
PHOTO: DAVID J. MURRAY, CLEAREYEPHOTO.COM

2019-2020 New Hampshire Coastal Flood Risk Summary

Webinar Training for Professionals
Tuesday March 31, 2020

Presented by:
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New Hampshire Department of Environmental Services

Webinar Training | Meet the Organizers

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NEW HAMPSHIRE DEPARTMENT OF Environmental Services

NEW HAMPSHIRE COASTAL PROGRAM

University of New Hampshire Cooperative Extension

Sea Grant New Hampshire

PREP Piscataqua Region Estuaries Partnership

Webinar Training | Agenda

- Background & Context
- Part I: Science
- Part II: Guidance for Using Scientific Projections
- How You Might Use the Science & Guidance
- Q & A


PHOTO: NATHALIE MORISON, NHDES COASTAL PROGRAM

New Hampshire Coastal Flood Risk Summary
Background & Context

Sea-level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Future Trends

Prepared by

Science and Technical Advisory Panel
New Hampshire Coastal Risks and Hazards Commission
(RSA 483-E)

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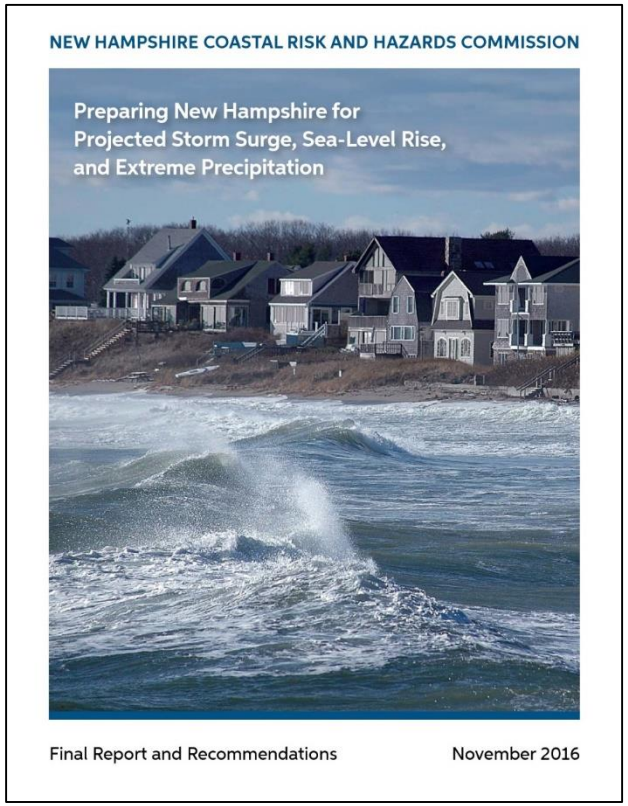
Outside Reviewers: Robert Kopp (Rutgers University), Stephen Gill (US NOAA), and Kerry Emanuel (Massachusetts Institute of Technology)

Adopted with Amendments by the
New Hampshire Coastal Risks and Hazards Commission
on July 18, 2014

Amendments and edits incorporated
August 11, 2014

https://www.nhcrhc.org/stap-report/

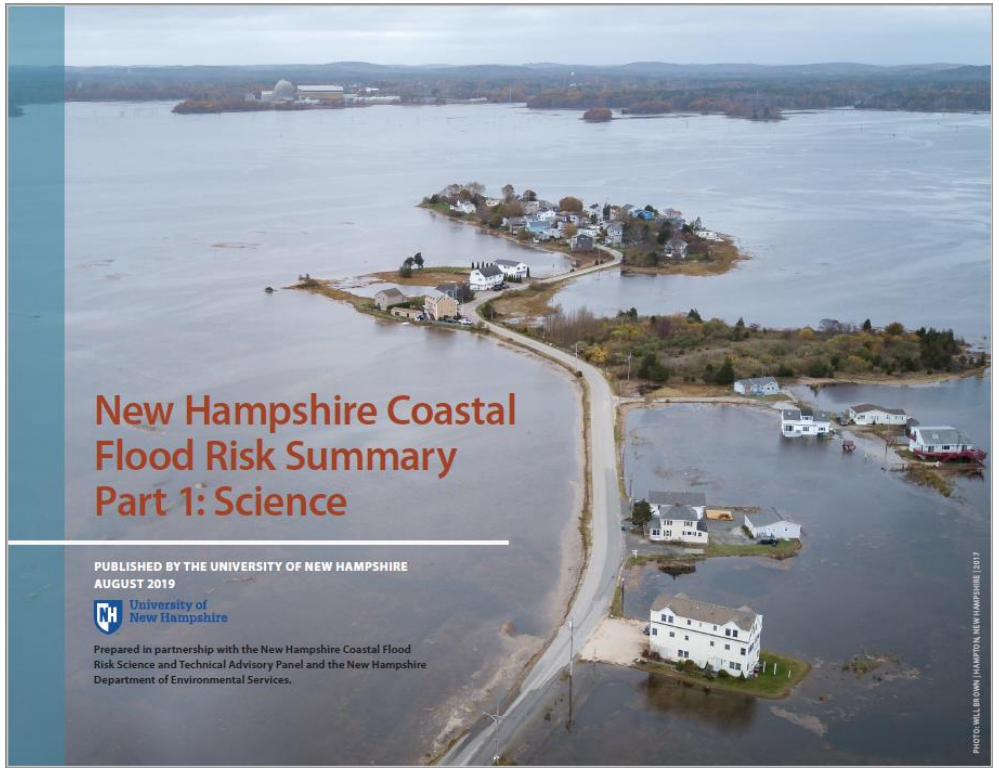


https://www.nhcrhc.org/final-report/

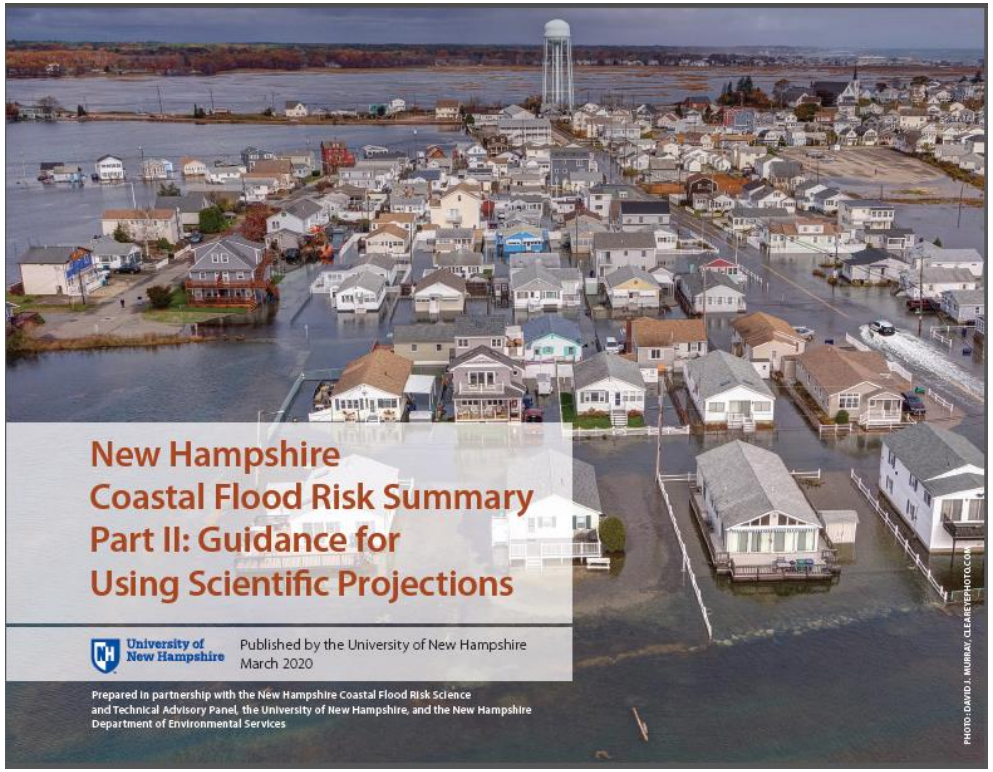
RSA 483-B:22 COASTAL AND GREAT BAY REPORTS

