Preparing for Tomorrow's High Tide

Recommendations for Adapting to Sea Level Rise in Delaware

September 2013

About this Document

This document was developed by Delaware's Sea Level Rise Advisory Committee and by staff of the Delaware Coastal Programs section of the Delaware Department of Natural Resources and Environmental Control (DNREC). It is intended to assist government agencies, businesses and individuals make well-informed choices about preparing for and responding to sea level rise. Its central component is a set of recommendations for building the state's ability to adapt to sea level rise. The document also contains background information about adaptation measures that can be taken to decrease Delaware's vulnerability to sea level rise and provides a set of guiding principles for consideration by those choosing adaptation measures.

The recommendations contained in this document were approved by the Sea Level Rise Advisory Committee and have been submitted to DNREC Secretary Collin O'Mara for consideration and for further collaboration with other state cabinet agencies. It is envisioned that a collaborative team composed of government agencies, businesses and individuals will be brought together to seek support and resources to implement the recommendations.

Other Documents in the Preparing for Tomorrow's High Tide Series

Progress Report of the Delaware Sea Level Rise Advisory Committee (November, 2011)

Sea Level Rise Vulnerability Assessment for the State of Delaware (July, 2012)

Mapping Appendix to the Sea Level Rise Vulnerability Assessment for the State of Delaware (July, 2012)

For More Information

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Preparing for Tomorrow's High Tide:

Recommendations for Adapting to Sea Level Rise in Delaware

Final Report of the Delaware Sea Level Rise Advisory Committee

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Delaware Department of Natural Resources and Environmental Control

Delaware Coastal Programs

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Copies of this publication are available at the Delaware National Estuarine Research Reserve, 818 Kitts Hummock Road, Dover, Delaware and online at http://de.gov/slradaptplan.

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August 15, 2013

The Honorable Collin P. O'Mara
Secretary
Department of Natural Resources and Environmental Control
89 Kings Highway
Dover, DE 19901

Dear Secretary O'Mara:

In September 2010, the Delaware Sea Level Rise Advisory Committee was convened under your directive to assess Delaware's vulnerability to the effects of rising sea levels and to provide recommendations for long-term policy decisions, management actions and resource investments. On behalf of the Committee, I am pleased to provide you with this document, *Preparing for Tomorrow's High Tide: Recommendations for Adapting to Sea Level Rise in Delaware.* The completion of this document fulfills your directive and represents the culmination of nearly three years of work by our committee and Department of Natural Resources and Environmental Control (DNREC) staff.

This document contains 55 recommendations that, if implemented, will improve Delaware's ability to adapt to sea level rise. Recommendations described in this document were vetted by the public at a series of engagement sessions and have the support of at least two-thirds of committee membership. Committee members have confidence that you will implement those recommendations that are under the purview of DNREC and ask that you strive to seek cooperation from other state agencies, local governments, businesses and citizens for implementation of recommendations that may be outside of DNREC's sole authority.

With the completion of the recommendations, this document and the significant public outreach that accompanied them, the state is poised to become resilient to the effects of sea level rise. Thank you for your leadership on this issue; your support and vision have been integral to completing this plan. We look forward to working with you to see its components become reality.

Sincerely,

Sarah W. Cooksey

Sarah W. Cooksey, Chair
Delaware Sea Level Rise Advisory Committee

Delaware's good nature depends on you!

The organizations listed below, through the signature of their duly appointed representative, herby acknowledge their participation in the development of the Recommendations for Adapting to Sea Level Rise in Delaware:

John Taylor
Delaware Chamber of Commerce

The Honorable Quinton Johnson
Delaware House of Representatives

Mark Davis
Delaware Department of Agriculture

Lorilee Harrison
Delaware Insurance Commissioner's Office

Kurt Reuther/Don Knox
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Homebuilders Association of Delaware

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Delaware League of Local Governments

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Executive Summary

Delaware's economy and quality of life are linked to its shores, its vast expanses of tidal wetlands and its fertile farm fields. Because of its location, low average elevation and dependence upon coastal resources for jobs and recreation, Delaware is particularly vulnerable to the effects sea level rise, including loss of low-lying land and structures, saltwater intrusion into groundwater and surface water and increased coastal flooding during storm events.

Delaware's Sea Level Rise Advisory Committee was established to investigate the state's vulnerability to sea level rise and to provide recommendations about how to best prepare for higher sea levels. The advisory committee was convened in November 2010 by invitation of Collin O'Mara, Secretary of the Delaware Department of Natural Resources and Environmental Control (DNREC). The advisory committee is composed of members from a wide variety of stakeholder groups including state agencies, local governments, citizen organizations, business organizations and environmental organizations.

The publication of "Preparing for Tomorrow's High Tide: Recommendations for Adapting to Sea Level Rise in Delaware" marks the completion of the advisory committee's work. The central component of this document is a list and description of 55 recommendations for adapting to sea level rise in Delaware. These recommendations focus on building the necessary capacity for Delaware agencies, local governments, businesses and individuals to plan for and put into place strategies for responding to sea level rise.

Sea Levels are Rising

Globally, sea levels rise as the earth gets warmer. This occurs for two primary reasons: (1) as ocean water warms, it expands and causes the average level of the ocean to increase, and (2) as land-based glaciers and ice-caps melt, the melt-water empties into the oceans and causes the average level of the ocean to increase. In addition, locally, sea levels can rise as a result of downward vertical movements of the earth's crust[1].

A combination of these factors is occurring in Delaware today, resulting in a local rate of sea level rise that has been about twice the global average. At the long-term tide gauge in Lewes, the observed sea level trend is 0.13 inches per year (or 13 inches over a 100-year period)[2]. The global average trend for the twentieth century was 0.07 inches per year. It is anticipated that both the local and global rate of sea level rise will accelerate in the coming decades due to climate change which is expected to increase the rates of glacier and ice sheet melt as well as rates of ocean water expansion[3]. A technical workgroup established by DNREC in 2009 reported that by 2100, this acceleration of sea level rise rates could cause the level of Delaware's oceans, bays and tidal rivers to rise between 1.6 feet (0.5 meters) and 4.9 feet (1.5 meters) above their present levels [4].

[1]From Williams, et al., 2009. Available online: http://library.globalchange.gov/products/assessments/2004-2009-synthesis-and-assessment-products/sap-4-1-coastal-sensitivity-to-sea-level-rise-a-focus-on-the-mid-atlantic-region

[2]Long term tide gauge data is maintained by the National Oceanic and Atmospheric Administration and is available online: http://www.tidesandcurrents.noaa.gov/sltrends/sltrends_states.shtml?region=de

[3]From Williams et al., Available online: http://library.globalchange.gov/products/assessments/2004-2009-synthesis-and-assessment-products/sap-4-1-coastal-sensitivity-to-sea-level-rise-a-focus-on-the-mid-atlantic-region

[4]From Sea Level Rise Technical Workgroup, 2009. Available online: http://www.dnrec.delaware.gov/coastal/Documents/SeaLevelRise/Final%20and%20Signed%20DNREC%20SLR%20scenarios.pdf

Delaware is Vulnerable to Sea Level Rise

Using these future scenarios as a guide, Delaware's Sea Level Rise Advisory Committee comprehensively assessed the impact of sea level rise on Delaware's communities, public safety, economy, infrastructure and natural resources. They found that, between 8% and 11% of land statewide is within an area that could be inundated with water at high tide[5] by 2100. Within those potentially inundated areas lie homes, industrial areas, roadways, protected land, wetlands, and wastewater facilities. In addition to inundation, saltwater intrusion into groundwater and surface water was identified as a significant issue, as was rising water tables and increased risk of damage from coastal storms. With each of these potential impacts come a number of secondary effects including loss of homes, reduction in employment opportunities, releases of contaminated material from industrial sites, increased drainage problems, and corrosion of pipelines among others[6].

The results of this comprehensive assessment of the state's vulnerability to sea level rise underscore the importance of adapting to sea level rise.

Adapting to Sea Level Rise

In a broad sense, adaptation means "adjusting" to new conditions and taking steps to moderate and cope with the effects of sea level rise. These steps can be planned and implemented at a variety of geographic levels, and by a variety of stakeholders. In Delaware and in many other locations, the process of adaptation involves two distinct efforts: (1) planning and implementing adaptation measures, and (2) building adaptive capacity.

Adaptation measures are on-the-ground actions that can be taken to prepare for sea level rise in a particular location. These measures include raising structures out of flood prone areas, building dikes to keep water out of low-lying areas, avoiding placement of new structures in vulnerable areas and restoring wetlands to improve flood benefits to upland areas. In general, these adaptation measures will be planned and implemented by landowners, business owners and local government officials to address projected impacts of sea level rise in a specific location. The Sea Level Rise Advisory Committee did not undertake any assessment of, or recommendations for, specific adaptation measures in Delaware. Rather, it focused its work on understanding and making recommendations that will improve Delaware's adaptive capacity.

Adaptive capacity can be defined as the ability to adapt. As it relates to sea level rise, adaptive capacity is the ability of individuals or agencies to assess potential impacts and to select and implement appropriate adaptation measures. Adaptive capacity includes availability of data and information, availability of technical assistance, availability of funding, ability to cooperate and communicate, and ability to gain support for adaptation measures.

Recommendations for Preparing for Sea Level Rise

Delaware's Sea Level Rise Advisory Committee was charged with developing recommendations for adapting the state to the likely impacts of sea level rise. Because sea level rise adaptation will occur at many different geographic levels, from an individual home to regional transportation networks, the advisory committee focused its efforts on researching and developing recommendations that will build the state's capacity to adapt, rather than pinpointing adaptation measures that should be used in specific locations. Over 100 separate options and seven objectives were developed by the advisory committee. After further research and discussion, the list was narrowed and released to the public for review at a series of public engagement sessions.

After review of public comments and additional investigation and discussion, the Sea Level Rise Advisory Committee formally approved the following recommendations for adapting to sea level rise:

[5] As referenced from Mean Higher High Water (MHHW).

[6] These impacts are fully described in Preparing for Tomorrow's High Tide: Sea Level Rise Vulnerability Assessment for the State of Delaware. Available online: http://de.gov/slrva

Objective 1: Improve Communication and Coordination among State, Federal, Local and Regional Partners to Streamline Sea Level Rise Adaptation Efforts.

Recommendations:

1.1 Improve coordination of permit decisions for adaptation projects among federal, state and local officials.

1.2 Create new partnerships to increase resources for research and development of adaptation options.

1.3 Increase opportunities for technology transfers and regional coordination for transportation issues affected by sea level rise.

1.4 Incorporate sea level rise into public and private sector regional planning efforts.

1.5 Provide sea level rise information to the Delaware Agricultural Land Preservation Program.

1.6 Provide technical assistance to Delaware's Open Space Council for incorporating sea level rise into its criteria for acquisition of natural areas.

1.7 Conduct a comprehensive inventory of key funding, coordination, regulations and policies and analyze them for barriers and opportunities for sea level rise adaptation.

Objective 2: Provide Increased Regulatory Flexibility for Adaptation and Improve Consistency among Regulatory Agency Decisions.

Recommendations:

2.1 Provide regulatory incentives that encourage sea level rise adaptation and that allow for innovative projects.

2.2 Encourage the governor to sign an executive order that would direct state agencies to plan for sea level rise.

2.3 Conduct a comprehensive update to the state's regulatory tidal wetlands maps and provide a way to periodically update the maps to reflect changes occurring from sea level rise.

2.4 Consider sea level rise implications in future regulatory updates for septic systems and wells.

2.5 Facilitate the connection of individual septic systems to community wastewater treatment systems with excess capacity when human safety and welfare are at risk.

2.6 Consider sea level rise implications in future updates to the state Coastal Zone Act regulations.

Objective 3: Provide Consistent and Predictable Policies for Future Growth, Investment, and Natural Resource Management.

Recommendations:

3.1 Incorporate sea level rise considerations into the Strategies for State Policies and Spending.

3.2 Consider incorporation of sea level rise considerations into municipal and county comprehensive development plans.

3.3 Consider use of a Transfer of Development Rights tool to direct future growth away from vulnerable areas.

3.4 Incorporate sea level rise into Delaware's Long Range Transportation Plan.

3.5 Incorporate sea level rise into the Transportation Operations Management Plan.

3.6 Encourage inclusion of sea level rise in Transportation Project Design Manuals.

3.7 Develop a dike safety program.

3.8 Develop a framework for decision-making regarding land protection and restoration strategies based on habitat vulnerability, migration potential and relative importance in the regional landscape, historical significance or other key factors.

3.9 Develop a comprehensive wetlands restoration, protection and retreat strategy in response to sea level rise.

3.10 Continue efforts to re-evaluate management strategies for existing coastal impoundments.

3.11 Evaluate the benefits and risks of permitting privately owned coastal impoundments.

3.12 Designate shoreline zones for adaptation action.

3.13 Conduct a legal review for disinvestment of publically owned infrastructure and privately owned buildings.

3.14 Develop a statewide retreat plan and update it periodically.

Objective 4: Increase Public Awareness of Sea Level Rise through Education, Outreach and Marketing.

Recommendations:

4.1 Develop a comprehensive outreach strategy to educate all stakeholders about sea level rise.

4.2 Provide education and outreach for impacted communities and citizens.

4.3 Improve the ability of homebuyers to investigate a property's potential vulnerability to sea level prior to purchase.

4.4 Provide targeted outreach to water and wastewater operators and water utilities.

Objective 5: Improve the Availability & Robustness of Sea Level Rise Data Sets.

Recommendations:

5.1 Improve monitoring of current sea level conditions and improve predictions for timing of inundation.

5.2 Install additional water level and salinity observational stations in Delaware's tidal waters.

5.3 Improve the accuracy of Delaware's elevation benchmark network.

5.4 Continue and expand studies regarding sediment accretion rates and susceptibility of wetlands to sea level rise.

5.5 Conduct research to better understand human response to sea level rise and adaptation.

5.6 Develop sea level models that incorporate storm surge impacts.

5.7 Conduct a risk assessment for Delaware's system of dikes & levees.

5.8 Encourage federal agencies to integrate sea level rise planning into their flood models.

5.9 Model potential stormwater inundation problems in highly vulnerable areas.

5.10 Develop a model that will predict changes to salinity in surface water that may occur under differing sea level rise scenarios

5.11 Develop a statewide groundwater model.

5.12 Develop and maintain a comprehensive database that contains the location and condition of all wastewater infrastructures.

5.13 Identify and preserve areas for potential wetland migration.

5.14 Identify the data necessary to plan transportation investments.

5.15 Increase understanding of the regional implications of loss of industrial areas in coastal Delaware.

5.16 Improve understanding of impacts to adjacent properties from adaptation actions.

5.17 Encourage the development of a research and policy center at a university or college campus that would focus on applied research for sea level rise and adaptation.

5.18 Foster pilot projects that demonstrate the effectiveness of best management practices for management of agricultural lands affected by sea level rise.

Objective 6: Provide Technical Assistance to Partners for Assessing Vulnerability and Choosing Adaptation Strategies.

Recommendations:

6.1 Create a coordinated effort to provide technical assistance to local governments.

6.2 Provide land managers, fisheries managers and farmers with the information and extension support necessary to manage lands and fisheries in areas affected by sea level rise.

6.3 Provide technical assistance for industrial and port facilities to incorporate sea level rise into investment plans and continuity of business plans.

6.4 Develop best management practice manuals for adaptation in Delaware.

6.5 Develop a database of costs of adaptation options for use by decision-makers and the public.

Objective 7: Expand Funding Opportunities for Adaptation Planning and Implementation Projects.

7.1 Convene an expert panel to provide an assessment and analysis of funding options for adaptation measures.

Adaptation in Delaware is Already Underway

Although formal recommendations for adapting to sea level rise are new, sea level rise adaptation is already occurring in Delaware. The state has routinely replenished publicly accessible beaches on the Atlantic Ocean and Delaware Bay coasts for decades. It has a robust land acquisition program and a statewide land-use regulation for coastal areas. It also requires counties and municipalities to plan for the future through comprehensive development plans. At a local level, at least seven municipal governments are actively planning for the future effects of sea level rise and storm surge with assistance from DNREC and Delaware Sea Grant College Program. These on-the-ground adaptation efforts will continue in parallel with implementation of the 55 recommendations listed above.

Guiding Principles for Adaptation

During the development of adaptation recommendations, the advisory committee had a number of discussions about how adaptation decisions should be made. For example, concerns were expressed about whether adaptation measures implemented in one location could have a negative impact on surrounding locations. Concerns were also expressed about how adaptation actions would be prioritized for state funding.

As a result of those discussions, the advisory committee has compiled the following "Guiding Principles for Adaptation." These principles should

be taken into consideration during the planning and implementation of on-the-ground adaptation projects:

- Begin adaptation planning and implementation: adjust and make improvements as more information becomes available.
- Avoid unnecessarily prescriptive adaptation actions: empower decisions at the local level.
- Incorporate adaptation into existing programs and mechanisms, so as to not create a new bureaucracy.
- Engage broad public participation in adaptation decisions.
- Use the best available science and technology for decision-making and adaptation actions.
- Coordinate and consider consequences of adaptation among jurisdictions and among resource types.
- Strike a balance between protection of homes, infrastructure and conservation of natural resources.
- Strive for equity in selection and funding of adaptation measures:
    - Consider impacts to environmental justice communities.
    - Consider trade-offs between adaptation projects up-state and downstate.
- Encourage development of funding mechanisms for adaptation based on fairness, equity and justice for all citizens.
    - Public investment in sea level rise adaptation should be directed toward endeavors that benefit the most citizens as possible.
    - Public investment in sea level rise adaptation should be considered and weighed against the many needs of Delaware's citizens.
    - Fee based funding options, if developed, should be user-related (such as motor fuel taxes that pay for roadway maintenance).

Next Steps

At its final meeting, Delaware's Sea Level Rise Advisory Committee presented these recommendations to the Secretary of the Delaware Department of Natural Resources and Environmental Control, marking the completion of the advisory committee's work. This event also represented the start of efforts to put the recommendations into place, a process that will take many years.

The DNREC Delaware Coastal Programs has committed to coordinating efforts to implement the recommendations for adapting to sea level rise, working in collaboration with state agencies, local and county governments, non-governmental organizations, educators, businesses and citizens. Some recommendations can be implemented quickly and with little new funding; others may take significant additional funding, time and coordination. A workshop will be held in 2014 that will bring together potential partners to prioritize recommendations for implementation and to compile additional information about the steps necessary to implement each recommendation.

Adaptation planning and selection of adaptation measures at the parcel, local or agency level can occur in parallel to state efforts to implement the 55 recommendations of the Sea Level Rise Advisory Committee. Although implementation of the recommendations will improve Delaware's ability to adapt in the future, technical assistance and grant funds are available now from a variety of sources to assist those wishing to proactively address sea level rise and prepare for tomorrow's high tide.

Chapter 1: Introduction

Delaware's Sea Level Rise Advisory Committee

Delaware's economy and quality of life are linked to its shores, its vast expanses of tidal wetlands and its fertile farm fields. Because of its location, low average elevation and dependence upon coastal resources for jobs and recreation, Delaware is particularly vulnerable to the effects sea level rise, including loss of low-lying land and structures, saltwater intrusion into groundwater and surface water and increased coastal flooding during storm events.

Delaware's Sea Level Rise Advisory Committee was established to investigate the state's vulnerability to sea level rise and to provide recommendations about how to best prepare for higher sea levels. The Committee was convened in November 2010 by invitation of Collin O'Mara, Secretary of the Delaware Department of Natural Resources and Environmental Control (DNREC). The advisory committee is composed of members from a wide variety of stakeholder groups including state agencies, local governments, citizen organizations, business organizations and environmental organizations.

The publication of "Preparing for Tomorrow's High Tide: Recommendations for Adapting to Sea Level Rise in Delaware" marks the completion of the advisory committee's work. The central component of this document is a list and description of 55 recommendations for adapting to sea level rise in Delaware. These recommendations focus on building the necessary capacity for Delaware agencies, local governments, businesses and individuals to plan for and put into place strategies for responding to sea level rise.

The advisory committee met its first milestone in July 2012 with the publication of "*Preparing for Tomorrow's High Tide: Sea Level Rise Vulnerability for the State of Delaware.*" This document and its appendices provide an exhaustive accounting of resources vulnerable to sea level rise of up to 1.5 meters (4.9 feet) in Delaware[7]. It also identifies a set of resources that are of the most concern statewide.

The publication of this document, "*Preparing for Tomorrow's High Tide: Recommendations for Adapting to Sea Level Rise in Delaware*," marks the completion of nearly three years of work by the advisory committee and DNREC staff. Its central component is a list and description of recommendations for adapting to sea level rise in Delaware. These recommendations were

Advisory Committee Goal

The goal of Delaware's Sea Level Rise Advisory Committee is "to assess Delaware's vulnerability to current and future inundation problems that may be exacerbated by sea level rise and to develop a set of recommendations for state agencies, local governments, businesses, and citizens to enable them to adapt programs, policies, business practices and make informed decisions."

[7]Available online: http://de.gov/slrva

developed through an extensive stakeholder and public process. The document also contains a set of guiding principles, developed by the advisory committee for use as decision-making criteria and background information about adaptation and adaptation strategies.

Sea Level is Rising

Sea level rise is occurring today, both locally and across the globe. Globally, sea levels rise for two primary reasons: (1) expansion of saltwater as it warms, and (2) loss of ice on land. As the ocean absorbs solar radiation in excess of what it emits, the water warms. When water warms, it expands and causes the average level of the water to rise. In addition, as Earth becomes warmer, land-based glaciers and ice sheets melt and slide into the sea. This melt-water and ice empties into oceans and cause the average level of the water to rise. In combination, these two processes constitute the eustatic (or global) rate of sea level rise. The eustatic sea level rate during the twentieth century, as determined by tide gauge measurements, was about 0.07 inches per year (or about 7 inches over 100 years) (Bindoff, et. al., 2007).

Tide gauges indicate that the increase in local mean sea level[8] in Delaware is greater than the increase in eustatic sea level. The sea level rise trend recorded at the tide gauge in Lewes is 0.13 inches per year (or 13 inches over 100 years), as compared to the eustatic trend of 0.07 inches per year. This difference is due to the vertical movement of Earth's crust which is causing the land in Delaware to slowly sink. Tide gauges record this combined motion of the land and the

Christina Pinkerton

Members and Alternates of the Sea Level Rise Advisory Committee from left to right: **1st Row:** Lew Killmer, Sarah Cooksey, Karen Weldin Stewart, Lorilee Harrison, Constance Holland, Ruth Ann Jones, Kevin Whittaker, Gerald Kauffman, Mary Ellen Gray, Pamela Bakerian, Rich Collins, Victor Letonoff. **2nd Row:** Richard Perkins, Barbara DeHaven, Chris Sommerfield, William Lucks, Don Knox, Jennifer Adkins, Rob McCleary, John Taylor, Brenna Goggin, Hal Godwin. Not pictured: Quinton Johnson, Marcus Henry, Jeff Shockley, Richard Jones, Michael Kirkpatrick, Mark Davis

Sea Level Rise Advisory Committee Member Agencies

Delaware Association of Realtors
Delaware Chamber of Commerce
Delaware Department of Agriculture
Delaware Department of Health and Social Services
Delaware Department of Natural Resources and Environmental Control
Delaware Department of Safety and Homeland Security
Delaware Department of Transportation
Delaware Economic Development Office
Delaware Farm Bureau
Delaware Insurance Commissioner's Office
Delaware League of Local Governments
Delaware Legislature
Delaware Nature Society
Delaware Office of the Governor
Delaware Office of Management and Budget
Home Builders Association of Delaware
Kent County
League of Women Voters of Delaware
The Nature Conservancy
New Castle County
Positive Growth Alliance
Sussex County
Tidewater Utilities, Inc.
University of Delaware

[8]Local Mean Sea Level is a term that describes the height of the ocean relative to land, measured hourly by a tide gauge and averaged over a nineteen year period known as the National Tidal Datum Epoch.

sea. Figure 1 shows the local mean sea level trend from the tide gauge at Lewes from 1919 to 2012. Other tide gauges throughout the Mid-Atlantic show similar trends[9].

While it cannot be known with certainty, climatologists have predicted that the rate of sea level rise occurring today will likely become greater in the decades to come (Williams et al., 2009). The extent of the increase will depend on a number of factors including future emissions of greenhouse gases (especially carbon dioxide), the rate at which the temperature of the ocean increases and the rate at which ice is lost from land-based glaciers.

In 2009, a Sea Level Rise Technical Workgroup was formed to provide DNREC with planning scenarios for sea level rise to the year 2100. This workgroup, composed of scientists from the University of Delaware, Delaware Geological Survey, Center for the Inland Bays, Partnership for the Delaware Estuary and DNREC, reviewed historical data for local sea level rise and findings of international and national sea level rise expert panels. Based on this information, the technical workgroup recommended three planning scenarios for sea level rise which were then reviewed by national experts[10] and used by DNREC in the development of an internal policy that directed it to plan for sea level rise (DNREC Sea Level Rise Technical Workgroup, 2009).

