Climate Change and Sea Level Rise

Overview

The pull of the ocean is strong, and since the dawn of the late 1800s tourist era, East Coast communities responded by embracing the construction of summer "cottages" and, later, year-round homes that in many towns effectively filled all the space between frontal dunes and back dunes, with extra "buildable" land sometimes made available through the filling of salt marshes separating the back dunes from upland. Geologically, "barrier beaches" and salt marshes are intended to protect the upland from storms and are intended to move in response to wind, current and tides. Their use to support permanent communities of man-made structures comes at high risk.

Since those earliest homes went up, our world has changed: over-use of fossil fuels has imperiled the planet in the form of ever-rising global air and water temperatures that are increasing sea level rise, wildfires, droughts, and storm intensity, all of which endanger not only these well-loved seashore houses and their owners' pocketbooks, but the very financial viability of the towns that host them. Although infamous storms such as Hurricane Katrina and Superstorm Sandy get the headlines, the Maine coast faces a mounting danger because, according to NASA, the Gulf of Maine is warming faster than 99% of other water bodies. Houses have been lost to the sea one by one, and these incremental changes don't make the national news.

A Beach Avenue home being lifted onto a higher foundation in 2020 Photo credit: Janice Vance

Kennebunk's early development patterns were similar to most oceanfront communities. A substantial number of homes in Kennebunk's beach neighborhoods date back to the 19th century, when tourism first became a viable industry. Many of these homes have been raised by their owners onto much higher foundations, to limit damage from flooding and to mitigate ever-increasing flood insurance premiums. This project occurs sometimes in concert with demolition and replacement, to utilize the entire 30% volume increase permitted by zoning ordinance. The vast majority of houses in the beach community are used only seasonally, with some purchased intentionally as commercial ventures, and size impacts rent. To towns, these homes are valuable. The owners add no students to the school system and demand little in the way of Town services, but do patronize restaurants, shops, construction companies, food stores, property managers and real estate agencies. They also carry high value assessments for tax purposes. But they are vulnerable to changes wrought by future climate change. According to Southern Maine Planning and Development, the 719 parcels in Kennebunk potentially impacted by a potential 3.9 feet of sea level rise comprise 35.6% of the Town's 2020 real estate assessments.

Sea Level Rise

Sea levels are predicted to rise between 3 and 5 feet by the end of 2100. When ocean water is measurably higher *all the time*, and the level of the adjacent land stays static, the ultimate winner in the battle for dominance will always be the water.

Long-time residents and visitors can readily see that the amount of sandy beach usable at high tide has decreased over the years, and that the sea wall constructed to protect the adjacent sidewalk and roadway gets battered *all the time*. Water sloshes over the sea wall onto Beach Avenue routinely during minor storms and during astronomically high tides, transporting cobble and seaweed across the street and down roads and driveways. This "nuisance flooding" has increased exponentially in southern Maine over the past decade. Just 1 foot of sea level rise will increase it by 15 fold. With 1.6 feet of sea level rise, 33% of Kennebunk's Coastal Residential district will be inundated, including homes near the creeks and wetlands behind the back dunes – sea level rise also means higher levels in rivers that flow into the sea. The risk of flooding is not limited to coastal properties; because of an increase in the frequency of extreme rainstorms, homes far upstream can be flooded during a high-intensity event.

The ocean crosses Beach Avenue and flows down Boothby Road during a 2018 nor'easter *Photo credit: Betsy Smith*

Besides physical damage to homes along the coast, sea level rise creates other, more insidious challenges to towns' abilities to maintain homes and roadways near the ocean and along tidal rivers:

- Rising sea levels push salt water further inland, raising the water table, and contaminating freshwater drinking wells with salt water;
- Drinking water aquifers near the coast can become contaminated by intrusion of salt water (the edge of the aquifer closest to the ocean in Kennebunk is along Branch Brook, a distance of about one mile inland);
- Septic systems and leach fields, which must be constructed above the water table in order to properly drain, fail as salt water inundates the ground and prevents drainage;
- Roadways are damaged when the underground base of stone and gravel becomes saturated by salt water and pavement is pushed up, causing premature fractures and ultimately failure of the road surface.

