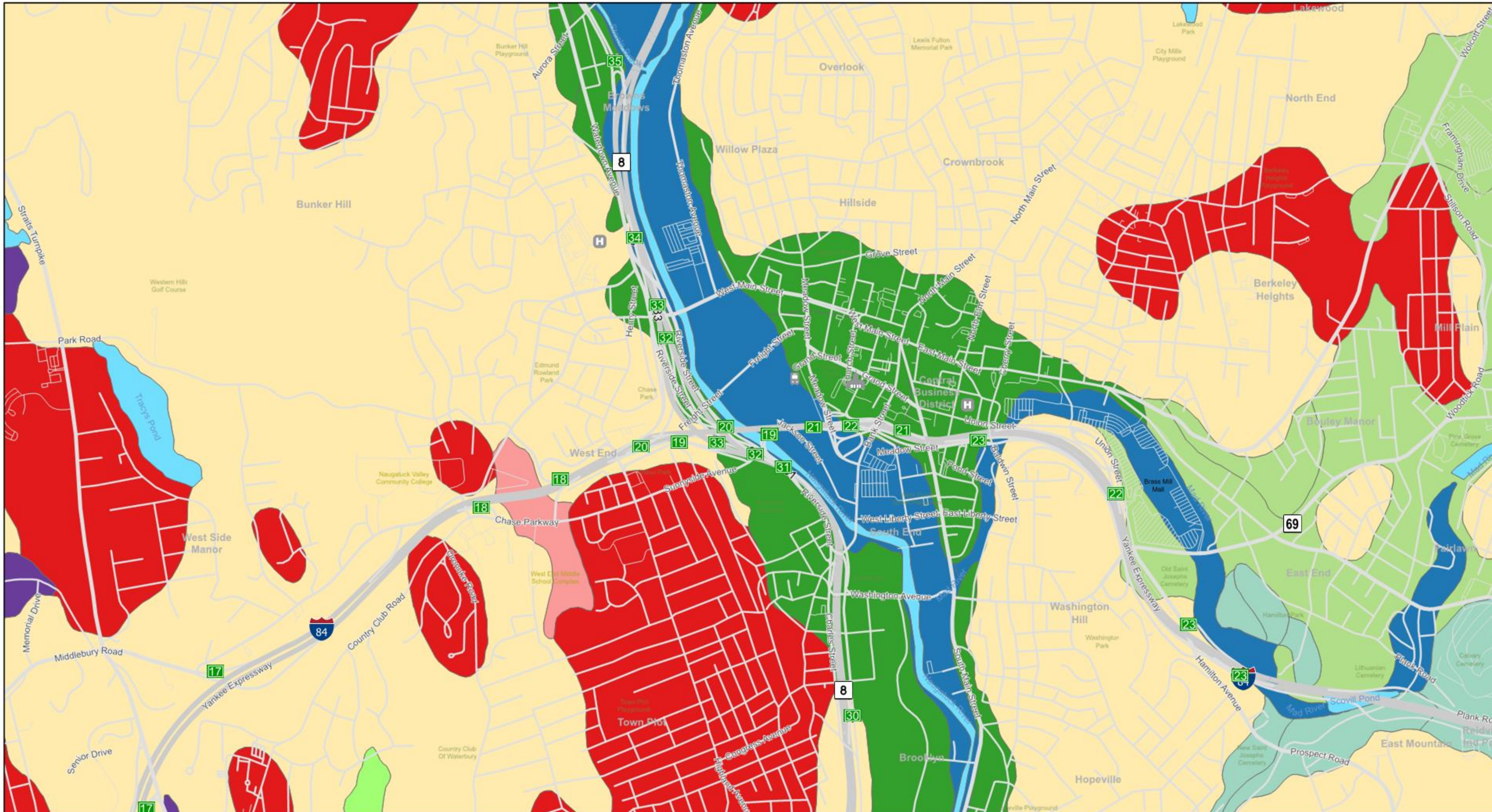
I-84 Waterbury Mixmaster Reconstruction Project

84 new mix

HNTB

Surficial Materials Map

Date: 11/22/2019 Figure No: 4-39



East Mountain Reservoir Deposits	Thin Till Deposits
Flood-plain Alluvium	Uncorrelated Deposits Of Proximal Meltwater Streams
Mad River Deposits	Uncorrelated Deposits of Ice Dammed Ponds
Naugatuck River Deposits, Naugatuck -Reynolds Bridge	Uncorrelated Deposits of Sediment Dammed Ponds
Swamp Deposits	Undifferentiated Meltwater Deposits
Thick Till Deposits	Water
	Woodbury Deposits

