PREPARING FOR SEA LEVEL RISE
DEVELOPMENT OF A SEA LEVEL RISE INITIATIVE

Sea Level Rise Initiative Project Compendium September 2009

Photo by: Delaware Shoreline and Waterway Management Section

A compendium of Delaware Coastal Program Projects that Address Sea Level Rise

Contact:
Delaware Coastal Programs Office
(302)739-9283

Table of Contents

The Sea Level Rise Initiative…….…….……..…….1

Compendium Purpose…….……..……2

The Climate Change Action Plan……..…….…….….2

Sea Level Rise Initiative Flow Chart Project…….…….3

Timelines.…….…….……...……...4

Project Descriptions……..…7

I: Scientific and Technical Support…..…….…….. 7

Bombay Hook Hydrology/Sediment Movement Study……9

Coastal Impoundment Accretion Study……..….……..…….11

Coastal Monitoring Gap Analysis……...…..……..13

Coastal Storm History……..……...……..…..……15

Development of Coastal Inundation Maps……17

Kitts Hummock Hydrologic Monitoring…….…..……19

Lidar Marsh Elevation Correction……...……...…..…….....21

Marsh Loss Analysis……..……23

Marsh Vulnerability Index (Phases I-IV)……...…….……...25

Sediment Elevation Tables…….…..…..……...…….29

Digital Coast……..31

II: Implementation Actions…….……33

Development of a Coastal Resiliency Action Plan for Bowers Beach.....35

City of New Castle Coastal Resiliency Project…….…..……..37

Development of a Coastal Flood Monitoring System…….…….……39

III: Policy Development……...…….....41

Statewide Adaptation Plan…….…….…….43

Sustainable Coastal Communities Project…….…….……..47

Mid-Atlantic Regional Council on Oceans……...…….……..49

IV: Communication, Training, and Public Involvement….51

Google KML Map Development…….….……53

Comprehensive Public Outreach Strategy…….……...……55

Survey of Sea Level Rise Attitudes and Perceptions…..……..……..57

The Sea Level Rise Initiative

Sea level rise has the potential to significantly impact Delaware's economy, coastal resources and communities over the next several decades. Rising sea levels can submerge low-lying lands; erode beaches; convert wetlands to open water; contribute to more severe coastal flooding; and increase the salinity of estuaries and aquifers.

Sea level rise is currently occurring in Delaware; data has shown that sea level has increased by over a foot over the past century. Scientists believe that the rate of sea level rise will accelerate in the coming years. Both the Intergovernmental Panel on Climate Change and the U.S. Climate Change Science Program have concluded that it is very likely that rates of sea level rise will be greater in the coming century than in the last century. Although sea levels have fluctuated significantly throughout the Earth's history, due to human development and alterations of the landscape, the coastline can no longer adapt naturally to these changes as it has in the past.

In order to prepare for sea level rise and prevent future damages to coastal communities, we must understand and plan for the potential impacts of accelerated sea level rise. To help reach this goal, the Delaware Coastal Programs Section of the Delaware Department of Natural Resources and Environmental Control has begun its multi-year Sea Level Rise Initiative. The goal of the Initiative is to develop policies that address sea level rise through the Statewide Sea Level Rise Adaptation Plan, provide scientific technical decision support for these policies, successfully implement the policies in order to effectively address sea level rise, and educate stakeholders and the public on sea level rise issues and adaptation strategies. These goals complement one another, and are interconnected with DNREC's climate change interests and its external, regional, and national efforts (see page 3).

The projects that have been initiated under the Sea Level Rise Initiative help Delaware reach the final goal of effectively preparing coastal communities and habitats for sea level rise in four ways. First, some projects are designed to provide the necessary data needed to assess vulnerabilities and to make policy decisions. For instance, the Marsh Vulnerability Index will use biomass sampling to assess which of Delaware's marshes are most vulnerable to sea level rise. This will allow decision makers to decide which marshes to protect and where to allocate resources. Second, some projects are designed to be pilot implementation projects, providing needed assistance to coastal communities while providing a learning opportunity for state staff. Pilot projects are currently underway in Bowers Beach and the City of New Castle; assistance will be provided to other communities in future years. Third, some projects are designed to provide tools, training and information to stakeholders, managers and the public. An on-line tool will soon be available to assist with inundation mapping and a Statewide survey of public attitudes and perceptions is underway. A comprehensive outreach strategy will be designed based upon the results of these, and other, initiatives. Lastly, all of the data, information and tools that are developed throughout the Sea Level Rise Initiative will be used to inform policy development through the Statewide Sea Level Rise Adaptation Plan. This plan will bring stakeholders together to develop plans and policies to address sea level rise.

The Sea Level Rise Initiative is designed to be iterative and will grow and change as new data, outreach and policy needs are identified.

Purpose of this Compendium of Sea Level Rise Initiative Projects

The purpose of this compendium is to provide an at-a-glance inventory and timeline of projects (see pages 4-6) that are currently underway as part of the Delaware Coastal Programs' Sea Level Rise Initiative. It also provides a way to visualize how these projects fit together. Projects conducted by other agencies are not represented in this document, but there are many other agencies whose work will be essential to preparing for sea level rise and coastal inundation.

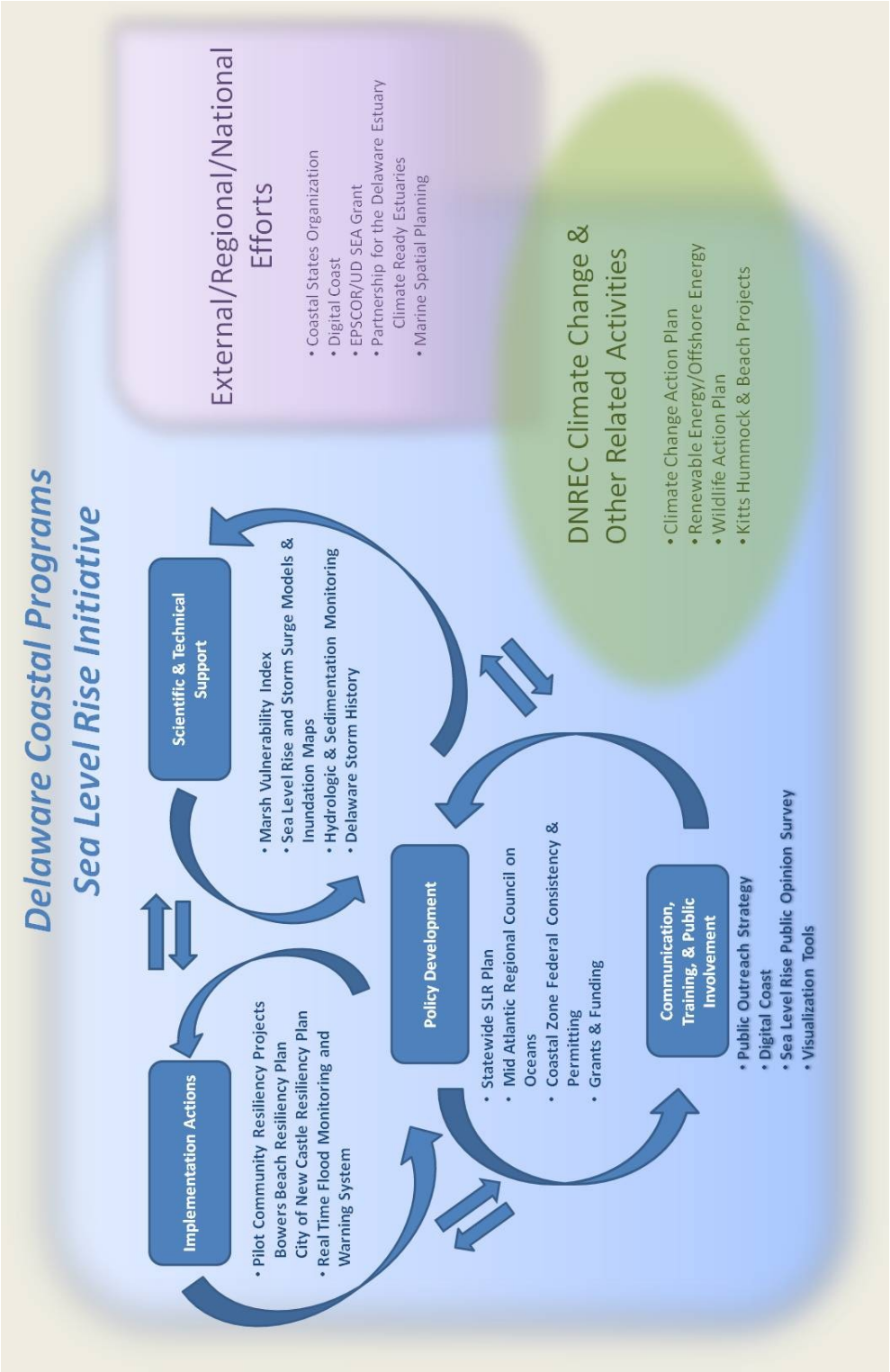
The projects listed in this document are evolving. The timelines, process and intended outcomes of each project within this compendium are subject to change. However, it is the intent to update this document on a routine basis so that our partner agencies can be kept up to date on sea level rise activities.

