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DRAFT TECHNICAL MEMORANDUM

DATE: **February 18, 2016**

TO: **Boston Region MPO**

FROM: **Chen-Yuan Wang, MPO Staff**

RE: **Summer Street/George Washington Boulevard Subregional Priority Roadway Study in Hingham and Hull**

The roadway corridor of Summer Street, Rockland Street, and George Washington Boulevard in Hingham and Hull was selected for analysis in a Boston Region Metropolitan Planning Organization (MPO) funded project for federal fiscal year (FFY) 2015: “Addressing Safety, Mobility, and Access on Subregional Priority Roadways.” The work program for this corridor was approved on October 16, 2014, and the selection was approved on April 2, 2015.

1 INTRODUCTION

This memorandum summarizes the existing conditions and issues, roadway operations and safety analyses, and proposed short- and long-term improvements for the entire study corridor and for specific locations. It contains the following sections:

1. Introduction
2. Existing Conditions and Issues
3. Roadway Operations Analysis
4. Crash Data Analysis
5. Proposed Improvements
6. Summary and Recommendations

This memorandum also includes technical appendices that contain the data and methods used in the study.

1.1 Study Background

During the MPO’s outreach for developing the Unified Planning Work Program (UPWP) and the Long-Range Transportation Plan (LRTP), Metropolitan Area Planning Council (MAPC) subregional groups and other entities submit comments and identify transportation problems and issues that concern them. These issues are related to bicycle, pedestrian, and freight accommodation, bottlenecks, safety, or lack of safe or convenient access for abutters along roadway corridors. They can affect not only mobility and safety along a roadway and its side streets, but also quality of life, including economic development and air quality.

The purpose of this study was to identify roadway corridors in the MPO region that are of concern to Boston Region MPO subregional groups, but which have not been identified in the LRTP regional needs assessment. In addition to identifying the problems, this study also recommends improvements to address them. In addition to mobility, safety, and access, the study considered transit feasibility, truck issues, bicycle and pedestrian transportation, preservation, and other topics.

1.2 Selection Procedure

This corridor was selected through a comprehensive process. First, MPO staff identified potential study locations using various sources: soliciting suggestions during the outreach process for the FFY 2015 UPWP; reviewing meeting records from the UPWP outreach process for the past five years; and appraising potential locations from the monitored roadways in the MPO's Congestion Management Process (CMP) program.

MPO staff identified 30 roadway corridors in the MPO region as potential study locations. The staff assembled detailed data on the identified roadways and evaluated them according to four selection criteria[1]:

- *Safety Conditions*: The location has a high crash rate for its functional class, or contains areas with a large number of crashes or with a significant number of pedestrian-bicycle collisions.
- *Multimodal Significance*: The location supports transit, bicycle, or pedestrian activity, or accommodates large amounts of heavy vehicles (trucks/busses).
- *Subregional Priority*: The location carries a significant proportion of subregional vehicle, bicycle, or pedestrian traffic and is essential for the subregion's economic, cultural, or recreational development.
- *Implementation Potential*: The location was proposed or endorsed by the roadway administrative agency/agencies and has strong support from its stakeholders.

The Summer Street/George Washington Boulevard corridor contains several high-crash and congested locations, such as the Route 3A and North Street

[1] Details of the criteria and rating system may be found in the CTPS technical memorandum "Selection of Study Location: FFY 2015 Addressing Safety, Mobility, and Access on Subregional Priority Roadways," April 2, 2015.

intersection, which need to be improved for the safety and mobility of users of all modes. Major portions of the corridor have strong potential for design and implementation toward a Complete Street[2] roadway. More importantly, the study site has strong support from all stakeholders, including officers and representatives from Hingham and Hull and the Massachusetts Department of Transportation (MassDOT).

1.3 Study Objectives

The objectives of this study were to:

- Identify the safety, mobility, access, and other transportation-related problems in the corridor.
- Develop and evaluate potential multimodal transportation solutions to the problems, including pedestrian, bicycle, truck, and transit modes.

1.4 Study Area and Data Collection

This study focuses on an almost three-mile corridor that consists of Summer Street (from North Street to Rockland Street), Rockland Street (from Summer Street to George Washington Boulevard), and the entire section George Washington Boulevard in Hingham and Hull. All segments of the corridors are under the jurisdiction of MassDOT Highway Division District 5.

Based on MPO staff requests, MassDOT collected extensive traffic volumes, spot speed data, and intersection turning-movement counts (including pedestrian and bicycle movements and the percentages of heavy vehicles) for this study. The data were collected during two periods: late spring (June 1-4, 2015), and high summer (July 9-12, 2015). Staff also collected various data from the towns, including recent transportation and land-use studies, information about adjacent developments, and multiple-year police crash reports.

1.5 Study Advisory Meetings

During the course of the study, MPO staff worked closely with the towns and MassDOT District 5. Two advisory meetings were held to guide and support the study. The advisory members included representatives from Hingham and Hull, State Senator Hedlund’s and Representative Bradley’s offices, MassDOT, and the Massachusetts Department of Conservation and Recreation (see Appendix A for a list of meeting participants).

[2] According to Smart Growth America, a “complete street” is a street for everyone. Complete streets are designed and operated to enable safe access for all users, including pedestrians, bicyclists, motorists and transit riders of all ages and abilities. They make it easy to cross the street, walk to shops, and bicycle to work.

In the first meeting (May 13, 2015), MPO staff introduced the study, received input about the corridor's issues and concerns, and coordinated data collection. In the second meeting (November 3, 2015), MPO staff reviewed the findings and proposed improvement alternatives. After the meetings, staff continued to receive comments from the advisory members and revised the proposals accordingly.

2 EXISTING CONDITIONS AND ISSUES

This section examines the corridor's location, associated major transportation facilities, transit services, existing roadway configurations, and adjacent land uses. It also summarizes the concerns raised in the first advisory meeting.

2.1 Corridor Location and Adjacent Transportation Facilities

As seen in Figure 1, the study corridor is located in the coastal areas of Hingham and Hull, approximately 15 miles from Boston Downtown. It runs along the south side of Hingham Bay from Hingham Harbor, across Weir River, to Nantasket Beach.

The corridor is the major roadway used by residents of Hull and North Hingham to access Boston proper and adjacent communities. It consists of three segments: Summer Street (from North Street to Rockland Street), Rockland Street (from Summer Street to George Washington Boulevard), and George Washington Boulevard (the entire section in Hingham and Hull).

The section of Summer Street from North Street to the Route 3A Rotary is part of State Route 3A. It is classified as an urban principal arterial and is the busiest section of the corridor. The other sections of the corridor all are classified as urban minor arterials and carry less traffic than the Route 3A section.

Major cross streets of the corridor include North Street, Water Street, Chief Justice Cushing Highway, Summer Street, and Rockland Street in Hingham; and Rockland Circle, Wharf Avenue, and Nantasket Avenue in Hull. Most of these cross streets are urban minor arterials, except Summer Street and Rockland Circle (both classified as collector roads).

Essentially, the corridor is a four-lane roadway, with two travel lanes in each direction. The adjacent land uses are mainly residential and public open space, with some businesses in the Hingham Harbor area. Sidewalks exist mainly on the north side of the corridor, except in the Harbor area, where sidewalks also exist on the south side. There are no dedicated or separated bicycle lanes in the corridor. A multi-use trail exists on the north side of the corridor in Hingham from

Martins Lane to the Hull border. The trial is about six- to-eight-feet wide and operates in both directions.

In addition to the roadway network, the Massachusetts Bay Transportation Authority (MBTA) Greenbush commuter rail line runs south of the corridor parallel to Summer Street and Rockland Street. This and other transit services are described further in the next section.

2.2 Transit Services in the Area

The MBTA provides a number of transit services in the study area, including the Greenbush commuter rail line, Bus Routes 220 and 714, and Hingham and Hull Ferries (See Figure 2.)

Greenbush Commuter Rail Line

The Greenbush line runs between South Station in Boston and Greenbush Station in Situate—through Quincy, East Braintree, Weymouth, Hingham, and Cohasset—and makes two stops in Hingham: West Hingham and Nantasket Junction. Nantasket Junction station is located on Summer Street near Route 3A (Chief Justice Cushing Highway) approximately 1,000 feet south of the study corridor. The station has 495 parking spaces, which are about 20-to-30 percent occupied during weekdays, with a lower occupancy rate on weekends.

MBTA Bus Route 220

Route 220 runs between Quincy Center Station (MBTA rapid transit Red Line) and Hingham Depot, with a relative high frequency of more than 40 weekday trips each way.[3] On Saturdays, it maintains approximately 30 trips each way, and on Sundays about 15 trips each way. It connects to Route 714 at Hingham Depot for various destinations in Hull, including Nantasket Beach and Hull Medical Center (on George Washington Boulevard).

MBTA Bus Route 714

Route 714 runs between Hingham Depot and Pemberton Point Ferry Station in Hull. It travels mainly on Nantasket Avenue and partly through the study corridor, with diversions to Nantasket Junction by request only. It provides 14 trips each way on weekdays and 9 trips each way on weekends. This service operates under contract, and uses smaller vehicles than the regular MBTA buses.

[3] The estimation based on MBTA 2015 bus summer schedules from June 27 to September 4.

MBTA Commuter Ferry

The MBTA ferry service consists of two major routes: Hingham-Boston and Hingham-Hull-Boston, via Logan Airport. The service is operated by Boston Harbor Cruises, and utilizes various vessels each with the capacity for about 350-to-400 passengers.

The Hingham-Boston route provides 18 round trips daily from Hingham (Hewitt's Cove/Hingham Shipyard Terminal) to Boston (Rowe's Wharf). The Hingham-Hull-Boston route provides 18-to-20 round trips daily from Hingham or Hull (Pemberton Point Terminal) to Boston (Long Wharf), with various arrangements of stops at Pemberton Point, Logan Airport, Grape Island, and George's Island. These trips include eight inbound stopovers/origins from Hull and 12 outbound stopovers/destinations to Hull.[4]

During weekends, the service provides 16 Saturday and 14 Sunday round trips from Hingham to Boston, with six inbound and four outbound trips stopping over at Pemberton Point in Hull and Logan Airport; the other trips stop over at Grape, George's and other Boston Harbor Islands. The weekend ferries, along with stopovers at the Boston Harbor Islands, usually end on Columbus Day weekend.

2.3 Roadway Conditions and Adjacent Land Uses

The study corridor has a consistent four-lane layout, but with quite different adjacent land uses and roadside conditions, as analyzed below.

2.3.1 Summer Street—Harbor Area

Summer Street from North Street to Route 3A Rotary is the busiest section of the corridor. In addition to local traffic, it carries regional traffic from Chief Justice Cushing Highway and North Street.

The top graphic in Figure 3-1 shows Summer Street's existing roadway conditions and adjacent land uses. The cross-section is based on the street view of an eastbound driver. The roadway surface consists of four 11-foot travel lanes. With almost no shoulders on both sides, the travel lanes contain catch basins, and bicycles need to travel with the traffic.

Summer Street has five-foot-wide sidewalks on both sides, which frequently are blocked by utility poles. Pedestrian access from the downtown side to the harbor side is limited and difficult. Crosswalks exist only at the North Street intersection; and the east-side crosswalk is hard to access because of fast and heavy right-turning traffic. There are no crosswalks at the rotary; its wide layout, with fast,

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[4] The estimation based on MBTA commuter ferry schedules effective May 25, 2015.

heavy traffic, makes it difficult for pedestrians and cyclists to access the harbor side.

Hingham Harbor occupies the roadway's north side with mainly public open spaces (Whitney Park and Veterans Memorial Park), and a few private developments, including a private wharf (Hingham Harbor Marina), a coffee shop, and a small office building near the rotary. A number of business developments, including restaurants, a bank, a supermarket, gas stations, and a car wash occupy the south side. This area is regarded as an extension of Downtown Hingham (also known as Hingham Square), which consists of businesses, shops, and restaurants that are thickly settled along North Street.

2.3.2 Summer Street—Residential Area

The bottom graphic of Figure 3-1 shows the existing roadway conditions and adjacent land uses on Summer Street in the resident area of Hingham. The similar four-lane roadway layout extends from the harbor area to the residential section, with five-foot sidewalks on only the north side, which frequently are blocked by utility poles. The adjacent land use is predominantly single-family houses on relatively large tracts.

2.3.3 Rockland Street and George Washington Boulevard—Hingham

The top graphic of Figure 3-2 shows the existing roadway conditions and adjacent land uses on Rockland Street and George Washington Boulevard. Rockland Street has the same four-lane layout as Summer Street: 11-foot lanes with narrow shoulders. The roadway gradually widens to include four 11.5-foot lanes on George Washington Boulevard, and the adjacent land areas gradually become more open.

In this section of the study area, the north-side sidewalks are replaced by a multi-use six- to-eight-foot-wide trail, which runs from Martins Lane to the bridge over the Weir River. A grassy, five-foot-wide buffer generally exists between the trail and the roadway. Though its size is considered substandard, this trail provides a much safer accommodation for pedestrians and cyclists than do other sections of the corridor.[5]

The land use on the north side generally consists of open spaces, including a large section of parkland owned by the town, and some private vacant land parcels. On the south side, the land use is mostly single-family residential, except for a major section of George Washington Boulevard occupied by Hingham District Court.

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[5] The trial was built about 20 years ago. Based on today's standards, a two-way multi-use trail should be at least ten-feet wide.

2.3.4 George Washington Boulevard in Hull

The bottom graphic of Figure 3-2 shows the existing roadway conditions and adjacent land uses on George Washington Boulevard in Hull. The layout is the same as that of George Washington Boulevard in Hingham: four 11.5-foot travel lanes with narrow shoulders. The north-side multi-use trails are replaced by six-foot sidewalks with no traffic buffers. They are suitable for pedestrians, but and not for bicyclists. Bicycles going to Nantasket Beach need to travel with the traffic.

The adjacent land on the north side is mainly coastal areas, including a single-family home neighborhood, community health care center, and the Steamboat Wharf commercial development. On the south side, south of Rockland Circle is the Weir River estuary with a commercial development, a multi-family home building, and a few single-family homes; north of Rockland Circle are the remote parking lots of Nantasket Beach with a few commercial developments near the roadway's intersection with Nantasket Avenue.

The northern part of this corridor section is adjacent to Nantasket Beach, a popular destination for beachgoers, walkers, joggers, and others coming to enjoy the ocean view. The beach, owned by the Department of Conservation and Recreation, is 1.3 miles long with nearly 1,500 parking spaces. During the summer, pedestrian and bicycle activities abound near the beach, especially on weekends. Hull is concerned with the high volume of traffic around Nantasket Beach, which causes congestion, as well as the lack of convenient transit service and safe bicycle accommodations to the beach.

2.4 Issues and Concerns

In the first study advisory meeting, representatives from the towns and MassDOT shared their views about the corridor, which general concerns are summarized below:

- Large number of crashes at Route 3A Rotary and North Street
- High travel speeds in most sections of the corridor
- Limited pedestrian access to Hingham Harbor
- Insufficient and substandard sidewalks
- Lack of bicycle accommodations
- Insufficient roadway shoulders
- Congestion during increased summer traffic
- Limited transit services to Nantasket Beach

The advisory members also discussed concerns about specific locations in the corridor, where analyses identified safety and operational problems, which along with the proposed improvements, are summarized by location in Section 5 of this memo.

3 ROADWAY OPERATIONS ANALYSIS

This section examines the corridor's traffic volumes and patterns, pedestrian and bicycle volumes, traffic operations at major intersections, and travel speeds at various locations. To support these analyses, MassDOT collected various transportation data, including daily traffic volumes, spot speed data, and intersection traffic, pedestrian, and bicycle counts during two periods: June 1-4, 2015 and July 9-12, 2015, one representing average daily traffic conditions and one representing high-summer Saturday traffic conditions.

3.1 Traffic Volumes

The most fundamental data for analyzing traffic intensity and patterns in a roadway corridor are daily traffic volumes. MassDOT collected traffic volumes at 12 locations: seven in the corridor and five on adjacent streets.

3.1.1 Daily Traffic Volumes

Figure 4 shows daily traffic volumes at the twelve locations based on Automatic Traffic Recorder (ATR) counts collected in the weekday period of June 1 to 4. The numbers in the graphic represent average daily directional volumes. The two tables in the graphic further summarize the data by count locations, directional split, combined volume of both directions, and adjusted annual average daily traffic (AADT).

In general, the June counts show that traffic in the corridor is split evenly, by approximately 50 percent in each direction. Total traffic volumes vary significantly among different locations in the corridor, ranging from approximately 13,000 vehicles per day (near Nantasket Avenue) to nearly 30,000 vehicles per day (west of Route 3A Rotary).

In June, traffic in this area is somewhat higher than the annual average volume. Adjusted by the seasonal factors, AADT data indicate that the corridor carries traffic volumes of different magnitude, from 11,500 vehicles near Nantasket Avenue to 26,500 vehicles west of Route 3A Rotary on an average day. Overall, traffic volumes gradually become less going from the western to the eastern segments of the corridor.

- Summer Street west of Hingham Harbor (Location 1) carries about 20,500 vehicles per day.

- Summer Street between North Street and Route 3A Rotary (Location 2) carries the highest volume in the corridor—approximately 26,500 vehicles per day. The increase mostly is a result of traffic at North Street (Location 8, carrying approximately 7,500 vehicles per day), and Chief justice Cushing Highway (Location 9, carrying approximately 12,000 vehicles per day).
- Summer Street and Rockland Street in the Hingham residential area (Locations 3 and 4) carry approximately 15,000 and 16,000 vehicles per day, respectively.
- George Washington Boulevard carries approximately 11,500 to 12,500 vehicles per day.

3.1.2 Summer Saturday Traffic Volumes

Figure 5 shows the average daily traffic volumes at the same 12 locations based on ATR counts collected during the weekend of July 9 to 12. The numbers in the graphic represent the highest level of daily directional volumes in that period—Saturday, July 11, 2015. The two tables in the graphic further summarize the data by location, directional split, and combined volume of both directions.

Similar to the weekday counts, the Saturday counts show that the corridor carries evenly split traffic on summer weekend days. Total traffic volumes vary among different locations, ranging from almost 22,000 vehicles per day on George Washington Boulevard near Nantasket Beach to 38,000 vehicles on Summer Street in the Hingham Harbor area. This accounts for an approximate 45-to-85 percent increase from the normal weekday traffic, mainly because of the traffic in and around Nantasket Beach in Hull.

Saturday, July 11, 2015, was dry, with a temperature of more than 85 degrees. These traffic counts represent almost the highest potential traffic volumes in the corridor under the conditions cited above, which presumably would occur approximately four-to-six weekends every year. The Saturday traffic volumes at the various locations are summarized below:

- Summer Street west of Hingham Harbor (Location 1) carries nearly 28,000 vehicles per day.
- Summer Street between North Street and Route 3A Rotary (Location 2) carries approximately 38,000 vehicles per day. Traffic on North Street (Location 8) increases from 7,500 to 11,500 vehicles in an average day. Traffic from Chief Justice Cushing Highway (Location 9) maintains a similar level of traffic on an average day (12,000 vehicles).

- Summer Street and Rockland Street in the Hingham residential area (Locations 3 and 4) carry approximately 27,000-to-27,500 vehicles per day.
- George Washington Boulevard carries approximately 21,500-to-24,500 vehicles per day.

3.2 Intersection Traffic, Pedestrian, and Bicycle Volumes

In addition to daily traffic counts, MassDOT collected turning movement counts at major intersections in the study corridor, including vehicle movements (by vehicle types), bicycle movements, and pedestrian crossings. They were collected during the morning peak period (7:00–9:00 AM) and the evening peak period (4:00–6:00 PM) on Thursday June 4, 2015, and during the midday peak period (10:00 AM–2:00 PM) on Saturday July 11, 2015. Staff then identified the peak hour in each of the peak periods for various traffic operational analyses.

3.2.1 Weekday Peak-Hour Traffic and Pedestrian Volumes

Figure 6 shows the weekday peak-hour traffic and pedestrian volumes at major intersections in the corridor. Entry volumes at these intersections vary from 1,000 vehicles per hour at the intersection of George Washington Boulevard at Wharf Avenue to 2,600 vehicles per hour at Route 3A Rotary, and generally are somewhat higher in the evening than in the morning.

The three intersections in the Hingham Harbor area had higher traffic entry volumes than did the other intersections, each carrying approximately 2,500-to-2,600 vehicles per peak hour. The two intersections in the Hingham residential area carried approximately 1,400-to-1,600 vehicles per peak hour each. The intersections on George Washington Boulevard carried approximately 1,000-to-1,300 vehicles per peak hour each.

Four pedestrians in the AM peak hour and ten pedestrians in the PM peak hour crossed the intersection of Summer Street at North Street. Thirty-three (33) pedestrians in the AM peak hour and 23 pedestrians in the PM peak hour crossed the intersection of George Washington Boulevard at Nantasket Avenue. The other intersections generally experienced five or fewer pedestrian crossings per peak hour.

3.2.2 Summer Saturday Peak-Hour Traffic and Pedestrian Volumes

Figure 7 shows the summer Saturday peak-hour traffic and pedestrian volumes at major intersections in the corridor. These intersections generally carried a total entry volume that was approximately 20 percent to 75 percent greater than during the June weekday peak hour.

The three intersections in Hingham Harbor carried between 3,000-to-3,200 vehicles per peak hour each. The two intersections in the Hingham residential area carried approximately 2,300-to-2,400 vehicles per peak hour each. The two intersections on George Washington Boulevard leading to Nantasket Beach carried approximately 2,000-to-2,100 vehicles per peak hour each.

Noticeably, the Saturday count showed that pedestrian activities were significant on the roadways in the Hingham Harbor and Nantasket Beach areas. The intersection of Summer Street at North Street had 74 pedestrian crossings during the midday per peak hour from 12:00 to 1:00. The intersection of George Washington Boulevard at Nantasket Avenue had 102 pedestrian crossings during the midday peak hour. The intersection of George Washington Boulevard at Bay Street/Nantasket Avenue had 51 pedestrian crossings during the midday peak hour.

3.2.3 Summer Saturday On-Road Bicycle Volumes

The turning movement counts at major intersections indicate that three or fewer bicycles traveled the corridor on a spring weekday (June 4, 2015). However, the cycling activity increased significantly during summer weekends.

The Saturday (July 11, 2015) counts show that there were between 20 and 30 bicycles traveling in the corridor during the four-hour period from 10:00 AM to 2:00 PM, and among them approximately 10-to-12 bicycles traveling in the peak hour from 10:00 to 11:00 AM. Figure 8 shows the estimated bicycle volumes by direction at various locations in the corridor, excluding bicycles that traveled on the multi-use path.

The adjacent areas of the corridor contain scenic coasts, wetlands, and woodlands. Presumably, bicycle volumes would be much higher if the corridor contained dedicated bicycle lanes.

3.2.4 Heavy Vehicle Percentage

It is essential to examine the amount of heavy-vehicle traffic in a study corridor, as an unusually high percentage of heavy vehicles (trucks and buses) may seriously affect roadway operations. The weekday turning movement counts by vehicle type indicate that, on average, most intersections in the study corridor carried about two percent of heavy vehicles during peak-hour traffic; and a few carried about three percent in the morning peak hour, and one percent in the evening peak hour. These percentages are considered normal, or even slightly less than average, and would not seriously affect roadway operations.

3.3 Intersection Capacity Analyses

Based on the turning movement counts, MPO staff constructed peak-hour traffic models for the entire corridor and conducted capacity analyses for major intersections by using the Synchro traffic analysis and simulation program.[6] The model set consists of two weekday AM and PM, and one Saturday midday peak-hour models, with scenarios under existing conditions or various proposed improvement alternatives.

3.3.1 Weekday Peak-Hour Analyses

Figure 9 shows weekday AM and PM peak-hour capacity analyses for major intersections in the corridor, under existing conditions. The graphic includes a table of intersection level-of-service (LOS) criteria based on average intersection control delay defined by the Highway Capacity Manual (HCM).[7] LOS is a qualitative measure used to relate the quality of traffic service. The HCM defines LOS—using a qualitative scale from “A” to “F”—for signalized and unsignalized intersections as a function of the average vehicle control delay. For the intersections in a metropolitan urban area, LOS C or better is considered desirable; LOS E or better is considered acceptable; and LOS F is considered undesirable.

Overall, staff estimate that all the major intersections generally operate at a desirable LOS C or better in both peak AM and PM hours, except the intersection of Summer Street at North Street and the Route 3A Rotary.

Staff estimate that the North Street intersection operates at LOS D in the AM peak hour with an average delay of about half a minute per vehicle. The westbound approach is critical to the intersection, where more than 250 left-turning vehicles need to share the inside lane with through traffic. Staff estimate that the approach operates at LOS D, with an average delay of about 50 seconds.

Staff estimate that the Route 3A rotary operates at LOS E in the AM peak hour, with an average delay of 45 seconds per vehicle.[8] The northbound approach is critical to the intersection, where one single lane carries heavy, primarily left-turning, commuter traffic. Staff estimate that this approach operates at LOS F, with an average delay of about one-and-a-half minutes.

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6 Synchro Version 8.0 was used for the analyses. This software is developed and distributed by Trafficware Ltd. It can perform capacity analysis and traffic simulation (when combined with SimTraffic) for an individual intersection or a series of intersections in a roadway network.

7 HCM 2010, Transportation Research Board of the National Academies, Washington D. C.

8 The rotary is considered an unsignalized intersection.

The two intersections' existing weekday operations are considered acceptable for their urban settings. Signal timings and lane assignments at all the signalized intersections appear to be appropriate under existing roadway layouts. Appendices B and C contain Synchro capacity analysis reports of the major intersections, including input volumes, signal timings, estimated delays and queue lengths, and LOS for AM and PM peak-hour existing conditions.

3.3.2 Summer Saturday Peak-Hour Analyses

Figure 10 shows the Saturday midday peak-hour capacity analyses for major intersections in the corridor, under existing conditions. The analyses include an additional location per Hingham's request: Route 3A (Otis Street) at Bathing Beach Driveway. This intersection is the main access to the beach's parking lot, where the popular Hingham Farmers Market is held every Saturday from 10:00 AM to 2:00 PM.

Although Saturday traffic volumes increase significantly from normal weekdays, the intersections' operations maintain about the same or slightly worse LOS compared to the weekdays. The analyses indicate that most intersections operate at desirable LOS C or better, including the intersection of Route 3A at Bathing Beach Driveway. Appendix D contains Synchro capacity analysis reports of the major intersections for the Saturday midday existing conditions.

Staff estimate that the North Street intersection operates at LOS D in the midday peak hour with an average delay of about 40 seconds per vehicle; and that the critical westbound approach deteriorates to LOS F, with an average delay of nearly one-and-a-half minutes. The Route 3A rotary operates at LOS E, with an average delay of nearly 45 seconds per vehicle, and maintains the same LOS as the weekday AM peak hour. However, staff estimate that the average delay on the northbound approach increases to nearly two minutes; this is because, under existing rotary traffic operations, the heavy eastbound traffic (toward Nantasket Beach) consistently blocks the approach.

3.4 Roadway Travel Speeds

The area's residents are very concerned about the high travel speeds in the corridor. In order to understand these fast driving patterns, MPO staff requested MassDOT to help collect spot speeds during the period when automatic traffic counts were being conducted in June and July 2015.

Figure 10 shows the existing speed regulations and estimated 85th percentile at selected locations in the corridor based on speed data collected on weekdays in the early June.[9] The "85th percentile" is the speed at or below which 85 percent of vehicles passing a given point are traveling, and is the principal value used to establish speed controls.

Currently, regulated travel speeds in the corridor are: 40 miles per hour (MPH) in the Bathing Beach area; 25 MPH in Hingham Harbor and the Route 3A rotary; 35 MPH on Summer Street and Rockland Street in the Hingham residential area; 45 MPH on George Washington Boulevard north of Rockland Street until south of Rockland Circle; and 35 MPH on George Washington Boulevard in the Nantasket Beach area from Rockland Circle to Nantasket Avenue.

In the Hingham residential area's 35-MPH zone, the estimated 85th percentile speeds are generally 8-to-10 MPH higher than the regulated speed, which confirms Hingham residents' concern. In the 35-MPH zone near Nantasket Beach, the 85th percentile speed also is between 8-to-10 MPH higher than the regulated speed. The prevailing traffic speed of 43-to-45 MPH presents unsafe conditions for pedestrians to cross the street and for cyclists to ride with traffic.

During the study (after the speed data had been collected), Hull raised the concern of high vehicle speeds on George Washington Boulevard in the Rockaway neighborhood, which is located in the middle of a 45-MPH zone. Judging from the magnitude of speed increases, and according to the Hull Police Department's observations, vehicles probably travel much more than 50 MPH in this 45-MPH zone.

4 CRASH DATA ANALYSIS

Crash data are an essential source for identifying safety and operational problems in a study area. Analyzing crash locations, collision types, time-of-day, roadway conditions, and other factors also help to develop improvement strategies. For this study, staff collected two datasets:

- 2008–12 MassDOT Registry of Motor Vehicles (RMV) Division Crash Data
- Recent five-year (March 2010 through April 2015) crash reports from the Hingham and Hull police departments

Staff used the five-year MassDOT data to examine crash locations and crash rates. It used the police crash reports to construct collision diagrams to analyze safety and operational problems at the major intersections and in different segments of the corridor.

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9 Because of limited resources, the July speed data were collected for fewer locations. Although the traffic volumes are higher in the summer weekend, the observed 85th percentile speeds are about the same or slightly lower than the weekday average.

4.1 Crash Locations and Crash Rates

Figure 12 shows the crash locations and quantities for the five-year period 2008–12. The corridor is divided into three sections, each with similar land use characteristics:

1. Hingham Harbor Section: Summer Street from North Street to Route 3A Rotary
2. Hingham Residential Section: Summer Street/Rockland Street from Route 3A Rotary to George Washington Boulevard
3. Low-Density Development Section: George Washington Boulevard in Hingham and Hull

Among the total 205 crashes, more than half (105 crashes) occurred in Section 1, which carried heavy traffic with frequent turning movements to and from adjacent developments; 56 crashes occurred in Section 2; and 44 crashes occurred in Section 3. Based on recent traffic counts, staff estimated the crash rates for the three sections:

- Section 1: 8.51 crashes per million vehicle miles traveled (MVMT)
- Section 2: 2.59 crashes per MVMT
- Section 3: 1.16 crashes per MVMT

The crash rate for Section 1 is much higher than the Massachusetts average for urban principal arterials (3.35 crashes per MVMT). The crash rates for Sections 2 and 3 are lower than the state average for urban minor arterials (3.74 crashes per MVMT). See Appendix E for worksheets.

Staff estimated the crash rates at major intersections of the corridor, as summarized below:

- Intersection of Summer Street at North Street: 0.78 crashes per million entering vehicles (MEV)—about the same as the MassDOT District 5 average for signalized intersections (0.77 crashes per MEV).
- Route 3A Rotary: 1.33 crashes per MEV—much higher than the MassDOT District 5 average for unsignalized intersections (0.58 crashes per MEV).
- All other major intersections: Crash rates lower than the MassDOT District 5 average for signalized/unsignalized intersections.

Appendix F contains worksheets for these crash rates. Appendix G summarizes the 2008–12 MassDOT crash data at each of the major intersections according to crash severity (property damage only, non-fatal injury, fatality, unknown), collision type (single-vehicle, rear-end, angle, sideswipe, head-on, rear-to-rear, unknown), pedestrian or bicycle involvement, time of day, pavement conditions, and light conditions.

4.2 Pedestrian and Bicycle Crashes

Figure 12 shows the pedestrian and bicycle crash locations in the corridor that were identified from both datasets—in total, four pedestrian crashes and five bicycle crashes: [10]

- Summer Street/North Street Intersection: three pedestrian crashes (two in 2009, one in 2011)
- Route 3A Rotary: one pedestrian crash (2011), three bicycle crashes (2008, 2009, 2010)
- George Washington Boulevard/Wharf Avenue Intersection: one bicycle crash (2013)
- George Washington Boulevard/Nantasket Avenue Intersection: one bicycle crash (2008)

Significantly, these crashes all occurred on roadways adjacent to the pedestrian and cyclist areas of Hingham Harbor and Nantasket Beach.

4.3 Collision Diagrams

To investigate safety and operational problems further, MPO staff constructed collision diagrams for the entire corridor by major intersections and in-between roadway segments, based on recent five-year crash reports provided by the towns' police departments. The crash reports contain detailed information about how and where those crashes occurred. Appendix H presents the collision diagrams for different locations in the corridor.

Below we summarize major findings from the collision diagrams and other factors affecting safety and operations:

Summer Street at North Street and at Water Street (Figure H-1)

- Thirty (30) crashes at the two adjacent intersections
- Sixteen (16) crashes (more than half of the total crashes) related to westbound traffic on Summer Street
- Eight crashes potentially related to a westbound left-turning vehicle

[10] In this study, the term "pedestrian crashes" refers to those that involve at least one vehicle and one pedestrian; "bicycle crashes" refers to crashes that involve at least one vehicle and one bicycle. No crashes between at least one bicycle and one pedestrian were identified in the available data.

- High westbound left-turn volumes during peak hours
- Short distance from Route 3A Rotary to the intersections with intensive lane-changing activities on westbound Summer Street
- One pedestrian crash in 2011 at west-side crosswalk on Summer Street

Summer Street at Route 3A Rotary (Figure H-2)

- Fifty-nine (59) crashes at the intersection
- Large number of side-swipe crashes inside rotary
- Large number of rear-end crashes on all major approaches, especially on Chief Justice Cushing Highway
- Lack of pavement markings inside rotary to indicate entry/exit paths
- Lack of pavement markings on Summer Street approaches to indicate lane assignments
- High travel speeds approaching and inside rotary
- One pedestrian crash, and one bicycle crash

Summer Street between Route 3A Rotary and Rockland Street (Figure H-3)

- Sixteen (16) crashes
- Large number of out-of-control single-vehicle crashes (about half of total crashes)
- Large proportion of crashes causing personal injuries (more than 60 percent of total crashes)
- Horizontal curves and vertical curves in the section
- High travel speeds (8-to-10 MPH higher than the posted 35-MPH speed limit) in the section

Summer Street at Rockland Street/Martins Lane (Figure H-4)

- Nine crashes
- Mostly rear-end crashes, an usual type of collision at signalized intersections
- Large number of crashes on westbound approach, where drivers approach intersection uphill, and face glaring afternoon sun
- No other noticeable crash patterns

Summer Street at Rockland Street/Martins Lane (Figure H-5)

- Ten (10) crashes
- Three out-of-control single-vehicle crashes near the intersection
- No other noticeable crash patterns

George Washington Boulevard in the vicinity of Hingham District Court (Figure H-6)

- Six crashes
- Crashes mainly because of relatively high-speed multi-lane traffic on George Washington Boulevard, with occasional turbulence from vehicles turning into or away from the district court
- No other noticeable crash patterns

George Washington Boulevard between Weir River and Rockland Circle (Figure H-7)

- Five crashes at Logan Avenue/Barnstable Road intersection
- Four crashes at/near Weir River Estuary
- Difficult pedestrian crossing on George Washington Boulevard because of high travel speeds (more than 50 MPH)
- No noticeable crash patterns

George Washington Boulevard at Rockland Circle (Figure H-8)

- Less than two crashes per year
- Mostly westbound rear-end crashes
- No other noticeable crash patterns

George Washington Boulevard at Wharf Avenue (Figure H-9)

- Only one identifiable crash per year
- No noticeable crash patterns
- One bicycle crash

George Washington Boulevard at Nantasket Avenue (Figure H-9)

- Less than two crashes per year
- Two crashes, possibly caused by pedestrian crossings at northeast corner near Nantasket Avenue
- One bicycle crash on Nantasket Avenue near the intersection
- Heavy pedestrian crossing during peak summer hours
- Poor visibility of pedestrians at northeast corner for drivers coming from Nantasket Avenue

Route 3A (Otis Street) between Hingham Bathing Beach and North Street (Figure H-10)

- Only the recent two-year (March 2013–April 2015) data available
- No noticeable crash patterns

5 PROPOSED IMPROVEMENTS

Based on the above analyses, MPO staff developed a series of short- and long-term improvements to address safety and operational problems. It is possible to implement the short-term improvements within two years at relatively low cost. Long-term improvements generally are more complicated and cover larger areas, which would require intensive planning, design, and funding.

As the corridor covers an extensive length of roadways with different land use characteristics, we describe the proposed improvements in four sections below.

5.1 Summer Street in the Harbor Area

Table 1-1 summarizes the proposed short- and long-term improvements for the section of Summer Street in the Hingham Harbor area, along with the area's issues and concerns; these are arranged according to general roadway section, and by specific location, from west to east.

Figure 13 shows locations and layouts of the proposed short-term improvements in this section, including:

- Restripe (retrofit) Route 3A Rotary similar to a double-lane modern roundabout by installing pavement markings in the inscribe circle and approaching lanes of the rotary.[11]
- Install MUTCD[12] Circular Intersection Ahead (W2-6) and 25-MPH speed limit plaque (W13-1P) assembly on approaches of Route 3A Rotary.
- Install MUTCD Advanced Intersection Lane Control (R3-8) on the two Summer Street approaches toward Route 3A Rotary.
- Consider prohibiting left turns from Summer Street onto Water Street.[13]
- Enhance signal visibility, crosswalk markings, and yield signage at North Street intersection.

[11] The retrofit would be accomplished through pavement markings under the existing rotary layout in order to save the high cost of reconstruction. The width of the traffic island on the Chief Justice Cushing Highway approach would need to be reduced slightly in order to allow two circulating lanes.

[12] *Manual on Uniform Traffic Control Devices*, 2009 Edition with Revisions 1 and 2, Federal Highway Administration, US Department of Transportation, May 2012.

[13] Most of the left turns presumably are cut-through traffic heading to Hingham Square or further southeast. If access to the nearby supermarket is a concern, at least the turns should be prohibited during the AM peak period from 7:00 to 9:00. Meanwhile, the prohibition would require readjusting the signal timing at North Street and continuing to monitor traffic conditions at the Summer Street/North Street intersection (and the North Street/Mill Street intersection).

Figure 14-1 shows locations and layouts of the proposed long-term improvements in this section. Staff did not create the conceptual plan to scale, but in approximate proportion, in order to show how the proposed improvements would relate to their surroundings. The upper graphic of Figure 15 shows the proposed roadway cross-section. Major long-term improvements proposed for this section include:

- Convert the Route 3A rotary into a signalized intersection.
- Reconstruct the North street intersection.
- Reconstruct the north-side sidewalks to 10-to-12-foot multi-use trails with a five-foot traffic buffer.
- Add a pedestrian bridge across Hingham Harbor.
- Maintain existing travel lanes to serve high traffic volumes.
- Add two-foot shoulders on both sides to improve drainage.

MPO staff proposed to convert the rotary mainly based on safety concerns. It has a high crash rate and its wide layout is difficult and unsafe for pedestrians and cyclists to traverse. Although the rotary currently operates at LOS E or better during peak hours, drivers on the Chief Justice Highway approach endure excessive delays on weekday morning and summer Saturday midday peak hours.

Staff evaluated both the traffic signal and modern roundabout options. The traffic signal option was studied in two variations: one with a driveway to access Lincoln Maritime Center, and one without the driveway. The roundabout option was examined in single- and double-lane layouts. The single-lane layout was not feasible as its operation would fail during all the peak hours on weekdays and summer weekend days. Staff consider the signal option somewhat more favorable than the roundabout option because it has a smaller layout and would be safer for pedestrians and cyclists.

As shown in Figure 14-1, the proposed traffic signal option would incorporate the driveway to Lincoln Maritime Center. The intersection would operate at desirable LOS C or better during peak hours, with exclusive pedestrian signal phases. Staff also suggest that, at the functional design stage for the rotary conversion, the other signal option (without the driveway connection) and the two-lane roundabout option should be included for further examination.

Figure 14-1A shows conceptual plans for the two additional options. The signal option without the driveway would have a smaller layout with shorter pedestrian crossing distances than the one with the driveway. The Lincoln Maritime Center driveway needs to remain at its existing location so would disturb traffic operations at the intersection.

The two-lane roundabout option would require an inscribed circle (150-foot diameter minimum, 160-foot as shown) with two entry lanes from all approaches. Traffic operation on the Chief Justice Cushing Highway approach would improve to LOS E. With this option, the estimated average delay per vehicle would be slightly higher (about five seconds) than the proposed signalization. In the meantime, pedestrians need to cross two lanes of constantly moving traffic during peak hours.

At the intersection of Summer Street at North Street, crosswalks exist across Summer Street from both sides of North Street. However, the east-side crosswalk is used less often because of inconvenient and unsafe pedestrian accommodations on the east side of North Street.[14] Staff propose to reconstruct the intersection by removing the right-turn channelization and reconfiguring the northbound approach with separate turning lanes, in order to slow down traffic and provide better and safer pedestrian accommodations. The reconstruction also includes upgrading the signal system with new mast arms and better traffic signal indications, relocating the signal control cabinet, increasing pedestrian staging areas and crosswalk widths (15-feet wide is desirable), and providing count-down and accessible pedestrian signals.

One essential long-term improvement proposed for this section is to reconstruct the harbor-side sidewalks as multi-use trails between the two major intersections. The Town of Hingham has improved many attractions in the harbor area, including Bathing Beach, Bandstand, Iron Horse Park, and Whitney Wharf Park. The proposed multi-use trail would serve as a foundation to connect all of these attractions. If the right-of-way (ROW) is available, it should extend from Bathing Beach (or even from the Crow Point neighborhood) to Steamboat Wharf.[15]Pedestrian access to Hingham Harbor would improve significantly by reconstructing these two major intersections.

5.2 Summer Street in the Residential Area

Table 1-2 summarizes the proposed short- and long-term improvements for the section of Summer Street in the Hingham residential area, with issues and

[14] The east side of North Street also is more convenient for pedestrians from Hingham Depot and the Hingham downtown area.

[15] Based on town' assessor's maps, the proposed multi-use trials in the Harbor area would extend slightly beyond the MassDOT Route 3A right-of-way and may require some land takings. Most of the adjacent lands are owned by the town, except Kimball's Wharf (Hingham Harbor Marina) and the nearby small office building.

concerns listed for reference. The key proposed short-term improvements include:

- Install solar-powered Your Speed warning signs in conjunction with the 35-MPH speed regulation at suitable locations approaching the horizontal curves (the segment between Steamboat Lane and Barnes Road).
- Update pedestrian signal timing and replace missing signal backplates at the intersection of Summer Street at Rockland Street/martins Lane.
- Trim overgrown vegetation in both directions.
- Patch/repave/seal rutting and cracking pavements.

Figure 14-2 shows the conceptual plan of proposed long-term improvements in this section. The lower graphic of Figure 15-1 shows the proposed roadway cross-section accordingly. Major long-term improvements proposed for this section include:

- Convert roadway from four- to two-lane traffic operation (one lane each direction) with center median/left-turn lane and five-and-a half-foot bicycle lanes on both sides.[16]
- Reconstruct existing north-side sidewalks to be eight-foot wide with a minimum five-foot clearance.
- Install five-foot sidewalks on the south side.
- Reconstruct intersection of Summer Street at Rockland Street/Martins Lane to include the following items:
  - Modify intersection according to proposed corridor configuration.
  - Maintain flare area and provide two approaching lanes northbound and southbound approaches.
  - Reduce curb turning radii and add crosswalks on westbound and northbound approaches.
  - Upgrade signal system with count-down/accessible pedestrian signals.

5.3 Rockland Street and George Washington Street in Hingham

Table 1-3 summarizes the proposed short- and long-term improvements for the section of Rockland Street and George Washington Street in Hingham. The key proposed short-term improvements include:

- Install solar-powered Your Speed warning signs on Rockland Street (in conjunction with existing 35-MPH regulation signs) in both directions.
- Trim overgrown vegetation in both directions.
- Patch/repave/seal rutting and cracking pavements.

[16] The bicycle lanes also can be used as roadway shoulders for emergency stopping.

Figure 14-3 shows the conceptual plan of proposed long-term improvements in this section. The upper graphic of Figure 15-2 shows the proposed roadway cross-section. Major long-term improvements proposed for this section include:

- Convert to two-lane traffic operation (one lane each direction) with center median/left-turn lane and five- to six-and-a half-foot bicycle lanes on both sides.
- Upgrade multi-use trail from 10- to 12-feet wide.
- Install five-foot sidewalks on south side.
- Consider changing George Washington Boulevard's speed limit from 45 to 40 MPH after the roadway reconfiguration
- Modify the intersection of Rockland Street at George Washington Boulevard according to proposed roadway reconfiguration.
    - Utilize the existing intersection layout by maintaining two westbound lanes (one for through movements and one for left turns) and adding traffic median on eastbound approach.
    - Add crosswalks on eastbound and northbound approaches.
    - Upgrade signal system with count-down/accessible pedestrian signals.

5.4 George Washington Street in Hull

Table 1-4 summarizes the proposed short- and long-term improvements for the section of George Washington Street in Hull. The key proposed short-term improvements include:

- Install solar-powered Your Speed warning signs in conjunction with 45-MPH regulation signs at suitable locations approaching Barnstable Road/Logan Avenue intersection.
- Continue monitoring crash and traffic conditions at Barnstable Road/Logan Avenue intersection.
- Update exclusive pedestrian signal timing from 17 to 21 seconds at intersection of George Washington Boulevard at Wharf Avenue.
- Patch/repave/seal the rutting and cracking pavements.

Figure 14-4 shows the conceptual plan of proposed long-term improvements in this section. The lower graphic of Figure 15-2 shows the proposed roadway cross-section. Major long-term improvements proposed for this section include:

- Convert to two-lane traffic operation (one lane each direction) with a center median/left-turn lane and six-and-a half-foot bicycle lanes on both sides.
- Install five-foot sidewalks on east side.
- Consider extending existing 35-MPH zone to vicinity of Barnstable Road/Logan Avenue after the roadway reconfiguration.

- Consider changing existing 45-MPH zone to 40 MPH after the roadway reconfiguration.
- Modify the intersection of George Washington Boulevard at Rockland Circle according to the proposed roadway reconfiguration.
    - Provide northbound right-turn lane of about 150 feet long.
    - Add crosswalks on northbound and westbound approaches.
    - Upgrade entire signal system, including count-down/accessible pedestrian signals, new mast arms, and detectors.
- Modify intersection of George Washington Boulevard at Wharf Avenue according to proposed roadway reconfiguration and upgrade signal system including count-down/accessible pedestrian signals and new mast arms.
- Redesign intersection of George Washington Boulevard at Nantasket Avenue with curb extension (pedestrian bulb-out) at northwest corner and realignments of two adjacent crosswalks. The design plan for this intersection depends on a future traffic circulation scheme that the Town of Hull is studying for the Nantasket Beach Revitalization Plan.

5.5 Multi-Use Trails: Long-Term Improvement Alternative

One long-term improvement alternative worthy of consideration is to extend the proposed multi-use trails from the Hingham Harbor area to cover the entire corridor until the Nantasket Beach area. The continuous multi-use path would be about three miles long and mostly on the scenic coastal side.

