Connecticut Department of Transportation

State Project No. 63-703
Relocation of I-91 NB Interchange 29
& Widening of I-91 NB & State Route
5/15 NB Towards I-84 EB
Hartford & East Hartford, CT

VALUE ENGINEERING REPORT

June 20, 2016

FINAL

benesch

TEAM MEMBERS

We express thanks to the Connecticut Department of Transportation (CTDOT) for their guidance during the VE process.

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EXECUTIVE SUMMARY

E.1 PROJECT DESCRIPTION

Alfred Benesch & Company (Benesch) performed a Value Engineering Workshop for the Connecticut Department of Transportation (CTDOT). State Project No. 63-703 involves the relocation of Interchange 29 on Interstate 91 (I-91) Northbound (NB) and the widening of I-91 NB and State Route 5/15 NB towards Interstate 84 (I-84) Eastbound (EB) in Hartford and East Hartford, Connecticut.

The project begins on I-91 NB in the vicinity of Wethersfield Cove, extending northerly to Route 15 NB and ends approximately 625 feet north of Silver Lane and before the I-84 EB merge. The purpose of the project is to address safety concerns associated with congestion and operational failures at Interchange 29 on I-91 NB.

The I-91 NB Interchange 29 off-ramp is a single-lane configuration with a steep vertical grade that contributes to significant traffic delays due to the heavy volume of vehicles. In addition to the geometric deficiencies of the off-ramp, there is a heavy weave condition occurring on the Charter Oak Bridge at the end of the ramp where motorists attempt to access I-84 EB, Route 5/15 NB, Route 2 and Silver Lane. The existing traffic queues extend onto the I-91 NB mainline, taking up the right lane of the three-lane facility. The length of the queue varies, but has been observed to extend approximately 1.4 miles in the vicinity of Wethersfield Cove. The safety issues are compounded by drivers that routinely cut into the right-lane queue from the center lane, which further increases congestion on I-91 in this area.

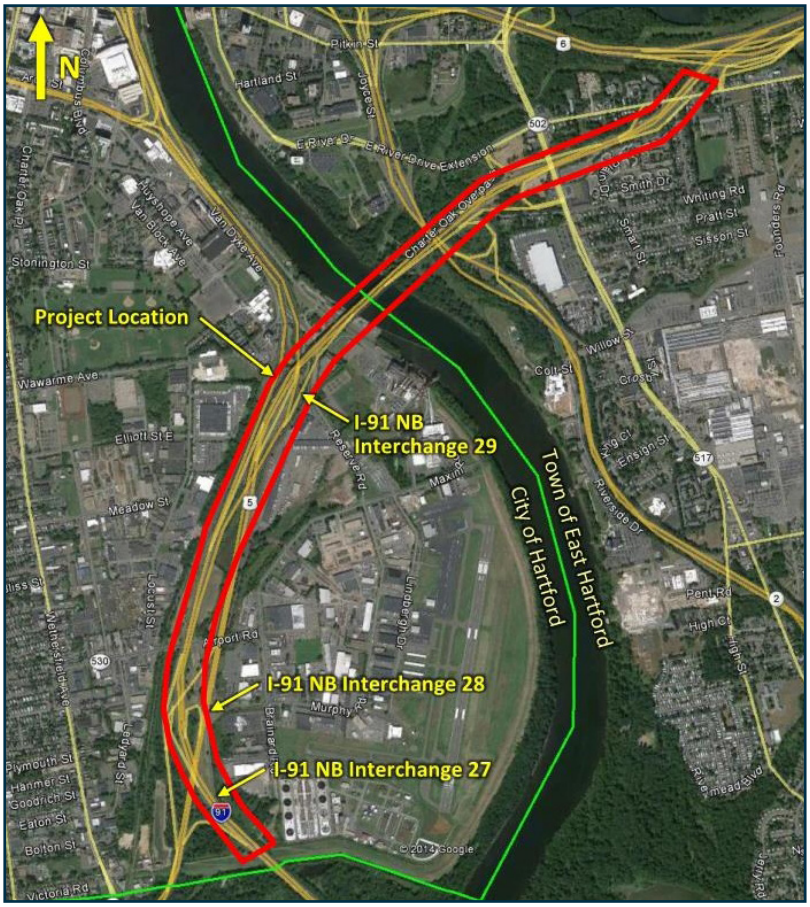

Figure E1: Project Area

The geometric and congestion issues associated with the Interchange 29 off-ramp will require the removal and relocation of the existing ramp to just south of Bridge No. 05992 (I-91 over Route 5/15) in the form of a major diverge. The proposed left-exit ramp will consist of two lanes and require a new bridge over Route 15 SB. The proposed diverge requires the realignment of Route 15 NB and widening of the southern approach to the Charter Oak Bridge (Bridge No. 06000A, Route 15 NB over I-91, Reserve Road and rail line). The Charter Oak Bridge (Bridge No. 06000A) consists of a 12-foot left shoulder, three 12-foot travel lanes and a 12-foot right shoulder. In order to accommodate the two lanes from I-91 and Route 15, it is proposed to modify the existing pavement markings to provide a 4-foot left shoulder, four 11-foot travel lanes, and a 12-foot right shoulder.

Due to the proximity of a four-lane merge and lane drop at Interchange 90, Route 15 would be widened to three travel lanes from north of the Charter Oak Bridge to the Silver Lane underpass and provide a lane-drop prior to its merge with I-84 EB. The widening addresses congestion concerns on Route 15 and allows a more desirable distance from Interchange 29 to merge from three travel lanes to two prior to its merge with I-84 EB. This improvement will require the widening of Bridge No. 06043A (Route 15 over Route 5) and Bridge No. 05796 (Route 15 over Silver Lane).

E.2 PROPOSED WORK

As part of the subject contract, CTDOT has requested that Benesch conduct a Value Engineering (VE) Study for the referenced project in accordance with Federal Regulation 23, CFR Part 627, ASTM E1699 and with the standards established by SAVE International, formerly known as the Society of American Value Engineers.

The project addresses the relocation of Interchange 29 on I-91 Northbound in Hartford and East Hartford for safety and operational improvements.

The VE Study was conducted the week of May 23, 2016. The Information Phase began with the project introduction and presentation by the Project Designer, CME Associates, of the current Preliminary Design. The remainder of the VE Study was carried out at the Glastonbury offices of Alfred Benesch & Company.

The results of the VE Study were presented to CTDOT and the Project Designer on Wednesday, June 1, 2016 at the Newington offices of CTDOT. A summary of the VE Study, including proposals, are as follows. **The recommended VE Alternative for each proposal is labeled in blue.**

E.3 PROPOSALS

Proposal P1 – Evaluation of CTDOT Interchange Alternatives

As Given: Alternative 8B proposed to relocate Exit 29 Ramp to the left side of I-91, and treat it as a two (2) lane major diverge instead of an exit ramp. The I-91 Exit 29 traffic will enter Route 5/15 on the left side of the roadway. Route 5/15 over the Charter Oak Bridge will be partially widened and re-striped to provide four (4)11-foot lanes with the right lane acting as an "Exit Only" lane to Exit 89 to Route 2 and Main Street. The maximum grade for Exit 29 will be 2.55%.

CTDOT Alternative 4: Alternative 4 proposed to relocate Exit 29 south and combine it with Exit 27 (Brainard Road). The new combined exit would be a two-lane exit, with the Exit 29 traffic continuing over Route 5/15 northbound on a two-lane flyover structure, intersecting with Route 5/15 traffic from the left. Route 5/15 would continue north as five lanes, with three lanes continuing onto the Charter Oak Bridge and two lanes exiting to I-91 northbound via Exit 89. The existing Exit 29 Ramp would be removed, and the existing three lanes on the Charter Oak Bridge will be maintained. Four bridges, two carrying I-91 over roadways and two carrying roadways over

I-91 will need replacement, as well as a major realignment and reconstruction of Route 5/15 between I-91 south of Exit 28 and the Charter Oak Bridge.

CTDOT Alternative 6C: Widen the existing Exit 29 Ramp to provide two lanes on the existing horizontal and vertical geometry. This Alternative leaves Exit 29 in its current location but would widen the ramp roadway to two lanes. The existing ramp geometry (horizontal and vertical) remains unchanged. The Charter Oak Bridge would be re-striped to provide four travel lanes by narrowing the shoulders and providing 11-foot travel lanes. The Route 5/15 Exit would be re-configured to eliminate the connection to Route 2, which allows the diverge point to be shifted east. This change allows for a longer weaving section along Route 5/15 between where the I-91 traffic merges to where the Exit 90 traffic leaves the mainline traffic stream.

CTDOT Alternative 6D: Similar to Alternative 6C, but does not alter / relocate Route 5/15 Exit 90 to Route 2 and Main Street.

RECOMMENDATION

The VE Team validates the As Given Alternative.

Proposal P2 - Maintain the I-91 NB Exit 29 Ramp on the Existing Alignment

As Given: It is proposed to relocate the Exit 29 Ramp to the left side of I-91 and treat it as a two (2) lane major fork instead of an exit ramp. The I-91 Exit 29 traffic will enter Route 5/15 on the left side of the roadway. Route 5/15 over the Charter Oak Bridge will be re-striped to provide four (4) 11-foot lanes with the right lane acting as an "Exit Only" lane to Exit 90 to Route 2 and Main Street. The maximum grade for Exit 29 will be 2.55%.

VE Alternative P2A: Widen the existing Exit 29 Ramp to provide two lanes on the existing horizontal and vertical geometry. This Alternative leaves Exit 29 in its current location but would widen the ramp roadway to two lanes. The existing ramp geometry (horizontal and vertical) remains unchanged. (This is similar to the original CTDOT Alternate 6C).

VE Alternative P2B: Widen the existing Exit 29 Ramp to provide two lanes on the existing horizontal alignment with new, flatter, vertical geometry.

VE Alternative P2C: Keep Exit 29 as a single-lane ramp, but move the diverge / decision point further south. This Alternative leaves Exit 29 in its current location. The existing ramp geometry (horizontal and vertical) remains unchanged, but move the physical separation of the ramp and mainline further south. The exit ramp would be separated from the mainline traffic by a physical barrier to minimize queue jumping.

RECOMMENDATION

The VE Team validates the As Given Alternative.

Proposal P3 - I-91 Capacity Improvements

As Given: Widen I-91 northbound to four (4) lanes from south of Exit 27 to the new Exit 29. The new Exit 29 will be a major fork with two (2) lanes diverging to the left for Exit 29 and three (3) lanes continuing north as I-91. Exit 27 will be converted from an "Exit Only" lane to a conventional exit.

VE Alternative P3A: Except for the minimum widening to develop four lanes for the Exit 29 major fork, keep I-91 northbound three lanes wide between Exit 27 and Exit 29. The widening to achieve the four (4) lane cross section in advance of the major fork must begin 2,000 feet prior to the decision point. This widening begins prior to Bridge 00480 (Airport Road), requiring widening of the bridge.

RECOMMENDATION:

The VE Team validates the As Given Alternative because it provides the necessary number of lanes along I-91 to meet future traffic volumes.

Proposal P4 - Revise Route 15 Eastern Project Limit

As Given: Route 15 is widened to accommodate three (3) travel lanes from the east end of the Charter Oak Bridge, matching the existing two (2) travel lanes approximately 300 feet east of Bridge No. 05796 over Silver Lane. This requires widening the existing bridge over Silver Lane. Noise barrier at the south curb line was recently reconstructed from Exit 91 to the project limit.

VE Alternative P4A: Match the existing two (2) travel lanes on Route 15 west of Silver Lane. A reduction of 550 feet of associated roadway widening of Route 15. This proposal eliminates the widening of Bridge No. 05796 – Route 15 over Silver Lane and reduces the amount of recently reconstructed Noise Barrier.

RECOMMENDATION

The VE Team recommends VE Alternative P4A, which shifts the eastern project limits of Route 15 northbound construction in East Hartford to west of Silver Lane.

Proposal P5 -New Exit 29 Bridge over Route 5/15 Southbound Width / Cross Section

As Given: Exit 29 - 12-foot Left Shoulder, 12-foot lanes, 12-foot Right Shoulder.

VE Alternative P5A: Construct the New Exit 29 Bridge over Route 5/15 Southbound with a 4-foot Left Shoulder, 12-foot Lanes, and a 10-foot Right Shoulder. Currently, the left shoulder along I-91 immediately to the south of the new bridge is six feet wide, and immediately to the north, the left shoulder is four feet wide along the Charter Oak Bridge.

VE Alternative P5B: Construct the New Exit 29 Bridge over Route 5/15 Southbound with a 4-foot Left Shoulder, 11-foot lanes, and a 10-foot Right Shoulder. This is similar to VE Alternative P4A, except instead of 12-foot travel lanes, 11-foot travel lanes will be provided. This 11-foot travel lane width matches the travel lane widths that are being provided upstream on the Charter Oak Bridge. This will reduce the overall width of the bridge from 48 feet curb-to-curb / 51 feet 10 inches out-to-out to 36 feet curb-to-curb / 39 feet 10 inches out-to-out, for a reduction of 12 feet of width.

RECOMMENDATION:

The VE Team recommends Alternative P5A.

Proposal P6 - Consider Alternate Approaches to Addressing Vertical Clearance Issues at I-91 Underpasses

As Given: Provide an increased under-clearance at the bridges to meet 14 feet- 6 inches by lowering the roadway profiles below the bridges, along with utilizing shallower beams for the widening. This underclearance is the minimum standard.

VE Alternative P6A: Maintain the existing minimum under-clearances at the bridge by utilizing shallower beams for the widening (wherever possible).

VE Alternative P6B: Provide an increased under-clearance at the bridges to meet 14 feet- 6 inches by replacing the superstructure with new, shallower superstructures.

RECOMMENDATION:

The VE Team validates the As-Given solution to increase the vertical clearance to 14 feet- 6 inches under the three bridges by lowering the roadway and utilizing shallow depth beams to complete the widening.

Proposal P7 -Optimize Span Configuration

As Given: Construct a five-span continuous Trapezoidal Box Girder. The spans are 140 feet, 215 feet, 215 feet, 170 feet and 140 feet. The total Bridge length is 880 feet. Piers #1, #3 and #4 are concrete wall piers with steel integral bent caps. Pier #2 is a Straddle Pier. The width is 51 feet - 10 inches. The deck area is 45,610 SF.

VE Alternative P7A: Construct a three-span Continuous Plate Girder. The spans are 215 feet, 215 feet, and 170 feet. The total Bridge length is 600 feet. Pier #1 is a Straddle Pier and Pier #2 will be a Hammerhead Pier. The abutment corners will be clipped to accommodate the barrier below. In addition, the wingwall will be set back to accommodate the barrier below. The width is 51 feet -10 inches. The deck area is 31,098 SF.

VE Alternative P7B: Construct a four-span continuous Plate Girder. The spans are 215 feet, 215 feet, 170 feet and 140 feet. Add a 40-foot approach span with precast beams / girders. The total Bridge length is 780 feet, including the single 40-foot approach span. Pier #2 is a Straddle Pier and Piers #1, #3 and #4 will be a Hammerhead Piers. The width is 51 feet - 10 inches. The deck area is 40,428 SF.

VE Alternative P7C: Construct a four-span continuous Plate Girder. The spans are 255 feet, 215 feet, 170 feet and 140 feet. The total Bridge length is 780 feet. Pier #1 is a Straddle Pier and Piers #2, #3 and #4 will be Hammerhead Piers. The width is 51 feet - 10 inches. The deck area is 40,428 SF.

RECOMMENDATION:

The VE Team recommends the implementation of Alternative P7C. Though Alternative P7A appears to offer greater savings, there are complexities with the design at the north abutment which make this Alternative undesirable.

E.4 SUMMARY OF PROPOSALS

The VE Team validated the following As Given options:

- Proposal No. 1 –Evaluation of CTDOT Interchange Alternatives
- Proposal No. 2 - Maintain the I-91 NB Existing Exit #29 on the Existing Alignment Alternative
- Proposal No. 3 - I-91 Capacity Improvements
- Proposal No. 6. Vertical Clearance Issues at I-91 Underpasses

Proposal Number	Description	As Given	VE Alternative	Cost Difference	Cost Difference (+) Savings Add'l Const.
P1	Evaluation of CTDOT Interchange Alternatives	$170,000,000	—	—	$0*
P2	Maintain the I-91 NB Existing Exit #29 on the Existing Alignment Alternative	$170,000,000	—	—	$0*
P3	I-91 Capacity Improvements	$36,741,000	—	—	$0*
P4	Revise Route 15 Eastern Project Limit	$12,812,000	$0	(+)$12,812,000	(+)$12,812,000
P5	New Exit #29 Bridge Typical Section	$38,489,000	$30,918,000	(+)$7,570,500	(+)$7,570,500
P6	Vertical Clearance Issues at I-91 Underpasses	$35,474,000	—	—	$0*
P7	Optimize Span Configuration	$39,812,000	$37,230,000	(+)$2,582,000	(+)$2,582,000
Total Potential Reduction					**$22,964,500**

* Validation

Figure E.1: Summary of Proposals

1 INTRODUCTION

1.1 PROJECT DESCRIPTION

Alfred Benesch & Company (Benesch) performed a Value Engineering Workshop for the Connecticut Department of Transportation (CTDOT). State Project No. 63-703 involves the relocation of Interchange 29 on Interstate 91 (I-91) Northbound (NB) and the widening of I-91 NB and State Route 5/15 NB towards Interstate 84 (I-84) Eastbound (EB) in Hartford and East Hartford, Connecticut.

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The I-91 NB Interchange 29 off-ramp is a single-lane configuration with a steep vertical grade that contributes to significant traffic delays due to the heavy volume of vehicles. In addition to the geometric deficiencies of the off-ramp, there is a heavy weave condition occurring on the Charter Oak Bridge at the end of the ramp where motorists attempt to access I-84 EB, Route 5/15 NB, Route 2 and Silver Lane. The existing traffic queues extend onto the I-91 NB mainline, taking up the right lane of the three-lane facility. The length of the queue varies, but has been observed to extend approximately 1.4 miles in the vicinity of Wethersfield Cove. The safety issues are compounded by drivers that routinely cut into the right-lane queue from the center lane, which further increases congestion on I-91 in this area.

The current preferred design Alternative is Alternate 8B, which includes the widening of I-91 NB for approximately 4,300 feet to provide four lanes from Interchange 27 to 29. The widening is anticipated to relieve congestion and address safety concerns due to motorists entering the queue from the center lane of I-91 NB. The widening will require modifications to Bridge No. 00813 (I-91 over Route 15), Bridge No. 03613 (I-91 over a drainage crossing), Bridge No. 01466 (I-91 over the SB entrance ramp to I-91 SB and Route 15 SB), and Bridge No. 00480 (I-91 over Airport Road).

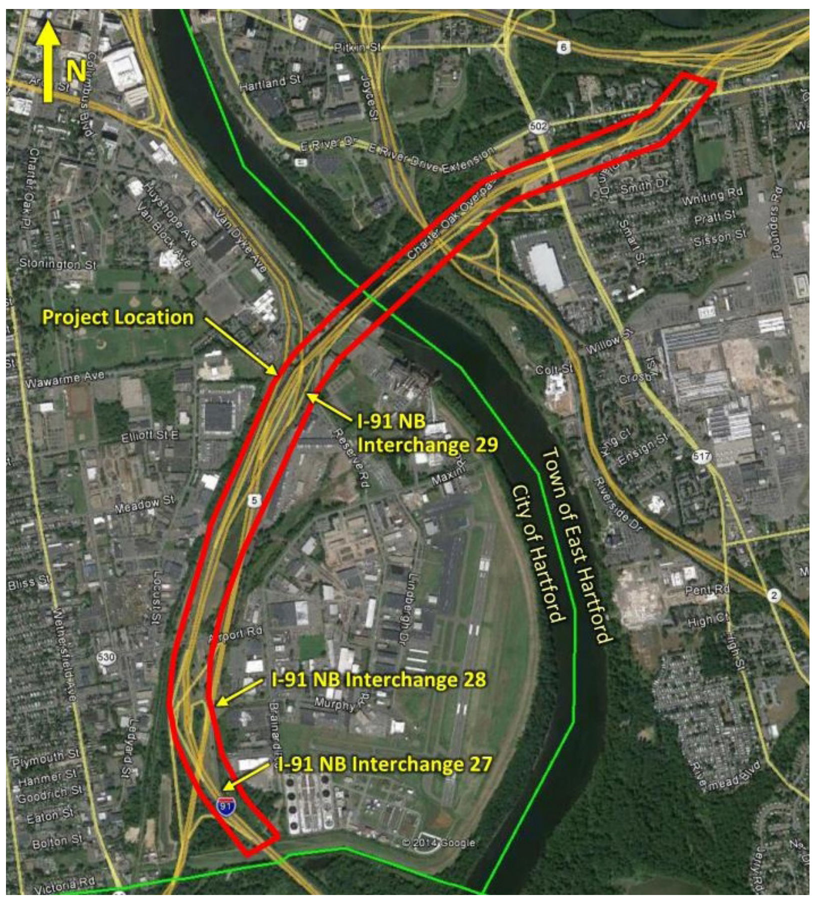

Figure 1.1: Study Area

The geometric and congestion issues associated with the Interchange 29 off-ramp will require the removal and relocation of the existing ramp to just south of Bridge No. 05992 (I-91 over Route 5/15) in the form of a major diverge. The proposed left-exit ramp will consist of two lanes and require a new bridge over Route 15 SB. The proposed diverge requires the realignment of Route 15 NB and widening of the southern approach to the Charter Oak Bridge (Bridge No. 06000A, Route 15 NB over I-91, Reserve Road and rail line). The Charter Oak Bridge (Bridge No. 06000A) consists of a 12-foot left shoulder, three 12-foot travel lanes and a 12-foot right shoulder. In order to accommodate the two lanes from I-91 and Route 15, it is proposed to modify the existing pavement markings to provide a 4-foot left shoulder, four 11-foot travel lanes, and a 12-foot right shoulder.

Due to the proximity of a four-lane merge and lane drop at Interchange 90, Route 15 would be widened to three travel lanes from north of the Charter Oak Bridge to the Silver Lane underpass, and provide a lane-drop prior to its merge with I-84 EB. The widening addresses congestion concerns on Route 15 and allows a more desirable distance from Interchange 29 to merge from three travel lanes to two prior to its merge with I-84 EB. This improvement will require the widening of Bridge No. 06043A (Route 15 over Route 5) and Bridge No. 05796 (Route 15 over Silver Lane).

1.2 VALUE ENGINEERING SCOPE

The Benesch VE Team was asked to review the As-Given design and its cost estimates to determine if cost savings could be identified without compromising the main purpose (the Task) of the project.

The scope of the assignment was to perform a VE Study on the design following the SAVE International model. The Alternatives' potential cost savings, performance and Stakeholder acceptance were compared with functions to assure that value was preserved or enhanced. This process was conducted over a five-day period with a presentation of the preliminary findings on June 1, 2016.

1.3 VALUE ENGINEERING PROCESS

The study was conducted utilizing value engineering techniques. Value engineering advocates a team-oriented, systematic approach. This systematic approach is embodied in the VE Job Plan (Figure 1.2). The VE Job Plan has several phases and imposes a set of rules that must be adhered to for each phase. The rules may appear to be simple, but they are vital to the success of the value planning process. This section describes the typical VE Job Plan and explains the rules of the VE Job Plan and the reasoning behind them.

The ultimate goal of a VE Study is to carefully transform the needs and desires for a project into functions. The VE Team then speculates about ideas for all functions and develops a solution that scores high on performance, with a reasonable acceptance and cost. At the end, VE efforts result in a solution that satisfies owners, users and Stakeholders. The VE Team keeps the following three principles in mind when determining value:

1. Every action is required or desired by someone (Stakeholders)
2. Every action has a reason or purpose (Function)
3. The cost of each action must be justified within the limits of constraints (Function Cost)

INFORMATION PHASE

The purpose of the Information Phase is to gain an understanding of the project and the Stakeholders who will be effected. The information phase can be summarized as follows:

- Review all relevant project information, including description and scope of work
- Identify owners, users and Stakeholders
- Identify needs, desires and constraints of owners, users and Stakeholders

FUNCTION ANALYSIS PHASE

- Using Stakeholder needs, desires and constraints, develop project related functions
- Determine the task, basic function(s) and supporting functions
- Estimate the cost of project elements and each critical function
- Analyze owner and Stakeholder attitudes toward each function

SPECULATION PHASE

The purpose of the Speculation Phase is to identify ideas that will perform the project functions or will enhance performance or acceptance at a reasonable cost.

EVALUATION PHASE

The purpose of the Evaluation Phase is to identify the most outstanding Alternatives for further development. This identification is accomplished through a series of screening processes that sort ideas by comparison and combination. Using these ideas, Alternatives are developed. These Alternatives are then rated for performance, acceptance and cost.

DEVELOPMENT PHASE

The purpose of the Development Phase is to add information that facilitates selection of a preferred Alternative. This is accomplished by comparing the remaining Alternatives. The following rules are considered during the Development Phase:

- Recognize ideas that may be unique
- Conduct research, as required, to provide additional information
- Analyze weaknesses of selected Alternatives and provide improvements

Figure 1.2 depicts the process from needs and desires of Stakeholders to the project solution, using the VE Job Plan.

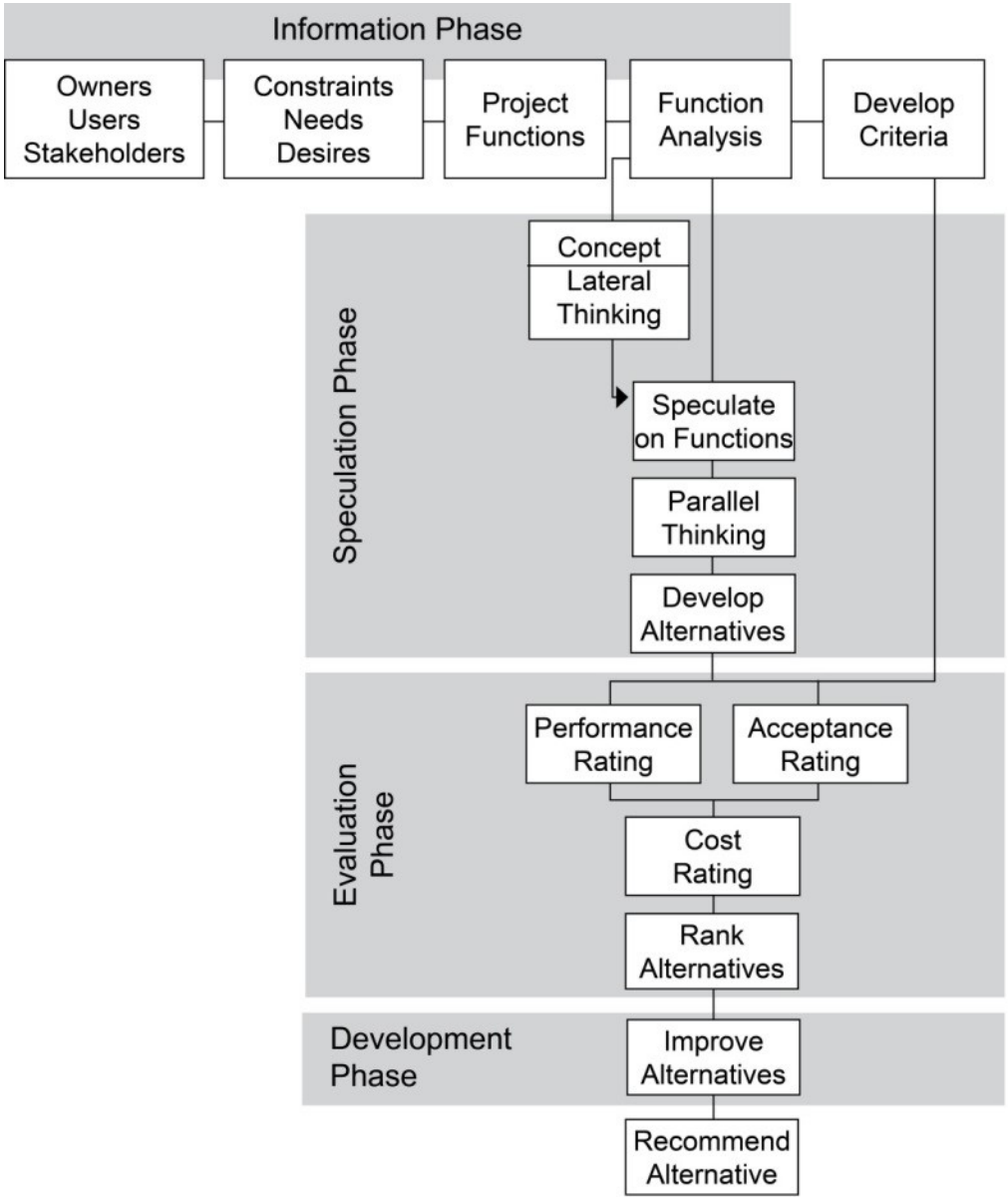

Figure 1.2: VE Job Plan Flow Diagram

2 INFORMATION PHASE

2.1 INTRODUCTION

The first step in Value Engineering is to understand the Purpose and Need of the project:

WHAT IS IT?

The question can be answered in two steps:

1. Identify owners, users, and other Stakeholders.
2. List their constraints, needs and desires.

Among the rules that govern the Information Phase are the following:

- Do not speculate
- Do not judge
- Understand the problem

Prior to the study, the VE Team was provided with design reports, preliminary cost estimates and other documentation to familiarize themselves with the project. On the first day, the VE Team met with the CTDOT Project Team. A presentation on the project was provided by CME Associates (the Designers) and questions of the VE Team were answered. An attendance sheet of those participating in the meeting is included in Appendix A.

The VE Team began the study by determining Owners, Users, and Stakeholders for the project. Constraints, Needs, and Desires were also defined by the end of Day One of the study.

2.2 DESCRIPTION OF OWNERS, USERS AND STAKEHOLDERS

In general, everyone involved in a project is a Stakeholder. However, during this part of the Information Phase, they are grouped separately as Owners, Users and Stakeholders, as defined below:

These groupings help the VE Team better understand what the project does and what it should do. In subsequent sections, the Owners, Users and Stakeholders will be referred to only as Stakeholders.

OWNERS
THOSE WHO:

1. Own the project
2. Fund the project
3. Share in the funding
4. Represent the owner's interests
5. Manage the project for the owner

USERS
THOSE WHO:

1. Use the project
2. Operate the project
3. Maintain the project

Stakeholders
THOSE WHO ARE:

1. Financially effected by the project
2. Environmentally concerned about the project
3. Disturbed by a required change in habits or recreation

2.3 OWNERS, USERS AND STAKEHOLDERS

The following is a list of Owners, Users and Stakeholders identified by the VE Team.