Linkages to the Climate Change Action Plan

The Delaware Department of Natural Resources and Environmental Control is in the process of creating a Climate Change Action Plan for the state of Delaware. This Sea Level Rise Initiative will be an important part of the Climate Change Action Plan, and the projects within this compendium will play an important role preparing the state for the effects of climate change.

For More Information

For more information about projects contained within the Sea Level Rise Initiative Compendium, please contact us at (302) 739-9283 or see our website: http://www.swc.dnrec.delaware.gov/coastal/Pages/SeaLevelRiseAdaptation.aspx


Delaware Coastal Programs
Sea Level Rise Initiative
Implementation Actions
• Pilot Community Resiliency Projects
Bowers Beach Resiliency Plan
City of New Castle Resiliency Plan
• Real Time Flood Monitoring and Warning System
Scientific & Technical Support
• Marsh Vulnerability Index
• Sea Level Rise and Storm Surge Models & Inundation Maps
• Hydrologic & Sedimentation Monitoring
• Delaware Storm History
Policy Development
• Statewide SLR Plan
• Mid Atlantic Regional Council on Oceans
• Coastal Zone Federal Consistency & Permitting
• Grants & Funding
Communication, Training, & Public Involvement
• Public Outreach Strategy
• Digital Coast
• Sea Level Rise Public Opinion Survey
• Visualization Tools
External/Regional/National Efforts
• Coastal States Organization
• Digital Coast
• EPSCOR/UD SEA Grant
• Partnership for the Delaware Estuary Climate Ready Estuaries
• Marine Spatial Planning
DNREC Climate Change & Other Related Activities
• Climate Change Action Plan
• Renewable Energy/Offshore Energy
• Wildlife Action Plan
• Kitts Hummock & Beach Projects

Project	FY09		FY10				FY11			
	3rd	*4th*	*1st*	*2nd*	*3rd*	*4th*	*1st*	*2nd*	*3rd*	*4th*
I: Scientific and Technical Support										
Coastal Impoundment Accretion Rate Study	Prime Hook Coring & Analysis									
		City of New Castle Impoundment Coring & Analysis								
			Lower New Castle County & Kent County Impoundment Coring & Analysis							
					Additional Coring & Analysis if Needed, Report Compilation					
Coastal Monitoring Gap Analysis	Determination of Additional Monitoring Locations									
Coastal Storm History	Update of 1974 Report on Coastal Storm Damage									
LiDAR -Marsh Elevation Correction			Site Selection and Survey of Spartina Locations							
							Site Selection & Survey of Targeted Species Locations			
Tidal Marsh Vulnerability Index	Biological Indicator Development									
			Correlation of BI w/ Elevations							
					Statewide & Species Expansion - Dependant on Outcomes of Earlier Work					
Sediment Elevation Tables	Ongoing Monitoring and Analysis of Sediment Elevation Tables w/ Bi-Annual Reports									
Kitts Hummock Hydrologic Monitoring	Water Level & Flow Monitoring									
				Tentative Project Expansion Dependant on Funding & Staffing						
Inundation Maps	Based on Statistically Derived Surge Elevations									
Bombay Hook Marsh Loss	Initial Monitoring and Analysis									
							Tentative Continued Monitoring & Analysis Dependant on Funding & Staffing			

Project	FY09		FY10				FY11			
	3rd	*4th*	*1st*	*2nd*	*3rd*	*4th*	*1st*	*2nd*	*3rd*	*4th*
II: Implementation Actions										
Bowers Beach Coastal Resiliency Project		Data Collection & Synthesis								
		Vulnerability Assessment								
			Strategy Development and Implementation							
City of New Castle Coastal Resiliency Project		Determination of Current and Future Needs for Coastal Protection								
			Engineering Analysis of Dikes and Tide Gates							
							Hydrodynamic Analysis of Diked Basins			
Development of a Coastal Flood Monitoring System	DEOS Early Warning System Development and Implementation									
III: Policy Development										
Statewide Adaptation Plan	Workshop & Committee, Workgroup Establishment									
			Issues Characterization & Strategy Development							
						Implementation Strategies				
Sustainable Coastal Communities Project		Release RFP and Award Grants								
			Grant Management							
MidAtlantic Council on Oceans		Stakeholder Summit								
			Refine Action Plan and Implementation Recommendations							

Project	FY09		FY10				FY11			
	3rd	*4th*	*1st*	*2nd*	*3rd*	*4th*	*1st*	*2nd*	*3rd*	*4th*
IV: Communication, Training, and Public Involvement										
Google KML Map Development		Develop Website and KML Maps								
Comprehensive Public Outreach Strategy		Strategy Development			Strategy Implementation (on-going)					
Digital Coast Inundation Tool Kit		Review &Application of CSC Digital Coast Toolkit								
Survey of Sea Level Rise Attitudes and Perceptions		Develop and Conduct Survey	Analyze Results and Final Report	Public Outreach & Meetings						

Scientific and Technical Decision Support

Bombay Hook Hydrology/Sediment Movement Study

Coastal areas and natural resources are particularly vulnerable to climate change, especially with respect to accelerated sea level rise, shoreline erosion, increased storm frequency and intensity, changes in rainfall, and related flooding among other potential impacts. Investigation of such impacts, specifically marsh depletion and increased mudflats at Bombay Hook, will be conducted to determine patterns of sediment flux in or out of the depleted marsh area.

Data collection will involve conducting river transects within the Leipsic River using the Acoustic Doppler Current Profiler (ADCP) and associated software to collect and process tide and current data. Water quality will also be monitored, specifically total sediment solids (TSS) to aid in determining sediment fluxes in or out of the depleted marsh area.

Geographic Location:

Bombay Hook National Wildlife Refuge.

Outcome:

This study will result in a written report that includes a summary of results; discussion of data analysis and statistical procedures. Results will be used to predict future changes in marsh depletion and to help determine marsh management techniques to counteract these impacts affecting the tidal marshes at Bombay Hook.

Activities/Schedule:

1. Installation of monitoring equipment. Install 5 water level recorders and 1 Acoustic Doppler Current Profiler.

2. Perform cross-section current profiles and collect data. Perform a series of cross-section current profiles at various locations over varying tidal stages and collect water level and ADCP data.

3. Analyze data and write report. Data analysis and interpretation leading to final report

Activity	# months req'd for completion	Estimated Completion Date	Status
1	1	May 2009	Completed
2	6	December 2009	Ongoing
3	3	March 2010	Pending

Agencies Involved:

DNREC Delaware Coastal Programs
USFWS

Coastal Impoundment Accretion Rate Study

As an accelerated rate of relative sea-level rise further stresses impounded marshes, there is a greater need to evaluate the long-term sustainability and utility of impoundments in Delaware. In order to do this, baseline data regarding historic sedimentation rates is needed.

Baseline data sets of long-term sedimentation rates in impounded and natural wetlands can be utilized to evaluate the impounded wetlands' ability to achieve optimal habitat benefit under different management strategies and under different sea level rise scenarios
Long-term sedimentation rates over the past 100 and 50 years can be calculated by collecting radioisotopic cores from wetland areas and analyzing them for ^{210}Pb and ^{137}Cs, . All core sites and the adjacent wetland will be surveyed to tie all data to the tidal datum (NAVD 88). Correlating long-term wetland sedimentation rates to current wetland elevation will enable a detailed analysis of the potential sedimentation deficits that exist within the impoundments, as compared to the reference wetlands. The elevation and sedimentation gradients between the reference and impounded wetlands can be used to calculate potential future elevation trajectories under different sea-level rise and management scenarios.

Geographic Location:

Monitoring sites were chosen within impounded and reference (natural marsh) sites throughout the State based upon a wetland area change analysis (using a time-series of available imagery), and basins that have been identified as needing detailed study to aid in their management to optimize the future available habitat. Sites that will be studied include: marshes along the Delaware River near New Castle; Ted Harvey Wildlife Area; St. Augustine Wildlife Area; and Primehook National Wildlife Refuge.

Outcome:

When complete, this study will provide information to coastal managers regarding marsh susceptibility to sea level rise under different marsh management scenarios and under different sea level rise scenarios A long-term comparison of the wetland elevation and sedimentation conditions between the impounded marsh and the "natural" marsh will enable a detailed analysis and comparison of the potential long-term growth conditions and highlight the potential implications for impoundment management that could affect the sustainability of the interior wetlands. This information will allow marsh managers to understand the potential outcomes of sea level rise and adapt their management techniques.

