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Subject: Vulnerability Assessment and Resilience Planning, Ferry Terminal, Vinalhaven, Maine
Penobscot Bay Working Waterfront Resiliency Analysis
State of Maine, Department of Marine Resources

Wood Environment & Infrastructure Solutions, Inc. (Wood) is pleased to provide the Maine Department of Marine Resources (DMR) this report on the baseline characterization, vulnerability assessment and resilience planning for the Ferry Terminal, Vinalhaven, Maine. This report provides findings for one of ten sites included in DMR's Penobscot Bay Working Waterfront Resiliency Analysis project. Reports on the other nine sites are provided under separate cover. Our work was performed in general accordance with the scope of work and the terms and conditions included in Wood's proposal dated 1 March 2019.

1.0 INTRODUCTION

As proposed for DMR's Penobscot Bay Working Waterfront Resilience project, Wood conducted an assessment of the Ferry Terminal in Vinalhaven, Maine which included:

- Facility baseline characterization including a review of available site documents, interviews with community representatives, survey of site topography and elevations of key site features, and review of the general condition of existing site structures by a Wood structural engineer;
- Facility vulnerability analyses based on the baseline survey data, condition of structures, and modelling of potential storm surge and wave affects under three sea-level rise (SLR) scenarios; and
- Development of resilience measures, including strategies for incremental adaptation under the modelled storm and SLR scenarios.

This report contains a summary of our document review, personnel interviews, structural observations, photographs documenting our observations (**Appendix A**), and the approximate location of potential structural deficiencies. Following our analysis of the site and as part of the vulnerability analysis, we were able to identify the risks for the affected site features (see **Table 5**) from inundation data. Inundation maps developed for the site by Wood's consulting partner, Woods Hole Group (WHG) are provided in **Appendix B**. The vulnerability analysis establishes the future risk framework for the site and its structural features. Wood has evaluated the degree of impact of these site-specific vulnerabilities, and we have provided recommendations for improved resilience (e.g., repair, reinforcement) in relation to the feature's immediate performance and/or expected performance per the vulnerability analysis.

As part of the subsequent discussion, the following terms are defined below:

Base Flood Elevation (BFE) -	Elevation of flooding, including wave height, having a 1% chance of being equaled or exceeded in any given year.
Checks	A separation of the wood occurring across or through the rings of annual growth and usually as a result of seasoning.
Coastal High hazard Area (CHHA) -	Area within a special flood hazard area extending from off-shore to the inland limit of a primary frontal dune along an open coast and any other area that is subject to high velocity wave action.
Design Flood Elevation (DFE)	Based on the design flood, the DFE is the higher of the base flood elevation (BFE) shown on FIRMs prepared by FEMA or the flood elevations shown on the map adopted by a community.
FIRM -	Flood Insurance Rate Map. Official map of a community on which FEMA has delineated both special flood hazard areas and the risk premium zones applicable to the community.
Highest Annual Tide (HAT) –	The elevation of the highest predicted astronomical tide expected to occur at a specific tide station over the National Tidal Datum Epoch.
Mean Higher High Water (MHHW) –	The average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch. The highest high tide or water height is referred to as the Highest Astronomical Tide (HAT) and is defined as the highest level which can be predicted to occur under average meteorological conditions and any combination of astronomical conditions.
National Tidal Datum Epoch –	The specific 19-year period (Currently 1983 to 2001) adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values (Mean Lower Low Water, etc.) for tidal datums.
Pre-FIRM	Construction or substantial improvement occurred on or before December 31, 1974.
Shakes	Lengthwise separations of the wood along the grain, usually occurring between or through the rings of annual growth.
Splits	A separation of the wood through the piece to the opposite surface or to an adjoining surface due to tearing apart of the wood cells.
Still Water Elevation –	Elevation that the surface of the water would assume in the absence of waves referenced to a specified vertical datum at the defined recurrence interval.
Wave Height –	Vertical distance between the crest and the trough of a wave.

2.0 DOCUMENT REVIEW AND PERSONNEL INTERVIEWS

Wood was escorted by Andrew Dorr, the Town Manager, during a site visit on 20 June 2019. We discussed the site features and historical development of the site. Mr. Dorr mentioned that the primary use of the harbor is to support the local fishing industry. He advised that the Crib structure (wave attenuator) adjacent to the ferry terminal was installed in the 1950's. Mr. Dorr also

mentioned that a dolphin of the current ferry terminal was rebuilt in 2006. He disclosed that a Harbor management plan is expected during the summer of 2019.

Mr. Dorr mentioned that a high tide took place in January 2018, possibly the record Winter Storm Grayson, which interrupted ferry service. In addition, he added that the ferry service is interrupted at least on two occasions annually. The following is a summary of key site features identified during the site visit:

- The site consists of the ferry terminal, bridge, wave attenuator, floating dock, and parking area (See **Figure 1** below).
- The Ferry Services Building was built between 1999 and 2000 according the as-built drawings.
- The crib wave attenuator/crib is constructed of timber framing and filled with large rocks and gravel.
- The original terminal was mostly demolished, however the concrete ramp which supports the floating dock remains.
- There is no formal ongoing maintenance plan in place; maintenance is addressed, as needed, when a deficiency is identified.

Figure 1: Site Overview

The following documents were provided from the Town to assist in our assessment of the site and its facilities:

- Design drawings for the Ferry Terminal by Childs Engineering Corporation, dated 30 September 2011.
- Design drawings for the Ferry Terminal and Services Building by Fay Spofford and Thorndike, Inc. Engineers, dated September 1999.
- Vinalhaven Resiliency Planning Memorandum regarding Adaption Options by Ransom Consulting Engineers and Scientists, dated 8 January 2018.
- Vinalhaven Resiliency Planning Memorandum regarding Local Sea Level Rise by Ransom Consulting Engineers and Scientists, dated 30 August 2017.
- Plan of Proposed Walkway Pier and Boat Ramp by Prock Marine Company, dated 22 March 2004.

3.0 OBSERVATIONS AND FINDINGS

Tirrell Day and Lane Gray of Wood performed a site assessment and gathered geospatial data for key site features during the 20 June 2019 visit. This assessment included documenting the general condition and recording elevations of key features and structures. At the request of the Town, the limits of our investigation include the ferry terminal, the ferry services building, floating dock, crib structure and parking area. Photos of the sites and Wood's noteworthy observations are included in the Photolog (**Appendix A**). Elevations discussed in this report are with respect to North American Vertical Datum of 1988 (NAVD88). The site facilities and their associated elevations are included in **Table 1** for reference. During our site visit the approximate tidal levels where between -4.55 ft and 4.52 ft (predicted min. of -5.99 ft, max. of 5.62 ft).

3.1 Property Overview

This site is a roughly 1.7-acre property consisting of a ferry terminal, ferry services building, floating dock, crib wave attenuators, and parking area (**Photographs 1 & 2**). The ferry terminal is located at the south portion of the property and includes the dolphins, transfer bridge, and main bridge. The six (6) dolphins consists of the concrete mooring bollards and attached fender panels (**Photograph 3 – 6**). The transfer bridge is a steel structure with a hoisting mechanism allowing unloading for varying tide levels (**Photographs 7, 8 & 15**). This structure is supported at one end by the hoisting frame and at the other end it shares a support with the main bridge at pier 3. All miscellaneous steel is designated on the drawings as hot-dipped galvanized.

The main bridge is a prestressed concrete deck on pipe piers and a concrete abutment. Per the design drawings, the piers are supported on rock via rock anchors (**Photographs 9 – 14**). During our site visit, the transfer bridge system functioned as intended. The electrical power provided to the bridge is located near pier 3 on the main bridge. We did not attempt to open or inspect any electrical panels; however, we did identify corrosion of some panels (**Photograph 16**).

