Preparing Freeport for Storms and the Potential Impacts of Sea Level Rise

Peter Slovinsky, Marine Geologist
Maine Geological Survey, Department of Conservation

Rick Harbison, Land Use Planner
Greater Portland Council of Governments

June 5, 2013

MAINE GEOLOGICAL SURVEY

Project Funding from:

Establishing the Scientific Groundwork
Sea Level Rise Implications
Storm Surge

"Educating" local stakeholders
Setting the stage for vulnerability assessment work
Linking past observations with current measurements to show importance
Making the data "local" as much as possible

Why does sea level change?

Global Sea Levels…

Ocean expands as it warms (Thermal Expansion)

The ocean's volume increases due to added water (Volumetric Increase due to melting glaciers and land-based ice sheets – big ones Greenland and Antarctica)

Global climate variation (impacts of ENSO, El Nino/La Niña warming and cooling patterns in the Pacific Ocean)

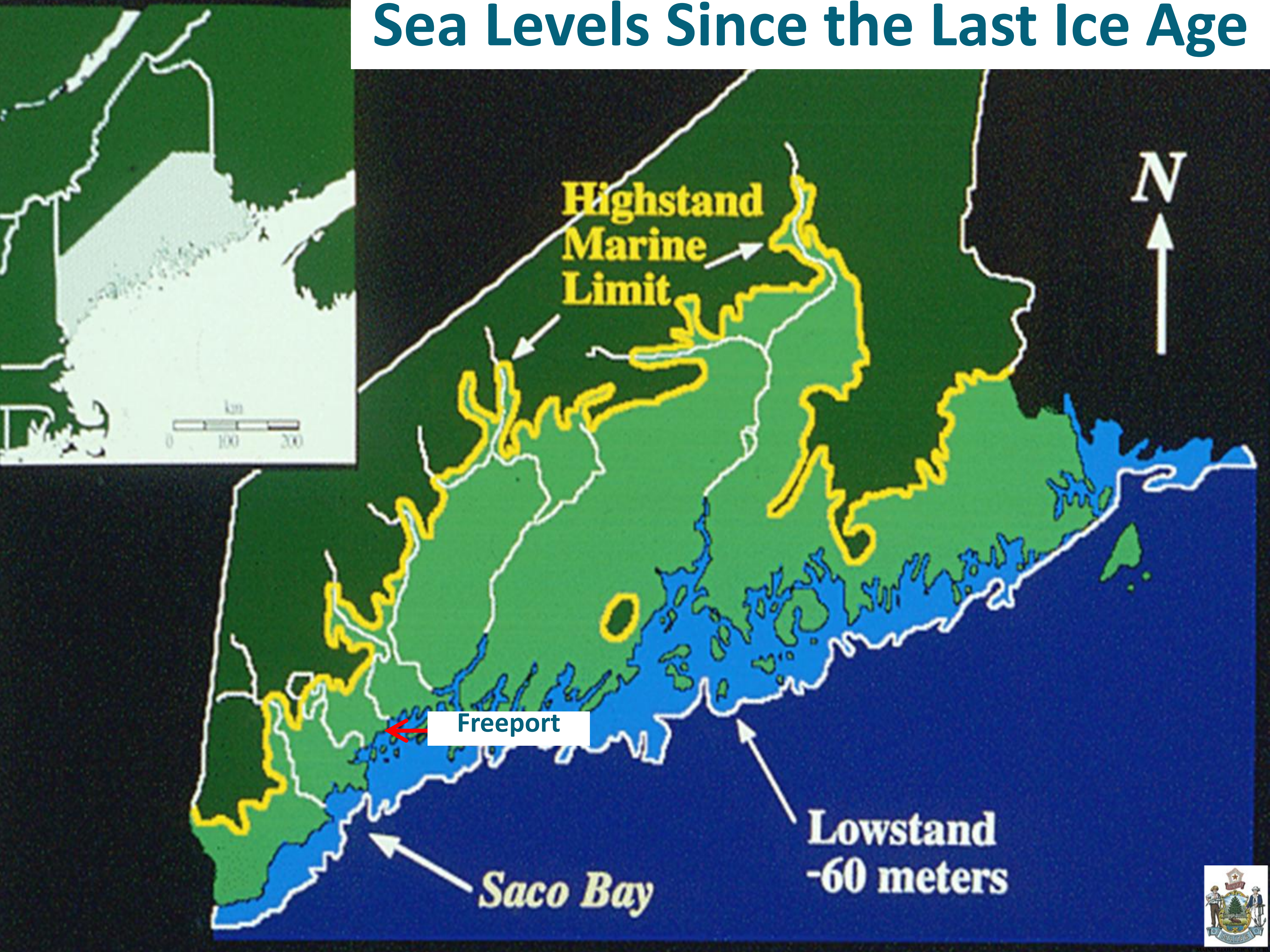
Relative (or "Local") Sea levels…

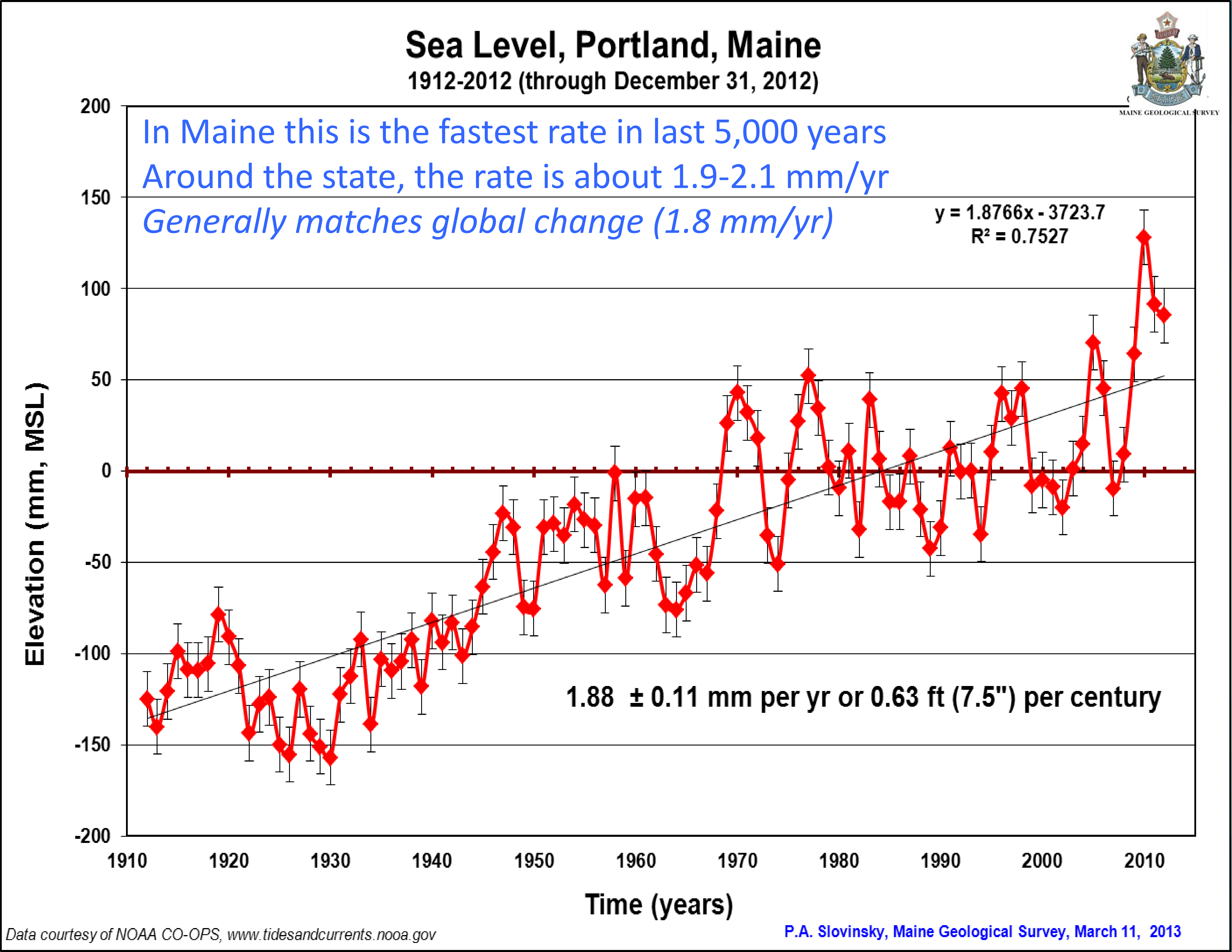
Isostatic rebound (response of the crust to glaciation)

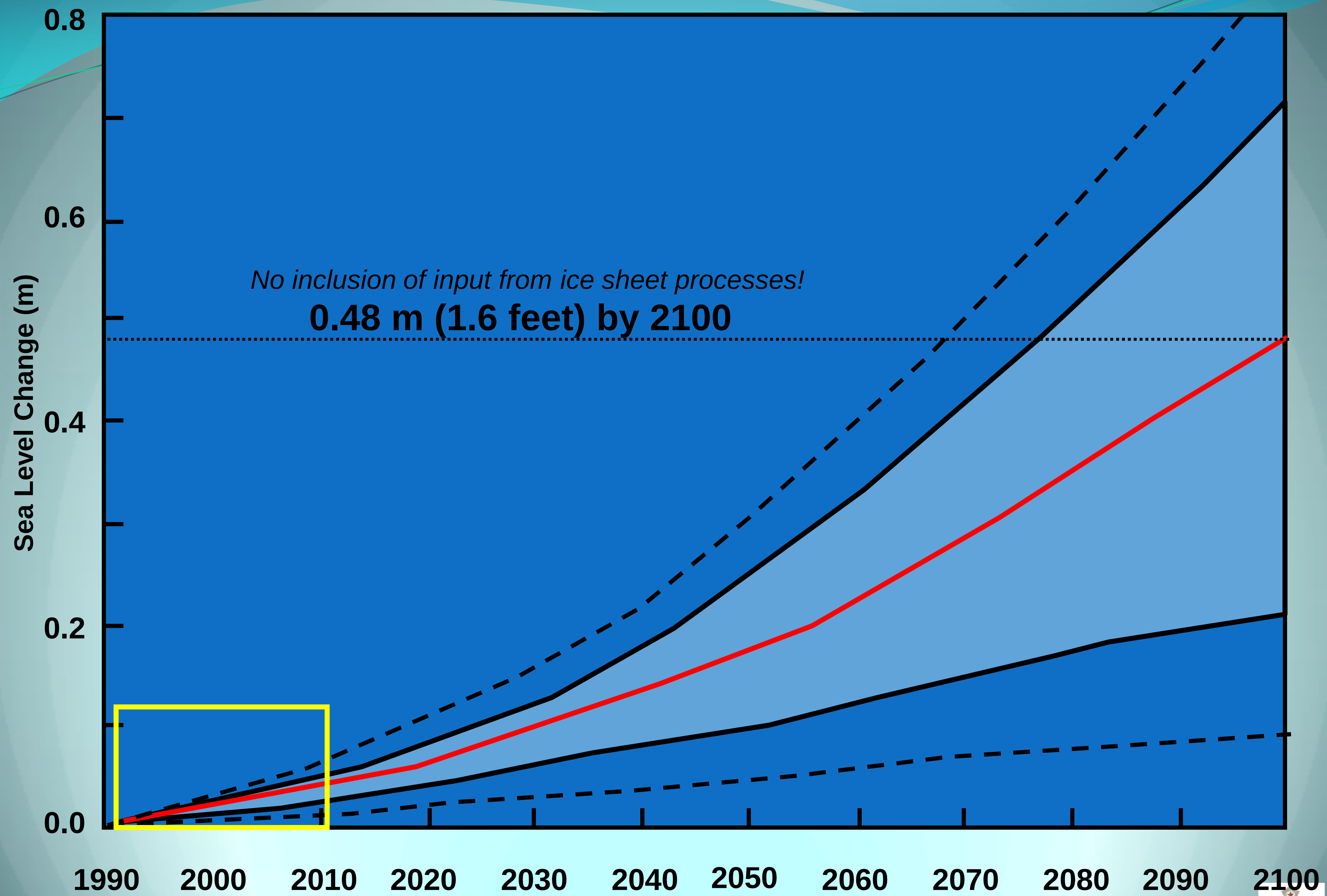
Subsidence (sinking of the land due to other factors than isostasy)

Seasonal Variations (due to local or regional weather patterns)

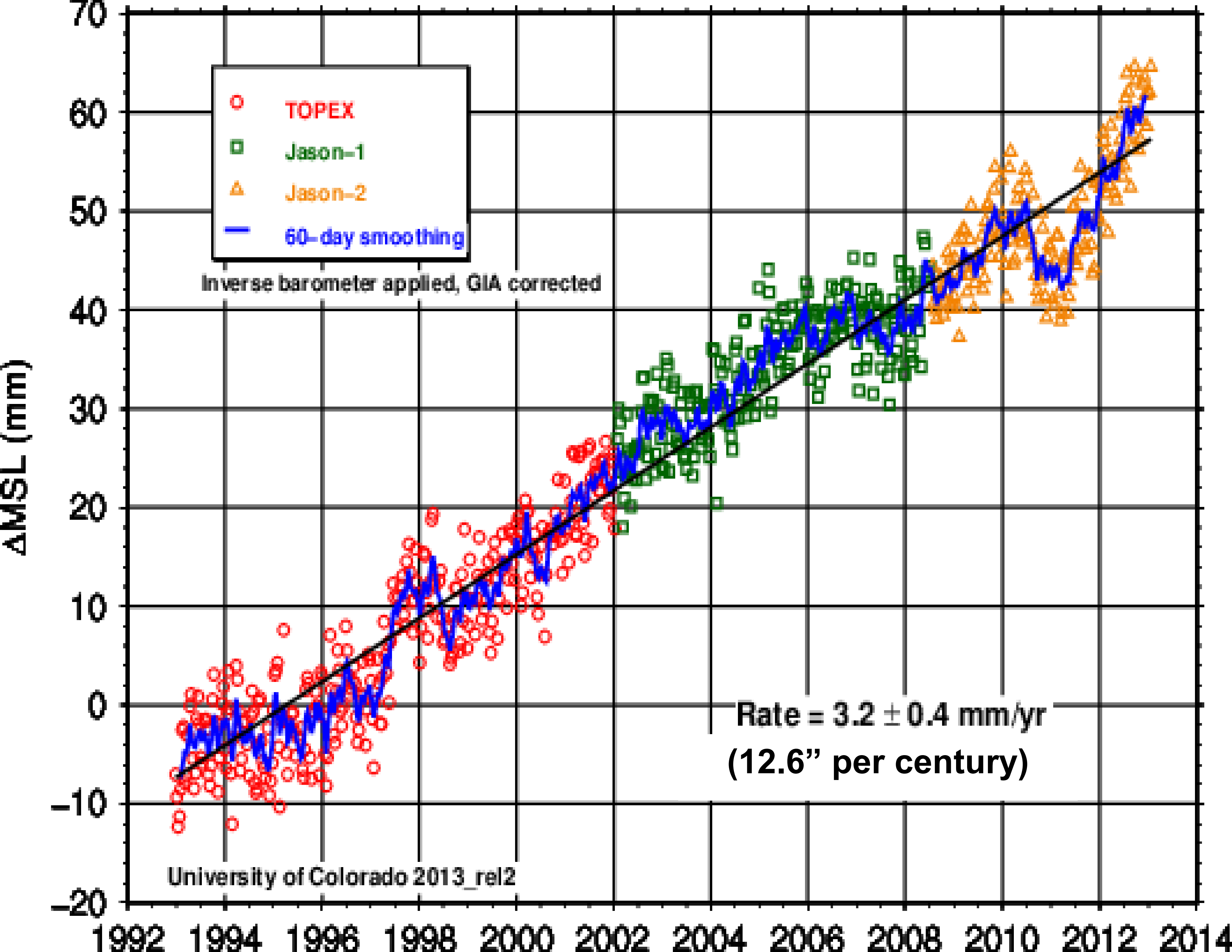
Sea Levels Since the Last Ice Age



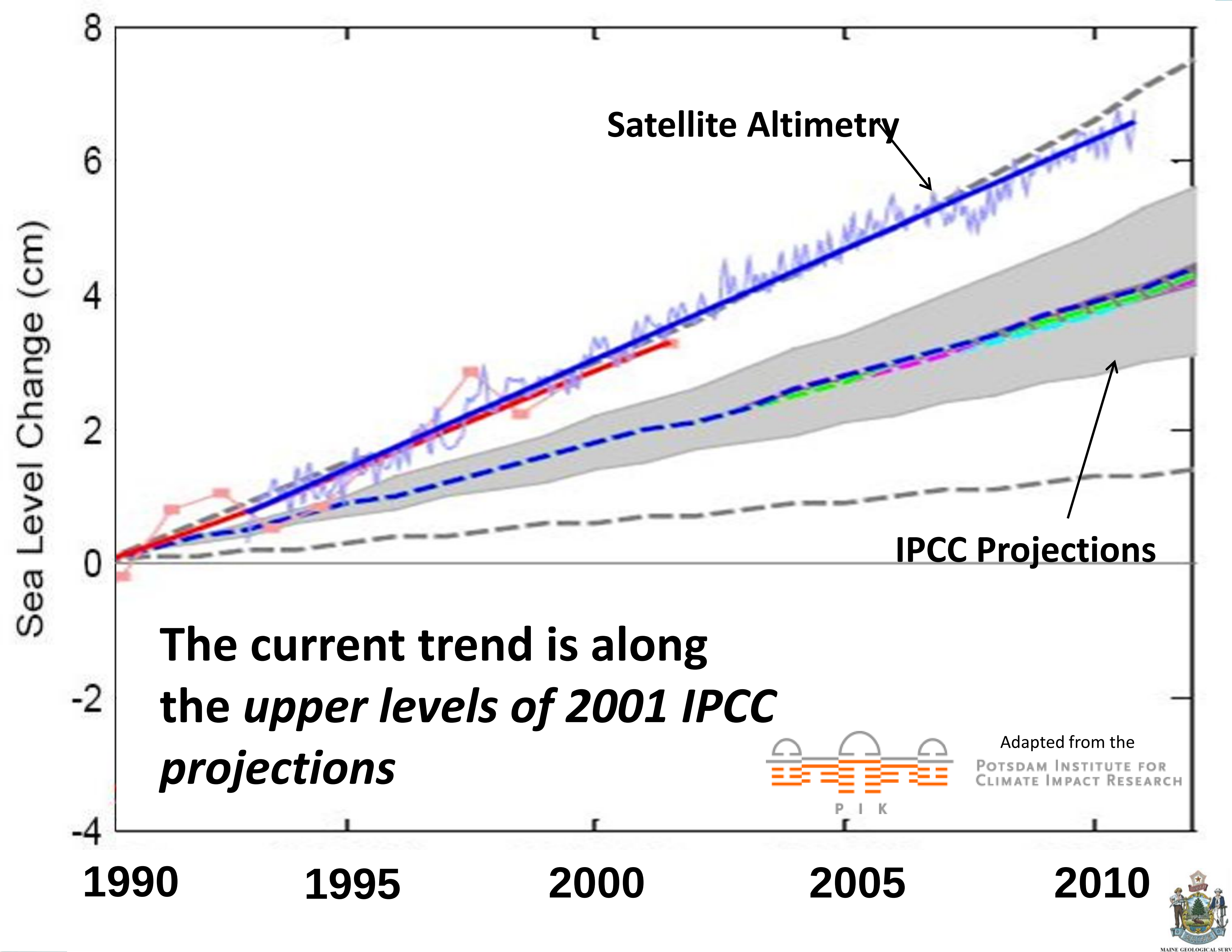

Sea Level, Portland, Maine
1912-2012 (through December 31, 2012)
In Maine this is the fastest rate in last 5,000 years
Around the state, the rate is about 1.9-2.1 mm/yr
Generally matches global change (1.8 mm/yr)
y = 1.8766x - 3723.7
R² = 0.7527
1.88 ± 0.11 mm per yr or 0.63 ft (7.5") per century
Elevation (mm, MSL)
200
150
100
50
0
-50
-100
-150
-200
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Time (years)
MAINE GEOLOGICAL SURVEY
Data courtesy of NOAA CO-OPS, www.tidesandcurrents.noaa.gov
P.A. Slovinsky, Maine Geological Survey, March 11, 2013

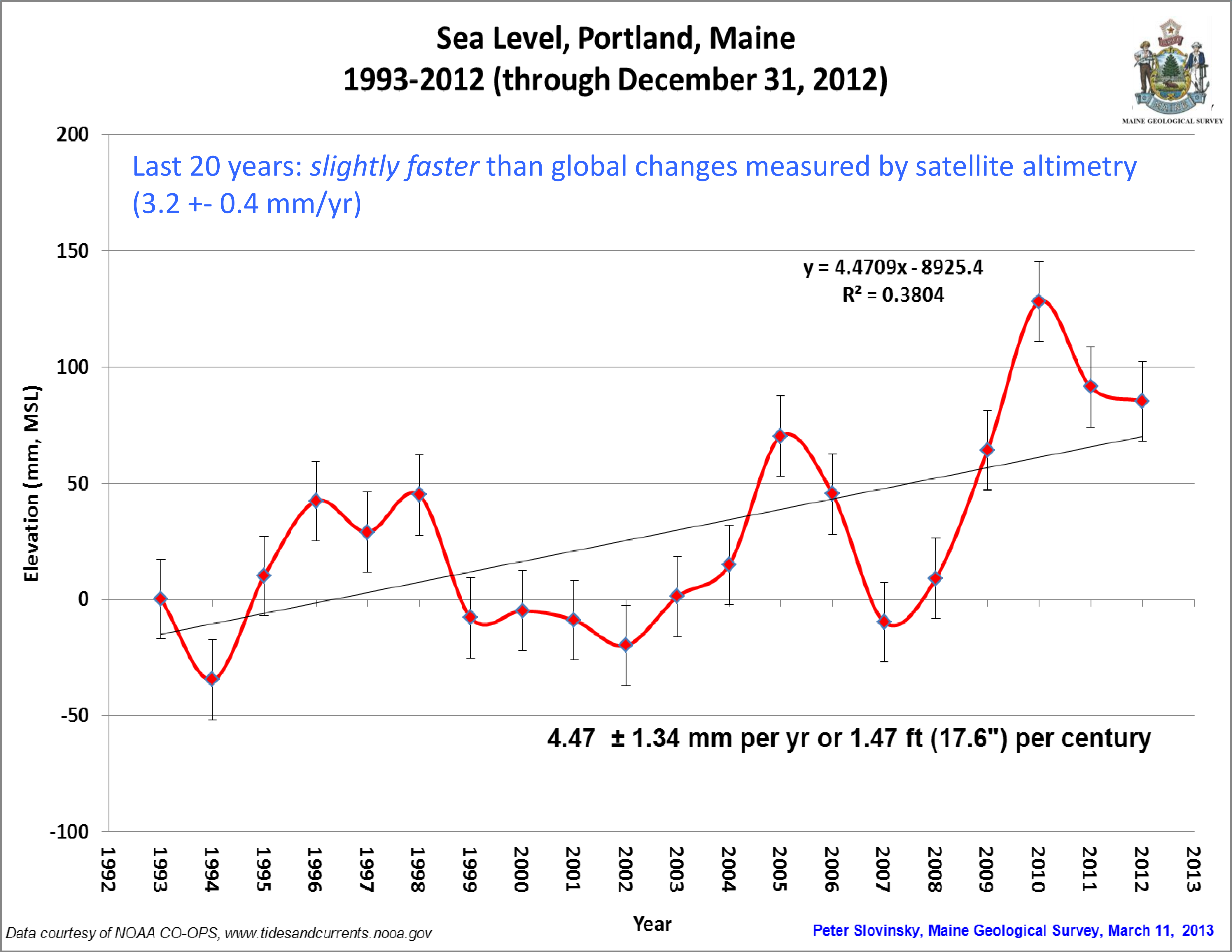


Adapted from the IPCC 3rd Assessment (Tech. Summary of Working Group I Report, Fig. 24, p. 74., 2001)

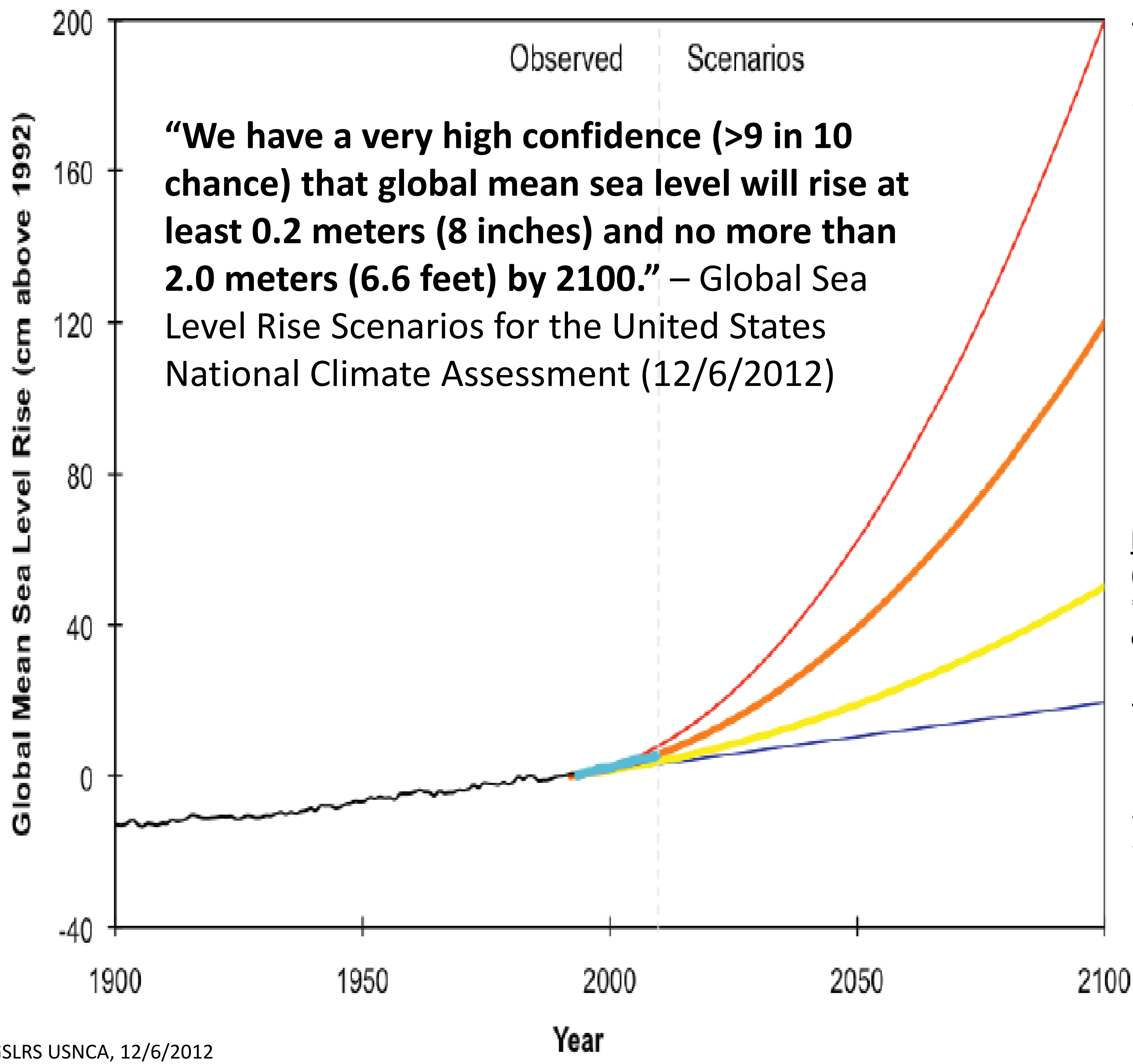


TOPEX
Jason-1
Jason-2
60-day smoothing
Inverse barometer applied, GIA corrected
Rate = 3.2 ± 0.4 mm/yr
(12.6" per century)
University of Colorado 2013_rel2
ΔMSL (mm)
70
60
50
40
30
20
10
0
−10
−20
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014


Sea Level Change (cm)
8
6
4
2
0
-2
-4
1990
1995
2000
2005
2010
Satellite Altimetry
IPCC Projections
The current trend is along the *upper levels of 2001 IPCC projections*
Adapted from the
Potsdam Institute for Climate Impact Research
PIK
MAINE GEOLOGICAL SURV



Sea Level, Portland, Maine
1993-2012 (through December 31, 2012)
MAINE GEOLOGICAL SURVEY
Last 20 years: *slightly faster* than global changes measured by satellite altimetry (3.2 +- 0.4 mm/yr)
y = 4.4709x - 8925.4
R² = 0.3804
4.47 ± 1.34 mm per yr or 1.47 ft (17.6") per century
Elevation (mm, MSL)
200
150
100
50
0
-50
-100
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Year
Data courtesy of NOAA CO-OPS, www.tidesandcurrents.noaa.gov
Peter Slovinsky, Maine Geological Survey, March 11, 2013



“We have a very high confidence (>9 in 10 chance) that global mean sea level will rise at least 0.2 meters (8 inches) and no more than 2.0 meters (6.6 feet) by 2100.” – Global Sea Level Rise Scenarios for the United States National Climate Assessment (12/6/2012)

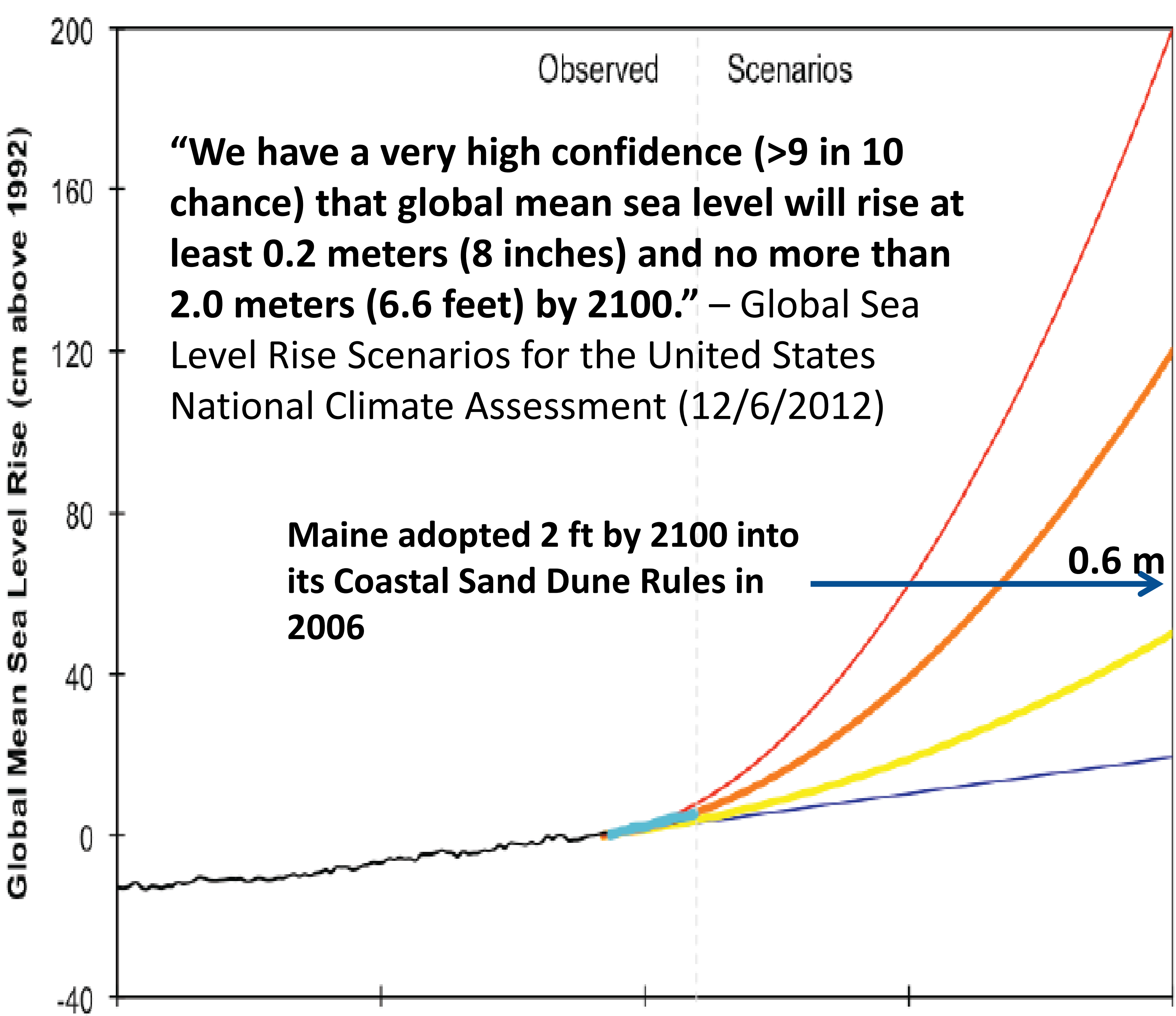
Highest
(2.0 m, 6.6 ft)
***Combines maximum warming, thermal expansion, and possible ice sheet loss**

Intermediate-High
(1.2 m, 3.9 ft)
***Average of high end global predictions, combines recent ice sheet loss and thermal expansion**

Intermediate-Low
(0.5 m, 1.6 ft)
***Includes only thermal expansion from warming**

Lowest
(0.2 m, 0.7 ft)
*** Historical trend continued; no additional thermal expansion from warming**

GSLRS USNCA, 12/6/2012



“We have a very high confidence (>9 in 10 chance) that global mean sea level will rise at least 0.2 meters (8 inches) and no more than 2.0 meters (6.6 feet) by 2100.” – Global Sea Level Rise Scenarios for the United States National Climate Assessment (12/6/2012)

