On-Call I-95 Construction Planning Agreement
Assignment Three

Traffic Mitigation for Selected Roadways in the New Haven Area

Study Report

June 27, 2006

Submitted to
South Central Regional Council of Governments

Submitted by
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STUDY REPORT

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Assignment Three – Traffic Mitigation for
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Overview

Urbitran is providing transportation planning and traffic engineering services to the South Central Regional Council of Governments (SCRCOG) related to ConnDOT's I-95 New Haven Harbor Crossing (NHHC) Corridor Improvement program. Urbitran is advising the SCRCOG and its member municipalities on methods for maintaining regional mobility during the associated long-term, major construction projects. This is the third assignment being performed related to the I-95 NHHC Corridor Improvement program.

The first assignment involved identifying proactive strategies for helping to maintain mobility in the region during Contracts "D" (I-95 construction in Branford) and "C" (I-95 construction from Woodward/Stiles Interchange to Lake Saltonstall Bridge) of the program. This included analyzing the maintenance and protection of traffic plans, reviewing the framework for the I-95 Construction Management Plan and its interaction with other transportation projects in the region, and identifying potential issues relating to construction on major routes that parallel I-95.

The second assignment involved developing a database of major highway and street projects in the South Central Connecticut Region and identifying which ones were relevant to the I-95 construction program. This involved the review of the list of Transportation Improvement Projects (TIP) for the Region, assessment of the highway and street projects on the list to identify which ones may be impacted by or impact on the I-95 construction program, application of the TELUS software to develop a framework for the database, conversion of the SCRCOG TIP database to a format that was consistent with TELUS, and the compilation of a status update for each of the identified projects from ConnDOT or the City of New Haven.

This memorandum presents the results of the third assignment that was performed to identify short-range actions to improve the traffic carrying capability of potential diversion routes during Contracts "B" (new Pearl Harbor Memorial Bridge) and "E" (reconfigured interchange of I-95/I-91/Route 34).

1.0 Introduction

The objective of Assignment #3 involved identifying possible temporary and/or permanent measures to help reduce/manage the transportation impacts of the Central I-95 Improvement Program (particularly Contracts B, C2 and E) and other major construction projects in the New Haven area. This assignment was a collaborative effort between South Central Regional Council of Governments (SCRCOG) and the City of New Haven – City Plan, Engineering, and Traffic & Parking departments. The tasks for this assignment involved the following steps:

- Identifying study corridors and priority intersections

- Collecting and reviewing existing transportation data
- Establishing base transportation network
- Establishing future transportation networks
- Performing sensitivity analysis
- Identifying potential bottlenecks
- Identifying improvement options
- Documenting and presenting findings

During the next 5 to 10 years, there will be traffic diversions in the New Haven area resulting from the I-95 improvements and other major roadway and bridge projects. Based on discussions with SCRCOG and New Haven staff, a sensitivity analysis was performed on selected, potential alternate/diversion routes to identify how much additional traffic could be accommodated and what short-term mitigation may be needed. The sensitivity analysis was performed for the weekday AM and PM peak hours, focusing on traffic traveling towards downtown New Haven in the AM peak and traffic traveling away from downtown New Haven in the PM peak within the study area. As shown in Figure 1, the study area limits generally include Quinnipiac Avenue to the east, State Street to the west, Middletown Avenue / Foxon Boulevard (Route 80) to the north and US Route 1 (US1) (Water Street / Forbes Avenue) to the south. The process is outlined in the flowchart shown in Figure 2.

The sensitivity analysis involved applying an incremental traffic growth to critical intersections (entrance and exit portals) along selected corridors where potential diversion may occur. SYNCHRO (Version 6) was used to reallocate traffic signal timing, determine offsets, and perform capacity analysis to identify the impact of the incremental growth on selected corridors in the New Haven area. SYNCHRO also was used to identify locations that may not operate as well as projected as a result of the backup of queued vehicles exceeding the storage length available.

This draft memorandum presents the results for four study corridors.

2.0 Areas of Focus in Study Area

The following study corridors were identified for further analysis and evaluation within the study area limits:

- US1 Corridor - Forbes Avenue from East Haven / New Haven town line to Water Street at Union Avenue / State Street
- Middletown Avenue / State Street Corridor from I-91 Exit 8 Interchange to Water Street
- Grand Avenue Corridor from Quinnipiac Avenue to State Street
- Chapel Street Corridor from Quinnipiac Avenue to State Street

The priority signalized intersections that were included in the analyses of these corridors are shown in Figure 3.

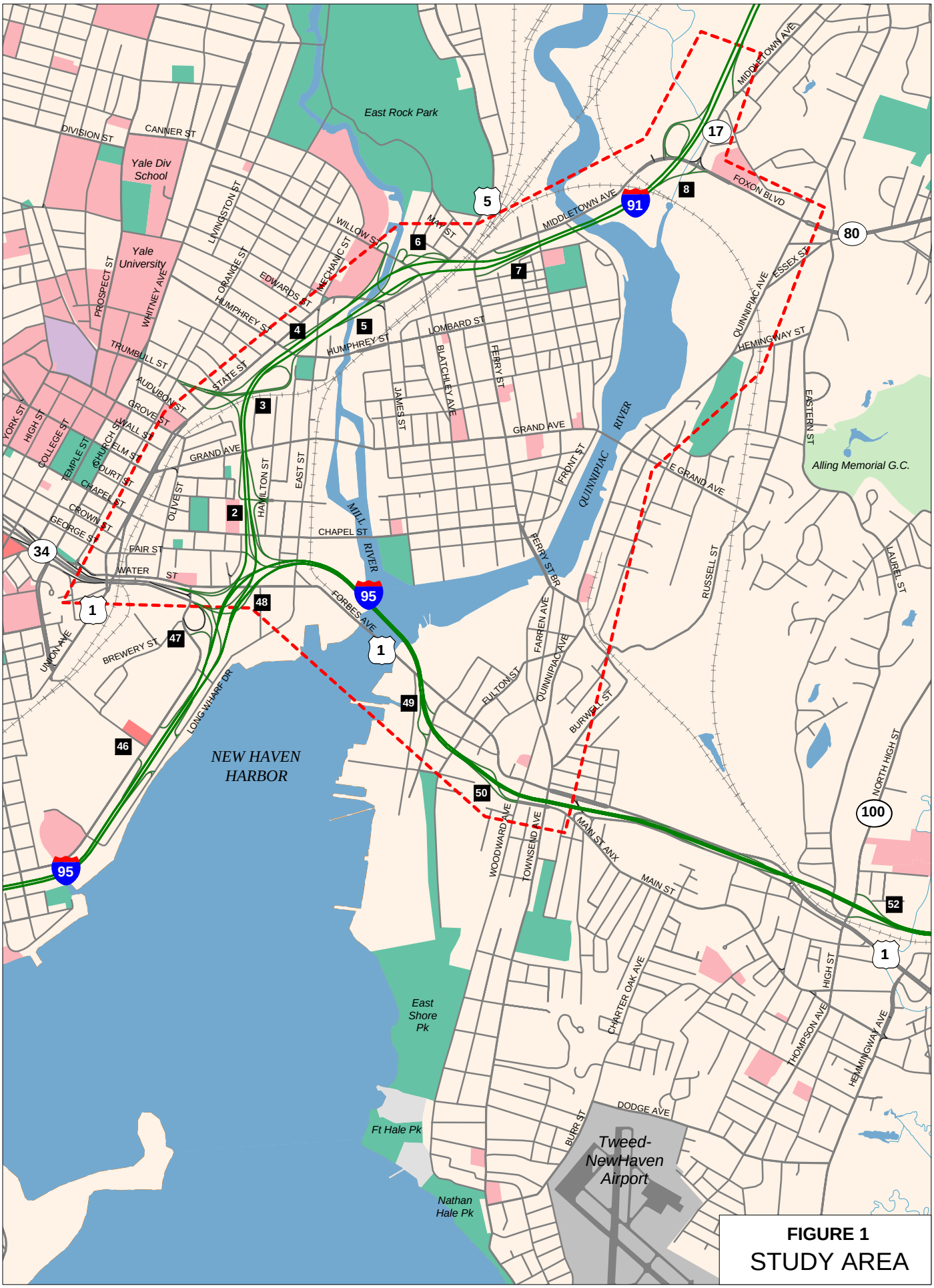
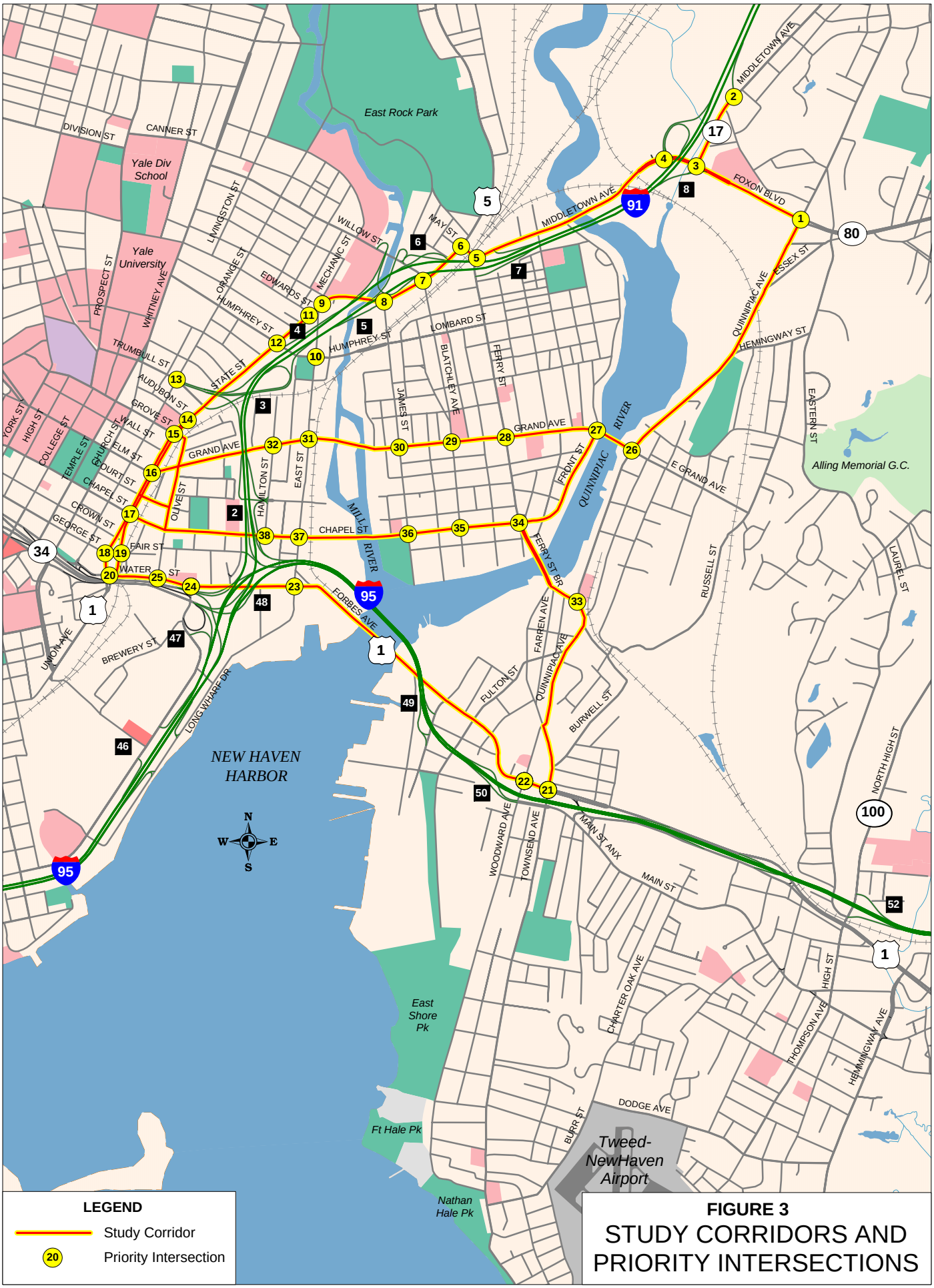


FIGURE 1

STUDY AREA

Figure 2 - Approach for Evaluating Future Transportation Scenarios


East Rock Park
Yale Div School
Yale University
DIVISION ST
CANNER ST
PROSPECT ST
WHITNEY AVE
LIVINGSTON ST
ORANGE ST
EDWARDS ST
MECHANIC ST
WILLOW ST
MAY ST
MIDDLETOWN AVE
FOXON BLVD
ESSEX ST
QUINNIPIAC AVE
HEMINGWAY ST
LOMBARD ST
HUMPHREY ST
TRUMBULL ST
AUDUBON ST
GROVE ST
STATE ST
YORK ST
HIGH ST
COLLEGE ST
TEMPLE ST
CHURCH ST
WALL ST
ELM ST
COURT ST
CHAPEL ST
CROWN ST
GEORGE ST
GRAND AVE
OLIVE ST
HAMILTON ST
EAST ST
JAMES ST
BLATCHLEY AVE
FERRY ST
FRONT ST
QUINNIPIAC RIVER
E GRAND AVE
EASTERN ST
Alling Memorial G.C.
MILL RIVER
FAIR ST
WATER ST
FORBES AVE
FERRY ST BR
FARREN AVE
QUINNIPIAC AVE
RUSSELL ST
LAUREL ST
UNION AVE
BREWERY ST
LONG WHARF DR
NEW HAVEN HARBOR
FULTON ST
BURWELL ST
WOODWARD AVE
TOWNSEND AVE
MAIN ST ANX
MAIN ST
NORTH HIGH ST
CHARTER OAK AVE
HIGH ST
THOMPSON AVE
HEMMINGWAY AVE
DODGE AVE
BURR ST
East Shore Pk
Ft Hale Pk
Nathan Hale Pk
Tweed-NewHaven Airport
N
W
E
S
LEGEND
Study Corridor
Priority Intersection
FIGURE 3
STUDY CORRIDORS AND PRIORITY INTERSECTIONS

3.0 Existing Conditions

The SYNCHRO traffic network developed for the City of New Haven as part of the 1999 Computerized Signal System Project was used as a basis in the development of the existing and future traffic networks for this assignment. Existing traffic data was obtained from SCRCOG, City of New Haven and ConnDOT to expand upon and establish baseline transportation conditions and to assess and evaluate future transportation conditions for this assignment. The locations for which traffic data were compiled are identified in the appendix at the end of this document.

Official signal timing was obtained from the City of New Haven and from ConnDOT. For the US1 corridor, field visits were conducted to verify signal timing. Differences that were noted in the field were reflected in the corridor analysis. However, for other corridors the signal timing provided was used in the analysis. Schedule and budget constraints did not allow for field verification.

4.0 Programmed and Planned Roadway and Bridge Improvement Projects in the New Haven Area

Over the next 5 to 10 years, several major, planned and programmed, roadway and bridge improvement projects are scheduled for construction in the New Haven area. These projects, when completed, may improve operation on the study area transportation network or, if under construction in the future analysis year, could result in traffic diversion or reduced capacity. The future transportation scenarios for 2008 and 2012 considered the following roadway and bridge projects:

- Ferry Street Bridge over the Quinnipiac River
- Grand Avenue Bridge over AMTRAK
- State Street Bridge over the Mill River
- Quinnipiac Avenue Reconstruction
- I-91 Exit 8 Interchange Redesign
- I-95 Contract C2
- I-95 Contract B
- I-95 Contract E
- I-95 Bridge over West River
- I-95 (Long Wharf): I-91 - Howard Avenue

Table 1 provides a brief description of each project including the anticipated construction schedule and the source of the information. Data sources included SCRCOG, City of New Haven, ConnDOT and RIDEWORKS. It appears that most of the improvement projects will be in various stages of construction between 2005 and 2014.

TABLE 1
Roadway and Bridge Improvement Projects in the New Haven Area as of March, 2006

Project Nos.		Project Name	Project Description	Traffic Operations	Estimated Construction Schedule		Analysis Years		Source
State	City				Start	End	2008	2012	
92-582	03-104-01	Ferry Street Bridge over Quinnipiac River	▪ Rehabilitation of Ferry Street Bridge	▪ Full Closure during construction period. ▪ During Quinnipiac Avenue reconstruction, the Ferry Street Bridge is expected to be open (or partially open) to traffic while any remaining bridge work is being completed.	06/2006	09/2008	▪ Construction near completion	▪ Project completed	▪ City of New Haven (Engineering)
92-412	97-185-01	Grand Avenue Bridge over AMTRAK	▪ Replacement of Grand Avenue Bridge	▪ Full Closure during construction period.	09/2006	12/2009	▪ Construction underway	▪ Project completed	▪ City of New Haven (Engineering)
92-585	99-198-01	State Street Bridge over the Mill River	▪ Replacement of State Street Bridge	▪ Full Closure during construction period. ▪ Replacement of the State Street Bridge is expected to begin after the Ferry Street Bridge rehabilitation; unless the State Street Bridge is determined, by the City, to be in bad condition (beyond any corrective repairs). In this case, the construction schedule will overlap with the Ferry Street Bridge rehabilitation.	01/2009	12/ 2010	▪ Construction not started	▪ Project completed	▪ City of New Haven (Engineering)
92-533	99-195-01	Quinnipiac Avenue Reconstruction	▪ Reconstruction of Quinnipiac Avenue from Fulton Street to Clifton Street ▪ Reconfiguration of Quinnipiac Avenue/Ferry Street intersection to provide roundabout	▪ Existing traffic operations will be maintained on Quinnipiac Avenue	09/2007	09/2009	▪ Construction underway	▪ Project completed	▪ City of New Haven (Engineering)
92-456	N/A	I-91 Exit 8 Interchange Redesign	▪ Reconfiguration of I-91 NB Exit Ramp	▪ Not available.	01/2009	12/2011	▪ Construction not started	▪ Project completed	▪ ConnDOT (Project Engineer)
92-533 92-569	99-195-01	I-95 Contract C2 Expansion of I-95 in New Haven	▪ Widening of I-95 between the frontage roads and Woodward Avenue with four lanes and full inside and outside shoulders in each direction. ▪ Replacement of the Woodward, Townsend and Forbes Avenue bridges. ▪ Construction of a new Woodward/Stiles interchange that will be accessible from a connector road originating at Waterfront Street and extending to the Fulton Terrace on-ramp. ▪ Replacement of the Fulton Terrace Bridge. ▪ Installation of a masonry noise wall near Allen Place along the I-95 Northbound off-ramp to Woodward Avenue.	▪ Existing traffic operations will be maintained on I-95 Northbound and I-95 Southbound on Mondays through Thursdays between 6AM and 10AM and between 2PM and 6PM; Fridays between 6AM and 7PM; Saturdays between 10AM and 6PM; and Sundays between 12PM and 6PM. ▪ Existing traffic operations will be maintained on I-95 Northbound and I-95 Southbound during all summer weekends (between Memorial Day and Labor Day) beginning 12:01PM on Fridays and ending 12:01AM on Mondays.	09/2005	06/2009	▪ Construction underway	▪ Project completed	▪ I-95 Improvement Program Website (www.i95newhaven.com)

TABLE 1 (CONT'D)
Roadway and Bridge Improvement Projects in the New Haven Area as of March, 2006

Project Nos.		Project Name	Project Description	Traffic Operations	Estimated Construction Schedule		Analysis Years		Source
State	City				Start	End	2008	2012	
	99-195-01	I-95 Contract B Pearl Harbor Memorial Bridge	▪ Replacement of the existing Pearl Harbor Memorial (Q) Bridge with a new, 10-lane signature bridge. ▪ Construction of five travel lanes in each direction from the bridge's west approach to a reconfigured/combined Woodward Avenue/Stiles Street interchange at the east approach. ▪ Closing of the existing Stiles Street on-ramps and off-ramps. ▪ Replacement of the Stiles Street Bridge.	▪ Existing traffic operations will be maintained on I-95 Northbound and I-95 Southbound on Mondays through Thursdays between 6AM and 10AM and between 2PM and 6PM; Fridays between 6AM and 7PM; Saturdays between 10AM and 6PM; and Sundays between 12PM and 6PM. ▪ Existing traffic operations will be maintained on I-95 Northbound and I-95 Southbound during all summer weekends (between Memorial Day and Labor Day) beginning 12:01PM on Fridays and ending 12:01AM on Mondays.	05/2007	11/2014	▪ Construction underway	▪ Construction underway	▪ I-95 Improvement Program Website (www.i95newhaven.com)
92-531	00-165-01	I-95 Contract E Redesign of I-95/I-91/Route 34 Interchange	▪ Reconfiguration of the I-95/I-91/Route 34 interchange in New Haven to accommodate lanes from the new Pearl Harbor Memorial Bridge and improve interstate-to-interstate travel. ▪ Reconstruction to occur along I-95 between Sargent Drive/Long Wharf Drive and East Street and on I-91 between Ivy Place and Route 34. ▪ Elimination of left-turn lane on-ramps and off-ramps; two-lane connections will be provided for I-91. ▪ On I-95, construction of three through travel lanes will full inside and outside shoulders and a new median barrier. ▪ Replacement of 18 bridges, including: o I-91 over Chapel Street o I-91 over the Wooster Street on-ramp to I-95 Northbound o Multiple crossing over Water Street o Route 34 Westbound over Brewery Street o I-95 over Canal Dock Road ▪ Removal of loop ramps near the Sargent Drive/Brewery Street intersection. ▪ Realignment of Sargent Drive between Canal Dock Road and Brewery Street. ▪ Widening of Water Street from East Street to Brewery Street. ▪ Retention of the Wooster Street on-ramp to I-95 Northbound.	▪ Existing traffic operations will be maintained on I-95 Northbound and I-95 Southbound on Mondays through Thursdays between 6AM and 10AM and between 2PM and 6PM; Fridays between 6AM and 7PM; Saturdays between 10AM and 6PM; and Sundays between 12PM and 6PM. ▪ Existing traffic operations will be maintained on I-95 Northbound and I-95 Southbound during all summer weekends (between Memorial Day and Labor Day) beginning 12:01PM on Fridays and ending 12:01AM on Mondays.	01/2009	11/2014	▪ Construction not started	▪ Construction underway	▪ I-95 Improvement Program Website (www.i95newhaven.com)

TABLE 1 (CONT'D)
Roadway and Bridge Improvement Projects in the New Haven Area as of March, 2006

Project Nos.		Project Name	Project Description	Traffic Operations	Estimated Construction Schedule		Analysis Years		Source
State	City				Start	End	2008	2012	
92-522	N/A	I-95 Bridge over West River	▪ Rebuilding and widening of West River Bridge over the West River, Kimberly Avenue and Ella Grasso Blvd. ▪ Consolidation of Exit 44 and Exit 45 on I-95	▪ Not available.	01/2009	12/2010	▪ Construction not started	▪ Project completed	▪ Rideworks ▪ New Haven Construction Projects, 05.25.05
92-572	N/A	I-95 (Long Wharf): I-91 to Howard Avenue	▪ Widening of I-95 from six to eight lanes between I-91/Route 34 interchange and Howard Avenue ▪ Restore shoreline - New Haven Harbor access improvements (alternative not selected)	▪ Not available.	01/2010	12/2012	▪ Construction not started	▪ Construction near completion	▪ SCRCOG ▪ FY05-FY09 TIP, 11/16/05

5.0 Existing and Future Transportation Networks

5.1 Existing Transportation Network

The existing base transportation network represents "typical" weekday AM and PM peak-hour traffic conditions in the year 2005. It reflects conditions with the Ferry Street Bridge over the Quinnipiac River closed to vehicular traffic. This bridge has been closed to traffic since late-2002. Repairs to the Ferry Street Bridge are expected to begin in spring 2006. (The bridge is expected to remain closed to vehicular traffic through late 2008.) Since the traffic data for a number of the analysis intersections are from 1999, with the Ferry Street Bridge open, some adjustments to the volumes were made to represent the existing conditions with the bridge closed. The weekday AM and PM peak-hour traffic volumes for the existing 2005 base condition are included in the appendix.

5.2 Future Analysis Years and Transportation Networks

Based on discussions with SCRCOG and the City of New Haven, two future analysis years were selected – 2008 and 2012. The year 2008 was selected as a future analysis year since the I-95 Improvement Program, specifically Contracts B and C2, will continue to be under various stages of construction. In addition, several roadway and bridge improvement projects in the New Haven area will also be underway, notably Ferry Street Bridge over Quinnipiac River, Grand Avenue Bridge over Amtrak, and Quinnipiac Avenue from Fulton Street and Clifton Street. The year 2012 was selected as a future analysis year since the construction on I-95 Contract B and Contract E will be on-going, as well as I-95 (Long Wharf Section) from I-91 to Howard Avenue.

The development of the future transportation networks for the future analysis years of 2008 and 2012 is described below. These networks were used as the bases for the analysis of future conditions for the weekday AM and PM peak-hour traffic conditions.

5.2.1 2008 Analysis Year

As noted above, the future base network for 2008 will represent conditions with the following roadway and bridge projects in the New Haven areas under construction:

- Ferry Street Bridge over Quinnipiac River
- Grand Avenue Bridge over Amtrak
- Quinnipiac Avenue Reconstruction from Fulton Street to Clifton Street

The existing AM and PM peak-hour traffic volumes, which represent 2005 conditions with Ferry Street Bridge closed, were projected to the 2008 future analysis year using a growth factor of one percent per year. This growth rate was established for this study in conjunction with SCRCOG and the City of New Haven. The development of the 2008 traffic volumes took into account the following:

1. In future analysis year 2008, the Grand Avenue Bridge over Amtrak also will be fully-closed to vehicular traffic while the bridge is being replaced. Alternate travel routes to and from the City of New Haven and Fair Haven will be used during the construction period. The diversion assumptions are included in the appendix at the end of this document.

2. It is expected that some traffic disruptions will occur periodically during the reconstruction of Quinnipiac Avenue. However, full closures are not anticipated to occur during peak periods. Therefore, in developing the 2008 traffic volumes, it was assumed that traffic patterns would remain relatively unchanged. As a result, no traffic diversions based on the Quinnipiac Avenue construction were reflected in future analysis year 2008.

The weekday AM and PM peak-hour traffic volumes for future analysis year 2008 are included in the appendix.

5.2.2 2012 Analysis Year

The future base network for 2012 represents conditions with construction completed on the Ferry Street Bridge, Grand Avenue Bridge, and Quinnipiac Avenue. In addition to these projects, the following roadway and bridge improvement projects were identified as being completed between 2009 and 2011:

- State Street Bridge over Mill River
- I-91 Exit 8 Interchange at Middletown Avenue / Foxon Boulevard (Route 80) / Route 17
- I-95 Improvement Program Contract C2
- I-95 Bridge over West River

The future transportation network for analysis year 2012 reflects the reopening of the Ferry Street Bridge over the Quinnipiac River and the Grand Avenue Bridge over Amtrak as well as the other improvement projects completed or under construction up to 2012. As a result, traffic reassignments were done to reflect traffic network changes. The development of the 2012 traffic volumes took into account the following:

1. For purposes of projecting 2012 traffic volumes, the 2005 volumes had to be adjusted to estimate the impact of the reopening of the Ferry Street Bridge. The reassignment assumptions are included in the appendix.

