1 Executive Summary

The Secretary of the Massachusetts Department of Transportation (MassDOT) charged the Independent Review Team (IRT) for the Allston I-90 Intermodal Project with evaluating the three design alternatives presented in the Draft Environmental Impact Report (DEIR) for the Throat portion of the project. The IRT was tasked with attempting to optimize each DEIR Alternative in order to address flaws that could impact the ultimate viability of each. The team was narrowly focused only on design issues related to the Throat. The IRT is reporting directly to the Secretary of Transportation, not to the design team that developed the DEIR. In this report, the use of "MassDOT" is meant to indicate this reporting relationship A list of acronyms used throughout this document can be found in **Appendix A.**

1.1 IRT Scope

Given only 90 days, the IRT was instructed to meet with stakeholders to determine project priorities and hear different viewpoints; examine pertinent design criteria and constraints, including environmental regulations; and to synthesize the stakeholder viewpoints with regulatory necessities to create an evaluation matrix (see **Tables 1.1** through **1.9**) for MassDOT. Several key themes were revealed through the stakeholder outreach, including: north-south connectivity; future flexibility; maintaining service throughout construction; environmental impacts, benefits and quality; Paul Dudley White Path improvements; environmental permitting; resiliency; the Little Grand Junction Bridge; and highway safety.

The IRT's review was also informed by the Massachusetts Environmental Policy Act (MEPA) Certificate issued by the Secretary of Energy and Environmental Affairs (EEA) on the DEIR, dated February 16, 2018. The DEIR Certificate took note of the many comments received:

> "Three significant themes are identified: importance of transportation access and choices; need for and the opportunity to restore and expand parkland; and the opportunity to connect neighborhoods, businesses and institutions through transportation and development…While acknowledging the necessity and potential benefits of the project, residents continue to express concerns with the significant construction period impacts and advocate for construction, design and operational measures to avoid and minimize impacts."[1]

[1] Certificate of the Secretary of Energy and Environmental Affairs on the Draft Environmental Impact Report, EEA Number 15278, dated February 16, 2018. p. 2

The DEIR Certificate found that the DEIR adequately and properly complied with MEPA and its implementing regulations, and that MassDOT could prepare and submit for review a Final Environmental Impact Report (FEIR).[2] The DEIR Certificate provided detailed guidance on issues to be addressed in the FEIR, including issues relating to the Throat. In particular, the DEIR Certificate stated:

> "I encourage MassDOT to incorporate desirable elements of all alternatives into the design of the Preferred Alternative…The FEIR should provide an alternative that maximizes parkland, restores the riverbank and improves bicycle and pedestrian access along the Charles River while balancing traffic and safety standards and goals."[3]

The IRT prepared a detailed report and evaluation matrix outlining the process, development, and application of evaluation criteria and development of variant design options for the Throat. This matrix serves as a fact sheet to inform MassDOT as it makes a decision on which Throat alternative will move forward at the conclusion of the independent review process. ***The IRT has not been tasked with making a recommendation to MassDOT or the public.*** The report and matrices contain the results of the IRT's evaluation of the alternatives for the Throat and are meant to inform MassDOT's decision-making process. The results are intended to be a factual review of the alternatives, without providing an opinion as to a preferred alternative. It is left to MassDOT to determine an outcome.

The IRT Technical Report summarizes the findings over this process. This section, Section 1, is an executive summary highlighting major findings. Section 2 and Section 3 summarize the IRT's scope and process. Sections 4 and 5 discuss the DEIR Alternatives, while Section 6 describes the evolution of concepts into IRT Variants. Finally, Section 7 evaluates the IRT Variants.

1.2 Throat Existing Conditions

The Throat is a relatively narrow rectangular corridor at the eastern end of the larger project site. The Throat measures approximately 2,500 feet long from east to west and is approximately 235 feet wide on average. It is bordered to the north by the Charles River, and to the south by the Boston University (BU) campus. The eastern boundary of the study area is approximately west of the BU Bridge and the Commonwealth Avenue Bridge; the western boundary is approximately at Agganis Way.

[2] DEIR Certificate, p. 1
[3] DEIR Certificate, pp. 38-39

The Throat accommodates five separate and parallel existing transportation elements, all of which must be included in order to meet the overall project purpose and need. These are:

- **Interstate highway:** Eight lanes of I-90 (the Massachusetts Turnpike), currently on an elevated viaduct in the southern half of the Throat;
- **Commuter rail:** Two tracks of the Worcester Main Line, currently at-grade beneath the I-90 viaduct;
- **Freight rail:** Two tracks of the Grand Junction Railroad, currently at-grade beneath the I-90 viaduct;
- **Limited access parkway:** Four lanes of Soldiers Field Road, currently at-grade within the Department of Conservation and Recreation's (DCR's) Charles River Reservation to the north of I-90; and
- **Pedestrian/bicycle path:** Paul Dudley White Path, located within the Charles River Reservation between Soldiers Field Road and the Charles River.

This report assumes that all five transportation elements, as aligned within the Throat, must meet the existing condition alignments at the eastern boundary (underneath the BU and Commonwealth Avenue Bridges), and they must meet the new design alignments shown in the DEIR at the western boundary of the Throat.

The various stakeholders hold differing views on the relative importance, appropriate use, and optimal design of the five elements. At a high level, all stakeholders generally agree that the existing capacity and connections of I-90, the Worcester Main Line, and Soldiers Field Road should be maintained in the reimagining of the viaduct. The Grand Junction Railroad is a subject of much discussion, with a shared sense among many stakeholders that the Railroad should be made capable of eventual upgrade for future passenger service. Many people, especially advocates for bicycle and pedestrian transportation, perceive the Paul Dudley White Path as inadequate in a number of ways, including the quality of the path and the connections it permits.

1.3 Families and Evaluation Criteria

The DEIR presented three different approaches for positioning the transportation infrastructure within the Throat, referred to as the three 'Families:'

- At-Grade (all elements at-grade)
- Highway Viaduct (I-90 elevated)
- Hybrid (some elements elevated, one at-grade)

Each Family has a set of two designs:

- DEIR Alternative – the design as it was contained within the DEIR of the project

- IRT Variant – the design as optimized by the IRT that would, as much as possible, address flaws that could challenge the viability of that Alternative

Within this report, each Family is discussed in further detail.

Some options have not yet been fully vetted by the IRT due to time constraints. At the September 26, 2018 Task Force Meeting, a new option was proposed by A Better City (ABC), herein referred to as the Proposed Elevated Multi-Use Path Concept. This option is discussed further in the Hybrid Family below and shown in more detail as an Addendum to this report.

For each of the three Families, the IRT applied eight areas of evaluation: Constructability, Cost, Environment, Permitting, Multimodal Connectivity, Public Realm, Resiliency, and Safety and Operations. Within each category, sub-criteria were added to address and encompass feedback collected during the outreach process. After consulting with MassDOT and drafting several iterations of the evaluation criteria matrix, the Task Force was asked to provide input on the matrix at the August 15, 2018 meeting, as well as through written comments accepted through August 22, 2018. The matrix was revised to incorporate public comments and provided to the Task Force in its final form on September 17, 2018, along with responses to comments. The criteria and measures contained in the matrix form the framework of the review of each family of Alternatives/Variants.

1.4 At-Grade Family

The At-Grade Family focuses on providing all five transportation elements of the Throat at roughly the same elevation between BU and the Charles River. The intention of this design concept is to offer an option that removes the need for structure and allows easier north-south crossings within the Throat.

1.4.1 DEIR ALTERNATIVE

Starting from the south, this Alternative provides two Worcester Main Line tracks, two Grand Junction Railroad tracks, four lanes for I-90 eastbound, four lanes for I-90 westbound, two lanes for Soldiers Field Road eastbound, two lanes for Soldiers Field Road westbound, and the Paul Dudley White Path at its existing width of 8.5 feet. Soldiers Field Road is raised approximately four feet on retained fill to provide some noise and flood protection. This Alternative includes the replacement of the Little Grand Junction Bridge over Soldiers Field Road. It also includes reconnecting the Paul Dudley White Path under the Little Grand Junction Bridge. The Paul Dudley White Path is proposed to be built on retained fill in the Charles River in the narrowest section of the Throat.

