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).

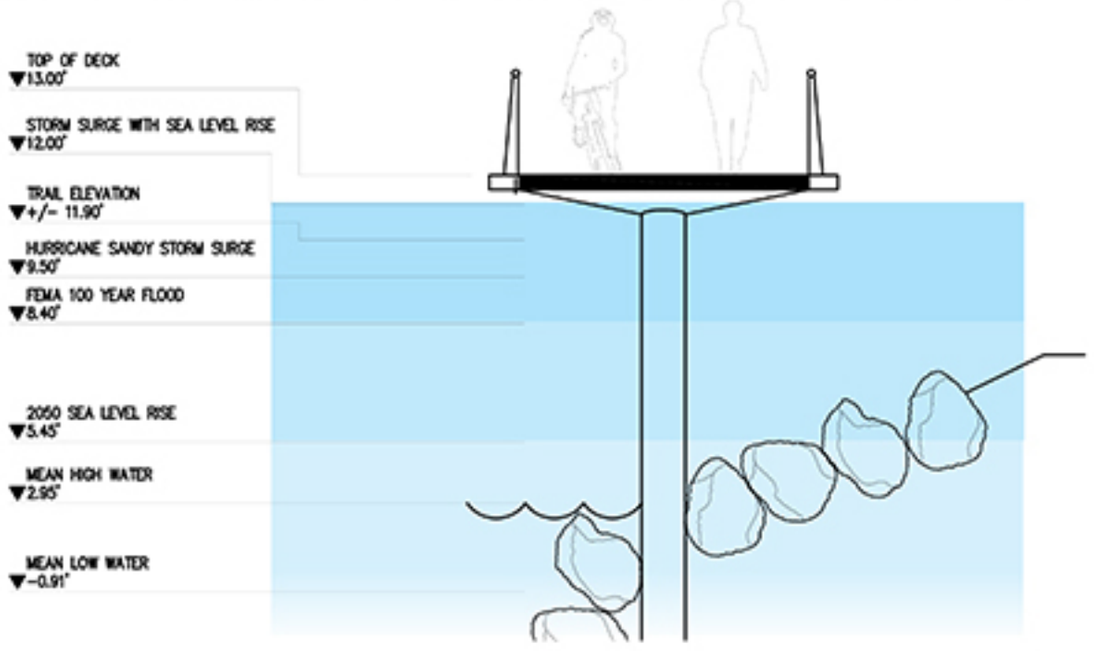


Figure 2.1: Expected sea-level-rise with Type 1 trail

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.

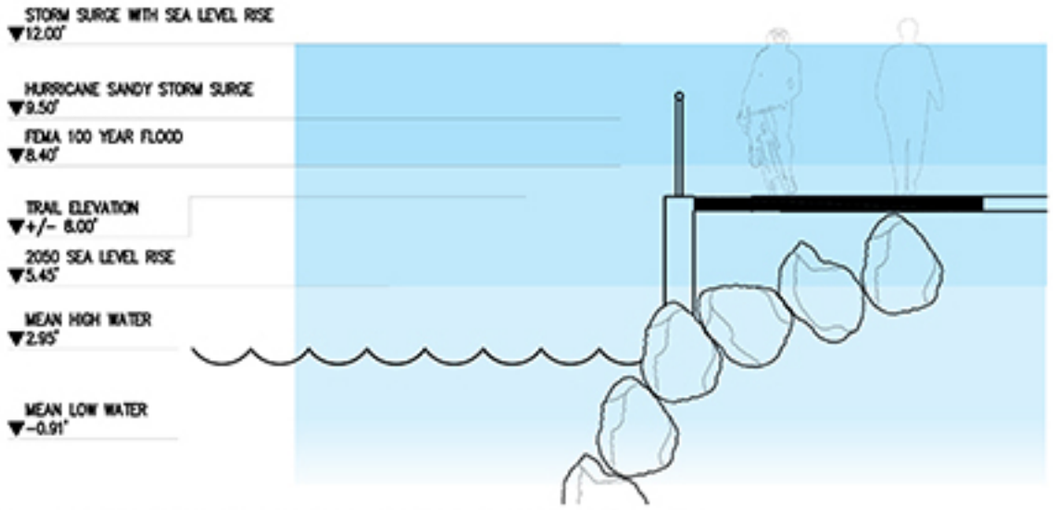


Figure 2.2: Expected sea-level-rise with at-grade trails along the Hudson

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.