The technical workgroup chose to recommend a range of scenarios to DNREC because it is not possible to precisely predict future rates of sea level rise (DNREC Sea Level Rise Technical Workgroup, 2009). The three scenarios can be used as a planning tool to determine a range of potential outcomes and options. The technical workgroup's scenarios were 0.5 meters (1.6 feet), 1.0 meter (3.3 feet), and 1.5 meters (4.9 feet) of sea level rise between now and 2100 based upon low, moderate and high estimates of future global warming rates, respectively. Figure 2 contains a graph of the three scenarios, which can be used to estimate a range of sea level rise scenarios for years between now and 2100. The upward curvature of the lines indicates that the rates increase with time. The

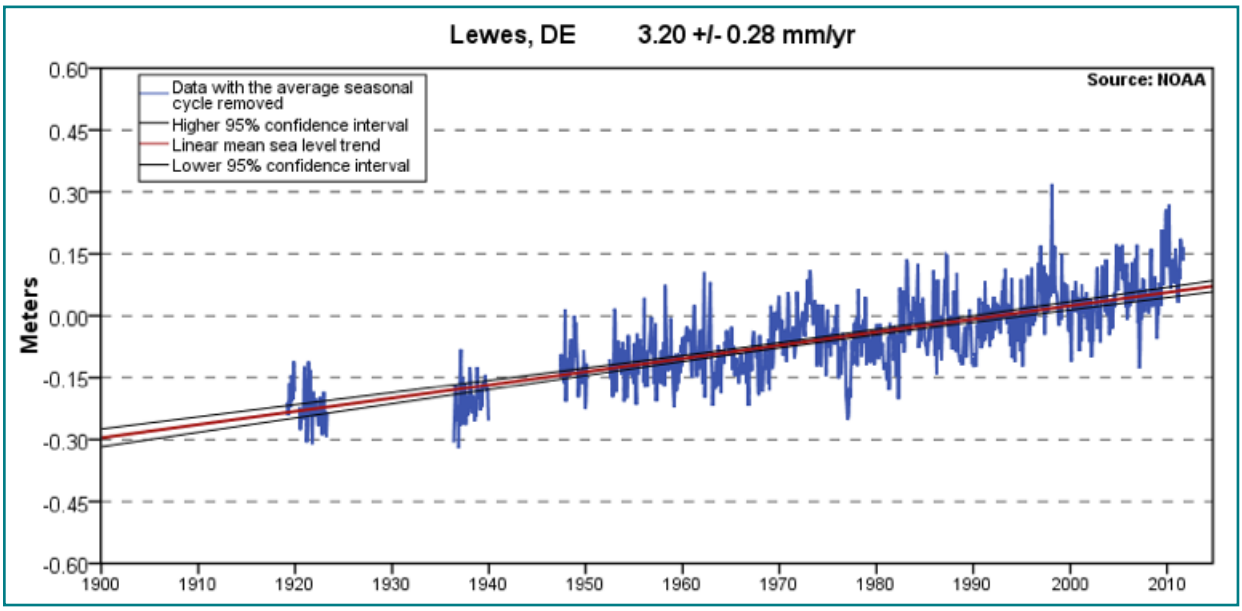

Figure 1. Local mean sea level trend at Lewes (NOAA, 2013).

[9] Tide gauge information is available from the National Oceanic and Atmospheric Administration: http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml.

[10] The scenarios were reviewed by S. Jeffress Williams, Coastal Marine Geologist at the US Geological Survey Woods Hole Science Center and Jim Titus, US Environmental Protection Agency

"stable," line is included for reference; it shows the sea level that would occur in Delaware if the past century's average rate of sea level rise continued into the future, rather than accelerating.

These three scenarios were provided to the Sea Level Rise Advisory Committee by DNREC and were used to assess resource vulnerability to sea level rise[11]. Evaluation and endorsement of these recommended sea level rise scenarios was outside of the purview of the advisory committee.

It is important to note that scientists are continually working to increase their knowledge about sea level rise and to provide better predictions of future sea levels. As new data and information become available, the planning scenarios will be revised in order to reevaluate potential impacts.

Delaware's Vulnerability to Sea Level Rise

Delaware's low average elevation makes it particularly vulnerable to the effects of rising sea levels, which include loss of low-lying land and structures, saltwater intrusion into groundwater and surface water and increased coastal flooding during storm events. Each of these impacts also has secondary social, economic and environmental effects. The Sea Level Rise Vulnerability Assessment for the State of Delaware found that sea level rise would have direct impacts statewide, including all three counties and 31 municipalities. The report also found that under the three planning scenarios described above, between 8% and 11% of Delaware's total current land area could be inundated at high tide[12] by the year 2100 (DNREC, 2012).

Of the 79 resources studied in the state's vulnerability assessment, the advisory committee ranked 16 as high concern statewide and six as moderate concern statewide (DNREC, 2012). Potential impacts from sea level rise for each high and moderate concern resource are briefly described below:

High Concern Resources

Beaches and Dunes

Delaware's coastline is an important ecological resource and economic driver for the state. Shorelines naturally shift and retreat in response to wind, waves, tides, storms and rising seas. Sea level rise can exacerbate shoreline erosion, further damaging dune habitat and leaving infrastructure along the coastline more vulnerable to storm damage. Beach replenishment has been the predominant means to offset sand loss and protect structures. Due to the economic value, natural resource value and significant state investment in sand replenishment, this resource was ranked as a high concern.

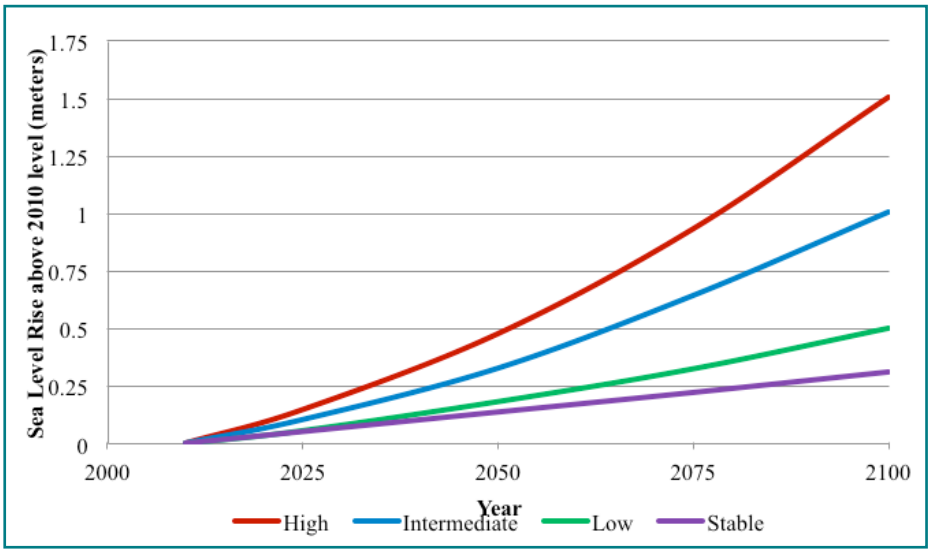

Figure 2. DNREC sea level rise planning scenarios (DNREC Sea Level Rise Technical Workgroup, 2009)

[11] An interactive map of these scenarios is available online: http://de.gov/slrmap.

[12] As measured by Mean Higher High Water

Coastal Impoundments

Coastal impoundments are managed wetlands that provide important habitat for a variety of birds and fish. Impoundments in each county are at risk from sea level rise. A sea level rise of 0.5 meters (1.6 feet) would result in the potential inundation of 81% of the state's acreage of impounded wetlands. Up to 99% of all the state's acreage of impounded wetlands could be inundated at both 1.0 meters (3.3 feet) and 1.5 meters (4.9 feet) of sea level rise. Since the majority of coastal impoundments within the state may be affected, this resource was ranked as a high concern.

Dams, Dikes and Levees

Between 39% and 78% of the state's 50 miles of dams, dikes and levees could be inundated by sea level rise by 2100. If a breach or structural failure were to occur, the resultant flooding could affect a large area inland of the structure. The highest concentration of potentially affected dikes is in Kent County, whose dikes primarily protect wildlife areas. In New Castle County, the acreage of potentially impacted dikes is fewer, however the potential damage from failure is greater as the majority of these dikes protect people, property, roadways and, in one case, a contaminated site. Due to these considerations, inundation of dams, dikes, and levees in the state was ranked as a high concern.

Chris Bennett

A snowy egret forages in a man-made impoundment at Bombay Hook National Wildlife Refuge. The majority of these impoundments in the state, which provide unique habitat and recreational opportunities, are at risk from the effects of sea level rise.

Delaware Coastal Programs

These maps depict mean higher-high water (MHHW) in Bowers Beach Delaware under the three planning scenarios for sea level rise. Blue represents MHHW today; green is MHHW with 0.5 meter of sea level rise; yellow is MHHW with 1.0 meter of sea level rise; red is MHHW with 1.5 meters of sea level rise. The Town of Bowers Beach is one of several municipalities in Delaware that is actively planning for current and future effects of storms and sea level rise.

Evacuation Routes

Between 1% and 6% of the state's 1,185 miles of designated evacuation routes could be inundated by sea level rise by 2100. As with any roadway, a small area of inundation can cause an entire roadway segment to become unusable. Because evacuations rely on automobile transportation and even small segments of flooded roadways can prevent or slow evacuation by car, inundation of evacuation routes was ranked as a high concern.

Freshwater Tidal Wetlands

Freshwater tidal wetlands occur at the upper reaches of estuaries and are home to unique plant and animal communities. Sea level rise could impact between 84% and 98% of the total freshwater tidal wetland acreage statewide by the year 2100, replacing freshwater tidal marshes with brackish marshes or open water and causing major shifts in species composition. Because of the unique habitats contained within freshwater tidal wetlands and because the majority of the resource within the state could be affected, this resource was ranked as a high concern.

Future Development Areas

Between 3% and 7% of land designated as future development areas by Delaware's Strategies for State Policies and Spending are within an area that could be inundated by sea level rise by 2100. These areas are typically rural or suburban in nature and are adjacent to the actively growing zones of Delaware's municipalities. Four-fifths of these potentially inundated areas are located in Sussex County and could be developed to meet the future demand for residential and commercial development in and around the resort areas. Due to the significant potential effects for development in Sussex County, coupled with the potential need for state funding of infrastructure repairs statewide, sea level rise within future development areas was ranked as a high concern.

Habitats of Conservation Concern

Habitats of Conservation Concern are habitats identified in the Delaware Wildlife Action plan as having special significance in Delaware, as being particularly sensitive to disturbance, and/or having a high diversity of rare plants. Between 55% and 65% of the total acreage of the 15 Habitats of Conservation Concern analyzed could be inundated by sea level rise by 2100. Because these exceptional habitat types often harbor rare plant and animal species and are sensitive to environmental stresses, including sea level rise, this resource was ranked as a high concern.

Heavy Industrial Areas

Between 16% and 25% of the acreage of heavy industrial lands in the coastal area (as permitted by Delaware's Coastal Zone Act) are within an area that could be inundated by sea level rise by 2100; the majority of these areas are in New Castle County. If the lands currently zoned for heavy industry become unsuitable for industrial operations, retaining these businesses within the state could prove difficult due to the lack of suitable industrially zoned land and the difficulties of rezoning land to industrial uses. Due to the significant potential statewide effects resulting from sea level rise, heavy industrial areas were ranked as a high concern.

Port of Wilmington

Between 36% and 73% of the Port of Wilmington's property is within an area that could be inundated by sea level rise by 2100. The port is based in northern New Castle County; however, its economic value to Delaware and the entire northeast region makes

State of Delaware

The Red Lion Dike, which protects a contaminated former industrial site from flood waters, is one of several dikes in New Castle County that will be repaired starting in 2013. Flooding of industrial land as a result of storm surge and sea level rise could cause contaminant releases to waterways.

exposure to sea level rise a state and regional issue. Due to these considerations, inundation of the Port of Wilmington was ranked as a high concern.

Protected Lands Statewide

Protected lands encompass a variety of lands owned by state, local and municipal governments, conservation groups and individuals, including state wildlife areas and parks, historical sites, national wildlife refuges, recreational facilities and conservation easements. Between 37% and 44% of these lands are exposed to sea level rise under the three scenarios. Because these lands represent a significant investment to protect natural habitats and recreational use and because sea level rise could impact their intended use, protected lands were ranked as a high concern.

Roads and Bridges

Between 1% and 5% of the state's 8,990 miles of roads and bridges are within an area that could be inundated by sea level rise by 2100. The highest concentration of roadway exposure was found in Sussex County; however, potential exposure was found throughout the state. Due to the potential regional impacts, inundation of roads and bridges from sea level rise was ranked as a high concern.

Railroad Lines

Between 2% and 6% of the state's railroad lines are within areas that could be inundated by sea level rise by 2100. While the majority of the potential impact is within New Castle County, if a single rail line segment becomes inundated, the functionality of the entire line could be lost. Because disruption of rail service in Delaware could have impacts throughout the state and region, inundation of railroad lines as a result of sea level rise was ranked as a high concern.

Tidal Wetlands

Tidal wetlands are among the most productive ecosystems in the world and provide habitat, food and breeding grounds for many species of plants and animals. Delaware's tidal wetlands are an intricate part of the local, regional, national, and international ecosystems. Up to 97% of the state's tidal wetlands could be impacted at the 0.5 meter (1.6 feet) scenario, and 99% at both the 1.0 meter (3.3 feet) and 1.5 meter (4.9 feet) scenarios. Since the majority of the resource within the state may be affected, impacts to tidal wetlands as a result of sea level rise were ranked as a high concern.

Delaware Coastal Programs

Route 9 near Odessa frequently floods during the highest tides of each month. Increasing sea levels will place more of Delaware's roadways at risk of flooding during high tides and storm surges.

Tourism and Coastal Recreation

Tourism and coastal recreation are important components of Delaware's economy and quality of life. Delaware's public beaches, a significant tourism asset, are currently replenished on a routine basis with federal and state funding. Accelerated rates of sea level rise may necessitate larger or more frequent beach replenishment projects to preserve recreational beach uses. Due to the potential for revenue losses statewide, coupled with the potential increased funding needs for maintenance or repair of tourist destinations, sea level rise impacts to tourism and coastal recreation was ranked as a high concern.

U.S. Fish and Wildlife Service Refuges

Delaware has two National Wildlife Refuges; Prime Hook in Milton and Bombay Hook near Smyrna. Area residents and tourists use the refuges for outdoor recreation activities such as hunting, fishing, birding, and wildlife watching. Refuge wetlands provide extensive habitat for numerous species. Between 85% and 95% of refuge acreage could be inundated under the three scenarios for sea level rise. While the impacts are localized, the acreage affected (21,354 to 24,120 acres) represents a significant loss of protected habitat and was ranked as a high concern.

Wells

Residents and businesses in Kent and Sussex Counties rely on groundwater resources for drinking, irrigation and industrial purposes. Sea level rise can compromise wells through inundation or through saltwater intrusion that can contaminate drinking water. Statewide, between 3% and 7% of domestic wells, 3% and 7% of industrial wells, 1% and 2% of irrigation wells, and 2% and 10% of public wells are within areas that could be inundated by sea level rise by 2100. Because access to clean water is a necessity and demand on inland wells may increase, sea level rise impacts to wells was ranked as a high concern.

Moderate Concern Resources

Agricultural Land Conservation Easements

Agricultural land conservation easements provide agricultural lands with permanent protection from development in order to maintain agricultural activities. Statewide, 13% to 17% of the land in agricultural conservation easements is within areas that could be inundated by sea level rise by 2100. The impact is primarily in Kent County. Conservation easements are considered to be an important tool to preserve farming operations and were ranked as a moderate concern.

Landfills

Between 1% and 3% of landfill acreage (including salvage yards, dumps and industrial landfills) in the state are within areas that could be inundated by sea level rise by 2100. However, no currently operating municipal landfills would be inundated under the three scenarios for sea level rise. Due to the likely difficulty of relocating impacted sites and because of potential for contaminant migration, inundation of landfills was ranked as a moderate concern.

Nature Preserves

Nature preserves are relatively undisturbed protected lands that represent some of Delaware's most important natural habitats. The percentage of affected acreage of dedicated nature preserves ranges from 34% to 43% under the three scenarios for sea level rise. The impact to nature preserves is local in scale; however, the habitat value of those sites may be exceptional. As a result of these factors, impacts to nature preserves from sea level rise were ranked as a moderate concern.

Delaware Coastal Programs

DNREC scientists collect samples of tidal wetland sediment to determine wetland resiliency to increasing sea levels. Modeling of sea level rise indicates that almost all of Delaware's tidal wetlands will be inundated by sea level rise if they cannot accrete enough sediment to keep pace vertically.

Residential Areas

Statewide, 1% to 5% of the 346,000 residences in Delaware are within areas that could be inundated by sea level rise by 2100. The highest concentration of potentially affected homes is in Sussex County along the barrier island south of Bethany Beach and around the Inland Bays. Additionally, residences within small coastal towns in Kent County are at risk of inundation from sea level rise, as are homes in the cities of Wilmington, New Castle, and Delaware City. Because potential impacts are concentrated in Sussex County but exist statewide, sea level rise impacts to residential addresses were ranked as a moderate concern.

Septic Systems

Statewide, between 1% and 4% of septic systems are within areas that could be inundated by sea level rise by 2100. The highest concentration of potentially affected septic systems is in Sussex County, particularly around the Inland Bays. The functionality of septic systems may be reduced as a result of rising water tables in addition to inundation. This may result in significant environmental and public health issues related to groundwater and resultant surface water contamination. Since potential impacts are concentrated in Sussex County but exist statewide, sea level rise impacts to septic systems were ranked as a moderate concern.

Wastewater Facilities

Statewide, between 7% and 21% of sewer pumping stations, up to 17% of spray irrigation fields, and up to 13% of public treatment and collection facilities are within areas that could be inundated by sea level rise by 2100. The majority of this exposure is focused within eastern Sussex County; however, New Castle and Kent Counties have wastewater facilities that could also be affected. Because of the statewide implications for clean water and public health, inundation of wastewater facilities was ranked as a moderate concern.

Delaware Coastal Programs

These row homes in the neighborhood of Southbridge in the City of Wilmington experience frequent flooding and are within a mapped sea level rise area. Sea level rise may have a disproportionate impact on minority and low-income communities like Southbridge.

Planning Early for Sea Level Rise is Important

In past decades, sea level rise has rarely been considered by governments, organizations and individuals when making decisions about where to develop, how to build or what lands to preserve for future generations. However, consideration of sea level rise in these decisions is important because changes in sea levels can impact the longevity, safety, and return on investment of projects that have long planning horizons or long life-spans. Improved tools, information and training are now available for those wishing to begin planning and adapting to sea level rise.

Adaptation

In a broad sense, adaptation can be defined as "adjusting" to new conditions by taking steps to moderate and cope with the effects of sea level rise (Levina & Tirpak, 2006). These steps can be planned and implemented at a variety of geographic levels, and by a variety of stakeholders. In Delaware and in many other locations, the process of adaptation involves two distinct efforts: (1) planning and implementing adaptation measures, and (2) building adaptive capacity.

Planning and Implementing Adaptation Measures

Adaptation measures can be defined as on-the-ground actions that can be taken to prepare for sea level rise in a particular location. They include raising buildings above flood prone areas, building dikes, and restoring wetlands. These measures are

Delaware Coastal Programs

Flood waters reach the edge of a pumping station facility in Bowers Beach during a nor'easter in November 2009. Pumping stations like this one are necessary to transport wastewater to regional treatment facilities; flooding from coastal storms and sea level rise can affect their operations and cause public health impacts.

described in more detail in Chapter 2 of this document. In general, these adaptation measures will be planned and implemented by landowners, business owners and local government officials to address projected impacts of sea level rise in a particular geographic location (a specific shoreline, park or roadway). The Sea Level Rise Advisory Committee did not undertake any assessment of, or recommendations for, specific adaptation measures in Delaware. Rather, it focused its work on understanding and making recommendations that will improve Delaware's adaptive capacity.

Building Adaptive Capacity

Adaptive capacity can be defined as the ability to adapt (Levina & Tirpak, 2006). As it relates to planning for sea level rise, adaptive capacity is the ability of individuals or agencies to assess potential impacts of sea level rise and to select and implement appropriate adaptation measures. Adaptive capacity includes the following, among many others:

- Availability of data and information necessary to plan successful adaptation measures
- Availability and level of technical knowledge and skills by those planning adaptation measures
- Availability of technical assistance
- Availability of funding to implement adaptation measures
- Existence of laws and regulations that do not impede implementation of adaptation measures
- Availability of information about the economic impact of adaptation measures
- Ability to cooperate and coordinate among jurisdictions
- Ability to gain public support for adaptation measures

While Delaware enjoys a high level of support for proactive planning for sea level rise (Responsive Management, 2010) and is among the first states to comprehensively plan for sea level rise at a statewide level, many barriers to adaptation still exist.

Recommendations for Adapting to Sea Level Rise in Delaware

Over a period of nearly three years, the Delaware Sea Level Rise Advisory Committee assessed the state's vulnerability to sea level rise, investigated adaptation options, developed objectives and approved recommendations aimed at improving the ability of Delaware's citizens, business owners, local governments and state agencies to make well-informed adaptation choices. More than one-hundred ideas for building capacity were considered by the advisory committee, with 55 ultimately approved as recommendations for inclusion in this report. These objectives and recommendations are fully described in Chapter 6. In addition, a set of guiding principles for implementing adaptation measures was also developed; these are outlined in Chapter 3 of this document.

The background information and recommendations contained in this document are intended to provide a roadmap for improving Delaware's ability to adapt to sea level rise in the coming decades. Implementation of these recommendations will require the continued dedication, cooperation, and coordination of citizens, elected officials, government agencies and non-governmental agencies. Chapter 7 outlines the next steps for implementing these recommendations. Implementation of these recommendations will build the adaptive capacity necessary to improve community resiliency for coastal storm impacts, foster wise use of public funding, lead to responsible siting of facilities and infrastructure and promote sustainable natural habitats.

Chapter 2: Adaptation Strategies and Measures

This chapter provides background information about adaptation strategies and specific adaptation measures that can be implemented by individuals or agencies in preparation for sea level rise. While the Sea Level Rise Advisory Committee has not recommended strategies or measures for any specific location, an understanding of the range of options available for adapting to sea level rise is helpful for understanding the rationale behind the 55 recommendations for preparing for sea level rise presented in Chapter 6.

Adaptation Strategies

Adaptation strategies are on-the-ground actions that can be taken to prepare for or respond to sea level rise in a specific location. There are four general categories of adaptation strategies: avoid, accommodate, protect, and retreat. Within each category are numerous measures that can be taken alone or in combination. The planning and selection of adaptation strategies will be done by individuals, business-owners and communities and will be dependent upon local conditions, funding availability and community support.

Each of the four adaptation strategies is described below, with a description of the types of measures that can be taken. This list is not exhaustive, as many very good references are widely available for those wanting more information[13]. In addition, Appendix H: Resources for Adaptation, provides a listing of tools, funding and technical assistance to those wishing to plan and select adaptation strategies.

Avoid

Avoidance adaptation strategies seek to limit new development or infrastructure in areas that are particularly vulnerable to sea level rise by redirecting development to less vulnerable areas (Deyle et al., 2007). Applying avoidance strategies in Delaware can help minimize liability in areas that can be impacted by sea level rise, potentially decreasing negative impacts to homes, businesses and infrastructure, while maintaining certain land uses. Some of these strategies can also allow for protected wetlands to naturally migrate landward in response to rising tides, permitting them to continue to provide natural buffers for the shoreline by absorbing the energy of storms and decreasing erosion (Bertness, 1999). These types of strategies can be implemented through transfer of development rights, conservation easements, setbacks, and other mechanisms (Deyle et al., 2007 and NOAA, 2010).

Transfer of Development Rights

Transfer of development rights (TDR) tools can be used by local governments to shift development trends to areas where development is more preferred. TDR tools "offer communities a potent tool for managing growth" (Williams-Derry & Cortes, 2011) by allowing landowners, in areas where development is less desired, to opt to sell their development rights and transfer them to

[13] The Adaptation Tool Kit, published by the Georgetown Climate Center is one such reference document that is particularly useful for local governments. It is available online: http://www.georgetownclimate.org/resources/adaptation-tool-kit-sea-level-rise-and-coastal-land-use. For homeowners, the recently published Homeowners Handbook to Prepare for Natural Hazards is also very useful. It is also available online: http://deseagrant.org/products/2012-homeowners-handbook

areas where the local government would like to encourage development (Grannis, 2011). Properties in which the owner sold the development rights are then placed into conservation easements to preserve the land in perpetuity. Both Kent County and New Castle County have established TDR ordinances for the purpose of helping to direct growth.

Conservation Easements

Conservation easements are voluntary landowner agreements that establish deed restrictions on land to prevent future development and are instrumental in maintaining open space. These preserved open spaces help reduce flooding and stormwater runoff, and can promote groundwater recharge. They can also allow for future wetland migration necessary to accommodate sea level rise (NOAA, 2010 and Titus & Craghan, 2009). Land preservation organizations in New York and Maryland have easements creating buffers specifically for allowing wetlands and beaches to naturally migrate landward (Titus & Craghan, 2009).

Setbacks

Setbacks are state, county or local regulations that can direct new development away from areas that experience impacts from inundation, beach erosion, and advancing coastal flood boundaries (Titus & Caghan, 2009 and Deyle et al., 2007). These regulations require development to be constructed a distance from the shore; either by a set distance or by an established multiple of the annual average erosion rate (Deyle et al., 2007). For example, "North Carolina requires new structures to be set back from the primary dune based on the current erosion rate times 30 years for easily moveable homes, or 60 years for large immovable structures (Titus & Craghan, 2009)."

Accommodate

Accommodation strategies acknowledge the long-term effects of sea level rise to an area, while implementing short-term measures to maintain the existing use (CSA International, 2008 and Boateng, 2008). These strategies decrease the risks of sea level rise impacts without employing potentially more costly protection strategies (Boateng, 2008). Examples of accommodation strategies include elevating a structure, drainage modifications, green infrastructure, and floodgates (Boateng, 2008 and Titus & Craghan, 2009), among others.

Elevation

Elevating structures involves raising a building's foundation to a level that accommodates for projections of increased flooding for the area over a specific time (Titus & Craghan, 2009). Elevation of a building can be implemented on an individual basis or as part of a comprehensive land use program for a local community. According to FEMA (2011), elevating a structure higher than the locally required lowest floor elevation provides additional protection against flood damage and can result in decreases in the cost of federal flood insurance.

