ADAPTATION PLANNING STUDY
DOWNTOWN WATERFRONT AREA
DAMARISCOTTA, MAINE

DECEMBER 22, 2014
(REVISED FEBRUARY 2, 2015)

PREPARED FOR:
COASTAL COMMUNITIES GRANT OVERSIGHT COMMITTEE
DAMARISCOTTA, MAINE

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This memorandum was prepared by Milone & MacBroom, Inc. and the Town of Damariscotta under award CZM NA13NOS4190045 to the Maine Coastal Program from the National Oceanic and Atmospheric Administration, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the National Oceanic and Atmospheric Administration or the Department of Commerce.

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1.0 INTRODUCTION

The Lincoln County Regional Planning Commission (LCRPC) and Maine Geological Survey in 2012 undertook a study of 450 miles of coastline in Maine's mid-coast region, including Damariscotta, to evaluate the effect of various sea level rise scenarios. The results of the study suggest that Main Street in Damariscotta and the town's municipal parking lot may be inundated under future conditions. As the primary commercial area of the town, the routine inundation of Main Street could have devastating effects on quality of life and may reduce the town's tax base.

The town, through its Waterfront Planning Committee (the Committee), secured a grant from the Maine Coastal Program and subsequently contracted Milone & MacBroom, Inc. to study the effects of sea level rise and develop options for protecting the town. The study is intended to answer the following question: Are there adaptation techniques that can be implemented to make downtown buildings and public infrastructure more resilient in the face of existing flooding hazards and potential future hazards created by rising sea levels?

The goals of this study are:

1. To **determine the location and elevation of structures that are vulnerable to coastal flooding**. This included surveying the elevation of windows, doors, and other openings in existing buildings that may allow for intrusion of floodwaters.
2. To **establish a sea level rise scenario** and elevation **for the town's use in planning** improvements.
3. To **identify opportunities** and **recommend improvements** for **protecting structures** as well as the town's parking lot from flooding.

This report presents the results of the study effort.

2.0 TIDE AND SEA LEVEL RISE ELEVATIONS

2.1 Existing Tide and Flood Elevations

The mean high water elevation at Damariscotta is approximately 4.4 feet based on the North American Vertical Datum of 1988 (NAVD88). This was estimated from data collected at the National Oceanographic and Atmospheric Administration (NOAA) gauge in Portland, Maine. Mean high water is the average of all high water levels recorded in the most recent 19-year tidal epoch, which extended from 1983 through 2001.

As part of its 2012 study, the LCRPC and the Maine Geological Survey determined the highest annual tide at Damariscotta to be elevation 6.2 based on NAVD88. This is the elevation of a tide event that would be likely to occur once in a given year. Figure 1 shows the highest annual tide inundation area as determined in the Lincoln County Study, with buildings shown in red that would be partially inundated under such an event.

Figure 1. Highest Annual Tide @ El 6.2 NAVD88. Mapping Courtesy of Lincoln County Planning Commission

Floodplain mapping prepared by the Federal Emergency Management Agency (FEMA) shows the limits of inundation during large storm events. Figure 2 shows the limits of Special Flood Hazard Area (SFHA) from preliminary mapping prepared by FEMA. The FEMA data was projected onto Google Earth imagery by the LCRPC, and it is the LCRPC projection that is shown in Figure 2. This inundated area is at elevation 10 NAVD88.

Figure 2. Preliminary 2014 FEMA Mapping. Floodplain Elevation 10 NAVD88. Mapping Courtesy of Lincoln County Planning Commission

Table 1 summarizes the relevant existing water elevations in the project area.

TABLE 1
Existing Water Elevation Data in Damariscotta, Maine

Parameter	Elevation, NAVD88
Mean High Water	4.4
Highest Annual Tide	6.2
1% Annual Chance Flood	10.0

2.2 Sea Level Rise Projections

The intent of this study is not to prove that climate change is or is not occurring, nor is it to debate the issue of climate change. Rather, it is to recognize that scientific data supports the fact that sea level is rising. Figure 3 is a graph developed by the NOAA using tide gauge data collected in Portland, Maine from March 1910 to the present day. The graph shows a clear trend of increasing sea levels at a rate of 1.82 millimeters per year.

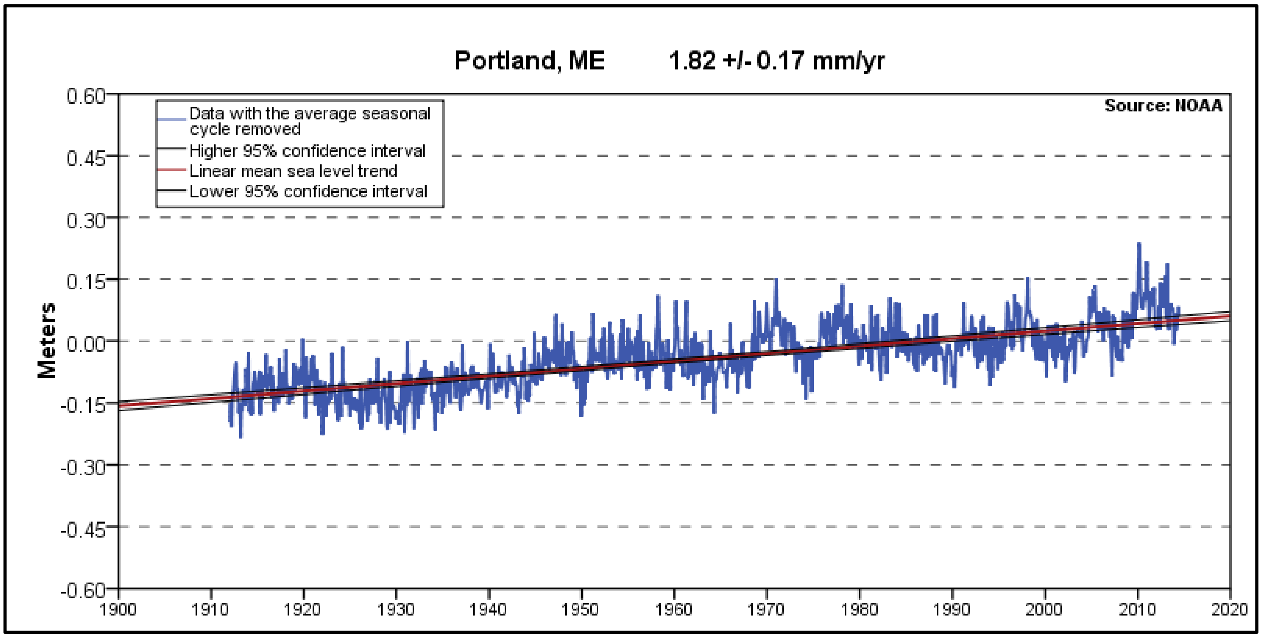

Figure 3. Sea Level as Measured in Portland, Maine 1910 - 2014

Based on the historic data in Figure 3 and the various climate predictions prepared by international organizations, NOAA has projected future increases in sea level rise as shown in Figure 4. Note that these numbers are a relative rise. Therefore, if the current mean tide elevation at a site is 6.2, then in 2100 mean sea level would be elevation 11.2 under the NOAA High scenario. The information presented in Figure 4 is developed based on the NOAA publication *Global Sea Level Rise Scenarios for the United States National Climate Assessment* dated December 2012.

Elevations estimated in the various scenarios are specific to Portland and consider the past trends as determined by the sea level gauge that has been operating since 1910. The Portland gauge was selected for our work in Damariscotta because it has been operating for a longer duration than the Bar Harbor gauge, which was installed in August 1947. The scenarios are defined as follows:

<u>NOAA Low Portland</u>: Represented by the blue line in Figure 4, this is the projected sea level rise in Portland assuming the historic trend shown in Figure 3 continues at the same pace.

NOAA Intermediate Low Portland: The yellow line depicts future sea level rise based only on ocean warming. Ocean warming leads to increases in sea level rise because water expands as it heats. As ocean temperatures increase, the oceans rise to accommodate this natural expansion. This is generally considered an optimistic rate of sea level rise, meaning it is a best case scenario that minimizes future risk.

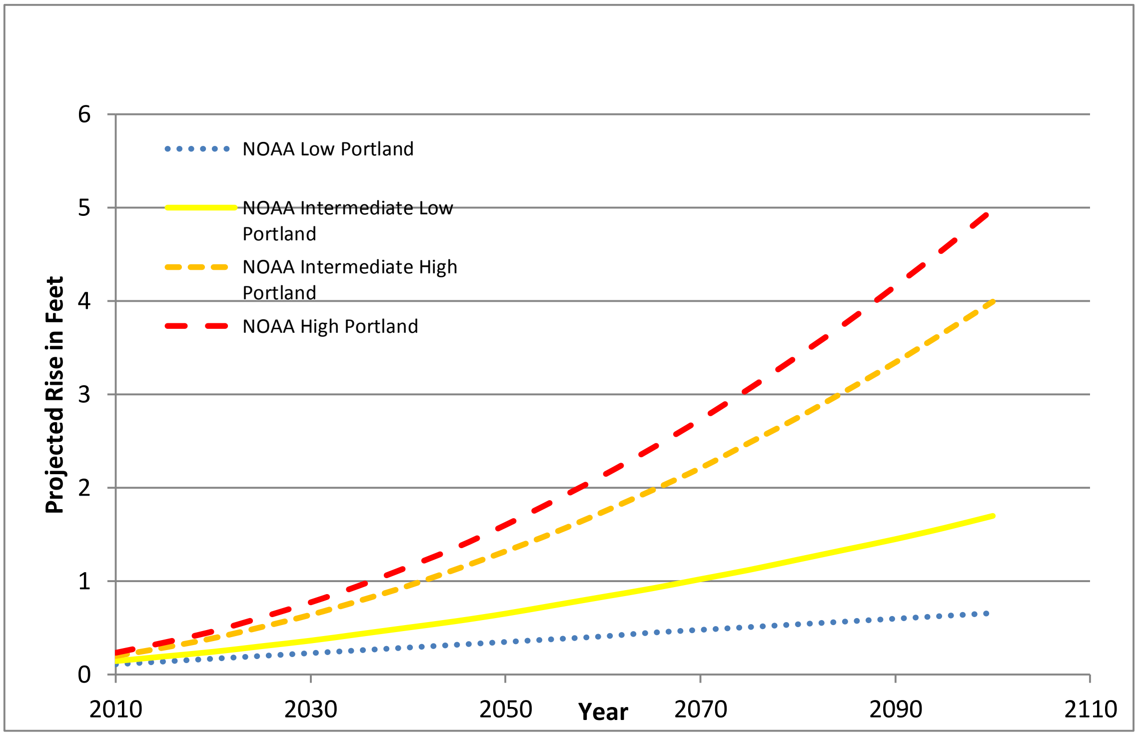

Figure 4. Projected Relative Sea Level Rise for Various Climate Change Scenarios

NOAA Intermediate High Portland: The orange line depicts the projected rate of sea level rise assuming both ocean warming and a moderate rate of melting of the arctic ice sheets. The increase is higher because the water expansion is exacerbated by the addition of new water from the melted ice sheets. The rate of ice sheet loss is considered the biggest unknown in climate change analysis, which is why two alternate scenarios (Intermediate High and High) are provided for ice sheet loss.