Activities/Schedule:

1. Initial Impoundment Core Collection. Radioisotopic cores will be collected from selected marshes. All core sites and adjacent wetlands will be surveyed. Samples will be sent for gamma spectroscopy analysis at the University of Delaware College of Earth, Ocean and Environment. Core analysis is scheduled to be complete by December 2009.

2. New Castle Impoundment Core Collection. Radioisotopic cores will be collected from 3 impoundments and 2 reference marshes along the Delaware River adjacent to the City of New Castle. All core sites and adjacent wetlands will be surveyed after collection. Samples will be sent for gamma spectroscopy analysis at the University of Delaware College of Earth, Ocean and Environment. Core analysis is expected to be complete by December 2010.

3. Kent County and Lower New Castle County Impoundment Core Collection. Radioisotopic cores will be collected from Ted Harvey Wildlife Area, St. Augustine Wildlife Area, and Primehook National Wildlife Refuge. The Ted Harvey and St. Augustine sites were selected to expand the scope of the impoundment investigation to include sites along the entire Bay and River coast. All core sites and adjacent wetlands will be surveyed after collection. Samples will be sent for gamma spectroscopy analysis at the University of Delaware College of Earth, Ocean and Environment. Core analysis by UD is expected to be completed by December 2011.

4. Gap Analysis of Delaware Coast. A gap analysis of the Delaware River and Bay Coast Impoundments and reference marshes will be conducted to identify areas where additional cores should be collected and analyzed. The previously analyzed cores will be examined to evaluate the spatial and temporal variability within the study areas and evaluate the need for additional coring sites. A total of 18 cores will be collected to fill in the identified data gaps and areas of high spatial sedimentation rate variability.

Activity	# months req'd for completion	Activity Start Date	Estimated DCP Completion Date	Estimated Laboratory Completion	Status
1	5	November 2008	March 2009	April 2010	In Progress
2	8 - 10	April 2009	November 2009	December 2010	In progress
3	6	December 2009	May 2010	December 2011	Pending
4	8	May 2010	January 2011	December 2012	Pending

Agencies Involved:

DNREC Delaware Coastal Programs
UD College of Earth, Ocean and Environment
Primehook National Wildlife Refuge (USFWS)
DNREC Division of Fish and Wildlife

Coastal Monitoring Gap Analysis

In the last two decades, storms such as Hurricanes Katrina and Ike along the Gulf of Mexico and Floyd and Hugo along the Atlantic Coast of the United States have resulted in significant loss of life, injuries and property damages reaching well over 100 billion dollars. Much of the damage associated with these and other tropical and extra-tropical weather systems is associated with severe coastal flooding. The Delaware coastline is extremely vulnerable to such events, examples being the great March, 1962 storm and the recent coastal flooding incident of May 12, 2008.

As part of a cooperative effort between the University of Delaware and several Delaware State Agencies to better monitor conditions along the Delaware coastline and to provide advance warning of impending coastal flooding events, we propose the completion of a GAP Analysis of pertinent coastal data needs and a comprehensive survey of inland inundation levels during previous coastal flooding events. The GAP Analysis will define the present state of coastal data collection efforts across the state, an "optimum" data collection network and the gap between them, indicating those data that need to be added to the current network. A survey of high water marks from previous coastal flooding events will be used to create a "baseline" data set to aid in understanding the relationships between water levels at tidal monitoring points and inland locations. In this research, an exhaustive inventory of real-time and archived coastal data will be conducted. This inventory will include meteorological, tidal, buoy, water quality and inundation data sources, along with ancillary sources of coastal information (i.e. research publications, modeling work, etc.).

Geographic Location: Coastal Delaware.

Outcome:

The final outcome/product will be a report that makes recommendations as to the type of data needed to reach an "optimum" coastal monitoring network, and the spatial placement and temporal resolution of additional sensors that may need to be deployed to reach the optimum configuration.

Activities/Schedule:

1. GAP Analysis Report. University of Delaware will conduct the analysis and develop a report that makes recommendations as to the type of data needed to reach an "optimum" coastal monitoring network.

Activity	# months req'd for completion	Estimated Completion Date	Status
1	9	March 2010	Contract issued

Agencies Involved:

DNREC Delaware Coastal Programs
University of Delaware

Coastal Storm History

Several coastal communities in Delaware currently experience storm damage, coastal erosion, and other coastal hazard impacts. In efforts to reduce hazard vulnerability that currently exists and that could potentially increase in the future due to climate change impacts, the Delaware Coastal Programs, along with the University of Delaware are compiling data on historical storms, nor'easters, subtropical storms or hurricanes that may have impacted Delaware's coasts in the past.

This data was previously compiled by the University of Delaware for years up through 1974 and a written report is available. This project will focus on updating the storm data from 1974 to 2009.

Geographic Location: Coast of Delaware.

Outcome:

Compendium of historical storm data categorized according to the type of storm, physical characteristics and impacts on coastal communities and natural resources. This can perhaps be used to derive specific scenarios to be modeled for the purpose of future adaptation and preparedness. It will also help to identify where outside expertise should be brought in to provide additional technical assistance for resiliency assessment, planning and implementing. Depending on the detail of the data collected, there may be some insight for prediction of the next potential storm, nor'easter or hurricane and the impacts of such events.

Activities/Schedule:

1. Storm data collection. Through analysis of historic data sets and communication with local and state officials and the public, historic storm information will be compiled.

2. Development of Report. A compilation report will be developed and distributed. The report will include storm data from 1974 to present including all pertinent data.

Activity	# months req'd for completion	Estimated Completion Date	Status
1	12	Sept 2010	Pending
2	6	March 2011	Pending

Agencies Involved:

DNREC Delaware Coastal Programs
University of Delaware

Development of Coastal Inundation Maps

Sea Level Rise inundation maps are necessary to determine areas and extent of coastal vulnerability to sea level rise, and will be a key component guiding the development of a Statewide Sea Level Rise Adaptation Plan. While it is relatively straight forward to overlay elevated sea level changes onto existing digital elevation models (DEMs), certain factors must be considered. Primarily, mean tide levels vary along the Delaware Bay Coast and any maps developed must take this into consideration. Secondly, solely using sea level rise will not give a true perspective of inundation, since the major concern will be the flooding from coastal storm surges.

To develop these maps (GIS Layers) a statistical evaluation from the existing 2 long-term NOAA tide level datasets of Lewes (Breakwater Harbor) and Delaware City (Reedy Point) will be performed to establish storm surge elevations above Mean Higher High Water (MHHW) for selected return periods (i.e. 10, 25 50, 100-year return periods). Once these are calculated, the current MHHW levels along the length of the coast will be determined using the NOAA VDatum software. These two datasets will be combined to establish the appropriate elevations to use for coastal inundation. After the Delaware Bay coast is completed, a similar effort will be performed for the Inland Bays and Atlantic Coast.

Geographic Location:

Coastal Delaware

Outcome:

The final outcome/product will be a series of maps in GIS format that will be based on the bare earth LIDAR data. Several scenarios will be developed using on current sea level rise, predicted average sea level rise and predicted maximum sea level rise for the years 2050 and 2100. Estimates of storm surge added to the predicted elevations will also be provided. These surges will be based on historic data and statistical analysis.

Activities/Schedule:

1. Statistical Analysis of existing tide data. Based on existing data for Lewes and Delaware City, develop expected storm surge levels for certain return periods.

2. Determine MHHW for Bay Coast. Using VDatum, determine MHHW along Delaware Bay coastline corrected to NAVD88

3. Develop Inundation Maps for Delaware Bay Coast. Combining the two developed datasets, produce GIS maps for different seal level and storm surge scenarios

4. Inland Bays and Atlantic Coast Maps. Repeat 1-3 for Inland Bays and Atlantic Coast.

Activity	# months req'd for completion	Estimated Completion Date	Status
1	2	September, 2009	Completed
2	<1	October, 2009	Pending
3	2	December, 2009	Pending
4	1	January, 2009	Pending

Agencies Involved:

DNREC Delaware Coastal Programs

Hydrologic Monitoring of the Kitts Hummock Area

To properly understand the relationships between the Delaware Bay, interior marsh water levels, ponds, impoundments and the drainage ditch network around Kitts Hummock, a comprehensive water level monitoring program will be established. Establishing a water level monitoring network at key locations will aid in the understating the interrelationships between the water bodies and the influence of the drainage network in the community on these water bodies. This baseline monitoring is one of the prerequisite needs for conducting any defensible modeling and evaluation of the effectiveness of any proposed drainage improvements to the Kitts Hummock area. Additional needs prior to modeling include validation of marsh elevations, detailed documentation and assessment of previous storms, and engineering designs of proposed alterations

This baseline network will use a total of 8 Inset HOBO water level recorders in conjunction with the USGS Tide gauge located approximately 5 kilometers south at Bowers Beach and other currently monitored parameters. Two water level recorders will be placed on the north and south sides of Kitts Hummock Road in the primary N/S drainage ditch approximately 250 meters inland from the Delaware Bay. An additional three water level recorders will be used to examine the effects of marsh water elevation and the northern impoundment of the Logan Lane Tract of the Ted Harvey Conservation Area on the open water area of a private property and the South Bay Drive drainage ditch. The final two water level recorders will be installed in open water areas of the marsh northeast of the community of Kitts Hummock to estimate the tidal backwater effects north of Kitts Hummock Road. A final recorder will be housed at the Delaware National Estuarine Research Reserve (DNERR) to measure barometric pressure changes which will be used to atmospherically correct the readings of the water level recorders. The recorders will be surveyed to an accuracy of +- 2 cm vertical, and maintained and downloaded monthly by staff from the DNERR.

