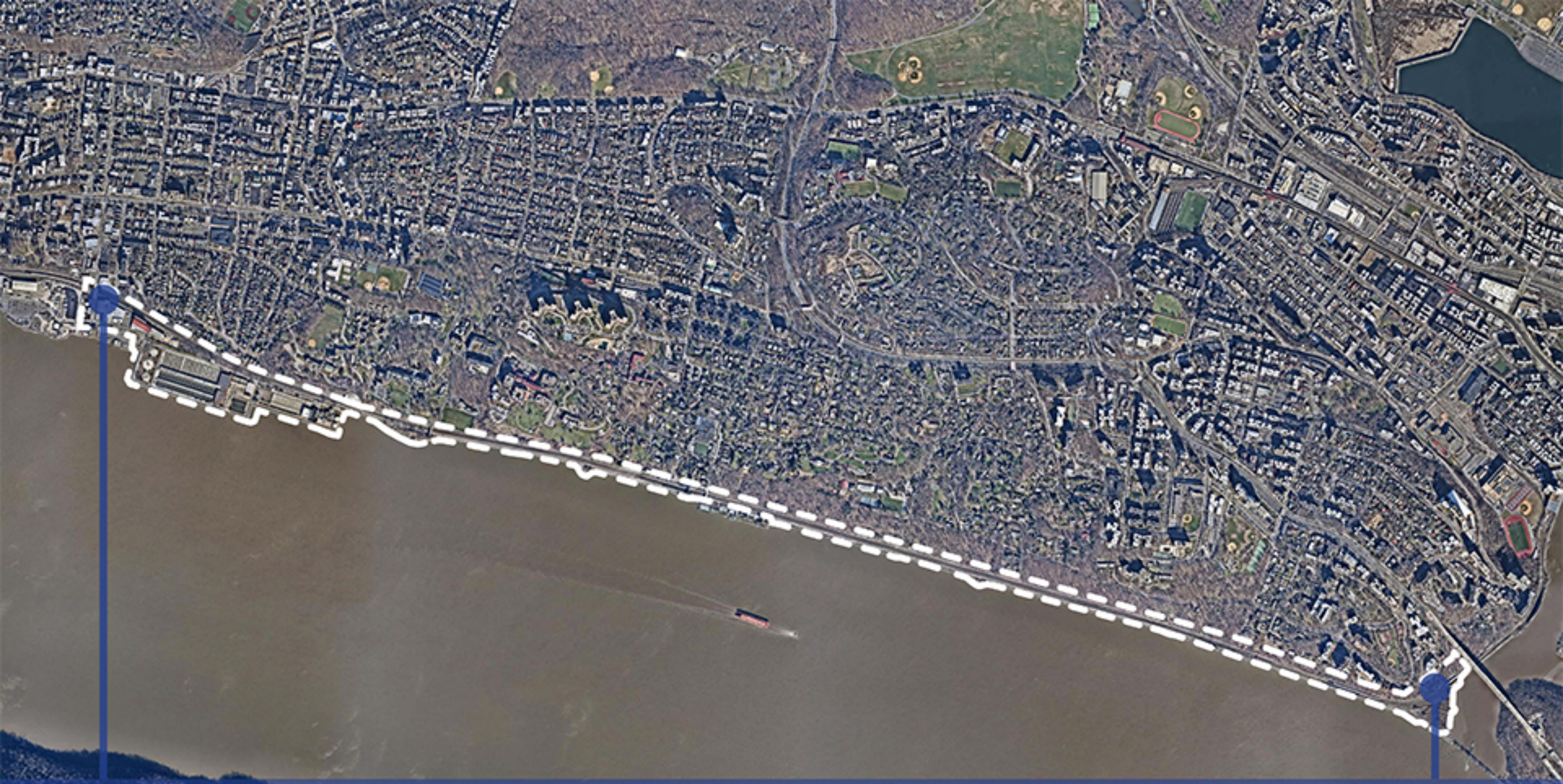


Bronx Greenway

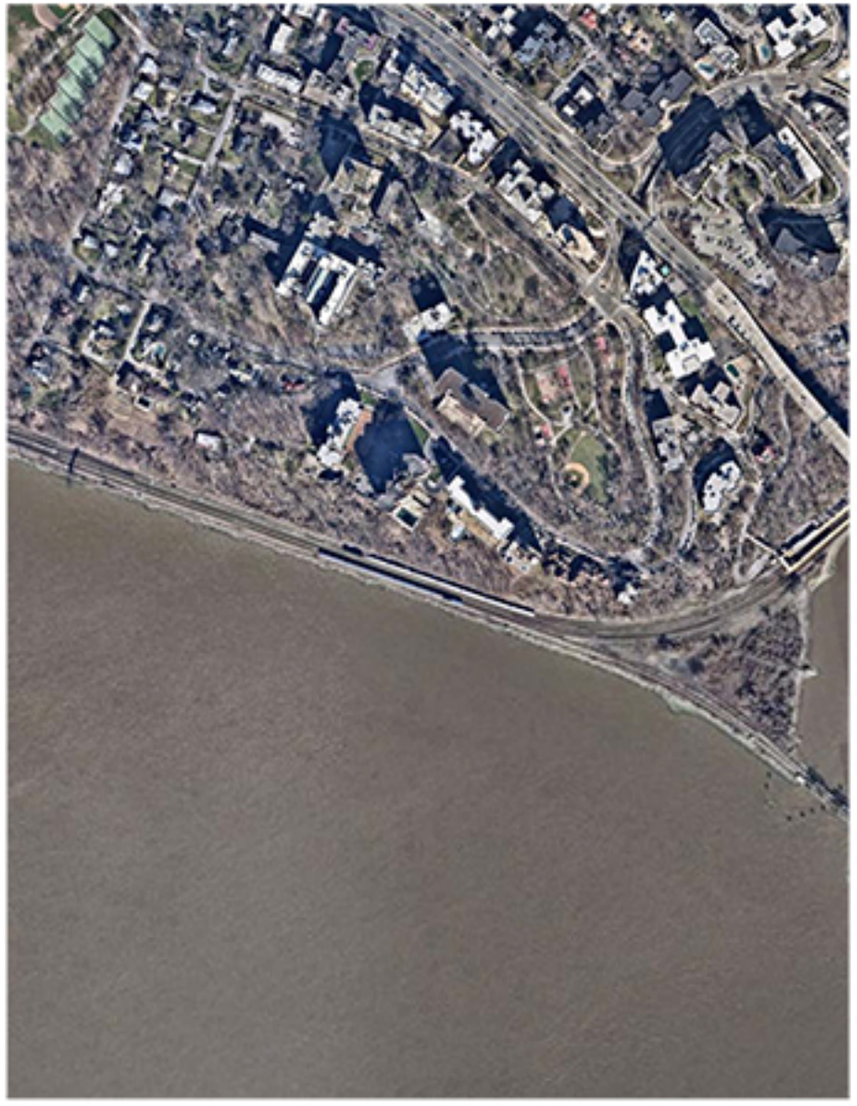
Feasibility Study

Volume 2

March 29, 2018

Metro-North Railroad

Table of Contents



Metro-North Railroad MATRIXNEWORLD Engineering Progress swa/Balsley

The project team would like to thank Bronx Community Board 8 for their support and New York State Senator Jeffrey D. Klein for providing the funding to complete this feasibility study.

INTRODUCTION

Matrix New World Engineering, Land Surveying and Landscape Architecture, P.C. (Matrix) presents Volume 2 of the Bronx Greenway Feasibility Study that investigates the potential for constructing a multi-use recreational trail along the Hudson River in the Bronx and Yonkers, New York. Building on the Existing Conditions Inventory and Preliminary Findings presented in Volume 1 of the Feasibility Study, Volume 2 details the results of the Opportunities and Challenges Assessment associated with potentially constructing a trail along the Hudson River (west of the railroad tracks), as well as summarizes the Evaluation of Feasible Trail Route Alternatives.

This Feasibility Study provides guidance as to the potential for developing a trail in this area, given the complications presented by the riverside location and the proximity to a busy commuter railroad line. No engineering design work was undertaken as part of this Feasibility Study. The ultimate end user/responsible party seeking to develop a proposed trail in this area can use this Feasibility Study as a tool to advance the project to subsequent phases, including undertaking the engineering design efforts necessitated by a project of this scale.

Future efforts to develop a trail in this location would require coordination and approvals from Amtrak, Metro-North Railroad, local community stakeholders and property owners along the potential trail corridor. The ultimate end user/responsible party for the trail would assume responsibility of the operation and maintenance of the trail, including ensuring all safety and security concerns are addressed. To aid in determining the potential funding that may be required to construct a project in this location, estimates of probable construction costs for the feasible trail alignments identified by this study are provided at the end of this Volume.

VOLUME 2, SECTION 1:
OPPORTUNITIES AND CHALLENGES ASSESSMENT

1.0 Opportunities and Challenges

The first step of the feasibility study is to understand what opportunities and challenges the siting of a trail would face in the project area. Several existing factors complicate the proposed siting a trail along the Hudson River shoreline in the area between the Spuyten Duyvil and Ludlow Metro-North stations. The project area is not readily accessible by the general public, due to the presence of the railroad right-of-way. Access to the project area would need to be created as part of any potential trail development. In addition, limited space is available between the railroad tracks and the shoreline to accommodate construction of a trail.

The following Opportunities and Challenges Assessment analyzes the project area against key several factors relevant to developing a trail in this area, including issues related to: safety, security and emergency access; trail user access; sea-level-rise, storm surge and resiliency; permitting and environmental review; design standards; and constructability and maintainability.

1.1 Safety, Security and Emergency Access

Safety, security and providing access for emergency services would be of the utmost concern for a trail sited in the proposed location along Metro-North's busy Hudson Line rail corridor. The development of a trail in this area must ensure the safety and security of Metro-North's customers, employees, and railroad operations. Moreover, the trail must strive to provide an enjoyable experience for trail users and make them feel safe and secure in their surroundings.

In order to promote safety and security at this location, the design of a trail would need to include a defined and consistent buffer that separates trail users from railroad areas and facilities. As discussed in more detail below in Section 1.5, "Design Standards," the design for a proposed trail in this location must incorporate a minimum separation distance of at least 15 feet from the trail to the edge of tie of the closest railroad track. This is the minimum setback distance Metro-North would require for a trail at this location. In addition, fixed railroad infrastructure present along the right-of-way would have to be kept separate from the trail areas. An eight-foot-high, non-scalable security fence would be required to separate the trail from active rail areas (See Photo A01).

Access to the project location is limited due to the railroad tracks separating the proposed trail site (along the Hudson River) from the land to the east. As a result, existing opportunities for potential access by emergency services would be limited. Currently, the only public access to the proposed trail area is via the Riverdale Station to the Riverdale Waterfront Promenade Park. Pedestrians cross one section of track (Track 6) to get to the pocket park located near the Riverdale Station. As discussed further in Section 1.2, "Trail User Access," the successful development of a trail in the project area would require new pedestrian bridges/overpasses created at set locations that could also serve to provide access for emergency services.

The new access points investigated for the project site (See Section 1.2, "Trail User Access") would need to be wide enough to allow, at a minimum, a small vehicle, such as an all-terrain vehicle, to gain access to the trail (See Photo A02). The safety and security of a trail in the proposed area depends on the trail developed with the access points contemplated in Section 1.2, as these access points would provide an efficient, secure and safe means to get to the trail.

If warranted by the magnitude of an emergency situation, the trail could be accessed from the waterside by marine vehicles. If the project were to advance, coordination would be necessary with Metro-North and the New York City Police and Fire Departments to develop an access plan for emergency situations. It is recommended that a minimum of one emergency call box be placed at each access point along the proposed trail and at approximately 1,000 feet of trail between access points.

Photo A01 Example of chain link security fence with mini-mesh

Photo A02 Example of emergency service all-terrain vehicle

1.2 Trail User Access

The overarching guiding principle for identifying locations for trail access is to provide safe and secure access points for potential trail users that would not disrupt Metro-North's operations and maintenance needs. In addition, several key factors were considered to determine potential trail access points, including:

1. Existing infrastructure over the railroad tracks that could be reused or repurposed
2. Land uses present east of the rail corridor
3. Connectivity to existing or planned pedestrian or bicycle facilities east of the rail corridor
4. Topography that may assist in providing the vertical clearance required to cross the tracks
5. Space available west of the tracks to facilitate a landing for an access point

Based on the guidance above, seven trail access points were identified in the study area (See Figures 1.1 and 1.2). The proposed access points are at the following locations:

Photo A03: Potential Spuyten Duyvil Station connection

Photo A04: Example of potential view from "Sky Way" looking south

- Spuyten Duyvil Station - The access at Spuyten Duyvil Station is envisioned as an extension of the existing pedestrian bridge that currently connects to the center platform. The new bridge could extend as a "Sky Way" (See Photos A03 and A04) across the Metro-North tracks and continue west across the Amtrak tracks of the Westside Connection, landing in the space available adjacent to the river (See Photo A03). This potential access point would require property access negotiations and agreements with both Metro-North Railroad and Amtrak.

- West 231st Street - Access at West 231st Street (See Photo A05) could potentially be created by repurposing the remnants of the existing derelict bridge that descended to the river. A landing area would need to be created in the narrow swath of land that exists between the tracks and the river, or a structure over the water would need to be developed to accommodate trail access in this area. In addition, the existing overpass is privately owned (i.e., not owned by Metro-North Railroad) and negotiations would be required with the property owner to grant permission for its use as an access point.

