Attachment #3

STATE OF CONNECTICUT

DEPARTMENT OF TRANSPORTATION
2800 BERLIN TURNPIKE, P.O. BOX 317546
NEWINGTON, CONNECTICUT 06131-7546

March 29, 2021

The Honorable Keith Hedrick
Mayor
City of Groton
295 Meridian Street
Groton, Connecticut 06340

Dear Mayor Hedrick:

Subject: Multiuse Path Feasibility Study
Rehabilitation of Bridge No. 03819, I-95 NB over Thames River
New London and Groton

The Department of Transportation (Department) is hereby forwarding you a copy of the *Gold Star Memorial Bridge Groton-New London, Connecticut, Northbound Bridge Multi-Use Path Draft Engineering Feasibility Study*, dated March 2021. The draft study was performed under Project No. 94-235.

This letter also serves as follow-up response to the city of Groton's (City) inquiry dated August 28, 2018 (enclosed), requesting an investigation into the possibility of adding a multiuse path on the northbound portion of I-95, carried by the Gold Star Memorial Bridge, and improving the existing sidewalk on its adjacent southbound sister bridge. An initial response letter from this Office was sent to the City dated October 3, 2018 (enclosed), in which the Department of Transportation (Department) agreed to perform a study and inform the City of any updates. Other parties that have shown interest in the study are the Southeastern Connecticut Council of Governments and local stakeholders.

The Department appreciates the City's patience through the development of the draft study, which involved several revisions and coordination efforts. Please be aware, due to the disadvantages of accommodating a multi-use path on the northbound span, the Department has initiated a feasibility study of the widening of the sidewalk on the southbound I-95 Goldstar Bridge for a multi-use path as an alternative to the addition of a multi-use path on the northbound bridge. Once the study of the southbound option is completed, the Department will conclude the most prudent and feasible option for a multi-use path across the Thames River to be carried by either the northbound or southbound Goldstar Bridge. The final determination is expected in September 2021.

Should you have any questions, please contact Ms. Priti Bhardwaj, Transportation Supervising Engineer, by email at priti.bhardwaj@ct.gov.

Very truly yours,

Bartholomew Sweeney, P.E.

Digitally signed by Bartholomew Sweeney, P.E.
DN: E=bartholomew.sweeney@ct.gov, CN="Bartholomew Sweeney, P.E.", OU=Department of Transportation, OU=Transportation Division Chief - Bridges, OU=Bureau of Engineering & Construction, O=State of Connecticut, L=Newington, S=Connecticut, C=US
Date: 2021.03.29 18:04:02-04'00'

Bartholomew P. Sweeney, P.E.
Division Chief of Bridges
Bureau of Engineering and Construction

Enclosures

cc: Mr. Timothy Snyder, Federal Highway Administration
Mr. James S. Butler, Executive Director, Southeastern Connecticut Council of Governments
The Honorable Patrice Granatosky, Mayor, Town of Groton
Mr. John Burt, Town Manager, Town of Groton
The Honorable Michael Passero, Mayor, City of New London

The Department of Transportation (Department) has completed the enclosed draft report for the *Gold Star Memorial Bridge Groton-New London, Connecticut, Northbound Bridge Multi-Use Path Draft Engineering Feasibility Study*, dated March 2021, under Project No. 94-235. PRIME AE Group, Inc. (Designer) prepared the draft report for the Department, under technical oversight by Close, Jensen, and Miller, P.C. (Consultant Liaison Engineer). The study was undertaken in response to requests by local stakeholders, including the City of Groton and the Southeastern Connecticut Council of Governments. The report is being kept in draft form until the completion of the southbound study, which is currently ongoing and expected to be complete in August 2021.

The study to date has focused on the engineering feasibility of accommodating a multi-use path (Path) on the northbound Gold Star Memorial Bridge (NB GSB). The purpose and need of the Path can be broadly described as a facility for enhanced local multimodal connectivity that aligns with the coordinated revitalization plans for the two local downtown areas of New London and Groton. Furthermore, it considered incorporation of the Path work into Phase 2 of the planned rehabilitation work for this bridge, which carries I-95 NB over the Thames River, from New London to Groton. Phase 2, which includes replacement of the existing deck, is currently planned for construction advertising in May of 2024. Phase 2 will be preceded by Phases 1A and 1B, which will primarily rehabilitate the steel superstructure of the truss spans and girder spans, respectively.

In summary, the feasibility study details three options for installation of the Path on the NB GSB, with some approach work geometric variations. It is important to note that the multi-use path options investigation was limited to alternatives within the curb-to-curb width limits of the bridge deck as the structural load capacity limitations of the bridge preclude widening of the bridge deck. The existing bridge girder and deck truss superstructure will be strengthened in the two Phase 1 projects to accommodate heavy permit vehicles that are currently routed from I-95 to the Mohegan Pequot bridge in Montville to bypass this bridge. The amount of strengthening required is substantial, but cannot provide capacity for widening. The northbound bridge originally constructed in the 1940s, was rehabilitated and widened in the 1970s, but still retains much of the older structural steel, which is of lower strength and less substantial than the adjacent 1970s southbound structure, which is currently being studied for widening to accommodate a wider multi-use path.

The three options studied for the NB GSB so far are listed below (see enclosed report for further details on each option):

- Option 1 (and Option 3)[1]: Reduce the number of lanes from 5 to 4 on the bridge to accommodate the Path;
- Option 2A: Reduce two outside lanes from 12 ft to 11 ft; reduce right shoulder to 2 ft;
- Option 2B: Reduce all 5 lanes to 11ft; reduce both shoulders to 5 ft each.

The above options all require either a reduction in the number of lanes carried by the structure or reductions in lane widths and shoulders. Thus, the Department has initiated the study of the feasibility and cost to incorporate a multi-use path on the southbound Goldstar Memorial Bridge which would widen the existing sidewalk on that structure. Upon completion of the study for

[1] At the Department's direction, an Option 3 was added after an initial draft report. Option 3's configuration is equivalent to Option 1 on the bridge, but conceptually widens I-95 NB to 3 lanes before the two entrance ramps west of the bridge. See study for further details.

widening the sidewalk on the southbound Goldstar Memorial Bridge, the Department will compare the pros and cons of each alternative against the purpose and need in order to determine the most favorable recommendation. This analysis will be included in the final draft, with a final determination expected in September 2021.

Gold Star Memorial Bridge
Groton-New London, Connecticut
Northbound Bridge Multi-Use Path
Draft Engineering Feasibility Study

Prepared for

Connecticut Department of Transportation

Project No. 94-235

Prepared by

PRIME AE Group, Inc.

March, 2021

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EXECUTIVE SUMMARY

Background

The towns of New London and City of Groton are separated by the Thames River but connected by the Gold Star Memorial Bridge. Both towns are currently focused on revitalizing their downtown areas and are anticipating the bridge to be a key connection to carry pedestrians and bicyclists between the two towns. Currently, the existing non-vehicular connection between the towns is a five-foot wide sidewalk on the southbound Gold Star Memorial Bridge. The narrow width creates potential conflicts between pedestrians, passing bicyclists and unauthorized motorized vehicles.

A future multi-use path connection across the Thames River, via the Gold Star Bridge, is listed in numerous plans as a critical regional and state connection for bicycle connectivity. A feasibility study for a new 8-foot-wide multi-use path has been proposed on the northbound bridge to improve regional bicycle connectivity, as well as improve local walking and biking, connectivity and safety between New London and Groton.

The Gold Star Memorial Bridge along I-95 over the Thames River is currently undergoing a major rehabilitation to strengthen its girders and replace its deck. Rehabilitation of the southbound bridge was completed in 2019 along with the replacement of the related sidewalk. The sidewalk was not able to be widened at that time due to the need for extensive structural modifications. The northbound bridge is currently in the design phase of its rehabilitation and it is an opportune time to determine the feasibility of a shared use path along its span.

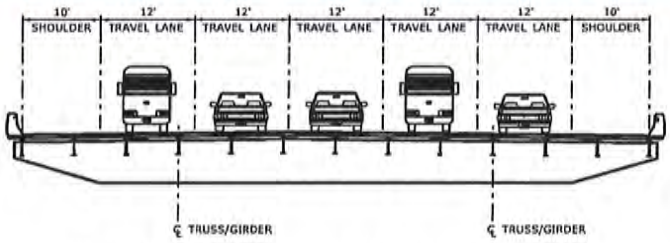
The Connecticut Department of Transportation (CTDOT) initiated this study to evaluate the feasibility of installing a multi-use path on the northbound Gold Star Bridge between New London and Groton. This connection would be accomplished by converting a lane on the northbound I-95 bridge or narrowing lanes and repurposing the existing shoulder for a protected multi-use path. In addition, connections to the path would be required at each end of the bridge. Four options for a protected multi-use path along northbound I-95 with connections on either side of the bridge have been evaluated. The following sections of this report examine the capacity and safety implications of each option on the bridge.

Concept Development

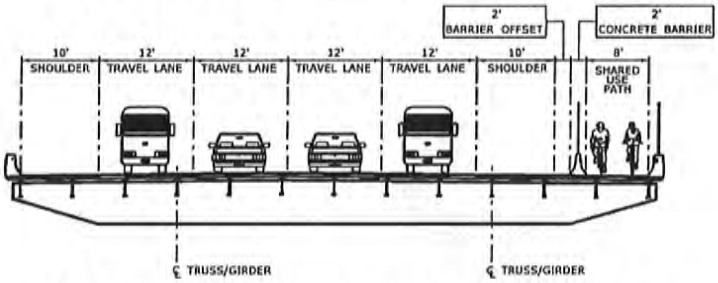
The study developed concepts to reconfigure I-95 travel lanes to create space to accommodate an 8-foot-wide pathway on the bridge, as well as alternatives for each connection to the bridge on each side of the river. In total, eight options were developed, four for the reconfiguration of I-95, two for the multi-use path connection on the west terminus, and two for the multi-path connection on the east terminus. The following table summarizes these options. Figure i shows the options examined.

Table i: Study Concepts

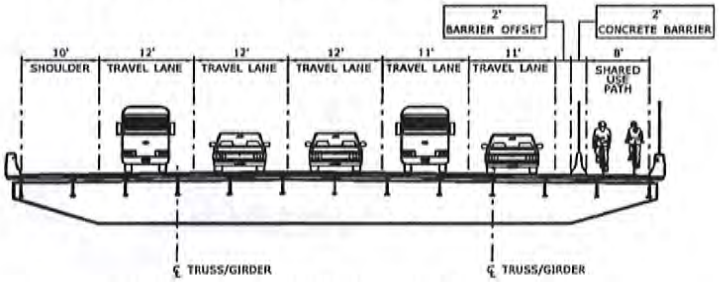
Project Segment	Concept Name	Description
Northbound I-95	Option 1	**Reduce from Five Lanes to Four Lanes with 10-foot Left and Right Shoulders.** Reduce number of lanes from 5 to 4. Right lane becomes an acceleration lane that ends on the bridge. Right shoulder is narrow (2± feet) while acceleration lane is present, then shoulder becomes 10 feet after acceleration lane drops.
	Option 2A	**Maintain Five Lanes with 10-foot Left Shoulder and 2-foot Right Shoulder.** Maintain five lanes across the bridge. Three left lanes remain 12 feet wide, two right lanes reduced from 12 feet to 11 feet wide. Maintain 10-foot left shoulder, reduce right shoulder from 10 feet to 2 feet.
	Option 2B	**Maintain Five Lanes. Reduce all lane widths to 11 feet, maintain left shoulder at 10 feet, reduce right shoulder to 5 feet.** Reduce all lane widths from 12 feet to 11 feet. Maintain existing left shoulder at 10-foot width. Reduce right shoulder from 10 feet to 5-foot width.
	Option 3	**Reduce from Five Lanes to Four Lanes with 10-foot Left and Right Shoulders. Two right lanes will serve as dedicated on-ramp lanes.** I-95 northbound will have two through lanes approaching the bridge rather than the current three lanes. This will be accomplished by eliminating the lane addition that opens the third lane of traffic on I-95, between Vauxhall St. Ext. and Colman Street. Add one lane at Briggs St/Frontage Rd On-Ramp. Add One lane at Water St/Huntington St. On-Ramp.
West Terminus	Concept West-S	***S***-Curve Design with 5% max longitudinal slope.
	Concept West-R	***R***oundabout Design with 8% max longitudinal slope.
East Terminus	Concept East-R	Alignment along off-ramp ***R***oadway.
	Concept East-S	Alignment along ***S***ide slope of off-ramp.



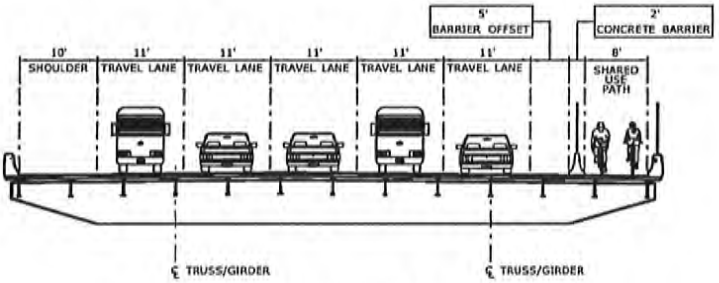
I-95 NORTHBOUND - EXISTING CONDITIONS



I-95 NORTHBOUND - OPTION 1 & OPTION 3



I-95 NORTHBOUND - OPTION 2A



I-95 NORTHBOUND - OPTION 2B

Figure i –Study Options

Impacts and Costs

Three of the five through lanes on the bridge serve mainline I-95. The two other lanes are added to the bridge from on-ramps to I-95 shortly before entering the bridge. Overall, reduction in the number of lanes

along the bridge from five lanes to four will result in a decrease in the level of service[1] from LOS C to LOS D in design year 2057. Level of service D is the lowest or worst acceptable level of service recommended for a planning level study.

Predicted Safety: The Highway Safety Manual analysis procedures predict that Option 1 will yield the lowest number of severe and fatal crashes in comparison to the other alternatives. A slight increase in the overall number of crashes is projected compared to Options 2A and 2B, but a reduction in the severity of the crashes is projected which may be attributed to the provision of full shoulder widths. The increase in crashes compared to the no-build is approximately one additional crash per year examined.

Environmental Impacts: No major environmental, utility or property impacts have been identified. It is anticipated that moderate impacts will need to be addressed for storm water management (SWM) facilities as part of the project, primarily because of additional impervious pavement.

Vehicular Level of Service: Capacity analysis was conducted for the existing conditions in the year 2019, build year 2027, and the year 2057. The analysis results are summarized in the table which follows.

The results show that the bridge currently operates at level of service (LOS) B. The impact of each option is shown. Options 1 and 3, which require removal of a lane along the bridge, will be most impactful and result in the lowering of the level of service to LOS D. Options 2A and 2B have more moderate impacts reducing the level of service to LOS C. Level of service D is generally the lowest acceptable level of service for planning activities.