Geographic Location:

This project encompasses the area surrounding Kitts Hummock, Kent County, DE, including the private marsh lands north and south of the community and the DNREC/DFW Logan Lane Tract of the Ted Harvey Conservation Area.

Outcome:

Once sufficient data has been collected, which includes a minimum of 3 months of data and at least 3 significant storm events, the data will be compiled. Data on rainfall and wave height, period and direction, currently being monitored by the DNERR, will be incorporated into the data set and then the dataset will be analyzed. This analysis will include examining the Bay tide effects on marsh water/drainage ditch elevations; relationships of surrounding water levels on the Thompson open water area; probable pathways of tide related flooding; and a qualitative evaluation of the expected effectiveness of drainage ditches in the area during different tidal cycles/storm events.

Activities/Schedule:

1. Data Collection. Install data recorders, survey locations and collect data.

2. Data Analysis. Analyze data, run computer simulations, develop qualitative evaluation of storm event drainage scenarios.

Activity	# months req'd for completion	Estimated Completion Date	Status
1	3-5	October 2009	In Progress
2	3	December 2009	Not Underway

Agencies Involved:

DNREC Delaware Coastal Programs
DNREC Drainage and Stormwater Section
DNREC District Operations

LiDAR -Marsh Elevation Correction

Light Detection and Ranging (LiDAR) data elevation models (DEMs) are now available state wide. LiDAR elevation data can be within a few centimeters of the actual elevation on a smooth, hard surface, however, over heavily vegetative or rough surfaces the accuracy can severely degrade to 20 to 30 cm or more. When developing maps or models for sea level rise and coastal inundation, these discrepancies can become critical. This project will examine various marsh habitats across the state to determine if a correction algorithm can be developed to refine the accuracy of the DEMs over the marsh.

Geographic Location:

The wetland cover from select watershed from each county will be used for the initial assessment stage of the project. The DNERR sites will be used for New Castle County (Blackbird Creek Watershed) and Kent County (St. Jones Watershed), while Rehoboth and Indian River Bay Wetlands will be used for Sussex County.

Outcome:

If successful, algorithms will be developed based on location (county) and predominate marsh species to correct existing LiDAR data to provide better elevation accuracy within marshes. These algorithms will be applied to the LiDAR GIS layers for the corresponding areas or species to produce Marsh DEMs of suitable accuracy for other sea level rise projects.

Activities/Schedule:

1. Preliminary Feasibility Assessment. An initial assessment will determine the reasonable feasibility of developing a wetland correction factor for the existing LiDAR. Real-Time Kinematic (RTK) GPS surveys will be conducted during March and April (the same time period in which the LiDAR was collected), throughout the three study areas to determine the amount of offset between the LiDAR and the true wetland surface elevation. Trends and difference statistics will be calculated to highlight the elevation offsets among the three largest vegetative covers within the marshes (potential species could include: *Spartina alterniflora*, *Phragmites australis*, *Spartina cynosuroides*, and/or high marsh community). An algorithm will be created for each of the wetland species for each study area. These algorithms will be then used to create new digital elevation models (DEM's) for each study area. The prototype corrected LiDAR for the three study wetland areas will then be validated through additional RTK surveys to assess the reliability of the correction algorithm. A statistical analysis of the predicted prototype wetland elevation comparison to the true RTK elevations will be reported at the completion of this activity. A detailed assessment of the feasibility of creating statewide wetland LiDAR corrections will be included in the final preliminary assessment report. This will include detailed expected timelines, data needs, and an assessment of the density of surveying that will need to be conducted.

2. RTK Surveys of Statewide Wetlands. RTK Surveys will be conducted in wetlands in all three counties, in the three dominate vegetation covers. Algorithms will be developed for each watershed in each county.

3. Develop new Statewide DEMs. New DEMs will be produced for marsh areas using existing LiDAR and developed algorithms.

Activity	# months req'd for completion	Estimated Start Date	Estimated Completion Date	Status
1	6	March 2010	August 2010	Proposed
2	7	March 2011	September 2011	Proposed
3	3	Sept 2011	December 2011	Proposed

Agencies Involved:

DNREC Delaware Coastal Programs
Center for the Inland Bays
DNREC Watershed Assessment

Marsh Loss Analysis (Interior Open Water Creation)

Staff from Bombay Hook NWR contacted the Delaware Coastal Programs for assistance with their 5-year Biologic Review of the refuge. Refuge staff felt that DCP's experience with GIS analysis could help them answer some questions they had about the changing habitat of the refuge. Coastal change, rising sea levels, erosion and land subsidence are increasingly tough issues facing coastal managers, engineers, and planners charged with developing and protecting coastal habitats and communities in vulnerable coastal zones. Understanding these threats depends on early detection, and solutions will require vigorous public debate over engineering solutions vs. strategic retreat. The drastic changes at Bombay Hook National Wildlife Refuge (NWR) may be a harbinger of coast-wide habitat changes in the future.

The coastal areas of Bombay Hook NWR have historically been subjected to significant erosion. Historical shorelines from as far back as 1842 paint a much different picture than exists today. Shores that face the East and Southeast take the worst damage. These areas have the longest fetch allowing the winds to add more power to the waves that break on these shores. For the period 1937-2002, roughly 1700 ft. of erosion occurred along the southern shoreline of Bombay Hook (26 ft/yr). This habitat loss is now coupled with increasing amounts of open water creation in the interior marsh.

Aerial photos from 1979, 1992, and 2002 were examined for expansion of open water areas in the interior marsh. Photos were viewed on a geographic information system and areas of open water were outlined. Results showed that, over the years, open water areas were growing larger and combining together. What had been a mosaic of small areas of open water mixed in vegetated marsh are becoming large tracts of open water with vegetation around the edges. This Study revealed that since 1979, the Refuge has lost a total of 12% of its wetland area; 10% attributed to the creation of interior, open water areas.

No single, direct cause for the wetland loss has yet been identified. Some potential causes including sea level rise, marsh/land subsidence, and snow goose grazing are being looked into. These effects are inter-related and tend to work together to make matters worse. Currently DCP and others are using sediment elevation tables to explore subsidence and sedimentation in regional marshes. It is hoped that if a cause(s) can be determined, adjustments in marsh management can be made to stem the loss of interior area.

This project will investigate the expansion of open water areas in four additional areas throughout the state: the Thousand Acre Marsh region; Blackbird Creek; Milford Neck and Primehook National Wildlife Refuge. For each area, open water areas will be digitized using ArcGIS from historic aerial photographs to determine extent of open water areas over time.

Geographic Location:

DCP is now expanding the study to other similar marsh areas around the State: 1000 Acre Marsh, Blackbird Creek, Milford Neck Wildlife Area and surrounding private conservation lands; and Prime Hook NWR with nearby areas in Broadkill Beach.

Outcome:

This project will result in GIS maps of marsh loss over time for the study areas.

It is also hoped that this information can be combined with results from other studies and may shed light on the causes of the wetland loss. This combination of information is expected to lead to management changes that can limit further loss and possibly aid recovery of the marshes.

Activities/Schedule:

1. Digitize open water areas – Bombay Hook.
2. Digitize open water areas – 1000 Acre Marsh.
3. Digitize open water areas – Blackbird Creek.
4. Digitize open water areas – Milford Neck.
5. Digitize open water areas – Prime Hook.

Activity	# months req'd for completion	Estimated Completion Date	Status
1.			Complete
2.			Complete
3.			Complete
4.			Complete
5.	1 week		2/3 Complete

Agencies Involved:

Delaware Coastal Programs

Tidal Marsh Vulnerability Index

An index is needed to allow assessment of the long-term viability of Delaware's marshes under differing sea level rise scenarios and to target areas for conservation, restoration and monitoring. The Tidal Marsh Vulnerability Index will be based upon the positive correlation between mean tidal range and elevational growth range of tidal wetland plant species. Biomass sampling, taken from the Mid-Atlantic Wetland Rapid Assessment Method (MidTRAM), will also be incorporated into the Marsh Vulnerability Index to assess marsh health. Once developed, the Sea Level Rise Index for Tidal Marshes tool could be transferred to other states and used for regional comparisons and regional planning.