Figures 16-1 and 16-2 show the proposed roadway cross-sections for the four different sections of the corridor. The curb-to-curb roadway configurations would remain the same as those proposed in the above four sections. The proposed multi-use trails would mostly be 12-foot wide, except some ROW limited areas (10-foot wide minimum).

A quick review of the highway layouts shows that most of the proposed multi-use trails would be within the MassDOT's right-of-way. The proposed reconstruction might require some land takings but most would be on public lands. As proposed previously, Hingham should at least consider the multi-use trails for the harbor section. If the right-of-way is unobtainable for some sections, a combination of trials, bicycle lanes, and sidewalks with carefully designed connections (such as crosswalks at intersections) could be considered.

5.6 Transit Services and Cycling to Nantasket Beach

Hull is concerned with traffic congestion in the Nantasket Beach area during the summer; the proposed bicycle accommodations in the corridor potentially would mitigate some of the congestion.

The MBTA Greenbush commuter line allows bicycles on most trains on weekdays and on all trains on Saturdays and Sundays. People can take their bicycles from the Nantasket Junction station and connect with the proposed bicycle lanes or multi-use trails all the way to Nantasket Beach. The parking at Nantasket Junction is underused, especially on weekends. Once the dedicated bicycle accommodation is available, a reduced fee or even free parking could be considered in order to promote cycling, instead of driving, to Nantasket Beach.

The MBTA will receive funding from Federal Transit Administration MAP-21 (Moving Ahead for Progress in the 21st Century Act) Passenger Ferry Grant Program to replace a twin engine and control equipment for the Quincy-Hull-Boston “Lightening” high-speed ferry (about $900K), and to upgrade the Pemberton Pier ferry terminal in Hull (about $200K). This funding would improve the Hull ferry service and would help to encourage use of the ferry to Nantasket Beach (via connection with MBTA Bus 714).

Further steps to mitigate congestion in the beach area and to increase transit usage include:

- Improve Nantasket Beach remote parking lots with sidewalks and, most importantly, a pedestrian path that connects to Nantasket Avenue and the beach directly.[17]
- Provide clear, sufficient information on parking locations, direction, and connection to the beach with a detailed map on the Department of Conservation and Recreation (DCR) Nantasket Beach Reservation website.
- Explore possibility of utilizing MBTA Bus 714 to provide shuttle services from remote parking lots to the beach. Currently, the route loops around the corner of Rockland Circle, about 200 feet from George Washington Boulevard.
- Promote MBTA Bus 714 weekend services through various media including the Town of Hull and Chamber of Commerce websites. If the ridership increases, the Town can request adding service trips.[18]

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[17] Field observations in July 2015 indicated that the two remote parking lots were underutilized, even during high summer.

[18] Currently, Bus 714 provides nine trips each direction on summer Saturdays and Sundays. It can be increased to 15 trips in conjunction with the existing Bus 220 schedule. No summer

- Provide MBTA Bus 714 service information on the DCR website.
- Continue to study the feasibility and explore the funding resources for the Steamboat Wharf Ferry service.[19]

5.7 Proposed Long-Term Improvements under Projected Future-Year (2040) Traffic Conditions

The most significant long-term improvement recommendation in the roadway corridor, except in the Hingham Harbor section, is the reconfiguration from four to two lanes plus a center lane as traffic median, or for left turns, and bicycle lanes on both sides. Such four- to three-lane road-diet applications have been applied in a number of US cities with positive results in improving safety for all modes of travel. The analyses in this section indicate that the proposed long-term improvements, including the road-diet section, would operate adequately under the future-year traffic conditions.

Similar to the base-year models, staff constructed future-year 2040 traffic models for the entire corridor based on the roadway layouts with the proposed long-term improvements. Staff also conducted future-year traffic analyses based on traffic growth projections from the transportation planning model recently developed for the MPO's Long-Range Transportation Plan.[20]

Recent counts indicate that all sections of the corridor (except the Harbor section) experience average daily traffic of fewer than 20,000 vehicles. These sections are suitable for the road-diet application. Although in a few sections, such as Summer Street and Rockland Street in the residential area, traffic surges to more than 25,000 vehicles per day on some summer Saturdays and Sundays, these represent about 10-to-15 days per year and usually are not considered for roadway design.

Traffic simulations from the 2040 Saturday traffic model show that traffic would move constantly in the corridor without spillbacks from one intersection to

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Saturday or Sunday ridership data are available. The data collected in the winter of 2013 show a relatively low ridership of about 50-to-60 riders on all trips on an average Saturday.

[19] The Town of Hull conducted a study with a service plan of the summer ferry from Boston to Steamboat Wharf in 2009 and received support from the Boston Region MPO's Subregional Mobility Program. The further study can be based on the previous study.

[20] The model predicts future traffic growths base on demographic changes from 2015 to 2040. As population and employment are predicted to increase slightly in Hingham, and practically not at all in Hull, traffic growth at various locations in the corridor is projected to increase by 5 percent or less. Therefore, staff therefore used 5 percent traffic growth for all 2040 weekday and Saturday peak-hour models.

another. The proposed three-lane configuration would remove left-turning vehicles from the main travel lane, and would widen appropriately at major intersections to include left- and right-turn lanes (and in some cases an additional through lane). Consequently, traffic would be able to continue moving on the main lane and pass through the intersections with no extensive delays.

Figures 17 and 18 show the intersection capacity of major intersections in the corridor under the projected 2040 traffic conditions for the weekday peak hours and summer Saturday midday peak hour. With the proposed long-term improvements, all intersections would operate at desirable LOS C or better during the weekday peak hours and at acceptable LOS D or better during the summer Saturday peak. Synchro capacity analysis reports of the major intersections for the future-year weekday AM, weekday PM, and summer Saturday midday peak hour conditions are included in Appendices I, J, and K.

6 SUMMARY AND RECOMMENDATIONS

This study performed a series of safety and operations analyses, identified safety and operational problems, and proposed a number of short- and long-term improvements to address identified problems in the study corridor.

The recommended key short-term improvements include:

- Restripe (retrofit) Route 3A Rotary similar to a double-lane modern roundabout with pavement markings and signage.
- Install solar-power Your Speed warning signs in conjunction with the existing speed regulation signs at suitable locations.
- Increase pedestrian signal timing at applicable intersections.
- Install traffic signal backplates with reflective borders at applicable intersections.
- Repaint faded crosswalk and pavement markings at applicable intersections.
- Trim overgrown vegetation at applicable locations.
- Patch/repave/seal rutting and cracking pavements.

These improvements could enhance safety for all users and improve traffic operations moderately. The recommended improvements at the rotary are more involved and more costly, but potentially could reduce crashes in the rotary and vicinity. With a high benefit/cost ratio, these short-term improvements should be implemented as soon as the resources are available from highway maintenance or local Chapter 90 funding.

Together, the conceptual plans and suggested long-term improvements create a vision that would accommodate all users and would improve their safety, mobility, and access in the corridor significantly. Some expected benefits from proposed long-term improvements include:

- The road-diet modification—conversion to two-lane traffic with center median/left-turn lane and dedicated bicycle lanes on both sides—would slow traffic, provide separate bicycle accommodations, and reduce pedestrian crossing distances and risks.
- The road-diet modification would reinforce the existing 35-MPH speed regulation, and support a potential speed limit reduction from 45 to 40 MPH. thus enhancing the safety of all users, including residents.
- The sidewalk and shoulder expansions would enhance pedestrian and cyclist accommodations and safety, and improve drainage and traffic operations.
- The proposed improvements at intersections, especially at North Street and the Route 3A rotary, would significantly improve safety and mobility for all users.
- The proposed multi-use trails in the Harbor area, in addition to the improvements at North Street, would improve safety, mobility, and access for pedestrians and cyclists, enhancing quality of life for the area's residents and visitors.
- The proposed bicycle accommodations in the entire corridor would enhance quality of life for residents and visitors, and potentially could mitigate traffic congestion in the Nantasket Beach area.

In addition, the corridor would benefit by promoting transit usage in the summer time and gaining a comprehensive parking and access management program at Nantasket Beach.

Implementing the proposed long-term improvements would require sufficient resources. MPO staff recommend the improvements be implemented in the following stages:

1) Summer Street in the Harbor area, including reconstruction of the two major intersections, expansion of harbor-side sidewalks, and pedestrian access improvements (the entire area should be considered as one project)
2) Summer Street and Rockland Street in the Hingham residential area, including the road-diet reconfiguration with pedestrian/bicycle accommodations and the proposed intersection improvements

3) George Washington Boulevard in Hingham and Hull, including the road-diet reconfiguration with pedestrian/bicycle accommodations and the proposed intersection improvements

At this preliminary planning stage, staff estimate reconstruction of the entire corridor would cost approximately $12,500,000 to $15,000,000.[21] The approximate costs of the three implementation stages are:

1) Summer Street in the Harbor area: $5,500,000 to $6,500,000[22]
2) Summer Street and Rockland Street in the Hingham residential area: $2,500,000 to $3,000,000
3) George Washington Boulevard in Hingham and Hull: $4,500,000 to $5,500,000

This study provides a vision for the corridor's long-term development, and confirms that the corridor has great potential to operate safely and efficiently for all users and various transportation modes. It will require significant effort and collaboration on the part of all stakeholders, including the Towns of Hingham and Hull, residents and owners of adjacent developments, MassDOT, MBTA and DCR to achieve the vision.

The implementation process must ensure that all parties concur about how the recommendations can be realized in a resourceful and fiscally responsible manner. The Towns need to work with MassDOT's Highway Division District 5 to initiate the project, obtain favorable review from MassDOT's Project Review Committee, and identify potential funding resources through MassDOT and the Boston Region MPO.

Appendix L details the actions that are required in the various steps of MassDOT's project development process, including a schematic timetable. Information regarding the project development process also may be found on MassDOT's website, at www.massdot.state.ma.us/planning/Main/PlanningProcess/ProjectDevelopmentProcess.aspx and at www.massdot.state.ma.us/Portals/8/docs/designGuide/CH_2_a.pdf.

CW/cw

[21] This cost was estimated using the general expenses of similar projects. The estimate is only for design and construction and does not include right-of-way, utility relocation, or other contingency costs.

[22] This estimate does not include relocating major gas lines at the middle of the Route 3A Rotary.

TABLE 1-1
Proposed Improvements: Summer Street in the Harbor Area

Location	Issues/Concerns	Short-Term Improvements	Long-Term Improvements
The section in general	• Insufficient pedestrian access to Hingham Harbor • Narrow sidewalks with frequent utility pole blockages • No separate bicycle accommodations • Multiple-lane (four-lane) traffic operation with extensive lane-change maneuvers • High crash rate • Pavement rutting and cracking	• Install pavement markings and signage at the Route 3A rotary to improve traffic operations. • Consider prohibiting left turns onto Water Street. • Patch/repave/seal the rutting and cracking pavements.	• Convert the Route 3A rotary into a signalized intersection. • Reconstruct the North Street intersection. • Reconstruct the north-side sidewalks as 10- to 12-foot multi-use trails with a 5-foot traffic buffer. • Add a pedestrian bridge across Hingham Harbor. • Maintain existing travel lanes because of high traffic volumes. • Add 2-foot shoulders on both sides to improve drainage. • Relocate utility poles if applicable.
Intersections: Summer Street at North Street and at Water Street	• Somewhat large number of crashes (30 in the past five years) • More than half of total crashes related to Summer Street westbound traffic and most of them involving a left-turning vehicle or a lane-change maneuver • No storage lane for left turns to Water Street or to North Street • Inconvenient and unsafe pedestrian accommodations on the east side of North Street • Poor visibility of signal indications, especially for the eastbound drivers	• Consider prohibiting left turns from Summer Street to Water Street. • Readjust signal timing and continue monitoring traffic conditions (including the North street/Mill Street). • Double up Yield (MUTCD R1-2) signs and add "Yield pavement marking on the right-turn approach to Summer Street. • Restripe faded crosswalks at the North Street intersection. • Install signal backplates with reflective borders (requiring further examination of the existing mast arms' capacities). • Trim overgrown trees that obstruct signal visibility	• Reconstruct the North Street intersection by removing the right-turn channelization and reconfiguring the northbound approach with separate turning lanes, so as to slow down traffic and provide better and safer accommodation for pedestrians. • Increase pedestrian staging areas at all corners of the North Street intersection. • Upgrade the entire signal system with new mast arms, better traffic signal indications, and count-down and accessible pedestrian signals. • Relocate the signal control cabinet and provide wider pedestrian crosswalks.
Route 3A Traffic Rotary: Summer Street at Chief Justice Cushing Highway/Green Street	• Large number of crashes (59 in the past five years) • High approaching and circulating speeds at the rotary • Lack of pavement marking to indicate entry/exit paths and lane assignments • Faded Yield pavement markings • High travel speeds approaching and inside the rotary • Drivers' sight to the rotary obstructed by overgrown vegetation from Chief Justice Cushing Highway	• Install pavement markings on circulation lanes and on all the approaches to guide drivers through the rotary. • Install MUTCD Advanced Intersection Lane Control (R3-8) signs on the Summer Street approaches. • Install MUTCD Circular Intersection Ahead (W2-6) and 25-MPH speed limit plaque (W13-1P) assembly on all three approaches. • Trim overgrown vegetation on the approach of Chief Justice Cushing Highway.	• Convert the rotary into a fully functional signalized intersection with count-down and accessible pedestrian signals. • Consider modern roundabout option in the functional design stage. • Consider providing access to Lincoln Marina. • Reconstruct the rotary adjacent areas. • Install a stop control on Green Street.
Route 3A (Otis Street) at Bathing Beach Driveway	• Traffic Signal Ahead warning sign on Route 3A eastbound blocked by overgrown vegetation • Route 3A eastbound left turns blocking through traffic during Saturday Farmers Market hours • Outdated traffic signal system	• Clear the overgrown vegetation for drivers' visibility of the warning sign.	• Upgrade the signal system to provide left-turn signal phases (requiring installation of detector loops) and to provide count-down/accessible pedestrian signals.
Route 3A (Otis Street) at Ship Street	• Faded crosswalk	• Restripe the crosswalks with white longitudinal lines to emphasize the pedestrian crossing area. • Install MUTCD Pedestrian Crossing warning signs (W11-2) with a location indication plaque (W16-7P) at both ends of the crosswalk to alert approaching drivers and to guide pedestrians to cross at this crosswalk.	• N/A

MPH: Miles per hour. MUTCD: Manual on Uniform Traffic Devices, Federal Highway Administration, 2009 Edition with Numbers 1 and 2 Revisions, May 2012. N/A: Not available or applicable.

TABLE 1-2
Proposed Improvements: Summer Street in the Residential Area

Location	Issues/Concerns	Short-Term Improvements	Long-Term Improvements
The section in general	• High travel speeds under multiple-lane traffic operation • Large proportion of injury crashes (more than 60%). • Narrow sidewalks with frequent utility pole blockages. • No separate bicycle accommodations. • Narrow 1-foot or less shoulders insufficient for bicycle accommodations or school bus/emergency vehicle standing. • Unsafe turning maneuvers to adjacent residences (crossing two lanes of fast and sometime busy traffic). • Horizontal curve with overgrown vegetation. • Pavement rutting and cracking.	• Install solar-powered Your Speed warning signs in conjunction with the 35-MPH speed regulation at suitable locations approaching the horizontal curves (the area between Steamboat Lane and Barnes Road). • Trim overgrown vegetation in both directions. • Patch/repave/seal the rutting and cracking pavements.	• Convert to two-lane traffic operation (one lane each direction) with a center median/left-turn lane and 5.5-foot bicycle lanes (also as roadway shoulders for emergency stopping) on both sides. • Reconstruct the existing north-side sidewalks to 8-foot wide with a minimal 5-foot clearance. • Install 5-sidewalks on the south side. • Reconstruct the Rockland Street/Martins Lane intersection.
Signalized Intersection: Summer Street at Rockland Street/Martins Lane	• Long crossing distance (about 70 feet) for pedestrians. • Lack of crosswalks across the westbound and northbound approaches. • Sun glare obstructs signal indications. • Missing overhead signal backplates.	• Update the exclusive pedestrian signal phase from 23 to 25 seconds. • Replace the missing signal backplates. • Install reflective borders on all signal backplates.	• Modify the intersection according to the proposed corridor configuration. • Maintain the flare area and provide two approaching lanes on the northbound and southbound approaches. • Reduce curb turning radii and add crosswalks on the westbound and the northbound approaches. • Upgrade the signal system with count-down/accessible pedestrian signals.

MPH: Miles per hour. MUTCD: Manual on Uniform Traffic Devices, Federal Highway Administration, 2009 Edition with Numbers 1 and 2 Revisions, May 2012.

TABLE 1-3
Proposed Improvements: Rockland Street/George Washington Boulevard in Hingham

Location	Issues/Concerns	Short-Term Improvements	Long-Term Improvements
The section in general	• High travel speeds under multiple-lane traffic operation. • Substandard multi-use trail (6- to 8-foot wide) on the north side. • Insufficient bicycle accommodations. • Narrow 1-foot or less shoulders. • Unsafe turning maneuvers to adjacent developments (crossing two lanes of fast traffic). • Pavement rutting and cracking.	• Install solar-powered Your Speed warning signs on Rockland Street (in conjunction with the existing 35-MPH regulation signs) in both directions. • Trim overgrown vegetation in both directions. • Patch/repave/seal the rutting and cracking pavements.	• Convert to two-lane traffic operation (one lane each direction) with a center median/left-turn lane and 5- to 6.5-foot bicycle lanes on both sides. • Upgrade the multi-use trail from 10- to 12-foot wide. • Install 5-foot sidewalks on the south side. • Consider changing George Washington Boulevard's speed limit from 45 to 40 MPH after the roadway reconfiguration.
Signalized Intersection: Rockland Street at George Washington Boulevard	• No crosswalks at the intersection.	• Add reflective borders on the existing signal backplates (if applicable).	• Restripe the intersection according to the proposed corridor configuration. • Utilize the existing intersection layout by maintaining two westbound approach lanes and adding eastbound traffic median. • Add crosswalks on the eastbound and the northbound approaches. • Upgrade the signal system with count-down/accessible pedestrian signals.

MPH: Miles per hour.

TABLE 1-4
Proposed Improvements: George Washington Boulevard in Hull

Location	Issues/Concerns	Short-Term Improvements	Long-Term Improvements
The section in general	• High travel speeds under multiple-lane traffic operation. • Unsafe turning maneuvers to adjacent developments (crossing two lanes of fast traffic). • Substandard multi-use trail (6-foot wide) on the north/west side. • Insufficient bicycle accommodations. • Narrow 1-foot or less shoulders. • Pavement rutting and cracking.	• Install solar-powered Your Speed warning signs in conjunction with 45-MPH regulation signs at suitable locations approaching the Barnstable Road/Logan Avenue intersection. • Continue monitoring crash and traffic conditions at the Barnstable Road/Logan Avenue intersection. • Patch/repave/seal the rutting and cracking pavements.	• Convert to two-lane traffic operation (one lane each direction) with a center median/left-turn lane and 6.5-foot bicycle lanes on both side. • Install 5-foot sidewalks on the east side. • Consider extending the existing 35-MPH zone to the vicinity of Barnstable Road/Logan Avenue after the roadway reconfiguration. • Consider changing the existing 45-MPH zone to 40 MPH after the roadway reconfiguration.
Unsignalized Intersection: George Washington Boulevard at Barnstable Road/Logan Avenue	• High travel speeds on George Washington Boulevard. • Unsafe for pedestrians to cross multi-lane traffic on George Washington Boulevard. • No left-turn lanes on George Washington Boulevard for vehicles to access the adjacent business and residential developments.	• Install solar-powered Your Speed warning signs in conjunction with 45-MPH regulation signs at suitable locations on George Washington Boulevard. • Continue monitoring crash and traffic conditions.	• Consider changing George Washington Boulevard's speed limit from 45 MPH to 35 MPH (extended from Rockland Circle), with further engineering study. • Convert to a through and right-turn lane and a left-turn lane with a median for pedestrian refuge in each direction of George Washington Boulevard. • Consider installing a crosswalk with pedestrian hybrid flashing beacons if the future traffic and crash conditions deteriorate and meet the warrants for such installations.
Signalized Intersection: George Washington Boulevard at Rockland Circle	• No crosswalks at the intersection. • Outdated signal system.	• N/A	• Restripe the intersection according to the proposed corridor configuration. • Provide a northbound right-turn lane of about 150 feet long. • Add crosswalks on the northbound and the westbound approaches. • Upgrade the entire signal system, including count-down/accessible pedestrian signals, new mast arms, and detectors.
Signalized Intersection: George Washington Boulevard at Wharf Avenue	• Heavy pedestrian crossing during peak summer hours. • Short time period (17 seconds) for pedestrians to cross George Washington Boulevard. • Outdated signal system.	• Update the exclusive pedestrian signal phase from 17 to 21 seconds.	• Restripe the intersection according to the proposed corridor configuration. • Upgrade the entire signal system, including count-down/accessible pedestrian signals, new mast arms, and detectors. • The final plan for this intersection depends on the future traffic circulation scheme that the Town is studying for the Nantasket Beach Revitalization Plan.
Unsignalized Intersection: George Washington Boulevard at Nantasket Avenue/Bay Street	• Heavy pedestrian crossings during peak summer hours. • Poor visibility of pedestrians and the existing crosswalk at the northwest corner (near the Superwash store) for drivers from Nantasket Avenue.	• The Town recently installed pedestrian crossing warning signs and improved pavement markings on Nantasket Avenue.	• Redesign the intersection with a curb extension (pedestrian bulb-out) at the northwest corner and realignments of the two adjacent crosswalks. • The design plan for this intersection depends on the area's traffic circulation scheme currently studied by the Town.

MPH: Miles per hour. MUTCD: Manual on Uniform Traffic Devices, Federal Highway Administration, 2009 Edition with Numbers 1 and 2 Revisions, May 2012. N/A: Not available or applicable.

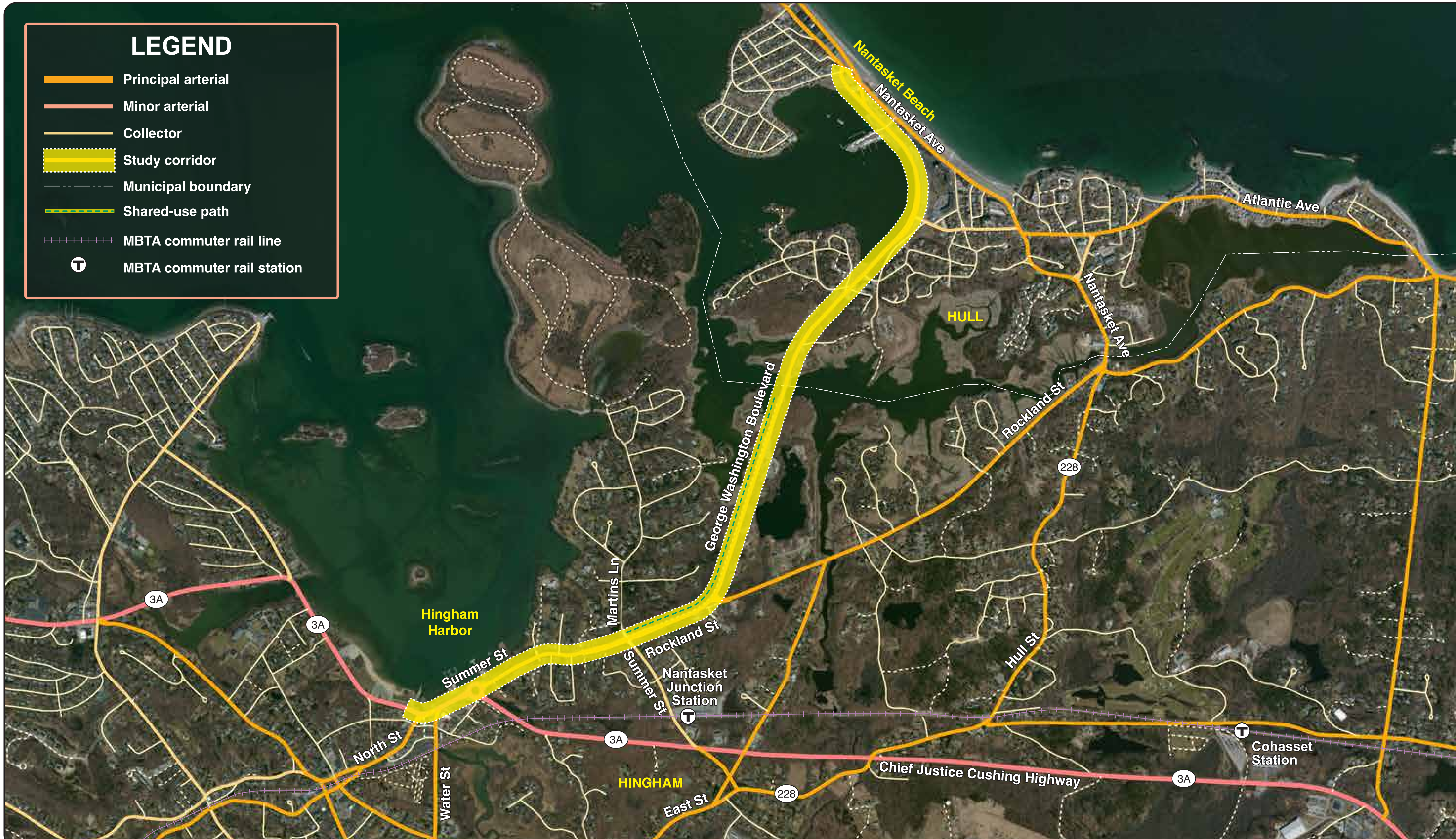

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FIGURE 1
Corridor Location and Adjacent Transportation Facilities
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways

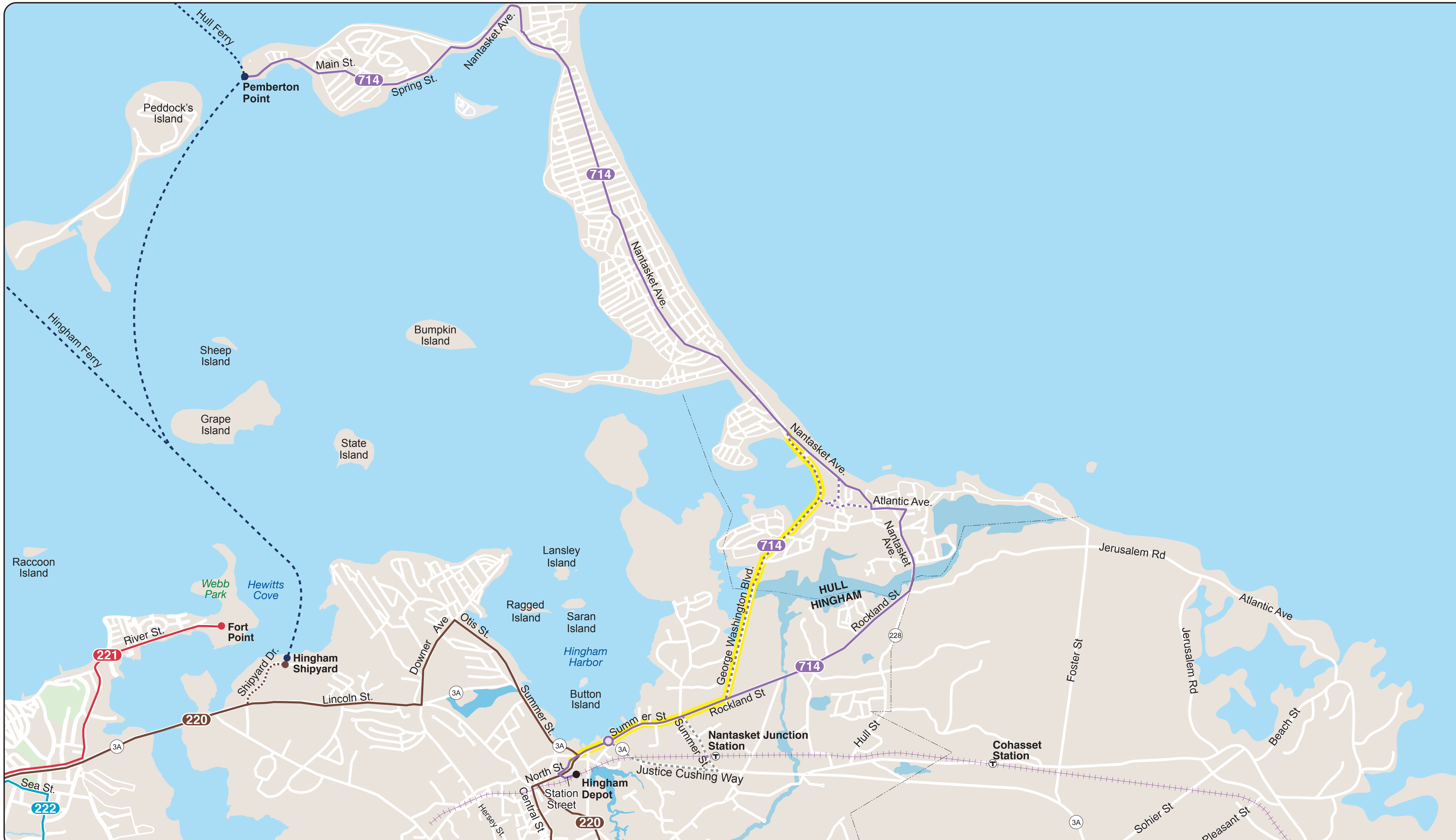

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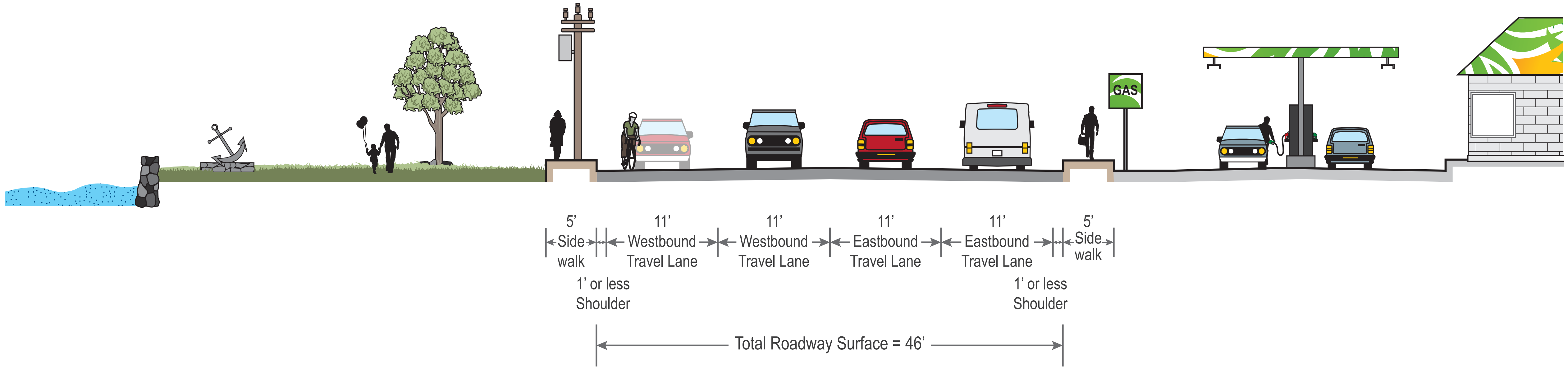
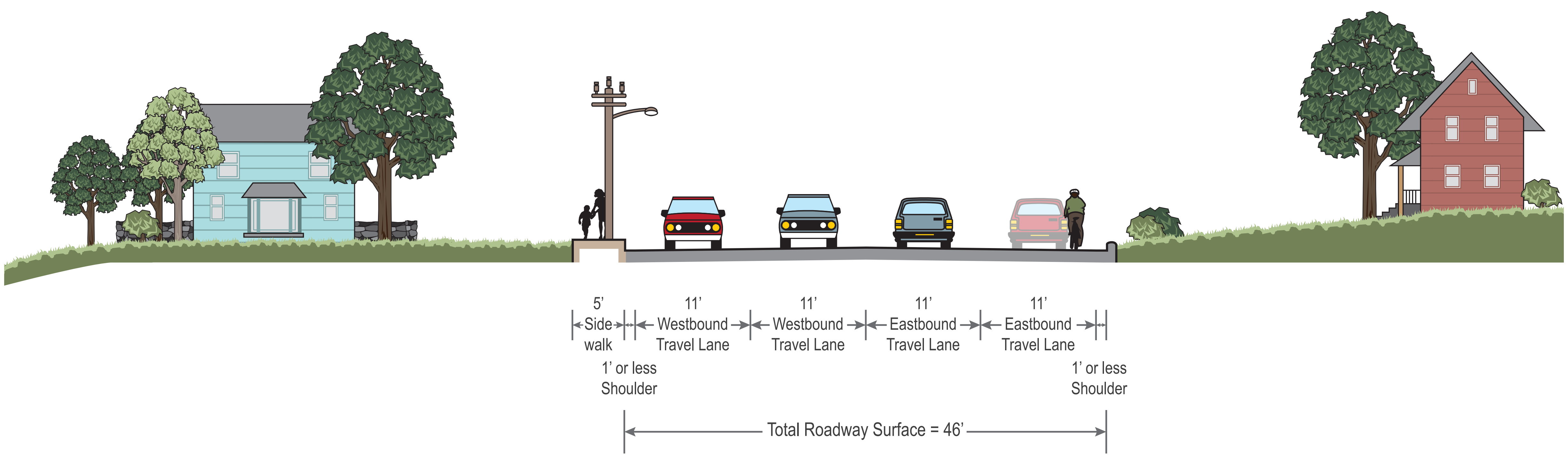
FIGURE 2
MBTA Transit Services in the Study Area
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways



Summer Street in the Harbor Area



Summer Street in the Residential Area

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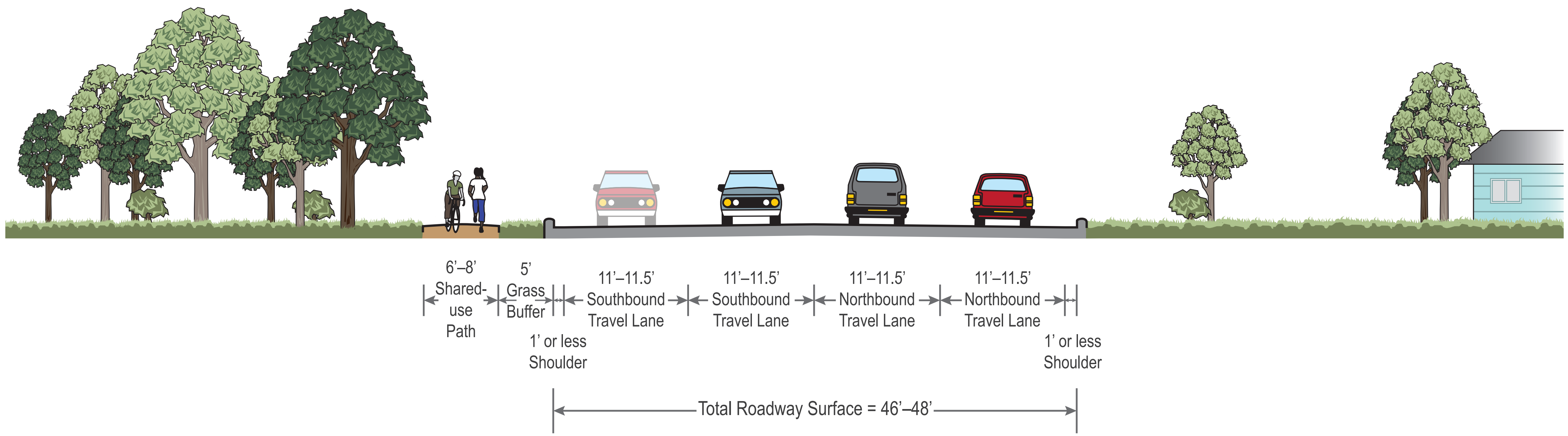
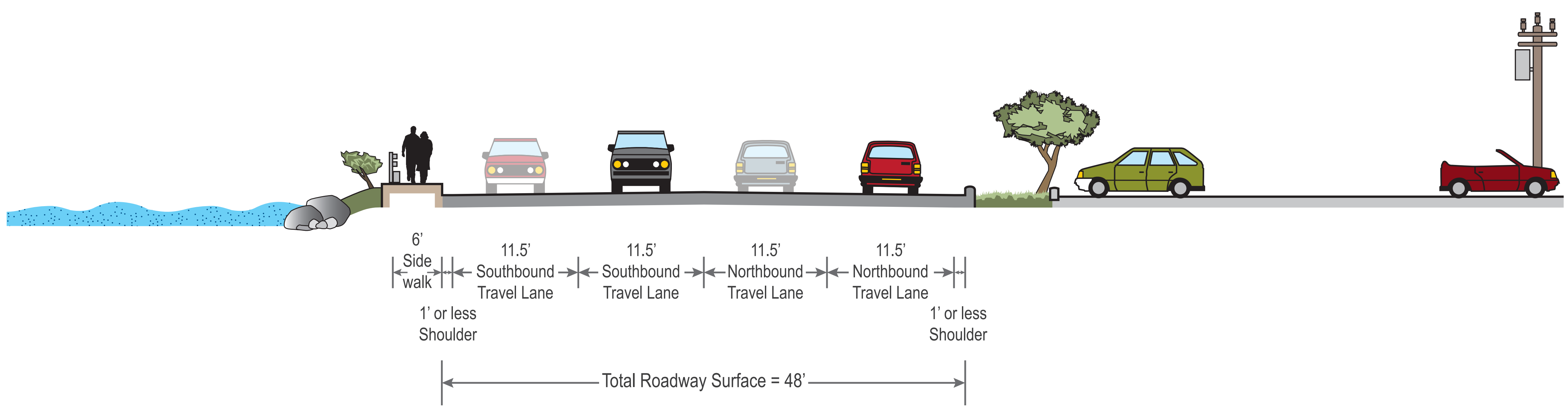
FIGURE 3-1
Existing Roadway Cross-Sections and Adjacent Land Uses
Summer Street/George Washington Street Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways



Rockland Street/George Washington Boulevard in Hingham



George Washington Boulevard in Hull

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FIGURE 3-2
Existing Roadway Cross-Sections and Adjacent Land Uses
Summer Street/George Washington Street Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways

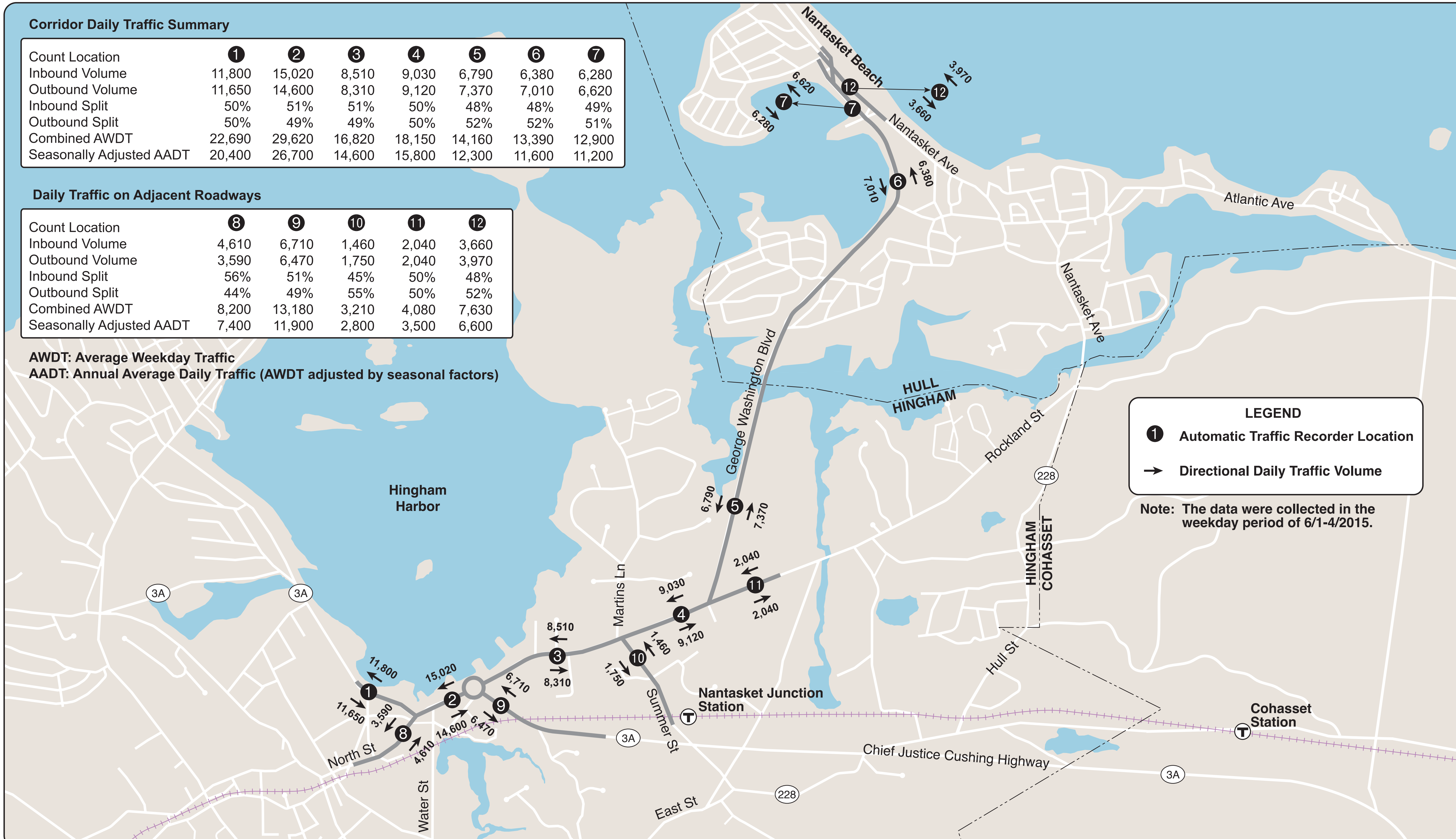
Corridor Daily Traffic Summary

Count Location	1	2	3	4	5	6	7
Inbound Volume	11,800	15,020	8,510	9,030	6,790	6,380	6,280
Outbound Volume	11,650	14,600	8,310	9,120	7,370	7,010	6,620
Inbound Split	50%	51%	51%	50%	48%	48%	49%
Outbound Split	50%	49%	49%	50%	52%	52%	51%
Combined AWDT	22,690	29,620	16,820	18,150	14,160	13,390	12,900
Seasonally Adjusted AADT	20,400	26,700	14,600	15,800	12,300	11,600	11,200

Daily Traffic on Adjacent Roadways

Count Location	8	9	10	11	12
Inbound Volume	4,610	6,710	1,460	2,040	3,660
Outbound Volume	3,590	6,470	1,750	2,040	3,970
Inbound Split	56%	51%	45%	50%	48%
Outbound Split	44%	49%	55%	50%	52%
Combined AWDT	8,200	13,180	3,210	4,080	7,630
Seasonally Adjusted AADT	7,400	11,900	2,800	3,500	6,600

AWDT: Average Weekday Traffic
AADT: Annual Average Daily Traffic (AWDT adjusted by seasonal factors)



LEGEND
Automatic Traffic Recorder Location
Directional Daily Traffic Volume

Note: The data were collected in the weekday period of 6/1-4/2015.