[1] Level of Service (LOS) is a qualitative measure that describes operational conditions within a traffic stream or at an intersection and reflects the perception by drivers and other roadway users. Principal considerations are factors such as speed and travel time, delay, density, freedom of maneuver, traffic interruptions, comfort, convenience and safety. Current engineering practice defines six (6) Levels of Service (A-F) with "A" representing best operating conditions, and "F" representing worst conditions. Level of Service "D" is generally considered as the minimum acceptable standard for planning and design purposes.

Table ii – Capacity Analysis Summary

	Levels of Service								
	AM PEAK HOUR			PM PEAK HOUR			WE PEAK HOUR		
	LOS	Density (pc/mi/ ln)	Volume to Capacity Ratio	LOS	Density (pc/mi/ln)	Volume to Capacity Ratio	LOS	Density (pc/mi/ln)	Volume to Capacity Ratio
2019 – Existing Condition	***B***	***13.8***	***0.42***	***B***	***16.8***	***0.52***	***B***	***17.9***	***0.55***
2027 No-Build Condition	***B***	***15.4***	***0.47***	***C***	***18.6***	***0.56***	***C***	***19.5***	***0.59***
2027 – Option 1	C	19.4	0.59	C	24.2	0.71	C	25.8	0.74
2027 – Option 2A	B	15.9	0.48	C	19.1	0.57	C	20.0	0.60
2027 – Option 2B	B	15.8	0.48	C	19.0	0.57	C	20.0	0.60
2027 – Option 3	C	19.4	0.59	C	24.2	0.71	C	25.8	0.74
2057 No-Build Condition	***B***	***17.9***	***0.55***	***C***	***22.0***	***0.66***	***C***	***23.4***	***0.69***
2057 – Option 1	C	23.2	0.68	D	30.1	0.82	D	32.7	0.86
2057 – Option 2A	C	18.4	0.55	C	22.5	0.66	C	23.9	0.69
2057 – Option 2B	C	18.3	0.55	C	22.5	0.66	C	23.8	0.69
2057 – Option 3	C	23.2	0.68	D	30.1	0.82	D	32.7	0.86

*HCS does not allow for different lane widths, Option 2A modeled using 5 lanes with 11' width and 2' shoulder. Capacity analysis on bridge only and does not consider the approach roadways.

Bridge Structural Impacts: The most significant impact of a project to incorporate the multi-use path will be the structural modifications needed to the existing bridge. A portion of the existing bridge deck is constructed with a 6% cross slope. The maximum cross slope to comply with the requirements of the Americans with Disabilities Act (ADA) is 2%. To meet this requirement, approximately 12,000 square feet of the existing bridge deck will need to be removed and replaced with new steel stringers and steel floor beam modifications. This work is currently beyond the requirements of the current bridge rehabilitation.

Temporary Traffic Control and Freeway Traffic Incident Management: In addition to the impacts noted above, any plans to implement lane reductions as part of future temporary traffic control measures for maintenance and inspection would be severely limited as the levels of service and queueing along the bridge would be impacted significantly. Options for freeway incident traffic management would also be impacted by a reduction in the number of lanes on the bridge.

Costs: Programming-level costs for the construction of the multi-use path project can be found in the table below. Costs are anticipated to be approximately $4.33M for the pathway construction approaches to the bridge as shown in Table iii. Approximately $9.00M is required to place the pathway on the bridge. Further investigation is required to identify the costs of roadway reconstruction needed to accommodate the multi-use path, however, a concept-level approximation of $4M to $8M was developed. The costs for the entire project are estimated to be $17.3 Million to $21.3 Million.

Table iii - Summary of Costs

DESCRIPTION	COST
MULTI-USE PATH CONSTRUCTION AT WEST TERMINUS - HUNTINGTON ST. ON-RAMP	$ 1,700,000
MULTI-USE PATH CONSTRUCTION AT EAST TERMINUS - BRIDGE ST. EXIT RAMP	$ 2,630,000
PROTECTIVE BARRIERS AND PROTECTIVE FENCE ACROSS BRIDGE	$ 3,500,000
BRIDGE STRUCTURE MODIFICATIONS (See Note)	$ 5,500,000
SUBTOTAL – APPROACHES AND BRIDGE	**$ 13,330,000**
I-95 NORTHBOUND ROADWAY LANE MODIFICATIONS	$4 - 8 MILLION
Project Estimate – Total: $17.3M TO $21.3M	

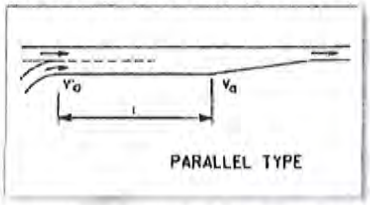
Note: Structure modification cost assumes work is coincident with project to replace the bridge deck.

Key Challenges

Project challenges identified by this study will require further evaluation during preliminary engineering and final project design. These challenges may have operational and safety impacts on I-95 due to the reconfiguration of the lanes. The following is a list of these challenges.

Challenge #1: Short Merge Length at the Huntington Street On-Ramp

To fit the pathway on the bridge one lane will need to be removed or the width of the travel lanes and shoulders will need to be reduced. Option 1 removes a lane. To transition the Huntington Street on-ramp into the right lane of the bridge for Option 1, an acceleration lane will be needed. The minimum length for the acceleration lane required to comply with AASHTO is 1220 ft. This is based on a ramp speed of 25 mph entering the freeway at a speed of 70 mph. In addition, a taper of length between 600 ft and 840 ft is required to transition the on-ramp into the travel lane along I-95. The available space for this transition is just over 130 ft. In addition, due to the peak hour volumes on the entrance ramps, changing the current entrance ramp lane-add to a merge could introduce operational issues.



Option 3 attempts to address this issue by reducing the number of lanes along I-95 in advance of the bridge and maintains a dedicated lane for each on-ramp. I-95 would be reduced to two lanes in advance of the Briggs Street Ramp and each ramp would enter into a dedicated lane as currently exits.

Challenge #2: Minimal Width of Pathway on Bridge

The pathway across the bridge is limited to a maximum width of 8 feet due to the distribution of the load of the barrier and the path live load on the bridge structure. This width of 8 feet is the minimal acceptable width for a 2-way multi-use pathway based on AASHTO Bicycle Guidelines. AASHTO recommends 11 feet and a preferable 14-foot pathway width for heavily travelled pathways. The barriers on both sides of the pathway will further reduce the comfort and the operational effectiveness of the pathway. The minimal passing space between two bicycles passing each other will leave little room for error, increasing the risk of bike crashes on the pathway.

Challenge #3: Sub-standard Pathway Design for Bicycles on New London side of Bridge

The pathway approach on the west (New London) side of the bridge is not able to accommodate an AASHTO compliant pathway for bicycles. AASHTO recommends maximum longitudinal slopes of 5% for bicycles and minimum curve radii of 27 ft to accommodate bicycle speeds of up to 12 mph. Slopes will reach 8.3% and curve radii will be 17 ft. This includes sufficient ADA compliant landing areas that are evenly spaced along the pathway. The limited right-of-way available and the grade differential between the bridge and the sidewalk does not allow AASHTO design requirements to be met. Bicyclists will be required to travel less than 12 mph, on the descent from the bridge to the sidewalk, on slopes that approach 8%.

Challenge #4: Reconstruction of the Bridge Deck Cross Slopes

Leading into the bridge there is a crown on the roadway that separates the 2 left lanes from the 2 right lanes. On the bridge there is a curve that is superelevated with the roadway around this crown to a maximum cross slope of 6%. This slope runs the full width of the roadway, including the shoulder, where the pathway is proposed. This 6% cross slope is unacceptable for ADA compliance which cannot exceed 2%. To correct this the roadway cross slopes along I-95 will need to be reconstructed on the bridge.

Challenge #5: Elimination of Dual Exit Lanes at Exit 85

Exit 85 is a two-lane exit with one exclusive and one shared exit lane. Of the five existing lanes on the bridge, four lanes continue past the exit along northbound I-95. In the proposed condition only four lanes would be carried across the bridge and only 1 lane will exit at Exit 85. The impacts to I-95 as a result this reduction would need to be further evaluated as impacts on the downstream surface street nodes and the downstream interchange which are outside the project limits would also need to be considered. In addition, an Interstate Access Modification will require approval from the Federal Highway Administration (FHWA) for this lane arrangement.

Challenge #6: Design Exceptions and FHWA Approval

For Options 2A & 2B, adding the pathway to the bridge at the Huntington Street on-ramp will result in substandard shoulder widths, either 2-foot or 5-foot outside right shoulder on I-95. Based on the posted speed of the roadway, this shoulder is not AASHTO compliant and would require a design exception for the section of road where the ramp acceleration lane is proposed.. In addition, an Interstate Access Modification approval from the Federal Highway Administration (FHWA) may be required for this lane arrangement.

Challenge #7: Limited Options for Temporary Traffic Control and Incident Management

There are currently five lanes with two ten-foot shoulders along the bridge. The current lane configuration allows easy use of the left and/or right shoulder during temporary traffic control or incident management. Removal of one or both shoulders or narrowing the shoulders to a width which is not viable for vehicles to travel will limit options for both temporary traffic control and freeway incident traffic management. Option 2 reduces the shoulder width throughout the bridge. Option 1 will reduce a portion of the shoulder width, unless the number of approach lanes to the bridge can be reduced prior to reaching the Huntington Street on-ramp. Option 3 reduces the number of through lanes on the west approach to the bridge from three to two.

Summary

The study has included the evaluation of several alternatives to providing the multi-use path on the northbound Gold Star Memorial bridge.

Current freeway design standards recommend full width shoulders and full width lanes on the bridge, which are included with two of the options: Option 1 and Option 3.

Option 2A and 2B maintain 5 lanes of traffic with the lanes narrowed to 11 feet, and the shoulders narrowed to 2 to 5 feet. These options minimize traffic impacts by maintaining all travel lanes, but the lane and shoulder widths are substandard and increase risk to motorists, limit options during emergencies and maintenance activities.

Each alternative presents several technical challenges as described above, however, it appears that the most significant impact will be on reduction of highway traffic capacity due to the need to reduce the number of lanes on the bridge from five to four with implementation of the most reasonable alternatives. The operational and geometric issues that the Department should carefully consider before moving forward with the implementation of the multi-use path are summarized as follows:

- Safety on mainline I-95 due to shifting the travel lanes and reduction of travel lanes which will

result in higher density of traffic in the remaining lanes. This will be especially acute during peak summertime travel periods.

- Roadway geometric considerations, particularly, the impacts to the entrance ramp from Huntington/Water Sts. in New London and the lane constrictions of the Exit 85 ramp in Groton. Developing the costs of these modifications on the approach roadways was beyond the scope of this study, but, it is likely that those costs will be in the $4-8 Million range.

1 INTRODUCTION

Project Background

The towns of New London and Groton are separated by the Thames River and connected by the Gold Star Memorial Bridge. Both towns are simultaneously focused on implementing economic revitalization plans, and both point to pedestrian and bicycle access across the bridge as a critical component of the revitalization effort. A 5-foot-wide sidewalk with 4-foot wide pinch points on the southbound bridge is the non-motorized vehicle connection between New London and Groton. No sidewalk or multi- use path exists on the northbound bridge. It is expected that the revitalization of the two towns will increase non-motorized travel demand between the communities.

Pedestrians, bicyclists, and moped riders frequently share this 5-foot wide path on the southbound Gold Star Memorial Bridge often resulting in conflicts between users. In August of 2018, the Mayor of Groton made a formal request to the Connecticut DOT (CTDOT) to investigate expanding the existing sidewalk as part of the bridge rehabilitation project. At the time, it was found to be infeasible to expand the scope of the southbound bridge project. However, CTDOT agreed to perform a feasibility study for a new multi-use pathway on the northbound bridge. The rehabilitation of the northbound bridge is currently in the design phase, therefore, if the new pathway is found to be feasible it may be incorporated into the rehabilitation project.

Scope of Feasibility Study

The purpose of this study is to determine how a new multi-use pathway on the northbound Gold Star Memorial bridge could be accomplished and the benefits, impact, costs and constructability of the improvements. The study reviews traffic and safety impacts to the operations on the bridge and impacts to the travel lanes, roadside and ramps approaching the bridge.

The findings and conclusions of this feasibility study will determine if a more detailed study and design is warranted. If warranted, the follow-on study will further the design of the alternatives, solicit community and stakeholder input and recommend a preferred alternative. This study seeks to answer the following questions:

I. Can a barrier and multi-use path be installed along the Gold Star Memorial Bridge and will the resulting levels of service remain within acceptable limits?
II. Will reconfiguration of the northbound bridge travel lanes result in unacceptable safety impacts?
III. Can the northbound bridge accommodate the weight of an additional barrier that will serve to protect the multi-use path from the adjacent traffic flow?
IV. Can a feasible pedestrian/bicycle connection be made between the sidewalks along Huntington Street and/or State Pier Road up to the northbound I-95 on-ramp?
V. Can a feasible bicycle/pedestrian connection be made between the sidewalk along the Bridge Street off ramp and the shoulder of northbound I-95?

2 EXISTING CONDITIONS & DESIGN STANDARDS

The Gold Star Memorial Bridge

The Gold Star Memorial Bridge consists of a pair of steel truss bridges with a total of ten travel lanes crossing the Thames River in the northbound and southbound directions of I-95. It is the state's longest bridge and the only bridge accessible to non-motorized vehicles for travel between New London and Groton (See Figure 1). The next closest crossing (excluding ferry service) is 11 miles away in Norwich, CT.

The southbound bridge has an existing sidewalk; the northbound bridge does not have a sidewalk. Both the northbound and southbound bridge carry five lanes of traffic each with an average daily traffic of 123,000 vehicles.

Figure 1: Gold Star Memorial Bridge Location Map
(Source: Google Maps)

Existing Sidewalk Network

The sidewalk on the I-95 southbound bridge was built in the 1970s and underwent deck repairs at certain locations under the recent southbound bridge rehabilitation. Widening of the existing 5-foot wide sidewalk was beyond the scope of that rehabilitation project. Several streets surrounding the bridge have existing sidewalks that provide possible connection points for the proposed improvements. This includes Huntington Street and State Pier Road on the New London side of the bridge, and the off-ramp to Bridge Street on the Groton side.

On the west side of the bridge in New London, the existing sidewalk connection leads to Bailey Circle (See Figure 3). The proposed connection to the bridge will be farther south, on the opposite side of I-95. Two options exist for tying into this sidewalk network: Huntington Road or State Pier Road (See Figure 2).