Maine adopted 2 ft by 2100 into its Coastal Sand Dune Rules in 2006

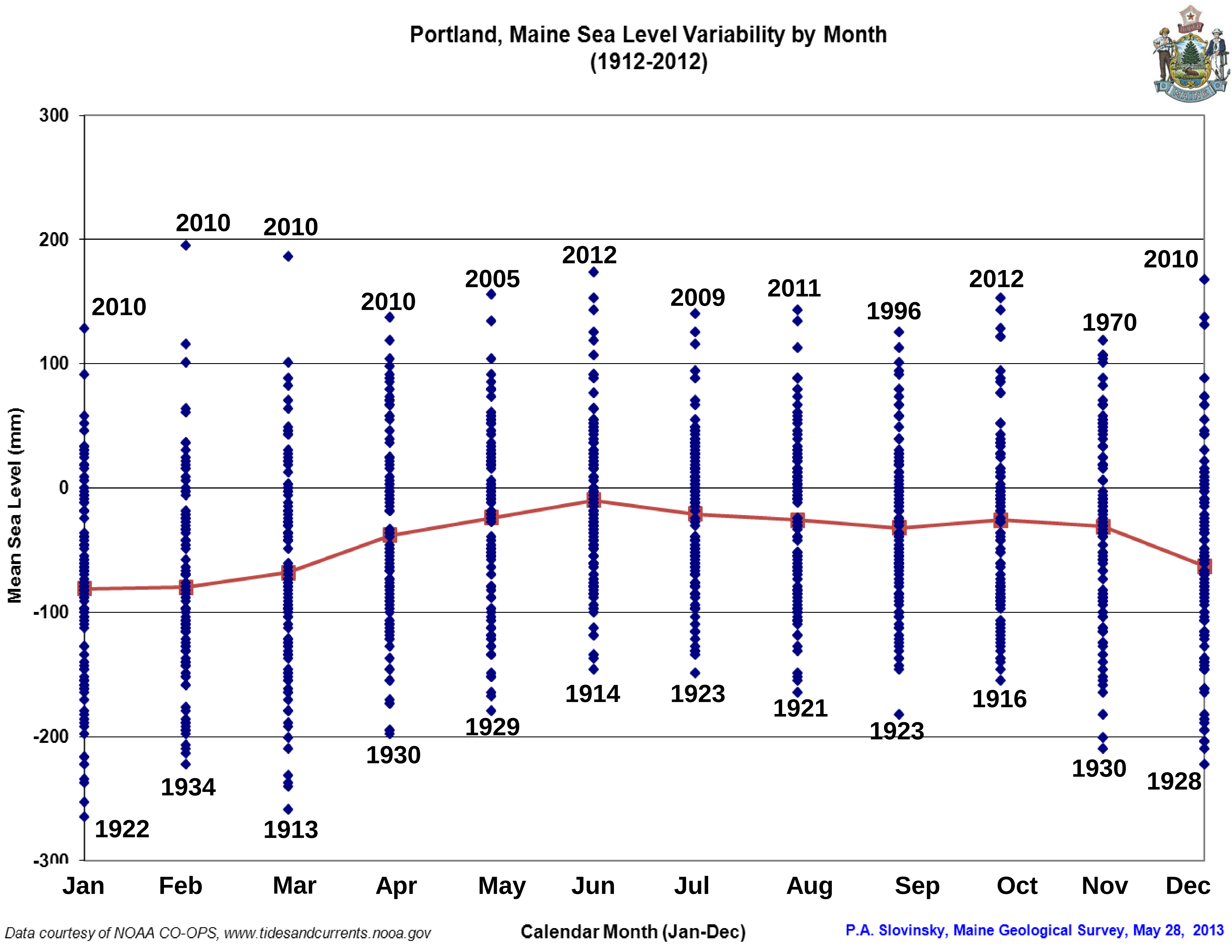
<u>Highest</u>
(2.0 m, 6.6 ft)
***Combines maximum warming, thermal expansion, and possible ice sheet loss**

<u>Intermediate-High</u>
(1.2 m, 3.9 ft)
***Average of high end global predictions, combines recent ice sheet loss and thermal expansion**

<u>Intermediate-Low</u>
(0.5 m, 1.6 ft)
***Includes only thermal expansion from warming**

<u>Lowest</u>
(0.2 m, 0.7 ft)
*** Historical trend continued; no additional thermal expansion from warming**

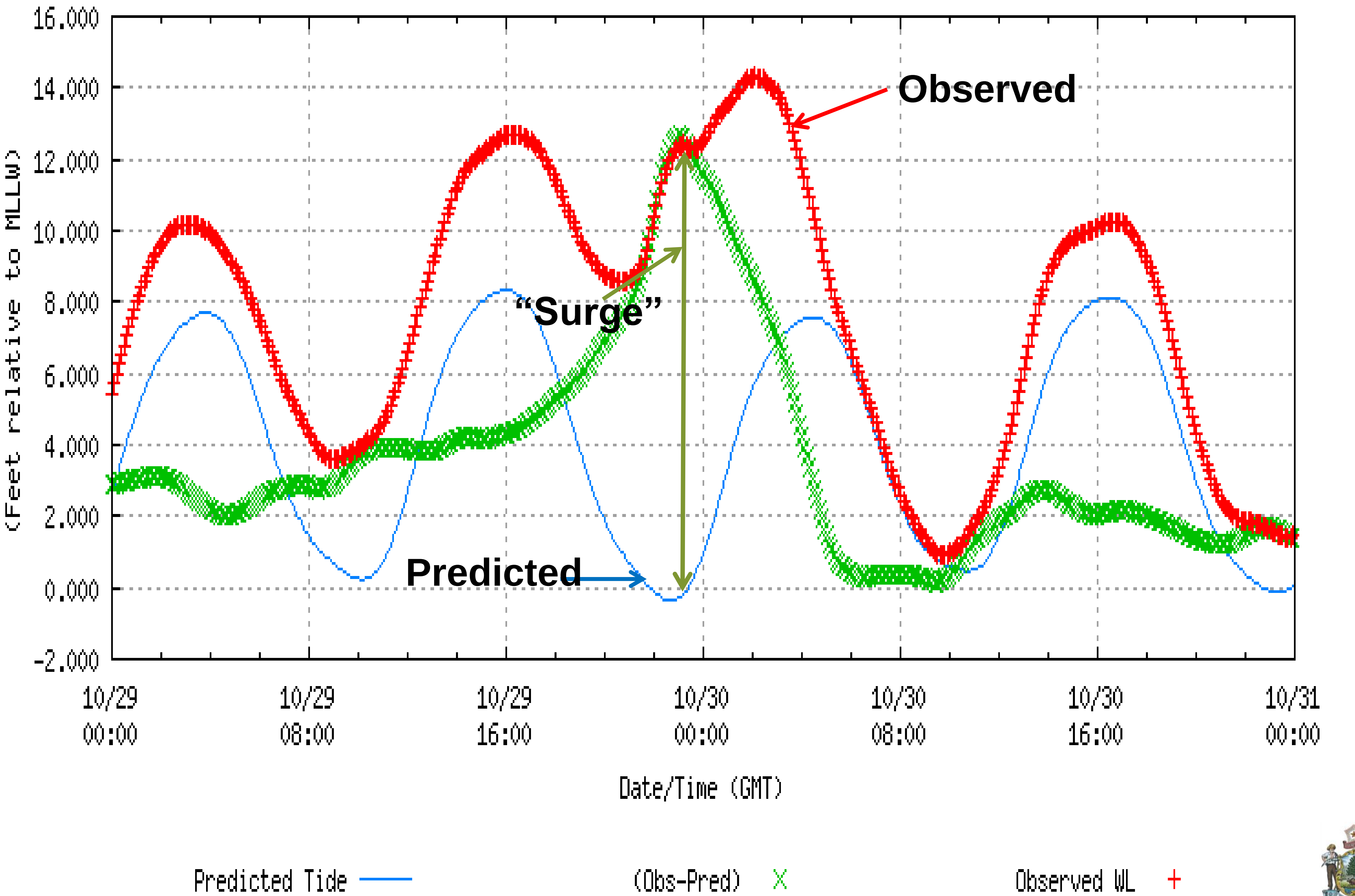
Recommend using a “Scenario” Based Approach


Portland, Maine Sea Level Variability by Month
(1912-2012)
Mean Sea Level (mm)
300
200
100
0
-100
-200
-300
2010
2010
2010
2010
2005
2012
2009
2011
1996
2012
1970
2010
1922
1934
1913
1930
1929
1914
1923
1921
1923
1916
1930
1928
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Data courtesy of NOAA CO-OPS, www.tidesandcurrents.noaa.gov
Calendar Month (Jan-Dec)
P.A. Slovinsky, Maine Geological Survey, May 28, 2013

Storm Surge
“Superstorm Sandy”

NOAA/NOS/CO-OPS
Verified Water Level vs. Predicted Plot
8516945 Kings Point, NY
from 2012/10/29 - 2012/10/30

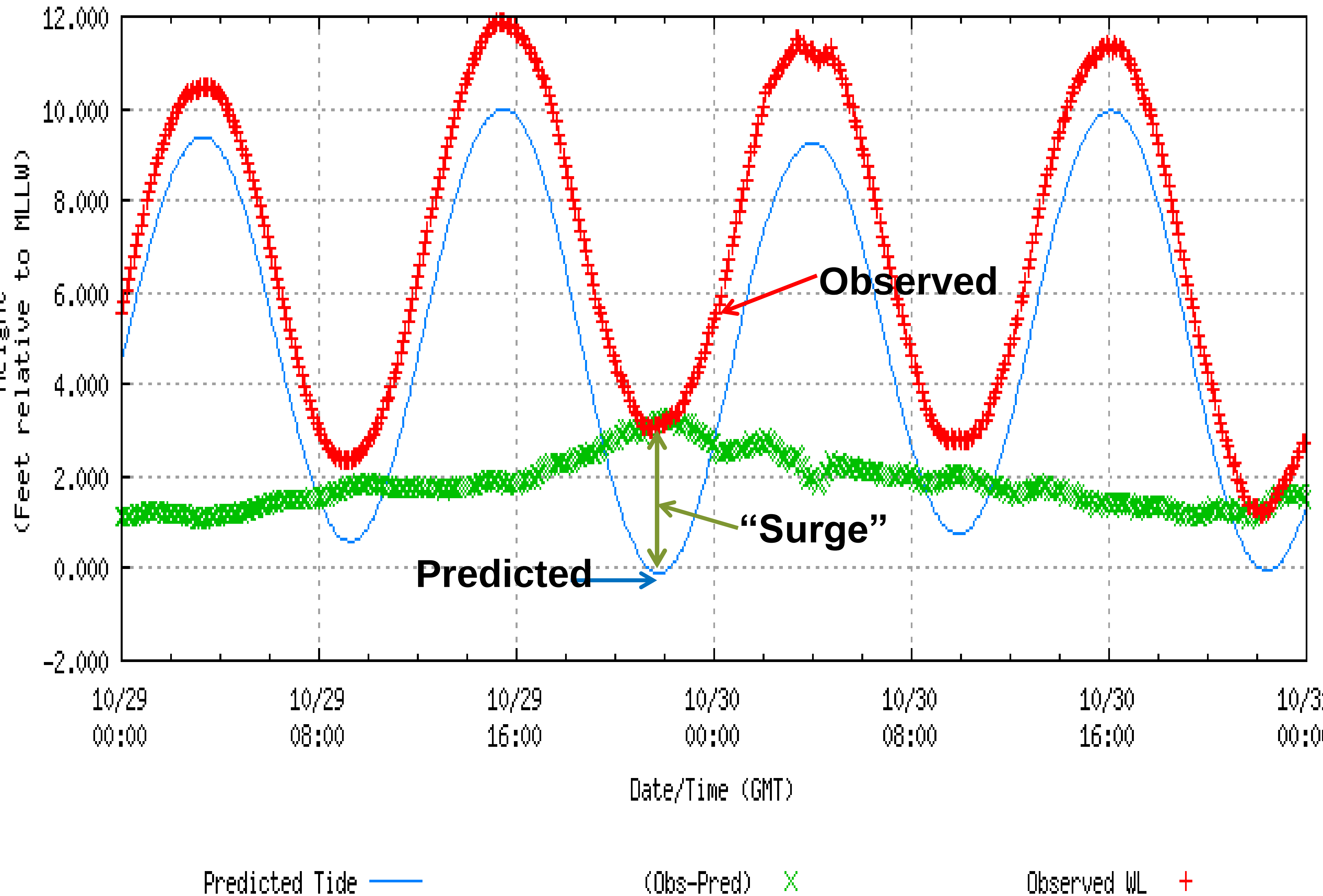
Kings Point, NY
10/29-10/30/2012

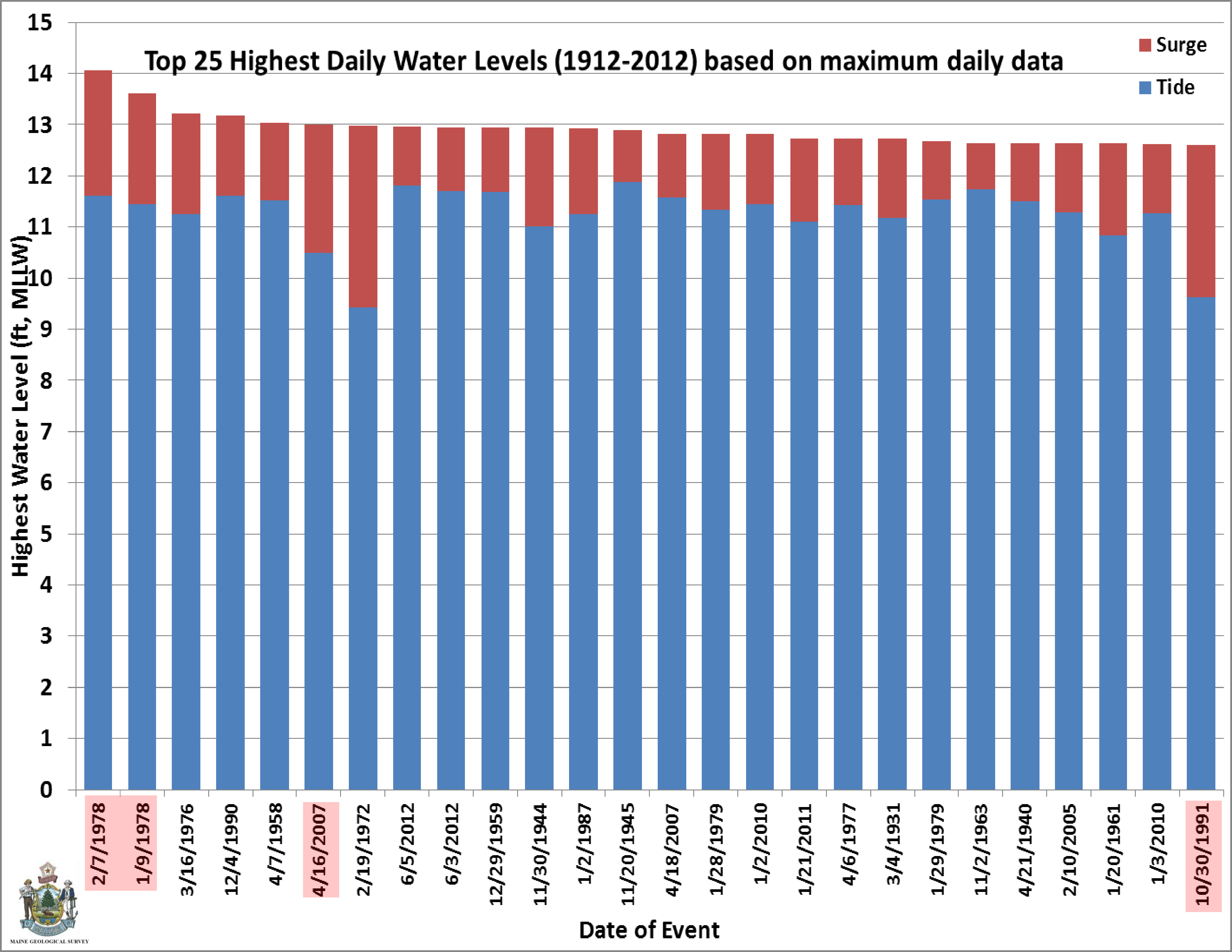


Storm Surge
"Superstorm Sandy"

NOAA/NOS/CO-OPS
Verified Water Level vs. Predicted Plot
8418150 Portland, ME
from 2012/10/29 - 2012/10/30

Portland, ME
10/29-10/30/2012





Top 25 Highest Daily Water Levels (1912-2012) based on maximum daily data
Surge
Tide
Highest Water Level (ft, MLLW)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
2/7/1978
1/9/1978
3/16/1976
12/4/1990
4/7/1958
4/16/2007
2/19/1972
6/5/2012
6/3/2012
12/29/1959
11/30/1944
1/2/1987
11/20/1945
4/18/2007
1/28/1979
1/2/2010
1/21/2011
4/6/1977
3/4/1931
1/29/1979
11/2/1963
4/21/1940
2/10/2005
1/20/1961
1/3/2010
10/30/1991
Date of Event
MAINE GEOLOGICAL SURVEY

Based on statistical analysis of hourly annual maximum tidal data at the Portland tide gauge from 1912-2012…

Interval (yrs)	High Water Level (ft, MLLW)
1	11.7
5	12.6
10	12.9
25	13.4
50	13.7
100	14.1

Sea Level and Storm Surge Summaries

- Latest scientific predictions for SLR: 1 ft 2050, 2-3 ft by 2100, or more, highly dependent on future ice sheet input; the **State of Maine has adopted 2 feet as a middle of the road prediction by the year 2100 for Coastal Sand Dunes**.
- Storm surges of 2-3 feet are relatively common, but only cause damage when they **coincide with high tides**.
- There is only about a one foot difference between the "10 year" event and the "100 year" event ; thus, a one-foot rise in sea level by 2050 would cause the "100 year" event to come about every 10 years because sea level rise lowers the recurrence interval of storms.
- A **two-foot rise in sea level** would result in water levels roughly equal to the 2007 Patriots' Day Storm during astronomically high tides even in good weather.
- **Work with the concept of thinking and planning for Today's Storms and Tomorrow's Tides**

Sea Level Rise Planning in Maine…

Maine's Coastal Policies - 1985

Title 38 M.R.S.A sec. 1801:

"The Legislature directs that state and local agencies and federal agencies as required by the United States Coastal Zone Management Act of 1972, PL 92-583, with responsibility for regulating, planning, developing or managing coastal resources, shall conduct their activities affecting the coastal area consistent with the following policies to:

…Discourage growth and new development in coastal areas where, because of coastal storms, flooding, landslides or sea-level rise, it is hazardous to human health and safety;"

United States Environmental Protection Agency | Policy, Planning, And Evaluation (2122) | EPA-230-R-95-900 September 1995

EPA

Anticipatory Planning For Sea-Level Rise Along The Coast of Maine

This report a joint effort in cooperation with State of Maine's State Planning Office.

On the right track… in 1995!

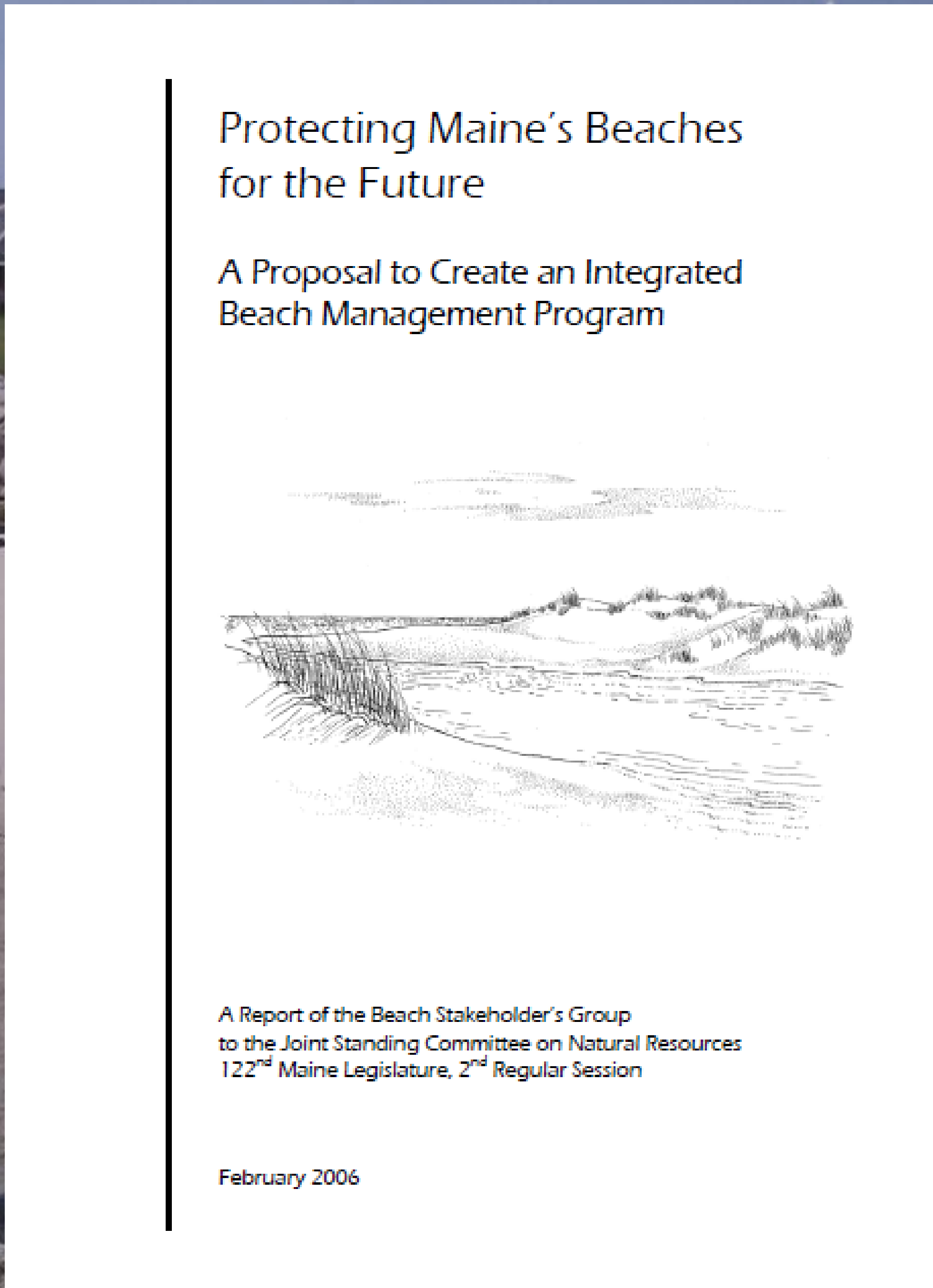
But it was never <u>engaged at the local level</u>

So it ended up shelved in the archives.

More reports…and updated sea level regulations

2006 - As the result of a 2 year stakeholder process, Maine adopted 2 feet of sea level rise over the next 100 years, which was a “middle-of-the road” prediction for global sea level rise, into its NRPA. Only coastal sand dunes.

P.A. Slovinsky, MGS


Protecting Maine's Beaches for the Future

A Proposal to Create an Integrated Beach Management Program

A Report of the Beach Stakeholder's Group
to the Joint Standing Committee on Natural Resources
122nd Maine Legislature, 2nd Regular Session

February 2006

Even More recently…

<u>Working Groups:</u>

Built Environment
Coastal Environment
Natural Environment
Social Environment

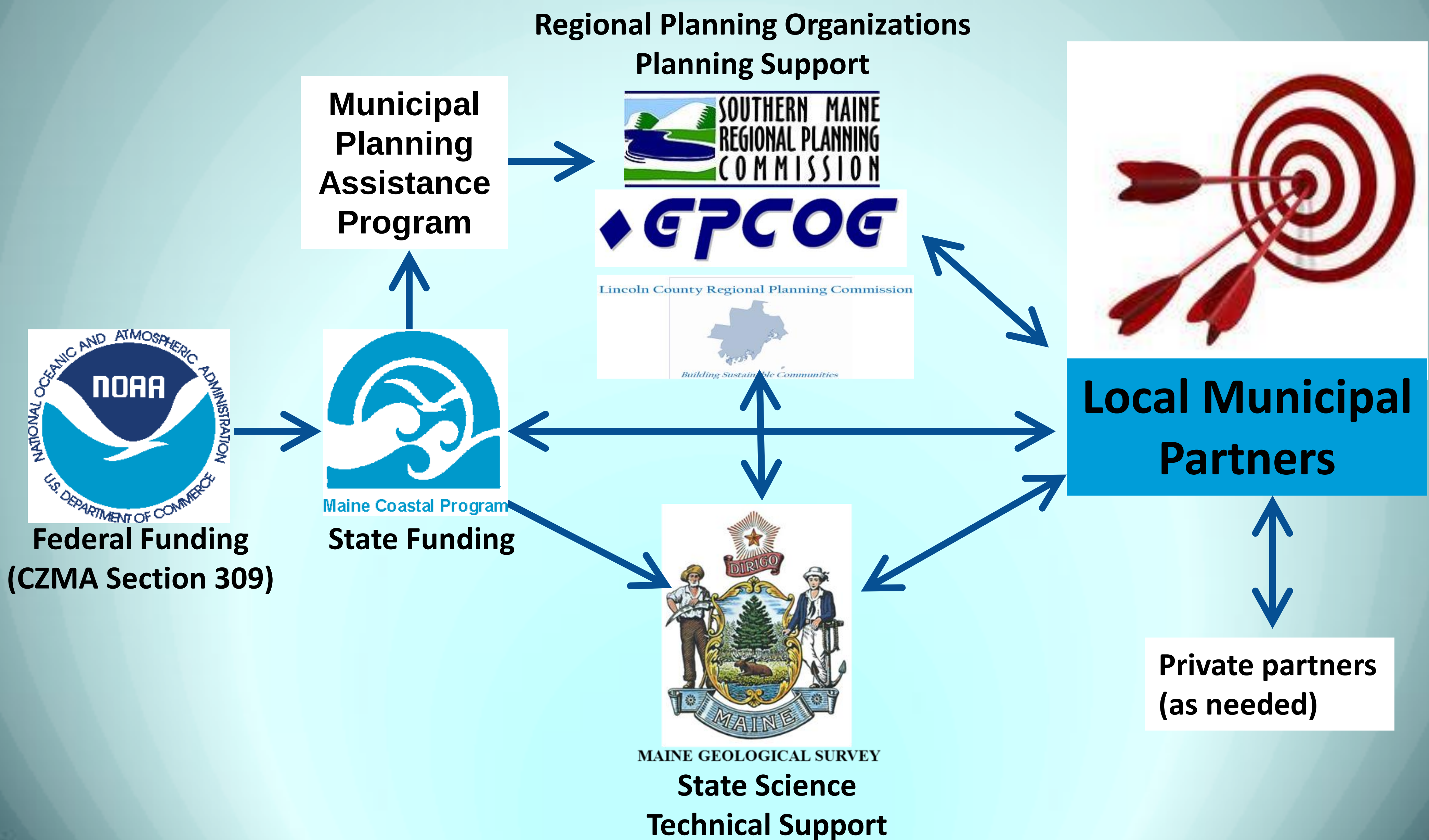
- Year-long Stakeholder Process led to the production of a report in early 2010.
- Major recommendations related to ***bringing tools, models, and technical data to the local decision-making level relating to sea level rise planning.***

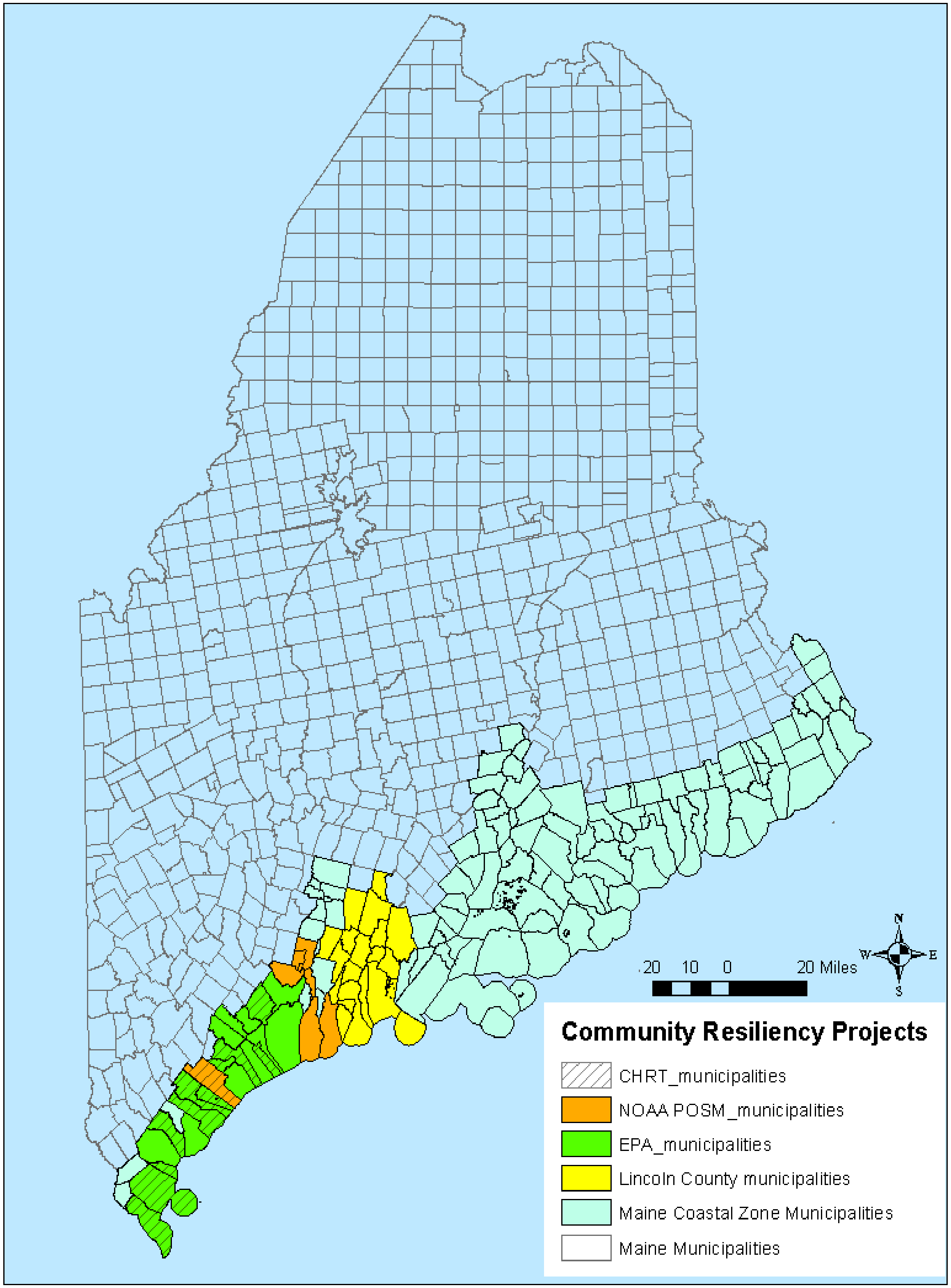
Resolves, Chapter 16, LD 460, "Resolve, To Evaluate Climate Change Adaptation Options for the State"

Bringing it down to the local level

Proactive Engagement

Coastal Hazard and Resiliency Tools (CHRT) Project





Coastal Hazard Resilience

Marsh Migration

Emergency Management

Impacts to the Built and Natural Environments

The CHRT Process…

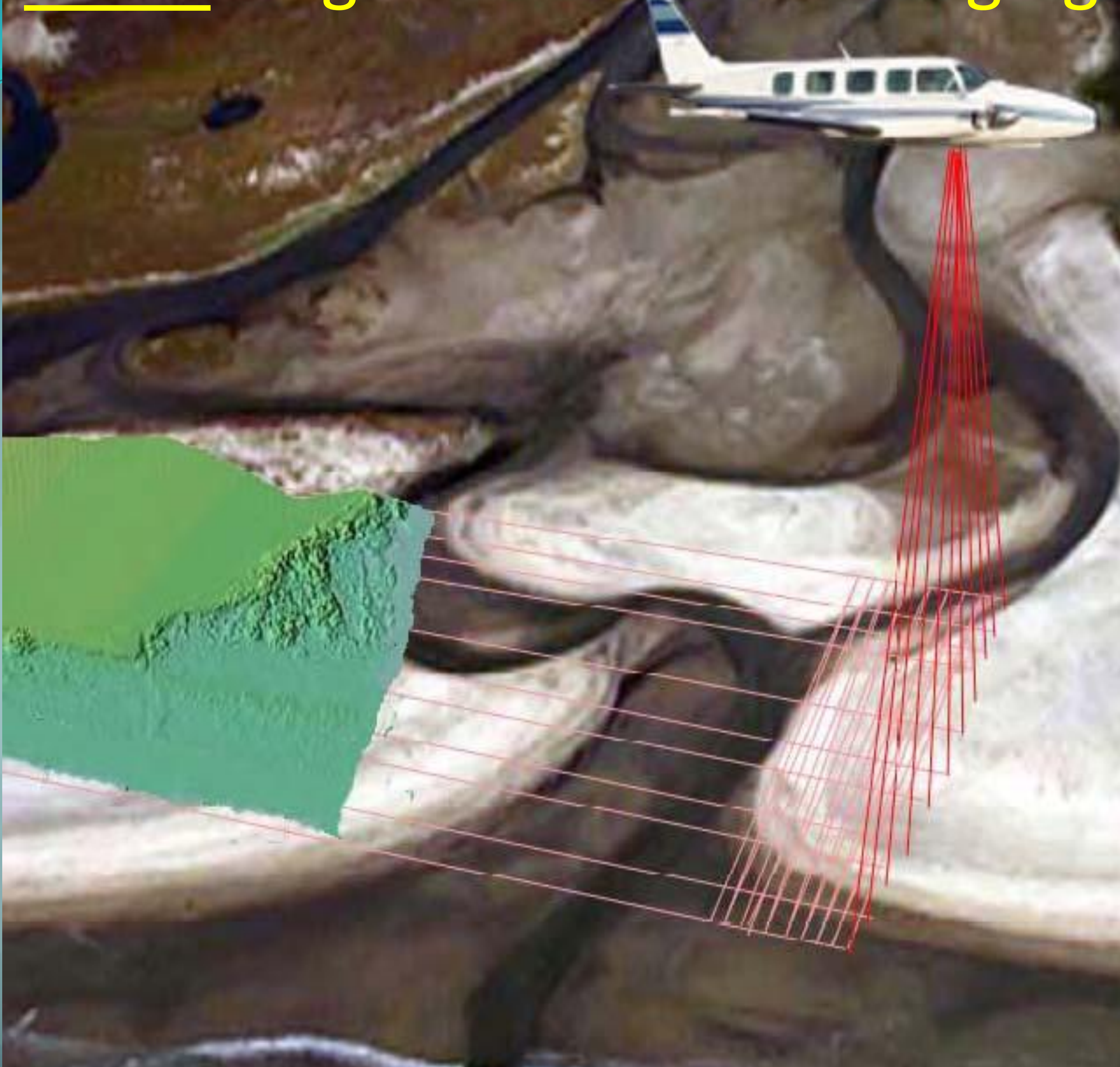
A Long Process from Initial Engagement to Implementation