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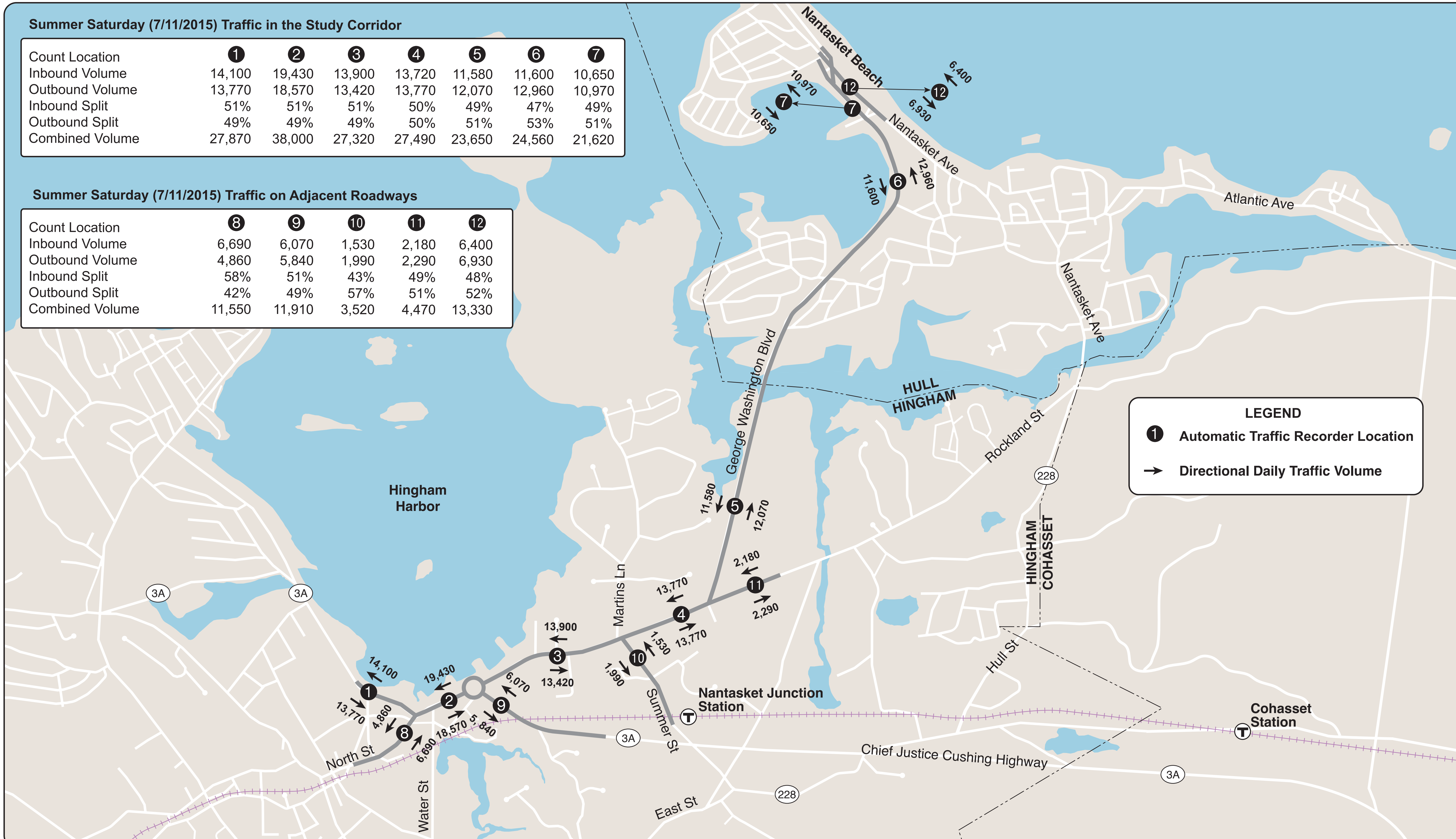
FIGURE 4
Daily Traffic Volumes
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways



Summer Saturday (7/11/2015) Traffic in the Study Corridor

Count Location	1	2	3	4	5	6	7
Inbound Volume	14,100	19,430	13,900	13,720	11,580	11,600	10,650
Outbound Volume	13,770	18,570	13,420	13,770	12,070	12,960	10,970
Inbound Split	51%	51%	51%	50%	49%	47%	49%
Outbound Split	49%	49%	49%	50%	51%	53%	51%
Combined Volume	27,870	38,000	27,320	27,490	23,650	24,560	21,620

Summer Saturday (7/11/2015) Traffic on Adjacent Roadways

Count Location	8	9	10	11	12
Inbound Volume	6,690	6,070	1,530	2,180	6,400
Outbound Volume	4,860	5,840	1,990	2,290	6,930
Inbound Split	58%	51%	43%	49%	48%
Outbound Split	42%	49%	57%	51%	52%
Combined Volume	11,550	11,910	3,520	4,470	13,330

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FIGURE 5
Summer Saturday Traffic Volumes
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways

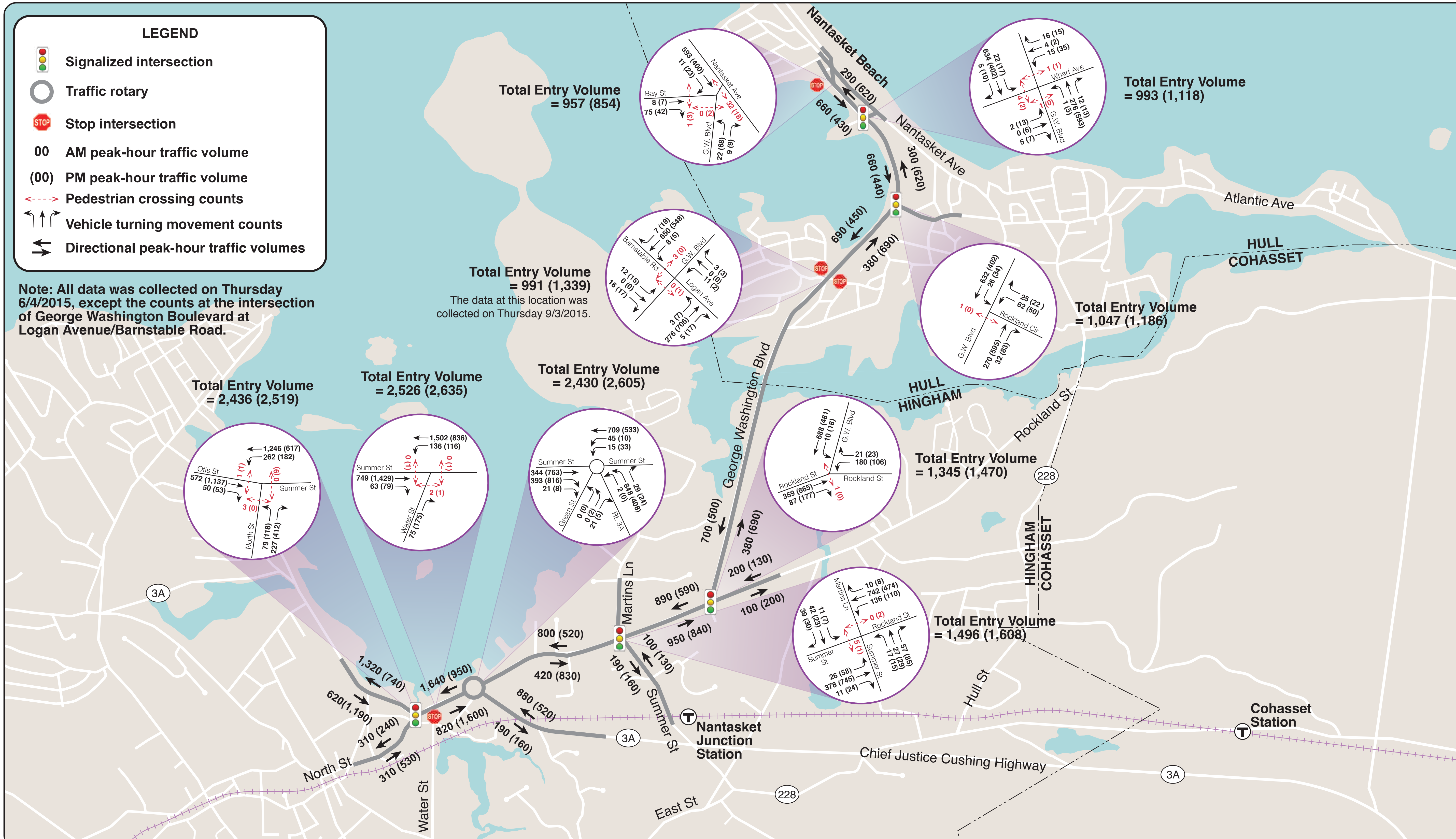

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FIGURE 6
Weekday Peak-Hour Traffic and Pedestrian Volumes
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways

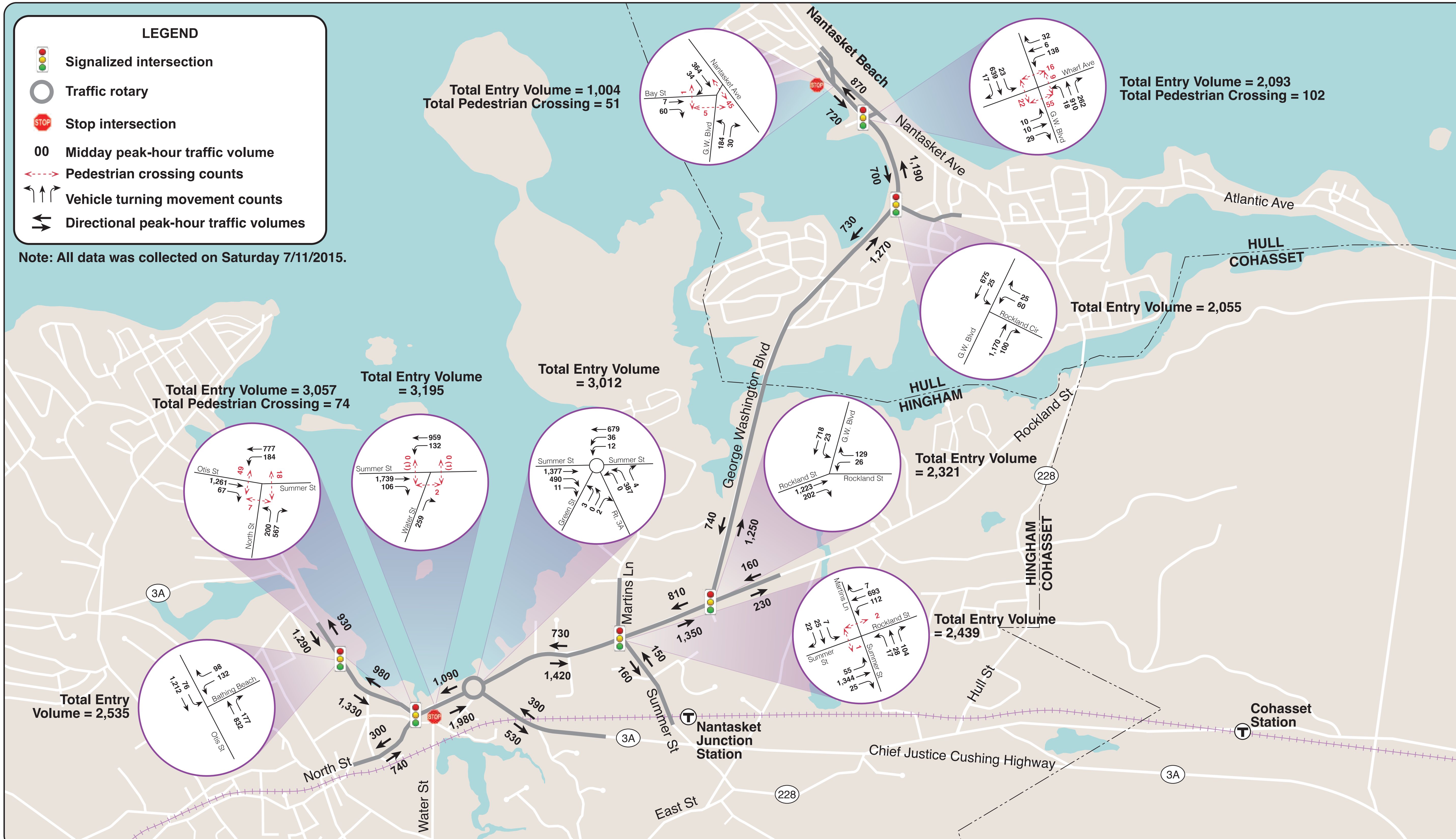

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FIGURE 7
Summer Saturday Peak-Hour Traffic and Pedestrian Volumes
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways

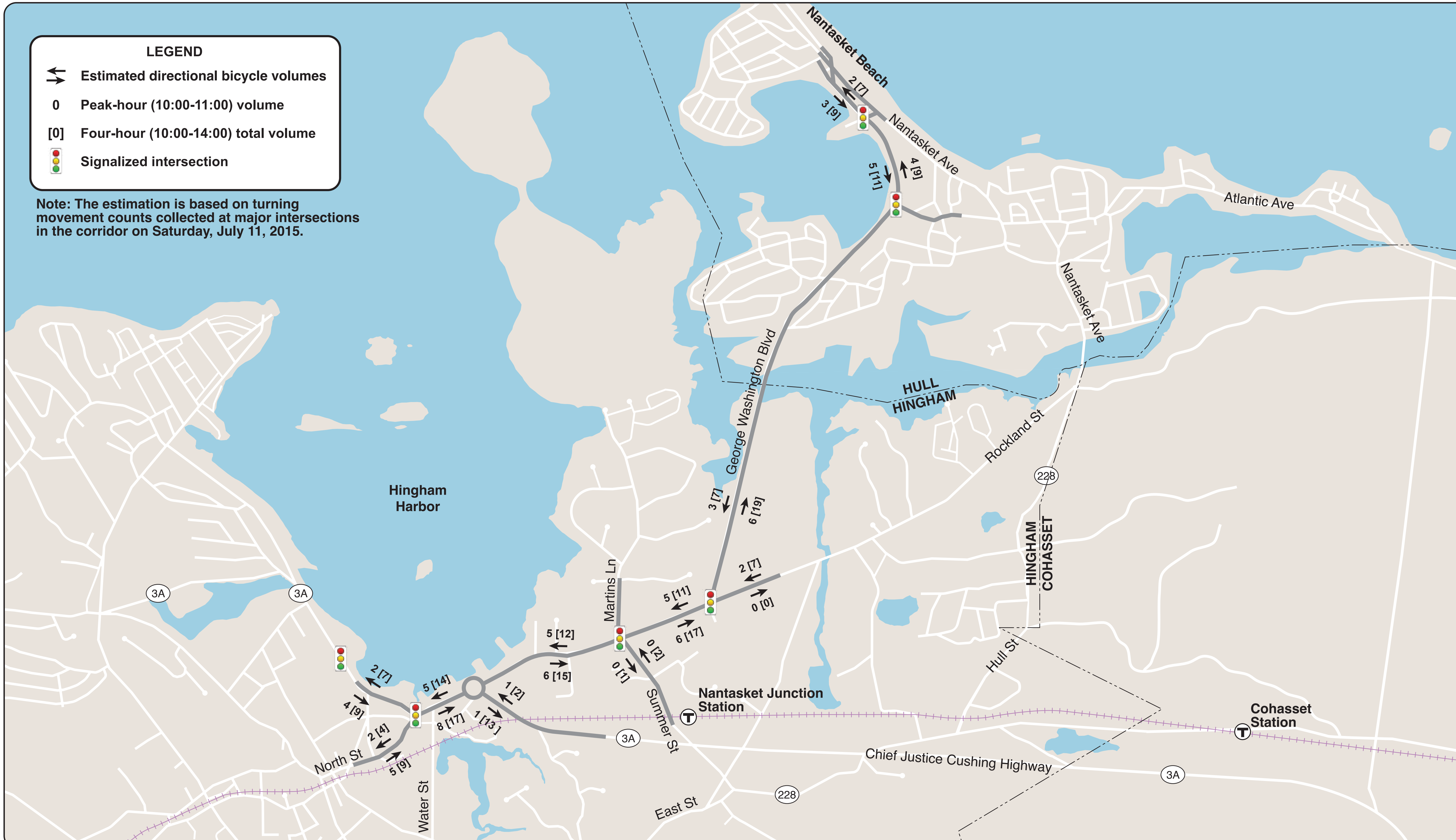

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FIGURE 8
Summer Saturday On-Road Bicycle Volumes
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways

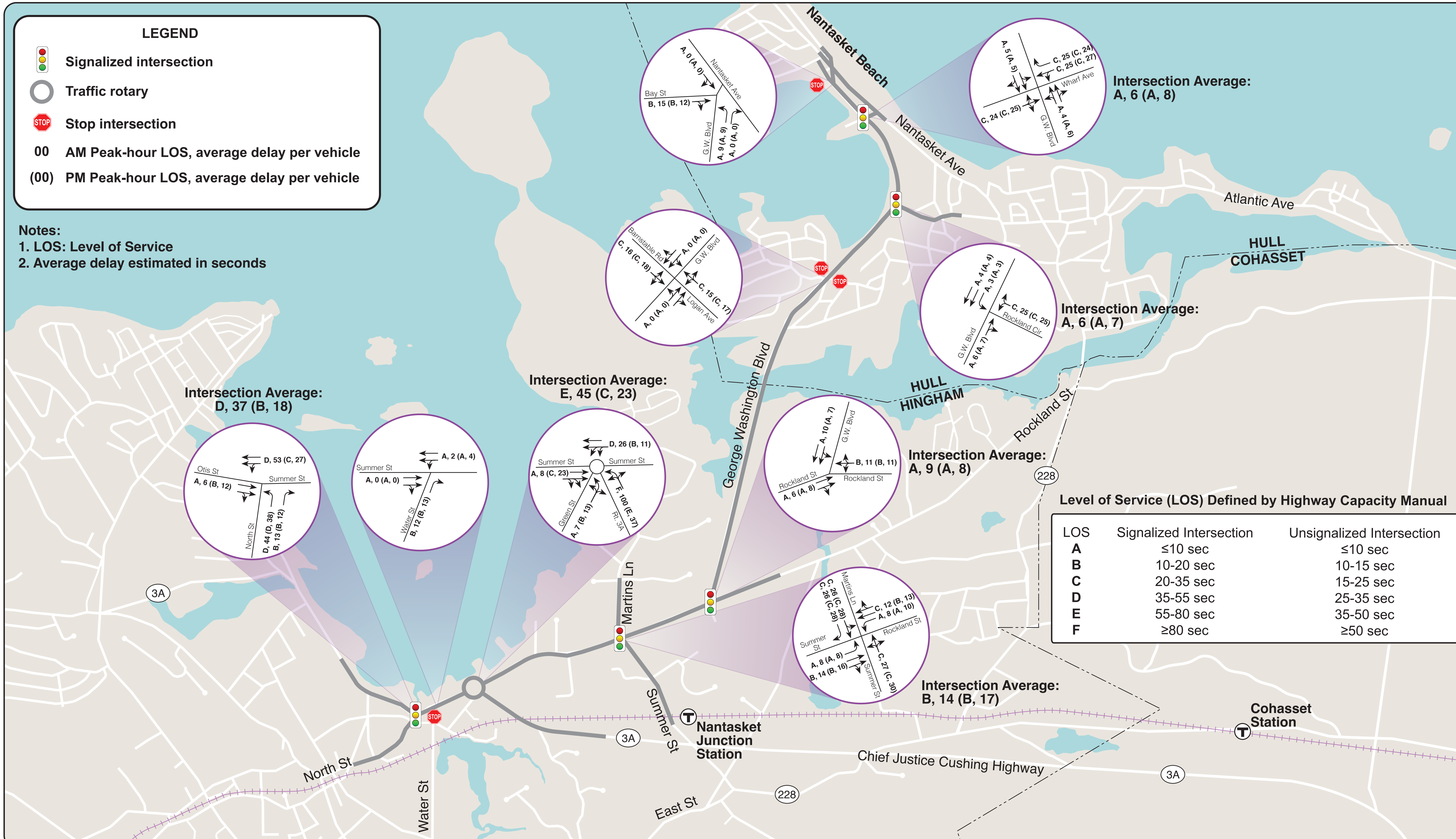

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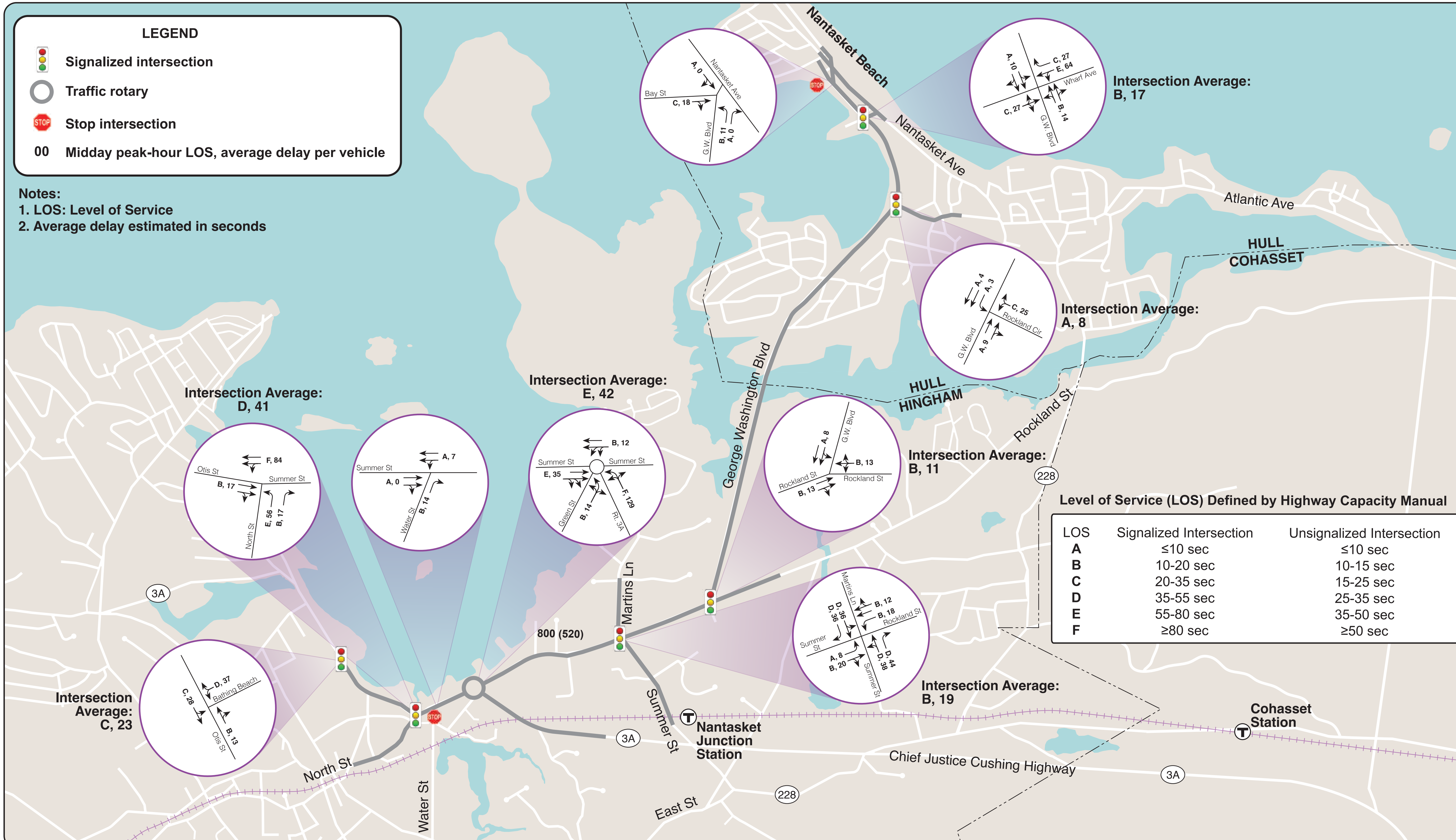
FIGURE 9
Weekday Peak-Hour Intersection Capacity Analyses
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways



LOS	Signalized Intersection	Unsignalized Intersection
A	≤10 sec	≤10 sec
B	10-20 sec	10-15 sec
C	20-35 sec	15-25 sec
D	35-55 sec	25-35 sec
E	55-80 sec	35-50 sec
F	≥80 sec	≥50 sec

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FIGURE 10
Summer Saturday Peak-Hour Intersection Capacity Analyses
Summer Street/George Washington Boulevard in Hingham and Hull

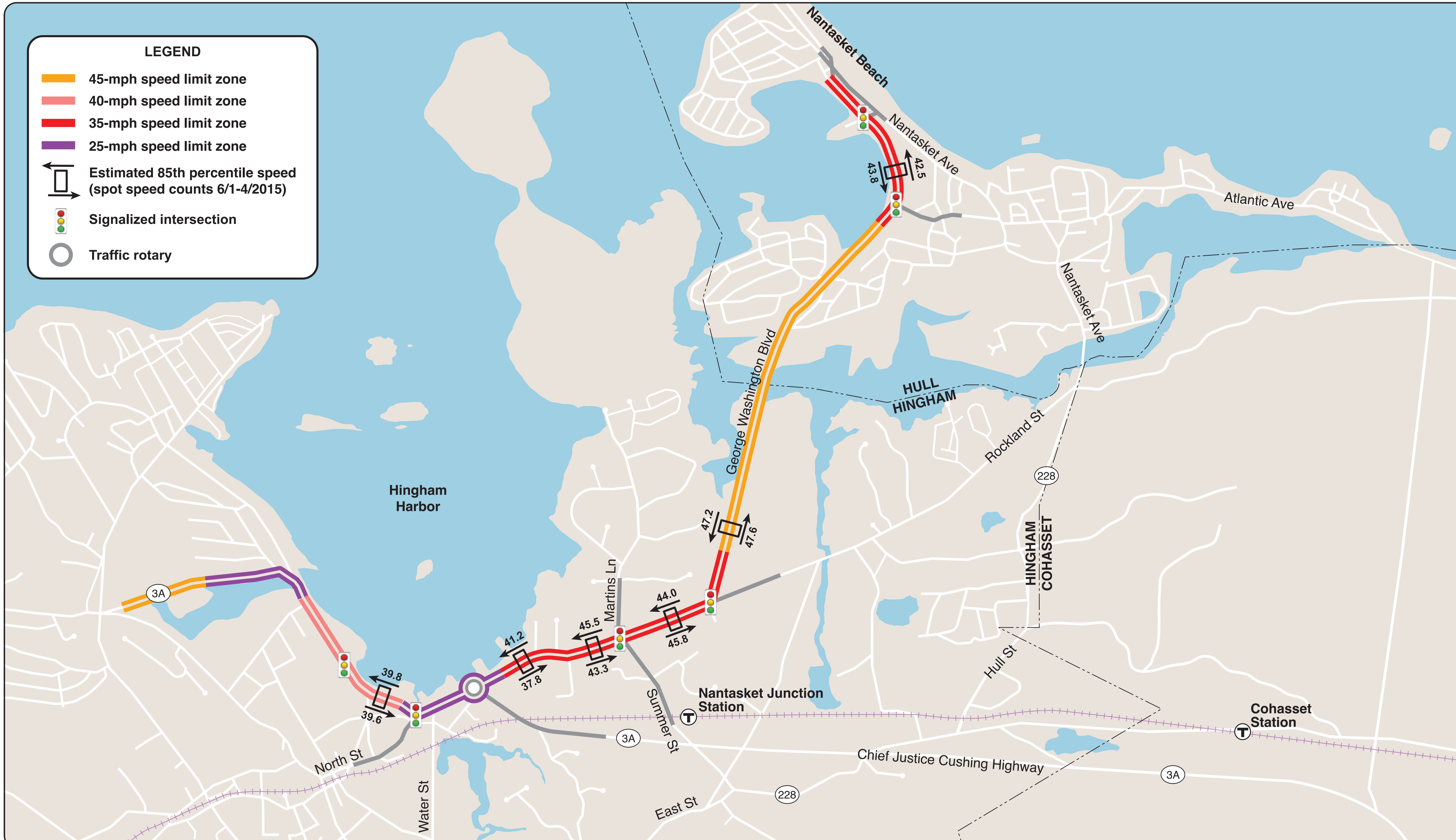

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FIGURE 11
Speed Regulations and Estimated 85th Percentile Speeds
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways

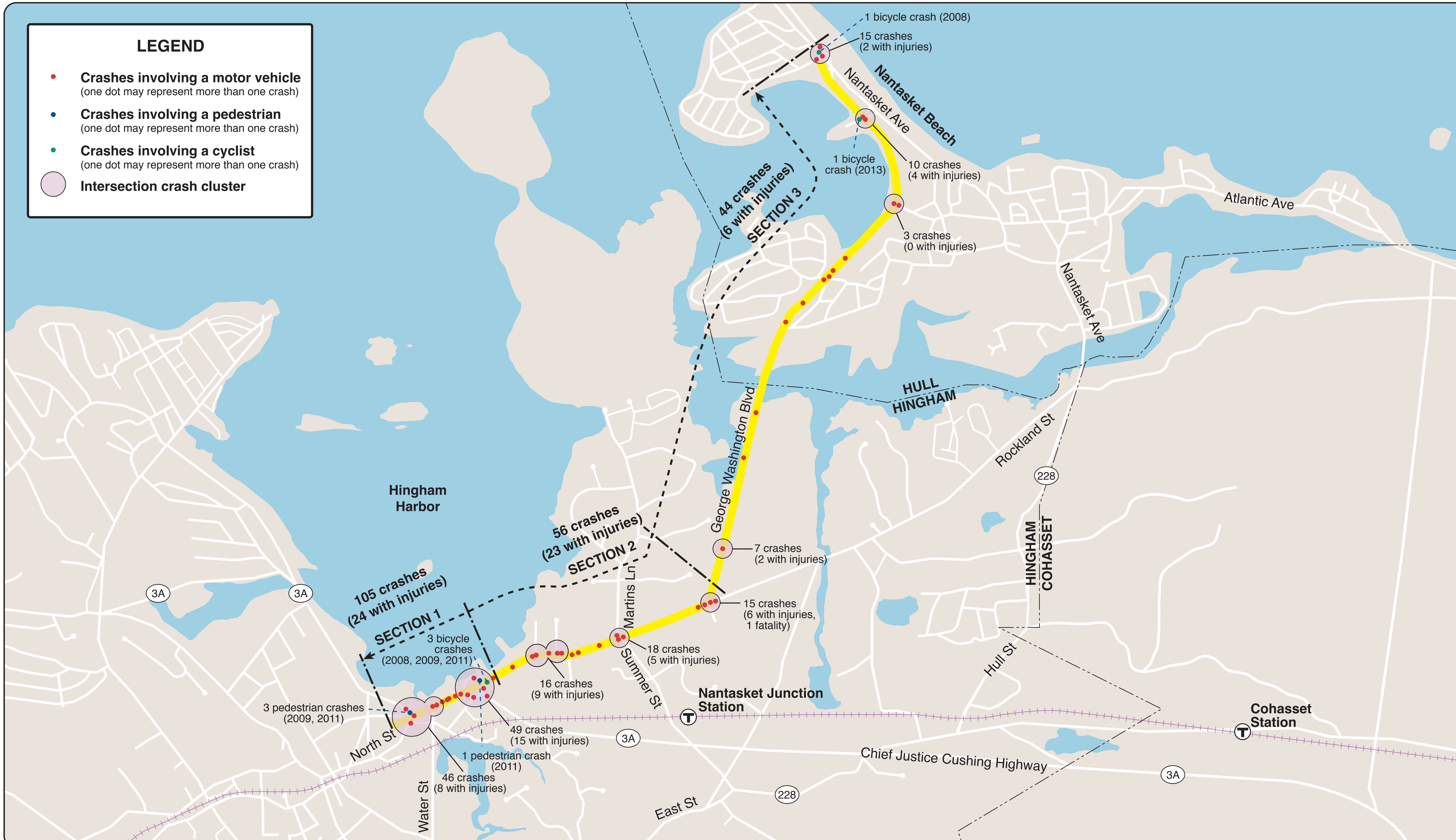

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FIGURE 12
Summary of MassDOT Crash Data 2008-12
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways

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FIGURE 13
Proposed Key Short-Term Improvement Conceptual Plan: Summer Street in the Harbor Area
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways

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FIGURE 14-1
Proposed Long-Term Improvement Conceptual Plan: Summer Street in the Harbor Area
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways

Alternative Signalized Intersection Design

Two-Lane Modern Roundabout

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FIGURE 14-1A
Route 3A Rotary Long-Term Improvement Alternatives
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways

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FIGURE 14-2
Proposed Long-Term Improvement Conceptual Plan: Summer Street in the Residential Area
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways

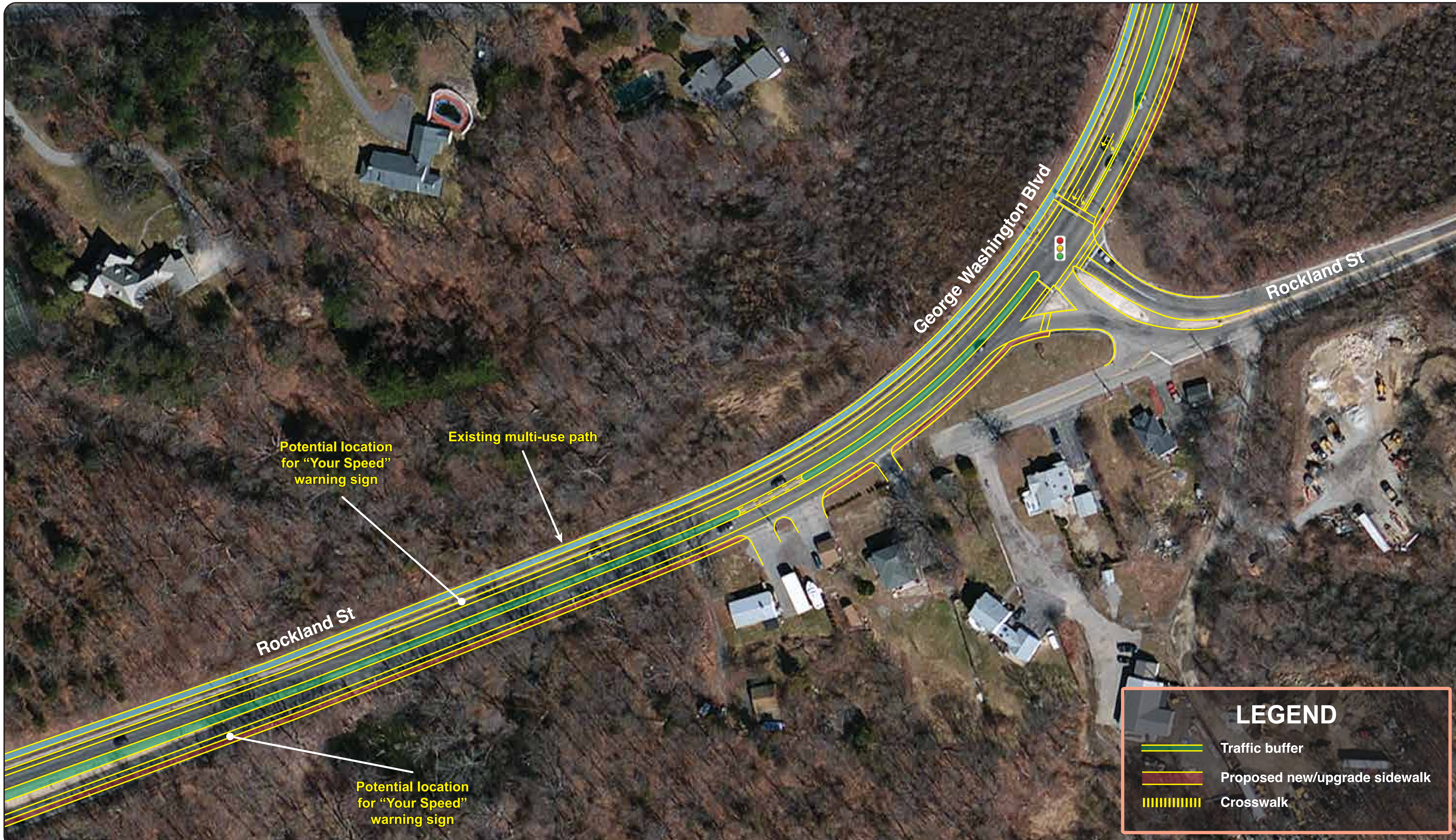

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FIGURE 14-3
Proposed Long-Term Improvement Conceptual Plan: Rockland Street/George Washington Boulevard in Hingham
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways

FIGURE 14-4
Proposed Long-Term Improvement Conceptual Plan: George Washington Boulevard in Hull
Summer Street/George Washington Boulevard in Hingham and Hull

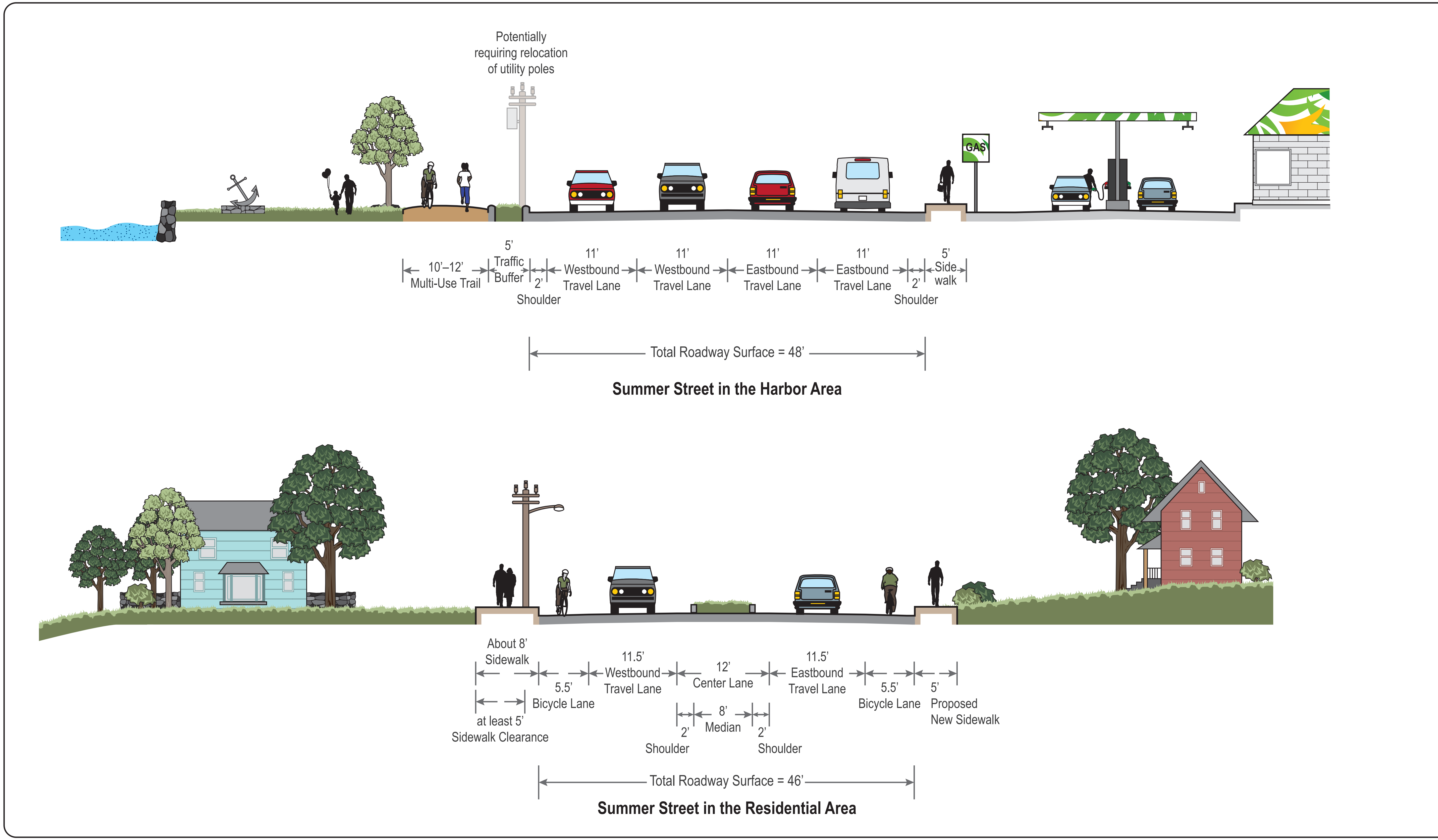

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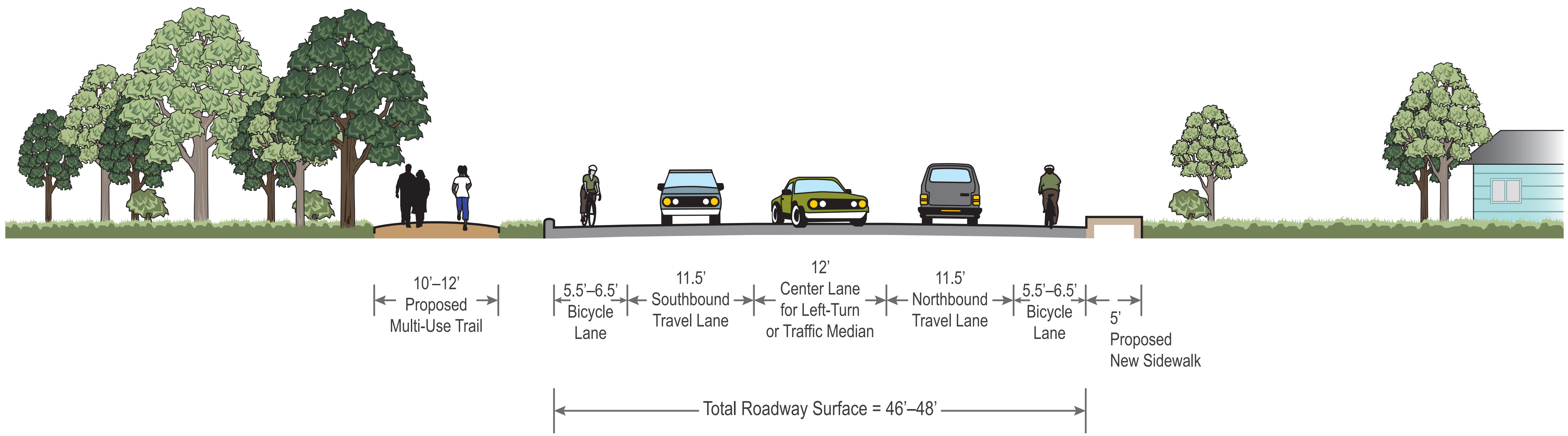
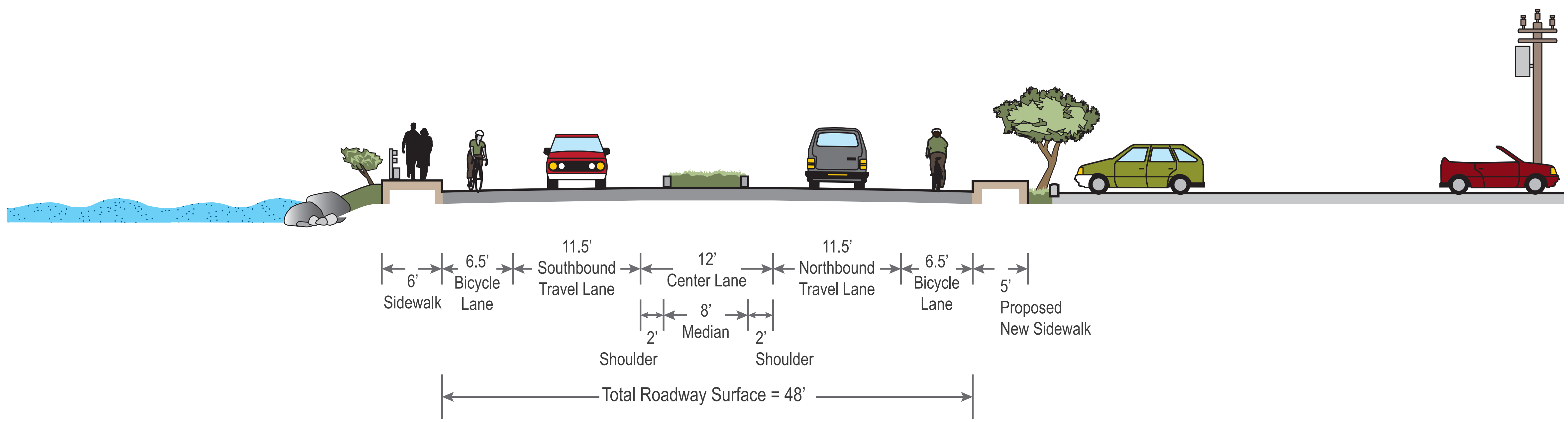
FIGURE 15-1
Proposed Long-Term Improvement Roadway Cross-Sections
Summer Street/George Washington Street Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways



Rockland Street/George Washington Boulevard in Hingham



George Washington Boulevard in Hull

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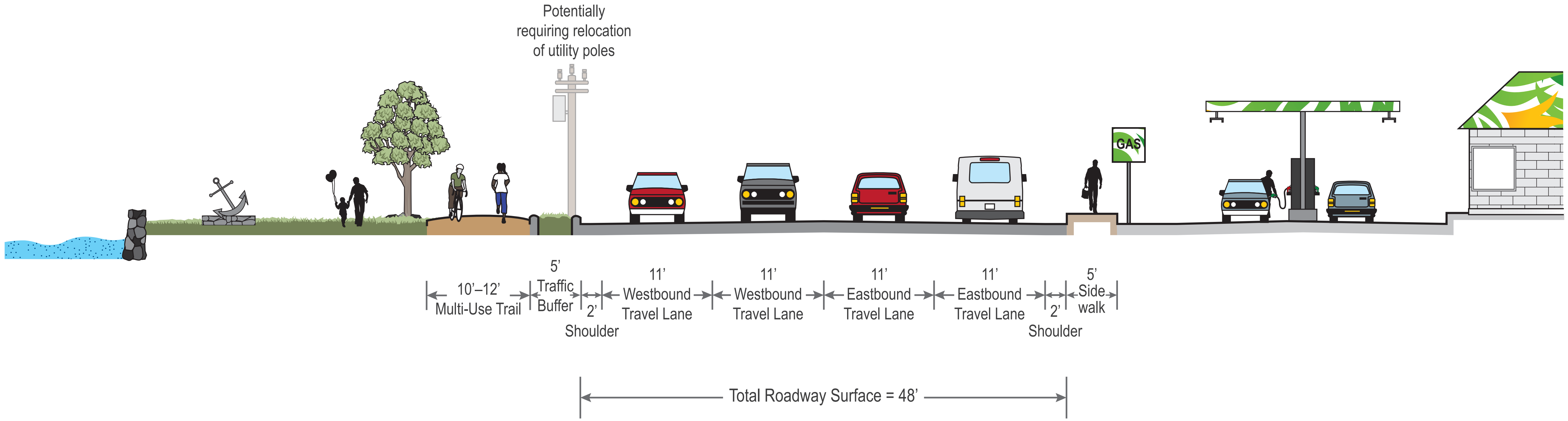
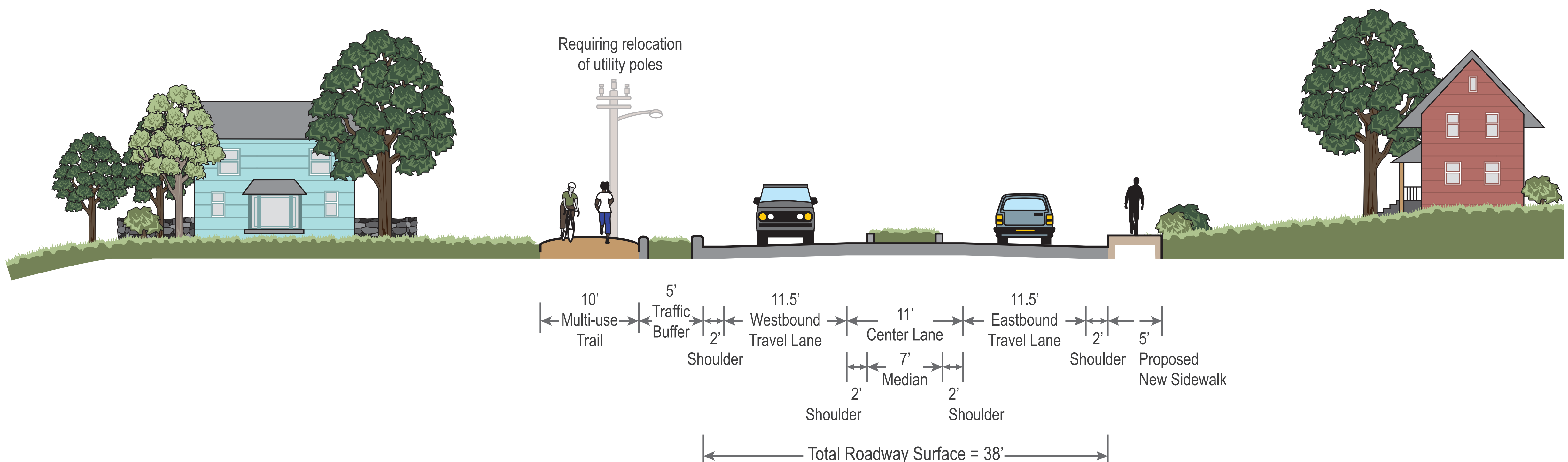
FIGURE 15-2
Proposed Long-Term Improvement Roadway Cross-Sections
Summer Street/George Washington Street Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways



Summer Street in the Harbor Area



Summer Street in the Residential Area

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FIGURE 16-1
Proposed Roadway Cross-Sections: Multi-Use Trail Alternative
Summer Street/George Washington Street Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways

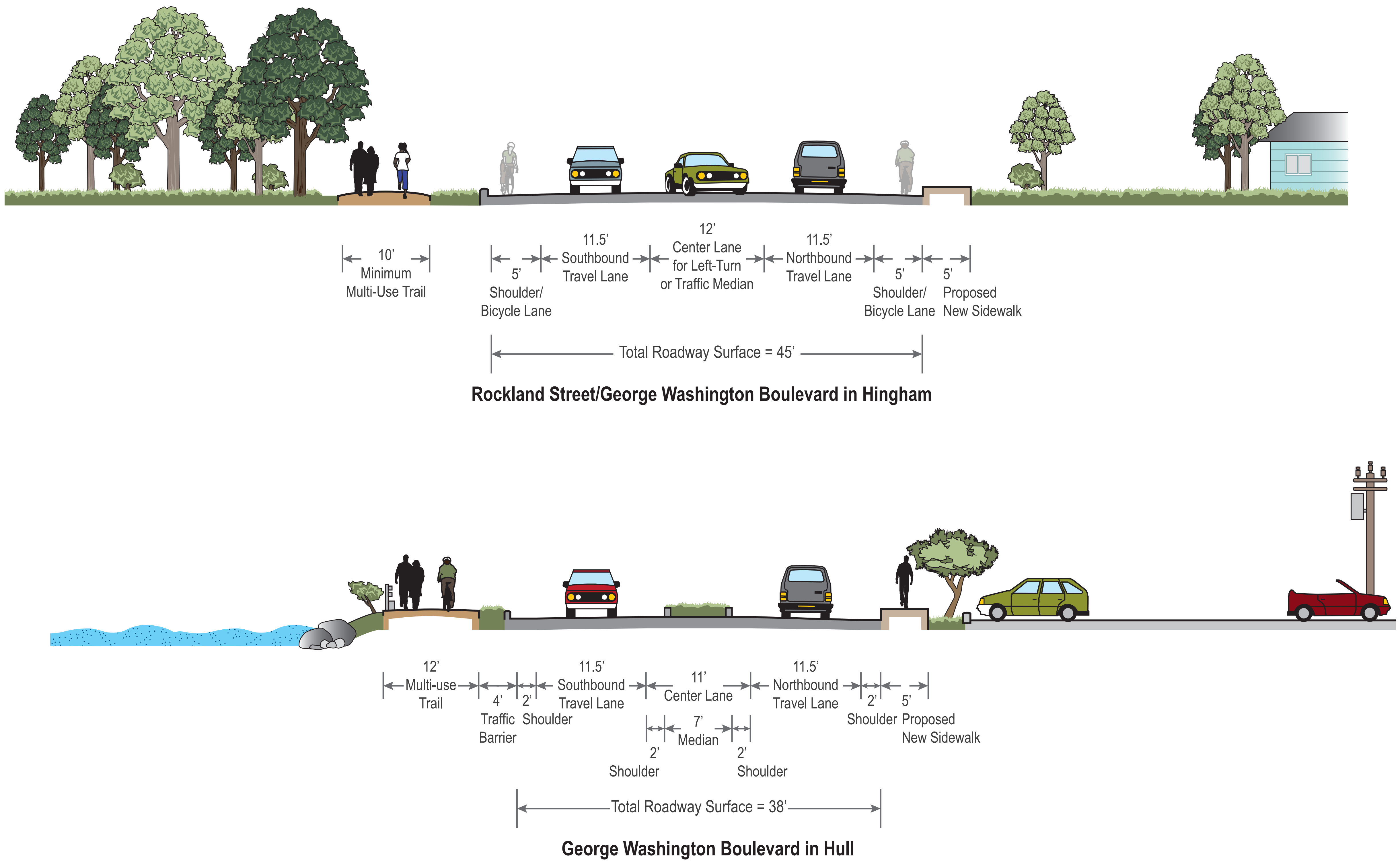

FIGURE 16-2
Proposed Roadway Cross-Sections: Multi-Use Trail Alternative
Summer Street/George Washington Street Boulevard in Hingham and Hull

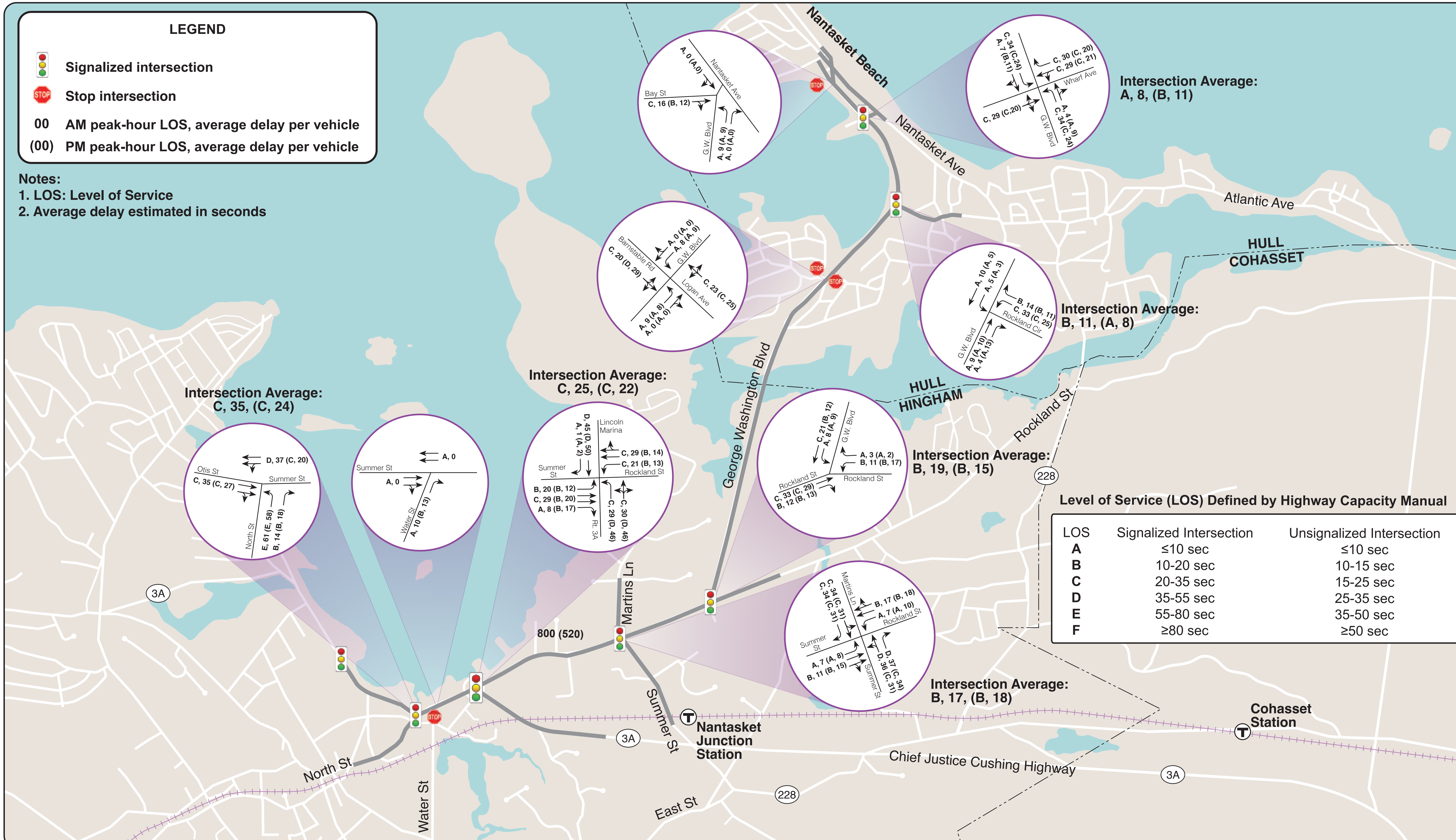

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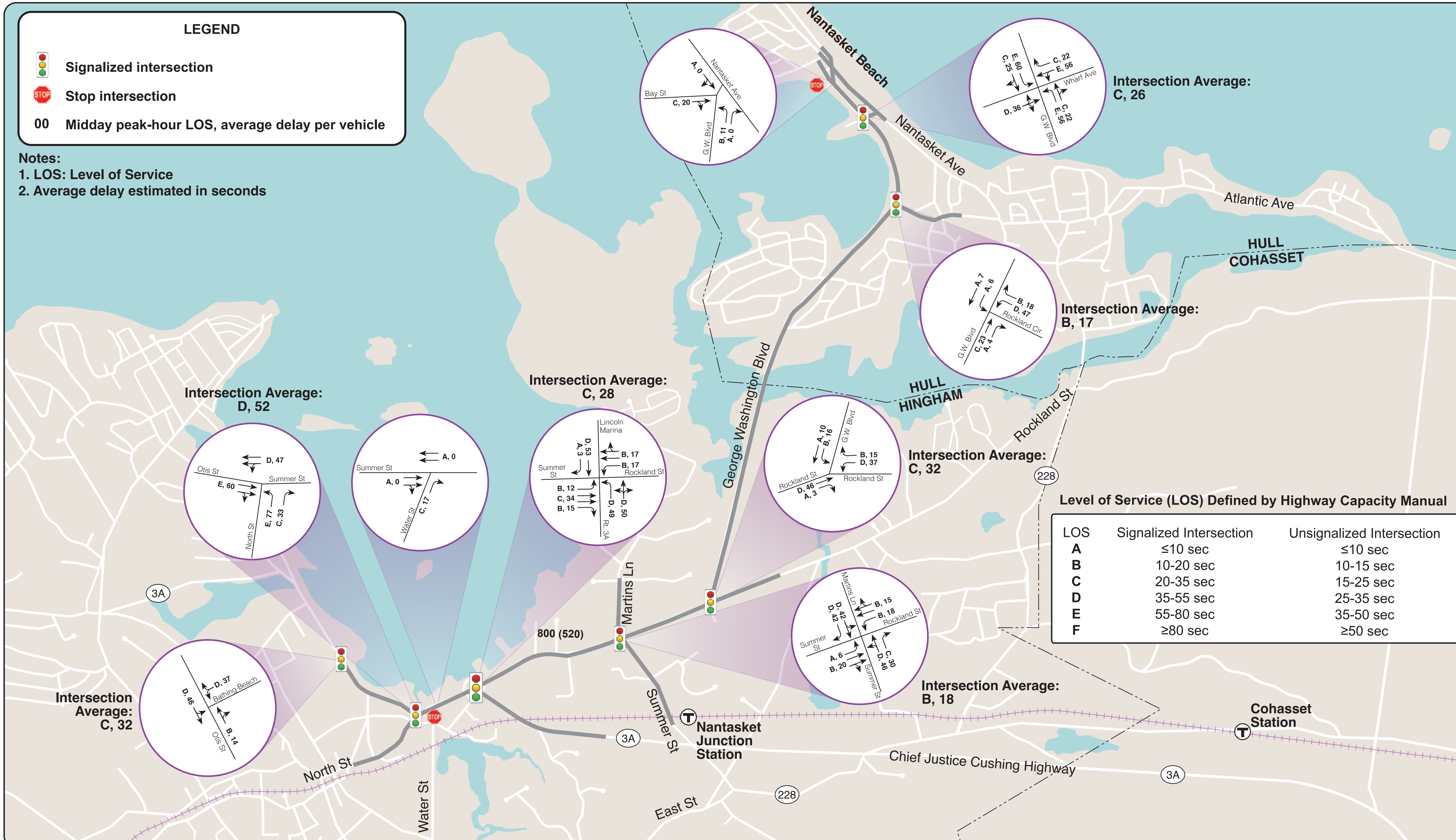
FIGURE 17
Projected 2040 Weekday Peak-Hour Intersection Capacity Analyses
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways



LOS	Signalized Intersection	Unsignalized Intersection
A	≤10 sec	≤10 sec
B	10-20 sec	10-15 sec
C	20-35 sec	15-25 sec
D	35-55 sec	25-35 sec
E	55-80 sec	35-50 sec
F	≥80 sec	≥50 sec

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FIGURE 18
Projected 2040 Summer Saturday Peak-Hour Intersection Capacity Analyses
Summer Street/George Washington Boulevard in Hingham and Hull

Addressing Safety, Mobility, and Access on Subregional Priority Roadways

APPENDIX A

Participants of Study Advisory Meetings
May 13 and November 3, 2015

Participants of Study Advisory Meetings

Summer Street/George Washington Boulevard Corridor in Hingham and Hull

May 13 and November 3, 2015

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Chen-Yuan Wang	CTPS	cwang@ctps.org
Katrina Crocker	CTPS	kcrocker@ctps.org

APPENDIX B

Intersection Capacity Analyses
Weekday AM Peak Hour
2015 Existing Conditions

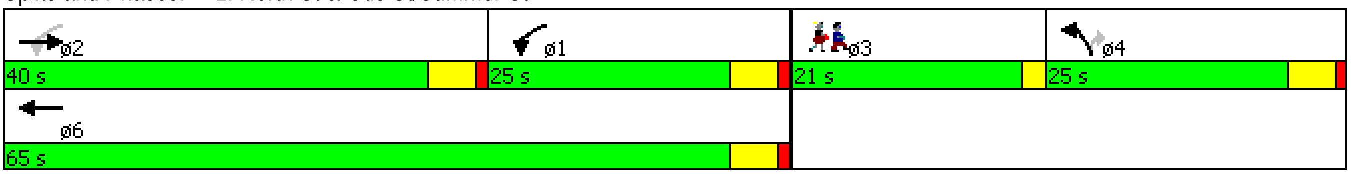
Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø3
Lane Configurations							
Volume (vph)	572	50	262	1246	79	227	
Satd. Flow (prot)	3036	0	0	3082	1577	1411	
Flt Permitted				0.696	0.950		
Satd. Flow (perm)	3036	0	0	2164	1577	1411	
Satd. Flow (RTOR)	9					261	
Confl. Peds. (#/hr)		3	3				
Peak Hour Factor	0.95	0.95	0.93	0.93	0.87	0.87	
Heavy Vehicles (%)	2%	2%	1%	1%	3%	3%	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	655	0	0	1622	91	261	
Turn Type	NA		D.P+P	NA	Prot	Perm	
Protected Phases	2		1	6	4		3
Permitted Phases			2			4	
Detector Phase	2		1	6	4	4	
Switch Phase							
Minimum Initial (s)	8.0		4.0	8.0	9.0	9.0	4.0
Minimum Split (s)	13.0		9.0	13.0	14.0	14.0	21.0
Total Split (s)	40.0		25.0	65.0	25.0	25.0	21.0
Total Split (%)	36.0%		22.5%	58.6%	22.5%	22.5%	19%
Yellow Time (s)	4.0		4.0	4.0	4.0	4.0	2.0
All-Red Time (s)	1.0		1.0	1.0	1.0	1.0	0.0
Lost Time Adjust (s)	0.0			0.0	0.0	0.0	
Total Lost Time (s)	5.0			5.0	5.0	5.0	
Lead/Lag	Lead		Lag		Lag	Lag	Lead
Lead-Lag Optimize?	Yes		Yes		Yes	Yes	Yes
Recall Mode	Min		None	Min	None	None	None
Act Effct Green (s)	61.2			61.2	11.0	11.0	
Actuated g/C Ratio	0.71			0.71	0.13	0.13	
v/c Ratio	0.30			1.05	0.45	0.64	
Control Delay	6.3			52.7	43.5	12.9	
Queue Delay	0.0			0.0	0.0	0.0	
Total Delay	6.3			52.7	43.5	12.9	
LOS	A			D	D	B	
Approach Delay	6.3			52.7	20.8		
Approach LOS	A			D	C		
Queue Length 50th (ft)	41			331	43	0	
Queue Length 95th (ft)	163			#904	104	65	
Internal Link Dist (ft)	764			218	85		
Turn Bay Length (ft)							
Base Capacity (vph)	2171			1546	373	533	
Starvation Cap Reductn	0			0	0	0	
Spillback Cap Reductn	0			0	0	0	
Storage Cap Reductn	0			0	0	0	
Reduced v/c Ratio	0.30			1.05	0.24	0.49	

Intersection Summary
Cycle Length: 111
Actuated Cycle Length: 85.6

Natural Cycle: 150	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.05	
Intersection Signal Delay: 36.9	Intersection LOS: D
Intersection Capacity Utilization 86.1%	ICU Level of Service E
Analysis Period (min) 15	

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: North St & Otis St/Summer St



Intersection	
Intersection Delay, s/veh	45.2
Intersection LOS	E

Approach	EB	WB	NB	NW
Entry Lanes	2	2	1	1
Conflicting Circle Lanes	2	2	2	2
Adj Approach Flow, veh/h	892	836	42	915
Demand Flow Rate, veh/h	927	844	44	934
Vehicles Circulating, veh/h	67	947	917	465
Vehicles Exiting, veh/h	1724	452	77	496
Follow-Up Headway, s	3.186	3.186	3.186	3.186
Ped Vol Crossing Leg, #/h	0	0	0	0
Ped Cap Adj	1.000	1.000	1.000	1.000
Approach Delay, s/veh	8.3	26.4	7.2	100.2
Approach LOS	A	D	A	F

Lane	Left	Right	Left	Right	Left	Left
Designated Moves	LT	TR	LT	TR	LR	LR
Assumed Moves	LT	R	LT	TR	LR	LR
RT Channelized						
Lane Util	0.454	0.546	0.470	0.530	1.000	1.000
Critical Headway, s	4.293	4.113	4.293	4.113	4.113	4.113
Entry Flow, veh/h	421	506	397	447	44	934
Cap Entry Lane, veh/h	1075	1078	555	582	595	816
Entry HV Adj Factor	0.962	0.962	0.990	0.991	0.955	0.980
Flow Entry, veh/h	405	487	393	443	42	915
Cap Entry, veh/h	1033	1038	550	577	568	799
V/C Ratio	0.392	0.469	0.715	0.768	0.074	1.145
Control Delay, s/veh	7.7	8.8	24.8	27.7	7.2	100.2
LOS	A	A	C	D	A	F
95th %tile Queue, veh	2	3	6	7	0	27

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	26	378	11	136	742	10	17	27	57	11	42	39
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width (ft)	11	11	11	11	11	11	12	12	12	16	16	16
Storage Length (ft)	150		0	150		0	0		50	0		75
Storage Lanes	1		0	1		0	0		1	0		1
Taper Length (ft)	25			25			25			25		
Satd. Flow (prot)	1694	3374	0	1728	3448	0	0	1775	1538	0	2090	1794
Flt Permitted	0.338			0.437				0.852			0.923	
Satd. Flow (perm)	603	3374	0	795	3448	0	0	1542	1538	0	1949	1794
Right Turn on Red			No			No			No			No
Satd. Flow (RTOR)												
Link Speed (mph)		35			35			35			35	
Link Distance (ft)		458			438			329			717	
Travel Time (s)		8.9			8.5			6.4			14.0	
Peak Hour Factor	0.93	0.93	0.93	0.90	0.90	0.90	0.84	0.84	0.84	0.92	0.92	0.92
Heavy Vehicles (%)	3%	3%	3%	1%	1%	1%	5%	5%	5%	2%	2%	2%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	28	418	0	151	835	0	0	52	68	0	58	42
Turn Type	pm+pt	NA		pm+pt	NA		Perm	NA	Perm	Perm	NA	Perm
Protected Phases	5	2		1	6			3			3	
Permitted Phases	2			6			3		3	3		3
Detector Phase	5	2		1	6		3	3	3	3	3	3
Switch Phase												
Minimum Initial (s)	4.0	15.0		4.0	15.0		8.0	8.0	8.0	8.0	8.0	8.0
Minimum Split (s)	8.0	20.0		8.0	20.0		13.0	13.0	13.0	13.0	13.0	13.0
Total Split (s)	14.0	55.0		14.0	55.0		25.0	25.0	25.0	25.0	25.0	25.0
Total Split (%)	12.0%	47.0%		12.0%	47.0%		21.4%	21.4%	21.4%	21.4%	21.4%	21.4%
Yellow Time (s)	3.0	4.0		3.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0
Lost Time Adjust (s)	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Lost Time (s)	4.0	5.0		4.0	5.0			5.0	5.0		5.0	5.0
Lead/Lag	Lead	Lag		Lead	Lag							
Lead-Lag Optimize?	Yes	Yes		Yes	Yes							
Recall Mode	None	Min		Min	Min		None	None	None	None	None	None
Act Effct Green (s)	28.7	21.5		34.0	32.2			10.9	10.9		10.9	10.9
Actuated g/C Ratio	0.53	0.40		0.63	0.60			0.20	0.20		0.20	0.20
v/c Ratio	0.06	0.31		0.24	0.40			0.17	0.22		0.15	0.12
Control Delay	7.9	14.4		8.1	12.0			26.7	27.1		25.9	26.1
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Delay	7.9	14.4		8.1	12.0			26.7	27.1		25.9	26.1
LOS	A	B		A	B			C	C		C	C
Approach Delay		14.0			11.4			27.0			26.0	
Approach LOS		B			B			C			C	
Queue Length 50th (ft)	2	41		14	52			11	15		12	9
Queue Length 95th (ft)	22	137		82	280			60	74		70	54
Internal Link Dist (ft)		378			358			249			637	
Turn Bay Length (ft)	150			150					50			75
Base Capacity (vph)	619	2991		714	3057			676	674		854	786

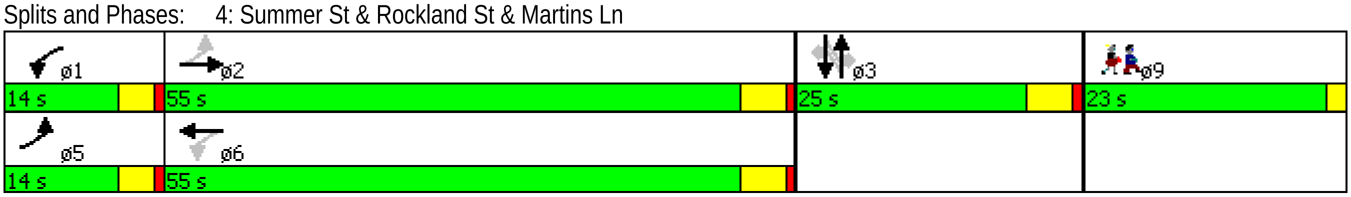
Lane Group	ø9
Lane Configurations	
Volume (vph)	
Ideal Flow (vphpl)	
Lane Width (ft)	
Storage Length (ft)	
Storage Lanes	
Taper Length (ft)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Right Turn on Red	
Satd. Flow (RTOR)	
Link Speed (mph)	
Link Distance (ft)	
Travel Time (s)	
Peak Hour Factor	
Heavy Vehicles (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	20%
Yellow Time (s)	2.0
All-Red Time (s)	0.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Starvation Cap Reductn	0	0		0	0			0	0		0	0
Spillback Cap Reductn	0	0		0	0			0	0		0	0
Storage Cap Reductn	0	0		0	0			0	0		0	0
Reduced v/c Ratio	0.05	0.14		0.21	0.27			0.08	0.10		0.07	0.05

Intersection Summary

Area Type: Other
Cycle Length: 117
Actuated Cycle Length: 53.7
Natural Cycle: 65
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.40
Intersection Signal Delay: 14.1 Intersection LOS: B
Intersection Capacity Utilization 46.7% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 4: Summer St & Rockland St & Martins Ln



Lane Group	WBL	WBR	NET	NER	SWL	SWT
Lane Configurations						
Volume (vph)	180	21	359	87	10	688
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Satd. Flow (prot)	3290	0	3322	0	0	3418
Flt Permitted	0.957					0.946
Satd. Flow (perm)	3285	0	3322	0	0	3236
Right Turn on Red		Yes		Yes		
Satd. Flow (RTOR)	26		85			
Link Speed (mph)	35		35			35
Link Distance (ft)	180		737			669
Travel Time (s)	3.5		14.4			13.0
Confl. Peds. (#/hr)	1					
Peak Hour Factor	0.77	0.77	0.91	0.91	0.90	0.90
Shared Lane Traffic (%)						
Lane Group Flow (vph)	261	0	491	0	0	775
Turn Type	Prot		NA		Perm	NA
Protected Phases	3		2			6
Permitted Phases					6	
Detector Phase	3		2		6	6
Switch Phase						
Minimum Initial (s)	7.0		7.0		7.0	7.0
Minimum Split (s)	12.0		12.0		12.0	12.0
Total Split (s)	20.0		30.0		30.0	30.0
Total Split (%)	40.0%		60.0%		60.0%	60.0%
Yellow Time (s)	4.0		4.0		4.0	4.0
All-Red Time (s)	1.0		1.0		1.0	1.0
Lost Time Adjust (s)	0.0		0.0			0.0
Total Lost Time (s)	5.0		5.0			5.0
Lead/Lag						
Lead-Lag Optimize?						
Recall Mode	Min		None		None	None
Act Effct Green (s)	10.0		14.7			14.7
Actuated g/C Ratio	0.29		0.42			0.42
v/c Ratio	0.27		0.34			0.57
Control Delay	10.6		6.2			9.5
Queue Delay	0.0		0.0			0.0
Total Delay	10.6		6.2			9.5
LOS	B		A			A
Approach Delay	10.6		6.2			9.5
Approach LOS	B		A			A
Queue Length 50th (ft)	17		23			51
Queue Length 95th (ft)	37		48			96
Internal Link Dist (ft)	100		657			589
Turn Bay Length (ft)						
Base Capacity (vph)	1468		2468			2382
Starvation Cap Reductn	0		0			0
Spillback Cap Reductn	0		0			0
Storage Cap Reductn	0		0			0
Reduced v/c Ratio	0.18		0.20			0.33

Intersection Summary	
Area Type: Other	
Cycle Length: 50	
Actuated Cycle Length: 35	
Natural Cycle: 40	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.57	
Intersection Signal Delay: 8.6	Intersection LOS: A
Intersection Capacity Utilization 40.3%	ICU Level of Service A
Analysis Period (min) 15	

Splits and Phases: 13:

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	270	32	26	632	62	25
Satd. Flow (prot)	3270	0	1728	3455	1972	0
Flt Permitted			0.507		0.966	
Satd. Flow (perm)	3270	0	922	3455	1972	0
Satd. Flow (RTOR)	17				20	
Confl. Peds. (#/hr)						1
Peak Hour Factor	0.92	0.92	0.93	0.93	0.87	0.87
Heavy Vehicles (%)	5%	5%	1%	1%	1%	1%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	328	0	28	680	100	0
Turn Type	NA		pm+pt	NA	Prot	
Protected Phases	2		1	6	3	
Permitted Phases			6			
Detector Phase	2		1	6	3	
Switch Phase						
Minimum Initial (s)	40.0		8.0	40.0	8.0	
Minimum Split (s)	46.0		12.0	46.0	13.0	
Total Split (s)	46.0		24.0	70.0	25.0	
Total Split (%)	48.4%		25.3%	73.7%	26.3%	
Yellow Time (s)	4.0		3.0	4.0	3.0	
All-Red Time (s)	2.0		1.0	2.0	2.0	
Lost Time Adjust (s)	0.0		0.0	0.0	0.0	
Total Lost Time (s)	6.0		4.0	6.0	5.0	
Lead/Lag	Lag		Lead			
Lead-Lag Optimize?	Yes		Yes			
Recall Mode	Min		None	None	None	
Act Effct Green (s)	45.0		50.0	49.2	9.4	
Actuated g/C Ratio	0.68		0.76	0.75	0.14	
v/c Ratio	0.15		0.04	0.26	0.33	
Control Delay	6.1		3.0	3.9	25.4	
Queue Delay	0.0		0.0	0.0	0.0	
Total Delay	6.1		3.0	3.9	25.4	
LOS	A		A	A	C	
Approach Delay	6.1			3.9	25.4	
Approach LOS	A			A	C	
Queue Length 50th (ft)	17		2	42	26	
Queue Length 95th (ft)	57		9	74	72	
Internal Link Dist (ft)	1154			331	60	
Turn Bay Length (ft)			200			
Base Capacity (vph)	2244		949	3263	621	
Starvation Cap Reductn	0		0	0	0	
Spillback Cap Reductn	0		0	0	0	
Storage Cap Reductn	0		0	0	0	
Reduced v/c Ratio	0.15		0.03	0.21	0.16	

Intersection Summary
Cycle Length: 95
Actuated Cycle Length: 65.7

Natural Cycle: 75	
Control Type: Semi Act-Uncoord	
Maximum v/c Ratio: 0.33	
Intersection Signal Delay: 6.4	Intersection LOS: A
Intersection Capacity Utilization 49.2%	ICU Level of Service A
Analysis Period (min) 15	

Splits and Phases: 3: Rockland Cir & G W Blvd

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	2	0	5	15	4	16	1	276	12	22	634	5
Satd. Flow (prot)	0	1720	0	0	1621	1432	0	3447	0	0	3564	0
Flt Permitted		0.907						0.954			0.939	
Satd. Flow (perm)	0	1579	0	0	1682	1412	0	3288	0	0	3353	0
Satd. Flow (RTOR)												
Confl. Peds. (#/hr)	1		1	1		1			4	4		
Peak Hour Factor	0.88	0.88	0.88	0.80	0.80	0.80	0.88	0.88	0.88	0.92	0.92	0.92
Heavy Vehicles (%)	10%	10%	10%	9%	9%	9%	4%	4%	4%	1%	1%	1%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	8	0	0	24	20	0	329	0	0	718	0
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	2	2		6	6	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0	4.0	33.0	33.0		33.0	33.0	
Minimum Split (s)	9.0	9.0		9.0	9.0	9.0	38.0	38.0		38.0	38.0	
Total Split (s)	15.0	15.0		15.0	15.0	15.0	38.0	38.0		38.0	38.0	
Total Split (%)	21.4%	21.4%		21.4%	21.4%	21.4%	54.3%	54.3%		54.3%	54.3%	
Yellow Time (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0		3.0	3.0	
All-Red Time (s)	2.0	2.0		2.0	2.0	2.0	2.0	2.0		2.0	2.0	
Lost Time Adjust (s)		0.0			0.0	0.0		0.0			0.0	
Total Lost Time (s)		5.0			5.0	5.0		5.0			5.0	
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	None	None		None	None	None	Min	Min		Min	Min	
Act Effct Green (s)		6.5			6.7	6.7		45.9			45.9	
Actuated g/C Ratio		0.12			0.12	0.12		0.83			0.83	
v/c Ratio		0.04			0.12	0.12		0.12			0.26	
Control Delay		23.7			24.5	24.8		4.3			4.7	
Queue Delay		0.0			0.0	0.0		0.0			0.0	
Total Delay		23.7			24.5	24.8		4.3			4.7	
LOS		C			C	C		A			A	
Approach Delay		23.7			24.6			4.3			4.7	
Approach LOS		C			C			A			A	
Queue Length 50th (ft)		2			7	6		0			0	
Queue Length 95th (ft)		14			26	23		61			141	
Internal Link Dist (ft)		20			82			386			422	
Turn Bay Length (ft)												
Base Capacity (vph)		288			307	258		2723			2777	
Starvation Cap Reductn		0			0	0		0			0	
Spillback Cap Reductn		0			0	0		0			0	
Storage Cap Reductn		0			0	0		0			0	
Reduced v/c Ratio		0.03			0.08	0.08		0.12			0.26	

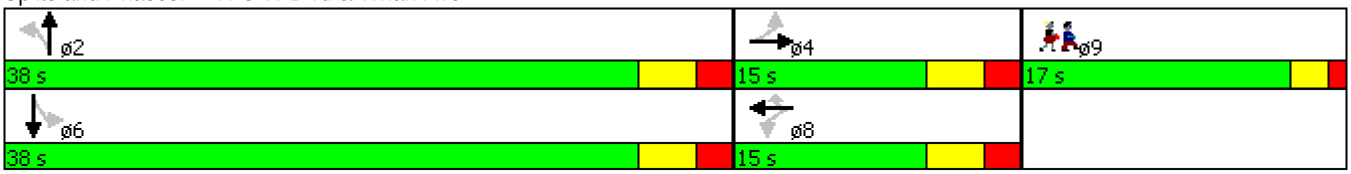
Intersection Summary
Cycle Length: 70
Actuated Cycle Length: 55.4

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Satd. Flow (RTOR)	
Confl. Peds. (#/hr)	
Peak Hour Factor	
Heavy Vehicles (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	17.0
Total Split (s)	17.0
Total Split (%)	24%
Yellow Time (s)	2.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Natural Cycle: 65	
Control Type: Semi Act-Uncoord	
Maximum v/c Ratio: 0.26	
Intersection Signal Delay: 5.5	Intersection LOS: A
Intersection Capacity Utilization 46.7%	ICU Level of Service A
Analysis Period (min) 15	

Splits and Phases: 7: G W Blvd & Wharf Ave



APPENDIX C

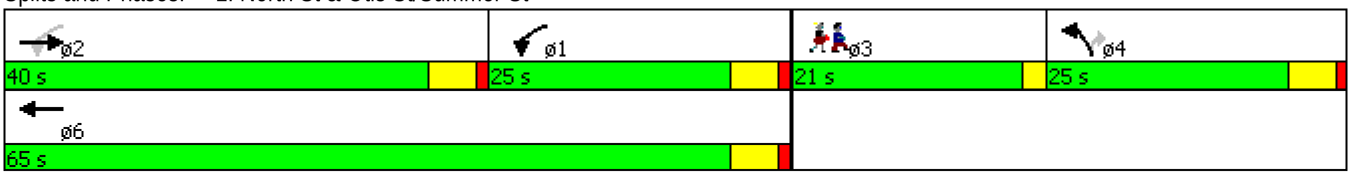
Intersection Capacity Analyses
Weekday PM Peak Hour
2015 Existing Conditions

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø3
Lane Configurations							
Volume (vph)	1137	53	182	617	118	412	
Satd. Flow (prot)	3085	0	0	3045	1608	1439	
Flt Permitted				0.521	0.950		
Satd. Flow (perm)	3085	0	0	1604	1584	1439	
Satd. Flow (RTOR)	4					509	
Confl. Peds. (#/hr)		1	1		9		
Peak Hour Factor	0.95	0.95	0.87	0.87	0.81	0.81	
Heavy Vehicles (%)	1%	1%	2%	2%	1%	1%	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	1253	0	0	918	146	509	
Turn Type	NA		D.P+P	NA	Prot	Perm	
Protected Phases	2		1	6	4		3
Permitted Phases			2			4	
Detector Phase	2		1	6	4	4	
Switch Phase							
Minimum Initial (s)	8.0		4.0	8.0	9.0	9.0	4.0
Minimum Split (s)	13.0		9.0	13.0	14.0	14.0	21.0
Total Split (s)	40.0		25.0	65.0	25.0	25.0	21.0
Total Split (%)	36.0%		22.5%	58.6%	22.5%	22.5%	19%
Yellow Time (s)	4.0		4.0	4.0	4.0	4.0	2.0
All-Red Time (s)	1.0		1.0	1.0	1.0	1.0	0.0
Lost Time Adjust (s)	0.0			0.0	0.0	0.0	
Total Lost Time (s)	5.0			5.0	5.0	5.0	
Lead/Lag	Lead		Lag		Lag	Lag	Lead
Lead-Lag Optimize?	Yes		Yes		Yes	Yes	Yes
Recall Mode	Min		None	Min	None	None	None
Act Effct Green (s)	47.6			47.6	13.6	13.6	
Actuated g/C Ratio	0.64			0.64	0.18	0.18	
v/c Ratio	0.64			1.20dl	0.50	0.75	
Control Delay	11.8			27.4	38.3	11.5	
Queue Delay	0.0			0.0	0.0	0.0	
Total Delay	11.8			27.4	38.3	11.5	
LOS	B			C	D	B	
Approach Delay	11.8			27.4	17.5		
Approach LOS	B			C	B		
Queue Length 50th (ft)	128			131	55	0	
Queue Length 95th (ft)	435			#479	143	46	
Internal Link Dist (ft)	764			218	85		
Turn Bay Length (ft)							
Base Capacity (vph)	1963			1324	462	776	
Starvation Cap Reductn	0			0	0	0	
Spillback Cap Reductn	0			0	0	0	
Storage Cap Reductn	0			0	0	0	
Reduced v/c Ratio	0.64			0.69	0.32	0.66	

Intersection Summary
Cycle Length: 111
Actuated Cycle Length: 74.8

Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.90
Intersection Signal Delay: 18.2 Intersection LOS: B
Intersection Capacity Utilization 81.6% ICU Level of Service D
Analysis Period (min) 15
\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 1: North St & Otis St/Summer St



Intersection	
Intersection Delay, s/veh	22.6
Intersection LOS	C

Approach	EB	WB	NB	NW
Entry Lanes	2	2	1	1
Conflicting Circle Lanes	2	2	2	2
Adj Approach Flow, veh/h	1824	720	14	508
Demand Flow Rate, veh/h	1842	734	14	519
Vehicles Circulating, veh/h	55	494	1875	900
Vehicles Exiting, veh/h	1173	925	22	989
Follow-Up Headway, s	3.186	3.186	3.186	3.186
Ped Vol Crossing Leg, #/h	0	0	0	0
Ped Cap Adj	1.000	1.000	1.000	1.000
Approach Delay, s/veh	23.3	11.0	12.6	37.2
Approach LOS	C	B	B	E

Lane	Left	Right	Left	Right	Left	Left
Designated Moves	LT	TR	LT	TR	LR	LR
Assumed Moves	LT	R	LT	TR	LR	LR
RT Channelized						
Lane Util	0.481	0.519	0.470	0.530	1.000	1.000
Critical Headway, s	4.293	4.113	4.293	4.113	4.113	4.113
Entry Flow, veh/h	886	956	345	389	14	519
Cap Entry Lane, veh/h	1084	1087	780	800	304	602
Entry HV Adj Factor	0.990	0.991	0.981	0.981	1.000	0.979
Flow Entry, veh/h	877	947	338	382	14	508
Cap Entry, veh/h	1074	1077	765	784	304	589
V/C Ratio	0.817	0.879	0.442	0.486	0.046	0.862
Control Delay, s/veh	20.4	26.0	10.6	11.3	12.6	37.2
LOS	C	D	B	B	B	E
95th %tile Queue, veh	10	12	2	3	0	10

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	58	745	24	110	474	8	15	29	85	7	23	30
Satd. Flow (prot)	1728	3435	0	1694	3378	0	0	1831	1583	0	2026	1743
Flt Permitted	0.433			0.229				0.888			0.926	
Satd. Flow (perm)	787	3435	0	408	3378	0	0	1654	1562	0	1898	1743
Satd. Flow (RTOR)												
Confl. Peds. (#/hr)			2	2					1	1		
Peak Hour Factor	0.91	0.91	0.91	0.83	0.83	0.83	0.75	0.75	0.75	0.88	0.88	0.88
Heavy Vehicles (%)	1%	1%	1%	3%	3%	3%	2%	2%	2%	5%	5%	5%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	64	845	0	133	581	0	0	59	113	0	34	34
Turn Type	pm+pt	NA		pm+pt	NA		Perm	NA	Perm	Perm	NA	Perm
Protected Phases	5	2		1	6			3			3	
Permitted Phases	2			6			3		3	3		3
Detector Phase	5	2		1	6		3	3	3	3	3	3
Switch Phase												
Minimum Initial (s)	4.0	15.0		4.0	15.0		8.0	8.0	8.0	8.0	8.0	8.0
Minimum Split (s)	8.0	20.0		8.0	20.0		13.0	13.0	13.0	13.0	13.0	13.0
Total Split (s)	14.0	55.0		14.0	55.0		25.0	25.0	25.0	25.0	25.0	25.0
Total Split (%)	12.0%	47.0%		12.0%	47.0%		21.4%	21.4%	21.4%	21.4%	21.4%	21.4%
Yellow Time (s)	3.0	4.0		3.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0
Lost Time Adjust (s)	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Lost Time (s)	4.0	5.0		4.0	5.0			5.0	5.0		5.0	5.0
Lead/Lag	Lead	Lag		Lead	Lag							
Lead-Lag Optimize?	Yes	Yes		Yes	Yes							
Recall Mode	None	Min		Min	Min		None	None	None	None	None	None
Act Effct Green (s)	34.8	26.9		38.7	35.6			12.9	12.9		12.9	12.9
Actuated g/C Ratio	0.57	0.44		0.63	0.58			0.21	0.21		0.21	0.21
v/c Ratio	0.12	0.56		0.32	0.30			0.17	0.34		0.09	0.09
Control Delay	8.1	17.0		9.7	12.8			28.5	30.8		28.0	28.2
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Delay	8.1	17.0		9.7	12.8			28.5	30.8		28.0	28.2
LOS	A	B		A	B			C	C		C	C
Approach Delay		16.4			12.3			30.0			28.1	
Approach LOS		B			B			C			C	
Queue Length 50th (ft)	6	104		14	63			16	32		9	9
Queue Length 95th (ft)	43	317		72	181			62	105		48	48
Internal Link Dist (ft)		378			358			249			637	
Turn Bay Length (ft)	150			150					50			75
Base Capacity (vph)	693	2867		518	2820			646	610		741	681
Starvation Cap Reductn	0	0		0	0			0	0		0	0
Spillback Cap Reductn	0	0		0	0			0	0		0	0
Storage Cap Reductn	0	0		0	0			0	0		0	0
Reduced v/c Ratio	0.09	0.29		0.26	0.21			0.09	0.19		0.05	0.05

Intersection Summary
Cycle Length: 117
Actuated Cycle Length: 61.2

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Satd. Flow (RTOR)	
Confl. Peds. (#/hr)	
Peak Hour Factor	
Heavy Vehicles (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	20%
Yellow Time (s)	2.0
All-Red Time (s)	0.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Natural Cycle: 65	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.56	
Intersection Signal Delay: 16.5	Intersection LOS: B
Intersection Capacity Utilization 48.1%	ICU Level of Service A
Analysis Period (min) 15	

Splits and Phases: 4: Summer St & Rockland St & Martins Ln

Lane Group	WBL	WBR	NET	NER	SWL	SWT
Lane Configurations						
Volume (vph)	106	23	665	177	18	481
Satd. Flow (prot)	3173	0	3312	0	0	3414
Flt Permitted	0.961					0.906
Satd. Flow (perm)	3173	0	3312	0	0	3100
Satd. Flow (RTOR)	27		96			
Peak Hour Factor	0.85	0.85	0.90	0.90	0.83	0.83
Heavy Vehicles (%)	5%	5%	2%	2%	2%	2%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	152	0	936	0	0	602
Turn Type	Prot		NA		Perm	NA
Protected Phases	3		2			6
Permitted Phases					6	
Detector Phase	3		2		6	6
Switch Phase						
Minimum Initial (s)	7.0		7.0		7.0	7.0
Minimum Split (s)	12.0		12.0		12.0	12.0
Total Split (s)	20.0		30.0		30.0	30.0
Total Split (%)	40.0%		60.0%		60.0%	60.0%
Yellow Time (s)	4.0		4.0		4.0	4.0
All-Red Time (s)	1.0		1.0		1.0	1.0
Lost Time Adjust (s)	0.0		0.0			0.0
Total Lost Time (s)	5.0		5.0			5.0
Lead/Lag						
Lead-Lag Optimize?						
Recall Mode	Min		None		None	None
Act Effct Green (s)	9.0		16.3			16.3
Actuated g/C Ratio	0.25		0.46			0.46
v/c Ratio	0.19		0.60			0.42
Control Delay	11.0		8.0			7.3
Queue Delay	0.0		0.0			0.0
Total Delay	11.0		8.0			7.3
LOS	B		A			A
Approach Delay	11.0		8.0			7.3
Approach LOS	B		A			A
Queue Length 50th (ft)	9		52			34
Queue Length 95th (ft)	28		96			58
Internal Link Dist (ft)	100		657			589
Turn Bay Length (ft)						
Base Capacity (vph)	1390		2419			2240
Starvation Cap Reductn	0		0			0
Spillback Cap Reductn	0		0			0
Storage Cap Reductn	0		0			0
Reduced v/c Ratio	0.11		0.39			0.27

Intersection Summary
Cycle Length: 50
Actuated Cycle Length: 35.6
Natural Cycle: 40

Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.60
Intersection Signal Delay: 8.0 Intersection LOS: A
Intersection Capacity Utilization 40.6% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 13:

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	595	83	34	402	50	22
Satd. Flow (prot)	3393	0	1728	3455	1975	0
Flt Permitted			0.322		0.967	
Satd. Flow (perm)	3393	0	586	3455	1975	0
Satd. Flow (RTOR)	20				22	
Peak Hour Factor	0.89	0.89	0.92	0.92	0.72	0.72
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	762	0	37	437	100	0
Turn Type	NA		pm+pt	NA	Prot	
Protected Phases	2		1	6	3	
Permitted Phases			6			
Detector Phase	2		1	6	3	
Switch Phase						
Minimum Initial (s)	40.0		8.0	40.0	8.0	
Minimum Split (s)	46.0		12.0	46.0	13.0	
Total Split (s)	46.0		24.0	70.0	25.0	
Total Split (%)	48.4%		25.3%	73.7%	26.3%	
Yellow Time (s)	4.0		3.0	4.0	3.0	
All-Red Time (s)	2.0		1.0	2.0	2.0	
Lost Time Adjust (s)	0.0		0.0	0.0	0.0	
Total Lost Time (s)	6.0		4.0	6.0	5.0	
Lead/Lag	Lag		Lead			
Lead-Lag Optimize?	Yes		Yes			
Recall Mode	Min		None	None	None	
Act Effct Green (s)	45.0		50.0	49.2	9.5	
Actuated g/C Ratio	0.68		0.76	0.75	0.14	
v/c Ratio	0.33		0.06	0.17	0.33	
Control Delay	7.2		3.1	3.6	24.8	
Queue Delay	0.0		0.0	0.0	0.0	
Total Delay	7.2		3.1	3.6	24.8	
LOS	A		A	A	C	
Approach Delay	7.2			3.6	24.8	
Approach LOS	A			A	C	
Queue Length 50th (ft)	49		3	26	25	
Queue Length 95th (ft)	138		11	46	56	
Internal Link Dist (ft)	1154			331	60	
Turn Bay Length (ft)			200			
Base Capacity (vph)	2326		796	3263	622	
Starvation Cap Reductn	0		0	0	0	
Spillback Cap Reductn	0		0	0	0	
Storage Cap Reductn	0		0	0	0	
Reduced v/c Ratio	0.33		0.05	0.13	0.16	

Intersection Summary
Cycle Length: 95
Actuated Cycle Length: 65.8
Natural Cycle: 75

Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.33
Intersection Signal Delay: 7.2 Intersection LOS: A
Intersection Capacity Utilization 49.2% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 3: Rockland Cir & G W Blvd

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	13	6	7	35	2	15	5	593	13	17	402	10
Satd. Flow (prot)	0	1920	0	0	1609	1432	0	3459	0	0	3553	0
Flt Permitted		0.815			0.762			0.953			0.925	
Satd. Flow (perm)	0	1602	0	0	1282	1412	0	3297	0	0	3293	0
Satd. Flow (RTOR)												
Confl. Peds. (#/hr)	1		1	1		1			2	2		
Peak Hour Factor	0.65	0.65	0.65	0.72	0.72	0.72	0.92	0.92	0.92	0.95	0.95	0.95
Heavy Vehicles (%)	5%	5%	5%	9%	9%	9%	4%	4%	4%	1%	1%	1%
Parking (#/hr)										0		
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	40	0	0	52	21	0	664	0	0	452	0
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	2	2		6	6	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0	4.0	33.0	33.0		33.0	33.0	
Minimum Split (s)	9.0	9.0		9.0	9.0	9.0	38.0	38.0		38.0	38.0	
Total Split (s)	15.0	15.0		15.0	15.0	15.0	38.0	38.0		38.0	38.0	
Total Split (%)	21.4%	21.4%		21.4%	21.4%	21.4%	54.3%	54.3%		54.3%	54.3%	
Yellow Time (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0		3.0	3.0	
All-Red Time (s)	2.0	2.0		2.0	2.0	2.0	2.0	2.0		2.0	2.0	
Lost Time Adjust (s)		0.0			0.0	0.0		0.0			0.0	
Total Lost Time (s)		5.0			5.0	5.0		5.0			5.0	
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	None	None		None	None	None	Min	Min		Min	Min	
Act Effct Green (s)		7.5			7.6	7.6		41.8			41.8	
Actuated g/C Ratio		0.13			0.14	0.14		0.75			0.75	
v/c Ratio		0.19			0.30	0.11		0.27			0.18	
Control Delay		24.6			27.4	23.8		5.8			5.4	
Queue Delay		0.0			0.0	0.0		0.0			0.0	
Total Delay		24.6			27.4	23.8		5.8			5.4	
LOS		C			C	C		A			A	
Approach Delay		24.6			26.4			5.8			5.4	
Approach LOS		C			C			A			A	
Queue Length 50th (ft)		11			14	6		35			22	
Queue Length 95th (ft)		30			40	21		134			88	
Internal Link Dist (ft)		20			82			386			422	
Turn Bay Length (ft)												
Base Capacity (vph)		292			233	257		2481			2478	
Starvation Cap Reductn		0			0	0		0			0	
Spillback Cap Reductn		0			0	0		0			0	
Storage Cap Reductn		0			0	0		0			0	
Reduced v/c Ratio		0.14			0.22	0.08		0.27			0.18	