By removing I-90 from the existing elevated viaduct and, in the final condition, relocating I-90 at-grade with Soldiers Field Road to its north and the Grand Junction and Worcester Main Lines to its south, the DEIR At-Grade Alternative would cause significant changes to the current condition of

the Throat. To the IRT, the apparent benefits of an at-grade alignment include its potential for noise mitigation (by varying the relative heights of the roadway to block sound propagation) and connectivity to the Paul Dudley White Path and the Charles River from local roads such as Agganis Way. Some apparent shortfalls of this scheme include the Paul Dudley White Path build out over the Charles River and bank, a lack of usable green space, and long shutdowns required of the Grand Junction Railroad during construction. A significant concern to the team is the relative level of permitting risk for this Alternative under a range of regulations, including state and federal wetlands and tidelands programs. The Alternative extends into the Charles River because of the amount of parkway, interstate, and rail being reconstructed adjacent to one another in the Throat area. This does not leave room for the Paul Dudley White Path to be constructed without extending into wetlands. A summary of the applicable permits that are at high risk can be seen in **Table 5.**

1.4.2 IRT VARIANT

In developing the IRT Variant for the At-Grade Family, the IRT focused on solutions to bring the Paul Dudley White Path out of the river and on reducing the construction-period closure of the Grand Junction Railroad. In focusing on the location of the Paul Dudley White Path and its relationship to the edge of the Charles River, the IRT asked four key questions:

- What are the minimum required widths of the rail, interstate, and parkway envelopes and can they be narrowed further?
- Are all lanes and rail lines required for the desired levels of service and can any be eliminated to create additional space for the path?
- Could property currently owned by BU be utilized to create more space for the alignment?
- Can the path be cantilevered over the riverbank and water, or elevated above the riverbank, and what would be the implications for permitting and user experience?

The IRT evaluated the horizontal and vertical roadway alignments and performed a study of the safety of the various schemes. Each Family was evaluated for safety using the Interactive Highway Safety Design Model (IHSDM) Crash Prediction Module, which is based on the Highway Safety Manual (HSM). The model uses geometric inputs to provide a prediction of how many crashes may occur due to the characteristics. The model results are not meant to suggest that these are the specific, accurate numbers for future crash predictions, but rather serve as a tool to measure the relative levels of safety across the alternatives.

A projected reduction of the number of crashes in this area can be provided equally across options by implementing 11-foot lanes and 2-foot shoulders on the at-grade I-90, or full 12-foot lanes with 4-foot and 8-foot shoulders on the elevated I-90 viaduct. The main reason that the viaduct requires wider lanes and shoulders for the same level of safety is due to the limited stopping sight distance at the highway's vertical curve as it ascends from Commonwealth Avenue. For this reason, the IRT

determined that the at-grade solution need only provide 11-foot lanes with 2-foot shoulders to keep the Alternative as safe as the equivalently replaced highway viaduct, still at an improvement from current crash occurrences. The MBTA guidelines clearly indicate the minimum clearances between adjacent rail, and the edge distances as 13 feet and 9 feet, respectively; therefore, there is not an opportunity to reduce the rail envelope, which remains at 62-feet for a four-track rail operation. The lanes of Soldiers Field Road are 10 feet each in its current condition; therefore, the IRT has proposed to retain 10-foot lanes with 1-foot shoulders. The total width of this section of rail, I-90, and Soldiers Field Road is 215 feet.

The traffic volumes seen on both Soldiers Field Road and I-90 require the full two-lane and four-lane configurations in each direction to simply maintain continuity of lanes throughout the system and process the current and anticipated traffic demand. The demands for a four-track configuration for the Worcester Main Line and Grand Junction Railroad in the Throat have been further studied, but MassDOT has determined that four tracks for all Variants was appropriate at this stage of development.

In conversations held by the IRT with BU, BU indicated that they are willing to provide some of their ROW:

- Buick Street must be maintained; therefore, land up to the curb line on Buick Street, or underneath Buick Street (if feasible), can be utilized;
- The parking garage and lot adjacent to 25 Buick Street can be relocated;
- The existing buildings at 25 Buick Street, 871 Commonwealth Avenue, and 855 Commonwealth Avenue must be maintained, including emergency access in the rear; and
- Other parking, open, or vegetated areas can be utilized.

The IRT At-Grade Variant aimed to use as much of this possibly available property as possible. However, moving the alignment further south resulted in several complications to geometry that render the alignments not viable at this stage of the project.

Finally, the IRT examined the possibility of elevating or cantilevering the Paul Dudley White Path. The DEIR At-Grade Alternative involved filling of state-regulated wetlands along the river bank beyond the regulatory performance standards. As a result, the DEIR At-Grade Alternative would not be permittable under the MassDEP wetlands and tidelands (Chapter 91) regulations, the federal Section 404 wetlands permit, and the federal/state Section 401 water quality certification, because of the existence of other viable alternatives that do not result in an alteration of wetlands resources.

The IRT, alongside stakeholders, developed a number of options for placing the path onto structure and this potentially eliminating or reducing the permitting hurdles, including:

- A cantilevered path, with transparent or semi-transparent flooring;
- A raised path elevated 6 – 10 feet or more above the bank supported on columns;
- A raised and cantilevered path;
- A permanent boardwalk supported on piles in the Charles River;
- A path placed on fill within the Charles River; and
- Options including a narrow path, equivalent to the current condition, and options with a widened path with separated pedestrian and bicycle lanes.

The cantilevered, raised, and raised/cantilevered path options were included in the IRT Variant, as they were deemed the most permittable of the options – though not without significant challenges themselves.

The evolution of the At-Grade Family showing the IRT Variant can be seen in Section 6.1.

1.4.3 DETAILED EVALUATION

Across the eight evaluation criteria categories, the IRT has the following major findings about the At-Grade Family. More detailed findings are found the in the matrix and report.

- Constructability
  - Interruption to Grand Junction Railroad operations is significant, but reduced in the IRT Variant
- Cost
  - Construction cost ranges from $988 Million for the DEIR Alternative to $1,113 Million for the IRT Variant (increase of 15%)
  - Life cycle costs increase by 8% from the DEIR Alternative to the IRT Variant
- Environment
  - The Family has impacts to open space, historic resources, wetlands and tidelands that generally exceed the impacts from other Families
- Permitting
  - The Family has greater permitting risk under wetlands permitting, and likely under open space and historic reviews
- Multimodal Connectivity
  - The Family has few challenges to multimodal connectivity
- Public Realm
  - The Family removes the visual impact of a viaduct and allows for improved connections
  - The Family provides the least open space, and the adjacency of the path to the roadway may be a concern
- Resiliency

  - A complex stormwater management system would be required for this Family
- Safety and Operations
  - The Family provides for 1-2' shoulders on I-90, which may impact operations
  - The Family has the lowest predicted crash rates due to the removal of a vertical curve

1.5 Highway Viaduct Family

The Highway Viaduct Family provides all five transportation elements of the Throat by elevating I-90 above other uses. This Family is most similar to the existing condition within the Throat. The intention of this design concept is to offer an option that replicates the existing condition.

1.5.1 DEIR ALTERNATIVE

In the DEIR, the Highway Viaduct Alternative has some transportation elements on a viaduct. Starting from the south, this Alternative provides two Worcester Main Line tracks and two Grand Junction Railroad tracks at-grade beneath a viaduct carrying the four lanes of I-90 eastbound and four lanes of I-90 westbound. A widened viaduct allows for the provision of 8-foot right side shoulders on I-90. There is also an area under the widened viaduct that can be used for stormwater management, infiltration and water quality treatment. The two lanes of Soldiers Field Road eastbound and two lanes of Soldiers Field Road westbound are realigned slightly to the south, allowing additional space for the Paul Dudley White Path to be improved while also providing additional open space. This Alternative does not include the replacement of the Little Grand Junction Bridge over Soldiers Field Road.

The DEIR Highway Viaduct Alternative rebuilds I-90's existing elevated viaduct with a similar elevated structure. The proposed footprint is similar though slightly wider, due to the desire on the part of MassDOT to widen the lanes and shoulders in the interest of safety and operations. To the IRT, the apparent benefits of the DEIR Highway Viaduct Alternative include: no impacts to the river, the ability to maintain Grand Junction Railroad service through construction, and the possibility of maintaining the existing Little Grand Junction Bridge. Some apparent shortfalls of this Alternative include: difficult north-south connectivity, complexity of staging with temporary structures, interactions between foundations and existing utilities, the apparent cost of maintaining a viaduct beyond its life cycle, lack of usable green space, and noise levels associated with elevated I-90 traffic.

