

EBEI-2: Observation Systems for Changes in Coastal Areas

Option Description

The Chesapeake Bay is the largest inner-coastal estuary in the Nation, covering over 166 thousand square kilometers, with more than 150 rivers and streams draining into the watershed, and home to about 15 million people. Most of Maryland's communities and economic activities in this low-lying coastal region are particularly vulnerable to storm surges and flooding, events that will be likely be intensified due to rising sea level associated with climate change. Maryland relies upon its coastal areas along the Chesapeake Bay and its Atlantic coast for healthy fisheries, and reliable transport and navigation. Its dependence on infrastructure networks (roads, power grids, etc) intensifies the potential vulnerability of these areas to impacts from climate change-induced natural disasters.

An enhanced ability to observe sea level rise induced changing along Maryland's coastal areas will provide key benefits to the state. Under climate change, managing resources in these areas is more important than ever and will require accurate information from integrated observation systems to allow for detection and prediction of the causes and consequences of changes in coastal systems, watersheds and infrastructural resources. This option aims to support, enhance and integrate observation systems already in place in Maryland. Specifically, the option aims to strengthen such systems to enable the comprehensive surveillance, monitoring, documentation, and dissemination of rates and locations of sea-level rise in Maryland. This includes the installation of surveillance equipment in coastal sites where current public/private infrastructure is potentially vulnerable to small increases in sea level, the incorporation of long-term coastal monitoring aspects into existing protocols, and the integration of observation activities in regional efforts.

Option Design

This policy option aims to enhance statewide monitoring programs in natural and urban settings to detect biological, physical and chemical changes and responses due to direct and indirect effects of climate change. This option will be facilitated through the observation, analysis, and interpretation of trends in coastal water levels, elevation (subsidence rates, if any), shoreline change, wetland loss, and tidal influence on estuaries and water supplies. The observation systems will enable the state to assess the responses of coastal landforms to sea level rise as well as the effects of an increase in storm activity. Implementation of the policy option will be coordinated with the policy options for Integrated Geographic Information System Mapping, Modelling and Monitoring and the

policy options related to detecting specific impacts of climate change and sea level rise to resources and resource based industries.

The specific objective of this option is to assess how existing observation systems for the Chesapeake Bay region can be enhanced to better understand and address long-term sea level rise and its impacts on the built environment. The overall option design is summarized in the bullets below.

Targets: Observation networks are an essential component of adaptive management in low-lying coastal areas. They are also essential in planning and evaluating the effectiveness of restoration programs in Maryland’s coastal zone. The target for this option is in the form of a detailed assessment regarding the adequacy of MD’s current observation system protocols, systems, technologies, and surveillance strategy to address long-term changes in sea level rise and the associated impacts. The output of the study should be a series of recommendations regarding how current observation networks could be reinforced and/or new component addressed to better address changing conditions regarding sea level rise. Components of the study should include:

- Enhance federal, state, regional and local level interagency integration and coordination of observations systems that detect trends in coastal water levels, elevation (subsidence rates, if any), shoreline change, wetland loss, and tidal influence on estuaries and water supplies
- Assess the suitability of vertically-controlled tide gauges;
- Investigate funding the installation of additional tide gauges in particular locations, including Jug Bay;
- Assess the adequacy of Surface Elevation Tables to measure whether marsh accretion is keeping pace with erosion/inundation; examine opportunities to add more SET’s with select marsh locations;
- Integrate findings and study objectives for the Statewide Wetlands Monitory Strategy, currently under development by the Maryland Department of Environment;
- Observe and record changes for a set of “leading indicators” of specific climate change impacts. This should include indicators that a representative of specific geographic ranges or behaviors or population characteristics of certain species (e.g., plants, birds, mammals, insects) that are known to be hypersensitive to sea level rise and other climatic changes;
- Enhance the utilization of the *Maryland Geological Survey Groundwater Quality Network* to conducts well water quality assessments in areas where saline intrusion adjacent to tidal waters is known to occur;

- Evaluate the need to expand the *Maryland Geological Survey Subsidence Studies Program* to assess the risk of elevation declines due to ground water withdrawals, which would exacerbate any impacts of sea level rise. Locations to be assessed could include those with significant current ground water withdrawals and/or those where population and associated groundwater withdrawals are projected to increase significantly in the near future.

