Cape Cod Bridges Program

Bourne, Massachusetts

Appendix 3.2
Construction Approach Technical Report

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
D-B	design-build
MassDOT	Massachusetts Department of Transportation
Program	Cape Cod Bridges Program
SUP	shared-use path
USACE	U.S. Army Corps of Engineers

1 Introduction

This Construction Approach Technical Report has been prepared in support of the Final Environmental Impact Statement (FEIS) for the Cape Cod Bridges Program (Program), in accordance with the following federal statutes, regulations, and guidance:

- National Environmental Policy Act of 1969, as amended, 42 United States Code (USC) 4321 et seq.
- *Efficient Environmental Reviews for Project Decisionmaking and One Federal Decision,* 23 USC 139.
- Federal Highway Administration's (FHWA) regulations implementing National Environmental Policy Act, *Environmental Impact and Related Procedures* (23 Code of Federal Regulations 771), and corresponding guidance, Technical Advisory (T 6640.8A): *Guidance for Preparing and Processing Environmental and Section 4(f) Documents* (October 30, 1987).

The Construction Approach Technical Report is supported by the following five attachments:

- Existing Conditions Plans (Attachment 1)
- Proposed Conditions Plans (Attachment 2)
- Tree Clearing Plans (Attachment 3)
- Construction Schematics (Attachment 4)
- Landscaping Plans (Attachment 5)

2 Proposed Action

2.1 Purpose and Need

In partnership with FHWA and the New England District of the U.S. Army Corps of Engineers (USACE), Massachusetts Department of Transportation (MassDOT) proposes advancing the Program in the town of Bourne, Barnstable County, Massachusetts.

The purpose of the Program is to improve cross-canal mobility and accessibility between Cape Cod and mainland Massachusetts for all road users and to address the increasing maintenance needs and functional obsolescence of the aging Sagamore and Bourne Bridges (also known as the Cape Cod Canal highway bridges), which are owned by the United States and operated and maintained by USACE as part of the Cape Cod Canal Federal Navigation Project.[1] The needs for the Program are as follows:

- Address the deteriorating structural condition and escalating maintenance demands of the Bourne and Sagamore Bridges.
- Address the substandard design elements of the Bourne and Sagamore Bridges, the immediate mainline approaches, and their adjacent interchanges and intersections.

[1] Hereinafter, the Cape Cod Federal Navigation Project is referenced as "USACE-owned."

- Improve vehicular traffic operations.
- Improve accommodations for pedestrians and bicyclists.

Attachment 1 provides the existing conditions plans, identified by Study Area quadrant as Sagamore North, Sagamore South, Bourne North, and Bourne South.

2.2 Build Alternative

The Program's Build Alternative would incorporate the U.S. Army Corps of Engineers' Major Rehabilitation Evaluation Report and Environmental Assessment's preferred alternative of replacing both highway bridges with new bridges, each with four through-travel lanes and two auxiliary lanes (in-kind bridge replacement that would be updated to comply with federal and state highway and design safety standards). The Program proposes to replace Sagamore Bridge and Bourne Bridge with parallel, twin tied-arch bridge structures that would be supported on delta frames with a 720-foot mainline span length. At both the Sagamore Bridge and Bourne Bridge crossings, the replacement mainline alignment locations would be offline and inboard of the existing bridges on the side of the canal between the bridges. At both canal crossings, the Program would reconfigure the highway interchange approach networks north and south of Cape Cod Canal to align with the replacement bridges. The replacement bridges and their interchange approaches would accommodate shared-use pedestrian and bicycle paths that would connect to the local roadway network on both sides of Cape Cod Canal in the town of Bourne.

Table 2-1 presents a description of the Program elements/design parameters of the recommended Build Alternative: Replacement Highway Bridges Built to Modern Design Standards (Preferred Alternative). **Figure 2-1 through Figure 2-4** present the recommended Build Alternative by Program quadrant, based on preliminary design plans**. Attachment 2** provides the Proposed Conditions Plans.

Table 2-1. Cape Cod Bridges Program Preferred Alternative

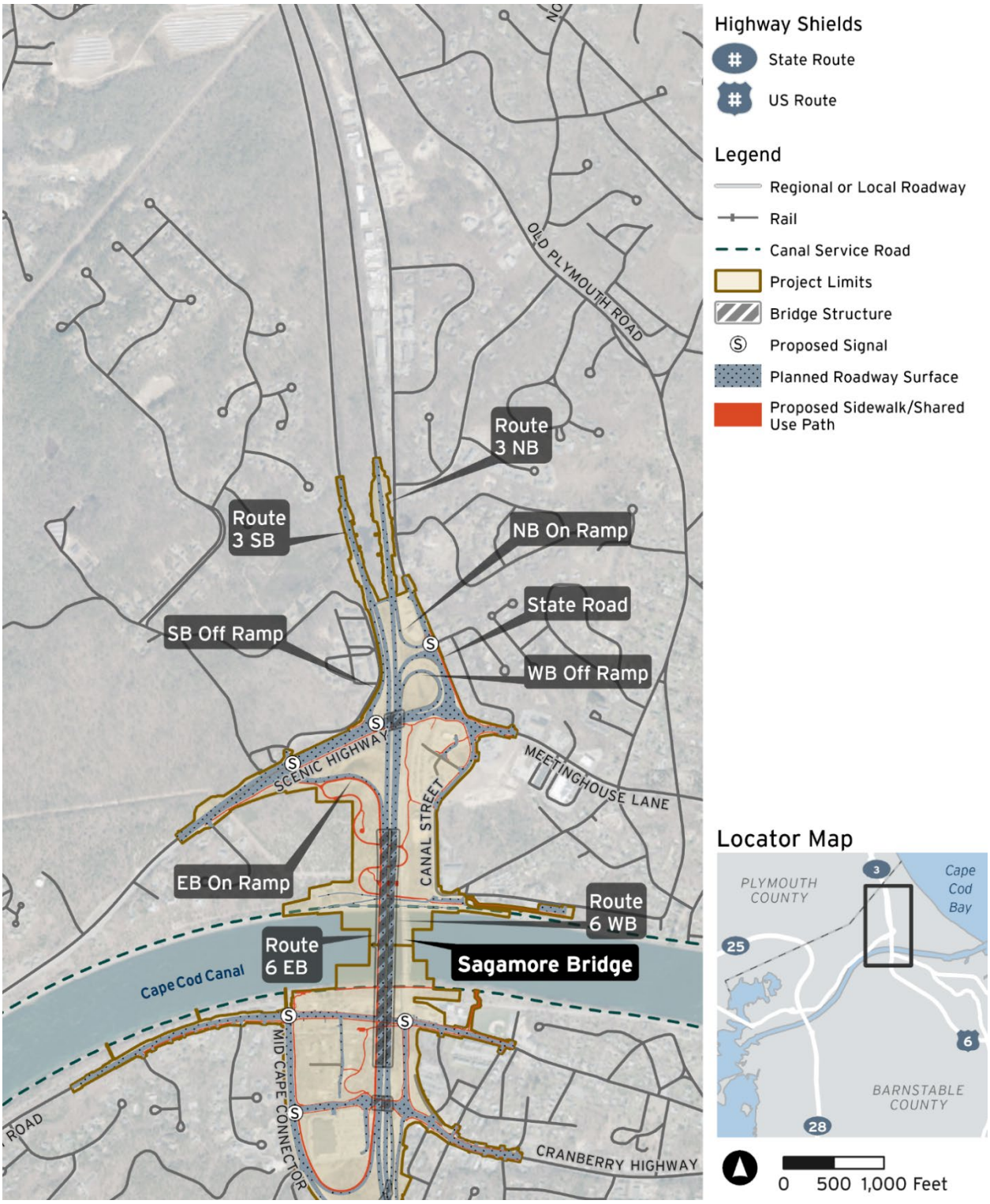
Program Element/ Program Design Parameter	Description
Highway Bridges	Replacement of both highway bridges with new bridges with four through-traffic lanes and two auxiliary lanes (in-kind bridge replacement, updated to comply with federal and state highway and design safety standards).
Highway Bridge Cross-Section and Shared-Use Path	Each replacement highway bridge span would provide two 12-foot-wide through-travel lanes (one in each direction), one 12-foot-wide entrance/exit (auxiliary) lane, a 6-foot-wide median shoulder, and a 12-foot-wide exterior shoulder. Each crossing location would include one bidirectional pedestrian and bicycle shared-use path, separated from vehicular traffic by the shoulder and barrier. The usable width of the shared-use path would be 14-feet-wide on the bridge main span, 20-feet-wide on the approach spans, and 12-feet-wide minimum on the connecting roadways.

Program Element/ Program Design Parameter	Description
Bridge Vertical and Horizontal Clearances	The replacement bridges would maintain the existing vertical clearance of 135 feet above mean high water and account for 3.3 feet of fluctuations in relative sea level, thereby providing a vertical clearance of 138.3 feet above mean high water. The replacement bridges would provide a minimum of 500 feet of horizontal channel width consistent with the authorized navigational channel width and existing conditions.
Main Span Length and Bridge Pier Location	The replacement bridges would have a main span length of 720 feet, which would locate the bridge piers at the waterline adjacent to the service road (shoreline piers) into the riprap slope but above the low tide line.
Bridge Deck Configuration	Each bridge (Sagamore and Bourne) would have two separate decks (twin structures).
Mainline Alignment	The mainline alignment locations at both bridges would be offline inboard. Both spans of the replacement highway bridges would be outside the footprint of the existing bridge, 7 feet apart and parallel to each other (offline) and on the side of Cape Cod Canal between the existing bridges (inboard). The replacement main spans at the Sagamore crossing would be west of existing Sagamore Bridge toward Buzzards Bay. The replacement main spans at the Bourne crossing would be east of existing Bourne Bridge toward Cape Cod Bay.
Bridge Type	The replacement bridges would be steel twin network tied-arch bridges, with delta frames supporting a 720-foot mainline span.
Interchange Approach Network	Interchange approach improvements at each bridge would be as follows: • Sagamore Bridge Crossing: Direct connection to State Road in the Sagamore North quadrant and Westbound On-Ramp Under U.S. Route 6 with Sandwich Road Extension in the Sagamore South quadrant • Bourne Bridge Crossing: Directional Interchange in the Bourne North quadrant and a Diamond Interchange in the Bourne South quadrant
Interchange Approach Network: Sagamore North Quadrant	The selected interchange approach option for the Sagamore North quadrant is: Direct Connection to State Road (Option SN-8A). Option SN-8A would provide a single exit point from a relocated U.S. Route 6/State Route 3. It would remove the Sagamore Bridge northbound off-ramp connection to Scenic Highway/Meetinghouse Lane eastbound, and instead it would connect to State Road, north of Scenic Highway/Meetinghouse Lane. The remaining ramp connections would remain similar to existing conditions with geometric adjustments to meet the new mainline location. A double roundabout would replace the signalized intersection of Scenic Highway/Meetinghouse Lane/State Road/Canal Street. Signalized intersections along Scenic Highway would be modified for new lane configurations. The intersection of the State Road at State Route 3 northbound on-ramp would be