Tony Pratt, DNREC, State of Delaware

Tony Pratt, DNREC, State of Delaware

The image on the left show houses that have been built set-back from the water. The image on the right illustrates homes with no set-back requirement. Setbacks provide a natural buffer from erosion and storm surge, and protect houses and public infrastructure from these elements.

Elevating structures, public facilities, and associated infrastructure, may be more cost effective than other adaptation strategies and should be considered after a site specific cost benefit analysis is conducted (CSA International, 2008).

Green Infrastructure

Green infrastructure projects use a natural means to address secondary impacts associated with development, such as stormwater management. These projects include drainage systems that incorporate bioswales, rain gardens, and naturally designed water retention ponds to hold and treat stormwater (Hamin & Gurran, 2008). Local communities can take steps to incorporate green infrastructure into projects to increase flood storage capacity and to avoid overwhelming combined storm and sewer overflows (Foster et al., 2011). Green infrastructure systems help provide many flood storage and water quality benefits, but may require large areas of open space that may not be available, or may be too costly to obtain (Hamin & Gurran, 2008).

Floodgates

Floodgates are moveable gates that span rivers to control water flow. They have been constructed throughout the United States, as well as in other areas of the world, to address storm surge and reduce flooding in areas prone to storm related flooding. These structures are built to span entire rivers and involve gates that are only lowered when storm surge is predicted to cause significant flooding to areas upstream of the gate. Titus and Craghan (2009) predict that as sea levels rise, the gates will need to be lowered on a more regular basis, which can impact navigation. These gates may be best suited for densely populated areas (Titus & Craghan, 2009 and CSA International, 2008).

Protect

Protection adaptation strategies focus on protecting land from inundation, erosion, or storm-induced flooding through the construction of various structures such as jetties, groins, living shorelines, bulkheads, and beach nourishment (Titus & Cragan, 2009). Construction of these structures helps preserve a static shoreline, which may provide a short-term solution to the long term impacts of sea level rise (NOAA, 2010). Many of these strategies are already commonly used in Delaware, including: periodic beach nourishment projects which have been successful in maintaining coastal beaches; bulkheads constructed by private homeowners to stabilize their properties; and dikes that protect public infrastructure, low lying communities, and environmentally sensitive areas. Hybrid approaches to protecting shorelines are also used to "retain some of the storm-resistance of a hard structure, while also maintaining some of the features of natural shorelines" (Titus & Cragan, 2009).

DNREC, State of Delaware

Houses in areas that experience flooding can be raised to a height that allows for water to pass underneath, reducing the risk of future flood damage to the structure from coastal storms and sea level rise. This image shows a home that has been retrofitted to accommodate increasing flood levels in the area, while a neighbor's house is not elevated and remains at risk.

DNREC, State of Delaware

This rain garden at the St. Jones component of the Delaware National Estuarine Research Reserve collects rain water that would otherwise flow into the St. Jones River. Rain gardens are planted with a variety of plants that are attractive, easy to care for, provide wildlife habitat, and improve water quality by filtering out pollutants.

Beach Nourishment

As stated in Delaware Code (7 Del. C. § 6801), beaches are "valuable natural features which furnish recreational opportunity and provide storm protection for persons and property, as well as being an important economic resource for the people of the State." Regular protection of Delaware's beaches occurs through periodic placement of sand on the beach. The sand placed on the beach can be dredged from offshore sand deposits or brought in by truck from inland sources. These beach nourishment projects prevent or slow beach erosion and shoreline migration that are caused, in part, by sea level rise. "Beach erosion and shoreline migration occur due to the influence of waves, currents, tides, storms and rising sea level. These natural forces have created, and will continue to alter, the beaches of the State (7 Del. C. § 6801)." Erosion and shoreline migration can still occur on nourished beaches; the rate of erosion can be greatly impacted by coastal storms such as hurricanes and nor'easters. Sustaining a nourished beach and its dune system requires continuing maintenance through subsequent nourishment projects at regular intervals (NOAA, 2010), which comes at a significant cost that is usually paid for with public funds. Development on or adjacent to beaches should consider the natural forces impacting upon them and the dynamic nature of those natural features. A cost-benefit analysis of beach nourishment can guide management decisions to determine the long-term financial implications of this adaptation strategy.

Bulkheads

Bulkheads are vertical walls constructed along the shoreline that are designed to reduce erosion and to protect existing structures and the land upon which they are built (NOAA, 2010). Bulkheads can be effective for the water elevations that they are designed for but as sea levels rise, alternative solutions may need to be explored (Titus & Cragan, 2009). Decisions about siting and design of homes often "underestimate the extent and magnitude of actual flood hazards that a coastal building will experience over its lifetime" (FEMA, 2011). Therefore, protection measures like bulkheads may not be a long-term solution for adapting to sea level rise.

DNREC, State of Delaware

A dune is constructed as part of the beach nourishment project in South Bethany in 2007. Beach nourishment projects can protect homes and infrastructure from flooding due to erosion and sea level rise while also maintaining the recreational uses of the shoreline residents and tourists.

Dikes

Dikes are elevated earthen or rock structures constructed parallel to a shoreline that prevent flooding and permanent inundation in the low-lying areas behind the structure (Titus & Cragan, 2009). These structures can be designed to include tide gates that manage the flow of water in and out of the low-lying areas behind the dike for storm protection and habitat purposes. To ensure continued protection, dikes must be inspected and maintained on a routine basis. Heights of many existing dikes in Delaware are not adequate to provide continued protection as sea levels rise, and a number of existing dikes in and around the City of New Castle have experienced significant erosion resulting from storms and poor maintenance (DNREC Delaware Coastal Programs, 2012). Due to the significant investments required, construction and maintenance of dikes can be cost prohibitive for some communities.

Retreat

Retreat adaptation strategies allow for natural shoreline migration through land conservation and the removal of structures that prevent shore-

line movement (e.g. dikes, berms and bulkheads). These adaptation strategies may occur as an unplanned response after a severe storm or as a proactive response to avoid the long-term costs associated with increased impacts from sea level rise. For existing structures, retreat strategies are usually employed after other adaptation strategies have been found to be ineffective (Titus & Craghan, 2009). Retreat strategies include moving development out of harm's way through managed retreat, rolling easements, and land acquisition (Deyle et al., 2007; NOAA, 2010 and Titus & Craghan, 2009).

Managed Retreat

Managed retreat involves planning for projected increases in sea levels by relocating vulnerable buildings, infrastructure and public facilities before significant inundation occurs. Managed retreat was used to address erosion and sea level rise by the National Park Service when it relocated the Cape Hatteras Lighthouse inland in 1999; it has also been used in the relocation plan for recreational amenities at Surfer's Point in Ventura, California (CARA, 2006 and White et al., 2012). Managed retreat usually requires significant time to plan and implement, and also requires significant consideration of the economic and social impacts of relocating homes, businesses and public facilities (Titus & Craghan, 2009).

Rolling Easements

Rolling easements are used to ensure that coastal development does not interfere with the natural migration of shorelines as they move inland due to sea level rise. Rolling easements can be implemented in several ways, including development of state or local statutes, placement of conditions on development permits or voluntary agreements. These land use restrictions are usually developed with reference to a tide line, or other natural feature, which allow the feature to "dynamically fluctuate with natural coastal processes" (Grannis, 2011). Therefore, as the sea level rises and the natural feature moves, the associated development or land use restrictions "roll" inland and allow for natural shoreline erosion and wetland migration to occur (NOAA, 2010).

Rolling easements are used in Texas, Maine, Rhode Island, and South Carolina, where development permits are conditioned to include a clause to relocate a structure when erosion threatens the structure (Deyle et al., 2007). These easements, based on the Public Trust Doctrine, make intertidal zones public lands, but "the doctrines vary substantially among the common laws of the individual states" (Deyle et al. 2007). While rolling easements may be

Henri Cormont, Rijkswaterstaat, Room for the River. https://beeldbank.rws.nl.

A dike between the towns of Kesteren and Opheusden in the Netherlands is built to an elevation that protects homes and infrastructure from extreme flooding events on the Lower Rhine River. Many of the dikes in Delaware were originally constructed by Dutch settlers during the 1600's.

NCDOT Photogrammetry Unit

In 1870, the Cape Hatteras Light Station in North Carolina was approximately 1,500 feet away from the ocean. In the hundred years since, storms, erosion, sea level rise, and other natural forces caused shoreline migration that resulted in the lighthouse being just 157 feet from the ocean. In 1999, the National Parks Service pursued a managed retreat strategy and moved the lighthouse and its outbuildings inland, where they are now safely 1,600 feet from the ocean (CARA, 2006).

less costly than measures that could achieve similar goals (e.g. land acquisition), easements would need to be established well before impacts occur to be effective.

Land Acquisition

Land acquisition by government entities, communities, businesses or not-for-profit organizations entails the purchase of vulnerable parcels for permanent protection and management, thereby allowing shoreline processes to occur naturally. Consent from the landowner to sell to the government or a conservation group is required for land acquisition programs. After purchase, the land can be managed as open space, public parks, or other passive infrastructure and is protected through conservation easements (NOAA, 2010; Titus & Craghan, 2009; and Grannis, 2011). Prioritization of properties for acquisition should include properties that have suffered severe repetitive losses due to storms; structures that are repeatedly damaged or destroyed; properties that have important habitats, such as wetlands, and are located in vulnerable areas; and properties where all other strategies are not cost effective to implement (e.g. elevating a structure) (NOAA, 2010). These programs can be an effective strategy for moving people and development away from vulnerable areas, but they do transfer management costs from the private property owner to the public (NOAA, 2010 and Titus & Craghan, 2009).

No Action

In addition to the four adaptation strategies described above, there is another option: no-action. A no-action strategy will be the default strategy for those who do not proactively plan ahead for future sea levels. By consciously or unconsciously choosing to not consider future sea level rise scenarios in planning and engineering design, decision-makers risk unintentionally pursuing a strategy of unplanned retreat. Unplanned retreat occurs when property, infrastructure and habitat losses from incremental erosion and inundation from sea level rise or a catastrophic flooding event are imminent or have already occurred, leaving few viable options for alternative protection, accommodation or avoidance strategies. To minimize no-action strategies and its associated increased likelihood of unplanned retreat, the guiding principles for adaptation described in Chapter 3 encourage initiation of adaptation planning now, with adjustments to plans as new information becomes available.

Chapter 3: Adaptation in Practice

This chapter provides information about the importance of planning for sea level rise and discusses the state's existing capacity to adapt. It also provides information about who should adapt to sea level rise and provides examples of how adaptation strategies may be implemented. Finally, this chapter provides a list of guiding principles that can be used in planning adaptation projects.

Proactive Planning for the Impacts of Sea Level Rise

The state's sea level rise scenarios provide information about potential high tide levels in 2100[14]; a planning horizon of 87 years (DNREC Sea Level Rise Technical Workgroup, 2009). However, as outlined in the Sea Level Rise Vulnerability Assessment (DNREC Delaware Coastal Programs, 2012), the impacts from sea level rise will not be experienced all at once in 2100. These impacts will be seen and felt incrementally from today onward. Many of the Sea Level Rise Advisory Committee's recommendations for adapting to sea level rise highlight the need for improved accuracy and resolution of sea level rise projections that would make the planning scenarios more useful to current planning, homeownership and business cycles of 20 to 30 years. However, the sea level rise information available now provides the basis for a variety of stakeholders at all levels to begin adapting.

Delaware Coastal Programs

The Southbridge Marsh in Wilmington will be restored as part of a plan to improve drainage and flood capacity in the area using green infrastructure techniques. Future sea levels will be considered in its final design.

Proactive adaptation has many benefits. By incorporating future tidal levels into plans for new development and re-development, communities can achieve a high level of resiliency to today's coastal storm events while also minimizing the need for costly upgrades in the future. Incorporating future tidal levels into the design of new infrastructure also has similar benefits and may expand the lifespan of infrastructure such as roads and central sewer systems. In addition, many communities in Delaware are currently faced with significant areas of chronic flooding and are planning drainage improvement solutions for these issues. If future tidal levels are taken into account, these drainage improvement projects will be able to continue to manage water flows even as sea levels rise. Proactive adaptation in each of these areas has the potential for significant long-term cost savings for individuals and communities and may reduce loss of property and structures.

[14] The scenarios are based upon mean higher high water and do not account for storm surges.

Existing Adaptive Capacity in Delaware

Significant adaptive capacity already exists within the state. Delaware has routinely replenished publically accessible beaches on the ocean and Delaware Bay coasts for over 40 years. It has a robust land acquisition program and a land-use regulation for coastal areas. It also requires counties and municipalities to plan for the future through comprehensive development plans. A brief summary of several of the key programs and legislation that have contributed to the state's existing adaptive capacity are outlined below.

Beach Preservation Act

Delaware's Beach Preservation Act (7 Del Code § 6801) gave DNREC the authority to enhance, preserve and protect public beaches and established a program for the prevention and repair of beach erosion. As a result, and with funding provided for projects through the Public Accommodations Tax, the beaches in Delaware from Fenwick Island to Pickering Beach have been routinely nourished with sand for over 40 years; a successful protection adaptation strategy that has minimized the effects of erosion and sea level rise.

The Beach Preservation Act also established a building line along the Delaware Bay and Atlantic coastline. Construction seaward of the building line is prohibited unless a permit is issued by the DNREC; permits can only be issued if a structure has been reduced in size to minimize encroachment over the line. This program has helped reduce the number of structures that could be vulnerable to erosion and sea level rise along the coast. The DNREC Division of Watershed Stewardship, Shoreline and Waterway Management Program is responsible for implementing the provisions of the Beach Preservation Act, and provides coordination and technical expertise for beach management issues statewide and throughout the region[15].

Coastal Zone Act

Delaware's Coastal Zone Act (7 Del Code § 7001) prohibits new heavy industrial facilities and bulk transfer facilities within the coastal zone, an area of land generally east of Route 9, along the C&D Canal and around Delaware's Inland Bays. Facilities in existence at the time of passage were grandfathered and permitted to continue operations. The act also requires that new manufacturing facilities, wastewater treatment plants not owned by a government entity, recycling plants and other similar facilities within this area receive permits prior to construction. Through its prohibition of new industrial development, the Coastal Zone Act has had a profound impact on coastal development, providing an opportunity for large scale conservation of low-lying land and minimizing the state's vulnerability to sea level rise impacts on population and infrastructure[16].

Quality of Life Act

Delaware's Quality of Life Act (9 Del Code § 6951) requires that counties and municipalities in the state prepare and implement comprehensive development plans that identify future growth needs, annexation areas and major infrastructure needs. These plans must be consistent with state plans for spending and growth.

The Office of State Planning Coordination is responsible for implementing this act and reviewing comprehensive development plans for consistency with state policies. It also provides technical assistance on a range of planning issues for county and municipal governments and coordinates with state agencies when discrepancies arise. The preparation of comprehensive development plans and the existence of a central planning entity provide an important opportunity for cooperation and sharing of technology among state, county and municipal governments on cross-jurisdictional issues like sea level rise.

Multi-Hazard Mitigation Planning

The Delaware Emergency Management Agency (DEMA) is responsible for periodically preparing and implementing a statewide multi-hazard mitigation plan, which contains an assessment of vulnerability to a variety of natural and man-made risks, including flooding and storm surges. The plan also identifies actions that can be taken to reduce the risks. DEMA provides technical assistance

[15] More information about the Beach Preservation Act and building line can be found online: http://www.dnrec.delaware.gov/swc/Shoreline/Pages/ShorelineConstruction.aspx

[16] More information about the Coastal Zone Act can be found online: http://www.dnrec.delaware.gov/Admin/CZA/Pages/default.aspx

to county and municipal governments that are developing their own mitigation plans or are applying for federal grants for hazard mitigation projects. In recognition of the expectation that flood and storm surge risks will be exacerbated in the future as a result of sea level rise, the 2013 update to the state's Multi-Hazard Mitigation plan includes consideration of sea level rise in its assessment and list of mitigation actions for flooding.

Many additional funding, regulatory and technical assistance programs exist to form the basis of the state's existing adaptive capacity[17]. These programs demonstrate how sea level rise planning and adaptation are already occurring within the state and how they can be incorporated into existing programs. Incorporation of sea level rise considerations into existing programs, rather than development of stand-alone programs, is a recurrent theme which is highlighted both in the guiding principles and the recommendations for adapting to sea level rise contained within this document.

Adaptation: From Individuals to States

A wide variety of individuals, communities, businesses and government agencies will choose to adapt through both implementation of on-the-ground adaptation measures and by building adaptive capacity. The various ways this can be achieved are outlined below. Many adaptation actions, whether they are capacity building or on-the-ground, will require cooperation and coordination with numerous entities. In addition, many adaptation actions are likely to be cross-jurisdictional, requiring the support and resources from communities, state entities and federal agencies.

Individuals and Business Owners

Individuals and business owners affected by sea level rise will make adaptation decisions primarily about the future of their own homes, land and businesses. Several of the recommendations proposed by the advisory committee are aimed at improving the ability of individuals and business owners to obtain information and technical assistance that will allow them to make the best decisions for their own particular circumstances. Individuals and business-owners may choose to elevate or relocate structures further away from vulnerable areas. Alternatively, they may choose not to make any structural or location decisions based upon the anticipated consequences of sea level rise at their location. Individuals and business owners may also choose to help their community prepare for the impacts of sea level rise by participating in planning activities.

Communities, Municipalities and Counties

Community, municipal and county responses to sea level rise will likely involve planning, on-the-ground projects and capacity building.

Communities, municipalities and counties wishing to adapt to sea level rise may choose to begin planning for its effects through their comprehensive planning process or emergency management plans[18]. Communities and municipalities can also develop coastal resiliency plans. These plans focus specifically on coastal hazards in a particular location and outline goals and objectives, assess risks and identify actions to reduce the risks. Grant funding and technical assistance are available from several agencies for this purpose.

Local governments may identify necessary infrastructure projects and be responsible for designing, implementing, building public support and funding. These types of projects can range from improving drainage systems to restoring wetlands to maintaining dikes and tide gates.

Planning processes may also identify capacity building needs that can be implemented by a community or local municipality. Capacity building at a local level could include providing new residents and prospective homeowners with a place to obtain information about sea level rise, inundation impacts and flood insurance. They could also include building in-house technical capacity through hiring planning staff or training staff on software such as Geographic Information System (GIS).

[17] Appendix H contains a list of additional tools, programs and funding mechanisms.

[18] See the City of Lewes case study in Chapter 4.

State and Regional Agencies
Similar to county and municipal governments, state and regional agencies choosing to adapt can do so through strategic planning for management of their landholdings, choosing adaptation strategies for on-the-ground action and by improving their adaptive capacity. In addition, some state and regional agencies will likely provide technical and financial assistance to others for planning and selection of sea level rise adaptation strategies.

Timing of Adaptation

Whether for an individual, a community or a state agency, the time to begin sea level rise adaptation is now. The Sea Level Rise Advisory Committee has compiled a large volume of information to assist in mapping and understanding statewide vulnerability to sea level rise, but additional site-specific or resource-specific data and information may be needed before adaptation measures can be implemented in a particular location.

At a local or regional level, planning and responding to sea level rise may occur over many years, with several adaptation strategies being employed at the same time to address a number of different community goals for the future. Figure 3 below illustrates an example of short-term, medium-term and long-term adaptation measures that can be taken to meet an adaptation goal of reducing vulnerability to homes and shorelines. It is important to note that the four adaptation strategies described in the previous chapter may be undertaken simultaneously to meet this goal.

Adaptation, by its very definition, must be flexible over time because data improves, public perceptions change, and new technologies emerge. Adaptation measures should be assessed and monitored over time, and long-term plans updated to incorporate new data and reflect changing conditions.

Guiding Principles for Adaptation

During the development of adaptation recommendations, the advisory committee had a number of discussions about how adaptation decisions should be made. For example, concerns were expressed about whether adaptation measures implemented in one location could have a negative impact on surrounding locations. Concerns

AVOID	ACCOMODATE	PROTECT	RETREAT
Short-Term • Increase set-back distances • Identify opportunities for voluntary conservation easements	Short-Term • Improve evacuation plans • Flood-proof at-risk structures	Short-Term • Identify beaches with high erosion rates • Inspect dams and dikes	Short-Term • Identify areas of high vulnerability
Medium-Term • Implement conservation easements • Monitor set back compliance	Medium-Term • Require elevation of new homes to 18 inches above base flood elevation	Medium-Term • Replenish beaches • Conduct necessary repairs of dams and dikes	Medium-Term • Create a special fund for purchase of frequently flooded structures • Implement rolling easements
Long-Term • Continue monitoring set back compliance • Monitor conservation easements	Long-Term • Construct new drainage systems	Long-Term •Increase height of dikes	Long-Term • Purchase frequently flooded areas from willing sellers and remove structures • Monitor rolling easement compliance

Figure 3. Short-, medium- and long-term adaptation measures for addressing a goal of reducing vulnerability to homes and shorelines.

were also expressed about how adaptation actions would be prioritized for state funding.

As a result of those discussions, the advisory committee has compiled the following "Guiding Principles for Adaptation." These principles should be taken into consideration during the planning and implementation of on-the-ground adaptation projects:

- Begin adaptation planning and implementation: adjust and make improvements as more information becomes available.
- Avoid unnecessarily prescriptive adaptation actions: empower decisions at the local level.
- Incorporate adaptation into existing programs and mechanisms, so as to not create a new bureaucracy. Engage broad public participation in adaptation decisions.
- Use the best available science and technology for decision-making and adaptation actions.
- Coordinate and consider consequences of adaptation among jurisdictions and among resource types.
- Strike a balance between protection of homes, infrastructure and conservation of natural resources.
- Strive for equity in selection and funding of adaptation measures:
    - Consider impacts to environmental justice communities.
    - Consider trade-offs between adaptation projects up-state and downstate.
- Encourage development of funding mechanisms for adaptation based on fairness, equity and justice for all citizens.
    - Public investment in sea level rise adaptation should be directed toward endeavors that benefit the most citizens as possible.
    - Public investment in sea level rise adaptation should be considered and weighed against the many needs of Delaware's citizens.
    - Fee based funding options, if developed, should be user-related (such as motor fuel taxes that pay for roadway maintenance).

Chapter 4: Case Studies

As discussed in previous chapters, many sea level rise adaptation activities are already occurring in Delaware. This chapter highlights several notable initiatives that have been undertaken related to storm surge and sea level rise preparedness: innovative marsh management, public lands acquisition, dike restoration and community planning. Each of these initiatives is contributing to the state's adaptive capacity and can serve as an example of proactive adaptation to sea level rise.

Accommodating Sea Level Rise by Elevating Marsh Surfaces

Tidal wetlands grow vertically by capturing sediment brought in by the tides, and by maintaining high plant production above ground and slow decomposition rates below ground. By accumulating dead plant matter and inorganic sediment, established marshes generally accrete at a rate sufficient to keep pace with sea level rise. However, the predicted accelerated rates of sea level rise will challenge this natural process.

When marshes do not accrete enough sediment to keep pace with rising sea levels, vegetation may die and portions of the marsh may become open water. This results in diminished flood storage capacity and reduced marsh habitat. One method to offset this sediment deficit is to reuse material dredged for navigation.

Sediments resulting from dredging of navigation channels are usually deposited in upland confined disposal sites, making those sediments unavailable in the natural system for marsh accretion. An alternative is to use the dredged material to increase the elevation of nearby tidal marshes. Applying a thin-layer of sediment over the marsh is a disposal option used successfully in other states and is currently being evaluated in Delaware as a sea level rise adaptation measure for tidal marshes.

A team of scientists from DNREC and the Center for the Inland Bays implemented a dredged material reuse pilot project in winter 2012 that is exhibiting initial signs of success. The project utilizes material from the maintenance dredging of Pepper Creek, near Dagsboro in Sussex County, to increase the elevation of an adjacent tidal marsh within the Piney Point Tract of the Assawoman Wildlife Area. This marsh was identified as having a comparatively lower elevation than other tidal wetlands in the Inland Bays and was therefore more vulnerable to rising sea levels.

Specialized equipment was constructed to transport the material from the dredge in the navigation channel to the shoreline. This included flexible piping and a pivoting nozzle mounted on a mini barge that could be moved along the marsh edge to direct the sprayed material. When the material is applied, it is a soupy mixture; about 85% water and 25% suspended sediment particles. The applied material will disperse across the marsh surface, leaving an even layer that will settle over time.

Dredging of Pepper Creek is planned to continue in winter 2013; up to six inches of dredged material will be placed on the large emergent wetland.

Scientists will continue to monitor for various indicators such as surface elevation, plant cover and below ground root mass for comparison to pre-project conditions. The results will be used to guide future marsh restoration projects.

Incorporating Sea Level Rise into Public Lands Acquisition

It is anticipated that 37% to 44% of the state's permanently protected land could be inundated by sea level rise under the three planning scenarios (DNREC Delaware Coastal Programs, 2012). Delaware's Open Space Program coordinates state acquisition of parks, fish and wildlife areas, forests, nature preserves and cultural sites.

In order to carry out the purposes of the Open Space Program, an Open Space Council provides recommendations to the Secretary of DNREC on all matters relating to the administration, implementation and financing of the protection of land. Because the Council typically works in a constrained environment of limited funding, a ranking process was developed to provide a strategic way of preserving open space by evaluating a property based on its own features compared to those of other similarly ranked properties in order to maximize resource benefits and to leverage all relevant funding sources. Point values are assigned for parcels under consideration based upon specific attributes within the following categories: ecological value (e.g., habitats of conservation concern or presence of rare plants or animals), land use (e.g., proximity to existing preserved lands, development pressure, and access issues), cultural/historical resources, water features (e.g., presence of riparian buffers or natural streams), and recreational uses.