1.5.2 IRT VARIANT

In developing the IRT Variant for the Highway Viaduct Family, the IRT studied ways to improve connectivity, which is complicated by the high elevation and clearances required for a crossing over the highway viaduct. There is little room to significantly modify the vertical profile of the viaduct, as

it must provide clearance to the rail lines below, and the structural depth is required at the piers to support the loads the viaduct carries. The viaduct's structural depth could be reduced by a few feet by reducing the superstructure span lengths, but this would require more piers and foundations, which likely would not be structurally efficient or cost effective and would disrupt rail movements beneath the viaduct. Therefore, there is little ability to improve the vertical clearances above the proposed viaduct to accommodate a lower pedestrian crossing.

The IRT then focused on improving the construction staging of the Highway Viaduct Family. The IRT found inefficiencies within the staging plans, such as:

- Stage 1 constructs an approximately 10-foot temporarily widened viaduct superstructure width which is demolished in Stage 4, while providing approximately 9.75 feet more width on the maintained I-90 eastbound than required.
- Temporary lines of column supports are required during both Stage 1 and Stage 2.

The IRT Highway Viaduct Variant considers ways to reduce the temporary structure required. In Stage 1, the temporary superstructure can be reduced by shifting both the Stage 1 and Stage 2 demolition and reconstruction zones by 10 feet. The number of temporary column supports required in Stage 2 may be reduced by changing the order of demolition/reconstruction.

In the DEIR Highway Viaduct Alternative, for approximately 50% of the Throat length, the north-most columns straddle an existing MWRA line, which adds to construction risk during installation. The IRT Highway Viaduct Variant considers a three-column replacement arrangement which offsets the outermost column and foundation to the south of the line. This column arrangement would also have the benefit of allowing Soldiers Field Road to tuck beneath the viaduct's cantilevered edge to create additional green space between the roadway and path. It would also reduce the total number of excavations for few foundations. The green space can be used to hold detention systems for stormwater management.

As this Family proposes to maintain I-90 on viaduct, more room is available to accommodate more standard lane widths and shoulders. The Family includes 11.5-foot lanes in both directions on I-90. A 2-foot left-side shoulder and 8-foot right-side shoulder are proposed. The lanes of Soldiers Field Road are 10 feet each in its current condition; therefore, the IRT has proposed to retain 10-foot lanes with 1-foot shoulders. The total width of this section of rail, I-90, and Soldiers Field Road is 215 feet.

The evolution of the Highway Viaduct Family showing the IRT Variant can be seen in Section 6.2.

1.5.3 DETAILED EVALUATION

Across the eight evaluation criteria categories, the IRT has the following major findings about the Highway Viaduct Family. More detailed findings are found the in the matrix and report.

- Constructability
  - No significant reductions in timeframe or railroad closures or complexity
  - Fewer foundations reduces complexity
- Cost
  - Construction cost ranges from $1,040 Million for the DEIR Alternative to $1,201 Million for the IRT Variant (increase of 7%)
  - Life cycle costs increase by 10% from the DEIR Alternative to the IRT Variant
- Environment
  - The Family has limited permanent and temporary impacts to open space, historic resources, wetland and tidelands
- Permitting
  - The Family has relatively low permitting risk
- Multimodal Connectivity
  - The Family creates a connectivity challenge to north-south connections
- Public Realm
  - The Family has the visual impact of a viaduct
  - The IRT Variant is able to increase open space by shifting Soldiers Field Road
- Resiliency
  - Ample space for stormwater management can be provided
- Safety and Operations
  - The Family provides for 2-8' shoulders on I-90, which help improve operations
  - The Family has moderate predicted crash rates due to the vertical curve

1.6 Hybrid Family

The Hybrid Family provides all five transportation elements of the Throat by elevating an element that is not I-90 above other uses. The intention of this design concept is to offer an option that provides an intermediate between a high viaduct and a fully at-grade option.

1.6.1 DEIR ALTERNATIVE

In the DEIR, the Hybrid Alternative has some transportation elements on viaduct. Starting from the south, this Alternative provides two Worcester Main Line tracks at-grade. The two Grand Junction Railroad tracks are on a viaduct over the four lanes of I-90 eastbound, which are at-grade adjacent to the four lanes of I-90 westbound. The two lanes of Soldiers Field Road eastbound and two lanes for Soldiers Field Road westbound are realigned slightly to the south, allowing additional space for the Paul Dudley White Path to be improved while also providing additional open space. This Alternative includes the replacement of the Little Grand Junction Bridge over Soldiers Field Road, as well as connections to the Paul Dudley White Path from the BU Bridge. It further includes an elevated

shared-use path connection from West Station to connect to the future pedestrian-bicycle path over the Charles River to Cambridge using the Grand Junction Bridge.

The DEIR Hybrid Alternative moves I-90 from the existing elevated viaduct and, in the final condition, relocates I-90 at-grade with Soldiers Field Road to its north and the Worcester Main Line to its south, with the Grand Junction Railroad elevated on a viaduct above I-90 eastbound. The DEIR Hybrid Alternative had some features considered attractive to many parties, including a lack of impact on the Charles River (and consequentially, fewer permitting risks), noise mitigation provided by an at-grade I-90 (the raised I-90 changes the noise profile for many receptors), and a pedestrian-bicycle path over the Charles River to Cambridge using the railroad viaduct to access the Grand Junction Bridge and Paul Dudley White Path from West Station. However, the DEIR Hybrid Alternative does not fully address north-south pedestrian connections to the Paul Dudley White Path over Soldiers Field Road from nearby roads, including Agganis Way. Additionally, the rail viaduct required for the DEIR Hybrid Alternative would be extremely heavy compared to the existing viaduct, while not being fully utilized in its span across I-90. Finally, the Alternative requires extremely long-term shutdowns of the Grand Junction Railroad throughout construction.

1.6.2 IRT VARIANT

In developing the IRT Variant for the Hybrid Family, the IRT studied ways to optimize stacked infrastructure and improve constructability while lowering cost. Key questions of the IRT included:

- Can the optimization of stacked infrastructure widths increase available green space and lower the elevation of a potential pedestrian/bicycle bridge crossing?
- Should alternate stacked infrastructure other than rail be considered? Rail viaducts are heavier and costlier than roadway viaducts, and rail cannot elevate vertically or turn as readily as a vehicular road.
- Can the overall timeframe for the Grand Junction Railroad closure be reduced?

To answer these questions, the IRT developed a Hybrid Variant which stacks Soldiers Field Road above I-90 westbound, with both directions of I-90 and all rail lines at-grade. The width of the four lanes (two in either direction) of Soldiers Field Road is similar to the width of I-90 westbound; therefore, there is little unused space in this stacked scheme. This optimization opens almost 20' of corridor which can be converted into green space adjacent to the river. Additionally, the vertical clearance required over Soldiers Field Road is only 11 feet as compared to the 18.5 feet required over rail, allowing a north-south connection for pedestrians/bicyclists to be pushed downwards to a lower crossing elevation; this would allow more gradual, comfortable grades to pass over all the other transportation elements.

An elevated Soldiers Field Road will cost less to construct than a rail viaduct because the carried loads are lighter. The noise of an elevated Soldiers Field Road will be less than an elevated I-90

because it does not carry truck traffic – instead, the elevated Soldiers Field Road is anticipated to mitigate noise from I-90 traffic, both the westbound lanes below the viaduct and the eastbound lanes to the south. Direct connections can be provided to the Paul Dudley White Path from local roads such as Agganis Way, and a connection can be made alongside the Grand Junction connecting pedestrian and bicyclists from Commonwealth Avenue to the Paul Dudley White Path at the BU Bridge.

The long closure window during construction of the DEIR Hybrid Alternative resulted from the assumption that the rail viaduct cannot be completed until after all roadways have been brought to grade and the existing viaduct has been demolished. To an extent, this remains true – the retained fill for the Grand Junction cannot be constructed until after the southern edge of the viaduct has been demolished. The space is constrained, and it appears that the southern edge of viaduct could be demolished sooner in the IRT Hybrid Variant with the installation of considerable temporary structure to divert I-90 eastbound to the stacked roadway temporarily. At this stage, it is unclear if the time and cost associated with those temporary structures would lead to a substantial reduction of construction duration for the project. Therefore, it isn't believed the Grand Junction Railroad reopening can be substantially improved relative to staging movements. The time savings is closely related to the smaller closure window due to eliminating the railroad viaduct and instead constructing shorter stretches of bridge and retained fill similar to the at-grade option.