1. Connecticut Department of Transportation
2. City of Hartford
3. Town of East Hartford
4. FHWA
5. MDC
6. MIRA
7. USACOE
8. Coast Guard
9. Regional Farmers Market
10. Railroad - CT Southern
11. DEEP
12. I-91 Traffic
13. Route 15 Traffic
14. Exit 29 Traffic
15. Local Businesses
16. UPS
17. Brainard Airport
18. Truck Traffic
19. Local Traffic
20. Boat Traffic
21. Charter Oak Landing
22. Great River Park
23. Miscellaneous Utilities
24. Eversource
25. Residents
26. Police
27. Fire
28. Ambulance
29. Pedestrian Traffic
30. Contractor
31. Designer
32. Governor
33. Maintenance Forces
34. US Fish and Wildlife
35. CTDOT District 1 Construction
36. CRCOG
37. Riverfront Recapture
38. River Cruise Companies

2.4 DESCRIPTION OF CONSTRAINTS, NEEDS AND DESIRES

Each Stakeholder expects something from the project. Stakeholder expectations were then grouped into constraints, needs and desires, as defined below:

CONSTRAINTS:

1. Legal requirements
2. Standards of the owner
3. Physical site conditions
4. Stakeholder commitments

NEEDS:

1. Expectations that must be fulfilled if constraints are not violated
2. Limitations or restrictions that are imposed by Stakeholders but which can be violated (the degree of violations will be considered in the evaluation of Alternatives)

DESIRES:

1. Expectations that should be fulfilled if cost is not a factor

There are several points to keep in mind in identifying the Stakeholder constraints, needs and desires. First, the majority of constraints are prescribed by law, applicable codes and standards. These constraints are too numerous to be listed for each VE Study. Constraints listed are those imposed by a Stakeholder or by a code or standard that applies strictly to this project. Secondly, design criteria are described as a constraint, need and desire. Lastly, needs and desires are generally not executable. They are generally visions of what the project should do.

2.5 LIST OF NEEDS, DESIRES AND CONSTRAINTS

1. Begin Construction - Spring 2018
2. I-91 NB - Exit 27-29 - Four Lanes
3. Two lane Exit 29 Ramp
4. Correct substandard geometry at Exit 29 Ramp
5. Improve weaving operation on COB
6. Bridge 813 (Route 15) - Provide 13'-10" Minimum Vertical Clearance
7. Bridge 813 (Route 15) - Provide 14'-6" Minimum Vertical Clearance
8. Bridge 1466 (15S - 91S Ramp) - Provide 14'-0" Minimum Vertical Clearance
9. Bridge 1466 (15S - 91S Ramp) - Provide 14'-6" Minimum Vertical Clearance
10. Bridge 480 (Airport Road) - Provide 13'-11" Minimum Vertical Clearance
11. Bridge 480 (Airport Road) - Provide 14'-6" Minimum Vertical Clearance
12. Bridge 6043A (Route 15 over Main St) - Provide 16'-10" Min Vert Clearance
13. Bridge 6043A (Route 15 over Main St) - Provide 14'-6" Min Vert Clearance
14. Bridge 5796 (Route 15 over Silver Lane) - Provide 15'-8" Min Vert Clearance
15. Bridge 5796 (Route 15 over Silver Lane) - Provide 14'-6" Min Vert Clearance
16. Bridge 5922 (I-91 NB over Route 15) - Match existing vertical clearance.
17. I-91 NB - Provide 12' Lanes
18. Route 15 - Provide 11' Lanes
19. Route 15 - Provide 12' Lanes
20. Exit 29 Ramps - Provide 11' Lanes
21. Exit 29 Ramps - Provide 12' Lanes
22. I-91 NB - 10' Right Shoulder
23. I-91 NB - 12' Right Shoulder
24. I-91 NB - 6' Left Shoulder
25. I-91 NB - 12' Left Shoulder
26. Route 15 - 4' Right Shoulder
27. Route 15 - 12' Right Shoulder
28. Route 15 - 4' Left Shoulder
29. Route 15 - 12' Left Shoulder
30. Exit 29 Ramp - 10' Right Shoulder
31. Exit 29 Ramp - 12' Right Shoulder
32. Exit 29 Ramp - 6' Left Shoulder
33. Exit 29 Ramp - 12' Left Shoulder
34. I-91 NB - 70 MPH Design Speed
35. I-91 NB - 55 MPH Design Speed
36. Route 15 - 55 MPH Design Speed
37. Route 15 - 70 MPH Design Speed
38. Route 15 Ramps - 55 MPH Design Speed
39. Route 15 Ramps - 70 MPH Design Speed
40. No Permanent ROW Takes
41. Match profile at I-91 Median Barrier
42. Maintain 45 MPH During Construction
43. I-91 - Maintain all existing lanes during peak hours.
44. Route 15 NB - Maintain 2 lanes all times.
45. Route 15 SB - Maintain 2 lanes all times.
46. Match profile at COB
47. Provide 4% Max. Profile Grade on I-91
48. Provide 4% Max. Profile Grade on Route 15
49. Provide 4% Max. Profile Grade on Exit 29 Ramp
50. Maintain Railroad Operating Clearances
51. Avoid Impacting Capped Landfills
52. Avoid Impacts to Wetlands
53. Minimize Impacts to Wetlands
54. Avoid Impacts to Watercourses
55. Minimize Impacts to Watercourses
56. Minimize Impacts to Endangered / Protected Species
57. Minimize Noise Impacts to Local Residents
58. Contain Construction Debris

3 FUNCTION ANALYSIS PHASE

3.1 INTRODUCTION

The next step is to answer the question:

WHAT DOES IT DO?
WHAT DOES IT COST?

This is the key question in the Function Analysis Phase and is developed by:

1. Using the constraints, needs and desires of the Stakeholders.
2. Splitting each element into parts and assigning the reason for the part as functions.

Among the rules that govern the Function Analysis Phase are the following:

- Functions are expressed in two words; an active Verb and descriptive Noun
- Avoid the description or action of an element as functions

3.2 FUNCTION AND FUNCTION LOGIC DIAGRAM

Function

The VE Team developed a list of functions for the project using the constraints, needs and desires. This involves the grouping of Stakeholders needs and desires, looking at them from a project perspective and separating general functions from actions. Functions are carefully defined to express the Team's understanding of the purpose of the elements.

Function Logic

The goal of the function logic phase of a VE Workshop is to develop an understanding of what the project must do (i.e. what functions must the project perform in order to be successful and what functions would it be nice for the project to perform if constraints are not violated and/or cost is not a factor). Basically, the process involves grouping the Stakeholder constraints, needs and desires and looking at them from the project's perspective. The process separates functions, which are general in nature, from actions, which are more specific. Later in the VE Process, the VE Team will speculate on different ways to accomplish the various Functions.

> **"The goal of the Function Logic Phase of a VE Workshop is to develop an understanding of what the project must do.**

Functions are classified into task, basic functions and enhancing functions. The task represents the reason for the project. The basic functions represent the minimum that the project must perform in order to perform the task. However, no project is complete with basic functions alone. They are usually required to perform enhancing functions, in order to make the project viable.

The driving force for the project is to Improve Operations, which is the Task of the Project. Exit 29 has design deficiencies that resulted in high level crashes, long queuing, and delays. To improve operations, three functions are needed. They are the basic functions: *Increase Ramp Capacity, Increase Charter Oak Bridge (COB) NB Capacity*, and *Minimize Conflicts*.

DEPENDABLE

The corridor is dependable when the following safety-related functions are satisfied:

- Protect Structure
- Safeguard Traffic
- Protect Workers

In addition, the existing structures should be properly restored to maintain the design strength (*Restore Structural Integrity)*. Two functions (*Exclude Elements* and *Strengthen Members*) will *Restore Structural Integrity*.

CONVENIENT

The next classification is how the project maintains and improves the convenience of drivers and residents. Even though CTDOT addresses the basic and dependability functions to the satisfaction of the public, the public feels good only when the project improvements address the convenient functions. *Increase I-91 NB Capacity* and *Maintain Traffic (During Construction)* are two such functions. In addition, the function, *Meet Expectations (Traffic)*, will result in assuring convenience to the traffic. There are four functions that are identified that will result in meeting the expectations of the traffic. They are *Store Vehicles* (Shoulder), *Guide Traffic, Comfort Traffic* and *Minimize Confusion*.

SATISFY Stakeholders

There are functions that are not directly related to the task, Improve Operations. However, they are critical to various Stakeholders to give their concurrence to the project improvements The following functions are desired by various Stakeholders:

Functions	Primary Stakeholders
• Facilitate Construction	• Contractor
• Limit Impacts	• Residents & Public
• Minimize ROW Impacts	
• Reduce Noise	
• Preserve Neighborhood	
• Protect Environment	
• Protect Utilities	• Utility Company
• Reduce Maintenance	• CTDOT

ATTRACT Stakeholders

There are elements that address Attract Stakeholder functions. They will improve the function, Improve Aesthetics. This includes wall treatments, Pier shape, Parapet Types and Noise Wall Finishes.

VALUE

Value is defined as fulfilling the project functions that are needed to make the project work and sell. *Basic* and *Assure Dependability* functions make it work, while *Assure Convenience, Satisfy Stakeholders and Attract Stakeholder* function to help to sell/accept the project. Further explanation of the functions are covered as part of the explanation of allocating cost to each function. Figure 3.1 is a Function-Logic Diagram, which shows the relationship of the Task, Basic, and Enhancing Functions. This diagram is the basis for the value engineering process.

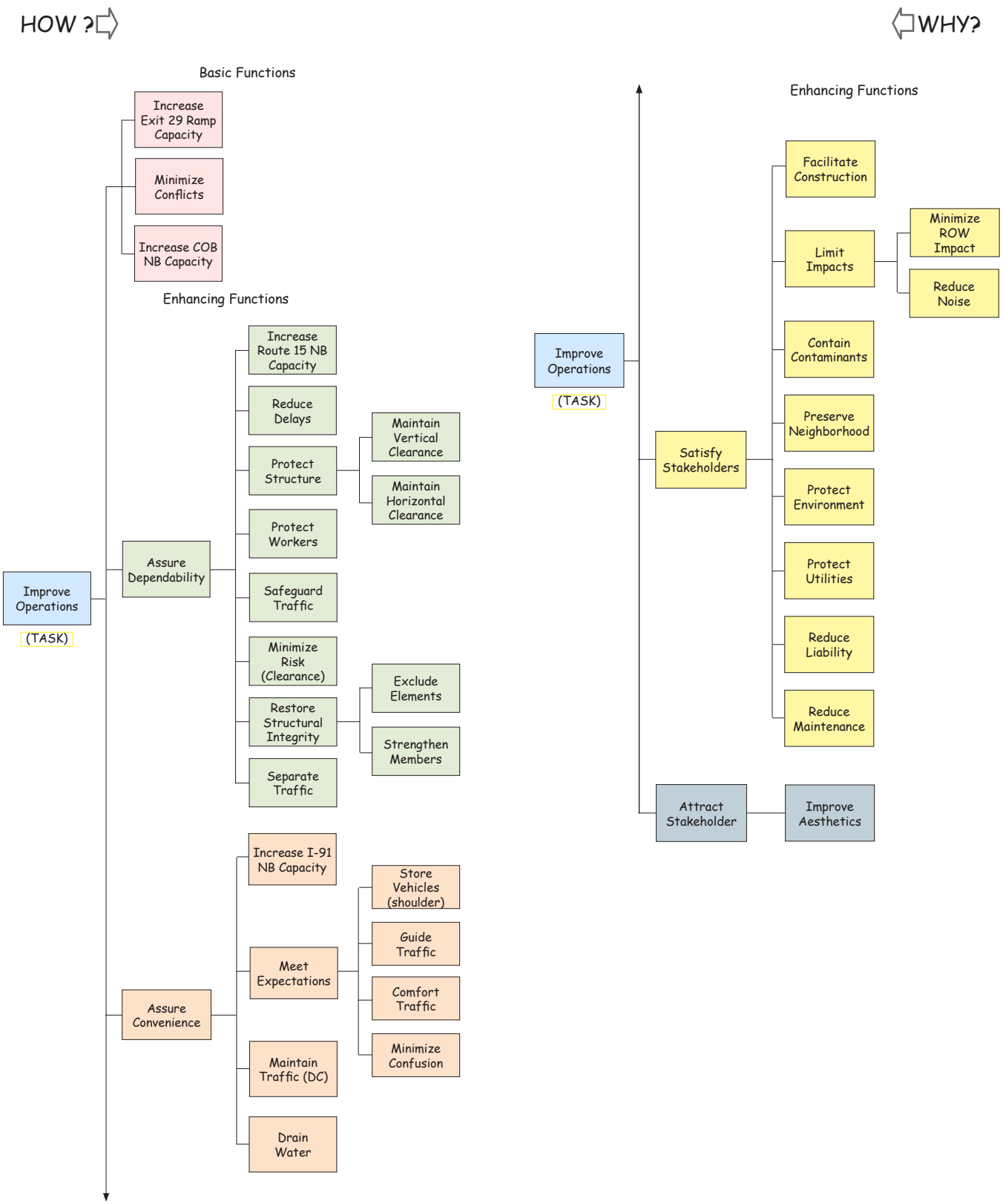

Figure 3.1: Function Logic Diagram

3.3 ESTIMATED COMPARATIVE COST

Figure 3.2 is a summary of the cost estimate received from the Design Team.

CME Project Number: 63703CT.1 Date: 1/15/16 Page: 1 of 5

STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
COST ESTIMATE
PRELIMINARY DESIGN SUBMISSION

Project Title: Relocation of I-91 NB Interchange 29 and Widening of I-91 and Route 15 NB to I-84 EB
I-91/US 5/Route 5 in City of Hartford/Town of East Hartford
Project Limits: Station 102+00 to 264+50
Federal Aid Project Number: [redacted]
State Project Number: 0063-0703
City / Town: Hartford/ East Harford

Estimated Cost Summary	Amount
STRUCTURE TOTAL	$ 94,070,438
ROADWAY TOTAL	$ 17,023,480
TRAFFIC TOTAL	$ 4,159,197
NOISE BARRIER WALL (STRUCTURE) EST.	$ 3,969,800
MS TOTAL	$ 763,800
ENVIRONMENTAL TOTAL	$ 4,045,800
TOTAL ITEMS =	$ 124,822,115

Item No.	Item Description		Unit		%	Total Items Cost	Amount
0201001	CLEARING AND GRUBBING	(% OF TOTAL ITEMS)	L.S.		1.0%	$ 124,822,115.28	$1,240,221
0971001	M & P OF TRAFFIC	(% OF TOTAL ITEMS)	L.S.		6%	$ 124,822,115.28	$7,441,327
0970002	MOBILIZATION AND PROJECT CLOSEOUT	(% OF TOTAL ITEMS)	L.S.		5%	$ 124,822,115.28	$6,201,106
0980001A	CONSTRUCTION STAKING	(% OF TOTAL ITEMS)	L.S.		1%	$ 124,822,115.28	$1,240,221
						LUMP SUM ITEMS =	$16,122,874

MINOR ITEMS (BASED ON % OF TOTAL ITEMS + LUMP SUM ITEMS)	23%	$28,029,000

BASE ESTIMATE = TOTAL ITEMS + LUMP SUM ITEMS + MINOR ITEMS
BASE ESTIMATE = $168,173,990

INCIDENTALS (% OF PRELIM. CONST. COST)	10%	$16,817,399
CONTINGENCIES (% OF PRELIM. CONST. COST)	23%	$33,634,799
INCIDENTALS & CONTINGENCIES =		50,452,197

UTILITY (CONSTRUCTION) 5% BASE ESTIMATE	$ 8,410,800
RAILROAD (CONSTRUCTION) 1% BASE ESTIMATE	$ 1,699,800
STATE POLICE COSTS	$ 700,800
TOWN/CITY POLICE COSTS	$ 200,800

5% INFLATION FOR 4.25 YEARS (from estimate date to midpoint of construction=Subtotal*1.05^4.25) INFLATION = 48,437,000

TOTAL PRELIMINARY DESIGN PROJECT COST = $276,173,187

SAY : $276,200,000

By: CLR Date: 1/15/2016
Checked By: DLS Date: 1/15/2016

Figure 3.2 Summary of Cost Estimate (As Given)

CME Project Number: 63703CT.1 Date: 1/15/18

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STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
COST ESTIMATE
STRUCTURE ITEMS

Project Title: Relocation of I-91 NB Interchange 29 and Widening of I-91 and Route 15 NB to I-84 EB
I-91/US 5/Route 5 in City of Hartford/Town of East Hartford

Federal Aid Project Number: [illegible]
State Project Number: 0063-0703

Project Limits: Station 103+00 to 264+65

City / Town: Hartford
East Hartford

Item No.	Item Description	Unit	Quantity			Unit Price	Amount
			Hwy	Bridge	Total		
0503000	REMOVAL OF EXISTING BRIDGE	L.S.		1	1	$ 2,143,000.00	$ 2,143,000
	REHABILITATION OF BRIDGE (BRIDGE NO. 02555)	L.S.		1	1	$ 224,000.00	$ 224,000
	REHABILITATION OF BRIDGE (BRIDGE NO. 03244)	L.S.		1	1	$ 119,000.00	$ 119,000
	REHABILITATION OF BRIDGE (BRIDGE NO. 00613)	L.S.		1	1	$ 8,890,000.00	$ 8,890,000
	REHABILITATION OF BRIDGE (BRIDGE NO. 03613)	L.S.		1	1	$ 10,900.00	$ 10,900
	REHABILITATION OF BRIDGE (BRIDGE NO. 03614)	L.S.		0	0	$ -	$ -
	REHABILITATION OF BRIDGE (BRIDGE NO. 01499)	L.S.		1	1	$ 4,403,000.00	$ 4,403,000
	REHABILITATION OF BRIDGE (BRIDGE NO. 03480)	L.S.		1	1	$ 3,094,000.00	$ 3,094,000
	REHABILITATION OF BRIDGE (BRIDGE NO. 06990A)	L.S.		1	1	$ 20,079,000.00	$ 20,079,000
	REHABILITATION OF BRIDGE (BRIDGE NO. 06990B)	L.S.		1	1	$ 2,229,000.00	$ 2,229,000
	REHABILITATION OF BRIDGE (BRIDGE NO. 06843A)	L.S.		1	1	$ 1,092,752.00	$ 1,092,752
	REHABILITATION OF BRIDGE (BRIDGE NO. 06843B)	L.S.		1	1	$ 453,080.00	$ 453,080
	REHABILITATION OF BRIDGE (BRIDGE NO. 05796)	L.S.		1	1	$ 2,669,696.00	$ 2,669,696
					0		$ -
	PROPOSED BRIDGE (BRIDGE NO. [illegible])	L.S.		1	1	$ 16,226,000.00	$ 16,226,000
					0		$ -
0601651	RETAINING WALL (SITE NO. 101)	L.S.		1	1	$ 1,360,000.00	$ 1,360,000
0601652	RETAINING WALL (SITE NO. 102)	L.S.		1	1	$ 1,318,000.00	$ 1,318,000
0601653	RETAINING WALL (SITE NO. 103)	L.S.		1	1	$ 10,948,000.00	$ 10,948,000
0601654	RETAINING WALL (SITE NO. 104)	L.S.		1	1	$ 7,309,000.00	$ 7,309,000
0601655	RETAINING WALL (SITE NO. 105)	L.S.		1	1	$ 4,459,000.00	$ 4,459,000
0601656	RETAINING WALL (SITE NO. 106)	L.S.		1	1	$ 1,934,000.00	$ 1,934,000
0601657	RETAINING WALL (SITE NO. 107)	L.S.		1	1	$ 1,579,000.00	$ 1,579,000
					0		$ -
0712010	REINFORCED SOIL SLOPE	L.S.		1	1	$ 1,167,000.00	$ 1,167,000
					0		$ -
					0		$ -
					0		$ -
					0		$ -
					0		$ -
						STRUCTURE ITEMS =	$ 94,070,438

Figure 3.3 Summary of Cost Estimate (Structure Items)

DME Project Number: 83703CT.1 Date: 9/15/18

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STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION
COST ESTIMATE
ROADWAY ITEMS

Project Title: Relocation of I-91 NB Interchange 29 and Widening of I-91 and Route 15 NB to I-84 EB
I-91/US 5/Route 5 in City of Hartford/Town of East Hartford
Federal Aid Project Number: 9999(999)
State Project Number: 0263-0713
Project Limits: Station 102+00 to 264+60
City / Town: Hartford/ East Hartford

Item No.	Item Description	Unit	Quantity			Unit Price	Amount
			Hwy	Bridge	Total		
0202000	EARTH EXCAVATION	C.Y.	62000		62000	$ 18.00	$ 1,116,000
0202452A	TEST PIT	EA.	100		100	$ 1,300.00	$ 130,000
0202501	CUT CONCRETE PAVEMENT	L.F.	11800		11800	$ 0.60	$ 7,080
0202502	REMOVAL OF CONCRETE PAVEMENT	S.Y.	5100		5100	$ 10.00	$ 51,000
0202529	CUT BITUMINOUS CONCRETE PAVEMENT	L.F.	11800		11800	$ 2.00	$ 23,600
0203001	FORMATION OF SUBGRADE	S.Y.	74000		74000	$ 3.00	$ 222,000
0210200	TEMPORARY SLOPE PROTECTION	S.Y.	14000		14000	$ 1.50	$ 21,000
0212000	SUBBASE	C.Y.	25000		25000	$ 40.00	$ 1,000,000
0219001	SEDIMENTATION CONTROL SYSTEM	L.F.	23500		23500	$ 6.00	$ 155,000
0304002	PROCESSED AGGREGATE BASE	C.Y.	130		130	$ 50.00	$ 6,500
0406159	PMA S0.5	TON	49000		49000	$ 100.00	$ 4,900,000
0406160	PMA S1	TON	28000		28000	$ 120.00	$ 3,360,000
0406170	HMA S1	TON	2000		2000	$ 105.00	$ 210,000
0406171	HMA S0.5	TON	2000		2000	$ 105.00	$ 210,000
0406236	MATERIAL FOR TACK COAT	GAL.	44100		44100	$ 3.00	$ 132,300
0406267	MILLING OF HMA (0"- 4")	S.Y.	200		200	$ 3.50	$ 700
0406268	MILLING OF HMA (OVER 4"- 8")	S.Y.	101000		101000	$ 4.50	$ 454,500
0697171A	HYDRODYNAMIC SEPARATOR	L.S.	3		3	$ 25,000.00	$ 75,000
0697201	TYPE "C-L" CATCH BASIN	EA.	130		130	$ 4,000.00	$ 520,000
0697601	MANHOLE	EA.	1		1	$ 4,000.00	$ 4,000
0801107	HIGH EARLY STRENGTH CONCRETE	EST.	1		1	$ 1,200,000	$ 1,200,000
0810102	15" R.C. PIPE	L.F.	800		800	$ 60.00	$ 48,000
0815001	BITUMINOUS CONCRETE LIP CURBING	L.F.	11000		11000	$ 6.00	$ 66,000
0821177	PRECAST CONCRETE BARRIER CURB ("F" SHAPE - SINGLE FACE)	L.F.	11000		11000	$ 100.00	$ 1,100,000
0910170	METAL BEAM RAIL (TYPE R-B 350)	L.F.	9000		9000	$ 25.00	$ 225,000
0910199	R-B 350 BRIDGE ATTACHMENT-VERTICAL SHAPED PARAPET 10 GA	EA.	16		16	$ 2,500.00	$ 40,000
0911925	R-B END ANCHORAGE (TYPE I - 10 GA)	EA.	5		5	$ 1,500.00	$ 7,500
0912503	REMOVE METAL BEAM RAIL	L.F.	9000		9000	$ 6.00	$ 54,000
0935201	PAVEMENT FOR RAILING	S.Y.	4000		4000	$ 45.00	$ 180,000
0943001	CALCIUM CHLORIDE FOR DUST CONTROL	TON	56		56	$ 550.00	$ 30,800
0944000	FURNISHING AND PLACING TOPSOIL	S.Y.	6000		6000	$ 7.00	$ 42,000
0950005	TURF ESTABLISHMENT	S.Y.	20000		20000	$ 2.00	$ 40,000
0969066A	CONSTRUCTION FIELD OFFICE, EXTRA LARGE	NO.	48		48	$ 8,000.00	$ 384,000
1002103	LIGHT STANDARD FOUNDATION	EA.	50		50	$ 600.00	$ 30,000
1003192	LIGHT STANDARD ALUMINUM (40' MOUNTING HEIGHT)	EA.	50		50	$ 1,200.00	$ 72,000
1003699	REMOVE LIGHT POLE FOUNDATION 24" BELOW FINISHED PAVEMENT SURFACE GRADE	EA.	50		50	$ 300.00	$ 15,000
1003925	REMOVE EXISTING LUMINAIRE	EA.	50		50	$ 750.00	$ 37,500
	STORMWATER QUALITY & DETENTION SYSTEMS	L.S.			1	$ 750,000.00	$ 750,000
						ROADWAY ITEMS =	$ 17,025,480

Figure 3.4 Summary of Cost Estimate (Roadway Items)

CME Project Number: 63703CT.1 Date: 1/15/18

STATE OF CONNECTICUT Page: 4 of 5

DEPARTMENT OF TRANSPORTATION

COST ESTIMATE

TRAFFIC ITEMS

Project Title: Relocation of I-91 NB Interchange 29 and Widening of I-91 and Route 15 NB to I-84 EB
I-91/US 5/Route 5 in City of Hartford/Town of East Hartford

Federal Aid Project Number: [redacted]
State Project Number: 0063-0703

Project Limits: Station 100+00 to 264+60

City / Town: Hartford/ East Hartford

Item No.	Item Description	Unit	Quantity			Unit Price	Amount
			Hwy	Bridge	Total		
1149051A	TEMPORARY SIGNALIZATION (SITE NO. 1)	L.S.	1		1	$ 7,000.00	$ 7,000
1201802	4 CHORD TRUSS BRIDGE SIGN STRUCTURE	EA.	10		10	$ 190,000.00	$ 1,900,000
1201804	4 CHORD TRUSS CANTILEVER SIGN STRUCTURE	EA.	5		5	$ 56,000.00	$ 280,000
1202239	OVERHEAD TRUSS SIGN SUPPORT FOUNDATION	EA.	25		25	$ 60,000.00	$ 1,500,000
1203109	SIDE MOUNTED SIGN FOUNDATION	EA.	8		8	$ 3,500.00	$ 28,000
1204211	SIGN PANEL OVERLAY - PLAIN	S.F.	150		150	$ 60.00	$ 9,000
1209325A	REMOVAL AND RELOCATION OF EXISTING OVERHEAD SIGNS	L.S.	1		1	$ 84,000.00	$ 84,000
1209313	REMOVAL AND RELOCATION OF EXISTING SIGNS	L.S.	1		1	$ 8,000.00	$ 8,000
1207034A	SIGN FACE - EXTRUDED ALUMINUM (TYPE IV REFLECTIVE SHEETING)	S.F.	12000		12000	$ 25.00	$ 300,000
1209114	HOT-APPLIED PAINTED PAVEMENT MARKINGS 4 INCH YELLOW	L.F.	30000		30000	$ 0.20	$ 6,000
1209124	HOT-APPLIED PAINTED PAVEMENT MARKINGS 4 INCH WHITE	L.F.	23000		23000	$ 0.20	$ 4,600
1209126	HOT-APPLIED PAINTED PAVEMENT MARKINGS 6 INCH WHITE	L.F.	9900		9900	$ 0.20	$ 1,980
1209128	HOT-APPLIED PAINTED PAVEMENT MARKINGS 8 INCH WHITE	L.F.	5200		5200	$ 0.20	$ 1,040
1209129	HOT-APPLIED PAINTED PAVEMENT MARKINGS 12 INCH WHITE	L.F.	1700		1700	$ 1.20	$ 2,040
1209131	HOT-APPLIED PAINTED LEGEND ARROWS AND MARKINGS	S.F.	31		31	$ 1.20	$ 37
1211000I	REMOVAL OF PAVEMENT MARKINGS	L.S.	1		1	$ 2,000.00	$ 2,000
1220012A	CONSTRUCTION SIGNS - BRIGHT FLUORESCENT SHEETING	S.F.	1700		1700	$ 15.00	$ 25,500
						TRAFFIC ITEMS =	$ 4,159,197

Figure 3.5 Summary of Cost Estimate (Traffic Items)

PROJECT NO. 0063-0703

Phase of Development: **Preliminary Design**

TOTAL COST SUMMARY

ACTIVITY	ESTIMATED COST	STATE SHARE	COST TO STATE PROJECT	YEAR OF EXPENDITURE
PRELIMINARY DESIGN	$ 4,200,000	100%	$ 4,200,000	2015
RIGHT OF WAY (PRE-ACQUISITION)	$ 500,000	100%	$ 500,000	2016
UTILITIES (ENGINEERING)	$ 4,210,000	50%	$ 2,105,000	2016
RAILROAD (ENGINEERING)	$ 850,000	100%	$ 850,000	2016
FINAL DESIGN	$ 8,500,000	20%	$ 1,700,000	2017
RIGHT OF WAY (ACQUISITION)	$ 500,000	100%	$ 500,000	2017
CONSTRUCTION CONTRACT	$ 250,245,788	100%	$ 250,245,788	2023
UTILITIES (CONSTRUCTION)	$ 8,410,000	50%	$ 4,205,000	2022
RAILROAD (CONSTRUCTION)	$ 1,690,000	100%	$ 1,690,000	2022
INCIDENTALS (CENG)	$ 16,817,399	100%	$ 16,817,399	2023
STATE and CITY/TOWN POLICE	$ 900,000	100%	$ 900,000	2022

All costs include contingencies and inflation to year of expenditure

CONTRACT COST SUMMARY

Scheduled Bid Letting	4/1/2018	Inflation (%)	3
Estimate Date	1/15/2018		
Construction Duration	4 years		

STRUCTURES (See breakout, separate sheet)		$	94,070,438
ROADWAY (See breakout, separate sheet)		$	17,033,480
TRAFFIC (See breakout, separate sheet)		$	4,159,197
NOISE BARRIER WALL (STRUCTURE) Est.		$	3,960,000
IMS		$	763,000
ENVIRONMENTAL		$	4,046,000
CLEARING AND GRUBBING (as % of total contract items)	1%	$	1,240,221
M&P OF TRAFFIC (as % of total contract items)	6%	$	7,441,327
CONSTRUCTION STAKING (as % of total contract items)	1%	$	1,240,221
MOBILIZATION & PROJ. CLOSEOUT(as % of total contract items)	5%	$	6,201,106
MINOR ITEM ALLOWANCE (as % of total contract items)	20%	$	28,039,000
Base Estimate		$	168,173,990
CONTRACT COST, INCLUDING CONTINGENCY (at designated %)	20%	$	201,808,788
CONTRACT COST WITH CONTINGENCY & INFLATION		$	**250,245,788**

ESTIMATED BY: CLR REVIEWED BY: DLS

Figure 3.6 Contract Cost Summary (Preliminary Design)

3.4 AS GIVEN FUNCTION COST

The Comparative Construction cost of $276 million is allocated to the Basic Function of Decreasing Exit 29 Ramp Capacity (19.8%), Minimizing Conflicts (3.1%), and Increasing the COB Northbound (NB) Capacity (2.8%).

