Belfast Shoreline Property Owners Guide:

Challenges From Our Changing Climate

Belfast Climate Crisis Committee

Revision 1 March, 2022

Preface

This short Guide is provided by the Belfast Climate Crisis Committee (an advisory committee to the Belfast City Council) as information for property owners who have shoreline footage on Belfast Harbor. It reviews the significant shoreline impacts from our changing climate, and provides references to additional detailed information. Climate Change is directly impacting coastal communities throughout the country, and especially those on the margins of the Gulf Of Maine. A short video of the challenges in Harpswell, Maine is illustrative (click on the link): https://youtu.be/SlTMIG4bNTk

The intent of this document is to provide information and focus attention on the challenges ahead; and to prompt interest in a productive community discussion about our response.

Introduction

The waters of the Gulf of Maine are warming faster than 99% of the ocean's waters in the rest of the world due to factors of geography and ocean currents. Over the last decade, the summer Sea Surface Temperatures (SST's) have been elevated 2.3degC above an increasing temperature trendline. (Gulf Of Maine Research Institute, October 26, 2021) This solar heating results in stored energy that has enormous local consequences: acceleration of local sea level rise due to thermal expansion of the water; increased evaporation of water leading to increased incidence and severity of coastal storms and rainfall.

There are four challenges for shoreline property owners:

1. Rising Mean Sea Level (MSL) that elevates waterlines and normal tidal cycles.
2. Increased potential from wind driven waves and storm surge, including cyclonic storms (hurricanes, localized bomb cyclones).
3. Coastal erosion from storm water runoff that overwhelms storm drain systems.
4. Nuisance flooding at high tide.

The document sections following expand on these challenges, and briefly discuss options for accommodation. The information presented has been drawn from two major sources, with others noted:

Maine Coastal Property Owner's Guide to Erosion, Flooding, and Other Hazards, 2nd edition;

Peter A. Slovinsky , Maine Geological Survey ***https://digitalmaine.com/mgs_publications/605/***

The Maine Climate Action Plan: ***https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/MaineWontWait_December2020.pdf***

https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/GOPIF_STS_REPORT_092320.pdf

Sea Level Rise In The Gulf of Maine

The well-publicized increase in sea level is generally reported as the global average or mean sea level increase (global MSL). The actual increase (or decrease) in sea level at a given coastal location depends on a number of factors: prevailing currents, ocean bottom topography, sea surface temperature (SST), average prevailing wind speed and direction, etc.

The guidance from the State of Maine Climate Plan is to prepare for **1.5 Feet** of Mean Sea level Rise By 2050, and **4 feet** by 2100. This assumes the most likely Intermediate Scenario for Greenhouse Gas Emissions, and is consistent with the best science available. Both the total amount of MSL, and the timing of the rise, is subject to a number of factors, such as continental ice loss in Greenland and Antarctica that are a subject of intense ongoing study.

There are currently 3 different types of sensors installed in Belfast Harbor which will provide a building database of local tides and waves which will 'ground truth' predictions.

Wind Driven Waves and Storm Surge

In the past, the relatively cool waters in the Gulf have ensured that hurricanes and local cyclonic storms were a relatively low threat. The predominant storms were, and are, the Nor'easters that commonly occur in the fall and early winter when surface water temperatures are the warmest, and atmospheric conditions are appropriate. The rapid warming of surface waters, and the deepening layer of warm water, have dramatically increase the probability of both types of storms.

Belfast Bay and Harbor present a funnel shaped topography oriented to the Southeast. The 'fetch' of open water to the southeast is fortunately limited by Islesboro and other landmasses. The harbor shallows rapidly towards the neck of the 'funnel'. The result is that wave energy from persistent south/southeast winds will build steep choppy waves with a dominant short period (3-4 second). Intense storms can cause large waves to develop, with longer periods. A recent example was the bomb cyclone on October 31,2018 which resulted in 8'+ waves off of the Belfast City Landing.

Accompanying large waves in a sustained storm is a temporary build of the water level: a surge condition. The height of surge developed is dependent on storm direction and dwell time. A slow-moving intense storm will generate a larger surge.

A sophisticated physics-based computer modeling tool has been developed by NOAA to predict the potential for storm surge that takes the geography of a particular location into account. It is called SLOSH, which is an acronym for Sea, Lake, and Overland Surges from Hurricanes. With the proper inputs specified, it will predict the probable surge height for a given storm intensity. SLOSH simulation runs are the best tool available to evaluate local surge coastal hazards.

