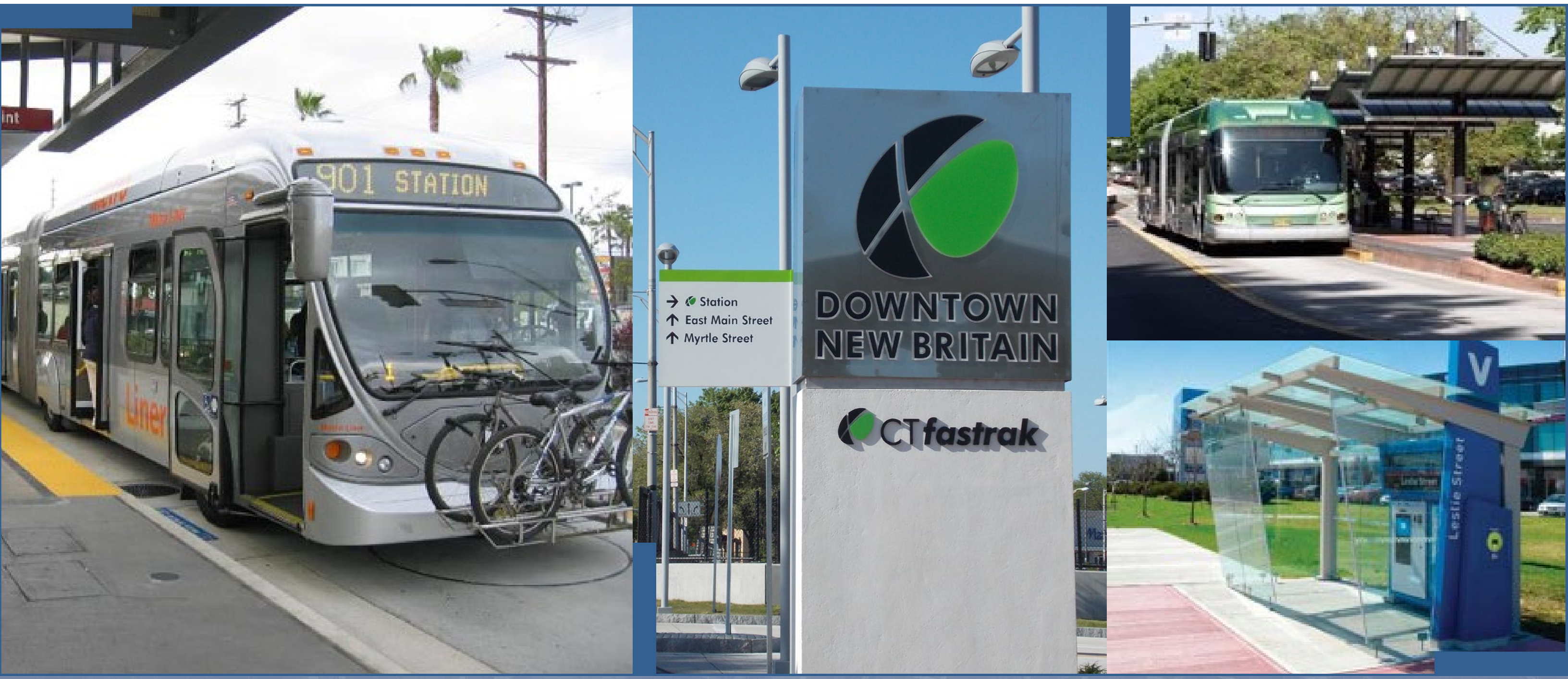
Route 1 Bus Rapid Transit Feasibility Study

Final Report



February, 2017

Prepared for:
Connecticut Department
of Transportation

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TASK ORDER PUBLIC TRANSPORTATION SERVICES

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Route 1 Bus Rapid Transit Feasibility Study

STATE PROJECT NO. 173-471

Final Report

February, 2017

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EXECUTIVE SUMMARY

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Executive Summary

The Route 1 Bus Rapid Transit (BRT) Feasibility Study is an important element of the 5-Year Ramp-Up Plan of Let'sGoCT!, Governor Malloy's transportation "Call to Action." Let'sGoCT! represents a 30-year vision for Connecticut's best in class transportation system, while the 5-Year Ramp-Up Plan outlines the initial steps toward that vision. The Route 1 BRT Feasibility Study seeks to provide a blueprint for bringing faster, more reliable bus service to the heavily traveled Route 1 corridor between the New York State Line and New Haven within the next five years.

Study Background

Study Goals

The Connecticut Department of Transportation (CTDOT), Bureau of Public Transportation, initiated the Route 1 BRT Feasibility Study with two specific goals for enhancing bus service in the study corridor:

- Develop alternatives and assess their viability in improving bus travel time and increasing bus ridership in targeted corridors.
- Determine where the best locations are for potential BRT enhancements to increase the effectiveness of bus services and improve operations.

The first goal served to focus the study on alternatives to improve travel times on bus service in the corridor, while the second goal recognizes that implementing the strategies to improve travel time and reliability across a long and complex corridor will require a phased approach. As a result, the study was used to identify one or more segments of the corridor for initial implementation of a package of improvements that could make a significant impact on travel time and service reliability on that corridor segment. An initial focused approach achieving success on one corridor segment can serve as a demonstration of successful strategies that can then be transferred to the rest of the study area.

Study Area

The study area consists of the four existing bus routes that roughly follow U.S. Route 1 from Port Chester, New York to the New Haven Green, namely CT*transit* Stamford Division Routes 311 and 341, the Coastal Link (jointly operated by Norwalk Transit District, Greater Bridgeport Transit, and Milford Transit District), and CT*transit* New Haven Division O (Route 1). Throughout this study, the Route 1 corridor is treated as five separate "corridor segments", based upon the existing bus routes, with the area served by the Coastal Link treated as two corridor segments separated at Bridgeport.

Technical Advisory Committee

The study included input from a Technical Advisory Committee (TAC) that was formed to assist in developing improvement options, providing feedback on study analyses, and providing guidance in prioritizing the corridors for improvement. The TAC initially included representatives from CTDOT, the five transit operators, and the three Councils of Governments in the corridor. Five meetings were held with the TAC. At the fourth and fifth meetings, the twelve municipalities in the corridor were invited to attend. At the fourth meeting, separate breakout sessions were held for each of the five corridor segments to review the five preliminary corridor improvement programs.

Development of BRT Corridor Improvement Programs

Elements of Bus Rapid Transit

Bus Rapid Transit (BRT) is typically defined as a combination of a number of elements that together create a bus transit service with the speed, frequency, comfort, and capacity characteristics of rail transit. These elements include:

- **Running Ways** - either full or partial exclusive right-of-way
- **Stations** – widely spaced distinct branded facilities with travel information, customer amenities, and level boarding
- **Vehicles** – distinct vehicle design that conveys the image and brand of the system
- **Fare Collection** - fares collected off-board to speed the boarding process
- **Real-time Information** – in station displays, online, and via mobile devices
- **Transit Signal Priority (TSP)** – technology that provides priority for transit vehicles at signalized intersections
- **Service and Operating Plans** – frequent service, including nights and weekends, and longer spacing between stops
- **Branding** – a unique, unified brand that is easily distinguished from other bus services

Route 1 Bus Rapid Transit Improvements Strategies

In the Route 1 corridor, a large-scale dedicated right-of-way is not envisioned at this time, nor is a uniquely branded service with branded vehicles. The Route 1 BRT Feasibility Study therefore focused on developing improvements in the following five categories of strategies:

- Service Design and Stop Spacing
- BRT Stations, Amenities and Information
- Fare Collection
- Transit Signal Priority
- Intersection and Running Way Improvements

Improvement strategies in each of the five categories were evaluated separately. Following the separate analyses, the recommendations for improvements in each category were combined into a proposed improvement program for each of the five corridor segments.

Data Used

The study worked with existing data on routes, stop locations, service levels, and ridership and gathered information on the ability of both the traffic control systems and transit vehicle location systems to accommodate transit priority treatments. New data on bus travel times and delays was collected for this study to identify locations where buses are currently experiencing the delays. The analysis of the new data identified 49 signalized intersections where buses experience the most intersection delay.

Service Design and Stop Spacing

A proposed limited stop overlay BRT route was identified for each corridor segment that would serve only a limited number of stops and operate weekdays for approximately 14 hours per day at the same frequency as the existing local route. No changes would be made to the existing local route. Additional vehicles would be required for the limited stop route and corridor operating costs would increase substantially. The limited stop overlay concept was selected over simply increasing service on the existing route and eliminating some stops, due to the greater travel time savings and the negative impacts of completely eliminating some stops in the latter alternative.

BRT Stations and Amenities

The proposed stations on each limited stop route were categorized into Major, Standard, and Minor Stations based on boarding ridership and site restrictions. The types of amenities included for each type were identified so that construction costs could be developed for each station and for each corridor segment. The cost of providing an accessible route from each station to the nearest sidewalk or intersection was included.

Fare Collection

Several fare collection strategies to reduce passenger boarding times were examined, starting with an estimate of the travel time impacts of CT*transit*'s plan to introduce contactless Smart Cards in 2017. It was recommended that the corridor improvement programs should assume the introduction of Smart Cards in all corridors, but would not assume any further changes to fare collection intended to reduce boarding times.

Transit Signal Priority

Several options for implementing Transit Signal Priority (TSP) along Route 1 were examined. It was recommended that a distributed system involving direct communication between a bus and a particular traffic signal controller (as proposed to one operating through a centralized traffic control system) would be most appropriate. Priority would only be granted on a conditional basis, when a bus is behind schedule, rather than unconditionally. TSP would require integration with each bus operator's Automatic Vehicle Location (AVL) system. Implementing TSP would require upgrading signal controllers at nearly all proposed locations, installing bus detection equipment at signals and on-board buses, and would require separate integration programing with each different bus operator's AVL system.

Intersection Improvements

Possible intersection improvements to improve travel time and reliability were examined for the intersections identified as having the most delays for buses. Each location was reviewed and recommendations were made for either a bus queue jump, Transit Signal Priority, passive priority, or other site-specific improvements. Travel time improvements and costs were identified for each location and corridor segment.

Study Analysis and Recommendations

Corridor Comparison and Evaluation

One of the goals of the Route 1 Bus Rapid Transit Feasibility Study was to "determine where *the best locations* are for potential BRT enhancements to increase the effectiveness of bus services and improve operations." Therefore, an evaluation and prioritization process was needed to determine which corridor segment poses the best opportunity for successful implementation of an initial BRT service. Working with CTDOT, the study team developed a series of evaluation questions that can be answered quantitatively or qualitatively for each corridor segment. From the evaluation questions, the matrix shown below was developed and populated with empirical data for the quantitative measures, and for the more qualitative measures, with the study team's judgment using a numeric rating along a scale of 1 (least favorable) to 5 (most favorable). The tables use a color scale to indicate the relative ratings for each measure, with green indicating the most favorable and red the least favorable values for each measure.

Evaluation of Route 1 Corridors

	311	341	CL West	CL East	O
Running Time					
Percent BRT Running Time Savings	24%	13%	9%	8%	25%
Ridership					
Current Weekday Daily Corridor Ridership	2,447	2,470	2,318	1,435	2,556
BRT Service Ridership Share	43%	45%	44%	44%	51%
Percent Corridor Ridership Increase	28%	32%	30%	30%	36%
Costs					
Total Capital Cost ($000)	$3,664	$4,280	$5,285	$4,330	$5,295
Annual Operating Cost ($000)	$955	$1,105	$1,287	$1,102	$1,413
Net Total Cost per New Rider	$6.11	$6.23	$8.75	$12.40	$7.14
Ease of Implementation					
Complementary Initiatives and Local Support	5	5	4	4	5
Creation of New One-Seat Connection	1	1	1	1	1
Scale of Governance Change Required	5	5	3	3	5
Construction Scale and Complexity	4	4	2	3	2
Complexity of Technology Integration	4	4	2	2	5

Recommendations for BRT in the Route 1 Corridor

The evaluation shown above illustrates that each of the five corridors has advantages and disadvantages. Overall, by most measures, the differences between the corridors are not large. There are clear, albeit modest, benefits that can be realized in each corridor and therefore there is little reason to exclude any one outright from consideration for eventual BRT service. Ultimately, there could be BRT service throughout the entire corridor, most likely using a number of routes rather than one single long service, but possibly using as few as two or three long routes, each covering one or two segments.

Keeping in mind that one of the goals of this project was to “determine where *the best locations* are for potential BRT enhancements to increase effectiveness of bus services and improve operations,” it was essential that this project identify which corridor segment poses the best opportunity for successful implementation of an initial BRT service. The other goal of this project was to “develop alternatives and assess their viability in improving bus travel time and increasing bus ridership in targeted corridors.” This emphasis on travel time improvements and increasing ridership indicated that the most emphasis in selecting an initial corridor segment for BRT implementation should be placed on travel time and ridership measures.

Taking this into account, but considering all of the evaluation measures evaluated above, the recommendation of this study is that the O (Route 1) corridor segment presents the best opportunity for a successful initial BRT service, while the Route 341 segment presents the second best opportunity. Service along the Route 341 corridor segment could be implemented alone or in combination with service on the Route 311 segment to create a single service from Norwalk to Port Chester. The Coastal Link Corridor has numerous service, governance, and technological issues on the existing service that must be resolved first, although BRT service could be implemented at a later date.

The above findings and recommendations are summarized below:

Route 1 Bus Rapid Transit Feasibility Study Findings and Recommendations

- All Route 1 corridor segments could benefit from BRT improvements.
- There could ultimately be BRT service throughout the entire Route 1 corridor using multiple BRT routes.
- The O (Route 1) segment presents the best opportunity for a successful initial BRT service.
- The Route 341 segment presents the second best initial opportunity and could be implemented alone or in combination with service on the Route 311 segment.
- The priority on the Coastal Link corridor should be improving the reliability and performance of the existing local service first, before adding BRT. BRT service could eventually be implemented possibly as extensions of the O (Route 1) and 341 BRT services to Bridgeport, provided governance issues can be resolved.

Possible Longer Term Improvements

This study focused on short-term improvements to services, facilities, and technology that could bring elements of BRT to the Route 1 corridor within the next five years. The study focused on the service and operating plan, stations, real-time information, and a limited application of TSP at key locations in the corridor. The proposed improvements are expected to result in shorter travel times and better reliability than is currently achieved by the existing local routes. Over the longer term, however, additional improvements implementing all of the elements of BRT are possible, leading to an even more robust implementation of BRT in the corridor. Some possible future enhancements could include:

- Expansion of Transit Signal Priority to additional locations
- Targeted implementation of dedicated or shared bus lanes where needed, especially in the context of a Complete Streets project
- Increased frequency and/or extended hours of service on the limited stop BRT route
- Combining BRT service in two adjacent corridors into one longer BRT route
- Introduction of future fare payment technology advances to speed boarding
- Creation of a unique brand with dedicated branded vehicles for BRT services in the corridor
- Pedestrian improvements and Complete Streets enhancements along the corridor and in surrounding areas.

PART I

1. Study Background and Organization

1.1 Study Goals

The Route 1 Bus Rapid Transit (BRT) Feasibility Study is an important element of the 5-Year Ramp-Up Plan of Let'sGoCT!, Governor Malloy's transportation "Call to Action." Let'sGoCT! represents a 30-year vision for Connecticut's best in class transportation system, while the 5-Year Ramp-Up Plan outlines the initial steps toward that vision. The Route 1 BRT Feasibility Study seeks to provide a blueprint for bringing faster, more reliable bus service to the heavily traveled Route 1 corridor between the New York State Line and New Haven within the next five years.

The Connecticut Department of Transportation (CTDOT), Bureau of Public Transportation, initiated the Route 1 BRT Feasibility Study in January of 2016 with two specific goals for enhancing bus service in the study corridor:

- Develop alternatives and assess their viability in improving bus travel time and increasing bus ridership in targeted corridors.
- Determine where the best locations are for potential BRT enhancements to increase effectiveness of bus services and improve operations.

The first goal served to focus the study on alternatives to improve travel times on bus service in the corridor. Bus service in the Route 1 corridor moves slowly, facing the same traffic delays as all other traffic, but is slowed even further by the need to frequently stop at the many closely-spaced bus stops to pick up and drop off passengers. Bus riders face further delays just waiting for the bus to arrive as traffic and other delays tend to make bus arrival times less reliable. Therefore, evaluating strategies to reduce travel time and improve service reliability were a key focus of the study.

The second goal recognizes that implementing the strategies to improve travel time and reliability across a long and complex corridor will require a phased approach. As a result, CTDOT elected early on in the study to identify possible improvements throughout the corridor, but to use the study to identify one or more segments of the corridor for initial implementation of a package of improvements that could make a significant impact on travel time and service reliability on that corridor segment. In that way, an initial focused approach achieving success on one corridor segment can serve as a demonstration of successful strategies that can then be transferred to other corridor segments in the study area.

1.2 Study Area

While the study was called the Route 1 study, the study area was actually defined by the four existing bus routes that roughly follow U.S. Route 1 from Port Chester, New York to the New Haven Green. The routes are listed in Table 1-1.

Table 1-1: Route 1 Corridor Bus Routes

Route	Western Terminus	Eastern Terminus	Operator(s)
311 *(formerly 11A/B)*	Port Chester (NY) Metro North Station	Stamford (CT) Transportation Center	CT*transit* (Stamford Division)
341 *(formerly 41)*	Stamford Transportation Center	Norwalk WHEELS Hub	CT*transit* (Stamford Division)
Coastal Link	Norwalk WHEELS Hub	Westfield CT Post Mall, Milford	Norwalk Transit District Greater Bridgeport Transit Milford Transit District
O (Route 1)	Westfield CT Post Mall, Milford	New Haven Green	CT*transit* (New Haven Division)

Route 311 operates from Port Chester, NY to Stamford, CT. It has two branches, Route 311 and Route 311B. The routes divert off U.S. Route 1 to serve downtown Greenwich and downtown Stamford. Route 311 more closely follows Route 1, while Route 311B serves residential areas in Greenwich. The two branches alternate trips throughout the day, although only Route 311B operates in the evening. Route 311/311B is interlined at all times with Route 341 in Stamford and the two Route 311 branches are interlined with each other in Port Chester.

Route 341 operates from Stamford to Norwalk and stays on U.S. Route 1, except at the ends, where it serves the Stamford and Norwalk bus hubs. Roughly, half of the trips on Route 341 divert off Route 1 to serve Norwalk Community College, and are designated as Route 341A.

The Coastal Link begins at the Norwalk hub, joins U.S. Route 1 in Norwalk, and follows Route 1 into Fairfield. There it shifts onto Route 130 where it stays into Stratford, except for a short diversion to the Bridgeport Transportation Center. In Stratford, it uses Route 113 to rejoin U.S. Route 1 and follows Route 1 into Milford, where it diverts to serve downtown Milford, before rejoining U.S. Route 1 as it approaches the CT Post Mall.

O (Route 1) follows U.S. Route 1 from the CT Post Mall into New Haven, where it then serves local streets on its way to the New Haven Green. O (Route 1) is interlined at all times at the New Haven Green with the O Winchester Avenue Route, which is not part of this study.

Throughout this study and in this report, the Route 1 corridor is treated as five separate “corridor segments”. The segments of the corridor served by Route 311, Route 341, and O (Route 1) were each considered a single corridor segment. The area served by the Coastal Link, due to its length and the existence of a scheduled layover in the middle at the Bridgeport Transportation Center, was treated as two separate corridor segments – Coastal Link West (CLW) from Norwalk to Bridgeport, and Coastal Link East (CLE) from Bridgeport to Milford.

1.3 Previous Studies

The study built upon the analyses from prior studies. The study team reviewed pertinent findings and recommendations from a number of prior studies that have been conducted in the study area. This information was helpful in identifying both problems and potential improvements to transit service and traffic flow in the study area. Prior to conducting any new analyses, a list of prior reports, transportation plans, and operational improvement studies related to the Route 1 Corridor, was developed. The list was derived from the experience of the study team, with input from CTDOT and other participating agencies. Reports and plans were reviewed from the following studies:

- Greenwich/Norwalk Bus Rapid Transit Study
- HART Bus Service Plan
- US Route 1 Greenwich/Stamford Operational Improvements Study
- Norwalk Transportation Management Plan
- Coastal Corridor Bus Study
- Darien Route 1 Corridor Study
- Stamford East Main Street Transit Node Feasibility Study
- Westport Bus Operations and Needs Study
- South Western Region Long Range Transportation Plan 2015-2040
- Downtown Westport Master Plan
- Greater Bridgeport Transit Long Range Transit Plan
- Stamford West Side Transportation Study

A synopsis of the key findings and recommendations from these studies is included in Appendix A.

In addition, there were two ongoing bus studies in the study area:

- City of New Haven Transit Alternatives Analysis Study
- Stamford Bus and Shuttle Study

The City of New Haven is currently undertaking an Alternatives Analysis Study that seeks to identify and enhance public transit. The study includes a review of transit needs and transit access, and will assess alternatives for an enhanced public transit network in the city. The study was in its early phases while this study was being completed.

The Stamford Bus and Shuttle Study began in June 2015. The study is organized in two parts: Phase A: Private Shuttle Study and Phase B: Broader Urban Transit Study. Primary Phase A activities in 2015 included data collection and field observation relating to private business shuttles. The study team conducted stakeholder interviews with members of the business community currently running shuttles and spoke with shuttle riders at the Stamford Transportation Center to assess challenges and opportunities of private shuttle operations. Phase A of the study also included an initial look at CT*transit* bus services, primarily in the context of citywide commuting/travel patterns and the relationship between the existing CT*transit* network and the array of private shuttle services in Stamford. Specific CT*transit* operating recommendations had not been developed as of the time this report was completed. CT*transit* service design approaches will be considered in greater depth in Phase B.

1.4 Study and Report Organization

The Route 1 BRT Feasibility Study was organized along the following tasks:

- Project Management
- Technical Advisory Committee Meetings
- Assemble Data and Existing Conditions
- Time and Delay Data Collection

- Development and Evaluation of Improvement Strategies
- Corridor Improvement Programs
- Prioritization of Corridors and Recommendation
- Final Report

Regular Project Management meetings between the consultant team and CTDOT staff were held throughout the study. The meetings covered review of task deliverables, Technical Advisory Committee meeting preparation, and review of the project schedule. A Technical Advisory Committee (TAC) made up of corridor stakeholders was convened to review study progress. Five TAC meetings were held and are described in greater detail in Section 1.5 below.

The remaining six tasks constituted the sequential steps of the work program for this study. The data assembled on existing conditions from existing sources is described in Chapter 2. New travel time and delay data collected for the purposes of this study are described in Chapter 3. Improvement strategies in the five different categories noted previously were then identified and evaluated. These are documented in Part II of this report. Each of the strategies were then applied to the five corridor segments to develop preliminary Corridor Improvement Programs for each corridor segment, which are detailed in Part III. Finally, the preliminary program of improvements for each corridor segment were compared and evaluated so that a preferred corridor segment initial implementation could be identified. Part IV describes the evaluation process and details the preliminary Improvement Program for the preferred initial segment between Milford and New Haven. The final chapter provides a vision for longer term improvements that could realize a more robust network of BRT services and features in the Route 1 corridor.

1.5 Stakeholder Involvement

The Technical Advisory Committee (TAC) was formed to assist in developing improvement options, provide feedback on study analyses, and provide guidance in prioritizing the corridors for improvement. The project team worked with CTDOT to identify the appropriate stakeholders to be involved. The TAC initially included representatives from the following departments, agencies, and organizations:

- CTDOT Public Transit
- CTDOT Traffic
- CTDOT Highway Operations
- CTDOT Signal Lab
- CT*Transit* (New Haven and Stamford Divisions)
- Greater Bridgeport Transit
- Norwalk Transit District
- Milford Transit District
- Western Connecticut Council of Governments (WestCOG)
- Connecticut Metropolitan Council of Governments (MetroCOG)
- South Central Regional Council of Governments (SCRCOG)
- The Kennedy Center

Initially it was decided to limit the size of the group to the above organizations in order to keep meetings to a manageable size. In lieu of a broader membership that could include one or more representatives from each of the twelve corridor municipalities, separate informational presentations about the study were given early in the study to the Transportation Technical Advisory Committees from each of the three Councils of Governments that cover the corridor.

The project team met with the TAC at the beginning of the study, on January 27, 2016, at the Bridgeport Transportation Center, to explain the study organization and discuss data needs. A second meeting was held on June 16, 2016 after the completion of data collection. That meeting focused on the initiation of the task to develop improvement strategies. The study team explained each of the five categories of improvement strategies, including discussion of the analysis methodologies that the study team intended to use to evaluate each category of strategies. The third TAC meeting was held on September 15, 2016, after the evaluation was completed. The study team presented findings from the time and delay data collection, followed by presentations on the findings from the evaluations of the five categories of improvement strategies.

Once the preliminary Corridor Improvement Programs were developed for each of the five corridors, the twelve municipalities were invited to the fourth TAC meeting on October 27, 2016. Two separate meetings were held on the same day (one in Milford and one in Norwalk) and within the two meetings separate breakout sessions were held for each of the five corridor segments. All twelve municipalities were invited to attend these expanded TAC meetings. Representatives from both the traffic and the planning departments in each municipality were invited. Representatives attended from the municipalities of Greenwich, Stamford, Darien, Norwalk, Westport, Stratford, Milford, West Haven and New Haven. Meeting attendees provided feedback on the proposed corridor program elements as well as an indication of both the consistency of the proposals with local transit initiatives and the level of support for BRT enhancements in each municipality.

A final TAC meeting was held on January 4, 2017 at the Government Center in Bridgeport. The municipal representatives were once again invited. The comparison and evaluation of the five corridor segments were presented along with the preliminary study findings. During and after the meeting, several comments were received which resulted in modifications to the preliminary findings. Those modifications were reflected in the study recommendations as presented in the Draft Final Report. The Draft Final Report was then circulated among the TAC and the municipalities. While a few comments were received, they did not result in any further changes to the study recommendations.

2. Existing Conditions

This chapter summarizes the previously existing data that was assembled for the study in preparation for identifying where buses in the study area encounter the most delays and developing improvement strategies for each corridor segment. A substantial amount of data was assembled and this chapter does not attempt to present it all. Instead, this chapter describes the data that was collected, cites the sources of that data, and presents some summary statistics.

The following sections describe the data assembled, grouped into the following categories:

- Bus Routes and Stops
- Bus Service Levels
- Bus Ridership
- Bus Automatic Vehicle Location System Capabilities
- Traffic Signal Control Data
- Traffic and Parking Data
- Major Trip Attractors
- Population Density and Growth Projections

2.1 Bus Routes and Stops

2.1.1 *Route 1 Corridor Bus Routes*

The study area is defined as the four bus routes that roughly follow Route 1 from Port Chester, New York to the New Haven Green. The Coastal Link is operated jointly by three local transit districts, Norwalk Transit District (NTD), Greater Bridgeport Transit (GBT), and Milford Transit District (MTD). The rest are operated by CT*transit,* either the Stamford Division (Routes 11A/B and 41) or the New Haven Division (Route O).

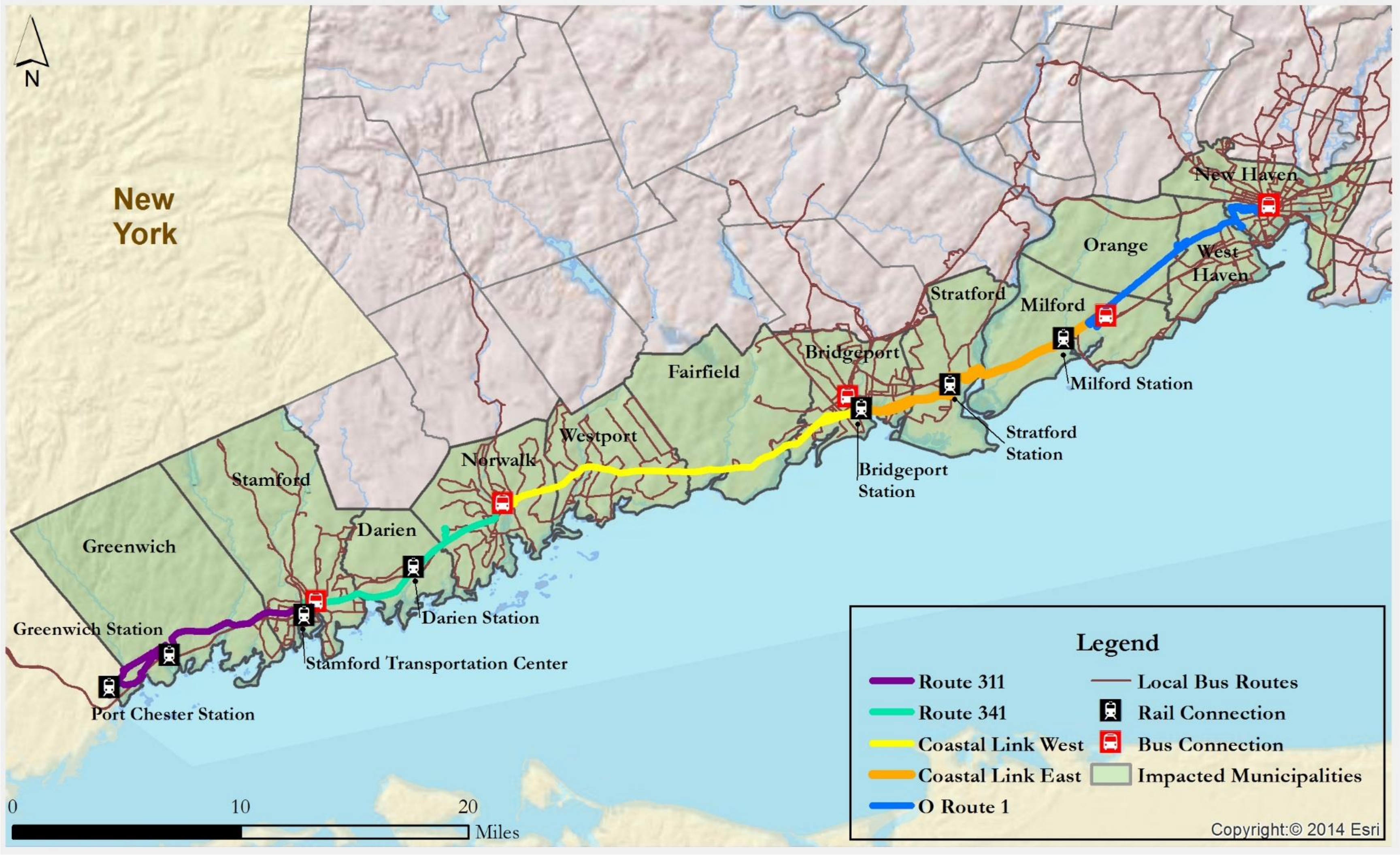
2.1.2 *GIS Data on Bus Routes and Stops*

Geographic Information System (GIS) files of all corridor routes and stops, as well as all connecting local bus services, were requested from the five transit operators. CT*transit* was able to provide the data for all routes in their Stamford and New Haven Divisions. GBT provided the data for their system, including the Coastal Link. MTD and NTD provided route files (but not stops) for their local routes. The routes served by these five operators are shown in Figure 2-1. The figure also shows the major bus connection points and the Metro North rail stations served by study area routes.

2.1.3 *Bus Stop Spacing, Position, and Amenities*

Information on stop spacing, stop position (e.g. near side vs. far side), and stop amenities (primarily shelter locations) were requested from the five transit operators. CT*transit* provided all the requested the data for their three study area routes. GBT provided the stop position data for the entire Coastal Link, but did not have data on stop spacing. Coastal Link stop spacing had to be derived from the GIS data by the project team. GBT and MTD provided data on shelter locations in their respective service areas. NTD indicated that they operate a flag stop system and do not provide shelters.

Figure 2-1: Route 1 Corridor Bus Routes



The data on stop spacing, stop position, and shelter counts are summarized by corridor segment[1] and direction in Table 2-1. The distribution of stop spacing is also shown in Figure 2-2 by corridor segment (both directions combined), while the distribution of stop position is shown similarly in Figure 2-3. O (Route 1) has the highest percentage of closely spaced stops (those less than 0.1 miles), while Route 341 has the smallest percentage. It is also worth noting that the Coastal Link has a far higher share of near side stops and very few mid-block stops in comparison to the three CT*transit* routes.

The five transit operating agencies were asked for any existing American with Disabilities Act (ADA) assessments that have been completed for their bus stops, however, none was available.

2.1 Bus Route Service Levels

2.1.1 *Bus Route Schedules*

Spring 2016 public timetables for all study area routes were downloaded from the CT*transit* and GBT websites. The two agencies were also asked to provide headway sheets (similar to public timetables but including block numbers) and vehicle blocks (listing all trips on a given block together in sequence) for study area routes in electronic format. CT*transit* provided headway sheets and blocks for the entire Stamford and New Haven Divisions (for weekday, Saturday and Sunday schedules) in PDF format. GBT provided Excel spreadsheets of the weekday, Saturday and Sunday Coastal Link schedule, that included block numbers and a designation as to which transit agency provides each block.

Table 2-1: Bus Stop Spacing and Position

	311		341		CL-West		CL-East		O (Route 1)	
	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB
Less than 0.1 miles	5	8		2	6	16	9	13	22	19
0.1 to 0.2 miles	32	27	31	37	54	42	32	27	39	37
0.2 to 0.3 miles	12	11	16	9	19	22	15	18	4	9
0.3 to 0.4 miles	4	6	4	3	1	3	3	1	3	1
0.4 to 0.5 miles	1	2				1	3	1		
More than 0.5 miles		1			1		3	2	1	1
Route Length	9.7	10.6	10	9	13.9	14.1	12.9	11.3	9.4	9.5
Average Spacing	0.18	0.19	0.2	0.18	0.17	0.17	0.2	0.18	0.14	0.14
Near Side	25	25	11	24	47	53	43	37	30	26
Mid-Block	20	18	34	23	8	1	4		35	28
Far Side	25	28	9	11	24	20	9	15	18	20
Other Location	2	2	1	2	3	10	9	11	1	4
Total Stops	72	73	55	60	82	84	65	63	84	78
Shelter Count	5	9	7	15	1	2	2	7	13	2

Sources: CT*transit* spreadsheets for Routes 311, 341 and O; GBT spreadsheet for Coastal Link stop positions; GBT GIS data for Coastal Link stop spacing; shelter lists provided by CT*transit*, GBT, and MTD

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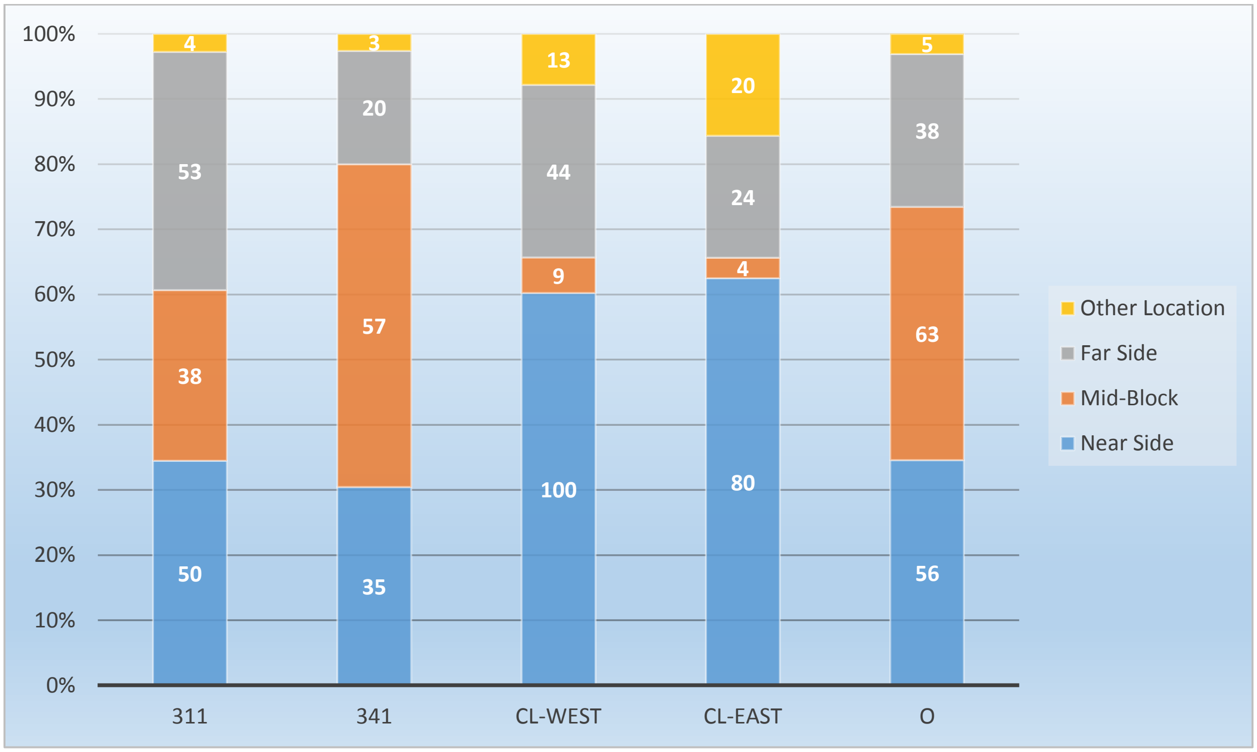
[1] The corridor is divided into corridor segments corresponding to the section of the corridor served by each route, with the Coastal Link divided into east and west segments at the Bridgeport Transportation Center

Figure 2-2: Bus Stop Spacing

Figure 2-3: Bus Stop Position



2.1.2 *Bus Service Frequency*

Service frequencies were documented using the public timetables for each route. The predominant scheduled frequency by route, direction, and time is shown in Table 2-2. The table also shows the number of scheduled trips in each direction by day of week. Most routes have peak period headways of 20-25 minutes, except for O (Route 1), which operates every 15 minutes in the PM peak. O (Route 1) also tends to be slightly more frequent in off-peak times (midday, evenings and weekends), while the Coastal Link, with only hourly midday service, is noticeably less frequent than other routes at that time.

2.1.3 *Scheduled Running Times*

Scheduled one-way running times were documented using the public timetables for each route. The predominant scheduled weekday running time by route, direction, and time is period shown in Table 2-3. The times shown do not include scheduled layover/recovery time at the route endpoints.

2.2 Observed Running Times

2.2.1 *Average Running Times*

CT*transit* provided actual running time observations of individual trips on their three corridor routes developed as part of their routine ridership checking program. The observations consisted of actual running times to the tenth of a minute by route segment for each of their three routes (the routes had between six and twelve segments in each directions). The project team summarized the data by segment and time period to produce average running times and speeds that can be used to identify segments with significant delays. For most segments and time periods the sample sizes are sufficient for conducting further analyses of the variability of observed running time to identify segments with highly variable times that could be targeted for improvements in reliability.

While average running times were calculated by route segment, Table 2-4 shows the average running time for each route as a whole, by direction and time period. When these times are compared to the scheduled times in Table 2-3, O (Route 1) averages close to or above the scheduled time, while the other two CT*transit* routes average less than the scheduled time.

GBT was able to provide some Coastal Link running time data, which is also included in Table 2-4. Coastal Link times are separated into western and eastern segments at Bridgeport, with the Bridgeport layover time excluded. When compared to the scheduled times, both parts of the Coastal Link average close to or above the scheduled time in the westbound direction, while eastbound times are either less than the scheduled time or not available.

2.2.2 *Variability of Running Times*

A subset of the CT*transit* data provided, representing only complete trips on the predominant service pattern on each route, was used to calculate the variability of running times on that pattern. Table 2-5 shows the coefficient of variation (CV)[2] of running time for each route, direction, and time period, wherever a sufficiently large sample of trips was available. (The limited number of observations on Route 311 westbound and Route 341 eastbound prevented calculation of the variability of running time.) The table shows that the CVs, within a given time period, are generally less than 0.15 – in other words, the standard deviation is less than 15% of the mean. This is typical for urban bus routes and does

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[2] Coefficient of Variation is defined as the standard deviation divided by the mean.

Table 2-2: Service Frequency and Daily Trips

	311		341		CL-West		CL-East		O (Route 1)	
	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB
AM Peak	20	20	25	25	20	20	20	20	20	20
Midday	30	30	30	30	60	60	60	60	20	20
PM Peak	25	20	20	25	20	20	20	20	15	15
Evening	60	60	60	60	60	60	60	60	35	30
Saturday	60	60	30	30	30	30	30	30	20	20
Sunday	60	60	40	40	60	60	60	60	40	60
Weekday Trips	36	38	42	43	32	36	37	33	51	52
Saturday Trips	17	17	33	33	28	30	31	29	47	48
Sunday Trips	12	14	19	21	10	10	10	10	28	34

Frequency in minutes.

Source: summarized from public timetables

Table 2-3: Weekday Scheduled Running Times

	311		341		CL-West		CL-East		O (Route 1)	
	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB
AM Peak	58	52	48	45	55	55	53	55	40	40
Midday	61	56	50	49	55	55	53	55	43	44
PM Peak	67	60	52	50	55	55	53	55	47	43
Evening	56*	51*	46	44	55	55	53	55	40	39

Travel time in minutes.

* Evening Data for Route 311B

Source: public timetables

Table 2-4: Weekday Running Times Observed by Operating Agencies

	311		341		Coastal Link West		Coastal Link East		O (Route 1)	
	EB	WB	EB	WB	EB	WB	EB	WB	EB	WB
AM Peak	49.4	49.9	43.0	39.9	**	51.2	47.9	54.8	39.1	39.3
Midday	50.2	57.1	45.6	43.0	**	54.5	44.7	56.0	45.7	43.7
PM Peak	56.3	*	*	43.8	**	51.9	49.0	50.5	51.7	43.8
Evening	*	*	*	37.3	**	47.8	**	51.8	39.4	35.8

Travel time in minutes.

* Fewer than four trips observed

** Incomplete data available

Source: CT*transit and GBT*

Table 2-5: Coefficient of Variation of Weekday Running Times Observed by Operating Agencies

	311		341		O (Route 1)	
	EB	WB	EB	WB	EB	WB
AM Peak	0.11	*	*	0.08	0.08	0.15
Midday	0.19	*	*	0.07	0.15	0.14
PM Peak	0.12	*	*	0.09	0.15	0.11
Evening	*	*	*	0.15	0.08	0.22

* Fewer than four complete trips observed

Source: CT*transit*

not indicate, based on the limited amount of data, a serious problem with running time variability. That said, the midday period on Route 311 eastbound shows slightly higher variability, and Route O running time appears to be a bit more variable than that of the other two routes.

2.3 Bus Ridership

2.3.1 *Daily Ridership*

Typical daily ridership for weekdays, Saturdays, and Sundays is shown in Table 2-6. CT*transit* provided typical daily recent ridership counts on their three routes from their ridership checking program. NTD provided average daily Coastal Link ridership by month on their buses from FY 2009 to the end of 2015. MTD provided current average daily Coastal Link ridership on their buses. GBT provided detailed and summarized ridership counts from the Coastal Corridor Study collected in 2010 for trips operated by all three operators. While GBT did not provide recent ridership data, the historical data from NTD exhibits a very stable weekday and Sunday ridership over the seven years of data, indicating that the Coastal Corridor Study data, while old, is still likely very representative of current ridership. While NTD reported a weekday ridership increase of 3% from FY2010 to FY2015 and a Sunday drop of 6% on their Coastal Link trips, Saturday ridership exhibited a 14% increase.

Table 2-6: Typical Daily Ridership

	311	341	CL-West*	CL-East*	O (Route 1)
Weekday	3,022	3,097	2,613	1,562	3,230
Saturday	1,666	2,142	1,594	1,313	3,034
Sunday	NA	NA	637	446	1,519

* Riders traveling through Bridgeport on the Coastal Link were counted only once on their boarding segment

Sources: CT*transit* 2015 ridership counts for CT*transit* routes; 2010 ride checks from the Coastal Corridor Study for the Coastal Link

2.3.2 *Stop-Level Ridership*

Both the CT*transit* ridership counts from their routine ridership checking program and the Coastal Corridor Study data on the Coastal Link break ridership down into boardings and alightings at each bus stop. The CT*transit* stop-level data is summarized at the time period level, while the Coastal Link data is at the individual trip level. Both datasets represent a single typical day of ridership. While GBT has some buses equipped with APCs, the agency has not developed summaries of ridership by stop for the Coastal Link. The available stop-level ridership data can be used to identify modifications to stopping patterns to speed bus travel times, as well as being used to identify high ridership stops for enhanced bus stop treatments.

2.3.3 *Coastal Corridor Study Rider Survey*

Coastal Corridor Study Survey Findings

GBT provided survey data files from the passenger survey completed as part of the Coastal Corridor Study. The survey findings included in the Coastal Corridor Study report are summarized in this section[3].

An onboard passenger survey was conducted on Coastal Corridor routes including 11A/B (now 311/311B), 41/A (now 341/341A), the Coastal Link, OS (O Route1), 55x and S. This survey was conducted in late 2010. It sought to obtain data describing passengers using each route including trip origin/destination, ridership history, passenger demographics, trip purpose, transit access mode (to/from stops), transfers, and service attributes that were most important to passengers.

In total, 5,667 surveys were returned, 14% of which were completed in Spanish. Most respondents were captive riders, as overwhelmingly it was reported they did not have cars available to make their trip. Most respondents (more than 95% on all routes) were between the ages of 18 and 62. Approximately half of respondents classified themselves as minorities. Respondents overwhelmingly reported low household incomes.

Each survey respondent was requested to give the addresses of his/her trip origin and trip destination. However, only 41% of origins and 27% of destinations contained sufficient information to be mapped. A majority of respondents were traveling to and from points in the Coastal Corridor towns. Town-to-town travel was extensive, but overall trip length rarely spanned more than two or three towns. Including the local Bridgeport trips, total trip lengths averaged 7.3 miles for the corridor as a whole and 6.9 miles for the Coastal Link; however, when local Bridgeport trips were excluded, the average trip length for travelers in the Coastal Corridor as a whole was 8.1 miles, while the average trip length for Coastal Link riders was 9.2 miles.

As part of the survey, passengers were asked which they valued more, frequency of service, reliability of service, overall travel time, or other service aspects. Overwhelmingly, passengers cited frequency as most important, followed closely by reliability, with overall travel time ranking a distant third.

Coastal Corridor Study Survey Origin-Destination Summary

The survey data shown in Table 2-7 was obtained from the consultant team that completed the Coastal Corridor Survey in 2010. The table shows origins and destinations of survey respondents by municipality. The shaded cells indicate an approximation of the trips that could be made using a single bus route[4]. These represent 85% of all surveyed trips. This supports the notion that most riders are not traveling far and that the existing route structure is meeting their needs, as far as continuity of service is concerned. It does, however indicate that there is some existing transferring between corridor routes and, given

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[3] AECOM, *Coastal Corridor Bus Study, Recommended Service Plan,* May 2012 – This sub-section is a summarized version of Section 3.1 Market Assessment pp 3-1 to 3-6.

[4] The indication is approximate because trips to or from the terminal cities of Stamford, Norwalk, and Milford were not separated by route, negating the ability to determine which route in the city respondents were using.

Table 2-7: Coastal Corridor Survey Origins and Destinations

Origin\Destination	Port Chester	Greenwich	Stamford	Darien	Norwalk	Westport	Fairfield	Bridgeport	Stratford	Milford	Orange	West Haven	New Haven	Other	Total
Port Chester	5	79	42	1	10	0	0	2	0	0	0	0	0	0	139
Greenwich	48	85	63	1	20	1	0	2	1	0	0	0	0	13	234
Stamford	61	123	194	55	234	6	4	16	1	1	0	2	1	18	716
Darien	2	1	13	0	13	1	0	0	0	0	0	0	0	0	30
Norwalk	3	17	218	27	126	43	12	74	5	12	0	1	5	12	555
Westport	0	0	7	0	20	11	6	34	4	1	0	0	0	1	84
Fairfield	0	1	0	0	6	4	9	50	4	3	0	0	0	1	78
Bridgeport	0	14	26	1	133	91	89	365	65	163	17	6	8	45	1023
Stratford	0	0	5	0	6	7	11	45	26	25	2	1	1	3	132
Milford	0	0	2	0	10	2	2	82	20	49	3	19	55	17	261
Orange	0	0	0	0	0	0	0	4	1	3	2	5	7	5	27
West Haven	0	0	0	0	1	0	0	5	3	56	15	33	36	12	161
New Haven	0	0	3	0	3	0	1	10	3	180	41	36	108	38	423
Other	1	15	22	1	14	2	0	17	4	33	8	14	47	29	207
Total	120	335	595	86	596	168	134	706	137	526	88	117	268	194	4070

that transfers are not currently coordinated, some latent demand may exist for longer trips if longer routes, or at least better transfer connections, were provided. It is worth noting that Bridgeport accounts for the largest number of current transfer trips to or from a single municipality.

2.4 Bus Automatic Vehicle Location System Capabilities

Each of the five transit providers along the U.S. Route 1 corridor were contacted to identify to what extent Automatic Vehicle Location (AVL) systems have been applied to their system operation, and future plans to expand the features of the system. This section also reviews overall compatibility of the AVL systems to implement Transit Signal Priority (TSP) and real-time passenger information, including mobile applications.

2.4.1 *Existing and Planned AVL Systems*

CTtransit New Haven Division[5]

The TransitMaster CAD/AVL System from Trapeze (www.trapezegroup.com/intelligent-transportation-systems) is now operational on the CT*transit* Hartford Division fleet, including CT*fastrak*, and includes Integrated Vehicle Logic Units on all buses. The polling rate in tracking vehicle location is every 30 seconds. There is currently no AVL on buses in the New Haven Division; however, the same system is expected to be installed on New Haven buses in the next several months. There are no current plans to

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[5] *Source: Phone call with scheduling department at CTtransit*

implement real-time passenger information at stops when the AVL system in New Haven becomes operational.

In the Hartford Division currently, the Trip Planner mobile application is maintained by a private application developer that links to a real-time feed from the CT*transit* website.

CTtransit Stamford Division[6]

The Xerox ACS system (www.xerox.com/en-us/services/transportation-solutions/public-transport-management) has been installed for the CT*transit* Stamford Division, different from the Trapeze TransitMaster system existing or soon to be installed at the Hartford and New Haven Divisions. This is because the Stamford system was acquired through a grant received from the Federal Transit Administration (FTA) to the City of Stamford and not to CTDOT. There have been problems with the video coding equipment with the ACS system, which required a vehicle retrofit, and the bugs have been worked out over a five-year period. According to the Director of Maintenance and Technology, TSP is not a priority for CT*transit* in Stamford, as there is a new transit-way that is operational in the Jefferson Street corridor between the Stamford Metro-North station to Elm Street. Real-time passenger information is focused on two applications: 1) next bus annunciators at the bus bays at the Stamford rail station, and 2) a mobile transit application (IOS/Android compatible) that is currently in beta testing.

Greater Bridgeport Transit[7]

GBT implemented the Trapeze TransitMaster CAD/AVL system in 2009, on all buses. Automatic Passenger Counters (APCs) have been installed on 15 of the 50 buses. The ideal polling rate is between 30 and 60 seconds, but can, in some circumstances, take as long as 120 seconds. There is no TSP currently interfaced with their AVL system. Real-time passenger information is provided at the GBT central bus station, in the form of on-street LED signage, which is fed by radio and in the form of all-weather monitors, which are fed by a T1 line. GBT does not have a mobile application. Their Bus Tracker system is a real time web service that is directly plugged into the AVL system.

There are no plans currently for TSP in the GBT service area, but GBT is open to the possibility if there is a demonstrated travel time savings.

GBT indicated that they could assist MTD in installation and maintenance of AVL equipment for their system, and setting up their database if funds were available and MTD has interest. An interagency agreement would be required to make this happen, and grant funding secured.

Norwalk Transit District[8]

The Avail AVL system (www.availtec.com/our-solutions) is currently installed on all 51 buses in the NTD fixed-route fleet, and on 50% of the paratransit vehicles. Location polling rate is every 30 seconds. AVL data is also sent with each text message from the vehicle, and as each stop is exited, so the "effective" frequency on average is actually less than 30 seconds. Also during an emergency alarm condition, the reporting frequency is changed to every 15 seconds.

All new vehicles to be acquired will include both AVL and APCs. AVL system implementation will involve three phases: 1) installing the basic Avail system to provide bus location information 2) adding vehicle

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[6] *Source: Phone call with the Director of Maintenance and Technology, CTtransit*

[7] *Source: Phone call with the Chief Executive Officer, Greater Bridgeport Transit*

[8] *Source: Phone call with the Chief Operating Officer, Norwalk Transit*

diagnostic capability and 3) implementing TSP. Real-time passenger information signs initially are to be located at Norwalk Transit's WHEELS Hub and at the South Norwalk Metro-North train station, with plans to install such information at the Westport Metro North station.

Avail is providing a mobile application during the AVL system acceptance phase. Since the accuracy of the real time information is somewhere between 89% and 92%, NTD currently is not ready to release the application.

Milford Transit District[9]

MTD operates three buses on the Coastal Link, and have the StreetTrek3 for MOTOTRBO AVL system in place (www.streettrek.com/solutions/solutions-streettrek3-gps/streettrek3). This system was developed by Motorola, and currently does not have integration capability with TSP. The system was provided by Northeastern Communications.

2.4.2 *AVL System Compatibility*

Compatibility of AVL Systems to Implement TSP

CTDOT has TSP in place at four intersections along the CT*fastrak* roadway. It is a simple loop detection system, which triggers a green extension or red truncation signal modification to provide some priority to CT*fastrak* vehicles. Priority is only given if the minimum green time on the cross street can be serviced, and is not tied into AVL to be triggered if a bus is behind schedule. There are no plans at this time to expand the TSP application on CT*fastrak*, or to tie AVL into TSP.

To date, there has been no application of true conditional TSP in Connecticut. The application on the CT*fastrak* project only provides for a separate signal phase to provide minimum added green time for buses, and is not applied conditionally (i.e. only if a bus is behind schedule). In the Route 1 corridor, all of the AVL systems – Trapeze TransitMaster, Avail, Xerox ACS, and StreetTrek3, could interface with the local signal system to achieve priority as long as there is an appropriate integration program that would allow the bus AVL system to talk with the signal system. Another key decision for TSP application will be whether it is activated at a centralized traffic management center or by one or more master controllers along the Route 1 corridor. Further discussion and analysis to identify an appropriate TSP architecture and Concept of Operations is discussed later in the report.

Compatibility of AVL Systems to Implement Real-Time Information

All of the AVL systems in the U.S. Route 1 study corridor have the capability of providing real-time passenger information. To date, real-time information has only been provided at the major downtown bus hubs and Metro-North stations. There are no current plans by any of the transit agencies for a broad scale application of real-time information at the smaller stop level.

Support for Mobile Applications

The only mobile application providing real-time passenger information is a private application linked to the CT*transit* website. NTD has plans to implement a mobile application in the next few months.

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[9] *Source: Phone call with the Executive Director, Milford Transit*

2.5 Traffic Signal Controller Capabilities

2.5.1 *Jurisdictional Responsibilities*

Information on traffic signal controlled intersections along the Route 1 study corridor was compiled from CTDOT's Traffic Signal Inventory General Report and is summarized by signal owner in Table 2-8.

Table 2-8: Signals in the Study Corridor by Owner

Signal Owner	Number of Signals
State of Connecticut	206
Town of Greenwich	30
City of Stamford	26
City of Norwalk	10
City of New Haven	9
City of Bridgeport	1
Town of Westport	1
City of Stratford	1
Total	**284**

Source: CTDOT's Traffic Signal Inventory General Report dated 10/15/2015

The following sections summarize the locations of the signalized intersections, by ownership, for CTDOT and the four municipalities that own a significant number of signals. (Signals that are the only one in the corridor owned by a particular municipality are not included.)

City of New Haven

The City of New Haven owns and operates nine traffic signalized intersections within the O Route corridor along Route 34 (MLK Boulevard/North Frontage Road) from College Street to Ella T. Grasso Boulevard (Route 10). Five intersections are operating fully actuated and four are operating semi-actuated. All intersections are coordinated during peak hours.

City of Norwalk

The City of Norwalk owns and operates ten signalized intersections on the study corridor, most located along Route 1. The signalized intersections along the bus route consist of nine intersections along Route 1, and one intersection at West and Belden Avenues and Wall Street. All signalized intersections within the study area are fully actuated and operating in coordination during peak hours.

City of Stamford

The City of Stamford owns and operates 26 signalized intersections along U.S. Route 1 (Main Street and W. Main Street) on Routes 11 and 41. All intersections are semi-actuated and operating in coordinated mode during peak hours.

Town of Greenwich

The Town of Greenwich owns and operates 30 signalized intersections along bus Route 11, with most located on U.S. Route 1. They consist of 5 fully actuated and 15 semi-actuated traffic signals. All traffic signals are operating in coordinated mode during peak hours.

Connecticut Department of Transportation

CTDOT owns and operates 206 signalized intersections on state routes along the study corridor in ten municipalities. All intersections are operating in coordinated mode during peak hours. Out of the 206 traffic signals, 168 are semi-actuated and 38 are fully actuated. The breakdown of State-owned traffic signals in each municipality along the corridor is shown in Table 2-9.

Table 2-9: CTDOT-Owned Signals in the Study Corridor by Municipality

Municipality	Number of Signals
Bridgeport	47
Darien	14
Fairfield	28
Milford	27
New Haven	2
Norwalk	24
Orange	9
Stratford	24
West Haven	10
Westport	21
TOTAL	**206**

Source: CTDOT's Traffic Signal Inventory
General Report dated 10/15/2015

2.5.2 *Existing Signal Controller Equipment*

CTDOT and the four municipalities were asked to provide information on the types of signal controller in use so that the feasibility of implementing TSP can be assessed later in the study. The City of New Haven, City of Norwalk and Town of Greenwich provided the controller information. CTDOT provided only a verbal description of existing traffic signal controllers. A list of all signal equipment by jurisdiction was developed and is summarized in Table 2-10.

2.5.3 *Planned Signal Controller Improvements*

CTDOT and the four municipalities were also asked about planned system improvements.

City of New Haven

- Replacing 2070 L, LN and LN2 with Trafficware/Naztec 900 series
- Upgrade 2 intersections along RT. 34/MLK/North Frontage Road with new equipment and Trafficware/Naztec 900 series controller. The upgraded signals will be equipped with EVP System, video detection, and Ethernet switch for communication with TOC over fiber optic cable

City of Norwalk

- No immediate plan for system improvements
- The City is planning to design and implement improvements to I-95 Diversion Routes from I-95 Exit #16 to Exit #14, which overlaps the Coastal Link on East Avenue from Route 1 to East Wall Street, on Belden Avenue from Wall Street to U.S. Route 1 (Van Buren Avenue), and on U.S. Route 1 from Van Buren Avenue to I-95 Exit/Entrance Ramps #14.

Table 2-10: Existing Signal Controller Equipment

	City of New Haven	City of Norwalk	Town of Greenwich	CTDOT
Controllers	Naztec/Trafficware controllers - 2070 LN, 2070 LN2, 2070L ITS, NEMA TS2 Type1	Trafficware/Naztec 900 series	PEEK 3000	NEMA TS1 controllers, Naztec Version 41, Naztec TS2 Type 2 Controllers; Transyt ELX, and Siemens MarcNx (Controller make/model, vintage and standards – Siemens/Eagle EPAC 3208-M10) along U.S. Route 1.*
Emergency Vehicle Pre-emption (EVP)	GTT/3M EVP System Phase Selectors 764 and 752	EVP locations by direction	3M Opticom	GTT Opticom Infrared (IR) system – various series installed since 1990s.
Cabinets	Type 4 modified (Hybrid), Rack mount - two doors; ITS Cabinet 8CH	Model 340 ITS cabinet	TS2	NEMA P44 (54” H 44” W x 26” D 42” H x 41” W)
Video Detection	Naztec Video Detection System; VD installed at all approaches.	Autoscope Solo Mini-Hub TS2 in all directions	GRIDSMART	Inductive Loop Detection
Central System Software	Streetwise 2WPF; ATMS.Now 2.4.2.0	Streetwise 2WPF; ATMS.Now 2.4.2.0	PEEK IQ Central (not TSP capable)	Naztec and PEEK
Version	4.5.46.61	4.5.46.61; the software has AVL module that is not activated		
Communication and Interconnect	Communication is through Ethernet switch over City owned single mode fiber optic cable	Communication is through Ethernet switch over city owned single mode fiber optic cable	Hybrid system, copper with cable modems from Master	Hard Wire (i.e. single pulse copper wire) TS2-1992 TYPE 2 NEMA traffic

* Many side street vehicle loops detectors are failing, causing increased delays. CTDOT indicated that its equipment and software along U.S. Route 1 is antiquated and not capable of TSP functions.

City of Stamford

- The City is planning to upgrade central software with TSP capabilities
- The City is planning to upgrade central system software with Trafficware ATMS. The controllers and local controller firmware will also be updated.

Town of Greenwich

- To implement an adaptive traffic control signal for Arch Street Corridor
- Upgraded IQ Central software
- TSP capabilities - the new adaptive system has yet to be selected. Looking at PEEK ATC Controllers for the system.
- Planning to upgrade communications to fiber. It is before the budget committee at this time. Probably one or two years out from installing.
- All the traffic signals on U.S. Route 1 currently operate with exclusive pedestrian phases. To improve operations, seven of these signals will be revised to concurrent pedestrian phasing.

CTDOT

- CTDOT has indicated that the Department is in the process of upgrading coordination parameters; replacing controllers, cabinet equipment, vehicle detection system, and firmware as funds become available.

2.5.4 *Cycle Length, Timing, and Coordination*

In the New Haven, Norwalk, Stamford, and Greenwich systems, all signals along the route are coordinated during the peak hours and in ‘Free’ mode at all other times. CTDOT did not provide timing sheets or any information on cycle lengths, splits, or offsets. However, CTDOT-owned traffic signals along Route 1 are operating in coordinated mode.

2.5.5 *Intergovernmental Agreements*

The CTDOT’s Policy Statement No. E&C-16, as updated August 1, 2014, describes ownership and operations for traffic control signals. CTDOT typically retains ownership when one or more approach roadways at the intersection are part of the State Highway System. Ownership may be transferred to a municipality under conditions, mainly that the Local Traffic Authority (LTA) accepts responsibility for ownership. Maintenance responsibilities will coincide with ownership. Signals in a coordinated system typically will be owned by one jurisdiction.

Maintenance of material or equipment that is considered not essential for operation by CTDOT will be the responsibility of the municipality, such as emergency vehicle pre-emption equipment.

The policy states, “Where previous agreements have been made that differ from this policy, those agreements will be honored.” If major modifications to these signals are made, revisions to ownership and electrical energy cost arrangements should be considered. To determine if special agreements exist, the traffic signal reports would have to be pulled from files at the Office of the State Traffic Administration (OSTA). This would be an exceptionally laborious task that is not necessary at this time in the study.

2.6 Traffic and Parking Data

Where available, roadway segment’s and intersection’s operational data was gathered, including level of service (LOS) and volume/capacity (v/c) ratios. CTDOT’s Office of Policy and Planning provided a v/c ratio data file of state routes. New Haven, Norwalk, and Stamford provided Synchro™ model files of their downtown areas. These were reviewed and are summarized in the appropriate section below.

2.6.1 *Traffic Level of Service*

CTDOT

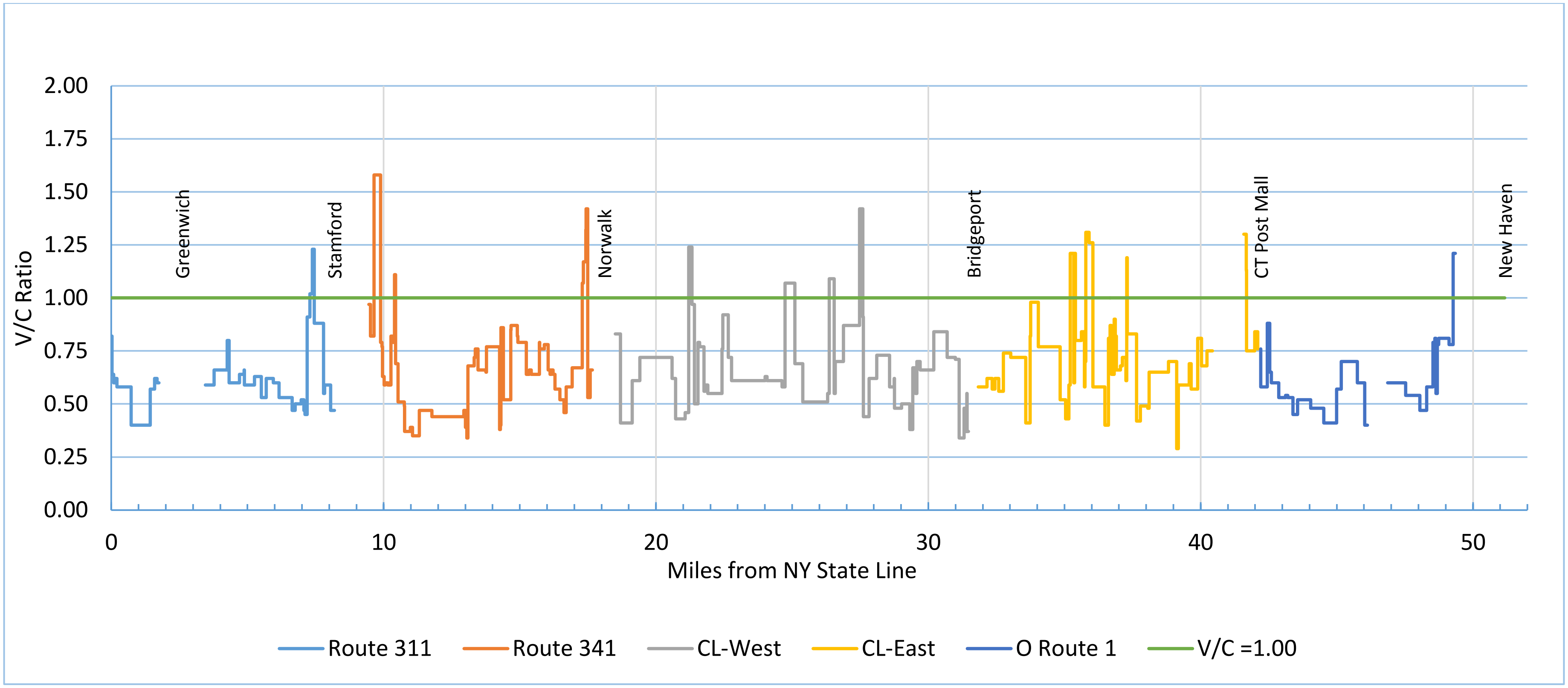
CTDOT's Office of Policy and Planning provided a v/c ratio data file of numbered state routes, which was last updated in 2011. Also provided was an estimate of 2035 v/c ratios using a total growth rate of 10% over 25 years. The 2011 v/c ratios in this file are estimated from available data and are used for developing estimates of statewide congestion levels. While this data is approximate and slightly dated, it provides a general picture of operations along the corridor bus routes. Figure 2-4 shows the 2011 peak hour v/c ratios along the bus corridor from the New York State Line to New Haven. Each corridor segment is shown in a different color and the gaps in the lines represent segments of the bus routes that are not on numbered state routes. A list of all study corridor roadway segments with v/c ratios equal to or greater than 1.00 is shown in Table 2-11.

Table 2-11: 2011 Route 1 Bus Corridor V/C Ratios Equal to or Greater than 1.00

Town	Route	V/C Ratio	Begin Mile	End Mile	Road Segment Start	Road Segment End
Stamford	1	1.02	6.18	6.27	Virgil Street	Roosevelt Ave
Stamford	1	1.23	6.27	6.34	Roosevelt Ave	Richmond Hill Ave
Stamford	1	1.58	7.85	8.09	Near Clarks Hill Ave	Near Metro North Tracks
Stamford	1	1.11	8.6	8.64	Courtland Ave (Rt. 106)	Exit From 1-95 SB
Stamford	493	1.29	0.11	0.17	Access to I-95	Richmond Hill Ave
Stamford	493	1.17	0.17	0.26	Richmond Hill Ave	Division St
Stamford	493	1.09	0.26	0.34	Division St	Tresser Blvd
Norwalk	1	1.07	15.49	15.53	Near Maple Ave	Near Bedford Ave
Norwalk	1	1.17	15.53	15.62	Near Bedford Ave	Exit from SB US 7
Norwalk	1	1.32	15.62	15.63	Exit from SB US 7	Exit from SB US 7
Norwalk	1	1.42	15.63	15.69	Exit from SB US 7	Riverside Ave
Westport	1	1.24	19.23	19.35	Wilton Rd	Parker Harding Plaza
Fairfield	1	1.07	22.77	23.13	Fairfield Town Line (Post Rd)	End of Sasco Brook Overpass
Fairfield	1	1.09	24.39	24.57	Near Granville St	Near Bungalow Ave
Fairfield	1	1.42	25.51	25.63	North Benson Rd	Eliot Pl
Stratford	113	1.21	5.61	5.74	Stratford Ave (Rt. 130)	Yale St
Stratford	113	1.21	5.77	5.8	Harvey Pl	West Broad St
Stratford	113	1.31	6.18	6.3	Broadbridge Ave	North Parade
Stratford	113	1.26	6.3	6.44	North Parade	Barnum Ave (Route 1)
Milford	1	1.19	35.5	35.52	Rivercliff Dr	Kerema Ave
Milford	1	1.30	39.8	39.89	Cherry St	Exit from NB I-95
Milford	1	1.13	39.89	39.9	Exit from NB I-95	Exit from NB I-95
New Haven	10	1.21	1.87	1.95	Legion Ave	North Frontage Rd

Source: CTDOT Office of Policy and Planning

Figure 2-4: Route 1 Bus Corridor V/C Ratios



Source: CTDOT Office of Policy and Planning

City of New Haven

The City provided a Synchro model of the MKL Blvd/South Frontage Road area from Church Street to Route 10 (Ella Grasso Blvd). The model used volumes for the 2011 Build Condition.

- In the AM Peak Hour all the intersections along the bus route from College Street to Ella Grasso Blvd were at LOS D or better.
- In the PM Peak Hour all the intersections along the bus route were at LOS E or better.
- The Ella Grasso Blvd at North Frontage Rd and Legion Ave operated at LOS D in the AM Peak Hour and LOS E in the PM Peak Hour.

City of Norwalk

The City of Norwalk provided a Synchro model of their business districts.

- In the AM Peak Hour all the intersections along the bus route were at LOS D or better.
- In the Midday Peak Hour all the intersections along the bus route were at LOS D or better.
- In the PM Peak Hour all the intersections along the bus route were at LOS D or better.
- A recent traffic impact study by Langan Engineering for a Major Traffic Generator (Shopping Mall) along West Avenue between N. Water Street and I-95 has been provided.

City of Stamford

The City provided a Synchro model of the West Main Street area that includes three traffic signals on the bus route from Alvord Avenue to West Avenue. The 2016 No Build model showed the following:

- In the AM Peak Hour all the intersections operate at LOS C or better.
- In the PM Peak Hour all the intersections operate at LOS D or better.

2.6.2 *Parking Conditions*

The existence of on-street parking along the study corridor was documented for the purpose of identifying where the potential exists for all-day or peak period bus lanes to replace parking. The data was collected using Google Earth Pro. Three types of on-street parking conditions were observed:

- Signed, designated parking
- Unsigned, shoulder parking
- No parking, travel lane

Observations are discussed by corridor segment below.

O (Route 1)

The bus route from downtown New Haven to Milford along the CT*transit* Route O has designated on-street parking in the central business district, on the Yale-NH Hospital campus, and on Sylvan Avenue (a two-way street with one lane and one shoulder in each direction) in New Haven. In these areas, given the width of roadway and signed on-street parking, buses are out of the travel way at the designated stops. There is no on-street parking observed on the Boston Post Road, a two-way four lane roadway with minimal shoulder width, from West Haven to Milford.

Coastal Link East

The bus route from Milford to downtown Bridgeport on the Coastal Link has signed on-street parking in the Milford central business district with some areas of minimal shoulder width observed. Traveling onto Bridgeport Avenue, no on-street parking was observed until Dorsey Lane, where the roadway develops a shoulder for on-street parking. Designated on-street parking is provided in the shoulder on Bridgeport Avenue, a two-way roadway, in the Devon neighborhood of Milford. In Stratford, there is designated on-street parking near the Stratford Main Library on Main Street and the intersection of Main and Stratford Avenues. There is an abundant amount of unsigned on-street parking on Stratford Avenue and Connecticut Avenue in Bridgeport. These are one-way, two lane roadways with shoulders on both sides.

Coastal Link West

The bus route from downtown Bridgeport to downtown Norwalk on the Coastal Link has designated on-street parking in downtown Bridgeport on John and State Streets and in the Black Rock neighborhood on Fairfield Avenue. On these roadways, buses are able to stop in the shoulder lane. Further along the bus route, there is signed on-street parking near the Westport Public Library, the central business district near the Saugatuck River, and in downtown on the Post Road. The Coastal Link ends in downtown Norwalk, where there is some designated on-street parking, mainly on Wall and Main Streets.