The floating dock is located east of the ferry terminal. As previously mentioned, access to the dock is provided via the gangway, which is attached to the old ferry bridge abutment. The pontoons are moored to mooring piles which are in turn braced to the crib structure. Wood observed the function of the gangway and floats during tidal action and the system appeared to function as intended (**Photographs 17 – 20**).

The Ferry services building is a wood-framed structure supported on concrete stem walls and continuous footings (**Photograph 21 & 22**). The building cover is an asphalt shingle roof and wood siding. The structure exhibited no signs of notable structural or building envelope damage during our site visit. Details of the building construction were provided in the design drawings. These drawings indicate that the structure was designed to the Building Officials Code Administrators International Building Code edition 1996.

The parking area is paved and covers the largest area of the site to the north. The area slopes to the south with a grade of roughly 2% from its site entrance at Sands Road to a low point on the opposite edge of the parking lot, near the bridge entrance. The parking lot exhibits signs of wear in the form of cracking and surface delamination throughout (**Photograph 22 – 25**).

The five (5) crib structures, which are the remaining elements of the original terminal, now serve as wave attenuators to protect the floating docks and smaller boats at the north side of the terminal from wake waves generated by the ferry. The crib is constructed of a wood framed structure filled with large rocks and gravel. The structure has been installed for almost 70 years and the structural fill appears to remain in stable condition. The wood framing has, however, experienced moderate to major weathering and possibly rot as evidenced from the splitting and checks observed (**Photograph 26 – 29**).

Shoreline protection extends along the site shoreline in the form of a revetment. Large riprap, from 1.5 to 4 foot in size, is placed from the top of slope down to the observed water level. No apparent signs of dislodgement or erosion of the embankment behind the slope were noted (**Photograph 30 – 33**).

Table 1: Site Elevations

Location	***Lowest Horizontal Member***	***Lowest Deck or Adjacent Grade***	***First Finished Floor / Mid Mark/ Buoy Limit***	***Lowest Opening/ Critical Elevation***
Source	***Estimate***	***Survey***	***Survey***	***Survey***
Facility	***[ft]***	***[ft]***	***[ft]***	***[ft]***
Ferry Terminal	n/a	-8.18	n/a	6.52
Floating Dock	n/a	n/a	11.72	10.04
Ferry Services Building	n/a	12.21	12.21	13.38
Parking	n/a	10.12	12.27	15
Crib wave attenuator	n/a	12.32	n/a	17.32
Shoreline Protection	n/a	11.16	n/a	16.16

**Estimates indicate measurements referenced or derived from the actual site survey data.*

3.2 Noted Deficiencies

Based on limited visual inspection of the site features, we have the following notable observations:

- Delamination and cracking of asphalt (**Photographs 22, 24 & 25**) - the parking lot top coat appears to be moderately weathered with signs of surface delamination and 1/8 inch or greater cracks. Repair patches have been observed throughout indicating maintenance work.
- Wood deterioration (**Photograph 27 – 29**) - Wood framing at wave attenuator (crib) structures exhibit moderate to severe weathering.
- Corroded Electrical Box (**Photograph 14 & 16**) – Metal electrical / utility box has corrosion on the exterior, and one appears to have experienced delamination of the cover.

3.3 Risk Framework

As a basis for the vulnerability analysis, water surface elevation (WSE) exposure profiles were developed by WHG which summarize current and potential future tidal and storm surge inundation/wave impacts. The key flood elevation profiles provided include the Mean Higher High Water (MHHW), the Highest Astronomical Tide (HAT), the 1% Still Water Level, and the Base Flood Elevation (BFE). Values for these scenarios are site specific and take into consideration the topographic survey data obtained by Wood.

The MHHW and HAT tidal datums (present day) were sourced from the nearest long-term NOAA tide station and from spatial files developed by Maine Geological Survey[1]. The 1%-annual-chance still water level (present day) was obtained from the 2016 FEMA Flood Insurance Study for Knox County.

[1] https://www.maine.gov/dacf/mgs/hazards/highest_tide_line/index.shtml

Table 2: Flood Modelling Data Summary – Transect 1

Scenario	*MHHW*	*HAT*	*1% Still Water Level*	*1% Wave Crest Elevation (BFE)*
Present day	4.7	6.5	8.8	13-18
Short Term (+1 ft)	5.7	7.5	9.8	15-20
Mid Term (+2 ft)	6.7	8.5	10.8	16-21
Long Term (+4 ft)	8.7	10.5	12.8	17-22

Table 3: Flood Modelling Data Summary – Transect 2

Scenario	*MHHW*	*HAT*	*1% Still Water Level*	*1% Wave Crest Elevation (BFE)*
Present day	4.7	6.5	8.8	14-18
Short Term (+1 ft)	5.7	7.5	9.8	15-20
Mid Term (+2 ft)	6.7	8.5	10.8	16-21 (updated)
Long Term (+4 ft)	8.7	10.5	12.8	17-22

Site-specific wave modelling was conducted for existing and future sea levels to better quantify wave hazards and potential increases in wave heights at the site. Wave modelling was conducted using FEMA's overland wave modelling approach for consistency in providing an estimate of the 1% BFE for the future scenarios.

For potential future flood impacts, relative SLR scenarios were reviewed using the U.S. Army Corps of Engineers' Sea-Level Change Curve Calculator (Version 2017.55), specifying the Bar Harbor long-term tide gauge, a regionally-informed vertical land movement rate (from NOAA), and the NOAA et. al (2017)[2] SLR curves.

In discussion with the project team, the preferred SLR scenarios defined for evaluating short-term, mid-term, and long-term impacts were selected as 1 ft, 2 ft, and 4 ft, respectively. These projected increases in sea level roughly correspond with NOAA's Intermediate scenario for the years 2030, 2050, and 2085 with a rather low exceedance probability (17%) and are within the range of the SLR scenarios recommended by Maine DOT for design of transportation infrastructure.

3.4 Site Vulnerabilities

The flood modelling data provided above in **Table 2 and 3** includes scenarios for the Short Term, Mid Term, and Long Term SLR scenarios. NOAA's Intermediate scenario mentioned above compared with these timeframes should be taken into consideration for the identified return periods as illustrated in **Table 4**.

Table 4: Flood Return Period

Event Return Period	Percent Chance of Occurrence per Period			
	5 Years	10 Years	25 Years	50 Years
100 Year Flood (1%)	4.9%	9.6%	22.2%	39.5%
500 Year Flood (0.2%)	1%	2%	4.9%	9.5%

The various site features have been summarized in **Table 5**, for each asset, indicating the associated risk and flood scenario which results in inundation. Those elevations noted as 0 ft indicate an elevation equal to the identified feature of the facility. No

[2] https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenarios_for_the_US_final.pdf

elevations are noted in Table 5 where no inundation of the feature was identified (i.e., flood elevation is lower than that of the site feature). Below are the site-specific vulnerabilities based on our review of the property.