Railroad

Open Space

Schools

20 Exit

Hospital

Train Station

City Hall

N

0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

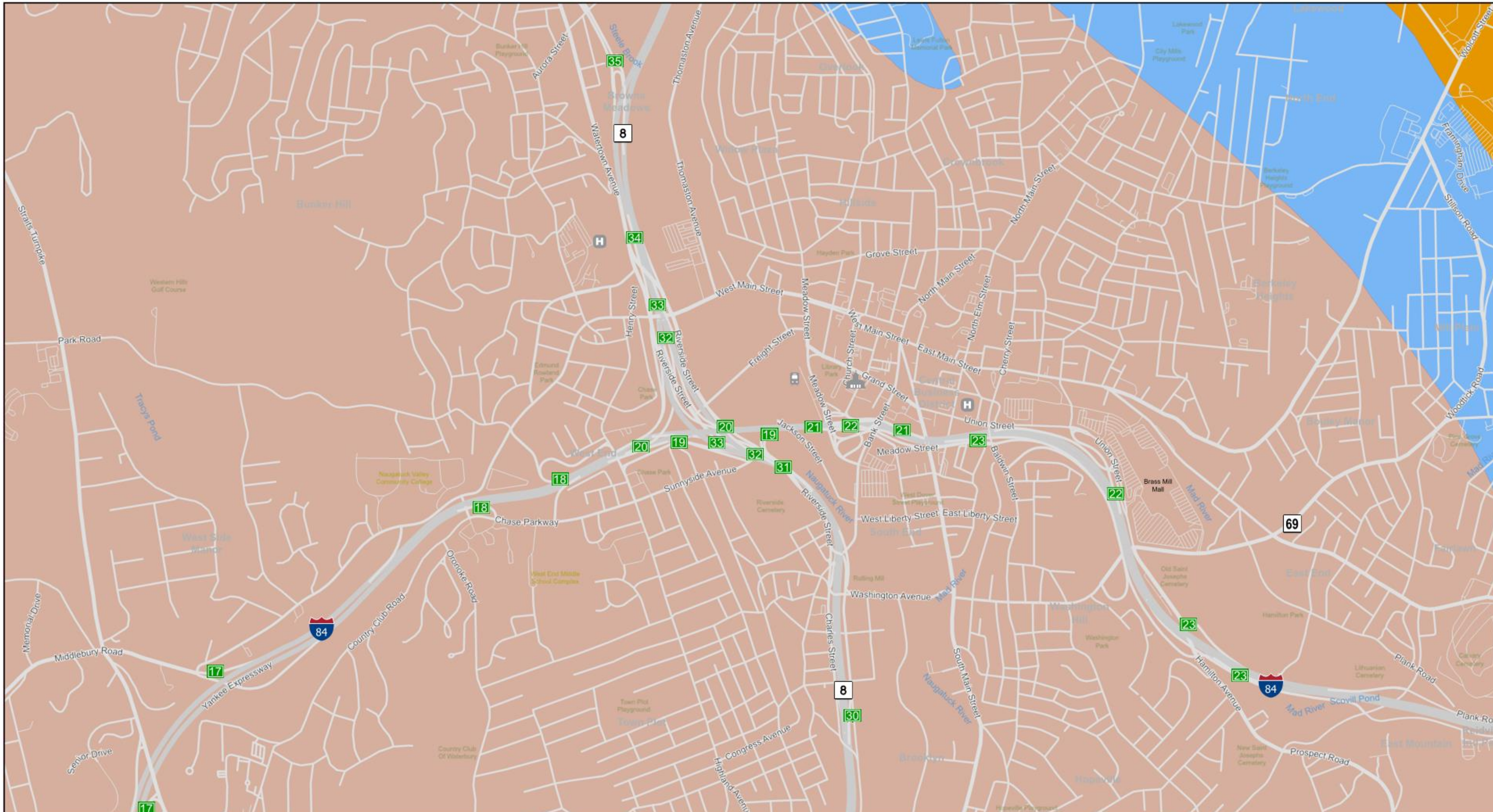
Quaternary Geology Map

Date: 11/22/2019 Figure No: 4-40

Bedrock Geology

The Bedrock Geology map of the Waterbury Quadrangle, with its related report No. 22, was published in 1967 by the State Geological and Natural History Survey of Connecticut. The map and report describe the "Waterbury Formation" (which outcrops within 1 ½ miles of the center of the City) as a meta-sedimentary complex (gneiss and schist) forming the core of a dome. The complexly folded meta-sediments are intermixed in magmatic fashion with granitic to quartz-diorite rocks. Rocks typical of the formation are found on Pine Hill within the City (see **Figure 4-41**)

The gneisses are in migmatitic mixtures (light-colored igneous rocks in a host of darker meta-sedimentary rocks). The formation is a series of thinly to thickly interlayered rocks, intricately folded, with the layers ranging from an inch to several feet. Metamorphic conditions, such as melting and regional migmatization, have produced the Waterbury Formation rocks which are generally hard, tough, coherent, and tend to weather with a rough surface. Most outcrops are irregularly rounded as a result of glacial abrasion. The age of the Waterbury Formation is most probably Pre-Cambrian, older than 360 million years.



Basal member of Taine Mountain Formation around Waterbury dome
Taine Mountain Formation
Waterbury Gneiss

Railroad
Open Space
Schools
Exit
Hospital
Train Station
City Hall

N

0 1,000 2,000 3,000 Feet

84 new mix

I-84 Waterbury Mixmaster Reconstruction Project

HNTB

Bedrock Geology Map

Date: 11/22/2019 Figure No: 4-41

4.5.2 Soil/Rock Data

This section presents the available subsurface information on the 62 bridges/structures within the Mixmaster in Waterbury, CT. Existing plans were not available for eleven structures and for six structures the existing plans did not contain any boring logs. The remaining 45 structures are summarized below.

Based on available information, subsurface conditions generally consist of medium dense (MD) to very dense (VD), Sand and Gravel (S&G) overlying predominantly Gneiss bedrock. The S&G contains small amounts of cohesive material, with layers of stiff Silt or Clayey Silt uncovered at some locations. Boulders and cobbles (B&Cs) were encountered at most structures. The Gneiss bedrock was generally jointed/fractured with the occasional seam of Quartz, and some cores samples were classified as Schist rock.

Deep foundations consist of steel H-piles driven to bedrock or 12-inch tapered cast-in-place (CIP) concrete piles bearing in dense sand. Shallow foundations consist of footings erected on compacted gravel fill, dense natural soil material, or bedrock.

Table 4-6 summarizes the general soil profile and foundations at each structure where existing plans were available. An average ground surface elevation was used when determining the range of depths to bedrock for each structure.

4.5.3 Summary

The anticipated site geology from online maps generally agrees with the subsurface conditions detailed in the existing plans. With dense sand and gravel overlying bedrock, the shallow and deep foundations appear adequate for the existing loads.