Route 341

The bus route from Norwalk to Stamford on the CT*transit* Route 341 passes through downtown Norwalk, where there is no on-street parking on Connecticut Avenue. Connecticut Avenue is a two-way, four lane roadway with no shoulders. There are mid-block bus stops along this stretch of highway. Further along this bus route, signed on-street parking was observed on Boston Post Road in downtown Darien. There is signed parking on the Boston Post Road, a two-way, one lane roadway with shoulders, before and after it traverses through downtown Darien. Continuing along the bus route, there is designated on-street parking traveling into downtown Stamford on Main Street. There is no on-street parking at the Stamford Transportation Center.

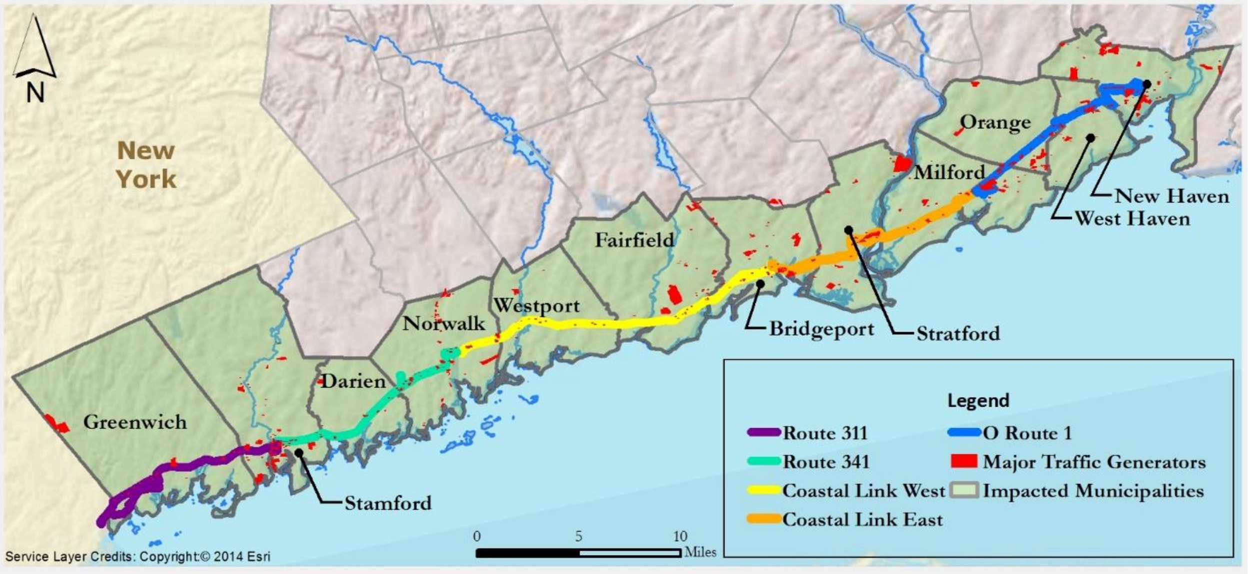
Route 311

On Route 311/311B from downtown Stamford to Greenwich there is both designated and unrestricted on-street parking at the bus stops on West Main Street in Stamford. Leaving Stamford and entering Greenwich (Cos Cob neighborhood), there is designated on-street parking on Mason Street. It was observed that the geometric roadway width accommodates a bus to pull in and out of the travel way here. There is ample designated on-street parking on Hamilton, Abendroth, and Delavan Avenues in Greenwich. Both the latter and Main Street consist of a two-way two lane roadway with shoulder lane in each direction.

2.7 Major Trip Attractors

Data on Major Traffic Generators (MTGs) in the twelve corridor municipalities was obtained from OSTA. MTGs are defined by OSTA as developments consisting of 100,000 square feet or more of gross floor area and/or 200 or more parking spaces that were proposed and regulated on or after July 1, 1967. Any development that existed prior to that date, which has not expanded or changed its use, is grandfathered in and is therefore not included until such time that it requires regulation by OSTA under the Statutes. The data provided was current as of March 16, 2016. Figure 2-5 presents a high-level view of the MTGs for the entire corridor. There are many MTGs along the study corridor.

Figure 2-5: Route 1 Corridor Major Trip Generators



Source: CTDOT Office of the State Traffic Administration

2.1 Population Density and Growth Projections

The study area 2010 population density as reported by the U.S. Census is illustrated in Figure 2-6 while Table 2-12 shows the population of each municipality in 2000 and 2012, alongside projected 2020 and 2025 population as reported by the Connecticut Data Collaborative (www.ctdata.org). Figure 2-7 illustrates the 2012 to 2025 growth projections. (It should be noted that projections are only available at the municipal level.) The figure shows that growth is expected in the more urban municipalities (shown in orange and red) while the smaller municipalities are projected to lose population.

Figure 2-6: Route 1 Corridor 2010 Population Density

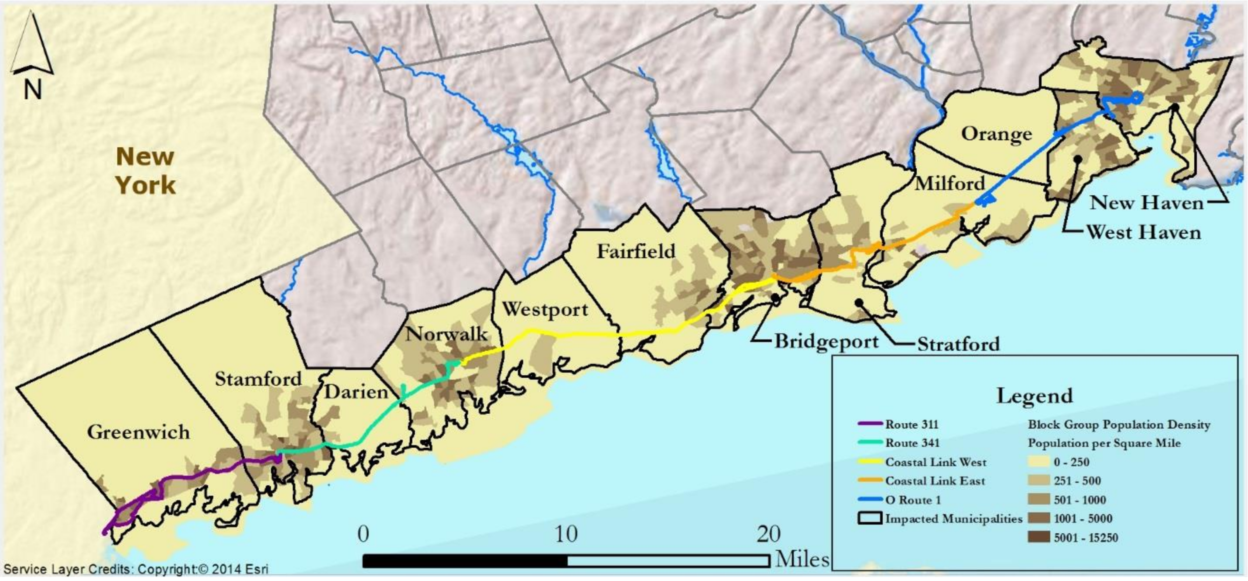
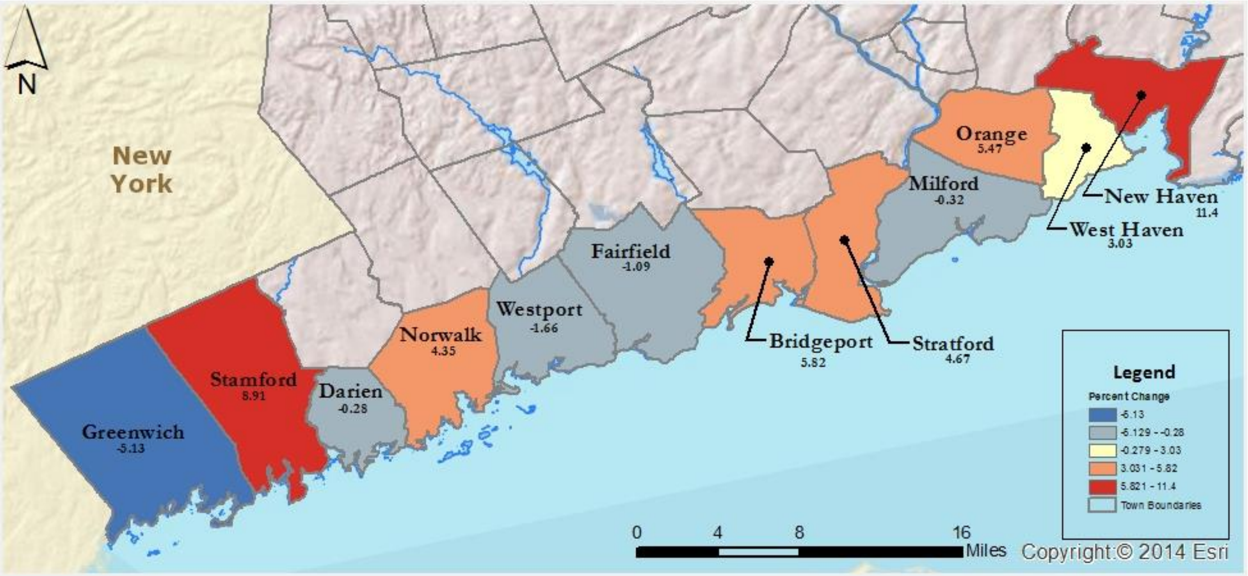


Table 2-12: Route 1 Corridor Municipal Population Projections

Municipality	2000 Population	2012 Population	Projected Population 2020	Projected Population 2025	2012-2025 Percent Change
Bridgeport	139,529	144,446	150,762	152,857	5.82
Darien	19,607	20,758	20,727	20,700	-0.28
Fairfield	57,340	59,562	59,025	58,915	-1.09
Greenwich	61,101	61,428	59,375	58,274	-5.13
Milford	52,305	52,826	53,041	52,658	-0.32
New Haven	123,626	129,898	140,445	144,711	11.40
Norwalk	82,951	85,853	88,795	89,591	4.35
Orange	13,233	13,919	14,449	14,680	5.47
Stamford	117,083	122,878	130,828	133,821	8.91
Stratford	49,976	51,440	53,128	53,841	4.67
West Haven	52,360	55,386	56,736	57,064	3.03
Westport	25,749	26,516	26,214	26,075	-1.66

Source: www.ctdata.org

Figure 2-7: Route 1 Corridor 2012-2025 Population Projections



3. Travel Time and Delay Data Collection

This chapter summarizes the travel time and delay data collection effort that was completed as part of the Route 1 BRT Feasibility Study. The following sections describe the travel time and delay data collection effort and findings, including the following topics:

- Running Time Data from Service Operators
- Sampling Plan
- Data Collection and Analysis Methodology
- Summary Statistics
- Delay Locations

3.1 Sampling Plan and Data Collection Methodology

3.1.1 *Sampling Plan*

With the principal goal of the study to increase ridership by improving bus travel times, the time and delay data collection effort was designed to obtain detailed information on the causes and locations of delays to bus service in the corridor. The limited running time data provided by the operators showed that travel times tend to be longest in the PM peak, especially in the eastbound direction, while midday times tend to be longer than in the AM peak. For that reason, it was decided to collect data during all three periods, rather than focus only on the peaks as had been initially proposed. It was also decided to focus equally on all four routes. Data was collected only on weekdays, as resources were limited, and there were a limited number of weekend days available on which to collect data.

Given the frequency of service on each of the routes, a sample of 15 weekday round trips, distributed as evenly as possible between the three periods[10], was deemed sufficient to provide a representative sample. The resulting sampling plan covered between 29% and 44% of trips on the weekday schedule of each of the routes. Trips to be observed were selected from the schedule in order to provide a representative sample of trips throughout each period.

In order to provide consistent data within each route, direction, and period, trips were selected such that all trips within a period on a given route and direction were on the same service pattern. Because Routes 311 and 311B are interlined in Port Chester, this resulted in a decision to collect data only on Route 311B in the eastbound direction, and only on Route 311 in the westbound direction. Similarly, data had to be collected on Route 341A trips instead of the regular Route 341 trips in the midday eastbound and PM peak westbound directions. A full listing of trips observed, and the dates observed, is provided in Appendix B.

3.1.2 *Data Collection Methodology*

The data collection was accomplished by surveyors carrying Global Positioning System (GPS) units riding on board buses on selected trips. The GPS units automatically recorded time, location (latitude and longitude), speed, and distance traveled between observations, at one second intervals for the entire duration of each observed trip. Surveyors observed reasons why a bus stopped or was delayed, and manually recorded a code for each type of delay when observed. Surveyors recorded the type of delay

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[10] In order to obtain sufficient data, peak periods were defined broadly. The AM peak was defined as trips beginning from the start of service until 8:30 AM. PM peak was defined as trips beginning from 2:30 to 7:00 PM.

each time the bus slowed to less than 15 miles per hour (mph). Surveyors also manually recorded the exact time (to the second) of their observation using the time displayed on the GPS unit.

Delays were coded as:

- Bus Stop (passenger boardings and alightings)
- Traffic Signal
- Congestion
- Construction
- Accident
- Emergency Vehicle
- Passenger-Related Delay
- Other Delay

Surveyors also recorded the door-open and door-close times at each bus stop made, and noted whether the stop included a passenger boarding or alighting using a wheelchair.

After each run was completed, the codes for each delay, as well as door-open and door-close observations, were added to GPS unit output files at the times noted by the surveyor. The times that the bus arrived at each scheduled timepoint were also noted by matching the recorded latitude and longitude to the known coordinates of each timepoint. This enabled the computation of travel times and delays by route segment, as defined by the scheduled timepoints.

3.1.3 *Data Analysis Methodology*

The speed recorded at each one-second interval was used to categorize the movement of the bus at each second as either stopped, moving slowly, or moving at normal speed. Speeds less than one mph were considered stopped, while any speeds greater than 15 mph were considered moving at normal speed. Each trip was then divided into intervals of time based on these three categories. Slow intervals were further categorized as accelerating if the preceding and following intervals were stopped and normal speed, respectively, and similarly slow intervals were categorized as decelerating if the preceding and following intervals were normal speed and stopped. Slow intervals, which met neither criteria, were simply left as moving slowly.

The delay codes were then assigned to each slow and/or stopped interval. The delay was considered to begin when the bus speed first dropped to 15 mph and was considered to continue until either the bus exceeded 15 mph again or a different delay code was recorded.

Running time statistics were calculated for each segment on each trip listing total time, stopped time, and delay time (moving slowly). The number of times the bus stopped (for any reason) and average speed were also calculated. For each trip, the number of delays of each type were counted. For each route, direction, and time period, time on all sampled trips was summed by category of movement and by type of delay. Bus dwell times (time spent with to door open to board or alight passengers) were also incorporated. These data are presented in the following section and in the appendices.

In order to identify locations where the most delays occurred; data was extracted for each individual delay. Data included:

- Type of delay
- Location at the time the delay type was noted (latitude and longitude)
- Time the delay began (speed dropped to 15 mph or new delay type recorded)

- Duration of stop
- Duration of delay (both stopped and slow moving)
- Distance traveled during the delay

Each traffic signal delay was then matched to a known traffic signal in the corridor using the location information. The average delay at each signal in each period was used to identify the signals causing the most delay. Findings are presented below in Section 3.3. The locations of all other delays (except passenger boardings and alightings) were also mapped to identify problem areas for further analysis.

3.2 Summary Statistics

3.2.1 *Running Times*

The end-to-end mean, maximum, and minimum running times observed for each route, direction and period are shown in Table 3-1.

Table 3-1: Observed Weekday Running Times

Route	Period	Eastbound			Westbound		
		Mean	Min	Max	Mean	Min	Max
311A WB 311B EB	AM Peak	51.6	43.6	55.6	50.0	46.7	54.0
	Midday	47.1	40.8	55.6	45.8	38.9	50.7
	PM Peak	56.1	47.5	65.0	53.5	48.5	58.8
341/341A	AM Peak	39.8	35.1	44.3	43.7	39.1	46.2
	Midday	53.8*	49.2*	56.6*	46.2	38.8	50.3
	PM Peak	49.4	39.6	56.8	54.0*	49.2*	64.0*
Coastal Link West	AM Peak	48.4	43.9	52.6	64.1	53.5	73.2
	Midday	57.3	54.8	59.3	65.5	60.2	74.4
	PM Peak	66.2	57.8	74.7	53.7	49.2	58.3
Coastal Link East	AM Peak	49.4	45.0	54.7	52.4	46.3	59.6
	Midday	50.8	44.6	55.4	54.2	49.3	63.4
	PM Peak	48.9	44.5	57.7	51.9	48.7	53.7
O Route 1	AM Peak	39.4	34.2	43.1	38.5	34.7	42.0
	Midday	43.9	37.9	48.6	44.5	40.1	46.0
	PM Peak	48.7	42.0	54.3	47.3	44.4	51.9

* Route 341A
Travel time in minutes.

For Route 311, the mean observed running times are fairly close to those provided by CT*transit* in peak periods, but somewhat less in the midday. For Route 341, the mean observed times are slightly longer, though in some periods the new data is for the longer Route 341A, and is therefore not directly comparable. For Coastal Link West (between Norwalk and Bridgeport), only the westbound direction can be compared and the mean observed times are substantially greater than those calculated from the data provided by GBT. For the Coastal Link East (Bridgeport to Milford) the times are comparable except for eastbound in the midday when the observed times are longer than those measured from GBT data. For O (Route 1), the observed times are probably the most comparable to those provided by CT*transit*.

Average speed and running time by time period and route segment (as defined by the scheduled timepoints), including the stopped and slow moving (delay) time, is contained in Appendix C.

3.2.2 *Stop and Delay Times*

Counts of stops and delays by type for each trip observed are contained in Appendix D, while Appendix E contains summaries of the percentage of time spent moving and delayed (by type) for each route, direction, and time period. This data is illustrated in Figure 3-1 through Figure 3-6. (In the figures, delay time includes stopped time, plus time spent moving less than 15 mph, while Appendix E breaks the time down into stopped, accelerating, decelerating, and slow moving time.) The figures show some variation between routes in the percentage of time buses are delayed. In the eastbound direction, delays are greatest on Route 311B and O (Route 1), especially in the peaks. Route 341 experiences the least delay eastbound in the peaks while the Coastal Link is the least delayed in the midday. Westbound, again Routes 341 and O experience the greatest delays in the PM peak, while all routes are similarly delayed in the AM Peak. In the midday period westbound, the Coastal Link is again the least delayed with other routes experiencing similar levels of delay.

3.3 Delay Locations

3.3.1 *Traffic Signals*

As shown in Figure 3-1 through Figure 3-6, the amount of delay to corridor bus routes caused by traffic signals is substantial. One of the key determinants of both the need to move buses through these intersections, as well as the potential effectiveness of strategies such as TSP, is overall intersection level of service (LOS). LOS is a calculation of traffic control delay for an intersection. LOS is an indication of driver discomfort, frustration, fuel consumption, and lost time. LOS is defined by an index from A (free flow) to F (long delays). LOS control delay values are given in Table 3-2.

Table 3-2: Signalized Intersection Level of Service Criteria

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

Source: 2010 Highway Capacity Manual

Intersection LOS is typically derived from traffic counts and signalized intersection analysis. Signalized intersection analysis is based upon the capacity of each lane group and the correlating control delay associated with the intersection. Capacity is a measurement of the ability of an intersection design to accommodate all movements within the intersection and is a function of physical geometry and signalization conditions. Delay is the measure of the user quality of service.

Ideally, recent turning movement counts and LOS calculations for study area signalized intersections would be available from prior traffic studies. However, for the vast majority of intersections in the study corridor, count data and LOS calculations are not available. In its place, it was assumed that the LOS for the bus movements on the approaches the bus is operating on was a good surrogate for overall intersection LOS, with LOS values assigned based on bus approach delay.

Figure 3-1: Distribution of Weekday AM Eastbound Travel Time

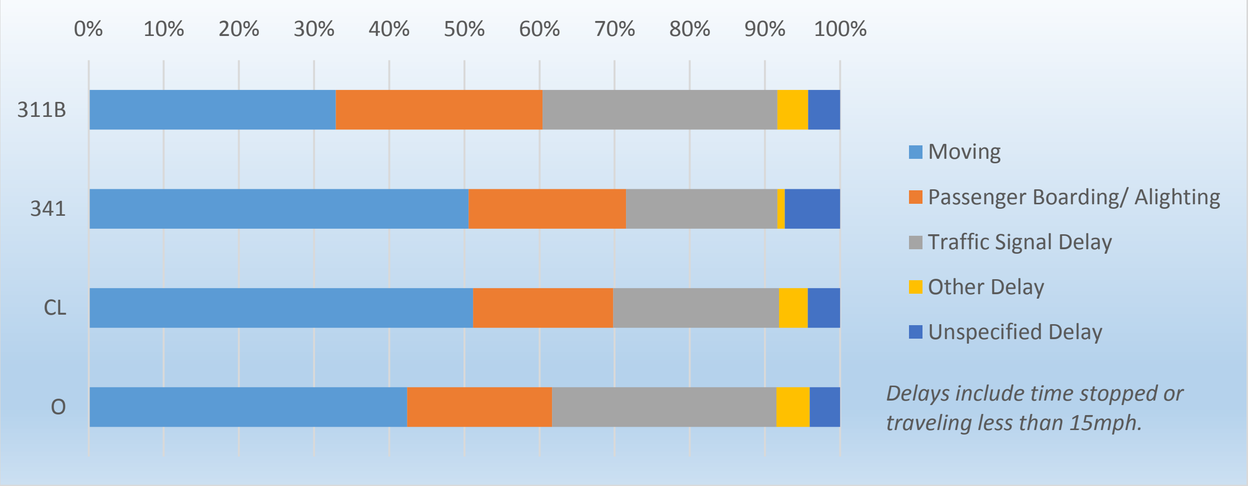


Figure 3-2: Distribution of Weekday Midday Eastbound Travel Time

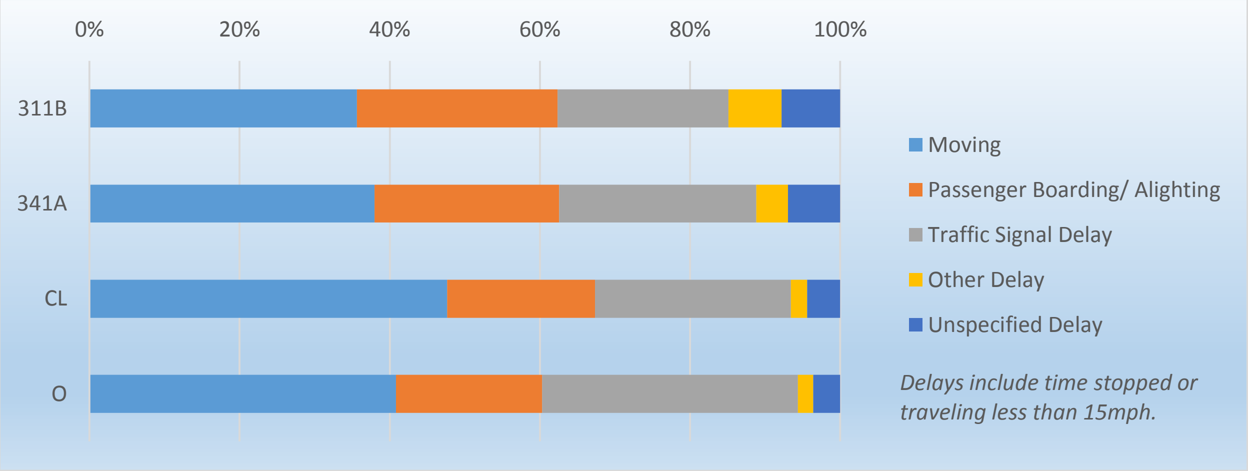


Figure 3-3: Distribution of Weekday PM Eastbound Travel Time

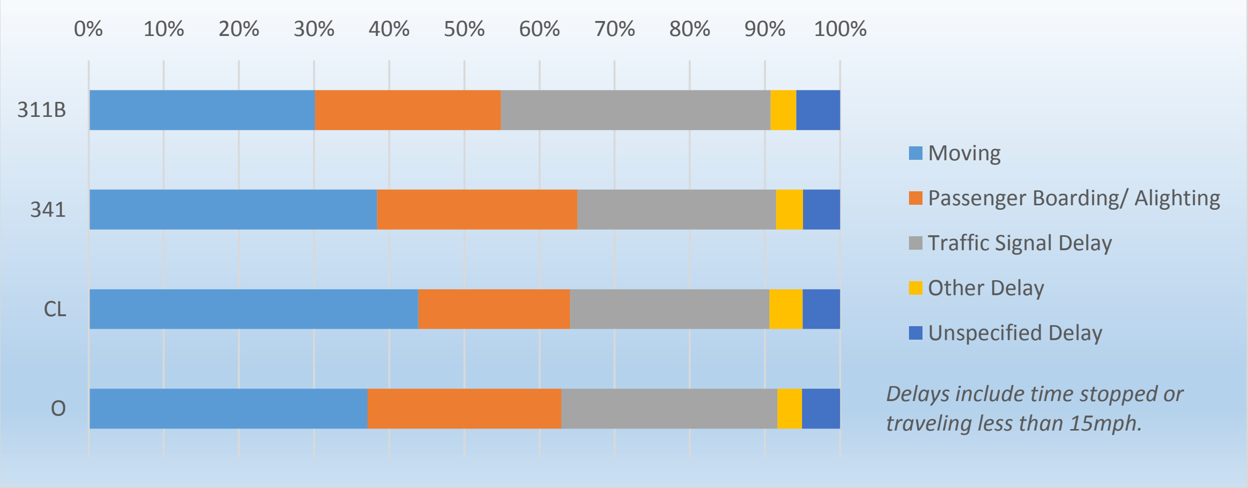


Figure 3-4: Distribution of Weekday AM Westbound Travel Time

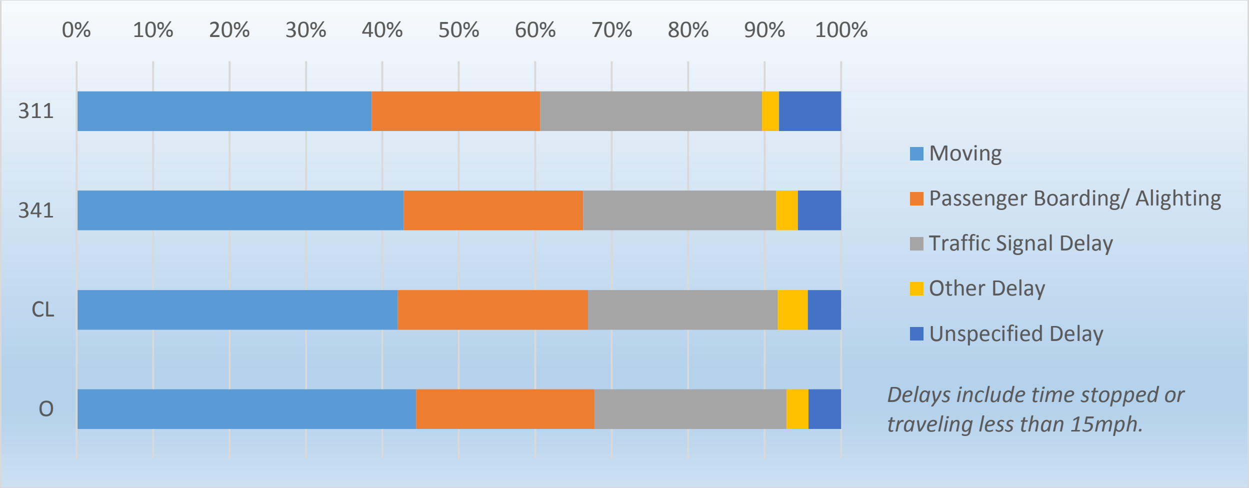


Figure 3-5: Distribution of Weekday Midday Westbound Travel Time

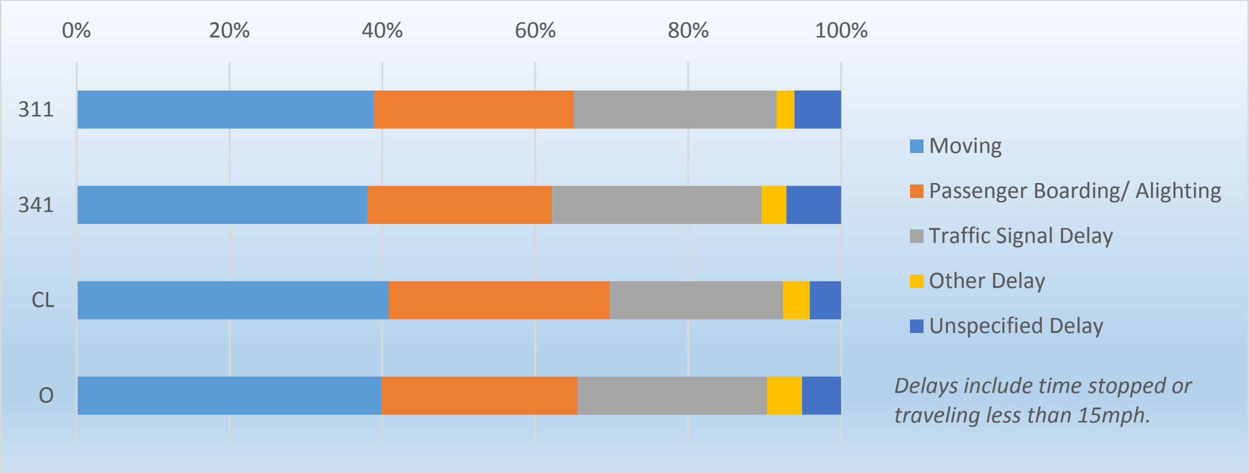
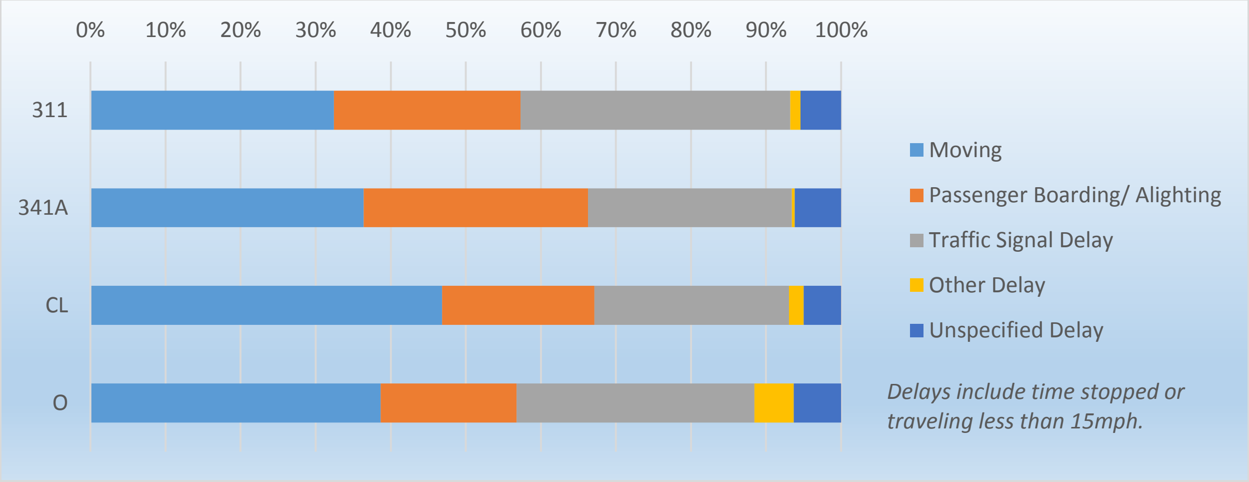


Figure 3-6: Distribution of Weekday PM Westbound Travel Time



Therefore, in order to estimate an approximate intersection approach LOS for buses along the study corridor, this analysis used the amount of time buses were observed to be stopped at each traffic signal in the corridor. The average length of time buses were stopped at each signal was calculated in each direction in each of the three weekday time periods using the GPS data collected. Each signal in each direction in each period was then assigned an estimated bus approach LOS using the average delay criteria in Table 3-2. An LOS of C, D, or low E typically indicates moderate delays and the best opportunities for improvements to speed bus service since longer delays usually indicate that preference to buses would have excessive impact on other users. Those intersections with a bus approach LOS of C or worse in either direction were identified and are listed in Appendix F. The location, municipality, signal ownership, and route are shown for each. For signals on the Coastal Link, the route column identifies whether the signal is east or west of downtown Bridgeport. Locations with an estimated bus approach LOS of C or worse in either direction are shown in Figure 3-7 through Figure 3-9 for the AM, Midday, and PM periods, respectively.

The data show that just 96 of the almost 300 signalized intersections are operating at an estimated LOS of C or worse in any time period for the bus approaches, while only 25 of these are estimated to operate at LOS D or worse. The bus approaches at just two signalized intersections (near the Greenwich train station) are estimated to be operating at LOS F in just one period each.

In the weekday AM period, Route 311 has the most intersections with moderate delays, including several with LOS D in addition to the one LOS F in Greenwich, and a cluster of intersections around downtown Stamford. Outside downtown Stamford, Route 311 is relatively free of intersection delays. The Coastal Link has a scattering of mostly LOS C bus delays, mostly in the city and town centers, while the O Route has several LOS C and LOS D locations, with a cluster of locations in downtown New Haven.

In the weekday Midday period, Route 311 has fewer delay locations, as conditions in Stamford appear to lessen, while more delay locations appear or worsen on Route 341 and on the O Route. The number of delay locations on the Coastal Link is similar to the AM, but several move from LOS C to LOS D. In the weekday PM period, delay locations increase and worsen again on Route 311, while the number of delay locations on the other routes does not change significantly.

Of the 96 signalized intersections shown in the figures and listed in the appendix, 47 operate at LOS C on the bus approach in just one direction and in just one time period, and better than LOS C at other times. The other 49 signalized intersections, that have an LOS worse than C or LOS C in multiple periods, were identified for further evaluation for intersection improvements and bus priority treatments.

3.3.2 *Other Delays*

Besides traffic signal delay, the only other significant source of delays observed were delays classified as resulting from general traffic congestion, other than at a traffic signal. Delays classified in the field as “Congestion” made up the vast majority of delays classified as “Other” in the figures above. The majority of observed congestion delays lasted less than ten seconds. In order to focus on the more severe delays, those individual bus delays greater than ten seconds of stopped time in duration were mapped for each time period. The results are shown in Figure 3-10 through Figure 3-12. In the figures, each symbol represents one bus trip that was delayed ten or more seconds due to traffic congestion.

Figure 3-7: Signalized Intersections with the Most Bus Approach Delay - Weekday AM

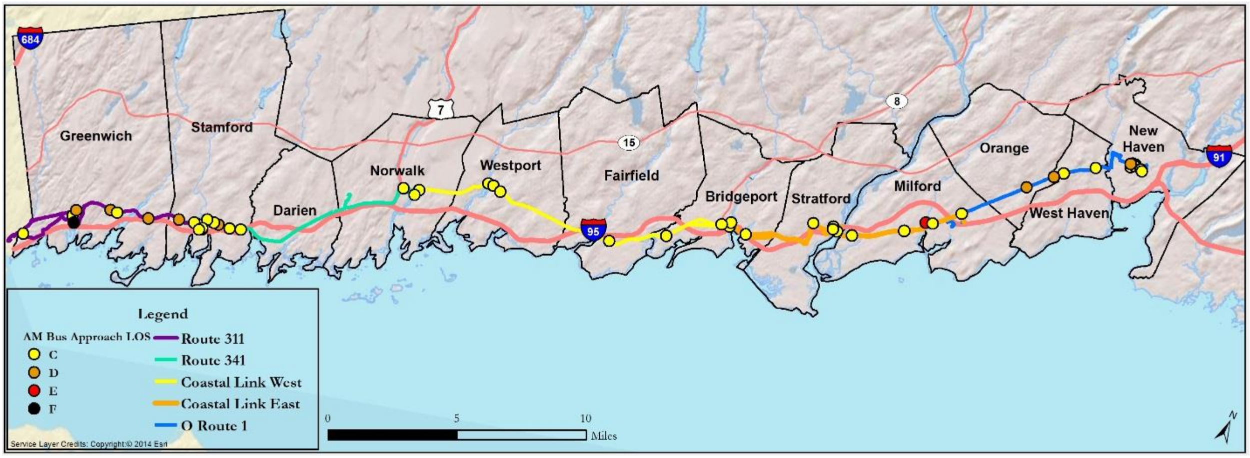


Figure 3-8: Signalized Intersections with the Most Bus Approach Delay - Weekday Midday

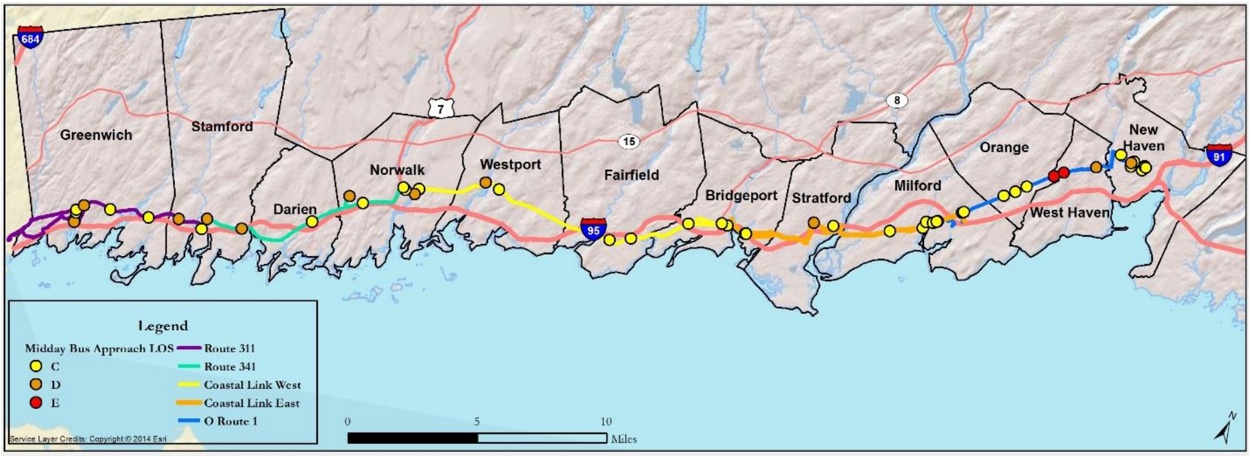


Figure 3-9: Signalized Intersections with the Most Bus Approach Delay - Weekday PM

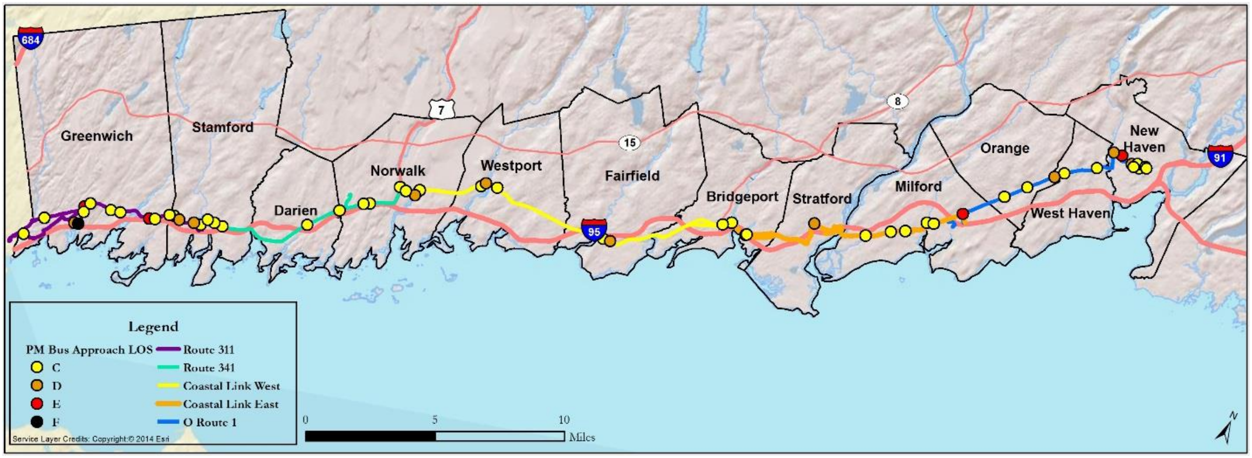


Figure 3-10: Bus Congestion Delay - Weekday AM

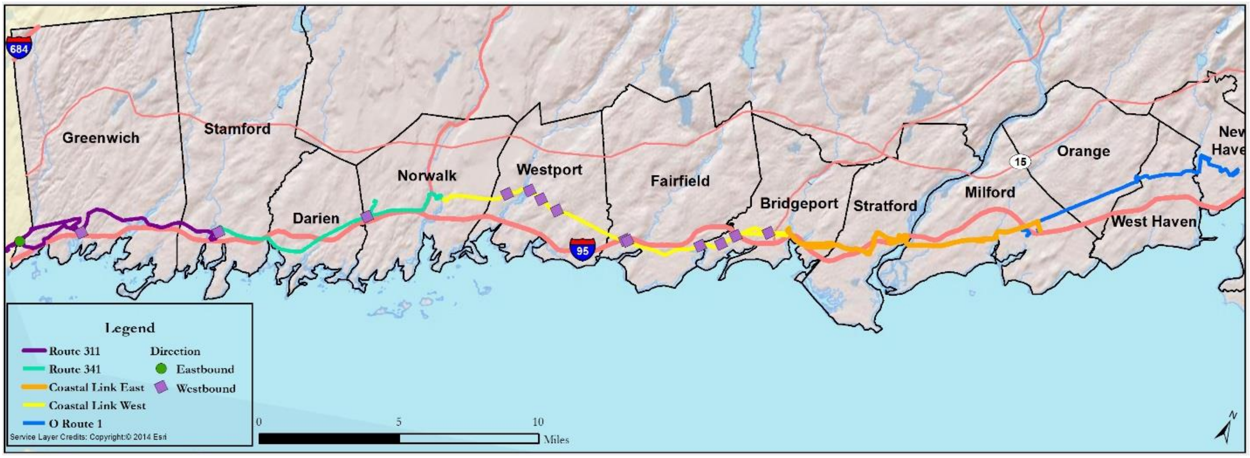


Figure 3-11: Bus Congestion Delay - Weekday Midday

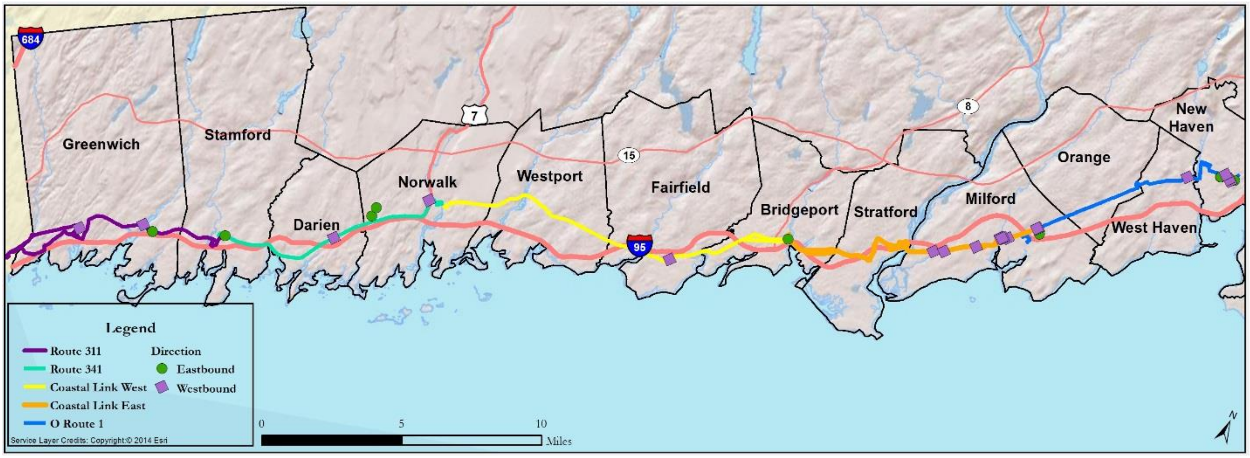
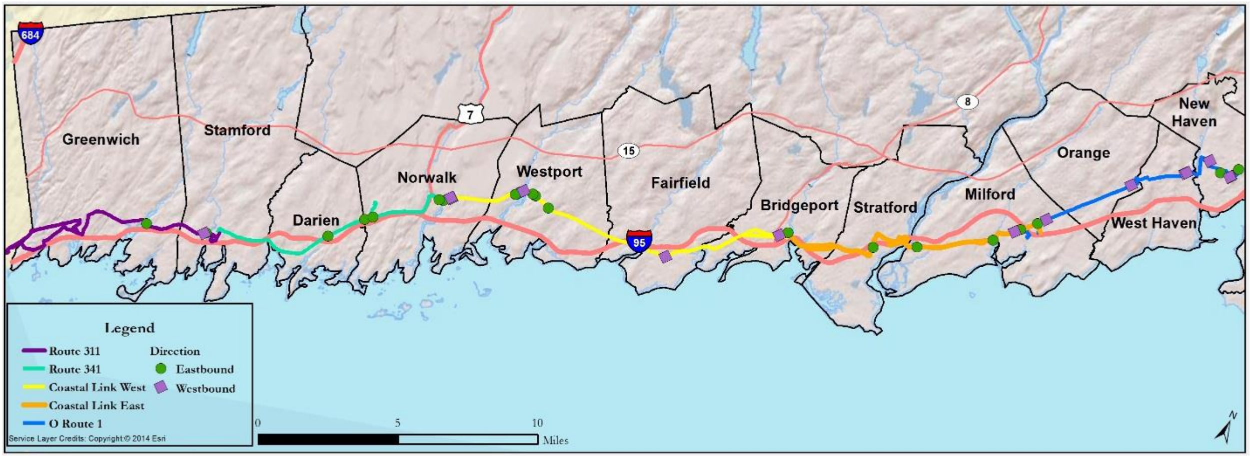


Figure 3-12: Bus Congestion Delay - Weekday PM



All but one of the weekday AM peak congestion delays greater than 10 seconds of stopped time were observed in the westbound direction, with the vast majority on the Coastal Link. The delays ranged from ten to 34 seconds of actual stopped time, but were between 25 and 111 seconds in length, when all slow moving (less than 15 mph) time is considered. The one eastbound delay on Route 11B was actually in Port Chester, New York and lasted over five minutes, including over three minutes of stopped time.

Weekday congestion delays greater than 10 seconds of stopped time were more numerous in the midday period and included delays in both directions, with westbound delays more numerous. There were delays on every route in both directions, but the most delays occurred westbound on the Coastal Link eastern leg. Westbound delays were also longer, averaging 44 seconds of stopped time, with the longest at almost 2½ minutes, and averaging 67 seconds in total, with the longest at almost three minutes. The bus with the longest eastbound delay was delayed for only 74 seconds in total and stopped for just 34 seconds.

Congestion delays in the weekday PM peak period were the most numerous, with a greater number of delays in the eastbound direction than in the westbound direction. Routes 11 and 41 had the fewest delays, while the Coastal Link again had the most. In this period, eastbound delays were longer, averaging 42 seconds of stopped time, with the longest at almost 3½ minutes, and averaging 84 seconds in total, with the longest at almost six minutes.

PART II

4. Overview of Bus Rapid Transit Improvement Strategies

4.1 Elements of Bus Rapid Transit

Bus Rapid Transit (BRT) is typically defined as a combination of a number of elements that together create a bus transit service with the speed, frequency, comfort, and capacity characteristics of rail transit. These elements include:

- **Running Ways** - either full or partial exclusive right-of-way
- **Stations** – widely spaced distinct branded facilities with travel information, customer amenities, and level boarding
- **Vehicles** – distinct vehicle design that conveys the image and brand of the system
- **Fare Collection** - fares collected off-board to speed the boarding process
- **Real-time Information** – in station displays, online, and via mobile devices
- **Transit Signal Priority (TSP)** – technology that provides priority for transit vehicles at signalized intersections
- **Service and Operating Plans** – frequent service, including nights and weekends, and longer spacing between stops
- **Branding** – a unique, unified brand that is easily distinguished from other bus services

CTDOT already has an existing BRT brand in the Hartford area, CT*fastrak*. The CT*fastrak* brand includes branded vehicles and stations, off-board fare collection, frequent service, and a dedicated right-of-way for much of the route. In the Route 1 corridor, a large-scale dedicated right-of-way is not envisioned at this time, nor is a uniquely branded service with branded vehicles. The Route 1 BRT Feasibility Study therefore focused on developing improvements in the following five categories of strategies:

- Service Design and Stop Spacing
- BRT Stations, Amenities and Information
- Fare Collection
- Transit Signal Priority
- Intersection and Running Way Improvements

Strategies to implement these five elements of BRT are presented and evaluated in Chapters 5 through 9. These elements can greatly affect the speed and reliability of service in the corridor. Increased frequency or additional limited stop service can reduce wait times. Fewer stops and off-board fare collection can reduce the amount of time spent at bus stops. Enhanced stations and customer information can improve passenger comfort and the overall perception of the service. Intersection improvements and signal priority can decrease travel times somewhat but can provide an even more significant improvement in service reliability.

4.2 Assessment of Ridership Impacts

The five sets of strategies would each result in different levels of improvement in travel times, both time on board the bus and time waiting for the bus. The method for assessing travel time impacts depends on the specific strategy and is therefore described in each of the following chapters. Ridership changes, however, are estimated from the cumulative changes in travel time and frequency from all strategies so the methodology for estimating ridership changes is described here.

Changes in transit ridership due to travel time and headways are typically calculated using an elasticity method. Elasticity relates a relative change in a service attribute (in this case travel time or headway) to a change in ridership. A negative elasticity value indicates an inverse relationship, that is, as travel time decreases, ridership increases. Values less than one indicate that the percent increase in ridership will be less than the percent decrease in travel time or headway. Elasticity values for ridership with respect to both travel time and headway elasticity have both been found to be in the range of -0.4 to -0.5. For this analysis, an elasticity of -0.45 was applied using an arc-elasticity formula.

For each corridor segment, the ridership change was calculated for the changes in running time and frequency of service. Because the resulting ridership change would impact bus travel times (due to more passenger boardings and possibly more bus stops served), the revised ridership was used to recalculate travel times through several iterations until the travel time and ridership estimates converged.

5. Service Design and Stop Spacing

This chapter focuses on service design and stop spacing strategies designed to address the study goals of improving bus travel times and increasing bus ridership in the corridor. Section 5.1, below, describes the various types of improvements included in this category, discussing the typical implementation challenges and best conditions for application. Section 5.2 describes the methodology used to identify opportunities to incorporate each strategy into the Route 1 corridor, and to estimate travel time savings and costs. Section 5.3 presents a summary of the findings and conclusions.

5.1 Service Improvement Concepts

Service design is one of the most important factors in the development of BRT and enhanced bus services. The speed of service can be improved by adjusting stop patterns, reducing the number of times a bus must stop for passengers and/or traffic signals. If existing stops are located close together, reducing the number of stops can increase the speed of travel and reduce the variability of travel time that is a major contributor to bus bunching. In high frequency corridors, a limited stop service can be overlaid onto local service to provide a faster alternative for longer trips. However, where frequencies are insufficient to support two tiers of service, improved frequency on the existing service with some reduction in the number of stops may be more effective.

Another way of reducing travel times through the design of the service is to streamline the route by eliminating diversions or bypassing congested areas. Benefits can also be realized by combining together two routes, improving passenger travel times by eliminating a transfer, as long as the combined route is not so long as to operate unreliably. Conversely, splitting very long routes in a way that minimizes the number of transfers introduced can improve ridership by providing more reliable service.

5.1.1 *Limited Stop Overlay Route*

Description

Limited stop overlays are new bus routes instituted along the same, or very similar, alignment as an existing local bus route. The route would stop at only a few designated stops, thus reducing the time to traverse the corridor and providing faster service to passengers. The number of stops is typically only one or two per mile, though there may be more at the downtown end of the route. The limited number of stops are selected so as to serve major ridership generators and bus transfer locations. Limited stop overlay routes tend to focus on longer distance trips within the corridor where the travel time savings is most pronounced. Except in the case of existing high frequency local service corridors, the local service frequency and schedule remains largely unchanged. The limited stop overlay route is provided with additional buses and at additional cost with its frequency based on an assessment of demand and a minimum frequency necessary to make the service attractive. A limited stop overlay service may operate during the full service span, or could be limited to peak hours only.

Challenges

The challenge in implementing a limited stop overlay service is making the service fast enough to make it worth the wait while still attracting enough riders to make it effective. Limiting the number of stops to far fewer than the number actually served per trip by the local service is the key to reducing travel times, but serving only a few stops limits the number of riders who can walk to the service. Poor pedestrian access can further restrict the ability of potential riders to access the limited number of stops. Providing adequate frequency is important, as many passengers will have a choice of taking the first bus that comes or waiting for the limited stop route. Any additional wait time would have to be outweighed by the travel time savings for passengers to wait for the limited stop route.

Best Conditions for Application

Limited stop overlay routes are most effective when existing ridership is concentrated at a few stops, creating a ready market of potential riders for the service. The service is also most effective when passengers are making long trips, making the time saved by having fewer stops significant enough for passengers to wait for (or plan their departure time to meet) the limited stop route. Having a sufficient number of buses and enough operating funding to provide a service that is at least as frequent as the underlying local route will also make it easier for passengers to take advantage of the faster service.

5.1.2 *Consolidating Stops with Improved Frequency*

Description

Travel times on an existing bus route can be improved by reducing the number of times the bus must stop to service passengers. In many areas, stops on local bus routes have been located very close together in order to attract ridership by minimizing the distance passengers must walk to access the service. Increasing the spacing between bus stops can reduce the number of times a bus must stop. This can reduce travel times with no change in the cost of operating the service. Table 5-1 shows estimated travel times based on different stop spacing that have been observed in research. In comparison to the limited stop overlay, which can typically double the cost of service, this can be a lower cost option, albeit with less of an impact on travel times and ridership. The buses and operating costs that might have been applied to a separate overlay route could be used to increase frequency on the local bus route, which would increase ridership, while continuing to provide the relatively smaller travel time improvements from the reduction in stops.

Table 5-1: Bus Travel Times with Different Stop Spacing
(Minutes per Mile)

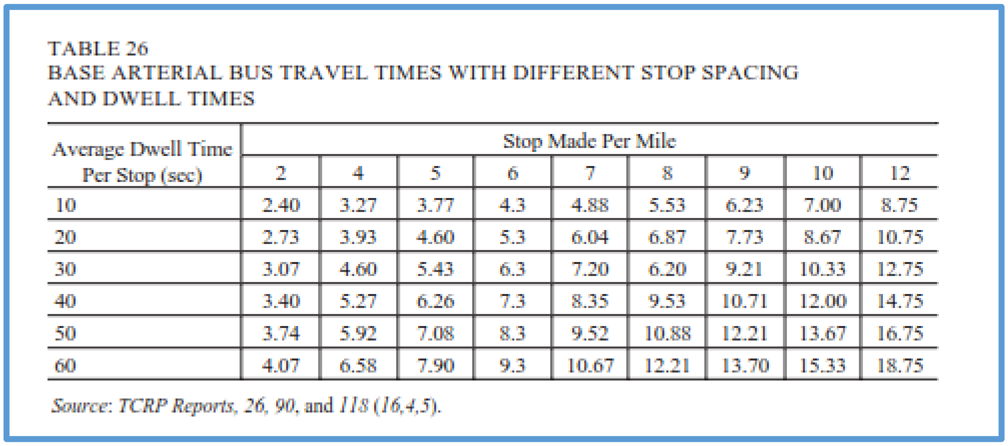


TABLE 26
BASE ARTERIAL BUS TRAVEL TIMES WITH DIFFERENT STOP SPACING AND DWELL TIMES

Average Dwell Time Per Stop (sec)	Stop Made Per Mile								
	2	4	5	6	7	8	9	10	12
10	2.40	3.27	3.77	4.3	4.88	5.53	6.23	7.00	8.75
20	2.73	3.93	4.60	5.3	6.04	6.87	7.73	8.67	10.75
30	3.07	4.60	5.43	6.3	7.20	6.20	9.21	10.33	12.75
40	3.40	5.27	6.26	7.3	8.35	9.53	10.71	12.00	14.75
50	3.74	5.92	7.08	8.3	9.52	10.88	12.21	13.67	16.75
60	4.07	6.58	7.90	9.3	10.67	12.21	13.70	15.33	18.75

Source: TCRP Reports, 26, 90, and 118 (16,4,5).

Source: TCRP Synthesis 83: Bus and Rail Preferential Treatments in Mixed Traffic, Transportation Research Board, 2010

Challenges

The challenge in implementing a stop consolidation strategy is to identify a sufficient number of stops to eliminate or consolidate so that travel times are reduced. Typically, buses do not stop at every stop on every trip, so the number of times a bus actually stops on any given trip may actually be far less than the number of actual bus stops on the route. Reducing the number of actual bus stops may not significantly affect the number of times a bus stops on any given trip, although it will limit the maximum number of times a bus can stop, thereby reducing travel time on the slowest and heaviest ridership trips, improving service reliability. Eliminating stops, however, forces some passengers to walk further to access the bus, which can actually reduce ridership if the walking distance for some passengers exceeds a quarter mile (1,320 feet). A poor pedestrian environment also makes it more difficult to increase walking distances without losing ridership.

Best Conditions for Application

A stop consolidation strategy is most effective when existing stops are closely spaced, and spacing can be increased to fewer than about six stops per mile. Having a good pedestrian environment also enables passengers to easily and safely walk the extra distance to the nearest bus stop. This strategy also works best when buses are already making most of the stops on most trips, so that the actual number of stops made decreases, resulting in decreased travel times. A stop consolidation strategy may also work best when a limited stop overlay would not be effective, and resources can be devoted to increasing ridership through improving frequency in addition to the time savings.

5.1.3 *Route Modifications*

Description

Travel time along a route can often be reduced by making the route more direct or by bypassing a congested area. Bus routes have been designed over the years to serve specific markets and ridership patterns may have changed, possibly reducing the need to serve some areas. Alternatively, some markets that are served by one route may also be served by another and one of the routes could be made faster to attract additional ridership by focusing on a specific subset of its current markets.

Challenges

Eliminating portions of routes or diversions through an area will inevitably impact some current riders. Provision of alternative service that is still attractive to these riders is needed to avoid ridership loss. The benefits of any travel time savings and increase in ridership for one market must outweigh the negative effects on riders who would no longer be served as well as they were served before.

Best Conditions for Application

A route that has a long indirect diversion through a congested area would be a candidate for streamlining, provided that alternative service is available for any impacted riders and the potential number of through riders who would benefit from the time savings is significant. Routes that travel more directly through a congested area may still have an alternative routing on a faster or less congested road that could be used to reduce travel times.

5.1.4 *Combining or Splitting Routes*

Description

In a corridor, such as Route 1, that is too long to be served by a single route, the places at which connections between routes occur can influence the number of transfers needed, passenger travel time, and ridership. Longer routes will tend to reduce travel time and encourage ridership through fewer transfers. Limited stop overlays may also be able to be operated over two shorter local routes due to their more consistent travel times and more long-distance oriented ridership patterns.

Challenges

Longer routes will tend to reduce travel time and encourage ridership through fewer transfers, while routes that are too long can become unreliable and lose ridership. Travel patterns must also be considered in setting the connection points between routes so as to minimize the number of transfers needed.

Best Conditions for Application

Changing the way route segments are combined into longer routes is most effective in a corridor with multiple routes laid end to end and that have multiple opportunities for locating the connection points between routes. Possible locations for connection points include city/town centers, bus terminals, rail stations, shopping malls, or other major destination where a large share of passengers board or alight.

5.2 Analysis Methodology

5.2.1 *Identification of Improvement Opportunities in the Route 1 Corridor*

The existing data assembled for this study, including detailed ridership data by stop and data on stop spacing, was used to identify possible stops for a limited stop overlay service in each of the five corridor segments. The analysis used a guideline of stops spaced approximately every half to three-fourths of a mile, located at currently higher volume bus stops, while still recognizing the need to serve major bus ridership generators. Limited stop overlays were assumed to operate only on weekdays for 14 hours per day, at the same frequency as the local bus route. The stop lists developed for the proposed limited stop routes in each corridor segment are presented in the individual Corridor Improvement Programs included in Part III of this report.

The same data was also used to develop a consolidated bus stop service concept with increased frequency for the existing local route in each corridor as an alternative to separate local and limited stop overlay routes. Considering the existing stop spacing and ridership at each stop, a number of the more closely spaced stops were identified for elimination. Consolidated stop service concepts were assumed to operate at increased frequency over the existing service, using the same number of vehicle-hours as the two services combined in the limited stop overlay concept in order to provide a direct comparison of benefits at comparable cost. Appendix G contains the full stop list for each route with the proposed eliminated stops identified.

In developing both service concepts for each corridor segment, consideration was given to choosing stops located at traffic signals, in order for passengers to safely cross the street at the bus stop. Stops were also selected in pairs on opposite sides of the street, so that passengers could board for their return trip at the same intersection where they alighted.

Travel time savings and ridership impacts were estimated for both concepts, as described in the following sections.

The review of prior studies completed for the study identified several route modifications that have been previously suggested by prior studies. The prior proposals in Table 5-2 were considered for inclusion in the service plan for the indicated corridor segment(s).

Table 5-2: Service Modifications Proposed in Prior Studies

Corridor Segment(s)	Proposal	Source
Route 311	Bypass Greenwich train station on Route 11A	Coastal Corridor Bus Study (SWRPA 2012)
Route 341	Use Tresser Boulevard westbound and Broad Street eastbound	Greenwich- Norwalk BRT Study (SWRPA 2009)
Route 341	Use the Urban Transitway to bypass downtown Stamford	Greenwich- Norwalk BRT Study (SWRPA 2009)
Route 341	Bypass downtown Darien and Darien train station	Greenwich- Norwalk BRT Study (SWRPA 2009)
Route 341	Re-route from Van Buren to West Avenue in Norwalk	Greenwich- Norwalk BRT Study (SWRPA 2009)
Coastal Link East	Reroute to Barnum Ave. in Bridgeport	Bridgeport Long Range Transit Plan (GBT 2016)
Coastal Link East, O (Route 1)	Split the Coastal Link in Bridgeport and combine the east segment with O (Route 1)	Coastal Corridor Bus Study (SWRPA 2012)
O (Route 1)	Re-route to Columbus Avenue in New Haven	Coastal Corridor Bus Study (SWRPA 2012)

5.2.2 *Bus Travel Time Savings*

The travel time saved by reducing the number of times a bus stops to pick up and discharge passengers can be broken down into: 1) deceleration and acceleration time saved making fewer stops, 2) opening and closing the door fewer times, and 3) reduced passenger boarding and alighting time (only if fewer passengers are being served). The first two are directly related to the change in the number of bus stops made per trip. The third is related to the number of passengers served per trip.

Savings due to the Number of Bus Stops Made

The time per stop spent decelerating and accelerating at bus stops was calculated for each route, direction, and time period from the time and delay data collected for this study[11]. The calculated average acceleration/deceleration time per stop varied from seven to as much as twelve seconds per stop, depending on the route and time of day. Door opening and closing time was assumed to be about 3.5 seconds per stop[12] which was added to the acceleration/deceleration time per stop to obtain the average number of seconds that could be saved by avoiding one stop.

Many stops in the Route 1 corridor are used infrequently. Therefore, predicting the number of times a bus will stop for a revised stop configuration and for a given change in total trip ridership would involve a complex simulation beyond the scope of this feasibility study. Therefore, simplifying assumptions had to be made for this analysis.

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[11] The time spent decelerating and accelerating at less than 15 mph (excluding time the bus was stopped) was calculated in each case, as well as the distance covered. Next, the time that it would have taken to cover that distance at a full 15 mph was subtracted to get the extra time decelerating and accelerating at bus stops.

[12] *Transit Capacity and Quality of Service Manual, 3rd Edition*, recommends 3-5 seconds

For the consolidated stops concept, riders who currently use stops that would be eliminated would switch to the next closest stop. However, it is difficult to predict without detailed simulation whether or not this would result in one less stop made since the bus may not have otherwise had to stop at the next closest stop. Therefore, a simplifying assumption was made that each eliminated stop with ridership would result in one less stop for the bus one-half of the time.

Under both concepts, the overall amount of service for some or all riders would effectively double. Even with the expected increase in total ridership, the number of riders per bus trip would decrease. This would likely reduce the number of stops made per trip. However, some stops would simply serve fewer riders on a given trip, while others would go from few to no riders, allowing the bus to skip the stop. Therefore, a simplifying assumption was made that the average number of stops made per trip would decrease by one-half of the percentage reduction in ridership per trip. In the case of the limited stop routes, if the resulting estimated number of stops made still exceeded the number of scheduled limited stops, the number of scheduled limited stops was used.

For each service, the change in the number of stops made per trip was multiplied by the travel time savings per stop avoided to get the savings in travel time per trip due to the number of bus stops made.

Savings due to the Number of Passengers Served

To estimate the change due to the number of passengers served per trip, the total time per trip stopped at bus stops was also calculated from the time and delay data. For each stop served, 3.5 seconds was deducted from that total (representing door opening and closing time). The remaining time represents the time spent boarding and alighting passengers. This time was multiplied by the percent change in ridership per trip to obtain the change in boarding and alighting time per trip due to the change in number of passengers served.

Savings due to Routing Changes

Where routing changes were proposed to shorten a route, the current travel time on a rerouted segment was estimated from average segment-level travel times from the time and delay data. This time was reduced proportionally by the reduction in mileage, essentially assuming a similar operating speed on the revised segment.

Total Bus Travel Time Savings

The travel time savings per trip due to the number of bus stops, the travel time savings per trip due to the change in the number of passengers served, and the travel time savings due to routing changes were added to obtain the total travel time savings per trip for each route, direction and time period. After completing the estimation of ridership impacts described previously, travel times were further adjusted to reflect the ridership change.

5.2.3 *Riders Affected*

For a limited stop overlay service, the potential ridership is limited to those riders who can access one of the limited stops served, at both the boarding and the alighting end of their trip. At a minimum, this would include riders who currently both board and alight at stops that would be served by the limited stop route. In addition, potential riders could include those who currently use one of two the stops that are immediately adjacent to a limited route stop, since the limited route stop may be the next closest stop to their origin or destination. This group might choose to walk a bit farther to take advantage of faster service on the limited stop route.

Potential ridership was estimated from the current stop-level ridership data. Current boardings at each proposed limited stop, plus half the boardings at the two immediately adjacent stops, was calculated for each limited stop and divided by total route ridership to get the percentage of boardings that might be able to use the limited stop service. The same was done for alightings. The percent of potential boarding riders and the percent of potential alighting riders at the proposed limited stops were then multiplied to derive an estimate of potential ridership for a limited stop route.

These potential riders would have a choice between the current local and the proposed limited stop overlay route. The actual ridership achieved on the limited stop route will be somewhere between the full potential market (assuming everyone who can use it waits for the limited stop route) and half the potential market (assuming equal headways and potential riders take whichever bus comes first, the local or the limited stop). The actual split will depend on how much travel time savings can be achieved by waiting for the limited stop route. For this analysis, a 60% share of the potential market for the limited route was assumed in most cases. In the two cases where the estimated travel time savings was found to be greater, a 75% share was assumed.

Under the consolidated stops with increased frequency concept, all riders, including those who would have to walk farther, would experience increased frequency of service.

Some passengers under the consolidated bus stop concept would experience a negative impact. The percentage of riders using the eliminated stops was estimated form the current stop-level ridership data. Those who currently use stops that would be eliminated would face longer walk access times to/from bus stops. These riders could choose either the stop before or the stop after their current stop, whichever is closer. The exact impact would depend on the rider’s exact origin or destination in relation to their current and new bus stop and therefore could not be estimated in this analysis.

For both concepts, the number of impacted riders was used to estimate both passenger travel time savings and increases in ridership.

5.2.4 *Passenger Travel Time Savings*

In either service scenario, passengers would experience travel time savings. Passengers traveling the full length would experience the full bus travel time savings while those making shorter trips would experience less of a savings. It can be reasonably assumed that riders on a limited stop service would be making longer trips, and therefore save more time, than those on the local service. Translating bus travel time savings into passenger travel time savings, however, would require data on current average trip length, which was not readily available for this study, as well as separate estimates of expected trip lengths on both the limited stop and local routes.

Nevertheless, because the goal of this study is to assess the viability of various strategies in *improving bus travel times* and *increasing bus ridership*, some measure of rider travel time impacts is necessary in order to project changes in ridership. The ridership estimation methodology described previously uses an elasticity-based approach, which requires only an estimate of the relative increase or decrease in travel time and headway. Therefore, the *percent* reduction in passenger travel time per trip was assumed to be the same as the *percent* reduction in bus travel time. Passenger wait time impacts stem from the assumed service levels identified in Section 5.2.1, that is, the limited stop service would operate at the same headway as the local service, with no change to local service headways, and the consolidated stop service would operate at one-half the existing headway. For the limited stop service concept, riders who could use either service (the potential riders described in Section 5.2.3 above) would see headways cut in half, while the remaining riders would see no change in headway.

5.2.5 *Capital and Operating Costs*

Capital Costs

The number of peak vehicles required for the additional service was estimated for the limited stop overlay route in each corridor segment, using the estimated round trip travel time for the limited stop route, plus a 15% layover, and then rounded up to an even multiple of the headway. A 15% spare ratio was applied to the increase in peak vehicles and rounded to estimate the number of new vehicles that would need to be added to the fleet. The additional vehicles were assumed to be made up of new vehicle purchases so a cost per new vehicle of $425,000 was used to estimate the capital cost for the service. The consolidated stop service was defined as requiring the same amount of additional buses as the limited stop route, so the number of additional vehicles required for each concept is the same.

Any other capital costs would be limited to stop removal and construction of any new or relocated stops. Bus stop and station costs are addressed in Chapter 6.

Operating Costs

The majority of costs for this type of improvement would be in ongoing bus operating costs. Additional annual operating costs for the limited stop overlay service were calculated based on the number of annual revenue-vehicle-hours required to operate the service. The number of daily weekday one-way trips was first calculated based on the number of trips required to provide the same frequency as the local route for the 14-hour period during which the limited route is proposed to operate. The resulting number of one-way weekday trips was multiplied by the one-way route travel time for the overlay route. Then 25% was added to that figure to reflect a combination of minimum layover time and additional layover time needed to operate the desired headway in order to obtain an estimate of additional weekday revenue-hours. Additional annual revenue-hours were then calculated assuming 255 weekdays. The additional annual cost was estimated using the current CT*transit* hourly operating cost of $72.72 for corridor segments operated by the CT*transit*. Coastal Link corridor operating cost increases were estimated using the GBT hourly operating cost of $69.49. No change in local route costs were assumed. The same additional annual operating cost was used for the consolidated stop concept since that concept was designed to use the same resources as the limited stop overlay in order to provide a direct comparison of strategies.

5.3 Evaluation of Service Concepts

In each of the five corridor segments data from the time and delay survey indicated that the average number of bus stops that are actually made is, in almost every case, less than half of the scheduled stops on the route. On the Coastal Link, the average number of stops made is often less than one fourth of the scheduled stops. This makes it difficult to reduce travel times by reducing the number of bus stops since buses will still tend to make about the same number of stops, with little to no reduction in travel time. As a result, the reductions in travel times that are achievable by limited stop overlays or consolidating stops throughout the corridor were found to be relatively minor unless changes to create more streamlined routings are possible. Devoting resources to increasing frequency, on the other hand, was found to attract more riders but would have an even more limited effect on travel times.

5.3.1 *Limited Stop Overlay Concepts*

A preliminary limited stop overlay concept was developed and evaluated for each of the five corridor segments. (The final proposed concepts described in detail in Part III in some cases differ slightly from the preliminary concepts evaluated here.) In the Route 341 and both Coastal Link corridors, the limited stop route was proposed to follow the exact same routing as the existing local route. In the Route 311 corridor, the limited stop route was proposed to follow Route 311 (not 311B), except that it would not serve downtown Greenwich but instead would remain on Route 1 all the way through the town. In the O (Route 1) corridor, the limited stop overlay was proposed to use Congress Avenue in New Haven instead of Sylvan Avenue. The limited stop overlay was proposed to operate at the same frequency as the local route. (In the case of the Route 311 corridor, the frequency was initially proposed to match that of Route 311, not the higher frequency of the Route 311/311B combination.) In each corridor, the proposed overlay route was assumed to be provided with additional resources with no changes to the local route frequency of service. A summary of the initial findings is shown in Table 5-3.