Table 5: Site Elevations and Risks

Facility			Inundation above Elevation of Facility															
Description			Present Day				Short Term Scenario				Mid Term Scenario				Long Term Scenario			
	Elevation (ft) to NAVD88		MHHW [ft]	HAT [ft]	1% Stillwater [ft]	BFE [ft]	MHHW [ft]	HAT [ft]	1% Stillwater [ft]	BFE [ft]	MHHW [ft]	HAT [ft]	1% Stillwater [ft]	BFE [ft]	MHHW [ft]	HAT [ft]	1% Stillwater [ft]	BFE [ft]
Dolphin & Berthing	Lower elevation	-6.68 ft	11.38	13.2	15.48	25	12.38	14.2	16.48	26.7	13.38	15.2	17.48	27.7	15.38	17.2	19.48	28.7
	Upper Elevation	19.32 ft								0.68				1.68				2.68
Ferry Terminal (Transfer Bridge)	Lower Limit	-8.18 ft	12.88	14.7	16.98	23	13.88	15.7	17.98	24.2	14.88	16.7	18.98	25.2	16.88	18.7	20.98	28.2
	Top of Roadway at Pier 3	9.82 ft				5.2				6.18			0.98	7.18		0.68	2.98	10.2
	Upper Limit	6.52 ft			2.28	8.5		0.98	3.28	9.48	0.18	1.98	4.28	10.5	2.18	3.98	6.28	13.5
Floating Dock	Buoy Chain max elevation	11.72 ft				6.3				4.28				6.28			1.08	10.3
	Gangway support	10.04 ft				5				5.96			0.76	6.96		0.46	2.76	9.96
Ferry Services Building	Adjacent Grade	12.21 ft				0.8				2.79				5.79			0.59	7.79
	First Floor Elevation	12.21 ft				0.8				2.79				5.79			0.59	7.79
	Lowest Opening	12.21 ft				0.8				2.79				5.79			0.59	7.79
Parking	Lower elevation	10.12 ft				2.9				4.88			0.68	7.88		0.38	2.68	9.88
	Mid mark	12.27 ft				0.7				2.73				5.73			0.53	7.73
	Upper elevation	15 ft								0				3				5
Crib Wave Attenuator	Top Elevation	12.32 ft				0.7				2.68				5.68			0.48	7.68
	Critical Elevation	17.32 ft												0.68				2.68
Shoreline Protection	Top Elevation	11.16 ft				1.8				3.84				6.84			1.64	8.84
	Critical Elevation	16.16 ft												1.84				3.84

3.4.1 Ferry Terminal

For the Present Day scenario the HAT is 1 foot above the upper limit for the transfer bridge operating range. The likelihood of an operational interruption taking place during the Mid Term scenario, when the MHHW elevation is slightly above the operating limit, will increase. A reliable operating schedule becomes a challenge for the Long Term scenario as the MHHW inundation increases beyond 2 feet above the operating range. The upper and lower bounds for the dolphin and ferry berth are indicated in Table 5; however, these values don't necessarily represent the allowable operational range for the transfer bridge. An analysis should be conducted to determine the ideal range for this structure and impact of rising water levels.

3.4.2 Floating Docks

The floating dock assembly consists of the gangway and pontoons. The critical elevation for proper function of the floating docks for regular use is the MHHW. This is based on the relatively frequent occurrence and the forces the gangway will exert on the attached header from rising water levels and functionality of the system for these levels. As is indicated in **Table 5** for the Present Day and all future scenarios, minimal risk is foreseen for damage to the header or attached structure from tidal action forces exerted from the gangway. During an event, for all scenarios, data indicates a risk of damage at the gangway header due to the

BFE or the 1% Stillwater. However, we anticipate that the mooring pile connection, or attachment of the mooring piles to the wave attenuator, will be the greatest points of weakness given the age and condition of the connection.

3.4.3 Facilities

The Ferry Services Building has a minimal risk from flooding for all scenarios except the Long Term, during which the 1% Stillwater reaches a height of roughly 7 inches above the first floor elevation. The paramount concern for this site, however, is the wave action near the coast during all scenarios. Forecasted wave heights range from 4 to 7 feet. Based on this and the structure's proximity to the shore, it is very likely the structure will be impacted by the BFE for all cases.

3.4.4 Parking

Using the mid-mark elevation as an indicator of the usability of the parking area, this area is not anticipated to be inundated under the MHHW or the HAT events. However, for the Long Term scenario at least half of the lot can expect to be inundated.

3.4.5 Crib Wave Attenuator

For the Present Day and Short Term scenarios, no notable risks were identified. However, based on the projected wave heights and sea level rising, the structure appears to be at risk of damage. Moreover, rising water levels compromise the effectiveness of the structure for wave dissipation.

3.4.6 Shoreline Protection

Although sufficient protection appears to be provided for the Present Day and Short Term scenarios, future data for the Mid Term and Long Term scenarios indicate a risk due to higher water levels and waves.

4.0 RECOMMENDATIONS

4.1 General Recommendations (New Construction)

In accordance with American Society of Civil Engineers / Structural Engineering Institute Standard 24 – Flood Resistant Design and Construction (ASCE 24), existing structures that sustain substantial damage, or that are substantially improved, are treated as new construction. This standard considers damage beyond routine maintenance or otherwise minimal damage following an event, which nonetheless requires major improvements and even applies to structures classified as pre-FIRM. **For new construction we recommend, in light of the forecasted increase in water levels and the schedule for these events in relationship to the life of the structure, design should be based on the either BFE plus 2 feet of freeboard, the DFE, or 500-year event, whichever is higher.** It is understood that local requirements coupled with available resources will dictate the ability for the communities to incorporate proactive designs. The following recommendations are provided with regard to areas of the site which fall within a special flood hazard area:

- All new construction, substantially improved, and substantially damaged buildings must be elevated on pilings, posts, wharfs, or columns so that the bottom of the lowest horizontal structural member of the lowest floor is at or above the BFE with any applicable freeboard (or DFE), per ASCE 24.
- The foundation system must be anchored to resist flotation, collapse, lateral movement due to wind and water loads acting simultaneously on all components of the building.
- Use of flood damage-resistant materials above the BFE per ASCE 24 and the local Building Code.
- Electrical equipment should be located on the landward side of any building and/or behind structural elements. They must be elevated and designed to prevent flood waters from entering and accumulating in components during flooding. Watertight conduits and fixtures should be used, and all metal should be stainless steel type 316 minimum.
- Install shutoff and isolation valves on water lines that extend into the flood-prone areas.

This list is not comprehensive but rather applies to site features observed during our site visit. There may exist other relevant items addressed in any of the above-mentioned design standards which are applicable for the site at a future date. We recommend a detailed site assessment be performed during the design stage to ensure implementation of all applicable items.

4.2 Site Specific Recommendations

Although the risks, vulnerabilities, and associated recommendations addressed herein are in reference to features located within the property limits of the Ferry Terminal, there may be features of similar construction in close proximity and exposed to similar risks as described in this report but fall outside the property limits. We recommend that these sites and features undergo a similar assessment with the assumption that similar or greater risks may apply. The following are recommendations for the features identified at risk within the Ferry Terminal in Vinalhaven.

4.2.1 Ferry Terminal

The following recommendations are provided in reference to the **Present Day** scenario for flood values provided in **Tables 2 & 3** above:

- Conduct a study to determine the actual safe operating range for the dolphin and fender structure.
- Consider adjusting ferry operation times to avoid periods of extremely high tides which exceed the safe operating range.
- Consider remediation of the electrical/utility box at the ferry bridge with a moisture resistant option.

The following recommendations are provided in reference to the **Short Term and Mid Term scenarios** for inundation values provided in **Table 2 & 3** above:

- Consider operating two (2) ships simultaneously in opposite directions if demand is too great for smaller window of operation due to future rising water levels.

The following recommendations are provided in reference to the **Long Term scenario** for inundation values provided in **Table 2 & 3** above:

- Recommend investigation of structural improvements to accommodate potential future sea level rise and extremely limited operation window (e.g., relocation, raising the bridge).

4.2.2 Floating Dock

The following recommendation is provided in reference to the **Present Day and all future scenarios** with regard to construction of the floating dock assemblies:

- Confirm the gangway attachments and mooring pile attachment to crib are sufficient to resist the design loading and repair or replace as needed.

