MODEL PREDICTIONS OF COASTAL GROUNDWATER RISE DUE TO CLIMATE CHANGE IN NEW HAMPSHIRE

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Southeast Watershed Alliance
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Graciously hosted by Shelley Frost

Outline

- Background
- Study 1: Climate Adaptation for Road Infrastructure and Impacts to Water Quality due to Coastal Groundwater Rise in New Hampshire
- Study 2: Sea-Level Rise Impacts on Drinking Water: A Groundwater Modeling Study in Newmarket, NH
- Concluding Remarks

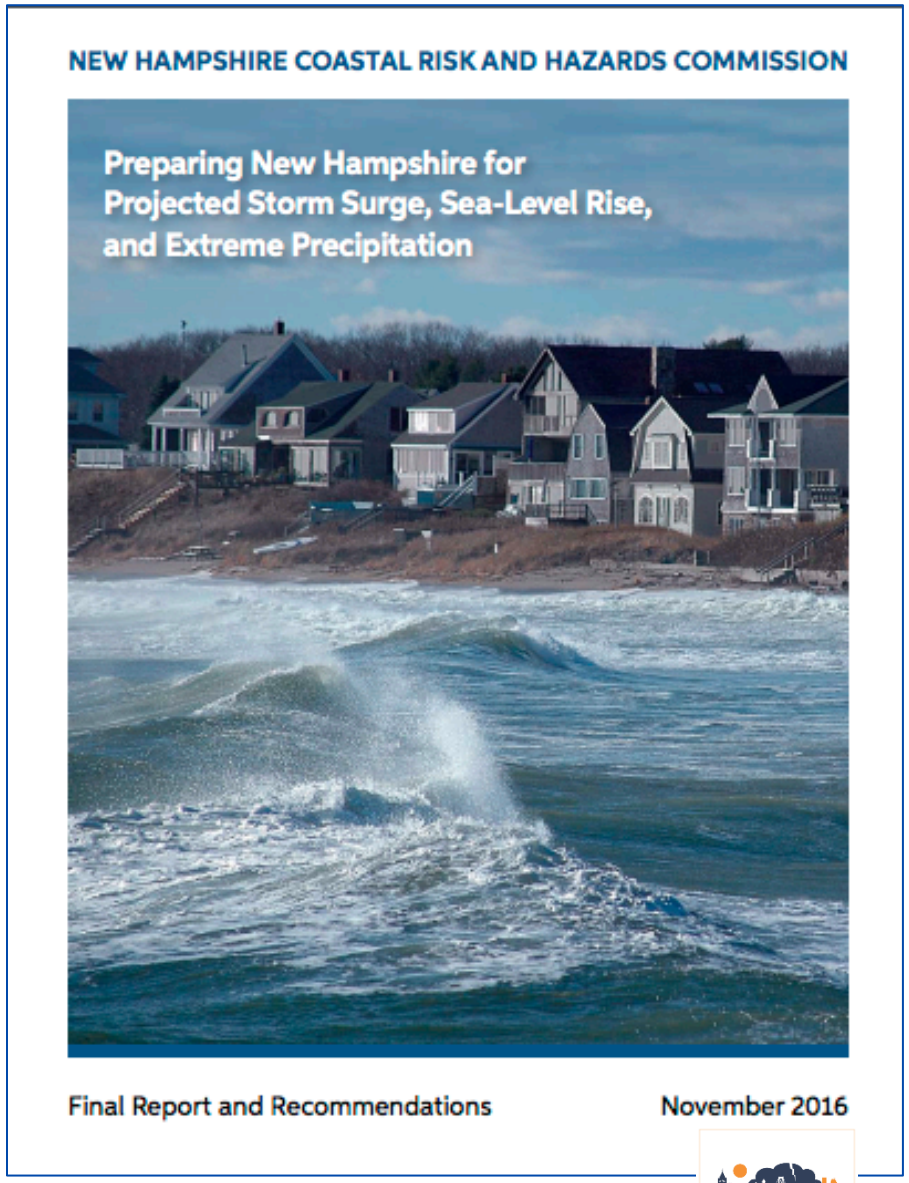
NH Sea-Level Rise Situational Awareness

NH Coastal Risk and Hazards Commission

NH Dept. of Environmental Services

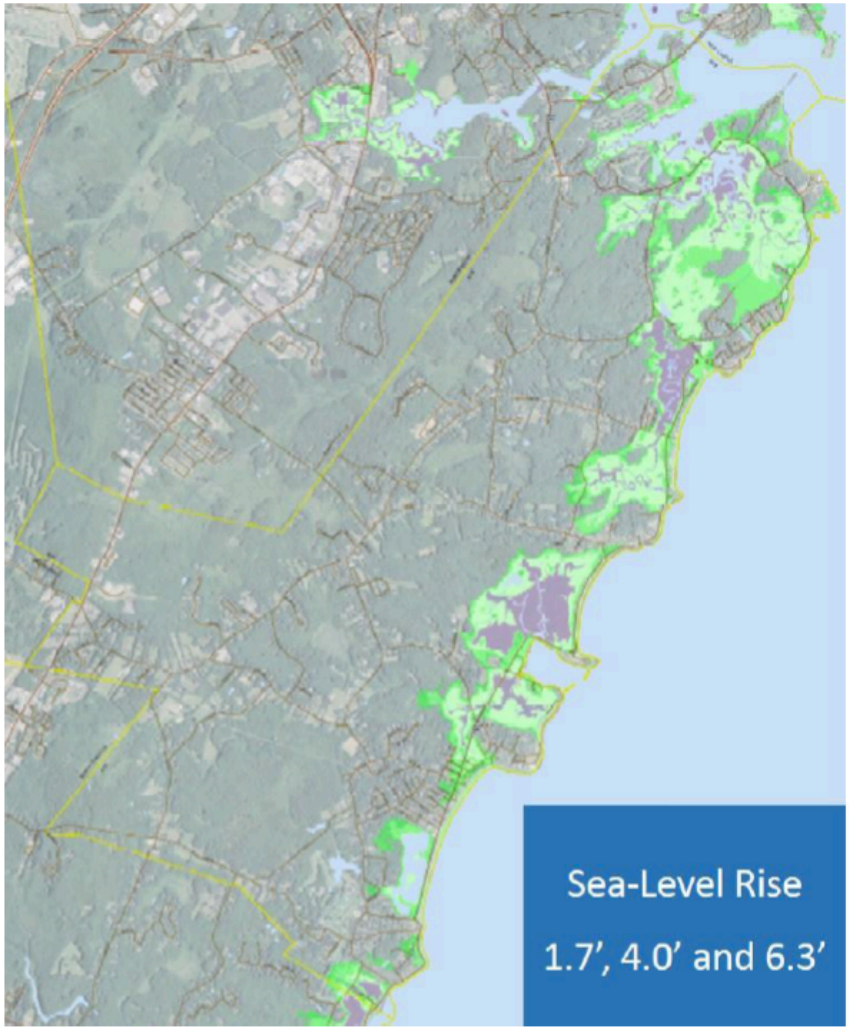
NH Coastal Adaptation Workgroup

Photo Credit: Dan Gobbi

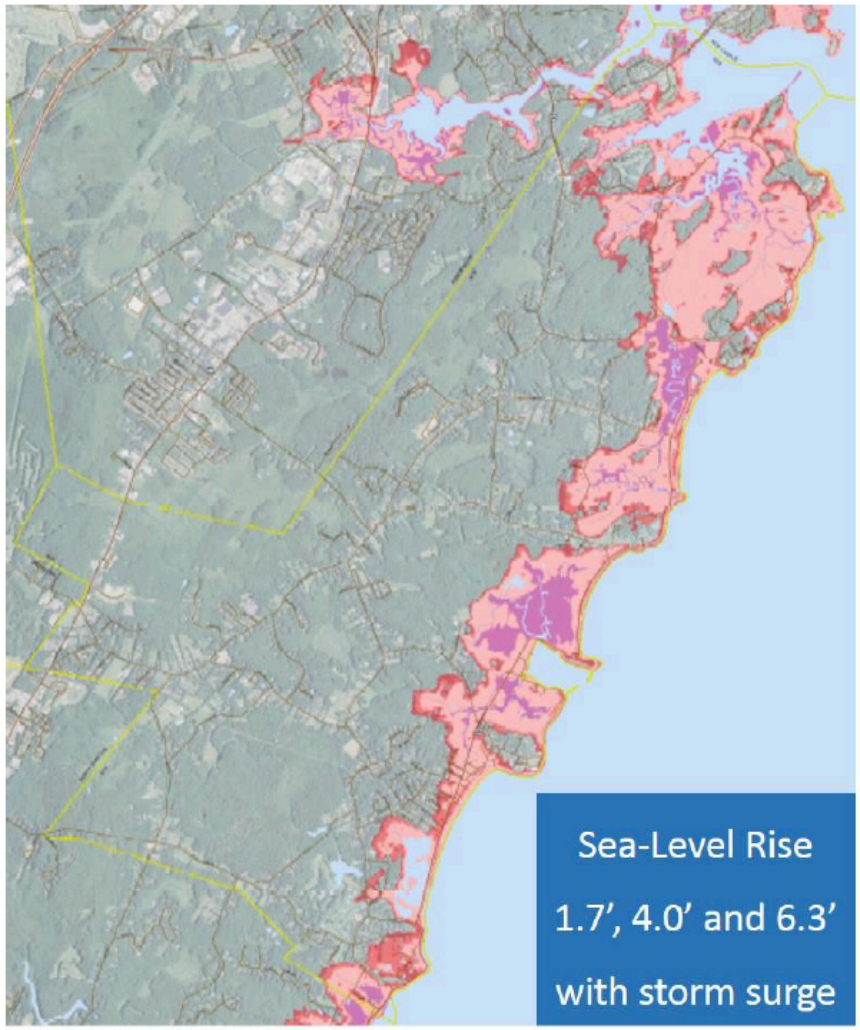


NH Sea-Level Rise Situational Awareness

Sea-Level Rise 1.7 feet, 4.0 feet and 6.3 feet



Sea-Level Rise 1.7 feet, 4.0 feet and 6.3 feet with storm surge



Note: Storm surge = 100-year /1% chance flood.

Map credit: Tides to Storms, Rockingham Planning Commission (2015)

Sea levels are rising - How will sea-level rise affect groundwater?

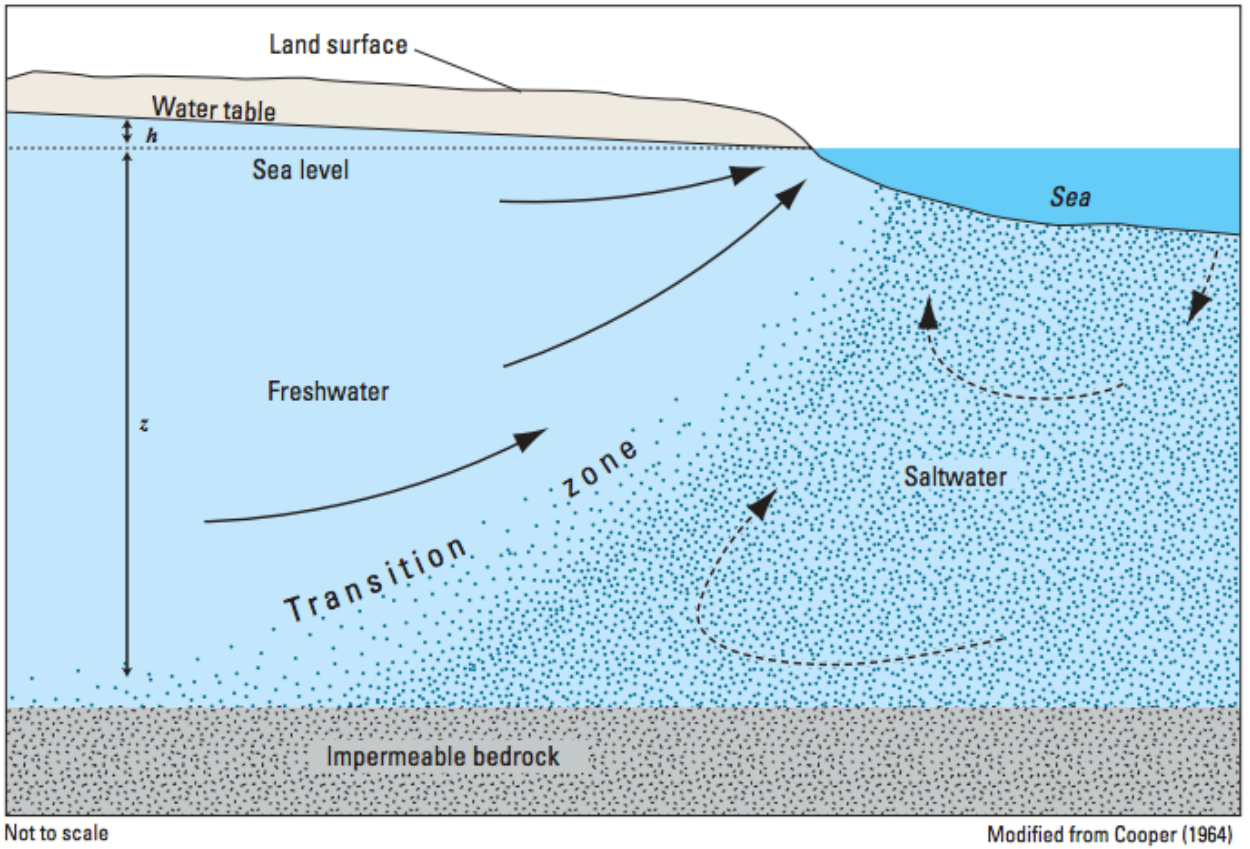


Figure 3. Groundwater-flow patterns and interface between freshwater and saltwater in an idealized coastal aquifer. [h, altitude of water table above local sea level; z, depth to the interface between freshwater and saltwater below local sea level]