NOAA High Portland: The red line represents the largest increase in sea level rise based on heating of the oceans and a maximum loss of the ice caps. NOAA suggests that this highest scenario is considered an appropriate planning tool for critical facilities that have a long life cycle such as major highways, power plants, and the like.

2.3 Potential Design Elevations for Damariscotta

Table 2 adds the elevations shown in the "Intermediate High" and "High" curves to the base elevations in Table 1. The LCRPC used 1, 2, 3, and 6 feet of rise for its analysis. The increases in Table 2 generally correlate to the 1-, 2-, and 3-foot scenarios. The 6-foot increase in sea level is higher than any of the computer-based projections but is a useful scenario for generating discussion as was the case in the LCRPC work.

TABLE 2
Potential Design Elevations Based on
NOAA Projections for Portland, Maine

		Intermediate High		High	
Parameter	**2014 Elevation NAVD88**	**2050 Elevation (+1.32) NAVD88**	**2070 Elevation (+2.2) NAVD88**	**2050 Elevation (+1.6) NAVD88**	**2070 Elevation (+2.7) NAVD88**
Mean High Water	4.4	5.7	6.6	6.0	7.1
Highest Annual Tide	6.2	7.5	8.4	7.8	8.9
1% Annual Chance Flood	10.0	11.3	12.2	11.6	12.7

Comparing the elevations in Table 2, the Waterfront Adaptation Planning Committee discussed the design implications of each. The current elevation of the parking lot on the south side of Main Street is approximately at elevation 8 NAVD88 with an elevation of 10 closer to the buildings on the west end of the lot. Figure 5 depicts ground and door elevations on buildings within the project area based on data collected by Maine Coast Survey. In reviewing Figure 5, the vulnerability of specific structures becomes clear.

DESIGN ELEVATION CONSIDERATIONS
STOREFRONT GROUND & DOOR ELEVATIONS

ADAPTATION PLANNING STUDY DOWNTOWN WATERFRONT AREA

DAMARISCOTTA, MAINE

NOVEMBER 24, 2014

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LEGEND

+ XX.X GROUND ELEVATIONS

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0 40' 80' 120' 160'

NORTH

FIGURE 5

2.4 Design Flood Elevation

The Committee, MMI, and representatives of the State of Maine Lincoln County Planning Commission discussed potential design elevations at length prior to proceeding with the study. Ultimately, the Committee established a design flood elevation (DFE) of 12.0 based on the North American Vertical Datum of 1988 (NAVD88). Design flood elevation is the elevation to which infrastructure adaptation options will be designed. This is different than the base flood elevation (BFE), which is the elevation of the 1% annual chance as established by FEMA. At our project site, the BFE is elevation 10.0 NAVD88. It is often recommended that communities develop a regulatory flood elevation (RFE) that is the BFE plus 1 foot (elevation 11.0 NAVD88 for the Damariscotta project site).

The 12.0 elevation was selected based on the recommended RFE for Damariscotta plus an allowance for future sea level rise. Figure 4 shows that in 2070 (the 50-year planning period) sea level rise will be 6 inches to 1 foot. Thus, the elevation 12.0 is the current BFE of 10.0, which includes one foot of elevation as identified by FEMA, plus an additional one foot to account for the most certain sea level rise scenarios that are likely to occur over the 50-year planning period.

Using elevation 12.0 is conservative and will provide the town with a buffer under the more frequent annual flood events. The current Highest Annual Tide (HAT) in Damariscotta is elevation 6.2 NAVD88. Therefore, the design flood elevation of 12.0 will provide ample protection against routine flooding, even if the higher sea level rise projections of up to almost 6 feet become a reality.

3.0 COASTAL ADAPTATION STRATEGIES

Coastal adaptation strategies include both planning (nonstructural) and structural-related modifications. Nonstructural measures include preparedness, emergency response, retreat, and regulatory and financial measures to reduce risk. Structural measures include dikes, seawalls, groins, jetties, temporary flood barriers, and the like. Ideally, the measures that are taken should be robust enough to provide adequate protection and flexible enough to allow them to be adapted to changing future conditions. Such robustness and flexibility typically require a combinations of methods rather than one solution.

Structural measures can be site-specific, "neighborhood-scale," or large-scale structures that protect multiple square miles of infrastructure. Each of these were considered in varying degrees of detail for Damariscotta. Site-specific measures pertain to floodproofing a specific structure on a case-by-case basis. Neighborhood-scale measures apply to a specific group of buildings that are adjacent to each other. Large-scale structures might include large dike and levee systems or tide gates that can prevent tidal surge from moving upstream.

This section starts with a discussion on the philosophy of resilience and adaptation and how the concept has evolved over time. This is followed by international strategies for adaptation, followed by neighborhood and site-specific strategies. The discussion focuses on structural measures of mitigation. While nonstructural modifications are important for risk reduction, evaluation of such planning processes is outside the scope of this current study.

In September 1995, the EPA, in cooperation with Maine's State Planning Office, published the report "Anticipatory Planning for Sea Level Rise Along the Coast of Maine." This document represents Maine's initial efforts at planning for sea level rise and adapting its coastal resources to the changing climate.

Some communities in Maine have begun to consider the implications of climate change and the potential impacts sea level rise may have on their infrastructure and economy. Damariscotta is on the leading edge, however, in the local efforts to identify solutions and implement mitigation plans.

Starting in 2007, the Maine Coastal Program, in coordination with the Maine Geologic Survey; the Southern Maine Regional Planning Commission; and the communities of Scarborough, Old Orchard Beach, Saco, and Biddeford, began efforts to develop a Coastal Resiliency Project in the Saco Bay area. Their work consisted of outreach to the local communities, developing GIS data to identify vulnerable areas, and implementing resiliency projects. One outgrowth of this effort was the Saco Bay Sea Level Adaptation Working Group (SLAWG). SLAWG was created in 2009 to identify regional strategies to respond to rising sea levels. The purpose of the SLAWG is to create a Vulnerability Assessment for Saco Bay and to develop an Action Plan of implementation strategies for regional solutions.

More recently, Maine Geologic Survey (MGS) and LCRPC prepared Sea Level Rise Mapping for the Lincoln County communities, including Damariscotta. The work done by LCRPC and MGS is an important first step in the process of adaptation planning because their work resulted in the development of mapping. This current study will build on those efforts by identifying adaptation techniques for the vulnerable areas.

3.1 Evolution of Options for Coastal Resilience

The Intergovernmental Panel on Climate Change (IPCC) published the landmark paper "Strategies for Adaptation to Sea Level Rise" in 1990. The preface states that "This report represents the first survey on a global scale of adaptive options for coastal areas in response to a possible acceleration of sea level rise and the implications of these options." This was one of the earliest reports to list the three traditional categories of adaptation "to protect human life and property." The following descriptions of these three types of adaptation are taken from the report:

- Retreat involves no effort to protect the land from the sea. The coastal zone is abandoned, and ecosystems shift landward. This choice can be motivated by excessive economic or environmental impacts of protection. In the extreme case, an entire area may be abandoned. While this may be a necessity for Damariscotta over the long term, this study focuses on managing the existing structures and infrastructure on Main Street rather than retreat. Under a retreat scenario, the town would need to undertake community planning focused on relocating its downtown commercial district away from the waterfront. Such high level planning is outside the scope of this current study.

- Accommodation implies that people continue to use the land at risk but do not attempt to prevent the land from being flooded. This option includes erecting emergency flood shelters, elevating buildings on piles, converting agriculture to fish farming, or growing flood- or salt-tolerant crops.

- Protection involves hard structures such as sea walls and dikes, as well as soft solutions such as dunes and vegetation to protect the land from the sea so that existing land uses can continue.

In 2010, the NOAA Office of Ocean and Coastal Resource Management published the manual *Adapting to Climate Change: A Planning Guide for State Coastal Managers*. Chapter 5 is dedicated to a discussion of adaptation strategies and methods. According to the manual, NOAA's seven categories of "Climate Change Adaptation Measures" and their subcategories are:

3.1.1 Impact Identification and Assessment

- Research and Data Collection – Predict possible social and economic effects of climate change on communities. Calculate cost-to-benefit ratios of possible adaptation measures. Encourage adaptation plans that are tailored to specific industries.
- Monitoring – A comprehensive monitoring program that incorporates multiple tools and considers a variety of systems and processes can provide input to the vulnerability assessment and adaptation strategy.
- Modeling and Mapping – Map which areas are more or less susceptible to sea level rise in order to prioritize management efforts.

3.1.2 Awareness and Assistance

- Outreach and Education – Create scientific fact sheets about climate change addressing community members, visitors, elected officials, businesses, and industries. Use multiple forms of communication such as news media, radio, brochures, community meetings, social networks, blogs, and websites.
- Real Estate Disclosure – The disclosure of a property's vulnerability to coastal hazards enables potential buyers to make informed decisions reflecting the level of impacts they are willing and able to accept.
- Financial and Technical Assistance – Provide flood insurance discounts for properties that exceed floodproofing standards by 1 or 2 feet. Encourage hazard mitigation by providing grants to areas that implement adaptation measures.

3.1.3 Growth and Development Management

- Zoning – Zoning can be used to regulate parcel use, density of development, building dimensions, setbacks, type of construction, shore protection structures, landscaping, etc. It can also be used to regulate where development can and cannot take place, making it an invaluable tool in efforts to protect natural resources and environmentally sensitive areas and guide development away from hazard-prone areas.

- Redevelopment Restrictions – Combining restrictions with acquisition/demolition/relocation programs provides safer options to property owners in the wake of the loss of or damage to their homes or businesses.
- Conservation Easements – A conservation easement is a legal agreement between a landowner and a land trust or government agency that can be used to restrict development in sensitive and hazard-prone areas.
- Compact Community Design – The high density development suggested by compact community design can allow for more opportunities to guide development away from sensitive and hazard-prone areas.