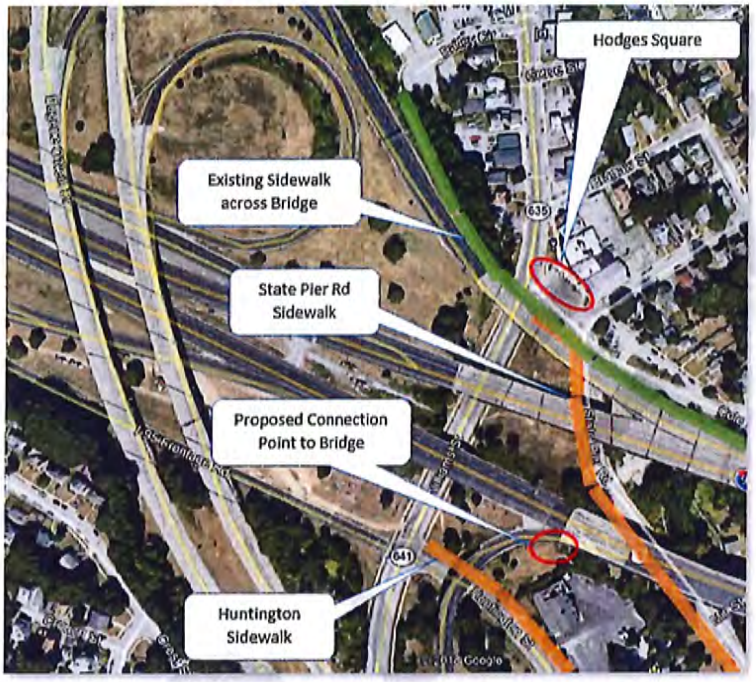


Figure 2: Sidewalk Connections in New London
(Source: Google Earth)

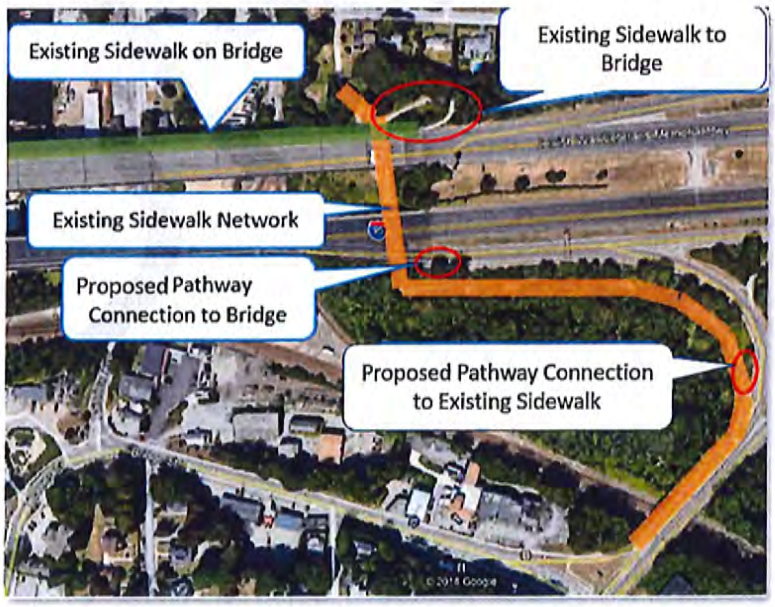


Figure 3: Sidewalk Connections in Groton
(Source: Google Earth)

Establishing Design Standards

ADA Standards

Compliance with the American with Disabilities Act (ADA) is required for all federally funded projects. In general, the ADA regulates facility slopes, widths, maneuvering clearances and heights to ensure people with disabilities can utilize facilities independently, as a person without disabilities would. The guiding document for ADA compliance for USDOT funded projects is the 2006 ADA Accessibility Guidelines (ADAAG). The ADAAG covers several aspects of design. At this stage, the following design requirements are assumed for ADA compliance:

- 2% maximum pathway cross-slope
- 5% maximum pathway normal walking surface (ramps have additional requirements)
- 8.3% maximum ramp slope
- 5-foot minimum pathway width

2012 AASHTO Bicycle Standards

The American Association of Highway Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities 2012 (4th Edition) is currently the national recognized standard for bicycle facilities, and as such, was used to guide the design of the options.

The 2012 AASHTO Bicycle Guidelines recommend the following:

- A maximum cross slope of 2%,
- A maximum longitudinal grade of 5%,
    - When terrain is challenging, the guideline will allow up to 11% grades for short sections no longer than 50 ft in length. It will also allow 8% slopes for up to 300 ft in length.
- A minimum design speed of 12 mph, preferred 20 mph on downhill sections,
    - This translates to a minimum pathway curve radius of 27 ft, with a preferred of 74 ft on downhill sections.
- Pathway width is:
    - 11-ft recommended width,
    - 8-ft minimum width with 15-ft preferred.

Moped Accommodations

The proposed multi-use path is intended to serve pedestrians and bicycles traversing the Thames River between New London and Groton. It has been noted in news articles that mopeds also use the sidewalk on the southbound bridge to cross the river. No standards exist for moped design, however, under Connecticut law mopeds are considered and treated as "motor driven bicycles". In general, Connecticut law prohibits motor driven bicycles from using sidewalks and multi-use pathways. There are exemptions that allow small, motorized vehicles under a certain size engine to use bicycle facilities. For purposes of this study, it is assumed that moped use will be prohibited on the multi-use pathway.

Barrier Height

The barrier between the multi-use path and I-95 roadway traffic should conform to AASHTO Roadside Design Guidelines. The recommended barrier is typically a 43-inch-high barrier. To ensure pedestrians do not scale the barrier and enter the roadway, a chain link fence or similar measure is recommended to be installed on top of the barrier.

Selecting Design Standards

The pathway across the bridge is limited to a maximum width of 8 feet due to the distribution of the load of the barrier and the path live load on the bridge structure. Beyond the bridge it shall be designed to the recommended AASHTO width where practicable.

The limited right-of-way and existing topography at the West Terminus present several challenges to conform to the guidelines for maximum grades. Smaller than desirable radii are also required along the pathway to reach the necessary grades. It may not be possible to conform to both the recommended maximum grade and the horizontal curve requirements in the AASHTO bicycle guidelines. Two options for the West Terminus will be considered. One option will seek to meet the desired grade, while the other will seek to minimize the number of substandard horizontal curves along the path. All options will meet ADA requirements for longitudinal grade and cross slopes.

3 DEVELOPMENT OF CONCEPTS

Concepts for the multi-use path were developed for each end of the bridge: The West Terminus and the East Terminus. The West Terminus is on the New London side of the bridge, and the East Terminus is on the Groton side. Two options were developed for each side of the bridge. They are listed in the table below as Concept West-S (S-Curve), West-R (Roundabout), East-R and East-S.

Along I-95, four options have been developed for the reconfiguration of the roadway lanes to accommodate the pathway across the bridge. These options are listed in the table below as Option 1, Option 2A, Option 2B and Option 3.

All supporting drawings for the concepts can be found in Appendix A. Options 1 and 3 are identical in nature except that I-95 northbound is reduced to two lanes in advance of the Gold Star Bridge and each on-ramp is added as a separate lane for a total of four lanes on the bridge. The impacts are similar. Estimates for each can be found in Appendix B. Photos of existing field conditions can be found in Appendix C.

List of Conceptual Alternatives

This study investigated conceptual alternatives for 3 different segments of the project area: The Gold Star Bridge (Northbound I-95), the West Terminus of the bridge and the East Terminus of the bridge. The options developed for I-95 are expressed with a numerical system, while the options for the termini are designated with "S" or "R". The following table summarizes each of the options.

Table 1 – Study Concepts

Project Segment	Concept Name	Description
Northbound I-95	Option 1	**Reduce from Five Lanes to Four Lanes with 10-foot Left and Right Shoulders.** Reduce number of lanes from 5 to 4. Right lane becomes an acceleration lane that ends on the bridge. Right shoulder is narrow (2± feet) while acceleration lane is present, then shoulder becomes 10 feet after acceleration lane drops.
	Option 2A	**Maintain Five Lanes with 10-foot Left Shoulder and 2-foot Right Shoulder.** Maintain five lanes across bridge. Three left lanes remain 12 feet wide, two right lanes reduced from 12 feet to 11 feet wide. Maintain 10-foot left shoulder, reduce right shoulder from 10 feet to 2 feet.
	Option 2B	**Maintain Five Lanes. Reduce all lane widths to 11 feet, maintain left shoulder at 10 feet, reduce right shoulder to 5 feet.** Reduce all lane widths from 12 feet to 11 feet. Maintain existing left shoulder at 10-foot width. Reduce right shoulder from 10 feet to 5-foot width.
	Option 3	**Reduce from Five Lanes to Four Lanes with 10-foot Left and Right Shoulders. Two right lanes will serve as dedicated on-ramp lanes.** Reduce I-95 northbound to two lanes prior to the Briggs Street on ramp. Remove left lane added between Vauxhall Street Ext and Colman Street. Maintain two lanes along I-95 adjacent to the Vauxhall street/I-95 Frontage Road. Total three lanes. Drop I-95 Frontage Road at existing off-ramp. Add one lane at Briggs Street/Frontage Road On-Ramp. Add one Lane at Water Street/Huntington Street On-Ramp.
West Terminus	Concept West-S	***S***-Curve Design with 5% max longitudinal slope.
	Concept West-R	***R***oundabout Design with 8% max longitudinal slope.
East Terminus	Concept East-R	Alignment along off-ramp ***R***oadway.
	Concept East-S	Alignment along ***S***ide slope of off-ramp.

Northbound I-95 Lane Configuration Options

In the existing conditions five 12-foot-wide travel lanes and two 10-foot-wide shoulders are provided on the northbound bridge. The shared-use path is proposed to be 8 feet wide and located adjacent to the right parapet of the northbound bridge. The width of the bridge is not being changed as part of the

rehabilitation; thus, reductions in the widths of the travel lanes and shoulders will be required to accommodate the path.

Four alternatives were developed for the shared-use path. Diagrams of each can be found in the figures below.

Option 1 (Figure 5): This alternative eliminates the rightmost travel lane (lane 5), providing for a 10 feet right shoulder, 2 feet barrier offset, 2 feet wide concrete barrier, and an 8 feet wide shared-use path. On the western end of the bridge, the width of the two rightmost lanes (lanes 4 and 5) will be reduced to 11 feet wide, and lane 5 will taper into lane 4. At this point, lane 4 will taper back to 12 feet wide. On the eastern end of the bridge, Exit 85 may need to be reconfigured from a two-lane exit ramp to a one-lane exit ramp. Further evaluation may be required.

Option 2A (Figure 6): This alternative reduces the widths of the two rightmost travel lanes (lanes 4 and 5) from 12 feet to 11 feet wide. Unlike Option 1, lane 5 is kept for the entire length of the bridge, allowing for Exit 85 to remain a two-lane exit ramp. These reduced lane widths provide for a 2 feet barrier offset, 2 feet wide concrete barrier, and an 8 feet wide shared-use path, but no right shoulder.

Option 2B (Figure 7): This alternative reduces all lane widths on the bridge from 12 feet to 11 feet wide. These reduced lane widths provide for a 5 feet shoulder/barrier offset, 2 feet wide concrete barrier, and an 8 feet wide shared-use path. However, the reduction in lane widths requires the roadway crown to be shifted to move it out of vehicle wheel paths.

Option 3 (Cross Section Identical to Figure 5/Option 1): This alternative may be considered a sub-option to Option 1. It reduces the number of lanes approaching the bridge on the mainline from three to two by removing the addition of the third inside through lane just prior to the on-ramp from Vauxhall Street. The scope of this study did not include this portion of I-95 and therefore figures are not provided, and benefits and challenges are not identified. The impacts are similar to that of the temporary construction conditions expected for the Gold Star Bridge rehabilitation project. Therefore, some estimates on levels of service along the bridge were determined. These may be found in Section 4 of this report, Table 2.

The existing conditions and these alternatives are illustrated in Figures 4 through 7 on the following pages.