Program Element/ Program Design Parameter	Description
	modified to accommodate the addition of the new State Route 3 northbound off-ramp with installation of a traffic signal. Option SN-8A would provide a shared-use path on the U.S. Route 6 eastbound main span that would provide connections to the south side of Scenic Highway, Canal Street, and Canal Service Road. This option would provide shared-use paths along the southern side of Scenic Highway and Meetinghouse Lane, as well as along the eastern side of State Road to Homestead Avenue and Canal Street to Bourne Park and Ride.
Interchange Approach Network: Sagamore South Quadrant	The selected interchange approach option for the Sagamore South quadrant is: Westbound On-Ramp Under U.S. Route 6 with Sandwich Road Extension (Option SS-3.1A). Option SS-3.1A would include Cranberry Highway Extension and would relocate the westbound on-ramp so it would share the same entrance point as the eastbound on-ramp off Mid-Cape Connector. Modifications to lane arrangements at the intersections of Mid-Cape Connector with Sandwich Road and Cranberry Highway Extension would accommodate the revised traffic patterns resulting from the extension of Cranberry Highway and the relocation of access to U.S. Route 6 (Scenic Highway) eastbound, including modifications to the existing traffic signals. There would be a connection from Cranberry Highway to Sandwich Road east of the new mainline bridge (Sandwich Road Connector). A roundabout would be provided at the intersection of the U.S. Route 6 westbound off-ramp with Cranberry Highway. An additional roundabout would be provided along Cranberry Highway providing access to Market Basket (Factory Outlet Road). There would be an access driveway to the former Christmas Tree Shops area. Option SS-3.1A would include a shared-use path on the U.S. Route 6 eastbound main span that would provide connections to Factory Outlet Road, Sandwich Road, and Canal Service Road. Pedestrian and bicycle improvements would also be included on Cranberry Highway. This option would add a new connection through Cranberry Highway Extension to Mid-Cape Connector.

Program Element/ Program Design Parameter	Description
Interchange Approach Network: Bourne North Quadrant	The selected interchange approach option for the Bourne North quadrant crossing is: Directional Interchange (BN-14.4b). Option BN-14.4b would provide a combination of direct-connection ramps between State Route 25 and U.S. Route 6 (Scenic Highway). The ramp connecting State Route 25 eastbound to Scenic Highway would be a flyover ramp passing over Nightingale Road and merging with the on-ramp from Belmont Circle before meeting up with the State Route 25 mainline. The ramp connecting Scenic Highway eastbound to State Route 25 eastbound would be a flyover ramp passing over Scenic Highway, allowing vehicles to bypass Belmont Circle and eliminating the need for an additional traffic signal. This ramp would use one of the travel lanes on Scenic Highway and be a free-flowing movement to reduce congestion. The existing interchange ramp over the State Route 25 bridge would be relocated to widen the bridge and allow for this new southbound to eastbound ramp movement. The existing southbound off-ramp would be revised to be an option lane, improving geometry and decision sight distance for drivers. The intersection control at Scenic Highway/Nightingale Road/Andy Oliva Drive would be provided by a single-lane roundabout. The new flyover ramp over Scenic Highway would provide a shared-use path and grade-separated crossing for pedestrians and bicyclists. The Scenic Highway Lane configuration would be reduced from four lanes to three lanes, which would provide additional space for multimodal accommodations. It would provide one continuous 12-foot-wide shared-use path along the south side of Scenic Highway connecting to Belmont Circle and a 6-foot-wide sidewalk along the north side of Scenic Highway.
Interchange Approach Network: Bourne South Quadrant	The selected interchange approach option for the Bourne South quadrant is: Diamond Interchange (BS-2). Option BS-2 would eliminate Bourne Rotary and replace it with a grade-separated diamond interchange, which would allow through movements on State Route 28 to bypass intersections with the non-mainline roadways. The two intersections within the diamond interchange would be a single-lane dogbone roundabout. Changes to the Trowbridge Road and Sandwich Road underpass would consist of a roundabout at a relocated Upper Cape Cod Regional Technical High School driveway entrance. Option BS-2's shared-use path improvements would include providing connections to Trowbridge Road, Canal Service Road, and Bourne Recreation Area.

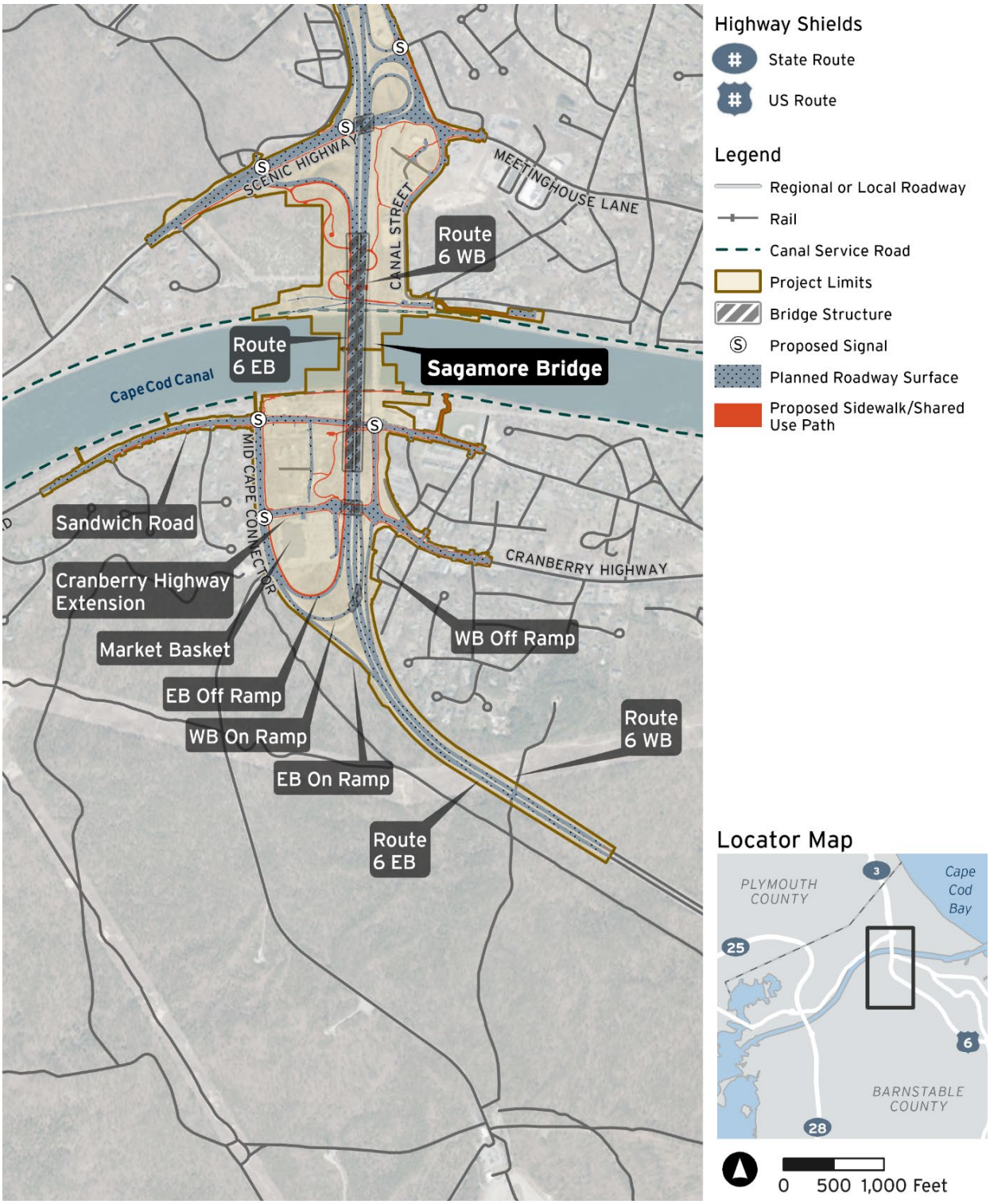
Figure 2-1. Option SN-8A: Direct Connection to State Road (Sagamore North Quadrant)