Table 5-3: Summary of Preliminary Limited Stop Overlay Concepts

	311	341	CL West	CL East	O
Number of Stops (each direction)	13	14	27	19	17
Potential Ridership Share	44%	65%	74%	66%	56%
Percent Running Time Saved on Overlay	23%	8%	5%	6%	22%
Corridor Ridership Increase	16%	27%	30%	27%	30%
Capital Cost - Buses (millions)	$2.1	$3.0	$3.4	$3.0	$3.8
Annual Additional Operating Cost (millions)	$0.55	$1.04	$1.13	$0.98	$1.25

A limited stop concept can be most effective when a set of limited stops can be identified that not only achieves travel time savings through a reduction in the number of times the bus stops, but also is still able to serve a significant share of riders in the corridor who can then benefit from the reduced travel time. For the proposed limited stop routes, the estimated percentage of current corridor segment riders who could potentially use the service (based on the boarding and alighting counts at the proposed limited stops and half of those at adjacent stops) is shown in Table 5-3. The highest percentage was found to be in the Coastal Link West corridor, where the 27 limited stops could serve 74% of current ridership. Serving 74% of riders at only 27 of the 82 stops indicates a fairly high concentration of riders at a few stops and a possible opportunity for a limited stop overlay route. The Coastal Link East and Route 341 corridors had the next highest share of current riders who could potentially use the limited stop route. O (Route 1) and Route 311 had the lowest share, largely because those overlay routes bypass whole segments of the local route, sacrificing potential ridership in order to save travel time.

In each of the corridors, a limited stop route that exactly follows the local route was found to reduce travel times by only a few percentage points. In the O (Route 1) and Route 311 corridors, the limited stop routes are proposed to bypass segments of the local route thereby providing a more direct, faster service. When combined with the travel time savings from the reduced number of stops, the estimated overall travel time savings per trip in both corridors is about ten minutes, possibly enough to make timing one’s trip to meet the limited stop route an attractive option.

In the other three corridors, the limited stop route would follow the local route exactly. In these cases, the estimated overall travel time savings per trip on the limited stop route is only about two to four minutes, while the local route would experience about a one minute reduction in travel time due to ridership being diverted to the limited stop route. The small travel time difference is unlikely to be much incentive to time one's trip. Furthermore, the estimated time savings is for a trip on the entire length corridor segment, from end to end. Riders making shorter trips would experience even smaller time savings.

The limited stop overlay concepts all included an increase in service, which would result in an increase in frequency for riders who could use the limited stops and have a choice of using either the limited stop or the local route. Ridership estimates showed that the frequency improvement would account for the vast majority of the estimated increase in ridership, with the travel time savings accounting for a very small percent, albeit a slightly larger percent on Route 311 and O (Route 1), where the significantly shorter limited stop route travel times would have more of an impact.

The estimated percent increase in weekday ridership is highest in both the Coastal Link West corridor (due to the highest share of riders able to use the limited stop route) and the O (Route 1) corridor (where travel time savings contribute more to the increase, despite a smaller share of riders able to use the limited stop service). The Route 41 and Coastal Link East corridors each show just a slightly lower increase in ridership, again primarily due to the frequency increase. The Route 311 corridor shows the smallest increase, but this is due to the fact that the overlay is on only one of the two branches and so represents an increase in frequency of only 50%, rather than the doubling of frequency in the other corridor segments.

5.3.2 *Consolidated Stops with Improved Frequency Concepts*

The consolidated stop with improved frequency concept in each corridor segment included both a reduction in the number of stops and an increase in frequency resulting in a comparable amount of service (and therefore comparable operating cost) to the limited stop overlay concept. A summary of the findings is shown in Table 5-4. In every case, the reduction in travel time is estimated at only about two minutes, which includes not only the reduction in stops, but also a reduction in ridership per trip resulting from the doubling of frequency. With such a small reduction in travel time, the doubling of frequency accounts for the vast majority of the estimated ridership increase of just about 40% in each corridor segment (except for Route 311, at 22%, due to only a 50% increase in frequency versus the 311/311B combination, rather than a doubling of service as would be the case on other corridors).

Table 5-4: Summary of Consolidated Stops with Improved Frequency Concepts

	311	341	CL West	CL East	O
Current Number of Stops (EB/WB)	56/55	52/55	82/84	65/63	69/68
Revised Number of Stops (EB/WB)	36/36	40/40	66/65	42/41	47/46
Average Percent Running Time Saved	3%	5%	4%	5%	4%
Ridership Increase	22%	40%	39%	40%	39%
Capital Cost	$2.1	$3.0	$3.4	$3.0	$3.8
Annual Additional Operating Cost (millions)	$0.55	$1.03	$1.13	$0.98	$1.24
Boardings & Alightings at Eliminated Stops	21%	7%	8%	13%	12%

The elimination of stops would have only a very small impact on travel times, due to the low ridership and low number of stops typically made per trip in each of the corridors. The elimination of bus stops would, however, have negative impacts on riders currently using those stops that would not exist in the overlay concepts where all existing local stops are retained. The negative impacts may be particularly severe in much of the Route 1 corridor given the extremely poor pedestrian environment throughout the corridor that riders would face when having to walk farther to reach a bus stop.

5.3.3 *Service Design Conclusions*

Both concepts would result in a substantial increase in resources and costs. Each corridor would require four to eight additional peak buses. By design, the two concepts in each corridor segment would have equal operating costs in order to provide a fair comparison of the alternative bus stop and service strategies.

Overall, the limited stop overlay concepts would provide more travel time savings, at least for riders who could use the limited stop route. The savings are significant where the limited stop route can also be made more direct than the existing local route. The lower, and likely more consistent, number of stops made per trip would also tend to improve service reliability. Nevertheless, the improved frequency for all riders under the consolidated stop with improved frequency concepts would result in a greater increase in ridership for the same level of increased resources.

The limited stop overlay concepts were shown to be somewhat ineffective at reducing travel times because the existing services currently make relatively few stops in comparison to the number of actual bus stops in the corridor so a route with fewer planned stops would not be significantly faster. While in most cases, a majority of riders could benefit from the reduced travel times and improved frequency, simply increasing the frequency of service on existing routes would benefit all riders and attract more additional ridership at the same cost. Reducing the number of bus stops on the local routes was also shown to be fairly ineffective at reducing travel times for similar reasons, and would also negatively impact riders who would have to walk farther in the poor pedestrian environment along Route 1.

Given the goal of reducing travel times in the corridor and improving service reliability, the limited stop overlay concept would be slightly more effective. Despite smaller estimated ridership increases, the limited stop overall concept would also not inconvenience any existing riders by making them walk further to a bus stop in the sometimes unfriendly pedestrian environment in the corridor. For these reasons, only the limited stop overlay concept was carried forward into the Corridor Improvement Programs detailed in Part III and evaluated in Part IV of this report.

6. BRT Stations and Passenger Amenities

This chapter focuses on bus stations and the passenger amenities and real-time information provided at those stations. Section 6.1 describes the improvements included in this category, listing the elements that can be included in BRT stations and identifying the features to be included in each category of station being considered for the Route 1 corridor. Section 6.2 describes the methodology used to identify the appropriate type of station to be included at each location, as well as the parameters used to estimate costs and ridership impacts. Section 6.3 presents a summary of the recommendations for stations in each corridor segment.

6.1 Station Types and Amenities

Stations are an important element of BRT. Although they do not have any significant impact on travel times in a corridor, attractive comfortable bus stations have been demonstrated to increase the attractiveness of transit service and increase ridership. Therefore, enhanced stations are included as one of the improvement strategies in the Route 1 corridor.

The analysis described in Chapter 5 identified a set of proposed stations for a limited stop route for each of the five corridor segments. These stations would be served by both the proposed limited stop route and the underlying local route in the corridor. They are referred to here as “stations” in order to distinguish them from local bus stops that would be served by the underlying local bus routes. These stations would have additional passenger amenities added beyond what is now provided at those locations. Station components and possible amenities are described below, followed by an identification of the categories of stations used to develop cost estimates.

6.1.1 *Station Components and Amenities*

Most bus stops in the corridor have been in place for many years and pre-date the passage of the Americans with Disabilities Act (ADA). Many have never been modified would not meet current ADA guidelines for accessibility in their current form. As a result, any existing stop that is altered or improved in the Route 1 corridor will have to be made fully ADA accessible. In addition, any new stop that involves construction (beyond placement of a sign) must be made fully ADA accessible.

A fully accessible stop must, at a minimum, consist of a level, five by eight foot, paved boarding and alighting area adjacent to the roadway. It must also include an accessible paved connection to the nearest sidewalk (or to the street – although a pedestrian connection to the street on Route 1 would not be recommended). It should also include accessible bus stop signage.

Many bus stops, especially those on BRT and other enhanced bus services, include additional amenities. These could include:

- Shelter on a concrete pad (which must, if included, have an accessible connection to the boarding and alighting area)
- System informational signage
- Real time transit information displays
- Lighting
- Emergency call box
- Trash receptacle
- Shelter heaters

- Bike rack
- Bench(es)
- Landscaping

Some stops in areas where on-street parking is allowed, may include an extension of the curb into the parking lane to allow buses to serve the stop without leaving the travel lane. Otherwise, it may be necessary to install a concrete bus pad in the roadway to prevent buses from damaging the roadway shoulder as they pull in and out of the bus stop.

6.1.2 *Categories of BRT Stations and Stops*

The proposed limited stop route stations are fewer in number and located farther apart than the stops on the underlying local bus routes. They were chosen based on typical weekday ridership, pedestrian accessibility, and proximity to major ridership generators and transfer points. Once general locations for stations have been determined, the precise location and the station elements to be included need to be identified in order to develop costs estimates for construction.

The position of the station relative to the nearest signalized intersection (i.e. near-side or far-side) is an important element in providing priority treatments to speed buses through the intersection. The analysis described later in Chapter 9 identified the optimal position for stations and stops at intersections where priority treatments are proposed. All other stations and stops were assumed to remain in their current positions relative to the nearest intersection.

The limited stop stations would be part of an enhanced bus service in the corridor and would generally be expected to serve more daily riders than most local route stops. Therefore, it is appropriate that these stations would have more passenger amenities than are typically found at local route stops. It is also appropriate to identify different categories of stations, having different sizes and amenities based on ridership and local conditions. This analysis considers three types of stations:

- Major Station – high ridership locations and transfer points
- Standard Station – most locations where space permits a shelter to be installed
- Minor Station – locations with few boardings (but may have many alightings) or locations that lack the space to include a shelter

6.2 Analysis Methodology

6.2.1 *Identification of Station Improvements in the Route 1 Corridor*

The number of potential weekday boardings, as defined in Section 5.2.3[13], for each proposed limited stop route station was used to identify stations that could be categorized as Major, Standard, or Minor Stations. Stations with at least 120 weekday daily potential boardings (or about an average of three per trip, assuming current schedules) were classified as Major Stations. Fifteen locations were identified as Major Stations. However, only six of the 15 are at locations other than the current route endpoints, where terminal facilities with extensive shelters and information displays are already present. Stations with fewer than ten weekday daily potential boardings were classified as Minor Stations. Many of those classified as Minor Stations largely serve as alighting stops, while others were selected as station locations despite low ridership in order to provide at least one BRT stop in a community.

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[13] Potential boardings at a proposed limited stop station was defined as the current boardings at the stop, plus one-half of the current boardings at the two adjacent stops.

All station locations were then reviewed using aerial photographs to determine whether sufficient space appears to be available to install a Standard Station. In some cases, it is proposed to move the station to a nearby location different from the existing stop in order to provide adequate space for an accessible boarding area and a shelter. In other cases, a feasible location to include a shelter does not appear possible, in which case the station was re-classified as a Minor Station. Eleven stations were re-classified from Standard to Minor Stations.

Details on each station location, including notes on the classification of the stations and the breakdown of station and pedestrian connection costs by station, are presented in the Corridor Improvement Programs in Part III.

It should be noted that a detailed engineering study of the feasibility of station locations to accommodate an accessible boarding area and a shelter has not been completed. Further analysis and design would be necessary to determine the suitability of each location, as well as the cost of construction, before any proposed improvements could be implemented.

It should also be noted that any final decision on the amenities to be located at stations in the corridor must be reviewed to ensure that amenities are distributed in an equitable manner in accordance with CTDOT's Title VI policy on transit amenities. In particular, the list of stations re-classified at Minor Stations due to site constraints will need to be reviewed to ensure that amenities are still allocated equitably. Of the eleven re-classified stations, the only municipalities with more than one are Greenwich (with four) and Westport (with three). Stamford, Darien, Fairfield, and West Haven each have one.

Table 6-1 shows the features that, for cost estimating purposes, were assumed to be included at each of the four station types. All four types would include the required boarding and alighting area, and a standard bus stop sign or specialized sign designating it as station on the limited stop service. With the exception of the Minor Station, all would include a shelter, with specially branded shelters for the Standard Stations, and larger branded shelters for the Major Stations. Each would have a connection constructed to the nearest sidewalk, if needed. All stations would have a route and system map, as well as a standalone wireless real-time information display. Only Major Stations would have additional features, such as lighting, a bike rack, a second bench, and a trash receptacle. The remaining features listed above in Section 6.1.1 would not be included[14].

6.2.2 *Ridership Impacts*

Although enhanced stations would not have any significant impact on travel times, research has shown that enhanced stations can impact ridership on BRT services separate from the impacts of service enhancements. Table 6-2 shows the ridership impacts estimated as part of the *TCRP A-23A, Cost and Effectiveness of Selected Bus Rapid Transit Components*, project. Using the values in the table, Standard Stations were estimated to have a 3% impact on ridership, due to unique shelters (2%) and some other passenger amenities (assuming 1% out of a possible 3%). Because the vast majority of stations are in the Standard category, a 3% factor was applied to the potential ridership estimate for limited stop route stations.

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[14] Emergency call boxes are probably not needed at highly visible locations on Route 1. Shelter heaters would require a utility connection and most locations are unlikely to have room for landscaping.

Table 6-1: Station/Stop Features by Category

	Major Station	Standard Station	Minor Station
Boarding Area	✓	✓	✓
Bus Stop Sign	✓	✓	✓
Large Branded Shelter with Bench	✓		
Branded Shelter with Bench		✓	
Standalone Bench	✓		✓
Standard Shelter			
Real time Information	✓	✓	✓
System Information	✓	✓	✓
Lighting	✓		
Trash Receptacle	✓		
Bike Rack	✓		
Sidewalk Connections and Curb Ramps	as needed	as needed	as needed

Table 6-2: BRT Station Component Contribution to Ridership Increases

Component	Contribution to Ridership Increase
Unique, attractively designed shelters	2%
Illumination	2%
Telephones/security phones	3%
Climate-controlled waiting area	3%
Passenger amenities	3%
Passenger services	2%
Total	15%

Source: Estimated by TCRP A-23A project team

6.2.3 *Capital Costs*

Unit costs were developed for each of the station elements and used to develop a single unit cost for each of the station/stop types. The existing terminal locations in Stamford, Norwalk, Bridgeport, and the CT Post Mall were assumed to require no capital improvements. The development of unit costs for each of the other station types is shown in Table 6-3. All costs include construction costs and a 25% contingency and are rounded to the nearest thousand dollars. For sidewalk connections, aerial photographs of all station locations were examined to determine the need for new sidewalks to connect each station to the nearest sidewalk. The length of additional sidewalk needed was measured from the aerial photographs. The need for curb ramps to connect to the nearest sidewalk was also assessed. Sidewalks were estimated to cost $175 per linear foot (including contingency) while each curb ramp was estimated to cost $1,600 (including contingency). All costs are in 2016 dollars.

Table 6-3: Station/Stop Unit Capital Costs by Category

	Major Station	Standard Station	Minor Station	Local Bus Stop
Sidewalk Removal	$13,800	$10,800	$4,800	$4,800
Boarding Area	$2,000	$2,000	$2,000	$2,000
Concrete Shelter Pad	$3,600	$2,250	-	$2,250
Large Branded Shelter with Bench	$18,000	-	-	-
Branded Shelter with Bench	-	$7,500	-	-
Standalone Bench	$1,500	-	$1,500	-
Standard Shelter	-	-	-	$3,750
Real Time Information	$4,000	$4,000	$4,000	-
Lighting	$7,000	-	-	-
Bike Rack	$900	-	-	-
Trash Receptacle	$1,500	-	-	-
Minor Items (20%)	$10,460	$5,310	$2,160	$2,160
General Costs of Construction	$7,845	$3,983	$1,620	$1,620
SUBTOTAL	$70,605	$35,843	$16,080	$16,580
Contingency (25%)	$17,651	$8,961	$4,020	$4,145
TOTAL	$88,256	$44,803	$20,100	$20,725
ROUNDED TOTAL*	$88,000	$45,000	$20,000	$21,000

In 2016 dollars

6.3 Recommended Station Improvements

Significant investment in bus station facilities and pedestrian connections in the Route 1 corridor would enhance ridership as well as passenger comfort and safety. In any one of the five corridor segments, the stops designated as stations could serve nearly 2,000 weekday boarding riders, based on current ridership levels. Improved stations with amenities including real-time information displays would benefit all of those riders regardless of whether they use the local or the limited stop service. The inclusion of the enhanced amenities should attract additional ridership to the corridor.

Each of the proposed 176 stations in the Route 1 corridor was assessed and designated as either a Major, Standard, or Minor Station. The number of stations of each type in each corridor is shown in Table 6-4. The table also shows the estimated corridor ridership increase due to the enhanced stations as well as the estimated capital cost of the stations for each corridor.

The proposed list of amenities to be provided at each station type was used to develop unit cost estimates for the installation of each station type. The cost of needed pedestrian connections at each station was individually assessed. The total cost of station improvements in each corridor segment is shown in Table 6-5 along with the estimated potential weekday boardings at the stations and estimated resulting ridership increase.

Table 6-4: Count of Stations by Corridor Segment

	311	341	CL West	CL East	O
Existing Transit Centers	2	5	4	4	2
Major Stations	0	4	0	0	2
Standard Stations	15	14	32	15	22
Minor Stations	7	4	18	18	8
Estimated Ridership Increase	1.8%	2.6%	2.8%	2.6%	2.5%
Capital Improvement Cost (millions)*	$0.92	$1.14	$1.97	$1.10	$1.79

* In 2016 dollars

Table 6-5: Summary of Ridership and Costs

	Potential Weekday Boardings at Stations	Estimated Weekday Ridership Increase	Capital Improvement Cost*
Route 311	1,498	45	$916,000
Route 341	2,100	63	$1,138,700
Coastal Link West	2,183	65	$1,969,150
Coastal Link East	1,232	37	$1,095,950
O (Route 1)	2,144	64	$1,788,100

* In 2016 dollars

Route 311, Route 341, and the Coastal Link East corridors each have estimated station improvement costs of around one million dollars. O (Route 1) and the Coastal Link West have higher costs, $1.8 million for O (Route 1) and almost two million for the Coastal Link West. The high costs on O (Route 1) are largely due to the need for pedestrian improvements associated with connecting the stations to the nearest sidewalks. The high costs on the Coastal Link West are largely due to the high number of stations proposed on this, the longest corridor segment on Route 1.

Implementation of new bus station facilities will require further design for each individual location. Close coordination with the municipalities involved will be essential, as well as Encroachment Permits from the CTDOT District Office for any changes within the state highway right-of-way.

7. Fare Collection Strategies

This chapter focuses on fare collection strategies designed to address the study goals of improving bus travel times and increasing bus ridership in the corridor. Section 7.1 describes the various fare collection strategies, discussing the typical implementation challenges and best conditions for application. Section 7.2 describes the methodology used to identify opportunities to incorporate each strategy into the Route 1 corridor, and to estimate travel time savings. Section 7.3 evaluates the potential impact of each strategy in each of the five corridor segments, including travel time savings and ridership impacts. (Note that for this strategy the cost of the strategy have not been identified, but rather factors are identified that would impact the cost of implementing each fare collection strategy.)

7.1 Fare Collection Strategies

Bus passenger boarding and alighting times are highly sensitive to the time involved in the fare collection process. The various methods of fare collection can result in dramatically different average boarding times, as can the number of different pathways, or channels, provided for boarding and alighting. For this analysis, implementation of a CT*transit* "smart card" is assumed to occur as a first step in decreasing the time involved in fare collection. Once the smart card is implemented, the next step in decreasing boarding times that is analyzed in this chapter is the implementation of all-door boarding, allowing passengers with valid fare media to board through the rear door, creating a second boarding channel. The maximum reduction in boarding times that can be achieved would be through the implementation of off-vehicle fare collection with proof of payment. With a proof of payment system, all fares are collected outside the bus so that passengers board freely through all doors without any delay for fare collection.

7.1.1 *Smart Cards*

Description

In recent years, many transit agencies have adopted contactless Smart Cards as their primary method of fare payment. Smart Cards have many benefits including allowing for a wide variety of fare products to be loaded onto the cards. Smart Cards are an important element of some bus rapid transit systems, as they can speed the boarding process as Smart Cards can be processed faster than magnetically-encoded fare cards and much faster that cash.

Challenges

Smart Cards can be effective at reducing boarding times, especially when on-board cash transactions are reduced. However, to be effective, riders must have easy access to fare machines in order to purchase passes or add value to their cards. Otherwise, riders may tend to add value to their cards using the farebox on board the bus, which can actually increase the average boarding time. There may also be some resistance to the adoption of Smart Cards by cash users as it involves pre-paying transit fares, which may be challenging for lower income riders. Without incentives to switch to Smart Cards, the number of cash users switching to Smart Cards can be as low as 10%. As a result, many agencies provide incentives to using stored value Smart Cards by offering slightly lower fares when paid by smart card and by limiting free transfers to smart card users.

Best Conditions for Application

Smart Cards can be effective for almost any agency with regular daily riders. There are many benefits beyond a reduction in boarding times. For this analysis of boarding times, the most significant results can be obtained when the largest share of riders switch from cash to stored value cards and from magnetic fare media to Smart Cards. Systems that currently rely primarily on flash passes (passes that only require visual inspection for boarding) can actually see an increase in boarding times as they move to Smart Cards.

7.1.2 *All-Door Boarding*

Description

The adoption of Smart Cards creates greater opportunity to increase the use of the rear door of the bus for boarding. With low cost smart card readers installed at the rear door, smart card users can choose to board at either door, decreasing the time it takes to board all passengers at a stop. Cash users and users of other media would continue to be required to board at the front door and to interact with the farebox.

Challenges

All door boarding has only been implemented system wide at one major US city transit agency, San Francisco Municipal Transportation Agency (SFMTA). SFMTA found that passenger education was necessary even though the policy of all-door boarding was adapted from an existing informal policy. Riders needed to be made aware of the policy and which door they should use for boarding. Riders also needed to be educated on the use of rear door card readers. An increase in fare evasion was anticipated at SFMTA as non-smart card riders could attempt to slip in the rear door among smart card users. As a result, SFMTA increased fare inspections by almost 20% and managed to maintain fare evasion at or below previous levels. Costs include increased fare inspection costs as well as the cost of the rear door card readers.

Best Conditions for Application

Rear door boarding works best where there are large numbers of riders boarding at many of the stops. When buses are stopping for just one, two, or three riders, they tend to board together at the front door, resulting in no decrease in boarding time. In addition, if stops have a balanced number of boardings and alightings, or a greater number of alightings, the number of rear door boardings can be limited by the number of alighting passengers. Rear door boarding also works best where the majority of riders are using Smart Cards.

7.1.3 *Proof of Payment*

Description

With off-vehicle fare payment, all fares are collected and/or validated at the bus stops rather than on the bus. Passengers must carry proof of payment with them at all times while on board the bus. Proof of payment consists of a valid unlimited use pass, or a validated ticket. Tickets are sold at ticket vending machines (TVMs) in the station. CTDOT has experience with this type of system on the CT*fastrak* BRT system in the greater Hartford area.

Challenges

Major challenges with proof of payment systems include the cost of procuring, installing, and maintaining TVMs at stops and stations, plus the cost of fare inspectors needed to inspect passengers' proof of payment. There can also be physical challenges installing TVMs, as many bus stops may not have available space to install the TVM. The machines also require electrical power and communications connections that may not currently exist.

Best Conditions for Application

Proof of payment works best where there are high volumes of passengers boarding and alighting so that the savings in average boarding times are significant. The policy also works best where there are few stops spaced widely apart in order to reduce the cost of the equipment needed at the stops or stations.

7.1.4 *Identification of Opportunities in the Route 1 Corridor*

CTDOT is currently planning implementation of a smart card system with a public rollout in 2017. This will be an account-based system. Passengers must load value into their account and the cost of travel is deducted from their account as each trip is taken. The system will automatically convert the account to a daily, weekly, or monthly pass as trips are taken to provide passengers with the lowest cost fare product to pay for their travel. This automatic upgrade feature will allow passengers to add value to their cards as needed and avoid the obstacle of having to pay for the entire cost of a monthly pass upfront, which can be a burden for lower income riders. It is anticipated that eventually the smart card will be accepted by all transit agencies in Connecticut. However, initially the card will be in use only on CT*transit* systems*,* and therefore will not initially be accepted by the three agencies operating the Coastal Link.

During the initial implementation phase of a smart card system, CT*transit* will continue to offer magnetically encoded "swipe" passes with the goal to discontinue those passes as customers become more comfortable with the new technology. Single rides will be able to be purchased with the smart card or with cash, and free transfers will continue to be available for all riders. CT*transit* ten-ride tickets will remain as swipe passes. While cash fares will still be accepted, it is anticipated that many who currently pay with cash will use the smart card to take advantage of the automatic upgrade feature. No estimates have been made as of yet regarding the share of cash users who would switch to the smart card.

While the services in the Route 1 corridor that will use the smart card will be on the Route 311, Route 341, and O (Route 1) corridor segments, the operators of the Coastal Link could eventually adopt a shared smart card. Therefore, in this analysis, the impact on running times resulting from the implementation of Smart Cards was examined for all five Route 1 corridor segments.

All five corridor segments were also considered for the All Door Boarding and Proof of Payment options. While most stops on these routes serve few passengers per day, the limited stop service designs recommended in Chapter 5 could result in fewer stops and stops with higher volumes of boarding passengers, making them more suitable to options with reduced boarding times per rider.

7.2 Analysis Methodology

7.2.1 *Bus Travel Time Savings*

Average Boarding and Alighting Time per Passenger

The first step in determining bus travel time savings was to estimate current average boarding and alighting times per passenger on existing services in each of the five corridor segments. Boarding and alighting times vary by fare payment method. While there may be many different fare products, such as passes, multi-ride tickets, transfers, full-fare cash, and reduced fare cash, there are only a few types of payment methods that determine boarding times. These currently include cash, magnetically encoded passes that are "swiped" through the farebox reader, and passes or tickets that are observed by the driver but not entered into the farebox (referred to as "flash" passes). CT*transit* will soon be adding Smart Cards, which are waved near the farebox reader, but do not need to touch the reader.

To estimate the current average boarding and alighting times per passenger for each route, it was necessary to determine the percent of riders on each route using each fare payment method. CT*transit* provided two days of recent counts of boardings by payment method for Routes 311, 341 and O (Route 1). Ridership was broken down into full-fare cash, swipe passes, and other. Because "other" could include youth and seniors paying cash, as well as flash passes and transfers that could not be read electronically[15], 2016 year-to-date summaries for the entire Stamford and New Haven Divisions were used to estimate youth and senior cash as a percentage of full-fare cash. This resulted in ridership estimates for each route broken down by fare payment method – cash, swipe, and flash pass. A similar breakdown for the month of June 2016 was obtained from GBT and applied to all services on the Coastal Link. There was no separate breakdown for flash passes provided for the Coastal Link so all passes received on the Coastal Link were assumed to be swipe passes.

Next, typical boarding times, in seconds, for each fare payment method were taken from the *Transit Capacity and Quality of Service Manual, 3rd Edition*. Estimated boarding times for each payment method are shown in Table 7-1. The values in the table assume low-floor vehicles. Swipe passes have the longest average boarding time, even longer than cash, while flash passes are the quickest of all payment types, slightly faster than Smart Cards. However, having no fare payment is faster than every type of payment method. Average boarding times were weighted by the percentage of riders in each category, in each corridor segment, to obtain the estimated average boarding time by corridor segment.

Table 7-1: Typical Boarding Times by Fare Payment Method

Payment Method	Seconds per Passenger
Swipe Pass	5.00
Cash	4.50
Smart Card	2.75
Flash Pass	2.00
None	1.75

Source: *Transit Capacity and Quality of Service Manual, 3rd Edition*, p. 6-7, Exhibit 6-4

For passenger alightings, the manual suggests an average alighting time of 1.75 seconds for all passengers. An adjustment was made to the suggested time to account for passengers who would alight through the rear door while others passengers board through the front door. Without trip-level boarding and alighting counts by stop, an estimate had to be used for the share of alighting passengers alighting while others board. In the Route 1 corridor, about one-half of all alightings on corridor routes (outside the terminals) occur at stops where alightings outnumber boardings. However, with alighting times typically about half of boarding times, the number of passengers who can alight through the rear while passengers board through the front can exceed the number of boardings. Therefore, it was assumed that 50% of alightings could occur concurrently with boardings, resulting in a 50% reduction in the average time per alighting passenger of 1.75 seconds to 0.88 seconds.

The calculations were repeated for the Smart Card option by re-assigning all "swipe" pass boardings to Smart Cards, except for ten-ride tickets. Given the advantage of the automatic upgrade feature of the

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[15] For example, Unitickets and transfers and passes from non-CT*transit* operators.

planned CT*transit* smart card, a significant percentage of cash riders would likely shift to smart card use. While no official projections of this percentage shift have been made to date, for this analysis it was assumed that 50% of cash users would switch to Smart Cards.

All door boarding allows passengers to board through both doors simultaneously, although research has shown that about 60% of riders will still use the front door. With the majority of corridor passengers not using Smart Cards, it was assumed that only 25% of smart card users would use the front door, resulting in about a 60%-70% overall front door share for all riders throughout most of the corridor. The average front door boarding time per smart card passenger would therefore be reduced by 75% from 2.75 seconds to just 0.69 seconds. Because some smart card users would board through the rear door, the assumed share of passengers alighting while others board was lowered from 50% to 25%, resulting in an average time per alighting passenger of 1.31 seconds.

Proof of payment would allow all riders to board and alight through any door without stopping to pay a fare. With 60% of both boarding and alighting passengers using the front door, the average boarding or alighting time per passenger would be just 1.05 seconds.

For the current fare collection system and each of the three options, the estimated average boarding time and the average alighting time per passenger were summed to get the total boarding plus alighting time per passenger for each corridor segment. The resulting time for each option was then compared to the time for the current fare collection system to obtain the estimated percentage reduction in boarding and alighting time for each option for each of the five corridor segments.

Bus Travel Time Savings per Trip

The time and delay data collection conducted for this study developed estimates of the amount of time per trip taken by passenger boardings and alightings, broken down by route, direction, and time period. As described in Section 5.2.2, the total time per trip stopped at bus stops was calculated from the time and delay data. For each stop served, 3.5 seconds (representing door opening and closing time) was deducted from that total to obtain the time spent actually boarding and alighting passengers.

To estimate the impact of each of the three fare collection options, the percent reduction in boarding and alighting time per passenger for each option was applied to the average time per trip spent actually boarding and alighting passengers for each route, direction, and time period. The resulting reduction in travel time was compared to the actual average running times collected, to obtain the percent reduction in running time for each route, direction, and time period.

The reductions in running time would benefit all riders on each of the routes.

7.2.2 *Capital and Operating Cost Issues*

It is not within the scope of this study to estimate the capital and operating costs of implementing the CT*transit* smart card. However, beyond initial implementation of the card, all-door boarding would require the additional cost of procuring and installing smart card readers at the rear door. Such readers would cost approximately $2,000-$5,000 per bus depending on the technology implemented by CT*transit*. Proof of payment, on the other hand, would require a considerable investment in a system of TVMs at each of the stops on each route, including a communications network and control center. Developing cost estimates for such a network would require considerable effort, and is beyond the scope of this study.

All-door boarding would require a small increase in maintenance costs for the added fare card readers, and a small increase in fare inspection costs. The proof of payment option would require considerable maintenance of the TVM network, plus a considerable increase in fare inspection costs. Estimates of these costs were not developed for this study.

7.3 Assessment of Fare Collection Options

7.3.1 *Impacts of Fare Collection Options by Corridor Segment*

For each corridor segment, the current percentage of boardings for each payment method is shown in Table 7-2. Estimated boarding plus alighting times per passenger were developed for each option based on these percentages are shown in Table 7-3. The table also shows the percent reduction in boarding and alighting time versus the current fare collection system. The estimated reduction in boarding and alighting time for the planned introduction of Smart Cards is only 19%-20% for the Route 311 and 341 corridor segments, due to lower current pass usage. The estimated reduction for both the Coastal Link and O (Route 1) corridors, at 26%-27%, is higher due to much higher existing pass usage. For all door boarding, the reductions are estimated to be 31%-32% for Routes 311 and 341, and 44%-45% for the Coastal Link and O (Route 1). With proof of payment, boarding times would be reduced considerably and would be the same for all routes. Given the slightly different existing boarding times, the reductions in boarding and alighting time would range from 60% to 62%.

Table 7-2: Route 1 Corridor Weekday Boardings by Fare Payment Method

	311	341	CLW	CLE	O
Cash	62%	57%	59%	59%	27%
Swipe Pass	30%	30%	41%	41%	65%
Flash Pass	8%	13%	0%	0%	7%

7.3.2 *Travel Time Savings*

The estimated percent reduction in boarding plus alighting time was applied to the board and alighting times per trip obtained from the time and delay data collection. The resulting change in average running times is shown by route, direction, and time period in Appendix H. The percent savings in running time averaged over both directions and all time periods for each corridor segment is shown in Table 7-4. The overall travel time savings would be modest, at 2% to 3%, or about a minute, on each route, with the introduction of Smart Cards. The savings are estimated to increase to 2% to 5%, or about one to three minutes, when all-door boarding is added. Proof of payment would increase the savings to 5% to 6%, or about two to five minutes.

7.3.3 *Ridership Impacts*

The percent reduction in running time was assumed to represent the percent reduction in travel time for passengers on each route in each direction and time period.

Table 7-5 shows the estimated increase in weekday ridership using the arc-elasticity method described previously. With fairly small savings in travel times, the estimated ridership increases are not large, about 1% for the introduction of Smart Cards, and 1-2% when all door boarding for Smart Cards is added, and 2-3% for proof of payment.

Table 7-3: Estimated Average Boarding and Alighting Times per Passenger

	311	341	CLW	CLE	O
Average Boarding Times per Passenger					
Current	4.45	4.33	4.71	4.71	4.64
Smart Cards	3.41	3.32	3.26	3.26	3.14
All Door Boarding	2.32	2.29	1.80	1.80	1.71
Proof of Payment	1.05	1.05	1.05	1.05	1.05
Average Alighting Times per Passenger					
Current	0.88	0.88	0.88	0.88	0.88
Smart Cards	0.88	0.88	0.88	0.88	0.88
All Door Boarding	1.31	1.31	1.31	1.31	1.31
Proof of Payment	1.05	1.05	1.05	1.05	1.05
Total Boarding and Alighting Time per Passenger					
Current	5.33	5.20	5.58	5.58	5.52
Smart Cards	4.29	4.20	4.14	4.14	4.02
All Door Boarding	3.64	3.60	3.12	3.12	3.02
Proof of Payment	2.10	2.10	2.10	2.10	2.10
Reduction in Boarding and Alighting Time					
Smart Cards	20%	19%	26%	26%	27%
All Door Boarding	32%	31%	44%	44%	45%
Proof of Payment	61%	60%	62%	62%	62%

Table 7-4: Estimated Bus Travel Time Savings

	311	341	CLW	CLE	O
Smart Cards	1.6%	1.9%	2.3%	2.7%	2.2%
All Door Boarding	2.7%	3.0%	3.9%	4.7%	3.7%
Proof of Payment	5.1%	5.9%	5.5%	6.6%	5.1%

Table 7-5: Estimated Weekday Ridership Increases

	11A	41	CLW	CLE	O
Percent Increase in Ridership					
Smart Cards	0.7%	0.9%	1.1%	1.3%	1.1%
All Door Boarding	1.2%	1.4%	1.9%	2.2%	1.8%
Proof of Payment	2.4%	2.8%	2.8%	3.2%	2.5%
Ridership Increase					
Smart Cards	18	22	26	18	27
All Door Boarding	30	35	45	32	45
Proof of Payment	58	70	64	46	63

7.3.4 *Conclusions*

The implementation of Smart Cards would have a small impact on travel times with about a one-minute savings on any of the routes, which could increase ridership by about 1%. Because O (Route 1) and the Coastal Link have higher percentages of pass users, a larger impact, in terms of both travel time savings and ridership, is expected on those routes. Allowing smart card users to board through the rear door would create a small amount of additional savings, no more than a minute in most cases. There would be added costs for the rear door card readers and possibly for increased fare inspection.

Changing to a proof of payment system would have a somewhat higher impact, reducing boarding and alighting times by about 60% on any of the routes. However, this would only reduce overall travel time by 5% or 6%, or about two to four minutes, and increase ridership by 2% to 3%. Proof of payment would come with significant added capital costs for TVMs at all stops, plus operating costs for fare inspectors.

The planned implementation of Smart Cards will be an immediate step towards decreasing boarding times in the Route 1 corridor. The other options would constitute a second step requiring further investment in technology and increases in the geographic extent and scale of fare inspections on CT*transit* buses. While all-door and proof-of-payment options may be possible future improvements, the rapidly evolving technology for fare collection and fare payment methods may lead to other equally effective, but lower cost, solutions in the near future. Therefore, only the initial planned implementation of Smart Cards is assumed in the Corridor Improvement Programs outlined in Part III.

8. Transit Signal Priority

This chapter focuses on the implementation of Transit Signal Priority (TSP) to address the study goals of improving bus travel times and increasing bus ridership in the corridor. Section 8.1 presents an overview of the various options for implementing TSP. Section 8.2 presents transit agency TSP-related issues while Section 8.3 presents TSP-related traffic signal system issues. Section 8.4 presents a summary of study recommendations regarding TSP.

8.1 Transit Signal Priority Concept and Options

TSP is a signal control strategy at intersections, applied on urban roadways, to reduce transit travel time and improve on-time performance. The concept involves extending the green signal phase or truncating the red signal phase sooner on the intersection approach on which a bus is operating in order to provide more green time for buses to get through the particular intersection. This “green extension/red truncation concept” is illustrated in Figure 8-1. The lengthened transit phase split time is recovered on the following signal cycle so that the corridor signal coordination timing plan can be maintained. The following sections describe important distinctions between various types of priority and outline several choices that need to be addressed before implementing TSP.

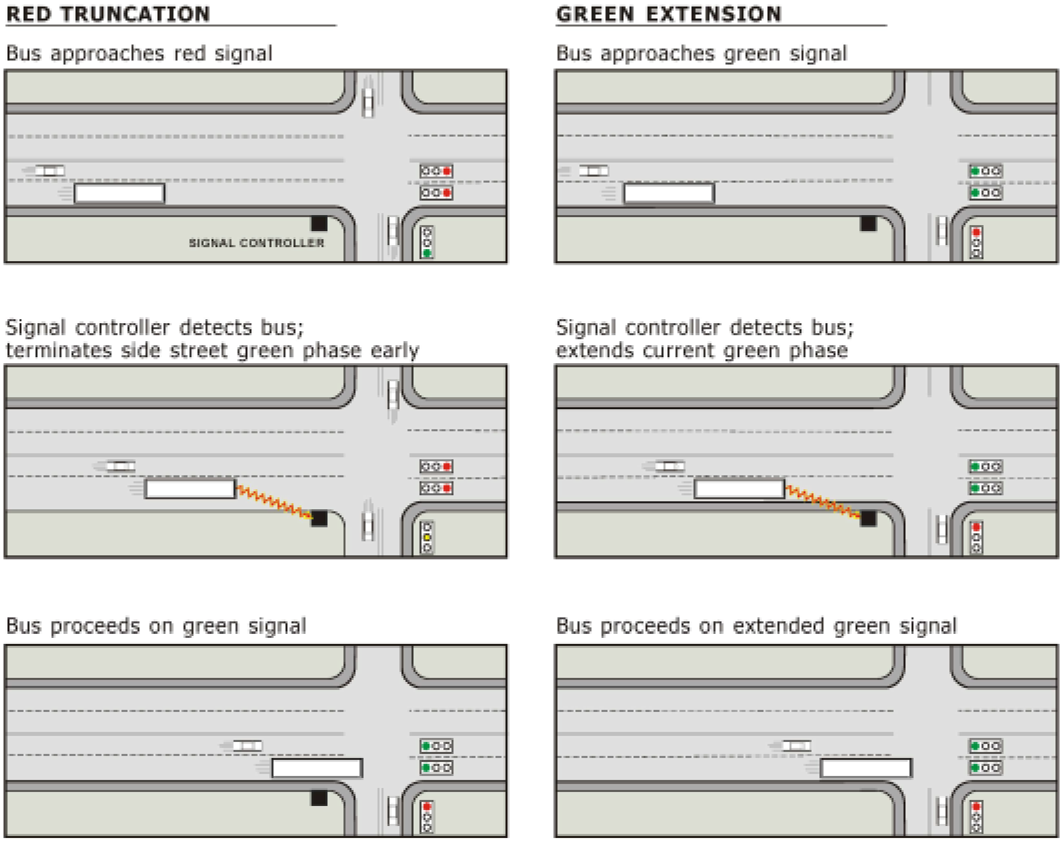
8.1.1 *Preference vs. Priority vs. Preemption*

While the terms Transit Signal “Preference” (used most often in Connecticut) and Transit Signal “Priority” and interchangeable, the concept of “priority” is much different from “preemption”. With priority, the signal cycle length is maintained thus keeping the signal system in coordination by minor green time reductions to other traffic movements at an intersection, while still allowing for such movements. Preemption, which is typically applied to accommodate special event conditions like approaching emergency vehicles or at railroad crossings, allows for shortening a signal cycle length to go immediately to a green signal on the approach on which the emergency vehicle or train is approaching. Two characteristics differentiate TSP from emergency vehicle preemption. First, the phase is served in its “normal” position in the signal cycle (as opposed to preemption, where the signal controller immediately brings up the preempt phase). Second, the background arterial coordination timing is maintained through the entire priority event (as opposed to preemption, where the controller immediately drops the coordination timing). Thus, preemption can have a far greater disruptive impact on traffic flow, while priority has minor impacts, mostly on cross street traffic, and actually improves traffic flow slightly for all types of vehicles in the priority direction.

8.1.2 *Active Priority: Unconditional vs. Conditional*

TSP is considered an “active” priority strategy, in that it is applied on demand by an approaching bus, either all the time (known as “unconditional” priority), or if the bus exhibits a certain operating characteristic, such as falling behind schedule or having a certain number of passengers on-board (known as “conditional” priority). Active priority is different from “passive” priority, which is undertaken to improve traffic flow in general along a corridor, but optimizes signal timing to facilitate bus operations, without on-demand activation by approaching buses.

Figure 8-1: TSP Green Extension/Red Truncation Concept



Source: Transit Capacity and Quality of Service Manual, p 6-42

8.1.3 *Distributed vs. Centralized Architecture*

TSP can be applied in a “distributed” communications architecture (illustrated in Figure 8-2) or in a “centralized” communications architecture (as shown in Figure 8-3). In a distributed system, the priority request generator in an approaching bus interfaces with the Automatic Vehicle Location (AVL) system, and then communicates directly with a priority request server within a signal controller cabinet. In this system, the signal priority decision is made on street, based on actual traffic conditions. In a centralized system, the priority request generator and server are integrated into the centralized signal control, which makes the decision whether and how to grant priority, again based on actual traffic conditions. In a centralized signal system, fiber optic cable or wireless technology is applied to facilitate communication between a local signal controller and the central traffic control center. The transit dispatch functions could be integrated into the centralized control system, or have its own facility, with communications with the central traffic control center to deal with special events or emergency situations.

8.1.4 *Vehicle Detection Options*

Priority is based on the TSP logic programmed into the traffic signal controller, and is applied when a request for signal priority is detected from the system on an approaching bus. TSP detection can be provided by several different means. In many cases in the United States and Canada, agencies use

Figure 8-2: Distributed TSP System

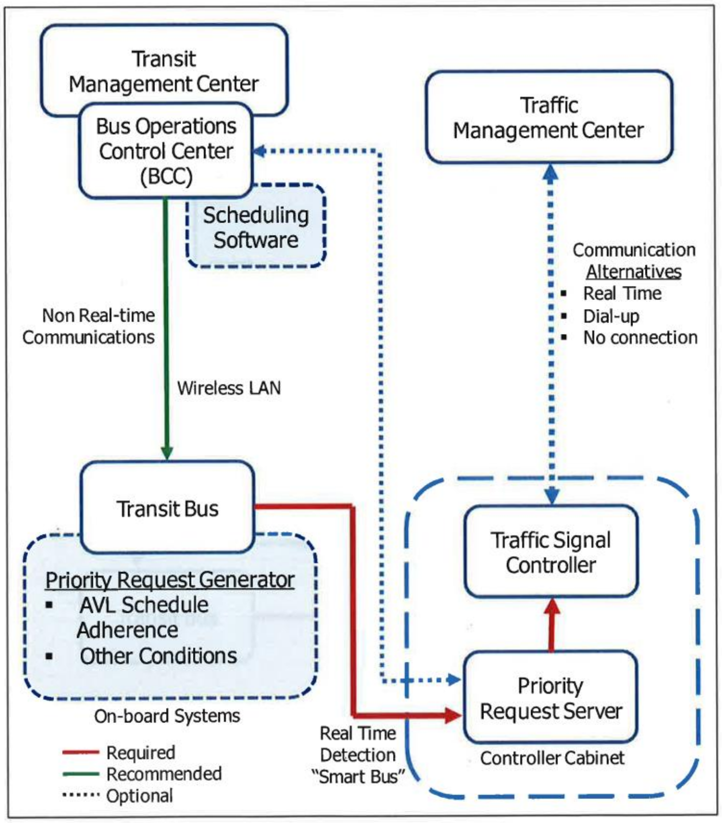
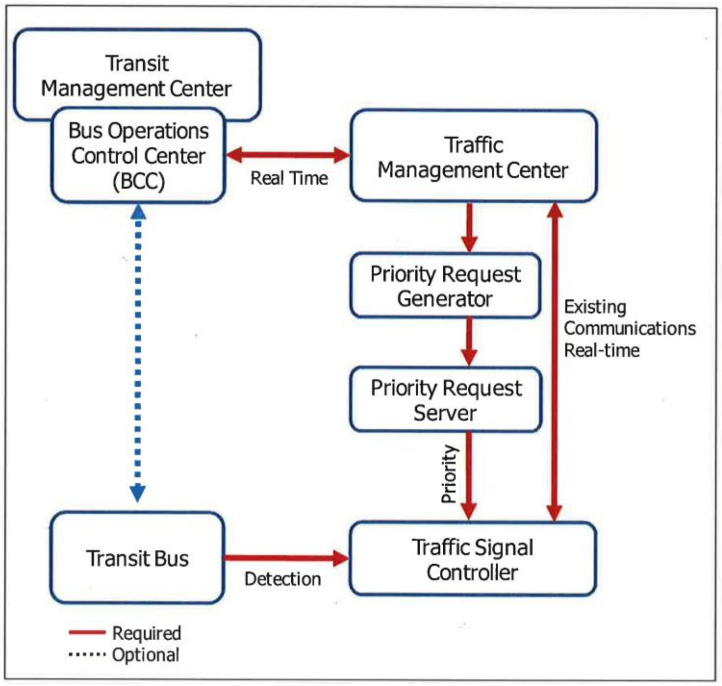
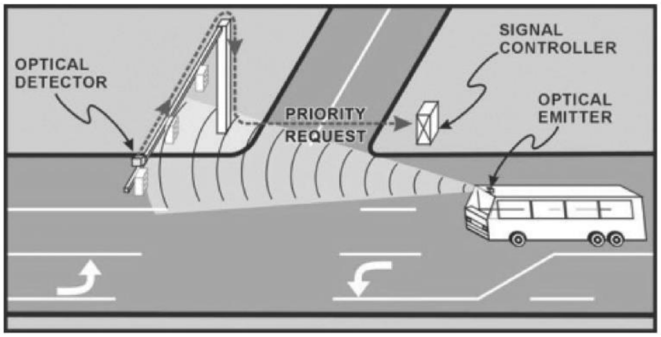


Figure 8-3: Centralized TSP System



Optical Infrared detection to transmit requests from buses through an emitter to an optical detector on a signal mast arm or span wire, then a connection to the traffic signal controller. The predominance of optical detection is generally attributed to its existing, widely deployed use for emergency vehicle preemption. Figure 8-4 illustrates this concept. An improved form of optical detection is GPS detection, where a bus interfaces with an emitter with a receiver at the intersection (typically mounted at or near the signal controller). GPS detection has the benefit of not being restricted to line of sight between a bus emitter and signal receiver and thus allows for TSP calls to be activated over greater distances from an intersection than optical infrared detection. Inductive loop–based systems use an inductive loop embedded in the pavement and a transponder mounted on the underside of the transit vehicle to distinguish transit vehicles from other traffic. Use of wayside readers and the use of radio frequency (RF) tags have been applied as well for bus detection.

Figure 8-4: Optical Infrared Bus Detection Concept



Source: Transit Capacity and Quality of Service Manual, p 6-42

8.1.5 *Passive Priority*

Passive priority does not require the hardware and software investment of active priority treatments. Passive priority operates continuously, regardless, based on knowledge of transit route and ridership patterns, and does not require a transit detection / priority request generation system. In general, when transit operations are predictable with a good understanding of routes, passenger loads, schedule, and/or dwell times, passive priority strategies can be an efficient form of TSP. One such passive priority strategy is establishing signal progression for transit. In this application, the signal timing plan would account for operational characteristics such as the average dwell time at transit stops, or considering that dwell times are highly variable, use as low a cycle length as possible. For example, in Denver the signal system uses cycle lengths based on the travel speed of the buses on the Denver Transit Mall so that the buses can stay in sync with the signals and so that the cross streets can be coordinated across the mall. Since the signals are coordinated for the flow of transit vehicles and not for other traffic, other traffic may experience unnecessary delays, stops, and frustration. Therefore, the volume of traffic parallel to the TSP movements should also be considered with a transit signal progression approach and so this approach may not be practical on higher volume roadways. It is important to note that other "passive" improvements may also be of benefit to transit. Operational improvements to signal timing plans, such as retiming, reducing cycle lengths, or coordinating signals on a corridor, may improve traffic flow and reduce transit travel time as well. Simply timing the intersection to minimize person delay, as opposed to vehicle delay, would be considered a passive strategy.

8.2 Transit Operator AVL Issues

8.2.1 *System Integration*

With the presence of five different transit operating divisions in the corridor, each agency has certain opportunities and constraints to implementing TSP at this time. This particularly relates to the configuration and capability of their AVL systems, assuming conditional priority (priority based on whether or not a bus is running late) will be the most appropriate TSP strategy for the Route 1 corridor. With five different transit districts or divisions providing bus operations in the Route 1 study corridor, there are four different AVL systems in place that have different levels of compatibility to trigger TSP. The AVL systems used by each operator and division were described in Section 2.4.1 and consist of:

- CT*transit* Stamford Division – Xerox ACS
- Norwalk Transit District – Avail
- Greater Bridgeport Transit – Trapeze Transit Master
- Milford Transit District – Motorola Street Trek 3
- CT*transit* New Haven Division – Trapeze Transit Master

For the existing Coastal Link service, three different AVL systems (Avail, Trapeze Transit Master, and Motorola) are in operation. For each AVL system, specific integration programming will be required to allow the AVL system to communicate with the signal system. This will be most complicated for the Coastal Link service if multiple operators continue to operate the service in the future, as multiple integration strategies will need to be developed with the signal control system to allow TSP for any bus operating on the service.

8.2.2 *Vehicle Equipment Needs and Costs*

A first cut at the number of buses to be retrofitted was developed by identifying the number of unique block numbers on each existing route. This is much higher than the number of peak vehicles per route as the CT*transit* routes are interlined (Routes 311 with 341, and O Route 1 with O Winchester) and there are AM blocks and PM blocks that could be covered by different buses. The Coastal Link is not interlined, but has a 3:1 peak-to-base ratio so there are considerably more blocks than peak buses. In addition to buses on the existing local routes, any buses added to implement the limited stop overlay service would also need to be retrofitted. Beyond that, a transit agency would want a number of additional buses equipped in order to guarantee assignment of a sufficient number of equipped buses every day.

Table 8-1 identifies, by corridor segment, the estimated number of buses that would need to be retrofitted with emitters in the Route 1 study corridor. A 25% contingency is applied to the number of buses, given the uncertainty of overall bus assignments to the corridor.

The total estimated bus-related capital and operating and maintenance (O&M) costs to implement TSP in the Route 1 study corridor is shown, by segment, in Table 8-2. The costs include the emitter, installation, and integration programming with the controller. The costs include a 40% contingency, to cover any unexpected added transit agency labor, equipment, or added integration programming. The costs reflect the following capital components and costs per vehicle:

- Infrared emitter - $1,300
- GPS Emitter - $1,800
- Emitter installation - $1,000
- Integration programming - $200

Table 8-1: Estimated Number of Buses Retrofitted with TSP Emitters – by Corridor Segment

Corridor Segment	Existing Service	Added for Service Options	25% Contingency	Total
Route 311	16	6	6	28
Route 341	15	8	6	29
Coastal Link West	20	12	8	40
Coastal Link East	20	10	8	38
O (Route 1)	19	8	7	34

Table 8-2: Estimated Costs for Bus-Related TSP Implementation – by Corridor Segment

Corridor Segment	Capital Cost*		Annual O&M Cost*
	Infrared Detection	GPS Detection	
Route 311	$98,000	$117,600	$7,000
Route 341	$101,500	$121,800	$7,250
Coastal Link West	$140,000	$168,000	$10,000
Coastal Link East	$133,000	$159,600	$9,500
O (Route 1)	$119,000	$142,800	$8,500

* In current dollars

The total capital cost per bus, including contingencies, would therefore be $3,500 for infrared detection and $4,200 for GPS detection. Annual maintenance costs for emitters is estimated at $250 per unit. Operating (power) costs are assumed nominal and absorbed within the overall bus operating costs.

8.3 Traffic Signal System Issues

8.3.1 *Range of TSP Application*

TSP normally is applied when intersection LOS is in the "C" to "D" range. This is where the signal timing can be adjusted to provide some benefit to bus operations with only a negligible impact on general traffic operations. It is important to realize that general traffic travelling along the same roadway as buses getting priority receive added green time as well. When intersection LOS is in the "E" to "F" range (near or over capacity), triggering signal priority normally has minimal benefit to bus operations, as the bus cannot arrive at the signal in a timely manner because of vehicle queuing. When intersection LOS is "A" or "B", there is little delay to buses and hence little benefit is achieved with TSP, though if applied there would only be a negligible impact on general traffic operations. If an intersection is operating near or over capacity during peak periods where TSP is not practical, it could still be implemented during off-peak periods, under less congested conditions.

Through the time and delay data that was collected, intersection LOS was identified by associating the observed bus delay on the approaches to intersections to LOS, and identifying those approaches having an estimated LOS in the "C" to "D" range. This initially identified 49 intersections for potential TSP application. Based on further review of each intersection as to whether TSP or another priority treatment such as a bus queue jump, curb extension, or passive priority through signal timing modifications were most applicable, 26 approaches at 19 intersections were identified for active TSP application. The specific benefits and costs associated with applying TSP at these locations is presented in Chapter 9.

8.3.2 *Need for Upgraded Controllers*

CTDOT has indicated that all CTDOT-owned signal controllers in the Route 1 corridor are antiquated and any intersection where TSP is to be implemented would require a new controller. At several locations where there are antiquated controllers today, there is also old copper wire used for interconnection of signals and for tying back to a central traffic control system. Fiber optic cable is only in place in the Stamford, Norwalk, and New Haven areas. There are no current plans by CTDOT or local jurisdictions to install fiber optic cable along the Route 1 study corridor to improve overall signal communications, and make it easier to implement a centralized TSP operation.

8.3.3 *Use of Existing Emergency Preemption System for Bus Priority Detection*

Several intersections identified for TSP application have emergency vehicle preemption capabilities today, and hence there would be an opportunity to incorporate TSP into the existing software, and take advantage of the optical detectors already in place. An issue expressed by CTDOT Traffic Operations is their ability to maintain such a system. Today, while most of the signals in the Route 1 study corridor are owned by CTDOT, the State is not committed to maintaining the detection systems, and maintenance falls to the local jurisdiction. If emergency vehicle preemption at an intersection is not working properly, CTDOT will shut off the system. A more formal arrangement to maintain these systems would be required in the future if the Optical Infrared detection concept for TSP were to be applied.

With infrared bus detection and TSP application, the emitter on the bus would interface with a receiver typically mounted on a signal mast arm or span wire, through a typical radar connection. For this connection to be effective there should be line of sight between the emitter and the receiver at the intersection. Given sight distance restrictions due to trees, buildings, or roadway alignment, the line of sight distance can be restrictive, thus creating less time to request a TSP call and thus limit the amount of added green time given to the approaching bus. The receiver on the span wire or mast arm is connected to the controller via cabling to a separate receiver in the signal controller cabinet.

8.3.4 *Unit Costs for Signal System Upgrades*

To provide input into the estimation of specific TSP costs in the Route 1 study corridor, unit capital costs per intersection were developed for a distributed TSP system, with either Infrared or GPS bus detection. Table 8-3 presents these costs for a typical intersection for the various components. As shown in the table, the total per intersection capital cost to implement TSP (in 2016 dollars) is estimated as $3,100 per intersection where there is existing Infrared detection, and $7,100 per intersection to install either infrared or GPS detection.

In addition to capital costs to implement TSP, there will be annual maintenance costs to maintain TSP field equipment and bus emitters. Based on recent data generated by AC Transit in Oakland on their new TSP system, there is an average cost of $500 per year per signalized intersection for maintaining field equipment. These unit costs were used to estimate TSP maintenance costs in the Route 1 corridor. It was assumed that operating (power) costs would be incidental and a part of the base signal and bus operating costs.

Table 8-3: Unit Costs for Signal System Upgrades to Activate TSP

Improvement Component	Distributed/ Existing Infrared	Distributed/ New Infrared	Distributed/ GPS
New Controller	$3,100	$3,100	$3,100
Cabinet Modification		$500	$500
Optical Detector		$1,000	
GPS Receiver			$1,500
Detector Amplifier		$1,000	$1,000
Cabling		$1,000	$500
Software		$500	$500
TOTAL*	**$3,100**	**$7,100**	**$7,100**

* In 2016 dollars

8.4 Transit Signal Priority Options and Recommendations

The assessment of TSP opportunities in the Route 1 study corridor revealed the challenge of integrating multiple AVL systems with different signal system configurations. This would particularly be true for the Coastal Link corridor, whether left in its existing configuration or separated into West and East services, if multiple operators would continue to operate the service. Consideration may need to be given to designating only one operator, at least for the limited stop service.

Given the lack of fiber optic cable in most of the Route 1 study corridor, and the dispersed location of the limited number of intersections where signal priority would be operationally feasible, a distributed TSP system would appear to be the most appropriate TSP strategy. This would certainly apply in Greenwich, Westport, Fairfield, and Bridgeport where copper wire for signal communications is still used. In Stamford, Norwalk, and New Haven, the presence of fiber optic cable and advanced *TMC Now* central control software allows for application of either centralized or distributed TSP.

With respect to bus detection, there appear to be two options. First, given that emergency vehicle preemption is in place on about 80% of the intersection approaches where TSP has been identified as a possible strategy, Optical Infrared detection could be extended to the remaining intersections. With proper integration programming, TSP could then be activated at these intersections if TSP compatible controllers are in place. The second option would be to move to an Opticom GPS bus detection system, which would provide improved bus detection capability but require the development of a different TSP bus detection system.

Therefore, there appear to be four potential signal/detection options from a technical standpoint to implement TSP in the Route 1 corridor:

- Distributed TSP with Optical Infrared bus detection
- Distributed TSP with Opticom GPS bus detection
- Centralized TSP with Optical Infrared bus detection
- Centralized TSP with Opticom GPS bus detection

The information gathered suggests that a distributed TSP system in the corridor in general would be initially preferable, given the limited application of fiber optic cable in the corridor for enhanced communications and the sporadic location of traffic signals identified for TSP from the Intersection and

Running Way Improvements assessment. The distributed TSP system with conditional activation would appear to be easiest to implement in the Route 1 study corridor with the proper controller hardware and software and integration programming between the bus and signal systems. Either Optical Infrared or Opticom GPS bus detection is recommended, with infrared detection being less costly because of its existing installation at most of the intersections along the Route 1 study corridor today to provide emergency vehicle preemption.

9. Intersection and Running Way Improvements

This chapter focuses on intersection and running way improvement strategies that address the study goals of improving bus travel times and service reliability in the corridor. Section 9.1 describes the various types of improvements included in this category, discussing the typical implementation challenges and best conditions for application. Section 9.2 describes the methodology used to identify opportunities to incorporate each strategy into the Route 1 corridor, and to estimate travel time savings and the cost of improvements. Section 9.3 presents a summary of opportunities for intersection improvements in the corridor.

9.1 Types of Improvements

Strategies to give preferential treatment to buses by making modifications to the roadway and signal systems can include physical changes to the roadway, restriping, or changing lane use, changes to intersection configurations, or changes to the traffic control system. While exclusive bus lanes would fit into this category of improvements, the volumes of buses in the Route 1 corridor would not support large-scale installation of exclusive bus lanes. As a result, this analysis addresses more focused improvements at intersections where buses have been observed to experience delays. The intersection and running way improvement strategies that were considered include:

- Queue jumps
- Transit Signal Priority (TSP)
- Curb extensions
- Business Access and Transit (BAT) lanes

It should be noted that while the various strategies examined as part of this study can reduce average bus travel time, they can also reduce the variability of bus travel time, which allows transit operators to provide more consistent and dependable service, thereby improving the quality of service and attracting and retaining ridership. The strategies considered in this chapter, as they are most commonly implemented, tend to provide more benefits in the area of reliability improvement, rather than average travel time reduction. As a result, the estimated reduction in average travel times achieved by these strategies is quite small, but the improvements in reliability can be assumed to be more significant. Potential reliability improvements, however, could not be assessed quantitatively as reliability measurements would require more extensive data on existing travel times than was available for this study in order to assess the extent of any reliability improvements.

9.1.1 *Queue Jump*

Description

A queue jump lane is a short stretch of bus lane combined with a dedicated traffic signal indication for buses. This enables buses to bypass waiting queues of traffic and receive an early green signal in order to cross the intersection and merge back into the through traffic lane before other vehicles. A queue jump lane can be in a right-turn-only lane where through movements are permitted for buses only, or in a short bus-only lane on the approach. (A similar arrangement can be used to permit a bus to cross traffic lanes to make a left turn immediately after serving a curb-side stop.) A queue jump lane can also be installed between the right-turn and the through lanes. Queue jumps should be avoided where there are right turn and left turn overlap phases, unless the phasing sequence is revised to accommodate the advanced queue jump phase. Appropriate lane use signs (per MUTCD) should be installed to guide motorists and buses.

A special bus-only signal and detection is required to discretely detect buses. The detector type would depend on the number of vehicles per hour sharing the same lane with buses. The advance signal should be actuated only by an approaching bus to avoid needlessly delaying other traffic when a bus is not present. Standard traffic signal detection, such as loop detectors or video detection can be used if the queue jump lane is designated as bus-only. If the queue jump lane is also a right turn lane and there is a low turning volume, then multiple loop detectors or video detection can be used so that only buses will actuate the lead phase. If there is higher demand for right turning vehicles in the shared queue jump lane, then infrared, video, or RFID detection is necessary. Concurrent pedestrian phases can generally run with a queue jump phase.

Separate signals must be used to indicate when transit proceeds and when general traffic proceeds. Transit signals can be either a transit specific signal head, a programmable signal head, or a louvered head for visibility-limited green indication, making it visible only to the right-most lane. If provided as a shared right-turn/queue jump, a protected right-turn signal may be used (MUTCD 4D-19), with a sign indicating RIGHT TURN SIGNAL (MUTCD R10-10) and EXCEPT BUSES. [16]

The queue jump concept, with right turning vehicles, is shown in Figure 9-1. A queue jump in a short bus-only approach lane is shown in Figure 9-2.

Challenges

The major challenges faced when implementing queue jumps primarily involve identifying a way to allow buses to bypass through traffic with minimal delay. The intersection must have a right turn lane or space available for a bus lane to separate buses from the main line traffic. In some cases, on-street parking may need to be removed. The lane must be long enough for buses to bypass the queue in the through lanes.

Right turning traffic can also pose challenges to queue jump operation. Right turning vehicles must be able to clear the intersection so that buses have the ability to reach the front of the queue by the beginning of the green cycle. If the number of right-turning vehicles is high enough for right-turn queues to occur with regularity, right turns may need to be accommodated by a separate lane from the transit queue jump lane. Sequence and phasing of traffic signals may be an obstacle to the implementation of a queue jump lane, when there are conflicting movements such as side street advanced left turn with right turn overlaps.

Without a sufficiently long right turn lane, additional right-of-way and funding may be needed for design and construction of a short bus only lane. Other challenges are associated with coordinating concerns of stakeholders, such as transit agencies, Department of Transportation, and communities.[17]

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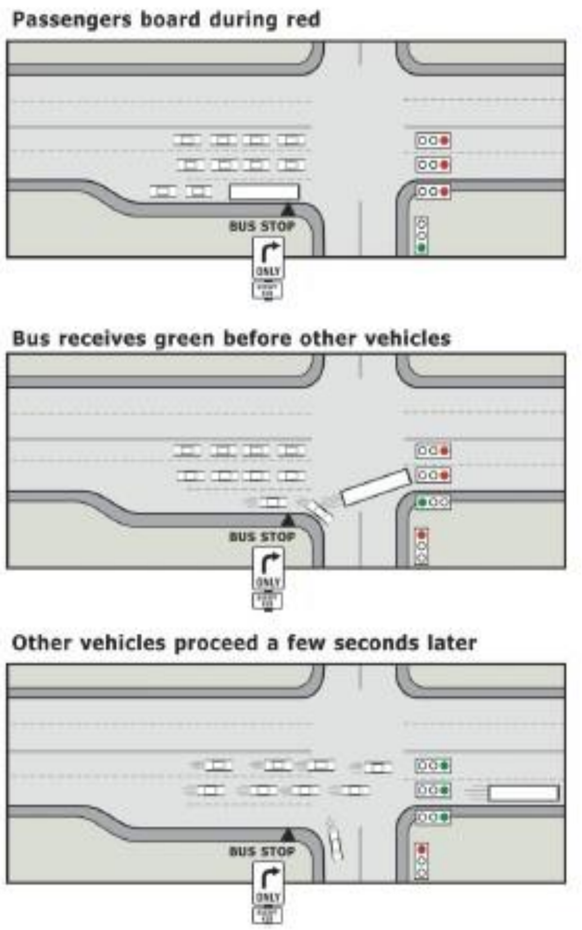
[16] Transportation Research Board Report 118. Bus Rapid Transit Practitioner's Guide. p. 4-37.

[17] Transportation Research Board, Report 118. Bus Rapid Transit Practitioner's Guide. p. 4-37.

Figure 9-1: Queue Jump in a Right Turn Lane

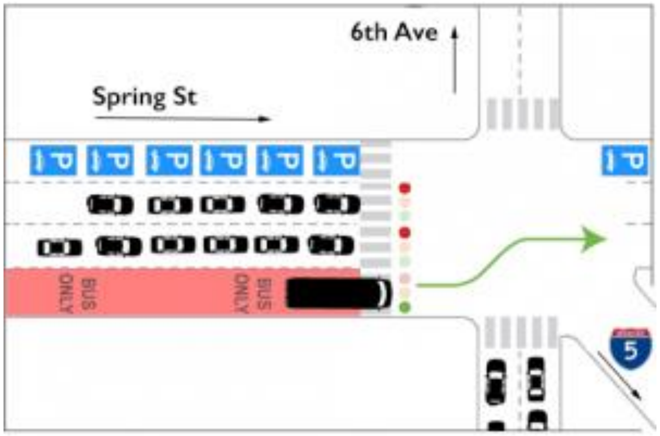


Passengers board during red

Bus receives green before other vehicles

Other vehicles proceed a few seconds later

Figure 9-2: Queue Jump in a Bus-Only Approach



Best Conditions for Application

Queue jumps are most effective at signalized intersections with low or moderately frequent bus routes, especially where transit operates in the right lane with high peak hour through volumes but with relatively low, or unrestricted, right turn volumes. In some locations, implementing parking restrictions may be necessary to provide a longer transit approach lane so buses are able to bypass longer queues.

Queue jumps are best applied at near-side or non-stop configurations. At near-side stops, the bus completes loading before rolling forward onto the detector that gives priority. Where stops are located far-side, moving to a near-side configuration is preferred so that buses stopped at the far-side stop do not obstruct through traffic, as the light turns green.

Queue jumps are best applied where there are no conflicts between the queue jump phase and other conflicting phases.

In municipalities where yield-to-transit laws are in place, the queue jump may operate effectively without a dedicated transit signal phase. Bus head starts may be made from a shared transit/turn lane or a short exclusive transit lane.

9.1.2 *Transit Signal Priority*

Description

The application of TSP is described separately in Chapter 8. That chapter discussed the challenges in implementing TSP and the conditions under which the various system options for implementing TSP would work best. TSP provides extended green time or reduced red time at traffic signals for buses, either conditionally or unconditionally, at intersections where moderate traffic delays are common. Conditional priority, applied only if the bus is running late, is preferred for the Route 1 corridor. Conditional priority can provide greater improvements in travel time reliability than unconditional priority, and can also improve average running times somewhat, though not by as much as can unconditional priority. As a result, conditional priority is seen as a valuable strategy to enhance the reliability of service, but with only a small impact on average travel times.

Challenges

The system wide challenges to implementing TSP in the Route 1 corridor were addressed in Chapter 8. Most revolve around integrating TSP with the many different traffic signal control systems in the corridor, many of which are antiquated, and integrating TSP with the four different Automatic Vehicle Location (AVL) systems employed by the five transit operations. If those challenges can be overcome, TSP can be implemented at individual intersections as prevailing traffic conditions dictate.

Best Conditions for Application

TSP normally is applied when intersection LOS is in the “C” to “D” range. This is where the signal timing can be adjusted to provide some benefit to bus operations with only a negligible impact on general traffic operations. When intersection LOS is in the “E” to “F” range (near or over capacity), triggering signal priority normally has minimal benefit to bus operations, as the bus cannot arrive at the signal in a timely manner because of vehicle queuing. When intersection LOS is “A” or “B”, there is little delay to buses and hence little benefit is achieved with TSP.

9.1.3 *Curb Extensions*

Description

Curb extensions can serve as bus preferential treatments along arterial streets with on-street parking. The concept involves extending the sidewalk area into the street so that buses do not have to leave the travel lane to serve passengers. After serving the stop with a curb extension, buses can continue forward in the travel lane without the need to wait for a gap in traffic to allow them to merge back into traffic. Curb extensions can be far-side, near-side, or mid-block. Curb extensions for near-side, mid-block and far-side locations are illustrated in Figure 9-3. To develop a curb extension, a section of either a parking lane or loading zone must be replaced to develop the expanded passenger waiting area. This treatment requires the elimination of two or more parking spaces, or a loading zone, to provide a sufficient length to develop the curb extension. Another term for these treatments is “bus bulbs.” [18]

Curb extensions can be provided at single stops or along a section of a bus route. A curb extension is typically the width of the parking lane or loading zone removed (8 feet). Lengths of curb extensions can range from 30 to 40 feet for a standard bus to 50+ feet if multiple standard buses and/or articulated buses are accommodated. Outside of the curb extension, there is typically a curb return to the side street on one side (if the extension is at an intersection) and a transition taper to a parking lane or loading zone on the other. Curb extensions are provided along bus routes in several U.S. cities, including San Francisco, Charlotte, Orlando, Grand Rapids, Lansing, Portland (OR), Seattle, West Palm Beach, and St. Petersburg. [19]

Challenges

There may be design challenges associated with integrating the extension into the existing sidewalk and roadway, most notably accommodating drainage needs. Another challenge would be the willingness of communities to remove parking. However, the number of parking spaces removed can actually be less than the number that should be provided for a conventional curbside stop, which can require up to 90 feet in a mid-block location for buses to be able to pull in close to, and parallel to, the curb.

Best Conditions for Application

Curb extensions are feasible where arterial traffic volumes are low, bus service is frequent, pedestrian volumes are substantial, development densities are high, and curb parking is permitted at all times along the roadway. Curb extensions can only be applied where it is possible to widen the sidewalk either at an intersection or mid-block. For use at bus stops, curb extensions are typically associated with near-side bus stops. If far-side stops are developed as curb extensions, blockage to general traffic caused by the bus stopping should not result in unacceptable queuing and potential traffic conflicts at the intersection. Unless traffic volumes are low, curb extensions work best when there are two lanes so that traffic can bypass stopped buses. Given the limited benefit associated with providing TSP in general traffic lanes where near-side bus stops exist, curb extensions are typically applied at near-side stops without TSP.[20]

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[18] TCRP Report 118, Bus Rapid Transit Practitioner’s Guide, TRB of the National Academics, Washington DC., 2007; PP 4-41

[19] TCRP Report 118, Bus Rapid Transit Practitioner’s Guide, TRB of the National Academics, Washington DC., 2007; PP 4-41

[20] Transportation Research Board Report 118, *Bus Rapid Transit Practitioner's Guide*. p. 4-42.