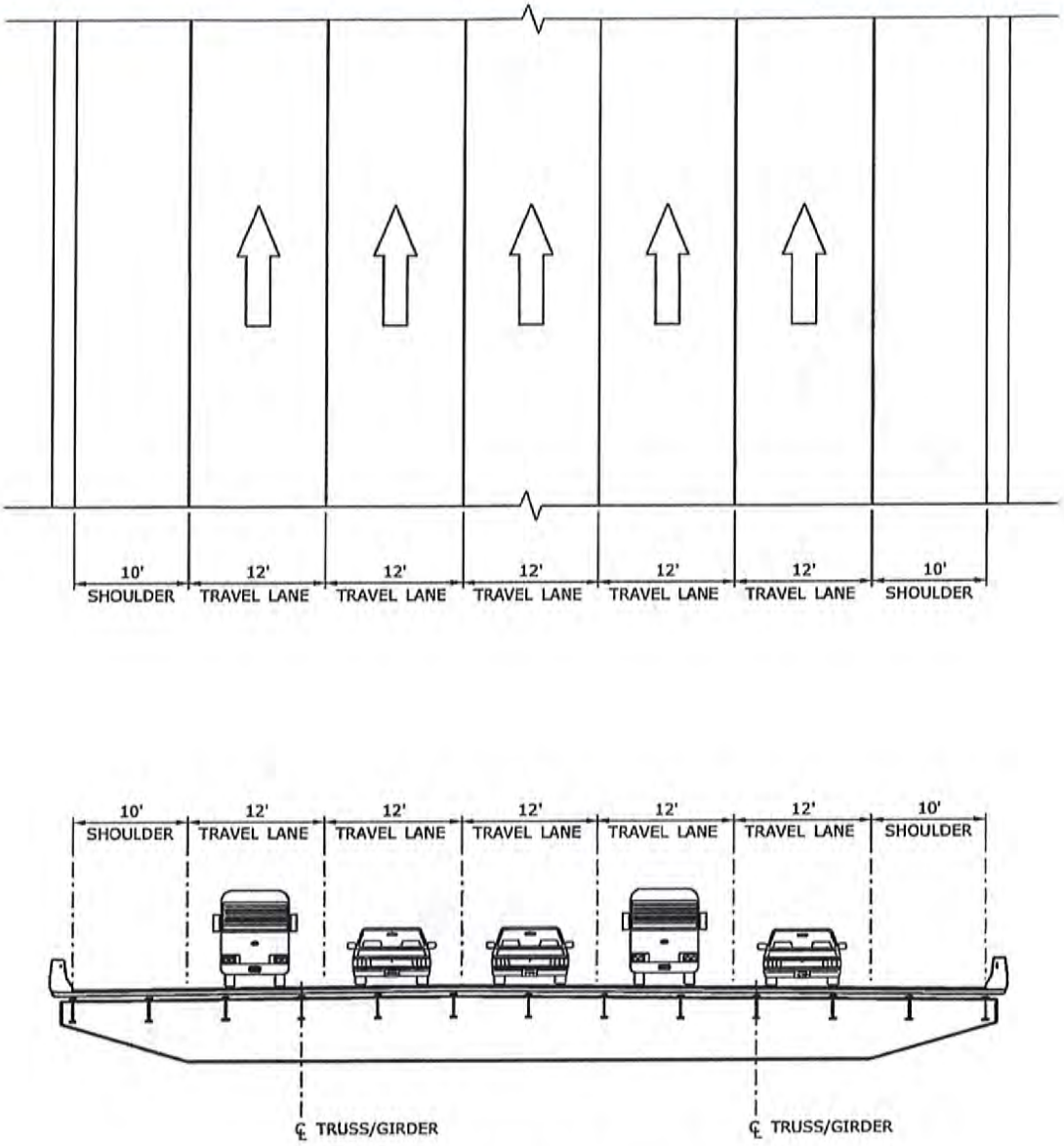


Figure 4: Northbound I-95 Existing Conditions

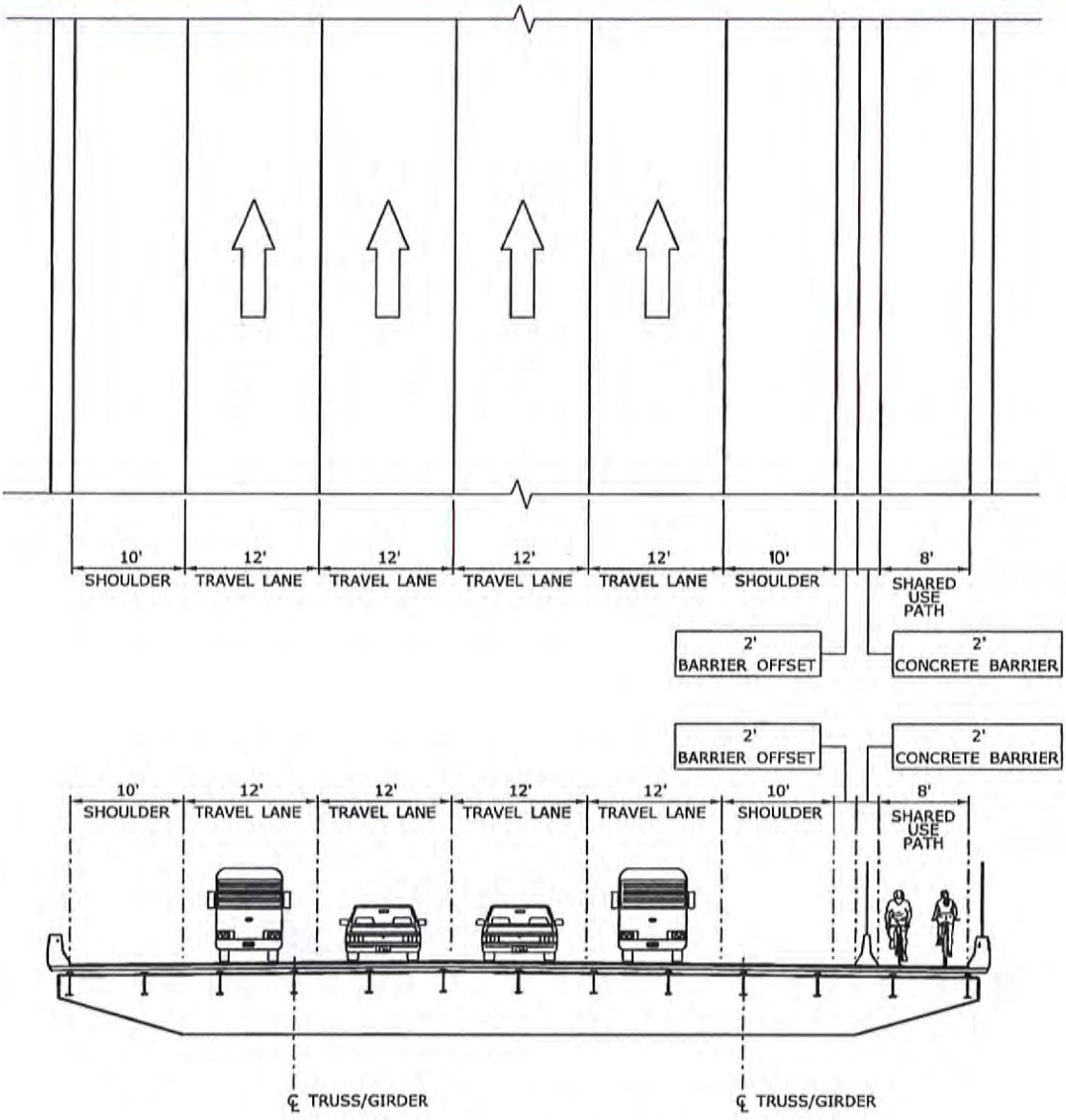


Figure 5: Northbound I-95 - Option 1 & Option 3

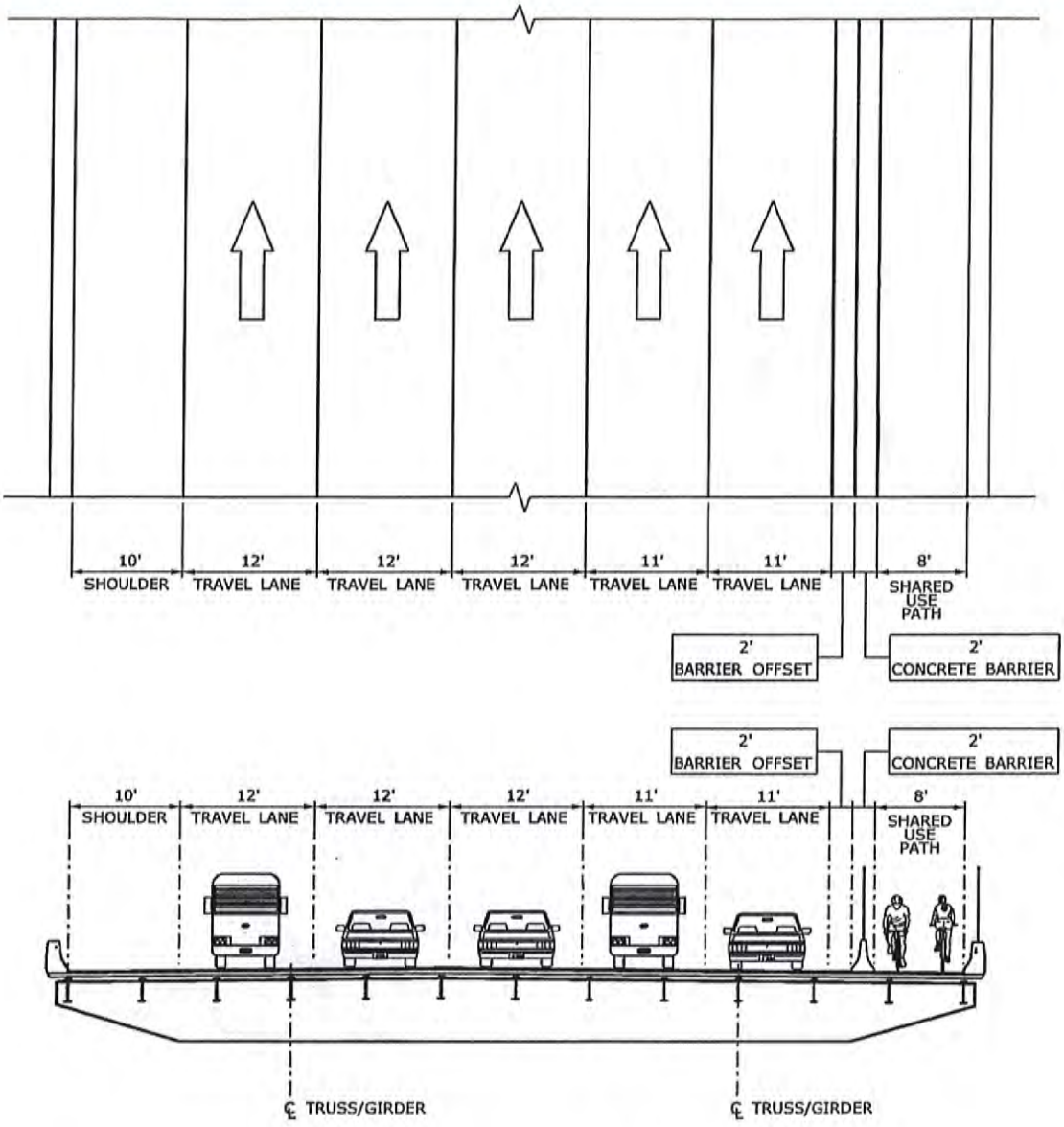


Figure 6: Northbound I-95 Option 2A

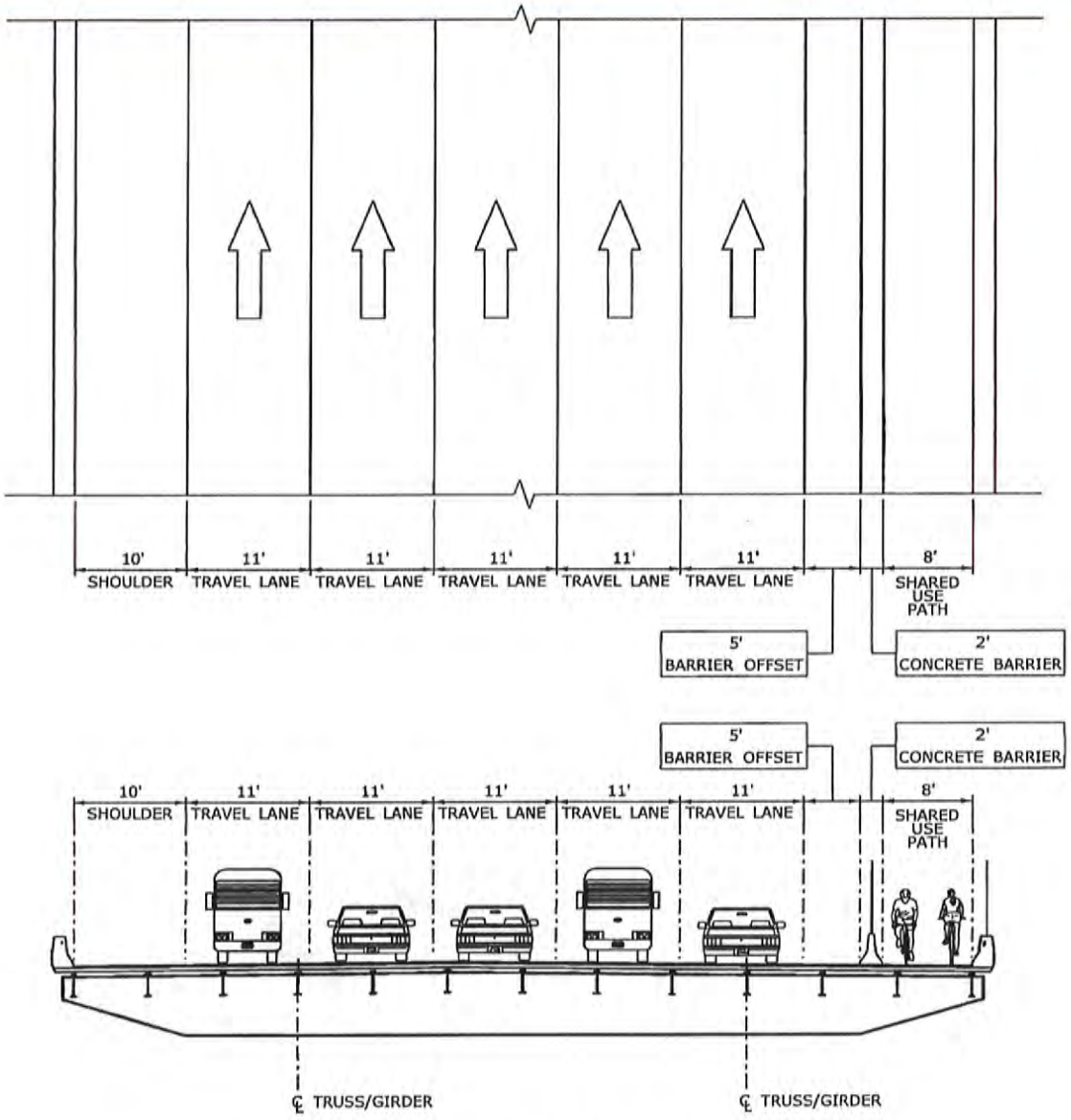


Figure 7: Northbound I-95 - Option 2B

The proposed multi-use path across the Gold Star Memorial Bridge on I-95 northbound must be included within the existing width of the bridge. To accommodate the multi-use path, reductions to the existing lane width and shoulder widths are necessary as shown in Options 1 thru 3. Options 1 and 3 find space on the bridge by reducing the number of travel lanes from five to four. Options 2A and 2B find space on the bridge by reducing the width of the lanes and the width of the right shoulder. Option 2A reduces the width of 2 lanes and provides a 2-foot right shoulder, while Option 2B reduces the width of all lanes and provides a 5-foot right shoulder.

Typically, the minimum width for a two directional multi-use path, with room for passing, is 11-foot with 14-foot being most desirable. Due to the restricted width of the bridge and load restrictions on the bridge, the proposed width of the multi-use path across the bridge will be 8-foot in all proposed options. This is the minimum acceptable width for a multi-use path. The multi-use path will be located along the existing right shoulder and will be separated from traffic with a concrete barrier and a protective fence . The multi-use path will widen beyond the bridge deck limits at both termini.

I-95 northbound on the west end of the project is in superelevation with a cross slope of more than 6% including the shoulder where the multi-use path is proposed. To make the multi-use path ADA compliant, the cross slope of the bridge where the multi-use path is proposed must be reconstructed to be no greater than 2%. This change in cross slope will require additional bridge modifications under all options studied.

Option 1

Option 1 focuses on providing the maximum lane and shoulder widths possible. It achieves this through a reduction in the number of lanes. Option 1 converts I-95 northbound lane 5 from a through lane to an acceleration lane that merges into lane 4. The acceleration lane is required to provide sufficient length for the merge of entering traffic; therefore, four lanes plus the acceleration lane will be required on the bridge. This preliminary layout of the modified acceleration lane maintains a minimum 2 ft. clear shoulder to the protective barrier.

At Sta. 102+00 (refer to Appendix A, Figure A-63 for Stations), the acceleration lane (lane 5) tapers into lane 4 after sufficient distance for acceleration is provided (1300 ft. is provided. Minimum is 1,220 feet based on a ramp speed of 25 mph and highway speed of 65 mph). After the taper, a 10-foot-wide right shoulder with a 2 ft barrier offset is provided along the remainder of the bridge (Sta. 102+00 to 141+00) adjacent to the multi-use path. Also, at Sta. 102+00, lane 4 tapers back to a 12-foot width (refer to Appendix A, Figure A-1).