3.1.4 Loss Reduction

- Acquisition, Demolition, and Relocation – The most effective way to reduce losses is to acquire hazard-prone properties, both land and structures, demolish or relocate structures, and restrict all future development on the land.
- Setbacks – Setbacks can protect structures from hazards by keeping the structures away from a property's most vulnerable areas.
- Building Codes – Building codes that regulate design, construction, and landscaping of new structures can improve the ability of structures in hazard-prone areas to withstand hazard events.
- Retrofitting – Existing structures can be protected from hazards through retrofitting.
- Infrastructure Protection – Infrastructure protection entails fortification against the impacts of climate change.
- Shore Protection Structures – Shore protection structures protect existing development allowing it to stay in place. They often damage or destroy other valuable coastal resources and create a false sense of security; nevertheless, in some cases for the purposes of protecting existing development, there may be no other acceptable or practical options.

3.1.5 Shoreline Management

- Regulation and Removal of Shore Protection Structures – To protect the natural shoreline and the benefits it provides, regulations can be used to limit shoreline hardening as well as promote alternative forms of protection.
- Rolling Easements – Rolling easements are shoreline easements designed to promote the natural migration of shorelines. Typically, rolling easements prohibit shore protection structures that interfere with natural shoreline processes and movement but allow other types of development and activities. As the sea rises, the easement moves or "rolls" landward, wetland migration occurs, and public access to the shore is preserved.
- Living Shorelines – Living shorelines can be effective alternatives to shore protection structures in efforts to restore, protect, and enhance the natural shoreline and its environment. Living shorelines use stabilization techniques that rely on vegetative plantings, organic materials, and sand fill or a hybrid approach combining vegetative

plantings with low rock sills or living breakwaters to keep sediment in place or reduce wave energy.

- Beach Nourishment – Beach nourishment is the process of placing sand on an eroding beach, typically making it higher and wider to provide a buffer against wave action and flooding.
- Dune Management – Dunes may be restored or created in conjunction with a beach nourishment project or may be managed as part of a separate effort.
- Sediment Management – Dredging and placing sediment, building shore protection structures and other structures that trap or divert sediment.

3.1.6 Coastal Ecosystem Management

- Ecological Buffer Zones – Ecological buffers are similar to setbacks (and may be included within setbacks) but are typically designed to protect the natural environment by providing a transition zone between a resource and human activities.
- Open Space Preservation and Conservation – Open space preservation and conservation can be accomplished through the management of lands dedicated as open space through a number of the measures previously discussed, such as zoning, redevelopment restrictions, acquisition, easements, setbacks, and buffers.
- Ecosystem Protection and Maintenance – In the context of coastal adaptation, ecosystem protection largely involves the protection of tidal wetlands and other ecosystems. The facilitation of wetland migration is an important aspect of this.
- Ecosystem Restoration, Creation, and Enhancement – Similar to the above, ecosystem restoration and creation can replace tidal wetlands that are lost to sea level rise.

3.1.7 Water Resource Management and Protection

- Stormwater Management – Drainage systems may be ill equipped to handle the amount of stormwater runoff that will accompany the more intense rainfall events expected in the future, and those in low-lying areas will be further challenged by losses in elevation attributed to rising sea levels.
- Water Supply Management – Climate change will negatively affect both water quantity and quality, and coastal populations will continue to grow, so water supply managers must be prepared to respond to associated challenges to water supply.

Elements of *protection, retreat*, and *accommodation* are found in several of these categories and subcategories of adaptation. For example, Growth and Development Management actions can be used to manage retreat or accommodation whereas Shoreline Management may include methods of protection as well as removing protection. NOAA notes that these adaptation measures are organized into categories that describe their primary purpose but, in many cases, they serve multiple purposes and could fit into multiple categories (e.g., acquisition could fit under Growth and Development Management, Coastal and Marine Ecosystem Management, and Shoreline Management in addition to Loss Reduction).

3.2 Large-Scale Adaptation Planning and Floodproofing

International thoughts on mitigating and adapting to sea level rise are as varied as the countries considering adaptation. Examples of large-scale mitigation measures can be seen throughout the world such as the levee system that protects New Orleans, the dike system that allows the Netherlands to survive below sea level, and the Thames Barrier that protects London from tidal surge. Following are some examples of large-scale projects. For Damariscotta, such alternatives can be discussed, but implementation of these requires considerable funding resources and, perhaps more importantly, the cooperative interests of numerous communities and watershed groups. Therefore, the implementation of this type of structure is outside the scope of this current study.

3.2.1 The Netherlands

Rising sea levels are recognized internationally as a critical issue that countries must address to preserve their economies. Some countries have developed national policies and approaches to adaptation and planning-level recommendations to guide adaptation efforts. Not surprisingly, the Netherlands is at the forefront of adaptation planning and has developed detailed plans for coastal adaptation including:

- A federal policy that promotes maintaining the 1990 coastline of the country through ongoing beach and shore nourishment. Nourishment is being aggressively implemented by distributing sand that naturally exists along the coast. One current project has been called "Mega Nourishment," where 20 million cubic meters of sand are proposed to be placed along the coast and its migration to be monitored over time. Such nourishment projects are intended to supplement the dike system, forcing waves to break prior to reaching the dikes.
- Reinforcement and reconstruction as necessary of the country's dike system. Each portion of the dike system has been assigned design standards based on the value of the property and extent of population being protected. The repairs are funded through taxes based on the value of the property protected by each dike.
- Projects typically assume 2 feet of sea level increase within 100 years.

It is critical to remember that the dike system includes mechanical pump stations to evacuate rainwater out over the dikes during large rain events. While the dike system requires routine inspection and maintenance, it generally performs without need of routine intervention. Pump stations, however, require monthly inspection and testing to ensure they perform as expected.

3.2.2 Littlehampton, United Kingdom

Littlehampton has taken a very traditional approach to reducing future tidal flooding, reinforcing and expanding an existing sea wall system in order to protect some 2,000 residents and businesses. The £14M construction effort includes 3,800 feet of steel sheet pile bulkhead and promenade ranging from 1 to 6 feet higher than an existing sea wall. The promenade will include plantings, walking paths, and lighting and includes crossing of private property. In addition, the walls of a public housing facility will be floodproofed using concrete and flood glass similar to that used in submarine construction.

3.2.3 Thames Barrier, London, United Kingdom

The Thames Barrier is one of the largest flood barriers in the world and one of the few large-scale movable flood barriers. The barrier was built in 1982, spans approximately 1,700 feet of the Thames River, and consists of 10 steel gates that are some 50 feet in height. In the open position, the gates lie on the riverbed and, in the closed position, they block flow from upstream and downstream. The gates are closed at low tide before a storm surge event (as predicted from detailed weather monitoring systems) creating a reservoir for freshwater upstream of the gates. The open and closed positions are shown below in Figure 6, and a photo of the structure in its open position is also shown.

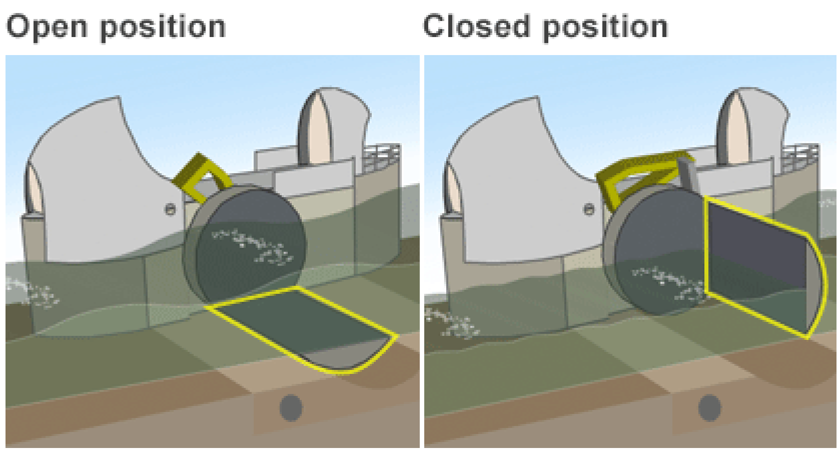


Figure 6. Left: Thames Barrier Schematic. Image: BBC World

Below: Photo of the barrier in open position

3.2.4 Maeslantkering, Port of Rotterdam

Construction of the Maeslantkering was completed in 1997. The barrier is connected to a computer system that is linked to weather and sea level data. Under normal weather conditions, the two doors are in dry docks, and the river is 1,200 feet wide. The barrier closes automatically when a storm surge of 9 feet above normal sea level is anticipated in Rotterdam. The computerized monitoring system determines when the gates are closed, monitors water levels on the upstream side of the gates, and allows for release of upstream water if levels become too high. Figure 7 depicts this structure in its closed position.

Figure 7. Maeslantkering in closed position

3.3 Neighborhood-Scale Adaptation Planning and Floodproofing

3.3.1 New York and New Jersey

Since Superstorm Sandy struck New York and New Jersey, many of the most innovative flood mitigation projects in the world are occurring in the United States. The "Rebuild by Design" program was initiated by the United States Department of Housing and Urban Development (HUD) and the Presidential Hurricane Sandy Rebuilding Task Force. The intent of the Rebuild by Design program is to bring the world's most innovative designers together to redevelop the impacted areas in ways that are environmentally and economically viable. Rebuild by Design, with funding from a variety of federal and private resources, sponsored a design competition to generate concepts for shoreline protection. Six projects have been selected to move forward as follows:

- A living breakwater project that will consist of a series of breakwaters to buffer Staten Island from wave action and erosion. The breakwaters will include a mix of above-water and below-water structures that will enhance habitat diversity while buffering the island.
- At Hunt's Point, a series of flood protection platforms are proposed to allow for recreational access in this largely industrial waterfront area; new pier infrastructure is proposed to develop a maritime emergency supply line to allow food distribution to continue along the East Coast when roadways are impassible; and a microgrid electric system is proposed to ensure the refrigeration demand of this critical facility can be met during emergency conditions.
- A proposal to protect Hoboken, New Jersey consists of providing flood protection measures to the elevation of the 500-year storm surge level plus sea level rise; construction of waterfront wetland and park systems to provide a defense from storm surge; and storing floodwaters in underground systems that reduce the frequency of street flooding and discharge the water once the capacity of the drainage systems have been restored. This proposal includes pump systems and major improvements in the drainage system of the area. A concept of this is shown in Figure 8.