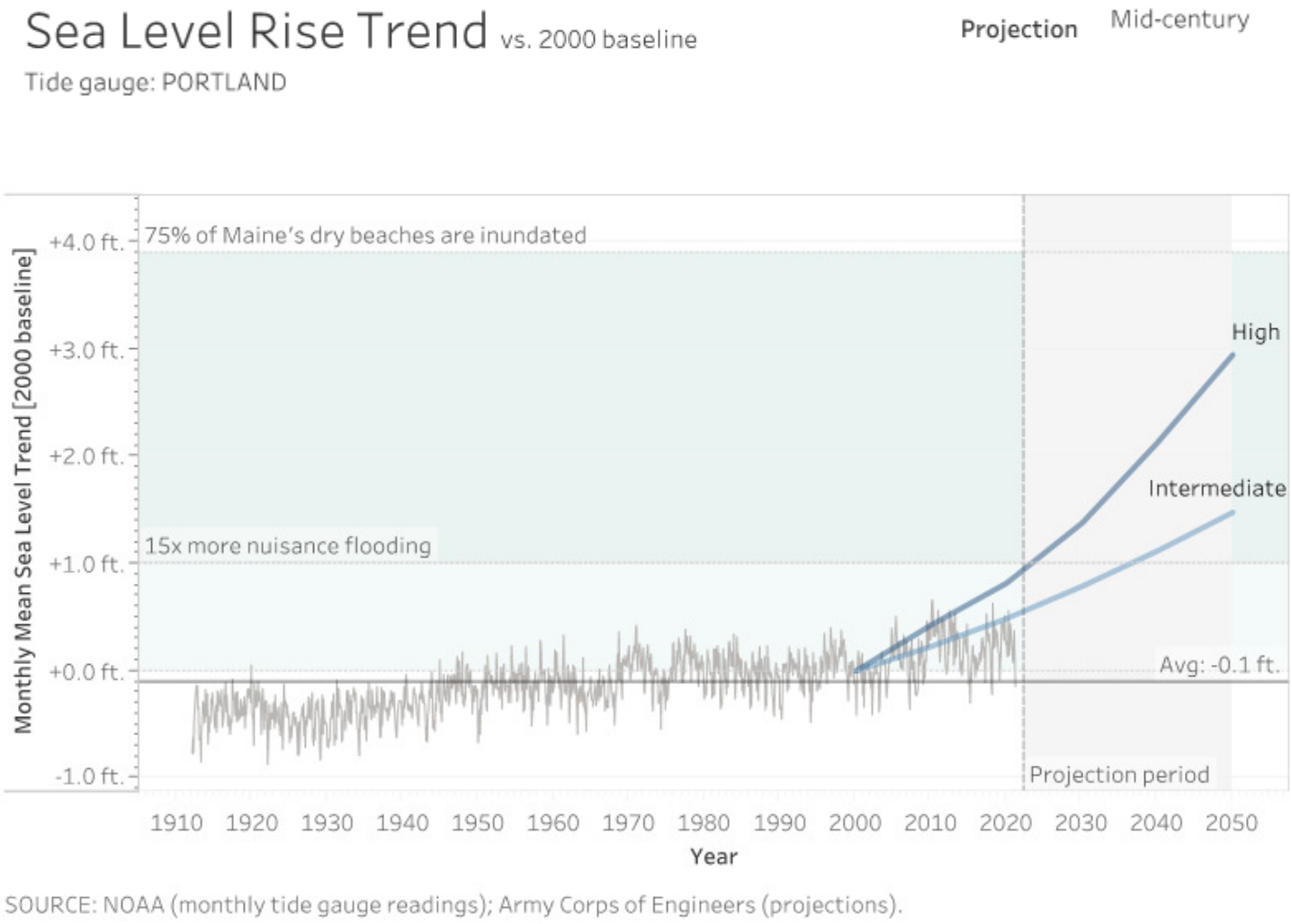
Storm Water Runoff

The increased Sea Surface Temperatures in the Gulf have resulted in increased evaporation. This additional water vapor has caused significant changes in precipitation patterns in coastal Maine; both in the amount of rainfall/snowfall and in its intensity. Since 1895, total annual precipitation has increased by more than 6". The pattern has shifted in recent years from regular moderate rain to storms of increased intensity. Rainstorms that can deliver 5" in a few hours are now more common, with double that amount possible. This rate of rainfall is beyond the capacity of our present stormwater sewer systems, resulting in flooding and erosion of coastal properties. In Belfast, the relatively shallow soils over bedrock limit rainwater storage, leading quickly to runoff. The generally steep contours of land surrounding Belfast Bay increase the potential for erosion at the coastal edges from runoff.

