

# A highlight from the Penobscot Bay Working Waterfront Resiliency NOAA Project of Special Merit







# Working Waterfronts in Maine

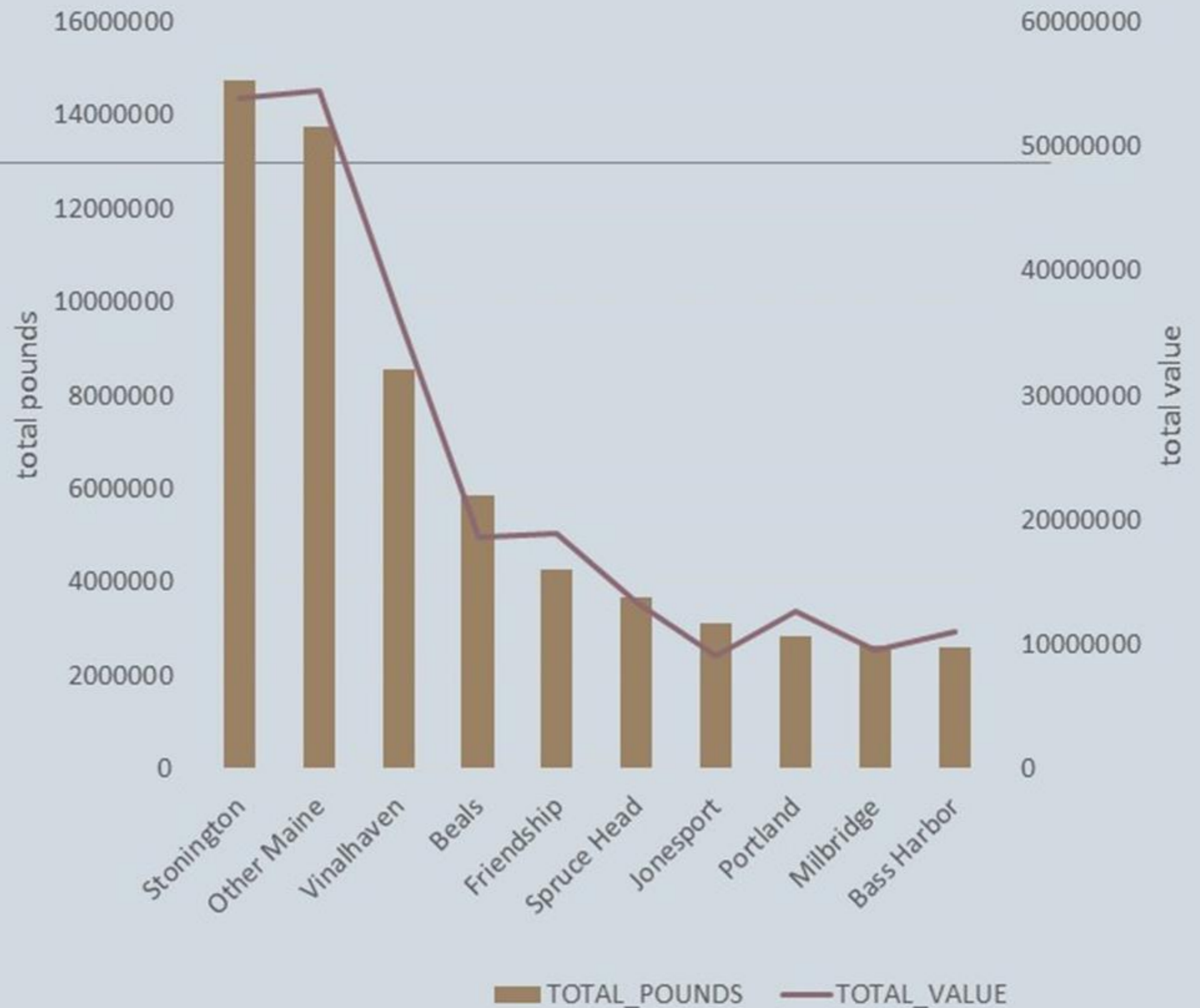
- 5,300 miles of coastline
- Historic studies have shown only 20 miles dedicated to working waterfront
- In 2016, the commercial fishing industry alone brought in \$636 million
- Supporting 35,000 jobs



# Why Penobscot Bay

- Largest bay in Gulf of Maine
- Ecologically diverse
- Epicenter for tourism, recreation and fishing
- Mix of island/mainland communities
- Increased interest in resiliency