3.5 FUNCTION ANALYSIS

Basic functions and dependability functions together should be above the 50% threshold. The project function cost shows this percentage as 60.5%. Due to the complex geometry, protecting the structures, including bridges and pavements, is the key function. Function cost for Protect Structure was found to be 13.2%. Even though the improvement will make it convenient to use, the purpose of the improvements is to make it dependable first. This is reflected in the higher percentage of Dependability functions (34.8%) and lower percentage of convenient functions (12.7%). Figure 3.7 shows the function cost distribution.

Summary			
Functions	**Cost**	**Percentage**	**Norm**
Basic Functions	$71,007,100	25.7%	20%
Enhancing Functions			
Assure Dependability	$96,015,000	34.8%	30%
Assure Convenience	$35,213,000	12.7%	25%
Satisfy Stakeholders	$71,914,000	26.0%	15%
Attract Stakeholders	$ 2,006,000	0.8%	10%

Figure 3.7: Function Cost Distribution

TASK Improve Operations	Cost	Basic Functions				
		Increase Exit 29 Ramp Capacity	Minimize Conflicts	Increase COB NB Capacity	Increase Route 15 NB Capacity	Reduce Delays
Structures						
Removal Of Bridges	$ 2,143,000					
Rehab 02555 - Tunnel	$ 224,000					
Rehab 03244 - Culvert	$ 119,000					
Rehab 00813 - Route 5/15	$ 8,890,000					
Rehab 03613 - Culvert	$ 16,900					
Rehab 01466 - Entrance To I-91 NB	$ 4,433,000					
Rehab 00480 - Airport Road	$ 3,064,000					
Rehab 06000A - COB NB	$ 20,079,000	$7,851,350	$905,925	$2,415,800		$905,925
Rehab 06000B - COB SB	$ 2,229,000					
Rehab 06043A - Main St NB	$ 1,992,762				$1,693,848	
Rehab 06043B - Main St SB	$ 453,080					
Rehab 05796 - Silver Lane	$ 2,469,696				$2,099,242	
Proposed Bridge - Exit 29	$ 18,226,000	$9,113,000	$3,645,200			$2,733,900
Ret Wall 101 - Exit 27	$ 1,360,000					
Ret Wall 102 - Entombed Material	$ 1,318,000					
Ret Wall 103 - New Exit 29 Near Approach	$ 10,546,000	$6,327,600				
Ret Wall 104 - New Exit 29 Far Approach	$ 7,309,000	$4,385,400				
Ret Wall 105 - I-91 Nb & Route 5/15 Nb	$ 4,499,000					
Ret Wall 106 - Main St - Residential	$ 1,934,000					
Ret Wall 107 - Wall - Silver Lane - East	$ 1,578,000					
Reinforced Soil Slope	$ 1,187,000					
Roadway						
Earth Excavation	$ 1,116,000	$167,400		$167,400	$167,400	
Test Pit	$ 130,000	$19,500		$19,500	$19,500	
Pavement	$ 536,880	$80,532		$80,532	$80,532	
Formation Of Subgrade	$ 222,000	$33,300		$33,300	$33,300	
Temporary Slope Protection	$ 21,000					
Processed Aggregate Base	$ 6,500	$975		$975	$975	
PMA	$ 9,812,300	$1,471,845		$1,471,845	$1,471,845	
Sedimentation Control System	$ 1,060,000					
Catch Basin	$ 572,000					
High Early Strength Concrete	$ 1,300,000					
Bituminous Concrete Lip Curbing	$ 66,000					
Precast Concrete Barrier Curb ("F" Shape - Single Face)	$ 1,100,000					
Metal Beam Rail	$ 511,500					
Calcium Chloride For Dust Control	$ 30,800					
Construction Field Office, Extra Large	$ 384,000					
Light Standard	$ 154,500					
Traffic						
Temporary Signalization (Site No. 1)	$ 7,000					
4 Chord Truss Bridge Sign Structure	$ 4,109,000					
Hot-Applied Painted Pavement	$ 17,697					
Construction Signs - Bright Fluorescent Sheeting	$ 25,500					
Noise Barrier	$ 3,960,000					
Environmental	$ 4,046,000					
IMS	$ 763,000					
Clearing And Grubbing	$ 1,240,221					
MPT	$ 7,441,327					
Construction Staking	$ 1,240,221					
Mobilization	$ 6,201,106					
Utilities	$ 8,410,000					
Subtotal	$ 148,554,990	$29,450,902	$4,551,125	$4,189,352	$5,566,641	$3,639,825
		19.8%	3.1%	2.8%	3.7%	2.5%
			$38,191,379			
			25.7%			

Total Construction Costs	$ 276,200,000	$54,756,418	$8,461,653	$7,789,028	$10,349,745	$6,767,323
		19.8%	3.1%	2.8%	3.7%	2.5%
			$71,007,099			
			25.7%			

Figure 3.8 Function Cost (As Given)

Assure Dependability							
Protect Structure		Protect Workers	Safeguard Traffic	Minimize Risk (Clearance)	Restore Structural Integrity		Separate Traffic
Maintain Vertical Clearance	Maintain Horizontal Clearance				Exclude Elements	Strengthen Members	
					$224,000		
					$119,000		
$6,000,000					$1,890,000		
$3,000,000					$900,000		
$2,000,000					$650,000		
$2,500,000					$5,500,000		
$1,114,500					$1,114,500		
$453,080							
							$1,822,600
$2,109,200							$2,109,200
$1,461,800							$1,461,800
$899,800							
				$167,400			
				$19,500			
				$80,532			
				$33,300			
				$975			
				$1,471,845			
			$550,000				$550,000
			$511,500				
		$1,860,332	$1,860,332				
$19,538,380		$1,860,332	$2,921,832	$1,773,552	$10,397,500		$5,943,600
13.2%		1.3%	2.0%	1.2%	7.0%		4.0%
$51,641,662							
34.8%							

$36,326,619	$3,458,811	$5,432,399	$3,297,466	$19,331,491	$11,050,604
13.2%	1.3%	2.0%	1.2%	7.0%	4.0%
$96,014,459					
34.8%					

Figure 3.8 Function Cost (As Given) cont.

TASK Improve Operations	Cost	Assure Convenience					
		Increase I-91 NB Capacity	Meet Expectations				Maintain Traffic (DC)
			Store Vehicles (Shoulder)	Guide Traffic	Comfort Traffic	Minimize Confusion	
Structures							
Removal Of Bridges	$ 2,143,000						
Rehab 02555 - Tunnel	$ 224,000						
Rehab 03244 - Culvert	$ 119,000						
Rehab 00813 - Route 5/15	$ 8,890,000	$850,000	$150,000				
Rehab 03613 - Culvert	$ 16,900	$16,900					
Rehab 01466 - Entrance To I-91 NB	$ 4,433,000	$458,000	$75,000				
Rehab 00480 - Airport Road	$ 3,064,000	$364,000	$50,000				
Rehab 06000A - COB NB	$ 20,079,000						
Rehab 06000B - COB SB	$ 2,229,000						
Rehab 06043A - Main St NB	$ 1,992,762		$298,914				
Rehab 06043B - Main St SB	$ 453,080						
Rehab 05796 - Silver Lane	$ 2,469,696		$370,454				
Proposed Bridge - Exit 29	$ 18,226,000		$911,300				
Ret Wall 101 - Exit 27	$ 1,360,000						
Ret Wall 102 - Entombed Material	$ 1,318,000						
Ret Wall 103 - New Exit 29 Near Approach	$ 10,546,000						
Ret Wall 104 - New Exit 29 Far Approach	$ 7,309,000						
Ret Wall 105 - I-91 Nb & Route 5/15 Nb	$ 4,499,000						$1,799,600
Ret Wall 106 - Main St - Residential	$ 1,934,000						
Ret Wall 107 - Wall - Silver Lane - East	$ 1,578,000						
Reinforced Soil Slope	$ 1,187,000						
Roadway							
Earth Excavation	$ 1,116,000	$167,400	$167,400		$111,600		
Test Pit	$ 130,000	$19,500	$19,500		$13,000		
Pavement	$ 536,880	$80,532	$80,532		$53,688		
Formation Of Subgrade	$ 222,000	$33,300	$33,300		$22,200		
Temporary Slope Protection	$ 21,000						$10,500
Processed Aggregate Base	$ 6,500	$975	$975		$650		
PMA	$ 9,812,300	$1,471,845	$1,471,845		$981,230		
Sedimentation Control System	$ 1,060,000						
Catch Basin	$ 572,000						
High Early Strength Concrete	$ 1,300,000						$1,300,000
Bituminous Concrete Lip Curbing	$ 66,000						
Precast Concrete Barrier Curb ("F" Shape - Single Face)	$ 1,100,000						
Metal Beam Rail	$ 511,500						
Calcium Chloride For Dust Control	$ 30,800						
Construction Field Office, Extra Large	$ 384,000						
Light Standard	$ 154,500			$154,500			
Traffic							
Temporary Signalization (Site No. 1)	$ 7,000						
4 Chord Truss Bridge Sign Structure	$ 4,109,000			$2,054,500		$2,054,500	
Hot-Applied Painted Pavement	$ 17,697			$8,849		$8,849	
Construction Signs - Bright Fluorescent Sheeting	$ 25,500						$12,750
Noise Barrier	$ 3,960,000						
Environmental	$ 4,046,000						
IMS	$ 763,000			$763,000			
Clearing And Grubbing	$ 1,240,221						
MPT	$ 7,441,327						$1,860,332
Construction Staking	$ 1,240,221						
Mobilization	$ 6,201,106						
Utilities	$ 8,410,000						
Subtotal	$ 148,554,990	$3,462,452	$3,629,221	$2,980,849	$1,182,368	$2,063,349	$4,983,182
		2.3%	2.4%	2.0%	0.8%	1.4%	3.4%
		$18,939,419					
		12.7%					

Total Construction Costs	$ 276,200,000	$6,437,544	$6,747,607	$5,542,125	$2,198,311	$3,836,269	$9,264,952
		2.3%	2.4%	2.0%	0.8%	1.4%	3.4%
		$35,213,005					
		12.7%					

Figure 3.8 Function Cost (As Given) cont.

	Satisfy Stakeholders									Attract Stakeholders
Drain Water	Facilitate Construction	Limit Impacts		Contain Contaminants	Preserve Neighborhood	Protect Environment	Protect Utilities	Reduce Liability	Reduce Maintenance	Improve Aethetics
		Minimize ROW Impact	Reduce Noise							
								$707,190	$728,620	$707,190
		$680,000				$680,000				
		$434,940		$448,120		$434,940				
	$1,799,600									
		$967,000			$967,000					
		$789,000			$789,000					
		$593,500				$593,500				
	$10,500									
						$1,060,000				
$572,000										
$66,000										
						$30,800				
	$384,000									
	$7,000									
	$12,750									
			$1,782,000		$1,782,000					$396,000
						$4,046,000				
	$1,240,221									
	$1,860,332									
	$1,240,221									
	$6,201,106									
							$8,410,000			
$638,000	$12,755,730	$3,464,440	$1,782,000	$448,120	$3,538,000	$6,845,240	$8,410,000	$707,190	$728,620	$1,103,190
0.4%	8.6%	2.3%	1.2%	0.3%	2.4%	4.6%	5.7%	0.5%	0.5%	0.7%
	$38,679,340									**$1,103,190**
	26.0%									**0.7%**

$1,186,198	$23,716,016	$6,441,240	$3,313,173	$833,165	$6,578,006	$12,726,973	$15,636,244	$1,314,839	$1,354,682	$2,051,100
0.4%	8.6%	2.3%	1.2%	0.3%	2.4%	4.6%	5.7%	0.5%	0.5%	0.7%
	$71,914,337									**$2,051,100**
	26.0%									**0.7%**

Figure 3.8 Function Cost (As Given) cont.

4 SPECULATION PHASE

4. 1 INTRODUCTION

Following the function and cost analysis, the next step is to answer the question:

WHAT ELSE WILL DO THE JOB?

This is the key question in the Speculation Phase and may be carried out in at least three ways:

1. Random 2. By function 3. By project element

Among the rules that govern the Speculation Phase of a VE Study are the following:

- Criticism is ruled out
- Quantity is wanted
- Combinations and improvements are sought

Below is a list of the ideas generated by the VE Team during the Speculation Phase.

IDEAS			
1	Add 4th Lane to I-91 (Exit 27-29)	14	Exit 29 - Replace Existing Bridge and Widen to 2 Lanes
2	Maintain 3 Lane I-91 (Exit 27-29)	15	Exit 29 - Eliminate
3	Exit 29 - 2 Lane Left Diverge	16	Exit 29 - Lengthen Deceleration and Separate With Median Barrier
4	Left Merge From I-91 NB to Route 5/15	17	Exit 29 - Lengthen Deceleration Lane
5	Exit 29 - 12' Left Shoulder	18	Exit 29 - No Build Configuration
6	Exit 29 - 12' Right Shoulder	19	Exit 29 - Left Exit With 1 Lane
7	Exit 29 - 12' Lanes	20	Exit 29 - 4' Left Shoulder
8	Remove Existing Exit 29 Structure	21	Exit 29 - 11' Lanes
9	Shift I-91 Exit 29 to Left	22	Exit 29 - 10' Right Shoulder
10	Remove Existing Exit 29 Structure	23	Exit 29 - 4' Left Shoulder, 11' Lanes, 10' Right Shoulder
11	Exit 29 - 12' Left Shoulder, 112' Lanes, 12' Right Shoulder	24	Exit 29 - 4' Left Shoulder, 12' Lanes, 10' Right Shoulder
12	Exit 29 - Widen Existing Ramp to 2 Lanes	25	Exit 29 - Move Diverge Point Further South
13	Exit 29 - Widen Existing Bridge	26	Do Nothing

27	Proposed Exit 29 Bridge - Lengthen to Eliminate Retaining Walls 103A/B
28	Proposed Exit 29 Bridge - Lengthen to Eliminate Retaining Walls 104A/B
29	Proposed Exit 29 Bridge - Lengthen South Approach
30	Proposed Exit 29 Bridge - Lengthen North Approach
31	Proposed Exit 29 Bridge - Reuse Existing Exit 29 Superstructure
32	Reuse Existing Exit 29 Superstructure on One Bridge Widening
33	Proposed Exit 29 Bridge - Use Plate Girder
34	Proposed Exit 29 Bridge - Use Box Girder
35	Exit 29 Bridge - 5-Span Structure
36	Exit 29 Bridge - Solid Pier
37	Exit 29 Bridge - Pier 3 - Cantilever Pier
38	Exit 29 Bridge - Pier 3 - 2 Columns With A Cantilever
39	Exit 29 Bridge - All Piers Skewed
40	Exit 29 Bridge - Some Piers Skewed
41	Exit 29 Bridge - Truss Structure
42	Exit 29 Bridge - Through Girder Structure
43	Exit 29 Bridge - Multiple Span With Shorter End Spans
44	Exit 29 Bridge - 2-Span Structure
45	Exit 29 Bridge - 3-Span Structure With Retaining Walls at Each End
46	Exit 29 Bridge - Single Circular Pier With A Trapezoidal Cap
47	Exit 29 Bridge - Re-purpose Existing For Non-Motorized Modes Of Travel
48	Increase Weave Length on COB
49	COB - Reconfigure to 4-11' Lanes, 12' Outside Shoulder
50	COB - Widen to Accommodate 2-Lane Exit 29
51	COB - Widen to Accommodate 4-12' Lanes
52	COB - 2' Inside Shoulder, 4-12' Lanes, 10' Outside Shoulder
53	COB - 4' Inside Shoulder, Lanes, 11'/12'/12'/11', 10' Outside Shoulder
54	Eliminate Route 2 / Main St Ramp
55	Relocate Route 2 / Main St Ramp
56	Eliminate Route 2 Ramp
57	Modular Retaining Walls
58	Cantilevered Retaining Walls
59	MSE Walls
60	Reinforced Concrete Gravity Walls
61	Soil Nail Wall
62	Precast Retaining Walls
63	Extend Bridge 2555
64	Extend Bridge 3244
65	Extend Bridges 2555 and 3244 and Eliminate Reinforced Slopes
66	Extend Bridge 2555 and Eliminate Reinforced Slopes
67	Extend Bridge 3244 and Eliminate Reinforced Slopes
68	Eliminate Rw 102 and Fill Over Entombed Area
69	Eliminate Reinforced Slopes
70	Retaining Wall 101 - Eliminate and Fill
71	Reinforced Slopes - Use With Retaining Wall Fills
72	Use Geofoam Fill
73	Improve Capacity on Putnam Bridge
74	Consistent Left Shoulders Along I-91
75	Consistent Right Shoulders Along I-91
76	Consistent Left Shoulders Along Route 5/15
77	Consistent Right Shoulders Along Route 5/15

78	Consistent Left Shoulders Along I-91 and Along Route 5/15
79	Consistent Right Shoulders Along I-91 and Along Route 5/15
80	Lower I-91 SB to Route 5/15 SB Roadway under I-91
81	Lower Airport Road under I-91
82	Lower Airport Road under I-91
83	Replace Bridge 813
84	Replace Bridge 1466
85	Replace Bridge 480
86	Bridge 480 - Widen Bridges With Shallower Section
87	Bridge 480 - Eliminate Joints By Building Continuous Structures
88	Bridge 1466 - Eliminate Joints By Building Continuous Structures
89	Bridge 813 - Eliminate Joints By Building Continuous Structures
90	Make Existing Beams Continuous
91	Eliminate Joints
92	Maintain Airport Road Existing Vertical Clearance
93	Maintain Airport Road Existing Vertical Profile
94	Maintain Route 5/15 Existing Vertical Clearance under I-91
95	Maintain Route 5/15 Existing Vertical Profile under I-91
96	Maintain I-91 SB to Route 5/15 SB Existing Vertical Clearance under I-91
97	Maintain I-91 SB to Route 5/15 SB Existing Vertical Profile under I-91
98	Do Not Replace Bridge 5922
99	Replace Bridge 5922 With A Longer Span
100	Realign Route 5/15 under Reconstructed Bridge 5922
101	CTDOT Alternate 4 - Left Diverge at I-91 NB
102	CTDOT Alternate 6C
103	CTDOT Alternate 6D
104	Build A Parallel Structure to Route 5/15 From I-91 to I-84
105	Build Route 5/15 Over I-91 - Flyover
106	Reconstruct I-91 at Route 5/15 at Grade
107	Exit 29 - Direct Connection From I-91 to I-84
108	Realign Route 5/15 Exit 89
109	Lower Route 5/15 under I-91
110	Route 5/15 - Add 3Rd Lane (COB - Silver Lane)
111	Left Merge From I-91 NB to Route 5/15
112	Shift Railroad East
113	Shift Railroad East and Move Diverge Point For Exit 29 Further South
114	I-91 NB Exit 28 - Eliminate
115	I-91 NB - Full Depth Reconstruction
116	Reconstruct Airport Road under Bridge 480 to Match Existing Vertical Clearance
117	Reconstruct I-91 SB to Route 5/15 SB under Bridge 1466 to Match Existing Vertical Clearance
118	Reconstruct Route 5/15 under Bridge 813 to Match Existing Vertical Clearance
119	Route 5/15 - Shorten 3-Lane Section to Avoid Silver Lane Bridge
120	Route 5/15 - Begin 3-Lane Section Drop Further South to Stop Short Of Silver Lane Bridge
121	Move I-91 NB to The East and Relocate Route 5/15 to The West
122	Route 5/15 - End 3-Lane Section With 3Rd Lane Exiting on Exit 91
123	Route 5/15 - Eliminate Main Street on Ramp (Exit 90)
124	Route 5/15 End 3-Lane Section With 3Rd Lane Exiting on Exit 91 and Eliminate Exit 20
125	MPT - I-91 - Existing Lanes Open During Peak Hours
126	MPT - Route 5/15 - Existing Lanes Open During Peak Hours
127	MPT - Airport Road - Existing Lanes Open During Peak Hours
128	MPT - I-91 Exit 28 - Detour
129	MPT - Airport Road - Lower Road Before I-91 Construction

130	MPT - Route 5/15 - Lower Road Before I-91 Construction
131	MPT - I-91 SB to Route 5/15 SB - Lower Road Before I-91 Construction
132	MPT - I-91 SB to Route 5/15 SB - 1/2 Width Reconstruction
133	MPT - VMS on I-91 South Of Route 3 Directing Traffic to Take Alternate Routes
134	MPT - Exit 29 Bridge - Abc
135	MPT - Airport Road - Detour
136	MPT - I-91 NB - Detour
137	MPT - Route 5/15 NB - Detour
138	MPT - I-91 SB to Route 5/15 SB - Detour
139	MPT - I-91 NB - Close Existing Right Through Lane During Construction
140	MPT - Airport Road - 1/2 Width Reconstruction
141	MPT - I-91 NB - 1/2 Width Reconstruction
142	MPT - Route 5/15 NB - 1/2 Width Reconstruction
143	MPT - I-91 Exit 28 - Stage Construction
144	MPT - Airport Road - Lower Road After I-91 Construction
145	MPT - Route 5/15 - Lower Road After I-91 Construction
146	MPT - I-91 SB to Route 5/15 SB - Lower Road After I-91 Construction
147	Relocate Noise Walls on Route 5/15 NB (Main St - Silver Lane)
148	Add Noise Walls on Route 5/15 SB (Main St - Silver Lane)
149	Relocate Noise Walls on Route 5/15 NB (Main St - Silver Lane)
150	Add Noise Walls on Route 5/15 SB (Main St - Silver Lane)
151	Route 5/15 SB - Eliminate Reconstructing Sound Barriers
152	Route 5/15 SB - Eliminate Constructing New Sound Barriers
153	Route 5/15 SB - Eliminate Reconstructing Sound Barriers and Construction on New Barriers
154	Route 5/15 NB - Eliminate Reconstructing Sound Barriers
155	Route 5/15 - Shorten 3-Lane Section to Avoid Silver Lane Bridge and Eliminate Reconstructing Sound Barriers
156	Route 5/15 - Begin 3-Lane Section Drop Further South to Stop Short Of Silver Lane Bridge and Eliminate Reconstructing Sound Barriers
157	Route 5/15 - End 3-Lane Section With 3Rd Lane Exiting on Exit 91 and Eliminate Reconstructing Sound Barriers
158	Reuse Existing Sound Barriers
159	Add Aesthetic Treatments on Sound Barrier
160	Reuse Existing Sound Barriers Add Aesthetic Treatments on Sound Barrier

5 EVALUATION PHASE

5.1 INTRODUCTION

Evaluate the performance, acceptance and cost of the Alternatives:

WILL IT WORK?
WILL IT BE ACCEPTABLE?
CAN WE AFFORD IT?

Evaluation can be:

1. As simple as judging with advantages and limitations.
2. A detailed matrix rating for performance acceptance and cost. In addition, measuring the sensitivity of the above ratings.

Among the rules that govern the Evaluation Phase are the following:

- Do not speculate
- Do not jump to conclusions
- Prepare to explain the conclusion

REJECTION REASONING

R1	Violates Constraints
R2	Not Feasible
R3	Too Expensive
R4	Low Acceptance
R5	High Cost, Low Benefit
R6	High Risk Solution
R7	Lack of Supporting Information
R8	No Significant Benefit
R9	Not Applicable

Figure 5.1: Reasons for Rejection

The objective of the Evaluation Phase is to identify the most outstanding Alternatives for further development. This is accomplished through a process of screening and ranking. Alternatives are developed using the ideas generated during the Speculation Phase and evaluated by comparison with the Base Plan Design.

5.2 SCREENING

Ideas generated during the Speculation Phase were not subject to criticism. This is done to promote free thinking. The next step is initial screening. At this time, each idea is reviewed and either selected for further consideration or rejected. In addition, ideas that violate project constraints are eliminated. Listed in Figure 5.1 are reasons for rejection. Below are the results of the screening process.

	IDEA	COMMENTS
1	Add 4th Lane to I-91 (Exit 27-29)	AG
2	Maintain 3 Lane I-91 (Exit 27-29)	S
3	Exit 29 - 2 Lane Left Diverge	AG

	IDEA	COMMENTS
4	Left Merge From I-91 NB to Route 5/15	AG
5	Exit 29 - 12' Left Shoulder	AG
6	Exit 29 - 12' Right Shoulder	AG
7	Exit 29 - 12' Lanes	AG
8	Remove Existing Exit 29 Structure	AG
9	Shift I-91 Exit 29 to Left	AG
10	Remove Existing Exit 29 Structure	AG
11	Exit 29 - 12' Left Shoulder, 112' Lanes, 12' Right Shoulder	AG
12	Exit 29 - Widen Existing Ramp to 2 Lanes	S
13	Exit 29 - Widen Existing Bridge	S
14	Exit 29 - Replace Existing Bridge and Widen to 2 Lanes	S
15	Exit 29 - Eliminate	R4
16	Exit 29 - Lengthen Deceleration and Separate With Median Barrier	S
17	Exit 29 - Lengthen Deceleration Lane	S
18	Exit 29 - No Build Configuration	R4
19	Exit 29 - Left Exit With 1 Lane	R5
20	Exit 29 - 4' Left Shoulder	S
21	Exit 29 - 11' Lanes	S
22	Exit 29 - 10' Right Shoulder	S
23	Exit 29 - 4' Left Shoulder, 11' Lanes, 10' Right Shoulder	S
24	Exit 29 - 4' Left Shoulder, 12' Lanes, 10' Right Shoulder	S
25	Exit 29 - Move Diverge Point Further South	S
26	Do Nothing	R4
27	Proposed Exit 29 Bridge - Lengthen to Eliminate Retaining Walls 103A/B	S
28	Proposed Exit 29 Bridge - Lengthen to Eliminate Retaining Walls 104A/B	S
29	Proposed Exit 29 Bridge - Lengthen South Approach	S
30	Proposed Exit 29 Bridge - Lengthen North Approach	S
31	Proposed Exit 29 Bridge - Reuse Existing Exit 29 Superstructure	R8
32	Reuse Existing Exit 29 Superstructure on One Bridge Widening	R8
33	Proposed Exit 29 Bridge - Use Plate Girder	S
34	Proposed Exit 29 Bridge - Use Box Girder	AG
35	Exit 29 Bridge - 5-Span Structure	AG
36	Exit 29 Bridge - Solid Pier	AG
37	Exit 29 Bridge - Pier 3 - Cantilever Pier	S
38	Exit 29 Bridge - Pier 3 - 2 Columns With A Cantilever	S

	IDEA	COMMENTS
39	Exit 29 Bridge - All Piers Skewed	S
40	Exit 29 Bridge - Some Piers Skewed	S
41	Exit 29 Bridge - Truss Structure	S
42	Exit 29 Bridge - Through Girder Structure	R4
43	Exit 29 Bridge - Multiple Span With Shorter End Spans	S
44	Exit 29 Bridge - 2-Span Structure	S
45	Exit 29 Bridge - 3-Span Structure With Retaining Walls at Each End	S
46	Exit 29 Bridge - Single Circular Pier With A Trapezoidal Cap	S
47	Exit 29 Bridge - Re-purpose Existing For Non-Motorized Modes Of Travel	R2
48	Increase Weave Length on COB	AG
49	COB - Reconfigure to 4-11' Lanes, 12' Outside Shoulder	AG
50	COB - Widen to Accommodate 2-Lane Exit 29	S
51	COB - Widen to Accommodate 4-12' Lanes	R5
52	COB - 2' Inside Shoulder, 4-12' Lanes, 10' Outside Shoulder	R1
53	COB - 4' Inside Shoulder, Lanes-11'/12'/12'/11', 10' Outside Shoulder	S
54	Eliminate Route 2 / Main St Ramp	S
55	Relocate Route 2 / Main St Ramp	S
56	Eliminate Route 2 Ramp	S
57	Modular Retaining Walls	AG
58	Cantilevered Retaining Walls	AG
59	MSE Walls	AG
60	Reinforced Concrete Gravity Walls	AG
61	Soil Nail Wall	S
62	Precast Retaining Walls	S
63	Extend Bridge 2555	R1
64	Extend Bridge 3244	R1
65	Extend Bridges 2555 and 3244 and Eliminate Reinforced Slopes	R1
66	Extend Bridge 2555 and Eliminate Reinforced Slopes	R1
67	Extend Bridge 3244 and Eliminate Reinforced Slopes	R1
68	Eliminate Rw 102 and Fill Over Entombed Area	R1
69	Eliminate Reinforced Slopes	R1
70	Retaining Wall 101 - Eliminate and Fill	R1
71	Reinforced Slopes - Use With Retaining Wall Fills	R5
72	Use Geofoam Fill	S
73	Improve Capacity on Putnam Bridge	R5

	IDEA	COMMENTS
74	Consistent Left Shoulders Along I-91	S
75	Consistent Right Shoulders Along I-91	S
76	Consistent Left Shoulders Along Route 5/15	S
77	Consistent Right Shoulders Along Route 5/15	S
78	Consistent Left Shoulders Along I-91 and Along Route 5/15	S
79	Consistent Right Shoulders Along I-91 and Along Route 5/15	S
80	Lower I-91 SB to Route 5/15 SB Roadway under I-91	AG
81	Lower Airport Road under I-91	AG
82	Lower Airport Road under I-91	AG
83	Replace Bridge 813	R7
84	Replace Bridge 1466	R7
85	Replace Bridge 480	R7
86	Bridge 480 - Widen Bridges With Shallower Section	S
87	Bridge 480 - Eliminate Joints By Building Continuous Structures	S
88	Bridge 1466 - Eliminate Joints By Building Continuous Structures	S
89	Bridge 813 - Eliminate Joints By Building Continuous Structures	S
90	Make Existing Beams Continuous	S
91	Eliminate Joints	S
92	Maintain Airport Road Existing Vertical Clearance	S
93	Maintain Airport Road Existing Vertical Profile	R1
94	Maintain Route 5/15 Existing Vertical Clearance under I-91	S
95	Maintain Route 5/15 Existing Vertical Profile under I-91	R1
96	Maintain I-91 SB to Route 5/15 SB Existing Vertical Clearance under I-91	S
97	Maintain I-91 SB to Route 5/15 SB Existing Vertical Profile under I-91	R1
98	Do Not Replace Bridge 5922	AG
99	Replace Bridge 5922 With A Longer Span	S
100	Realign Route 5/15 under Reconstructed Bridge 5922	S
101	CTDOT Alternate 4 - Left Diverge at I-91 NB	S
102	CTDOT Alternate 6C	S
103	CTDOT Alternate 6D	S
104	Build A Parallel Structure to Route 5/15 From I-91 to I-84	R3
105	Build Route 5/15 Over I-91 - Flyover	R5
106	Reconstruct I-91 at Route 5/15 at Grade	R5
107	Exit 29 - Direct Connection From I-91 to I-84	R3
108	Realign Route 5/15 Exit 89	AG