The Tidal Marsh Vulnerability Index will classify marshes as healthy, degrading or severely degrading. These classifications will be utilized to select areas to conduct detailed sediment accretion rate and other monitoring. Degraded and severely threatened marshes are known to have lower elevations, relative to the tidal prism, and are more prone to catastrophic losses due to sea-level rise and storm events. Understanding the current and historic sedimentation accretion rates of these marshes can help to better predict the longevity and the sediment deficits of these areas and possible management practices that might be implemented to prevent marsh elevation losses (i.e. thin layer application of sediment, vegetation plantings, etc.).

The Tidal Marsh Vulnerability Index, in conjugation with time-series analysis of aerial imagery, will be essential for evaluating wetland vulnerability on a watershed or statewide basis, while enabling the strategic placement of monitoring resources to enhance our efforts to understand the future evolution potential of Delaware's tidal wetlands. All field based monitoring and sampling efforts can be initiated and implemented to evaluate the most severely threatened marsh areas first; the monitoring can then be expanded to encompass other marsh regions as resources become available. Marsh Vulnerability Index classification optimizes the monitoring efforts and resources to the highest levels possible, so the broadest extent of Delaware's tidal wetlands may be evaluate and managed.

Geographic Location:

Phase I & II will occur in the two components of the Delaware National Estuarine Research Reserve, and the National Estuary Program, Center for the Inland Bays. *Phase III & IV* will occur in tidal marshes along the Delaware Bay Coast and Inland Bays

Outcome:

Phase I will develop a marsh vulnerability index for *Spartina alterniflora* at three test sites located within the Delaware National Estuarine Research Reserve and the National Estuary Program's Center for the Inland Bays. These three target sites encompass all three counties and three different salinity regimes. This phase will use GIS data, aerial photos, LiDAR data and the Statewide Wetland Mapping Program data along with field validation to develop a *Spartina alterniflora* tidal growth range. These site specific values will be compared with the other regions and values the literature to determine if a Statewide or regional Marsh Vulnerability

Index can be developed for *Spartina alterniflora* marshes. Individual marsh polygon elevations will then be compared with the Marsh Vulnerability Index to estimate the sustainability of that particular marsh.

Phase II will develop a marsh vulnerability index for other vegetation types within the same three test sites. Indicator species will be identified that are typically found in other areas of coastal Delaware. These species can be homogeneous communities (species specific index) or common heterogeneous communities (composite index). Based on the maximum/minimum elevations derived from the Arc/GIS analysis, a site specific indicator species composite tidal growth range will be developed. These site specific values will be compared with the other regions to determine if a Statewide or regional composite Marsh Vulnerability Index can be developed for marshes dominated by certain indicator species. The individual marsh polygon elevations will be compared with the Marsh Vulnerability Index to estimate the sustainability of that particular marsh. The outcome of Phase II is contingent upon Phase I and a positive index created for *Spartina alterniflora*.

Phase III will develop a statewide Marsh Vulnerability Index for *Spartina alterniflora* marshes. Contiguous areas of *Spartina alterniflora* will be identified using SWMP data and ArcGIS polygons will be created. Marsh elevation and tidal ranges and mean tide elevations will be determined from the LiDAR dataset and/or additional on the ground sampling. Based on the maximum/minimum elevations derived from the Arc/GIS analysis a refined *Spartina alterniflora* tidal growth range will be developed. The *Spartina alterniflora* marshes throughout the State will then be classified using the Marsh Vulnerability Index

Phase IV will produce a Statewide Marsh Vulnerability Index for several indicator marshes throughout the State. Contiguous areas of indicator marshes along the Delaware Coast will be identified and these areas will be defined as polygons in Arc/GIS. A random sampling of the sites will be done to insure the proper identification of the species. Mean, median, maximum and minimum elevations will be determined for each marsh polygon, and actual marsh elevation will be determined with LiDAR data. Additional field sampling may be conducted to verify elevations. The tidal ranges and mean tide elevation will be determined for a range of regions along the Delaware Bay coast. Based on the maximum/minimum elevations derived from the Arc/GIS analysis, a refined indicator species tidal growth range (both species specific and composite indexes) will be developed. The indicator species in marshes throughout the State will then be classified based on marsh species structure, larger contiguous marshes will then be classified using the Marsh Vulnerability Index. The outcome of Phase IV is contingent upon Phase I and a positive index created for *Spartina alterniflora*.

Activities/Schedule:

1. Phase I. Develop *Spartina alterniflora* index for DNERR and CIB locations.

2. Phase II. Develop multiple species indexes for DNERR and CIB locations.

3. Phase III. Develop *Spartina alterniflora* index for coastal Delaware locations.

4. Phase IV. Develop multiple species indexes for coastal Delaware locations

Activity	# months req'd for completion	Estimated Completion Date	Status
1	12	March 2010	In progress
2	12	March 2011	Pending
3	12	March 2012	Pending
4	12	March 2013	Pending

Agencies Involved:

DNREC Delaware Coastal Programs
University of Delaware

Sediment Elevation Tables

Sediment elevation tables (SETs) provide a nondestructive method for making highly accurate and precise measurements of sediment elevation in intertidal and subtidal wetlands over long periods of time, relative to a fixed subsurface datum. Data collected using SETs can be used to determine both the influence of a single meteorological event on sediment surface elevation and a long-term trend in elevation change. This information will help increase our understanding of sedimentation rates in different marshes, sea level rise effects in these marshes, and potential management techniques.

This project will continue to collect data from established SETs within the St. Jones and Blackbird Creek estuaries. These SET's have datasets that began in 2004-2005 for Blackbird Creek and 2004 and 2007 for St. Jones River. The datasets contain total surface elevation change, shallow surface elevation change, sedimentation, deep subsidence, and shallow subsidence trends.

Marsh surface elevation changes are not merely being controlled by sediment deposition or erosion; subsurface processes are playing a major role in controlling elevation. Separating the influences of the biological (root growth), geological (soil compaction) and hydrological processes (groundwater storage) can be very difficult at best. Measurements from the deep benchmark will document and illustrate the effect that subsidence and compaction (the consolidation and dewatering of the fine grained material deep in the marsh sediments) are having on marsh surface elevation, with these changes in the zone of deep subsidence. The shallow benchmark will localize the effects that occur in the root zone (from the surface to ~ 30 to 50 cm below the sediment surface), such as enhanced growth due to nutrient fluxes, decomposition, compaction, dewatering, and pore water fluxes. Thus, it can be determined whether the subsurface influences are occurring (in the root zone or at deeper depths) and make a first approximation of which processes are dominating elevation change.

Geographic Location:

The project will be conducted within the St. Jones Estuary in Kent County, Delaware and the Blackbird Creek Estuary in New Castle County, Delaware.

Outcome:

This study will result in a written report that includes a summary of results, discussion of data analysis and statistical procedures. Results can then be used to determine both the influence of a single meteorological event on sediment surface elevation and a long-term trend (i.e. decades) in elevation change, as well as make predictions for future elevation changes in our local marshes.

Activities/Schedule:

1. SET Monitoring. SETs will be monitored and read in the St. Jones and Blackbird watershed every 3 months, approximately, at the end of each season (i.e. fall, winter, etc.) on the same lunar cycle. Readings will take a total of 4 days per monitoring cycle (2 days each for the St. Jones and Blackbird), for a total of 16 field days for the year. Winter readings could be skipped due to high ice volumes on the marsh surface, which negate the ability to reliable measure the marsh surface.

2. Status and Trends Report. A status and trends report of the SET data will be drafted and peer reviewed every two years, for both the St. Jones and Blackbird SET networks. The first report will be completed by May 2010. The report will also include a gap analysis on the current coverage of SET networks across the state and highlight the gaps in spatial distribution, and make recommendations for future SET placements that could help increase the wetland monitoring.

Activity	# months req'd for completion	Estimated Completion Date	Status
1	On going	Expected 15 to 20 year data set (2019)	On going
2	2	First report, May 2010	On going

Agencies Involved:

DNREC Delaware Coastal Programs
DNREC Watershed Assessment
Center for the Inland Bays

Digital Coast

The Digital Coast is a nationwide initiative that is designed to ensure the wise use and management of coastal resources by providing coastal managers with data, training, tools and examples to assist them with emerging and priority coastal issues. The partner network identifies Digital Coast priorities and then works together to address coastal issues. Currently, the Digital Coast partnership is focused on providing data, tools and examples to coastal managers regarding coastal inundation and sea level rise. Projects to address other coastal issues (i.e., marine spatial planning, conservation) will be developed in the future. One of the goals behind the creation of the Digital Coast was to unify groups that might not otherwise work together and build a strong collaboration of coastal professionals intent on addressing coastal conservation needs. The Digital Coast Partnership Group is currently comprised of representatives from the Association of State Floodplain Managers, the Coastal States Organization, the National Association of Counties, the National States Geographic Information Council, The Nature Conservancy, and the NOAA Coastal Services Center. Delaware Coastal Programs staff have actively served as part of the Coastal States Organization representatives on this project. The National Oceanic and Atmospheric Administration's (NOAA) Coastal Services Center is the lead organization for Digital Coast efforts.