Timing: The timing of the study is immediate. It is anticipated that a 3-year period will be needed to complete the study. By the end of this period, there should be a detailed recommended program regarding the additional integrated observations required, supplemental data management and distribution systems (if any), and a set of analytical products that respond to user-specific needs (i.e., commercial, management, recreational, educational, scientific, regulatory, safety, hazard protection, and restoration communities).

Parties Involved: There are several parties that would be involved in the design and oversight of the study. At the state level, it would include the MD Department of Natural Resources, Maryland Department of Environment, and local national weather services offices. At the regional/national levels, it would include the National Oceanic and Atmospheric Administration, National Geodetic Survey, Chesapeake Bay Observation System, the United States Geological Survey, and the National Office for Integrated and Sustained Ocean Observations.

Implementation Mechanisms

This option would be implemented by first preparing a feasibility study on the scope, issues, challenges, and likely costs associated with upgrading existing observation systems. On the basis of this study, terms of reference for the assessment would be prepared and implemented by a qualified organization/consortium. The recommendations of the study would become the input for changes to existing rules/regulations or new legislation to implement the activities identified as necessary to adequately monitor sea level rise and the effectiveness of Maryland's adaptation responses to climate change.

Related Policies/Programs in Place

Chesapeake Bay Observing System (CBOS): There are important observation systems already in place in Maryland to monitor the Chesapeake Bay. The Chesapeake Bay Observing System (CBOS) is an organization that provides integrated data observation, management, and distribution systems and information for use by Chesapeake Bay and coastal communities. It is part of an evolving sub-regional observing system embedded in the Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA) and the Congressionally-mandated Integrated Ocean Observing System (IOOS).

NOAA, Center for Operational Oceanographic Products and Services (CO-OPS): Tides and Currents: NOAA Tides and Currents, managed by the Center for Operational Oceanographic Products and Services (CO-OPS), is the portal to the National Oceanic and Atmospheric Administration's collection of oceanographic and meteorological data (historical and real-time), predictions, and nowcasts and forecasts. Historic tide gauge data for the Chesapeake Bay can be found on the following website:

<http://tidesandcurrents.noaa.gov/index.shtml>

National Water Level Observation Network (NWLON): NWLON is a network of 200 long-term, continuously operating water-level stations throughout the U.S., which provide tidal datums and water level observations for the US, as well as long-term sea level trends. They are also the foundation reference stations for NOAA's tide prediction products, and serve as controls in determining tidal datums for all short-term water-level stations.

VDatum: VDatum is a software tool administered by NOAA that is designed to transfer between 28 different vertical datums consisting of tidal, orthometric, and ellipsoidal datums. For more info – <http://www.nauticalcharts.noaa.gov/csdl/vdatum.htm>

Climate Change Science Program (CCSP): U.S. Climate Change Science Program Synthesis and Assessment Product, Draft Report 4.1: “Coastal Elevation and Sensitivity to Sea Level Rise.” Available for public comment at <http://www.climatechange.gov/Library/sap/sap4-1/public-review-draft/>

National Geodetic Survey (NGS): NOAA's National Geodetic Survey (NGS) defines and manages a national coordinate system. This network, the National Spatial Reference System (NSRS), provides the foundation for transportation and communication; mapping and charting; and a multitude of scientific and engineering applications. Additional related programs include:

- *Continuously Operating Reference Stations (CORS):* The CORS network includes over 1,200 Global Positioning System (GPS) stations that run 24/7 and get adjusted daily. CORS system enables positioning accuracies that approach a few centimeters relative to the National Spatial Reference System, both horizontally and vertically. The National Geodetic Survey is working with CO-OPS to co-locate CORS with NWLON stations. This has already been done at several coastal sites, including Charleston, SC and Key West, FL. This enables local land elevation changes to be accounted for within local sea level measurements.
- *Height Modernization Program (HMP):* The HMP provides accurate height information by integrating GPS technology with existing survey techniques.

- *Remote Sensing Division:* The RSN is responsible for collecting national shoreline information, to be fed into nautical charts.
- *State Geodetic Advisors:* Geodesists are placed within States to assist with surveying and geospatial data issues
- *Surface Elevation Tables (SETs).* NGS is currently working on guidance documents concerning using GPS to tie SETs to local tidal and geodetic datums to enable measurement of vertical movement of coastal habitats.