Photo A05: Existing bridge near West 231st Street

Photo A06: Looking northeast at surviving abutments of former pedestrian bridge near Riverdale Park / West 246th Street

- West 246th Street - Proximate to West 246th Street and Palisades Avenue, a link between the Riverdale Park and a potential waterfront trail could be a great opportunity to enhance both recreational spaces. There are existing abutments of a former bridge crossing that could potentially be reused for an access point at this location. In addition, there is a small point formed on the bank of the river that could be used as a landing for an overpass (See Photo A06). This proposed access point would require negotiations with New York City to use a portion of Riverdale Park as an access point to the trail. In addition, Riverdale Park is designated "Forever Wild" and creating a trail access point in this location would need to be compliant with all relevant regulations or restrictions that govern use of the park.

- West 254th Street - There is an existing vehicular bridge that crosses the tracks and serves the Riverdale Yacht Club. A separate access ramp could be developed using the infrastructure of the existing bridge, to provide access to the trail. An investigation of property boundaries and access rights would likely be necessary to develop West 254th Street as an access point for a trail (See Photo A07).

Photo A07: West 254th Street Bridge

- Palisade Avenue/South of Hebrew Home (RiverSpring Health) – The spit of land on the shoreline near this location could be used as a bridge landing making this an attractive location for an access point. However, a trail crossing at this location would be limited by the institutional and residential properties between the railroad right-of-way and Palisade Avenue. Property access negotiations would need to be pursued if this location were considered as a future potential access point (See Photo A08).

- 261st Street – A potential access point at West 261st Street, through the College of Mount Vincent, would achieve the dual purpose of trail access and provide the College with a new recreational amenity. A bridge over the tracks exists at this location, as does a generous landing area west of the bridge (College Point). Negotiations and agreement with the College for access here would

be necessary to take advantage of the opportunities at this location (See Photo A09).

- Ludlow Street - The northernmost access point for the trail could be created via Fernbrook Street to Ludlow Street in Yonkers. Ludlow Street spans over the railroad tracks, serving both vehicles and pedestrians. The trail in this area would use the existing street network to access Ludlow Street and points north of the proposed trail (See Photos A10 and A11).

Most of the proposed access points could be linked to an existing street, walkway or public space with minimal improvements. Proposed access points could take advantage of the raised elevation east of the tracks to enable the necessary vertical clearance required for a trail to cross the railroad tracks. In addition, access points are opportunities to create places of visual interest along a potential trail, as well as beacons that invite users to the new waterfront asset.

Photo A08: Potential Trail Access - Palisade Ave / South of Hebrew Home (Riverdale Spring Health)

Photo A09: College Point Bridge near West 261st Street

Photo A10: Ludlow Street Bridge over Metro-North tracks, looking east

Photo A11: Ludlow Street Bridge over Metro-North tracks, looking west

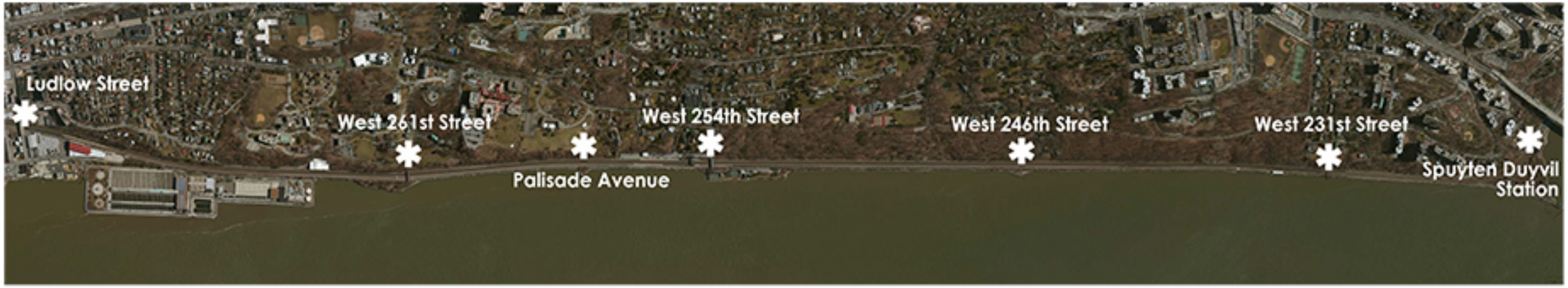
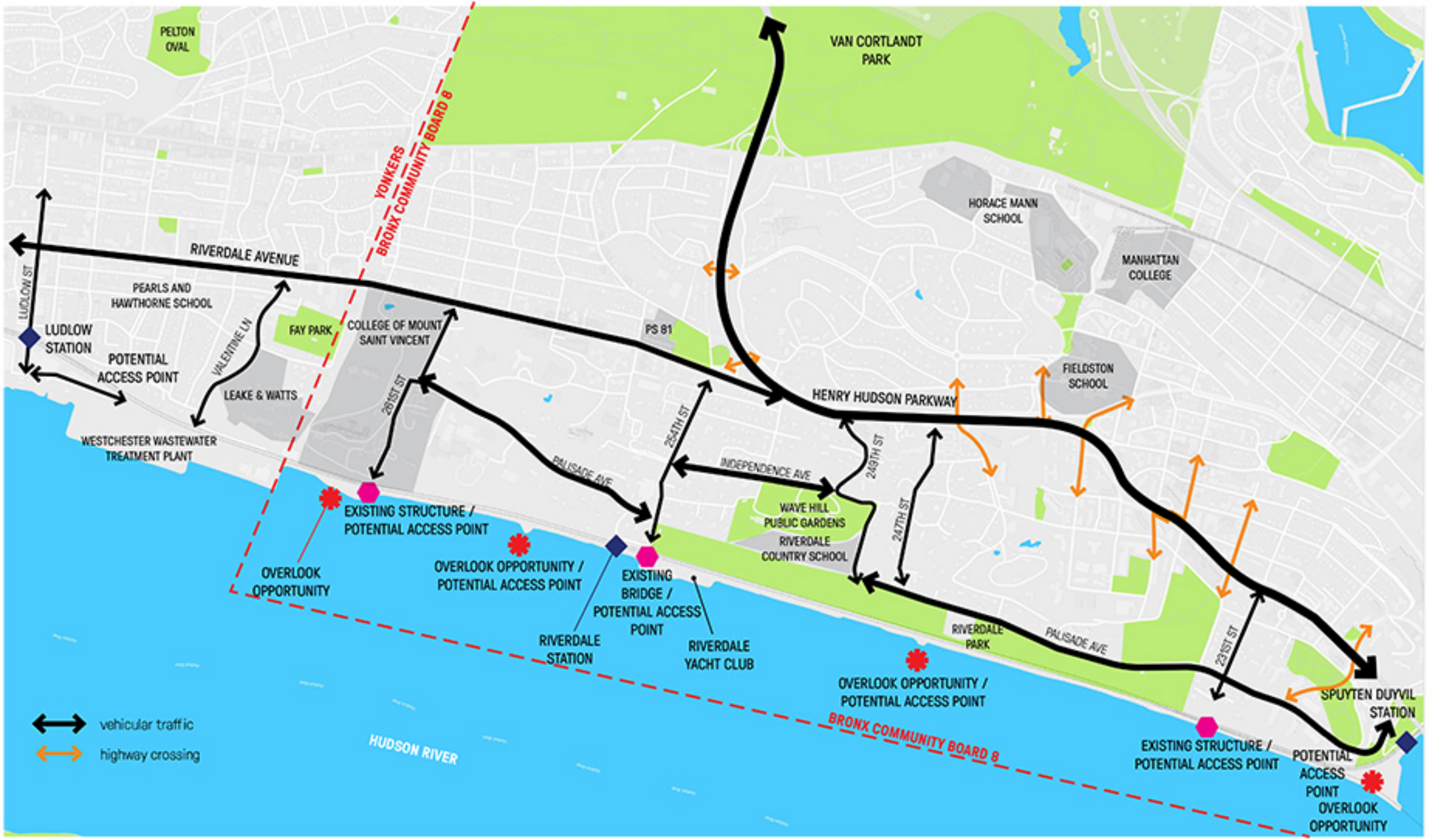


Figure 1.1: Potential Access Points



0 200 400 800 N

FIGURE 1.2: COMMUNITY CONTEXT DIAGRAM

1.3 Sea-Level-Rise, Storm Surge and Flooding

Following the impact from Superstorm Sandy in October 2012, Metro-North Railroad, New York City and New York State have embraced designing resiliency into all capital construction projects to prepare the City's infrastructure to withstand storm and tidal forces from future storm events.

The proposed project, located within the floodplain of the Hudson River, is particularly vulnerable to coastal flooding. Consequently, the area is sensitive to rising sea levels. There are various projections and guidance for sea-level-rise. The New York State Department of Environmental Conservation (NYSDEC) has recently provided ClimAID Sea-Level-Rise Projections for New York City from the 2020s through 2100. Based upon the current projections, the water level can be expected to rise 21-50 inches by 2100. (See Figure 1.3)

Combined with a major storm, similar to Superstorm Sandy, sea-level-rise would increase the potential impacts from coastal flooding substantially. Based upon the guidance from the NYSDEC, and historical data of the water levels observed during Superstorm Sandy, a reasonable design base flood elevation for the area has been recommended to be an elevation of 12 feet. (See Figure 1.4)

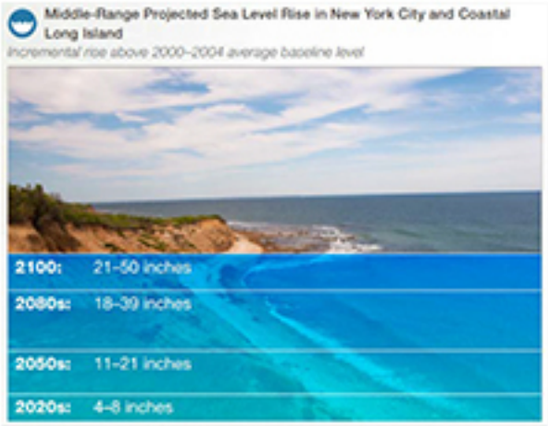


Figure 1.3: ClimAID Sea-Level-Rise Projections (NYC)

The design of the shoreline and walkway must balance providing protection from coastal flooding with producing additional flooding from rain events. Raising the walkway and shoreline provides additional protection from coastal flooding; however, since the stormwater runoff from the existing project area currently drains to the river, a raised shoreline would impede stormwater drainage.

Potential impacts on Metro-North infrastructure must also be considered in the design of the shoreline walkway. The resiliency design of the walkway must account for the possibility of flooding or storm surge events dislodging portions of the walkway and interfering with Metro-North infrastructure and operations. In addition, when determining the height of the walkway to address sea-level-rise, storm surge and flooding, the potential for visual impacts due to a walkway obstructing views for passengers riding along the iconic Hudson Line should also be considered.

Although NYSDEC has provided official guidance for sea-level-rise projections, there are currently no regulations or construction standards in place. The height of the walkway would be a design decision that balances project goals, input from stakeholders (including Metro-North Railroad) and guidance from permitting agencies. Raising the walkway elevation could lower the probability of flooding under unique and severe storm conditions in the future.

There are pros and cons to constructing an elevated walkway along the water in the project area to address issues related to sea-level-rise, storm surge and flooding. Elevated walkway sections can easily be raised by extending the piles that support them. However, raising the walkway elevation would require longer ADA-compliant transition areas between the portions of elevated walkway and any walkway sections that are at-grade. This would result in a higher percentage of the overall walkway length to be constructed with the more expensive elevated walkway sections, adding to cost of the project.

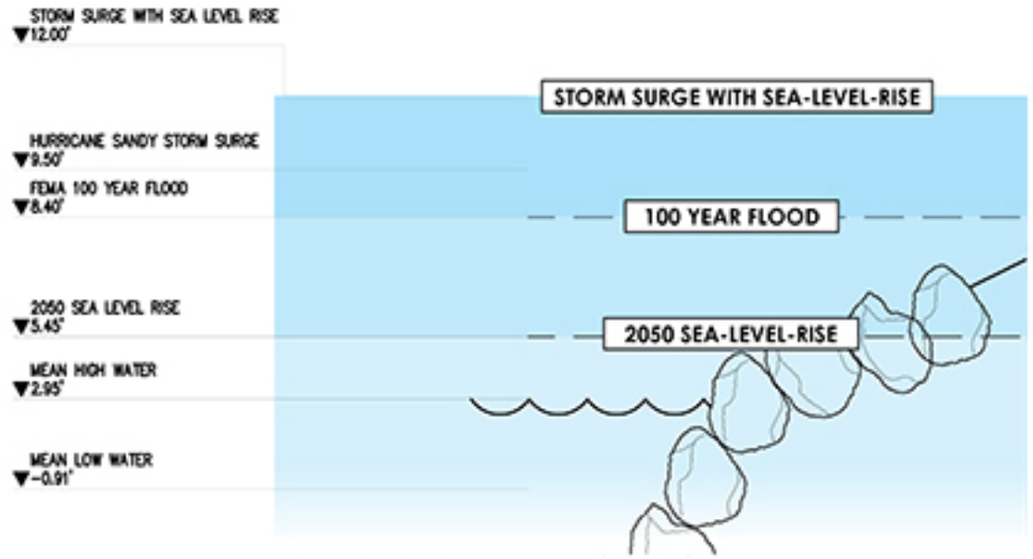


Figure 1.4: Expected sea-level-rise in the project area

Any attempts to raise the elevation of the at-grade walkway sections to address issues related to sea-level- rise, storm surge and flooding would prove to be more difficult. In order to raise the elevation of an at-grade walkway in areas along the water, the revetment slope would need to be expanded, which may not be feasible where the available space for the walkway is limited. The construction costs increase with the height of the walkway, as additional fill will be required. In addition, the stormwater from Metro-North facilities currently slopes gently towards the existing shoreline. Elevating the shoreline would prevent runoff from reaching the river, necessitating special stormwater considerations, such as tide valves or stormwater pump station(s), which would substantially increase the cost of the project.