Due to the anticipated impacts upon the Charles River and the associated state and federal permitting requirements for construction in or near wetlands, the location of the path was a continued topic of discussion between the IRT and A Better City (ABC), the primary proponent of the At-Grade Alternative. To attempt to mitigate potential permitting challenges, ABC staff and the IRT both worked to develop variants of the core At-Grade Family that might be able to avoid wetlands-related impacts (those that were understood to most likely trigger impediments to permitting). Following the Task Force meeting on September 26, 2018, ABC developed an additional option for consideration, which elevated the Paul Dudley White Path above Soldiers Field Road westbound (the Proposed Elevated Multi-Use Path Concept). This Concept remains very close to the river with the intent to not enter or impact the wetland. The Proposed Elevated Multi-Use Path Concept is shown in an Addendum to this report. It was not feasible to study this Concept and maintain schedule for release of the report. The IRT will evaluate this Concept during the comment period and submit that evaluation to MassDOT in time for review prior to a decision being made.

The evolution of the Hybrid Family showing the IRT Variant can be seen in Section 6.3.

1.6.3 DETAILED EVALUATION

Across the eight evaluation criteria categories, the IRT has the following major findings about the Hybrid Family. More detailed findings are found the in the matrix and report.

- Constructability
  - This Family has the longest projected construction timeframe
  - The construction timeframe can be reduced in the IRT Variant
- Cost
  - Construction cost ranges from $1,195 Million for the DEIR Alternative to $1,112 Million for the IRT Variant (decrease of 7%)
  - Life cycle costs decrease by 25% from the DEIR Alternative to the IRT Variant
- Environment
  - The Family has limited permanent and temporary impacts to open space, historic resources, wetland and tidelands
- Permitting
  - The Family has relatively low permitting risk
- Multimodal Connectivity
  - The Family creates a slight connectivity challenge to north-south connections
  - New connections may be possible in the IRT Variant
- Public Realm
  - The Family has the visual impact of a viaduct, though lower than the Highway Viaduct Family
  - The IRT Variant provides the greatest amount of additional open space
- Resiliency
  - Ample space for stormwater management can be provided
  - The IRT Variant significantly reduces overall impervious surface
- Safety and Operations
  - The Family provides for 2'-8' shoulders on I-90, which help improve operations
  - The Family has moderate predicted crash rates due to the vertical and horizontal curves

1.7 Synopsis

1.7.1 FAMILY DESIGNS

The common elements of all Alternatives and Variants in the At-Grade Family are:

- All transportation elements are at-grade
- I-90 has eight 11-foot lanes and 2-foot shoulders
- Soldiers Field Road has four 10-foot lanes and 1-foot shoulders
- The Paul Dudley White Path has a potential river impact
- There are varying effects on wetlands, waterways and open space
- Land from BU is required (7 feet)

- North-south pedestrian/bicycle connections to the river are allowed

The evolution of the At-Grade Family from DEIR Alternative to IRT Variant includes the following changes:

- Changing the slope and alignment of the Grand Junction Railroad to create a less costly and shorter construction alternative, shortening the required closure
- Exploring cantilevering or raising the Paul Dudley White Path along the river's edge

The common elements of all Alternatives and Variants in the Highway Viaduct Family are:

- I-90 elevated above other transportation elements (height of 28 feet above rail, width of 127 feet, closest distance to the river of 82 feet)
- I-90 has eight 12-foot lanes and 4-to-8-foot shoulders
- Soldiers Field Road has four 10-foot lanes and 1-foot shoulders
- The Paul Dudley White Path can be expanded
- Land from BU is not required
- North-south pedestrian/bicycle connections to the river are difficult
- Room for expanded open space is created

The evolution of the Highway Viaduct Family from DEIR Alternative to IRT Variant includes the following changes:

- Changing the viaduct column scheme from 4 columns to 3 columns
- Tucking Soldiers Field Road under the northern edge of the I-90 viaduct to provide additional open space or path width
- Relocation of the stormwater management system
- Simplified staging due to fewer foundations

The common elements of all Alternatives and Variants in the Hybrid Family are:

- One non-I-90 element elevated above other transportation elements
- I-90 has eight 11-foot lanes and 2-foot shoulders
- Soldiers Field Road has four 10-foot lanes and 1-foot shoulders
- The Paul Dudley White Path can be expanded
- Land from BU is not required, but may be used to improve the design (up to 7 feet)
- North-south pedestrian/bicycle connections to the river can be accommodated, though in different locations
- Room for expanded open space is created

The evolution of the Hybrid Family from DEIR Alternative to IRT Variant includes the following changes:

- Soldiers Field Road is elevated onto viaduct over I-90 westbound (height of 20 feet above I-90 – which may be depressed)
- Potential to improve the Paul Dudley White Path and expand open space
- Reduces the Grand Junction Railroad closure
- Easier to accommodate north-south pedestrian/bicycle connections due to a shorter viaduct

1.7.2 EVALUATION CRITERIA

The IRT examined 54 evaluation sub-criteria over eight categories for all three DEIR Alternative Families and IRT Variant Families. The majority of evaluation criteria determinations were seen as roughly equivalent – there was not a significant variation between different Families or between DEIR Alternatives and IRT Variants. This helped the IRT focus evaluation onto categories where differences were more apparent.

The category with the greatest amount of variation is Permitting. By examining the criteria within this category, it becomes clear that any design that impinges upon the Charles River (through actual filling, new structures or increased shadow) carries a high risk of MassDOT not obtaining the required environmental permits for the project. See **Table 5** for a detailed assessment of permitting risk. The IRT was unable to review or develop a true at-grade design that did not encounter permitting challenges. This indicates to the IRT that the solution must include one element of the five transportation elements of the throat (I-90, Framingham/Worcester Line, Grand Junction Railroad, Soldiers Field Road and the Paul Dudley White Path) raised above another element (in whole or part), creating a stacked condition.

The IRT views that the remainder of the evaluation criteria can be utilized to help determine what transportation elements should be included in that stack, and how they should be arranged. As shown in this review, there are multiple options, including raising I-90, Soldiers Field Road, the Grand Junction Railroad and the Paul Dudley White Path. Each of these elements has advantages and disadvantages to being included in a stacked arrangement, and it is left to MassDOT to determine the outcome in order to continue with the project.

1.8 Evaluation Matrix

This matrix serves as a fact sheet to inform MassDOT as it makes a decision on which Throat alternative will move forward at the conclusion of the independent review process. The IRT has not been tasked with making a recommendation to MassDOT or the public. The report and matrices contain the results of the IRT's evaluation of the alternatives for the Throat and are meant to inform MassDOT's decision-making process. The results are intended to be a factual review of the alternatives, without providing an opinion as to a preferred alternative. It is left to MassDOT to determine an outcome.

The IRT developed the evaluation criteria early on in review process. Due to project time constraints, not all the evaluation criteria were fully evaluated to the detailed level originally anticipated. However, each criterion was measured comparatively against all alternatives. It is the IRT's opinion that this matrix is an important tool for MassDOT to utilize as part of the decision-making process. The matrices are comprised of **Tables 1.1** through **1.9**.