Maryland Dept. of Natural Resources, TEA/MANTA Tidal monitoring: Maryland's Chesapeake Bay Water Quality Monitoring Program includes an integrated set of components that together provide a comprehensive assessment of water quality conditions. This set of water quality and habitat indicators includes: physical/chemical properties, nutrient limitation of algal growth, ecosystem processes, river inputs of nutrients and sediments, phytoplankton, zooplankton, and benthic organisms. The design, analysis and interpretation of each component of the program address three objectives: Characterize existing conditions; Detect changes and trends in key water quality variables in response to management actions; Determine attainment or non-attainment of water quality criteria; and, Understanding processes of how the Bay ecosystem functions as it relates to anthropogenic and natural stresses, management actions, and relationships between water quality and living resources. Data is physically collected by scientists 16 times a year at 22 stations located in Maryland's Chesapeake Bay mainstem, 12 to 20 times a year at 55 stations sampled in the Chesapeake Bay tidal tributaries, and 12 times a year at 45 stations in the Coastal Bays.

MD-DNR, MANTA/TEA Non-tidal monitoring: Long Term Water Quality Monitoring has occurred at 54 locations on major (4th order and larger) non-tidal portion of Maryland's rivers since 1976. Sampling at these stations provides the data to determine trends in water quality constituents commonly associated with urban and agricultural landuse. Some of the TEA/MANTA monitoring data mentioned above can be access via *Eyes on the Bay*.

Eyes on the Bay (EOTB): A website of DNR's Tidewater Ecosystem Assessment (TEA) Division, Eyes on the Bay (EOTB), provides easy access to near real-time, mapped and historical Chesapeake and Coastal Bays water quality information and data. Available data includes water temperature, salinity, dissolved oxygen (the amount of oxygen available for aquatic life), water clarity, chlorophyll (the amount of algae in the water), and pH levels (the acidity/alkalinity of the water). Monthly, Continuous Monitoring and Water Quality Mapping data can be retrieved at EOTB.

MDNR – MANTA-MD Biological Stream Survey: Since 1994, Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division (MANTA) has

sampled and assessed more than 2,000 freshwater, wadeable streams for biological, habitat, and chemical quality through the Maryland Biological Stream Survey (MBSS). Stream quality indicators have been developed for fish, benthic macroinvertebrates, salamanders, and physical habitat. MBSS results have been used in a variety of ways, including 1) watershed characterizations (i.e., targeting areas in need of both restoration and protection) via the Clean Water Action Plan and the resultant Watershed Restoration Action Strategies, 2) listing impaired streams for MDE's 303d list, 3) evaluation of stressors to aquatic fauna, and 4) determining geographic ranges of rare, threatened, or endangered aquatic species.

MANTA's Sentinel Site Network: To track natural variability in stream chemical, physical, and biological conditions, the Maryland Biological Stream Survey (MBSS) established a long-term monitoring component, the Sentinel Site Network, in 2000. The Network consists of 26 of the highest quality, minimally disturbed streams in Maryland based on physical, chemical, and biological data collected by the MBSS from 1995-1997. Long-term monitoring of sentinel sites offer the best hope for detecting the effects of climate change on Maryland's non-tidal streams/rivers and will provide important information for the management of stream resources in the face of this threat. In addition, MANTA has developed a Proposed Monitoring Program for Tidal Freshwater Ecosystems – there is currently a paucity of information available on these unique transitional habitats.

Comprehensive Shoreline Inventory (CSI): Maryland's Coastal Program contracted with the Virginia Institute of Marine Sciences (VIMS) to prepare a Comprehensive Shoreline Inventory that captures baseline shoreline conditions throughout the tidal portions of Maryland's coastal counties. Shoreline features and conditions were identified through a three-tiered shoreline assessment approach. The Inventory divided the shorezone into three regions: 1) immediate riparian zone (land use), 2) bank (bank characteristics such as height, bank type, etc., and shoreline buffers), and 3) shoreline features (shoreline attributes including bulkheads, riprap, marinas, boat ramps, docks, etc.). Data from the survey was processed to create three GIS coverages, displayed through reports, summary tables, and maps, which are viewable online at <http://ccrm.vims.edu/gisdatabases.html>. Uses of *CSI*, for changes in shoreline conditions due to climate change and sea level rise impacts are numerous. The *CSI* has already been used by St. Mary's County to conduct a shoreline structure damage assessment following Tropical Storm Isabel. The *CSI* was incorporated into HAZUS-MH to provide shoreline conditions to conduct the level-one analysis of flood vulnerability in Maryland. And, the *CSI* was merged with the Stream Corridor Assessment used in the development of the Watershed Restoration Action Strategy (WRAS) program to provide a watershed view of non-tidal and tidal shoreline conditions. The *CSI* information was used in conjunction with historical shoreline position data by the Maryland Geological Survey to assess the loading of sediments to the Chesapeake Bay from shore erosion. Changes in shore erosion rates and sediment loading that accompany accelerating sea level rise can be assessed from this database.