"The commissioner of the department of environmental services shall convene representatives of the department of transportation, the division of homeland security and emergency management, the office of strategic initiatives, and other agencies as he or she deems appropriate, at least every five years, commencing July 1, 2019 to supervise an updating of storm surge, sea-level rise, precipitation, and other relevant projections recommended in the coastal risks and hazards commission 2014 report "Sea-Level Rise, Storm Surges, and Extreme Precipitation in Coastal New Hampshire: Analysis of Past and Projected Trends." This report shall be distributed to all state agencies, municipalities in the coastal and Great Bay region, the governor, the speaker of the house of representatives, the president of the senate and the chairs of the house and senate committees with jurisdiction over issues related to such projections."

New Hampshire Coastal Flood Risk Summary
Background & Context



Part I: Science
Released August 2019
https://scholars.unh.edu/ersc/210/



Part II: Guidance for Using Scientific Projections
Released March 2020
https://scholars.unh.edu/ersc/211/

New Hampshire Coastal Flood Risk Summary Part 1: Science

PUBLISHED BY THE UNIVERSITY OF NEW HAMPSHIRE
AUGUST 2019

University of New Hampshire

Prepared in partnership with the New Hampshire Coastal Flood Risk Science and Technical Advisory Panel and the New Hampshire Department of Environmental Services.

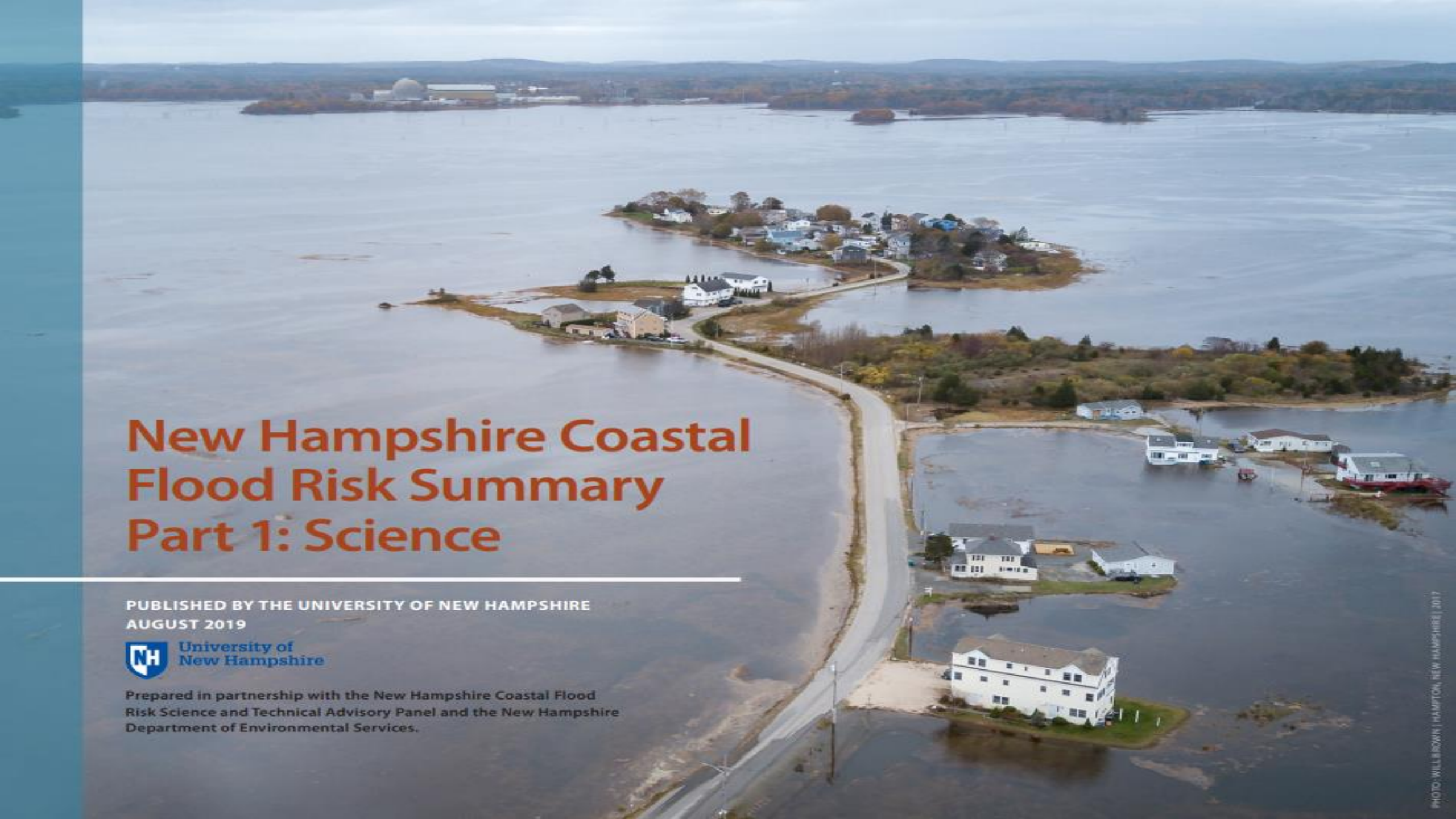


PHOTO: WILL BROWN | HAMPTON, NEW HAMPSHIRE | 2017

Part I: Science | Key Findings
Relative Sea-Level Rise (RSLR)

- Relative sea level in New Hampshire is rising and projected to rise for centuries
- Melting land based glaciers and ice sheets are now the major contributor to sea-level rise