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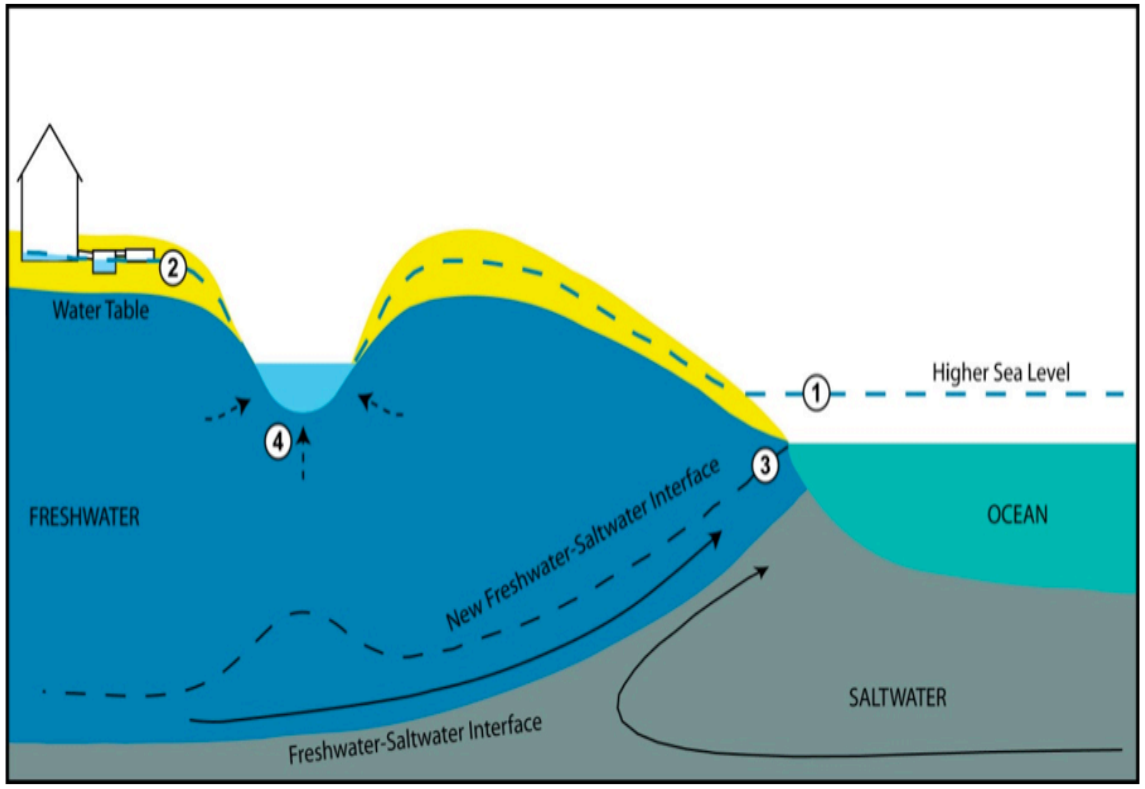
Sea levels are rising - How will sea-level rise affect groundwater?



Source: U.S. Geological Survey

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Groundwater Rise and Sea Level: Cape Cod

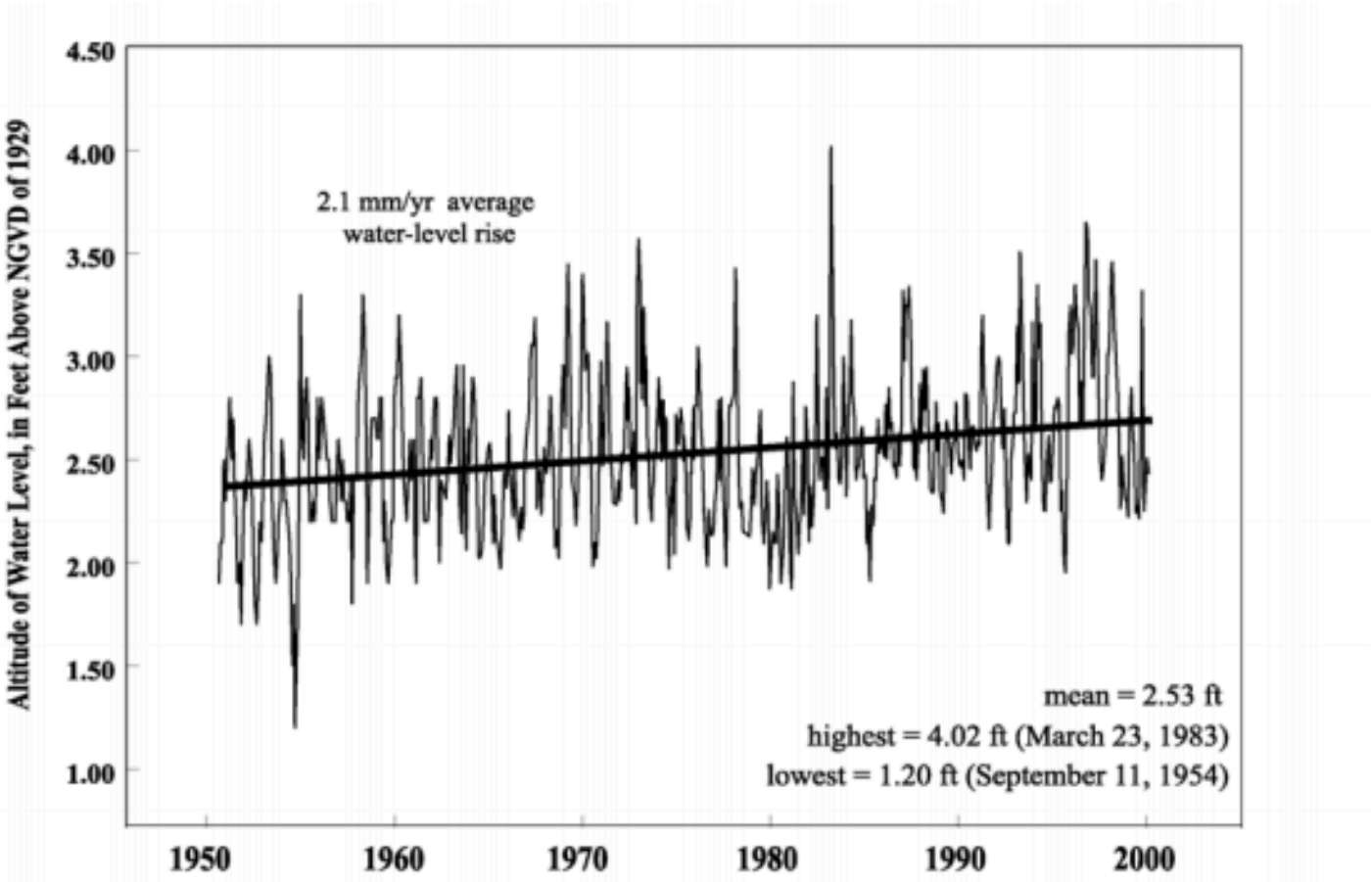
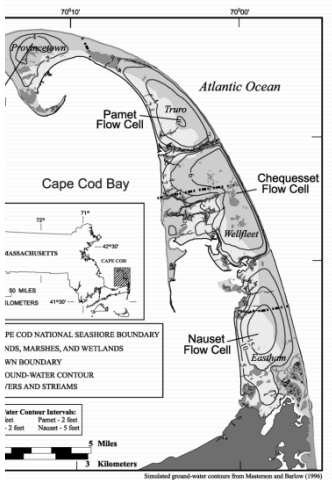


Figure 4. Long-term hydrograph of water levels in observation well TSW 1-0068 near the coast and near a water-supply well in Truro, Massachusetts.



McCobb and Weiskel (2003)

Modeling Groundwater Rise w/SLR: Cape Cod

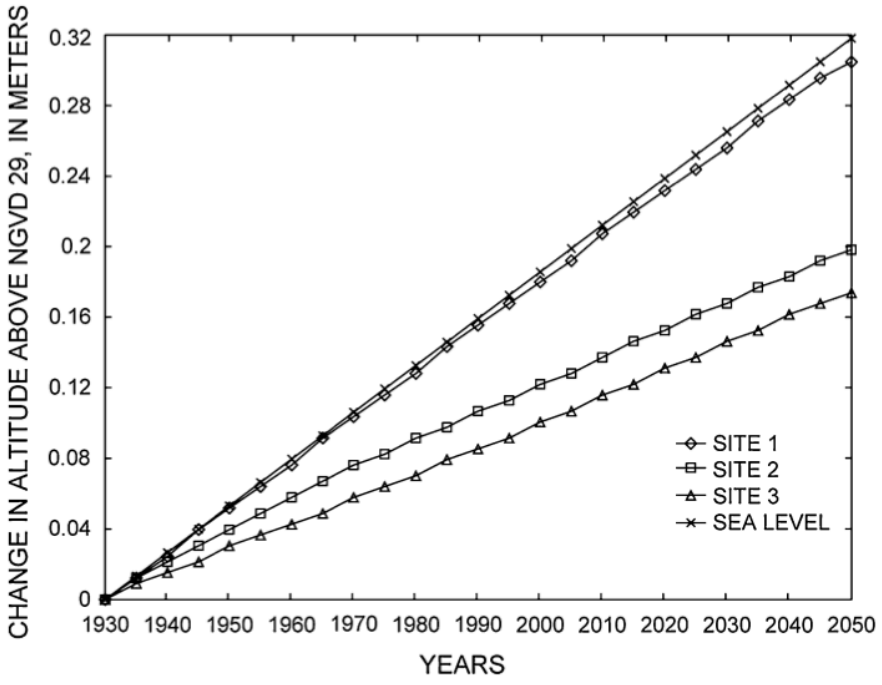


Figure 5. Changes in model-calculated water levels at sites 1, 2, and 3 in response to a simulated sea-level rise of 2.65 mm/year from 1929 to 2050.

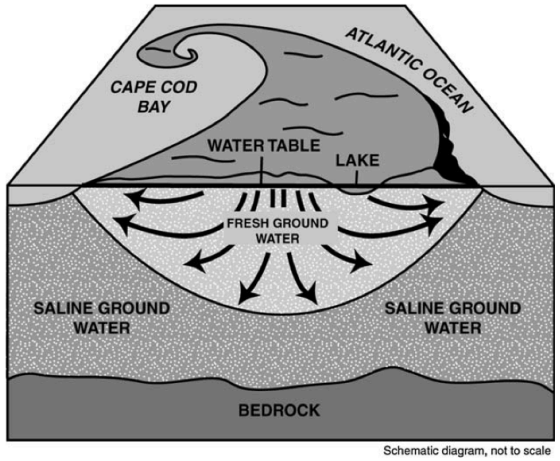
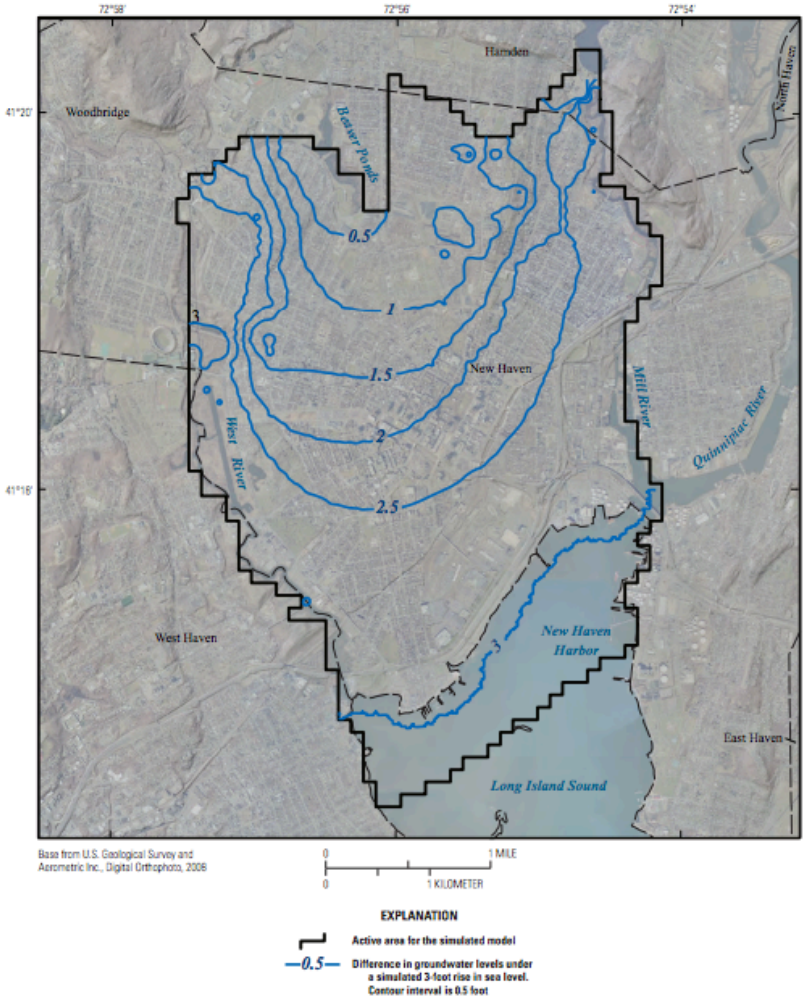


Figure 2. Schematic diagram of the Lower Cape Cod Aquifer system, Cape Cod, Massachusetts (modified from Strahler 1972).