Outcome:

In the fall of 2009, the current phase of the digital coast project, the Coastal Inundation Toolkit, will be released. The toolkit is being developed by the Digital Coast Partnership Group to help communities understand and address coastal inundation issues. Website components include:

- Understand – Learn about inundation basics and common hazard concepts
- Identify – Download the county-specific charts and graphs that tell your story
- Map – Use the steps provided to discover and map areas of potential impact
- Assess – Use inundation maps to assess community risk, vulnerability, and resilience
- Inform – Use risk communication strategies to illicit change
- Discover – See how other communities are addressing this issue

This tool is expected to be of enormous value as a resource tool for the many groups concerned with and working to address coastal flooding and Sea Level Rise issues in Delaware.

Current and future Modules of Digital Coast resources are available at:
http://www.csc.noaa.gov/digitalcoast/

Implementation Actions

Development of a Coastal Resiliency Action Plan for Bowers Beach

Bowers Beach, Delaware is a small Bayfront community in Kent County located between the St. Jones and the Murderkill River. This small town is home to a small commercial fishing fleet and is a popular place for recreational boaters. Although its location makes it attractive for waterfront living and recreating, its location also makes the Town particularly vulnerable to the effects of coastal storms and sea level rise.

This project is designed to assist the community of Bowers Beach, Delaware in their efforts to reduce coastal hazard vulnerability that currently exists and that could potentially increase in the future due to the impacts of sea level rise. Bowers Beach currently experiences a number of coastal related problems including nuisance flooding of streets, episodic storm damage, coastal erosion, and other coastal hazard impacts.

The goal of this project is to develop a community-wide action plan that increases the resiliency of Bowers Beach, Delaware to the current and future effects of coastal storms and seal level rise. The project will develop a proactive plan that outlines the specific vulnerabilities of the community and the best actions to be pursued to address these issues. This will include actions to address current risks as well as future risks associated with climate change, including the potential impacts of sea level rise, increased storm frequencies and intensities, increased rates of erosion, salt water intrusion, wetland loss, and other impacts.

Geographic Location:

Town of Bowers Beach, Kent County, Delaware.

Outcome:

The final outcome will be an action plan of prioritized projects designed to make the community more resilient, or at a minimum be prepared to recover, from damages associated with coastal hazards. The Town will also acquire the skills necessary to identify and seek out funding opportunities to finance project implementation.

Activities/Schedule:

1. Phase I-Data Collection and Synthesis- This first phase of the project will include the collection, analysis, and dissemination of existing information to provide information to community members about their current storm flooding risk and vulnerabilities.

2. Phase II-Vulnerability Assessment - Phase two will include a detailed workshop(s) to gather further information and to conduct a detailed vulnerability assessment to be used as a guide for developing mitigation strategies and prioritizing mitigation projects. A Hazards Characterization workshop was conducted to collect the personal experiences from coastal storm and flooding events from the town residents, as well as to identify their initial concerns relating to these storm events. The information gathered during this

workshop will be used by a technical workgroup, comprised of State and County experts in project planning and hazard preparations and town representatives, for development of a formal vulnerability assessment and initial mitigation strategy.

3. Phase III-Strategy Development- Phase three will utilize the detailed results of the vulnerability assessment to develop a final prioritization of needs and a set of strategies to address these needs.

4. Phase IV-Implementation- This phase will be a longer term effort to implement the action plan. Delaware Coastal Programs will take on an advisory role in assisting the town with procuring funding, project design and tracking.

Activity	# months req'd for completion	Estimated Completion Date	Status
Phase I	4	Fall/Winter 2009	Data collection on-going; project webpage published
Phase II	3	Fall 2009	Hazard Workshop conducted and summary document completed; Assessment workgroup to meet in October, 2009
Phase III	9	Winter 09/Spring 2010	--------
Phase IV	12	Winter 09/Spring 2010	--------

Agencies Involved:

Town of Bowers Beach
Division of Soil and Water Conservation-Shoreline and Waterway Management Section and Drainage Section
Delaware Emergency Management Agency
Kent County Emergency Management
Federal Emergency Management Agency
Delaware Department of Transportation
UD Sea Grant

City of New Castle Coastal Resiliency Project

This project is designed to assist the community of the City of New Castle, Delaware in their efforts to reduce hazard vulnerability that currently exists and that could potentially increase in the future due to the impacts of climate change. The City of New Castle currently experiences a number of coastal related problems including; nuisance flooding of streets and road closures due to flooding; storm damage and erosion of dikes; periodic property flooding; and other coastal hazard impacts.

Before communities can develop effective hazard mitigation strategies, they must first identify their hazard risks and assess their vulnerability to the impacts of those hazards. This project will conduct a community-wide vulnerability assessment with broad community involvement and engagement. This will result in an action plan of prioritized projects designed to make the community more resilient, or at a minimum be prepared to recover, from damages associated with coastal hazards.

Geographic Location:

City of New Castle

Outcome:

The goal of this project is to develop a community-wide action plan that increases the resiliency of the City of New Castle, Delaware to the current and future affects of coastal storms and climate change. The project will develop a proactive plan that outlines the specific vulnerabilities of the community and the best actions to be pursued to address these issues. This will include actions to address current risks as well as future risks associated with climate change, including the potential impacts of sea level rise, increased storm frequencies and intensities, tidegate and dike problems or failures, wetland loss, and other impacts.

Activities/Schedule:

1. Data Collection and Synthesis. DCP has submitted a Request for Qualifications (RFQ) in search of firms that will assist in collecting data on the existing tide gates and dikes. More specifically, the selected firm will:

    a. Perform dike breach analysis and prepare inundation mapping for selected dikes around the City of New Castle
    b. Perform tide gate analysis including functionality with anticipated sea level rise.
    c. Prepare Emergency Action Plans for selected dikes around the City of New Castle.
    d. Prepare Operation and Maintenance Manuals for dikes and tide gates around the City of New Castle.
    e. Provide engineering support services to the Department as requested in response to dike-related incidents and emergencies including post-incident tasks such as

data collection, review and assessment of structures and facilities, and assisting the Department or City of New Castle with planning, designing, and implementing dike repairs.

In addition, existing information will be analyzed and disseminated to provide a factual context to community members about their current storm flooding risk and vulnerabilities.

2. Vulnerability Assessment. Conduct a more detailed vulnerability assessment to be used as a guide for developing mitigation strategies and prioritizing mitigation projects.
3. Strategy Development. Utilize the detailed results of the vulnerability assessment to develop a final prioritization of needs and a set of strategies to address these needs.
4. Action Plan Implementation. A longer term effort to implement the action plan with short term assistance from DCP.

Activity	# months req'd for completion	Estimated Completion Date	Status
Data Collection and Synthesis		Nov 20, 2009	In Progress
a. Deadline for Receipt of Qualifications		Dec 31, 2009	
b. Date of RFQ award			
c. Anticipated Date of Completion		Sept 30, 2010	
Vulnerability Assessment			Not Started
Strategy Development			Not Started
Action Plan Implementation			Not Started

Agencies Involved:

DNREC
Division of Soil and Water Conservation-Shoreline and Waterway Management Section and Drainage Section
Delaware Emergency Management Agency
New Castle County Emergency Management
Federal Emergency Management Agency
Delaware Department of Transportation
UD Sea Grant
City of New Castle

Development of a Coastal Flood Monitoring System for Delaware

In the last two decades, storms such as Hurricanes Katrina and Ike along the Gulf of Mexico and Floyd and Hugo along the Atlantic Coast of the United States have resulted in significant loss of life, injuries and property damages reaching well over 100 billion dollars. Much of the damage associated with these and other tropical and extra-tropical weather systems is associated with severe coastal flooding. The Delaware coastline is extremely vulnerable to such events, examples being the great March 1962 storm and the recent coastal flooding incident of May 12, 2008 which left at least one person dead and many homeless after ocean flood waters destroyed homes, especially along the Delaware Bay Coast of Kent County. The added concern of sea-level rise and its effect on the frequency and intensity of coastal flooding events, further emphasizes the need for a modern, dependable coastal flood monitoring system for Delaware's coastal communities.

This project will develop a real-time coastal flood monitoring and warning system for the coastal communities within Kent County, Delaware. This system will serve as a prototype for similar protection along the entire Delaware coast. We will build on the existing competencies of the Delaware Environmental Observing System (DEOS) and the Delaware Geological Survey (DGS) in the development of this prototype system. The deliverables from this project will directly impact several State agencies including the Delaware Department of Natural Resources and Environmental Control (DNREC), the Delaware Emergency Management Agency (DEMA), the Delaware Department of Transportation (DelDOT) and the Delaware National Estuarine Research Reserve (DNERR). Moreover, the proposed system will have a direct impact upon the safety and well-being of Delaware's coastal communities. The system will allow State constituencies to be informed as to tidal conditions and possible flooding situations up to 120-hours in advance of their occurrence. Moreover, the system will indicate those areas that are most likely to be affected by any tidal flooding (roadways, facilities, homes, etc.) allowing for immediate response by appropriate State and County agencies.