Source: Massachusetts Department of Transportation, 2025

EB = eastbound, NB = northbound, SB = southbound, WB = westbound

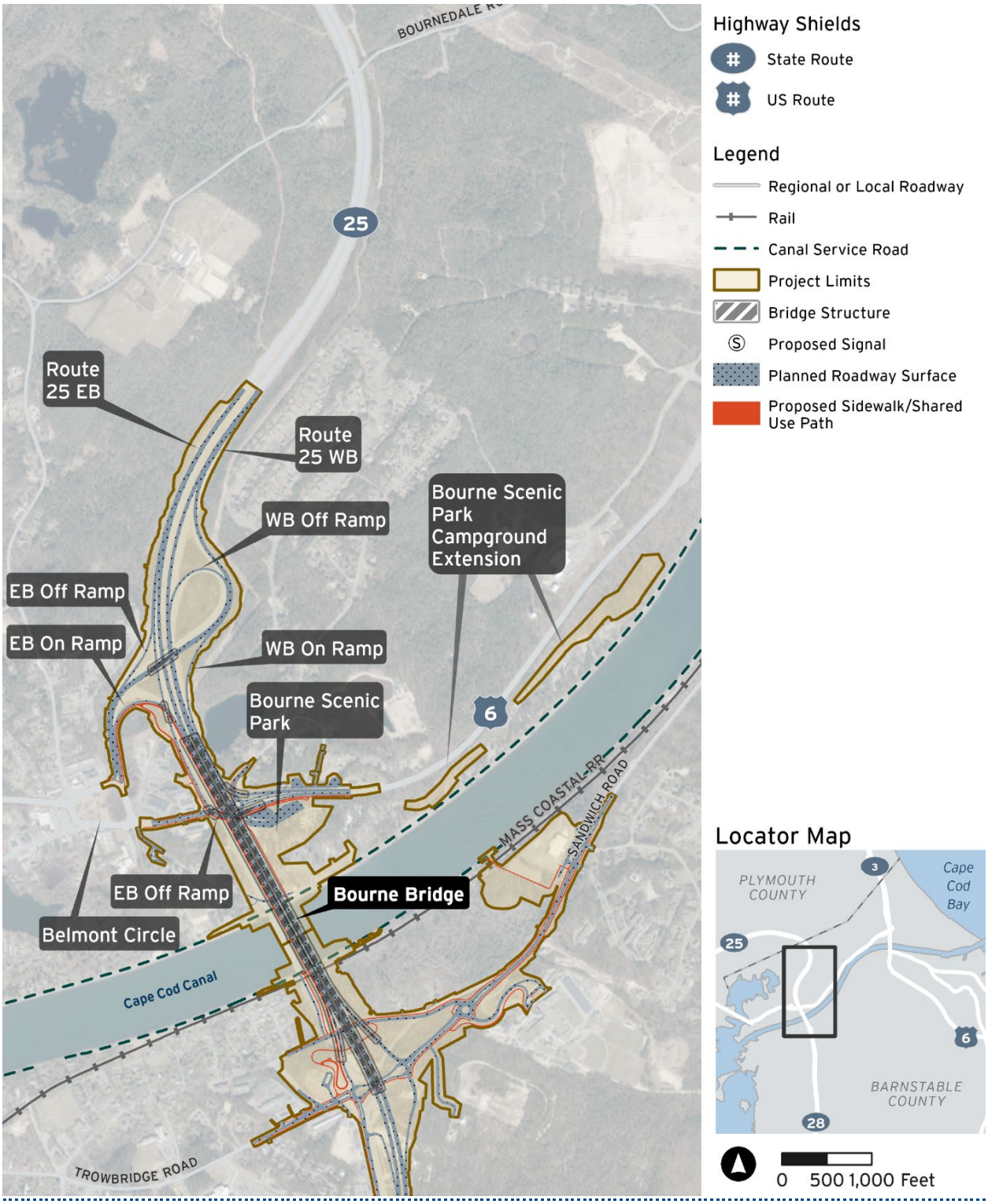
Figure 2-2. Option SS-3.1A: Westbound On-Ramp under U.S. Route 6 with Cranberry Highway Extension and Sandwich Road Connector (Sagamore South Quadrant)



Source: Massachusetts Department of Transportation, 2025

EB = eastbound, WB = westbound

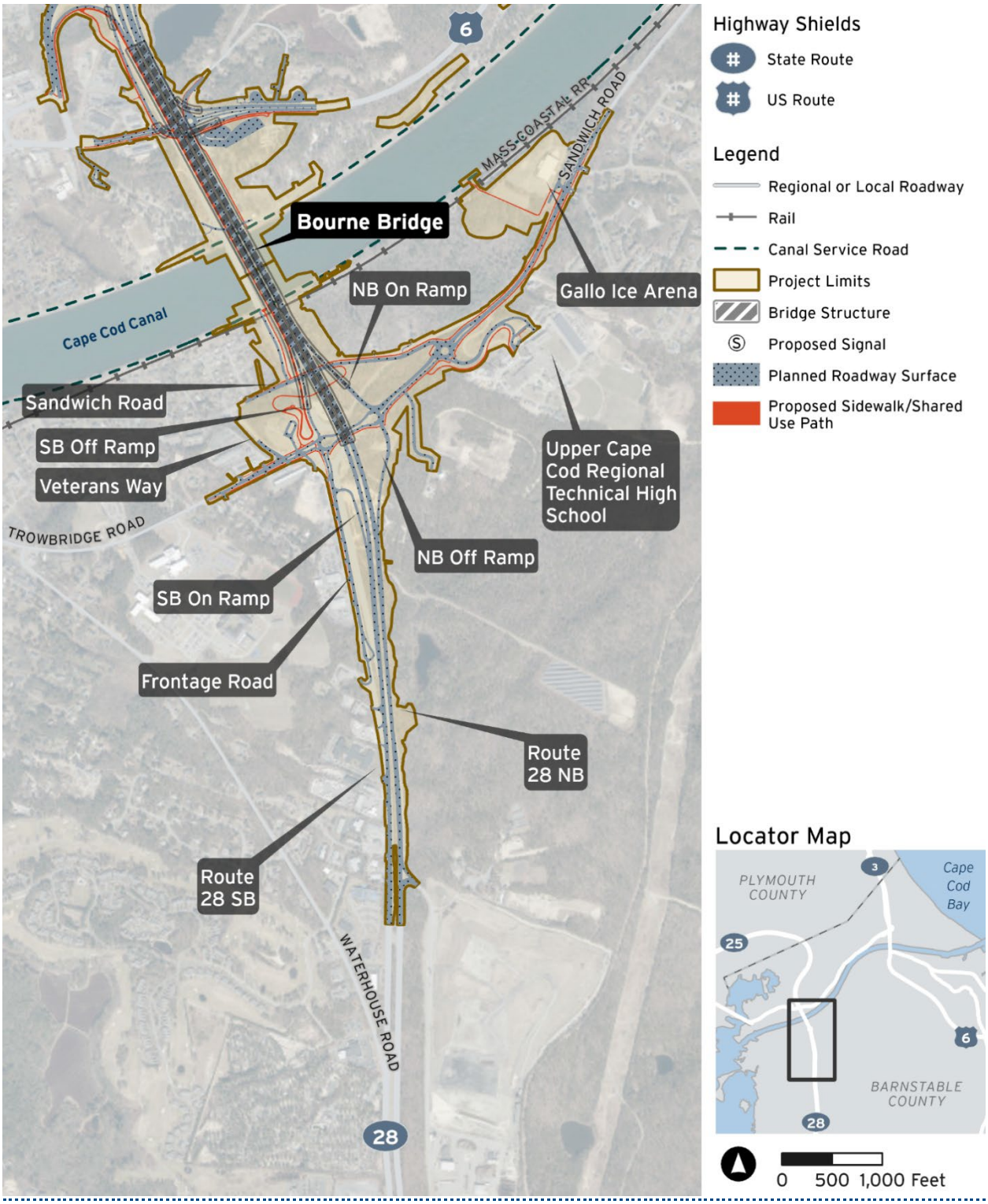
Figure 2-3. Option BN-14.4b: Directional Interchange (Bourne North Quadrant)



Source: Massachusetts Department of Transportation, 2025

EB = eastbound, WB = westbound

Figure 2-4. Option BS-2: Diamond Interchange (Bourne South Quadrant)



Source: Massachusetts Department of Transportation, 2025

NB = northbound, SB = southbound

3 Introduction to the Program's Construction Approach

This technical report presents the following construction scenarios for the Program based on preliminary design. MassDOT evaluated these construction scenarios in consultation with a construction specialist. MassDOT expects to contract the Program as a design-build (D-B); note that the Design-Build team could propose different construction means and methods.

3.1 Overview of Design-Build Construction Method

MassDOT will be using a "Best Value" D-B procurement method for the construction of the Program, pursuant to Chapter 149A of the Massachusetts General Law. As described in **Chapter 1, Introduction**, the Program is planned to be delivered in two phases, with the Sagamore Bridge Project as Phase 1 and the Bourne Bridge Replacement Project as Phase 2.

A D-B process is a construction delivery system that combines design and construction services within a single contract. A "best value" method is one that that provides the highest overall value to MassDOT, considering both cost and quality. Section 15 of Massachusetts General Law Chapter 149A defines quality as the basis on which MassDOT will evaluate the elements of a project that MassDOT has determined are most important, including, for example, quality of design, innovative approach, constructability, life-cycle and other long-term maintenance costs, maintenance of traffic, aesthetics, environmental impacts, local impacts, traveler and other user costs, service life, and time to construct.

The D-B method can provide substantial time savings compared to the more traditional design-bid-build approach, which typically involves three sequential project phases consisting of the:

1. Design Phase, in which MassDOT contracts separately with a design firm for project design development, progressing from preliminary to final design, and preparation of construction documents.
2. Bid Phase, when the construction documents are available for general contractor review and pricing (bidding).
3. Build or Construction Phase, when the project is built by the selected (the lowest bid) contractor.

The sequential nature of the design-bid-build project delivery method can result in project delays as construction cannot begin until the design and procurement phases have been completed.

By awarding one contract under the D-B procurement method, there is no bidding phase or delay between the final design and construction phases. In addition to accelerating project delivery by integrating the design and construction phases, other benefits of the D-B procurement method include greater cost and schedule control through the use of incentives and disincentives, close collaboration between the design and contractor that can promote development of innovative design and construction methodologies to reduce environmental- and traffic-related impacts to the maximum

extent feasible, and reduced overall project risk as the Design-Builder is responsible for the design and construction under a single contract.

The Best Value D-B procurement method is a two-phase selection process, which begins after MassDOT issues public notice of a project and solicits and receives Letters of Interest from proposers. In Phase 1, MassDOT will create a short list of qualified Design-Builders (proposers) based on the responses to its Request for Qualifications. In Phase 2, MassDOT will receive technical and price proposals from the short list of proposers based on its Request for Proposals. MassDOT will then award the construction contract to one proposer (a Design-Builder) based on Best Value, the highest overall value to MassDOT, considering quality and cost. Given the scale of the Program and the environmental resources within and abutting the Program Limits, MassDOT's evaluation of technical proposals will incentivize environmental mitigation strategies, which may include alternative designs or construction methods that minimize impact.

Under the D-B procurement method for the Program, MassDOT's advertised construction contract (Request for Proposal) will provide the Base Technical Concept, defined as approximately 25% level of design, to establish the minimum baseline requirements (performance standards and design criteria) that must be equaled or exceeded by the Design-Builder. As such, the Design-Builder could propose different construction means and methods that improve efficiency, reduce impacts, and/or enhance constructability, provided all project requirements are met. Similarly, the Design-Builder would have the flexibility to change the proposed intersection controls, ramp locations, wall types, and other project elements, as long as any changes demonstrate equal or improved performance.