- A proposal at the Meadowlands area calls for construction of a natural reserve that will include a system of marshes and berms to protect against storm surge and collect rainfall. Around the reserve (known as Meadowpark) will be a transportation ring (called the Meadowband) that includes a roadway, Bus Rapid Transit line, and public spaces. Together, the park and band protect existing development areas and allow for future development.
- In Nassau County, Long Island, a multifaceted approach will include constructing marshes, dikes, and similar structures along the urbanized edge; managing stormwater to reduce damage from more frequent rain events; and expanding housing in areas near public transportation that are outside of the floodplain.
- The southern tip of Manhattan is the final area targeted by a winning proposal. The proposal known as The Big U protects approximately 10 miles of shoreline from West 57th Street to East 42nd Street. The proposal calls for a series of berms, marshes, and deployable walls combined with recreational spaces and a reverse aquarium that will allow visitors to observe future underwater areas.

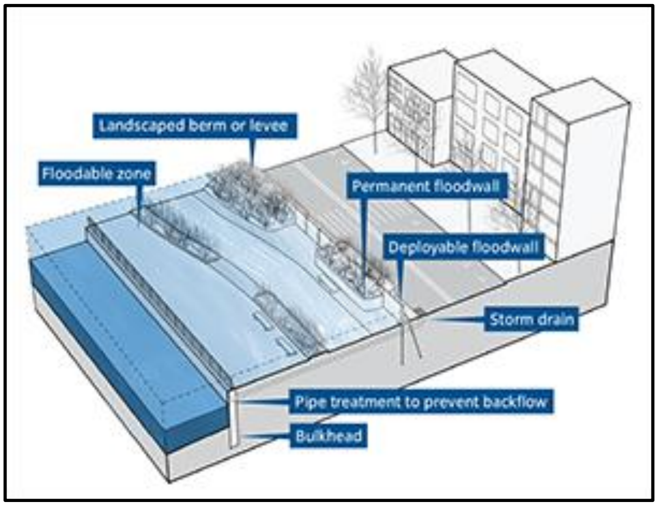


Figure 8. Sample of Proposed Improvements under Consideration in New York. Source: NYC Coastal Storm Plan

3.3.2 Guilford, Connecticut

The Town of Guilford developed a three-part Vulnerability Study and Coastal Resilience Plan that considers adaptation on a neighborhood-by-neighborhood basis. The analysis developed in Guilford was a planning study that made broad recommendations for future land use and infrastructure modifications such as those shown in Figure 9. The town used the recommendations in this plan to develop a capital improvement program, and many of the improvements have been implemented.

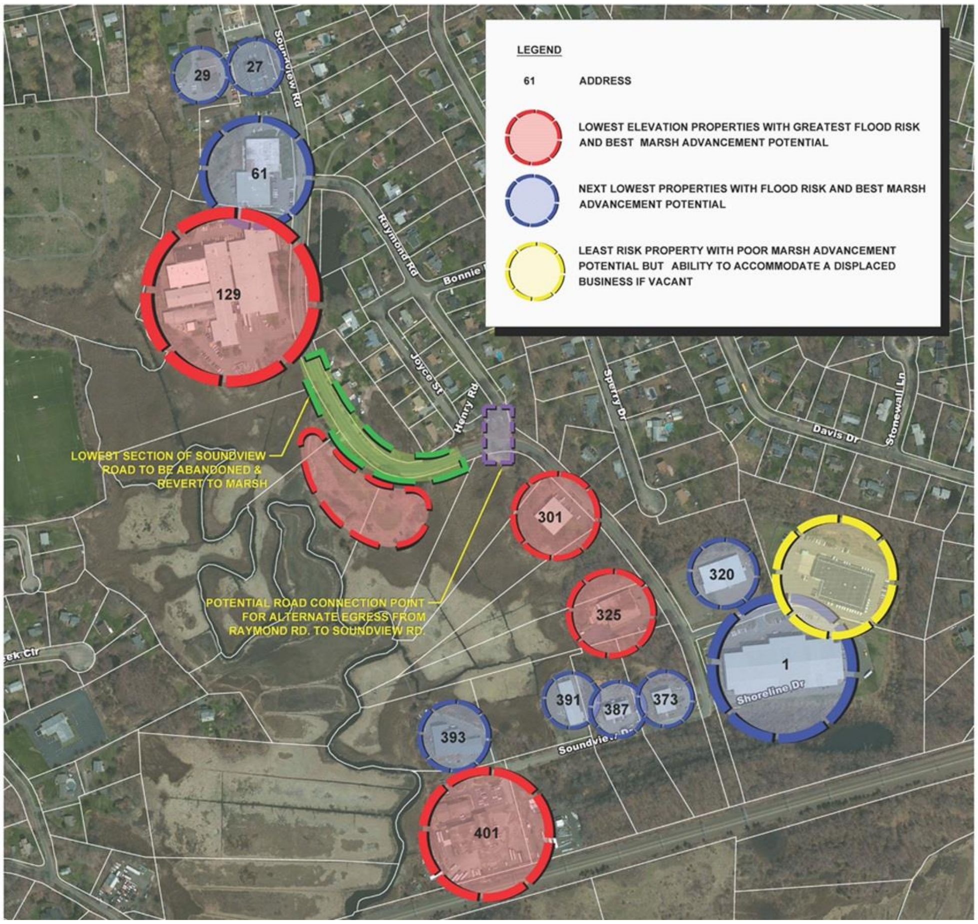


Figure 9. Soundview Area Plan, Guilford, Connecticut

3.4 <u>Structure-Specific Floodproofing and Retrofitting</u>

The National Flood Proofing Committee (NFPC) defines floodproofing as "any combination of structural or nonstructural changes or adjustments incorporated in the design, construction, or alteration of individual structures or properties that will reduce flood damages." Properly designed and constructed floodproofing measures can effectively reduce flood damages. However, the only way to prevent all damage is to relocate the structures (i.e., retreat).

The following are general approaches to floodproofing that may be used individually or in combination:

- Relocating the structure
- Elevating the structure and/or critical systems
- Abandon lowest floors and wet floodproof
- Permanent barriers such as floodwalls or levees
- Temporary floodwalls
- Installing gates at doors and windows
- Waterproofing building walls

While each of these is described in detail in the following report sections, Table 3 provides a summary of the methods.

TABLE 3
Structural Floodproofing Methods of Commercial Buildings

Floodproofing Measure	Summary	Barriers to Implementation and Benefits	Relative Cost
Relocation	Moving buildings to new nonfloodprone location	• Potential loss of business due to change of location • Potential loss of tax revenue if new location has lower assessed value • Unraveling of fabric of community unless entire business district is relocated	****
Elevation	Raising structures above flood elevation	• Loss of visibility from street, which is generally unacceptable to retail buildings • Creation of potential "dead space" under building may create safety hazard • Difficult in attached buildings • Reduces flood insurance premiums	***
Abandon Lowest Floor (wet floodproofing)	Remove all contents	• Requires wet floodproofing of lowest floor (retrofit to ensure water can easily enter and exit structure) • Reduces damage to material and equipment by eliminating storage below flood elevation	**
Floodwalls / Levees / Ringwalls	Concrete or earth barrier protection	• Levees require significant land area. • Floodwalls obstruct water view. • Stormwater can be trapped on interior side necessitating pumping.	****
Temporary Flood Barriers	Plastic or metal barrier	• Require manual labor prior to every flood event for installation • Require advance notification and planning; may not be fully installed before storm • May not protect from long-term flooding • Vulnerable to human error	*
Building Opening Barriers	Metal or plastic barriers for doors, windows	• Require shop or building owner to be present to install	***

TABLE 3 Structural Floodproofing Methods of Commercial Buildings			
Floodproofing Measure	**Summary**	**Barriers to Implementation and Benefits**	**Relative Cost**
Waterproofing Building Siding	Coating or material to provide waterproofing	• Not viable for wood frame buildings	**

3.4.1 Structure Relocation

Relocating a structure is the most dependable method of floodproofing. The method involves moving the structure out of the floodplain away from potential flood hazards. Costs are usually a major concern associated with building relocation. Aside from cost, large-scale relocation such as would be required for the Main Street Damariscotta properties is not currently socially acceptable, and it does not meet the town's economic development goals. Therefore, relocation is not considered as part of this plan.

3.4.2 Structure and/or Critical System Elevation

Elevating a structure requires raising the lowest floor so that it is above the target design level. Almost any structurally sound small building can be elevated. However, the process becomes more difficult and virtually impossible with a large building that has slab on grade, is constructed out of block or brick, has multiple stories, or is connected to adjacent buildings. Elevation can also create unattractive and hard to manage areas below the buildings since ideally these areas are left open or secured with material that can allow floodwaters to enter below the building. Elevation has gained much wider acceptance in recent years as a means of managing coastal structures, particularly in residential areas. In commercial buildings, such as the subject of this study, elevation to more than a few feet above street level makes for uninviting and hard to access retail space, so its viability is somewhat limited. Plus, there is additional complexity for Damariscotta due to the fact that many of the structures on the south side of Main Street are "walkouts" meaning that the rear of the building is up to one story lower than Main Street. Elevating a multilevel building is not readily feasible.

One elevation alternative that may be prudent for some portions of the project area is the elevation of critical systems such as boilers, propane tanks, oil tanks, hot water heaters, etc. This can be accomplished by constructing decking along the building that can support the utility infrastructure or by placing utilities on the roof of the building. Many of the buildings in the study area have pitched roofs, making placement of utilities on the roof impractical, so providing elevated platforms in discrete locations is the best potential method of raising utilities.

3.4.3 Operational Modifications

Many of the alternatives discussed are considered "dry floodproofing" technologies; that is, they are intended to prevent floodwaters from entering the buildings. Modifying the operations and use of existing structures to allow flooding to occur while minimizing property damage is considered "wet floodproofing." Under this scenario, all contents (including utilities) are removed from below the flood elevation, and openings in the building wall are either maintained or increased to size to allow water to readily enter the lower floors. The openings allow the hydrostatic pressure inside and outside the building to equalize, reducing the potential for structural failure.

Wet floodproofing may be feasible for some buildings in the study area, but our observations suggest that many businesses are located within the finished walkout basements of structures in the study area making this an extremely difficult alternative to implement.

3.4.5 Permanent Ringwalls, Floodwalls, and Levees

Ringwalls, floodwalls, and levees are located away from the structure to be protected and are designed to prevent the encroachment of floodwaters. They may completely surround the structure (ringwalls) or protect only the low side of the property. It is also possible to install floodwalls on a "neighborhood scale" such that one structure protects multiple buildings. A well-designed and constructed levee or floodwall prevents any floodwater forces on buildings, which can be important when the buildings are older construction that may not meet current codes. As long as the flood protection structure is not overtopped, the buildings would not be exposed to hydrostatic or hydrodynamic forces.