Unless the walkway is proposed to be constructed entirely from elevated walkway sections, raising the shoreline would increase the cost of the project and may detract from the travel experience and views along Metro-North's Hudson Line. Section 2 of this report provides an assessment of the potential trail types (e.g., elevated, at-grade) that could be implemented in the project area, as well as their associated costs.

1.4 Permitting and Environmental Review

As noted in Volume 1, Existing Conditions and Preliminary Findings for the project, several types of environmentally sensitive resources (ESRs) are mapped as being present within the project area. However, upon closer examination (conducted utilizing literature reviews and field investigations), only a few of the resource types were determined to be present or likely present within the project area. For the purpose of this report, ESRs refer to land and water areas that are either mapped or regulated by government agencies due to their value as habitat for wildlife species. ESRs include: open waters, wetlands, essential fish habitat (EFH) and woodland areas that support rare ecological communities/species. As the multi-use trail is intended to serve as a waterfront walkway and as there is only a narrow area of land along the waterfront, impacts to these resource types would be unavoidable. As impacts to these resources are highly regulated, multiple permits under the jurisdiction of various city, state and federal agencies would be required.

The following regulatory programs and permits would apply to any trail alignment under consideration in the study area:

- United State Army Corps of Engineers (USACE) Section 10 Individual Permit
- New York State Department of Environmental Conservation (NYSDEC) Article 25: Tidal Wetlands Permit
- New York State Office of General Services (NYSOGS) – Lands Now and Formerly Under Water
- NYS Department of State (NYSDOS) – Coastal Consistency Review
- New York City Waterfront Revitalization Program Coastal Consistency Assessment

The extent of impacts, and thus compliance with the various regulatory programs, would vary based on the in-water fill necessary to accomplish any trail alignment in the project area (see Section 3, Evaluation of Trail Route Alternatives).

It is recognized that potential funding sources for the project would likely require the project to undergo environmental review potentially in accordance with National Environmental Policy Act (NEPA); State Environmental Quality Review (SEQR) and New York City Environmental Quality Review (CEQR) processes. The appropriate level of environmental review (i.e. Categorical Exclusion; Environmental Assessment; Environmental Impact Statement) cannot be definitively determined at this point. However, as the proposed trail would not be able to avoid impacts to ESRs, it is likely that either an Environmental Assessment or Environmental Impact Statement would be required.

As any project design would likely not avoid in water fill (see Section 3, Evaluation of Trail Route Alternatives), under the state and federal review processes, mitigation would be required for the filling of open waters to compensate for the resource impacts. Mitigation can be in the form of restoration, enhancement or construction depending on several factors. The mitigation review, approval, construction and monitoring processes are burdensome, time consuming and costly efforts requiring the proper allocation of resources and funding.

1.5 Design Standards

There are no national standards that specifically address the design of multi-use trails proximate to active rail lines. The following sources of trail design guidelines were reviewed and considered while developing design standards for the feasibility study:

- Metro-North Right-of-Way Trail Design Guidelines
- US DOT report FTA-MA-26-0052-04-1 (Rails with Trails – Lessons Learned)
- Guide for the Development of Bicycle Facilities, 4th Edition, AASHTO (2012)
- Cycling for Cities Bikeway Design Guide, NACTO (2011)
- Accommodating Bicycle and Pedestrian Travel: A Recommended Approach, FHWA
- America's Rails-with-Trails, Rails-to-Trails Conservancy (2013)

A study of existing conditions was commenced to review the following primary design standards for opportunities and challenges in the project area:

15' minimum clear maintenance zone between track and separation fence

Throughout the entire trail corridor, a minimum 15-foot-wide buffer zone should be preserved between the edge of the westernmost railroad tie and proposed trail. This buffer would maintain a distance between rail operations and trail users and allow for maintenance vehicles to access the railroad to perform necessary work (See Figure 1.5). In addition to maintaining the 15-foot buffer zone, the actual design of the trail would have to account for the existing and future presence of railroad infrastructure in the project area, including but limited to: cable troughs, conduit trays and equipment platforms.

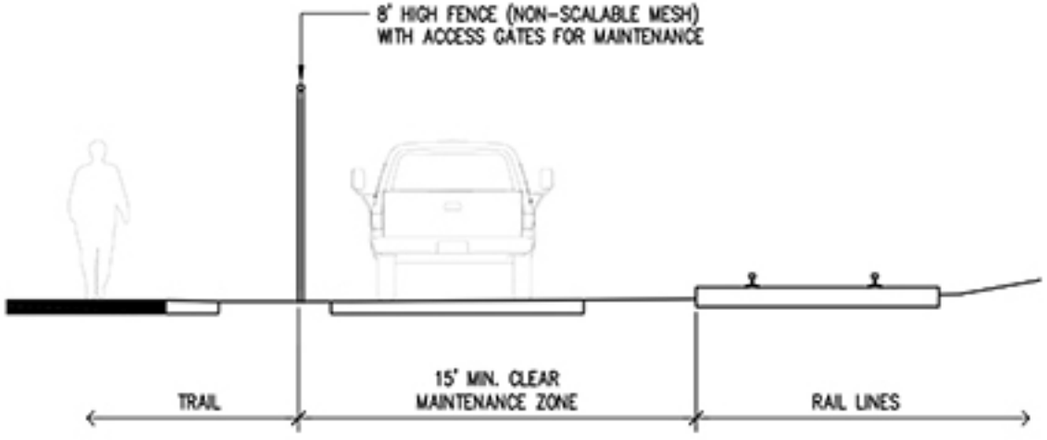


Figure 1.5: Minimum Clear Zone and Separation Fence

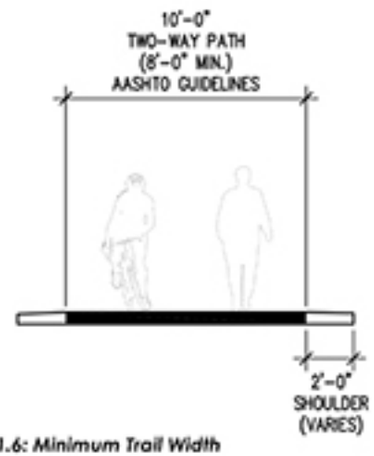


Figure 1.6: Minimum Trail Width

Right-of-way separated from trail with a fence with a minimum height of eight feet

A security fence with a minimum height of eight feet is needed to maintain sufficient separation between the right-of-way and area of the trail (See Figure 1.5 and Photo A01 in Section 1.1). Fences would need to be non-scalable but could include decorative features at periodic points along the trail to create visual interest and draw the trail users' attention away from the rails (See Photos A12-A14 for examples). These decorative fence 'moments' would be limited to access points and overlook areas. The separation fence would have strategically placed gates to allow authorized railroad and emergency personnel to access to both sides of the fence.

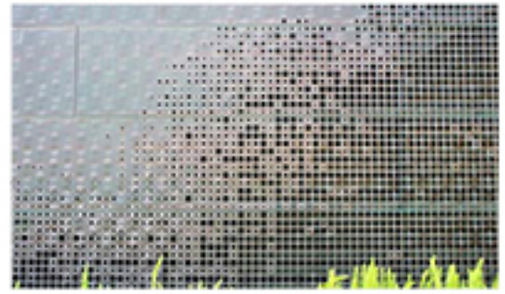


Photo A12: Decorative fence example

Photo A13: Decorative fence example

Photo A14: Decorative fence example

10' two-way trail is the preferred width

A ten-foot wide trail is considered preferable to support two-way bicycle and pedestrian traffic, due to the potential for a significant volume of users at this location (See Figure 1.6). However, an eight-foot wide trail would be acceptable in some constricted locations. The trail should be constructed with a permanent smooth, but slip-resistant finish. Primary surface materials preferred would be concrete or asphalt due to durability and minimal maintenance requirements. Limited feature locations such as overlooks and trail access points could be paved with materials such as unit pavers made from natural stone, concrete or asphalt.

Trail access points

As discussed in Section 1.2 Trail User Access, there are several potential access points for the trail. These entry points can provide a unique opportunity to design spaces and structures that would be attractive and appealing to the user while providing safe and effective conveyance to the trail. Creating these gateways/gathering spaces in the landscape could provide identifying markers for the potential access points along the trail.

1.6 Constructability and Maintainability

There are unique challenges faced by constructing a proposed trail in the project area, due to the limited space available between the busy commuter rail corridor and the Hudson River waterfront. Additional challenges are presented by the site location, including safety and security restrictions and resiliency concerns, which reduce the options available for the construction means and materials to develop a trail in the project area. In addition, many of the concerns regarding the construction of the trail would also have an impact on the maintenance of the proposed trail. It is important to note that the preliminary assessment of constructability and maintainability prepared for this feasibility study was conducted without the benefit of a detailed engineering study.

Construction Methods

Construction of the trail would be limited by the access to the site, and the materials and methods for constructing the trail should take these restraints into consideration, as well as resiliency concerns.

Photo A15: Example of construction of elevated walkway from barge

Photo A16: Example of rip-rap installation from a barge

Photo A17: Example of placement of large rip-rap

Photo A18: Example of concrete installation by barge

The recommended method for delivering equipment and materials to the site is from the Hudson River by barge (See Photos A15 through A18). All construction materials for the trail should be selected based upon resiliency of the trail and potential impact on Metro-North's operations and by the ease of transportation and installation from the waterfront side. In particular, the use of asphalt for the trail is discouraged due to the challenges of delivering it to the project site.

Prefabricated components, such as precast concrete, should be utilized wherever possible to minimize on-site labor. Due to the proximity to the railroad tracks, an allowance for railroad protective services should be considered when estimating the time and expense for the project. Minimizing on-site fabrication would also limit the need for railroad protective services (e.g., flagmen) and expedite construction.

Materials

Recommended materials for the construction of the trail and shoreline protection should include materials typically used for waterfront sites, such as concrete and stone. Quality marine-grade concrete requires minimal maintenance and is recommended for the walkway sections at the project site. The regular maintenance for concrete includes patching spalled concrete and sealing of large cracks.

Revetment stone is a natural product with a functionally unlimited lifespan. Provided the stones are properly sized, the rip-rap should require no maintenance for storm events up to the design storm. In order to maximize the structural stability of the rip-rap, stones should be carefully placed and chinked with smaller stones to lock the individual rock together, forming a single cohesive structure. (See Photos A16 & A17)

Maintenance

Access to the site for maintenance would be limited, similar to the access for construction. In order to prevent high maintenance costs, the design for the walkway should utilize construction materials and details which allow regular long-term maintenance to be performed using the completed trail for access.

Staging and Material Storage

Most material storage and construction staging would occur offsite, as there are few accessible areas suitable for this purpose. On-site storage and staging would be limited to the footprint of the proposed walkway.

VOLUME 2, SECTION 2:
PROPOSED TRAIL TYPES

2.0 Proposed Trail Types

Based on the Opportunities and Challenges Assessment presented in Section 1, three different multi-use walkway types were developed for the potential area of the trail adjacent to the shoreline. The three multi-use trail types developed for the area - Type 1 (On Piers), Type 2 (Built-up Rip-Rap) and Type 3 (Wall) - are presented and discussed in detail below. In addition, a trail type for at-grade portions of the trail (Type 4 – At Grade) not along the waterfront was developed and is presented below.

2.1 Multi-Use Trail Elevated Walkway (Type 1 – On Piers)

The Multi-Use Trail Option Type 1 – On Piers ("Type 1") – See Figure 2.3 on Page 17 - walkway section proposes an elevated walkway, engineered structure designed to span between support foundations of pilings or piers. To provide resiliency from storm surge and flooding, elevated walkways in coastal areas are typically constructed at an elevation above potential floodwaters. The substructure is designed to withstand the impacts of flooding and waves, while the main walkway structure is suspended above the design flood elevation.

Elevated walkways, however, become much more vulnerable to wave action should the walkway be inundated. When the underside of an elevated walkway is exposed to wave action, it can result in large hydrodynamic forces being applied to the bottom of the structure. These wave forces can dislodge the pilings which support the structure or separate the walkway from the substructure, causing failure of the walkway. The proximity to the railroad tracks raises concerns that dislodged pilings or other portions of the walkway could affect critical and vulnerable portions of the railroad infrastructure and right-of-way. Therefore, a deck elevation of 13 feet is recommended to ensure freeboard (1 foot higher than anticipated base flood elevation discussed in Section 1.3) for the walkway sections (See Figure 2.1).