2. The resultant AM and PM peak-hour, adjusted 2005 traffic volumes were then projected to the 2012 future analysis year using a growth factor of one percent per year.

3. The 2012 traffic network was modified further to reflect the reopening of the Grand Avenue Bridge over Amtrak. This was accomplished by reassigning the Grand Avenue Bridge volumes diverted in the 2008 analysis year.

4. Other network modifications were made to reflect projects completed or under construction.

The weekday AM and PM peak-hour traffic volumes for future analysis year 2012 are included in the appendix.

6.0 Analysis Methodology

The sensitivity analysis was performed for each of the selected study corridors. A controlling entry movement (for the AM peak hour) traveling towards downtown New Haven and exit

movement (for the PM peak hour) traveling away from downtown New Haven were used as the starting points for increasing the volumes to represent conditions with diverted traffic.

The sensitivity analysis as outlined below was performed for each of the future transportation scenarios for each corridor:

a. Analyze the control intersection to determine the incremental volume that could be accommodated before operations for the lane group or approach reach an operational threshold. For this assignment, all critical and other priority intersections are signalized. The threshold values were selected to be the mid-range of Level of Service (LOS) E (about 65 to 70 seconds of delay per vehicle) for turning movements and the upper range of LOS D to lower range of LOS E (about 55 to 60 seconds of delay per vehicle) for through movements[1]. Low-cost mitigation measures were examined (e.g., signal phasing and timing modifications, lane use modifications and/or parking restrictions) to improve operational conditions and increase the volume that could be handled.

b. Add the incremental volume to specific movements at priority locations along the corridor. The priority intersections analyzed along each selected corridor for analysis years 2008 and 2012 are shown in Figures 4 through 9.

c. Apply SYNCHRO to the selected study corridors to identify potential impacts of the incremental traffic volumes.

d. Identify low-cost mitigation measures to improve operational conditions at the control and priority locations, if applicable.

e. Identify potential bottlenecks with the incremental volume that may not be mitigated using low-cost measures.

7.0 Traffic Analysis by Corridor

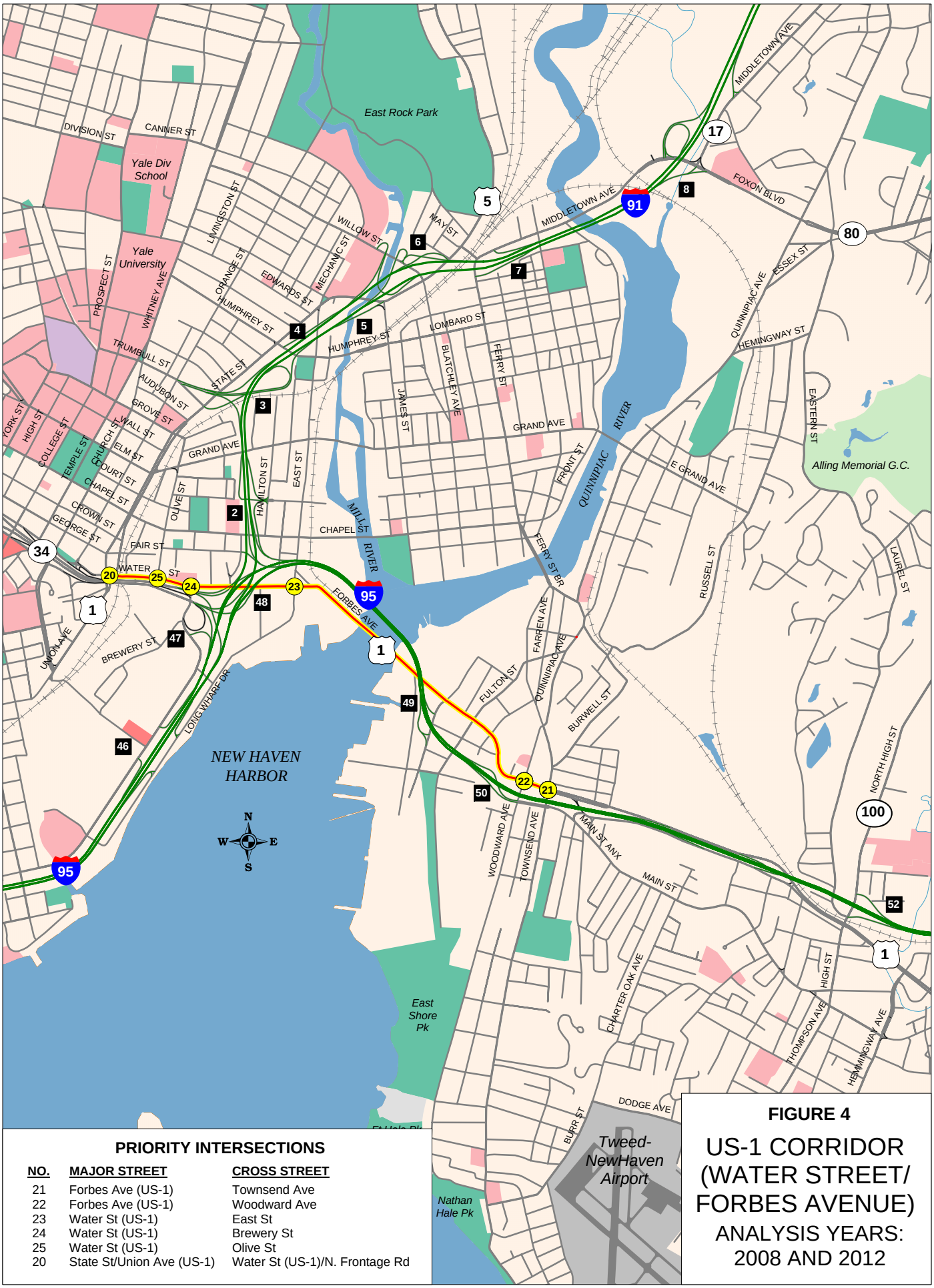
The results and findings of the SYNCHRO analysis are summarized in the following sub-sections for each of the four study corridors.

7.1. US1 Corridor - Forbes Avenue from East Haven / New Haven Town Line to Water Street at Union Avenue / State Street

The results of the SYNCHRO analysis for the Water Street / Forbes Avenue (Route 1) corridor are presented for the base and future transportation conditions for the weekday AM and PM peak hours. The priority locations along this corridor, which were included in the SYNCHRO analysis for years 2008 and 2012, were shown earlier in Figure 4.

The signal operations for the six priority intersections along the US1 corridor vary. The Forbes Avenue intersections at Townsend Avenue and Woodward Avenue are under ConnDOT

[1] Level of service (LOS) is a measure in the *Highway Capacity Manual* of traffic operating conditions. Six levels of service are defined using delay as the measure of effectiveness, from A to F, with LOS A representing the best operating conditions and LOS F the worst. Each LOS represents a range of operating conditions.



PRIORITY INTERSECTIONS

NO.	MAJOR STREET	CROSS STREET
21	Forbes Ave (US-1)	Townsend Ave
22	Forbes Ave (US-1)	Woodward Ave
23	Water St (US-1)	East St
24	Water St (US-1)	Brewery St
25	Water St (US-1)	Olive St
20	State St/Union Ave (US-1)	Water St (US-1)/N. Frontage Rd

FIGURE 4

US-1 CORRIDOR (WATER STREET/ FORBES AVENUE)

ANALYSIS YEARS: 2008 AND 2012

PRIORITY INTERSECTIONS

NO.	MAJOR STREET	CROSS STREET
1	Foxon Blvd (CT-80)	Quinnipiac Ave
2	Middletown Ave	I-91 NB Entrance Ramp (Exit 8)
3	Middletown Ave/Foxon Blvd (CT-80)	I-91 NB Exit Ramp (Exit 8)/Middletown Ave
4	Middletown Ave	I-91 SB Entrance & Exit Ramps (Exit 8)
5	Middletown Ave	Ferry St
6	State St	Ferry St/May St
7	State St	Blatchley Ave/Willow St
8	State St	James St/I-91 NB Exit Ramp (Exit 5)
9	State St	East St/Mechanic St
10	East St	Humphrey St
11	State St	Edwards St
12	State St	Humphrey St
13	Trumble St	Orange St/I-91 NB & SB Entrance & Exit Ramps (Exit 3)
14	State St	Audubon St
15	State St	Olive St/Grove St
16	State St	Grand Ave/Elm St
17	SB State St	Chapel St
18	NB State St	George St/Fair St
19	State St	Fair St
20	State St/Union Ave (US-1)	Water St (US-1)/N. Frontage Rd

FIGURE 5

MIDDLETOWN AVENUE/ STATE STREET CORRIDOR

ANALYSIS YEARS: 2008 AND 2012

PRIORITY INTERSECTIONS

NO.	MAJOR STREET	CROSS STREET
1	Foxon Blvd (CT-80)	Quinnipiac Ave
26	E Grand Ave	Quinnipiac Ave
27	Grand Ave	Front St
28	Grand Ave	Ferry St
29	Grand Ave	Blatchley Ave
30	Grand Ave	James St
31	Grand Ave	East St
32	Grand Ave	Hamilton St
14	State St	Audubon St
15	State St	Olive St/Grove St
16	State St	Grand Ave/Elm St
17	State St	Chapel St

FIGURE 6

GRAND AVENUE CORRIDOR

ANALYSIS YEAR: 2008

Replacement of Grand Avenue Bridge over AMTRAK Underway

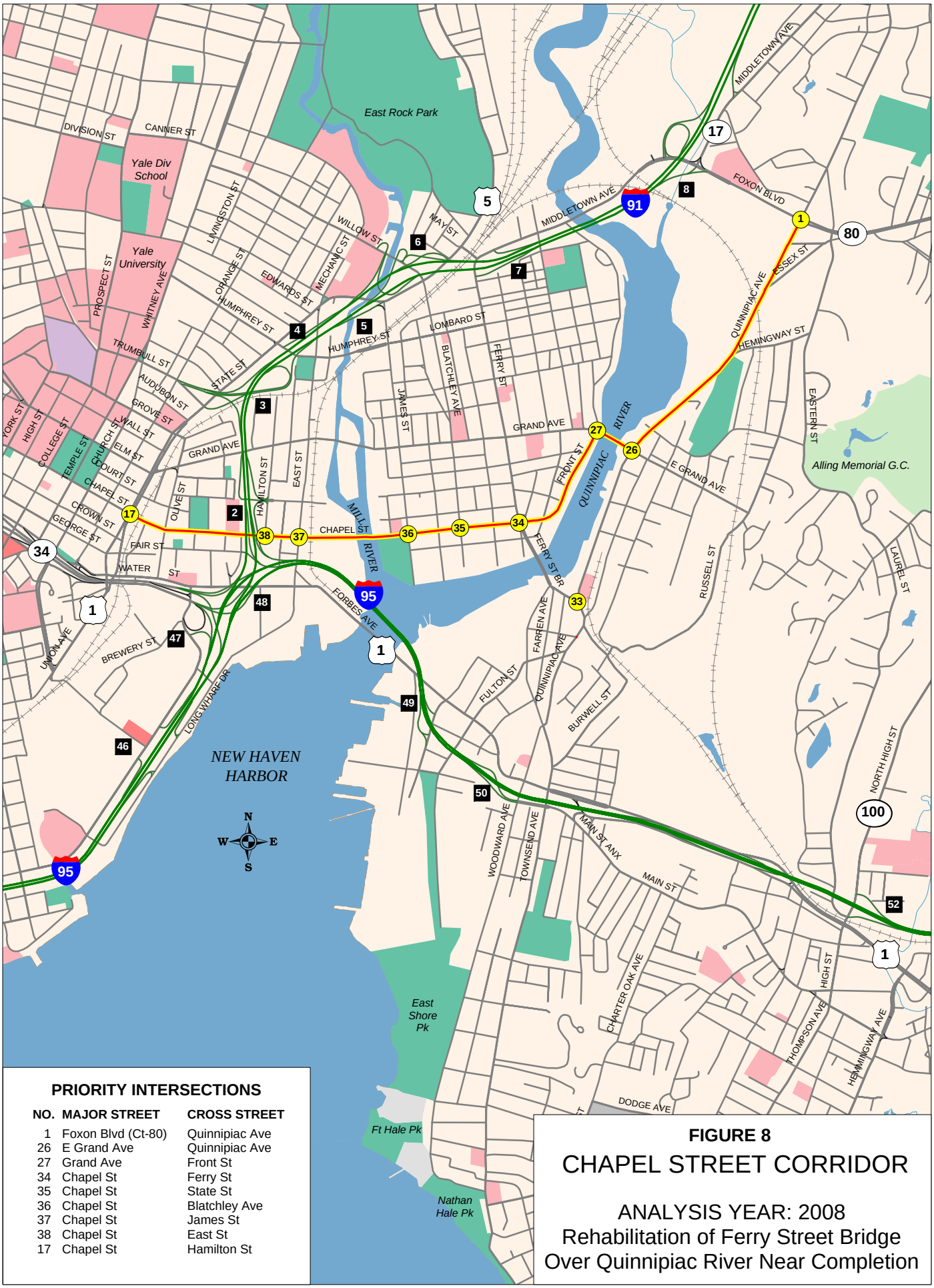
PRIORITY INTERSECTIONS

NO.	MAJOR STREET	CROSS STREET
1	Foxon Blvd (CT-80)	Quinnipiac Ave
26	E Grand Ave	Quinnipiac Ave
27	Grand Ave	Front St
28	Grand Ave	Ferry St
29	Grand Ave	Blatchley Ave
30	Grand Ave	James St
31	Grand Ave	East St
32	Grand Ave	Hamilton St
15	State St	Olive St/Grove St
16	State St	Grand Ave/Elm St
17	State St	Chapel St

FIGURE 7

GRAND AVENUE CORRIDOR

ANALYSIS YEAR: 2012
Replacement of Grand Avenue Bridge over AMTRAK Completed



PRIORITY INTERSECTIONS

NO.	MAJOR STREET	CROSS STREET
1	Foxon Blvd (Ct-80)	Quinnipiac Ave
26	E Grand Ave	Quinnipiac Ave
27	Grand Ave	Front St
34	Chapel St	Ferry St
35	Chapel St	State St
36	Chapel St	Blatchley Ave
37	Chapel St	James St
38	Chapel St	East St
17	Chapel St	Hamilton St

FIGURE 8

CHAPEL STREET CORRIDOR

ANALYSIS YEAR: 2008

Rehabilitation of Ferry Street Bridge Over Quinnipiac River Near Completion

PRIORITY INTERSECTIONS

NO.	MAJOR STREET	CROSS STREET
21	Forbes Ave (US-1)	Townsend Ave
33	E Ferry St	Quinnipiac Ave
34	Ferry St	Chapel St
35	Chapel St	State St
36	Chapel St	Blatchley Ave
37	Chapel St	James St
38	Chapel St	East St
17	Chapel St	Hamilton St

FIGURE 9

CHAPEL STREET CORRIDOR

ANALYSIS YEAR: 2012
Rehabilitation of Ferry Street Bridge Over Quinnipiac River Completed

jurisdiction and are part of a closed loop system. The remaining signals at the priority locations are under City of New Haven jurisdiction. The Water Street intersections at East Street and Brewery Street have loop detectors on minor and left-turn approaches, but were observed to operate as pretimed. The Water Street intersection at Olive Street has no detectors and operates as pretimed. The Water Street / North Frontage Road intersection at Union Avenue / State Street is actuated-coordinated with pedestrian push buttons. It has quad left phasing for the northbound and southbound approaches, which assigns time to minor movements as needed and skips phases when there is no demand.

2005 AM Peak-Hour Conditions

As noted previously, the Ferry Street Bridge over the Quinnipiac River was closed during the year 2005. A summary of the existing conditions for the AM peak hour for the US1 corridor is presented in Figure 10, which contains information on the Level of Service and the delay in seconds per vehicle (s/v) for each lane group at each of the six study intersections. All lane groups operate at LOS D or better, which is generally considered acceptable for urban areas.

2008 AM Peak-Hour Conditions and Potential Mitigation

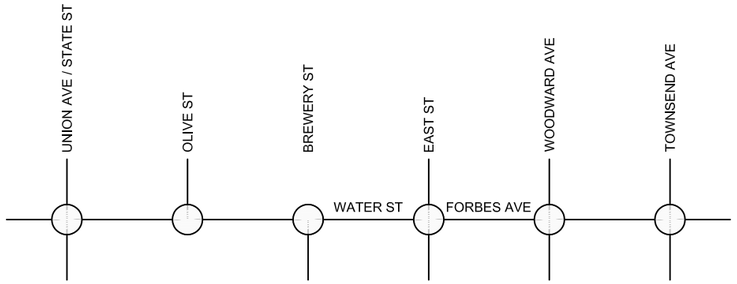
During the year 2008, the Ferry Street Bridge is expected to stay closed and not reopen until the end of the year. The Grand Avenue Bridge also is expected to be closed during 2008. Therefore, the base condition for year 2008 reflects both bridges closed. Since the Ferry Street Bridge was closed in 2005 and the Grand Avenue Bridge closure is not expected to directly affect traffic on the US1 corridor, the only difference between the 2005 existing condition and the 2008 base condition is a one percent annual background growth.

Using SYNCHRO software to simulate operations, traffic volume was incrementally added in the peak (westbound) direction until one or more lane groups reached the thresholds described previously. The increments were applied as follows: 85 percent entered the study area at Forbes Avenue and Townsend Avenue via the westbound through movement, and 15 percent entered via the northbound left-turn movement. At all other priority intersections, the increments were applied to the westbound through movements, except where otherwise noted. Low cost mitigation measures were then applied to allow additional traffic increments. A schematic representation identifying the incremental volumes and the mitigation measures needed to achieve these incremental volumes at the priority intersections along the westbound US1 corridor is presented in Figure 11. The mitigation measures and the Levels of Service for the maximum cumulative incremental volume are presented in Figure 12.

During the base condition (Condition A), all lane groups operate below the threshold. It is projected that with no improvements, this corridor can handle an additional 210 vehicles before the estimated average delay per vehicle reaches the threshold at the control intersection of Water and East Streets (Condition B). All other intersections are projected to operate below the threshold.

Basic adjustments were made to the signal at this intersection as a mitigation measure to allow additional traffic increments. The recall mode was set to allow the northbound, southbound and eastbound left-turn phases to gap out – turn to red indication when demand was satisfied during a

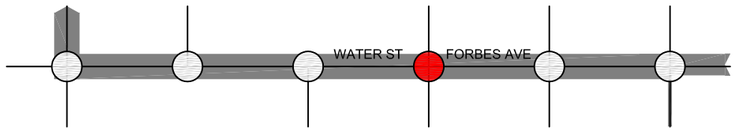

WATER ST & EAST ST
WB-Left/Through: LOS D (36 s)
All other lane groups LOS C or better.
WATER ST & BREWERY ST
All lane groups LOS C or better.
WATER ST & OLIVE ST
All lane groups LOS C or better.
STATE ST & WATER ST
NB-Left: LOS D (50 s)
SB-Left: LOS D (38 s)
All other lane groups LOS C or better.
FORBES AVE & WOODWARD AVE
All lane groups LOS C or better.
FORBES AVE & TOWNSEND AVE
NB-Left/Through/Right: LOS D (50 s)
All other lane groups LOS C or better.
WATER ST
FORBES AVE
CHAPEL ST
RIVER ST
MILL RIVER
QUINNIPIAC RIVER
N
W
E
S
91
95
1
34
48
47
46
49
50
FIGURE 10
LEVEL OF SERVICE AND DELAY
Corridor: US1
Peak Hour: AM
Year: 2005 Existing Condition



CONDITION A
Base Condition

THRESHOLD NOT REACHED

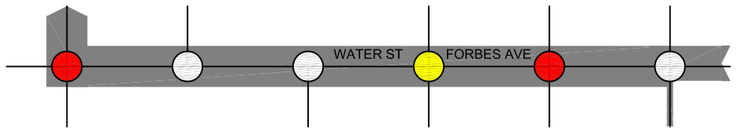
MITIGATION MEASURES:
1. No mitigation necessary. All lane groups operate at LOS D or better.



CONDITION B
Incremental Volume: 210 veh
Cumulative Incremental Volume: 210 veh

THRESHOLD REACHED AT:
Water St & East St

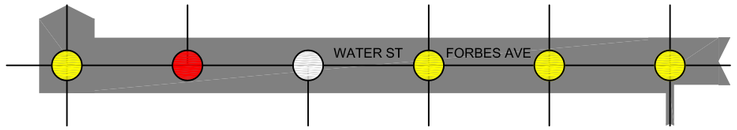
MITIGATION MEASURES:
1. Implement actuation: set recall mode to allow minor movements to gap out, giving unused time to eastbound/westbound phase.
2. Using existing phasing and cycle length (104 sec), reallocate green time to allow maximum green time for eastbound/westbound phase.
3. Consider early scheduling of planned Water Street widening.



CONDITION C
Incremental Volume: 130 veh
Cumulative Incremental Volume: 340 veh

THRESHOLD REACHED AT:
Water St & State St
Forbes Ave & Woodward Ave

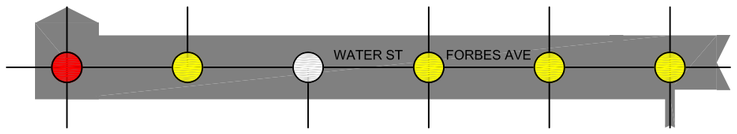
MITIGATION MEASURES:
1. Using existing phasing and cycle length, reallocate green time to allow maximum green time for eastbound/westbound phase.
1. Coordinate with adjacent Townsend Avenue intersection by changing cycle length from 60 sec to 76 sec.
2. Set offset to favor westbound direction.
3. Implement actuation: set recall mode to allow minor movements to gap out, giving unused time to eastbound/westbound phase (same action for adjacent Townsend Avenue intersection).
4. Reallocate green time to allow maximum green time for eastbound/westbound phase (same action for adjacent Townsend Avenue intersection).



CONDITION D
Incremental Volume: 120 veh
Cumulative Incremental Volume: 460 veh

THRESHOLD REACHED AT:
Water St & Olive St

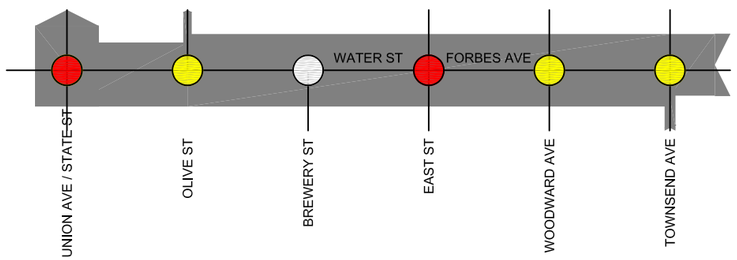
MITIGATION MEASURES:
1. Coordinate with adjacent Brewery Street intersection by changing cycle length from 50 to 67 sec.
2. Set offset to favor westbound direction.
3. Reallocate green time to allow maximum green time for eastbound/westbound phase.



CONDITION E
Incremental Volume: 70 veh
Cumulative Incremental Volume: 530 veh

THRESHOLD REACHED AT:
Water St & State St

MITIGATION MEASURES:
1. Threshold has been reached and no further low-cost mitigation is possible. However, additional downtown-bound traffic could use an alternate route via westbound right turn at Water and Olive Streets.

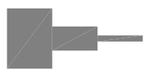


CONDITION F
Incremental Volume: 70 veh
Cumulative Incremental Volume: 600 veh

THRESHOLD REACHED AT:
Water St & East St

MITIGATION MEASURES:
1. Threshold has been reached and no further low-cost mitigation is possible.

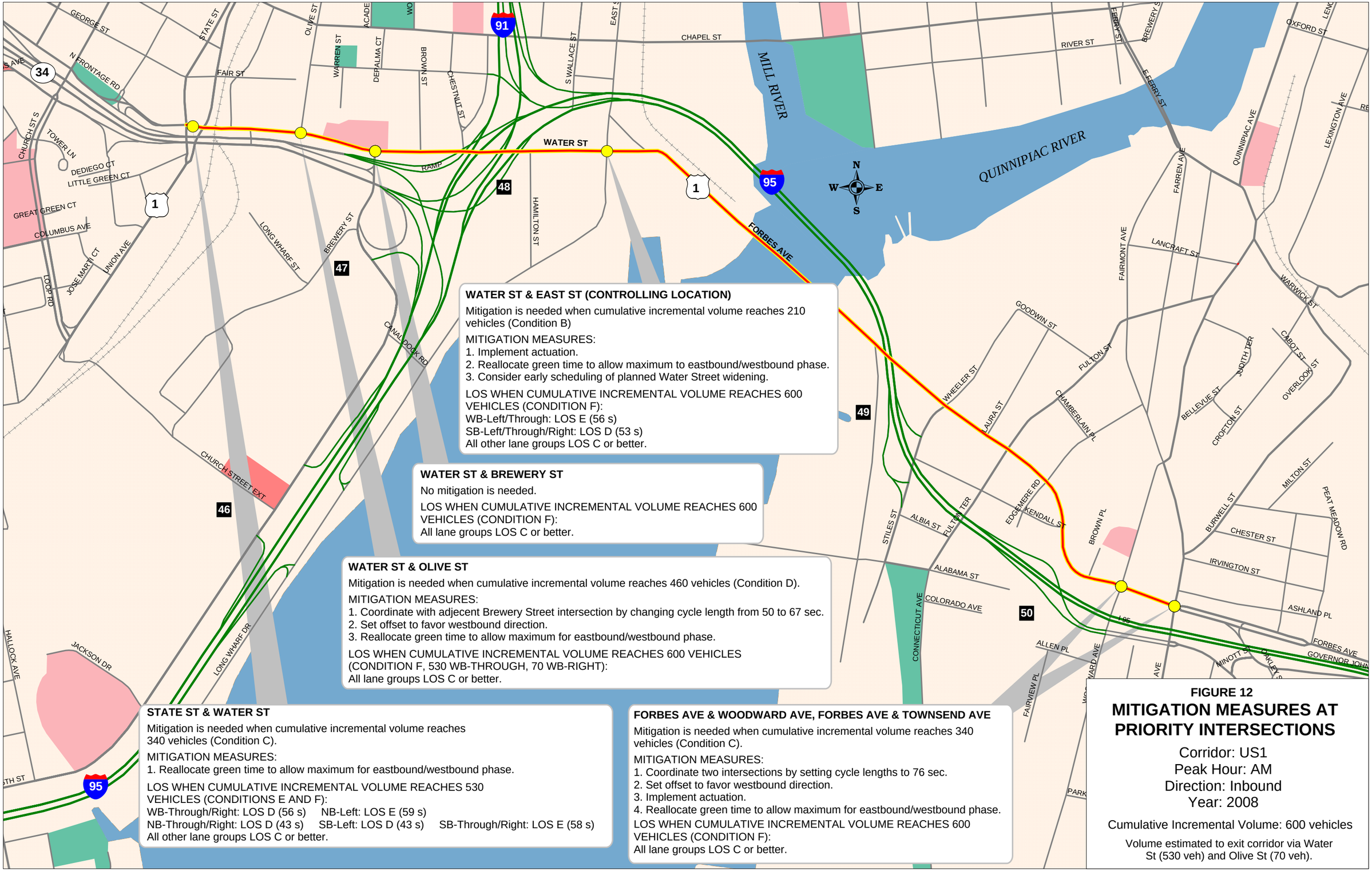
LEGEND



- LOS threshold not reached at current condition.
- LOS threshold reached at current condition. Mitigation needed to achieve additional incremental volumes.
- LOS threshold not reached at current condition due to prior mitigation measures.