2017 top 10 Maine ports (lobster only)





# The Project

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Facility baseline  
characterization

- i.e. elevation, age and condition, flood history

Facility vulnerability  
analysis

- Analysis of sea level rise, flooding, and storm surge
- Short, mid and long term economic disruption

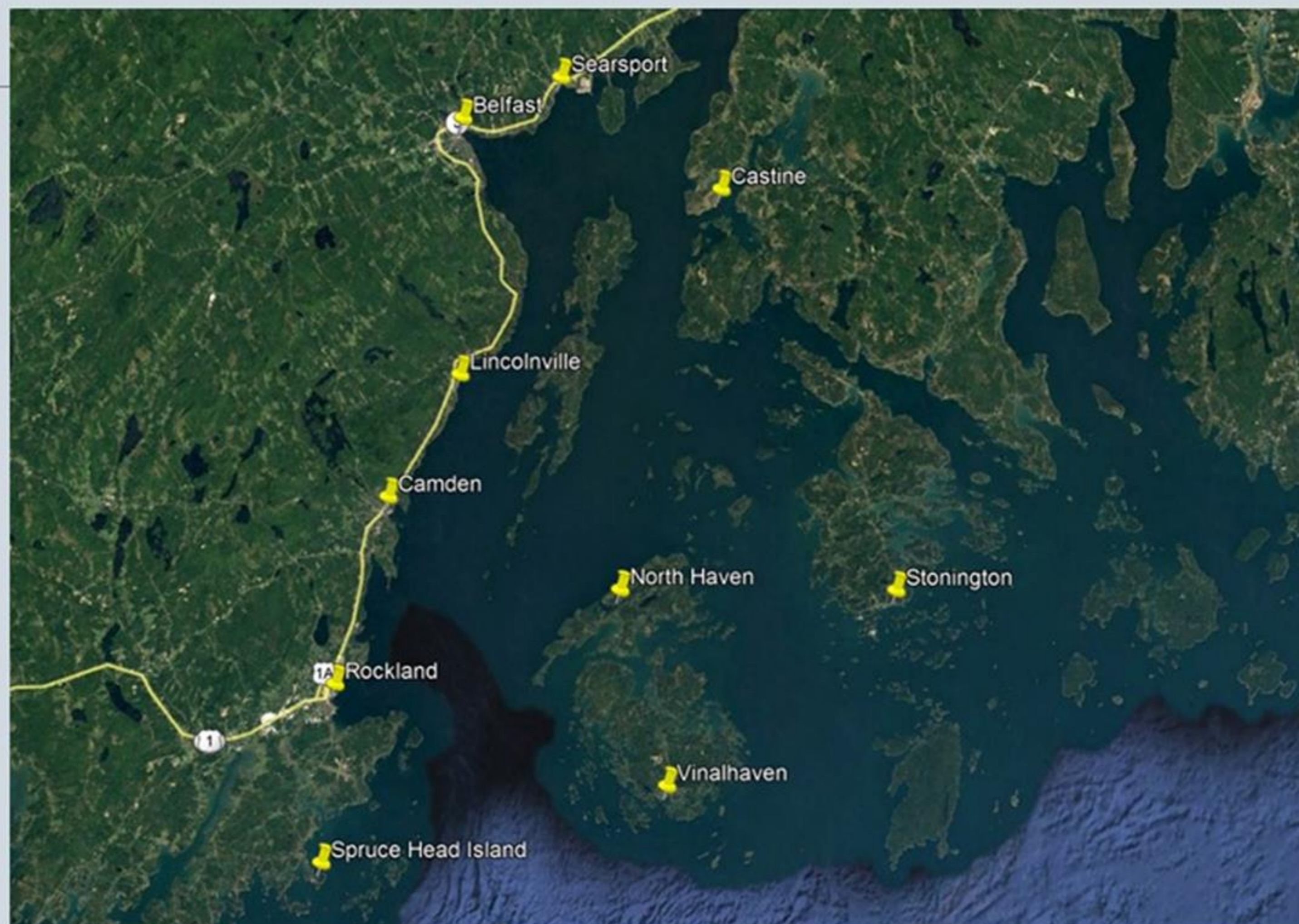
Recommendations for  
incremental adaption  
strategies