- Develop an appropriate project team (state, regional, local) most comfortable with local stakeholders
- Provide significant levels of Technical Assistance (SLR Background, Policy, Vulnerability Assessment Data Development, Policy)
- Significant Community Education and Outreach
- Partnership Development
- Strategy Identification and Implementation

Assemble Vulnerability Assessment Data

- Need adequate, *ground-truthed* LiDAR data coverage
- Sea Level Rise Scenarios (we typically have used a "scenario based approach", so 1, 2, 3, 6 feet by 2100)
- Data supporting storm elevations (i.e., effective "100-year" storm Flood Insurance Study data or other data)
- Data supporting natural feature mapping and simulation of SLR impacts (we use NOS tidal stations and VDATUM tool)
- Data supporting "assets at risk" (GIS layers from state, local sources, and others)

LiDAR - Light Detection & Ranging Data

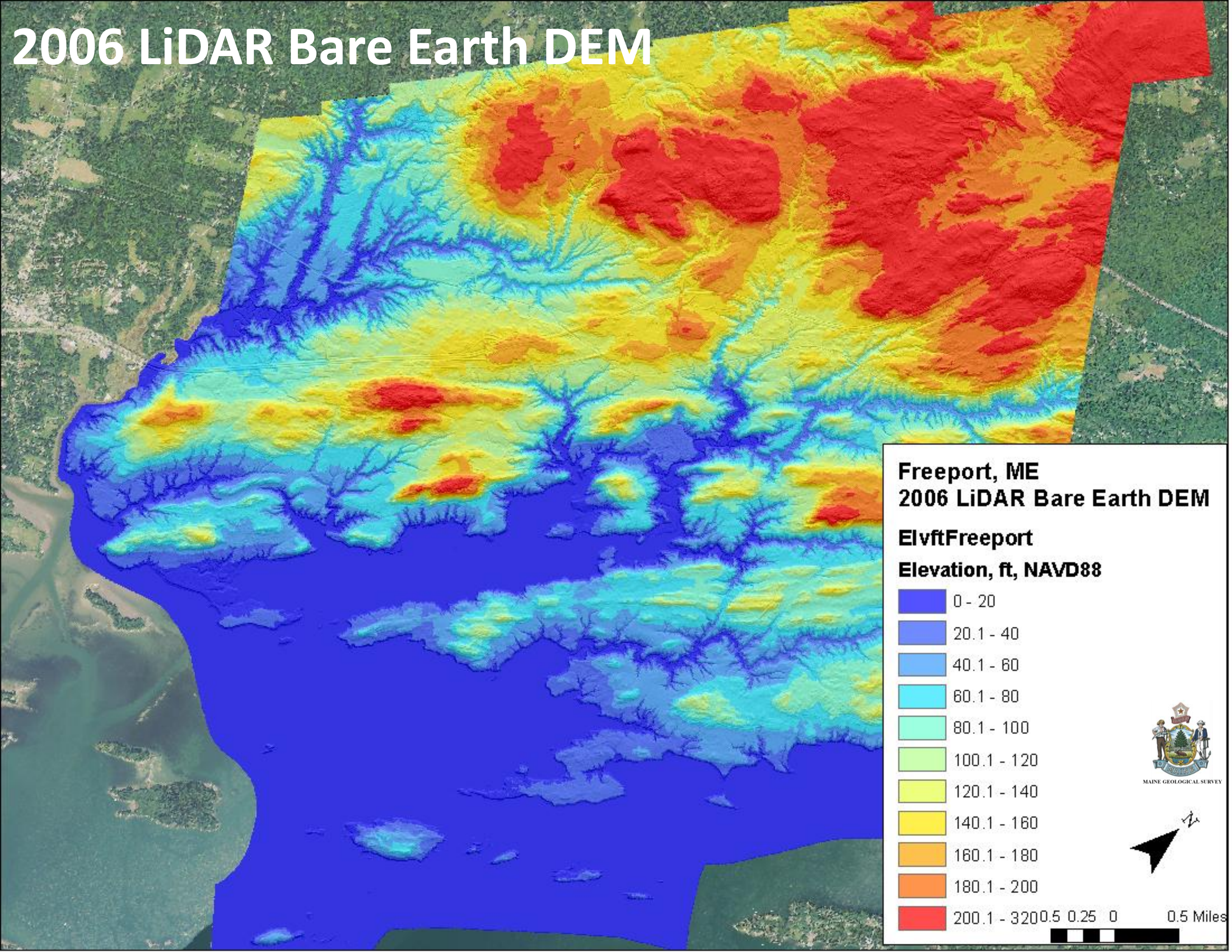


100,000 pulses of laser light per second are sent to the ground in sweeping lines

Sensors measure how long it takes each pulse to reflect back to the unit and calculates an “elevation”

Algorithms are used to “remove” buildings and vegetation types to create a “bare earth” digital elevation model (DEM)

Image from the Kelly Research and Outreach Lab, California Coastal LiDar Project


2006 LiDAR Bare Earth DEM
Freeport, ME
2006 LiDAR Bare Earth DEM
ElvftFreeport
Elevation, ft, NAVD88
0 - 20
20.1 - 40
40.1 - 60
60.1 - 80
80.1 - 100
100.1 - 120
120.1 - 140
140.1 - 160
160.1 - 180
180.1 - 200
200.1 - 320
0.5 0.25 0 0.5 Miles
N
MAINE GEOLOGICAL SURVEY

Vulnerability Assessment
Major Assumptions

- Sea level rise scenarios simulated (by 2100):
  - 1 foot, 2 feet, 3.3 feet, and 6.0 feet
- Scenarios **assume static topography** (‘bathtub model’).
- Scenarios **do not include** the effects of **freshwater runoff from rain events or waves.**
- The **Highest Annual Tide (HAT)**, the **1% storm stillwater elevation, and a Category 1 Hurricane** were used as a basis for simulating impacts to infrastructure.
- For assessing impacts to wetlands, **tidal elevations were used as proxies** for different marsh surfaces.
- For assessing impacts to roads, it was assumed that inundation of a road made it **impassable** but did not assume the road would be damaged.
- For assessing impacts to buildings, it was assumed that the **entire building was impacted** if inundation intersected the building footprint.

Potential Impacts to Coastal Wetlands
(Room for Wetland Transgression?)

Coastal wetlands

"Coastal wetlands" means all tidal and subtidal lands; all areas with vegetation present that is tolerant of salt water and occurs primarily in salt water or estuarine habitat; and any swamp, marsh, bog, beach, flat or other contiguous lowland that is subject to tidal action during the *highest tide level for each year* in which an activity is proposed as identified in tide tables published by the National Ocean Service. Coastal wetlands may include portions of coastal sand dunes.

Required in Maine's Municipal Shoreland Zoning

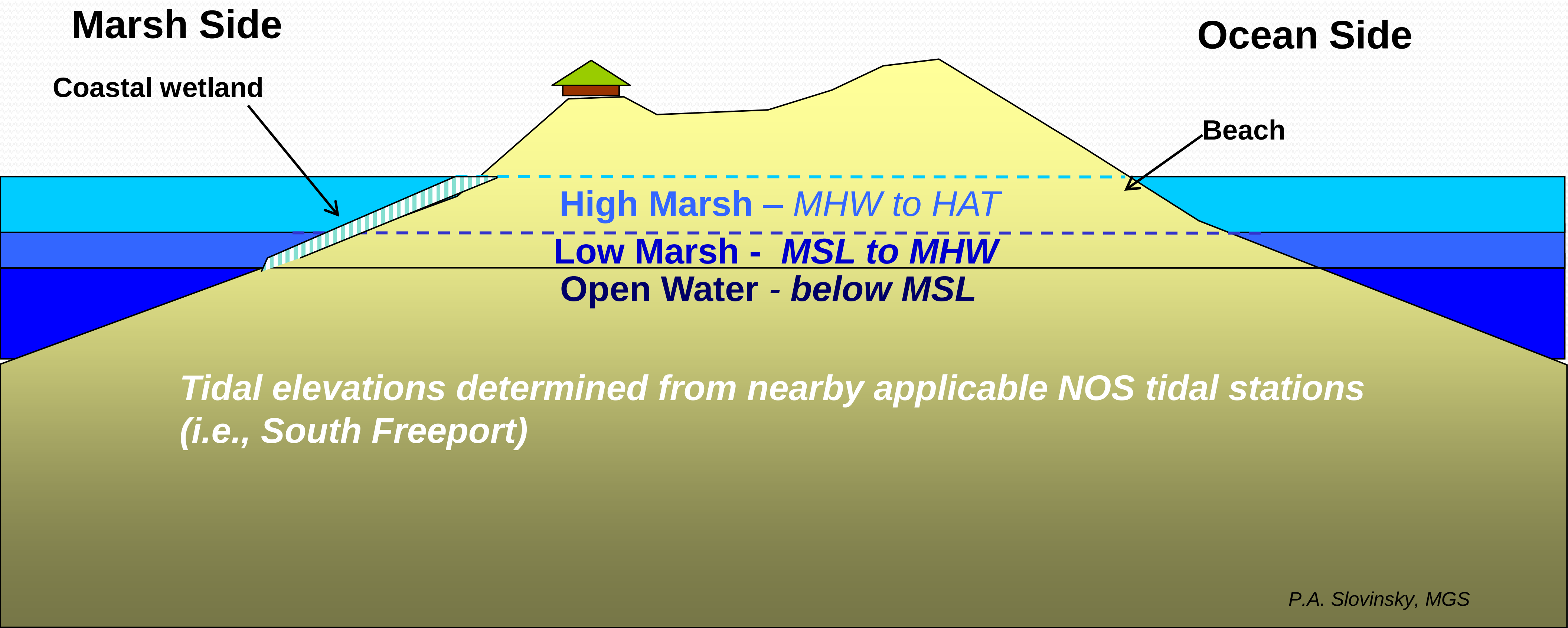
P.A. Slovinsky, MGS

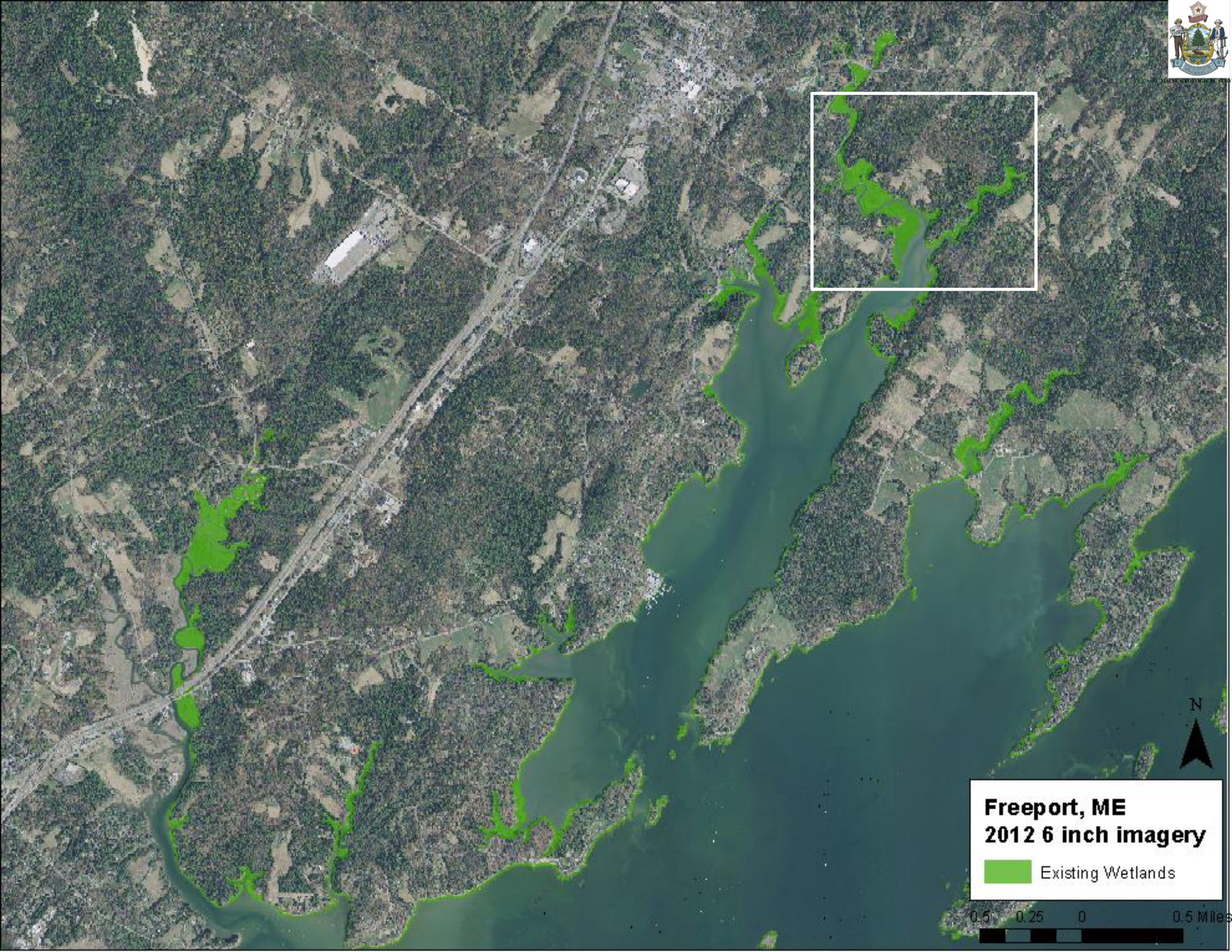
Step 2: Setting the Stage with Tidal Elevations

Highest Annual Tide (HAT) - “spring” tide, the highest predicted water level for any given year but is reached within several inches numerous tides a year

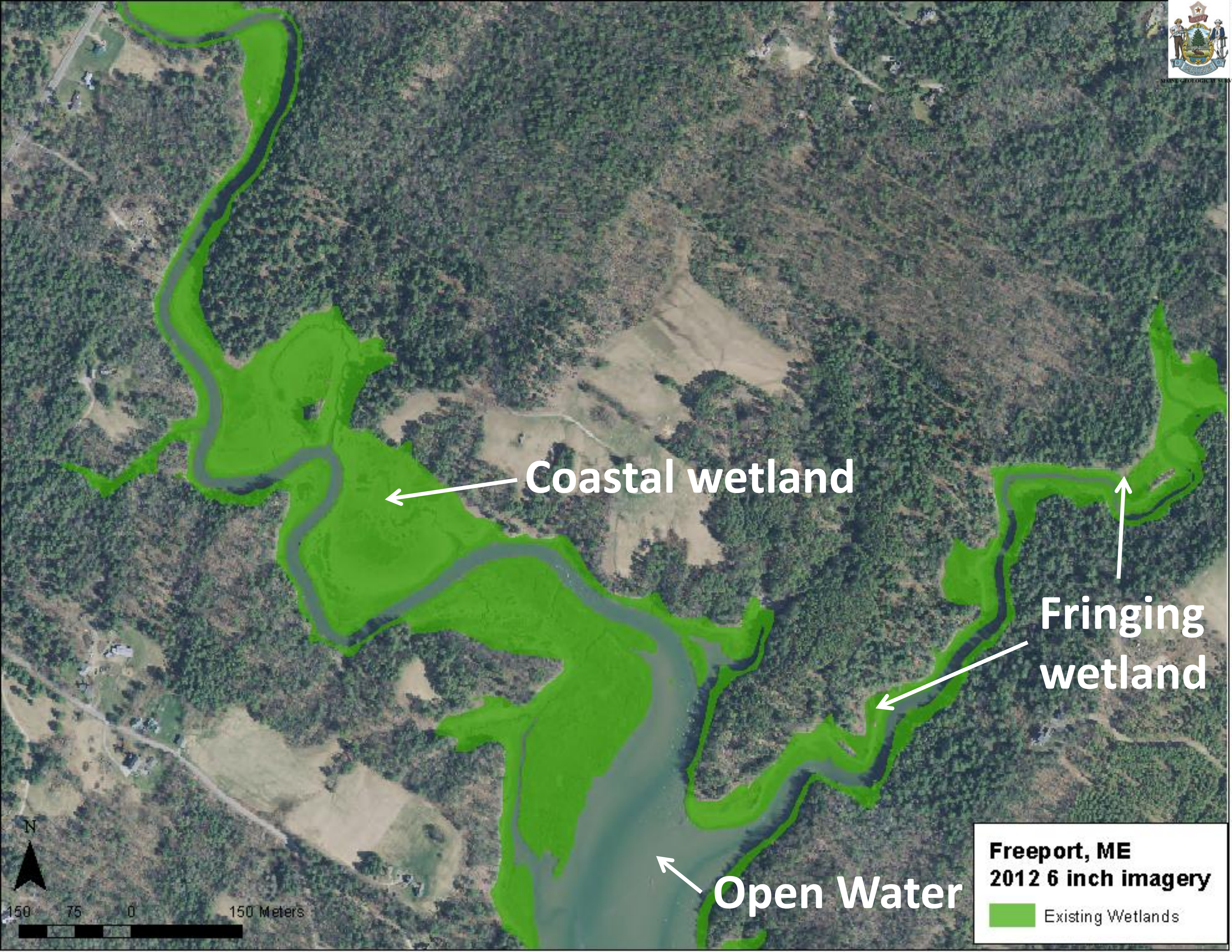
Mean sea level (MSL) = average height of the ocean’s surface (high and low tide).

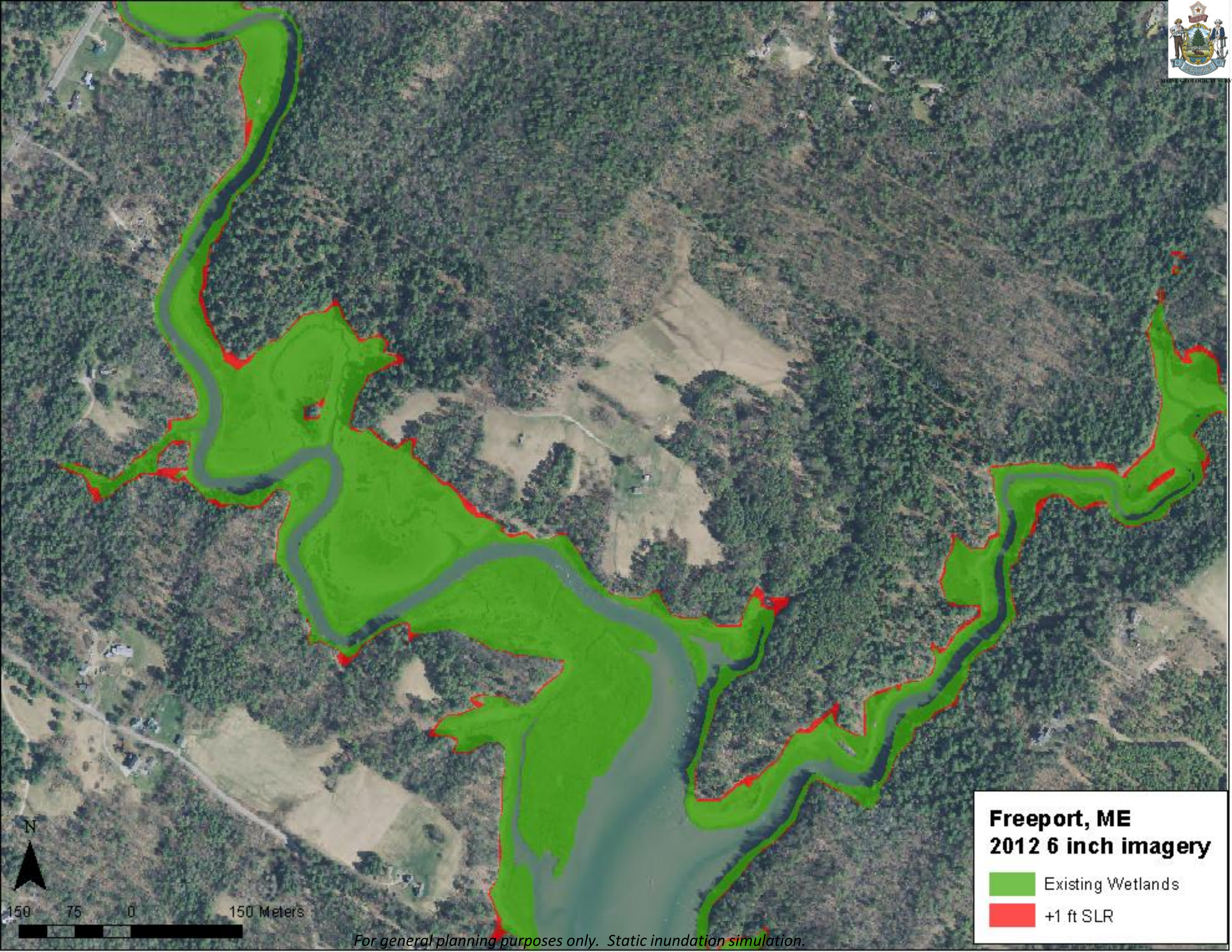
Coastal Wetlands exist from MSL to HAT



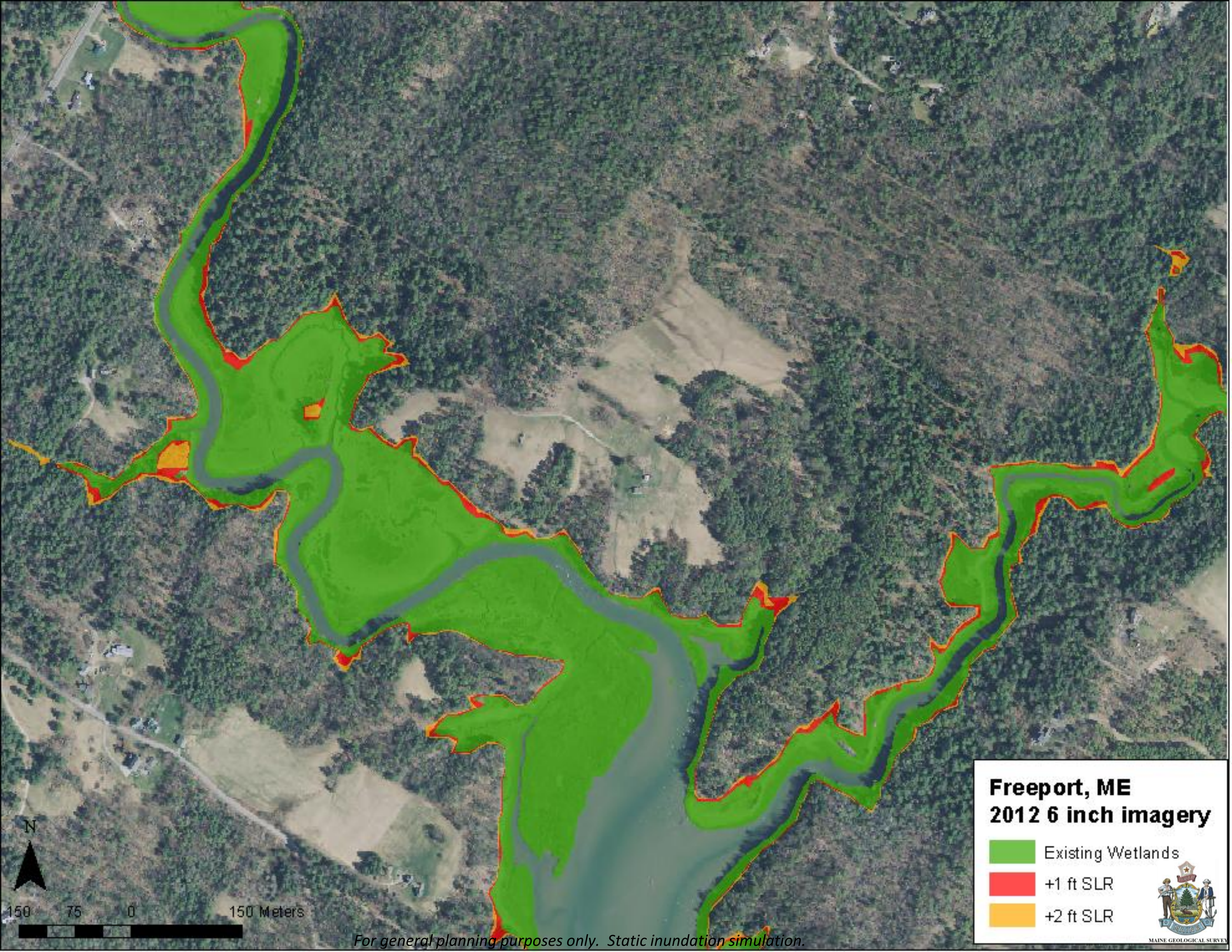

Freeport, ME
2012 6 inch imagery
Existing Wetlands
0.5 0.25 0 0.5 Miles
N


Lower Mast Landing Rd.
Coastal wetland
Fringing wetland
Bartol Isl. Rd.
N
Freeport, ME
2012 6 inch imagery
Open Water
0.08 0.04 0 0.08 Miles

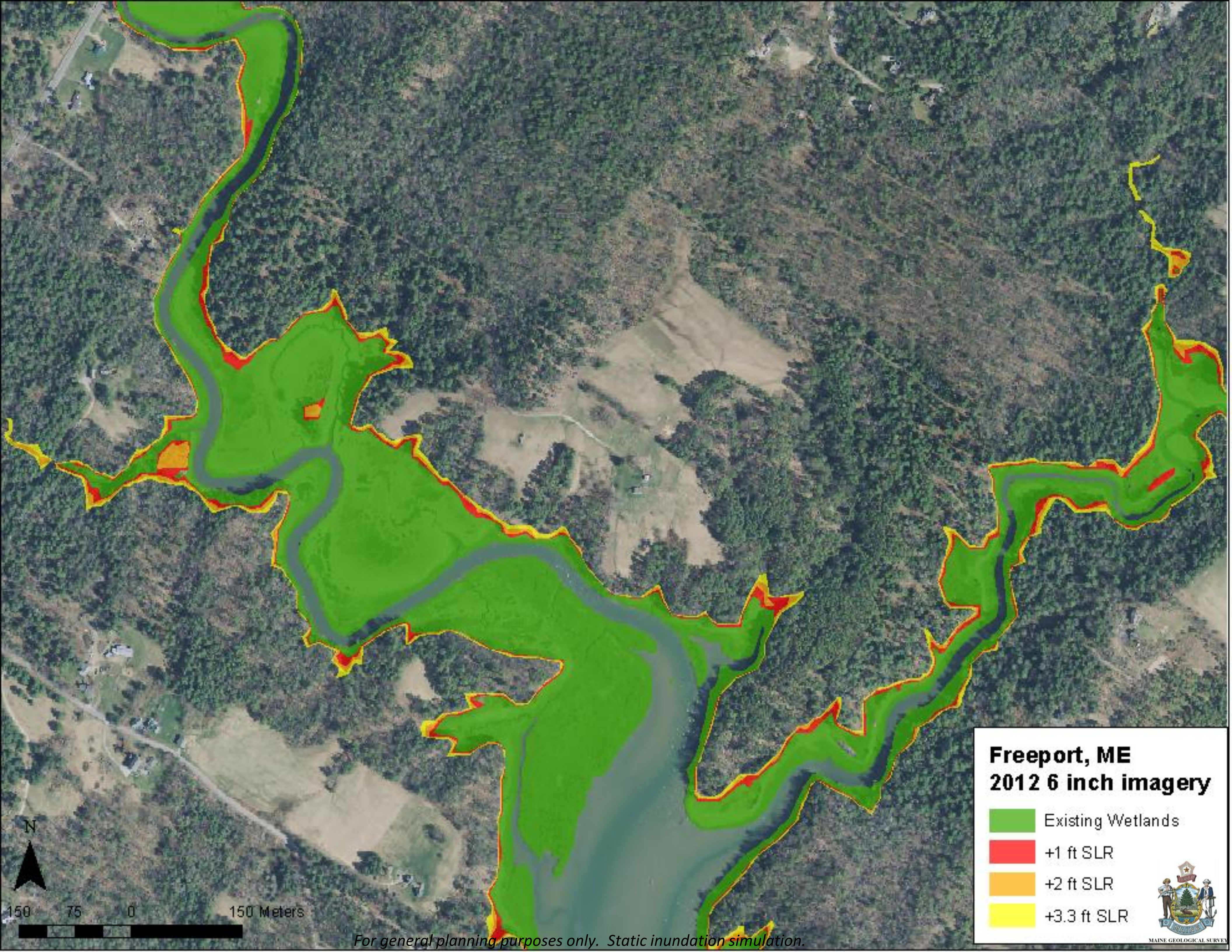

Coastal wetland
Fringing wetland
Open Water
Freeport, ME
2012 6 inch imagery
Existing Wetlands
N
150 75 0 150 Meters

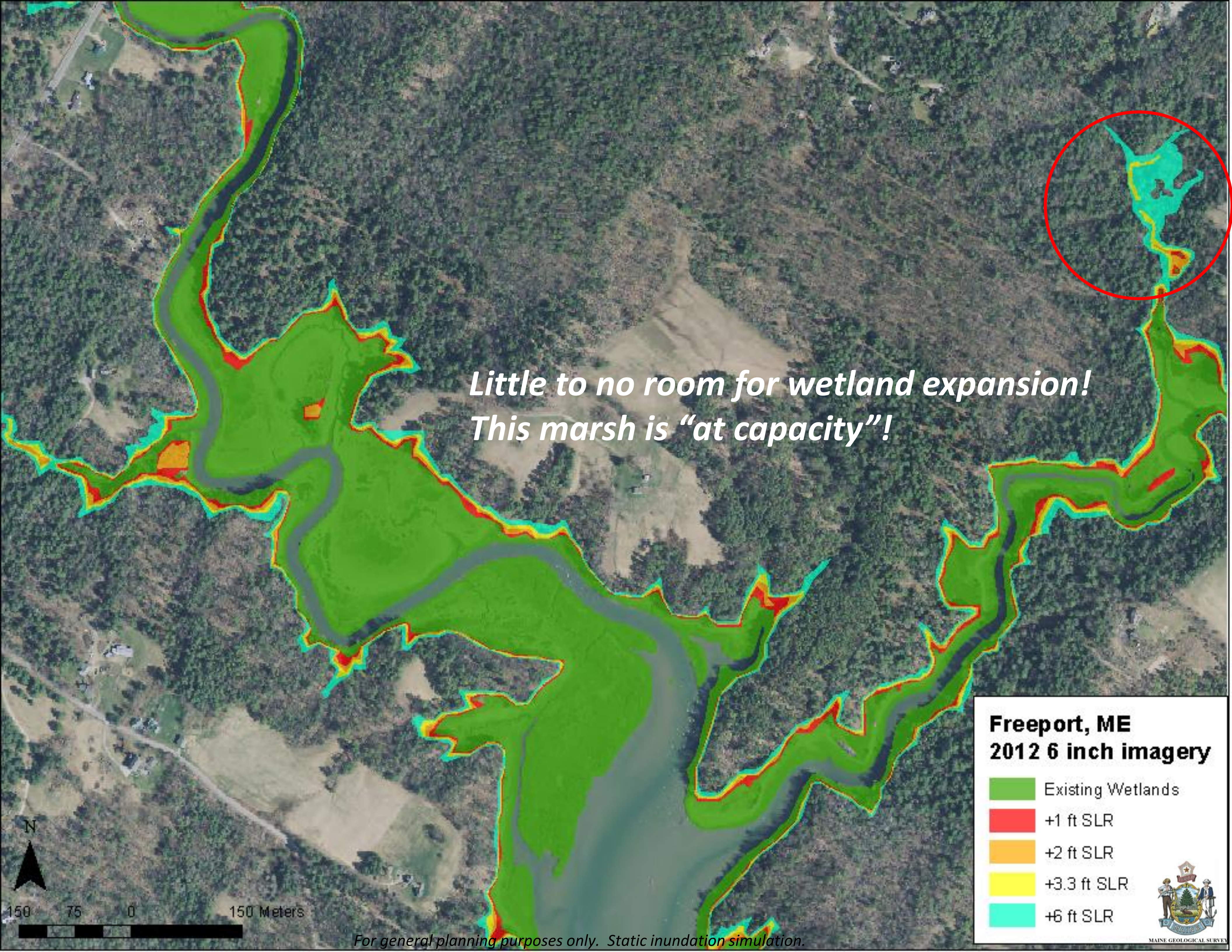


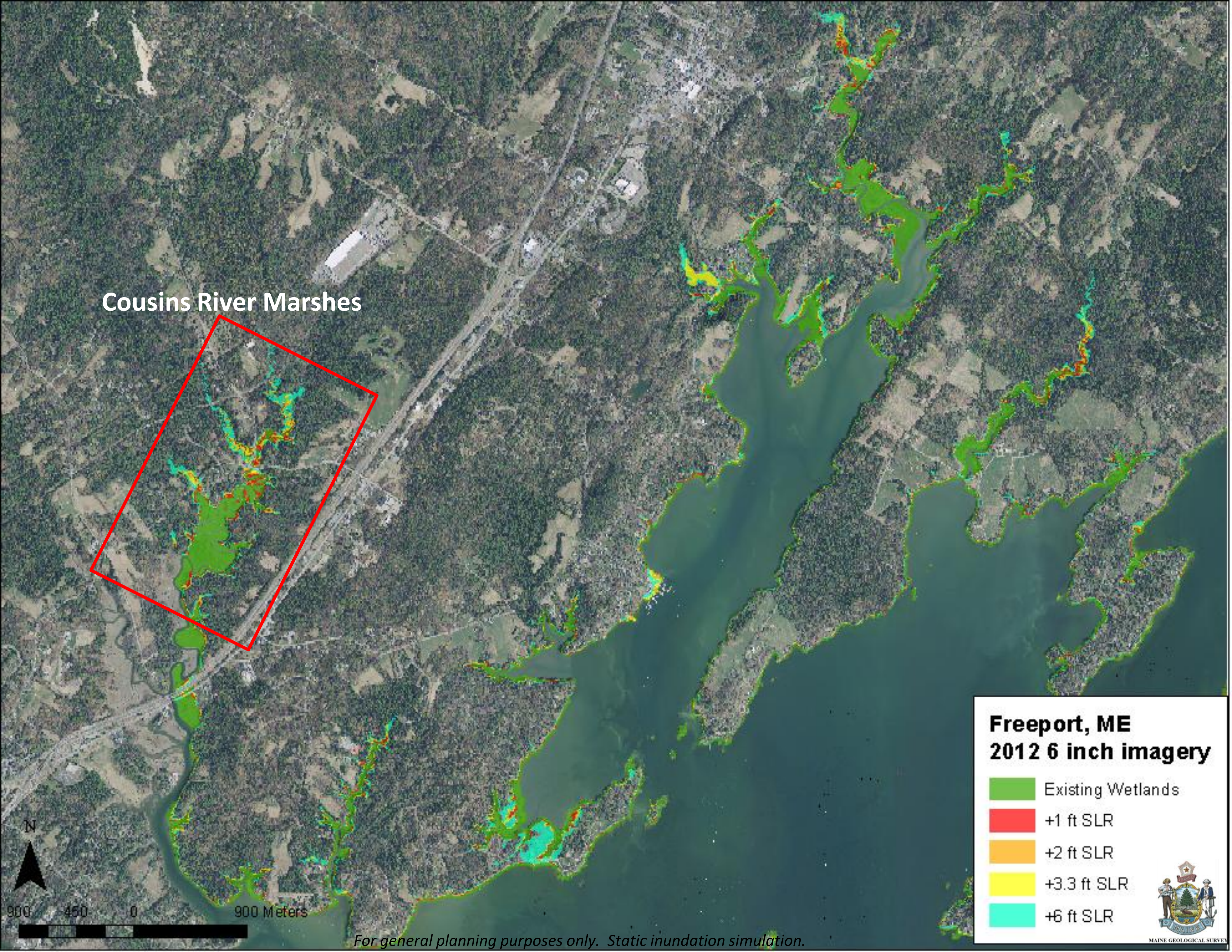
Freeport, ME
2012 6 inch imagery
Existing Wetlands
+1 ft SLR
N
150
75
0
150 Meters
For general planning purposes only. Static inundation simulation.