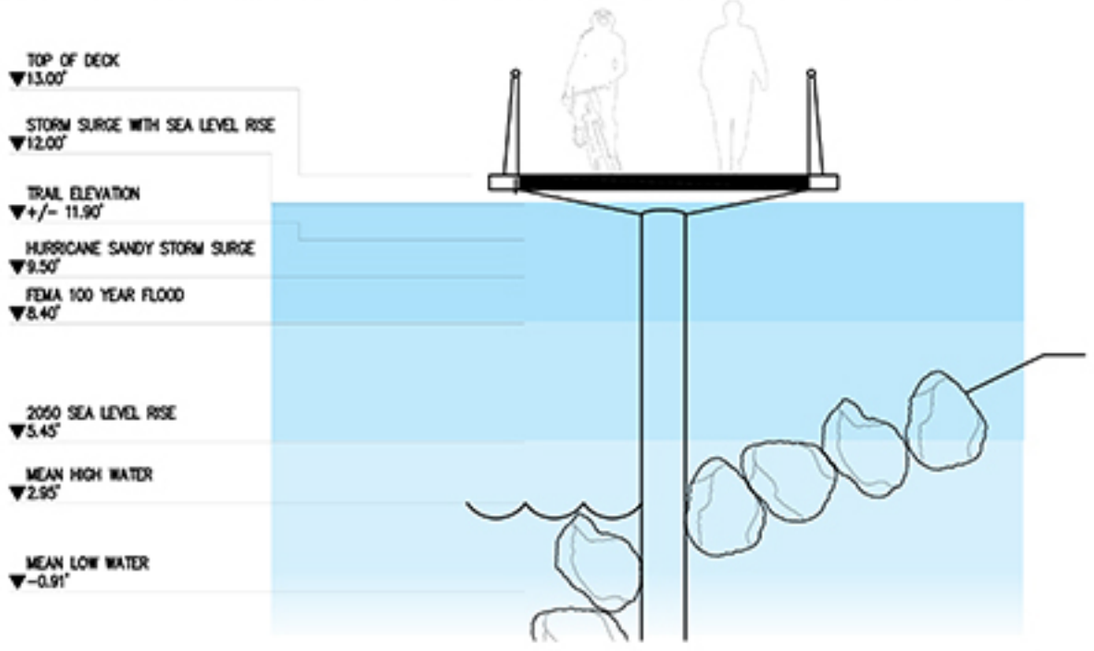


Figure 2.1: Expected sea-level-rise with Type 1 trail

A deck elevation of 13 feet will reasonably account for sea-level-rise while minimizing adverse viewing impacts to riders on the Hudson Line.

The Type 1 walkway section is proposed to be constructed from precast concrete sections supported by concrete caissons. Maintenance of the Type 1 walkway would primarily consist of repairing or replacing sections of the proposed railings from excessive wear or vandalism. Any large cracks in the concrete should be filled and sealed, and any spalled concrete should be patched to reduce further damage.

2.2 Multi-Use Trail At-Grade Walkway (Type 2 - Built-Up Rip Rap)

The Multi-Use Trail Option Type 2 – Built-Up Rip-Rap ("Type 2") – See Figure 2.4 on Page 18 - consists of at-grade walkways behind proposed shoreline protection. If properly constructed, these walkway sections could easily be designed to withstand damage from coastal flooding. Since the walkway is flush with the surrounding earth, the water and waves can overtop the walkway without resulting in high hydrostatic or hydrodynamic uplift forces on the structure of the walkway.

One complication for providing an at-grade walkway in the project area is the limited space available. In order to construct the trail, the shoreline must be properly stabilized to prevent erosion on the waterfront side of the walkway. For safety and security reasons, the proposed trail would have to maintain a sufficient buffer from Metro-North operations and facilities. Due to the location of Metro-North's infrastructure, there is limited space for constructing shoreline protection.

The Type 2 walkway section enhances the existing rip-rap shoreline protection by adding additional stone to the existing revetment slope. The slope and irregular shapes of the revetment stones dissipate energy, providing added protection from waves and storm surge. In addition, revetment stone has a long life-span and requires little maintenance.

The proposed Type 2 walkway section consists of an at-grade concrete walkway behind a rip-rap slope. Maintenance of the Type 2 trail is anticipated to include weed control. The concrete walkways and revetment stone would need to be monitored for any movement or settlement. Should rip-rap stones be dislodged in a storm event, additional stone may need to be placed to prevent erosion or settlement of the walkway. If settlement of the walkway occurs, sections of walkway may need to be removed and replaced. Diligent repair of observed failures would prevent additional damage to the revetment and walkway.

2.3 The Multi-Use Trail At-Grade Walkway (Type 3 – Wall)

With similar advantages as discussed above for Type 2, the Multi-Use Trail Option Type 2 – Wall ("Type 3") – See Figure 2.5 on Page 19- proposes the construction of a concrete wall anchored into the existing rip-rap at the face of the walkway. Less wave energy would be dissipated by the proposed wall as compared to the proposed rip-rap; however, the wall still provides shoreline protection from erosion and undermining of the walkway (See Figure 2.2). The vertical wall allows the walkway to be located much closer to the mean high water level than with a revetment, enabling more flexibility for the walkway alignment, considering the limited space available.

The primary design concern with at-grade walkways for coastal resiliency are waves breaking onto the walkway. For this reason, flexible pavements, like pavers or asphalt, are less ideal because breaking waves can cause movement of the surface, leading to failure.

Concrete is the recommended surface material for the at-grade walkways. The design for the concrete

walkway can be integrated with the design of the shore protection for additional resiliency to wave action. For example, for Type 3 walkway sections, tying the steel reinforcement from the concrete wall to steel reinforcement in the concrete walkway slabs, the waterfront edge of the walkway will be protected from undermining. In addition, large concrete sections have more mass and are structurally superior to flexible pavements, providing additional resistance to displacement from direct wave action.

The proposed Type 3 walkway section is comprised of a concrete vertical wall over the existing rip-rap slope with a concrete walkway behind the proposed wall. The anticipated maintenance for the Type 3 trail includes weed control, sealing of cracks, and patching of spalled concrete. The proposed railing would require maintenance as described above.

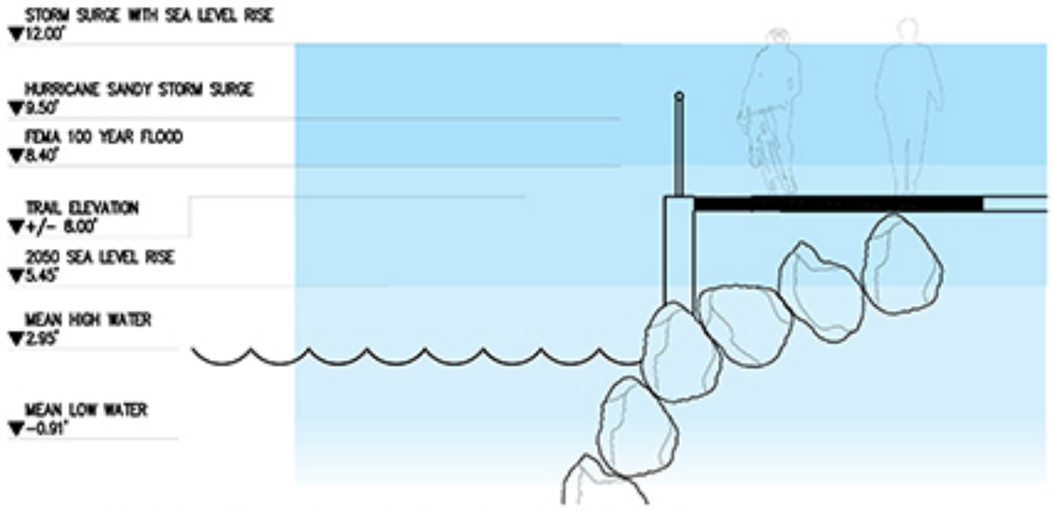


Figure 2.2: Expected sea-level-rise with at-grade trails along the Hudson

2.4 Multi-Use Trail Option (Type 4 – At-Grade)

The Multi-Use Trail Option Type 4 – At Grade ("Type 4") – See Figure 2.6 on Page 20 - consists of an at-grade walkway located along the east side of the Metro-North tracks or at the end of the potential trail as it connects to the street network by Ludlow Station. The locations of the Type 4 walkway are described in more detail below in Section 3, "Evaluation of Trail Route Alternatives." This type of walkway would be constructed of concrete pavement. Most of this walkway type would be located at higher elevations away from the water and waves that could potentially interact with the other walkway types and as such should require less maintenance.

Space to construct this walkway type can be limited by the number of mature trees located along the east side of the tracks. In order to construct the trail, mature trees selected to be preserved could be avoided by adjusting the trail around them. This proposed trail type would also have to maintain a sufficient buffer from Metro-North operations and facilities.

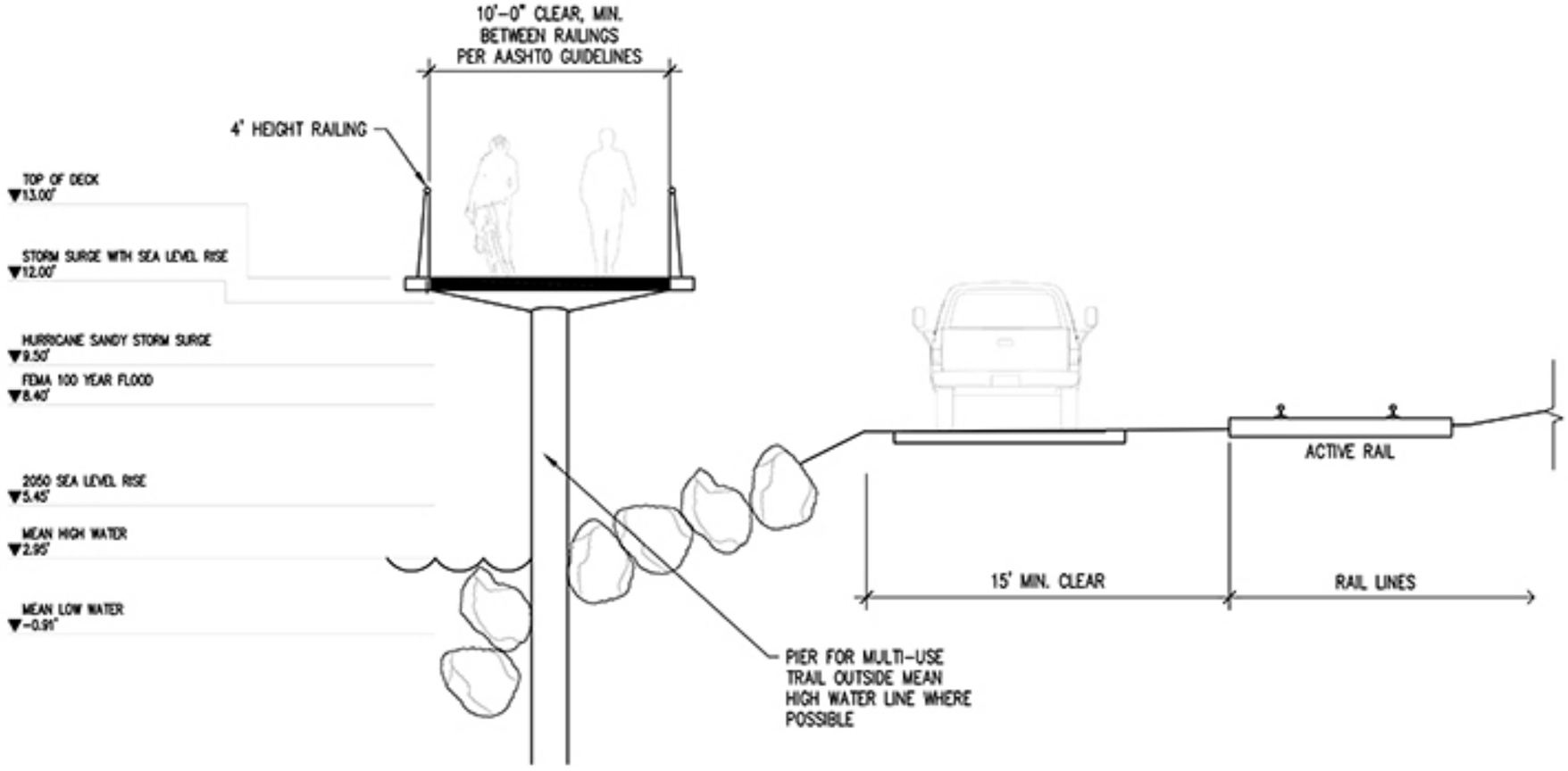
Maintenance of the Type 4 trail is anticipated to include weed control and replacing/patching of the pavement as required. Periodic monitoring of the condition of this walkway type would be required to maintain an optimal trail surface for users.

2.5 Multi-Use Trail Option (Trail Types Construction Cost Estimates)

Providing potential costs for the walkway gives the end user/ responsible party of the trail the ability to forecast the construction of the project. It can also allow them to reach out to funding sources for potential grants. The funding available for the project can dictate what segments may be constructed. Section 3, "Evaluation of Trail Route Alternatives" discusses potential alignments and segments of the trail in further detail.