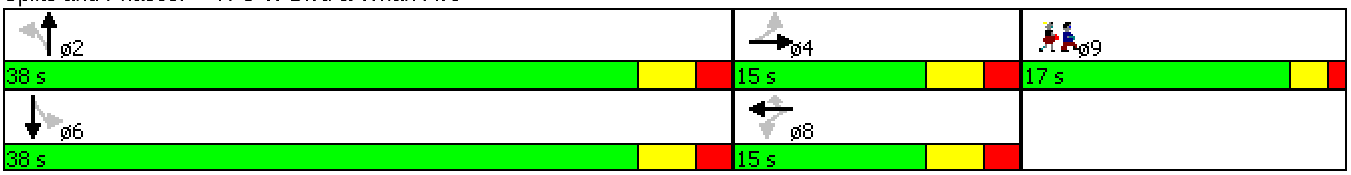
Intersection Summary
Cycle Length: 70

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Satd. Flow (RTOR)	
Confl. Peds. (#/hr)	
Peak Hour Factor	
Heavy Vehicles (%)	
Parking (#/hr)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	17.0
Total Split (s)	17.0
Total Split (%)	24%
Yellow Time (s)	2.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Actuated Cycle Length: 55.6
Natural Cycle: 65
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.30
Intersection Signal Delay: 7.5 Intersection LOS: A
Intersection Capacity Utilization 46.7% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 7: G W Blvd & Wharf Ave



APPENDIX D

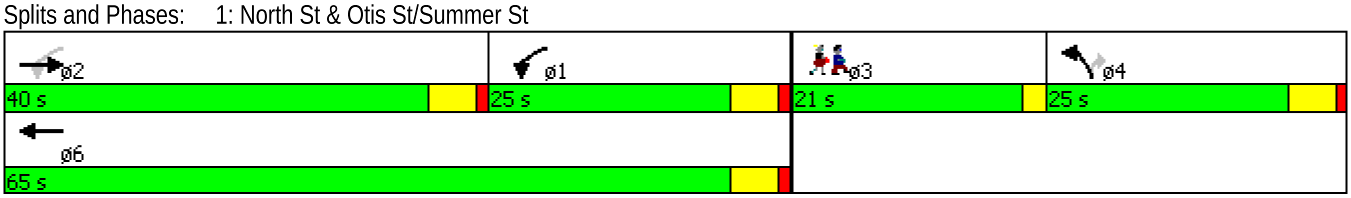
Intersection Capacity Analyses
Summer Saturday Midday Peak Hour
2015 Existing Conditions

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø3
Lane Configurations							
Volume (vph)	1261	67	184	777	200	567	
Satd. Flow (prot)	3080	0	0	2899	1608	1439	
Flt Permitted				0.502	0.950		
Satd. Flow (perm)	3080	0	0	1468	1477	1380	
Satd. Flow (RTOR)	5					576	
Confl. Peds. (#/hr)		7	7		49	18	
Peak Hour Factor	0.94	0.94	0.93	0.93	0.94	0.94	
Heavy Vehicles (%)	1%	1%	2%	2%	1%	1%	
Parking (#/hr)				0			
Shared Lane Traffic (%)							
Lane Group Flow (vph)	1412	0	0	1033	213	603	
Turn Type	NA		D.P+P	NA	Prot	Perm	
Protected Phases	2		1	6	4		3
Permitted Phases			2			4	
Detector Phase	2		1	6	4	4	
Switch Phase							
Minimum Initial (s)	8.0		4.0	8.0	9.0	9.0	4.0
Minimum Split (s)	13.0		9.0	13.0	14.0	14.0	21.0
Total Split (s)	40.0		25.0	65.0	25.0	25.0	21.0
Total Split (%)	36.0%		22.5%	58.6%	22.5%	22.5%	19%
Yellow Time (s)	4.0		4.0	4.0	4.0	4.0	2.0
All-Red Time (s)	1.0		1.0	1.0	1.0	1.0	0.0
Lost Time Adjust (s)	0.0			0.0	0.0	0.0	
Total Lost Time (s)	5.0			5.0	5.0	5.0	
Lead/Lag	Lead		Lag		Lag	Lag	Lead
Lead-Lag Optimize?	Yes		Yes		Yes	Yes	Yes
Recall Mode	Min		None	Min	None	None	None
Act Effct Green (s)	59.6			59.6	16.7	16.7	
Actuated g/C Ratio	0.64			0.64	0.18	0.18	
v/c Ratio	0.72			1.69dl	0.74	0.84	
Control Delay	17.1			83.9	55.6	16.5	
Queue Delay	0.0			0.0	0.0	0.0	
Total Delay	17.1			83.9	55.6	16.5	
LOS	B			F	E	B	
Approach Delay	17.1			83.9	26.7		
Approach LOS	B			F	C		
Queue Length 50th (ft)	210			~327	109	12	
Queue Length 95th (ft)	537			#629	#253	#216	
Internal Link Dist (ft)	764			218	85		
Turn Bay Length (ft)							
Base Capacity (vph)	1962			965	352	752	
Starvation Cap Reductn	0			0	0	0	
Spillback Cap Reductn	0			0	0	0	
Storage Cap Reductn	0			0	0	0	
Reduced v/c Ratio	0.72			1.07	0.61	0.80	

Intersection Summary
Cycle Length: 111

Actuated Cycle Length: 93.6
Natural Cycle: 130
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.11
Intersection Signal Delay: 40.6 Intersection LOS: D
Intersection Capacity Utilization 95.7% ICU Level of Service F
Analysis Period (min) 15
~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 1: North St & Otis St/Summer St



Intersection	
Intersection Delay, s/veh	42.2
Intersection LOS	E

Approach	EB	WB	NB	NW
Entry Lanes	2	2	1	1
Conflicting Circle Lanes	2	2	2	2
Adj Approach Flow, veh/h	1998	855	8	460
Demand Flow Rate, veh/h	2018	863	8	465
Vehicles Circulating, veh/h	56	465	2020	1485
Vehicles Exiting, veh/h	1272	1485	54	543
Follow-Up Headway, s	3.186	3.186	3.186	3.186
Ped Vol Crossing Leg, #/h	0	0	0	0
Ped Cap Adj	1.000	1.000	1.000	1.000
Approach Delay, s/veh	35.1	12.3	13.6	129.2
Approach LOS	E	B	B	F

Lane	Left	Right	Left	Right	Left	Left
Designated Moves	LT	TR	LT	TR	LR	LR
Assumed Moves	LT	TR	LT	TR	LR	LR
RT Channelized						
Lane Util	0.470	0.530	0.470	0.530	1.000	1.000
Critical Headway, s	4.293	4.113	4.293	4.113	4.113	4.113
Entry Flow, veh/h	948	1070	406	457	8	465
Cap Entry Lane, veh/h	1083	1087	797	816	275	400
Entry HV Adj Factor	0.991	0.990	0.990	0.991	1.000	0.989
Flow Entry, veh/h	939	1059	402	453	8	460
Cap Entry, veh/h	1073	1075	789	809	275	395
V/C Ratio	0.875	0.985	0.509	0.560	0.029	1.164
Control Delay, s/veh	25.6	43.5	11.7	12.8	13.6	129.2
LOS	D	E	B	B	B	F
95th %tile Queue, veh	12	19	3	4	0	18

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	55	1344	25	112	693	7	17	28	104	7	25	22
Satd. Flow (prot)	1728	3443	0	1728	3448	0	0	1864	1615	0	2088	1794
Flt Permitted	0.328			0.093				0.888			0.940	
Satd. Flow (perm)	596	3443	0	169	3448	0	0	1687	1593	0	1984	1794
Satd. Flow (RTOR)												
Confl. Peds. (#/hr)			2	2					1	1		
Peak Hour Factor	0.95	0.95	0.95	0.89	0.89	0.89	0.85	0.85	0.85	0.90	0.90	0.90
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	0%	0%	0%	2%	2%	2%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	58	1441	0	126	787	0	0	53	122	0	36	24
Turn Type	pm+pt	NA		pm+pt	NA		Perm	NA	Perm	Perm	NA	Perm
Protected Phases	5	2		1	6			3			3	
Permitted Phases	2			6			3		3	3		3
Detector Phase	5	2		1	6		3	3	3	3	3	3
Switch Phase												
Minimum Initial (s)	4.0	15.0		4.0	15.0		8.0	8.0	8.0	8.0	8.0	8.0
Minimum Split (s)	8.0	20.0		8.0	20.0		13.0	13.0	13.0	13.0	13.0	13.0
Total Split (s)	14.0	55.0		14.0	55.0		25.0	25.0	25.0	25.0	25.0	25.0
Total Split (%)	12.0%	47.0%		12.0%	47.0%		21.4%	21.4%	21.4%	21.4%	21.4%	21.4%
Yellow Time (s)	3.0	4.0		3.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0
Lost Time Adjust (s)	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Lost Time (s)	4.0	5.0		4.0	5.0			5.0	5.0		5.0	5.0
Lead/Lag	Lead	Lag		Lead	Lag							
Lead-Lag Optimize?	Yes	Yes		Yes	Yes							
Recall Mode	None	Min		Min	Min		None	None	None	None	None	None
Act Effct Green (s)	55.6	48.8		58.8	52.2			13.1	13.1		13.1	13.1
Actuated g/C Ratio	0.64	0.56		0.68	0.60			0.15	0.15		0.15	0.15
v/c Ratio	0.13	0.74		0.53	0.38			0.21	0.51		0.12	0.09
Control Delay	7.5	20.0		18.1	12.4			37.6	44.4		36.1	36.0
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Delay	7.5	20.0		18.1	12.4			37.6	44.4		36.1	36.0
LOS	A	B		B	B			D	D		D	D
Approach Delay		19.5			13.2			42.3			36.1	
Approach LOS		B			B			D			D	
Queue Length 50th (ft)	7	245		15	96			24	59		16	11
Queue Length 95th (ft)	39	#721		91	274			68	136		54	41
Internal Link Dist (ft)		378			358			249			637	
Turn Bay Length (ft)	150			150					50			75
Base Capacity (vph)	546	2052		303	2092			402	379		473	427
Starvation Cap Reductn	0	0		0	0			0	0		0	0
Spillback Cap Reductn	0	0		0	0			0	0		0	0
Storage Cap Reductn	0	0		0	0			0	0		0	0
Reduced v/c Ratio	0.11	0.70		0.42	0.38			0.13	0.32		0.08	0.06

Intersection Summary

Cycle Length: 117

Actuated Cycle Length: 86.7

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Satd. Flow (RTOR)	
Confl. Peds. (#/hr)	
Peak Hour Factor	
Heavy Vehicles (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	20%
Yellow Time (s)	2.0
All-Red Time (s)	0.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Natural Cycle: 90	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.74	
Intersection Signal Delay: 19.2	Intersection LOS: B
Intersection Capacity Utilization 64.9%	ICU Level of Service C
Analysis Period (min) 15	

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 4: Summer St & Rockland St & Martins Ln

Lane Group	WBL	WBR	NET	NER	SWL	SWT
Lane Configurations						
Volume (vph)	26	129	1223	202	23	718
Satd. Flow (prot)	3062	0	3383	0	0	3448
Flt Permitted	0.992					0.877
Satd. Flow (perm)	3062	0	3383	0	0	3030
Satd. Flow (RTOR)	30		53			
Peak Hour Factor	0.88	0.88	0.92	0.92	0.88	0.88
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	177	0	1549	0	0	842
Turn Type	Prot		NA		Perm	NA
Protected Phases	3		2			6
Permitted Phases					6	
Detector Phase	3		2		6	6
Switch Phase						
Minimum Initial (s)	7.0		7.0		7.0	7.0
Minimum Split (s)	12.0		12.0		12.0	12.0
Total Split (s)	20.0		30.0		30.0	30.0
Total Split (%)	40.0%		60.0%		60.0%	60.0%
Yellow Time (s)	4.0		4.0		4.0	4.0
All-Red Time (s)	1.0		1.0		1.0	1.0
Lost Time Adjust (s)	0.0		0.0			0.0
Total Lost Time (s)	5.0		5.0			5.0
Lead/Lag						
Lead-Lag Optimize?						
Recall Mode	Min		None		None	None
Act Effct Green (s)	9.4		24.4			24.4
Actuated g/C Ratio	0.21		0.56			0.56
v/c Ratio	0.26		0.81			0.50
Control Delay	13.2		12.9			7.5
Queue Delay	0.0		0.0			0.0
Total Delay	13.2		12.9			7.5
LOS	B		B			A
Approach Delay	13.2		12.9			7.5
Approach LOS	B		B			A
Queue Length 50th (ft)	15		133			56
Queue Length 95th (ft)	34		#260			98
Internal Link Dist (ft)	100		657			589
Turn Bay Length (ft)						
Base Capacity (vph)	1072		1960			1735
Starvation Cap Reductn	0		0			0
Spillback Cap Reductn	0		0			0
Storage Cap Reductn	0		0			0
Reduced v/c Ratio	0.17		0.79			0.49

Intersection Summary
Cycle Length: 50
Actuated Cycle Length: 43.8
Natural Cycle: 40

Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.81	
Intersection Signal Delay: 11.1	Intersection LOS: B
Intersection Capacity Utilization 54.4%	ICU Level of Service A
Analysis Period (min) 15	

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 13:

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Volume (vph)	1170	100	25	675	60	25
Satd. Flow (prot)	3410	0	1728	3455	1977	0
Flt Permitted			0.157		0.966	
Satd. Flow (perm)	3410	0	286	3455	1977	0
Satd. Flow (RTOR)	13				20	
Peak Hour Factor	1.00	0.92	0.92	0.92	0.92	0.92
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%
Shared Lane Traffic (%)						
Lane Group Flow (vph)	1279	0	27	734	92	0
Turn Type	NA		pm+pt	NA	Prot	
Protected Phases	2		1	6	3	
Permitted Phases			6			
Detector Phase	2		1	6	3	
Switch Phase						
Minimum Initial (s)	40.0		8.0	40.0	8.0	
Minimum Split (s)	46.0		12.0	46.0	13.0	
Total Split (s)	46.0		24.0	70.0	25.0	
Total Split (%)	48.4%		25.3%	73.7%	26.3%	
Yellow Time (s)	4.0		3.0	4.0	3.0	
All-Red Time (s)	2.0		1.0	2.0	2.0	
Lost Time Adjust (s)	0.0		0.0	0.0	0.0	
Total Lost Time (s)	6.0		4.0	6.0	5.0	
Lead/Lag	Lag		Lead			
Lead-Lag Optimize?	Yes		Yes			
Recall Mode	Min		None	None	None	
Act Effct Green (s)	45.0		49.9	49.2	9.2	
Actuated g/C Ratio	0.69		0.76	0.75	0.14	
v/c Ratio	0.55		0.07	0.28	0.31	
Control Delay	9.3		3.1	3.9	24.9	
Queue Delay	0.0		0.0	0.0	0.0	
Total Delay	9.3		3.1	3.9	24.9	
LOS	A		A	A	C	
Approach Delay	9.3			3.9	24.9	
Approach LOS	A			A	C	
Queue Length 50th (ft)	99		2	45	23	
Queue Length 95th (ft)	285		8	79	69	
Internal Link Dist (ft)	1154			331	60	
Turn Bay Length (ft)			200			
Base Capacity (vph)	2344		663	3269	624	
Starvation Cap Reductn	0		0	0	0	
Spillback Cap Reductn	0		0	0	0	
Storage Cap Reductn	0		0	0	0	
Reduced v/c Ratio	0.55		0.04	0.22	0.15	

Intersection Summary
Cycle Length: 95
Actuated Cycle Length: 65.5
Natural Cycle: 75

Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.55
Intersection Signal Delay: 8.1 Intersection LOS: A
Intersection Capacity Utilization 51.4% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 3: Rockland Cir & G W Blvd

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	10	29	138	6	32	18	910	262	23	639	17
Satd. Flow (prot)	0	1709	0	0	1735	1546	0	3431	0	0	3549	0
Flt Permitted		0.912			0.688			0.940			0.889	
Satd. Flow (perm)	0	1567	0	0	1125	1476	0	3228	0	0	3161	0
Satd. Flow (RTOR)												
Confl. Peds. (#/hr)	16		55	55		16	22		9	9		22
Peak Hour Factor	0.75	0.75	0.75	0.88	0.88	0.88	0.95	0.95	0.95	0.91	0.91	0.91
Heavy Vehicles (%)	6%	6%	6%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Parking (#/hr)										0		
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	65	0	0	164	36	0	1253	0	0	746	0
Turn Type	Perm	NA		Perm	NA	Perm	Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8		8	2			6		
Detector Phase	4	4		8	8	8	2	2		6	6	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0	4.0	33.0	33.0		33.0	33.0	
Minimum Split (s)	9.0	9.0		9.0	9.0	9.0	38.0	38.0		38.0	38.0	
Total Split (s)	15.0	15.0		15.0	15.0	15.0	38.0	38.0		38.0	38.0	
Total Split (%)	21.4%	21.4%		21.4%	21.4%	21.4%	54.3%	54.3%		54.3%	54.3%	
Yellow Time (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0		3.0	3.0	
All-Red Time (s)	2.0	2.0		2.0	2.0	2.0	2.0	2.0		2.0	2.0	
Lost Time Adjust (s)		0.0			0.0	0.0		0.0			0.0	
Total Lost Time (s)		5.0			5.0	5.0		5.0			5.0	
Lead/Lag												
Lead-Lag Optimize?												
Recall Mode	None	None		None	None	None	Min	Min		Min	Min	
Act Effct Green (s)		10.2			10.2	10.2		36.3			36.3	
Actuated g/C Ratio		0.16			0.16	0.16		0.58			0.58	
v/c Ratio		0.26			0.90	0.15		0.67			0.41	
Control Delay		27.4			77.9	26.3		13.6			9.8	
Queue Delay		0.0			0.0	0.0		0.0			0.0	
Total Delay		27.4			77.9	26.3		13.6			9.8	
LOS		C			E	C		B			A	
Approach Delay		27.4			68.6			13.6			9.8	
Approach LOS		C			E			B			A	
Queue Length 50th (ft)		18			49	10		104			50	
Queue Length 95th (ft)		49			#180	38		318			156	
Internal Link Dist (ft)		20			82			386			422	
Turn Bay Length (ft)												
Base Capacity (vph)		253			182	239		1868			1829	
Starvation Cap Reductn		0			0	0		0			0	
Spillback Cap Reductn		0			0	0		0			0	
Storage Cap Reductn		0			0	0		0			0	
Reduced v/c Ratio		0.26			0.90	0.15		0.67			0.41	

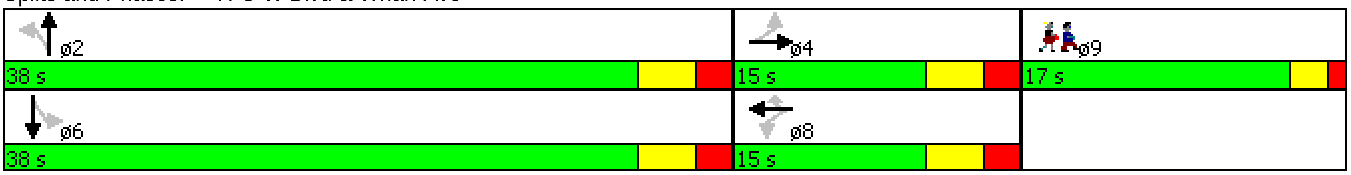
Intersection Summary
Cycle Length: 70

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Satd. Flow (RTOR)	
Confl. Peds. (#/hr)	
Peak Hour Factor	
Heavy Vehicles (%)	
Parking (#/hr)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	17.0
Total Split (s)	17.0
Total Split (%)	24%
Yellow Time (s)	2.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Actuated Cycle Length: 62.8
Natural Cycle: 70
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.90
Intersection Signal Delay: 17.6 Intersection LOS: B
Intersection Capacity Utilization 69.8% ICU Level of Service C
Analysis Period (min) 15
\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 7: G W Blvd & Wharf Ave



Lane Group	WBL	WBR	NBT	NBR	SBL	SBT	ø3
Lane Configurations							
Volume (vph)	132	98	832	177	76	1212	
Satd. Flow (prot)	1665	0	3365	0	0	3445	
Flt Permitted	0.972					0.743	
Satd. Flow (perm)	1660	0	3365	0	0	2567	
Satd. Flow (RTOR)			33				
Confl. Peds. (#/hr)	4						
Peak Hour Factor	0.91	0.91	0.89	0.89	0.95	0.95	
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	253	0	1134	0	0	1356	
Turn Type	Prot		NA		Perm	NA	
Protected Phases	4		2			6	3
Permitted Phases					6		
Detector Phase	4		2		6	6	
Switch Phase							
Minimum Initial (s)	4.0		40.0		40.0	40.0	4.0
Minimum Split (s)	13.0		45.0		45.0	45.0	25.0
Total Split (s)	25.0		45.0		45.0	45.0	25.0
Total Split (%)	26.3%		47.4%		47.4%	47.4%	26%
Yellow Time (s)	4.0		4.0		4.0	4.0	4.0
All-Red Time (s)	1.0		1.0		1.0	1.0	1.0
Lost Time Adjust (s)	0.0		0.0			0.0	
Total Lost Time (s)	5.0		5.0			5.0	
Lead/Lag	Lag						Lead
Lead-Lag Optimize?	Yes						Yes
Recall Mode	None		Max		Max	Max	None
Act Effct Green (s)	16.1		41.0			41.0	
Actuated g/C Ratio	0.23		0.58			0.58	
v/c Ratio	0.67		0.58			0.92	
Control Delay	36.6		13.2			27.8	
Queue Delay	0.0		0.0			0.0	
Total Delay	36.6		13.2			27.8	
LOS	D		B			C	
Approach Delay	36.6		13.2			27.8	
Approach LOS	D		B			C	
Queue Length 50th (ft)	91		122			213	
Queue Length 95th (ft)	#250		375			#675	
Internal Link Dist (ft)	1		775			511	
Turn Bay Length (ft)							
Base Capacity (vph)	480		1954			1480	
Starvation Cap Reductn	0		0			0	
Spillback Cap Reductn	0		0			0	
Storage Cap Reductn	0		0			0	
Reduced v/c Ratio	0.53		0.58			0.92	

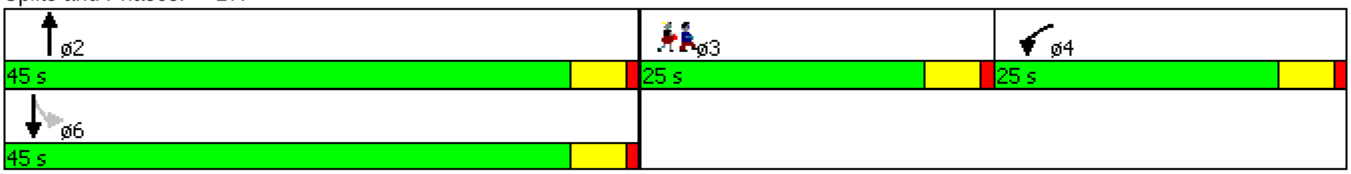
Intersection Summary
Cycle Length: 95
Actuated Cycle Length: 71.1

Natural Cycle: 125
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 0.92

Intersection Signal Delay: 22.6	Intersection LOS: C
Intersection Capacity Utilization 94.9%	ICU Level of Service F

Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 17:



APPENDIX E

Segment Crash Rate Worksheets

massDOT Highway

SEGMENT CRASH RATE WORKSHEET

CITY/TOWN : Hingham COUNT DATE : NA (2012)

DISTRICT : 5

~ SEGMENT DATA ~

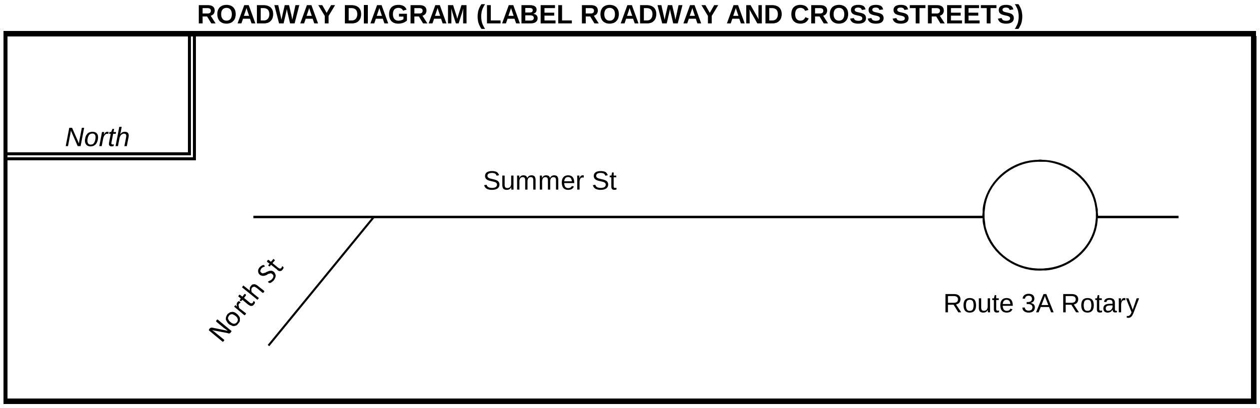
ROADWAY NAME: Summer Street between North Street and Route 3A Rotary

START POINT: West of North Street

END POINT: East of Route 3A Rotary

FUNCTIONAL CLASSIFICATION OF ROADWAY: Urban Principal Arterial - Other

ROADWAY DIAGRAM (LABEL ROADWAY AND CROSS STREETS)



AVERAGE DAILY TRAFFIC

SEGMENT LENGTH IN MILES (**L**):	**0.26**
AVERAGE DAILY TRAFFIC VOLUME (**V**):	26,000

TOTAL # OF CRASHES:	105	# OF YEARS :	5	AVERAGE # OF CRASHES PER YEAR (**A**) :	**21.00**

CRASH RATE CALCULATION : **8.51**

$$\text{RATE} = \frac{(A * 1{,}000{,}000)}{(L * V * 365)}$$

Comments : 2012 State Average for Urban Principal Arterial (Other) = 3.35

Project Title & Date: Summer St/G.W.Blvd Subregioanl Roadway Study

SEGMENT CRASH RATE WORKSHEET

CITY/TOWN : Hingham-Hull COUNT DATE : NA (2012)

DISTRICT : 5

~ SEGMENT DATA ~

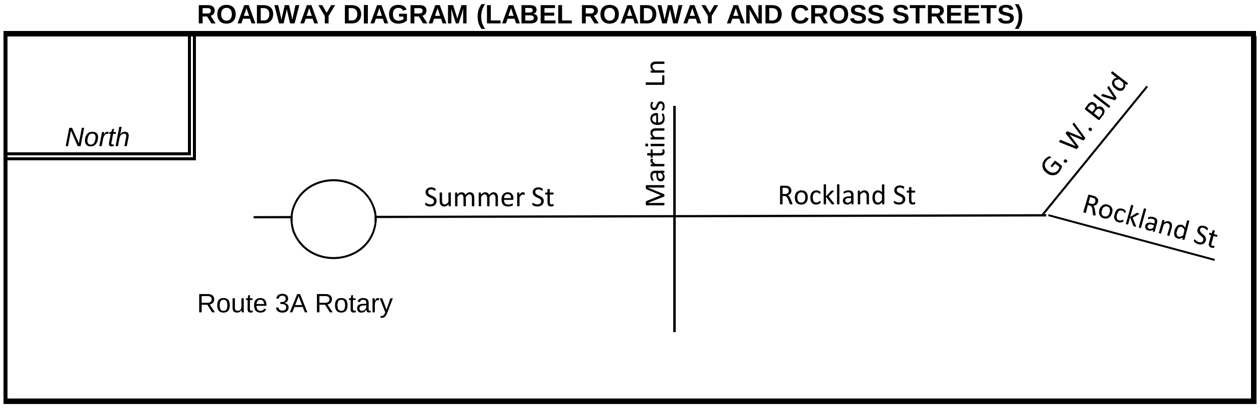
ROADWAY NAME: Summer Street/Rockland Street between Route 3A Rotary and G. W. Boulevard

START POINT: East of Route 3A Rotary

END POINT: East of Rockland Street

FUNCTIONAL CLASSIFICATION OF ROADWAY: Urban Minor Arterial - Other

ROADWAY DIAGRAM (LABEL ROADWAY AND CROSS STREETS)



AVERAGE DAILY TRAFFIC

SEGMENT LENGTH IN MILES (**L**):	**0.74**
AVERAGE DAILY TRAFFIC VOLUME (**V**):	16,000

TOTAL # OF CRASHES:	56	# OF YEARS :	5	AVERAGE # OF CRASHES PER YEAR (**A**) :	**11.20**

CRASH RATE CALCULATION : **2.59**

$$RATE = \frac{(A * 1,000,000)}{(L * V * 365)}$$

Comments : 2012 State Average for Urban Minor Arterial = 3.74

Project Title & Date: Summer St/G.W.Blvd Subregioanl Roadway Study

SEGMENT CRASH RATE WORKSHEET

CITY/TOWN : Hingham-Hull

COUNT DATE : NA (2012)

DISTRICT : 5

~ SEGMENT DATA ~

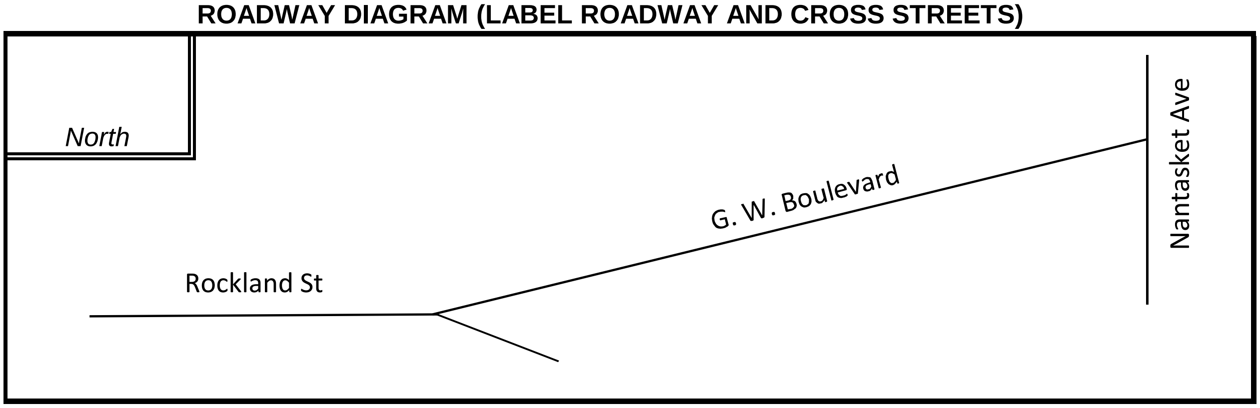
ROADWAY NAME: G. W. Boulevard from Rockland Street to Nantasket Avenue

START POINT: East of Rockland Street

END POINT: North of Nantasket Avenue

FUNCTIONAL CLASSIFICATION OF ROADWAY: Urban Minor Arterial - Other

ROADWAY DIAGRAM (LABEL ROADWAY AND CROSS STREETS)



AVERAGE DAILY TRAFFIC

SEGMENT LENGTH IN MILES (**L**):	**1.8**
AVERAGE DAILY TRAFFIC VOLUME (**V**):	11,500

TOTAL # OF CRASHES:	44	# OF YEARS :	5	AVERAGE # OF CRASHES PER YEAR (**A**) :	**8.80**

CRASH RATE CALCULATION : **1.16**

RATE = $\frac{(A * 1{,}000{,}000)}{(L * V * 365)}$

Comments : 2012 State Average for Urban Minor Arterial = 3.74

Project Title & Date: Summer St/G.W.Blvd Subregioanl Roadway Study

APPENDIX F

Intersection Crash Rate Worksheets

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Hingham　　　COUNT DATE : 6/14/2015

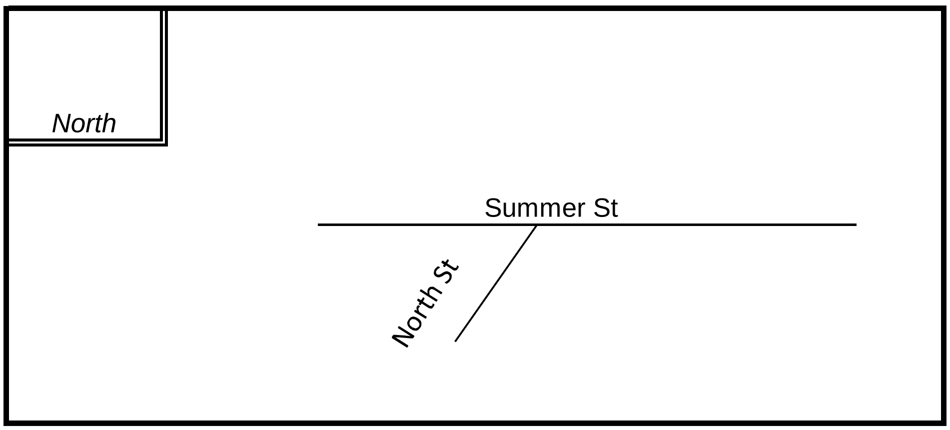
DISTRICT : 5　　　UNSIGNALIZED : 　　　SIGNALIZED : X

~ INTERSECTION DATA ~

MAJOR STREET : Summer St

MINOR STREET(S) : North St

INTERSECTION DIAGRAM
(Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :						
PEAK HOURLY VOLUMES (AM/PM) :						2,478

" K " FACTOR : **0.090**　　INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME : **27,528**

TOTAL # OF CRASHES : 34　　# OF YEARS : 5　　AVERAGE # OF CRASHES PER YEAR (**A**) : **6.80**

CRASH RATE CALCULATION : **0.78**　　RATE = $\frac{(A * 1{,}000{,}000)}{(V * 365)}$

Comments : 2010 Average Crash Rate for MassDOT District 5 Signalized Intersections = 0.77

Project Title & Date: Summer St/G.W.Blvd Subregioanl Roadway Study

Moving Massachusetts Forward. massDOT Highway

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Hingham

COUNT DATE : 6/14/2015

DISTRICT : 5

UNSIGNALIZED : X

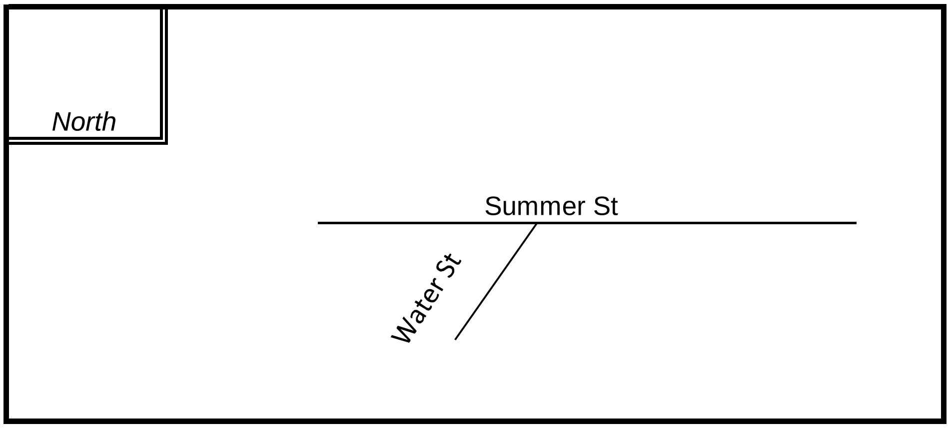
SIGNALIZED :

~ INTERSECTION DATA ~

MAJOR STREET : Summer St

MINOR STREET(S) : Water St

INTERSECTION DIAGRAM (Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :						
PEAK HOURLY VOLUMES (AM/PM) :						2,581

" K " FACTOR : **0.090**

INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME : **28,672**

TOTAL # OF CRASHES : 12

OF YEARS : 5

AVERAGE # OF CRASHES PER YEAR (**A**) : **2.40**

CRASH RATE CALCULATION : 0.26

$$RATE = \frac{(A * 1{,}000{,}000)}{(V * 365)}$$

Comments : 2010 Average Crash Rate for MassDOT District 5 Unsignalized Intersections = 0.58

Project Title & Date: Summer St/G.W.Blvd Subregioanl Roadway Study

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Hingham COUNT DATE : 6/14/2015

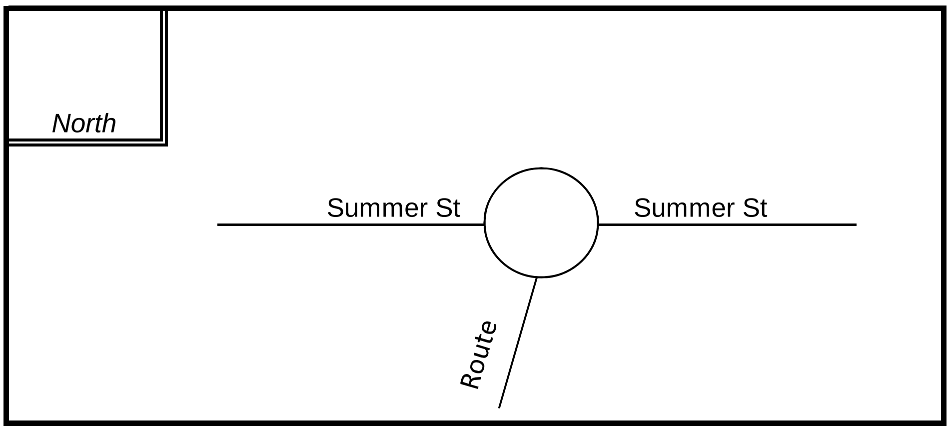
DISTRICT : 5 UNSIGNALIZED : SIGNALIZED : X

~ INTERSECTION DATA ~

MAJOR STREET : Summer St

MINOR STREET(S) : North St

INTERSECTION DIAGRAM
(Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :						
PEAK HOURLY VOLUMES (AM/PM) :						2,518

" K " FACTOR : **0.090**

INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME : **27,972**

TOTAL # OF CRASHES : 59

OF YEARS : 5

AVERAGE # OF CRASHES PER YEAR (**A**) : **11.80**

CRASH RATE CALCULATION : 1.33

$$\text{RATE} = \frac{(A * 1,000,000)}{(V * 365)}$$

Comments : 2010 Average Crash Rate for MassDOT District 5 Unsignalized Intersections = 0.58

Project Title & Date: Summer St/G.W.Blvd Subregioanl Roadway Study

Moving Massachusetts Forward. massDOT Highway

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Hingham COUNT DATE : 6/14/2015

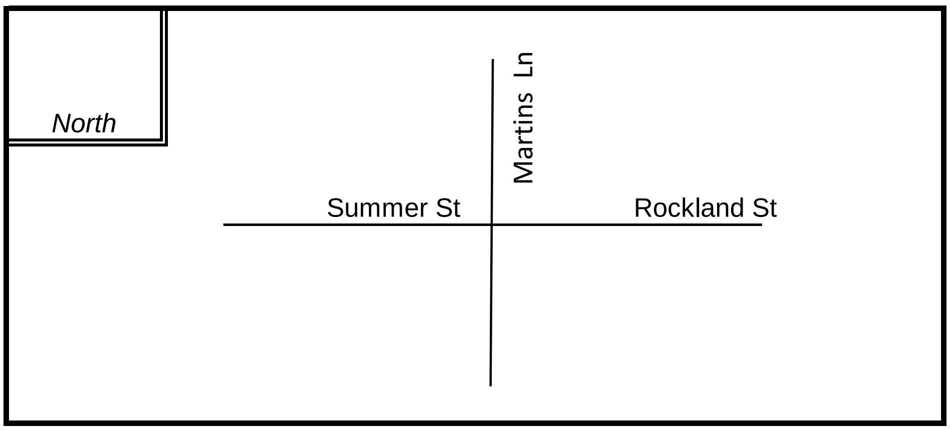
DISTRICT : 5 UNSIGNALIZED : SIGNALIZED : X

~ INTERSECTION DATA ~

MAJOR STREET : Summer St

MINOR STREET(S) : Rockland St/Martins Ln

INTERSECTION DIAGRAM
(Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :						
PEAK HOURLY VOLUMES (AM/PM) :						1,552

" K " FACTOR : **0.090**

INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME : **17,244**

TOTAL # OF CRASHES : 18

OF YEARS : 5

AVERAGE # OF CRASHES PER YEAR (**A**) : **3.60**

CRASH RATE CALCULATION : **0.66**

RATE = $\frac{(A * 1{,}000{,}000)}{(V * 365)}$

Comments : 2010 Average Crash Rate for MassDOT District 5 Signalized Intersections = 0.77

Project Title & Date: Summer St/G.W.Blvd Subregioanl Roadway Study

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Hingham

COUNT DATE : 6/14/2015

DISTRICT : 5

UNSIGNALIZED :

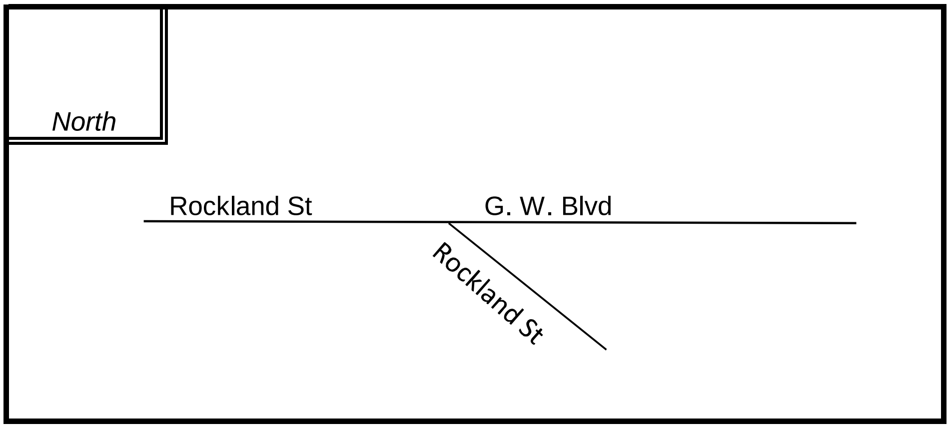
SIGNALIZED : X

~ INTERSECTION DATA ~

MAJOR STREET : Rockland St/G. W. Blvd

MINOR STREET(S) : Rockland St

INTERSECTION DIAGRAM (Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :						
PEAK HOURLY VOLUMES (AM/PM) :						1,408

" K " FACTOR :	0.090	INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME :	15,639
TOTAL # OF CRASHES :	15	# OF YEARS : 5	AVERAGE # OF CRASHES PER YEAR (**A**) : 3.00

CRASH RATE CALCULATION : **0.60**

$$\text{RATE} = \frac{(A * 1{,}000{,}000)}{(V * 365)}$$

Comments : 2010 Average Crash Rate for MassDOT District 5 Signalized Intersections = 0.77

Project Title & Date: Summer St/G.W.Blvd Subregioanl Roadway Study

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Hull

COUNT DATE : 9/3/2015

DISTRICT : 5

UNSIGNALIZED : X

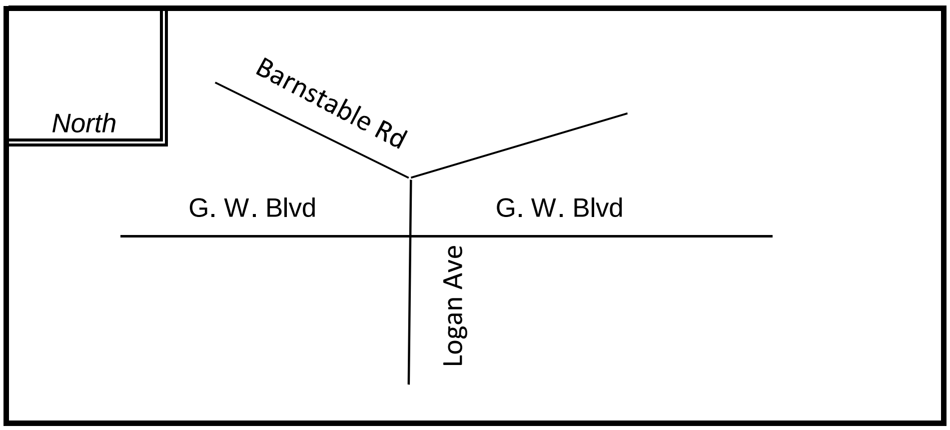
SIGNALIZED :

~ INTERSECTION DATA ~

MAJOR STREET : G. W. Blvd

MINOR STREET(S) : Logan Ave/Barnstable Rd

INTERSECTION DIAGRAM
(Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :						
PEAK HOURLY VOLUMES (AM/PM) :						1,165

" K " FACTOR : **0.090**

INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME : **12,944**

TOTAL # OF CRASHES : 6

OF YEARS : 5

AVERAGE # OF CRASHES PER YEAR (**A**) : **1.20**

CRASH RATE CALCULATION : **0.29**

$$\text{RATE} = \frac{(A * 1{,}000{,}000)}{(V * 365)}$$

Comments : 2010 Average Crash Rate for MassDOT District 5 Unsignalized Intersections = 0.58

Project Title & Date: Summer St/G.W.Blvd Subregioanl Roadway Study

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Hull | COUNT DATE : 6/14/2015

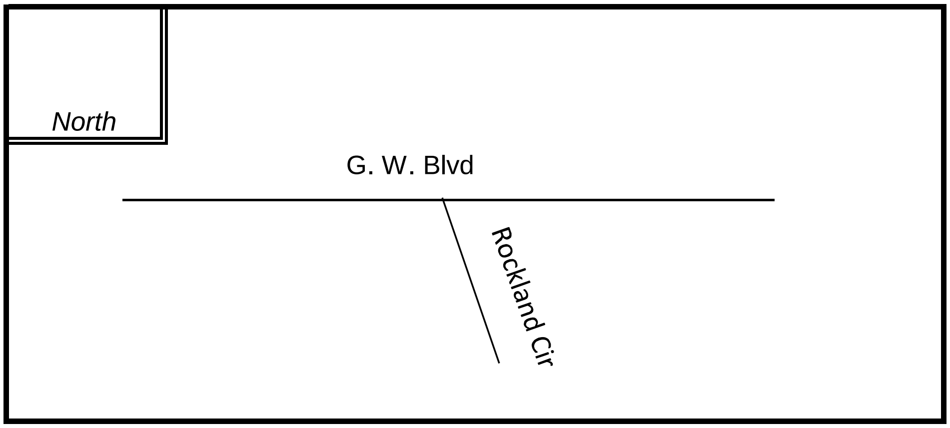
DISTRICT : 5 | UNSIGNALIZED : | SIGNALIZED : X