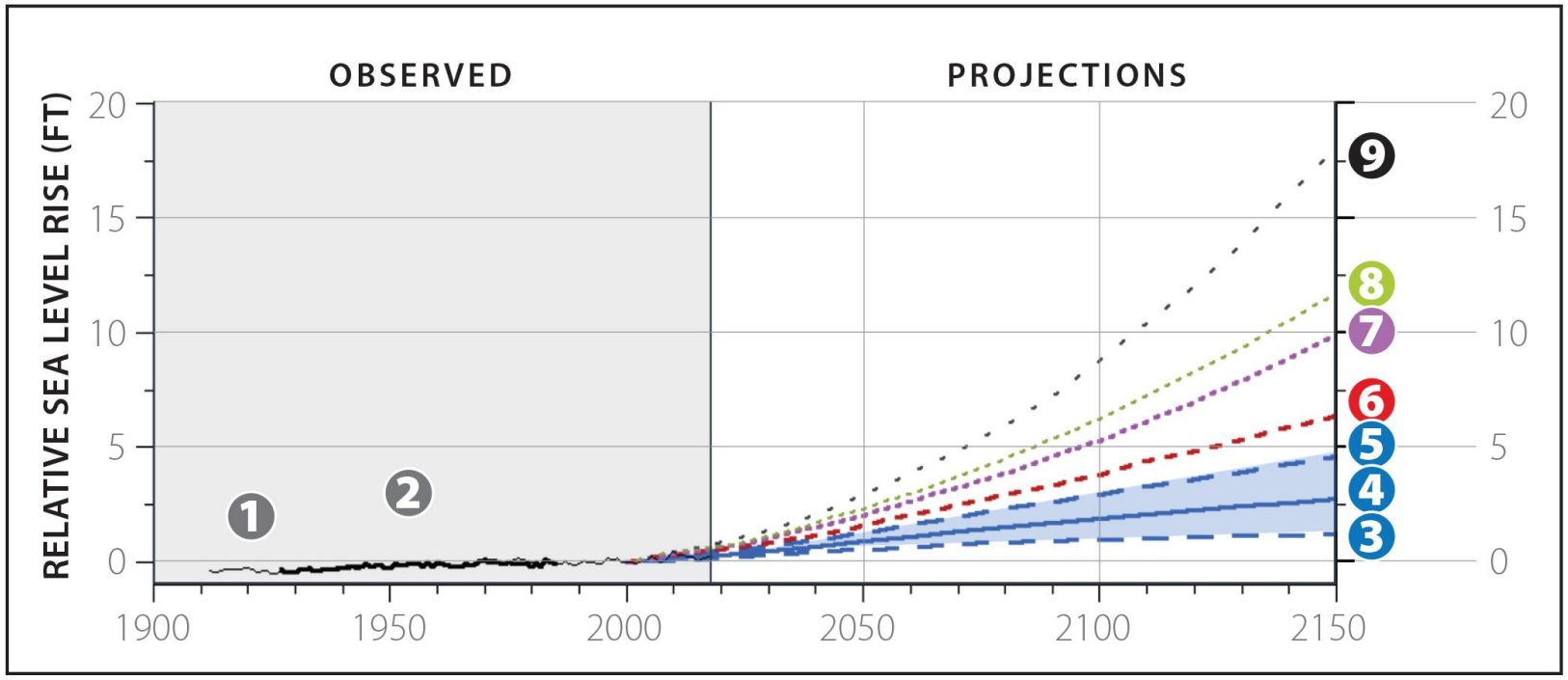


Figure 4.5. Observed and Projected Relative Sea-Level Rise for Seavey Island Tide Gauge K14 Projections | Stabilized Greenhouse Gas Concentrations (RCP 4.5).

1. Historical data for Portland, ME (1912-2018; thin black line)
2. Historical data for Seavey Island, ME (1927-1986; thick black line)
3. Lower end of "likely range"
4. Central estimate
5. Upper end of "likely range"
6. 1-in-20 chance estimate
7. 1-in-100 chance estimate
8. 1-in-200 chance estimate
9. 1-in-1000 chance estimate

Part I: Science | Key Findings
Relative Sea-Level Rise (RSLR)

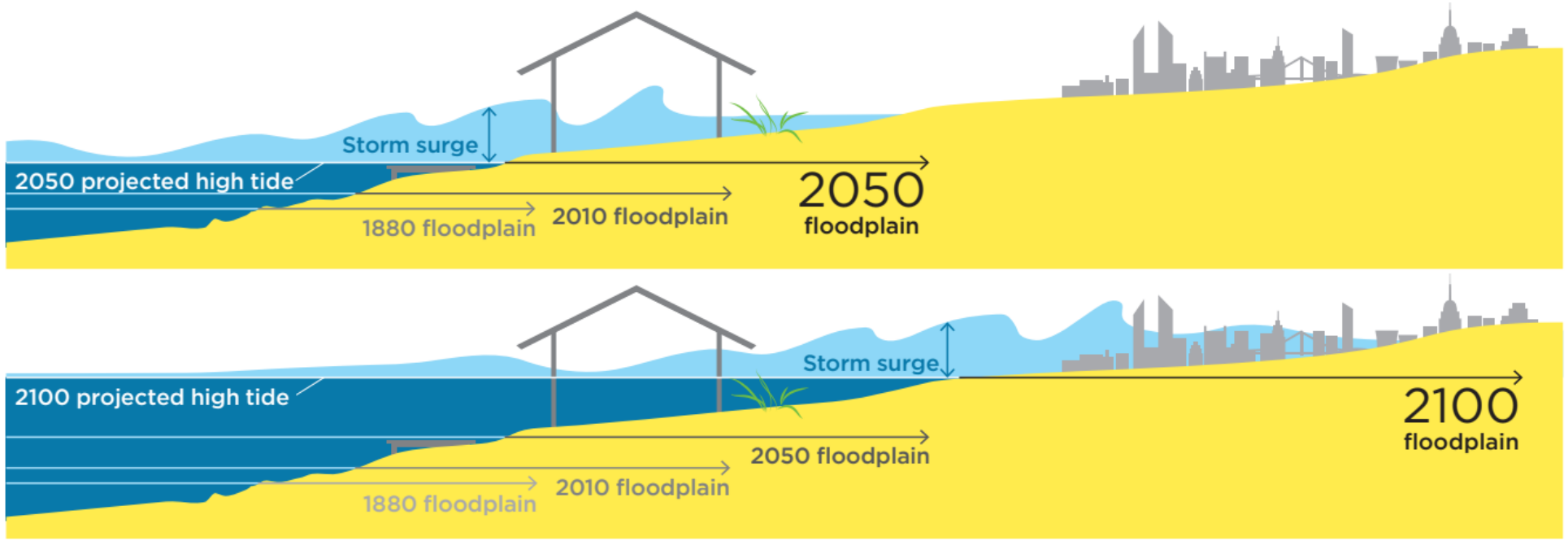
Assuming global greenhouse gas concentrations stabilize by 2100, relative sea level in coastal New Hampshire is "likely" to rise by:

- **0.5 – 1.3 feet by 2050** (but could exceed 2.9 feet)
- **1.0 – 2.9 feet by 2100** (but could exceed 8.7 feet)
- **1.2 – 4.6 feet by 2150** (but could exceed 18.1 feet)

Note that RSLR estimates are much higher if we assume that global greenhouse gas concentrations will continue to grow through 2100 and the rate of ice mass loss from Antarctica accelerates rapidly.

Part I: Science | Key Findings
Coastal Storms

- Projected changes in coastal storms remain uncertain
- Impacts from storm surge in coastal New Hampshire will increase with RSLR



Source: Adapted from Union of Concerned Scientists

Part I: Science | Key Findings
RSLR-Induced Groundwater Rise

- Average groundwater levels are projected to rise as a percentage of RSLR up to 3 miles inland from the coast:
  - 66% of RSLR between 0-0.6 miles from the coast
  - 34% of RSLR between 0.6-1.2 miles from the coast
  - 7% of RSLR between 1.9-2.5 miles from the coast
  - 3% of RSLR between 2.5-3.1 miles from the coast