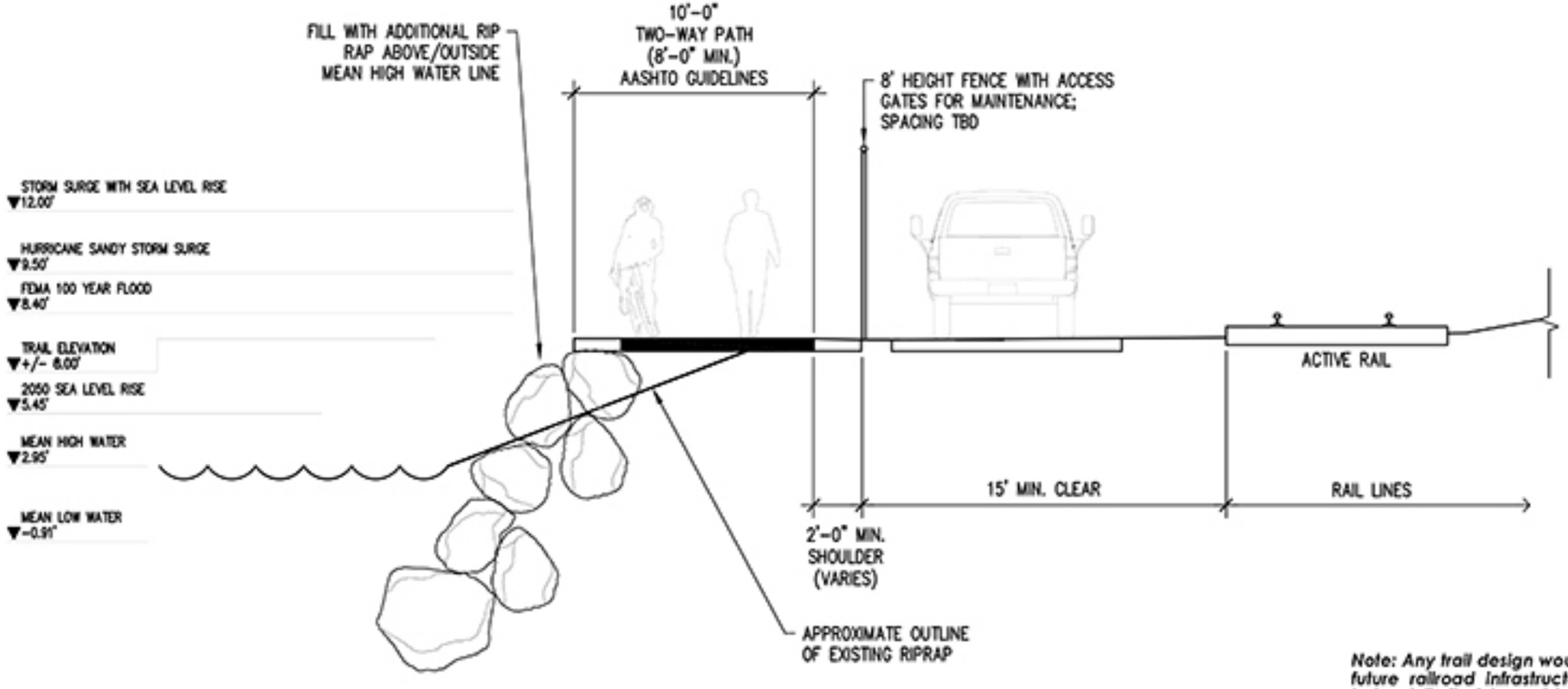
Probable construction costs were developed for each of the four types of walkways anticipated in the study area. The costs depicted in Figure 2.7 are based on the construction of a 20 – foot section of each type of walkway to derive linear foot costs. These linear foot costs were used to provide the estimates for Trail Alignments 1 and 2 and their various options, as described in more detail below in Section 3, "Evaluation of Trail Route Alternatives."

Photo A19: Example of New York City Greenway trail at Riverside Park



Photos shown in this figure are for discussion purposes only

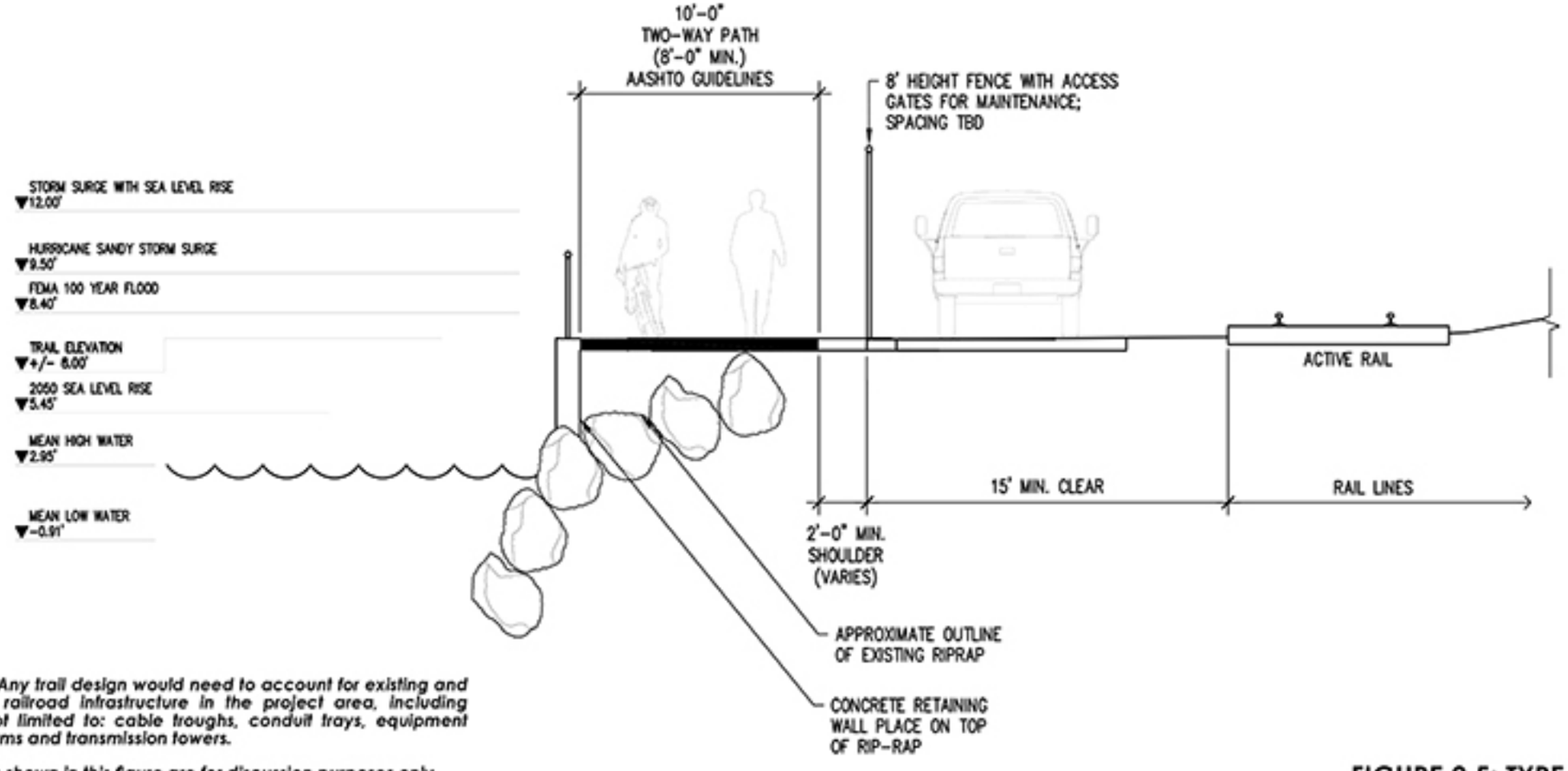
FIGURE 2.3: TYPE 1 TRAIL - BUILT ON PIERS



Note: Any trail design would need to account for existing and future railroad infrastructure in the project area, including but not limited to: cable troughs, conduit trays, equipment platforms and transmission towers.

Photos shown in this figure are for discussion purposes only

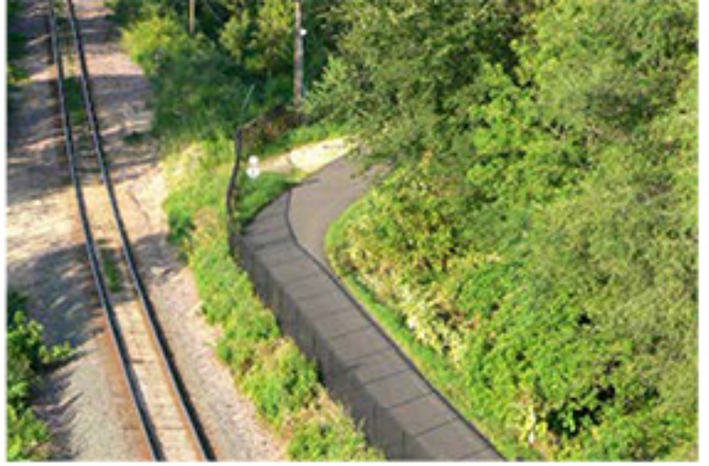
FIGURE 2.4: TYPE 2 TRAIL- BUILT-UP RIP-RAP

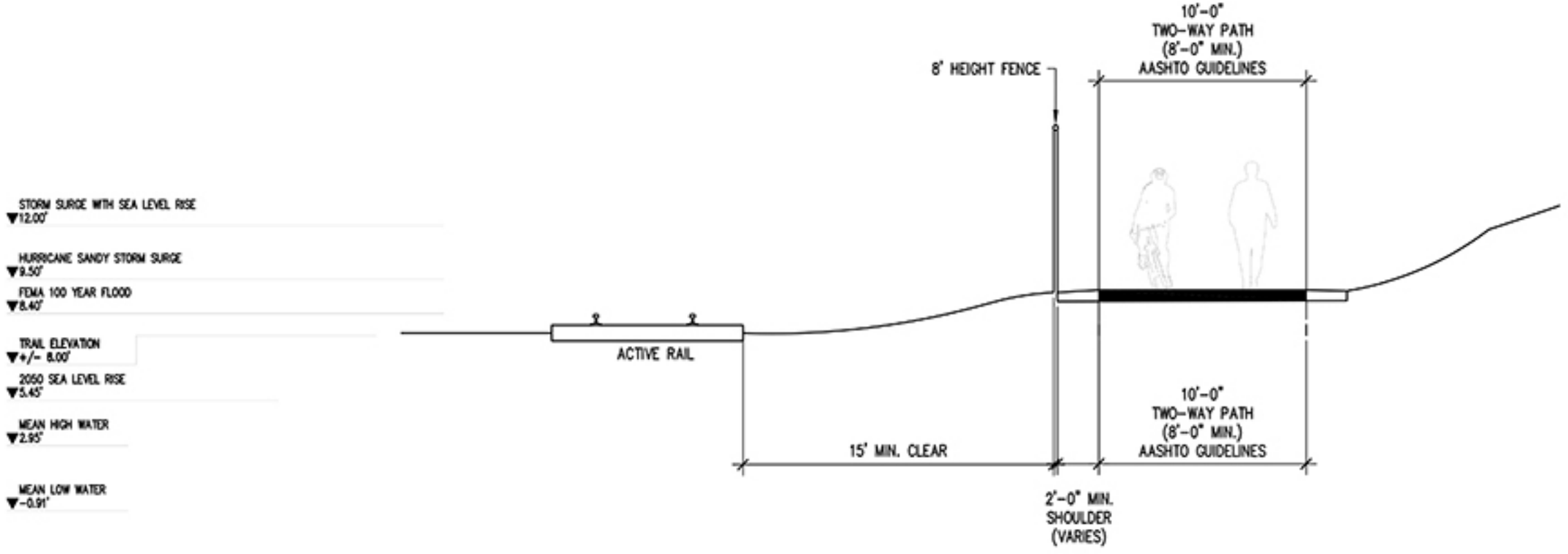


Note: Any trail design would need to account for existing and future railroad infrastructure in the project area, including but not limited to: cable troughs, conduit trays, equipment platforms and transmission towers.

Photos shown in this figure are for discussion purposes only

FIGURE 2.5: TYPE 3 TRAIL - RETAINING WALL



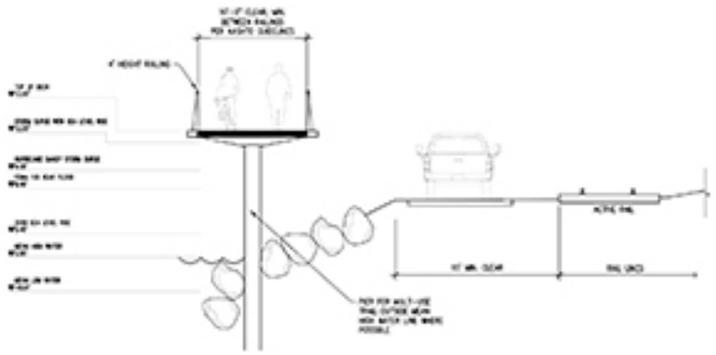


Note: Any trail design would need to account for existing and future railroad infrastructure in the project area, including but not limited to: cable troughs, conduit trays, equipment platforms and transmission towers.