Figure 9-3: Curb Extension Applications

Near-side and Mid-Block Curb Extensions

Far-side Curb Extension

9.1.4 *Business Access and Transit Lanes*

Description

Business Access and Transit (BAT) lanes are provided along arterials in commercial areas to allow buses to travel along the corridor with minimum delay, increasing transit speed and reliability while maintaining access to local businesses and residents. Except for buses, through traffic is prohibited in BAT lanes, but vehicles may use them to turn right into businesses or at the next intersection. BAT lanes also can be used by emergency vehicles and taxis. BAT lanes make the best use of limited street space to move more people and help the transit system operate more efficiently and provide service that is more reliable.

Challenges

Implementation of BAT lanes can be faced with resistance from transportation and municipal agencies where there are few buses utilizing the lane and the restrictions impact traffic operations along the street and at intersections. Where streets are heavily traveled and bus flows are light, installing BAT lanes may be met with resistance from street traffic and transportation agencies. In these cases, queue bypasses or TSP at intersections may be a more appropriate solution to improve bus flow.

Best Conditions for Application

The best condition for BAT lane implementation is when the following traffic and right of way characteristics are present:

- There is a heavy vehicular traffic that make right turns into businesses along the lane.
- There is frequent bus service that will use the lane.
- There are moderate through traffic volumes.
- When all agencies are in concurrence to invest in converting a lane for buses and right turning vehicles.

9.1.5 *Implementation of Intersection Improvements*

Implementation of any of the strategies described in this section would require additional analysis followed by approvals from multiple departments within CTDOT, as well as the affected municipalities. Detailed intersection capacity analysis would be needed at each location to confirm the findings of this study and to determine the impact of TSP, queue jump lanes, and BAT lanes on traffic operations. Geometric review would also be required where physical roadway modifications are proposed. When detailed plans are developed, any modifications to traffic signals will require approval from OSTA, and changes to phasing plans will require the approval of CTDOT Highway Operations. Any work within the State Highway right-of-way, will require an Encroachment Permit, and modifications to on-street parking conditions will need permission or an agreement with the affected municipality.

9.2 Analysis Methodology

9.2.1 *Identification of Improvement Opportunities in the Route 1 Corridor*

Travel time and delay data collected for this study were used to identify locations where buses experience moderate to severe traffic signal delay. Locations in the study corridor that experienced estimated average delays to buses within the ranges for LOS C through F were identified in Section 3.3.1. A total of 49 intersections met these criteria. A field reconnaissance of the entire corridor was also conducted to evaluate the intersections for the possible improvement opportunities described above. These intersections were examined for the best application of the strategies using the following criteria:

- Where there is an exclusive right turn lane, or right of-way appears readily available, a queue jump lane was proposed.
- If a queue jump lane was not found to be possible, mainline TSP was proposed. If the intersection approach that the bus was operating on was estimated to be operating at LOS E or F during one or more time periods, TSP was proposed only for time periods where the estimated LOS was C or D. If an intersection is proposed for improvement as part of a planned project, optimization with passive transit priority was proposed.
- Where there is on-street parking, and either multiple lanes or a single low volume lane, a curb extension was considered.
- Where there are multiple through lanes available and the rightmost lane was adjacent to many curb cuts to access businesses, a BAT lane was considered. Only one location was identified for a possible BAT lane in this analysis. (However, because the analysis focused on addressing intersections with significant bus delays, there may be more street segments where BAT lanes would be beneficial but that have not been identified.)

9.2.2 *Bus Travel Time Savings*

Queue Jump

By allowing a transit vehicle to bypass general traffic queuing at a signalized intersection, transit travel time can be reduced and service reliability improved. The extent of transit travel time savings will depend on the extent of general traffic queuing at a signalized intersection and the extent to which a bypass treatment can be developed to bypass the general traffic queue. If buses are interspersed with right turning traffic, the savings will also depend on the magnitude of right-turning traffic and whether or not free right turns are allowed. Transit travel time savings would be reduced if the right-turn lane traffic volume is heavy and there is limited opportunity for free right turns or right turns on red. Application of bus queue jumps has been shown to produce 5% to 15% reductions in intersection delay (the time it takes for buses in the queue of traffic to cross the intersection) for buses.[21] Reported travel time savings associated with queue jumps include:

- 7 to 10 second bus intersection delay savings on Lincoln Street at 13th Avenue in Denver.
- 27 second reduction in bus travel time along the NE 45th Street route in Seattle during the weekday a.m. peak period.
- 12 second reduction in bus travel time along the NE 45th Street route in Seattle during the weekday p.m. peak period.
- 6 second reduction in bus travel time along the NE 45th Street route in Seattle across an entire day.

For this study, an average of 10% reduction in intersection delay was assumed, which is the middle of the 5% to 15% recommended range. The 10% reduction factor was applied to the average bus delay observed at each intersection where a queue jump is proposed to yield the estimated average travel time savings for that location in each time period. Average bus delays were calculated using the time and delay data collected for this study averaged over the entire day.

Mainline Transit Signal Priority (TSP)

National research into preferential treatments for bus services indicates that travel time savings associated with the implementation of TSP in North America have ranged from % to 18% of *total travel time* along the route, with typical reductions of 8% to 12%.[22] In Los Angeles, the MTA saw a 7.5% reduction in travel times along its two BRT corridors after TSP was installed. In Chicago, buses along a TSP corridor along Cermak Road saw an average of a 15% reduction in travel time.

The same study also showed that the reduction in bus *delay* at TSP-enabled signals ranges from 15% to 80%. Other studies estimated the savings in bus intersection delay at 6% to 25% in San Francisco, 20% in Portland, 34% and 57% at two locations in Seattle, 35% in Los Angeles, and 40% to 80% at various locations in Europe.[23]

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[21] TCRP Report 118, Bus Rapid Transit Practitioner's Guide, TRB of the National Academics, Washington DC., 2007; PP 4-39,4-40

[22] TCRP Synthesis 83, Bus and Rail Transit Preferential Treatment in Mixed Traffic, TRB of the National Academics, Washington DC., 2010; P 65

[23] TCRP Report 118, Bus Rapid Transit Practitioner's Guide, TRB of the National Academics, Washington DC., 2007; P 4-31

Typically, TSP benefits are highest when the intersection in question is at LOS C or D, and when TSP is implemented universally along the corridor. For this study, TSP is proposed only at a relatively small number of intersections where bus delay was observed. As a result, a conservative estimate of 25% of intersection delay was selected for use in this study. The 25% reduction factor was applied to the average bus delay observed at each intersection where TSP is proposed to yield the estimated average travel time savings for that location in each time period. Average bus delays were calculated using the time and delay data collected for this study averaged over the entire day.

For some intersections where improvement plans are in place to replace and optimize signals, delays may no longer warrant TSP after the improvements are in place. In that case, it was recommended that the improvements include passive priority for transit and a 10% delay reduction was assumed.

Business Access and Transit Lane

BAT lanes are similar to exclusive bus lanes in that buses are allowed to move more freely along the street than would traffic in the general-purpose lane. Travel time savings are based on the length of the lane. Typical travel time reductions, in minutes per mile, are shown in Table 9-1. For this study, a BAT lane was suggested in only one location that would likely have relatively few right-turning vehicles that could reduce potential savings. Therefore, an estimate of one minute per mile was selected for use in this study. The one minute per mile reduction was applied to the length of the proposed BAT lane to yield the estimated average travel time savings.

Table 9-1: Estimated Travel Time Rate Reduction with Arterial Bus Lanes

Location	Minutes per Mile Reduction
Highly congested CBD	3 to 5
Typical CBD	1 to 2
Typical Arterial	0.5 to 1

Corridor Segment Travel Time Savings and Reliability Improvements

For each corridor segment, the average bus travel time savings in each period, in each direction, for all the suggested improvements was combined to obtain an average bus travel time savings for the entire corridor segment. While the overall average time savings in each corridor is small, it is worth noting that much of the benefit derived from conditional TSP is in the form of improved reliability. By giving priority only to buses that are running behind schedule, TSP limits the tendency of late buses to be further delayed (due to higher ridership that can, in turn, lead to bus bunching). When fewer buses are late, it leads to more balanced loading, better on-time performance, fewer complaints, and increased overall customer satisfaction.

9.2.3 *Capital and Maintenance Costs*

Queue Jump Capital Costs

Capital improvements associated with a queue jump location using an existing right turn lane include a programmable signal head ($500), pavement markings ($500), and controller modification, system integration, and wiring ($1,000), resulting in a total cost per intersection of $2,000 which was applied in all cases where a queue jump is proposed. In most cases, the additional signal head would be placed on an existing mast arm or wire. However, in a few cases, a 12’ aluminum pedestal and foundation ($2,000) would be needed, and in one case, a much more expensive mast arm replacement would be needed. In locations where the right turn lane would have to be extended, the extension of pavement and curbing was estimated to cost an additional $70 per linear foot. Any costs for potential right-of-way purchases were not considered in the cost estimates.

TSP Capital Costs

The cost of the signal upgrades necessary to implement TSP for one direction at an intersection was estimated in Section 8.3.4 to be $7,100 per intersection for signals without existing emergency vehicle preemption.[24] Including detectors for both directions would increase the cost to $8,100. For signals with emergency vehicle preemption detectors already in place, the cost would be $3,100 for a new controller only.

These costs assume that the signal controller would have to be replaced because, according to CTDOT Traffic Operations, all CTDOT-owned controllers in the corridor are antiquated and would have to be replaced with newer models capable of supporting TSP. However, in some cases, if it were known that an existing non-CTDOT-owned controller is capable of supporting TSP but lacks emergency vehicle preemption equipment, the cost of implementing TSP would be $4,000 ($7,100 minus $3,100 for the controller).

In all applications of TSP, $1,000 per intersection was added for integration and programming.

The above costs were used to assess the cost of implementing TSP at intersections where no signal improvement is currently planned. It is important to note that, where improvements are planned, it was assumed that new controllers with optical detectors capable of supporting TSP would be supplied by the improvement project, so only the $1,000 per intersection cost of integration and programming would be attributable to this project.

BAT Lane Capital Costs

The cost of a BAT lane, which consists only of additional signage and pavements markings, is estimated to be about $20,000 per mile.

Maintenance Costs

The cities, towns, and CTDOT have their traffic signal maintenance program in place and the cost of maintaining traffic signals are in the annual budget. However, in addition to their annual maintenance budget, we have assumed $500 per year per intersection for maintaining the additional traffic signal equipment, listed above, associated with TSP and queue jump improvements.

9.3 Opportunities in the Route 1 Corridor

The intersections identified as causing the most delays for buses, were examined for possible improvements. Table 9-2 summarizes the number and types of improvements proposed for each corridor segment. The numbers reflect the number of intersection approaches for which each type of improvement is proposed. Details on the locations of each improvement are included in the individual Corridor Improvement Programs described in Part III of this report. Illustrations of the proposed improvements are included in Appendix I. Implementation costs would be lowest on Route 341, and

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[24] Includes a new signal controller, cabinet modifications, optical or GPS detection equipment, cabling, and software. Intersections with existing emergency vehicle preemption would require only a new signal controller.

Table 9-2: Summary of Proposed Intersection Improvements and Costs

	311	341	CL West	CL East	O
Queue Jump Locations	3	1	1	3	1
TSP Locations	4	2	7	6	7
Passive Priority	2	1	1		6
BAT Lane / Other Improvements			1	3	
Capital Cost*	$130,620	$15,680	$49,980	$152,460	$55,860

* In 2016 dollars

highest on the Costal Link East and Route 311. Planned signalization improvements in Greenwich (Route 311), Stamford (Routes 311 and 341) and New Haven (O Route 1) would be paid for as part of other projects and so would reduce bus travel times at no cost to a project implementing the proposals resulting from this study.

The time savings and costs for each of the five corridor segments are shown in Table 9-3. The estimated reduction in bus travel time in all cases is less than one minute per trip. Although small, the largest savings are achievable on the Coastal Link with the smallest savings on Route 341. Estimated savings tend to be largest in the midday time period with the smallest savings in the AM peak when running times are typically shortest. Ridership impacts were not estimated as the estimated travel time reductions for these strategies by themselves are not large enough to significantly impact ridership.

Table 9-3: Seconds of Travel Time Saved per Trip

		311	341	CL West	CL East	O
Eastbound Savings (seconds)	AM Peak	15.6	2.8	6.9	17.3	16.8
	Midday	2.8	4.8	26.6	33.9	43.4
	PM Peak	14.3	2.3	30.4	34.8	5.3
Westbound Savings (seconds)	AM Peak	14.0	11.6	11.2	21.7	5.2
	Midday	22.0	21.3	59.6	25.7	12.1
	PM Peak	26.8	5.6	39.7	7.1	24.3

The strategies recommended here would reduce bus delay and average bus travel time in each segment of the Route 1 corridor. However, the proposed improvements would have only a small impact on average travel times. Nevertheless, the most proposed improvement, conditional TSP, would have the greatest impact on the most delayed trips because it is activated only when buses are most delayed. As a result, the most delayed trips would receive the most benefit, which would greatly enhance the overall reliability of bus travel times.

PART III

10. Overview of Corridor Improvement Programs

The development of improvement strategies in the five categories of improvements were discussed separately, in detail, in Part II of this report. Following the separate analyses, the recommendations for improvements in each of the categories were combined into proposed improvement programs for each corridor segment. The following five chapters each focus on one of the five corridor segments, combining all of the improvement strategies into a single program of improvements for the corridor segment and presenting estimates of the impacts of the combined program on cost, travel time, and ridership.

Section 10.1 of this chapter summarizes how the recommendations for each strategy were incorporated into the corridor improvement programs. Section 10.2 discusses possible challenges for the initial implementation. Section 19 presents ideas for expanding the use of these and other strategies in the corridor over the longer term, given the possibility of increased congestion, higher demand for transit services, and developments in technology.

10.1 BRT Improvement Strategies Included in the Corridor Programs

Service Design and Stop Spacing

Chapter 5 evaluated two alternative service concepts for each corridor segment and recommended that a new limited stop overlay route be considered in each one. The route would serve only a limited number of stops and operate weekdays for approximately 14 hours per day at the same frequency as the existing local route. No changes would be made to the existing local route. Additional vehicles would be required for the limited stop route and corridor operating costs would increase substantially.

Stations and Amenities

Chapter 6 described the types of stations and categorized the proposed stations on each limited stop route into Major, Standard, and Minor Stations based on boarding ridership and site restrictions. Construction costs were developed for each station and for each corridor segment.

Fare Collection

Chapter 7 evaluated several fare collection strategies to reduce passenger boarding times, starting with an estimate of the travel time impacts of CT*transit*’s plan to introduce contactless Smart Cards in 2017. It was recommended that the corridor improvement programs should assume the introduction of Smart Cards in all corridors, but would not assume any further changes to fare collection intended to reduce boarding times.

Transit Signal Priority

Chapter 8 examined the options for implementing TSP along Route 1. It was recommended that a distributed system involving direct communication between a bus and a particular traffic signal controller (as proposed to one operating through a centralized traffic control system) would be most appropriate. Priority would only be granted on a conditional basis, when a bus is behind schedule, rather than unconditionally. TSP would require integration with each bus operator’s AVL system. Implementing TSP would require upgrading signal controllers at nearly all proposed locations, installing bus detection equipment at signals and on-board buses, and would require separate integration programing with each different bus operator’s AVL system.

Intersection Improvements

Chapter 9 identified possible intersection improvements to improve travel time and reliability focusing on the signalized intersections identified as having the most delays for buses. Each location was reviewed and recommendations were made for either a bus queue jump, TSP, passive priority, or other site-specific improvements. Travel time improvements and costs were identified for each location and corridor segment.

Running Times and Ridership

The travel time savings and ridership in each corridor was re-estimated for the combination improvements, considering the proposed limited stop service, BRT stations, Smart Cards, TSP, and other intersection improvements. As a result, the travel times and ridership estimates presented in the individual Corridor Improvement Programs consider all of the proposed improvements and differ from the estimates in previous chapters that considered only a single type of improvement.

10.2 Possible Implementation Challenges

10.2.1 *Timing of Improvements*

Implementation of a limited stop overlay service with enhanced stations and intersection improvements that would reduce travel times, improve service reliability, and increase ridership in any or all of the corridor segments would require a significant amount of time for planning, design, procurement, and construction. Further planning would be needed, including a detailed implementation plan that identifies a feasible timeline for implementation. Several factors that could influence the timing of implementation are listed here.

Limited Stop Service and Bus Procurement

Implementing only the service elements, operating the limited stop service with no station or intersection improvements, would still require the purchase of additional buses. Bus procurement, following mandated federal procedures, can take up to 18 months once funding has been identified.

Intersection Improvements

The lead time for implementation of the various intersection improvements would need to be determined. Improvements suggested that could involve various lead times include:

- Replacement of CTDOT-owned controllers and installation of detectors to accommodate TSP
- Integration and programming of existing city-owned signal controllers to accommodate TSP
- Retiming of city-owned signals to implement passive priority
- Addition of new signal heads and modifications to signage and pavement markings at queue jump locations

Each of the intersections where improvements are proposed would require an intersection operational analysis to determine the impact on traffic and to develop optimal signal timings. Proposed improvements would also require approvals from OSTA and from CTDOT Highway Operations.

In some instances, existing projects to implement planned signal improvements at multiple intersections would also need to be completed before implementation.

Integration of AVL with TSP

In order to take advantage of TSP at selected intersections, bus operators would need to equip a sufficient number of buses with emitters and integrate the emitters with their AVL system. Each system is unique in the corridor and the level of effort and time needed to activate the system for conditional TSP still needs to be determined. Emitters would also require procurement and installation.

Stations

The stations to be improved in each corridor would largely be constructed at existing bus stops within the existing city/town or state-owned right-of way. A few, however, are proposed to be relocated to the opposite side of the intersection, and some would require additional sidewalk and curb ramp connections. City/town approval would be required as well as encroachment permits for work in the state highway right-of-way. Station construction would require design, procurement of shelters and information displays, contractor procurement, and construction.

Funding

Funding sources would need to be identified for both the capital and operating costs of the improvements. Timing of implementation would have to take into account application schedules for various potential funding sources as well as state and local budget cycles.

10.2.2 *Agency Coordination*

Implementation of intersection improvements and construction of stations would require coordination among CTDOT, the bus operators, and the municipalities. Municipal traffic engineers would need to be involved for locally owned signals. Municipal public works departments may also need to be involved for any stations being installed on locally owned property.

Agency coordination would be more complex for either of the two Coastal Link corridors since the Coastal Link is a jointly operated service involving three different bus operators. An agreement would need to be reached among the operators as to which agency or agencies would operate the limited stop service. Providing a service with multiple operators would involve particular challenges with implementing TSP and real time information, as well as challenges for managing the service and ensuring on-time performance.

10.2.3 *Maintenance Responsibilities*

Several elements of the improvements would require occasional ongoing maintenance. The bus operators would be responsible for maintaining the buses and the on-board emitters. However, the signals and optical detectors at the intersections are currently maintained by the municipalities. Bus operations would be dependent on the city/town maintaining the system at each intersection. Responsible parties for cleaning and maintaining the stations, including real-time information displays, would also need to be identified.

11. Route 311 Corridor

11.1 Program of Improvements

11.1.1 *Limited Stop Service*

The Route 311 corridor segment is currently served by CT*transit* Routes 311 and 311B, which alternate service along the segment between Stamford and downtown Greenwich before splitting into a branched service between Greenwich and Port Chester. A limited stop service would be overlaid only on Route 311, as shown in Figure 11-1. Its alignment would differ from Route 311 in that it would bypass downtown Greenwich and remain entirely on Route 1 through the town, similar to the recommended revised Route 11A in the 2012 *Coastal Corridor Bus Study*. Routes 311 and 311B would continue to serve downtown and the station, as well as all local stops in the corridor. Only the limited stop route would bypass downtown and the station providing a more direct, faster service between Port Chester, Stamford, and points along Route 1 in between.

Proposed service frequencies are shown in Table 11-1. The limited stop route would operate at the same frequency as the combined Route 311/311B, effectively doubling service between Port Chester and Stamford and more than doubling service along the segment of Route 1 served only by Route 311. Limited stop service would operate approximately 14 hours per day, about the same span of service as Route 311. The limited stop route is expected to require five buses to operate in the weekday peak periods. No changes would be made to the 311 and 311B schedule, alignment, or stops.

Table 11-1: Route 311 Corridor Service Frequency and Daily Trips

	311		311B		311 Limited	
	EB	WB	EB	WB	EB	WB
AM Peak	40	40	40	40	20	20
Midday	60	60	60	60	30	30
PM Peak	50	50	50	50	25	25
Evening			60	60		
Saturday	120	120	120	120		
Sunday	120	120	120	120		
Weekday Trips	15	14	21	21	32	32
Saturday Trips	6	6	11	10		
Sunday Trips	5	6	7	7		

Frequency in minutes.

11.1.2 *Station Locations*

The locations of the proposed stations in the Route 311 corridor are shown in **Error! Reference source not found.**. The 26 proposed stations (13 in each direction) are listed in Table 11-2 along with the proposed station type, estimated capital cost of improvements, potential weekday daily boardings (including local and limited stop routes and assuming some riders would shift from the adjacent stops to take advantage of limited stop service), and notes regarding site-specific improvements proposed. The

Figure 11-1: Route 311 Corridor Proposed Stations and Improvements

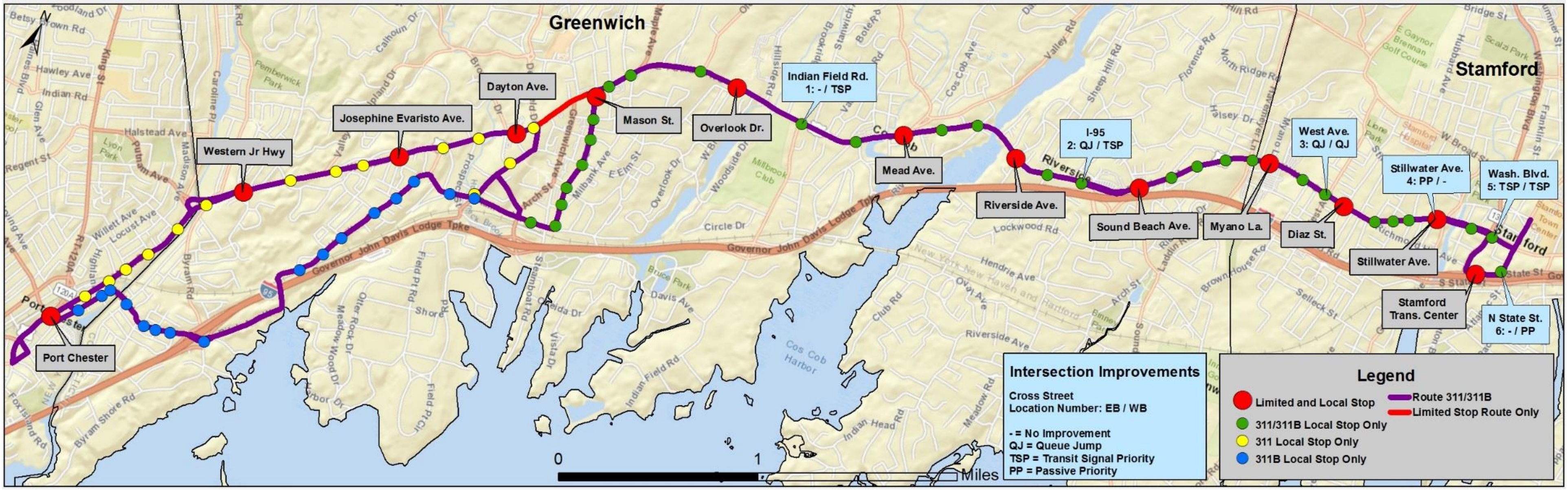


Table 11-2: Route 311 Corridor Proposed Stations

Stop Name	Potential Daily Boardings	Station Type*	Notes	Station Cost	Other Costs
Eastbound					
N MAIN ST & WESTCHESTER AVE	344	None	No CTDOT Improvement (in New York State)	-	-
W PUTNAM AVE & WESTERN JR HWY	27	Standard		$45,000	$0
W PUTNAM AVE & JOSEPHINE EVARISTO AVE	11	Minor	No room for shelter	$20,000	$0
W PUTNAM AVE & DAYTON AVE	6	Minor		$20,000	$0
MASON ST & E PUTNAM AVE	52	Standard	Relocate stop to Putnam after Mason, extend curb and remove parking	$45,000	$20,000 for curb extension
E PUTNAM AVE & OVERLOOK DR	18	Standard		$45,000	$0
E PUTNAM AVE & MEAD AVE	34	Standard		$45,000	$0
E PUTNAM AVE & RIVERSIDE AVE	33	Minor	No room for shelter	$20,000	$0
E PUTNAM AVE & SOUND BEACH AVE	44	Standard		$45,000	$0
W MAIN ST & OPP MYANO LA	59	Minor	No room for shelter	$20,000	$0
W MAIN ST & DIAZ ST	87	Standard	Remove parking and construct curb extension	$45,000	$20,000 for curb extension
W MAIN ST & OPP STILLWATER AVE	43	Standard	Move to far side of Greenwich	$45,000	$0
STAMFORD TRANS CTR BAY 1		Existing	Existing Transit Center	$0	$0
Westbound					
STAMFORD TRANS CTR BAY 1	369	Existing	Existing Transit Center	$0	$0
W MAIN ST & STILLWATER AVE	77	Standard	Move to near side of Greenwich	$45,000	$0
W MAIN ST & OPP DIAZ ST	63	Standard	Remove parking and construct curb extension	$45,000	$20,000 for curb extension
W MAIN ST & STOP & SHOP	27	Standard		$45,000	$0
E PUTNAM AVE & SOUND BEACH AVE	21	Standard		$45,000	$0
E PUTNAM AVE & RIVERSIDE LN	24	Minor	No room for shelter	$20,000	$0
E PUTNAM AVE & ORCHARD ST	47	Standard		$45,000	$0
E PUTNAM AVE & OPP W BROTHER DR	39	Standard		$45,000	$0
MASON ST & E PUTNAM AVE	50	Standard	Relocate stop to Putnam after Mason, extend curb and remove parking	$45,000	$20,000 for curb extension
W PUTNAM AVE & OPP DAYTON AVE	14	Standard		$45,000	$0
W PUTNAM AVE & MELROSE AVE	12	Minor	No room for shelter	$20,000	$0
W PUTNAM AVE & OPP WESTERN JUNIOR HWY	2	Minor	Move to far side of Byram	$20,000	$0
S MAIN ST & WESTCHESTER AVE		None	No CTDOT Improvement (in New York State)	-	-
Sub-Total				$815,000	$80,000
TOTAL	**1,498**			**$895,000**	

* Existing – Existing terminal station with no need for enhancements
Major – Large shelter, bench and real time information display
Standard – Shelter and real time information display
Minor – Bench and real time information display (no shelter due to few boardings or limited space)

13 stations in each direction are far fewer than the 56 possible stops on the current Route 311, although Route 311 averages only between 21 and 30 actual stops per trip, depending on the direction and time of day.

Two of the proposed stations (one in each direction) would be the existing Stamford Transportation Center, which would not need any improvements. The other end of the route, in Port Chester NY, is outside the jurisdiction of CTDOT and therefore no improvements are proposed. Of the remaining 22 stations, none are proposed to be Major Stations, 17 are proposed to be Standard Stations, and seven would be Minor Stations. Five of the Minor Stations have potential daily boardings greater than ten but have constrained sites that would not permit a shelter to be installed.

All of the proposed stations would be existing bus stops, although five would be moved to another location at the same intersection and four are proposed to be constructed on extensions of the curb and sidewalk into the parking lane.

At East Putnam Avenue and Mason Street in Greenwich, the existing stop is on Mason Street. With the limited stop route staying on Route 1, a new station is needed on East Putnam Avenue. East Putnam Avenue has four travel lanes and parking on both sides at this location. Curb extensions are proposed to be constructed in the parking lanes allowing buses to remain in the rightmost travel lane while traffic continues to flow in the leftmost lane. The curb extensions would also provide additional space for the bus shelter.

The stop at West Main Street and Diaz Street in Stamford is in a very constrained area with narrow sidewalks. There is no room for shelters or even an adequate passenger boarding area. Proposed curb extensions at this location would eliminate two parking spaces on each side of the street and would provide more space for boarding passengers, though buses would block traffic as they serve the station.

11.1.3 *Intersection Improvements*

Intersection improvements to speed bus service and improve service reliability are proposed at six locations in the Route 311 corridor. The six locations are numbered in **Error! Reference source not found.** The proposed improvements for each intersection are described below, including the corresponding number from the map. Estimated capital costs are shown in Table 11-3. Improvements include TSP on four intersection approaches, queue jumps on three approaches and two intersections where passive priority is proposed. Note that where passive priority is proposed, signal improvements are already planned by the city so no additional costs are assumed to result from this project.

East Putnam Ave (Route 1) and Indian Field Rd – Greenwich – (1)

Implement TSP for the westbound approach and move the westbound stop to a far-side location.

East Putnam Ave (Route 1) and I-95 Interchange – Greenwich – (2)

Implement a queue jump on the eastbound approach. (This would require replacing the signal mast arm.) Implement TSP for the westbound approach

West Main St (Route 1) and West Avenue - Stamford - (3)

Implement a queue jump for both the eastbound and westbound approaches.

Table 11-3: Route 311 Corridor Proposed Intersection Improvements

Intersection	Town	Owner	Map Location	Improvements		Cost
				EB	WB	
E Putnam Ave (Rt 1) and Indian Field Rd	Greenwich	Greenwich	1	-	TSP	$1,000
East Putnam Ave (Rt 1) and I-95 Interchange	Greenwich	Greenwich	2	QJ	TSP	$82,800
W Main St (Rt 1) and West Ave	Stamford	Stamford	3	QJ	QJ	$8,500
W Main St (Rt 1) and Stillwater Ave	Stamford	Stamford	4	PP	-	$0
Tresser Blvd (Rt 1) and Washington Blvd (Rt 137)	Stamford	Stamford	5	TSP	TSP	$1,000
N State St and Atlantic St	Stamford	Stamford	6	-	PP	$0
Sub-Total						$93,300
Incidentals @15%						$13,995
Contingencies @25%						$23,325
TOTAL COST						**$130,620**

QJ = Queue Jump TSP = Transit Signal Priority PP = Passive Priority

West Main St (Route 1) and Stillwater Ave- Stamford – (4)

Implement passive signal priority. The City is in the process of optimizing traffic signals citywide, which should improve intersection operations.

Tresser Blvd (Route 1) and Washington Blvd (Route 137) - Stamford – (5)

Implement TSP for the eastbound and northbound approaches. Further evaluation should be conducted due to the close proximity of the transportation center and the large number of buses using this intersection. In addition, the City is in the process of optimizing traffic signals citywide.

N State St and Atlantic St- Stamford – (6)

Implement passive signal priority. The City is in the process of retiming and coordinating traffic signals, which will improve overall operations at the intersection.

Other Traffic Signal Improvements

The City of Stamford is embarking upon a project to optimize all traffic signals within the City. While the improvements will reduce bus travel times and delays, the cost of these planned improvements are assumed to be borne by the city and therefore are not included in cost estimates for this project.

11.2 Capital Costs

The capital costs associated with instituting limited stop bus service with enhanced stations and TSP capability are summarized in Table 11-4. The table includes the costs, detailed above, for stations and intersection improvements, plus capital costs for additional buses and for equipping all buses in the Route 311 corridor to support conditional TSP.

Table 11-4: Route 311 Corridor Summary of Estimated Capital Cost

Cost Category	Capital Cost*	Annualized Cost
Stations	$895,000	$69,654
Intersection Improvements	$131,000	$8,012
Buses (6)	$2,550,000	$241,127
TSP emitters (28)	$98,000	$9,267
TOTAL*	**$3,663,500**	**$328,120**

*In 2016 dollars

CT*transit* currently schedules 16 different vehicle blocks on Route 311/311B, so as many as 16 buses may have to be equipped with TSP emitters. Adding six more buses for the proposed limited stop route would increase the total to as many as 22. A further 25% contingency is assumed to allow CT*transit* some flexibility in vehicle assignment, for a total of 28 TSP-equipped buses. While 28 TSP-equipped buses was assumed for estimation of costs for the corridor, in reality, CT*transit* may want to consider equipping the entire Stamford Division fleet in anticipation of a more widespread implementation of TSP in the Stamford region.

Capital costs were annualized assuming a useful life of 12 years for buses and TSP emitters, 15 years for stations, and 20 years for intersection improvements, all assuming a 2% discount rate, per FTA guidance.

11.3 Additional Annual Operating Costs

CTtransit

The limited stop service is estimated to require approximately 51 additional vehicle-revenue-hours of service per weekday. Assuming the current CT*transit* hourly operating cost of $72.72, the additional annual operating cost would be approximately $949,000. Maintenance of the TSP emitters is expected to add about another $7,000, for a total of $956,000.

CTDOT and Municipalities

Other additional maintenance costs borne by others would include approximately $500 per year per traffic signal equipped with optical detectors to accommodate TSP. Many of the signals in the corridor are already equipped with optical detectors that are owned and maintained by the municipalities, so this may not be an additional cost. Other possible additional ongoing costs could be those associated with snow removal and shelter cleaning and maintenance.

11.4 Travel Time Savings

Several factors would combine to reduce the end-to-end running time on the limited stop route versus the current Route 311. The biggest factor would simply be the more direct routing. Another important factor would be that fewer stops are made. With fewer stops, the time spent slowing down, opening and closing the doors, and then merging back into traffic would be reduced. The increase in frequency would also decrease running times because, while overall ridership would increase, the number of riders on each trip would go down resulting in less time spent at stops boarding and unloading passengers. The planned introduction of Smart Cards would also reduce boarding times versus the current fare media. Finally, priority measures such as conditional TSP and queue jumps would reduce running times, especially on trips that are running late due to traffic or high passenger loads.

Table 11-5 shows the combined effect of all of the proposed strategies on running times in the corridor. Overall, the combined strategies are estimated to result in an average 12 minute running time savings over the current Route 311, or a savings of about 24%. Table 11-6 shows the percentage breakdown of running time savings by strategy. For the Route 311 corridor, the proposed limited stop route alignment would differ from Route 311, bypassing downtown Greenwich and reducing end-to-end running time. That bypass would be the largest contributor to running time savings. The reduction in stops and the reduced number of riders per trip would also play significant parts. Smart Cards and priority measures would have just a small impact on average running times.

Table 11-5: Route 311 Corridor Estimated Limited Stop Running Times

	Eastbound			Westbound			Average
	AM	Mid	PM	AM	Mid	PM	
Current Route Running Time	51.6	47.1	56.1	50.0	45.8	53.5	50.7
Estimated Limited Stop Running Time	38.8	35.1	42.9	40.6	34.2	40.2	38.6
Running Time Saved	12.8	12.0	13.2	9.4	11.6	13.3	12.0
Percent Running Time Saved	24.8%	25.4%	23.5%	18.8%	25.3%	24.8%	23.7%

Table 11-6: Route 311 Corridor Estimated Running Time Savings by Strategy

Strategy	Share of Running Time Reduction
Reduced Stops	22%
Reduced Riders/Trip	16%
Smart Cards	6%
TSP/Queue Jumps	2%
Greenwich Bypass	53%

Running times on local Routes 311 and 311B would also be affected slightly, as riders would be drawn to the new limited stop route, reducing passenger volumes on Routes 311 and 311B and allowing them to make slightly fewer stops, on average.

11.5 Ridership Impacts

11.5.1 *Ridership Increase*

Several factors would combine to increase ridership in the corridor. The biggest impact would be from the overall increase in frequency of service in the corridor. Passengers traveling between the 13 limited stops would be able to use the limited stop route, Route 311, or in some cases Route 311B. The increased availability of service would encourage increased ridership. Reduced travel times on the limited stop route, and slightly shorter travel times on Route 311, would also encourage increased ridership. Finally, the installation of more substantial station amenities would have a positive impact on ridership as well.

Table 11-7 shows the combined effect of all of the proposed strategies on ridership in the corridor. Overall, the combined strategies are estimated to result in a 28% increase in ridership over the current Route 311, almost 700 additional daily riders, or about 175,000 annual riders. Table 11-8 shows the

Table 11-7: Route 311 Corridor Estimated Weekday Ridership

Route	Current	Proposed	Change
Route 311/311B	2,447	1,798	-649
Limited Stop Route	-	1,334	1,334
Total	2,447	3,132	685
Percent Increase			28%

Table 11-8: Route 311 Corridor Estimated Ridership Increase by Strategy

Strategy	Share of Ridership Increase
Frequency Increase	58%
Running Time Reduction	32%
Improved Stations	10%

percentage breakdown of ridership increases by strategy. The increase in frequency would account for the largest share of the ridership increase, followed by reductions in running time. Station improvements would have a small impact on ridership.

11.5.2 *Cost per New Rider*

While the improved services would enhance ridership in the corridor, the costs, both operating and capital, are also significant. Table 11-9 shows both the estimated operating cost per new rider, and the estimated total cost per new rider. Both these measures indicate that the Route 311 corridor is estimated to have lowest cost per new rider of the five Route 1 corridor segments, just slightly lower than the Route 341 corridor.

Table 11-9: Route 311 Corridor Estimated Cost per New Rider

Estimated Cost per New Rider	
Annual Ridership Increase (000)	175
Estimated Revenue Increase *	$214
Annual Operating Cost*	$956
Net Annual Operating Cost *	$743
Net Operating Cost per New Rider	**$4.24**
Annualized Capital Cost*	$328
Net Annual Total Cost *	$1,071
Net Total Cost per New Rider	**$6.12**

*In thousands of 2016 dollars

12. Route 341 Corridor

12.1 Program of Improvements

12.1.1 *Limited Stop Service*

The Route 341 corridor segment is currently served by CT*transit* Routes 341 and 341A (which alternate service) with the only difference being that Route 341A includes a diversion to Norwalk Community College. A limited stop service would be overlaid on Route 341, as shown in Figure 12-1. Routes 341 and 341A would continue to serve all stops in the corridor, but the limited stop route would differ slightly from Route 341 using Tresser Boulevard, instead of Broad Street, between East Main Street and Atlantic Street. The alignment analyzed would terminate at the Stamford Transportation Center, as Route 341 does today. However, consideration of alternative termination points and turnaround locations has been suggested by the City of Stamford and should be considered before any new service is implemented in this corridor. Regardless of the location of the terminal point, the limited stop route would provide a faster service between Stamford, Norwalk, and points along Route 1 in between.

Proposed service frequencies are shown in Table 11-1. The limited stop route would operate at the same frequency as Route 341/341A, effectively doubling service between Stamford and Norwalk. Limited stop service would operate approximately 14 hours per day. The limited stop route is expected to require six buses to operate in the weekday peak periods. No changes would be made to the schedule, alignment, or stops on Routes 341 and 341A.

Table 12-1: Route 341 Corridor Service Frequency and Daily Trips

	341/341A		341 Limited	
	EB	WB	EB	WB
AM Peak	25	25	25	25
Midday	30	30	30	30
PM Peak	20	25	20	25
Evening	60	60		
Saturday	30	30		
Sunday	40	40		
Weekday Trips	40	40	33	33
Saturday Trips	31	32		
Sunday Trips	18	19		

Frequency in minutes.

12.1.2 *Station Locations*

The locations of the proposed stations in the Route 341 corridor are shown in Figure 12-1. The 27 proposed stations (14 eastbound and 13 westbound) are listed in Table 12-2 along with the proposed station type, estimated capital cost of improvements, potential weekday daily boardings (including local and limited stop routes and assuming some riders would shift from the adjacent stops to take advantage of limited stop service), and notes regarding site- specific improvements proposed. The 13 or 14 stations

Figure 12-1: Route 341 Corridor Proposed Stations and Improvements

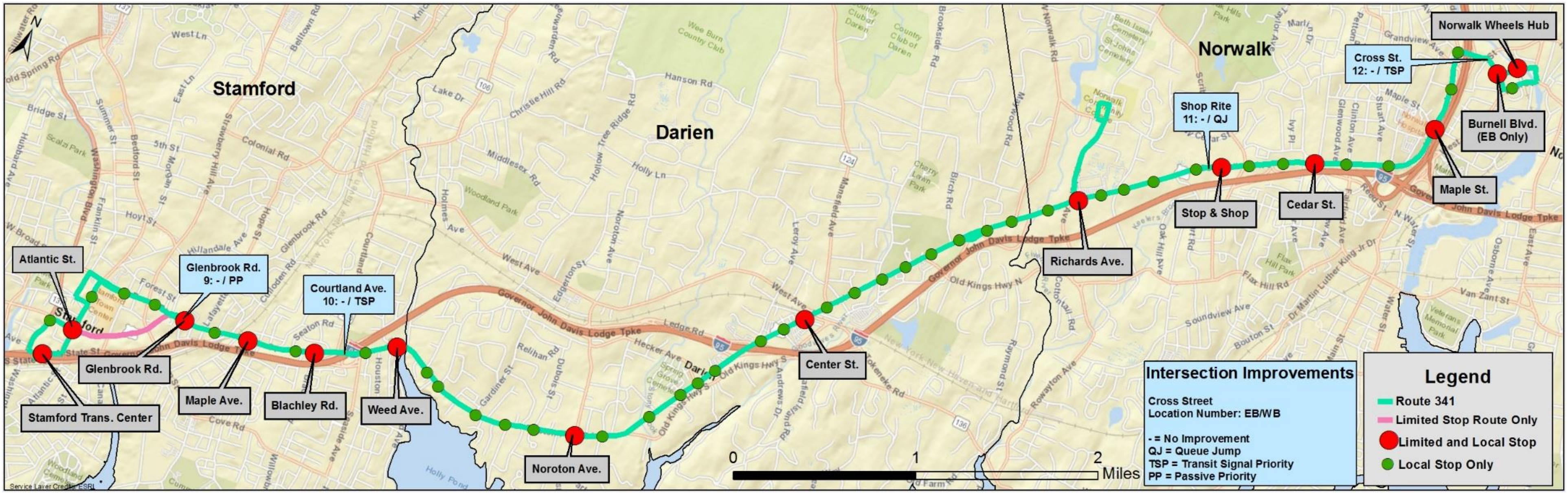


Table 12-2: Route 341 Corridor Proposed Stations

Stop Name	Potential Daily Boardings	Station Type	Notes	Station Cost	Other Costs
Eastbound					
STAMFORD TRANS CTR	284	Existing	Existing Transit Center	$0	$0
TRESSER & ATLANTIC ST	388	Major		$88,000	$0
E MAIN ST & OPP GLENBROOK RD	76	Standard		$45,000	$0
E MAIN ST & MAPLE AVE	181	Major		$88,000	$0
E MAIN ST & BLACHLEY RD	40	Standard		$45,000	$0
E MAIN ST & WEED AVE	21	Standard		$45,000	$0
BOSTON POST RD & NOROTON AVE	4	Minor		$20,000	$0
BOSTON POST RD & CENTER ST	35	Minor	No room for shelter	$20,000	$0
CONNECTICUT AVE & AMF BOWLING ALLEY**	9	Minor	Move closer to Richards Ave	$20,000	$66,350 sidewalk & ramp
CONNECTICUT AVE & STOP & SHOP 2	29	Standard		$45,000	$0
CONNECTICUT AVE & W CEDAR ST	23	Standard	Move to far side	$45,000	$0
VAN BUREN AVE & MAPLE ST	13	Standard	Move to far side	$45,000	$10,350 sidewalk & ramp
BELDEN AVE & OPP BURNELL BLVD	0	Minor	No room for shelter	$20,000	$0
BURNELL BLVD & OPP RIVER ST		Existing	Existing Transit Center	$0	$0
Westbound					
BURNELL BLVD & OPP RIVER ST	297	Existing	Existing Transit Center	$0	$0
VAN BUREN AVE & MAPLE ST	51	Standard		$45,000	$0
CONNECTICUT AVE & NORWALK COMMUNITY HEALTH CTR	45	Standard		$45,000	$0
CONNECTICUT AVE & PEARL VISION	77	Standard		$45,000	$0
CONNECTICUT AVE & RICHARDS AVE**	135	Major		$88,000	$0
BOSTON POST RD & OPP TOKENEKE RD	51	Standard		$45,000	$0
BOSTON POST RD & NOROTON AVE	11	Standard		$45,000	$0
E MAIN ST & OPP WEED AVE	30	Standard		$45,000	$0
E MAIN ST & OPP BLACHLEY RD	55	Standard		$45,000	$0
E MAIN ST & GRANT AVE	155	Major	Move to far side of Lincoln	$88,000	$0
E MAIN ST & GLENBROOK RD	26	Standard		$45,000	$0
ATLANTIC ST & TRESSER BLVD	63	Standard		$45,000	$0
STAMFORD TRANS CTR		Existing	Existing Transit Center	$0	$0
Sub-Total				$1,107,000	$76,700
TOTAL	**2,096**			**$1,183,700**	

* Existing – Existing terminal station with no need for enhancements

** The exact stop location and related pedestrian safety improvements will need to be determined through further study

Major – Large shelter, bench, and real time information display

Standard – Shelter and real time information display

Minor – Bench and real time information display (no shelter due to few boardings or limited space)

in each direction are far fewer than the 55 possible stops on the current Route 341, although Route 341 averages only between 17 and 23 actual stops per trip, depending on the direction and time of day.

Two of the proposed stations (one in each direction) would be the existing Stamford Transportation Center, and two (one in each direction) would be the existing Norwalk Wheels Hub, neither of which would need any improvements. Of the remaining 23 stations, four are proposed to be Major Stations, 15 are proposed to be Standard Stations, and four would be Minor Stations.

All of the proposed stations would be existing bus stops, although four would be moved to another location at the same intersection and two of those (both in Norwalk) would require construction of new sidewalks and curb ramps.

12.1.3 *Intersection Improvements*

Intersection improvements to speed bus service and improve service reliability are proposed at four locations in the Route 341 corridor. The four locations where specific intersection improvements are proposed are numbered in Figure 12-1. The proposed improvements are described below, including the corresponding number from the map. Estimated capital costs are shown in Table 12-3. Improvements include TSP on two intersection approaches, a queue jump on one approach, and one intersection where passive priority is proposed. Note that where passive priority is proposed, signal improvements are already planned by the city, so no additional costs are assumed to result from this project.

Table 12-3: Route 341 Corridor Proposed Intersection Improvements

Intersection	Town	Owner	Map Location	Improvements		Cost
				EB	WB	
E Main St (Rt 1) and Glenbrook Rd	Stamford	Stamford	9	-	PP	$0
East Main Street (Route 1) w/ Courtland Avenue (Route 106), I-95 Ramps, and Seaside Avenue	Stamford	CTDOT	10	-	TSP	$8,200
Connecticut Ave (Rt 1) and Shop Rite	Norwalk	CTDOT	11	-	QJ	$2,000
Cross St (Rt 1)/Bylington Pl/Belden Ave	Norwalk	Norwalk	12	-	TSP	$1,000
Sub-Total						$11,200
Incidentals @15%						$1,680
Contingencies @25%						$2,800
TOTAL COST						**$15,680**

QJ = Queue Jump TSP = Transit Signal Priority PP = Passive Priority

E Main St (Route 1) and Glenbrook Rd- Stamford - (9)

Implement passive signal priority. The City is in the process of retiming and coordinating traffic signals, which will improve the overall operation of the intersection and improve operations for buses both eastbound and westbound.

E Main St (Route 1) /Courtland/I-95 Ramps/Seaside Ave - (10)

Implement TSP for the westbound approach. This area includes three signalized intersections and two signal controllers.

Connecticut Ave (Route 1) and Shop Rite – Norwalk - (11)

Implement a queue jump lane for the westbound approach. With a queue jump the stop would ideally be moved to near side, however, this does not appear feasible given the slope away from the street. The existing far side stop is located about 250 feet beyond the intersection in a location wide enough for traffic to pass a stopped bus.

Cross St (Route 1)/Bylington Pl/Belden Ave – Norwalk - (12)

Implement TSP for the westbound approach.

Possible Additional Future Improvements

In addition to the proposed intersection improvements, the City of Stamford is interested in exploring the possibility of introducing BAT lanes on Route 1 (East Main Street and Tresser Boulevard) from the Darien line to at least downtown Stamford. The cross-section varies from four to seven lanes making the dedication of one or more lanes to transit a possibility. Bus lanes could also benefit other CT*transit* routes as well as several shuttle bus routes serving the Stamford Transportation Center. Implementation of BAT lanes in this area would require additional traffic studies to determine their feasibility, extent, and cost, and would also depend on the final routing recommendation for the limited stop service. Therefor the cost of BAT lanes in Stamford is not included in this analysis of intersection improvements.

12.2 Capital Costs

The capital costs associated with instituting limited stop bus service with enhanced stations and TSP capability are summarized in Table 12-4. The table includes the costs, detailed above, for stations and intersection improvements, plus capital costs for additional buses and for equipping all buses in the Route 341 corridor to support conditional TSP.

Table 12-4: Route 341 Corridor Summary of Estimated Capital Cost

Cost Category	Capital Cost*	Annualized Cost
Stations	$1,184,000	$92,145
Intersection Improvements	$23,000	$1,407
Buses (7)	$2,975,000	$281,315
TSP emitters (28)	$98,000	$9,267
TOTAL	**$4,280,000**	**$384,134**

*In 2016 dollars

CT*transit* currently schedules 15 different vehicle blocks on Route 341, so as many as 15 buses may have to be equipped with TSP emitters. Adding seven more buses to the fleet for the proposed limited stop route would increase the total to as many as 22. A further 25% contingency is assumed to allow CT*transit* some flexibility in vehicle assignment, for a total of 28 TSP-equipped buses. While 28 TSP-equipped buses was assumed for estimation of costs for the corridor, in reality, CT*transit* may want to consider equipping the entire Stamford Division fleet in anticipation of a more widespread implementation of TSP in the Stamford region.

Capital costs were annualized assuming a useful life of 12 years for buses and TSP emitters, 15 years for stations, and 20 years for intersection improvements, all assuming a 2% discount rate, per FTA guidance.

12.3 Additional Annual Operating Costs

CTtransit

The limited stop service is estimated to require approximately 59 additional vehicle-revenue-hours of service per weekday. Assuming the current CT*transit* hourly operating cost of $72.72, the additional annual operating cost would be approximately $1.098 million. Maintenance of the TSP emitters is expected to add about another $7,000, for a total of $1.105 million.

CTDOT and Municipalities

Other additional maintenance costs borne by others would include approximately $500 per year per traffic signal equipped with optical detectors to accommodate TSP. Many of the signals in the corridor are already equipped with optical detectors that are owned and maintained by the municipalities, so this may not be an additional cost. Other possible additional ongoing costs could be those associated with snow removal and shelter cleaning and maintenance.

12.4 Travel Time Savings

Several factors would combine to reduce the end-to-end running time on the limited stop route versus the current Route 341. The increase in frequency would decrease running times because, while overall ridership would increase, the number of riders on each trip would go down resulting in less time spent at stops boarding and unloading passengers. With fewer stops made, the time spent slowing down, opening and closing the doors, and then merging back into traffic would also be reduced. Bypassing Broad Street would also shorten the route, decreasing travel time. The planned introduction of Smart Cards would also reduce boarding times versus the current fare media. Finally, priority measures such as conditional TSP and queue jumps would reduce running times, especially on trips that are running late due to traffic or high passenger loads.

Table 12-5 shows the combined effect of all of the proposed strategies in the Route 341 corridor. Overall, the combined strategies are estimated to result in a savings of almost six minutes over the current Route 341, or a savings of about 12.7%. Table 12-6 shows the percentage breakdown of running time savings by strategy. The reduced number of riders per trip, reduction in stops and the Broad Street Bypass would play the most significant parts. Smart Cards would have a lesser impact and priority measures would have just a small impact on average running times.

Running times on local Routes 341 and 341A would also be affected slightly, as riders would be drawn to the new limited stop route, reducing passenger volumes on Routes 341 and 341A and allowing them to make slightly fewer stops, on average.

Table 12-5: Route 341 Corridor Estimated Limited Stop Running Times

	Eastbound			Westbound			Average
	AM	Mid	PM	AM	Mid	PM	
Current Route Running Time	39.8	46.8	49.4	43.7	46.2	47.0	45.5
Estimated Limited Stop Running Time	35.8	40.1	44.2	37.9	40.0	40.2	39.7
Running Time Saved	4.0	6.7	5.2	5.8	6.2	6.8	5.8
Percent Running Time Saved	10.0%	14.4%	10.4%	13.2%	13.4%	14.5%	12.7%

Table 12-6: Route 341 Corridor Estimated Running Time Savings by Strategy

Strategy	Share of Running Time Reduction
Reduced Stops	26%
Reduced Riders/Trip	33%
Smart Cards	13%
TSP/Queue Jumps	2%
Broad Street Bypass	26%

12.5 Ridership Impacts

12.5.1 *Ridership Increase*

Several factors would combine to increase ridership in the corridor. The biggest impact would be from the overall increase in frequency of service in the corridor. Passengers traveling between the 14 limited stops would be able to use the limited stop route, Route 341, or Route 341A. The increased availability of service would encourage increased ridership. Reduced travel times on the limited stop route, and slightly shorter travel times on Route 341, would also encourage increased ridership. Finally, the installation of more substantial station amenities would have a positive impact on ridership as well.

Table 12-7 shows the combined effect of all of the proposed strategies. Overall, the combined strategies are estimated to result in a 32% increase in ridership over the current Route 341/341A, over 780 additional daily riders, or about 200,000 annual riders. Table 12-8 shows the percentage breakdown of ridership increases by strategy. The increase in frequency would account for the majority of the ridership increase, with the reduction in running time and station improvements each having a smaller impact.

Table 12-7: Route 341 Corridor Estimated Weekday Ridership

Route	Current	Proposed	Change
Route 341/341A	2,470	1,804	-666
Limited Stop Route	-	1,449	1,449
Total	**2,470**	**3,253**	**783**
Percent Increase			32%

Table 12-8: Route 341 Corridor Estimated Ridership Increase by Strategy

Strategy	Share of Ridership Increase
Frequency Increase	75%
Running Time Reduction	17%
Improved Stations	8%

12.5.2 *Cost per New Rider*

While the improved services would enhance ridership in the corridor, the costs, both operating and capital, are also significant. Table 12-9 shows both the estimated operating cost per new rider, and the estimated total cost per new rider. Both these measures indicate that the Route 341 corridor is estimated to have second lowest cost per new rider of the five Route 1 corridor segments. Only the Route 311 corridor would be slightly lower.

Table 12-9: Route 341 Corridor Estimated Cost per New Rider

Estimated Cost per New Rider	
Annual Ridership Increase (000)	200
Estimated Revenue Increase *	$244
Annual Operating Cost*	$1,105
Net Annual Operating Cost *	$861
Net Operating Cost per New Rider	**$4.31**
Annualized Capital Cost*	$384
Net Annual Total Cost *	$1,245
Net Total Cost per New Rider	**$6.23**

*In thousands of 2016 dollars

13. Coastal Link West Corridor

13.1 Program of Improvements

13.1.1 *Limited Stop Service*

The Coastal Link West corridor segment is currently served by the Coastal Link, which is jointly operated by the Norwalk Transit District (NTD), Greater Bridgeport Transit (GBT), and the Milford Transit District (MTD). A limited stop service would be overlaid on the western half of the Coastal Link from Norwalk to Bridgeport, as shown in Figure 13-1. The existing Coastal Link route would continue to serve all stops in the corridor. The limited stop route would provide a faster service between Norwalk, Bridgeport, and points in between.

Proposed service frequencies are shown in Table 13-1. The limited stop route would operate at the same frequency as the Coastal Link, effectively doubling service between Norwalk and Bridgeport. Limited stop service would operate approximately 14 hours per day. The limited stop route is expected to require seven buses to operate in the weekday peak periods. No changes would be made to the regular Coastal Link schedule, alignment, or stops.

Table 13-1: Coastal Link West Corridor Service Frequency and Daily Trips

	Coastal Link West		Coastal Link West Limited	
	EB	WB	EB	WB
AM Peak	20	20	20	20
Midday	60	60	60	60
PM Peak	20	20	20	20
Evening	60	60		
Saturday	30	30		
Sunday	60	60		
Weekday Trips	32	32	31	31
Saturday Trips	28	30		
Sunday Trips	10	10		

Frequency in minutes.

13.1.2 *Station Locations*

The locations of the proposed stations in the Coastal Link West corridor are shown in Figure 13-1. The 48 proposed stations (24 in each direction) are listed in Table 13-2 along with the proposed station type, estimated capital cost of improvements, potential weekday daily boardings (including local and limited stop routes and assuming some riders would shift from the adjacent stops to take advantage of limited stop service), and notes regarding site-specific improvements proposed. The 24 stations in each direction are far fewer than the 84 possible stops on the current western segment of the Coastal Link, although the Coastal Link averages only between 17 and 37 actual stops per trip in this area, depending on the direction and time of day.

Figure 13-1: Coastal Link West Corridor Proposed Stations and Improvements

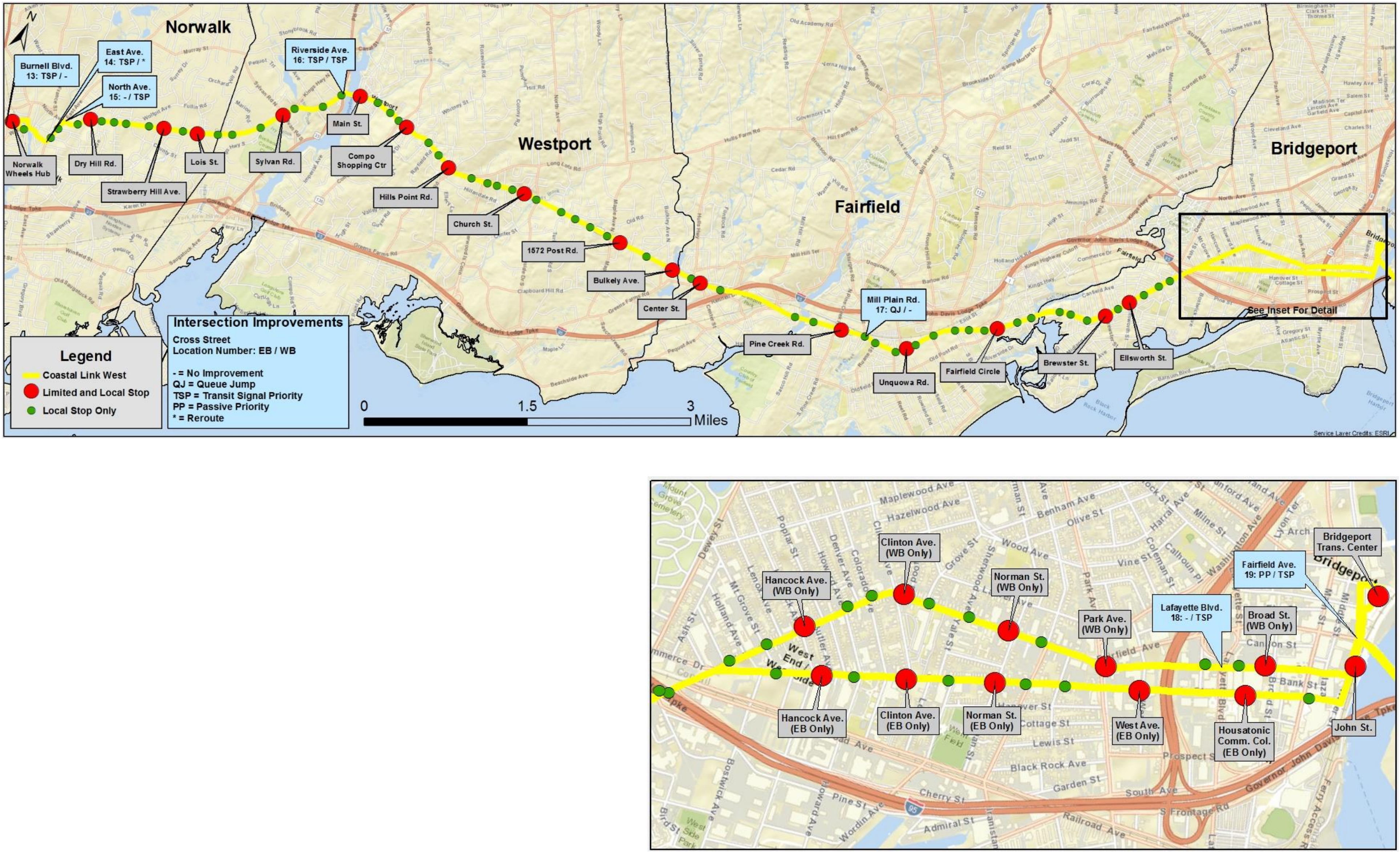


Table 13-2: Coastal Link West Corridor Proposed Stations

Coastal Link West (eastbound)

Stop Name	Potential Daily Boardings	Station Type	Notes	Station Cost	Other Costs
Eastbound					
WALL ST. at NORWALK WHEEL HUB	320	Existing	Existing Transit Center	$0	$0
WESTPORT AVE. at DRY HILL RD.	15	Standard	Move to near side	$45,000	$0
WESTPORT AVE. at STRAWBERRY HILL AVE.	12	Standard		$45,000	$0
WESTPORT AVE. at OPPOSITE LOIS ST.	18	Standard	Move to near side	$45,000	$0
POST RD. WEST at SYLVAN RD. SOUTH	4	Minor		$20,000	$36,600 sidewalk & ramp
POST RD. EAST at OPPOSITE MAIN ST.	24	Standard		$45,000	$0
POST RD. EAST at 400 POST RD. EAST	14	Minor	No room for shelter	$20,000	$0
POST RD. EAST at HILLS POINT RD.	14	Standard		$45,000	$22,600 sidewalk & ramp
POST RD. EAST at CHURCH ST. SOUTH	15	Minor	No room for shelter	$20,000	$0
POST RD. EAST at 1572	26	Standard	Move closer to Lansdowne	$45,000	$0
POST RD. EAST at BULKLEY AVE. SOUTH	40	Standard		$45,000	$52,500 sidewalk
POST RD. at CENTER ST.	16	Standard		$45,000	$0
POST RD. at SOUTH PINE CREEK RD.	10	Minor	No room for shelter	$20,000	$0
POST RD. at OPPOSITE UNQUOWA PL.	53	Standard		$45,000	$0
POST RD. at 417 POST RD.	30	Standard		$45,000	$0
FAIRFIELD AVE. at BREWSTER ST.	32	Standard		$45,000	$0
FAIRFIELD AVE. at ELLSWORTH ST.	66	Standard		$45,000	$0
STATE ST. at HANCOCK AVE.	33	Standard		$45,000	$0
STATE ST. at CLINTON AVE.	61	Standard		$45,000	$0
STATE ST. at NORMAN ST.	71	Standard		$45,000	$0
STATE ST. at WEST AVE.	33	Standard		$45,000	$0
STATE ST. at HOUSATONIC COMMUNITY COLLEGE	35	Standard		$45,000	$0
WATER ST. at OPPOSITE JOHN ST.	5	Minor		$20,000	$0
Generic Berth at BTC		Existing	Existing Transit Center	$0	$0

* Existing – Existing terminal station with no need for enhancements
Major – Large shelter, bench, and real time information display
Standard – Shelter and real time information display
Minor – Bench and real time information display (no shelter due to few boardings or limited space)

Coastal Link West (westbound)

Stop Name	Potential Daily Boardings	Station Type	Notes	Station Cost	Other Costs
Westbound					
Departure BTC	570	Existing	Existing Transit Center	$0	$0
WATER ST. at JOHN ST.	55	Standard		$45,000	$0
JOHN ST. at BROAD ST.	50	Standard		$45,000	$0
JOHN ST. at PARK AVE.	112	Standard		$45,000	$0
FAIRFIELD AVE. at NORMAN ST.	42	Standard		$45,000	$0
FAIRFIELD AVE. at CLINTON AVE.	54	Standard		$45,000	$0
FAIRFIELD AVE. at HANCOCK AVE.	32	Standard		$45,000	$0
FAIRFIELD AVE. at ELLSWORTH ST.	26	Standard		$45,000	$0
FAIRFIELD AVE. at BREWSTER ST.	42	Standard		$45,000	$0
KINGS HWY. CUTOFF at 1296 KINGS HWY. CUTOFF	33	Standard		$45,000	$0
POST RD. at UNQUOWA RD.	5	Minor		$20,000	$0
POST RD. at NORTH PINE CREEK RD.	5	Minor	No room for shelter	$20,000	$0
POST RD. at 3330 POST RD.	0	Minor	Move 300' west	$20,000	$0
POST RD. EAST at NORTH BULKLEY AVE.	7	Minor		$20,000	$0
POST RD. EAST at WESTPORT INN	7	Minor	Move closer to Lansdowne	$20,000	$0
POST RD. EAST at CHURCH ST. NORTH	1	Minor		$20,000	$5,100 sidewalk & ramp
POST RD. EAST at CRESCENT RD.	2	Minor	Move to near side of Roseville	$20,000	$20,850 sidewalk & ramp
POST RD. EAST at 431 POST RD. EAST	13	Minor	No room for shelter	$20,000	$0
POST RD. WEST at MAIN ST.	5	Minor	No room for shelter	$20,000	$0
POST RD. WEST at SYLVAN RD. NORTH	1	Minor		$20,000	$10,500 sidewalk
WESTPORT AVE. at LOIS ST.	10	Standard		$45,000	$0
WESTPORT AVE. at STRAWBERRY HILL AVE.	7	Minor		$20,000	$0
WESTPORT AVE. at DRY HILL RD.	10	Minor		$20,000	$0
WALL ST. at NORWALK WHEEL HUB		Existing	Existing Transit Center	$0	$0
Sub-Total				$1,555,000	$148,150
TOTAL (both directions)	**2,183**			**$1,703,150**	

* Existing – Existing terminal station with no need for enhancements
Major – Large shelter, bench and real time information display
Standard – Shelter and real time information display
Minor – Bench and real time information display (no shelter due to few boardings or limited space)

Two of the proposed stations (one in each direction) would be the existing Bridgeport Transportation Center, and two (one in each direction) would be the existing Norwalk Wheels Hub, neither of which would need any improvements. Of the remaining 44 stations, none are proposed to be Major Stations, 27 are proposed to be Standard Stations, and 17 would be Minor Stations. Nearly all the Minor Stations are in Westport (in both directions) or Fairfield (westbound), where boarding ridership is lowest. It should be noted that the Town of Westport is developing pedestrian improvements between Riverside Avenue and Compo Road, which could support additional ridership in that area.

All of the proposed stations would be existing bus stops, although five would be moved to another location at the same intersection. One local bus stop is also proposed for relocation to facilitate TSP. (The stop on East Avenue at Saint Paul's Place would be relocated onto Saint Paul's Place.) Six stations in Westport would require construction of sidewalks and four of those would require curb ramps.

13.1.3 *Intersection Improvements*

Intersection improvements to speed bus service and improve service reliability are proposed at seven locations in the Coastal Link West corridor. The seven locations are numbered in Table 13-3. The proposed improvements for each intersection are described below, including the corresponding number from the map. Estimated capital costs are shown in Table 13-3. Improvements include TSP on seven intersection approaches, a queue jump on one approach, one intersection where passive priority is proposed, and one where modifications to an island are proposed.

Table 13-3: Coastal Link West Corridor Proposed Intersection Improvements

Intersection	Town	Owner	Map Location	Improvements		Cost
				EB	WB	
Belden Ave and Burnell Blvd	Norwalk	Norwalk	13	TSP	-	$5,000
E Wall St and East Ave (Rt 53)	Norwalk	Norwalk	14	TSP	*	$8,500
North Ave (Rt 1) and East Ave	Norwalk	Norwalk	15	-	TSP	$1,000
Post Rd W (Rt 1) and Riverside Ave (Rt 33)	Westport	CTDOT	16	TSP	TSP	$9,600
Post Rd (Rt 1) and Mill Plain Rd	Fairfield	CTDOT	17	QJ	-	$2,500
Lafayette Blvd and John St	Bridgeport	Bridgeport	18	-	TSP	$1,000
Fairfield Ave and Water St	Bridgeport	CTDOT	19	PP	TSP	$8,100
Sub-Total						$35,700
Incidentals @15%						$5,355
Contingencies @25%						$8,925
TOTAL COST						**$49,980**

QJ = Queue Jump TSP = Transit Signal Priority PP = Passive Priority
* Modify the island and create a right turn lane

Belden Ave and Burnell Blvd. – Norwalk – (13)

Implement TSP for the westbound approach on Burnell Boulevard to facilitate bus movements from the Norwalk Transit Wheels Hub. This could benefit all Norwalk Transit bus routes as well.

East Wall St and East Ave (Route 53) – Norwalk – (14)

Implement TSP for the eastbound approach. Move the westbound bus route from East Avenue southbound to Saint Paul's Place, then Park Street southbound to East Wall Street at the East Avenue intersection. Modify the traffic median and provide a channelized right turn lane and two southbound through lanes on Park Street. Move the westbound stop from East Avenue to Saint Paul's Place.

North Ave (Route 1) and East Ave – Norwalk – (15)

Implement TSP on the westbound approach.

Post Rd (Route 1) and Riverside Ave (Route 33) – Westport – (16)

Implement TSP for the eastbound and westbound approaches, relocate the existing near-side bus stop to far-side. However, this would require removal of on street parking on the approach to the bridge and town approval would be needed.

Post Rd (Route 1) and Mill Plain Rd – Fairfield – (17)

Implement a queue jump lane on the eastbound approach and realign pavement markings.

Lafayette Blvd and John St - Bridgeport – (18)

Implement TSP for the westbound approach. This intersection is currently being studied for realignment and TSP should be included.

Fairfield Ave and Water St – Bridgeport – (19)

Implement TSP for the southbound approach to the intersection from the Bridgeport Transportation Center. This could benefit all GBT bus routes as well.

13.2 Capital Costs

The capital costs associated with instituting limited stop bus service with enhanced stations and TSP capability are summarized in Table 13-4. The table includes the costs, detailed above, for stations and intersection improvements, plus capital costs for additional buses and for equipping all buses in the Coastal Link West corridor to support conditional TSP.

Table 13-4: Coastal Link West Corridor Summary of Estimated Capital Cost

Cost Category	Capital Cost*	Annualized Cost
Stations	$1,703,000	$132,537
Intersection Improvements	$59,000	$3,608
Buses (8)	$3,400,000	$321,503
TSP emitters (35)	$122,500	$11,584
TOTAL	**$5,284,500**	**$469,231**

*In 2016 dollars

The three operators currently schedule 20 different vehicle blocks on the Coastal Link, so as many as 20 buses may have to be equipped with TSP emitters. Adding eight more buses to the fleet for the proposed limited stop route would increase the total to as many as 28. A further 25% contingency is assumed to allow some flexibility in vehicle assignment, for a total of 35 TSP-equipped buses.

Capital costs were annualized assuming a useful life of 12 years for buses and TSP emitters, 15 years for stations, and 20 years for intersection improvements, all assuming a 2% discount rate, per FTA guidance.

13.3 Additional Annual Operating Costs

Bus Operators

The limited stop service is estimated to require approximately 72 additional vehicle-revenue-hours of service per weekday. Assuming the current GBT hourly operating cost of $69.49 as typical for the route, the additional annual operating cost would be approximately $1.278 million. Maintenance of the TSP emitters is expected to add about another $9,000, for a total of $1.287 million.

CTDOT and Municipalities

Other additional maintenance costs borne by others would include approximately $500 per year per traffic signal equipped with optical detectors to accommodate TSP. Many of the signals in the corridor are already equipped with optical detectors that are owned and maintained by the municipalities, so this may not be an additional cost. Other possible additional ongoing costs could be those associated with snow removal and shelter cleaning and maintenance.

13.4 Travel Time Savings

Several factors would combine to reduce the end-to-end running time on the limited stop route versus the current Coastal Link. One major factor would simply be that fewer stops are made. With fewer stops, the time spent slowing down, opening and closing the doors, and then merging back into traffic would be reduced. The increase in frequency would also decrease running times because, while overall ridership would increase, the number of riders on each trip would go down resulting in less time spent at stops boarding and unloading passengers. The planned introduction of Smart Cards would also reduce boarding times versus the current fare media. Finally, priority measures such as conditional TSP and queue jumps would reduce running times, especially on trips that are running late due to traffic or high passenger loads.

Table 13-5 shows the combined effect of all of the proposed strategies in the Coastal Link West corridor. Overall, the combined strategies are estimated to result in a savings of just over five minutes versus the current Coastal Link, or a savings of about 8.6%. Table 13-6 shows the percentage breakdown of running time savings by strategy. The reduced number of riders per trip would play the most significant part. The reduction in the number of stops is expected to have a more limited impact on average travel times because buses currently make so few stops. Smart Cards would also have a lesser impact and priority measures would have just a small impact on average running times.

Running times on the local Coastal Link route would also be affected slightly, as riders would be drawn to the new limited stop route, reducing passenger volumes and allowing it to make slightly fewer stops, on average.