Maryland Geological Survey Groundwater Quality Network: DNR's Maryland Geological Survey routinely conducts well water quality assessments in areas where saline intrusion adjacent to tidal waters is known to occur. Currently, wells on Kent Island and at Ocean City are sampled annually, Annapolis Neck less frequently, and Indian Head on the Potomac River only occasionally. Groundwater is the major source of potable water in the rapidly developing tidewater region of the State, and the combination of increased pumpage and sea-level rise are likely to increase the areas where saline water intrudes into aquifers and the salinity where intrusion is currently known to occur. The methodologies currently utilized and the database in areas already under study can be extended to other areas at risk of saline intrusion.

Maryland Geological Survey Subsidence Studies: DNR's Maryland Geological Survey in cooperation with Anne Arundel County and the State Highway Administration, have been conducting elevation surveys at three county water supply wellfields since 1994. These surveys have indicated only minor declines in elevation at the locations of the withdrawals, but ground water levels at these sites have not declined significantly to date. This methodology can be extended to other locations which might be at risk of elevation declines due to ground water withdrawals, which would exacerbate any impacts of sea level rise. Locations to be assessed could include those with significant current ground water withdrawals and/or those where population and associated groundwater withdrawals are projected to increase significantly in the near future.

Additional Benefits and Costs

TBD.

Feasibility Issues

TBD.

Status of Group Approval

TBD.

Barriers to Consensus

TBD.

EBEI-3: Adaptation of Vulnerable Public and Private Sector Infrastructure

Option Description

Maryland has thousands of miles of developed waterfront property along the Chesapeake Bay and its tributaries. Much of this area contains public and private sector infrastructure that will be adversely impacted by sea level rise (SLR) and increased climatic severity (storms and wind driven tides) caused by climate change and subsidence. Public sector infrastructure (i.e., roads, bridges, airports, wastewater treatment facilities, municipal water systems, etc.) is essential for community framework. Private sector infrastructure (i.e., residential properties, boating facilities, retail and office buildings, farms, etc.) has historically enjoyed higher market value compared to inland properties because of its proximity to the water especially in more recent times.

As sea level continues to rise, both state and local governments in Maryland, as well as many other public and private property owners are facing the very real and hard decision about how to adapt and at what expense. Decisions about how to adapt to the impacts of sea level rise will be different for varying land uses, taking into consideration the value of the land (monetary, resource-value, and perceived value), public opinion, public safety and risk assessments, ecosystem survival and replacement, environmental and development opportunities, and others.

There is a range of potential adaptation options such as protection, relocation and retrofitting that can be utilized to respond to sea level rise. Protection of vulnerable coastal infrastructure can be accomplished by use of structural bulkheads, seawalls, or revetments which are the least desirable means. Protection can also be accomplished that will improve ecosystems and create new opportunities. However, it will not be practical (socially, economically or environmentally) to do so for all areas at risk. Developing a framework for making abandon/modify/move/protect decisions must be done in combination with other comprehensive planning and emergency management decision-making frameworks.

The objectives of this option are to identify and assess Maryland's SLR impacted public and private sector infrastructure (based on various SLR scenarios agreed upon by the STWG which identify vulnerable inundation areas), categorized and assess impacted infrastructure based on research to determine feasible option strategies, and formulate strategies to integrate action plans at the federal, state, and local levels.

In order to plan and ascertain priorities, there needs to be differentiation between properties that can adapt to SLR and those which may need to be abandoned and/or relocated. In the case of public infrastructure, one important factor in this determination can be made by comparing the impact of projected SLR and the projected useful life of the facility. Coordinated plans need to be developed between the private sector, local,

state, and federal authorities for how adaptation can best be accomplished. Existing laws and regulations, processes, and practices need to be re-visited and possibly changed, eliminated, and/or supplemented so that they facilitate positive potential results from adaptation in recognition of the changing climate and environment.