~ INTERSECTION DATA ~

MAJOR STREET : G. W. Blvd

MINOR STREET(S) : Rockland Circle

INTERSECTION DIAGRAM (Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :						
PEAK HOURLY VOLUMES (AM/PM) :						1,117

" K " FACTOR : 0.090

INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME : 12,406

TOTAL # OF CRASHES : 3

OF YEARS : 5

AVERAGE # OF CRASHES PER YEAR (**A**) : 0.60

CRASH RATE CALCULATION : 0.15

$$\text{RATE} = \frac{(A * 1{,}000{,}000)}{(V * 365)}$$

Comments : 2010 Average Crash Rate for MassDOT District 5 Signalized Intersections = 0.77

Project Title & Date: Summer St/G.W.Blvd Subregioanl Roadway Study

Moving Massachusetts Forward. massDOT Highway

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Hull COUNT DATE : 6/14/2015

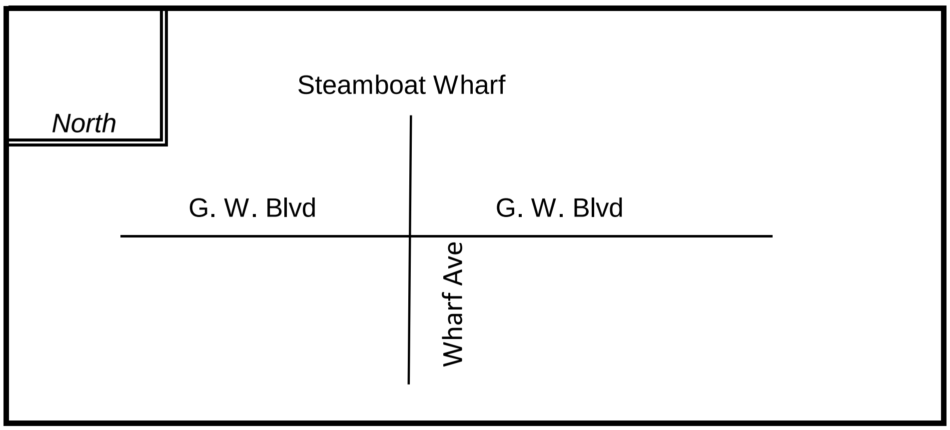
DISTRICT : 5 UNSIGNALIZED : SIGNALIZED : X

~ INTERSECTION DATA ~

MAJOR STREET : G. W. Blvd

MINOR STREET(S) : Wharf Ave

INTERSECTION DIAGRAM (Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :						
PEAK HOURLY VOLUMES (AM/PM) :						1,056

" K " FACTOR :	0.090	INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME :	11,728

TOTAL # OF CRASHES :	10	# OF YEARS :	5	AVERAGE # OF CRASHES PER YEAR (**A**) :	2.00

CRASH RATE CALCULATION : **0.54**

RATE = $\frac{(A * 1{,}000{,}000)}{(V * 365)}$

Comments : 2010 Average Crash Rate for MassDOT District 5 Signalized Intersections = 0.77

Project Title & Date: Summer St/G.W.Blvd Subregioanl Roadway Study

Moving Massachusetts Forward. massDOT Highway

INTERSECTION CRASH RATE WORKSHEET

CITY/TOWN : Hull

COUNT DATE : 6/14/2015

DISTRICT : 5

UNSIGNALIZED : X

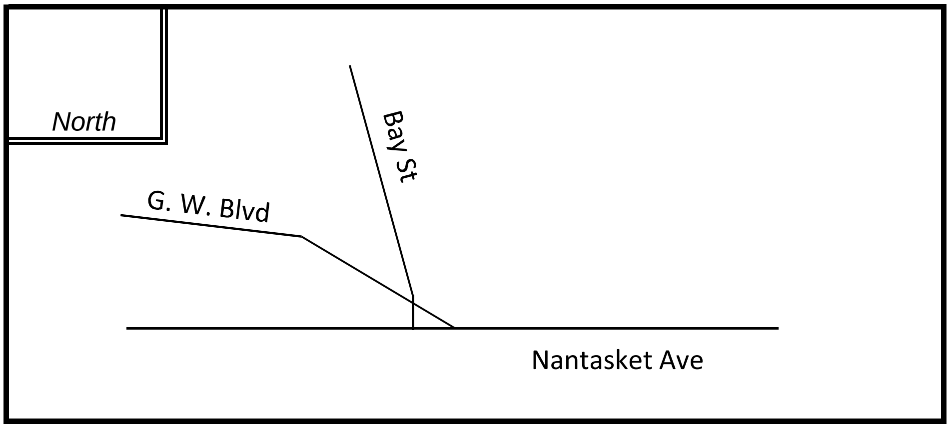
SIGNALIZED :

~ INTERSECTION DATA ~

MAJOR STREET : G. W. Blvd

MINOR STREET(S) : Bay St/Nantasket Ave

INTERSECTION DIAGRAM
(Label Approaches)



PEAK HOUR VOLUMES

APPROACH :	1	2	3	4	5	Total Peak Hourly Approach Volume
DIRECTION :						
PEAK HOURLY VOLUMES (AM/PM) :						906

" K " FACTOR : **0.090**

INTERSECTION ADT (**V**) = TOTAL DAILY APPROACH VOLUME : **10,061**

TOTAL # OF CRASHES : 8

OF YEARS : 5

AVERAGE # OF CRASHES PER YEAR (**A**) : **1.60**

CRASH RATE CALCULATION : **0.50**

$$\text{RATE} = \frac{(A * 1{,}000{,}000)}{(V * 365)}$$

Comments : 2010 Average Crash Rate for MassDOT District 5 Unsignalized Intersections = 0.58

Project Title & Date: Summer St/G.W.Blvd Subregioanl Roadway Study

APPENDIX G

Crash Statistics
Major Intersections in the Study Corridor
MassDOT Crash Data 2008–12

TABLE G-1
Summer Street at North Street and at Water Street, Hingham

Statistics Period		2008	2009	2010	2011	2012	5-Yr. Total	Annual Avg.	Percentages
Total number of crashes		7	15	10	11	3	46	9.2	100.0%
Severity	Property damage only	5	13	9	8	2	37	7.4	80.4%
	Non-fatal injury	2	2	0	3	1	8	1.6	17.4%
	Fatality	0	0	0	0	0	0	0.0	0.0%
	Not reported/unknown	0	0	1	0	0	1	0.2	2.2%
Collision type	Single vehicle	0	2	3	3	1	9	1.8	19.6%
	Rear-end	5	9	4	5	0	23	4.6	50.0%
	Angle	2	2	0	1	0	5	1.0	10.9%
	Sideswipe, same direction	0	1	2	0	1	4	0.8	8.7%
	Sideswipe, opposite direction	0	1	0	1	0	2	0.4	4.3%
	Head-on	0	0	1	1	0	2	0.4	4.3%
	Rear-to-rear	0	0	0	0	0	0	0.0	0.0%
	Not reported/unknown	0	0	0	0	1	1	0.2	2.2%
Involved pedestrian(s)		0	2	0	1	0	3	0.6	6.5%
Involved cyclist(s)		0	0	0	0	0	0	0.0	0.0%
Occurred during weekday peak periods*		1	7	5	3	2	18	3.6	39.1%
Wet or icy pavement conditions		0	3	2	2	1	8	1.6	17.4%
Dark conditions (lit or unlit)		2	4	2	4	0	12	2.4	26.1%

* Peak periods are defined as 07:00–10:00 and 15:30–18:30.

TABLE G-2
Summer Street at Chief Justice Cushing Highway (Route 3A Rotary), Hingham

Statistics Period		2008	2009	2010	2011	2012	5-Yr. Total	Annual Avg.	Percentages
Total number of crashes		14	8	17	6	4	49	9.8	100.0%
Severity	Property damage only	8	6	12	4	4	34	6.8	69.4%
	Non-fatal injury	6	2	5	2	0	15	3.0	30.6%
	Fatality	0	0	0	0	0	0	0.0	0.0%
	Not reported/unknown	0	0	0	0	0	0	0.0	0.0%
Collision type	Single vehicle	3	0	1	2	0	6	1.2	12.2%
	Rear-end	2	1	4	1	2	10	2.0	20.4%
	Angle	3	4	5	1	1	14	2.8	28.6%
	Sideswipe, same direction	6	3	7	1	1	18	3.6	36.7%
	Sideswipe, opposite direction	0	0	0	0	0	0	0.0	0.0%
	Head-on	0	0	0	0	0	0	0.0	0.0%
	Rear-to-rear	0	0	0	0	0	0	0.0	0.0%
	Not reported/unknown	0	0	0	1	0	1	0.2	2.0%
Involved pedestrian(s)		0	0	0	1	0	1	0.2	2.0%
Involved cyclist(s)		1	1	1	0	0	3	0.6	6.1%
Occurred during weekday peak periods*		5	3	7	1	0	16	3.2	32.7%
Wet or icy pavement conditions		1	3	3	2	0	9	1.8	18.4%
Dark conditions (lit or unlit)		4	0	0	1	3	8	1.6	16.3%

* Peak periods are defined as 07:00–10:00 and 15:30–18:30.

TABLE G-3
Summer Street at Martins Lane, Hingham

Statistics Period		2008	2009	2010	2011	2012	5-Yr. Total	Annual Avg.	Percentages
Total number of crashes		5	4	2	3	4	18	3.6	100.0%
Severity	Property damage only	2	3	2	2	3	12	2.4	66.7%
	Non-fatal injury	3	1	0	1	0	5	1.0	27.8%
	Fatality	0	0	0	0	0	0	0.0	0.0%
	Not reported/unknown	0	0	0	0	1	1	0.2	5.6%
Collision type	Single vehicle	1	1	0	0	1	3	0.6	16.7%
	Rear-end	2	3	1	2	3	11	2.2	61.1%
	Angle	1	0	1	0	0	2	0.4	11.1%
	Sideswipe, same direction	0	0	0	0	0	0	0.0	0.0%
	Sideswipe, opposite direction	0	0	0	1	0	1	0.2	5.6%
	Head-on	1	0	0	0	0	1	0.2	5.6%
	Rear-to-rear	0	0	0	0	0	0	0.0	0.0%
	Not reported/unknown	0	0	0	0	0	0	0.0	0.0%
Involved pedestrian(s)		0	0	0	0	0	0	0.0	0.0%
Involved cyclist(s)		0	0	0	0	0	0	0.0	0.0%
Occurred during weekday peak periods*		0	1	1	1	1	4	0.8	22.2%
Wet or icy pavement conditions		0	1	0	1	0	2	0.4	11.1%
Dark conditions (lit or unlit)		2	0	0	1	1	4	0.8	22.2%

* Peak periods are defined as 07:00–10:00 and 15:30–18:30.

TABLE G-4
Rockland Street at George Washington Boulevard, Hingham

Statistics Period		2008	2009	2010	2011	2012	5-Yr. Total	Annual Avg.	Percentages
Total number of crashes		4	2	2	5	2	15	3.0	100.0%
Severity	Property damage only	1	1	1	3	1	7	1.4	46.7%
	Non-fatal injury	1	1	1	2	1	6	1.2	40.0%
	Fatality	1	0	0	0	0	1	0.2	6.7%
	Not reported/unknown	1	0	0	0	0	1	0.2	6.7%
Collision type	Single vehicle	1	1	1	1	2	6	1.2	40.0%
	Rear-end	0	1	1	1	0	3	0.6	20.0%
	Angle	1	0	0	2	0	3	0.6	20.0%
	Sideswipe, same direction	1	0	0	1	0	2	0.4	13.3%
	Sideswipe, opposite direction	0	0	0	0	0	0	0.0	0.0%
	Head-on	1	0	0	0	0	1	0.2	6.7%
	Rear-to-rear	0	0	0	0	0	0	0.0	0.0%
	Not reported/unknown	0	0	0	0	0	0	0.0	0.0%
Involved pedestrian(s)		0	0	0	0	0	0	0.0	0.0%
Involved cyclist(s)		0	0	0	0	0	0	0.0	0.0%
Occurred during weekday peak periods*		1	1	0	0	1	3	0.6	20.0%
Wet or icy pavement conditions		0	0	0	1	1	2	0.4	13.3%
Dark conditions (lit or unlit)		2	1	1	2	1	7	1.4	46.7%

* Peak periods are defined as 07:00–10:00 and 15:30–18:30.

TABLE G-5
George Washington Boulevard at Rockland Circle, Hull

Statistics Period		2008	2009	2010	2011	2012	5-Yr. Total	Annual Avg.	Percentages
Total number of crashes		1	1	0	1	0	3	0.6	100.0%
Severity	Property damage only	1	1	0	1	0	3	0.6	100.0%
	Non-fatal injury	0	0	0	0	0	0	0.0	0.0%
	Fatality	0	0	0	0	0	0	0.0	0.0%
	Not reported/unknown	0	0	0	0	0	0	0.0	0.0%
Collision type	Single vehicle	0	0	0	0	0	0	0.0	0.0%
	Rear-end	0	1	0	0	0	1	0.2	33.3%
	Angle	0	0	0	1	0	1	0.2	33.3%
	Sideswipe, same direction	0	0	0	0	0	0	0.0	0.0%
	Sideswipe, opposite direction	0	0	0	0	0	0	0.0	0.0%
	Head-on	0	0	0	0	0	0	0.0	0.0%
	Rear-to-rear	0	0	0	0	0	0	0.0	0.0%
	Not reported/unknown	1	0	0	0	0	1	0.2	33.3%
Involved pedestrian(s)		0	0	0	0	0	0	0.0	0.0%
Involved cyclist(s)		0	0	0	0	0	0	0.0	0.0%
Occurred during weekday peak periods*		1	1	0	0	0	2	0.4	66.7%
Wet or icy pavement conditions		1	0	0	0	0	1	0.2	33.3%
Dark conditions (lit or unlit)		1	0	0	0	0	1	0.2	33.3%

* Peak periods are defined as 07:00–10:00 and 15:30–18:30.

TABLE G-6
George Washington Boulevard at Wharf Avenue, Hull

Statistics Period		2008	2009	2010	2011	2012	5-Yr. Total	Annual Avg.	Percentages
Total number of crashes		4	2	1	3	0	10	2.0	100.0%
Severity	Property damage only	3	1	0	2	0	6	1.2	60.0%
	Non-fatal injury	1	1	1	1	0	4	0.8	40.0%
	Fatality	0	0	0	0	0	0	0.0	0.0%
	Not reported/unknown	0	0	0	0	0	0	0.0	0.0%
Collision type	Single vehicle	0	1	1	0	0	2	0.4	20.0%
	Rear-end	1	0	0	2	0	3	0.6	30.0%
	Angle	0	1	0	0	0	1	0.2	10.0%
	Sideswipe, same direction	0	0	0	1	0	1	0.2	10.0%
	Sideswipe, opposite direction	2	0	0	0	0	2	0.4	20.0%
	Head-on	0	0	0	0	0	0	0.0	0.0%
	Rear-to-rear	0	0	0	0	0	0	0.0	0.0%
	Not reported/unknown	1	0	0	0	0	1	0.2	10.0%
Involved pedestrian(s)		0	0	0	0	0	0	0.0	0.0%
Involved cyclist(s)		0	0	0	0	0	0	0.0	0.0%
Occurred during weekday peak periods*		0	0	1	2	0	3	0.6	30.0%
Wet or icy pavement conditions		0	1	0	0	0	1	0.2	10.0%
Dark conditions (lit or unlit)		1	0	0	1	0	2	0.4	20.0%

* Peak periods are defined as 07:00–10:00 and 15:30–18:30.

TABLE G-7
George Washington Boulevard at Nantasket Avenue and Bay Street, Hull

Statistics Period		2008	2009	2010	2011	2012	5-Yr. Total	Annual Avg.	Percentages
Total number of crashes		6	2	4	3	0	15	3.0	100.0%
Severity	Property damage only	4	1	4	3	0	12	2.4	80.0%
	Non-fatal injury	2	0	0	0	0	2	0.4	13.3%
	Fatality	0	0	0	0	0	0	0.0	0.0%
	Not reported/unknown	0	1	0	0	0	1	0.2	6.7%
Collision type	Single vehicle	3	0	0	1	0	4	0.8	26.7%
	Rear-end	2	0	2	2	0	6	1.2	40.0%
	Angle	0	2	1	0	0	3	0.6	20.0%
	Sideswipe, same direction	0	0	1	0	0	1	0.2	6.7%
	Sideswipe, opposite direction	0	0	0	0	0	0	0.0	0.0%
	Head-on	0	0	0	0	0	0	0.0	0.0%
	Rear-to-rear	0	0	0	0	0	0	0.0	0.0%
	Not reported/unknown	1	0	0	0	0	1	0.2	6.7%
Involved pedestrian(s)		0	0	0	0	0	0	0.0	0.0%
Involved cyclist(s)		1	0	0	0	0	1	0.2	6.7%
Occurred during weekday peak periods*		1	1	0	2	0	4	0.8	26.7%
Wet or icy pavement conditions		1	0	2	0	0	3	0.6	20.0%
Dark conditions (lit or unlit)		2	0	1	0	0	3	0.6	20.0%

* Peak periods are defined as 07:00–10:00 and 15:30–18:30.

APPENDIX H

Collision Diagrams
Major Intersections and Segments in the Corridor

FIGURE H-1
Collision Diagram: Summer Street at North Street and at Water Street
Hingham Police Reports: March 2010–April 2015

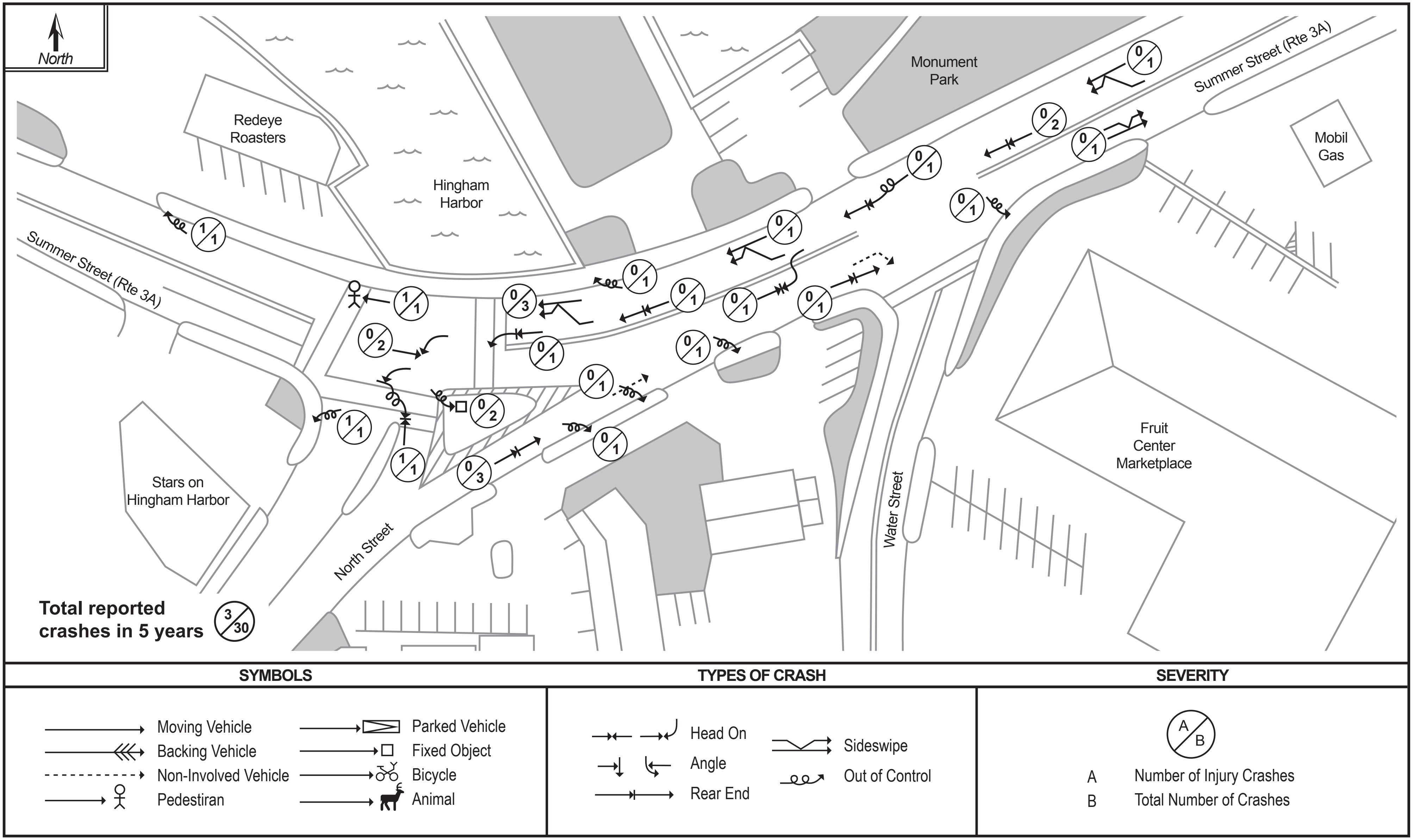
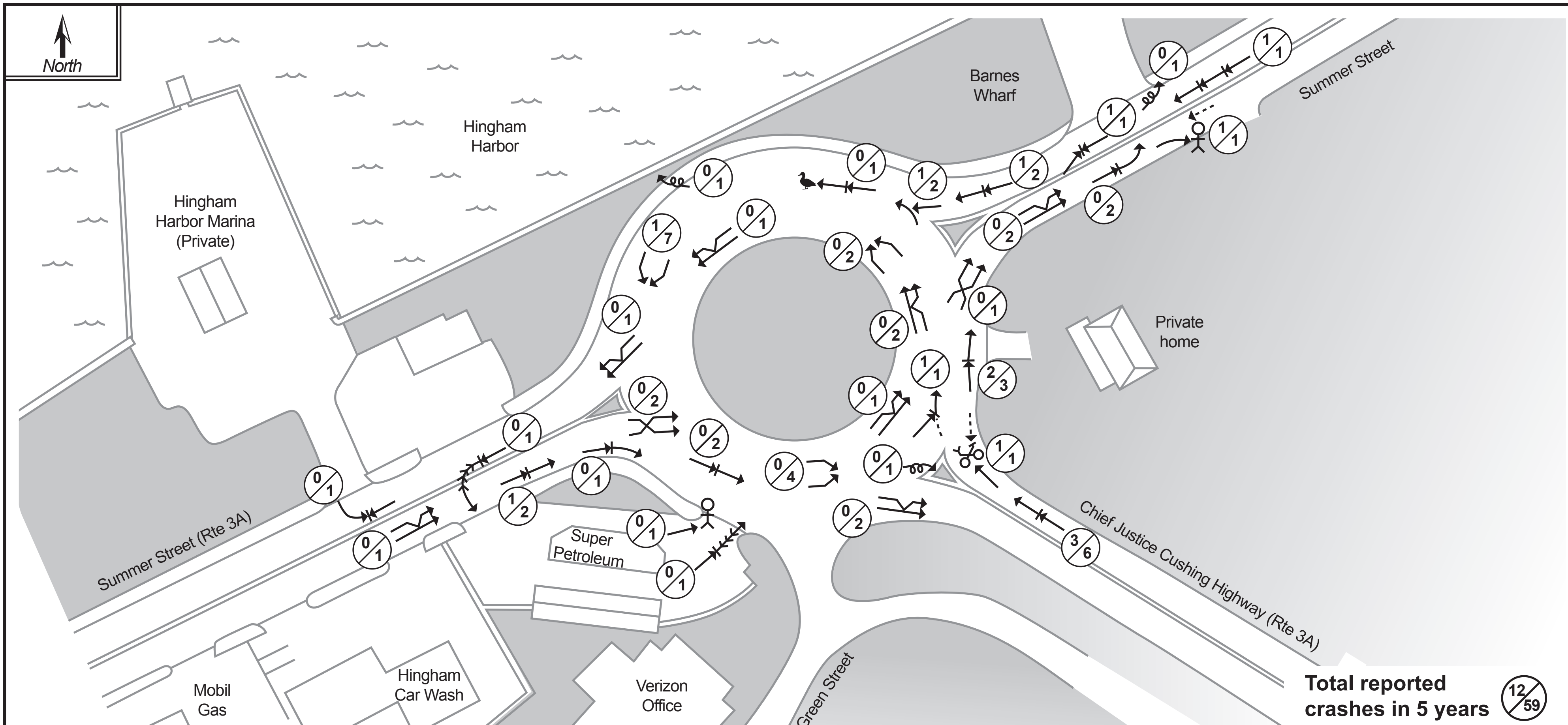


FIGURE H-2
Collision Diagram: Summer Street at Route 3A Rotary
Hingham Police Reports: March 2010–April 2015



SYMBOLS	TYPES OF CRASH	SEVERITY
Moving Vehicle Backing Vehicle Non-Involved Vehicle Pedestiran Parked Vehicle Fixed Object Bicycle Animal	Head On Angle Rear End Sideswipe Out of Control	A/B A Number of Injury Crashes B Total Number of Crashes

FIGURE H-3
Collision Diagram: Summer Street between Route 3A Rotary and Martins Lane
Hingham Police Reports: March 2010–April 2015

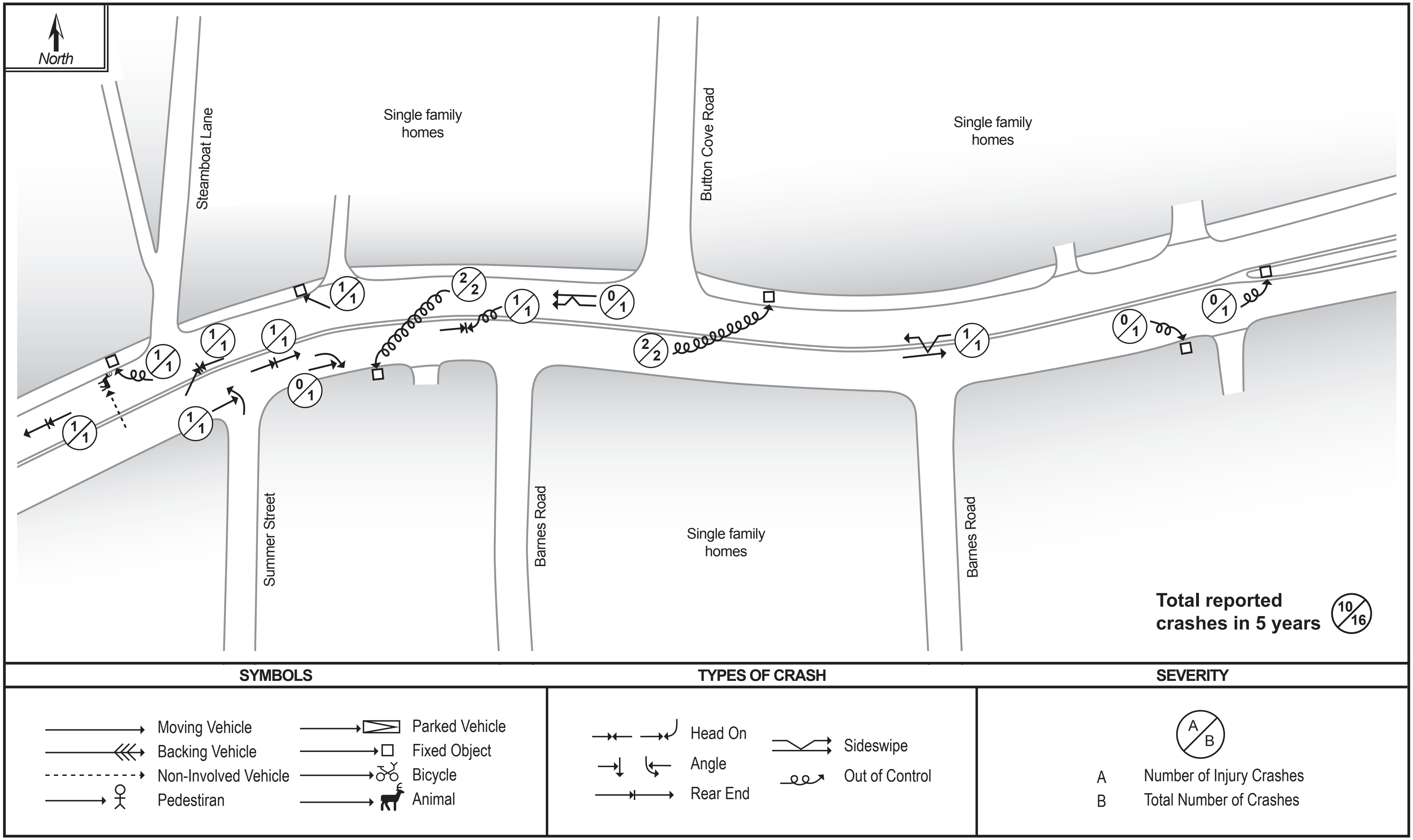
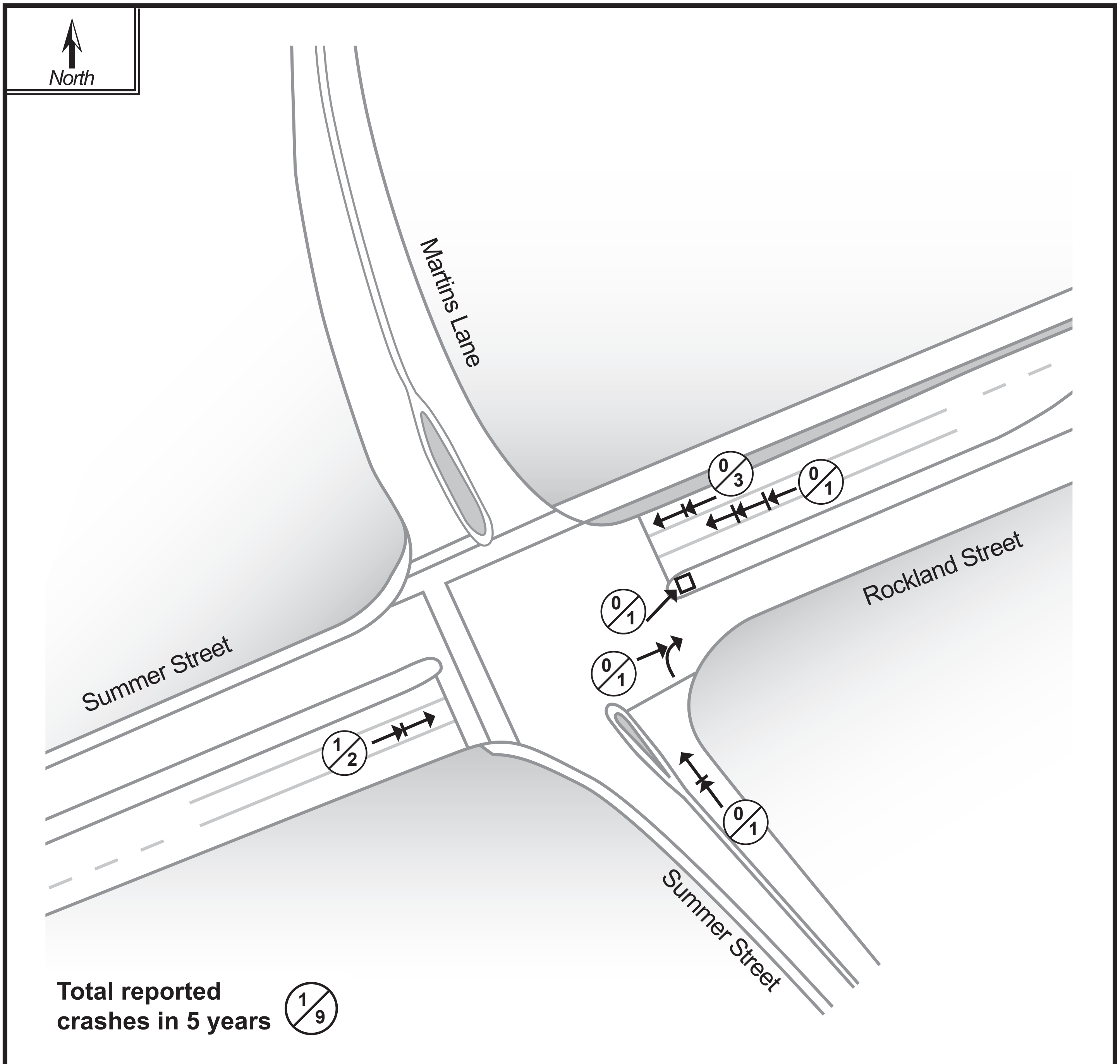


FIGURE H-4
Collision Diagram: Summer Street at Rockland Street/Martins Lane
Hingham Police Reports: March 2010–April 2015



SYMBOLS	TYPES OF CRASH	SEVERITY
Moving Vehicle	Head On	A/B
Backing Vehicle	Angle	A Number of Injury Crashes
Non-Involved Vehicle	Rear End	B Total Number of Crashes
Pedestiran	Sideswipe	
Parked Vehicle	Out of Control	
Fixed Object		
Bicycle		
Animal		

FIGURE H-5
Collision Diagram: Rockland Street at George Washington Boulevard
Hingham Police Reports: March 2010–April 2015

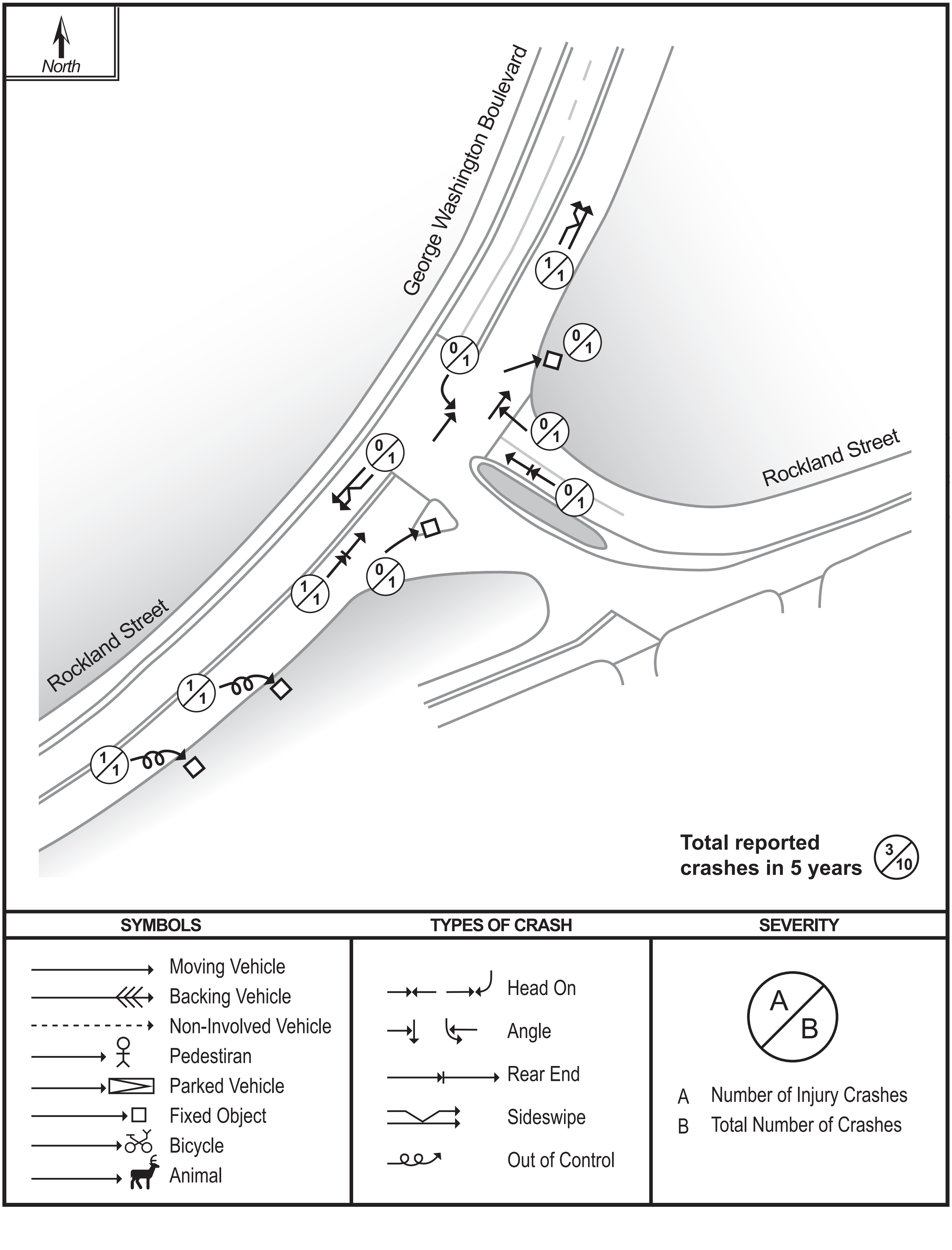
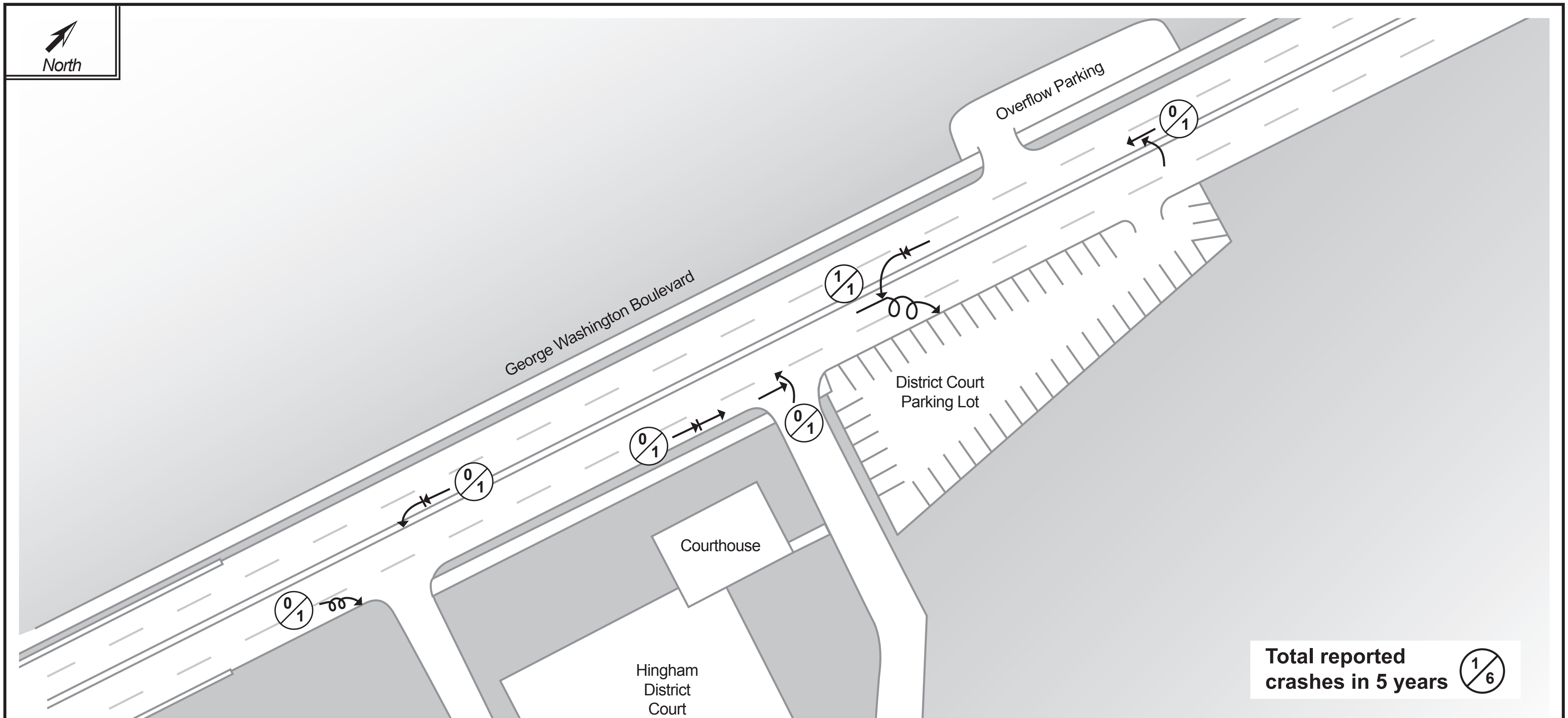


FIGURE H-6
Collision Diagram: George Washington Boulevard in the Vicinity of District Court
Hingham Police Reports: March 2010–April 2015



SYMBOLS		TYPES OF CRASH		SEVERITY
Moving Vehicle	Parked Vehicle	Head On	Sideswipe	A / B
Backing Vehicle	Fixed Object	Angle	Out of Control	A Number of Injury Crashes
Non-Involved Vehicle	Bicycle	Rear End		B Total Number of Crashes
Pedestiran	Animal			

FIGURE H-7
Collision Diagram: George Washington Boulevard between Weir River and Rockland Circle
Hull Police Reports: 2009–2011 and 2013–May 2015

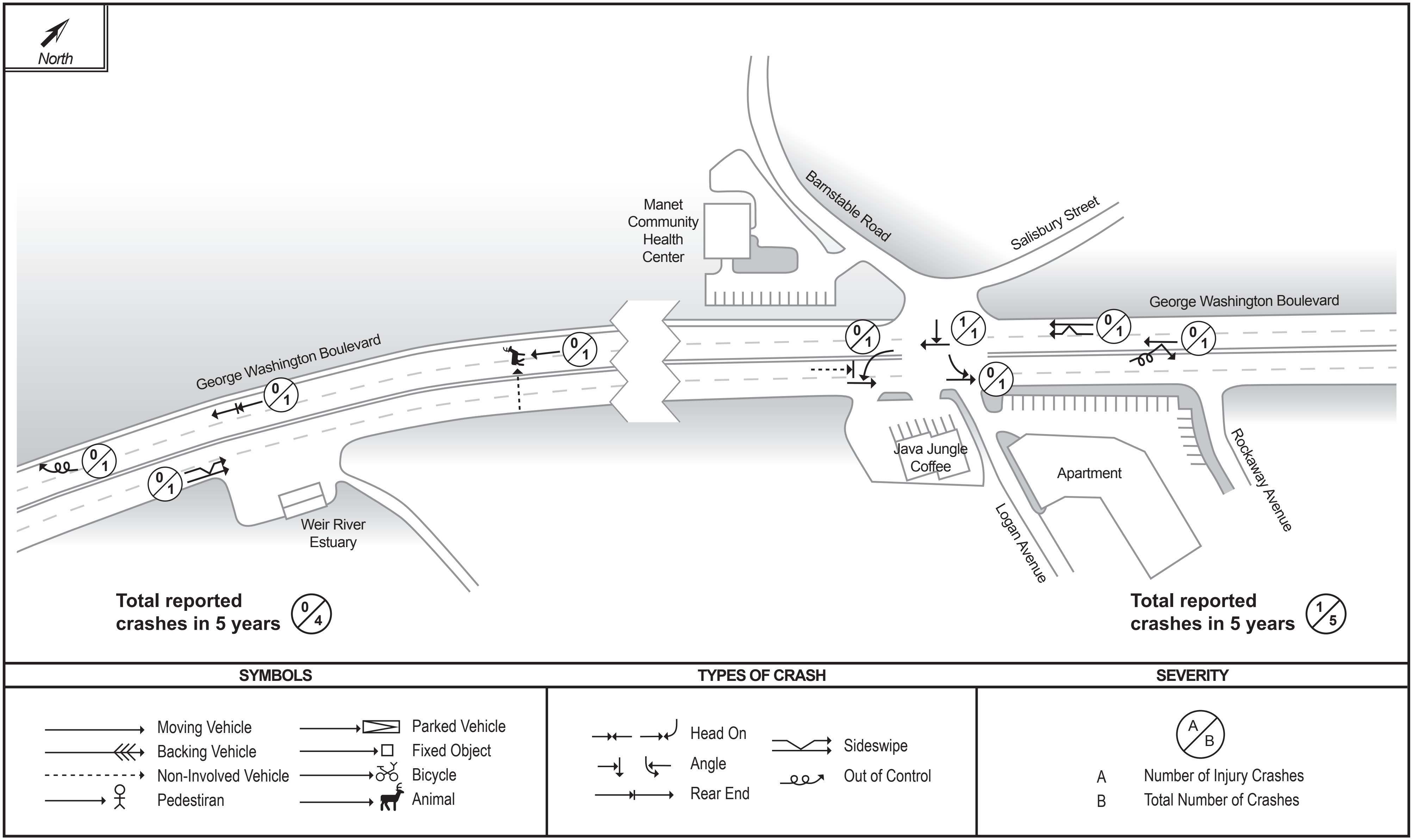


FIGURE H-8
Collision Diagram: George Washington Boulevard at Rockland Circle
Hull Police Reports: 2009–2011 and 2013–May 2015

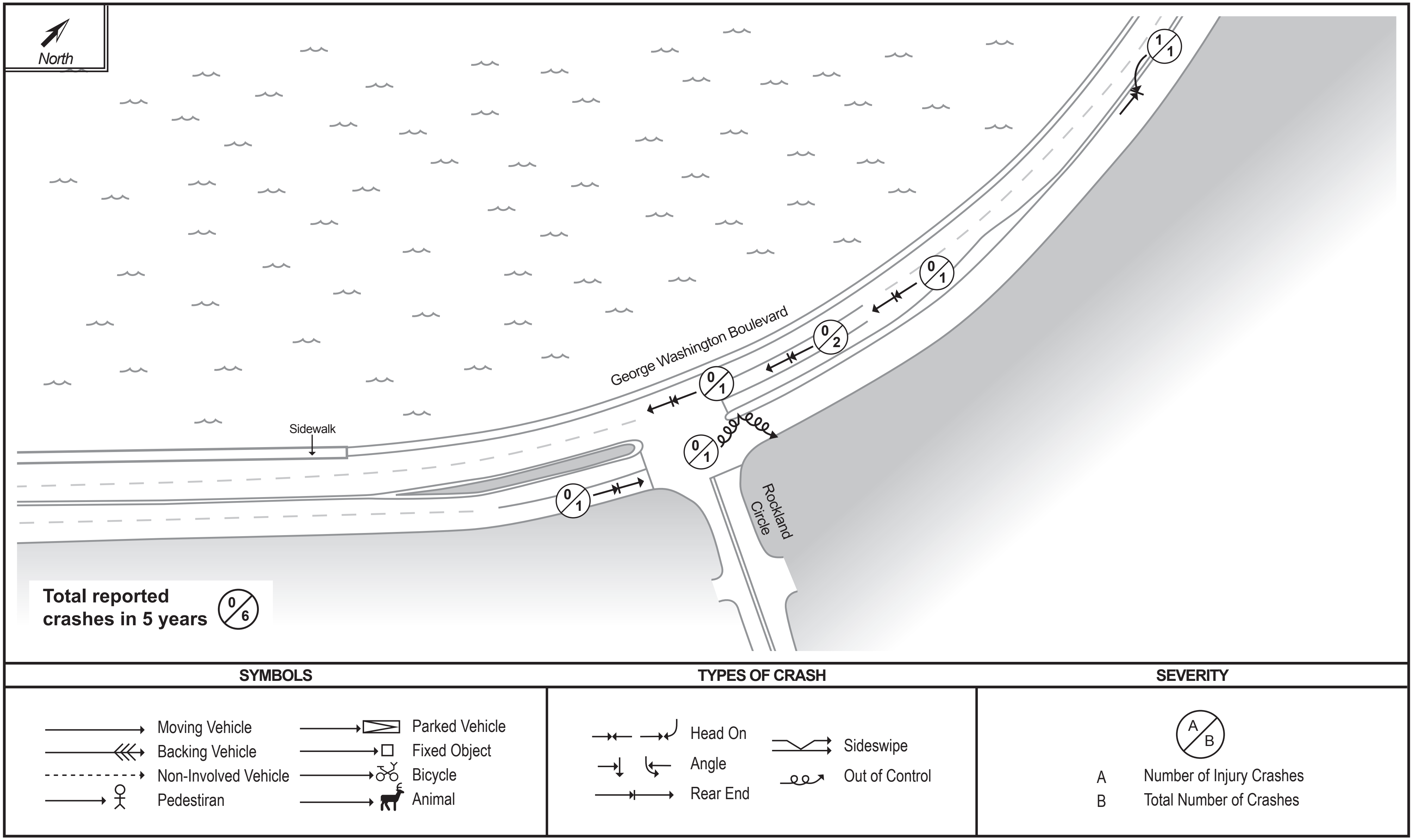


FIGURE H-9
Collision Diagram: George Washington Boulevard at Wharf Avenue and at Bay Street/Nantasket Avenue
Hull Police Reports: 2009–2011 and 2013–May 2015