Table 13-5: Coastal Link West Corridor Estimated Limited Stop Running Times

	Eastbound			Westbound			Average
	AM	Mid	PM	AM	Mid	PM	
Current Route Running Time	48.4	57.3	66.2	64.1	65.5	53.7	59.2
Estimated Limited Stop Running Time	45.2	53.4	60.9	58.6	56.4	50.0	54.1
Running Time Saved	3.2	3.9	5.3	5.5	9.1	3.7	5.1
Percent Running Time Saved	6.6%	6.8%	8.0%	8.5%	13.8%	6.9%	8.6%

Table 13-6: Coastal Link West Corridor Estimated Running Time Savings by Strategy

Strategy	Share of Running Time Reduction
Reduced Stops	28%
Reduced Riders/Trip	44%
Smart Cards	19%
TSP/Queue Jumps	9%

13.5 Ridership Impacts

13.5.1 *Ridership Increase*

Several factors would combine to increase ridership in the corridor. The biggest impact would be from the overall increase in frequency of service in the corridor. Passengers traveling between the 24 limited stops would be able to use the limited stop route or the regular Coastal Link. The increased availability of service would encourage increased ridership. Reduced travel times on the limited stop route, and slightly shorter travel times on the Coastal Link, would also encourage increased ridership. Finally, the installation of more substantial station amenities would have a positive impact on ridership as well.

Table 13-7 shows the combined effect of all of the proposed improvement strategies in the Coastal Link West corridor. Overall, the combined strategies are estimated to result in a 30% increase in ridership over the current Coastal Link, about 700 additional daily riders, or about 180,000 annual riders. Table 13-8 shows the percentage breakdown of ridership increases by strategy. The increase in frequency would account for the majority of the ridership increase, with the reduction in running time and station improvements each having a smaller impact.

Table 13-7: Coastal Link West Corridor Estimated Weekday Ridership

Route	Current	Proposed	Change
Coastal Link	2,318	1,690	-628
Limited Stop Route	-	1,332	1,332
Total	**2,318**	**3,023**	**705**
Percent Increase			30%

Table 13-8: Coastal Link West Corridor Estimated Ridership Increase by Strategy

Strategy	Share of Ridership Increase
Frequency Increase	78%
Running Time Reduction	14%
Improved Stations	8%

13.5.2 *Cost per New Rider*

While the improved services would enhance ridership in the corridor, the costs, both operating and capital, are also significant. Table 13-9 shows both the estimated operating cost per new rider, and the estimated total cost per new rider. Both these measures indicate that the Coastal Link West corridor is estimated to have second highest cost per new rider of the five Route 1 corridor segments. Only the Coastal Link East corridor would be higher.

Table 13-9: Coastal Link West Corridor Estimated Cost per New Rider

Estimated Cost per New Rider	
Annual Ridership Increase (000)	180
Estimated Revenue Increase *	$180
Annual Operating Cost*	$1,287
Net Annual Operating Cost *	$1,107
Net Operating Cost per New Rider	**$6.15**
Annualized Capital Cost*	$469
Net Annual Total Cost *	$1,576
Net Total Cost per New Rider	**$8.75**

*In thousands of 2016 dollars

14. Coastal Link East Corridor

14.1 Program of Improvements

14.1.1 *Limited Stop Service*

The Coastal Link East corridor segment is currently served by the Coastal Link, which is jointly operated by the Norwalk Transit District (NTD), Greater Bridgeport Transit (GBT), and the Milford Transit District (MTD). A limited stop service would be overlaid on the eastern half of the Coastal Link from Bridgeport to the CT Post Mall in Milford, as shown in Figure 14-1. The existing Coastal Link Route would continue to serve all stops in the corridor. The limited stop route would provide a faster service between Bridgeport, Stratford, and Milford.

It should be noted, however, that GBT has been considering alternative alignments for the existing Coastal Link route through the east side of Bridgeport and Stratford as part of its long range transit planning effort. One proposal is to re-route the Coastal Link along Barnum Avenue to serve the proposed new Barnum Station and the surrounding planned development with complementary changes to local bus service. The proposed limited stop overlay could follow the revised Coastal Link alignment serving the station area or it could continue to follow the current alignment (which is likely to provide a faster travel time). Other possible changes to the alignment could include using Ferry Boulevard to bypass Main Street in Stratford, as well changes to accommodate a proposed conversion of the Stratford Avenue and Connecticut Avenue one-way pair to two-way. Because these changes are likely many years away, this analysis assumes that the limited stop overlay route would follow the existing Coastal Link alignment. However, any further planning of this corridor should consider all the options for service through Bridgeport.

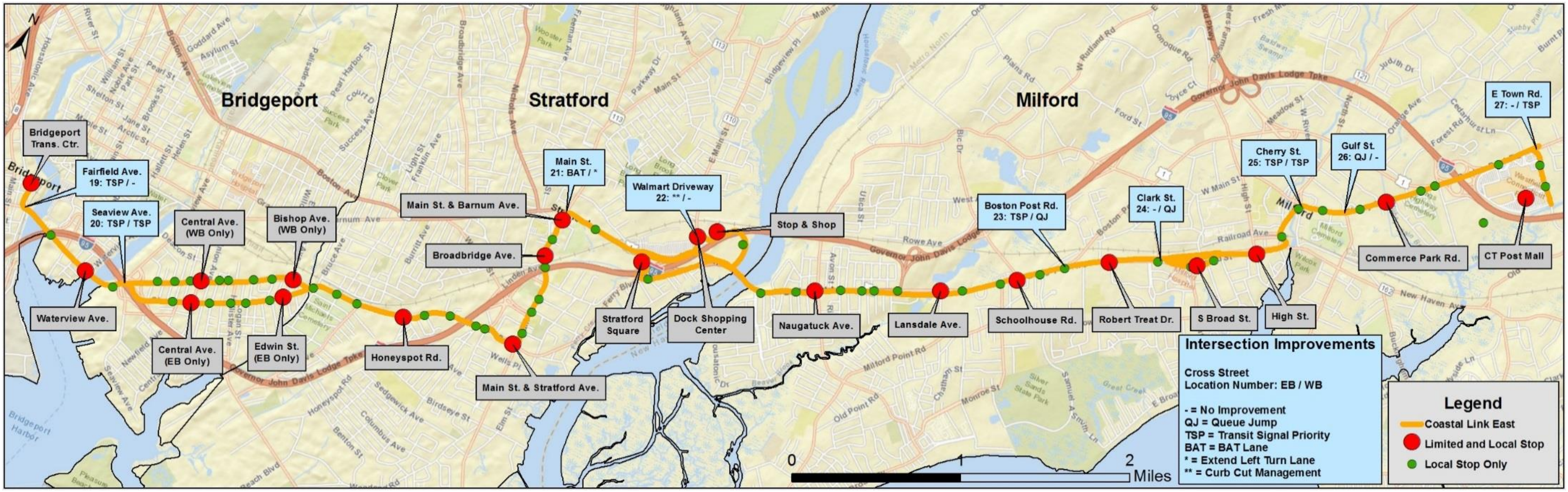
Proposed service frequencies are shown in Table 14-1. The limited stop route would operate at the same frequency as the Coastal Link, effectively doubling service between Bridgeport and the CT Post Mall. Limited stop service would operate approximately 14 hours per day. The limited stop route is expected to require six buses to operate in the weekday peak periods. No changes would be made to the regular Coastal Link schedule, alignment, or stops.

Table 14-1: Coastal Link East Corridor Service Frequency and Daily Trips

	Coastal Link East		Coastal Link East Limited	
	EB	WB	EB	WB
AM Peak	20	20	20	20
Midday	60	60	60	60
PM Peak	20	20	20	20
Evening	60	60		
Saturday	30	30		
Sunday	60	60		
Weekday Trips	31	33	30	31
Saturday Trips	29	28		
Sunday Trips	10	10		

Frequency in minutes.

Figure 14-1: Coastal Link East Corridor Proposed Stations and Improvements



14.1.2 *Station Locations*

The locations of the proposed stations in the Coastal Link East corridor are shown in Figure 14-1. The 37 proposed stations (19 in each direction including one served in both directions) are listed in Table 14-2 along with the proposed station type, estimated capital cost of improvements, potential weekday daily boardings (including local and limited stop routes and assuming some riders would shift from the adjacent stops to take advantage of limited stop service), and notes regarding site-specific improvements proposed. The 19 stations in each direction are far fewer than the 65 possible stops on the current eastern segment of the Coastal Link, although the Coastal Link averages only between 14 and 21 actual stops per trip in this area, depending on the direction and time of day.

Two of the proposed stations (one in each direction) would be the existing Bridgeport Transportation Center, and two (one in each direction) would be the existing hub at the CT Post Mall, neither of which would need any improvements. Of the remaining 33 stations, none are proposed to be Major Stations, 15 are proposed to be Standard Stations, and 18 would be Minor Stations. The Coastal Link East has the largest share of stations designated as Minor Stations. Most Minor Stations are in the eastbound direction and are designated as such due to low boardings.

All of the proposed stations would be existing bus stops, although one in Milford would be moved to another location at the same intersection. One local bus stop was proposed for relocation to facilitate TSP. (The stop at Bridgeport Avenue and Clark Street in Milford would be relocated to the near side of the intersection.) Two stations, one in Bridgeport, and one in Milford would require construction of sidewalks and curb ramps.

14.1.3 *Intersection Improvements*

Intersection improvements to speed bus service and improve service reliability are proposed at nine locations in the Coastal Link East corridor. The nine locations are numbered in Figure 14-1. The proposed improvements for each intersection are described below, including the corresponding number from the map. Estimated capital costs are shown Table 14-3. Improvements include TSP on six intersection approaches, queue jumps on three approaches, one intersection where a BAT Lane is proposed, and two locations with other improvements.

Stratford Avenue at Seaview/Connecticut Avenue and Connecticut Avenue at Stratford/Seaview – Bridgeport – (20)

Implement TSP for the eastbound and westbound approaches.

Main St (Route 113) - Stratford – (21)

The Town of Stratford is developing a complete streets plan for Main Street, including the intersection with Barnum Avenue. This analysis assumed a ¼ mile Business Access/Transit (BAT) lane during AM and PM Peak Hours along Main Street (Route 113) northbound starting from north of Stratford Train Station driveway to the intersection of Main Street (Route 113) at Barnum Avenue (Route 1) to serve the buses and the right turning vehicles exclusively. This concept will need to be evaluated in further detail for its impact on intersection operations and for consistency with the town’s planning efforts.

Barnum Ave (Route 1) and Main St (Route 113) – Stratford – (21)

Extend the left turn storage for the westbound approach to the intersection if roadway width permits.

Table 14-2: Coastal Link East Corridor Proposed Stations

Stop Name	Potential Daily Boardings	Station Type	Notes	Station Cost	Other Costs
Eastbound					
Departure BTC	422	Existing	Existing Transit Center	$0	$0
STRATFORD AVE. at WATERVIEW AVE.	8	Minor		$20,000	$0
STRATFORD AVE. at CENTRAL AVE.	24	Standard		$45,000	$0
STRATFORD AVE. at EDWIN ST.	7	Minor	No room for shelter	$20,000	$0
STRATFORD AVE. at HONEYSPOT RD.	3	Minor		$20,000	$0
STRATFORD AVE. at MAIN ST.	8	Minor		$20,000	$0
MAIN ST. at OPPOSITE BROADBRIDGE AVE.	1	Minor		$20,000	$0
BARNUM AVE. at MAIN ST.	6	Minor		$20,000	$0
VETERANS BLVD. at SIDE OF STRATFORD SQ	2	Minor		$20,000	$0
EAST MAIN ST. at DOCK SHOPPING CENTER	7	Minor		$20,000	$0
DOCK SHOPPING CENTER at STOP & SHOP	59	Standard	Same stop as Westbound stop	$45,000	$8,750 sidewalk
BRIDGEPORT AVE. at NAUGATUCK AVE.	6	Minor	No room for shelter	$20,000	$0
BRIDGEPORT AVE. at LANSDALE AVE.	9	Minor		$20,000	$0
BRIDGEPORT AVE. at OPP. SCHOOLHOUSE RD.	4	Minor	Move to far side	$20,000	$0
BRIDGEPORT AVE. at ROBERT TREAT DR.	9	Minor		$20,000	$0
BRIDGEPORT AVE. at SOUTH BROAD ST.	5	Minor		$20,000	$0
SOUTH BROAD ST. at HIGH ST.	11	Standard		$45,000	$0
CHERRY ST. at COMMERCE PARK RD.	4	Minor		$20,000	$0
WESTFIELD CONNECTICUT POST MALL		Existing	Existing Transit Center	$0	$0
Westbound					
WESTFIELD CONNECTICUT POST MALL	218	Existing	Existing Transit Center	$0	$0
CHERRY ST. at SUNNYSIDE CT.	19	Standard		$45,000	$0
NORTH BROAD ST. at HIGH ST.	51	Standard		$45,000	$0
BRIDGEPORT AVE. at OSBORNE ST.	8	Minor		$20,000	$0
BRIDGEPORT AVE. at ROBERT TREAT DR.	7	Minor		$20,000	$27,850 sidewalk & ramp
BRIDGEPORT AVE. at SCHOOLHOUSE RD.	22	Standard		$45,000	$0
BRIDGEPORT AVE. at LANSDALE AVE.	8	Minor		$20,000	$0
BRIDGEPORT AVE. at NAUGATUCK AVE.	8	Minor	No room for shelter	$20,000	$0
DOCK SHOPPING CENTER at STOP & SHOP	43	None	Same stop as Eastbound stop	$0	$0
EAST MAIN ST. at BARNUM AVE. CUTOFF	26	Standard		$45,000	$0
BARNUM AVE.CUTOFF at OPPOSITE VETERANS BLVD.	15	Standard		$45,000	$0
BARNUM AVE.CUTOFF at BURLINGTON COAT	14	Standard		$45,000	$0
MAIN ST. at 2505 MAIN ST.	13	Standard		$45,000	$0
MAIN ST. at STRATFORD AVE.	32	Standard		$45,000	$0
STRATFORD AVE. at OPP. HONEYSPOT RD.	19	Standard		$45,000	$3,350 sidewalk & ramp
CONNECTICUT AVE. at BISHOP AVE.	28	Standard		$45,000	$0
CONNECTICUT AVE. at CENTRAL AVE.	104	Standard		$45,000	$0
STRATFORD AVE. at WATERVIEW AVE.	11	Standard		$45,000	$0
Generic Berth at BTC		Existing	Existing Transit Center	$0	$0
Sub-Total				$1,035,000	$39,950
TOTAL (both directions)	**1,232**			**$1,074,950**	

Notes for Table 14-2:

* Existing – Existing terminal station with no need for enhancements
Major – Large shelter, bench, and real time information display
Standard – Shelter and real time information display
Minor – Bench and real time information display (no shelter due to few boardings or limited space)

Table 14-3: Coastal Link East Corridor Proposed Intersection Improvements

Intersection	Town	Owner	Map Location	Improvements		Cost
				EB	WB	
Stratford Avenue at Seaview/Connecticut Avenue	Bridgeport	CTDOT	20	TSP	TSP	$9,100
Main St (Rt 113)	Stratford	CTDOT	21	BAT	-	$5,000
Barnum Ave (Rt 1) and Main St (Rt 113)	Stratford	CTDOT	21	-	*	$500
E Main St (Rt 110) and Walmart	Stratford	CTDOT	22	**	-	$11,000
Bridgeport Ave (Rt 162) and Boston Post Rd (Rt 1)	Milford	CTDOT	23	TSP	QJ	$32,600
Bridgeport Ave (Rt 162)/Clark St/Golden Hill St	Milford	CTDOT	24	-	QJ	$21,000
W Main St/Plymouth Pl/Cherry St/Prospect St/River St	Milford	CTDOT	25	TSP	TSP	$10,100
Cherry St and Gulf St	Milford	CTDOT	26	QJ	-	$11,500
Boston Post Rd (Rt 1) and E Town Rd	Milford	CTDOT	27	-	TSP	$8,100
Sub-Total						$108,900
Incidentals @15%						$16,335
Contingencies @25%						$27,225
TOTAL COST						**$152,460**

QJ = Queue Jump TSP = Transit Signal Priority PP = Passive Priority
* = Extend Left Turn Lane ** = Curb Cut Management

East Main St (Route 110) and Walmart – Stratford – (22)

Consolidate curb cuts to the parking lot at the westbound approach to the intersection and revise pavement markings to reconfigure lane use to a left turn lane, a through lane, and a through/right turn lane. This location is on private property and changes would require an agreement with the property owner.

Bridgeport Ave (RT 162) and Boston Post Rd (RT 1) – Milford – (23)

Implement TSP for the eastbound approach. Provide for a bus only lane to function as a queue jump lane for the westbound approach and reconstruct the channelized island.

Bridgeport Ave (RT 162)/Clark St/Golden Hill St. – Milford – (24)

Reconfigure the existing right turn lane to implement a queue Jump for the westbound approach and reconstruct the channelized island. Move the westbound bus stop to a near side location.

W Main St/Plymouth Pl/Cherry St/Prospect St/River St – Milford – (25)

Implement TSP for the eastbound and westbound approaches, relocate the existing eastbound near-side bus stop farther away from the intersection and closer to the stop across the street, retime and optimize the traffic signal, and remove parking between North Street and this intersection on the south side of

Cherry Street to provide for a longer right turn lane. Provide for an extended left turn storage lane of 200 feet on the westbound approach by shifting the centerline.

Cherry St and Gulf St. – Milford – (26)

Shift the centerline, extend the right turn lane, and implement a queue Jump for the eastbound approach.

Boston Post Rd (Route 1) and E Town Rd - Milford – (27)

Implement TSP for the East Town Road left turn to Route 1.

14.2 Capital Costs

The capital costs associated with instituting limited stop bus service with enhanced stations and TSP capability are summarized in Table 14-4. The table includes the costs, detailed above, for stations and intersection improvements, plus capital costs for additional buses and for equipping all buses in the Coastal Link East corridor to support conditional TSP.

Table 14-4: Coastal Link East Corridor Summary of Estimated Capital Cost

Cost Category	Capital Cost*	Annualized Cost
Stations	$1,075,000	$83,662
Intersection Improvements	$161,000	$9,846
Buses (7)	$2,975,000	$281,315
TSP emitters (34)	$119,000	$11,253
TOTAL	**$4,330,000**	**$386,076**

*In 2016 dollars

The three operators currently schedule 20 different vehicle blocks on the Coastal Link, so as many as 20 buses may have to be equipped with TSP emitters. Adding seven more buses for the proposed limited stop route would increase the total to as many as 27. A further 25% contingency is assumed to allow some flexibility in vehicle assignment, for a total of 34 TSP-equipped buses.

Capital costs were annualized assuming a useful life of 12 years for buses and TSP emitters, 15 years for stations, and 20 years for intersection improvements, all assuming a 2% discount rate, per FTA guidance.

14.3 Additional Annual Operating Costs

Bus Operators

The limited stop service is estimated to require approximately 62 additional vehicle-revenue-hours of service per weekday. Assuming the current GBT hourly operating cost of $69.49 as typical for the route, the additional annual operating cost would be approximately $1.093 million. Maintenance of the TSP emitters is expected to add about another $9,000, for a total of $1.102 million.

CTDOT and Municipalities

Other additional maintenance costs borne by others would include approximately $500 per year per traffic signal equipped with optical detectors to accommodate TSP. Many of the signals in the corridor are already equipped with optical detectors that are owned and maintained by the municipalities, so this may not be an additional cost. Other possible additional ongoing costs could be those associated with snow removal and shelter cleaning and maintenance.

14.4 Travel Time Savings

Several factors would combine to reduce the end-to-end running time on the limited stop route versus the current Coastal Link. One major factor would simply be that fewer stops are made. With fewer stops, the time spent slowing down, opening and closing the doors, and then merging back into traffic would be reduced. The increase in frequency would also decrease running times because, while overall ridership would increase, the number of riders on each trip would go down resulting in less time spent at stops boarding and unloading passengers. The planned introduction of Smart Cards would also reduce boarding times versus the current fare media. Finally, priority measures such as conditional TSP and queue jumps would reduce running times, especially on trips that are running late due to traffic or high passenger loads.

Table 14-5 shows the combined effect of all of the proposed strategies in the Coastal Link East corridor. Overall, the combined strategies are estimated to result in an average four minute running time savings over the current Coastal Link, or a savings of about 8%. Table 14-6 shows the percentage breakdown of running time savings by strategy. The reduced number of riders per trip would play the most significant part. The reduction in the number of stops is expected to have limited impact on average travel times because buses currently make so few stops. Smart Cards would also have a lesser impact and priority measures would have just a small impact on average running times. Running times on the local Coastal Link route would also be affected slightly, as riders would be drawn to the new limited stop route, reducing passenger volumes and allowing it to make slightly fewer stops, on average.

Table 14-5: Coastal Link East Corridor Estimated Limited Stop Running Times

	Eastbound			Westbound			Average
	AM	Mid	PM	AM	Mid	PM	
Current Route Running Time	49.4	50.8	48.9	52.4	54.2	51.9	51.3
Estimated Limited Stop Running Time	45.3	46.1	45.8	48.8	49.5	48.3	47.3
Running Time Saved	4.1	4.7	3.1	3.6	4.7	3.6	3.9
Percent Running Time Saved	8.2%	9.3%	6.2%	6.8%	8.6%	6.9%	7.7%

Table 14-6: Coastal Link East Corridor Estimated Running Time Savings by Strategy

Strategy	Share of Running Time Reduction
Reduced Stops	18%
Reduced Riders/Trip	57%
Smart Cards	15%
TSP/Queue Jumps	10%

14.5 Ridership Impacts

14.5.1 *Ridership Increase*

Several factors would combine to increase ridership in the corridor. The biggest impact would be from the overall increase in frequency of service in the corridor. Passengers traveling between the 19 limited stops would be able to use the limited stop route or the regular Coastal Link. The increased availability of service would encourage increased ridership. Reduced travel times on the limited stop route, and slightly shorter travel times on the Coastal Link, would also encourage increased ridership. Finally, the installation of more substantial station amenities would have a positive impact on ridership as well.

Table 14-7 shows the combined effect of all of the proposed strategies in the Coastal Link East corridor. Overall, the combined strategies are estimated to result in a 30% increase in ridership over the current Coastal Link, over 430 additional daily riders, or about 111,000 annual riders. Table 14-8 shows the percentage breakdown of ridership increases by strategy. The increase in frequency would account for the majority of the ridership increase, with the reduction in running time and station improvements each having a smaller impact.

Table 14-7: Coastal Link East Corridor Estimated Weekday Ridership

Route	Current	Proposed	Change
Coastal Link	1,435	1,038	-397
Limited Stop Route	-	832	832
Total	**1,435**	**1,869**	**434**
Percent Increase			30%

Table 14-8: Coastal Link East Corridor Estimated Ridership Increase by Strategy

Strategy	Share of Ridership Increase
Frequency Increase	80%
Running Time Reduction	12%
Improved Stations	8%

14.5.2 *Cost per New Rider*

While the improved services would enhance ridership in the corridor, the costs, both operating and capital, are also significant. Table 14-9 shows both the estimated operating cost per new rider, and the estimated total cost per new rider. Both these measures indicate that the Coastal Link East corridor is estimated to have highest cost per new rider of the five Route 1 corridor segments. While costs would be comparable to the other corridors, estimated ridership is lowest in this segment.

Table 14-9: Coastal Link East Corridor Estimated Cost per New Rider

Estimated Cost per New Rider	
Annual Ridership Increase (000)	111
Estimated Revenue Increase *	$111
Annual Operating Cost*	$1,102
Net Annual Operating Cost *	$991
Net Operating Cost per New Rider	**$8.92**
Annualized Capital Cost*	$386
Net Annual Total Cost *	$1,377
Net Total Cost per New Rider	**$12.40**

*In thousands of 2016 dollars

15. O (Route 1) Corridor

15.1 Program of Improvements

15.1.1 *Limited Stop Service*

A limited stop BRT service would be overlaid on the western half (the Route 1 half) of the CT*transit* New Haven Division O Route, but would differ from the local O (Route 1) in two locations. As shown in Figure 15-1, the proposed limited stop BRT overlay route would stay on Route 1 in West Haven, skipping the diversion along Meloy and Canton Streets. In New Haven, instead of using Sylvan Avenue, the BRT route would follow a more direct route to the New Haven Green. Several routing alternatives are possible in New Haven. The preliminary route evaluated in this study would follow Congress Avenue, South Frontage Road and Church Street inbound to the New Haven Green. Outbound, the route would use Temple Street (including a planned new crossing of the Route 34 corridor) directly to Congress Avenue. Buses would turn around using Trumbull Street.

The City of Haven is currently evaluating transit and traffic circulation alternatives in the city and has suggested several possible alternate routes that could take advantage of traffic circulation changes, provide service closer to Union Station, and include a more convenient way to turn buses around at the end of the route. The city has suggested an alternative alignment in New Haven via Columbus Avenue and Church Street (turning around on Chapel and Temple) that would provide service closer to Union Station while stopping farther away from Yale New Haven Hospital. A final routing decision would have to be developed in conjunction with the city before BRT service could be implemented in the corridor. Regardless of the final routing, the limited stop route would provide a faster, more direct service between the CT Post Mall, businesses on Route 1, and New Haven. (No changes would be made to the routing of the existing local O route.)

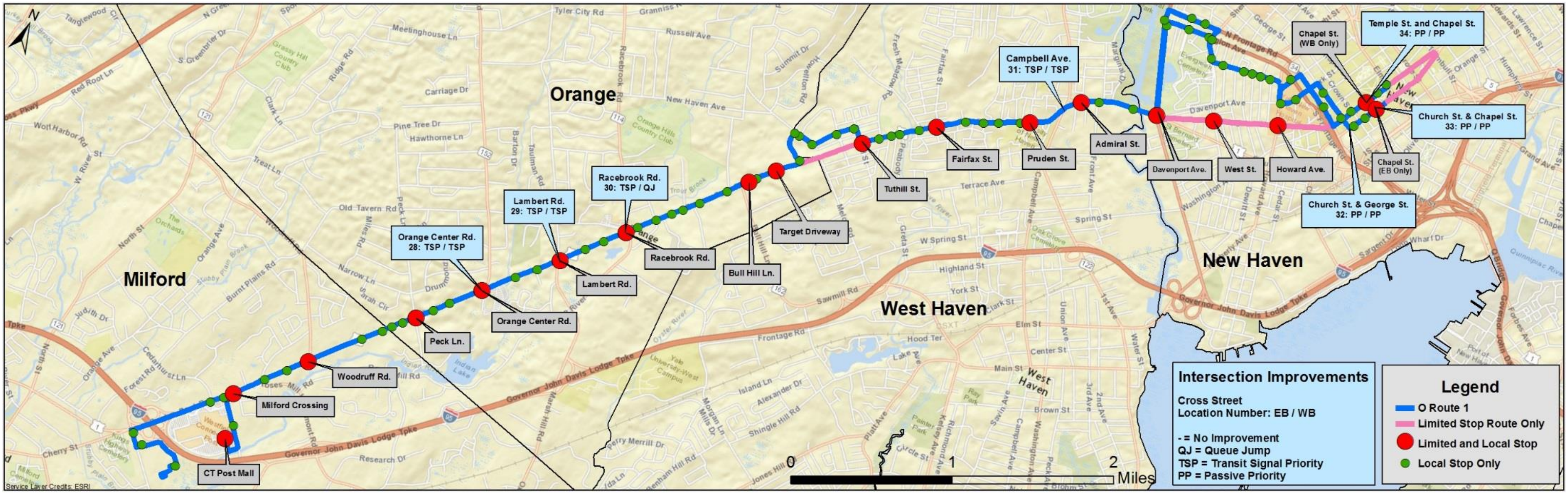
Proposed service frequencies are shown in Table 15-1. The limited stop route would operate at the same frequency as the O (Route 1), effectively doubling service between the CT Post Mall and New Haven. Limited stop service would operate approximately 14 hours per day. The limited stop route is expected to require seven buses to operate in the weekday peak periods. No changes would be made to the existing O Route schedule, alignment, or stops.

Table 15-1: O (Route 1) Corridor Service Frequency and Daily Trips

	O (Route 1)		O (Route 1) Limited	
	EB	WB	EB	WB
AM Peak	20	20	20	20
Midday	20	20	20	20
PM Peak	15	15	15	15
Evening	35	30		
Saturday	20	20		
Sunday	40	60		
Weekday Trips	50	50	43	45
Saturday Trips	41	40		
Sunday Trips	14	15		

Frequency in minutes.

Figure 15-1: O (Route 1) Corridor Proposed Stations and Improvements



15.1.2 *Station Locations*

The locations of the proposed stations in the O (Route 1) corridor are shown in Figure 15-1. The 34 proposed stations (17 in each direction) are listed in Table 15-2 along with the proposed station type, estimated capital cost of improvements, potential weekday daily boardings (including local and limited stop routes and assuming some riders would shift from the adjacent stops to take advantage of limited stop service), and notes regarding site-specific improvements proposed. The 17 stations in each direction are far fewer than the 69 possible stops on the current O (Route 1), although the O Route averages only between 18 and 26 actual stops per trip, depending on the direction and time of day.

Two of the proposed stations (one in each direction) would be the existing hub at the CT Post Mall, which would not need any improvements. Of the remaining 32 stations, two are proposed to be Major Stations, 22 are proposed to be Standard Stations, and eight would be Minor Stations. All but one of the Minor Stations are westbound in Orange, where boarding ridership is lowest.

All of the proposed stations would be existing bus stops, although four would be moved to another location at the same intersection. Fifteen stations would require construction of sidewalks and 13 would need curb ramps, nearly all in the Town of Orange. The O (Route 1) corridor segment has, by far, the greatest need for sidewalk connections and crosswalks of the five corridor segments studied. It should be noted, however, that there are significant needs, beyond those identified here, for improvements to the pedestrian environment in this area, as sidewalks are not continuous and crosswalks are lacking.

15.1.3 *Intersection Improvements*

Intersection improvements to speed bus service and improve service reliability are proposed at seven locations in the O (Route 1) corridor. The seven locations are numbered in Figure 15-1. The proposed improvements for each intersection are described below, including the corresponding number from the map. Estimated capital costs are shown in Table 15-3.

Improvements include TSP on seven intersection approaches, a queue jump on one approach and three intersections where passive priority is proposed. Note that where passive priority is proposed, signal improvements are already planned by the City of New Haven, so no additional costs are assumed to result from this project. The City of New Haven is currently undertaking a project to replace traffic signal equipment, improve coordination timing, and implement TSP in the downtown area. While the improvements will reduce bus travel times and delays in the downtown, the cost of these planned improvements are assumed borne by the city and therefore are not included in cost estimates for this project.

Boston Post Rd (Route 1) and Orange Center Rd (Route 152) – Orange – (28)

Implement TSP for the eastbound and westbound approaches. With TSP, the eastbound stop would ideally be moved to far side; however, this does not appear feasible given the slope away from the street. Crosswalks, sidewalks, and curb ramps should be provided to allow better access to the bus stops; however, the highly skewed intersection would create challenges for making any pedestrian improvements.

Boston Post Rd (RT 1) and Lambert Rd – Orange – (29)

Implement TSP for the eastbound and westbound approaches. Move the westbound stop to a far side location, before the fire station.

Table 15-2: O (Route 1) Corridor Proposed Stations

Stop Name	Potential Daily Boardings	Station Type	Notes	Station Cost	Other Costs**
Eastbound					
CT POST MALL AT TRANSIT HUB	399	Existing	Existing Transit Center	$0	$0
BOSTON POST RD & MILFORD CROSSING	106	Standard		$45,000	$0
BOSTON POST RD & WOODRUFF RD	11	Standard	Move to far side for better sidewalk connection	$45,000	$0
BOSTON POST RD & PECK LN	25	Standard	No nearby sidewalk	$45,000	$0
BOSTON POST RD & ORANGE CENTER RD	23	Standard		$45,000	$19,100
BOSTON POST RD & S LAMBERT RD	23	Standard	Move eastward past driveways	$45,000	$61,250
BOSTON POST RD & RACEBROOK RD	23	Standard	No nearby sidewalk	$45,000	$10,350
BOSTON POST RD & BULL HILL LN	64	Standard		$45,000	$22,600
BOSTON POST RD & WALGREENS	45	Standard	Connect to Walgreens and nearest intersection	$45,000	$45,350
ORANGE AVE & TUTHILL ST	35	Standard		$45,000	$15,600
ORANGE AVE & OPP FAIRFAX ST	33	Minor	No room for shelter	$20,000	$10,350
ORANGE AVE & OPP PRUDEN ST	38	Standard		$45,000	$0
ORANGE AVE & OPP ADMIRAL ST	41	Standard		$45,000	$0
CONGRESS AVE & DAVENPORT AVE	17	Standard		$45,000	$0
CONGRESS AVE & WEST ST	56	Standard		$45,000	$0
CONGRESS AVE & HOWARD ST	59	Standard		$45,000	$0
CHURCH ST & CHAPEL ST		Minor		$20,000	$0
Westbound					
TEMPLE ST & CHAPEL ST	726	Major		$88,000	$0
CONGRESS AVE & HOWARD ST	39	Standard		$45,000	$0
CONGRESS AVE & WEST ST	48	Standard		$45,000	$0
CONGRESS AVE & DAVENPORT AVE	25	Standard		$45,000	$0
ORANGE AVE & ADMIRAL ST	140	Major	Move 100' east to make room for shelter	$88,000	$0
ORANGE AVE & PRUDEN ST	45	Standard	Move to far side	$45,000	$1,600
ORANGE AVE & FAIRFAX ST	13	Standard		$45,000	$0
ORANGE AVE & TUTHILL ST	6	Minor		$20,000	$12,100
BOSTON POST RD & McDONALD'S	20	Standard	Connect to Walgreens and nearest intersection	$45,000	$71,600
BOSTON POST RD & BULL HILL LN	28	Standard		$45,000	$22,600
BOSTON POST RD & RACEBROOK RD	9	Minor	No nearby sidewalk	$20,000	$10,350
BOSTON POST RD & LAMBERT RD	4	Minor		$20,000	$8,750
BOSTON POST RD & ORANGE CENTER RD	6	Minor		$20,000	$19,100
BOSTON POST RD & PECK LANE	2	Minor	No nearby sidewalk	$20,000	$27,850
BOSTON POST RD & WOODRUFF RD	1	Minor		$20,000	$52,500
BOSTON POST RD & TURNPIKE SQUARE	4	Minor		$20,000	$0
WESTFIELD CONNECTICUT POST MALL		Existing	Existing Transit Center	$0	$0
Sub-Total				$1,301,000	$411,050
TOTAL	**2,144**			**$1,712,050**	

* Existing – Existing terminal station with no need for enhancements
Major – Large shelter, bench, and real time information display
Standard – Shelter and real time information display
Minor – Bench and real time information display (no shelter due to few boardings or limited space)
** Sidewalks and ramps needed at all locations where costs are shown.

Table 15-3: O (Route 1) Corridor Proposed Intersection Improvements

Intersection	Town	Owner	Map Location	Improvements		Cost
				EB	WB	
Boston Post Rd (Rt 1) and Orange Center Rd (Rt 152)	Orange	CTDOT	28	TSP	TSP	$9,100
Boston Post Rd (Rt 1) and Lambert Rd	Orange	CTDOT	29	TSP	TSP	$9,100
Boston Post Rd (Rt 1) and Racebrook Rd (Rt 114)	Orange	CTDOT	30	TSP	QJ	$12,600
Boston Post Rd (Rt 1) and Campbell Ave (Rt 122)	West Haven	CTDOT	31	TSP	TSP	$9,100
Church St and George St	New Haven	New Haven	32	PP	PP	$0
Church St and Chapel St	New Haven	New Haven	33	PP	PP	$0
Temple St and Chapel St	New Haven	New Haven	34	PP	PP	$0
Sub-Total						$39,900
Incidentals @15%						$5,985
Contingencies @25%						$9,975
TOTAL COST						**$55,860**

QJ = Queue Jump   TSP = Transit Signal Priority   PP = Passive Priority

Boston Post Rd (Route 1) and Racebrook Rd (Route 114) - Orange – (30)

Implement TSP for the eastbound approach. Establish a queue jump lane on the westbound approach by utilizing the existing right turn lane.

Boston Post Rd (Route 1) and Campbell Ave (Route 122) - West Haven approaches – (31)

The intersection is under construction. Implement TSP for the eastbound and westbound approaches.

Church St and George St. - New Haven – (32)

The City of New Haven is currently undertaking a project to replace traffic signal equipment, improve coordination timing, and implement TSP. The eastbound and westbound approaches will be subject to operational improvements. The proposed improvements should reduce bus travel times and delays in the downtown.

Church St and Chapel St. - New Haven – (33)

The City of New Haven is currently undertaking a project to replace traffic signal equipment, improve coordination timing, and implement TSP. The westbound approach will be subject to operational improvements. The proposed improvements should reduce bus travel times and delays in the downtown.

Temple St and Chapel St. - New Haven – (34)

The City of New Haven is currently undertaking a project to replace traffic signal equipment, improve coordination timing, and implement TSP. The westbound approach will be subject to operational improvements. The proposed improvements should reduce bus travel times and delays in the downtown.

15.2 Capital Costs

The capital costs associated with instituting limited stop bus service with enhanced stations and TSP capability in the O (Route 1) corridor are summarized in Table 15-4. The table includes the costs, detailed above, for stations and intersection improvements, plus capital costs for additional buses and for equipping all buses in the O (Route 1) corridor to support conditional TSP.

Table 15-4: O (Route 1) Corridor Summary of Estimated Capital Cost

Cost Category	Capital Cost*	Annualized Cost
Stations	$1,712,000	$133,237
Intersection Improvements	$64,000	$3,914
Buses (8)	$3,400,000	$321,503
TSP emitters (34)	$119,000	$11,253
TOTAL	**$5,295,000**	**$469,906**

*In 2016 dollars

CT*transit* currently schedules 19 different vehicle blocks on the O Route, so as many as 19 buses may have to be equipped with TSP emitters. Adding eight more buses for the proposed limited stop route would increase the total to as many as 27. A further 25% contingency is assumed to allow CT*transit* some flexibility in vehicle assignment, for a total of 34 TSP-equipped buses. While 34 TSP-equipped buses was assumed for estimation of costs for the corridor, in reality, CT*transit* may want to consider equipping the entire New Haven Division fleet in anticipation of a more widespread implementation of TSP in the New Haven region.

Capital costs were annualized assuming a useful life of 12 years for buses and TSP emitters, 15 years for stations, and 20 years for intersection improvements, all assuming a 2% discount rate, per FTA guidance.

15.3 Additional Annual Operating Costs

CTtransit

The limited stop service is estimated to require approximately 75 additional vehicle-revenue-hours of service per weekday. Assuming the current CT*transit* hourly operating cost of $72.72, the additional annual operating cost would be approximately $1.404 million. Maintenance of the TSP emitters is expected to add about another $9,000, for a total of $1.413 million.

CTDOT and Municipalities

Other additional maintenance costs borne by others would include approximately $500 per year per traffic signal equipped with optical detectors to accommodate TSP. Many of the signals in the corridor are already equipped with optical detectors that are owned and maintained by the municipalities, so this may not be an additional cost. Other possible additional ongoing costs could be those associated with snow removal and shelter cleaning and maintenance.

15.4 Travel Time Savings

Several factors would combine to reduce the end-to-end running time on the limited stop route versus the current O (Route 1). The biggest factor would simply be the more direct routing. Another important factor would be that fewer stops are made. With fewer stops, the time spent slowing down, opening and closing the doors, and then merging back into traffic would be reduced. The increase in frequency would also decrease running times because, while overall ridership would increase, the number of riders on each trip would go down resulting in less time spent at stops boarding and unloading passengers. The planned introduction of Smart Cards would also reduce boarding times versus the current fare media. Finally, priority measures such as conditional TSP and queue jumps would reduce running times, especially on trips that are running late due to traffic or high passenger loads.

Table 15-5 shows the combined effect of all of the proposed strategies in the O (Route 1) corridor. Overall, the combined strategies are estimated to result in an average eleven minute running time savings over the current O (Route 1), or a savings of about 25%. Table 15-6 shows the percentage breakdown of running time savings by strategy. For the O (Route 1) corridor, the proposed limited stop route alignment would differ from the current O (Route 1), following a more direct route and reducing end-to-end running time. The more direct routing would be the largest contributor to running time savings. The reduction in stops, the reduced number of riders per trip, and Smart Cards would play lesser roles but together would account for 30% of the running time savings. Priority measures would have just a small impact on average running times. Running times on O (Route 1) would also be affected slightly, as riders would be drawn to the new limited stop route, reducing passenger volumes and allowing them to make slightly fewer stops, on average.

Table 15-5: O (Route 1) Corridor Estimated Limited Stop Running Times

	Eastbound			Westbound			Average
	AM	Mid	PM	AM	Mid	PM	
Current Route Running Time	39.4	43.9	48.7	38.5	44.5	47.3	43.7
Estimated Limited Stop Running Time	30.3	32.5	36.4	28.3	31.5	36.3	32.6
Running Time Saved	9.1	11.4	12.3	10.2	13.0	11.0	11.1
Percent Running Time Saved	23.1%	25.9%	25.2%	26.4%	29.2%	23.2%	25.5%

Table 15-6: O (Route 1) Corridor Estimated Running Time Savings by Strategy

Strategy	Share of Running Time Reduction
Reduced Stops	8%
Reduced Riders/Trip	10%
Smart Cards	12%
TSP/Queue Jumps	3%
More Direct Routing	67%

15.5 Ridership Impacts

15.5.1 *Ridership Increase*

Several factors would combine to increase ridership in the O (Route 1) corridor. The biggest impact would be from the overall increase in frequency of service in the corridor. Passengers traveling between the 17 limited stops would be able to use either the limited stop route or O (Route 1). The increased availability of service would encourage increased ridership. Reduced travel times on the limited stop route, and slightly shorter travel times on O (Route 1), would also encourage increased ridership. Finally, the installation of more substantial station amenities would have a positive impact on ridership as well.

Table 15-7 shows the combined effect of all of the proposed strategies. Overall, the combined strategies are estimated to result in a 36% increase in ridership over the current O (Route 1), almost 920 additional daily riders, or about 234,000 annual riders. Table 15-8 shows the percentage breakdown of ridership increases by strategy. The increase in frequency would account for the largest share of the ridership increase, followed by reductions in running time. Station improvements would have a small impact on ridership.

Table 15-7: O (Route 1) Corridor Estimated Weekday Ridership

Route	Current	Proposed	Change
O (Route 1)	2,556	1,686	-870
Limited Stop Route	-	1,788	1,788
Total	**2,556**	**3,474**	**918**
Percent Increase			36%

Table 15-8: O (Route 1) Corridor Estimated Ridership Increase by Strategy

Strategy	Share of Ridership Increase
Frequency Increase	57%
Running Time Reduction	35%
Improved Stations	8%

15.5.2 *Cost per New Rider*

While the improved services would enhance ridership in the corridor, the costs, both operating and capital, are also significant. Table 15-9 shows both the estimated operating cost per new rider, and the estimated total cost per new rider. Both these measures indicate that the O (Route 1) corridor is in the middle of the five Route 1 corridor segments in terms of cost per new rider. This corridor is estimated have the highest ridership increase, but also the highest costs.

Table 15-9: O (Route 1) Corridor Estimated Cost per New Rider

Estimated Cost per New Rider	
Annual Ridership Increase (000)	234
Estimated Revenue Increase *	$211
Annual Operating Cost*	$1,413
Net Annual Operating Cost *	$1,202
Net Operating Cost per New Rider	**$5.14**
Annualized Capital Cost*	$470
Net Annual Total Cost *	$1,672
Net Total Cost per New Rider	**$7.14**

*In thousands of 2016 dollars

PART IV

16. Corridor Comparison and Evaluation

This chapter presents a summary and evaluation of the impacts on running time, ridership, and cost of BRT service in each of the corridor programs. Section 16.1 present a comparison of the five corridor segments and also four possible combinations of adjacent corridor segments. Section 16.2 outlines a set of evaluation criteria while Section 16.3 applies the evaluation criteria to each corridor and corridor combination.

16.1 Comparison of Corridors

Table 16-1 contains a summary of the technical analysis of potential BRT service conducted for each of the five corridor segments. The table shows the headways assumed for each limited stop BRT service, (which are equivalent to the headways on the existing local service that currently operates in each corridor segment). The table also shows the current running times on the local service and the estimated running time saved by the proposed limited stop BRT service.

The Ridership section of the table shows the “potential ridership” for limited stop service. “Potential ridership” is based on the current ridership at proposed limited stops plus half the ridership at the two adjacent stops, adjusted to estimate the number of riders who could both board and alight at the limited BRT stops. Current corridor ridership, estimated revised corridor ridership with BRT service, and estimated ridership on just the limited stop BRT service are also shown, along with the estimated corridor ridership increase over current levels.

The Capital Cost section shows some of the figures on which capital costs are based. It includes the total number of stations to be constructed, as well as the number of stations with more complex needs, such as those that would be located at a different corner of the intersection from the current bus stop, and those requiring construction of curb ramps, additional sections of sidewalk, or curb extensions. The number of buses to be added to the fleet reflects the number of buses required for the limited stop BRT service, plus spares. In addition to station costs and bus procurement costs, the costs of intersection improvements (primarily signalization improvements for TSP) and the cost to transit operators for signal priority equipment are shown.

The Operating Costs section shows the total and net annual operating cost for the limited stop BRT service that would be borne by the bus operators, and also shows the estimated net additional operating cost per new rider. The Total Cost section factors in the annualized capital cost in addition to operating cost and shows net additional total cost per new rider.

In developing recommendations for Route 1 BRT service and in discussions with the expanded TAC, the idea of a limited stop BRT route spanning two adjacent corridors was considered. To evaluate this possibility, the same summary analysis was prepared for the four possible combinations of adjacent corridor segments, and is shown in Table 16-2. In developing the summary, it was noted that the proposed headways differ for two of the pairs of segments (341+CLW and CLE+O). In those two cases, the entire combined segment service was assumed to operate at the more frequent headway, as indicated in the Service Frequency section of the table. This resulted in some measures, such as ridership, bus procurement costs, and operating costs, being higher than that for the total of the two segments separately. For the other two combination segments, proposed headways on the two corridors are equal, so the impacts of combined service are equal to the sum of the impacts on the two individual segments.

Table 16-1: Comparison of Corridors

	311	341	CL West	CL East	O
Service Frequency					
Peak Period Headway	20	20	20	20	15
Midday Headway	30	30	60	60	20
Running Time					
Current Average Route Running Time	50.7	45.5	59.2	51.3	43.7
BRT Average Running Time Savings	12.0	5.8	5.1	3.9	11.1
Percent BRT Running Time Savings	24%	13%	9%	8%	25%
Ridership					
Potential BRT Ridership Share	45%	65%	65%	66%	56%
Current Weekday Daily Corridor Ridership	2,447	2,470	2,318	1,435	2,556
Estimated Revised Corridor Ridership	3,132	3,253	3,023	1,869	3,474
Estimated BRT Service Ridership	1,334	1,449	1,332	832	1,788
BRT Service Ridership Share	43%	45%	44%	44%	51%
Weekday Corridor Ridership Increase	685	783	705	434	918
Percent Corridor Ridership Increase	28%	32%	30%	30%	36%
Annual Corridor Ridership Increase (000)	175	200	180	111	234
Capital Costs					
Total Stations Constructed	22	23	44	33	32
Stations Relocated	5	4	4	1	4
Stations with Additional Construction	4	2	6	3	16
Additional Buses	6	7	8	7	8
Station Cost ($000)	$895	$1,184	$1,703	$1,075	$1,712
Intersection Improvement Cost ($000)	$131	$23	$59	$161	$64
Bus Procurement Cost ($000)	$2,550	$2,975	$3,400	$2,975	$3,400
Transit Agency TSP Cost ($000)	$88	$98	$123	$119	$119
Total Capital Cost ($000)	$3,664	$4,280	$5,285	$4,330	$5,295
Annualized Capital Cost ($000)	$327	$384	$469	$386	$470
Operating Costs					
Annual Operating Cost ($000)	$955	$1,105	$1,287	$1,102	$1,413
Estimated Revenue Increase ($000)	$214	$244	$180	$111	$211
Net Annual Operating Cost ($000)	$742	$861	$1,107	$991	$1,202
Net Operating Cost per New Rider	$4.24	$4.31	$6.15	$8.92	$5.14
Total Costs					
Net Annual Total Cost ($000)	$1,069	$1,245	$1,576	$1,377	$1,672
Net Total Cost per New Rider	$6.11	$6.23	$8.75	$12.40	$7.14

Table 16-2: Comparison of Combination Corridors

	311+341	341+ CLW	CLW+CLE	CLE+O
Service Frequency				
Peak Period Headway	20	20	20	15
Midday Headway	30	30	60	20
Running Time				
Current Average Route Running Time	96.2	104.7	110.5	95.0
BRT Average Running Time Savings	17.8	10.7	9.0	14.7
Percent BRT Running Time Savings	19%	10%	8%	15%
Ridership				
Potential BRT Ridership Share		0		0
Current Weekday Daily Corridor Ridership	4,917	4,788	3,753	3,991
Estimated Revised Corridor Ridership	6,385	6,429	4,892	5,497
Estimated BRT Service Ridership	2,783	2,876	2,164	2,715
BRT Service Ridership Share	44%	45%	44%	49%
Weekday Corridor Ridership Increase	1,468	1,641	1,139	1,506
Percent Corridor Ridership Increase	30%	34%	30%	38%
Annual Corridor Ridership Increase (000)	375	418	291	384
Capital Costs				
Total Stations Constructed	45	67	77	65
Stations Relocated	9	8	5	5
Stations with Additional Construction	6	8	9	19
Additional Buses	13	15	15	18
Station Cost ($000)	$2,079	$2,887	$2,778	$2,787
Intersection Improvement Cost ($000)	$154	$82	$220	$226
Bus Procurement Cost ($000)	$5,525	$6,375	$6,375	$7,650
Transit Agency TSP Cost ($000)	$186	$221	$242	$252
Total Capital Cost ($000)	$7,944	$9,565	$9,615	$10,915
Annualized Capital Cost ($000)	$711	$853	$855	$978
Operating Costs				
Annual Operating Cost ($000)	$2,060	$2,705	$2,388	$3,049
Estimated Revenue Increase ($000)	$458	$464	$291	$361
Net Annual Operating Cost ($000)	$1,603	$2,241	$2,097	$2,689
Net Operating Cost per New Rider	$4.27	$5.36	$7.21	$7.00
Total Costs				
Net Annual Total Cost ($000)	$2,314	$3,094	$2,952	$3,667
Net Total Cost per New Rider	$6.17	$7.40	$10.15	$9.55

It should be noted that no increases in ridership were assumed to result from the actual combining of adjacent corridors. While the 2012 Coastal Corridor Study survey showed little evidence of need for such service among current riders, members of the expanded TAC felt that the unmet need exists in some cases and such a service is worth considering.

16.2 Evaluation Criteria

One of the goals of the Route 1 Bus Rapid Transit Feasibility Study is to "determine where *the best locations* are for potential BRT enhancements to increase the effectiveness of bus services and improve operations." Therefore, an evaluation and prioritization process was needed to determine which corridor segment poses the best opportunity for successful implementation of an initial BRT service. Any evaluation and ranking of the corridor programs should be based on a series of measures resulting from questions that can be answered with either quantitative or qualitative information. Quantitative data can be used to assess the overall cost effectiveness and value proposition for the improvement plan, while a qualitative assessment is needed to consider less quantifiable measures, such as factors that could facilitate a successful implementation and also the degree of complexity of the implementation, in terms of construction, technology integration, and governance.

Working with CTDOT, the study team developed the following evaluation questions that can be answered quantitatively for each corridor segment using the data in Table 16-1 or Table 16-2:

- How many customers are served today?
- What would be the potential travel time savings versus the existing service?
- What would be the anticipated corridor ridership growth?
- How large a share of corridor riders would a limited stop BRT service attract?
- What would be the total capital cost associated with the improvements?
- What would be the total annual operating cost associated with the improvements?
- What would be the net cost per new rider?

To consider the ease and complexity for implementation in each corridor, the following qualitative questions were posed:

- Are there ongoing complementary initiatives in the corridor that could facilitate a successful implementation and is there support among the local municipalities and transit operators?
- Would the improvement plan involve creation of a new one-seat connection?
- Would the plan require governance changes relative to the current service(s)?
- What would be the scale and complexity of construction activities?
- How complex would the integration of technology be for real time information and TSP applications?

To address these more qualitative questions, a numeric rating along a scale of 1 (least favorable) to 5 (most favorable) was given to each corridor for each question. Complementary initiatives and local support were judged primarily using input from the expanded TAC meeting. (TAC meeting #4 held in October 2016). New one-seat connections are provided by some of the combination corridors, whereas the existing corridors provide no new connections. Governance issues arise for any new service in the Coastal Link corridor (where three operators now share control), as well as any combination corridor that combines corridors now served by different operators. Scale and complexity of construction was judged based on how many stations are needed and how many stations would require more complex construction and coordination. Complexity of technology integration was based on an estimate of the complexity of integrating transit AVL systems for the operator(s) on each segment, or combination, with the signal systems on that segment.

16.3 Corridor Evaluation

From the evaluation questions, a matrix was developed and populated with empirical data for the quantitative measures, and with the study team's judgment concerning the more qualitative measures. Separate matrices were prepared for the five corridor segments (Table 16-3) and for the four combination corridors (Table 16-4). The tables use a color scale to indicate the relative ratings for each measure, with green indicating the most favorable and red the least favorable values for each measure. The colors for intermediate values are scaled along a color gradient between green and red based on where the data lies along the range between the most and least favorable values. Data for the quantitative measures was taken from the above tables while the study team's reasoning behind the ratings given for the qualitative measures are discussed below.

Complementary Initiatives and Local Support

In October 2016, the program of improvements for each corridor segment was reviewed at the two sessions of the expanded TAC. The expanded committee included not only the initial representatives from CTDOT, the five bus operating divisions, and the three Councils of Governments, but also representatives from the impacted municipalities. All twelve municipalities were invited to participate. Representatives attended from the municipalities of Greenwich, Stamford, Darien, Norwalk, Westport, Stratford, Milford, West Haven and New Haven. Meeting attendees provided feedback on the proposed corridor program elements as well as an indication of the level of support for BRT enhancements and service in each municipality.

The municipal representatives at the expanded TAC meetings expressed considerable general support for improved bus service in the corridor. Representatives from the Cities of New Haven and Stamford provided information about the ongoing transit studies in their respective cities and noted possible synergies between the proposed BRT improvements and improvements being considered as part of the New Haven Alternatives Analysis and the Stamford Bus and Shuttle Study. As a result, the O (Route 1), Route 311, and Route 341 corridors were rated most highly. The two Coastal Link corridors were also rated highly. Greater Bridgeport Transit noted proposed improvements from its Long Range Transit Plan, including an alternative Coastal Link routing, although implementation of that proposal is at least several years away. For the four combination corridors, the individual corridor ratings were averaged.

Creation of New One-Seat Connection

Only two of the combination corridors (341+CLW and CLE+O) would create new one-seat connections, while none of the single corridors, nor the combination of Coastal Link East and West, would do so. Routes 311 and 341 already operate much like a single service, but the combination would be a slight improvement with a single route identity and most likely a more direct through-routing in Stamford, so that combination was given a slightly higher rating.

Table 16-3: Evaluation of Corridors

	311	341	CL West	CL East	O
Running Time					
Percent BRT Running Time Savings	24%	13%	9%	8%	25%
Ridership					
Current Weekday Daily Corridor Ridership	2,447	2,470	2,318	1,435	2,556
BRT Service Ridership Share	43%	45%	44%	44%	51%
Percent Corridor Ridership Increase	28%	32%	30%	30%	36%
Costs					
Total Capital Cost ($000)	$3,664	$4,280	$5,285	$4,330	$5,295
Annual Operating Cost ($000)	$955	$1,105	$1,287	$1,102	$1,413
Net Total Cost per New Rider	$6.11	$6.23	$8.75	$12.40	$7.14
Ease of Implementation					
Complementary Initiatives and Local Support	5	5	4	4	5
Creation of New One-Seat Connection	1	1	1	1	1
Scale of Governance Change Required	5	5	3	3	5
Construction Scale and Complexity	4	4	2	3	2
Complexity of Technology Integration	4	4	2	2	5

Table 16-4: Evaluation of Combination Corridors

	311+341	341+ CLW	CLW+CLE	CLE+O
Running Time				
Percent BRT Running Time Savings	19%	10%	8%	15%
Ridership				
Current Weekday Daily Corridor Ridership	4,917	4,788	3,753	3,991
BRT Service Ridership Share	44%	45%	44%	49%
Percent Corridor Ridership Increase	30%	34%	30%	38%
Costs				
Total Capital Cost ($000)	$7,944	$9,565	$9,615	$10,915
Annual Operating Cost ($000)	$2,060	$2,705	$2,388	$3,049
Net Total Cost per New Rider	$6.17	$7.40	$10.15	$9.55
Ease of Implementation				
Complementary Initiatives and Local Support	5	4.5	4	4.5
Creation of New One-Seat Connection	2	5	1	5
Scale of Governance Change Required	5	2	4	2
Construction Scale and Complexity	4	3	2.5	2.5
Complexity of Technology Integration	4	2	2	2

Scale of Governance Change Required

Issues of governance revolve around the number of different operating agencies that would be responsible for providing the service and how the operations, supervision, costs, and revenues would be divided among them. The details of governance cannot be fully answered in the process of this evaluation, although it is clear that the Route 311, Route 341 and O (Route 1) corridors could each be operated by the local CT*transit* Division alone. A new BRT service in one or both Coastal Link corridors would require an agreement concerning operations, supervision, costs, and revenues of the BRT service and could result in revisions to the agreement between the three operators governing the existing local Coastal Link service. Having a single operator for the BRT service would make implementation of TSP and real-time information far less complex, but could raise questions impacting the existing governance structure. Combining one of the Coastal Link segments with one of the CT*transit* segments would add a fourth transit operator to the mix, further complicating governance.

Construction Scale and Complexity

The Route 311 and Route 341 corridors would have the fewest stations to construct and the areas served generally have the best pedestrian connections requiring the least construction of additional pedestrian improvements. The Coastal Link East and O (Route 1) would have more stations to construct, but the O (Route 1) corridor has by far the most need for construction of additional sidewalks and curb ramps. The Coastal Link West is the longest segment and would involve construction of the most stations. For the combination corridors, the individual corridor ratings were averaged.

Complexity of Technology Integration

The CT*transit* New Haven Division, operator of O (Route 1), is installing the current version of the Trapeze AVL system, which is designed to support both real-time information dissemination and TSP. The older Xerox AVL system operated by the Stamford Division in the Route 311 and Route 341 corridors has less proven ability to support the two technologies. Implementing the two technologies on all or part of the Coastal Link corridor would involve three different operators with three different AVL systems, each with different levels of capability and different procedures for integration. Adding either of the adjacent CT*transit* divisions to Coastal Link service would add a fourth operator and a fourth AVL system to the mix. The feasibility of supporting the two technologies with multiple AVL systems is not known but limiting the operation to one operator would raise governance issues.

17. Recommendations for BRT in the Route 1 Corridor

The evaluation shown in the tables in the previous chapter illustrates that each of the five corridors has advantages and disadvantages. The Route 311 and O (Route 1) corridors could provide the biggest travel time savings. The O (Route 1) corridor could also provide the most ridership benefits, albeit at the highest costs, while the Route 311 corridor has the lowest costs and least ridership benefits. The Route 341 corridor has a slight advantage over the O Route and Route 311 corridors in ease of implementation, along with ridership, travel time, and costs that lie in the middle of the pack. The Coastal Link corridors would have the lowest travel time benefit and the most implementation challenges, due to the complexity of the existing operation.

Overall, by most measures, the differences between the corridors are not large. There are clear, albeit modest, benefits that can be realized in each corridor and therefore there is little reason to exclude any one outright from consideration for eventual BRT service. Ultimately, there could be BRT service throughout the entire corridor, most likely using a number of routes rather than one single long service, but possibly using as few as two or three long routes, each covering one or two segments.

Keeping in mind that one of the goals of this project was to “determine where *the best locations* are for potential BRT enhancements to increase effectiveness of bus services and improve operations,” it is essential that this project identify which location, or which corridor segment, poses the best opportunity for successful implementation of an initial BRT service. Implementation in one corridor segment would also be less of an undertaking than a corridor-wide program and an initial successful example in one segment can provide the impetus for services on additional segments, or extension of the initial service to cover a second segment. Therefore, while all corridor segments could benefit from BRT improvements, an initial segment has to be identified at this time.

The other goal of this project was to “develop alternatives and assess their viability in improving bus travel time and increasing bus ridership in targeted corridors.” This emphasis on travel time improvements and increasing ridership indicates that the most emphasis in selecting an initial corridor segment for BRT implementation should be placed on travel time and ridership measures.

Taking this into account, but considering all of the evaluation measures evaluated above, the recommendation of this study is that the O (Route 1) corridor segment presents the best opportunity for a successful initial BRT service, due to the potential for the greatest travel time savings, the highest estimated ridership increases, and consistency with the city’s plans for bus service improvements. While the cost of implementation in this corridor may be slightly higher than the others, the cost per new rider is not far above that of the lowest cost corridor segments.

The Route 341 segment appears to present the second best opportunity and could be considered for a second phase, given the ease of implementation, low cost, and moderate travel time and ridership benefits. Service in the Route 341 corridor could be implemented alone or in combination with service on the Route 311 segment to create a single service from Norwalk to Port Chester.

The Coastal Link Corridor has numerous governance and technological issues to be resolved. It has also been recently made clear that there are schedule and performance issues that must be given higher priority and there is a need to improve the reliability, and possibly the frequency, of service on the existing route, before considering BRT service in the corridor. Separate BRT service could be implemented at a later date in the Coastal Link corridor, or there could eventually be extensions of both the O (Route 1) and Route 341 BRT services to Bridgeport, provided governance issues can be resolved.

The above findings and recommendations are summarized in Table 17-1.

Table 17-1: Route 1 Bus Rapid Transit Feasibility Study Findings and Recommendations

• All Route 1 corridor segments could benefit from BRT improvements.
• There could ultimately be BRT service throughout the entire Route 1 corridor using multiple BRT routes.
• The O (Route 1) segment presents the best opportunity for a successful initial BRT service.
• The Route 341 segment presents the second best initial opportunity and could be implemented alone or in combination with service on the Route 311 segment.
• The priority on the Coastal Link corridor should be improving the reliability and performance of the existing local service first, before adding BRT. BRT service could eventually be implemented possibly as extensions of the O (Route 1) and 341 BRT services to Bridgeport, provided governance issues can be resolved.

18. O (Route 1) Corridor BRT Program

This chapter describes the improvement program for the preferred initial corridor, the O (Route 1) corridor between Milford and New Haven. Section 18.1 summarizes the Service Plan for the corridor while Section 18.2 describes the Capital Plan, including a breakdown of improvements by municipality. Finally, Section 18.3 presents a discussion of specific implementation issues to be resolved before BRT service can be implemented.

18.1 Service Plan

18.1.1 *Route and Stations*

A limited stop BRT service would be overlaid on the western half (the Route 1 half) of the CT*transit* New Haven Division O Route, but would differ from the local O (Route 1) in two locations. As shown in Figure 18-1, the proposed limited stop BRT overlay route would stay on Route 1 in West Haven, skipping the diversion along Meloy and Canton Streets. In New Haven, instead of using Sylvan Avenue, the BRT route would follow a more direct route to the New Haven Green. Several routing alternatives are possible in New Haven. The preliminary route evaluated in this study would follow Congress Avenue, South Frontage Road and Church Street inbound to the New Haven Green. Outbound, the route would use Temple Street (including a planned new crossing of the Route 34 corridor) directly to Congress Avenue. Buses would turn around using Trumbull Street.

The City of Haven is currently evaluating transit and traffic circulation alternatives in the city and has suggested several possible alternate routes that could take advantage of traffic circulation changes, provide service closer to Union Station, and include a more convenient way to turn buses around at the end of the route. The city has suggested an alternative alignment in New Haven via Columbus Avenue and Church Street (turning around on Chapel and Temple) that would provide service closer to Union Station while stopping farther away from Yale New Haven Hospital. A final routing decision would have to be developed in conjunction with the city before BRT service could be implemented in the corridor. Regardless of the final routing, the limited stop route would provide a faster, more direct service between the CT Post Mall, businesses on Route 1, and New Haven. (No changes would be made to the routing of the existing local O route.)

The locations of the proposed BRT stations in this corridor are shown in Figure 18-1. The 34 proposed stations (17 in each direction) are listed in Table 18-1 along with the estimated potential weekday daily boardings and proposed station type. The 17 stations in each direction are far fewer than the 69 possible stops on the current O (Route 1), although the O Route averages only between 18 and 26 actual stops made per trip, depending on the direction and time of day.

Stations were categorized into Major, Standard and Minor Stations based on boarding ridership and site restrictions, as follows:

- Major Station – high ridership locations and transfer points
- Standard Station – most locations - where space permits a shelter to be installed
- Minor Station – locations with few boardings (but may have many alightings) or locations that lack the space to include a shelter

Figure 18-1: O (Route 1) Corridor Proposed Stations and Improvements

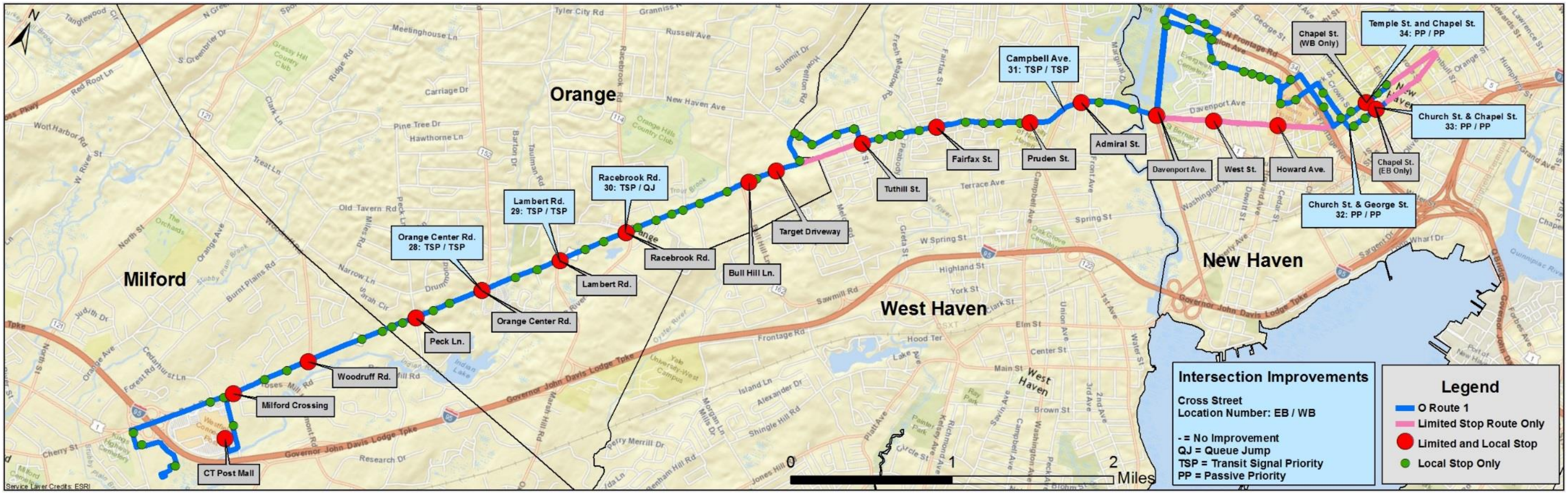


Table 18-1: O (Route 1) Corridor Proposed Stations

Stop Name	Potential Daily Boardings	Station Type
Eastbound		
CT POST MALL AT TRANSIT HUB	399	Existing
BOSTON POST RD & MILFORD CROSSING	106	Standard
BOSTON POST RD & WOODRUFF RD	11	Standard
BOSTON POST RD & PECK LN	25	Standard
BOSTON POST RD & ORANGE CENTER RD	23	Standard
BOSTON POST RD & S LAMBERT RD	23	Standard
BOSTON POST RD & RACEBROOK RD	23	Standard
BOSTON POST RD & BULL HILL LN	64	Standard
BOSTON POST RD & WALGREENS	45	Standard
ORANGE AVE & TUTHILL ST	35	Standard
ORANGE AVE & OPP FAIRFAX ST	33	Minor
ORANGE AVE & OPP PRUDEN ST	38	Standard
ORANGE AVE & OPP ADMIRAL ST	41	Standard
CONGRESS AVE & DAVENPORT AVE	17	Standard
CONGRESS AVE & WEST ST	56	Standard
CONGRESS AVE & HOWARD ST	59	Standard
CHURCH ST & CHAPEL ST		Minor
Westbound		
TEMPLE ST & CHAPEL ST	726	Major
CONGRESS AVE & HOWARD ST	39	Standard
CONGRESS AVE & WEST ST	48	Standard
CONGRESS AVE & DAVENPORT AVE	25	Standard
ORANGE AVE & ADMIRAL ST	140	Major
ORANGE AVE & PRUDEN ST	45	Standard
ORANGE AVE & FAIRFAX ST	13	Standard
ORANGE AVE & TUTHILL ST	6	Minor
BOSTON POST RD & McDONALD'S	20	Standard
BOSTON POST RD & BULL HILL LN	28	Standard
BOSTON POST RD & RACEBROOK RD	9	Minor
BOSTON POST RD & LAMBERT RD	4	Minor
BOSTON POST RD & ORANGE CENTER RD	6	Minor
BOSTON POST RD & PECK LANE	2	Minor
BOSTON POST RD & WOODRUFF RD	1	Minor
BOSTON POST RD & TURNPIKE SQUARE	4	Minor
WESTFIELD CONNECTICUT POST MALL		Existing
Sub-Total		
TOTAL	**2,144**	

Major and Standard Stations would include specially branded shelters with larger shelters at the Major Stations. All would have a route and system map, as well as a standalone wireless real-time information display. Major Stations would have additional features, such as lighting, a bike rack, a second bench, and a trash receptacle. Each station would have a connection constructed to the nearest sidewalk, if needed. The amenities included for each station type in developing station costs are shown in Table 18-2.

Table 18-2: Station Features by Category

	Major Station	Standard Station	Minor Station
Boarding Area	✓	✓	✓
Bus Stop Sign	✓	✓	✓
Large Branded Shelter with Bench	✓		
Branded Shelter with Bench		✓	
Standalone Bench	✓		✓
Standard Shelter			
Real time Information	✓	✓	✓
System Information	✓	✓	✓
Lighting	✓		
Trash Receptacle	✓		
Bike Rack	✓		
Sidewalk Connections and Curb Ramps	as needed	as needed	as needed

Two of the proposed stations (one in each direction) would be the existing hub at the CT Post Mall, which would not need any improvements. Of the remaining 32 stations, two are proposed to be Major Stations, 22 are proposed to be Standard Stations, and eight would be Minor Stations.

18.1.2 *Frequency and Span of Service*

Proposed service frequencies are shown in Table 18-3. The limited stop BRT route would operate at the same frequency as O (Route 1), effectively doubling service between the CT Post Mall and New Haven. Limited stop BRT service would operate approximately 14 hours per day. The limited stop route is expected to require seven buses to operate in the weekday peak periods. No changes would be made to the existing O Route schedule.

18.1.3 *Running Times and Reliability*

Several factors would combine to reduce the end-to-end running time on the limited stop BRT route versus the current O (Route 1). The biggest factor would simply be the more direct routing. Other important factors include fewer planned stops, use of Smart Cards for fare payment, TSP, and fewer passengers per trip (resulting from the increased frequency in the corridor. Table 18-4 shows the combined effect of all of the proposed strategies. Overall, the combined strategies are estimated to result in an average 11 minute running time savings over the current O (Route 1), or a savings of about 25%.

Table 18-3: O (Route 1) Corridor Service Headway and Daily Trips

	O (Route 1)		O (Route 1) Limited	
	EB	WB	EB	WB
AM Peak	20	20	20	20
Midday	20	20	20	20
PM Peak	15	15	15	15
Evening	35	30		
Saturday	20	20		
Sunday	40	60		
Weekday Trips	50	50	43	45
Saturday Trips	41	40		
Sunday Trips	14	15		

Headway in minutes.

Table 18-4: O (Route 1) Corridor Estimated Limited Stop Running Times

	Eastbound			Westbound			Average
	AM	Mid	PM	AM	Mid	PM	
Current Route Running Time	39.4	43.9	48.7	38.5	44.5	47.3	43.7
Estimated Limited Stop Running Time	30.3	32.5	36.4	28.3	31.5	36.3	32.6
Running Time Saved	9.1	11.4	12.3	10.2	13.0	11.0	11.1
Percent Running Time Saved	23.1%	25.9%	25.2%	26.4%	29.2%	23.2%	25.5%

While sufficient detailed data is not available to estimate current on-time performance as a measure of service reliability in the corridor, introduction of enhanced service in the corridor will highlight the need for reliable on-time service in order to both attract and retain ridership. TSP will reduce intersection delays to late buses and limited stop service will result in a more consistent number of stops made per trip, as well as more consistent dwell times, both of which can result in improvements to on-time performance.

18.1.4 *Ridership*

Several factors would combine to increase ridership in the corridor. The biggest impact would be from the overall increase in frequency of service in the corridor. The increased availability of service would encourage increased ridership, as would the reduced travel times. The installation of more substantial station amenities would have a positive impact on ridership as well. Table 18-5 shows the combined effect of all of the proposed strategies. Overall, the combined strategies are estimated to result in a 36% increase in ridership in the corridor over the current O (Route 1), almost 920 additional daily trips, or about 234,000 trips annually.