It is most important that every effort be made to encourage and facilitate opportunities where appropriate to offset the impact of the losses that are inevitable.

Option Design

Targets: The following are the key targets for this option:

1. Raise the awareness of the impact of SLR in impacted areas. Since SLR is so gradual, one of the obstacles to implementing successful option strategies will be to overcome denial and achieve “buy-in” and participation from stakeholders.
2. Identify vulnerable SLR inundation areas along Maryland’s shoreline using newly acquired topographic data.
3. Assess public and private sector infrastructure within these vulnerable areas to gain a statewide sense of the breadth of infrastructure impacted.
4. Categorized and assess impacted infrastructure based on research to determine feasible option strategies. This should be conducted by team of experts considering successes and failures of other actions attempted or contemplated worldwide, potential engineering solutions and technological applications to determine potential applicability to the impacted projected areas. The scope of this study should be to prepare generic adaptation methods descriptions, and the feasibility (costs, impacts, etc.) of implementing various adaptation scenarios (abandon/modify/move/protect).
5. Formulate and prioritize strategies to adapt to climate changes and SLR, along with a plan to integrate plans of action at the state and local levels.

Timing: The following represents some of the key schedule milestones for this option:

1. Raising the awareness level has already begun and is an important part or all options in this effort.
2. Compiling existing data on projected SLR inundation areas and existing infrastructure within those areas could utilize existing tools, programs and resources, and could therefore begin immediately and be targeted for completion by the end of 2009.
3. Categorizing and assessing impacted infrastructure of adaptation options should follow the initial data compilation. This phase of the option should begin in late 2009 and be completed by 2011.
4. Formulate strategies, priorities and implementation action plans (*timing??*)

Parties Involved:

Coordinated involvement will be needed from property owners, local town/city governments, county governments, Maryland agencies including DNR, MDOT, MDE, MDP (Maryland Department of Planning, Maryland Utilities Commission, federal agencies including USDA, US Army Corps of Engineers.

Implementation Mechanisms

Identification and assessment of impacted properties, research, determining strategies, and creating incentives and enabling legislation and/or changes in processes, practices are needed before widespread adaptive measures can be successfully implemented.

Related Policies/Programs in Place

There are several related policies/programs in place in Maryland, as outlined below:

- ❑ *Comprehensive Shoreline Inventory (CSI)*. Maryland's Coastal Program contracted with the Virginia Institute of Marine Sciences (VIMS) to prepare a Comprehensive Shoreline Inventory that captures baseline shoreline conditions throughout the tidal portions of Maryland's coastal counties. Shoreline features and conditions were identified through a three-tiered shoreline assessment approach. The Inventory divided the shorezone into three regions: 1) immediate riparian zone (land use), 2) bank (bank characteristics such as height, bank type, etc., and shoreline buffers), and 3) shoreline features (shoreline attributes including bulkheads, riprap, marinas, boat ramps, docks, etc.). Data from the survey was processed to create three GIS coverages, displayed through reports, summary tables, and maps, which are viewable online at <http://ccrm.vims.edu/gisdatabases.html>. The CSI can be used as a state and local planning tool to inventory and assess coastal infrastructure vulnerable to sea level rise inundation or coastal flooding.
- ❑ *Strategic Shore Erosion Assessment (SSEA)*. From 2000 – 2002, a NOAA Coastal Services Center, Coastal Management Fellow, worked with the Coastal Program to initiate the development of a comprehensive approach to shore erosion planning for Maryland. The Fellow was tasked with developing a protocol to create regional strategies to deal with shoreline erosion issues. The Fellow worked closely with two counties, Dorchester and St. Mary's, to identify an approach to balance the need to address risk from erosion, while also maintaining natural shoreline habitat. The developed protocol became the foundation for the Strategic Shore Erosion Assessment (SSEA), currently under development. In 2002, Coastal Program staff worked with DNR's Shore Erosion Control Program to integrate the protocol developed for the SSEA into the Program's Project Selection Criteria and Financial Assistance Priority Rating System. Environmental and habitat enhancement considerations are now incorporated into the rating system which creates a score for each homeowner's project based on criteria such as infrastructure threat from erosion, and an applicant's financial need.