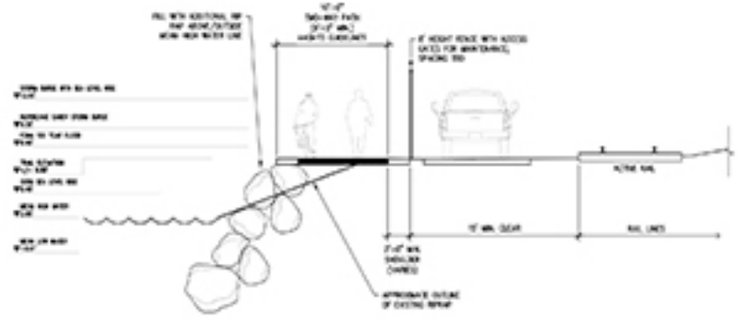
Photos shown in this figure are for discussion purposes only

FIGURE 2.6: TYPE 4 TRAIL - AT GRADE

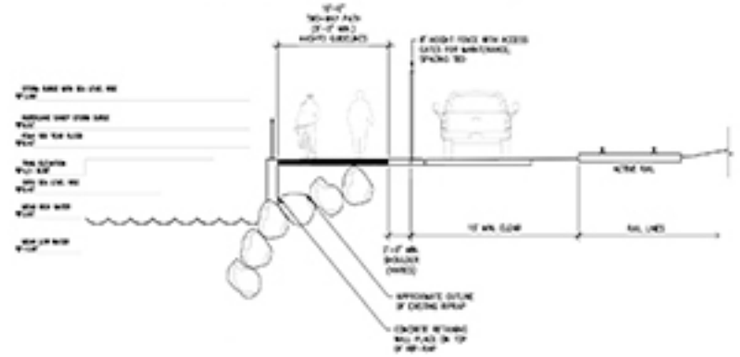
TYPE 1 - BUILT ON PIER (20 FT SECTION)				
CONCRETE PILES (30" DIA)	UNIT	1	$25,000.00	$25,000.00
CONCRETE	CUBIC YARDS	8	$2,000.00	$16,000.00
4' RAILING	LINEAR FOOT	40	$300.00	$12,000.00
			SUBTOTAL	$53,000.00
			10% CONTINGENCY	$5,300.00
			TOTAL FOR 20 FT SECTION	**$58,300.00**
			TOTAL PER LF	**$2,920.00**



TYPE 2 - BUILT-UP RIP-RAP (20 FT SECTION)				
CLEAN FILL	CUBIC YARDS	12	$120.00	$1,440.00
RIP-RAP	TONS	27	$130.00	$3,510.00
4" DENSE-GRADED AGGREGATE	SQUARE YARDS	29	$20.00	$580.00
CONCRETE WALKWAY	SQUARE YARDS	27	$150.00	$4,000.00
CHAIN-LINK FENCE	LINEAR FOOT	20	$80.00	$1,600.00
			SUBTOTAL	$11,130.00
			10% CONTINGENCY	$1,113.00
			TOTAL FOR 20 FT SECTION	**$12,243.00**
			TOTAL PER LF	**$620.00**



TYPE 3 - RETAINING WALL (20 FT SECTION)				
CLEAN FILL	CUBIC YARDS	15	$120.00	$1,800.00
CONCRETE WALL	CUBIC YARDS	4	$1,500.00	$6,000.00
4" DENSE-GRADED AGGREGATE	SQUARE YARDS	29	$20.00	$4,000.00
CONCRETE WALKWAY	SQUARE YARDS	27	$150.00	$4,000.00
4' RAILING	LINEAR FOOT	20	$300.00	$6,000.00
CHAIN-LINK FENCE	LINEAR FOOT	20	$80.00	1,600.00
			SUBTOTAL	$19,980.00
			10% CONTINGENCY	$1,998.00
			TOTAL FOR 20 FT SECTION	**$21,978.00**
			TOTAL PER LF	**$1,100.00**



TYPE 4 - AT GRADE (20 FT SECTION)				
4" DENSE-GRADED AGGREGATE	SQUARE YARDS	29	$20.00	$580.00
CONCRETE WALKWAY	SQUARE YARDS	27	$150.00	$4,000.00
CHAIN-LINK FENCE	LINEAR FOOT	40	$80.00	$3,200.00
			SUBTOTAL	$7,780.00
			10% CONTINGENCY	$778.00
			TOTAL FOR 20 FT SECTION	**$8,558.00**
			TOTAL PER LF	**$430.00**

Note: Engineer's estimate of probable Construction Cost is based on a feasibility study and not based on any design work and excludes any and all potential soft costs, including railroad support costs. Engineer's opinion of probable Construction Cost is made on the basis of Engineer's experience and qualifications and represent Engineer's best judgment as an experienced and qualified professional engineer generally familiar with the construction industry. However, since Engineer has no control over the costs of labor, materials, equipment, or other services furnished by others, or over the Contractor's methods of determining prices, or over competitive bidding and market conditions, Engineer cannot and does not guarantee that proposals, bids, or actual Construction Cost will not vary.

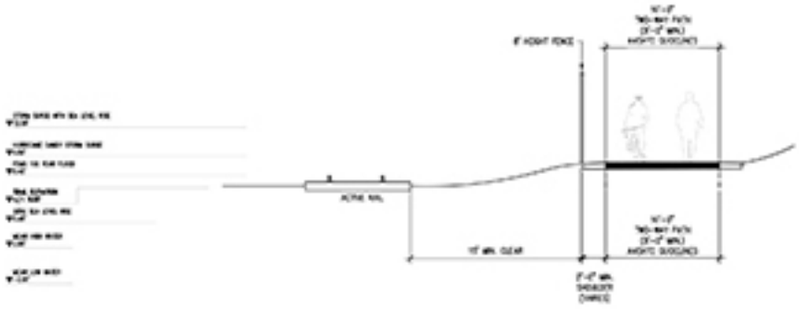


FIGURE 2.7: TRAIL TYPE CONSTRUCTION COSTS

VOLUME 2, SECTION 3:
EVALUATION OF TRAIL ALTERNATIVES

3.0 Evaluation of Trail Route Alternatives

In Section 3, Evaluation of Trail Route Alternatives, two overall potential Trail Alignments (Trail Alignment 1 and Trail Alignment 2) are presented. These Trail Alignments are comprised of a series of segments developed using the four trail types discussed and shown in Section 2, Proposed Trail Types (i.e., Type 1- On Piers, Type 2 - Built-up Rip Rap, Type 3 - Retaining Wall, Type 4 - At Grade). The selection of the Trail Alignments is based on the project area limitations and conditions identified along the approximately 3-mile project area from Spuyten Duyvil Station to Ludlow Station.

The proposed routes for Trail Alignment 1 and Trail Alignment 2 are depicted in Maps 1.1-1.3 and Maps 2.1-2.3. There are route segments within each alignment developed to address route options for the unique challenges and limitations found in the project area. The ultimate end user/responsible party who would develop, own and operate the walkway would have the option of selecting trail segments, under either trail alignment alternative, which best meet their project goals.

Each Trail Alignment is described in detail below and corresponds to the Maps at the end of this Section. Order of magnitude construction cost estimates are provided for each Trail Alignment and its route alternatives.

3.1 Trail Alternatives

Trail Alignment 1

Under Trail Alignment 1, the entirety of the proposed trail would be constructed using the Multi-Use Trail Option Type 1 – On Piers (Type 1) elevated walkway (See Figure 2.3 for an example of the Type 1 walkway). This alignment alternative is the more expensive alignment of the two trail alignments considered in this report, as it is on piers for much of its entire length and a good portion of the walkway is built in the water. However, despite its higher cost, there are many advantages to Trail Alignment 1 that make it a feasible option for the project area. Maps 1.1-1.3 show Trail Alignment 1.

One of the primary challenges faced in determining a feasible route for a multi-use trail in the project area is the limited space available along the shoreline, due to the location of the railroad tracks and its critical ancillary infrastructure and equipment near the bank of the Hudson River. Further, in order to ensure access for maintenance, public safety, and security there would need to be a minimum setback distance from the railroad infrastructure for any trail constructed in the project area (see Section 1.5 Design Standards).

Given the limited space available in the project area, the advantage of Trail Alignment 1 is that the elevated trail would be located in the water and be independent of the shoreline. As a result, the design of this alignment would not have to maintain a minimum setback distance or address changes in the shoreline landscape. Moreover, Trail Alignment 1 would be installed at an elevation above expected levels of sea-level-rise and storm surge predictions, improving the resiliency characteristics of the walkway and protecting the adjacent railroad from potential damage.

There is one location in the project area where an elevated walkway in the water is not considered feasible – the shoreline area west of the Riverdale Yacht Club. The Riverdale Yacht Club would likely object to the placement of a walkway in this area as it would impede its water access, a core purpose of the yacht club.

Further complicating the design of a trail in this location is the insufficient space available to construct a walkway in the area east of the Riverdale Yacht Club and west of the railroad tracks. The setback distance from the railroad tracks required by Metro-North's design standards (see Section 1.5 Design Standards) preclude developing a trail in the limited area available east of the Riverdale Yacht Club. To construct a walkway in this location, the trail would have to be partially or fully located within the eastern edge of the Riverdale Yacht Club property. This would require an easement or other access agreement with the yacht club to use their property for this section of the trail.

A potential option to address the constraint posed by the Riverdale Yacht Club would be to locate the trail east of the railroad tracks, on the western boundary of Riverdale Park. The proposed trail could cross the tracks by repurposing an existing bridge abutment (See Map 1.1) and continue north along the western edge of the park, approximately 3,500 feet to Riverdale Station. The trail portion along the western side of Riverdale Park would use the Multi-Use Trail Option Type 4 – At-Grade (Type 4) walkway (See Figure 2.6 in Section 2 for an example of the Type 4 walkway).

To demonstrate the various options for Trail Alignment 1, the project area has been divided into several segments. The first segment of Trail Alignment 1 is shown on Map 1.1 as Segment 1A, connecting the proposed trail access point at Spuyten Duyvil Station to an area approximately around West 246th Street. At this point, Trail Alignment 1 has the option to cross east, over the railroad tracks, to avoid the Riverdale Yacht Club, shown as Segment 1B on Maps 1.1 & 1.2. Segment 1C shows the route Trail Alignment 1 would take if it were to use portions of the east side of the Riverdale Yacht Club's property, see Maps 1.1 & 1.2.

North of the yacht club constraint, the next segment of Trail Alignment 1 is Segment 1D, extending from approximately West 254th Street to West 261st Street (as shown in Map 1.2). The trail could terminate at West 261st Street, taking advantage of the overpass present at this location, and avoid the pinch point created by the Westchester County Waste Water Treatment Plant in the project area (as shown on Maps 1.2 & 1.3). If the trail were to continue north to Ludlow Station, the final segment would be Segment 1E, routed around the western edge of the treatment plant, and returning users to the local street network via Fernbrook and Ludlow Streets, in the Ludlow section of Yonkers (See Maps 1.2 & 1.3).

Trail Alignment 2

For Trail Alignment 2, the trail would be primarily constructed by a combination of Multi-Use Trail Options Type 2 - Built-Up Rip-Rap (Type 2) and Type 3 - Wall (Type 3) walkway. In the areas where Type 2 and Type 3 walkways would not be feasible, the Type 1 walkway would be used. Relative to Trail Alignment 1, this alignment alternative would be the lesser expensive of the trail options considered in this study. See Figures 2.4 & 2.5 in Section 2 for an example of the Type 2 and Type 3 walkways.

The Type 2 walkway is proposed for Trail Alignment 2 where sufficient land area is available. The advantage of the Type 2 walkway is it is the least expensive and has the longest lifespan of all walkway types considered for the project area. The disadvantage of the Type 2 walkway is it requires the most land area for the installation of the enhanced rip-rap slope.

Where space available is limited to fit the trail on the shoreline, the Type 3 walkway is proposed. This walkway section is also less expensive compared to the Type 1 walkway, but more expensive than the Type 2 walkway. Unlike the Type 2 walkway, the Type 3 walkway can be built vertically from the edge of the water, necessitating less space (compared to Type 2).

Trail Alignment 2 cannot be constructed solely by a combination of the Type 2 and Type 3 walkways. There are areas where the Type 1 walkway must be used, due to insufficient space available and to transition to access points for the trail that cross over the tracks. The Spuyten Duyvil station access point is a good example of this transition area (See Maps 1.1 & 2.1). The trail must cross two sets of tracks to get to the shoreline. This can only be accomplished by constructing bridges over both the Metro-North

and Amtrak tracks in this area. The height of the bridges would not allow another type of trail to be constructed except Type1.

To demonstrate the various options for Trail Alignment 2, the project area has been divided into segments. The first segment of Trail Alignment 2 is shown on Map 2.1 as Segment 2A and connects the proposed trail access point at Spuyten Duyvil to a point just south of West 231st Street. As Trail Alignment 2 is constructed primarily using the Type 2 and Type 3 walkway options on the landside of the shoreline, the alignment is complicated by the existing overhead power feeders that run approximately from Metro-North's traction power Substation A-12 to the area just south of the Riverdale Yacht Club. One option, shown as Segment 2B on Map 2.1, would be to stay west of the overhead power feeders by using a combination of Type 1 and Type 3 walkways. Another option to address the constriction created by the overhead power utilities in this area, is to relocate the utilities underground, creating additional space for the construction of the walkway. In this option, shown as Segment $2B_1$ on Map 2.1, the reliance on the more expensive Type 1 walkway to get around the overhead power feeders would be reduced, and a significant portion of the trail could be constructed using the Type 2 walkway.

Trail Alignment 2 shares the same constriction issue at the Riverdale Yacht Club location, as discussed above for Trail Alignment 1. Thus, similar to Trail Alignment 1, a potential option for Trail Alignment 2 is to cross the railroad tracks and follow the western edge of Riverdale Park to avoid the constraint posed by the Riverdale Yacht Club. This is shown as Segment 2C on Maps 2.1 & 2.2, the less feasible option of using a portion of the yacht club's property under Trail Alignment 2 is shown on Maps 2.1 & 2.2 as Segment 2D.

The combination of trail types used in Segment 2D is dependent on if the trail route can take advantage of the option to bury the power feeder cable. If the overhead power feeders remain, the trail would follow Segment 2D, if the power cable were buried, the trail would follow Segment $2D_1$ (See Maps 2.1 & 2.2). The trail portion along the western side of Riverdale Park would use the Multi-Use Trail Option Type 4 – At-Grade (Type 4) walkway (See Figure 2.6 for an example of the Type 4 walkway).

After the yacht club constraint, the next segment of Trail Alignment 2 is Segment 2E, extending from approximately West 254th Street to West 261st Street (as shown in Maps 2.2 & 2.3). The trail could terminate at West 261st Street, taking advantage of the overpass present at this location, avoiding the pinch point created by the Westchester County Waste Water Treatment Plant in the project area (as shown on Map 2.3). If the trail were to continue north to Ludlow, the final portion would be Segment 2F, routed around the western edge of the treatment plant, and returning users to the local street network via Fernbrook and Ludlow Streets, in the Ludlow section of Yonkers (See Map 2.3).