	IDEA	COMMENTS
109	Lower Route 5/15 under I-91	AG
110	Route 5/15 - Add 3rd Lane (COB - Silver Lane)	AG
111	Left Merge From I-91 NB to Route 5/15	AG
112	Shift Railroad East	S
113	Shift Railroad East and Move Diverge Point For Exit 29 Further South	S
114	I-91 NB Exit 28 - Eliminate	R4
115	I-91 NB - Full Depth Reconstruction	R5
116	Reconstruct Airport Road under Bridge 480 to Match Existing Vertical Clearance	R7
117	Reconstruct I-91 SB to Route 5/15 SB under Bridge 1466 to Match Existing Vertical Clearance	R7
118	Reconstruct Route 5/15 under Bridge 813 to Match Existing Vertical Clearance	R7
119	Route 5/15 - Shorten 3-Lane Section to Avoid Silver Lane Bridge	S
120	Route 5/15 - Begin 3-Lane Section Drop Further South to Stop Short Of Silver Lane Bridge	S
121	Move I-91 NB to The East and Relocate Route 5/15 to The West	R5
122	Route 5/15 - End 3-Lane Section With 3Rd Lane Exiting on Exit 91	S
123	Route 5/15 - Eliminate Main Street on Ramp (Exit 90)	S
124	Route 5/15 End 3-Lane Section With 3Rd Lane Exiting on Exit 91 and Eliminate Exit 20	S
125	MPT - I-91 - Existing Lanes Open During Peak Hours	AG
126	MPT - Route 5/15 - Existing Lanes Open During Peak Hours	AG
127	MPT - Airport Road - Existing Lanes Open During Peak Hours	AG
128	MPT - I-91 Exit 28 - Detour	AG
129	MPT - Airport Road - Lower Road Before I-91 Construction	AG
130	MPT - Route 5/15 - Lower Road Before I-91 Construction	AG
131	MPT - I-91 SB to Route 5/15 SB - Lower Road Before I-91 Construction	AG
132	MPT - I-91 SB to Route 5/15 SB - 1/2 Width Reconstruction	AG
133	MPT - VMS on I-91 South Of Route 3 Directing Traffic to Take Alternate Routes	S
134	MPT - Exit 29 Bridge - Abc	R5
135	MPT - Airport Road - Detour	R1
136	MPT - I-91 NB - Detour	R1
137	MPT - Route 5/15 NB - Detour	R1
138	MPT - I-91 SB to Route 5/15 SB - Detour	R1
139	MPT - I-91 NB - Close Existing Right Through Lane During Construction	R4
140	MPT - Airport Road - 1/2 Width Reconstruction	R2
141	MPT - I-91 NB - 1/2 Width Reconstruction	R2
142	MPT - Route 5/15 NB - 1/2 Width Reconstruction	R2
143	MPT - I-91 Exit 28 - Stage Construction	R5

	IDEA	COMMENTS
144	MPT - Airport Road - Lower Road After I-91 Construction	R1
145	MPT - Route 5/15 - Lower Road After I-91 Construction	R1
146	MPT - I-91 SB to Route 5/15 SB - Lower Road After I-91 Construction	R1
147	Relocate Noise Walls on Route 5/15 NB (Main St - Silver Lane)	AG
148	Add Noise Walls on Route 5/15 SB (Main St - Silver Lane)	AG
149	Relocate Noise Walls on Route 5/15 NB (Main St - Silver Lane)	AG
150	Add Noise Walls on Route 5/15 SB (Main St - Silver Lane)	AG
151	Route 5/15 SB - Eliminate Reconstructing Sound Barriers	R4
152	Route 5/15 SB - Eliminate Constructing New Sound Barriers	R4
153	Route 5/15 SB - Eliminate Reconstructing Sound Barriers and Construction on New Barriers	R4
154	Route 5/15 NB - Eliminate Reconstructing Sound Barriers	R4
155	Route 5/15 - Shorten 3-Lane Section to Avoid Silver Lane Bridge and Eliminate Reconstructing Sound Barriers	R4
156	Route 5/15 - Begin 3-Lane Section Drop Further South to Stop Short Of Silver Lane Bridge and Eliminate Reconstructing Sound Barriers	R4
157	Route 5/15 - End 3-Lane Section With 3Rd Lane Exiting on Exit 91 and Eliminate Reconstructing Sound Barriers	R4
158	Reuse Existing Sound Barriers	S
159	Add Aesthetic Treatments on Sound Barrier	R8
160	Reuse Existing Sound Barriers Add Aesthetic Treatments on Sound Barrier	R8

6 DEVELOPMENT PHASE

6. 1 INTRODUCTION

The last step before implementation is to summarize the VE recommendations:

WHAT ARE THE VE RECOMMENDATIONS?
WHY SHOULD THE RECOMMENDATIONS BE ACCEPTED?

Proposals should be clearly presented:

1. Describe As Given with sketches.
2. Present VE Alternatives.
3. Compare advantages, limitations and cost.
4. Recommend a VE Alternative or validate As Given.

Among the rules that govern the Development Phase of a VE Study are the following:

- Improve ideas
- Combine ideas
- Verify features

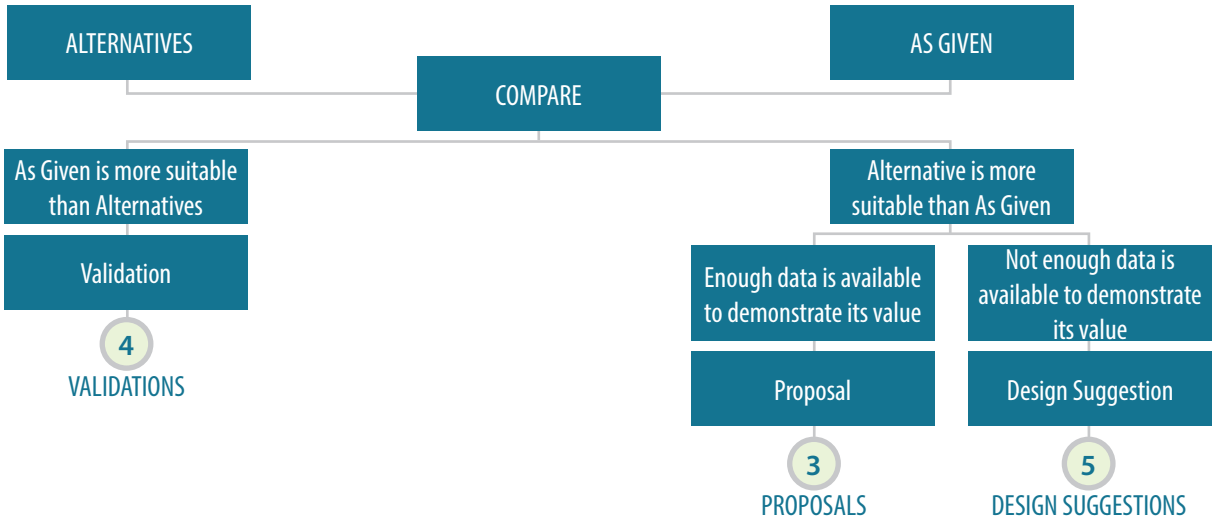


Figure 6. 1: Development Phase Flow Chart

As a result of the speculation and screening process, a number of Alternatives are developed for proposals. These Alternatives are compared with the As Given. It should be noted that Alternatives can be macro in scale and address the design concept or micro in scale and address individual design elements. If the As Given is considered better than the Alternative, then the As Given design element is validated. However, if the Alternative can provide value, without compromising functions, then the Alternative is developed into a proposal or design suggestion. A proposal is an Alternative that can be supported by cost, design features and a clear advantage over the As Given design. If not enough data is available to demonstrate an Alternative's value, then it is considered a design suggestion. The conclusion of the VE Study included four (4) validations, three (3) proposals and five (5) design suggestions. The following is a more detailed discussion of each Alternative and its results.

6. 2 PROPOSALS

PROPOSAL NO. P1

DESCRIPTION: Evaluation of CTDOT Interchange Alternatives

This proposal compares the As Given Alternative to the three (3) other Alternatives proposed in the original CTDOT scoping of the project. Reviewing each alternative concept, it can be noted that there are certain key decisions that are made, which impact the remainder of the design. The sequencing of various decisions for each Alternative shows how one decision that is made on a project may affect subsequent decisions and eventually determines how each Alternative will perform. To illustrate this point, a Decision Matrix was created for each of the Alternatives reviewed, starting with the Goal of "Improve I-91 Exit 29 Capacity and Traffic Operations throughout The Corridor" and ending with four potential end results: "Increase Ramp Capacity", "Eliminate Queue Jumping", "Improve Weaving on the Charter Oak Bridge", and "Improve the Overall Roadway Geometry". The decisions that needed to be made for each Alternative included:

- Exit 29 Ramp Geometry
- Weaving and lane configurations on the Charter Oak Bridge
- Location and operation of the Route 2 Main Street Ramps in East Hartford
- Where Exit 29 would be located on I-91 (Right or Left Exit), and number of lanes
- Number of lanes on I-91
- How to best widen the I-91 bridges over other roadways
- Driver expectancy

Each Decision Matrix demonstrates the logic behind each of the Alternatives and how well they meet the desired goal.

EXISTING: The existing Exit 29 Exit Ramp is a single-lane right exit, entering Route 5/15 on the right side on the Charter Oak Bridge. The existing ramp has a 5% upgrade from I-91 to Route 5/15. This grade causes trucks to slow significantly as they merge onto the Charter Oak Bridge. The slowing of the truck traffic, and adverse volumes associated with the weaving operation on the Charter Oak Bridge causes significant queuing along the ramp which extends onto the I-91 mainline for a significant distance.

6. 2 PROPOSALS

AS GIVEN – CTDOT ALTERNATIVE 8B: Alternative 8B proposed to relocate the Exit 29 Ramp to the left side of I-91, and treat it as a two (2) lane major fork instead of an exit ramp. The I-91 Exit 29 traffic will enter Route 5/15 on the left side of the roadway. Route 5/15 over the Charter Oak Bridge will be partially widened and re-striped to provide four (4) 11-foot lanes with the right lane acting as an "Exit Only" lane to Exit 89 to Route 2 and Main Street. The maximum grade for Exit 29 will be 2.55%.

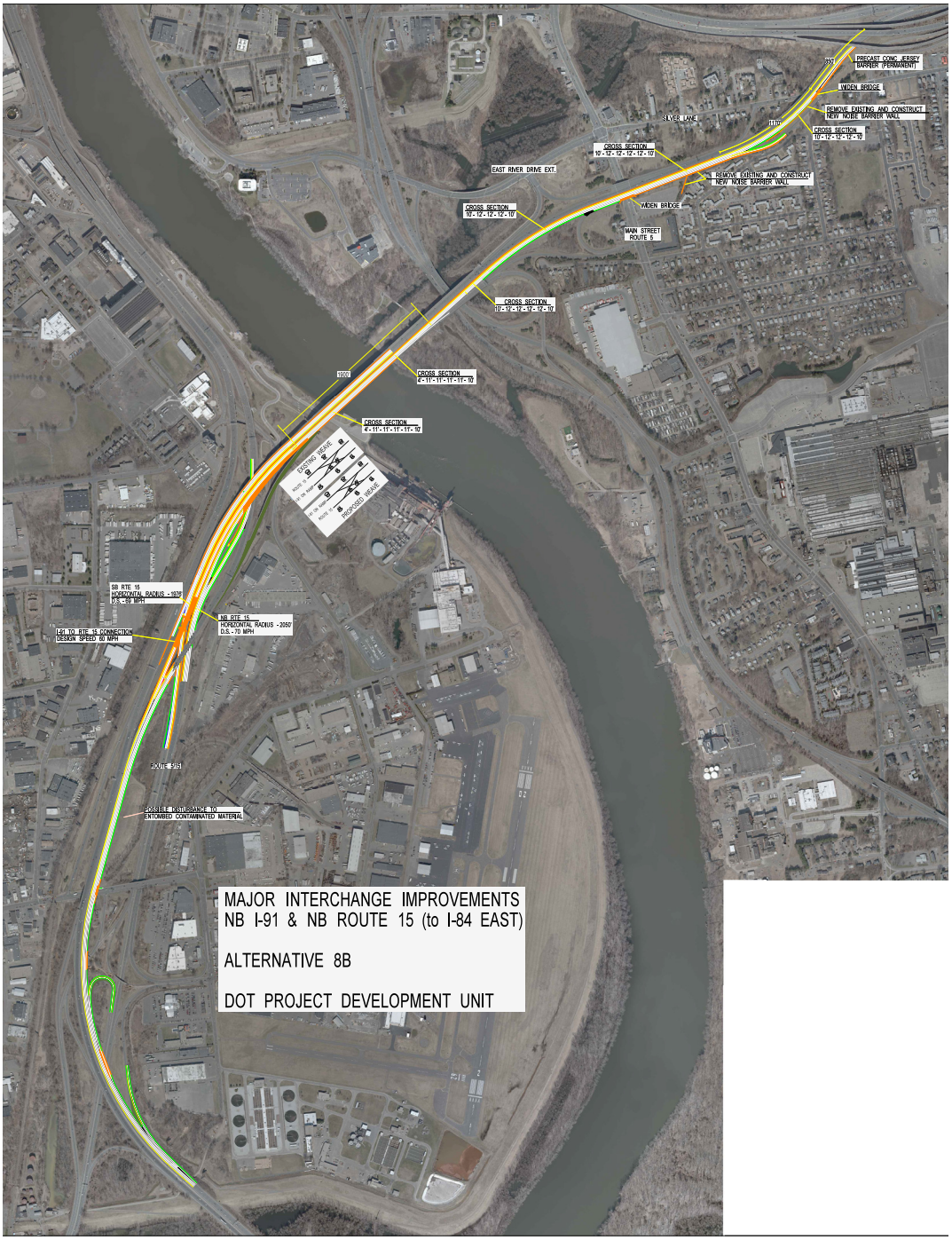


Figure P1.1: CTDOT Alternative 8B As Given

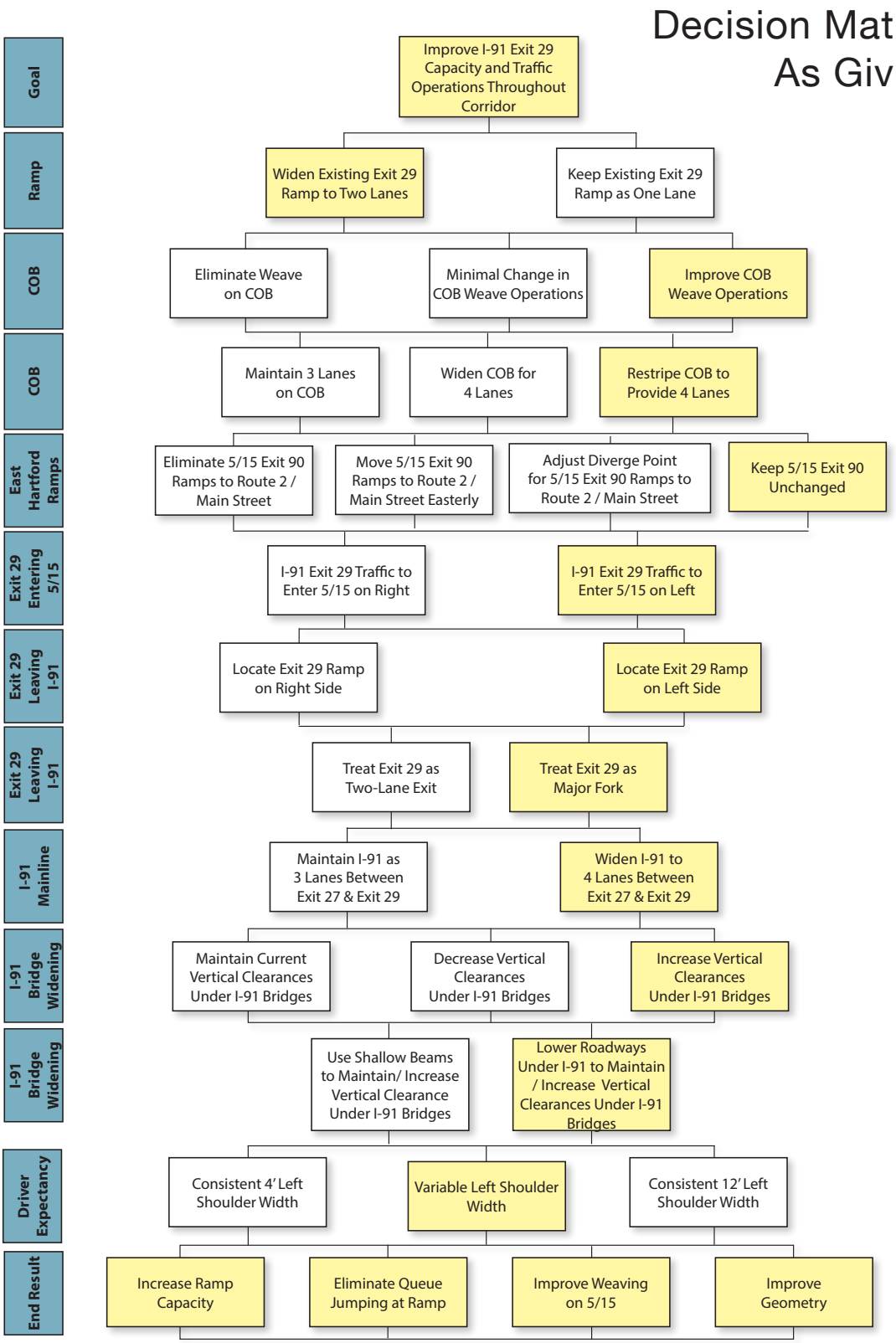


Figure P1.2: Decision Matrix for the As Given

The As Given design provides an improvement to the traffic operations along I-91, Route 5/15 and the Exit 29 Ramp by:

- Adding a lane to the Exit 29 Ramp
- Treating Exit 29 as a major highway fork
- Flattening the vertical geometry of the ramp and connector roadway
- Shifting the I-91 Exit 29 traffic entering Route 5/15 on the right to the left. This change greatly improves the weaving operation on the Charter Oak Bridge.
- Lengthens the distance of between the diverge from I-91 and the merge onto Route

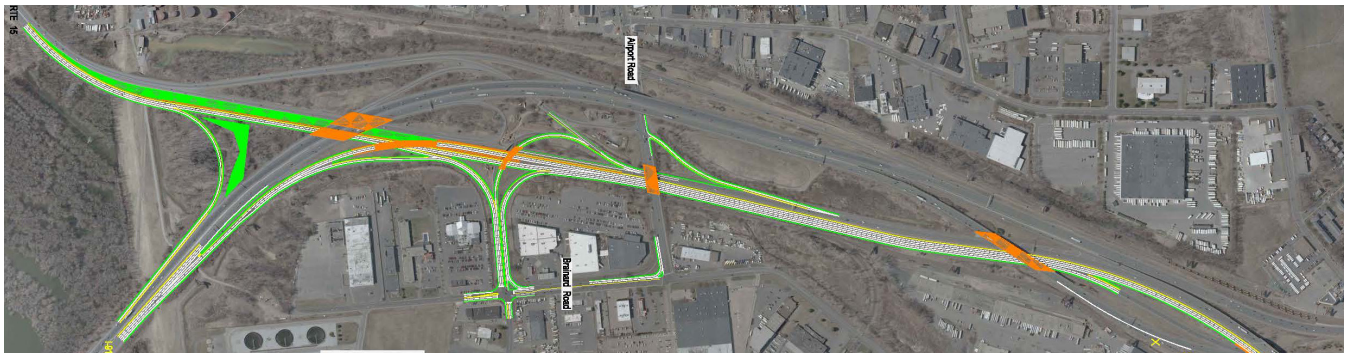


Figure P1.3: Aerial View of CTDOT Alternative 4

5/15 by 1,800 feet (2,000 feet existing / 3,800 feet proposed) significantly reducing the possibility of any Exit 29 queues extending onto I-91 mainline.

CTDOT Alternative 4:

Alternative 4 proposed to relocate Exit 29 south and combine it with Exit 27 (Brainard Road). The new combined exit would be a two-lane exit, with the Exit 29 traffic continuing over Route 5/15 northbound on a two lane flyover structure, intersecting with Route 5/15 traffic from the left. Route 5/15 would continue north as five lanes with three lanes continuing onto the Charter Oak Bridge and two lanes exiting to I-91 northbound via Exit 89. The existing Exit 29 Ramp would be removed, and the existing three lanes on the Charter Oak Bridge will be maintained. Four bridges, two carrying I-91 over roadways and two carrying roadways over I-91 will need replacement, as well as a major realignment and reconstruction of Route 5/15 between I-91 south of Exit 28 and the Charter Oak Bridge.

This Alternative provides an improvement to the traffic operations along I-91, Route 5/15 and the Exit 29 Ramp by:

- Adding a lane to the Exit 29 Ramp
- Flattening the vertical geometry of the ramp and connector roadway
- Eliminating the weave on the Charter Oak Bridge

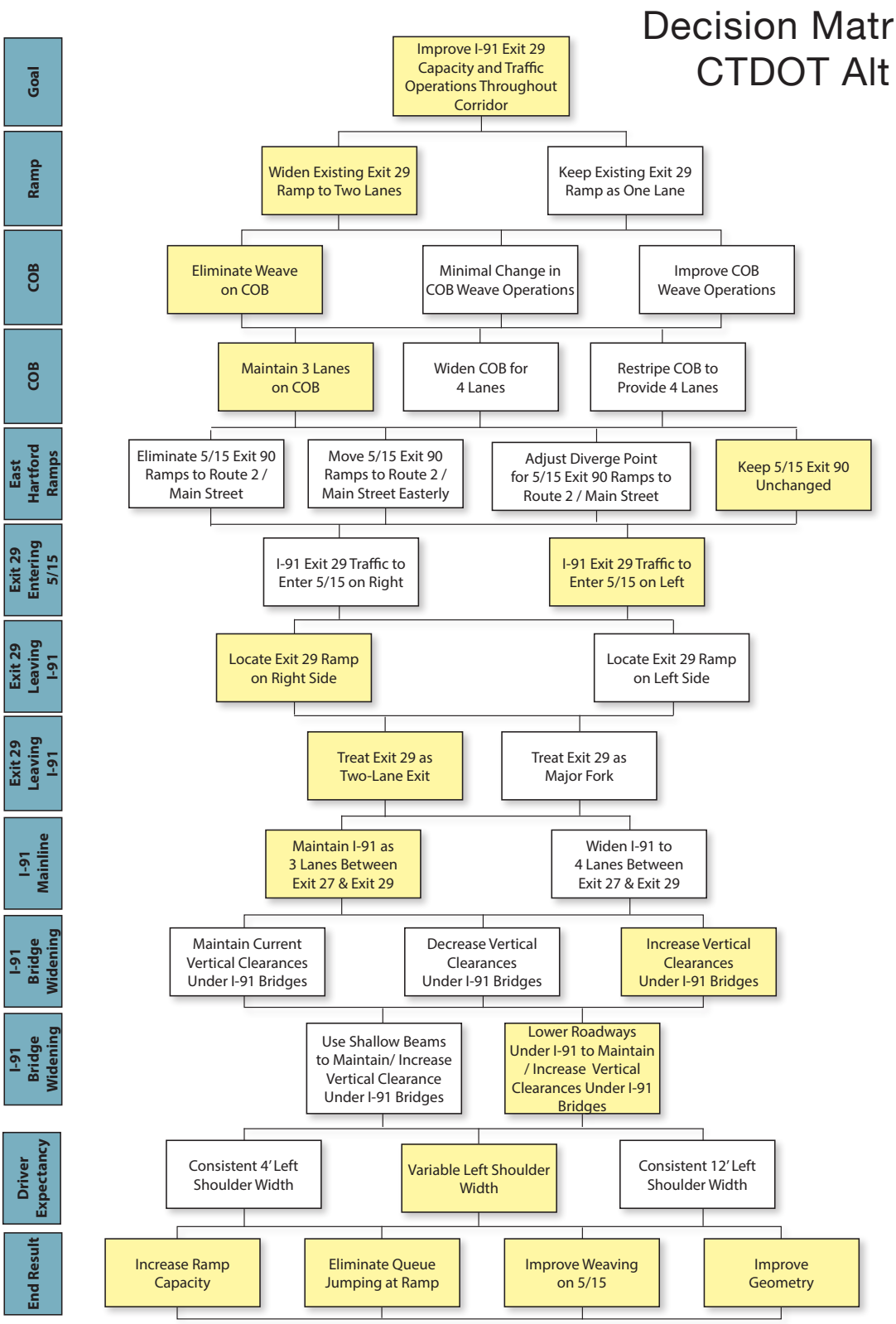


Figure P1.4: Decision Matrix for CTDOT Alternative 4

CTDOT Alternative 6C:

Widen the existing Exit 29 Ramp to provide two lanes on the existing horizontal and vertical geometry. This Alternative leaves Exit 29 in its current location but would widen the ramp roadway to two lanes. The existing ramp geometry (horizontal and vertical) remains unchanged. The Charter Oak Bridge would be re-striped to provide four travel lanes by narrowing the shoulders and providing 11-foot travel lanes. The Route 5/15 Exit would be re-configured to eliminate the connection to Route 2, which allows the diverge point to be shifted east. This change allows for a longer weaving section along Route 5/15 between where the I-91 traffic merges to where the Exit 90 traffic leaves the mainline traffic stream.

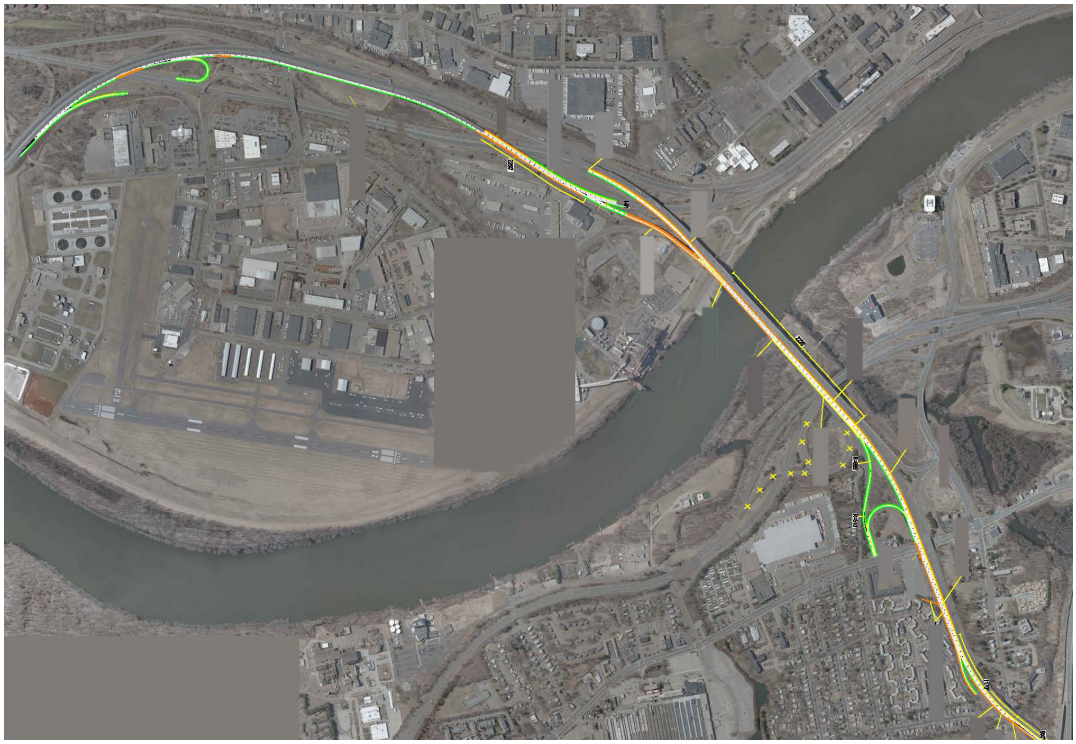


Figure P1.5: Aerial View of CTDOT Alternative 6C

This Alternative provides an improvement to the traffic operations along I-91, Route 5/15 and the Exit 29 Ramp by:

- Adding a lane to the Exit 29 Ramp provides additional capacity and a “de facto” heavy vehicle climbing lane.
- Improves the weaving operation on the Charter Oak Bridge
- Less expensive than Alternatives 8B and 4

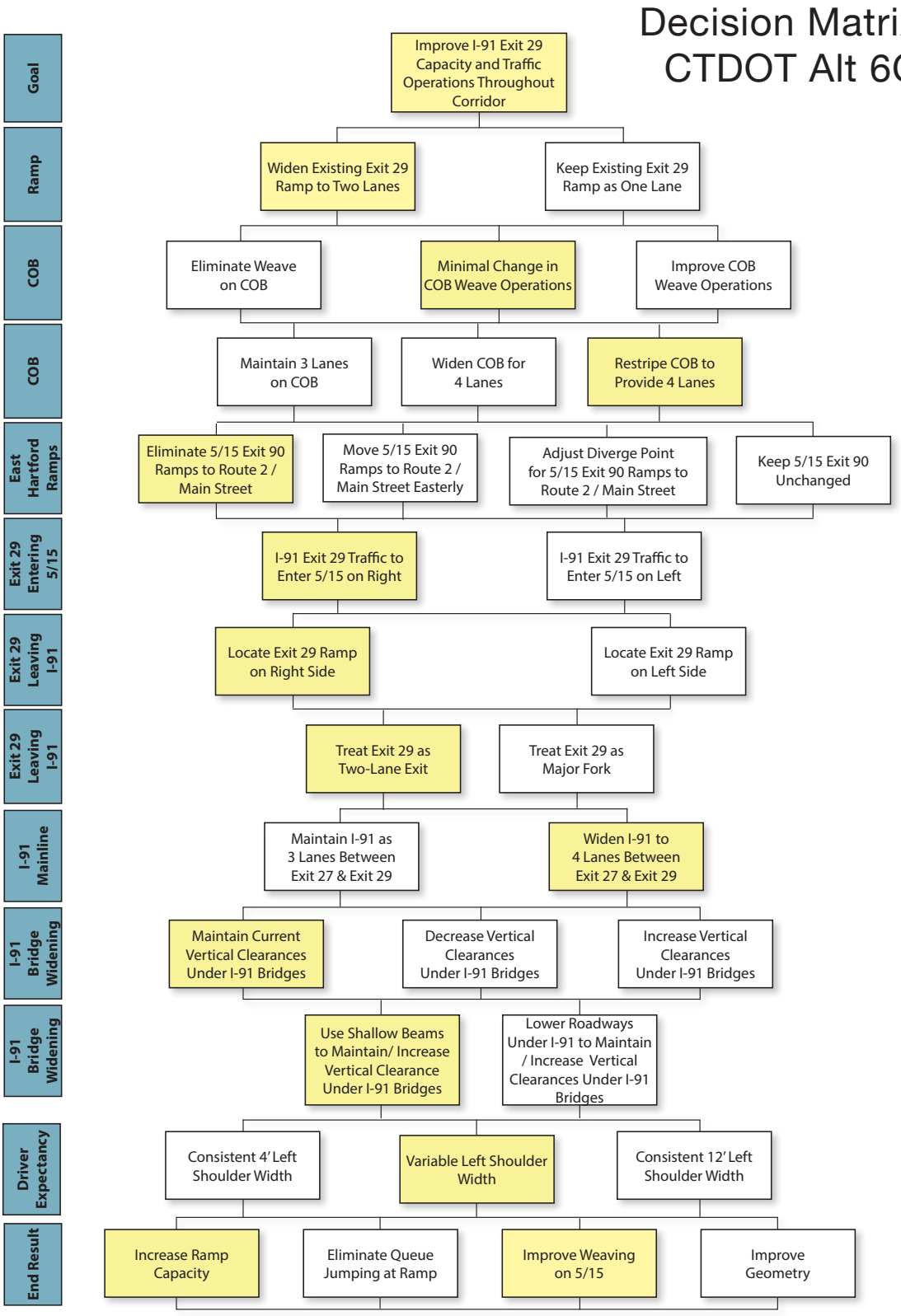


Figure P1.6: Decision Matrix for CTDOT Alternative 6C

CTDOT Alternative 6D:

Similar to Alternative 6C, but does not alter / relocate Route 5/15 Exit 90 to Route 2 and Main Street.