- ❑ *Maryland's 2006 – 2010, CZMA §309 Coastal Hazard Strategy:* The Strategy, approved by NOAA in 2006, sets for the current workplan for development of the SSEA. The project is being implemented in three phases: (1) generation of fetch exposure tool, community risk assessment, and environmental risk assessment; (2) application and validation of GIS tools through development of the Corps Feasibility Study Master Plan; (3) incorporation into the interactive mapping application; and (4) workshop development and training of State and local coastal managers and planners.
- ❑ *Chesapeake Bay Shore Erosion Control Master Plan.* Maryland's Coastal Program is currently participating in the development of the *Chesapeake Bay Shore Erosion Control Master Plan* along with the U.S. Army Corps of Engineers (USACE) and MDE. The Plan, being developed as a component of Chesapeake Bay Coastal Management Feasibility Study, will result in outreach material for contractors and homeowners as well as a Master Plan that uses modeling tools to evaluate stretches of shoreline and prioritizes these areas for erosion control activities. The Master Plan will serve as a guide for potential shore erosion management strategies and assist the agencies in being consistent with promoting strategies along tidal shorelines. These strategies will likely include: structural and non-structural erosion control devices, designation of natural erosion areas, land acquisition, and establishment of local erosion-based setback requirements.
- ❑ *Draft Report of CCSP Synthesis and Assessment Product 4.1, "Coastal elevations and sensitivity to sea level rise:"* This report is one of 21 synthesis and assessment products being prepared by the U.S. Climate Change Science Program (CCSP). The Draft Report is posted on the CCSP web site at: www.climatechange.gov/Library/sap/sap4-1/public-review-draft/. The report is currently out for public review. Comments must be received by COB **10 April 2008**. The draft report includes the results of a research project entitled the Likelihood of Shore Protection in Maryland. This project, conducted by the EPA, was based upon interviews with state regulators and county planners to investigate existing and anticipated coastal policies and land uses. The study developed maps that distinguish coastal areas in Maryland that are likely to be protected as sea level rises and areas that will likely retreat because of protection cost or currently land use policy.
- ❑ **HAZUS-Multi Hazard (MH):** HAZUS is a risk assessment software program for analyzing potential losses from floods, hurricane winds and earthquakes. HAZUS-MH estimates damage before, or after, a disaster occurs and takes into account various social and economic impacts of a hazard event. MDE partnered in {insert year} with Salisbury University to complete a statewide analysis of flood vulnerability estimated through the HAZUS-MH flood module. The Level One analysis completed in June 2005, estimates flood damage from a 100-year coastal or riverine flood event to commercial and residential properties. This study takes the

next step from identifying flood vulnerability to understanding the risk to the built environment. The final report, “An Assessment of Maryland’s Vulnerability to Flood Damage” is now available.

- ❑ Moreover, the coordination and reinforcement for this option should be with the following other options in this report:
 - Assessment of Coastal Zone Adaptation Options and Evaluation of Shoreline Protection Structures
 - Integrated Planning for SLR and Associated Coastal Hazards
 - State Agency Reporting on Response to CCC Findings
 - Preserve Undeveloped, Vulnerable Lands
 - Integrated geographic information systems, monitoring, and modeling
 - New Criteria for Identifying Priority Protection Areas
 - Forest and Wetland Protection
 - Modify Environmental Protection Regulations to Promote
 - Sustainable Shoreline and Buffer Area Management Practices

Estimation of Adaptation Benefits and Costs

Implementing a program for the adaptation of vulnerable public and private sector infrastructure will undoubtedly have tremendous costs to local, state, and federal government, and the private sector. Much of this cost can be off-set by implementing laws, regulations, and policies that encourage innovative, environmentally sound, practical solutions even though some of these will require a new paradigm regarding adaptation. Considerations of costs are:

- ❑ estimated detailed cost of adapting, relocating & replacing public infrastructure can only be determined after the assessment and identification of impacted properties is performed. Some properties, particularly major infrastructure, will be able to serve out their useful life before the need to replace them. In the meantime, care should be taken to not site new public sector infrastructure in impacted areas. However there will be a considerable financial cost to local, state, and federal governments from replacing or relocating impacted public infrastructure that becomes inundated prior to fulfilling their projected useful life. This contrasts with the current perception that often the life spans of certain properties can be extended by renovation/modernization which may be more cost effective than relocation and replacement;
 - ❑ abandonment of properties will result in loss of asset value and thus loss of tax revenues for local and state governments;
 - ❑ Environmental/ecological costs will result from the fact that currently existing, productive, useful farmland and marshes will be eliminated as SLR progresses.
- Benefits and opportunities will accrue from several sources including:

- ❑ protecting existing properties where practical and feasible by facilitating an environment that encourages innovation to maintain or improve value while maintaining or improving environmental and ecological sensitivity.
- ❑ Innovative incentives should be made available to the private sector to stimulate opportunities to help off-set asset losses when appropriate.

