massDOT
Massachusetts Department of Transportation

CAPE COD CANAL
TRANSPORTATION STUDY

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Alternatives Development and Analysis

This chapter describes the alternatives development and analysis process conducted to identify multimodal transportation improvements that advance the study's goals and objectives (listed in Section 1.4). The development of alternatives was guided by MassDOT' s Project Development and Design Guide (with consideration of the study's issues, constraints, and opportunities described in Section 2.8) and the study's design assumptions. Through regular and meaningful coordination, the study Working Group provided substantial input into the alternative's development process.

This process was also influenced by the U.S. Army Corps of Engineers (USACE) on-going planning study of the Bourne and Sagamore Bridges. The result of their study will be a decision by the USACE to either continue to maintain the Bourne and Sagamore Bridges or prepare for their replacement. This decision may not be the same for both bridges.

While MassDOT and the USACE are coordinating their respective study efforts, it is acknowledged that the potential transportation improvements described in this chapter represent conceptual scenarios that could occur in the future given the uncertainties in permitting, funding, and actions by the USACE affecting the study area's transportation system. Ultimately, continued coordination would be required between the USACE and MassDOT to ensure that future infrastructure investments by these agencies are compatible with each other in terms of alignment, design elements and standards, and future travel demand.

4.1 DESIGN APPROACH AND ASSUMPTIONS

MassDOT' s standard approach to alternatives development was used, which focuses on:

- Satisfying the study goals and objectives (Section 1.4);
- Consideration of issues, constraints, and opportunities (Section 2.8); and
- Minimizing impact to property, community facilities, and environmental resources.

Also, recognizing that Cape Cod is a major summertime tourist destination and trying to design transportation improvements to accommodate the summertime peak period traffic volumes would require the construction of very substantial infrastructure improvements. In consultation with the Working Group, it was concluded that this level of infrastructure would likely be considered an 'over-build' not in line with the type or scale of development desired on Cape Cod. As a result, the following **assumptions** guided the alternatives analysis process:

- Focus on future (2040) year-round safety and mobility problem locations;
- Focus on improvements to existing infrastructure;
- Focus on improvements that reduce cut-through traffic on local roadways;
- Design to accommodate the future (2040) non-summer weekday PM peak period traffic volumes;
- Provide further feasible improvements to accommodate summer Saturday peak period travel volumes, in line with community character;
- Design in accordance with design standards and processes found within the MassDOT Project Development and Design Guide, LRFD Bridge Manual, Separated Bike Lane Planning and Design Guide, and other MassDOT design standards, as appropriate.
- Design will incorporate Intelligent Transportation System (ITS) improvements to provide real-time traveler

information, weather conditions, work-zone management, and emergency management information.

- Recommended alternatives to be compatible with future Canal bridges with minimal modification; and
- Replacement Canal bridges to be built adjacent to existing bridges. The replacement Bourne Bridge would be located immediately to the east of the existing bridge and the replacement Sagamore Bridge immediately to the west (this assumption is made with the knowledge that the Canal bridges are owned by the USACE who will decide if the Canal bridges will be replaced or rehabilitated).

4.2 ALTERNATIVES DEVELOPMENT AND ANALYSIS

Transportation improvement alternatives were developed - in coordination with the Working Group and based on the existing and future traffic conditions and environmental constraints in the study area. The 'design assumptions' described above provided a framework for the development of these alternatives.

As noted in Section 4.1, evaluation of potential improvements focused on 'year-round problem intersections'. These are intersections (listed on Table 3 7) that operate (or are forecast to operate) as a LOS E or F during at least one summer Saturday and non-summer weekday peak travel period in 2014 or 2040. Problem intersections also include those identified as high-crash locations under the Highway Safety Improvement Program (HSIP). While not meeting the definition of a 'year-round problem intersection', the Scenic Highway at Nightingale Pond Road intersection and the Route 6 Exit 1C interchange were also evaluated due to their effect on traffic operations in the study area.

Overall, eight locations were advanced to alternatives development (Table 4-1). Several of these are a combination of more than one year-round problem intersection, as proximity to one another resulted in them operating as a single traffic point.

Transportation improvements were developed in accordance with the requirements of MassDOT' s Project Development and Design Guide and reflect a commitment to complete streets and mode shift objectives to the degree appropriate for each individual location, consistent with the principles of MassDOT' s Healthy Transportation Policy Directive. This policy seeks to increase and encourage the use of a greater variety of transportation modes including walking, bicycling, and transit.

Table 4-1 Future (2040) Year-Round Problem Intersections

LOCATION NO. ON EXHIBIT 3-19/3-20	LOCATION	TOWN	HIGH CRASH CLUSTER[1]	LOS E OR F (2040)
8	Scenic Highway/Meetinghouse Lane at Canal Street/State Road	Bourne	Yes	Yes
10/11[2]	Sandwich Road at Bourne Rotary Connector/High School Drive	Bourne	Yes	Yes
15	Route 6A (Sandwich Road) at Cranberry Highway	Bourne	No	Yes
21	Route 130 at Cotuit Road	Sandwich	Yes	Yes
4/52	Belmont Circle and Scenic Highway at Nightingale Pond Road	Bourne	Yes	Yes
9	Bourne Rotary	Bourne	Yes	Yes
16/17	Route 6A/Route 130/ Tupper Road[3]	Sandwich	Yes	No
N/A	Route 6 Exit 1C Relocation[4]	Bourne	No	No

1 High crash locations identified by MassDOT for the 2011-2013 or 2012-2014 periods.
2 Locations combined due to their proximity.
3 To be combined with Route 6 Exit 1C Relocation.
4 Advanced to Alternatives Development due to substandard design.

Ultimately, the recommended alternatives were developed to address the evaluation criteria (described in Section 1.5). These alternatives were compared to each other to identify a suite of recommended build alternatives. An evaluation matrix is provided for each of the travel demand model cases described in Section 5.2. The evaluation matrix provides a summary of the analysis of the recommended alternatives against the evaluation criteria.

4.2.1 Traffic Analysis – Measures of Effectiveness

As described in Section 2.5.5, the measures of effectiveness for the traffic analysis are based on level of service (LOS) and queue lengths (which is a measure of intersection delay). Delay is defined as the difference between travel time during free-flow travel periods and the travel time during congested conditions.

LOS is a qualitative measure used to relate the quality of peak-hour traffic operating conditions. LOS is based on density for highway sections and ramps and average delay traffic at intersections. LOS ranges from A, the optimal free-flow condition, to F, where traffic demands are beyond roadway capacity or create excessive delays (Table 2-17). LOS E or LOS F is generally considered to be unacceptable travel delay.

While LOS is a useful measure of effectiveness along highways and signalized and unsignalized intersections, it is not a helpful measure at complex, non-traditional traffic circles such as Belmont Circle and the Bourne Rotary which are described in terms of queuing, vehicle delays, and travel time.

Queues are the length of a line of vehicles waiting to pass through an intersection, generally calculated during the peak period. These vehicles may be stopped or advancing slowing. The

50% queue is the median length of this line of vehicles (during the peak hour) and the 95% queue is the maximum length of this line of vehicles.

Generally, each vehicle (including the space between vehicles) occupies approximately 25 feet; so a queue of 250 feet includes approximately 10 vehicles.

4.2.2 Conceptual Cost Estimate Methodology

Conceptual cost estimates were prepared for each of the potential transportation improvements. The cost estimates were based on MassDOT 2017 unit costs per linear foot of new roadway and bridge sections (see the methodology section of Appendix E).

The cost estimates were escalated by 4% per year to develop cost for 2017, 2030, and 2040, to provide an understanding of the increasing cost of these projects at different time periods. The conceptual cost estimates, including the unit costs for various roadway and bridge sections, are provided in Appendix E.

The unit-costs for the various alternatives were increased by an additional 25% to 40% to account for contingencies such as environmental mitigation, traffic management, utility relocation, traffic management and/or structural elements (such as retaining walls). A lower contingency was used for less complex design alternatives (e.g., local intersection improvements) while a 40% contingency was used for larger, more complex mid- and long-term design alternatives. A 75% contingency was used for larger projects involving substantial utility conflicts/potential relocations. The conceptual cost estimates do not include the costs of design, permanent or temporary right-of-way costs, or construction engineering.

4.3 ROADWAY IMPROVEMENT ALTERNATIVES ANALYSIS

The following sections describe the transportation improvements alternatives developed for the year round problem intersections listed in Table 4-1. Based on anticipated project complexity and cost, these potential improvements are divided into ‘local intersection improvements’ and ‘gateway intersection improvements’. The gateway intersections are those immediately adjacent to the Bourne and Sagamore Bridges, including Belmont Circle, Bourne Rotary, and Route 6 Exit 1C. A brief description of each location is provided, including roadway layout, adjacent land uses and environmental resources. A summary of the existing and future traffic conditions is also provided.

For clarity, traffic operations are provided for the two key travel periods; the non-summer weekday PM period (4:00 – 6:00

PM) and the summer Saturday (10:00 AM to 12:00 PM) period. The non-summer weekday PM period represents the weekday commuter period and the summer Saturday represents the peak travel period for visitors.

More detailed information related to existing and future traffic operations at these locations is provided in Chapters 2 (Section 2.5) and Chapter 3 (Section 3.3), respectively, and Appendix H.

4.3.1 Working Group Transportation Improvement Submissions

Numerous thoughtful suggestions for transportation system improvements were received from individual members of the Working Group or members of the public. Each of these concepts was considered to ascertain whether they warranted inclusion in the alternatives analysis. Several of these concepts were similar to alternatives already being pursued by the study. These transportation improvement concepts and the results of the evaluation of them are provided in Table 4-2.

Table 4-2 Working Group Submissions

TRANSPORTATION SYSTEM CONCEPT	RESULT OF STUDY EVALUATION
Funding transportation improvements through bridge tolling	Bridge tolling not allowed by USACE bridge legislation (PL 516, Chapter 188, Section 109 33 USC 534)
Expanded rail service	Expanding rail service would improve multimodal mobility on Cape Cod, however it would not have the capacity to meaningfully alleviate traffic congestion in study area.
Additional Canal bridges and approach highways connecting Route 25 to Route 6	Not advanced due to substantial environmental impact; including wetlands, ACECs, open space, and tribal resources. Contrary to the goal of focusing on existing infrastructure.
Cross-Canal tunnel	Based on conceptual analysis, tunneling options not advanced due to high cost of construction and maintenance compared to bridge options and substantial property acquisition requirements.
Route 6 Exit 2 (Route 130) improvements	Additional capacity at Exit 2 not needed.
Scenic Highway to Route 25 entrance ramp	Concept advanced into conceptual design (see Section 4.6.4).
Sandwich Road capacity improvements	Capacity improvements not needed on Sandwich Road. Widening Sandwich Road would also result in substantial impact to public open space.
Bourne Rotary Improvements	Similar concept advanced into conceptual design (see Section 4.6.5).

4.4 LOCAL INTERSECTION IMPROVEMENTS

Improvements to local intersections include incorporation of Transportation System Management (TSM) measures at key intersections in the study area. Examples of TSM improvements include: traffic signal optimization, installation of new traffic signals and/or signal control equipment, installation of turning lanes, and improved roadway markings and signage. Local intersection improvements generally take less than three years to implement.

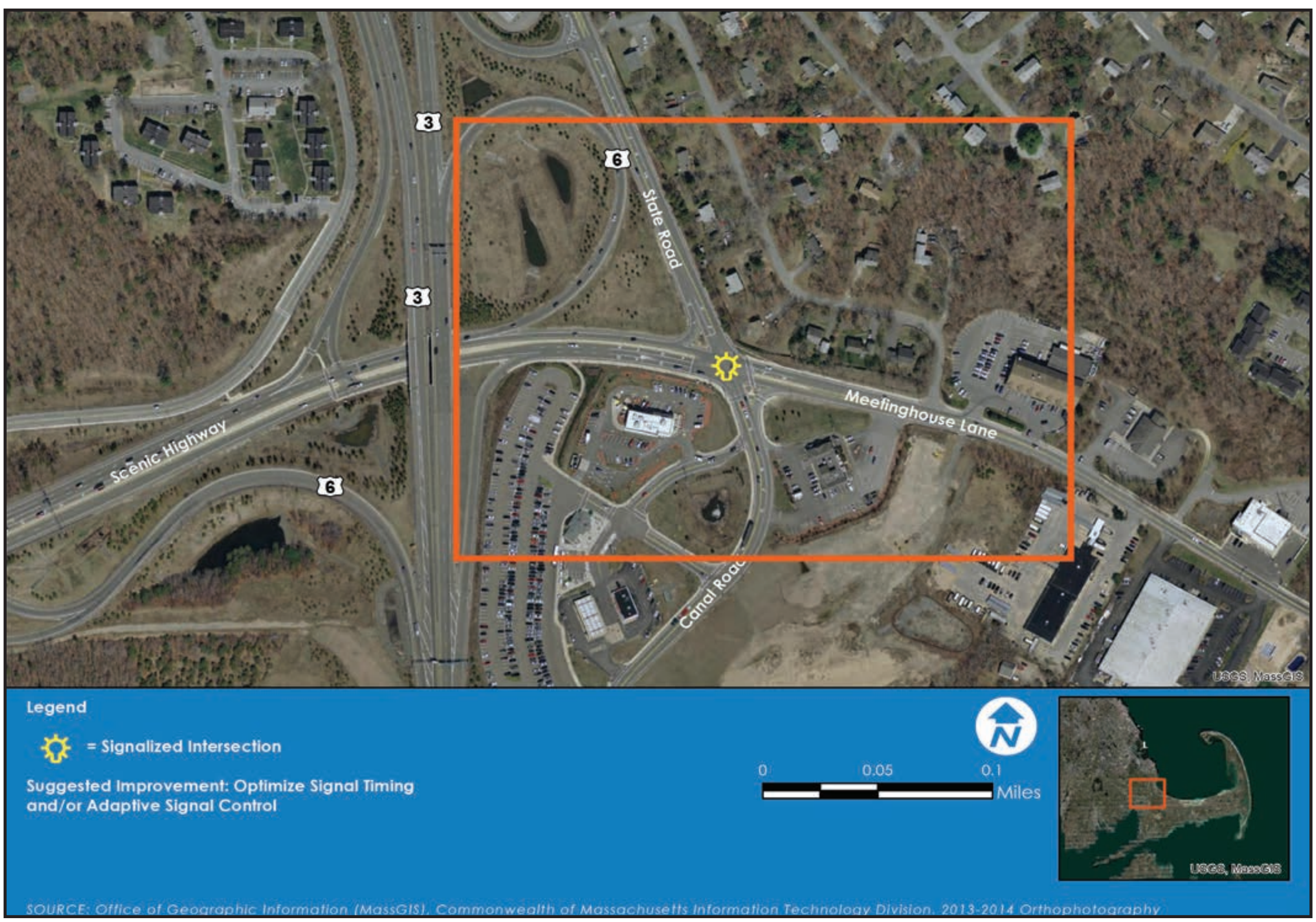
Conceptual cost estimates were prepared for each of the potential transportation improvements. The methodology used for preparing the cost estimates can be found in Section 4.2.2. More detailed conceptual cost estimates are provided in Appendix E.

4.4.1 Scenic Highway/Meetinghouse Lane at Canal Road/State Road

Existing Conditions

The Scenic Highway/Meetinghouse Lane intersection with Canal Road/State Road in Bourne (Exhibit 4-1) is a signalized

Exhibit 4-1 Scenic Highway/Meetinghouse Lane at Canal Road/State Road



intersection north of the Cape Cod Canal. The intersection is immediately east of Route 6 Exit 1A (Sagamore interchange). Each approach to the intersection features multiple lanes providing separate through or left-turn lanes. The Scenic Highway eastbound approach has three lanes; a right-, through-, and left-turn lane.

At this intersection, sidewalks exist on the south side of the Scenic Highway, the north side of Meetinghouse Lane and both sides of Canal Road. Crosswalks on both sides of Canal Road lead pedestrians to a roadway island and then to the north side of Meetinghouse Lane.

Land Uses and Environmental Resources

MassDOT' s Sagamore Park & Ride lot, a McDonald's restaurant, a Dunkin' Donuts restaurant, and a Shell gas station are accessed from Canal Road south of the intersection. Residential properties are present along Homestead Road at the northeast quadrant of the intersection. The northwest quadrant of the intersection features highway ramps and grassed areas related to the Route 6 at Scenic Highway interchange. No regulated environmental resources exist at this intersection.

Traffic Conditions

This intersection experiences high traffic volumes during both the non-summer weekday PM and the summer Saturday periods because of its proximity to the Route 6 at Scenic Highway interchange (Table 4-3). These high traffic volumes result in predominately LOS C and D during non-summer weekday and summer Saturdays for the existing and future periods. LOS F conditions are forecast in 2040 during the non summer weekday PM peak period for several intersection approaches, including Scenic Highway eastbound and Meetinghouse Lane westbound.

Suggested Improvements

The optimization of the timing of the traffic signals would provide more efficient processing of vehicles traveling through the intersection. Traffic signal optimization generally reduces overall intersection delay by approximately 10%, which can improve LOS. With traffic signal optimization, the non-summer weekday PM peak period is forecast to improve from LOS F to LOS E. During the non-summer weekday PM peak period, average delay at the intersection would be reduced from140 seconds to 66 seconds. Delay during the summer Saturday peak period would improve from 34 seconds to 23 seconds (Table 4-3).

The installation of 'adaptive signal control' should also be evaluated. Adaptive signal control uses real-time traffic

Table 4-3 Traffic Operations – Scenic Hwy/Meetinghouse Lane at Canal Road/State Road

	EXISTING (2014) CONDITIONS					FUTURE (2040) NO-BUILD CONDITIONS					FUTURE (2040) BUILD CONDITIONS				
	AVERAGE DELAY Sec (Min)	LOS	V/C	50% QUEUE Feet (Miles)	95% QUEUE Feet (Miles)	AVERAGE DELAY Sec (Min)	LOS	V/C	50% QUEUE Feet (Miles)	95% QUEUE Feet (Miles)	AVERAGE DELAY Sec (Min)	LOS	V/C	50% QUEUE Feet (Miles)	95% QUEUE Feet (Miles)
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)															
Scenic Highway EB Lt	26	C	0.78	225	450	173 (2.9)	**F**	1.3	621	930	84 (1.4)	**F**	1.06	779	1,035
Scenic Highway EB Th	21	C	0.35	87	202	25	C	0.5	134	298	10	B	0.3	130	181
Scenic Highway EB Rt	18	B	0.12	0	8	19	B	0.14	0	29	9	A	0.14	0	27
Meetinghouse Ln WB Lt	38	D	0.09	4	16	38	D	0.14	6	21	46	D	0.11	16	42
Meetinghouse Ln WB Th/Rt	156 (2.6)	**F**	1.16	146	295	418 (7.0)	**F**	1.79	305	488	99 (1.7)	**F**	0.99	325	538
Canal Road NB Lt	45	D	0.62	96	153	45	D	0.67	115	175	129 (2.2)	**F**	1.01	176	340
Canal Road NB Th/Rt	33	C	0.29	65	116	32	C	0.33	81	134	46	D	0.37	115	186
State Road SB Lt	49	D	0.34	17	44	50	D	0.46	23	56	66	**E**	0.44	34	74
State Road SB Th	39	D	0.11	16	42	39	D	0.14	20	49	62	**E**	0.25	29	66
State Road SB Rt	39	D	0.08	0	0	39	D	0.1	0	0	61 (1.0)	**E**	0.1	0	72
Intersection (Overall)	**46.8**	**D**	**0.74**			**140 (2.3)**	**F**	**1.09**			**66.5 (1.1)**	**E**	**1.03**		
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)															
Scenic Highway EB LT	14	B	0.34	73	149	16	B	0.42	81	154	13	B	0.49	57	100
Scenic Highway EB Th	22	C	0.35	147	274	25	C	0.49	226	386	14	B	0.45	123	196
Scenic Highway EB Rt	19	B	0.14	0	52	20	C	0.17	0	59	11	B	0.17	0	37
Meetinghouse Ln WB Lt	20	C	0.07	11	33	21	C	0.09	13	37	22	C	0.15	14	38
Meetinghouse Ln WB Th/Rt	27	C	0.31	106	220	31	C	0.49	185	368	32	C	0.67	130	250
Canal Road NB Lt	32	C	0.51	129	165	33	C	0.58	148	192	30	C	0.74	87	165
Canal Road NB Th/Rt	44	D	0.58	161	214	49	D	0.7	191	257	21	C	0.46	88	155
State Road SB Lt	42	D	0.21	27	47	43	D	0.35	47	74	36	D	0.59	37	82
State Road SB Th	49	D	0.38	68	110	51	D	0.48	80	131	31	C	0.43	46	91
State Road SB Rt	48	D	0.3	0	99	49	D	0.26	0	95	30	C	0.26	0	78
Intersection (Overall)	**32.6**	**C**	**0.47**			**34.1**	**C**	**0.60**			**23.0**	**C**	**0.76**		

Notes:
•LOS E and LOS F movements are shaded ***bold***
•Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
•LOS = Level of Service.
•V/C = Volume to Capacity Ratio
•Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

information to actively adjust signal timing at each approach. This technology can further reduce traffic congestion and delay. Although ADA-compliant sidewalks and crosswalks already exist at this intersection, they should be evaluated to ensure a state of good repair.

Property or Environmental Resource Impact

Signal optimization would not impact any regulated environmental resources. No property taking would be required.

Conceptual Cost Estimate

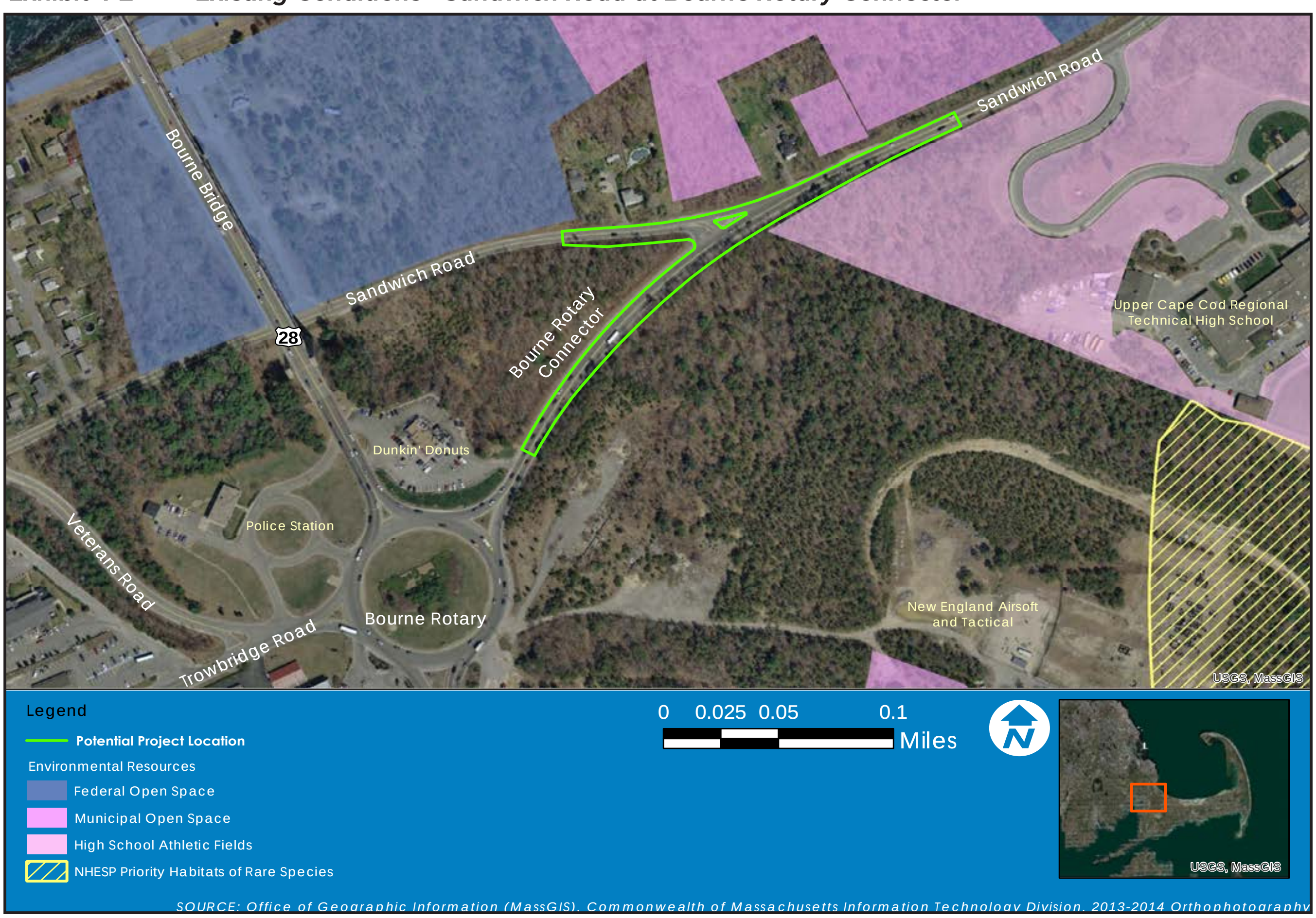
The cost of these improvements would range from approximately $25,000 to $50,000 (2017 costs).

4.4.2 Sandwich Road at Bourne Rotary Connector

Existing Conditions

Sandwich Road at Bourne Rotary Connector in Bourne (Exhibit 4-2) is an unsignalized Y intersection immediately east of the Bourne Rotary, which is south of the Cape Cod Canal. Each approach to the intersection features a single lane. The Bourne

Exhibit 4-2 Existing Conditions - Sandwich Road at Bourne Rotary Connector



Rotary Connector provides direct access from Sandwich Road to the Bourne Rotary (and the Bourne Bridge and other points north). The combination of the Bourne Rotary Connector and Sandwich Road (east of the intersection) acts as the through movement at this intersection with the Sandwich Road approach from the west acting as the minor roadway approach. There are no sidewalks or crosswalks on any of the approaches to this intersection.

Land Uses and Environmental Resources

Except for three residential properties, land uses north of the intersection consist of public open space owned by either the Town of Bourne or the U.S. Army Corps of Engineers. The Cape Cod Regional Technical High School property is southeast of the intersection (with its entrance drive approximately 1,000 feet east on Sandwich Road).

There are no wetlands, floodplains, or other regulated water resources within 100 feet of the intersection. Land south of the intersection is designated by the Massachusetts Natural Heritage and Endangered Species Program as a ‘Priority Habitat for Rare Species’.

Traffic Conditions

This intersection experiences high traffic volumes during both the non-summer weekday PM and the summer Saturday peak periods. Combined with the lack of signalization at this intersection, these factors result in LOS F conditions during existing and future at the Old Sandwich Road eastbound approach for left-turning vehicles entering Sandwich Road.

Suggested Improvements

The effectiveness of installing traffic signals at this intersection (Exhibit 4-3) was evaluated. Both the Sandwich Road eastbound and the Bourne Rotary Connector eastbound approach would have designated left-turn lanes. Additionally, a through-lane would provide a direct connection from the Bourne Rotary Connector to Sandwich Road eastbound. This movement would be free-flow, instead of being subject to traffic signals. This through lane would be separated from the other lanes with a raised median barrier.

Due to these improvements, traffic operations along the Old Sandwich Road eastbound approach would be improved considerably from LOS F to LOS C for the non-summer weekday PM period (Table 4-4). Overall, this intersection would operate at LOS A and LOS B for the non-summer weekday and summer Saturday peak periods, respectively. The timing of the new traffic

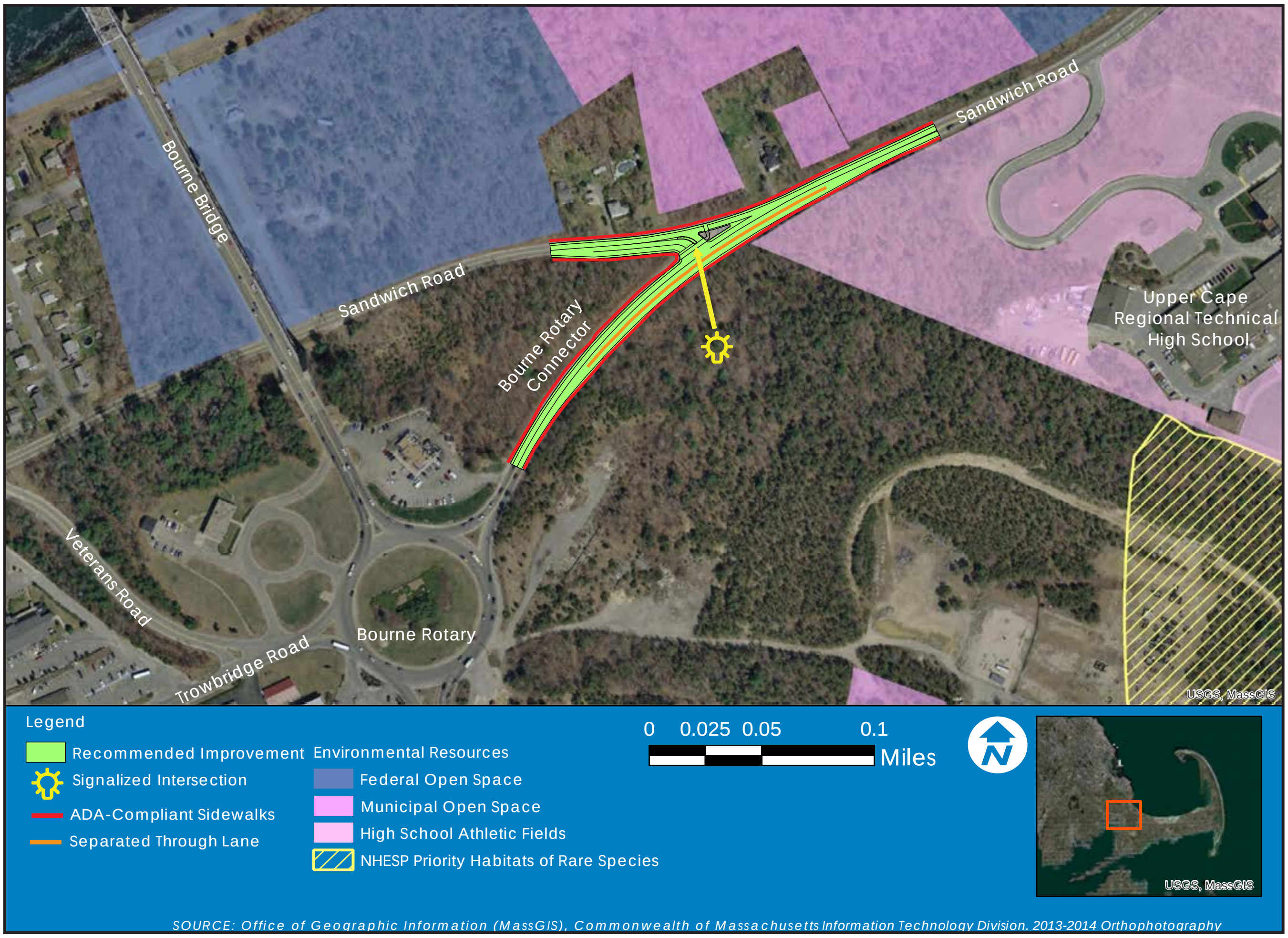


Exhibit 4-3 Sandwich Road at Bourne Rotary Connector

signals would be optimized to provide more efficient processing of vehicles traveling through the intersection. The installation of 'adaptive signal control' would also be evaluated.

Improvements to bicycle/pedestrian facilities including ADA-compliant sidewalks and crosswalks along Sandwich Road, in addition to a sidewalk connection to the Technical High School driveway are also proposed. In addition to the roadway travel lanes, shoulders would provide safe accommodation for bicyclists.

Property or Environmental Resource Impact

The improvements may require the acquisition of less than 1,000 square feet of Town of Bourne open space and undeveloped commercial property. No regulated wetland/water resources would be impacted.

Table 4-4 *Traffic Operations - Sandwich Road at Bourne Rotary Connector*

	EXISTING (2014) CONDITIONS					FUTURE (2040) NO-BUILD CONDITIONS					FUTURE (2040) BUILD CONDITIONS				
	AVERAGE DELAY *Sec (Min)*	LOS	V/C	50% QUEUE *Feet (Miles)*	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	50% QUEUE *Feet (Miles)*	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	50% QUEUE *Feet (Miles)*	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)															
Bourne Rotary Connector NEB Lt/Th	0	A	0	--	0	0	A	0	--	0					
Sandwich Rd WB Th/Rt	0	A	0.57	--	0	0	A	0.69	--	0					
Old Sandwich Road EB Lt	537 (8.9)	**F**	1.89	--	313	n/a	**F**	3.35	--	n/a	22	C	0.54	69	127
Old Sandwich Road EB Rt	47	**E**	0.82	--	179	131 (2.2)	**F**	1.14	--	363	14	B	0.47	63	131
Bourne Rotary Connector NEB Lt											0	A	0	0	0
Bourne Rotary Connector NEB Th											1	A	0.59	0	0
Sandwich Road WB Th											17	B	0.79	205	436
Sandwich Road WB Rt											9	A	0.29	0	41
Intersection (Overall)											**9.7**	**A**	**0.78**		
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)															
Bourne Rotary Connector NEB Lt/Th	1	A	0.02	--	2	1	A	0.03	--	2					
Sandwich Rd WB Th/Rt	0	A	0.65	--	0	0	A	0.67	--	0					
Old Sandwich Road EB Lt	606 (10.1)	**F**	1.74	--	165	n/a	**F**	6.25	--	n/a	36	D	0.7	108	192
Old Sandwich Road EB Rt	27	D	0.41	--	48	31	D	0.5	--	66	19	B	0.15	14	52
Bourne Rotary Connector NEB Lt											33.1	C	0.13	10	32
Bourne Rotary Connector NEB Th											2.2	A	0.69	0	0
Sandwich Road WB Th											23.9	C	0.9	396	715
Sandwich Road WB Rt											7	A	0.12	0	25
Intersection (Overall)											**13.9**	**B**	**0.89**		

Notes:
- *LOS E and LOF movements are* ***bold***
- *Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound*
- *LOS = Level of Service; V/C = Volume to Capacity Ratio*
- *Overall LOS, V/C and queues not calculated for unsignalized intersections.*
- *Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.*
- *n/a = Volume exceeds capacity to the point where the respective value cannot be determined.*
- *Shaded areas do not exist in listed configuration during this period.*

Conceptual Cost Estimate

Reconstruction and signalization at the Sandwich Road at Bourne Rotary Connector intersection would cost approximately $1.9 million (2017 costs). More detailed conceptual cost estimates are provided in Appendix E.

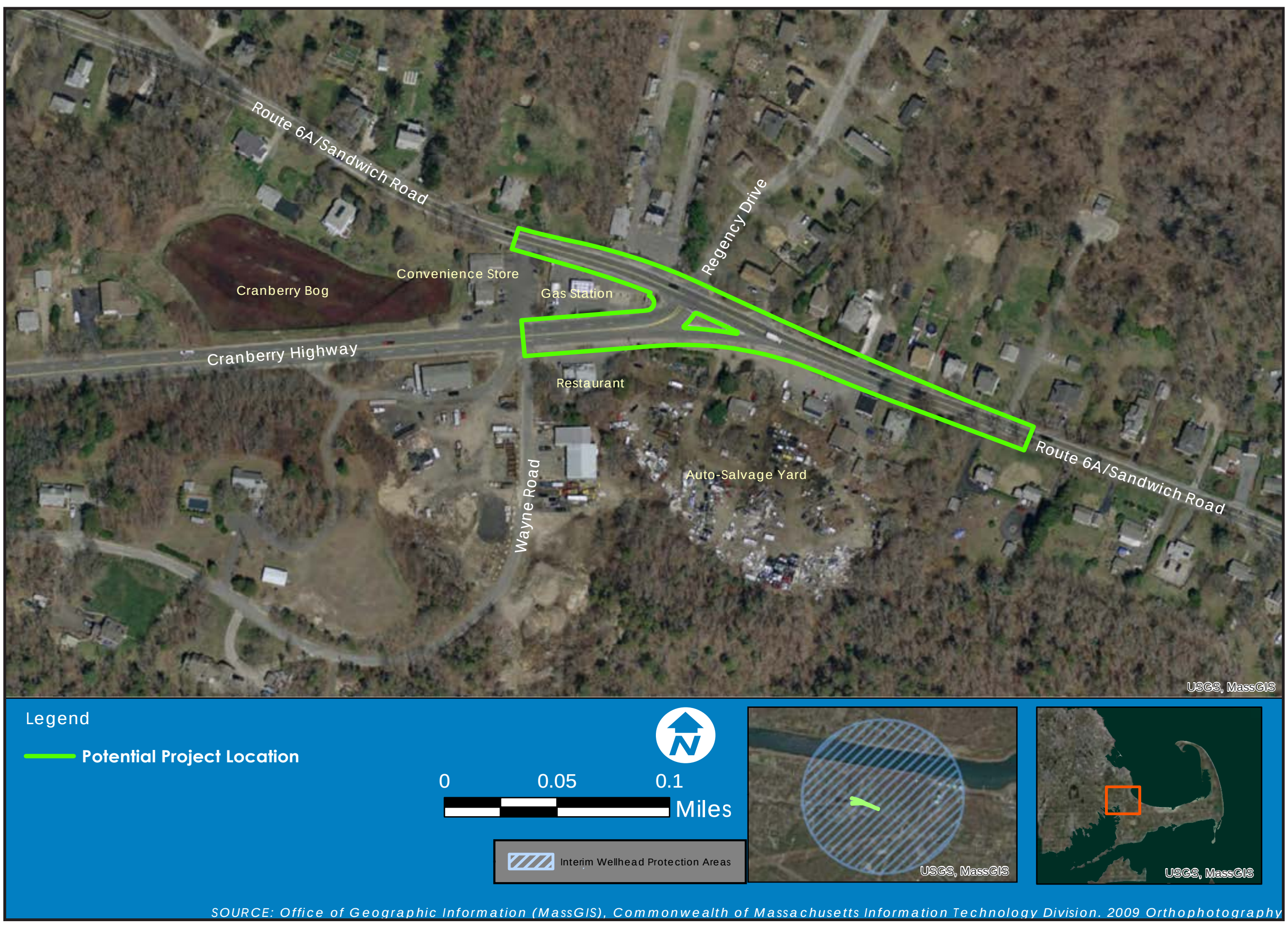
4.4.3 Route 6A (Sandwich Road) at Cranberry Highway

Existing Conditions

The Sandwich Road at Cranberry Highway intersection in Bourne (Exhibit 4-4) is an unsignalized Y-intersection approximately 0.75-miles east of the Route 6/Cranberry Highway Interchange (Exit 1C). Each approach to the intersection features a single lane. The Cranberry Highway eastbound approach has a channelized right-turn lane separated from the left-turn lane by a large traffic island.

Regency Drive, a dead-end residential street, has access from Sandwich Road directly opposite the Cranberry Highway approach. The north side of Sandwich Road has sidewalks that

Exhibit 4-4 Existing Conditions - Route 6A (Sandwich Road) at Cranberry Highway



are frequently interrupted by driveways. These sidewalks are generally not ADA-compliant. There are no sidewalks along Cranberry Highway, or any crosswalks on any of the approaches to this intersection.

Land Uses and Environmental Resources

Land uses in the area include residential properties along Sandwich Road, and a gas station and a convenience store on the parcel between Sandwich Road and Cranberry Highway. The Cranberry Highway approach features a mix of residential properties, a cranberry bog, restaurant, and an auto salvage yard.

There are no wetlands, floodplains, or other regulated water resources within 100 feet of the intersection. The entire intersection is within an interim wellhead protection area of a public water supply.

Traffic Conditions

This intersection experiences generally acceptable traffic conditions (LOS A and B) except for the Cranberry Highway east-bound approach. Left-turning vehicles on this approach experience LOS E and F conditions during the future non-summer weekday PM and the summer Saturday periods, respectively. Vehicles entering this intersection from Regency Drive are expected to experience LOS F conditions during the future non summer weekday peak period.

Suggested Improvements

The suggested improvements include the construction of a left-turn lane on the Sandwich Road westbound approach (Exhibit 4 5). This left-turn lane would reduce queuing on this approach that currently form behind vehicles on Sandwich Road westbound turning left onto Cranberry Highway. Reducing these queues would create more gaps in traffic, allowing vehicles from Cranberry Highway to more easily enter Sandwich Road (Table 4-5). During the non-summer weekday PM peak period, traffic operations for vehicles entering from Regency Drive would improve from LOS F to LOS B.

Improvements to bicycle/pedestrian facilities including ADA-compliant sidewalks and crosswalks along Sandwich Road and Cranberry Highway are also proposed. Roadway shoulders would be widened to provide safer accommodation for bicyclists.

Property or Environmental Resource Impact

The improvements may require the acquisition of less than 1,000 square feet of residential property. No regulated environmental resources would be impacted.

Exhibit 4-5 Route 6A (Sandwich Road) at Cranberry Highway

Conceptual Cost Estimate

These improvements would cost approximately $584,000 (2017 costs). More detailed conceptual cost estimates are provided in Appendix E.

4.4.4 Route 130 (Forestdale Road) at Cotuit Road

Existing Conditions

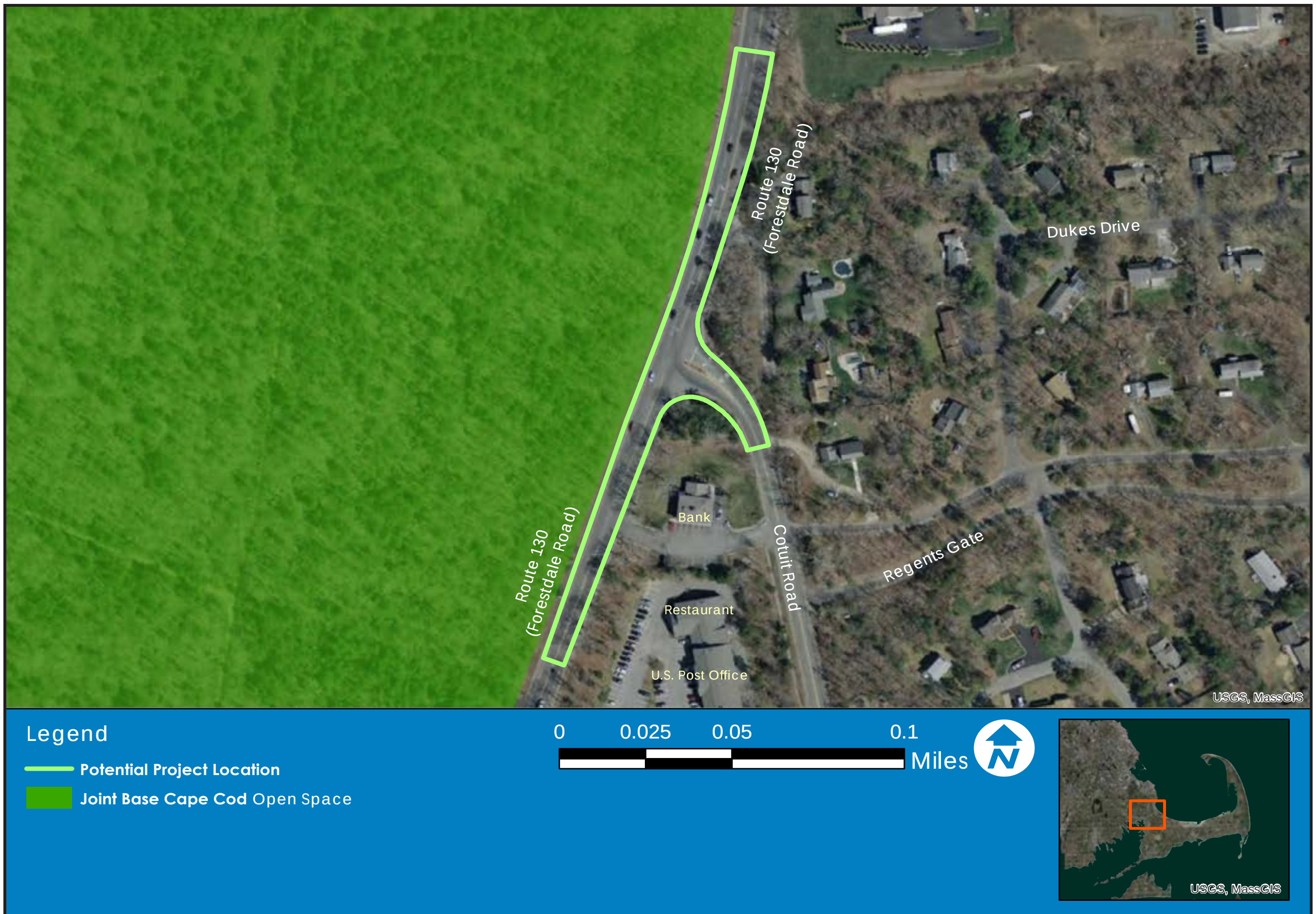
The Route 130 (Forestdale Road) at Cotuit Road intersection in Sandwich (Exhibit 4-6) is an unsignalized T intersection approximately 1.6 miles south of the Route 6/Route 130 (Exit 2) interchange. The Route 130 southbound approach to the intersection has two lanes; a through- and a left-turn lane. The Route 130 northbound approach is a single-lane approach. The Cotuit Road northbound approach is stop-controlled and has two lanes; a left- and right-turn lane.