Figure P1.7: Aerial View of CTDOT Alternative 6D

This Alternative provides an improvement to the traffic operations along I-91, Route 5/15 and the Exit 29 Ramp by:

- Adding a lane to the Exit 29 Ramp provides additional capacity and a “de facto” heavy vehicle climbing lane.
- Less expensive than Alternatives 8B, 4 and 6C

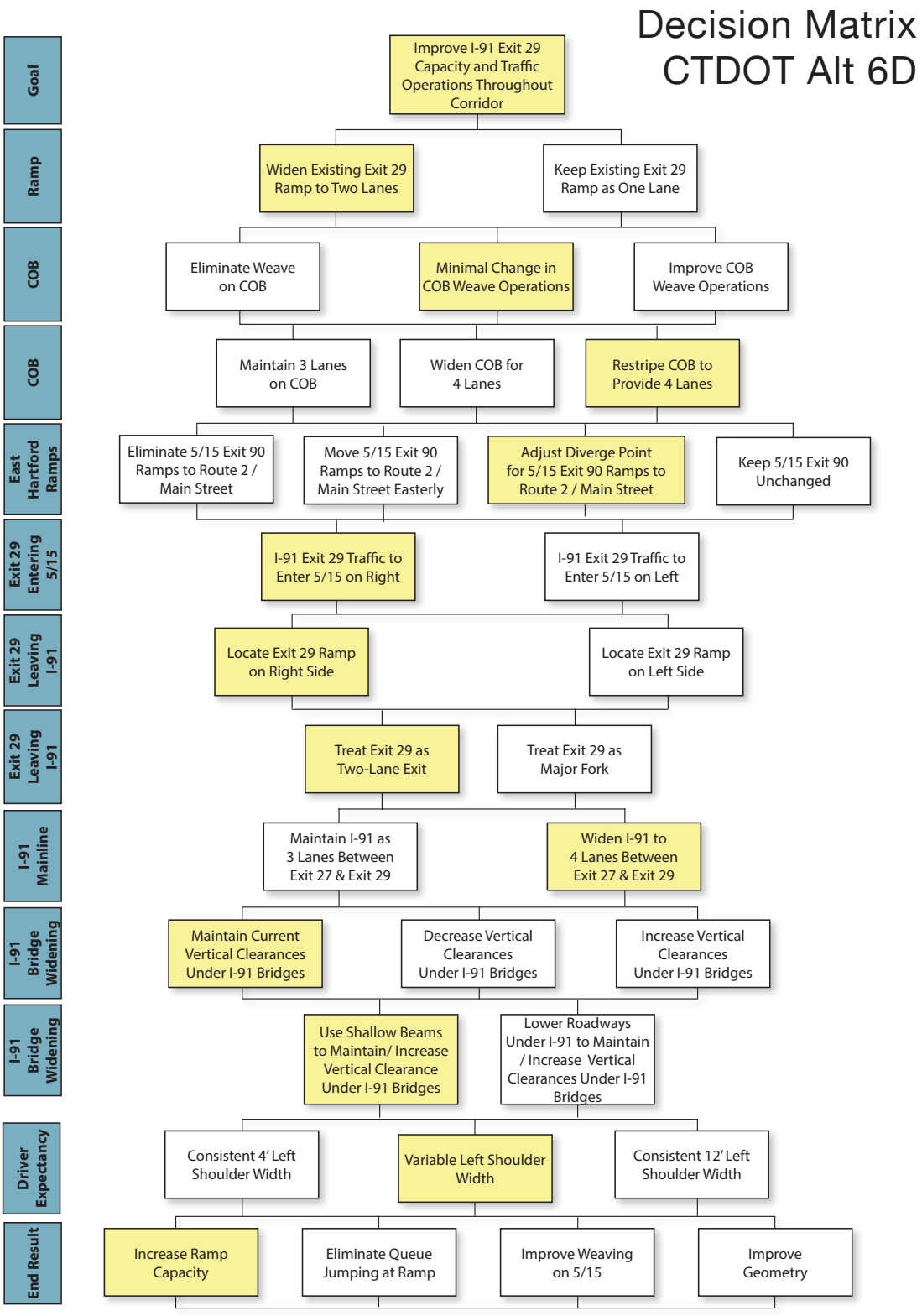


Figure P1.8: Decision Matrix for CTDOT Alternative 6D

VE ALTERNATIVE PROPOSAL EVALUATION

Alternative	Advantages	Limitations
CTDOT Alternative 8B (As Given)	• Adds a Lane to the Exit 29 Ramp • Treats Exit 29 as a Major Highway Fork • Flattens the Vertical Grade • Improves Weave on Charter Oak Bridge • Lengthens Exit 29 Queue Storage	• Left Exit
CTDOT Alternative 4	• Traffic from I-91 to Route 5/15 Exits on the Right • Adds a Lane to the Exit 29 Ramp • Flattens the Vertical Grade • Eliminates Weave on Charter Oak Bridge • Lengthens Exit 29 Queue Storage	• Most Difficult Alternative to Construct • Most Expensive Alternative • Cannot be Completed within the Current Project Schedule.
CTDOT Alternative 6C	• Potential Cost Savings • Potential For Shorter Construction Duration • Improves Weave on Charter Oak Bridge	• Does not improve Vertical Grade on Ramp. • Could Result in Increase of Certain Crashes (Rear-End)
CTDOT Alternative 6D	• Potential Cost Savings • Potential for Shorter Construction Duration	• Does not Improve Vertical Grade on Ramp. • Makes Weave on Charter Oak Bridge Worse • Could Result in Increase of Certain Crashes (Rear-End)

Figure P1.9: VE Alternative Proposal Evaluation

COST COMPARISON

The costs used for each Alternative were the costs developed by CTDOT at the time the project was scoped.

CTDOT Alternative 8B (AS GIVEN): **$170,000,000**

CTDOT Alternative 4 $330,000,000
(increase from Alternative 8B / As Given)

CTDOT Alternative 6C: $130,000,000
(decrease from Alternative 8B / As Given)

CTDOT Alternative 6D: $128,000,000
(decrease from Alternative 8B / As Given)

EVALUATION PROCESS

This section describes how the VE Team took the evaluation of the four (4) Alternatives one step forward in developing a Performance, Acceptance and Cost Evaluation.

Evaluation Phase Process

Accurately judging Alternatives requires an intricate process—part of which is subjective and part objective. In many cases, judging is done sequentially in three (3) independent steps: Performance Rating, Acceptance Rating and Cost Rating. The four (4) Alternatives studied, as well as the "Do-Nothing" option, were evaluated.

RANKING OF CRITERIA (PERFORMANCE & ACCEPTANCE)

Criteria were compared to each other, ranked in order of importance, and assigned a weight of importance on a scale of 1 to 10. Each criterion was compared against the other criteria for its relative importance. At each diagonal, the horizontal row and vertical column will be opposite numbers. The rest of the criteria were compared similarly. When numbers were added vertically, the ranking of criteria was obtained. If there is a breakdown in logic, two criteria may have the same ranking. For example, there may be two 3's and either a 2 or 4 may be missing. Recheck the logic to correct this error.

ASSIGNING WEIGHT OF IMPORTANCE

The most important criterion is always given a rating of 10. The second most important criterion must be a weight of importance of 10 or less. Weight ratings tend to be higher than five. When they drop to five or lower, their impact to the analysis is diminished. If any Alternative receives a rating of 0 or 1 for any of the criteria, the Alternative is considered to have a "Fatal Flaw" and is dropped from consideration in the final analysis

RANKING OF ACCEPTANCE CRITERIA

Acceptance criteria were similarly compared, ranked and weighted. The next step uses these weighted criteria to rate Alternatives for performance and acceptance.

PERFORMANCE AND ACCEPTANCE EVALUATION OF ALTERNATIVES

Using weighted performance criteria, the two Alternatives were evaluated based on how well they satisfied each performance criteria. Each Alternative is rated on how well it performs with respect to the criteria on a scale of 5 to 0, where 5 is excellent, 4 is very good, 3 is good, 2 is satisfactory, 1 is poor and 0 is unsatisfactory. Any Alternative receiving a rating of 0 or 1 for any of the criteria is considered to have a "Fatal Flaw" and is dropped from consideration in the final analysis.

By multiplying these ratings by the weight of the criteria and adding products, a total score for each Alternative is found. This score, divided by the sum of the weight of importance, is the average rating of the Alternative, which is used to select the optimum solution.

Figures P1.10 through P1.13 are the Performance and Acceptance Matrices used for evaluating the Alternatives.

CRITERIA RANKING - PERFORMANCE

	Criteria	Minimize Weaving	Reduce Congestion	Maintain Movements	MPT	Provide Adequate Geometry
1	Minimize Weaving	1	0	0	1	0
2	Reduce Congestion	1	1	1	1	1
3	Maintain Movements	1	0	1	1	0
4	MPT	0	0	0	1	0
5	Provide Adequate Geometry	1	0	1	1	1
Rank		4	1	3	5	2
Weight of Importance		7	10	7	5	8

Figure P1.10: Criteria Ranking - Performance

PERFORMANCE RATING

Excellent = 5 Very Good = 4 Good = 3 Satisfactory = 2 Poor = 1 Unacceptable = 0		Weighted Importance	As Given		Do Nothing		Alternate 4		Alternate 6C		Alternate 6D	
			Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Criteria		(1-10)										
1	Minimize Weaving	7	3	21	2	14	5	35	2	14	2	14
2	Reduce Congestion	10	4	40	0	0	4	40	3.5	35	3	30
3	Maintain Movements	7	5	35	5	35	5	35	2	14	5	35
4	MPT	5	3.5	17.5	5	25	3	15	3	15	3	15
5	Provide Adequate Geometry	8	4	32	2	16	4	32	3	24	2	16
Total Weighted Rating		37	145.50		90.00		157.00		102.00		110.00	
Average Weighted Rating			3.93		2.43		4.24		2.76		2.97	

Figure P1.11: Performance Rating

CRITERIA RANKING - ACCEPTANCE						
Criteria		Constructability	Meet Schedule (Design & Construction Duration)	Driver Satisfaction	Accommodate Expansion	Environmental Permitting
1	Constructability	1	0	0	1	0
2	Meet Schedule (Design & Construction Duration)	1	1	0	1	0
3	Driver Satisfaction	1	1	1	1	1
4	Accommodate Expansion	0	0	0	1	0
5	Environmental Permitting	1	1	0	1	1
Rank		4	3	1	5	2
Weight of Importance		6	8	10	5	8

Figure P1.12: Criteria Ranking - Acceptance

ACCEPTANCE RATING

Excellent = 5 Very Good = 4 Good = 3 Satisfactory = 2 Poor = 1 Unacceptable = 0		Weighted Importance	As Given		Do Nothing		Alternate 4		Alternate 6C		Alternate 6D	
			Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating	Rating	Weighted Rating
Criteria		**(1-10)**										
1	Constructability	6	3	18	5	30	2	12	4	24	4	24
2	Meet Schedule (Design & Construction Duration)	8	5	40	5	40	2	16	4	32	4	32
3	Driver Satisfaction	10	3	30	1	10	4	40	3	30	3	30
4	Accommodate Expansion	5	3	15	2.5	12.5	3.5	17.5	2	10	2	10
5	Environmental Permitting	8	4	32	5	40	3	24	4	32	4	32
Total Weighted Rating		37	135.00		132.50		109.50		128.00		128.00	
Average Weighted Rating			3.65		3.58		2.96		3.46		3.46	

Figure P1.13: Acceptance Rating

6. 2 PROPOSALS

Next, costs for each Alternative were evaluated based on a linear relationship. For the purposes of this exercise, the VE Team decided that a cost of $400 million or higher was unacceptable. The cost used for each Alternative was the cost developed by CTDOT at the time the project was scoped. The cost for each Alternative is placed on the graph and a rating was assigned to each of the Alternatives studied.

1	As Given	$170,000,000
2	Do Nothing	-
3	Alternative 4	$330,000,000
4	Alternative 6C	$130,000,000
5	Alternative 6D	$128,000,000

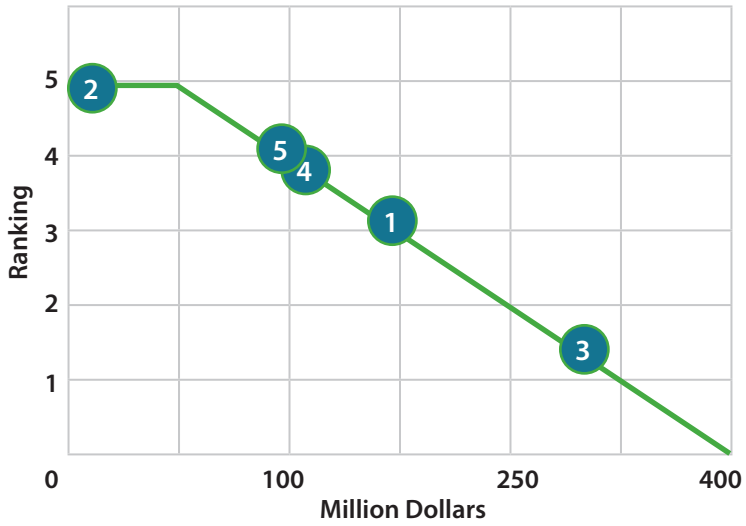


Figure P1.14: Ranking vs Cost

The Third Phase is a Sensitivity Analysis. The Sensitivity Analysis was also performed to determine if any differences are realized if more emphasis is placed on any of those categories. The following figure summarizes the rating of each Alternative for performance, acceptance and cost. A weighted average for each parameter was developed.

RATING SUMMARY

				As Given	Do Nothing	Alternate 4	Alternate 6C	Alternate 6D
Ratings	Performance - P			3.93	2.43	4.24	2.76	2.97
	Acceptance - A			3.65	3.58	2.96	3.46	3.46
	Cost - C			3.00	5.00	1.50	3.50	3.50
	P	A	C					
Value Indicator	1	1	1	3.53	3.67	2.90	3.24	3.31
	2	1	1	3.63	3.36	3.24	3.12	3.23
	1	2	1	3.56	3.65	2.92	3.29	3.35
	1	1	2	3.40	4.00	2.55	3.30	3.36

Figure P1.15: Rating Summary

The results of the evaluation showed the As Given design to outperform the other Alternatives, based on all sensitivity checks, thus supporting the original CTDOT decision. Note that the "Do Nothing" Alternative is rejected because it received a performance rating of 0 for Reducing Congestion.

RECOMMENDATION

The VE Team validates the As Given Alternative.

Reviewing the four (4) CTDOT Alternatives, the VE Team finds the significantly higher costs associated with CTDOT Alternative 4 disqualifies that Alternative and that although keeping Exit 29 along the existing alignment, as proposed in CTDOT Alternatives 6C & 6D, might result in a cost savings, many of the operational concerns throughout the project area will not be addressed. The two major concerns addressed by CTDOT Alternative 8B (As-Given) are:

- Shifting the I-91 Exit 29 traffic entering Route 5/15 on the right to the left. This change greatly improves the weaving operation on the Charter Oak Bridge.
- Lengthening the distance between the diverge from I-91 and merge onto Route 5/15 significantly reducing the possibility of any Exit 29 queues extending onto I-91 mainline.

Additionally, when completing the Performance and Acceptance Analysis, the As Given Alternative had a higher rating than any of the Alternates keeping the Exit 29 Ramp in its current location.

PROPOSAL COMPARISON COST TABLE

The table below summarizes As Given, Alternative Costs and the Cost Difference between As Given and the respective Alternatives. The costs used for each Alternative were the costs developed by CTDOT at the time the project was scoped.

Item	First Cost		Maintenance & Operation Cost		Cost Difference (+) Savings (-) Add'l Cost
	As Given	VE Proposal	As Designed	VE Proposal	
CTDOT Alternative 8B (As Given)	$170,000,000				Validation
CTDOT Alternative 4		$330,000,000	—	—	$0*
CTDOT Alternative 6C		$130,000,000	—	—	$0*
CTDOT Alternative 6D		$128,000,000	—	—	$0*

Accepted: ☐ Needs Further Study: ☐

Rejected: ☐ Needs to be Resolved: ☐

* Validation

6. 2 PROPOSALS

PROPOSAL NO. P2

DESCRIPTION: Maintain the I-91 NB Exit 29 Ramp on the Existing Alignment

EXISTING: The existing Exit 29 Exit Ramp is a single-lane right exit, entering Route 5/15 on the right side on the Charter Oak Bridge. The existing ramp has a 5% upgrade from I-91 to Route 5/15. This grade causes trucks to slow significantly as they merge onto the Charter Oak Bridge. The slowing of the truck traffic and adverse volumes associated with the weaving operation on the Charter Oak Bridge causes significant queuing along the ramp which extends onto the I-91 mainline for a significant distance.

AS GIVEN: It is proposed to relocate the Exit 29 Ramp to the left side of I-91 and treat it as a two (2) lane major fork instead of an exit ramp. The I-91 Exit 29 traffic will enter Route 5/15 on the left side of the roadway. Route 5/15 over the Charter Oak Bridge will be re-striped to provide four (4) 11-foot lanes with the right lane acting as an "Exit Only" lane to Exit 90 to Route 2 and Main Street. The maximum grade for Exit 29 will be 2.55%.

The As Given design provides an improvement to the traffic operations along I-91, Route 5/15 and the Exit 29 Ramp by:

- Adding a lane to the Exit 29 Ramp
- Treating Exit 29 as a major highway fork
- Flattening the vertical geometry of the ramp and connector roadway
- Shifting the I-91 Exit 29 traffic entering Route 5/15 on the right to the left. This change greatly improves the weaving operation on the Charter Oak Bridge.
- Lengthening the distance of the diverge between I-91 and the merge onto Route 5/15 by 1,800 feet (2,000 feet existing / 3,800 feet proposed), significantly reducing the possibility of any Exit 29 queues extending onto I-91 mainline.

Cost As Given: $170,000,000

VE Alternative P2A:

Widen the existing Exit 29 Ramp to provide two lanes on the existing horizontal and vertical geometry. This Alternative leaves Exit 29 in its current location but would widen the ramp roadway to two lanes. The existing ramp geometry (horizontal and vertical) remains unchanged. (This is similar to the original CTDOT Alternate 6C).

This improvement will improve the capacity of the ramp by adding a second lane but will not alter the existing 5% grade and will not improve the weave operation on the Charter Oak Bridge. Due to the fact that the weave operation will not be improved, there is still the potential for queues along the Exit 29 Ramp to spill onto I-91 mainline mimicking current operations.

The cost of this Alternate is estimated to be $128,000,000.

VE Alternative P2B

Widen the existing Exit 29 Ramp to provide two lanes on the existing horizontal alignment with new, flatter, vertical geometry.

This improvement will improve the capacity of the ramp by adding a second lane but will not improve the weave operation on the Charter Oak Bridge. Due to the fact that the weave operation will not be improved, there is still the potential for queues along the Exit 29 Ramp to spill onto I-91 mainline mimicking current operations.

The cost of this Alternate is estimated to be $140,000,000.

VE Alternative P2C

Keep Exit 29 as a single-lane ramp, but move the diverge / decision point further south. This Alternative leaves Exit 29 in its current location. The existing ramp geometry (horizontal and vertical) remains unchanged, but move the physical separation of the ramp and mainline further south. The exit ramp would be separated from the mainline traffic by a physical barrier to minimize queue jumping.

This improvement does nothing to increase the capacity of the ramp and does not alter the existing 5% grade and will not improve the weave operation on the Charter Oak Bridge. The purpose of this Alternative is to simply contain and isolate the queues that currently exist and does little to improve traffic operations throughout the project area.

The cost of this Alternate is estimated to be $70,000,000

VE ALTERNATIVE PROPOSAL EVALUATION

Alternative	Advantages	Limitations
As Given	• Adds a Lane to the Exit 29 Ramp • Treats Exit 29 as a Major Highway Fork • Flattens the Vertical Grade • Improves Weave on Charter Oak Bridge • Lengthens Exit 29 Queue Storage	• Most Expensive Option • Left Exit
VE Alternative P2A	• Adds a Lane to the Exit 29 Ramp	• Does Not Improve Weave on Charter Oak Bridge • Does Not Eliminate the 5% Grade on the Ramp • Does Not Lengthen Exit 29 Queue Storage
VE Alternative P2B	• Adds a lane to the Exit 29 Ramp • Flattens the Vertical Grade	• Does Not Improve Weave On Charter Oak Bridge • Does Not Lengthen Exit 29 Queue Storage

6. 2 PROPOSALS

Alternative	Advantages	Limitations
VE Alternative P2C	• Lengthens Exit 29 Queue Storage	• Does Not Improve Capacity of Ramp. • Does Not Improve Weave on Charter Oak Bridge • Does Not Eliminate the 5% Grade on the Ramp • Does Not Lengthen Exit 29 Queue Storage

Figure P2.1: VE Alternative Proposal Evaluation

COST COMPARISON

Cost As Given: **$170,000,000**

VE Alternative P2A: $128,000,000

VE Alternative P2B: $140,000,000

VE Alternative P2C: $70,000,000

RECOMMENDATION

The VE Team validates the As Given Alternative.

Throughout the Value Engineering analysis, the VE Team considered several different options that included the Exit 29 Ramp exiting I-91 from the right. While keeping Exit 29 along the existing alignment might result in a cost savings, many of the operational concerns throughout the project area will not be addressed that are addressed by the As-Given Alternative. Operational deficiencies addressed by the As-Given Alternative that are not addressed if the ramp remains on the current alignment include:

- Shifting the I-91 Exit 29 traffic entering Route 5/15 on the right to the left. This change greatly improves the weaving operation on the Charter Oak Bridge.
- Lengthening the distance between the diverge from I-91 and merge onto Route 5/15 significantly reduces the possibility of any Exit 29 queues extending onto I-91 mainline.

Additionally, when completing the Performance and Acceptance Analysis, the As Given Alternative had a higher rating than any of the Alternates keeping the Exit 29 Ramp in its current location.

6. 2 PROPOSALS

PROPOSAL COMPARISON COST TABLE

The table below summarizes As Given, Alternative Costs and the Cost Difference between As Given and the respective Alternatives.

Item	First Cost		Maintenance & Operation Cost		Cost Difference (+) Savings (-) Add'l Cost
	As Given	VE Alternative	As Designed	VE Proposal	
As Given	$170,000,000				Validation
Alternative P2A		$128,000,000	—	—	$0*
Alternative P2B		$140,000,000	—	—	$0*
Alternative P2C		$70,000,000	—	—	$0*

Accepted: ☐ Needs Further Study: ☐

Rejected: ☐ Needs to be Resolved: ☐

* Validation

PROPOSAL NO. P3

DESCRIPTION: I-91 Capacity Improvements

EXISTING: I-91 NB south of Exit 27 is four (4) lanes wide with the right most lane acting as an "Exit Only" lane. North of Exit 27, I-91 NB is three (3) lanes wide until the Route 5/15 entrance ramp north of Exit 29.

AS GIVEN: Widen I-91 NB to four (4) lanes from south of Exit 27 to the new Exit 29. The new Exit 29 will be a major fork with two (2) lanes diverging to the left for Exit 29 and three (3) lanes continuing north as I-91. Exit 27 will be converted from an "Exit Only" lane to a conventional exit.

While the existing three lanes are presently operating, at, or, near capacity with the 2015 traffic volumes, with the projected 2039 volumes, this segment will be over capacity.

Cost As Given: $36,741,000

VE Alternative P3A:

Except for the minimum widening to develop four (4) lanes for the Exit 29 major fork, keep I-91 NB three lanes wide between Exit 27 and Exit 29. The widening to achieve the four (4) lane cross section in advance of the major fork must begin 2,000 feet prior to the decision point. This widening begins prior to Bridge 480 (Airport Road), requiring widening of the bridge.

The total distance between Exit 27 and the new Exit 29 is 4,000 feet, leaving 2,000 feet potentially available for a three (3) lane section. This proposal would eliminate the need to reconstruct Bridge 1466 and Bridge 813.

The cost of this Alternate is estimated to be $7,068,000.

VE Alternative Proposal Evaluation

Alternative	Advantages	Limitations
As Given	• Improves Traffic Operations • Meets Capacity Needs for the Anticipated 2039 Traffic Volumes	• Requires Widening of Three (3) of the I-91 Bridges • Requires Construction of Retaining Walls to Avoid Environmental and ROW Impacts.
VE Alternative P3A	• Eliminates Need to Widen Two of the I-91 Bridges • Eliminates a Retaining Wall (Wall 101)	• Creates a Short Three-Lane Segment Between Two (2) Four-Lane Sections • Does Not Provide Capacity to Accommodate Anticipated 2039 Traffic Volumes

Figure P3.1: VE Alternative Proposal Evaluation

6. 2 PROPOSALS

COST COMPARISON

Cost As Given **$36,741,000**

VE Alternative P3A: $7,068,000

RECOMMENDATION

The VE Team validates the As Given Alternative because it provides the necessary number of lanes along I-91 to meet future traffic volumes.

PROPOSAL COMPARISON COST TABLE

The table below summarizes As Given, Alternative Costs and the Cost Difference between As Given and the respective Alternatives.

Item	First Cost		Maintenance & Operation Cost		Cost Difference (+) Savings (-) Add'l Cost
	As Given	VE Alternative	As Designed	VE Proposal	
As Given	$36,741,000				Validation
Alternative P3A		$7,068,000	—	—	$0*

Accepted: ☐ Needs Further Study: ☐

Rejected: ☐ Needs to be Resolved: ☐

* Validation

PROPOSAL NO. P4

DESCRIPTION: Revise Route 15 Eastern Project Limit

EXISTING: Route 15 from the east end of the Charter Oak Bridge has two (2) through travel lanes to the merge with I-84.

AS GIVEN: Route 15 is widened to accommodate three (3) travel lanes from the east end of the Charter Oak Bridge, matching the existing two (2) travel lanes approximately 300 feet east of Bridge No. 05796 over Silver Lane. This requires widening the existing bridge over Silver Lane. Noise barrier at the south curb line was recently reconstructed from Exit 91 to the project limit.

Figure P4.1: Reconstructed Noise Barrier at South Curb Line from Exit 91 to Project Limit

Cost As Given	Rehabilitate Bridge 05796 – Route 15 over Silver Lane	$10,525,740
	Roadway Reconstruction	$427,800
	Noise Barrier	$1,858,140
	TOTAL	**$ 12,812,000**

VE Alternative P4A: Match the existing two (2) travel lanes on Route 15 west of Silver Lane. A reduction of 550 feet of associated roadway widening of Route 15. This proposal eliminates the widening of Bridge No. 05796 – Route 15 over Silver Lane and reduces the amount of recently reconstructed Noise Barrier.

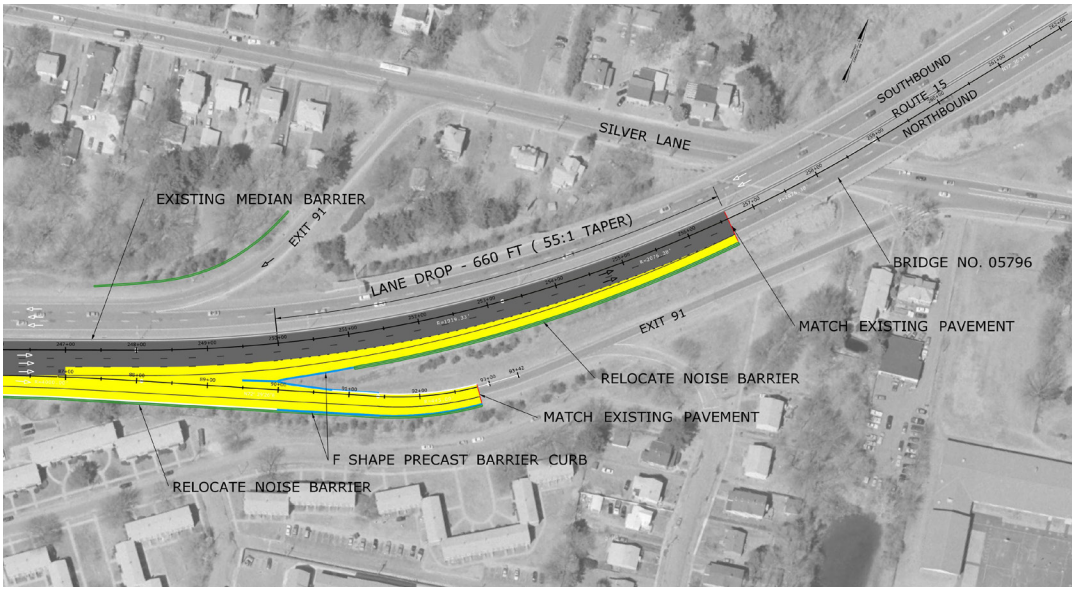


Figure P4.2: Proposal P4A eliminates the widening of Bridge No. 05796 – Route 15 over Silver Lane and reduces the amount of recently reconstructed Noise Barrier.

The cost of this Alternate is estimated to be $0 or a $12,811,680 savings from the As Given. The value refers to the cost of the work that would be eliminated should this alternative be chosen.