Table 1.1. ***Evaluation Criteria Matrix***

Constructability		Cost		Environment		Permitting		Multimodal Connectivity		Public Realm		Resiliency		Safety and Operations	
Criteria	**Measures**	**Criteria**	**Measures**	**Criteria**	**Measures**	**Criteria**	**Measures**	**Criteria**	**Measures**	**Criteria**	**Measures**	**Criteria**	**Measures**	**Criteria**	**Measures**
Construction timeframe	# Years and months	Construction cost	Estimated construction costs (including non-capital construction costs)	Permanent effects on designated historic resources	Amount of impacts/benefits	Risk of not receiving necessary permit(s)	High / Medium / Low	Impact (if any) on West Station constructability/ expandability	Impact Y/N	Accommodates filed land use plans for project area (including any air rights development plans)	Y/N	Protects key components of project from flood impacts	# Facilities impacted / Mapping of key components relative to flood elevations	Effects on safety for I-90	Presence of safety elements per lane mile / Safety model analysis
Effects on ramp connections for I-90 and SFR	Y/N / Service interruption duration / User delays (hours)	Life-cycle cost	Estimated life-cycle cost for each option	Temporary effects on designated historic resources	Amount of impacts	Risk of permitting delay	High / Medium / Low	Number of N-S access points to river for peds/bikes	# Connections / Travel time to destinations	Effects on noise (both sides of river)	Change in noise impacts on receptors / Mitigation feasibility	Addresses stormwater runoff impacts from future rainfall projections	BMPs included / Amount of space available for BMPs / Drainage sized for future projections	Effects on safety for SFR	Presence of safety elements per lane mile / Safety model analysis
Effects on current rail service to Grand Junction	Service interruption duration / User delays (hours)	Need to acquire/take property	Estimated cost of acquisition	Permanent effects on parks/open space	Amount of impacts/benefits	Able to meet all state wetlands regulatory requirements without variances	Y/ Variance required	Provides minimum 50 mph railroad design speed	Y/N	Effects on visual quality of the riverfront and other open spaces	Vegetation coverage / Vegetation types / Positive or negative man-made elements	Protects highway infrastructure from flood impacts	% Roadway inundated based on future flood projections	Effects on operations and maintenance on I-90	Shoulder width / Lane width
Effects on current rail service to Framingham/ Worcester	Single v. double track operation / Service interruption duration / User delays (hours)	Mitigation costs	Estimated cost range of required mitigation for permitting	Temporary effects on parks/open space	Amount of impacts	Able to meet all state tidelands regulatory requirements without variances	Y/ Variance required	Provides desired 79 mph railroad design speed	Y/N	Increases / decreases navigable water sheet area available	Amount of increase/ decrease	Accommodates FHWA guidance on building of interstate highway in flood plain	Y/N	Effects on operations and maintenance on SFR	Shoulder width / Lane width
Effects on access to PDW during construction	Y/N / Service interruption duration / User delays (hours)			Permanent effects on wetlands	Amount of impacts/benefits	Existence of alternative with lesser impact to wetlands, tidelands, parklands or historic resources	Y/N, as applicable to specific permit	Maintains desired clearance (18'-6") over train operations	Y/N	Effects on physical quality of open space and PDW through amenities	Shade / Surface / Furniture	Amount of impervious surface created	Amount (acres)	Requires design exception from NHS Design Standards	Y/N
Complexity of staging	# Stages / Duration / Interruptions to service / Temporary structures required			Temporary effects on wetlands	Amount of impacts	4(f) parkland impacts	Amount of impacts, potential mitigation	Allows future 2- or 3-track operation on Grand Junction	Y/N	Effects on amount of open space in area	# Acres added			Accommodates addition of shoulders	Y/N
Risk of delay / Cost increase due to uncertainty / Complexity	High / Medium / Low			Permanent effects on tidelands	Amount of impacts/benefits	Sect. 106 historic resource impacts	Amount of impacts, potential mitigation	Effect on future multimodal connectivity	Potential for multi-use path connection to Grand Junction railroad and N-S connections for bus/transit	Effect on quality of riverfront access points	Width / Material / Continuity of neighborhood feel			Allows separation of modes on PDW Path	Level of comfort (buffer or physical barrier / width of shoulder / width of path)
				Temporary effects on tidelands	Amount of impacts	Risk of I-90 inundation by 50-year flood	Y/N / Amount of risk								
				Effects on air quality	Roadway congestion / Stopped traffic / Active ventilation										

Table 1.2. ***Constructability Criteria Matrix***

Constructability		DEIR Alternatives			IRT Alternatives		
Criteria	**Measures**	**At-Grade**	**Highway Viaduct**	**Hybrid**	**At-Grade**	**Highway Viaduct**	**Hybrid**
Construction time frame	# Years and months	6 years 6 months	6 years 6 months	8 years	6 years 6 months	6 years 6 months	7 years 6 months
Effects on ramp connections for I-90 and SFR	Y/N / Service interruption duration / User delays (hours)	Yes; Maintains ramps for I-90 and SFR through all phases of construction	Yes; Maintains ramps for I-90 and SFR through all phases of construction	Yes; Maintains ramps for I-90 and SFR through all phases of construction	Yes; Maintains ramps for I-90 and SFR through all phases of construction	Yes; Maintains ramps for I-90 and SFR through all phases of construction	Yes; Maintains ramps for I-90 and SFR through all phases of construction
Effects on current rail service to Grand Junction	Service interruption duration / User delays (hours)	Significant interruption	Minor/moderate interruption	Significant interruption	Signifcant interruption, reduced from DEIR Alternative	Minor/moderate interruption	Moderate interruption
Effects on current rail service to Framingham/ Worcester	Single v. double track operation / Service interruption duration / User delays (hours)	Minor interruption; primarily 2 track operation	Moderate interruption; primarily 1 track operation	Minor interruption; primarily 2 track operation	Minor interruption; primarily 2 track operation	Moderate interruption; primarily 1 track operation	Minor interruption; primarily 2 track operation
Effects on access to PDW during construction	Yes/No / Service interruption duration / User delays (hours)	Yes; Temporary during construction of path in river, detour delay of 5 minutes via two detour routes	No; Unless there are any planned improvements to PDW	Yes; During construction of SFR, detour delay of 5 minutes via two detour routes	Yes; Temporary during construction of path in river, detour delay of 5 minutes via two detour routes	No; Unless there are any planned improvements to PDW	Yes; During construction of SFR, detour delay of 5 minutes via two detour routes
Complexity of staging	# Stages / Duration / Interruptions to service / Temporary structures required	6 stages, 3 year Grand Junction closure, 2 years impacted Worcester Line operations, temporary viaduct structure to bring I-90 to grade at western edge	6 stages, 3 year Grand Junction closure, 2 years impacted Worcester Line operations, temporary viaduct structure to bring I-90 to grade at western edge	7 stages, 4 year Grand Junction closure, 5 year PDW closure or detour, temporary structure limited to viaduct	6 stages, 3 year Grand Junction closure, 2 years impacted Worcester, temporary support limited to viaduct supports during demolition	6 stages, Grand Junction operational, Worcester Line single track, PDW in service without temporary structure, temporary columns and foundations required for viaduct	6 stages, 3.75 year Grand Junction closure, 5 year PDW closure or detour, temporary structure limited to viaduct
Risk of delay / Cost increase due to uncertainty / Complexity	High / Medium / Low	Medium - High	Medium	Medium - High	Slightly less than DEIR Highway At-Grade Alternative	Slightly less than DEIR Highway Viaduct Alternative	Slightly less than DEIR Hybrid Alternative

Table 1.3. ***Cost Criteria Matrix***

Cost		DEIR Alternatives			IRT Variants		
Criteria	**Measures**	**At-Grade**	**Highway Viaduct**	**Hybrid**	**At-Grade**	**Highway Viaduct**	**Hybrid**
Construction cost	Estimated construction costs (including non-capital construction costs such as rail detours during construction)	$987,942,000	$1,039,947,000	$1,195,396,000	$1,133,017,000	$1,200,605,500	$1,111,736,000
Life-cycle cost	Estimated life-cycle cost for each option	$54,329,000	$71,814,000	$81,549,000	$59,329,000	$78,872,000	$60,506,000
Need to acquire/take property	Estimated cost of acquisition	11,860 SF	0 SF	9,605 SF	3,245 SF	0 SF	0 SF
Mitigation costs	Estimated cost range of required mitigation for permitting	Relatively greater risk of mitigation costs	Relatively lesser risk of mitigation costs	Relatively lesser risk of mitigation costs	Relatively greater risk of mitigation costs	Relatively lesser risk of mitigation costs	Relatively lesser risk of mitigation costs