Nuisance Tidal Flooding

The earliest indication of change will be flooding of the lowest shoreline at times of high tide, beginning with periodic King tides. These highest tides occur when the gravitational effects of the sun and moon move in to alignment. The present highest tides in Belfast harbor are about 13', and come near or at the top of the existing breakwater and crib at the City Landing. A sea level rise of 1 foot would ensure periodic flooding of some areas. The figure below is from the State Of Maine climate dashboard. It shows the trend of rising sea level that will result in a **15 times higher** likelihood of flooding at tidal extremes in Portland, ME. The Intermediate trendline is for 1.5 Ft of sea level rise by 2050. Belfast will trend in a similar fashion.

https://climatecouncil.maine.gov/maine-climate-science-dashboard

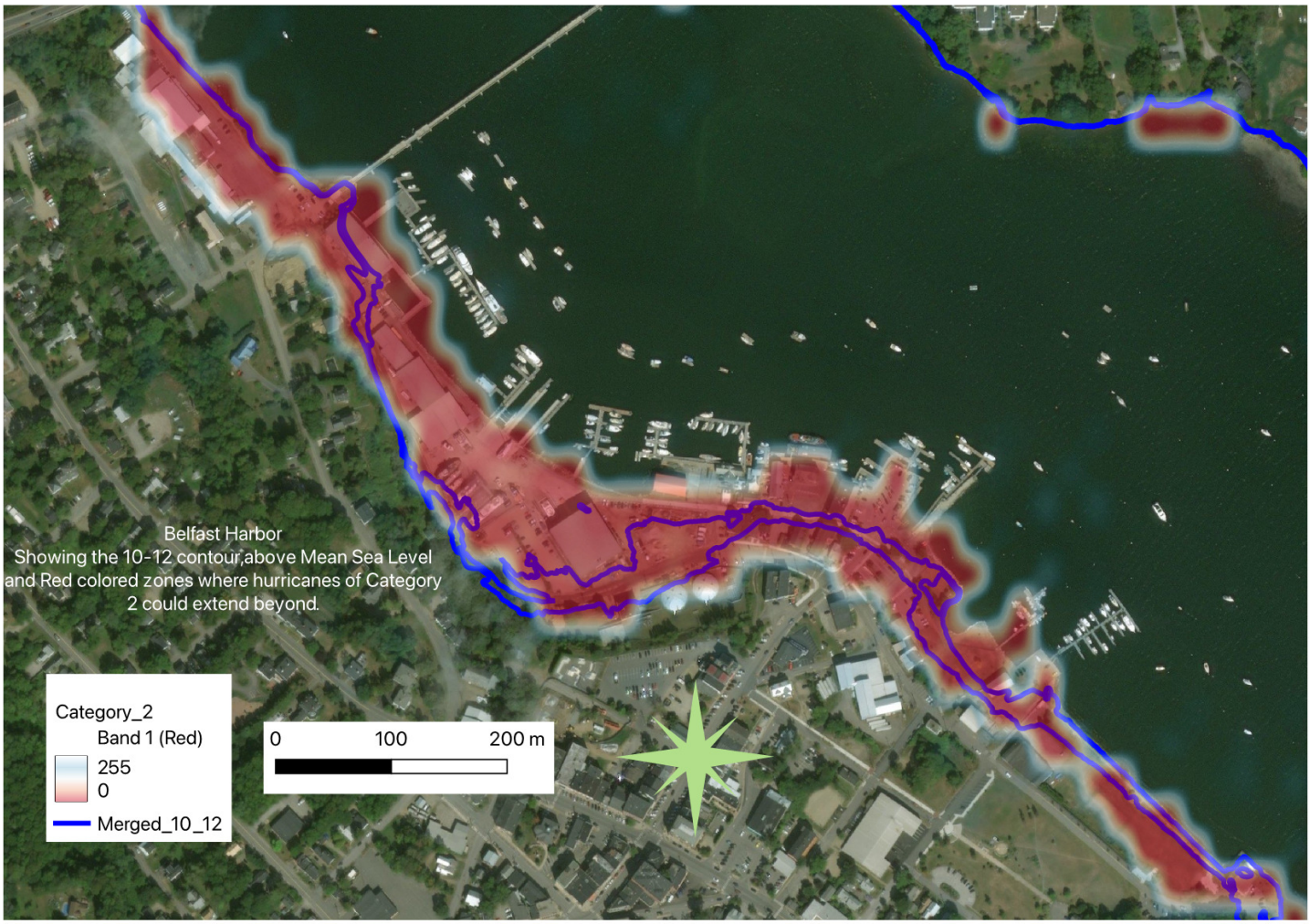


Worst Case Scenarios

Emergency response planning is based on developing worst case scenarios and understanding the statistical probability of their occurrence. In the case of shoreline threats, a worst case event would be a slow-moving cyclonic storm, occurring around a highest tide, with torrential rain, and on top of significant sea level rise. This sounds improbable. However, one of the effects of Climate Change is that 100 year storms (a storm with a statistical 1% probability of occurrence at any given time) are now happening every 10 years or less. In October of 2021, Belfast experienced intense rainfall (over 5" in ~6 hours) that caused significant flooding, notably on the Route 3 approach to the bridge. It would approximate a 100 year storm condition. Potentially damaging storms are now **not** a rare event.

The figure below is a snapshot of a **portion** of Belfast Harbor, as an example, showing the predictions of inundation (shaded red) from the SLOSH model for a category 2 hurricane. This result is based on current Mean Sea Level, with no allowance for sea level rise. As mentioned above, the SLOSH model can be tuned to a specific set of conditions that are relevant to a specific location; that was not done here. The figure shows contour lines in blue for 10' and 12' contours above MSL. *Those height contours serve as a reasonable threshold for flooding risk.*

It is important to keep in mind that the SLOSH modeling image is a composite of many runs with varying inputs, such as storm dwell time or duration. It does present a worst case for the stated storm intensity, and is intended for emergency planning.



SLOSH output for a Category 2 hurricane. It is clear that the 10' to 12' vertical contours from GIS topographical maps are a reasonable indication for a particular properties' exposure to the threats posed by Climate Change that were outlined.

Adaptation and Mitigation Measures

There are three main strategies that can be implemented.

- Allowing natural processes to occur: Do nothing
- Mitigating hazards
- Altering or enhancing the shoreline