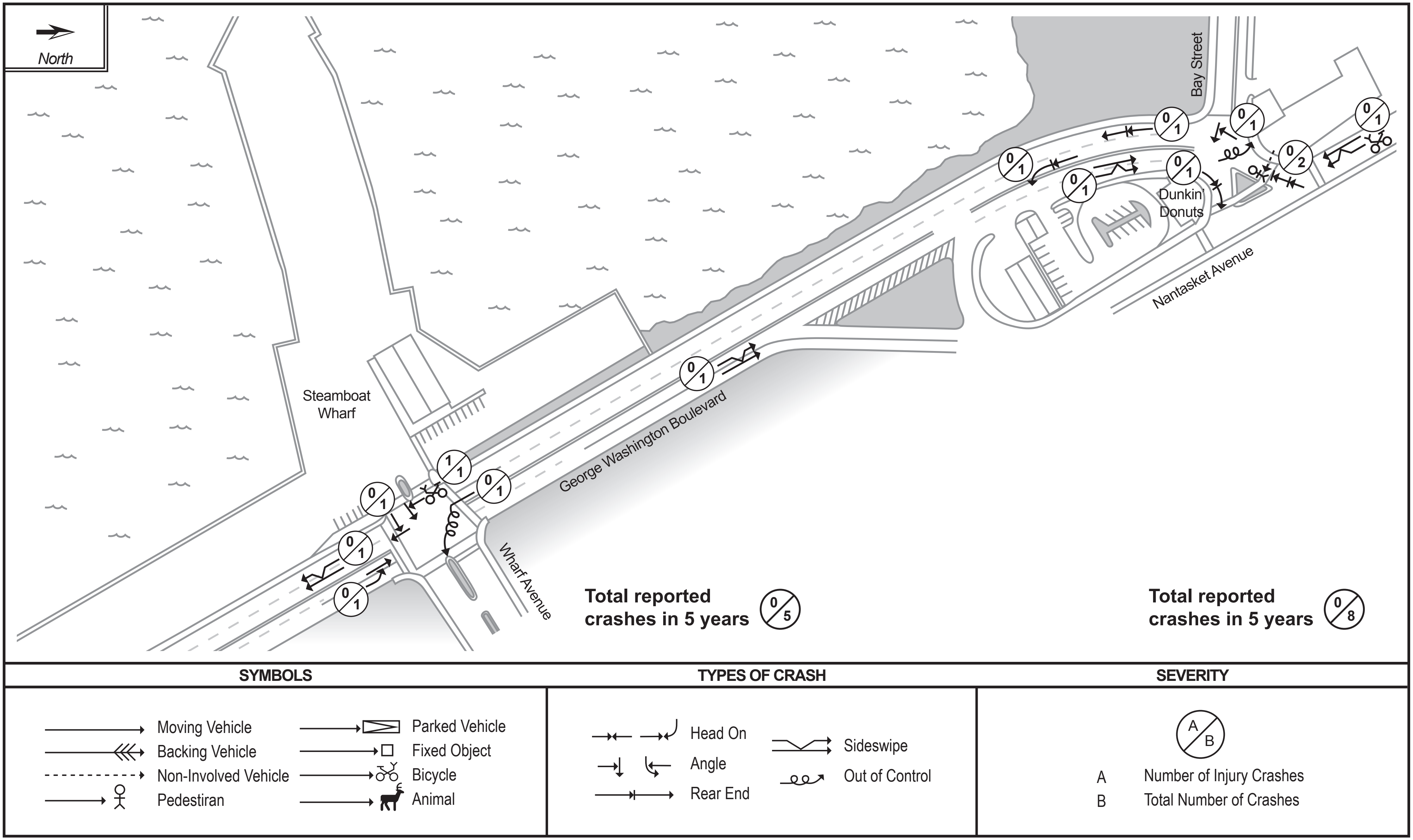
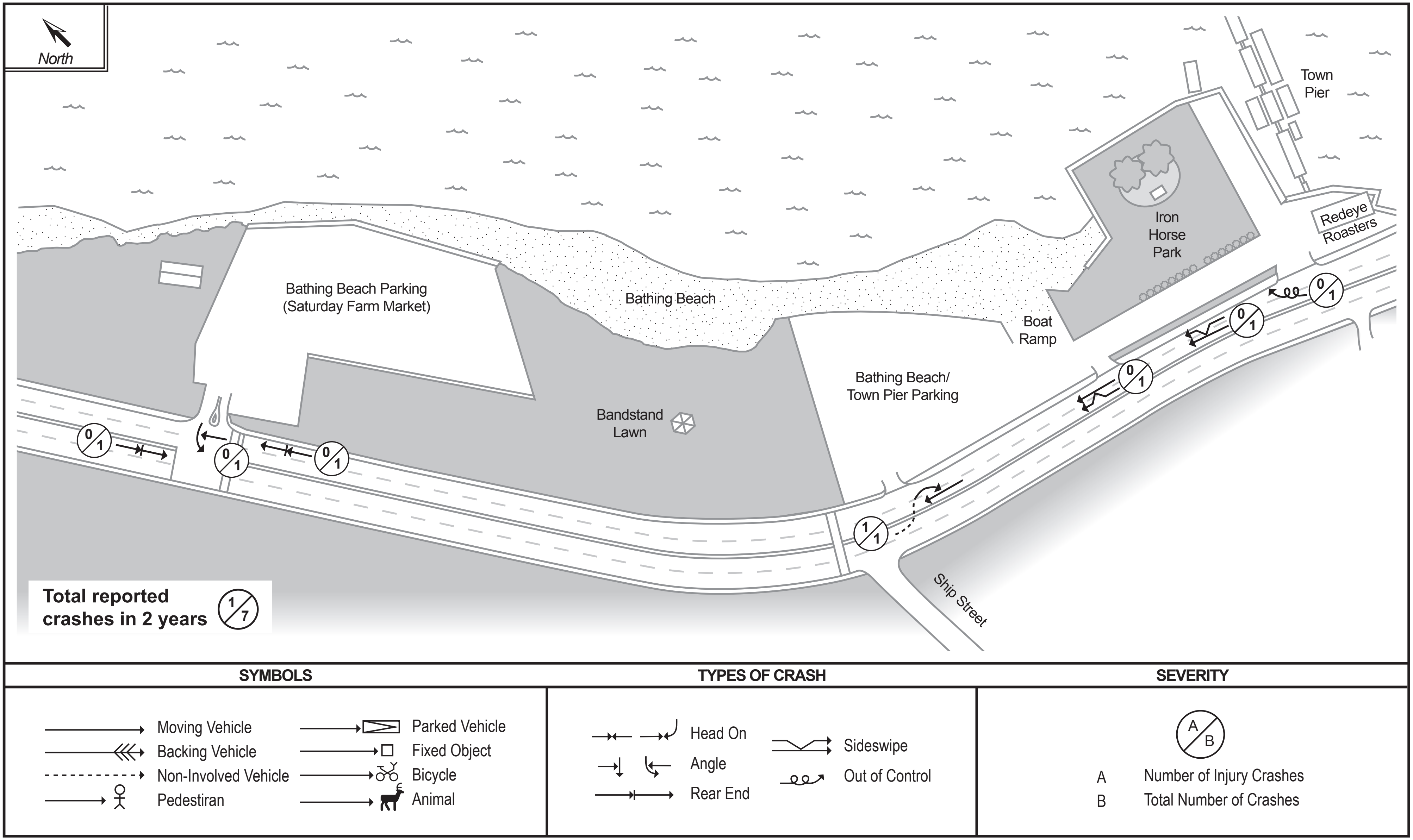


FIGURE H-10
Collision Diagram: Otis Street (Route 3A) between Bathing Beach Driveway and North Street
Hingham Police Reports: March 2013–April 2015



APPENDIX I

Intersection Capacity Analyses
Weekday AM Peak Hour
Projected 2040 Traffic Conditions with Proposed Improvements

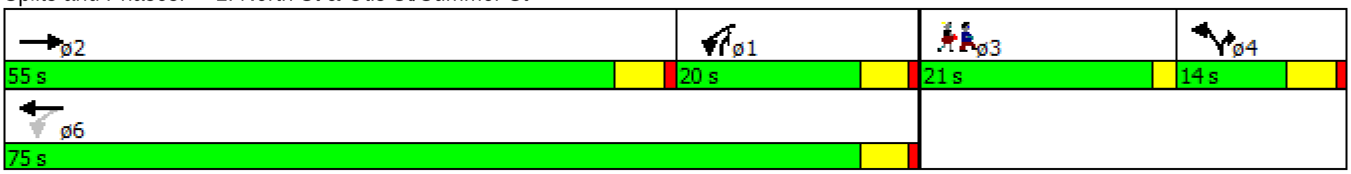
Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø3
Lane Configurations							
Volume (vph)	572	50	398	1246	79	227	
Confl. Peds. (#/hr)		3	3				
Peak Hour Factor	0.95	0.95	0.93	0.93	0.87	0.87	
Growth Factor	105%	105%	105%	105%	105%	105%	
Heavy Vehicles (%)	2%	2%	1%	1%	3%	3%	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	687	0	0	1856	95	274	
Turn Type	NA		pm+pt	NA	Prot	pt+ov	
Protected Phases	2		1	6	4	4 1	3
Permitted Phases			6				
Detector Phase	2		1	6	4	4 1	
Switch Phase							
Minimum Initial (s)	8.0		4.0	8.0	9.0		4.0
Minimum Split (s)	13.0		9.0	13.0	14.0		21.0
Total Split (s)	55.0		20.0	75.0	14.0		21.0
Total Split (%)	50.0%		18.2%	68.2%	12.7%		19%
Yellow Time (s)	4.0		4.0	4.0	4.0		2.0
All-Red Time (s)	1.0		1.0	1.0	1.0		0.0
Lost Time Adjust (s)	0.0			0.0	0.0		
Total Lost Time (s)	5.0			5.0	5.0		
Lead/Lag	Lead		Lag		Lag		Lead
Lead-Lag Optimize?	Yes		Yes		Yes		Yes
Recall Mode	Min		None	Min	None		None
Act Effct Green (s)	27.7			70.6	9.1	51.2	
Actuated g/C Ratio	0.30			0.76	0.10	0.55	
v/c Ratio	0.76			0.99	0.62	0.35	
Control Delay	34.8			36.7	61.0	14.0	
Queue Delay	0.0			0.0	0.0	0.0	
Total Delay	34.8			36.7	61.0	14.0	
LOS	C			D	E	B	
Approach Delay	34.8			36.7	26.1		
Approach LOS	C			D	C		
Queue Length 50th (ft)	180			246	52	72	
Queue Length 95th (ft)	267			#1025	#145	159	
Internal Link Dist (ft)	764			218	85		
Turn Bay Length (ft)							
Base Capacity (vph)	1644			1871	153	773	
Starvation Cap Reductn	0			0	0	0	
Spillback Cap Reductn	0			0	0	0	
Storage Cap Reductn	0			0	0	0	
Reduced v/c Ratio	0.42			0.99	0.62	0.35	

Intersection Summary
Cycle Length: 110
Actuated Cycle Length: 93.3
Natural Cycle: 150
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.99

Intersection Signal Delay: 34.9	Intersection LOS: C
Intersection Capacity Utilization 94.0%	ICU Level of Service F
Analysis Period (min) 15	

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: North St & Otis St/Summer St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	334	414	60	689	10	871	5	24	5	5	20
Satd. Flow (prot)	1711	3355	1501	1728	3448	0	1681	1621	0	0	1757	1531
Flt Permitted	0.193			0.360			0.950	0.955			0.976	
Satd. Flow (perm)	348	3355	1501	655	3448	0	1681	1621	0	0	1757	1531
Satd. Flow (RTOR)			511		1			3				138
Peak Hour Factor	0.92	0.85	0.85	0.92	0.92	0.92	0.96	0.92	0.96	0.92	0.92	0.92
Growth Factor	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%
Heavy Vehicles (%)	2%	4%	4%	1%	1%	2%	2%	2%	2%	2%	2%	2%
Shared Lane Traffic (%)							48%					
Lane Group Flow (vph)	11	413	511	68	797	0	496	489	0	0	12	23
Turn Type	pm+pt	NA	Perm	pm+pt	NA		Split	NA		Split	NA	Perm
Protected Phases	5	2		1	6		7	7		8	8	
Permitted Phases	2		2	6								8
Detector Phase	5	2	2	1	6		7	7		8	8	8
Switch Phase												
Minimum Initial (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		3.0	3.0	3.0
Minimum Split (s)	8.0	30.5	30.5	8.0	21.0		21.0	21.0		9.0	9.0	9.0
Total Split (s)	8.0	34.0	34.0	8.0	34.0		36.0	36.0		9.0	9.0	9.0
Total Split (%)	7.2%	30.6%	30.6%	7.2%	30.6%		32.4%	32.4%		8.1%	8.1%	8.1%
Yellow Time (s)	3.0	4.0	4.0	3.0	4.0		4.0	4.0		4.0	4.0	4.0
All-Red Time (s)	1.0	1.0	1.0	1.0	1.0		1.0	1.0		1.0	1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0		0.0	0.0			0.0	0.0
Total Lost Time (s)	4.0	5.0	5.0	4.0	5.0		5.0	5.0			5.0	5.0
Lead/Lag	Lead	Lag	Lag	Lead	Lag		Lead	Lead		Lag	Lag	Lag
Lead-Lag Optimize?	Yes	Yes	Yes	Yes	Yes		Yes	Yes		Yes	Yes	Yes
Recall Mode	None	Min	Min	Min	Min		None	None		None	None	None
Act Effct Green (s)	22.7	17.5	17.5	26.3	24.7		32.3	32.3			4.2	4.2
Actuated g/C Ratio	0.30	0.23	0.23	0.35	0.32		0.42	0.42			0.06	0.06
v/c Ratio	0.06	0.54	0.69	0.24	0.71		0.70	0.71			0.12	0.11
Control Delay	19.9	29.3	8.3	21.4	28.7		29.0	29.6			45.4	1.0
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0			0.0	0.0
Total Delay	19.9	29.3	8.3	21.4	28.7		29.0	29.6			45.4	1.0
LOS	B	C	A	C	C		C	C			D	A
Approach Delay		17.7			28.1			29.3			16.2	
Approach LOS		B			C			C			B	
Queue Length 50th (ft)	3	89	0	21	166		194	192			5	0
Queue Length 95th (ft)	17	158	57	62	#354		#586	#589			28	0
Internal Link Dist (ft)		641			654			102			1	
Turn Bay Length (ft)	100		150	100								
Base Capacity (vph)	178	1330	903	284	1367		712	688			96	214
Starvation Cap Reductn	0	0	0	0	0		0	0			0	0
Spillback Cap Reductn	0	0	0	0	0		0	0			0	0
Storage Cap Reductn	0	0	0	0	0		0	0			0	0
Reduced v/c Ratio	0.06	0.31	0.57	0.24	0.58		0.70	0.71			0.13	0.11

Intersection Summary
Cycle Length: 111
Actuated Cycle Length: 76.2

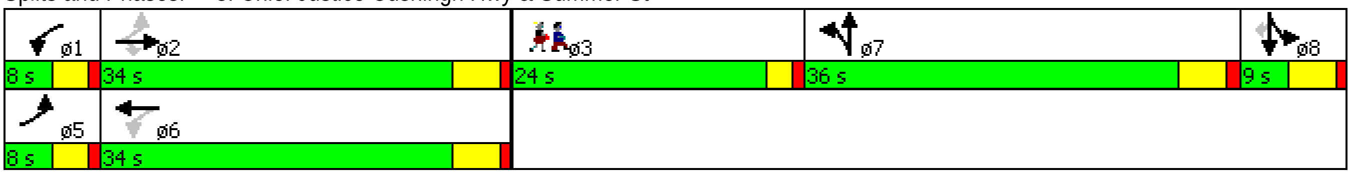
Lane Group	ø3
Lane Configurations	
Volume (vph)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Satd. Flow (RTOR)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	3
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	24.0
Total Split (s)	24.0
Total Split (%)	22%
Yellow Time (s)	2.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Natural Cycle: 105	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.71	
Intersection Signal Delay: 24.9	Intersection LOS: C
Intersection Capacity Utilization 68.2%	ICU Level of Service C
Analysis Period (min) 15	

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 3: Chief Justice Cushingh Hwy & Summer St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	26	378	11	136	742	10	17	27	57	11	42	39
Satd. Flow (prot)	1694	3374	0	1728	1815	0	0	1775	1538	0	2088	1794
Flt Permitted	0.207			0.457				0.848			0.918	
Satd. Flow (perm)	369	3374	0	831	1815	0	0	1534	1538	0	1938	1794
Satd. Flow (RTOR)												
Peak Hour Factor	0.93	0.93	0.93	0.90	0.90	0.90	0.84	0.84	0.84	0.92	0.92	0.92
Growth Factor	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%
Heavy Vehicles (%)	3%	3%	3%	1%	1%	1%	5%	5%	5%	2%	2%	2%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	29	439	0	159	878	0	0	55	71	0	61	45
Turn Type	pm+pt	NA		pm+pt	NA		Perm	NA	Perm	Perm	NA	Perm
Protected Phases	5	2		1	6			3			3	
Permitted Phases	2			6			3		3	3		3
Detector Phase	5	2		1	6		3	3	3	3	3	3
Switch Phase												
Minimum Initial (s)	4.0	15.0		4.0	15.0		8.0	8.0	8.0	8.0	8.0	8.0
Minimum Split (s)	8.0	20.0		8.0	20.0		13.0	13.0	13.0	13.0	13.0	13.0
Total Split (s)	8.0	51.0		10.0	53.0		26.0	26.0	26.0	26.0	26.0	26.0
Total Split (%)	7.3%	46.4%		9.1%	48.2%		23.6%	23.6%	23.6%	23.6%	23.6%	23.6%
Yellow Time (s)	3.0	4.0		3.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0
Lost Time Adjust (s)	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Lost Time (s)	4.0	5.0		4.0	5.0			5.0	5.0		5.0	5.0
Lead/Lag	Lead	Lag		Lead	Lag							
Lead-Lag Optimize?	Yes	Yes		Yes	Yes							
Recall Mode	None	Min		Min	Min		None	None	None	None	None	None
Act Effct Green (s)	48.3	43.1		53.5	51.8			10.6	10.6		10.6	10.6
Actuated g/C Ratio	0.65	0.58		0.72	0.70			0.14	0.14		0.14	0.14
v/c Ratio	0.09	0.22		0.24	0.69			0.25	0.32		0.22	0.18
Control Delay	7.4	10.6		7.2	17.0			35.7	37.0		34.4	34.1
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Delay	7.4	10.6		7.2	17.0			35.7	37.0		34.4	34.1
LOS	A	B		A	B			D	D		C	C
Approach Delay		10.4			15.5			36.5			34.3	
Approach LOS		B			B			D			C	
Queue Length 50th (ft)	3	43		16	163			21	27		23	17
Queue Length 95th (ft)	22	135		86	#889			66	81		75	60
Internal Link Dist (ft)		378			358			249			637	
Turn Bay Length (ft)	150			150					50			75
Base Capacity (vph)	317	2210		678	1274			458	460		579	536
Starvation Cap Reductn	0	0		0	0			0	0		0	0
Spillback Cap Reductn	0	0		0	0			0	0		0	0
Storage Cap Reductn	0	0		0	0			0	0		0	0
Reduced v/c Ratio	0.09	0.20		0.23	0.69			0.12	0.15		0.11	0.08

Intersection Summary
Cycle Length: 110
Actuated Cycle Length: 73.8

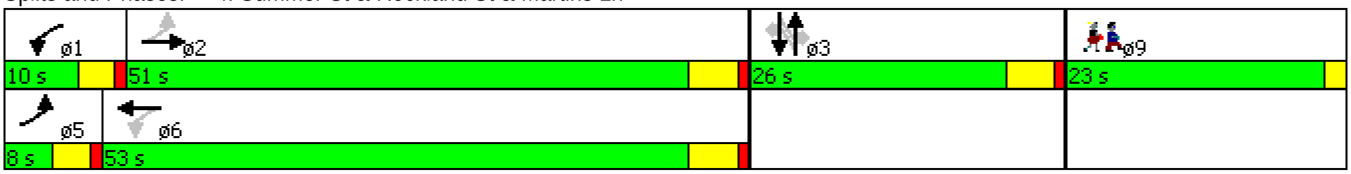
Lane Group	ø9
Lane Configurations	
Volume (vph)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Satd. Flow (RTOR)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	21%
Yellow Time (s)	2.0
All-Red Time (s)	0.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Natural Cycle: 90	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.69	
Intersection Signal Delay: 16.8	Intersection LOS: B
Intersection Capacity Utilization 67.5%	ICU Level of Service C
Analysis Period (min) 15	

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 4: Summer St & Rockland St & Martins Ln

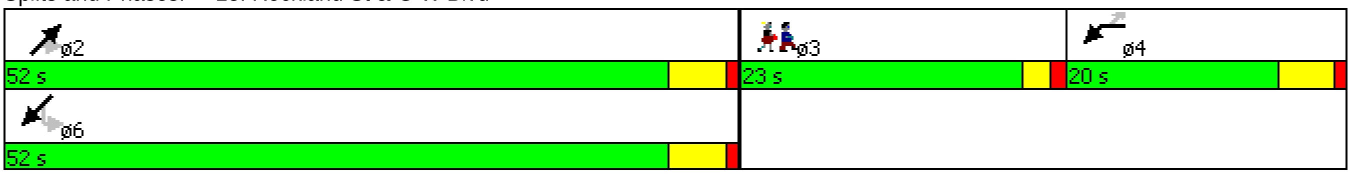


Lane Group	WBL	WBR	NET	NER	SWL	SWT	ø3
Lane Configurations							
Volume (vph)	180	21	359	87	10	688	
Satd. Flow (prot)	1711	1531	1801	1531	1711	1801	
Flt Permitted	0.950				0.457		
Satd. Flow (perm)	1706	1531	1801	1531	823	1801	
Satd. Flow (RTOR)		29		100			
Confl. Peds. (#/hr)	1						
Peak Hour Factor	0.77	0.77	0.91	0.91	0.90	0.90	
Growth Factor	105%	105%	105%	105%	105%	105%	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	245	29	414	100	12	803	
Turn Type	Prot	Perm	NA	Perm	Perm	NA	
Protected Phases	4		2			6	3
Permitted Phases		4		2	6		
Detector Phase	4	4	2	2	6	6	
Switch Phase							
Minimum Initial (s)	7.0	7.0	7.0	7.0	7.0	7.0	4.0
Minimum Split (s)	12.0	12.0	12.0	12.0	12.0	12.0	23.0
Total Split (s)	20.0	20.0	52.0	52.0	52.0	52.0	23.0
Total Split (%)	21.1%	21.1%	54.7%	54.7%	54.7%	54.7%	24%
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	2.0
All-Red Time (s)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	5.0	5.0	5.0	5.0	5.0	5.0	
Lead/Lag	Lag	Lag					Lead
Lead-Lag Optimize?	Yes	Yes					Yes
Recall Mode	Min	Min	None	None	None	None	None
Act Effct Green (s)	15.5	15.5	34.6	34.6	34.6	34.6	
Actuated g/C Ratio	0.25	0.25	0.55	0.55	0.55	0.55	
v/c Ratio	0.58	0.07	0.42	0.11	0.03	0.82	
Control Delay	32.7	11.9	10.7	2.6	8.4	21.1	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	32.7	11.9	10.7	2.6	8.4	21.1	
LOS	C	B	B	A	A	C	
Approach Delay	30.5		9.1			20.9	
Approach LOS	C		A			C	
Queue Length 50th (ft)	75	0	71	0	2	192	
Queue Length 95th (ft)	#208	18	216	23	12	#630	
Internal Link Dist (ft)	100		657			589	
Turn Bay Length (ft)				250	50		
Base Capacity (vph)	426	403	1406	1217	642	1406	
Starvation Cap Reductn	0	0	0	0	0	0	
Spillback Cap Reductn	0	0	0	0	0	0	
Storage Cap Reductn	0	0	0	0	0	0	
Reduced v/c Ratio	0.58	0.07	0.29	0.08	0.02	0.57	

Intersection Summary
Cycle Length: 95
Actuated Cycle Length: 63.2

Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.82
Intersection Signal Delay: 18.8 Intersection LOS: B
Intersection Capacity Utilization 56.8% ICU Level of Service B
Analysis Period (min) 15
\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 13: Rockland St & G W Blvd



Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø3
Lane Configurations							
Volume (vph)	270	32	26	632	62	25	
Satd. Flow (prot)	1749	1487	1728	1818	2025	1812	
Flt Permitted			0.526		0.950		
Satd. Flow (perm)	1749	1487	957	1818	2025	1766	
Satd. Flow (RTOR)		37				30	
Confl. Peds. (#/hr)						1	
Peak Hour Factor	0.92	0.92	0.93	0.93	0.87	0.87	
Growth Factor	105%	105%	105%	105%	105%	105%	
Heavy Vehicles (%)	5%	5%	1%	1%	1%	1%	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	308	37	29	714	75	30	
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm	
Protected Phases	2		1	6	4		3
Permitted Phases		2	6			4	
Detector Phase	2	2	1	6	4	4	
Switch Phase							
Minimum Initial (s)	40.0	40.0	4.0	40.0	8.0	8.0	4.0
Minimum Split (s)	46.0	46.0	8.0	46.0	13.0	13.0	21.0
Total Split (s)	66.0	66.0	8.0	74.0	15.0	15.0	21.0
Total Split (%)	60.0%	60.0%	7.3%	67.3%	13.6%	13.6%	19%
Yellow Time (s)	4.0	4.0	3.0	4.0	3.0	3.0	2.0
All-Red Time (s)	2.0	2.0	1.0	2.0	2.0	2.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	6.0	6.0	4.0	6.0	5.0	5.0	
Lead/Lag	Lag	Lag	Lead		Lag	Lag	Lead
Lead-Lag Optimize?	Yes	Yes	Yes		Yes	Yes	Yes
Recall Mode	Min	Min	None	None	None	None	None
Act Effct Green (s)	46.2	46.2	49.7	49.0	9.0	9.0	
Actuated g/C Ratio	0.68	0.68	0.73	0.72	0.13	0.13	
v/c Ratio	0.26	0.04	0.04	0.54	0.28	0.12	
Control Delay	8.9	4.1	5.3	9.6	32.8	14.2	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	8.9	4.1	5.3	9.6	32.8	14.2	
LOS	A	A	A	A	C	B	
Approach Delay	8.4			9.4	27.5		
Approach LOS	A			A	C		
Queue Length 50th (ft)	36	0	2	113	24	0	
Queue Length 95th (ft)	172	16	18	413	81	25	
Internal Link Dist (ft)	1154			331	60		
Turn Bay Length (ft)		150	200				
Base Capacity (vph)	1580	1347	746	1722	306	292	
Starvation Cap Reductn	0	0	0	0	0	0	
Spillback Cap Reductn	0	0	0	0	0	0	
Storage Cap Reductn	0	0	0	0	0	0	
Reduced v/c Ratio	0.19	0.03	0.04	0.41	0.25	0.10	

Intersection Summary
Cycle Length: 110

Actuated Cycle Length: 67.9	
Natural Cycle: 90	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.54	
Intersection Signal Delay: 10.7	Intersection LOS: B
Intersection Capacity Utilization 50.8%	ICU Level of Service A
Analysis Period (min) 15	

Splits and Phases: 3: Rockland Cir & G W Blvd

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	2	0	5	15	4	16	1	276	12	22	634	5
Satd. Flow (prot)	0	1703	0	0	1621	1432	1736	3447	0	1787	1879	0
Flt Permitted							0.950			0.950		
Satd. Flow (perm)	0	1721	0	0	1675	1408	1736	3447	0	1726	1879	0
Satd. Flow (RTOR)												
Confl. Peds. (#/hr)	1		1	1		1			4	4		
Peak Hour Factor	0.88	0.88	0.88	0.80	0.80	0.80	0.88	0.88	0.88	0.92	0.92	0.92
Growth Factor	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%
Heavy Vehicles (%)	10%	10%	10%	9%	9%	9%	4%	4%	4%	1%	1%	1%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	8	0	0	25	21	1	343	0	25	730	0
Turn Type	Perm	NA		Perm	NA	Perm	Prot	NA		Prot	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8		8						
Detector Phase	4	4		8	8	8	5	2		1	6	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0	4.0	4.0	33.0		4.0	33.0	
Minimum Split (s)	9.0	9.0		9.0	9.0	9.0	8.0	38.0		8.0	38.0	
Total Split (s)	12.0	12.0		12.0	12.0	12.0	8.0	69.0		8.0	69.0	
Total Split (%)	10.9%	10.9%		10.9%	10.9%	10.9%	7.3%	62.7%		7.3%	62.7%	
Yellow Time (s)	3.0	3.0		3.0	3.0	3.0	3.0	3.0		3.0	3.0	
All-Red Time (s)	2.0	2.0		2.0	2.0	2.0	1.0	2.0		1.0	2.0	
Lost Time Adjust (s)		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Lost Time (s)		5.0			5.0	5.0	4.0	5.0		4.0	5.0	
Lead/Lag							Lead	Lag		Lead	Lag	
Lead-Lag Optimize?							Yes	Yes		Yes	Yes	
Recall Mode	None	None		None	None	None	None	Min		None	Min	
Act Effct Green (s)		6.6			6.9	6.9	4.3	48.1		4.3	48.1	
Actuated g/C Ratio		0.12			0.12	0.12	0.08	0.84		0.08	0.84	
v/c Ratio		0.04			0.12	0.12	0.01	0.12		0.19	0.46	
Control Delay		29.4			29.4	30.0	34.0	4.2		33.8	7.3	
Queue Delay		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Delay		29.4			29.4	30.0	34.0	4.2		33.8	7.3	
LOS		C			C	C	C	A		C	A	
Approach Delay		29.4			29.7			4.3			8.2	
Approach LOS		C			C			A			A	
Queue Length 50th (ft)		2			4	4	0	0		5	0	
Queue Length 95th (ft)		18			35	31	6	71		40	439	
Internal Link Dist (ft)		20			82			386			422	
Turn Bay Length (ft)							50			50		
Base Capacity (vph)		228			222	187	131	3238		135	1765	
Starvation Cap Reductn		0			0	0	0	0		0	0	
Spillback Cap Reductn		0			0	0	0	0		0	0	
Storage Cap Reductn		0			0	0	0	0		0	0	
Reduced v/c Ratio		0.04			0.11	0.11	0.01	0.11		0.19	0.41	

Intersection Summary
Cycle Length: 110

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Satd. Flow (RTOR)	
Confl. Peds. (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	21.0
Total Split (s)	21.0
Total Split (%)	19%
Yellow Time (s)	2.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Actuated Cycle Length: 57.2	
Natural Cycle: 80	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.46	
Intersection Signal Delay: 8.0	Intersection LOS: A
Intersection Capacity Utilization 47.0%	ICU Level of Service A
Analysis Period (min) 15	

Splits and Phases: 7: G W Blvd & Wharf Ave

APPENDIX J

Intersection Capacity Analyses
Weekday PM Peak Hour
Projected 2040 Traffic Conditions with Proposed Improvements

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø3
Lane Configurations							
Volume (vph)	1137	53	298	617	118	412	
Satd. Flow (prot)	3085	0	0	3030	1608	1439	
Flt Permitted				0.516	0.950		
Satd. Flow (perm)	3085	0	0	1589	1572	1439	
Satd. Flow (RTOR)	5					332	
Confl. Peds. (#/hr)		1	1		9		
Peak Hour Factor	0.95	0.95	0.87	0.87	0.81	0.81	
Growth Factor	105%	105%	105%	105%	105%	105%	
Heavy Vehicles (%)	1%	1%	2%	2%	1%	1%	
Adj. Flow (vph)	1257	59	360	745	153	534	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	1316	0	0	1105	153	534	
Turn Type	NA		pm+pt	NA	Prot	pt+ov	
Protected Phases	2		1	6	4	4 1	3
Permitted Phases			6				
Detector Phase	2		1	6	4	4 1	
Switch Phase							
Minimum Initial (s)	8.0		4.0	8.0	9.0		4.0
Minimum Split (s)	13.0		9.0	13.0	14.0		21.0
Total Split (s)	51.0		20.0	71.0	18.0		21.0
Total Split (%)	46.4%		18.2%	64.5%	16.4%		19%
Yellow Time (s)	4.0		4.0	4.0	4.0		2.0
All-Red Time (s)	1.0		1.0	1.0	1.0		0.0
Lost Time Adjust (s)	0.0			0.0	0.0		
Total Lost Time (s)	5.0			5.0	5.0		
Lead/Lag	Lead		Lag		Lag		Lead
Lead-Lag Optimize?	Yes		Yes		Yes		Yes
Recall Mode	Min		None	Min	None		None
Act Effct Green (s)	46.5			65.3	12.4	30.4	
Actuated g/C Ratio	0.51			0.72	0.14	0.33	
v/c Ratio	0.84			1.08dl	0.70	0.76	
Control Delay	27.0			20.0	57.9	17.7	
Queue Delay	0.0			0.0	0.0	0.0	
Total Delay	27.0			20.0	57.9	17.7	
LOS	C			C	E	B	
Approach Delay	27.0			20.0	26.7		
Approach LOS	C			C	C		
Queue Length 50th (ft)	309			108	82	90	
Queue Length 95th (ft)	#656			#338	#181	142	
Internal Link Dist (ft)	764			218	85		
Turn Bay Length (ft)							
Base Capacity (vph)	1573			1377	231	709	
Starvation Cap Reductn	0			0	0	0	
Spillback Cap Reductn	0			0	0	0	
Storage Cap Reductn	0			0	0	0	
Reduced v/c Ratio	0.84			0.80	0.66	0.75	

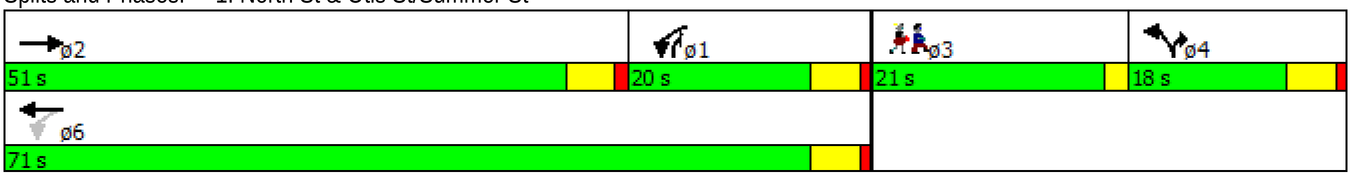
Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 91.3
Natural Cycle: 110
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.84

Intersection Signal Delay: 24.4	Intersection LOS: C
Intersection Capacity Utilization 88.8%	ICU Level of Service E

Analysis Period (min) 15
\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.
dl Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 1: North St & Otis St/Summer St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	753	824	43	508	0	408	10	14	10	5	25
Satd. Flow (prot)	1711	3455	1546	1711	3421	0	1681	1621	0	0	1745	1531
Flt Permitted	0.373			0.199			0.950	0.957			0.969	
Satd. Flow (perm)	672	3455	1546	358	3421	0	1681	1621	0	0	1745	1531
Satd. Flow (RTOR)			759					3				139
Peak Hour Factor	0.92	0.87	0.87	0.80	0.80	0.92	0.85	0.92	0.85	0.92	0.92	0.92
Growth Factor	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%
Heavy Vehicles (%)	2%	1%	1%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Adj. Flow (vph)	11	909	994	56	667	0	504	11	17	11	6	29
Shared Lane Traffic (%)							47%					
Lane Group Flow (vph)	11	909	994	56	667	0	267	265	0	0	17	29
Turn Type	pm+pt	NA	Perm	pm+pt	NA		Split	NA		Split	NA	Perm
Protected Phases	5	2		1	6		7	7		8	8	
Permitted Phases	2		2	6								8
Detector Phase	5	2	2	1	6		7	7		8	8	8
Switch Phase												
Minimum Initial (s)	4.0	4.0	4.0	4.0	4.0		4.0	4.0		4.0	4.0	4.0
Minimum Split (s)	8.0	20.0	20.0	8.0	20.0		9.0	9.0		9.0	9.0	9.0
Total Split (s)	8.0	46.0	46.0	8.0	46.0		23.0	23.0		9.0	9.0	9.0
Total Split (%)	7.3%	41.8%	41.8%	7.3%	41.8%		20.9%	20.9%		8.2%	8.2%	8.2%
Yellow Time (s)	3.0	4.0	4.0	3.0	4.0		4.0	4.0		4.0	4.0	4.0
All-Red Time (s)	1.0	1.0	1.0	1.0	1.0		1.0	1.0		1.0	1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0		0.0	0.0			0.0	0.0
Total Lost Time (s)	4.0	5.0	5.0	4.0	5.0		5.0	5.0			5.0	5.0
Lead/Lag	Lead	Lag	Lag	Lead	Lag		Lead	Lead		Lag	Lag	Lag
Lead-Lag Optimize?	Yes	Yes	Yes	Yes	Yes		Yes	Yes		Yes	Yes	Yes
Recall Mode	None	Min	Min	Min	Min		None	None		None	None	None
Act Effct Green (s)	43.1	38.0	38.0	46.6	45.0		18.6	18.6			4.1	4.1
Actuated g/C Ratio	0.52	0.46	0.46	0.56	0.54		0.22	0.22			0.05	0.05
v/c Ratio	0.03	0.58	0.89	0.21	0.36		0.71	0.73			0.20	0.14
Control Delay	11.5	19.6	17.1	12.4	13.8		45.6	46.5			49.6	1.4
Queue Delay	0.0	0.0	0.0	0.0	0.0		0.0	0.0			0.0	0.0
Total Delay	11.5	19.6	17.1	12.4	13.8		45.6	46.5			49.6	1.4
LOS	B	B	B	B	B		D	D			D	A
Approach Delay		18.3			13.7			46.1			19.2	
Approach LOS		B			B			D			B	
Queue Length 50th (ft)	2	175	90	12	94		144	142			9	0
Queue Length 95th (ft)	14	316	#501	37	197		#318	#355			35	0
Internal Link Dist (ft)		630			618			73			1	
Turn Bay Length (ft)	100		150	100								
Base Capacity (vph)	400	1760	1160	268	1939		375	364			86	208
Starvation Cap Reductn	0	0	0	0	0		0	0			0	0
Spillback Cap Reductn	0	0	0	0	0		0	0			0	0
Storage Cap Reductn	0	0	0	0	0		0	0			0	0
Reduced v/c Ratio	0.03	0.52	0.86	0.21	0.34		0.71	0.73			0.20	0.14

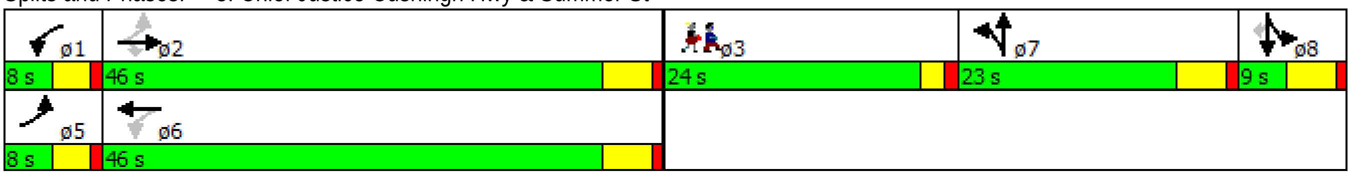
Intersection Summary
Cycle Length: 110

Lane Group	ø3
Lane Configurations	
Volume (vph)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Satd. Flow (RTOR)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Adj. Flow (vph)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	3
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	24.0
Total Split (s)	24.0
Total Split (%)	22%
Yellow Time (s)	2.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Actuated Cycle Length: 83
Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.89
Intersection Signal Delay: 21.9 Intersection LOS: C
Intersection Capacity Utilization 71.9% ICU Level of Service C
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 3: Chief Justice Cushingh Hwy & Summer St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	58	745	24	110	474	8	15	29	85	7	23	30
Satd. Flow (prot)	1728	3435	0	1694	1780	0	0	1831	1583	0	2028	1743
Flt Permitted	0.309			0.232				0.884			0.926	
Satd. Flow (perm)	562	3435	0	413	1780	0	0	1647	1561	0	1898	1743
Satd. Flow (RTOR)												
Confl. Peds. (#/hr)			2	2					1	1		
Peak Hour Factor	0.91	0.91	0.91	0.83	0.83	0.83	0.75	0.75	0.75	0.88	0.88	0.88
Growth Factor	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%
Heavy Vehicles (%)	1%	1%	1%	3%	3%	3%	2%	2%	2%	5%	5%	5%
Adj. Flow (vph)	67	860	28	139	600	10	21	41	119	8	27	36
Shared Lane Traffic (%)												
Lane Group Flow (vph)	67	888	0	139	610	0	0	62	119	0	35	36
Turn Type	pm+pt	NA		pm+pt	NA		Perm	NA	Perm	Perm	NA	Perm
Protected Phases	5	2		1	6			3			3	
Permitted Phases	2			6			3		3	3		3
Detector Phase	5	2		1	6		3	3	3	3	3	3
Switch Phase												
Minimum Initial (s)	4.0	15.0		4.0	15.0		8.0	8.0	8.0	8.0	8.0	8.0
Minimum Split (s)	8.0	20.0		8.0	20.0		13.0	13.0	13.0	13.0	13.0	13.0
Total Split (s)	10.0	57.0		10.0	57.0		20.0	20.0	20.0	20.0	20.0	20.0
Total Split (%)	9.1%	51.8%		9.1%	51.8%		18.2%	18.2%	18.2%	18.2%	18.2%	18.2%
Yellow Time (s)	3.0	4.0		3.0	4.0		4.0	4.0	4.0	4.0	4.0	4.0
All-Red Time (s)	1.0	1.0		1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0
Lost Time Adjust (s)	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Lost Time (s)	4.0	5.0		4.0	5.0			5.0	5.0		5.0	5.0
Lead/Lag	Lead	Lag		Lead	Lag							
Lead-Lag Optimize?	Yes	Yes		Yes	Yes							
Recall Mode	None	Min		Min	Min		None	None	None	None	None	None
Act Effct Green (s)	37.7	30.2		39.8	36.2			12.7	12.7		12.7	12.7
Actuated g/C Ratio	0.60	0.48		0.63	0.57			0.20	0.20		0.20	0.20
v/c Ratio	0.15	0.54		0.35	0.60			0.19	0.38		0.09	0.10
Control Delay	7.5	14.8		9.7	18.2			31.1	34.0		30.5	30.7
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Delay	7.5	14.8		9.7	18.2			31.1	34.0		30.5	30.7
LOS	A	B		A	B			C	C		C	C
Approach Delay		14.3			16.6			33.0			30.6	
Approach LOS		B			B			C			C	
Queue Length 50th (ft)	7	112		15	165			19	37		10	11
Queue Length 95th (ft)	40	287		68	416			67	116		52	53
Internal Link Dist (ft)		378			358			249			637	
Turn Bay Length (ft)	150			150					50			75
Base Capacity (vph)	473	2844		404	1473			464	440		535	491
Starvation Cap Reductn	0	0		0	0			0	0		0	0
Spillback Cap Reductn	0	0		0	0			0	0		0	0
Storage Cap Reductn	0	0		0	0			0	0		0	0
Reduced v/c Ratio	0.14	0.31		0.34	0.41			0.13	0.27		0.07	0.07

Intersection Summary

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Satd. Flow (RTOR)	
Confl. Peds. (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Adj. Flow (vph)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	21%
Yellow Time (s)	2.0
All-Red Time (s)	0.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 63.3
Natural Cycle: 80
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.60
Intersection Signal Delay: 17.5 Intersection LOS: B
Intersection Capacity Utilization 52.5% ICU Level of Service A
Analysis Period (min) 15

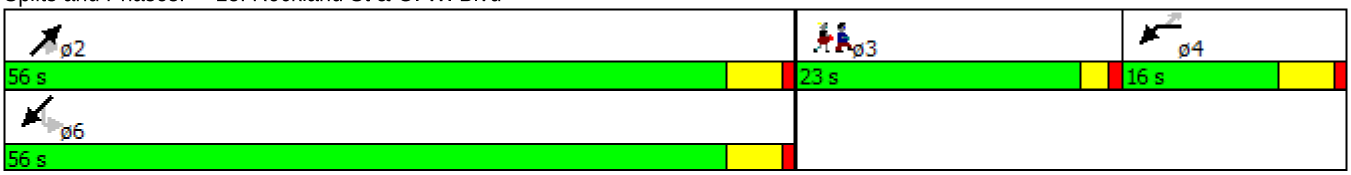
Splits and Phases: 4: Summer St & Rockland St & Martins Ln

Lane Group	WBL	WBR	NET	NER	SWL	SWT	ø3
Lane Configurations							
Volume (vph)	106	23	665	177	18	481	
Satd. Flow (prot)	1662	1487	1801	1531	1711	1801	
Flt Permitted	0.950				0.187		
Satd. Flow (perm)	1662	1487	1801	1531	337	1801	
Satd. Flow (RTOR)		28		206			
Peak Hour Factor	0.85	0.85	0.90	0.90	0.83	0.83	
Growth Factor	105%	105%	105%	105%	105%	105%	
Heavy Vehicles (%)	5%	5%	2%	2%	2%	2%	
Adj. Flow (vph)	131	28	776	206	23	608	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	131	28	776	206	23	608	
Turn Type	Prot	Perm	NA	Perm	Perm	NA	
Protected Phases	4		2			6	3
Permitted Phases		4		2	6		
Detector Phase	4	4	2	2	6	6	
Switch Phase							
Minimum Initial (s)	7.0	7.0	7.0	7.0	7.0	7.0	4.0
Minimum Split (s)	12.0	12.0	12.0	12.0	12.0	12.0	23.0
Total Split (s)	16.0	16.0	56.0	56.0	56.0	56.0	23.0
Total Split (%)	16.8%	16.8%	58.9%	58.9%	58.9%	58.9%	24%
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	2.0
All-Red Time (s)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	5.0	5.0	5.0	5.0	5.0	5.0	
Lead/Lag	Lag	Lag					Lead
Lead-Lag Optimize?	Yes	Yes					Yes
Recall Mode	Min	Min	None	None	None	None	None
Act Effct Green (s)	11.4	11.4	30.2	30.2	30.2	30.2	
Actuated g/C Ratio	0.21	0.21	0.55	0.55	0.55	0.55	
v/c Ratio	0.38	0.08	0.78	0.22	0.12	0.61	
Control Delay	29.2	13.3	17.2	2.0	9.0	12.1	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	29.2	13.3	17.2	2.0	9.0	12.1	
LOS	C	B	B	A	A	B	
Approach Delay	26.4		14.0			12.0	
Approach LOS	C		B			B	
Queue Length 50th (ft)	32	0	142	0	3	96	
Queue Length 95th (ft)	#135	23	483	29	18	281	
Internal Link Dist (ft)	100		657			589	
Turn Bay Length (ft)				250	50		
Base Capacity (vph)	366	349	1622	1400	303	1622	
Starvation Cap Reductn	0	0	0	0	0	0	
Spillback Cap Reductn	0	0	0	0	0	0	
Storage Cap Reductn	0	0	0	0	0	0	
Reduced v/c Ratio	0.36	0.08	0.48	0.15	0.08	0.37	

Intersection Summary
Cycle Length: 95

Actuated Cycle Length: 54.9	
Natural Cycle: 75	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.78	
Intersection Signal Delay: 14.4	Intersection LOS: B
Intersection Capacity Utilization 51.2%	ICU Level of Service A
Analysis Period (min) 15	
# 95th percentile volume exceeds capacity, queue may be longer.	
Queue shown is maximum after two cycles.	