Table 1.4. ***Environment Criteria Matrix***

Environment		DEIR Alternatives			IRT Variants		
Criteria	**Measures**	**At-Grade**	**Highway Viaduct**	**Hybrid**	**At-Grade**	**Highway Viaduct**	**Hybrid**
Permanent effects on designated historic resources	Amount of impacts / benefits	41,430 SF of CRBHD land used -6,044 SF net loss of accessible open space Narrower PDW than existing Eliminate viaduct visual, shadow impacts; cause river impacts N-S ped/bike connections feasible Reconstructed LGJ Bridge/improved PDW east end	11,640 SF of CRBHD land used 16,942 SF net gain of accessible open space Wider PDW than existing Maintain viaduct visual, shadow impacts N-S ped/bike connections infeasible No reconstructed LGJ for improved PDW east	19,420 SF of CRBHD land used 12,422 SF net gain of accessible open space Wider PDW than existing Reduce viaduct visual, shadow impacts N-S ped/bike connections feasible Reconstructed LGJ Bridge/improved PDW east end	46,950 SF of CRBHD land used -10,251 SF net loss of accessible open space Narrower PDW than existing Eliminated viaduct visual, shadow impacts; cause river impacts N-S ped/bike connections feasible Reconstructed LGJ Bridge/improved PDW east end	8,353 SF of CRBHD land used 38,722 SF net gain of accessible open space Considerably wider PDW than existing Maintain viaduct visual, shadow impacts N-S ped/bike connections infeasible No reconstructed LGJ for improved PDW east	47,290 SF of CRHBD land used 47,242 SF net gain of accessible open space Considerably wider PDW than existing Viaduct visual, shadow impacts differ from existing; better landscape screening N-S ped/bike connections feasible Reconstructed LGJ Bridge/improved PDW east end
Temporary effects on designated historic resources	Amount of impacts	Assumed that all alternatives will occupy throat during full construction period	Assumed that all alternatives will occupy throat during full construction period	Assumed that all alternatives will occupy throat during full construction period	Assumed that all alternatives will occupy throat during full construction period	Assumed that all alternatives will occupy throat during full construction period	Assumed that all alternatives will occupy throat during full construction period
Permanent effects on parks/open space	Amount of impacts / benefits	For Article 97, project-wide open space benefits compensate For 4(f) review, see historic resource impacts/benefits	For Article 97, project-wide open space benefits compensate For 4(f) review, see historic impacts/benefits	For Article 97, project-wide open space benefits compensate For 4(f) review, see historic impacts/benefits	For Article 97, project-wide open space benefits compensate For 4(f) review, see historic impacts/benefits	For Article 97, project-wide open space benefits compensate For 4(f) review, see historic impacts/benefits	For Article 97, project wide open space benefits compensate For 4(f) review, see historic impacts/benefits
Temporary effects on parks/open space	Amount of impacts	Assumed that all alternatives will occupy throat during full construction period, and that PDW path will be closed and relocated, with route to be determined	Assumed that all alternatives will occupy throat during full construction period, and that PDW path will be closed and relocated, with route to be determined	Assumed that all alternatives will occupy throat during full construction period, and that PDW path will be closed and relocated, with route to be determined	Assumed that all alternatives will occupy throat during full construction period, and that PDW path will be closed and relocated, with route to be determined	Assumed that all alternatives will occupy throat during full construction period, and that PDW path will be closed and relocated, with route to be determined	Assumed that all alternatives will occupy throat during full construction period, and that PDW path will be closed and relocated, with route to be determined
Permanent effects on wetlands	Amount of impacts / benefits	330 LF Bank 420 SF of LUW 1,100 SF Waters of the U.S. In addition to stormwater outfall work, common to all alternatives	Stormwater outfall work, common to all alternatives: 10 LF Bank 40 SF of LUW 60 SF Waters of the U.S.	Stormwater outfall work, common to all alternatives: 10 LF Bank 40 SF of LUW 60 SF Waters of the U.S.	400 / 670 LF Bank 1,100 / 4,310 SF LUW In addition to stormwater outfall work, common to all alternatives	Stormwater outfall work, common to all alternatives: 10 LF Bank 40 SF of LUW 60 SF Waters of the U.S.	Stormwater outfall work, common to all alternatives: 10 LF Bank 40 SF of LUW 60 SF Waters of the U.S.
Temporary effects on wetlands	Amount of impacts	Additional 20 LF of Bank 3,300 SF of LUW In addition to temporary impacts for stormwater installation, common to all alternatives	Additional temporary impacts for stormwater installation, common to all alternatives: 90 LF of Bank 240 SF of LUW	Additional temporary impacts for stormwater installation, common to all alternatives: 90 LF of Bank 240 SF of LUW	Additional temporary impacts for stormwater installation, common to all alternatives: 90 LF of Bank 240 SF of LUW	Additional temporary impacts for stormwater installation, common to all alternatives: 90 LF of Bank 240 SF of LUW	Additional temporary impacts for stormwater installation, common to all alternatives: 90 LF of Bank 240 SF of LUW
Permanent effects on tidelands	Amount of impacts / benefits	Fill 1,100 SF of flowed tidelands NWDIF impacts on filled tidelands - 6,044 net loss accessible open space Narrower PDW than existing	NWDIF impacts on filled tidelands 16,942 SF net gain accessible open space Wider PDW than existing	NWDIF impacts on filled tidelands 12,422 SF net gain accessible open space Wider PDW than existing	NWDIF impacts on filled tidelands -10,251 SF net loss accessible open space Narrower PDW than existing	NWDIF impacts on filled tidelands 38,722 SF net gain accessible open space Wider PDW than existing	NWDIF impacts on filled tidelands 47,242 SF net gain accessible open space Wider PDW than existing
Temporary effects on tidelands	Amount of impacts	Temporary impact on 3,000 SF of flowed tidelands Assumed that PDW path closed and relocated during construction for all alternatives	Assumed that PDW path closed and relocated during construction for all alternatives	Assumed that PDW path closed and relocated during construction for all alternatives	Assumed that PDW path closed and relocated during construction for all alternatives	Assumed that PDW path closed and relocated during construction for all alternatives	Assumed that PDW path closed and relocated during construction for all alternatives

Table 1.5. ***Permitting Criteria Matrix***

Permitting		DEIR Alternatives			IRT Variants		
Criteria	**Measures**	**At-Grade**	**Highway Viaduct**	**Hybrid**	**At-Grade**	**Highway Viaduct**	**Hybrid**
Risk of not receiving necessary permit(s)	Overall Risk	High	Low - Medium	Low - Medium	High	Low - Medium	Low - Medium
	MassDEP State Wetlands Permit	High - unlikely to receive variance	Low - No variance required		High - likely to require variance; variance could not be granted	Low - no variance required	
	US Army Corps of Engineers Federal Wetlands Permit	Medium to High - may require individual permit, with heightened standards	Low - may not require individual permit		Low - may not require individual permit		
	MassDEP Section 401 Water Quality Certification	Medium to High - may require certification, with heightened standards	Low - may not require certification		Low - may not require certification		
	MassDEP State Tidelands (Chapter 91) Permit	High - unlikely to receive variance	Low to Medium - no variance required; but outcome depends upon whether another alternative is judged superior on grounds of public access		Low to Medium - no variance required; but outcome depends upon whether another alternative is judged superior on grounds of public access		
Risk of permitting delay	Overall Risk	High	Low - Medium	Low - Medium	Medium - High	Low - Medium	Low - Medium
	MassDEP State Wetlands Permit	High - due to extended length of variance process	Low - no variance process		Medium to High - due to extended length of variance process	Low - no variance process	
	US Army Corps of Engineers Federal Wetlands Permit	Medium to High - due to extended length of individual permit process, if one is required	Low - likely not to require individual permit		Low - likely not to require individual permit		
	MassDEP Section 401 Water Quality Certification	Medium to High - due to extended length of individual permit process, if one is required	Low - likely not to require certification		Low - likely not to require certification		
	MassDEP State Tidelands (Chapter 91) Permit	High - due to extended length of variance process	Low - no variance process		Low - no variance process		
Able to meet all state wetlands regulatory requirements without variances	Y/ Variance required	Variance required, would not be granted due to other reasonable alternatives without these impacts	Yes	Yes	Variance likely required, would not be granted due to other reasonable alternatives without these impacts	Yes	Yes
Able to meet all state tidelands regulatory requirements without variances	Y/ Variance required	Variance required, would not be obtained due to other reasonable alternatives without these impacts	Yes	Yes	Yes	Yes	Yes
Existence of alternative with lesser impact to wetlands, tidelands, parklands or historic resources	Y/N, as applicable to specific permit	Yes for wetlands and tidelands, potentially for parklands or historic resources	No for wetland and tidelands, Potentially for parklands or historic resources	No for wetlands and tidelands, Potentially for parklands or historic resources	Yes for wetlands, No for tidelands, Potentially for parklands or historic resources	No for wetland and tidelands, Potentially for parklands or historic resources	No for wetland and tidelands, Potentially for parklands or historic resources
4(f) parkland impacts	Amount of impacts, potential mitigation	Medium risk - outcome depends on whether another alternative is judged superior. This alternative has lesser area of riverfront open space	Low - Medium risk - outcome depends on whether another alternative is judged superior. This alternative has greater area of riverfront open space	Low - Medium risk - outcome depends on whether another alternative is judged superior. This alternative has greater area of riverfront open space	Medium risk - outcome depends on whether another alternative is judged superior. This alternative has lesser area of riverfront open space	Low - Medium risk - outcome depends on whether another alternative is judged superior. This alternative has greater area of riverfront open space	Low - Medium risk - outcome depends on whether another alternative is judged superior. This alternative has greater area of riverfront open space