Table 4-6 Studied Bridge Soil Profiles and Existing Foundations

Bridge #	Bridge Description	Soil Profile (feet)	Existing Foundation	Existing Bridge Plan	Existing Bridge Plan Notes
01173	I-84 EB over RTE 63 (Middlebury)	5-20': S&G, MD to D, some B&C, some peat behind East Abut. Rock: Hard, gray, seamy	E/W Piers: footings on rock Abuts: footing on fill	1962	"Part A" Pg 117-130 Use avg gnd El. 402
01174	I-84 WB over RTE 63 (Middlebury)	5-20': S&G, MD to D, some B&C Rock: Hard, gray, seamy	E. Pier: combined ftng on fill W. Pier: footings on rock Abuts: footing on fill	1962	"Part A" Pg 117-130 Use avg. gnd El. 402
01714	RTE 8 Ramp 079 over SR 846 NB				Only inspection reports available
01715	RTE 8 over SR 846 NB				Only inspection reports and rehab plans available
01716	RTE 8 SB over RTE 73 WB	70-90': Sand, MD to D Rock: Granite Gneiss, 48-99% Rec.	Piers: combined ftng on fill Abuts: footing on fill	1963	Structure #17"Br. 01716" Pg 93-103Use RTE 73 as gnd El. 270
01717	RTE 8 SB over Steele Brook	70-120': Sand, M. Dense. At 50' becomes Dense w/ more Gravel.	Pier & Abuts: tapered CIP concrete piles (12-8" diam.) with battered outer piles	1963	Structure #18"Br. 01716" Pg 104-112Use channel as gnd El. 260
01718	RTE 8 NB over Steele Brook	80-110': Sand, M. Dense. At 60' becomes Dense w/ more Gravel.	Pier & Abuts: tapered CIP concrete piles (12-8" diam.) with battered outer piles	1963	Structure #18"Br. 01716" Pg 104-112 Use channel as gnd El. 260
01731	SR 845 Chase Parkway over I-84 & Ramp 053	5-20': S&G, li. Silt, MD to VD, over shallow ledge Rock: Gneiss with seams of Schist	Pier: footings on rock Abuts: footing on rock	1962	Structure #31 Over RTE 84 EB & WB "Br. 01731." Pg 56-65
03183A	RTE 8 NB over Fifth Street				Only inspection reports available
03183B	RTE 8 SB over Fifth Street				Only inspection reports and rehab plans available
03184A	RTE 8 NB over Porter Street				Only inspection report available
03184B	RTE 8 SB over Porter Street				Only inspection report and rehab plan available
03185	RTE 8 NB over Washington Street	60-70': Sand, MD to Dense Rock: Gneiss, 12-22% Rec.	Abuts: footing on sand	1964	Structure #30 "Br. 03189…" Pg 67-76 Washington as gnd El. 275
03186	RTE 8 SB over Washington Street	60': Sand, MD to Dense Rock: Gneiss, 55-58% Rec.	Abuts: footing on sand	1964	Structure #30 "Br. 03189…" Pg 67-76 Washington as gnd El. 275
03187	RTE 8 SB over Bank Street & S. Leonard Street	60-80': Sand & Gravel, MD to VD Rock: Gneiss, 35-60% Rec.	Piers: combined ftng on sand Abuts: footing on fill	1962	Struct #33 over Riverside "Br. 03189…" Pg 77-90 Use Bank St as gnd El. 265
03188	RTE 8 NB over Bank Street &S. Leonard Street	80': S&G, MD to VD (Nested B&Cs at 70' depth) Rock: Gneiss, 50-60% Rec.	Pier: combined ftng on fill Abuts: footing on fill	1964	Struct #29 over Riverside "Br. 03189…" Pg 57-66 Use Bank St as gnd El. 260
03189	RTE 8 Ramp 077 over Bank Street	70-80': Sand, li. Gravel, MD to VD Rock: Gneiss, 22-55% Rec.	Abuts: footing on fill	1964	Structure #34 Ramp 34 "Br. 03189…" Pg 91-101 Use Bank St as gnd El. 258
03190A	RTE 8 NB over RTE 8 SB &Local Roads	45-55': S&G, MD to Dense Rock: Gneiss w/ quartz, 30-90% Rec.	All fdns: 10BP42 & 12BP53 H-piles, outer piles battered Piers: indiv. & comb. ftngs	1964	Structure #20 RTE 8 NB & SB Use avg. gnd El. 270
03190B	RTE 8 SB over Riverside Street & Sunnyside Avenue	45-55': S&G, MD to Dense Rock: Gneiss w/ quartz, 30-90% Rec.	All fdns: 10BP42 & 12BP53 H-piles, outer piles battered Piers: indiv. & comb. ftngs	1964	Structure #20 RTE 8 NB & SB Use avg. gnd El. 270
03190C	I-84 TR 811 over I-84 TR 812& Naugatuck River	Fill: up to 15' misc. Fill w/ Cinders Natural: S&G, MD to VD Rock: 45-90' depth, Gneiss	All fdns: 12BP53 H-piles, outer piles battered Piers: indiv. & comb. ftngs	1964	Structure #11 SE & ES Roadways over Naugatuck Use avg. gnd El. 262
03190D	I-84 TR 812 over Riverside Street & Naugatuck River	Fill: up to 10' misc. Fill w/ Cinders Natural: S&G, loose to VD Rock: 60-85' depth, Gneiss	All fdns: 12BP74 H-piles, outer piles battered	1964	Structure #12 RTE 84 EB & WB Use El. 265 for gnd
03190E	RTE 8 Ramp 128 over Riverside Street SB	20-50': S&G, loose to Dense Rock: Gneiss, seam of Schist	All fdns: 10BP42 H-piles, outer piles battered	1964	Structure #16 Ramp 20 Use El. 270 for gnd
03190F	I-84 TR 808 over RTE-8 SB & RAMP 129	~5': Dense S&G over shallow rock Rock: Granite Gneiss w/ seams of Schist & Quartz, some wthrd	Abut & Piers: footings on rock Pier 9: footing on sand	1964	Structure #24 SW Roadway over Conn. 8 SB & Ramp 21
03191A	I-84 EB over I-84 WB, RTE 8 & Naugatuck River	~10': Fill w/ cinders, ashes, iron 90-120': Sand & Gravel, MD to VD	12" CIP conc. piles and 10BP42 H- piles, outer piles battered	1963	Structure #9 RTE 84 EB & WB Bi-Level East of Naugatuck River
03191B	I-84 WB over RTE 8 & Naugatuck River	~10': Fill w/ cinders, ashes, iron 90-120': Sand & Gravel, MD to VD	12" CIP conc. piles and 10BP42 H- piles, outer piles battered	1963	Structure #9RTE 84 EB & WB Bi-Level East of Naugatuck River
03191C	I-84 Ramp 169 over I-84 TR 805 & 808	5-40': S&G, li. Silt, many B&Cs, MD to VD Rock: Gneiss w/ seams of Quartz	Abuts & Piers: spread footing on soil/rock Pier 14 & 15: 10BP42 H-piles	1964	Structure #25 & #27 Ramp 25 & RTE 84 EB & WB West of Naugatuck River
03191D	I-84 TR 809 over RTE 8 NB &Riverside Street	No boring logs in plans. "N-E Roadway" borings D-56, D-225 to-230, D-216, D-205	All fdns: 10BP42 H-piles, outer piles battered	1964	Structure #22 N-E Roadway
03191E	I-84 TR 810 over RTE 8 NB &Ramp 128	No boring logs in plans. "E-N Roadway" borings D-217 to -224 and D-216-2	All fdns: 10BP42 H-piles, outer piles battered	1964	Structure #26 E-N Roadway