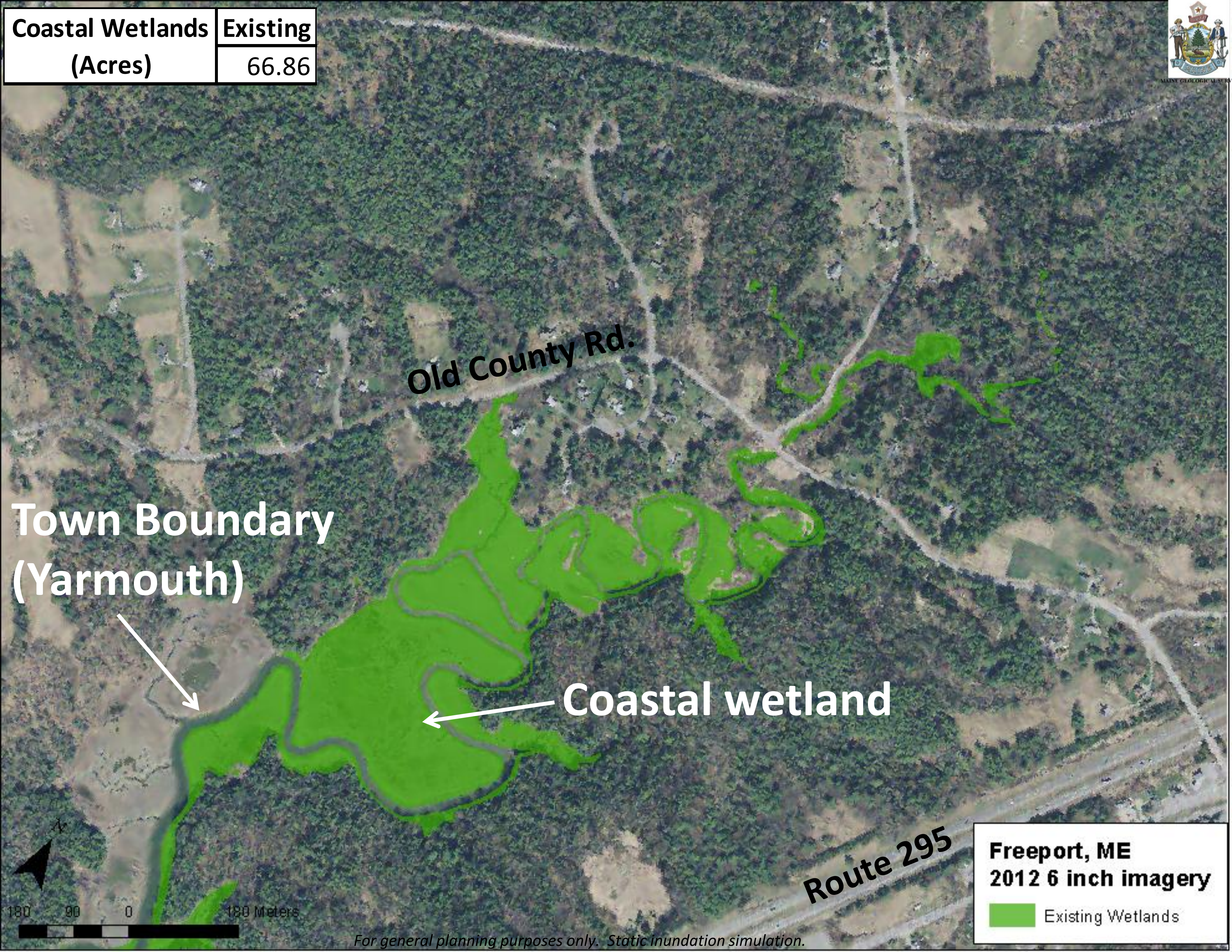


For general planning purposes only. Static inundation simulation.


Freeport, ME
2012 6 inch imagery
Existing Wetlands
+1 ft SLR
+2 ft SLR
+3.3 ft SLR
N
150 75 0 150 Meters
MAINE GEOLOGICAL SURVEY
For general planning purposes only. Static inundation simulation.

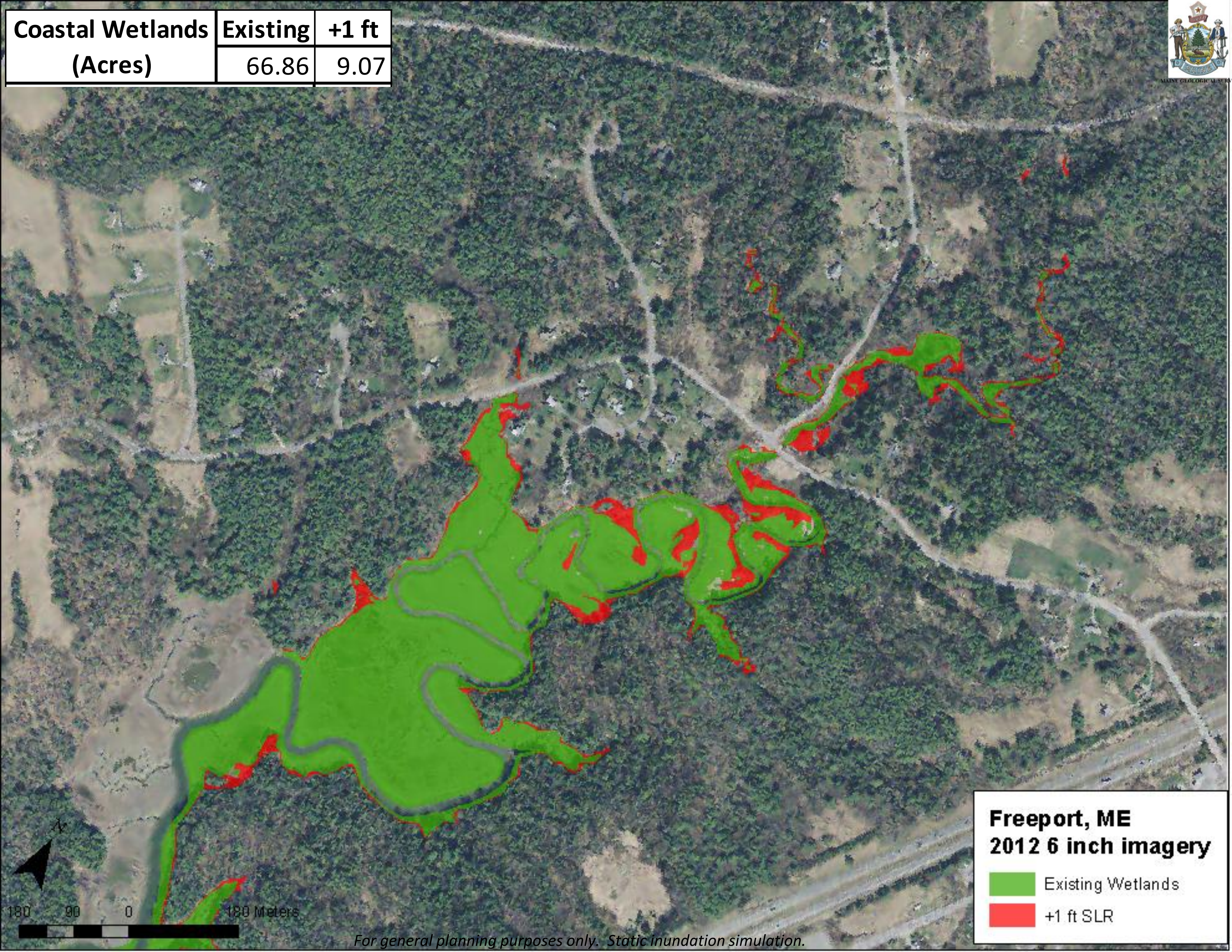

Little to no room for wetland expansion!
This marsh is "at capacity"!
Freeport, ME
2012 6 inch imagery
Existing Wetlands
+1 ft SLR
+2 ft SLR
+3.3 ft SLR
+6 ft SLR
N
150 75 0 150 Meters
MAINE GEOLOGICAL SURVEY
For general planning purposes only. Static inundation simulation.


Cousins River Marshes
Freeport, ME
2012 6 inch imagery
Existing Wetlands
+1 ft SLR
+2 ft SLR
+3.3 ft SLR
+6 ft SLR
N
900 450 0 900 Meters
MAINE GEOLOGICAL SURVEY
For general planning purposes only. Static inundation simulation.

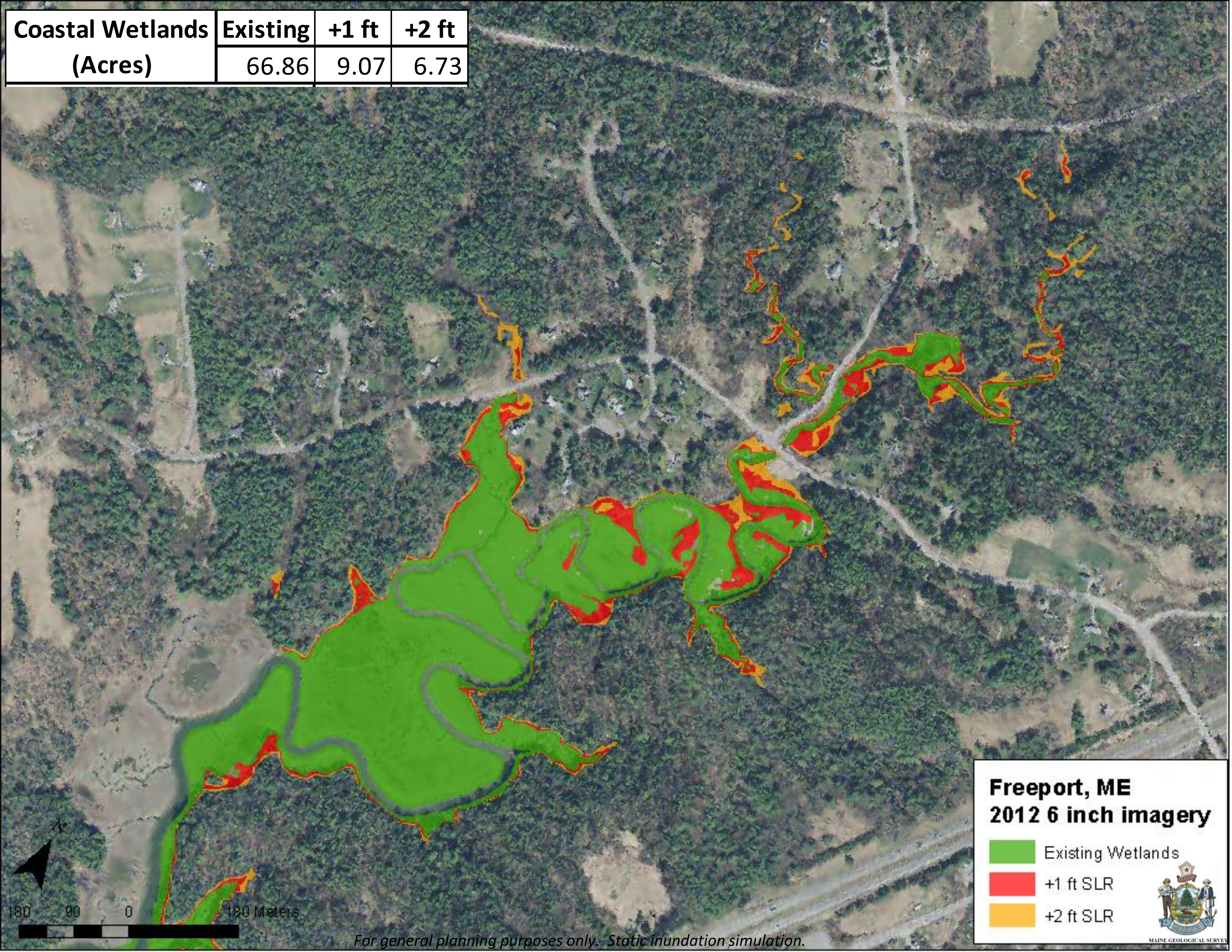


Coastal Wetlands (Acres)
Existing
66.86
MAINE GEOLOGICAL SURVEY
Old County Rd.
Town Boundary (Yarmouth)
Coastal wetland
Route 295
180 90 0 180 Meters
Freeport, ME
2012 6 inch imagery
Existing Wetlands
For general planning purposes only. Static inundation simulation.

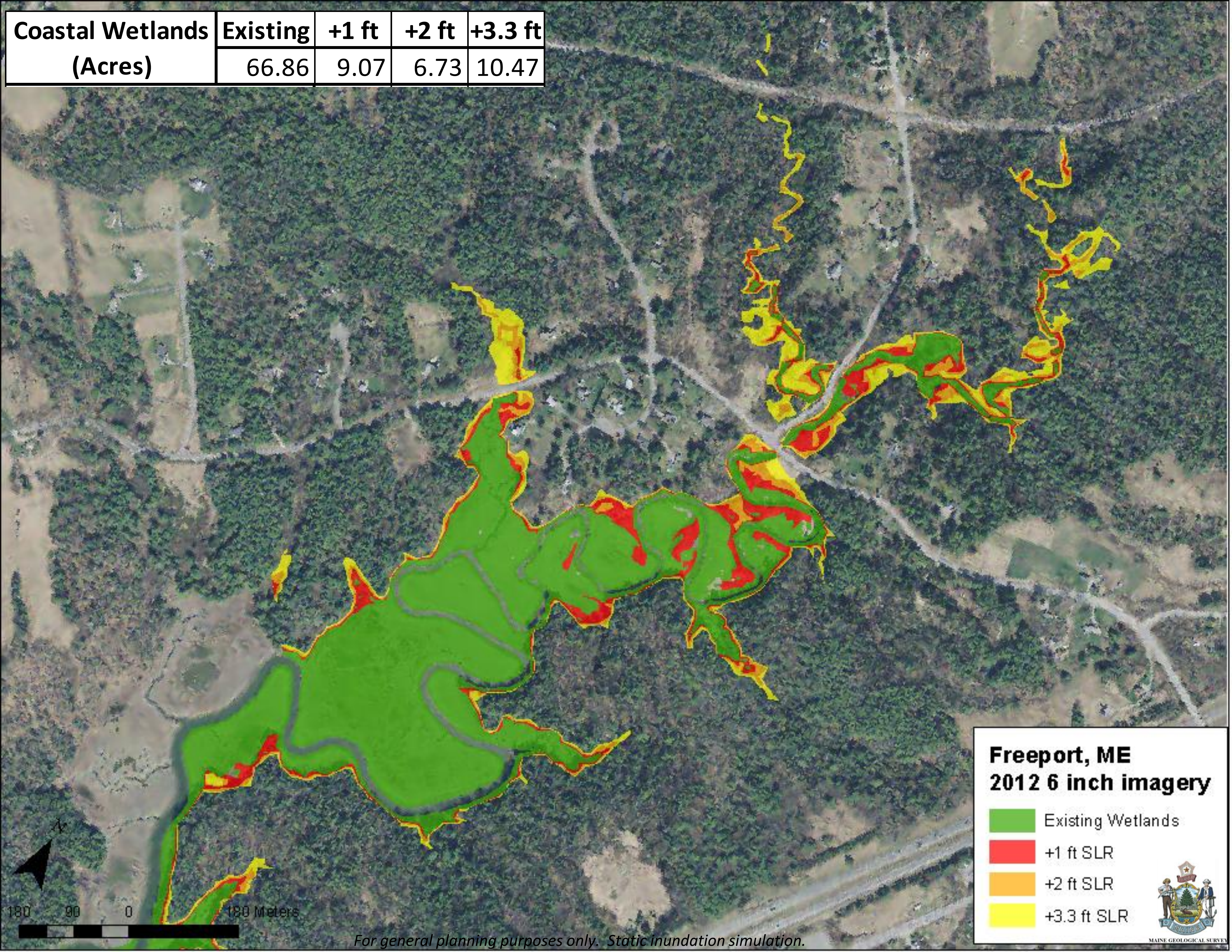
Coastal Wetlands (Acres)	Existing	+1 ft
	66.86	9.07



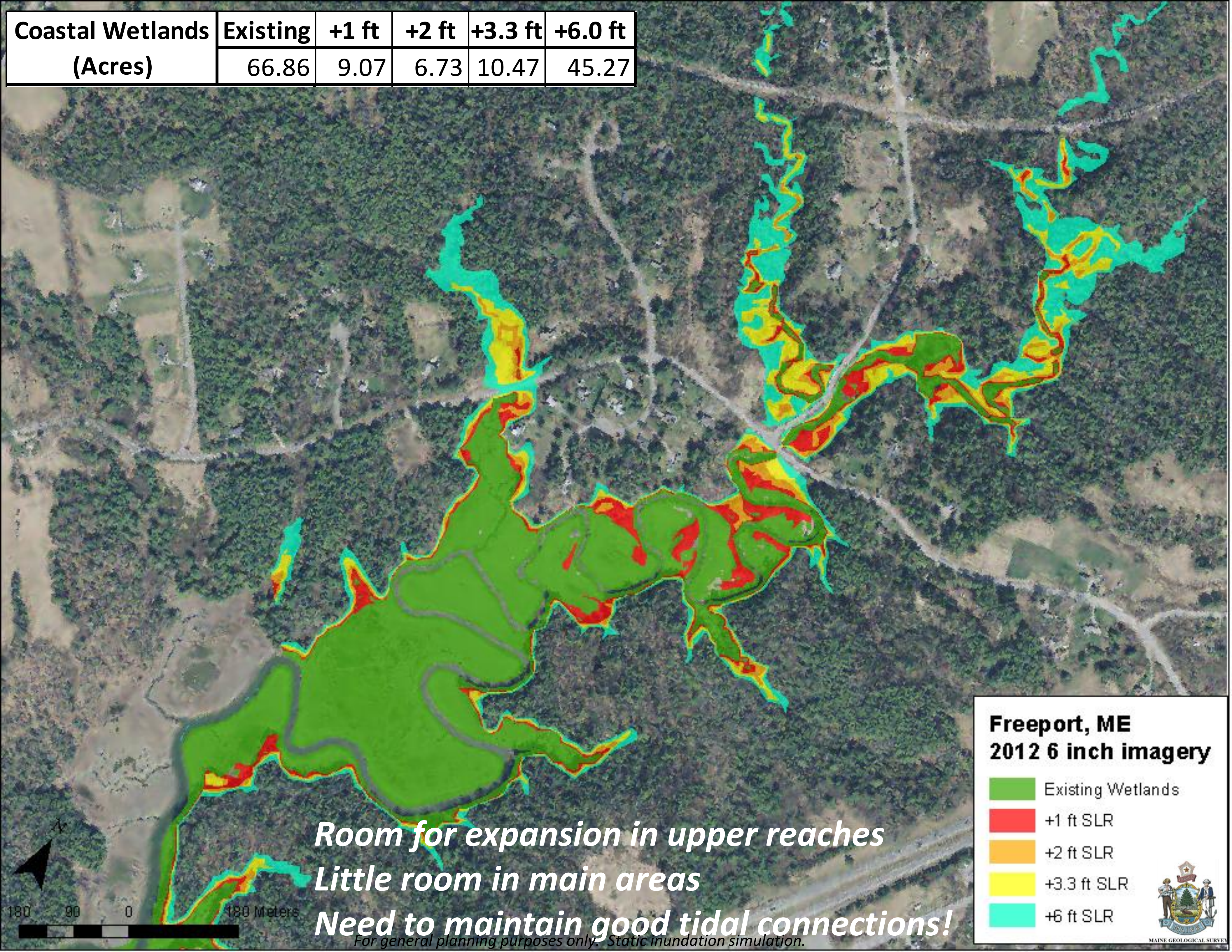
Coastal Wetlands (Acres)	Existing	+1 ft	+2 ft
	66.86	9.07	6.73

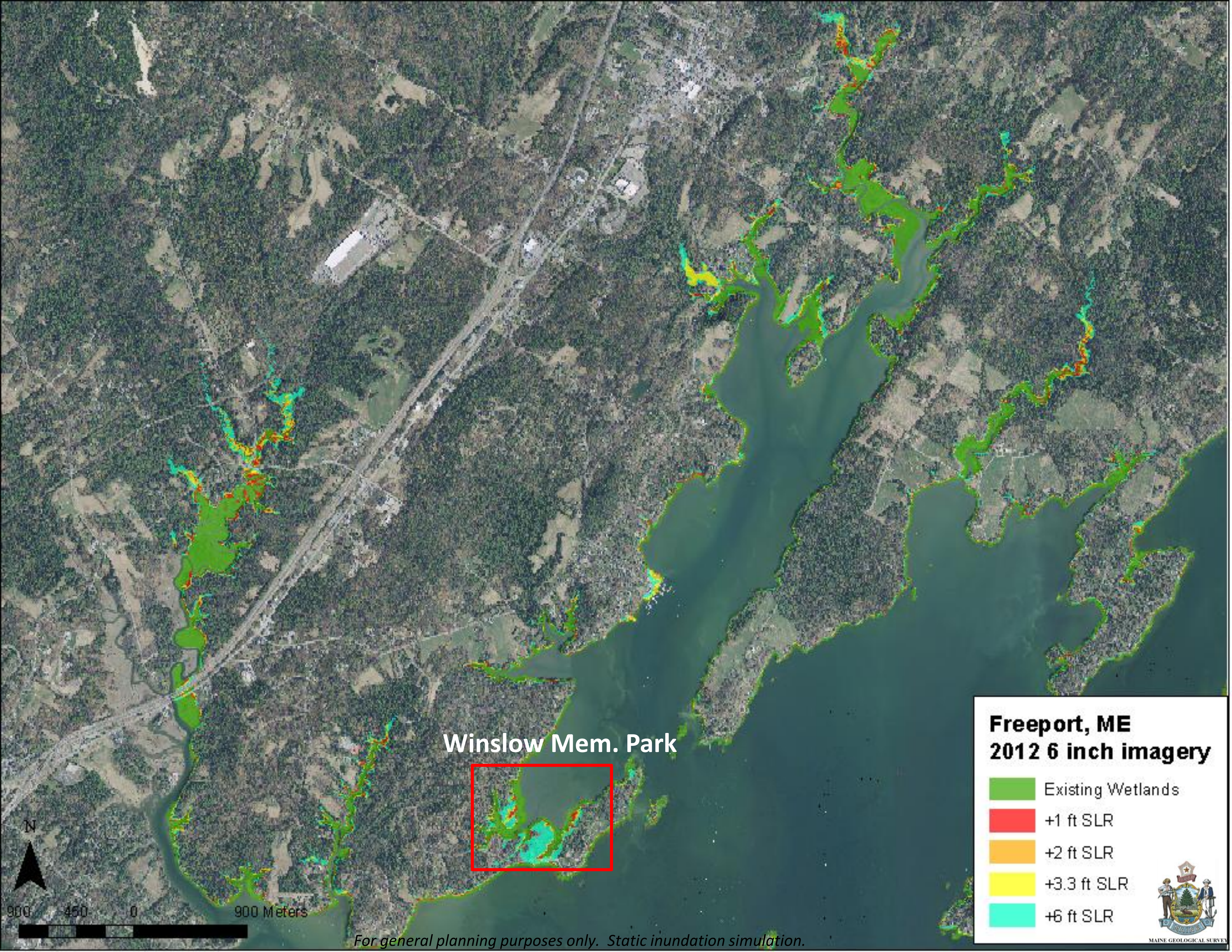


Coastal Wetlands (Acres)	Existing	+1 ft	+2 ft	+3.3 ft
	66.86	9.07	6.73	10.47



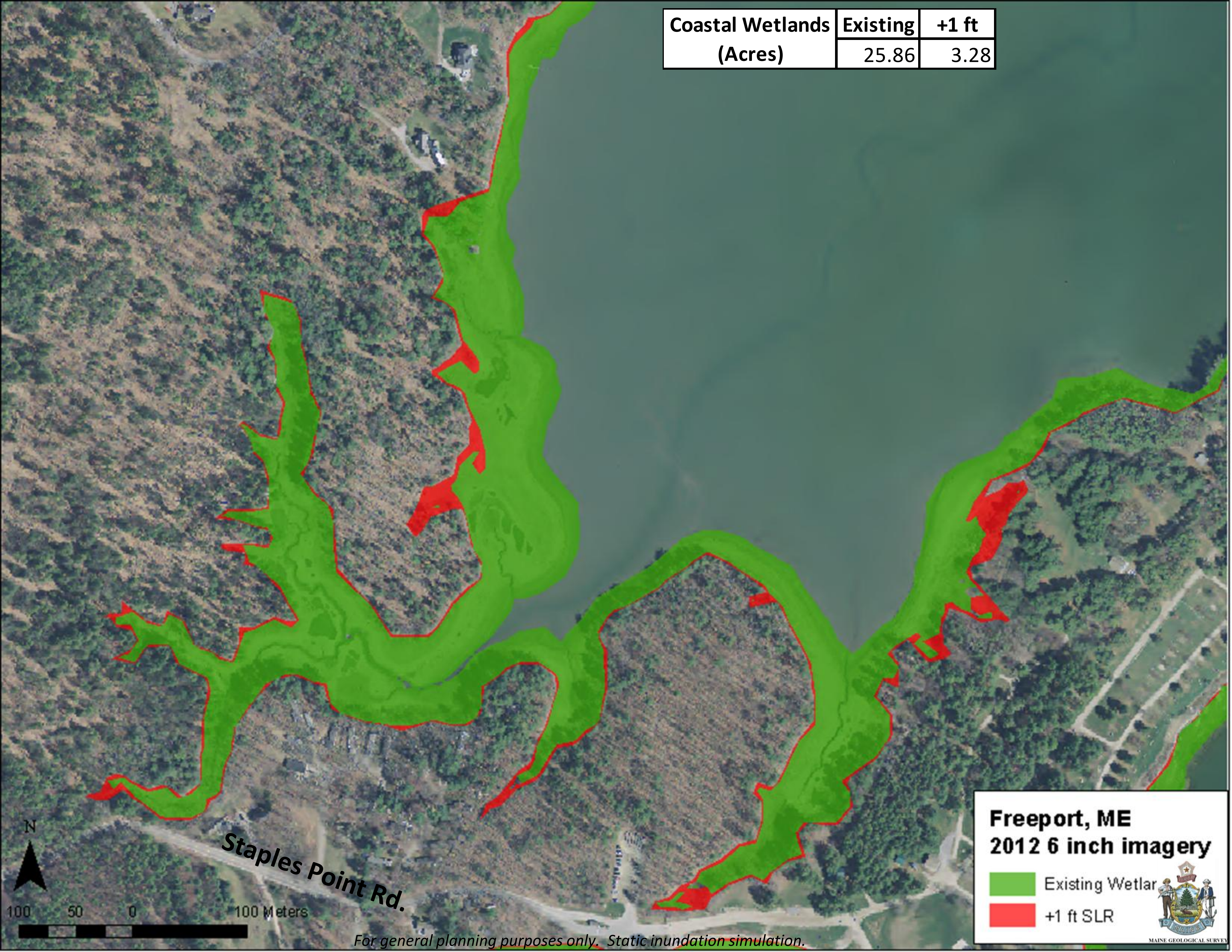
Coastal Wetlands (Acres)	Existing	+1 ft	+2 ft	+3.3 ft	+6.0 ft
	66.86	9.07	6.73	10.47	45.27



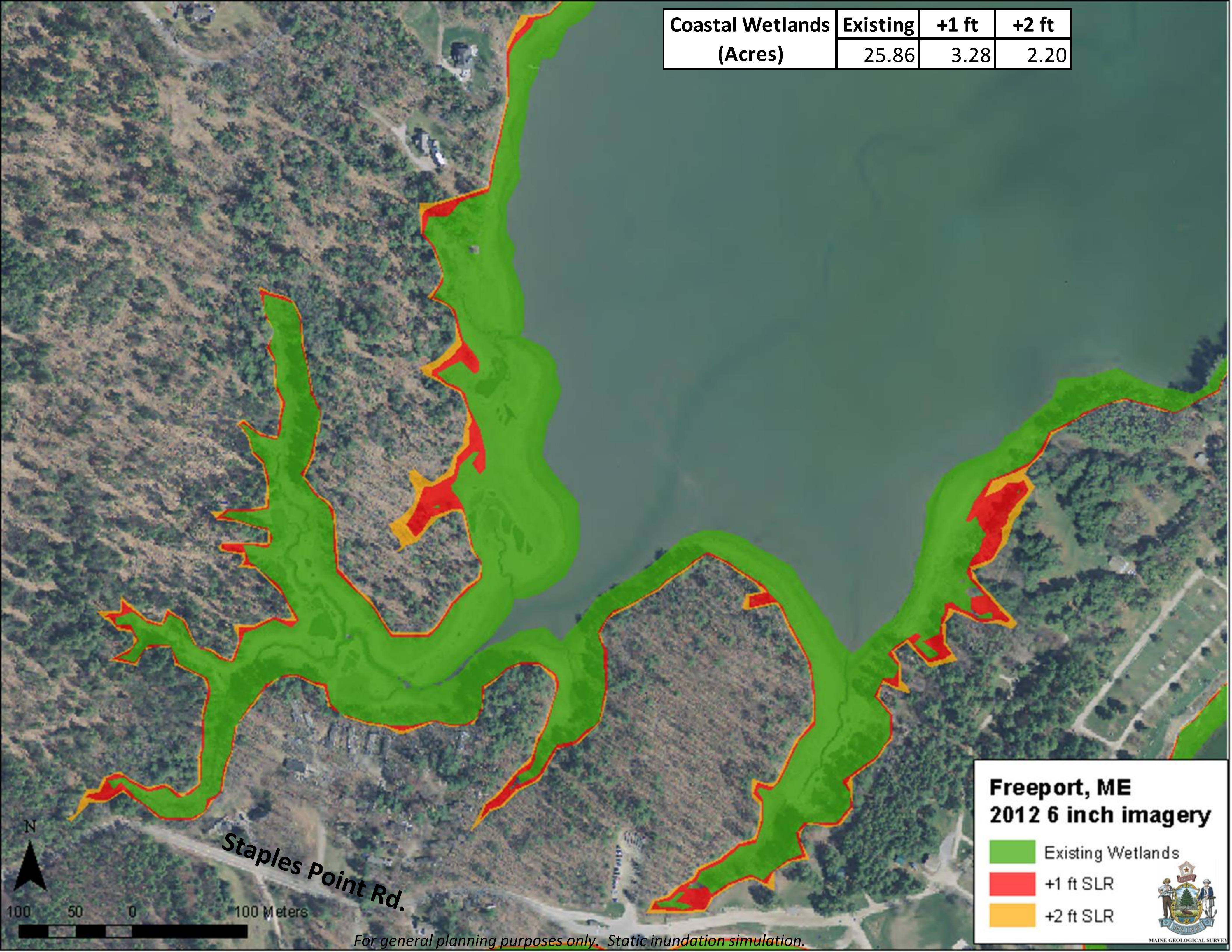

Winslow Mem. Park
Freeport, ME
2012 6 inch imagery
Existing Wetlands
+1 ft SLR
+2 ft SLR
+3.3 ft SLR
+6 ft SLR
N
900 450 0 900 Meters
MAINE GEOLOGICAL SURVEY
For general planning purposes only. Static inundation simulation.