Sites 1 and 3 300 m from coast;
Site 2 center of island
Site 3 adjacent to stream

The assumption that the primary threat to coastal aquifer systems from rising sea levels is the increased potential for surface inundation of saline water in low-lying areas does not consider the potential for a decrease in fresh water lens thickness from a net decrease in water levels relative to an increased sea-level position. [Masterson and Garabedian, 2007]

Groundwater Rise and Sea Level: CT



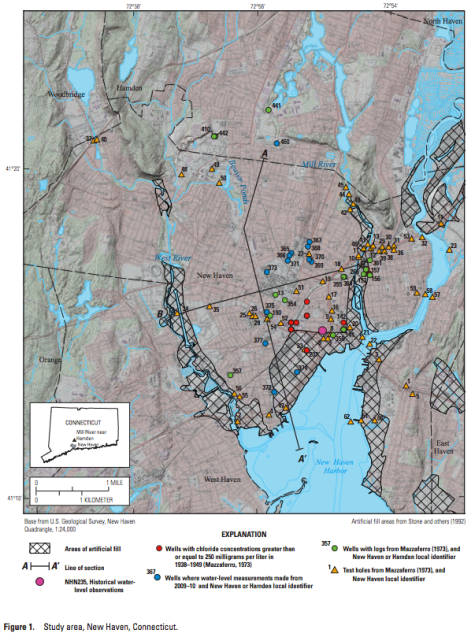


Figure 1. Study area, New Haven, Connecticut.

For 3-ft rise in sea level, simulated groundwater levels near the coast rose by 3 ft; increased water level tapered off toward a discharge area at the only nontidal stream in the study area. Stream discharge increased at the nontidal stream because of the increased gradient. *Bjerklie et al.,* 2012

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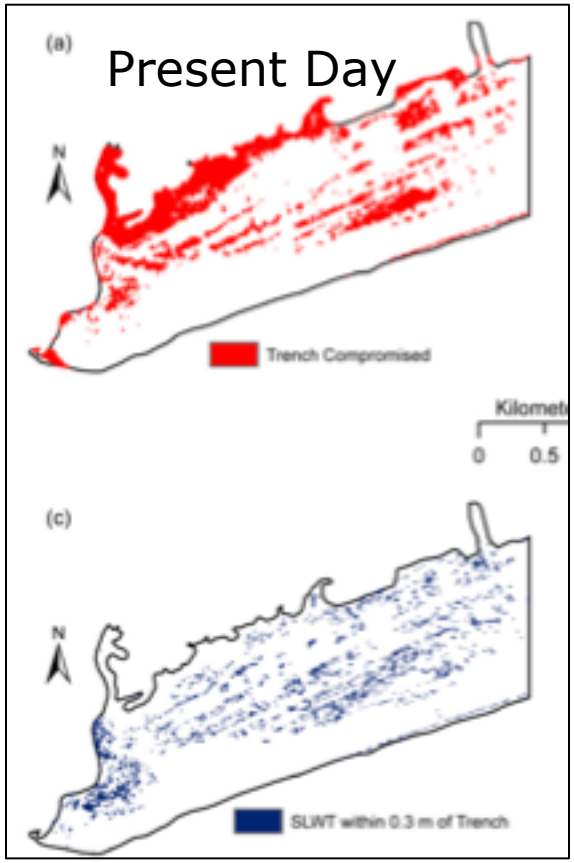
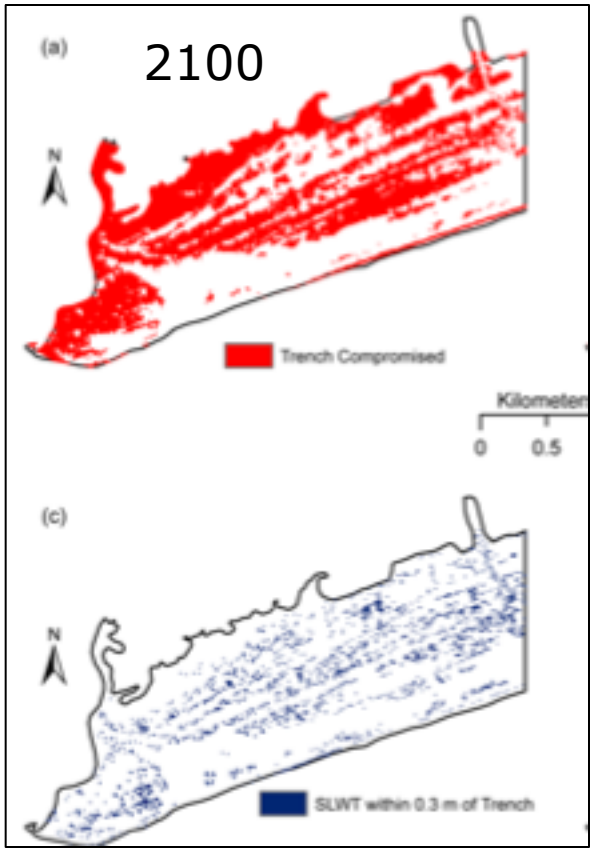
Groundwater Rise and Onsite Wastewater Treatment: NC

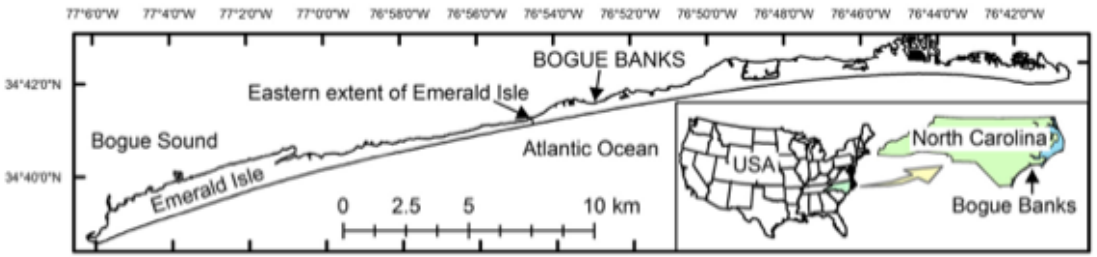




Simulated separation distance between the water table and the trench field for OWTS under a 1.0-m rise in sea level. show areas where the water table is above the drainfield trenches when the trenches are (a) 0.9 m below ground and (b) 0.45 m below ground.

Left: Present Day
Right: 2100

Manda et al. 2015



Study 1: Climate Adaptation for Coastal New Hampshire

Funding: New Hampshire Sea Grant

Climate adaptation for road infrastructure in coastal N.H.

- The goal is to further the mission of resilient seacoast communities by the coupling of nonstationary climate change and sea level rise information with **pavement design and performance methods** to inform vulnerability assessments and adaptation planning.

- The region's physical infrastructure is at increasing and critical risk from sea level rise resulting in increased inundation and **rising groundwater tables**.

- Anticipated changes could change the frequency, duration, and severity of road failures as well as the time and cost of reconstructing the pavement systems.

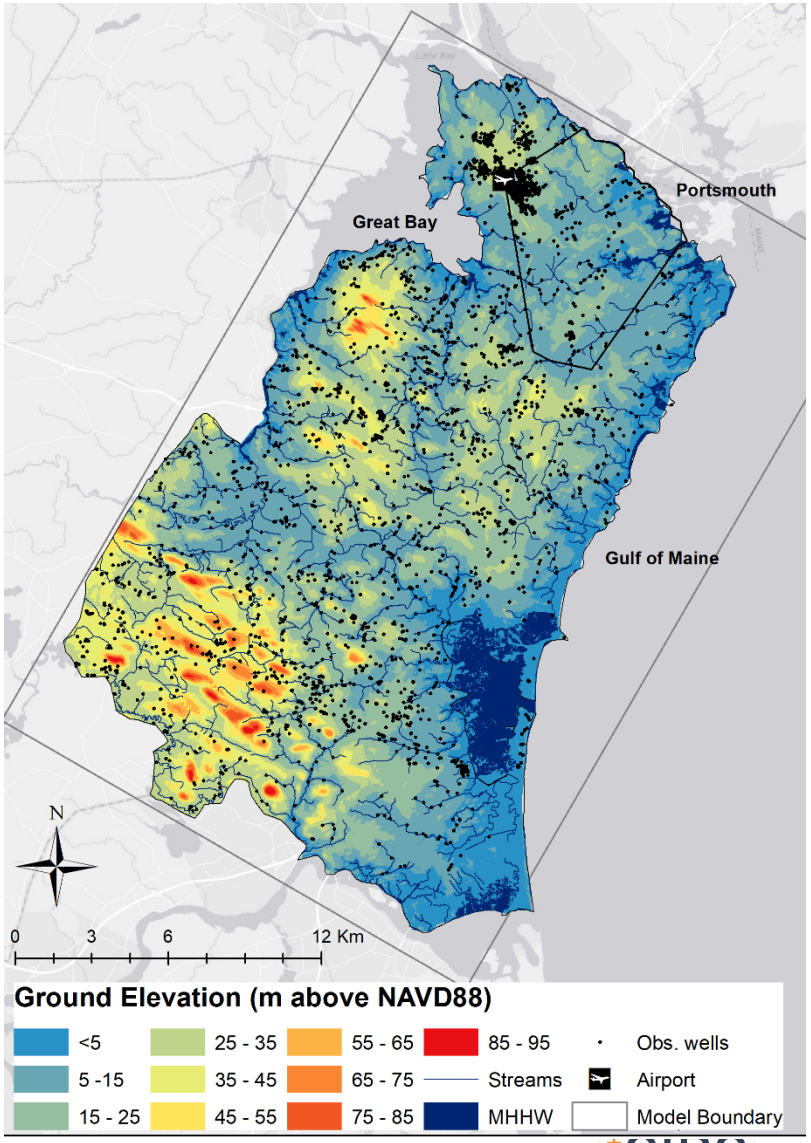
Modeling Groundwater Rise with SLR

Groundwater model

- USGS MODFLOW
- 3-dimensional finite difference model
- Existing model constructed for water supply prediction - modified for this study
- Run in steady state – no seasonal effects

Model construction

- Grid cell – 200'x 200'
- Surficial and bedrock geology
- Areal recharge
- Streamflow
- Groundwater pumping