The following recommendation is provided in reference to the **Long Term scenario** with regard to construction of the floating dock assembly:

- Consider raising the gangway and providing a gangway platform to accommodate the rising water level. This alternative will provide an elevated gangway platform above the abutment elevation, and greater resilience during future extreme high tide and storm events.

4.2.3 Ferry Services Building

The following recommendation is provided in reference to the **Present Day and all other scenarios** with regard to the site facilities:

- Wave heights range from 4 to 7 feet for this analysis. We recommend either relocation of the structure 75 to 100 feet inland from the shoreline, or construction of a minimum 6-ft high sea wall between the building and the shoreline (BFE plus 1 foot of freeboard) in consideration of the Mid Term scenario. These recommendations should be compared for minimum compliance with current flood mapping per FEMA at the time of construction and any local requirements.

The following recommendation is provided in reference to the **Mid and Long Term scenario** with regard to the site facilities:

- With 1% Stillwater elevation at approximately 0.59 ft above FFE in combination with 7 ft wave heights we recommend relocation and incorporation of a sustainable design.

4.2.4 Parking Area

The following recommendation is provided in reference to the **Present Day and all future scenarios** with regard to the parking area:

- No pressing concerns were identified beyond regular maintenance required due to normal wear and tear.

4.2.5 Crib wave attenuator

The following recommendation is provided in reference to the **Present Day and all future scenarios** with regard to the current crib wave attenuator:

- Many members of the structure appear to have experience major deterioration and require replacement. Opportunity should be taking to perform detailed analysis of the structure's ability to support the design loading during any repair or retrofit effort. Deteriorated and damaged members should be replaced immediately following a detailed assessment.

The following recommendation is provided in reference to the **Mid and Long Term scenarios** with regard to the current crib wave attenuator:

- Recommend redesign and upgrading and/or raising structure to accommodate the high water levels and expected waves.

4.4.6 Shoreline Protection

The following recommendation is provided in reference to the **Mid and Long Term scenarios** with regard to the current revetment:

- Consider localized re-grading and raising area to accommodate rising water levels and increased wave height above the top of riprap. Design and apply correctly sized stone at the shoreline based on this analysis.

5.0 OPINION OF PROBABLE CONSTRUCTION COSTS

The costing information below is based on our recommendations for remedial action considering the flood modelling and observation of structures reported herein. These estimated costs include the associated design and engineering services where applicable. **Table 6** provides a summary of the estimated cost for repair or replacement of the identified vulnerabilities. A cost savings may also be expected for combined efforts for items similar in nature, for example, replacing an electrical cabinet while

updating and/or securing electrical conduits. We have not considered this variable in our values. Where a complete replacement option is provided, this option and associated costs may be implemented sooner depending on the priorities and funding available to the Town. Costing for the referenced scenario represents summation of all non-complementary improvements. That is, where other repairs or intermediate retrofitting are performed during preceding scenarios the associated costs become additive. All costs are based on present value without inflation. Provided below is a more detailed description of the items included for the associated risk scenario.

A recommendation was provided above for the Ferry Terminal which involved altered or increased services based on the current design and operating constraints of the terminal. Indirect costs associated with these changes in service should be considered by the Town during resilience planning, including the benefits and timing of major structural improvements for the Ferry Terminal.

Table 6: Repair / Replacement / Retrofitting Costs

Facility	Present Day	Short Term	Mid Term	Long Term
Ferry Terminal	$5,000	$5,000	$5,000	$8,000,000
Floating Dock	$250,000	$250,000	$250,000	$500,000
Ferry Services Building	$400,000	$400,000	$400,000	$400,000
Parking Area		$200,000	$200,000	$200,000
Crib Wave Attenuator	$550,000	$550,000	$700,000	$700,000
Shoreline Protection			$300,000	$300,000
TOTAL:	**$1,205,000**	**$1,405,000**	**$1,855,000**	**$10,100,000**

5.1 Present Day Scenario

The following costs should be expected to accommodate events associated with the Present Day scenario.

Ferry Terminal:

- Replace electrical/utility box at ferry bridge. Design and Construction **$5,000.**

Floating Dock:

- Confirm the gangway attachments and mooring pile attachment to crib are sufficient to resist the design loading and repair or replace as needed. Design and Construction **$250,000.**

Ferry Services Building:

- Relocate structure or build sea wall between structure and shoreline. Design and Construction **$400,000.**

Crib Wave Attenuator:

- Hydrologic and structural analysis. Replace deteriorated and damaged members following a detailed assessment. Design and Construction **$550,000.**

5.2 Short Term Scenario

Items addressed for this section include any unaddressed items of the previous scenario (Present Day) and new risks related to the Short Term scenario. The following costs should be expected to accommodate events associated with the Short Term scenario:

Ferry Terminal:

- Replace electrical/utility box at ferry bridge. Design and Construction **$5,000.**

Floating Dock:

- Confirm the gangway attachments and mooring pile attachment to crib are sufficient to resist the design loading and repair or replace as needed. Design and Construction **$250,000.**

Ferry Services Building:

- Relocate structure or build sea wall between structure and shoreline. Design and Construction **$400,000.**

Parking Area:

- Maintenance repaving and strategic regrading. Design and Construction **$200,000.**

Crib Wave Attenuator:

- Hydrologic and structural analysis. Replace deteriorated and damaged members following a detailed assessment. Design and Construction **$550,000.**

5.3 Mid Term Scenario

Ferry Terminal:

- Replace electrical/utility box at ferry bridge. Design and Construction **$5,000.**

Floating Dock:

- Confirm the gangway attachments and mooring pile attachment to crib are sufficient to resist the design loading and repair or replace as needed. Design and Construction **$250,000**

Ferry Services Building:

- Relocate structure or build sea wall between structure and shoreline. Design and Construction **$400,000.**

Parking Area:

- Maintenance repaving and strategic regrading. Design and Construction **$200,000.**

Crib Wave Attenuator:

- Hydrologic and structural analysis. Redesign and raise structure based on analysis. Design and Construction **$700,000.**

Shoreline Protection:

- Localized regrading, resizing riprap and raising of structure. Design and Construction **$300,000.**

5.4 Long Term Scenario

This section includes costs which are expected due to the need for substantial site improvements; however, some of these actions are recommended as early as the Present Day Term scenario. Items which are not addressed in earlier time periods are included here when not addressed during the course of other referenced improvements.

Ferry Terminal:

- Recommend investigation and implementation of structural improvements to accommodate the rising water levels. Design and Construction **$8,000,000.**

Floating Dock:

- Consider raising the gangway and gangway platform to accommodate the rising water level. Design and Construction **$500,000**

Ferry Services Building:

- Relocate structure or build sea wall between structure and shoreline. Design and Construction **$400,000.**

Parking Area:

- Maintenance repaving and strategic regrading. Design and Construction **$200,000.**

Crib Wave Attenuator:

- Hydrologic and structural analysis. Redesign and raise structure based on analysis. Design and Construction **$700,000.**

Shoreline Protection:

- Localized regrading, resizing riprap and raising of structure. Design and Construction **$300,000.**

6.0 QUALIFICATIONS OF THE REPORT

The DMR should understand that our observations may be inconclusive, or it may not be possible to identify a definitive cause of distress based on a structural inspection and visual observations alone/without further testing. The recommendations are made based on these limitations.

The "Opinion of Probable Construction Costs" is made on the basis of Wood PLC's judgment, as experienced and qualified professionals generally familiar with the construction industry. However, since Wood, PLC has no control over the cost of labor, materials, equipment, or services furnished by others, or over the construction contractor's methods of determining prices, or over competitive bidding or market conditions, Wood cannot, and does not, guarantee that proposals, bids, or actual construction cost will not vary from the Opinion of Probable Construction Costs prepared by Wood PLC. We have attempted to consider the general nature of the work and site conditions, based on information made available to us at this stage of the project. All costs are based on actual costs as provided by RS Means Costworks 2018, additional or other specified suppliers vendors and contractors.