Fringing wetland
Coastal wetland
Staples Point Rd.
N
100 50 0 100 Meters
For general planning purposes only. Static inundation simulation.
Freeport, ME
2012 6 inch imagery

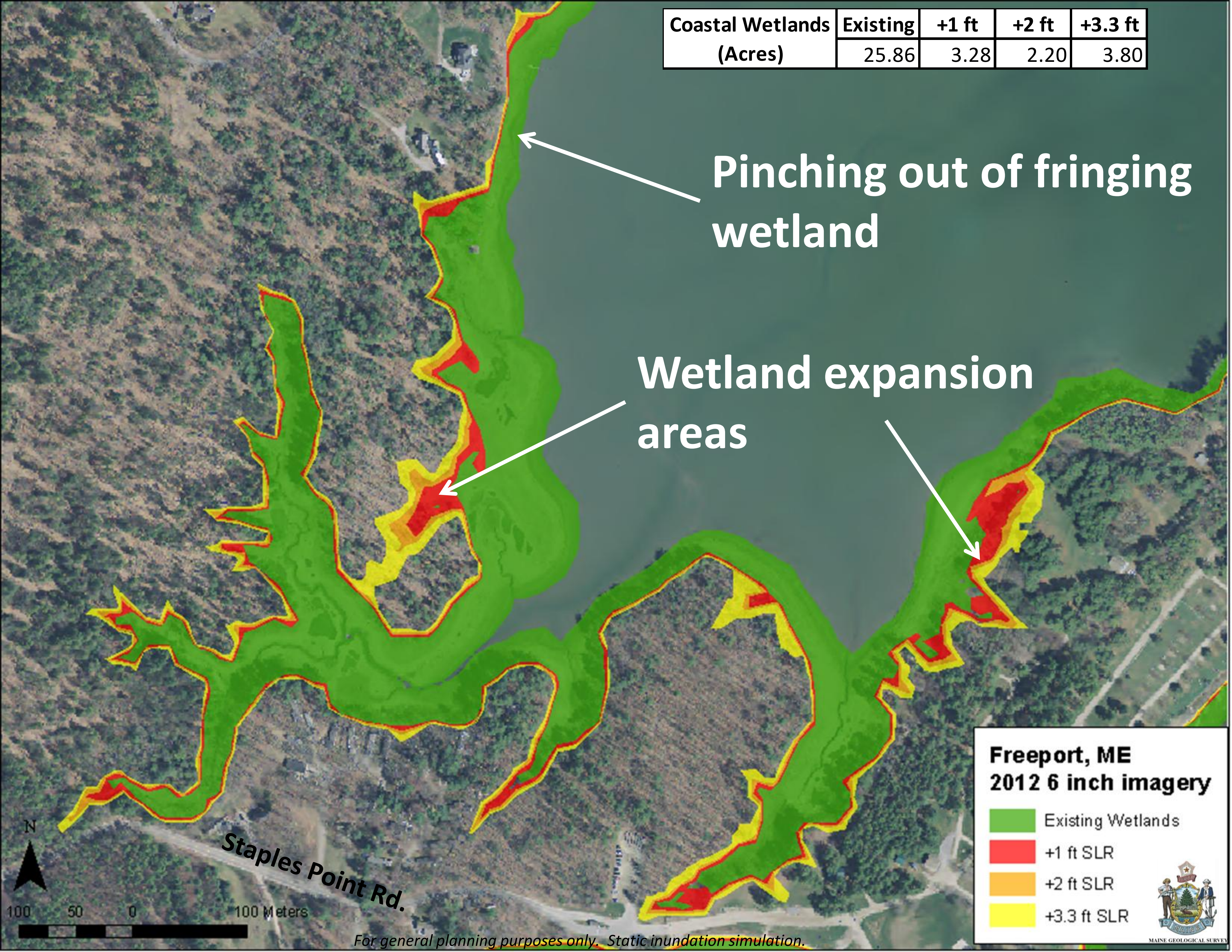
Coastal Wetlands (Acres)
Existing
25.86
Fringing wetland
Coastal wetland
Staples Point Rd.
N
100 50 0 100 Meters
Freeport, ME
2012 6 inch imagery
Existing Wetlands
For general planning purposes only. Static inundation simulation.



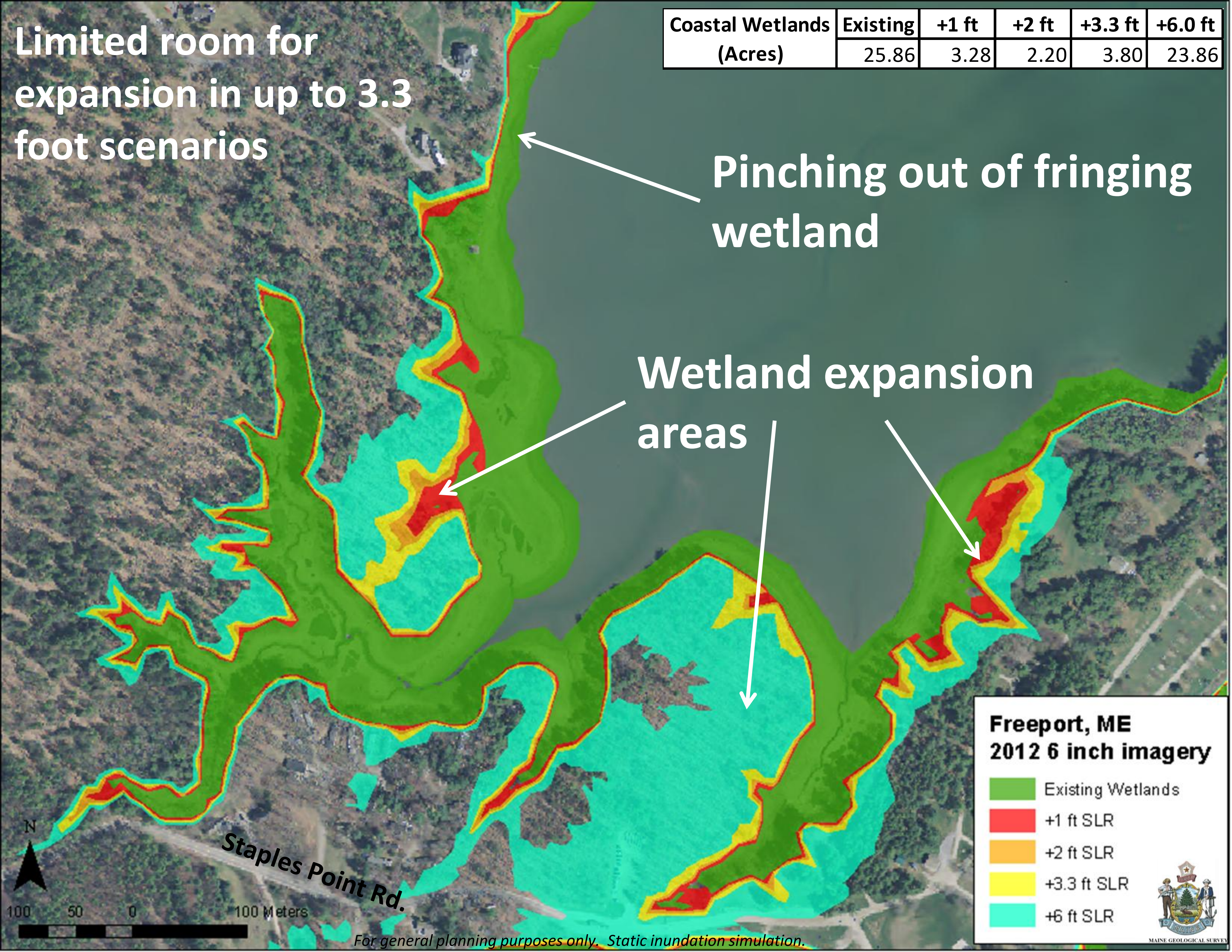
Coastal Wetlands (Acres)
Existing
+1 ft
25.86
3.28
Staples Point Rd.
N
100
50
0
100 Meters
Freeport, ME
2012 6 inch imagery
Existing Wetlar
+1 ft SLR
MAINE GEOLOGICAL SURVEY
For general planning purposes only. Static inundation simulation.



Coastal Wetlands (Acres)	Existing	+1 ft	+2 ft
	25.86	3.28	2.20

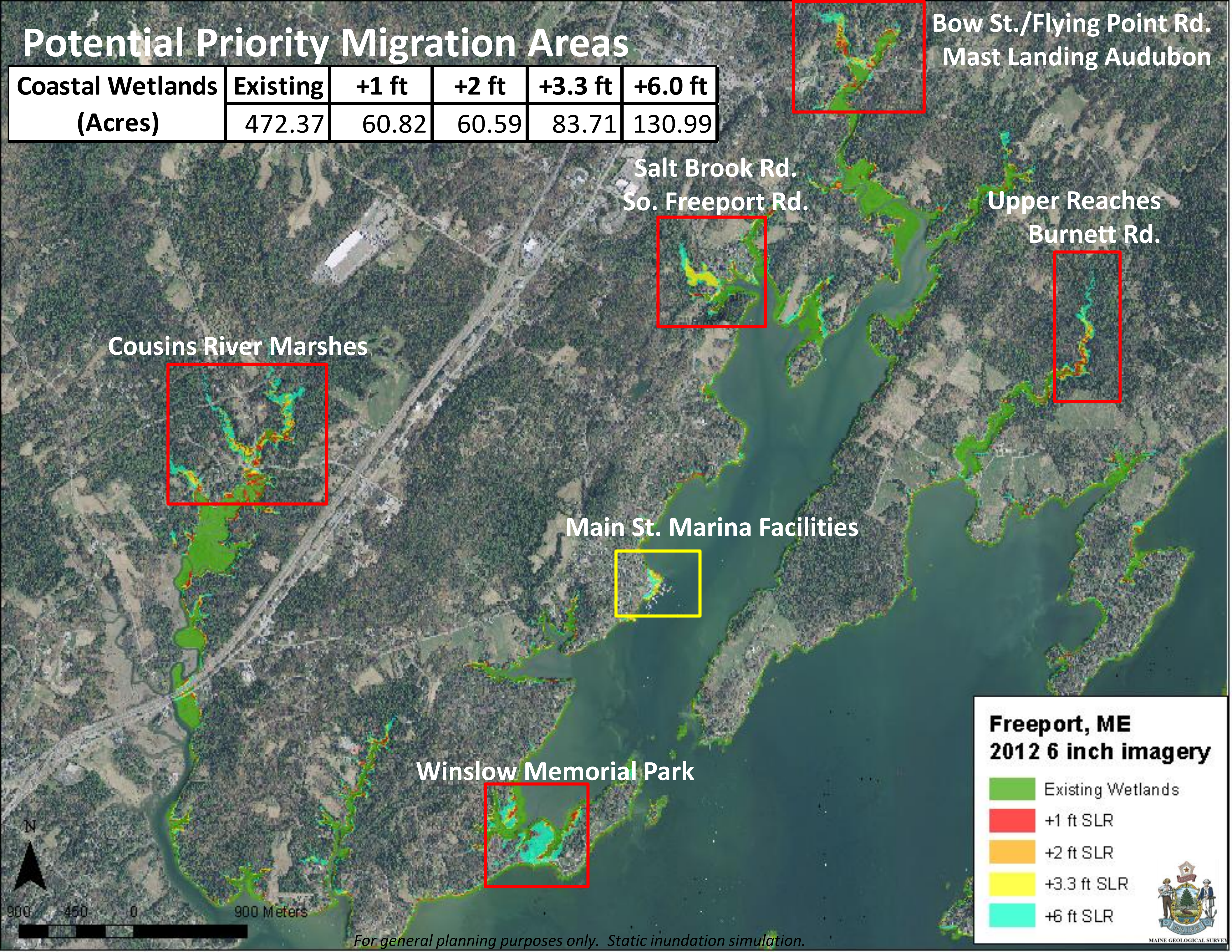


Coastal Wetlands (Acres)	Existing	+1 ft	+2 ft	+3.3 ft
	25.86	3.28	2.20	3.80


Limited room for expansion in up to 3.3 foot scenarios
Coastal Wetlands (Acres)	Existing	+1 ft	+2 ft	+3.3 ft	+6.0 ft
	25.86	3.28	2.20	3.80	23.86
Pinching out of fringing wetland
Wetland expansion areas
Freeport, ME
2012 6 inch imagery
Existing Wetlands
+1 ft SLR
+2 ft SLR
+3.3 ft SLR
+6 ft SLR
Staples Point Rd.
N
100 50 0 100 Meters
For general planning purposes only. Static inundation simulation.
MAINE GEOLOGICAL SURVEY

Potential Priority Migration Areas

Coastal Wetlands (Acres)	Existing	+1 ft	+2 ft	+3.3 ft	+6.0 ft
	472.37	60.82	60.59	83.71	130.99



Conclusions on Coastal Wetlands

In the whole town, approximately 335 acres of upland (under the 6 foot scenario) are *available for potential conversion* to marsh, with 5 identified “priority areas” for potential management.

Many of the existing larger expanses of marsh are currently near capacity, and simulations show limited areas of expansion except for upper reaches. Certain areas (e.g., Cousins River, Upper reaches Harraseeket River) have areas of fringing uplands with elevations that may allow conversion to coastal wetlands over time. *Identification of these uplands for management, and maintenance/enhancement of tidal connections to upper reaches is key to allowing natural marsh migration.*

Simulations demonstrate that *many narrow, fringing marsh areas may be lost (converted to open water)* due to adjacent steeper sloped uplands.

Estimates do not account for erosion or sedimentation and assume static topography.

MAINE GEOLOGICAL SURVEY

Conditions Simulated – Infrastructure Vulnerability Assessment

Highest Annual Tide (HAT) is the highest predicted water level due to tides for any given year but is reached within several inches numerous tides a year.

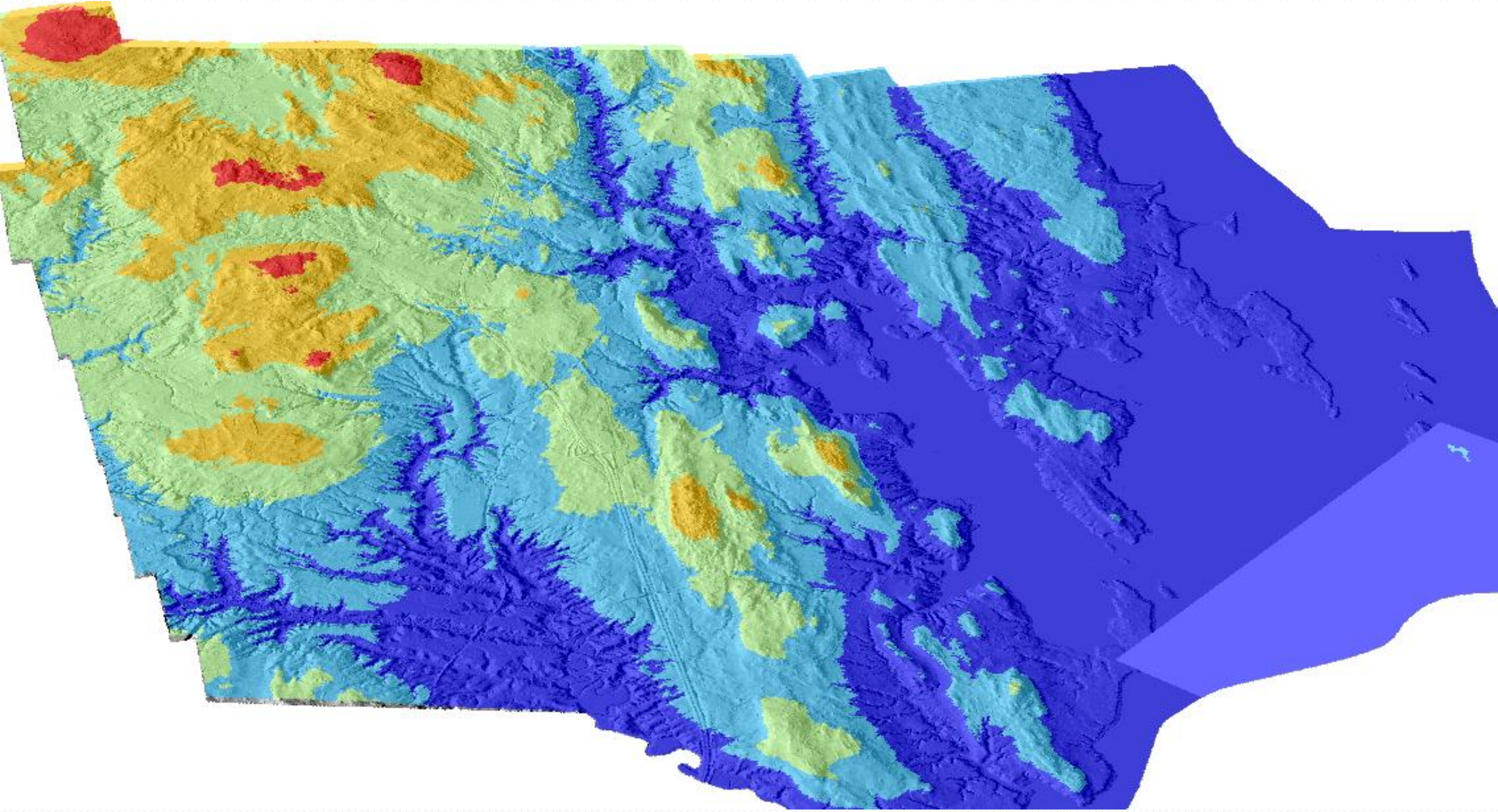
1% stillwater level is the "100 year" storm water level, taken from the Freeport's effective FEMA Flood Insurance Study (FIS). This was the February 7, 1978 Noreaster' Storm.

Category 1, high MOM is the expected "Maximum of Maximums" water level from a land-falling Category 1 hurricane at mean high tide from NWS SLOSH Model.

Water Level	Elevation (ft, MLLW)				
	Existing	+1 ft	+2 ft	+3.3 ft	+6 ft
Highest Annual Tide	11.8	12.8	13.8	15.1	17.8
1% stillwater level	14.2	15.2	16.2	17.5	20.2
Category 1, high MOM	17.6	18.6	19.6	20.9	23.6

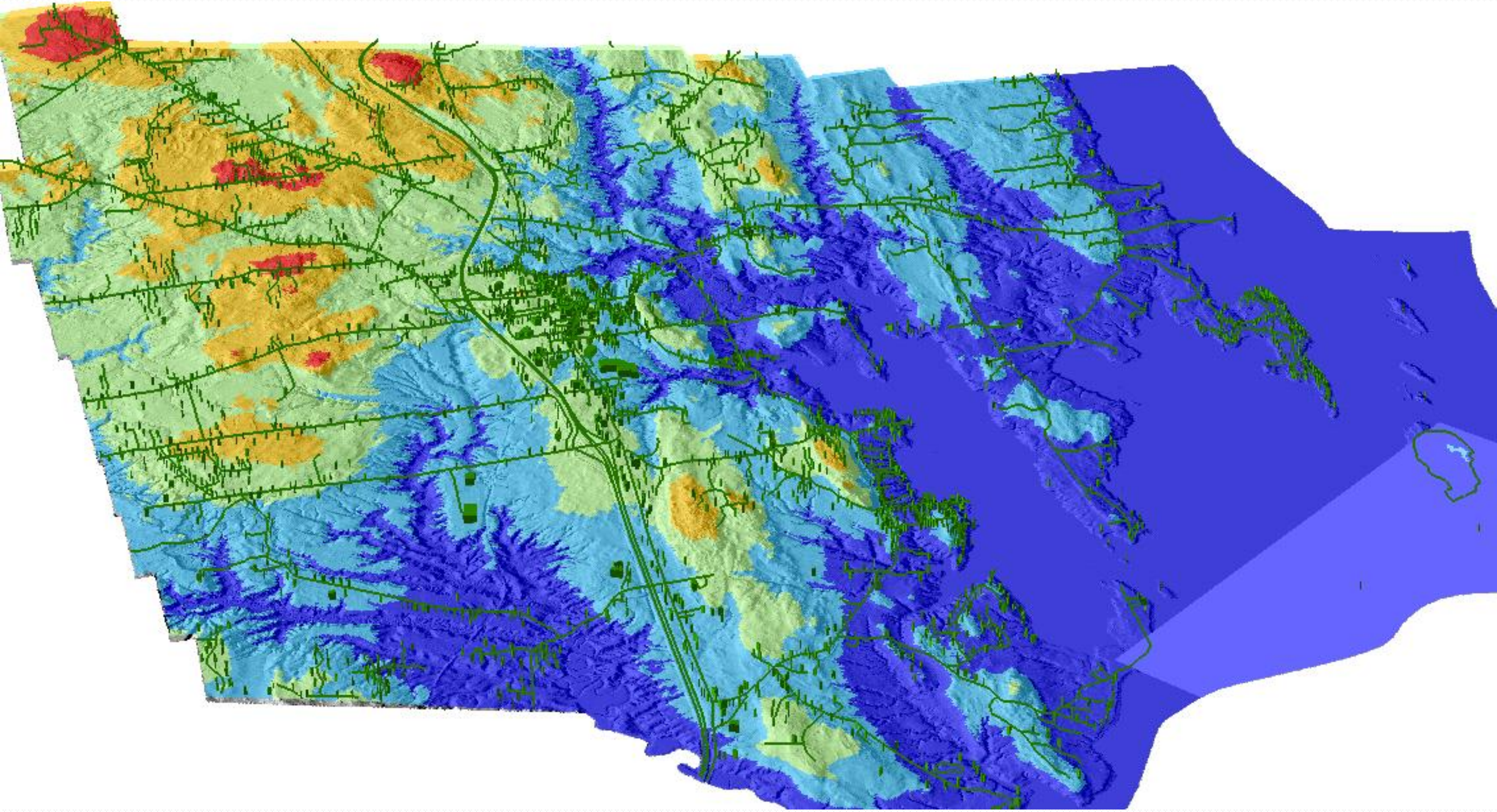
For each scenario, *projected sea level rise was added to each tidal elevation for simulation of potential impacts* to buildings, and transportation infrastructure.

Base 2006 “Bare Earth” LiDAR
2x hillshade

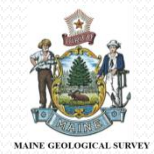


Mosaic and clip to municipal boundaries

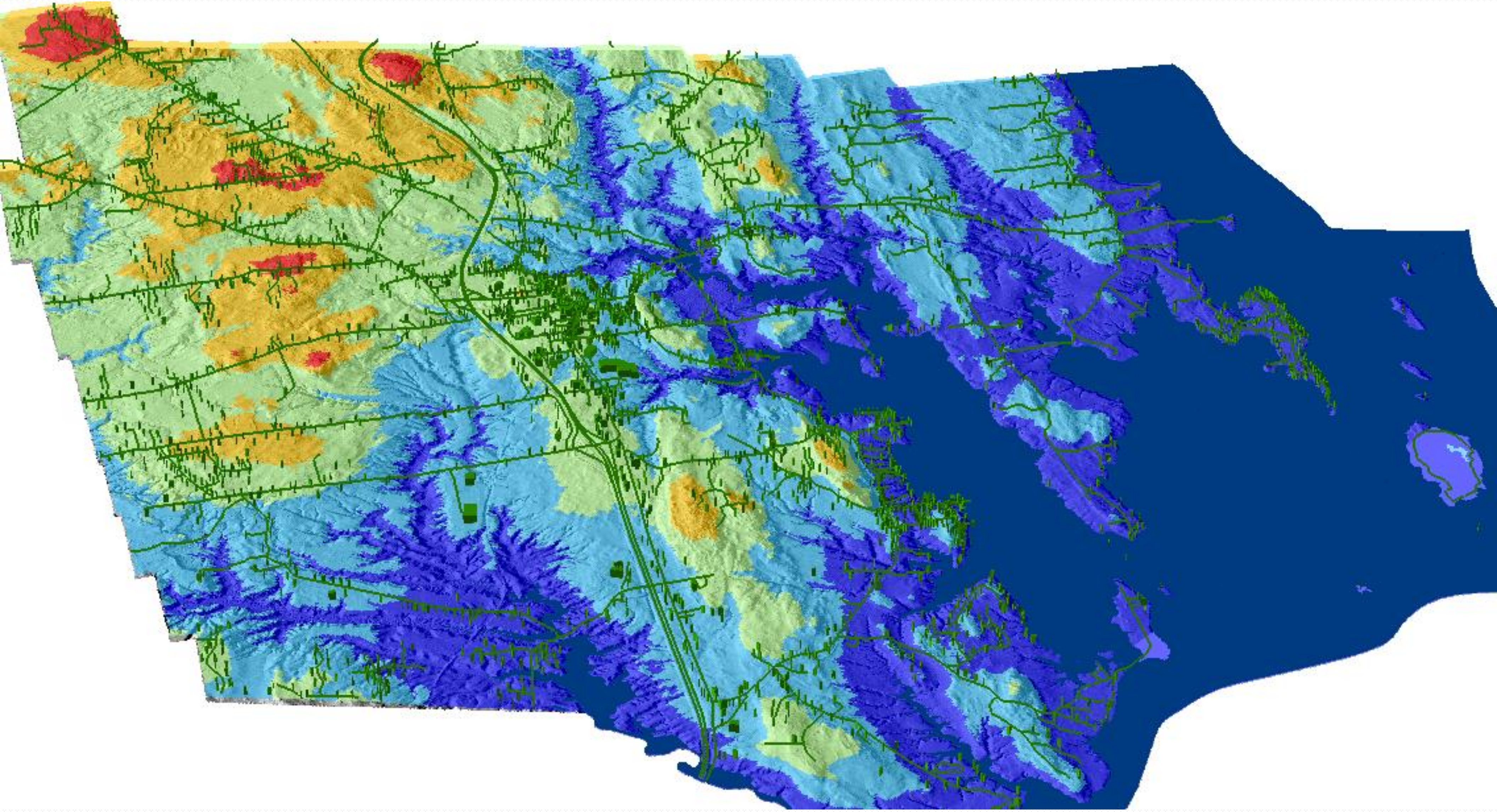
Buildings and Transportation Infrastructure (overlain onto Base LiDAR)



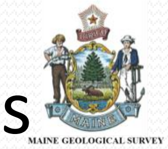
Polygon layers for parcels and buildings (municipal)
Polyline layers for roads and rail lines (State)



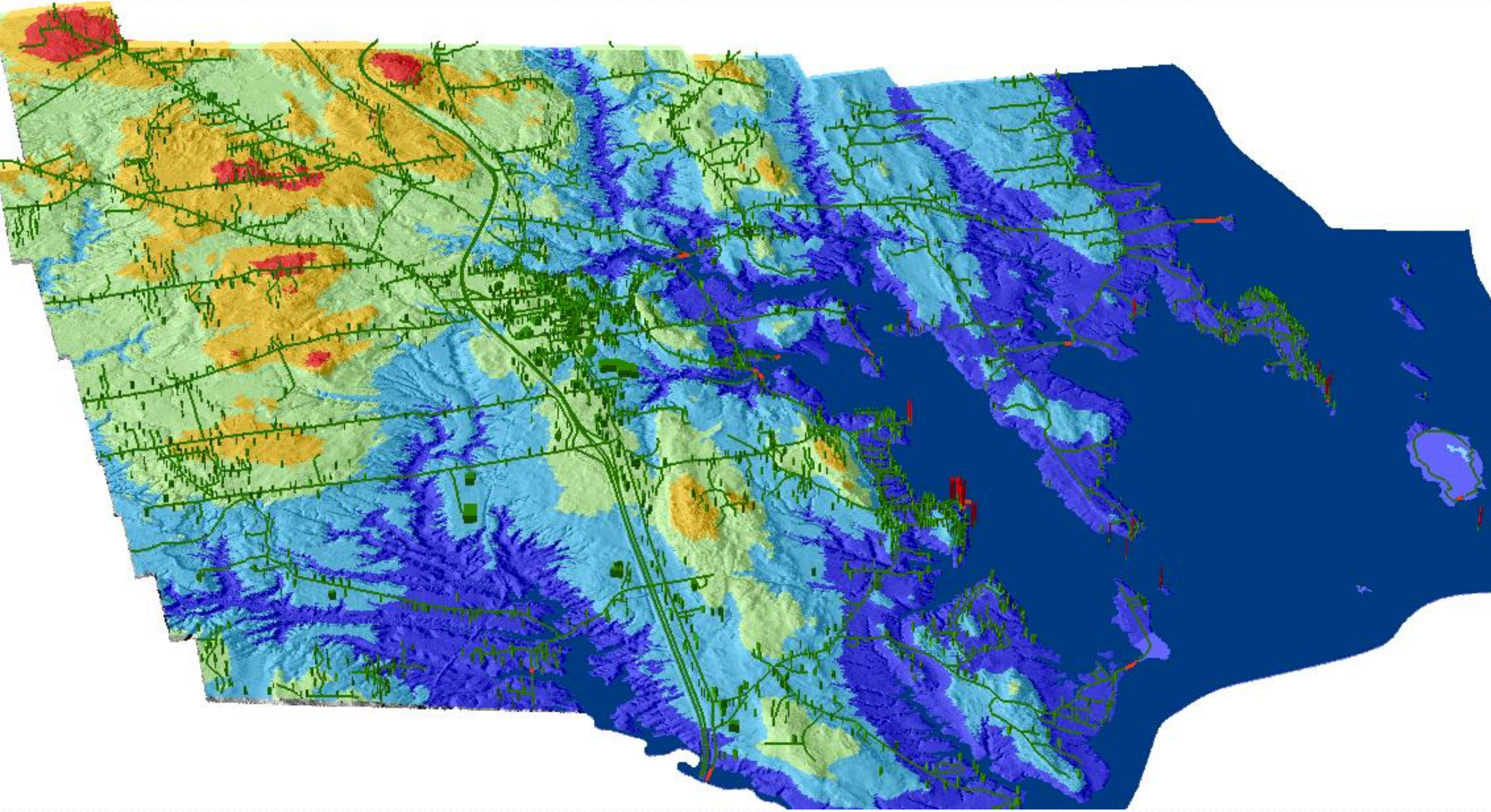
Simulate Inundation Levels



Determine future inundation levels under different scenarios



Identify Inundated Infrastructure



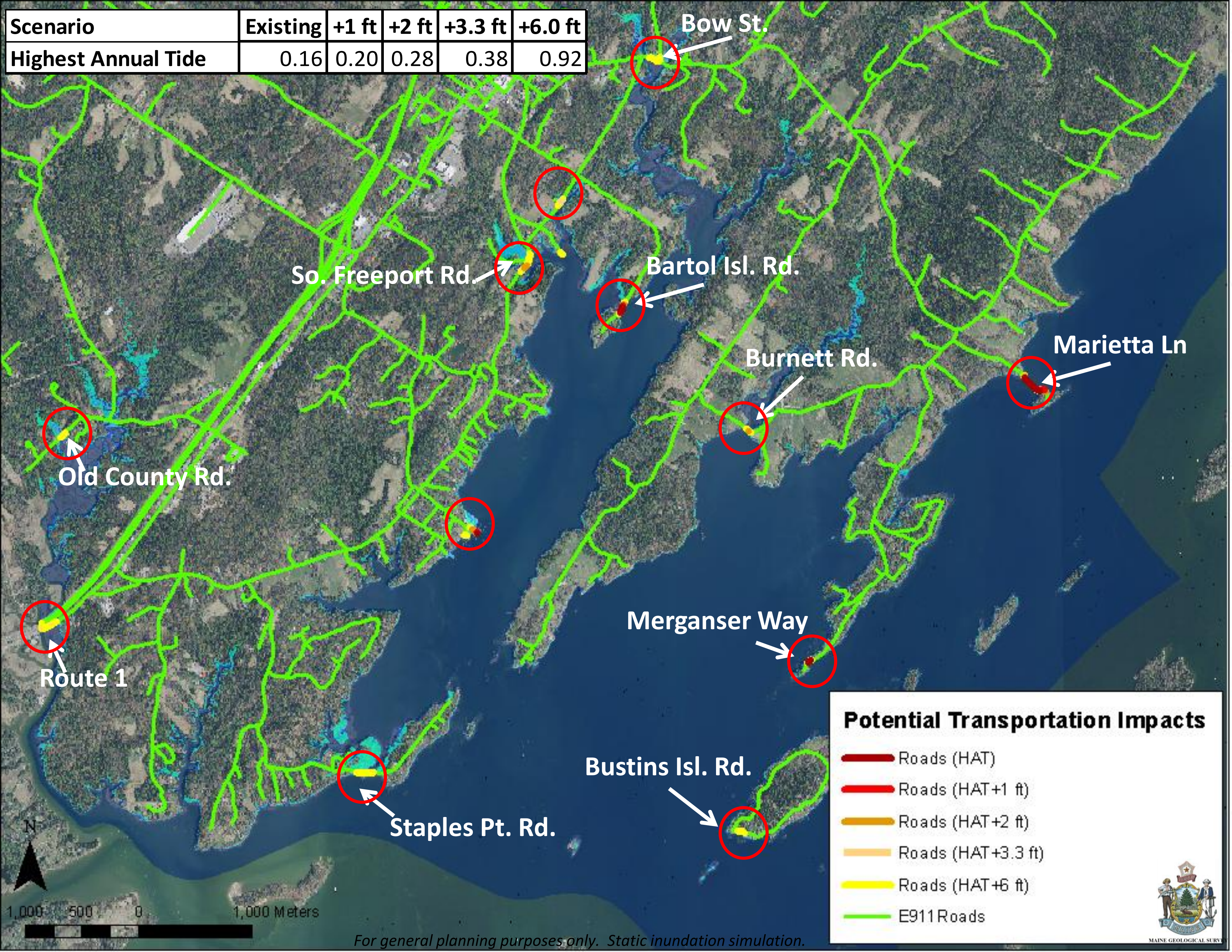
Determine inundation impacts to buildings/infrastructure