The ability of a parcel to provide a means for sea level rise adaptation is a criterion under the land use category. Using the inundation scenario maps, properties with a landscape position that may allow landward migration of wetlands, for example an upland area adjacent to wetlands that may become open water as sea levels rise, would score higher in this particular sub-category than properties that are currently or predicted to be inundated as waters rise.

Recently, a potential acquisition known as the Morris property scored high in numerous categories, including ecological importance and land use, and also met the criterion for wetland migration potential. The Morris property is a 740-acre parcel to be purchased in 2013 with a combination of conservation grants and Open Space Program funding. The property, located northwest of the town of Bowers Beach in Kent

DNREC, State of Delaware

Sediment dredged to maintain navigable waterways can be used to elevate marsh surfaces. Here, material from Pepper Creek near Dagsboro in Sussex County is being sprayed on a marsh within the Assawoman Wildlife Area as part of a dredged material reuse pilot project.

DNREC, State of Delaware

The Morris Property will purchased by the State of Delaware with conservation grants and Open Space Program funding. It contains a mix of habitat types including uplands adjacent to tidal marsh, which may allow for marshes to naturally move inland in response to sea level rise.

County, contains a mix of habitat types including uplands adjacent to tidal marsh, which would allow marshes to naturally move inland in response to sea level rise. Preserving the property will also protect habitats of conservation concern, expand the boundary of the Ted Harvey Wildlife Area, and preserve additional lands within the Delaware National Estuarine Research Reserve core area. The Delaware Ornithological Society and Delaware Wild Lands, among other private and public funding sources will partner with DNREC for the purchase.

Holding Back the River with the New Castle Dike Restoration Project

Historic dikes, portions of which date back to the mid to late 1600's, form an earthen barrier between the city of New Castle and the Delaware River. Initially the dikes were constructed to hold back the river, thereby increasing lands suitable for agriculture. A secondary benefit was protection from flooding from coastal storms. Currently, four dikes line the Delaware River within New Castle: Buttonwood Dike, Broad Marsh Dike, Gambacorta Dike and Army Creek Dike. Another dike, located just to the south, also plays an important role in flood protection for the area.

Maintenance is necessary to sustain the integrity of these structures, and is typically very expensive. Over time, the responsibility of maintaining these structures, including removal of vegetation, repair of scoured and eroded banks, and removal of animal burrows, passed from one group to another. These groups were primarily stakeholders with an interest in the continued existence of the dikes, and they built, repaired and rebuilt them as necessary.

Dikes are continually impacted by wind, waves and tide; natural forces that can gradually erode and weaken the face of these structures or cause significant damage during coastal storm events. Seepage, or water permeating through the structure via cracks or animal burrows, can also compromise the integrity of the structure. Erosion, overtopping, and seepage are all factors that may lead to a dike's collapse and these negative effects are exacerbated by sea level rise (DNREC Delaware Coastal Programs, 2012).

DNREC, State of Delaware

Dikes protecting the City of New Castle are in need of reconstruction in order to increase the crest height and resiliency to coastal storms and sea level rise, and to be eligible for federal funding for future repairs. A walking path on Army Creek dike, shown here, has been undermined by erosion and is in need of repair.

Recognizing the need to evaluate the integrity of the dikes and decrease the city of New Castle's vulnerability, DNREC's Delaware Coastal Programs funded a study to assess the condition of the four dikes within the city. Not unexpectedly, the results indicated that a combination of decades of neglect, a decrease in the protective wetlands buffering wave energy from the river, and a recent string of coastal storms resulted in an unacceptable state of disrepair. Multiple agencies and stakeholders were needed to coordinate a response to address the deficiencies.

The New Castle Dike Maintenance Advisory Committee was created with representatives from the city of New Castle, DNREC, the Delaware Department of Transportation, the Delaware Emergency Management Agency, New Castle County, the Trustees of New Castle Commons and residents of the city. The committee set out to devise a maintenance plan and evaluate repair options. One option was a full reconstruction of each dike, an approach that was too costly for the city if done all at once. Undertaken as a step-by-step approach, this option would cost more over time but could be done as funds became available.

A series of coastal storms heavily battered all of the dikes and it became apparent that their reconstruction needed to occur soon in order to protect the health, safety and property of the residents and businesses in the region. The Delaware Legislature allocated initial funding, which covered the cost for design, archeological studies, permitting, and a portion of construction. Total construction costs are estimated to reach nearly $10 million, making this a major multi-year undertaking. The project timeline was hastened after Hurricane Sandy struck in October 2012 and resulted in the near failure of several dikes. Current plans are to have all five dikes repaired and raised to an elevation that will provide greater protection, and would make the dikes eligible for inclusion in the US Army Corps of Engineers' Rehabilitation and Inspection Program (RIP) by the end of 2013. Inclusion in the RIP allows for 80% of the costs for future damages to the structures to be covered by the USACE.

Operations and maintenance plans, which will identify inspection requirements and outline responsible parties for management activities, are being developed for each of the five dikes.

City of Lewes Hazard Mitigation and Climate Adaptation Pilot Project

The Sea Level Rise Advisory Committee report, *Preparing for Tomorrow's High Tide: Sea Level Rise Vulnerability Assessment for the State of Delaware* (2012) identified the need for detailed vulnerability assessments to be performed at the local level to determine specific resources at risk within communities. One municipality has already completed this analysis and adopted a plan to better prepare for coastal hazards that incorporates future flood risk and potential sea level rise impacts.

The City of Lewes is a quiet resort town on the mouth of the Delaware Bay. It is known for its historic district and small town atmosphere and has many natural features such as tidal creeks and wetlands, sandy beaches, and agricultural lands. The Lewes and Rehoboth Canal, a man-made waterway, bisects the town, which is highly vulnerable to many natural hazards, including coastal storms, flooding, and high winds.

Coastal storms have caused severe damage in the past. The March 1962 Ash Wednesday storm is the most notorious. The surge associated with this storm resulted in a record tide level of 1.4 meters above mean higher-high water (NOAA, 2013). More recent storms in 2008, 2009 and Hurricane Sandy in 2012, brought widespread flooding of low-lying areas and evacuation routes. Their current vulnerability, coupled with projected accelerated sea level rise, spurred the city to be proactive in addressing their risks. The City of Lewes partnered with the University of Delaware's Sea Grant Program and ICLEI Local Governments for Sustainability to develop the City of Lewes Hazard Mitigation and Climate Adaptation Plan, which was completed in June 2011 and adopted by Mayor and Council in August 2011[19].

The plan was a culmination of the efforts of local officials and residents who participated in a series of workshops to identify existing and future vulnerabilities and ways to reduce potential impacts. Several key vulnerabilities were identified: (1) flood impacts to homes, property, and land use, (2) flood impacts to city infrastructure, and (3) impacts to water resources due to precipitation pattern changes, flooding, and salt water intrusion. The City adopted a plan that includes six specific actions and implementation guidance to integrate its hazard mitigation and climate adaptation efforts. Actions identified to address key vulnerabilities fit within the following general categories:

- Knowledge building, including further study of evacuation route vulnerability and updating education and outreach programs
- Incentives, specifically the improvement of the city's participation in the Community Rating System to reduce citizens' flood insurance premiums
- Planning and regulatory recommendations

[19] Full text of the City of Lewes plan and more information on the planning process can be found online: http://www.deseagrant.org/lewes_pilot_project

The planning document also includes guidance to help the City of Lewes begin to implement the identified actions to achieve greater resiliency to coastal hazards and climate change. Planning exercises such as this one, and the subsequent adoption of the plan by the Town Council, positions local municipalities for grant funding for implementation projects and helps to maintain a consistent focus as changes occur in council membership and other town leadership positions.

University of Delaware, Sea Grant

The City of Lewes is a quiet resort town at the mouth of the Delaware Bay that is vulnerable to many natural hazards including coastal storms, flooding and high winds. Recognition of these risks prompted the development and adoption of the City of Lewes Hazard Mitigation and Climate Adaptation Plan to prepare for future weather events.

Chapter 5: Development of Recommendations for Adapting to Sea Level Rise in Delaware

This chapter outlines the rationale and process used for the development of the Recommendations for Adapting to Sea Level Rise in Delaware. It also details the public and stakeholder processes used to generate information and ideas and discusses the decision-making process of the Sea Level Rise Advisory Committee.

Focusing Recommendations on Priority Resources

The Sea Level Rise Advisory Committee was charged by DNREC Secretary Collin O'Mara with assessing the state's vulnerability to sea level rise and developing recommendations for the state to prepare and respond to the challenges it poses. The state's vulnerability to sea level rise was comprehensively assessed in the 2012 document *Preparing for Tomorrow's High Tide, Sea Level Rise Vulnerability Assessment for the State of Delaware*[20], highlights of which are outlined in Chapter 1 of this document. The assessment identified and characterized the vulnerability of 79 resources to sea level rise impacts. It also ranked each vulnerable resource as having a high, moderate or low concern statewide. Through this process, 16 resources were identified as being of high concern, and 6 of moderate concern.

Developing recommendations that would encompass all 79 vulnerable resources was not possible with available time and resources, so the advisory committee focused its work on developing recommendations for resources of high and moderate concern statewide. Focusing recommendations only on these 22 resources allowed the advisory committee to conduct a more in-depth investigation of barriers to adaptation and potential improvements to adaptive capacity for these resources. While several of the recommendations approved by the committee have implications for all vulnerable resources, the majority have a more limited scope.

Resources of High Concern

Beaches and Dunes
Coastal Impoundments
Dams, Dikes and Levees
Evacuation Routes
Freshwater Tidal Wetlands
Future Development Areas
Habitats of Conservation Concern
Heavy Industrial Areas
Port of Wilmington
Protected Lands Statewide
Roads and Bridges
Railroad Lines
Tidal Wetlands
Tourism and Coastal Recreation
U.S. Fish and Wildlife Service Refuges
Wells

[20] Available online: http://de.gov/slrva

Building Adaptive Capacity versus Local Adaptation Measures

From the beginning of this initiative, the Sea Level Rise Advisory Committee recognized that its recommendations could not be place-based. Decisions about the adaptation strategies to be utilized in a particular area will need to be informed by local conditions, site-specific engineering, community desires and the availability of funding, among other considerations. For a statewide planning process to weigh in on local adaptation strategies without the benefit of site-specific information would be inappropriate. However, understanding the range of actions that may be taken in the future in specific places (as outlined in Chapter 2) is important for ensuring that adequate coordination, regulations, policies, management practices and funding are available. For this reason, the process of developing recommendations for adaptation focused on actions that could be taken to increase Delaware's adaptive capacity.

The Process for Developing Options for Preparing Delaware for Sea Level Rise

The first step in development of recommendations to increase adaptive capacity was to create a comprehensive list of actions that could be considered. Development of this list of actions was initiated at stakeholder focus groups and then refined by the Sea Level Rise Advisory Committee.

Focus Groups

In October 2012, six focus group sessions were held for the purpose of increasing stakeholder involvement and creating a list of actions that could be taken to improve Delaware's capacity to adapt to sea level rise. The focus groups centered on high and moderate concern resources, categorized as follows:

Coastal Defenses, including beaches and dunes, dams, dikes and levees, and tourism

Industrial Land Use, including industrially zoned land, landfills and salvage yards, and Port of Wilmington

Land Preservation and Habitat, including coastal impoundments, protected lands statewide, U.S. Fish and Wildlife Service lands, nature preserves, tidal and non-tidal wetlands, tourism, and habitats of conservation concern

Land Use, including agricultural conservation areas, future development areas, and residential areas

Transportation, including evacuation routes, railroads, roads, and bridges

Water and Wastewater, including septic systems, wastewater treatment and transmission facilities, and wells

For each focus group, key stakeholders, including individuals, agencies and businesses not represented on the advisory committee but who could be affected by sea level rise were invited to participate. See Appendix D for a full list of focus group participants. The focus groups were attended by 77 persons.

Participants in each focus group reviewed the vulnerabilities of their specific resource categories and discussed the suite of potential adaptation strategies that could be taken in the future. Participants were then asked if there were adequate tools in place for individuals, businesses and governments to plan for, choose and implement adaptation strategies. Where tools were not adequate, participants were asked to list ways to improve and build the capacity to adapt. They were specifically asked to list any improvements that could be made to the following: funding mechanisms and financial incentives, coordination and planning tools, regulatory and policy tools, data and information and, outreach and education.

The focus groups identified over 100 ideas for improving the state's capacity to adapt to sea level rise.

Refining Focus Group Ideas

Over a three-month period, the advisory committee reviewed ideas and debated their benefits and consequences. A summary of the rationale

and impact of each idea was also drafted and reviewed. After significant review and discussion, the advisory committee retained 61 ideas. As all 61 did not have the full support of the advisory committee, public input was solicited prior to their incorporation into a final list of recommendations for adaptation. The ideas were compiled into a document entitled *Options for Preparing Delaware for Sea Level Rise*. This document was distributed to the public for comments at public engagement sessions and electronically.

Public Engagement Sessions

To share information about potential adaptation strategies and to obtain public input on the 61 options, the Sea Level Rise Advisory Committee hosted three Adaptation Engagement Sessions in February, 2013.

In total, 236 people attended the three public engagement sessions, held in the cities of New Castle, Dover and Lewes. For those not able to attend, all presentations and displays were posted online. Participants were able to provide comments at the meeting, online, by email or by US mail. A total of 57 written comments were received. Comments were reviewed and considered by the committee as they made their final list of recommendations. A summary of comments received is available in Appendix E.

Turning Options into Recommendations

After consideration of the public comments and additional debate among Sea Level Rise Advisory Committee members, the 61 options were revised. The revised options were then voted on by Committee members. In all, 55 options had the necessary support of two-thirds of committee members to be included in this document as final recommendations of the Sea Level Rise Advisory Committee[21].

During its discussions and decision-making process, the Sea Level Rise Advisory Committee strove for consensus. Building consensus for adaptation options required significant compromise on several options and resulted in the omission of others. However, the final recommendations of this advisory committee have strong support amongst almost all advisory committee members. See Appendix B for dissenting opinions of advisory committee members.

Delaware Coastal Programs

Participants at the Lewes Adaptation Public Engagement Session gather around a map of the state showing areas that could be inundated by sea level rise in 2100.

[21] A record of the votes cast by each advisory committee member organization can be found online: http://www.dnrec.delaware.gov/coastal/Documents/SLR%20Advisory%20Committee/Meeting19May2013/ResultsofFinalVoteswithMotions.pdf

Chapter 6: Recommendations for Adapting to Sea Level Rise in Delaware

Delaware's Sea Level Rise Advisory Committee was charged with developing recommendations for adapting the state to the likely impacts of sea level rise. Because sea level rise adaptation will occur at many different geographic levels—from an individual home to a regional transportation network—the Sea Level Rise Advisory Committee focused its efforts on researching and developing recommendations that will build the state's capacity to adapt, rather than pinpointing adaptation measures that should be used in specific locations. As a result, the Sea Level Rise Advisory Committee approved 55 recommendations for adapting to sea level rise that meet seven capacity building objectives. This chapter provides a complete list and description of each recommendation of the advisory committee.

Objectives for Sea Level Rise Adaptation

The goal of the Sea Level Rise Advisory Committee, in part, was to "develop a set of recommendations for state agencies, local governments, businesses, and citizens to enable them to adapt programs, policies, and business practices and to make informed decisions." As described in previous sections, the Sea Level Rise Advisory Committee spent considerable time gathering input from their organizations, other stakeholder groups, and the public to determine whether barriers and opportunities for adaptation exist for the vulnerable resources identified as of high or moderate concern. Seven objectives for building capacity to adapt to sea level rise emerged from these discussions:

- Improve Communication and Coordination among State, Federal, Local and Regional Partners to Streamline Sea Level Rise Adaptation Efforts.
- Provide Increased Regulatory Flexibility for Adaptation and Improve Consistency among Regulatory Agency Decisions.
- Provide Consistent and Predictable Policies for Future Growth, Investment, and Natural Resource Management.
- Increase Public Awareness of Sea Level Rise through Education, Outreach and Marketing.
- Improve the Availability and Robustness of Sea Level Rise Data Sets.
- Provide Technical Assistance to Partners for Assessing Vulnerability and Choosing Adaptation Strategies.
- Expand Funding Opportunities for Adaptation Planning and Implementation Projects.

The final recommendations of the Sea Level Rise Advisory Committee are grouped below according to the objective it will most help achieve, although there may be recommendations that meet more than one objective.

Recommendations for Adapting to Sea Level Rise in Delaware

The Recommendations for Adapting to Sea Level Rise in Delaware have been presented to Collin O'Mara, Secretary of the Department of Natural Resources and Environmental Control as the final product of Delaware's Sea Level Rise Advisory Committee. These recommendations are intended to provide a starting point for state, local and individual efforts to improve Delaware's ability to adapt to sea level rise; they do not represent a regulatory or statutory action.

Although these recommendations were developed at the request of the DNREC Secretary, they do not address only issues under the jurisdiction of DNREC. Many will require the support and cooperation of other agencies and groups to be implemented.

The recommendations below have not been prioritized by the Sea Level Rise Advisory Committee but are organized by objective, with recommendations numbered in a way that groups similar recommendations together for ease of reading. Prioritizing recommendations for implementation will occur at a later date, as outlined in the Chapter 7. Appendix A provides a table identifying the vulnerable resource each recommendation addresses.

Objective 1: Improve Communication and Coordination among State, Federal, Local and Regional Partners to Streamline Sea Level Rise Adaptation Efforts

Sea Level Rise Advisory Committee members, public engagement session attendees and stakeholder groups consulted during the development of these recommendations often expressed the need for improved coordination across jurisdictional and resource boundaries. The seven recommendations below are aimed at improving the ability of stakeholders at different organizational levels to coordinate and share information related to sea level rise and inundation.

Recommendation 1.1: Improve coordination of permit decisions for adaptation projects among federal, state and local officials.
Permitting processes that involve several different agencies, particularly those for transportation, sewer infrastructure, shoreline protection, and commercial or residential development, can be delayed when agencies lack a common set of goals or have conflicting regulatory requirements. As sea level rise adaptation becomes incorporated into project proposals, conflicting regulations may delay permitting processes. Early coordination of projects between state, federal and local officials could help minimize regulatory conflicts and delays, as would incorporation of sea level rise consideration into regulatory decisions. These actions may lead to more rapid issuance of permits for adaptation projects, more predictability for applicants, and an increased predictability and empowerment for local governments when planning and designing their own adaptation projects.

Recommendation 1.2: Create new partnerships to increase resources for research and development of adaptation options.
New and innovative solutions may exist for adaptation to sea level rise, including new shoreline stabilization methods, wave attenuation structures, oyster reefs, and offshore structures. Pilot projects to determine the efficacy of untested techniques may yield positive results. Forming new partnerships or strengthening existing partnerships with neighboring states, federal agencies, the consulting community, universities, and non-profits will greatly expand the knowledge and funding available for research and development. Collaboration can also expand regional sediment management research and opportunities for beneficial reuse of dredged spoil.

Recommendation 1.3: Increase opportunities for technology transfers and regional coordination for transportation issues affected by sea level rise.
Delaware, Maryland, Pennsylvania and New Jersey have an integrated road, bridge and railway system which will require coordination and cooperation among the states and the U.S. Department of Transportation to adequately address sea level rise. Using existing professional venues, such as

regional Metropolitan Planning Organizations and the American Association of State Highway Transportation Officials, DelDOT should integrate this new dimension into its planning, design, and operation policy discussions and standards development.

Recommendation 1.4: Incorporate sea level rise into public and private sector regional planning efforts.
Much of Delaware's infrastructure is part of regional networks, including electrical generation, roads, rail, and landfills. Delaware's wetlands, habitats of conservation concern, beaches and nature preserves are also part of a regional system of wildlife and fish habitats. Incorporation of a common set of sea level rise information into regional planning processes for these resources will help ensure that informed decisions about adaptation are made and that the entire regional system is sustainable. Regional planning processes that should be targeted include: Wilmington Area Planning Council and Dover/Kent Metropolitan Planning Council long range plans for transportation, Amtrak long range plans, business group and industry contingency plans, and regional habitat plans.

Recommendation 1.5: Provide sea level rise information to the Delaware Agricultural Land Preservation Program for consideration.
The Agricultural Land Preservation Program protects land for agricultural purposes through voluntary measures. Included among these are the purchases of preservation easements that permanently protect farmland from development while allowing agricultural uses to continue. High quality soils, significant agricultural infrastructure, historical and environmental significance are all factors that have been considered in program eligibility.

Recommendation 1.6: Provide technical assistance to Delaware's Open Space Council for incorporating sea level rise into its criteria for acquisition of natural areas.
Delaware's Open Space Council works to secure the permanent protection of open spaces in Delaware including parklands, forests, fish and wildlife areas, nature preserves and cultural sites. The Open Space Council has developed criteria that it uses to prioritize and assess potential land purchases. Sea level rise has been included in these criteria, but additional assistance may be necessary to further refine and modify the criteria.

Recommendation 1.7: Conduct a comprehensive inventory of key funding, coordination, regulations and policies and analyze them for barriers and opportunities for sea level rise adaptation.
Many recommendations of the Sea Level Rise Advisory Committee propose changes that would remove obstacles for adaptation and increase coordination among agencies. However, many other barriers and opportunities may exist that could not be considered within the time frame of the advisory committee's work. A comprehensive study of key funding, coordination, regulation and policies could help shed light on opportunities for coordination and removal of barriers that had not previously been considered. Private sector plans could also be considered and incorporated.

Objective 2: Provide Increased Regulatory Flexibility for Adaptation and Improve Consistency among Regulatory Agency Decisions

Sea Level Rise Advisory Committee members, public engagement session attendees and stakeholder groups consulted during the development of these recommendations were concerned that regulatory agencies in the state could respond to sea level rise by implementing or retaining contradictory regulatory and policy changes. There was also concern that there could be negative consequences if regulations do not consider the potential impact of sea level rise; both because sea level rise can change the ability of a project to meet a technical standard and because adapting to sea level rise may require regulatory flexibility that does not yet exist. The following six recommendations are aimed at ensuring that sea level rise is considered during future regulatory updates for certain environmental regulatory programs and ensuring that state agencies work together in considering the impact of sea level rise on the implementation of their programs.

Recommendation 2.1: Provide regulatory incentives that encourage sea level rise adaptation and that allow for innovative projects.
Sea level rise is an emerging issue that many state and local regulations do not yet consider. A variety of adaptation measures from raising buildings to protecting shorelines may not be permissible or may take longer to permit than measures which do not include sea level rise considerations, setting up a perverse incentive that could result in no adaptation or maladaptation. Local and state regulations and building codes should be assessed for opportunities to provide incentives for adaptation, particularly for demonstration projects. As an example, the Delaware Department of Natural Resources and Environmental Control recently issued a "Statewide Activity Approval" for shoreline stabilization projects that incorporate natural and planted marshes. Under this approval, average permitting times will be reduced to one to two weeks.

Recommendation 2.2: Encourage the governor to sign an executive order that would direct state agencies to plan for sea level rise.
The vulnerability assessment demonstrates that sea level rise has consequences throughout the state and to a wide variety of resources. Adapting to sea level rise at the state level will require state agencies to work together using a consistent set of data and predictions. An executive order could direct each state agency to conduct an agency specific vulnerability assessment using a common set of future scenarios. It could also direct each agency to consider future sea levels in the design of state projects and infrastructure, identify adaptation plans for state owned assets, and identify regulatory and policy opportunities and barriers.

Recommendation 2.3: Conduct a comprehensive update to the state's regulatory tidal wetlands maps and provide a way to periodically update the maps to reflect changes occurring from sea level rise.
Activities in tidal wetlands are regulated by the state through its Wetlands Act (Del Code 7, Chapter 66). Tidal wetlands were inventoried and drawn on maps; any tidal wetland depicted on this map is regulated by the state. However, the aerial photographs for these maps were flown in 1988 and have not been comprehensively updated since then. Sea level rise, erosion and coastal storms cause wetlands to migrate; the existing maps may no longer be accurate. The vulnerability assessment concluded that 99% of the state's existing tidal wetlands could be inundated by sea level rise – comprehensively updating the regulatory wetland maps on a routine basis will help protect tidal wetland areas that migrate land ward.

Recommendation 2.4: Consider sea level rise implications in future regulatory updates for septic systems and wells.
Sea level rise and its associated impacts, such as increased flooding, rising water table, and salt water intrusion, can reduce or eliminate the functionality of on-site wastewater treatment systems and groundwater wells. Permit criteria for the siting, design, and construction of wastewater disposal systems and wells are specified in state regulations. Incorporating sea level rise considerations into future updates of these regulations to implement protective design and siting requirements could reduce vulnerability of septic systems and wells. Additional studies of sea level rise implications for Delaware's groundwater would be necessary before criteria could be developed. The costs of any additional requirements should be carefully considered and weighed against the lifespan of each system.

Recommendation 2.5: Facilitate the connection of individual septic systems to community wastewater treatment systems with excess capacity when human safety and welfare are at risk.
The vulnerability assessment identified over 3,000 septic systems at risk of inundation in Delaware – many of these could begin to fail prior to inundation due to rising water tables. Although it is possible to provide central sewer service to residents with failing septic systems, in some cases it is not economically feasible to do so. In these cases, it may be feasible to connect failing septic systems to nearby community wastewater treatment systems that have excess treatment capacity. This would allow systems failing due to sea level rise to connect to a treatment facility as an interim measure that may expand the lifespan of a residence in a vulnerable area. An agreement would have to be made between the individual landowner and the operator of the community system. It is unknown

at this point if the costs would be the sole responsibility of the landowner or if existing grant and loan programs could be utilized to defray costs. There is concern that allowing connection to community systems could foster residential growth in vulnerable areas.