7.0 CLOSING

Wood appreciate the opportunity to provide these services to DMR on this project. Please contact us with any questions or comments.

Sincerely,
Wood Environment & Infrastructure Solutions, Inc.

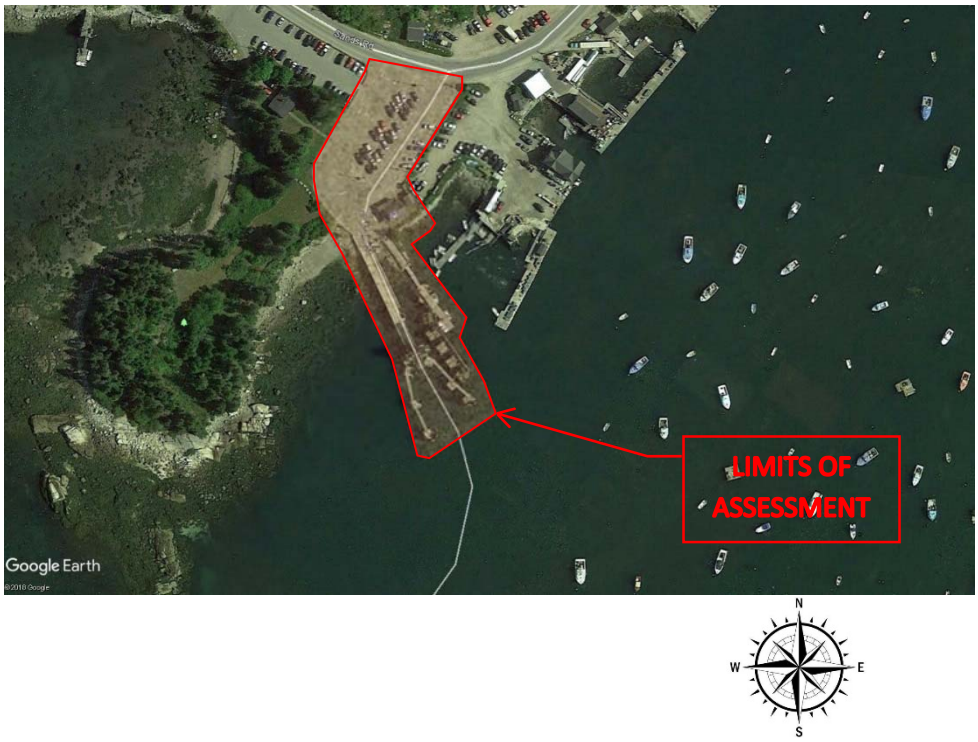
Tirrell Day, PE
Senior Structural Engineer

D. Todd Coffin
Associate Project Manager

Attachments: Appendix A - Photolog
Appendix B – Inundation Maps

Appendix A - Photolog for Ferry Terminal Vinalhaven, ME

By: T. Day *Date:* 22OCT2019 *Reviewed:* K. Sun *Date:* 25OCT2019

Photograph No. 1: 	**Comment:** **Overview of Site**
Photograph No. 2: 	**Comment:** **Overview of site from west side.** **View of ferry services building, main approach bridge and transfer bridge.**

By: T. Day Date: 22OCT2019 Reviewed: K. Sun Date: 25OCT2019

Photograph No. 3: 	**Comment:** **View from ferry including concrete pier, fender system and mooring bollards on dolphins No. 5 and 6.**
Photograph No. 4: 	**Comment:** **View of mooring bollard for dolphin No. 1 from back of fender panels.**

By: T. Day Date: 22OCT2019 Reviewed: K. Sun Date: 25OCT2019

Photograph No. 5:

Comment:

Close-up of (1) concrete pier and view of (2) concrete piles below.

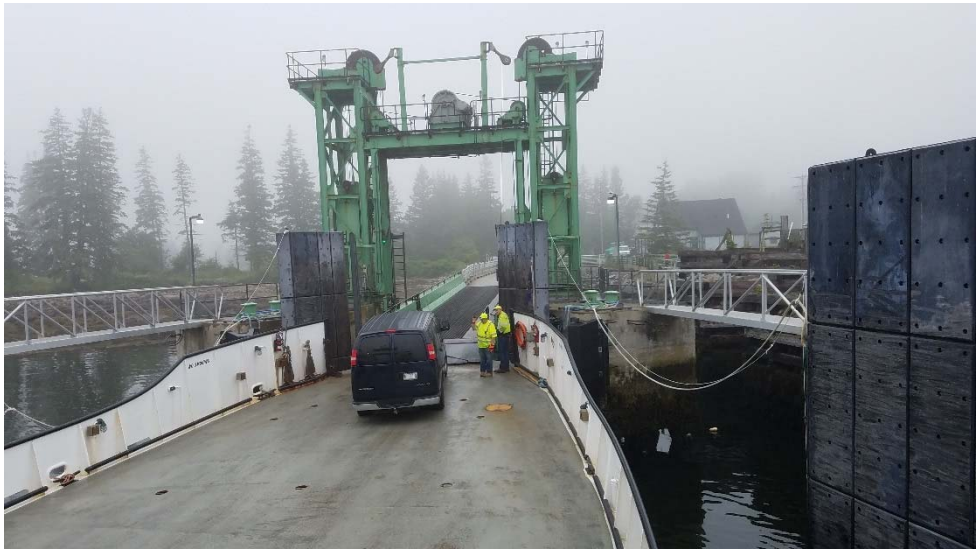
Photograph No. 6:

Comments:

View of top of pier and gangway attachment to pier.

By: T. Day Date: 22OCT2019 Reviewed: K. Sun Date: 25OCT2019

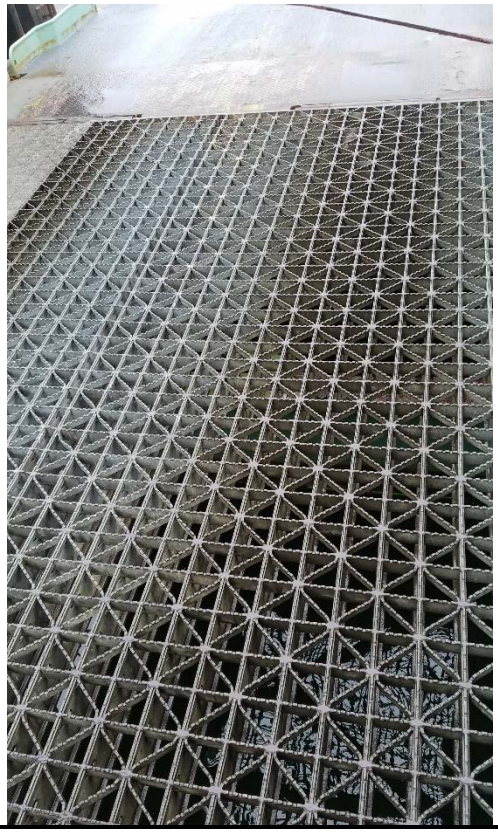
Photograph No. 7:



Comment:

View of transfer bridge operation from ferry. Showing bridge tower and fender system on dolphins No. 3 and 4.

Photograph No. 8:



Comment:

View of transfer bridge grating noted. Appears in good condition.