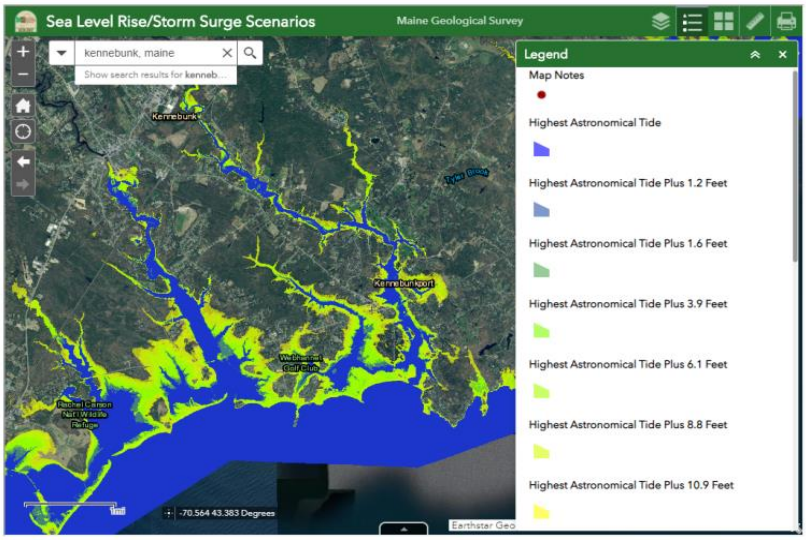
Most of Kennebunk's coastal neighborhoods are served by public water and sewer – with some exceptions. That would help delay the effect of groundwater rise for a time; however, because water and sewer lines are generally placed under roadways, when groundwater rises to a point where the road surface is profoundly damaged, the integrity of the lines beneath it will be compromised as well.

A few coastal areas in Kennebunk do rely on private septic systems, which are at risk of failure as sea level rise continues. Oceanfront homes that could be impacted are along Great Hill Road, Parson's Beach Road, and Crescent Surf Road; in addition, tidal sections of the Kennebunk River that could be potentially affected are predominantly in the River Locks neighborhood, on Hussey Drive, Sea River Oaks, Bufflehead Cove Road, and Ship Locks Lane.

Storm Tide and Storm Surge

If sea level rise is responsible for so-called "nuisance flooding," that nuisance escalates to crisis proportions during nor'easters and hurricanes. Nor'easters – which occur often in Maine - bring high winds, torrential rain, and storm tide, sometimes for multiple days, raising the already-elevated sea level exponentially. A typical

nor'easter pattern is that during each subsequent high tide during the duration of the storm, storm surge pushes further and further inland as frontal dunes erode or flatten. When the next obstacle in the path of waves is a row of structures, anything built close to ground level – garages, sheds, homes on their original (lower) foundations – can easily be damaged or destroyed. During bad storms, ocean water meets back creek and coastal wetlands water.



These storms are now more intense than in earlier decades – due to climate change - with heavier rainfall and higher winds. Both storm tides and storm surge played a role in the severe flooding New Jersey, New York and Connecticut experienced during Superstorm Sandy in October 2012. Because of Maine's tidal variation, the potential combination of astronomical tide and storms is extremely concerning.

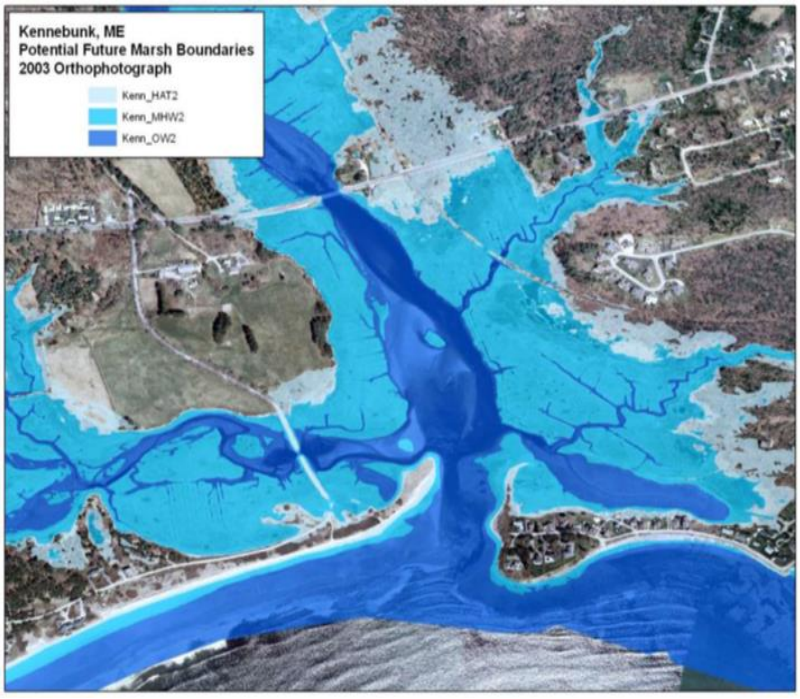
Potential Hurricane Inundation

Potential hurricane inundation mapping has been done in Maine through a FEMA grant to Maine's Floodplain Management Office accompanied by consultation with National Hurricane Partnership representatives on tool development, proposed process and techniques. The Geographic Information System (GIS) tool that was developed uses Sea Lake and Overland Surges from Hurricanes (SLOSH – developed by the National Hurricane Center) to model the data.