Geographic Location:

Coastal Kent County Delaware

Outcome:

When complete, DEOS and DGS observation sites will continuously monitor environmental conditions across the Delmarva Peninsula. The DEOS will also ingest forecasted tidal levels, based upon astronomical and meteorological conditions, provided through NOAA. When a forecasted (or real-time) critical tidal level is reached, the DEOS ALERTS system will send a message to all interested State officials warning that a coastal flooding situation is possible, which will prompt them to go to the Coastal Flood Monitoring web page. The web page will contain pertinent real-time and forecasted tidal and meteorological information as well as flood inundation maps for each major coastal community along the Kent County coast. Maps will be produced at appropriate flood levels using the latest LIDAR elevation data. Both paper (for

dissemination to State and County agencies) and digital (for inclusion on the Coastal Flood Monitoring web page) maps will be produced.

Development of the system will proceed in tandem with the completion of the coastal monitoring GAP Analysis and the inland flood inundation survey. The GAP Analysis will both inform and be informed by the coastal flood monitoring system development. The survey of high water marks during previous coastal flooding events will be conducted using standard surveying techniques by the Delaware Geological Survey. High water marks will be identified, their history confirmed and the inundation level recorded. This data will be used in conjunction with observed tide heights at USGS tidal monitoring points to better understand the inland inundation associated with various tidal levels along the coast. The association between tide levels at current coastal monitoring sites and inland flood levels is critical in developing statistical relationships that can be used in the development of a coastal flood model that accurately depicts possible inland flooding given a prediction of tidal anomalies at current monitoring sites.

Activities/Schedule:

1. Data Collection & Database Modification. Perform coastal flood inundation surveys, integration of "forecast" data into DEOS data base structure, initial production of flood inundation maps for coastal communities, modification of DEOS ALERTS system for forecast data.

2. System Integration, Testing & Implementation. Completion of flood inundation maps, testing of DEOS ALERTS system with forecasted data, development of Coastal Flood Monitoring web page, development of prototype coastal flood statistical model, implementation of system and final report of the project to be presented to DNREC.

Activity	# months req'd for completion	Estimated Completion Date	Status
1	6	January 2010	Contract to UD Issued Data Collection underway
2	6	July 2010	Not Underway

Agencies Involved:

DNREC Delaware Coastal Programs
University of Delaware, Dept of Geography
Delaware Geological Survey
University of Delaware EPSCOR

Policy Development

Development of a Statewide Sea Level Rise Adaptation Plan

Sea level rise will have economic, social and environmental effects throughout the State of Delaware. Sea level rise increases the height of storm waves, making more areas vulnerable to storm damage and can inundate low lying areas, causing losses to tidal wetlands, habitat, and agricultural areas. Sea level rise also can cause higher water tables and salt water intrusion, interfering with the septic systems, drinking water and irrigation water. These effects have implications for coastal access and recreation, transportation networks, public safety and land use patterns.

To address these issues, the Delaware Coastal Programs will develop a Statewide Adaptation Plan for Sea Level Rise. The adaptation plan will recommend policy changes and practices that will ensure that Delaware makes informed policy and investment decisions today to prevent damage and losses to infrastructure, resources and homes tomorrow. Recommendations will be based upon a careful assessment of potential effects to landowners, communities, economies, natural resources and infrastructure using the best available science and technology.

The Plan will be developed with a team of stakeholders from a diverse network of interests including municipal governments, highway planners, landowners, emergency managers, wildlife managers, agricultural professionals, insurance agents, and tourism officials.

The Adaptation Plan will include the following phases:

- An issues characterization and prioritization phase, during which, teams of experts will research and document environmental, economic and social resources at risk from the effects of sea level rise
- A strategy development phase, during which, teams of experts will recommend ways to address the issues and minimize loss of resources
- An implementation phase, during which, recommendations will be incorporated into policies and programs at all levels of government and where additional research will occur.

Geographic Location:

This project will be Statewide.

Outcomes:

The final outcome of this project will be the publication of a Statewide Sea Level Rise Adaptation Strategy that will outline recommended policies and management strategies to reduce the State's vulnerability to the impacts of Sea Level Rise.

Additional outcomes will include:

- Proceedings Document; Sea Level Rise Issues Characterization Workshop
- Sea Level Rise Issues Characterization
- Increased awareness of the impacts of Sea Level Rise at the state and local level
- Increased interagency coordination on Sea Level Rise issues
- Public outreach
- Implementation of strategies

Activities/Schedule:

1. Initial Issues Characterization Workshop. One-day workshop to begin discussing and outlining potential impacts of sea level rise in Delaware.

2. Establishment of Steering Committee. A 15-20 person committee comprised of policy and decision makers will be established to provide recommendations for Adaptation Plan development

3. Establishment of Technical Working Groups. Several teams of technical experts will be established to provide in-depth research of priority sea level rise issues and to provide strategy recommendations.

4. Issues Characterization: Technical Working Groups working together with the Steering Committee will characterize and prioritize potential social, economic and environmental impacts of sea level rise in Delaware and draft a written report.

5. Strategy Development: Technical Working Groups working together with the Steering Committee will develop strategies to address sea level rise issues.

6. Implementation of Strategies: State, Federal and local agencies and individuals will begin working to implement high priority strategies.

Activity	# months req'd for completion	Estimated Completion Date	Status
1	2	March 2009	Completed
2	1	October 2009	In progress
3	2	November 2009*	Not yet begun
4	6	June 2010*	Not yet begun
5	6	December 2010	Not yet begun
6	**	**	Not yet begun

* Assumes that all necessary data and modeling scenarios are available for use
** Implementation will be an on-going task with no certain end date

Agencies Involved:

The following agencies and organizations, and many others, will be invited to participate in the process:

Delaware Department of Natural Resources and Environmental Control
Delaware Department of Transportation
Delaware Department of Agriculture
Delaware Department of Safety and Homeland Security
Delaware Department of Health and Human Services
Delaware Economic Development Office
Delaware Office of Management and Budget

Delaware League of Local Governments
Other local government entities
University of Delaware

The Nature Conservancy, Delaware Chapter
The Sierra Club, Delaware Chapter
Positive Growth Alliance

Delaware Farm Bureau
Tidewater Utilities
Delaware Homebuilders Association
Delaware Realtors Association

Sustainable Coastal Communities

Most land use decisions in Delaware are made at the local level, yet those making decisions often lack technical expertise and/or planning resources. To address the lack of technical and planning resources, the Delaware Coastal Programs offers grants and technical assistance to local governments, state agencies and not-for-profit organizations for planning, natural resource management and coastal hazard mitigation.

In previous years, this funding and technical assistance has helped communities develop ordinances, incorporate natural resource considerations into comprehensive land use plans, inventory natural resources and restore important coastal habitats. In 2009 and beyond, the grant program will be more focused toward assisting communities plan for coastal hazards and future impacts of sea level rise. Funding will also be available for developing ordinances that will help protect natural resources and habitat; developing environmental conservation design standards for inclusion in local comprehensive land use plans; and conduct coastal habitat restoration project planning and implementation projects.

Geographic Location:

Grants will be available Statewide, through a competitive RFP process.

Outcome:

This program will result in improved management of Delaware's coastal resources through incorporation of coastal hazard and natural resource considerations into local comprehensive plans. This includes coastal storm resiliency planning, development of natural resource ordinances, habitat restoration projects and educational outreach for Delaware's local governments.

The DCP anticipates funding and assisting with 3 – 5 projects per year.

Activities/Schedule:

1. Release RFP and Award Grants. The funding will be announced through a "Request for Proposals." Grant proposals received will be ranked by a committee of resource experts and successful grant applicants will be notified.

2. Grants Management. DCP staff will negotiate contracts for each grant recipient and will provide technical assistance until the project has been completed.

Activity	# months req'd for completion	Estimated Completion Date	Status
1	4	January 2009	Pending
2	14	March 2009	Not yet underway

Agencies Involved:

Delaware Coastal Programs

Mid-Atlantic Regional Council on the Oceans (MARCO)

Coastal and ocean resources are facing competing demands and new and emerging pressures like climate change and energy development. The risks of failing to address ocean and coastal problems are high, with serious implications at the regional, national, and global level for sustaining human communities and the ecosystems on which they depend. Recent national reports, including the U.S. Commission on Ocean Policy, the Pew Oceans Commission, and the resultant Joint Ocean Commission Initiative, have endorsed regional governance approaches to address existing and emerging challenges to ocean ecosystem health. The Mid-Atlantic is the only coastal region in the U.S. that still lacks a regional forum to discuss interstate offshore concerns at an ecosystem scale.