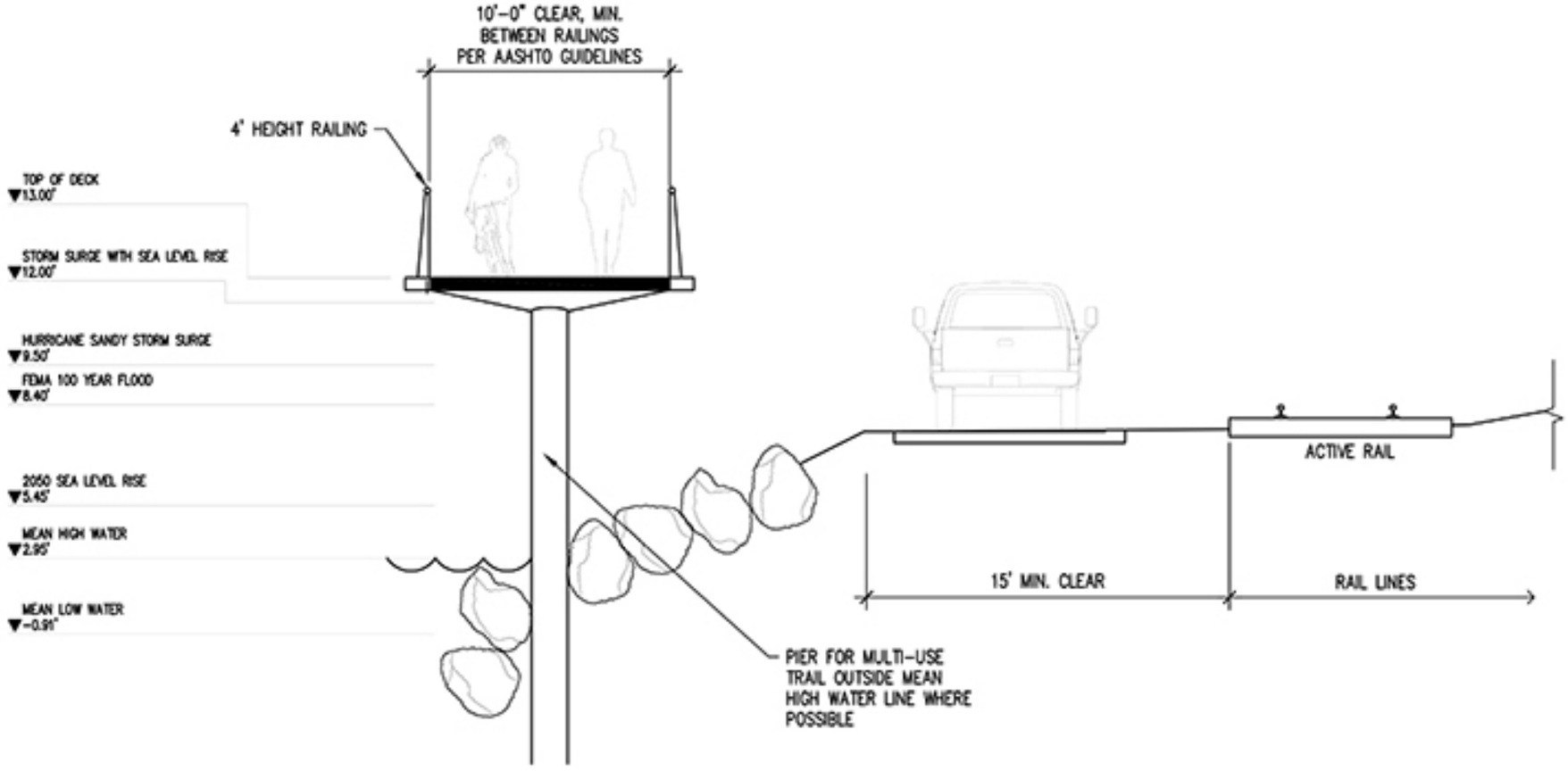
Maintenance of the Type 4 trail is anticipated to include weed control and replacing/patching of the pavement as required. Periodic monitoring of the condition of this walkway type would be required to maintain an optimal trail surface for users.