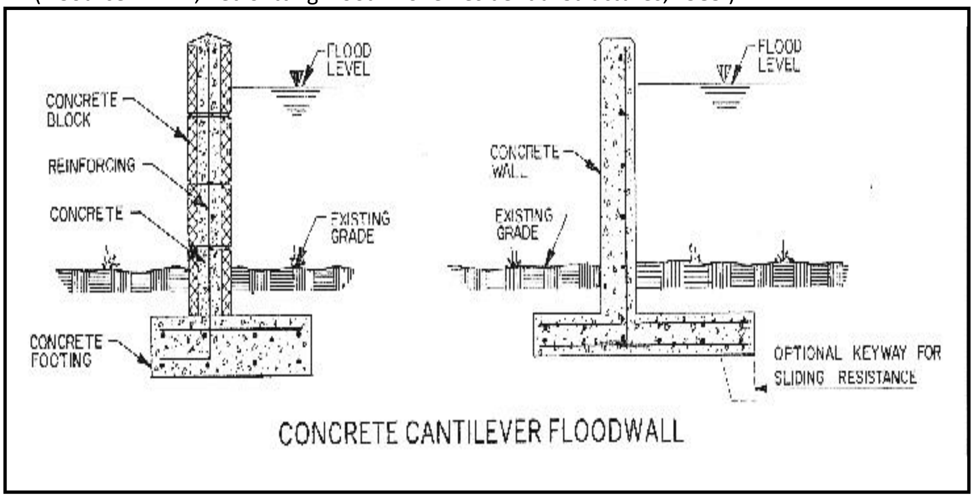
These types of protections can have openings to allow for driveways, sidewalks, and doorways as long as these openings are equipped with a sealed closure device. Temporary closure devices may be used for driveways and pedestrian access points but require human intervention to be put in place when flooding is predicted. Temporary barriers are described in more detail in subsequent report sections.

Levees are earthen embankments of compacted soils that can keep floodwater away from the structure. The distinct disadvantage of levees is that they require large amounts of land area since they typically are constructed with side slopes of 2:1 or 3:1. As a result, a levee that is 5 feet high may be 27 feet wide. The need for the town to reconstruct the existing parking lot on the south side of Main Street presents the potential opportunity to raise the parking lot and use the elevated parking lot as a levee or berm. In fact, we see this as one of the most surefire ways to protect the buildings on the south side of Main Street; however, as we evaluate this in more detail in the next phase of the project, we will need to consider how to protect the low-lying area near Misery Gulch, which would not benefit from raising the parking lot.

Floodwalls differ from levees in that they are constructed of a variety of man-made materials. Cantilever walls and gravity walls are the two most common types. Gravity walls are used for low level flood elevations and rely on the mass and weight of the structure to resist flood forces. By design, they are wider at the bottom than at the top.

Cantilever floodwalls are the most commonly used structures and require less construction area than other types of floodwalls and can be designed to have aesthetic value. The cantilever floodwall is designed to use the weight of soil and water over a portion of its footing to hold it in place. Figure 10 shows a detail of a typical cantilever wall.

(* Source: FEMA, Retrofitting Flood-Prone Residential Structures, 1985.)



The type of soil material at the construction site dictates the design requirements of floodwalls. It is our understanding that soil borings have been completed for areas within the parking lot and while they may be useful in assessing floodwall foundation and support requirements, analysis of the borings is beyond the scope of this project. The parking lot area in the south side of the project area generally consists of fill material as this area was open water prior to its development. Based on this, the structural characteristics of the soils will require careful investigation.

With these types of structures, there is no need to make structural alterations to the building being protected. A common practice is to install a sump pump, which will enable seepage water flowing through the levee or floodwall, and rainwater falling inside the levee or floodwall, to be evacuated prior to damaging the protected structure.

Periodic maintenance will be required for a floodwall. After each storm, check valves on the pump discharge pipes should be cleared of debris, and an inspection of the sump pump should be completed. Floodwalls should be inspected annually for cracking and spalling.

In recent years, floodwalls have become more and more advanced. For example, at the National Archives Building in Washington, DC, self-closing flood walls were installed in 2009 following a flood event in 2006 that almost destroyed some of the country's most important historic documents. An example of the self-closing system is shown in Figure 11.

When not in use, the entire wall system is contained underground. The sump is covered with a lid that is flush to the ground. As water begins to fill the underground sump, the buoyant floodwall rises, and a watertight seal provides flood protection for the inland area. As floodwater recedes and pressure on the barrier is reduced, it automatically drops under its own weight back into the underground container.

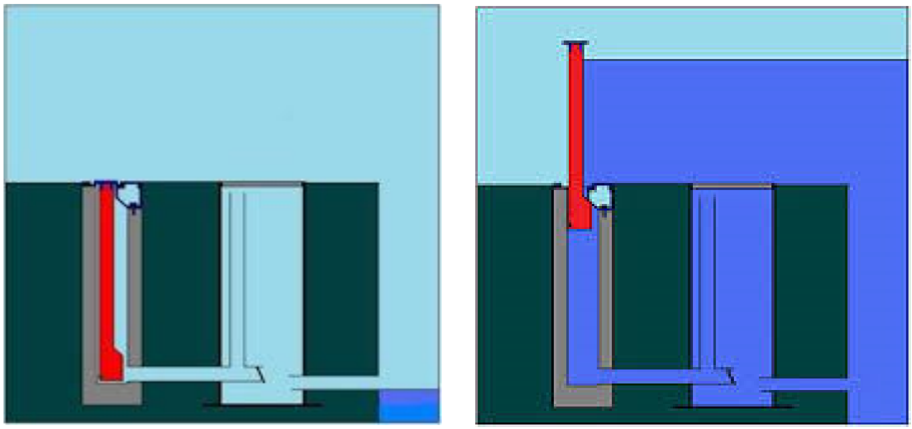


Figure 11. Self-Closing Flood Barrier. Left figure shows gate in closed position. As water fills underground sump, gate rises to open as shown at left.

Self-closing barriers provide the distinct advantage of not being a visual barrier the way a concrete or steel sheet pile floodwall would. Since preservation of the viewshed is so critical to Damariscotta, a self-closing system that is normally buried presents an opportunity to manage flooding while protecting the aesthetics of the area. These systems also do not require manpower to set up prior to flooding. This may be critical in a small community where Public Works resources are limited.

3.4.6 Temporary Floodwalls

Flood barriers are temporary structures that are erected manually only when flooding is imminent. These systems have a lower capital cost than a floodwall or the self-closing barriers described above, but they require human intervention prior to flooding, generating a risk that the installation is not completed and the structures are not protected.

Samples of temporary barrier products include:

- Floodstop: This modular barrier system can be installed by one person as shown in Figure 12 on the right. Gaskets secure each unit to the next and provide a watertight seal. This is one of the few freestanding flood barriers currently on the market. The units come in heights of 20 inches (1.7 feet) and 35 inches (2.9 feet). If the parking lot on the south side of the Main Street remains at (approximately) elevation 8.5, this system may provide protection up to elevation 11.4.

Figure 12. Floodstop Modular Barrier

- Temporary Floodwalls: There are a number of companies that manufacture temporary floodwall systems. Generally speaking, these systems have three components: a base plate, support posts, and a support system. The actual system construction varies by manufacturer, with some walls mounted on temporary movable support systems and others mounted on a permanently installed base that is embedded in a poured concrete foundation. One example of a temporary system is manufactured by Hydro Response (http://www.hydroresponse.com/flood_barrier2.htm) and is shown in Figure 13. Following completion of the construction as shown in the figure, the system is covered in a plastic barrier to provide waterproofing. This particular photo shows an aluminum barrier, but the barriers can also be constructed of plywood or pallets. The systems come in heights ranging from 1 foot to over 6.5 feet.

  Similar temporary systems are available as vertical systems such as shown in Figure 14. For this system, FastLogs are mounted in front of the opening using Jamb Brackets mounted on the face of the building. They have mounting holes for concrete anchors and bolts. The height of these systems can vary, in 6” increments, based on the specifications required for the specific application.

Figure 13. Hydro Response Temporary Barrier. Photo taken during training installation. Image: Hydro Response

Figure 14. Temporary Floodwall. Support system is located on landward side of wall. Image: Presray

- Inflatable Tubes: There are a number of products on the market that consist of inflatable tubes. One such product is shown in Figure 15. These tube systems are laid flat and filled with water or a slurry mix prior to the flood event. Following the event, they are simply drained and stored. Achieving higher levels of flood protection requires using multiple bags that then must be strapped together to ensure they are stable during larger storm events.

Figure 15. Inflatable Flood Protection. Image: Tiger Dams

3.4.7 Temporary Gates at Building Openings

Floodwalls protect large areas and prevent hydrostatic forces from being exerted on building walls. However, it may be tolerable for parking lots and similar open spaces to flood while retrofitting buildings to prevent water from entering at windows and doors. In determining whether it is feasible and practical to mitigate flooding at building openings, it is important to consider the number of openings, their location and elevation, and their type (e.g., windows, doors, vents, loading docks, etc.). In some cases, providing flood protection at all openings in a building may not be practical, and a flood barrier type of system would be preferable. Survey has been completed at the structures within the Damariscotta study area, so the elevation of building openings has been compiled and will be used to evaluate specific technologies for use in the study area. It is important to note that the success of these products at preventing water from entering the building relies on the building walls being floodproofed as well.

The following are sample products that can serve this purpose. It is important to note that there is a large number of products of this type on the market. The information below is not intended to be an exhaustive survey but rather is meant to provide a sample of the types of products that can be considered.

- Hinged Floodgates: These types of systems can be installed to provide either manual or automatic operation. Manual operation requires that someone be available to raise the gate prior to a flood event. Automatic operations are ideal where the building owner or operator may not be available to close a manual system. Figure 16 is one example of a bottom-hinged gate system that stows below grade when not needed. Side-hinged systems are also available. The side-hinged systems close like a typical door and include a handle that is turned to create a seal after the door is closed.

Figure 16. Hinged Floodgates. Image: Presray

Hinged gates are custom built for each specific building and opening and can vary in width and height. Widths can be as much as 25 feet, and heights can be up to 5 feet.

- Door Protection Barriers: In contrast to the sealed systems that are permanently installed such as discussed above, there are a number of window and door protection systems on the market that can be installed manually as storm events are predicted. An example of these is shown in Figure 17. These systems typically require some type of infrastructure to be installed along the door frame to allow for a seal to be performed following the installation. In some cases, the door is bolted into place prior to a flood; in others, a gasket system allows for a seal to be formed at the turn of a handle.