There are no sidewalks or crosswalks on Route 130 or Cotuit Road near the intersection. Route 130 has roadway shoulders, approximately eight feet in width, on both sides of the road. Cotuit Road has three-foot shoulders.

Table 4-5 Traffic Operations - Route 6A (Sandwich Road) at Cranberry Highway

	EXISTING (2014) CONDITIONS				FUTURE (2040) NO-BUILD CONDITIONS				FUTURE (2040) BUILD CONDITIONS			
	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)												
Sandwich Road EB Lt/Th/Rt	0	A	0	0	0	A	0	0	0	A	0	0
Sandwich Road WB Lt									22	A	0.22	22
Sandwich Road WB Lt/ Th/Rt	4	A	0.18	16	22	A	0.22	22	0	A	0.23	0
Cranberry Hwy EB Lt/Th	32	D	0.07	5	8	**E**	0.1	8	8	E	0.1	8
Cranberry Hwy EB Rt	12	B	0.08	7	9	B	0.11	9	9	B	0.11	9
Regency Drive SB Lt/Th/Rt	35	D	0.04	3	5	**A**	0.06	5	1	B	0.01	1
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)												
Sandwich Road EB Lt/Th/Rt	0	A	0.01	0	0	A	0.01	0	0	A	0.01	0
Sandwich Road WB Lt									184 (3.1)	C	0.75	184
Sandwich Road WB Lt/ Th/Rt	14	B	0.61	110	184 (3.1)	C	0.75	184	0	A	0.36	0
Cranberry Hwy EB Lt/Th	1,416 (23.6)	**F**	2.71	124	n/a	**F**	7.13	n/a	n/a	**F**	7.11	n/a
Cranberry Hwy EB Rt	12	B	0.11	9	13	B	0.15	13	13	B	0.15	13
Regency Drive SB Lt/Th/Rt	12	B	0.01	1	1	B	0.01	1	1	B	0.01	1

Notes:
- *LOS E and LOS F movements are **bold***
- *Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound*
- *LOS = Level of Service; V/C = Volume to Capacity Ratio*
- *Overall LOS, V/C and queues not calculated for unsignalized intersections.*
- *Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.*
- *Shaded areas do not exist in listed configuration during this period.*



SOURCE: Office of Geographic Information (MassGIS), Commonwealth of Massachusetts Information Technology Division. 2013-2014 Orthophotog

Exhibit 4-6 Existing Conditions - Route 130 at Cotuit Road

Land Uses and Environmental Resources

Land uses in the area include residential properties along the east side of Cotuit Road and Route 130. Land to the west of Route 130 is undeveloped forest belonging to Joint Base Cape Cod (JBCC). Numerous commercial developments exist in the land between Route 130 and Cotuit Road.

There are no wetlands, floodplains, or other regulated wetland resources within 100 feet of the intersection. Land west of Route 130 within JBCC is designated by the Massachusetts Natural Heritage and Endangered Species Program as a 'Priority Habitat for Rare Species'.

Traffic Conditions

This intersection experiences generally acceptable traffic conditions (LOS A and B) except for the Cotuit Road northbound approach. Left-turning vehicles on this approach experience LOS F conditions during both the existing and future non-summer weekday PM and the summer Saturday periods (Table 4-6).

Table 4-6 Traffic Operations – Route 130 at Cotuit Road

	EXISTING (2014) CONDITIONS				FUTURE (2040) NO-BUILD CONDITIONS				FUTURE (2040) BUILD CONDITIONS				
	AVERAGE DELAY Sec (Min)	LOS	V/C	95% QUEUE Feet (Miles)	AVERAGE DELAY Sec (Min)	LOS	V/C	95% QUEUE Feet (Miles)	AVERAGE DELAY Sec (Min)	LOS	V/C	50% QUEUE Feet (Miles)	95% QUEUE Feet (Miles)
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)													
Route 130 NB Th/Rt	0	A	0.25	0	0	A	0.3	0	19	B	0.71	141	403
Route 130 SB Lt	11	B	0.5	72	14	B	0.64	121	14	B	0.77	72	285
Route 130 SB Th	0	A	0.27	0	0	A	0.32	0	1	A	0.34	0	70
Cotuit Road NB Lt	137 (2.3)	**F**	0.16	12	387 (6.5)	**F**	0.37	24	33	C	0.18	2	12
Cotuit Road NB Rt	16	C	0.5	71	27	D	0.74	157	14	B	0.49	74	136
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)													
Route 130 NB Th/Rt	0	A	0.24	0	0	A	0.33	0	16	B	0.74	106	281
Route 130 SB Lt	10	A	0.34	37	12	B	0.47	65	8	A	0.63	15	165
Route 130 SB Th	0	A	0.24	0	0	A	0.25	0	1	A	0.28	0	56
Cotuit Road NB Lt	57	**F**	0.14	11	133 (2.2)	**F**	0.29	24	28	C	0.31	3	16
Cotuit Road NB Rt	25	D	0.75	167	88 (1.5)	**F**	1.07	432	17	B	0.71	93	228
Intersection (Overall)									**11.4**	**B**	**0.8**		

Notes:
*•LOS E and LOS F movements are **bold***
•Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
•LOS = Level of Service; V/C = Volume to Capacity Ratio
•Overall LOS, V/C and queues not calculated for unsignalized intersections.
•Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

Suggested Improvements

The installation of a traffic signal at this intersection would provide opportunities for vehicles from Cotuit Road to safely enter Route 130, reducing delays on this approach (Exhibit 4-7).

This would result in an improvement in traffic operations for left-turning vehicles on the Cotuit Road northbound approach from LOS F to LOS C for the non-summer weekday and summer Saturday peak periods. During the non-summer period, this would reduce average delay by 91% (387 seconds reduced to 33 seconds).

Additionally, improvements to pedestrian facilities including ADA-compliant sidewalks along the east side of Route 130 extending to the entrance of the Trade Winds Plaza are also proposed. The roadway shoulders on Route 130, which currently meet MassDOT' s bicycle accommodation standards, would be maintained.

Exhibit 4-7 Route 130 at Cotuit Road

Property or Environmental Resource Impact

These improvements may require the acquisition of less than 1,000 square feet of residential property along the roadway frontage. No regulated environmental resources would be impacted.

Conceptual Cost Estimate

The improvements would cost approximately $956,000 (2017 costs). Conceptual cost estimates are provided in Appendix E.

4.5 SCREENING-LEVEL ANALYSIS

A screening-level analysis was completed for the potential larger transportation improvements. The initial purpose of the screening-level analysis is to identify potential significant impact to natural and social environmental resources or property. For this screening analysis stage, it is assumed that the existing Canal bridges remain.

This step is completed in anticipation of the requirement of any potential improvements to complete federal and state environmental review in compliance with the National Environmental Policy Act and Massachusetts Environmental Policy Act (NEPA, 40 CFR 1500-1508 and MEPA, 301 CMR 11:00). These environmental laws require federal and state agencies – prior to receiving funding or other approvals – to evaluate the potential environmental effects of their actions and, through a detailed alternative analysis, select an alternative that meets the project purpose and need with the least environmental impact.

Project alternatives that would result in significant environmental or property impact – projects which would be unlikely to receive approval under MEPA and NEPA – were dismissed from further consideration.

Project alternatives that were not anticipated to result in significant environmental impact were advanced to the next stage of the screening analysis, preliminary traffic analysis. Based on a conceptual design, the effectiveness of potential projects as stand-alone improvements were evaluated using future (2040) traffic volumes.

As described in the following sections, a new Canal bridge on new highway alignment (Public-Private Partnership alternatives) were determined to result in significant environmental impact and were dismissed from further consideration. Potential transportation improvements at gateway intersections were advanced to the traffic analysis stage, and through coordination with the Working Group, suggested alternatives were advanced for further study. Section 4.8 describes the evaluation of combinations of these potential improvements using the regional travel demand model.

4.5.1 Public-Private Partnership Alternatives

Concurrent with the beginning of this study, MassDOT began consideration of several projects as potential Public-Private Partnerships (P3). An infrastructure P3 is generally a method of project delivery in which a private entity designs, constructs, finances, and manages a facility in exchange for a portion of the funds generated or through availability payments. In the case of a highway P3 project, the funds generated by the project are generally the tolls charged to users of the facility.

Based on the long-standing highway congestion in the Canal area, the age and condition of the Canal bridges, and the uncertainty of the USACE's plans related to the rehabilitation or replacement of the bridges, MassDOT identified the Canal area as a potential P3 project envisioned to provide major transportation infrastructure improvements including a new highway bridge over the Canal.

The highway alternatives developed as part of this P3 development process were informed by the cross-Canal travel patterns. As described in Section 2.5.9, the origin-destination analysis identified a high percentage of vehicles traveling between the Route 3/Route 6 corridor to the Route 25/Route 28 corridor, particularly during the summer Saturday peak period. The transition from one corridor to the other occurs in the Canal area using either Sandwich Road or Scenic Highway. These movements place tremendous pressure on the interchanges adjacent to the Canal such as the Sagamore Rotary, Belmont Circle, and the Bourne Rotary, which lead to high levels of congestion at these locations during peak travel periods.

P3 Alternatives – Project Description

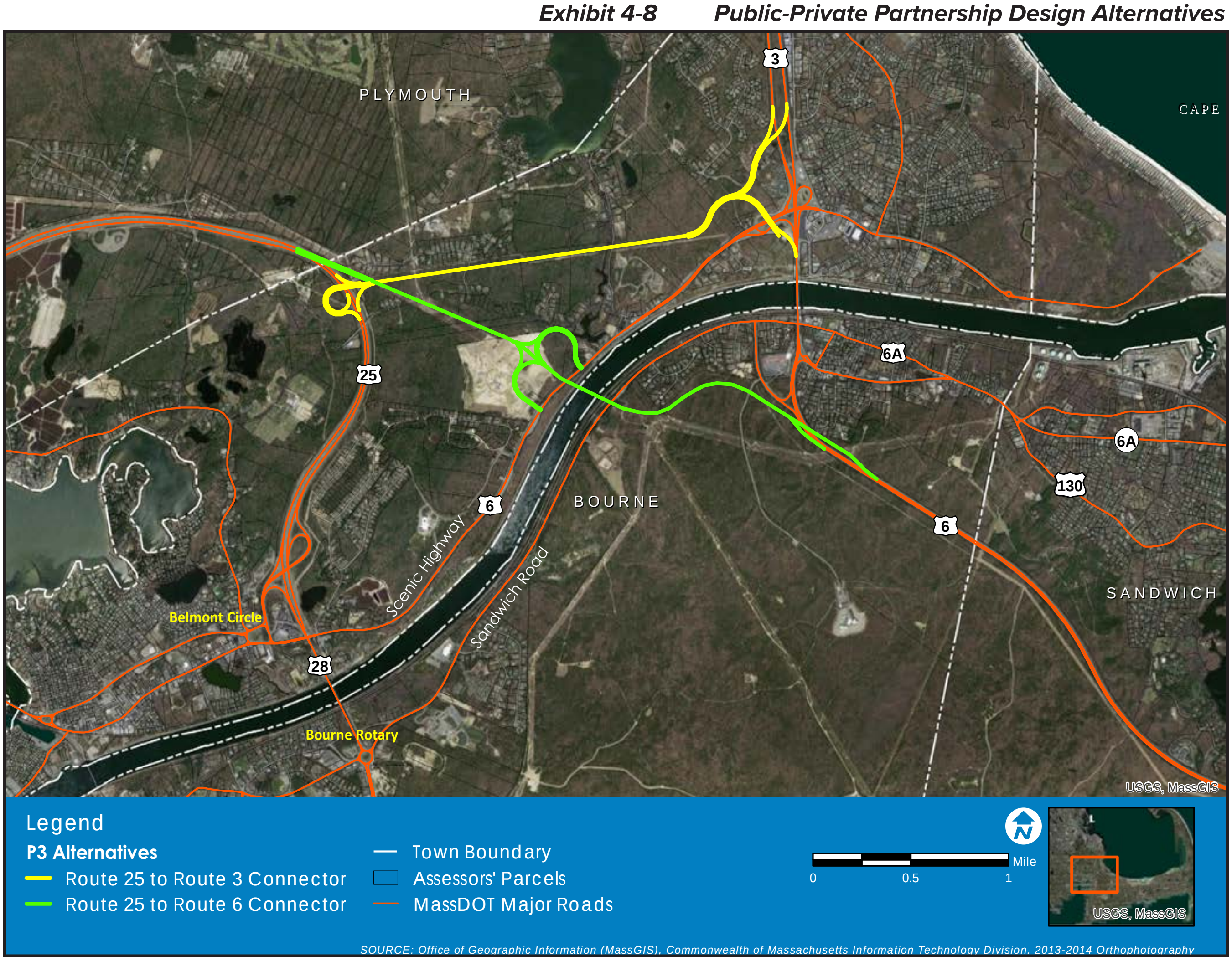
To address this desire for cross-Canal travel, two primary alternatives were developed (Exhibit 4-8). The first alternative would provide a direct roadway connection from Route 25 to Route 3 (north of the Canal). The second alternative would provide a roadway connection from Route 25 to Route 6, including an interchange at Scenic Highway and a new bridge over the Canal. Both alternatives were envisioned to address the high percentage of vehicles traveling between the Route 3/Route 6 highway corridor to the Route 25/Route 28 corridor. These alternatives would be multi-lane highways with interchanges connecting them to the existing highways (Route 3, Route 6, and Route 25).

Public-Private Partnership Alternatives – Environmental Impact

A GIS-based review was conducted to evaluate the potential environmental and social impacts of the two P3 alternatives (Exhibits 4-9 and 4-10). Using a conceptual-level design, the impact analysis was based on two potential roadway widths; a 160-foot width corridor for highway segments having two lanes in each direction and an 80-foot width corridor for those roadway segments and highway ramps having one lane in each direction. As shown on Tables 4-7 and 4-8, each of the P3 alternatives would result in substantial impact to wetlands, open space, Areas of Critical Environmental Concern (ACEC), and rare species habitat. The Route 25 to Route 6 Connector would also impact land within Joint Base Cape Cod (JBCC), the Upper Cape Water Reserve and numerous residential properties.

As noted in Section 2.1.7, the Massachusetts Legislature created the Upper Cape Water Reserve in 2002 to serve as a military training center and as a drinking water and wildlife protection

Exhibit 4-8 Public-Private Partnership Design Alternatives



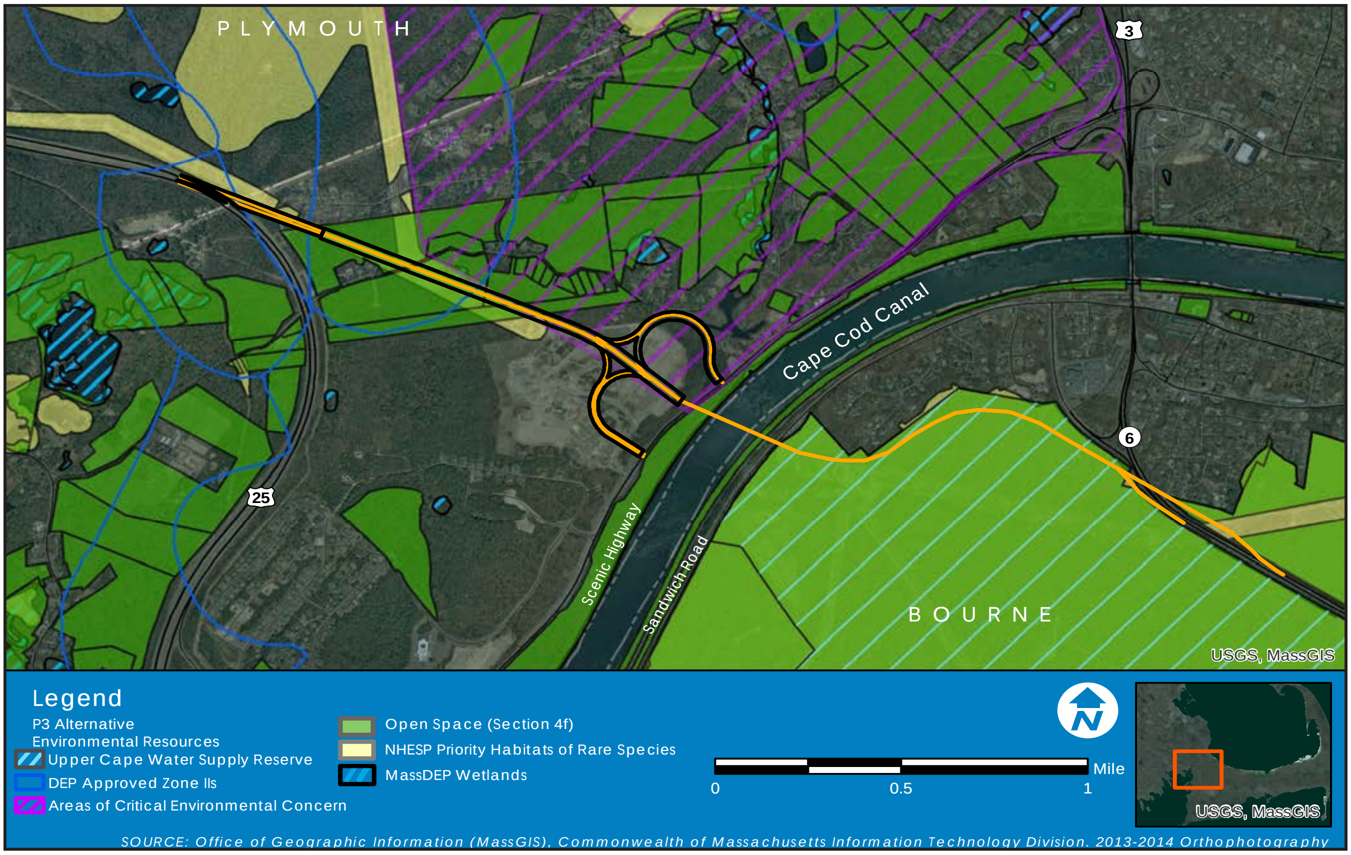


Exhibit 4-9 Route 25 to Route 6 Connector (Mid-Canal Bridge) – Environmental Impact

Exhibit 4-10 Route 25 to Route 3 Connector – Environmental Impact

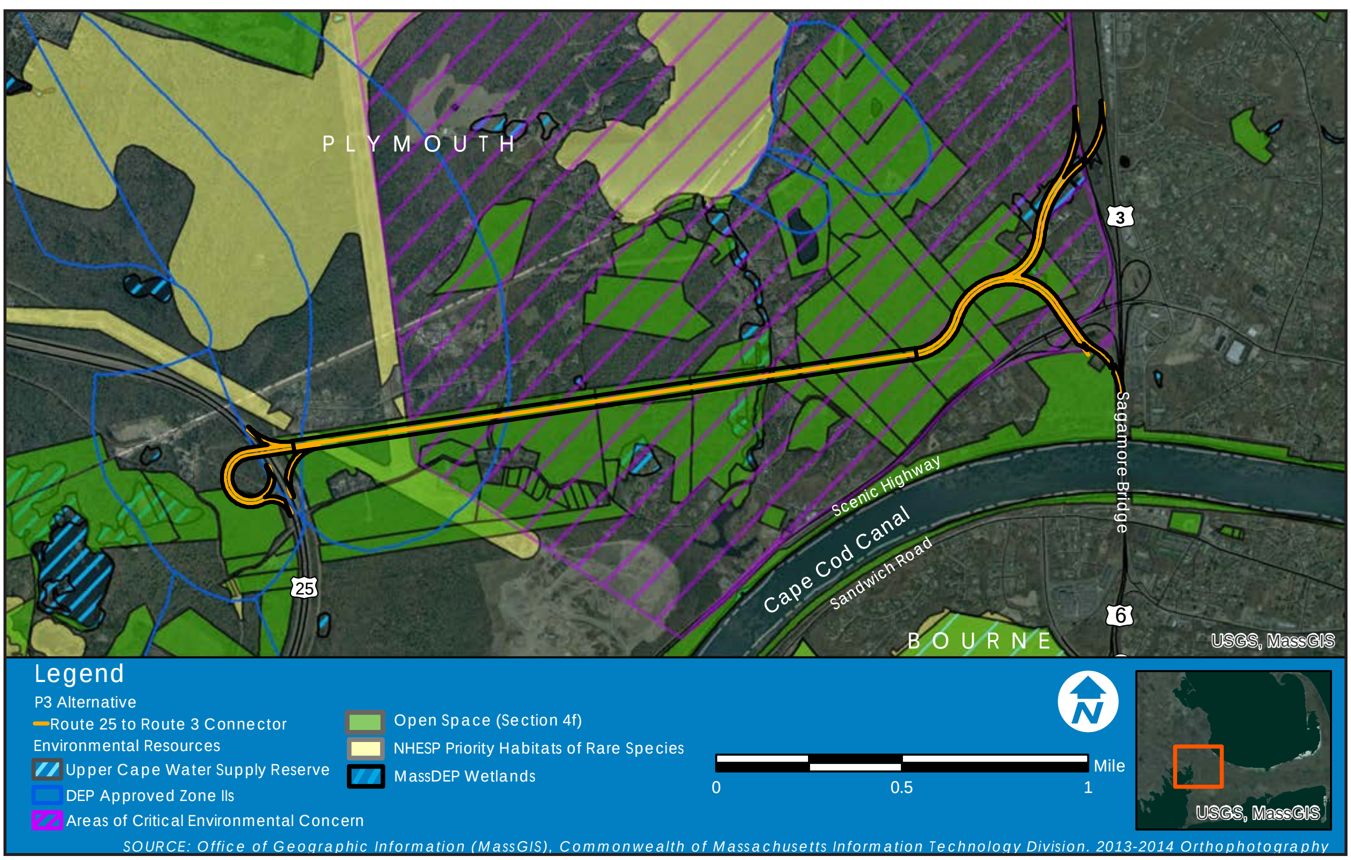


Table 4-7 Route 25 to Route 6 Connector (Mid-Canal Bridge) - Environmental Impact

P3 ALTERNATIVE	WETLANDS	OPEN SPACE (ARTICLE 97)	ACEC	RARE SPECIES	JBCC	RESIDENTIAL PARCELS
	ACRES OF IMPACT (ACRES)					# OF PARCELS
Route 3 to Route 25 Connector	7.2	53.6	54.7	51.3	0	1

Table 4-8 Route 25 to Route 6 Connector - Environmental Impact

P3 ALTERNATIVE	WETLANDS	OPEN SPACE (ARTICLE 97)	ACEC	RARE SPECIES	JBCC	RESIDENTIAL PARCELS
	ACRES OF IMPACT (ACRES)					# OF PARCELS
Route 25 to Route 6 Connector	1.2	37.8	19.2	63.1	19.9	17

area. As designated public open space protected under Article 97 of the Massachusetts Constitution, any change in the ownership or use of the Reserve would require the authorization of the Massachusetts Legislature.

Public-Private Partnership (P3) Alternatives Analysis Determination

The two P3 alternatives evaluated during this study were presented at several Working Group and Public Informational meetings. The P3 alternatives included a new highway connection from Route 25 to Route 6, including a new bridge crossing of the Cape Cod Canal and a new highway connection from Route 25 to Route 3.

The reaction to these alternatives were mixed, with some people expressing strong support for these alternatives as a potentially effective means of alleviating traffic congestion. Others expressed substantial concern regarding the potential impact of these alternatives on residential neighborhoods, wetland and drinking water resources, and sensitive tribal areas. Several Working Group members noted that any construction within Joint Base Cape Cod (JBCC), particularly the portion of JBCC designated as the Upper Cape Water Reserve, would very likely be met with considerable opposition.

Based on the determination of the significant environmental impact which would not likely receive approval during the NEPA and MEPA environmental review process, and the determination that that the project's goals and objectives could be met through improvements to existing infrastructure, these two P3 alternatives were dismissed from further consideration for this study.

4.6 GATEWAY INTERSECTION IMPROVEMENTS

The following section describes roadway improvement alternatives at the major intersections in the focus area which provide access between the Route 3 – Route 6 corridor and the Route 25 – Route 28. These so-called 'gateway intersections' include Belmont Circle, Bourne Rotary, and Route 6 Exit 1C. The fourth gateway intersection is the Route 6 Sagamore Interchange which was reconstructed by MassDOT in 2006.

Multiple alternatives were evaluated at each of the gateway intersections to determine their effectiveness at improving traffic operations and their potential impact on environmental resources and property.

4.6.1 Route 6 Exit 1C Relocation

The following presents the evaluation of the relocation of Route 6 Exit 1C from its existing location at the base of the south end of the Sagamore Bridge to a point further east on Route 6.

Existing Roadway Conditions

Route 6 at Exit 1C (at Cranberry Highway) provides an exit and entrance on Route 6 for westbound vehicles only (Exhibit 4-11). Exit 1C is the last westbound interchange on Route 6 prior to crossing the Cape Cod Canal on the Sagamore Bridge. The geometry of Exit 1C is substandard and not in compliance with current MassDOT highway design standards. The deficiencies of Exit 1C include short acceleration and deceleration lanes, and steep grades approaching the Sagamore Bridge.

Deceleration lanes allow vehicles to safely separate from the through-travel lanes, slow down, and exit a highway at an interchange. Acceleration lanes allow vehicles to enter the highway on a separate lane, while accelerating up to highway speed before merging safely into the through-traffic lane. According to MassDOT' s Project Development and Design Guide, the desired length of a deceleration lane is 600 feet, while the desired length of an acceleration lane is 1,000 feet. At Exit 1C, these lanes are well below these desired lengths, with the existing deceleration lane approximately 300 feet long and the acceleration lane approximately 200 feet long.

Additionally, vehicles traveling west on Route 6 toward Exit 1C are on a long downgradient section (greater than one mile) of the highway. They must then quickly contend with a right-hand bend on Route 6 together with traffic entering the travel lane from Exit 1C and the steep grades (greater than six percent) on Route 6 as it approaches the Sagamore Bridge. These changes

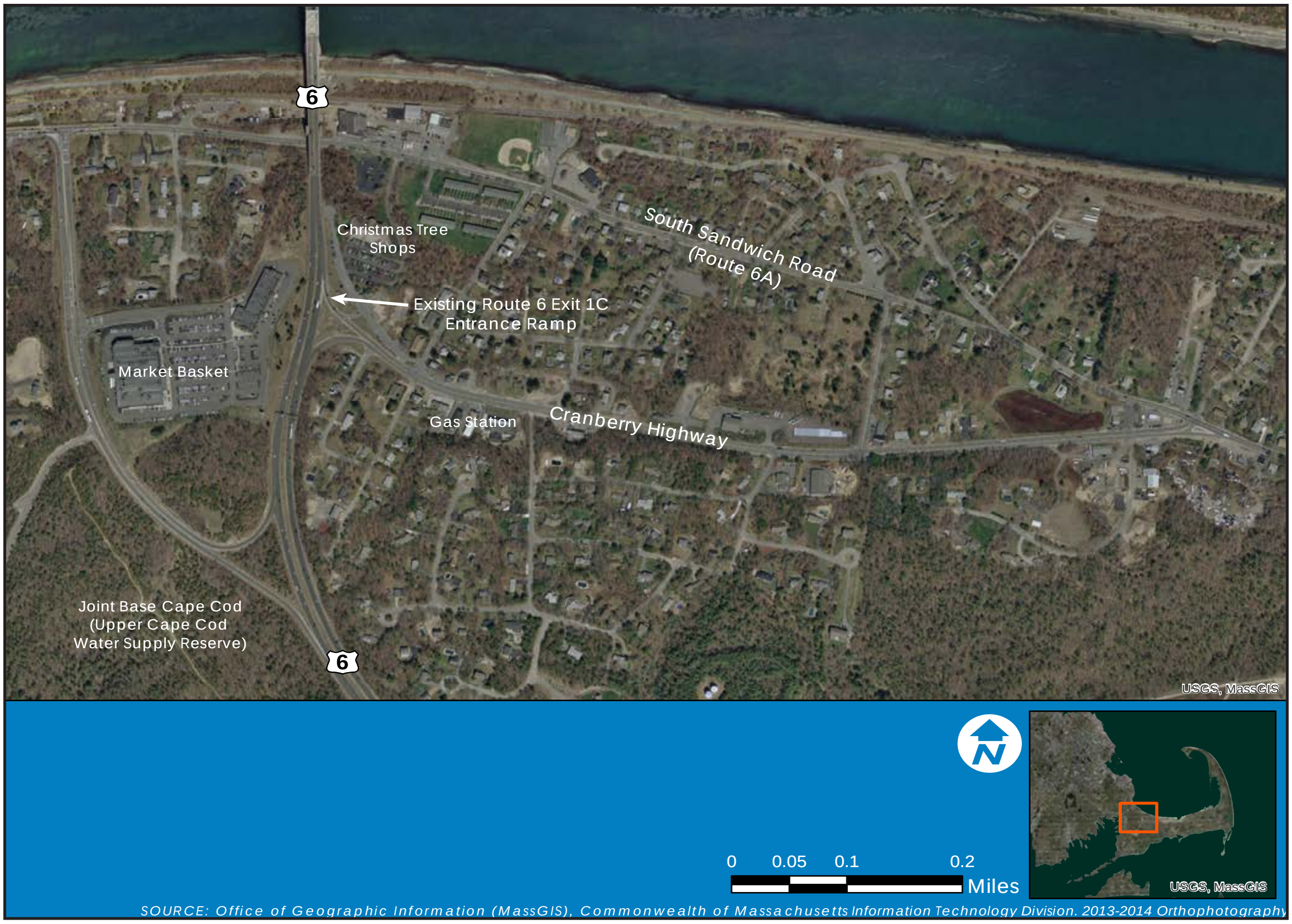


Exhibit 4-11 Existing Conditions - Route 6 Exit 1C

in the highway profile and the high volume of vehicles entering from Exit 1C cause substantial congestion on Route 6.

In the near-term, the relocation of Exit 1C would reduce delay by providing acceleration lanes for vehicles entering Route 6 westbound from Cranberry Highway. Additionally, it is anticipated that the future profile of a replacement Sagamore Bridge would be less steep than the six-percent grade on the existing bridge. This would result in a longer bridge, which would tie into Route 6 further east, requiring the relocation of the existing Exit 1C.

Land Uses and Environmental Resources

Land uses around Exit 1C include residential properties east of Route 6 and a retail shopping plaza (including a Market Basket grocery store) on the west side of Route 6 (Exhibit 4-12). Land uses along Cranberry Highway include the Christmas Tree Shops retail store, and mix of residential, retail, restaurant, and auto-related shops. Further east, Joint Base Cape Cod abuts the west side of Route 6 from the Mid-Cape Connector interchange to Exit 2. Land use east of Route 6 includes residential

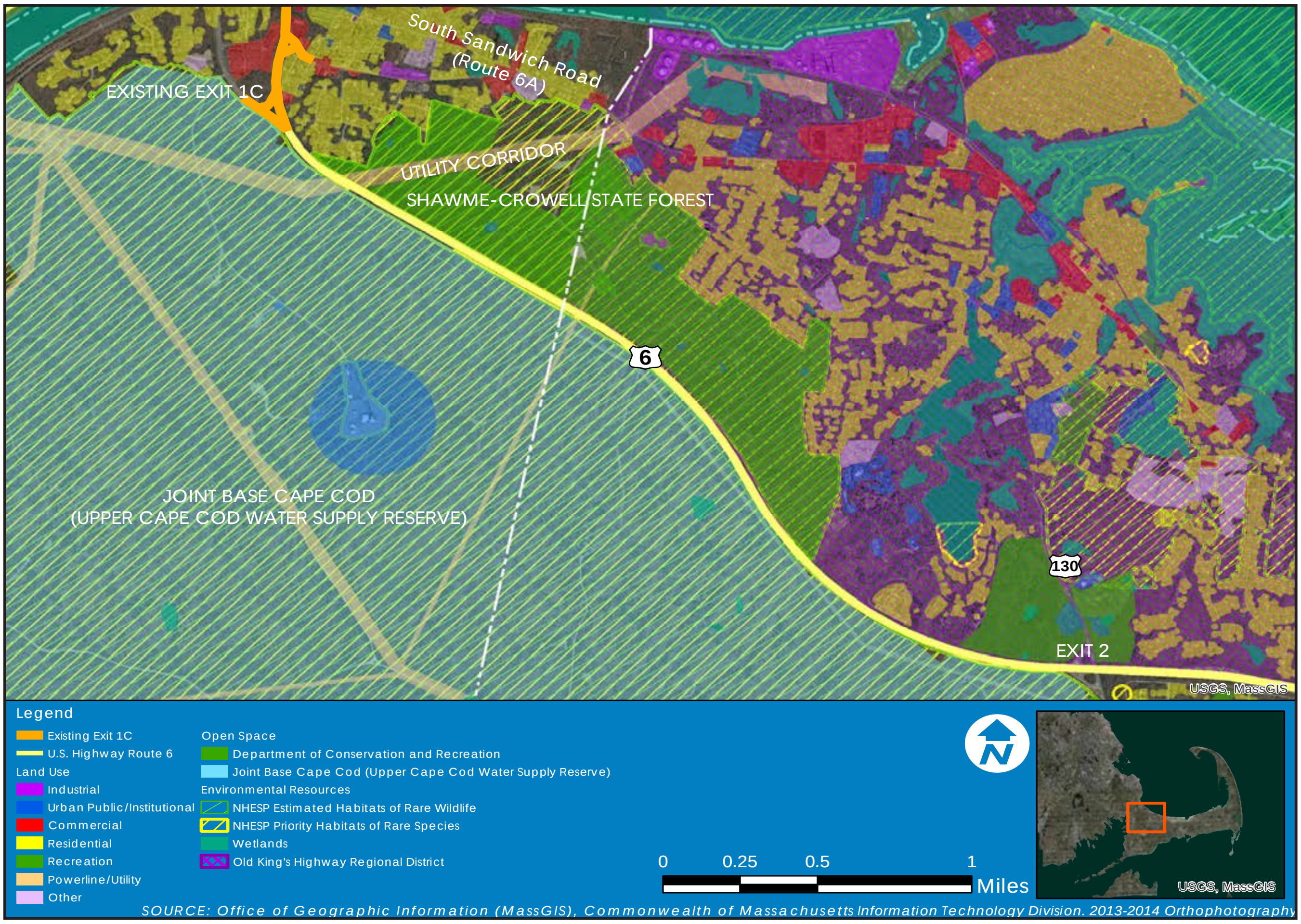


Exhibit 4-12 Adjacent Land Uses - Route 6 Between Exit 1C and Exit 2 (Route 130)

neighborhoods and the Shawme-Crowell State Forest (which extends nearly to Exit 2). An electrical utility corridor divides the state forest and extends 3,600 feet from Route 6 to the Route 6A at Route 130 intersection, continuing northeast approximately 3,300 feet to the Canal Electrical Generating Plant.

There are no wetlands, floodplains, or other regulated wetland resources within 100 feet of the Exit 1C interchange. The land within JBCC, the Shawme Crowell State Forest, and the utility corridor is designated by the Massachusetts Natural Heritage and Endangered Species Program as a 'Priority Habitat for Rare Species'.

Traffic Conditions on Route 3 / Route 6 Approaches to Sagamore Bridge

Currently, the Route 6 westbound approach to the Sagamore Bridge at the Exit 1C interchange experiences acceptable traffic conditions (LOS A, with an average delay of five seconds) during the non-summer weekday peak period. However, conditions during summer Saturday peak periods are often characterized by substantial congestion with average queuing on Route 6 westbound extending 4.4 miles, resulting in LOS F conditions. This congestion results in substantial delays (average delay of 11.4 minutes) for vehicles heading off-Cape. The peak period delays on Route 6 westbound are forecast to increase by 2040 to 3.0- to 13.5-minutes during the non-summer and summer Saturday peak period, respectively (Table 4-9).

Existing summer Saturday peak period traffic conditions on the Route 3 southbound approach to the Sagamore Bridge are also poor with existing average delays of 6.9 minutes. These are forecast to increase to 14.8 minutes by 2040.

The location and sub-standard geometry of Exit 1C contributes to this traffic congestion. Exit 1C's short acceleration- and deceleration-lanes require vehicles to rapidly decelerate or accelerate when exiting or entering through-traffic lanes. These sudden movements cause other drivers to react by slowing down, increasing traffic congestion.

Additionally, the steep grades (greater than six percent) as Route 6 approaches the Sagamore Bridge beyond Exit 1C make it more difficult for entering vehicles to increase speed and merge into traffic.

Identification of Interchange Location

Potential locations for the relocation of Exit 1C further to the east were evaluated. Relocating Exit 1C to the east would allow it to be designed in accordance with current MassDOT design standards, thereby providing a safer and smoother transition to and from Route 6. Relocating Exit 1C to the east would also be necessary to accommodate the anticipated lower profile of an assumed replacement of the Sagamore Bridge.

The selection for a new location for the Route 6 Exit 1C interchange was informed by existing land uses and compliance with Federal Highway Administration (FHWA) guidelines. As described above, the land uses adjacent to the east side of Route 6 consists of developed residential neighborhoods and state forest land (Exhibit 4-12). Additionally, in accordance with FHWA guidance, a new highway interchange should be one-mile or more from an adjacent interchange (in this case, Exit 2 at Route 130) and must provide a connection to and from an existing public street.

Given these existing constraints, the electrical utility corridor was identified as the most appropriate location for the relocated interchange. This relocated interchange would provide a roadway connection from Route 6 eastbound to the Route 6A/Route 130 intersection (Exhibits 4-13 and 4-14). This location would have

Text continues on page 4-32.

Table 4-9 Traffic Operations – Route 3 / Route 6 Approaches to Sagamore Bridge

	EXISTING (2014) CONDITIONS				FUTURE (2040) NO-BUILD CONDITIONS				FUTURE (2040) BUILD CONDITIONS			
	AVERAGE DELAY *Sec (Min)*	LOS	AVERAGE QUEUE *Feet (Miles)*	MAXIMUM QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	AVERAGE QUEUE *Feet (Miles)*	MAXIMUM QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	AVERAGE QUEUE *Feet (Miles)*	MAXIMUM QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)												
Route 3 Southbound	11	B	77	478	460 (7.7)	**F**	7,481 (1.4)	8,476 (1.6)	453 (7.5)	**F**	3,534 (0.7)	4,090 (0.8)
Route 6 Westbound	5	A	53	232	178 (3.0)	**F**	6,801 (1.3)	7,967 (1.5)	2	A	0	0
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)												
Route 3 Southbound	416 (6.9)	**F**	4,823 (0.91)	5,393 (1.02)	887 (14.8)	**F**	22,814 (4.3)	24,484 (4.6)	895 (14.9)	**F**	23,308 (4.4)	24,826 (4.7)
Route 6 Westbound	683 (11.4)	**F**	23,318 (4.4)	25,014 (4.7)	812 (13.5)	**F**	24,825 (4.7)	25,029 (4.7)	210 (3.5)	**F**	7,253 (1.4)	10,037 (1.9)

Notes:
*LOS E and LOS locations are **bold***
LOS = Level of Service.
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

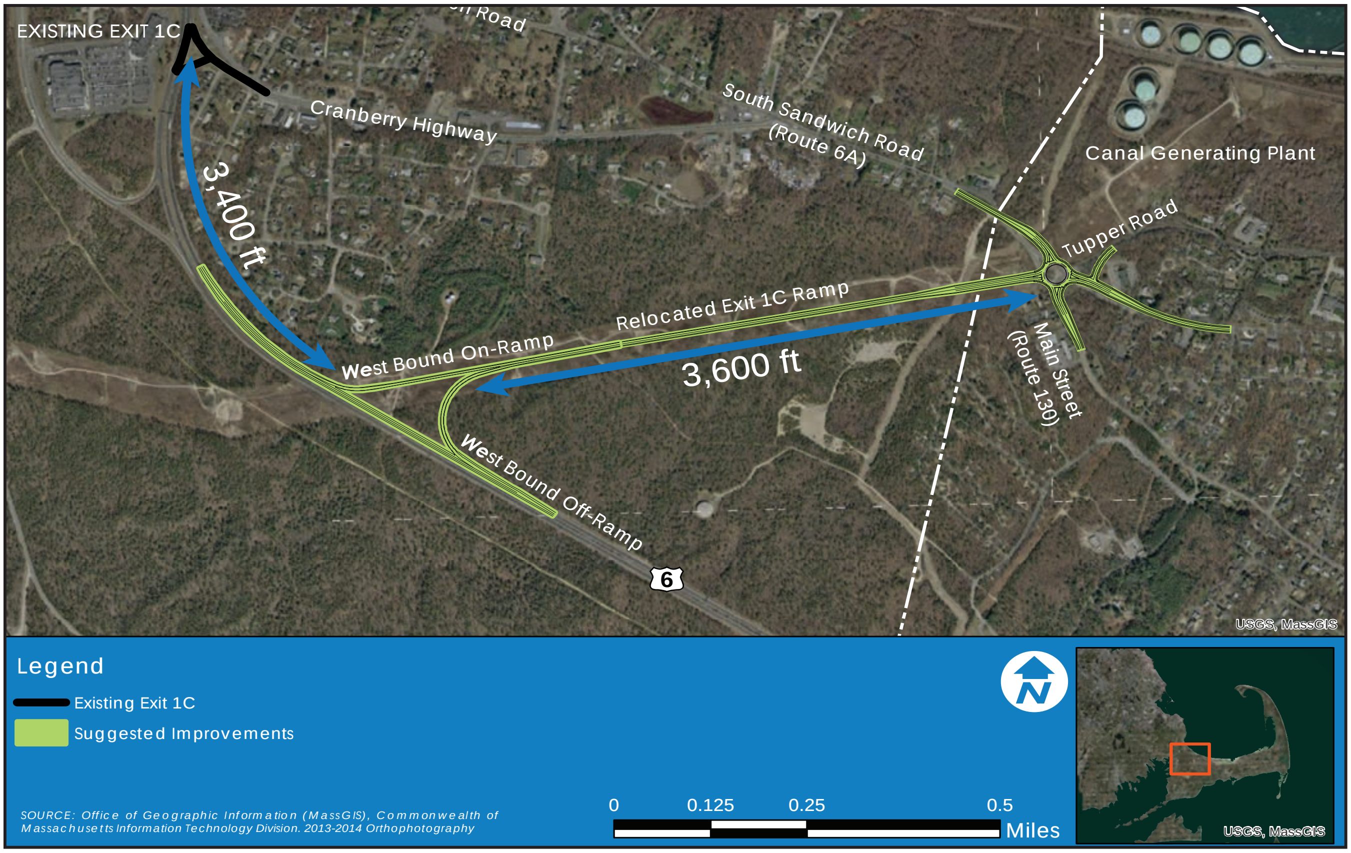


Exhibit 4-13 Route 6 Exit 1C Relocation

Exhibit 4-14 Route 6 Exit 1C Ramp

only a minor effect on existing commercial and residential properties and state forest land, is more than one mile from Exit 2, and would connect to a public street.