Bridge #	Bridge Description	Soil Profile (feet)	Existing Foundation	Existing Bridge Plan	Existing Bridge Plan Notes
03191F	I-84 Ramp 197 over Ramp 202 Meadow Street	~10': Fill w/ cinders, ashes & coal 30-90': S&G, li. Silt, MD to VD Rock: Gneiss, 40-100' depth	Abut & Piers: 10BP42 H-piles, outer piles battered	1963	Structure #10 Ramp 10 over Meadow St. & Ramp 5 Use El. 265 for gnd
03191G	I-84 Ramp 199 over Meadow Street			1963	Only inspection report and rehab plan available
03191H	I-84 Ramp 198 over No Notable Feature			1963	Only inspection report and rehab plan available
03191I	I-84 Ramp 200 over I-84 Ramps 199 & 202, Bank Street				Only inspection report and rehab plan available
03192	I-84 Ramp 202 over Bank Street	30-40': S&G, MD to Dense, B&Cs Rock: Gneiss w/ Granite, 3-67% Rec.	W. Abut: shallow footing E. Abut: shallow footing on fill	1963	Structure #5 Ramp 5 Use Bank St. as gnd @ El. 262
03193	I-84 WB over Ramp 198 & Bank Street	40-50': S&G, MD. Layers of Silt starting @20' w/ lenses of clay Rock: Gneiss, 22-87% Rec.	W. Abut & Pier: 10BP42 H-piles E. Abut: shallow footing	1963	Structure #4 over Ramp 9 Use Bank St. as gnd @ El. 270
03194	I-84 Ramp 201 over I-84 Ramp 198 & Bank Street	35-55': S&G, MD to VD Rock: Gneiss, 53-92% Rec. with nested Boulders	Pier 1: shallow footing Pier 2: 10BP42 H-piles Abuts: footing on fill	1963	Structure #7, Ramps 8, 9 Use Bank St. as gnd @ El. 275
03195	I-84 over Great Brook	No boring logs in plans	Concrete culvert on soil surrounded by pervious structure backfill	1963	Relocated Great Brook Culvert
03196	I-84 over SR 847 (South Main St.)	5-10': FILL Sand, li. Gravel, MD Natural: S&G, many B&Cs, VD Rock: Gneiss, 20-35' depth	E/W Abuts: shallow footing on fill	1963	Structure #2 RTE 8 EB & WB Use South Main St. as gnd @ El. 270
03197	South Elm St. over I-84 & Mcmahon St.	10': Sand & Silt, Medium Dense 10-15': S&G, many B&Cs, D to VD Rock: Gneiss, 20-25' depth	Piers: combined footing on natural sand Abuts: footing on sand	1963	Structure #1 over 84 EB & WB, Ramp 3 & McMahon St Use 84 EB as gnd El. 282
03198	RTE 8 NB over Freight Street	20-25': S&G, many B&C, MD to VD Rock: Gneiss & Schist, 0-72% Rec.	Piers: combined ftng on sand Abuts: footing on fill	1964	Structure #14Use Freight St as gnd @ El. 280
03199	RTE 8 over Sled Haul Brook	Sand & Gravel overlying shallow rock - Gneiss with Quartz banding	Concrete culvert on natural sand and rock	1964	NB: D-701, STA 168+20 to 168+60SB: D-236, 164+50 to 164+90
03200	I-84 TR 806 over I-84 TR808, 809, Riverside	10-50': S&G, few B&Cs, MD to VD Rock: Gneiss, shallow to south, slopes down to north	Piers: footing N. Abut: 10BP42 H-piles S. Abut: footing on fill	1964	Struct. #21 WN Roadway ovr 8- SB, NE, Riverside & R-18Use avg. gnd of El. 315
03201	Pedestrian Walk over RTE 8 SB	0-35': Sand, some Gravel, li. Silt, few B&Cs, MD to VD Rock: Gneiss w/ Quartz & Feldspar	Piers: footings on rock/soil W. Abut: footing on sand E. Abut: footing on fill	1963	Structure #37Use RTE 8 SB as gnd @ El. 330

Bridge #	Bridge Description	Soil Profile (feet)	Existing Foundation	Existing Bridge Plan	Existing Bridge Plan Notes
03202	I-84 over Welton Brook	Previously ~25' of Peat overlying firm material, Peat removed	Swamp/peat removed and replaced with 24" min. gravel for full length of culvert	1962	Welton Brook Culvert Page 78
03203A	RTE 8 NB over West Main Street No. 1	50': Sand & Gravel, MD to VD 70': Fine Sand, Dense to VD Rock @120': Gneiss, 82% Rec.	Tapered CIP piles installed 20 to 50' below abut. footing	1963	Structure #19 (Pg 113) Use W. Main St as gnd @ El. 275
03203B	RTE 8 SB over West Main Street No. 1	50': Sand & Gravel, MD to VD 70': Fine Sand, Dense to VD Rock @120': Gneiss, 72% Rec.	Tapered CIP piles installed 20 to 50' below abut. footing	1963	Structure #19 (Pg 113) Use W. Main St as gnd @ El. 275
03203C	RTE 8 Ramp 131 over West Main Street No. 1	80': Sand & Gravel, MD to VD 50': Fine Sand, Dense to VD Rock @130': Gneiss, 72% Rec.	Tapered CIP piles installed 20 to 50' below abut. footing	1963	Structure #19 (Pg 113) Use W. Main St as gnd @ El. 275
03204	RTE 64 EB/ I-84 Ramp over I-84	Sand & Clayey Silt & decomposed rock overlying shallow ledge Rock: Gneiss, 10-95% Rec.	Piers: footings on rock Abuts: footing on sand	1962	Structure #32 Ramp 32 over RTE 84 EB & WB Use El. 485 for 84 EB/WB
03205	RTE 8 SB over Riverside Street	Sand & Gravel w/ B&Cs overlying shallow rock - Gneiss w/ Quartz	N/S Abuts: footing on rock Long Wingwalls: on rock	1964	Structure #13 RTE 8 SB, NE & NW Roadway over Riv. Use Riv St as gnd El. 305
03206	I-84 EB over Sled Haul Brook	10': Sand, li. Gravel, MD to VD, cobbles above top of rock Rock: Gneiss, 52% Rec.	Concrete culvert on rock surrounded by pervious structure backfill	1964	Relocated Sled Haul Brook Boring D-702
03207	Highl & Ave over I-84	At E. Abut: Sand & Silt, li. Gravel, few B&Cs, VD Rock: Gneiss & seam of Schist	Piers: indiv. footings on rock W. Abut: footing on rock E. Abut: footing on Sand	1964	Structure #23 Use 84 EB as gnd @ El. 412
03208	I-84 WB over Sled Haul Brook	30': S&G, Dense, many Boulders Rock: ~5' decomposed rock over Gneiss with 67% Rec.	Concrete culvert on rock surrounded by pervious structure backfill	1964	Relocated Sled Haul Brook Boring D-286-1
03209	I-84 EB TR 806 over I-84 WB	30-40': S&G, many B&C, VD@S. Abut: hard clayey Silt El. 375 Rock: Gneiss & Schist, 15-100%	Abuts: shallow footing on natural sand, SW wingwall partially on rock	1964	Structure #15 WN Roadway over RTE 84 WB Boring D-280-1
03296	RTE 8 NB over Dye Shop Brook	12" Gravel Fill installed below culvert, no other subsurface info available	Concrete culvert on gravel fill	1963	Dye Shop Brook Culvert Pg 151-154
03297	RTE 8 SB over Dye Shop Brook	12" Gravel Fill installed below culvert, no subsurface info available	Concrete culvert on gravel fill	1963	Dye Shop Brook Culvert Pg 151-154
04166	Freight Street over Naugatuck River				Only inspection reports available