Table 1.6. ***Multimodal Connectivity Criteria Matrix***

Multimodal		DEIR Alternatives			IRT Variants		
Criteria	**Measures**	**At-Grade**	**Highway Viaduct**	**Hybrid**	**At-Grade**	**Highway Viaduct**	**Hybrid**
Impact (if any) on West Station constructability/ expandability	Impact Y/N	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Number of N-S access points to river for peds/bikes	# Connections / Travel time to destinations	Multiple; likely 2 including west end	None	Potentially at west end	Multiple; likely 2	None	Multiple; likely 2 including west end
Provides minimum 50 mph railroad design speed	Y/N	Yes	Yes	Yes	Yes	Yes	Yes
Provides desired 79 mph railroad design speed	Y/N	No; requires spreading of track and West Station relocation	No; requires spreading of track and West Station relocation	No; requires spreading of track and West Station relocation	No; requires spreading of track and West Station relocation	No; requires spreading of track and West Station relocation	No; requires spreading of track and West Station relocation
Maintains desired clearance (18'-6") over train operations	Y/N	Yes	Yes	Yes	Yes	Yes	Yes
Allows future 2- or 3-track operation on Grand Junction	Y/N	Yes	Yes	Yes	Yes	Yes	Yes
Effect on future multimodal connectivity	Potential for multi-use path connection to Grand Junction railroad and N-S connections for bus/transit	No	Yes	No	No	Yes	Yes

Table 1.7. ***Public Realm Criteria Matrix***

Public Realm		DEIR Alternatives			IRT Variants		
Criteria	**Measures**	**At-Grade**	**Highway Viaduct**	**Hybrid**	**At-Grade**	**Highway Viaduct**	**Hybrid**
Accommodates filed land use plans for project area (including any air rights development plans)	Y/N	Yes	Yes	Yes	Yes	Yes	Yes
Effects on noise (both sides of river)	Change in noise impacts on receptors / Mitigation feasibility	Noise increases over existing conditions, especially for receptors close to the highway (BU). Rail viaduct shields PDW and noise decreases. Noise wall near Nickerson Field feasible. No feasible mitigation for PDW because of physical constraints. Magazine Beach noise reduced but mitigation not feasible or cost effective. Rail noise mitigated with special track turnout or relocating turnout away from receptors.	Noise increases over existing conditions, especially for receptors close to the highway (BU). Noise decreases some along PDW and at Magazine Beach. Noise wall near Nickerson Field feasible. No feasible mitigation for PDW because of physical constraints. Magazine Beach noise reduced but mitigation not feasible or cost effective. Rail noise mitigated with special track turnout or relocating turnout away from receptors.	Noise increases over existing conditions, especially for receptors close to the highway (BU). Rail viaduct shields PDW and noise decreases. Noise wall near Nickerson Field feasible. No feasible mitigation for PDW because of physical constraints. Magazine Beach noise reduced but mitigation not feasible or cost effective. Rail noise mitigated with special track turnout or relocating turnout away from receptors.	Noise levels at BU receptors should be similar to DEIR alternatives because of proximity to the highway and rail traffic. A noise wall along Nickerson Field would be feasible. Noise from SFR traffic and I-90 will continue to impact receptors along PDW, although constructing the trail on structure along SFR with a profile that is higher than the roadways would reduce noise levels along a portion of PDW. Magazine Beach noise levels would be similar as existing conditions. Noise mitigation is not likely to benefit this area.	Noise levels at BU receptors should be similar to DEIR alternatives because of proximity to the highway and rail traffic. A noise wall along Nickerson Field would be feasible. Shifting SFR traffic away from the Charles River (partially under I-90 viaduct) should reduce noise at PDW receptors, and created green space could support a noise wall along a portion of the length. Magazine Beach noise levels should also be reduced. No further mitigation is likely.	Noise levels at BU receptors should be similar to DEIR alternatives because of proximity to the highway and rail traffic. A noise wall along Nickerson Field would be feasible. Depressing I-90 westbound traffic into a boat section and shifting SFR traffic away from the Charles River and on top of the I-90 boat section should reduce noise at PDW receptors, and created green space could support a noise wall along a portion of the length. Magazine Beach noise levels should also be reduced. No further mitigation is likely.
Effects on visual quality of the riverfront and other open spaces	Vegetation coverage / Vegetation types / Positive or negative man-made elements	"Wall" effect of viaduct is eliminated All vegetation is removed and replaced with retained fill	"Wall" effect of highway Slightly increased space for landscaping between SFR and PDW Little to no change in man-made elements with potential for improved path	"Wall" effect of rail viaduct is shorter than existing No change to river's edge No added vegetation	"Wall" effect of viaduct is eliminated All vegetation is removed and replaced with paved area or cantilevered paved path	"Wall" effect of highway Increased space for landscaping between SFR and PDW Reduced presence of man-made roads in existing parkland area	"Wall" effect reduced with lower viaduct Large increase in space for landscaping between SFR and PDW Increased presence of man-made elements with multiple roads adjacent to parkland Potential for improved PDW man-made facilities
Increases/decreases navigable water sheet area available	Amount of increase/ decrease	Decreases by 481 SF	No Change	No Change	Decreases by 1,760 SF	No Change	No Change
Effects on physical quality of open space and PDW through amenities	Shade / Surface / Furniture	This option does not provide any additional open space. Due to the narrowness of the PDW and with no additional space, furniture or green space is not an option.	Due to the distance between the viaduct and the PDW, shade is not anticipated to be a issue. This option provides the most space for the PDW and green space/buffer.	Shade is not anticipated to be a factor. This option does not provide any additional open space. Due to the narrowness, there is only an opportunity to increase the PDW width by 2 feet.	This option does not provide any additional open space. Due to the narrowness of the PDW and with no additional space, furniture or green space is not an option.	Due to the distance between the viaduct and the PDW, shade is not anticipated to be an issue. This option provides additional space compared to the DEIR Option for the PDW and green space/buffer.	This option is anticipated to have shading impacts due to the proximity of the SFR over I-90 WB viaduct to the PDW. The imapcts should not encorach on the PDW but rather the green space from the rasied structure to the path. This option provides additional space for expanding the PDW or for green space/buffer
Effects on amount of open space in area	# Acres added	Decreases by .66 acres	Decreses by .09 acres	Decreases by .23 acres	Decreases by .61 acres	Increases by .27 acres	Increases by .55 Acres
Effect on quality of riverfront access points	Width / Material / Continuity of neighborhood feel	Low, gradual access across throat. Requires additional space for landing stairs/ramps along river. Barriers along edges.	Very high access across throat with stairs and ramps at both ends. Barriers along edges.	Very high access across throat with stairs and ramps at both ends. Barriers along edges.	Low, gradual access across throat. Requires additional space for landing stairs/ramps along river. Barriers along edges.	Very high access across throat with stairs and ramps at both ends. Barriers along edges.	Medium-high access with stairs and ramps required only along river. Barriers along edges