Recommendation 2.6: Consider sea level rise implications in future updates to the state Coastal Zone Act regulations.
Delaware's Coastal Zone Act prohibits new heavy industrial uses in the coastal zone and requires permits and environmental offset projects for modifications to existing heavy industrial facilities. Existing heavy industry in the coastal zone is very important to Delaware's economy; these facilities should be allowed the flexibility to adapt to sea level rise. Sea level rise considerations, including the potential future need for shoreline improvements, drainage improvements and facility upgrades, should be included in any future regulatory updates.

Objective 3: Provide Consistent and Predictable Policies for Future Growth, Investment, and Natural Resource Management.

During conversations and meetings with stakeholders, a desire for predictable land use, management and investment policies emerged. Clearly articulating strategies for adapting to sea level rise early will help these stakeholders make informed decisions about where they locate and invest. The following 14 recommendations are aimed at providing consistency for growth and investment by identifying planning documents and tools that should incorporate sea level rise as a consideration, identifying new plans that should be developed, and calling for development of decision-making tools.

Recommendation 3.1: Incorporate sea level rise considerations into the Strategies for State Policies and Spending.
Land-use decisions in Delaware are made at the local level, but the bulk of infrastructure and service that support these decisions are funded by the state. The Strategies for State Policies and Spending set forth clear advisory policies (including maps) about where the state will allocate financial resources for conservation, infrastructure improvements, and social services and are updated every five years. Incorporation of sea level rise into the suite of issues considered when the strategies are updated would provide an opportunity for coordination between agencies and local governments regarding sea level rise and may help further ensure wise use of state funding.

Recommendation 3.2: Consider incorporation of sea level rise considerations into municipal and county comprehensive development plans.
State law requires that every municipality in Delaware develop, and periodically update, a comprehensive development plan. These plans contain a municipal development strategy that includes expansion of boundaries, future plans for residential and commercial growth, and future infrastructure investments, among others. They also contain environmental and demographic information. Consideration of sea level rise impacts and potential adaptation actions would ensure that all municipalities in the state are proactively taking into account potential sea level rise impacts in their future plans for growth and development and may allow for increased communication about sea level rise between municipal, county and state governments.

Recommendation 3.3: Consider use of a Transfer of Development Rights tool to direct future growth away from vulnerable areas.
A Transfer of Development Rights (TDR) tool helps to direct future growth away from vulnerable areas by allowing for increased densities in areas more appropriate for development. This could help to ensure future growth needs are met by utilizing land outside of potentially vulnerable areas. TDRs have been used by county governments to direct residential and commercial growth away from agricultural areas, but their use is not yet widespread.

Recommendation 3.4: Incorporate sea level rise into Delaware's Long Range Transportation Plan.
Delaware's Long Range Transportation Plan serves as a strategic planning tool for the state to chart the course of transportation for the next 20 years. Including sea level rise in the evaluation of transportation needs, and as a specific statement in the plan, will provide the necessary policy support for DelDOT to incorporate sea level rise into

project planning, establish a framework for directing investments, and identify financial resources to sustain the plan's vision.

Recommendation 3.5: Incorporate sea level rise into the Transportation Operations Management Plan.
Future updates to DelDOT's Transportation Operations Management Plan for each county should consider sea level rise impacts on the safe and efficient operation of the state's roadways and on evacuation route planning.

Recommendation 3.6: Encourage inclusion of sea level rise in Transportation Project Design Manuals.
To ensure consistency of highway infrastructure across the country, national standards are cooperatively developed by state Department of Transportations and the Federal Highway Administration under the banner of the American Association of State Highway and Transportation Officials. These adopted standards cover all aspects of design and road geometry, as well as signals, signs and markings. These standards need to be updated to reflect the predicted effects of sea level rise on such long-lived assets such as roadways and bridges, accounting for differences in sea level rise scenarios in different areas of the nation.

Recommendation 3.7: Develop a dike safety program.
There are numerous dikes throughout the state that act to protect infrastructure, natural resources and private property from flooding during storms and extreme high tides. However, there is no single entity in charge of inspecting, maintaining and improving these dikes. The dikes are also owned by a variety of different entities, further complicating their management and operation. The creation of a Dike Safety Program would ensure a single point of contact for dike repairs and management. It could also be responsible for conducting feasibility studies for improving or abandoning dikes and obtaining funding for repairs and upgrades. A similar program has recently been implemented for dams within the state. Creation of such a program may require new legislation.

Recommendation 3.8: Develop a framework for decision-making regarding land protection and restoration strategies based on habitat vulnerability, migration potential and relative importance in the regional landscape, historical significance or other key factors.
In order to prioritize land acquisition and protection strategies in light of sea level rise impacts, a decision tree, process model, cost/benefit analysis, or similar tools are needed. The U.S. Geological Survey is developing a computer model to prioritize habitat types for the northeast region. Upon completion, this model may assist in determining priority needs that consider a broader, regional context. Consideration should also be given to the ecological services provided by these lands and economic values placed on them. Land acquisition should be aggressively targeted for the highly ranked habitat types.

Recommendation 3.9: Develop a comprehensive wetlands restoration, protection and retreat strategy in response to sea level rise.
A comprehensive wetlands restoration strategy for the state is necessary given the anticipated impacts from sea level rise. The strategy should include: identification of uplands for preservation and acquisition to provide areas for marsh migration; prevention of the construction of structures that would act as barriers to migration; identification of wetland restoration techniques to allow wetlands to keep pace with sea level rise; cataloging of pertinent research needs; identification of policy and regulatory changes, and; development of an outreach strategy. Specific ideas that could also be incorporated include evaluating Phragmites control techniques, beneficial re-use of sediment, and rolling easements.

Recommendation 3.10: Continue efforts to re-evaluate management strategies for existing coastal impoundments.
The DNREC Division of Fish and Wildlife and the U.S. Fish and Wildlife Service own and operate coastal impoundments in the state that provide bird habitat, fish nursery grounds, and flood abatement. In recognition that current management practices for impoundments may be unsustain-

able in light of sea level rise, the Division of Fish and Wildlife has begun research and planning to improve impoundment management and develop adaptation strategies. Future management strategies could consider incorporating beneficial re-use of dredge disposal sediments to build up elevation and possibly adjusting locations of impoundments after considering the landscape and resource needs. Lessons learned from pilot projects and new management techniques should be shared with the U.S. Fish and Wildlife Service and others throughout the region that manage impoundment structures. Outreach to surrounding communities about any changes to impoundment management should also be considered.

Recommendation 3.11: Evaluate the benefits and risks of permitting privately owned coastal impoundments.
The vulnerability assessment found that virtually all of the state's coastal impoundments are vulnerable to sea level rise. These areas provide important breeding, migration and wintering habitat for birds and serve as nursery grounds for fish. Construction of coastal impoundments in state regulated tidal wetlands is rarely approved due to a variety of natural resource concerns, habitat management issues and impacts to surrounding landowners. However, in light of potential losses of existing large impoundments, providing similar alternatives at a smaller scale can provide beneficial habitat if impoundments are properly managed. An endowment could be required for any new impoundment to ensure future maintenance. Conservation easements, which would provide permanent protection to the land and direct management practices, should also be required. Impacts to local hydrology, mosquito control, flooding and drainage issues and potential liabilities will need to be evaluated prior to permitting new impoundments on private land.

Recommendation 3.12: Designate shoreline zones for adaptation action.
Shoreline protection and restoration projects require federal, state and sometimes local permits. Hardening of shorelines (e.g., with bulkheads or riprap) is generally discouraged by state policies, but may be the most appropriate adaptation response in urban or industrial areas. Conversely, soft or "living" shorelines may be the most appropriate in rural or environmentally sensitive areas. Criteria for shoreline adaptation would have to be based on peer-reviewed literature and done in collaboration with stakeholders. Planning for and designating areas statewide where shoreline hardening would be allowed, where hardening would be discouraged, and where living shorelines will be encouraged will provide certainty for permit applicants and may streamline the permitting process. These designations should also be incorporated into appropriate federal, state and local permitting processes.

Recommendation 3.13: Conduct a legal review for disinvestment of publicly owned infrastructure and privately owned buildings.
Retreat is an important strategic option for dealing with sea level rise. Many private and public buildings and other infrastructure, such as roads, may become impractical to maintain as the environment changes and may be abandoned. There are many public health and safety implications that must be addressed, such as removal of contaminants, as well as legal implications, such as loss of access to a property or loss of property value due to removal of an inter-related public or private asset. In addition, there are also equal protection and environmental justice implications for low income and/or minority communities that could be affected by disinvestment. A review of the legal framework, especially real estate and environmental law, will be needed in order to begin to understand the legal feasibility as well as true costs and consequences of a retreat strategy.

Recommendation 3.14: Develop a statewide retreat plan and update it periodically.
There are certain locations within the state where "retreat" may be the best adaptation strategy, including some natural areas, agricultural areas and developed areas where protection may not be feasible due to expense or engineering constraints. There is a desire from businesses, citizens and state agencies to have predictability in adaptation responses so that they can make long-term plans. A statewide plan outlining areas where retreat may be the most appropriate adaptation option would allow state agencies to put lifespan limits on infrastructure in vulnerable areas, allow targeted

land acquisition for inland migration of wetlands and shorelines, and provide predictability for citizens. Significant new data about adaptation costs, shoreline responses to sea level rise and demographic information would be required before a retreat strategy could be crafted. Any retreat plan would also require extensive dialogue with elected officials, business and commercial property owners and citizens.

Objective 4: Increase Public Awareness of Sea Level Rise through Education, Outreach and Marketing

Availability of information to improve decision-making in the face of changing conditions caused by sea level rise was immediately recognized by the Sea Level Rise Advisory Committee as an important component of adaptation planning, the importance of which was reinforced during stakeholder and public meetings. The following four recommendations, coupled with several listed under Objective 5, seek to ensure that those wishing to incorporate future sea levels into their planning and decision-making have access to the tools and information they need.

Recommendation 4.1: Develop a comprehensive outreach strategy to educate all stakeholders about sea level rise.

A comprehensive outreach strategy should be developed to increase stakeholders' understanding of sea level rise, its effect on many aspects of life, and ways to reduce these impacts. A strategy may include consideration of the best ways to reach different audiences. Education efforts should include both year-round and seasonal residents, children, government officials, businesses, commercial property owners, farmers, real estate agents, insurance agents, utilities and industries so that informed decisions can be made in the future. Increased education could engage more agencies, increase funding opportunities and result in support to help integrate sea level rise into long-range management plans, gain acceptance of the management decisions made, and possibly influence legislative decision making. In addition, providing information about other successful sea level rise adaptation programs and initiatives may further increase Delaware's acceptance of sea level rise and adaptation strategies.

Recommendation 4.2: Provide education and outreach for impacted communities and citizens.

Communities that may be the most impacted by sea level rise should be provided with up-to-date information on sea level rise scenarios and be informed of adaptation measures that can reduce the impacts on their homes and communities. Residents of these areas should be made aware of available information about long-term and short-term adaptation measures, benefits and risks of various adaptation measures, combinations of risk factors (e.g., drainage and stormwater, coastal storms and sea level rise), and changes occurring in the insurance industry that may impact insurance availability and cost.

Recommendation 4.3: Improve the ability of homebuyers to investigate a property's potential vulnerability to sea level prior to purchase.

Homebuyers' access to information about future sea levels should be improved through development of a comprehensive website that illustrates current flooding and future sea level rise inundation risks. In addition, prospective homeowner understanding of flood risks should be improved through increased interactions with local municipal planners. For example, the city of Newark has a successful program where prospective homeowners meet with land use planners prior to their purchase to review the property and surrounding land uses. A similar model could be employed in other municipalities to include sea level rise information.

Recommendation 4.4: Provide targeted outreach to water and wastewater operators and water utilities.

Opportunities exist to reach out to state, municipal, county and private water and wastewater professionals at annual conferences of water associations, such as the Delaware Rural Water Association and the Delaware Onsite Wastewater Recycling Association. These conferences are key venues for disseminating information on sea level rise, engaging stakeholders and experts in planning for its impacts, and evaluating preferred adaptation options and strategies to meet long-term goals.

Objective 5: Improve the Availability & Robustness of Sea Level Rise Data Sets

While numerous tools have been developed that will assist individuals, communities, businesses and governments to adapt to sea level rise, several significant data gaps still remain. In many cases, adequate adaptation planning can occur with the existing information and tools, however the following 18 recommendations aim to improve the scale at which adaptation planning can occur and to improve the tools available to incorporate storm surge and precipitation concerns into inundation models.

Recommendation 5.1: Improve monitoring of current sea level conditions and improve predictions for timing of inundation.
The number of monitoring stations should be expanded to improve the sea level rise data currently being collected. Increasing the number of tide gauges along the coast of Delaware would provide widespread water level data needed to refine model projections of inundation and our ability to identify potential risks on small spatial scales. Increased monitoring should include more information on changing landscapes, including agricultural lands and wetland areas.

Recommendation 5.2: Install additional water level and salinity observational stations in Delaware's tidal waters.
Variations in salinity and tidal levels in the Delaware Bay and inland waters can be highly localized. The number and location of existing water level and salinity observation stations in Delaware are inadequate to understand site-specific conditions. Such stations can help with understanding the extent and frequency of storm flooding in the short term while providing data and information useful for planning adaptation responses. A report entitled, *A Data GAP Analysis and Inland Inundation Survey for the Delaware Coastline*, recommended additional stations in the vicinity of Slaughter Beach, Longneck, the city of New Castle, Woodland Beach and Port Mahon (Leathers et al., 2010).

Recommendation 5.3: Improve the accuracy of Delaware's elevation benchmark network.
Delaware's network of benchmarks used for elevation surveys are currently inadequate due to lack of coverage in key coastal areas and problems with the accuracy of existing benchmarks. Existing benchmarks should be re-surveyed and additional benchmarks created. This is necessary to ensure that adaptation projects in coastal areas are designed and constructed with accurate elevation data.

Recommendation 5.4: Continue and expand studies regarding sediment accretion rates and susceptibility of wetlands to sea level rise.
The state, University of Delaware and the National Estuary Programs have been working together to study and monitor sediment accretion rates and plant composition in Delaware's marshes in order to better understand susceptibility of certain marshes to inundation from sea level rise. Expanding this work to targeted additional locations across the state will provide a better data set from which to base land acquisition, restoration and retreat decisions.

Recommendation 5.5: Conduct research to better understand human response to sea level rise and adaptation.
People are the core of any decision about adaptation measures, yet there are currently only a few studies about coastal residents' opinions of adaptation actions, thresholds for action and likely emotional responses to flooding and inundation. A better understanding of coastal residents' attitudes, perceptions and motivations could be very helpful in working with communities to choose adaptation options.

Recommendation 5.6: Develop sea level models that incorporate storm surge impacts.
Sea level rise can exacerbate the effects of storm surges. The current sea level rise vulnerability assessment is based on a bathtub model, where the extent of inundation is estimated based on mean higher high water (MHHW) and land elevations. This model does not yet incorporate storm surges due to the complexity of accurately modeling storm surge at a statewide level. However, a storm surge model that takes into account future sea levels would provide a tool to better plan for inundation impacts.

Recommendation 5.7: Conduct a risk assessment for Delaware's system of dikes & levees.
Dikes and levees act to protect infrastructure, natural resources and private property from flooding during storms and extreme high tides. An inventory of the dikes and levees in the state should be conducted to determine which ones are most at risk, including a specific analysis of each dike for possible future risks posed by sea level rise, storm surge and stormwater. This would lead to a risk analysis to evaluate if there is an escalating risk from the projected sea level rise scenarios discussed in the vulnerability assessment.

Recommendation 5.8: Encourage federal agencies to integrate sea level rise planning into their flood models.
The National Flood Insurance Program and Federal Emergency Management Agency do not currently include consideration of sea level rise in their floodplain models, which are based upon historic storm and flood data rather than future projections. This results in floodplain maps that may underrepresent flood risk to residents. Delaware and other low-lying states can encourage the federal agencies to incorporate sea level rise into flood models and can provide data and local knowledge for the development of floodplain maps that include sea level rise.

Recommendation 5.9: Model potential stormwater inundation problems in highly vulnerable areas.
Sea level rise may reduce the ability of stormwater to drain from an area if the outfalls are located on tidal water bodies or are linked to tide gates. This can worsen the effects of flooding from both heavy rainfall and storm surge events. Watershed scale or smaller models should be developed for a better understanding of flooding impacts from the combination of stormwater and higher tides.

Recommendation 5.10: Develop a model that will predict changes to salinity in surface water that may occur under differing sea level rise scenarios.
Improving our understanding of sea level rise impacts resulting from migration of salt water into the Delaware River is necessary to better assess risk to infrastructure, facilities and natural systems. Modeling can provide the information necessary to better anticipate impacts to natural systems and develop an understanding of the different threshold of these systems. This could be done on a smaller watershed scale using nested models.

Recommendation 5.11: Develop a statewide groundwater model.
A general, screening-level groundwater computer model can provide information on how groundwater movements and water table levels may be impacted by sea level rise. This data would provide the necessary information needed to understand which industries and businesses may be at risk from corrosion, which contaminated sites may be at risk, and which habitats may be threatened. Site specific evaluations may be necessary, but an improved understanding of overall sea level rise impacts to the water table is required to better assess risk.

Recommendation 5.12: Develop and maintain a comprehensive database that contains the location and condition of all wastewater infrastructures.
The vulnerability assessment analyzed public wastewater facilities and pumping stations: data regarding private or community systems, pumping stations and pipelines are not available in a consolidated format. This information should be entered into a comprehensive database and routinely updated to plan more accurately for sea level rise impacts to wastewater systems and to identify opportunities to integrate services in vulnerable areas with systems that may be more reliable over time. The database should include a condition assessment of the facility in order to plan for anticipated maintenance and upgrades. It should also triage areas for repairs and relocation to expedite the process when funds are available.

Recommendation 5.13: Identify and preserve areas for potential wetland migration.
As coastal wetlands become permanently inundated, it is vital to facilitate the landward migration of these habitats to maintain their valuable functions. Available geographic information system (GIS)

data can help identify lands adjacent to wetlands that have the potential to accommodate future marsh migration. Criteria should be developed to prioritize lands for acquisition or permanent conservation easements. As an example, areas that are undeveloped or lack barriers such as major transportation routes or other infrastructure woul more easily accommodate wetland migration. Also agricultural land that is no longer productive due to salt-water intrusion may better accommodate future wetland migration. Areas identified as suitable for potential migration and the means to prohibit structures or obstructions in these areas should be thoroughly evaluated.

Recommendation 5.14: Identify the data necessary to plan transportation investments.
Roads and bridges that are located in areas that are expected to have flooding issues as illustrated through the inundation models in the vulnerability assessment should be specifically identified. Routes should then be prioritized based on: system performance, age and condition, lifespan, origin and destination, replacement schedule, adjoining land use (both present and future), and choke points. Sea level rise inundation scenarios should be incorporated into the existing mechanisms used by DelDOT to prioritize projects.

Recommendation 5.15: Increase understanding of the regional implications of loss of industrial areas in coastal Delaware.
Reduction in capacity at power generating facilities and ports may have regional implications for the electrical grid as well as availability of goods and services. In order for businesses to make wise decisions about future investments in their coastal industrial properties, additional information will be needed about impacts to other facilities throughout the region.

Recommendation 5.16: Improve understanding of impacts to adjacent properties from adaptation actions.
Certain adaptive measures taken to mitigate the impacts of sea level rise may have unforeseen secondary and cumulative impacts to adjacent properties. For example, the hardening of a segment of shoreline with rock can result in accelerated erosion of adjacent unprotected shorelines. Understanding the complex impacts of various adaptive measures will help guide more effective adaptive response plans.

Recommendation 5.17: Encourage the development of a research and policy center at a university or college campus that would focus on applied research for sea level rise and adaptation.
There are many regional data gaps related to sea level rise. Filling these gaps through collaboration with networks of university researchers and policy analysts would improve adaptation planning efforts. It may be worthwhile to provide incentives to university researchers to address these topics. Developing clear statements of research needs may improve the academic community's ability to obtain grant funding for research.

Recommendation 5.18: Foster pilot projects that demonstrate the effectiveness of best management practices for management of agricultural lands affected by sea level rise.
Pilot projects to demonstrate or to study the effectiveness of best management practices could be used to provide guidance to land managers to better adapt to sea level rise. These projects would provide insight on the effectiveness of the adaptation strategy and provide information on the associated costs.

Objective 6: Provide Technical Assistance to Partners for Assessing Vulnerability and Choosing Adaptation Strategies

Although information, data, and planning tools exist for those wishing to incorporate sea level rise into their decisions or plans, the information can be difficult for non-technical audiences to interpret and use. These datasets are also continually being updated and refined. In recognition of these complexities, the following five recommendations are aimed at providing a central entity for distribution of sea level rise information, ensuring that technical assistance is available and providing a variety of tools for decision-making.

Recommendation 6.1: Create a coordinated effort to provide technical assistance to local governments.

Municipal and county governments may not currently have the staff resources, technical capability or funding to plan for and adapt to sea level rise. There is no one coordinated entity that is providing coastal hazard and sea level rise assistance to municipal governments. The DNREC Delaware Coastal Programs provides technical assistance and grant funding annually. The University of Delaware Sea Grant College Program provides technical assistance through its Sustainable Communities Program. The Office of State Planning and Coordination provides technical assistance to communities conducting comprehensive development plan revisions, as does the University of Delaware's Institute for Public Administration. The DNREC Shoreline and Waterway Management Program provides assistance to communities to develop floodplain regulations and receive discounted flood insurance rates through the Community Ratings System. A coordinated effort by these (and other) entities could result in consistency among local jurisdictions and ensure that all municipal governments wishing to plan for coastal hazards and sea level rise have an opportunity to obtain the technical assistance they need. It could also result in coordinated grant funding opportunities for municipalities.

Recommendation 6.2: Provide land managers, fisheries managers and farmers with the information and extension support necessary to manage lands and fisheries in areas affected by sea level rise.

Technical assistance for land managers and agricultural producers is needed to disseminate information about salt-water intrusion into irrigation wells, salt tolerant plant species, and best management practices (BMP) for land in transition due to changes in water level or salinity. University extension agencies, or other established programs such as the Natural Resource Conservation Service, could be encouraged to provide this service. An additional goal might be to foster pilot projects to demonstrate or study the effectiveness of BMPs.

Recommendation 6.3: Provide technical assistance for industrial and port facilities to incorporate sea level rise into investment plans and continuity of business plans.

Facilities often have robust continuity plans where they address interdependencies, but no inventory of these plans has been conducted. Sea level rise could be incorporated into these plans to ensure facilities are resilient to the impacts of storm surge coupled with sea level rise. Technical assistance could be provided through one-on-one outreach or through databases and information clearinghouses.

Recommendation 6.4: Develop best management practice manuals for adaptation in Delaware.

Adaptation measures will be implemented by a variety of stakeholders including municipal and county governments, state government, businesses and individuals. A set of best management practices (BMPs) should be provided for their use and reference. BMP manuals could be created for several different topics including infrastructure siting, residential development, and natural lands management. Manuals should be based upon successful strategies employed by other states, non-profits and the private sector and could be developed in cooperation with local colleges and universities. A toolbox for adaptation could also be created that would highlight successful policies in other states.

Recommendation 6.5: Develop a database of costs of adaptation options for use by decision-makers and the public.

Such a database should include examples of the costs of elevating buildings, beach nourishment, abandoning buildings, elevating roadways, building hardened shorelines, elevating and repairing dikes, and constructing living shorelines. Cost estimates cannot be site-specific but may be able to provide general guidelines. This database should also incorporate cost benefit analyses that would evaluate retreat, accommodation, avoidance and protection measures, including return on investment.

Objective 7: Expand Funding Opportunities for Adaptation Planning and Implementation Projects

Sea Level Rise Advisory Committee members, public engagement session attendees and stakeholder groups consulted during the development of these recommendations had many questions about what it would cost to adapt to sea level rise. There were also many concerns about whose responsibility it is to pay for adaptation and whether funds are (or would be) available. In addition, there were many concerns regarding fairness and equity of funding for adaptation[22]. The Sea Level Rise Advisory Committee recognizes the critical importance of these funding issues, but feels it did not have enough information about potential costs of adaptation in Delaware to make specific recommendations about new or amended funding sources. The following recommendation is intended to be a starting point for a comprehensive investigation into funding options that can be considered for implementation as adaptation costs become apparent.

Recommendation 7.1: Convene an expert panel to provide an assessment and analysis of funding options for adaptation measures.

At the current time, there is little specific information available regarding the potential cost of on-the-ground adaptation measures in Delaware. Because costs are unclear, it is difficult to recommend a particular course of action. An expert panel should be brought together to investigate the suite of options that are available to state and local governments and individuals to fund future adaptation measures. Included in this analysis should be traditional revenue generators such as taxes and fees, but it should also include innovative funding mechanisms such as special tax districts, incentives and cost-share programs. The analysis should utilize the preliminary funding options formulated by the Sea Level Rise Advisory Committee and public comments received during the Adaptation Engagement Sessions as a baseline[23].

[22] Many of these concerns are reflected in the Guiding Principles listed in Chapter 3.

[23] See Appendix E for comments received by the public and Appendix I for a list of the preliminary funding options created by public comments and the advisory committee.

Chapter 7: Next Steps for Adapting to Sea Level Rise

The Delaware Sea Level Rise Advisory Committee was established to make recommendations about adapting to sea level rise in Delaware, but not to implement them. With the completion of this document, the Sea Level Rise Advisory Committee will be disbanded and the DNREC Delaware Coastal Programs plans to lead implementation efforts, in coordination with willing partners.