Option 1 contemplates realigning the ramp from Water St. to I-95 northbound near the gore and a concrete barrier is introduced to separate the multi-use path from ramp traffic on the west terminus. The ramp width at this point is 15 feet with a 5-foot offset to the proposed concrete barrier. AASHTO Table 3-29, Case 1C requires a width of 16 feet + 1 foot for vertical curb (assuming concrete barrier is treated as a curb in this case). Therefore, the AASHTO minimum for pavement width is met despite the shoulder width reduction. A WB-67 design vehicle was evaluated on the ramp to confirm the ramp width was adequate.

Based on the AASHTO publication "A Policy on Design Standards – Interstate System," May 2016, all lane widths on Interstates *shall* be 12 ft. Paved shoulders for interstates with three or more lanes are

typically 10 feet for both the left and right shoulders. Option 1 will require a design exception for shoulder width for the right shoulder for a 1400-foot section (Sta. 88+00 to 102+00).

Reducing the lanes on I-95 from five lanes to four lanes on the bridge changes the weaving patterns for vehicles exiting at Exit 85 immediately after the bridge and reduces the capacity of lanes exiting to Bridge Street and Kings Highway. Currently the far-right lane is an 'Exit Only' lane. The adjacent lane bifurcates at the exit, with one leg that exits, and the other leg which continues through on mainline I-95. In the proposed conditions for Option 1, however, only one lane will serve as an exit serving what is equivalent to two lanes currently. There is approximately 830 ft. between the end of the bridge and the beginning of the off-ramp to Bridge Street, therefore, adding a second lane to I-95 to create a dual exit will require significant roadway reconstruction. Additional study is needed to evaluate the roadway geometry at Exit 85 beyond the bridge under Option 1.

Option 2A

The goal of Option 2A is to maintain five lanes by reducing lane and shoulder widths across the bridge. It also seeks to maintain at least one full-size shoulder on the bridge. Two alternates of this option have been developed, 2A and 2B where both alternates maintain a full-size inside shoulder while reducing the outside shoulder. AASHTO requires all lanes on interstates to be 12 feet, Option 2 will require a design exception for the entire length of the pathway. Option 2A attempts to maintain 12-foot lanes for three of the lanes but narrows the right shoulder to 2 ft., below the AASHTO minimum of 4 feet.

Option 2A reduces lane widths of the two right lanes approaching the bridge similar to Option 1, however, Option 2A does not drop lane 5 after the merge. Instead, lane 5 is maintained as an auxiliary lane. Keeping lane 5 as an auxiliary lane allows the exit ramp at the north end of the bridge to remain as a two-lane exit ramp, as in existing condition.

The disadvantage of keeping lane 5 as an auxiliary lane is that a 2-foot right shoulder extends the full length of the bridge, which is deficient compared to the current design standard. Also, the lane widths for lanes 4 and 5 are also deficient with an 11-ft. width versus the required 12-ft. width.

Option 2A will require a design exception for lane width for the two right lanes and shoulder width for the right shoulder.

Option 2B

Option 2B contemplates reducing all lane widths on I-95 northbound from 12 feet to 11 feet and keeps the same lane/ramp arrangements as the existing condition. The width gained from reducing the width of three additional lanes to 11-ft. is used to provide a 5-ft. right shoulder. The multi-use path and concrete separation barrier occupies the existing right shoulder.

The uniform lane widths across all five lanes provides a more consistent driver experience along the bridge. A challenge to implementing this arrangement is the location of changes of the cross slope.

Currently a crown exists on the bridge just north of the curve. After the roadway transitions out of superelevation on the bridge, it comes back to normal crown while still on the bridge. The crown is located between lane 2 and lane 3. Lane 1 and 2 will be narrowed down to 11 feet each in this option,

therefore, the crown will be shifted to 2 feet within Lane 3. Appendix A – Figures A-61 to A-68 show the aerial view and typical section for Existing I-95, Option 1, Option 2A and Option 2B.

Option 2B provides a greater width for the right shoulder than Option 2A , however, the 5 ft. width is undesirable as it is less than required according to AASHTO design standards. Option 2B will require a design exception for lane width for all lanes and shoulder width for the right shoulder.

Option 3

Option 3 was established to address travel lane continuity relative to I-95 northbound approaching the bridge with the lane arrangements established in accordance with Option 1. Option 1 will operate optimally with three lanes approaching the bridge. If the existing four lanes approaching the bridge is maintained, such as the existing condition, the on-ramp from Huntington Street will not have sufficient length to merge onto I-95 safely. Therefore, under Option 3, the lanes approaching the bridge will be reduced to three lanes prior to reaching Huntington Street. To accomplish this, I-95 Northbound prior to Briggs Street would be reduced to two lanes and the Briggs Street entrance ramp will be a lane-add. Huntington Street will also be a lane add, similar to the existing condition.

Evaluation of the highway operations associated with the modifications contemplated under Option 3 are beyond the scope of this study and will need to be studied in greater detail to make a determination regarding the feasibility of these changes. Operational analysis was conducted at the bridge which indicates it appears to be feasible to implement these changes without adverse impact. However, the geometrics of the required roadway modifications will require further study.

West Terminus Pathway Connection

The west terminus is planned to be constructed next to the ramp approach between Huntington Street and I-95. This area is very constricted due to a lack of right of way and due to steep slopes along the embankment leading up to the bridge. The multi-use path must exit the roadway as soon as possible when leaving the I-95 northbound Gold Star Memorial bridge so that the I-95 northbound on-ramp can maintain an adequate width. As soon as the multi-use path departs from the footprint of the existing roadway it traverses the on-ramp embankment. At the bottom of this embankment, the right-of-way is restricted due to adjacent private property. Due to the close proximity of a building and parking lot, it is undesirable to acquire right of way at the bottom of the embankment, therefore, the concept at this time attempts to limit right-of-way acquisition from this property. The restrictive footprint for the West Terminus multi-use path will require retaining walls.

Two options were developed for the West Terminus. The first option, Option West-S, uses a long switch-back trail. The primary goal of this option is to maintain a maximum longitudinal grade of 5%. The second option, Option West-R, uses a shorter trail with a steeper grade, however, it limits the number of substandard curves in the design. This option also involves less earthwork and allows for more public open space. Option West-S meets the maximum recommended grade of the AASHTO Bicycle Guidelines, while Option West-R meets max grades for ADA compliance of 8%. West-S minimizes grades, while West-R minimizes the use of tight curves. Selection of an option should depend on the selected goals of the project. All plans, profiles and cross sections for these options can be found in Appendix A – Figures A-1 to A-24.

Option West-S

The West Terminus Option West-S is an "S-Curve" option. It provides an S-shaped switchback multi-use path that traverses from the bridge to the sidewalk on Huntington Street. It uses a maximum grade of 5% which meets both AASHTO Bicycle and ADA guidelines. The switchback design is not the most direct route for users, and it introduces additional tight turns. However, meandering the path allows for less steep grades. To achieve the 5% maximum grade, the embankment is filled to provide a gradual downward grade from the I-95 northbound on-ramp to the elevation of the sidewalk along Huntington Street. At Huntington Street, the multi-use path connects to the existing sidewalk network with a T-intersection. The T-intersection is channelized with a raised island allowing path users to go north or south along Huntington Street.

The elevation difference between the proposed switchback pathway and the sidewalk along State Pier Road makes providing a connection to State Pier Road very challenging. It is not possible to make a straight connection to State Pier Road that is ADA compliant or maintains a 5% maximum grade. A functional connection to State Pier Road, which minimizes this condition, is possible by connecting to the sidewalk further north along State Pier Road where the elevation is higher. Connecting to State Pier Road at a point further north allows a grade of less than 5% to be maintained for this section of path.

The following will be required as part of Option West-S:

1. A retaining wall on the right side of the path between the path and the I-95 NB on-ramp will be necessary beginning approximately at Sta. 401+00 and extending through the curve to Sta. 402+50. The average height of the wall at this location will be 4 ft.

2. A retaining wall on the left side of the path between the path and the Faith Fellowship Church property will be necessary beginning approximately at Sta. 403+50 and extending to Sta. 403+90. The average height of the wall at this location is 5 ft.

3. There is a drainage pipe inlet on the I-95 northbound on-ramp halfway between the ramp bridge and the I-95 northbound Gold Star Memorial Bridge. This inlet appears to outfall about 75 feet away at the bottom of the embankment. The path must cross over this drainage pipe. The multi-use path at the pipe crossing undercuts the existing ground by about 6 feet and may impact the pipe if it is not deep enough in existing conditions. The outfall of the pipe may need to be reconfigured.

4. Some right of way near Sta. 500+60 LT and Sta. 700+50 RT will be required which is likely limited to acquiring rights to grade onto the adjacent private property.

Plan view drawings, profiles and cross sections for Option West-S can be found in Appendix A, Figures A-1 to A-10.

Option West-R

The West Terminus Option West-R is designed to minimize the number of sharp curves along the pathway and minimize the footprint of the path. It is designed to meet ADA requirements; however, it

does not meet the AASHTO recommended maximum grades. It allows for a shorter and more direct multi-use path and maintains more open space due to its smaller footprint. The proposed concept, West-R, traverses to a three-legged roundabout at the bottom of the embankment, close to Huntington Street and the adjacent private property. The roundabout eliminates the direct conflict point of a T-intersection, allows for large turn radii for bicyclists approaching the intersection at higher speeds, provides greater separation between bicyclists and pedestrians at the intersection, and it maintains more open space which may be used for planting and beautification and/or within the roundabout.

The roundabout is 42 feet in outside diameter with a 26 ft. inner diameter. Leg 1 of the multi-use path exits Gold Star Memorial Bridge and traverses the embankment to enter at the north side of the roundabout. Leg 2 extends from the roundabout to State Pier Road and Leg 3 extends from the roundabout to Huntington Street.

Leg 1 exits the bridge on maximum grades allowed under ADA from Sta. 400+75 to 401+75 to bring the elevation down quickly enough to tie in at the roundabout. The ramps are limited to 8.33% grade for a 30-inch elevation change with 2% grade at landings to meet ADA standards. The profile flattens to a 5% grade from Sta. 401+75 to 402+75 before tying into the 2% roundabout grade.

Leg 2 begins by exiting the roundabout at a 2% grade, then it uses maximum grades along most of the distance to tie into the existing grade at State Pier Road.

Leg 3 is a short leg between the roundabout and Huntington Street. It exits the roundabout at a 2% grade and ties into the sidewalk along Huntington Street using a ramp at 8.33% grade.

The following will be required as part of Option West-R:

1. Retaining wall on the right side of the Leg 1 path between the path and the Water Street ramp will be necessary beginning approximately at Sta. 400+80 and extending through the curve to Sta. 402+30. The average height of the wall at this location is 6 ft.

2. There is a drainage inlet on the Water Street ramp halfway between the Ramp bridge and the I-95 NB Gold Star Memorial Bridge. This inlet appears to outfall about 75 feet away at the bottom of the embankment. Leg 1 must cross over this drainage pipe. The multi-use path at the pipe crossing undercuts the existing ground by about 5 feet and may impact the pipe if it is not deep enough in existing conditions.

3. Along Leg 2 there appears to be a drainage swale from Sta. 501+50 to 503+00 that will be impacted.

4. The roundabout itself appears to cover the outfall from the drainage structure from impact #2 and part of the existing ditch system.

5. A retaining wall from Sta. 501+75 to 501+60 will be required on the right side of the path. The average height of the wall at this location will be 6 ft.

6. Some right of way from Sta. 500+75 to 502+50 will be required, likely limited to rights to grade, from adjacent private property.

Plan view drawings, profiles and cross sections for Option West-R can be found in Appendix A, Figure A-11 to A-24.

Connection to State Pier Road

The connection to State Pier Road is set at a maximum of 5% grade for Option West-S and a max of 8.3% grade for Option West-R. This leg can be designed at less than 5% for both options. Either West-S or West-R can use the alignment shown in Option West-S for this section of path. This report notes that it is possible to construct this section of the path either way. It is preferable to construct the path while avoiding a series of ADA-compliant ramps and landing areas if possible. Connecting to State Pier Road further north by wrapping the path under the bridge would be a more desirable option. This option may not be feasible if a more direct connection to State Pier Road is required.

Variations for West Terminus

Additional design options for the West Terminus may be possible. Combinations or variations of the options evaluated may ultimately be selected. Some level of compromise may be needed in the design standards followed due to the differences in elevations and the restrictions in right-of-way.

East Terminus Pathway Connection

The East Terminus multi-use path is proposed to be constructed along the ramp from I-95 to Exit 85 where it will then connect to existing sidewalk infrastructure. There is sufficient right-of-way to accommodate the improvements at the East Terminus. Due to the available right-of-way and gradual grades in the area, both options developed for the East Terminus can meet grades less than 5% and not require switchbacks. A roundabout was chosen for the intersection of the new pathway and existing sidewalk for both options because it opens the conflict area, reducing conflict points that a T-intersection design might have. The open roundabout intersection also allows for planting and beautification within the roundabout.

Both options developed for the East Terminus contain similar roundabouts. The roundabouts are 54 ft. in outside diameter with a 20 ft. inside radius. Leg 1 connects the multi-use path from the Gold Star Memorial Bridge to the north side of the roundabout. Leg 2 extends from the south side of the roundabout and connects to the existing sidewalk that leads to the intersection at Bridge Street. Leg 3 extends from the west side of the roundabout and ties into the existing sidewalk infrastructure that currently passes under the Gold Star Memorial Bridge.

The two options developed for the East Terminus differ primarily only in Leg 1, the section that connects to the Gold Star Memorial Bridge. The first option, Option East-R, uses the existing roadway to carry the path from the I-95 Gold Star Memorial Bridge along Exit 85 to the existing sidewalk infrastructure adjacent to the off-ramp. The "R" is used to denote "Roadway." The second option, Option East-S, uses the side slope adjacent to the road to carry the path from the Gold Star Memorial Bridge to the same tie-in point. The "S" is used to denote "Side slope."

All plans, profiles and cross sections for these East Terminus options can be found in Appendix A – Figures A-25 to A-60.

Option East-R

Option East-R is the option that uses the road to carry the pathway from the bridge to the sidewalk adjacent to the off-ramp. The primary goal of this option is to reduce construction costs by using the existing pavement width provided by the two-lane off-ramp. To accomplish this the ramp to Bridge Street is converted from a two-lane exit to a one lane exit. The one lane exit will provide a 10-foot right shoulder, concrete median barrier, and an 8 ft. wide multi-use path within the existing pavement width. The multi-use path will begin to exit the ramp around Sta 110+/-, and at this location the ramp will open back up to two lanes. This will be a cost-saving option for the East Terminus since it will not require retaining walls. This option will impact traffic on I-95, whereas the other option (East-S) will not. The following will be required as part of Option East-R:

- The off ramp from I-95 to Bridge St. will need to become a one lane exit before opening up to two lanes near Sta. 110+00.
- Light poles will have to be relocated near Sta. 110+80 +/- and Sta. 112+40 +/-.
- There is a drainage inlet at Sta 107+65+/- LT that will need to be adjusted.
- There is an existing drainage inlet at Sta. 111+15+/- LT that will need to be relocated.