NH SLR Scenarios

1 ft by 2030, 2.7 ft by 2060, 5.2 ft by 2090, 6.6 ft by 2100

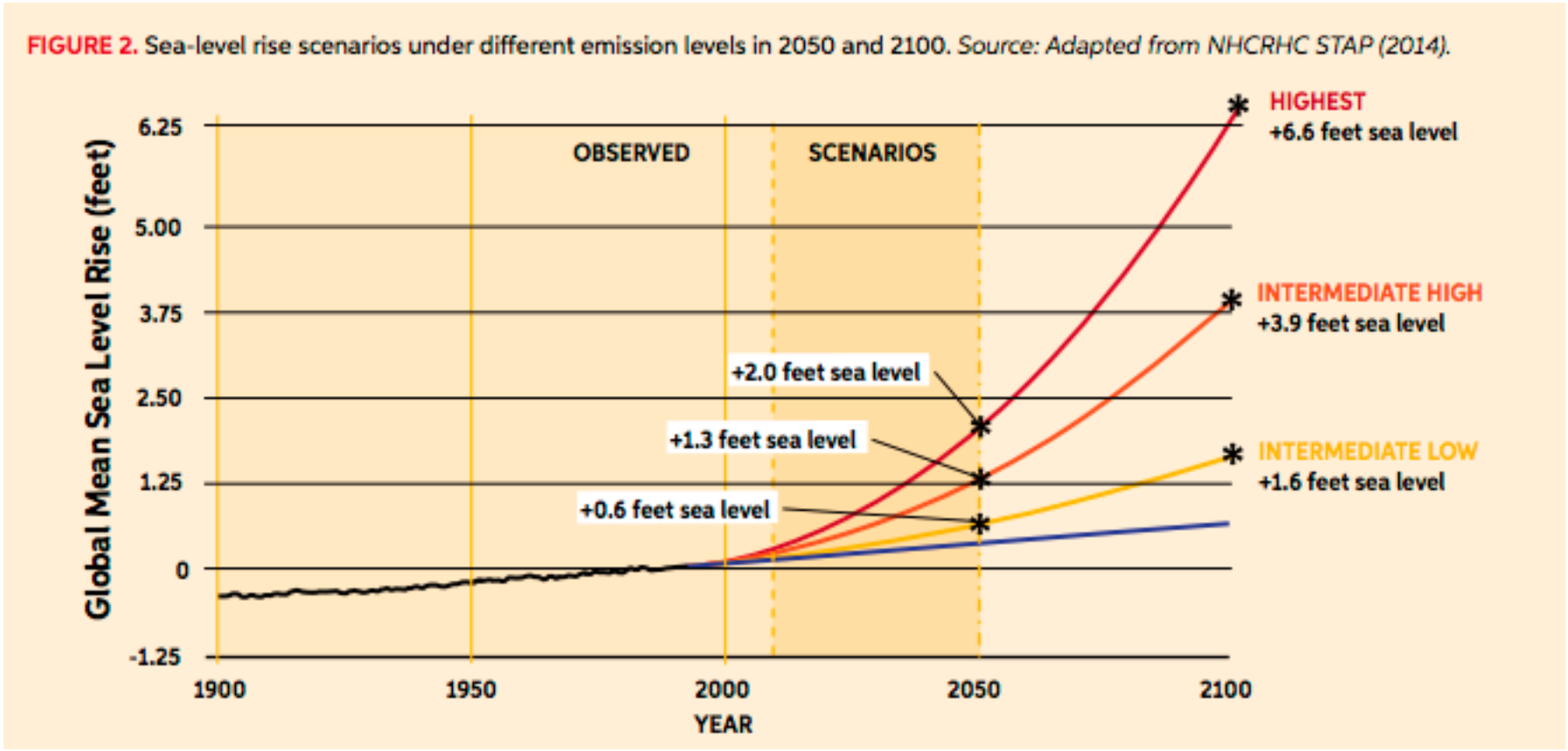
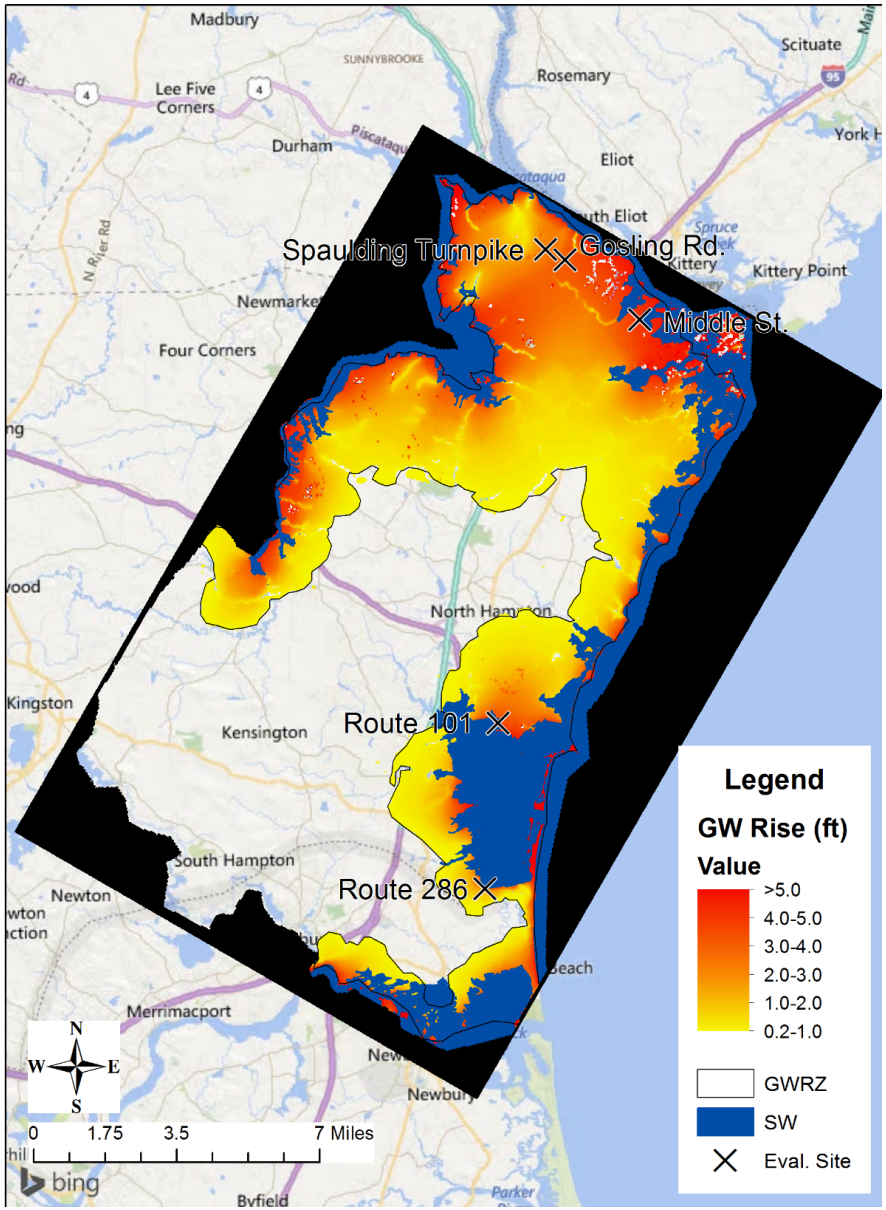


Figure 2 adapted from the NH Coastal Risk and Hazards Commission's Preparing New Hampshire for Projected Storm Surge, Sea-Level Rise, and Extreme Precipitation (2016).

Groundwater Rise with 6.6-ft of SLR

Groundwater rise with sea-level rise:

- Occurs further inland than surface-water flooding
- Magnitude is reduced in the proximity of streams
- Affected by local groundwater pumping



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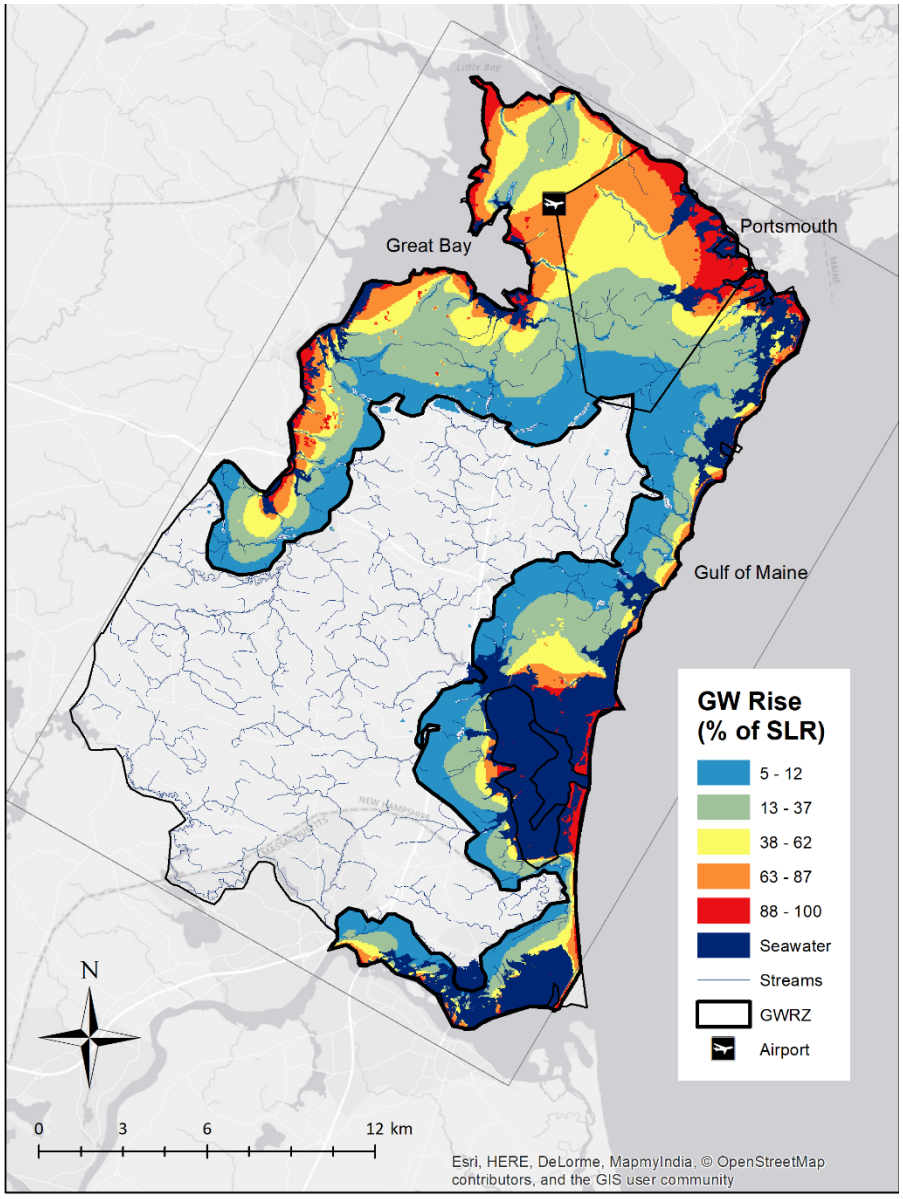
Groundwater-Rise Zone (GWRZ) - 6.6-ft of SLR

Groundwater rise (% of sea-level rise)