The Mid-Atlantic Governors' Ocean Summit was held on June 4, 2009 to address this issue. The Summit was attended by regional state and federal officials and staff from Delaware, New York, New Jersey, Maryland, and Virginia and select issue experts from academia, NGO's, and industry. The Summit marked the signing of the Mid-Atlantic Governors' Agreement on Ocean Conservation. This Agreement has brought the five Governors together as the Mid-Atlantic Regional Council on the Ocean (MARCO) and has charged the States to collaboratively address priorities for shared action. These priorities include: protection of important habitats and sensitive and unique offshore areas; support the sustainable development of renewable energy in offshore areas; prepare the region's coastal communities for the impacts of climate change on ocean and coastal resources, including sea level rise and ocean acidification; and promote improvements in the region's coastal water quality. The Agreement also calls for a meeting with Mid-Atlantic Ocean stakeholders to create new partnerships in the development and implementation of these actions.

More information can be found on the MARCO website: www.midatlanticocean.org.

Geographic Location:

Mid-Atlantic region, including the states of Delaware, New York, New Jersey, Maryland, and Virginia.

Outcome:

MARCO will result in improved management of Mid-Atlantic coastal and ocean resources. The collaborative effort will improve outcomes by instituting a regional, ecosystem-based approach and will foster a cooperative and constructive relationship among the states. It will also provide leverage for greater federal investment and action on the states' coastal and ocean management priorities.

Activities/Schedule:

1. Draft issue papers and priority actions: Four priority issues and associated action items have been identified and characterized by the States.

2. Stakeholder Summit: Conduct summit of broad stakeholders in December 2009. The purpose of the summit is to provide opportunity for stakeholder input on MARCO priorities and action items.

3. Refine action plan and implement recommendations. The action plan will be refined based upon the results of the stakeholder workshop. The plan outlines the goals, specific objectives, and initial actions for each of the four priority areas. Each initial action specifies which state will take the lead on it, which objective(s) it advances, and a proposed timeframe or completion date.

Activity	# months req'd for completion	Estimated Completion Date	Status
1	6	September 2009	Complete
2	6	December 2009	Pending
3	12	June 2010	Not yet underway

Agencies Involved:

States of Delaware, New York, New Jersey, Maryland, and Virginia

Communication, Training, and Public Involvement

Google KML Map Development

Land-use decisions in Delaware are primarily made at the local level yet, often these smaller towns lack the GIS infrastructure that would allow large scale planning efforts, particularly those related to coastal hazards. Delaware Coastal Programs has made significant investment in GIS data, personnel, and hardware over the years. Transferring the benefits of this investment to community decision makers is vital to the success of these planning efforts.

As part of DCP's efforts assisting local governments with Coastal Hazard and Community Resilience Planning, data will be created and shared with the local decision makers and the community. Internet based mapping applications, particularly those based on KML, can be a useful tool to affect this sharing. Most local governments and citizens have access to basic internet browsers either at home or in public libraries. Online mapping tools such as Google Maps and Virtual Earth provide free, lightweight mapping tools that members of the public can use to participate in planning efforts. More robust applications, such as ArcIMS and Google Earth, allow for more complex views of Community Resiliency information while keeping costs at a minimum (i.e. free to end user).

DCP will utilize data distribution functions built into current GIS software (ESRI ArcGIS) and available extensions (Arc2Earth) to produce and distribute Community Resilience information for these planning efforts. This will involve exporting existing data layers to KML; creating KML versions of new data as acquired; and producing map products that can be used during planning workshops and distributed in this open format.

Geographic Location:

Distribution will initially focus on individual communities undergoing resiliency planning (i.e. Town of Bowers and City of New Castle).

Outcome:

Website(s) providing citizen access to Community Resilience Planning Maps.

Activities/Schedule:

1. Software needs assessment and acquisition. Evaluate capabilities of various software to provide mapping data to public through open GIS browsers. Acquire selected software.

2. Data List. Develop and initial list of data to be distributed to community members.

3. Data Conversion. Convert selected data and maps for distribution.

4. Website creation. Establish a new set of pages within DCP's Sea Level Rise web section for distribution of mapping information.

Activity	# months req'd for completion	Estimated Completion Date	Status
1	1 month		Complete
2	1 month	8/1/2009	Ongoing
3	1 month	9/1/2009	Ongoing
4	1 month	9/1/2009	Ongoing

Agencies Involved:

Delaware Coastal Programs
DNREC – Office of Information Technology

Comprehensive Marketing & Outreach Strategy for Sea Level Rise

The Coastal Training Program (CTP), a national initiative to provide skill-building opportunities and up-to-date scientific information to Delaware's coastal decision makers, will lead marketing, training, and outreach for the Delaware Coastal Programs' Sea Level Rise initiatives. In order to effectively reach a target audience, the CTP will develop comprehensive sea level rise marketing and outreach strategy. This strategy will provide a clear, coordinated message with information and materials developed and disseminated by the Coastal Training Program. The most suitable delivery mechanism will be identified to present this message, supplying participants (public/Delaware coastal decision makers) with up-to-date scientific information regarding sea level rise in Delaware.

In order to effectively design and implement a successful educational and outreach program on sea level rise, a statewide survey to gauge public knowledge and opinions on sea level rise and its impacts on Delaware will be conducted in the fall of 2009. This survey will provide information about Delaware residents' awareness and understanding of key issues regarding climate change and sea level rise; determine their perception of its overall effect on the economy and ecology of the state; and explore public opinion regarding long range planning for sea level rise loss and damage prevention. Using the results of this survey, a comprehensive marketing and outreach strategy will be designed and targeted towards enhancing the public and coastal stakeholders' awareness and response to sea level rise.

The strategy will consider several audiences (such as local, county, and state government officials, local and regional planners, economic development representatives, agriculture representatives, university researchers, and property owners) and could include workshops, seminars, brochures, factsheets, public service announcements, website development and/or outreach displays.

Geographic Location:

Statewide

Outcome:

A comprehensive marketing and outreach strategy will be developed and an implementation plan will be put into place.

Activities/Schedule:

1. Strategy Development. An inventory of existing Sea Level Rise marketing and outreach programs will be completed and will be analyzed along with results of the Sea Level Rise Attitudes and Perception Survey. This analysis will then be interpreted to design a targeted Marketing and Outreach program.

2. Strategy Implementation. Activities listed in the strategy will be implemented.

Activity	# months req'd for completion	Estimated Completion Date	Status
1	4	Spring 2010	Awaiting Results of SLR Survey
2	Ongoing as needed	-	Not yet underway

Agencies Involved:

DNREC Delaware Coastal Programs
Responsive Management

Statewide Survey to Gauge Public Knowledge and Opinions on Sea Level Rise and its Impact in Delaware

In order to effectively plan and target sea level rise outreach and technical assistance, it is important to understand the public perception of sea level rise. However, there is currently no statewide information available regarding the level of knowledge Delawareans possess regarding sea level rise and its future impacts; nor whether Delawareans are motivated to change their behaviors to reduce their risk to impacts associated with sea level rise.

In order to address this need, the Delaware Coastal Programs, in cooperation with The Nature Conservancy and with contractual assistance from Responsive Management Inc. will conduct a statewide telephone survey during the summer of 2009. The survey will be designed to be statistically significant and to assess Delaware residents' awareness and understanding of key issues regarding climate change and sea level rise; to determine their perception of its overall effect on the economy and ecology of the state; and to explore public opinion regarding long range planning for sea level rise loss and damage prevention.

The survey will result in a written report that includes a summary of results; discussion of data analysis and statistical procedures, a tabular data report, survey graphs and tables, frequency distributions and cross-tabulations. Several workshops will also be held to explain the results of the survey to targeted audiences.

Geographic Location:

The telephone survey will be conducted statewide. Workshops will be held at locations across the state.

Outcome:

The survey will result in a written report that includes a summary of results; discussion of data analysis and statistical procedures, a tabular data report, survey graphs and tables, frequency distributions and cross-tabulations. Several workshops will also be held to explain the results of the survey to targeted audiences.

Activities/Schedule:

1. Develop survey instrument. In cooperation with other interested agencies and Responsive Management, design and test the survey.

2. Conduct Telephone Survey. Responsive Management will conduct the phone survey using random dialing.

3. Analyze Results. Responsive Management will analyze the results of the survey with appropriate statistical tests.

4. Prepare Report. Responsive Management will prepare a final report that provides an executive summary, methodology, data and appropriate charts and graphs.

5. Distribute and Explain Report. Final report will be made available via the web and hard copy. Workshops will be held in cooperation with the Nature Conservancy and Responsive Management to explain the results of the survey.

Activity	# months req'd for completion	Estimated Completion Date	Status
1	2	July 2009	In progress
2	2	August 2009	Not underway
3	2	September 2009	Not underway
4	1	September 2009	Not underway
5	6	March 2010	Not underway

Agencies Involved:

DNREC Delaware Coastal Programs
The Nature Conservancy
Responsive Management