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.

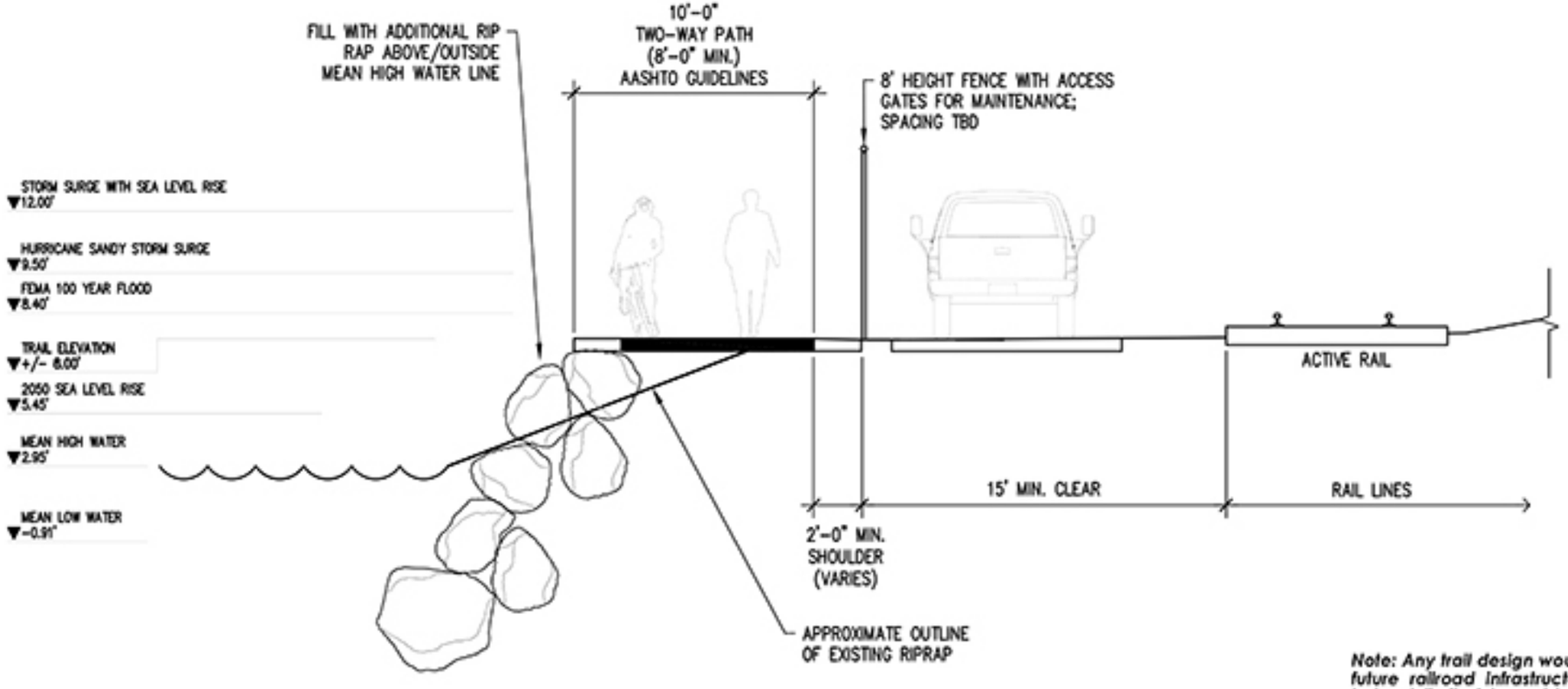
Probable construction costs were developed for each of the four types of walkways anticipated in the study area. The costs depicted in Figure 2.7 are based on the construction of a 20 – foot section of each type of walkway to derive linear foot costs. These linear foot costs were used to provide the 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