- Can result in ground-surface inundation from below



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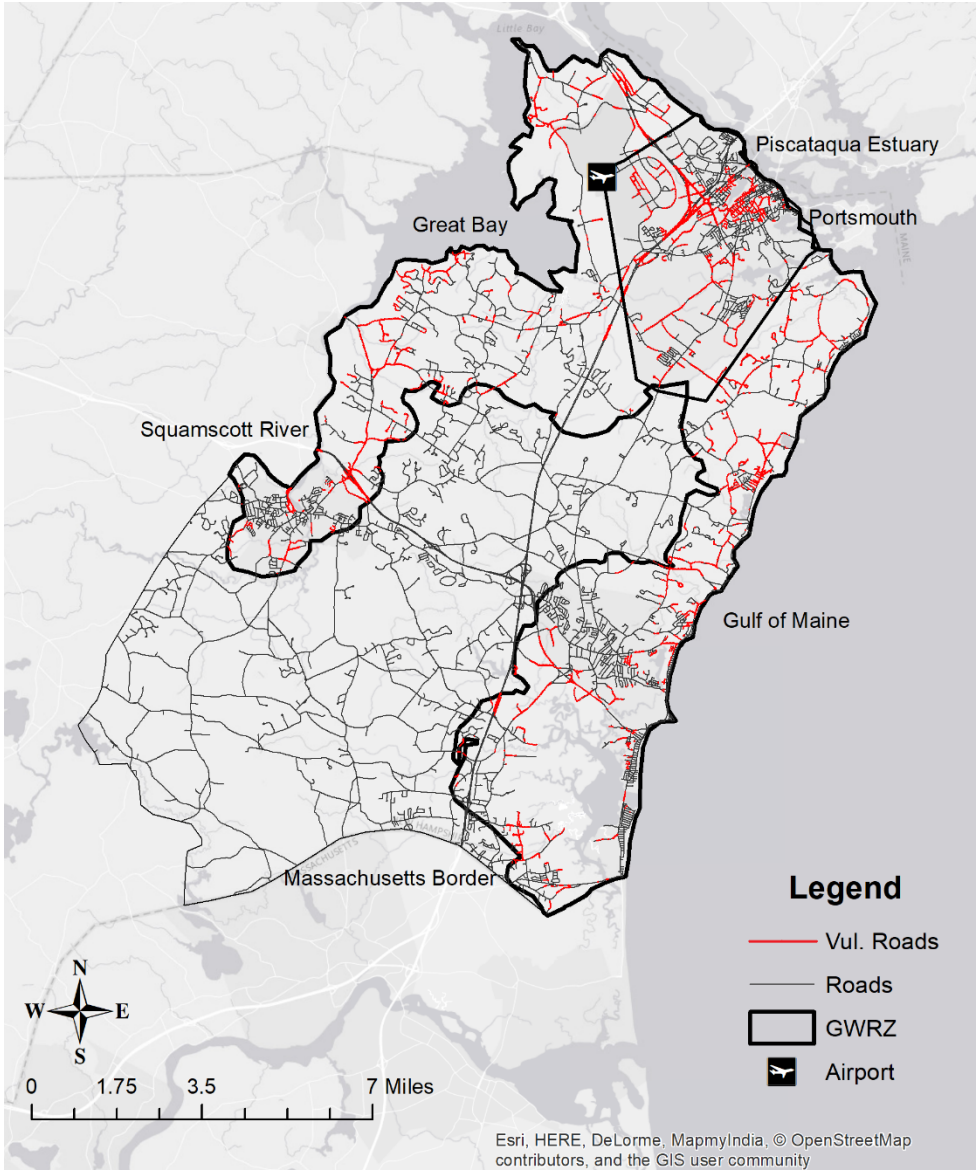
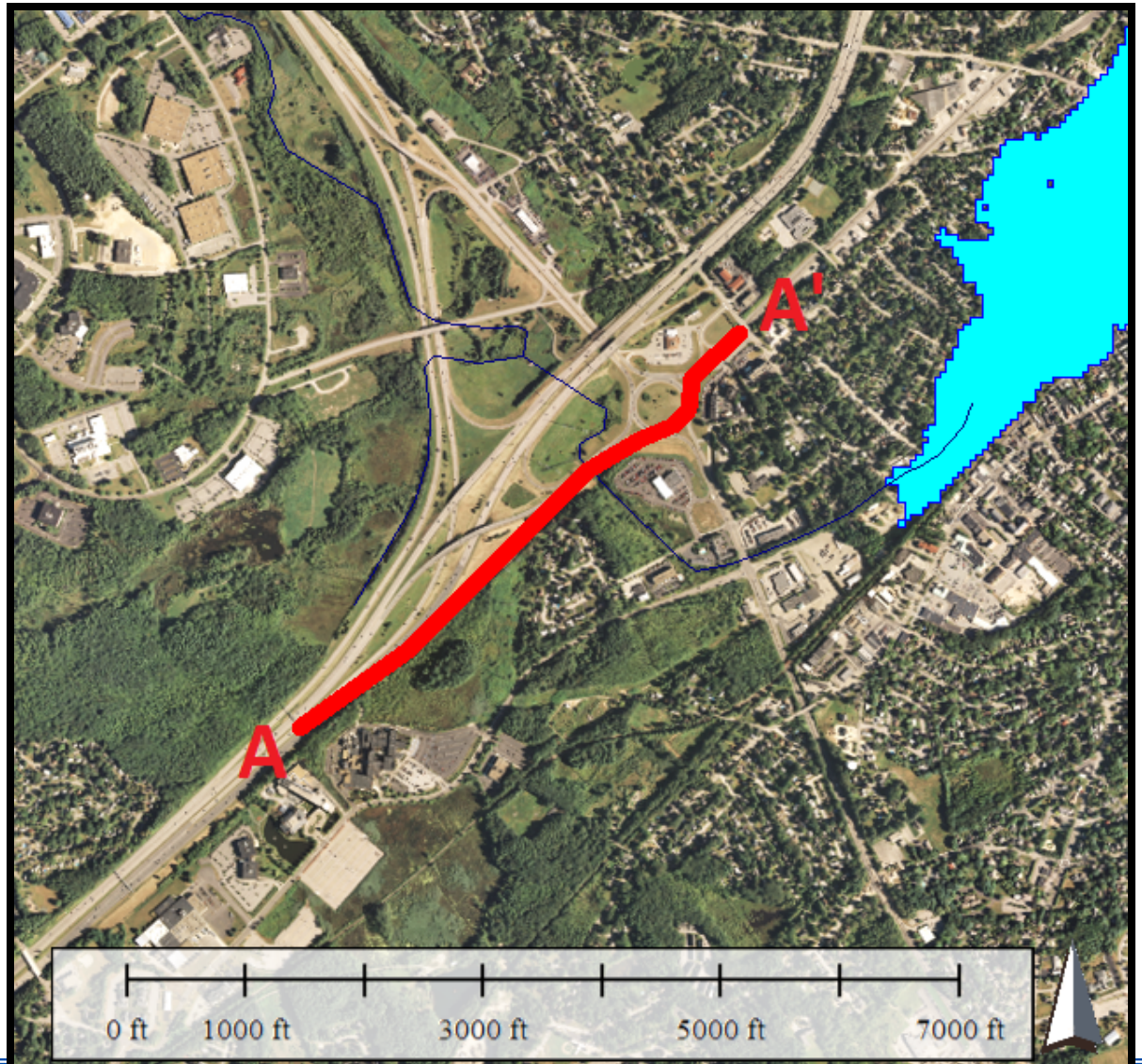
Where is infrastructure vulnerable?

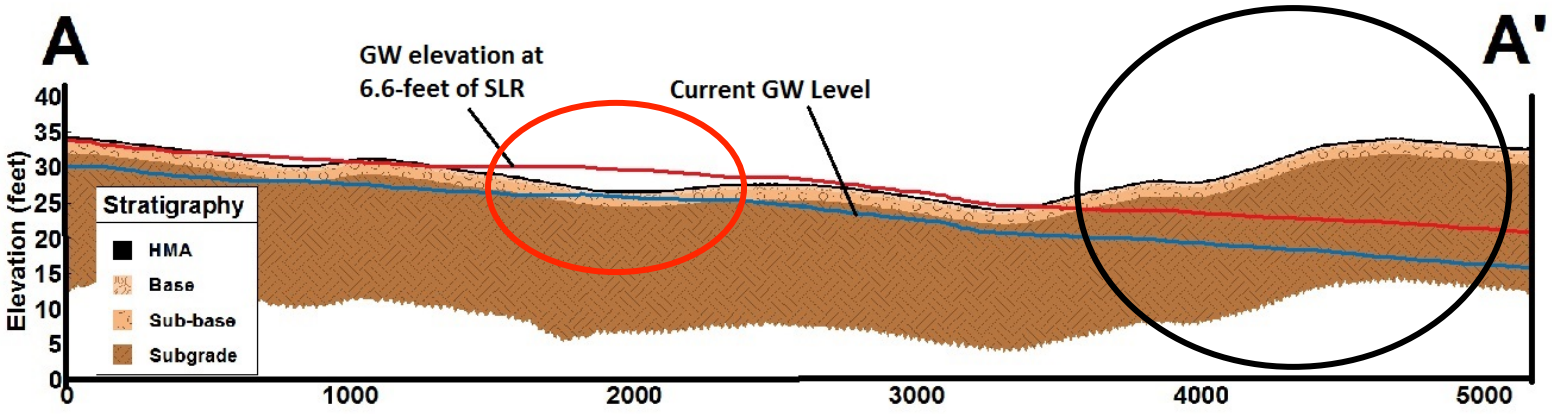


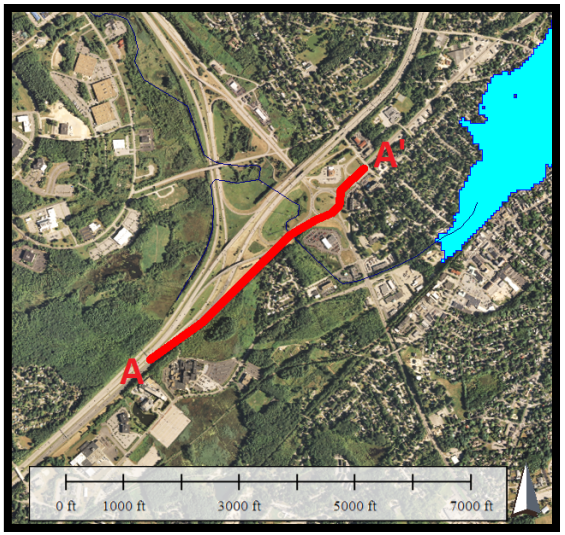
Vulnerable roads, within the groundwater rize zone (GWRZ) with groundwater less than 5 feet below the road surface, are highlighted in red.

Where is infrastructure vulnerable to damage from rising groundwater?



Where is infrastructure vulnerable to damage from rising groundwater?





The most vulnerable infrastructure are in the zone of groundwater rise where groundwater is already close to the ground surface

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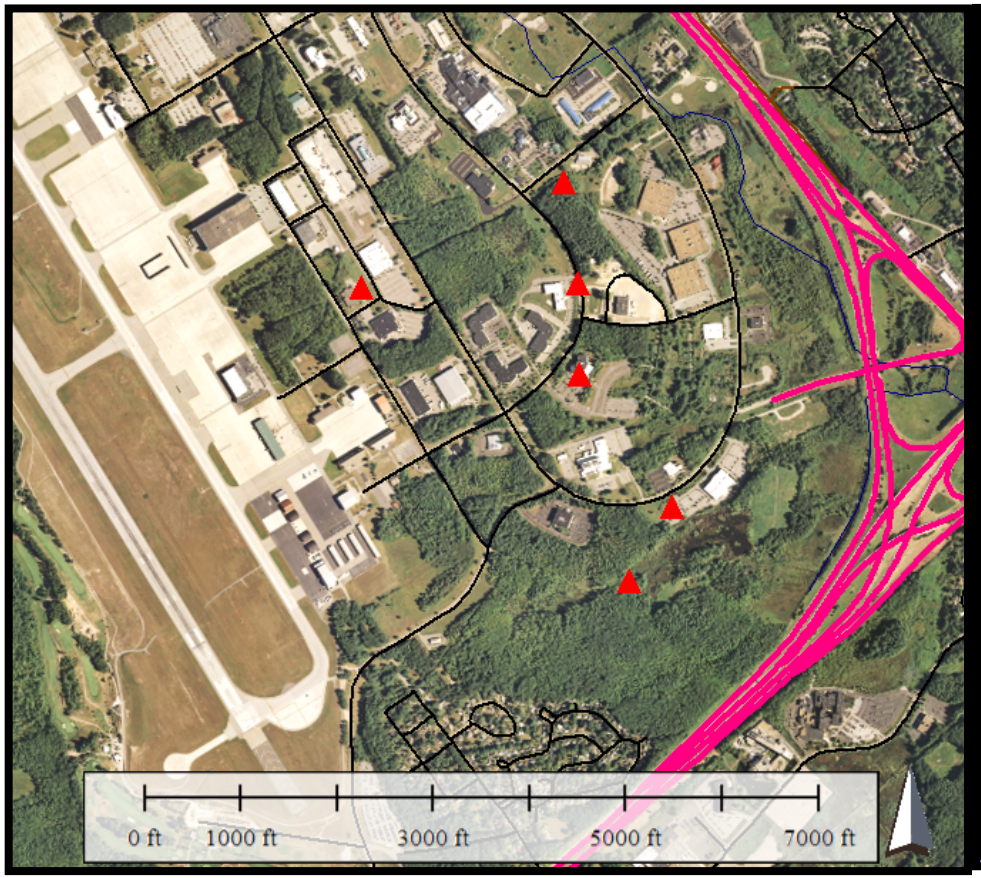
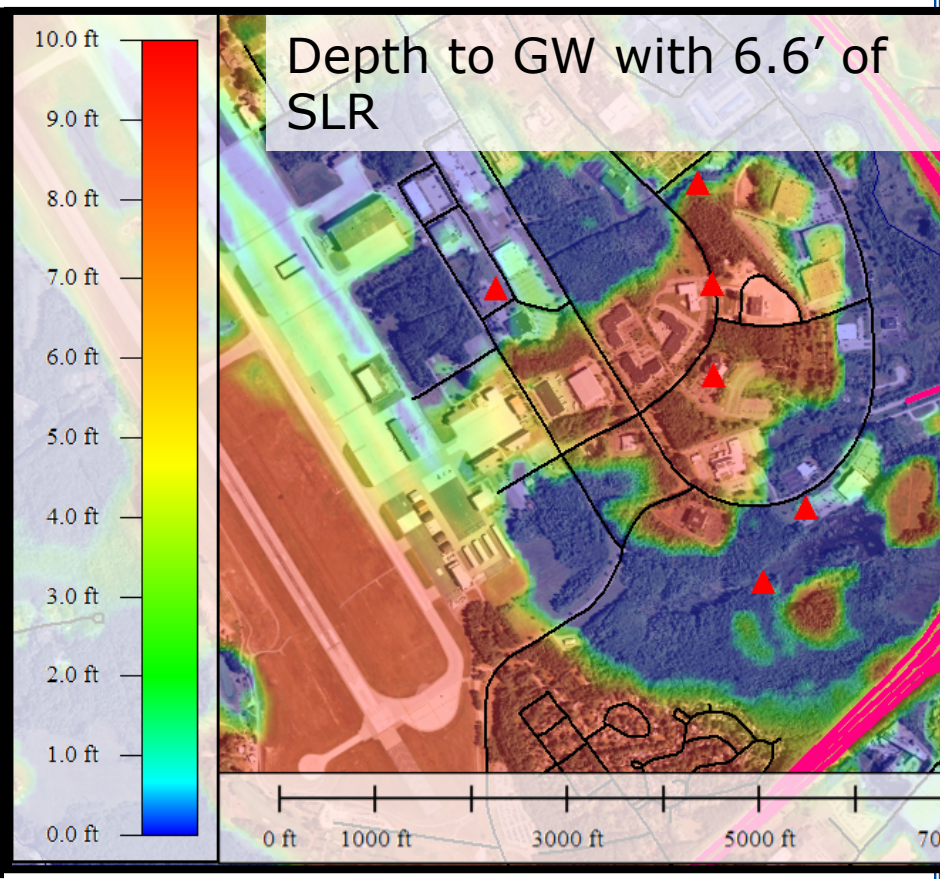
Where might rising groundwater come in contact with contaminated soils?