Table 18-5: O (Route 1) Corridor Estimated Weekday Ridership

Route	Current	Proposed	Change
O (Route 1)	2,556	1,686	-870
Limited Stop Route	-	1,788	1,788
Total	**2,556**	**3,474**	**918**
Percent Increase			36%

18.1.5 *Operating Cost*

The limited stop service is estimated to require approximately 75 additional vehicle-revenue-hours of service per weekday. Assuming the current CT*transit* hourly operating cost of $72.72, the additional annual operating cost would be approximately $1.404 million. Maintenance of the on-board emitters for TSP is expected to add about another $9,000, for a total of $1.413 million.

18.2 Capital Plan

Capital improvements to support the BRT service in the O (Route 1) corridor would include the 32 stations, plus emitters for TSP on-board buses and intersection signalization improvements to implement TSP. The proposed stations and intersection improvements are listed in the following sections by the municipality in which they are located, although many improvements would be within the state-owned right-of-way and involve state-owned traffic signals not under local control.

Each of the stations would be constructed to meet current accessibility guidelines under the ADA and require construction of a firm, level boarding and alighting area and an accessible connection to the nearest sidewalk. In addition, each station would include a specialized sign designating it as a station on the limited stop BRT service. With the exception of Minor Stations, all would include specially branded shelters, with larger branded shelters for the Major Stations. All stations would have a route and system map, as well as a standalone wireless real-time information display. Major Stations would have additional features, such as lighting, a bike rack, a second bench, and a trash receptacle. Costs were estimated for each generic station type, with additional station-specific costs estimated for additional pedestrian sidewalk and curb ramp connections.

For this particular TSP implementation (at a limited number of intersections in a single corridor), it is recommended that a distributed system involving direct communication between a bus and a particular traffic signal controller would be most appropriate (as opposed to one operating through a centralized traffic control system). Priority would only be granted on a conditional basis, when a bus is behind schedule, rather than unconditionally. TSP would require integration with CT*transit*'s Trapeze AVL system and the addition of emitters on board all buses serving the corridor.

The intersections identified for TSP implementation in each municipality represent only those that were identified through the bus travel time data collected for this study as the locations causing the most significant delays for buses. Other locations may exhibit less consistent delays but may, over time, begin to experience more significant delays. In the future TSP could be implemented at those additional locations, as needed, at relatively low additional cost.

18.2.1 *Milford*

The proposed BRT stations in Milford are listed in Table 18-6. All of the proposed stations in Milford would be existing bus stops, although the eastbound stop on Route 1 at Woodruff Road could be moved to the far side of the intersection to provide for a better pedestrian connection to existing sidewalks in the area. The westbound stop on Route 1 at Woodruff Road also has no existing sidewalk and would require construction of a connection to the sidewalk on the east side of Woodruff Road.

Table 18-6: Milford Capital Improvements

Station Location	Station Type	Notes	Est. Station Cost	Pedestrian Improvement Est. Cost
Eastbound Stations				
CT POST MALL AT TRANSIT HUB	Existing	Existing Transit Center	$0	$0
BOSTON POST RD & MILFORD CROSSING	Standard		$45,000	$0
BOSTON POST RD & WOODRUFF RD	Standard	Move to far side for better sidewalk connection	$45,000	$0
Westbound Stations				
BOSTON POST RD & WOODRUFF RD	Minor		$20,000	$52,500
BOSTON POST RD & TURNPIKE SQUARE	Minor		$20,000	$0
WESTFIELD CONNECTICUT POST MALL	Existing	Existing Transit Center	$0	$0

The station at the CT Post Mall would use the existing bus stop facility there which would not need to be upgraded. The two eastbound stations on Route 1 would be standard stations, while the two westbound stations have very few boardings and would be minor stations with no shelter.

There are no intersections proposed for TSP along the route in Milford.

18.2.2 *Orange*

The proposed BRT stations in Orange are listed in Table 18-7. All of the proposed stations in Orange would be existing bus stops, although the eastbound stop on Route 1 at Lambert Road would need to be moved further east to avoid a driveway. More importantly, 11 of the 12 station locations have no adjacent sidewalks. As a result, additional pedestrian improvements, such as extended sidewalks and curb ramps, would need to be constructed to make those stations accessible. The station locations at Peck Lane and Racebrook Road do not even have nearby sidewalks to connect to, so a connection can be made only to the nearest intersection. This is indicative of the significant needs, beyond those identified here, for improvements to the pedestrian environment along Route 1 in Orange, as sidewalks are not continuous and crosswalks are often lacking.

All of the eastbound stations and two of the westbound stations in Orange would be standard stations, while the four westbound stations closest to the CT Post Mall are expected to have very few boardings and would be minor stations with no shelter.

The three intersections in Orange proposed for TSP are also listed in Table 18-7. At the Racebrook Road intersection, it may be feasible to implement a bus queue jump instead utilizing the existing right turn lane. There buses could use the right-turn-only lane and receive an advanced green signal to proceed through the intersection ahead of general traffic. A new signal head and modifications to signage and pavement markings would be needed.

Table 18-7: Orange Capital Improvements

Station Location	Station Type	Notes	Est. Station Cost	Pedestrian Improvement Est. Cost
Eastbound Stations				
BOSTON POST RD & PECK LN	Standard	No nearby sidewalk to connect to	$45,000	$0
BOSTON POST RD & ORANGE CENTER RD	Standard		$45,000	$19,100
BOSTON POST RD & S LAMBERT RD	Standard	Move eastward past driveways	$45,000	$61,250
BOSTON POST RD & RACEBROOK RD	Standard	No nearby sidewalk to connect to	$45,000	$10,350
BOSTON POST RD & BULL HILL LN	Standard		$45,000	$22,600
BOSTON POST RD & WALGREENS	Standard	Connect to Walgreens and nearest intersection	$45,000	$45,350
Westbound Stations				
BOSTON POST RD & McDONALD'S	Standard	Connect to nearest intersection	$45,000	$71,600
BOSTON POST RD & BULL HILL LN	Standard		$45,000	$22,600
BOSTON POST RD & RACEBROOK RD	Minor	No nearby sidewalk to connect to	$20,000	$10,350
BOSTON POST RD & LAMBERT RD	Minor		$20,000	$8,750
BOSTON POST RD & ORANGE CENTER RD	Minor		$20,000	$19,100
BOSTON POST RD & PECK LANE	Minor	No nearby sidewalk to connect to	$20,000	$27,850
Intersection Improvements	**Signal Owner**	**Notes**	**Est. Cost**	
Boston Post Rd and Orange Center Rd	CTDOT	Transit Signal Priority	$12,740	
Boston Post Rd and Lambert Rd	CTDOT	Transit Signal Priority	$12,740	
Boston Post Rd and Racebrook Rd	CTDOT	Transit Signal Priority (possible WB queue jump)	$17,640	

18.2.3 *West Haven*

The proposed BRT stations in West Haven are listed in Table 18-8. All of the proposed stations in West Haven would be existing bus stops, although the westbound stop on Route 1 at Admiral Street would need to be moved farther east to make room for the larger shelter and station amenities that the ridership at this location warrants, and the westbound stop on Route 1 at Pruden Street would need to be moved to the far side where there is more space for a shelter. Four of the eight station locations have no adjacent sidewalks, so pedestrian improvements, such as extended sidewalks and curb ramps, would need to be constructed to make those stations accessible.

The westbound station at Admiral Street currently attracts a significant number of boarding passengers and therefore is proposed to be a Major Station with a larger shelter and additional features, such as lighting, a bike rack, a second bench, and a trash receptacle. All of the eastbound stations and all but one of the westbound stations attract sufficient boarding ridership to be Standard Stations; however, the location on Route 1 opposite Fairfax Street does not appear to have room for a shelter and would therefore be a Minor Station. The eastbound stop on Route 1 at Tuthill Street is proposed to be a Minor

Table 18-8: West Haven Capital Improvements

Station Location	Station Type	Notes	Est. Station Cost	Pedestrian Improvement Est. Cost
Eastbound Stations				
ORANGE AVE & TUTHILL ST	Standard		$45,000	$15,600
ORANGE AVE & OPP FAIRFAX ST	Minor	No room for shelter	$20,000	$10,350
ORANGE AVE & OPP PRUDEN ST	Standard		$45,000	$0
ORANGE AVE & OPP ADMIRAL ST	Standard		$45,000	$0
Westbound Stations				
ORANGE AVE & ADMIRAL ST	Major	Move 100' east to make room for shelter	$88,000	$0
ORANGE AVE & PRUDEN ST	Standard	Move to far side	$45,000	$1,600
ORANGE AVE & FAIRFAX ST	Standard		$45,000	$0
ORANGE AVE & TUTHILL ST	Minor		$20,000	$12,100
Intersection Improvements	**Signal Owner**	**Notes**	**Est. Cost**	
Boston Post Rd and Campbell Ave	CTDOT	Transit Signal Priority	$12,740	

Station with no shelter, due to low ridership, but could be upgraded to a Standard Station if pedestrian improvements can be made to attract riders from the adjacent neighborhood around Meloy and Canton Streets.

The one intersection in West Haven proposed for TSP, Route 1 at Campbell Avenue, is also listed in Table 18-8.

18.2.4 *New Haven*

The proposed BRT stations in New Haven are listed in Table 18-9. All of the proposed stations in New Haven would be existing bus stops, none of which would need to be moved. All eight station locations in New Haven are on existing sidewalks, so no additional pedestrian improvements would be needed.

The eastbound station on Church Street at Chapel Street is assumed to be the end of the eastbound route where all riders would be expected to alight. Therefore, that location is designated as a Minor Station with no need for a new branded shelter. Conversely, the westbound station on Temple Street at Chapel Street (on the New Haven Green) would be the beginning of the westbound route and would be a Major Station with a larger shelter and additional features, such as lighting, a bike rack, a second bench, and a trash receptacle. The other six stations in New Haven would be Standard Stations.

The three intersections listed in Table 18-9 were identified as candidates for improvements. The City of New Haven is currently undertaking a project to replace traffic signal equipment, improve coordination timing, and implement TSP throughout the downtown area. While the improvements are expected to reduce bus travel times and delays in the downtown, the cost of these planned improvements are assumed borne by the city and therefore are not included in cost estimates for this project.

Table 18-9: New Haven Capital Improvements

Station Location	Station Type	Notes	Est. Station Cost
Eastbound Stations			
CONGRESS AVE & DAVENPORT AVE	Standard		$45,000
CONGRESS AVE & WEST ST	Standard		$45,000
CONGRESS AVE & HOWARD ST	Standard		$45,000
CHURCH ST & CHAPEL ST	Minor		$20,000
Westbound Stations			
TEMPLE ST & CHAPEL ST	Major		$88,000
CONGRESS AVE & HOWARD ST	Standard		$45,000
CONGRESS AVE & WEST ST	Standard		$45,000
CONGRESS AVE & DAVENPORT AVE	Standard		$45,000
Intersection Improvements	**Signal Owner**	**Notes**	**Est. Cost**
Church St and George St	New Haven	Transit Signal Priority (by City of New Haven)	$0
Church St and Chapel St	New Haven	Transit Signal Priority (by City of New Haven)	$0
Temple St and Chapel St	New Haven	Transit Signal Priority (by City of New Haven)	$0

18.2.5 *CTtransit New Haven Division*

The proposed limited stop BRT route in the corridor would require seven buses to operate during peak periods. Providing one spare bus means that eight additional buses would have to be added to the fleet at a typical cost of $425,000 per bus, including all standard CT*transit* add-on bus features (such as fareboxes, vehicle location system, radio, etc.).

The only other capital equipment that CT*transit* would need would be the emitters for communicating with the traffic signals to receive priority. At a minimum, the eight buses on the limited stop BRT route would have to be equipped. In addition, it was assumed that all buses operating in the corridor would also be equipped with emitters and be able to take advantage of TSP when needed. CT*transit* currently schedules 19 different vehicle blocks on the local O (Route 1), so as many as 19 local buses may have to be equipped. Adding the eight buses for the proposed limited stop BRT route would increase the total to as many as 27. A further 25% contingency was assumed to allow CT*transit* some flexibility in vehicle assignment, for a total of 34 TSP-equipped buses. While 34 TSP-equipped buses was assumed for estimation of costs for the corridor, in reality CT*transit* may want to consider equipping the entire New Haven Division fleet in anticipation of a more widespread implementation of TSP in the New Haven region.

18.2.6 *Capital Cost Summary*

The capital costs associated with instituting limited stop BRT service with enhanced stations and TSP capability in the O (Route 1) corridor are summarized in Table 18-10. The table includes the costs, detailed above, for stations and intersection improvements, plus capital costs for additional buses and

Table 18-10: O (Route 1) Corridor Summary of Estimated Capital Cost

Cost Category	Capital Cost*	Annualized Cost
Stations	$1,712,000	$133,237
Intersection Improvements	$64,000	$3,914
Buses (8)	$3,400,000	$321,503
TSP emitters (34)	$119,000	$11,253
TOTAL	**$5,295,000**	**$469,907**

*In 2016 dollars

for equipping all buses in the O (Route 1) corridor to support conditional TSP. Capital costs were annualized assuming a useful life of 12 years for buses and TSP emitters, 15 years for stations, and 20 years for intersection improvements, all assuming a 2% discount rate, per FTA guidance.

18.3 Implementation Challenges

Implementation of a limited stop BRT overlay service with enhanced stations and intersection improvements that would reduce travel times, improve service reliability, and increase ridership in the O (Route 1) corridor would require a significant amount of time for planning, design, procurement, and construction. Further planning is needed, including a detailed implementation plan that identifies a feasible timeline. Several factors that could influence the timing of implementation are listed here.

18.3.1 *New Haven Routing*

The routing in the City of New Haven was discussed at the expanded TAC meeting. The City of New Haven is currently evaluating transit and traffic circulation alternatives in the city and has suggested several possible alternate routes that could take advantage of proposed traffic circulation changes and provide service closer to Union Station, as well as provide for a more efficient routing to turn around at the New Haven end of the line. A final routing decision would have to be developed in conjunction with the city and any necessary changes to the street network made before BRT service could be implemented in this corridor.

18.3.2 *Station Development*

The 32 stations to be improved in the O (Route 1) corridor would be constructed at existing bus stops within the existing city or state-owned right-of way. However, there are many cases of stations where construction would be complicated by a need to relocate the stop or to complete additional construction to make them fully accessible. Four stations are proposed to be relocated to the opposite side of the intersection and the new location would need to be reviewed for impacts on traffic and on abutting properties. Sixteen stations would require additional construction of sidewalks and/or curb ramps. Construction of all stations and sidewalk improvements will require design, procurement of shelters and information displays, contractor procurement, and a phased construction schedule.

Construction of stations will require coordination among CTDOT, CT*transit* (New Haven Division), and the four municipalities. While local municipal involvement is expected in the final siting of stations, most stations would be located on state-owned right-of-way. However, local public works departments will need to be involved for any stations being installed on city-owned property.

18.3.3 *Signalization Upgrades to Support TSP*

The lead-time for implementation of signalization upgrades for TSP would need to be determined. Upgrades needed for the O (Route 1) corridor that could involve various lead times include:

- Controller replacement and addition of detectors at four CTDOT-owned signals
- Addition of a new signal head and modifications to signage and pavement markings to accommodate a possible queue jump at Racebrook Road
- Implementation of City of New Haven proposals for signal improvements, possibly including TSP, as well as changes to traffic circulation

Each of the seven intersections where improvements are proposed would require an intersection operational analysis to determine the impact on traffic and to develop optimal signal timings. Proposed improvements would also require approvals from the OSTA and from CTDOT Highway Operations. Implementation of TSP will also require coordination among CTDOT, City of New Haven, and CT*transit* (New Haven Division).

18.3.4 *Bus Procurement*

Even implementing just the service elements, operating the limited stop service with no station or intersection improvements, would still require the purchase of additional buses. Bus procurement, following mandated federal procedures, can take up to 18 months once funding has been identified.

18.3.5 *Implementation of AVL*

CTtransit New Haven Division is still in the early stages of implementing the Trapeze AVL System. A working AVL system is essential for implementing the real-time information aspects of a BRT project, as well as implementing TSP.

18.3.6 *Integration of CTtransit AVL with TSP*

In order to take advantage of the TSP at selected intersections, CT*transit* will need to equip a sufficient number of buses with emitters and integrate the emitters with their Trapeze AVL system. That system is capable of supporting TSP although the level of effort and time needed to activate the system for conditional TSP still needs to be determined. Emitters will require procurement and installation.

18.3.7 *Maintenance Responsibilities*

Several elements of the improvements would require occasional ongoing maintenance. CT*transit* would be responsible for maintaining the buses and the on-board emitters. At CTDOT-owned signals CTDOT maintains the signals but the municipality maintains the optical detectors and phase selectors. CT*transit* operations would be dependent on the city and state maintaining the system at each intersection. Responsible parties for cleaning and maintaining the stations, including real-time information displays, would also need to be identified.

18.3.8 *Funding*

Funding sources would need to be identified for both the capital and operating costs of the improvements. Timing of implementation would have to take into account application schedules for various potential funding sources as well as state and local budget cycles.

19. Longer Term Improvements

BRT is typically defined as a combination of a number of elements that together create a bus transit service with the speed, frequency, comfort, and capacity characteristics of rail transit. A full implementation of BRT is considered to consist of the following eight elements:

- **Running Ways** - either full or partial exclusive right-of-way
- **Stations** – widely spaced distinct branded facilities with travel information, customer amenities, and level boarding
- **Vehicles** – distinct vehicle design that conveys the image and brand of the system
- **Fare Collection** - fares collected off-board to speed the boarding process
- **Real-time Information** – in station displays, online, and via mobile devices
- **Transit Signal Priority (TSP)** – technology that provides priority for transit vehicles at signalized intersections
- **Service and Operating Plans** – frequent service, including nights and weekends, and longer spacing between stops
- **Branding** – a unique, unified brand that is easily distinguished from other bus services

This study focused on short-term improvements to services, facilities, and technology that could bring elements of Bus Rapid Transit to the Route 1 corridor within the next five years. The study focused on the service and operating plan, stations, real-time information, and a limited application of TSP at key locations in the corridor. The proposed improvements are expected to result in shorter travel times and better reliability than is currently achieved by the existing local routes. Over the longer term, however, additional improvements implementing all of the elements of BRT are possible, leading to an even more robust implementation of BRT in the corridor. Some possible future enhancements are discussed in this section.

TSP Expansion

The initial implementation of TSP at a few select intersections in each corridor segment should address many of the currently observed delay and reliability issues. However, expansion to additional locations over time could also prove beneficial. If additional locations begin to experience more significant delays, TSP could be expanded to those locations at relatively low cost. At most CTDOT-owned signals, the signal controller would have to be upgraded in order to implement TSP, but as the older controllers are replaced, TSP could be incorporated as part of the replacement project. Many of the municipally owned signals are already capable of accommodating TSP. As a result, the cost per additional intersection could be quite low. Even if buses typically do not experience significant delays on a regular basis at a particular location, implementing TSP at additional locations could provide reliability benefits on those less common occasions when more significant delays do occur.

Bus Lanes

Other than several possible queue jump locations, bus lanes, either exclusive or shared, were generally not included as part of the recommended corridor improvement programs. However, as any future corridor studies are completed for sections of the corridor, consideration should be given to the inclusion of exclusive or shared (BAT) lanes as part of any Complete Streets improvement project. Taking into account all users of the roadway will result in more efficient operations and can recognize the benefits to users of higher occupancy vehicles such as buses.

Increased Service

The recommended limited stop BRT services are proposed to operate at the same frequency as the existing local bus service. This is expected to result in increased ridership in the corridor, although with fewer riders per trip. However, if the improved service generates additional ridership, the frequency could be increased to meet demand and to attract yet more riders. The recommended services were also proposed to operate only on weekdays for 14 hours a day. The services could eventually be extended to nights and weekends to provide the benefits of shorter travel times to riders at those times.

Longer Routes

This study considered the possibility of running the BRT service as longer routes combining two or more corridor segments. While longer bus routes tend to be more subject to fluctuations in travel time and, as a result, can be less reliable, the limited stop service plan and implementation of TSP can be expected to result in a more reliable service, thus making make longer routes a possible future option for the corridor. Longer routes could provide a one-seat ride between New Haven and Bridgeport, or between Bridgeport and Stamford, creating new, more convenient options for bus riders in the corridor.

Off-Board Fare Collection

Fare collection strategies to speed boarding were examined as part of this study but the moderate expected passenger boarding volumes and the cost of proof-of-payment fare collection were not found to support the implementation of off-board fare collection at this time. Future advances in payment technology, however, may result in new methods of fare payment that could minimize boarding times. Such advances should be evaluated for implementation in this and other high-ridership corridors.

Branding

As service frequency is improved and service made more reliable, the new services could be given a distinct brand identity to further aid in distinguishing them from the local services which would serve a different market niche. Branding of the service would require an effort to develop a clearly defined value proposition for the service in additional to dedicated marketing and inclusion of identifying features in the stations and on vehicles.

Dedicated Vehicles

Part of the branding effort could involve a dedicated fleet of vehicles to provide the service that are clearly identified as BRT vehicles, either through colors, logos, or a completely different vehicle type. However, dedicated vehicles typically increase operating costs due to the need to keep them separate from the regular bus fleet.

Pedestrian Improvements

Though not specifically a feature of BRT, improved pedestrian connections to the stations will make the service more attractive to potential riders. While pedestrian access to the nearest sidewalk or intersection was included in the station proposals, in many cases much more is needed to provide safe and convenient access for all users within walking distance of the stations. Along Route 1, this could be done through a Complete Streets project in areas where sidewalks and crosswalks are lacking. However, in many places, the need extends beyond Route 1 itself into the adjacent neighborhoods where there are no sidewalks for potential riders to get to the stations on Route 1.

TASK ORDER PUBLIC TRANSPORTATION SERVICES

CORE ID. No. 15DOT0090AA

Route 1 Bus Rapid Transit Feasibility Study

STATE PROJECT NO. 173-471

Appendices

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Appendices

Appendix A – Summary of Findings and Recommendations from Prior Studies

US ROUTE 1 CORRIDOR BRT STUDY - RELATED PROJECTS, STUDIES, AND INITIATIVES

TITLE	DESCRIPTION	OWNER / INITIATOR	AUTHOR	COMPLETION DATE	SOURCE	KEY FINDINGS/RELEVANCE TO US ROUTE 1
Greenwich/Norwalk Bus Rapid Transit Study: Final Report	This study looked at the feasibility of bus rapid transit service in the U.S. Route 1 corridor between Greenwich and Norwalk, and reviewed existing transit and traffic operations in the corridor.	South Western Regional Planning Agency	AECOM Transportation & TranSystems	June 2009	http://66.165.136.235/default.aspx?Transport=247	Preferred Route Concepts Recommended: • Stamford: Enhanced Bus Service (EBS) alignment following Tresser Blvd inbound & Broad St outbound • Darien: EBS and local service follow Boston Post Rd contingent on traffic improvements including queue bypass each direction on Rt 1 approaching Metro North railroad underpass • Norwalk - realignment of the local CT Transit RT 41 service & proposed EBS between the Norwalk WHEELS Hub and U.S. RT 1. ○ The modified alignment would use West Ave., Reed St., and Fairfield Ave. before rejoining US RT 1 New station locations are recommended for EBS service along CTtransit Rt 41 including five in Norwalk, two in Darien, and six in Stamford, many of them along RT 1, with a proposed EBS Service Plan: • Initial implementation weekdays between Stamford Transportation Center & Norwalk WHEELS Hu ○ 6am-7pm M-F, 30 Minute Peak, 40 minutes off-peak ○ Route 41 operates on normal route with 30 Minute Peak, 40 minutes off-peak service ○ Route 41Bx operates as full round trip ○ Route 11A bypasses Greenwich Railroad Station ○ Increased trip frequency on Route 41 Roadway Improvements • Parking restrictions during peak hours on Route 1 N.B. (Day St.-Center St., Center St.-Tokeneke Rd) • Auxiliary right-turn lane, used as a queue jump lane for buses (Tokeneke Rd.) • Existing right-turn lane at West Ave as an aux. queue jump lane • Remove or prohibit peak hour parking on Route 1 S.B. between Sedgewick Ave and West Ave • Advanced bus preemption phase for buses on Route 1 at Tokeneke Rd and West Ave • Preemption devices at 3 signalized intersections
HART Bus Service Plan	This plan outlined the current conditions and future plans for bus service provided by the Housatonic Area Regional Transit District	Housatonic Area Regional Transit District	Housatonic Area Regional Transit District	March 2010	https://westcog.org/bus/	Future Regional Improvements • Danbury-Norwalk Route 7 LINK (jointly operated by HART and WHEELS [Norwalk]) • Current operations: Hourly service M-F 6am-12pm, 3pm-730pm. Provided connection to Coastal Link or CTtransit route • Ridership Average: 230 trips per day • Future service should be provided throughout the day on weekdays. • Creation of a new Danbury-Bridgeport bus route via Routes 6 and 25. • Proposal was for a three bus service during weekday peak times operated jointly by GBTA and HART Goals • Hourly service on all Weekday/Saturday Routes between 6am-9pm • Hourly Sunday service on all routes except Route 7 between 9am-4pm • Provide buses throughout the weekday on the 7 LINK and initiate a similar service between Danbury and Bridgeport • Develop Employer-based Bus Transit Service • Continued support of road widening projects on Route 7 and Route 6

US ROUTE 1 CORRIDOR BRT STUDY - RELATED PROJECTS, STUDIES, AND INITIATIVES

TITLE	DESCRIPTION	OWNER / INITIATOR	AUTHOR	COMPLETION DATE	SOURCE	KEY FINDINGS/RELEVANCE TO US ROUTE 1
U.S. Route 1: Greenwich/Stamford Operational Improvements Study	The purpose of this study is to develop a coordinated plan to improve traffic operations on Route 1, improve pedestrian safety, manage access, accommodate transit, and enhance the corridor's economic potential.	South Western Regional Planning Agency	Urban Engineers, Inc., Fitzgerald & Halliday, Inc.	August 2010	http://www.ct.gov/dot/lib/dot/documents/dpolicy/rt1grnwchstmfd/us1_greenwich-stamford_study_final_report_v1.pdf	Action Plans Include: • All Sections o Retime and coordinate signals using Synchro o Adaptive signal technology • West Stamford o Realign Richmond Hill Ave intersection o Implement 2/1 hybrid lane roundabout at Rt 1 and West Main o Implement single lane roundabout at Rt 1/Alvord Ln o Create consistent roadway cross section from W. Main Street/Greenwich Avenue through Havemeyer Lane • Downtown Greenwich o Intersection bulb-outs between Dearfield and Maple o Pedestrian accommodations at Maher/Millbank/Maple • Riverside o Improve Exit 5 by modifying existing ramps and connecting Neil Lane to Sound Beach Ave o Reconfigure Route 1 between Neil Lane and Sound Beach Ave o Replace Neil Lane and Sound Beach Ave signals with roundabouts o Implement Road diet from Havemeyer Lane to Rockmere Ave, with bicycle lanes • Byram o Road diet from State Line to Brookside Dr. with bike lanes o Reconfigure Byram Circle • Cos Cob: o Redevelop Rt 1 at Sinawoy Road o Implement road diet & bulb outs in Cos Cob between Orchard Street & River Road, Road Diet from Old Church Road to Sinawoy Rd
Norwalk Transportation Management Plan	A comprehensive Transportation Management Plan for the City of Norwalk that provides a clear guide for the future of the City's overall transportation system including guidelines on how to: Increase efficiency and safety on Norwalk roadways; Develop consistent transportation plans and policies across all levels; Evaluate and prioritize the value of transportation investment; Provide clear guidance on policies as related to future growth.	Town of Norwalk	Vanasse Hangen Brustlin, Inc., Fuss & O'Neill, Walkable and Livable Communities Institute, Inc., Helen Neuhaus & Associates, Inc.	June 2011	http://projects.vhb.com/norwalktmp/documents.asp	Transit • Performing a comprehensive review of commuter bus service (especially connections with Metro North) • Study the feasibility of operational improvements such as queue jump lanes, Transit Signal Priority (TSP), and access to highway shoulders for buses • Improvement of amenities at all bus stops, including real time bus system information • Development of intermodal connections • Better serve riders by evaluating regional coordination of local routes and intraregional trips to work. Roadway • Develop specialized signal timing programs • Emergency/incident guide signs Study included "demonstration" intersections and corridors including: • Corridor 1: West Rocks Road/France Street/Park Street • Corridor 2: Washington St/Fairfield Ave • Intersection 1: West Ave at Belden Ave/Mott Ave • Intersection 2: Taylor Ave at Flax Hill Rd • Intersection 3: Flax Hill Rd at Rowayton Ave and Richards Ave • Intersection 4: Route 53 at Dry Hill Rd and Murray St • Intersection 5: Route 123 at Bartlett Ave and Ells St

US ROUTE 1 CORRIDOR BRT STUDY - RELATED PROJECTS, STUDIES, AND INITIATIVES

TITLE	DESCRIPTION	OWNER / INITIATOR	AUTHOR	COMPLETION DATE	SOURCE	KEY FINDINGS/RELEVANCE TO US ROUTE 1
Coastal Corridor Bus Study: Recommended Service Plan	The study examined local bus services in the U.S. Route 1 corridor (the "Coastal Corridor") between Port Chester, New York and Madison, Connecticut. The purpose of the study was to evaluate existing bus services, assess travel markets and characteristics of bus riders, identify strengths and weaknesses in regional mobility, and provide recommendations for improvements.	Norwalk Transit District, South Western Regional Planning Agency	AECOM Technical Services, Inc.	May 2012	http://66.165.136.235/Default.aspx?Transport=257	The report recommends that emphasis be placed on improving on-time performance, more effectively coordinating transfers, increasing public information, and awareness through marketing and branding, improving localized traffic operations, and reevaluating trip patterns including the potential for an express/limited stop service. Preferred recommendation • Improve local services • increase frequency • increase hours of operation Recommended Plan: • Underlying local service (7 days per week, throughout the day) ○ Route 11B: Port Chester-Stamford ○ Route 41: Stamford-Norwalk ○ Abridged Coastal Link: Norwalk-Bridgeport ○ New Coastal Link: Bridgeport-New Haven (including Route O) Route F: New Haven-Branford • Limited-stop/express services ○ Streamlined Route 11A: Port Chester-Stamford (all day, weekdays) ○ Limited-stop overlay: Norwalk-Bridgeport (weekday peaks) ○ Limited-stop overlay: Bridgeport-New Haven (including Route 55x) ○ Extension to Hamden via Dixwell Ave (weekday peak, weekend afternoon) ○ Express Route S: New Haven-Guilford, Madison on weekdays ITS • Near term recommendations for increased efficiency ○ Bus Signal Priority (BSP) and queue jumps ○ Real time arrival/departure information & AVL • Implementation of BSP and other ITS at 4 key locations: ○ U.S. Route 1 at Benedict Place (Greenwich) ○ Atlantic Street between Tresser Blvd and Broad Street (Stamford) ○ U.S. Route 1 between Keeler St and Rampart Rd (Norwalk) ○ Belden Ave between Van Buren Ave and Cross St (Norwalk)

US ROUTE 1 CORRIDOR BRT STUDY - RELATED PROJECTS, STUDIES, AND INITIATIVES

TITLE	DESCRIPTION	OWNER / INITIATOR	AUTHOR	COMPLETION DATE	SOURCE	KEY FINDINGS/RELEVANCE TO US ROUTE 1
Route 1 Corridor Study: Final Report	A comprehensive transportation plan for US Route 1 (Boston Post Road) in Darien that will: provide improved mobility, accessibility, and safety for all users; incorporate land uses and development strategies that support the transportation system. The study evaluated conditions in the study area relative to vehicular and multimodal safety, mobility, and accessibility. The study also considered future Downtown development opportunities and forecasted the potential traffic and parking demands associated with those opportunities.	South Western Regional Planning Agency	Clough Harbor & Associates LLP	January 2013	http://66.165.136.235/default.aspx?Transport=198	• Insufficient roadway width between Noroton Avenue and Rings End Road to accommodate on-street parking and four travel lanes; no delineation of on-street parking stalls; a general lack of lane definition, particularly north of Sedgwick Avenue; and poor intersection geometry at the Old Kings Highway South and the I-95 Interchange 11 northbound on-ramp intersections with Route 1. • Peak travel periods cause the longest delays and traffic backups at the West Avenue, Mansfield Avenue, and Sedgwick Avenue intersections, particularly in the southbound direction. • Opportunities to enhance the convenience of using transit in the corridor including better amenities at key bus stops; improved commuter parking and rail station information; and better connections between modes. • More than 300 accidents were recorded in the study corridor during 3 yr. period, most were rear-end and sideswipe collisions and nine involved pedestrians. • Limited vertical clearance at the Metro-North railroad underpass with high frequency of truck collisions Specific Locations for improvements include: • Nearwater Lane to Noroton Avenue • Noroton Avenue to Rings End Road • Rings End Road to Hecker Avenue • Hecker Avenue to I-95 Interchange 11 • Ledge Road to Leroy Avenue • Corbin Drive to Day Street • Day Street to Sedgwick Avenue • Sedgwick Avenue to Brookside Road • Brookside Road to Old Kings Highway North
Stamford East Main Street Transit Node: Feasibility Report & Action Plan	This study examines the possibility of a transit node at East Main Street by providing a plan to develop a viable transit option and development scenario that generates the community and political support needed to implement these changes.	South Western Regional Planning Agency	Parsons Brinckerhoff	November 2013	http://www.sustainablenyct.org/docs/EastMainStTransitNodeReport_FINAL_LowQuality.pdf	Focuses on the Utilization of the Stamford Urban Transitway Bus Station Option: • Premium bus system: branded, well designed, comfortable • Attractive stations: well lit, safe, routinely maintained, real time travel information 2 possible Routes: • Between East Main Street and STC ○ Out of STC via State Street, return to STC via Urban Transitway ○ Out of STC via downtown, return to STC via Urban Transitway ○ 5 to 10 minute frequency during peak periods ○ 7 minute run time ○ Cost similar to other local CTtransit services ($1.30) Traffic mitigation through the rerouting of North State Street Maintain high LOS (A-C throughout the study area) The study also recommends the route improvements via the implementation of frequent service during AM and PM peak service, approximately every 5-10 minutes to improve reliability, while also utilizing a bus signal priority system that could lower trip time by up to 7 minutes.

US ROUTE 1 CORRIDOR BRT STUDY - RELATED PROJECTS, STUDIES, AND INITIATIVES

TITLE	DESCRIPTION	OWNER / INITIATOR	AUTHOR	COMPLETION DATE	SOURCE	KEY FINDINGS/RELEVANCE TO US ROUTE 1
Westport Bus Operations and Needs Study: Final Report	The study assessed current operations to develop an updated service and administrative plan for Westport Transit District bus services including fixed route services to the two Westport rail stations, ADA paratransit, and services for the elderly.	South Western Regional Planning Agency / Westport / CTDOT	AECOM	January 2015	https://westcog.org/wp-content/uploads/2015/09/WestportWestport-BusWestport-Final-Report_1-14-15-doc.pdf	Norwalk Transit District (NTD) provides bus service in Westport through an agreement with the Town of Westport. NTD has operated the Westport bus services since 1992. Two types of services are provided: fixed route and ADA elderly demand response. Recommendations include changes to existing service, new route proposals, and a staffing addition at NTD. The route changes and proposals are meant to enhance bus service for existing customers, attract new riders, and reduce demand for station parking. Six Westport commuter routes connect with MTA Metro-North Railroad New Haven Line at Westport (Saugatuck) Station and Greens Farms Station. Service is provided in the morning and evening peak periods. There is no mid-day service. If Westport continues its current service agreement with the NTD, the fixed route services will be enhanced by implementation of an Automated Vehicle Location (AVL) system, which NTD will be testing in a pilot program beginning in December 2014. Specific recommendations include: • extend hours of operation of existing Westport Commuter Route on AM and PM service by one hour • new midday Circulator between Saugatuck Station and downtown *operating plans for new services were not developed as part of this study
Going Forward: The Plan to Maintain & Improve Mobility – South Western Region Long Range Transportation Plan 2015-2040	The goals of this plan are aimed at providing safe, efficient, cost effective, reliable, and balanced multimodal transportation systems that promote mobility, access, and choice by optimizing investment in transportation systems to meet the needs of users while promoting responsible land use that is linked to the transportation network.	South Western Region Metropolitan Planning Organization	Western Connecticut Council of Governments	May 2015	https://westcog.org/wp-content/uploads/2015/12/LRTP-Update-2.pdf	• Extend service hours on busiest weekday routes in region with possibility of converting evening and weekend shuttles to regular service routes, Increase the frequency of Coastal Link Service • Increase service on CT Transit Route 41 • Expand the hours of commuter shuttles, • Implementation of a bus right of way system Darien • Traffic Flow Improvements: Corbin Dr & Center St. Greenwich • Greenwich Ave signal system upgrade • CMAQ Traffic signal upgrade • Route 1 Greenwich Stamford Study Implementation Norwalk • New Route: West Ave Transit Circulator • New Stop: South Norwalk Intermodal Facility Design/Construction • Route 1-Connecticut Ave signal improvements • Intersection Improvements: US1 at CT53 • CMAQ traffic signal upgrades at 10 locations Stamford • Urban Transitway completion • STC: Parking Garage Replacement, Parking Study, Improvements Study, Master Plan • Widening of Atlantic St • Reconstruction/Roadway improvements: Greenwich Ave/W Main St • Intersection Improvements: Main St/Summer St • Stamford real time traveler info and TSP • Rehabilitation of US1 bridge over I-95 Westport • Downtown parking study • Intersection improvements: Rt 136/Bayberry Ln, CT57/CT33, US1/CT33, CT33/Riverside, CT136/Clinton Ave

US ROUTE 1 CORRIDOR BRT STUDY - RELATED PROJECTS, STUDIES, AND INITIATIVES

TITLE	DESCRIPTION	OWNER / INITIATOR	AUTHOR	COMPLETION DATE	SOURCE	KEY FINDINGS/RELEVANCE TO US ROUTE 1
Downtown Westport Master Plan	The purpose of the study was to serve as a guide for future public and private investments in Downtown Westport by addressing key aspects such as Character and Design, Land Use and Development, Open Space, Public Works, Streetscapes, and Traffic and Parking.	Town of Westport	The RBA Group of Connecticut	June 2015	http://downtownwestportct.com/	Recommendations include: • Traffic Signal Modifications at Post Rd intersection • Route 1/Route 33 Intersection traffic flow improvements • Support initiatives to connect downtown through transit • Public transit amenities • Redesign Main St/Elm St & Myrtle Ave intersections • Redesign Taylor Pl into a shared street • Create a new street: Library Lane • Imperial Ave parking lot bridge • Jesup Rd Redesign • Real-time parking info system

Greater Bridgeport Transit Long Range Transit Plan	The goals of this plan include increasing service in high ridership areas, responding to community requests for more or different bus services delineate improvements necessary to implement BRT and regional services, address infrastructure and operational changes needed for new service, and consider land use changes that impact bus transit.	Greater Bridgeport Transit, Greater Bridgeport Regional Council	Stantec	September 2015	http://www.slideshare.net/goGBT/gbt-long-range-transit-plan-92315	The scope of this study focused on the Greater Bridgeport area and the improvement of its transit services. Themes for improving service in the area includes: more service, higher levels of service, building a system for the future and improving connections and access.
						
						Specifically, the study recommends that fulfilling the last two themes entailed improving limited stop/express service and regional connectivity, while at the same time improving access at the local level through improved streetscapes and TOD communities. The study concludes that BRT systems and technology (i.e. enhanced stops, AVL/APC systems, real-time info, etc.) would be beneficial to the Greater Bridgeport area.
						
						Proposed Routes:
						• Split Coastal Link into East and West that meet at the GBT Transit Station. Coastal Link East follows Route 1, continuation to New Haven
						• Realignment of Coastal Link to Barnum Ave, intersection improvement at Barnum Ave/E Main St
						• Proposed new Stratford Station
						• Realignment of Route 7 and Route 5/Extension of Route 5 through the GBT Transit Station, with new Facility on Bond St
						• Intersection Improvements at Black Rock Tpk/Canfield Ave, Black Rock Tpk/Fairfield Ave
						• Proposed creation of 2 new routes, Route 24 and Route 27
						
						BRT Routes:
						• Coastal Link East: GBT Transit Station > The Dock Shopping Centre > New Haven (with new Stratford Station)
						    ○ Required intersection improvements at E Main/Barnum
						• Coastal Link West: GBT Transit Station > Norwalk
						    ○ Required intersection improvement at Fairfield/Black Rock Tpk
						• Route 8: GBT Transit Station > Westfield-Trumbull
						
						Frequent Routes:
						• Route 10: Spans between two new proposed bus interchange facilities via GBT Transit Station (Stratford Station and Black Rock Tpk/Stillson Rd)
						• Route 13 and Route 18 serving Uni. of Bridgeport to new interchange facility at Bond St, via GBT Transit Station
						• Route 9 service between GBT Transit Station and Hawley Lane Mall (required intersection improvements at E Main/Barnum and E Main/Arctic

US ROUTE 1 CORRIDOR BRT STUDY - RELATED PROJECTS, STUDIES, AND INITIATIVES

TITLE	DESCRIPTION	OWNER / INITIATOR	AUTHOR	COMPLETION DATE	SOURCE	KEY FINDINGS/RELEVANCE TO US ROUTE 1
Stamford West Side Transportation Study	This study is aimed at providing actions to be put into motion by the City of Stamford to complement and augment current the current development program along Stillwater Avenue in the city's west side.	City of Stamford	Fitzgerald & Halliday, Inc.	Oct. 2015	http://www.stamfordct.gov/sites/stamfordct/files/uploads/westside_recguidebook_final1_oct2015.pdf	The recommended goals include a number of transportation related recommendations including improving intra-city mobility, connectivity, and streetscapes. Specific recommendations include: • Intersection improvements and reconfigurations • Lane improvements • Transit stop enhancements • Increase bus transit ridership by ○ Reducing stop frequency ○ Providing enhanced shelters with passenger amenities at high boarding stops ○ Providing real time bus information ○ Offering bi-directional service Specific Transportation Goals: • Modify Boxer Square • Streetscape Improvements: Stillwater Ave, West Ave, Richmond Hill Ave, W Main St • Intersection Improvements: Diaz/Route 1, Route 1/West Ave • Realign Richmond Hill Ave • Build new connection from Progress Dr to Myano Ct, Catoona Ln to Acosta St • Provide "distinctive shuttle service during select times to West side"
Stamford Bus and Shuttle Study	The purpose of this study is to complete an evaluation of current bus and shuttle operations in the city and will develop strategies to enhance components of the urban transit and transportation network including CTtransit services, roadway operations, connectivity improvements, and access to the STC hub.	CTDOT	FHI	On-going	http://stamfordbusandshuttle.com/index.php	While this study is currently ongoing, it has already provided valuable information from the community perspective in terms of what they would like to see. Businesses in the Greater Stamford area identified bus service as an important amenity that attracts potential employees, and has become an operational necessity in the area, though there are concerns over congestion at the Stamford Transportation Center and how it affects service efficiency and reliability. Riders identify that the bus service in the area is important as a cost effective method of transportation though concerns over safety, reliability, and commute times were prevalent. The study itself has not yet proposed any specific recommendations, improving reliability by reducing congestion in, and around, the STC seem to be key areas to focus on.

Appendix B – Bus Sampling Plan and Dates Checked

Route 11A/11B - "PORT CHESTER"

Run Number	Westbound			Eastbound			Date Completed
	Route	Leave Stamford Transp. Center	Arrive Port Chester	Route	Leave Port Chester	Arrive Stamford Transp. Center	
46	11A	6:10 AM	6:53 AM	11B	7:04 AM	7:50 AM	5/2/2016*
47	11A	6:45 AM	7:23 AM	11B	7:39 AM	8:25 AM	5/4/2016
48	11A	7:20 AM	7:58 AM	11B	8:09 AM	8:55 AM	5/11/2016
49	11A	7:20 AM	7:58 AM	11B	8:09 AM	8:55 AM	5/12/2016
50	11A	8:00 AM	8:38 AM	11B	8:54 AM	9:40 AM	5/2/2016
51	11A	9:00 AM	9:43 AM	11B	9:54 AM	10:45 AM	5/23/2016
52	11A	9:55 AM	10:42 AM	11B	10:54 AM	11:45 AM	5/11/2016
53	11A	11:50 AM	12:37 PM	11B	12:54 PM	1:45 PM	5/2/2016**
54	11A	12:50 PM	1:37 PM	11B	1:49 PM	2:40 PM	5/4/2016
55	11A	1:50 PM	2:37 PM	11B	2:49 PM	3:40 PM	5/11/2016
56	11A	3:20 PM	4:07 PM	11B	4:25 PM	5:20 PM	5/2/2016
57	11A	3:20 PM	4:07 PM	11B	4:25 PM	5:20 PM	5/12/2016
58	11A	4:10 PM	5:01 PM	11B	5:15 PM	6:10 PM	5/4/2016
59	11A	4:50 PM	5:41 PM	11B	6:05 PM	7:00 PM	5/11/2016
60	11A	4:50 PM	5:41 PM	11B	6:05 PM	7:00 PM	5/23/2016

* some missing data for westbound trip

** some missing data for eastbound trip

Route 41/41A - "STAMFORD/NORWALK"

Run Number	Eastbound			Westbound			Date Completed
	Route	Leave Stamford Transp. Center	Arrive Norwalk WHEELS Hub	Route	Leave Norwalk WHEELS Hub	Arrive Stamford Transp. Center	
31	41	5:25 AM	6:07 AM	41	6:10 AM	6:55 AM	5/3/2016
32	41	5:55 AM	6:43 AM	41	6:50 AM	7:25 AM	5/5/2016
33	41	6:20 AM	7:08 AM	41	7:10 AM	7:55 AM	5/10/2016
34	41	6:45 AM	7:33 AM	41	7:50 AM	8:35 AM	5/9/2016
35	41	7:55 AM	8:43 AM	41	9:05 AM	9:50 AM	5/3/2016
36	41A	9:25 AM	10:21 AM	41	10:26 AM	11:15 AM	5/5/2016
37	41A	11:20 AM	12:16 PM	41	12:26 PM	1:15 PM	5/10/2016
38	41A	11:20 AM	12:16 PM	41	12:26 PM	1:15 PM	5/9/2016
39	41A	12:20 PM	1:16 PM	41	1:26 PM	2:15 PM	5/3/2016
40	41A	1:50 PM	2:46 PM	41A	2:50 PM	3:45 PM	5/5/2016
41	41	2:45 PM	3:35 PM	41A	3:50 PM	4:45 PM	5/10/2016
42	41	3:25 PM	4:15 PM	41A	4:30 PM	5:26 PM	5/3/2016
43	41	4:25 PM	5:17 PM	41A	5:24 PM	6:20 PM	5/5/2016
44	41	4:25 PM	5:17 PM	41A	5:24 PM	6:20 PM	5/9/2016*
45	41	5:25 PM	6:17 PM	41A	6:39 PM	7:35 PM	5/10/2016

* Slightly earlier trip erroneously checked on 41A EB/41 WB. Data excluded from travel time and delay time measurements but not from delay counts or signal delays.

Coastal Link (from NORWALK)

Run Number	Operator	Eastbound Leave Norwalk WHEELS Hub	Eastbound Arrive Connecticut Post Mall	Westbound Leave Connecticut Post Mall	Westbound Arrive Norwalk WHEELS Hub	Date Completed
23	NTD	5:50 AM	7:43 AM	7:50 AM	9:45 AM	5/12/2016
24	NTD	6:30 AM	8:23 AM	8:30 AM	10:25 AM	5/16/2016
25	GBTA	6:50 AM	8:43 AM	8:50 AM	10:45 AM	5/17/2016
26	GBTA	10:50 AM	12:43 PM	12:50 PM	2:45 PM	5/12/2016
27	MT	11:50 AM	1:43 PM	1:50 PM	3:45 PM	5/19/2016
28	GBTA	2:50 PM	4:43 PM	4:50 PM	6:45 PM	5/17/2016
29	NTD	3:30 PM	5:23 PM	5:30 PM	7:25 PM	5/12/2016
30	MT	3:50 PM	5:43 PM	5:50 PM	7:45 PM	5/16/2016

Coastal Link (from MILFORD)

Run Number	Operator	Westbound Leave Connecticut Post Mall	Westbound Arrive Norwalk WHEELS Hub	Eastbound Leave Norwalk WHEELS Hub	Eastbound Arrive Connecticut Post Mall	Date Completed
16	MT	5:50 AM	7:45 AM	7:50 AM	9:43 AM	5/12/2016
17	MT	6:30 AM	8:25 AM	8:30 AM	10:23 AM	5/17/2016
18	GBTA	6:50 AM	8:45 AM	8:50 AM	10:43 AM	5/23/2016
19	GBTA	10:50 AM	12:45 PM	12:50 PM	2:43 PM	5/12/2016
20	GBTA	2:50 PM	4:45 PM	4:50 PM	6:43 PM	5/23/2016
21	MT	3:30 PM	5:05 PM	5:30 PM	7:03 PM	5/23/2016
22	NTD	3:50 PM	5:45 PM	5:50 PM	7:43 PM	5/24/2016

Route O - "Route 1"					
	Westbound		**Eastbound**		
Run Number	**Leave New Haven (Temple & Chapel)**	**Arrive Connecticut Post Mall**	**Leave Connecticut Post Mall**	**Arrive Downtown New Haven**	**Date Completed**
1	6:00 AM	6:34 AM	6:42 AM	7:18 AM	5/10/2016
2	6:45 AM	7:19 AM	7:29 AM	8:09 AM	5/5/2016
3	7:05 AM	7:45 AM	7:55 AM	8:35 AM	5/9/2016
4	7:40 AM	8:20 AM	8:30 AM	9:10 AM	5/2/2016
5	8:20 AM	9:00 AM	9:10 AM	9:53 AM	5/10/2016
6	10:00 AM	10:44 AM	10:50 AM	11:33 AM	5/5/2016
7	11:00 AM	11:44 AM	11:50 AM	12:33 PM	5/4/2016
8	12:00 PM	12:44 PM	12:50 PM	1:33 PM	5/2/2016
9	1:00 PM	1:44 PM	1:50 PM	2:33 PM	5/5/2016
10	2:10 PM	2:58 PM	3:10 PM	3:57 PM	5/4/2016
11	3:05 PM	3:53 PM	4:00 PM	4:47 PM	5/10/2016
12	3:50 PM	4:38 PM	4:48 PM	5:35 PM	5/11/2016
13	4:20 PM	5:03 PM	5:31 PM	6:20 PM	5/4/2016
14	5:00 PM	5:43 PM	6:01 PM	6:50 PM	5/9/2016
15	5:15 PM	5:58 PM	6:28 PM	7:10 PM	5/2/2016

Appendix C – Segment Level Bus Speeds and Travel Times

Route 11B - *Eastbound*

Segment & Period	Average Speed (mph)	Average Travel Time	Average Delay Time	Average Stopped Time	Average Number of Stops
Port Chester (Metro-North) - North Main & Westchester to Hamilton & Armstrong					
AM	10.5	8.9	3.1	3.3	8.3
MID	16.0	5.7	2.1	0.9	3.3
PM	12.7	7.4	3.1	1.7	5.2
Hamilton & Armstrong to Greenwich (Metro-North) on Railroad Ave					
AM	10.3	8.7	2.3	3.5	7.3
MID	12.9	7.1	2.3	1.9	6.0
PM	12.5	8.4	2.4	2.6	6.3
Greenwich (Metro-North) on Railroad Ave to Greenwich - East Putnam & Mason					
AM	9.9	5.8	2.1	2.0	7.0
MID	7.5	7.2	2.8	3.0	6.4
PM	7.3	7.3	3.0	2.9	7.3
Greenwich - East Putnam & Mason to Cos Cob - East Putnam & Mead					
AM	14.6	6.7	1.9	1.8	6.3
MID	11.3	8.6	2.3	3.4	6.8
PM	13.5	7.8	2.7	1.8	6.2
Cos Cob - East Putnam & Mead to Adams Corner - East Putnam & Sound Beach					
AM	15.0	5.8	1.4	1.9	5.3
MID	15.0	5.4	1.3	1.6	3.8
PM	11.6	7.4	2.4	2.5	6.3
Adams Corner - East Putnam & Sound Beach to West Main Street & West Avenue					
AM	14.2	4.7	1.5	1.4	4.5
MID	13.0	5.1	1.1	2.0	4.0
PM	9.7	6.7	1.9	2.8	5.3
West Main Street & West Avenue to Stamford Transportation Center					
AM	7.8	10.9	3.8	4.8	10.8
MID	9.7	8.8	3.1	3.1	8.2
PM	7.6	11.1	5.2	4.2	11.8

Route 11A - *Westbound*

Segment & Period	Average Speed (mph)	Average Travel Time	Average Delay Time	Average Stopped Time	Average Number of Stops
Stamford - Transp. Center Bay # 1 to West Main Street & West Avenue					
AM	8.3	7.9	3.5	2.7	7.0
MID	10.3	7.3	3.1	2.4	8.8
PM	7.4	8.3	3.6	3.0	9.2
West Main Street & West Avenue to Adams Corner - East Putnam & Sound Beach					
AM	23.2	3.6	1.2	0.6	3.8
MID	13.4	5.0	1.1	1.7	4.8
PM	10.6	6.1	1.7	2.3	6.0
Adams Corner - East Putnam & Sound Beach to Cos Cob East Putnam & Orchard					
AM	14.7	5.1	1.5	1.3	4.0
MID	14.8	5.5	1.5	1.5	5.0
PM	13.8	5.6	1.2	1.6	3.8
Cos Cob East Putnam & Orchard to Greenwich - Mason & E. Putnam					
AM	12.4	8.1	2.2	2.6	6.4
MID	14.2	7.0	1.7	2.1	6.6
PM	11.4	9.1	3.1	2.8	7.4
Greenwich - Mason & E. Putnam to Greenwich (Metro-North) on Railroad Ave					
AM	10.7	5.1	2.2	1.3	6.4
MID	9.7	6.0	2.9	1.6	6.0
PM	7.9	7.0	3.6	2.1	8.6
Greenwich (Metro-North) on Railroad Ave to W Putnam & Pemberwick					
AM	13.2	10.8	2.8	3.3	7.8
MID	15.0	8.7	2.3	2.2	6.8
PM	12.4	10.5	3.1	3.3	7.8
W Putnam & Pemberwick to Port Chester (Metro-North) - S. Main & Westchester					
AM	12.3	7.8	3.1	1.7	6.0
MID	12.4	6.3	2.2	1.7	5.4
PM	11.1	7.0	3.0	1.8	5.6

Route 41/41A - *Eastbound*

Segment & Period	Average Speed (mph)	Average Travel Time	Average Delay Time	Average Stopped Time	Average Number of Stops
Stamford Transportation - Center Bay # 4 to Atlantic Square - Atlantic @ Veterans Park					
AM	11.6	3.1	1.5	0.6	1.6
Mid	8.6	3.6	1.7	1.1	2.2
PM	10.2	3.2	1.4	0.9	1.8
Atlantic Square - Atlantic @ Veterans Park to East Main St. & Blachley					
AM	10.3	8.0	2.5	2.7	7.6
Mid	8.3	10.3	3.5	4.2	9.4
PM	7.8	11.0	4.0	4.4	10.3
East Main St. & Blachley to Darien RR Station - Boston Post Rd.					
AM	19.4	9.8	2.0	1.4	5.6
Mid	17.4	10.9	2.8	2.5	9.4
PM	16.0	12.0	3.2	3.0	9.3
Darien RR Station - Boston Post Rd. to Connecticut Ave. & Richards Ave. (Route 41)					
AM	18.5	5.2	1.0	0.8	3.6
Mid	-	-	-	-	-
PM	12.9	7.6	1.9	2.2	5.5
Darien RR Station - Boston Post Rd. to Norwalk Community College West Campus (Route 41A)					
AM	-	-	-	-	-
Mid	14.7	9.2	2.1	2.8	7.4
PM	-	-	-	-	-
Norwalk Community College West Campus to Connecticut Ave. & Richards Ave. (Route 41A)					
AM	-	-	-	-	-
Mid	10.9	4.0	1.7	1.4	2.6
PM	-	-	-	-	-
Connecticut Ave. & Richards Ave. to Connecticut Ave. & Scribner Ave.					
AM	15.1	4.2	1.1	1.0	3.4
Mid	11.9	5.1	1.6	1.4	4.8
PM	9.8	6.1	2.1	2.0	6.3
Connecticut Ave. & Scribner Ave. to Norwalk WHEELS Hub - Burnell Ave					
AM	14.7	9.6	2.7	2.3	8.0
Mid	13.6	10.8	3.6	3.1	7.8
PM	16.1	9.1	2.8	2.3	7.8

Route 41/41A - *Westbound*

Segment & Period	Average Speed (mph)	Average Travel Time	Average Delay Time	Average Stopped Time	Average Number of Stops
Norwalk WHEELS Hub - Burnell Ave to Connecticut Ave. & Scribner Ave.					
AM	11.9	10.2	3.4	2.9	9.5
Mid	10.9	10.5	4.1	3.1	8.4
PM	10.5	10.9	4.1	3.2	9.8
Connecticut Ave. & Scribner Ave. to Connecticut Ave. & Richards Ave.					
AM	14.8	4.5	1.2	1.2	3.5
Mid	9.6	6.3	2.1	2.3	6.8
PM	10.1	5.9	1.8	2.0	5.8
Connecticut Ave. & Richards Ave. to Norwalk Community College West Campus (Route 41A)					
AM	-	-	-	-	-
Mid	-	-	-	-	-
PM	18.7	1.9	0.5	0.2	1.0
Norwalk Community College West Campus to Darien RR Station - Boston Post Rd. (Route 41A)					
AM	-	-	-	-	-
Mid	-	-	-	-	-
PM	13.2	11.6	4.4	2.9	7.2
Connecticut Ave. & Richards Ave. to Darien RR Station - Boston Post Rd. (Route 41)					
AM	17.2	5.9	1.5	1.3	3.8
Mid	14.7	6.6	1.9	1.7	4.4
PM	-	-	-	-	-
Darien RR Station - Boston Post Rd. to East Main St. & Courtland					
AM	21.6	8.4	1.3	1.3	4.8
Mid	17.7	10.1	2.2	2.3	6.0
PM	17.4	10.3	2.6	2.3	6.2
East Main St. & Courtland to Atlantic Square - Atlantic St. & Main St.					
AM	9.1	10.1	3.1	4.1	10.3
Mid	10.5	8.9	3.3	2.6	9.2
PM	8.8	11.0	4.0	4.4	9.8
Atlantic Square - Atlantic St. & Main St. to Stamford Transportation Center					
AM	6.9	4.6	1.9	1.9	3.3
Mid	7.5	3.8	1.1	2.0	2.6
PM	9.9	3.1	1.6	0.8	2.2

Coastal Link - *Eastbound*

Segment & Period	Average Speed (mph)	Average Travel Time	Average Delay Time	Average Stopped Time	Average Number of Stops
Norwalk WHEELS Hub - Burnell Ave to Post Road & Lois St.					
AM	14.6	8.5	2.1	2.1	6.8
MID	12.4	10.4	3.1	3.2	9.5
PM	11.0	11.9	4.2	3.6	12.5
Post Road & Lois St. to Westport - Post Road & Main St.					
AM	21.6	4.5	0.7	0.6	3.4
MID	15.3	6.4	1.5	1.8	6.8
PM	11.4	9.1	3.0	3.2	10.3
Westport - Post Road & Main St. to Post Road & Bulkley Ave.					
AM	21.1	9.4	1.4	1.6	7.8
MID	18.1	11.0	2.1	2.4	9.3
PM	14.3	14.0	4.4	3.5	15.2
Post Road & Bulkley Ave. to Fairfield Circle					
AM	21.3	9.3	1.3	1.7	5.8
MID	17.4	11.1	2.8	2.0	8.3
PM	15.4	13.0	3.6	3.3	11.5
Fairfield Circle to Arrive GBTA Terminal					
AM	13.1	18.5	4.6	6.2	17.6
MID	12.9	18.5	5.2	5.3	17.3
PM	13.2	18.2	5.2	5.2	19.8
Arrive GBTA Terminal to Depart GBTA Bus Terminal					
AM	0.0	6.5	0.0	6.5	1.0
MID	0.0	5.3	0.0	5.3	1.0
PM	0.0	1.3	0.0	1.3	1.0
Depart GBTA Bus Terminal to Main Street Stratford					
AM	16.2	12.9	2.9	3.0	12.8
MID	17.4	12.0	2.3	2.8	10.5
PM	15.1	14.0	3.4	3.9	13.3
Main Street Stratford to The Dock Shopping Center					
AM	13.3	11.4	2.6	4.3	8.8
MID	14.1	10.0	3.1	2.5	9.0
PM	14.2	10.3	3.8	1.9	10.0
The Dock Shopping Center to Milford Green					
AM	15.8	14.9	3.7	3.7	11.2
MID	13.7	17.9	4.3	5.6	14.5
PM	15.9	15.0	4.1	3.2	10.3
Milford Green to Westfield CT Post - Bus Hub					
AM	14.3	10.2	2.7	3.2	10.0
MID	13.1	11.0	3.1	3.4	10.3
PM	15.0	9.6	2.7	2.4	6.3

Coastal Link - *Westbound*

Segment & Period	Average Speed (mph)	Average Travel Time	Average Delay Time	Average Stopped Time	Average Number of Stops
Westfield CT Post - Bus Hub to Milford Green					
AM	14.2	9.8	2.5	2.9	7.8
MID	11.3	12.4	3.2	5.1	9.8
PM	11.7	11.5	3.4	4.0	9.8
Milford Green to The Dock Shopping Center					
AM	19.1	12.3	2.8	1.9	7.4
MID	16.1	14.5	3.8	3.2	12.5
PM	15.7	14.5	4.1	2.9	10.7
The Dock Shopping Center to Main Street Stratford					
AM	8.4	16.0	3.4	8.9	8.2
MID	9.6	13.4	3.6	6.3	11.0
PM	9.7	12.9	3.8	5.5	11.0
Main Street Stratford to Arrive GBTA Bus Terminal					
AM	14.6	14.4	4.1	3.5	12.6
MID	15.3	14.0	4.1	3.4	13.5
PM	16.2	13.1	3.6	2.7	11.0
Arrive GBTA Bus Terminal to Depart GBTA Bus Terminal					
AM	0.0	6.3	0.0	6.3	1.0
MID	0.0	4.7	0.0	4.7	1.0
PM	0.0	3.8	0.0	3.8	1.0
Depart GBTA Bus Terminal to Fairfield Circle					
AM	11.4	22.6	8.0	6.8	28.8
MID	11.0	22.8	6.9	8.0	26.5
PM	12.0	20.9	6.6	6.3	26.5
Fairfield Circle to Post Road & Bulkley Ave.					
AM	15.8	12.3	3.5	2.9	11.8
MID	14.4	13.6	3.4	4.0	12.8
PM	19.0	10.2	2.1	2.1	7.3
Post Road & Bulkley Ave. to Westport - Post Road & Main St.					
AM	13.7	14.8	5.0	4.1	18.8
MID	15.2	13.0	3.0	3.7	13.0
PM	21.1	9.5	1.7	1.3	6.0
Westport - Post Road & Main St. to Post Road & Lois St.					
AM	16.5	6.4	1.4	1.8	6.2
MID	16.9	5.8	1.3	1.5	5.5
PM	18.4	5.3	1.0	1.3	4.0
Post Road & Lois St. to Norwalk WHEELS Hub - Burnell Ave					
AM	14.6	7.9	2.3	1.8	8.2
MID	11.3	10.3	2.7	3.8	8.8
PM	14.9	7.8	2.0	1.8	5.7

O Route 1 - *Eastbound*

Segment & Period	Average Speed (mph)	Average Travel Time	Average Delay Time	Average Stopped Time	Average Number of Stops
Westfield CT Post to Route 1 & Bull Hill Lane					
AM	19.2	12.2	2.2	3.0	9.3
MID	16.5	14.3	3.0	3.5	11.2
PM	14.4	16.4	4.4	4.5	14.3
Route 1 & Bull Hill Lane to Allingtown - Orange & Admiral					
AM	16.4	10.6	2.6	3.1	9.8
MID	12.4	12.7	2.7	4.9	11.2
PM	12.6	12.3	3.4	3.8	12.2
Allingtown - Orange & Admiral to Winthrop & Sylvan					
AM	15.4	5.9	1.4	1.8	5.3
MID	17.0	5.4	1.1	1.5	5.2
PM	13.0	7.8	2.0	2.3	7.8
Winthrop & Sylvan to Yale-New Haven Hospital					
AM	7.9	4.4	1.3	2.0	5.0
MID	7.9	4.4	1.3	2.0	4.8
PM	8.8	3.9	1.4	1.4	4.7
Yale-New Haven Hospital to Church & Chapel					
AM	7.2	6.2	2.3	2.9	6.5
MID	6.9	7.0	2.7	3.2	8.0
PM	6.8	8.2	3.2	3.6	8.0

O Route 1 - *Westbound*

Segment & Period	Average Speed (mph)	Average Travel Time	Average Delay Time	Average Stopped Time	Average Number of Stops
Temple & Chapel to Yale-New Haven Hospital					
AM	6.8	8.3	2.7	3.2	8.6
MID	6.2	8.4	3.4	3.9	9.2
PM	6.5	7.6	3.3	3.1	8.8
Yale-New Haven Hospital to Winthrop & Sylvan					
AM	10.7	2.9	0.8	1.2	4.0
MID	9.6	3.0	1.0	1.1	4.0
PM	9.0	3.4	1.1	1.5	3.6
Winthrop & Sylvan to Allingtown - Orange & Admiral					
AM	15.0	6.8	1.7	2.2	6.8
MID	12.6	8.1	1.9	3.1	7.8
PM	12.3	8.5	2.4	3.1	6.8
Allingtown - Orange & Admiral to Route 1 & Bull Hill Lane					
AM	16.2	9.6	2.7	2.0	10.4
MID	15.0	10.3	2.9	2.3	11.8
PM	12.9	12.0	3.5	3.4	11.4
Route 1 & Bull Hill Lane to Westfield CT Post					
AM	19.5	10.9	2.7	2.6	13.0
MID	16.5	14.8	3.2	3.8	11.4
PM	15.5	15.7	3.5	4.0	10.6

Appendix D – Bus Delay Counts by Trip

Route 11B - *Eastbound*

Trip	Passenger Boarding/ Alighting	Wheelchair Boarding/ Alighting	Traffic Signal	Congestion	Construction	Accident	Emergency Vehicle	Passenger Delay	Other Delay
7:04 AM	33		13						
7:39 AM	29		20						
8:09 AM	29		21	3					1
8:09 AM	28		22	4					
8:54 AM	23		13	3					
9:54 AM	24		19	1					2
10:54 AM	11		18		1				3
12:54 PM*	25		16	1					
1:49 PM	22	2	12		1				
2:49 PM	24		24	4					
4:25 PM	23		23	9					
4:25 PM	31		31	3					
5:15 PM	29		30	2					
6:05 PM	20		18	1					
6:05 PM	19		19						1

* incomplete data for this trip

Route 11A - *Westbound*

Trip	Passenger Boarding/ Alighting	Wheelchair Boarding/ Alighting	Traffic Signal	Congestion	Construction	Accident	Emergency Vehicle	Passenger Delay	Other Delay
6:10 AM*	11		12						1
6:45 AM	22		17						
7:20 AM	27		18	2					
7:20 AM	21		20		1				
8:00 AM	24		25	2					
9:00 AM	25		25	1					
9:55 AM	28		17		1				
11:50 AM	24		16	3					
12:50 PM	26		9	3					
1:50 PM	21	1	19		2				
3:20 PM	25		22						
3:20 PM	29		22	2					
4:10 PM	34		12	2					
4:50 PM	19		29	3					
4:50 PM	26		27	2					

* incomplete data for this trip

Route 41/41A - *Eastbound*

Trip	Passenger Boarding/ Alighting	Wheelchair Boarding/ Alighting	Traffic Signal	Congestion	Construction	Accident	Emergency Vehicle	Passenger Delay	Other Delay
5:25 AM	14		9						
5:55 AM	11		10	1					
6:20 AM	22		14						1
6:45 AM	19		20	1					
7:55 AM	18		13	1					
9:25 AM*	20		27						
11:20 AM*	18		17	1	1				
11:20 AM*	20		25						
12:20 PM*	27		21	1					
1:50 PM*	24		21	2					
2:45 PM	27		28	1					1
3:25 PM	15		13	2					1
4:25 PM	26		20	3					
4:25 PM*	17		24	1					
5:25 PM	17		23	2					

* Route 41A

Route 41/41A - *Westbound*

Trip	Passenger Boarding/ Alighting	Wheelchair Boarding/ Alighting	Traffic Signal	Congestion	Construction	Accident	Emergency Vehicle	Passenger Delay	Other Delay
6:10 AM	18		10						2
6:50 AM	28		18						
7:10 AM	20		16	2					
7:50 AM	16		20	2					
9:05 AM	16		15	1					
10:26 AM	16		16	1					
12:26 PM	13		23	2	1				
12:26 PM	18		24	1					
1:26 PM	25		16	2					
2:50 PM*	33		18						
3:50 PM*	11		22	2					
4:30 PM*	20		21	1					
5:24 PM*	25		20						
5:24 PM	25		20	4					
6:39 PM*	22		26						

* Route 41A

Coastal Link - *Eastbound*

Trip	Passenger Boarding/ Alighting	Wheelchair Boarding/ Alighting	Traffic Signal	Congestion	Construction	Accident	Emergency Vehicle	Passenger Delay	Other Delay
5:50 AM	36		55						4
6:30 AM	39		34						1
6:50 AM	48		48						
7:50 AM	41		50	1			2		2
8:30 AM	37		44	9					5
8:50 AM	30	1	51	1					
10:50 AM	46		65						
11:50 AM	40		42		1				
12:50 PM	44	1	56	13					10
2:50 PM	51		46						
3:30 PM	47		75	5					
3:50 PM	51		57	1					
4:50 PM	53	2	51	33	1				4
5:30 PM	38	1	55	3					
5:50 PM	38		46	11					7

Coastal Link - *Westbound*

Trip	Passenger Boarding/ Alighting	Wheelchair Boarding/ Alighting	Traffic Signal	Congestion	Construction	Accident	Emergency Vehicle	Passenger Delay	Other Delay
5:50 AM	45		48	12					4
6:30 AM	46		55	24					6
6:50 AM	54		56	2					
7:50 AM	65		72						
8:30 AM	48		43	1					
8:50 AM	47		50						
10:50 AM	63		48	6					8
12:50 PM	65		54	15					
1:50 PM	56		52						
2:50 PM	63	3	42	11					3
3:30 PM	41		48	3					
3:50 PM	54		45	7					7
4:50 PM	29		45						
5:30 PM	31		57	1					
5:50 PM	27		55						

O Route 1 - *Eastbound*

Trip	Passenger Boarding/ Alighting	Wheelchair Boarding/ Alighting	Traffic Signal	Congestion	Construction	Accident	Emergency Vehicle	Passenger Delay	Other Delay
6:42 AM	24		17		1				
7:29 AM	13		16	4					1
7:55 AM	19		18	1	1				
8:30 AM	16	1	18						
9:10 AM	13		16	5			1		3
10:50 AM	24		25	1					
11:50 AM	25		18						
12:50 PM	20		24	2					
1:50 PM	19		18	1					
3:10 PM	23		20	5					
4:00 PM	24		18	4					
4:48 PM	29		23	2					
5:31 PM	32		16	3					1
6:01 PM	21		25	4		1		2	3
6:28 PM	19		17						

O Route 1 - *Westbound*

Trip	Passenger Boarding/ Alighting	Wheelchair Boarding/ Alighting	Traffic Signal	Congestion	Construction	Accident	Emergency Vehicle	Passenger Delay	Other Delay
6:00 AM	21		13					1	2
6:45 AM	27		14	6					
7:05 AM	20		18						
7:40 AM	31		18						4
8:20 AM	22	1	16	5					3
10:00 AM	27		18	3					4
11:00 AM	23	1	13	4					1
12:00 PM	22	2	15						1
1:00 PM	28		16	3					1
2:10 PM	26		16	7				1	
3:05 PM	15	1	16	5				1	4
3:50 PM	17		22	3					4
4:20 PM	21		18	5					1
5:00 PM	20		25	4					2
5:15 PM	19		19	1					

Appendix E – Distribution of Bus Travel Time by Delay Type

Route 11B - *Eastbound*

Period/ Category of Motion	No Delay Reported	Passenger Boarding/ Alighting	Traffic Signal	Other Delay	Total
AM Peak					
Moving	33%				33%
Decelerating	0%	6%	4%	0%	10%
Accelerating	0%	6%	3%	0%	10%
Slow	3%	3%	3%	1%	11%
Stopped	0%	13%	21%	2%	36%
Total	37%	28%	31%	4%	100%
Midday					
Moving	36%				36%
Decelerating	1%	6%	3%	1%	11%
Accelerating	0%	4%	3%	0%	8%
Slow	5%	3%	2%	1%	11%
Stopped	2%	13%	14%	5%	33%
Total	43%	27%	23%	7%	100%
PM Peak					
Moving	30%				30%
Decelerating	0%	6%	5%	0%	13%
Accelerating	0%	5%	6%	0%	11%
Slow	5%	3%	5%	1%	13%
Stopped	0%	11%	20%	2%	33%
Total	36%	25%	36%	3%	100%