Dissolution of the Sea Level Rise Advisory Committee

The completion of this document represents the conclusion of the work of the Delaware Sea Level Rise Advisory Committee, which was convened to develop recommendations, but not to implement them. The advisory committee was convened in November, 2010 and participated in a final document signing ceremony in August, 2013. During that time, the committee held 20 advisory committee meetings, numerous ad-hoc committee and workgroup meetings, 6 focus groups, and 8 public engagement sessions. Advisory committee members have spent countless hours in support of their goal, provided valuable insights and expertise and successfully fulfilled their obligation.

Implementation Workshop

Time, staff and funding constraints prevented the Sea Level Rise Advisory Committee from prioritizing the recommendations and from gathering more specific information about each one, such as how much implementation would cost, the specific steps required to implement and identification of a willing lead entity. However, such information will be necessary in order to begin implementing many, if not all, of these recommendations.

The Delaware Coastal Programs section of the DNREC has committed to hosting a stakeholder workshop in 2014 to answer these, and other questions about each recommendation. Similar workshops have been successfully held in the past to discuss ideas and recommendations. The result of this workshop would be a list of priority recommendations for implementation. Workshop participants and others will help develop each recommendation into a small proposal, including cost estimates, activities and the groups, organizations or agencies necessary to implement.

Establishing an Implementation Team

Once specific details about each recommendation have been developed, the Delaware Coastal Programs will put together an informal implementation team that will focus on coordinating to secure funding and resources for priority recommendations. It is also anticipated that some of the recommendations can be implemented without additional funding or coordination. See Appendix H for resources useful for implementation.

Implementation of Adaptation Measures

Adaptation planning and selection of adaptation measures at the parcel, local or agency level will occur in parallel to state efforts to implement the 55 recommendations of the Sea Level Rise

Advisory Committee. Although implementation of the recommendations will improve Delaware's ability to adapt in the future, technical assistance and grant funds are available now from a variety of sources to assist those wishing to proactively address sea level rise.

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Appendix A: Vulnerable Resources Affected by Recommendations

While a few of the 55 recommendations of the Sea Level Rise Committee are specific to one or two vulnerable resources, many address adaptation capacity building for a number of vulnerable resources. The chart contained in this appendix illustrates the breadth of the recommendations by indicating those resources that will be affected by implementation of each recommendation. This chart can be used as a guide by those wishing to consider actions for specific resources.

	Natural Resources					Society and the Economy				Public Safety and Infrastructure						
	Vulnerabilities															
	Wetlands	Coastal Impoundments	Beaches and Dunes	Habitats of Conservation Concern	Protected Lands (state and federal) and Conservation Easements	Heavy Industrial Areas	Future Development Areas	Tourism and Coastal Recreation	Residential Areas	Dams, Dikes and Levees	Port of Wilmington	Railroad Lines	Roads, Bridges, and Evacuation Routes	Wells	Septic Systems, Disposal Fields, and Wastewater Treatment Facilities	Landfills
Improve Communication and Coordination between State, Federal, Local and Regional Partners to Streamline Sea Level Rise Adaptation Efforts																
1.1: Improve coordination of permit decisions for adaptation projects between federal, state and local officials	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1.2: Create new partnerships to increase resources for research and development of adaptation options	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1.3: Increase opportunities for technology transfers and regional coordination for transportation issues affected by sea level rise												X	X			
1.4: Incorporate sea level rise into public and private sector regional planning efforts	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1.5: Provide sea level rise information to the Delaware Agricultural Land Preservation Program for consideration					X											
1.6: Provide technical assistance to Delaware's Open Space Council for incorporating sea level rise into its criteria for acquisition of natural areas	X			X	X											
1.7: Conduct a comprehensive inventory of key funding, coordination, regulations and policies and analyze them for barriers and opportunities for sea level rise adaptation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Provide Increased Regulatory Flexibility for Adaptation and Improve Consistency between Regulatory Agency Decisions																
2.1: Provide regulatory incentives that encourage sea level rise adaptation and that allow for innovative projects	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2.2: Encourage the governor to sign an executive order that would direct state agencies to plan for sea level rise	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2.3: Conduct a comprehensive update to the state's regulatory tidal wetlands maps and provide a way to periodically update the maps to reflect changes occurring from sea level rise	X			X	X											
2.4: Consider sea level rise implications in future regulatory updates for septic systems and wells							X		X					X	X	
2.5: Facilitate the connection of individual septic systems to community wastewater treatment systems with excess capacity when human safety and welfare are at risk							X		X						X	
2.6: Consider sea level rise implications in future updates to the state Coastal Zone Act regulations						X	X									
Provide Consistent and Predictable Policies for Future Growth, Investment, and Natural Resource Management																
3.1: Incorporate sea level rise considerations into the Strategies for State Policies and Spending	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3.2: Consider incorporation of sea level rise considerations into municipal and county comprehensive development plans	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3.3: Consider use of a Transfer of Development Rights tool to direct future growth away from vulnerable areas	X			X	X		X		X				X	X	X	X
3.4: Incorporate sea level rise into Delaware's Long Range Transportation Plan (LRTP)												X	X			
3.5: Incorporate sea level rise into the Transportation Operations Management Plan												X	X			
3.6: Encourage inclusion of sea level rise in Transportation Project Design Manuals												X	X			
3.7: Develop a dike safety program	X	X		X	X	X	X		X	X		X	X			
3.8: Develop a framework for decision making regarding land protection and restoration strategies based on habitat vulnerability, migration potential and relative importance in the regional landscape, historical significance or other key factors	X	X	X	X	X											
3.9: Develop a comprehensive wetlands restoration, protection and retreat strategy in response to sea level rise	X	X		X	X		X	X								
3.10: Continue efforts to re-evaluate management strategies for existing coastal impoundments	X	X	X	X	X			X								
3.11: Evaluate the benefits and risks of permitting privately owned coastal impoundments	X	X	X	x	x					X						
3.12: Designate shoreline zones for adaptation action	X	X	X	X	X		X	X	X							
3.13: Conduct a legal review for disinvestment of publically owned infrastructure and privately owned buildings						X	X	X	X			X	X		X	X
3.14: Develop a statewide retreat plan and update it periodically	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

	Wetlands	Coastal Impoundments	Beaches and Dunes	Habitats of Conservation Concern	Protected Lands (state and federal) and Conservation Easements	Heavy Industrial Areas	Future Development Areas	Tourism and Coastal Recreation	Residential Areas	Dams, Dikes and Levees	Port of Wilmington	Railroad Lines	Roads, Bridges, and Evacuation Routes	Wells	Septic Systems, Disposal Fields, and Wastewater Treatment Facilities	Landfills
Increase Public Awareness of Sea Level Rise through Education, Outreach and Marketing																
4.1: Develop a comprehensive outreach strategy to educate all stakeholders about sea level rise	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4.2: Provide education and outreach for impacted communities and citizens	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4.3: Improve the ability of homebuyers to investigate a property's potential vulnerability to sea level prior to purchase							X		X							
4.4: Provide targeted outreach to water and wastewater operators and water utilities														X	X	
Improve the Availability & Robustness of Sea Level Rise Data Sets																
5.1: Improve monitoring of current sea level conditions and improve predictions for timing of inundation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5.2: Install additional water level and salinity observational stations in Delaware tidal waters	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5.3: Improve the accuracy of Delaware's elevation benchmark network	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5.4: Continue and expand studies regarding sediment accretion rates and susceptibility of wetlands to sea level rise	X	X	X	X	X											
5.5: Conduct research to better understand human response to sea level rise and adaptation						X	X	X	X	X			X			
5.6: Develop sea level models that incorporate storm surge impacts	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5.7: Conduct a risk assessment for Delaware's system of dikes & levees						X	X		X	X		X	X			
5.8: Encourage federal agencies to integrate sea level rise planning into their flood models							X		X							
5.9: Model potential stormwater inundation problems in highly vulnerable areas						X	X	X	X	X		X	X	X	X	X
5.10: Develop a model that will predict changes to salinity in surface water that may occur under differing sea level rise scenarios	X	X		X		X	X		X					X		
5.11: Develop a statewide groundwater model	X			X		X	X		X		X			X	X	X
5.12: Develop and maintain a comprehensive database that contains the location and condition of all wastewater infrastructure							X		X						X	
5.13: Identify and preserve areas for potential wetland migration	X	X		X	X		X	X								
5.14: Identify the data necessary to plan transportation investments												X	X			
5.15: Increase understanding of the regional implications of loss of industrial areas in coastal Delaware						X					X					
5.16: Improve understanding of impacts to adjacent properties from adaptation actions	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5.17: Encourage the development of a research and policy center at a university or college campus that would focus on applied research for sea level rise and adaptation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5.18: Foster pilot projects that demonstrate the effectiveness of best management practices for management of agricultural lands affected by sea level rise	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

	Wetlands	Coastal Impoundments	Beaches and Dunes	Habitats of Conservation Concern	Protected Lands (state and federal) and Conservation Easements	Heavy Industrial Areas	Future Development Areas	Tourism and Coastal Recreation	Residential Areas	Dams, Dikes and Levees	Port of Wilmington	Railroad Lines	Roads, Bridges, and Evacuation Routes	Wells	Septic Systems, Disposal Fields, and Wastewater Treatment Facilities	Landfills
Provide Technical Assistance to Partners for Assessing Vulnerability and Choosing Adaption Strategies																
6.1: Create a coordinated effort to provide technical assistance to local governments	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
6.2: Provide land managers, fisheries managers and farmers with the information and extension support necessary to manage lands and fisheries in areas affected by sea level rise	x	x	x	x	x									x		
6.3: Provide technical assistance for industrial and port facilities to incorporate sea level rise into investment plans and continuity of business plans						x	x				x					
6.4: Develop best management practice manuals for adaptation in Delaware	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
6.5: Develop a database of costs of adaptation options for use by decision-makers and the public	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Expand Funding Opportunities for Adaptation Planning and Implementation Projects																
7.1: Convene an expert panel to provide an assessment and analysis of funding options for adaptation	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Appendix B: Dissenting Opinions

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HOME BUILDERS ASSOCIATION OF DELAWARE

Frederick T. Fortunato
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SERVING DELAWARE SINCE 1947

August 9, 2013

Susan E. Love via email susan.love@state.de.us
Delaware Coastal Programs
5 East Reed Street, Suite 201
Dover, DE 19901

RE: Sea Level Rise Position Statement

Dear Susan:

Thank you for the opportunity to participate in the Sea Level Rise Committee. The Home Builders Association of Delaware (HBADE) is committed to short and long term statewide planning for storm emergencies and science-based sea level rise.

HBADE is a housing and business advocacy association representing more than 400 Delaware businesses with nearly 8,000 employees. As such, we are committed to creating a business friendly and vibrant economy for our state. By necessity our association is a professional volunteer organization that now spends the bulk of our volunteers' time reviewing DNREC proposed and enacted regulations – much more than changes for all other State and County bodies. The recent increase in DNREC regulatory proposals, from sea level rise, storm water management regulations, flood plain, to Energy Code, and Watershed Implementation Plans have far reaching unintended consequences to Delaware's economy. These unintended consequences of DNREC actions are directly related to Delaware's struggling economy, business and job growth, and real estate values. Although the housing economy is improving, growth is slow and can easily be upset by numerous changes to the local community.

The Delaware Sea Level Rise Advisory Committee "Committee" has developed a recommendation report "Recommendations for adapting to Sea Level Rise in Delaware," in which it provides a series of environmental problems that may result from possible sea level rise within the next 100 years. As such the Committee has provided Delaware with a series of preferred adaptation strategies that can be used to adapt to – and mitigate for – potential sea level rise. While HBADE is committed to working with the State to ensure there is rounded discussion of issues and impacts, we are concerned with several determinations that have come out of this research. We believe no action should be taken on recommendations without full review by the public and the Delaware General Assembly. It is unclear if DNREC is authorized to take any action under the Delaware Code.

Our concerns begin with the ongoing effort by the State to portray Delaware to have 3' - 5' (1 - 1.5 meters) - of sea level rise by 2100 and the resulting negative economic impact of using the unscientific and faulty models of measurements. Based upon the information produced by the SLR Committee, it is evident that DNREC's approach will stigmatize our Delaware coastal areas and cost citizens of Delaware greatly for an event that current science indicates may not happen over the course of 87 years. This includes changing how communities are planned, financed and developed, mortgage financing requirements, payments of additional flood insurance, loss of ability to construct or sell homes in the stigmatized areas assumed to be, and identified as being subject to sea level rise, and changing how infrastructure is invested in areas assumed to be below the rise levels. Is it worth the cost to our local economy to have the State and their scientific agency (DNREC) promote the permanent flooding of 11% of the States land, which is equivalent to 20,000 dwellings lost, the loss of all state tidal wetlands and the loss of entire communities?

Current scientific data shows 12" of sea level rise during the last century. This data now shows a slight increase and projection of 13" of sea level rise this century. HBADE understands that the environment is ever changing and is dedicated to Statewide planning for 19.5" (.5 meters) of sea level this Century which equals 50% more rise than what current science shows. We also stand behind the effort for continued monitoring of this issue and adapting programs, policies and other efforts as data changes.

Unfortunately, since Delaware is utilizing planning for worst case scenarios, rather than implementing an adaptive management approach to possible sea level rise, we feel the current path taken will lead to the destruction of the Delaware coast and its economy.

We request the State discontinue an opinion-based narrative and web site describing the Delaware coast to be under water. The degree of sea level rise is a projection and is not based on conclusive and universally agreed comprehensive science. As such Delaware must be cautious with accepting positions and policies that unduly impacts the State's economies while yielding minimal environmental benefit. HBADE is thankful for the opportunity to comment on this issue and our membership is more than willing to discuss these concerns in more depth at your convenience.

Very truly yours,

Howard Fortunato
Executive Vice President

cc: Kevin Whittaker
Keith Rudy

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MINORITY STATEMENT BY THE LEAGUE OF WOMEN VOTERS OF DELAWARE FOR THE SEA LEVEL RISE ADVISORY COMMITTEE ADAPTATION REPORT

As with the earlier Vulnerability Assessment Report, the staff of DNREC's Coastal Programs did a good job of leading the Sea Level Rise Advisory Committee in its work to develop the Adaptation Report, incorporating many of the comments and suggestions suggested by members of the Committee and the public. There was, however, one important issue on which we were not able to get the agreement of a majority of the Committee. That issue is disclosure. The League's alternate recommendation follows:

Require disclosure of the risks of sea level rise and storm surge in the sale of all real property, as well as the cost and availability of federal flood insurance.

The committee has agreed that homebuyers' access to information about future sea levels be improved through development of a comprehensive website that illustrates current flooding and future sea level rise inundation risks. The League would add storm surge to "information about future sea levels."

The League would greatly strengthen the force of the Committee's recommendation by requiring disclosure of the risks of sea level rise (and storm surge), as well as cost and availability of flood insurance, rather than simply making the information available if a potential buyer searches for it. We recognize that disclosure of location in a flood plain is currently required. We further recognize that because of the risk of property loss in the event of sea level rise and storm surge and greatly increased premiums for flood insurance, not to disclose these risks could lead to great economic loss to buyers. To fail to require disclosure is to fail to provide what may be the low-lying fruit in Delaware's adaptation strategies; "avoidance." Without such disclosure a family could unwittingly purchase a home today in a quintessentially vulnerable community, such as Prime Hook, thereby not only putting that family at risk but possibly also putting the citizens of Delaware at risk to pay for damages when the next storm comes.

Charlotte King (CT)
Charlotte King, President, LWVD

Chad Tolman
Chad Tolman, Climate Change Chair, LWVD

July 26, 2013

POSITIVE GROWTH ALLIANCE

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August 14, 2013

Minority Report on Recommendations of the Sea Level Rise Advisory Committee

Even though the Positive Growth Alliance had a seat on the Delaware Sea Level Rise Advisory Committee, we have many deep concerns about the both the recommendations in the report and the sea level rise predictions we were forced to accept as fact. These concerns forced us to vote against many of the formal recommendations.

On predictions of .5, 1, and 1.5 meter levels of sea level rise by 2100

Daily, there are new reports coming out, including from the U.N., that the earth has not warmed for approximately 15 years. In fact, climate models are being revised to try and accommodate this apparently unexpected situation.

It is no surprise to us that 100 year climate predictions based on computer models are difficult. What is surprising is that our small state has chosen to put its economy at risk on the basis of such predictions.

Many of the recommendations in this report could lead to action in the near future that will have immense economic consequences, yet it will not be known if those actions are truly necessary for decades. For most human interactions with sea level rise, remaining flexible and taking action when the need clearly presented itself has been an effective and profitable tactic since before the founding of our nation. No convincing evidence has been presented to us that would negate this strategy as the best overall course for the future.

Can government be trusted to make accurate predictions of the future?

We do not believe that government can predict the future any better than those outside of government. In fact, because of the effect of politics, government's predictive ability is almost surely considerably worse.

In the real world, most decisions are based on economic necessity. In addition, those actions usually affect only the entity making the decision. Private interests have little or no ability to compel the behavior of others.

While hard economic choices certainly play a role in government decision making, small but powerful special interests with strong political connections often prove to be far more influential.

For example, there are special interests with an agenda of stopping development. Parts of this Sea Level Rise report could be utilized by these groups to prevent others from using their private properties. The arguments typically made by these interests often do not take economic realities into account.

Have government proposals for restrictive regulations always been supported by actual results?
Decisions made in the private economy are judged very quickly by actual results. If actions are taken that turn out to be incorrect, either adjustments are made or bankruptcy or liquidation will occur.

On the other hand, poor decisions by government lead to reversals of policy only with great difficulty. Once rights are lost, they typically stay lost. Money lost is made up by the taxpayers.

As an example, just a few years ago, DNREC published a regulation that would have established a limited use zone of 120 acres around every eagle's nest. While this regulation was killed due to resistance by the public, DNREC now tells us that the Nanticoke River basin has the highest concentration of bald eagles in the northeastern United States, with phenomenal nesting success.

If that regulation had actually been imposed, which DNREC said at the time was necessary for eagle protection, thousands of acres would have been placed off limits for use by their private owners, as well as the public, at the whim of an eagle establishing a nest. The passage of time has shown that DNREC was wrong about the need for this regulation. Similarly, we believe that this document could well lead to the imposition of many regulations in regards to sea level rise that could turn out to be totally unwarranted, but that will likely cause great economic harm and loss of property rights.

Comments on selected specific recommendations

1.1 Coordination between government agencies is typically for the benefit of the agencies and to the detriment of citizens. Most decisions should be made by an elected government as close to the voters as possible. This government entity will be more likely to understand that it has an obligation to represent its constituents' concerns, rather than a few special interests which are politically connected. In cases that involve land use, the state constitution and state law actually designates county and municipal governments as the prime decision makers and other government agencies should not have veto power over their decisions.

1.4 The future is too unpredictable to require planning for sea level rise at this point. The fact that flood insurance claims are incredibly low (according to FEMA, every claim made from 1978 to 2010 is paid for with 1.2 years of premium) tells us it is not time to further restrict property owners beyond current flood insurance requirements.

1.7 If this is a recommendation for more regulation, we are opposed.

2.1 There is not enough information available at the present time to create new incentives related to SLR.

2.2 Too many government decisions are being mde by regulators rather than elected officials. The General Assembly should play a role in any SLR requirements that require overall government action.

2.4 Septic systems and wells are perfect vehicles for government agencies to impose political agendas on landowners. An example is when DNREC tried to deny a central sewer permit for a proposed development near Leipsic based on sea level rise before there were any regulations at all. The landowner was forced to go to court to get a permit.

2.5 These sewer facilities are mostly privately owned. It should only be done with the full cooperation of the private owner.

3.1 This another opportunity for non-elected government officials to impose their political agendas on citizens with little opportunity for accountability.
3.6 It is difficult enough to predict rapidly changing traffic conditions without having to take into account changes that will take place over decades, if ever.
3.14 We simply do not have enough hard evidence to develop a retreat strategy at this time.
4.1 There is not enough hard evidence to justify indoctrinating our children and the public at this time.
5.1 We strongly agree with this recommendation. It should be listed first as 1.1.
5.2, 5.3, 5.4 We agree with all. In general, section 5 should be changed to section 1.
5.5 We agree with this only if it includes strong considerations for the rights of Delaware citizens.
5.8 We strongly disagree because Delaware flood insurance policy holders are currently being dramatically overcharged for the risk of flooding in Delaware as proven by FEMA loss records.
5.13 We are concerned this recommendation could have a heavy negative impact on personal property rights.

In conclusion, we are very concerned that the work of the Sea Level Rise committee could be used to cause great economic harm to the citizens of Delaware. There is no doubt in our minds that this document will be used as the basis of creation for many new regulations over the next few years.

Economic trends are moving in the wrong in direction in our state. The U.S. Department of Commerce has announced that Delaware is now second to last among the states in economic growth. In addition, they also state that personal income has declined from 19th to 23rd among the states in the last four years. This is ample warning that Delaware should get its economic house in order before considering new, opportunity-killing restrictions based on sea level rise.

Sincerely,

Richard G. Collins

Richard G. Collins
Executive Director

Appendix C: Sea Level Rise Advisory Committee Members

The following is a list of the 24 members and organizations of the Delaware Sea Level Rise Advisory Committee. The list is alphabetical by organization. Where tenure on the committee was shared by two individuals due to organizational changes or retirement, two names appear above the organization. In addition, designated alternates for each committee member are listed.

John Taylor
Delaware Chamber of Commerce
Delaware Public Policy Institute

Mark Davis
Delaware Department of Agriculture
Office of the Secretary

Kurt Reuther
Delaware Department of Homeland Security
Alternate: Don Knox

Dr. Richard Perkins
Delaware Department of
Health and Social Services
Division of Public Health

Barbara DeHaven
Delaware Economic Development Office

Pamela Bakerian
Delaware Farm Bureau

The Honorable Quinton Johnson
Delaware House of Representatives

Lorilee Harrison/Karen Weldin Stewart
Delaware Insurance Commissioner's Office

Dr. Chad Tolman
Delaware League of Women Voters
Alternate: Peggy Schultz

Brenna Goggin
Delaware Nature Society

Ruth Ann Jones
Andrea Godfrey
Delaware Office of Management and Budget
Budget Development, Planning and Administration
Alternate: Rebecca Steel

Constance Holland
Delaware Office of Management and Budget
Office of State Planning Coordination

William Lucks
Delaware Realtor's Association

Michael Kirkpatrick
Delaware Department of Transportation
Office of Planning
Alternate: Robert McCleary

Sarah Cooksey
Delaware Department of Natural Resources and
Environmental Control
Office of the Secretary

Keith Rudy
Homebuilders Association of Delaware
Alternate: Kevin Whittaker

Mary Ellen Grey
Kent County
Department of Planning
Alternate: Sarah Keifer

Victor Letonoff
Lewis Killmer
Delaware League of Local Governments

Karl Kalbacher
Marcus Henry
New Castle County
Department of Economic Development
Alternate: Michael Bowser

Richard Collins
Positive Growth Alliance

Jeff Shockley
Sussex County
Planning and Zoning Office

Richard Jones
The Nature Conservancy

Jerry Esposito
Tidewater Utilities, Inc.

Dr. Chris Sommerfield
University of Delaware
College of Earth, Ocean and the Environment

Appendix D: Adaptation Focus Group Attendees

In October, 2012 six stakeholder focus group sessions were held to develop a list of actions that could be taken to improve Delaware's capacity to adapt to sea level rise. The focus groups centered on the high and moderate concern resources. Attendees are listed below alphabetically.