Identification of Intersection Type

Several alternatives for incorporating the new highway ramp into the Route 6A at Route 130 intersection (Exhibit 4-15) were evaluated. These alternatives included:

- Alternative 1 – Two Signalized Intersections
- Alternative 2 – Four-Leg Roundabout
- Alternative 3 – Five-Leg Roundabout

Traffic Operations at Route 6A/Route 130 Intersection

During existing and future no-build peak periods, traffic operates acceptably at the existing unsignalized intersection of Route 6A at Route 130 intersection (LOS A and B) except for the Route 6A eastbound approach, which operates at LOS F during the summer for both the existing and future peak periods. During the summer Saturday peak period, the Route

Exhibit 4-15 Route 6 Exit 1C - Route 6A Intersection Alternatives

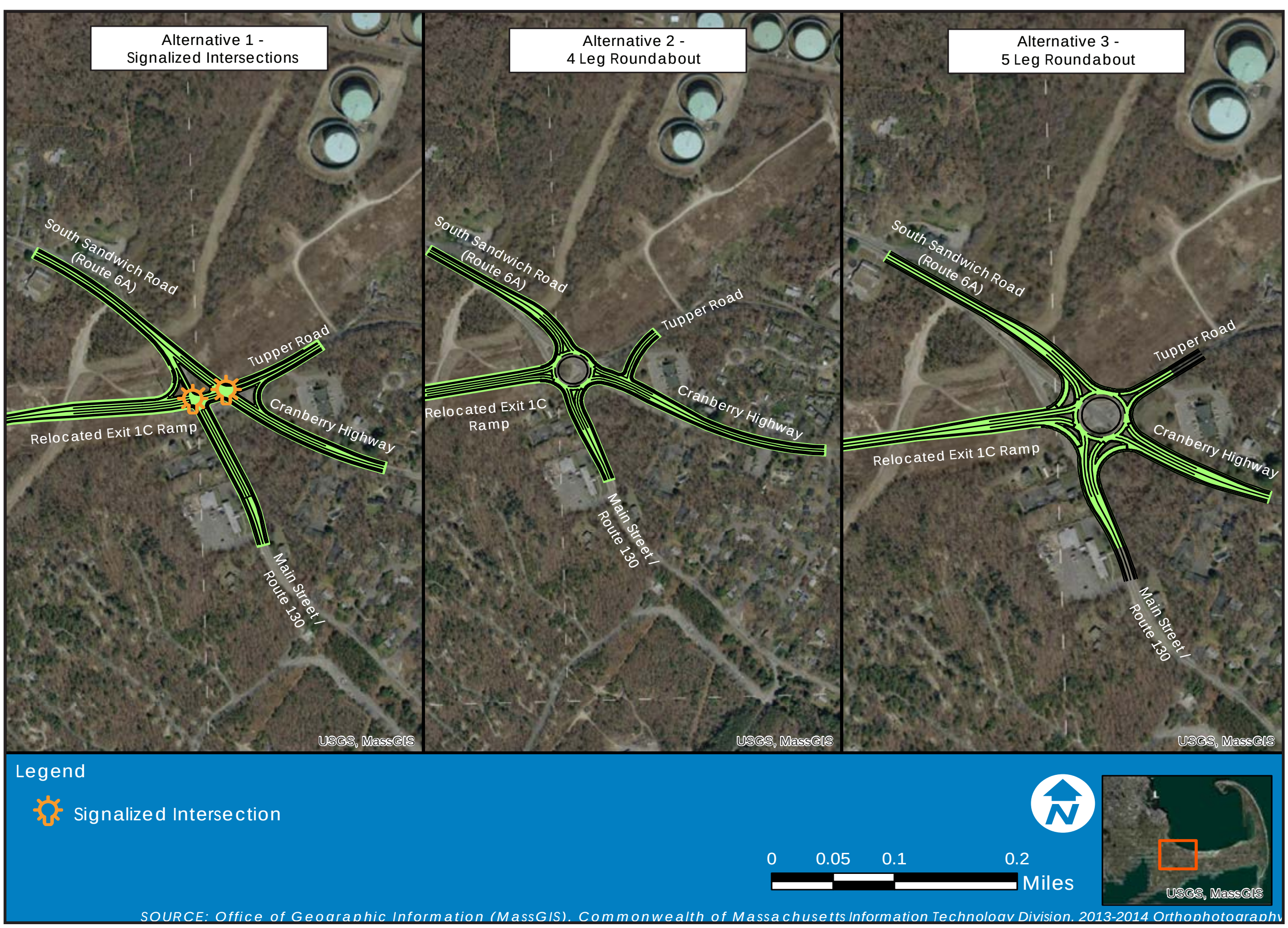


Table 4-10 Traffic Operations – Existing and Future No-Build Conditions, Route 6A at Route 130

	EXISTING (2014) CONDITIONS				FUTURE (2040) NO-BUILD CONDITIONS			
	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)								
Route 6A EB Lt/Th/Rt	32	D	0.52	70	74	**F**	0.83	151
Route 6A WB Lt/Th/Rt	11	B	0.17	16	12	B	0.21	19
Route 130 NB Lt/Th/Rt	2	A	0.06	5	2	A	0.08	6
Tupper Road WB Lt/Th/Rt	0.2	A	0	0	0.1	A	0	0
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)								
Route 6A EB Lt/Th/Rt	n/a	**F**	5.62	n/a	n/a	**F**	24.15	n/a
Route 6A WB Lt/Th/Rt	30	D	0.69	128	703 (11.7)	**F**	0.94	251
Route 130 NB Lt/Th/Rt	3	A	0.11	9	4	A	0.16	14
Tupper Road WB Lt/Th/Rt	0.1	A	0	0	0.1	A	0	0

Notes:
*•LOS E and LOS F movements are **bold***
•Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
•LOS = Level of Service; V/C = Volume to Capacity Ratio
•Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.
•n/a = Volume exceeds capacity to the point where the respective value cannot be determined.

6A westbound approach operates at LOS F/D under existing and future no-build conditions, respectively (Table 4-10).

Future Traffic Operations at new intersection of the Route 6 Exit 1C Ramp at Route 6A and Route 130

Traffic operations at the new intersection consisting of the Exit 1C ramp, Route 6A and Route 130 under the three different intersection alternatives was evaluated. The results of this analysis for these three different intersection alternatives are summarized below on Table 4-11(Alternative 1 - Two Signalized Intersections) and Table 4-12 (Alternatives 2 and 3, Four-Leg and Five-Leg Roundabouts).

Overall, Alternative 1 would operate at LOS B during the non-summer weekday peak period and LOS F during the summer Saturday peak period. However, at 152 and 206 seconds, the average delay during the summer Saturday peak period is longer than the summer Saturday peak period delay for either roundabout alternative.

Under the future build conditions, Alternative 2, the Four-Leg Roundabout, and Alternative 3, the Five-Leg Roundabout, would operate similarly. During the non-summer weekday peak period, the LOS for each approach to the roundabout would range from LOS A to LOS D, with delays ranging from eight to 27 seconds. During the summer Saturday peak period, the delays at the approaches to both roundabout alternatives would range from nine- to 213 seconds.

Table 4-11 Traffic Operations – Exit 1C Ramp at Route 6A/Route. 130, Two Signalized Intersection Alternative

ALTERNATIVE 1 - INTERSECTION 1 ROUTE 6 EXIT 1C RAMP AT ROUTE 6A AND TUPPER RD	FUTURE (2040) BUILD CONDITIONS - INITIAL SCREENING				
	AVERAGE DELAY *Sec (Min)*	LOS	V/C	50% QUEUE *Feet (Miles)*	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)					
Route 6A (Sandwich Rd) SB Lt	18	B	0.14	14	36
Route 6A (Sandwich Rd) SB Th/Rt	19	B	0.35	54	99
Route 6A NB Lt	27	C	0.71	80	149
Route 6A SB Th/Rt	18	B	0.27	41	79
Exit1C Off Ramp Connector Rd EB Lt	9	A	0.8	22	323
Exit1C Off Ramp Connector Rd EB Lt/Th/Rt	7	A	0.74	10	65
Tupper Road WB Lt/Th/Rt	43	D	0.71	41	140
Intersection (Overall)	**15.5**	**B**	**0.75**		
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)					
Route 6A (Sandwich Rd) SB Lt	28	C	0.39	51	102
Route 6A (Sandwich Rd) SB Th/Rt	30	C	0.56	229	330
Route 6A NB Lt	505 (8.4)	**F**	2.01	605	816
Route 6A SB Th/Rt	31	C	0.58	247	352
Exit1C Off Ramp Connector Rd EB Lt	17	B	0.82	64	567
Exit1C Off Ramp Connector Rd EB Lt/Th/Rt	14	B	0.8	51	88
Tupper Road WB Lt/Th/Rt	356 (5.9)	**F**	1.62	359	550
Intersection (Overall)	**151.9**	**F**	**1.45**		

ALTERNATIVE 1 - INTERSECTION 2 ROUTE 130 AT EXIT 1C CONNECTOR RAMP	FUTURE (2040) BUILD CONDITIONS - INITIAL SCREENING				
	AVERAGE DELAY *Sec (Min)*	LOS	V/C	50% QUEUE *Feet (Miles)*	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)					
Route 130 (Main Street) (NB) Lt	18	B	0.27	27	60
Route 130 (Main Street) (NB) Rt	17	B	0.04	0	8
Route 6A SB Th	18	B	0.24	37	72
Route 6A SB Rt	18	B	0.28	0	56
Exit1C Off Ramp EB Th/Rt	20	C	0.77	177	323
Exit1C Off Ramp Connector Rd WB Lt/Th	14	B	0.32	108	221
Intersection (Overall)	**18.5**	**B**	**0.56**		
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)					
Route 130 (Main Street) (NB) Lt	30	C	0.51	141	223
Route 130 (Main Street) (NB) Rt	24	C	0.12	0	47
Route 6A SB Th	25	C	0.18	67	113
Route 6A SB Rt	26	C	0.3	51	125
Exit1C Off Ramp EB Th/Rt	33	C	0.69	303	377
Exit1C Off Ramp Connector Rd WB Lt/Th	605 (10)	**F**	2.23	1008	504
Intersection (Overall)	**206.1 (3.4)**	**F**	**1.59**		

Notes:
*LOS E and LOS F movements are **bold***
Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB- Southbound
LOS = Level of Service; V/C = Volume to Capacity Ratio
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

Table 4-12 Exit 1C Ramp at Route 6A and Route 130, Roundabout Alternatives

ROUTE 6 EXIT 1C RAMP AT ROUTE 6A AND ROUTE 130	ALTERNATIVE 2 – 4 LEG ROUNDABOUT				ALTERNATIVE 3 – 5 LEG ROUNDABOUT			
	FUTURE (2040) BUILD CONDITIONS - SCREENING ANALYSIS							
	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)								
Exit 1C Ramp (EB) Lt	27	D	0.85	10	27	D	0.85	10
Exit 1C Ramp (EB) Th/Rt	9	A	0.37	2	8	A	0.37	2
Route 6A (WB) Lt/Th	17	C	0.56	3	14	B	0.44	2
Route 6A (WB) Rt	10	B	0.32	1	10	A	0.25	1
Route 130 (NB) Lt/Th	13	B	0.32	1	13	B	0.32	1
Route 130 (NB) Rt	8	A	0.03	0	8	A	0.03	0
Route 6A (Sandwich Rd) SB Lt/Th	10	B	0.44	2	8	A	0.28	1
Route 6A (Sandwich Rd) SB Rt	12	B	0.54	3	6	A	0.15	1
Tupper Road WB Lt/Th/Rt					13	B	0.31	1
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)								
Exit 1C Ramp (EB) Lt	54	F	0.98	15	55	F	0.98	15
Exit 1C Ramp (EB) Th/Rt	9	A	0.32	1	9	A	0.32	1
Route 6A (WB) Lt/Th	213 (3.6)	F	1.39	32	112 (1.9)	F	1.13	18
Route 6A (WB) Rt	73 (1.2)	F	1.02	15	44	E	0.86	9
Route 130 (NB) Lt/Th	48	E	0.87	9	48	E	0.87	9
Route 130 (NB) Rt	9	A	0.11	0	9	A	0.11	0
Route 6A (Sandwich Rd) SB Lt/Th	105 (1.8)	F	1.13	20	26	D	0.73	6
Route 6A (Sandwich Rd) SB Rt	16	C	0.53	3	12	B	0.38	2
Tupper Road WB Lt/Th/Rt					171 (2.9)	F	1.23	16

Notes:
Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service; V/C = Volume to Capacity Ratio
Overall LOS, V/C and delay not calculated for unsignalized intersections
Shaded areas do not exist in listed configuration during this period

Future Traffic Operations along Route 3 and Route 6 Approaches to Sagamore Bridge

With a relocated Route 6 Exit 1C in place, queuing and delays in the future (2040) would be substantially reduced for vehicles heading off-Cape on Route 6 westbound during both the non-summer weekday PM and summer Saturday peak periods (Table 4-9). For example, the future summer Saturday peak period delay would be reduced from 13.5 minutes to 3.5 minutes. During the non-summer weekday peak period, delay would be reduced from 3.0 minutes to 0.0 minutes. Delay on Route 3 southbound would not be reduced with the relocation of Exit 1C.

For this screening analysis stage, it is assumed that the existing Canal bridges remain. More detailed information on results of the future traffic operations on Route 6 westbound with the relocated Exit 1C in place is discussed under Travel Demand Model Case 1 and Case 3A (Section 4.8).

Property or Environmental Resource Impact

The relocation of Exit 1C would require the use of approximately 3.8 acres of land owned by the utility provider, Eversource, either as a land acquisition or a permanent easement. The improvements may also require the acquisition of approximately 0.15 acres of residential property and approximately 0.9-acres of commercial property at the Route 6A (Sandwich Road) at Route 130 intersection (Table 4-13).

No wetland, floodplain, or other regulated water resources would be impacted. These improvements would impact approximately 7.2 acres of land designated as a 'Priority Habitat for Rare Species'.

Table 4-13 Potential Environmental Impact - Exit 1C Ramp at Route 6 and Route 130

	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
RESOURCE AREAS (ACRES):			
Rare Species Habitat	7.4	7.2	7.0
OPEN SPACE (ACRES):			
DCR - Shawme-Crowell State Forest	0.5	0.6	0.5
Interim Wellhead Protection Area (IWPA)	4.6	5.7	5.5
RIGHT OF WAY (ACRES):			
Residential	0.02	0.15	0.03
Commercial	0.02	0.9	0.26
Utility	3.5	3.8	3.8

Notes:
Environmental and right-of-way impact based on conceptual design and GIS-based data.

Suggested Alternative

The suggested alternative involves the relocation of Route 6 Exit 1C interchange approximately 3,400 feet to the east (Exhibit 4-13). A relocated highway interchange would be constructed on Route 6 providing westbound-only access (the Mid-Cape Connector provides eastbound access to Route 6). The new interchange ramp would extend approximately 3,600 feet within the electrical utility corridor to the Route 6A (Sandwich Road) and Route 130 intersection (Exhibit 4-16).

Alternative 2 – Relocated Interchange with Four-Leg Roundabout – was advanced for further study during the travel demand model analysis. This alternative was selected because it would provide better traffic operations at the Route 6A/Route 130 intersection (when compared to Alternative 1). Furthermore, when compared to the larger Five-Leg Roundabout featured in Alternative 3, the

Four-Leg Roundabout was considered a simpler design and more in line with the community context. Environmental impacts were approximately the same for all alternatives.

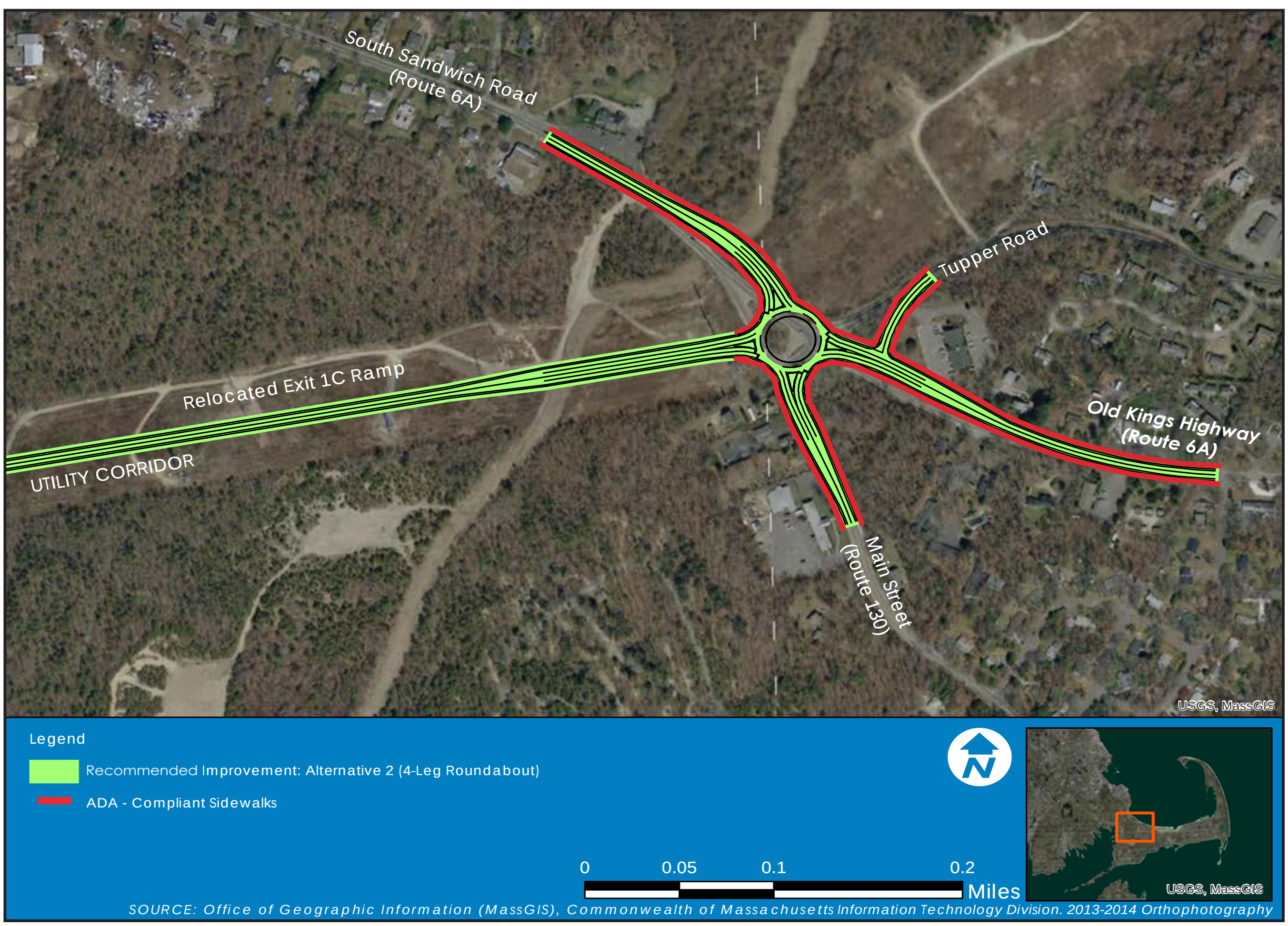
Conceptual Cost Estimate

The conceptual cost estimates for the three alternatives to relocate the Route 6 Exit 1C interchange are provided by construction year in Table 4-14. More detailed conceptual cost estimates are provided in Appendix E.

Table 4-14 Relocation of Route 6 Exit 1C, Conceptual Cost Estimate

	2017 ($ MILLION)	2030 ($ MILLION)	2040 ($ MILLION)
Alternative 1	27	45	67
Alternative 2 (suggested alternative)	30	51	75
Alternative 3	28	47	69

Exhibit 4-16 Route 6 Exit 1C at Route 6A/Route 130 Intersection – Suggested Alternative



4.6.2 Route 6 Additional Eastbound Travel Lane

The construction of an additional travel lane on Route 6 eastbound for approximately 3.4 miles from the Mid-Cape Connector to Exit 2 (Route 130) was evaluated. It is assumed that this additional travel lane would be constructed concurrent with the construction of a replacement Sagamore Bridge. A replacement Sagamore Bridge in envisioned to include auxiliary lanes extending from the Scenic Highway entrance ramp to Route 3 southbound, over the Sagamore Bridge, to the Mid-Cape Connector entrance ramp to Route 6 eastbound.

An additional eastbound travel lane on Route 6 would act an extension of this auxiliary lane providing additional capacity and distance for entering vehicles to merge onto the heavily-traveled section of Route 6 eastbound between the Sagamore Bridge and Exit 2 (Route 130). The extension of this additional eastbound travel lane is not required beyond Exit 2 because traffic volumes drop substantially after this point. For example, during the future no-build period, traffic volumes west of Exit 2 drop by more than 27%, from 2,765 to 2,000 vehicles, during the non-summer weekday PM peak period.

Existing Conditions

Currently, Route 6 between the Mid-Cape Connector and Exit 2 (Route 130) consists of two 12-foot wide travel lanes in each direction separated by a 30-foot wide grassed median. An eight-foot wide gravel shoulder abuts the right travel lane in each direction.

Route 6 eastbound currently operates at LOS C during the non-summer weekday peak period and LOS D during the summer Saturday peak period. This degrades to LOS D and LOS E in 2040.

Land Uses and Environmental Resources

Land uses in the area include approximately 100 residential properties east of Route 6, with access to Cranberry Highway at Exit 1C. Other than a utility corridor and a small residential development south of Shawme Lake, land uses adjacent to Route 6 for the remainder of the corridor consist of undeveloped forest within Joint Base Cape Cod west of Route 6 and the Shawme-Crowell State Forest east of Route 6 (Exhibit 4-17).

There are no wetlands, floodplains, or other regulated wetland resources within 100 feet of the Route 6 corridor. The forested land within Joint Base Cape Cod and the Shawme-Crowell State Forest is designated by the Massachusetts Natural Heritage and Endangered Species Program as a ‘Priority Habitat for Rare Species’.

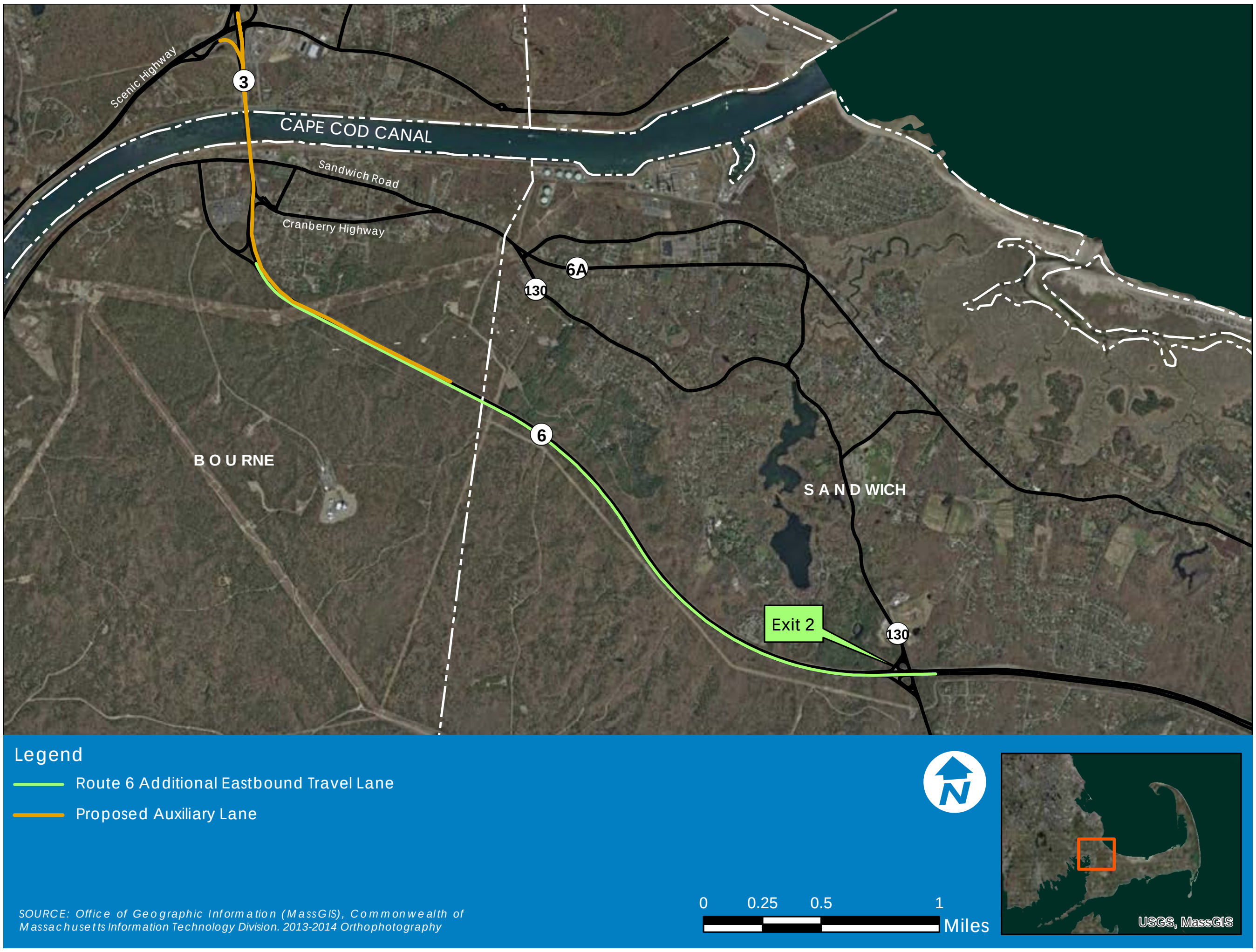


Exhibit 4-17 Route 6 - Additional Eastbound Travel Lane and Westbound Auxiliary Lane

Suggested Improvements

Suggested improvements on Route 6 involve the construction of an additional travel lane on Route 6 eastbound for approximately 3.4 miles from the Mid-Cape Connector to Exit 2 at Route 130 (Exhibit 4-17).

The effect of the relocation of Exit 1C on queuing on Route 6 is provided in Section 4.8; under Case 1 for the existing Canal bridge condition and under Case 3A for the replacement Canal bridge condition.

Property or Environmental Resource Impact

These improvements could be constructed entirely within the MassDOT right-of-way, with no property acquisitions required. The work may impact up to 3.9 acres of rare species habitat. No other regulated environmental resources, such as wetlands or floodplains, would be impacted.

Conceptual Cost Estimate

The conceptual cost of the additional Route 6 eastbound travel lane is provided by construction year in Table 4-15. More detailed conceptual cost estimates are provided in Appendix E.

Table 4-15 Route 6 Eastbound Travel Lane - Conceptual Cost Estimate by Build Year

	2017 ($ MILLION)	2030 ($ MILLION)	2040 ($ MILLION)
Route 6 Eastbound Travel Lane	29	48	71

4.6.3 Belmont Circle and Bourne Rotary – Introduction

Belmont Circle and the Bourne Rotary, located north and south of the Bourne Bridge, respectively, are two of the most critical intersections in the study area. Motorists often must navigate both traffic circles when traveling through Bourne and when crossing the Bourne Bridge. Belmont Circle is the intersection of Route 25, Main Street, Scenic Highway, and the Buzzards Bay Bypass. Bourne Rotary processes vehicles from Route 28, Sandwich Road, and Trowbridge Road.

From the west, access to the Bourne Bridge is provided on Route 25. To avoid traffic congestion on Route 25 eastbound while heading toward the Bourne Bridge, travelers often leave Route 25 at Exit 2 (Glen Chen Charlie Road) to access Route 6 eastbound in Wareham towards Main Street and Belmont Circle in Bourne. A strong traveler preference for Main Street eastbound rather than the parallel route of the Buzzards Bay Bypass has been observed.

The existing land uses and environmental resources at Belmont Circle and Bourne Rotary, presented in Chapter 2 (Section 2.2.3), informed the constraints on the potential transportation improvements in these areas. In developing improvement alternatives, avoiding impact to property and environmental resources was prioritized.

The high traffic volumes and sub-standard design of these unsignalized traffic circles result in severe traffic congestion during peak periods. Each operate at LOS F during all peak travel period during the non-summer weekday and summer Saturday peak periods resulting in lengthy queues of vehicles extending from the approaches to both Belmont Circle and the Bourne Rotary. The existing and future traffic operations at Belmont Circle and Bourne Rotary are described in Chapters 2 and 3 (Sections 2.5.10 and 3.3.7).

Further, the proximity of these traffic circles to one another results in their having a substantial effect on each another. For example, during peak periods the traffic queuing on Route 28 southbound extends over the Bourne Bridge, and several thousand feet north along Route 25. These queues in turn delay other motorists trying to enter Belmont Circle from Route 25 Exit 3 or Scenic Highway.

The key to improving traffic operations at both Belmont Circle and Bourne Rotary was identifying transportation improvements that:

1. Reduce traffic volumes entering the Belmont Circle and Bourne Rotary;
2. Safely accommodate both regional and local traffic;
3. Maintain access to local businesses; and
4. Ensure compatibility with a future replacement Bourne Bridge alignment (assumed to the east of the existing bridge).

Transportation improvements at Belmont Circle and Bourne Rotary (and the other problem intersections in the study area) is the most important factor in minimizing diversions of regional traffic diversions to local roadways.

The following sections describe the transportation improvements alternatives at Belmont Circle and Bourne Rotary that were evaluated by the study team, in conjunction with the study Working Group.

4.6.4 Belmont Circle

As described below, several alternatives were evaluated to improve traffic operations at Belmont Circle. To provide the context of Belmont Circle, Exhibit 4-18 presents the existing roadways at Belmont Circle. These alternatives were conceived to be compatible with the existing Bourne Bridge as well as with the vertical and horizontal alignment of an assumed replacement of the Bourne Bridge. The traffic analysis is based on location and geometry of the existing Bourne Bridge.

Suggested Improvement – New Entrance Ramp, Scenic Highway Westbound to Route 25 Westbound

Currently, vehicles traveling from the east on Scenic Highway heading for Route 25 enter the east side of Belmont Circle and then immediately exit onto the Route 25 entrance ramps. This roadway configuration contributes to congestion in Belmont Circle because it requires vehicles to enter Belmont Circle when their destination is Route 25.

Exhibit 4-18 Belmont Circle - Existing Conditions

As noted previously, one key to improving traffic operations at Belmont Circle is to reduce traffic volumes entering the Circle. To achieve this goal, roadway improvements were evaluated involving the construction of a new highway entrance ramp from Scenic Highway westbound to Route 25 westbound (Exhibit 4-19). The Scenic Highway at Nightingale Pond Road intersection would be reconstructed to accommodate this new ramp. This new ramp would divert vehicles from entering Belmont Circle from Route 25 eastbound before they entered Belmont Circle.

Traffic Analysis

A new Scenic Highway to Route 25 westbound entrance ramp would achieve the goal of reducing traffic volumes entering Belmont Circle by diverting approximately 40% of vehicles on Scenic Highway westbound to this new Route 25 westbound ramp. Specifically, during peak periods this ramp would result in the diversion from Belmont Circle 680 of 1,605 vehicles (non-summer weekday PM) and 875 of 2,095 vehicles (summer Saturday).

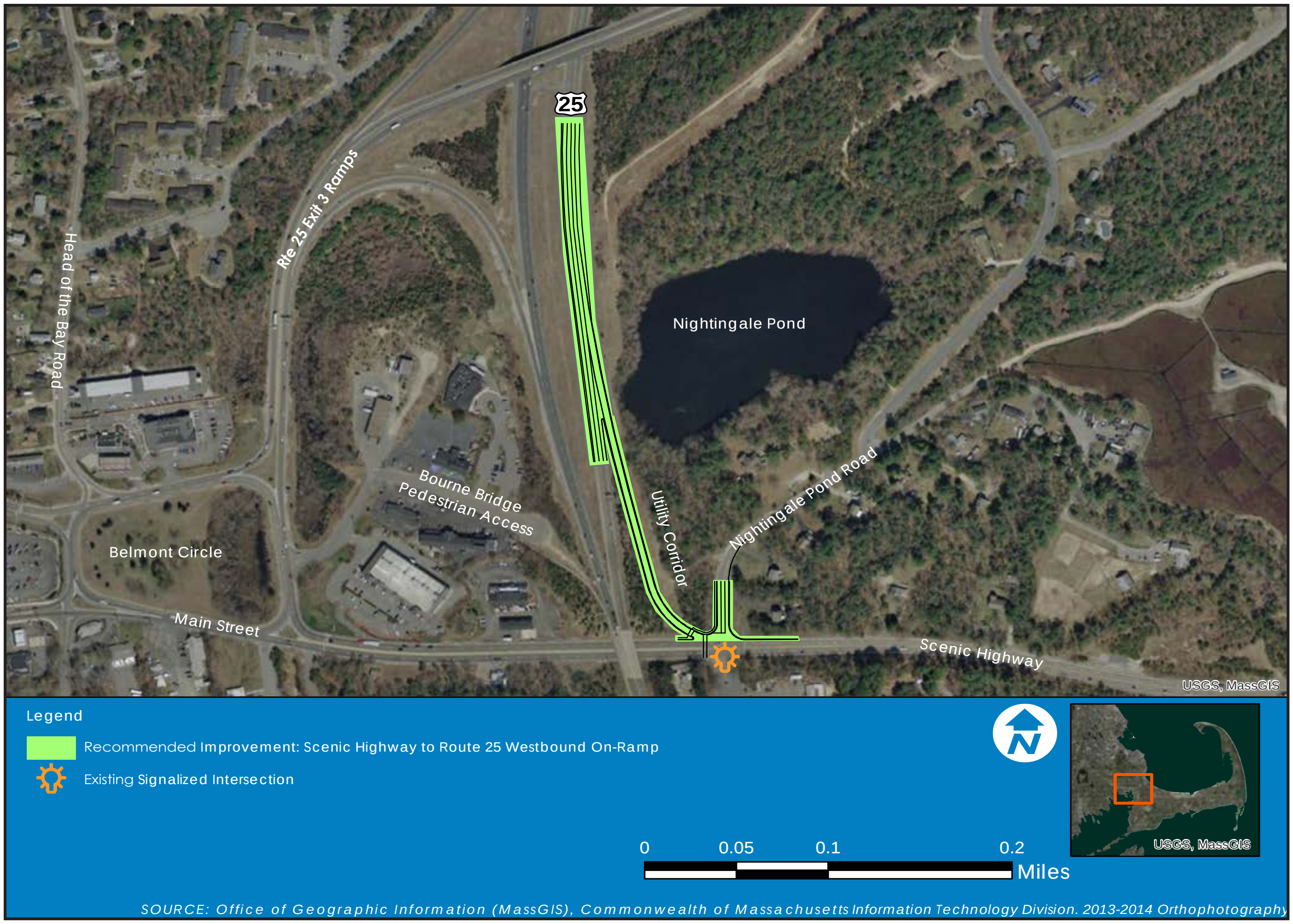


Exhibit 4-19 Suggested Improvements - Scenic Highway Westbound to Route 25 Westbound Ramp

These improvements would result in a reduction in the length of queues on the Scenic Highway westbound approach to Belmont Circle during both the non-summer weekday and summer Saturday peak periods. During the summer Saturday peak period, other approaches to Belmont Circle would not experience a notable reduction in queuing or delays (Table 4-16).

Environmental Resource/Utility Impact

A Route 25 westbound entrance ramp from Scenic Highway would result in approximately 0.2 acres of impact to land within an interim wellhead protection area. No wetland, floodplain, or rare species habitat areas would be impacted (Table 4-20).

This ramp would be partially within an area containing natural gas lines, requiring close coordination with the utility company to determine if relocation of these gas lines would be necessary.

Table 4-16 *Scenic Highway to Route 25 WB Ramp - Traffic Operations at Belmont Circle*

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Exit 3 Off Ramps SB	5	A	515	2	A	645	1	A	65
Head of Bay Rd SB	15	C	270	317 (5.3)	**F**	1,780	35	D	520
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	85
Main Street EB	13	B	530	29	D	1,245	27	D	1,085
Scenic Highway WB	7	A	380	14	B	840	1	A	60
Intersection (Overall)	**8.6**	**A**		**73**	**F**		**13.4**	**B**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	2	A	280
Head of Bay Rd SB	83 (1.4)	**F**	570	656 (11.0)	**F**	2,700 (0.51)	451 (7.5)	**F**	2,100
Buzzards Bay Bypass EB	19	C	335	11	B	305	12	B	305
Main Street EB	82 (1.4)	**F**	5,755 (1.1)	126 (2.1)	**F**	6,140 (1.2)	185 (3.1)	**F**	6,140 (1.2)
Scenic Highway WB	125 (2.1)	**F**	10,605 (2.0)	161 (2.7)	**F**	11,610 (2.2)	154 (2.6)	**F**	10,630 (2.2)
Intersection (Overall)	**62.6 (1.0)**	F		**191.4 (3.2)**	F		**160.8 (2.7)**	F	

Notes:
LOS E and Los F movements are shaded ***bold***
Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service; V/C = Volume to Capacity Ratio
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

Table 4-17 *Scenic Highway to Route 25 WB Ramp – Conceptual Cost Estimate*

	2017 ($ MILLION)	2030 ($ MILLION)	2040 ($ MILLION)
Scenic Highway to Route 25 WB Ramp	7	11	16

Conceptual Cost Estimate

The conceptual cost estimate for the Route 25 entrance ramp from Scenic Highway is provided by construction year in Table 4-17. More detailed conceptual cost estimates are provided in Appendix E.

Belmont Circle Reconstruction – Alternatives Evaluated

Several alternatives to improve traffic operations at Belmont Circle were evaluated. These alternatives each incorporate the construction of the Route 25 westbound entrance ramp from Scenic Highway.

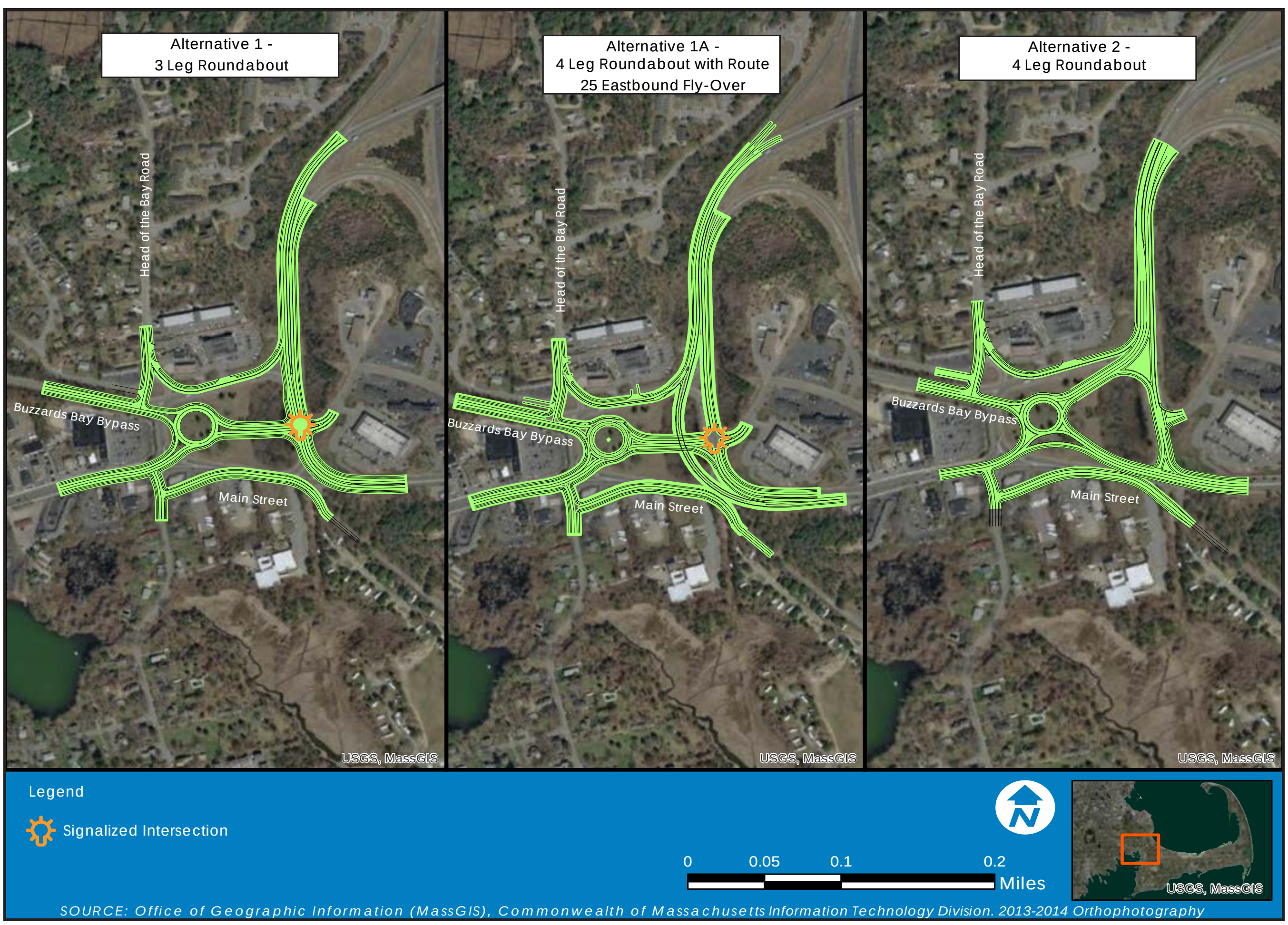
All alternatives would include improvements for bicycle and pedestrian accommodations and maintain access to adjacent properties. Sidewalks, crosswalks, and bicycle lanes would be constructed to provide access between businesses and residential areas west of Belmont Circle in Bourne and Scenic Highway, the Canal bike trail and the Bourne Scenic Park Campground.

As shown on Exhibit 4-20, three alternatives were advanced for analysis. These alternatives included:

Alternative 1 - Three-Leg Roundabout with Signalized Intersection

Alternative 1 involves the construction of a three-leg roundabout (approximately 200 feet in diameter) within the existing Belmont Circle infield with legs of the roundabout for Main Street, Buzzards Bay Bypass, and a new connector roadway from a new signalized intersection on the eastern side of the Circle. This new intersection would accommodate vehicles from Scenic Highway and the Route 25 Exit 3 ramps.

Exhibit 4-20 Alternatives Evaluated - Belmont Circle



Alternative 1A – Three-Leg Roundabout with Signalized Intersection and Flyover Ramp

Alternative 1A is similar to Alternative 1 in that it involves the construction of a three-leg roundabout within the existing Belmont Circle infield with legs of the roundabout for Main Street, Buzzards Bay Bypass, and an approach roadway from a new signalized intersection on the eastern side of the Circle. Alternative 1A differs with the addition of a ramp directly from the Route 25 Exit 3 off-ramp to Scenic Highway eastbound. This ramp would pass directly over the roundabout eastern approach road (on a new bridge). Vehicles with destinations other than eastbound on Scenic Highway would use the separate ramp to access Head of the Bay Road or use the new signalized intersection to access the roundabout.

Alternative 2 – Four-Leg Roundabout

Alternative 2 involves the construction of a four-leg roundabout (approximately 200 feet in diameter) within the existing Belmont Circle infield. The legs of the roundabout would include Main Street, Buzzards Bay Bypass, Scenic Highway, and the Route 25 Exit 3 ramps. Vehicles destined for Head of the Bay Road from this Route 25 off-ramp would use a separate ramp.

Traffic Analysis

A traffic analysis was completed of the three alternatives developed for Belmont Circle. The results of this analysis are summarized below and shown on Table 4-18. A comparison of the maximum peak period queue lengths for the approaches to Belmont Circle for the existing, future no-build and the three alternatives are provided in Table 4-19. The existing and future no-build traffic conditions at Belmont Circle are provided in Section 3.3.7.

Alternative 1 (Three-Leg Roundabout with Signalized Intersection)

The approaches to the Belmont Circle roundabout would operate within the range of LOS A to E, with average delay ranging from nine to 42 seconds. In comparison, Belmont Circle would operate at LOS F during both the non-summer weekday and summer Saturday peak period under the future no-build condition.

At 42- and 272-seconds during the non-summer weekday and summer Saturday peak periods, respectfully, the Main Street approach to the Circle would have the longest delays. Other than the Roundabout Connector (1.7 minutes) during the summer Saturday peak period, all other average delays are less than one minute.