VE ALTERNATIVE PROPOSAL EVALUATION

Alternative	Advantages	Limitations
As Given	• Extends 3-Lane Section as Long as Possible • Lane Drop Further from Exit 91	• Requires Widening of Bridge No. 05976 • Relocating Recently Constructed Noise Barrier
VE Alternative P4A	• Eliminates Widening Bridge 05796 • Eliminates Relocating Noise Barrier over Silver Lane	• Lane Drop Closer To Exit 91

Figure P4.3: VE Alternative Proposal Evaluation

COST COMPARISON

Cost As Given: $12,812,000

VE Alternative P4A: **$0 ($12,812,000 savings from the As Given)**

6. 2 PROPOSALS

RECOMMENDATION

The VE Team recommends VE Alternative P4A, which shifts the eastern Project Limits of Route 15 Northbound construction in East Hartford to west of Silver Lane. This revision eliminates the need to widen Bridge No. 05796 – Route 15 over Silver Lane and the additional 550 feet of roadway.

PROPOSAL COMPARISON COST TABLE

The table below summarizes As Given, Alternative Costs and the Cost Difference between As Given and the respective Alternatives.

Item	First Cost		Maintenance & Operation Cost		Cost Difference (+) Savings (-) Add'l Cost
	As Given	VE Alternative	As Designed	VE Proposal	
As Given	$12,812,000				
Alternative P4A		$0			(+)$12,812,000

Accepted: ☐ Needs Further Study: ☐

Rejected: ☐ Needs to be Resolved: ☐

PROPOSAL NO. P5

DESCRIPTION: New Exit 29 Bridge over Route 5/15 Southbound Width / Cross Section

EXISTING: N/A – This is a New Structure.

AS GIVEN: Exit 29 - 12-foot Left Shoulder, 12-foot Lanes, 12-foot Right Shoulder.

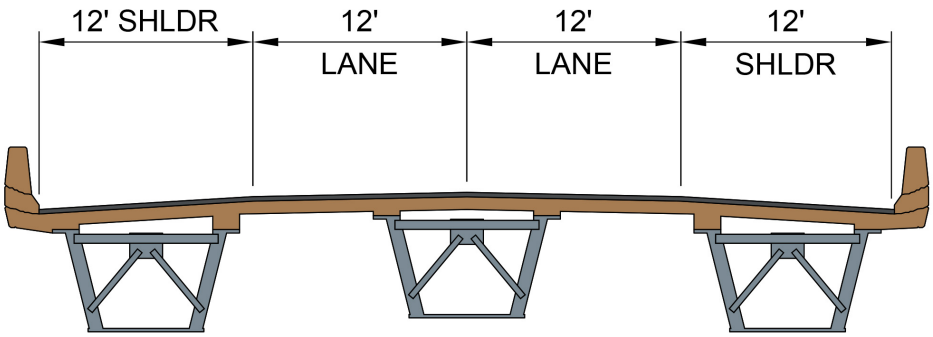


Figure P5.1: As Given Lane Configuration over New Structure.

Cost As Given	Bridge	$34,629,400
	Roadway	$ 3,860,000
	TOTAL	**$38,489,400**

VE Alternative P5A

Construct the New Exit 29 Bridge over Route 5/15 Southbound with a 4-foot Left Shoulder, 12-foot Lanes, and a 10-foot Right Shoulder. Currently, the Left Shoulder along I-91 immediately to the south of the new bridge is 6-feet wide, and immediately to the north, the Left Shoulder is 4-feet wide along the Charter Oak Bridge.

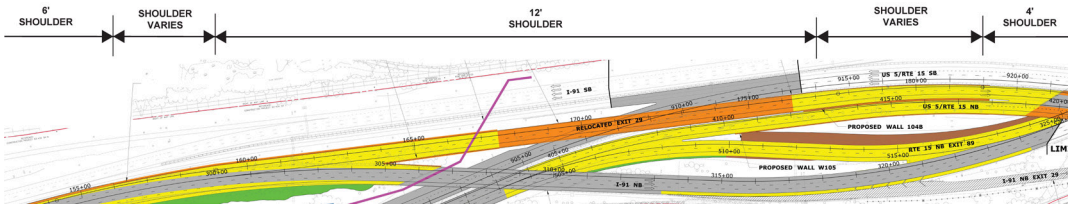


Figure P5.2: Alternative P5A – Construct New Exit 29 Bridge over Route 5/15 Southbound with a 4-foot Left Shoulder, 12-foot Lanes, and a 10-foot Right Shoulder

Narrowing the shoulder to 4 feet on the connector roadway and new bridge will provide a consistent shoulder width without negatively impacting traffic flow. Providing a 10-foot wide Right Shoulder will reduce the overall width of the roadway without negatively impacting traffic flow or safety. This cross section meets the 70 MPH design standards for a 2-lane connector road. This will reduce the overall width of the bridge from 48 feet

curb-to-curb / 51 feet - 10 inches out-to-out to 38 feet curb-to-curb / 41 feet - 10 inches out-to-out a reduction of 10 feet of width. An additional benefit to be gained by narrowing the connector roadway and bridge for the new Exit 2 Ramp is the potential to alter the alignments of the Route 5/15 mainline and Exit 89 between the I-91 northbound overpass (Bridge 5922) and the Charter Oak Bridge. The potential changes could realign these roadways closer to the existing alignments.

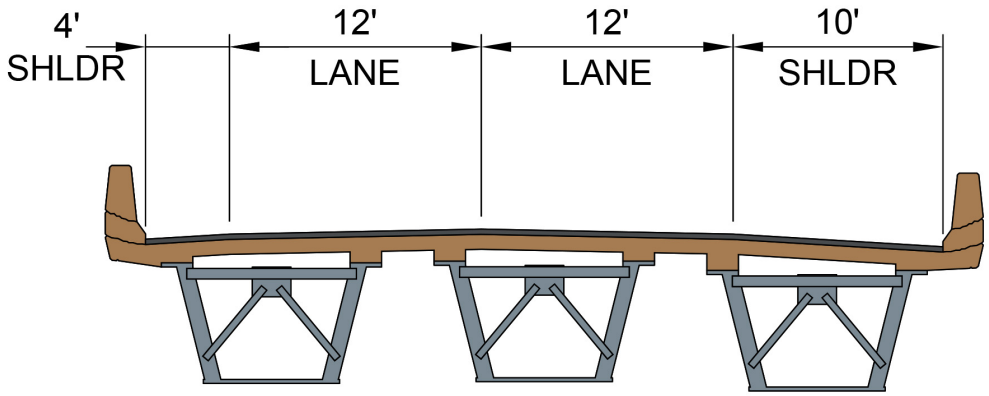


Figure P5.3: Narrowing of the Shoulder to 4' on the Connector Roadway.

The cost of this Alternate is estimated to be $30,918,940.

VE Alternative P5A:	Bridge	$27,883,640 (Decrease from As Given)
	Roadway	$ 3,585,300 (Decrease from As Given)
	TOTAL	**$30,918,940** **(Decrease from As Given)**

VE Alternative P5B

Construct the New Exit 29 Bridge over Route 5/15 Southbound with a 4-foot Left Shoulder, 11-foot Lanes, and a 10-foot Right Shoulder. This is similar to VE Alternative P4A, except instead of 12-foot travel lanes, 11-foot travel lanes will be provided. This 11-foot travel lane width matches the travel lane widths that are being provided upstream on the Charter Oak Bridge. This will reduce the overall width of the bridge from 48 feet curb-to-curb / 51 feet 10 inches out-to-out to 36 feet curb-to-curb / 39 feet 10 inches out-to-out, for a reduction of 12 feet of width.

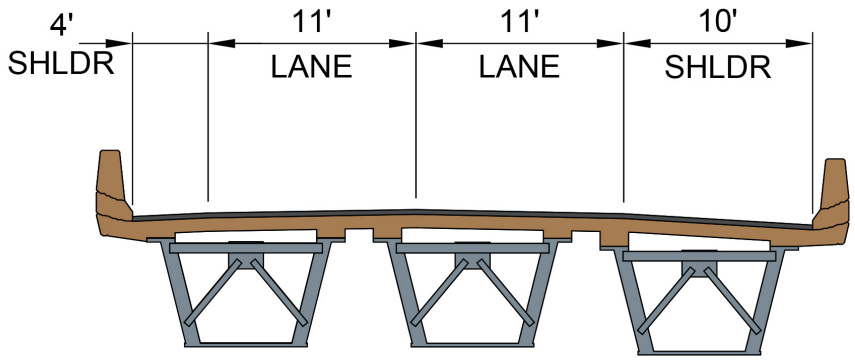


Figure P5.4: New Exit 29 Bridge over Route 5/15 Southbound with a 4-foot Left Shoulder, 11-foot Lanes and a 10-foot Right Shoulder..

The cost of this Alternate is estimated to be $29,431,040.

VE ALTERNATIVE PROPOSAL EVALUATION

Alternative	Advantages	Limitations
As Given	• Provides Maximum Shoulder Widths. • Exceeds Design Criteria	• Inconsistent Shoulder Widths Compared to Downstream and Upstream Roadways • Forces Shifting of Route 5/15 Mainline and Exit 89
VE Alternative P5A	• Consistent Shoulder Widths With Upstream Roadway • Meets Design Criteria • Potential to Improve Geometry Along Route 5/15	• Narrower Shoulder Could Affect Traffic Flows Due to High Truck Volumes
VE Alternative P5B	• Consistent Shoulder Widths with Upstream Roadway • Potential to Improve Geometry Along Route 5/15	• Narrower Shoulders Could Effect Traffic Flows due to High Truck Volumes • Narrower Lanes Could Effect Traffic Flows due to High Truck Volumes • Does Not Meet Design Criteria – Design Exception Required

Figure P5.5: VE Alternative Proposal Evaluation

Cost Comparison

Cost As Given: **$38,489,400**

VE Alternative P5A: **$30,918,000 ($7.5 million savings from As Given)**

VE Alternative P5B: **$29,431,000 ($9.0 million savings from As Given)**

RECOMMENDATION

The VE Team recommends Alternative P5A. This Alternative will result in a cost savings while conforming to the Design Criteria and provides the potential to improve geometry along Route 5/15.

PROPOSAL COMPARISON COST TABLE

The table below summarizes As Given, Alternative Costs and the Cost Difference between As Given and the respective Alternatives.

Item	First Cost		Maintenance & Operation Cost		Cost Difference (+) Savings (-) Add'l Cost
	As Given	VE Alternative	As Designed	VE Proposal	
As Given	$38,489,400				
Alternative P5A		$30,918,940			(+) $7,570,460
Alternative P5B		$29,431,040			(+) $9,058,360

Accepted: ☐ Needs Further Study: ☐

Rejected: ☐ Needs to be Resolved: ☐

PROPOSAL NO. P6

DESCRIPTION: Consider Alternate Approaches to Addressing Vertical Clearance Issues at I-91 Underpasses

The intent of this proposal is to limit or eliminate (if possible) the roadway reconstruction work proposed under the bridges carrying I-91 which have substandard under-clearances.

EXISTING: Within the project limits, there are three (3) bridges carrying I-91 with substandard under-clearances. The bridges include the following:

Bridge No.	Description	Existing Clearance
00813	I-91 over Route 5/15	13′-9″
01466	I-91 over I-91 TR827	14′-0″
00480	I-91 over Airport Road	13′-11″

Figure P6.1: Bridge No. 00813 Elevation

Figure P6.2: Bridge No. 01466 Elevation

The proposed design includes widening of these bridges to accommodate a fourth lane on I-91 NB. Due to the cross slope of the roadway (I-91), the widening would generally result in a lowering of the low chord of the bridge.

AS GIVEN: Provide an increased under-clearance at the bridges to meet 14 feet- 6 inches by lowering the roadway profiles below the bridges, along with utilizing shallower beams for the widening.

The As-Given Design calls for improving the under-clearance at all three bridges to meet 14 feet- 6 inches, which is the minimum standard.

This is proposed to be accommodated though the following measures:

- Use of lower profile members for the bridge widening
- Lowering of the roadway profile below the bridge

	Bridge No.	Structure Cost	Roadway Cost	Total (Incl. % Costs)
Cost As Given	00813	$8,890,000	$1,276,000	$19,359,000
	01466	$4,433,000	$321,000	$9,081,000
	00480	$3,064,000	$596,000	$7,034,000
	TOTAL	**$16,387,000**	**$2,193,000**	**$35,474,000**

VE Alternative P6A

Maintain the existing minimum under-clearances at the bridge by utilizing shallower beams for the widening (wherever possible).

Under this Alternative, the existing under-clearances would be maintained, wherever possible. Widening of the bridges would be performed utilizing beams shallower than the existing to offset the effect of the cross slope.

The VE Team evaluated the proposed cross section to see what savings could be achieved. The existing critical fascia beam depth was compared with the value resulting from AASHTO LRFD Manual Table 2.5.2.6.3-1 *"Traditional Minimum Depths for Constant Depth Superstructures"*.

The following is a summary of the evaluation performed.

Bridge No.	Loss of Clearance (Cross Slope and Profile Below)	Potential Reduction in Beam Depth	Potential Solution?
00813	8.19"	4.52"	No
01466	4.44"	10.39"	Yes
00480	13.28"	Minimal	No

Based on the evaluation, this Alternate only presents a viable solution at Bridge No. 01466.

The cost of this Alternate is estimated to be $34,860,000 ($614,000 Decrease from As Given).

VE Alternative P6B

Provide an increased under-clearance at the bridges to meet 14 feet- 6 inches by replacing the superstructure with new, shallower superstructures.

Under this Alternative, all three (3) bridge superstructures will be replaced with new superstructures. For the multi-span bridges (Bridge No. 00813 and 01466), the proposed bridge superstructures would be designed as continuous to reduce the structure depth.

The cost of this Alternate is estimated to be $58,400,000 ($22 million increase from As Given).

VE ALTERNATIVE PROPOSAL EVALUATION

Alternative	Advantages	Limitations
As Given	• Meets the 14'-6" Under-Clearance • Mitigate Against Future Vehicular Impacts • Reduced Superstructure Costs	• Potential Utility Impacts • Greater Impact on Below Roadways • Greater Roadway Costs.
VE Alternative P6A	• No Roadway Construction Under Bridge • Less Impact to Traffic Below Bridge • No Impact to Utilities Below Bridge • Cost Savings	• Does Not Improve Existing Clearance Issues • Only Applicable to Bridge No. 01466
VE Alternative P6B	• Meets the 14'-6" Under-Clearance • Mitigate Against Future Vehicular Impacts • New Bridge Structures (Current Bridges Constructed In 1961)	• Highest Cost Alternative • Major Traffic Impacts to I-91 NB & SB

Figure P6.3: VE Alternative Proposal Evaluation

COST COMPARISON

Cost As Given: **$35,474,000**

VE Alternative P6A: $34,860,000 ($614,000 Decrease from As Given).

VE Alternative P6B: $58,400,000 ($22,926,000 Increase from As Given)

RECOMMENDATION

The VE Team validates the As-Given solution to increase the vertical clearance to 14 feet - 6 inches under the three (3) bridges by lowering the roadway and utilizing shallow depth beams to complete the widening.

Though Alternative P6A offers a potential limited cost savings, it does not address the concerns associated with vehicular collisions into the bridge due to the insufficient clearance.

Though there are potential benefits to be realized with Proposal P6B, there is a high cost associated with the work and significant temporary (M&PT) and permanent (Profile) impacts to I-91 associated with the work.

As the bridges are not structurally deficient and appear to have twenty or more years of service life remaining, replacement does not appear warranted at this time.

PROPOSAL COMPARISON COST TABLE

The table below summarizes As Given, Alternative Costs and the Cost Difference between As Given and the respective Alternatives.

Item	First Cost		Maintenance & Operation Cost		Cost Difference (+) Savings (-) Add'l Cost
	As Given	VE Alternative	As Designed	VE Proposal	
As Given	$35,474,000				Validation
Alternative P6A		$34,860,000	—	—	$0*
Alternative P6B		$58,400,000	—	—	$0*

Accepted: ☐ Needs Further Study: ☐

Rejected: ☐ Needs to be Resolved: ☐

* Validation

PROPOSAL NO. P7

DESCRIPTION: Optimize Span Configuration

EXISTING: None.

AS GIVEN: Construct a five-Span continuous Trapezoidal Box Girder. The spans are 140 feet, 215 feet, 215 feet, 170 feet and 140 feet. The total Bridge length is 880 feet. Piers #1, #3 and #4 are concrete wall piers with steel integral bent caps. Pier #2 is a Straddle Pier. The width is 51 feet - 10 inches. The deck area is 45,610 SF.

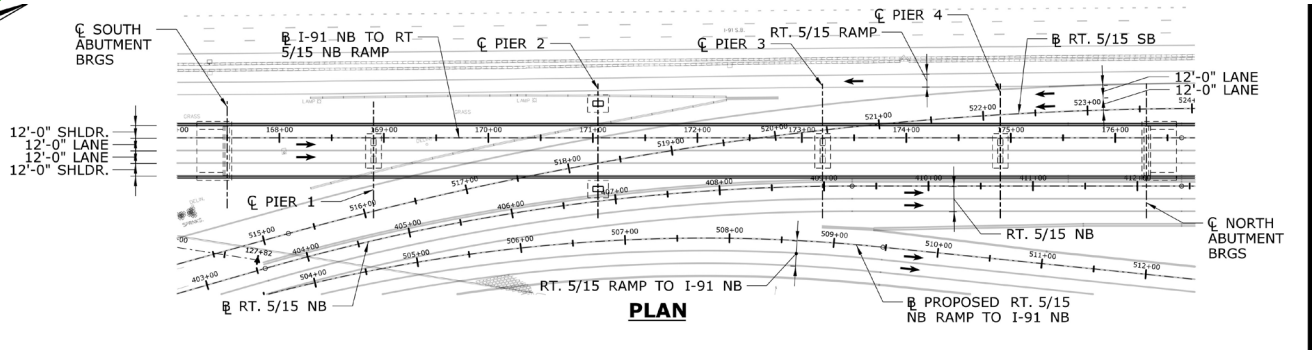


Figure P7.1: As Given Plan Elevation

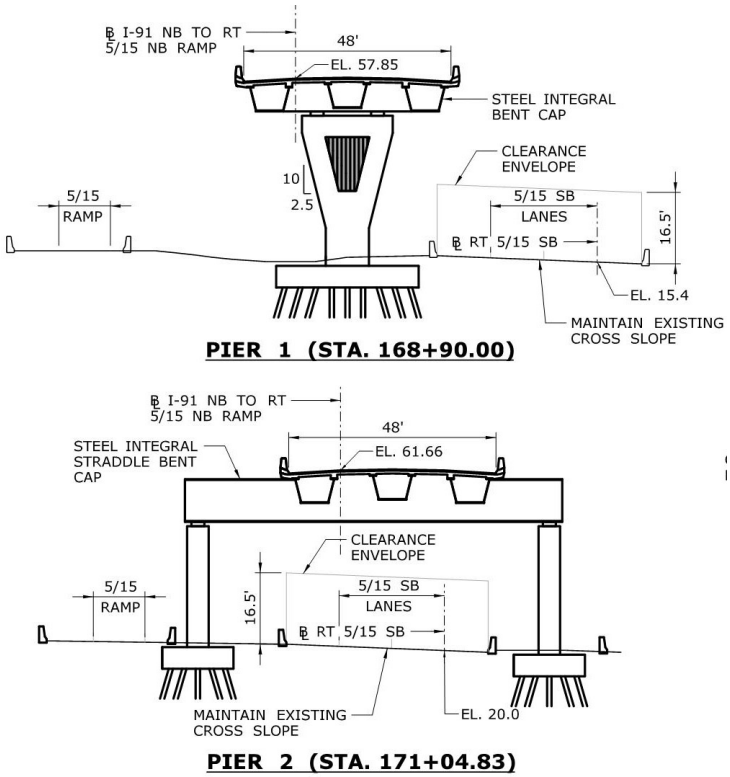


Figure P7.2: As Given Pier 1 and Pier 2 Elevations

COST AS GIVEN: $39,812,000

As Given	Bridge Cost	$18,266,000
	TOTAL COST*	**$39,812,000**

*Includes incidentals, contingencies, and minor items.

VE Alternative P7A: Three Span Plate Girder

Construct a three-Span continuous Plate Girder. The spans are 215 feet, 215 feet, and 170 feet. The total Bridge length is 600 feet. Pier #1 is a Straddle Pier and Pier #2 will be a Hammerhead Pier. The abutment corners will be clipped to accommodate the barrier below. In addition, the wingwall will be set back to accommodate the barrier below. The width is 51 feet -10 inches. The deck area is 31,098 SF.

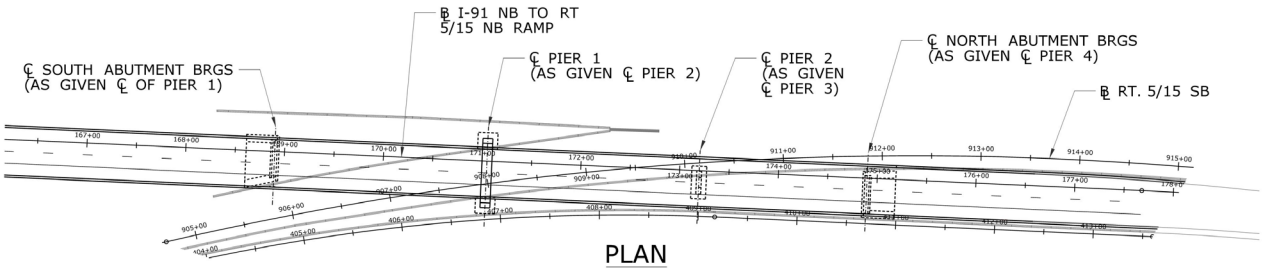


Figure P7.3: Three-Span Continuous Plate Girder Bridge

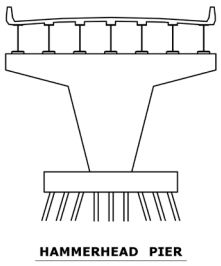


Figure P7.4: Hammerhead Pier

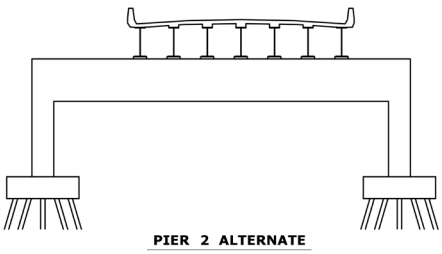


Figure P7.5: Pier 2 Alternate

The cost of this Alternate is estimated to be $32,570,000.

Alternative P7A	Bridge Cost	$12,284,000
	Total Cost*	$27,149,000
	Additional Wall Cost	$5,421,000
	TOTAL COST*	**$32,570,000 ($2,062,000 SAVINGS FROM AS GIVEN)**

*Includes incidentals, contingencies, and minor items.

VE Alternative P7B – Four Span Plate Girder with Approach Span

Construct a four-Span Continuous Plate Girder. The spans are 215 feet, 215 feet, 170 feet and 140 feet. Add a 40-foot approach span with precast beams / girders. The total Bridge length is 780 feet, including the single 40-foot approach span. Pier #2 is a Straddle Pier and Piers #1, #3 and #4 will be a Hammerhead Piers. The width is 51 feet - 10 inches. The deck area is 40,428 SF.

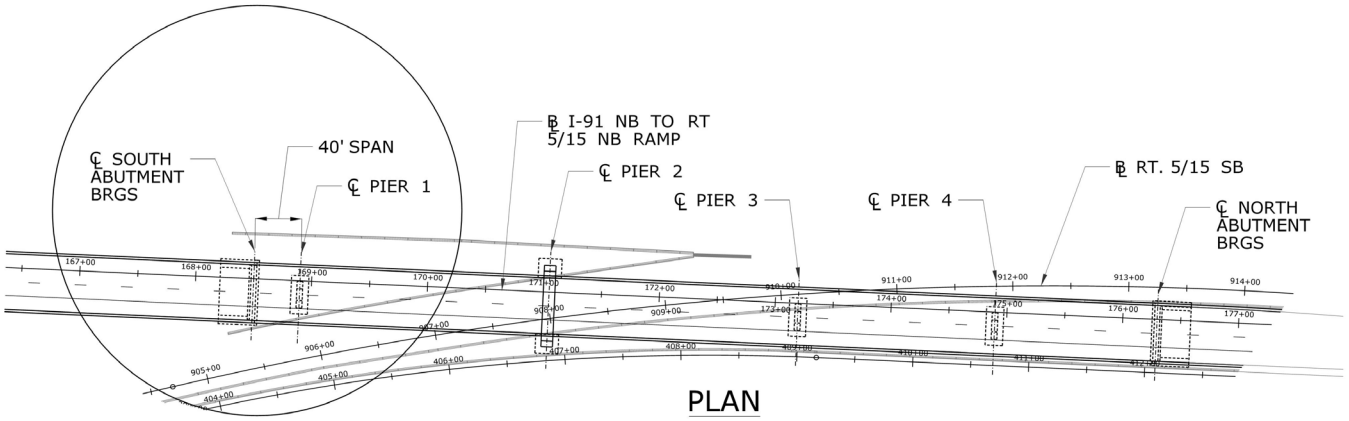


Figure P7.6: Four-Span Plate Girder with Approach Span

The cost of this Alternate is estimated to be $36,346,000

Alternative P7B	Primary Bridge Span Cost	$15,150,000
	Approach Span Cost	$420,000
	Bridge Cost	$15,570,000
	Total Cost*	$34,410,000
	Additional Wall Cost	$1,936,000
	TOTAL COST*	**$36,346,000 ($3,466,000 SAVINGS FROM AS GIVEN)**

*Includes incidentals, contingencies, and minor items.

VE Alternative P7C – Four Span Plate Girder

Construct a four-Span continuous Plate Girder. The spans are 255 feet, 215 feet, 170 feet and 140 feet. The total Bridge length is 780 feet. Pier #1 is a Straddle Pier and Piers #2, #3 and #4 will be Hammerhead Piers. The width is 51 feet - 10 inches. The deck area is 40,428 SF. piers. The width is 51'-10". The deck area is 40,428 SF.

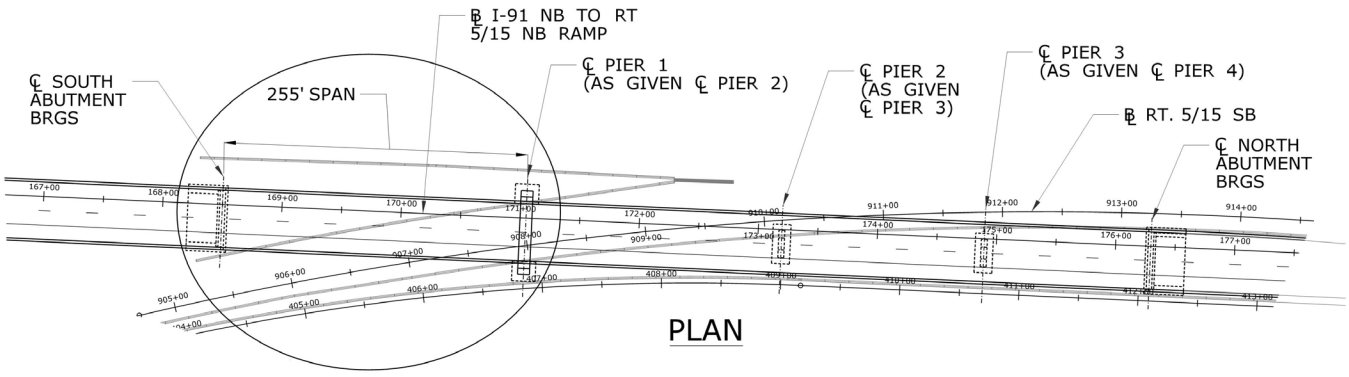


Figure P7.7: Four-Span Plate Girder

The cost of this Alternative is estimated to be $37,230,000.

Alternative P7C	Bridge Cost	$15,969,000
	Total Cost*	$35,294,000
	Additional Wall Cost	$1,936,000
	TOTAL COST*	**$37,230,000. ($2,582,000 SAVINGS FROM AS GIVEN)**

*Includes incidentals, contingencies, and minor items.

VE ALTERNATIVE PROPOSAL EVALUATION

Alternative	Advantages	Limitations
As Given	• Has Higher Vertical Clearance • Has Minimum Expansion Joints	• Integral Caps Require More Cranes to Erect • May Take Longer Construction Time
VE Alternate P7A	• Shorter Bridge Length • Plate Girders are Simpler to Erect • Satisfies Minimum Vertical Clearance Requirement	• Unconventional Abutment and Approach Slab. • Requires Longer Retaining Walls
VE Alternate P7B	• Shorter Bridge Length • Plate Girders Are Simpler to Erect • Satisfies Minimum Vertical Clearance Requirement	• Has One More Joint than As Given • Requires Longer Retaining Walls
VE Alternate P7C	• Shorter Bridge Length • Plate Girders are Simpler to Erect • Satisfies Minimum Vertical Clearance Requirement • One Less Pier	• Requires Longer Retaining Walls

Figure P7.8: VE Alternative Proposal Evaluation

COST COMPARISON

For the purposes of this cost comparison, unit costs of construction were computed based on the Preliminary Design cost estimates as shown in the tables, which follow.

Bridge Cost				
Bridge Length	880	Ft		
Bridge Width	51.83	Ft		
Bridge Area	45610.4	SF		
Item	**Quantity**	**Unit**	**Unit Cost**	**Amount**
Excavation	2140	CY	23.40	$ 50,076.00
Backfill	7280	CY	45.80	$ 333,424.00
HMA So.5	280	FT	94.20	$ 26,376.00
S0.25	560	CY	81.00	$ 45,360.00
Strip Seal	50	LB	500.00	$ 25,000.00
Expansion Joint	50	CY	600.00	$ 30,000.00
Bearings	14	LB	2,500.00	$ 35,000.00
Class A Substructure concrete	2460	CY	900.00	$ 2,214,000.00
Class F Deck concrete	2580	FT	804.40	$ 2,075,352.00
Steel Bar	352390	CY	1.20	$ 422,868.00
Steel Bar Epoxy	251200	LB	1.40	$ 351,680.00
Structural Steel	1	CY	7,840,000.00	$ 7,840,000.00
FurnishingSteel Piles	4457330	LB	0.60	$ 2,674,398.00
Driving Steel Piles	52250	CY	26.00	$ 1,358,500.00
Test pile	2	LB	15,750.00	$ 31,500.00
Membrane Water Proofing	4960	FT	80.80	$ 400,768.00
Temporary Earth Retension	5140	CY	18.00	$ 92,520.00
Bridge Rail	2040	LB	93.00	$ 189,720.00
Bridge cost				**$ 18,006,822**
Construction Cost				**$ 39,812,000**
Bridge cost Per SF				**$ 394.80**
Construction Cost per SF				**$ 872.87**
Retaining Wall W103				
Total Length	1299	Ft		
Wall Cost	$ 6,359,000			
Wall Construction Cost	$ 12,574,000			
Wall Cost	$ 4,895.30	Per Ft		
Wall Construction Cost	$ 9,679.75	Per Ft		

Figure P7.9: Unit Cost Comparisons

NOTE: A multiplier of 2.21 was incorporated with the estimated costs to account for minor items, incidentals, contingencies and inflation. This number was based on the Preliminary Design Estimate prepared by the Designer.