Bridge #	Bridge Description	Soil Profile (feet)	Existing Foundation	Existing Bridge Plan	Existing Bridge Plan Notes
04234R	Torrington Secondary over Freight Street				Only inspection reports available
04318	Baldwin Street #1 over I-84, Ramps & Local Roads	Sand, li. Gravel, MD to VD Rock: Gneiss & Schist, jointed & fractured, 10-40' depth	Piers: combined ftng on HP 10x57 H-piles Abuts: HP 10x57 H-piles	1967 / 1976 Reconstruct	Structure No. 151-112-1 Use El. 300 for gnd
04319A	I-84, Ramps & Local Roads over Mad River	S&G, MD to VD, many B&Cs Rock: Gneiss 10-15' below ftngs, jointed, some weathering	Concrete culvert on natural soil	1976 Reconstruct	Structure No. 151-112-2Borings B-16, 18, 19, 22, 23Use El. 275 for gnd
04319B	I-84, Ramp, EB Coll over No Notable Feature	S&G, MD to VD, many B&Cs Rock: Gneiss 10-15' below culvert, jointed, some weathering	Abuts: footing on fill	1976	Structure No. 151-112-2Borings B-16, 18, 19, 22, 23Use El. 275 for gnd
04320A	I-84 EB over Washington Street	Sand & Gravel, many B&Cs, MD to VD, no cored rock	Abuts: shallow footing on natural soil and fill	1976	Structure No. 151-112-4 Borings B-52 and B-64 Use El. 365 for gnd
04320B	I-84 WB over Washington Street	Sand, li. Gravel & Silt, many B&Cs Rock: Gneiss at 15-30' depth, highly fractured & weathered	Abuts: shallow footing on natural soil and fill	1976 Reconstruct	Structure No. 151-112-3Borings B-50, 51, 65, 66 Use El. 365 for gnd
04320C	I-84 EB Collector over Washington	S&G, li. Silt, few B&Cs, D to VD Rock: Gneiss & Schist at 10-30' depth, fractured and weathered	Abuts: shallow footing on natural soil and fill. Wingwall 5B on rock	1976 Reconstruct	Structure No. 151-112-5Borings B-52, 53, 62, 63 Use El. 365 for gnd
04321	RTE 69 over I-84	No borings done, existing plans are widening of RTE 69 (Hamilton Avenue) bridge	Abuts/Pier: appear to be shallow footings with no H-piles, should confirm	1976	Route 84 Under Hamilton Avenue Widening

5 Summary of Findings

This section summarizes the needs and deficiencies identified in the analysis.

5.1 EXISTING AND FUTURE TRAFFIC OPERATIONS

Section 2.3 Existing Traffic Operations and **Section 3.4 Future Traffic Operations** summarized existing and forecasted future traffic operations for freeway facilities and local intersections within the study area. A summarization and comparison of the findings and deficiencies identified in those sections that follow

Interstate 84

Table 5-1 below summarizes the deficient freeway segments as analyzed by HCS along Interstate 84 under 2017 and 2045 conditions:

Table 5-1 2017 and 2045 Deficient I-84 Freeway Segments

Segment Type	# of Segments	# of Deficient Segments					
		2017			2045 No Build		
		AM Peak	PM Peak	SAT Peak	AM Peak	PM Peak	SAT Peak
WESTBOUND							
Mainline	7	1 (14%)	1 (14%)	-	1 (14%)	2 (29%)	1 (14%)
Weave	6	-	-	-	1 (17%)	1 (17%)	-
Ramp / Diverge	5	2 (40%)	1 (20%)	-	3 (60%)	3 (60%)	3 (60%)
EASTBOUND							
Mainline	5	-	-	-	-	1 (20%)	1 (20%)
Weave	6	-	-	-	4 (67%)	3 (50%)	-
Ramp / Diverge	4	-	-	-	1 (25%)	2 (50%)	2 (50%)

The Existing Condition Traffic Simulation Model (VISSIM) also identified deficient facilities along Interstate 84 based on the interaction of freeway facilities as a system. Overall, 2017 Interstate 84 deficient segments include:

Eastbound

- Western study limit to Exit 20 Route 8 On-Ramp (VISSIM)

Westbound

- Mainline east of Exit 22 Off-Ramp (HCS)
- Exit 22 Off-Ramp (HCS)
- Exit 17 Off-Ramp (HCS)

The Future Condition Traffic Simulation Model identified additional deficient facilities along Interstate 84 based on the interaction of freeway facilities as a system. Overall, 2045 Interstate 84 deficient segments include:

Eastbound

- West of Exit 18 On-Ramp (HCS & VISSIM)
- Exit 18 On-Ramp to Exit 19 Route 8 SB On-Ramp (VISSIM)
- Exit 19 On-Ramp and Exit 22 Off-Ramp (HCS & VISSIM)

Westbound

- Eastern study limit to Exit 20 Route 8 NB Off-Ramp (VISSIM)
- Exit 22 On-Ramp to Exit 21 Off-Ramp (HCS)
- Between Exit 21 Off-Ramp and Exit 21 On-Ramp (HCS)
- Exit 19 Off-Ramp to Exit 20 Off-Ramp (HCS)
- Exit 19 Route 8 SB On-Ramp to Exit 18 Off-Ramp (HCS)
- Exit 18 On-Ramp to Exit 17 Off-Ramp (HCS)

Route 8

Table 5-2 summarizes the deficient freeway segments as analyzed by HCS along Route 8 under 2017 and 2045 conditions.