MAINE GEOLOGICAL SURVEY

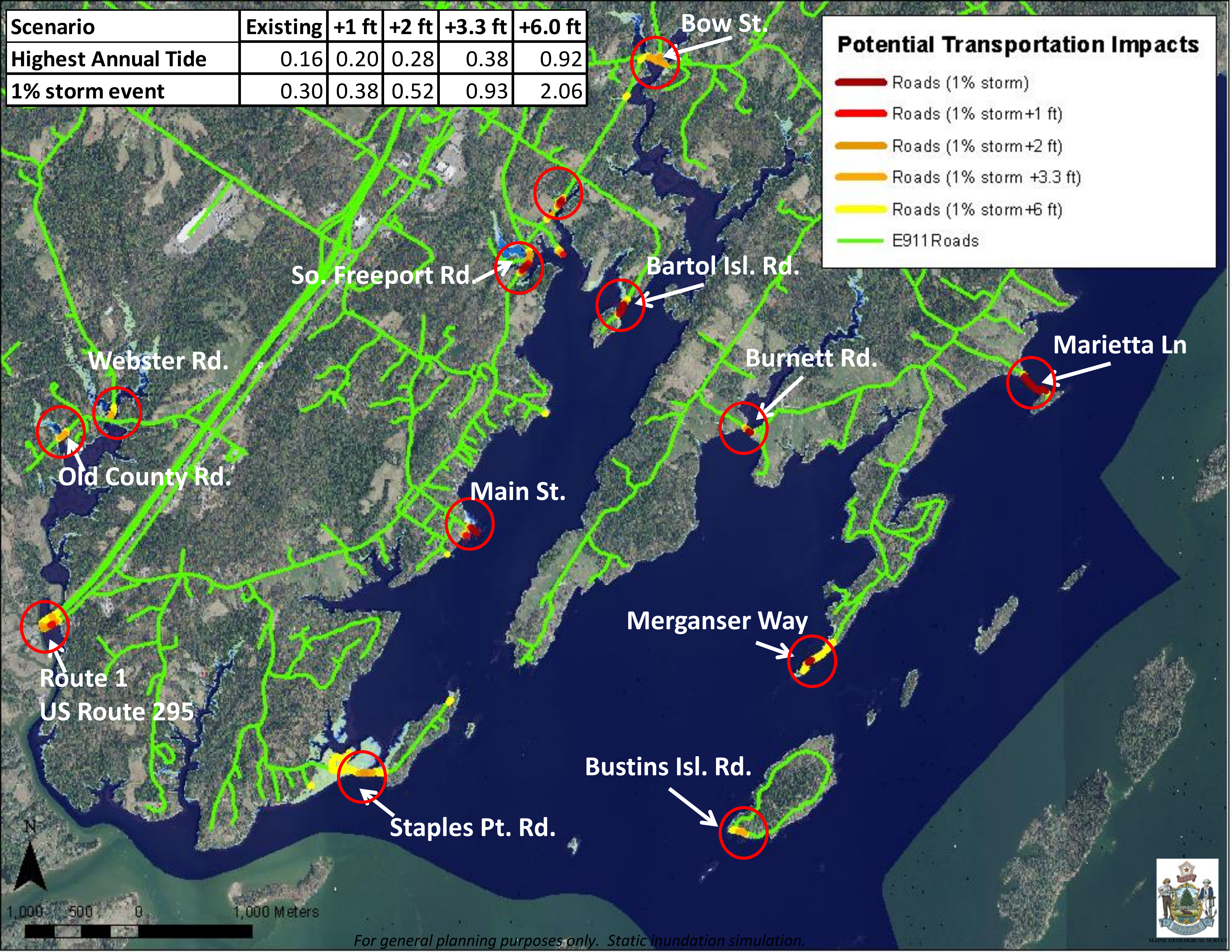
Potential Impacts to Transportation Infrastructure

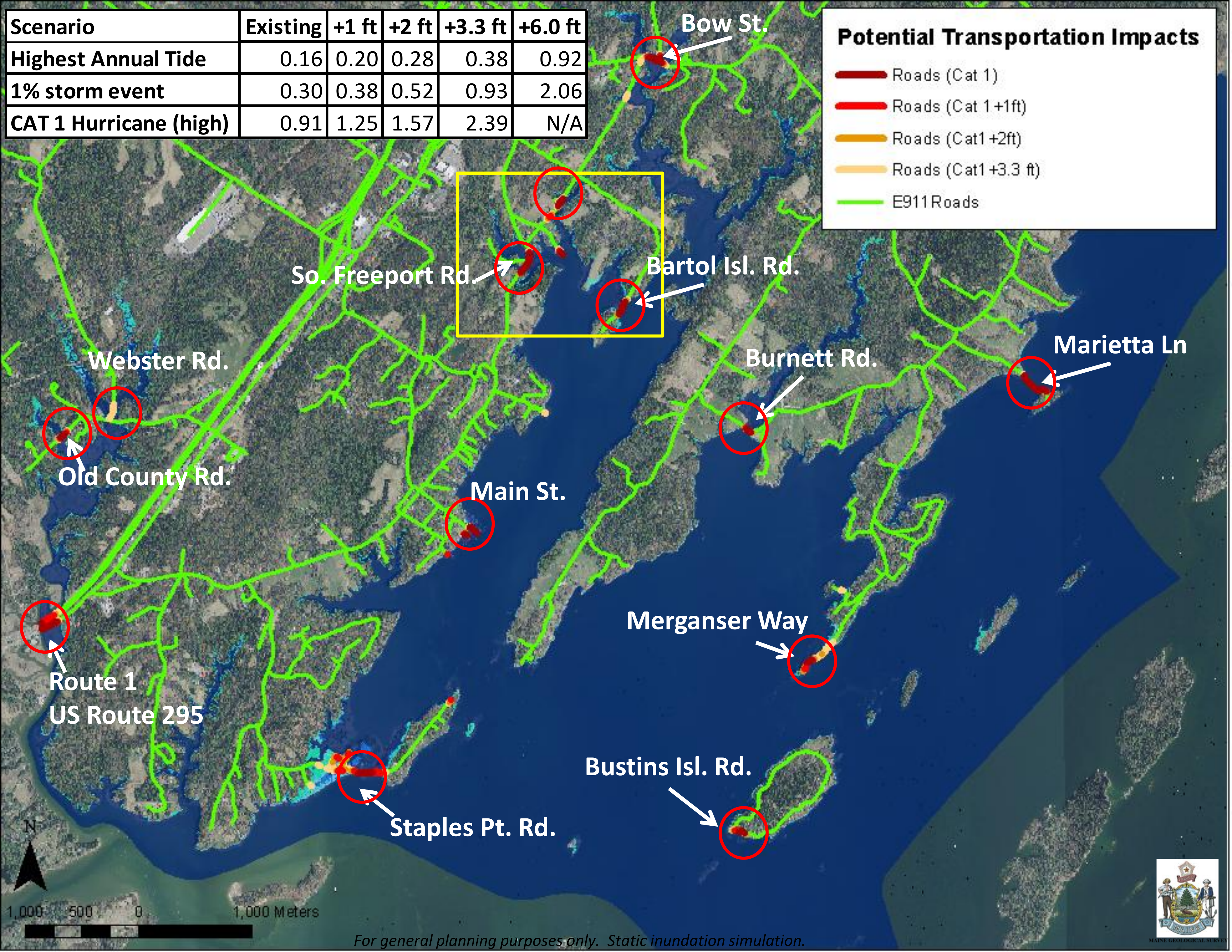
Assumption: road is "impacted" if inundated with any water

Scenario	Existing	+1 ft	+2 ft	+3.3 ft	+6.0 ft
Highest Annual Tide	0.16	0.20	0.28	0.38	0.92

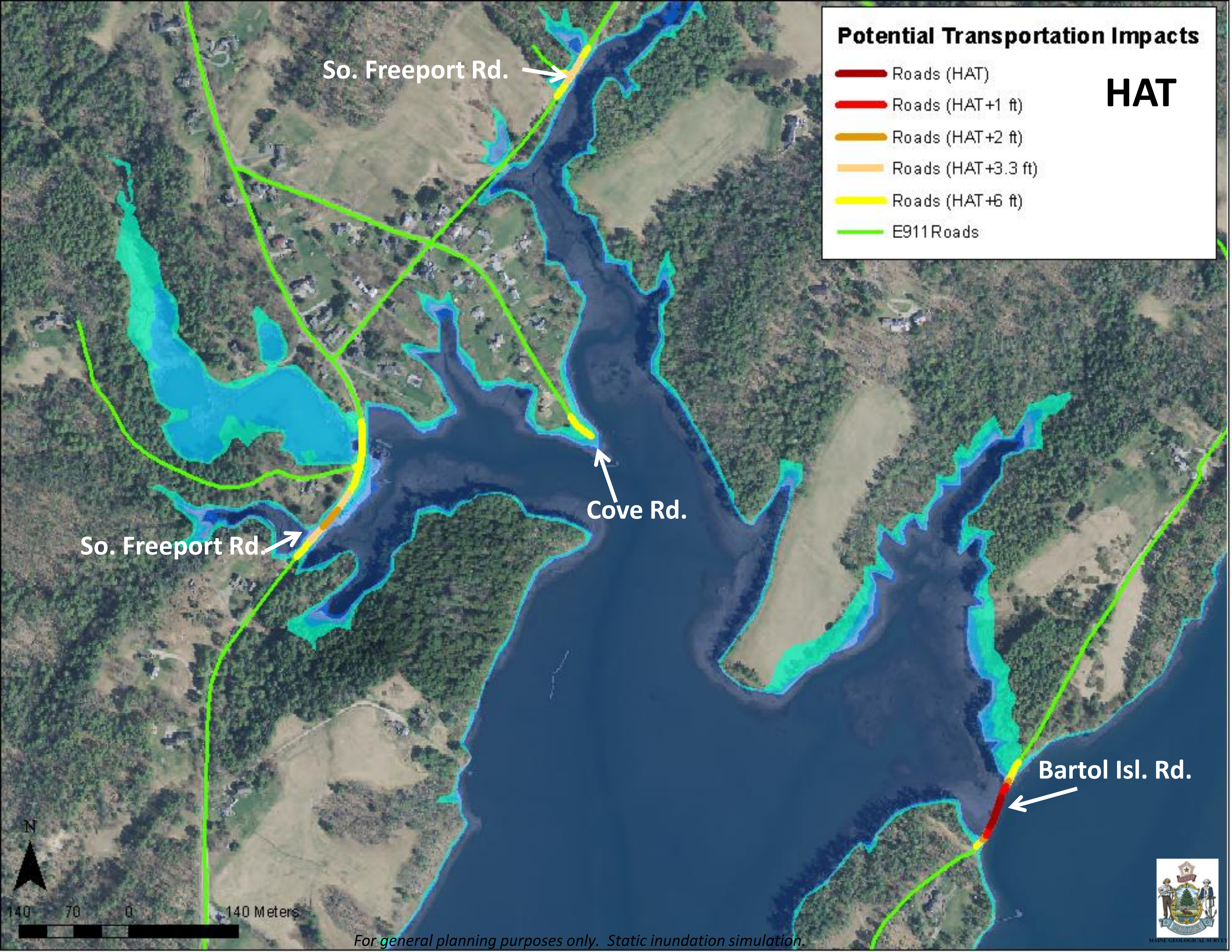


Scenario	Existing	+1 ft	+2 ft	+3.3 ft	+6.0 ft
Highest Annual Tide	0.16	0.20	0.28	0.38	0.92
1% storm event	0.30	0.38	0.52	0.93	2.06

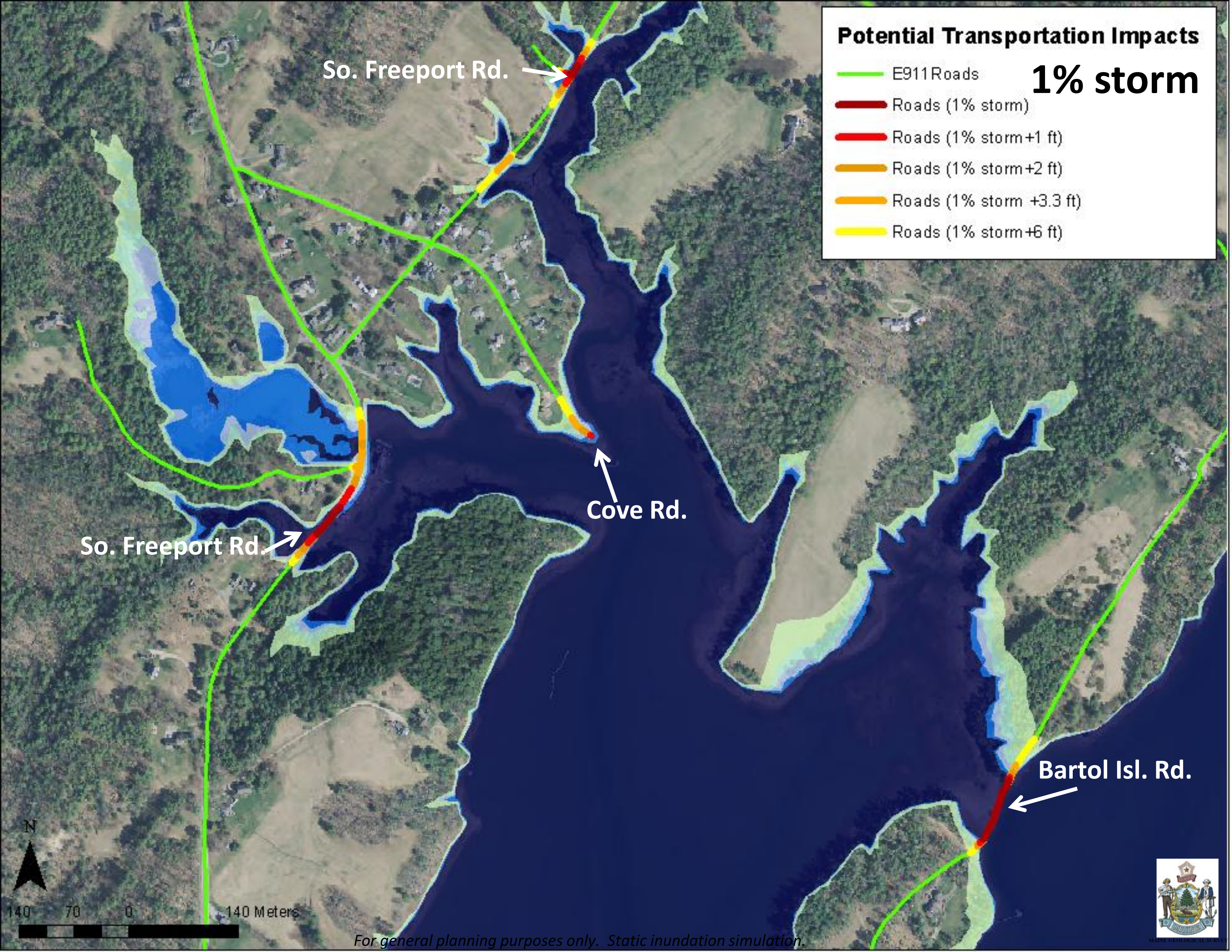


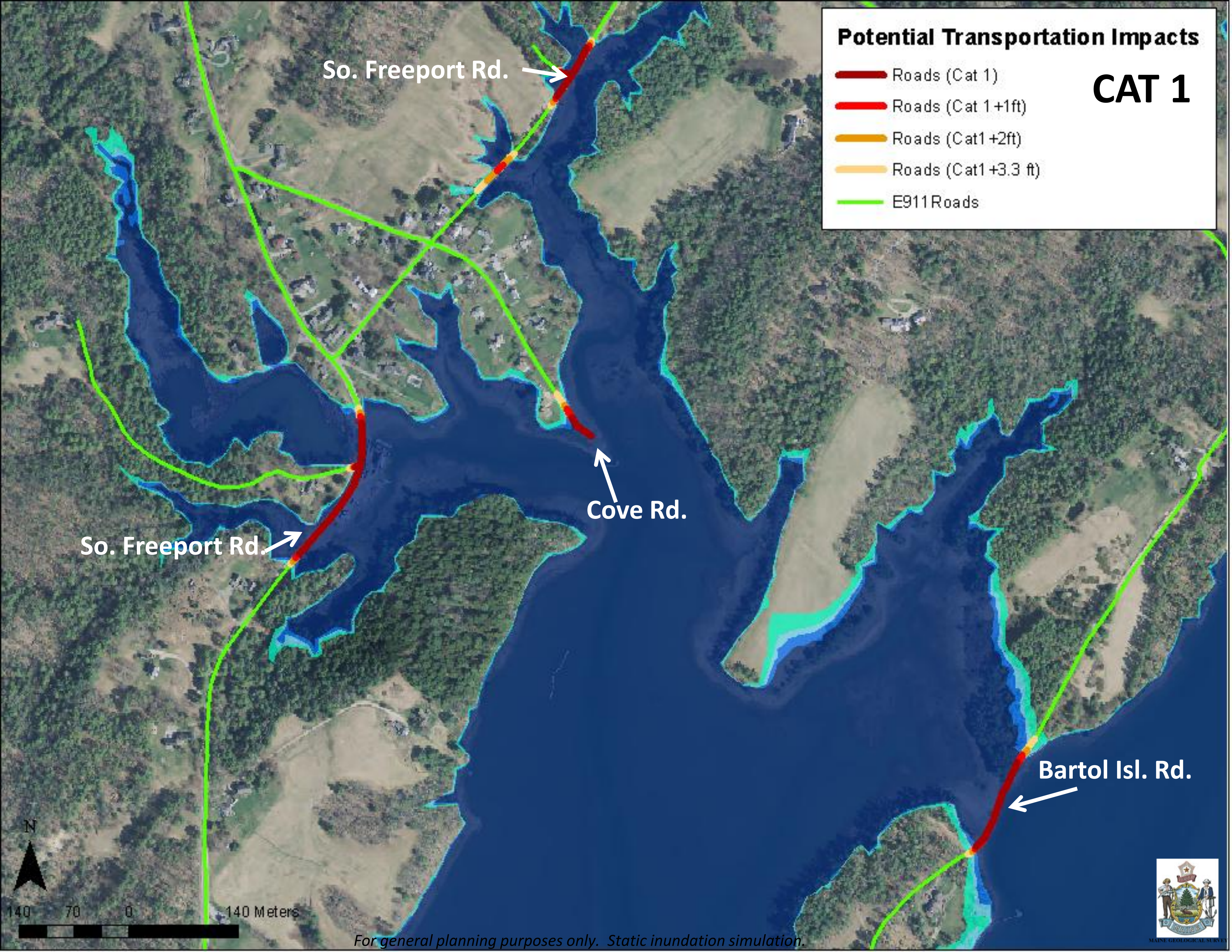


Scenario	Existing	+1 ft	+2 ft	+3.3 ft	+6.0 ft
Highest Annual Tide	0.16	0.20	0.28	0.38	0.92
1% storm event	0.30	0.38	0.52	0.93	2.06
CAT 1 Hurricane (high)	0.91	1.25	1.57	2.39	N/A

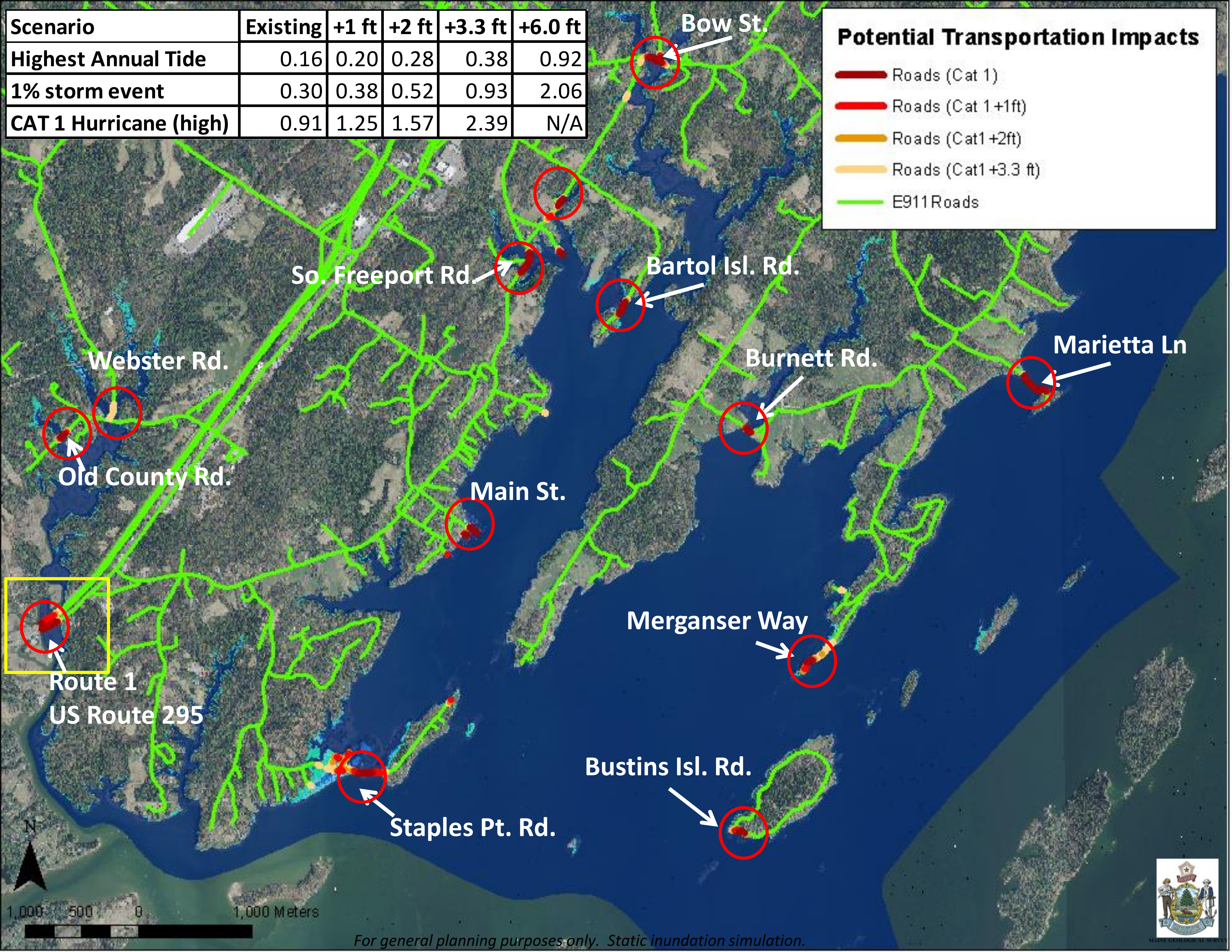


Potential Transportation Impacts
Roads (HAT)
Roads (HAT+1 ft)
Roads (HAT+2 ft)
Roads (HAT+3.3 ft)
Roads (HAT+6 ft)
E911 Roads
HAT
So. Freeport Rd.
So. Freeport Rd.
Cove Rd.
Bartol Isl. Rd.
N
140 70 0 140 Meters
For general planning purposes only. Static inundation simulation.

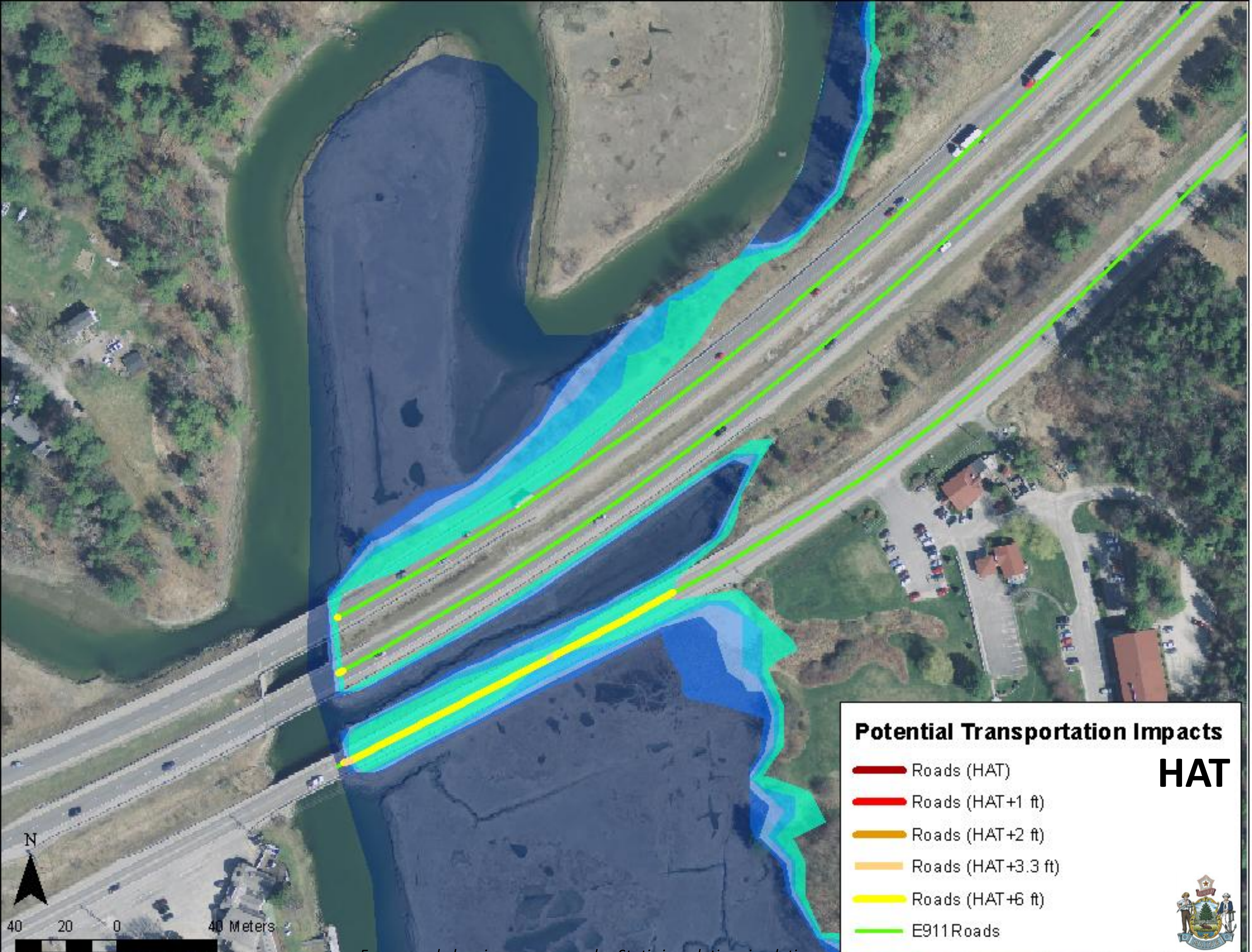

Potential Transportation Impacts
1% storm
E911Roads
Roads (1% storm)
Roads (1% storm+1 ft)
Roads (1% storm+2 ft)
Roads (1% storm +3.3 ft)
Roads (1% storm+6 ft)
So. Freeport Rd.
So. Freeport Rd.
Cove Rd.
Bartol Isl. Rd.
N
140 70 0 140 Meters
For general planning purposes only. Static inundation simulation.


Potential Transportation Impacts
Roads (Cat 1)
Roads (Cat 1 +1ft)
Roads (Cat1 +2ft)
Roads (Cat1 +3.3 ft)
E911 Roads
CAT 1
So. Freeport Rd.
So. Freeport Rd.
Cove Rd.
Bartol Isl. Rd.
N
140 70 0 140 Meters
For general planning purposes only. Static inundation simulation.

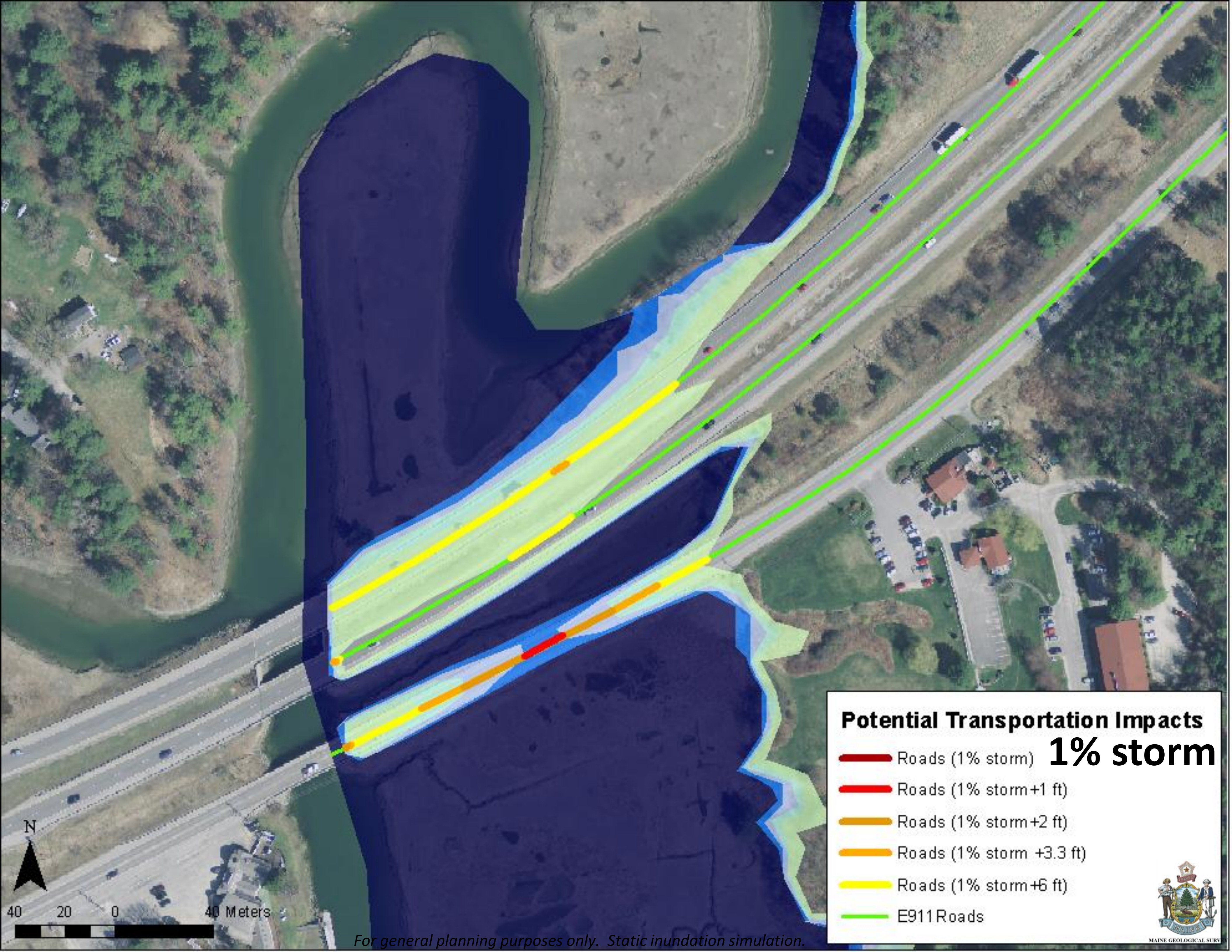
Scenario	Existing	+1 ft	+2 ft	+3.3 ft	+6.0 ft
Highest Annual Tide	0.16	0.20	0.28	0.38	0.92
1% storm event	0.30	0.38	0.52	0.93	2.06
CAT 1 Hurricane (high)	0.91	1.25	1.57	2.39	N/A

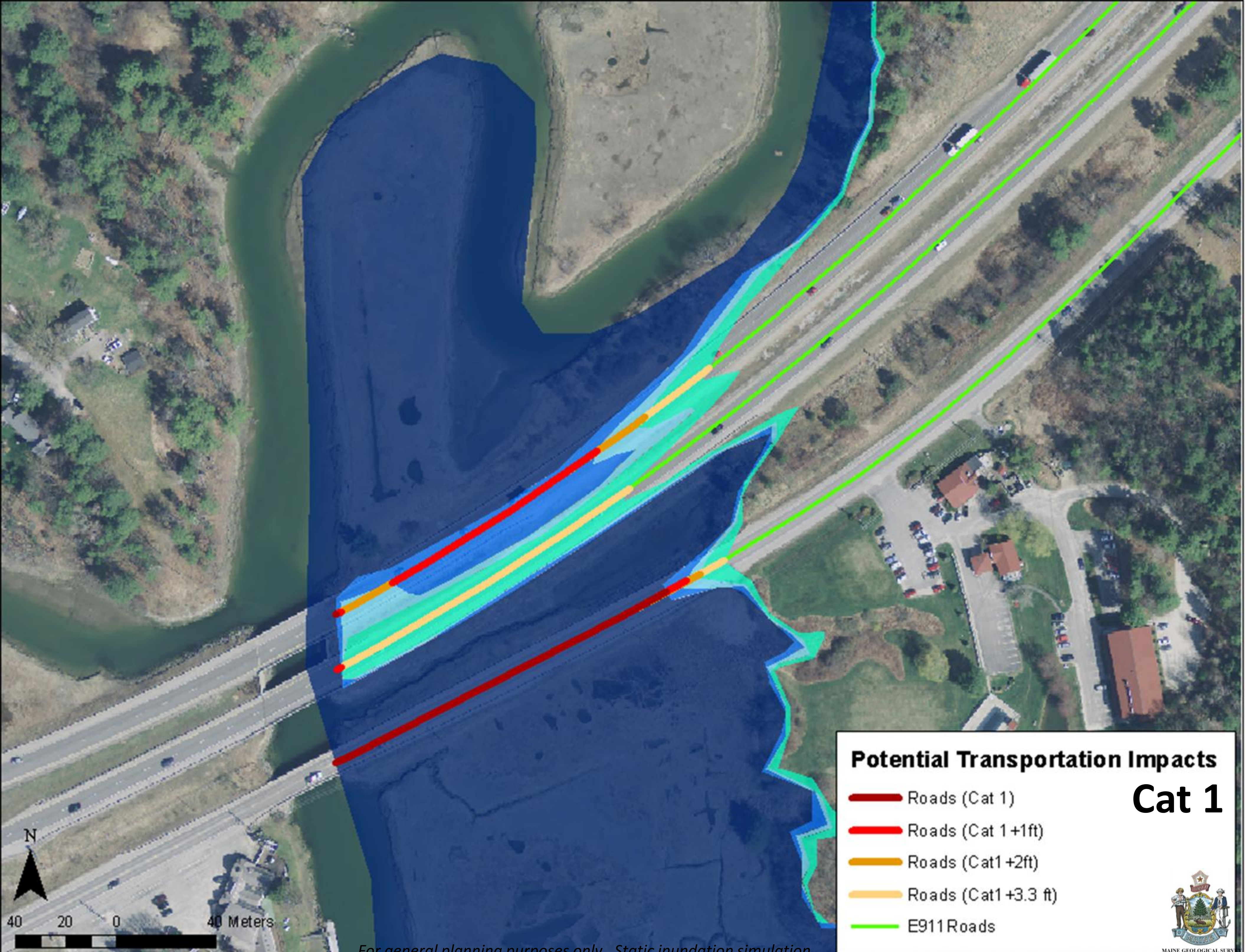


For general planning purposes only. Static inundation simulation.



For general planning purposes only. Static inundation simulation.


Potential Transportation Impacts
1% storm
Roads (1% storm)
Roads (1% storm+1 ft)
Roads (1% storm+2 ft)
Roads (1% storm +3.3 ft)
Roads (1% storm+6 ft)
E911Roads
N
40 20 0 40 Meters
For general planning purposes only. Static inundation simulation.