Plan view drawings for Option East-R can be found in Appendix A, Figure A-25 to A-43.

Option East-S

Option East-S uses the side slope adjacent to the road to carry the multi-use path down from the bridge to the sidewalk adjacent to the off-ramp. The multi-use path must exit the roadway as soon as possible when leaving the I-95 northbound Gold Star Memorial Bridge so that the I-95 off ramp to Bridge Street lane configuration is not affected. Once the path exits the roadway, it is offset far enough from the edge of the roadway to avoid the existing overhead sign at Sta. 106+/- and subsequent overhead light poles. Grading from the edge of the proposed trail along Leg 1 is set at 2:1 slopes. Option East-S is expected to be more costly than Option East-R, however, it maximizes user comfort by pushing the pathway further from I-95 and allowing Exit 85 to maintain 2 exit lanes.

The roundabout is a 3-leg intersection very similar to the one described in Option East-R. The design of Leg 2 and Leg 3 are expected to also be the same. This option will be more expensive; however, it will minimize traffic impacts on I-95.

The following will be required as part of Option East-R:

- A light pole will have to be relocated near Sta. 103+00.
- Retaining walls will be necessary from Sta. 104+50 to approximately Sta. 109+50 mainly between the ramp and the path. The average height of the wall at this location is 5 ft.
- There is a drainage inlet at Sta 105+90+/- RT. Drainage in this area will have to be modified.

Plan view drawings, profiles and cross sections for Option East-S can be found in Appendix A, Figure A-44 to A-60.

Additional Cost-Saving Options

Two primary alternatives were developed for each end of the bridge, as described above, however, there are also several variations within the options that could also be considered. These variations are not included in the cost estimates, nor reflected in the plans and profiles. They are being noted as options for consideration should the project move into the engineering design phase.

East Terminus Leg 3

Option East-S and East-R may have similar impacts to Leg 3, the portion of the pathway that connects under I-95. Local plans identify a need to upgrade the sidewalk connecting the multi-use path to Bliven Street, therefore, as part of this study, the cost of fully upgrading this pathway has been included in the estimates.

Roundabout Design

The roundabout is used at the intersection of the new pathway and the intersecting pathway in several designs. It was intentionally designed to be large to mitigate potential conflicts and allow for public placemaking. To reduce costs on those options the roundabout could be narrowed, or the intersection changed to a T-intersection.

Pathway Width

The preferred pathway width according to AASHTO is 15 ft. wide to comfortably accommodate two bicyclists passing two pedestrians walking side-by-side. The pathway width on most options were designed at 15 feet. To reduce costs, it is possible to narrow the pathway width. The recommended width for a pathway to allow one bicyclist to pass two pedestrians walking side-by-side is 11 feet. This could be used instead of the 15 ft. if the pathway is not expected to be heavily travelled.

The minimal pathway width is 8 ft which will allow two bicyclists or two pedestrians to safely pass each other. However, 8 ft. will not allow for pedestrians to walk side-by-side and be passed by a bicyclist. A comfortable recreational pathway should be expected to have frequent groups of pedestrians walking side-by-side and the occasional bicyclist passing them. Therefore, 11 ft. is typically the standard width. Heavily used recreational pathways should be 15 ft. This width was used in the developed options.

West Terminus Retaining Walls

Option West-S was designed to avoid impacts to the right-of-way at the bottom of the embankment. As a result, the pathway was moved closer to the embankment using retaining walls and cut/fill lines were held back with retaining walls to avoid impacts to the property. The cost-benefit of installing these retaining walls versus acquiring right of way may be evaluated through detailed engineering design.

West Terminus Connection to State Pier Road

In both West Terminus options, a connection was provided to State Pier Road to determine the funding needs of the project for programming. This pathway extension to State Pier Road is an option that may not be necessary, however, it is included for planning purposes. The cost of the additional extension to State Pier Road is anticipated to increase the cost of the West Terminus by 20%.

Further Pedestrian Network Enhancements

Other options exist to further enhance the pedestrian network in areas that were outside the scope of this study. One option includes providing a more direct connection from the existing southbound bridge sidewalk by constructing a ramp from the sidewalk directly into Hodges Square. This may be possible by constructing a separate structure adjacent to the existing bridge next to State Pier Road. In addition, there may be opportunity to realign State Pier Road so that it connects to Williams Street between the northbound and southbound bridge. This would move traffic away from Hodges Square and significantly increase public open space connected to the square. This could enhance redevelopment and revitalization opportunities for Hodges Square.

4 OPERATIONAL IMPACTS ON I-95

The proposed multi-use path on the Gold Star Bridge may be implemented with either removal of a lane on the northbound bridge or the reduction of lane and shoulder widths. Currently there are five lanes on the northbound bridge with a 10 foot outside and inside shoulder. This report evaluates the impacts on traffic operations and safety that may result from the addition of the multi-use path to the northbound bridge using either strategy. The following sections detail the operational impacts. Supporting documentation can be found in Appendix D.

Background Traffic Volumes

If a multi-use path is pursued, the current project schedule shows installation may be completed by 2027. To determine the anticipated traffic flow conditions at the time of construction, traffic volume data was collected along the Gold Star Memorial Bridge for a seven-day period from July 30 to August 5, 2019. Existing traffic volumes were projected to 2027. These volumes were combined with the background traffic volumes from approved, but not yet constructed developments, to determine the projected total 2027 traffic. Traffic growth factors were determined from historical traffic data obtained from the Department's website. Traffic volumes were projected to the year 2057, equal to the build year of 2027 plus 30 years to evaluate long-term operations.

Growth Factors

PRIME AE received recent historical traffic volume data from the Department and retrieved other available traffic volume data from the Department website. The data was used to derive traffic volume growth factors for the past 10 years. The data shows a 0.4% yearly decline in traffic over the past 10 years for the New England and Groton region. PRIME AE pulled population data from the Connecticut Department of Health. The data shows a 2% population growth per annum statewide and a corresponding 0.4% growth in the New England and Groton region over the past 10 years.

The City of New London has an ongoing urban revitalization initiative to spur economic development and growth in the City. Based on information provided by the City, the City has received grant funding to be expended in 2020 to perform some revitalization work. The Town of Groton plans a Transportation Alternate Project (TAP) for enhancements to the City streetscape.

If the population trend continues, the current regional decline in traffic growth will reach an inflection point and begin to increase. With a turnaround, vehicle miles traveled will ultimately realign with population growth as the larger population will make greater use of the transportation network to access goods and services.

Considering the factors mentioned above, we have assumed a short-term traffic growth factor of 1% reflective a short-term boost in the local economy. For longer term traffic growth, a growth factor of 0.5%, which is in line with the regional population trend previously noted, is appropriate. The short-term factor was used to project future 2027 traffic – the build year. The long-term factor was used to project traffic beyond 2027 to examine the long-term traffic impacts.

The COVID 19 pandemic has caused changes in travel patterns. Although planners can only postulate on what traffic patterns will be post pandemic, the assumed 1% and 0.5% growth rates are reasonable and consistent with best practices.

Capacity Analysis

Four (4) alternates have been advanced for installation of the planned multi-use path:

Option 1 (Figure 5)	Removal of the right-most travel lane
Option 2A (Figure 6)	Reduction of the widths of the two right-most travel lanes with 2-foot right shoulder
Option 2B (Figure 7)	Reduction of the widths of all 5 northbound travel lanes with 5-foot right shoulder
Option 3 (Figure 5)	Reduction of a lane on mainline I-95 immediately after Exit 82A. This maintains 2 through lanes on the mainline I-95 all the way to the bridge. A third lane is added at the US 1/Route 636/Briggs Street on-ramp. The fourth lane is added at the Huntington Street on-ramp

Capacity analysis was conducted for existing conditions and each alternate to evaluate the impact of removal of the lane and reduction of the lane widths and shoulder on the bridge. The Highway Capacity Software (HCS) was used to conduct the analysis. The HCS does not allow adjustment of individual lane widths. Lane widths are assigned globally for each section of roadway. As a result, two scenarios were evaluated: removal of a single lane, and reduction in width of all travel lanes. Performance of the roadway with the two lanes narrowed is considered an intermediate condition and the performance of the roadway under this condition will fall between the two conditions analyzed.

Total 2027 traffic including trips associated with background developments and traffic growth was developed. Total 2027 no-build traffic volumes were analyzed, and results are presented for the AM, PM and weekend peaks. Traffic was projected to the year 2057 and capacity analysis was conducted to determine future roadway performance under each peak period scenario. These no-build base conditions were compared to the build condition for each of the three options of the multi-use path for peak hour conditions in 2027 and 2057.

All supporting figures are found in Appendix D – Traffic Analysis. Figure D-1 shows the existing lane configurations. Figure D-2 shows proposed lane configurations for Option 1. Figure D-3 through Figure D- 5 shows existing traffic volumes, 2027 traffic volume, and 2057 traffic volumes, respectively. Figure D-6 through Figure D-8 show the results of the capacity analysis (LOS) for existing, 2027, and 2057. Results of the analysis are summarized in Table 2 on the following page. The results show that the bridge currently operates at level of service B during all peak periods analyzed. With volumes projected to 2027, under Option 1, removal of a single lane, the bridge will operate at level of service C during each peak period. Under Option 2A and Option 2B, with lane narrowing, the bridge will operate at LOS B during AM peak and LOS C during the PM and weekend peak period.

For the year 2057, the results show that under Option 1, with the single lane removed, the bridge will operate at LOS C during the AM peak period. The bridge will operate at LOS D during the PM and weekend peaks. With lane narrowing under Option 2A and Option 2B, the bridge will operate at LOS C during each peak.

Table 2 – Capacity Analysis Summary

	Level of Service								
	AM PEAK HOUR			PM PEAK HOUR			WE PEAK HOUR		
	LOS	Density (pc/mi/ ln)	Volume to Capacity Ratio	LOS	Density (pc/mi/ln)	Volume to Capacity Ratio	LOS	Density (pc/mi/ln)	Volume to Capacity Ratio
2019 – Existing Condition	***B***	***13.8***	***0.42***	***B***	***16.8***	***0.52***	***B***	***17.9***	***0.55***
2027 No-Build Condition	***B***	***15.4***	***0.47***	***C***	***18.6***	***0.56***	***C***	***19.5***	***0.59***
2027 – Option 1	C	19.4	0.59	C	24.2	0.71	C	25.8	0.74
2027 – Option 2A	B	15.9	0.48	C	19.1	0.57	C	20.0	0.60
2027 – Option 2B	B	15.8	0.48	C	19.0	0.57	C	20.0	0.60
2027 – Option 3	C	19.4	0.59	C	24.2	0.71	C	25.8	0.74
2057 No-Build Condition	***B***	***17.9***	***0.55***	***C***	***22.0***	***0.66***	***C***	***23.4***	***0.69***
2057 – Option 1	C	23.2	0.68	D	30.1	0.82	D	32.7	0.86
2057 – Option 2A	C	18.4	0.55	C	22.5	0.66	C	23.9	0.69
2057 – Option 2B	C	18.3	0.55	C	22.5	0.66	C	23.8	0.69
2057 – Option 3	C	23.2	0.68	D	30.1	0.82	D	32.7	0.86

Note: Analysis was conducted at the bridge only. Roadways on each approach to the bridge are not included.

Reduction of Lane at Exit 85 – Terminus East Option East-R

The Option East-R relies on the ability for the two-lane exit at Exit 85 to be reduced to one lane until it reaches about mid-way through the off-ramp. Option East-R utilizes the shoulder of the off-ramp onto Bridge Street to accommodate the multi-use path down to the existing sidewalk adjacent to the off-ramp. To accomplish this, the existing two-lane off-ramp will need to be reduced to one lane. The outside lane is to be utilized for the multi-use path. The elimination of this second off-ramp lane will have impacts to I-95 on queuing for vehicles waiting at the Bridge Street intersection for the signal to change. A traffic analysis was not conducted to determine the impact on I-95.

The reconfiguration of I-95, Option 1 and Option 3, contemplates four travel lanes across the bridge. Four travel lanes may need to be maintained past Exit 85 along the northbound I-95 mainline to maintain existing mainline capacity. Therefore, under Option 1 and Option 3, lane 4 may be designed as a choice lane that splits into 2 lanes immediately leaving the bridge at Exit 85.

5 SAFETY IMPACTS ON I-95

The addition of a shared-use path to the northbound span requires modifying the roadway cross-section by removing the right-most lane and/or reducing lane widths to accommodate the path. Four alternatives have been proposed:

Option 1 (Figure 5)	Removal of the right-most travel lane
Option 2A (Figure 6)	Reduction of the widths of the two right-most travel lanes with 2-foot right shoulder width
Option 2B (Figure 7)	Reduction of the widths of all 5 northbound travel lanes with 5-foot right shoulder width
Option 3 (Figure 5)	Almost identical to Option 1 with removal of I-95 northbound lane prior to Briggs Streets on-ramp and addition of the two on-ramps in separate lanes.

Each option would reduce the capacity of I-95 and may result in an increase in safety risks.

A safety analysis to evaluate how each alternative would impact roadway safety was performed using the Interactive Highway Safety Design Model (IHSDM), a Federal Highway Administration (FHWA) safety analysis software package. IHSDM utilizes the methods from the AASHTO Highway Safety Manual to predict crash rates based on inputs such as roadway geometry, traffic volume, and crash history. Using this software, the impact of each alternative on roadway safety relative to the existing conditions was evaluated. The following section summarizes the IHSDM analysis. The full report and supporting data can be found in Appendix E.

Interactive Highway Safety Design Model

The Interactive Highway Safety Design Model (IHSDM) is a roadway safety analysis software package developed by FHWA based on the AASHTO Highway Safety Manual (HSM). The current release of the software includes five evaluation modules: Crash Prediction, Policy Review, Design Consistency, Traffic Analysis, and Driver/Vehicle. IHSDM can be used to check roadway compliance with AASHTO standards, review the suitability of at-grade intersections, and perform safety analysis of a variety of road types. Crash analysis is performed using IHSDM's Crash Prediction Module (CPM), which can be used to predict current and future crash frequencies based on a roadway's geometric design and traffic flow characteristics.

Figure 8: IHSDM Plan View with Annotations

The first step in using the CPM is to model the subject roadway in IHSDM. This is accomplished by inputting data for the roadway's horizontal alignment, vertical alignment, lane and shoulder widths, cross slopes, and ramps. Figure 15 above illustrates the modeling of the roadway geometry. The next step is to input roadway traffic characteristics for the analysis period. The required data is listed below. Finally, with all data entered, the CPM can be run to generate expected crash frequencies.