FIGURE 11
INCREMENTAL VOLUMES AND MITIGATION MEASURES AT PRIORITY INTERSECTIONS

Corridor: US1
Peak Hour: AM
Direction: Westbound
Year: 2008


WATER ST & EAST ST (CONTROLLING LOCATION)
Mitigation is needed when cumulative incremental volume reaches 210 vehicles (Condition B)
MITIGATION MEASURES:
1. Implement actuation.
2. Reallocate green time to allow maximum to eastbound/westbound phase.
3. Consider early scheduling of planned Water Street widening.
LOS WHEN CUMULATIVE INCREMENTAL VOLUME REACHES 600 VEHICLES (CONDITION F):
WB-Left/Through: LOS E (56 s)
SB-Left/Through/Right: LOS D (53 s)
All other lane groups LOS C or better.
WATER ST & BREWERY ST
No mitigation is needed.
LOS WHEN CUMULATIVE INCREMENTAL VOLUME REACHES 600 VEHICLES (CONDITION F):
All lane groups LOS C or better.
WATER ST & OLIVE ST
Mitigation is needed when cumulative incremental volume reaches 460 vehicles (Condition D).
MITIGATION MEASURES:
1. Coordinate with adjecent Brewery Street intersection by changing cycle length from 50 to 67 sec.
2. Set offset to favor westbound direction.
3. Reallocate green time to allow maximum for eastbound/westbound phase.
LOS WHEN CUMULATIVE INCREMENTAL VOLUME REACHES 600 VEHICLES (CONDITION F, 530 WB-THROUGH, 70 WB-RIGHT):
All lane groups LOS C or better.
STATE ST & WATER ST
Mitigation is needed when cumulative incremental volume reaches 340 vehicles (Condition C).
MITIGATION MEASURES:
1. Reallocate green time to allow maximum for eastbound/westbound phase.
LOS WHEN CUMULATIVE INCREMENTAL VOLUME REACHES 530 VEHICLES (CONDITIONS E AND F):
WB-Through/Right: LOS D (56 s) NB-Left: LOS E (59 s)
NB-Through/Right: LOS D (43 s) SB-Left: LOS D (43 s) SB-Through/Right: LOS E (58 s)
All other lane groups LOS C or better.
FORBES AVE & WOODWARD AVE, FORBES AVE & TOWNSEND AVE
Mitigation is needed when cumulative incremental volume reaches 340 vehicles (Condition C).
MITIGATION MEASURES:
1. Coordinate two intersections by setting cycle lengths to 76 sec.
2. Set offset to favor westbound direction.
3. Implement actuation.
4. Reallocate green time to allow maximum for eastbound/westbound phase.
LOS WHEN CUMULATIVE INCREMENTAL VOLUME REACHES 600 VEHICLES (CONDITION F):
All lane groups LOS C or better.
WATER ST
FORBES AVE
CHAPEL ST
RIVER ST
MILL RIVER
QUINNIPIAC RIVER
CHURCH STREET EXT
LONG WHARF DR
BREWERY ST
HAMILTON ST
CANAL DOCK RD
FAIRMONT AVE
LANCRAFT ST
GOODWIN ST
FULTON ST
WHEELER ST
LAURA ST
CHAMBERLAIN PL
BELLEVUE ST
CROFTON ST
JUDITH TER
CABOT ST
OVERLOOK ST
WARWICK ST
MILTON ST
PEAT MEADOW RD
BURWELL ST
CHESTER ST
IRVINGTON ST
ASHLAND PL
ALBANY AVE
ALBIA ST
STILES ST
EDGEMERE RD
KENDALL ST
BROWN PL
ALABAMA ST
COLORADO AVE
CONNECTICUT AVE
ALLEN PL
FAIRVIEW PL
I-95
MINOTT ST
OAKLEY ST
GOVERNOR JOHN
JACKSON DR
HALLOCK AVE
PARK
FIGURE 12
MITIGATION MEASURES AT PRIORITY INTERSECTIONS
Corridor: US1
Peak Hour: AM
Direction: Inbound
Year: 2008
Cumulative Incremental Volume: 600 vehicles
Volume estimated to exit corridor via Water St (530 veh) and Olive St (70 veh).

cycle. Unused time was given to the eastbound-westbound phase. Also, using the same 104 second cycle length, green time was reallocated so that the minor movements operated near the threshold, thus allowing maximum green time for additional westbound traffic.

There may be future opportunities for more long-term improvements along US1 between East Street and Brewery Street. This segment of US1 is shown as being widened in Phase 17 of Contract E (the redesign of the I-95/I-91/Route 34 interchange). Phase 17 is scheduled to be implemented towards the end of Contract E construction. Additional traffic along this segment of US1 could be accommodated if the widening was to be done earlier in the Contract E schedule, when disruptions to I-95 traffic are possible.

Traffic was then incrementally added (Condition C). An additional 130 vehicles (340 cumulative) resulted in the threshold being reached at two intersections: Water Street and State Street; and Forbes Avenue and Woodward Avenue. However, potential queuing problems are projected at these two intersections with this incremental volume. On westbound State Street at Water Street, the 95th percentile queue length is projected to be about 270 feet, exceeding the 200-foot storage length. On westbound Forbes Avenue at Woodward Avenue, the 95th percentile queue length is projected to be about 450 feet, close to the 460 feet of available storage. Basic timing adjustments were made to the signals at these intersections to allow additional traffic increments. At Water Street and State Street, the existing phasing, cycle length and offset were retained, while the green time was reallocated so that the minor movements operated near the established threshold, thus allowing maximum green time for the eastbound-westbound phase. At Forbes Avenue and Woodward Avenue, measures were taken to allow coordination with the adjacent Forbes Avenue and Townsend Avenue intersection. The cycle length was changed from 60 seconds to 76 seconds, which is the cycle length at Forbes Avenue and Townsend Avenue. The offsets at the two intersections were set to give priority to the westbound movement. At both intersections, green time was reallocated so that the minor movements operated near the threshold, thus allowing maximum green time for westbound traffic.

More traffic was then incrementally added (Condition D). An additional 120 vehicles (460 cumulative) resulted in the threshold being reached at Water Street and Olive Street. Measures were taken to allow coordination with the adjacent Water Street and Brewery Street intersection. The cycle length was changed from 50 seconds to 67 seconds, the cycle length at Water Street and Brewery Street. The offsets at the two intersections were set to give priority to the westbound movement. While retaining pretimed operation, green time was reallocated so that the minor movements operated near the threshold, thus allowing maximum green time for westbound traffic.

Traffic was then incrementally added again (Condition E). An additional 70 vehicles (530 cumulative) resulted in the threshold being reached again at Water Street and State Street. The green time was already reallocated here as a mitigating measure after Condition C. No adjustments were made to the phasing (which already works very well), or the cycle length or offset, because this would interfere with coordination in the north-south direction along State Street. Therefore, this intersection reached its practical limit.

Additional traffic volumes can be accommodated along this corridor if some drivers make a change in their travel route. Drivers could get to downtown New Haven by following this

corridor and turning right onto Olive Street instead of proceeding to State Street. Olive Street has available capacity with the mitigation measures performed after Condition D. For Condition F, an additional 70 vehicles (600 cumulative) were added following this revised route until the threshold was reached again at Water Street and East Street. At this point, no further increments can be accommodated using low-cost mitigation measures.

2012 AM Peak-Hour Conditions and Potential Mitigation

During the year 2012, the Ferry Street Bridge and the Grand Avenue Bridge are expected to be open. The Ferry Street Bridge opening is expected to result in some traffic diversion from the US1 corridor. The Grand Avenue Bridge opening is not expected to have any direct affect on this corridor. Some movements have slightly greater traffic volume due to the additional one percent annual growth. However, the diversion due to the Ferry Street Bridge opening causes a slight net loss in volume at other locations along the US1 corridor.

The same procedure of incrementing the traffic volume was applied to the 2012 AM peak-hour condition. A schematic representation identifying the incremental volumes and the mitigation measures needed to achieve these incremental volumes at the priority intersections along the westbound US1 corridor is presented in Figure 13. The mitigation measures and the Levels of Service for the maximum cumulative incremental volume are presented in Figure 14. The same mitigation measures were used as discussed for 2008. The incremental volume for each condition varied somewhat because of the slightly different base conditions. As shown in Figures 13 and 14, the maximum cumulative increment is 640 vehicles.

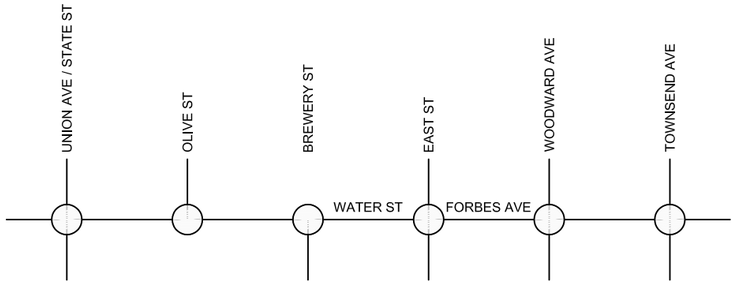
2005 PM Peak-Hour Conditions

As noted previously, the Ferry Street Bridge over the Quinnipiac River was closed during the year 2005. A summary of the existing conditions for the PM peak hour for the US1 corridor is presented in Figure 15 which contains information on the Level of Service and the delay in seconds per vehicle (s/v) for each lane group at each of the six study intersections. All lane groups operate at LOS D or better, which is generally considered acceptable for urban areas.

2008 PM Peak-Hour Conditions and Potential Mitigation

During the year 2008, the Ferry Street Bridge is expected to stay closed and not reopen until the end of the year. The Grand Avenue Bridge is also expected to be closed during 2008. Therefore, the base condition for year 2008 reflects both bridges closed. Since the Ferry Street Bridge was closed in 2005 and the Grand Avenue Bridge closure is not expected to directly affect traffic on the US1 corridor, the only difference between the 2005 existing condition and the 2008 base condition is a one percent annual background growth. The results are similar to the 2005 existing condition.

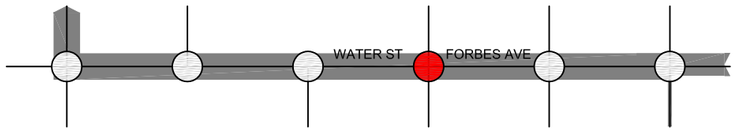
Using SYNCHRO software to simulate operations, traffic volume was incrementally added in the peak (eastbound) direction until one or more lane groups reached the established thresholds. The increments were applied to traffic volume entering the study area via the southbound left-turn movement at State Street and Water Street (the eastbound through movement is prohibited here). At the eastern terminus of the US1 corridor, the increments were applied the traffic volume exiting the study area at the eastbound approach at Forbes Avenue and Townsend



CONDITION A
Base Condition

THRESHOLD NOT REACHED

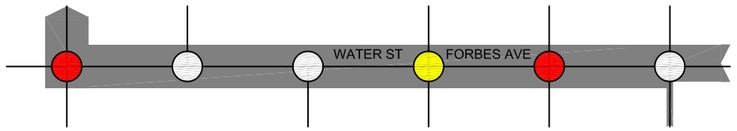
MITIGATION MEASURES:
1. No mitigation necessary. All lane groups operate at LOS D or better.



CONDITION B
Incremental Volume: 220 veh
Cumulative Incremental Volume: 220 veh

THRESHOLD REACHED AT:
Water St & East St

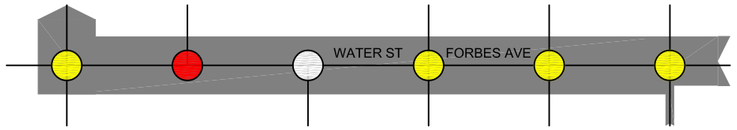
MITIGATION MEASURES:
1. Implement actuation: set recall mode to allow minor movements to gap out, giving unused time to eastbound/westbound phase.
2. Using existing phasing and cycle length (104 sec), reallocate green time to allow maximum green time for eastbound/westbound phase.
3. Consider early scheduling of planned Water Street widening.



CONDITION C
Incremental Volume: 140 veh
Cumulative Incremental Volume: 360 veh

THRESHOLD REACHED AT:
Water St & State St
Forbes Ave & Woodward Ave

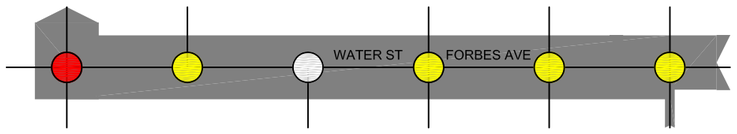
MITIGATION MEASURES:
1. Using existing phasing and cycle length, reallocate green time to allow maximum green time for eastbound/westbound phase.
1. Coordinate with adjacent Townsend Avenue intersection by changing cycle length from 60 sec to 76 sec.
2. Set offset to favor westbound direction.
3. Implement actuation: set recall mode to allow minor movements to gap out, giving unused time to eastbound/westbound phase (same action for adjacent Townsend Avenue intersection).
4. Reallocate green time to allow maximum green time for eastbound/westbound phase (same action for adjacent Townsend Avenue intersection).



CONDITION D
Incremental Volume: 120 veh
Cumulative Incremental Volume: 480 veh

THRESHOLD REACHED AT:
Water St & Olive St

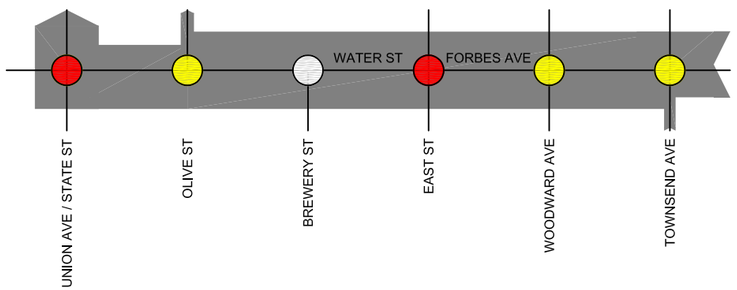
MITIGATION MEASURES:
1. Coordinate with adjacent Brewery Street intersection by changing cycle length from 50 to 67 sec.
2. Set offset to favor westbound direction.
3. Reallocate green time to allow maximum green time for eastbound/westbound phase.



CONDITION E
Incremental Volume: 50 veh
Cumulative Incremental Volume: 530 veh

THRESHOLD REACHED AT:
Water St & State St

MITIGATION MEASURES:
1. Threshold has been reached and no further low-cost mitigation is possible. However, additional downtown-bound traffic could use an alternate route via westbound right turn at Water and Olive Streets.

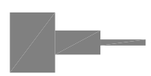


CONDITION F
Incremental Volume: 110 veh
Cumulative Incremental Volume: 640 veh

THRESHOLD REACHED AT:
Water St & East St

MITIGATION MEASURES:
1. Threshold has been reached and no further low-cost mitigation is possible.

LEGEND



CUMULATIVE INCREMENTAL VOLUME
500 200 50

LOS threshold not reached at current condition.

LOS threshold reached at current condition. Mitigation needed to achieve additional incremental volumes.

LOS threshold not reached at current condition due to prior mitigation measures.

FIGURE 13
INCREMENTAL VOLUMES AT PRIORITY INTERSECTIONS

Corridor: US-1
Peak Hour: AM
Direction: Westbound
Year: 2012

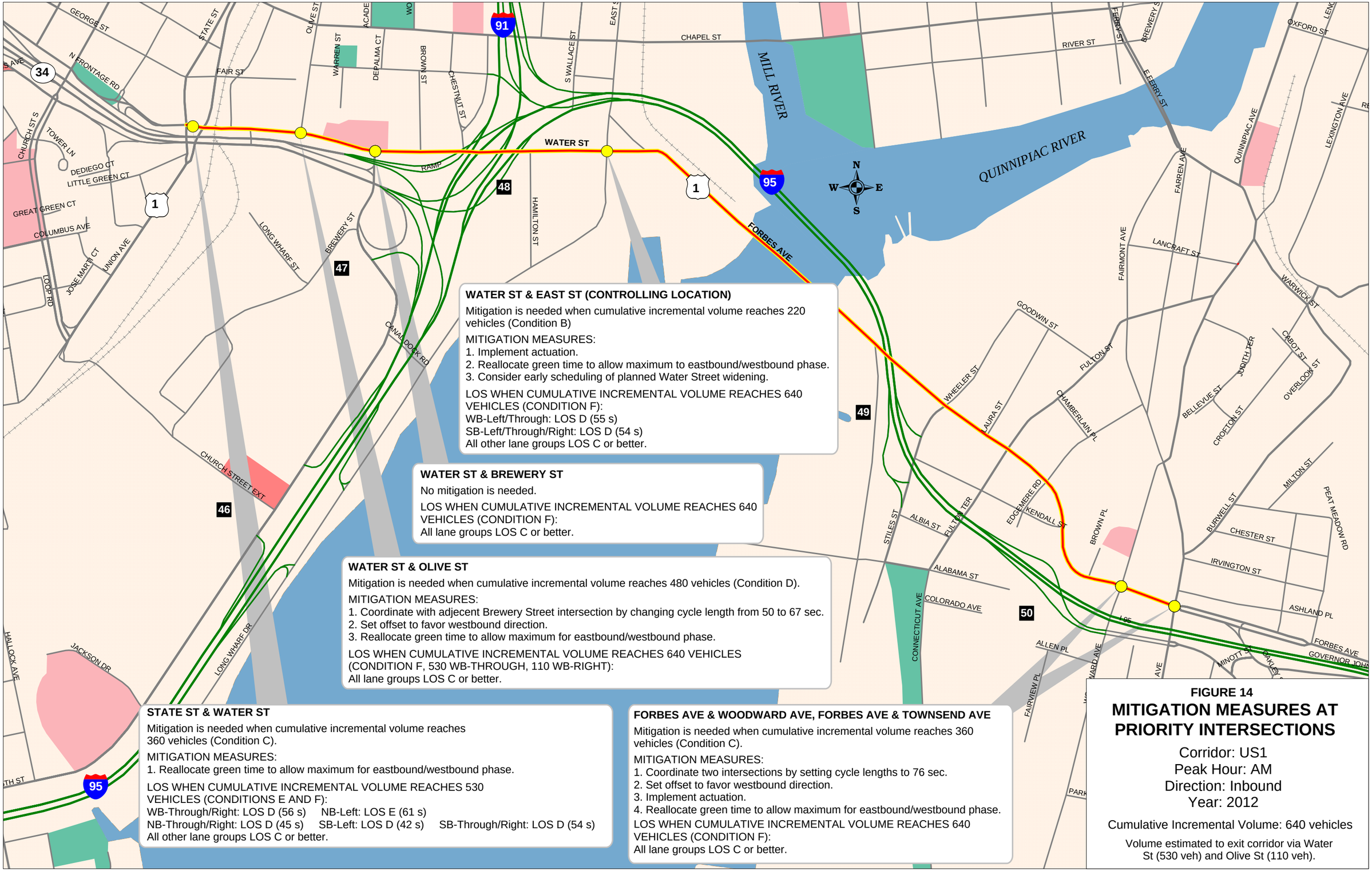


FIGURE 14

MITIGATION MEASURES AT PRIORITY INTERSECTIONS

Corridor: US1
Peak Hour: AM
Direction: Inbound
Year: 2012

Cumulative Incremental Volume: 640 vehicles

Volume estimated to exit corridor via Water St (530 veh) and Olive St (110 veh).

FIGURE 15

LEVEL OF SERVICE AND DELAY

Corridor: US1
Peak Hour: PM
Year: 2005 Existing Condition

Avenue, with 85 percent proceeding through and 15 percent turning right. At other priority intersections, the increments were applied to the eastbound through movements, except where noted otherwise. Low cost mitigation measures were then applied to allow additional increments. A schematic representation identifying the incremental volumes and the mitigation measures needed to achieve these incremental volumes at the priority intersections along the eastbound US1 corridor is presented in Figure 16. The mitigation measures and the Levels of Service for the maximum cumulative incremental volume are presented in Figure 17.

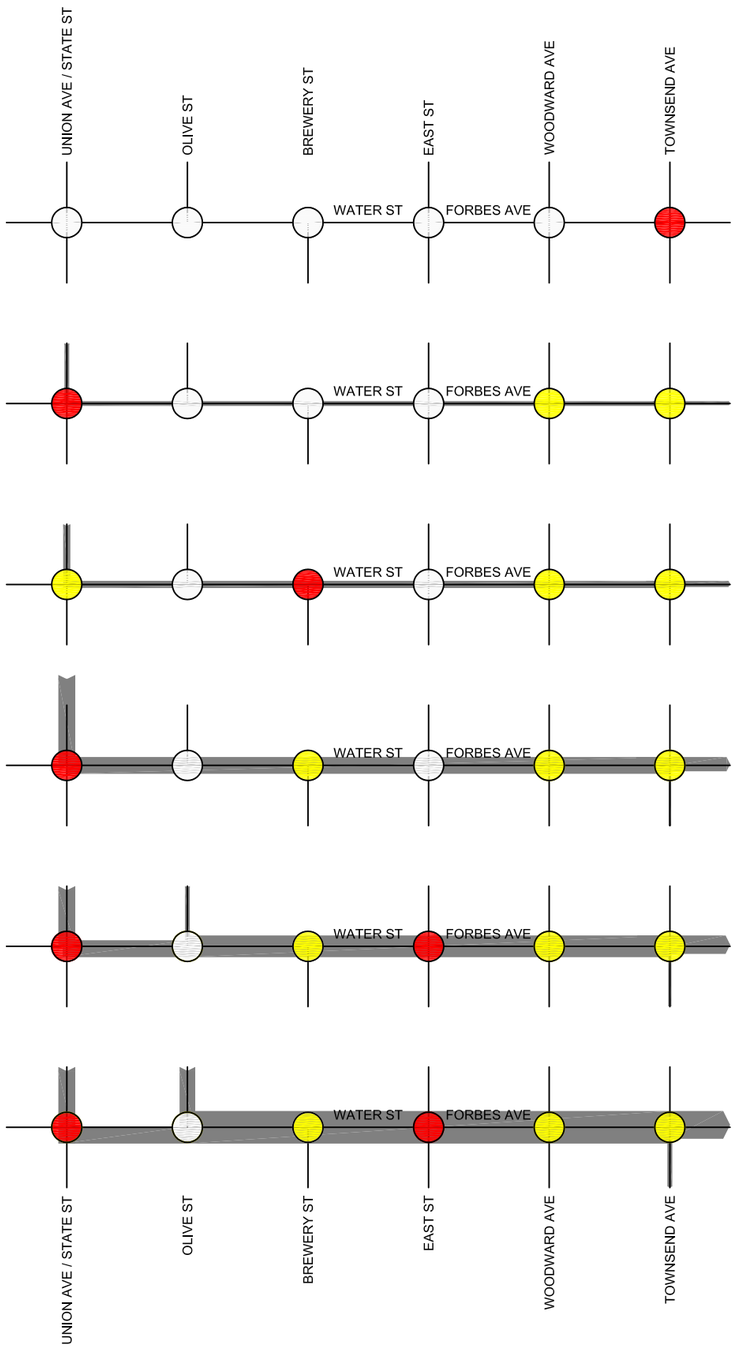
During the base condition (Condition A), the intersection of Forbes Avenue and Townsend Avenue operates slightly above the threshold. Mitigating measures were applied to allow coordination with the adjacent Forbes Avenue and Woodward Avenue intersection. The cycle length at Woodward Avenue was changed from 60 seconds to 76 seconds, which is the cycle length at Forbes Avenue and Townsend Avenue. The offsets at the two intersections were set to give priority to the eastbound movement. At both intersections, green time was reallocated so that the minor movements operated near the threshold, thus allowing maximum green time for eastbound traffic.

Traffic was then incrementally added (Condition B). Forty vehicles were added until the threshold was reached at Water Street and State Street. Basic timing adjustments were made to the signal at this intersection to allow additional traffic increments. The existing phasing, cycle length and offset were retained, while the green time was reallocated so that the other movements operated near the threshold, thus allowing maximum green time for the southbound-left turn phase.

Traffic was then incrementally added (Condition C). An additional 20 vehicles (60 cumulative) resulted in the threshold being reached at Water Street and Brewery Street. Basic timing adjustments were made to the signal at this intersection as a mitigation measure to allow additional traffic increments. The recall mode was set to allow the northbound, southbound and eastbound left-turn phases to gap out (i.e. to change to a red indication when demand was satisfied during any cycle). Unused time was given to the eastbound-westbound phase. Also, using the same 104-second cycle length, green time was reallocated so that the minor movements operated near the threshold, thus allowing maximum green time for additional eastbound traffic.

There may be future opportunities for more long-term improvements along US1 between East Street and Brewery Street. This segment of US1 is shown as being widened in Phase 17 of Contract E (the redesign of the I-95/I-91/Route 34 interchange). Phase 17 is towards the end of Contract E construction. Additional traffic along this segment of US1 could be accommodated if the widening was to be done earlier in the Contract E schedule, when disruptions to I-95 traffic are possible.

Traffic was then incrementally added again (Condition D). An additional 80 vehicles (140 cumulative) were added until the threshold was reached again at Water Street and State Street. The green time was already reallocated here as a mitigating measure after Condition B. No adjustments were made to the phasing (which already works very well), or the cycle length or offset, because this would interfere with coordination in the north-south direction along State Street. Therefore, this intersection has reached its practical limit.



CONDITION A
Base Condition

THRESHOLD REACHED AT:
Forbes Ave & Townsend Ave

MITIGATION MEASURES:
1. Coordinate with adjacent Woodward Avenue intersection by changing Woodward Avenue cycle length from 60 sec to 76 sec.
2. Set offset to favor eastbound direction.
3. Implement actuation: set recall mode to allow minor movements to gap out, giving unused time to eastbound/westbound phase (same action for adjacent Woodward Avenue intersection).
4. Reallocate green time to allow maximum green time for eastbound/westbound phase (same action for adjacent Woodward Avenue intersection).

CONDITION B
Incremental Volume: 40 veh
Cumulative Incremental Volume: 40 veh

THRESHOLD REACHED AT:
Water St & State St

MITIGATION MEASURES:
1. Using existing phasing and cycle length (90 sec), reallocate green time to allow maximum green time for southbound left phase.