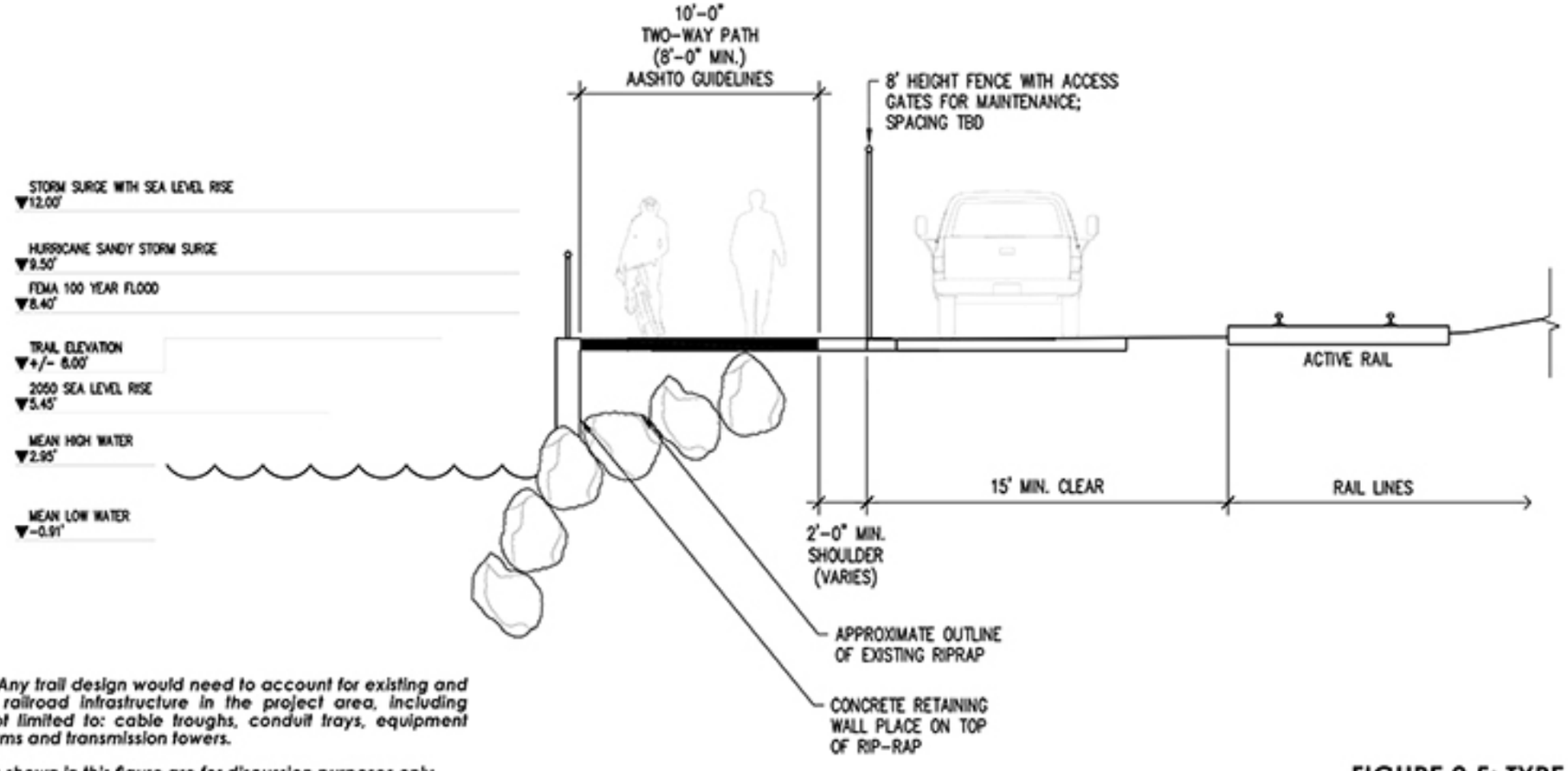
FIGURE 2.3: TYPE 1 TRAIL - BUILT ON PIERS