Table 4-18 *Belmont Circle Reconstruction, Traffic Operations - Comparison of Alternatives*

	ALTERNATIVE 1 (RECOMMENDED)				ALTERNATIVE 1A				ALTERNATIVE 2			
	FUTURE (2040) BUILD CONDITIONS - SCREENING ANALYSIS											
	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	V/C	95% QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)												
Buzzards Bay (EB) Lt/Th	16	C	0.64	5	16	C	0.64	5	89 (1.5)	**F**	1.06	15
Buzzards Bay (EB) Rt	6	A	0.16	1	6	A	0.16	1	7	A	0.17	1
Roundabout Conn. (WB) Lt	11	B	0.52	3	11	B	0.52	3				
Roundabout Conn. (WB) Th/Rt	11	B	0.51	3	11	B	0.51	3				
Main Street (NB) Lt	9	A	0.35	2	9	A	0.35	2				
Main Street (NB) Th/Rt	42	**E**	0.93	13	42	**E**	0.93	13				
Main Street (NB) Lt/Th/Rt									188 (3.1)	**F**	1.33	26
Scenic Highway (WB) Lt/Th									15	C	0.45	2
Exit 3 Off Ramps SB LT									18	C	0.64	5
Exit 3 Off Ramps SB Th/Rt									15	B	0.55	3
Exit 3 Off Ramps SB Rt									10	B	0.4	2
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)												
Buzzards Bay (EB) Lt/Th	25	D	0.66	5	25	D	0.66	5	288 (4.8)	**F**	1.49	18
Buzzards Bay (EB) Rt	46	**E**	0.88	10	46	**E**	0.88	10	131 (2.2)	**F**	1.16	17
Roundabout Conn. (WB) Lt	101 (1.7)	**F**	1.16	31	101 (1.7)	**F**	1.16	31				
Roundabout Conn. (WB) Th/Rt	8	A	0.36	2	8	A	0.36	2				
Main Street (NB) Lt	6	A	0.21	1	6	A	0.21	1				
Main Street (NB) Th/Rt	272 (4.5)	**F**	1.56	68	272 (4.5)	**F**	1.56	68				
Main Street (NB) Lt/Th/Rt									348 (5.8)	**F**	1.70	45
Scenic Highway (WB) Lt/Th									110 (1.8)	**F**	1.12	17
Exit 3 Off Ramps SB LT									88 (1.5)	**F**	1.1	18
Exit 3 Off Ramps SB Th/Rt									204 (3.4)	**F**	1.38	35
Exit 3 Off Ramps SB Rt									7	A	0.19	1

Notes:
*LOS E and LOS F movements are **bold***
Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service; V/C = Volume to Capacity Ratio
Overall LOS, V/C and queues not calculated for unsignalized intersections.
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.
Shaded areas: Lane configuration does not exist during listed period.

Table 4-19 Belmont Circle - Comparison of Alternatives, Maximum Queue Length

APPROACHES	EXISTING (2014)		FUTURE (2040) NO-BUILD		ALTERNATIVE 1 (RECOMMENDED)		ALTERNATIVE 1A		ALTERNATIVE 2	
	NON-SUMMER	SUMMER	NON-SUMMER	SUMMER	NON-SUMMER	SUMMER	NON-SUMMER	SUMMER	NON-SUMMER	SUMMER
	(FEET/MILES)		(FEET/MILES)		(FEET/MILES)		(FEET/MILES)		(FEET/MILES)	
Route 25 Exit 3 Exit Ramp	515	510	645	**1,025**	135	24	35	60	75	525
Buzzards Bay Bypass WB	100	335	110	305	261	36	261	636	225	270
Main Street EB	530	**5,755 (1.1)**	1,245	**6,140 (1.2)**	474	1,749	474	1,749	390	675
Scenic Highway WB	380	**10,605 (2.0)**	840	**11,610 (2.2)**	290	870	290	870	30	255

Notes:
Queues over 2,500 feet also provided in miles.
*Locations of excessive delay are **bold***

Under Alternative 1, maximum queue lengths during the non-summer weekday peak period for all approaches except the Buzzards Bay Bypass would be reduced to less than half of the future no-build condition. For example, the queuing at the Route 25 Exit 3 ramps approaching Belmont Circle would be reduced from 645 feet to 135 feet. However, the peak period maximum queue for the Buzzards Bay Bypass would increase from 110 feet to 261 feet. The reductions in maximum peak period queue length during the summer Saturday peak period is even more favorable with all approaches experiencing substantial reductions including the queuing on the Scenic Highway approach being reduced from 11,610 feet to 870 feet.

Alternative 1A (Three-Leg Roundabout with Signalized Intersection and Flyover Ramp)

The approaches to the roundabout would operate the same as Alternative 1 having the same result for LOS and delay for each roundabout approach. As in Alternative 1, the longest queues for Alternative 1B would be found on Main Street.

The new signalized intersection of Scenic Highway at the Route 25 exit ramp and the new roundabout connector road would operate at LOS B and LOS D during the non-summer weekday and summer Saturday peak periods, respectively. The signalized intersection is forecast to reduce the number and severity of crashes at this high crash location.

The results for the peak period maximum queue lengths under Alternative 1A would be very similar to Alternative 1 with the queues for all approaches except the Buzzards Bay Bypass being reduced to less than half of the future no-build condition. The reductions in the maximum length of peak period queues during the summer Saturday peak period would also be favorable with all approaches experiencing substantial reductions including a reduction in the Main Street queue from 6,140 feet to 1,749 feet.

Alternative 2 (Four-Leg Roundabout)

The approaches to Belmont Circle would operate within a range of LOS A to LOS F during the non-summer weekday peak period, with delays ranging from seven seconds at the Buzzards Bay Bypass to 3.1 minutes at Main Street approaches. However, during the summer Saturday peak period, all approaches would at LOS F with average delays ranging from 1.5 minutes (Exit 3 off ramps) to 5.8 minutes (Main Street).

Under Alternative 2, maximum queue lengths during the non-summer weekday peak period for all approaches except the Buzzards Bay Bypass would be reduced to less than half of the future no-build condition. For example, the queue at the Route 25 Exit 3 ramps approaching Belmont Circle would be reduced from 645 feet to 75 feet. However, the peak period maximum queue for the Buzzards Bay Bypass would increase from 110 feet to 225 feet. The reductions in maximum peak period queue length during summer Saturdays are even more favorable with all approaches experiencing substantial reductions including the queue on the Main Street approach being reduced from 11,610 feet to 255 feet.

Environmental Resource Impact

As shown on Table 4-20, each of the three alternatives for the reconstruction of Belmont Circle would impact wetland resources and 100-year floodplain. Open space and residential and commercial property acquisitions may also be required.

Table 4-20 Belmont Circle Reconstruction - Environmental Impact by Alternative

	SCENIC HWY TO ROUTE 25 WB RAMP	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
RESOURCE AREAS (ACRES):				
Rare Species Habitat	0	0	0	0
DEP Wetlands	0	0.3	0.5	0.03
100-year Floodplain	0	4.7	5.4	4.6
Rare Species Habitat	0	0	0	0
IWPA (Interim Wellhead Protection Area)	0.2	0.5	0.5	0.4
RIGHT OF WAY (ACRES):				
USACE	0	0.1	0.1	0.1
Residential	0	0.02	0.02	0.02
Commercial	0	0.02	0.02	0.02
Utility	0.88	0	0	0

Notes:
Environmental and right-of-way impact based on conceptual design and GIS-based data.

Conceptual Cost Estimate

The conceptual cost estimate for alternatives to reconstruct Belmont Circle are provided by construction year in Table 4-21. More detailed conceptual cost estimates are provided in Appendix E.

Suggested Alternative

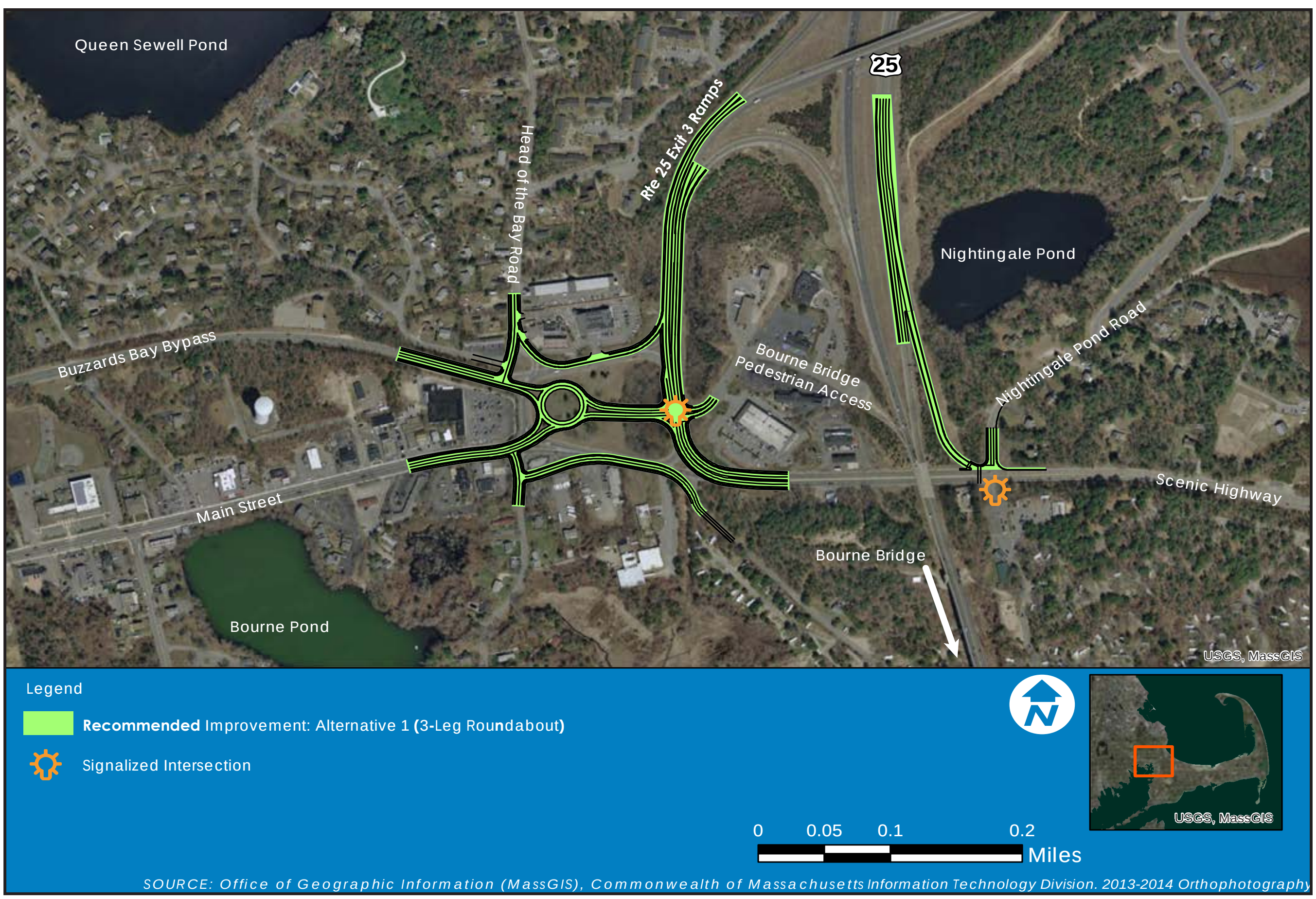
Alternative 1 – Three-Leg Roundabout with Signalized Intersection was advanced for further study during the travel model analysis (Exhibit 4-21). This alternative was selected because it would improve traffic operations with a simpler,

Table 4-21 Belmont Circle Reconstruction – Conceptual Cost Estimate

	2017 ($ MILLION)	2030 ($ MILLION)	2040 ($ MILLION)
Alternative 1 (recommended)	14	23	33
Alternative 1A	24	41	60
Alternative 2	13	21	26

Note:
Cost estimates do not include construction cost for the Scenic Highway to Route 25 WB Ramp

Exhibit 4-21 Belmont Circle - Suggested Alternative



less costly design (not having the bridge structure included in Alternative 1A).

Alternative 1 would substantially reduce queuing and vehicle delays compared to the future no-build condition. Environmental impacts were approximately the same for all alternatives.

4.6.5 Bourne Rotary

Several alternatives were evaluated to improve traffic operations at the Bourne Rotary. These alternatives were conceived to be compatible with the existing Bourne Bridge as well as with the vertical and horizontal alignment of an assumed replacement of the Bourne Bridge. The traffic analysis is based on location and geometry of the existing Bourne Bridge.

Each of these alternatives assumes that the local intersection improvements at the Sandwich Road at the Bourne Rotary Connector (described in Section 4.4.2) are completed. A larger-scale alternative to reconstruct Bourne Rotary as a highway interchange, likely in conjunction with the replacement of the Bourne Bridge, is described in Section 4.6.6.

All alternatives would include improvements to bicycle and pedestrian accommodations and maintain access to adjacent properties. Sidewalks, crosswalks, and bicycle lanes would be constructed on Old Sandwich Road to provide east-west access under the Bourne Bridge. These facilities would enhance access between public facilities such as the Upper Cape Cod Technical High School and the Bourne Middle School and High School. Pedestrian and bicycle access would also be improved between residential neighborhoods west of Route 28 and the Canal bike trail at the Bourne Recreational Area.

The development of alternatives is constrained by the existing environmental resources (Exhibit 2-16) and land uses at the Bourne Rotary (Exhibit 4-22) including the State Police Station and other commercial developments immediately adjacent to the Rotary. The existing and future traffic operations at Belmont Circle and Bourne Rotary are provided in Section 3.3.7.

As shown on Exhibit 4-23, three alternatives were advanced for analysis. A larger-scale improvement alternative for Bourne Rotary was also evaluated, as described in Section 4.6.6. The alternatives evaluated include:

Alternative 1 - Route 28 Northbound Ramp

Alternative 1 involves the construction of a ramp immediately east of the Rotary leading vehicles directly from Route 28 northbound to Sandwich Road, via the Bourne Rotary Connector.

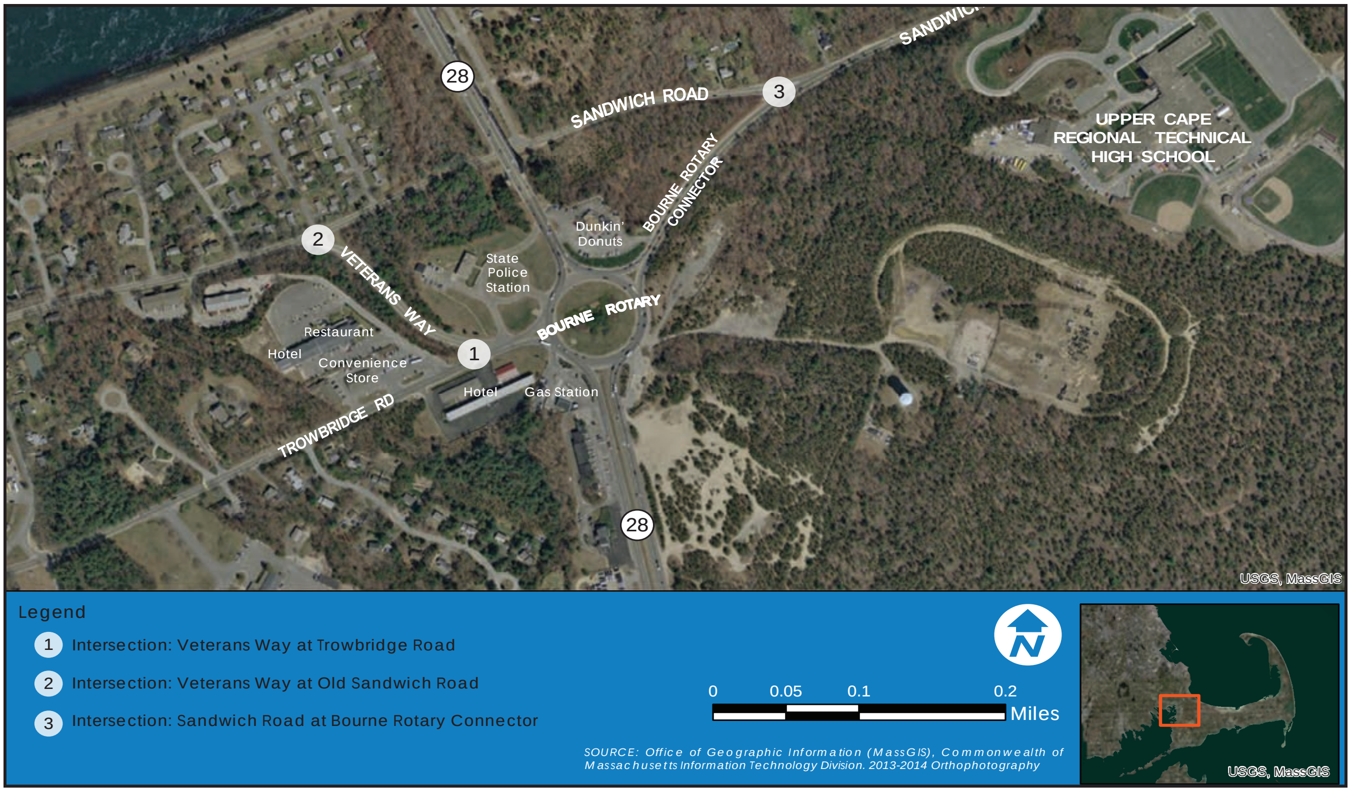


Exhibit 4-22 Bourne Rotary - Existing Conditions

Exhibit 4-23 Alternatives Evaluated – Bourne Rotary

This ramp would allow northbound vehicles on Route 28 direct access to Sandwich Road without having to enter the Rotary.

In addition to the reconstruction of the Sandwich Road at Bourne Rotary Connector intersection, this alternative includes the relocation of the Upper Cape Technical High School driveway approximately 300 feet to the east to provide some separation of the traffic entering and exiting the high school from the traffic entering Sandwich Road from the new Route 28 northbound ramp[1].

Alternative 1A – Route 28 Northbound and Southbound Ramp with Sandwich Road Underpass

Alternative 1A builds upon the Route 28 northbound ramp to Sandwich Road (proposed under Alternative 1) in proposing a second ramp leading from Route 28 southbound looping around State Police property at Veterans Way and continuing north to Sandwich Road. These ramps would allow northbound and southbound vehicles on Route 28 direct access to Sandwich Road without having to enter the Rotary.

This alternative also includes the relocation and conversion of an approximately 0.3 mile section of the Sandwich Road eastbound lanes into an underpass at the Bourne Rotary Connector intersection. The relocated section of Sandwich Road eastbound would begin immediately east of the Bourne Bridge underpass and re-connect with the existing Sandwich Road alignment approximately 300 feet east of the Bourne Rotary Connector. This new eastbound alignment of Sandwich Road, with the Bourne Rotary Connector underpass, would allow eastbound vehicles a direct path to Sandwich Road without having to enter the Bourne Rotary.

This alternative also includes the relocation of the Technical High School driveway approximately 300 feet to the east to provide some separation of the traffic entering and exiting the high school from the traffic entering Sandwich Road from the new Route 28 northbound ramp.

1 The relocation of the high school driveway is a conceptual element of the reconstruction of Bourne Rotary. When the project advances into the implementation phase, MassDOT will hold coordination meetings with the Upper Cape Cod Technical High School

Alternative 2 – Three Signalized Intersections

Alternative 2 involves the reconstruction and signalization of three intersections in the immediate Bourne Rotary area at the following locations:

- Intersection 1: Veterans Way at Trowbridge Road
- Intersection 2: Veterans Way at Old Sandwich Road
- Intersection 3: Sandwich Road at Bourne Rotary Connector

In addition to construction of these three signalized intersections, Alternative 2 includes the construction of a ramp providing a direct connection from Route 28 northbound to Sandwich Road, via the Bourne Rotary Connector, as in Alternatives 1and 1A. A second ramp leading from Route 28 southbound, looping around the State Police property at Veterans Way and continuing north to Sandwich Road is also incorporated, as well as the relocation of the Technical High School driveway approximately 300 feet to the east.

Unique to Alternative 2 is the reconstruction of the Rotary such that travel across the north side of the Rotary would not be allowed. Vehicles entering the Rotary from Trowbridge Road or Route 28 northbound would only be allowed to exit at the Bourne Rotary Connector (to Sandwich Road) or continue to Route 28 northbound across the Bourne Bridge. This disconnection would reduce traffic volumes in the Rotary and allow for freer movement from Route 28 southbound into the Rotary. East-west travel in this area would be accomplished using Sandwich Road.

Traffic Analysis

A traffic analysis was completed of the three alternatives developed for the Bourne Rotary. Traffic operations at the three intersections adjacent to the Rotary (listed above for Alternative 2) were compared to identify a preferred alternative. The results of this analysis are summarized below and shown on Table 4-22 through Table 4-24. A comparison of the maximum peak period queue lengths for the approaches to Belmont Circle for the existing condition, future no-build condition, and the three alternatives are provided in Table 4-25.

Alternative 1 - Route 28 Northbound Ramp

1. Veterans Way at Trowbridge Road: This intersection would remain unsignalized with the approaches operating within the range of LOS A – C. At 22 and 20 seconds, the Veterans Way approach would have the longest delay during the non-summer weekday and summer Saturday peak periods, respectively.

Text continues on page 4-58.

Table 4-22 Bourne Rotary, Traffic Operations - Comparison of Alternatives, Veterans Way at Trowbridge Road

	ALTERNATIVE 1				ALTERNATIVE 1A				ALTERNATIVE 2 (RECOMMENDED)				
	FUTURE (2040) BUILD CONDITIONS - SCREENING ANALYSIS												
	AVERAGE DELAY *Sec (Min)*	**LOS**	**V/C**	**95% QUEUE** *Feet (Miles)*	**AVERAGE DELAY** *Sec (Min)*	**LOS**	**V/C**	**95% QUEUE** *Feet (Miles)*	**AVERAGE DELAY** *Sec (Min)*	**LOS**	**V/C**	**50% QUEUE** *Feet (Miles)*	**95% QUEUE** *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)													
Trowbridge Road EB Th	0.5	A	0.02	2	0.5	A	0.02	2					
Trowbridge Road WB Th/Rt	0	A	0.26	0	0	A	0.26	0					
Veterans Way NB Lt/Rt	22	C	0.29	29	22	C	0.29	29					
Trowbridge Rd EB Lt/Th									19	B	0.81	136	241
Trowbridge Rd WB Th									10	B	0.34	44	80
Trowbridge Rd WB Rt									12	B	0.56	0	49
Veteran's Way SB Lt									16	B	0.62	102	221
Veteran's Way SB Rt									10	A	0.1	0	29
Intersection (Overall)									**14.3**	**B**	**0.72**		
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)													
Trowbridge Road EB Th	0.3	A	0.01	1	0.3	A	0.01	1					
Trowbridge Road WB Th/Rt	0	A	0.24	0	0	A	0.24	0					
Veterans Way NB Lt/Rt	20	C	0.18	17	20	C	0.18	17					
Trowbridge Rd EB Lt/Th									42	D	0.93	262	458
Trowbridge Rd WB Th									17	B	0.27	56	100
Trowbridge Rd WB Rt									21	C	0.62	0	96
Veteran's Way SB Lt									29	C	0.88	311	549
Veteran's Way SB Rt									10	A	0.14	0	31
Intersection (Overall)									**26.9**	**C**	**0.9**		

Notes:
Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service; V/C = Volume to Capacity Ratio
Overall LOS, V/C and queues not calculated for unsignalized intersections.
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.
Shaded areas: Lane configuration does not exist during listed period.

Table 4-23 Bourne Rotary, Traffic Operations - Comparison of Alternatives, Veterans Way at Old Sandwich Road

	ALTERNATIVE				ALTERNATIVE 1A				ALTERNATIVE 2 (RECOMMENDED)				
	FUTURE (2040) BUILD CONDITIONS - SCREENING ANALYSIS												
	AVERAGE DELAY Sec (Min)	LOS	V/C	95% QUEUE Feet (Miles)	AVERAGE DELAY Sec (Min)	LOS	V/C	95% QUEUE Feet (Miles)	AVERAGE DELAY Sec (Min)	LOS	V/C	95% QUEUE Feet (Miles)	95% QUEUE Feet (Miles)
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)													
Old Sandwich Road EB Th/Rt	0	A	0.24	0	0	A	0.25	0	25	C	0.6	75	111
Old Sandwich Road WB Th/Lt	3	A	0.05	4	2	A	0.02	2					
Veterans Way NB Lt/Rt	13	B	0.1	8	13	B	0.09	8					
Old Sandwich Road WB Th									28	C	0.9	138	317
Old Sandwich Road WB Rt									8	A	0.13	24	46
Veterans Way NB Lt									16	B	0.19	30	65
Veterans Way NB Rt									28	C	0.72	46	281
Intersection (Overall)									**25.4**	**C**	**0.88**		
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)													
Old Sandwich Road EB Th/Rt	0	A	0.13	0	0	A	0.14	0	49	D	0.6	80	120
Old Sandwich Road WB Th/Lt	1	A	0.02	2	0.5	A	0.01	1					
Veterans Way NB Lt/Rt	10	B	0.05	4	11	B	0.06	5					
Old Sandwich Road WB Th									25	C	0.89	424	897
Old Sandwich Road WB Rt									5	A	0.13	29	71
Veterans Way NB Lt									37	D	0.14	29	57
Veterans Way NB Rt									53	D	0.69	23	274
Intersection (Overall)									**37.1**	**D**	**0.88**		

Notes:
Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service; V/C = Volume to Capacity Ratio
Overall LOS, V/C and queues not calculated for unsignalized intersections.
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.
Shaded areas: Lane configuration does not exist during listed period.

Table 4-24 Bourne Rotary, Traffic Operations - Comparison of Alternatives, Sandwich Road at Bourne Rotary Connector

	ALTERNATIVE					ALTERNATIVE 1A				ALTERNATIVE 2 (RECOMMENDED)				
	FUTURE (2040) BUILD CONDITIONS - SCREENING ANALYSIS													
	AVERAGE DELAY Sec (Min)	LOS	V/C	50% QUEUE Feet (Miles)	95% QUEUE Feet (Miles)	AVERAGE DELAY Sec (Min)	LOS	V/C	95% QUEUE Feet (Miles)	AVERAGE DELAY Sec (Min)	LOS	V/C	95% QUEUE Feet (Miles)	95% QUEUE Feet (Miles)
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)														
Bourne Rotary Connector EB Lt	0	A	0	0	0					13	B	0.37	17	37
Bourne Rotary Connector EB Th	1	A	0.59	0	0					11	B	0.49	118	190
Sandwich Road WB Th	17	B	0.79	205	436					31	C	0.88	236	422
Sandwich Road WB Rt	98 (1.6)	A	0.29	0	41					15	B	0.38	0	58
Old Sandwich Road EB Lt	22	C	0.54	69	127					28	C	0.86	194	297
Old Sandwich Road EB Rt	14	B	0.47	63	131	51	F	0.73	126					
Old Sandwich Road EB Lt/Rt										16	B	0.12	0	38
Bourne Rotary Conn. EB Lt/Th						0.5	A	0.02	1					
Sandwich Rd WB Th/Rt						0	A	0.71	0					
Intersection (Overall)	**9.7**	**A**	**0.78**							**21.9**	**C**	**0.85**		
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)														
Bourne Rotary Connector EB Lt	33	C	0.13	10	32					38	D	0.87	50	172
Bourne Rotary Connector EB Th	2	A	0.69	0	0					15	B	0.76	237	384
Sandwich Road WB Th	24	C	0.9	396	715					37	D	0.92	262	467
Sandwich Road WB Rt	7	A	0.12	0	25					18	B	0.58	2	82
Old Sandwich Road EB Lt	36	D	0.7	108	192					34	C	0.9	195	303
Old Sandwich Road EB Rt	19	B	0.15	14	52	110 (1.8)	F	0.91	158					
Old Sandwich Road SB Lt/Rt										17	B	0.09	0	35
Bourne Rotary Conn EB Lt/Th						1	A	0.03	3					
Sandwich Rd WB Th/Rt						0	A	0.92	0					
Intersection (Overall)	**13.9**	**B**	**0.89**							**26**	**C**	**0.93**		

Notes:
Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service; V/C = Volume to Capacity Ratio
Overall LOS, V/C and queues not calculated for unsignalized intersections.
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles
Shaded areas: Lane configuration does not exist during listed period.

2. Veterans Way at Old Sandwich Road: This intersection would remain unsignalized with the approaches operating within the range of LOS A – B. At 13 and 10 seconds, the Veterans Way approach would have the longest delay during the non-summer weekday and summer Saturday peak periods, respectively.

3. Sandwich Road at Bourne Rotary Connector: Under Alternative 1, this intersection would be signalized with dedicated turning lanes provided at the Old Sandwich Road eastbound and Bourne Rotary Connector eastbound approaches. This intersection would operate at an overall LOS A during the non-summer weekday and LOS B during the summer Saturday peak periods.

Under Alternative 1, maximum queue lengths would vary for the four approaches to the Bourne Rotary when compared to the future no-build condition during the non-summer weekday peak period (Table 4-25). While the queues for Route 28 northbound and Bourne Rotary Connector approaches would experience modest or no improvement, the peak period queues on the Route 28 southbound and Trowbridge Road approaches would increase. The queue at the Route 28 southbound approach would increase from 620 feet to 9,320 feet and the Trowbridge Road queue would increase from 3,465 feet to 4,895 feet. The results for the summer Saturday peak period are similar except for Trowbridge Road would experience a modest increase in queuing and the Route 28 southbound approach queue would increase from 1.9 miles to 5.2 miles.

Table 4-25 Bourne Rotary - Comparison of Alternatives, Maximum Queues Length

APPROACHES	EXISTING (2014)		FUTURE (2040) NO-BUILD		ALTERNATIVE 1		ALTERNATIVE 1A		ALTERNATIVE 2 (RECOMMENDED)	
	NON-SUMMER	SUMMER	NON-SUMMER	SUMMER	NON-SUMMER	SUMMER	NON-SUMMER	SUMMER	NON-SUMMER	SUMMER
	Feet (Miles)		*Feet (Miles)*		*Feet (Miles)*		*Feet (Miles)*		*Feet (Miles)*	
Route 28 SB	650	**8,885 (1.7)**	620	**9,935 (1.9)**	**9,340 (1.8)**	**27,564 (5.2)**	**2,955 (1.8)**	**17,029 (3.2)**	**5,620 (1.1)**	**13,685 (2.6)**
Trowbridge Road EB	840	335	**3,465 (0.7)**	**2,225**	**4,895 (0.9)**	**3,052 (0.6)**	**1,760**	**1,684**	**7,445 (1.4)**	**7,443 (1.4)**
Route 28 NB	340	4,130 (0.8)	1,275	**3,605 (0.7)**	635	309	175	214	210	371
Bourne Rotary	1,530	1,475	855	**6,430 (1.2)**	875	877	875	874	50	50

Notes:
Lt = Left Rt = Right Th = Through; EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service; V/C = Volume to Capacity Ratio
Overall LOS, V/C and queues not calculated for unsignalized intersections.
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.
*Excessive delays **bold***

Alternative 1A - Route 28 Northbound and Southbound Ramp

1. Veterans Way at Trowbridge Road: This intersection would remain unsignalized with the approaches operating within the range of LOS A – C. At 22 and 20 seconds, the Veterans Way approach would have the longest delay during the non-summer weekday and summer Saturday peak periods, respectively.

2. Veterans Way at Old Sandwich Road: This intersection would remain unsignalized with the approaches operating within the range of LOS A – B. At 13 and 11 seconds, the Veterans Way approach would have the longest delay during the non-summer weekday and summer Saturday peak periods, respectively.

3. Sandwich Road at Bourne Rotary Connector: This intersection would remain unsignalized under Alternative 1A. Similar to the existing condition, vehicles would have difficulty entering Sandwich Road from Old Sandwich Road, with that minor approach operating at LOS F during both the non-summer weekday and summer Saturday peak periods.

Under Alternative 1A, maximum queue lengths would vary for the four approaches to the Bourne Rotary when compared to the future no-build condition during the non-summer weekday peak period. Similar to Alternative 1, the queues for Route 28 northbound and Bourne Rotary Connector approaches would experience modest or no improvement. However, the peak period queues on the Route 28 southbound and Trowbridge Road approaches would increase. The queue at the Route 28 southbound approach would increase from 620 feet to 2,955 feet and the Trowbridge Road queue would increase from 3,465 feet to 4,895 feet. The results for the summer Saturday peak period are similar except for Trowbridge Road would experience a modest reduction in queue length. During the summer Saturday peak period the Route 28 southbound queue would increase from 1.9 miles to 3.2 miles.

Alternative 2 - Three Signalized Intersections

1. Veterans Way at Trowbridge Road: Under Alternative 2, this intersection would be signalized with dedicated turn lanes at the Trowbridge Road westbound and Veterans Way southbound approaches. The intersection would have an overall LOS of B in the non-summer weekday and LOS C during the summer Saturday peak periods. Average delay for the intersection would be approximately 14 seconds (non summer weekday) and 27 seconds (summer Saturday).

2. Veterans Way at Old Sandwich Road: Under Alternative 2, this intersection would be signalized with dedicated turn lanes at the Old Sandwich Road westbound and Veterans Way northbound approaches. The intersection would have an overall LOS of C during the non-summer weekday and LOS D during the summer Saturday peak periods. Average delay for the intersection during peak periods would be approximately 25 seconds (non summer weekday) and 37 (summer Saturday).

3. Sandwich Road at Bourne Rotary Connector: Under Alternative 2, this intersection would be signalized with dedicated turn lanes at the Bourne Rotary Connector eastbound and Old Sandwich Road southbound approaches. The intersection would have an overall LOS of C during the non-summer weekday and summer Saturday peak periods. Average delay for the intersection during peak periods would be approximately 25 seconds (non-summer weekday) and 37 seconds (summer Saturday).

Under Alternative 2, maximum queue lengths would vary for the four approaches to the Bourne Rotary when compared to the future no-build condition during the non-summer weekday peak period. The queue for Route 28 northbound approach would be substantially reduced from 1,275 feet to 210 feet and the queue at the Bourne Rotary Connector reduced from 855 feet to 50 feet. However, the peak period queues would persist on the Route 28 southbound and Trowbridge Road approaches with non-summer weekday queues at 5,620 feet and 7,445 feet, respectively.

The results for the summer Saturday peak period are similar to the non-summer weekday period with only minor queues at the Route 28 northbound and Bourne Rotary Connector approaches but persistent, longer queues at the Route 28 southbound and Trowbridge Road approaches. However, the queue on Route 28 southbound is substantially shorter when compared to Alternatives 1 and 1A.

Environmental Resource and Property Impacts

As shown on Table 4-26, none of the three alternatives evaluated for the reconstruction of the Bourne Rotary would impact wetland resources, 100-year floodplain, or rare species habitat. Alternative 1A would require the acquisition of approximately one acre of land from the Town of Bourne. All alternatives may require minor property acquisitions from the USACE and adjacent residential and commercial properties.

This Route 28 ramp may require a minor property acquisition from the Massachusetts State Police barracks.

Table 4-26 Bourne Rotary - Environmental Impact by Alternative

	ALTERNATIVE 1	ALTERNATIVE 1A	ALTERNATIVE 2
RESOURCE AREAS (ACRES):			
DEP Wetlands	0	0	0
100-year Floodplain	0	0	0
Rare Species Habitat	0	0	0
RIGHT OF WAY (ACRES):			
Town of Bourne	0	1.0	0
USACE	0.1	0.2	0.4
Residential	0.02	0.02	0.3
Commercial	0	0.2	0.01

Notes:
Environmental and right-of-way impact based on conceptual design and GIS-based data.

Table 4-27 Bourne Rotary Reconstruction – Conceptual Cost Estimates

	2017 ($ MILLION)	2030 ($ MILLION)	2040 ($ MILLION)
Alternative 1	8	13	19
Alternative 1A	16	27	39
Alternative 2 (recommended)	11	18	26

Conceptual Cost Estimate

The conceptual costs for alternatives to reconstruct Bourne Rotary are provided by construction year in Table 4-27. More detailed conceptual cost estimates are provided in Appendix E.

Suggested Alternative

Alternative 2 – Three Signalized Intersection – was advanced for further study during the travel model analysis (Exhibit 4-24). This alternative was selected because it would result in acceptable traffic operations at all three adjacent intersections. The Veterans Way at Trowbridge Road intersection would operate LOS B and C for the non-summer weekday and summer Saturday peak periods, respectively. The Veterans Way at Old Sandwich Road intersection would operate at LOS C and D and the Sandwich Road at Bourne Rotary Connector intersection would operate at LOS C for both time periods.

Based on the conceptual design, this alternative could be incorporated into the Bourne Rotary Interchange alternative and, ultimately, a replacement Bourne Bridge. This alternative would have less property impact to the Massachusetts State Police barracks.

Exhibit 4-24 Bourne Rotary - Suggested Alternative

4.6.4 Bourne Rotary Interchange

A larger-scale alternative to improve traffic operations at the Bourne Rotary was evaluated. This alternative involves the reconstruction of the Bourne Rotary as a highway interchange. This alternative assumes the prior intersection improvements at Bourne Rotary (Alternative 2 – Three Signalized Intersections) are already in place.

This alternative was conceived to be constructed concurrent with an assumed replacement of the Bourne Bridge, with an alignment immediately east of the existing bridge. The existing and future traffic operations at the Bourne Rotary are described in Sections 2.5.10 and 3.3.7, respectively. The existing land uses and environmental resources in the Bourne Rotary area are described in Section 2.2.2.

Suggested Improvements

The reconstruction of the Bourne Rotary as a highway interchange intersection involves the removal of the Rotary and the construction of a grade-separated highway ramp system allowing vehicles to enter Route 28 (northbound or southbound)

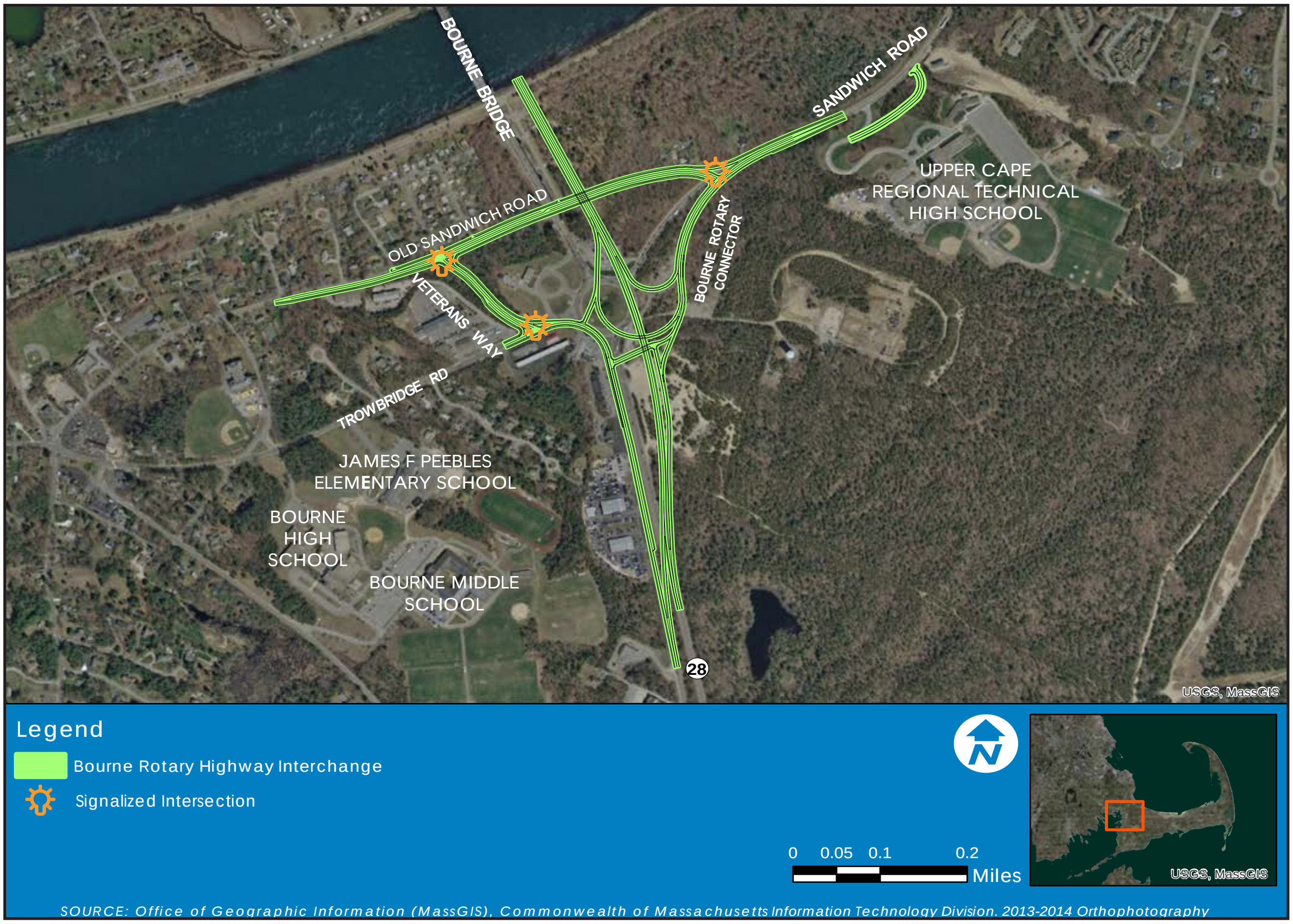


Exhibit 4-25 Bourne Rotary Interchange

directly from Sandwich Road (via the Bourne Rotary Connector) or Trowbridge Road (Exhibit 4-25). Local traffic would pass directly over Route 28 on an overpass. The grade-separated interchange would remove the numerous conflict points that currently exist at the Rotary, substantially reducing queuing and crash rates.

Traffic Conditions

The reconstruction of the Bourne Rotary as a highway interchange would substantially reduce peak period queuing on the Rotary approach roadways including Route 28 (northbound and southbound), Trowbridge Road, and the Bourne Rotary Connector (Table 4-28). Currently, the Bourne Rotary suffers from LOS F conditions during all peak periods. Construction of a highway interchange would improve traffic operations, forecast to range from LOS A to LOS C conditions.

Property or Environmental Resource Impact

As shown on Table 4-29, the Bourne Rotary Interchange alternative would not impact wetland resources, 100-year

Table 4-28 Traffic Operations - Bourne Rotary Interchange

	FUTURE (2040) BUILD CONDITIONS - BUILD CASE 3A		
	DELAY *Sec*	LOS	95% QUEUE *Feet/Direction*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)			
Trowbridge Rd & Veteran's Way	9	A	73/SB
Bourne Rotary Connector & Old Sandwich Road	11	B	200/EB
Veteran's Way & Old Sandwich Road	21	C	348/EB
Exit 4 SB On Ramp/Trowbridge Road & Sandwich Rd Connector	1	--	4/WB
Exit 4 NB Off Ramp & Sandwich Rd Connector	9	--	42/NB
Trowbridge Road & Exit 4 SB Off Ramp	1	--	12/SB
Intersection (Overall)	**8.9**	**A**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)			
Trowbridge Rd & Veteran's Way	10	A	107/SB
Bourne Rotary Connector & Old Sandwich Road	13	B	257/EB
Veteran's Way & Old Sandwich Road	28	C	452/WB
Exit 4 SB On Ramp/Trowbridge Road & Sandwich Rd Connector	0.4	--	2/WB
Exit 4 NB Off Ramp & Sandwich Rd Connector	13	--	99/NB
Trowbridge Road & Exit 4 SB Off Ramp	2	--	28/SB
Intersection (Overall)	**11.0**	**B**	

Notes:
EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service

Table 4-29 Bourne Rotary Interchange - Potential Property or Environmental Impact

	ALTERNATIVE 1
ENVIRONMENTAL RESOURCES	
DEP Wetlands	0
100-year Floodplain	0
Rare Species Habitat	0.2
PROPERTY IMPACT	
Town of Bourne	0
USACE	0.4
Residential	0.3
Commercial	2.2

floodplains or land owned by the Town of Bourne. This alternative may impact a minor amount of rare species habitat (0.2 acres). The interchange alternative would require the acquisition of approximately 0.4 acres of land from the USACE and 0.3 acres of residential property. The interchange would also require approximately 2.2 acres of commercial land east of the Rotary.