3.2 Estimated Probable Costs of Construction for Alternatives

Based on the Opportunities and Challenges Assessment of the project area, four trail types were developed for the walkway from Spuyten Duyvil to Ludlow. These four trail types are discussed in detail in Section 2, "Proposed Trail Types" and are shown in Figures 2.3-2.6 and the estimates of each of the four walkway types are presented in Figure 2.7 of Section 2. These estimates for the four walkway types were used to estimate the construction cost of Trail Alignment 1 and Trail Alignment 2 and the various segment options, as described in more detail below and shown in Figures 3.1-3.3.

The construction cost estimates shown in Figures 3.1-3.3 include the construction cost for the access points and bridges that would be required for the trail. However, it is important to note that the construction costs presented below and in Figures 3.1-3.3 do not include "soft costs." Examples of "soft costs" include (but not limited to) the costs associated with design, property acquisition, permitting, railroad support, and project/contract management. Typically, "soft costs" can represent an additional 25-30 percent to the construction cost for a project of this magnitude, depending on the complexity of the project. Furthermore, this study presents order of magnitude construction cost estimates that are based on study concepts only and not any level of engineering design.

Estimated Construction Costs of Trail Alignment 1

As discussed in Section 3.1, "Trail Alternatives," Trail Alignment 1 has several options and for this reason is divided into five segments (Segments 1A, 1B, 1C, 1D, 1E). Each segment has a corresponding construction cost estimate. This segmented approach allows the ultimate end user/responsible party of the trail to determine the route, by segment, that fit best their goals and objectives for a potential walkway in the project area. The selected route can then be estimated by adding up the estimated construction cost for each segment of Trail Alignment 1.

For example, if Trail Alignment 1 is routed from the Spuyten Duyvil Station to West 246th Street (Segment 1A), avoids the constriction point in the project area created by the Riverdale Yacht Club by crossing the railroad tracks to use a portion of Riverdale Park (Segment 1B) and proceeds to West 261st Street (Segment 1D), the construction cost of Trail Alignment 1 would be approximately $68M (absent soft costs). If Trail Alignment 1 were to stay west of the tracks and use a portion of the property of the Riverdale Yacht Club (Segment 1C) instead of crossing the tracks (i.e., not following Segment 1B), the construction cost of Trail Alignment 1 would increase to approximately $79M. Under either of these two options for Trail Alignment 1, continuing past West 261st Street to Ludlow Street in Yonkers (Segment 1E) would add approximately $17M to the construction cost of the project.

The varying construction cost of the options for the segments of Trail Alignment 1 are shown Figure 3.1. The "soft costs" mentioned previously would add approximately 25-30 percent to the construction costs shown in Figure 3.1.

Estimated Construction Costs of Trail Alignment 2

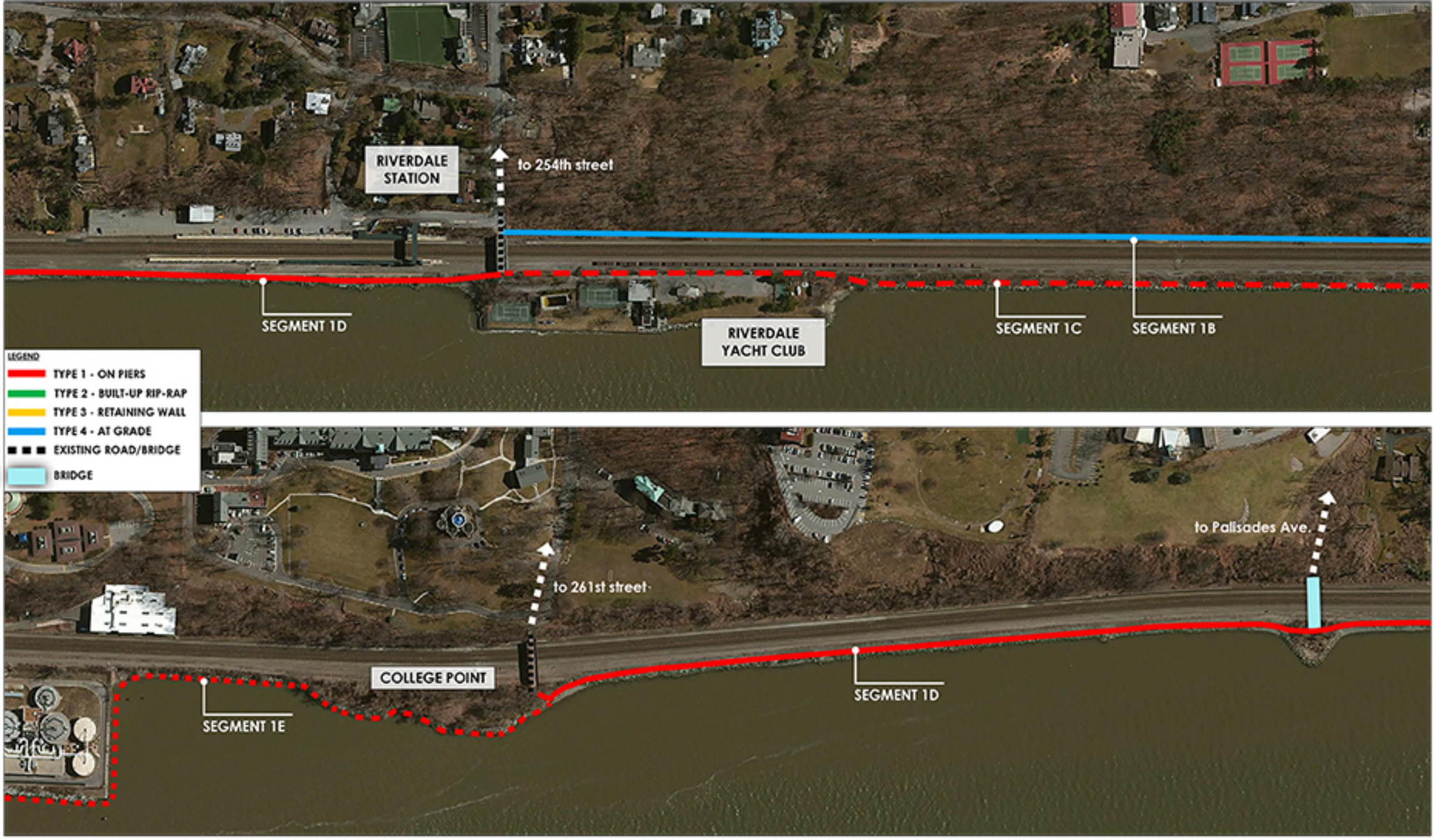
As discussed in Section 3.1, "Trail Alternatives," Trail Alignment 2 has several options and is divided into several segments (Segments 2A, 2B, $2B_1$, 2C, 2D, $2D_1$, 2E, 2F). Each segment has a corresponding construction cost estimate. This segmented approach allows the ultimate end user/responsible party of the trail to determine the route, by segment, that fit best their goals and objectives for a potential walkway in the project area. The selected route can then be estimated by adding up the estimated construction cost for each segment of Trail Alignment 2.

For example, if the trail would span from the Spuyten Duyvil Station to just south of West 231st Street (Segment 2A), run west of the overhead power feeders (Segment 2B), avoid the constriction point in the project area created by the Riverdale Yacht Club by crossing the railroad tracks to use a portion of Riverdale Park (Segment 2C) and proceed to West 261st Street (Segment 2E), the construction cost of Trail Alignment would be approximately $60M (absent soft costs). Continuing past West 261st Street to Ludlow Street in Yonkers (Segment 2F) would add approximately $14M to the construction cost of the project.

The varying construction cost of the options for the segments Trail Alignment 2 are shown in Figures 3.2-3.3. The tables show the construction cost difference by segment for the option to stay west of the overhead power feeders or bury the power cable. The "soft costs" mentioned previously would add approximately 25-30 percent to the construction costs shown in Figures 3.2-3.3.

Metro-North Railroad | MATRIXNEWORLD Engineering Progress | swa/Balsley | 0 100

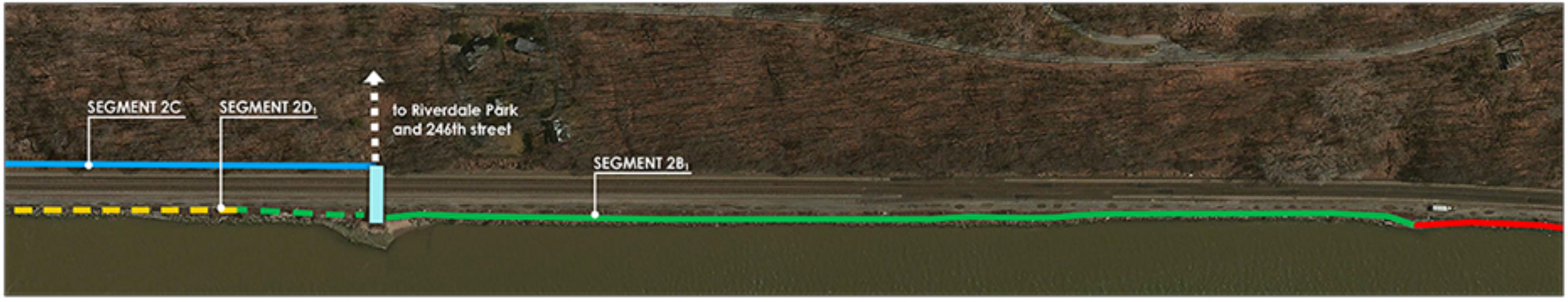
ALIGNMENT 1 | 1.1



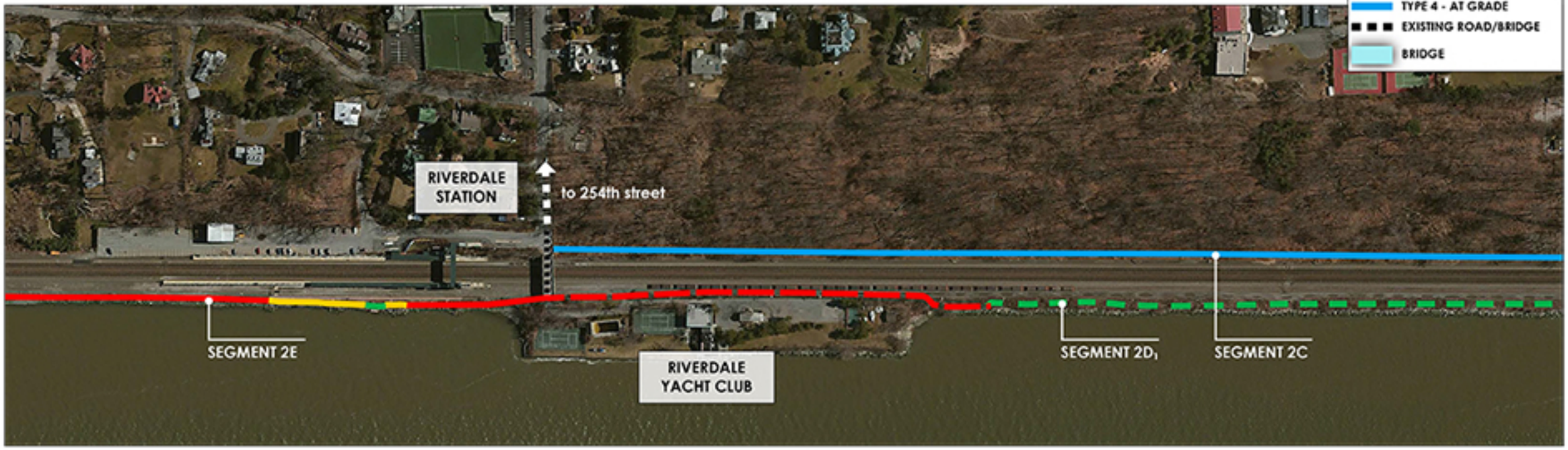
Metro-North Railroad | MATRIXNEWORLD Engineering Progress | swa/Balsley | 0 100 | ALIGNMENT 1 | 1.2