- Adaptive measures, costs and improvements



# Project Scope

## Ten Waterfront Sites in Penobscot Bay





# Methodology

Vulnerability Assessment & Resilience Planning

## Ten Working Waterfront Sites

Middle Pier, Rockland

Public Landing, Camden

Municipal Fish Pier, Lincolnville

Public Landing/Breakwater, Belfast

Hamilton Wharf, Searsport

Ferry Terminal, Vinalhaven

Lobster Coop, Stonington

Town Dock, Castine

*Additional Analyses: Island Rd, South Thomaston; Waterfront Access, Northaven*





# Methodology

## Vulnerability Assessment & Resilience Planning

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Site visits w/officials

Structural review

Site survey

**Flood modeling**

**Vulnerability assessment**

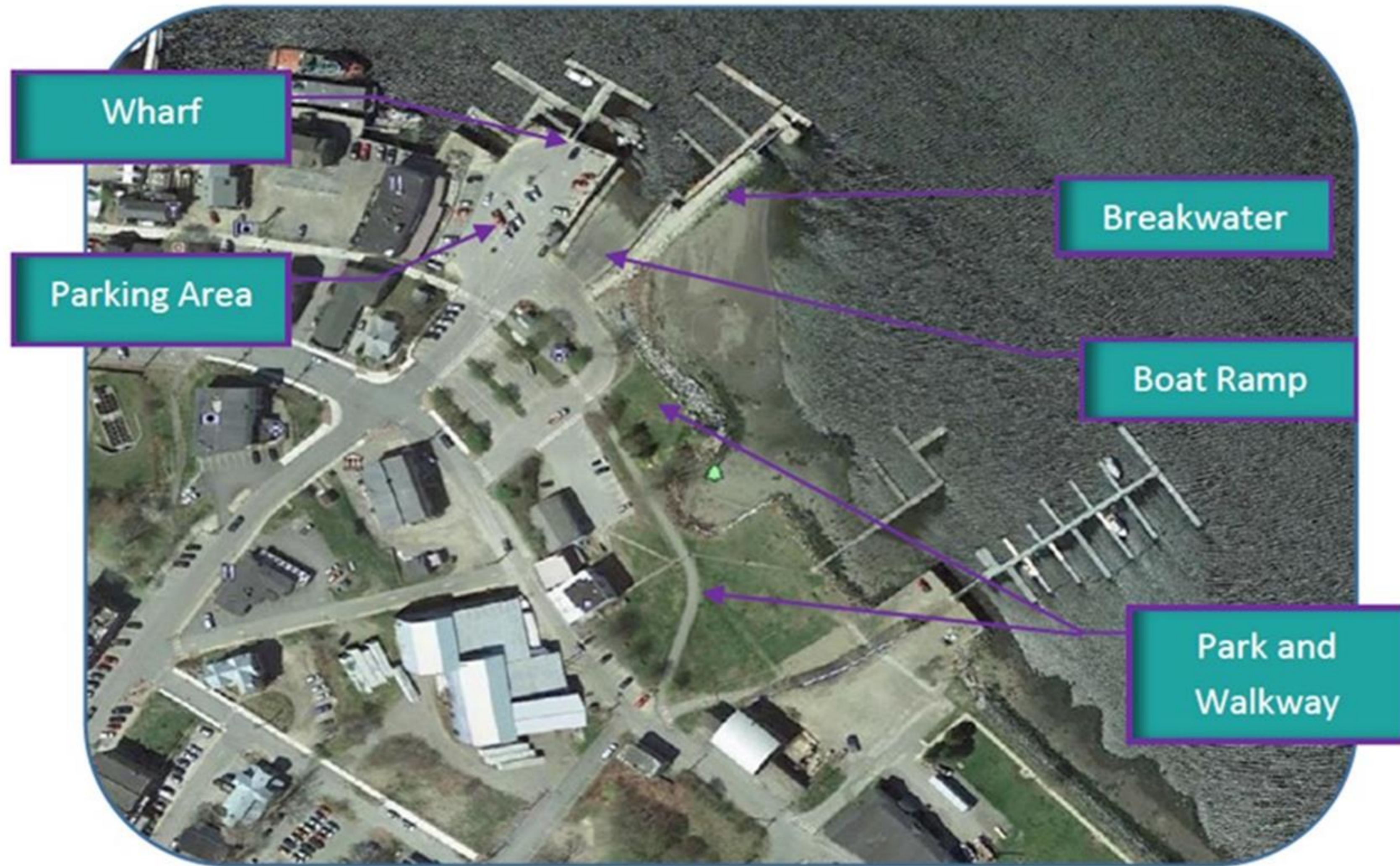
**Resilience planning**





# Public Landing, Belfast, ME

Figure 1: Site Overview





# Structural Deficiencies

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- **Superstructure**
- Substructure
- Connections





# Structural Deficiencies

Photograph No. 27:



**Comments:**

Condition of steel at mooring structure noted. Moderate to major corrosion noted.