Modeling potential hurricane inundation scenarios can assist in investigation of potential impacts to critical infrastructure, storm evacuation planning, emergency management planning and community outreach and education.

Impacts to Marshes

Coastal wetlands as defined in Maine's shoreland zoning regulations refer to all tidal and subtidal lands which have salt water tolerant vegetation present and any swamp, marsh, bog, beach flat or lowland that is subject to tidal action during the highest tide level. Coastal wetlands can include portions of coastal sand dunes. There are two types of coastal wetlands, called marshes, which play a role in protecting Kennebunk. *Low marsh* is intertidal, so is covered and exposed by the tide each day. *High marsh* is the area of salt marsh that is only sporadically covered by water. High marsh and low marsh areas are delineated using tidal elevations as proxies



for actual on-the-ground surveying. To quote a 2013 report on sea level rise undertaken for Sustain Southern Maine*: "Marshes provide valuable ecosystem services, including pollution filtering and flood buffering. Not only do they slow and buffer waters during coastal flood events, but they also slow erosion which might otherwise affect developed areas."* The report provides assessments for each of 13 southern Maine communities, and for Kennebunk, it concludes that *"marsh migration is…likely to be an issue for Kennebunk…along lowlands adjacent to the Kennebunk River. Even modest amounts of (sea level rise) could cause extensive changes to marshland in this area."*

Marshes can migrate inland and have been able to do so during the gradual sea level rise experienced since the last Ice Age; but when sea level rise rates increase, high marsh environments cannot survive the increased inundation and give way to low marsh environments. This decreases the diversity of salt marshes as a whole and diminishes their ability to buffer the shoreline from erosion. If the rate of sea level rise is too rapid or abrupt, low marsh environments will also drown, leaving the shore unprotected from battering waves. Another factor that limits marsh migration is development – houses and roads block marshes from moving inland.

Planning for Future Infrastructure Impacts

Losing expensive oceanfront real estate during a storm is financially devastating. But flooding of roadways and bridges during a storm event, potentially trapping residents in their homes and preventing emergency service response, can potentially result in loss of life. A further concern is permanent damage to infrastructure including roadways, bridges, culverts, sea walls and public utilities, which impacts tourism, access to homes, and a town's financial integrity. The table on this page shows data that indicates the linear footage of roads impacted under multiple flooding scenarios, including the effects of Category 1 and 2 storms when added to increases above the current HAT. Four streets are of immediate concern: Parsons Beach Road, Crescent Surf Drive, Beach Avenue, and