Conceptual Cost Estimate

The conceptual cost for the Bourne Rotary Interchange is provided by construction year in Table 4-30. More detailed conceptual cost estimates are provided in Appendix E.

Table 4-30 Bourne Rotary Interchange – Conceptual Cost Estimate by Build Year

	2030 ($ MILLION)	2040 ($ MILLION)
Bourne Rotary Interchange[1]	69	101

Note:
[1] Includes cost of Bourne Rotary - Three Signalized Intersections Improvements.

4.7 BOURNE AND SAGAMORE BRIDGE REPLACEMENT OR REHABILITATION

The Bourne and Sagamore Bridges play an integral part of the transportation network in the study area. However, they are both owned by the USACE, not the Commonwealth of Massachusetts, and decisions regarding their future rehabilitation or replacement will be made by the USACE. The following section provides information regarding the existing bridge features and the potential features of replacement bridge structures based on current highway design standards, characteristics of the adjacent highway network, and future traffic volumes. Multimodal transportation facilities have also been considered for the potential future bridge design.

4.7.1 Bourne and Sagamore Bridges – Potential Replacement Design Features

The Sagamore and Bourne Bridges both opened in 1935 and are nearing the end of their usable service lives. The bridges have been designated as eligible for individual listing on the National Register of Historic Places by the Massachusetts Historic Commission.

As noted in chapter 1, the U.S. Army Corps of Engineers (USACE) owns and maintains these bridges. The USACE is currently conducting a study of both bridges called a Major Rehabilitation Evaluation Report. The outcome of this study will be a determination of whether to continue long-term maintenance of the bridges or to replace them. This determination may be different for each bridge.

For this planning study, it is assumed that the USACE will determine that both Bridges require complete replacement. However, most study alternatives were developed to be compatible with the existing or replacement bridges.

Identical in design, each highway bridge is approximately 48-feet in width, providing four 10-foot-wide traffic lanes (two lanes in each direction), with no roadway shoulder or median. A single six-foot-wide sidewalk and a two-foot safety walk are provided along opposite sides of the Bridges.

The sidewalks are on the east side of the Sagamore Bridge and the west side of the Bourne Bridge. The design of the bridges is substandard for lane widths, lack of roadway shoulders and medians, and having no ADA compliant bicycle and pedestrian accommodation. At a six-percent grade, the vertical profile of the bridges is steeper than the four- to five-percent maximum grade typical for a limited-access highway.

Additional substandard design features at the highway approaches to the bridges contribute to peak period congestion. Approaching the Sagamore Bridge from the north, one of the two travel lanes in Route 3 southbound is dropped to allow travelers from Scenic Highway to merge onto Route 3 at Exit 1A, reinstating the second travel lane. This substandard roadway geometry contributes to congestion and delays on Route 3 southbound, especially during peak periods.

Immediately south of the Bourne Bridge, the unsignalized Bourne Rotary constrains Route 25 eastbound traffic flows over the bridge. During peak periods, queues extend from all rotary approaches, particularly on Route 28 northbound and Route 25 eastbound. The queue on Route 25 often extends several thousand feet over the Bourne Bridge, to the point where vehicles are constrained from entering Route 25 from Belmont Circle.

Based on the local topography, existing land uses, and environmental resources, it is assumed that these replacement bridges would be constructed immediately adjacent to and inside of the existing Bridges. A replacement Bourne Bridge would be built to the east of the existing bridge and a replacement Sagamore Bridge would be built to the west of the existing bridge (Exhibit 4-26).

It is also assumed that replacement Canal Bridges would be multimodal structures designed to current MassDOT highway design standards and policies. Specifically, a bridge with a much

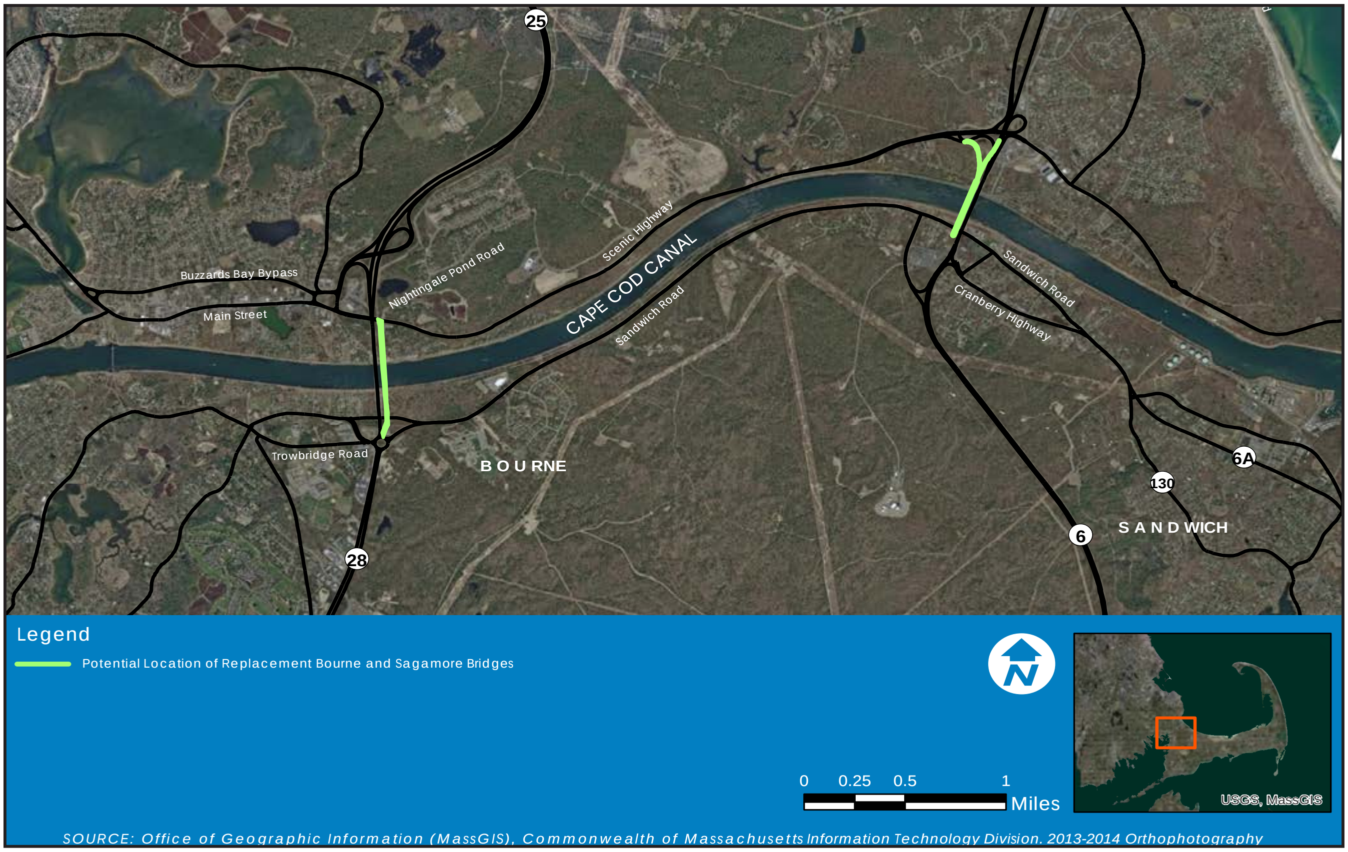
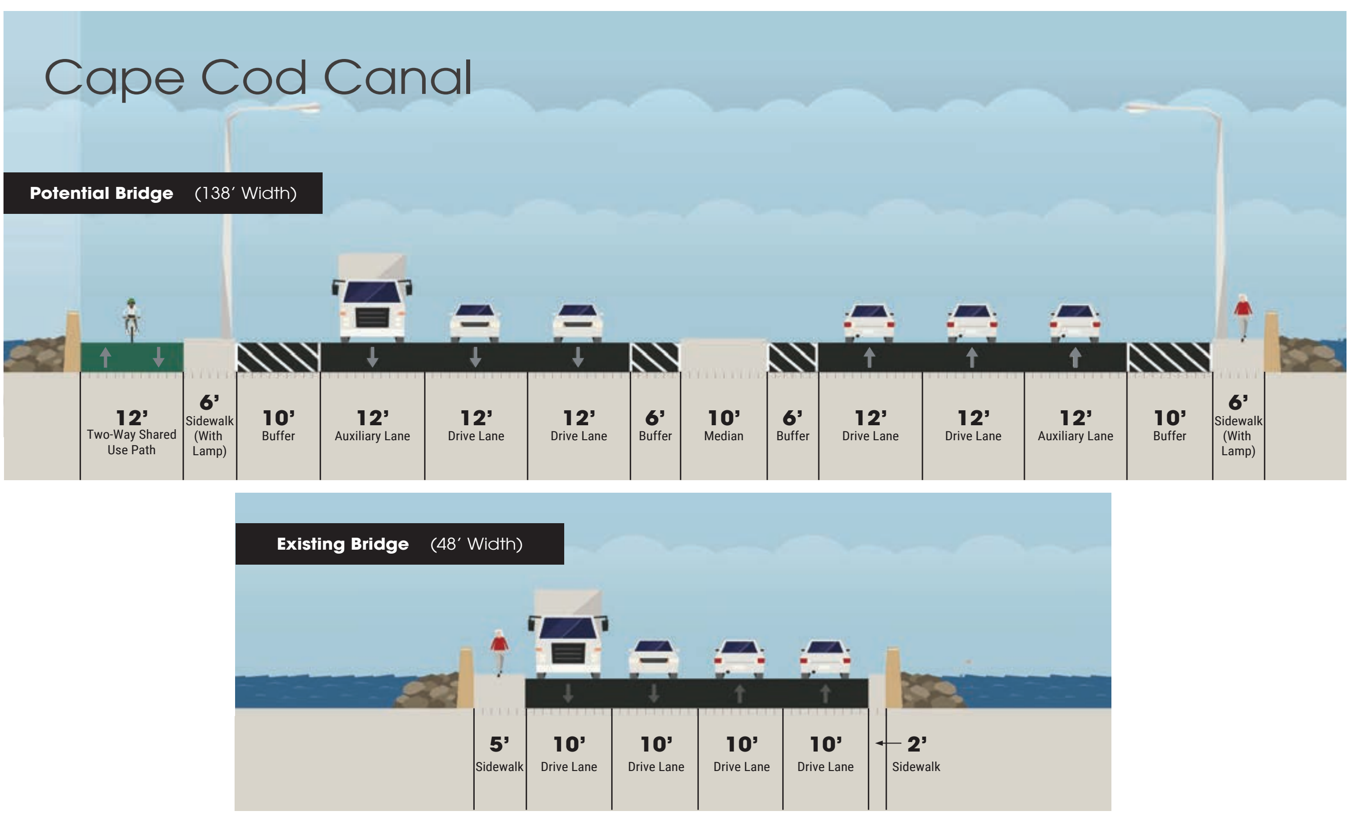


Exhibit 4-26 Potential Alignment - Bourne and Sagamore Bridge Replacement

Exhibit 4-27 Potential Cross Section - Bourne and Sagamore Bridge Replacements



wider cross section is envisioned to accommodate all users. This cross section could be up to 138 feet wide, including two 12-foot lanes in each direction and a single12-foot auxiliary traffic lane in each direction. These lanes would be separated by a 10-foot wide median. Bicyclists and pedestrians could cross the bridge on a 12-foot wide shared-use path on one side of the bridge with a 6.0-foot wide pedestrian sidewalk on the other side of the bridge (Exhibit 4-27).

The addition of auxiliary lanes on the replacement bridges would provide appropriate acceleration and deceleration lanes for vehicles entering or exiting at the gateway intersections in the Canal area and eliminate the need for the lane drop present at the Route 3 southbound approach to the Sagamore Bridge. By separating the vehicles entering and exiting the highway from through traffic, the auxiliary lanes would reduce turbulence in the roadway system, alleviating the traffic bottleneck common at the Canal bridges.

These auxiliary lanes are intended to reduce congestion and improve safety in the immediate area of the bridges but not result in a significant increase in the capacity of the overall Canal-area roadway system.

4.8 REGIONAL TRANSPORTATION ANALYSIS MODELING

The following sections describe the analysis conducted using the regional travel demand model to identify the most effective combination of transportation improvements in the study area.

As noted in Section 3.3.1, future no-build traffic conditions in the study area were forecast using a regional travel demand model (based on existing travel volumes and forecast socio-economic conditions in the study area). The maximum queuing and average delays for the future no-build, non-summer weekday and summer Saturday at Belmont Circle and Bourne Rotary are presented on Exhibit 3-18. Building on that data, the travel demand model was also used to test the effectiveness of transportation improvements in the study area.

The travel demand model provides a method for combining groups of transportation improvements (known as ‘cases’) to evaluate their effectiveness. Based on the 2040 traffic volumes presented in Chapter 3, the travel demand model also estimates potential shifts or diversions in travel patterns in the study area that may cause unforeseen traffic congestion in other locations. For example, improved roadway and bridge infrastructure may result in travelers diverting trips across the Canal from one bridge rather than the other.

This exercise enabled the understanding of the level of transportation improvements necessary to provide acceptable traffic operations in the study area for the 2040 non summer weekday PM period without overbuilding in a manner inconsistent with the character of Cape Cod.

The initial alternative screening analysis (described in Sections 4.5) was based on future no-build traffic volumes at specific locations. The travel demand model simulates traffic movements throughout the study area, assuming existing traffic patterns continue in the future. The model produces future traffic volumes at numerous locations throughout the study area for various daily time periods and time of year. Using these traffic volumes, further analysis is conducted using traffic analysis software including VISSIM™ and Synchro™ (as described in Section 2.5.5). As the travel demand model re assigns travel routes based on travel times, the volume of vehicles traveling through intersections in the study area often changes compared to the volumes used during the screening analysis, resulting in somewhat different results.

Seven cases were selected for analysis to provide logical and comprehensive groups of improvements. These seven cases, presented in the following sections, generally build upon one another with the first cases incorporating smaller intersection improvements and subsequent cases including an increasing number of transportation improvements. The nine different potential components of the travel demand model cases are listed on Table 4-31 and shown on Exhibit 4-28.

Table 4-31 Components of the Seven Travel Analysis Cases

MAP LOCATION	IMPROVEMENTS	CASE 1	CASE 1A	CASE 1B	CASE 2	CASE 2B	CASE 3	CASE 3A
A	Scenic Highway to Route 25 Westbound On-Ramp	✱	✱	✱	✱	✱	✱	✱
B	Route 6 Exit 1C Relocation	✱			✱	✱	✱	✱
C	Route 28 Northbound Ramp to Sandwich Road		✱	✱	✱	✱	✱	
D	Bourne Rotary (3 New Signalized Intersections)			✱	✱	✱	✱	
E	Belmont Circle (3-Leg Roundabout plus Signalized Intersection)				✱		✱	✱
F	Belmont Circle with Route 25 Eastbound Flyover					✱		
G	Replacement Canal Bridges (Bourne and Sagamore)						✱	✱
H	Route 6 Eastbound Travel Lane from Exit 1A to Exit 2						✱	✱
I	Bourne Rotary with Highway Interchange							✱

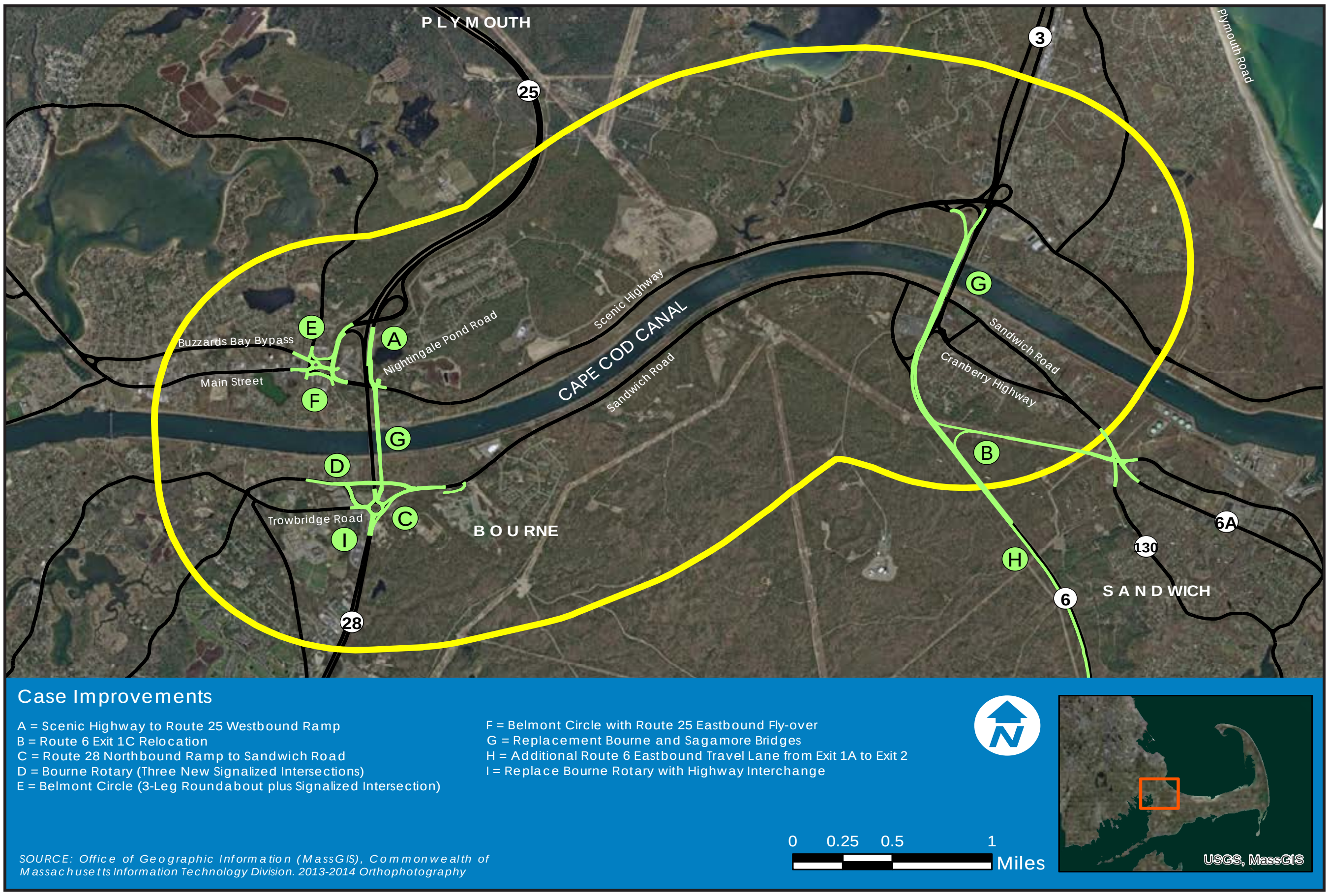
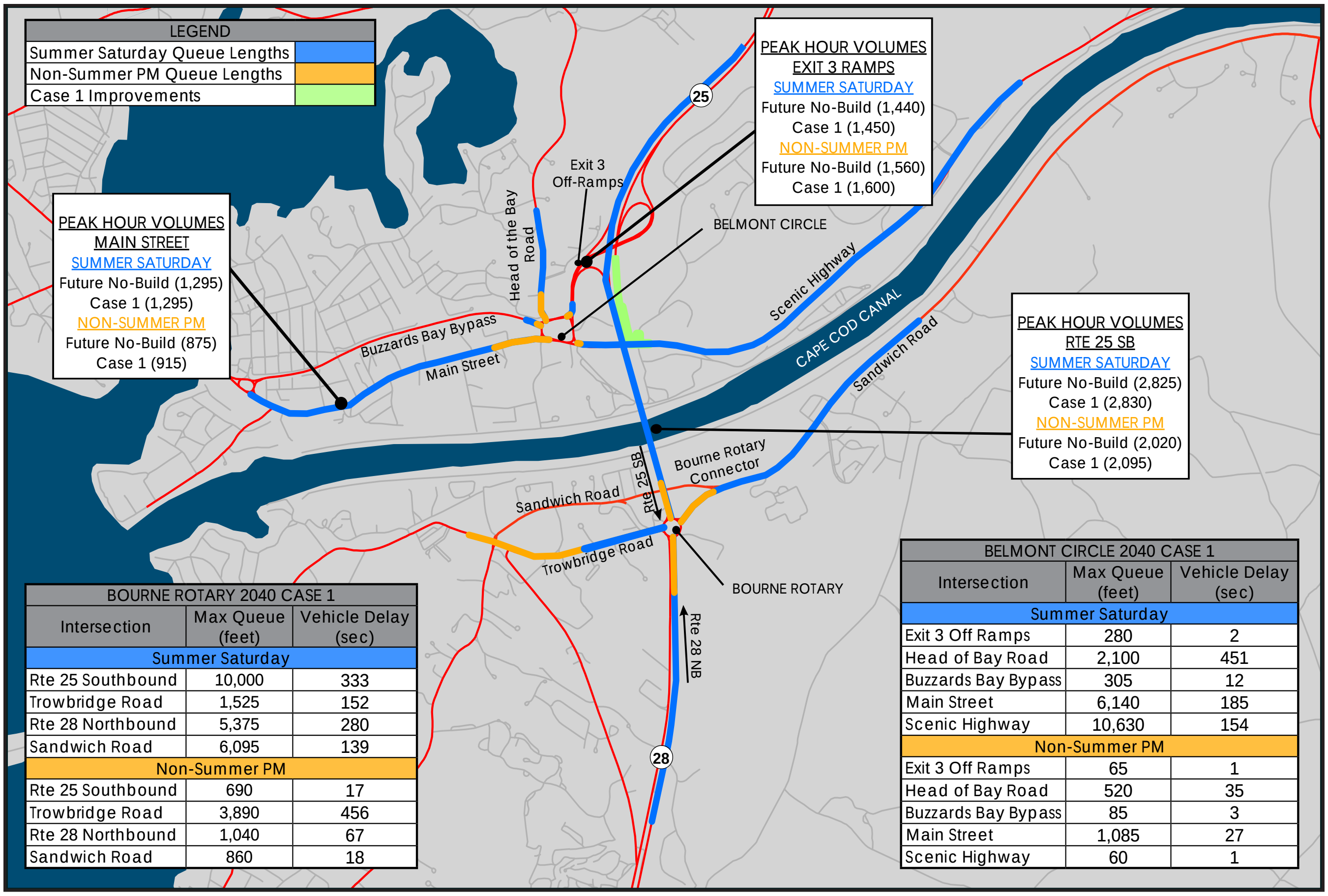


Exhibit 4-28 Location of Components of Travel Demand Model Cases

Cases 1, 1A, 1B, 2, and 2B were analyzed with the existing Canal bridges remaining in place as the improvements proposed under these cases could proceed as stand-alone projects without requiring any future action by the USACE. However, if the USACE proceeds with the replacement of the Canal bridges, these improvements, with modest modifications, would be compatible with the assumed location and layout of these replacement bridges. Cases 3 and 3A assume that replacement Canal bridges are in place.

The effectiveness of the following cases was determined by how they perform during the non-summer weekday PM (4:00 – 6:00 PM) and summer Saturday (10:00 AM – 12:00 PM) peak periods, when compared to the future no-build conditions at Belmont Circle and Bourne Rotary in terms of vehicle queuing, delays, and level of service.

Traffic conditions were also analyzed for the Route 3 southbound and Route 6 westbound approaches to the Sagamore Bridge (Exhibit 4-29). The results of this analysis are described in the following sections for Cases 1, 3, and 3A. A description of the results for Cases 1A and 1B are not provided as they effectively



BOURNE ROTARY 2040 CASE 1		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Rte 25 Southbound	10,000	333
Trowbridge Road	1,525	152
Rte 28 Northbound	5,375	280
Sandwich Road	6,095	139
Non-Summer PM		
Rte 25 Southbound	690	17
Trowbridge Road	3,890	456
Rte 28 Northbound	1,040	67
Sandwich Road	860	18

BELMONT CIRCLE 2040 CASE 1		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Exit 3 Off Ramps	280	2
Head of Bay Road	2,100	451
Buzzards Bay Bypass	305	12
Main Street	6,140	185
Scenic Highway	10,630	154
Non-Summer PM		
Exit 3 Off Ramps	65	1
Head of Bay Road	520	35
Buzzards Bay Bypass	85	3
Main Street	1,085	27
Scenic Highway	60	1

Exhibit 4-29 Case 1- Maximum Queue and Average Delay, Belmont Circle and Bourne Rotary

unchanged from the future no-build condition because these cases do not include improvements in the Sagamore Bridge area (such as the relocation of Route 6 Exit 1C or the addition of a travel lane of Route 6 eastbound). The results for Cases 2 and 2B are effectively the same as Case 1.

4.9 TRAVEL DEMAND MODEL – CASE ANALYSIS

The following sections describe the seven travel demand model cases evaluated and the findings of this analysis.

4.9.1 Case 1

Case 1 includes the evaluation of the following transportation improvements:

- Scenic Highway to Route 25 Westbound Entrance Ramp
- Route 6 – Relocation of Exit 1C

These two improvements were selected to be evaluated together as Case 1 because they are modestly-priced improvements that would improve peak period traffic operations in two of the most congested intersections in the study area, Belmont Circle and Bourne Rotary. They could both be built entirely within MassDOT right-of-way.

More detailed information is provided below on the forecast traffic operations under Case 1 at Belmont Circle and Bourne Rotary (also see Table 4-32 and Exhibit 4-29), and the Route 3 and Route 6 approaches to the Sagamore Bridge (Table 4-33 and Exhibit 4-30).

Belmont Circle

Result: Overall, Implementation of Case 1 would result in a modest improvement to traffic operations in Belmont Circle with more substantial improvement forecast during the non-summer weekday than the summer Saturday peak period.

Cause: The construction of a new Route 25 westbound entrance ramp (described in Section 4.6.4) would divert 1,340 of 1,705 vehicles during the non-summer weekday peak period that currently travel west on Scenic Highway and enter Belmont Circle to the new ramp. With fewer vehicles entering the Circle from Scenic Highway westbound, there would be a notable reduction in queuing at certain approaches to Belmont Circle, including the Route 25 Exit 3 ramp and Head of the Bay Road during both the non-summer weekday PM and summer Saturday peak periods. However, other approaches to Belmont Circle, including Scenic Highway, Buzzards Bay Bypass, and Main Street would not see a reduction in queuing and delays.

Bourne Rotary

Result: Traffic operations at the Bourne Rotary would not improve under Case 1 either in the non-summer weekday or summer Saturday peak periods. As shown in Table 4-32, some approaches would experience a reduction in queuing and related delays, while others may experience an increase in queuing and delays. Bourne Rotary would experience little improvement in traffic operations.

Cause: Roadway design at Bourne Rotary remains unchanged and there is no change in traffic volumes entering the Rotary.

Sagamore Bridge Approaches - Route 3 Southbound and Route 6 Westbound

Result: With the relocation of Route 6 Exit 1C, implementation of Case 1 would also affect traffic operations on the Route 3/Route 6 corridor. Queuing and delays are forecast to be substantially reduced for vehicles heading off-Cape on Route 6 westbound. Compared to the future no-build condition, during the summer

Table 4-32 Case 1 - Future (2040) Traffic Operations, Belmont Circle and Bourne Rotary

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 1		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*
BELMONT CIRCLE									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Exit 3 Off Ramps SB	5	A	515	2	A	645	1	A	65
Head of Bay Rd SB	15	C	270	317 (5.28)	**F**	1,780	35	D	520
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	85
Main Street EB	13	B	530	29	D	1,245	27	D	1,085
Scenic Highway WB	7	A	380	14	B	840	1	A	60
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**13.4**	**B**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	2	A	280
Head of Bay Rd SB	83 (1.38)	**F**	570	656 (10.93)	**F**	2,700 (0.51)	451 (7.52)	**F**	2,100
Buzzards Bay Bypass EB	19	C	335	11	B	305	12	B	305
Main Street EB	82 (1.36)	**F**	5,755 (1.09)	126 (2.1)	**F**	6,140 (1.16)	185 (3.08)	**F**	6,140 (1.16)
Scenic Highway WB	125 (2.08)	**F**	10,605 (2.01)	161 (2.68)	**F**	11,610 (2.20)	154 (2.57)	**F**	10,630 (2.01)
Intersection (Overall)	**62.6 (1.04)**	**F**		**191.4 (3.19)**	**F**		**160.8 (2.68)**	**F**	
BOURNE ROTARY									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Route 25 SB	19	C	650	14	B	620	17	C	65
Trowbridge Rd EB	75 (1.25)	**F**	840	394 (6.57)	**F**	3,465 (0.66)	456 (7.6)	**F**	520
Route 28 NB	14	B	340	102 (1.7)	**F**	1,275	67 (1.12)	**F**	85
Sandwich Rd WB	20	C	1,530	19	C	855	18	C	1,085
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**139.5 (2.33)**	**F**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Route 25 SB	280 (4.67)	**F**	8,885 (1.68)	329 (5.48)	**F**	9,935 (1.88)	333 (5.55)	**F**	10,000 (1.89)
Trowbridge Rd EB	30	D	335	265 (4.42)	**F**	2,225	152 (2.53)	**F**	1,525
Route 28 NB	301 (5.02)	**F**	4,135 (0.78)	189 (3.15)	**F**	3,605 (0.68)	280 (4.67)	**F**	5,375 (1.02)
Sandwich Rd WB	27	D	1475	135 (2.25)	**F**	6,430 (1.22)	139 (2.32)	**F**	6,095 (1.15)
Intersection (Overall)	**159.5 (2.66)**	**F**		**229.5 (3.83)**	**F**		**226 (3.77)**	**F**	

Notes:
*LOS E and LOS F movements are **bold***
EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

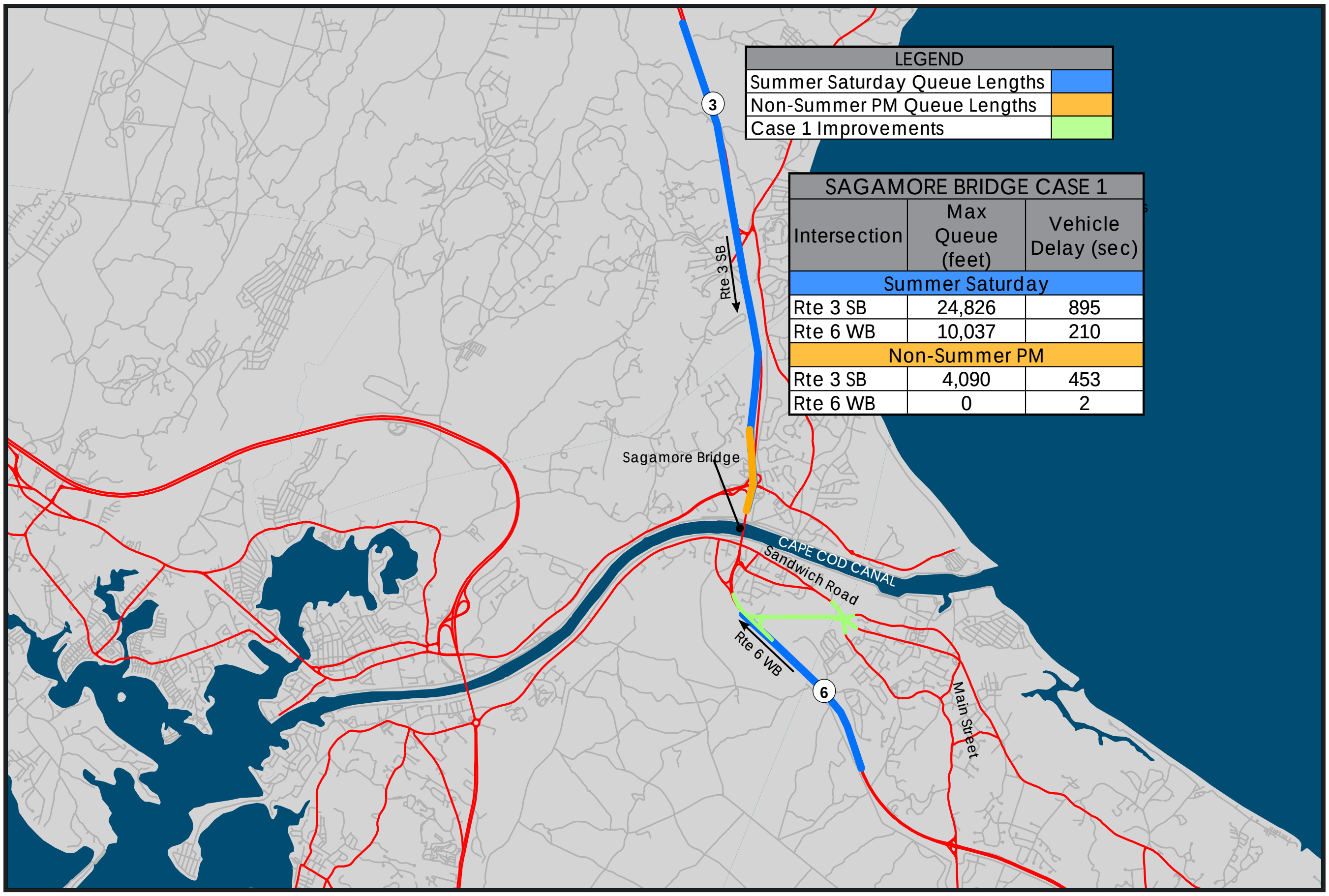


Exhibit 4-30 Case 1 - Maximum Queues and Average Delay, Sagamore Bridge Approaches

Table 4-33 Case 1 Traffic Operations, Sagamore Bridge Approaches

	EXISTING (2014) CONDITIONS				FUTURE (2040) NO-BUILD CONDITIONS				FUTURE (2040) BUILD CONDITIONS - BUILD CASE 1			
	AVERAGE DELAY *Sec (Min)*	LOS	AVERAGE QUEUE *Feet (Miles)*	MAXIMUM QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	AVERAGE QUEUE *Feet (Miles)*	MAXIMUM QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	AVERAGE QUEUE *Feet (Miles)*	MAXIMUM QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)												
Route 3 Southbound	11	B	77	478	460 (7.7)	F	7,481 (1.4)	8,476 (1.6)	453 (7.5)	F	3,534 (0.7)	4,090 (0.8)
Route 6 Westbound	5	A	53	232	178 (3.0)	F	6,801 (1.3)	7,967 (1.5)	2	A	0	0
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)												
Route 3 Southbound	416 (6.9)	F	4,823 (0.91)	5,393 (1.02)	887 (14.8)	F	22,814 (4.3)	24,484 (4.6)	895 (14.9)	F	23,308 (4.4)	24,826 (4.7)
Route 6 Westbound	683 (11.4)	F	23,318 (4.4)	25,014 (4.7)	812 (13.5)	F	24,825 (4.7)	25,029 (4.7)	210 (3.5)	F	7,253 (1.4)	10,037 (1.9)

Notes:
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

Saturday peak period, the maximum queue length is forecast to decline from approximately 4.7 miles to 1.9 miles (Table 4-33). Average delay during this same peak period would decrease from 13.5 minutes to 3.5 minutes. During the non-summer weekday period, in 2040 queuing and delays on Route 6 westbound would be eliminated, improving traffic conditions from LOS F to LOS A.

However, traffic queuing and delays on Route 3 southbound is not forecast to change compared to the future no-build condition because no roadway improvements are proposed that would change traffic conditions on Route 3 southbound. The result of the traffic analysis at the proposed roundabout at the Route 6 Exit 1C ramp at Route 6A and Route 130 is provided in Table 4-12 in Section 4.6.1.

Cause: The longer acceleration and deceleration lanes associated with the relocated Exit 1C and the greater distance from the Sagamore Bridge approach both contribute to reduced turbulence along Route 6 westbound.

4.9.2 Case 1A

Case 1A includes the following transportation improvements:

- Scenic Highway to Route 25 Westbound Entrance Ramp
- Route 28 Northbound Ramp to Sandwich Road (at Bourne Rotary)

Case 1A represents two transportation improvements with modest cost and limited environmental permitting requirements based on conceptual design completed for this study. This case assumes that the improvement at the intersection of Sandwich Road at Bourne Rotary Connector (including the relocation of the Technical High School driveway) has been implemented. More detailed information on the forecast traffic operations under Case 1A at Belmont Circle and Bourne Rotary is provided below (also see Table 4-34 and Exhibit 4-31).

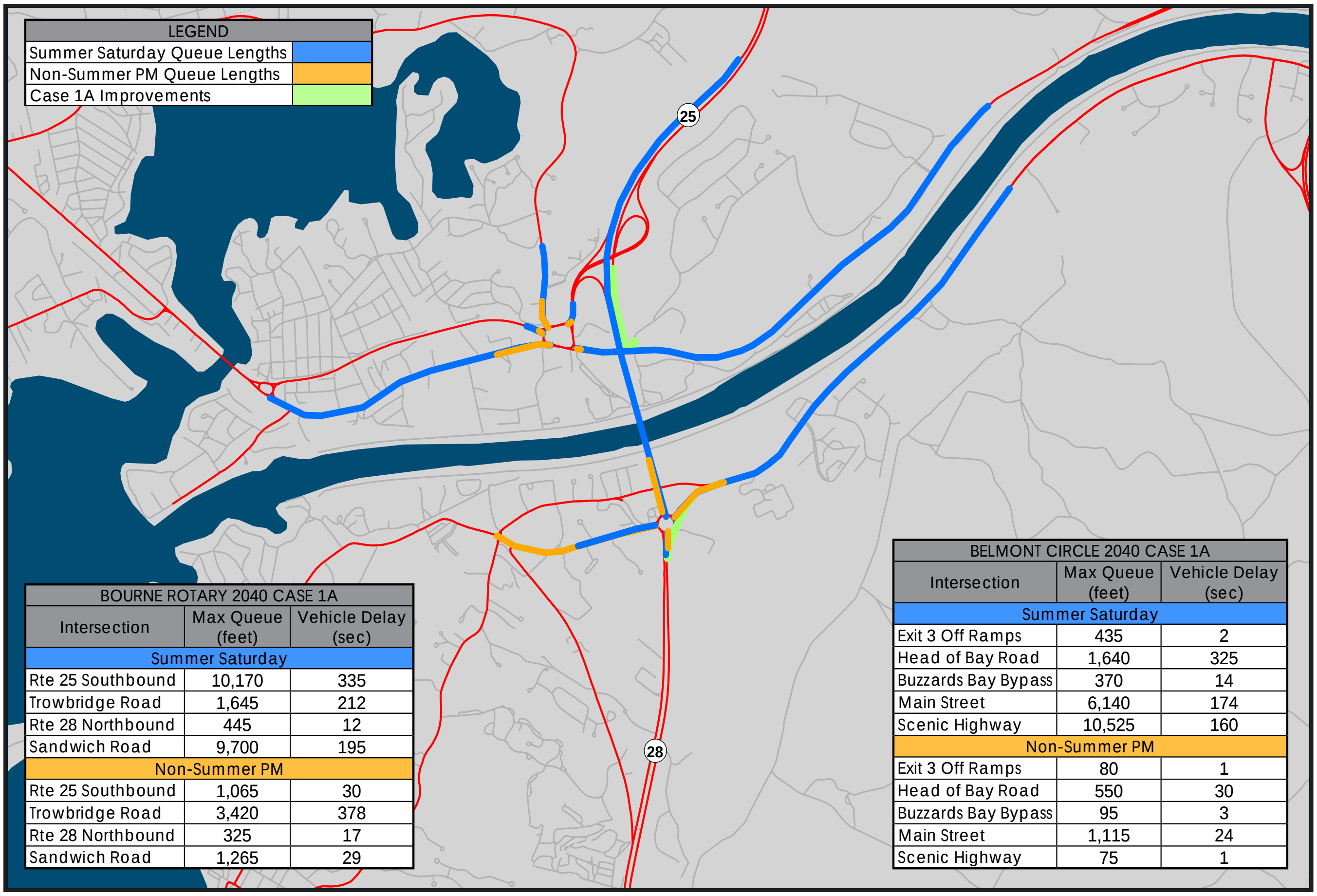
Belmont Circle

Result: Overall, the implementation of the Case 1A improvements would result in a moderate improvement in traffic operations at Belmont Circle with more substantial improvement forecast during the non-summer weekday than the summer Saturday peak period when comparing the future no-build condition to the build condition. Greater reductions in queues are forecast at the Route 25 off-ramps and Head of the Bay Road approach to the Circle but little improvement at the other approaches to the Circle, including Scenic Highway, Buzzards Bay Bypass, and Main Street.

Table 4-34 Case 1A - Future (2040) Traffic Operations, Belmont Circle and Bourne Rotary

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 1A		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*
BELMONT CIRCLE									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Exit 3 Off Ramps SB	5	A	515	2	A	645	1	A	80
Head of Bay Rd SB	15	C	270	317 (5.28)	**F**	1,780	30	D	550
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	95
Main Street EB	13	B	530	29	D	1,245	24	C	1,115
Scenic Highway WB	7	A	380	14	B	840	1	A	75
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**11.8**	**B**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	2	A	435
Head of Bay Rd SB	83 (1.38)	**F**	570	656 (10.93)	**F**	2,700 (0.51)	337 (5.62)	F	1,640
Buzzards Bay Bypass EB	19	C	335	11	B	305	14	B	370
Main Street EB	82 (1.36)	**F**	5,755 (1.09)	126 (2.1)	**F**	6,140 (1.16)	172 (2.87)	F	6,140 (1.16)
Scenic Highway WB	125 (2.08)	**F**	10,605 (2.01)	161 (2.68)	**F**	11,610 (2.20)	154 (2.57)	F	10,525 (1.99)
Intersection (Overall)	**62.6 (1.04)**	**F**		**191.4 (3.19)**	**F**		**135.8 (2.26)**	**F**	
BOURNE ROTARY									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Route 25 SB	19	C	650	14	B	620	30	D	1,065
Trowbridge Rd EB	75 (1.25)	**F**	840	394 (6.57)	**F**	3,465 (0.66)	378 (6.3)	F	3,420 (0.65)
Route 28 NB	14	B	340	102 (1.7)	**F**	1,275	17	C	325
Sandwich Rd WB	20	C	1,530	19	C	855	29	D	1,265
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**113.5 (1.89)**	**F**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Route 25 SB	280 (4.67)	**F**	8,885 (1.68)	329 (5.48)	**F**	9,935 (1.88)	337 (5.62)	F	10,170 (1.93)
Trowbridge Rd EB	30	D	335	265 (4.42)	**F**	2,225	213 (3.55)	F	1,645
Route 28 NB	301 (5.02)	**F**	4,135 (0.78)	189 (3.15)	**F**	3,605 (0.68)	13	B	445
Sandwich Rd WB	27	D	1,475	135 (2.25)	**F**	6,430 (1.22)	198 (3.3)	F	9,700 (1.84)
Intersection (Overall)	**159.5 (2.66)**	**F**		**229.5 (3.83)**	**F**		**190.25 (3.17)**	**F**	

Notes:
*LOS E and LOS F locations are **bold***
EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.



BOURNE ROTARY 2040 CASE 1A		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Rte 25 Southbound	10,170	335
Trowbridge Road	1,645	212
Rte 28 Northbound	445	12
Sandwich Road	9,700	195
Non-Summer PM		
Rte 25 Southbound	1,065	30
Trowbridge Road	3,420	378
Rte 28 Northbound	325	17
Sandwich Road	1,265	29

BELMONT CIRCLE 2040 CASE 1A		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Exit 3 Off Ramps	435	2
Head of Bay Road	1,640	325
Buzzards Bay Bypass	370	14
Main Street	6,140	174
Scenic Highway	10,525	160
Non-Summer PM		
Exit 3 Off Ramps	80	1
Head of Bay Road	550	30
Buzzards Bay Bypass	95	3
Main Street	1,115	24
Scenic Highway	75	1

Exhibit 4-31 Case 1A - Maximum Queue and Average Delay, Belmont Circle and Bourne Rotary

Cause: The construction of a new Route 25 westbound entrance ramp would divert 1,310 of 1,735 vehicles during the non-summer weekday peak period to the ramp that currently travel west on Scenic Highway and enter Belmont Circle. With fewer vehicles entering the Circle from Scenic Highway westbound, there would be a notable reduction in queuing at certain approaches to Belmont Circle, including the Route 25 Exit 3 off-ramp and Head of the Bay Road during both the non-summer weekday and summer Saturday peak periods. However, other approaches to Belmont Circle, including Scenic Highway, Buzzards Bay Bypass, and Main Street would not see a reduction in queues and delay substantial traffic volumes would continue to enter the Circle from those approaches.