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



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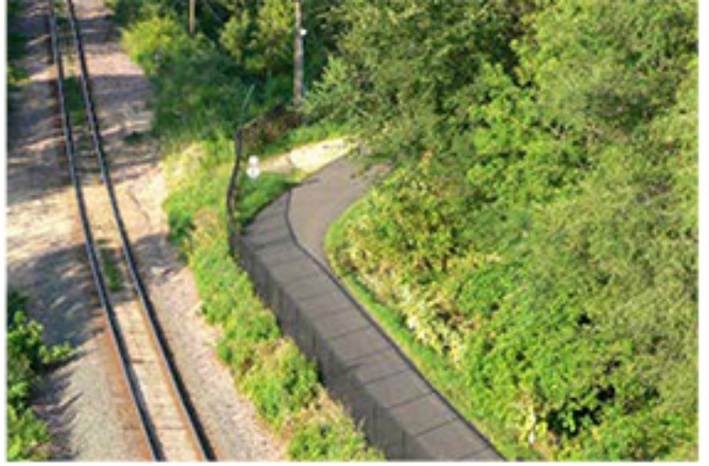
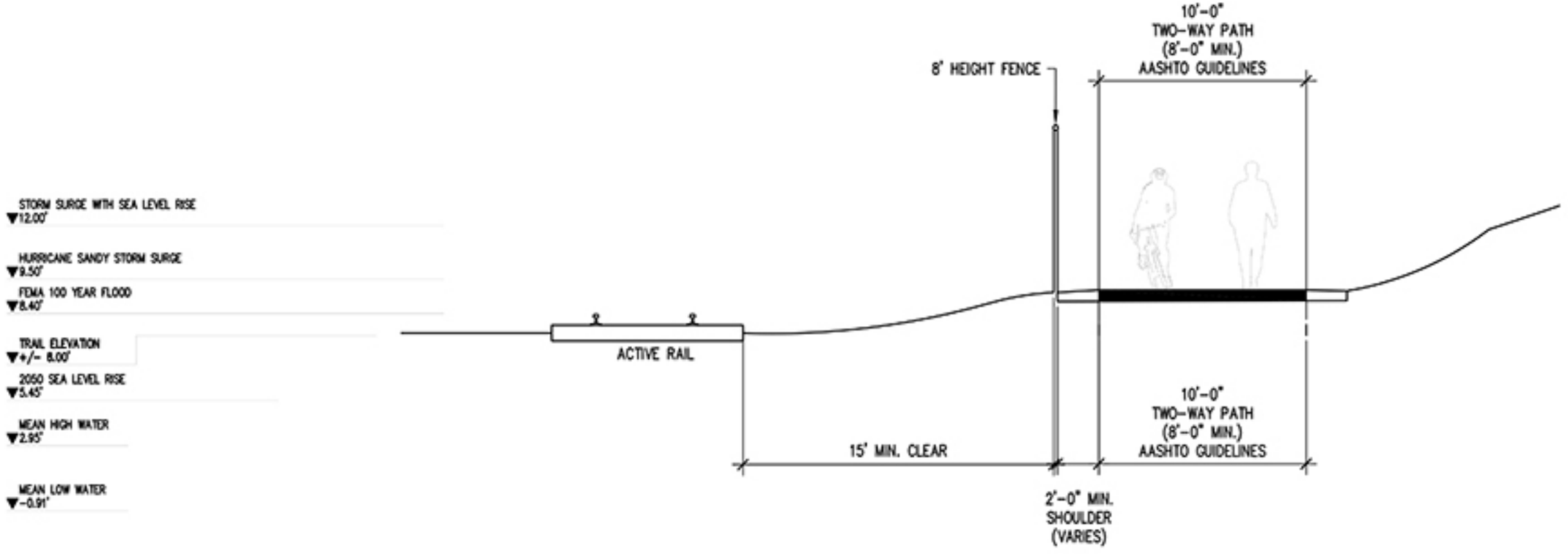
Photos shown in this figure are for discussion purposes only