Table 5-2 2017 and 2045 Deficient Route 8 Freeway Segments

Segment Type	# of Segments	# of Deficient Segments			
		2017		2045 No Build	
		AM Peak	PM Peak	AM Peak	PM Peak
NORTHBOUND					
Mainline	4	-	-	-	-
Weave	4	-	-	-	-
Ramp / Diverge	3	-	-	-	-
SOUTHBOUND					
Mainline	6	-	-	-	-
Weave	2	-	-	2 (100%)	-
Ramp / Diverge	4	-	-	-	-

The Future Condition Traffic Simulation Model also identified deficient facilities along Route 8 based on the interaction of freeway facilities as a system. Overall, 2045 Route 8 deficient segments include:

Northbound

- Southern study extent to Exit 31 I-84 EB Off-Ramp (VISSIM)

Southbound

- Exit 35 On-Ramp to Exit 34 Off-Ramp (HCS)
- Exit 33 I-84 WB On-Ramp to Exit 30 Off-Ramp (HCS & VISSIM)

Intersection Operations

- In the Year 2017, eight (8) intersections operate at a LOS E or F, all in the PM peak hour
- In the Year 2045, sixteen (16) during the PM peak hour operate at a LOS E or F and six (6) operate at a LOS E or F during the AM peak hour. Four (4) intersections operate at a LOS E or F for the AM and PM peak hour. These intersections are:
  - West Main Street at Park Road and Interstate 84 Westbound Off Ramp (Exit 18)
  - West Main Street at Highland Avenue and Private Drive
  - West Main Street at Watertown Avenue and CT Route 8 Southbound Off Ramp (Exit 34)
  - South Main Street at Union Street and Grand Street

5.2 ROADWAY GEOMETRICS

Interstate 84

Based on the controlling design criteria, geometric deficiencies identified at least once along Interstate 84 within the study area include:

- Design speed below design standard
- Shoulder width below design standard
- Auxiliary lane width below design standard
- Minimum horizontal radius below design standard
- K value crest and sag below design standard
- Maximum vertical grade above design standard
- Stopping sight distance below design standard
- Travel lane and shoulder cross slope below design standard
- Superelevation above design standard
- Vertical clearance below design standard

Based on operational factors, geometric deficiencies identified along Interstate 84 within the study area include:

- Interchange spacing for several ramps are below design standard
- Two left hand ramps on Interstate 84 Eastbound. Two on-ramps can cross two through lanes to reach the left-hand off-ramps.
- Three left-hand ramps on Interstate 84 Westbound. One on-ramp can cross three through lanes to reach one of the right-hand off-ramps.
- The Interstate 84 Eastbound auxiliary lane that exists between the Route 8 Northbound on-ramp (TR 811) and the Exit 21 off-ramp has a very short weave distance.

Route 8

Based on the controlling design criteria, geometric deficiencies identified at least once along Route 8 within the study area include:

- Shoulder width below design standard
- Compound curvature ratio above design standard
- K value sag below design standard
- Vertical clearance below design standard

Based on operational factors, geometric deficiencies identified along Interstate 84 within the study area include:

- Interchange spacing for several ramps are below design standard
- Four left-hand ramps on Route 8 Northbound
- Four left-hand ramps on Route 8 Southbound
- On Route 8 Northbound, the left lane add from the Interstate 84 Westbound on-ramp (TR 810) followed simultaneously by the left lane ramp from Interstate 84 Eastbound on-ramp (TR 806). The drivers from TR 810 may not realize this is a lane add and may be looking to merge while additional traffic is merging in on their left-hand side.
- On Route 8 Southbound, the lane striping/configuration is confusing in the vicinity of the Exit 34 off-ramp.
- On Route 8 Southbound, the extended parallel section of the Interstate 84 Westbound on-ramp (TR 812) while on structure, then terminating/merging with the center lane.

System Ramps

Based on the controlling design criteria, geometric deficiencies identified at least once along the eight existing system ramps within the study area include:

- Design speed below design standard for all existing system ramps.
- Shoulder width below design standard
- Minimum horizontal radius below design standard
- Compound curvature ratio below design standard on Exit 19.
- K value sag below design standard
- Minimum vertical grade below design standard
- Stopping sight distance below design standard
- Superelevation transition length below design standard on Exit 33.
- Vertical clearance below design standard on Exit 19.

Service Ramps

Based on the controlling design criteria, geometric deficiencies identified at least once along the existing Interstate 84 service ramps within the study area include:

- Design speed below design standard
- Shoulder width below design standard
- Auxiliary lane width below design standard on Collector Distributor Ramp 2
- Minimum horizontal radius below design standard
- Compound curvature ratio below design standard
- K value crest and sag below design standard
- Maximum vertical grade above design standard
- Minimum vertical grade below design standard
- Stopping sight distance below design standard on Exit 30 Northbound On-Ramp
- Travel lane and cross slope below design standard
- Superelevation transition length below design standard
- Vertical clearance below design standard on Exit 19 Eastbound Off-Ramp.
- Vertical clearance below design standard on Exit 19 Eastbound Off-Ramp.

Based on operational factors, geometric deficiencies identified along the existing Interstate 84 service ramps within the study area include:

- Deceleration length below design standard on Exit 18 Eastbound Off-Ramp

Based on the controlling design criteria, geometric deficiencies identified at least once along the existing Route 8 service ramps within the study area include:

- Design speed below design standard
- Travel lane width below design standard on Exit 30 Southbound Off-Ramp
- Shoulder width below design standard
- Compound curvature ratio below design standard
- K value crest and sag below design standard
- Maximum vertical grade above design standard on Exit 30 Northbound On-Ramp
- Minimum vertical grade below design standard
- Stopping sight distance below design standard
- Travel lane and cross slope below design standard
- Superelevation transition length below design standard
- Vertical clearance below design standard on Exit 35 Northbound Off-Ramp

Based on operational factors, geometric deficiencies identified along the existing Route 8 service ramps within the study area include:

- Acceleration length below design standard on Exit 32 Northbound On-Ramp
- Deceleration length below design standard on Exit 30 Northbound Off-Ramp

5.3 STRUCTURAL CONDITIONS

Overall, 10 of the 62 bridges (16%) within the study limits are categorized as poor as determined by the lowest rating of deck, superstructure, substructure, or culvert. If measured by deck area, 696,067 square feet (sf) of the overall 1,167,436 sf of deck area (60%) within the study limits is categorized as poor.