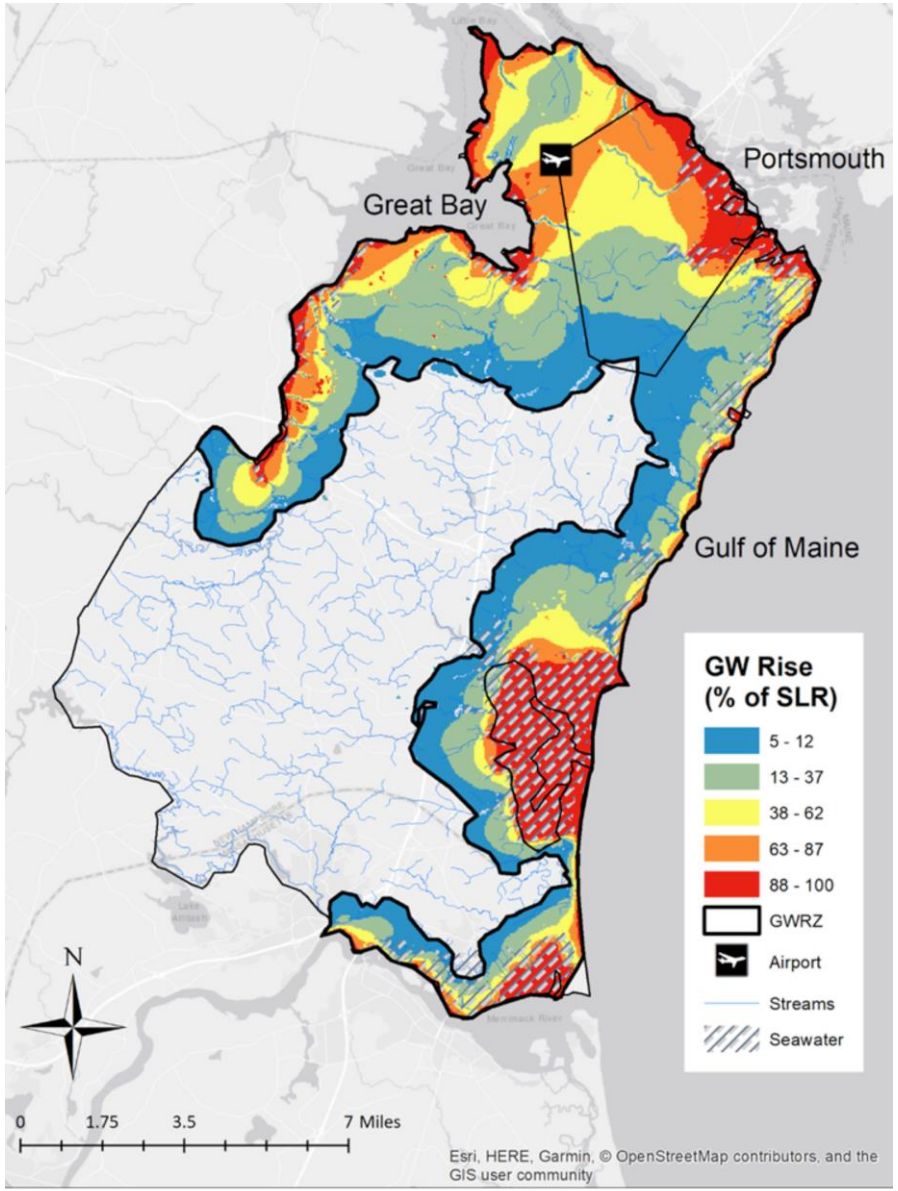
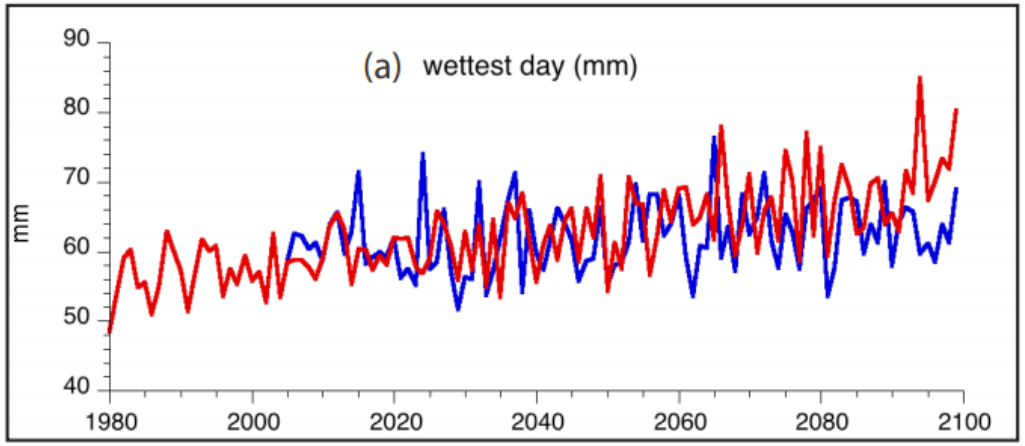


Figure 6.5. Projected groundwater rise as a percent of RSLR in the coastal New Hampshire study area. **Source: Modified from Knott et al. (2018a).**

Part I: Science | Key Findings

Extreme Precipitation

- The frequency and magnitude of extreme precipitation events is projected to increase, especially in the springtime



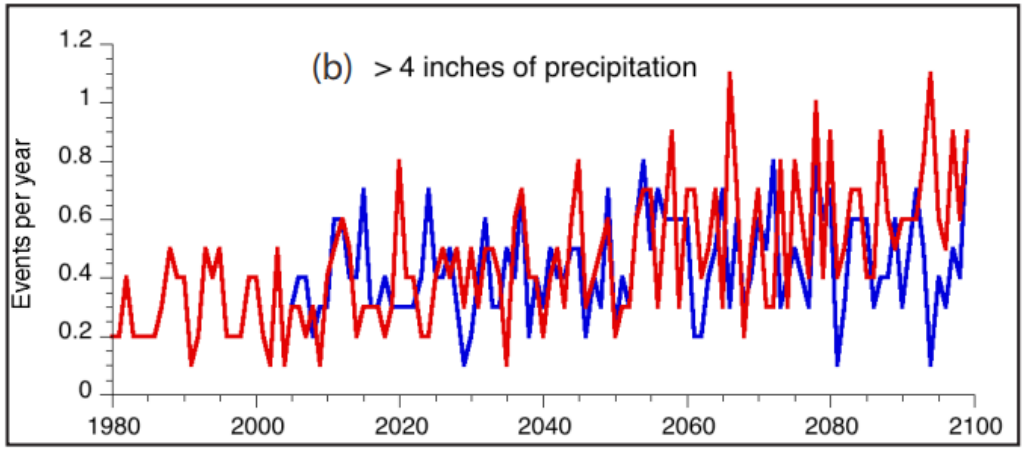
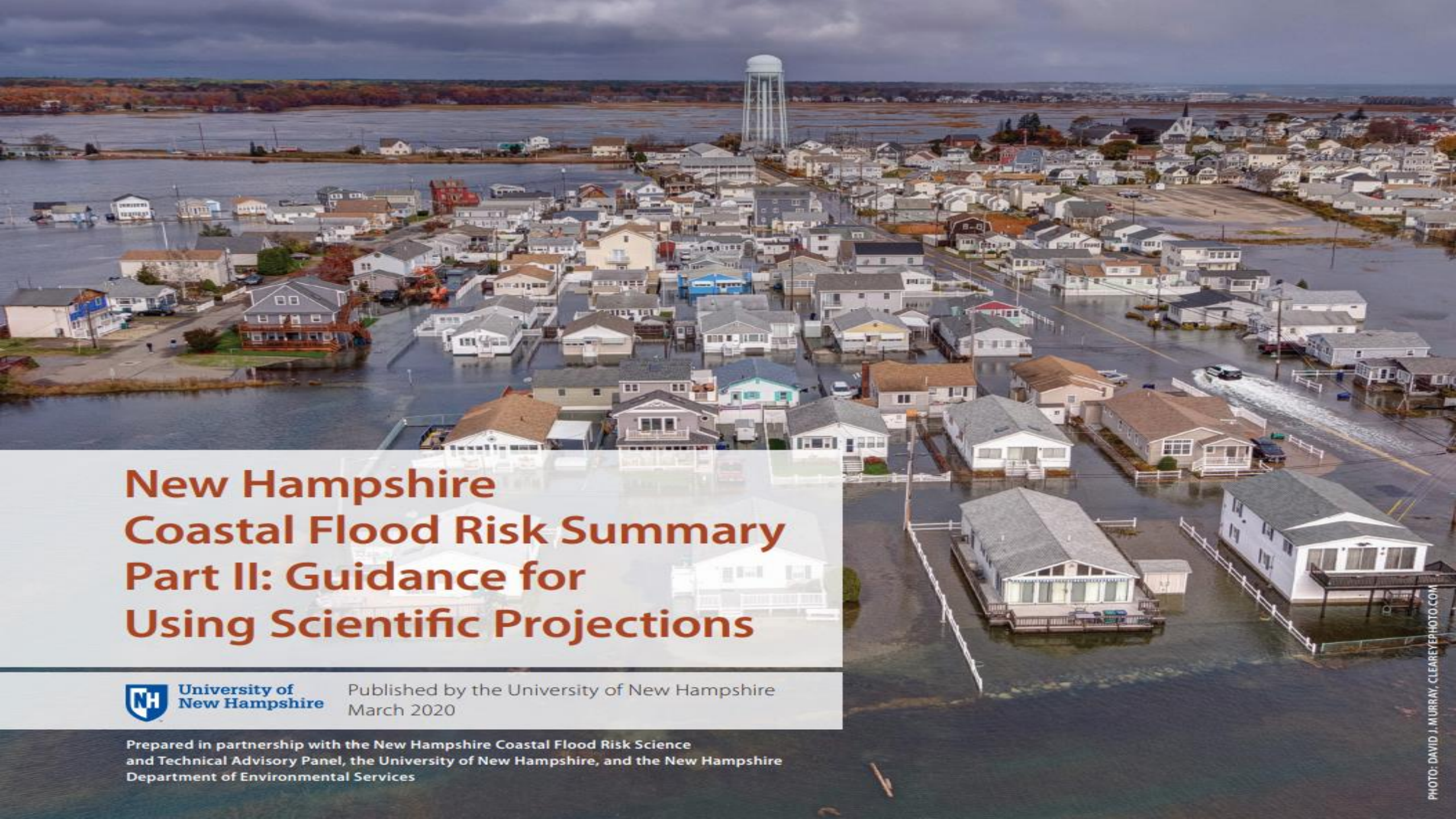