Pease Tradeport, Portsmouth NH

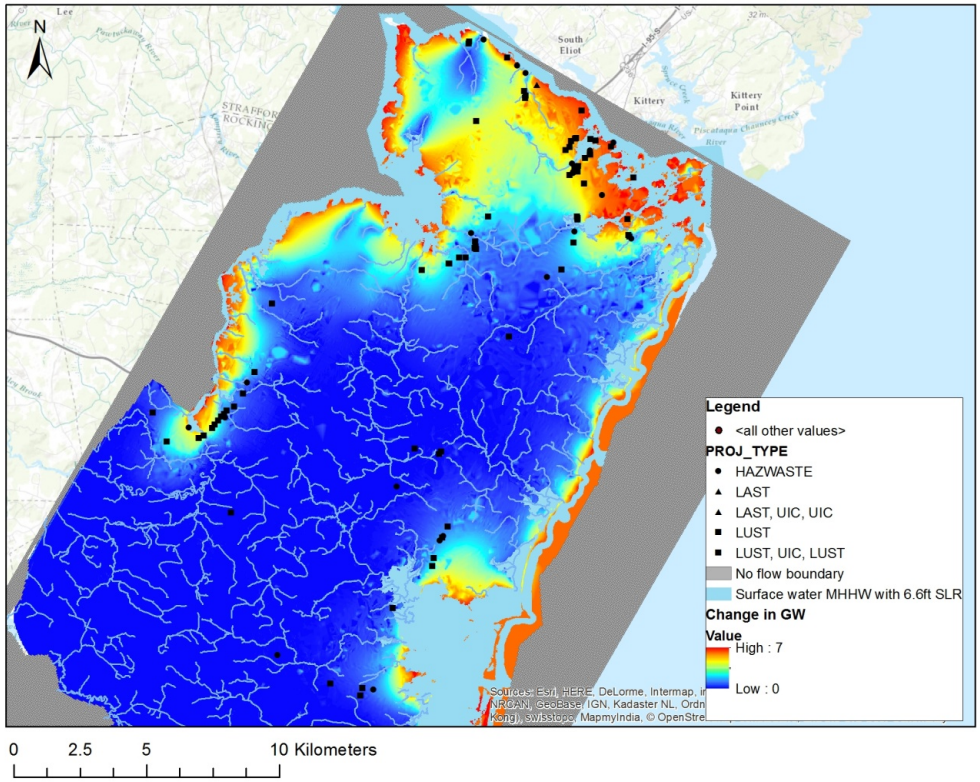




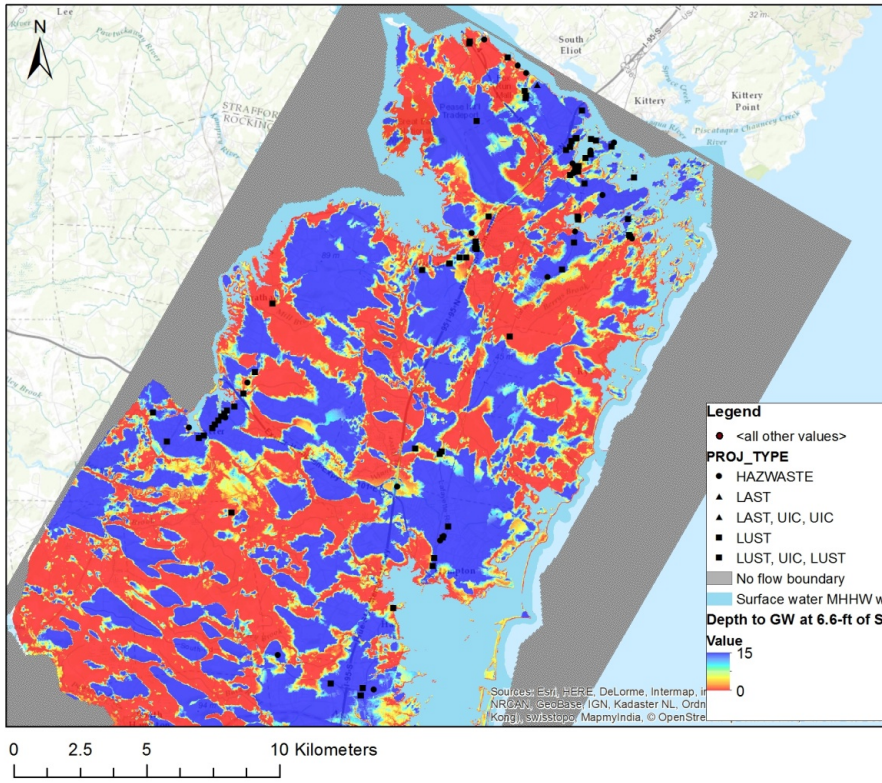
The red triangles are active remediation sites.

Where might rising groundwater come in contact with underground storage tanks & hazardous waste?

The change in groundwater level with 6.6 ft of sea level rise



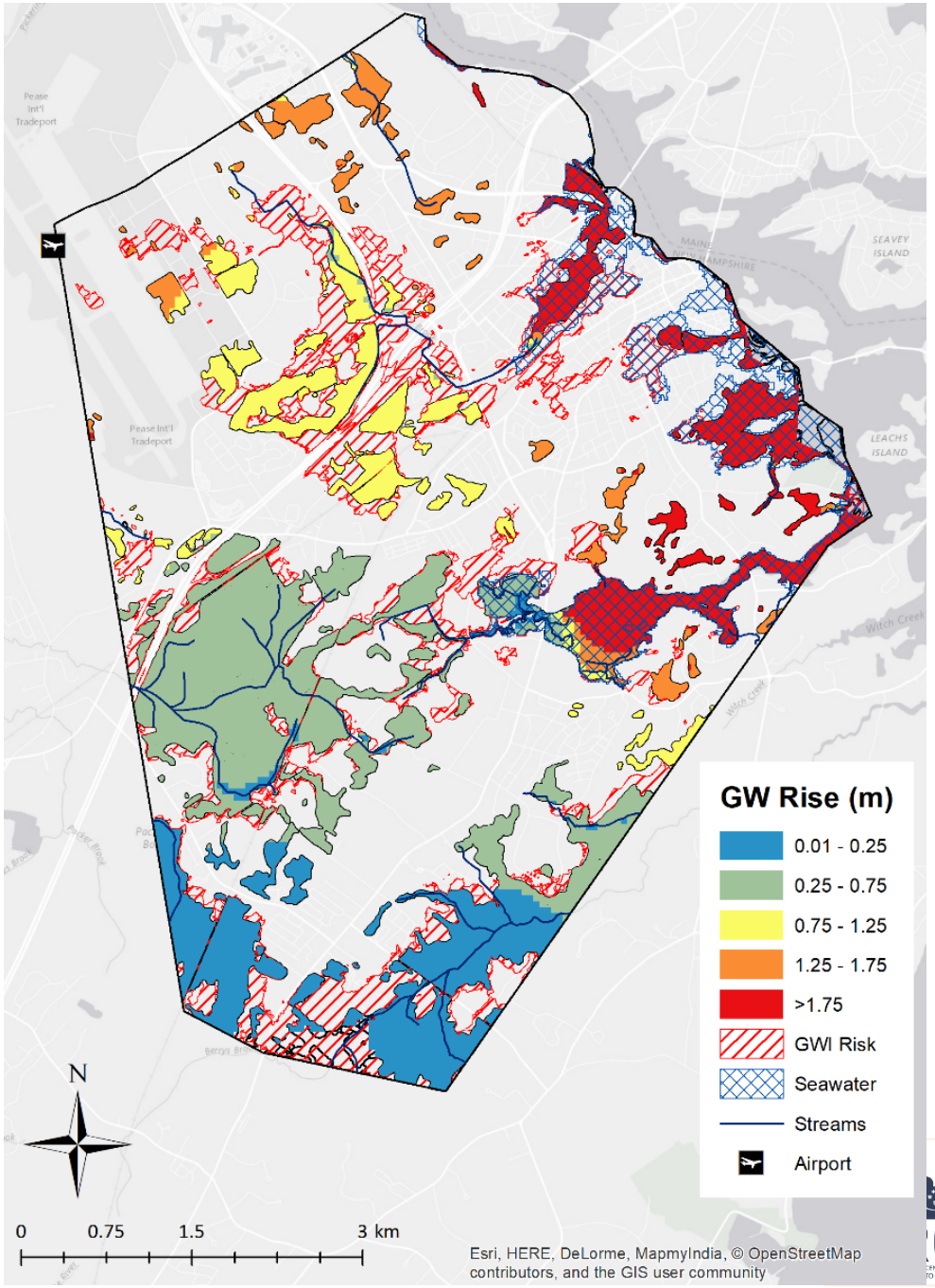
Depth to groundwater with 6.6 ft of sea level



96 sites, 73 leaking underground storage tanks (LUST), two leaking above ground storage tank sites (LAST), and 21 hazardous waste sites. 10 sites are potentially vulnerable.

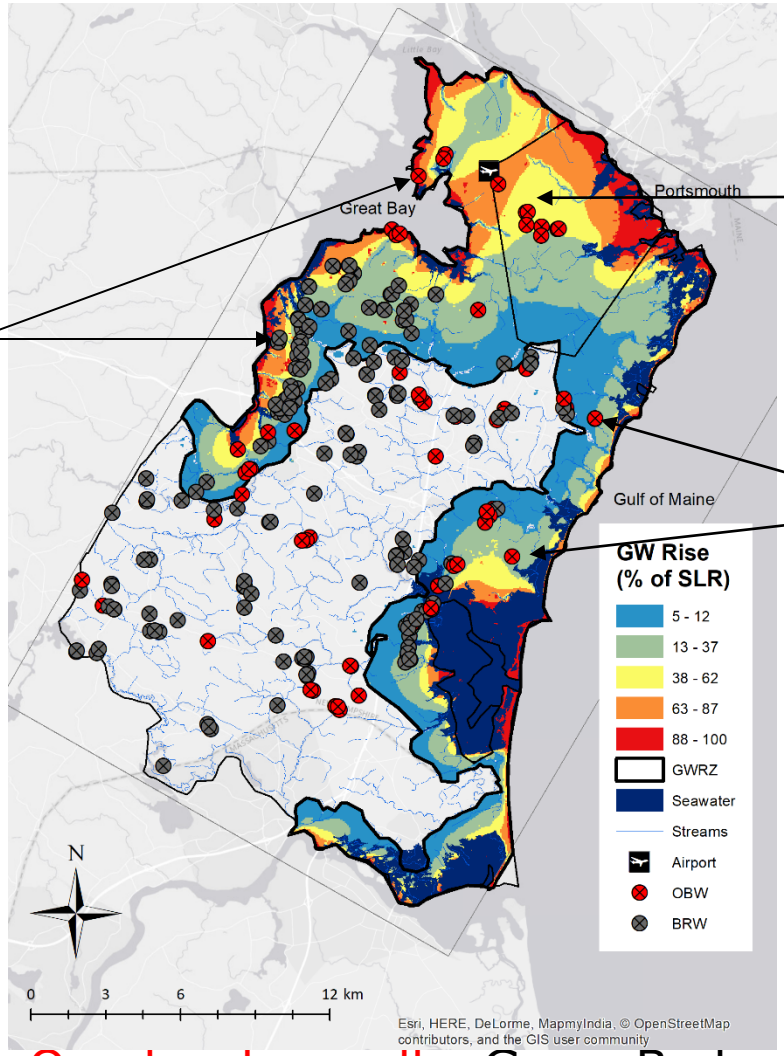
Where might rising groundwater impact marine and freshwater wetlands?

Portsmouth: Freshwater wetlands currently occupy 8.8 km^2. Wetland expansion in this area is projected to begin slowly with a 3% increase by 2030, a 10% increase by mid-century, and a 19 to 25% increase by the end of century.