By: T. Day Date: 22OCT2019 Reviewed: K. Sun Date: 25OCT2019

Photograph No. 9: 	**Comment:** **View of main approach bridge from east side.**
Photograph No. 10: 	**Comment:** **View of main approach bridge from west side.**

By: T. Day Date: 22OCT2019 Reviewed: K. Sun Date: 25OCT2019

Photograph No. 11:

Comment:

View of abutment at north end of main approach bridge.

No obvious signs of corrosion or efflorescence.

Photograph No. 12:

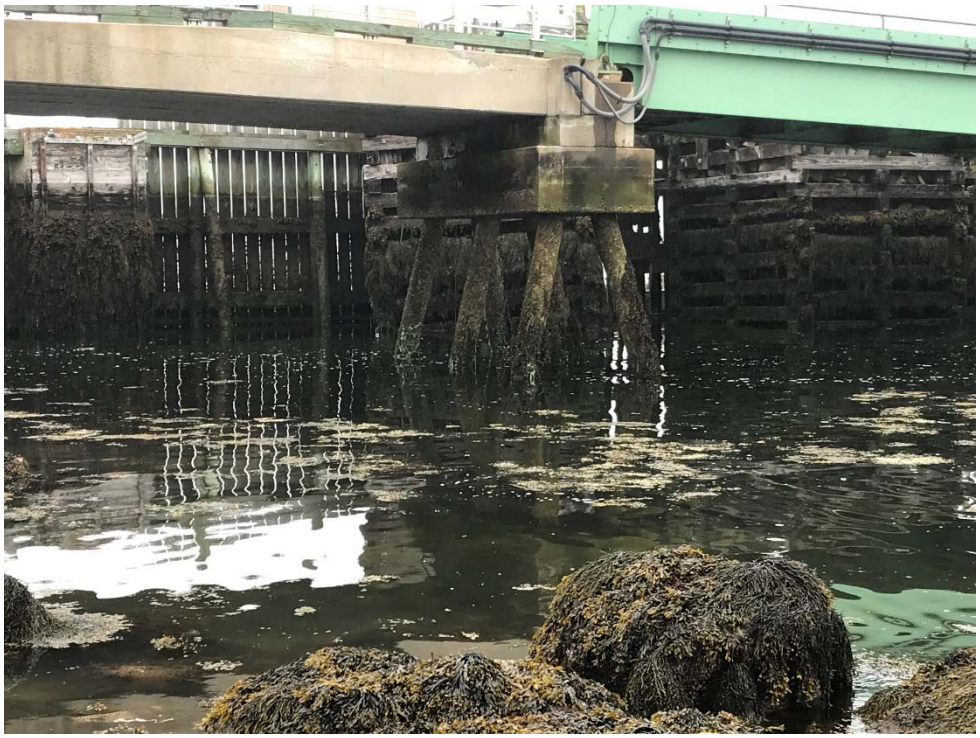
Comments:

View at west side of approach bridge during lower tide.

View of pipe piles. Piles appear in decent condition from view of exposed areas. Recoating may be necessary to avoid deterioration of material. Condition of anchor connection to rock could not be observed.

By: T. Day Date: 22OCT2019 Reviewed: K. Sun Date: 25OCT2019

Photograph No. 13:



Comment:

View of Pier 3 for support of main approach bridge and transfer bridge from west side.

No signs of serious deterioration noted from this vantage point. Closer examination of concrete pier and support is recommended.

Photograph No. 14:

Comment:

View of main bridge to transfer bridge transition. Support conditions were inaccessible for viewing.

By: T. Day Date: 22OCT2019 Reviewed: K. Sun Date: 25OCT2019

Photograph No. 15:

Comment:

View of transfer bridge hoisting assembly and framing.

Photograph No. 16:

Comment:

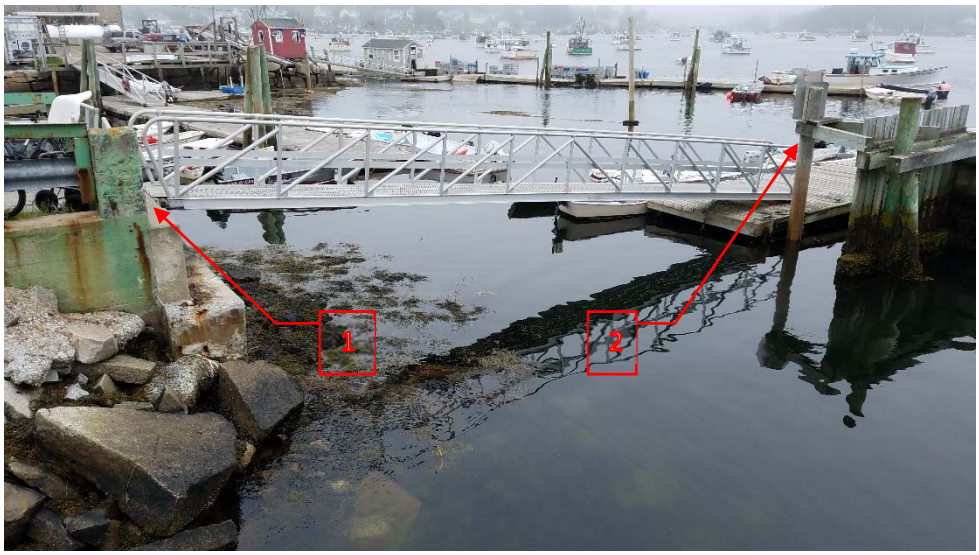
View of electrical equipment at east end of main bridge.

Some components appear to be watertight. Other components should be verified.

1. **Corroded electrical box appears to have loss material due to delamination.**

By: T. Day Date: 22OCT2019 Reviewed: K. Sun Date: 25OCT2019

Photograph No. 17:

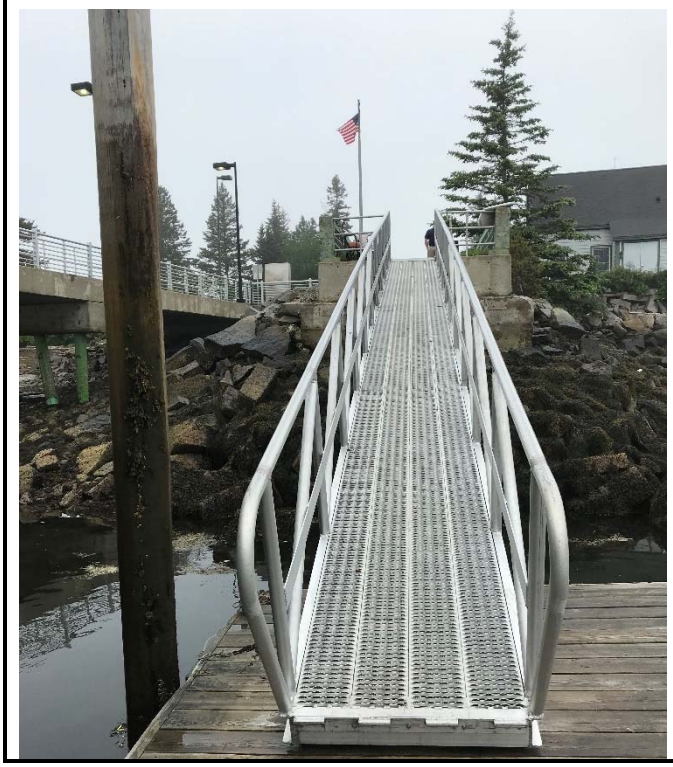


Comment:

View of floating dock and gang way.

1. **Gangway attachment to existing abutment.**
2. **Timber pile as support for floating dock, braced to crib.**

Photograph No. 18:



Comment:

View of floating dock gangway facing north.

By: T. Day Date: 22OCT2019 Reviewed: K. Sun Date: 25OCT2019

Photograph No. 19:

Comment:

View of attachment of gangway to abutment at south side.