- Vent Protection: There are few products on the market to retrofit building vents. Most vent systems constructed for floodproofing are intended to provide for wet floodproofing and allow floodwater into the building. Dry floodproofing of vents will need to be evaluated on a structure-by-structure basis. In some cases, it may be best to seal the existing vents altogether. In cases where that is not possible, custom solutions, such as scaled-down versions of the flood doors, will need to be considered.

Figure 17. Manual Install Flood Door. Image: UK Flood Barriers

3.4.8 <u>Waterproofing Building Walls</u>

There is a number of commercial products available to waterproof building walls and foundations. These range from Dry-Lok type of "paint on" materials to engineered elastomeric coatings. Products like Dry-Lok are available at most hardware stores but are intended to protect against groundwater weeps and seepage as opposed to flooding that produces standing water of varying heights.

Examples of commercially available waterproofing products are made by Quest Construction products. Two materials – FlexCoat and Aquathon – are specifically intended to provide coating over masonry and brick structures, sealing cracks and providing a flexible coating that allows for movement as the building siding settles and cracks. It is important to note that these coatings are exactly that – coatings – and while a number of color options are available, the coating will change the aesthetic of the building. A number of companies make similar products and, if the town would like to pursue this type of alternative, vendors will need to be contacted to discuss the appropriate application and product.

In addition to walls, consideration will need to be given to basement floors. Many of the old buildings in the study area have basement floors that are cracking, and some structures have floor sections that are earth. At least one building has floor drains with discharge locations that are unknown. Floodproofing of the buildings will require sealing the basement floor and walls to prevent water from entering.

The use of coatings to floodproof basements and exterior walls will increase the hydrostatic pressure on the building walls and foundation, and this will need to be considered on a case-by-case basis to ensure that the structural integrity of the building is not compromised.

4.0 MITIGATION OPTIONS

Based on the information provided in Section 3, the Committee discussed the advantages and disadvantages of a number of solutions for protecting its downtown waterfront properties. Riverine and watershed-based options, such as flood control or tide gate structures, were discounted due to cost and complexity. A number of options were discussed for building-specific protections such as flood doors, etc. The Committee is interested in these as short-term solutions but recognizes that these solutions often rely on human intervention to provide adequate protection and are not appropriate for long term, robust mitigation of the area. In the event a building owner is out of town, his/her structure may not be protected prior to the flood event. Solutions such as temporary flood barriers present similar concerns and would require implementation by the town prior to a storm event. The town's limited staffing resources make implementation of this type of solution concerning.

Given the potential implementation hurdles with building-specific and riverine solutions, the Committee focused on "neighborhood"-based solutions. Under this scenario, the downtown area would be protected using earthen berms, floodwalls, raising the grade of the parking lot, or some combination thereof. These types of solutions present some distinct advantages as follows:

- Their reliance on human intervention prior to flooding is limited. These solutions would be constructed and permanently in place, providing protection at all times.
- They may allow the downtown buildings to be removed from the mapped floodplain. If the wall and levee system is appropriately designed and constructed, the town may be able to secure a Letter of Map Revision from FEMA that changes the limit of the floodplain and removes the buildings. More information regarding this process can be found on the FEMA website by following this link: http://www.fema.gov/forms-documents-and-software/flood-map-related-fees#2 . See section "Requests for Map Changes Requiring Special Technical Review." This would result in lower flood insurance premiums for these building owners and increase the long-term marketability of the properties.
- They can be integrated into the town's long-term vision for using the waterfront area as a focal point for community activities and waterfront access.

The following options were considered:

Option 1 – Fill Parking Lot to Elevation 12 with Steel or Concrete Floodwall
Option 2 – North Side

In developing these options, the following are assumptions that were made:

- All options are intended to maintain the viewshed from the parking lots.
- The number of existing parking spaces at the waterfront area must be maintained or increased.
- The barber shop building is removed and the property incorporated into the parking lot. Our survey data collected as part of this study shows the floor elevations of this building are 8.3 to 8.5 making it difficult to protect this low-lying structure.
- Schooner Landing will not be protected.
- The sewer pump station must be maintained in its current location. Relocating the sewer infrastructure would require extensive reconstruction within the system and, in our opinion, should be avoided if possible.

4.1 Option 1 – Parking Lot Fill to Elevation 12

Option 1 (see Appendix A) includes the following:

- Install either a concrete or steel sheet bulkhead along the waterfront area to elevation 12.0. This would be installed at or near the existing top of the bank.

  Fill the parking lot to elevation 11.5 across the first (southerly) row of parking with grades sloping back down toward the north.
- Provide waterfront access.

  - Place a concrete sidewalk and wooden boardwalk at elevation 12.0 from the bulkhead location toward the water.

- Provide a stop log structure at the boat ramp. This may be a structure below the self-rising system (such as those available from Presray) or manual stop logs to be placed prior to the storm event. We do not currently have the exact location of the sanitary sewer outfall in our survey data. A potential conflict with the sewer main may preclude the use of the Presray self-rising gates and necessitate use of traditional stop logs.

- Provide concrete or steel sheet pile bulkhead along the east and north sides of Misery Gulch to elevation 12.0. This would allow the town to provide the much desired pedestrian access to Schooner Landing behind the building at 49 Main Street.

- Provide a stop log or gate system across the drive to Schooner Landing.

- Provide a bulkhead from the Schooner Landing driveway to tie into existing high ground near the Damariscotta River Bridge.

4.2 Option 2 – North Side

The Committee and MMI focused much attention on the south side of Main Street because the south side is larger and is more flood prone. However, there is an area susceptible to flooding on the north side of Main Street that also must be addressed. Option 2 considers the area north of Damariscotta Pottery and near the Damariscotta Bank and Trust Operations Center.

Option 2 presents a concept that formalizes the low-lying parking area along the waterfront area north of the buildings. Some formal parking would be created, and a pedestrian viewing area would be created at an elevation of 12.0. Survey completed during this study shows elevations in this area of 6.4, suggesting a fairly large amount of fill to achieve protection to elevation 12.0.

4.3 Selection of Preferred Options

A summary of the options considered and our opinion of probable construction costs are presented in Table 4. Supporting documentation for the cost opinions is in Appendix B.

TABLE 4
Summary of Options

Option	Engineer's Opinion of Probable Construction Costs
1: Parking Lot Fill to Elevation 12	$1,605,000
2: North Side Improvements	$304,000

4.4 Utilities Management

Implementation of a structural solution to flooding will require consideration for utility services and connections. Specifically, stormwater evacuation from the parking lot, protection of water and sewer services and mains, and the propane tanks must be considered as described below.

4.4.1 Stormwater

Gravity discharge of stormwater is always an important consideration in low-lying coastal areas. Under existing conditions, storm drainage inlets in the parking lot are somewhat in a state of disrepair and some have settled over time. The most low-lying structures (such as near Bistro) sometimes "surcharge" (or have river water flow backwards through them) during high tide events. Our concept plans suggest raising the parking lot, which will lead to raising the drainage structures; however, the drainage system will continue to be a flooding vulnerability.

Reducing the flood risk associated with river water surcharging the drainage system requires a) either pumping the stormwater out with enough force to overcome the river water, or b) preventing the river water from entering the system. Stormwater pump stations are feasible (and becoming more common thanks to sea level rise), but they are costly to construct and operate, and they represent an ongoing maintenance burden. Preventing river water from entering the gravity system will reduce the flooding frequency in the parking lot, with limited capital and operating expenses.

In repairing or replacing the drainage system in a floodprone area, consideration should be given to using watertight pipe. Gaskets at the pipe joints reduce the ability of groundwater to enter the drainage system. Gasketed piping is common in water supply and sewer systems and readily available on the market.

Perhaps more important is placing a flap gate or duck bill structure on the pipe outlet. A traditional flap gate is shown in Figure 18. These are typically made of steel or aluminum and open under the force of water building up in the pipe behind the gate. A duck bill is shown in Figure 19. Either device can work for this application, and both have different installation requirements so will need to be selected during the design process.

Figure 18: Stormwater Flap Gate

Figure 19: Duck Bill Flap Gate

4.4.2 Water Supply

We did not investigate the location of water mains and service laterals in this study. We presume the water mains are located within Main Street and that the system is watertight in order to protect potable water quality from groundwater intrusion. Therefore, water supply is not discussed in detail here.

4.4.3 Sanitary Sewer

The buildings on the south side of Main Street are served by sanitary sewer and with laterals discharging out the rear of the buildings to a gravity main that runs to the pump station near the boat launch. The below grade pump station pumps wastewater in a force main through the parking lot to the wastewater treatment plant. A gravity line from the treatment plant then discharges water back through the parking lot somewhere near the boat launch and dinghy dock.

Information in the Shore and Harbor Master Plan regarding the sewer system suggests that the service laterals from the buildings may be in relatively poor shape. These should be replaced with new watertight piping when the parking lot repair (or improvements as suggested herein) is completed.

The gravity line that discharges to the pump station and the gravity line from the treatment plant are reportedly in good condition but should continue to be monitored regularly. Infiltration into the pipe system from rising groundwater (an almost inevitable effect of sea level rise) will effect operation of the pump station and possibly the treatment plant and so must be avoided. The force main is less of a concern since it operates under pressure, reducing the possibility of water entering the pipe from infiltration.

The pump station was not evaluated in detail for this study, but we recommend that a separate evaluation of the system be completed. The wet well and pump system must be protected from river water intrusion. It may be possible to accomplish this through waterproofing of the concrete and gasketing and bolting the manhole covers. At some point in the future, depending on the rates of observed sea level rise in Damariscotta, it may be necessary to elevate the pump station or relocate it entirely.

4.4.4 Electric Service

Overhead electric service is present throughout the study area. Our option plans call for relocating select poles to accommodate the proposed improvements. The continued use of overhead electric service is preferable in this area to any efforts to install the service below grade. At this time, significant modification to the electric service in the area is not recommended.

4.4.5 Propane

Many of the buildings within the study area (and throughout downtown Damariscotta) are served by propane as evidenced by the many tanks observed during our work. Propane tanks are of concern in flood environments because of their propensity to float. If a tank becomes dislodged, gas leaks will occur thus creating a fire hazard. If the tank becomes detached from the structure entirely, it would be capable of floating down river, creating navigation hazard.