Route 11A - *Westbound*

Period/ Category of Motion	No Delay Reported	Passenger Boarding/ Alighting	Traffic Signal	Other Delay	Total
AM Peak					
Moving	39%				39%
Decelerating	0%	5%	5%	0%	11%
Accelerating	1%	5%	5%	0%	10%
Slow	7%	2%	3%	1%	12%
Stopped	1%	10%	16%	1%	28%
Total	47%	22%	29%	2%	100%
Midday					
Moving	39%				39%
Decelerating	0%	6%	4%	0%	11%
Accelerating	1%	5%	5%	0%	10%
Slow	5%	3%	3%	1%	12%
Stopped	0%	13%	15%	0%	29%
Total	45%	26%	27%	2%	100%
PM Peak					
Moving	32%				32%
Decelerating	0%	5%	5%	0%	11%
Accelerating	0%	5%	5%	0%	11%
Slow	5%	4%	5%	0%	14%
Stopped	0%	11%	20%	0%	32%
Total	38%	25%	36%	1%	100%

Route 41/41A - *Eastbound*

Period/ Category of Motion	No Delay Reported	Passenger Boarding/ Alighting	Traffic Signal	Other Delay	Total
AM Peak (Route 41)					
Moving	51%				51%
Decelerating	0%	5%	4%	0%	10%
Accelerating	1%	4%	4%	0%	9%
Slow	6%	1%	2%	0%	9%
Stopped	0%	11%	11%	1%	22%
Total	58%	21%	20%	1%	100%
Midday (Route 41A)					
Moving	38%				38%
Decelerating	1%	5%	5%	0%	11%
Accelerating	0%	5%	5%	0%	10%
Slow	5%	2%	2%	1%	10%
Stopped	0%	13%	15%	2%	30%
Total	45%	25%	26%	4%	100%
PM Peak (Route 41)					
Moving	38%				38%
Decelerating	0%	5%	3%	0%	9%
Accelerating	0%	4%	5%	0%	9%
Slow	4%	4%	4%	1%	13%
Stopped	0%	13%	15%	2%	30%
Total	43%	27%	26%	4%	100%

Route 41/41A - *Westbound*

Period/ Category of Motion	No Delay Reported	Passenger Boarding/ Alighting	Traffic Signal	Other Delay	Total
AM Peak (Route 41)					
Moving	43%				43%
Decelerating	0%	5%	4%	0%	10%
Accelerating	1%	5%	4%	0%	10%
Slow	4%	1%	2%	1%	8%
Stopped	0%	12%	15%	1%	29%
Total	48%	23%	25%	3%	100%
Midday (Route 41)					
Moving	38%				38%
Decelerating	1%	4%	5%	1%	10%
Accelerating	1%	4%	5%	1%	11%
Slow	5%	3%	2%	1%	10%
Stopped	0%	13%	16%	1%	30%
Total	45%	24%	27%	3%	100%
PM Peak (Route 41A)					
Moving	36%				36%
Decelerating	0%	6%	4%	0%	10%
Accelerating	1%	6%	5%	0%	11%
Slow	5%	5%	4%	0%	14%
Stopped	0%	14%	15%	0%	29%
Total	43%	30%	27%	0%	100%

Coastal Link - *Eastbound*

Period/ Category of Motion	No Delay Reported	Passenger Boarding/ Alighting	Traffic Signal	Other Delay	Total
AM Peak					
Moving	51%				51%
Decelerating	0%	4%	4%	0%	8%
Accelerating	0%	3%	4%	0%	7%
Slow	3%	1%	2%	0%	7%
Stopped	1%	10%	13%	3%	26%
Total	55%	19%	22%	4%	100%
Midday					
Moving	48%				48%
Decelerating	1%	4%	5%	0%	10%
Accelerating	0%	4%	5%	0%	9%
Slow	3%	1%	2%	1%	7%
Stopped	0%	12%	14%	1%	27%
Total	52%	20%	26%	2%	100%
PM Peak					
Moving	44%				44%
Decelerating	0%	4%	5%	1%	10%
Accelerating	0%	4%	5%	0%	10%
Slow	4%	2%	3%	2%	11%
Stopped	0%	10%	14%	2%	26%
Total	49%	20%	26%	4%	100%

Coastal Link - *Westbound*

Period/ Category of Motion	No Delay Reported	Passenger Boarding/ Alighting	Traffic Signal	Other Delay	Total
AM Peak					
Moving	42%				42%
Decelerating	0%	5%	5%	1%	10%
Accelerating	0%	4%	4%	1%	9%
Slow	3%	2%	3%	1%	10%
Stopped	1%	15%	13%	1%	30%
Total	46%	25%	25%	4%	100%
Midday					
Moving	41%				41%
Decelerating	0%	5%	5%	1%	10%
Accelerating	0%	5%	3%	0%	9%
Slow	3%	2%	2%	1%	8%
Stopped	0%	17%	13%	2%	32%
Total	45%	29%	23%	3%	100%
PM Peak					
Moving	47%				47%
Decelerating	0%	4%	5%	0%	9%
Accelerating	0%	4%	4%	1%	9%
Slow	4%	2%	3%	0%	9%
Stopped	0%	11%	14%	1%	26%
Total	52%	20%	26%	2%	100%

O Route 1 - *Eastbound*

Period/ Category of Motion	No Delay Reported	Passenger Boarding/ Alighting	Traffic Signal	Other Delay	Total
AM Peak					
Moving	42%				42%
Decelerating	0%	4%	5%	0%	9%
Accelerating	1%	4%	4%	0%	10%
Slow	3%	1%	2%	1%	6%
Stopped	0%	10%	19%	3%	33%
Total	46%	19%	30%	4%	100%
Midday					
Moving	41%				41%
Decelerating	0%	4%	4%	0%	8%
Accelerating	1%	4%	4%	0%	9%
Slow	3%	1%	3%	1%	8%
Stopped	0%	11%	23%	1%	35%
Total	44%	19%	34%	2%	100%
PM Peak					
Moving	37%				37%
Decelerating	0%	5%	5%	1%	11%
Accelerating	1%	5%	4%	0%	10%
Slow	3%	2%	3%	1%	9%
Stopped	1%	14%	17%	1%	33%
Total	42%	26%	29%	3%	100%

O Route 1 - *Westbound*

Period/ Category of Motion	No Delay Reported	Passenger Boarding/ Alighting	Traffic Signal	Other Delay	Total
AM Peak					
Moving	44%				44%
Decelerating	0%	5%	4%	1%	10%
Accelerating	0%	4%	3%	1%	9%
Slow	3%	2%	2%	1%	9%
Stopped	0%	12%	16%	0%	29%
Total	49%	23%	25%	3%	100%
Midday					
Moving	40%				40%
Decelerating	1%	5%	3%	1%	9%
Accelerating	0%	5%	3%	1%	9%
Slow	4%	2%	2%	1%	10%
Stopped	0%	14%	16%	2%	32%
Total	45%	26%	25%	5%	100%
PM Peak					
Moving	39%				39%
Decelerating	1%	4%	4%	1%	10%
Accelerating	0%	3%	5%	1%	9%
Slow	4%	1%	3%	2%	10%
Stopped	1%	10%	20%	2%	32%
Total	45%	18%	32%	5%	100%

Appendix F - Signalized Intersections with Estimated LOS C through F on Bus Approaches

Location	Municipality	Ownership	Route	AM		Mid		PM	
				E	W	E	W	E	W
LOS F									
Railroad Ave and Arch St	Greenwich	Greenwich	11	F	C	D		D	
Railroad Ave and Greenwich Ave	Greenwich	Greenwich	11					C	F
LOS E									
Connecticut Ave (Rt 1) and Richards Ave	Norwalk	CTDOT	41	D			C	E	D
East Putnam Ave (Rt 1) and Neil Ln	Greenwich	Greenwich	11	D		E		D	C
Boston Post Rd (Rt 1) and Dogburn Rd	Orange	CTDOT	O	E	C	C	C	C	
W Main St/Plymouth Pl/Cherry St/Prospect St/River St	Milford	CTDOT	CLE		C		D		E
Boston Post Rd (Rt 1) and E Town Rd	Milford	CTDOT	CLE			D		E	C
W Putnam Ave (Rt 1) and Church St	Greenwich	Greenwich	11	C		E		C	
Boston Post Rd (Rt 1) and Tuthill St	West Haven	CTDOT	O				C		E
LOS D									
Howard Ave and Sylvan Ave	New Haven	New Haven	O		D	D	D	D	D
E Wall St and East Ave (Rt 53)	Norwalk	Norwalk	CLW	C		D	D	D	C
W Main St (Rt 1) and West Ave	Stamford	Stamford	11	D		C	D	D	C
Barnum Ave (Rt 1) and Main St (Rt 113)	Stratford	CTDOT	CLE		C	C	D		D
Post Rd (Rt 1) and Mill Plain Rd	Fairfield	CTDOT	CLW		C	C	C	C	D
Broad St and Atlantic St	Stamford	Stamford	41	C		D	C	C	
Boston Post Rd (Rt 1) and Racebook Rd (Rt 114)	Orange	CTDOT	O	D		C	C		C
Post Rd W (Rt 1) and Riverside Ave (Rt 33)	Westport	CTDOT	CLW			C	D	D	
Boston Post Rd (Rt 1) and Campbell Ave (Rt 122)	West Haven	CTDOT	O		C	D			C
E Putnam Ave (Rt 1) and Indian Field Rd	Greenwich	Greenwich	11		D		C		C
W Putnam Ave (Rt 1)/Field Point Rd/Dearfield Dr	Greenwich	Greenwich	11		D		C		
E Main St (Rt 1) and Glenbrook Rd	Stamford	Stamford	41		D				
W Main St (Rt 1) and Stillwater Ave	Stamford	Stamford	11					D	
W Cedar St and Richards Ave	Norwalk	CTDOT	41			D			
N Frontage Rd (Rt 34) and Ella Grasso Blvd (Rt 10)	New Haven	New Haven	O						D
E Main St (Rt 1) and Brookside Dr	Stamford	Stamford	41				D		
LOS C									
Tresser Blvd (Rt 1) and Washington Blvd (Rt 137)	Stamford	Stamford	11	C				C	C
N Frontage Rd (Rt 34) and York St	New Haven	New Haven	O	C	C				C
North Ave (Rt 1) and East Ave	Norwalk	Norwalk	CLW		C		C		C
Cherry St and Gulf St	Milford	CTDOT	CLE	C		C		C	
Connecticut Ave (Rt 130) and Seaview Ave	Bridgeport	CTDOT	CLE		C		C		C
Lafayette Blvd and John St	Bridgeport	CTDOT	CLW		C		C		C
Belden Ave and Burnell Blvd	Norwalk	Norwalk	CLW			C		C	
Bridgeport Ave (Rt 162) and Boston Post Rd (Rt 1)	Milford	CTDOT	CLE				C	C	
Fairfield Ave and Water St	Bridgeport	CTDOT	CLW		C				C
N State St and Atlantic St	Stamford	Stamford	11		C		C		
Bridgeport Ave (Rt 162)/Clark St/Golden Hill St	Milford	CTDOT	CLE		C				C
Connecticut Ave (Rt 1) and Shop Rite	Norwalk	CTDOT	41				C		C
E Main St (Rt 110) and Wal Mart	Stratford	CTDOT	CLE		C		C		
Boston Post Rd (Rt 1) and Lambert Rd	Orange	CTDOT	O			C	C		
Boston Post Rd (Rt 1) and Orange Center Rd (Rt 152)	Orange	CTDOT	O			C			C
Connecticut Ave (Rt 130) and Seaview Ave	Bridgeport	CTDOT	CLE			C		C	
Broad St and Grove St	Stamford	Stamford	41		C				C
Howard Ave and Davenport Ave	New Haven	New Haven	O	C		C			
Mill St and Water St	Greenwich	Greenwich	11	C				C	
Church St and Chapel St	New Haven	New Haven	O			C		C	
Temple St and Chapel St	New Haven	New Haven	O				C		C

Location	Municipality	Ownership	Route	AM		Mid		PM	
				E	W	E	W	E	W
Church St and George St	New Haven	New Haven	O	C		C			
S Frontage Rd and Park St	New Haven	New Haven	O		C		C		
Cross St (Rt 1)/Bylington Pl/Belden Ave	Norwalk	Norwalk	41		C		C		
Post Rd (Rt 1)/Myrtle Ave/Imperial Ave	Westport	CTDOT	CLW		C				
Boston Post Rd (Rt 1) at Milford Crossing	Milford	CTDOT	CLE				C		
Connecticut Ave (Rt 1) and Scribner Ave	Norwalk	CTDOT	41						C
Bridgeport Ave (Rt 1) and Naugatuck Ave	Milford	CTDOT	CLE		C				
Fairfield Ave (Rt 130) and Brewster St	Bridgeport	CTDOT	CLW		C				
Post Rd (Rt 1) and Pine Creek Rd	Fairfield	CTDOT	CLW					C	
E Putnam Ave (Rt 1) and Sound Beach Ave	Greenwich	Greenwich	11						C
Post Rd (Rt 1) at Compo Shopping Center	Westport	CTDOT	CLW		C				
W Main St (Rt 1) and Alvord Ln	Stamford	Stamford	11						C
Post Rd (Rt 1) and Benson Rd (Rt 135)	Fairfield	CTDOT	CLW				C		
E Putnam Ave (Rt 1)/Laddin Rock Rd/Havemeyer Ln	Greenwich	Greenwich	11						C
Atlantic St and Federal St	Stamford	Stamford	11		C				
Temple St and George St	New Haven	New Haven	O		C				
E Main St (Rt 1)/Lincoln Ave/Lockwood Ave	Stamford	Stamford	41		C				
Boston Post Rd (Rt 1) and Center St	Darien	CTDOT	41					C	
Barnum Ave (Rt 1) and Ferry Blvd at The Dock Shopping	Stratford	CTDOT	CLE	C					
Lewis St and Mason St	Greenwich	Greenwich	11						C
Cherry St and Sunnyside Ct	Milford	CTDOT	CLE				C		
E Putnam Ave (Rt 1)/Maple Ave/Milbank Ave	Greenwich	Greenwich	11						C
State St and Water St	Bridgeport	CTDOT	CLW	C					
George St and York St	New Haven	New Haven	O					C	
E Main St (Rt 1) and Courtland Ave	Stamford	Stamford	41	C					
Post Rd (Rt 1) and Compo Rd (Rt 136)	Westport	CTDOT	CLW			C			
Barnum Ave (Rt 1) and E Main St (Rt 110)	Stratford	CTDOT	CLE		C				
E Putnam Ave (Rt 1)/Cross Ln/Taylor Dr	Greenwich	Greenwich	11	C					
Van Buren Ave (Rt 1)/Riverside Ave (Rt 809)/Spring Hill	Norwalk	Norwalk	41						C
Boston Post Rd (Rt 1) and Sedgewick Ave	Darien	CTDOT	41				C		
N Frontage Rd (Rt 34) and Park St	New Haven	New Haven	O				C		
Post Rd (Rt 1) at Playhouse Plaza Shopping Ctr	Westport	CTDOT	CLW					C	
York St and Cedar St	New Haven	New Haven	O					C	
E Main St (Rt 1) and Lafayette St	Stamford	Stamford	41						C
Post Rd (Rt) and Lincoln St	Westport	CTDOT	CLW					C	
New Haven Ave (Rt 162)/Factory Ln/River St	Milford	CTDOT	CLE			C			
Cherry St at Milford Plaza	Milford	CTDOT	CLE			C			
N Frontage Rd and College St	New Haven	New Haven	O						C
Post Rd (Rt 1)/Jesup Rd/Parker Harding Plz	Westport	CTDOT	CLW		C				
S Frontage Rd and York St	New Haven	New Haven	O	C					
Fairfield Ave and Commerce Dr	Bridgeport	CTDOT	CLW				C		
State St and Main St	Bridgeport	CTDOT	CLW			C			
Boston Post Rd (Rt 1) at Interstate 95 Exit 13	Darien	CTDOT	41					C	
E Putnam Ave (Rt 1) and Sinawoy Rd	Greenwich	Greenwich	11						C
W Putnam Rd (Rt 1)/Holly Hill Ln/E Weaver St	Greenwich	Greenwich	11						C
Bridgeport Ave (Rt 1) at Interstate 95 Exit 34 on/off ramps	Milford	CTDOT	CLE						C
Field Point Rd and W Elm St	Greenwich	Greenwich	11				C		
Tresser Blvd (Rt 1)/W Main St/Greenwich Ave	Stamford	Stamford	11	C					
N State St and Guernsey Ave	Stamford	Stamford	11	C					
Field Point Rd and Brookside Dr	Greenwich	Greenwich	11		C				

Appendix G - Proposed Stops on Consolidated Stop Routes

Eastbound			Westbound		
Stop Name	Municipality	Mileage to Next Stop	Stop Name	Municipality	Mileage to Next Stop
Route 11A					
N MAIN ST & WESTCHESTER AVE	PORT CHESTER	0.20	STAMFORD TRANS CTR BAY 1	STAMFORD	0.31
N MAIN ST & WILLET AVE	PORT CHESTER	0.24	TRESSER BLVD & WASHINGTON BLVD	STAMFORD	0.26
N MAIN ST & MILL ST	PORT CHESTER	removed	TRESSER BLVD & CLINTON AVE	STAMFORD	removed
N MAIN ST & WILKINS AVE	PORT CHESTER	0.14	W MAIN ST & STILLWATER AVE	STAMFORD	0.20
N MAIN ST & OPP RECTORY ST	PORT CHESTER	0.39	W MAIN ST & SPRUCE ST	STAMFORD	removed
N MAIN ST & OPP TERRACE AVE	PORT CHESTER	removed	W MAIN ST & HAZEL ST	STAMFORD	removed
W PUTNAM AVE & BYRAM RD	GREENWICH	0.20	W MAIN ST & FAIRFIELD AVE	STAMFORD	0.28
W PUTNAM AVE & WESTERN JR HWY	GREENWICH	0.24	W MAIN ST & LIBERTY ST	STAMFORD	removed
W PUTNAM AVE & HOLLY HILL LN	GREENWICH	0.23	W MAIN ST & OPP DIAZ ST	STAMFORD	0.31
W PUTNAM AVE & 500 W PUTNAM AVE	GREENWICH	0.32	W MAIN ST & WEST AVE	STAMFORD	removed
W PUTNAM AVE & HOLLY HILL LN 2	GREENWICH	removed	W MAIN ST & CYTEC	STAMFORD	removed
W PUTNAM AVE & JOSEPHINE EVARISTO AVE	GREENWICH	0.23	W MAIN ST & STOP & SHOP	STAMFORD	0.32
W PUTNAM AVE & EDGEWOOD AVE	GREENWICH	0.38	W MAIN ST & MYANO LA	STAMFORD	removed
W PUTNAM AVE & PROSPECT ST	GREENWICH	removed	W MAIN ST & HAVEMEYER LN	GREENWICH	removed
W PUTNAM AVE & DAYTON AVE	GREENWICH	0.37	E PUTNAM AVE & WENDLE PL	GREENWICH	0.29
W PUTNAM AVE & FIELD POINT RD	GREENWICH	removed	E PUTNAM AVE & 1455 E PUTNAM AVE	GREENWICH	removed
FIELD POINT RD & BROOKSIDE DR	GREENWICH	0.57	E PUTNAM AVE & OLD KINGS HWY	GREENWICH	0.20
FIELD POINT RD & RAILROAD AVE	GREENWICH	removed	E PUTNAM AVE & SOUND BEACH AVE	GREENWICH	0.22
GREENWICH RAILROAD STATION EB	GREENWICH	0.24	E PUTNAM AVE & NEIL LN 1	GREENWICH	0.23
MASON ST & BRUCE PARK AVE	GREENWICH	removed	E PUTNAM AVE & NEIL Ln 2	GREENWICH	removed
MASON ST & FAWCETT PL	GREENWICH	0.23	E PUTNAM AVE & SHEEPHILL RD	GREENWICH	0.17
MASON ST & HAVEMEYER PL	GREENWICH	removed	E PUTNAM AVE & RIVERSIDE LN	GREENWICH	0.27
MASON ST & E ELM ST	GREENWICH	0.13	E PUTNAM AVE & RIVER RD	GREENWICH	0.37
MASON ST & LEWIS ST	GREENWICH	0.22	E PUTNAM AVE & ORCHARD ST	GREENWICH	0.27
MASON ST & LEXINGTON AVE	GREENWICH	removed	E PUTNAM AVE & TAYLOR DR	GREENWICH	0.25
MASON ST & E PUTNAM AVE	GREENWICH	0.22	E PUTNAM AVE & OLD POST RD	GREENWICH	0.32
E PUTNAM AVE & WASHINGTON AVE	GREENWICH	removed	E PUTNAM AVE & OPP W BROTHER DR	GREENWICH	0.28
E PUTNAM AVE & MILBANK AVE	GREENWICH	0.37	E PUTNAM AVE & OLD CHURCH RD	GREENWICH	0.38
E PUTNAM AVE & OPP OLD CHURCH RD	GREENWICH	0.20	E PUTNAM AVE & MAHER AVE	GREENWICH	0.20
E PUTNAM AVE & OVERLOOK DR	GREENWICH	0.37	MASON ST & E PUTNAM AVE	GREENWICH	0.20
E PUTNAM AVE & INDIAN FIELD RD	GREENWICH	0.29	MASON ST & AMOGERONE PL	GREENWICH	removed
E PUTNAM AVE & STRICKLAND RD	GREENWICH	0.24	MASON ST & LEWIS ST	GREENWICH	0.17
E PUTNAM AVE & MEAD AVE	GREENWICH	0.38	MASON ST & E ELM ST	GREENWICH	0.24
E PUTNAM AVE & CITIBANK	GREENWICH	removed	MASON ST & HAVEMEYER PL	GREENWICH	removed
E PUTNAM AVE & RIVER RD	GREENWICH	0.27	MASON ST & FAWCETT PL	GREENWICH	0.22
E PUTNAM AVE & RIVERSIDE AVE	GREENWICH	0.18	MASON ST & BRUCE PARK AVE	GREENWICH	removed
E PUTNAM AVE & LOCKWOOD LN	GREENWICH	0.18	RAILROAD AVE & OPP GREENWICH STATION	GREENWICH	0.43
E PUTNAM AVE & 1212 E PUTNAM AVE	GREENWICH	0.30	FIELD POINT RD & CITY HALL	GREENWICH	0.34
E PUTNAM AVE & SOUND BEACH AVE	GREENWICH	0.17	W PUTNAM AVE & OPP DAYTON AVE	GREENWICH	0.36
E PUTNAM AVE & 1392 E PUTNAM AVE	GREENWICH	0.28	W PUTNAM AVE & OPP PROSPECT ST	GREENWICH	removed
E PUTNAM AVE & ROCKMERE AVE	GREENWICH	removed	W PUTNAM AVE & OPP EDGEWOOD AVE	GREENWICH	0.29
E PUTNAM AVE & OPP WENDLE PL	GREENWICH	0.22	W PUTNAM AVE & MELROSE AVE	GREENWICH	0.33
E PUTNAM AVE & LADDIN ROCK RD	GREENWICH	removed	W PUTNAM AVE & OPP HOLLY HILL LN	GREENWICH	removed
W MAIN ST & OPP MYANO LA	STAMFORD	0.43	W PUTNAM AVE & VALLEY DR	GREENWICH	0.18
W MAIN ST & HARVARD AVE	STAMFORD	removed	W PUTNAM AVE & E WEAVER ST	GREENWICH	0.23
W MAIN ST & WEST AVE	STAMFORD	removed	W PUTNAM AVE & OPP WESTERN JUNIOR	GREENWICH	0.36
W MAIN ST & DIAZ ST	STAMFORD	0.26	W PUTNAM AVE & PEMBERWICK RD	GREENWICH	removed
W MAIN ST & OPP HIGH ST	STAMFORD	removed	N MAIN ST & PUTNAM AVE	PORT CHESTER	0.28
W MAIN ST & FAIRFIELD AVE	STAMFORD	0.22	N MAIN ST & TERRACE AVE	PORT CHESTER	removed
W MAIN ST & SPRUCE ST	STAMFORD	removed	N MAIN ST & RECTORY ST	PORT CHESTER	0.21

Eastbound			**Westbound**		
W MAIN ST & OPP STILLWATER AVE	STAMFORD	0.30	N MAIN ST & HORTON AVE	PORT CHESTER	0.43
TRESSER BLVD & CLINTON AVE	STAMFORD	removed	S MAIN ST & WESTCHESTER AVE	PORT CHESTER	0.17
TRESSER BLVD & WASHINGTON BLVD	STAMFORD	0.47	S MAIN ST & BOSTON POST RD	PORT CHESTER	0.50
ATLANTIC ST & TRESSER BLVD	STAMFORD	removed			
ATLANTIC ST & N STATE ST	STAMFORD	removed			
STAMFORD TRANS CTR BAY 1	STAMFORD	0.00			
Route 41					
STAMFORD TRANS CTR BAY 4	STAMFORD	0.65	BURNELL BLVD & OPP RIVER ST	NORWALK	0.18
WASHINGTON BLVD & TRESSER BLVD	STAMFORD	removed	BELDEN AVE & 24 BELDEN AVE	NORWALK	0.28
ATLANTIC ST & VETERANS PARK	STAMFORD	0.26	VAN BUREN AVE & GRANDVIEW AVE	NORWALK	0.13
BROAD ST & GREYROCK PL	STAMFORD	0.37	VAN BUREN AVE & BEDFORD AVE	NORWALK	0.26
BROAD ST & GROVE ST	STAMFORD	removed	VAN BUREN AVE & MAPLE ST	NORWALK	0.37
E MAIN ST & OPP GLENBROOK RD	STAMFORD	0.18	CONNECTICUT AVE & AREDS CAR WASH	NORWALK	0.31
E MAIN ST & OPP QUINTARD TER	STAMFORD	0.25	CONNECTICUT AVE & CLINTON AVE	NORWALK	removed
E MAIN ST & MAPLE AVE	STAMFORD	0.30	CONNECTICUT AVE & NORWALK HEALTH CTR	NORWALK	0.11
E MAIN ST & NOROTON HILL PL	STAMFORD	removed	CONNECTICUT AVE & N TAYLOR AVE	NORWALK	0.35
E MAIN ST & BLACHLEY RD	STAMFORD	0.28	CONNECTICUT AVE & 200 CONNECTICUT	NORWALK	removed
E MAIN ST & HOME CT	STAMFORD	0.17	CONNECTICUT AVE & SCRIBNER AVE	NORWALK	0.12
E MAIN ST & WEED AVE	STAMFORD	0.33	CONNECTICUT AVE & PEARL VISION	NORWALK	0.18
BOSTON POST RD & OPP HILLSIDE AVE	DARIEN	removed	CONNECTICUT AVE & SPORTS AUTHORITY	NORWALK	0.18
BOSTON POST RD & CATALPA ST	DARIEN	0.25	CONNECTICUT AVE & KOHL'S PLAZA	NORWALK	0.16
BOSTON POST RD & OPP GARDINER ST	DARIEN	0.33	CONNECTICUT AVE & OAK KNOLL APTS	NORWALK	0.27
BOSTON POST RD & BEACH DR	DARIEN	removed	CONNECTICUT AVE & RICHARDS AVE	NORWALK	0.15
BOSTON POST RD & OPP DUBOIS ST	DARIEN	0.23	CONNECTICUT AVE & RIVER PARK	NORWALK	0.21
BOSTON POST RD & NOROTON AVE	STAMFORD	0.15	BOSTON POST RD & W NORWALK RD	DARIEN	0.35
BOSTON POST RD & DICKENSON RD	DARIEN	0.29	BOSTON POST RD & RICHMOND DR	DARIEN	removed
BOSTON POST RD & CLUBHOUSE CIR	DARIEN	0.33	BOSTON POST RD & FRIENDLY'S	DARIEN	0.18
BOSTON POST RD & DARIEN MED CTR	DARIEN	removed	BOSTON POST RD & OPP OLD KINGS HWY N	DARIEN	0.28
BOSTON POST RD & OPP HECKER AVE	DARIEN	0.41	BOSTON POST RD & 523 BOSTON POST RD	DARIEN	removed
BOSTON POST RD & OPP THORNDAL CIR	DARIEN	removed	BOSTON POST RD & BROOKSIDE RD	DARIEN	0.33
BOSTON POST RD & OPP LEROY AVE	DARIEN	0.14	BBOSTON POST RD & ACADEMY ST	DARIEN	removed
BOSTON POST RD & CORBIN DR	DARIEN	0.12	BOSTON POST RD & MANSFIELD AVE	DARIEN	0.12
BOSTON POST RD & CENTER ST	DARIEN	0.14	BOSTON POST RD & OPP TOKENEKE RD	DARIEN	0.16
BOSTON POST RD & OPP MANSFIELD AVE	DARIEN	0.34	BOSTON POST RD & OPP CORBIN DR	DARIEN	0.19
BOSTON POST RD & OPP ACADEMY ST	DARIEN	removed	BOSTON POST RD & LEDGE RD	DARIEN	0.38
BOSTON POST RD & BROOKSIDE RD	DARIEN	0.30	BOSTON POST RD & THORNDAL CIR	DARIEN	removed
BOSTON POST RD & 528 BOSTON POST RD	DARIEN	removed	BOSTON POST RD & HECKER AVE	DARIEN	0.26
BOSTON POST RD & 408 BOSTON POST RD	DARIEN	0.17	BOSTON POST RD & SPRING GROVE CEM.	DARIEN	removed
BOSTON POST RD & BIRCH RD	DARIEN	0.32	BOSTON POST RD & RENSHAW RD	DARIEN	0.35
BOSTON POST RD & OPP RICHMOND DR	DARIEN	removed	BOSTON POST RD & DICKINSON RD	DARIEN	0.17
BOSTON POST RD & OPP W NORWALK RD	DARIEN	0.21	BOSTON POST RD & NOROTON AVE	DARIEN	0.18
CONNECTICUT AVE & DOUBLETREE	NORWALK	0.18	BOSTON POST RD & DUBOIS ST	DARIEN	0.33
CONNECTICUT AVE & AMF BOWLING ALLEY	NORWALK	0.26	BOSTON POST RD & OPP BEACH DR	DARIEN	removed
CONNECTICUT AVE & RAYMOUR & FLANAGAN	NORWALK	removed	BOSTON POST RD & GARDINER ST	DARIEN	0.27
CONNECTICUT AVE & KEELER AVE	NORWALK	0.17	BOSTON POST RD & HOLLOW TREE RIDGE	DARIEN	0.33
CONNECTICUT AVE & DOMINIC'S	NORWALK	0.24	BOSTON POST RD & HILLSIDE AVE	DARIEN	removed
CONNECTICUT AVE & STOP & SHOP 1	NORWALK	0.14	E MAIN ST & OPP WEED AVE	STAMFORD	0.19
CONNECTICUT AVE & STOP & SHOP 2	NORWALK	0.15	E MAIN ST & OPP SEASIDE AVE	STAMFORD	0.26
CONNECTICUT AVE & SCRIBNER AVE	NORWALK	0.36	E MAIN ST & STANDISH	STAMFORD	removed
CONNECTICUT AVE & RECREATIONAL EQ.	NORWALK	removed	E MAIN ST & OPP BLACHLEY RD	STAMFORD	0.26
CONNECTICUT AVE & W CEDAR ST	NORWALK	0.17	E MAIN ST & SEATON RD	STAMFORD	removed
CONNECTICUT AVE & FAIRFIELD AVE	NORWALK	0.23	E MAIN ST & GRANT AVE	STAMFORD	0.16
CONNECTICUT AVE & OPP WOODBURY AVE	NORWALK	0.35	E MAIN ST & OPP MYRTLE AVE	STAMFORD	0.14
VAN BUREN AVE & MAPLE ST	NORWALK	0.24	E MAIN ST & QUINTARD TER	STAMFORD	0.18
VAN BUREN AVE & BEDFORD AVE	NORWALK	0.21	E MAIN ST & LAFAYETTE ST	STAMFORD	removed
VAN BUREN AVE & BELDEN AVE	NORWALK	0.28	E MAIN ST & GLENBROOK RD	STAMFORD	0.38

Eastbound			Westbound		
BELDEN AVE & OPP BURNELL BLVD	NORWALK	0.15	BROAD ST & GROVE ST	STAMFORD	removed
WALL ST & 77 WALL ST	NORWALK	0.32	BROAD ST & GREYROCK PL	STAMFORD	0.30
BURNELL BLVD & OPP RIVER ST	NORWALK	0.00	ATLANTIC ST & MAIN ST	STAMFORD	0.49
			ATLANTIC ST & TRESSER BLVD	STAMFORD	removed
			ATLANTIC ST & N STATE ST	STAMFORD	removed
			STAMFORD TRANS CTR BAY 4	STAMFORD	0.00
Coastal Link West					
WALL ST. at NORWALK WHEEL HUB	NORWALK	0.15	Departure BTC	BRIDGEPORT	0.24
WALL ST. at COMMERCE ST	NORWALK	0.43	WATER ST. at JOHN ST.	BRIDGEPORT	0.23
EAST AVE. at BETTSWOOD RD.	NORWALK	removed	JOHN ST. at BROAD ST.	BRIDGEPORT	0.16
EAST AVE. at PARK HILL AVE.	NORWALK	0.35	JOHN ST. at LAFAYETTE BLVD.	BRIDGEPORT	removed
WESTPORT AVE. at 56 WESTPORT AVE.	NORWALK	removed	JOHN ST. at COURTLAND ST.	BRIDGEPORT	0.26
WESTPORT AVE. at DRY HILL RD.	NORWALK	0.10	JOHN ST. at PARK AVE.	BRIDGEPORT	0.19
WESTPORT AVE. at GEORGE AVE	NORWALK	0.23	FAIRFIELD AVE. at IRANISTAN AVE.	BRIDGEPORT	0.09
WESTPORT AVE. at WALTER AVE.	NORWALK	removed	FAIRFIELD AVE. at NORMAN ST.	BRIDGEPORT	0.11
WESTPORT AVE. at OPPOSITE WOLFPIT AVE.	NORWALK	0.35	FAIRFIELD AVE. at SHERWOOD AVE.	BRIDGEPORT	0.18
WESTPORT AVE. at 330 WESTPORT AVE.	NORWALK	removed	FAIRFIELD AVE. at GROVE ST.	BRIDGEPORT	removed
WESTPORT AVE. at STRAWBERRY HILL AVE.	NORWALK	0.31	FAIRFIELD AVE. at CLINTON AVE.	BRIDGEPORT	0.15
WESTPORT AVE. at OPPOSTIE WILLARD RD.	NORWALK	removed	FAIRFIELD AVE. at COLORADO AVE.	BRIDGEPORT	removed
WESTPORT AVE. at OPPOSITE LOIS ST.	NORWALK	0.19	FAIRFIELD AVE. at HOWARD AVE.	BRIDGEPORT	0.12
POST RD. WEST at OPPOSITE HILLS LN.	NORWALK	0.13	FAIRFIELD AVE. at HANCOCK AVE.	BRIDGEPORT	0.11
POST RD. WEST at 375 POST RD. WEST	WESTPORT	0.27	FAIRFIELD AVE. at MOUNTAIN GROVE ST.	BRIDGEPORT	0.41
POST RD. WEST at KINGS HWY. SOUTH	WESTPORT	0.24	FAIRFIELD AVE. at SILLIMAN AVE.	BRIDGEPORT	removed
POST RD. WEST at SYLVAN RD. SOUTH	WESTPORT	0.12	FAIRFIELD AVE. at OPPOSITE PINE ST.	BRIDGEPORT	removed
POST RD. WEST at OPPOSITE KINGS HWY. NO.	WESTPORT	0.27	FAIRFIELD AVE. at ORLAND ST.	BRIDGEPORT	0.18
POST RD. WEST at LINCOLN ST.	WESTPORT	0.20	FAIRFIELD AVE. at HANSEN ST.	BRIDGEPORT	0.22
POST RD. WEST at RIVERSIDE AVE.	WESTPORT	0.18	FAIRFIELD AVE. at WALDORF AVE.	BRIDGEPORT	removed
POST RD. EAST at OPPOSITE MAIN ST.	WESTPORT	0.17	FAIRFIELD AVE. at ELLSWORTH ST.	BRIDGEPORT	0.30
POST RD. EAST at IMPERIAL AVE.	WESTPORT	0.15	FAIRFIELD AVE. at SCOFIELD AVE.	BRIDGEPORT	removed
POST RD. EAST at 286-292 POST ROAD EAST	WESTPORT	0.20	FAIRFIELD AVE. at PRINCETON ST.	BRIDGEPORT	removed
POST RD. EAST at COMPO RD. SOUTH	WESTPORT	removed	FAIRFIELD AVE. at BREWSTER ST.	BRIDGEPORT	0.18
POST RD. EAST at 400 POST RD. EAST	WESTPORT	0.25	FAIRFIELD AVE. at FOX ST.	BRIDGEPORT	0.24
POST RD. EAST at OPPOSITE CRESCENT RD.	WESTPORT	0.15	FAIRFIELD AVE. at DAVIDSON ST.	BRIDGEPORT	removed
POST RD. EAST at 606 POST RD. EAST	WESTPORT	0.15	FAIRFIELD AVE. at POLAND ST.	BRIDGEPORT	0.28
POST RD. EAST at HILLS POINT RD.	WESTPORT	0.23	POST RD. at GRASMERE AVE.	FAIRFIELD	0.18
POST RD. EAST at OPPOSITE LONG LOTS RD.	WESTPORT	0.15	POST RD. at OPP SHOREHAM VILLAGE DR.	FAIRFIELD	0.30
POST RD. EAST at SHERWOOD ISLAND CONN.	WESTPORT	0.24	KINGS HWY. CUTOFF at 1296 KINGS HWY	FAIRFIELD	0.21
POST RD. EAST at WEST PARISH RD.	WESTPORT	removed	POST RD. at ELIOT PL.	FAIRFIELD	0.11
POST RD. EAST at 1000 POST RD. EAST	WESTPORT	0.12	POST RD. at NORTH BENSON RD.	FAIRFIELD	0.18
POST RD. EAST at CHURCH ST. SOUTH	WESTPORT	0.12	POST RD. at ROUND HILL RD.	FAIRFIELD	0.30
POST RD. EAST at MORNINGSIDE DR. SOUTH	WESTPORT	0.26	POST RD. at UNQUOWA RD.	FAIRFIELD	0.14
POST RD. EAST at TURKEY HILL RD. SOUTH	WESTPORT	0.29	POST RD. at SANFORD ST.	FAIRFIELD	removed
POST RD. EAST at MILLS ST.	WESTPORT	removed	POST RD. at MILLER ST.	FAIRFIELD	0.14
POST RD. EAST at REGENTS PARK	WESTPORT	0.18	POST RD. at OPPOSITE RUANE ST.	FAIRFIELD	0.13
POST RD. EAST at MAPLE AVE. SOUTH	WESTPORT	0.41	POST RD. at MILL PLAIN RD.	FAIRFIELD	0.24
POST RD. EAST at 1572 POST RD. EAST	WESTPORT	removed	POST RD. at NORTH PINE CREEK RD.	FAIRFIELD	0.21
POST RD. EAST at OPPOSITE WESTFAIR DR.	WESTPORT	0.27	POST RD. at PENT CT.	FAIRFIELD	0.19
POST RD. EAST at BULKLEY AVE. SOUTH	WESTPORT	0.28	POST RD. at LACEY PL.	SOUTHPORT	0.79
POST RD. at OPPOSITE HULLS HWY.	SOUTHPORT	removed	POST RD. at MILL HILL RD.	SOUTHPORT	removed
POST RD. at CENTER ST.	SOUTHPORT	0.19	POST RD. at PEASE AVE.	SOUTHPORT	removed
POST RD. at JELLIFF LN.	SOUTHPORT	0.74	POST RD. at 3330 POST RD.	SOUTHPORT	0.18
POST RD. at OPPOSITE LACEY PL.	SOUTHPORT	0.18	POST RD. at KINGS HWY. WEST	SOUTHPORT	0.36
POST RD. at SASCO HILL RD.	FAIRFIELD	0.26	POST RD. EAST at NORTH BULKLEY AVE.	WESTPORT	0.15
POST RD. at SOUTH PINE CREEK RD.	FAIRFIELD	0.22	POST RD. EAST at WESTFAIR DR.	WESTPORT	0.38
POST RD. at THORPE ST.	FAIRFIELD	0.12	POST RD. EAST at WESTPORT INN	WESTPORT	removed
POST RD. at RUANE ST.	FAIRFIELD	0.20	POST RD. EAST at MAPLE AVE. NORTH	WESTPORT	0.27

Eastbound			Westbound		
POST RD. at REEF RD.	FAIRFIELD	0.11	POST RD. EAST at 1385 POST RD. EAST	WESTPORT	0.26
POST RD. at OPPOSITE UNQUOWA PL.	FAIRFIELD	0.28	POST RD. EAST at NORTH TURKEY HILL RD	WESTPORT	0.26
POST RD. at 1261 POST RD.	FAIRFIELD	removed	POST RD. EAST at MORNINGSIDE DR. NORTH	WESTPORT	0.08
POST RD. at BEACH RD.	FAIRFIELD	0.20	POST RD. EAST at CHURCH ST. NORTH	WESTPORT	0.17
POST RD. at SOUTH BENSON RD.	FAIRFIELD	0.13	POST RD. EAST at 991 POST RD. EAST	WESTPORT	0.25
POST RD. at BELMONT ST.	FAIRFIELD	0.26	POST RD. EAST at CEDAR RD.	WESTPORT	removed
POST RD. at OLD POST RD.	FAIRFIELD	removed	POST RD. EAST at OPP SHERWOOD IS. CONN.	WESTPORT	0.14
POST RD. at 417 POST RD.	FAIRFIELD	0.19	POST RD. EAST at LONG LOTS RD.	WESTPORT	0.23
POST RD. at SHOREHAM VILLAGE DR.	FAIRFIELD	0.13	POST RD. EAST at CRESCENT RD.	WESTPORT	0.14
POST RD. at RIVERSIDE DR.	FAIRFIELD	0.27	POST RD. EAST at 605 POST RD. EAST	WESTPORT	0.19
FAIRFIELD AVE. at BEACHVIEW AVE.	BRIDGEPORT	0.27	POST RD. EAST at CRESCENT PARK RD.	WESTPORT	0.17
FAIRFIELD AVE. at COURTLAND AVE.	BRIDGEPORT	removed	POST RD. EAST at 431 POST RD. EAST	WESTPORT	0.16
FAIRFIELD AVE. at GILMAN ST.	BRIDGEPORT	0.18	POST RD. EAST at COMPO RD. NORTH	WESTPORT	removed
FAIRFIELD AVE. at BREWSTER ST.	BRIDGEPORT	0.25	POST RD. EAST at PLAYHOUSE SQUARE	WESTPORT	0.23
FAIRFIELD AVE. at MELROSE AVE.	BRIDGEPORT	removed	POST RD. WEST at MYRTLE AVE.	WESTPORT	0.17
FAIRFIELD AVE. at ELLSWORTH ST.	BRIDGEPORT	0.31	POST RD. WEST at MAIN ST.	WESTPORT	0.14
FAIRFIELD AVE. at MARTIN TER.	BRIDGEPORT	removed	POST RD. WEST at WILTON RD.	WESTPORT	0.21
FAIRFIELD AVE. at WORDIN AVE.	BRIDGEPORT	0.11	POST RD. WEST at LUDLOW RD.	WESTPORT	0.26
FAIRFIELD AVE. at ALBION ST.	BRIDGEPORT	0.44	POST RD. WEST at KINGS HWY. NORTH	WESTPORT	0.14
FAIRFIELD AVE. at PINE ST.	BRIDGEPORT	removed	POST RD. WEST at SYLVAN RD. NORTH	WESTPORT	0.25
STATE ST. at BOSTWICK AVE.	BRIDGEPORT	0.12	POST RD. WEST at OPPOSITE KINGS HWY. SO.	WESTPORT	0.24
STATE ST. at HANCOCK AVE.	BRIDGEPORT	0.08	POST RD. WEST at OPPOSITE 375 POST RD. W.	WESTPORT	0.13
STATE ST. at HOWARD AVE.	BRIDGEPORT	0.13	POST RD. WEST at HILLS LN.	WESTPORT	0.22
STATE ST. at CLINTON AVE.	BRIDGEPORT	0.11	WESTPORT AVE. at LOIS ST.	NORWALK	0.33
STATE ST. at WORDIN AVE.	BRIDGEPORT	0.12	WESTPORT AVE. at WILLARD RD.	NORWALK	removed
STATE ST. at NORMAN ST.	BRIDGEPORT	0.08	WESTPORT AVE. at STRAWBERRY HILL AVE.	NORWALK	0.29
STATE ST. at IRANISTAN AVE.	BRIDGEPORT	0.10	WESTPORT AVE. at WOLFPIT AVE.	NORWALK	0.28
STATE ST. at SEELEY ST.	BRIDGEPORT	0.19	WESTPORT AVE. at VOLLMER AVE.	NORWALK	removed
STATE ST. at WEST AVE.	BRIDGEPORT	0.27	WESTPORT AVE. at OPPOSITE GEORGE AVE.	NORWALK	0.09
STATE ST. at HOUSATONIC COMM. COLLEGE	BRIDGEPORT	0.16	WESTPORT AVE. at DRY HILL RD.	NORWALK	0.38
STATE ST. at MAIN ST.	BRIDGEPORT	0.18	WESTPORT AVE. at WALGREEN'S	NORWALK	removed
WATER ST. at OPPOSITE JOHN ST.	BRIDGEPORT	0.20	EAST AVE. at SAINT PAUL'S PL.	NORWALK	0.30
Generic Berth at BTC	BRIDGEPORT	0.00	EAST WALL ST. at EAST AVE.	NORWALK	removed
			EAST WALL ST. at KNIGHT ST.	NORWALK	0.25
			WALL ST. at NORWALK WHEEL HUB	NORWALK	0.00
		Coastal Link East			
Departure BTC	BRIDGEPORT	0.41	WESTFIELD CONNECTICUT POST MALL	MILFORD	0.20
STRATFORD AVE. at KOSSUTH ST.	BRIDGEPORT	0.30	EAST TOWN RD. at WESTFIELD CT POST MALL	MILFORD	0.09
STRATFORD AVE. at WATERVIEW AVE.	BRIDGEPORT	0.59	EAST TOWN RD. at WESTFIELD CT POST MALL	MILFORD	0.91
STRATFORD AVE. at SEAVIEW AVE.	BRIDGEPORT	removed	CHERRY ST. at LOCUST ST.	MILFORD	0.17
STRATFORD AVE. at NEWFIELD AVE.	BRIDGEPORT	0.11	CHERRY ST. at SUNNYSIDE CT.	MILFORD	0.37
STRATFORD AVE. at CENTRAL AVE.	BRIDGEPORT	0.32	CHERRY ST. at 158 CHERRY ST.	MILFORD	removed
STRATFORD AVE. at CARROLL AVE.	BRIDGEPORT	removed	CHERRY ST. at 50 CHERRY ST.	MILFORD	0.21
STRATFORD AVE. at HOLLISTER AVE.	BRIDGEPORT	removed	RIVER ST. at MILFORD CITY HALL	MILFORD	0.12
STRATFORD AVE. at HEWITT ST.	BRIDGEPORT	0.22	RIVER ST. at MILFORD RAILROAD STATION	MILFORD	0.25
STRATFORD AVE. at COWLES ST.	BRIDGEPORT	removed	NORTH BROAD ST. at HIGH ST.	MILFORD	0.38
STRATFORD AVE. at EDWIN ST.	BRIDGEPORT	0.19	GREENSEND PL. at SOUTH BROAD ST.	MILFORD	removed
STRATFORD AVE. at OPPOSITE BRUCE AVE.	STRATFORD	0.28	BRIDGEPORT AVE. at OSBORNE ST.	MILFORD	0.23
STRATFORD AVE. at SAINT MICHAEL'S CEM.	STRATFORD	removed	BRIDGEPORT AVE. at CLARK ST.	MILFORD	0.26
STRATFORD AVE. at SURF AVE.	STRATFORD	0.29	BRIDGEPORT AVE. at ROBERT TREAT DR.	MILFORD	0.20
STRATFORD AVE. at HONEYSPOT RD.	STRATFORD	0.28	BRIDGEPORT AVE. at DORSEY LN.	MILFORD	removed
STRATFORD AVE. at ELEANOR ST.	STRATFORD	removed	BRIDGEPORT AVE. at BOSTON POST RD.	MILFORD	0.39
STRATFORD AVE. at OPPOSITE LUPES DR.	STRATFORD	0.22	BRIDGEPORT AVE. at SILVER SANDS PARK	MILFORD	removed
STRATFORD AVE. at HAMILTON AVE.	STRATFORD	removed	BRIDGEPORT AVE. at SCHOOLHOUSE RD.	MILFORD	0.39
STRATFORD AVE. at SHERWOOD PL.	STRATFORD	0.19	BRIDGEPORT AVE. at OPP MEADOWS END RD.	MILFORD	removed
STRATFORD AVE. at MAIN ST.	STRATFORD	0.25	BRIDGEPORT AVE. at OPPOSITE K-MART	MILFORD	removed

Eastbound			Westbound		
MAIN ST. at ACADEMY HILL RD.	STRATFORD	removed	BRIDGEPORT AVE. at LANSDALE AVE.	MILFORD	0.44
MAIN ST. at BROAD ST.	STRATFORD	0.36	BRIDGEPORT AVE. at TOWER PLAZA	MILFORD	removed
MAIN ST. at JUDSON PL.	STRATFORD	removed	BRIDGEPORT AVE. at I-95 EXIT 34	MILFORD	removed
MAIN ST. at OPPOSITE LINDEN AVE.	STRATFORD	removed	BRIDGEPORT AVE. at BAKER ST.	MILFORD	removed
MAIN ST. at OPPOSITE BROADBRIDGE AVE.	STRATFORD	0.35	BRIDGEPORT AVE. at COWLES ST.	MILFORD	0.20
MAIN ST. at TEMPLE CT.	STRATFORD	removed	BRIDGEPORT AVE. at JUDSON PL.	MILFORD	removed
MAIN ST. at CEMETERY DR.	STRATFORD	removed	BRIDGEPORT AVE. at BERWYN ST.	MILFORD	0.12
BARNUM AVE. at MAIN ST.	STRATFORD	0.27	BRIDGEPORT AVE. at NAUGATUCK AVE.	MILFORD	0.11
BARNUM AVE. CUTOFF at OPPOSITE BURLINGTON COAT FACTORY	STRATFORD	0.35	BRIDGEPORT AVE. at ORMOND ST.	MILFORD	0.25
VETERANS BLVD. at SIDE OF STRATFORD SQ	STRATFORD	0.74	BRIDGEPORT AVE. at COLONIAL AVE.	MILFORD	removed
FERRY BLVD. at MINOR ST.	STRATFORD	removed	BRIDGEPORT AVE. at OPP RIVERCLIFF DR.	MILFORD	0.53
EAST MAIN ST. at DOCK SHOPPING CENTER	STRATFORD	0.17	DOCK SHOPPING CENTER at OPP BJ'S	STRATFORD	0.20
DOCK SHOPPING CENTER at STOP & SHOP	STRATFORD	0.26	DOCK SHOPPING CENTER at STOP & SHOP	STRATFORD	0.19
DOCK SHOPPING CENTER at BJ'S WHOLESALE	STRATFORD	0.53	EAST MAIN ST. at BARNUM AVE. CUTOFF	STRATFORD	0.45
BRIDGEPORT AVE. at RIVERCLIFF DR.	MILFORD	0.21	BARNUM AVE.CUTOFF at OPP VETERANS	STRATFORD	0.27
BRIDGEPORT AVE. at SPRING ST.	MILFORD	0.11	BARNUM AVE.CUTOFF at BURLINGTON COAT	STRATFORD	0.25
BRIDGEPORT AVE. at NAUGATUCK AVE.	MILFORD	0.16	MAIN ST. at ESSEX PL.	STRATFORD	0.22
BRIDGEPORT AVE. at FAIRVIEW ST.	MILFORD	0.19	MAIN ST. at 2505 MAIN ST.	STRATFORD	0.35
BRIDGEPORT AVE. at HAYES DR.	MILFORD	removed	MAIN ST. at CHURCH ST.	STRATFORD	removed
BRIDGEPORT AVE. at CLEVELAND AVE.	MILFORD	0.40	MAIN ST. at WEST BROAD ST.	STRATFORD	0.23
BRIDGEPORT AVE. at OPPOSITE I-95 EXIT 34	MILFORD	removed	MAIN ST. at KINGS COLLEGE PL.	STRATFORD	removed
BRIDGEPORT AVE. at LANSDALE AVE.	MILFORD	0.46	MAIN ST. at STRATFORD AVE.	STRATFORD	0.08
BRIDGEPORT AVE. at K-MART SHOPPING	MILFORD	removed	STRATFORD AVE. at MAIN ST.	STRATFORD	0.33
BRIDGEPORT AVE. at MEADOWS END RD.	MILFORD	removed	STRATFORD AVE. at I-95 OVERPASS	STRATFORD	removed
BRIDGEPORT AVE. at OPP SCHOOLHOUSE RD.	MILFORD	0.29	STRATFORD AVE. at LUPES DR.	STRATFORD	0.30
BRIDGEPORT AVE. at SILVER SANDS PKWY.	MILFORD	removed	STRATFORD AVE. at OPPOSITE ELEANOR ST.	STRATFORD	removed
BRIDGEPORT AVE. at BOSTON POST RD.	MILFORD	0.27	STRATFORD AVE. at OPP HONEYSPOT RD.	STRATFORD	0.24
BRIDGEPORT AVE. at ROBERT TREAT DR.	MILFORD	0.29	STRATFORD AVE. at OPPOSITE SURF AVE.	STRATFORD	0.30
BRIDGEPORT AVE. at OPPOSITE CLARK ST.	MILFORD	0.24	STRATFORD AVE. at 2200 STRATFORD AVE.	STRATFORD	removed
BRIDGEPORT AVE. at SEASIDE AVE.	MILFORD	removed	STRATFORD AVE. at BRUCE AVE.	STRATFORD	0.16
BRIDGEPORT AVE. at SOUTH BROAD ST.	MILFORD	0.36	CONNECTICUT AVE. at BISHOP AVE.	BRIDGEPORT	0.24
SOUTH BROAD ST. at OPP GREENSEND PL.	MILFORD	removed	CONNECTICUT AVE. at OPP WATERMAN ST.	BRIDGEPORT	removed
SOUTH BROAD ST. at HIGH ST.	MILFORD	0.25	CONNECTICUT AVE. at HEWITT ST.	BRIDGEPORT	0.31
RIVER ST. at MILFORD RAILROAD STATION	MILFORD	0.22	CONNECTICUT AVE. at WILMOT AVE.	BRIDGEPORT	removed
RIVER ST. at PROSPECT ST.	MILFORD	0.14	CONNECTICUT AVE. at CARROLL AVE.	BRIDGEPORT	removed
CHERRY ST. at 51-61 CHERRY ST.	MILFORD	0.39	CONNECTICUT AVE. at CENTRAL AVE.	BRIDGEPORT	0.15
CHERRY ST. at MILFORD PLAZA	MILFORD	removed	CONNECTICUT AVE. at BUNNELL ST.	BRIDGEPORT	removed
CHERRY ST. at COMMERCE PARK RD.	MILFORD	0.31	CONNECTICUT AVE. at FIFTH ST.	BRIDGEPORT	0.55
CHERRY ST. at BOSTON POST RD.	MILFORD	removed	CONNECTICUT AVE. at THIRD ST.	BRIDGEPORT	removed
BOSTON POST RD. at HOME ACRES AVE.	MILFORD	0.46	STRATFORD AVE. at SEAVIEW AVE.	BRIDGEPORT	removed
SCHICK-WILKINSON SWORD	MILFORD	1.15	STRATFORD AVE. at WATERVIEW AVE.	BRIDGEPORT	0.29
BOSTON POST RD. at WESTFIELD POST MALL	MILFORD	removed	STRATFORD AVE. at KOSSUTH ST.	BRIDGEPORT	0.36
EAST TOWN RD. at WESTFIELD CT POST MALL	MILFORD	0.13	Generic Berth at BTC	BRIDGEPORT	0.00
EAST TOWN RD. at WESTFIELD CT POST MALL	MILFORD	0.18			
WESTFIELD CONNECTICUT POST MALL	MILFORD	0.00			

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CT POST MALL AT TRANSIT HUB	MILFORD	0.30	TEMPLE ST & CHAPEL ST	NEW HAVEN	0.12
EAST TOWN RD & OPP STOP & SHOP	MILFORD	0.18	TEMPLE ST & CROWN ST	NEW HAVEN	0.44
EAST TOWN RD & BOSTON POST RD	MILFORD	0.07	N FRONTAGE RD & COLLEGE ST	NEW HAVEN	removed
BOSTON POST RD & MILFORD CROSSING	MILFORD	0.21	N FRONTAGE RD & YORK ST	NEW HAVEN	0.14
BOSTON POST RD & RED BUSH LN	MILFORD	0.29	PARK ST & S FRONTAGE RD	NEW HAVEN	0.09
BOSTON POST RD & WESTY STORAGE	MILFORD	removed	SOUTH ST & HOWARD AVE	NEW HAVEN	0.17
BOSTON POST RD & WOODRUFF RD	MILFORD	0.36	SYLVAN AVE & OPP VERNON ST	NEW HAVEN	removed
BOSTON POST RD & SMILES	MILFORD	0.13	SYLVAN AVE & WARD ST	NEW HAVEN	removed
BOSTON POST RD & OPP MILFORD MARKET	MILFORD	0.22	SYLVAN AVE & OPP ASYLUM ST	NEW HAVEN	0.12

Eastbound			Westbound		
BOSTON POST RD & AMF BOWLING	MILFORD	removed	SYLVAN AVE & ORCHARD ST	NEW HAVEN	0.15
BOSTON POST RD & RAYMOUR & FLANIGAN	ORANGE	removed	SYLVAN AVE & GREENWOOD ST	NEW HAVEN	removed
BOSTON POST RD & PECK LN	ORANGE	0.22	SYLVAN AVE & WINTHROP AVE	NEW HAVEN	0.14
BOSTON POST RD & T J MAXX	ORANGE	removed	WINTHROP AVE & LEGION AVE	NEW HAVEN	0.17
BOSTON POST RD & OP BOB'S FURNITURE	ORANGE	0.22	N FRONTAGE RD & SHERMAN AVE	NEW HAVEN	0.31
BOSTON POST RD & ORANGE CENTER RD	ORANGE	0.22	N FRONTAGE RD & OPP TYLER ST	NEW HAVEN	removed
BOSTON POST RD & OPP ODD LOT	ORANGE	0.14	ELLA T GRASSO BLVD & OPP LEGION AVE	NEW HAVEN	0.57
BOSTON POST RD & SILVERBROOK RD	ORANGE	0.15	ELLA T GRASSO BLVD & ORANGE AV	NEW HAVEN	0.16
BOSTON POST RD & S LAMBERT RD	ORANGE	0.17	ORANGE AVE & OPP DUNKIN DONUTS	WEST HAVEN	0.18
BOSTON POST RD & NAMCO STORE	ORANGE	0.27	ORANGE AVE & GILBERT ST	WEST HAVEN	0.14
BOSTON POST RD & PARTY CITY	ORANGE	removed	ORANGE AVE & ADMIRAL ST	WEST HAVEN	0.35
BOSTON POST RD & RACEBROOK RD	ORANGE	0.20	ORANGE AVE & FOREST RD	WEST HAVEN	removed
BOSTON POST RD & FASHION PARK	ORANGE	removed	ORANGE AVE & PRUDEN ST	WEST HAVEN	0.29
BOSTON POST RD & INDIAN RIVER RD	ORANGE	0.18	ORANGE AVE & WADE ST	WEST HAVEN	removed
BOSTON POST RD & AMERICAN PLAZA	ORANGE	removed	ORANGE AVE & HOFFMAN ST	WEST HAVEN	removed
BOSTON POST RD & LINDY ST	ORANGE	0.11	ORANGE AVE & OPP ROCKVIEW ST	WEST HAVEN	0.30
BOSTON POST RD & SAVERS	ORANGE	0.19	ORANGE AVE & HORTON PL	WEST HAVEN	removed
BOSTON POST RD & DOGBURN LN	ORANGE	0.15	ORANGE AVE & FAIRFAX ST	WEST HAVEN	0.12
BOSTON POST RD & BULL HILL LN	ORANGE	0.19	ORANGE AVE & ARDALE ST	WEST HAVEN	0.18
BOSTON POST RD & STAPLES	ORANGE	removed	ORANGE AVE & OPP PEABODY ST	WEST HAVEN	removed
BOSTON POST RD & WALGREENS	ORANGE	0.17	ORANGE AVE & OPP NORFOLK ST	WEST HAVEN	0.18
DOGWOOD RD & BOSTON POST RD	WEST HAVEN	0.34	ORANGE AVE & TUTHILL ST	WEST HAVEN	0.12
DOGWOOD RD & MELOY RD	WEST HAVEN	removed	CANTON ST & TUTHILL ST	WEST HAVEN	0.26
MELOY RD & KNOX ST	WEST HAVEN	removed	CANTON ST & JAFFREY ST	WEST HAVEN	removed
MELOY RD & OPP CANTON ST	WEST HAVEN	0.28	CANTON ST & MELOY RD	WEST HAVEN	0.37
CANTON ST & JAFFREY ST	WEST HAVEN	removed	MELOY RD & KNOX ST	WEST HAVEN	removed
CANTON ST & TUTHILL ST	WEST HAVEN	0.12	MELOY RD & GOLDMAN RD	WEST HAVEN	removed
ORANGE AVE & TUTHILL ST	WEST HAVEN	0.19	DOGBURN RD & BOSTON POST RD	WEST HAVEN	0.09
ORANGE AVE & OPP FARWELL ST	WEST HAVEN	removed	BOSTON POST RD & DOGWOOD RD	WEST HAVEN	removed
ORANGE AVE & NORFOLK ST	WEST HAVEN	0.17	BOSTON POST RD & McDONALD'S	WEST HAVEN	0.25
ORANGE AVE & PEABODY ST	WEST HAVEN	removed	BOST POST RD & STAPLES	ORANGE	removed
ORANGE AVE & OPP ARDALE ST	WEST HAVEN	0.11	BOSTON POST RD & BULL HILL LN	ORANGE	0.16
ORANGE AVE & OPP FAIRFAX ST	WEST HAVEN	0.29	BOSTON POST RD & DOGBURN LN	ORANGE	0.11
ORANGE AVE & OPP HORTON ST	WEST HAVEN	removed	BOSTON POST RD & PEPBOYS AUTO	ORANGE	0.17
ORANGE AVE & ROCKVIEW ST	WEST HAVEN	0.28	BOSTON POST RD & LINDY ST	ORANGE	0.19
ORANGE AVE & OPP HOFFMAN ST	WEST HAVEN	removed	BOSTON POST RD & SMITH FARM RD	ORANGE	0.16
ORANGE AVE & OPP WADE ST	WEST HAVEN	removed	BOSTON POST RD & RACEBROOK RD	ORANGE	0.29
ORANGE AVE & OPP PRUDEN ST	WEST HAVEN	0.36	BOSTON POST RD & DIPTOP ICE CREAM	ORANGE	removed
ORANGE AVE & OPP ADMIRAL ST	NEW HAVEN	0.11	BOSTON POST RD & VISTA DINETTES	ORANGE	removed
ORANGE AVE & FRONT ST	WEST HAVEN	0.22	BOSTON POST RD & CHIP'S RESTAURANT	ORANGE	0.18
ORANGE AVE & DUNKIN DONUTS	WEST HAVEN	0.18	BOSTON POST RD & LAMBERT RD	ORANGE	0.16
ELLA T GRASSO BLVD & ORANGE AVE	NEW HAVEN	0.53	BOSTON POST RD & SILVERBROOK RD	ORANGE	0.12
ELLA T GRASSO BLVD & LEGION AVE	NEW HAVEN	0.18	BOSTON POST RD & ODD LOT	ORANGE	0.23
LEGION AVE & TYLER ST	NEW HAVEN	0.13	BOSTON POST RD & ORANGE CENTER RD	ORANGE	0.28
LEGION AVE & WINTHROP AVE	NEW HAVEN	0.14	BOSTON POST RD & COLONIAL BUILDING	ORANGE	removed
WINTHROP AVE & SYLVAN AVE	NEW HAVEN	0.17	BOSTON POST RD & BOB'S FURNITURE	ORANGE	0.22
SYLVAN AVE & STEVENS ST	NEW HAVEN	removed	BOSTON POST RD & MR COLD KUT	ORANGE	removed
SYLVAN AVE & ORCHARD ST	NEW HAVEN	0.10	BOSTON POST RD & PECK LANE	ORANGE	0.18
SYLVAN AVE & ELLIOT ST	NEW HAVEN	removed	BOSTON POST RD & COSTCO	MILFORD	removed
SYLVAN AVE & ASYLUM ST	NEW HAVEN	0.17	BOSTON POST RD & MILFORD MARKET PL	MILFORD	0.15
SYLVAN AVE & WARD ST	NEW HAVEN	removed	BOSTON POST RD & OPP SMILES	MILFORD	0.31
SYLVAN AVE & VERNON ST	NEW HAVEN	removed	BOSTON POST RD & WOODRUFF RD	MILFORD	0.33
SYLVAN AVE & HOWARD AVE	NEW HAVEN	0.14	BOSTON POST RD & CHILI'S RESTAURANT	MILFORD	removed
YORK ST & HOWARD AVE	NEW HAVEN	0.10	BOSTON POST RD & RED BUSH LN	MILFORD	0.11
YORK ST & CEDAR ST	NEW HAVEN	0.16	BOSTON POST RD & TURNPIKE SQUARE	MILFORD	0.27
YORK ST & GEORGE ST	NEW HAVEN	0.27	EAST TOWN RD & SEARS	MILFORD	0.13

Eastbound			Westbound		
GEORGE ST & OPP HIGH ST	NEW HAVEN	removed	EAST TOWN RD & STOP & SHOP	MILFORD	0.33
GEORGE ST & TEMPLE ST	NEW HAVEN	0.20	EAST TOWN RD & CT POST ENTRANCE	MILFORD	removed
CHURCH ST & GEORGE ST	NEW HAVEN	removed	WESTFIELD CONNECTICUT POST MALL	MILFORD	0.00
CHURCH ST & CENTER ST	NEW HAVEN	0.00			

Appendix H - Estimated Travel Time Savings

Route 11A

	Eastbound			Westbound		
	AM	Mid	PM	AM	Mid	PM
Average Running Time (mins)						
Existing Service	51.6	47.1	56.1	50.0	45.8	53.5
Smart Cards	50.6	46.3	55.2	49.3	45.0	52.7
All Door Boarding	50.0	45.7	54.6	48.9	44.5	52.2
Proof of Payment	48.6	44.5	53.3	47.9	43.4	51.0
Running Time Saved (mins.)						
Smart Cards	1.0	0.8	0.9	0.7	0.8	0.8
All Door Boarding	1.6	1.4	1.5	1.1	1.3	1.3
Proof of Payment	3.0	2.6	2.8	2.1	2.4	2.5
Percent Running Time Saved						
Smart Cards	1.9%	1.8%	1.6%	1.4%	1.7%	1.5%
All Door Boarding	3.1%	2.9%	2.6%	2.2%	2.7%	2.5%
Proof of Payment	5.9%	5.5%	5.0%	4.2%	5.2%	4.7%

Route 41

	Eastbound			Westbound		
	AM	Mid	PM	AM	Mid	PM
Average Running Time (mins)						
Existing Service	39.8	46.8	49.4	43.7	46.2	47.0
Smart Cards	39.2	45.7	48.6	42.9	45.3	46.0
All Door Boarding	38.8	45.1	48.1	42.4	44.7	45.5
Proof of Payment	37.8	43.5	47.0	41.2	43.3	44.0
Running Time Saved (mins.)						
Smart Cards	0.6	1.1	0.8	0.8	0.9	1.0
All Door Boarding	1.0	1.7	1.3	1.3	1.5	1.5
Proof of Payment	2.0	3.3	2.4	2.5	2.9	3.0
Percent Running Time Saved						
Smart Cards	1.6%	2.3%	1.6%	1.9%	2.0%	2.0%
All Door Boarding	2.6%	3.6%	2.5%	3.0%	3.2%	3.3%
Proof of Payment	5.0%	7.0%	4.9%	5.8%	6.3%	6.3%

Coastal Link West

	Eastbound			Westbound		
	AM	Mid	PM	AM	Mid	PM
Average Running Time (mins)						
Existing Service	48.4	57.3	66.2	64.1	65.5	53.7
Smart Cards	47.2	56.3	64.8	62.8	62.9	52.9
All Door Boarding	46.4	55.6	63.9	61.9	61.1	52.3
Proof of Payment	45.6	54.9	62.9	61.0	59.3	51.7
Running Time Saved (mins.)						
Smart Cards	1.2	1.0	1.4	1.3	2.6	0.8
All Door Boarding	2.0	1.7	2.3	2.2	4.4	1.4
Proof of Payment	2.8	2.4	3.3	3.1	6.2	2.0
Percent Running Time Saved						
Smart Cards	2.4%	1.7%	2.1%	2.0%	3.9%	1.5%
All Door Boarding	4.1%	2.9%	3.5%	3.5%	6.7%	2.6%
Proof of Payment	5.8%	4.2%	5.0%	4.9%	9.5%	3.7%

Coastal Link East

	Eastbound			Westbound		
	AM	Mid	PM	AM	Mid	PM
Average Running Time (mins)						
Existing Service	49.4	50.8	48.9	52.4	54.2	51.9
Smart Cards	48.1	49.3	48.1	50.9	52.2	50.5
All Door Boarding	47.1	48.3	47.5	49.8	50.9	49.5
Proof of Payment	46.2	47.3	47.0	48.7	49.5	48.5
Running Time Saved (mins.)						
Smart Cards	1.3	1.5	0.8	1.5	2.0	1.4
All Door Boarding	2.3	2.5	1.4	2.6	3.3	2.4
Proof of Payment	3.2	3.5	1.9	3.7	4.7	3.4
Percent Running Time Saved						
Smart Cards	2.7%	2.9%	1.6%	2.9%	3.6%	2.8%
All Door Boarding	4.6%	4.9%	2.8%	5.0%	6.2%	4.7%
Proof of Payment	6.5%	6.9%	4.0%	7.0%	8.7%	6.6%

O Route 1

	Eastbound			Westbound		
	AM	Mid	PM	AM	Mid	PM
Average Running Time (mins)						
Existing Service	39.4	43.9	48.7	38.5	44.5	47.3
Smart Cards	38.6	43.0	47.3	37.7	43.4	46.4
All Door Boarding	38.1	42.3	46.4	37.1	42.6	45.9
Proof of Payment	37.7	41.7	45.5	36.6	41.9	45.4
Running Time Saved (mins.)						
Smart Cards	0.8	0.9	1.4	0.8	1.1	0.9
All Door Boarding	1.3	1.6	2.3	1.4	1.9	1.4
Proof of Payment	1.7	2.2	3.2	1.9	2.6	1.9
Percent Running Time Saved						
Smart Cards	1.9%	2.2%	2.9%	2.1%	2.6%	1.8%
All Door Boarding	3.2%	3.6%	4.8%	3.5%	4.3%	3.0%
Proof of Payment	4.4%	4.9%	6.6%	4.8%	5.8%	4.1%

Appendix I - Intersections with Proposed Improvements

FIG: A1

East Putnam Avenue (Route 1) and Indian Field Road

Route 11:

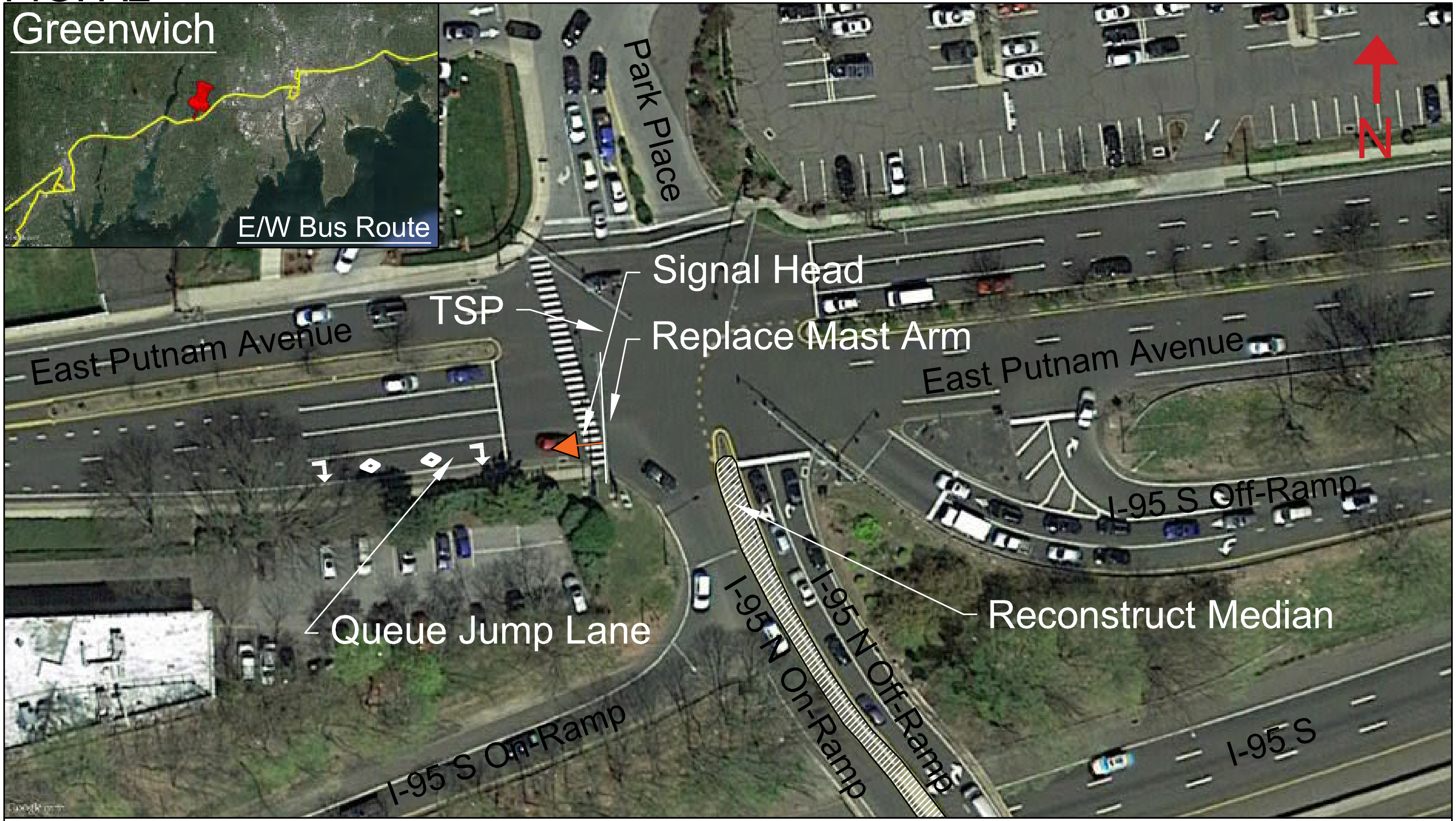
Improvement Strategy:

Westbound Route

- Transit Signal Priority
- Relocate bus stop to far side

SCALE: NTS	Eastbound Bus Stop: None Westbound Bus Stop: Far side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A2



East Putnam Avenue (Route 1) and I-95 Interchange

Route 11:

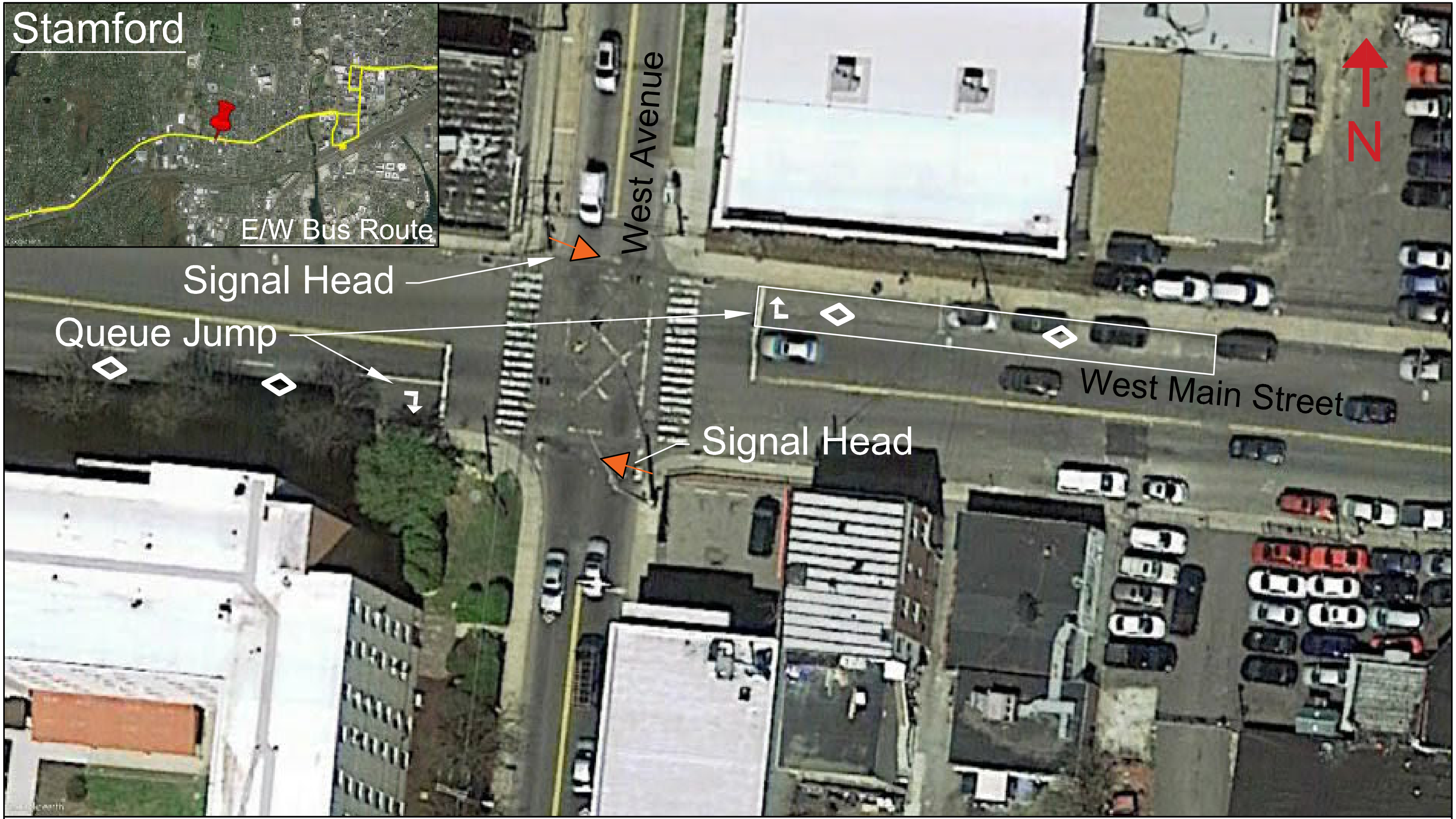
Improvement Strategy:

Eastbound Route - Queue jump; add a programmable signal head, mast arm, bus detection, and reconstruct median end at I-95 ramps

Westbound Route - Transit Signal Priority

SCALE: NTS	Eastbound Bus Stop: Near side Westbound Bus Stop: Near side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A3



West Main Street (Route 1) and West Avenue

Route 11:

Improvement Strategy:

Eastbound Route - Queue Jump; add a programmable Signal Head, bus detection

Westbound Route - Remove parking; queue jump; add a programmable signal head, bus detection

SCALE: NTS	Eastbound Bus Stop: Near side Westbound Bus Stop: Near side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A4

West Main Street (Route 1) and Stillwater Avenue

Route 11:

Improvement Strategy:

Eastbound Route

- Intersection timing optimization by city

SCALE: NTS

Eastbound Bus Stop: Far side
Westbound Bus Stop: None

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FIG: A5

Tresser Boulevard (Route 1) and Washington Boulevard (Route 137)

Route 11:

Improvement Strategy:

Eastbound Route
- Transit Signal Priority

Westbound Route
- Transit Signal Priority

SCALE: NTS	Eastbound Bus Stop: Far side Westbound Bus Stop: Far side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A6

North State Street and Atlantic Street

Route 11:
Improvement Strategy:
Westbound Route
- Passive intersection timing optimization by City of Stamford

SCALE: NTS	Eastbound Bus Stop: None Westbound Bus Stop: Near side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A7

Broad Street and Atlantic Street

Route 11:

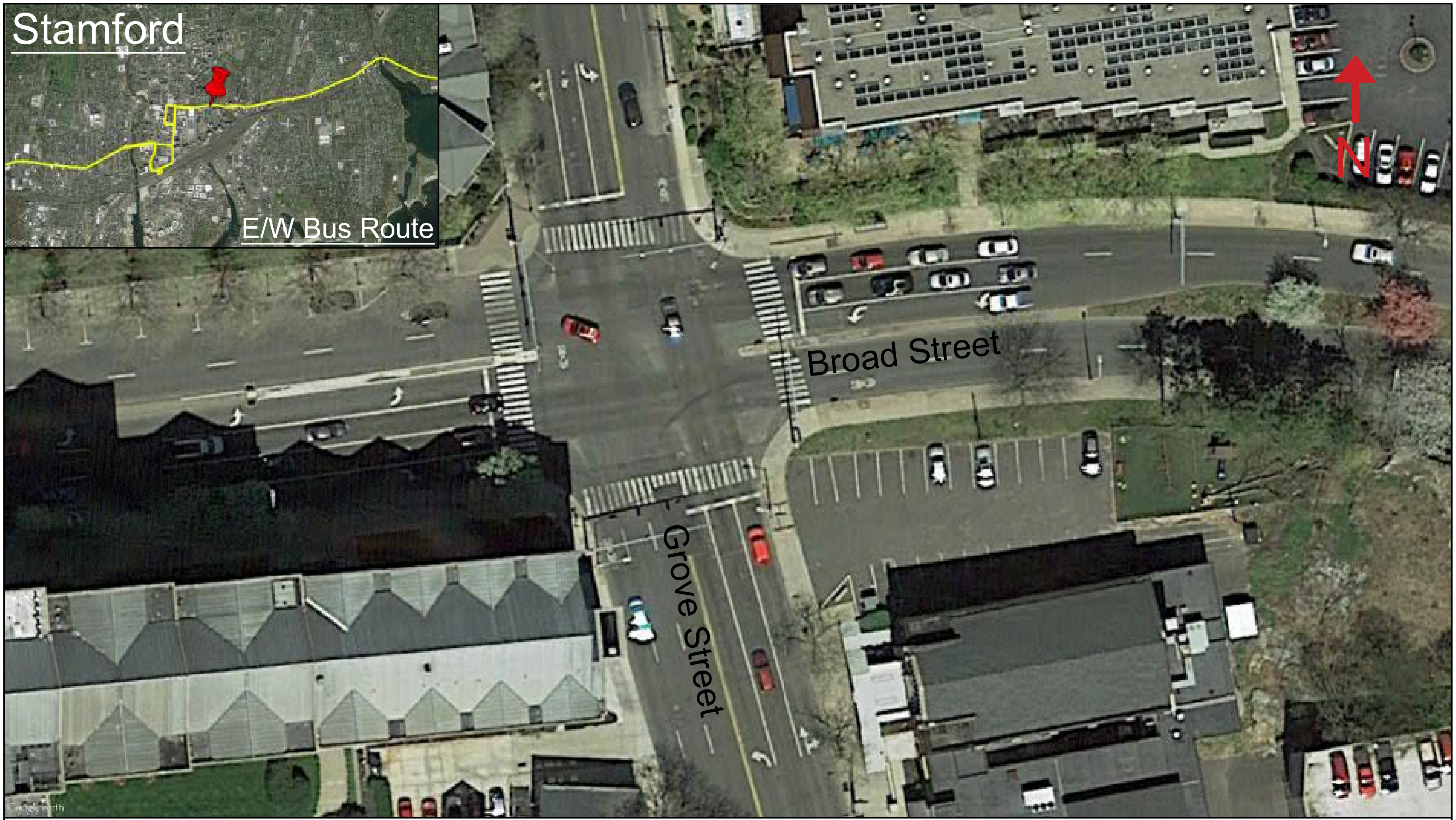
Improvement Strategy:

Eastbound and Westbound Route

- Passive intersection timing optimization by City of Stamford

SCALE: NTS	Eastbound Bus Stop: None Westbound Bus Stop: None	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A8



Broad Street and Grove Street

Route 41:

Improvement Strategy:

Westbound Route

- Passive intersection timing optimization by City of Stamford

SCALE: NTS	Eastbound Bus Stop: None Westbound Bus Stop: Near side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A9

East Main Street (Route 1) and Glenbrook Road

Route 41:

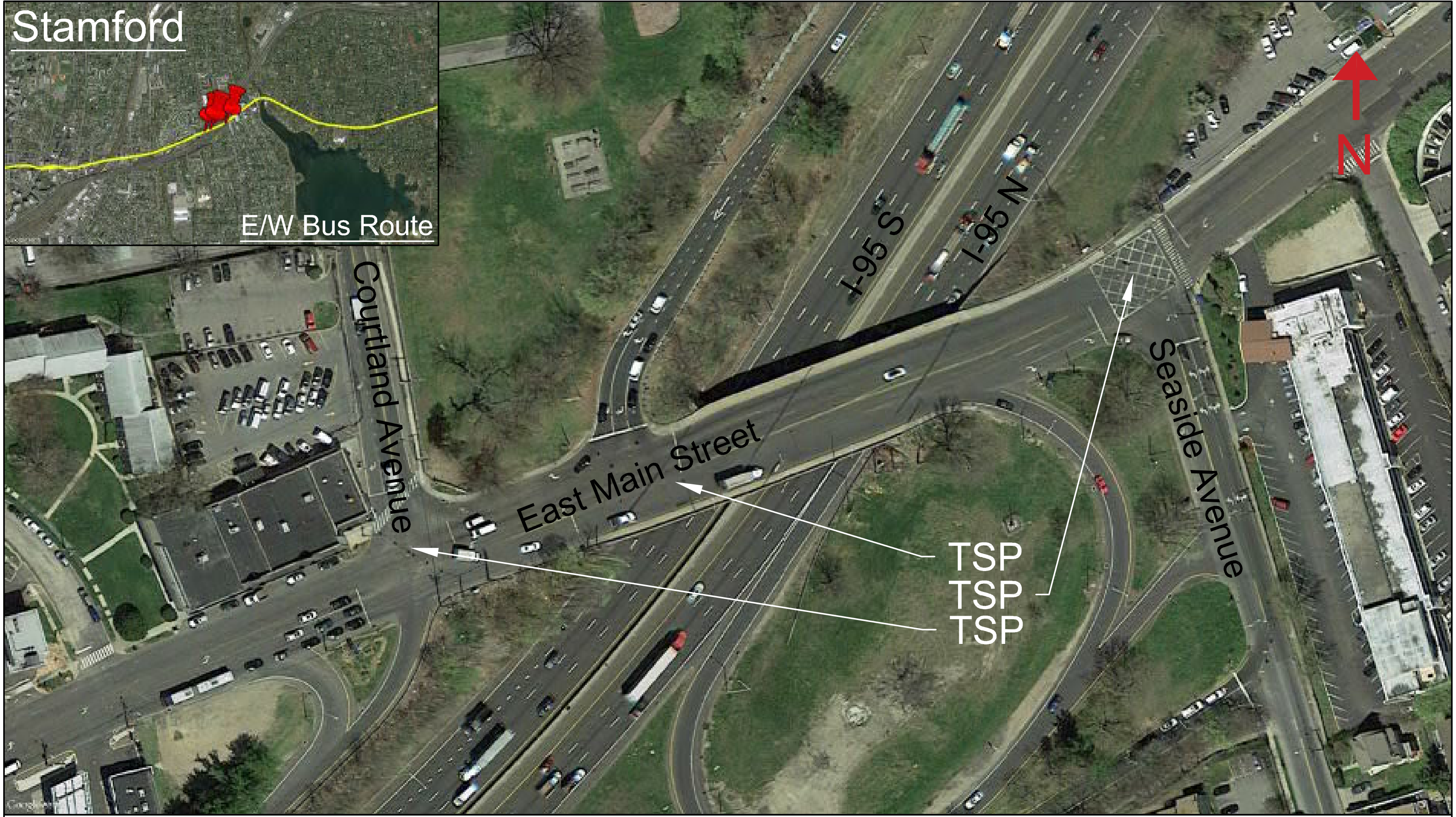
Improvement Strategy:

Westbound

- Passive intersection timing optimization by City of Stamford
- Coordination with nearby signals

SCALE: NTS	Eastbound Bus Stop: NS Westbound Bus Stop: None	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A10



East Main Street (Route 1) w/ Courtland Avenue (Route 106), I-95 Ramps, and Seaside Avenue

Route 41:

Improvement Strategy:

Westbound Route

- Transit Signal Priority for all three signalized intersections

SCALE: NTS	Eastbound Bus Stop: None Westbound Bus Stop: Far side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A11

Connecticut Avenue (Route 1) and Shop Rite

Route 41:

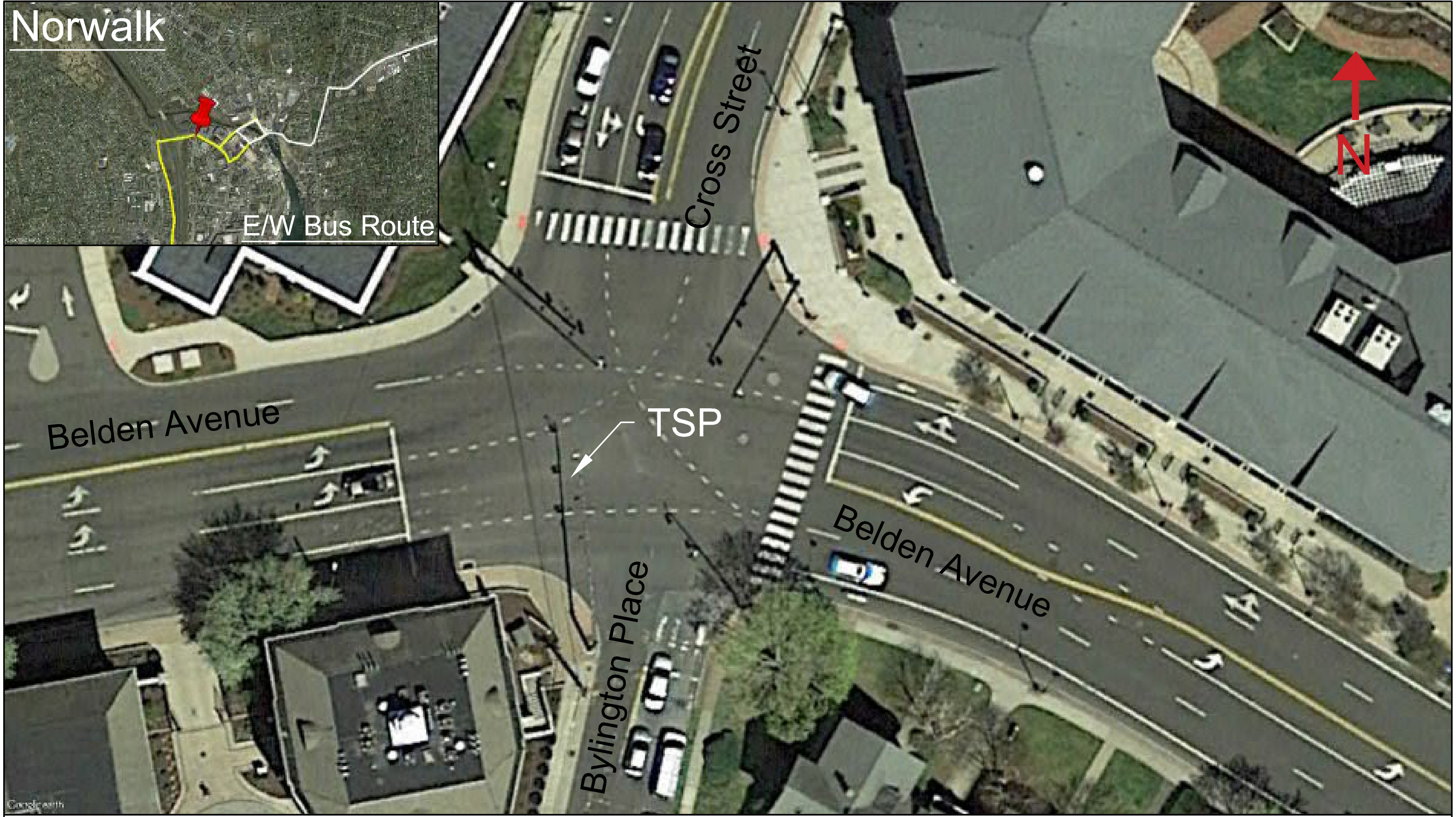
Improvement Strategy:

Westbound Route

- Queue Jump
- Add a programmable signal head
- Bus detection

SCALE: NTS	Eastbound Bus Stop: None Westbound Bus Stop: Far side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A12



Cross Street (Route 1)/ Bylington Place/ Belden Avenue

Route 41:

Improvement Strategy:

Westbound Route

- Transit Signal Priority

SCALE: NTS

Eastbound Bus Stop: None
Westbound Bus Stop: Near side

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FIG: A13

Belden Avenue and Burnell Boulevard

Route CLW:

Improvement Strategy:

Eastbound Route

- Transit Signal Priority
- Traffic signal timing improvements

SCALE: NTS

Eastbound Bus Stop: Near side
Westbound Bus Stop: None

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FIG: A14

East Wall Street and East Avenue (Route 53)

Route CLW:

Improvement Strategy:

Eastbound Route

- Transit Signal Priority

Westbound Route

- Reroute bus route: See Fig. A14a; Reconstruct Park Street median to accommodate 2 Thru, and a Right Turn Lane

SCALE: NTS	Eastbound Bus Stop: Farside Westbound Bus Stop: Farside	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A14a

East Wall Street and East Avenue

Route CLW:

Improvement Strategy:

Eastbound Route - Keep current route path

Westbound Route - Reroute Bus Route: North Ave, to East Ave, to Parkhill Ave, to Park S, to E Wall St

SCALE: NTS

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FIG: A15

North Avenue (Route 1) and East Avenue

Route CLW:
Improvement Strategy:
Westbound Route
- Transit Signal Priority

SCALE: NTS

Eastbound Bus Stop: None
Westbound Bus Stop: None

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FIG: A16

Post Road West (Route 1) and Riverside Avenue (Route 33)

Route CLW:

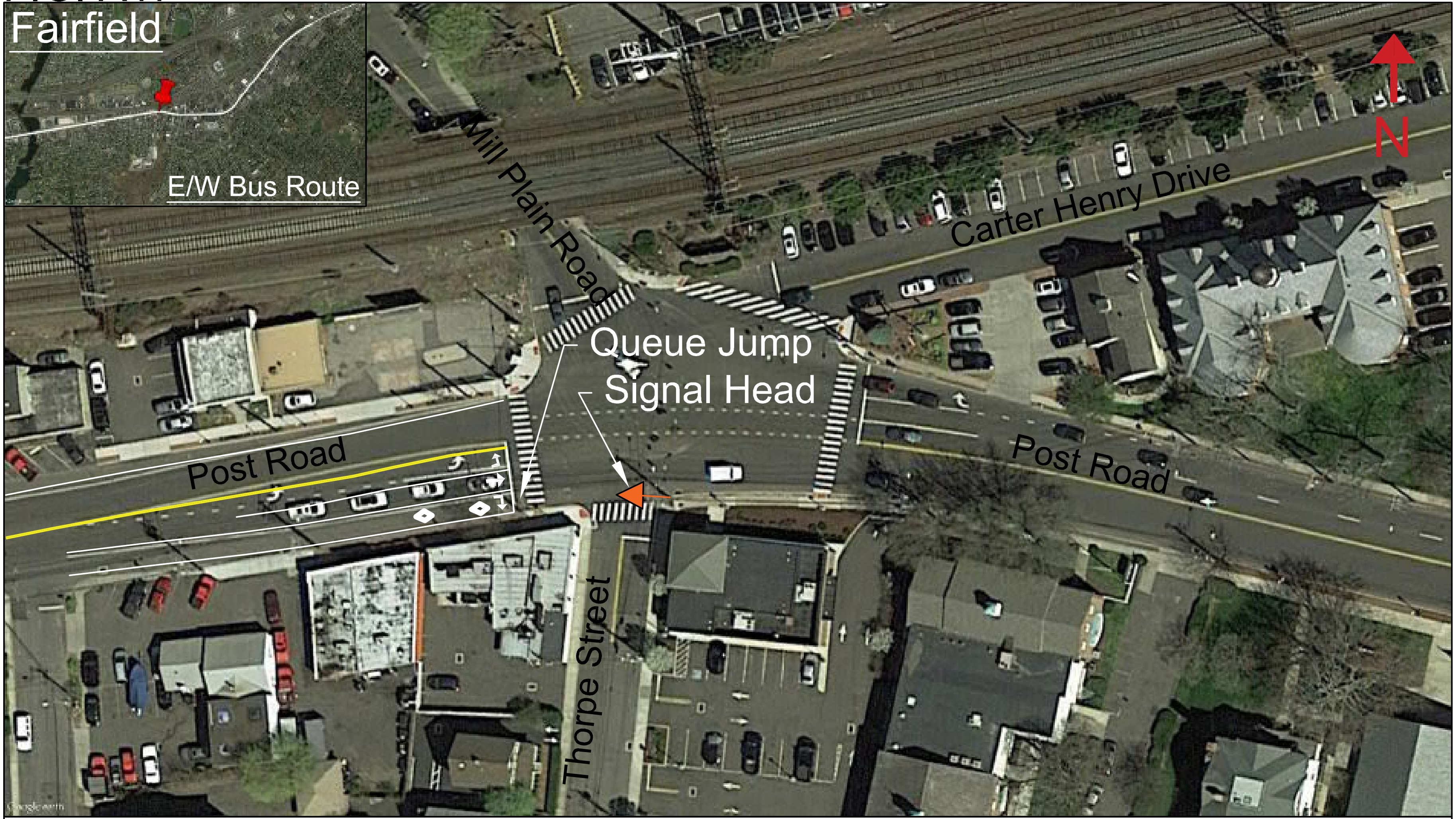
Improvement Strategy:

Eastbound Route
- Transit Signal Priority; remove parking and relocate bus stop to far side

Westbound Route
- Transit Signal Priority

SCALE: NTS	Eastbound Bus Stop: Far side Westbound Bus Stop: Far side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A17



Post Road (Route 1) and Mill Plain Road

Route CLW:

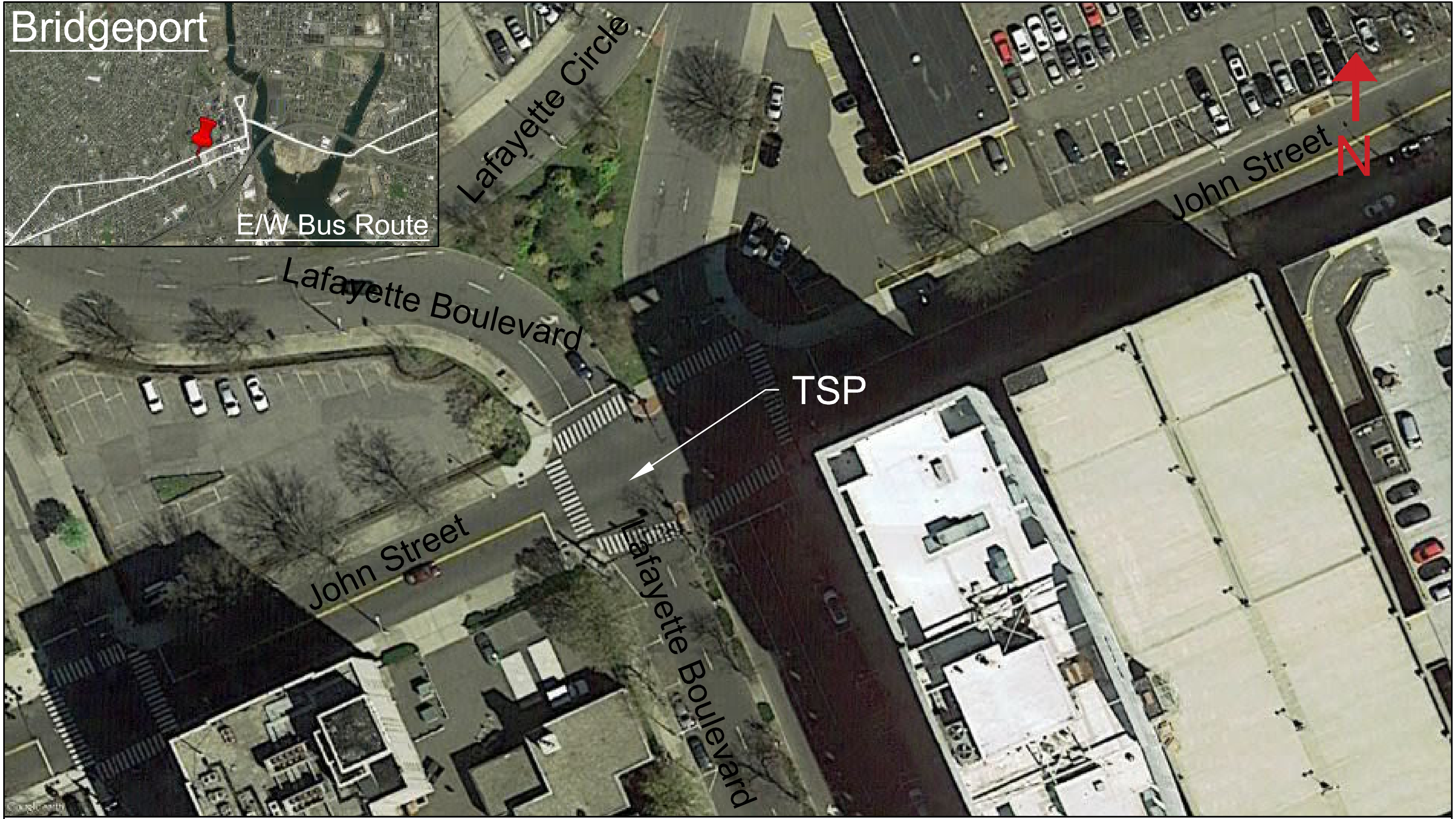
Improvement Strategy:

Eastbound Route

- Queue Jump
- Add a programmable signal head, and bus detection

SCALE: NTS	Eastbound Bus Stop: Near side Westbound Bus Stop: Near side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A18



Lafayette Boulevard and John Street

Route CLW:

Improvement Strategy:

Intersection is being realigned under a separate project

Westbound Route

- Transit Signal Priority

SCALE: NTS

Eastbound Bus Stop: None

Westbound Bus Stop: Near side

Route 1 Bus Rapid Transit Feasibility Study

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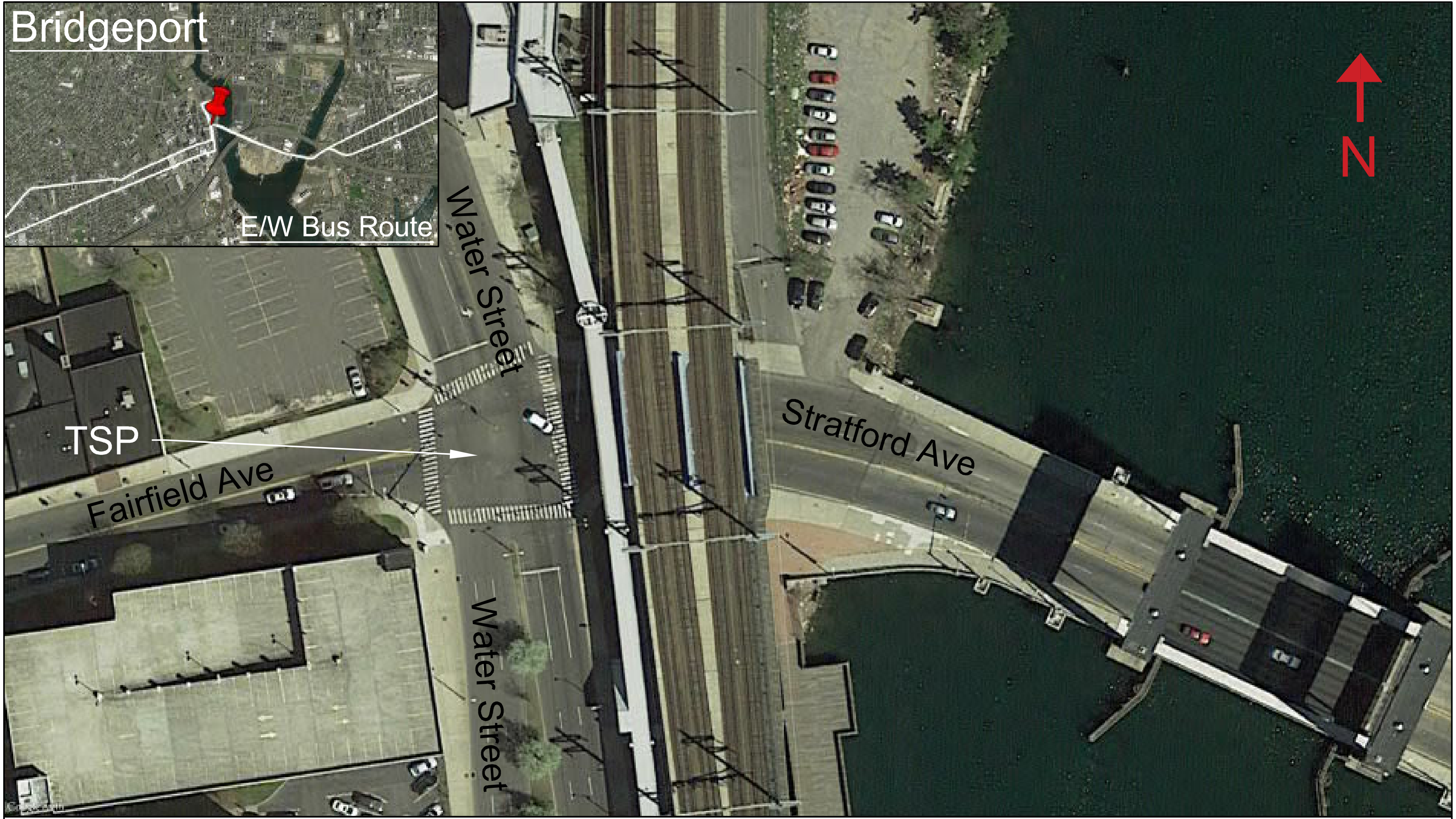
FIG: A19



Fairfield Avenue and Water Street

Route CLW:

Improvement Strategy:

Eastbound Route

- Southbound Improvements to traffic signal timing and coordination

Westbound Route

- Transit Signal Priority

SCALE: NTS

Eastbound Bus Stop: Near side
Westbound Bus Stop: None

Route 1 Bus Rapid Transit Feasibility Study
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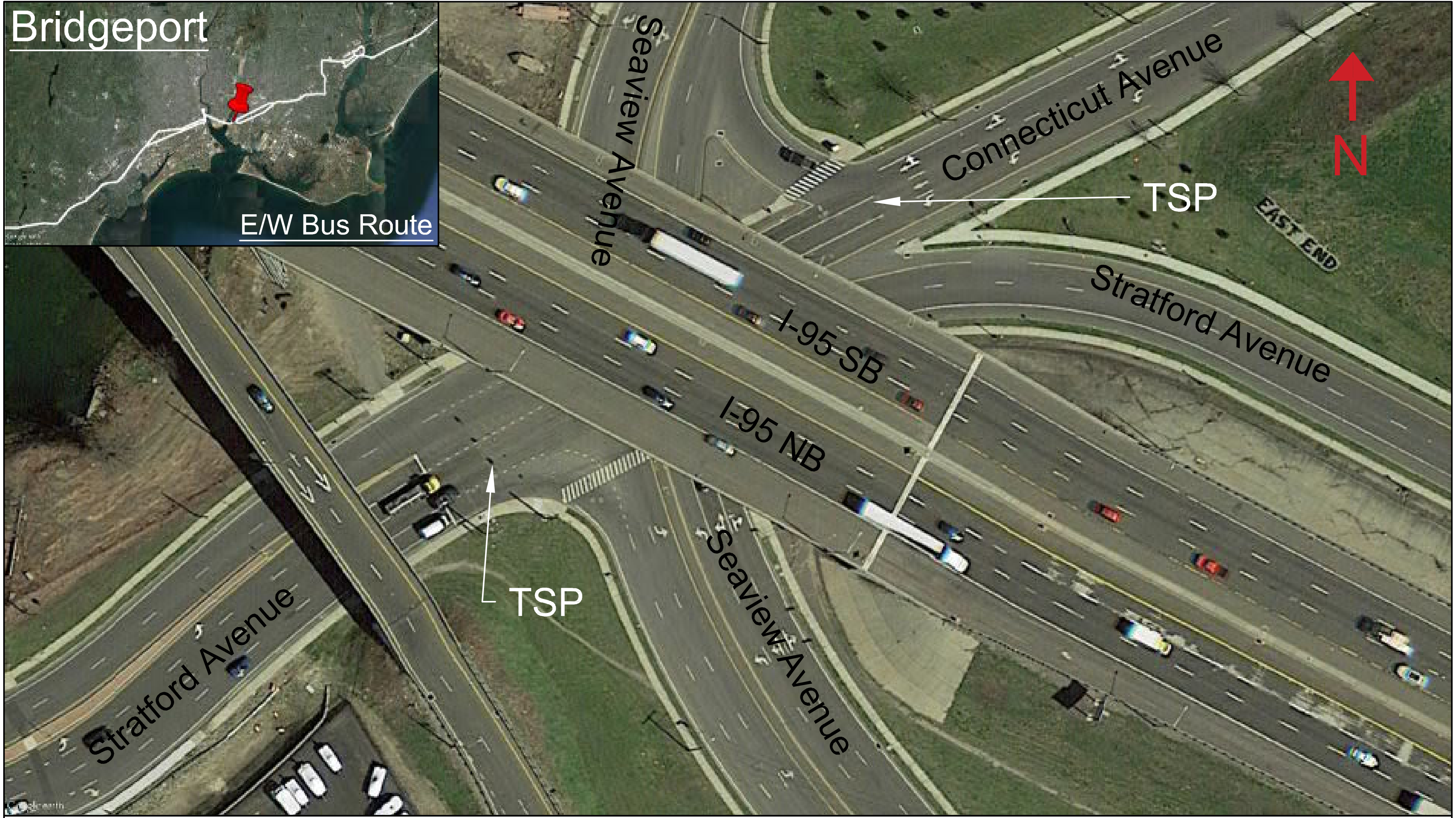
FIG: A20



Stratford Avenue at Seaview Avenue and Connecticut Avenue

Route CLE:

Improvement Strategy:

Eastbound Route

- Transit Signal Priority

Westbound Route

- Transit Signal Priority

SCALE: NTS	Eastbound Bus Stop: Near side Westbound Bus Stop: None	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A21

Barnum Avenue (Route 1) and Main Street (Route 113)

Route CLE:

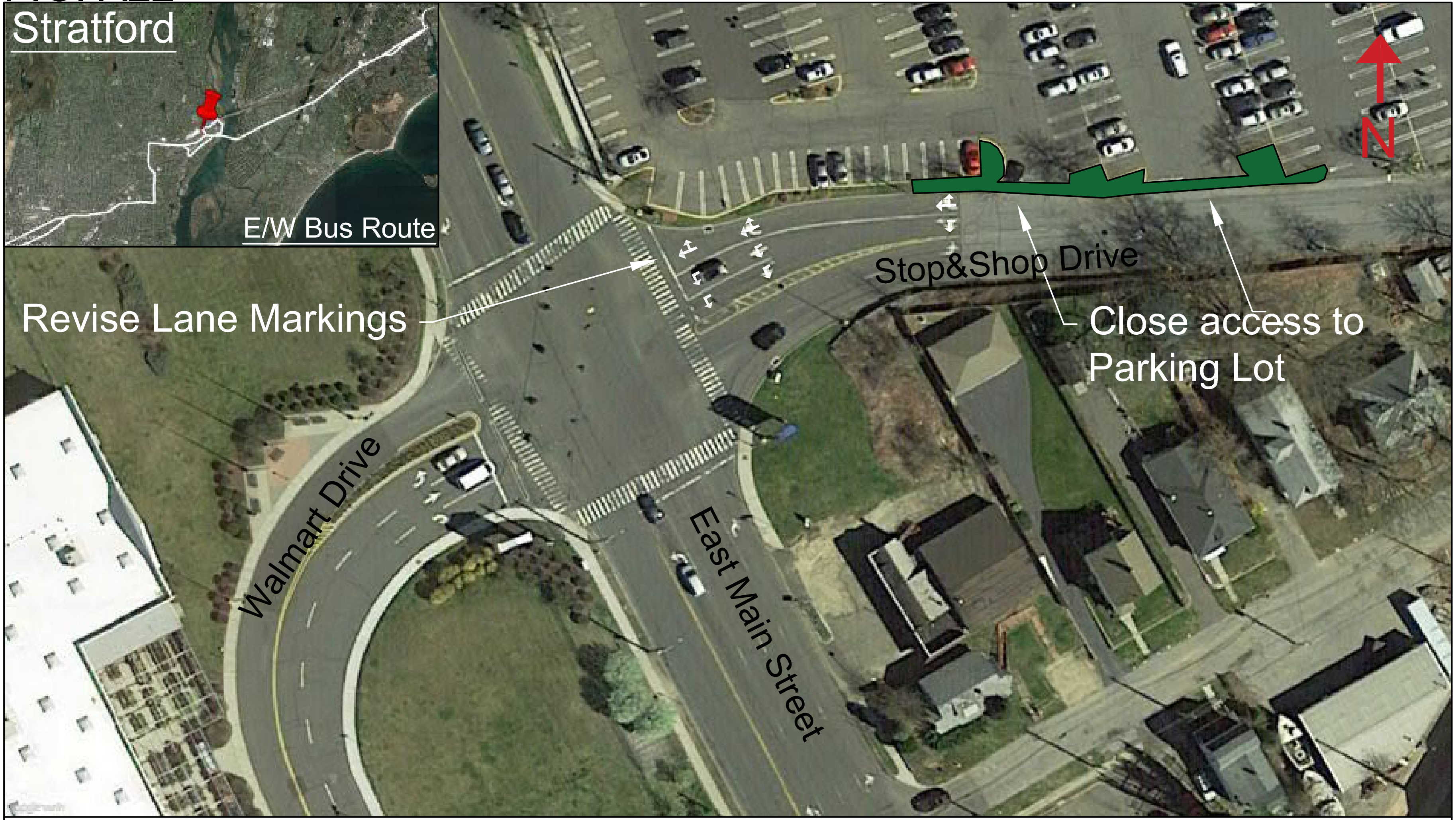
Improvement Strategy:

Eastbound Route - Northbound Right Lane as BAT (Business Access and Transit) Lane during peak times

Westbound Route - Extend Left Turn Lane storage if feasible

SCALE: NTS	Eastbound Bus Stop: Near side Westbound Bus Stop: Far side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A22



East Main Street (Route 110) and Walmart Driveway

Route CLE:

Improvement Strategy:

Westbound Route

- Curb cut management
- Revise lane use

SCALE: NTS

Eastbound Bus Stop: None

Westbound Bus Stop: Far side

Route 1 Bus Rapid Transit Feasibility Study

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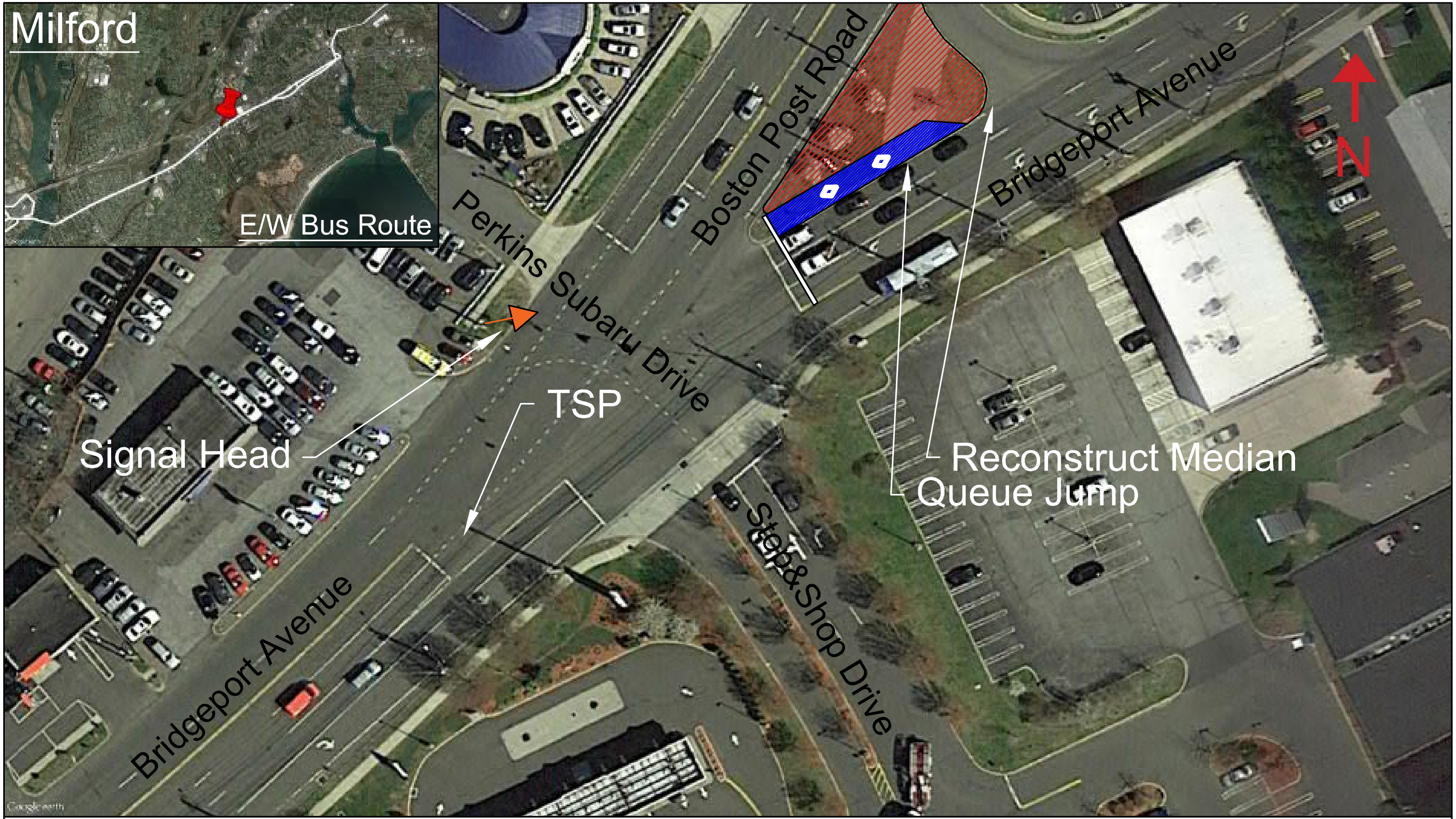
FIG: A23



Bridgeport Avenue (Route 162) and Boston Post Road (Route 1)

Route CLE:

Improvement Strategy:

Eastbound Route

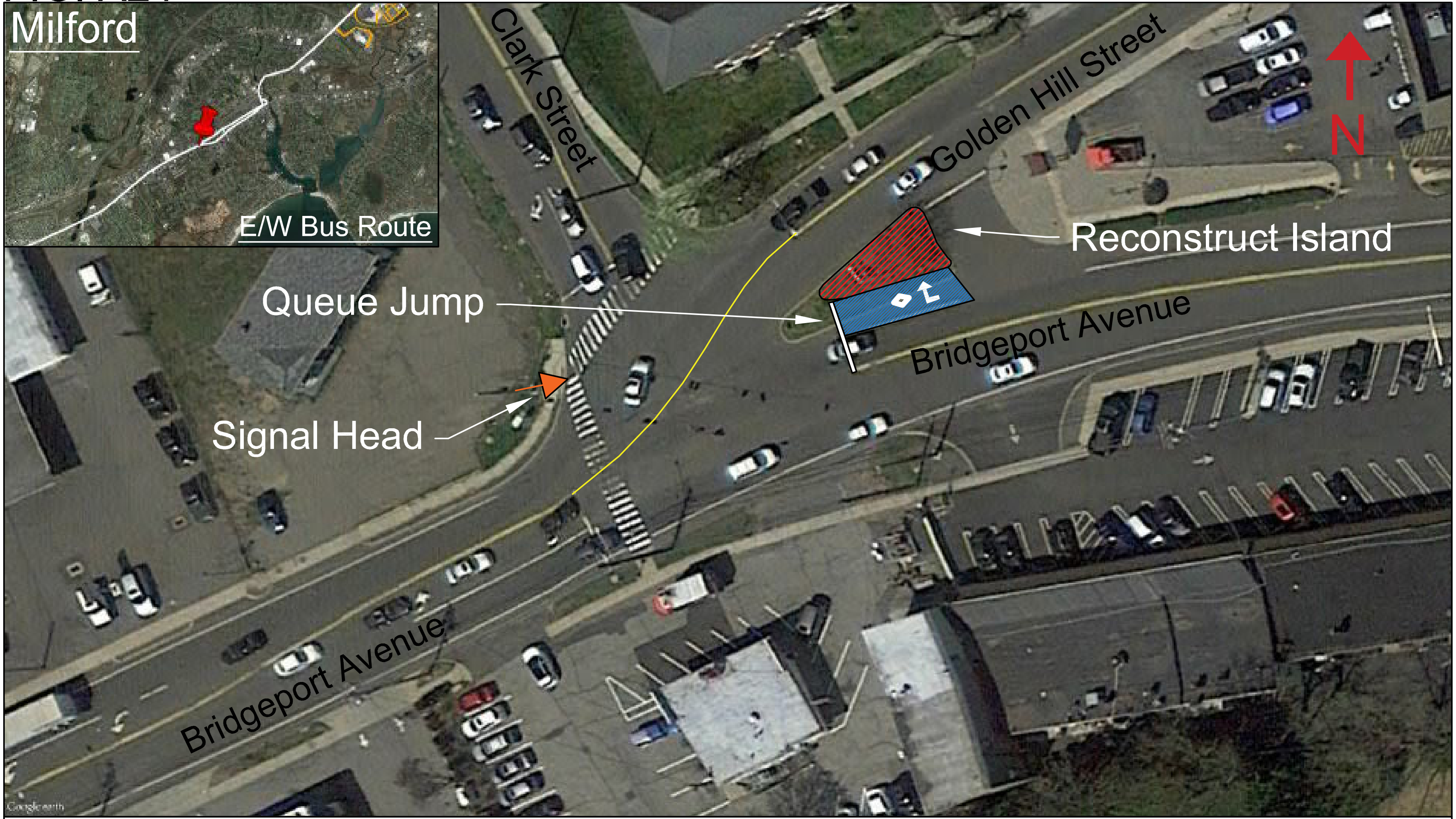
- Transit Signal Priority

Westbound Route

- Reconstruct median; queue jump; add a signal head and bus detection

SCALE: NTS	Eastbound Bus Stop: Near side Westbound Bus Stop: Near side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A24



Bridgeport Avenue (Route 162), Clark Street and Golden Hill Street

Route CLE:

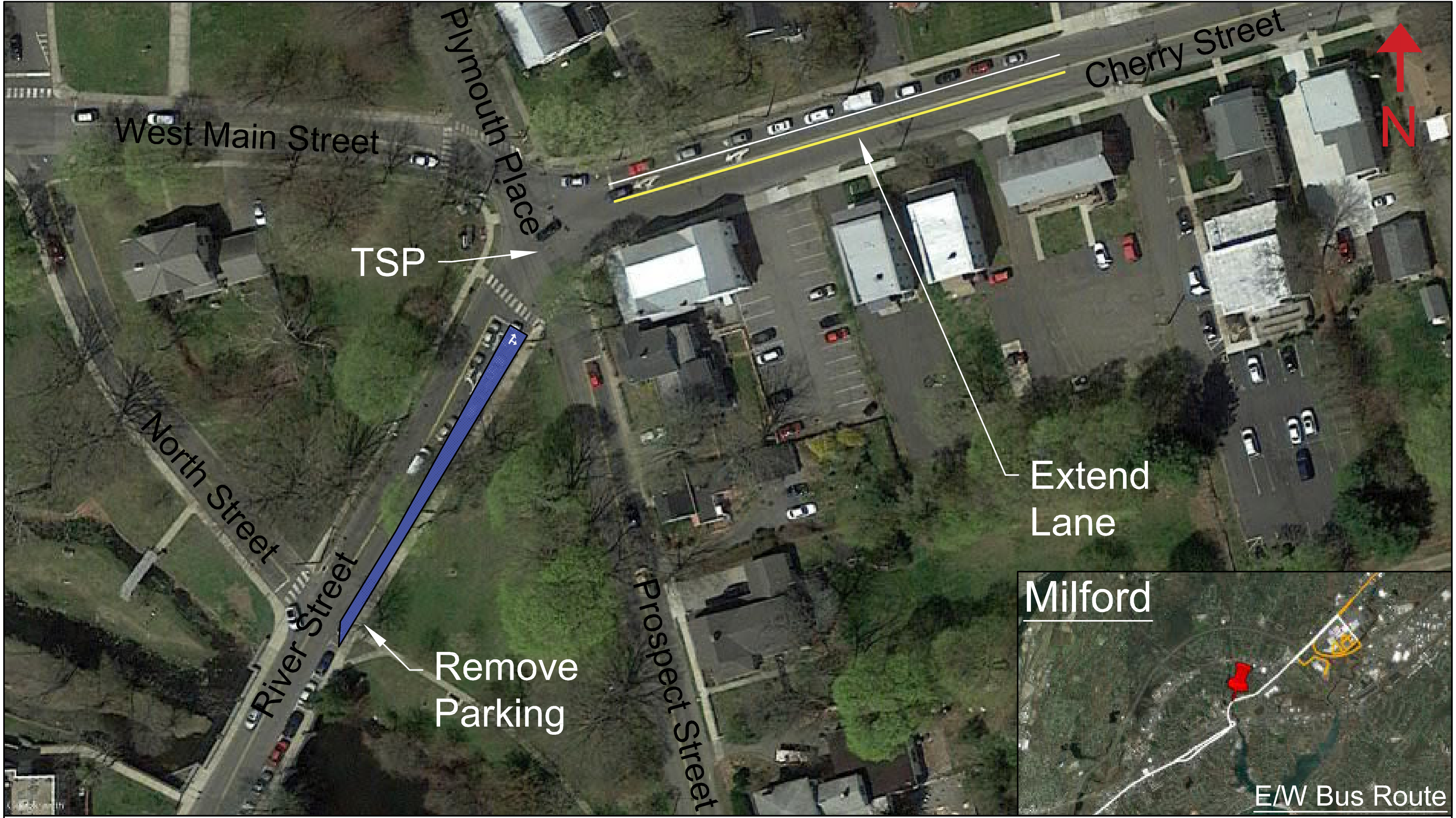
Improvement Strategy:

Westbound Route

- Queue Jump; add a programmable signal head, and bus detection
- Reconstruct channelized island

SCALE: NTS	Eastbound Bus Stop: None Westbound Bus Stop: Far side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A25



West Main Street, Plymouth Place, Prospect Street, and River Street

Route CLE:

Improvement Strategy:

Eastbound Route

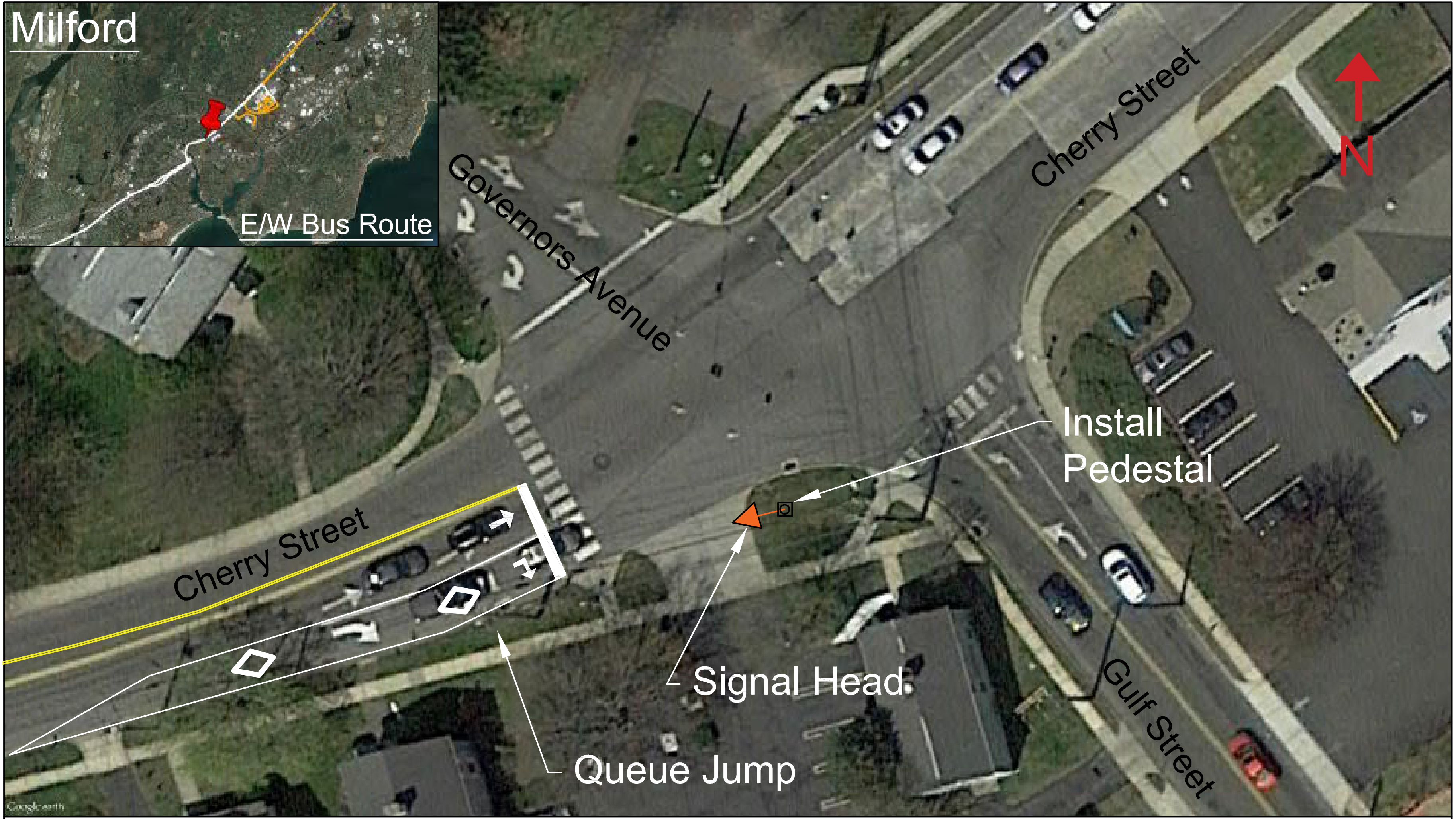
- Transit Signal Priority; remove parking; timing optimization

Westbound Route

- Transit Signal Priority; extend Left Turn Lane; traffic signal timing optimization

SCALE: NTS	Eastbound Bus Stop: Near side Westbound Bus Stop: Far side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A26



Cherry Street and Gulf Street

Route CLE:

Improvement Strategy:

Eastbound Route

- Queue Jump
- Extend Right Turning Lane
- Add a programmable signal head, pedestal, and bus detection

SCALE: NTS	Eastbound Bus Stop: None Westbound Bus Stop: None	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A27

Boston Post Road (Route 1) and East Town Road

Route CLE:

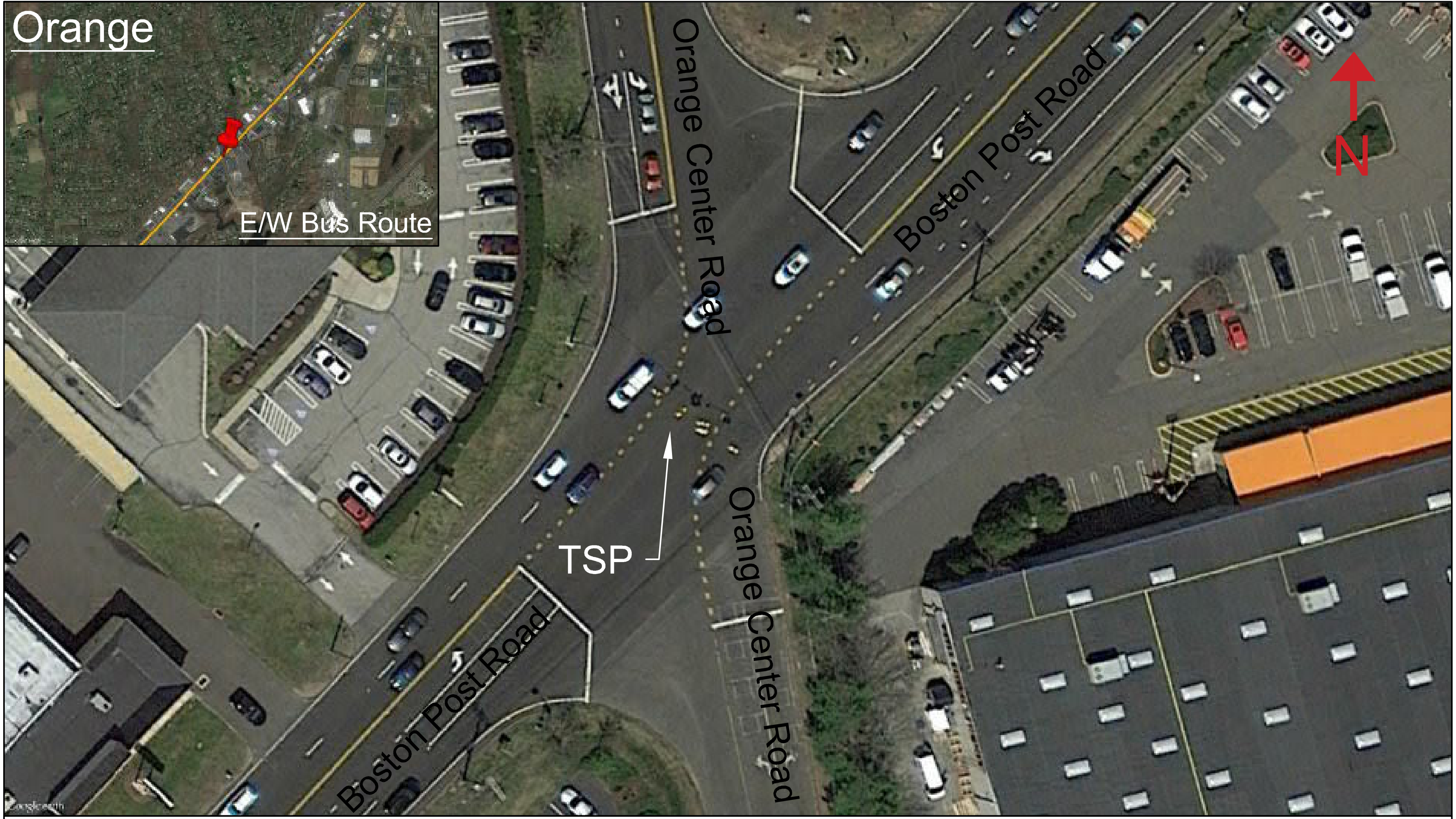
Improvement Strategy:

Westbound Route

- Transit Signal Priority

SCALE: NTS	Eastbound Bus Stop: Near side Westbound Bus Stop: None	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A28



Boston Post Road (Route 1) and Orange Center Road (Route 152)

Route O:
Improvement Strategy:
Eastbound Route and Westbound Route
- Transit Signal Priority

Other Improvements:
- Install crosswalks, ADA compliant sidewalks & ramps

SCALE: NTS	Eastbound Bus Stop: Near side Westbound Bus Stop: Far side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A29

Boston Post Road (Route 1) and Lambert Road

Route O:

Improvement Strategy:

Eastbound Route and Westbound Route

- Transit Signal Priority

SCALE: NTS

Eastbound Bus Stop: Far side
Westbound Bus Stop: Near side

Route 1 Bus Rapid Transit Feasibility Study
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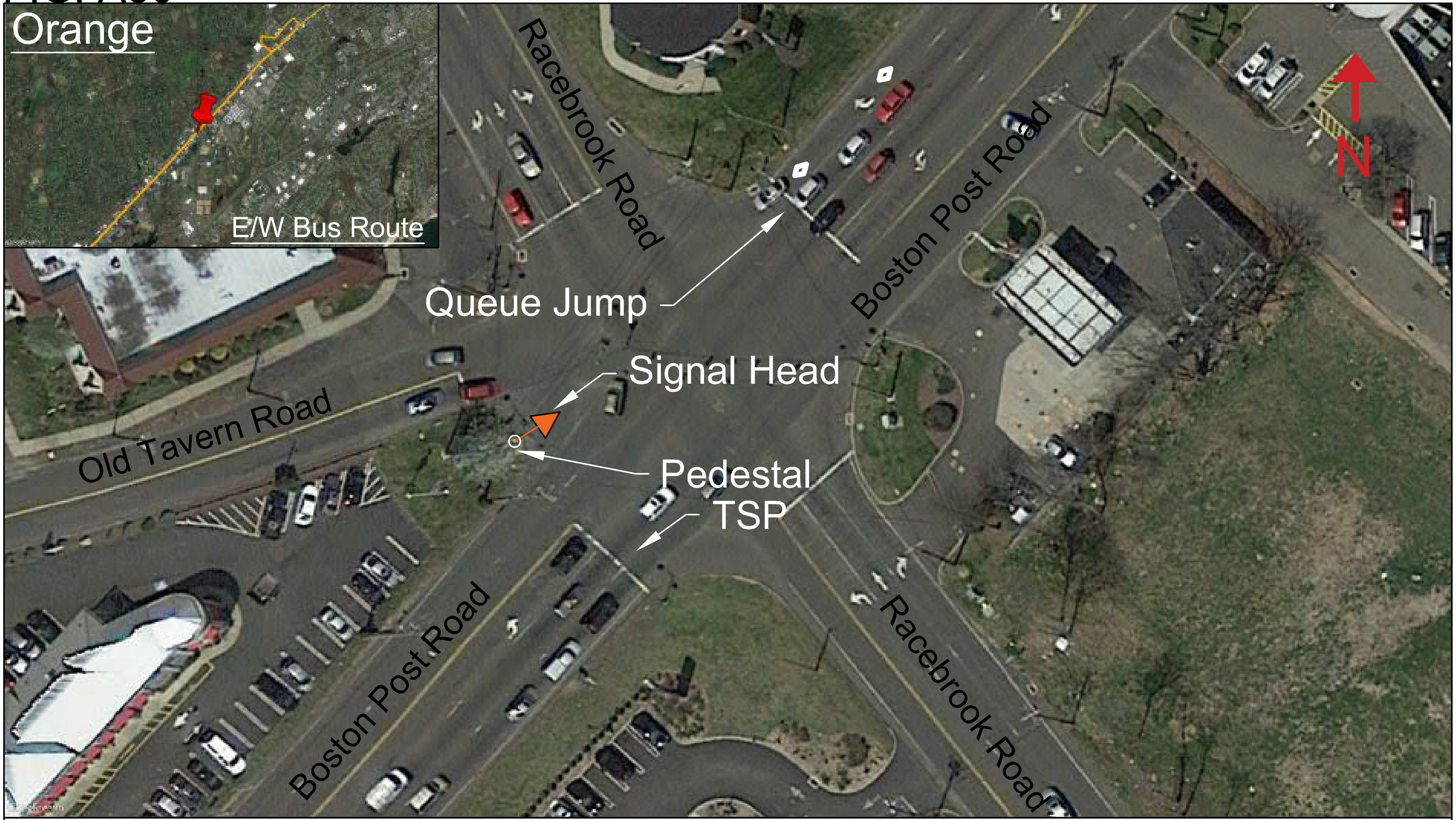
FIG: A30



Boston Post Road (Route 1) and Racebrook Road (Route 114)

Route O:

Improvement Strategy:

Eastbound Route - Transit Signal Priority

Westbound Route - Queue Jump; bus detection, pedestal, and a programmable signal head

SCALE: NTS	Eastbound Bus Stop: Near side Westbound Bus Stop: Near side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A31

Boston Post Road (Route 1) and Campbell Avenue (Route 122)

Route O:

Improvement Strategy:

Eastbound Route and Westbound Route

- Intersection is currently under construction
- Transit Signal Priority

SCALE: NTS	Eastbound Bus Stop: None Westbound Bus Stop: Near side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A32

Church Street and George Street

Route O:

Improvement Strategy:

Eastbound Route

- Improvements to the intersection operation are planned by the City of New Haven

SCALE: NTS

Eastbound Bus Stop: Near side
Westbound Bus Stop: None

Route 1 Bus Rapid Transit Feasibility Study
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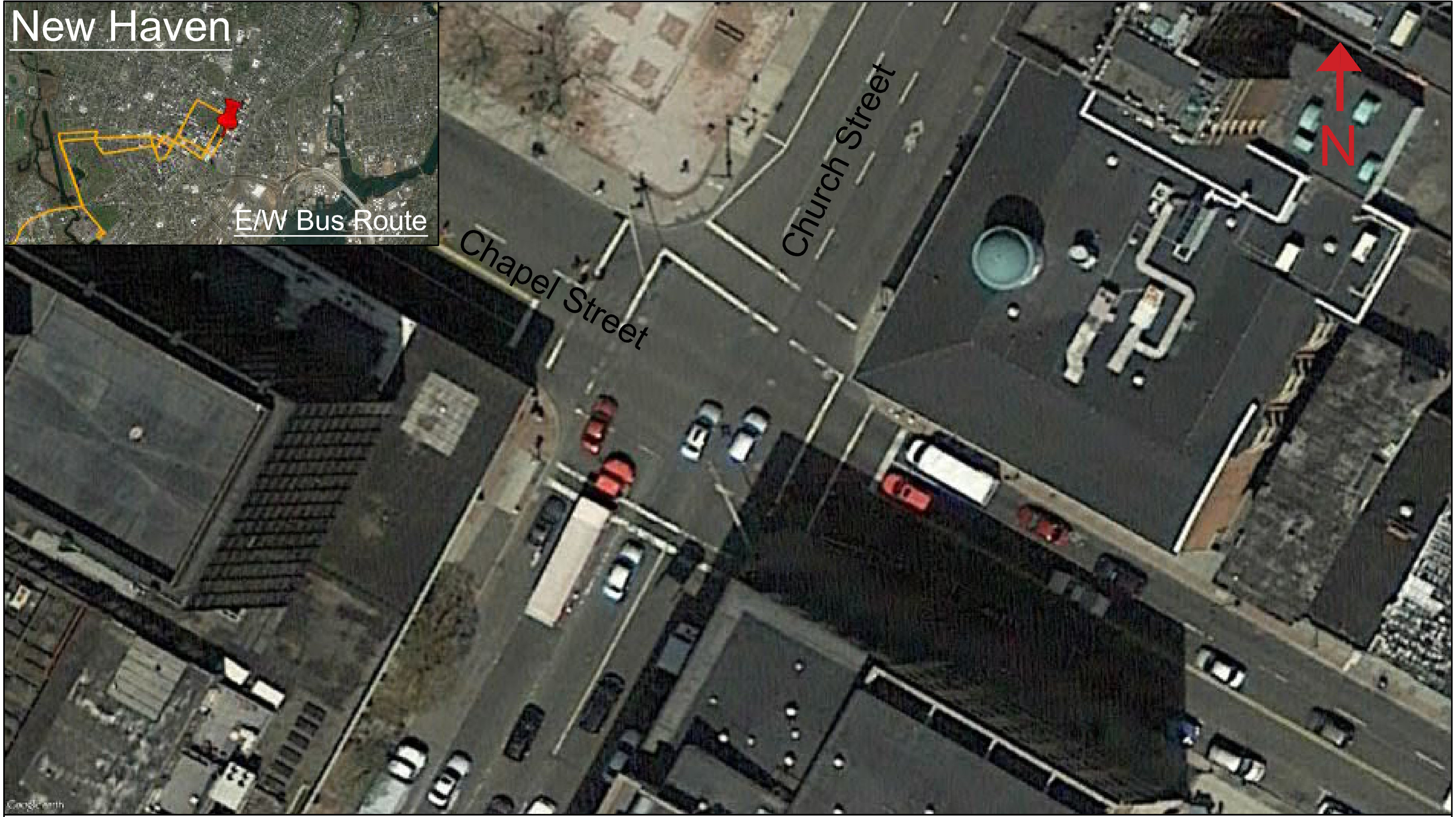
FIG: A33



Church Street and Chapel Street

Route O:

Improvement Strategy:

Eastbound Route

- Improvements to the intersection operation are planned by the City of New Haven

SCALE: NTS	Eastbound Bus Stop: Near side Westbound Bus Stop: None	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471

FIG: A34

Temple Street and Chapel Street

Route O:

Improvement Strategy:

Eastbound and Westbound Route

- Improvements to the intersection operation are planned by the City of New Haven

SCALE: NTS	Eastbound Bus Stop: None Westbound Bus Stop: Near side	Route 1 Bus Rapid Transit Feasibility Study STATE PROJECT NO. 173-471