Coastal Defenses Focus Group Attendees

Jeff Bergstrom
City of New Castle

David Carlson
Delaware Department of Homeland Security
Delaware Emergency Management Agency

Sarah Cooksey
Delaware Department of Natural Resources and Environmental Control
Office of the Secretary

Ron Hunsicker
Town of Bowers Beach

Jim Kirkbride
Pickering Beach

Jim Laird
Dewey Beach

Frank Piorko
Delaware Department of Natural Resources and Environmental Control
Division of Watershed Stewardship

Tony Pratt
Delaware Department of Natural Resources and Environmental Control
Division of Watershed Stewardship

Kash Srinivasan
City of Wilmington
Department of Public Works

Scott Thomas
Southern Delaware Tourism Bureau

David Twing
Delaware Department of Natural Resources and Environmental Control
Division of Watershed Stewardship

Industrial Land Use Focus Group Attendees

David Bacher
NRG Energy

Marjorie Crofts
Delaware Department of Natural Resources and Environmental Control
Division of Waste and Hazardous Substances

Kevin Coyle
Delaware Department of Natural Resources and Environmental Control
Office of the Secretary

Barbara DeHaven
Delaware Economic Development Office

Rebecca Gudgeon
Delaware City Refinery

Tom Heck
Delaware Solid Waste Authority

Cheryl Hess
Calpine Corporation

Randall Horne
Diamond State Port Corporation

Karl Kalbacher
New Castle County
Economic Development Office

Kurt Reuther
Delaware Department of Safety
and Homeland Security

Stu Widom
Calpine Corporation

Land Preservation and Habitat Focus Group Attendees

Jennifer Adkins
Partnership for the Delaware Estuary

Sarah Cooksey
Delaware Department of Natural Resources
and Environmental Control
Office of the Secretary

Robert Coxe
Delaware Department of Natural Resources and
Environmental Control
Division of Fish and Wildlife

Andrea Godfrey
Delaware Office of Management and Budget

Virgil Holmes
Delaware Department of Natural Resources
and Environmental Control
Division of Water

Ron Hunsicker
Bowers Beach

Richard Jones
The Nature Conservancy, Delaware Chapter

Kevin Kalasz
Delaware Department of Natural Resources and
Environmental Control
Division of Fish and Wildlife

Jim Kirkbride
Pickering Beach

Dr. Chris Sommerfield
University of Delaware
College of Earth, Oceans and the Environment

Bart Wilson
Center for the Inland Bays

Land Use Focus Group Attendees

Rick Allen
Alliance of Bay Communities

Brooks Cahall
Delaware Department of Natural Resources
and Environmental Control
Division of Watershed Stewardship

Rich Collins
Positive Growth Alliance

Mark Davis
Delaware Department of Agriculture

Mary Ellen Grey
Kent County
Department of Planning

Lorilee Harrison
Delaware Department of Insurance

Constance Holland
Delaware Department of Management and Budget
Office of State Planning Coordination

The Honorable Quinton Johnson
Delaware House of Representatives

Victor Letonoff
Delaware League of Local Governments

Guy Phillips
Delaware Farm Bureau

Michael Powell
Delaware Department of Natural Resources
and Environmental Control
Division of Watershed Stewardship

Thomas Powers
University of Delaware
Center for Science, Ethics and Public Policy

Keith Rudy
Homebuilders Association of Delaware

Chad Tolman
Delaware League of Women Voters

Richard Wilkins
Delaware Farm Bureau

Transportation Focus Group Attendees

Rick Allen
Alliance of Bay Communities

Barry Benton
Delaware Department of Transportation
Division of Transportation Solutions

Brooks Cahall
Delaware Department of Natural Resources and
Environmental Control
Division of Watershed Stewardship

Silvana Croope
Delaware Department of Transportation
Transportation Management Center

Jennifer DeMooy
Delaware Department of Natural Resources and
Environmental Control
Division of Energy and Climate

Gene Donaldson
Delaware Department of Transportation
Transportation Management Center

Rob McCleary
Delaware Department of Transportation
Division of Transportation Solutions

Cathy Smith
Delaware Transit Corporation

Water and Wastewater Focus Group Attendees

Jerry Esposito
Tidewater Utilities

Matthew Miller
City of Wilmington
Department of Public Works

Doug Rambo
Delaware Department of Natural Resources
and Environmental Control
Division of Water

Davison Mwale
Delaware Department of Natural Resources
and Environmental Control
Office of the Secretary

Dave Schepens
Delaware Department of Natural Resources
and Environmental Control
Division of Water

Stewart Lovell
Delaware Department of Natural Resources
and Environmental Control
Division of Water

Hillary Moore-Valentine
Delaware Technical and Community College

Jennifer DeMooy
Delaware Department of Natural Resources
and Environmental Control
Division of Climate and Energy

Dr. Chris Sommerfield
University of Delaware
College of Earth, Oceans and the Environment

Dr. Richard Perkins
Delaware Department of Health
and Social Services
Division of Public Health

Appendix E: Public Comments

The Sea Level Rise Advisory Committee held three public engagement sessions to solicit feedback on 61 Options for Adapting Delaware to Sea Level Rise (Options), the precursor to the final 55 recommendations contained within this document. A comment form was provided to all public engagement session participants; these forms were submitted in-person, via email and via US mail. In addition, the comment form was available to fill out online. A total of 57 comments were received. All comments received were compiled, summarized and reviewed by Sea Level Rise Advisory Committee members. A summary of these comments is below. Please note that the numbering scheme changed when the recommendations were finalized. Comments specific to funding options can be found in Appendix I.

This Appendix provides only a summary of the comments received on the Options; full text of the comments received is available for viewing online at http://de.gov/slradaptplan. The comments appear online as received by the Delaware Coastal Programs office, however personal information has been redacted.

Overarching Comments

Organization and prioritization of options

Multiple comments were received requesting that the Options be reorganized and/or prioritized for the sake of clarity and to help with implementation.

Climate change

There were several comments regarding how emission rates and global climate change are influencing sea level rise and storm surge. A more in-depth description of climate change, and Delaware's vulnerabilities associated with climate change, is currently being worked on by the DNREC Division of Energy and Climate.

Options vs. recommendations

Commenters were concerned that referring to the adaptation action items as "Options" would reduce the strength of the document and that they should be referred to as "recommendations." The term "Options" was utilized during the public sessions to imply that consensus had not been reached yet by the Sea Level Rise Advisory Committee.

Specific Comments about each Option

Comments received about specific options are summarized and/or directly quoted in bullet form in the following sections. The general number of supportive comments and non-supportive comments are also

tallied. Please note that the options are numbered as they were presented at the public engagement sessions; the numbering scheme changed for the final document.

IMPROVE COMMUNICATION AND COORDINATION AMONG STATE, FEDERAL, LOCAL AND REGIONAL PARTNERS TO STREAMLINE SEA LEVEL RISE ADAPTATION EFFORTS

1. **Conduct a comprehensive inventory of key funding, coordination, regulations and policies and analyze them for barriers and opportunities for sea level rise adaptation.** *There was support for this option. 10 commenters specifically supported it; 3 did not.*
   - Comment to specifically prioritize a review and legal analysis of the Coastal Zone Act, Beach Preservation Act and Public Accommodations Tax
   - Several specifically wanted to prioritize this work

2. **Increase opportunities for technology transfers and regional coordination for transportation issues affected by sea level rise.** *There was support for this option. 10 commenters specifically supported it; 2 did not.*
   - Suggestion to include/highlight work that is already ongoing

3. **Develop a Federal Highways Administration climate change framework.** *There was support for this option; 8 specifically supported; 3 did not.*
   - Suggestion to also recommend use of pilot projects in this option
   - Suggestion to use this option to coordinate with others to determine what is essential to maintain roadways

4. **Improve coordination of permit decisions for adaptation projects among federal, state and local officials.** *There was support for this with 15 specifically supporting; 2 not supporting.*
   - May wish to include "streamlining" into this option
   - One commenter thought this should be prioritized

5. **Incorporate sea level rise into public and private sector regional planning efforts.** *There was support for this option; 15 in support; 2 not supporting.*
   - At least 4 commenters thought this was very important/should be prioritized
   - Comment to include the Port of Wilmington, USFWS Comprehensive Conservation Plans and Office of State Planning Coordination in the text
   - Comment that this is critical to evacuations

6. **Create new partnerships to increase resources for research and development of adaptation options.** *There was support for this with 11 specifically supporting and 2 not supporting.*
   - Amend to include that is should also "enhance existing partnerships"
   - Include consultants as part of the partnerships to be developed
   - Perhaps this should specifically call for pilot projects, rather than partnerships?
   - One commenter thought this was very important/priority

7. **Provide sea level rise information to the Delaware Agricultural Land Preservation Program for consideration.** *There was support for this option with 8 specifically supporting and 3 not in support.*
   - Question as to why this wasn't already happening.
   - Suggestion to also include the Nutrient Management Commission
   - Comment that this might be more suited to the Technical Assistance section

8. **Provide technical assistance to Delaware's Open Space Council for incorporating sea level rise into its criteria for acquisition of natural areas.** *There was support for this option with 10 specifically supporting and 2 not in support.*
   - This has already occurred, should it be deleted and instead included as a success story?
   - Similar comments to Ag Land Preservation Program with respect to classification

9. **Encourage the establishment of a sea level rise group within American Association of State Highway Transportation Officials (AASHTO).** T*here was support for this option with 7 in support and 3 not in support.*
   - Commenter reported that there is already a Transportation Climate Change group in AASHTO
   - AASHTO Climate group could be narrowed to SLR

PROVIDE INCREASED REGULATORY FLEXIBILITY FOR ADAPTATION AND IMPROVE CONSISTENCY AMONG REGULATORY AGENCY DECISIONS

10. **Encourage early transportation planning and conceptual infrastructure design for sea level rise adaptation.** *There was support for this option with 10 specifically supporting and 1 not in support.*
    - Commenter thought that "encourage" is a wimpy word.
    - Commenter thought this could be included with the executive order recommendation.
    - One commenter thought this should be prioritized

11. **Allow for the connection of individual septic systems to community septic systems with excess capacity when human safety and welfare are at risk.** *There was support for this option with 9 specifically supporting and 1 not in support.*
    - No actionable comments, but one commenter reiterated that adequate ordinances at the county and municipal level are essential and questioned how the state/locals worked with respect to state guidelines and regulations and local ordinances.

12. **Develop local land use ordinances that encourage consideration of the effects of sea level rise in the siting and maintenance of public infrastructure.** *There was support for this with 12 commenters specifically supporting and 1 not in support.*
    - One commenter reiterated that adequate ordinances at the county and municipal level are essential and questioned how the state/locals worked with respect to state guidelines and regulations and local ordinances.
    - One commenter pointed out that local governments would need lots of help
    - One commenter asked for a more robust way of enforcing the "guidelines" that this option discusses developing
    - Several commenters pointed this out as very important or should be a priority

13. **Consider sea level rise implications in future regulatory updates for septic systems and wells.** *There was support for this action with 9 specifically supporting and 1 not in support. No specific comments received.*

14. **Encourage the governor to sign an executive order that would direct state agencies to plan for sea level rise.** T*his had support with 13 specifically supporting and 1 not supporting.*
    - Several commenters pointed out that this should be a priority and one of the first actions to be undertaken
    - One commenter thought there should also be a Cabinet level council established
    - One commenter believed that the Executive Order would be inadequate; that a high level official should be appointed to ensure implementation of SLR actions

15. **Provide regulatory incentives that encourage sea level rise adaptation and that allow for innovative projects.** *There was support for this with 12 specifically in support and 2 not in support.*
    - One commenter thought this should be a priority. No other actionable comments received.

16. **Evaluate the state Coastal Zone Act Regulations for changes that would increase flexibility for industries to adapt their shorelines and facilities to sea level rise.** *This had support, with caveats, with 10 specifically supporting and 3 not supporting.*
    - There were several commenters who did not want to see this Act weakened and that they perceive that the Act is already too flexible in its interpretation.
    - One commenter said don't weaken, but provide technical assistance
    - One commenter wanted to require climate change impacts and sea level rise to be considered in issuance of Coastal Zone Act Permits.
    - One commenter said that streamlining and increasing flexibility are good objectives.

17. **Create a financial assurance program to minimize the state's liability to clean up industrial sites if they are abandoned as a result of sea level rise.** *This had support with 12 specifically supporting and 2 not in support.*
    - One commenter wished to prioritize this option
    - No other actionable comments received, though there were general comments reflecting concern for Burton Island landfill at the NRG Indian River Power Plant

18. **Conduct a comprehensive update to the state's regulatory tidal wetlands maps and provide a way to periodically update the maps to reflect changes occurring from sea level rise.** *There was support for this option with 12 specifically commenting in support and 1 not in support.*
    - Several commenters thought this should be prioritized
    - Several comments highlighted their desire to protect wetlands and the functions and benefits they provide.

PROVIDE CONSISTENT AND PREDICTABLE POLICIES FOR FUTURE GROWTH, INVESTMENT AND NATURAL RESOURCE MANAGEMENT

19. **Incorporate sea level rise considerations into the Strategies for State Policies and Spending.** *There was support for this option with 12 specifically commenting in support and 3 not in support.*
    - Several commenters thought this should be prioritized.

20. **Incorporate sea level rise considerations into municipal comprehensive development plans.** *There was support for this option with 14 specifically supporting and 3 not supporting.*
    - Many commenters thought this was very important and/or should be a high priority

21. **Incorporate sea level rise into Delaware's Long Range Transportation Plan.** *There was support for this option with 11 specifically in support and 3 not in support.*
    - No actionable comments received

22. **Incorporate sea level rise into the Transportation Operations Management Plan.** *There was support for this option with 8 specifically in support and 3 not in support.*
    - No actionable comment received

23. **Encourage inclusion of sea level rise in Transportation Project Design Manuals.** *There was support for this option with 7 specifically in support and 3 not in support.*
    - One commenter questioned whether AASHTO was already doing this.

24. **Develop a statewide retreat plan.** *There was support for this option with 13 specifically supporting and 4 not in support.*
    - Several commenters thought that this was very important and/or should be a priority
    - A good retreat plan – updated periodically as the climate and sea level change – might save wasted money and resources.
    - Concern that this option and the entire section is a "kiss of death"

25. **Conduct a legal review for disinvestment of publically owned infrastructure and privately owned buildings.** *Support for this option was mixed, with 7 specifically in support and 5 not in support.*
    - One commenter thought that such a legal review must also include questions of "equal protection" and "environmental justice"

26. **Consider use of a Transfer of Development Rights tool to direct future growth away from vulnerable areas.** *There was general support for this with 12 specifically in support and 4 not in support.*
    - One commenter said "The development of innovative and flexible approaches for encouraging and incentivizing movement of property owners from vulnerable areas should be a priority. In addition to TDR's, new forms of buyouts that might include longer term and novel arrangements should be explored"
    - One commenter thought that TDRs would be difficult to implement

27. **Develop a dike safety program.** *There was general support for this with 7 specifically supporting and 4 not in support.*
    - One commenter thought this was very important, but that the write-up lacked the sense of urgency that it should have.
    - One commenter wanted it to mention that this would likely require legislative and/or executive action
    - One commenter thought that it would just be more bureaucracy

28. **Designate shoreline zones for adaptation action.** *There was mixed support for this, with 6 specifically supporting and 3 not in support.*
    - One commenter questioned if urban shorelines would be included
    - One commenter mentioned the strong link with the Bayshores Initiative

29. **Develop comprehensive wetlands restoration strategy in response to sea level rise.** *There was support for this with 13 specifically in support and 3 not in support.*
    - One commenter pointed out that this should be linked to Option 49, which calls for a study of wetland migration areas.
    - One commenter believed that this should be a priority action
    - There was specific support for 'beneficial reuse of sediment'
    - One commenter wanted to recognize the built communities which have a symbiotic relationship with the surrounding wetlands.

30. **Continue efforts to re-evaluate management strategies for existing coastal impoundments.** *There was support for this option with 8 specifically in support and 3 not in support.*
    - One commenter thought that this option might want to explore in detail the value of developing "new" formal management collaboration (federal and state) for the National Wildlife Refuges that incorporate the interests of the diverse communities (including farmers) that adjoins them.

31. **Evaluate the benefits and risks of permitting privately owned coastal impoundments.**
There was support for this with 8 specifically in support and 4 not in support.
- One commenter said that impoundments endanger local communities

32. **Develop a framework for decision making regarding land protection and restoration strategies based on habitat vulnerability, migration potential and relative importance in he regional landscape, historical significance or other key factors.**
T*here was mixed support for this with 7 specifically in support and 3 not in support.*
- One commenter wanted to recognize and integrate the reality of the extensive research process and management analysis that has already been done for the two federal refuges (the recently completed Comprehensive Conservation Plan).

INCREASE PUBLIC AWARENESS OF SEA LEVEL RISE THROUGH EDUCATION, OUTREACH AND MARKETING

33. **Develop a comprehensive outreach strategy to educate public about sea level rise.**
T*here was support for this with 17 specifically in support and 1 not in support.*
- Two commenters thought this should be a priority action
- There was a suggestion to include utilities, the real estate community, farmers and insurance community as targeted audiences
- One suggested that we include the "non-impacted" communities whose tax dollars are being utilized to fix problems on the coast
- There was a suggestion to specifically include school children beginning no later than junior high using state science curriculum standards and to learn what other states have done for k-12 education and copy the best practices.

34. **Provide education and outreach for impacted communities and citizens.**
There was support for this with 8 specifically in support and 1 not in support.
- Comment to be explicit that SLR affects some communities more than others.
- Concern that insurance be part of the discussion for communities and citizens
- Include dangers of living behind dikes and levees in educational efforts.

35. **Improve the ability of homebuyers to investigate a property's potential vulnerability to sea level prior to purchase.** *There was mixed support for this option. Approximately 16 commenters supported this option; 6 did not support it.*
- One commenter wanted to wait until there is better data about what areas sea level rise will affect, and when (phase in after data collection options 44, 47, 65 and 55)
- One comment also addressed education efforts for living behind dikes and levees and that there may be a need for vulnerability "disclosure for people and businesses behind dikes and levees with questionable maintenance regimes
- Focus more on the education component, and less on the disclosure component. Spend more time describing the "Newark Model"
- Include better information about cost and availability of flood insurance in education efforts

36. **Provide targeted outreach to water and wastewater operators and water utilities.**
There was support for this with 5 specifically supporting and 1 not in support.
- One commenter wanted to include adding state, municipal, and county water and wastewater professionals.

IMPROVE THE AVAILABILITY AND ROBUSTNESS OF SEA LEVEL RISE DATA SETS:

37. **Conduct a risk assessment for Delaware's system of dikes & levees.**
There was support for this with 8 specifically supporting and 1 not in support.
- One commenter suggested that there may be a need for vulnerability "disclosure" for people and businesses behind dikes and levees with questionable maintenance regimes

38. **Develop and maintain a comprehensive database that contains the location and condition of all wastewater infrastructures.** *There was support for this with 7 specifically in support and 2 not in support.*
- One commenter believed that there might be too many legal issues with this for it to be viable

39. **Identify data needs to plan transportation investments.** *There was support for this with 6 specifically in support and 1 not in support.*
- No specific or actionable comments received

40. **Model potential stormwater inundation problems in highly vulnerable areas.**
There was support for this with 6 specifically in support and 1 not in support.
- No specific or actionable comments received

41. **Develop a model that will predict changes to salinity in surface water that may occur under differing sea level rise scenarios.** *There was support for this option with 4 specifically supportive and 2 not supportive.*
- No specific or actionable comments received.

42. **Develop a statewide groundwater model.** *There was support for this option with 6 specifically in support and 2 not in support.*
- One commenter suggested we mention agriculture as an important end user of this info.

43. **Encourage the development of a research and policy center at a university or college campus that would focus on applied research for sea level rise and adaptation.**
There was support for this with 10 specifically in favor and 2 not supportive.
- Two commenters said this should be a priority/high importance
- One commenter believed this option gets lost in a series of options about data – when it could be a stand-alone recommendation of great importance.
- Comment that this could also be a "consortium" of research and policy resources that connect Delaware's academic institutions
- Comment that this could be funded by a Coastal tax

44. **Improve monitoring of current sea level conditions and improve predictions for timing of inundation.** *There was support for this option with 9 specifically in support and 1 not in support.*
- One commenter wanted recent funding cuts (DCP note, this may reference federal budget cuts) to be mentioned.
- One comment that this could be funded with coastal tax

45. **Increase understanding of the regional implications of loss of industrial areas in coastal Delaware.** *There was support for this with 6 specifically supportive and 2 not supportive.*
- One commenter wanted the private sector to take more initiative

46. **Improve understanding of impacts to adjacent properties from adaptation actions.**
There was support for this with 5 specifically supportive and 1 not supportive.
- One commenter thought that this is a good place to also raise the need for stormwater management requirements
- One commenter thought this was applicable also to property owners where "adaptive measures" might result in "water trespass" on neighboring properties.

47. **Develop sea level models that incorporate storm surge impacts.**
There was support for this with 15 specifically supportive and 1 not supportive.
- Many commenters (at least 6) thought this was of high importance or should be a priority
- Explain the reasons why this hasn't already been done
- Several specific comments about Inland Bays flooding and the Indian River Inlet

48. **Foster pilot projects that demonstrate the effectiveness of best management practices for management of agricultural lands affected by sea level rise.**
There was support for this with 6 specifically supportive and 2 not supportive.
- One commenter pointed out that the Prime Hook area would be a good place to foster best management practices of agricultural land because the Farm Preservation Program is active there, salt water intrusion is increasing, and UD has been doing research at the College of Earth, Ocean and Environment on non-traditional crops better suited to such conditions.

49. **Identify and preserve areas for potential wetland migration.**
There was support for this with 13 specifically supportive and 1 not supportive.
- Link to Option 29 (develop comprehensive wetlands strategy)
- One commenter suggested prioritizing the purchase of farmland for this purpose
- Several commenters identified this as a priority item

50. **Encourage federal agencies to integrate sea level rise planning into their flood models.**
There was a support for this with 13 specifically supportive and 1 not in support.
- There was concern from at least one commenter that data is not yet good enough to produce reliable flood maps that incorporate sea level rise. Data from options about monitoring sea level, incorporating sea level rise into flood maps, adding tide stations should be done first.
- There was a comment to also ensure that floodplain maps are routinely updated (DCP comment: they are only periodically updated now with many not having been comprehensively reviewed for several decades)
- Consider the social and economic impact of this action

51. **Conduct research to better understand human response to sea level rise and adaptation.**
There was support for this option with 7 specifically supportive and 1 not in support.
- One commenter thought this was very important/should be a priority. Believes that lack of consideration for the human dimensions of SLR have made job of outreach and education much more difficult.
- Could be linked to #43, development of a research center in Delaware

52. **Improve the accuracy of Delaware's elevation benchmark network.**
There was support for this option with 7 specifically supportive and 1 not in support.
- Question about whether the 10-Year Bay Beach Management Plan produced a good model for this

53. **Continue and expand studies regarding sediment accretion rates and susceptibility of wetlands to sea level rise.** *There was support for this option with 7 specifically supportive and 1 not in support.*
    - No specific actionable comments received

54. **Add additional tidal observation stations in Delaware.** *There was a high level of support for this with 10 supportive and 1 not supportive.*
    - No specific actionable comments received

55. **Install inland inundation water level monitoring sites.** *There was support for this with 6 supportive comments and 1 not in support.*
    - One commenter said that improving monitoring of inland sites is necessary to show what even usually high tides can do
    - One commenter indicated that this should be prioritized
    - The more residents and property owners in the inland begin to understand that their interests are at risk just as the coast dwellers the more likely good policy and necessary resources will result.

PROVIDE TECHNICAL ASSISTANCE TO PARTNERS FOR ASSESSING VULNERABILITY AND CHOOSING ADAPTATION OPTIONS

56. **Create a coordinated effort to provide technical assistance to local governments.** *There was support for this with 12 providing supportive comments and 1 not in support.*
    - At least 6 commenters believed this to be a high priority item
    - One commenter wanted the text to be much stronger – indicating that there should be consequences for local governments who do not plan ahead (in the form of reduced assistance from the state/fed)
    - Increased insurance regulation at the state was also cited as a need here

57. **Provide land managers, fisheries managers and farmers with the information and extension support necessary to manage lands and fisheries in areas affected by sea level rise.** *There was support for this with 9 providing supportive comments and 1 not in support.*
    - One commenter thought this should be a priority action

58. **Provide technical assistance for industrial and port facilities to incorporate sea level rise into investment plans and continuity of business plans.** *There was support for this with 10 providing supportive comments and 1 not in support.*
    - There was a question as to who would be providing this technical assistance.
    - Suggestion to use the US Navy's vigorous effort and developing technical experience in adapting its world-wide port assets to SLR.
    - One commenter believed this should be prioritized

59. **Develop best management practice manuals for adaptation in Delaware.** *There was support for this with 10 providing supportive comments and 1 not in support.*
    - Manuals could be developed in collaboration with faculty at colleges and universities
    - This helps with public education and outreach in a concrete way.
    - One commenter believed this should be prioritized

60. **Conduct a cost benefit analysis for adaptation.** T*here was support for this option with 10 commenters supportive and 3 not supportive.*
    - One commenter said that this can't be done until specific actions are proposed
    - Add Cost/Benefit study conducted for Bay Beaches as basis
    - One commenter thought this should be prioritized
    - One commenter thought this would be helpful in deciding among adaptation options.

61. **Develop a database of costs of adaptation options for use by decision-makers and the public.** *There was support for this with 9 comments in support and 2 not in support.*
    - One commenter thought that the database should include past adaptation experiences – including dates, description of the work done and its total costs, and costs per unit (e.g. cubic yards of added beach, feet or meters of dike or road repaired, feet of elevation added to structures), as well as the name and contact information of the contractor who did the work – as well as projections of likely future costs.
    - One commenter thought that the database of costs should be connected with a technical piece on the efficacy of the actual adaptation options to be considered.
    - One commenter thought this should be prioritized

Appendix F: Acronyms

AASHTO - American Association of State Highway Transportation Officials
BMP - Best Management Practices
CAKE - Climate Adaptation Knowledge Exchange
CREAT - Climate Resilience Evaluation and Awareness Tool
CZA - Delaware Coastal Zone Act
DelDOT - Delaware Department of Transportation
DEMA - Delaware Department of Homeland Security, Delaware Emergency Management Agency
DNREC - Delaware Department of Natural Resources and Environmental Control
FEMA - Federal Emergency Management Agency
GIS - Geographic Information Systems
HCC - Habitat of Conservation Concern
IPCC - Intergovernmental Panel on Climate Change
ICLEI - International Council for Local Environmental Initiatives
LMSL - Local Mean Sea Level
LRTP - Long Range Transportation Plan
MHW - Mean High Water
MHHW - Mean Higher High Water
MLLW - Mean Lower Low Water
MSL - Mean Sea Level
MPO - Metropolitan Planning Organization
NOAA - National Oceanic and Atmospheric Administration, U.S. Department of Commerce
PLUS - Preliminary Land Use Service
RAS - Regulatory Advisory Service
RIP - Rehabilitation and Inspection Program
TDR - Transport of Development Rights
TOMP - Transportation Operations Management Plan
USACE - United States Army Corps of Engineers

Appendix G: Definitions

Accretion – The accumulation of a sedimentary deposit that increases the size of a land area.

Adaptation – An action that can be taken to adjust to new or emerging conditions such as sea level rise.

Adaptive capacity – The ability of individuals, or agencies, to assess potential impacts and to select and implement appropriate adaptation measures to cope with a changing environment.

Agricultural land conservation easements – Land permanently protected through deed restrictions to maintain agricultural land and agricultural uses.

Bathtub model – A water surface model that maps flooding scenarios where the extent of inundation is estimated based on mean higher high water and land elevation. Bathtub models do not incorporate storm surges or future land conditions.

Bioswale – A naturalized landscape element that can remove silt and nutrients from stormwater run-off, improving water quality in rivers and streams. Bioswales have gently sloped sides and are frequently planted with vegetation.