The construction of a flood wall or berm system would protect the propane tanks from flooding and alleviate the concern raised. Regardless, the town may like to recommend to property owners that the tanks be secured with tie-downs to reduce the risk for flotation. Building connections should be fitted with quick disconnect devices so, if service is disconnected, the flow of propane would cease, thereby reducing the fire hazard.

Another alternative to consider would be construction of a small, neighborhood-scale propane distribution system. These are somewhat uncommon but may create a practical solution to the potential flood hazards associated with propane. A small distribution system would also have the added benefit of improving the aesthetics of the rear of the buildings. This is an alternative that would need to be explored in more detail outside the scope of this study.

5.0 IMPLEMENTATION OF PREFERRED PLAN

5.1 Interim Measures

In selecting its preferred alternative, the Committee recognized that design, funding, and implementation may take a number of years and asked that this report include property-specific recommendations that building owners can implement to reduce their flood liability. Using the survey of ground and building elevations completed by Maine Coast Survey, MMI has identified the vulnerabilities of each structure along the waterfront. Vulnerabilities include windows, doors, vents, electric services, propane tanks, etc. that are below elevation 12.0. For each vulnerability, we have suggested means of protection. These recommendations are shown in Table 5 below.

TABLE 5
Flood Vulnerabilities and Recommendations

Building Address	Vulnerabilities	Elevation	Recommended Solutions	Cost Range	Average Cost
Midcoast Kayaks	Door	11.99	Install gasketed doors (a)	$1,500-$2,000	$1,750
Fisherman's Catch - 49 Main St.	Door threshold at SW building corner	10.64	Install gasketed doors (a)	$1,500-$2,000	$1,750
				$1,500-$2,000	$1,750
	Center door on north side	11.63		$1,500-$2,000	$1,750
	West door on north side	11.97		$1,500-$2,000	$1,750
	East door on north side	11.76		$1,500-$2,000	$1,750
	Vent	10.74	Retrofit vent (b)	$1,500	$1,500
	North door on east side	11.74	Install gasketed doors (a)	$1,500-$2,000	$1,750
	Middle door on east side	11.84		$1,500-$2,000	$1,750
	Door - Metcalf Subs	11.86		$1,500-$2,000	$1,750
	Propane tanks on south side	~8.5	Install quick disconnect fittings and strap down propane tanks (c)	$500/tank	$2,500
	Propane tanks on east side	~9.5		$500/tank	$1,000
	Electric meter on east side		Elevate utility / install temporary flood barrier (d)	$1,500-$2,000	$1,750

TABLE 5
Flood Vulnerabilities and Recommendations

Building Address	Vulnerabilities	Elevation	Recommended Solutions	Cost Range	Average Cost
Stars Jewelry - 65 Main St.	Rear door threshold	10.81	Install gasketed doors (a)	$1,500-$2,000	$1,750
	Main door threshold	10.88		$1,500-$2,000	$1,750
	Propane	~8.75	Install quick disconnect fittings and strap down propane tanks (c)	$500/tank	$1,000
Two Fish - 77 Main St.	Westerly metal vent on south side	9.86	Retrofit vent (b)	$1,500	$1,500
	Easterly metal vent on south side	10.05		$1,500	$1,500
	Threshold double door on south side	10.12	Install gasketed doors (a)	$3,000-$4,000	$3,500
	Granite threshold main door	11.4		$1,500-$2,000	$1,750
	Oil fill up on south side		Elevate utility / install temporary flood barrier (d)	$500-$1,500	$1,000
	Propane tank on south side	~8.52	Install quick disconnect fittings and strap down propane tanks (c)	$500/tank	$500
Newcastle Square Realty - 87 Main St.	Door	10.81	Install gasketed doors (a)	$1,500-$2,000	$1,750
	Rear door threshold	10.81		$1,500-$2,000	$1,750
	Propane tanks on south side	~8.3	Install quick disconnect fittings and strap down propane tanks (c)	$500/tank	$1,000
	A/C Units on south side		Elevate utility / install temporary flood barrier (d)	$1,500-$2,000	$1,750

TABLE 5
Flood Vulnerabilities and Recommendations

Building Address	Vulnerabilities	Elevation	Recommended Solutions	Cost Range	Average Cost
Nicoll Fine Art - 93 Main St.	Door threshold Nicoll Fine Art	11.77	Install gasketed doors (a)	$1,500-$2,000	$1,750
	Door threshold The Accessories Shop	11.76		$1,500-$2,000	$1,750
	Door threshold Ice Cream Shop	11.73		$1,500-$2,000	$1,750
	Rear door threshold	11.71		$1,500-$2,000	$1,750
	East side door threshold	11.72		$1,500-$2,000	$1,750
	Oil fill up on east side		Elevate utility / install temporary flood barrier (d)	$1,500-$2,000	$1,750
	Cable on south side			$1,500-$2,000	$1,750
	Vent on south side		Retrofit vent (b)	$1,500	$1,500
	Oil fill up on west side		Elevate utility / install temporary flood barrier (d)	$1,500-$2,000	$1,750
Sheepscot River Pottery - 115 Main St.	East side windowsill	9.26	Install gasketed doors (a)	$1,500-$2,000	$1,750
	East side door threshold	7.33		$1,500-$2,000	$1,750
	South side windowsill	9.63		$1,500-$2,000	$1,750
	South side electric meters		Elevate utility / install temporary flood barrier (d)	$1,500-$2,000	$1,750
Bistro J - 85 Main St.	East side door threshold	10.61	Install gasketed doors (a)	$1,500-$2,000	$1,750
	South side door threshold	10.01		$1,500-$2,000	$1,750
	West side door threshold	12		$1,500-$2,000	$1,750
	Propane tank on north side	~9.4	Install quick disconnect fittings and strap down propane tanks (c)	$500/tank	$500
	Electric meter on west side		Elevate utility / install temporary flood barrier (d)	$1,500-$2,000	$1,750
Pine Tree Variety	South side door threshold	8.2	Install gasketed doors (a)	$1,500-$2,000	$1,750
	West side double door	7.28		$3,000-$4,000	$3,500
	South wall windowsill	9.57		$1,500-$2,000	$1,750

TABLE 5
Flood Vulnerabilities and Recommendations

Building Address	Vulnerabilities	Elevation	Recommended Solutions	Cost Range	Average Cost
Ocean Point Furniture - 133 Main St.	East side door	9.01	Install gasketed doors (a)	$1,500-$2,000	$1,750
	Propane on south side		Install quick disconnect fittings and strap down propane tanks (c)	$500/tank	$2,500
	Electric on south side		Elevate utility / install temporary flood barrier (d)	$1,500-$2,000	$1,750
Se Vende Imports	West side windowsill	10.75	Install gasketed doors (a)	$1,500-$2,000	$1,750
	East side door threshold	8.13		$1,500-$2,000	$1,750
Barber Shop	Northeast door threshold	8.29	Install gasketed doors (a)	$1,500-$2,000	$1,750
	Main door threshold	8.54		$1,500-$2,000	$1,750
	West side door threshold	8.56		$1,500-$2,000	$1,750
Artsake/Shapers/Damariscotta River Grill - 151/155 Main St.	Shapers door threshold	7.67	Install gasketed doors (a)	$1,500-$2,000	$1,750
	South side door threshold	7.86		$1,500-$2,000	$1,750
	South side easterly door	7.71		$1,500-$2,000	$1,750
	Propane tanks on south side		Install quick disconnect fittings and strap down propane tanks (c)	$500/tank	$2,000
	Electric/gas on south side		Elevate utility / install temporary flood barrier (d)	$1,500-$2,000	$1,750
	A/C Units on south side			$1,500-$2,000	$1,750
Damariscotta Center - 157 Main St.	South side door threshold	8.23	Install gasketed doors (a)	$1,500-$2,000	$1,750
				$1,500-$2,000	$1,750
Reny's Underground	South side easterly door	9.61	Install gasketed doors (a)	$1,500-$2,000	$1,750
	South side main door	9.28		$1,500-$2,000	$1,750
Seawicks - 112 Main St.	North door threshold	11.81	Install gasketed doors (a)	$1,500-$2,000	$1,750
	A/C & Electric north side		Elevate utility	$1,500-$2,000	$1,750

TABLE 5
Flood Vulnerabilities and Recommendations

Building Address	Vulnerabilities	Elevation	Recommended Solutions	Cost Range	Average Cost
Chapman & Chapman Insurance - 108 Main St.	Main entrance door - 108 Main St.	11.37	Install gasketed doors (a)	$1,500-$2,000	$1,750
	A/C units on north side		Elevate utility / install temporary flood barrier (d)	$1,500-$2,000	$1,750
Salt Bay Café - 88 Main St.	Main entrance on Main St.	10.39	Install gasketed doors (a)	$1,500-$2,000	$1,750
	Trench drain with sump pump on south side				
D. B. & T. Operations Center - 100 Main St.	East side lowest door threshold	10.46	Install gasketed doors (a)	$1,500-$2,000	$1,750
	Generac power system west side		Elevate utility / install temporary flood barrier (d)	$1,500-$2,000	$1,750
	A/C units on east side			$1,500-$2,000	$1,750
Weatherbird Building	North side three windowsills	10.3	Install gasketed doors (a)	$4,500-$6,000	$5,000
Colby & Gale Plaza	West side windowsill	10.34	Install gasketed doors (a)	$1,500-$2,000	$1,750
	West side northern door threshold	7.67		$1,500-$2,000	$1,750
	West side southern door threshold	8.08		$1,500-$2,000	$1,750
Total Cost					$136,750

Notes:

a. A low door shield costs $1,500 (PS Doors). Dewberry reports a range of $500-$1,500 for door gaskets and seals. Fully floodproofed doors can cost more but may be excessive given many of the existing door elevations in the downtown area.
b. Cost of $1,500 provided are for typical vent replacement at a higher elevation.
c. FEMA reports a typical cost of $500 to anchor one propane tank.
d. Dewberry reports a range of $500-$1,500 to elevate electrical service and meter, a range of $500-$1,500 to floodproof electrical service and meter, a range of $500-$1,500 to elevate HVAC equipment, and a range of a range of $500-$1,500 (and up) to floodproof HVAC equipment. FEMA reports a range of $1,500-$2,000 to include outlets and switches in the elevation of electric service and meter. Given the uncertainty related to actions that business owners may choose, the upper range of $1,500-2,000 is provided for all utility-related costs.