Road Name	Scenario							Legend	
	HAT	HAT + 1 ft	HAT+2 ft	HAT+3.3 ft	Cat 1 MHT	HAT+6 ft	Cat 2 MHT		No impact
Arundel Way			188	328	324	520	520		1-50 ft
Atlantic Cir			141	236	264	334	356		50-100 ft
Bayberry Ave		168	714	2276	2365	3182	3182		100-150 ft
Beach Ave	50	52	54	947	1017	5849	7447		>150 ft or entire road
Blue Heron Ln							132		
Boothby Rd		243	652	963	983	2081	2412		
Bruen Pl				177	226	346	347		
Bufflehead Cove Ln						16	141		
Cattail Path							40		
Christensen Ln						156	243		
Christopher Rd							141		
Commodores Way							26		
Coveside Ln						17	42		
Crescent Ave					27	137	137		
Crescent Surf Dr	21	310	1151	1352	1428	1826	2174		
Doanes Wharf Rd		39	149	220	223	330	357		
Durrells Bridge Rd	11	11	14	16	20	296	302		
Dutcher Ln			124	277	286	439	440		
Ebb Tide Ln			57	109	113	254	280		
Evergreen Ave			258	745	761	761	761		
Fairway Dr						259	404		
Forest Hill Ln		136	256	325	341	467	642		
Gooch Ave			223	693	831	1454	1454		
Governors Way						238	404		
Great Hill Rd				486	279	2589	2770		
Harbor Ln			230	425	425	816	816		
Harris Ln			196	303	320	448	483		
Harts Rd			76	925	1015	2035	2461		
Hickory Ln						75	221		
Larboard Ln						761	923		
Leeward Ln				174	177	212	212		
Linden Ave						49	95		
Little River Way					31	136	229		
Lords Point Rd				414	518	693	738		
Magnolia Ave		102	238	249	249	249	249		
Marsh View Ave			167	1007	1017	1332	1331		
Mineral Spring Way						133	186		
Oak St						59	341		
Oceanside Ln				43	61	261	262		
Old Port Rd						15	175		
Parsons Beach Rd	376	1082	1473	2473	2296	3630	4992		
Peninsula Dr		32	518	1318	1327	1374	1374		
Preserve Dr				115	121	275	363		
Railroad Ave				135	135	622	622		
Ridge Ave						346	401		
Robie Rd			123	512	578	632	632		
Rocky Shore Ln							27		
Sand Dollar Ln						102	144		
Sandy Point Ln						87	167		
Sea Fields Dr						312	648		
Sea Garden Cir				129	171	454	677		
Sea Grass Ln			104	448	474	962	962		
Ship Locks Dr						85	277		
Shorebreezes Ln						94	476		
Shoreline Way				22	22	249	382		
Starboard Ln			59	123	170	300	300		
Strong Ln							33		
Surf Ln			467	2049	2224	2604	2604		
Tidewater Ct							122		
Valley Ave						431	696		
Water St				49	33	95	294		
Wentworth Ave							14		
Western Ave		14	1125	2971	3167	6059	7321		
Woodland Ave			10	124	138	626	1068		

Durrell's Bridge Road. Although the first two serve a private oceanfront community that is predominantly seasonal, the second two are highly-traveled public roads.

Having this information allows the Town to create adaptation or mitigation strategies so that evacuation and/or detour routing plans are readily available when a storm is expected. It also allows long-term planning, when a community opts to build new roadways or bridges further inland, or elevate those deemed to be critical to the functioning of the community.

The Town is currently engaged with the *Tides, Taxes, & New Tactics* project, led by Southern Maine Planning and Development Commission (SMPDC) and funded by the Maine Coastal Communities Grant program. The project involves the towns of Kennebunk, Wells, and York and addresses the need to provide towns with vital information about sea level rise impacts, local vulnerabilities, and tailored strategies for protecting people, property, and natural resources from the impacts of coastal flooding. The project team is working in partnership with the three towns to investigate municipal-level economic and social impacts of 1.6, 3.9, and 6.1 feet of sea level rise and develop adaptation and resilience planning strategies that address those impacts. Municipal staff members from each community serve on a Project Advisory Committee (PAC) to guide the project and ensure that the methodology, findings, and recommendations are tailored to and suit the needs of each town.

Prevention of Climate Change

It is broadly accepted that a primary cause of climate change is the centuries-long build-up of CO2 in the earth's atmosphere caused by the burning of hydrocarbons to fuel global industrialization. Therefore, a primary climate change mitigation strategy is reduction of CO2 emissions via reduced dependence on hydrocarbons and increased reliance on renewable energy sources such as wind, solar and hydro. Part of the Kennebunk Energy Efficiency Committee's mission is "to promote ways for the government and residents of Kennebunk to reduce fossil fuel use, resulting in lower energy bills and greater use of sustainable energy sources" by making recommendations to the Town for such projects as energy audits of Town-owned buildings. At its suggestion, the Select Board signed onto the Global Covenant of Mayors for Climate and Energy in 2018, an international body that provides technical support for towns and cities around the world in their efforts to address climate disruption.

Green building techniques can also help limit CO2 emissions by lessening reliance on oil and propane as heating sources, as does limiting the percentage of tree clearing on lots for new homes, and keeping existing houses and retrofitting them instead of tearing them down and replacing them.

As mentioned in the Public Facilities & Services chapter, Kennebunk Light & Power's West Kennebunk solar array puts renewable, locally-produced energy directly into the grid, lowering the need to purchase supplies from ISO New England, which uses natural gas as a fuel for 55% of its power generation. KLPD also makes three electric car chargers available for use at no charge to support the gradual changeover from internal combustion automobiles. Homeowners and businesses that incorporate solar arrays on buildings help, however incrementally, to the overall goal of reducing CO2 emissions.