Figure 7.6. CMIP5 mean modeled historical (1980-2005) and projected future (2006-2099) for (a) annual maximum daily precipitation and (b) events greater than 4" at Portsmouth, NH under RCP4.5 (blue) and RCP8.5 (red) (from Burakowski et al., 2019). Ensemble means are weighted following (Sanderson et al., 2017)



New Hampshire Coastal Flood Risk Summary Part II: Guidance for Using Scientific Projections

University of New Hampshire

Published by the University of New Hampshire
March 2020

Prepared in partnership with the New Hampshire Coastal Flood Risk Science and Technical Advisory Panel, the University of New Hampshire, and the New Hampshire Department of Environmental Services

PHOTO: DAVID J. MURRAY, CLEAREYEPHOTO.COM

Part II: Guidance for Using Scientific Projections

Guiding Principles for Enhancing Coastal Resilience

- Support greenhouse gas reduction policies
- Determine tolerance for flood risk
- Prioritize equity and justice
- Protect natural/cultural/historic resources and public access
- Create a bold vision, start immediately, and act incrementally and opportunistically
- Consider the full suite of actions
- Adopt a flexible adaptation approach and continuously monitor performance
- Coordinate and collaborate
- Consider the liability of not taking action

Part II: Guidance for Using Scientific Projections

Step-by-Step Approach

STEP 1. DEFINE PROJECT GOAL, TYPE, LOCATION, AND TIMEFRAME(S)

STEP 2. DETERMINE TOLERANCE FOR FLOOD RISK

STEP 3. SELECT AND ASSESS RELATIVE SEA-LEVEL RISE (RSLR)

STEP 4. IDENTIFY AND ASSESS RSLR-ADJUSTED COASTAL STORMS

STEP 5. IDENTIFY AND ASSESS RSLR-INDUCED GROUNDWATER RISE

STEP 6. IDENTIFY AND ASSESS PROJECTED EXTREME PRECIPITATION

STEP 7. ASSESS CUMULATIVE RISK AND EVALUATE ADAPTATION OPTIONS

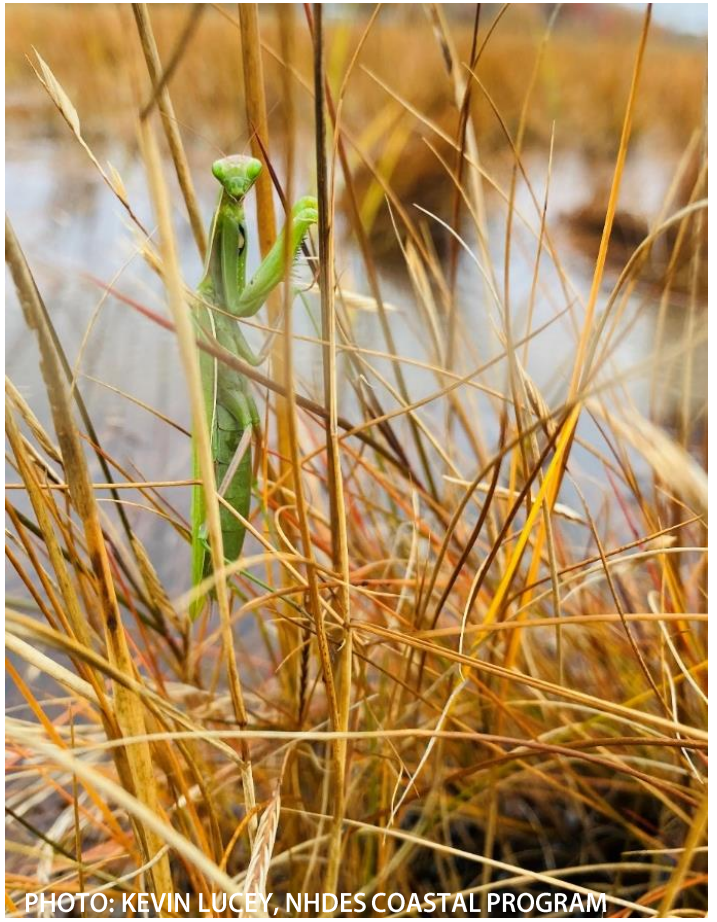


PHOTO: KEVIN LUCEY, NHDES COASTAL PROGRAM

Part II: Guidance for Using Scientific Projections

Step-by-Step Approach

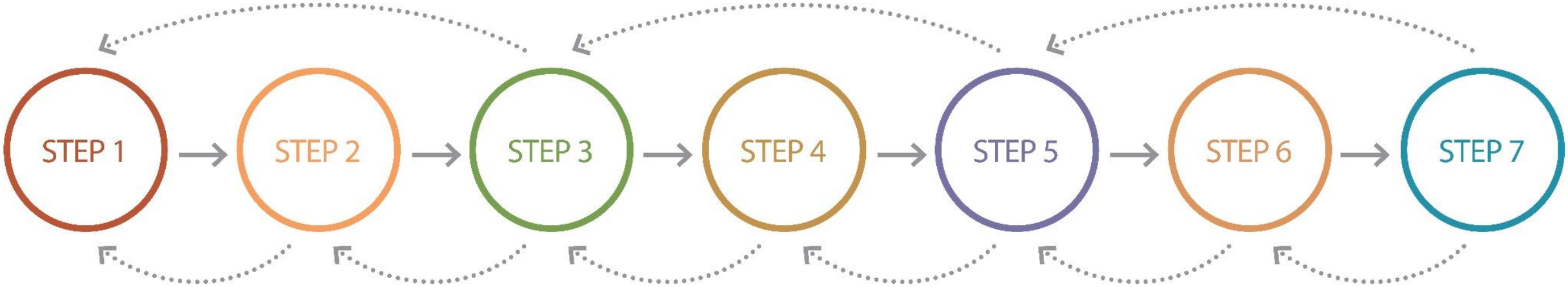


Figure 1. The seven step approach for selecting and incorporating updated coastal flood risk projections into projects is intended to be iterative.