Photograph No. 41:



**Comment:**

View at north side of breakwater.

1. Material at north side which appears to have eroded from breakwater interior.

Photograph No. 38:



**Comment:**

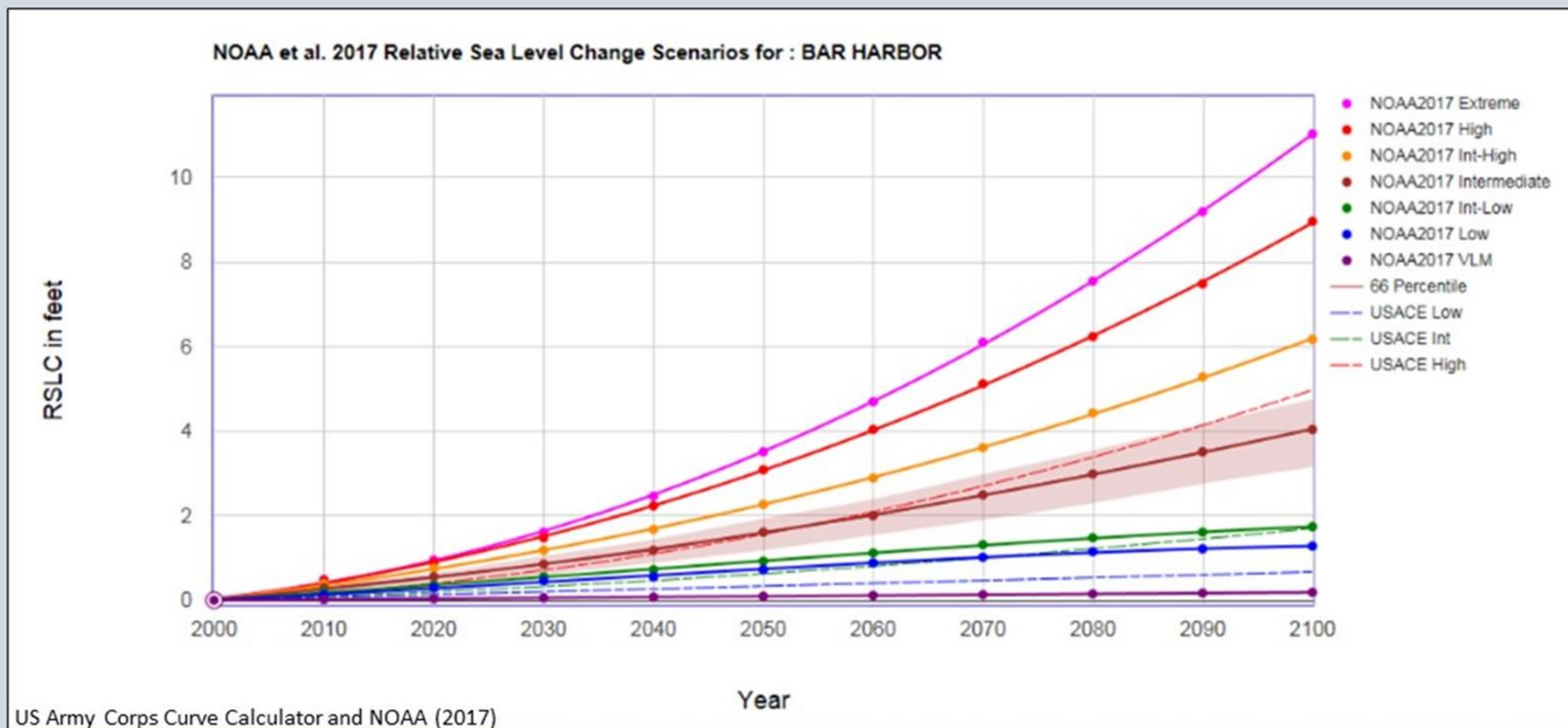
View of drain pipe which drains into shoreline.

An unprotected channel is noted with signs of erosion.