Beach nourishment – A process by which sediment (sand) lost to erosion is replaced with sand from another source. Nourishment projects typically utilize large dredges to bring in sand from offshore sources, but sand mined inland can also be utilized though truck-haul.

Brackish water – Water that results from the mixing of a saltwater and freshwater body of water, such as in an estuary. Brackish water has a salt content of between 0.05% to 3%.

Bulkhead – A wall that is constructed parallel to a shoreline to prevent erosion.

Coastal impoundment – A man-made structure adjacent to open water or wetlands where water levels can be managed for a variety of outcomes including controlling mosquito populations, creating foraging and breeding habitat for wildlife and providing recreational opportunities.

Conservation easements – A voluntary agreement between a landowner and a government or other organization that restricts certain uses of the property for a variety of purposes (habitat creation, scenic vistas, agriculture) while the property remains in private ownership.

Datum – A point, line or surface used as a reference in measuring locations or elevations.

Dike – A wall generally of earthen materials designed to prevent the permanent submergence of lands below sea level or storm-surge flooding of the coastal floodplain.

Dune – A mound of sand parallel to a shoreline that can be built naturally by wind and water flow or can be constructed during beach nourishment projects. Dunes help protect areas inland from erosion and storm damage. They also provide important wildlife habitat.

Environmental Justice Community – Communities where residents are predominantly minority or low-income; where residents have been excluded from the environmental policy setting or decision-making process; where they are subject to a disproportionate impact from one or more environmental hazards; and where residents experience disparate implementation of environmental regulations, requirements, practices and activities.

Estuary – A partially enclosed body of brackish water that is a transition zone between river and ocean environments.

Eustatic sea level rate – The worldwide change of sea level elevation with time.
Green infrastructure – An approach to managing stormwater that utilizes natural techniques like bioswales and wetlands.

Glacier – A large and persistent body of ice that forms over a period of many years when accumulation of snow exceeds melting. Glaciers form only on land and can be found in mountain ranges of every continent except Australia.

Geographic Information System (GIS) – A hardware and software system that allows the visualization, analysis and interpretation of geographic data.

Groin – A low wall or sturdy barrier built perpendicular from a shoreline into a waterway. It is intended to reduce erosion by trapping the sand that moves parallel to the shoreline. These structures can also cause of increase erosion of adjacent shorelines.

Groundwater – Water located beneath the surface in fractures or rock formations.

Habitats of Conservation Concern (HCC) – Lands identified in the Delaware Wildlife Action Plan that are sensitive to disturbance and have a high density of rare species with ecological significance.

Ice sheet – A mass of glacier ice that covers land and is greater than 19,000 square miles in area. Ice sheets are also known as continental glaciers. The only ice sheets in existence today are in Antarctica and Greenland.

Inundation – The movement of coastal waters over land.

Living shorelines - A structure that prevents shoreline erosion and maintains coastal processes by restoring or enhancing natural shoreline habitat through the strategic placement of plants, stone, sand fill, and other organic materials.

Maladaptation – Poor or inadequate adaptation.

Marsh – A frequently or continually inundated wetland characterized by herbaceous vegetation adapted to saturated soil conditions.

Marsh migration – A process by which tidal wetlands adjust to rising sea levels by advancing inland into areas previously above the ebb and flow of the tides.

Mean Higher Water (MHW) – a tidal datum; the average height of high water levels observed over a 19-year period.

Mean Higher High Water (MHHW) – the average of the highest of the high water heights of each tidal day observed over a 19-year period known as the national tidal datum epoch.

Mean Lower Low Water (MLLW) – A tidal datum that measures the average of the lower low water height of each tidal day.

Mean Sea Level (MSL) - A tidal datum that measures the mean of hourly heights of each tidal day.

Nested Model – A model in which all of the terms of a smaller model are contained within a larger model.

Protected lands – For the purposes of this document, protected lands are lands owned by state, local and municipal government, conservation groups, and individuals including State Wildlife Areas, State Parks, historical sites, and county and municipal parks.

Public Trust Doctrine – A legal principle derived from English Common Law which holds that the waters of a state are a public resource owned by and available to all citizens and that these public property rights are not invalidated by private ownership of the underlying or adjacent land.

Resiliency – The ability to recover after an event with negative consequences.

Salt wedge – The boundary that is formed when freshwater from a river flows over more dense saltwater, forming a wedge between the freshwater and the saltwater.

Saltwater intrusion – Displacement of fresh or ground water by the advance of salt water, due to its greater density.

Sea level rise, local – The rise in sea level measured with respect to a specified vertical datum relative to the land, which also may be changing elevation over time. Local sea level rise is typically measured with a tide gauge.

Sea level rise, eustatic – the worldwide average rise in mean sea level.

Salt marsh – A grassland containing salt-tolerant vegetation established on sediments bordering saline water bodies where water level fluctuates with the tides.

Species composition – The number of different species present in a given geographic area.

Storm surge – An abnormal rise in sea level that accompanies a coastal storm. The height of the storm surge is the difference between the observed level of the sea surface and the level that would have occurred without influence of the storm.

Tidal wetlands – Wetlands that are exposed to the periodic rise and fall of the tides.

Tide gate – A mechanical structure that allows water to flow freely when the tide is moving in one direction, but which closes to prevent water from flowing in the opposite direction.

Tide gauge – A device that measures changes in sea level relative to a fixed land elevation. These devices measure daily tide heights and storm tide heights. Long term tide gauge records can provide local long-term sea level trends.

Vulnerability – The susceptibility of a resource to negative impacts from sea level rise.

Watershed – A drainage basin or area of land where surface water converges to a single point, usually the exit of the basin flows into a river, lake, reservoir, estuary, or ocean

Wetland – Areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soils.

Appendix H: Resources for Adaptation Planning and Implementation

The main body of this document lays out a path forward for preparing for the impacts of sea level rise to the State of Delaware, but does not put forth any specific adaptation measures for specific locations. Selection, planning and implementation of specific measures to combat sea level rise will occur through the activities of a wide variety of individuals, communities, businesses and agencies. This appendix provides those wishing to begin the process of adaptation with a list and description of resources that are currently available to help them plan, design and fund adaptation measures.

Planning and Technical Assistance

This section provides a list and description of programs that can provide planning and technical assistance to those wishing to plan adaptation actions or implement adaptation projects. This list is not exhaustive and is intended to be a starting point for potential adaptation projects. Where possible, contact information for a person or agency capable of providing more information or technical assistance is listed.

Delaware Coastal Programs

The DNREC Delaware Coastal Programs provides technical assistance, guidance, data, training and grants for a wide range of coastal issues, including planning and adapting to sea level rise. Technical assistance is available to communities, non-governmental agencies, government agencies and universities and specific training for these audiences is announced periodically. Communities and agencies seeking to begin a planning process for sea level rise and coastal vulnerability or develop specific adaptation solutions to existing flooding issues are encouraged to contact the program for assistance. Information about the Delaware Coastal Programs is available online: www.dnrec.delaware.gov/coastal.

For more information, contact:

Robert Scarborough, Ph.D
Department of Natural Resources and Environmental Control
Delaware Coastal Programs
5 East Reed Street, Suite 201
Dover, DE 19901
(302) 739-9283
Bob.Scarborough@state.de.us

Delaware Sea Grant Marine Advisory Service
The Delaware Sea Grant Marine Advisory Service is a resource provided by the University of Delaware that advocates for the wise use, conservation and development of marine resources. Information and planning assistance is available to address flooding and sea level rise as well as other coastal issues including water quality, resource management and sustainable communities. The Marine Advisory Service transfers science-based information and expertise of the University's researchers to local citizens, resource managers and business owners in a variety of ways such as workshops, publications, trainings, and consultations. Additional information is available online: http://www.deseagrant.org/outreach.

For more information contact:
Jim Falk
Delaware Sea Grant Marine Advisory Service
University of Delaware
700 Pilottown Road
Lewes, DE 19958-1298
(302) 645-4235
jfalk@udel.edu

Flood Mitigation Program
Delaware's Flood Mitigation Program provides flood-related assistance to individuals and communities for the purpose of reducing the state's vulnerability to flood damages. Specifically, the program helps communities comply with floodplain standards and flood insurance requirements. It also assists individuals and communities obtain funding for projects which reduce vulnerability to flooding. Information about the Flood Mitigation Program is available online: http://www.dnrec.delaware.gov/swc/drainage/pages/flooding.aspx.

For more information, contact:
Michael Powell
DNREC Division of Watershed Stewardship
89 Kings Highway
Dover, Delaware 19901
(302) 739-9921
Michael.Powell@state.de.us

Office of State Planning Coordination
The Delaware Office of State Planning Coordination provides a range of information and services to local and county governments to foster responsible growth and compliance with requirements for Comprehensive Land Use Plans. Technical assistance is available to cities and towns to help incorporate sea level rise into comprehensive development plans, zoning codes and ordinances. Information about the Office of State Planning Coordination is available online: http://www.stateplanning.delaware.gov/.

For more information, contact:
Constance Holland
State Planning Director
Office of State Planning Coordination
122 Martin Luther King Jr. Blvd. South
3rd Floor
Dover, DE 19901
(302) 739-3090
Connie.Holland@state.de.us

Preliminary Land Use Service
The Preliminary Land Use Service (PLUS) allows for state agency review of major land use changes and comprehensive development plans. Certain development projects are required to undergo review; however, a municipal or county government can request a state review for any project regardless of size or scope. Local communities wishing to understand potential future flooding issues resulting from proposed development are encouraged to consider the PLUS process. Additional information about PLUS is available online: http://stateplanning.delaware.gov/plus.

For more information, contact:
Constance Holland, AICP
State Planning Director
Office of State Planning Coordination
122 Martin Luther King Jr. Blvd. South
3rd Floor
Dover, DE 19901
(302) 739-3090
Connie.Holland@state.de.us

Private Lands Assistance Program
The DNREC Private Lands Assistance Program assists private landowners improve and protect their lands for wildlife. The program has biologists dedicated to informing landowners about available programs, providing technical assistance for developing habitat projects and securing financial assistance as incentives for participation. Landowners faced with inundation issues on their property who wish to choose a natural adaptation method are encouraged to consult with program scientists for ideas and funding. Additional information is available online: http://www.dnrec.delaware.gov/fw/dplap/Pages/default.aspx.

For more information contact:
William Jones
Fish & Wildlife Regional Manager
Delaware Division of Fish & Wildlife
89 Kings Highway
Dover, DE 19901
(302) 284-4795
William.Jones@state.de.us

Jason Davis
Delaware Division of Fish and Wildlife
89 Kings Highway
Dover, DE 19901
(302) 735-3600
Jason.Davis@state.de.us

Regulatory Advisory Service
The Regulatory Advisory Service (RAS) provides an opportunity for developers or business owners seeking to relocate or expand within the state to consult with DNREC agencies about environmental permitting and design considerations. The RAS provides a one-stop-shop for information about necessary permits and regulations but can also help individuals understand and mitigate potential future flood risk at a particular site. More information is available online: http://www.dnrec.delaware.gov/SBA/Pages/RegulatoryAdvisoryService.aspx.

For more information, contact:
Gail Henderson
Office of the Secretary
89 Kings Highway
Dover, DE 19901
(302) 739-9909
Gail.Henderson@state.de.us

Shoreline and Waterway Management Section
DNREC's Shoreline and Waterway Management Section regulates coastal construction and implements beach and dune management practices. Their mission is to protect and enhance the state's beaches for recreational use and to improve resilience to storm events and erosion. The section has a variety of resources and publications to assist communities and individuals in understanding and adapting to coastal hazards including sea level rise. Additional information is available online: http://www.dnrec.delaware.gov/swc/shoreline/Pages/Shoreline.aspx.

For more information, contact:
Jennifer Luoma
DNREC Division of Watershed Stewardship
89 Kings Highway
Dover, Delaware 19901
(302) 739-9921
Jennifer.Luoma@state.de.us

Funding and Grant Assistance

This section provides a list and description of grant and loan programs that can be utilized by agencies wishing to plan adaptation actions or implement adaptation projects. This list is not exhaustive and is intended to be a starting point for agencies seeking funding; many other funding opportunities may be available from county, federal and private source and innovative financing mechanisms. Where possible, contact information for a person or agency capable of providing more information or technical assistance is listed.

Coastal Management Assistance Grants
The DNREC Delaware Coastal Programs currently offers competitive grants of up to $25,000 annually for coastal planning and research pertaining to coastal resiliency and sea level rise. These grants are available to state agencies, municipal and county governments, academic institutions and not-for-profit organizations. Grant funding can be used for adaptation planning (including comprehensive planning and building code updates) and adaptation project design as well as adaptation research or sea level rise monitoring. Funding cannot be used for construction. Additional information is available online: http://www.dnrec.delaware.gov/coastal/Pages/CoastalProgramRFP.aspx.

For more information, contact:
Bonnie Arvay
Delaware Coastal Programs
Department of Natural Resources and Environmental Control
5 E. Reed Street, Suite 201
Dover, DE 19901
(302) 739-9283
Bonnie.Arvay@state.de.us

Green Project Reserve
The DNREC Financial Assistance Branch offers below market rate loans for state, county and municipal agencies to assist with the planning and construction of green infrastructure, water efficiency and environmentally innovative projects. A wide range of adaptation strategies could be funded through this program. To be eligible, projects must first be placed on the Project Priority List; development of the list begins in January each year. Additional information is available online: http://www.dnrec.delaware.gov/fab/Pages/Green-Project-Reserve.aspx.

For more information, contact:
Greg Pope P.E
Delaware Department of Natural Resources & Environmental Control
Office of the Secretary
5 E. Reed Street, Suite 200
Dover, DE 19901
Greg.Pope@State.de.us
(302) 739-9941

Pre-Disaster Mitigation Program
The Federal Emergency Management Agency offers competitive grants for projects seeking to reduce risk to people and structures from hazard events, including storms and inundation. These grants are available to states, territories, tribal governments, local communities and universities. The application period is June through December each year. In most cases, applicants for funding must provide matching funds no less than 25% of the total project cost. Additional information is available online: http://www.fema.gov/pre-disaster-mitigation-grant-program.

David Carlson
Delaware Emergency Management Agency
165 Brick Store Landing Road
Smyrna, Delaware 19977
Phone: (302) 659-2213
David.Carlson@state.de.us

Surface Water Matching Planning Grants
The DNREC Financial Assistance Branch provides competitive grants of up to $50,000 annually for planning and engineering design of projects that seek to improve surface water quality within the state. Adaptation projects that have a water quality component, including stormwater retrofits, wetland restoration, drainage plans and green infrastructure, would qualify for funding through this program. Funding is available to state, county and municipal agencies. A 1:1 cash match is required for the grant. More information is available online: http://www.dnrec.delaware.gov/fab/Pages/Surface-Water-Matching-Planning-Grants.aspx.

For more information, contact:
Jim Sullivan
Division of Watershed Stewardship
Department of Natural Resources and Environmental Control
89 Kings Highway
Dover, DE 19901
(302) 739-9921
James.Sullivan@state.de.us

Wastewater Matching Planning Grants
The DNREC Financial Assistance Branch provides competitive grants of up to $50,000 annually to municipal and county wastewater utilities for wastewater planning projects. Projects which propose to modify facilities in order to adapt to sea level rise would qualify for funding under this program. A 1:1 cash match is required for the grant. More information is available online: http://www.dnrec.delaware.gov/fab/Pages/Wastewater-Matching-Planning-Grants.aspx.

For more information, contact:
Greg Pope P.E
Delaware Department of Natural Resources & Environmental Control
Office of the Secretary
5 E. Reed Street, Suite 200
Dover, DE 19901
(302) 739-9941
Greg.Pope@State.de.us

Online Tools, Guidebooks and Decision Aids

This section provides a list and description of online tools, guidebooks and decision-aids that can be used by individuals or agencies to understand the potential impacts of sea level rise and to evaluate options to adapt to sea level rise. All tools listed below are available free of charge to anyone wishing to utilize them. Where possible, contact information for a person or agency capable of providing more information or technical assistance is listed.

Climate Adaptation Knowledge Exchange Website
The Climate Adaptation Knowledge Exchange (CAKE) is a website that provides easy access to sea level rise adaptation case studies, adaptation reports and adaptation tools from around the country. It also provides a directory of adaptation practitioners and experts and a discussion form. Its "virtual library" provides options for targeted searches on scientific research and planning strategies. The website is available here: www.cakex.org.

For more information, contact:
EcoAdapt
P.O. Box 11195
Bainbridge Island, WA 98110
Phone: 206 201 3834
info@cakex.org

CREAT Tool
The Climate Resilience Evaluation & Awareness Tool (CREAT) is a software tool developed by the U.S. Environmental Protection Agency to assist drinking water and wastewater utility owners and operators understand potential climate change threats and related risks at their facilities. The tool helps water utility operators plan for sea level rise by providing risk reduction and cost reports for evaluation of potential adaptation options. CREAT also provides users with access to the most recent national assessment of climate change impacts for use in considering how these changes will impact utility operations and missions. The software can be downloaded free of charge at http://water.epa.gov/infrastructure/watersecurity/climate/creat.cfm.

For more information:
U.S. Environmental Protection Agency Region 3
1650 Arch Street
Philadelphia, PA 19103-2029
(800) 438-2474
CREAThelp@epa.gov

Delaware Homeowner's Handbook to Prepare for Natural Hazards
The "Delaware Homeowners Handbook to Prepare for Natural Hazards" is a guidebook for Delaware homeowners interested in preparing themselves and their homes for coastal storms, flooding, tornadoes, sea level rise and climate change. It provides practical information about steps that can be taken to prevent damage to homes in the event of storms and provides information about flood insurance. In addition, the guidebook contains emergency contact numbers and shelter information. The guidebook can be downloaded online: http://www.deseagrant.org/sites/deseagrant.org/files/product-docs/DE_Homeowner_Handbooklr.pdf.

For more information, contact:
Dr. Wendy Carey
Delaware Sea Grant Program
700 Pilottown Road
Lewes, DE 19958
(302) 645-4258
wcarey@udel.edu

Delaware Sea Level Rise Viewer
The Delaware Sea Level Rise Viewer is a web-based mapping tool developed by the DNREC Delaware Coastal Programs that allows users to visualize the potential impact of sea level rise within Delaware under three scenarios—0.5 meter, 1.0 meter and 1.5 meters in 2100. The map is based upon existing elevation data and does not account for future rates of erosion, subsidence, or construction. Water levels are shown as they would appear during an average high tide (mean higher high water). The viewer can be accessed online: http://de.gov/slrmap.

For more information, contact:
Susan Love
Delaware Department of Natural Resources and Environmental Control
Delaware Coastal Programs
5 East Reed Street, Suite 201
Dover, DE 19901
(302) 739-9283
Susan.Love@state.de.us

Digital Coast Website
The Digital Coast Website provides data, tools and training modules for decision-makers to address coastal issues, including sea level rise and climate change. This website hosts the U.S. Sea Level Rise and Coastal Flooding Impacts Viewer and provides a portal for users to download mapping data. It also provides Coastal County Snapshots for flooding in all of Delaware's counties, providing a quick way for decision makers to understand land use, population and demographic changes inundation. It also provides several downloadable modeling tools. The website is available here: http://csc.noaa.gov/digitalcoast/.

Getting to Resilience Website and Questionnaire
The Getting to Resilience Questionnaire is a non-regulatory tool created by the New Jersey Department of Environmental Protection's Coastal Management Program to assist local decision makers identify planning, mitigation and adaptation opportunities for coastal storms and sea level rise. The questionnaire is intended to stimulate dialogue among local leaders as they answer the questions it poses about storm and sea level rise preparedness and identify actions that can be taken to improve resiliency to storms and sea level rise. Although developed specifically for communities in New Jersey, it can easily be transferred and utilized in Delaware communities. The questionnaire can be filled out online at www.prepareyourcommunitynj.org or downloaded at www.state.nj.us/dep/cmp/docs/gtr-resilience.pdf.

For more information, contact:
Lisa Auermuller, Watershed Coordinator
Jacques Cousteau National Estuarine Research Reserve
(609) 812-0649 x204
auermull@marine.rutgers.edu

Storm Smart Coasts Delaware Website
The Storm Smart Coasts website is a web resource designed to provide local and state officials with resources for addressing the challenges of storms, flooding, sea level rise and climate change. It has information specific to Delaware on these topics specifically tailored to planning board members, council members, town managers, building officials and public works departments. It can be used to prepare for a storm, communicate with emergency contacts during a storm, provide for safe and smart recovery after a storm and seek funding. Website users can also find and contact peers through the site, share files and create or join discussion groups. The website is available here: http://de.stormsmart.org/.

U.S. Sea Level Rise and Coastal Flooding Impacts Viewer

The U.S. Sea Level Rise and Coastal Flooding Impacts Viewer is a web-based mapping tool developed by the National Oceanic and Atmospheric Administration that allows users to visualize the potential impacts of sea level rise and coastal flooding in the U.S. at 1-foot increments. It also provides visualizations of sea level rise at local landmarks, communicates the uncertainty of mapped sea levels and models potential marsh migration due to sea level rise. Users can also overlay social and economic data and examine how tidal flooding will become more frequent with sea level rise. The viewer can be accessed online: http://www.csc.noaa.gov/digitalcoast/tools/slrviewer.

For more information, contact:
NOAA Coastal Services Center
2234 South Hobson Avenue
Charleston, SC 29405-2413
(843) 740-1200
www.csc.noaa.gov

Appendix I: Funding Options Considered

The information presented in this appendix is meant to inform implementation of Recommendation 7.1, which calls for the convening of an expert panel to provide an assessment and analysis of funding options for adaptation measures. It presents both ideas that were discussed by the advisory committee but dropped from consideration and ideas that were submitted during the public engagement sessions held in February 2013. The Sea Level Rise Advisory Committee did not endorse any of these ideas; they are simply presented here as information that could be useful for subsequent activities.

Specific Comments about Funding from Public Engagement Sessions

In its comment form for the adaptation public engagement sessions, the Sea Level Rise Advisory Committee asked the question: "Adapting to sea level rise can be costly for individuals, businesses and governments alike. Do you have ideas about how adaptation projects should be paid for?" At least 6 commenters specifically requested or encouraged the advisory committee to include funding provisions in the final plan and emphasized the importance of this issue. Many specific funding ideas were also submitted.

Public comments in response to this question generally fell in to one of four categories: (1) specific ideas for new or revised revenue streams, (2) general principles for spending funding (3) incentive and disincentives, or (4) new approaches that reduce need for revenue.

Specific Ideas for new or revised revenue streams

Taxes

- Create a carbon tax
- Create a National Flood Tax
- Increase the rate for Delaware's Public Accommodations Tax
- Include short-term rentals in Delaware's Public Accommodations Tax
- Allow for funds from the Public Accommodations Tax to be spent in New Castle County (and northern Kent)
    - Specific comments from a resident of Woodland Beach were received expressing frustration that she couldn't get help for erosion issues from the state.
- Reassess properties to increase funds to local governments from property taxes
- Implement a Coastal Security and Preservation Tax
- Increase the Real Estate Transfer Tax on homes near the coast
- Include a check-box on Delaware state taxes for contributions for adaptation

Fees

- Create new laws giving the Department of Natural Resources the authority to regulate development in the floodplain; set permit fees high enough to provide revenue for adaptation
- Create a stormwater utility
- Add a surcharge on the Route 1 toll to fund transportation adaptation projects

Incentives and Disincentives

- Include sea level rise in the funding and/or selection criteria for state funding programs
    - Water Pollution Control Revolving Fund
    - Drinking Water State Revolving Fund
- Allow funding/assistance for local governments/communities only if they have already implemented "best practices"
- Provide funding for sea level rise planning

General Principles for spending funds

- Require a local/community cost-share for adaptation projects
    - This particular idea came up numerous times, particularly with regard to drainage problems and beach replenishment
- Don't pay for short term fixes – invest in long term solutions
- Encourage planning for sea level rise through carrot and stick approaches
    - Incentivize good practices with grant funding or special programs
    - Deny funding to parties who are not participating

New Approaches

- Utilize innovative financial strategies
    - This could include reverse mortgages for long-term buyouts
    - Not specifically mentioned in comments, but could be considered under this category
- Property Assessed Clean Energy (PACE) example: homeowner upgrades paid for through loans made to homeowners through municipal bonds that are repaid via annual assessment on their property tax bill
- Special Financing Districts: Yearly taxes or fees established voluntarily by property owners within a specific geographic area for a community purpose. In Delaware, Tax Ditches and Tax Lagoons are an example

Initial List of Funding Ideas Considered by the Sea Level Rise Advisory Committee

The following list of ideas was generated for the consideration of the Sea Level Rise Advisory Committee as a result of focus group sessions held in October, 2012. These ideas were deleted from consideration prior to the public engagement sessions in February 2013 as the advisory committee thought it was premature to discuss any funding options until the overall funding need in the state was better understood. The following ideas, coupled with the ideas above that resulted from the public meetings, will be taken into consideration for the implementation of Recommendation 7.1.

- Modify the Hotel Accommodations Tax to increase funds
- Revise Strategies for State Spending to allow State Revolving Fund and other public funding to be allocated for projects in Level 4 areas
- Create a Revolving Loan Fund for adaptation responses
- Consider use of Regional Greenhouse Gas Initiative funds for adaptation actions in industrial areas
- Evaluate the federal Farm Bill or farmland conservation programs to identify financial compensation to encourage wetland migration on farmlands adjacent to wet areas
- Possible, broad funding sources: Total Maximum Daily Load funds, Cancer Settlement Funds, Hazardous Substance Cleanup Act funding, Federal Highway Administration Moving Ahead for Progress-21 Funding, and the new federal Energy Bill
- Increase funding availability for the Port of Wilmington

Delaware Sea Level Rise Advisory Committee

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