CONDITION C
Incremental Volume: 20 veh
Cumulative Incremental Volume: 60 veh

THRESHOLD REACHED AT:
Water St & Brewery St

MITIGATION MEASURES:
1. Implement actuation: set recall mode to allow minor movements to gap out, giving unused time to eastbound/westbound phase.
2. Reallocate green time to allow maximum green time for eastbound/westbound phase.
3. Consider early scheduling of planned Water Street widening.

CONDITION D
Incremental Volume: 80 veh
Cumulative Incremental Volume: 140 veh

THRESHOLD REACHED AT:
Water St & State St

MITIGATION MEASURES:
1. Threshold has been reached and no further low-cost mitigation is possible. However, additional eastbound traffic could use an alternate route via southbound left turn at Water and Olive Streets.

CONDITION E
Incremental Volume: 40 veh
Cumulative Incremental Volume: 180 veh

THRESHOLD REACHED AT:
Water St & East St

MITIGATION MEASURES:
1. Implement actuation: set recall mode to allow minor movements to gap out, giving unused time to eastbound/westbound phase.
2. Using existing phasing and cycle length (104 sec), reallocate green time to allow maximum green time for eastbound/westbound phase.

CONDITION F
Incremental Volume: 90 veh
Cumulative Incremental Volume: 270 veh

THRESHOLD REACHED AT:
Water St & East St

MITIGATION MEASURES:
1. Threshold has been reached and no further low-cost mitigation is possible.

LEGEND

CUMULATIVE INCREMENTAL VOLUME
500 200 50

- LOS threshold not reached at current condition.
- LOS threshold reached at current condition. Mitigation needed to achieve additional incremental volumes.
- LOS threshold not reached at current condition due to prior mitigation measures.

FIGURE 16
INCREMENTAL VOLUMES AT PRIORITY INTERSECTIONS

Corridor: US-1
Peak Hour: PM
Direction: Eastbound
Year: 2008

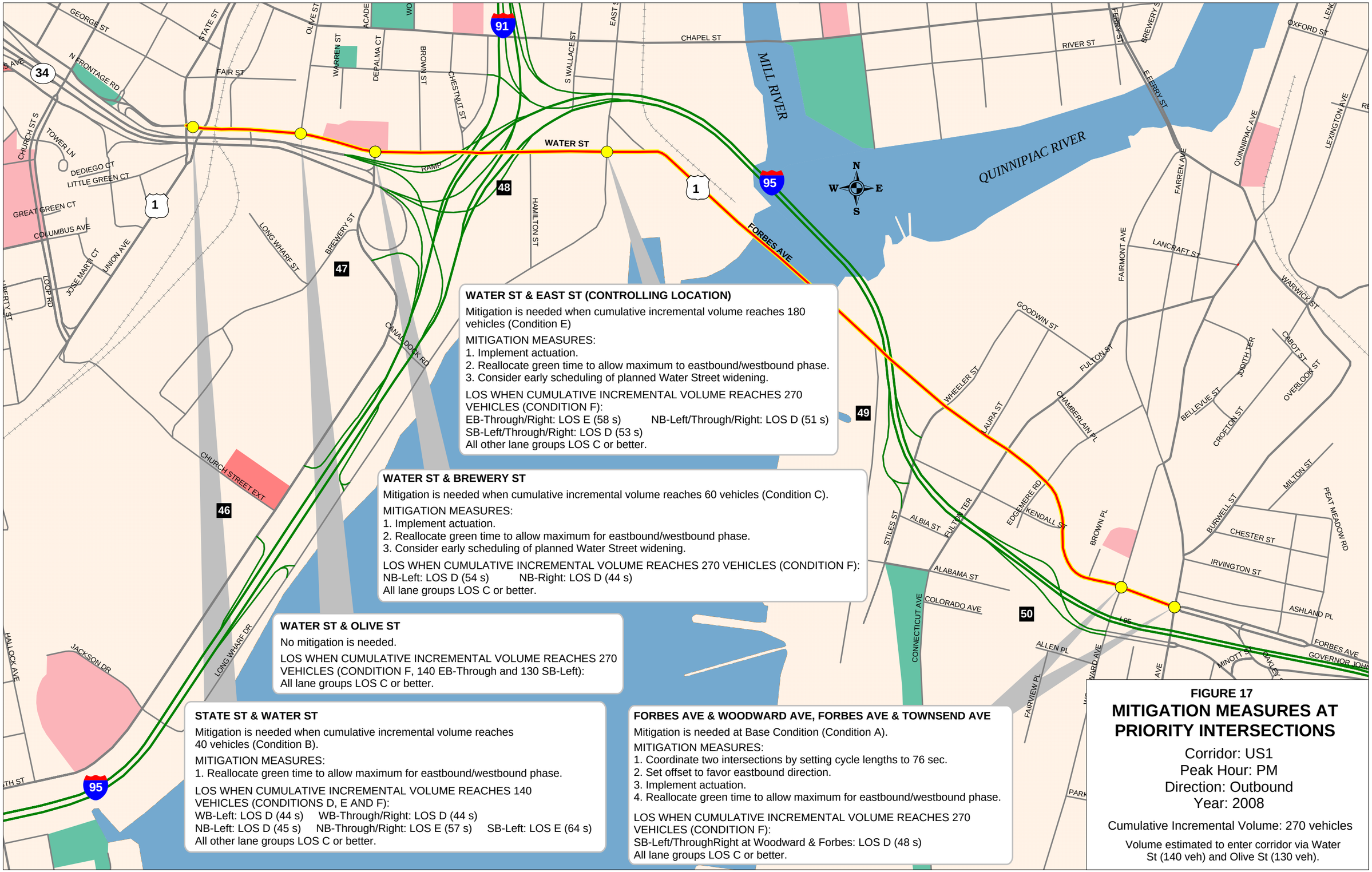


FIGURE 17

MITIGATION MEASURES AT PRIORITY INTERSECTIONS

Corridor: US1
Peak Hour: PM
Direction: Outbound
Year: 2008

Cumulative Incremental Volume: 270 vehicles

Volume estimated to enter corridor via Water St (140 veh) and Olive St (130 veh).

Additional traffic volumes can be accommodated along this corridor if some drivers make a change in their travel route. Drivers could leave downtown New Haven by following this corridor and turning left onto eastbound Water Street from southbound Olive Street instead of from southbound State Street. Olive Street has available capacity. For Condition E, 40 vehicles (180 cumulative) were added following this revised route until the threshold was reached at Water Street and East Street. Basic timing adjustments were made to the signal at this intersection as a mitigation measure to allow additional traffic increments. The recall mode was set to allow the northbound, southbound and eastbound left-turn phases to gap out – turn to red indication when demand was satisfied during a cycle. Unused time was given to the eastbound-westbound phase. Also, using the same 104-second cycle length, green time was reallocated so that the minor movements operated near the threshold, thus allowing maximum green time for additional eastbound traffic.

Traffic was then incrementally added again (Condition F). An additional 90 vehicles (270 cumulative) were added until the threshold was reached again at Water Street and East Street. The green time was already reallocated here as a mitigating measure after Condition E. No adjustments were made to the cycle length or offset, because this would interfere with coordination in the north-south direction along East Street. However, the reduction of green time for the north-south phase is projected to result in the 95 percentile queue length for the southbound approach reaching the available storage length. Therefore, this intersection has reached its practical limit.

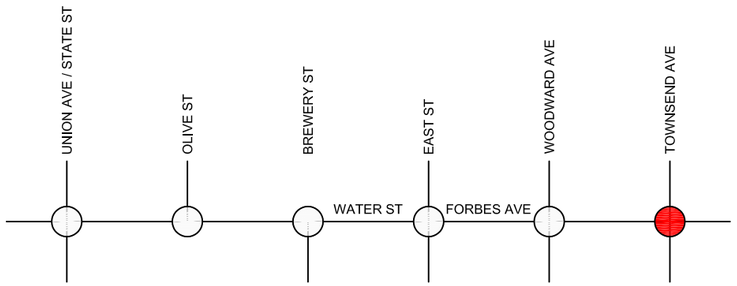
After implementing the low-cost mitigation measures, the weekday AM peak hour allows for a larger cumulative increment than the PM peak hour – 600 vehicles versus 270 vehicles. Generally, there is more traffic during the PM peak hour in the non-peak direction than there is during the AM peak hour. For example, during the PM peak hour, there was considerable traffic on the southbound approach at East Street, limiting the amount of green time that can be reallocated to the eastbound movement along the study corridor. Also, typically there are more non-work-based trips during the PM peak hour than during the AM peak hour.

2012 PM Peak-Hour Conditions and Potential Mitigation

During the year 2012, the Ferry Street Bridge and the Grand Avenue Bridge are expected to be open. The Ferry Street Bridge opening is expected to result in some traffic diversion from the US1 corridor. The Grand Avenue Bridge opening, however, is not expected to have any direct effect on this corridor. Some movements have slightly greater traffic volume due to the additional one percent annual growth. However, the diversion due to the Ferry Street Bridge opening causes a slight net loss in volume at other locations along the US1 corridor.

The same procedure of incrementing the traffic volume was applied to the 2012 PM peak-hour condition. A schematic representation identifying the incremental volumes and the mitigation measures needed to achieve these incremental volumes at the priority intersections along the eastbound US1 corridor is presented in Figure 18. The mitigation measures and the Levels of Service for the maximum cumulative incremental volume are presented in Figure 19. The same mitigation measures were used as discussed for 2008. The incremental volume for each condition varied somewhat because of the slightly different base conditions. As shown in Figures 18 and 19, the maximum cumulative increment is 290 vehicles.

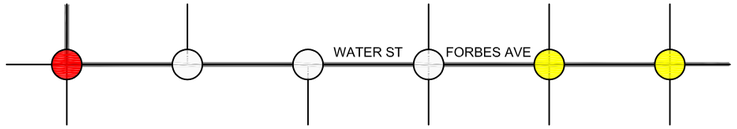
CONDITION A
Base Condition



THRESHOLD REACHED AT:
Forbes Ave & Townsend Ave

MITIGATION MEASURES:
1. Coordinate with adjacent Woodward Avenue intersection by changing Woodward Avenue cycle length from 60 sec to 76 sec.
2. Set offset to favor eastbound direction.
3. Implement actuation: set recall mode to allow minor movements to gap out, giving unused time to eastbound/westbound phase (same action for adjacent Woodward Avenue intersection).
4. Reallocate green time to allow maximum green time for eastbound/westbound phase (same action for adjacent Woodward Avenue intersection).

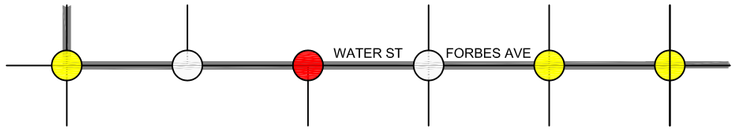
CONDITION B
Incremental Volume: 40 veh
Cumulative Incremental Volume: 40 veh



THRESHOLD REACHED AT:
Water St & State St

MITIGATION MEASURES:
1. Using existing phasing and cycle length (90 sec), reallocate green time to allow maximum green time for southbound left phase.

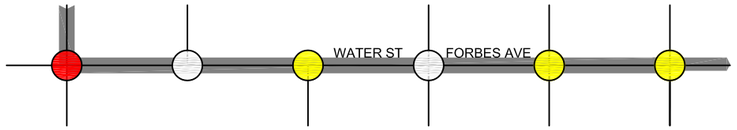
CONDITION C
Incremental Volume: 30 veh
Cumulative Incremental Volume: 70 veh



THRESHOLD REACHED AT:
Water St & Brewery St

MITIGATION MEASURES:
1. Implement actuation: set recall mode to allow minor movements to gap out, giving unused time to eastbound/westbound phase.
2. Reallocate green time to allow maximum green time for eastbound/westbound phase.
3. Consider early scheduling of planned Water Street widening.

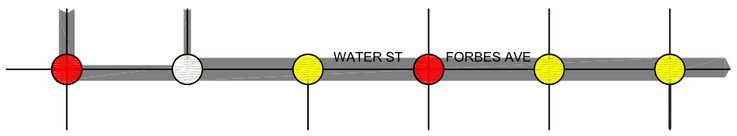
CONDITION D
Incremental Volume: 60 veh
Cumulative Incremental Volume: 130 veh



THRESHOLD REACHED AT:
Water St & State St

MITIGATION MEASURES:
1. Threshold has been reached and no further low-cost mitigation is possible. However, additional eastbound traffic could use an alternate route via southbound left turn at Water and Olive Streets.

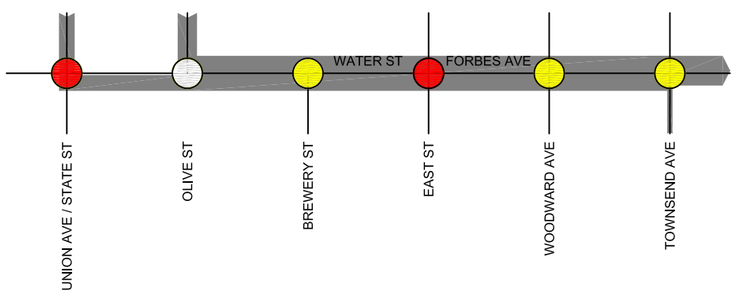
CONDITION E
Incremental Volume: 60 veh
Cumulative Incremental Volume: 190 veh



THRESHOLD REACHED AT:
Water St & East St

MITIGATION MEASURES:
1. Implement actuation: set recall mode to allow minor movements to gap out, giving unused time to eastbound/westbound phase.
2. Using existing phasing and cycle length (104 sec), reallocate green time to allow maximum green time for eastbound/westbound phase.

CONDITION F
Incremental Volume: 100 veh
Cumulative Incremental Volume: 290 veh



THRESHOLD REACHED AT:
Water St & East St

MITIGATION MEASURES:
1. Threshold has been reached and no further low-cost mitigation is possible.

LEGEND

LOS threshold not reached at current condition.

LOS threshold reached at current condition. Mitigation needed to achieve additional incremental volumes.

LOS threshold not reached at current condition due to prior mitigation measures.

FIGURE 18
INCREMENTAL VOLUMES AT PRIORITY INTERSECTIONS

Corridor: US-1
Peak Hour: PM
Direction: Eastbound
Year: 2012


WATER ST & EAST ST (CONTROLLING LOCATION)
Mitigation is needed when cumulative incremental volume reaches 190 vehicles (Condition E)
MITIGATION MEASURES:
1. Implement actuation.
2. Reallocate green time to allow maximum to eastbound/westbound phase.
3. Consider early scheduling of planned Water Street widening.
LOS WHEN CUMULATIVE INCREMENTAL VOLUME REACHES 290 VEHICLES (CONDITION F):
EB-Through/Right: LOS E (58 s) NB-Left/Through/Right: LOS D (52 s)
SB-Left/Through/Right: LOS D (55 s)
All other lane groups LOS C or better.
WATER ST & BREWERY ST
Mitigation is needed when cumulative incremental volume reaches 70 vehicles (Condition C).
MITIGATION MEASURES:
1. Implement actuation.
2. Reallocate green time to allow maximum for eastbound/westbound phase.
3. Consider early scheduling of planned Water Street widening.
LOS WHEN CUMULATIVE INCREMENTAL VOLUME REACHES 290 VEHICLES (CONDITION F):
NB-Left: LOS E (59 s) NB-Right: LOS D (46 s)
All lane groups LOS C or better.
WATER ST & OLIVE ST
No mitigation is needed.
LOS WHEN CUMULATIVE INCREMENTAL VOLUME REACHES 290 VEHICLES (CONDITION F, 130 EB-Through and 160 SB-Left):
All lane groups LOS C or better.
STATE ST & WATER ST
Mitigation is needed when cumulative incremental volume reaches 40 vehicles (Condition B).
MITIGATION MEASURES:
1. Reallocate green time to allow maximum for eastbound/westbound phase.
LOS WHEN CUMULATIVE INCREMENTAL VOLUME REACHES 130 VEHICLES (CONDITIONS D, E AND F):
WB-Left: LOS D (44 s) WB-Through/Right: LOS D (44 s)
NB-Left: LOS D (45 s) NB-Through/Right: LOS E (57 s) SB-Left: LOS E (64 s)
All other lane groups LOS C or better.
FORBES AVE & WOODWARD AVE, FORBES AVE & TOWNSEND AVE
Mitigation is needed at Base Condition (Condition A).
MITIGATION MEASURES:
1. Coordinate two intersections by setting cycle lengths to 76 sec.
2. Set offset to favor eastbound direction.
3. Implement actuation.
4. Reallocate green time to allow maximum for eastbound/westbound phase.
LOS WHEN CUMULATIVE INCREMENTAL VOLUME REACHES 290 VEHICLES (CONDITION F):
SB-Left/ThroughRight at Woodward & Forbes: LOS D (48 s)
All lane groups LOS C or better.
FIGURE 19
MITIGATION MEASURES AT PRIORITY INTERSECTIONS
Corridor: US1
Peak Hour: PM
Direction: Outbound
Year: 2012
Cumulative Incremental Volume: 290 vehicles
WATER ST
CHAPEL ST
RIVER ST
FORBES AVE
MILL RIVER
QUINNIPIAC RIVER
N
W
E
S
91
95
34
1
48
47
46
49
50
GEORGE ST
STATE ST
OLIVE ST
WARREN ST
DEPALMA CT
BROWN ST
CHESTNUT ST
S WALLACE ST
FERRY ST
BREWERY ST
E FERRY ST
OXFORD ST
QUINNIPIAC AVE
LEXINGTON AVE
FARREN AVE
N FRONTAGE RD
FAIR ST
CHURCH ST S
TOWER LN
DEDIEGO CT
LITTLE GREEN CT
GREAT GREEN CT
COLUMBUS AVE
UNION AVE
JOSE MARTI CT
LOOP RD
LIBERTY ST
HAMILTON ST
LONG WHARF ST
CANAL DOCK RD
RAMP
LANCRAFT ST
FAIRMONT AVE
WARWICK ST
GOODWIN ST
FULTON ST
WHEELER ST
LAURA ST
CHAMBERLAIN PL
BELLEVUE ST
JUDITH TER
CROFTON ST
CABOT ST
OVERLOOK ST
MILTON ST
PEAT MEADOW RD
BURWELL ST
CHESTER ST
IRVINGTON ST
ASHLAND PL
FORBES AVE
GOVERNOR JOHN
MINOTT ST
OAKLEY ST
BROWN PL
KENDALL ST
EDGEMERE RD
FULTON TER
ALBIA ST
STILES ST
ALABAMA ST
COLORADO AVE
CONNECTICUT AVE
ALLEN PL
FAIRVIEW PL
WOODWARD AVE
TOWNSEND AVE
I-95
CHURCH STREET EXT
JACKSON DR
HALLOCK AVE
LONG WHARF DR

7.2 Middletown Avenue / State Street Corridor from I-91 Exit 8 Interchange to State Street at Water Street/North Frontage Road

The results of the SYNCHRO analysis for the Middletown Avenue / State Street corridor are presented for the base and future transportation conditions for the weekday AM and PM peak hours. The priority locations along this corridor, which were included in the SYNCHRO analysis for years 2008 and 2012, were shown earlier in Figure 5.

The signal operations for the 16 priority intersections along the Middletown Avenue / State Street corridor fall into three basic groups: those along Middletown Avenue, those along upper State Street, and those along lower State Street. The signalized intersections along Middletown Avenue (except at Ferry Street) are under ConnDOT jurisdiction. They have loop detectors on minor movements, have coordinated-actuated capabilities and are part of a closed loop system. The signalized intersections along upper State Street (Humphrey Street and north, including Middletown Avenue and Ferry Street) are under City of New Haven jurisdiction. Most have pedestrian push buttons, and two intersections have loop detectors. The signalized intersections along lower State Street (Audubon Avenue and south) are also under City of New Haven jurisdiction. They have greater versatility than those on upper State Street. Most of the signalized intersections have pedestrian push buttons and coordination capabilities and two are traffic-demand actuated.

2005 AM Peak-Hour Conditions

As noted previously, the Ferry Street Bridge over the Quinnipiac River was closed during the year 2005. This appears to have had little impact on the Middletown Avenue / State Street corridor. Under existing conditions, all lane groups operate within the thresholds established for this study. However, a condition exists where the queue length exceeds the available storage on the northbound Ferry Street approach to State Street. The 95^{th} percentile queue length is projected to be about 520 feet compared to the 320-foot storage length. As a result, there are times when traffic backs up to the upstream intersection of Ferry Street and Middletown Avenue. Figures 20 and 21 present existing Levels of Service for upper State Street/Middletown Avenue and lower State Street, respectively.

2008 AM Peak-Hour Conditions and Potential Mitigation

During the year 2008, the Ferry Street Bridge is expected to stay closed and not reopen until the end of the year. The Grand Avenue Bridge is also expected to be closed during 2008. The east leg at the intersection of State Street and Grand Avenue will be completely closed off. This will affect operations on State Street at the intersections of Grove Street/Olive Street and Chapel Street, as drivers are expected to be diverted to these intersections. A growth rate of one per cent per year was applied to project 2008 traffic volumes. There is one intersection that is projected to exceed the threshold under the 2008 base condition. The northbound left-turn from Ferry Street onto State Street is projected to operate at LOS E with 78 seconds delay. All other movements at the intersections in this corridor are projected to operate within the threshold.

Using SYNCHRO software to simulate operations, traffic volume was incrementally added in the peak (westbound and southbound) direction until one or more lane groups reached the

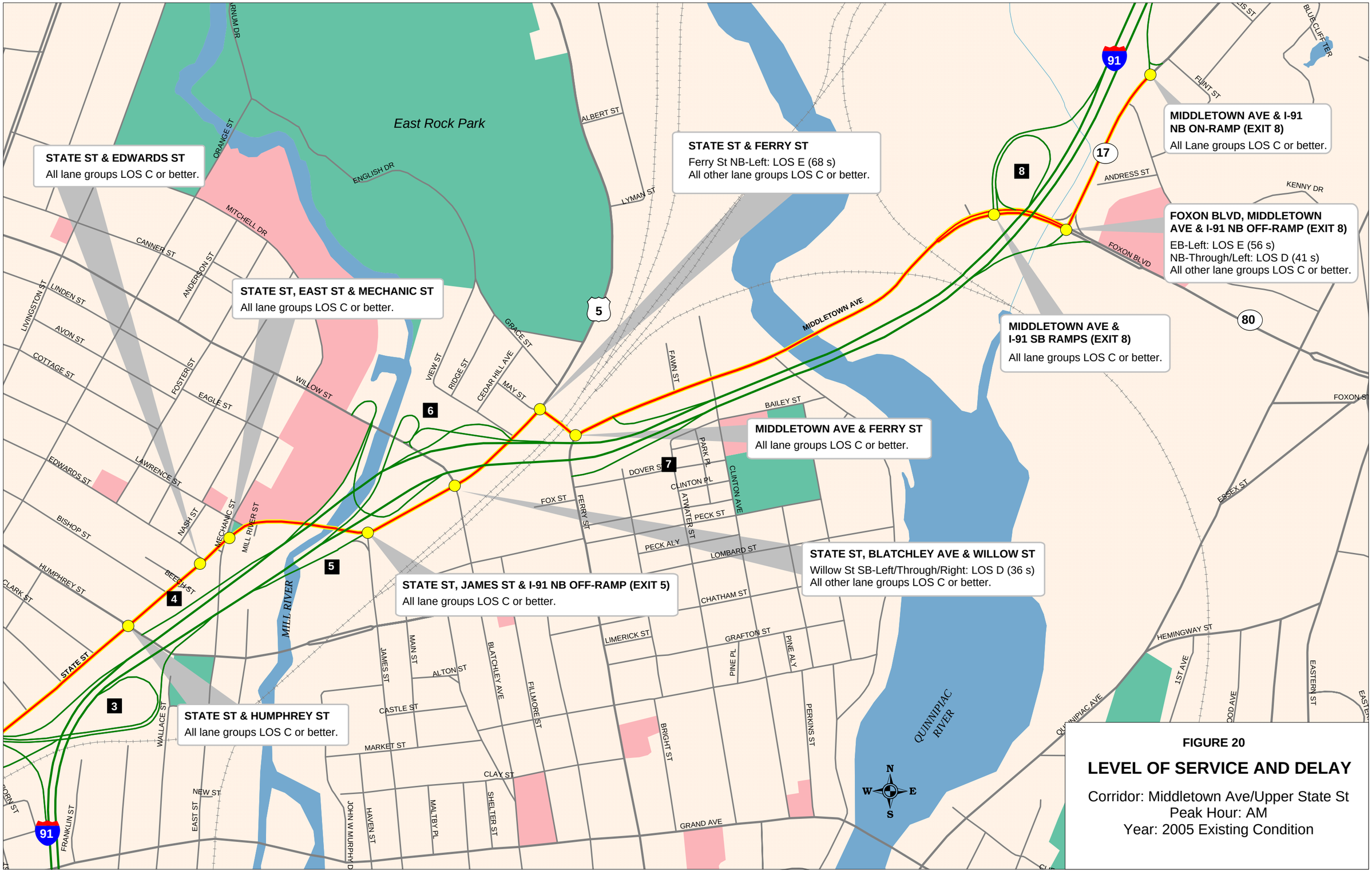


FIGURE 20

LEVEL OF SERVICE AND DELAY

Corridor: Middletown Ave/Upper State St
Peak Hour: AM
Year: 2005 Existing Condition

STATE ST, GROVE ST & OLIVE ST
NB-Left: LOS E (67 s)
NB-Through/Right: LOS D (40 s)
SB-Left: LOS D (41 s)
SB-Through/Right: LOS D (42 s)
All other lane groups LOS C or better.

STATE ST & AUDUBON ST
EB-Left: LOS D (39 s)
EB-Right: LOS D (44 s)
NB-Left: LOS D (36 s)
All other lane groups LOS C or better.

STATE ST, ELM ST & GRAND AVE
WB-Left: LOS D (48 s)
NB-Through/Right: LOS D (36 s)
All other lane groups LOS C or better.

STATE ST & CHAPEL ST
NB-Left: LOS D (45 s)
SB-Left: LOS E (56 s)
All other lane groups LOS C or better.

SB STATE ST, GEORGE ST & FAIR ST
EB-Through: LOS D (41 s)
EB-Right: LOS D (37 s)
All other lane groups LOS C or better.

NB STATE ST & FAIR ST
All lane groups LOS C or better.