# Sea Level Rise Planning

Short-term 2030 1 foot SLR  
Mid-term 2050 2 feet SLR  
Long-term 2085 4 feet SLR





# Updating FEMA Base Flood Elevations

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Defined site-specific 1-D model transects

Collected bathymetry/topography data (NOAA, FEMA, MGS)

Updated topography with survey from Wood

1% SWEL and wave conditions (offshore) from nearest FEMA transect

Conducted overland wave modeling using FEMA's CHAMP model

Conducted analyses of wave runup (where applicable)

Flood zone mapping



Site: Belfast, ME

Present Day



Short Term (1 ft SLR)



Mid Term (2 ft SLR)



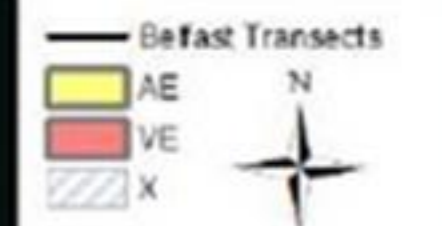
Long Term (4 ft SLR)



Penobscot Bay



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



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.





# Detailed infrastructure vulnerability assessments

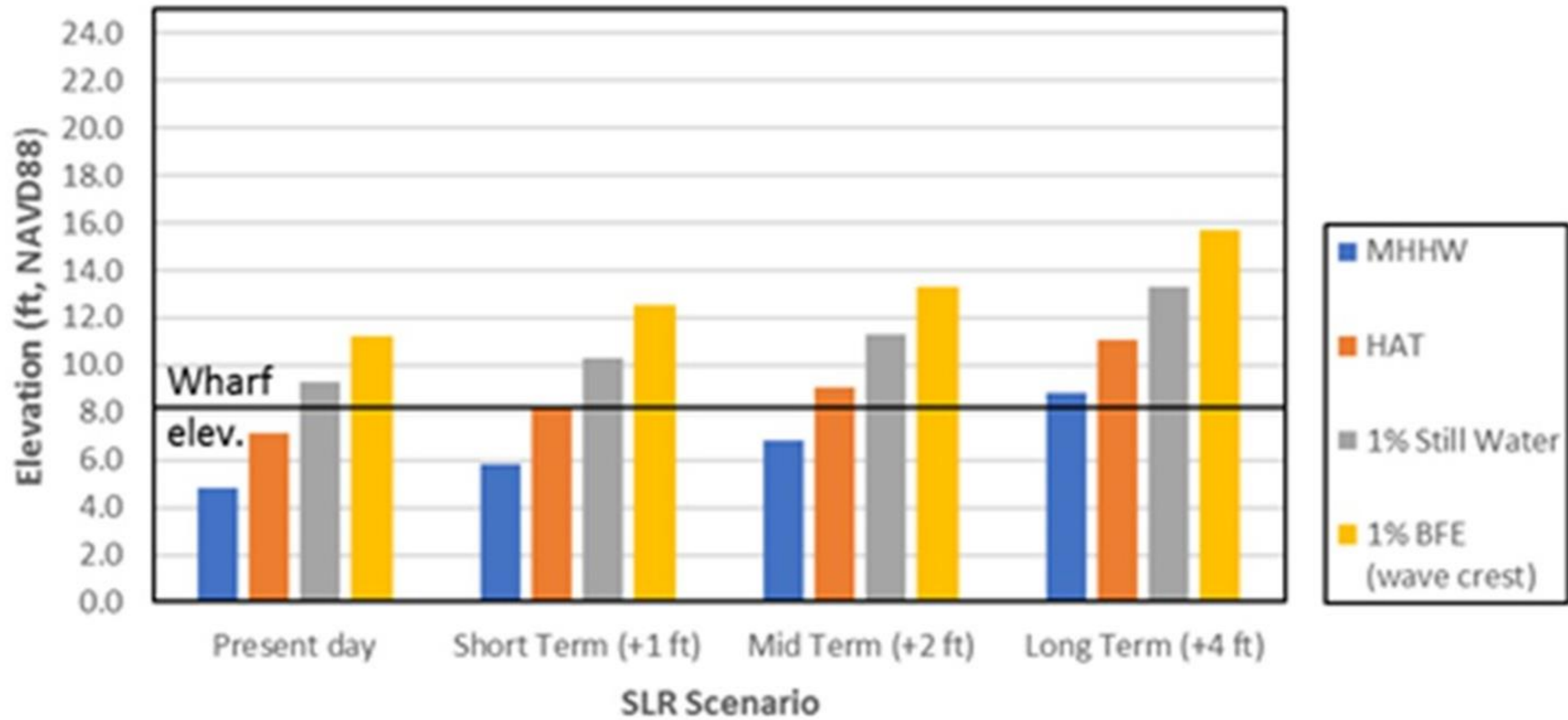
**Table 5: Site Elevations and Risks**

Facility			Inundation above Elevation of Facility															
Description	Elevation (ft) to NAVD88		Present Day 1%				Short Term Scenario 1%				Mid Term Scenario 1%				Long Term Scenario 1%			
			MHHW	HAT	Stillwater	BFE	MHHW	HAT	Stillwater	BFE	MHHW	HAT	Stillwater	BFE	MHHW	HAT	Stillwater	BFE
			[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]
Wharf / Pier	Lowest Horizontal	6.44 ft		1.06	3.26	4.6		2.06	4.26	6.56	0.76	3.06	5.26	7.56	2.76	5.06	7.26	11.1
	Lowest Deck or Adjacent Grade	8.19 ft			1.51	2.8		0.31	2.51	4.81		1.31	3.51	5.81	1.01	3.31	5.51	9.31
Floating Dock 1	Buoy Chain max elevation	9.17 ft			0.53	1.8			1.53	3.83		0.33	2.53	4.83	0.03	2.33	4.53	8.33
	Gangway support	8.03 ft			1.67	3		0.47	2.67	4.97		1.47	3.67	5.97	1.17	3.47	5.67	9.47
Floating Dock 2	Buoy Chain max elevation	10.75 ft				0.3				2.25			0.95	3.25		0.75	2.95	6.75
	Gangway support	8.65 ft			1.05	2.4			2.05	4.35		0.85	3.05	5.35	0.55	2.85	5.05	8.85
Floating Dock 3	Buoy Chain max elevation	8.35 ft			1.35	2.7		0.15	2.35	4.65		1.15	3.35	5.65	0.85	3.15	5.35	9.15
	Gangway support																	