Table 3 - IHSDM Inputs

IHSDM Traffic Data Inputs	
Historical Crash Data Inputs	Volume Data Inputs
Crash year	Analysis year(s)
Crash type – PDO or fatal/nonfatal injury	AADT
Crash type – single vehicle or multi vehicle	High volume sections – proportion of AADT volume that occurs when volume exceeds 1,000 vehicles/hr/ln
Crash stationing	
Direction of roadway – station increasing/decreasing	
Relation to intersection/ramp – intersection or non-intersection	

I-95 Geometric Data

Geometric and cross-sectional data for I-95 and the Gold Star Memorial Bridge were obtained from the 1971 as-built plans, Contract 94-107. These plans were used to obtain horizontal alignment, vertical alignment, and cross-sectional data for input into IHSDM. A maximum superelevation of 6% was input per the Connecticut Department of Transportation Highway Design Manual. For on and off-ramps where geometric data was unavailable, the horizontal alignment was reconstructed from aerial imagery and the vertical alignment from GIS contours.

Traffic Volume Data

Traffic volume data for this section of I-95 was obtained from counts performed in July and August 2019. The data shows traffic volumes consistent with the roadway classification, with a current Annual Average Daily Traffic (AADT) of 123,611 vehicles for the roadway. By 2057, the AADT is projected to rise to 150,885 vehicles, the potential result of population growth and economic development.

As one of the inputs for its crash prediction model, IHSDM requires a value that describes how often the roadway experiences heavy traffic volumes. This value is called the P_{hv}, the proportion of freeway AADT volume that occurs during hours when the lane volume exceeds one thousand vehicles per hour per lane (1,000 vphpl). For the year 2019, this value is approximately 0.02; in 2057, for the five-lane I-95 northbound section, the P_{hv} is projected to rise to approximately 0.06. This represents a three-fold increase. The table below lists the traffic volume data.

Table 4 - Gold Bridge Memorial Bridge – Traffic Volumes

Year	AADT	P_{hv}		Notes
		4 Lanes*	5 Lanes	
2019	123,611	-	0.02	Baseline
2027	133,853	0.08	0.05	Expected construction completion
2057	150,885	0.11	0.06	30 years after completion of construction

*Note: This reflects the lane configuration for Option 1. Existing conditions, Option 2A, and Option 2B have five lanes.

Historical Crash Data

Crash data for all reported crashes in the State of Connecticut is stored online at the University of Connecticut's Connecticut Crash Data Repository (CTCDR). The CTCDR stores a wide variety of information about each crash, including the date, time, location, severity, and number of involved vehicles. Since 2015, data has been collected in accordance with the Model Minimum Uniform Crash Criteria (MMUCC) guidelines, a nationally recognized format for recording crash information. Prior to 2015, data was collected using CTDOT guidelines, which did not capture certain crash elements such as driver behavior.

To ensure uniformity of the crash data, only data from the years 2015 through 2018 was used in the analysis. Crash data for the Gold Star Memorial Bridge was found using the CTCDR's advanced query tool between I-95 mileposts 93.3 and 95.0. The tool can be found at https://www.ctcrash.uconn.edu/. Using the latitude and longitude data provided for each crash, all crashes from 2015 through 2018 were mapped, and inapplicable crashes were manually removed. After reviewing and filtering the data, 189 total crashes were found along this section of I-95 from 2015 through 2018. 166 of these crashes were classified as property damage only (PDO) and 23 were classified as Injury of Any Type. Note that for data input, IHSDM does not distinguish between Fatal Crashes and Injury crashes and groups them together as fatal/injury (FI) crashes. A yearly breakdown of these crashes is shown in Table 5. Note that this data is for I-95 in both directions, both northbound and southbound.

Table 5 - Historical Crash Data Summary, 2015-2018

Year	PDO Crashes	FI Crashes*	Total Crashes
2015	24	3	27
2016	31	6	37
2017	47	7	54
2018	64	7	71
Total	**166**	**23**	**189**
Average	**42**	**6**	**47**

Data source: Connecticut Crash Data Repository
*For historical crash data input, IHSDM does not distinguish between Fatal versus Injury crashes. There are no records of fatal crashes from 2015 through 2018, only Injury of Any Type crashes.

Crash Prediction Results

The IHSDM Crash Prediction Module (CPM) was used to generate expected crash frequencies for the years 2027 through 2057. To generate these results, the CPM first used the methodologies laid out in the HSM to generate predicted crash frequencies for each year. Then, the CPM utilized the Empirical-Bayes method, a statistical analysis technique, to adjust these predicted results based on the 2015- 2018 historical crash data. IHSDM refers to these adjusted results as expected crash frequencies.

Expected crash counts for the years 2027 (expected completion of the bridge) and 2057 are shown in Table 6. The crash counts are for I-95 in both directions, as up to the current release, neither IHSDM nor the HSM have methods for predicting crash rates for only one direction of a freeway. Note that the values in each column may not add up to the total because IHSDM derives each value independently.

Table 6 - Crash Prediction Results

		PDO	FI	Total
2015 – 2018 Average		**42**	**3**	**47**
2027	No Build	46	13	59
	Option 1	47	13	60
	Option 2A	46	13	60
	Option 2B	46	13	60
2057	No Build	55	14	69
	Option 1	56	15	71
	Option 2A	55	15	70
	Option 2B	55	15	70

Note: Crash incidence for Option 3 is expected to be the same as Option 1 within the limits of the bridge.

The Crash Predication Module uses the methods in the AASHTO Highway Safety Manual (HSM) to predict crashes. Like the HSM, IHSDM uses data collected from multiple states to calibrate its predictive model. Jurisdictions may improve the accuracy of predictions by calibrating the CPM to their region using local data and characteristics of climate, animal populations, and driver populations.

As of November 2019, none of the New England states have developed local calibration factors for the HSM or IHSDM; thus, for this report, the CPM was not calibrated to account for local conditions but was run using the default IHSDM calibration factors based on nationwide averages. It must be noted that the crash prediction results contained in this report are not absolute but should be considered as a baseline from which to compare alternatives. Crash prediction results are shown in Tables 6 and 7 and Figures 16 and 17.

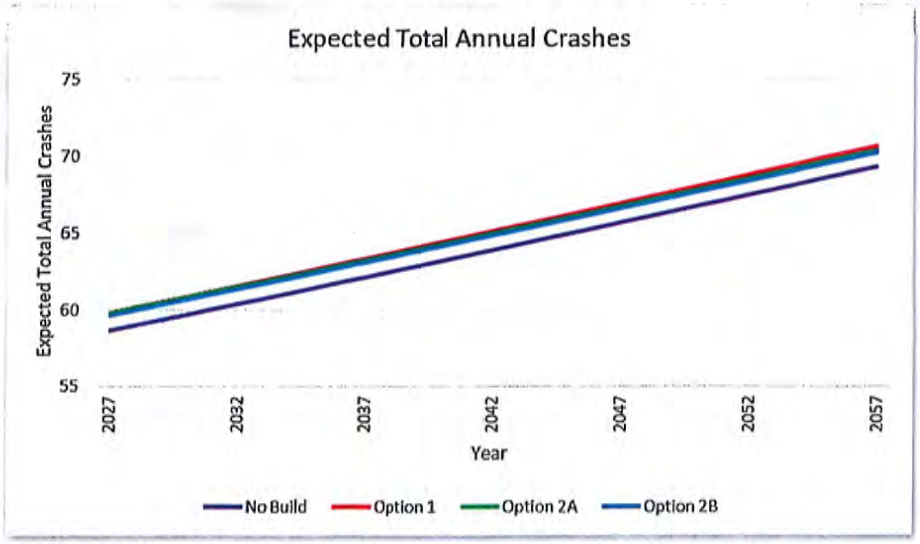


Figure 9: Expected Total Annual Crashes, 2027 through 2057

As shown in Table 7 and Figure 17, irrespective of which alternative is selected, the total number of crashes will increase versus the no build condition. Option 1 will experience the largest growth in crashes, with a 1.95% increase in total crash count versus the no build condition. However, as shown in Table 6, most of this growth can be accounted for as an increase in PDO crashes. As shown in Table 7 and Figure 17, although ***Option 1 has the largest increase in PDO crashes, it also has the lowest increase in Fatal or Injury Crashes, an increase of 1.43% over the no build condition, versus 5.37% and 4.45% for Option 2A and Option 2B, respectively.***

Table 7 - Comparison of Expected Total Crashes vs. Existing Conditions, 2027-2057

	PDO		FI		Total Crashes	
	Total Count, 2027 - 2057	% Change vs. No Build	Total Count, 2027 - 2057	% Change vs. No Build	Total Count, 2027 - 2057	% Change vs. No Build
No Build	1562	-	417	-	1979	-
Option 1	1595	+2.09%	423	+1.43%	2018	+1.95%
Option 2A	1575	+0.83%	440	+5.37%	2014	+1.75%
Option 2B	1573	+0.70%	436	+4.45%	2009	+1.50%

Note: Crash incidence for Option 3 is expected to be the same as Option 1 within the limits of the bridge.

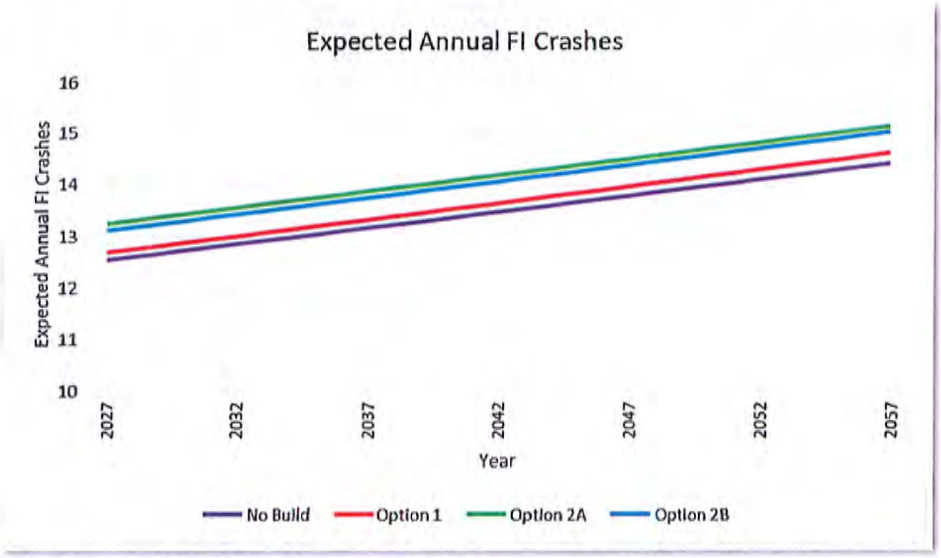


Figure 10: Expected Annual FI Crashes, 2027 through 2057

For the analysis period of 2027 through 2057, IHSDM can estimate how the expected crashes will breakdown according to the KABCO scale. The KABCO scale provides five levels for rating the severity of a crash based on the resulting injuries. Per the Highway Safety Manual, the five levels of the KABCO scale are:

- K: Fatal injury
- A: Incapacitating injury
- B: Non-incapacitating injury
- C: Possible injury
- O: No injury/property damage only

The breakdown of the expected crashes for each option is shown in Table 8. As shown in the table, Option 1 results in no change in the total number of fatal (K) and incapacitating injury (A) crashes from 2027 through 2057 but results in the greatest increase in the number of no injury/property damage only crashes (O). Option 2A results in an increase in incapacitating injury (A) crashes, and Option 2B results in an increase in both fatal (K) and incapacitating injury (A) crashes.

Table 8 – Breakdown of total crashes by KABCO level, 2027-2057

	K		A		B		C		O	
	Total Count, 2027 - 2057	% Change vs. No Build	Total Count, 2027 - 2057	% Change vs. No Build	Total Count, 2027 - 2057	% Change vs. No Build	Total Count, 2027 - 2057	% Change vs. No Build	Total Count, 2027 - 2057	% Change vs. No Build
No Build	7	-	18	-	127	-	265	-	1562	-
Option 1	7	-	18	-	126	-0.79%	272	+2.61%	1595	+2.09%
Option 2A	7	-	19	+5.41%	134	+5.36%	279	+5.15%	1575	+0.83%
Option 2B	8	+13.33 %	19	+5.41%	134	+5.36%	275	+3.70%	1573	+0.70%

Note: Crash incidence for Option 3 is expected to be the same as Option 1 within the limits of the bridge.

Safety Conclusion

Of the options reviewed, using the relative number of crashes, no option appears to offer a significant safety benefit over the other. Projected benefits based on the criteria of the HSM are marginal. Option 2B shows the greatest percent increase in severe crashes; fatal and incapacitating crashes over the No Build option, but the projections are that it would result in the lowest overall number of crashes. Option 1 results in the highest increase in total crashes relative to existing conditions. However, Option 1 results in the lowest number of fatal or injury crashes as there is no change in the number of severe crashes.

6 BRIDGE AND ROADSIDE IMPACTS

The most significant physical impacts from implementation of the multi-use path will occur to the Gold Star Memorial Bridge when reducing the number of lanes or the lane widths and correcting the cross slope of the bridge so it meets ADA compliance. The area is heavily urbanized, as such no environmental resources are expected to be impacted. Major impacts that have been identified follow.

Impacts to Gold Star Bridge

Multi-use Path Width on Bridge

The recommended width for a two directional multi-use path with room for passing is 11 ft. AASHTO states 14 ft is desirable. Due to the restricted width of the bridge and the weight of the protective barrier for the multi-use path, the width of the multi-use path across the bridge is restricted 8 feet. The multi-use path will be located along the existing right shoulder and will be separated from traffic with protective concrete barrier. The weight of this barrier is anticipated to be accounted for in the strengthening of the girders on the bridge when placed with an 8-foot pathway, however, placing the barrier in a different location cannot be accommodated.

Bridge Cross Slope

To accommodate pedestrians, the multi-use path must meet ADA standards for both cross slope and grade. The multi-use path is required to be designed using a 2% maximum cross slope and 5% maximum grade to meet ADA and AASHTO Bicycle standards. The cross slope of the shoulder on the Gold Star Bridge does not currently meet this requirement. The bridge is constructed with a curve that begins just east of the west abutment. As the road enters the curve it transitions into superelevation with a cross slope of more than 6% across all the lanes and the outside shoulder. To make the multi- use path ADA compliant the outside shoulder, where the multi-use path is proposed, must be altered to be no greater than 2%. This change in cross slope will require additional bridge modifications such as lowering the outer most stringer.

Utility Impacts

A draft utility map was developed by combining information from the as-builts with field marked utility locations. Field marked utilities included water, gas and electric. The areas planned for pathway installations do not appear to impact any utilities based on this map other than roadway illumination.

Drainage Impacts

Some modifications to drainage systems will be required. Replacement and/or relocation of a few existing drainage structures are likely. Additional drainage structures will be needed to treat the new multi-use pathways, which may require tying into existing nearby structures. Depending on the option selected for I-95, it is also possible that the drainage pattern of the bridge deck could change, requiring alterations to the surrounding drainage systems. Overall, impacts to the drainage systems to accommodate the multi-use path are considered to be relatively minor.