STEP 1. DEFINE PROJECT GOAL, TYPE, LOCATION, AND TIMEFRAME(S)

PROJECT

For the purposes of this Guidance, the term "project" refers broadly to any private, local, state, and federal planning, regulatory, or site-specific efforts that should consider and incorporate coastal flood risk projections. Examples of applicable private, local, state, or federal projects include, but are not limited to:

Planning projects: master plans; hazard mitigation plans; post-disaster redevelopment/relocation/recovery plans; emergency operations and evacuation plans; capital improvement plans; transportation improvement plans; economic development plans; open space plans; etc.

Regulatory projects: zoning ordinances; site plan and/or subdivision regulations; wetlands and shoreland regulations; alteration of terrain regulations; waste management regulations; etc.

Site-specific projects: new construction and redevelopment or relocation of buildings and structures; road, bridge, culvert construction, maintenance, or relocation; shoreline stabilization projects; wetland restoration; land conservation; etc.

Step 1.1 | Define the project goal and project type.

Step 1.2 | Define and inventory the project area.

Step 1.3 | Define the timeframe(s) for the project.

PHOTO: JO-ANN THERIAULT

STEP 1. DEFINE PROJECT GOAL, TYPE, LOCATION, AND TIMEFRAME(S)

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Step 1.1 | Define the project goal and project type

Step 1.2 | Define and inventory the project area

Step 1.3 | Define the timeframe(s) for the project

For Example:

Project goal: Build a new hospital
Project type: Site-specific
Useful life: 100 years (2120)
Incremental action point: *30 years (2050)*

STEP 2. DETERMINE TOLERANCE FOR FLOOD RISK

Step 2.1 | Identify project characteristics that influence tolerance for flood risk

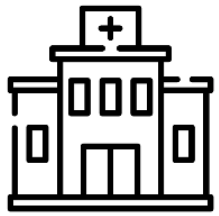
Step 2.2 | Determine tolerance for flood risk based on project characteristics

The willingness of decision makers to accept a higher or lower probability of flood impacts, based on relevant project characteristics such as:

- project value or replacement cost
- capacity to adapt
- importance for public function or safety
- sensitivity to inundation

HIGH TOLERANCE FOR FLOOD RISK

Example:



VERY LOW TOLERANCE FOR FLOOD RISK

STEP 2. DETERMINE TOLERANCE FOR FLOOD RISK

STEP 2 TABLE. FRAMEWORK FOR DETERMINING PROJECT TOLERANCE FOR FLOOD RISK.

		HIGH TOLERANCE FOR FLOOD RISK	MEDIUM TOLERANCE FOR FLOOD RISK	LOW TOLERANCE FOR FLOOD RISK	VERY LOW TOLERANCE FOR FLOOD RISK
DESCRIPTION		Decision makers have a High tolerance for flood risk to the project	Decision makers have a Medium tolerance for flood risk to the project	Decision makers have a Low tolerance for flood risk to the project	Decision makers have a Very Low tolerance for flood risk to the project
POSSIBLE PROJECT CHARACTERISTICS *Tolerance for flood risk will depend on the mix and importance of these project characteristics.*		Low value or cost	Medium value or cost	High value or cost	Very high value or cost
		Easy or likely to adapt	Moderately easy or somewhat likely to adapt	Difficult or unlikely to adapt	Very difficult or very unlikely to adapt
		Little to no implications for public function and/or safety	Moderate implications for public function and/or safety	Substantial implications for public function and/or safety	Critical implications for public function and/or safety
		Low sensitivity to inundation	Moderate sensitivity to inundation	High sensitivity to inundation	Very high sensitivity to inundation
PROJECT EXAMPLES	**PLANNING**	Updating a local master plan Developing a capital improvement plan			
	REGULATORY	Updating a floodplain zoning ordinance Updating a subdivision site plan regulation Updating state alteration of terrain rules			
	SITE-SPECIFIC	Designing a walking path; Siting a temporary or accessory structure; Upgrading a minor storage facility	Replacing a local culvert; Constructing a residential, commercial, or industrial building	Maintaining a school; Siting a community center or recreational facility; Upgrading a wastewater treatment plant	Renovating a hospital or police/fire station; Siting an emergency shelter or response center; Repairing a power station
CORRESPONDING ASCE 24-14[14,15] FLOOD DESIGN CLASS		1	2	3	4
RECOMMENDED COASTAL FLOOD RISK PROJECTIONS		Lower magnitude, Higher probability	← →		Higher magnitude, Lower probability

STEP 3. SELECT AND ASSESS RSLR

Step 3.1 | Select RSLR estimate(s) for the project

STEP 3 TABLE A. RECOMMENDED DECADAL RSLR ESTIMATES (IN FEET ABOVE 2000 LEVELS) BASED ON RCP 4.5, PROJECT TIMEFRAME, AND TOLERANCE FOR FLOOD RISK.

TIMEFRAME	HIGH TOLERANCE FOR FLOOD RISK	MEDIUM TOLERANCE FOR FLOOD RISK	LOW TOLERANCE FOR FLOOD RISK	VERY LOW TOLERANCE FOR FLOOD RISK
	Plan for the following RSLR estimate (ft)* *compared to sea level in the year 2000*			
	Lower magnitude, Higher probability	←	→	Higher magnitude, Lower probability
2030	0.7	0.9	1.0	1.1
2040	1.0	1.2	1.5	1.6
2050	1.3	1.6	2.0	2.3
2060	1.6	2.1	2.6	3.0
2070	2.0	2.5	3.3	3.7
2080	2.3	3.0	3.9	4.5
2090	2.6	3.4	4.6	5.3
2100	2.9	3.8	5.3	6.2
2110	3.3	4.4	6.1	7.3
2120	3.6	4.9	7.0	8.3
2130	3.9	5.4	7.9	9.3
2140	4.3	5.9	8.9	10.5
2150	4.6	6.4	9.9	11.7