RECOMMENDATION

The VE Team recommends the implementation of Alternative P7C. Though Alternative P7A appears to offer greater savings, there are complexities with the design at the north abutment which make this Alternative undesirable. Likewise, the additional potential savings associated with P7B are offset by the inclusion of an additional deck joint and the incorporation of an additional pier. Alternative P7C offers significant cost savings without these drawbacks and thus is the recommended Alternative.

PROPOSAL COMPARISON COST TABLE

The table below summarizes As Given, Alternative Costs and the Cost Difference between As Given and the respective Alternatives.

Item	First Cost		Maintenance & Operation Cost		Cost Difference (+) Savings (-) Add'l Cost
	As Given	VE Alternative	As Designed	VE Proposal	
As Given	$39,812,000				
Alternative P7A		$32,570,000			(+)$7,242,000
Alternative P7B		$36,346,000			(+)$3,466,000
Alternative P7C		$37,230,000			(+)$2,582,000

Accepted: ☐ Needs Further Study: ☐

Rejected: ☐ Needs to be Resolved: ☐

6. 3 DESIGN SUGGESTIONS

DS1 –Wide Area Use of Portable Variable Message Signs (VMS): Provide VMS signing to motorists of construction at all major points for alternate routes south of the construction Area:

- I-91 NB South of I-691
- Route 15 (Wilbur Cross Parkway) South of I-691
- I-91 South of Route 9
- I-91 South of Route 3 – Putnam Bridge

Figure DS1.1: Variable Message Signs

DS2 – Shoulder Widths Provide consistent, uniform shoulder widths along the corridor and avoid the varying widths currently proposed.

The suggestion is to provide 4-Foot Shoulders on the Left Side and Consistent Shoulder Width on the Right Side. Twelve-foot widths are the standard and desirable; however, if constraints preclude a consistent use of standard 12-foot lanes, a smaller, consistent width over a longer stretch is preferable than a zig-in and zig-out effect.

Figure DS2.1: Existing I-91 NB

DS3 – Sound Barrier Reuse: The current design includes an estimated cost for construction of noise barrier walls along Route 5/15 in East Hartford.

The greater part of this cost is associated with reconstruction of portions of noise barrier walls being shifted due to the addition of a lane to this stretch of road. It is the understanding of the VE Team that in these locations, the existing noise barrier walls are intended to be disposed of with new walls installed.

The VE Team suggests that the designer consider options for reusing the existing walls were applicable.

Figure DS3.1:Sound Barrier Reuse

DS4 – Alternative Pier Construction Concepts: Due to the congested nature of the site, placement of the pier elements for the new ramp bridge for Exit 29 traffic is restricted. The As Given Alternative incorporates a straddle-bent to avoid the ramp structure below while the three-span Alternative considered in the Rehabilitation Study Report consisted two straddle bents.

Figure DS4.1:Cantilever Pier I-355 / I-88 Interchange – Downers Grove, IL

In the Chicago area, a similar ramp structure is supported by a cantilever-arm pier which provides some flexibility for the placement of the foundation relative to the point of support for the superstructure. The VE Team offers this as a suggestion to be considered by the Design Team if it will afford a benefit to the project.

It is noted that the example provided supported a single lane ramp and further evaluation would be required to determine if a similar solution would be feasible in this location.

DS5 –Consider Precast Wall Sections for Proposed Cast-In-Place Wall Sections: Evaluate the use of Precast Concrete Retaining Walls as an alternative to Cast-in-Place Concrete Walls when soils and site conditions are advantageous.

The proposed approach for site retaining walls is to utilize a combination of wall types, including Mechanically Stabilized Earth (MSE) walls, as well as, Cast-In-Place (CIP) wall sections. The VE Team suggests that the Design Team consider the use of precast concrete for the portions of the walls planned to be cast-in-place. Benesch has successfully utilized this concept in prior projects. The precast footings were erected on 3-inch thick cast-in-place sub-footing and the 3-inch gap between the bottom of the footing and the sub-footing was filled with high strength flowable grout. Footings were cast in the plant with protruding dowels and walls are cast with grout filled mechanical splicers. Figure DS5.1 on the following page shows the connection utilized for this work

Benesch utilized this concept for our I-196 project for the Michigan Department of Transportation. The erection rate for precast footing segments was 20 precast footing segments per day (12 foot-long segments) and 20 precast stem segments in the same time frame. The system worked flawlessly even though some of the heavier walls have many alignment changes. This innovative system reduced the construction schedule by four months. The project included 6,762 feet long (160,240 square feet) of retaining walls. The wall height varied from 3 feet -2 inches to 26 feet - 0 inches. The bid price for this type was about 15% lower than the cast in place concrete wall.

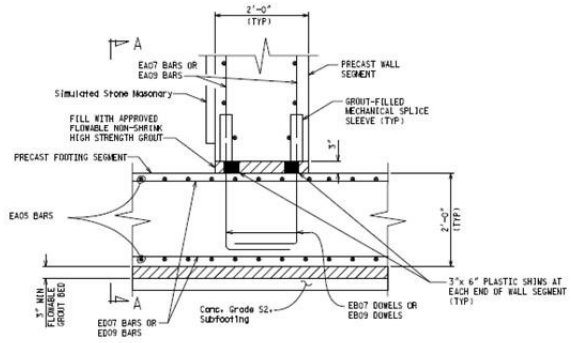


Figure DS5.1: Moment Connection with Mechanical Splicers

Figure DS5.2: Precast Concrete Wingwalls

The advantages of this option over CIP walls are as follows:

- Faster Construction
- Better Control of Quality
- Less inconvenience to the travelling motorists
- Potential Cost Savings

7 CONCLUSION

7.1 CONCLUSION

Alfred Benesch & Company completed a VE Study of State Project No. 63-703 involving the reconfiguration of the I-91 NB Interchange 29 in Hartford.

The goal of this project is to improve operations at this deficient interchange in order to reduce congestion, which occurs on a daily basis, and to, in-turn, improve the safety of the traveling public, which utilizes this facility. The existing interchange includes a ramp, which is under capacity with poor geometry, whose connection to the Charter Oak Bridge produces an unsafe weave condition.

As a part of the planning phase for the bridge, the CTDOT Concepts Unit investigated many options for improving this interchange. Due to the level of effort performed by the Department and the time limitations inherent with a VE Study, the VE Team was not able to identify a uniquely new Alternative for the reconfiguration of the interchange. Despite this fact, the VE Team chose to perform an independent evaluation of the "short-listed" Alternatives considered by the State to either validate the chosen solution or to recommend an alternate option (Proposal P1).

In addition to the evaluation of the overall interchange improvement concepts, the VE Team also looked deeper into specific components of the proposed design to determine if improvements could be achieved. These included an evaluation of the ramp configuration (Proposal P2), the widening limits of I-91 NB (Proposal P3), the widening limits of Route 15 NB (Proposal P4), the cross section of the proposed ramp structure (Proposal P5), the vertical clearances at bridge structures (P6) and the span configuration of the new ramp structure (Proposal P7).

A summary of the proposals is included on the following page.

Summary

In summary, after completing a detailed evaluation of the project, understanding the goals, and identifying the various constraints under which this design was conceived, the VE Team has validated the proposed design concept and several of the specific design components investigated. This validation is indicative of the level of thought invested by the State in the initial study to find the optimal solution to enhancing this important interchange.

Beyond the validated concepts, the VE Team has identified several areas where some improvements (in value and cost savings) may be achieved. These include a consideration of reducing the construction limits along Route 15 and optimizing the cross section and span configuration of the proposed Exit 29 Ramp and associated bridge structure. Several design suggestions were likewise also offered, which may add value to the project.

Disclaimer

The cost differences developed are based on the design information provided to the VE Team and should not be considered absolute cost savings guarantees; but rather indicators of potential value magnitudes requiring further detailed engineering as the project develops.

Proposal Number	Description	As Given	VE Alternative	Cost Difference	Change in Projected Construction Costs	Design Team Determination				
						Accepted	Rejected	Needs Further Study	Needs to be Resolved	Reason
P1	Evaluation of CTDOT Interchange Alternatives	$170,000,000	—	—	$0*					
P2	Maintain the I-91 NB Existing Exit #29 on the Existing Alignment Alternative	$170,000,000	—	—	$0*					
P3	I-91 Capacity Improvements	$36,741,000	—	—	$0*					
P4	Revise Route 15 Eastern Project Limit	$12,812,000	$0	+$12,812,000	+$12,812,000					
P5	New Exit #29 Bridge Typical Section	$38,489,000	$30,918,000	+$7,570,500	+$7,570,500					
P6	Vertical Clearance Issues at I-91 Underpasses	$35,474,000	—	—	$0*					
P7	Optimize Span Configuration	$39,812,000	$37,230,000	+$2,582,000	+$2,582,000					
Total Potential Reduction					**$22,964,500**					

* Validation

Figure 7.1: Proposal Summary

8 PRESENTATION PHASE

8. 1 INTRODUCTION

Prepare to convince decision makers to accept the study results:

HOW DO WE PRESENT OUR RECOMMENDATIONS?
WHAT ARE THE ROAD BLOCKS?

Presentation is client driven:

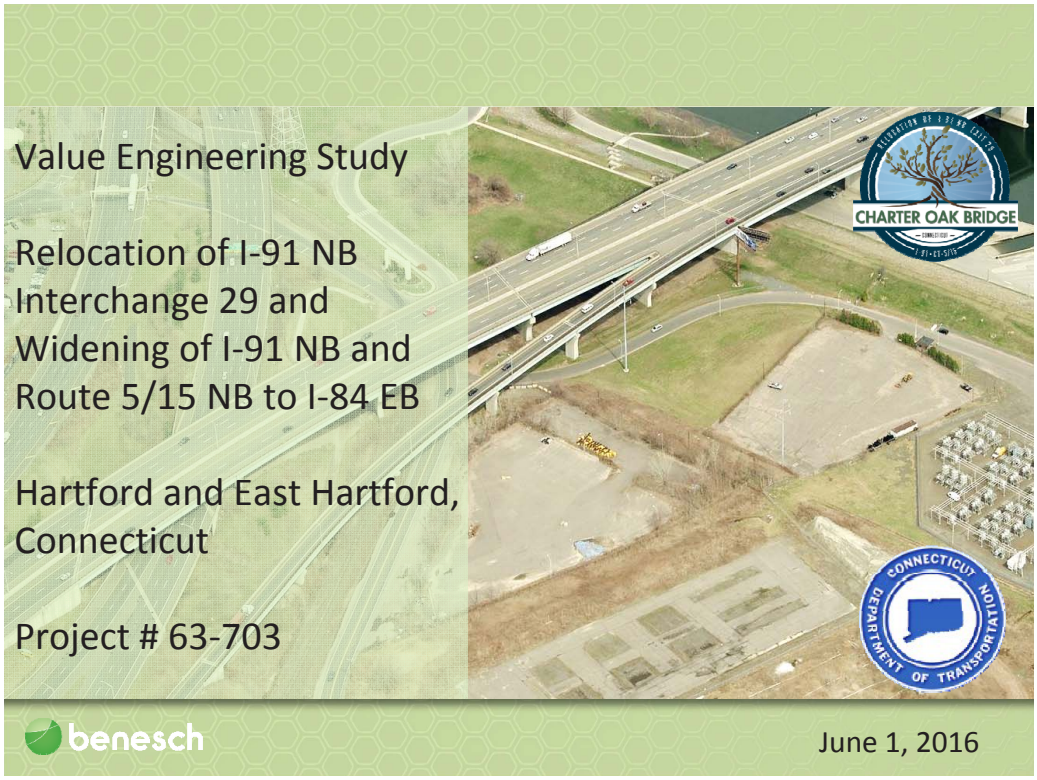
1. Common practice is a informal report on the last day of the workshop
2. A Power Point presentation improves the understanding of the VE Proposals

Among the rules that govern the Presentation Phase are the following:

- Do not assume that ideas are good
- Demonstrate their worth

8. 2 PRESENTATION

The following presentation was made to CTDOT on June 1, 2016.



Value Engineering Study

Relocation of I-91 NB Interchange 29 and Widening of I-91 NB and Route 5/15 NB to I-84 EB

Hartford and East Hartford, Connecticut

Project # 63-703

benesch June 1, 2016

Thanks

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CTDOT – Design
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Thanks

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Benesch VE Approach

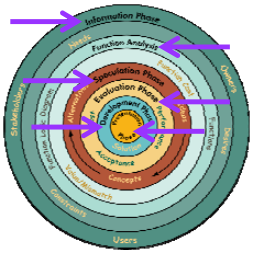
Purpose of Value Engineering is to show Possibilities.

Good features of As Designed are validated → Validation

Opportunities to enhance Value are illustrated → Proposal

Potential improvements are suggested → Design Suggestion

VE Job Plan



Information Phase

- Owners
  Financially res project
- Users
  Actively uses project
- Stakehold
  Affected, concerned, or habits will change due to the project

12 I-91 Traffic
13 Route 15 Traffic
14 Exit 29 Traffic
15 Local Businesses
16 UPS
17 Brainard Airport

Owner
User
Stakeholder

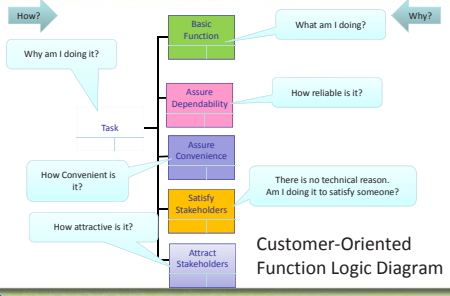
Information Phase

- Constraints
  Legal requirements, standards, site conditions
- Needs
  Expectations that must be fulfilled if constraints are not violated
- Desires
  Expectatic be fulfille not a facto

17 I-91 NB - Provide 12' Lanes C
18 Route 15 - Provide 11' Lanes C
19 Route 15 - Provide 12' Lanes N
20 Exit 29 Ramps - Provide 11' Lanes C
21 Exit 29 Ramps - Provide 12' Lanes N
22 I-91 NB - 10' Right Shoulder C
23 I-91 NB - 12' Right Shoulder N
24 I-91 NB - 6' Left Shoulder C

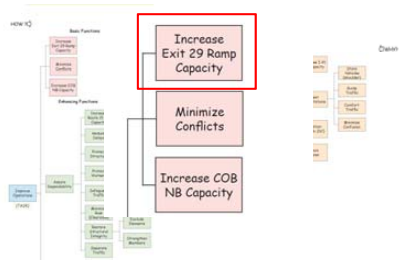
Constraint
Need
Desire

Function Logic Diagram

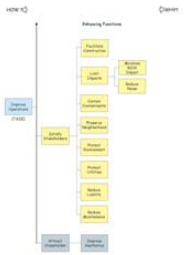


Customer-Oriented Function Logic Diagram

Function Logic Diagram



Function Logic Diagram



Function Analysis

As Given		
Basic Functions:	$71.01M	25.7%
Enhancing Functions		
Assure Dependability	$96.01M	34.8%
Assure Convenience	$35.21M	12.7%
Satisfy Stakeholders	$71.91M	26.0%
Attract Stakeholders	$2.06M	0.8%

Speculation Phase

Idea generation / outside-the-box thinking

13 Exit 29 - Widen Existing Bridge
14 Exit 29 - Replace Existing Bridge and Widen to 2 Lanes
15 Exit 29 - Eliminate
16 Exit 29 - Lengthen Decel and Separate With Median Barrier
17 Exit 29 - Lengthen Decel Lane
18 Exit 29 - No Build Configuration
19 Exit 29 - Left Exit With 1 Lane
20 Exit 29 - 4' Left Shoulder
21 Exit 29 - 11' Lanes
22 Exit 29 - 10' Right Shoulder

160 IDEAS

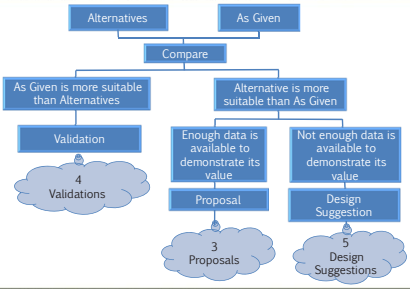
Evaluation Phase

Ideas generated are screened for consideration and grouped into proposals and design suggestions.

13 Exit 29 - Widen Existing Bridge	S
14 Exit 29 - Replace Existing Bridge and Widen to 2 Lanes	S
15 Exit 29 - Eliminate	R4
16 Exit 29 - Lengthen Decel and Separate With Median Barrier	S
17 Exit 29 - Lengthen Decel Lane	S
18 Exit 29 - No Build Configuration	R4
19 Exit 29 - Left Exit With 1 Lane	R5
20 Exit 29 - 4' Left Shoulder	S
21 Exit 29 - 11' Lanes	S
22 Exit 29 - 10' Right Shoulder	S

R4	Low Acceptance
R5	High Cost, Low Benefit
R6	High Risk Solution
R7	Lack of Support Information
R8	No Significant Benefit
R9	Not Applicable

Proposal Development



Proposal P1

Evaluation of CTDOT Interchange Alternatives

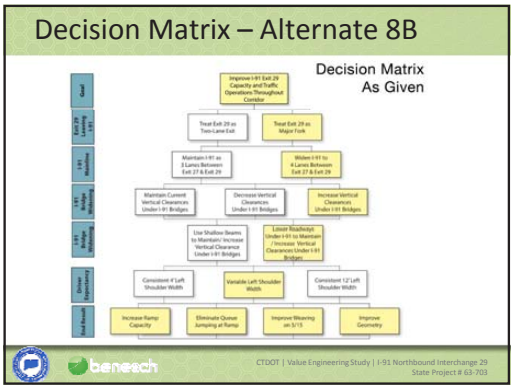
P1 – Evaluate CTDOT Alternatives

The VE Team performed a re-evaluation of the following concepts considered by CTDOT during the planning phase:

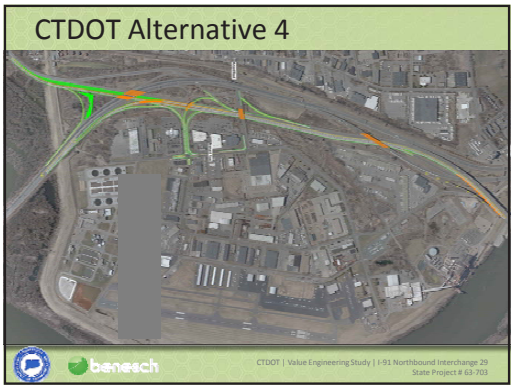
- CTDOT Alternative 8B (As Given)
- CTDOT Alternative 4
- CTDOT Alternative 6C
- CTDOT Alternative 6D

As Given – CTDOT Alternative 8B

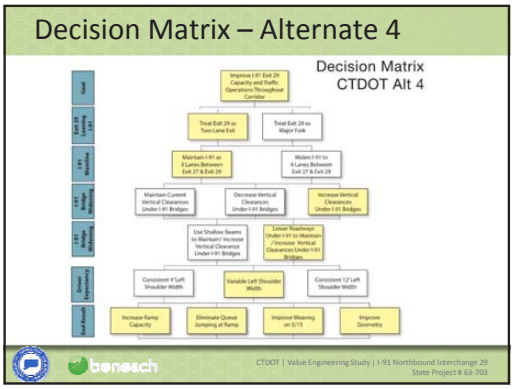
Decision Matrix – Alternate 8B



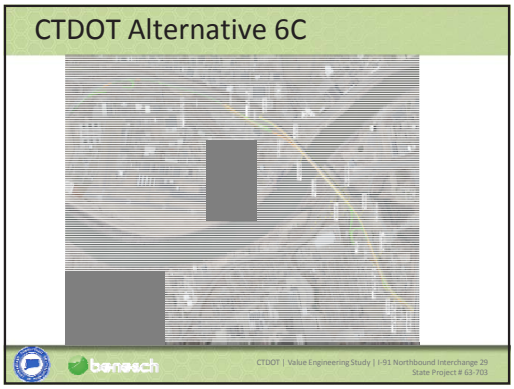
CTDOT Alternative 4



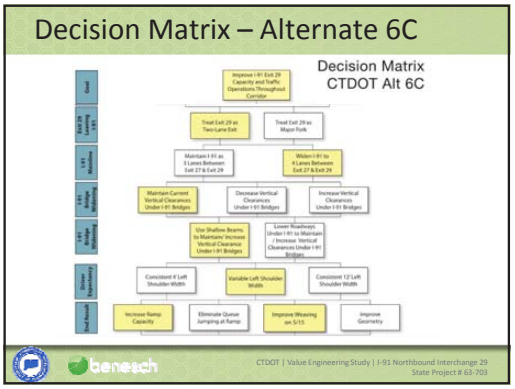
Decision Matrix – Alternate 4



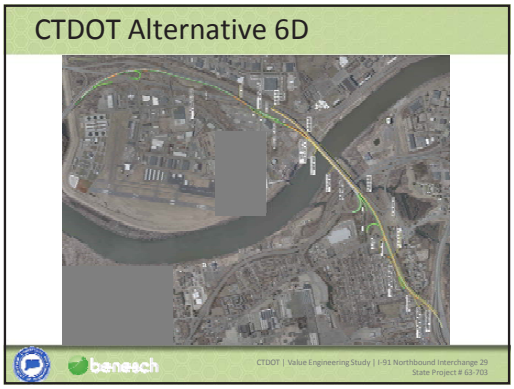
CTDOT Alternative 6C



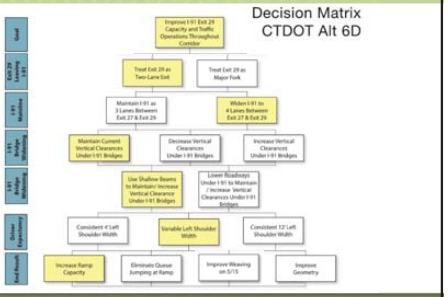
Decision Matrix – Alternate 6C



CTDOT Alternative 6D



Decision Matrix – Alternate 6D



Proposal P1

Performance / Acceptance / Cost Evaluation

Performance Criteria

Criteria Ranking - Performance

	Criteria	Minimize Weaving	Reduce Congestion	Maintain Movements	MPT	Provide Adequate Geometry
1	Minimize Weaving	1	0	0	1	0
2	Reduce Congestion	1	1	1	1	1
3	Maintain Movements	1	0	1	1	0
4	MPT	0	0	0	1	0
5	Provide Adequate Geometry	1	0	1	1	1
	Rank	4	1	3	5	2
	Weight of Importance	7	10	7	5	8

Performance Rating

Performance Rating

Excellent = 5
Very Good = 4
Good = 3
Satisfactory = 2
Poor = 1
Unacceptable = 0

	Criteria	Weight of Importance	As Given Rating	As Given Weighted Rating	Do Nothing Rating	Do Nothing Weighted Rating	Alternate 4 Rating	Alternate 4 Weighted Rating	Alternate 6C Rating	Alternate 6C Weighted Rating	Alternate 6D Rating	Alternate 6D Weighted Rating
		[1-10]										
1	Minimize Weaving	7	3	21	2	14	5	35	2	14	2	14
2	Reduce Congestion	10	4	40	0	0	4	40	3.5	35	3	30
3	Maintain Movements	7	5	35	5	35	5	35	2	14	5	35
4	MPT	5	3.5	17.5	5	25	3	15	3	15	3	15
5	Provide Adequate Geometry	8	4	32	2	16	4	32	3	24	2	16
	Total Weighted Rating	37		145.50		90.00		157.00		102.00		110.00
	Average Weighted Rating			3.93		2.43		4.24		2.76		2.97

Acceptance Criteria

Criteria Ranking Chart - Acceptance

	Criteria	Constructability	Meet Schedule (Design & Construction Duration)	Driver Satisfaction	Accommodate Expansion	Environmental Permitting
1	Constructability	1	0	0	1	0
2	Meet Schedule (Design & Construction Duration)	1	1	0	1	0
3	Driver Satisfaction	1	1	1	1	1
4	Accommodate Expansion	0	0	0	1	0
5	Environmental Permitting	1	1	0	1	1
	Rank	4	3	1	5	2
	Weight of Importance	6	8	10	5	8

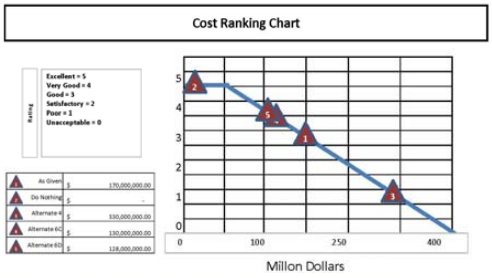
Acceptance Rating

Acceptance Rating

Excellent = 5
Very Good = 4
Good = 3
Satisfactory = 2
Poor = 1
Unacceptable = 0

	Criteria	Weight of Importance	As Given Rating	As Given Weighted Rating	Do Nothing Rating	Do Nothing Weighted Rating	Alternate 4 Rating	Alternate 4 Weighted Rating	Alternate 6C Rating	Alternate 6C Weighted Rating	Alternate 6D Rating	Alternate 6D Weighted Rating
		[1-10]										
1	Constructability	6	3	18	5	30	2	12	4	24	4	24
2	Meet Schedule (Design & Construction Duration)	8	5	40	5	40	2	16	4	32	4	32
3	Driver Satisfaction	10	3	30	1	10	4	40	3	30	3	30
4	Accommodate Expansion	5	3	15	2.5	12.5	3.5	17.5	2	10	2	10
5	Environmental Permitting	8	4	32	5	40	3	24	4	32	4	32
	Total Weighted Rating	37		135.00		132.50		109.50		128.00		128.00
	Average Weighted Rating			3.65		3.58		2.96		3.46		3.46

Cost Criteria



Rating Summary and Sensitivity Analysis

Rating Summary

		As Given	Do Nothing	Alternate 4	Alternate 6C	Alternate 6D
Ratings	Performance - P	3.93	2.43	4.24	2.76	2.97
	Acceptance - A	3.65	3.58	2.96	3.46	3.46
	Cost - C	3.00	5.00	1.50	3.50	3.50
	P	A	C			
Value Indicator	1	1	1	3.53	3.67	2.90	3.24	3.31
	2	1	1	3.63	3.36	3.24	3.12	3.23
	1	2	1	3.56	3.65	2.92	3.29	3.35
	1	1	2	3.40	4.00	2.55	3.30	3.36

Recommendation (Validation)

VE Team validates the As Given design concept (CTDOT Alternative 8B) based on the following reasons:

- Significant Improvement to Traffic Operations
- Reduces Congestion
- Minimizes Weave on Charter Oak Bridge
- Cost Savings over Alternative 4.