The awarded Design-Builder will be required to complete final design and construction in compliance with regulatory permits and approvals, identified in **Chapter 7, Authorizations, Permits, and Approvals,** and within the timeframe determined by the project schedule. Also, the Design-Builder must adhere to the Project Management Plan, Quality Management Plan, Site Control Plan, Construction Staging Plan, Noise and Dust Control Plans, Health and Safety Plan, and all other applicable laws, negotiations, regulations, ordinances, and other requirements, taking into account the right-of-way and other physical constraints affecting the Program. Further, all final Program design and construction components will be reviewed by MassDOT and performed in accordance with MassDOT Design Standards and criteria, specifications, and contract administration practices.

MassDOT will secure all necessary environmental approvals and clearances based on the Program's Base Technical Concept. By selecting the D-B procurement methodology for the Program, MassDOT shares responsibility for environmental compliance with the Design-Builder. Accordingly, the Design-Builder, in coordination with MassDOT, will be responsible for obtaining any amendments to environmental approvals/clearances necessitated by any proposed deviations from the Base Technical Concept.

3.2 Program Timeline and Durations

The Program is proposed to be constructed in two phases: the first phase of the Program (Phase 1 project) would consist of the Sagamore Bridge Project, and the second phase of the Program (Phase 2 project) would be the Bourne Bridge Project. Construction activities for the replacement of Sagamore Bridge and Bourne Bridge are expected to occur over the course of eight to ten years, respectively. Construction of the Sagamore Bridge Project would begin first, followed by the Bourne Bridge Project once funding is secured. It is currently planned that construction of the replacement Bourne Bridge would commence one year following commencement of the replacement Sagamore Bridge construction, assuming funding is identified for the Bourne Bridge Project. Further, timing of construction sequencing is dependent upon funding.

Pending the completion of National Environmental Policy Act environmental reviews and receipt of federal and state permits and approvals,[2] anticipated in summer/fall 2026, MassDOT proposes to initiate the D-B procurement and construction process for the Sagamore Bridge Project in fall 2026.

The Sagamore Bridge Project is proceeding according to the following timeline:

- **Summer 2026:** Preliminary design complete
- **Fall 2026:** Request for Proposal issued for the D-B contract
- **Winter 2027/Spring 2028:** D-B contract Notice to Proceed issued
- **Spring 2037:** Substantial construction complete

3.3 Program Milestones and Phasing

There are four key milestones for the Program's bridge and interchange network phasing:

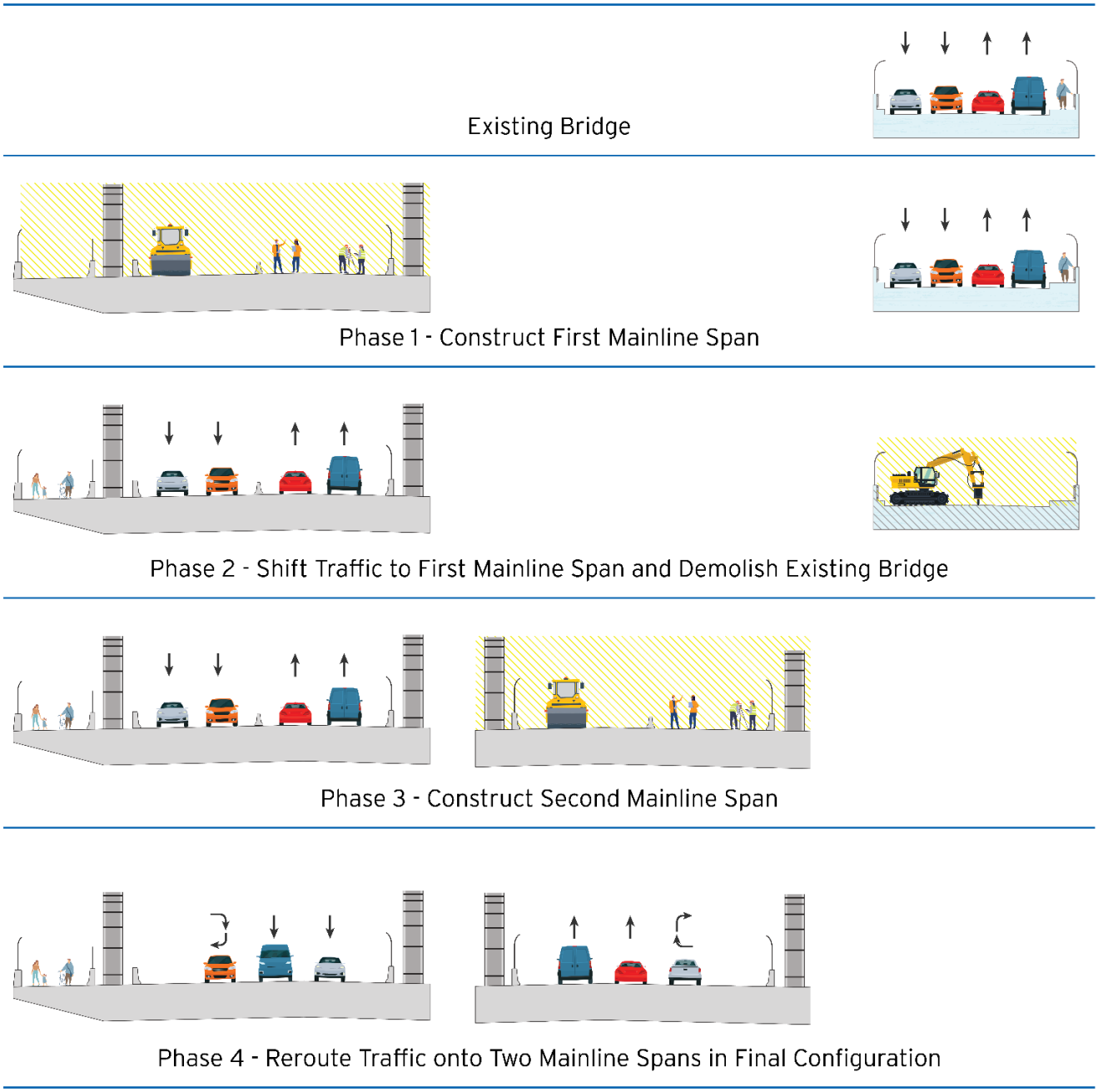
- Phase 1 – Construct the first mainline span and approaches, consisting of the eastbound mainline at the Sagamore Bridge crossing and the northbound mainline at the Bourne Bridge crossing.
- Phase 2 – Shift all traffic off the existing bridge and onto the new mainline structure and demolish the existing bridge.
- Phase 3 – Construct the second mainline span and approaches, consisting of the westbound mainline at the Sagamore Bridge crossing and the southbound mainline at the Bourne Bridge crossing.
- Phase 4 – Reroute the traffic onto the two mainline spans in the final configuration and open connections to the shared-use path (SUP) over the canal and supporting path network.

Figure 3-1 presents a simplified schematic of the bridge construction sequencing approach. The proposed Sagamore Bridge crossing is shown; the Bourne Bridge crossing would have a similar approach. The Design-Builder would be required to develop and implement construction sequencing

[2] MassDOT is submitting separate federal and state permit applications for each bridge project.

and methods that maintain two lanes of travel in each direction across Cape Cod Canal throughout all construction phases.

Figure 3-1. Proposed Bridge Construction Phasing



Source: Massachusetts Department of Transportation, 2024

4 Early Action/Initial Construction Activities

Prior to the start of construction, MassDOT would be responsible for developing resource protection and impact control plans.

Following the Notice to Proceed, for each Program quadrant, initial construction activities would include the following:

- Tree removal
- Right-of-way takings/structure demolition
- Mobilization/Establishment of approximate limits of work
- Utility relocations (including electric, sewer, potable water, gas, and telecommunications)
- Construction of temporary SUP connections (where needed), consisting of a minimum 6-foot-wide sidewalk for temporary multimodal access.

This section provides an overview of tree removal, structure demolition, and establishment of project limits. **Section 4.6, Land Use, Zoning, and Community Cohesion; Section 4.8, Property Acquisition, Displacement, and Relocation;** and **Section 4.19, Utilities and Services** provide further descriptions of tree clearing, the property acquisition process, and utility relocations, respectively.

4.1 Development of Resource Protection Plans and Impact Control Plans

In accordance with project commitments and permit conditions, and as referenced in applicable sections of the FEIS, MassDOT would develop resource protection plans and impact control plans for implementation by the Design-Builder throughout the construction period. These plans would include, but would not be limited to, the following:

- Stormwater Pollution Prevention Plan/Construction Period Erosion, Sedimentation, and Pollution Prevention Plan
- Noise Control Plan
- Vibration Control and Mitigation Plan
- Environmental Health and Safety Plan
- Sediment Sampling and Analysis Plan
- Soil and Groundwater Management Plan
- Asbestos and Lead Paint Abatement Work Plans

4.2 Tree Removal

MassDOT would conduct tree removal as an initial construction activity. Tree removal would be required within designated areas to allow for bridge construction and laydown, roadway and SUP construction, highway and ramp widening, construction of stormwater management basins, and

embankment and slope construction. Tree clearing also would be required for mitigation required for impacts to resources protected under Section 4(f) of the U.S. Department of Transportation Act (Section 4(f)).

The total approximate acreage of tree removal would be 146.77 acres, divided among the four Program quadrants, as follows:

- Sagamore North quadrant: 31.31 acres
- Sagamore South quadrant: 19.74 acres
- Bourne North quadrant: 39.29 acres
- Bourne South quadrant: 56.43 acres

Attachment 3 provides the Tree Clearing Plans for the Program quadrants. **Table 4-1** presents the total acreage of land alteration, consisting of the following: tree clearing; alteration to existing pavement, such as mill and overlay and roadway reconstruction; and alteration to previously disturbed areas, such as the implementation of stormwater management best management practices.