Vulnerable drinking water supplies

Areas potentially at risk from saltwater intrusion with SLR



Area where GW is predicted to rise the most with SLR

Areas potentially at risk from saltwater intrusion with SLR

Red: Overburden wells Gray: Bedrock wells

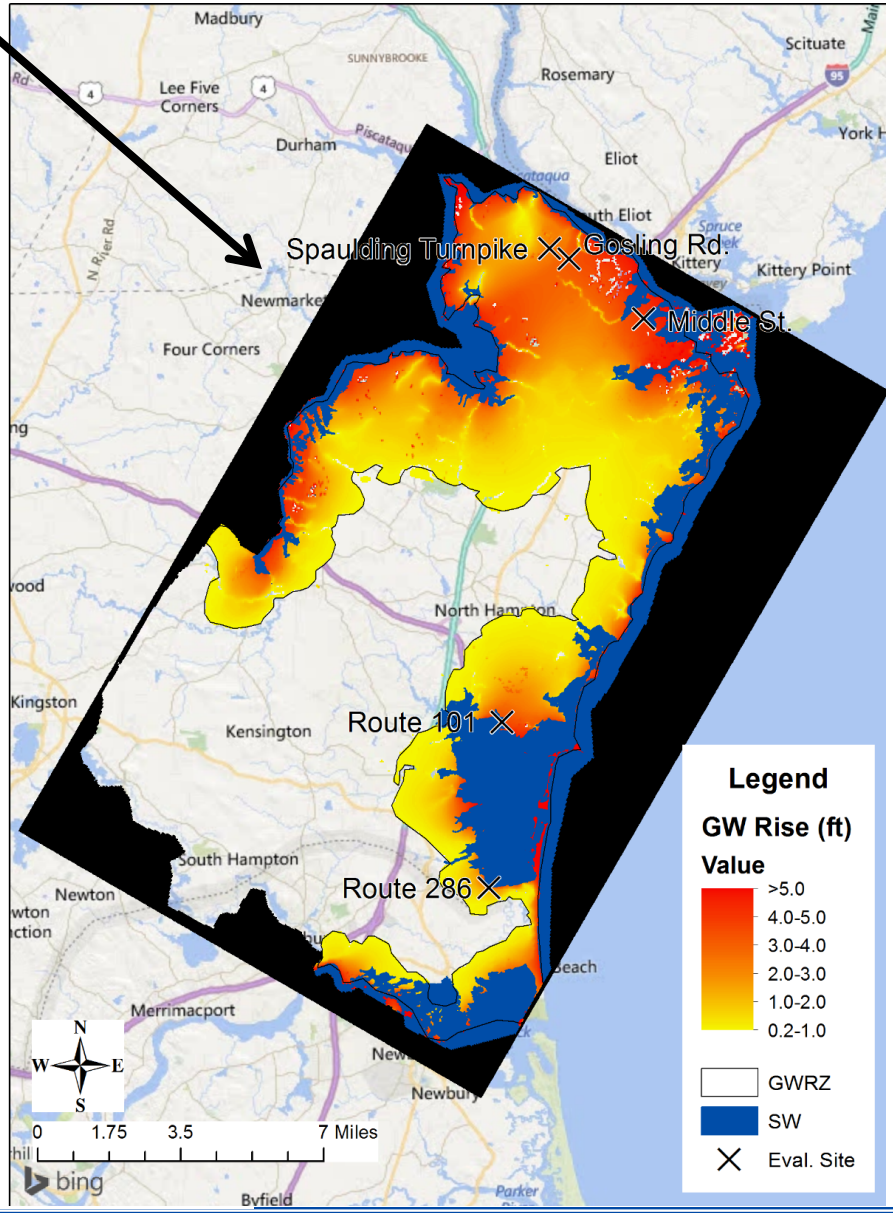
Study 2: Sea-Level Rise Impacts on Drinking Water A Groundwater Modeling Study in Newmarket, NH

Lead by Liz Durfee and Kyle Pimental, Strafford Regional Planning Commission

Funding: NHDES Local Source Water Protection Grant 2016

Newmarket, NH

Figure 1. Newmarket's Coastal Shoreline. [SRPC, 2017]



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Sea-Level Rise Impacts on Drinking Water A Groundwater Modeling Study in Newmarket, NH

The purpose of this study was to identify existing and potential future locations where public water systems may be vulnerable to sea-level rise impacts on groundwater.

With guidance from a Technical Planning Committee, a computer model was developed to analyze potential impacts of saltwater intrusion on groundwater and drinking water in the Town of Newmarket based on four sea-level rise projections.

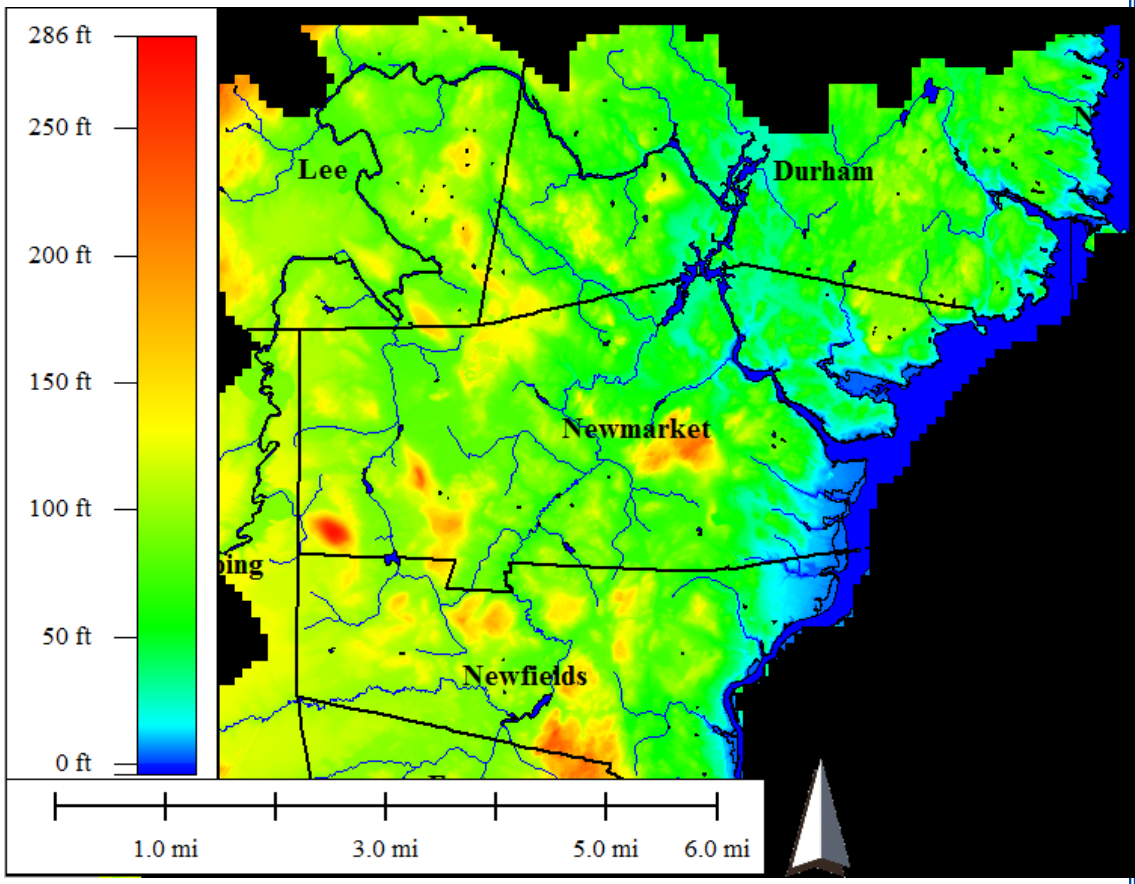
Modeling GW Rise and Saltwater Intrusion with SLR

Groundwater Model

- USGS MODFLOW2000 with SEAWAT2000
- 3-dimensional model with variable density and salt transport
- Transient model – inputs can vary with time

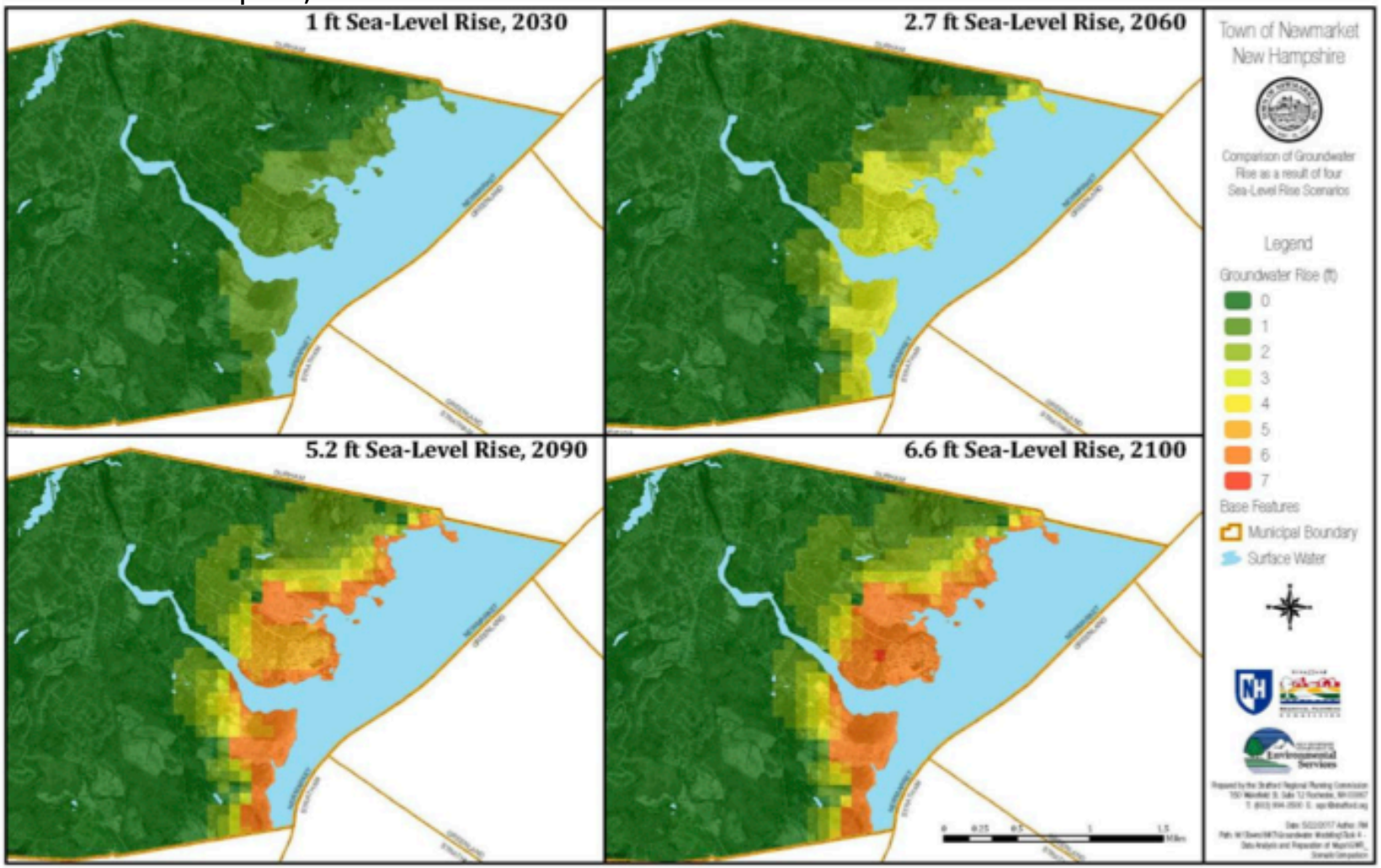
Model construction

- Grid cell size – 400'x 400'
- 22 layers
- Surficial and bedrock geology
- Areal recharge
- Streamflow
- Groundwater pumping