Total costs to retrofit a small business to make it more resilient in the long term are rarely reported in the literature. Recently, in the "New York Rising" Community Reconstruction Plan for the Red Hook section of Brooklyn, New York, total cost estimates per small business in this close-knit coastal neighborhood ranged from $6,000 to $50,000 for implementing a variety of floodproofing measures such as those listed above in Table 5. Given the number of doors, openings, and utilities associated with some of the businesses in Damariscotta, this range appears to be reasonable for businesses in Damariscotta.

5.2 Implementation of Preferred Alternative

Having identified a preferred alternative, the Committee must now go about the task of determining a path toward implementation. One issue of primary concern is funding, and this is addressed in the following section. Aside from funding, moving the project forward will require design development, permitting, and construction documents. Following are the steps that we suggest are necessary to move the project to construction:

1. Detailed Survey: This includes 1-foot topographic information in the upland area, as well as hydrographic survey extending some 100 feet from the mean tide line. One-foot topographic information is suggested for the upland information because the parking lot has such limit topographic relief under existing conditions. Understanding the existing topography, particularly around the buildings, will be critical to developing a successful design. The hydrographic survey will be needed to support design and permitting.
2. Geotechnical Evaluation: Design of a wall, steel sheeting, and piles for the boardwalk will require an understanding of subsurface conditions. This information is vital, and the project concepts cannot, in our opinion, undergo additional refinement without this information.
3. Structural Type Study: Determining the design of the steel sheeting or concrete wall will require a structural engineer to evaluate the geotechnical data and perform structural computations to identify the most cost effective design.
4. Biological Investigation: An assessment of the waterfront area should be performed by a wetland scientist or biologist to identify the presence and location of any tidal wetland species that may be impacted by the project.
5. Preliminary Design (30% Completion): Using the information collected in the tasks outlined above, the project design can be advanced and additional detail provided. This will allow the Committee to more fully vet the proposed improvements and increase their understanding of the construction requirements. It will also allow for much needed refinement of the construction cost opinion.
6. 60% Design: The next step would be to further refine the design to a level that will provide more detail on construction methodology and costs. Utility company coordination (e.g., for relocating the electric poles along the waterfront) would begin at this phase.
7. Regulatory Coordination and Permitting: While regulatory coordination is something that will likely occur throughout the design process, we recommend submitting a permit application following completion of the 60% design. At 60%, the project plans are advanced enough that major changes should not be necessary but not so advanced that changes made to the design by regulators require complete redesign of the project.

8. Final Design: Following completion of permitting, development of construction documents can begin, providing the final details that a contractor will need to bid the work and successfully build the project.

To some degree, these project stages can be completed in a piecemeal fashion as funding becomes available. For example, the initial design contract could cover only items 1 through 5. Following 30% design, the town could reassess the funding requirements before advancing the design.

5.3 <u>Funding Opportunities</u>

Implementation of any of the concept plans will require that the town secure funding, preferably from a state or federal source. Many of the programs that fund flood mitigation and sea level rise are opportunistic, meaning they are developed following specific storms and will require the town to pay attention to funding availability. The following is a summary of potential programs that can be investigated.

5.3.1 <u>FEMA Mitigation Funds</u>

The Hazard Mitigation Assistance (HMA) "umbrella" contains several competitive grant programs designed to mitigate the impacts of natural hazards. These programs are briefly described below.

- <u>Pre-Disaster Mitigation (PDM) Program</u>: The PDM Program was authorized by Part 203 of the Robert T. Stafford Disaster Assistance and Emergency Relief Act (Stafford Act), 42 U.S.C. 5133. The PDM program provides funds to states, territories, tribal governments, communities, and universities for hazard mitigation planning and implementation of mitigation projects prior to disasters, providing an opportunity to reduce the nation's disaster losses through PDM planning and the implementation of feasible, effective, and cost-efficient mitigation measures. Funding of pre-disaster plans and projects is meant to reduce overall risks to populations and facilities. PDM funds should be used primarily to support mitigation activities that address natural hazards. In addition to providing a vehicle for funding, the PDM program provides an opportunity to raise risk awareness within communities.

- <u>Hazard Mitigation Grant Program (HMGP)</u>: The HMGP is authorized under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The HMGP provides grants to states and local governments to implement long-term hazard mitigation measures <u>after</u> a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster. A key purpose of the HMGP is to ensure that any opportunities to take critical mitigation measures to protect life and property from future disasters are not "lost" during the recovery and reconstruction process following a disaster. The "5% Initiative" is a subprogram that provides the opportunity to fund mitigation actions that are consistent with the goals and objectives of state and local mitigation plans and meet all HMGP requirements, but for which it may be difficult to conduct a standard benefit-cost analysis to prove cost effectiveness.

- Flood Mitigation Assistance (FMA) Program: The FMA program was created as part of the National Flood Insurance Reform Act (NFIRA) of 1994 (42 U.S.C. 4101) with the goal of reducing or eliminating claims under the National Flood Insurance Program (NFIP). FEMA provides FMA funds to assist states and communities with implementing measures that reduce or eliminate the long-term risk of flood damage to buildings, homes, and other structures insurable under the NFIP. The long-term goal of FMA is to reduce or eliminate claims under the NFIP through mitigation activities.

  The Biggert-Waters Flood Insurance Reform Act of 2012 eliminated the Repetitive Flood Claims (RFC) and Severe Repetitive Loss (SRL) programs and made the following significant changes to the FMA program:

  - The definitions of repetitive loss and severe repetitive loss properties have been modified
  - Cost-share requirements have changed to allow more federal funds for properties with repetitive flood claims and severe repetitive loss properties
  - There is no longer a limit on in-kind contributions for the nonfederal cost share

  Effective August 15, 2013, acquisitions and elevations will be considered cost-effective if the project costs are less than $276,000 and $175,000, respectively. Structures must be located in Special Flood Hazard Areas (the area of the 1% annual chance flood). The benefit-cost analysis (BCA) will not be required.

  The NFIP provides the funding for the FMA program. The PDM and FMA programs are subject to the availability of appropriation funding as well as any program-specific directive or restriction made with respect to such funds.

  One potentially important change to the PDM, HMGP, and FMA programs is that "green open space and riparian area benefits can now be included in the project benefit cost ratio (BCR) once the project BCR reaches 0.75 or greater." The inclusion of environmental benefits in the project BCR is limited to acquisition-related activities.

  Table 6 presents potential mitigation project and planning activities allowed under each FEMA grant program described above as outlined in the most recent HMA Unified Guidance document.

TABLE 6
Eligible Mitigation Project Activities by Program

Eligible Activities	HMGP	PDM	FMA
Property Acquisition and Structure Demolition or Relocation	X	X	X
Structure Elevation	X	X	X
Mitigation Reconstruction			X
Dry Floodproofing of Historic Residential Structures	X	X	X
Dry Floodproofing of Nonresidential Structures	X	X	X
Minor Localized Flood Reduction Projects	X	X	X
Structural Retrofitting of Existing Buildings	X	X	
Nonstructural Retrofitting of Existing Buildings and Facilities	X	X	X
Safe Room Construction	X	X	
Wind Retrofit for One- and Two-Family Residences	X	X	
Infrastructure Retrofit	X	X	X
Soil Stabilization	X	X	X
Wildfire Mitigation	X	X	
Post-Disaster Code Enforcement	X		
Generators	X	X	
5% Initiative Projects	X		
Advance Assistance	X		

Source: Table 3 – HMA Unified Guidance document

5.3.2 Clean Water State Revolving Fund (CWSRF)

The CWSRF, administered by the Maine DEP, provides low interest loans to municipalities and quasimunicipal corporations, i.e., sanitary districts, for construction of wastewater facilities. The CWSRF is funded by a combination of federal capitalization grants, state matching funds equal to 20% of the federal grant, and loan repayment funds set at 2% below market rate for up to 20 years.

The primary purpose of the CWSRF is to acquire, plan, design, construct, enlarge, repair, and/or improve publicly-owned sewage collection systems, intercepting sewers, pumping stations, and wastewater treatment plants.

We have seen some states begin using this funding to assist with sea level rise mitigation for sanitary sewer systems. Maine does not seem to have adopted this strategy yet, but it seems likely the state may move this direction in the future.

5.3.3 Maine DOT Small Harbor Improvement Program

This grant application is open to coastal communities that can demonstrate a need to improve economic activity and improve access to a tidewater river or the ocean on publicly accessible property. Typical types of projects funded under this program include commercial and municipal wharf improvements, hoist systems, boat ramps, gangways, stairwells to clam flats, piling replacements, etc. The goal of this program is to promote economic development, improve public marine infrastructure, and improve public access.

In many ways, the options presented here by MMI fit nicely into this funding program's goals and objectives, particularly those options that would provide access to the water in combination with the boardwalk construction. In 2014, MDOT approved 19 projects under this program with total funding of $2.75M. The largest award in 2014 was $250,000 to Searsport for reconstruction of floating docks and its utilities.

5.3.4 Maine Coastal Communities Grants

These are small grants with a total FY2015 allocation of $185,000 (and it is the grant program that provided funding for this study). At least 25% of the funds available for Coastal Communities Grants are expected to be allocated to adaptation planning for projects, which have a primary focus on preparing for coastal storms, erosion and flooding, and coastal hazards. At the present time, the limited amount of funding in this program makes it of limited value, for design and construction but, in coming years, it seems possible that it may grow as more of Maine's coastal towns begin to address sea level rise issues.

5.3.5 U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers (ACOE) has a number of potential funding sources that can be investigated for project design and construction. These are described briefly below.

- Section 205 – Small Flood Damage Reduction Projects: This program was created under the Flood Control Act of 1948 and allows the ACOE, working with a nonfederal sponsor, to plan and construct small flood control projects that are not authorized by congressional earmark. Work under this program can include floodwalls and levees. To obtain funding under this program, a written request must be made to the ACOE. When funding is available for the project, ACOE initiates a feasibility study to determine if the project meets program requirements and whether federal participation is appropriate. If the feasibility study indicates that the project is consistent with the Section 205 requirements, then design and construction can proceed under the ACOE guidance. The maximum project cost that can be funded under this program is $7M.

- Section 103 – Hurricane and Storm Damage Reduction Projects: Section 103 of the 1962 River and Harbor Act authorizes the ACOE to study, design, and construct small coastal storm damage reduction projects in partnership with nonfederal government agencies. Projects funded under this program can consist of any number of improvements including structural flood proofing (e.g., floodwalls). Similar to other programs with ACOE funding, the project must go through feasibility assessment and environmental justification before proceeding with design and construction. The maximum project cost that can be funded under this program is $5M. The feasibility study can be funded up to $100,000. Design and construction is funded at 65% of the total cost with the nonfederal partner paying the remaining 35%.

3461-04-j1415-rpt