For general planning purposes only. Static inundation simulation.

Summary of Road Vulnerability and Potential Action

Road Name	Highest Annual Tide					When Act?	1% storm					When Act?	Cat 1 Hurricane				When Act?
	Exist	+1ft	+2ft	+3.3ft	+6ft		Exist	+1ft	+2ft	+3.3ft	+6ft		Exist	+1ft	+2ft	+3.3ft	
Bartol Isl. Rd.	Red	Red	Red	Red	Red	Now	Red	Red	Red	Red	Red	Now	Red	Red	Red	Red	Now
Marietta Way	Red	Red	Red	Red	Red	Now	Red	Red	Red	Red	Red	Now	Red	Red	Red	Red	Now
Merganser Ln.	Red	Red	Red	Red	Red	Now	Red	Red	Red	Red	Red	Now	Red	Red	Red	Red	Now
Main St. (end)	Green	Yellow	Red	Red	Red	Now	Red	Red	Red	Red	Red	Now	Red	Red	Red	Red	Now
Burnett Rd.	Green	Green	Green	Yellow	Red	>2050	Yellow	Yellow	Red	Red	Red	Now	Red	Red	Red	Red	Now
Bow St./Upper Mast	Green	Green	Green	Green	Red	>2050	Green	Green	Yellow	Red	Red	<2050	Red	Red	Red	Red	Now
So. Freeport Rd.	Green	Green	Red	Red	Red	<2050	Red	Red	Red	Red	Red	Now	Red	Red	Red	Red	Now
Cove Rd.	Green	Green	Green	Green	Red	>2050	Green	Yellow	Red	Red	Red	<2050	Red	Red	Red	Red	Now
Old County Rd.	Green	Green	Green	Green	Red	>2050	Green	Green	Green	Red	Red	>2050	Red	Red	Red	Red	Now
Webster Rd.	Green	Green	Green	Green	Green	None	Green	Green	Green	Yellow	Red	>2050	Green	Green	Green	Red	>2050
US Route 295N	Green	Green	Green	Green	Green	None	Green	Green	Green	Green	Red	>2050	Green	Green	Red	Red	>2050
US Route 295S	Green	Green	Green	Green	Green	None	Green	Green	Green	Yellow	Red	>2050	Green	Red	Red	Red	<2050
US Route 1	Green	Green	Green	Yellow	Red	>2050	Green	Red	Red	Red	Red	Now	Red	Red	Red	Red	Now
Staples Pt Rd.	Green	Green	Green	Green	Red	>2050	Green	Green	Yellow	Red	Red	>2050	Red	Red	Red	Red	Now
Bustins Isl Rd.	Green	Green	Green	Green	Red	>2050	Green	Green	Green	Red	Red	>2050	Red	Red	Red	Red	Now

Green	No impact
Yellow	Little impact
Red	Moderate to severe impact

For general planning purposes only. Is not meant to be an exact planning time horizon and does not account for all potential mpacts.

MAINE GEOLOGICAL SURVEY

Summary of Road Vulnerability

The GOOD news…

- Only 15 vulnerable roads have been identified (there are other small associated segments not discussed).
- Only 3 of 15 roads have immediate impacts and planning needs to highest tides, and are privately owned
- Majority of public roads will not be impacted by highest tides until sometime likely around or after 2050, which allows planning time
- Of 7 roads that may require immediate potential adaptation to the 1% storm event, 3 are privately owned.

The not so good news…

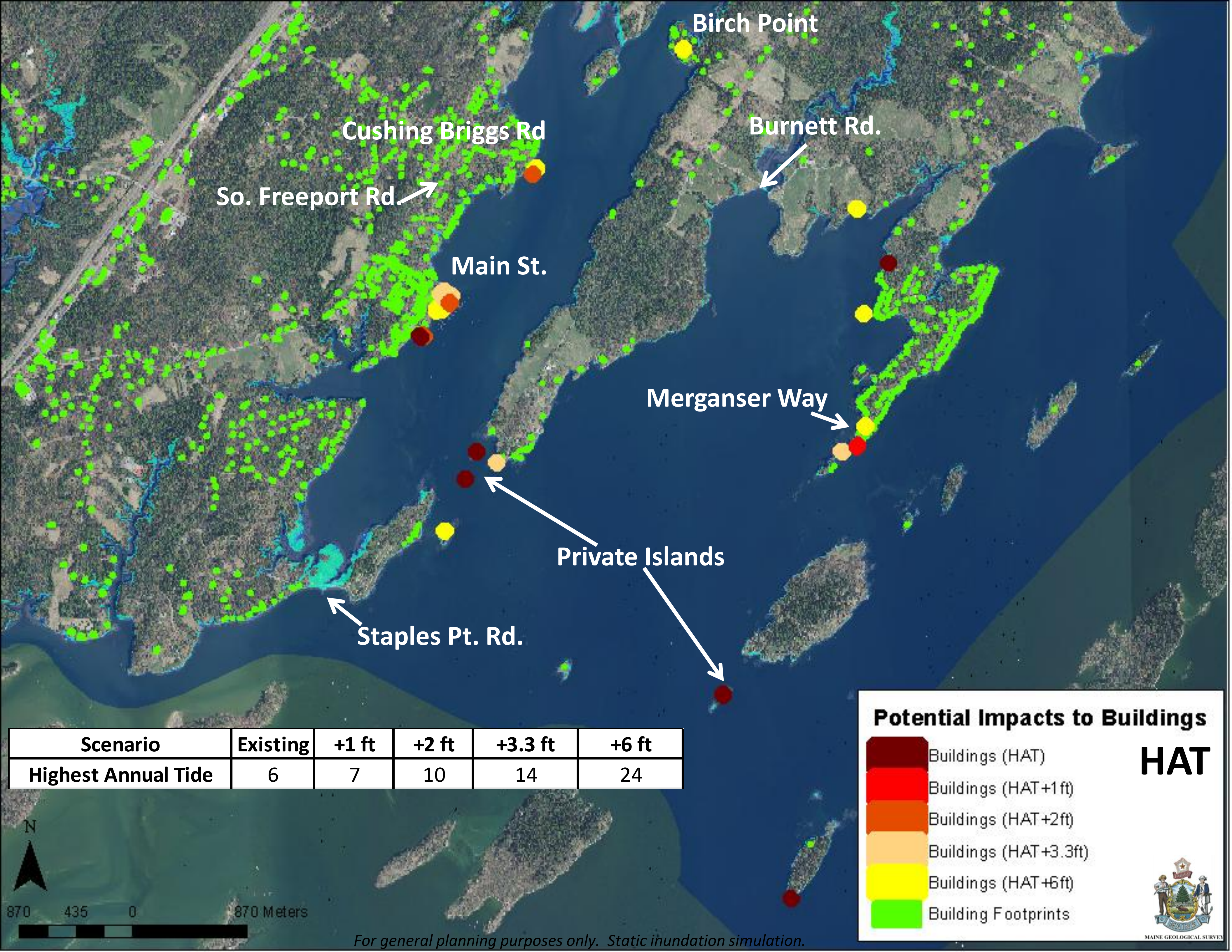
- 7 of 15 roads may require immediate potential adaptation to the 1% storm event; the majority by 2050
- 12 of 15 roads may require immediate potential adaptation to a Category 1 hurricane.

MAINE GEOLOGICAL SURVEY

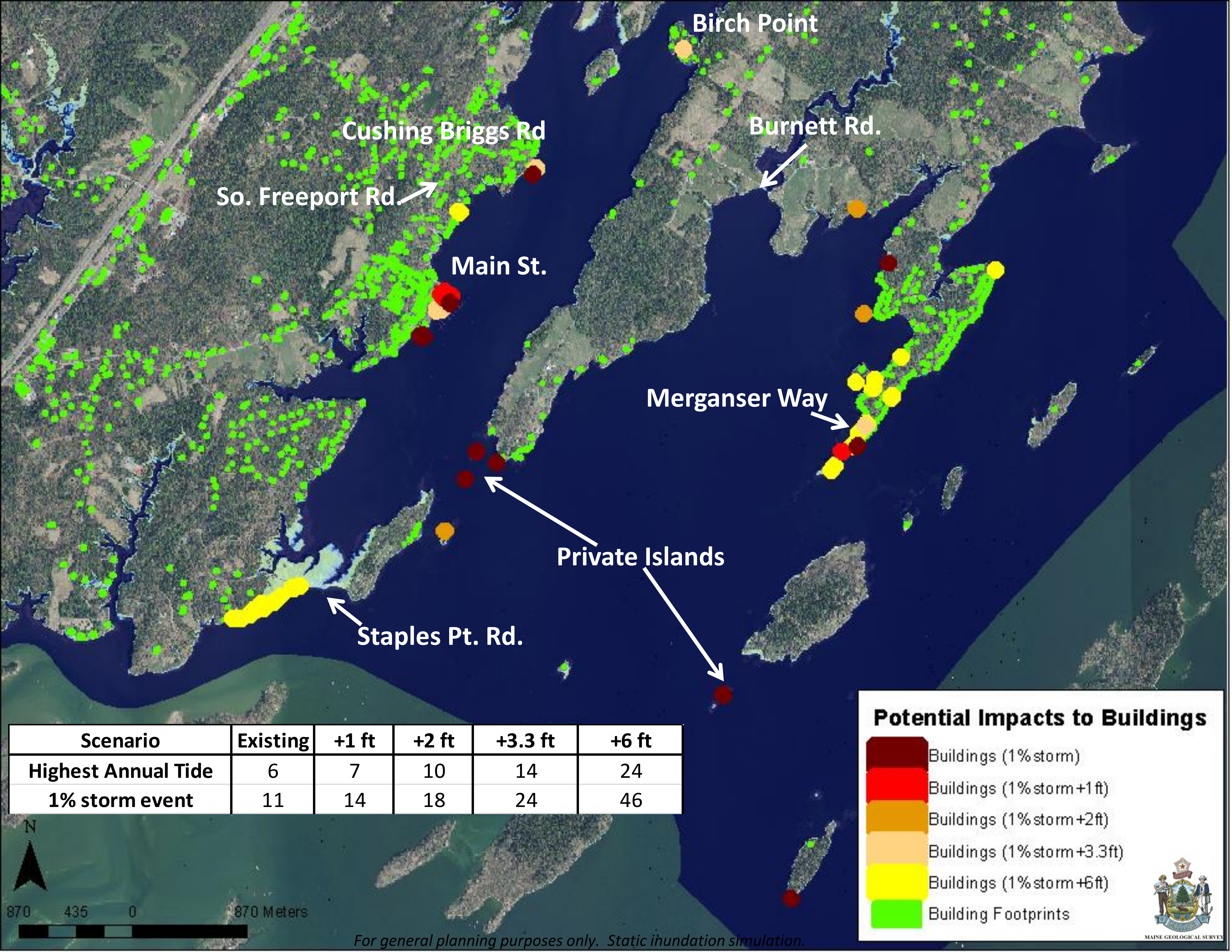
Potential Impacts to Buildings and Infrastructure

Assumption: a building is "impacted" if the footprint is intersected by water (includes piers and wharves)

R. Harbison, GPCOG

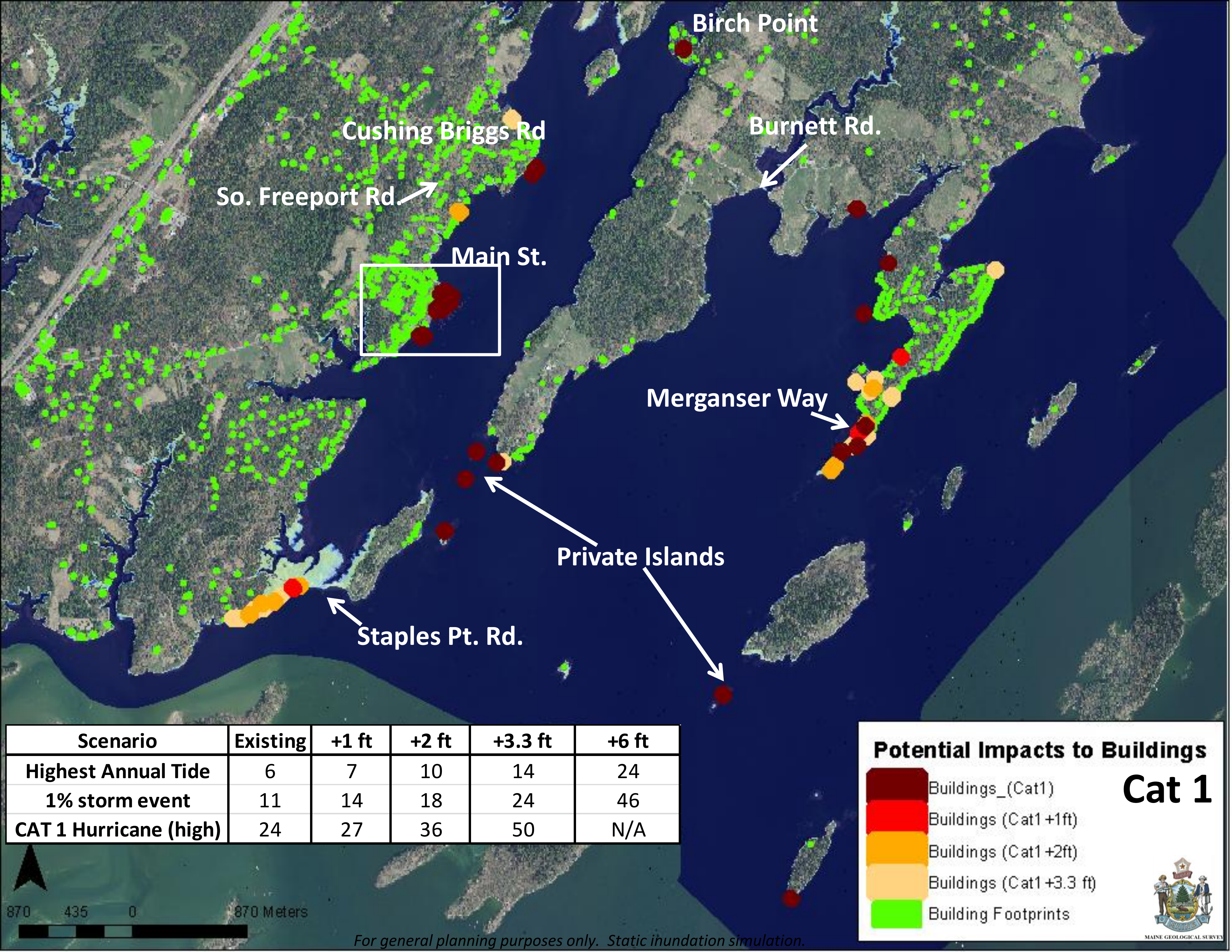


Scenario	Existing	+1 ft	+2 ft	+3.3 ft	+6 ft
Highest Annual Tide	6	7	10	14	24



Scenario	Existing	+1 ft	+2 ft	+3.3 ft	+6 ft
Highest Annual Tide	6	7	10	14	24
1% storm event	11	14	18	24	46

For general planning purposes only. Static inundation simulation.



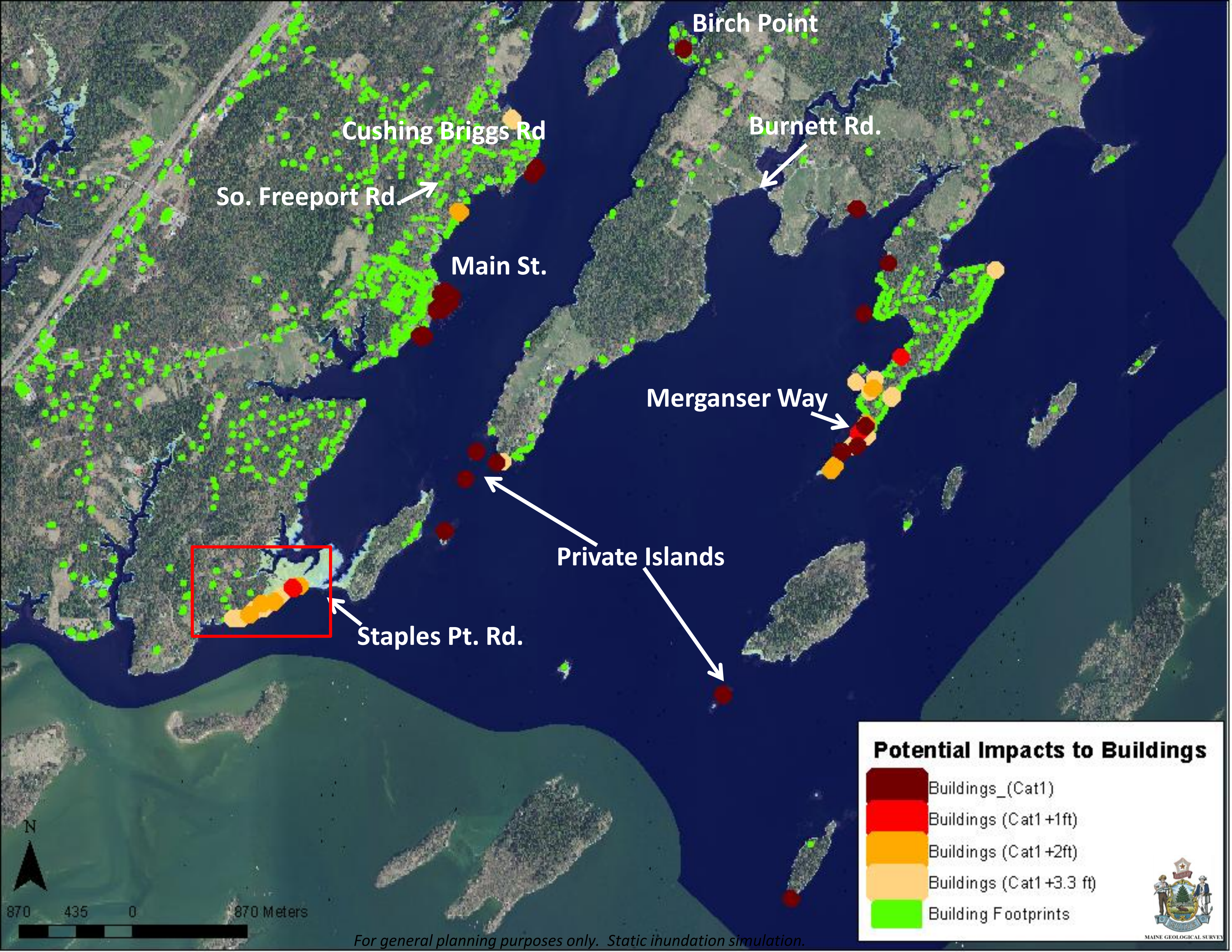
Scenario	Existing	+1 ft	+2 ft	+3.3 ft	+6 ft
Highest Annual Tide	6	7	10	14	24
1% storm event	11	14	18	24	46
CAT 1 Hurricane (high)	24	27	36	50	N/A

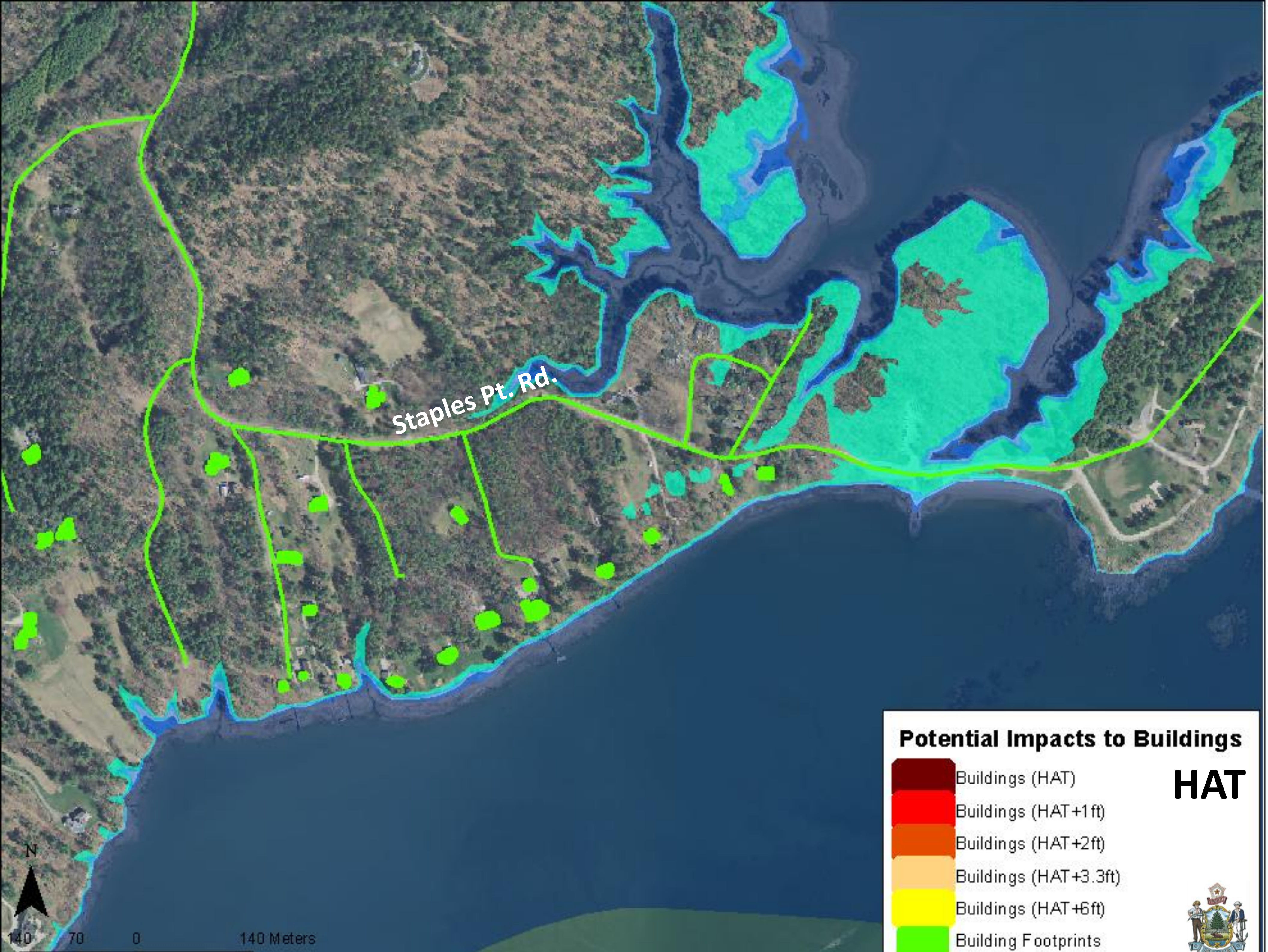
For general planning purposes only. Static inundation simulation.

For general planning purposes only. Static inundation simulation.

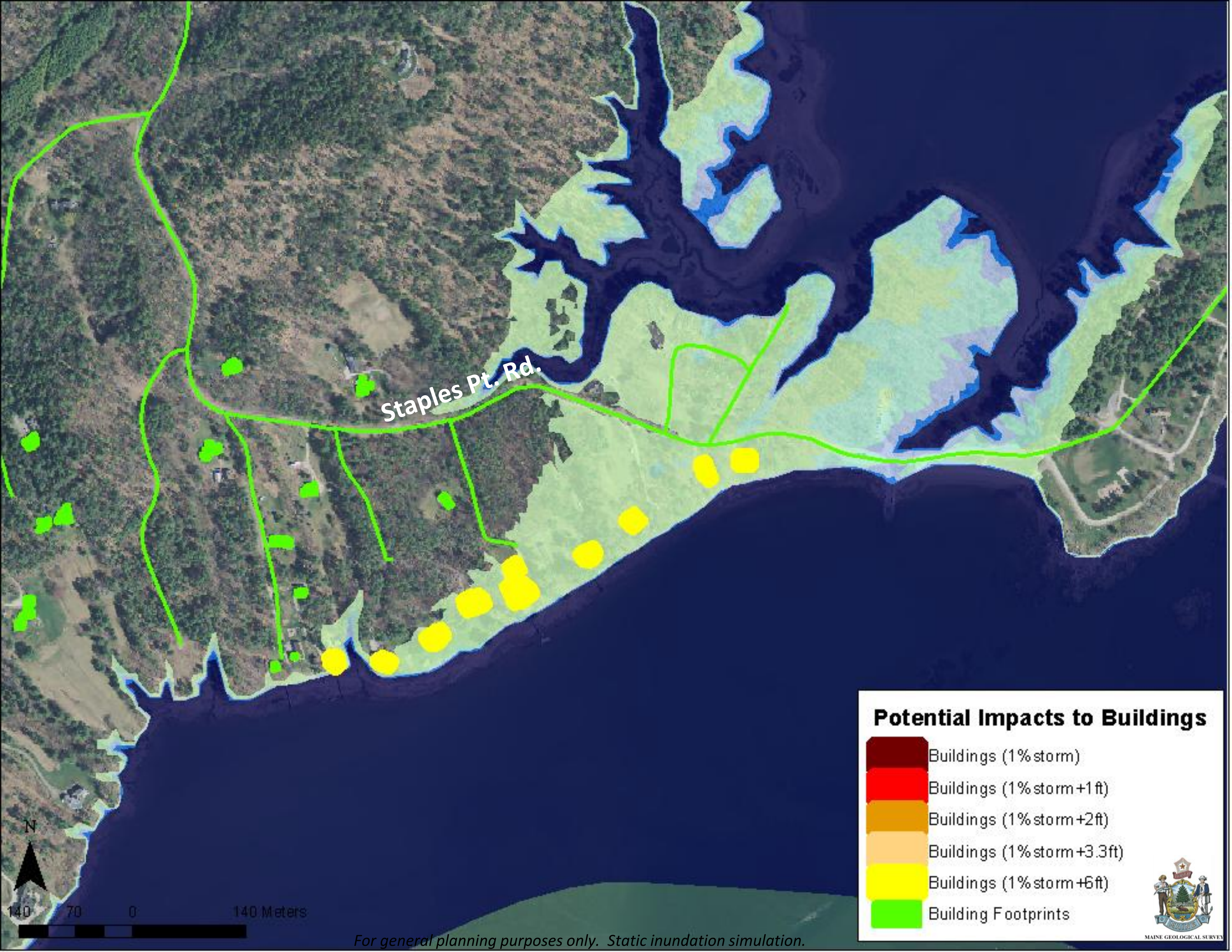
For general planning purposes only. Static inundation simulation.

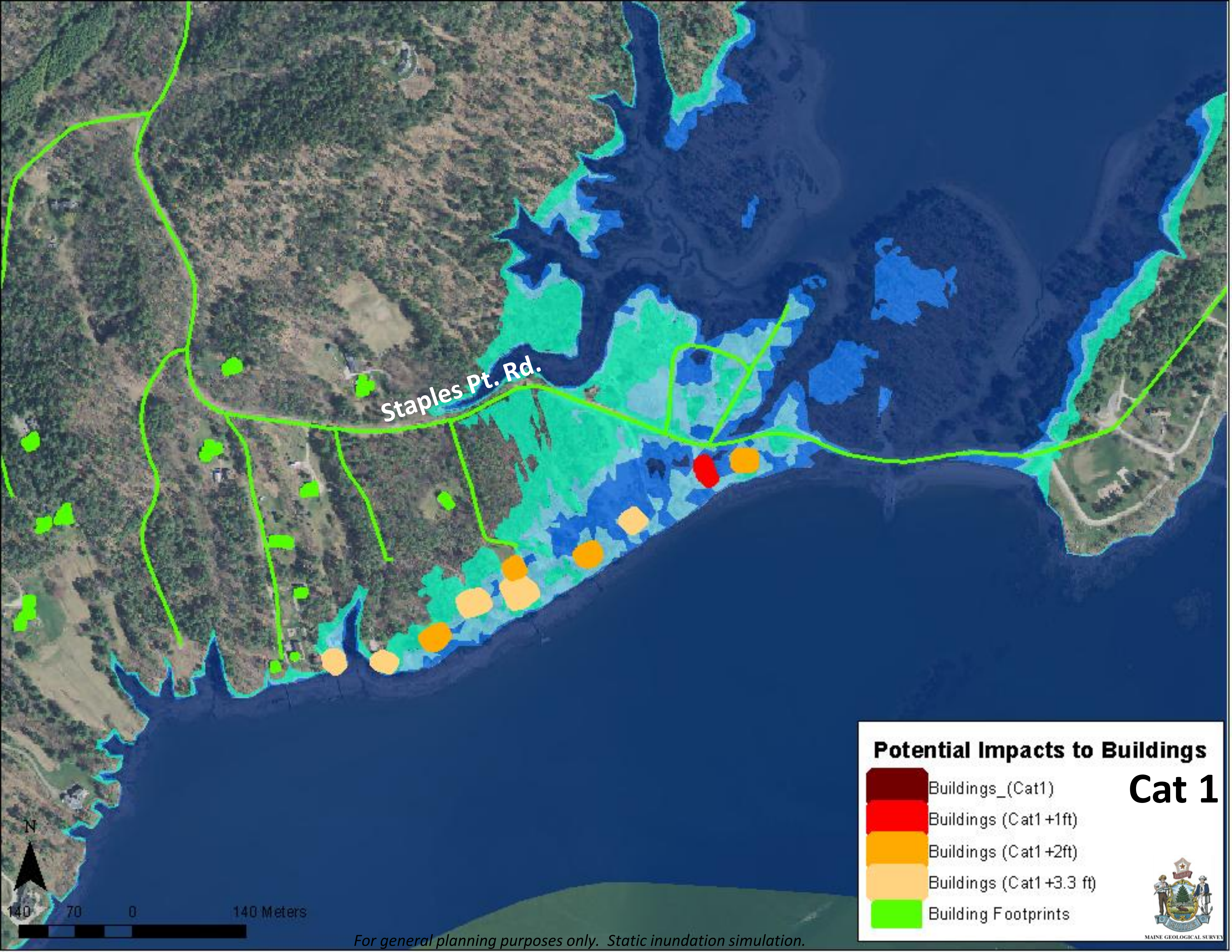
For general planning purposes only. Static inundation simulation.

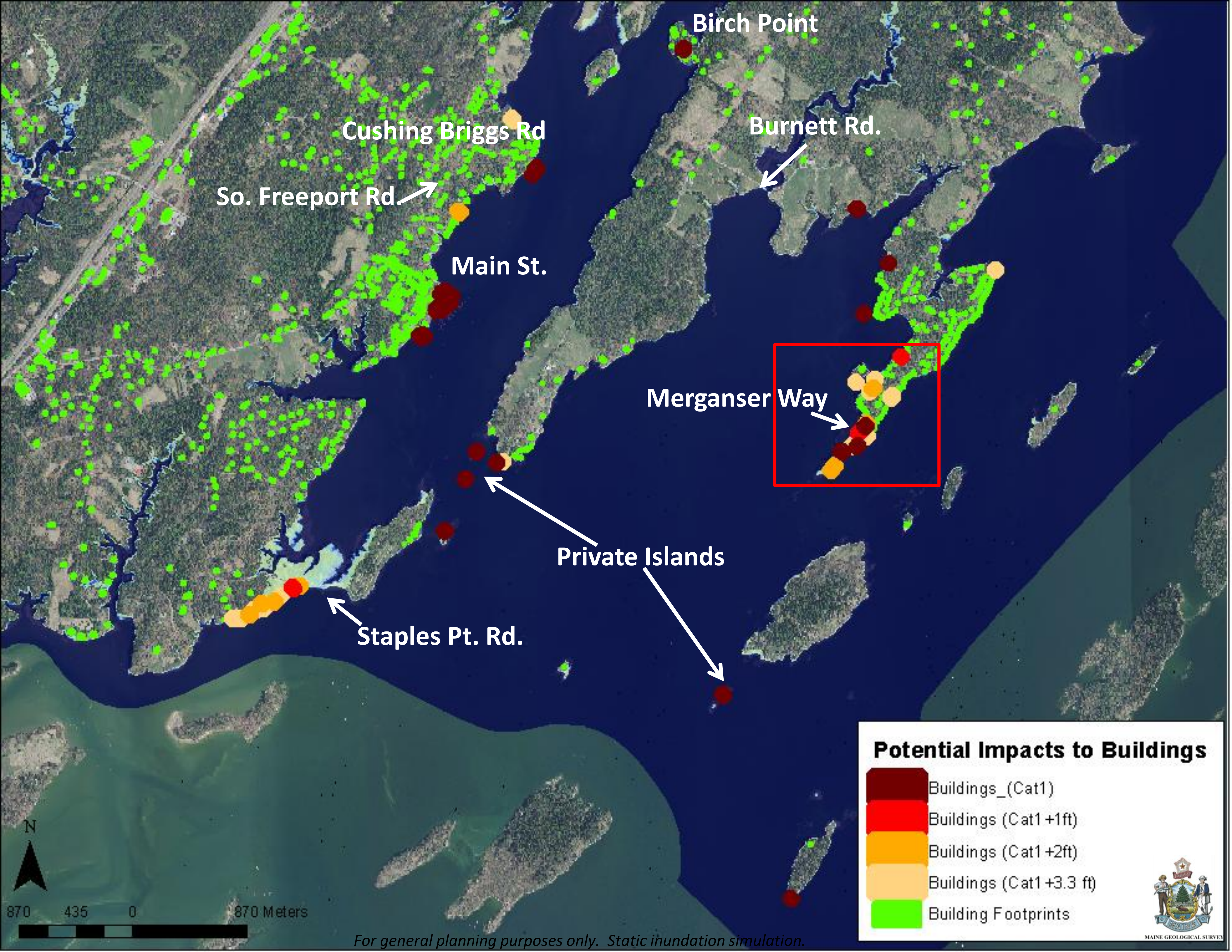

Birch Point
Cushing Briggs Rd
Burnett Rd.
So. Freeport Rd.
Main St.
Merganser Way
Private Islands
Staples Pt. Rd.
Potential Impacts to Buildings
Buildings_(Cat1)
Buildings (Cat1 +1ft)
Buildings (Cat1 +2ft)
Buildings (Cat1 +3.3 ft)
Building Footprints
N
870 435 0 870 Meters
MAINE GEOLOGICAL SURVEY
For general planning purposes only. Static inundation simulation.