FIGURE 21

LEVEL OF SERVICE AND DELAY

Corridor: Lower State St
Peak Hour: AM
Year: 2005 Existing Condition

established thresholds. The increments were applied as follows: the entry to the study area was via southbound I-91 Exit 8 right-turn at Middletown Avenue. Increments were then applied on westbound Middletown Avenue until its terminus at Ferry Street, where they were applied to the westbound right-turn. Then the increments were applied to the northbound left-turn at State Street, and then on westbound/southbound State Street to the downtown area. The increments were applied to right-turns from State Street to the downtown area in the following proportion: 40 per cent at Grove Street, 10 percent at Wall Street, 30 per cent at Chapel Street and 20 per cent at Crown Street. Mitigation measures were then applied to identify additional increments in traffic that could be accommodated. However, mitigation includes new signal hardware that would not be considered low-cost.

Mitigation measures for the study intersections are presented in two separate figures for clarity - Figure 22 for Middletown Avenue and upper State Street (south to Humphrey Street), and Figure 23 for lower State Street. A summary of general mitigation measures is as follows:

- Middletown Avenue – no mitigation needed.

- Upper State Street

    1. Set the cycle length to 90 seconds. Reallocate green time as necessary to balance intersection operations so that no movement exceeds the threshold.

    2. Allow coordination by giving unused pedestrian time (and minor movement time for the intersections that are actuated) to the major movements. Currently, when the push buttons are activated, the crossing time is added to the cycle so that offsets do not achieve the desired signal progression. This will require new signal hardware.

    3. Set offsets to achieve progression in the peak direction.

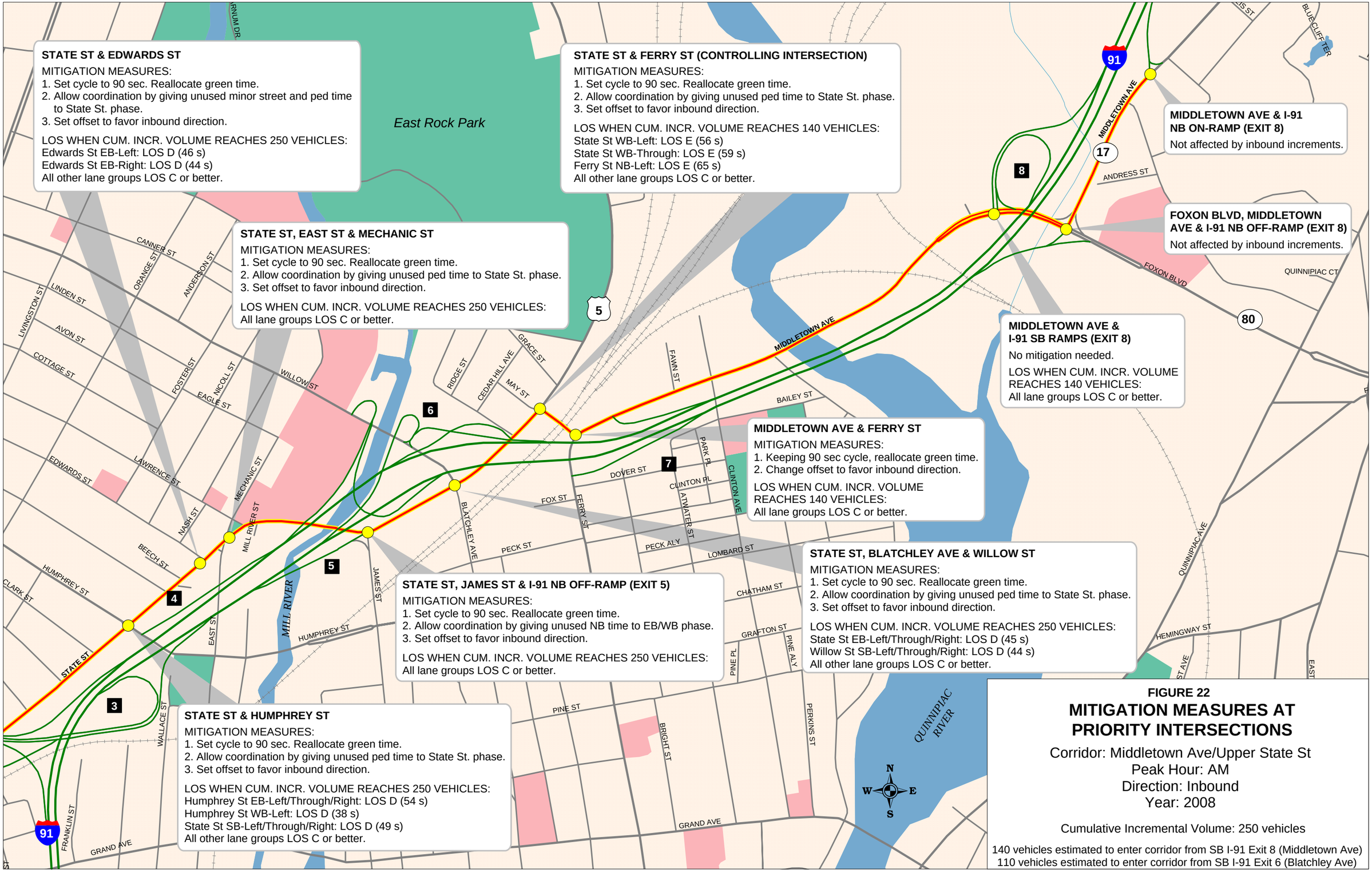
- Lower State Street

    1. Set cycle length to a uniform 90 seconds (most intersections are already set at 90 seconds). Reallocate green time as necessary.

    2. Allow coordination by giving unused pedestrian time and minor movement time to the southbound movement (this condition already exists for most of these intersections).

    3. Set offsets to optimize progression along State Street.

In addition, there are two location-specific mitigation measures. Currently, there is one through lane and one exclusive left-turn lane on the southbound State Street approach at Audubon Street. Less than 20 vehicles per hour make this southbound left-turn, since Audubon Street dead ends at the eastern leg. This may be the remnant from when Audubon Street connected to Olive Street. In addition, continuing south at the far side of the intersection, yellow diagonal striping effectively narrows the usable pavement to allow only one southbound lane. However, downstream at the approach to Grove Street/Olive Street, the roadway flairs to allow two through lanes and one left-turn lane. Drivers were observed driving over the yellow striping and using the roadway as two lanes. It is recommended to convert the left-turn lane at the southbound


East Rock Park
STATE ST & EDWARDS ST
MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused minor street and ped time to State St. phase.
3. Set offset to favor inbound direction.
LOS WHEN CUM. INCR. VOLUME REACHES 250 VEHICLES:
Edwards St EB-Left: LOS D (46 s)
Edwards St EB-Right: LOS D (44 s)
All other lane groups LOS C or better.
STATE ST & FERRY ST (CONTROLLING INTERSECTION)
MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused ped time to State St. phase.
3. Set offset to favor inbound direction.
LOS WHEN CUM. INCR. VOLUME REACHES 140 VEHICLES:
State St WB-Left: LOS E (56 s)
State St WB-Through: LOS E (59 s)
Ferry St NB-Left: LOS E (65 s)
All other lane groups LOS C or better.
MIDDLETOWN AVE & I-91 NB ON-RAMP (EXIT 8)
Not affected by inbound increments.
FOXON BLVD, MIDDLETOWN AVE & I-91 NB OFF-RAMP (EXIT 8)
Not affected by inbound increments.
STATE ST, EAST ST & MECHANIC ST
MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused ped time to State St. phase.
3. Set offset to favor inbound direction.
LOS WHEN CUM. INCR. VOLUME REACHES 250 VEHICLES:
All lane groups LOS C or better.
MIDDLETOWN AVE & I-91 SB RAMPS (EXIT 8)
No mitigation needed.
LOS WHEN CUM. INCR. VOLUME REACHES 140 VEHICLES:
All lane groups LOS C or better.
MIDDLETOWN AVE & FERRY ST
MITIGATION MEASURES:
1. Keeping 90 sec cycle, reallocate green time.
2. Change offset to favor inbound direction.
LOS WHEN CUM. INCR. VOLUME REACHES 140 VEHICLES:
All lane groups LOS C or better.
STATE ST, JAMES ST & I-91 NB OFF-RAMP (EXIT 5)
MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused NB time to EB/WB phase.
3. Set offset to favor inbound direction.
LOS WHEN CUM. INCR. VOLUME REACHES 250 VEHICLES:
All lane groups LOS C or better.
STATE ST, BLATCHLEY AVE & WILLOW ST
MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused ped time to State St. phase.
3. Set offset to favor inbound direction.
LOS WHEN CUM. INCR. VOLUME REACHES 250 VEHICLES:
State St EB-Left/Through/Right: LOS D (45 s)
Willow St SB-Left/Through/Right: LOS D (44 s)
All other lane groups LOS C or better.
STATE ST & HUMPHREY ST
MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused ped time to State St. phase.
3. Set offset to favor inbound direction.
LOS WHEN CUM. INCR. VOLUME REACHES 250 VEHICLES:
Humphrey St EB-Left/Through/Right: LOS D (54 s)
Humphrey St WB-Left: LOS D (38 s)
State St SB-Left/Through/Right: LOS D (49 s)
All other lane groups LOS C or better.
FIGURE 22
MITIGATION MEASURES AT PRIORITY INTERSECTIONS
Corridor: Middletown Ave/Upper State St
Peak Hour: AM
Direction: Inbound
Year: 2008
Cumulative Incremental Volume: 250 vehicles
140 vehicles estimated to enter corridor from SB I-91 Exit 8 (Middletown Ave)
110 vehicles estimated to enter corridor from SB I-91 Exit 6 (Blatchley Ave)
MIDDLETOWN AVE
STATE ST
MILL RIVER
QUINNIPIAC RIVER
BLUE CLIFF TER
ANDRESS ST
FOXON BLVD
QUINNIPIAC CT
QUINNIPIAC AVE
HEMINGWAY ST
CANNER ST
LINDEN ST
AVON ST
COTTAGE ST
LIVINGSTON ST
ORANGE ST
ANDERSON ST
FOSTER ST
EAGLE ST
NICOLL ST
WILLOW ST
RIDGE ST
CEDAR HILL AVE
GRACE ST
MAY ST
FAWN ST
BAILEY ST
EDWARDS ST
LAWRENCE ST
MECHANIC ST
NASH ST
BEECH ST
MILL RIVER ST
HUMPHREY ST
CLARK ST
EAST ST
JAMES ST
WALLACE ST
FRANKLIN ST
GRAND AVE
BLATCHLEY AVE
PECK ST
FOX ST
FERRY ST
DOVER ST
PARK PL
CLINTON PL
ATWATER ST
CLINTON AVE
PECK ALY
LOMBARD ST
CHATHAM ST
GRAFTON ST
PINE PL
PINE ALY
PINE ST
BRIGHT ST
PERKINS ST
N
W
E
S

STATE ST, GROVE ST & OLIVE ST (CONTROLLING INTERSECTION)

MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused left-turn and ped time to NB/SB phase.
3. Set offset to favor SB-Left and SB-Through movements.

LOS WHEN CUM. INCR. VOLUME REACHES 250 VEHICLES (150 SB-THROUGH, 100 SB-RIGHT):
WB-Left/Through/Right: LOS E (58 s)
NB-Left: LOS D (52 s)
SB-Left/Through/Right: LOS E (58 s)
All other lane groups LOS C or better.

STATE ST & AUDUBON ST

MITIGATION MEASURES:
1. Restripe SB left-turn lane to shared through/left lane. Remove yellow diagonal striping on far side of intersection. to allow two SB through lanes.
2. Set offset to favor SB direction.

LOS WHEN CUM. INCR. VOLUME REACHES 250 VEHICLES:
EB-Right: LOS D (46 s)
All other lane groups LOS C or better.

STATE ST, ELM ST & GRAND AVE

MITIGATION MEASURES:
1. Change phasing to skip WB phase. Reallocate green time.
2. Set offset to favor SB direction.

LOS WHEN CUM. INCR. VOLUME REACHES 250 VEHICLES (125 SB-THROUGH AT THIS INTERSECTION):
EB-Left: LOS D (42 s)
SB-Through: LOS D (42 s)
All other lane groups LOS C or better.

STATE ST & CHAPEL ST

MITIGATION MEASURES:
1. Keeping 90 sec cycle, reallocate green time.
2. Allow coordination by giving unused left-turn and ped time to NB/SB phase.
3. Set offset to favor SB direction.

LOS WHEN CUM. INCR. VOLUME REACHES 250 VEHICLES (50 SB-THROUGH, 75 SB-RIGHT AT THIS INTERSECTION):
EB-Left/Through/Right: LOS D (47 s)
WB-Left/Through/Right: LOS D (53 s)
All other lane groups LOS C or better.

SB STATE ST, GEORGE ST & FAIR ST

Not affected by inbound increments.

NB STATE ST & FAIR ST

Not affected by inbound increments.

FIGURE 23

MITIGATION MEASURES AT PRIORITY INTERSECTIONS

Corridor: Lower State St
Peak Hour: AM
Direction: Inbound
Year: 2008

Cumulative Incremental Volume: 250 vehicles

Volume estimated to exit corridor by turning right from SB State St onto Grove St (100 veh), Wall St (25 veh), Chapel St (75 veh) and Crown St (50 veh)

approach at Audubon Street to shared through/left, and remove the yellow diagonal striping in the southbound lanes south of Audubon Street to provide two lanes for through traffic.

The other location-specific mitigation measure is to set the offset to allow coordination with the southbound right-turn at Grove Street and the next signal at Orange Street. Spillback on southbound State Street at Grove Street was observed as a result of poor progression on westbound Grove Street at Orange Street.

When applying these mitigation measures after incrementally adding volume to the corridor, a practical limit was reached at State Street and Ferry Street. A cumulative incremental volume of 140 vehicles for the northbound left-turn is the most this intersection can handle without exceeding the threshold. The mitigation measures (using a common 90 second cycle length and setting the offsets to minimize the number of vehicles that get trapped on Ferry Street between Middletown Avenue and State Street) would reduce the existing queuing problem on the northbound Ferry Street approach. However, if more than about 140 vehicles bound for downtown use Exit 8 from southbound I-91 to avoid construction delays, they will encounter a bottleneck when turning left from northbound Ferry Street to westbound State Street. In addition, with the reduction of green time on westbound State Street to accommodate the increment for the northbound left-turn movement, the available storage on this approach is just enough to handle the 95 percentile queue lengths. Therefore, this is the controlling intersection.

However, additional traffic increments could be accommodated if drivers can continue on southbound I-91 to Exit 6 (Blatchley Avenue) and bypass the controlling intersection of State Street and Ferry Street. They would enter the corridor via the southbound right-turn from Willow Street onto State Street. An additional 110 vehicles (250 cumulative increment) could be accommodated in this manner with the controlling intersection then becoming State Street and Grove Street/Olive Street. At this point, no further increments could be accommodated using low-cost measures.

2012 AM Peak-Hour Conditions and Potential Mitigation

During the year 2012, the Ferry Street Bridge and the Grand Avenue Bridge are expected to be open. The Ferry Street Bridge opening is expected to have a minimal impact on the Middletown Avenue / State Street corridor. However, the opening of the Grand Avenue Bridge is expected to positively affect traffic conditions at the intersections of State Street at Grove Street/Olive Street, Grand Avenue/Elm Street, and Chapel Street.

A growth rate of one per cent per year was applied to project 2012 traffic volumes. The network was analyzed using SYNCHRO for the 2012 volumes with the same mitigation measures for 2008 applied. Figures 24 and 25 present the results for upper State Street/Middletown Avenue and lower State Street, respectively. Once again, the controlling intersection was State Street and Ferry Street. With additional reallocation of green time from the 2008 settings, the practical limit was reached at a cumulative increment of 100 vehicles, 40 less than during the year 2008.

An additional increment of 140 vehicles (240 cumulative increment) can be achieved by using Exit 6 as an alternate to Exit 8 as described for the year 2008. The controlling intersection for this additional increment would be State Street and Blatchley Avenue. This represents a change

STATE ST & EDWARDS ST

MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused minor street and ped time to State St. phase.
3. Set offset to favor inbound direction.

LOS WHEN CUM. INCR. VOLUME REACHES 240 VEHICLES:
Edwards St EB-Left: LOS D (46 s)
Edwards St EB-Right: LOS D (44 s)
All other lane groups LOS C or better.

STATE ST & FERRY ST (CONTROLLING INTERSECTION)

MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused ped time to State St. phase.
3. Set offset to favor inbound direction.

LOS WHEN CUM. INCR. VOLUME REACHES 100 VEHICLES:
State St WB-Left: LOS D (47 s)
State St WB-Through: LOS E (54 s)
Ferry St NB-Left: LOS E (69 s)
All other lane groups LOS C or better.

MIDDLETOWN AVE & I-91 NB ON-RAMP (EXIT 8)

Not affected by inbound increments.

STATE ST, EAST ST & MECHANIC ST

MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused ped time to State St. phase.
3. Set offset to favor inbound direction.

LOS WHEN CUM. INCR. VOLUME REACHES 240 VEHICLES:
All lane groups LOS C or better.

FOXON BLVD, MIDDLETOWN AVE & I-91 NB OFF-RAMP (EXIT 8)

Not affected by inbound increments.

MIDDLETOWN AVE & I-91 SB RAMPS (EXIT 8)

No mitigation needed.

LOS WHEN CUM. INCR. VOLUME REACHES 100 VEHICLES:
All lane groups LOS C or better.

MIDDLETOWN AVE & FERRY ST

MITIGATION MEASURES:
1. Keeping 90 sec cycle, reallocate green time.
2. Change offset to favor inbound direction.

LOS WHEN CUM. INCR. VOLUME REACHES 100 VEHICLES:
All lane groups LOS C or better.

STATE ST, JAMES ST & I-91 NB OFF-RAMP (EXIT 5)

MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused NB time to EB/WB phase.
3. Set offset to favor inbound direction.

LOS WHEN CUM. INCR. VOLUME REACHES 240 VEHICLES:
All lane groups LOS C or better.

STATE ST, BLATCHLEY AVE & WILLOW ST (CONTROLLING INTERSECTION)

MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused ped time to State St. phase.
3. Set offset to favor inbound direction.

LOS WHEN CUM. INCR. VOLUME REACHES 240 VEHICLES:
State St EB-Left/Through/Right: LOS E (58 s)
Willow St SB-Left/Through/Right: LOS E (58 s)
All other lane groups LOS C or better.

STATE ST & HUMPHREY ST

MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused ped time to State St. phase.
3. Set offset to favor inbound direction.

LOS WHEN CUM. INCR. VOLUME REACHES 240 VEHICLES:
Humphrey St EB-Left/Through/Right: LOS E (59 s)
Humphrey St WB-Left: LOS D (42 s)
State St SB-Left/Through/Right: LOS D (50 s)
All other lane groups LOS C or better.

FIGURE 24

MITIGATION MEASURES AT PRIORITY INTERSECTIONS

Corridor: Middletown Ave/Upper State St
Peak Hour: AM
Direction: Inbound
Year: 2012

Cumulative Incremental Volume: 240 vehicles

100 vehicles estimated to enter corridor from SB I-91 Exit 8 (Middletown Ave)
140 vehicles estimated to enter corridor from SB I-91 Exit 6 (Blatchley Ave)

STATE ST, GROVE ST & OLIVE ST

MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused left-turn and ped time to NB/SB phase.
3. Set offset to favor SB-Left and SB-Through movements.

LOS WHEN CUM. INCR. VOLUME REACHES 240 VEHICLES (144 SB-THROUGH, 96 SB-RIGHT):
WB-Left/Through/Right: LOS D (41 s)
NB-Left: LOS E (58 s)
SB-Left/Through/Right: LOS D (50 s)
All other lane groups LOS C or better.

STATE ST & AUDUBON ST

MITIGATION MEASURES:
1. Restripe SB left-turn lane to shared through/left lane. Remove yellow diagonal striping on far side of intersection. to allow two SB through lanes.
2. Set offset to favor SB direction.

LOS WHEN CUM. INCR. VOLUME REACHES 240 VEHICLES:
EB-Left: LOS D (40 s)
EB-Right: LOS D (42 s)
NB-Left: LOS D (36 s)
All other lane groups LOS C or better.

STATE ST, ELM ST & GRAND AVE

MITIGATION MEASURES:
1. Change phasing to include WB phase. Reallocate green time.
2. Set offset to favor SB direction.

LOS WHEN CUM. INCR. VOLUME REACHES 240 VEHICLES (120 SB-THROUGH AT THIS INTERSECTION):
EB-Left: LOS D (36 s)
WB-Left: LOS D (49 s)
SB-Through: LOS D (43 s)
All other lane groups LOS C or better.

STATE ST & CHAPEL ST

MITIGATION MEASURES:
1. Keeping 90 sec cycle, reallocate green time.
2. Allow coordination by giving unused left-turn and ped time to NB/SB phase.
3. Set offset to favor SB direction.

LOS WHEN CUM. INCR. VOLUME REACHES 240 VEHICLES (48 SB-THROUGH, 72 SB-RIGHT AT THIS INTERSECTION):
EB-Left/Through/Right: LOS D (36 s)
SB-Right: LOS D (37 s)
All other lane groups LOS C or better.

SB STATE ST, GEORGE ST & FAIR ST

Not affected by inbound increments.

NB STATE ST & FAIR ST

Not affected by inbound increments.

FIGURE 25

MITIGATION MEASURES AT PRIORITY INTERSECTIONS

Corridor: Lower State St
Peak Hour: AM
Direction: Inbound
Year: 2012

Cumulative Incremental Volume: 240 vehicles

Volume estimated to exit corridor by turning right from SB State St onto Grove St (96 veh), Wall St (24 veh), Chapel St (72 veh) and Crown St (48 veh)

from 2008 when the controlling intersection was State Street and Grove Street/Olive Street. The opening of the Grand Avenue Bridge is expected to bring some relief to this intersection of State Street and Grove Street/Olive Street.

2005 PM Peak-Hour Conditions

Figures 26 and 27 present existing Levels of Service for upper State Street/Middletown Avenue and lower State Street, respectively. The following lane groups either operate above the threshold and/or the 95 percentile queue length exceeds the storage length under existing conditions:

- Eastbound State Street approach at East Street.
- Eastbound Grove Street approach at State Street.
- Elm Street eastbound through/right lane group at State Street.
- Southbound State Street left turn at Chapel Street.

These conditions will be mitigated during the increment analysis process.

2008 PM Peak-Hour Conditions and Potential Mitigation

The closing of the Grand Avenue Bridge during the year 2008 is expected to have significant impacts along lower State Street during the PM period. In particular, eastbound and westbound Grand Avenue traffic will be diverted to either State Street at Grove Street/Olive Street to the north, or State Street at Chapel Street to the south. Without mitigation, these two intersections are projected to operate beyond the established thresholds, even without any incremental volume,.

The following mitigation could help alleviate the adverse effects of closing the Grand Avenue Bridge:

- Prohibit parking during the PM peak period on the south side of Chapel Street, west of State Street, to allow two eastbound approach lanes on Chapel Street at State Street.

- Similarly, prohibit parking during the PM peak period on the south side of Grove Street, west of State Street, to allow two eastbound approach lanes on Grove Street at State Street.

With these measures, along with the general mitigation measures mentioned previously, traffic volume was incrementally added in the peak (northbound and eastbound) direction until one or more lane groups reached the established thresholds. The results are shown in Figures 28 and 29 for upper State Street/Middletown Avenue and lower State Street, respectively. A cumulative increment of 50 vehicles can be accommodated. Beyond that, the threshold would be reached at the controlling intersection of State Street and Grove Street/Olive Street. There were two entry points to the State Street study corridor. Half of the increments were added via the through movement on eastbound George Street at southbound State Street to Fair Street, then left onto northbound State Street. The other half was added via the left turn from eastbound Elm Street to northbound State Street. The rest of the corridor is essentially the reverse of the AM route, following State Street north and east to Ferry Street, right onto Ferry Street, left onto Middletown Avenue to the northbound on-ramp to I-91 at Exit 8.