Bourne Rotary

Result: Overall, traffic operations at the Bourne Rotary would improve moderately under Case 1A compared to the future no-build condition. Route 28 northbound is the only approach that is forecast to experience a substantial reduction in delay, especially during the summer Saturday peak period. Delay at all other approaches would remain approximately the same as the future no-build condition during both the non-summer weekday and summer Saturday peak periods.

Cause: The new Route 28 northbound ramp to Sandwich Road reduces delay on the Route 28 northbound approach to the Bourne Rotary. During the summer Saturday peak period, maximum queues are forecast to drop from over 3,600 feet to 445 feet, with a corresponding reduction in average delay from 3.1 minutes to 13 seconds. The results for the other approaches during the summer Saturday peak period would be mixed, with some delays increasing and others decreasing. Compared to the future no-build condition, the maximum queue on the Sandwich Road westbound approach to the Bourne Rotary would increase from 6,430 feet to 9,700 feet while the Trowbridge Road approach would decrease from 2,225 feet to 1,645 feet.

Sagamore Bridge Approaches - Route 3 Southbound and Route 6 Westbound

As shown on Exhibit 4-39, under Case 1A travel conditions on the approaches to the Sagamore Bridge would be effectively unchanged for the future no-build condition during both the non-summer weekday PM and summer Saturday peak periods. Because these cases do not include improvements in the Sagamore Bridge area (including the relocation of Route 6 Exit 1C or the addition of a travel lane of Route 6 eastbound).

4.9.3 Case 1B

Case 1B includes the following transportation improvements:

- Scenic Highway to Route 25 Westbound Ramp
- Route 28 Northbound Ramp to Sandwich Road (at Bourne Rotary)
- Bourne Rotary Reconstruction (Alternative 2 – Three Signalized Intersections)

Case 1B includes a highway entrance ramp from Scenic Highway westbound to Route 25 westbound, a ramp from Route 28 northbound to Sandwich Road, and the full reconstruction of the Bourne Rotary, including three new signalized intersections in the immediate are of the Rotary. This case represents a potential interim condition if the Bourne Rotary reconstruction were to be completed prior to the Belmont Circle reconstruction.

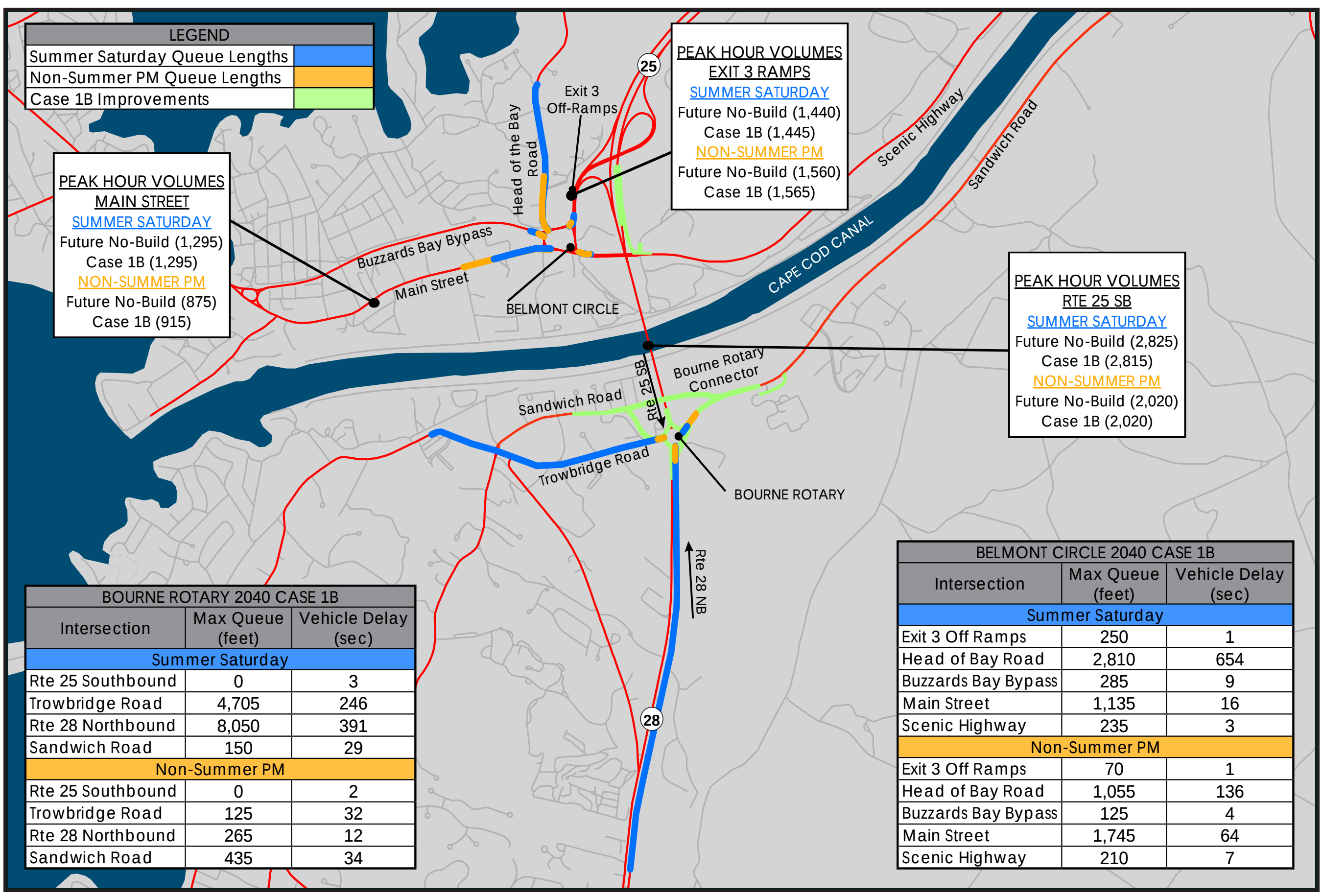
The reconstruction of Bourne Rotary prior to Belmont Circle would be desirable because of the proximity of Belmont Circle and Bourne Rotary to one another. Improvements to Bourne Rotary – particularly at the Route 25 southbound approach – are required for improvements at Belmont Circle to be effective because of queuing on the Route 25 southbound approach to the Bourne Rotary. During the summer Saturday peak period, these queues extend nearly 9,000 feet, delaying vehicles trying to exit Route 25 to Belmont Circle. More detailed information is provided below on the forecast traffic operation at Belmont Circle and Bourne Rotary (also see Table 4-35 and Exhibit 4-32).

Belmont Circle

Result: Overall, Case 1B would result in a moderate improvement in traffic operations at Belmont Circle. The results for the non-summer weekday and summer Saturday peak periods are inconsistent, with the most pronounced delay reductions forecast on the Main Street and Scenic Highway approaches during the summer Saturday peak period. During the non-summer weekday peak period, Head of the Bay Road is forecast to experience the greatest delay reductions.

Cause: With the Scenic Highway westbound to Route 25 westbound ramp as the only roadway improvements to be implemented at Belmont Circle under Case 1B, traffic operations in Belmont Circle would only moderately improve compared to the future no-build condition.

Exhibit 4-32 Case 1B - Maximum Queue and Average Delay, Belmont Circle and Bourne Rotary



BOURNE ROTARY 2040 CASE 1B		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Rte 25 Southbound	0	3
Trowbridge Road	4,705	246
Rte 28 Northbound	8,050	391
Sandwich Road	150	29
Non-Summer PM		
Rte 25 Southbound	0	2
Trowbridge Road	125	32
Rte 28 Northbound	265	12
Sandwich Road	435	34

BELMONT CIRCLE 2040 CASE 1B		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Exit 3 Off Ramps	250	1
Head of Bay Road	2,810	654
Buzzards Bay Bypass	285	9
Main Street	1,135	16
Scenic Highway	235	3
Non-Summer PM		
Exit 3 Off Ramps	70	1
Head of Bay Road	1,055	136
Buzzards Bay Bypass	125	4
Main Street	1,745	64
Scenic Highway	210	7

Table 4-35 Case 1B - Future (2040) Traffic Operations, Belmont Circle and Bourne Rotary

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 1B		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*
BELMONT CIRCLE									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Exit 3 Off Ramps SB	5	A	515	2	A	645	1	A	70
Head of Bay Rd SB	15	C	270	317 (5.28)	**F**	1,780	142 (2.37)	**F**	1,055
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	125
Main Street EB	13	B	530	29	D	1,245	61 (1.02)	**F**	1,745
Scenic Highway WB	7	A	380	14	B	840	7	A	210
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**42.8**	**E**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	2	A	250
Head of Bay Rd SB	83 (1.38)	**F**	570	656 (10.93)	**F**	2,700 (0.51)	622 (10.37)	**F**	2,810 (0.53)
Buzzards Bay Bypass EB	19	C	335	11	B	305	9	A	285
Main Street EB	82 (1.36)	**F**	5,755 (1.09)	126 (2.1)	**F**	6,140 (1.16)	17	C	1,135
Scenic Highway WB	125 (2.08)	**F**	10,605 (2.01)	161 (2.68)	**F**	11,610 (2.20)	3	A	235
Intersection (Overall)	**62.6 (1.04)**	**F**		**191.4 (3.19)**	**F**		**130.6 (2.18)**	**F**	
BOURNE ROTARY									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Route 25 SB	19	C	650	14	B	620	2	A	0
Trowbridge Rd EB	75 (1.25)	**F**	840	394 (6.57)	**F**	3,465 (0.66)	33	D	125
Route 28 NB	14	B	340	102 (1.7)	**F**	1,275	13	B	265
Sandwich Rd WB	20	C	1,530	19	C	855	32	D	435
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**20**	**C**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Route 25 SB	280 (4.67)	**F**	8,885 (1.68)	329 (5.48)	**F**	9,935 (1.88)	3	A	0
Trowbridge Rd EB	30	D	335	265 (4.42)	**F**	2,225	249 (4.15)	F	4,705 (0.89)
Route 28 NB	301 (5.02)	F	4,135 (0.78)	189 (3.15)	F	3,605 (0.68)	409 (6.82)	F	8,050 (1.52)
Sandwich Rd WB	27	D	1475	135 (2.25)	**F**	6,430 (1.22)	24	C	150
Intersection (Overall)	**159.5 (2.66)**	**F**		**229.5 (3.83)**	**F**		**171.25 (2.85)**	**F**	

Notes:
*LOS E and LOS F movements are **bold***
EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

During the summer Saturday peak period, queuing and delays would decrease substantially on the Scenic Highway and Main Street approaches, while remaining about the same on the other approaches to Belmont Circle. With a forecast delay of over 11 minutes during the summer Saturday peak period (similar to the future no-build condition), the Head of the Bay Road approach would continue to be the most problematic approach. This is likely travelers bypassing Route 25 or Route 6 in Wareham and approaching Belmont Circle from Head of the Bay Road.

Bourne Rotary

Result: Overall, traffic operations at the Bourne Rotary would improve substantially under Case 1B compared to the future no-build condition. More substantial improvement is forecast during the non-summer weekday peak period than the summer Saturday period. During the summer Saturday peak period, approaches to the Bourne Rotary that would continue to experience considerable delay include Trowbridge Road and Route 28 northbound.

Cause: Improvements at Bourne Rotary include modifications that would not allow traffic to cross over the north side of the Rotary. This action would allow traffic from the Route 25 southbound approach to enter freely without having to contend with traffic coming from the east side of the Rotary. This would eliminate both the non-summer weekday and non-summer Saturday peak period delays from the Route 25 southbound approach.

However, the current configuration, having vehicles circulate counter-clockwise around the Rotary results in regular gaps in the rotary traffic for vehicles entering from all approaches. Not allowing traffic to cross the top of the Rotary would result in fewer gaps for traffic entering from Trowbridge Road and Route 28 northbound, resulting in continued extended queues from those approaches during the summer Saturday peak period.

Sagamore Bridge Approaches - Route 3 Southbound and Route 6 Westbound

As shown on Exhibit 4-39, under Case 1B travel conditions on the approaches to the Sagamore Bridge would be effectively unchanged for the future no-build condition during both the non-summer weekday PM and summer Saturday peak periods. Because these cases do not include improvements in the Sagamore Bridge area (including the relocation of Route 6 Exit 1C or the addition of a travel lane of Route 6 eastbound).

4.9.4 Case 2

Case 2 includes the following transportation improvements:

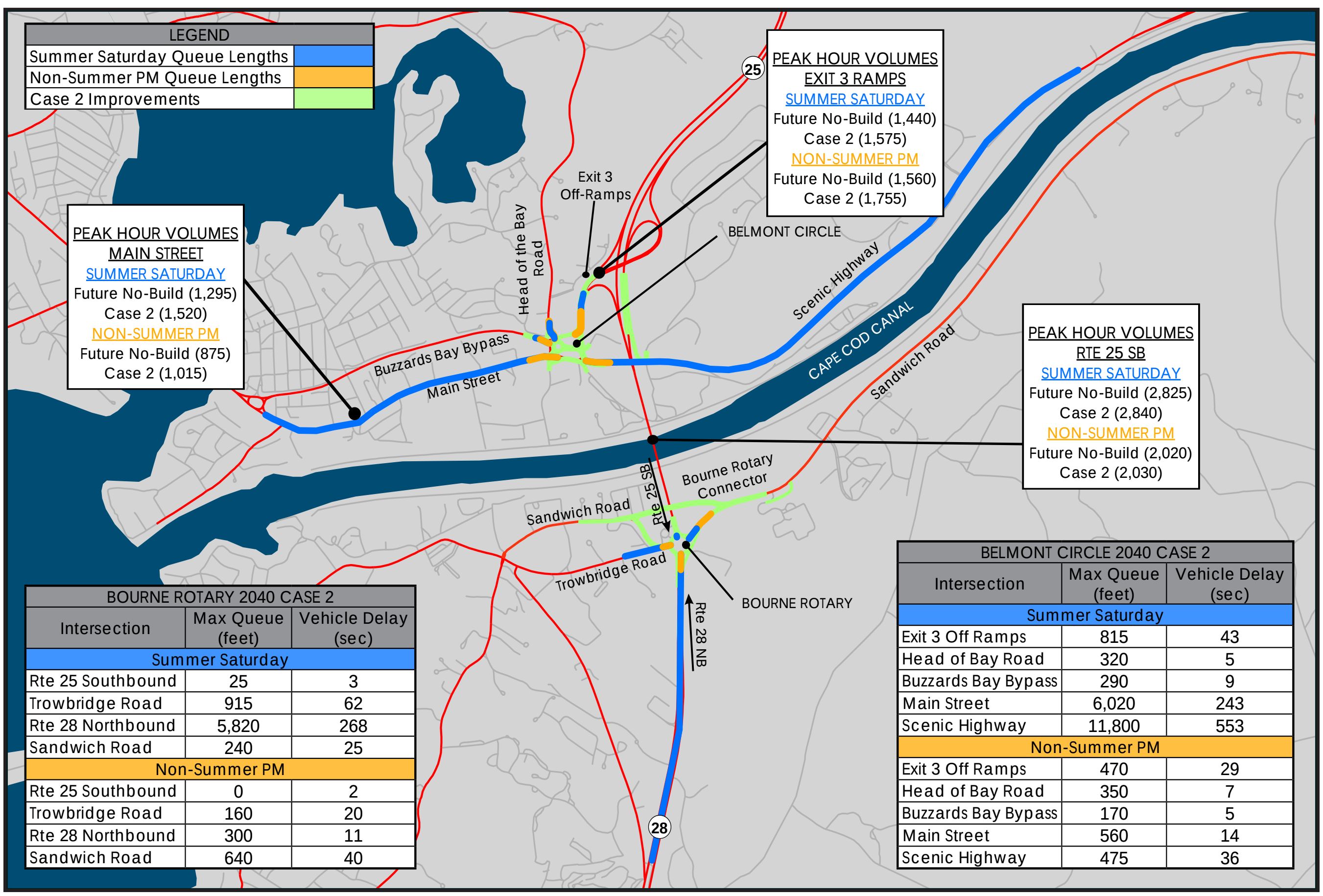
- Scenic Highway to Route 25 Westbound Ramp
- Route 6 – Relocation of Exit 1C
- Belmont Circle Reconstruction (Alternative 1 – Four-Leg Roundabout and Signalized Intersection)
- Bourne Rotary Reconstruction (Alternative 2 – Three Signalized Intersections)

This case represents the implementation of all suggested transportation improvements, prior to the assumed replacement of the Bourne and Sagamore Bridges (although these improvements would also be compatible with replacement Canal bridges). More detailed information is provided below on the forecast traffic operation at Belmont Circle and Bourne Rotary (also see Table 4-36 and Exhibit 4-33).

Belmont Circle

Result: Overall, implementing the Case 2 improvements would modestly improve traffic operations at Belmont Circle compared to the future no-build condition. More substantial reduction

Exhibit 4-33 Case 2 - Maximum Queue and Average Delay, Belmont Circle and Bourne Rotary



BOURNE ROTARY 2040 CASE 2		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Rte 25 Southbound	25	3
Trowbridge Road	915	62
Rte 28 Northbound	5,820	268
Sandwich Road	240	25
Non-Summer PM		
Rte 25 Southbound	0	2
Trowbridge Road	160	20
Rte 28 Northbound	300	11
Sandwich Road	640	40

BELMONT CIRCLE 2040 CASE 2		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Exit 3 Off Ramps	815	43
Head of Bay Road	320	5
Buzzards Bay Bypass	290	9
Main Street	6,020	243
Scenic Highway	11,800	553
Non-Summer PM		
Exit 3 Off Ramps	470	29
Head of Bay Road	350	7
Buzzards Bay Bypass	170	5
Main Street	560	14
Scenic Highway	475	36

Table 4-36 Case 2 - Future (2040) Traffic Operations, Belmont Circle and Bourne Rotary

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 2		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*
BELMONT CIRCLE									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Exit 3 Off Ramps SB	5	A	515	2	A	645	29	D	470
Head of Bay Rd SB	15	C	270	317 (5.28)	**F**	1,780	7	A	350
Buzzards Bay Bypass EB	3	A	100	3	A	110	5	A	170
Main Street EB	13	B	530	29	D	1,245	14	B	560
Scenic Highway WB	7	A	380	14	B	840	36	**E**	475
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**18.2**	**C**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	43	E	815
Head of Bay Rd SB	83 (1.38)	**F**	570	656 (10.93)	**F**	2,700 (0.51)	5	A	320
Buzzards Bay Bypass EB	19	C	335	11	B	305	9	A	290
Main Street EB	82 (1.36)	**F**	5,755 (1.09)	126 (2.1)	**F**	6,140 (1.16)	243 (4.05)	**F**	6,020 (1.14)
Scenic Highway WB	125 (2.08)	**F**	10,605 (2.01)	161 (2.68)	**F**	11,610 (2.20)	553 (9.22)	**F**	11,800 (2.23)
Intersection (Overall)	**62.6 (1.04)**	**F**		**191.4 (3.19)**	**F**		**170.6 (2.84)**	**F**	
BOURNE ROTARY									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Route 25 SB	19	C	650	14	B	620	2	A	0
Trowbridge Rd EB	75 (1.25)	**F**	840	394 (6.57)	**F**	3,465 (0.66)	20	C	160
Route 28 NB	14	B	340	102 (1.7)	**F**	1,275	11	B	300
Sandwich Rd WB	20	C	1,530	19	C	855	40	E	640
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**18.25**	**B**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Route 25 SB	280 (4.67)	**F**	8,885 (1.68)	329 (5.48)	**F**	9,935 (1.88)	3	A	25
Trowbridge Rd EB	30	D	335	265 (4.42)	**F**	2,225	62 (1.03)	**F**	915
Route 28 NB	301 (5.02)	**F**	4,135 (0.78)	189 (3.15)	**F**	3,605 (0.68)	268 (4.47)	**F**	5,820 (1.10)
Sandwich Rd WB	27	D	1,475	135 (2.25)	**F**	6,430 (1.22)	25	D	240
Intersection (Overall)	**159.5 (2.66)**	**F**		**229.5 (3.83)**	**F**		**89.5 (1.49)**	**F**	

Notes:
*LOS E and LOS F movements are **bold***
EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

in queuing and delays would occur during the non-summer weekday than the summer Saturday peak period at both locations.

Cause: Traffic operations substantially improve under Case 2 compared to the future no-build condition during the non-summer weekday peak period. Compared to the future no-build condition, the average delay on the Head of the Bay Road approach would decrease from 317 seconds to seven seconds during the non-summer weekday peak period and from 656 seconds to five seconds during the summer Saturday peak period. All other approaches to Belmont Circle during the non-summer weekday peak period are modest (less than 30 seconds) for the future no-build condition and would remain so under Case 2.

During the summer Saturday peak period, extended queuing would persist at the Main Street and Scenic Highway approaches. The persistent queuing and delays on Main Street can be partly attributed to the increased traffic volumes of regional travelers and local residents accessing the numerous business on Main Street. During the summer Saturday peak period, traffic volumes increase 16%, from 1,295 to 1,520 vehicles per hour. As additional improvements are implemented, travelers who may have avoided Belmont Circle because of the delay, are forecast to more frequently use Main Street to access Belmont Circle.

Bourne Rotary

Result: Traffic operations at Bourne Rotary under Case 2 would substantially improve during the non-summer weekday peak period compared to the future no-build condition. Average delay would be less than one minute at all approaches during both the non-summer weekday and summer Saturday peak periods except for Trowbridge Road (62 seconds) and Route 28 northbound (4.5 minutes). These two approaches would continue to experience LOS F conditions during the summer Saturday peak period.

Cause: The new configuration of the Bourne Rotary - which doesn't allow traffic to cross over the north side of the Rotary - is forecast to improve overall traffic operations, especially during the non-summer weekday period. However, this configuration results in fewer gaps for vehicles trying to enter the Rotary from Route 28 northbound, preventing delay reductions at that approach.

Sagamore Bridge Approaches - Route 3 Southbound and Route 6 Westbound

As shown on Exhibit 4-39, under Case 2 travel conditions on the approaches to the Sagamore Bridge would be effectively the same as Case 1 for the future no-build condition during both the non-summer weekday PM and summer Saturday peak periods. Because these cases do not include improvements in the Sagamore Bridge area (including the relocation of Route 6 Exit 1C or the addition of a travel lane of Route 6 eastbound).

4.9.5 Case 2B

Case 2B includes the following transportation improvements:

- Scenic Highway to Route 25 Westbound Ramp
- Route 6 – Relocation of Exit 1C
- Belmont Circle Reconstruction (Alternative 1A – Four-Leg Roundabout with Route 25 Flyover to Scenic Highway Eastbound)
- Bourne Rotary Reconstruction (Alternative 2 – Three Signalized Intersections)

Under Case 2A, a flyover ramp would allow traffic from Route 25 Exit 3 to bypass the signalized intersection on the east side of Belmont Circle and merge directly onto Scenic Highway. All improvements included in Case 2B would be implemented prior to the assumed replacement of the Bourne and Sagamore Bridges.

More detailed information is provided below on the forecast traffic operation at Belmont Circle and Bourne Rotary (also see Table 4-37 and Exhibit 4-34).

Belmont Circle

Result: Overall, Case 2B would result in substantially reduced queuing and delays in Belmont Circle during the non-summer weekday period with delay at all approaches less than 10 seconds, except Scenic Highway, which would only be 16 seconds. However, during the summer Saturday peak period extended queues are forecast at several approaches, including Head of the Bay Road and Buzzards Bay Bypass.

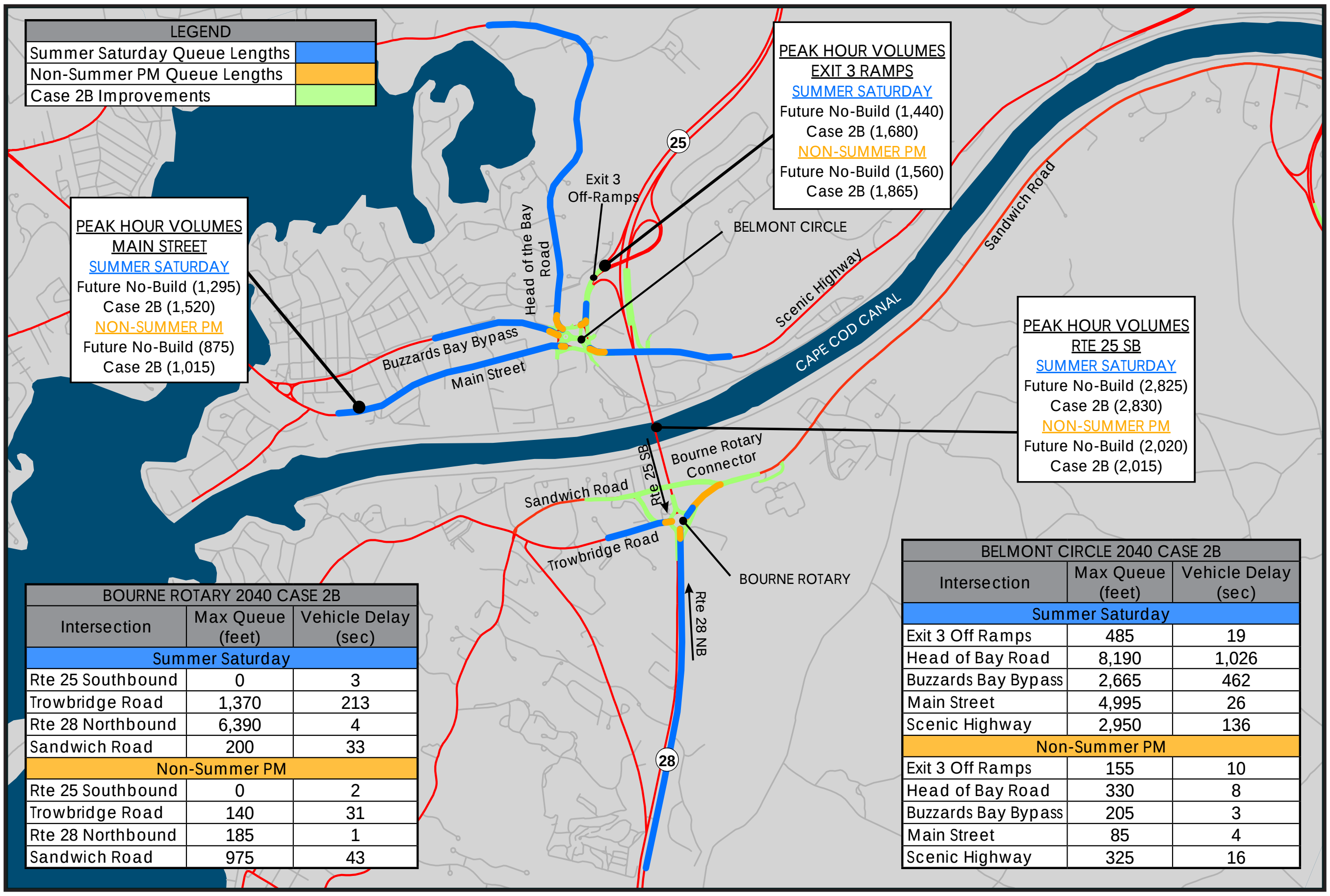
The new flyover ramp from Route 25 to Scenic Highway westbound would reduce queuing and delays at Belmont Circle, resulting in only minor delay (3-16 seconds) during the non-summer weekday peak period. However, traffic conditions during the summer Saturday peak period would be worse than the forecast future no-build conditions with extended queuing and delays at the Head of the Bay Road (15.5-minute delay) and the Buzzards Bay Bypass (7.5-minute delay).

Cause: The more freely flowing traffic entering the new roundabout from the Route 25 Exit 3 exit ramp results in fewer gaps between vehicles in the roundabout. This increases the difficulty for vehicles trying to enter from other approaches,

Table 4-37 *Case 2B - Future (2040) Traffic Operations, Belmont Circle and Bourne Rotary*

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 2B		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*
BELMONT CIRCLE									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Exit 3 Off Ramps SB	5	A	515	2	A	645	9	A	155
Head of Bay Rd SB	15	C	270	317 (5.28)	**F**	1,780	8	A	330
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	205
Main Street EB	13	B	530	29	D	1,245	4	A	85
Scenic Highway WB	7	A	380	14	B	840	16	C	325
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**8**	**A**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	18	C	485
Head of Bay Rd SB	83 (1.38)	**F**	570	656 (10.93)	**F**	2,700 (0.51)	940 (15.67)	**F**	8,190 (1.55)
Buzzards Bay Bypass EB	19	C	335	11	B	305	446 (7.43)	**F**	2,665 (0.50)
Main Street EB	82 (1.36)	**F**	5,755 (1.09)	126 (2.1)	**F**	6,140 (1.16)	45	**E**	4,995 (0.94)
Scenic Highway WB	125 (2.08)	**F**	10,605 (2.01)	161 (2.68)	**F**	11,610 (2.20)	147 (2.45)	**F**	2,950 (0.56)
Intersection (Overall)	**62.6 (1.04)**	F		**191.4 (3.19)**	F		**319.2 (5.32)**	F	
BOURNE ROTARY									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Route 25 SB	19	C	650	14	B	620	2	A	0
Trowbridge Rd EB	75 (1.25)	**F**	840	394 (6.57)	**F**	3,465 (0.66)	17	C	140
Route 28 NB	14	B	340	102 (1.7)	**F**	1,275	7	A	185
Sandwich Rd WB	20	C	1,530	19	C	855	49	**E**	975
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**18.75**	**C**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Route 25 SB	280 (4.67)	**F**	8,885 (1.68)	329 (5.48)	**F**	9,935 (1.88)	3	A	0
Trowbridge Rd EB	30	D	335	265 (4.42)	**F**	2,225	136 (2.27)	**F**	1370
Route 28 NB	301 (5.02)	**F**	4,135 (0.78)	189 (3.15)	**F**	3,605 (0.68)	344 (5.73)	**F**	6,930 (1.31)
Sandwich Rd WB	27	D	1,475	135 (2.25)	**F**	6,430 (1.22)	24	C	200
Intersection (Overall)	**159.5 (2.66)**	F		**229.5 (3.83)**	F		**126.75 (2.11)**	F	

Notes:
*LOS E and LOS F movements are **bold***
EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.



BOURNE ROTARY 2040 CASE 2B		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Rte 25 Southbound	0	3
Trowbridge Road	1,370	213
Rte 28 Northbound	6,390	4
Sandwich Road	200	33
Non-Summer PM		
Rte 25 Southbound	0	2
Trowbridge Road	140	31
Rte 28 Northbound	185	1
Sandwich Road	975	43

BELMONT CIRCLE 2040 CASE 2B		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Exit 3 Off Ramps	485	19
Head of Bay Road	8,190	1,026
Buzzards Bay Bypass	2,665	462
Main Street	4,995	26
Scenic Highway	2,950	136
Non-Summer PM		
Exit 3 Off Ramps	155	10
Head of Bay Road	330	8
Buzzards Bay Bypass	205	3
Main Street	85	4
Scenic Highway	325	16

Exhibit 4-34 Case 2B - Maximum Queue and Average Delay, Belmont Circle and Bourne Rotary

particularly the Head of the Bay Road and Main Street approaches.

As noted under Case 2, a contributing factor in the poor traffic conditions at Belmont Circle during the summer Saturday peak period includes the diversion of additional traffic to the Bourne Bridge area as overall traffic conditions in this area improve. The persistent queuing and delays on Main Street can be partly attributed to the increased traffic volumes. During the summer Saturday peak period, traffic volumes increase from 1,295 to 1,520 vehicles per hour.

Bourne Rotary

Result: Traffic operations at Bourne Rotary under Case 2B would substantially improve during the non-summer weekday peak period compared to the future no-build condition. Average delay would be less than one minute at all approaches during both the non-summer weekday and non-summer Saturday peak periods except for Trowbridge Road (2.2 minutes) and Route 28 northbound (5.7 minutes). These two approaches would continue to experience LOS F conditions during the summer Saturday peak period.

Cause: The new configuration of the Bourne Rotary which would not allow traffic to cross over the north side of the Rotary would allow increased traffic flow from Route 28 southbound. This improves overall traffic operations, especially during the non-summer weekday peak period. However, during the summer Saturday peak period, this configuration results in fewer gaps for vehicles trying to enter the Rotary from Trowbridge Road and Route 28 northbound, preventing delay reductions at those approaches.

Sagamore Bridge Approaches - Route 3 Southbound and Route 6 Westbound

As shown on Exhibit 4-39, under Case 2B travel conditions on the approaches to the Sagamore Bridge would be effectively the same as Case 1 for the future no-build condition during both the non-summer weekday PM and summer Saturday peak periods. Because these cases do not include improvements in the Sagamore Bridge area (including the relocation of Route 6 Exit 1C or the addition of a travel lane of Route 6 eastbound).

4.9.6 Case 3

Case 3 includes the following transportation improvements:

- Scenic Highway to Route 25 Westbound Ramp
- Belmont Circle Reconstruction (Alternative 1 – Four-Leg Roundabout and Signalized Intersection)
- Bourne Rotary Reconstruction (Alternative 2 – Three Signalized Intersections)
- Sagamore Bridge Replacement
- Bourne Bridge Replacement
- Route 6 – Relocation of Exit 1C
- Route 6 – Additional Eastbound Travel Lane to Exit 2 (Route 130)

Case 3 includes all transportation improvements described under Case 2, plus several additional major transportation improvements including the assumed replacement of the Bourne and Sagamore Bridges (by the USACE) and the construction of an additional eastbound travel lane on Route 6 to Exit 2 (Route 130). Case 3 represents the implementation of nearly all suggested transportation improvements. More detailed information is provided below on the forecast traffic operation at Belmont Circle and Bourne Rotary (also see Table 4-38 and Exhibit 4-35).

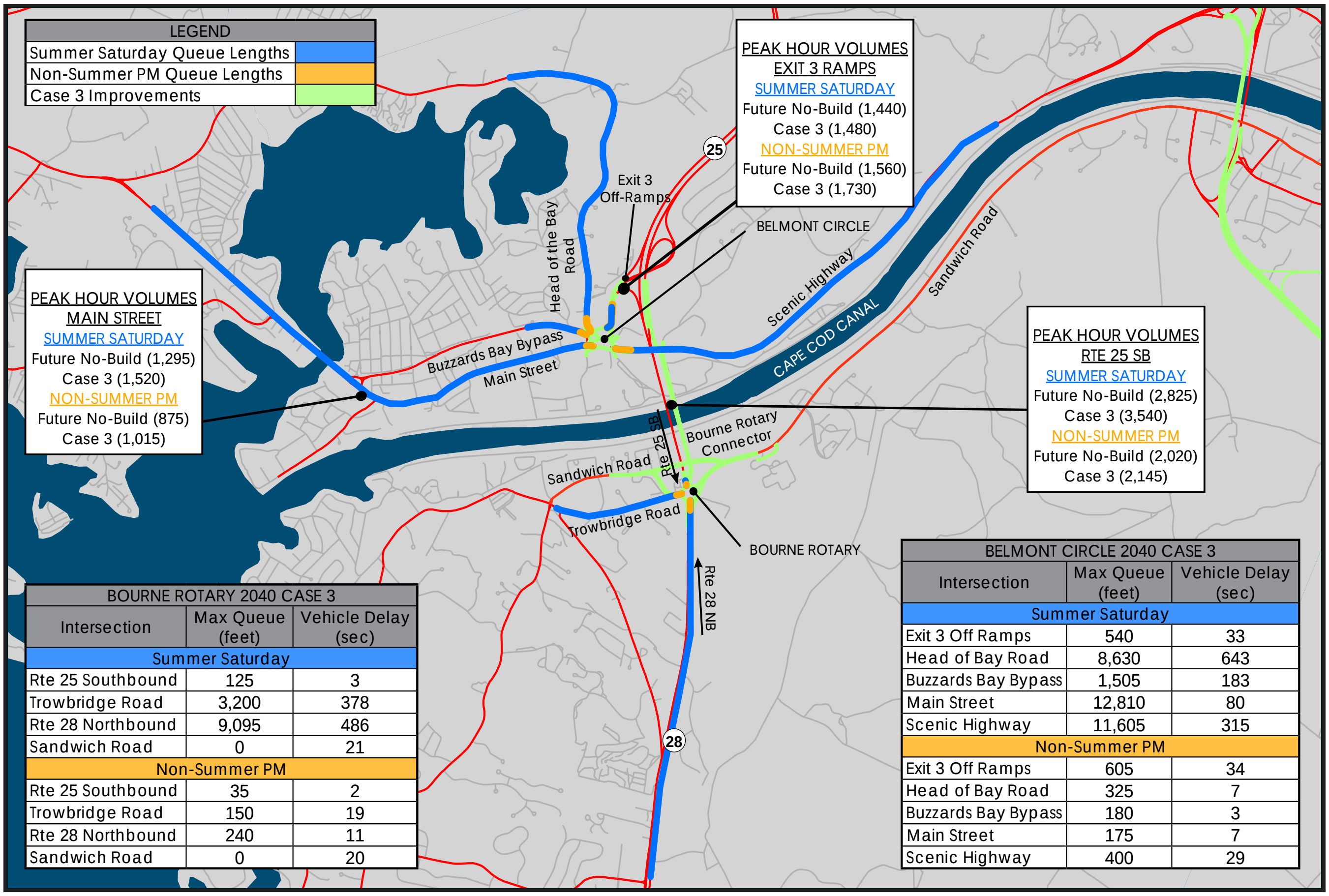
Belmont Circle

Result: The replacement bridges (with auxiliary lanes for entering and exiting traffic) together with the highway

Table 4-38 *Case 3 - Future (2040) Traffic Operations, Belmont Circle and Bourne Rotary*

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 3		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*
BELMONT CIRCLE									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Exit 3 Off Ramps SB	5	A	515	2	A	645	34	D	605
Head of Bay Rd SB	15	C	270	317 (5.28)	**F**	1,780	7	A	325
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	180
Main Street EB	13	B	530	29	D	1,245	7	A	175
Scenic Highway WB	7	A	380	14	B	840	29	D	400
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**16**	**C**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	33	D	540
Head of Bay Rd SB	83 (1.38)	**F**	570	656 (10.93)	**F**	2,700 (0.51)	643 (10.72)	**F**	8,630 (1.63)
Buzzards Bay Bypass EB	19	C	335	11	B	305	183 (3.05)	**F**	1,505
Main Street EB	82 (1.36)	**F**	5,755 (1.09)	126 (2.1)	**F**	6,140 (1.16)	80 (1.33)	**F**	12,810 (2.43)
Scenic Highway WB	125 (2.08)	**F**	10,605 (2.01)	161 (2.68)	**F**	11,610 (2.20)	315 (5.25)	**F**	11,605 (2.20)
Intersection (Overall)	**62.6 (1.04)**	**F**		**191.4 (3.19)**	**F**		**250.8 (4.18)**	**F**	
BOURNE ROTARY									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Route 25 SB	19	C	650	14	B	620	2	A	35
Trowbridge Rd EB	75 (1.25)	**F**	840	394 (6.57)	**F**	3,465 (0.66)	19	C	150
Route 28 NB	14	B	340	102 (1.7)	**F**	1,275	11	B	240
Sandwich Rd WB	20	C	1,530	19	C	855	20	C	0
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**13**	**B**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Route 25 SB	280 (4.67)	**F**	8,885 (1.68)	329 (5.48)	**F**	9,935 (1.88)	3	A	125
Trowbridge Rd EB	30	D	335	265 (4.42)	**F**	2,225	378 (6.3)	**F**	3,200 (0.61)
Route 28 NB	301 (5.02)	**F**	4,135 (0.78)	189 (3.15)	**F**	3,605 (0.68)	486 (8.1)	**F**	9,095 (1.72)
Sandwich Rd WB	27	D	1,475	135 (2.25)	**F**	6,430 (1.22)	21	C	0
Intersection (Overall)	**159.5 (2.66)**	**F**		**229.5 (3.83)**	**F**		**222 (3.7)**	**F**	

Notes:
*LOS E and LOS F movements are **bold***
EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.



BOURNE ROTARY 2040 CASE 3		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Rte 25 Southbound	125	3
Trowbridge Road	3,200	378
Rte 28 Northbound	9,095	486
Sandwich Road	0	21
Non-Summer PM		
Rte 25 Southbound	35	2
Trowbridge Road	150	19
Rte 28 Northbound	240	11
Sandwich Road	0	20

BELMONT CIRCLE 2040 CASE 3		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Exit 3 Off Ramps	540	33
Head of Bay Road	8,630	643
Buzzards Bay Bypass	1,505	183
Main Street	12,810	80
Scenic Highway	11,605	315
Non-Summer PM		
Exit 3 Off Ramps	605	34
Head of Bay Road	325	7
Buzzards Bay Bypass	180	3
Main Street	175	7
Scenic Highway	400	29

Exhibit 4-35 Case 3- Maximum Queue and Average Delay, Belmont Circle and Bourne Rotary

interchange at the existing Bourne Rotary and improvements to Belmont Circle would reduce existing vehicle conflict points and separate regional from local traffic. With these transportation improvements in place, traffic would operate substantially better during the non-summer weekday peak period at Belmont Circle compared to the future no build condition.

However, during the summer Saturday peak period, traffic operations degrade substantially, becoming worse than the future no build conditions. Average delay during the summer Saturday peak period would exceed 10.7 and 5.2 minutes at the Head of the Bay Road and Scenic Highway approaches, respectively.

Cause: A contributing reason for the poor traffic operations at Belmont Circle under Case 3 is that the improved roadway system in the Bourne Bridge area results in a diversion of a substantial number of additional vehicles from other locations to this area. For example, during the summer Saturday peak period, Main Street is forecast to process 225 additional vehicles (increasing from 1,295 to 1,520 vehicles).

Bourne Rotary

Result: Traffic operations under Case 3 at the Bourne Rotary would improve substantially during the non-summer weekday peak period. Average delay for all approaches would range from two- to 20-seconds. However, during the summer Saturday peak period, delay would vary depending on the approach. The Route 25 southbound and Sandwich Road approaches would have relatively minor delay at three- and 21-seconds, respectively. Conversely, average delay during the summer Saturday peak period at the Trowbridge Road and Route 28 northbound approaches would each be worse than future no-build conditions, at 6.3 and 8.1 minutes, respectively.

Cause: The replacement Bourne Bridge together with the new configuration of the Bourne Rotary, which would not allow traffic to cross over the north side of the Rotary, would result in diversions of traffic to the Bourne Bridge. Under existing and future no-build conditions, traffic congestion at Belmont Circle and the Bourne Rotary discourages use of the Bourne Bridge. As traffic operations improve, traffic that currently diverts to the Sagamore Bridge is forecast to shift to the more direct route over the Bourne Bridge. Specifically, during the summer Saturday peak period, the Bourne Bridge is forecast to have an additional 715 vehicles (increasing from 2,825 to 3,540 vehicles).

These increased summer period traffic volumes, without corresponding improvements in the roadway infrastructure at the Bourne Rotary, result in fewer gaps for vehicles trying to enter the Rotary from Trowbridge Road and Route 28 northbound, preventing delay reductions at those approaches (Exhibit 4-35).

4.9.7 Case 3A

Case 3A includes the following transportation improvements:

- Scenic Highway to Route 25 Westbound Ramp
- Route 6 – Relocation of Exit 1C
- Belmont Circle Reconstruction (Alternative 1 – Four-Leg Roundabout and Signalized Intersection)
- Sagamore Bridge Replacement
- Bourne Bridge Replacement
- Route 6 – Additional Travel Lane to Exit 2 (Route 130)
- Bourne Rotary Reconstruction as Highway Interchange

Case 3A includes all the transportation improvements described under Case 3 plus the reconstruction of Bourne Rotary as a highway interchange.