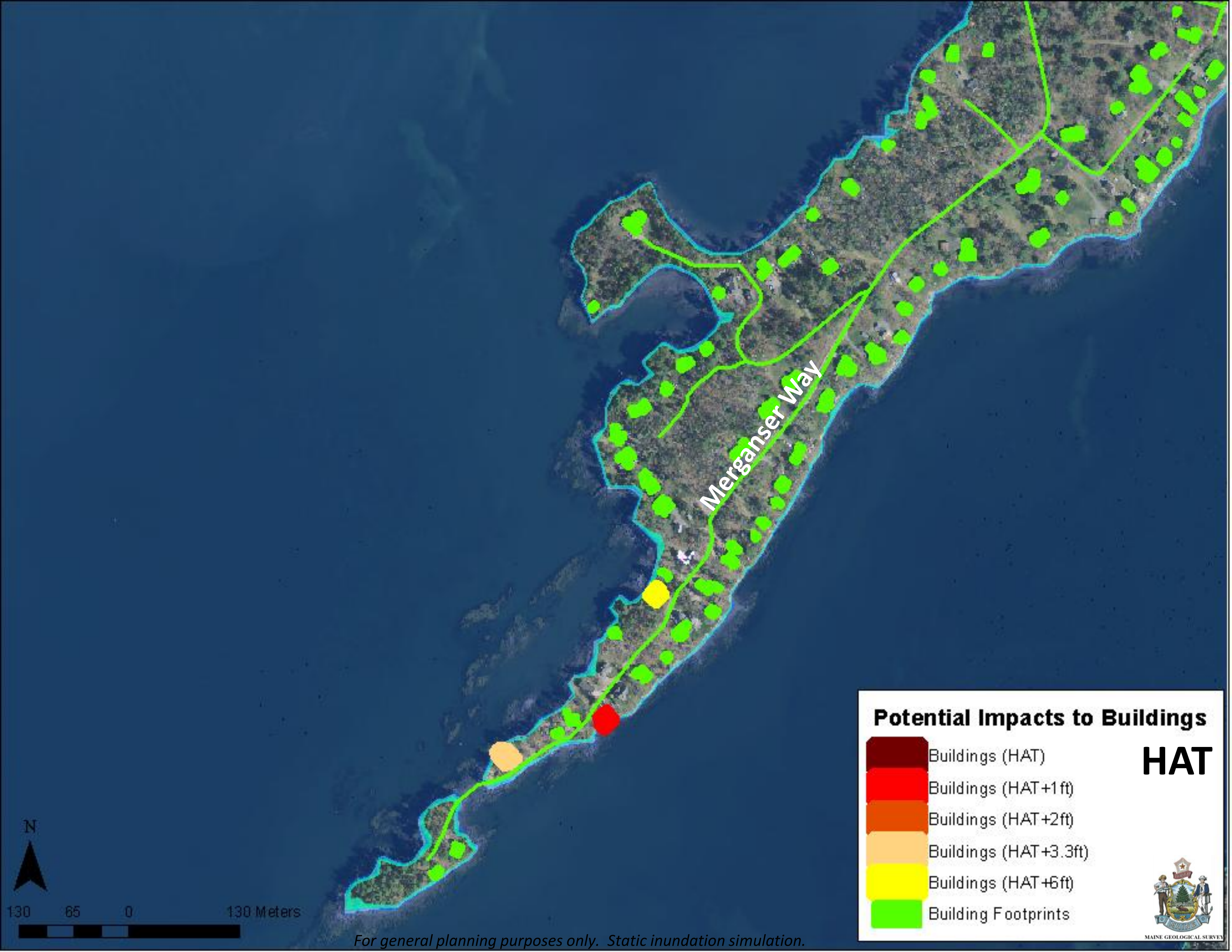
For general planning purposes only. Static inundation simulation.

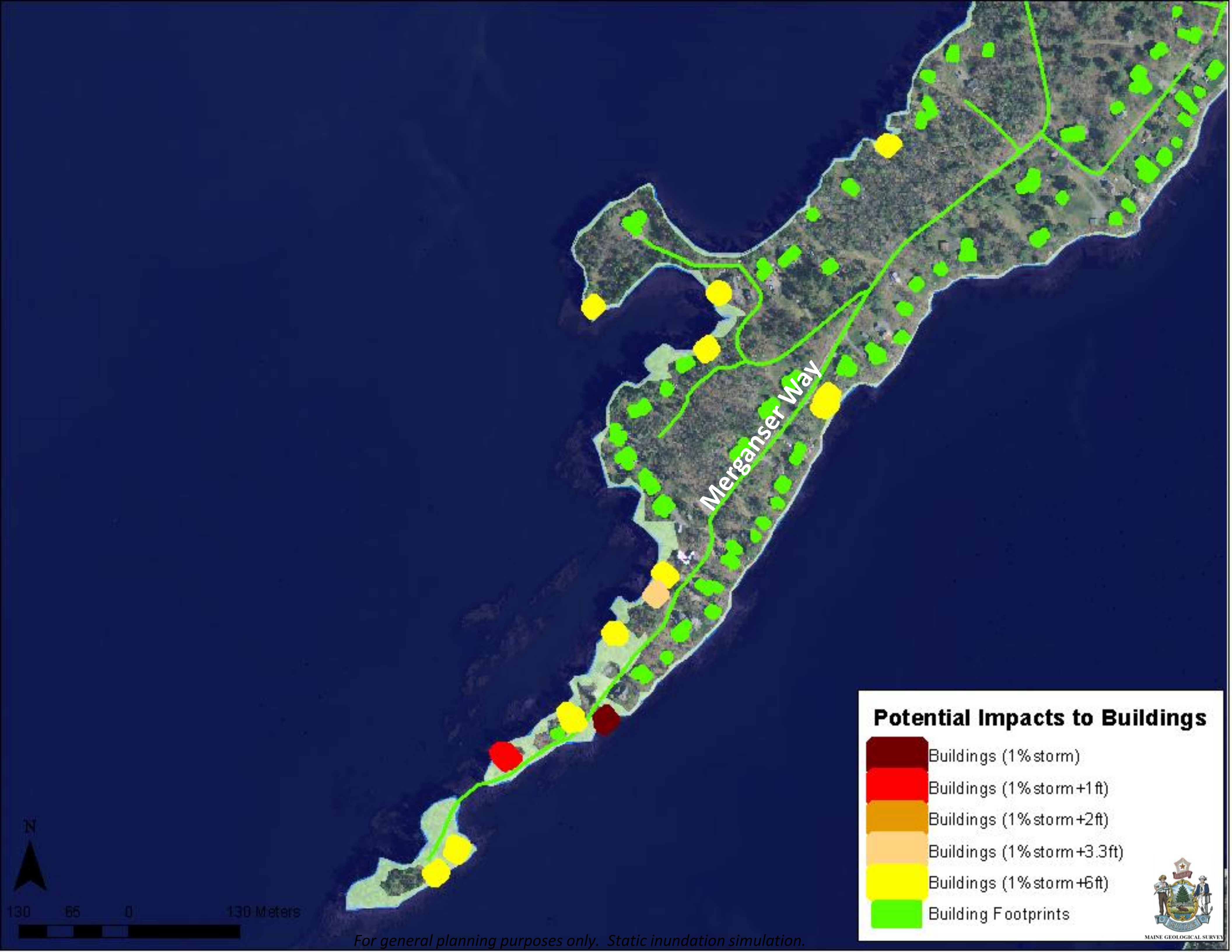

Staples Pt. Rd.
Potential Impacts to Buildings
Buildings (1% storm)
Buildings (1% storm +1 ft)
Buildings (1% storm +2ft)
Buildings (1% storm +3.3ft)
Buildings (1% storm +6ft)
Building Footprints
N
140
70
0
140 Meters
MAINE GEOLOGICAL SURVEY
For general planning purposes only. Static inundation simulation.


Staples Pt. Rd.
Potential Impacts to Buildings
Cat 1
Buildings_(Cat1)
Buildings (Cat1 +1ft)
Buildings (Cat1 +2ft)
Buildings (Cat1 +3.3 ft)
Building Footprints
N
140 70 0 140 Meters
MAINE GEOLOGICAL SURVEY
For general planning purposes only. Static inundation simulation.



Birch Point
Cushing Briggs Rd
Burnett Rd.
So. Freeport Rd.
Main St.
Merganser Way
Private Islands
Staples Pt. Rd.
Potential Impacts to Buildings
Buildings_(Cat1)
Buildings (Cat1 +1ft)
Buildings (Cat1 +2ft)
Buildings (Cat1 +3.3 ft)
Building Footprints
N
870 435 0 870 Meters
MAINE GEOLOGICAL SURVEY
For general planning purposes only. Static inundation simulation.


Merganser Way
Potential Impacts to Buildings
HAT
Buildings (HAT)
Buildings (HAT+1ft)
Buildings (HAT+2ft)
Buildings (HAT+3.3ft)
Buildings (HAT+6ft)
Building Footprints
N
130 65 0 130 Meters
MAINE GEOLOGICAL SURVEY
For general planning purposes only. Static inundation simulation.



Merganser Way
Potential Impacts to Buildings
Buildings (1% storm)
Buildings (1% storm +1 ft)
Buildings (1% storm +2 ft)
Buildings (1% storm +3.3 ft)
Buildings (1% storm +6 ft)
Building Footprints
N
130 65 0 130 Meters
MAINE GEOLOGICAL SURVEY
For general planning purposes only. Static inundation simulation.

For general planning purposes only. Static inundation simulation.

Summary of Building Vulnerability and Action

Neighborhood	Highest Annual Tide					When	1% storm					When	Cat 1 Hurricane				When
	Exist	+1ft	+2ft	+3.3ft	+6ft	Act?	Exist	+1ft	+2ft	+3.3ft	+6ft	Act?	Exist	+1ft	+2ft	+3.3ft	Act?
Merganser Way						Now						Now					Now
Main St. (end)						Now						Now					Now
Staples Pt Rd.						None						>2050					<2050
Cushing Briggs Road						>2050						Now					Now

	No impact
	Little impact (1-3 structures)
	More than 3 structures

For general planning purposes only. Is not meant to be an exact planning time horizon and does not account for all potential impacts.

Summary of Infrastructure Vulnerability

The GOOD news…

- There are relatively few impacts overall – only 4 general areas of impacts, with some isolated other areas.
- Impacts under HAT are isolated to piers and wharves and private island structures.
- Only 1 area is currently at moderate risk to HAT flooding and 1% storm flooding (Main Street area)
- Critical infrastructure (sewer treatment plant, police, fire and emergency facilities, rail lines) **are *currently* positioned to avoid impacts from future SLR/storms**.

The not so good news…

- 3 of the 4 identified areas may need adaptation to deal with existing 1% storm or Category 1 hurricane in order to avoid severe (greater than 3 structures) impacts.

MAINE GEOLOGICAL SURVEY

<u>Some Potential</u>
Adaptation Techniques to consider

Potential Adaptation Techniques

Acquire Open Space

- *Prevent conflicts before they occur*
- *Protect wetlands and allow the ocean to migrate inland naturally*
- *Wetlands act as a buffer against storm surge*

Consider prioritizing wetlands, and areas of undeveloped uplands which may have potential to allow for the landward migration of coastal marshes.

Freeport Conservation Trust, Cousin's River


Potential Adaptation Techniques
Protect Clam Flats
Consider protecting clam flats and their upland areas to allow for inland migration
Google Earth

Though it was beyond the scope of this study, consider how SLR may impact vital clam flat resources. Inundation times? Depths? Losses? Conversion? Changes of species?

In Maine, green crabs threaten clamming | The Portland Press Herald / Maine Sunday Telegram - Mozilla Firefox

File Edit View History Bookmarks Tools Help

In Maine, green crabs threaten clamming | T...

www.pressherald.com/news/in-maine-green-crabs-threaten-clamming_2013-05-27.html

Portland Press Herald | news

News Business Sports Outdoors Opinion Food & Drink Lifestyle

Keep thinking how other species might be impacted by changes

Posted: May 27, 2013 10:56PM
Last modified: May 28, 2013 12:40PM

In Maine, green crabs threaten clamming

Freeport funds study as clammers take the offensive.

Potential Adaptation Techniques

Manage Coastal Bluff Stability

Maine Sea Grant
Marine Science for Maine People

Home › Maine Property Owner's Guide to Managing Flooding, Erosion & Other Coastal Hazards

Search this site: Search

Search this guide: Search

Maine Property Owner's Guide to Managing Flooding, Erosion & Other Coastal Hazards

- Guide Home
- Beaches & Dunes
- Bluffs & Rocky Shores
- Coastal Wetlands
- The Maine Coast
- Maps & Data
- Permitting & Rules
- Assistance
- About
- References
- FAQ
- Printer-friendly version
- Site Map

Bluffs & Rocky Shores

The majority (58%) of the Maine coast is hard rock. The rocky coast is relatively stable over time, but soil can erode along the shoreline. Another 40% or 1,400 miles of Maine's shoreline has soft bluffs: tall (over three feet), with steep slopes of loose rock, gravel, clay, or sand that easily erode. One of the biggest hazards associated with soft bluffs is the threat of landslides, especially in high coastal bluffs made of muddy sediment.

NOTE: Maine classifies all areas below the highest annual tide elevation, including rocky shores, sand beaches, mud flats, and salt marshes, as "Coastal Wetlands." In order to facilitate problem solving on this website, Coastal Wetland types have been grouped into three categories: Beaches & Dunes; Bluffs & Rocky Shores; and Coastal Wetlands.

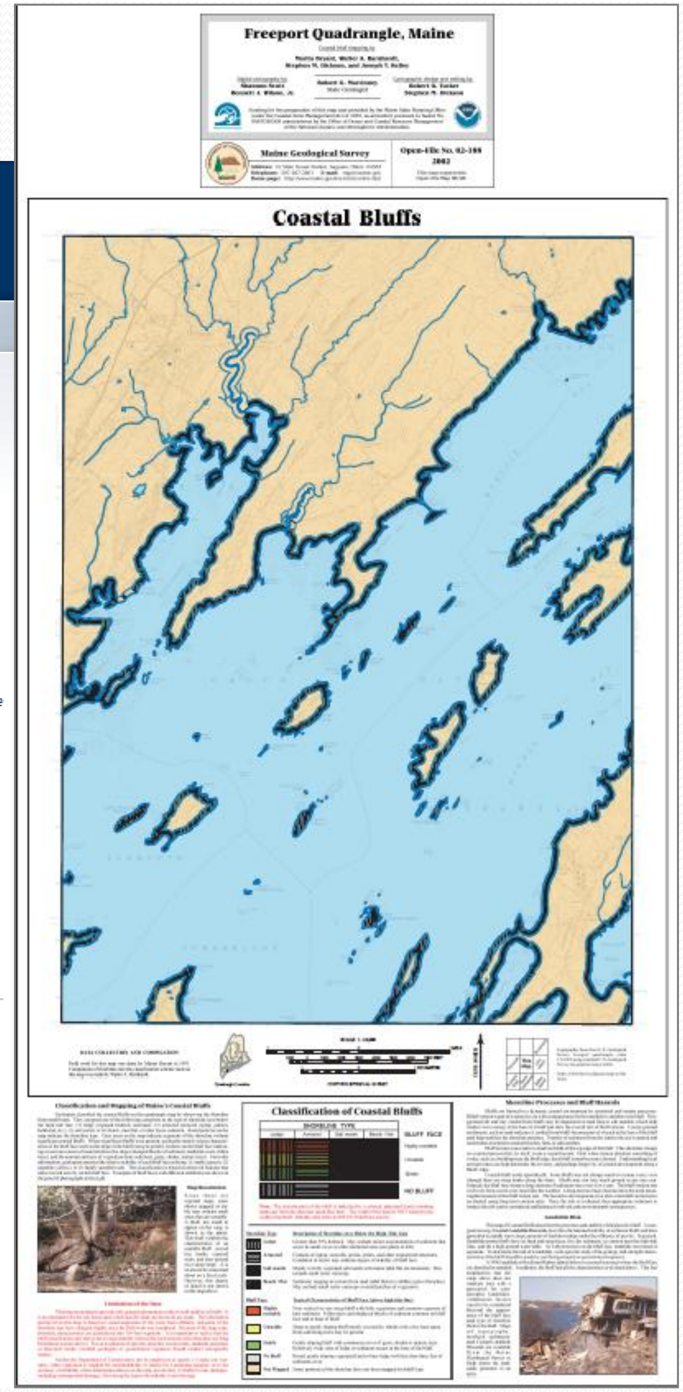
Learn more about Maine's rocky shores and soft bluffs.

A checklist has been developed to help you identify and rank bluff hazards, using the maps and other resources in this guide and by conducting a field inventory of your property.

Download Bluff & Landslide checklist - 123KB

Hard Bluff

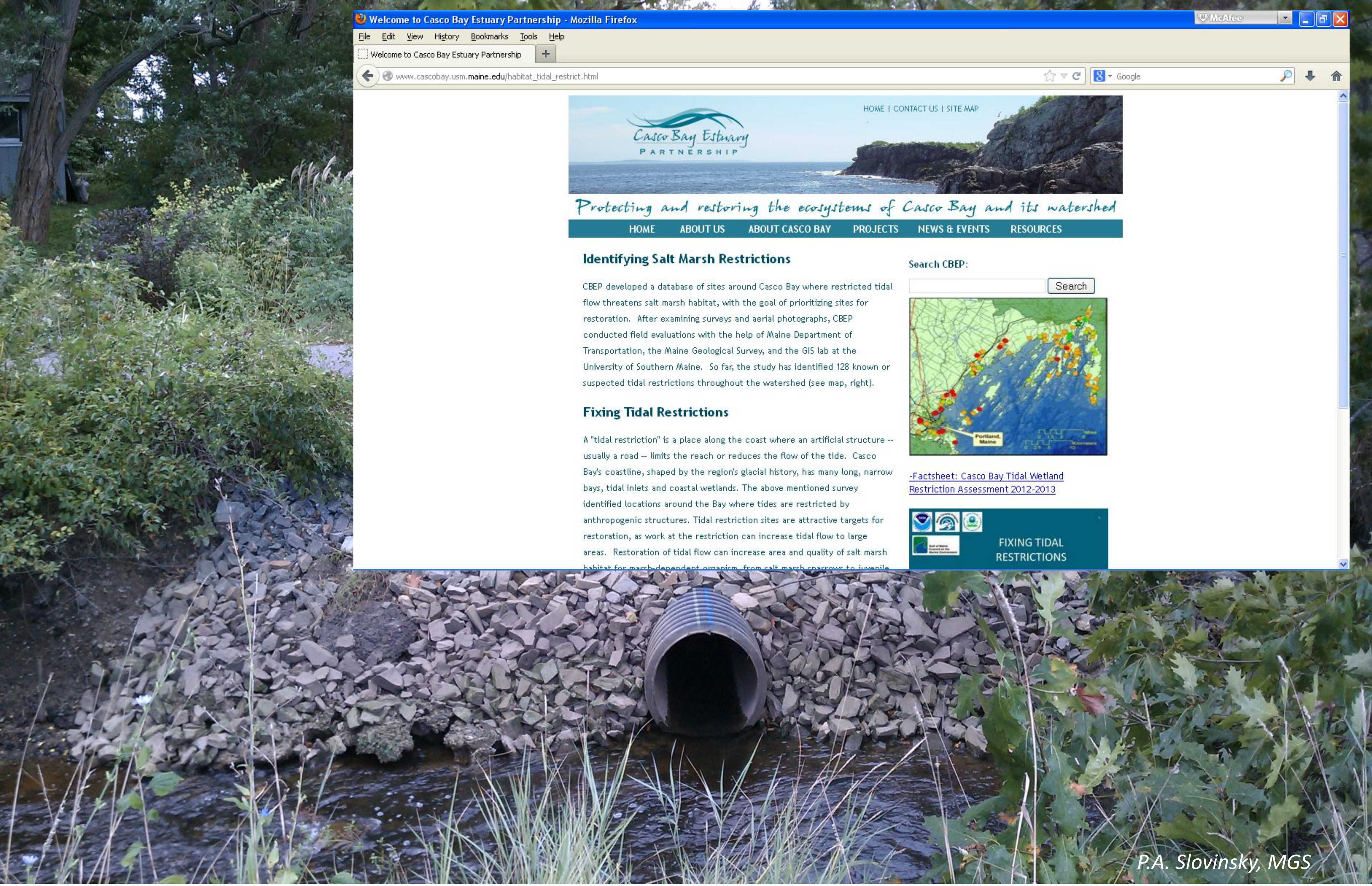
Soft Bluff



Potential Adaptation Techniques

Improve Shoreland Zoning Maps

- You can’t begin to deal with adaptation unless you know where your shoreline is!
- **Use LiDAR (Light Detection and Ranging) data to set an accurate shoreline position**
- Highest Annual Tide Level – HAT can be defined using LiDAR data; this is being developed at the State level for next year.

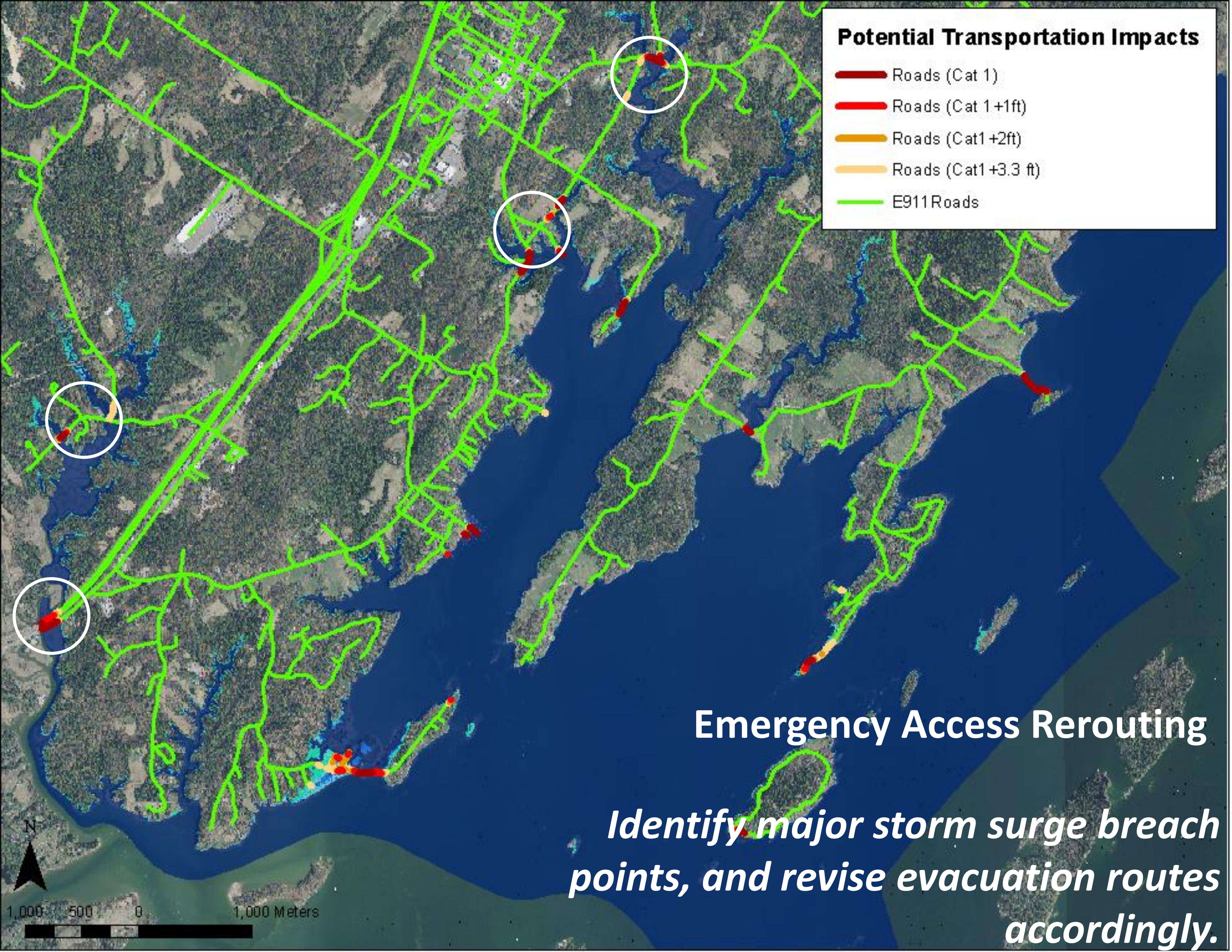


Consider removing or enhancing identified tidal restrictions to maintain flow for wetland expansion


Ensure proper culvert sizing
R. Harbison, GPCOG


Ensure vulnerable infrastructure is adequately protected…the sewer treatment plant is!


Elevate vulnerable infrastructure, including sewer pump stations, roads, culverts and bridges
R. Harbison, GPCOG



Emergency Access Rerouting

Identify major storm surge breach points, and revise evacuation routes accordingly.


Consider elevating, relocating, or protecting vulnerable transportation infrastructure
South Freeport Road
R. Harbison, GPCOG

Consider elevating, relocating, or protecting vulnerable transportation infrastructure

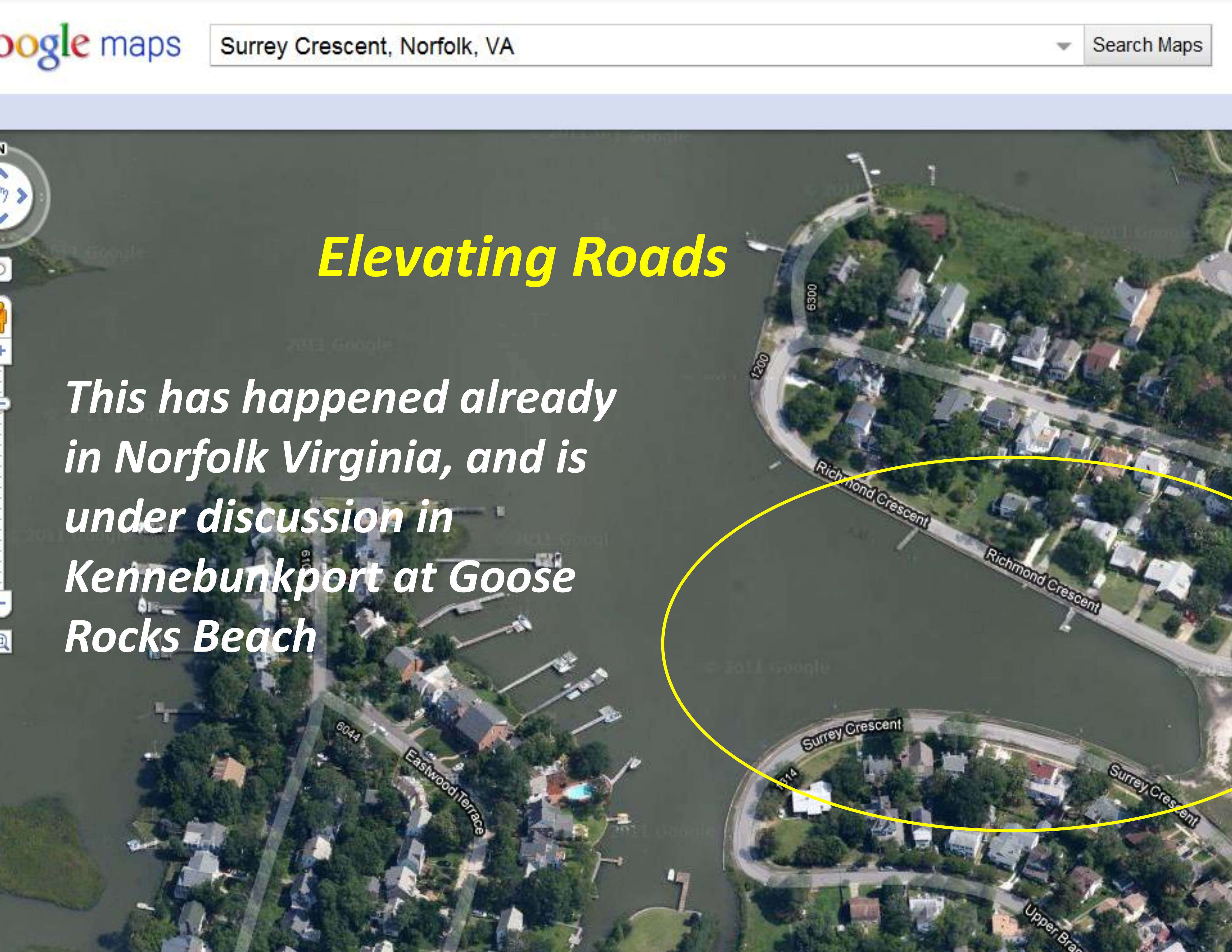
Route 1, Yarmouth into Freeport

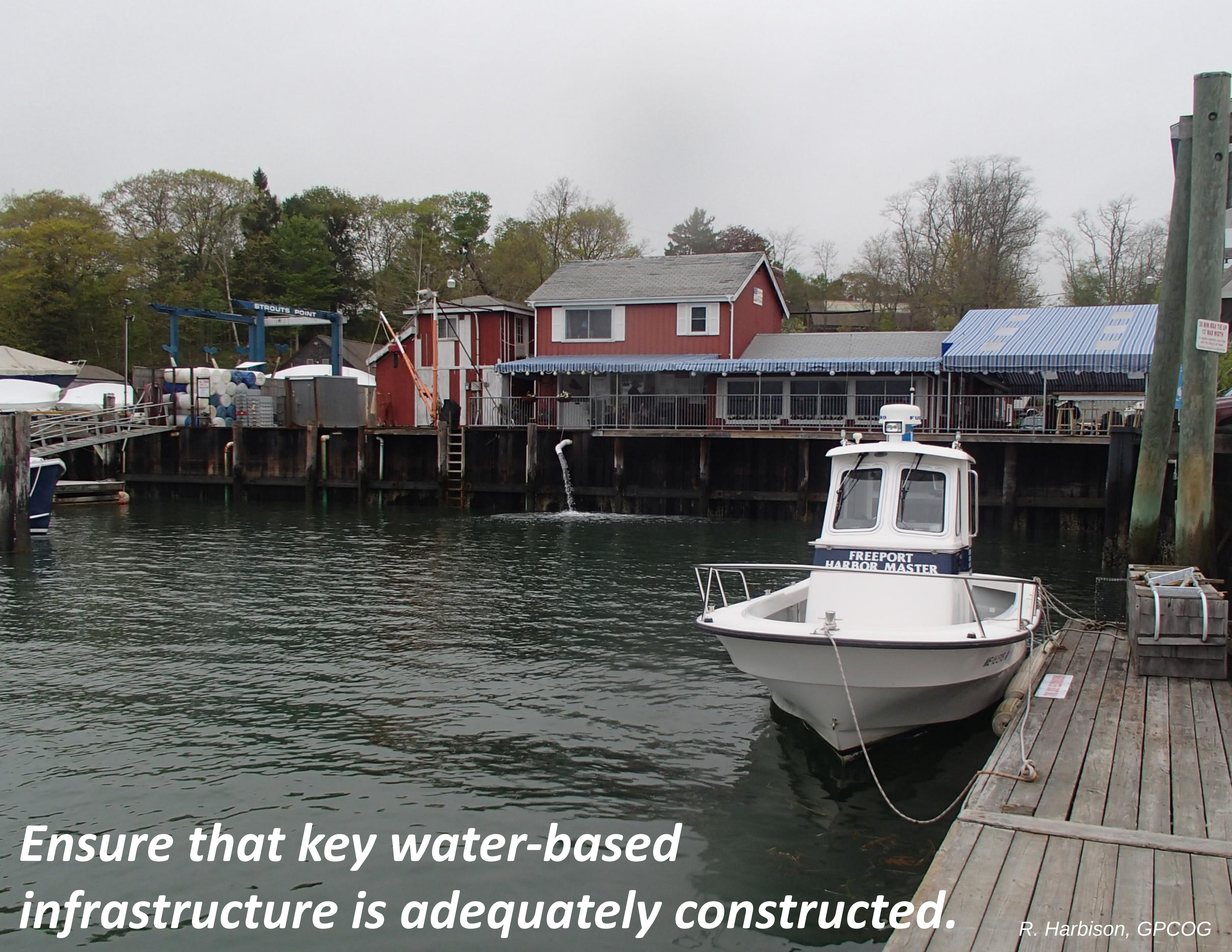
R. Harbison, GPCOG


MUDDY
RUDDER
Consider elevating, relocating, or protecting vulnerable transportation infrastructure
Route 1, Freeport into Yarmouth
R. Harbison, GPCOG

Elevating Roads

This has happened already in Norfolk Virginia, and is under discussion in Kennebunkport at Goose Rocks Beach





Ensure that key water-based infrastructure is adequately constructed.

R. Harbison, GPCOG

In vulnerable floodplain areas, consider increasing "freeboard" to include sea level rise (i.e., 3 feet above the 100 year BFE); this can significantly decrease flood insurance policies.

Transferable Lessons Learned

- Consider multi-level partnerships related to SLR planning issues. They bring **resources** to the table that **are not currently available at each level**.

- Consider incorporating SLR into **local ordinances and comprehensive plan**

- For vulnerability assessments, consider using a "Scenario Based Approach" - it builds on the concept of "no regrets actions" and **covers a range of scientific predictions, criticality of infrastructure, and enables manageable planning horizons.**

- Consider using a **range of adaptation strategies (do nothing, fortification, relocation, abandonment, soft-solutions) based on vulnerability and criticality of infrastructure. There are C-B tools out there to help do this.**

Lessons Learned…continued

- Consider all adaptation actions, but **bring planning time horizons and goals down to realistic levels**…you don't have to tackle it all at once! (shoot for the "low hanging fruit")

- Don't necessarily separate **the discussion of natural from built environment impacts** – keep environmentalists, planners, architects, public works staff, engineers and emergency personnel around the same table.

- Expect unforeseen delays and to **work on extended timeframes** - *expect to take your time!*

- **Stick with the concept of planning for the storms of today and tides of tomorrow**

Preparing Freeport for Storms and the Potential Impacts of Sea Level Rise

Peter A. Slovinsky, Marine Geologist
Maine Geological Survey
Department of Conservation
peter.a.slovinsky@maine.gov
http://www.maine.gov/doc/nrimc/mgs/mgs.htm

MAINE GEOLOGICAL SURVEY

Rick Harbison, Land Use Planner
Greater Portland Council of Governments
rharbison@gpcog.org
http://www.gpcog.org