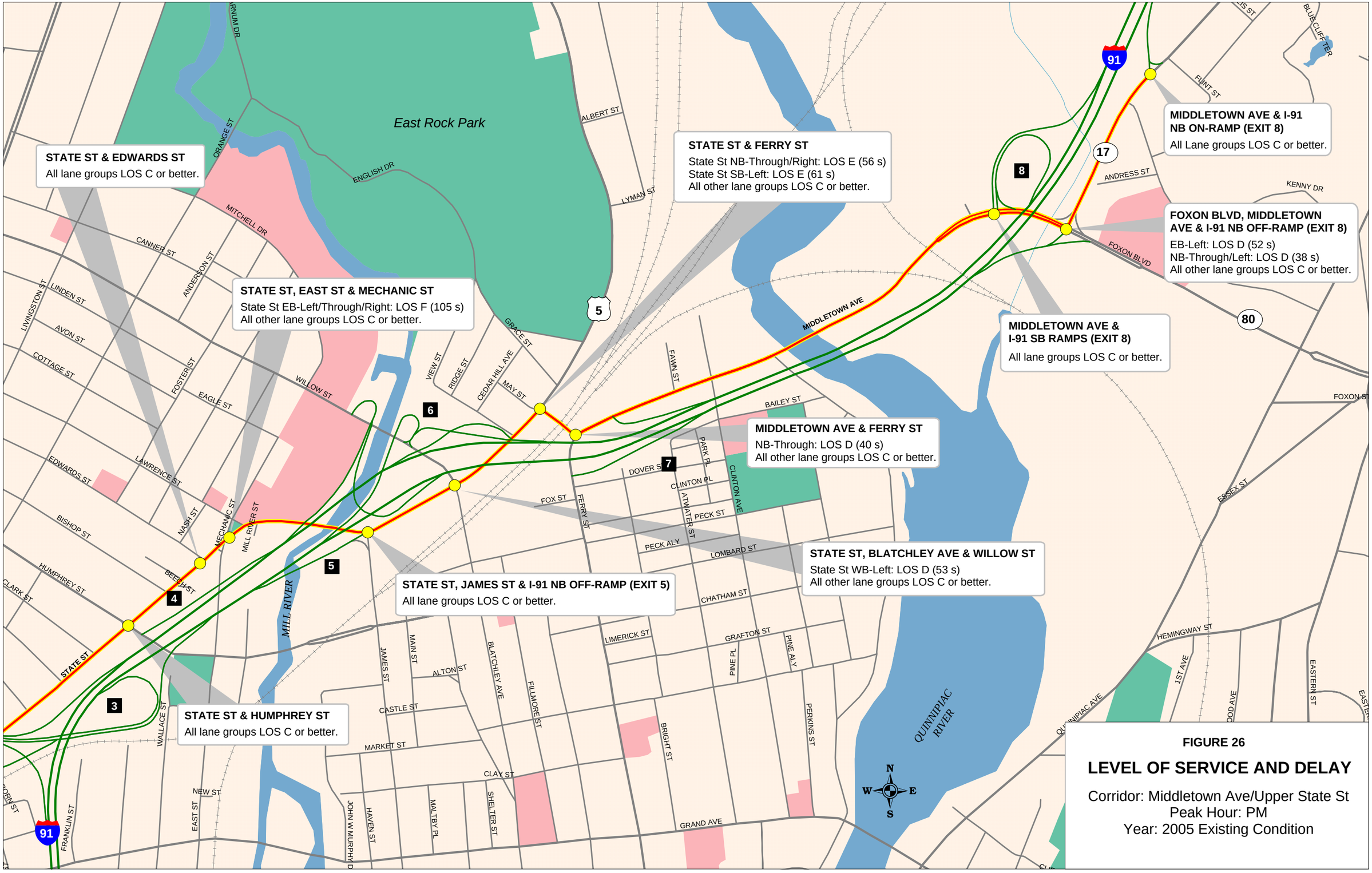
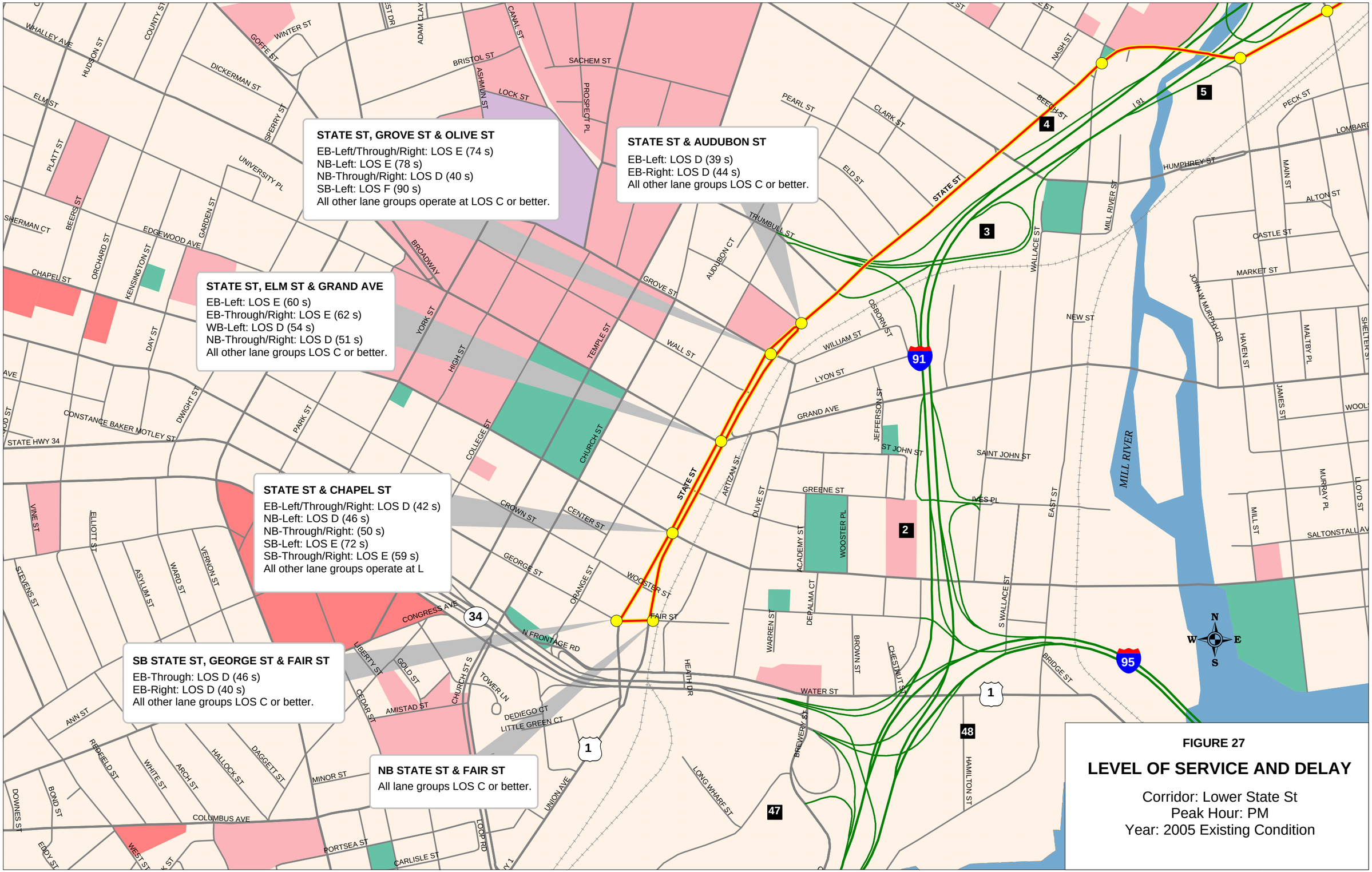


FIGURE 26

LEVEL OF SERVICE AND DELAY

Corridor: Middletown Ave/Upper State St
Peak Hour: PM
Year: 2005 Existing Condition


STATE ST, GROVE ST & OLIVE ST
EB-Left/Through/Right: LOS E (74 s)
NB-Left: LOS E (78 s)
NB-Through/Right: LOS D (40 s)
SB-Left: LOS F (90 s)
All other lane groups operate at LOS C or better.
STATE ST & AUDUBON ST
EB-Left: LOS D (39 s)
EB-Right: LOS D (44 s)
All other lane groups LOS C or better.
STATE ST, ELM ST & GRAND AVE
EB-Left: LOS E (60 s)
EB-Through/Right: LOS E (62 s)
WB-Left: LOS D (54 s)
NB-Through/Right: LOS D (51 s)
All other lane groups LOS C or better.
STATE ST & CHAPEL ST
EB-Left/Through/Right: LOS D (42 s)
NB-Left: LOS D (46 s)
NB-Through/Right: (50 s)
SB-Left: LOS E (72 s)
SB-Through/Right: LOS E (59 s)
All other lane groups operate at L
SB STATE ST, GEORGE ST & FAIR ST
EB-Through: LOS D (46 s)
EB-Right: LOS D (40 s)
All other lane groups LOS C or better.
NB STATE ST & FAIR ST
All lane groups LOS C or better.
WHALLEY AVE
HUDSON ST
COUNTY ST
GOFFE ST
WINTER ST
DICKERMAN ST
ELM ST
SPERRY ST
ADAM CLAY ST DR
BRISTOL ST
ASHMUN ST
CANAL ST
SACHEM ST
LOCK ST
PROSPECT PL
PLATT ST
UNIVERSITY PL
BEERS ST
SHERMAN CT
EDGEWOOD AVE
GARDEN ST
ORCHARD ST
KENSINGTON ST
CHAPEL ST
BROADWAY
YORK ST
DAY ST
HIGH ST
TEMPLE ST
GROVE ST
WALL ST
AUDUBON CT
TRUMBULL ST
PEARL ST
CLARK ST
ELD ST
NASH ST
BEECH ST
191
PECK ST
LOMBARD
HUMPHREY ST
MAIN ST
ALTON ST
CASTLE ST
MARKET ST
JOHN W MURPHY DR
HAVEN ST
MALTBY PL
JAMES ST
WOOL
SHELTER ST
NEW ST
OSBORN ST
WILLIAM ST
LYON ST
GRAND AVE
JEFFERSON ST
ST JOHN ST
SAINT JOHN ST
MILL RIVER
MILL RIVER ST
WALLACE ST
STATE ST
91
95
34
1
2
3
4
5
47
48
CONSTANCE BAKER MOTLEY ST
STATE HWY 34
DWIGHT ST
PARK ST
COLLEGE ST
CHURCH ST
CROWN ST
CENTER ST
GEORGE ST
ORANGE ST
WOOSTER ST
FAIR ST
CONGRESS AVE
N FRONTAGE RD
LIBERTY ST
GOLD ST
CEDAR ST
AMISTAD ST
CHURCH ST S
TOWER LN
DEDIEGO CT
LITTLE GREEN CT
HEATH DR
WATER ST
BREWERY ST
LONG WHARF ST
UNION AVE
MINOR ST
COLUMBUS AVE
PORTSEA ST
CARLISLE ST
LOOP RD
VINE ST
ELLIOTT ST
ASYLUM ST
WARD ST
VERNON ST
STEVENS ST
ANN ST
REDFIELD ST
WHITE ST
ARCH ST
HALLOCK ST
DAGGETT ST
DOWNES ST
BOND ST
EDDY ST
WEST ST
ARTIZAN ST
OLIVE ST
GREENE ST
IVES PL
WOOSTER PL
ACADEMY ST
DEPALMA CT
WARREN ST
BROWN ST
CHESTNUT ST
S WALLACE ST
EAST ST
HAMILTON ST
BRIDGE ST
MILL ST
MURRAY PL
LLOYD ST
SALTONSTALL AV
N
W
E
S
FIGURE 27
LEVEL OF SERVICE AND DELAY
Corridor: Lower State St
Peak Hour: PM
Year: 2005 Existing Condition

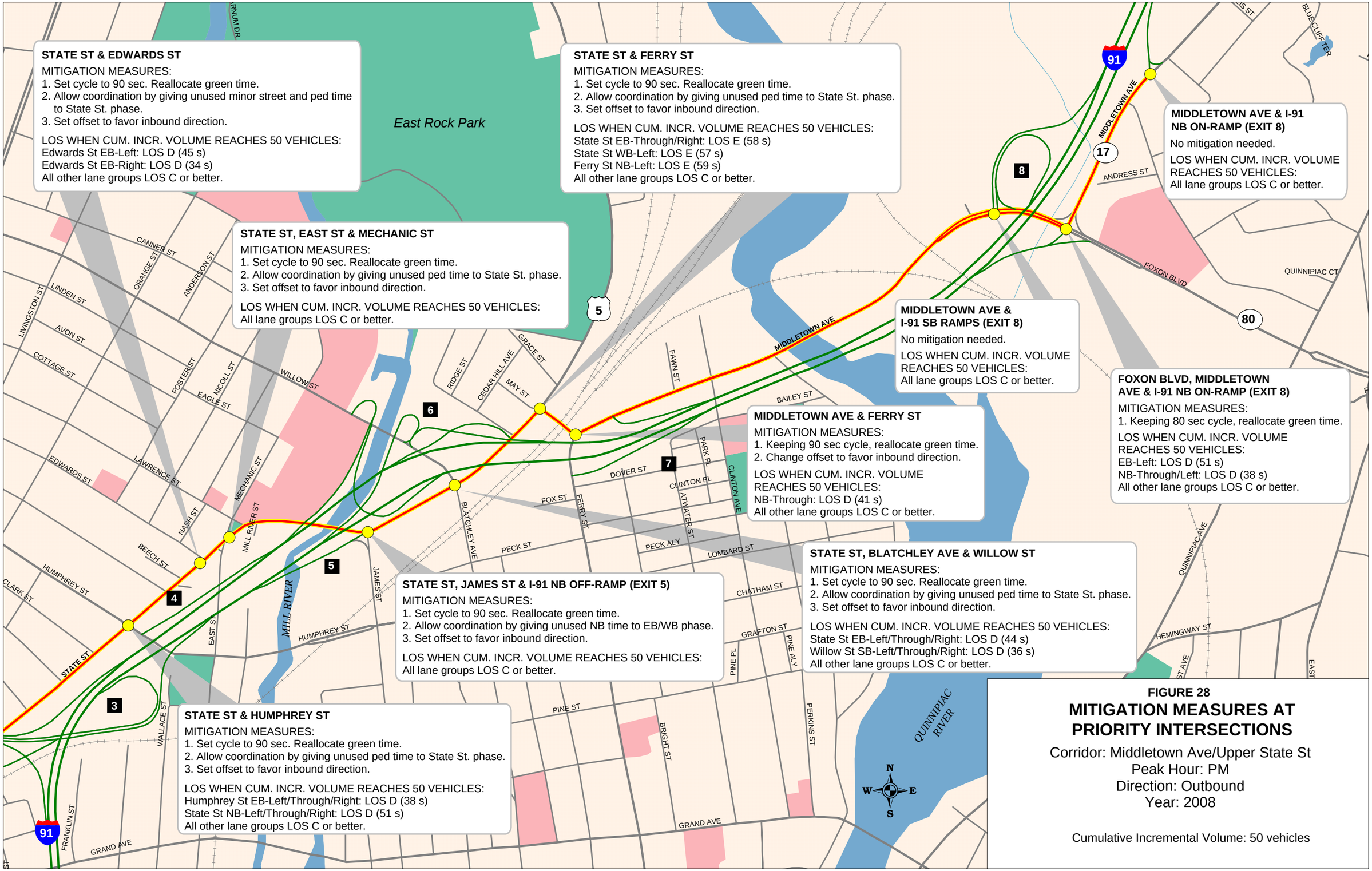


FIGURE 28

MITIGATION MEASURES AT PRIORITY INTERSECTIONS

Corridor: Middletown Ave/Upper State St
Peak Hour: PM
Direction: Outbound
Year: 2008

Cumulative Incremental Volume: 50 vehicles

STATE ST, GROVE ST & OLIVE ST (CONTROLLING INTERSECTION)

MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused left-turn and ped time to NB/SB phase.
3. Set offset to favor SB-Left and SB-Through movements.
4. Prohibit parking on south side of Grove St. east of State St. during PM peak.

LOS WHEN CUM. INCR. VOLUME REACHES 50 VEHICLES:
WB-Left/Through/Right: LOS E (66 s)
NB-Left: LOS D (37 s)
NB-Through/Right: LOS E (60 s)
SB-Left: LOS E (62 s)
SB-Through/Right: LOS D (39 s)
All other lane groups operate at LOS C or better.

STATE ST & AUDUBON ST

MITIGATION MEASURES:
1. Restripe SB left-turn lane to shared through/left lane. Remove yellow diagonal striping on far side of intersection. to allow two SB through lanes.
2. Optimize offset.

LOS WHEN CUM. INCR. VOLUME REACHES 50 VEHICLES:
EB-Left: LOS D (36 s)
EB-Right: LOS D (46 s)
All other lane groups LOS C or better.

STATE ST, ELM ST & GRAND AVE

MITIGATION MEASURES:
1. Change phasing to skip WB phase. Reallocate green time.
2. Optimize offset.

LOS WHEN CUM. INCR. VOLUME REACHES 50 VEHICLES (25 EB-LEFT, 25 NB-THROUGH):
All lane groups LOS C or better.

STATE ST & CHAPEL ST

MITIGATION MEASURES:
1. Keeping 90 sec cycle, reallocate green time.
2. Allow coordination by giving unused left-turn and ped time to NB/SB phase.
3. Optimize offset.
4. Prohibit parking on south side of Chapel St. east of State St. during PM peak.

LOS WHEN CUM. INCR. VOLUME REACHES 50 VEHICLES (25 NB-THROUGH AT THIS INTERSECTION):
WB-Left/Through/Right: LOS D (50 s)
NB-Left: LOS D (41 s)
NB-Through/Right: LOS D (46 s)
SB-Left: LOS E (65 s)
All other lane groups operate at LOS C or better.

SB STATE ST, GEORGE ST & FAIR ST

MITIGATION MEASURES:
1. Optimize offset.

LOS WHEN CUM. INCR. VOLUME REACHES 50 VEHICLES (25 EB-THROUGH AT THIS INTERSECTION):
EB-Through: LOS D (39 s)
EB-Right: LOS D (39 s)
All other lane groups LOS C or better.

NB STATE ST & FAIR ST

MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Optimize offset.

LOS WHEN CUM. INCR. VOLUME REACHES 50 VEHICLES (25 EB-LEFT AT THIS INTERSECTION):
All lane groups LOS C or better.

FIGURE 29

MITIGATION MEASURES AT PRIORITY INTERSECTIONS

Corridor: Lower State St
Peak Hour: PM
Direction: Outbound
Year: 2008

Cumulative Incremental Volume: 50 vehicles

Volume estimated to enter corridor by turning left onto NB State Street from EB Elm Street (25 veh) and EB George St/Fair St (25 veh)

2012 PM Peak-Hour Conditions and Potential Mitigation

The opening of the Grand Avenue Bridge during 2012 will provide some relief for the lower State Street corridor. A cumulative increment of 80 vehicles can be accommodated. The results are presented in Figures 30 and 31 for upper State Street/Middletown Avenue and lower State Street, respectively. The controlling intersection is State Street and Ferry Street. Due to the typically greater number of non-work trips during the PM peak period, the incremental volume in the outbound direction during the PM peak hour is less than in the inbound direction during the AM peak hour.

7.3 Grand Avenue Corridor from Quinnipiac Avenue to State Street

The results of the SYNCHRO analysis for the Grand Avenue corridor are presented for the base and future transportation conditions for the weekday AM and PM peak hours. The priority locations along this corridor, which were included in the SYNCHRO analysis for 2012, were shown earlier in Figure 7. In 2008, the replacement of the Grand Avenue Bridge over AMTRAK (State Project 92-412) will require full closure during the construction period. This will create a discontinuity in the Grand Avenue corridor that will constrain the traffic volume that could be accommodated. As a result, there is no incremental volume projected for this corridor in 2008. The traffic analysis to identify the incremental volume was focused on 2012, by which time the construction on the Grand Avenue Bridge will have been completed.

The signals on Grand Avenue are all under City of New Haven jurisdiction. Most have loop detectors on the cross street approaches and in the left-turn lanes, pedestrian push buttons, and coordinated- actuated capabilities. The intersection of Foxon Boulevard and Quinnipiac Avenue is considered part of this corridor because drivers that would be diverted to Grand Avenue may pass through this intersection. The traffic signal at this intersection, which is under ConnDOT jurisdiction, has loop detectors in the left-turn lanes and on the cross street approaches, pedestrian push buttons, and coordinated-actuated capabilities.

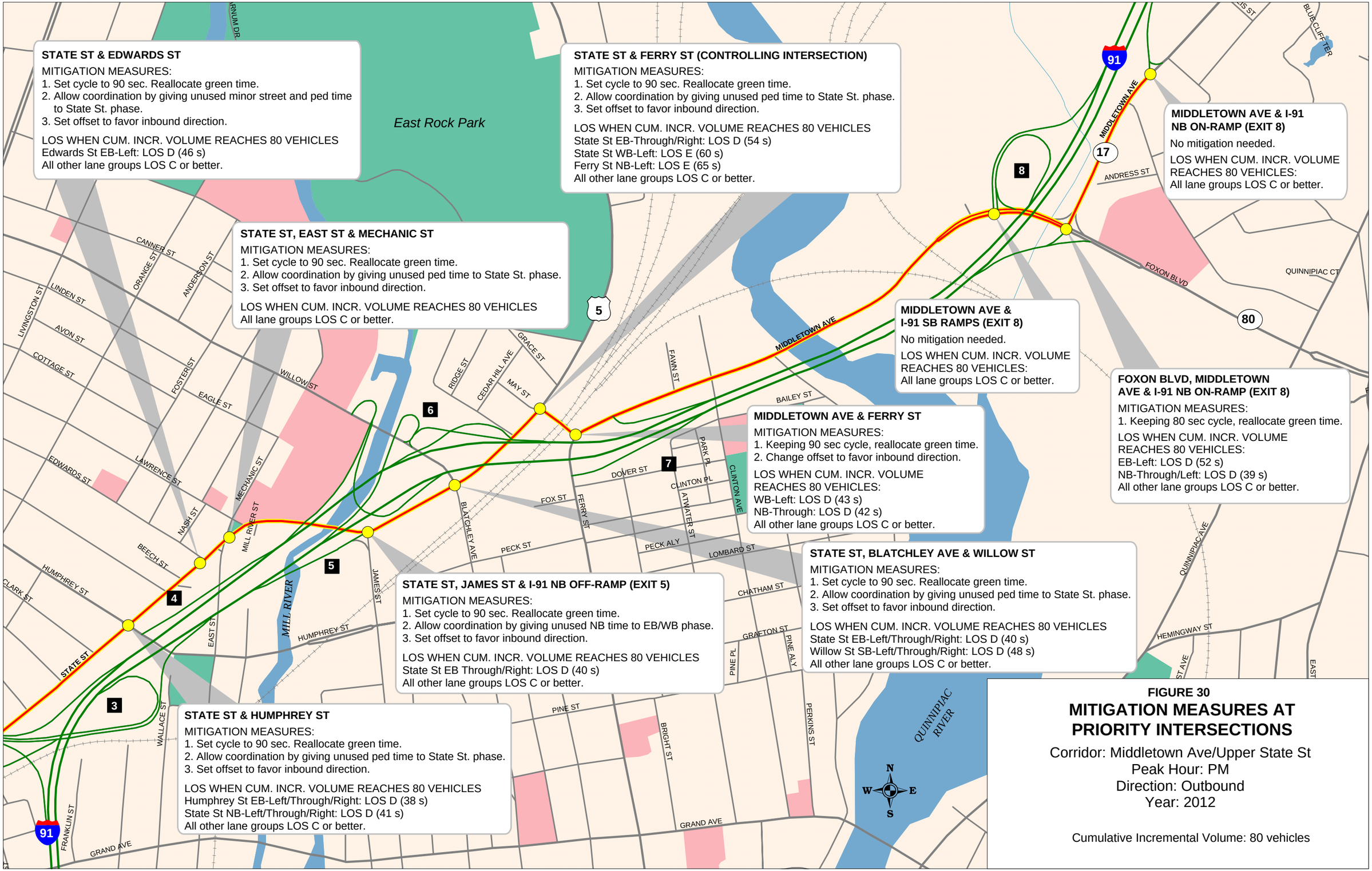
2005 AM Peak-Hour Conditions

As noted previously, the Ferry Street Bridge over the Quinnipiac River was closed in 2005. This has impacted the Grand Avenue corridor, especially in the area of Ferry Street and Quinnipiac Avenue. Figure 32 presents existing Levels of Service for the corridor. All lane groups operate at or below the established threshold, except the southbound left turn at Foxon Boulevard and Quinnipiac Avenue operates at Level of Service E, with an average delay of 78 seconds per vehicle.

2012 AM Peak-Hour Conditions and Potential Mitigation

During the year 2012, the Ferry Street Bridge and the Grand Avenue Bridge are expected to be open. The opening of the Ferry Street Bridge is expected to provide relief for the Grand Avenue corridor. In addition to the rerouting of vehicles due to these two bridges becoming available, a one per cent growth rate was applied to project 2012 traffic volumes.

Using SYNCHRO software to simulate operations, traffic volume was incrementally added in the peak (westbound) direction until one or more lane groups reached the established thresholds.


East Rock Park
STATE ST & EDWARDS ST
MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused minor street and ped time to State St. phase.
3. Set offset to favor inbound direction.
LOS WHEN CUM. INCR. VOLUME REACHES 80 VEHICLES
Edwards St EB-Left: LOS D (46 s)
All other lane groups LOS C or better.
STATE ST & FERRY ST (CONTROLLING INTERSECTION)
MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused ped time to State St. phase.
3. Set offset to favor inbound direction.
LOS WHEN CUM. INCR. VOLUME REACHES 80 VEHICLES
State St EB-Through/Right: LOS D (54 s)
State St WB-Left: LOS E (60 s)
Ferry St NB-Left: LOS E (65 s)
All other lane groups LOS C or better.
MIDDLETOWN AVE & I-91 NB ON-RAMP (EXIT 8)
No mitigation needed.
LOS WHEN CUM. INCR. VOLUME REACHES 80 VEHICLES:
All lane groups LOS C or better.
STATE ST, EAST ST & MECHANIC ST
MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused ped time to State St. phase.
3. Set offset to favor inbound direction.
LOS WHEN CUM. INCR. VOLUME REACHES 80 VEHICLES
All lane groups LOS C or better.
MIDDLETOWN AVE & I-91 SB RAMPS (EXIT 8)
No mitigation needed.
LOS WHEN CUM. INCR. VOLUME REACHES 80 VEHICLES:
All lane groups LOS C or better.
FOXON BLVD, MIDDLETOWN AVE & I-91 NB ON-RAMP (EXIT 8)
MITIGATION MEASURES:
1. Keeping 80 sec cycle, reallocate green time.
LOS WHEN CUM. INCR. VOLUME REACHES 80 VEHICLES:
EB-Left: LOS D (52 s)
NB-Through/Left: LOS D (39 s)
All other lane groups LOS C or better.
MIDDLETOWN AVE & FERRY ST
MITIGATION MEASURES:
1. Keeping 90 sec cycle, reallocate green time.
2. Change offset to favor inbound direction.
LOS WHEN CUM. INCR. VOLUME REACHES 80 VEHICLES:
WB-Left: LOS D (43 s)
NB-Through: LOS D (42 s)
All other lane groups LOS C or better.
STATE ST, JAMES ST & I-91 NB OFF-RAMP (EXIT 5)
MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused NB time to EB/WB phase.
3. Set offset to favor inbound direction.
LOS WHEN CUM. INCR. VOLUME REACHES 80 VEHICLES
State St EB Through/Right: LOS D (40 s)
All other lane groups LOS C or better.
STATE ST, BLATCHLEY AVE & WILLOW ST
MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused ped time to State St. phase.
3. Set offset to favor inbound direction.
LOS WHEN CUM. INCR. VOLUME REACHES 80 VEHICLES
State St EB-Left/Through/Right: LOS D (40 s)
Willow St SB-Left/Through/Right: LOS D (48 s)
All other lane groups LOS C or better.
STATE ST & HUMPHREY ST
MITIGATION MEASURES:
1. Set cycle to 90 sec. Reallocate green time.
2. Allow coordination by giving unused ped time to State St. phase.
3. Set offset to favor inbound direction.
LOS WHEN CUM. INCR. VOLUME REACHES 80 VEHICLES
Humphrey St EB-Left/Through/Right: LOS D (38 s)
State St NB-Left/Through/Right: LOS D (41 s)
All other lane groups LOS C or better.
FIGURE 30
MITIGATION MEASURES AT PRIORITY INTERSECTIONS
Corridor: Middletown Ave/Upper State St
Peak Hour: PM
Direction: Outbound
Year: 2012
Cumulative Incremental Volume: 80 vehicles
MIDDLETOWN AVE
STATE ST
MILL RIVER
QUINNIPIAC RIVER
91
80
17
8
5
6
7
4
3
N
W
E
S