STEP 3. SELECT AND ASSESS RSLR

Step 3.1 | Select RSLR estimate(s) for the project

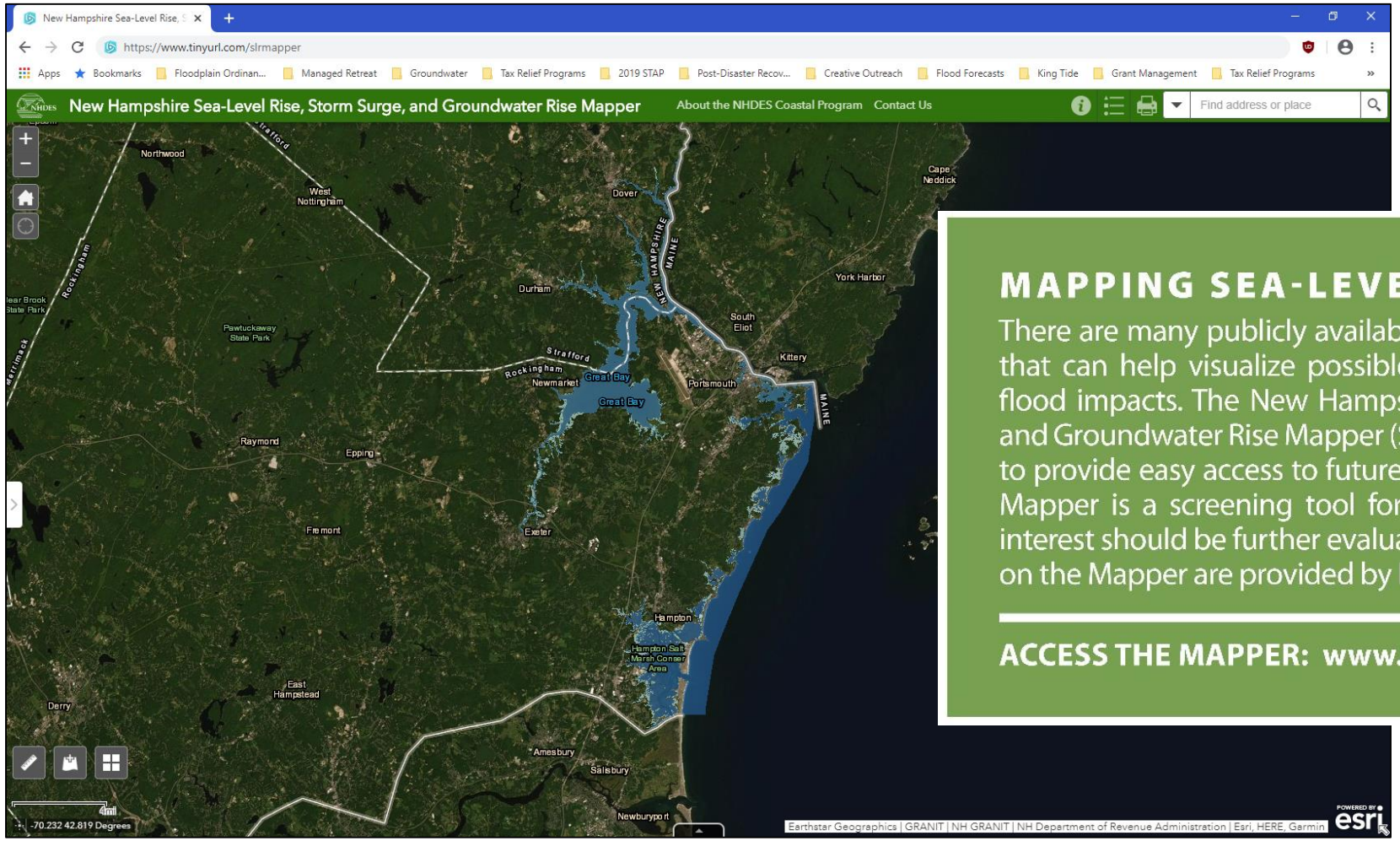
Example:

Useful life: 100 years (2120)
Incremental action point: 30 years (2050)
Tolerance for flood risk: Very Low

TIMEFRAME	VERY LOW TOLERANCE FOR FLOOD RISK Higher magnitude, Lower probability
2030	1.1
2040	1.6
2050	2.3
2060	3.0
2070	3.7
2080	4.5
2090	5.3
2100	6.2
2110	7.3
2120	8.3
2130	9.3
2140	10.5
2150	11.7

STEP 3. SELECT AND ASSESS RSLR

Step 3.2 | Assess RSLR impacts to the project



MAPPING SEA-LEVEL RISE

There are many publicly available datasets and visualization tools that can help visualize possible sea-level rise and other coastal flood impacts. The New Hampshire Sea-Level Rise, Storm Surge, and Groundwater Rise Mapper (Sea-Level Rise Mapper) is intended to provide easy access to future coastal inundation scenarios. The Mapper is a screening tool for planning purposes, and sites of interest should be further evaluated with a site-based survey. Data on the Mapper are provided by New Hampshire GRANIT.

ACCESS THE MAPPER: www.tinyurl.com/slrmapper

STEP 4. IDENTIFY AND ASSESS RSLR-ADJUSTED COASTAL STORMS

Step 4.1 | Identify RSLR-adjusted Design Flood Elevation (DFE)

Step 4.2 | Assess RSLR-adjusted coastal storm impacts to the project

STEP 4 TABLE. RSLR-ADJUSTED DESIGN FLOOD ELEVATIONS (DFE) BASED ON TOLERANCE FOR FLOOD RISK.

<table>
<tr><th></th><th>HIGH
TOLERANCE FOR FLOOD RISK</th><th>MEDIUM
TOLERANCE FOR FLOOD RISK</th><th>LOW
TOLERANCE FOR FLOOD RISK</th><th>VERY LOW
TOLERANCE FOR FLOOD RISK</th></tr>
<tr><td>IF PROJECT AREA IS LOCATED IN:</td><td colspan="4">RSLR-ADJUSTED DESIGN FLOOD ELEVATION (DFE) =</td></tr>
<tr><td>A, AO, OR AE ZONE* NOT IDENTIFIED AS COASTAL A ZONE**</td><td rowspan="2">[BFE] + RSLR</td><td rowspan="2">[BFE + (required freeboard ≥ 1 ft)] + RSLR</td><td>[BFE + (required freeboard ≥ 1 ft)] + RSLR</td><td rowspan="2">Whichever is greater:
[BFE + (required freeboard ≥ 2ft)] + RSLR
OR
0.2% annual chance flood elevation + RSLR</td></tr>
<tr><td>VE ZONE*** AND COASTAL A ZONE</td><td>[BFE + (required freeboard ≥ 2 ft)] + RSLR</td></tr>
</table>

STEP 4. IDENTIFY AND ASSESS RSLR-ADJUSTED COASTAL STORMS

STEP 4 TABLE. RSLR-ADJUSTED DESIGN FLOOD ELEVATIONS (DFE) BASED ON TOLERANCE FOR FLOOD RISK.

	HIGH TOLERANCE FOR FLOOD RISK	MEDIUM TOLERANCE FOR FLOOD RISK	LOW TOLERANCE FOR FLOOD RISK	VERY LOW TOLERANCE FOR FLOOD RISK
IF PROJECT AREA IS LOCATED IN:	**RSLR-ADJUSTED DESIGN FLOOD ELEVATION (DFE) =**			
A, AO, OR AE ZONE* NOT IDENTIFIED AS COASTAL A ZONE**	[BFE] + RSLR	[BFE + (required freeboard ≥ 1 ft)] + RSLR	[BFE + (required freeboard ≥ 1 ft)] + RSLR	Whichever is greater: [BFE + (required freeboard ≥ 2ft)] + RSLR OR 0.2% annual chance flood elevation + RSLR
VE ZONE*** AND COASTAL A ZONE			[BFE + (required freeboard ≥ 2 ft)] + RSLR	

Example:

Tolerance for flood risk: Very Low
RSLR estimate: 8.3 feet by 2120
BFE: 8 feet NGVD

RSLR-adjusted DFE = 18.3 feet NGVD29
8 feet (BFE) + 2 feet (freeboard) + 8.3 feet (RSLR)

STEP 5. IDENTIFY AND ASSESS RSLR-INDUCED GROUNDWATER RISE

Step 5.1 | Identify RSLR-induced groundwater rise for the project

Step 5.2 | Estimate depth to present-day and future groundwater

Step 5.3 | Assess RSLR-induced groundwater rise impacts to the project

STEP 5 TABLE. APPROACHES FOR CALCULATING DEPTH TO RSLR-ADJUSTED GROUNDWATER.