Table 4-1. Program Land Alteration

Program Quadrant	Tree Clearing (acres)	Alterations to Existing Pavement (acres)	Alterations to Previously Disturbed Areas (acres)	Total Land Alteration (acres)
Sagamore North	31.31	18.00	18.33	67.64
Sagamore South	19.74	20.80	17.13	57.67
Bourne North	39.29	21.70	41.46	102.45
Bourne South	56.43	15.83	28.08	100.34
Total	**146.77**	**76.33**	**105.00**	**328.10**

MassDOT would use its standard specifications to conduct tree removal, which would include clearing and grubbing, tree trimming, tree removal, and stump removal.[3] In preparation for tree removal, an arborist would develop a tree-removal plan. The plan would include inspecting the area of trees to determine the safest option for tree removal, such as identifying where trunks fall and options for lowering trees via rope, crane, or bucket etc., and identifying how tree pieces would be hauled out after cutting to avoid damaging trees that are outside of the designated cut area. When possible, tree removal by climbing is preferred. Tree removal would include removal of all brush, trees, stumps, and roots within the designated area, including dead, dying, and diseased trees, previously fallen trees, branches, uprooted stumps, and other debris. Tree-removal equipment can vary based on the size of

[3] Massachusetts Department of Transportation. 2026 Standard Specifications for Highway and Bridges. Subsections 101 through 105. https://www.mass.gov/doc/2026-standard-specifications-for-highways-and-bridges-division-ii-construction-details/download

the area required to be cleared, the terrain type, ease of access, density of vegetation and timeline; however, the following equipment may be used:

- Versatile equipment (such as excavators, bulldozers, skid steer loaders, tractors, and backhoes) that can clear land
- Specialized equipment (such as stump grinders, brush mowers, and string trimmers)
- Mulchers to clear underbrush, small trees, and leftover fencing (mulching attachments can be used with machines like tractors, skid steers, and excavators).

MassDOT would employ multiple mitigation measures, minimization measures, and best management practices to reduce impacts to federally listed and proposed species with the potential to occur in the Terrestrial Study Area (Project Limits), including implementing time-of-year restrictions on tree clearing. Trees would not be cleared from March 15 through November 30 on the Cape Cod side of Cape Cod Canal and from April 15 through October 31 on the mainland side of Cape Cod Canal.

4.3 Individual Structure Removal

To demolish the existing bridges and construct the new bridges, including the realignment of the mainlines, MassDOT would acquire properties and demolish existing structures. Of the 30 total full parcel acquisitions within the Project Limits, 17 parcels contain structures to be demolished.

Prior to structure demolition, MassDOT would conduct building inspections. The Program would follow Massachusetts Division of Fisheries and Wildlife (MassWildlife) guidance in developing exclusionary measures to ensure that bats are not present in or are removed from structures.[4]

Demolition of existing structures on properties acquired by MassDOT could be completed prior to commencement of the Program construction contract(s).

4.4 Mobilization and Establishment of Project Limits of Work

MassDOT would establish project limits of work within the four Program quadrants to accommodate bridge and roadway construction, retaining wall construction, installation of stormwater management features, construction access, and equipment laydown and staging areas. **Attachment 4, Construction Schematics** provides schematics of the approximate bridge and mainline construction limits of work, including equipment staging concepts for bridge and mainline construction.

[4] Massachusetts Division of Fisheries & Wildlife. 2020. Massachusetts Homeowner's Guide to Bats. (7th edition) https://www.mass.gov/doc/massachusetts-homeowners-guide-to-bats/download

5 Construction Sequencing and Traffic Management

5.1 Program Goals

The construction sequencing and traffic management goals for each phase of the Program area are as follows:

- Remove traffic off the existing bridge as soon as possible.
- Maintain existing roadway and ramp connections throughout the duration of construction.
- Avoid the need for construction detours.
- Reduce or minimize traffic shifts.
- Reduce schedule delays by providing large work zones at the bridge sites.
- Design temporary roadways at 10 miles per hour less than the existing roadway design speed.
- Maintain pedestrian and bicycle connectivity access equal to or better than existing conditions throughout the duration of construction.

5.2 Design Standards

MassDOT has established design standards for the following to be maintained throughout construction:

- Mainlines
  - Lane Configuration – 2 lanes minimum in each direction
  - Travel Lane Width – 11-foot minimum
  - Shoulder Width – 0-foot minimum on structure; 2 feet preferred; 1-foot minimum at-grade
  - Pedestrian/Bicycle Facility – Maintain existing widths where existing facilities are present; where new connections are being established due to work zones, a minimum width of 6 feet is required.
  - Vertical Clearance – Maintain existing vertical clearance as a minimum.
- Ramps
  - Travel Lane Width – 11-foot minimum
  - Inside Shoulder Width – 2 feet preferred; 1-foot minimum
  - Outside Shoulder Width – 2 feet preferred; 1-foot minimum
  - Total Ramp Width – 18-foot minimum to accommodate emergency vehicles
  - Entrance/Exit Ramp Design – Taper style ramps preferred; parallel style where necessary.
- Local Roads
  - Travel Lane Width – 10-foot minimum
  - Shoulder Width – 2 feet preferred; 1-foot minimum

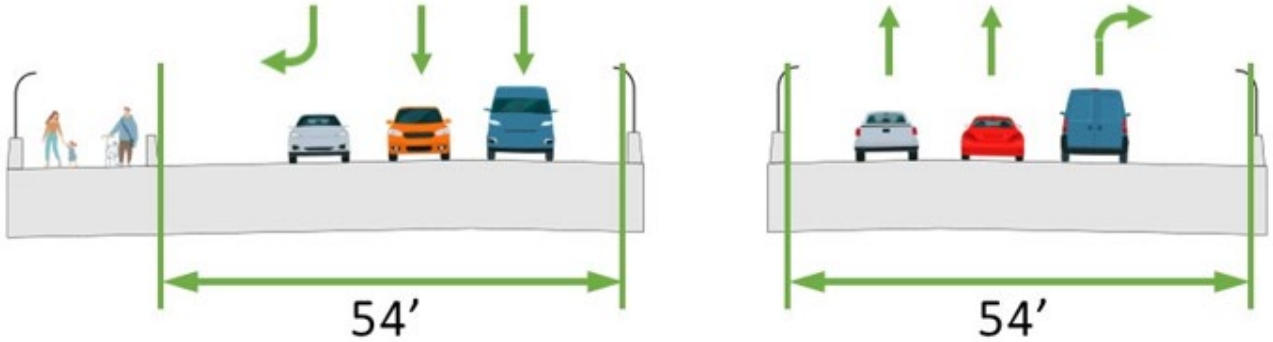
5.3 Summary Description

The replacement bridges would be constructed offline (outside of the existing footprint) and a maximum of 250 feet inboard of the existing highway bridges. Sagamore Bridge would be replaced first followed by Bourne Bridge. At each site, the inboard main span (inboard bridge) would be constructed first. At the Sagamore Bridge site, this would be the westernmost bridge, which would ultimately carry traffic onto Cape Cod. For the Bourne Bridge site, this would be the easternmost bridge, which would ultimately carry traffic off Cape Cod. After construction of the first new span, all traffic would be shifted onto it so the existing bridge can be demolished, and the second main span (bridge) can be constructed. **Figure 5-1** presents a highway bridge typical section in the temporary condition; the inboard span would contain all through traffic, leaving the existing bridge without traffic prior to its demolition. **Figure 5-2** presents a typical highway bridge section following construction completion, with both spans operational and traffic rerouted in the final configuration. Typical section widths are provided in **Section 5.3.1.**

Figure 5-1. Highway Bridge Typical Section, Temporary Condition (First Bridge with all Through Traffic)

Source: Massachusetts Department of Transportation, 2024

Figure 5-2. Highway Bridge Typical Section, Completed Construction



Source: Massachusetts Department of Transportation, 2024

5.3.1 Bridge Construction and Demolition Sequencing

In the Sagamore Bridge Project, the eastbound mainline would be constructed first (Phase 1 in **Figure 3-1**). To enable the demolition of the existing Sagamore Bridge and construction of the westbound mainline bridge, all traffic would be shifted onto the eastbound mainline (Phase 2 in **Figure 3-1**). To do this, while also maintaining two lanes of traffic in the eastbound and westbound directions, a combination of temporary crossovers and pavement widening would be needed. Furthermore, when traffic is on the proposed eastbound mainline structure, the typical section would be reduced to two 11-foot travel lanes in each direction, with two 2-foot shoulders, and separated by temporary median barrier. The SUP would be a minimum of 14 feet wide separated by a concrete barrier (**Figure 5-1**). While all traffic is on this eastbound structure, demolition of the existing bridge and construction of the proposed westbound mainline span could occur without conflicts (Phase 3 in **Figure 3-1**). Following construction of the southbound mainline span, traffic would be rerouted onto the two mainline spans in the final configuration (Phase 4 in **Figure 3-1**; **Figure 5-2**)

In the Bourne Bridge Project, the northbound mainline would be constructed first (Phase 1 in **Figure 3-1**). To enable the demolition of the existing Bourne Bridge and construction of the southbound mainline bridge, all traffic would be shifted onto the northbound mainline built (Phase 2 in **Figure 3-1**). To do this, while also maintaining two lanes of traffic in the northbound and southbound direction, a combination of temporary crossovers and pavement widening would be needed. Furthermore, when traffic is on the proposed northbound mainline structure, the typical section would be reduced to two 11-foot travel lanes in each direction, with no shoulder, and separated by a temporary median barrier. This section would allow space for four lanes of traffic and the 6-foot-wide temporary pedestrian/bicycle facility separated from vehicular traffic by a temporary concrete barrier (**Figure 5-1**). While all traffic is on this northbound structure, demolition of the existing bridge and construction of the proposed southbound mainline bridge could occur without conflicts (Phase 3 in **Figure 3-1**). Following construction of the westbound mainline span, traffic would be rerouted onto the two mainline spans in the final configuration (Phase 4 in **Figure 3-1**; **Figure 5-2**).

5.3.2 Interchange Approach Construction Phasing

The following provides a general approach to construction phasing for the four quadrants based on preliminary design. The phasing described herein is limited to major construction activities and vehicle and pedestrian/bicycle movements. Note that there are some activities that cannot occur before previous activities are completed (critical path construction activities); however, there may be an opportunity to construct other activities that do not have critical predecessor tasks. These non-critical-path construction activities could occur earlier than indicated herein. Additionally, as indicated in **Section 3.5.1**, the Design-Builder could propose different construction phasing, as well as different means and methods.