The choice of what strategy, or combination, should be applied to a particular property will be a unique decision about risks, benefits, and cost. If the decision is to alter or enhance the shoreline, some options are best pursued as a collaborative effort with other property owners to achieve best results.

Hazard Mitigation

The most serious risk is when buildings and roads are within a zone where they are subject to flooding from tidal action, surge, and damage from wave action. A structure may be raised or moved upslope to a safer elevation. The critical systems (heating and electrical) may be hardened. A probability-based risk assessment and cost/benefit analysis must guide the choices.

When the hazard is erosion or destruction of shoreline, a number of options are available.

Altering or Shoreline Enhancement

Some defensive measures may include:

- Dissipating wave energy with large stone rip-rap or engineered concrete shapes. This will not reduce flooding.
- Implementing a “living shoreline” with vegetation through the intertidal zone and shore that will stabilize the shore material and dissipate wave energy. This can be a cost-effective choice to reduce erosion from wave action and runoff. This may be used in combination with a berm to help with flooding where the natural slope is low. A Living Shoreline decision tool is available at:
  Living Shorelines Decision Support Tool: Maine's Geologic Hazards: Maine Geological Survey: Maine ACF
- Building a seawall that encloses the property to a “safe” vertical elevation. The most durable and long-life construction would be stone, engineered concrete structural shapes, or driven polymer sheet piles. Other choices of materials would likely lead to 20 year replacement cycles. This is clearly the most costly measure.

Any alteration of existing shoreline will likely be subject to review and permitting from several levels of government agencies; City of Belfast, Maine DEP, and at the federal level the Army Corp of Engineers.

The Silver Lining

All change has both positive and negative consequences. Some of the positive aspects of the changing climate relative to Belfast Harbor are:

- Even 1 foot of Mean Sea Level will significantly increase the amount of navigable water through the tidal cycle. This is particularly true of waters inland from the footbridge.
- If the erosion and sedimentation due to stormwater runoff is controlled, it is possible that the increased water depth and quality would allow the establishment of Eel grass beds. These beds are natures’ nursery in the life cycle of many (tasty) aquatic species.

Summary

Some combination of mitigation and shoreline defense may yield the most cost effective long term approach. Collaboration with property abutters can help achieve practical solutions with shared resources and construction costs. The Belfast Climate Crisis Committee would like to engage stakeholders in conversations with expert resources and each other to arrive at good solutions.