More Information on Climate Change, Sea Level Rise and Predicting Risk

NOAA Climate Service - https://www.climate.gov/
US Climate Resilience Toolkit - https://toolkit.climate.gov/#steps
Digital Coast - https://coast.noaa.gov/digitalcoast/
FEMA Map Service Center - https://msc.fema.gov/portal
Local Government and Climate Change Adaptation Toolkit - http://www.iclei.org/

Northeast Regional Climate Center - http://www.nrcc.cornell.edu/
Surging Seas: Riskfinder: https://riskfinder.climatecentral.org/
Sea-level rise and storm surge mapping portal: https://www.maine.gov/dacf/mgs/hazards/slr_ss/index.shtml
Flood map search: https://floodfactor.com/city/kennebunk-maine/2336500_fsid

Goals, Policies and Strategies

State Goal

- To plan for the effects of the rise in sea level on buildings, transportation infrastructure, sewage treatment facilities and other relevant state, regional, municipal or privately held infrastructure, property or resources.
- To encourage municipalities to develop policies that assess community needs and environmental effects of municipal regulations.

Local Goal

- To recognize the full range of potential climate change impacts on Town residents and the local economy and formulate a set of strategies to minimize the negative consequences therefrom.

Policies

- To continue to monitor information about the effects of climate change and sea level rise and associated impact on the Town of Kennebunk, and review and update policies and ordinances accordingly.
- To continue to use cost benefit analysis to inform decision-making with regard to the location and design of new infrastructure as well as the fortification or retrofitting of existing infrastructure.

Strategies

Timeframes: Short term = 0-3 years; Medium term = 3-5 years; Long term = 5+ years

Description	Timeframe	Responsible Parties
Incorporate sea level rise into decision-making and design of transportation improvements such as road and bridge elevations, surfaces, and storm water management	*Ongoing*	*Community Planning & Development, Town Engineer*
Continue to participate in the National Flood Insurance Program (NFIP) and Community Rating System (CRS)	*Ongoing*	*Community Planning & Development*
Collaborate in local and regional efforts to address climate change and sea level rise	*Ongoing*	*Community Planning & Development*
Continue to increase the use of renewable energy resources, conservation of energy, make carbon-free decisions wherever possible, and to seek out cost-effective materials created from recycled material and support companies using this material whenever feasible	*Ongoing*	*Energy Efficiency Committee, Select Board*
Identify the types and extent of capital investment needed to safeguard at-risk infrastructure	*Ongoing*	*Select Board, Finance Board, Community Planning & Development*
Continue to educate residents on the steps the Town is taking to address and plan for sea level rise and climate change	*Ongoing*	*Community Planning & Development*
Update HAT (Highest Annual Tide) levels on the Shoreland zoning map as needed	*Review Annually*	*Community Planning & Development*
Set an annual joint meeting of the Select Board, Community Planning & Development, Planning Board and Conservation Commission to review storm-related and everyday changes that have occurred during the previous 12 months in coastal and riverine areas, to Identify the types and extent of capital investment needed to safeguard at-risk infrastructure, and if specific land use changes should be enacted to protect resources.	*Prior to beginning the following year's budget process*	*Select Board*

Improve analysis and mapping capabilities in order to identify and inventory public assets at risk	*Medium Term*	*Community Planning & Development*
Review floodplain management and land use ordinances to strengthen standards in vulnerable areas, and consider enhanced setback requirements to discourage growth in threatened areas	*Medium Term*	*Planning Board*
Consider a new Coastal Resilience Overlay Zone to identify vulnerable homes and businesses which will require enhanced protection when changes are made, including increased freeboard, elevation, limits on volume expansion	*Medium Term*	*Planning Board*
Adopt a policy to restore more natural flows where tidal flows have been restricted by existing road crossings or other development	*Medium Term*	*Community Planning & Development, Town Engineer*
Study Department of Agriculture and Forestry topographic maps to determine where lots, houses, roadways and potential development limit marsh migration, both along the Mousam and Kennebunk Rivers, to determine what action, including, but not limited to, the creation of a Marsh Migration overlay zone, are necessary to allow migration.	*Medium Term*	*Planning Board, Conservation Commission*
Identify and upgrade as necessary storm water management infrastructure to cope with increased frequency and intensity of precipitation events	*Medium Term*	*Community Planning & Development, Public Services*
Discuss and plan for the eventuality of managed retreat, and conservation of floodable open space	*Long Term*	*Community Planning & Development, Select Board, Planning Board*