Splits and Phases: 13: Rockland St & G. W. Blvd



Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø3
Lane Configurations							
Volume (vph)	595	83	34	402	50	22	
Satd. Flow (prot)	1818	1546	1728	1818	2025	1812	
Flt Permitted			0.267		0.950		
Satd. Flow (perm)	1818	1546	486	1818	2025	1812	
Satd. Flow (RTOR)		73				32	
Peak Hour Factor	0.89	0.89	0.92	0.92	0.72	0.72	
Growth Factor	105%	105%	105%	105%	105%	105%	
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	
Adj. Flow (vph)	702	98	39	459	73	32	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	702	98	39	459	73	32	
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm	
Protected Phases	2		1	6	4		3
Permitted Phases		2	6			4	
Detector Phase	2	2	1	6	4	4	
Switch Phase							
Minimum Initial (s)	8.0	8.0	4.0	8.0	8.0	8.0	4.0
Minimum Split (s)	46.0	46.0	8.0	46.0	13.0	13.0	21.0
Total Split (s)	68.0	68.0	8.0	76.0	13.0	13.0	21.0
Total Split (%)	61.8%	61.8%	7.3%	69.1%	11.8%	11.8%	19%
Yellow Time (s)	4.0	4.0	3.0	4.0	3.0	3.0	2.0
All-Red Time (s)	2.0	2.0	1.0	2.0	2.0	2.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	6.0	6.0	4.0	6.0	5.0	5.0	
Lead/Lag	Lag	Lag	Lead		Lag	Lag	Lead
Lead-Lag Optimize?	Yes	Yes	Yes		Yes	Yes	Yes
Recall Mode	Min	Min	None	None	None	None	None
Act Effct Green (s)	34.9	34.9	37.7	37.6	8.5	8.5	
Actuated g/C Ratio	0.68	0.68	0.73	0.73	0.17	0.17	
v/c Ratio	0.57	0.09	0.09	0.35	0.22	0.10	
Control Delay	9.9	2.7	2.9	4.8	24.9	11.1	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	9.9	2.7	2.9	4.8	24.9	11.1	
LOS	A	A	A	A	C	B	
Approach Delay	9.0			4.6	20.7		
Approach LOS	A			A	C		
Queue Length 50th (ft)	104	2	3	56	20	0	
Queue Length 95th (ft)	268	19	8	91	48	15	
Internal Link Dist (ft)	1154			331	60		
Turn Bay Length (ft)		150	200				
Base Capacity (vph)	1801	1532	458	1818	334	326	
Starvation Cap Reductn	0	0	0	0	0	0	
Spillback Cap Reductn	0	0	0	0	0	0	
Storage Cap Reductn	0	0	0	0	0	0	
Reduced v/c Ratio	0.39	0.06	0.09	0.25	0.22	0.10	

Intersection Summary
Cycle Length: 110

Actuated Cycle Length: 51.5
Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.57
Intersection Signal Delay: 8.4 Intersection LOS: A
Intersection Capacity Utilization 48.7% ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 3: Rockland Cir & G W Blvd

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	13	6	7	35	2	15	5	593	13	17	402	10
Satd. Flow (prot)	0	1920	0	0	1609	1432	1736	3459	0	1608	1874	0
Flt Permitted		0.814			0.778		0.950			0.950		
Satd. Flow (perm)	0	1599	0	0	1307	1412	1736	3459	0	1596	1874	0
Satd. Flow (RTOR)												
Confl. Peds. (#/hr)	1		1	1		1			2	2		
Peak Hour Factor	0.65	0.65	0.65	0.72	0.72	0.72	0.92	0.92	0.92	0.95	0.95	0.95
Growth Factor	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%
Heavy Vehicles (%)	5%	5%	5%	9%	9%	9%	4%	4%	4%	1%	1%	1%
Parking (#/hr)										0		
Adj. Flow (vph)	21	10	11	51	3	22	6	677	15	19	444	11
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	42	0	0	54	22	6	692	0	19	455	0
Turn Type	Perm	NA		Perm	NA	Perm	Prot	NA		Prot	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8		8						
Detector Phase	4	4		8	8	8	5	2		1	6	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0	4.0	4.0	8.0		4.0	8.0	
Minimum Split (s)	9.0	9.0		9.0	9.0	9.0	8.0	38.0		8.0	38.0	
Total Split (s)	22.0	22.0		22.0	22.0	22.0	10.0	64.0		10.0	64.0	
Total Split (%)	18.6%	18.6%		18.6%	18.6%	18.6%	8.5%	54.2%		8.5%	54.2%	
Yellow Time (s)	3.0	3.0		3.0	3.0	3.0	3.5	3.0		3.5	3.0	
All-Red Time (s)	2.0	2.0		2.0	2.0	2.0	0.5	2.0		0.5	2.0	
Lost Time Adjust (s)		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Lost Time (s)		5.0			5.0	5.0	4.0	5.0		4.0	5.0	
Lead/Lag							Lead	Lag		Lead	Lag	
Lead-Lag Optimize?							Yes	Yes		Yes	Yes	
Recall Mode	None	None		None	None	None	None	Min		None	Min	
Act Effct Green (s)		8.3			8.5	8.5	6.5	27.9		6.7	27.9	
Actuated g/C Ratio		0.20			0.20	0.20	0.16	0.67		0.16	0.67	
v/c Ratio		0.13			0.20	0.08	0.02	0.30		0.07	0.36	
Control Delay		20.2			21.2	20.4	24.2	8.6		23.9	10.4	
Queue Delay		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Delay		20.2			21.2	20.4	24.2	8.6		23.9	10.4	
LOS		C			C	C	C	A		C	B	
Approach Delay		20.2			21.0			8.7			10.9	
Approach LOS		C			C			A			B	
Queue Length 50th (ft)		6			8	3	1	35		3	47	
Queue Length 95th (ft)		33			45	24	15	186		30	278	
Internal Link Dist (ft)		20			82			386			422	
Turn Bay Length (ft)							50			50		
Base Capacity (vph)		755			617	667	289	3274		268	1774	
Starvation Cap Reductn		0			0	0	0	0		0	0	
Spillback Cap Reductn		0			0	0	0	0		0	0	
Storage Cap Reductn		0			0	0	0	0		0	0	
Reduced v/c Ratio		0.06			0.09	0.03	0.02	0.21		0.07	0.26	

Intersection Summary

Cycle Length: 118	
Actuated Cycle Length: 41.6	
Natural Cycle: 80	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.36	
Intersection Signal Delay: 10.6	Intersection LOS: B
Intersection Capacity Utilization 39.4%	ICU Level of Service A
Analysis Period (min) 15	

Splits and Phases: 7: G W Blvd & Wharf Ave

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Satd. Flow (RTOR)	
Confl. Peds. (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Parking (#/hr)	
Adj. Flow (vph)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	22.0
Total Split (s)	22.0
Total Split (%)	19%
Yellow Time (s)	2.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

APPENDIX K

Intersection Capacity Analyses
Summer Saturday Midday Peak Hour
Projected 2040 Traffic Conditions with Proposed Improvements

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø3
Lane Configurations							
Volume (vph)	1261	67	316	777	200	567	
Satd. Flow (prot)	3080	0	0	2884	1608	1439	
Flt Permitted				0.521	0.950		
Satd. Flow (perm)	3080	0	0	1524	1442	1439	
Satd. Flow (RTOR)	5					308	
Confl. Peds. (#/hr)		7	7		49	18	
Peak Hour Factor	0.94	0.94	0.93	0.93	0.94	0.94	
Growth Factor	105%	105%	105%	105%	105%	105%	
Heavy Vehicles (%)	1%	1%	2%	2%	1%	1%	
Parking (#/hr)				0			
Shared Lane Traffic (%)							
Lane Group Flow (vph)	1484	0	0	1234	223	633	
Turn Type	NA		pm+pt	NA	Prot	pt+ov	
Protected Phases	2		1	6	4	4 1	3
Permitted Phases			6				
Detector Phase	2		1	6	4	4 1	
Switch Phase							
Minimum Initial (s)	8.0		4.0	8.0	9.0		4.0
Minimum Split (s)	13.0		9.0	13.0	14.0		21.0
Total Split (s)	55.0		22.0	77.0	22.0		21.0
Total Split (%)	45.8%		18.3%	64.2%	18.3%		18%
Yellow Time (s)	4.0		4.0	4.0	4.0		2.0
All-Red Time (s)	1.0		1.0	1.0	1.0		0.0
Lost Time Adjust (s)	0.0			0.0	0.0		
Total Lost Time (s)	5.0			5.0	5.0		
Lead/Lag	Lead		Lag		Lag		Lead
Lead-Lag Optimize?	Yes		Yes		Yes		Yes
Recall Mode	Min		None	Min	None		None
Act Effct Green (s)	50.4			72.6	17.2	37.6	
Actuated g/C Ratio	0.47			0.68	0.16	0.35	
v/c Ratio	1.02			1.30dl	0.87	0.90	
Control Delay	59.5			46.5	77.2	33.2	
Queue Delay	0.0			0.0	0.0	0.0	
Total Delay	59.5			46.5	77.2	33.2	
LOS	E			D	E	C	
Approach Delay	59.5			46.5	44.7		
Approach LOS	E			D	D		
Queue Length 50th (ft)	448			165	137	195	
Queue Length 95th (ft)	#856			#631	#335	#391	
Internal Link Dist (ft)	764			213	85		
Turn Bay Length (ft)							
Base Capacity (vph)	1449			1247	256	703	
Starvation Cap Reductn	0			0	0	0	
Spillback Cap Reductn	0			0	0	0	
Storage Cap Reductn	0			0	0	0	
Reduced v/c Ratio	1.02			0.99	0.87	0.90	

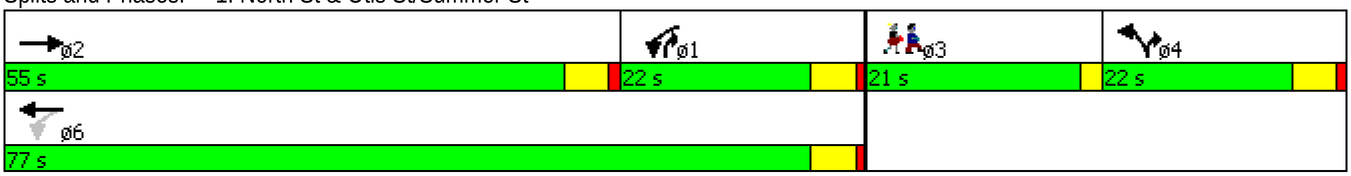
Intersection Summary

Cycle Length: 120
Actuated Cycle Length: 107.4
Natural Cycle: 130
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.02

Intersection Signal Delay: 51.5	Intersection LOS: D
Intersection Capacity Utilization 104.4%	ICU Level of Service G

Analysis Period (min) 15
\#   95th percentile volume exceeds capacity, queue may be longer.
    Queue shown is maximum after two cycles.
dl   Defacto Left Lane. Recode with 1 though lane as a left lane.

Splits and Phases: 1: North St & Otis St/Summer St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	SEL	SET	SER	NWL	NWT	NWR
Lane Configurations												
Volume (vph)	40	1357	501	48	679	10	10	10	40	387	10	4
Satd. Flow (prot)	1711	3455	1546	1728	3448	0	0	1757	1531	1698	1644	0
Flt Permitted	0.264			0.089				0.976		0.950	0.955	
Satd. Flow (perm)	475	3455	1546	162	3448	0	0	1757	1531	1698	1644	0
Satd. Flow (RTOR)			256		1				139		1	
Peak Hour Factor	0.92	0.94	0.94	0.85	0.85	0.92	0.92	0.92	0.92	0.85	0.92	0.85
Growth Factor	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%
Heavy Vehicles (%)	2%	1%	1%	1%	1%	2%	2%	2%	2%	1%	2%	1%
Shared Lane Traffic (%)										48%		
Lane Group Flow (vph)	46	1516	560	59	850	0	0	22	46	249	245	0
Turn Type	pm+pt	NA	Perm	pm+pt	NA		Split	NA	Perm	Split	NA	
Protected Phases	5	2		1	6		4	4		8	8	
Permitted Phases	2		2	6					4			
Detector Phase	5	2	2	1	6		4	4	4	8	8	
Switch Phase												
Minimum Initial (s)	4.0	8.0	8.0	4.0	8.0		4.0	4.0	4.0	8.0	8.0	
Minimum Split (s)	8.0	13.0	13.0	8.0	13.0		9.0	9.0	9.0	13.0	13.0	
Total Split (s)	8.0	46.0	46.0	8.0	46.0		9.0	9.0	9.0	23.0	23.0	
Total Split (%)	7.3%	41.8%	41.8%	7.3%	41.8%		8.2%	8.2%	8.2%	20.9%	20.9%	
Yellow Time (s)	3.0	4.0	4.0	3.0	4.0		4.0	4.0	4.0	4.0	4.0	
All-Red Time (s)	1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	
Total Lost Time (s)	4.0	5.0	5.0	4.0	5.0			5.0	5.0	5.0	5.0	
Lead/Lag	Lead	Lag	Lag	Lead	Lag		Lag	Lag	Lag			
Lead-Lag Optimize?												
Recall Mode	None	Min	Min	Min	Min		None	None	None	None	None	
Act Effct Green (s)	46.6	41.5	41.5	48.4	45.1			4.1	4.1	17.3	17.3	
Actuated g/C Ratio	0.53	0.48	0.48	0.56	0.52			0.05	0.05	0.20	0.20	
v/c Ratio	0.15	0.92	0.64	0.36	0.48			0.27	0.23	0.74	0.75	
Control Delay	12.0	33.8	14.5	17.3	17.4			52.6	2.6	49.4	50.5	
Queue Delay	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	
Total Delay	12.0	33.8	14.5	17.3	17.4			52.6	2.6	49.4	50.5	
LOS	B	C	B	B	B			D	A	D	D	
Approach Delay		28.2			17.4			18.8			49.9	
Approach LOS		C			B			B			D	
Queue Length 50th (ft)	10	385	112	13	161			12	0	132	129	
Queue Length 95th (ft)	36	#758	318	41	282			41	0	#288	#318	
Internal Link Dist (ft)		610			627			20			83	
Turn Bay Length (ft)	100		150	100								
Base Capacity (vph)	311	1646	870	162	1782			81	203	355	344	
Starvation Cap Reductn	0	0	0	0	0			0	0	0	0	
Spillback Cap Reductn	0	0	0	0	0			0	0	0	0	
Storage Cap Reductn	0	0	0	0	0			0	0	0	0	
Reduced v/c Ratio	0.15	0.92	0.64	0.36	0.48			0.27	0.23	0.70	0.71	

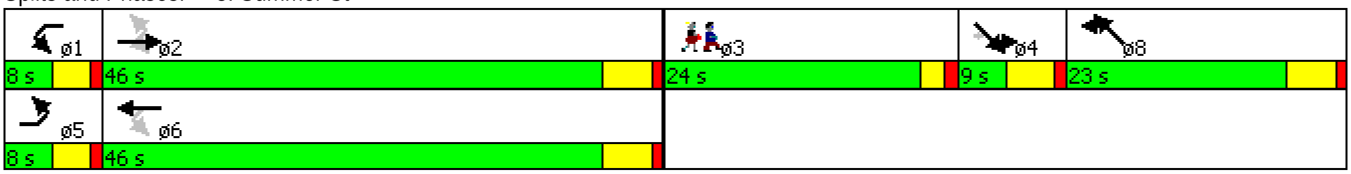
Intersection Summary
Cycle Length: 110
Actuated Cycle Length: 87.2

Lane Group	ø3
Lane Configurations	
Volume (vph)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Satd. Flow (RTOR)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	3
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	24.0
Total Split (s)	24.0
Total Split (%)	22%
Yellow Time (s)	2.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	Lead
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Natural Cycle: 110
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.92
Intersection Signal Delay: 28.3 Intersection LOS: C
Intersection Capacity Utilization 68.5% ICU Level of Service C
Analysis Period (min) 15
\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 3: Summer St



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	55	1344	25	112	693	7	17	28	104	7	25	22
Satd. Flow (prot)	1728	3443	0	1728	1817	0	0	1866	1615	0	2088	1794
Flt Permitted	0.228			0.087				0.861			0.922	
Satd. Flow (perm)	415	3443	0	158	1817	0	0	1636	1615	0	1945	1794
Satd. Flow (RTOR)												
Confl. Peds. (#/hr)			2	2					1	1		
Peak Hour Factor	0.95	0.95	0.95	0.89	0.89	0.89	0.85	0.85	0.85	0.90	0.90	0.90
Growth Factor	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	0%	0%	0%	2%	2%	2%
Shared Lane Traffic (%)												
Lane Group Flow (vph)	61	1513	0	132	826	0	0	56	128	0	37	26
Turn Type	pm+pt	NA		pm+pt	NA		Perm	NA	pt+ov	Perm	NA	Prot
Protected Phases	5	2		1	6			3	3 1		3	3
Permitted Phases	2			6			3			3		
Detector Phase	5	2		1	6		3	3	3 1	3	3	3
Switch Phase												
Minimum Initial (s)	4.0	15.0		4.0	15.0		8.0	8.0		8.0	8.0	8.0
Minimum Split (s)	8.0	20.0		8.0	20.0		13.0	13.0		13.0	13.0	13.0
Total Split (s)	8.0	63.0		11.0	66.0		13.0	13.0		13.0	13.0	13.0
Total Split (%)	7.3%	57.3%		10.0%	60.0%		11.8%	11.8%		11.8%	11.8%	11.8%
Yellow Time (s)	3.5	4.0		3.0	4.0		4.0	4.0		4.0	4.0	4.0
All-Red Time (s)	0.5	1.0		1.0	1.0		1.0	1.0		1.0	1.0	1.0
Lost Time Adjust (s)	0.0	0.0		0.0	0.0			0.0			0.0	0.0
Total Lost Time (s)	4.0	5.0		4.0	5.0			5.0			5.0	5.0
Lead/Lag	Lead	Lag		Lead	Lag							
Lead-Lag Optimize?	Yes	Yes		Yes	Yes							
Recall Mode	None	Min		Min	Min		None	None		None	None	None
Act Effct Green (s)	52.6	47.4		58.4	52.1			8.3	18.5		8.3	8.3
Actuated g/C Ratio	0.65	0.59		0.73	0.65			0.10	0.23		0.10	0.10
v/c Ratio	0.18	0.74		0.54	0.70			0.33	0.35		0.18	0.14
Control Delay	5.7	15.9		17.9	15.5			45.6	29.9		42.2	42.0
Queue Delay	0.0	0.0		0.0	0.0			0.0	0.0		0.0	0.0
Total Delay	5.7	15.9		17.9	15.5			45.6	29.9		42.2	42.0
LOS	A	B		B	B			D	C		D	D
Approach Delay		15.6			15.8			34.7			42.1	
Approach LOS		B			B			C			D	
Queue Length 50th (ft)	5	227		11	211			25	50		17	12
Queue Length 95th (ft)	31	558		#101	629			76	98		59	46
Internal Link Dist (ft)		424			358			249			637	
Turn Bay Length (ft)	150			150					50			75
Base Capacity (vph)	339	2584		257	1434			169	382		201	185
Starvation Cap Reductn	0	0		0	0			0	0		0	0
Spillback Cap Reductn	0	0		0	0			0	0		0	0
Storage Cap Reductn	0	0		0	0			0	0		0	0
Reduced v/c Ratio	0.18	0.59		0.51	0.58			0.33	0.34		0.18	0.14

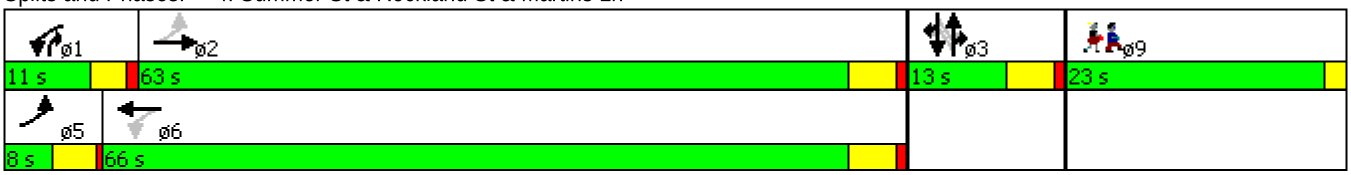
Intersection Summary
Cycle Length: 110

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Satd. Flow (RTOR)	
Confl. Peds. (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	23.0
Total Split (s)	23.0
Total Split (%)	21%
Yellow Time (s)	2.0
All-Red Time (s)	0.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Actuated Cycle Length: 80.4
Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.74
Intersection Signal Delay: 17.5 Intersection LOS: B
Intersection Capacity Utilization 67.2% ICU Level of Service C
Analysis Period (min) 15
\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 4: Summer St & Rockland St & Martins Ln



Lane Group	WBL	WBR	NET	NER	SWL	SWT	ø3
Lane Configurations							
Volume (vph)	26	129	1223	202	23	718	
Satd. Flow (prot)	1728	1546	1818	1546	1728	1818	
Flt Permitted	0.950				0.072		
Satd. Flow (perm)	1728	1546	1818	1546	131	1818	
Satd. Flow (RTOR)		154		134			
Peak Hour Factor	0.88	0.88	0.92	0.92	0.88	0.88	
Growth Factor	105%	105%	105%	105%	105%	105%	
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	31	154	1396	231	27	857	
Turn Type	Prot	Perm	NA	Perm	Perm	NA	
Protected Phases	4		2			6	3
Permitted Phases		4		2	6		
Detector Phase	4	4	2	2	6	6	
Switch Phase							
Minimum Initial (s)	7.0	7.0	7.0	7.0	7.0	7.0	4.0
Minimum Split (s)	12.0	12.0	12.0	12.0	12.0	12.0	23.0
Total Split (s)	12.0	12.0	60.0	60.0	60.0	60.0	23.0
Total Split (%)	12.6%	12.6%	63.2%	63.2%	63.2%	63.2%	24%
Yellow Time (s)	4.0	4.0	4.0	4.0	4.0	4.0	2.0
All-Red Time (s)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	5.0	5.0	5.0	5.0	5.0	5.0	
Lead/Lag	Lag	Lag					Lead
Lead-Lag Optimize?	Yes	Yes					Yes
Recall Mode	Min	Min	None	None	None	None	None
Act Effct Green (s)	7.1	7.1	55.5	55.5	55.5	55.5	
Actuated g/C Ratio	0.09	0.09	0.73	0.73	0.73	0.73	
v/c Ratio	0.19	0.54	1.05	0.20	0.28	0.64	
Control Delay	37.4	14.6	52.8	2.6	15.6	9.7	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	37.4	14.6	52.8	2.6	15.6	9.7	
LOS	D	B	D	A	B	A	
Approach Delay	18.5		45.6			9.9	
Approach LOS	B		D			A	
Queue Length 50th (ft)	13	0	~472	8	3	124	
Queue Length 95th (ft)	44	54	#1276	52	32	486	
Internal Link Dist (ft)	100		459			589	
Turn Bay Length (ft)				200	50		
Base Capacity (vph)	161	283	1330	1167	96	1330	
Starvation Cap Reductn	0	0	0	0	0	0	
Spillback Cap Reductn	0	0	0	0	0	0	
Storage Cap Reductn	0	0	0	0	0	0	
Reduced v/c Ratio	0.19	0.54	1.05	0.20	0.28	0.64	

Intersection Summary
Cycle Length: 95
Actuated Cycle Length: 75.8

Natural Cycle: 150
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.05

Intersection Signal Delay: 32.1	Intersection LOS: C
Intersection Capacity Utilization 84.3%	ICU Level of Service E

Analysis Period (min) 15
~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 13:

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	ø3
Lane Configurations							
Volume (vph)	1170	100	25	675	60	25	
Satd. Flow (prot)	1818	1546	1728	1818	2025	1812	
Flt Permitted			0.057		0.950		
Satd. Flow (perm)	1818	1546	104	1818	2025	1812	
Satd. Flow (RTOR)		49				29	
Peak Hour Factor	1.00	0.92	0.92	0.92	0.92	0.92	
Growth Factor	105%	105%	105%	105%	105%	105%	
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	1228	114	29	770	68	29	
Turn Type	NA	Perm	pm+pt	NA	Prot	Perm	
Protected Phases	2		1	6	4		3
Permitted Phases		2	6			4	
Detector Phase	2	2	1	6	4	4	
Switch Phase							
Minimum Initial (s)	40.0	40.0	4.0	40.0	8.0	8.0	4.0
Minimum Split (s)	46.0	46.0	8.0	46.0	13.0	13.0	21.0
Total Split (s)	68.0	68.0	8.0	76.0	13.0	13.0	21.0
Total Split (%)	61.8%	61.8%	7.3%	69.1%	11.8%	11.8%	19%
Yellow Time (s)	4.0	4.0	3.0	4.0	3.0	3.0	2.0
All-Red Time (s)	2.0	2.0	1.0	2.0	2.0	2.0	1.0
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0	0.0	
Total Lost Time (s)	6.0	6.0	4.0	6.0	5.0	5.0	
Lead/Lag	Lag	Lag	Lead		Lag	Lag	Lead
Lead-Lag Optimize?	Yes	Yes	Yes		Yes	Yes	Yes
Recall Mode	Min	Min	None	None	None	None	None
Act Effct Green (s)	67.2	67.2	70.9	70.1	8.1	8.1	
Actuated g/C Ratio	0.76	0.76	0.80	0.79	0.09	0.09	
v/c Ratio	0.89	0.10	0.18	0.53	0.37	0.15	
Control Delay	23.1	4.1	6.3	7.4	46.8	18.2	
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	
Total Delay	23.1	4.1	6.3	7.4	46.8	18.2	
LOS	C	A	A	A	D	B	
Approach Delay	21.5			7.3	38.3		
Approach LOS	C			A	D		
Queue Length 50th (ft)	343	6	2	121	33	0	
Queue Length 95th (ft)	#1276	45	16	424	91	29	
Internal Link Dist (ft)	1154			331	60		
Turn Bay Length (ft)		150	200			25	
Base Capacity (vph)	1382	1187	157	1513	185	192	
Starvation Cap Reductn	0	0	0	0	0	0	
Spillback Cap Reductn	0	0	0	0	0	0	
Storage Cap Reductn	0	0	0	0	0	0	
Reduced v/c Ratio	0.89	0.10	0.18	0.51	0.37	0.15	

Intersection Summary
Cycle Length: 110
Actuated Cycle Length: 88.4

Natural Cycle: 140
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.89
Intersection Signal Delay: 17.2 Intersection LOS: B
Intersection Capacity Utilization 80.5% ICU Level of Service D
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 3: Rockland Cir & G W Blvd

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	10	10	29	138	6	32	18	910	262	23	639	17
Satd. Flow (prot)	0	1665	0	0	1735	1546	1728	3430	0	1608	1872	0
Flt Permitted		0.927			0.752		0.950			0.950		
Satd. Flow (perm)	0	1553	0	0	1196	1487	1545	3430	0	1576	1872	0
Satd. Flow (RTOR)												
Confl. Peds. (#/hr)	16		55	55		16	22		9	9		22
Peak Hour Factor	0.75	0.75	0.75	0.88	0.88	0.88	0.95	0.95	0.95	0.91	0.91	0.91
Growth Factor	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%
Heavy Vehicles (%)	6%	6%	6%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Parking (#/hr)										0		
Shared Lane Traffic (%)												
Lane Group Flow (vph)	0	69	0	0	172	38	20	1296	0	27	757	0
Turn Type	Perm	NA		Perm	NA	Perm	Prot	NA		Prot	NA	
Protected Phases		4			8		5	2		1	6	
Permitted Phases	4			8		8						
Detector Phase	4	4		8	8	8	5	2		1	6	
Switch Phase												
Minimum Initial (s)	4.0	4.0		4.0	4.0	4.0	4.0	8.0		4.0	8.0	
Minimum Split (s)	9.0	9.0		9.0	9.0	9.0	8.0	38.0		8.0	38.0	
Total Split (s)	25.0	25.0		25.0	25.0	25.0	8.0	56.0		8.0	56.0	
Total Split (%)	22.7%	22.7%		22.7%	22.7%	22.7%	7.3%	50.9%		7.3%	50.9%	
Yellow Time (s)	3.0	3.0		3.0	3.0	3.0	3.5	3.0		3.5	3.0	
All-Red Time (s)	2.0	2.0		2.0	2.0	2.0	0.5	2.0		0.5	2.0	
Lost Time Adjust (s)		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Lost Time (s)		5.0			5.0	5.0	4.0	5.0		4.0	5.0	
Lead/Lag							Lead	Lag		Lead	Lag	
Lead-Lag Optimize?							Yes	Yes		Yes	Yes	
Recall Mode	None	None		None	None	None	None	Min		None	Min	
Act Effct Green (s)		18.2			18.2	18.2	4.4	43.9		4.4	45.3	
Actuated g/C Ratio		0.21			0.21	0.21	0.05	0.51		0.05	0.53	
v/c Ratio		0.21			0.67	0.12	0.23	0.73		0.33	0.76	
Control Delay		36.1			51.1	35.5	55.5	21.9		60.0	25.3	
Queue Delay		0.0			0.0	0.0	0.0	0.0		0.0	0.0	
Total Delay		36.1			51.1	35.5	55.5	21.9		60.0	25.3	
LOS		D			D	D	E	C		E	C	
Approach Delay		36.1			48.3			22.4			26.5	
Approach LOS		D			D			C			C	
Queue Length 50th (ft)		38			107	21	13	373		18	362	
Queue Length 95th (ft)		67			#211	50	39	464		#55	#664	
Internal Link Dist (ft)		20			82			386			422	
Turn Bay Length (ft)							100			100		
Base Capacity (vph)		399			307	382	88	2248		82	1243	
Starvation Cap Reductn		0			0	0	0	0		0	0	
Spillback Cap Reductn		0			0	0	0	0		0	0	
Storage Cap Reductn		0			0	0	0	0		0	0	
Reduced v/c Ratio		0.17			0.56	0.10	0.23	0.58		0.33	0.61	

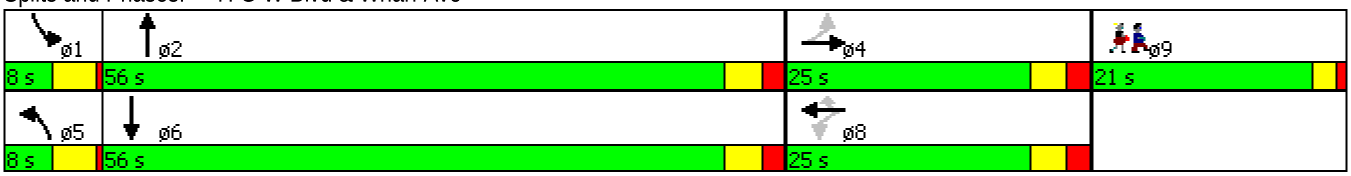
Intersection Summary

Lane Group	ø9
Lane Configurations	
Volume (vph)	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Satd. Flow (RTOR)	
Confl. Peds. (#/hr)	
Peak Hour Factor	
Growth Factor	
Heavy Vehicles (%)	
Parking (#/hr)	
Shared Lane Traffic (%)	
Lane Group Flow (vph)	
Turn Type	
Protected Phases	9
Permitted Phases	
Detector Phase	
Switch Phase	
Minimum Initial (s)	4.0
Minimum Split (s)	21.0
Total Split (s)	21.0
Total Split (%)	19%
Yellow Time (s)	2.0
All-Red Time (s)	1.0
Lost Time Adjust (s)	
Total Lost Time (s)	
Lead/Lag	
Lead-Lag Optimize?	
Recall Mode	None
Act Effct Green (s)	
Actuated g/C Ratio	
v/c Ratio	
Control Delay	
Queue Delay	
Total Delay	
LOS	
Approach Delay	
Approach LOS	
Queue Length 50th (ft)	
Queue Length 95th (ft)	
Internal Link Dist (ft)	
Turn Bay Length (ft)	
Base Capacity (vph)	
Starvation Cap Reductn	
Spillback Cap Reductn	
Storage Cap Reductn	
Reduced v/c Ratio	

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 85.4
Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 26.4 Intersection LOS: C
Intersection Capacity Utilization 59.8% ICU Level of Service B
Analysis Period (min) 15
\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 7: G W Blvd & Wharf Ave

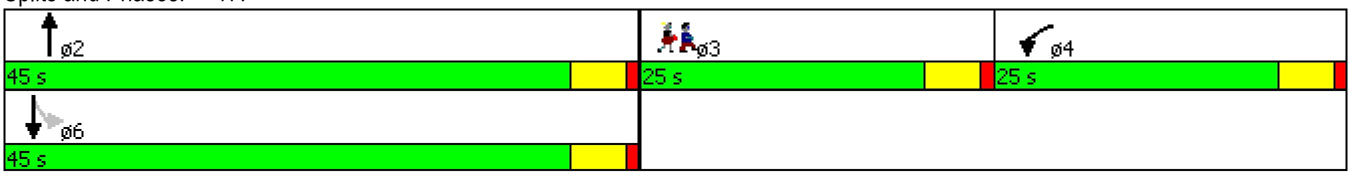


Lane Group	WBL	WBR	NBT	NBR	SBL	SBT	ø3
Lane Configurations							
Volume (vph)	132	98	832	177	76	1212	
Satd. Flow (prot)	1665	0	3365	0	0	3445	
Flt Permitted	0.972					0.714	
Satd. Flow (perm)	1660	0	3365	0	0	2467	
Satd. Flow (RTOR)			33				
Confl. Peds. (#/hr)	4						
Peak Hour Factor	0.91	0.91	0.89	0.89	0.95	0.95	
Growth Factor	105%	105%	105%	105%	105%	105%	
Heavy Vehicles (%)	1%	1%	1%	1%	1%	1%	
Shared Lane Traffic (%)							
Lane Group Flow (vph)	265	0	1191	0	0	1424	
Turn Type	Prot		NA		Perm	NA	
Protected Phases	4		2			6	3
Permitted Phases					6		
Detector Phase	4		2		6	6	
Switch Phase							
Minimum Initial (s)	4.0		40.0		40.0	40.0	4.0
Minimum Split (s)	13.0		45.0		45.0	45.0	25.0
Total Split (s)	25.0		45.0		45.0	45.0	25.0
Total Split (%)	26.3%		47.4%		47.4%	47.4%	26%
Yellow Time (s)	4.0		4.0		4.0	4.0	4.0
All-Red Time (s)	1.0		1.0		1.0	1.0	1.0
Lost Time Adjust (s)	0.0		0.0			0.0	
Total Lost Time (s)	5.0		5.0			5.0	
Lead/Lag	Lag						Lead
Lead-Lag Optimize?	Yes						Yes
Recall Mode	None		Max		Max	Max	None
Act Effct Green (s)	16.7		41.0			41.0	
Actuated g/C Ratio	0.23		0.57			0.57	
v/c Ratio	0.68		0.62			1.01	
Control Delay	36.9		14.1			46.0	
Queue Delay	0.0		0.0			0.0	
Total Delay	36.9		14.1			46.0	
LOS	D		B			D	
Approach Delay	36.9		14.1			46.0	
Approach LOS	D		B			D	
Queue Length 50th (ft)	96		137			260	
Queue Length 95th (ft)	#268		403			#735	
Internal Link Dist (ft)	1		775			511	
Turn Bay Length (ft)							
Base Capacity (vph)	475		1936			1409	
Starvation Cap Reductn	0		0			0	
Spillback Cap Reductn	0		0			0	
Storage Cap Reductn	0		0			0	
Reduced v/c Ratio	0.56		0.62			1.01	

Intersection Summary
Cycle Length: 95

Actuated Cycle Length: 71.7
Natural Cycle: 145
Control Type: Semi Act-Uncoord
Maximum v/c Ratio: 1.01
Intersection Signal Delay: 32.0 Intersection LOS: C
Intersection Capacity Utilization 97.3% ICU Level of Service F
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 17:



APPENDIX L

MassDOT Project Development Process

Overview of the Project Development Process

Transportation decision-making is complex and can be influenced by legislative mandates, environmental regulations, financial limitations, agency programmatic commitments, and partnering opportunities. Decision-makers and reviewing agencies, when consulted early and often throughout the project development process, can ensure that all participants understand the potential impact these factors can have on project implementation. Project development is the process that takes a transportation improvement from concept through construction.

The MassDOT Highway Division has developed a comprehensive project development process which is contained in Chapter 2 of the *MassDOT Highway Division's Project Development and Design Guide*. The eight-step process covers a range of activities extending from identification of a project need, through completion of a set of finished contract plans, to construction of the project. The sequence of decisions made through the project development process progressively narrows the project focus and, ultimately, leads to a project that addresses the identified needs. The descriptions provided below are focused on the process for a highway project, but the same basic process will need to be followed for non-highway projects as well.

1. Needs Identification

For each of the locations at which an improvement is to be implemented, MassDOT leads an effort to define the problem, establishes project goals and objectives, and defines the scope of the planning needed for implementation. To that end, it has to complete a Project Need Form (PNF), which states in general terms the deficiencies or needs related to the transportation facility or location. The PNF documents the problems and explains why corrective action is needed. For this study, the information defining the need for the project will be drawn primarily, perhaps exclusively, from the present report. Also, at this point in the process, MassDOT meets with potential participants, such as the Metropolitan Planning Organization (MPO) and community members, to allow for an informal review of the project.

The PNF is reviewed by the MassDOT Highway Division district office whose jurisdiction includes the location of the proposed project. MassDOT also sends the PNF to the MPO, for informational purposes. The outcome of this step determines whether the project requires further planning, whether it is already well supported by prior planning studies, and, therefore, whether it is ready to move forward into the design phase, or whether it should be dismissed from further consideration.

2. Planning

This phase will likely not be required for the implementation of the improvements proposed in this planning study, as this planning report should constitute the outcome of this step. However, in general, the purpose of this implementation step is for the project proponent to identify issues, impacts, and approvals that may need to be obtained, so that the subsequent design and permitting processes are understood.

The level of planning needed will vary widely, based on the complexity of the project. Typical tasks include: define the existing context, confirm project need, establish goals and objectives, initiate public outreach, define the project, collect data, develop and analyze alternatives, make recommendations, and provide documentation. Likely outcomes include consensus on the project definition to enable it to move forward into environmental documentation (if needed) and design, or a recommendation to delay the project or dismiss it from further consideration.

3. Project Initiation

At this point in the process, the proponent, MassDOT Highway Division, fills out a Project Initiation Form (PIF) for each improvement, which is reviewed by its Project Review Committee (PRC) and the MPO. The PRC is composed of the Chief Engineer, each District Highway Director, and representatives of the Project Management, Environmental, Planning, Right-of-Way, Traffic, and Bridge departments, and the MassDOT Federal Aid Program Office (FAPO). The PIF documents the project type and description, summarizes the project planning process, identifies likely funding and project management responsibility, and defines a plan for interagency and public participation. First the PRC reviews and evaluates the proposed project based on the MassDOT's statewide priorities and criteria. If the result is positive, MassDOT Highway Division moves the project forward to the design phase, and to programming review by the MPO. The PRC may provide a Project Management Plan to define roles and responsibilities for subsequent steps. The MPO review includes project evaluation based on the MPO's regional priorities and criteria. The MPO may assign project evaluation criteria score, a Transportation Improvement Program (TIP) year, a tentative project category, and a tentative funding category.

4. Environmental Permitting, Design, and Right-of-Way Process

This step has four distinct but closely integrated elements: public outreach, environmental documentation and permitting (if required), design, and right-of-way acquisition (if required). The outcome of this step is a fully designed and permitted project ready for construction. However, a project does not have to be fully designed in order for the MPO to program it in the TIP. The sections below provide more detailed information on the four elements of this step of the project development process.

Public Outreach

Continued public outreach in the design and environmental process is essential to maintain public support for the project and to seek meaningful input on the design elements. The public outreach is often in the form of required public hearings, but can also include less formal dialogues with those interested in and affected by a proposed project.

Environmental Documentation and Permitting

The project proponent, in coordination with the Environmental Services section of the MassDOT Highway Division, will be responsible for identifying and complying with all applicable federal, state, and local environmental laws and requirements. This includes determining the appropriate project category for both the Massachusetts Environmental Protection Act (MEPA) and the National Environmental Protection Act (NEPA). Environmental documentation and permitting is often completed in conjunction with the **Preliminary Design** phase described below.

Design
There are three major phases of design. The first is **Preliminary Design**, which is also referred to as the 25-percent submission. The major components of this phase include full survey of the project area, preparation of base plans, development of basic geometric layout, development of preliminary cost estimates, and submission of a functional design report. Preliminary Design, although not required to, is often completed in conjunction with the Environmental Documentation and Permitting. The next phase is **Final Design**, which is also referred to as the 75-percent and 100-percent submission. The major components of this phase include preparation of a subsurface exploratory plan (if required), coordination of utility relocations, development of traffic management plans through construction zones, development of final cost estimates, and refinement and finalization of the construction plans. Once Final Design is complete, a full set of **Plans, Specifications, and Estimates (PS&E)** is developed for the project.

Right-of-Way Acquisition
A separate set of Right-of-Way plans are required for any project that requires land acquisition or easements. The plans must identify the existing and proposed layout lines, easements, property lines, names of property owners, and the dimensions and areas of estimated takings and easements.

5. Programming (Identification of Funding)
Programming, which typically begins during the design phase, can actually occur at any time during the process, from planning to design. In this step, which is distinct from project initiation, the proponent requests that the MPO place the project in the region's Transportation Improvement Program (TIP). The proponent requesting the project's listing on the TIP can be the community or it can be one of the MPO member agencies (the Regional Planning Agency, MassDOT, and the Regional Transit Authority). The MPO then considers the project in terms of state and regional needs, evaluation criteria, and compliance with the regional Transportation Plan and decides whether to place it in the draft TIP for public review and then in the final TIP.

6. Procurement
Following project design and programming of a highway project, the MassDOT Highway Division publishes a request for proposals. It then reviews the bids and awards the contract to the qualified bidder with the lowest bid.

7. Construction
After a construction contract is awarded, MassDOT Highway Division and the contractor develop a public participation plan and a management plan for the construction process.

8. Project Assessment
The purpose of this step is to receive constituents' comments on the project development process and the project's design elements. MassDOT Highway Division can apply what is learned in this process to future projects.

Project Development Schematic Timetable

Description	Schedule Influence	Typical Duration
Step I: Problem/Need/Opportunity Identification The proponent completes a Project Need Form (PNF). This form is then reviewed by the MassDOT Highway District office which provides guidance to the proponent on the subsequent steps of the process.	The Project Need Form has been developed so that it can be prepared quickly by the proponent, including any supporting data that is readily available. The District office shall return comments to the proponent within one month of PNF submission.	1 to 3 months
Step II: Planning Project planning can range from agreement that the problem should be addressed through a clear solution to a detailed analysis of alternatives and their impacts.	For some projects, no planning beyond preparation of the Project Need Form is required. Some projects require a planning study centered on specific project issues associated with the proposed solution or a narrow family of alternatives. More complex projects will likely require a detailed alternatives analysis.	Project Planning Report: 3 to 24+ months
Step III: Project Initiation The proponent prepares and submits a Project Initiation Form (PIF) and a Transportation Evaluation Criteria (TEC) form in this step. The PIF and TEC are informally reviewed by the Metropolitan Planning Organization (MPO) and MassDOT Highway District office, and formally reviewed by the PRC.	The PIF includes refinement of the preliminary information contained in the PNF. Additional information summarizing the results of the planning process, such as the Project Planning Report, are included with the PIF and TEC. The schedule is determined by PRC staff review (dependent on project complexity) and meeting schedule.	1 to 4 months
Step IV: Design, Environmental, and Right of Way The proponent completes the project design. Concurrently, the proponent completes necessary environmental permitting analyses and files applications for permits. Any right of way needed for the project is identified and the acquisition process begins.	The schedule for this step is dependent upon the size of the project and the complexity of the design, permitting, and right-of-way issues. Design review by the MassDOT Highway district and appropriate sections is completed in this step.	3 to 48+ months
Step V: Programming The MPO considers the project in terms of its regional priorities and determines whether or not to include the project in the draft Regional Transportation Improvement Program (TIP) which is then made available for public comment. The TIP includes a project description and funding source.	The schedule for this step is subject to each MPO's programming cycle and meeting schedule. It is also possible that the MPO will not include a project in its Draft TIP based on its review and approval procedures.	3 to 12+ months
Step VI: Procurement The project is advertised for construction and a contract awarded.	Administration of competing projects can influence the advertising schedule.	1 to 12 months
Step VII: Construction The construction process is initiated including public notification and any anticipated public involvement. Construction continues to project completion.	The duration for this step is entirely dependent upon project complexity and phasing.	3 to 60+ months
Step VIII: Project Assessment The construction period is complete and project elements and processes are evaluated on a voluntary basis.	The duration for this step is dependent upon the proponent's approach to this step and any follow-up required.	1 month

Source: MassDOT Highway Division Project Development and Design Guide