Groundwater Rise

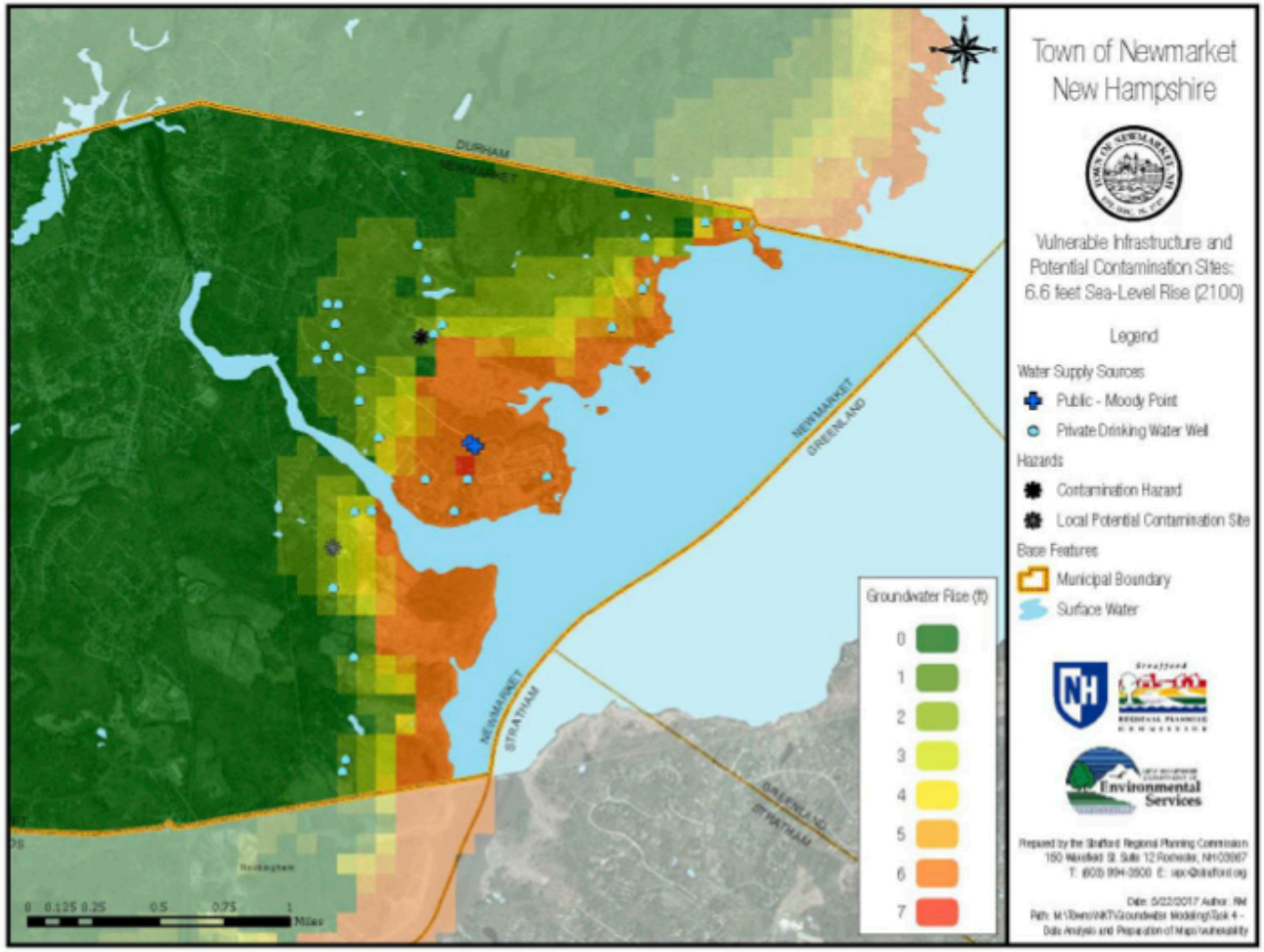
SRPC Draft Report, 2017



Groundwater rise ranging from 1 to approximately 7 feet with 6.6 feet of sea level rise is predicted to occur within 0.8 miles from the coast. Newmarket can expect to see impacts in a range of approximately 565 acres to 1,250 acres in the highest sea-level scenario.

Vulnerable Infrastructure & Contamination Sites

SRPC Draft Report, 2017



Three public drinking water supply wells at Moody Point, 30 private drinking water wells, and two potential contamination hazards are within the GW Rise area.

Salt Water Intrusion

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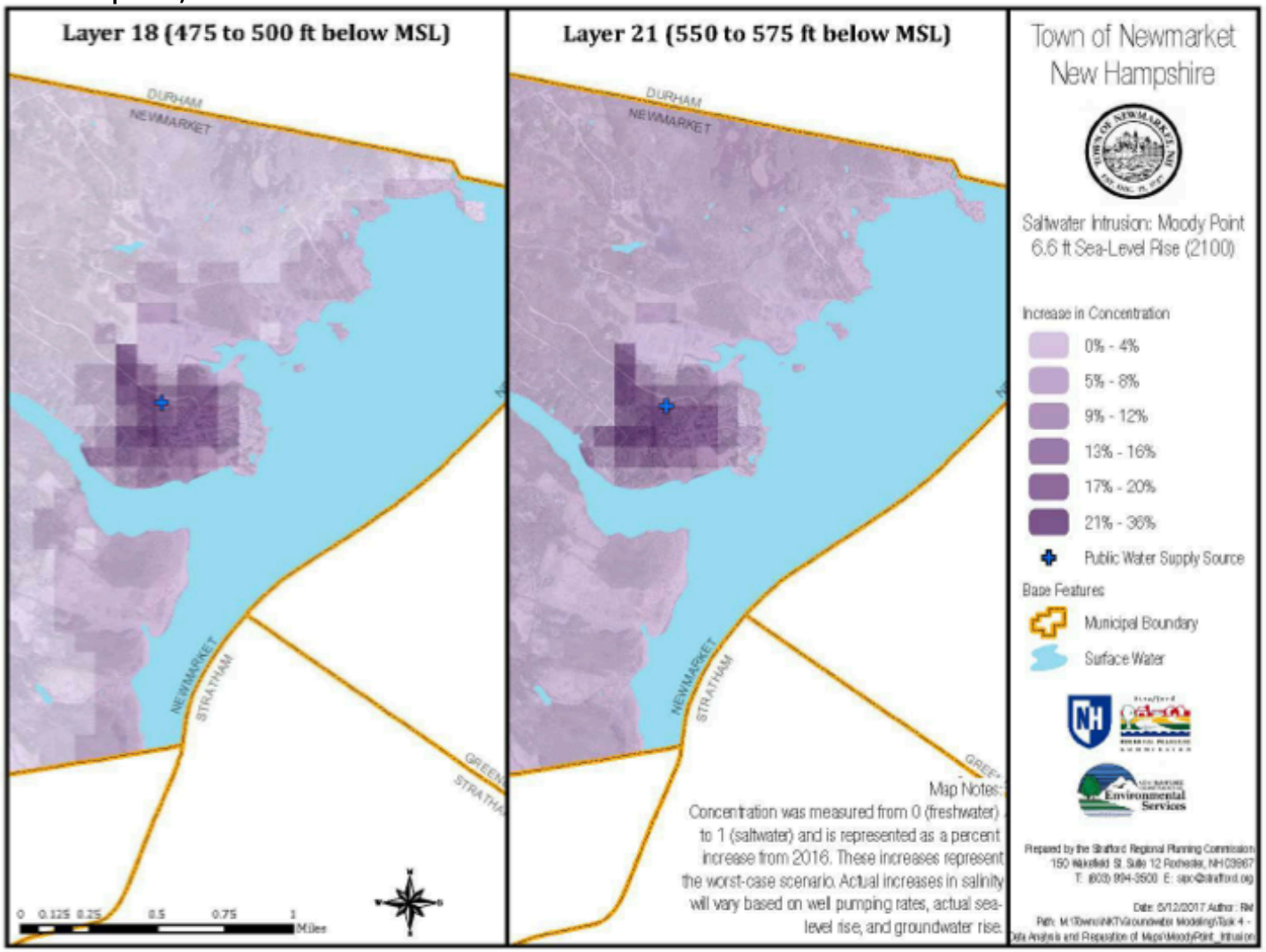

Moody Point, which already has elevated chloride levels (1000, 240, & 1400 mg/L), may experience an 8-12% in salinity concentrations.

Septic System Environmental Impacts

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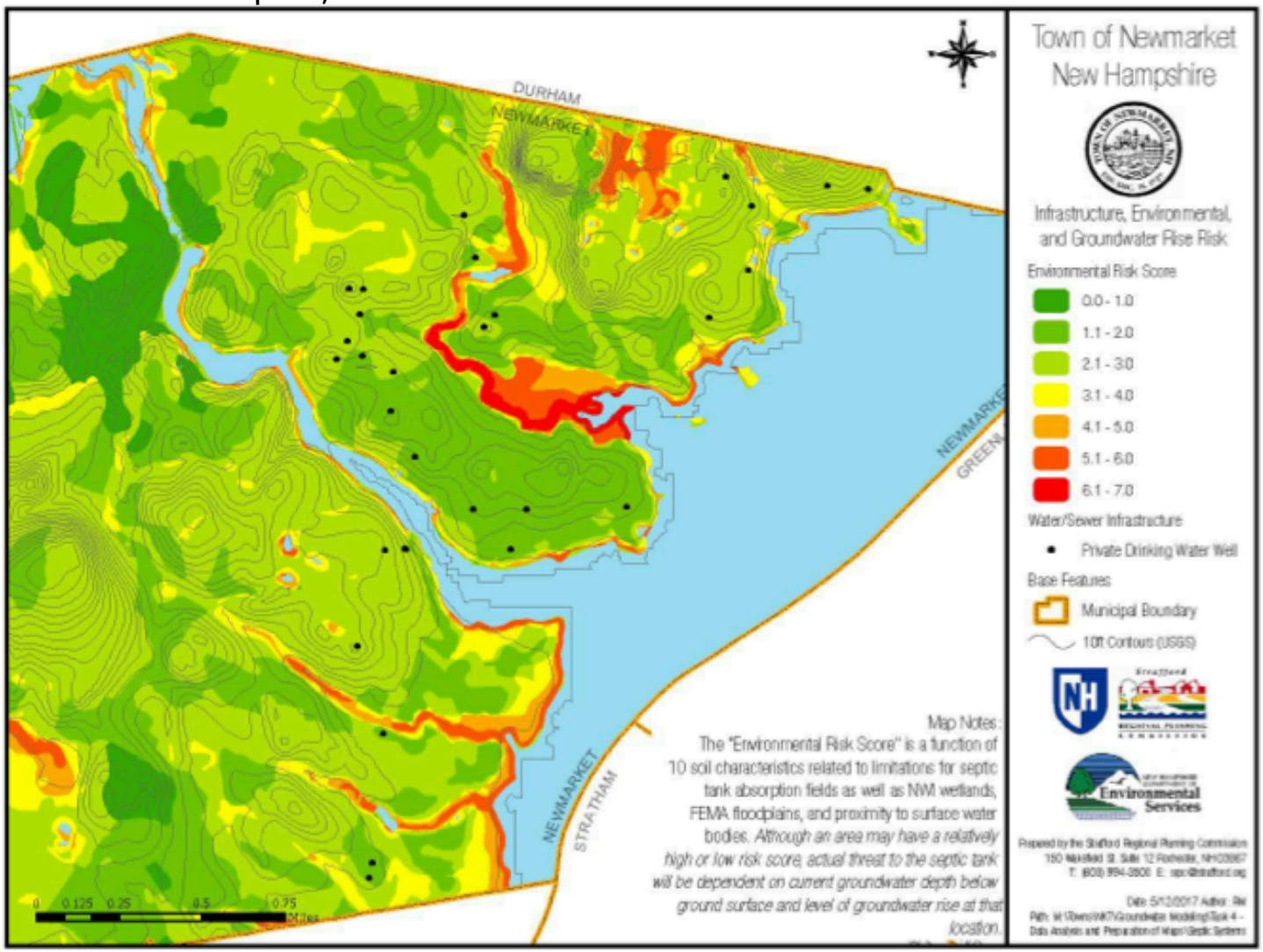

The Environmental Risk Score can be used to indicate where septic tanks & leach fields are more vulnerable to groundwater rise due to soil type and proximity to surface water features.

Groundwater will Rise with Sea-Level Rise – Why do we care?

1. Rising groundwater can **expand wetland areas**, cause **wetland ecosystem transition,** and result in **ground-surface inundation**.
2. Rising groundwater may **contact contaminated soils** from active and inactive disposal sites and **reduce on-site wastewater treatment effectiveness** resulting in **groundwater contamination**.
3. Sea-level rise can exacerbate **saltwater intrusion** associated with groundwater pumping in coastal areas.
4. When groundwater rises into the underlying supportive layers of **coastal road infrastructure**, it weakens the pavement structure.

How Actionable is Our Information?

Notes on Use and Applicability of this Report and Results:

The purpose of this vulnerability assessment report is to provide a broad overview of the potential risk and vulnerability of drinking water resources as a result of projected changes in sea-levels and coastal storm surge. This report should be used for preliminary and general planning purposes and to guide further investigations. The model is a conceptual model that is limited by factors including: a simplified representation of the geology; limited data on material properties, saltwater concentrations, and piezometric heads in groundwater; assumption of a constant pumping rate throughout simulation; a changing coastline was not simulated with sea-level rise scenarios; the uncertainties in sea-level rise projections.

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Thank you

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Including a publication on GW Modeling
https://www.unh.edu/erg/sites/www.unh.edu.erg/files/modeling_the_effects_of_sea-level_rise_on_groundwater_levels_in_coastal_nh.pdf
and its application to roads
https://www.unh.edu/erg/sites/www.unh.edu.erg/files/knott_et_al_2017_1.pdf

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