FIGURE 2.5: TYPE 3 TRAIL - RETAINING WALL



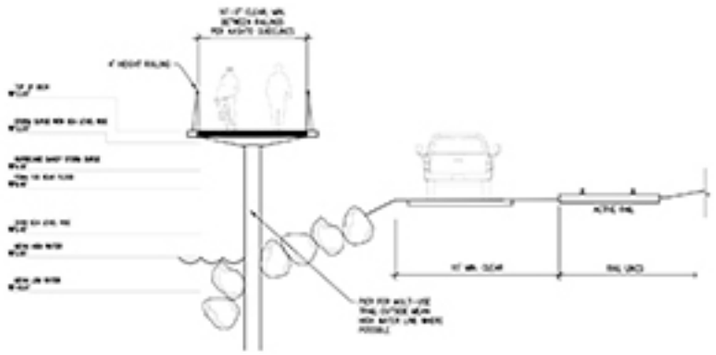


Note: Any trail design would need to account for existing and future railroad infrastructure in the project area, including but not limited to: cable troughs, conduit trays, equipment platforms and transmission towers.

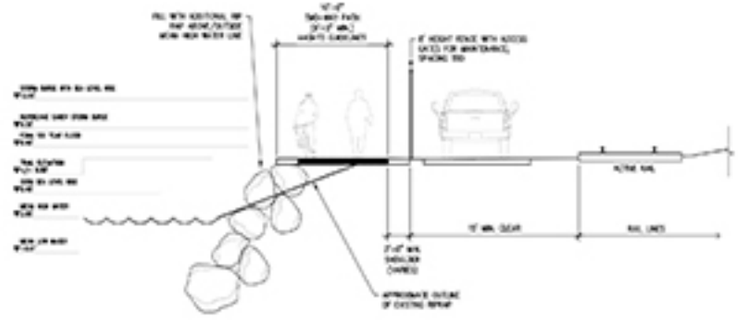
Photos shown in this figure are for discussion purposes only

FIGURE 2.6: TYPE 4 TRAIL - AT GRADE

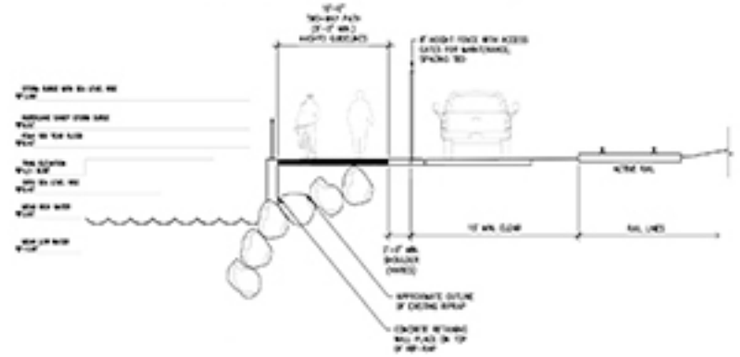
TYPE 1 - BUILT ON PIER (20 FT SECTION)				
CONCRETE PILES (30" DIA)	UNIT	1	$25,000.00	$25,000.00
CONCRETE	CUBIC YARDS	8	$2,000.00	$16,000.00
4' RAILING	LINEAR FOOT	40	$300.00	$12,000.00
			SUBTOTAL	$53,000.00
			10% CONTINGENCY	$5,300.00
			TOTAL FOR 20 FT SECTION	**$58,300.00**
			TOTAL PER LF	**$2,920.00**



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.

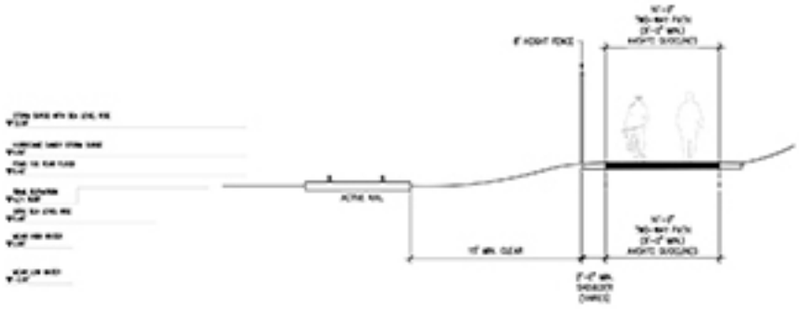


FIGURE 2.7: TRAIL TYPE CONSTRUCTION COSTS