5.3.2.1 Sagamore North Quadrant

Eleven construction phases are proposed for the Sagamore North quadrant. In the first phase, existing traffic patterns would be maintained, with a potential one-lane traffic and minor lane or shoulder

closings at specific locations. Phases 2 through 11 would require revised traffic patterns. Milestone construction points would be reached at the end of Phase 4 and Phase 8. At the end of Phase 4, the U.S. Route 6 eastbound bridge over Cape Cod Canal including approaches must be completed. At the end of Phase 8, the U.S. Route 6 westbound bridge over Cape Cod Canal, including approaches, must be completed. Phases 10 and 11 consist of construction closeout and construction completion. The pedestrian and bicycle connections would be constructed and opened to the public in Phases 1, 5, 7, 9, and 10.

- Phase 1 - Construct the proposed U.S. Route 6 eastbound bridge over the canal, including U.S. Route 6 eastbound approaches and portions of State Route 3 mainline/ramps, while maintaining existing traffic patterns. The Canal Service Road would be temporarily closed to pedestrians and bicyclists and re-routed within a limited portion of the construction work zone limits. A pedestrian/vehicle turnaround would be constructed at each end of the work zone.
- Phase 2 - Continue constructing the mainline and State Route 3 on- and off-ramps with tie-ins at State Road.
- Phase 3 - Phase 3 work would be confined to the Sagamore South quadrant; no work would occur within the Sagamore North quadrant.
- Phase 4 - Construct the embankment and remaining portion of new State Route 3 southbound.
- Phase 5 - Construct portions of the U.S. Route 6 westbound mainline. Shift eastbound traffic to the newly constructed U.S. Route 6 eastbound outside shoulder; maintain westbound traffic on the existing bridge. Construct Sagamore Bridge permanent SUP along the U.S. Route 6 eastbound mainline crossing approach sections.
- Phase 6 - Construct the remainder of U.S. Route 6 westbound off-ramp, including completion of the bridge over Scenic Highway, a portion of State Route 3 northbound, remainder of State Route 3 northbound, and State Route 3 northbound on-ramp.
- Phase 7 - Demolish existing bridge structure and remove existing mainline and ramps. Begin construction of new U.S. Route 6 westbound bridge and final structural sections of State Route 3 northbound. The permanent SUP would be fully online from Scenic Highway to Cranberry Highway and Sandwich Road at the end of Phase 7. A temporary SUP would be used for Scenic Highway from the State Road roundabout to the State Route 3 southbound off-ramp from Phase 7 to Phase 9; work would continue on the State Route 3 northbound bridge and Scenic Highway underpass.
- Phase 8 - Continue construction of new U.S. Route 6 westbound bridge and approaches.
- Phase 9 - Remove temporary crossovers, construct permanent median barrier, and remove temporary State Route 3 northbound bypass. Construction of the permanent SUP would be completed at the end of this phase. Restore portions of the Canal Service Road impacted by construction activities.
- Phase 10 - Begin Project closeout (landscaping, punch list, etc.), including removing temporary widening of State Route 3 southbound off-ramp and installing guardrail. Open the Canal Service Road to pedestrians and bicyclists.
- Phase 11 - Construction complete.

5.3.2.2 Sagamore South Quadrant

Eleven construction phases are proposed for the Sagamore South quadrant. In the first phase, existing traffic patterns would be maintained. Phases 2 through 9 would require revised traffic patterns. Milestone construction points would be reached at the end of Phase 4 and Phase 8. At the end of Phase 4, the U.S. Route 6 eastbound bridge over Cape Cod Canal including approaches must be completed. At the end of Phase 8, the U.S. Route 6 westbound bridge over Cape Cod Canal, including approaches, must be completed. Phases 10 and 11 consist of construction closeout and construction completion. Pedestrian and bicycle connections would be constructed and opened to the public in Phases 1 and 10.

- Phase 1 - Construct proposed U.S. Route 6 mainline and ramps eastbound bridge over the canal including eastbound approaches and portions of U.S. Route 6 while maintaining existing traffic patterns. Construct and open permanent SUP connections from Sandwich Road to Canal Service Road at the Mid-Cape Connector intersection and Keith Field Recreation Area. Construct a SUP along Sandwich Road connecting the access points from Sandwich Road to Canal Service Road.
- Phase 2 - Construct temporary U.S. Route 6 temporary mainline and ramp crossovers.
- Phase 3 - Construct proposed U.S. Route 6 eastbound and on ramps.
- Phase 4 - Construct remainder of the U.S. Route 6 westbound and on- and off-ramps and temporary crossover from U.S. Route 6 westbound to U.S. Route 6 eastbound.
- Phase 5 - Construct a portion of U.S. Route 6 westbound and westbound on-ramp.
- Phase 6 - Construct permanent U.S. Route 6 westbound off-ramp and Cranberry Highway Extension.
- Phase 7 - Demolish existing bridge structure. Remove existing mainline and ramps. Begin construction of new U.S. Route 6 westbound bridge.
- Phase 8 - Continue construction of new U.S. Route 6 westbound bridge and approaches.
- Phase 9 - Remove existing crossovers and finalize mainline and ramp entrance construction. Restore portions of the Canal Service Road impacted by construction activities.
- Phase 10 - Begin Project closeout (landscaping, punch list, etc.), including installing guardrail. Open the Canal Service Road to pedestrians and bicyclists.
- Phase 11 - Construction complete.

5.3.2.3 Bourne North Quadrant

Seven construction phases are proposed for the Bourne North quadrant. In the first two phases, existing traffic patterns would be maintained; lane or shoulder closures may be required on some roadways. Phases 3 through 6 would require revised traffic patterns. Milestone construction points would be reached at the end of Phases 3, 4, and 6. At the end of Phase 3, the northbound mainline would be open and the northbound on-ramp from U.S. Route 6 would be open. At the end of Phase 4, the southbound off-ramp to U.S. Route 6 would be open. At the end of Phase 6, the southbound mainline structure would be open with the final traffic patterns. The pedestrian and bicycle connections would be constructed and opened to the public in Phases 2, 3C, and 6.

- Phase 1 - Construct the temporary Bourne Scenic Park entrance and proposed Nightingale Extension. Construct roadway off Nightingale Road (for future operations and maintenance by the Town of Bourne).
- Phase 2 - Construct temporary pavement on mainline, including temporary crossover for mainline traffic shifts, temporary widening for mainline traffic shifts, temporary pavement for ramp movements. Begin construction of northbound mainline structure and relocate stormwater interceptor. Construct a portion of Nightingale Road. Construct the Bourne Scenic Park SUP to provide pedestrian access along U.S. Route 6 throughout the duration of construction.
- Phase 3
  - Phase 3A - Continue construction of northbound mainline structure, proposed structure over State Routes 25/28, portions of northbound on-ramp from U.S. Route 6, and temporary southbound on-ramp over existing mainline.
  - Phase 3B - Demolish portion of existing northbound mainline and northbound on-ramp. Continue construction of northbound mainline structure and portions of the northbound on-ramp from U.S. Route 6. Construct the temporary northbound off-ramp.
  - Phase 3C - Demolish remaining portion of existing northbound mainline, northbound off-ramp, and east portion of existing structure over State Routes 25/28. Construct remaining portion of northbound mainline structure, temporary pedestrian path, and northbound on-ramp from U.S. Route 6, including the structure over Nightingale Road. Construct a portion of U.S. Route 6. Construct a temporary SUP connection between the proposed northbound mainline and westbound on-ramp to provide pedestrian access over the canal for the remainder of construction.
- Phase 4 - Demolish remaining portion of the existing mainline, including structure over U.S. Route 6 and the southbound on-ramp. Begin construction of southbound mainline structure and portion of the southbound on-ramp. Construct southbound off-ramp to U.S. Route 6, including the structure under the southbound on-ramp and structures over U.S. Route 6 and Andy Oliva Drive, and permanent SUP connection, which will remain open after Phase 4.
- Phase 5 - Demolish the west portion of the existing structure over State Routes 25/28 and the existing southbound off-ramp. Continue construction of the southbound mainline. Construct the remaining portion of the southbound off-ramp and southbound off-ramp to Belmont Circle.
  - Phase 5A - Construct a portion of U.S. Route 6. Construct the remaining portion of Nightingale Road.
  - Phase 5B - Construct the remaining portion of U.S. Route 6 and Andy Oliva Drive.
- Phase 6 - Demolish the temporary southbound on-ramp. Construct the remaining portions of the southbound mainline and median separating the westbound on-ramp from Belmont Circle and the westbound off-ramp to Belmont Circle. The permanent SUP over the canal will be open after Phase 6.

- Phase 7 – Begin project closeout (e.g., landscaping, punch list), including installing guardrail. Demolish the remaining temporary pavement and temporary crossovers.

5.3.2.4 Bourne South Quadrant

Seven construction phases are proposed for the Bourne South quadrant. In the first phase, existing traffic patterns would be maintained; lane or shoulder closures may be required on some roadways. In the second phase, existing traffic patterns would be maintained, with some exceptions; lane or shoulder closures may be required on some roadways. Phases 3 through 6 would require revised traffic patterns. Milestone construction points would be reached at the end of Phase 3 and Phase 5. At the end of Phase 3, the northbound mainline would be open. At the end of Phase 5, the southbound mainline would be open. Construction would be completed with the final traffic patterns in Phase 7. The pedestrian and bicycle connections would be constructed and opened to the public in Phases 1A, 2, and 6.

- Phase 1
  - Phase 1A - Begin construction of the temporary crossover and temporary southbound off-ramp, portion of at-grade northbound and southbound mainlines, structure portion of northbound mainline, portion of southbound on-ramp, northbound off-ramp, and roundabout west of the mainline. Construct Sandwich Road and a portion of Trowbridge Road, including two roundabouts east of the mainline, Upper Cape Technical Way, and permanent SUPs, which will be open the duration of construction. Phase 1A includes the Sandwich Road improvements west of and including the entrance to Gallo Ice Arena, new SUPs, and SUP connections.
  - Phase 1B - Continue construction of the temporary crossover and temporary southbound off-ramp, portion of the at-grade northbound and southbound mainlines, structure portion of the northbound mainline, portion of the southbound on-ramp, northbound off-ramp, and roundabout west of the mainline. Begin construction of the northbound on-ramp.
- Phase 2 - Construct the temporary crossover and temporary southbound off-ramp U-turn, portion of at-grade northbound and southbound mainlines, structure portion of northbound mainline, northbound on-ramp, northbound off-ramp, and Trowbridge Road through the existing Bourne Rotary. Temporary pedestrian access would be open along the outside of the northbound mainline after Phase 2 and remain open until the permanent SUP along the southbound mainline opens after Phase 6.
- Phase 3 - Demolish the existing bridge structure. Begin construction of the structure portion of the proposed southbound mainline, portion of at-grade northbound and southbound mainlines, and southbound off-ramp. Continue construction of portions of Trowbridge Road.
- Phase 4 - Continue construction of the southbound off-ramp and remaining portion of Trowbridge Road. Continue construction of the structure portion of the southbound mainline and portion of the at-grade northbound and southbound mainlines.
- Phase 5 - Continue construction of the structure portion of the southbound mainline and portion of the at-grade northbound and southbound mainlines.