7 of the 62 bridges (11%) within the study limits are categorized as having poor decks. If measured by deck area, 60% of the decks are categorized as poor.

8 of the 62 bridges (13%) within the study limits are categorized as having poor superstructures. If measured by deck area, 60% of the superstructures are categorized as poor.

6 of the 62 bridges (10%) within the study limits are categorized as having poor substructures. If measured by deck area, 51% of the substructures are categorized as poor.

In the year 2045 (assuming the "no build" condition):

- Mainline Structures will remain stacked: Interstate 84 approximately 2,455 feet of the westbound bridge under the eastbound bridge, Route 8 approximately 1,400 feet of the southbound bridge under the northbound bridge. There are ongoing safety concerns associated with these stacked structures.
- Non-redundant, fracture critical spans will remain on the Route 8 and I-84 mainline bridges. These fracture critical spans have fatigue prone connections that continue to crack and deteriorate.
- The majority of the concrete decks on I-84 as well as steel members and the substructures will be 80 years old. Preservation or rehabilitation projects will by necessity become increasing frequent to maintain the condition of these bridges. These preservation/rehabilitation efforts will become less effective and more costly as the bridges continue to age.

5.4 SAFETY CRASH ANALYSIS

Interstate 84

The contributing circumstances for crashes on Interstate 84 Eastbound were congestion (80%) and geometry and driving behavior related factors (20%). On Interstate 84 Westbound the contributing circumstances were congestion (60%) and geometry and driving behavior related factors (40%). This leads to the following conclusions:

Eastbound

West of the interchange area, the predominant influence on crashes is attributed to congestion. The steep uphill grade approaching the study area has a climbing lane to provide relief from slower moving vehicles. Nonetheless, this grade contributes to a lower overall travel speed and congested conditions.

- Immediately west of and through the core of the interchange area, some crashes may be influenced by curvature, grades and short spacing between ramps. However, the primary influence is attributed to congestion and queuing of traffic to the east, which backs up into the study area and impacts the operation of this freeway segment with close interchange spacing and multiple lane drops.
- East of the interchange area, crashes are predominantly attributed to congestion, although other influences are seen more frequently, suggesting that difficult geometry entering the construction zone, driver impatience, difficult merges and unexpected, sudden traffic slowdown may all contribute to the crashes in this area.

Westbound

- East of the interchange core, crash history indicates that the predominant influence on crashes is attributed to the westbound congestion leading to the Route 8 ramps.
- West of the interchange core, Interstate 84 crashes are also influenced primarily by congestion;
- A relatively high percentage of "other" causes, such as driver inattentiveness, objects in the road, weather, and speeding could be influenced, in part, by the return to an open freeway after passing through the construction area or attributed to the unusual roadway features in the core interchange.

Route 8

The contributing circumstances for crashes on Route 8 Northbound are road geometry and driver behavior related factors (64%) and traffic congestion (36%). On Route 8 Southbound. the contributing circumstances are traffic congestion (56%), and geometry and driver behavior related factors (44%). This leads to the following conclusions:

Northbound

- South of the interchange core, congestion levels appear to be low. As traffic approaches the interchange, speeds are reduced as congestion increases, and the influences of ramps merging and diverging are noticed. The mix of contributing factors begins to shift to a higher percentage of congestion related crashes closer to the interchange core.
- Route 8 Northbound through the core area exhibits a crash pattern that is more evenly distributed between contributing factors. This is likely attributed to the lower congestion levels, and is influenced by the multiple merges, diverges, lane drops, and weaves through the interchange core.
- North of the interchange, Route 8 Northbound has a mix of influencing factors, with congestion being less of an influence as speeds increase and geometric issues, such as weaves, become less common.

Southbound

- Route 8 Southbound enters the study area at a merge with Route 73, where Route 73 simultaneously merges from 2 lanes to 1 lane. There is a major weave across the Route 8 Southbound operational lanes, as the freeway approaches the core area. Crash history in this area shows a fairly even split between contributing factors.
- Approaching the core interchange, the influence of geometric issues, such as multiple merging and diverging ramps, lane drops, lane additions and weaves, becomes apparent, although the influence of congestion is significant. It is likely that these weaving and lane change maneuvers, which occur on a short highway segment, are influenced by queues and congestion, which shorten the available maneuvering room, and force merges to occur in more restricted areas.
- South of the core interchange, highest crash numbers are influenced by the multiple ramps, poor weaving geometry and congestion. It is also likely that the very long acceleration lane from the Interstate 84 Westbound ramp causes merging issues, because it functions more like a lane drop than an acceleration lane.

System Ramps

The primary contributing circumstances for crashes on interchange ramps were road geometry (50%) and driver behavior related factors (27%). Traffic congestion contributed to 22% of crashes. This leads to the following conclusions:

- The Interstate 84 Westbound exit ramp to Route 8 Southbound (TR812) exhibits a crash history that is influenced by congestion and a mix of other factors. The geometry of this left-hand exit does not appear to be a significant factor. Other than improved operations that would result from a reduction in congestion, the crash rates do not show a significant pattern.
- The Route 8 Northbound exit to Interstate 84 Eastbound (TR811) shows a strong influence by the poor ramp geometrics. The tightening, sharp curve catches drivers unaware and they lose control on the ramp. This is further influenced by poor weather conditions.

Intersections

Of the 65 intersections analyzed within the study area, 36 (55%) were found to be high crash locations, indicating that the intersection had more than 15 crashes and a ratio of actual crashes to the intersection's critical crash rate was equal to or over 1.00.

Bicyclists and Pedestrians

Within the study area, a total of 27 pedestrian crashes and 3 cyclist collisions were identified.

5.5 TRANSIT AND RAIL

The Waterbury area has a robust fixed-route transit network including local bus services; regularly scheduled intercity services; and paratransit and dial-a-ride services. The area is further serviced by CTtransit express bus and CTfastrak service between Hartford and Waterbury, and between New Haven and Waterbury. In addition, the Metro North Waterbury Branch Line provides commuter rail service from Waterbury to Bridgeport for rail connections to the New Haven Line and Grand Central Terminal in New York. While the transit and rail services in the Waterbury area are extensive, there is little direct impact of these services on the day-to-day traffic of the Mixmaster. Although the transit routes in the region do operate in part, on both Interstate 84 and Route 8, they do not go through the interchange itself. Moreover, much of the traffic generated on the Mixmaster originates outside of Waterbury and therefore changes in transit dependency in the region are not likely to significantly impact traffic volumes over the Mixmaster.