	PREFERRED APPROACH (MAPPED COASTAL COMMUNITY)	**ALTERNATE APPROACH** (UNMAPPED COASTAL COMMUNITY)
	IF PROJECT AREA IS LOCATED IN A MAPPED COASTAL COMMUNITY:	**IF PROJECT AREA IS LOCATED WITHIN 3 MILES OF TIDAL SHORELINE IN AN UNMAPPED COASTAL COMMUNITY:**
RSLR-INDUCED GROUNDWATER RISE =	Refer to Sea-Level Rise Mapper[38] to estimate RSLR-induced groundwater rise	Commit to manage = (RSLR) x (0.33) Be prepared to manage = (RSLR) x (0.66)
DEPTH TO RSLR-ADJUSTED GROUNDWATER =	(Present-day depth to groundwater) - (RSLR-induced groundwater rise)	

STEP 5. IDENTIFY AND ASSESS RSLR-INDUCED GROUNDWATER RISE

STEP 5 TABLE. APPROACHES FOR CALCULATING DEPTH TO RSLR-ADJUSTED GROUNDWATER.

	PREFERRED APPROACH (MAPPED COASTAL COMMUNITY)	ALTERNATE APPROACH (UNMAPPED COASTAL COMMUNITY)
	IF PROJECT AREA IS LOCATED IN A MAPPED COASTAL COMMUNITY:	**IF PROJECT AREA IS LOCATED WITHIN 3 MILES OF TIDAL SHORELINE IN AN UNMAPPED COASTAL COMMUNITY:**
RSLR-INDUCED GROUNDWATER RISE =	Refer to Sea-Level Rise Mapper[38] to estimate RSLR-induced groundwater rise	Commit to manage = (RSLR) x (0.33) Be prepared to manage = (RSLR) x (0.66)
DEPTH TO RSLR-ADJUSTED GROUNDWATER =	(Present-day depth to groundwater) - (RSLR-induced groundwater rise)	

Example:

RSLR estimate: 8.3 feet by 2120
GWR estimate (from SLR Mapper): 5 feet
Present-day depth to SHWT: 4 feet

RSLR-adjusted depth to SHWT = -1 feet
4 feet (present-day depth) – 5 feet (GWR estimate)

STEP 6. IDENTIFY AND ASSESS PROJECTED EXTREME PRECIPITATION

Step 6.1 | Account for projected increases in extreme precipitation

Step 6.2 | Assess projected extreme precipitation impacts to the project

STEP 6 TABLE. APPROACH FOR CALCULATING PROJECTED EXTREME PRECIPITATION ESTIMATES BASED ON TOLERANCE FOR FLOOD RISK.

	HIGH TOLERANCE FOR FLOOD RISK	MEDIUM TOLERANCE FOR FLOOD RISK	LOW TOLERANCE FOR FLOOD RISK	VERY LOW TOLERANCE FOR FLOOD RISK
PROJECTED EXTREME PRECIPITATION ESTIMATE =	**(Best available precipitation data) x (1.15)**		**(Best available precipitation data) x (>1.15)**	

STEP 6. IDENTIFY AND ASSESS PROJECTED EXTREME PRECIPITATION

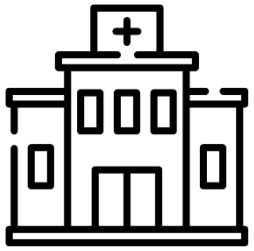
Step 6.1 | Account for projected increases in extreme precipitation

Step 6.2 | Assess projected extreme precipitation impacts to the project

STEP 6 TABLE. APPROACH FOR CALCULATING PROJECTED EXTREME PRECIPITATION ESTIMATES BASED ON TOLERANCE FOR FLOOD RISK.

	HIGH TOLERANCE FOR FLOOD RISK	MEDIUM TOLERANCE FOR FLOOD RISK	LOW TOLERANCE FOR FLOOD RISK	VERY LOW TOLERANCE FOR FLOOD RISK
PROJECTED EXTREME PRECIPITATION ESTIMATE =	**(Best available precipitation data) x (1.15)**		**(Best available precipitation data) x (>1.15)**	

Example:



Tolerance for flood risk: Very Low
Present-day rainfall estimate (24-hour, 10-year event): 4.9 inches

Projected rainfall estimate (24-hour, 10-year event) = 5.9 inches
4.9 inches (present-day estimate) x 1.2

STEP 7. ASSESS CUMULATIVE RISK AND EVALUATE ADAPTATION OPTIONS

Step 7.1 | Assess cumulative coastal flood risk to the project

Step 7.2 | Identify and evaluate adaptation options to mitigate coastal flood risk

Step 7.3 | Select and implement preferred option(s) or revisit previous steps

STEP 7 TABLE A. FRAMEWORK OF TYPES OF ACTION TO MANAGE COASTAL FLOOD RISK.

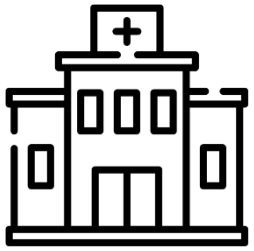
	NO ACTION	AVOID	ACCOMMODATE	RESIST	RELOCATE
IN OTHER WORDS, RECOGNIZE RISK AND...	*Don't change anything**	*Prioritize investment out of the water's way*	*Live with the water*	*Keep the water out*	*Move assets or facilitate migration*
DECISION MAKERS MIGHT CHOOSE THIS ACTION CATEGORY BECAUSE...					
COASTAL FLOOD RISK IS:	**Very Low to Low**	**Very Low**	**Moderate**	**High**	**High**
AND/OR					
TOLERANCE FOR FLOOD RISK IS:	**High**	**Medium to Very Low**	**Medium**	**Low to Very Low**	**Low to Very Low**

STEP 7. ASSESS CUMULATIVE RISK AND EVALUATE ADAPTATION OPTIONS

STEP 7 TABLE A. FRAMEWORK OF TYPES OF ACTION TO MANAGE COASTAL FLOOD RISK.

	NO ACTION	AVOID	ACCOMMODATE	RESIST	RELOCATE
IN OTHER WORDS, RECOGNIZE RISK AND...	*Don't change anything**	*Prioritize investment out of the water's way*	*Live with the water*	*Keep the water out*	*Move assets or facilitate migration*
		DECISION MAKERS MIGHT CHOOSE THIS ACTION CATEGORY BECAUSE...			
COASTAL FLOOD RISK IS:	**Very Low to Low**	**Very Low**	**Moderate**	**High**	**High**
			AND/OR		
TOLERANCE FOR FLOOD RISK IS:	**High**	**Medium to Very Low**	**Medium**	**Low to Very Low**	**Low to Very Low**

Example:



Tolerance for flood risk: Very Low

New Hampshire Coastal Flood Risk Summary
How you might use the Science & Guidance

- Use for your own property
- Use for your neighborhood or for places you care about
- Advocate for its use by your community
  - Plans
  - Regulations
- Expected to be used by NHDES and other state agencies in permitting and best practices

New Hampshire Coastal Flood Risk Summary

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