- Phase 6 - Complete construction of the structure portion of the southbound mainline and portion of the at-grade northbound and southbound mainlines. Construct Frontage Road. The permanent SUP over the canal will be open after Phase 6.
- Phase 7 - Begin project closeout (e.g., landscaping, punch list), including installing guardrail. Demolish the remaining temporary pavement and temporary crossovers.

5.3.3 Pedestrian and Bicycle Connections

Maintaining pedestrian and bicycle connectivity during construction is a Program priority. Replacement of Sagamore and Bourne Bridges would be phased to maintain continuous access for all road users, including pedestrians and bicyclists, throughout construction. Due to safety concerns during the proposed bridge and mainline construction, localized closures and rerouting of pedestrian and bicycle facilities would be required, primarily beneath the bridges on the Canal Service Roads (i.e., primary crane operations area) and along portions of Scenic Highway and Sandwich Road. The closures are expected to range from several weeks to seven or eight years, depending on location and proximity to the main span structure (primary crane operations area) and the Design-Builder's means and methods.

For each bridge project, a portion of the Canal Service Roads would be closed for the duration of the construction work, as large cranes would be positioned within the work zone to support major activities associated with the construction of the two new bridges and the demolition of the existing bridges. These operations require substantial time and space for loading and unloading equipment, lifting and placing steel, and performing other heavy construction activities. Because these crane operations create elevated safety risks and require a fully controlled environment, a portion of the Canal Service Roads must remain closed for construction efficiency and safety.

Attachment 4, Construction Schematics provides schematics illustrating temporary pedestrian and bicycle connections for the Program quadrants. MassDOT's conceptual plan for the Sagamore South and Bourne South quadrants would temporarily reroute pedestrians and bicyclists traveling east-west along Canal Service Road to Sandwich Road before reconnecting to Canal Service Road.

In the Sagamore North quadrant, MassDOT is proposing to provide temporary connections for pedestrians and bicyclists traveling to the Bourne Park and Ride lot via Scenic Highway or Meetinghouse Lane. Additionally, MassDOT is evaluating options to provide temporary connections to the north Canal Service Road in the Sagamore North and Bourne North quadrants.

The Design-Builder could revise the proposed temporary pedestrian and bicycle connections, provided that the changes demonstrate equal or improved performance. Final routing, detours, and operational measures would be defined in the Transportation Management Plan, described in **Section 4.2, Transportation, Traffic, and Safety,** and would be refined as construction phasing and means and methods are finalized.

In both bridge projects, pedestrians and bicyclists will continue to have access across Cape Cod Canal through construction completion, as illustrated in **Figure 3-1** and described in **Section 5.3.1.** Once the Sagamore Bridge eastbound mainline is complete, pedestrians and bicyclists would have access to the permanent SUP. The construction of the Bourne Bridge northbound mainline would include a

temporary SUP (Phases 1 and 2). Upon completion of the Bourne Bridge southbound mainline (Phase 3), all roadway users would be shifted to the final configuration (Phase 4).

6 In-Water Construction Activities

This section provides a description of MassDOT's approach to in-water construction activities, including an overall approach (**Section 6.1**) and additional details on specific in-water work activities (**Sections 6.2 through 6.7**).

6.1 Overall Approach and Durations

As Cape Cod Canal is a main thoroughfare for shipping vessels, the width and depth of the navigational channel would be maintained during construction, and the channel would be operational as much as feasibly possible.

MassDOT estimates that the construction of each replacement bridge and demolition of each existing bridge would take approximately eight to 10 years, with in-water work occurring over multiple phases. Construction in the north and south quadrants of each bridge site is anticipated to occur concurrently. Except for six short-term closures, replacement bridge construction and existing bridge demolition would be outside of the navigation channel and would not affect ongoing navigation.

Construction of the in-water temporary work structures, drilled shafts, and substructures at the canal delta piers would require approximately two years for each new span. MassDOT plans to construct the delta frames either from cranes on work trestles (platforms) over the water near the shore or from cranes on land near the shoreline. The trestles would be arranged to be close to the canal banks to be completely clear of the navigation channel. Construction of each new delta frame would require approximately one year. Demolition of the existing bridge approach spans would require nine months per bridge and demolition of the existing piers within cofferdams would require six months per bridge.

Each new center span/bridge arch would be constructed off-site, floated on barges to the bridge site, and lifted into place by cable jacks mounted on the previously constructed delta frames. The deconstructed bridge arches would be lowered onto barges and floated out of the canal to an off-site construction/staging area.

To the greatest extent practicable, encroachment into the navigation channel would be minimized throughout the duration of construction and demolition activities. The new piers would be located within and above the canal's intertidal zone and well outside the navigation channel. They would be constructed within cofferdams from temporary work platforms near the edge of the canal and would not affect navigation. The existing piers, located in the waterway and outside the navigation channel, would be surrounded by containment cells for demolition. MassDOT proposes to remove the existing piers to a minimum of two feet below the mudline. Some demolished materials could be lifted away by crane, and some could be reduced to rubble in the containment cell and then removed by a clamshell bucket. Demolition materials would be disposed of off-site.

Construction of new elements farther from the canal, such as the proposed approach spans, would occur from cranes located either on work trestles or land at the shoreline and would not directly affect navigation. Similarly, the portions of the existing structure beyond the canal zone could be demolished without directly affecting navigation.

In-water work requiring closure of the navigation channel would be limited to six short-term, full canal closures associated with the float-in of the new bridge arches (two per bridge site) and float-out of the deconstructed bridge arch (one per bridge site). Four canal closures (each lasting approximately three to five days) would be required for the float-in of the new bridge arches. Two canal closures (each lasting approximately three to five days) would be required for the float-out of the existing bridge arches. Once started, the float-in and float-out operations cannot be halted or paused. MassDOT would coordinate channel encroachments and canal closures with USACE and the U.S. Coast Guard Sector Southeastern New England. Aids to navigation would include Notices to Mariners, on-site signs, and lighting.

6.2 Installation and Removal of Temporary Work Structures

In preparation for bridge construction and demolition, existing shoreline riprap would be removed to allow for installation of sheeting and piles that are needed for the temporary work structures. The temporary work structures would be positioned near the shoreline outside of the navigation channel. Upon completion of in-water work, all temporary support structures would be removed. Dimensions provided herein are approximate and subject to change based on final design and the Design-Builder's means and methods. Temporary work structures may include the following within each quadrant:

- Cofferdams (approximately 180 feet by 100 feet) constructed of sheeting around the proposed new bridge pier locations
- Containment cells (approximately 120 feet by 100 feet) constructed of sheeting around the demolition zone of the existing bridge piers
- Steel pipe piles (36 inch) installed in key locations to support the cofferdams and containment cells surrounding the proposed and existing bridge piers
- Shoreline stabilization consisting of 18-inch steel sheeting installed along the approximate high tide line to create upland (landside) work areas, potentially reinforced with tiebacks through the sheeting and into land
- Bulkhead constructed of 18-inch steel sheeting located below the high tide line for contractor use, potentially reinforced with tiebacks through the sheeting and into land
- Barge docks (approximately 80 feet by 30 feet), two per quadrant, constructed of sheeting and fill for mooring construction barges
- Mooring dolphins supported by 36-inch steel pipe piles for construction vessel mooring
- Construction trestles (approximately 24,900 square feet) supported on 36-inch steel pipe piles for staging equipment to construct the new bridge piers and demolish the existing bridge piers, potentially with rip rap placed at the trestle base for scour protection

While it is anticipated that most temporary works would not be contained, depending upon the contractor's means and methods, some of the work could be contained within the same containment cell that is used for pier demolition, including the portion of the temporary trestle that overlaps with the existing pier and some of the trestle supporting structure such as driven piles or columns resting on the remaining footings of the existing pier.

Attachment 4, Construction Schematics presents schematics of the conceptual temporary structures work plan at the Program quadrants.

6.3 New Bridge Construction

At each bridge site, two new permanent canal-side concrete pier structures (Piers 4 and 5 at Sagamore Bridge and Piers 5 and 6 at Bourne Bridge), each measuring approximately 12 feet wide by 80 feet long, would be installed in the intertidal and supratidal riprap zones of each bank, for a total of four piers per site. The proposed foundations would consist of drilled shafts socketed into rock, with each pier supported by approximately eight 8-foot diameter shafts (totaling 16 drilled shafts per quadrant). The drilled shafts, installed with steel casings, would be filled with reinforced concrete.

Construction of the new bridge piers could be conducted from floating shoreline barges moored to the temporary dolphins, from land, or from a temporary construction trestle over the footing and cofferdam. All work on the pier foundations and footings would be contained within the temporary cofferdams, and the steel sheeting to create the cofferdams would be installed via vibratory or impact hammering. The additional interior piers and abutments required per bridge (Piers 1, 2, 3, 6, and 7 at Sagamore Bridge and Piers 1 through 4 and Piers 7 through 14 at Bourne Bridge) would be installed on land, each with approximately six 5-foot diameter shafts or driven piles and would not affect the waterway.

It is anticipated that the approximately 600-foot-long main span arches would be fabricated and assembled off-site. MassDOT identified feasible sites in Massachusetts, including New Bedford and other locations in New England, for bridge arch fabrication. However, the selected Design-Builder would be responsible for identifying and contracting with one or more ports with the physical and operational features that would be most expedient for the construction and transport of the bridge arches and potential transport of other materials and equipment to the Sagamore and Bourne Bridges sites.