Attachment of gangway to concrete appears in decent condition.

Photograph No. 20:

Comment:

View of floating dock.

Decking appears moderately weathered but functional.

Pontoons appear to function as intended.

By: T. Day Date: 22OCT2019 Reviewed: K. Sun Date: 25OCT2019

Photograph No. 21:

Comment:

View of west side of ferry services building

Photograph No. 22:

Comment:

View of north side of ferry services building

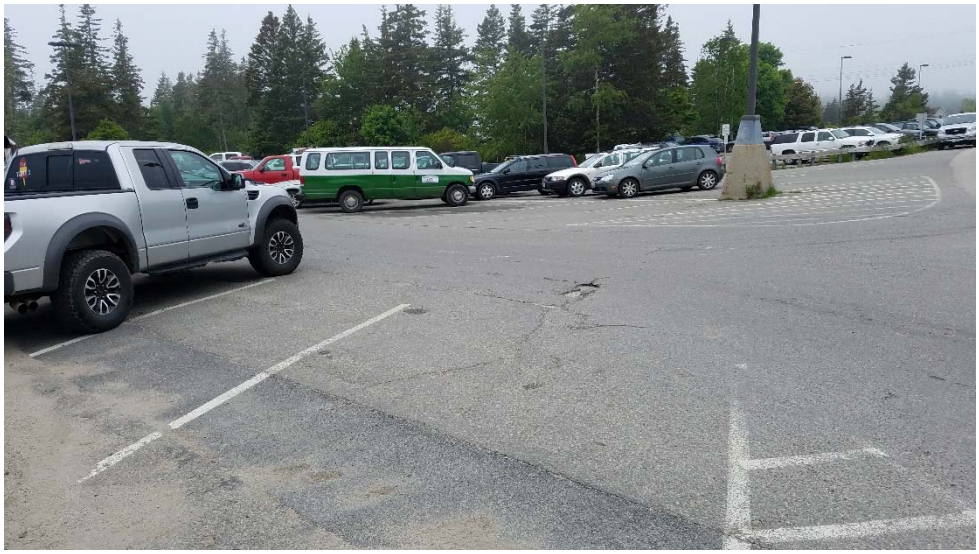
1. **Signs of major surface delamination of the asphalt top coat.**

By: T. Day Date: 22OCT2019 Reviewed: K. Sun Date: 25OCT2019

Photograph No. 23: 	**Comment:** **View of parking area at northeast corner looking south**
Photograph No. 24: 	**Comment:** **View of parking lot at northwest corner looking south.**

By: T. Day Date: 22OCT2019 Reviewed: K. Sun Date: 25OCT2019

Photograph No. 25:



Comment:

View of entrance to site and parking.

Signs of surface delamination at top coat.

Photograph No. 26:

Comment:

View of Breakwater crib from north side looking south.

Previous crib as part of original berthing station for ferry.

By: T. Day Date: 22OCT2019 Reviewed: K. Sun Date: 25OCT2019

Photograph No. 27:

Comment:

Closer view of breakwater/crib.

Timber framing filled with large rocks.

Photograph No. 28:

Comment:

Additional view of cribbing.

By: T. Day Date: 22OCT2019 Reviewed: K. Sun Date: 25OCT2019

Photograph No. 29:

Comment:

Close-up of crib indicating construction and condition of timber framing.

Moderate to major weatheriing noted.

Photograph No. 30:

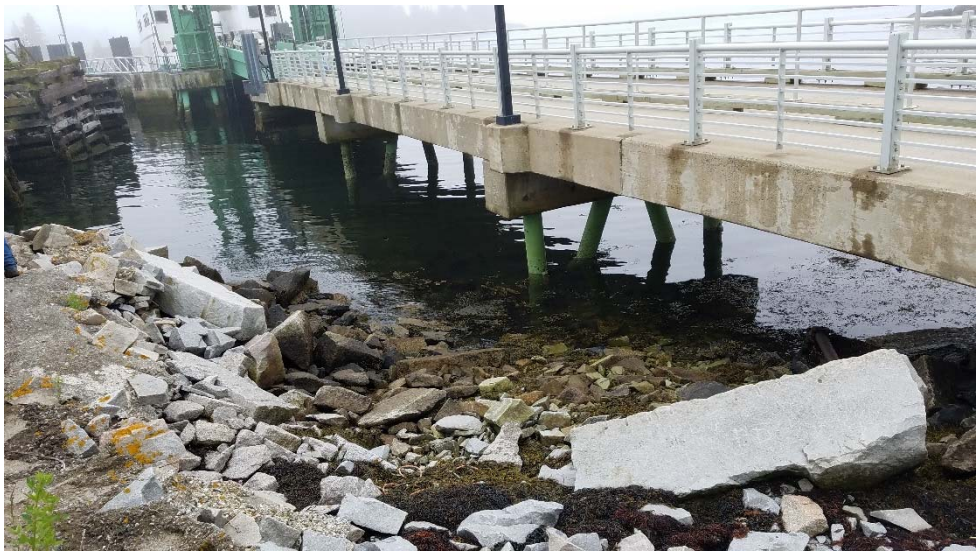
Comment:

View of shoreline projection near floating dock gangway.

Riprap noted beyond the abutment.

By: T. Day Date: 22OCT2019 Reviewed: K. Sun Date: 25OCT2019

Photograph No. 31:



Comments:

View of shoreline protection near north bent of bridge.

Photograph No. 32:

Comments:

View of revetment at west side of bridge.

Extents of protection can be viewed.

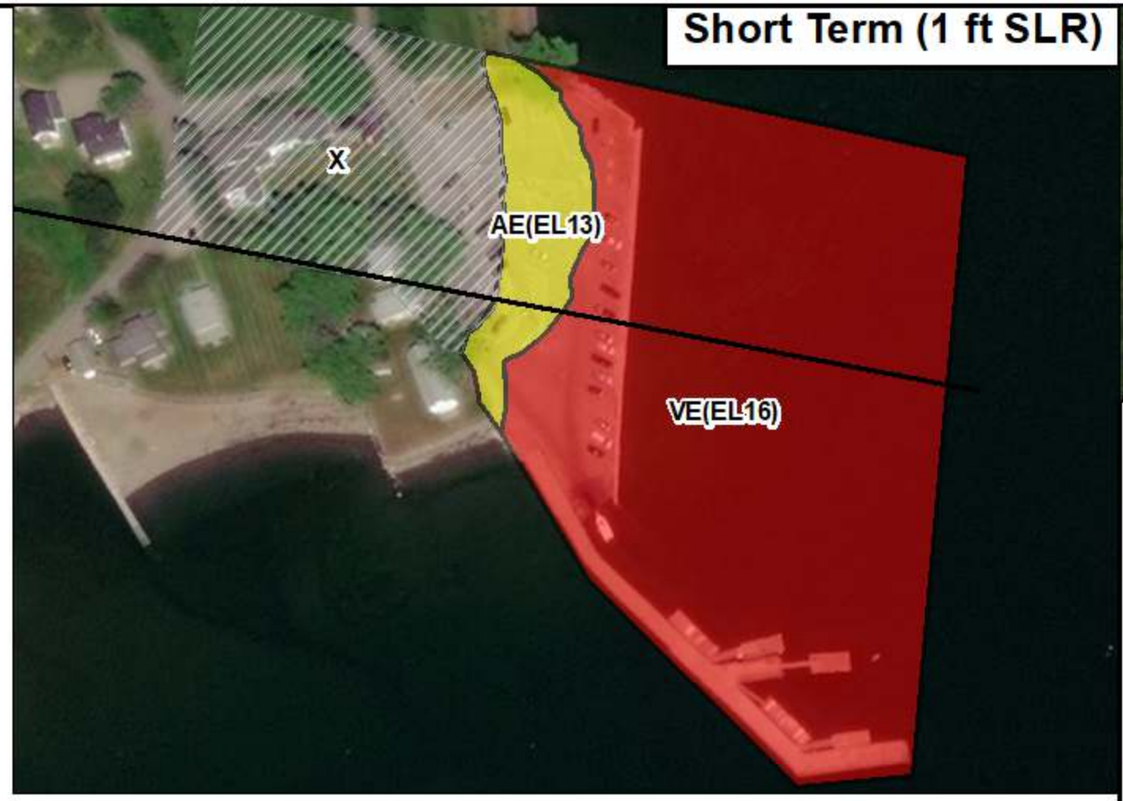
By: T. Day Date: 22OCT2019 Reviewed: K. Sun Date: 25OCT2019

Photograph No. 33:

Comment:
View of shoreline protection at the north side of the ferry terminal and floating dock.