Floating Dock 4	Buoy Chain max elevation	9.98 ft				1			0.72	3.02			1.72	4.02		1.52	3.72	7.52
	Gangway support																	
Harbor Master's Office	Adjacent Grade	8.97 ft			0.73	2			1.73	4.03		0.53	2.73	5.03	0.23	2.53	4.73	8.53
	Lowest Horizontal	10.01 ft				1			0.69	2.99			1.69	3.99		1.49	3.69	7.49
	Lowest Opening	10.3 ft				0.7			0.4	2.7			1.4	3.7		1.2	3.4	7.2



# Water levels vs. key infrastructure

Water Level Elevation Summary  
Public Landing, Belfast





# Detailed recommendations and cost estimates

## *Present Day:*

### **Wharf:**

- Confirm positive attachment of all structural members to their substrate or load-bearing elements. Incorporate redundancies in design as needed based on a detailed structural analysis. Repair or replace damaged section designated as Finger A herein. Design and Construction **\$175,000**
- Utilities and equipment should be properly secured to resist design wind and water loading or relocated above the flood elevation as specified in ASCE 24. Watertight enclosures should be incorporated for electrical equipment and conduits. **\$10,000 - \$25,000**

## *Short and longer-term*

### **Wharf:**

- Consider raising the wharf and pier to accommodate rising water levels. Design and Construction **\$4,500,000.**



# Detailed recommendations and cost estimates

**Table 6: Repair / Replacement / Retrofitting Costs**

Facility	Present Day	Short Term	Mid Term	Long Term
Pier / Wharf	\$200,000	\$4,500,000	\$4,500,000	\$4,500,000
Floating Docks	\$75,000			
Facilities	\$150,000	\$150,000	\$250,000	\$500,000
Breakwater	\$150,000	\$250,000	\$250,000	\$450,000
Shoreline Protection	\$225,000	\$225,000	\$225,000	\$300,000
Boat Ramp			\$180,000	\$250,000
<b>TOTAL:</b>	<b>\$800,000</b>	<b>\$5,125,000</b>	<b>\$5,405,000</b>	<b>\$6,000,000</b>



# Community Outreach



- Workshop with participating communities
- On-line workshop with communities (that could not attend)
- “Funding” workshop and discussions
- Post-workshop follow ups from Team, as needed, on implementing improvements