Case 3A represents the implementation of all suggested transportation improvements. More detailed information is provided below on the forecast traffic operation at Belmont Circle and Bourne Rotary (also see Table 4-39 and Exhibit 4-36), and the Route 3 and Route 6 approaches to the Sagamore Bridge (also see Table 4-41 and Exhibit 4-37).

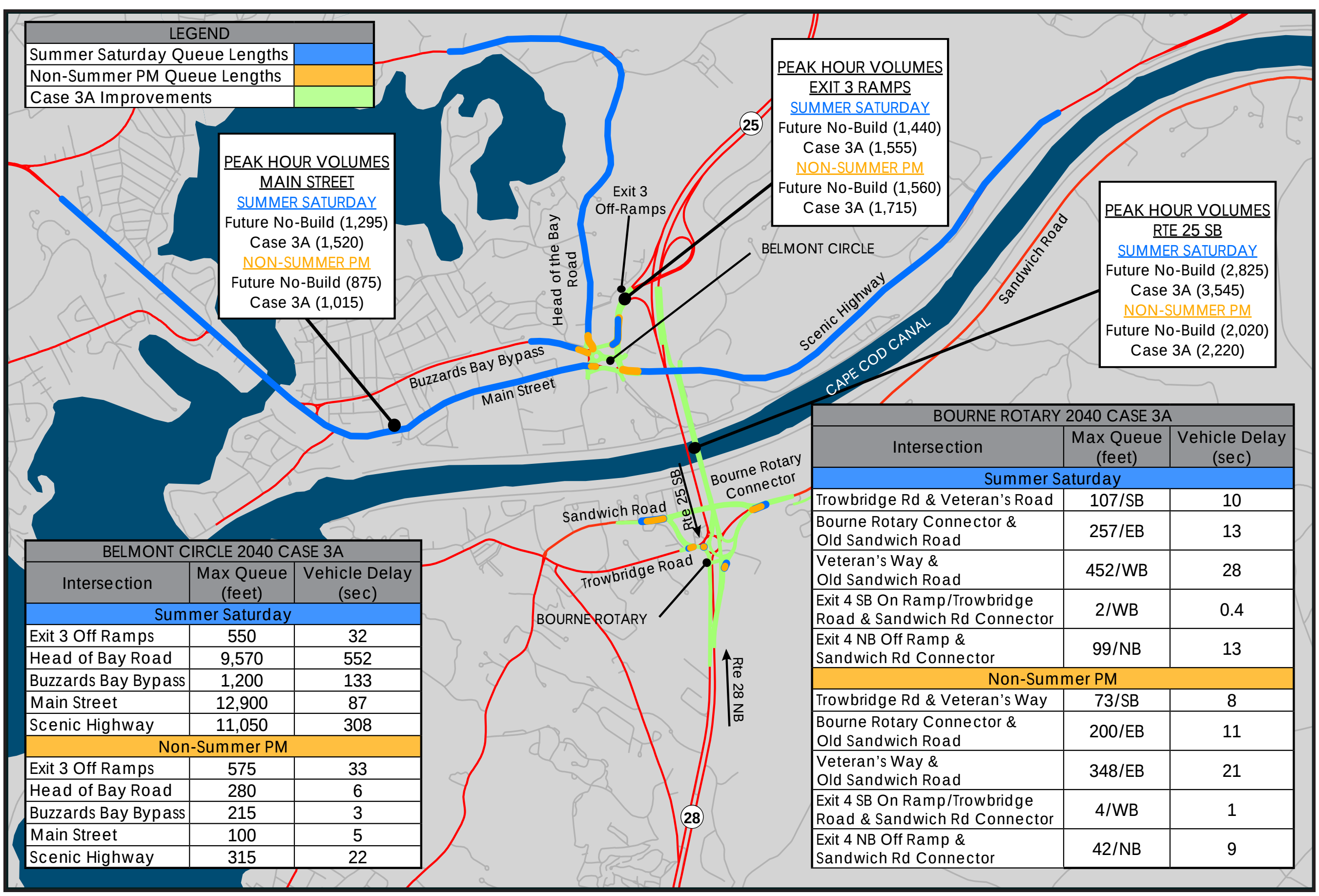
Belmont Circle

Result: Traffic operations under Case 3A would operate substantially better at Belmont Circle during the non summer weekday peak period compared to the future no build condition. Average delay for all approaches would range from three- to 33-seconds. Traffic operations at Belmont Circle degrade during the summer Saturday peak period as the improved roadway system results in diversions of additional vehicles to the Bourne Bridge area. Average delay would be worse than the future no-build condition, with delays ranging from 0.5 minutes at the Route 25 Exit 3 Exit ramps, to 9.2 minutes at the Head of the Bay Road approach.

Cause: The reason for the poor performance at Belmont Circle during the summer Saturday peak period is that as overall traffic

Text continues on page 4-95.

Exhibit 4-36 Case 3A - Maximum Queue and Average Delay, Belmont Circle and Bourne Rotary



BELMONT CIRCLE 2040 CASE 3A		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Exit 3 Off Ramps	550	32
Head of Bay Road	9,570	552
Buzzards Bay Bypass	1,200	133
Main Street	12,900	87
Scenic Highway	11,050	308
Non-Summer PM		
Exit 3 Off Ramps	575	33
Head of Bay Road	280	6
Buzzards Bay Bypass	215	3
Main Street	100	5
Scenic Highway	315	22

BOURNE ROTARY 2040 CASE 3A		
Intersection	Max Queue (feet)	Vehicle Delay (sec)
Summer Saturday		
Trowbridge Rd & Veteran's Way	107/SB	10
Bourne Rotary Connector & Old Sandwich Road	257/EB	13
Veteran's Way & Old Sandwich Road	452/WB	28
Exit 4 SB On Ramp/Trowbridge Road & Sandwich Rd Connector	2/WB	0.4
Exit 4 NB Off Ramp & Sandwich Rd Connector	99/NB	13
Non-Summer PM		
Trowbridge Rd & Veteran's Way	73/SB	8
Bourne Rotary Connector & Old Sandwich Road	200/EB	11
Veteran's Way & Old Sandwich Road	348/EB	21
Exit 4 SB On Ramp/Trowbridge Road & Sandwich Rd Connector	4/WB	1
Exit 4 NB Off Ramp & Sandwich Rd Connector	42/NB	9

Table 4-39 Case 3A - Future (2040) Traffic Operations, Belmont Circle and Bourne Rotary

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 3A		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Miles)*
BELMONT CIRCLE									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Exit 3 Off Ramps SB	5	A	515	2	A	645	33	D	575
Head of Bay Rd SB	15	C	270	317 (5.28)	**F**	1,780	6	A	280
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	215
Main Street EB	13	B	530	29	D	1,245	5	A	100
Scenic Highway WB	7	A	380	14	B	840	22	C	315
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**13.8**	**B**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	32	D	550
Head of Bay Rd SB	83 (1.38)	**F**	570	656 (10.93)	**F**	2,700 (0.51)	552 (9.2)	**F**	9,570 (1.81)
Buzzards Bay Bypass EB	19	C	335	11	B	305	133 (2.22)	**F**	1,200
Main Street EB	82 (1.36)	**F**	5,755 (1.09)	126 (2.1)	**F**	6,140 (1.16)	87 (1.45)	**F**	12,900 (2.44)
Scenic Highway WB	125 (2.08)	**F**	10,605 (2.01)	161 (2.68)	**F**	11,610 (2.20)	308 (5.13)	**F**	11,050 (2.09)
Intersection (Overall)	**62.6 (1.04)**	**F**		**191.4 (3.19)**	**F**		**222.4 (3.71)**	**F**	
BOURNE ROTARY									
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)									
Route 25 SB	19	C	650	14	B	620			
Trowbridge Rd EB	75 (1.25)	**F**	840	394 (6.57)	**F**	3,465 (0.66)			
Route 28 NB	14	B	340	102 (1.7)	**F**	1,275			
Sandwich Rd WB	20	C	1,530	19	C	855			
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**8.9**	**A**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)									
Route 25 SB	280 (4.67)	**F**	8,885 (1.68)	329 (5.48)	**F**	9,935 (1.88)			
Trowbridge Rd EB	30	D	335	265 (4.42)	**F**	2,225			
Route 28 NB	301 (5.02)	**F**	4,135 (0.78)	189 (3.15)	**F**	3,605 (0.68)			
Sandwich Rd WB	27	D	1475	135 (2.25)	**F**	6,430 (1.22)			
Intersection (Overall)	**159.5 (2.66)**	**F**		**229.5 (3.83)**	**F**		**11**	**B**	

Notes:
LOS E and LOS F movements are ***bold***
EB – Eastbound, WB – Westbound, NB – Northbound, SB - Southbound
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.
Data not available in shaded areas. Highway interchanges not evaluated with VISSIM software

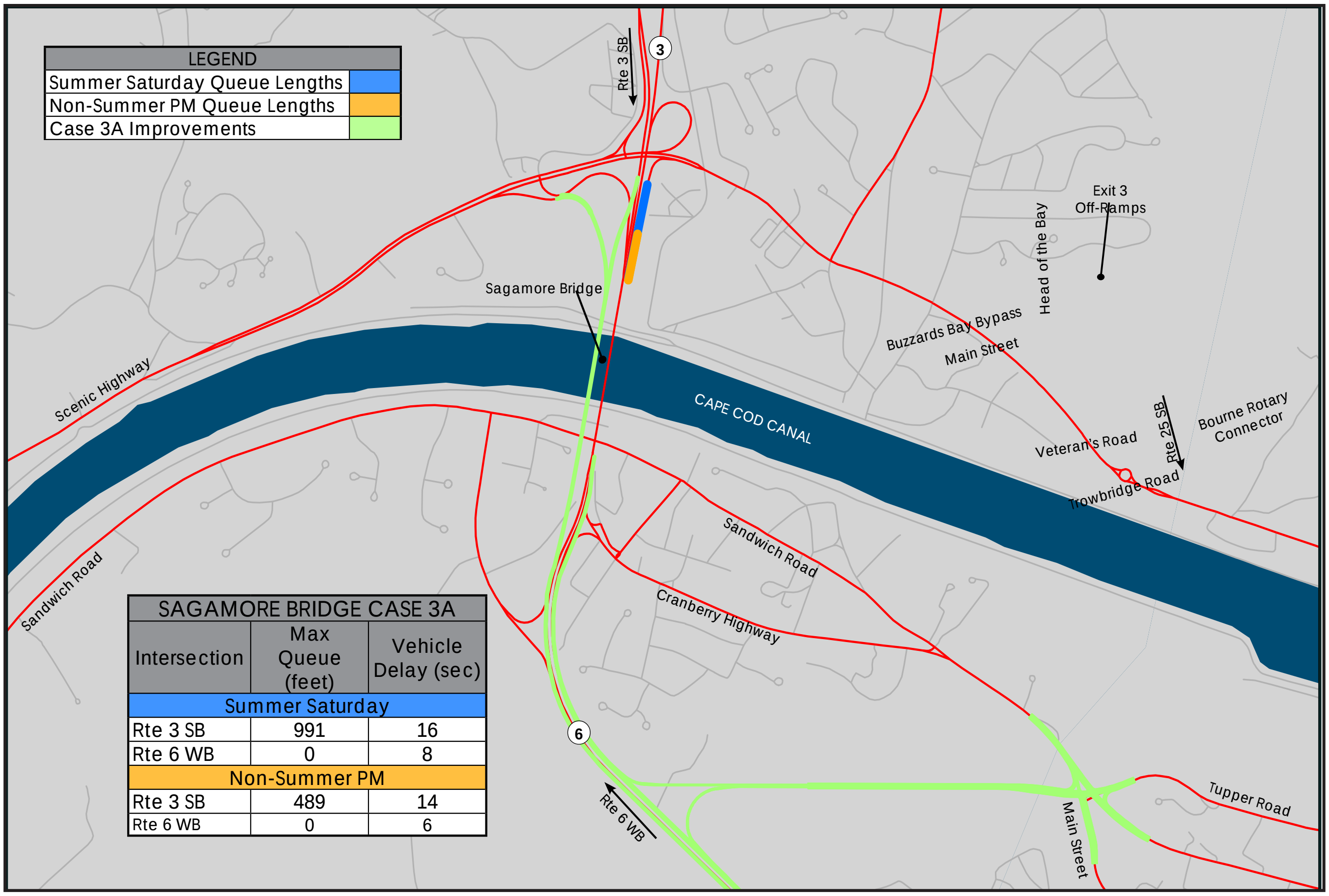


Exhibit 4-37 Case 3A - Maximum Queue and Average Delay, Sagamore Bridge Approaches

Table 4-40 Case 3A - Future (2040) Traffic Operations, Sagamore Bridge Approaches

	EXISTING (2014) CONDITIONS				FUTURE (2040) NO-BUILD CONDITIONS				FUTURE (2040) BUILD CONDITIONS - BUILD CASE 1			
	AVERAGE DELAY *Sec (Min)*	LOS	AVERAGE QUEUE *Feet (Miles)*	MAXIMUM QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	AVERAGE QUEUE *Feet (Miles)*	MAXIMUM QUEUE *Feet (Miles)*	AVERAGE DELAY *Sec (Min)*	LOS	AVERAGE QUEUE *Feet (Miles)*	MAXIMUM QUEUE *Feet (Miles)*
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)												
Route 3 Southbound	11	B	77	478	460 (7.7)	F	7,481 (1.4)	8,476 (1.6)	14	B	45	296
Route 6 Westbound	5	A	53	232	178 (3.0)	F	6,801 (1.3)	7,967 (1.5)	5	A	0	0
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)												
Route 3 Southbound	416 (6.9)	F	4,823 (0.91)	5,393 (1.02)	887 (14.8)	F	22,814 (4.3)	24,484 (4.6)	16	C	581	990
Route 6 Westbound	683 (11.4)	F	23,318 (4.4)	25,014 (4.7)	812 (13.5)	F	24,825 (4.7)	25,029 (4.7)	8	A	0	0

Notes:
LOS = Level of Service
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.

conditions improve, additional vehicles would be diverted to the Bourne Bridge area. For example, during the summer Saturday peak period, Main Street is forecast to have 225 additional vehicles (increasing from 1,295 to 1,520 vehicles).

Further, the major improvement at the Bourne Rotary results in the elimination of queuing on the Route 25/Route 28 southbound approach to the Bourne Rotary. These southbound queues act to limit the volume of vehicles entering Belmont Circle from Route 25. With the elimination of queues on Route 25, more vehicles can freely enter Belmont Circle. This increases the difficulty for vehicles to enter the Circle from other approaches such as Head of the Bay Road and Main Street.

Bourne Rotary Interchange

Result: Traffic operations under Case 3A would improve substantially during the non-summer weekday and summer Saturday peak periods at the Bourne Rotary Interchange. Average delay for all approaches during the non-summer Saturday peak period would range from one- to 21-seconds. During the summer Saturday peak period, delay would also be modest with average delay ranging from one- to 28-seconds (Table 4-40).

Cause: The interchange design allows the free-flow of vehicles on Route 28 with local traffic on Sandwich Road and Trowbridge Road directed under and over Route 28 to signalized intersections.

Sagamore Bridge Approaches - Route 3 Southbound and Route 6 Westbound

Result: On the highway approaches to the Sagamore Bridge on Routes 3 and Route 6, the construction of an additional eastbound travel lane, combined with the relocation of Route 6 Exit 1C and assumed replacement Canal Bridges would result in substantial improvements compared to the no-build condition.

Compared to the future no-build condition, the average delay on Route 6 westbound would be reduced from 3.0 minutes to five seconds during the non-summer weekday peak period. During the summer Saturday peak period, the delay on Route 6 westbound would be reduced from 13.5 minutes to eight seconds. Delay on Route 3 southbound would experience similar delay reductions compared to the future no-build condition. Delay would drop from 7.7 minutes to 14 seconds and 14.8 minutes to 16 seconds for the non-summer weekday and summer Saturday peak periods, respectively.

Cause: The highway and bridge improvements proposed under Case 3A would provide the capacity and design features necessary to safely accommodate non-summer weekday PM and summer Saturday peak period traffic volumes in 2040 and beyond. The additional westbound travel lane on Route 6 eastbound would provide additional highway capacity. The northbound and southbound auxiliary lanes envisioned on the replacement Sagamore Bridge would allow vehicles to safely enter and exit the highway without causing additional congestion.

4.9.8 Overall Findings of Transportation Demand Modeling Analysis

After review of the results of the seven travel demand modeling cases, overall conclusions of their effectiveness in improving traffic operations within the study area were reached. Because the modeling cases provide a reflection of traffic conditions throughout the focus area, this analysis is predominately based on how the cases would affect traffic operations at Belmont Circle, Bourne Rotary, and the Route 3 and Route 6 approaches to the Sagamore Bridge.

In developing the overall findings, the study team remained mindful of the design assumptions that guided the alternatives development process (see Section 4.1). These design assumptions include maintaining a focus on the future year-round problem locations, prioritizing improvements to accommodate the future non-summer weekday peak period and providing further improvements to accommodate the summer Saturday peak period, as feasible.

The following tables and exhibits summarize findings for the seven cases analyzed. Table 4-41 provides a summary of the primary measures of effectiveness for traffic operations at Belmont Circle and Bourne Rotary, including average queues, maximum queues, average delays, and LOS.

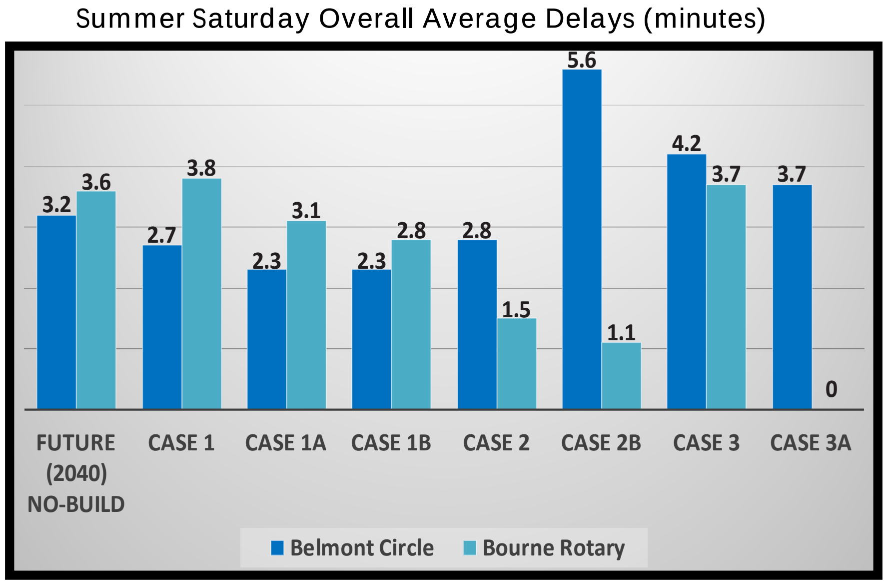
Exhibits 4-38 and 4-39 provide a comparison of the average delays at Belmont Circle, Bourne Rotary and the Sagamore Bridge approaches during the non-summer weekday period and summer Saturday peak periods for the future no-build condition and each of the seven cases analyzed.

The following is a summary of the overall findings the for regional transportation modeling case analyses for the roadways within the vicinity of the Bourne and Sagamore Bridges. This analysis is divided into cases that include replacement Canal bridges and those that do not.

Table 4-41 Summary of Case Analysis for Queues, Delay, and LOS at Belmont Circle and Bourne Rotary

	EXISTING (2014) CONDITIONS			FUTURE (2040) NO-BUILD CONDITIONS			FUTURE (2040) BUILD CONDITIONS - BUILD CASE 1			FUTURE (2040) BUILD CASE 1A			FUTURE (2040) BUILD CASE 1B			FUTURE (2040) BUILD CASE 2			FUTURE (2040) BUILD CASE 2B			FUTURE (2040) BUILD CASE 3			FUTURE (2040) BUILD CASE 3A		
	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*	AVERAGE DELAY *Sec (Min)*	LOS	95% QUEUE *Feet (Mile)*
BELMONT CIRCLE																											
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)																											
Exit 3 Off Ramps SB	5	A	515	2	A	645	1	A	65	1	A	80	1	A	70	29	D	470	9	A	155	34	D	605	33	D	575
Head of Bay Rd SB	15	C	270	317 (5.28)	**F**	1,780	35	D	520	30	D	550	142 (2.37)	**F**	1,055	7	A	350	8	A	330	7	A	325	6	A	280
Buzzards Bay Bypass EB	3	A	100	3	A	110	3	A	85	3	A	95	3	A	125	5	A	170	3	A	205	3	A	180	3	A	215
Main Street EB	13	B	530	29	D	1,245	27	D	1,085	24	C	1,115	61 (1.02)	**F**	1,745	14	B	560	4	A	85	7	A	175	5	A	100
Scenic Highway WB	7	A	380	14	B	840	1	A	60	1	A	75	7	A	210	36	**E**	475	16	C	325	29	D	400	22	C	315
Intersection (Overall)	**8.6**	**A**		**73 (1.22)**	**F**		**13.4**	**B**		**11.8**	**B**		**42.8**	**E**		**18.2**	**C**		**8**	**A**		**16**	**C**		**13.8**	**B**	
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)																											
Exit 3 Off Ramps SB	4	A	510	3	A	1,025	2	A	280	2	A	435	2	A	250	43	**E**	815	18	C	485	33	D	540	32	D	550
Head of Bay Rd SB	83 (1.38)	**F**	570	656 (10.93)	**F**	2,700 (0.51)	451 (7.52)	**F**	2,100	337 (5.62)	**F**	1,640	622 (10.37)	**F**	2,810 (0.53)	5	A	320	940 (15.67)	**F**	8,190 (1.55)	643 (10.7)	**F**	8,630 (3.4)	552 (9.2)	**F**	9,570 (3.8)
Buzzards Bay Bypass EB	19	C	335	11	B	305	12	B	305	14	B	370	9	A	285	9	A	290	446 (7.43)	**F**	2,665 (0.50)	183 (3.1)	**F**	1,505	133 (2.2)	**F**	1200
Main Street EB	82 (1.36)	**F**	5,755 (1.09)	126 (2.1)	**F**	6,140 (1.16)	185 (3.08)	**F**	6,140 (1.16)	172 (2.87)	**F**	6,140 (1.16)	17	C	1,135	243 (4.05)	**F**	6,020 (1.14)	45	**E**	4,995 (0.94)	80 (1.3)	**F**	12,810 (5.1)	87 (1.5)	**F**	12,900 (5.2)
Scenic Highway WB	125 (2.08)	**F**	10,605 (2.01)	161 (2.68)	**F**	11,610 (2.20)	154 (2.57)	**F**	10,630 (2.01)	154 (2.57)	**F**	10,525 (1.99)	3	A	235	553 (9.22)	**F**	11,800 (2.23)	147 (2.45)	**F**	2,950 (0.56)	315 (5.3)	**F**	11,605 (4.6)	308 (5.1)	**F**	11,050 (4.4)
Intersection (Overall)	**62.6 (1.04)**	**F**		**191.4 (3.19)**	**F**		**160.8 (2.68)**	**F**		**135.8 (2.26)**	**F**		**130.6 (2.18)**	**F**		**170.6 (2.84)**	**F**		**319.2 (5.32)**	**F**		**250.8 (4.2)**	**F**		**222.4 (3.7)**	**F**	
BOURNE ROTARY																											
NON-SUMMER WEEKDAY PM PEAK PERIOD (4:00 - 6:00 PM)																											
Route 25 SB	19	C	650	14	B	620	17	C	65	30	D	1,065	2	A	0	2	A	0	2	A	0	2	A	35			
Trowbridge Rd EB	75 (1.25)	**F**	840	394 (6.57)	**F**	3,465 (0.66)	456 (7.6)	**F**	520	378 (6.3)	**F**	3,420 (0.65)	33	D	125	20	C	160	17	C	140	19	C	150			
Route 28 NB	14	B	340	102 (1.7)	**F**	1,275	67 (1.12)	**F**	85	17	C	325	13	B	265	11	B	300	7	A	185	11	B	240			
Sandwich Rd WB	20	C	1,530	19	C	855	18	C	1,085	29	D	1,265	32	D	435	40	E	640	49	E	975	20	C	0			
Intersection (Overall)	**32**	**D**		**132.25 (2.20)**	**D**		**139.5 (2.33)**	**F**		**113.5 (1.89)**	**F**		**20**	**C**		**18.25**	**B**		**18.75**	**C**		**13**	**B**				
SUMMER SATURDAY PEAK PERIOD (10:00 AM - 12:00 PM)																											
Route 25 SB	280 (4.67)	**F**	8,885 (1.68)	329 (5.48)	**F**	9,935 (1.88)	333 (5.55)	**F**	10,000 (1.89)	337 (5.62)	**F**	10,170 (1.93)	3	A	0	3	A	25	3	A	0	3	A	125			
Trowbridge Rd EB	30	D	335	265 (4.42)	**F**	2,225	152 (2.53)	**F**	1,525	213 (3.55)	**F**	1,645	249 (4.15)	**F**	4,705 (0.89)	62 (1.03)	**F**	915	136 (2.27)	**F**	1,370	378 (6.3)	**F**	3,200 (1.3)			
Route 28 NB	301 (5.02)	**F**	4,135 (0.78)	189 (3.15)	**F**	3,605 (0.68)	280 (4.67)	**F**	5,375 (1.02)	13	B	445	409 (6.82)	**F**	8,050 (1.52)	268 (4.47)	**F**	5,820 (1.10)	344 (5.73)	**F**	6,930 (1.31)	486 (8.1)	**F**	9,095 (3.6)			
Sandwich Rd WB	27	D	1,475	135 (2.25)	**F**	6,430 (1.22)	139 (2.32)	**F**	6,095 (1.15)	198 (3.3)	**F**	9,700 (1.84)	24	C	150	25	D	240	24	C	200	21	C	0			
Intersection (Overall)	**159.5 (2.66)**	**F**		**229.5 (3.83)**	**F**		**226 (3.77)**	**F**		**190.25 (3.17)**	**F**		**171.25 (2.85)**	**F**		**89.5 (1.49)**	**F**		**126.75 (2.11)**	**F**		**222 (3.7)**	**F**				

Notes:
LOS E and LOS F movements for the existing and future no-build problem locations are **bold**
Delay over 60 seconds also provided in minutes. Queues over 2,500 feet also provided in miles.
Data not available for Case 3A at Bourne Rotary. As a highway interchange, analysis at this location was completed with Synchro software, not VISSIM™ software as was used for other locations.
Results for Case 3A for the intersections adjacent to the Bourne Rotary Interchange are shown on Table 4-29



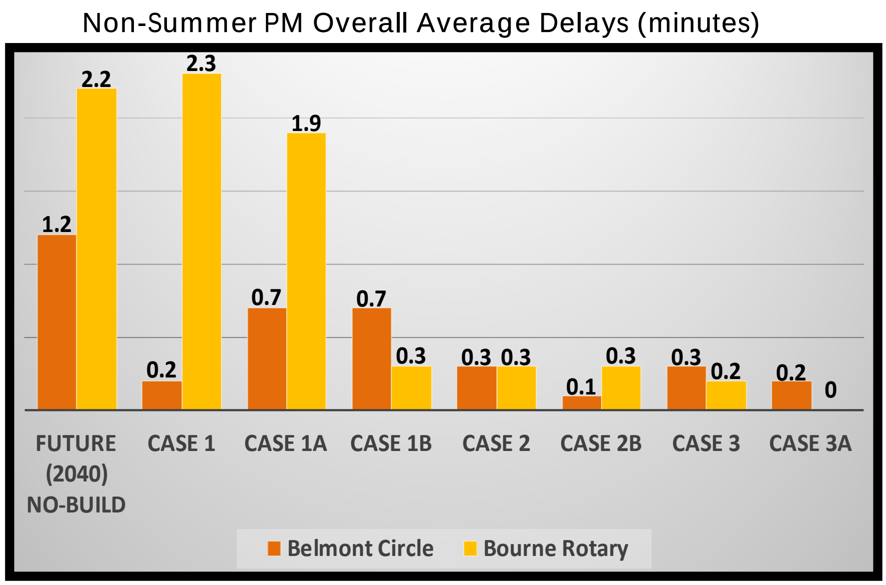


Exhibit 4-38 Average Non-Summer Weekday and Summer Saturday Peak Period Delay, Belmont Circle and Bourne Rotary

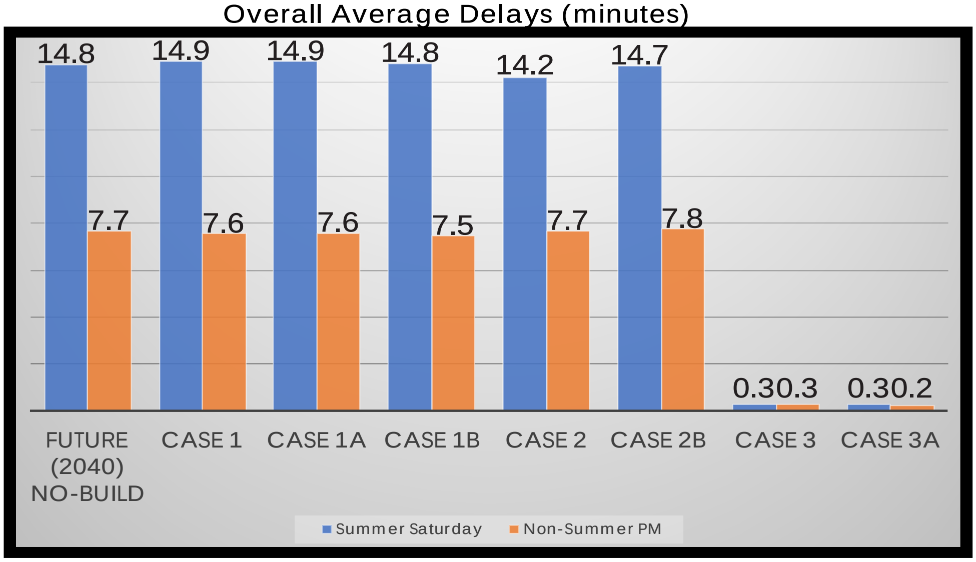
Cases 1, 1A, 1B, 2, and 2B (Cases without replacement Canal bridges) - Bourne Bridge Area

Non-Summer Weekday Peak Period: Modest reductions in average delay during the non-summer weekday peak period can be achieved at Belmont Circle and Bourne Rotary with Case 1 and Case 1A when compared to the future no-build condition. Belmont Circle under Case 1 experiencing greater delay reduction.

More substantial reduction in delays can be achieved at Belmont Circle and Bourne Rotary with Case 1B and Case 2 improvements. Case 2B is also very effective during non-summer weekdays.

Summer Saturday Peak Period: More modest delay reductions can be achieved at Belmont Circle and Bourne Rotary under Case

Route 3 Southbound Approach to Sagamore Bridge
Overall Average Delays (minutes)



Route 6 Westbound Approach to Sagamore Bridge
Overall Average Delays (minutes)

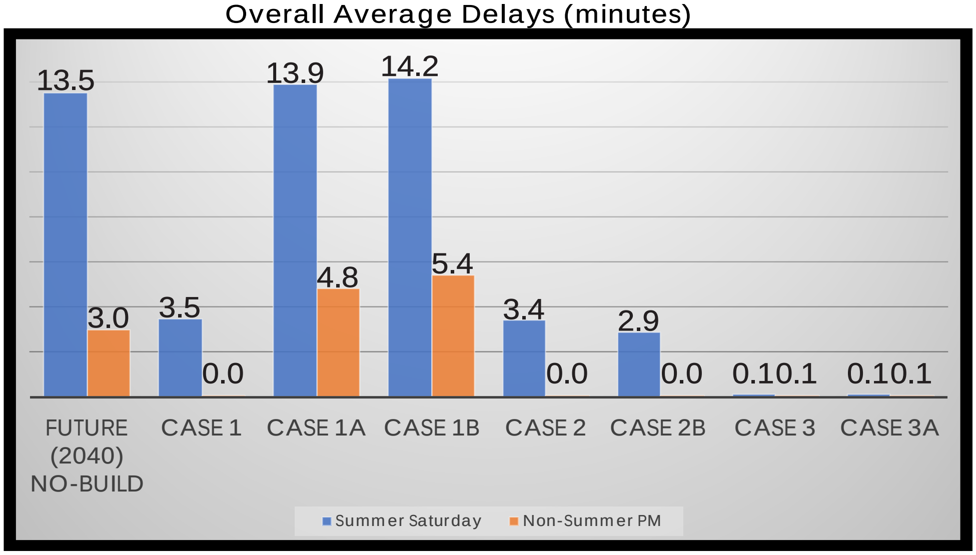


Exhibit 4-39 Average Non-Summer Weekday and Summer Saturday Peak Period Delay, Sagamore Bridge Approaches

1A, Case 1B, and Case 2. Case 2 would provide the greatest delay reduction at Bourne Rotary.

Roadway approaches to Belmont Circle that would continue to experience some delays during summer Saturday peak periods under these cases include Head of the Bay Road, Main Street, and Scenic Highway. Other than the Head of the Bay Road approach, Case 1B operates the best during the summer Saturday peak period among all the cases at Belmont Circle.

Roadway approaches to Bourne Rotary that would continue to experience some delays under these cases include Route 28 northbound and Trowbridge Road. Case 2 operates the best at Bourne Rotary among all the cases.

Overall, delay reduction in the Bourne Bridge area is dampened because, as roadway improvements are implemented, diversions of traffic to this area would occur. For example, under Case 2, compared to the 2040 no-build condition, peak hour volumes on Main Street would increase by 17% (1,295 to 1,520 vehicles) during the non-summer PM and by 16% during summer Saturdays.

Cases 1, 1A, 1B, 2, and 2B (Cases without replacement Canal bridges) - Sagamore Bridge Area

Non-Summer Weekday Peak Period: With the relocation of Route 6 Exit 1C under Case 1 and Case 2, a substantial reduction in delay can be achieved on the Route 6 westbound approach to the Sagamore Bridge during non-summer weekday peak period. Average delay would be reduced from three minutes to two seconds when compared to the future no-build condition. The delay during the summer Saturday peak period on Route 3 southbound for these cases would be reduced from 13.5 minutes to 3.5 minutes. These delay reductions do not occur under Cases 1A and 1B because they do not include the relocation of Exit 1C.

The Route 3 southbound approaches to the Sagamore Bridge would not see any reductions during delay for the non-summer weekday peak period under Cases 1, 1A, 1B, 2, and 2B with average delay remaining at approximately 7.5 minutes. Under these cases no transportation improvements would be implemented that would divert traffic from Route 3 southbound during the non-summer weekday peak period.

Summer Saturday Peak Period: A substantial reduction in delay under Case 1 and Case 2 can also be achieved on the Route 6 westbound approach to the Sagamore Bridge during the summer Saturday peak period, with average delay being reduced from 13.5 minutes to 3.4 minutes. These delay reductions do not occur under Cases 1A and 1B because they do not include the relocation of Exit 1C.

The Route 3 southbound approaches to the Sagamore Bridge would not see any reductions in delay during summer Saturday peak period under Cases 1, 1A, 1B, 2, and 2B with average delay remaining at approximately 15 minutes. Under these cases no transportation improvements would be implemented that would divert traffic from Route 3 southbound during the summer Saturday peak period.

Cases 3 and 3A (Cases with replacement Canal bridges) – Bourne Bridge Area

Non-Summer Weekday Peak Period: Cases 3 and 3A include the assumed replacement Canal bridges, the relocation of Route 6

Exit 1C, and an additional Route 6 eastbound travel lane. Both Belmont Circle and Bourne Rotary would operate well with average delays ranging from two to 34 seconds on the various roadway approaches. Few delays would be experienced during the non-summer weekday peak period.

Summer Saturday Peak Period: Traffic would operate worse than the future no-build conditions at both Belmont Circle and Bourne Rotary under Case 3. Extended queuing and delays would be experienced at the Scenic Highway, Main Street, and Head of the Bay Road approaches to Belmont Circle.

Under Case 3A (which differs from Case 3 with the construction of a highway interchange replacing the Bourne Rotary), the Bourne Rotary area would operate with very few delays. Belmont Circle however, would continue to suffer from extended queuing at several approaches.

Cases 3 and 3A (Cases with replacement Canal bridges) – Sagamore Bridge Area

Non-Summer Weekday Peak Period: Implementation of the improvements proposed under Cases 3 and 3A would result in a substantial reduction in delay on the Route 6 westbound approach to the Sagamore Bridge during the non-summer weekday peak period. Average delay would be reduced from three minutes to six seconds, when compared to the future no-build condition.

The Route 3 southbound approaches to the Sagamore Bridge are also forecast to experience a substantial reduction in delay during the non-summer weekday peak period under both Cases 3 and 3A, with average delay being reduced from 7.6 minutes to 14 seconds.

Summer Saturday Peak Period: Under Cases 3 and 3A, a substantial reduction in delay can also be achieved on the Route 6 westbound approach to the Sagamore Bridge during the summer Saturday peak period, with average delay being reduced from 13.5 minutes to only eight seconds.

The Route 3 southbound approaches to the Sagamore Bridge are forecast to experience a substantial reduction in delay during the summer Saturday peak period under both Cases 3 and 3A, with average delay being reduced from 14.7 minutes to 16 seconds.

4.10 ADDITIONAL STUDY ANALYSIS

The following sections describe the results of the additional analysis conducted for the travel demand model cases to determine the degree of impact and/or benefit to air quality, highway noise, and economic conditions.

The preliminary air quality and noise evaluations were conducted based on the potential location of roadway and traffic forecasts for Case 2 and Case 3A. These two cases were chosen because they represent the most complete cases involving in which the existing Canal bridges remain and those in which replacement bridges replacement Canal bridges and those that replacement Canal bridges are in place. These cases represent the maximum potential air quality and highway noise impact.

4.10.1 Air Quality Evaluation

A preliminary air quality evaluation was conducted based on the conceptual design of potential transportation improvements and future traffic forecasts. As such, the study did not include roadway prediction modeling of air quality levels with the U.S. Environmental Protection Agency (EPA) and FHWA approved air quality models. Instead, a more qualitative evaluation was conducted to assess the potential for increased or decreased air quality impacts within the study area utilizing EPA and FHWA guideline criteria. The complete preliminary air quality analysis can be reviewed in Appendix F.

A detailed air quality study would be conducted during the preparation of an environmental document for future projects. These future detailed air quality analyses would evaluate existing and future air quality impacts associated with project roadways. Impact would be assessed with respect to the methodologies and assumptions for each pollutant consistent with FHWA and EPA guidance as well as that of the MassDOT and Massachusetts Department of Environmental Protection (MassDEP).

A qualitative carbon monoxide (CO), Mobile Source Air Toxics (MSATs), VOCs/NOX, and greenhouse gas (GHG) analysis was conducted. Below is a summary of the preliminary air quality evaluation. The complete preliminary air quality analysis can be reviewed in Appendix F.

Preliminary Air Quality Evaluation Findings

Carbon Monoxide (CO): Typically, CO is used in microscale studies to indicate roadway pollutant levels since it is the most abundant pollutant emitted by motor vehicles and can result in so-called “hot spot” (high concentration) locations around congested intersections.

A total of twelve intersections were included in the analysis, which were comprised of both existing and future intersections. In general, the LOS for the Peak AM and PM conditions are approximately the same for Case 2 and Case 3A, when compared to the future No Build conditions. Similarly, the intersection Peak AM and PM delay, volumes and VHT also generally increased for the two cases compared to the future no-build conditions. There were only a few intersections where the LOS, peak period volumes and delay were expected to improve under Case 2A or Case 3A, compared to the future no-build.

Overall, it can therefore reasonably be concluded that implementation of Case 2 or Case 3A could increase traffic volumes and delay at most of the 12 intersections evaluated, which could result in an increase of CO emissions compared to the future no-build conditions.

Mobile Source Air Toxics (MSAT): MSATs include a large suite of pollutants emitted from motor vehicles, airplanes, locomotives, and other engine-powered transportation modes. The forecast in increase in average daily traffic (ADT), which would result in an increase in vehicle miles traveled (VMT), would lead to overall higher MSAT emissions in the study area for the Build Alternatives.

However, regardless of the option chosen, vehicle emissions would likely be lower than present levels because of the U.S. EPA's national air quality control programs mandated under the federal Clean Air Act. These programs are projected to reduce annual MSAT emissions by over 90% between 2010 and 2050. Note that local conditions may differ from these national projections in terms of fleet mix and turnover, VMT growth rates, and local control measures. However, the magnitude of the EPA-projected reductions is so great (even after accounting for VMT growth) that MSAT emissions in the study area are likely to be lower in the future in nearly all cases.

VOCs/NOX: A mesoscale analysis was performed to calculate the potential regional air quality impact of future projects using a measure of the total daily emissions of volatile organic compounds (VOCs) and oxides of nitrogen (NOx) within the study area. Calculations were performed to compare area-wide emissions for future build scenarios with the existing and future no-build conditions. Typically, emission factors for each pollutant are generated for each roadway link using the EPA emission models based on vehicle miles traveled, vehicle speeds and other roadway data relative to the proposed cases.

As summer ADT is expected to slightly increase with Case 2 and Case 3A compared to the future no-build condition, overall emissions of VOCs and NOx could also slightly increase with the implementation of the projects that make up these cases. Given the relatively small expected ADT increase associated with the cases of approximately two percent and 1.5 percent relative to the total VMT's in the region, it is unlikely that this would result in a substantial change in emissions or any subsequent direct or indirect impacts to the mesoscale analysis.

Greenhouse Gases: The transportation system is a critical component of Massachusetts' infrastructure and contributes over one third of the Commonwealth's greenhouse gas (GHG) emissions. The Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA), in consultation with other state agencies and the public, released the Massachusetts Clean Energy and Climate Plan for 2020. This implementation plan establishes targets for overall, statewide GHG emissions:

- By 2020, 20% reduction below statewide 1990 GHG emission levels;
- By 2050, 80% reduction below statewide 1990 GHG emission levels

MassDOT's Healthy Transportation Policy Directive, released in September 2013, includes the primary goals of reducing GHG emissions; promoting the healthy transportation modes of walking, bicycling, and public transit; and supporting smart growth development. The Cape Cod Regional Transportation Plan (RTP) reflects the vision of the Healthy Transportation Policy Directive Policy with the Multimodal Options/Healthy Transportation Goal, including a performance measure reflecting the state Mode Shift Goal. The Cape Cod Commission conducted a GHG analysis as part of the 2016 Regional Transportation Plan[2]. Anticipated GHG impacts from nine specific regional target projects were conducted. Two of those projects, Belmont Circle/Route 25 Ramp Improvements and Route 6 Exit 1C reconfiguration were included in the GHG analysis. The results of the anticipated GHG impacts from these two projects were documented as "quantified decrease in emissions from traffic operation improvement-to be verified by statewide modeling".

Overall, even with the larger improvements proposed under Case 3A, potential impact to air quality would be minor and Barnstable County is forecast to remain in attainment, based on the current National Ambient Air Quality Standards (NAAQS).