Metro-North Railroad | MATRIXNEWORLD Engineering Progress | swa/Balsley | 0 100

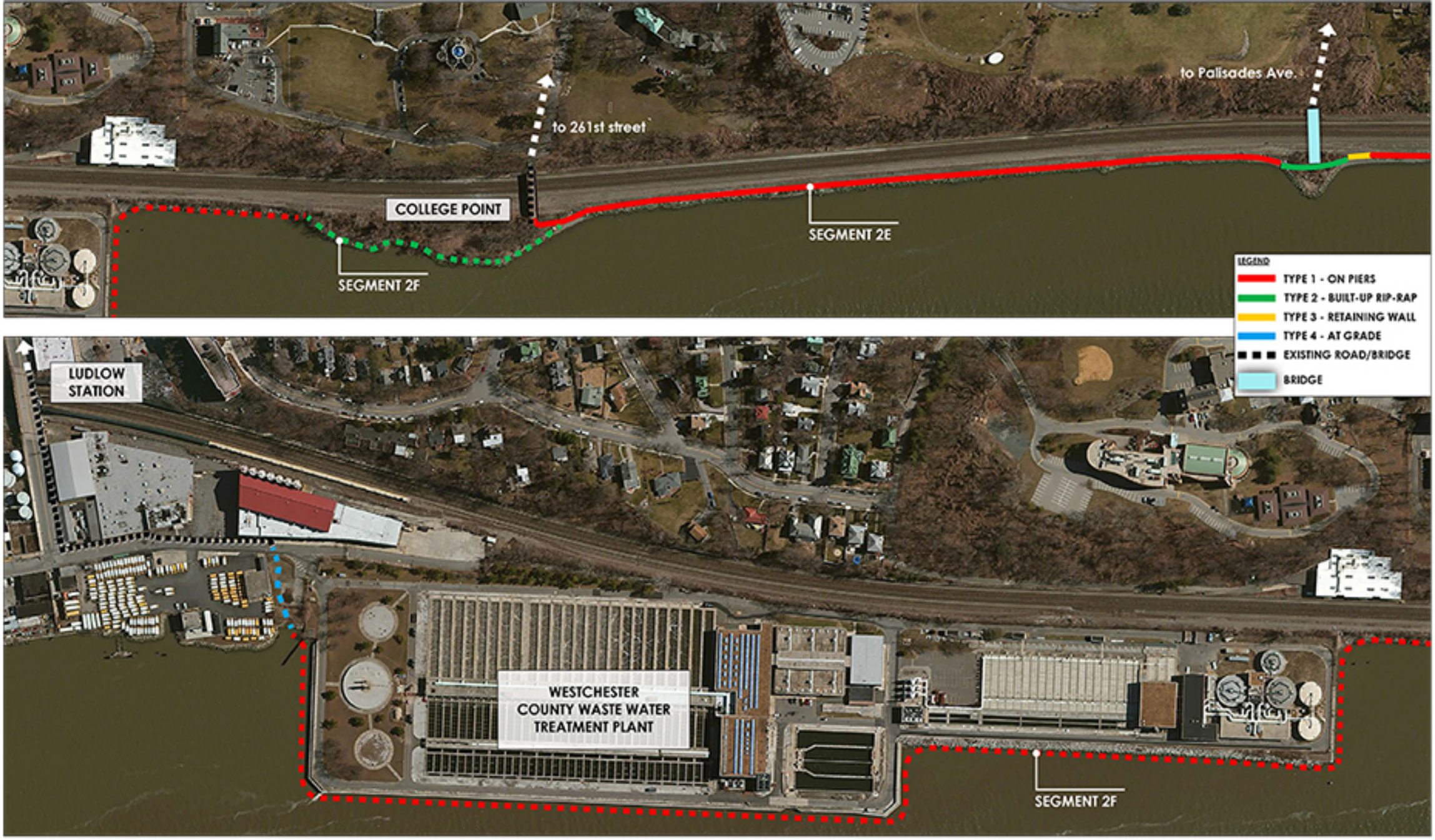
ALIGNMENT 1 | 1.3



Metro-North Railroad | MATRIXNEWORLD Engineering Progress | swa/Balsley | ALIGNMENT 2 | 2.1



Metro-North Railroad | MATRIXNEWORLD Engineering Progress | swa/Balsley | 0 100 | ALIGNMENT 2 | 2.2



Metro-North Railroad | MATRIXNEWORLD Engineering Progress | swa/Balsley | ALIGNMENT 2 | 2.3

SEGMENT 1A				
TYPE 1 WALKWAY ON PIERS	LINEAR FOOT	6,030	$2,920.00	$17,607,600.00
ACCESS POINTS	LUMP SUM	1	$12,000,000.00	$12,000,000.00
BRIDGES	LUMP SUM	1	$2,500,000.00	$2,500,000.00
			SUBTOTAL	$32,107,600.00
			30% CONTINGENCY	$9,632,280.00
			TOTAL SEGMENT 1A	**$41,739,880.00**
SEGMENT 1B				
TYPE 4 WALKWAY AT GRADE	LINEAR FOOT	3,550	$430.00	$1,526,500.00
			SUBTOTAL	$1,526,500.00
			30% CONTINGENCY	$457,950.00
			TOTAL SEGMENT 1B	**$1,984,450.00**
SEGMENT 1C				
TYPE 1 WALKWAY ON PIERS	LINEAR FOOT	3,600	$2,920.00	$10,512,000.00
			SUBTOTAL	$10,512,000.00
			30% CONTINGENCY	$3,153,600.00
			TOTAL SEGMENT 1C	**$13,665,600.00**

SEGMENT 1D				
TYPE 1 WALKWAY ON PIERS	LINEAR FOOT	3,560	$2,920.00	$10,395,200.00
ACCESS POINTS	LUMP SUM	1	$6,000,000.00	$6,000,000.00
BRIDGES	LUMP SUM	1	$2,000,000.00	$2,000,000.00
			SUBTOTAL	$18,395,200.00
			30% CONTINGENCY	$5,518,560.00
			TOTAL SEGMENT 1D	**$23,913,760.00**
SEGMENT 1E				
TYPE 1 WALKWAY ON PIERS	LINEAR FOOT	4,400	$2,920.00	$12,848,000.00
TYPE 4 WALKWAY AT GRADE	LINEAR FOOT	200	$430.00	$86,000.00
			SUBTOTAL	$12,934,000.00
			30% CONTINGENCY	$3,880,200.00
			TOTAL SEGMENT 1E	**$16,814,200.00**

Note: Engineer's estimate of probable Construction Cost is based on a feasibility study and not based on any design work and excludes any and all potential soft costs, including railroad support costs. Engineer's opinion of probable Construction Cost is made on the basis of Engineer's experience and qualifications and represent Engineer's best judgment as an experienced and qualified professional engineer generally familiar with the construction industry. However, since Engineer has no control over the costs of labor, materials, equipment, or other services furnished by others, or over the Contractor's methods of determining prices, or over competitive bidding and market conditions, Engineer cannot and does not guarantee that proposals, bids, or actual Construction Cost will not vary.

FIGURE 3.1: ESTIMATED PROBABLE COST OF CONSTRUCTION FOR ALIGNMENT 1

SEGMENT 2A				
TYPE 1 WALKWAY ON PIERS	LINEAR FOOT	1,750	$2,920.00	$5,110,000.00
TYPE 3 WALKWAY RETAINING WALL	LINEAR FOOT	1,150	$1,100.00	$1,265,000.00
ACCESS POINTS	LUMP SUM	1	$6,000,000.00	$6,000,000.00
BRIDGES	LUMP SUM	1	$2,500,000.00	$2,500,000.00
			SUBTOTAL	$14,875,000.00
			30% CONTINGENCY	$4,462,500.00
			TOTAL SEGMENT 2A	**$19,337,500.00**
SEGMENT 2B				
TYPE 1 WALKWAY ON PIERS	LINEAR FOOT	1,400	$2,920.00	$4,088,000.00
TYPE 2 WALKWAY BUILT-UP RIP-RAP	LINEAR FOOT	130	$620.00	$80,600.00
TYPE 3 WALKWAY RETAINING WALL	LINEAR FOOT	1,600	$1,100.00	$1,760,000.00
ACCESS POINTS	LUMP SUM	1	$6,000,000.00	$6,000,000.00
			SUBTOTAL	$11,928,600.00
			30% CONTINGENCY	$3,578,580.00
			TOTAL SEGMENT 2B	**$15,507,180.00**
SEGMENT 2C				
TYPE 4 WALKWAY AT GRADE	LINEAR FOOT	3,550	$430.00	$1,526,500.00
			SUBTOTAL	$1,526,500.00
			30% CONTINGENCY	$457,950.00
			TOTAL SEGMENT 2C	**$1,984,450.00**

SEGMENT 2D				
TYPE 1 WALKWAY ON PIERS	LINEAR FOOT	1,750	$2,920.00	$5,110,000.00
TYPE 2 WALKWAY BUILT-UP RIP-RAP	LINEAR FOOT	525	$620.00	$325,500.00
TYPE 3 WALKWAY RETAINING WALL	LINEAR FOOT	1,325	$1,100.00	$1,457,500.00
			SUBTOTAL	$5,110,000.00
			30% CONTINGENCY	$1,533,000.00
			TOTAL SEGMENT 2D	**$6,643,000.00**
SEGMENT 2E				
TYPE 1 WALKWAY ON PIERS	LINEAR FOOT	1,750	$2,920.00	$8,833,000.00
TYPE 2 WALKWAY BUILT-UP RIP-RAP	LINEAR FOOT	215	$620.00	$133,300.00
TYPE 3 WALKWAY RETAINING WALL	LINEAR FOOT	320	$1,100.00	$352,000.00
ACCESS POINTS	LUMP SUM	1	$6,000,000.00	$6,000,000.00
BRIDGES	LUMP SUM	1	$2,500,000.00	$2,500,000.00
			SUBTOTAL	$17,318,300.00
			30% CONTINGENCY	$5,195,490.00
			TOTAL SEGMENT 2E	**$22,513,790.00**
SEGMENT 2F				
TYPE 1 WALKWAY ON PIERS	LINEAR FOOT	3,700	$2,920.00	$10,804,000.00
TYPE 2 WALKWAY BUILT-UP RIP-RAP	LINEAR FOOT	700	$620.00	$434,000.00
TYPE 4 WALKWAY AT GRADE	LINEAR FOOT	200	$430.00	$86,000.00
			SUBTOTAL	$11,324,000.00
			30% CONTINGENCY	$3,397,200.00
			TOTAL SEGMENT 2F	**$14,721,200.00**

Note: Engineer's estimate of probable Construction Cost is based on a feasibility study and not based on any design work and excludes any and all potential soft costs, including railroad support costs. Engineer's opinion of probable Construction Cost is made on the basis of Engineer's experience and qualifications and represent Engineer's best judgment as an experienced and qualified professional engineer generally familiar with the construction industry. However, since Engineer has no control over the costs of labor, materials, equipment, or other services furnished by others, or over the Contractor's methods of determining prices, or over competitive bidding and market conditions, Engineer cannot and does not guarantee that proposals, bids, or actual Construction Cost will not vary.

FIGURE 3.2: ESTIMATED PROBABLE COST OF CONSTRUCTION FOR ALIGNMENT 2

SEGMENT 2B1				
TYPE 1 WALKWAY ON PIERS	LINEAR FOOT	670	$2,920.00	$1,956,400.00
TYPE 2 WALKWAY BUILT-UP RIP-RAP	LINEAR FOOT	2,460	$620.00	$1,525,200.00
ACCESS POINTS	LUMP SUM	1	$6,000,000.00	$6,000,000.00
			SUBTOTAL	$9,481,600.00
			30% CONTINGENCY	$2,844,480.00
			TOTAL SEGMENT 2B1	**$12,326,080.00**

SEGMENT 2D1				
TYPE 1 WALKWAY ON PIERS	LINEAR FOOT	1,435	$2,920.00	$4,190,200.00
TYPE 2 WALKWAY BUILT-UP RIP-RAP	LINEAR FOOT	1,625	$620.00	$1,007,500.00
TYPE 3 WALKWAY RETAINING WALL	LINEAR FOOT	540	$1,100.00	$594,000.00
			SUBTOTAL	$4,190,200.00
			30% CONTINGENCY	$1,257,060.00
			TOTAL SEGMENT 2D1	**$5,447,260.00**

Note: Engineer's estimate of probable Construction Cost is based on a feasibility study and not based on any design work and excludes any and all potential soft costs, including railroad support costs. Engineer's opinion of probable Construction Cost is made on the basis of Engineer's experience and qualifications and represent Engineer's best judgment as an experienced and qualified professional engineer generally familiar with the construction industry. However, since Engineer has no control over the costs of labor, materials, equipment, or other services furnished by others, or over the Contractor's methods of determining prices, or over competitive bidding and market conditions, Engineer cannot and does not guarantee that proposals, bids, or actual Construction Cost will not vary.

FIGURE 3.3: ESTIMATED PROBABLE COST OF CONSTRUCTION FOR ALIGNMENT 2

CONCLUSION

The Bronx Greenway Feasibility Study investigates the potential for constructing a multi-use recreational trail along the Hudson River, west of the railroad tracks, in the Bronx and Yonkers, New York. In conjunction with data presented in Volume 1 of the Feasibility Study (Existing Conditions Inventory and Preliminary Findings), Volume 2 presents the results of the Opportunities and Challenges Assessment for potentially constructing a trail in the project area, as well as summarizes the Evaluation of Feasible Trail Route Alternatives.

The results of the Bronx Greenway Feasibility Study show that developing a trail in the project area would be feasible; however, the design and construction of a potential walkway would have to overcome the serious locational and engineering challenges presented by the project area. The Feasibility Study identifies pressing safety, security and access concerns raised by locating a trail next to busy rail lines that are vital to the region's mobility. The trail design would have to sufficiently address these issues, while also accounting for the limited area available along the shoreline, the presence of several pinch points, and multiple property owners.

This Feasibility Study can be used as a guidance tool for future planning efforts to develop a potential trail in the project area. The study identifies trail alignment alternatives and options that the ultimate responsible party for developing the walkway can select to best meet their project goals. No engineering design work was undertaken as part of this Feasibility Study and the ultimate responsible party seeking to advance the project to subsequent phases, would have to undertake the engineering design efforts necessitated by a project of this scale.

To aid in determining the potential funding that may be required to construct a project in this location, estimates of probable construction costs for the feasible trail alignments have been identified as part of this study. Whatever the final alignment chosen for the project area, the cost for the project has been determined to be substantial and funding sources would need to be identified and pursued. The cost estimates presented in the Feasibility Study represent the potential construction costs only. Additional costs for property agreements, design and construction support services or other potential project "soft costs" are not factored in the estimated construction costs. In addition, the construction costs are projected without the benefit of any engineering design work performed for the project.

The ultimate responsible party for the trail would need to assume the obligation associated with the operation and maintenance of the trail, including ensuring all safety, security and access concerns are addressed. Any effort to develop a trail in this location would require coordination and approvals from Amtrak, Metro-North Railroad, local community stakeholders and property owners along the potential trail corridor.