Right-of-Way Impacts

Only one option will result in possible right-of-way impacts, Option West-R. This option requires some small easements or acquisitions to construct the path because a goal of this option is to limit the number of tight curves along the pathway. Tightening some of the curves may allow this property to be avoided.

Environmental Impacts

A high-level environmental review was conducted as part of this study. No significant environmental features were identified as part of this review.

7 COST ESTIMATES

Costs were developed following the 2019 Connecticut DOT Cost Estimating Guidelines. Cost estimates were developed for the Programming Stage of the project. The cost of each option for the new multi-use path was calculated by first determining quantifiable base pay items and minor items. Available unit prices were pulled from the CTDOT AASHTOWare Project Estimator. Other unit costs were determined using the 2019 CTDOT Cost Estimating Guidelines. A contingency of 30% was used and a 3.5% inflation factor was added over a 5 year period, a percentage was added for Incidentals and Preliminary Engineering, according to recommended rates provided in the 2019 CTDOT Cost Estimating Guidelines.

Approach Pathway Costs

Approach pathway costs were developed from conceptual plans for the pathway approaches to the bridge. Conceptual plans were developed for the west side of the bridge and the east side. Two cost estimates were determined for each approach to the bridge.

Table 9 – Summary of Preliminary Costs for Approach Pathways

OPTION	*West-S (Preferred)*	*West-R*	*East-R*	*East-S (Preferred)*
Identified Work + Minor Items	$678,000	$554,000	$602,000	$1,048,000
Construction Lump Sum Items	$163,000	$135,000	$145,000	$252,000
Contingency (30%)	$252,000	$206,000	$224,000	$391,000
Inflation (3.5% - 5 yr)	$191,000	$156,000	$170,000	$296,000
Incidentals (CENG)	$193,000	$157,000	$171,000	$298,000
Preliminary Engineering (15%)	$223,000	$182,000	$198,000	$345,000
TOTAL	**$1,700,000**	**$ 1,390,000**	**$1,510,000**	**$ 2,630,000**

The cost for the approach pathways to the bridge range between $2.90M to $4.33M, depending on which of the two options are selected. The largest cost savings may be realized on the East Terminus pathway, through selection of whether the path remains along the existing shoulder or is constructed along the side slope of the embankment. The preferred options costs for these pathways include Option West-S and East-S. The breakdown of preliminary costs can be found in Appendix B.

The cost of the pathway on the bridge is not included above. Additional costs for adding a barrier and protective fence on the bridge are anticipated to be approximately $3.50M.

Pathway lighting is not anticipated at this time because it is expected that the existing roadway lighting will be adequate to light the pathway. If pedestrian lighting is required, the additional cost would be approximately $1.8M.

Bridge Structure Modification Costs

The Gold Star Bridge deck must be modified to accommodate the pathway. The bridge cross slope will need to be adjusted across several spans which have significant superelevation. The structure modifications will require replacing stringers and modifying floor beams under the deck of the bridge so the deck cross slope can accommodate an ADA-compliant cross slope for the pathway. This work is anticipated to cost approximately $5.50M. This estimate assumes that this steel reconstruction would coincide with replacement of the concrete deck on the bridge and that the cost of the deck replacement is not added here. Should a project to add the multi-use path to the bridge not coincide with the deck replacement, there will be a significant increase in cost to the project.

I-95 Lane Modifications Costs

Additional work is required to modify the lane configurations on both approaches to the bridge. Evaluating the complete impact of the construction required on the roadway approaches is beyond the scope of this study. A concept-level estimate of the required construction items was developed and an approximate range of the cost for this work is estimated to be $4 Million to $8 Million.

Total Project Costs

The total project cost includes a combination of the West Terminus and the East Terminus path construction, plus the cost of the bridge structure modifications and the cost for I-95 roadway reconstruction.

Preliminary cost estimates can be found in Appendix B. The following table summarizes the costs for the multi-use path construction.

Table 10 – Summary of Project Costs

DESCRIPTION	*COST*
MULTI-USE PATH CONSTRUCTION AT WEST TERMINUS - HUNTINGTON ST. ON-RAMP	$ 1,700,000
MULTI-USE PATH CONSTRUCTION AT EAST TERMINUS - BRIDGE ST. EXIT RAMP	$ 2,630,000
PROTECTIVE BARRIERS AND PROTECTIVE FENCE ACROSS BRIDGE	$ 3,500,000
BRIDGE STRUCTURE MODIFICATIONS (See Note)	$ 5,500,000
SUBTOTAL – APPROACHES AND BRIDGE	**$ 13,330,000**
I-95 NORTHBOUND ROADWAY LANE MODIFICATIONS	$4 - 8 MILLION
Project Estimate – Total: $17.3M TO $21.3M	

Note: Structure modification cost assumes work is coincident with project to replace the bridge deck.

8 EVALUATION AND MEASURES OF EFFECTIVENESS

For the connections, to determine the optimal Concept, the relative costs, benefits and impacts of each Concept were compared to determine the most cost-beneficial options. Below are matrices that compare parameters for each option.

Table 11 – Measure of Effectiveness – Pathway Options

Option	West-S	West-R	East-R	East-S
Max Longitudinal Slope	5%	8%	5%	5%
Minimum Radius	17'	15'	20'	20'
Substandard Curves	2	1	1	1
Property Impacts	0	1	0	0
Connections to Community	2	2	2	2
Cost ($M)	**$1.7**	**$1.39**	**$1.51**	**$2.63**

Table 12 – Measure of Effectiveness – Gold Star Bridge

Option	No Build (2027)	No Build (2057)	Option 1 (2057)	Option 2A (2057)	Option 2B (2057)
Level of Service (LOS)*	C	C	D	C	C
Density* (pc/mi/ln)	19.5	23.4	32.7	23.9	23.8
Volume to Capacity Ratio*	0.59	0.69	0.86	0.69	0.69
Average Speed* (mph)	67.9	65.9	58.8	64.4	64.6
Number of Crashes per year	58.57	69.25	70.61	70.34	70.18
Fatal or Injury Crashes per year	12.53	14.40	14.62	15.13	15.01

*Values for weekend peak hour

West Terminus

The primary differences between the West-S (S-Curve) and West-R (Roundabout) option are the longitudinal grades, number of substandard curves for bicyclists, and property impacts. In each case, the West-S option is preferred. If pursued, it is recommended that the West-S, or S-Curve Option be further evaluated for the West Terminus.

East Terminus

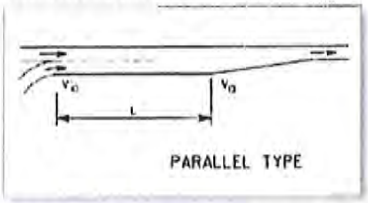
The key differences in the East-S and East-R Option are in the cost vs. traffic impacts. Traffic impacts will be the greater differentiating factor between the two options; however, this may not be a differentiating factor if Options 1 or 3 along I-95 is selected. Option 1 or 3 reduces the lanes across the bridge from five lanes to four lanes, therefore, the number of lanes exiting at Exit 85 may need to be reduced from two to one lane. If Option 1 or 3 is used on I-95 the benefit to East- S over East-R would be the additional space between the pathway and the travel lanes on I-95.

9 SUMMARY OF CHALLENGES

This section summarizes the challenges that will need to be addressed in order for the new multipurpose lanes to be constructed while minimizing the impact to roadway capacity and safety.

Challenge #1: Short Merge Length at the Huntington Street On-Ramp

To fit the pathway on the bridge one lane will need to be removed or the width of the travel lanes and shoulders will need to be reduced. Option 1 removes a lane. To transition the Huntington Street on-ramp into the right lane of the bridge for Option 1, an acceleration lane will be needed. The minimum length for the acceleration lane required to comply with AASHTO is 1220 ft. This is based on a ramp speed of 25 mph entering the freeway at a speed of 70 mph. In addition, a taper of length between 600 ft and 840 ft is required to transition the on-ramp into the travel lane along I-95. The available space for this transition is just over 130 ft. In addition, due to the peak hour volumes on the entrance ramps, changing the current entrance ramp lane-add to a merge could introduce operational issues.



Option 3 attempts to address this issue by reducing the number of lanes along I-95 in advance of the bridge and maintains a dedicated lane for each on-ramp. I-95 would be reduced to two lanes in advance of the Briggs Street Ramp and each ramp would enter into a dedicated lane as currently exits.

Challenge #2: Minimal Width of Pathway on Bridge

The pathway across the bridge is limited to a maximum width of 8 feet due to the distribution of the load of the barrier and the live load of the path on the bridge. This width of 8 feet is the minimal acceptable width for a 2-way multi-use pathway based on AASHTO Bicycle Guidelines. AASHTO recommends 11 feet and a preferable 14-foot pathway width for heavily travelled pathways. The barriers on both sides of the pathway will further reduce the comfort and the operational effectiveness of the pathway. The minimal passing space between two bicycles passing each other will leave little room for error, increasing the risk of bike crashes on the pathway.

Challenge #3: Sub-standard Pathway Design for Bicycles on New London side of Bridge

The pathway approach on the west (New London) side of the bridge is not able to accommodate an AASHTO compliant pathway for bicycles. AASHTO recommends maximum longitudinal slopes of 5% for bicycles and minimum curve radii of 27 ft to accommodate bicycle speeds of up to 12 mph. Slopes will reach 8.3% and curve radii will be 17 ft. This includes sufficient ADA compliant landing areas that are evenly spaced along the pathway. The limited right-of-way available and the grade differential between the bridge and the sidewalk does not allow AASHTO design requirements to be met. Bicyclists will be required to travel less than 12 mph, on the descent from the bridge to the sidewalk, on slopes that approach 8%.

Challenge #4: Reconstruction of the Bridge Deck Cross Slopes

Leading into the bridge there is a crown on the roadway that separates the 2 left lanes from the 2 right lanes. On the bridge there is a curve that is superelevated with the roadway around this crown to a maximum cross slope of 6%. This slope runs the full width of the roadway, including the shoulder, where the pathway is proposed. This 6% cross slope is unacceptable for ADA compliance which cannot exceed 2%. To correct this the roadway cross slopes along I-95 will need to be reconstructed on the bridge.

Challenge #5: Elimination of Dual Exit Lanes at Exit 85

Exit 85 is a two-lane exit with one exclusive and one shared exit lane. Of the five existing lanes on the bridge, four lanes continue past the exit along northbound I-95. In the proposed condition only four lanes would be carried across the bridge and only 1 lane will exit at Exit 85. The impacts to I-95 as a result this reduction would need to be further evaluated as impacts on the downstream surface street nodes and the downstream interchange which are outside the project limits would also need to be considered. In addition, an Interstate Access Modification will require approval from the Federal Highway Administration (FHWA) for this lane arrangement.

Challenge #6: Design Exceptions and FHWA Approval

For Options 2A & 2B, adding the pathway to the bridge at the Huntington Street on-ramp will result in substandard shoulder widths, either 2-foot or 5-foot outside right shoulder on I-95. Based on the posted speed of the roadway, this shoulder is not AASHTO compliant and would require a design exception for the section of road where the ramp acceleration lane is proposed. In addition, an Interstate Access Modification approval from the Federal Highway Administration (FHWA) may be required for this lane arrangement.

Challenge #7: Limited Options for Temporary Traffic Control and Incident Management

There are currently five lanes with two ten-foot shoulders along the bridge. The current lane configuration allows easy use of the left and/or right shoulder during temporary traffic control or incident management. Removal of one or both shoulders or narrowing the shoulders to a width which is not viable for vehicles to travel will limit options for both temporary traffic control and freeway incident traffic management. Option 2 reduces the shoulder width throughout the bridge. Option 1 will reduce a portion of the shoulder width, unless the number of approach lanes to the bridge can be reduced prior to reaching the Huntington Street on-ramp. Option 3 reduces the number of through lanes on the west approach to the bridge from three to two.

10 SUMMARY OF FINDINGS

The following is a summary of the major findings of this report.

1. There is an existing access path on the I-95 Southbound bridge. Adding a path to the I-95 Northbound bridge would provide redundancy should one path need to be closed.

2. An eight-foot wide path could be added to the northbound bridge. Due to load restrictions, a path added to the bridge would need to be within the existing deck width. Adding a path would require extensive structural modifications to several spans on the west approach of the bridge to accommodate a 2% maximum cross slope to meet ADA requirements.

3. No significant impacts to environmental resources are expected with the construction this multi-use path.

The following are several items which the Department should consider carefully prior to moving forward with a project to construct a multi-use path on the bridge.

4. Due to load restriction and the available width on the existing bridge deck, the trail would be limited to 8 feet on the bridge. The recommended width for a two-way bike trail is 11 feet with a preferred width of 14 feet. In addition, the grades and curves of the trail at some locations would be steeper or more severe than standard guidelines allow unless right-of-way takings were incorporated into the project.

5. Under Options 2A and 2B, the highway lanes would need to be narrowed to 11 feet, or, under Options 1 and 3, one of the lanes would need to be eliminated. In either case, the Level of Service (LOS) for motorists would be reduced from LOS C to LOS D during peak periods for the design year 2057.

6. Depending on the option selected, the merge lane from the Huntington Street On-Ramp would be shortened, resulting in a merge which is a significant change from the current on-ramp lane addition. Roadway modifications to this ramp were beyond the scope of this study, however, it appears that widening the ramp to improve the merge deficiency would also require widening of the bridge supporting the ramp over Huntington St.

7. The impacts of narrowing lanes or dropping a lane on the Bridge would extend beyond the limits of the Bridge. Evaluating the safety and capacity impacts of these modifications is beyond the scope of this study and would need to be evaluated in more depth before proceeding with design of the path on the bridge. For example, there is a significant amount of traffic entering I-95 northbound at the Briggs Street Ramp and the Water Street Ramp. This volume of traffic may not have a sufficient merge length to weave into adjacent lanes prior to the Bridge.

   Under Option 3, dropping a lane along I-95 N would need to be initiated at the I-95 Frontage

Road between Vauxhall Street Ext. and Colman Street with a merge of that ramp into two northbound lanes. Then, a single lane add at the Briggs Street and Water Street Ramps as the third and fourth lanes respectively prior to reaching the Bridge. The operational and safety impacts of this modification and any additional mitigation would need to be evaluated.

8. There would be significant impacts to future temporary traffic control and freeway incident traffic management on the Bridge resulting from removal of a lane, removal of shoulder(s) or narrowing of lanes. This would reduce the Department's ability to limit traffic impacts during routine bridge maintenance and incident response.

9. Preliminary costs of adding the path to the Bridge and constructing the connections are estimated at approximately $13.33M plus roadway reconstruction costs. The roadway reconstruction, including transitioning the roadway into and out of the new lane configurations, would need to be studied further to more accurately identify impacts and costs.

The Department should consider conducting a preliminary engineering study of approach roadway impacts on each approach to the bridge for the options identified in this report to gain a better understanding of the operational, safety and cost implications of moving forward with construction of a multi-use path on the bridge.