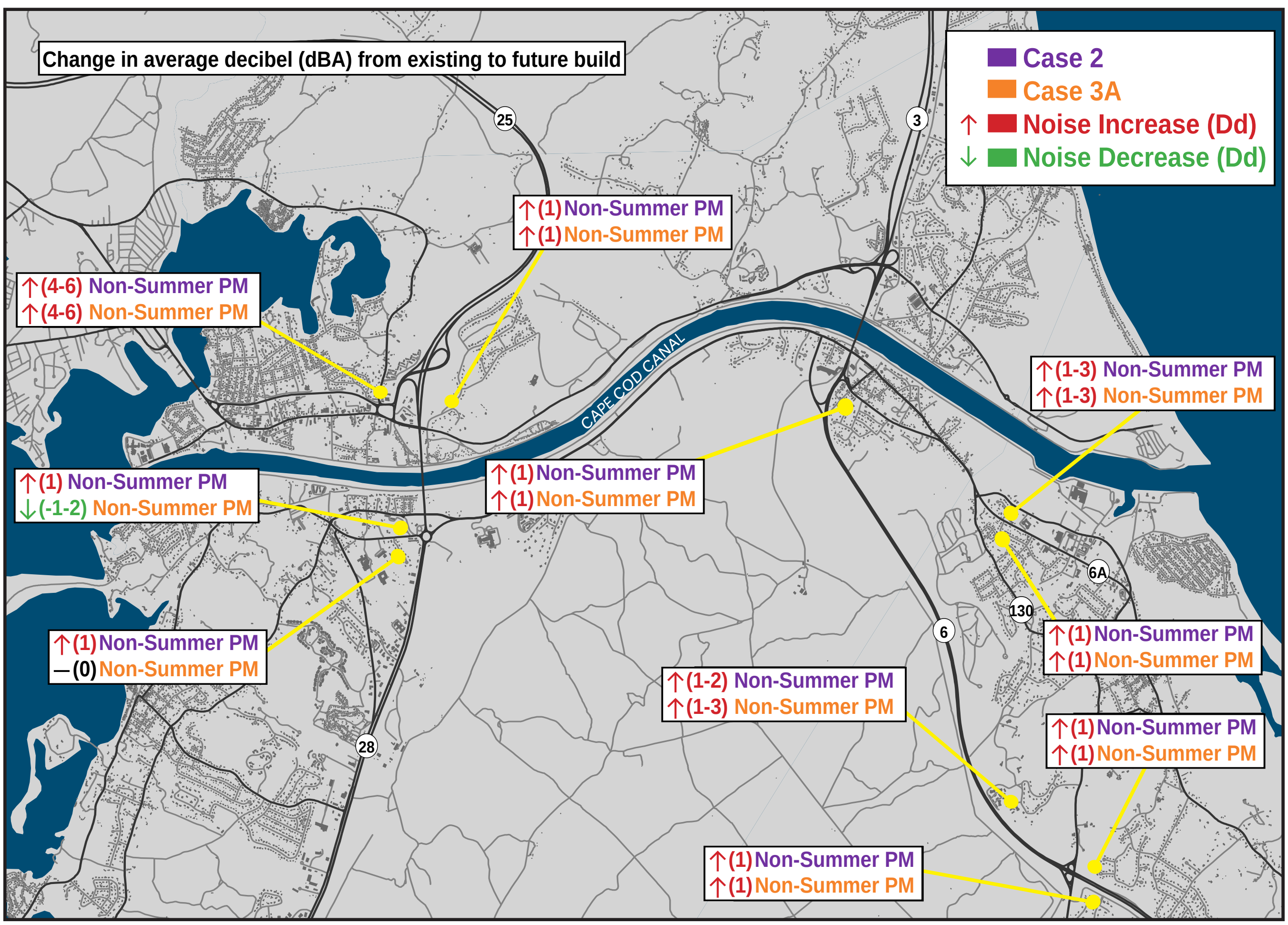
2 http://www.capecodcommission.org/resources/transportation/rtp/2016/FinalReport/Appendices/RTP%20Appendix%20N%20-%20Greenhouse%20Gas%20Analysis%20(Endorsed%207-20-15).pdf

4.10.2 Preliminary Noise Evaluation

FHWA and MassDOT regulations and policies require noise assessments to evaluate future equivalent noise levels in decibels (dB) during the loudest hour of the day (known as Leq dBA). The worst-case existing and future traffic conditions (i.e. highest traffic volumes found during the summer Saturday peak period) were used to correlate to higher (i.e. worst case) noise impacts at noise sensitive locations (mostly residential neighborhoods).

The increases in the hourly sound level from the 2014 Existing to 2040 Build conditions were computed for all three peak hours for Cases 2 and 3A. The range of increases and the peak hour with the highest increase are reported for the areas near residential land use. For reference, a sound level increase of three dB or less is generally not noticeable under most circumstances. An increase of five dB is generally noticeable in a community setting. An increase of 10 dB is perceived by most people as about twice as loud. Also, MassDOT' s Noise Policy considers an increase of 10 dB or more above existing noise levels to be a "substantial increase." This is a more impactful noise increase that would require consideration of abatement in a final environmental document.

Exhibit 4-40 Preliminary Noise Analysis



The predicted sound level increases are small for most roadways, generally less than three decibels, which is expected to be generally not noticeable (Exhibit 4-40). However, due to expected changes in traffic patterns, the Head of the Bay Road adjacent to Belmont Circle is predicted to experience up to four-fold increases in traffic volumes in both Cases 2 and 3A, which would result in increases up to six decibels. These are expected to be readily noticeable, but not approach a 'substantial increase' per MassDOT policy.

The complete preliminary noise evaluation is provided in Appendix G.

4.10.3 Economic Analysis

Transportation improvements can affect social and economic conditions within the local area and region in which they occur in several ways. They can improve or constrain physical access to existing commercial and residential uses. They can also open land for potential development where access did not exist or was limited prior to the implementation of the transportation improvements. In the case of the alternatives under consideration (discussed in terms of groups of alternatives, known as 'cases'), physical access is essentially maintained for existing uses and currently vacant land. This type of social and economic effect, which may include impacts on property values, is therefore limited and not measured in this analysis.

There are also social and economic benefits to reducing crashes because of the roadway geometry, shoulder widths, and other design characteristics of the transportation improvements. Benefits may also accrue because of operational improvements in signalization and other traffic control measures. While such benefits are important and discussed in Sections 4.4 through 4.6, they will not be sufficiently quantified in this planning study to allow for economic measures of their magnitude.

An additional class of social and economic effects of transportation improvements, and often the most significant from a social and economic impact standpoint, are changes in accessibility. Accessibility has three components with direct social and economic consequences: travel times, vehicle miles travelled, and mode choices. In this study, travel time differences between the existing and future no-build conditions, and the proposed 'cases' represent the primary measurable social and economic effects of alternatives.

The analyses which follow compare the differences in travel times between alternative cases derived in the traffic demand model. The analyses then estimate the dollar value of those changes using commonly accepted measures of the value of time found in transportation literature. Finally, the economic analysis compares the annualized value of travel time savings to the annualized cost of the alternative transportation investments.

Travel Time Savings

Travel time savings can benefit local and regional economies in several ways:

- Reduction in commuting times benefits workers by increasing the amount of time they can spend in more pleasurable and/or more productive activities than commuting.
- It can boost the productivity of labor – travel time savings increase output per hour because workers are less stressed by their commute, more focused and able to spend more time on work tasks.
- Business productivity is boosted by increasing the effective reach of a business to its potential labor force; the same commuting times now apply to a larger geographic area and pool of potential workers.
- For goods movements, where even very minor travel time savings have direct consequences to the costs of shipping, businesses can increase the effective geographic reach of their markets.
- For seasonal visitors – an especially important segment of traveler for the Cape Cod economy – reduced travel allows more opportunities to spend time on shopping and other recreational activities, thereby enhancing the value of their experience on the Cape and possibly increasing visitor spending within the local economy.
- Finally, reduced travel times for non-work trips enhance the quality of life and personal satisfaction of residents, making Cape Cod a more desirable place to live and work, with consequent effects on property values and business location decisions.

Exhibit 4-41 presents the annual vehicle hour savings during weekday AM and PM peak periods (commuter travel periods) attributable to each demand model case compared to future (2040) no-build condition. The annual vehicle hour savings increases as additional transportation improvements are implemented, from 38,000 annual hours of savings for Case 1 to nearly 91,000 hours savings in Case 3A.

For the average daily commuter, the time saved annually could range from as much as 2 hours in Case 1 to over 4 hours in Case

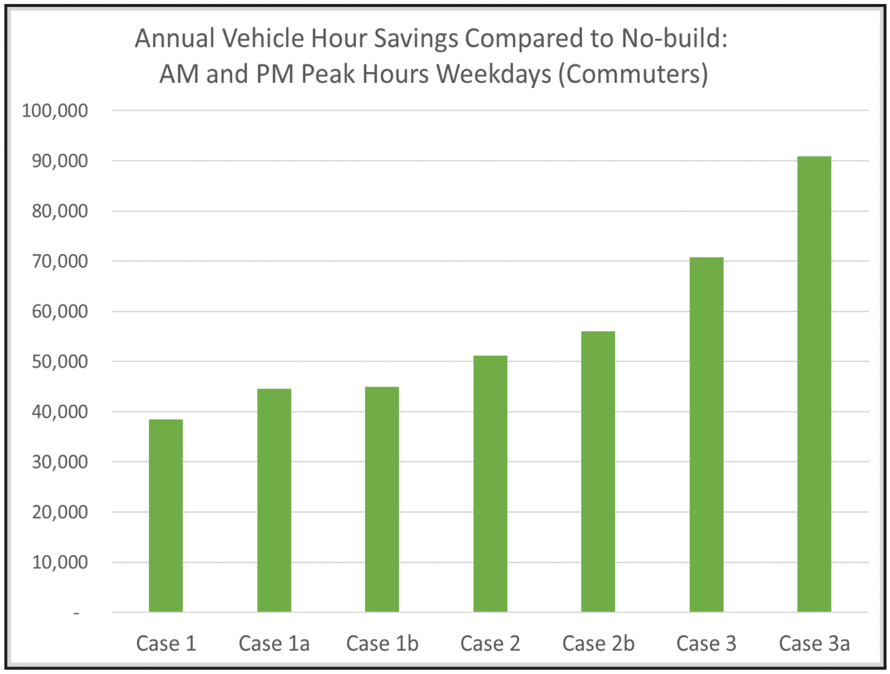


Exhibit 4-41 Annual Vehicle Hours Savings (2040 Weekday AM/PM Peak Periods)

3a. [3] As noted, these reductions in travel times can improve not only commuter satisfaction but also business productivity, including accessibility to a larger labor force, making the Cape more attractive for new businesses and investment to expand existing businesses.

Exhibit 4-42 presents annual vehicle hour savings compared to future no-build during summer weekend days, illustrating the relative merits of each case in facilitating seasonal visitations.[4] The annual vehicle hour savings increases during the summer weekend days as additional transportation improvements are implemented, from 150,000 annual hours of savings for Case 1 to 300,000 hours savings in Case 3A. Case 3A performs best in this comparison, reducing by almost 25% the delays otherwise experienced under no-build. Visitor spending can be boosted with less time (and expense) on the roads as well as the overall quality of their vacation experience. This can improve prospects for return visits as well as their personal and social media communications that might encourage others to visit.

Exhibit 4-43 presents annual vehicle hour savings compared to no-build for all trips, including the non-summer weekday PM and summer Saturdays peak hours, plus non-peak trips

3 There are approximately 21,400 daily commuters, 12,800 (60%) Cape to off-Cape and 8,600 (40%) off-Cape to Cape. On the roadway links for which travel times are measured for this study the improvements will save peak periods travelers between 4% (Case 1) and 9% (Case 3a) of the time they would otherwise spend under no-build in 2040.

4 Peak season weekend days, for the purposes of this analysis, are defined as the 30 weekend days and holidays between Memorial Day and Labor Day.

(therefore, the hours saved for the combination of the 'summer Saturday' and 'AM and PM commute' do not equal 'all trips' in Exhibit 4-43 because there are time periods included for 'all trips' calculation that are not included in either the non-summer weekday PM or summer Saturday peak periods).

The greater level of transportation investment in Cases 2B, 3, and 3A compared to the other alternatives leads to a greater reduction

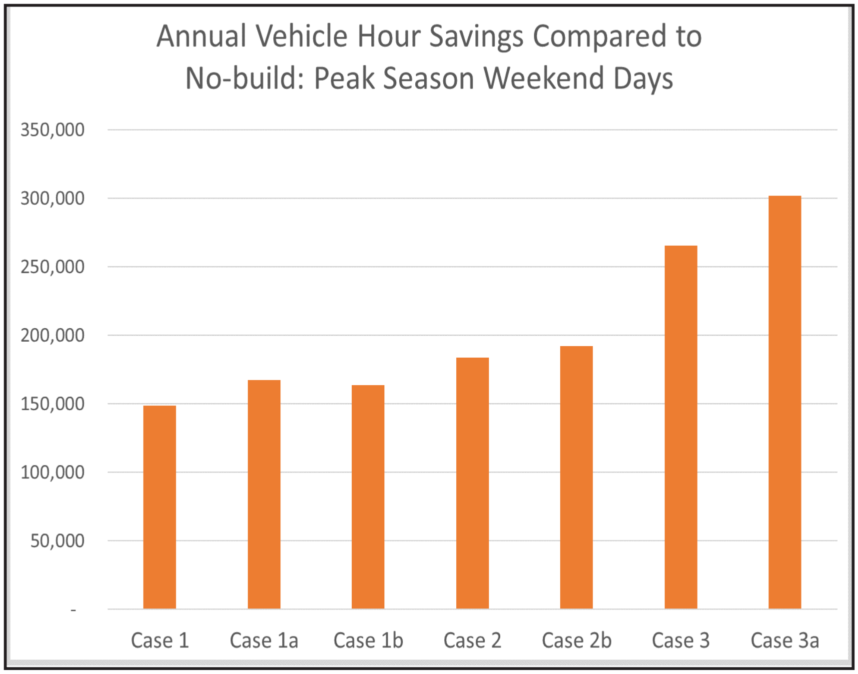
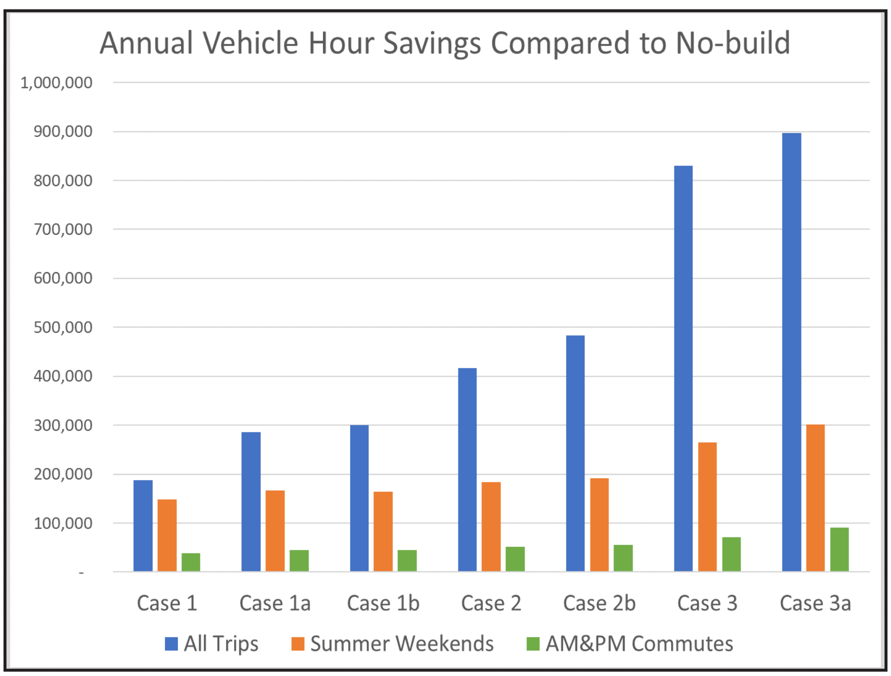


Exhibit 4-42 Annual Vehicle Hours Savings (2040 Summer Saturday Peak Period)

Exhibit 4-43 Annual Vehicle Hour Savings (2040 All Trips)



in travel times when all peak and non-peak trips are considered. For the aggregate annual vehicle hours traveled along the links analyzed in this study, the transportation improvements would save between 1% (Case 1) and 6% (Case 3A) in total travel time compared to the no-build condition in 2040.

As noted, these reductions in travel times can improve not only commuter satisfaction but also business productivity, including accessibility to a larger labor force, making the Cape more attractive for new businesses and investment to expand existing businesses.

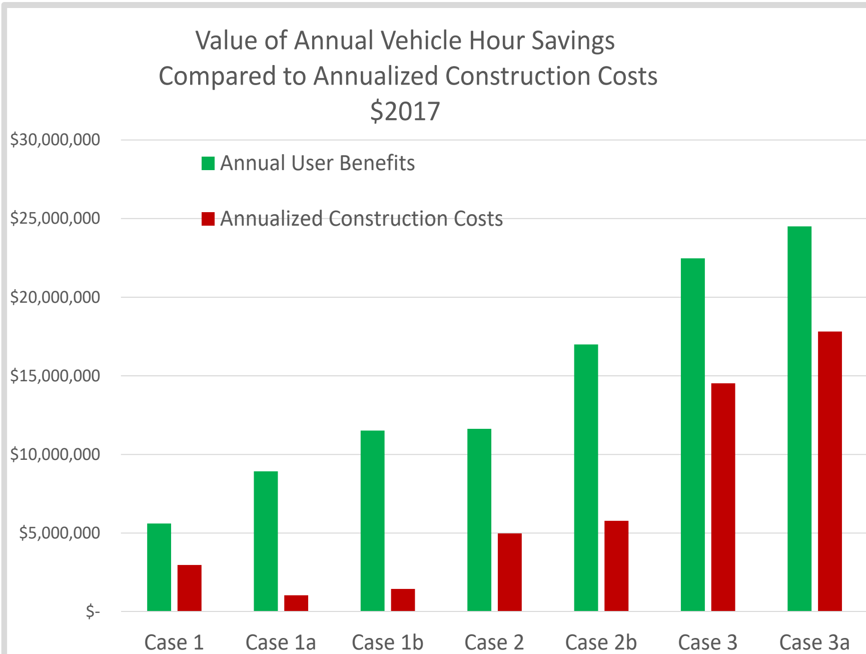
Travel time savings can be assigned per-hour dollar values and compared to annualized construction costs to measure the relative benefits of each alternative to users of the roadways[5]. This "User Benefit/Cost Analysis" is a tool commonly used by the Federal Highway Administration (FHWA) to evaluate funding applications for TIGER grants and other federal-aid projects. It is one measure of the relative merits of transportation projects but is not meant to substitute for the more inclusive evaluations conducted under state/federal environmental review under the Massachusetts Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA). These reviews would include a broader analysis of potential environmental, social, and economic effect.

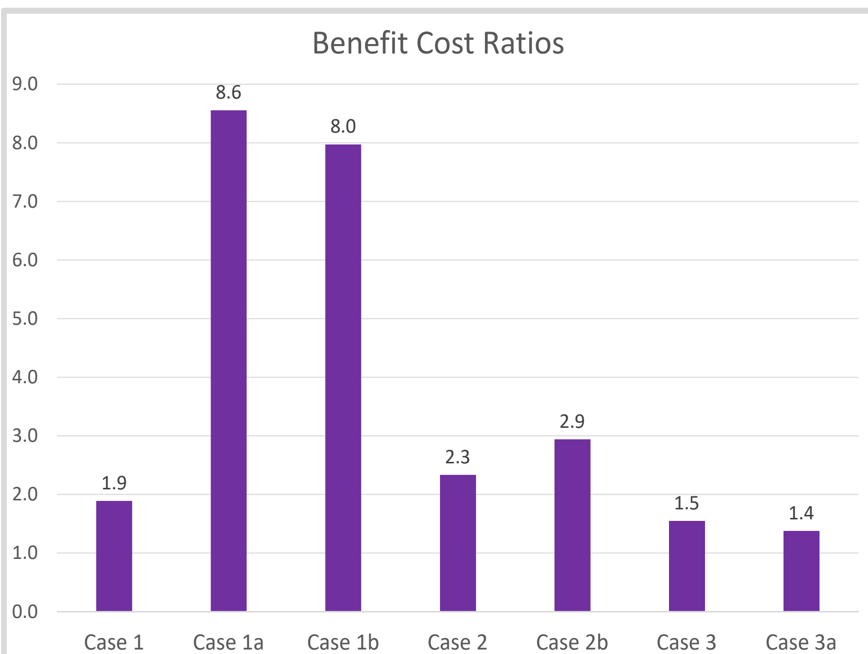
Exhibit 4-44 show the comparison of annual vehicle hour savings values to annualized construction costs. This exhibit demonstrates the favorable cost-benefit ratio of these improvements, ranging from 1.9:1 for Case 1, 7.9:1 for Case 1A, 2.3:1 for Case 2 and 1.4:1 for Case 3A. In each case, the value of travel time savings to users – which include commuters, other personal trips, peak weekends seasonal visitors, and truck trips – substantially exceed the annualized construction costs. The

5 The study team used dollar values for commuter, visitor, and non-business resident trips recommended in USDOT, Office of the Secretary of Transportation, Revised Guidance on Valuation of Travel Time in Economic Analysis, September 27, 2016 and adapted to local wage and income data provided by the Massachusetts Department of Labor & Workforce Development and the US Department of Commerce Bureau of Economic Analysis Regional Economic Information System (2016); and hourly value of freight estimates (assumed at 12% of total trips) from sources in the peer reviewed transportation literature, including Mahady & Lahr, Endogenous Regional Growth through Transportation Investment, National Academy of Sciences, Transportation Research Record, January 2009. Construction costs were estimated by Stantec (October 2018) and annualized over 20 years at a presumed 5% bond rate. Any and all of these analytic assumptions are subject to revision in subsequent project evaluations. The per hour dollar value of trip types used in this analysis are: commuters $32.41; seasonal visitors $19.04; other resident trips $16.20; trucks $90.

higher dollar value of user benefits shown in Cases 1A and 1B is a consequence of its relatively better performance in facilitating peak period commuter trips, which are valued higher than seasonal visitor and non-commuting resident trips[6].

Exhibit 4-44 Annual Vehicle Hour Savings Compared to Annualized Costs





6 The per hour dollar value of trip types used in this analysis (see above footnote for sources) are: commuters $32.41; seasonal visitors $19.04; other resident trips $16.20; trucks $90.

4.11 SUMMARY OF CONCEPTUAL COST ESTIMATES

Conceptual cost estimates were developed for each of the potential transportation improvements. Table 4-42 provides a summary of the conceptual cost estimates by location and Table 4-43 provides a summary of the conceptual cost estimate by case. More detailed conceptual cost estimates, including alternatives not selected for advancement, are provided in Appendix E. The methodology used to develop these costs is described in Section 4.2.2.

The cost estimate for potential roadway improvements and multimodal improvements are presented in Sections 4.4 and 4-11, respectively.

Table 4-42 Summary of Conceptual Cost Estimate by Location

ALTERNATIVES	2017 ($ MILLION)	2030 ($ MILLION)	2040 ($ MILLION)
Scenic Highway to Route 25 WB Ramp	$7	$11	$16
Route 6 Exit 1C Relocation	$30	$51	$75
Route 28 NB Ramp to Sandwich Road and Intersection Signalization	$6	$11	$16
Bourne Rotary Reconstruction (3 signalized intersections)[1]	$11	$18	$26
Belmont Circle Reconstruction	$14	$23	$33
Route 6 Eastbound Travel Lane	$29	$48	$71
Bourne Rotary Interchange[2]	$52	$87	$127
Bourne Bridge Approaches[3]	$51	$84	$125
Sagamore Bridge Approaches[3]	$39	$64	$95

[1] Includes cost of Route 28 NB Ramp to Sandwich Road and Intersection Signalization.
[2] Includes cost of Bourne Rotary Reconstruction (Alternative 2)
[3] Includes approach roadway and bridge relocation and retaining walls

Table 4-43 Summary of Conceptual Cost Estimate by Case

CASE	2017	2030	2040
Case 1	$37	$62	$91
Case 1A	$13	$22	$32
Case 1B	$18	$29	$42
Case 2	$62	$103	$150
Case 2B	$72	$121	$177
Case 3[1]	$181	$299	$441
Case 3A[1]	$222	$368	$542

[1] Includes highway approaches to Bourne and Sagamore Bridges. Does not include cost of replacement Bourne and Sagamore Bridges

4.12 SUMMARY OF POTENTIAL ENVIRONMENTAL, COMMUNITY, AND PROPERTY IMPACTS

A summary of potential impact to environmental and community resources, and public and private property are provided below in Table 4-44 and Table 4-45 by location and by case, respectively. The boundaries of these resources are based on information from the MassGIS database or generated using publicly available information. Potential impact to these resources are based on the conceptual designs for transportation improvements developed and analyzed as part of the study process, and serve as a means to provide an order-of-magnitude understanding of the potential impact and provide a means to compare alternatives to one another.

Table 4-44 Potential Environmental, Community, and Property Impact by Location

LOCATION	ENVIRONMENTAL (ACRES)				COMMUNITY (ACRES)		PROPERTY (ACRES)		
	WETLAND	100-YEAR FLOODPLAIN[1]	RARE SPECIES	WATER SUPPLY (ZONE I/II IWPA[2])	OPEN SPACE	HISTORIC RESOURCES	RESIDENTIAL/ PUBLIC	COMMERCIAL	UTILITY
Route 6 Exit 1C Relocation	0	0	7.2	5.7	0.6	0.2	0.2	0.9	3.8
Scenic Hwy to Route 25 Ramp	0	0	0	0.2	0	0	0	0	0.9
Belmont Circle (3 Leg Roundabout with Signalized Intersection)	0.3	4.7	0	0.5	0.1	0	<0.1	<0.1	0
Belmont Circle (Route 25 Eastbound Flyover)	0.5	5.4	0	0.5	0.1	0	<0.1	<0.1	0
Bourne Rotary (3 Signalized Intersections)	0	0	0	0	0.4	0	0.4	0	0
Bourne Rotary Interchange	0	0	0.2	0	0.4	0	0.3	2.2	0
Route 6 Eastbound - Additional Travel Lane	0	0	3.9	0	0	0	0	0	0

[1] *Conceptual impact to 100-year floodplain calculated in acres.*
[2] *IWPA – Interim Well Protection Area*

Table 4-45 Potential Environmental, Community, and Property Impact by Case

CASE (COMPONENTS OF EACH CASE LISTED ON TABLE 4-31)	ENVIRONMENTAL (ACRES)				COMMUNITY (ACRES)		PROPERTY (ACRES)		
	WETLAND	100-YEAR FLOODPLAIN[1]	RARE SPECIES	WATER SUPPLY (ZONE I/II IWPA[2])	OPEN SPACE	HISTORIC RESOURCES	RESIDENTIAL/ PUBLIC	COMMERCIAL	UTILITY
Case 1	0	0	7.2	5.9	0.6	0.2	0.2	0.9	4.7
Case 1A	0	0	0	0.2	0.2	0	0	0	0.9
Case 1B	0	0	0	0.2	0.4	0	0.4	0	0.9
Case 2	0.3	4.7	7.2	6.4	1.1	0.2	0.6	0.9	4.7
Case 2B	0.5	5.4	7.2	6.4	1.1	0.2	0.6	0.9	4.7
Case 3	0.3	4.7	11.1	6.4	1.1	0.2	0.6	0.9	4.7
Case 3B	0.3	4.7	11.3	6.4	1.1	0.2	0.5	3.1	4.7

[1] Conceptual impact to 100-year floodplain calculated in acres.
[2] IWPA – Interim Well Protection Area

4.13 MULTIMODAL IMPROVEMENTS

Improvements to multimodal transportation facilities in the study area were evaluated, including improvements to pedestrian, bicycle, transit, bus, and park-and-ride facilities. This evaluation considered improvements to existing facilities, new connections between existing facilities, and construction of new facilities. The existing multimodal transportation facilities in the study area are described in Section 2.6.

4.13.1 Bicycle/Pedestrian Facility Improvements

There are several high-quality bicycle/pedestrian facilities in the study area including the seven-mile long service roads (bike paths) along the north and south side of the Cape Cod Canal and the 10.6-mile long Shining Sea Bike Path in Falmouth. Route 6A in the study area is a designated bike route (Exhibit 2-45).

Currently ongoing improvements to bicycle/pedestrian facilities in the study area include the development of a shared-use path adjacent to the Service Road in Sandwich (a state project scheduled for 2022 construction) and the reconstruction and widening of portions of the Shining Sea Bikeway in Falmouth (municipal project, scheduled for 2020 construction).

The Cape Cod Commission completed a feasibility study in 2017 of the Bourne Rail Trail – a bike trail that would connect the north end of the Shining Sea bikeway to the Cape Cod Canal bike path. There is strong local support for this trail from state senators and representatives, the boards of selectman in Bourne, Falmouth, and Sandwich, and the 'Friends of the Bourne Rail Trail' advocacy group.

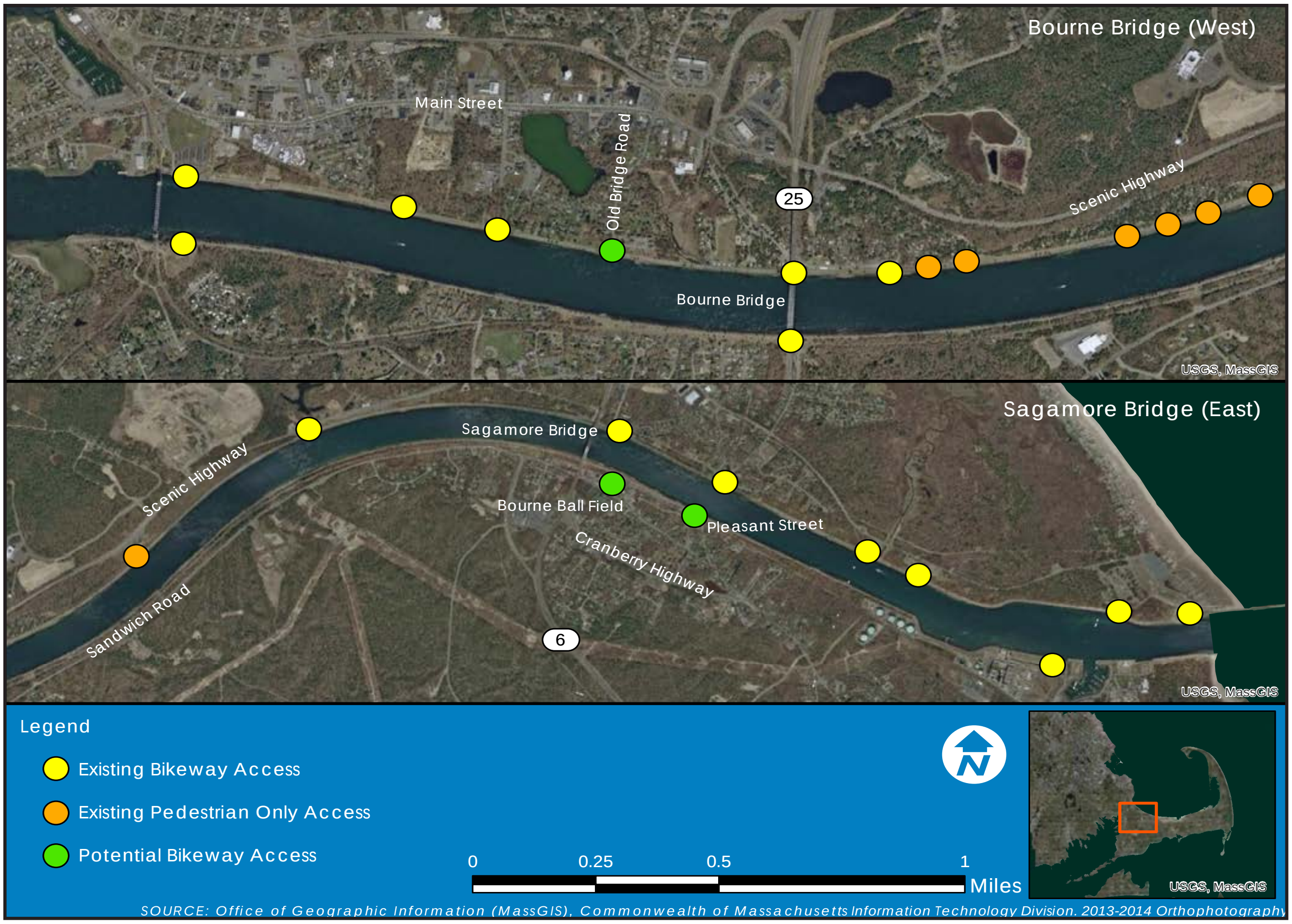


Exhibit 4-45 New Bicycle/Pedestrians Connections to Cape Cod Canal Bike Trail

Bicycle/Pedestrian Improvements

The following section presents potential improvements to bicycle and pedestrian facilities in the study area.

Improved Bicycle/Pedestrian Connections to Canal Service Roads

While there are several accessible connections to the Canal service roads (bike paths) from the local roadway network or parking lots, there are also notable areas that lack an accessible, ADA-compliant connection to the service road. Access and use of the Canal service road by all users could be improved through the construction of new accessible connections to the service road from the local roadway network.

Gaps in the accessible connections to the Canal service road were identified both north and south of the Canal. Three potential locations were identified to provide access to the service road from local roads, including new connections from Pleasant Street and the Bourne Ball Field, (south of the Canal in Bourne) and at Old Bridge Road on the north side of the Canal in Bourne (Exhibit 4-45).

Pleasant Street, Bourne

Location: Pleasant Street in Bourne is south of the Canal and east of the Sagamore Bridge. The new connector path to the service road would be to the west of 39 Pleasant Street.

Challenges: While this new connection to the Canal service road would not impact any regulated environmental resources, it would require a minor acquisition of private property and close coordination with the USACE (owner of the Canal service road) and the MBTA to allow a crossing of the Cape Cod Rail Line adjacent to the Canal service road.

Conceptual Cost Estimate: $25,000 (2017 costs)

Bourne Ball Field, Bourne

Location: The Bourne Ball Field is located at 861 Sandwich Road in Bourne. The Ball Field is south of the Canal, east of the Sagamore Bridge. An informal 125-foot long path currently exists, which extends from Pleasant Street, crossing the Canal rail line, to the Canal service road.

Challenges: While this new connection to the Canal service road would not impact any regulated environmental resources, it would require close coordination with the USACE and the MBTA to allow a crossing of the Cape Cod Rail Line adjacent to the Canal service road.

Conceptual Cost Estimate: $50,000 (2017 costs)

Old Bridge Road, Bourne

Location: Old Bridge Road is accessed from Main Street in Bourne, north of the Canal and west of the Bourne Bridge. An informal 125-foot long path currently exists, which extends from Pleasant Street, crossing the Canal rail line, to the Canal service road.

Challenges: This new connection to the Canal service road would require the filing of a Notice of Intent with the Bourne Conservation Commission, as it is within the 100-year floodplain of the Canal. It would require close coordination with the USACE to allow access to the Canal service road.

Conceptual Cost Estimate: $20,000 (2017 costs)

Improved Bicycle/Pedestrian Access to and Across the Cape Cod Canal

Residents and visitors in the study area would benefit from improved bicycle/pedestrian facilities crossing the Canal on the Sagamore and Bourne bridges. The existing Canal bridges each have five-foot wide sidewalks on one side of the bridge but generally lack suitable sidewalk connections between the bridges, the local roadway system, and the Canal bike path. As the travel lanes on the bridges lack roadway shoulders, vehicles travel right next to the existing sidewalk. The proximity of vehicles to pedestrians on the bridge sidewalk creates discomfort for some pedestrians, discouraging sidewalk use. Viewing platforms and benches for pedestrians are also lacking along the bridges' approximately 2,000-foot length. The lack of roadway shoulders also results in the bridges being unsuitable for bicycle travel.

Several potential locations to improve bicycle/pedestrian travel across the Canal were evaluated. While the facilities on the bridges themselves cannot be updated at this time, the sidewalks that approach the bridges could be widened and reconstructed to meet ADA-compliance. Further, gaps in the sidewalk network could be completed to allow for an uninterrupted sidewalk access across the Canal to the local roadway network or the Canal bike path. Specific improvements at the Sagamore and Bourne Bridges are described below.

Location: Sagamore Bridge Area (Exhibit 4-46)

North of the Sagamore Bridge: reconstruct and widen existing 800-foot sidewalk from Canal Road (at the Sagamore Park and Ride lot) to the north side of the Sagamore Bridge.

South of the Sagamore Bridge: Construct 1,000 feet of new ADA-compliant sidewalk adjacent to the east side Route 6 and Cranberry Highway from the south end of the existing sidewalk to Adams Street. To provide a connection to Sandwich Road, construct a shared-use path along Adams Street. Since Adams was converted in 2015 to one-way (south) travel only, additional paved space exists for use as a shared-use path. From the north end of Adams Street (at Sandwich Road), an additional crosswalk connection could be made to the Canal Bike Path using the Bourne Ball Field connector.

Conceptual Cost Estimate: $3.9 million (2017 costs)

Location: Bourne Bridge Area (Exhibit 4-47)

North of the Bourne Bridge: Construct a 1,200-foot-long ADA-compliant sidewalk from the east side of Belmont Circle (shopping plaza entrance drive) to the north side of the Bourne Bridge.

Conceptual Cost Estimate: $800,000 (2017 costs)

South of the Bourne Bridge: A bicycle/pedestrian improvement project was completed by MassDOT during the summer of 2017, when MassDOT constructed a 750-foot long extension of the

Text continues on page 4-120.

Exhibit 4-46 Bicycle/Pedestrian Connections at Sagamore Bridge

Desired Bicycle/Pedestrian Access over Sagamore Bridge

Bicycle/Pedestrian Access over Sagamore Bridge (North of Canal)

Bicycle/Pedestrian Access over Sagamore Bridge (South of Canal)

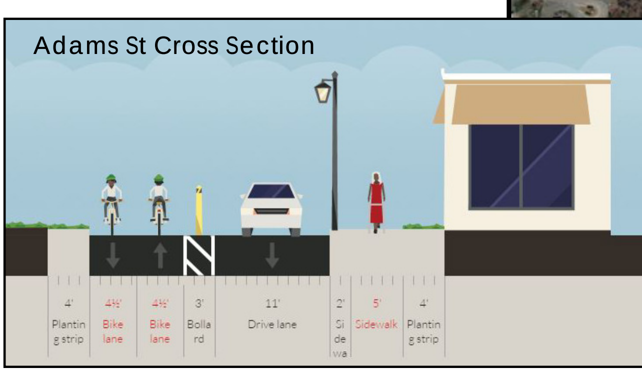
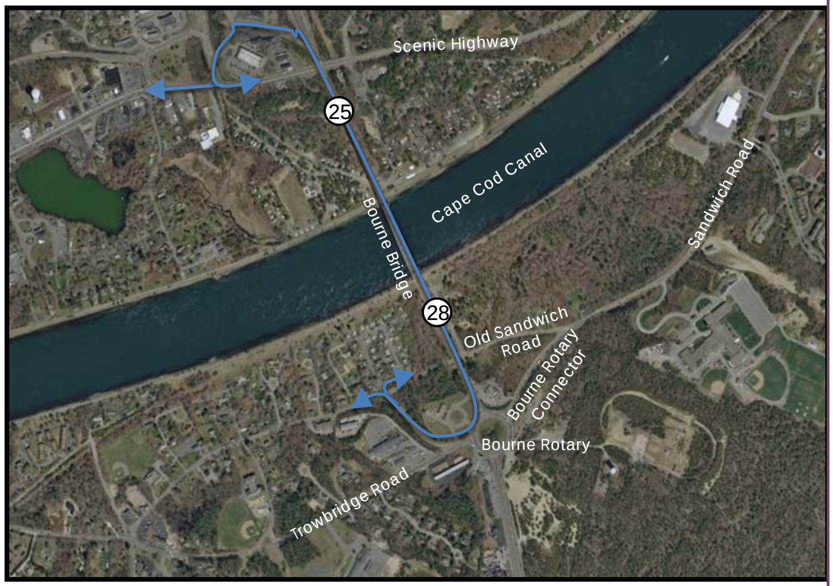


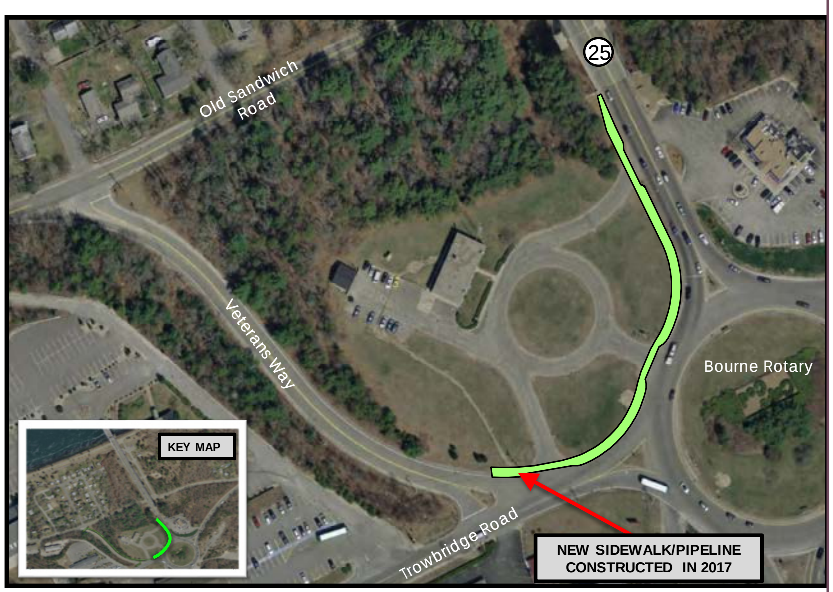
Exhibit 4-47 Bicycle/Pedestrian Connections at Bourne Bridge

Desired Bicycle/Pedestrian Access over Bourne Bridge



Bicycle/Pedestrian Access over Bourne Bridge (North of Canal)

Bicycle/Pedestrian Access over Bourne Bridge (South of Canal)



sidewalk on the south side of the Bourne Bridge. This 10-foot wide sidewalk wraps around the state police barracks property to the intersection of Veterans Way and Trowbridge Road.

Improved Bicycle/Pedestrian Accommodation along Bus Routes

Multimodal travel in the study area could be enhanced through improvements in bicycle and pedestrian facilities along bus routes. This is an important part of an overall effort towards creating an integrated multimodal transportation system.

Several key bus routes in the study area, including those along County Road and Route 151 along the Bourne Run bus line and Route 6A, Route 130, Service Road, and Quaker Meeting House Road along the Sandwich Line. The roadways along these bus routes lack consistent ADA-compliant sidewalks, roadway shoulders suitable for bicycle travel, bus shelters, and bike racks.

4.13.2 Multimodal Transportation Center

Multimodal centers provide commuters and other travelers with free and secure parking when transferring to carpool or transit services. These centers are beneficial for reducing the cost of daily commutes and reducing traffic volumes by limiting single-occupant vehicle travel. A transportation center, such as the Hyannis Transportation Center, generally provides vehicle parking, bike racks, indoor areas to purchase transit tickets, public bathrooms, visitor information, and vending. A simpler transportation center (a Park & Ride lot) typically provides parking and a bus shelter.

As noted in Section 2.6.9, there are two Park & Ride lots along the Route 3/Route 6 corridor, including the 377-space Sagamore lot located north of the Cape Cod Canal at Route 3 Exit 1A (the Route 3/Route 6 [Scenic Highway]) interchange in Bourne and the 365-space lot at Route 6 Exit 6 in Barnstable. These lots are serviced by the Plymouth & Brockton (P&B) Bus Company, which operates daily bus routes from Hyannis to Boston. Local bus connections to the Park & Ride lots are provided by the Cape Cod Regional Transit Authority (CCRTA).

A new Park & Ride lot at Route 6 Exit 2 (Route 130) would reduce traffic volumes by providing additional commuter parking.

These lots are heavily used by commuters and are often at or near capacity. A mid-week occupancy count, conducted at the Sagamore lot in October 2016, found the lot was 99% occupied.

The feasibility of constructing an additional Park & Ride lot along Route 6 between the existing lots at Exit 1A in Bourne and Exit 6 in Barnstable was evaluated.

A new lot at Exit 2 (Route 130) was determined feasible because MassDOT owns sufficient land at the southwest quadrant of the interchange, there are no wetland resources present, and the P&B bus line and CCRTA Sandwich line already pass by this location. Furthermore, the western terminus of the upcoming Service Road shared-use path is Route 130 at this location. The hilly topography of this parcel may initially limit the size of the lot to approximately 100 cars, but a larger lot could be constructed with additional site grading (Exhibit 4-48).

Conceptual Cost Estimate

The conceptual cost for the Park & Ride lot at Route 6 Exit 2 is provided in Table 4-46, by construction year. More detailed conceptual cost estimates are provided in Appendix E.

Table 4-46 Route 6 Exit 2 Park and Ride Lot - Conceptual Cost Estimate by Build Year

	2017 ($ MILLION)	2030 ($ MILLION)	2040 ($ MILLION)
Park and Ride Lot	2.8	4.6	6.8

Exhibit 4-48 Park & Ride Lot, Route 6 Exit 2 (Route 130)