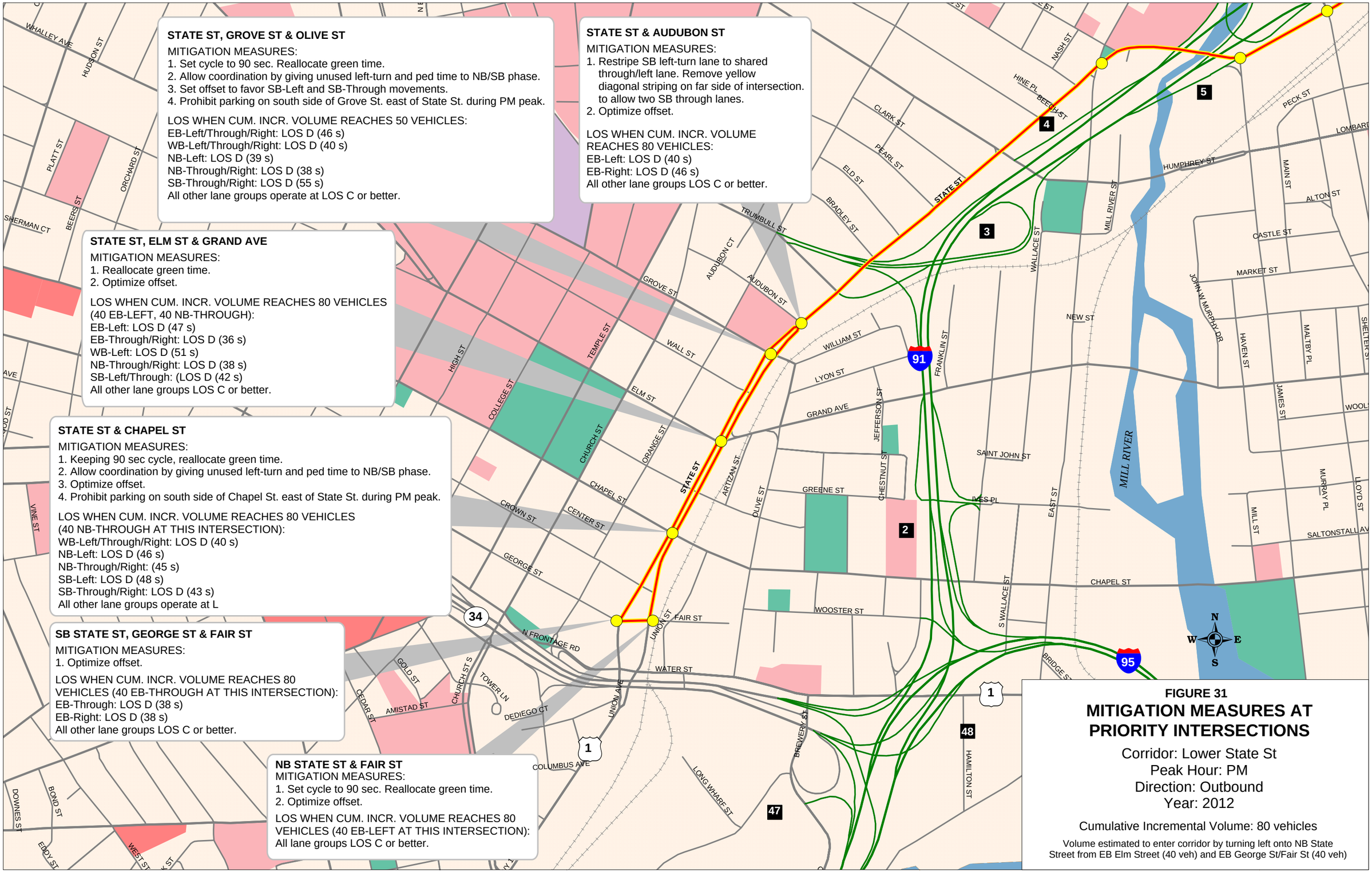


FIGURE 31

MITIGATION MEASURES AT PRIORITY INTERSECTIONS

Corridor: Lower State St
Peak Hour: PM
Direction: Outbound
Year: 2012

Cumulative Incremental Volume: 80 vehicles

Volume estimated to enter corridor by turning left onto NB State Street from EB Elm Street (40 veh) and EB George St/Fair St (40 veh)

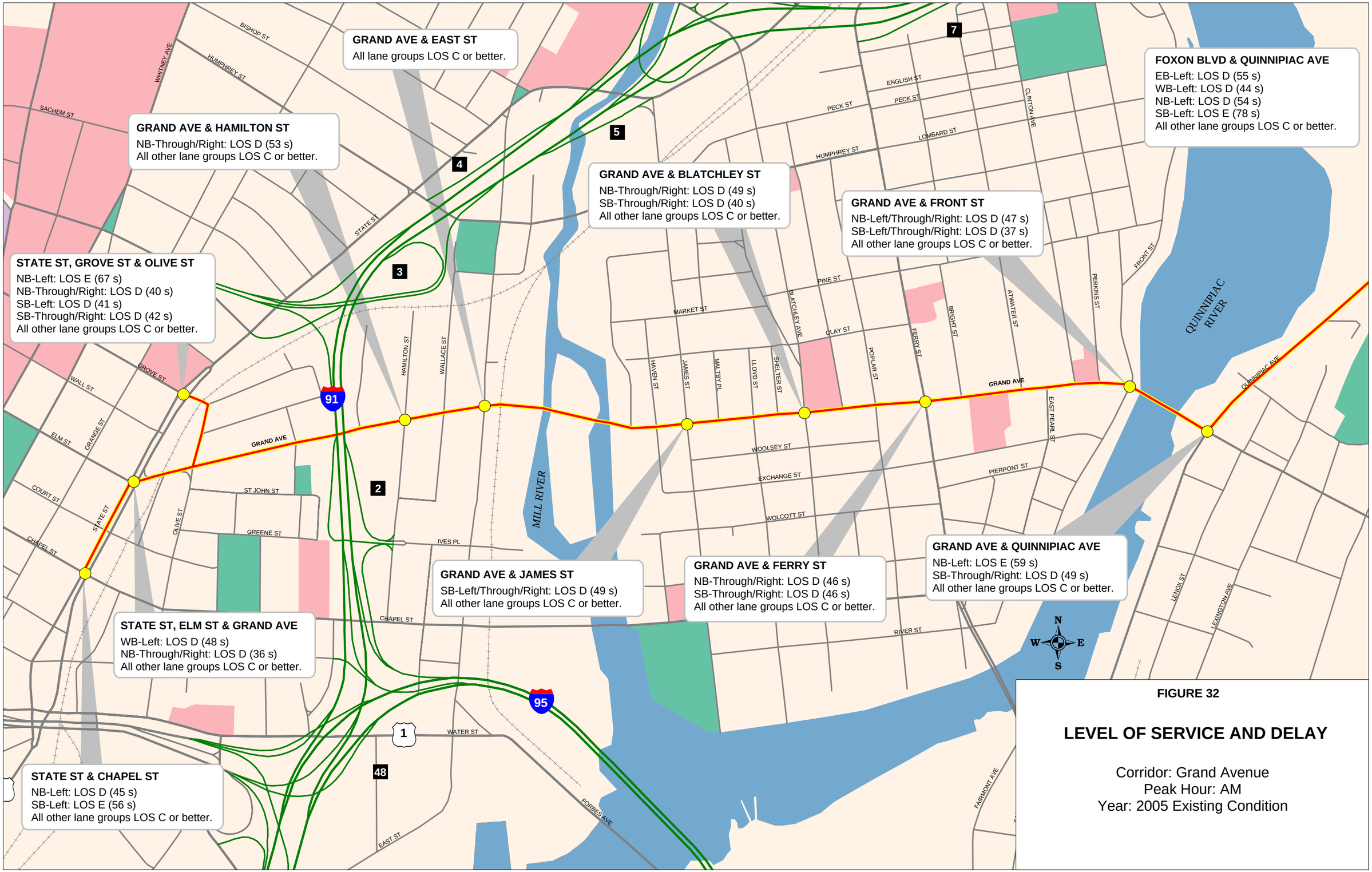


FIGURE 32

LEVEL OF SERVICE AND DELAY

Corridor: Grand Avenue
Peak Hour: AM
Year: 2005 Existing Condition

The increments were applied as follows: the entry to the study area was via the westbound left turn from Foxon Boulevard onto Quinnipiac Avenue. The increments were then applied to southbound Quinnipiac Avenue for the right-turn onto Grand Avenue and then along westbound Grand Avenue to State Street. Drivers cannot directly enter downtown New Haven via Grand Avenue, because Elm Street, the roadway on the opposite side of State Street, is one-way eastbound. Therefore, it was assumed that downtown-bound drivers using Grand Avenue would access downtown either by turning left onto State Street and right onto Chapel Street, or right onto Olive Street to Grove Street. The increments were divided equally among these two routes. Therefore, the intersections of State Street at Chapel Street, Elm Street/Grand Avenue, and Grove Street/Olive Street are study intersections for this corridor during the AM period. They are also study intersections for the Middletown Avenue/State Street corridor. For these three intersections, the mitigation presented in Section 6.2.2 was applied.

For most other intersections, the only mitigation measure was to adjust the green time, while maintaining the current cycle length and offset. Many intersections did not need any further mitigation.

There was one location-specific mitigation measure. At Grand Avenue and East Street, it is recommended to stripe a left-turn lane in the eastbound direction. With the current single shared lane arrangement, drivers waiting for a gap to make the eastbound left turn block through vehicles, causing this lane group to reach the threshold after very little incremental volume. This would be a low-cost mitigation measure, but would necessitate removing parking in the immediate area of the intersection, and could possibly require that a bus stop be relocated. This improvement would need to be integrated into plans for upgrading the nearby at-grade railroad crossing. The mitigation measures for each location is presented in Figure 33.

The cumulative incremental volume that this corridor can accommodate with the above mentioned low-cost mitigation measures is 310 vehicles. The controlling intersection that reaches its practical limit is Grand Avenue at Ferry Street. Other intersections that are very close to reaching their practical limit are at the entry to the corridor – Foxon Boulevard at Quinnipiac Avenue, and Grand Avenue at Quinnipiac Avenue. Also, the three State Street study intersections at the western end of the corridor are close to reaching their practical limits.

The cumulative incremental volumes for the Middletown Avenue / State Street corridor and the Grand Avenue corridor were determined independently. Since there are common intersections in these two corridors, the cumulative incremental volumes that are given are for either one corridor or the other, not both. Both corridors together could accommodate only part of the stated cumulative incremental volumes.

2005 PM Peak-Hour Conditions

Figure 34 presents the existing Levels of Service for the Grand Avenue corridor. The following lane groups operate above the established threshold under existing conditions:

- Quinnipiac Avenue southbound left-turn at Foxon Boulevard.
- Grand Avenue eastbound through/right lane group at Quinnipiac Avenue.
- Front Street southbound approach at Grand Avenue.
- Elm Street eastbound through/right lane group at State Street.

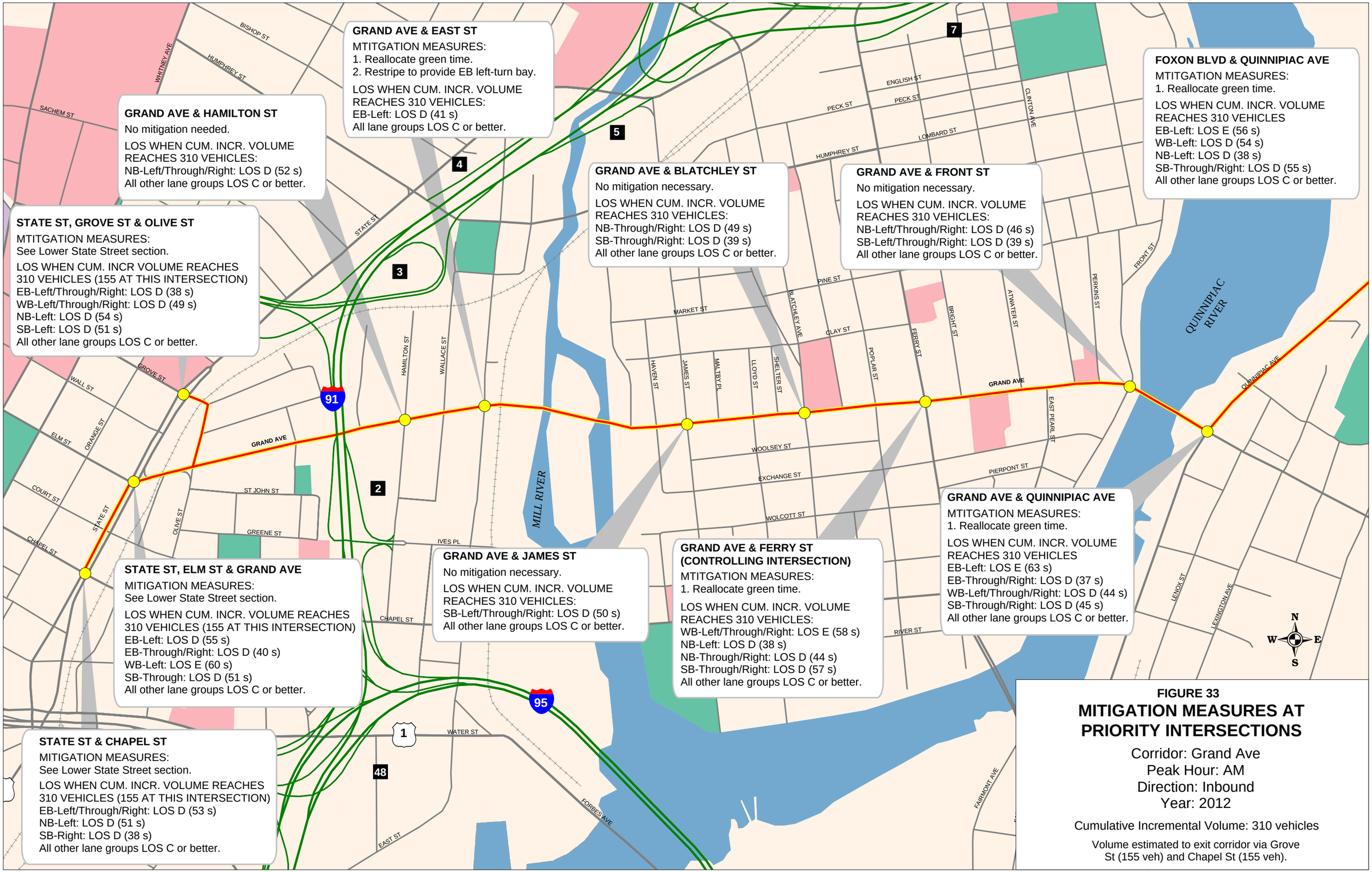


FIGURE 33

MITIGATION MEASURES AT PRIORITY INTERSECTIONS

Corridor: Grand Ave
Peak Hour: AM
Direction: Inbound
Year: 2012

Cumulative Incremental Volume: 310 vehicles

Volume estimated to exit corridor via Grove St (155 veh) and Chapel St (155 veh).

GRAND AVE & EAST ST
EB-Left/Through/Right: LOS E (56 s)
SB-Left/Through/Right: LOS D (36 s)
All other lane groups LOS C or better.

GRAND AVE & HAMILTON ST
NB-Through/Right: LOS D (47 s)
All other lane groups LOS C or better.

GRAND AVE & BLATCHLEY ST
NB-Through/Right: LOS D (40 s)
SB-Left: LOS D (38 s)
SB-Through/Right: LOS D (47 s)
All other lane groups LOS C or better.

GRAND AVE & FRONT ST
NB-Left/Through/Right: LOS D (36 s)
SB-Left/Through/Right: LOS E (76 s)
All other lane groups LOS C or better.

FOXON BLVD & QUINNIPIAC AVE
EB-Left: LOS D (43 s)
WB-Left: LOS D (44 s)
NB-Left: LOS E (45 s)
NB-Through/Right: LOS D (38 s)
SB-Left: LOS E (73 s)
SB-Through/Right: LOS D (51 s)
All other lane groups LOS C or better.

GRAND AVE & JAMES ST
SB-Left/Through/Right: LOS D (50 s)
All other lane groups LOS C or better.

GRAND AVE & FERRY ST
NB-Through/Right: LOS D (49 s)
SB-Left: LOS D (40 s)
SB-Through/Right: LOS E (58 s)
All other lane groups LOS C or better.

GRAND AVE & QUINNIPIAC AVE
EB-Through/Right: LOS E (63 s)
NB-Left: LOS E (58 s)
All other lane groups LOS C or better.

STATE ST, ELM ST & GRAND AVE
EB-Left: LOS E (60 s)
EB-Through/Right: LOS E (62 s)
WB-Left: LOS D (54 s)
NB-Through/Right: LOS D (51 s)
All other lane groups LOS C or better.

BISHOP ST
WHITNEY AVE
HUMPHREY ST
SACHEM ST
STATE ST
HAMILTON ST
WALLACE ST
GROVE ST
WALL ST
ELM ST
ORANGE ST
COURT ST
CHAPEL ST
OLIVE ST
ST JOHN ST
GREENE ST
IVES PL
MILL RIVER
WATER ST
FORBES AVE
EAST ST
GRAND AVE
MARKET ST
PINE ST
BLATCHLEY AVE
CLAY ST
HAVEN ST
JAMES ST
MALTBY PL
LLOYD ST
SHELTER ST
POPLAR ST
FERRY ST
BRIGHT ST
ATWATER ST
PERKINS ST
FRONT ST
ENGLISH ST
PECK ST
LOMBARD ST
CLINTON AVE
WOOLSEY ST
EXCHANGE ST
WOLCOTT ST
PIERPONT ST
EAST PEARL ST
QUINNIPIAC RIVER
QUINNIPIAC AVE
RIVER ST
LENOX ST
LEXINGTON AVE
FAIRMONT AVE
91
95
1
2
3
4
5
7
48
N
W
E
S

FIGURE 34

LEVEL OF SERVICE AND DELAY

Corridor: Grand Avenue
Peak Hour: PM
Year: 2005 Existing Condition

These conditions will be mitigated during the increment analysis process.

2012 PM Peak-Hour Conditions and Potential Mitigation

The outbound route followed for the PM peak hour is essentially the reverse of the inbound route. However, entering the outbound Grand Avenue corridor from downtown New Haven is easier than entering downtown from Grand Avenue. Elm Street provides for a one-way eastbound direct movement onto Grand Avenue. Therefore, State Street at Chapel Street and State Street at Grove Street/Olive Street are not study intersections for the Grand Avenue corridor during the PM peak.

The same mitigation measures were used for the PM outbound increments as were used for the AM inbound increments. The mitigation measures are presented in Figure 35. The cumulative incremental volume that this corridor can accommodate with low-cost mitigation measures is estimated to be 170 vehicles. The controlling intersection is Grand Avenue and East Street. Also near their practical limit are the intersections of Foxon Boulevard at Quinnipiac Avenue, Grand Avenue at Ferry Street, and Grand Avenue at State Street.

7.4 Chapel Street Corridor from Quinnipiac Avenue to State Street

The results of the SYNCHRO analysis for the Chapel Street corridor are presented for the base and future transportation conditions for the weekday AM and PM peak hours. The priority locations for this corridor were shown earlier in Figures 8 and 9 for the years 2008 and 2012, respectively. During the year 2008, the Ferry Street Bridge over the Quinnipiac River, and the Grand Avenue Bridge over AMTRAK are expected to be closed. During the year 2012, both are expected to be open. During the Ferry Street Bridge closure in 2008, Foxon Boulevard and Quinnipiac Avenue is considered a study intersection since there may be diversions to this corridor from Foxon Boulevard to the north. With the Ferry Street Bridge open in 2012, Forbes Avenue and Townsend Avenue is considered a study intersection as part of this corridor, since there may be diversions to this corridor from US1 to the south.

The signals on Chapel Street are all under City of New Haven jurisdiction. Some have loop detectors and some have pedestrian push buttons. None have coordinated-actuated capabilities. The two intersections mentioned earlier that serve as portals to the study area, Foxon Boulevard at Quinnipiac Avenue and Forbes Avenue at Townsend Avenue, are currently under ConnDOT jurisdiction. They have pedestrian push buttons, loop detectors and are capable of coordinated-actuated control.

2005 AM Peak-Hour 2005 Conditions

As noted previously, the Ferry Street Bridge over the Quinnipiac River was closed during 2005. Figure 36 presents existing Levels of Service for the corridor. All lane groups operate at or below the established threshold, except the southbound left turn from Quinnipiac Avenue at Foxon Boulevard which operates at Level of Service E, with an average delay of 78 seconds per vehicle.

GRAND AVE & EAST ST (CONTROLLING INTERSECTION)

MTITGATION MEASURES:
1. Reallocate green time.
2. Restripe to provide EB left-turn bay.

LOS WHEN CUM. INCR. VOLUME REACHES 170 VEHICLES:
EB-Through/Right: LOS E (60 s)
SB-Left/Through/Right: LOS E (56 s)
All lane groups LOS C or better.

GRAND AVE & HAMILTON ST

No mitigation needed.

LOS WHEN CUM. INCR. VOLUME REACHES 170 VEHICLES:
NB-Left/Through/Right: LOS D (48 s)
All other lane groups LOS C or better.

GRAND AVE & BLATCHLEY ST

No mitigation necessary.

LOS WHEN CUM. INCR. VOLUME REACHES 170 VEHICLES:
NB-Through/Right: LOS D (39 s)
SB-Left: LOS D (38 s)
SB-Through/Right: LOS D (46 s)
All other lane groups LOS C or better.

GRAND AVE & FRONT ST

No mitigation necessary.

LOS WHEN CUM. INCR. VOLUME REACHES 170 VEHICLES:
NB-Left/Through/Right: LOS D (36 s)
SB-Left/Through/Right: LOS E (61 s)
All other lane groups LOS C or better.

FOXON BLVD & QUINNIPIAC AVE

MTITGATION MEASURES:
1. Reallocate green time.

LOS WHEN CUM. INCR. VOLUME REACHES 170 VEHICLES
EB-Left: LOS D (43 s)
EB-Through: LOS D (53 s)
WB-Left: LOS D (46 s)
NB-Through/Right: LOS D (48 s)
SB-Left: LOS D (52 s)
SB-Through/Right: LOS D (37 s)
All other lane groups LOS C or better.

STATE ST, ELM ST & GRAND AVE

MITIGATION MEASURES:
See Lower State Street section.

LOS WHEN CUM. INCR. VOLUME REACHES 170 VEHICLES
EB-Through/Right: LOS D (48 s)
WB-Left: LOS D (46 s)
NB-Through/Right: LOS D (51 s)
SB-Through: LOS D (52 s)
All other lane groups LOS C or better.

GRAND AVE & JAMES ST

No mitigation necessary.

LOS WHEN CUM. INCR. VOLUME REACHES 170 VEHICLES:
SB-Left/Through/Right: LOS D (50 s)
All other lane groups LOS C or better.

GRAND AVE & FERRY ST

MTITGATION MEASURES:
1. Reallocate green time.

LOS WHEN CUM. INCR. VOLUME REACHES 170 VEHICLES:
WB-Left/Through/Right: LOS D (50 s)
NB-Through/Right: LOS D (48 s)
Northbound-Through/Right: LOS D (42 s)
SB-Through/Right: LOS E (59 s)
All other lane groups LOS C or better.

GRAND AVE & QUINNIPIAC AVE

MTITGATION MEASURES:
1. Reallocate green time.

LOS WHEN CUM. INCR. VOLUME REACHES 170 VEHICLES
SB-Through/Right: LOS D (52 s)
All other lane groups LOS C or better.

FIGURE 35

MITIGATION MEASURES AT PRIORITY INTERSECTIONS

Corridor: Grand Ave
Peak Hour: PM
Direction: Outbound
Year: 2012

Cumulative Incremental Volume: 170 vehicles

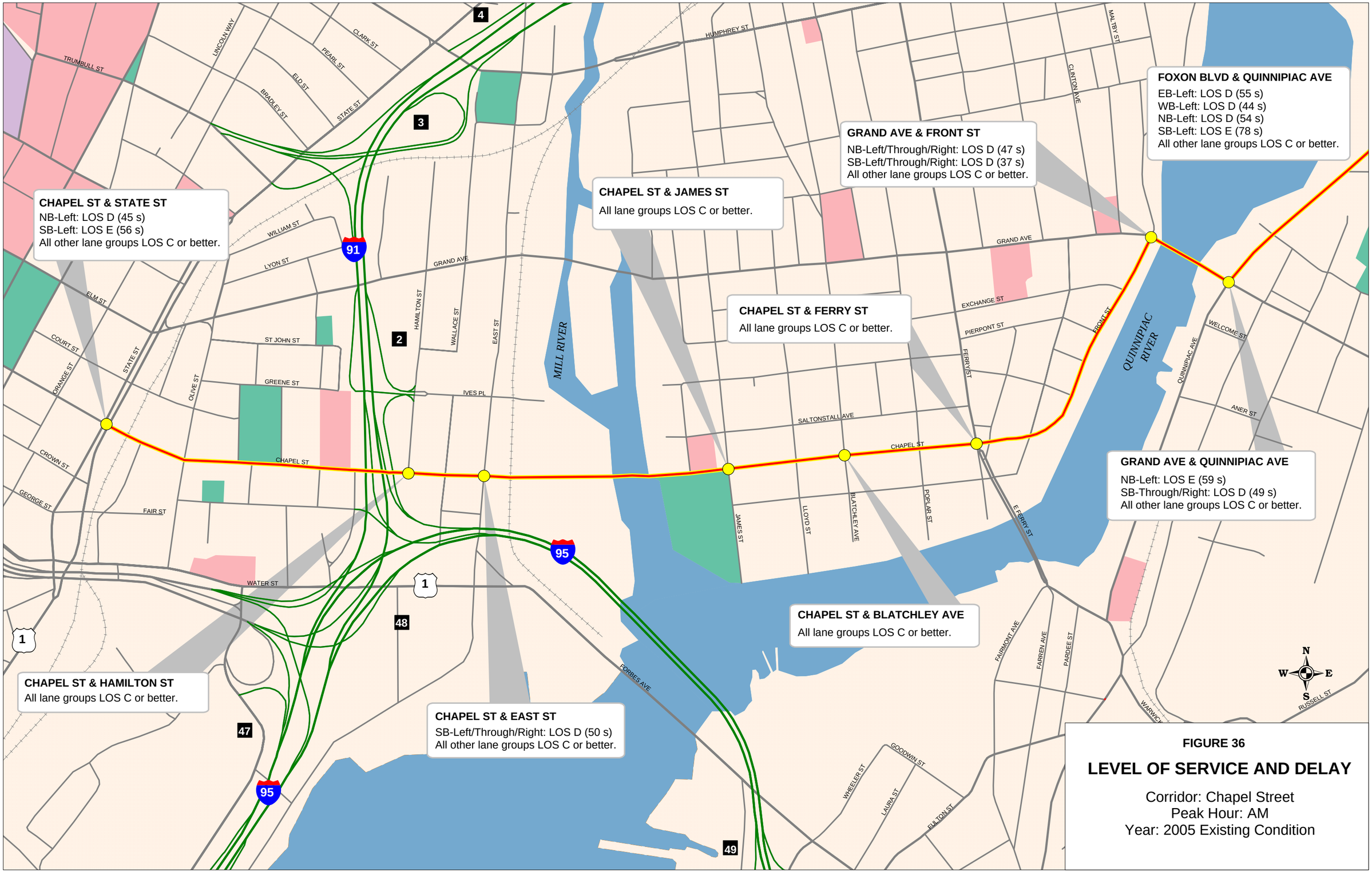


FIGURE 36

LEVEL OF SERVICE AND DELAY

Corridor: Chapel Street
Peak Hour: AM
Year: 2005 Existing Condition

2008 *AM Peak-Hour Conditions and Potential Mitigation*

During the year 2008, the Ferry Street Bridge and the Grand Avenue Bridge are expected to be closed. The closing of the Grand Avenue Bridge is expected to result in some traffic diversion to the Chapel Street. In addition to the rerouting of vehicles due to the closure of these bridges, a one per cent growth rate was applied to project the 2008 traffic volumes.