Appendix B – Inundation Maps

Site: Searsport, ME

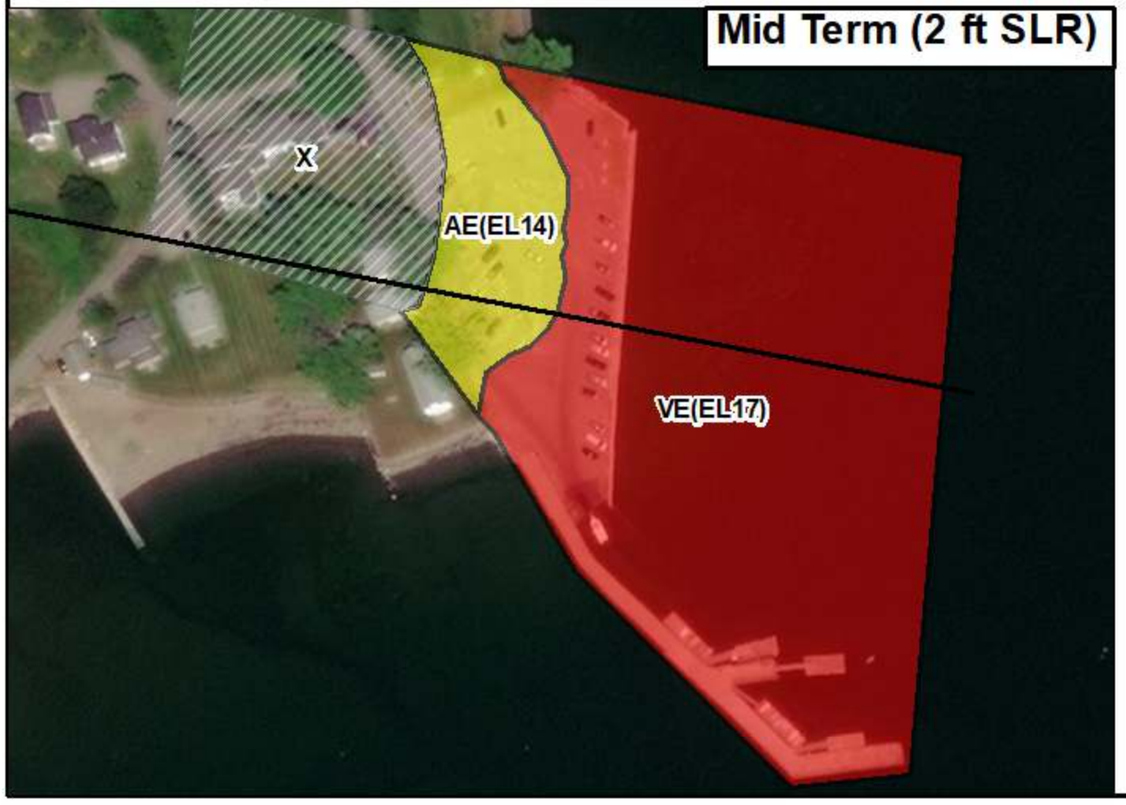


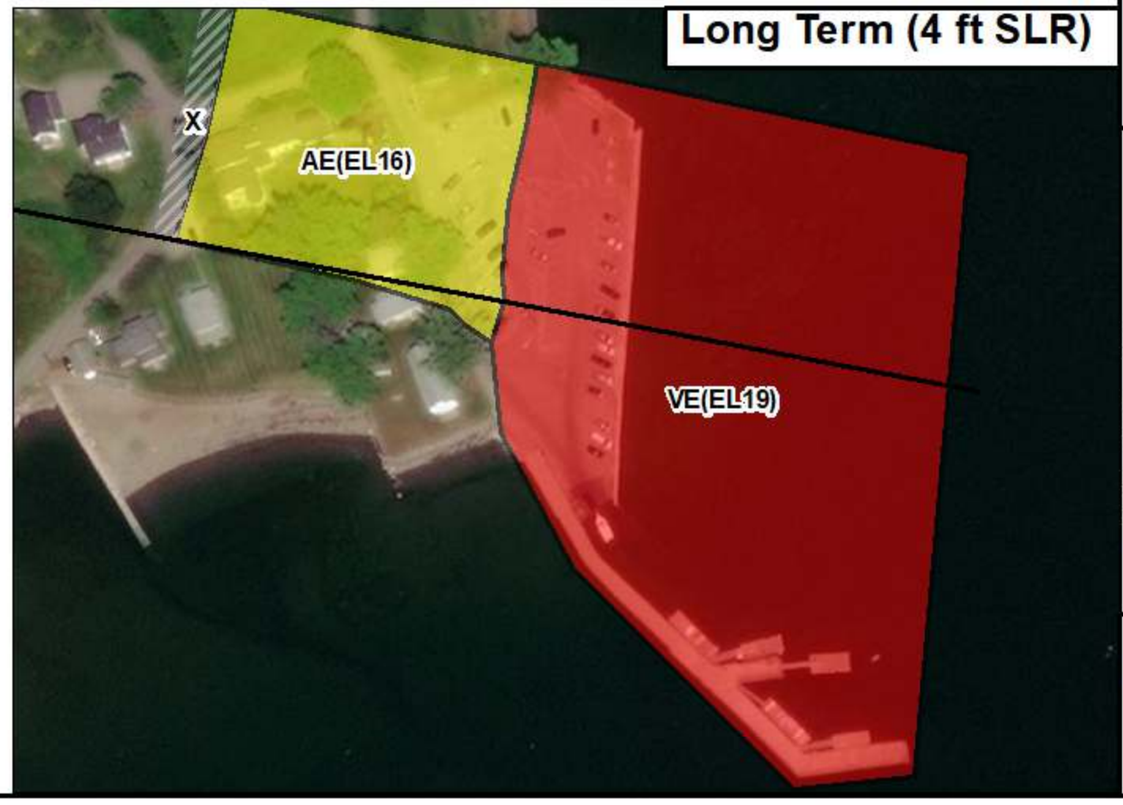
1. Maps indicate the 1%-annual-chance flood zones and base flood elevations.

2. This does not constitute a revision to the FEMA FIRM map which is done through FEMA's Letter of Map Revision process for which additional analysis and/or modeling may be required.

3. Flood mapping was developed for planning purposes only. No other use of this map should be made.

4. Elevations in reference to vertical datum NAVD88





Searsport Transect

AE

VE

X

N

Zone AE : Coastal flood zone. Base Flood Elevations determined.

Zone VE : Coastal flood zone with velocity hazard (wave action). Base Flood Elevations determined.

Zone X : Areas determined to be outside the 1% annual chance floodplain.

0 37.5 75 150 Feet

WOODS HOLE GROUP
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