Proposal P2

Maintain the I-91 NB Exit 29 Ramp on the Existing Alignment

P2 – Maintain the I-91 NB Exit 29 Ramp on the Existing Alignment

As Given: Two-Lane Left Diverge

VE Alternative P2A: Widen Ramp to Two Lanes on Existing Geometry

VE Alternative P2B: Widen Ramp to Two Lanes on New Vertical Geometry

VE Alternative P2C: Single Lane Ramp / Move Diverge Decision Point South

As Given

As Given: Exit 29 Two-Lane Left Diverge

- Exit 29 Exits I-91 on Left Side
- Two-Lane Ramp
- Exit 29 Enters Route 5/15 on Left Side
- Improves Weave on Charter Oak Bridge

As Given

As Given

Advantages

- Adds a Lane to the Exit 29 Ramp
- Treats Exit 29 as a Major Highway Fork
- Flattens the Vertical Grade
- Improves Weave on Charter Oak Bridge

Limitations

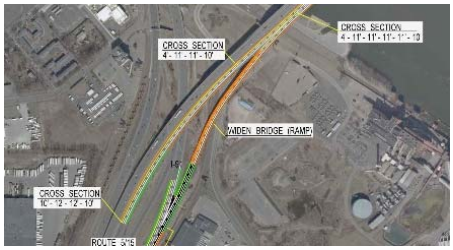
- Most Expensive Option
- Left Exit

VE Alternative P2A

VE Alternative P2A: Widen Ramp to Two Lanes on Existing Geometry

- Maintain Current Ramp Configuration
- Add Lane to Ramp
- Two-Lane Exit from I-91, Two-Lane Entrance to Route 5/15

VE Alternative P2A



VE Alternative P2A

Advantages

- Adds a Lane to the Exit 29 Ramp

Limitations

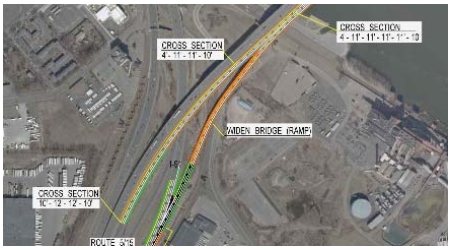
- Does Not Improve Weave on Charter Oak Bridge
- Does Not Eliminate the 5% Grade on the Ramp
- Does Not Lengthen Exit 29 Queue Storage

VE Alternative P2B

VE Alternative P2B: Widen Ramp to Two Lanes on New Vertical Geometry

- New Ramp with Shallower Vertical Grade
- Two-Lane Ramp
- Two-Lane Exit from I-91, Two-Lane Entrance to Route 5/15

VE Alternative P2B



VE Alternative P2B

Advantages

- Adds a Lane to the Exit 29 Ramp
- Flattens the Vertical Grade

Limitations

- Does Not Improve Weave on Charter Oak Bridge
- Does Not Lengthen Exit 29 Queue Storage

VE Alternative P2C

VE Alternative P2C: Single Lane Ramp / Move Diverge Decision Point South

- Maintain Single Lane Ramp
- Move I-91 NB Exit South, Route 5/15 Entrance Ramp North
- Lessen Vertical Grade
- Separate Traffic at 95th Percentile Location

VE Alternative P2C

Advantages

- Lengthens Exit 29 Queue Storage

Limitations

- Does Not Improve Capacity of Ramp.
- Does Not Improve Weave on Charter Oak Bridge

Recommendation (Validation)

VE Team validates that the As Given Alternative (Two-Lane Left Diverge) should be adopted due to the following reasons:

- Adds a Lane to the Exit 29 Ramp
- Flattens the Vertical Grade
- Improves Weave on Charter Oak Bridge

Proposal P3

I-91 Capacity Improvements

P3 – I-91 Capacity Improvements

As Given: Widen I-91 Northbound to Four Lanes

VE Alternative P3A: Minimize I-91 Northbound Widening

As Given

As Given: Widen I-91 Northbound to Four Lanes

- Extend Fourth Lane from Exit 27 Through Exit 29
- Widen Structures for Fourth Lane

As Given

Advantages

- Improves Traffic Operations
- Meets Capacity Needs for the Anticipated 2039 Traffic Volumes

Limitations

- Widening of Three of the I-91 Bridges
- Construction of Retaining Walls to Avoid Environmental and ROW impacts

VE Alternative P3A

VE Alternative P3A: Minimize I-91 Northbound Widening

- Limit Widening to Lane Addition Length Needed for Two-Lane Diverge
- Widen Bridges as Needed

VE Alternative P3A

Advantages

- Eliminates Need to Widen Two of the I-91 Bridges
- Eliminates a Retaining Wall (Wall 101)

Limitations

- Short 3-Lane Segment Between Two 4-Lane Segments
- Does Not Provide Capacity to Accommodate Anticipated 2039 Traffic Volumes

Costs

Alternative	Construction Cost
As Given	$36,741,000
Alternative P3A	$ 7,068,000

Recommendation (Validation)

VE Team validates the As Given design (Widen I-91 Northbound to Four Lanes) should be adopted due to the following reasons:

- Improves Traffic Operations
- Meets Capacity Needs for the Anticipated 2039 Traffic Volumes

Proposal P4

Revise Route 15 Eastern Project Limit

P4 – Revise Route 15 Eastern Project Limit

As Given: Widen to East of Silver Lane

VE Alternative P4A: Widen to West of Silver Lane

As Given

As Given: Widen to East of Silver Lane

- Widen to Accommodate Three Lanes
- Match Existing Two Lanes 300' East of Bridge No. 05796
- Noise Barrier Reconstruction

As Given

Advantages

- Extends 3 Lane Section as Long as Possible
- Lane Drop Further from Exit 91

Limitations

- Requires Widening of Bridge No. 05976
- Relocate / Replace Recently Constructed Noise Barrier

VE Alternative P4A

VE Alternative P4A: Widen to West of Silver Lane

- Match Existing Two Lanes on Route 15 West of Silver Lane
- Avoid Widening of Bridge 05796
- Avoid Sound Barrier Reconstruction East of Silver Lane

VE Alternative P4A

Advantages
- Eliminates Widening Bridge 05796
- Eliminates Relocating Noise Barrier over Silver Lane

Limitations
- Lane Drop Closer to Exit 91

Costs

Alternative	Construction Cost
As Given	$12,812,000
Alternative P4A	$0

Recommendation

VE Team recommends that VE Alternative P4A (Widen to West of Silver Lane) should be adopted due to the following reasons:

- Eliminates Widening Bridge 05796
- Eliminates Relocating / Reconstructing Noise Barrier over Silver Lane

Proposal P5

New Exit 29 Bridge
Typical Section

P5 – New Exit 29 Bridge Typical Section

As Given:
12' Left Shoulder, 12' Lanes, 12' Right Shoulder

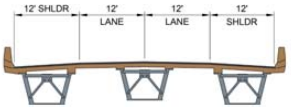
VE Alternative P5A:
4' Left Shoulder, 12' Lanes, 10' Right Shoulder

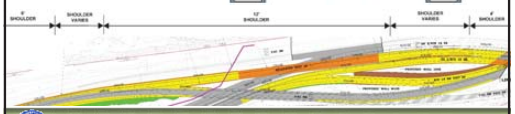
VE Alternative P5B:
4' Left Shoulder, 11' Lanes, 10' Right Shoulder

As Given

As Given:
12' Left Shoulder, 12' Lanes, 12' Right Shoulder

- 12’ Left Shoulder
- Two 12’ Lanes
- 12’ Right Shoulder





As Given

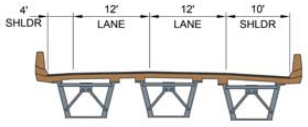
Advantages
- Provides Maximum Shoulder Widths
- Exceeds Design Criteria

Limitations
- Inconsistent shoulder widths compared to downstream and upstream roadways
- Forces Shifting of Route 5/15 Mainline and Exit 89

VE Alternative P5A

VE Alternative P5A:
4' Left Shoulder, 12' Lanes, 10' Right Shoulder

- 4’ Left Shoulder
- Two 12’ Lanes
- 10’ Right Shoulder



VE Alternative P5A

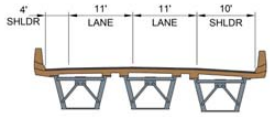
Advantages
- Consistent Shoulder Widths with Upstream Roadway
- Meets Design Criteria
- Potential to Improve Geometry along Route 5/15

Limitations
- Narrower Shoulder Could Affect Traffic Flows due to High Truck Volumes

VE Alternative P5B

VE Alternative P5B:
4' Left Shoulder, 11' Lanes, 10' Right Shoulder

- 4’ Left Shoulder
- Two 11’ Lanes
- 10’ Right Shoulder



VE Alternative P5B

Advantages
- Consistent Shoulder and Lane Widths with Upstream Roadway
- Potential to Improve Geometry along Route 5/15

Limitations
- Narrower Shoulders Could Affect Traffic Flows due to High Truck Volumes
- Narrower Lanes Could Affect Traffic Flows due to High Truck Volumes
- Does not Meet Design Criteria – Design Exception Required

Costs

Alternative	Construction Cost
As Given	$38,489,400
Alternative P5A	$30,918,900
Alternative P5B	$29,431,000

Recommendation

VE Team recommends that VE Alternative P5A (4' Left Shoulder, 12' Lanes, 10' Right Shoulder) should be adopted due to the following reasons:

- Consistent Shoulder Widths with Upstream Roadway
- Meets Design Criteria
- Potential to Improve Geometry along Route 5/15

Proposal P6

Vertical Clearance Alternates at I-91 Underpasses

Existing Conditions

Existing Under-Clearances

Bridge No.	Description	Existing Clearance
00813	I-91 over Route 5/15	13'-10"
01466	I-91 over I-91 TR827	14'-0"
00480	I-91 over Airport Road	13'-11"

P6 – Vertical Clearance Alternates at I-91 Underpasses

As Given:
Increase Under-clearance at Bridges to 14'-6"

VE Alternative P6A:
Maintain Minimum Under-clearances by using Shallower Beams

VE Alternative P6B:
Replace Superstructures to Meet 14'-6" Clearance

As Given

As Given:
Increase Under-clearance at Bridges to 14'-6"

- Lower Roadway Profile Below Bridge Structures
- Minimize Beam Depths for Widening
- Meet 14'-6" Minimum Vertical Clearance

As Given

Advantages

- Meets the 14'-6" Under-clearance
- Limits Superstructure Costs

Limitations

- Potential Utility and Drainage Impacts
- Greater Traffic Impact on Roadways Below

VE Alternative P6A

VE Alternative P6A:

Maintain Minimum Under-Clearances by Using Shallower Beams for Widening

- No Roadway Reconstruction Under Bridges
- Use Shallower Beams than Existing for Widening
- Match Existing Minimum Vertical Clearance

VE Alternative P6A

Bridge No.	Loss of Clearance (Cross Slope and Profile Below)	Potential Reduction in Beam Depth	Potential Solution?
00813	8.19"	4.52"	No
01466	4.44"	10.39"	Yes
00480	13.28"	Minimal	No

VE Alternative P6A

Advantages

- No roadway construction under bridge
- Less impact to traffic below bridge
- No impact to utilities below bridge
- Cost Savings

Limitations

- Does not improve existing clearance issues
- Only applicable to Bridge No. 01466

VE Alternative P6B

VE Alternative P6B:

Replace Superstructures to Meet 14'-6" Clearance

- Replace Superstructures to Meet 14'-6" Vertical Minimum Clearance
- Minimize Beam Depth – Consider Continuous Beams Where Applicable
- No Roadway Reconstruction Under Bridges
- If needed, raise beams to meet required clearance.

VE Alternative P6B

Advantages

- Meets the 14'-6" Under-clearance
- New Bridge Structures (Current Structures Built in 1961)

Limitations

- Highest Cost Alternate
- Significant Construction Impacts to I-91

Costs

Alternative	Construction Cost
As Given	$35,474,000
Alternative P6A	$34,860,000
Alternative P6B	$58,400,000

Recommendation (Validation)

VE Team recommends that the As-Given Alternate should be adopted due to the following reasons:

- Improves Bridge Underclearances to 14’-6”
- Limited Impact to I-91 Traffic
- Reduced Cost as Compared to Superstructure Replacement Alternate (P6B)

Proposal P7

Optimize Span Configuration

P7 – Optimize Span Configuration

As Given:
Five Span Continuous Trapezoidal Box Girder

VE Alternative P7A:
Three Span Continuous Plate Girder

VE Alternative P7B:
Four Span Continuous Plate Girder with an Approach Span

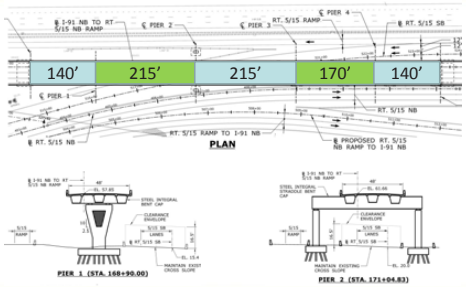
VE Alternative P7C:
Four Span Continuous Plate Girder

As Given

As Given: Five Span Continuous Trapezoidal Box Girder

- Spans – 140’, 215’, 215’, 170’ and 140’
- Bridge Length – 880’
- Piers #1, #3 and #4 – Concrete Wall Piers with Steel Integral Bent Caps
- Pier #2 – Straddle Pier

As Given



As Given

Advantages

- Higher Vertical Clearance
- Minimum Expansion Joints

Limitations

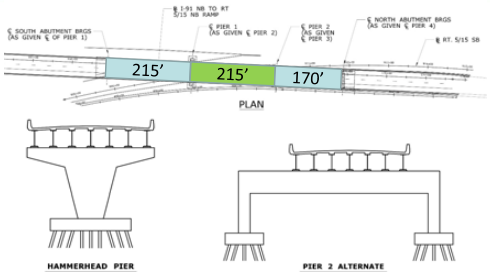
- Integral Caps Require More Complicated Erection
- Longer Construction Time

VE Alternative P7A

VE Alternative P7A: Three Span Continuous Plate Girder

- Spans – 215', 215' and 170'
- Bridge Length – 600'
- Pier #1 – Straddle Pier
- Pier #2 – Hammerhead Pier

VE Alternative P7A



VE Alternative P7A

Advantages
- Shorter Bridge Length
- Simplifies Construction of the Bridge
- Satisfies Minimum Vertical Clearance Requirement

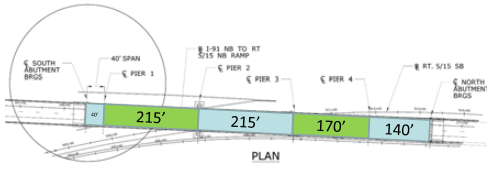
Limitations
- Unconventional Abutment and Approach Slab
- Longer Retaining Walls

VE Alternative P7B

VE Alternative P7B: Four Span Continuous Plate Girder with an Approach Span

- Spans – 215', 215', 170' and 140' + 40' Approach Span
- Bridge Length – 740' and single 40'
- Pier #1, #3 and #4 – Hammerhead Pier
- Pier #2 – Straddle Pier

VE Alternative P7B



VE Alternative P7B

Advantages
- Shorter Bridge Length
- Simplifies Construction of the Bridge
- Satisfies Minimum Vertical Clearance Requirement

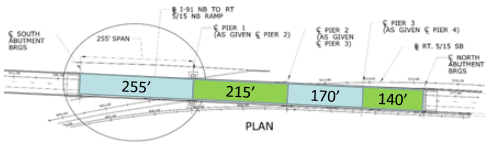
Limitations
- One More Joint than As-Given
- Requires Longer Retaining Walls

VE Alternative P7C

VE Alternative P6C: Four Span Continuous Plate Girder

- Spans – 255', 215', 170' and 140'
- Bridge Length – 780'
- Pier #1 – Straddle Pier
- Piers #2, #3 and #4 – Hammerhead Pier

VE Alternative P7C



VE Alternative P7C

Advantages
- Shorter Bridge Length
- Simplifies Construction of the Bridge
- Satisfies Minimum Vertical Clearance Requirement
- One Less Pier

Limitations
- Requires Longer Retaining Walls

Costs

Alternative	Construction Cost
As Given	$39,812,000
Alternative P7A	$32,570,000
Alternative P7B	$36,346,000
Alternative P7C	$37,230,000

Recommendation

VE Team recommends that VE Alternative P7C (Four Span Continuous Plate Girder) should be adopted due to the following reasons:

- Shorter Bridge Length
- Simplified Construction
- Satisfies Minimum Vertical Clearance Requirement
- One Less Pier

Design Suggestions

- DS1: Extensive use of Portable Variable Message Signs
- DS2: Shoulder Widths
- DS3: Sound Barrier Reuse
- DS4: Alternative Pier Construction Concepts
- DS5: Precast Concrete Wingwalls

DS1 – Extensive Use of Portable Variable Message Signs

- Provide VMS signing to Motorists of construction at key interchanges south of the construction area:
  I-691 / Route 9 / Route 3 (Putnam Bridge)

DS2 – Shoulder Widths

- Investigate Providing Consistent Shoulder Widths Between Connected Roadways,

  Example: I-91NB to Exit 29 to Route 15(Charter Oak Bridge

DS2 – Shoulder Widths

I-91 Shoulders
- Right Shoulder Width varies 10’ to 12’
- Left Shoulder width varies 6’ to 12’

Route 5/15 Shoulders
- Right Shoulder Width varies 10’ to 12’
- Left Shoulder Width varies 4’ to 12’

Exit 29 Shoulders
- Right Shoulder Width 12’
- Left Shoulder Width Varies 4’ to 12’

DS2 – Shoulder Widths

- I-91 Shoulder Widths

Station	Station	Length (ft)	Shoulder Width Left	Shoulder Width Right
Match Existing			8' +/-	10' +/-
102+00	106+50	450	varies	10' to 12'
106+50	107+28	78	varies	10'
107+28	113+17	589	varies	10' to 12'
115+14	118+50	336	varies	12'
118+50	128+27	977	varies	10'to 12'
130+39	140+00	961	varies	12'
140+00	144+00	400	varies	10' to 12'
144+00	154+00	1000	varies	10' to 12'
154+00	159+07	507	6' to 12'	10'

- Route 5/15

Station	Station	Length (ft)	Shoulder Width Left	Shoulder Width Right
East End of Charter Oak Bridge			4'	Ramp
218+12	221+67	355	varies	varies
221+67	231+17	950	varies	12'
231+17	233+19	202	varies	Exit 91
233+19	235+76	257	4'	12'
236+76	240+90	414	4'	12'
246+09	250+09	400	4'	Exit 91
250+09	255+50	541	4'	12'
255+50	257+47	197	4'	varies
260+56	264+50	394	4'	varies
Match Existing			4'	10'+/-

- Route 5/15 Shoulder Widths

Station	Station	Length (ft)	Shoulder Width Left	Shoulder Width Right
391+81	400+00	819	4'	12'
400+00	403+11	311	4'	12'
403+11	408+69	558	4'	Exit 89
408+69	413+60	491	4'	12'
413+60	417+91	431	4'	12'
West End of Charter Oak Bridge			4'	12'

- Exit 29 Shoulder Widths

Station	Station	Length (ft)	Shoulder Width Left	Shoulder Width Right
159+07	160+75	168	12'	I-91 NB
160+75	164+03	328	12'	I-91 NB
164+03	167+21	318	12'	12'
New Exit 29 Bridge		938	12'	12'
176+59	176+70	11	12'	12'
176+70	182+16	546	varies	12'
182+19	184+33	214	4'	Route 15
West End of Charter Oak Bridge			4'	

DS3 – Sound Barrier Reuse

- Consider Reuse of Materials from the Newer Noise Barrier Wall Installations

DS4 – Alternative Pier Construction Types

Alternate Pier Concept:

I-355 / I-88 Interchange – Downers Grove, IL

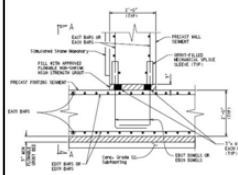
DS5 – Precast Concrete Retaining Walls

Precast Concrete Cantilever Walls

- Precast Stem and Footing with Grout Sleeve Connection
- Up To 26' Height
- Consider for use in lieu of cast-in-place concrete wall sections.
- 15% Cost Savings over cast-in-place walls based on past experience

DS5 – Precast Concrete Retaining Walls

- Benesch Project – I-196 / Baldwin Interchange – Grand Rapids, MI
- 6,762 LF of Wall (160,240 SF)
- Approx. 250 LF of walls erected in two days



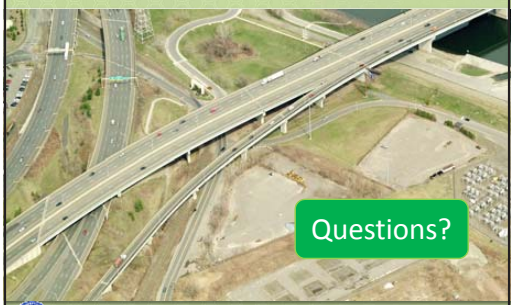
Summary

VE Study Savings

Proposal Number	Description	As Given	VE Alternative	Cost Difference	Cost Difference (+) Savings Add'l Const.
P1	Evaluation of CTDOT Interchange Alternatives	$170,000,000	Validation	$0	$0
P2	Maintain the I-91 NB Existing Exit #29 on the Existing Alignment Alternative	$170,000,000	Validation	$0	$0
P3	I-91 Capacity Improvements	$28,581,000	Validation	$0	$0
P4	Revise Route 15 Eastern Project Limit	$12,812,000	$0	+$12,812,000	+$12,812,000
P5	New Exit #29 Bridge Typical Section	$38,489,000	$30,918,000	+$7,570,500	+$7,570,500
P6	Vertical Clearance Issues at I-91 Underpasses	$35,474,000	Validation	$0	$0
P7	Optimize Span Configuration	$39,812,000	$37,230,000	+$2,582,000	+$2,582,000
Total Potential Reduction					$22,964,500

Action Plan

- Proposals are subject to one of the following when the report is submitted:
  - Accepted
  - Rejected
  - Accepted for further Technical Feasibility
  - Accepted for further Resolution
  - Accepted for future Project Considerations



APPENDIX A

AGENDA

Value Engineering Study
#63-703 - I-91 (NB)-Interchange #29, Hartford and East Hartford
Benesch Project # 70325.04 – Task Assignment # 4

Project Manager:	Jim Fuda, PE
Facilitator:	Al Tomaselli, PE, PTOE, AVS
VE Team:	Muthiah Kasi, PE, CVS (Life)
	Steve Drechsler, PE
	Steve Ulman, PE
	Jeff Koerner, PE
	Jim Fuda, PE

MONDAY – May 23, 2016

Information Phase

08:00	Benesch Team convenes at Glastonbury office	
09:00	Meeting at CTDOT (Newington)	CTDOT, Designers, VE Team
	Introductions: Intro of VE Team	M Baier/CTDOT J Fuda/ Benesch
09:15	Project Description / Presentation	Designers
10:15	Questions of VE Team	VE Team
11:00	End of Designers Presentation, Site visit	VE Team
13:00	Return to Benesch office for working lunch. Review Cost Estimate, Traffic and other Design Data	VE Team
14:00	List Owners, Users, and Stakeholders	VE Team
14:30	Design Team review existing data at Benesch offices	VE Team and Designer
15:30	Break – 15 minutes	
15:45	Complete and wrap up Owners, Users, and Stakeholders	VE Team
16:00	List Constraints, Needs, and Desires	VE Team
17:30	Begin Function Analysis Define and Finalize Project Functions	VE Team
17:55	Wrap up and Next Steps	Facilitator
18:00	Adjourn	

Note: VE Team to e-mail CTDOT questions for the Designer (if any)

Value Engineering Study
#63-703 - I-91 (NB)-Interchange #29, Hartford and East Hartford
Benesch Project # 70325.04 – Task Assignment # 4

TUESDAY – May 24, 2016		**VE Team**
Information Phase (cont'd)		
07:15	Team arrives at Benesch Glastonbury Office	VE Team
07:30	Complete Function Analysis	VE Team
09:00	Develop Function-Logic Diagram	VE Team
10:15	Break – 15 minutes	
10:30	Function Cost Evaluation	VE Team
12:00	Lunch (working)/continue Function Cost Evaluation	VE Team
Speculation Phase		
13:00	Complete Function Cost Evaluation	VE Team
14:00	Speculation The VE Team will have a creative session for the purpose of generating as many ideas as possible for alternative ways to perform the functions defined during the Information Phase.	VE Team
15:15	Initial Screening The VE Team will review all ideas generated and Eliminate those that violate stakeholder or project Constraints.	VE Team
17:55	Wrap up and Next Steps	Facilitator
18:00	Adjourn	

Value Engineering Study
#63-703 - I-91 (NB)-Interchange #29, Hartford and East Hartford
Benesch Project # 70325.04 – Task Assignment # 4

WEDNESDAY – May 25, 2016		**VE Team**
Evaluation Phase		
07:15	Team arrives at Benesch Glastonbury Office	VE Team
07:30	Grouping of Ideas/Identification of Proposals The VE Team will group the ideas remaining from the Initial Screening into proposals for development and evaluation and assign proposals to individuals and begin proposal evaluation.	VE Team
09:00	Proposal Development Upon completion of the Grouping of Proposals, the VE Team will identify specific Value Engineering Proposals and Design Suggestions. Concurrent with the development of specific Value Engineering Proposals, the Draft Value Engineering Report will be worked on.	VE Team
11:00	Proposal Evaluation Each individual or VE Team will begin evaluating individual proposal with preparation of rough sketches, estimates, pros and cons, and develop preliminary Performance Acceptance and Cost Criteria. *Templates to be provided*.	VE Team
11:45	CTDOT will be briefed on the status of the findings of the VE Study and offer preliminary comments. VE Team will continue with proposal development.	Facilitator/PM
12:00	Lunch	
13:00	Continue work on Proposals and Design Suggestions	VE Team
18:00	Adjourn	

Value Engineering Study
#63-703 - I-91 (NB)-Interchange #29, Hartford and East Hartford
Benesch Project # 70325.04 – Task Assignment # 4

THURSDAY- May 26, 2016		**VE Team**
Development Phase		
07:15	Team arrives at Benesch Glastonbury Office	VE Team
07:30	Prepare Proposals and Design Sections (cont'd) Concurrent with development of specific VE Proposals, Design Suggestions and continuation of the preparation of the Value Engineering Report.	VE Team
	Preparation of draft Presentation PowerPoint concurrent with VE Team developing VE Proposals and Design Suggestions.	Facilitator
12:00	Lunch	
13:00	Continue work on Proposals and Design Suggestions	VE Team
15:00	Complete Proposals and Design Suggestions Proposals and Design Suggestions in Final Draft form	VE Team
16:00	Break	All
16:45	Dry Run of Presentation, set speaker timing	VE Team
18:00	Adjourn – study and presentation completed	VE Team

~~19:00 Team Dinner~~

Note: due to the Memorial Day holiday weekend the presentation will be done on Wednesday, June 1st

Wednesday – June 1, 2016		**VE Team (CT)**
Presentation Phase		
08:15	Leave Glastonbury Office for CTDOT (Newington)	VE TEAM (CT)
09:00	Presentation at CTDOT (Newington)	VE TEAM (CT)
12:00	Adjourn	

APPENDIX B

ATTENDANCE LIST

The following is list of personnel who attended the CTDOT/Designer presentation to the VE Team on May 23, 2016.

STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION

Date: 23-May-16
Location: DOT - Newington Conf Rm G328 - 9am to 12pm
Project No: 63-703 Hartford - I-91 NB interchange 29
Meeting Description: Design Team presentation to VE team
Day 1

Name	Organization	Phone No.	E-Mail Address
Mary Baier	DOT - OOC- Quality Assurance	(860) 594-3256	mary.baier@ct.gov
Jerry Graci	DOT - OOC- Quality Assurance	(860) 594-3257	gerard.graci@ct.gov
Eric Tallarita	DOT - OOC- Quality Assurance	(860) 594-3545	eric.tallarita@ct.gov
Jan Mazeau	DOT - OOC- Quality Assurance	(860) 594-2674	janet.mazeau@ct.gov
Nick Ozkan	DOT - OOC- Quality Assurance	(860) 594-3222	nick.ozkan@ct.gov
ALFRED TORASELLI	BENESCH		ATORASELLI@BENESCH.COM
~~ALFRED~~ MUTHIAH KAS	BENESCH		mkasi@benesch.com
Jeff Koerner	Benesch	860 633-8371	jkoerner@benesch.com
STEVE UMAN	BENESCH	860-633-8341	SUMAN@BENESCH.com
Jim FUDA	BENESCH	860-633-8341	jfuda@benesch.com
Rick Camelan	CME	4602804100	rvc@cmea.co
Meredith Andrews	DOT Highways	860-594-3824	meredith.andrews@ct.gov
STEVE DRECHSLER	BENESCH	860-633-8341	SDRECHSLER@BENESCH.com
SEBASTIAN CANNAMELA	DOT HIGHWAY DESIGN	860-594-2693	SEBASTIAN.CANNAMELA@CT.gov
SUSAN M LIBATIQUE	DOT Highways	860-594-3179	SUSAN.LIBATIQUE@CT.GOV
RYAN ALLARD	HWL	860-995-1054	RALLARD@HWLOCHNER.COM
Steve Wexell	HWL	860-760-5871	swexell@hwlochner.com
MARK ROLFE	CTDOT	860-594-2670	mark.rolfe@ct.gov
Nathan Whetten	Freeman Cos	860-462-6073	nwhetten@freemancos.com

ATTENDANCE LIST

The following continues the list of personnel who attended the CTDOT/Designer presentation to the VE Team on May 23, 2016.

STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION

Date: 23-May-16
Location: DOT - Newington Conf Rm G328 - 9am to 12pm
Project No: 63-703 Hartford - I-91 NB interchange 29
Meeting Description: Design Team presentation to VE team
Day 1

Name	Organization	Phone No.	E-Mail Address
CHUCK EATON	CME	8602904100	CEATON@CMEENGINEERING.COM
BRYAN BUSCH	CME	8602904100	bb@cmea.co
Donald Newell	DOT Dist 1 Maint. Planning	860-258-4520	dnewell@ct.gov
C SCOTT SPEAR	DOT OEP	860-594-2918	CHARLES.SPEAR@CT.GOV * PLEASE INVITE ME TO FINAL VE RESULTS PRESENTATION
Juan Ruiz	DOT construction	860-258-4629	Juan.Ruiz@CT.GOV

ATTENDANCE LIST

The following is list of personnel who attended the presentation of the study by the Benesch VE Team on June 1, 2016.

STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION

Date: 1-Jun-16
Location: DOT - Newington Conf Rm G328 - 9am to 12pm
Project No: 63-703 Hartford - I-91 NB interchange 29
Meeting Description: VE team reveal
Day 5

Name	Organization	Phone No.	E-Mail Address
Mary Baier	DOT - OOC- Quality Assurance	(860) 594-3256	mary.baier@ct.gov
Jerry Graci	DOT - OOC- Quality Assurance	(860) 594-3257	gerard.graci@ct.gov
Eric Tallarita	DOT - OOC- Quality Assurance	(860) 594-3545	eric.tallarita@ct.gov
Jan Mazeau	DOT - OOC- Quality Assurance	(860) 594-2674	janet.mazeau@ct.gov
Nick Ozkan	DOT - OOC- Quality Assurance	(860) 594-3222	nick.ozkan@ct.gov
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Jeff Koerner	BENESCH	860-633-8341	jKoerner@benesch.com
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Dale Spencer	CME	860 290 4100	dspencer@cmeengineering.com
TIM WILSON	DOT	860-594-3189	timothy.william@ct.gov ✓
BRYAN BUSCH	CME	860 290 4100	bb@cmea.co
George Jacobs	CME	" " "	gjacobs@cmeengineering.com
Jay Koolis	CME	" " "	jkoolis@cmeengineering.com
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TED ALDIERI	FHWA	860 594-7882	ted.aldieri@dot.gov
Juan Ruiz	DOT Distr. I Construction	860-258-4629	Juan.Ruiz@ct.gov.
DONALD WARD	CTDOT	860 594-2670	
Charles Harlow	CT DOT- Traffic Engr	860 594-2788	Charles.Harlow@ct.gov

Value Engineering Recommendation Approval Form

Project: #63-703 Relocation of I-91 NB Interchange 29 & Widening of I-91 NB & State Route 5/15 NB Towards I-84 EB – Hartford & East Hartford, CT

VE Study Date: May 23, 2016 to May 27, 2016

	VE Proposal	Recommendation	Approved, rejected or Accepted for further review	Reason for acceptance or rejection (Or use the pages at the end of this memo)	Safety	Operations	Environment	Construction	Other	VE Team Estimated Savings or Cost Avoidance (-) or Cost Added (+)	Actual Estimated Savings or Cost Avoidance (-) or added cost (+)
P1	Evaluation of CTDOT Interchange Alternatives	Adopt As Given		Validation	✓	✓	✓	✓		$0	$
P2	Maintain the I-91 NB Existing Exit #29 on the Existing Alignment Alternative	Adopt As Given		Validation	✓	✓	✓	✓		$0	$
P3	I-91 Capacity Improvements	Adopt As Given		Validation	✓	✓	✓	✓		$0	$
P4	Revise Route 15 Eastern Project Limit	Adopt Alternative P4A				✓		✓		(-)$12,812,000	$
P5	Consider Alternative Median Barrier Construction Methods on Bridges New Exit #29 Bridge Typical Section	Adopt Alternative P5A				✓		✓	✓	(-)$7,570,500	$
P6	Vertical Clearance Issues at I-91 Underpasses	Adopt As Given		Validation	✓	✓	✓	✓		$0	$
P7	Optimize Span Configuration	Adopt Alternative P7C			✓			✓	✓	(-)$2,582,000	$

Please provide justification if the value engineering study recommendations are **not** approved or are implemented in a modified form.

Value Engineering Recommendation Approval Form

Project: #63-703 Relocation of I-91 NB Interchange 29 & Widening of I-91 NB & State Route 5/15 NB Towards I-84 EB – Hartford & East Hartford, CT

VE Study Date: May 23, 2016 to May 26, 2016

CTDOT is required to report Value Engineering results annually to FHWA. To facilitate this reporting requirement, a Value Engineering Recommendation Approval Form is included in the Appendix of this report. If the region elects to reject or modify a recommendation, please include a brief explanation of why. Please complete the form and return it to Mary K. Baier P.E., CTDOT State Value Engineer.

James L. Fuda

Signature Project Manager

6/8/2016

Date

James L. Fuda, P.E.

Name (please print)

FHWA Functional Benefit Criteria

Each year, State DOT's are required to report on VE recommendations to FHWA. In addition to cost implications, FHWA requires the DOT's to evaluate each approved recommendation in terms of the project feature or features that recommendation benefits. If a specific recommendation can be shown to provide benefit to more than one feature described below, count the recommendation in **each category that is applicable**.

Safety: Recommendations that mitigate or reduce hazards on the facility
Operations: Recommendations that improve real-time service and/or local, corridor, or regional levels of service of the facility.
Environment: Recommendations that successfully avoid or mitigate impacts to natural and or cultural resources.
Construction: Recommendations that improve work zone conditions, or expedite the project delivery.
Other: Recommendations not readily categorized by the above performance indicators.

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