Table 1.8. ***Resiliency Criteria Matrix***

Resiliency		DEIR Alternatives			IRT Variants		
Criteria	**Measures**	**At-Grade**	**Highway Viaduct**	**Hybrid**	**At-Grade**	**Highway Viaduct**	**Hybrid**
Protects key components of project from flood impacts	# Facilities impacted / Mapping of key components relative to flood elevations	2070 1% flood: Grand Junction Rail and Commuter Rail are not vulnerable. PDW path is vulnerable. 2070 0.1% flood: Grand Junction Rail and Commuter Rail are not vulnerable.	2070 1% flood: Grand Junction Rail and Commuter Rail are not vulnerable. PDW path is vulnerable. 2070 0.1% flood: Grand Junction Rail and Commuter Rail are vulnerable.	2070 1% flood: Grand Junction Rail and Commuter Rail are not vulnerable. PDW path is vulnerable. 2070 0.1% flood: Grand Junction Rail is not vulnerable. Commuter Rail is vulnerable.	2070 1% flood: Grand Junction Rail and Commuter Rail are not vulnerable. PDW path is vulnerable. 2070 0.1% flood: Grand Junction Rail and Commuter Rail are not vulnerable.	2070 1% flood: Grand Junction Rail and Commuter Rail are not vulnerable. PDW path is vulnerable. 2070 0.1% flood: Grand Junction Rail and Commuter Rail are vulnerable.	2070 1% flood: Grand Junction Rail and Commuter Rail are not vulnerable. PDW path is vulnerable. 2070 0.1% flood: Grand Junction Rail and Commuter Rail are not vulnerable.
Addresses stormwater runoff impacts from future rainfall projections	BMPs included / Amount of space available for BMPs / Drainage sized for future projections	BMPs provide 59% phosphorus removal / Constrained space for BMPs / Limited capacity to address future rainfall	BMPs provide 66% phosphorus removal / Substantial space for BMPs / Sufficient capacity to address future rainfall	BMPs provide 59% phosphorus removal / Moderate space for BMPs / Limited capacity to address future rainfall	BMPs anticipated to provide 59% phosphorus removal / Constrained space for BMPs / Limited capacity to address future rainfall	BMPs anticipated to exceed 59% phosphorus removal / Moderate space for BMPs / Sufficient capacity to address future rainfall	BMPs anticipated to exceed 59% phosphorus removal / Moderate space for BMPs / Limited capacity to address future rainfall
Protects highway infrastructure from flood impacts	% Roadway inundated based on future flood projections	2030 1% flood: I-90 and SFR not vulnerable. 2070 1% flood: I-90 is not vulnerable; SFR at BU Bridge and outside the throat is vulnerable 2070 0.1% flood: Large sections of I-90 and SFR (Throat and at BU Bridge) are vulnerable.	2030 1% flood: I-90 and SFR not vulnerable 2070 1% flood: I-90 is not vulnerable; SFR at BU Bridge and outside the throat is vulnerable 2070 0.1% flood: I-90 at BU Bridge Underpass and large sections of SFR (Throat and at BU Bridge) are vulnerable.	2030 1% flood: I-90 and SFR not vulnerable 2070 1% flood: I-90 is not vulnerable; SFR at BU Bridge and outside the throat is vulnerable 2070 0.1% flood: Large sections of I-90 and SFR (Throat and at BU Bridge) are vulnerable.	2030 1% flood: I-90 and SFR not vulnerable 2070 1% flood: I-90 is not vulnerable; SFR at BU Bridge and outside the throat is vulnerable 2070 0.1% flood: Large sections of I-90 and SFR (Throat and at BU Bridge) are vulnerable.	2030 1% flood: I-90 and SFR not vulnerable 2070 1% flood: I-90 is not vulnerable; SFR at BU Bridge and outside the throat is vulnerable 2070 0.1% flood: I-90 at BU Bridge Underpass and large sections of SFR (Throat and at BU Bridge) are vulnerable.	2030 1% flood: I-90 and SFR not vulnerable 2070 1% flood: I-90 is not vulnerable; SFR at BU Bridge and outside the throat is vulnerable 2070 0.1% flood: SFR at BU Bridge Underpass and large sections of I-90 (Throat and at BU Bridge) are vulnerable.
Accommodates FHWA guidance on building of interstate highway in flood plain	Yes/No	Yes	Yes	Yes	Yes	Yes	Yes
Amount of impervious surface created	Amount (acres)	4.90	5.90	5.39	4.95	5.56	3.56

Table 1.9. ***Safety and Operations Criteria Matrix***

Safety and Operations		DEIR Alternatives			IRT Alternatives		
Criteria	**Measures**	**At-Grade**	**Highway Viaduct**	**Hybrid**	**At-Grade**	**Highway Viaduct**	**Hybrid**
Effects on safety for I-90	Presence of safety elements per lane mile / Safety model analysis	10 crashes 0.86 crashes/MVMT No safe place for vehicles to pull out of traffic	11 crashes 0.94 crashes/MVMT	11 crashes 0.94 crashes/MVMT No safe place for vehicles to pull out of traffic	11 crashes 0.94 crashes/MVMT No safe place for vehicles to pull out of traffic	10 crashes 0.86 crashes/MVMT	11 crashes 0.94 crashes/MVMT No safe place for vehicles to pull out of traffic
Effects on safety for SFR	Presence of safety elements per lane mile / Safety model analysis	16 crashes 1.60 crashes/MVMT	13 crashes 1.30 crashes/MVMT	16 crashes 1.60 crashes/MVMT	15 crashes 1.50 crashes/MVMT	17 crashes 1.70 crashes/MVMT	15 crashes 1.50 crashes/MVMT
Effects on operations and maintenance on I-90	Shoulder width / Lane width	Substandard shoulders result in impact to traffic operations and worker safety issues when there is a breakdown or accident; Trench drains full length of throat area or drain inlets every 5-10 feet are required to prevent 10-year storm gutter flow spreading into travel lanes	8-foot shoulders provide safe refuge area for breakdowns and responders; Drain inlets every 190 feet are required to prevent 10-year storm gutter flow spreading into travel lanes	Substandard shoulders result in impact to traffic operations and worker safety issues when there is a breakdown or accident; Drain inlets every 15-20 feet are required to prevent 10-year storm gutter flow spreading into travel lanes	Substandard shoulders result in impact to traffic operations and worker safety issues when there is a breakdown or accident; Trench drains full length of throat area or drain inlets every 5-10 feet are required to prevent 10-year storm gutter flow spreading into travel lanes	8-foot shoulder provides safe refuge area; Drain inlets every 350 feet are required to prevent 10-year storm gutter flow spreading into travel lanes	Substandard shoulders result in impact to traffic operations and worker safety issues when there is a breakdown or accident; Trench drains full length of throat area or drain inlets every 5-10 feet are required to prevent 10-year storm gutter flow spreading into travel lanes
Effects on operations and maintenance on SFR	Shoulder width / Lane width	No opportunity for maintenance vehicles to pull over. Limited snow storage.	Opportunity for maintenance vehicles to pull over. More snow storage.	No opportunity for maintenance vehicles to pull over. Limited snow storage.	No opportunity for maintenance vehicles to pull over. Limited snow storage.	Opportunity for maintenance vehicles to pull over. More snow storage.	No opportunity for maintenance vehicles to pull over. Limited snow storage.
Requires design exception from NHS Design Standards	Y/N	Yes - shoulder, lane	Yes - shoulder	Yes - shoulder, lane	Yes - shoulder, lane	Yes - shoulder, lane, vertical clearance	Yes - shoulder, lane, vertical clearance
ccommodates addition of outside shoulders on I-90	Y/N	2-foot shoulder	8-foot shoulder	2-3-foot shoulder	2-foot shoulder	8-foot shoulder	2-foot shoulder
Allows separation of modes on PDW Path	Level of comfort (width of path / buffer or physical barrier / width of shoulder)	No separation of modes (8.5'). Concrete barrier separation from traffic. Edge of path is 2.5' from travel lane.	No separation of modes (12'). Guard rail and landscaped buffer separation from traffic. Edge of path is 11.5' from travel lane.	No separation of modes (12'). Guard rail separation from traffic. Edge of path is 3' from travel lane.	No separation of modes (8.5' - 12'). Various separation alternatives from traffic (vertical and horizontal). Edge of path is 2.5' from travel lane or vertically separated.	Room for separation of modes (26'). Various option for separation from traffic including guard rail and landscaped buffer. Edge of path is 8'-18' from travel lane.	Room for separation of modes (26'). Various option for separation from traffic including guard rail and landscaped buffer. Edge of path is 20-'30' from travel lane.