5.6 KEY CONTEXT FEATURES AND CHARACTERISTICS

The local context such as natural resources, scenic, aesthetic, historic and cultural identifiers will be considered as part of an integrated design process to enhance and expand upon the unique character of the community within the study area.

Design concepts should integrate with the intent of the following local planning and development projects:

- W.A.T.E.R (Waterbury Active Transportation and Economic Resurgence) Project
- Naugatuck River Greenway
- Freight Street District
- Waterbury Next

City-wide analysis shows that:

- Environmental justice communities surround the interchange and their needs will be an important consideration during concept development.
- Most of the historical properties, cultural, and institutional resources are in downtown Waterbury.
- Naugatuck River and Mad River are two important natural resources that lack community access.

Neighborhood assessment illustrates that:

- The Central Business District (CBD) is a historic urban core and generally well-maintained. However, there are pockets of area that are underutilized and unmaintained.
- The neighborhood of South End has a mix of big box retail, light industrial, and single family residential. Some parcels and properties in the neighborhood are underutilized and vacant, and there is a prevalence of large parking lots.
- Brooklyn is highly residential, developed and well-maintained for area on the west side of Route 8. There are underutilized and vacant land east of Route 8, in the area zoned as light industrial. It is difficult to access downtown from Brooklyn.
- Overpasses, underpasses and crossings have an unsafe and uninviting character.

Existing and future primary and neighborhood generators were identified to help inform the effort to identify opportunities and develop an urban planning strategy.

- Majority of the existing generators are in the Central Business District including:
  - Metro North Railroad (MNR) Train Station
  - St. Mary's Hospital
  - University of Connecticut Waterbury Campus
  - The Palace Theater
  - Local churches, schools, and retail establishments
- Future generators currently under design or implementation include:
  - Freight Street District
  - W.A.T.E.R.
  - Former Anamet Site

5.7 BICYCLE AND PEDESTRIAN INFRASTRUCTURE

The existing bicycle and pedestrian infrastructure and activities as related to the Mixmaster were evaluated to identify opportunities to improve pedestrian and cyclist circulation and overall experience across and around Interstate 84 and Route 8.

Demographics show that the City of Waterbury has a relatively large transit dependent population with most transit activities taking place at Waterbury Green and MNR Train Station. Bicycle and pedestrian infrastructure connections from surrounding neighborhoods to major transit, cultural and institutional destinations are limited and uninviting.

A summary of current bicycle and pedestrian initiatives is shown below:

- The Connecticut Bicycle Plan and Map is currently undergoing an updating process.
- The Naugatuck River Greenway project would incorporate bicycle and pedestrian infrastructure and recommend improvements for various intersections in Waterbury.
- The W.A.T.E.R. project includes two bicycle/pedestrian initiatives: Reconstruction of Freight Street and Library Park-Train Station-Riverfront Connector.

The following ongoing projects have bicycle and pedestrian infrastructure as major components:

- Naugatuck River Greenway
- Jackson Street Reconstruction and Extension
- The Library-Train-Riverfront Connector
- Freight Street Reconstruction

A summary of the existing condition of sidewalk and crossings is listed below:

- The CBD has well-maintained sidewalks throughout much of the district.
- South End does not have strong pedestrian infrastructure; some areas are badly maintained or non-existent.
- Brooklyn and West End have some deficient sidewalks.
- Overpasses and underpasses have narrow sidewalks and lack lighting and safe crossings.

5.8 ENVIRONMENTAL CONSTRAINTS

Fourteen environmental mapping resources at the state or federal level were consulted during the desktop investigation to identify resource impacts within the existing alignment. The following was found:

- Multiple riverine, freshwater forested/shrub wetlands, and freshwater ponds were identified including Wooster Brook, Welton Brook, Sled Haul Brook, the Naugatuck River, and Mad River. Several other smaller, unnamed tributaries and wetlands or ponds also appear on the mapping. Numerous watercourses appear to be piped through culverts along the existing alignment.
- No federally listed species or critical habitats are anticipated within the existing alignment.
- Fourteen (14) birds protected by the Migratory Birds Treaty Act and the Bald and Golden Eagle Protection Act were identified.
- Two wetland soil series were mapped within the limits, including Ridgebury, Leicester, and Whitman soils (3) and Catden and Freetown Soils (18).
- Both Prime Farmland Soils and Statewide Important Farmland Soils are present. No Locally Important Farmland Soils are mapped within the existing alignment.
- No sole source aquifer is situated within nor in immediate proximity to the existing alignment.
- Present floodways associated with Wooster Brook, Naugatuck River, and the Mad River were located within the existing alignment. Wooster Brook, Welton Brook, and the Mad River also have 100-year floodplains and 500-year floodplains mapped near Wooster Brook, the Naugatuck River, and the Mad River.
- Three historically significant areas were found that are partially located within the existing alignment, including the Riverside Cemetery, a cultural resource site, and Downtown Waterbury Historic District and Hamilton Park.
- No Coastal Area Management (CAM) Zone is located within the existing alignment.
- No public water supply watershed is located within the existing alignment.
- No Aquifer Protection Area (APA) is located within the existing alignment.
- At least one mapped Natural Diversity Data Base (NDDB) area was identified within the existing alignment.
- No critical habitat is mapped within or adjacent to the existing alignment.
- Ground water quality is mapped as “GA” for the western portion of the existing alignment and “GB” for the central and eastern portion of the existing alignment.
- Wooster Brook, Welton Brook, and Sled Haul Brook are all classified as “A” surface waters. The Naugatuck River and Mad River are both classified as “B” surface waters.
- No known Northern Long-Eared Bat hibernacula or roost trees are located in or immediately adjacent to the existing alignment.
- Several areas throughout the existing alignment that appear to be wetlands or watercourses include Wooster Brook, Welton Brook, Sled Haul Brook, Tamarack Swamp, Naugatuck River and potential floodplain wetlands, Mad River and potential floodplain wetlands. A small wetland a potential vernal pool was identified in addition to a potentially isolated wetland that may also function as a vernal pool.