Concurrently with the construction of the bridge arches, construction of the piers and delta spans (the shorter approach spans located between the main span and the adjacent approach structures) would progress on site. After pier construction, the steel delta frames (the triangular steel support structures that connect the piers to the delta spans) would be erected by stick-build using land- and trestle-based cranes to lift and assemble the individual steel members on site.

Once the delta frames have been constructed, the completed main span bridge arches (without the deck concrete) would be floated into position on barges and lifted into place from the cantilever ends of the delta frames using strand jacks. The installation of the bridge arch would occur over the course of approximately three to five days per span, for a total of two three to five day closures per bridge.

The float-in of the main span arches would require full closure of Cape Cod Canal throughout the duration of the operation and could not be halted or paused once commenced. Bridge decks would be either cast-in-place concrete or precast panels.

Pier construction and steel erection could be conducted using a temporary construction trestle, land-based cranes, or floating shoreline barges, the latter of which would likely require temporary dolphins to reduce barge movement in the fast-flowing canal. Pier installation would require dredging.

At each bridge crossing, MassDOT is proposing to create a walkway/viewing platform at the top of the delta pier footing, which would be accessible from Canal Service Road.

6.4 Existing Bridge Demolition

The main spans of the existing bridges (bridge superstructure) are proposed to be cut and lowered onto construction barges and floated out of the canal to an off-site location for disassembly. Depending upon the Design-Builder's approach, the materials likely would be removed from the canal by barge for dismantling and/or recycling off site. The lowering of the main spans and float-out of the main spans would occur over the course of approximately three to five days per bridge. The float-out would require full closure of Cape Cod Canal and cannot be halted or paused once commenced.

After removal of the bridge superstructure, the existing abutments, piers, foundations, and retaining walls would be demolished and removed. At each bridge site, the existing two concrete pier columns in the intertidal and/or subtidal zones would be enclosed by a containment cell and demolished into the containment cell. Demolition of the above-water portions of the existing bridge piers may entail cutting or hoe-ramming. Demolition of the bases of the existing concrete bridge piers may include saw-cutting, hoe-ramming, and excavation of the canal bottom to expose the pier base. Demolition would be controlled to minimize debris falling into the canal outside the containment cell. Some demolished materials may be lifted away by crane, and some may be reduced to rubble in the containment cell. Rubble would be removed from the containment cell in the wet and transferred off-site by truck.

The existing pier substructure located under riprap would be removed to two feet below the riprap. At all other locations, the existing substructure would be removed to two feet below the finished grade/mudline. At each Program quadrant, the removal of the existing pier structure would restore an approximate 2,000 square foot area to open water for a total open water restoration of approximately 8,000 square feet.

6.5 Installation of Pier Protection System

After completion of bridge construction and bridge demolition, MassDOT would expand the existing/restored shoreline riprap and install a permanent riprap pier protection system on the three waterward sides of the pier bases supporting the main arch span (Piers 4 and 5 at Sagamore Bridge and Piers 5 and 6 at Bourne Bridge). The intent of the riprap pier protection system is to absorb potential vessel impacts, prevent direct impact of the vessel's bow or prow to the foundation or substructure, and prevent direct impact of the vessel's mast or deck house to the delta legs or superstructure.

The pier protection system would not encroach into the navigation channel. Only the base of the riprap footprint would extend into the 480-foot navigation channel boundary, but at an elevation lower than the allowable dredge overdepth.

It is anticipated that the dredging and fill equipment to install the pier protection system would temporarily encroach into the navigation channel during each day's work. Waterward of the pier protection system, the existing channel bottom would remain unchanged. **Attachment 4, Construction Schematics** presents schematics of the pier protection system in the Program quadrants.

6.6 Use of Construction Vessels

MassDOT estimates that the Program would require as many as four work barges and two delivery barges in each quadrant at any time during daily marine-based construction activities. Each work or delivery barge may require a dedicated tug. Up to four support launch vessels may also be required in each quadrant. Work barges are anticipated to be spud barges with six spuds per barge. **Table 6-1** provides the estimated number and sizes of the types of construction vessels required for day-to-day marine-based construction activities. **Attachment 4, Construction Schematics** includes schematics of the conceptual construction vessel layout at the Sagamore and Bourne Bridges sites.

Table 6-1. Proposed Vessels Employed in Day-to-Day Marine Operations for the Program

Description Program-wide at Any Time During Construction	Quantity Per Construction Quadrant[a]	Approximate Size
Work barges (6 spuds per barge)	4	40 feet x 80 feet
Delivery barges	2	60 feet x 180 feet
Tugs	6	65-foot to 105-foot overall length
Support launches	4	To be determined
Total Vessels per Quadrant	**16**	**40 feet x 80 feet and larger**

[a] Construction quadrants are: Sagamore North, Sagamore South, Bourne North, Bourne South.

Note: This table does not include the work vessels required for arch float-in and float-out operations.

In addition to the estimated 16 construction vessels per quadrant that would be used daily for in-water construction work, listed in **Table 6-1**, other vessels would be required for the float-in of replacement bridge main spans over three to five days and the float-out of the demolished existing bridge main spans over three to five days (total of six float-in or float-out operations for the entire Program). These short-duration activities would require a different configuration of barges and support vessels and would be separate from the daily marine-based operations. While the specific size and number of these work vessels have not yet been determined, MassDOT estimates that each float-in or float-out operation would require two large barges in the canal, with an approximate size of 60 feet x 160 feet each. Up to six tugs of the sizes identified in **Table 6-1** could be required to control the barges during float-in and float-out; up to eight support launches may also be used. Additional work barges of the

type identified in **Table 6-1** are expected to be required during float-in and float-out as well. The float-in and float-out operations are exclusive of day-to-day operations.

The selected Design-Builder would be responsible for identifying and contracting with one or more ports with the physical and operational features that would be most expedient for the transport of materials and equipment to the Sagamore and Bourne Bridges sites.

6.7 Dredge, Fill, and Management of Dredged Material

Dredge and fill would be required for the installation and removal of temporary work structures, (**Section 6.2**), new bridge construction (**Section 6.3**), existing bridge demolition and removal (**Section 6.4**), the installation of the pier protection system (**Section 6.5**), and ensuring an appropriate draft for construction support vessels (**Section 6.6**).

For most activities, dredging would take place outside of the navigation channel and would not affect navigation. MassDOT would coordinate with USACE and USCG in advance of instances where dredging equipment would encroach into the navigation channel.

MassDOT would prioritize the most practicable and expedient methods for dredging. The Design-Builder would be responsible for determining these means and methods, which may include the use of cutterhead suction dredges, clamshell excavation dredges, or a combination of these methods. As applicable, MassDOT would conduct dredging following USACE's excavation best management practices per the Engineering and Design, Dredging, and Dredged Material Management (Engineer Manual 1110-2-5205, 31 July 2015). The excavated sediment would be loaded onto material barges and modified to include side boards and containment fabric as a holding area, prior to its final disposition.

MassDOT is confirming the management of dredged material required for the Sagamore and Bourne Bridge Projects in coordination with the Massachusetts Department of Environmental Protection (MassDEP) and USACE, including developing a sediment testing plan. Depending upon the sediment sampling test results, project schedule, and agency coordination and approvals, management options for the Program's dredged material include:

- Disposing the material at the Cape Cod Bay Disposal Site, a USACE-managed open-water disposal site approximately 8 nautical miles southwest of Long Point, Provincetown
- Disposing the material at a MassDEP-approved upland site in Massachusetts
- Beneficially reusing the material at the Springhill Beach disposal site, a feeder berm located approximately 600 meters (2,000 feet) offshore of Springhill Beach in Sandwich.
- A combination of the above options.

MassDOT's sediment testing, management, and disposal methods would comply with MassDEP directives, including, as applicable, MassDEP's Interim Policy COMM-93-007: Dredged Sediment Reuse or Disposal.

7 Site Maintenance and Restoration

7.1 Water-Based Restoration

Following the completion of new bridge construction and existing bridge demolition and removal, the temporary work structures would be removed. To the maximum extent possible, the shoreline riprap and canal side slopes would be restored to pre-existing conditions. Additionally, as described in **Section 6.5,** MassDOT would install the pier protection system at the bridge sites. Waterward of the restored shoreline riprap and outside the riprap pier protection boundary, the impacted resource areas would be allowed to restore naturally.

MassDOT would confirm the extent of shoreline riprap and canal restoration in coordination with USACE. Following installation of the riprap, a hydrographic survey would be conducted to confirm that the dredging and installation of the pier protection system were completed in conformance with the allowable and permitted project footprints and depths.

7.2 Site Maintenance and Land-Based Restoration

7.2.1 Construction Period Site Maintenance

Throughout the duration of construction, MassDOT would incorporate mitigation measures into the Program to minimize adverse effects of land-based disturbance through permits, special provisions, and guidance documents, as well as its Standard Specifications for Highways and Bridges.

The Program's Construction Stormwater General Permit will contain multiple measures to reduce adverse effects from construction, including, among other control measures, the requirement to stabilize disturbed areas immediately when construction has ceased and will not resume for more than 14 days.

For trees that would not be cleared, MassDOT has issued extensive guidance for tree preservation, including plant protection fencing for public places and staging or other construction activity near desirable vegetation. As applicable, MassDOT will use plant protection fencing to minimize impacts to visual natural resources.

Section 4.6, Land Use, Zoning, and Community Cohesion, provides details on measures that will be implemented during construction to avoid, minimize, and mitigate impacts.

Following completion of the land-based construction activities, acquired areas that are not used for the State Highway Layout will be restored to pre-existing conditions to the maximum extent practicable. There will be instances where site restoration could occur following completion of that specific phase of the Program, such as Trowbridge Road and the new entrance to the Upper Cape Regional Technical High School in the Bourne South quadrant, where the proposed construction would be offline.

7.2.2 Permanent Land Restoration

MassDOT proposes to provide new landscaping and vegetation, including reforestation, for approximately 185.83 acres within the Program Limits to repair, restore, and enhance the landscape flanking the mainline highways, bridges, and local roads and connections. **Attachment 2, Proposed Conditions Plans** identifies the areas for landscape restoration and reforestation within the Program quadrants. **Attachment 5** provides landscaping plans for the Program quadrants based on preliminary design. **Section 4.6, Land Use, Zoning, and Community Cohesion,** provides details of the landscape approach.