Using SYNCHRO software to simulate operations, traffic volume was incrementally added in the peak (westbound) direction until one or more lane groups reached the established thresholds. The increments were applied as follows: the entry to the study area was via the westbound left turn from Foxon Boulevard onto Quinnipiac Avenue. The increments were then applied to southbound Quinnipiac Avenue for the right-turn onto Grand Avenue and then along westbound Grand Avenue to the next intersection at Front Street. Increments were applied to Front Street as it turns in to Chapel Street, continuing westbound to State Street. The first three intersections along the corridor are common to the Grand Avenue corridor. The last intersection at State Street and Chapel Street is common to the Middletown Avenue / State Street corridor and the Grand Avenue corridor.

For most intersections, the mitigation method was to adjust green time without changing the cycle length. However, one location-specific mitigation measure was at Chapel Street and Hamilton Street. It is recommended to stripe a left-turn lane in the eastbound direction. With the current single shared lane arrangement, drivers waiting for a gap to make the eastbound left turn block through vehicles, causing this lane group to reach the threshold after very little incremental volume. The left-turn volume here is substantial, since it leads to I-91. This would be a low-cost mitigation measure, but would necessitate removing parking in the immediate area of the intersection, and could possibly require that a bus stop be relocated. The mitigation measures for each location is presented in Figure 37. In addition, the provision of a northbound left-turn lane from Hamilton Street to the northbound I-91 entrance ramp at Ives Place is recommended.

The cumulative incremental volume that this corridor can accommodate with the mitigation measures noted above is 150 vehicles. The controlling intersection that reaches its practical limit is Grand Avenue at Front Street.

It is recommended that the signals along the Chapel Street corridor be considered for upgrading to provide for coordinated-actuated capabilities, similar to what exists on Grand Avenue. This will help to prepare for additional traffic expected when the Grand Avenue Bridge is closed for construction.

2012 AM Peak-Hour Conditions and Potential Mitigation

During the year 2012, the Ferry Street Bridge and Grand Avenue Bridge are expected to be open. As shown in Figure 38, a cumulative incremental volume of 230 vehicles can be accommodated until a practical limit is reached at Hamilton Street. This increment would require the addition of the eastbound left-turn lane previously mentioned.

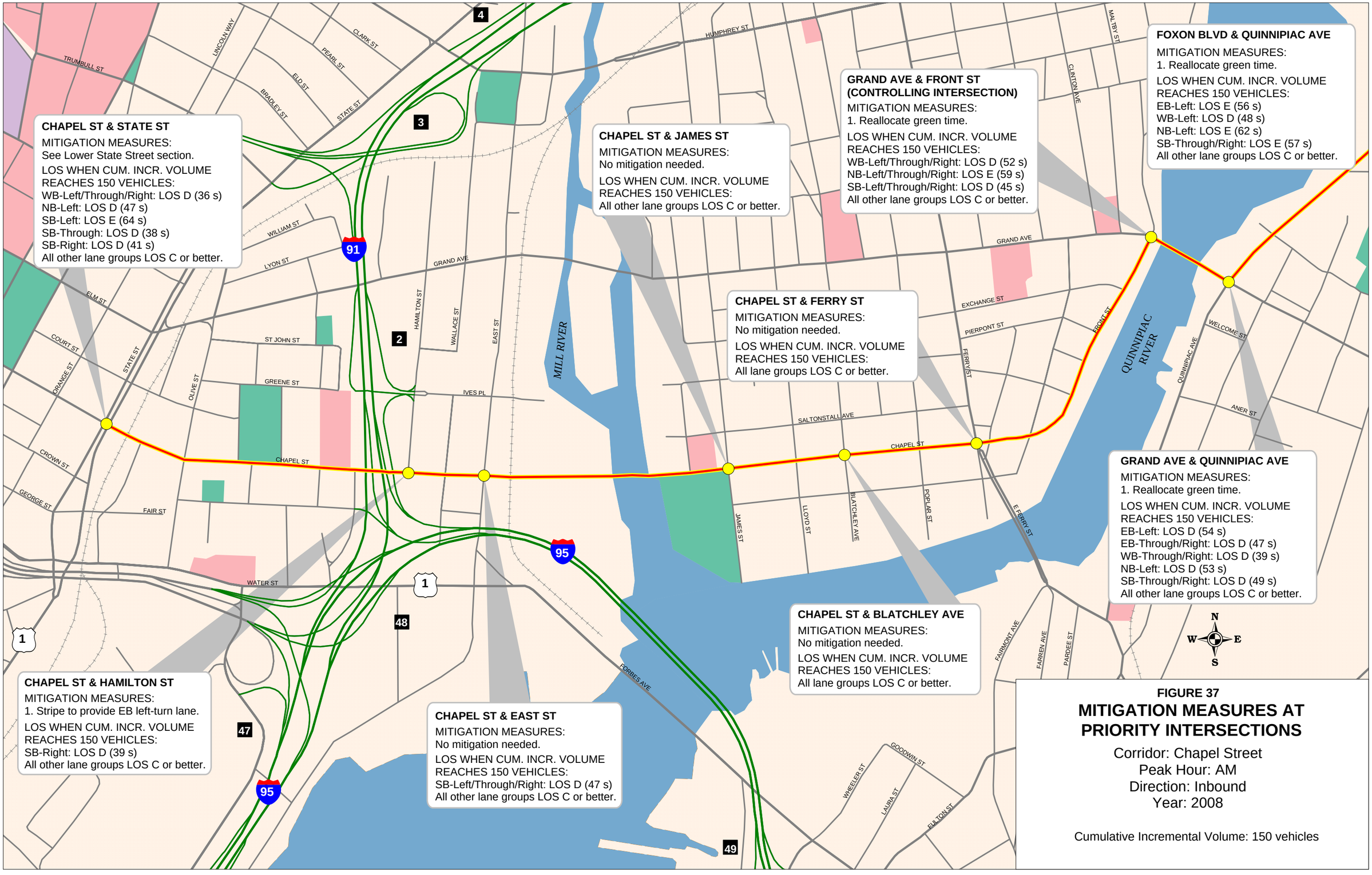


FIGURE 37

MITIGATION MEASURES AT PRIORITY INTERSECTIONS

Corridor: Chapel Street
Peak Hour: AM
Direction: Inbound
Year: 2008

Cumulative Incremental Volume: 150 vehicles

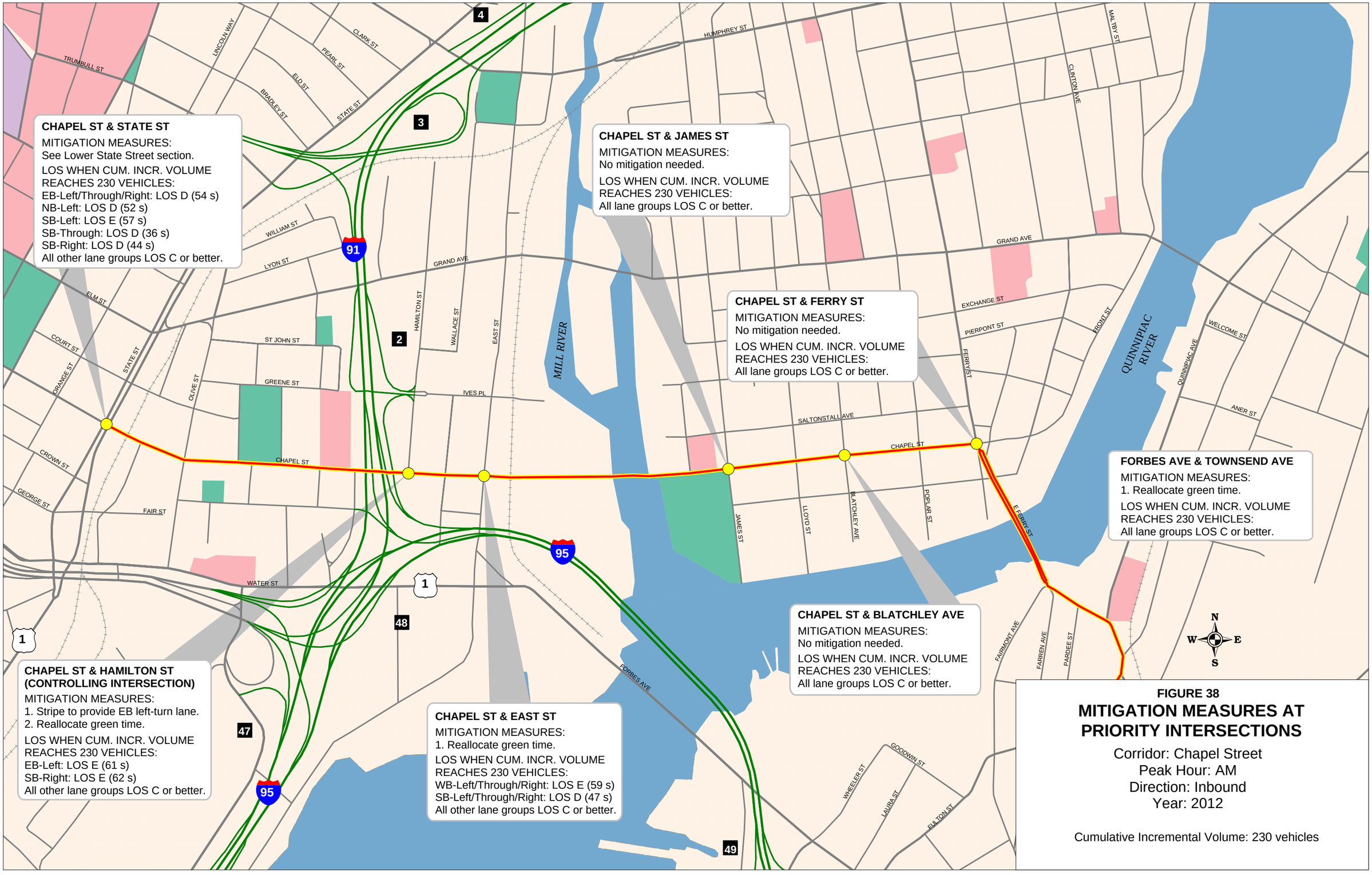


FIGURE 38

MITIGATION MEASURES AT PRIORITY INTERSECTIONS

Corridor: Chapel Street
Peak Hour: AM
Direction: Inbound
Year: 2012

Cumulative Incremental Volume: 230 vehicles

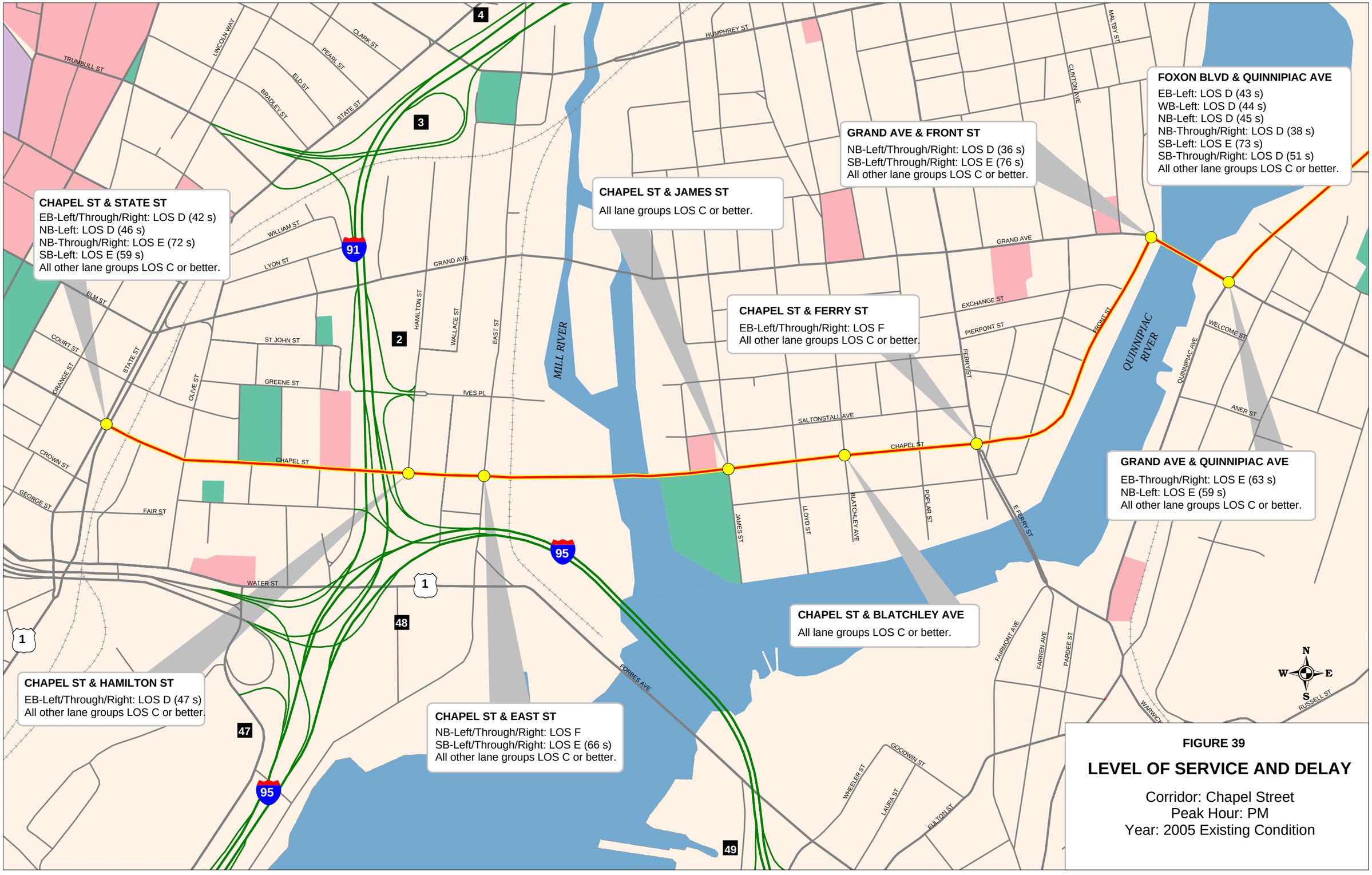


FIGURE 39

LEVEL OF SERVICE AND DELAY

Corridor: Chapel Street
Peak Hour: PM
Year: 2005 Existing Condition

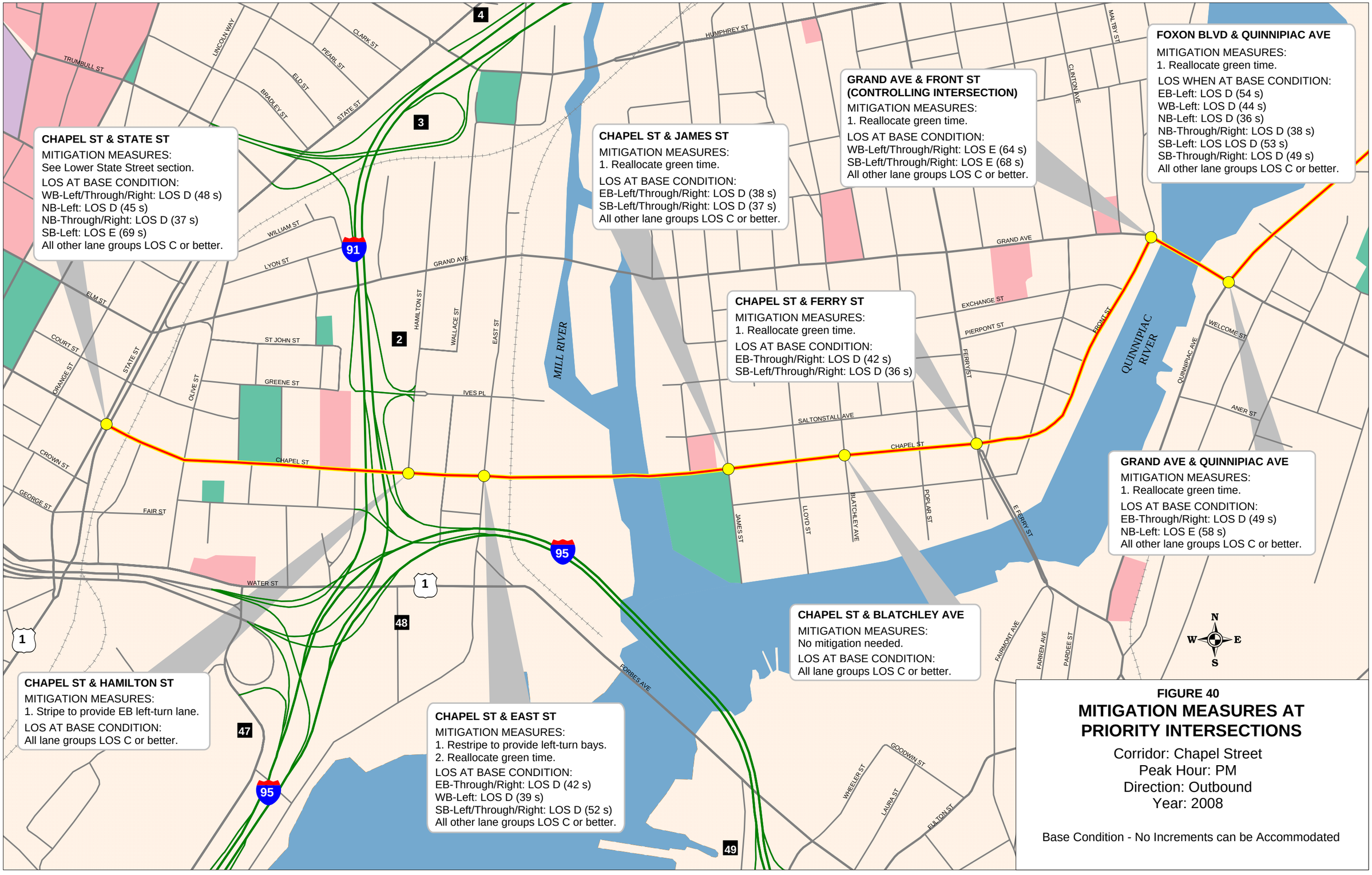


FIGURE 40

MITIGATION MEASURES AT PRIORITY INTERSECTIONS

Corridor: Chapel Street
Peak Hour: PM
Direction: Outbound
Year: 2008

Base Condition - No Increments can be Accommodated

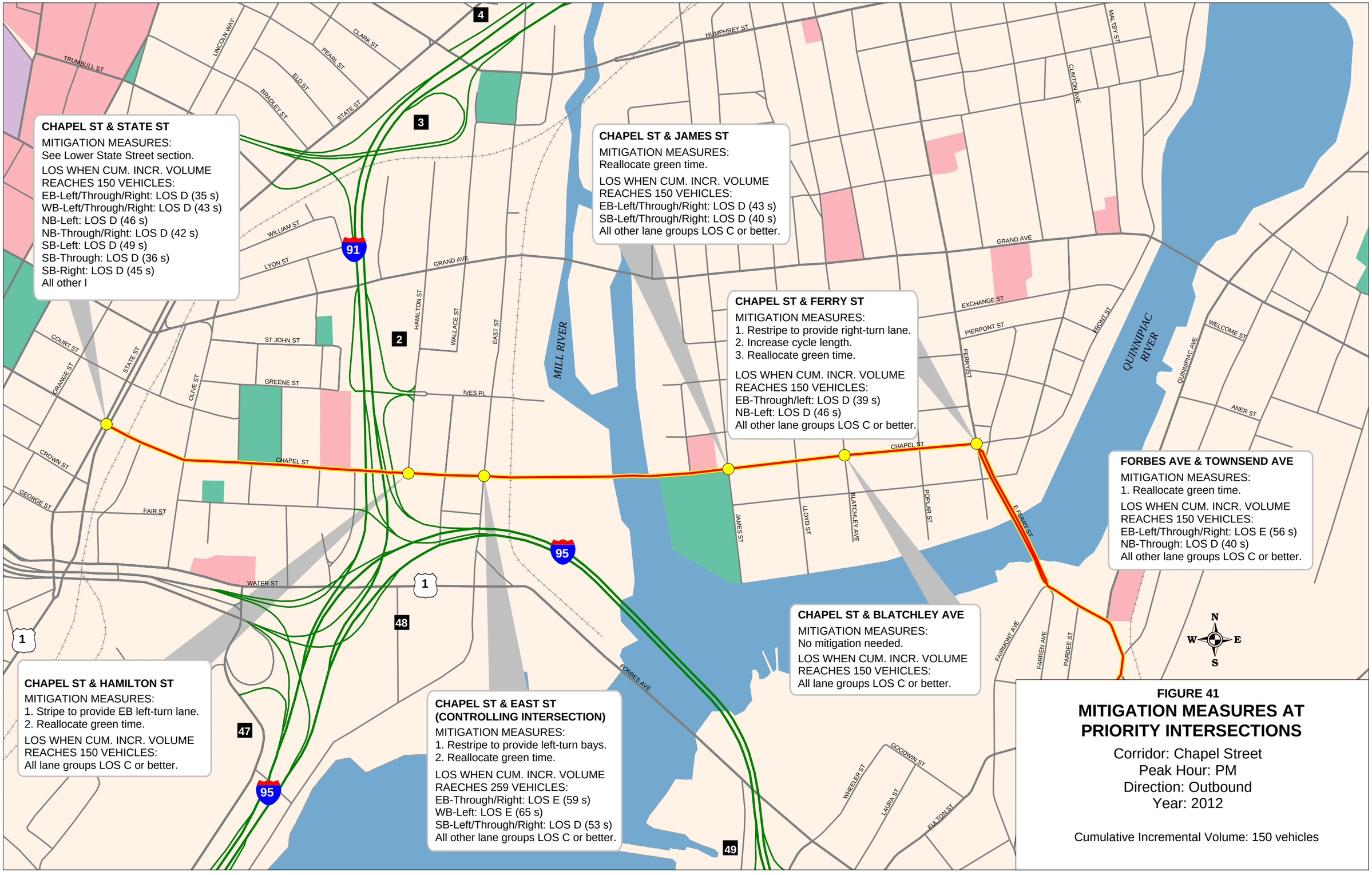


FIGURE 41

MITIGATION MEASURES AT PRIORITY INTERSECTIONS

Corridor: Chapel Street
Peak Hour: PM
Direction: Outbound
Year: 2012

Cumulative Incremental Volume: 150 vehicles

2005 PM Peak-Hour Conditions

Figure 39 presents the existing Levels of Service for the Chapel Street corridor during the PM peak hour. The following lane groups operate above the established threshold under existing conditions:

- Quinnipiac Avenue southbound left-turn at Foxon Boulevard.
- Grand Avenue eastbound through/right lane group at Quinnipiac Avenue.
- Front Street southbound approach at Grand Avenue.
- Chapel Street eastbound approach at State Street.
- East Street northbound and southbound approaches at Chapel Street.

The East Street intersection with Chapel Street will require mitigation beyond signal timing changes.

2008 PM Peak-Hour Conditions and Potential Mitigation

Chapel Street has one lane approaches to East Street, causing the same backup problems mentioned earlier at Hamilton Street. Restriping to enable passing of left-turning vehicles on the eastbound and westbound Chapel Street approaches would enable an incremental volume of 70 vehicles in the corridor. Westbound Chapel Street already has protected left-turn signal phasing, even though there is no left-turn lane. Without this action, there can be no traffic increments with the established thresholds. With this action, a cumulative increment of 70 vehicles can be accommodated before the practical limit is reached again at Front Street and Grand Avenue. Figure 40 identifies the mitigation measures for each location. Signal upgrade should also be considered at East Street.

2012 PM Peak-Hour Conditions and Potential Mitigation

The opening of the Ferry Street Bridge during the year 2012 will add considerable volume to the intersection of Ferry Street and Chapel Street. It is recommended to lengthen the cycle to 90 seconds to provide additional capacity, as well as to allocate more green time to the north-south movements. It is also recommended to provide a right-turn lane on the eastbound approach. This can be accomplished by shifting the median about 5-feet north of its present alignment. However, it would result in the loss of a few parking spaces and may necessitate relocating a bus stop. As shown in Figure 41, this is estimated to allow an increment of 150 vehicles to the corridor. The controlling intersection would then be Chapel Street at East Street.

8.0 Results and Findings

Table 2 summarizes the cumulative incremental volumes that may be achieved by implementing the low-cost mitigation measures identified for the intersections in each of the corridors. The potential incremental volumes are highest on US1 for both the AM and PM peak hours in 2008 and 2012.

The analysis results suggest a focus on upgrading the signalization on US1 and State Street corridors to make them better able to accommodate changing traffic conditions and demands that

TABLE 2

CUMULATIVE INCREMENTAL VOLUMES*

CORRIDOR	AM PEAK HOUR**		PM PEAK HOUR**	
	2008	2012	2008	2012
US1	600	640	270	290
Middletown Ave/State St	250	240	50	80
Grand Ave	NA	310	NA	170
Chapel St	150	230	70	150

* Based on providing low-cost mitigation measures.

** Inbound to New Haven in the AM and outbound from New Haven in the PM.

may result from the long-term I-95 construction and related impacts on I-91. The US1 corridor offers opportunities for both short-term mitigation identified above, as well as future opportunities for long-term improvements between East Street and Brewery Street, that could result in better conditions during the I-95 construction program. This segment of US1 is shown as being widened in Phase 17 of Contract E (the redesign of the I-95/I-91/Route 34 interchange). Phase 17 is scheduled to be implemented towards the end of Contract E construction. Additional traffic along this segment of US1 could be accommodated if the widening was to be done earlier in the contract E schedule, when disruptions to I-95 traffic are possible.

There are benefits and system flexibility that could be achieved by upgrading the traffic signalization along the US1 and State Street corridors to be traffic responsive. This would be especially useful when there are lane closures on I-95 and potential traffic diversions to US1or lane closures on I-91 and potential traffic diversions to State Street.

The segment of US1 to the east is on ConnDOT's closed loop system. It is anticipated that the traffic signals on US 1 at Woodward Avenue and at Townsend Avenue, currently under ConnDOT jurisdiction, will become part of the City of New Haven system. The closed loop system on US1 should be extended into New Haven. Consideration should also be given to consolidating the management and operation of the US1 traffic signals to one agency to facilitate a more rapid response to changing travel conditions.

Traffic signal coordination along Upper State Street will require upgrades to the signal hardware. Although traffic signal coordination along Lower State Street could be provided using existing equipment, hardware would be needed to provide more system flexibility and achieve a demand-responsive system. The upgrading of the signal equipment along both Upper and Lower State Street to provide for a system that could respond to changing traffic demands would enable the City of New Haven to better deal with traffic diversions related to the I-95 construction.

Provision for a traffic control center for monitoring traffic and adjusting signal timing on US1 and State Street based on actual conditions would be beneficial to responding to changes related to the I-95 construction program.

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