Some data sources that are relevant to the assessment of costs and potential benefits of this option are outlined below:

- ❑ Town of Oxford, Maryland Flood Insurance Rate Map, Community panel number 240068-001 A, effective September 28 1984
- ❑ Earth From Space. http://earthfromspace.photoglobe.info/spc_netherlands_dikes.html
- ❑ The Tye. <http://thetye.ca/News/2007/05/28/FloodControl/>
- ❑ MSN Encarta. http://encarta.msn.com/encyclopedia_761572410/netherlands_the.html
- ❑ Maryland Shorelines Online: <http://shorelines.dnr.state.md.us/living.asp>
- ❑ Chesapeake Bay Funders Network:
http://www.campbellfoundation.com/html/related_projects.html
- ❑ Coastal defense solutions (approach of ComCoast)
 - **Henk Jan Verhagen and Paul J. Visser:**
<http://www.citg.tudelft.nl/live/pagina.jsp?id=dcc8f165-73c7-475f-a9a5-5d8eca330d5f&lang=en>
- ❑ Intergovernmental Panel on Climate Change: <http://www.ipcc-wg2.org/index.html>

Feasibility Issues

Feasibility of the strategies and priorities from research depends on accurate projections of SLR, as well as the availability of adequate funding for strategies developed can be justified and become available because both short term and long term ecological, environmental, and financial benefit.

Moreover, several uncertainties can affect the feasibility of this option. These include the uncertainty regarding a) the rate and extent of SLR. the relative impact of subsidence, b) property protection across multiple owners should one or more not wish to participate, and c) the nature of the future federal response to the threat of sea level rise.

Status of Group Approval

TBD.

Barriers to Consensus

TBD.

EBEI-8: Building Code Revisions and Infrastructure Design Standards

Option Description

This option involves strengthening existing building codes and construction techniques for new infrastructure and structures in vulnerable coastal areas. This will involve evaluating existing codes and design standards with respect to their proven effectiveness in past storm events, identifying causes of failure, and implementing changes to codes to improve performance in the future. In addition to past performance, codes and standards should be reviewed and strengthened by taking into account future increased hazards caused by sea level rise and the associated possible increase in storm frequency and intensity caused by climate change. All types of development (residential, commercial, institutional, etc.), as well as public infrastructure such as roads and bridges, should be analyzed. Standards for marine-related structures such as piers and wharves should be included in this review.

In addition to the overall evaluation and strengthening of codes, the entire development process must begin to recognize the potential impacts of sea level rise and climate change. Design professionals must look for ways to reduce future impacts, and local governments must increase plan review, inspection and enforcement efforts.

This effort is ongoing at several levels. FEMA regularly publishes a “Summary Report on Building Performance” after major natural disasters (such as Hurricane Andrew and Hurricane Katrina). These reports study the damage resulting from the event, identify areas of strength and weakness in building design and construction, and recommend improvements. The International Code Council also studies code effectiveness and regularly makes improvements to its codes. It is imperative that these reviews begin to consider the effects of climate change and sea levels rise on the long-term sustainability of structures and infrastructure.

Option Design

Targets: All construction-related codes and design standards should be evaluated for their effectiveness in protecting against the future effects of climate change and sea level rise. This will include the following issues:

- Elevation of buildings – FEMA and local governments should mandate freeboard for all construction in coastal flood hazard zones. Freeboard is an elevation above a design high water level (base flood elevation). For example, the bottom of the lowest horizontal structural member should be elevated a minimum of two feet (or more) above the base flood elevation. This is especially pertinent with regard to sea level rise, since base flood elevations will be higher in the future. The required freeboard should relate to the amount of sea level rise expected, potential wave height, and the

expected life of the structure. Experience from Hurricane Katrina shows that building elevation is the most effective deterrent to flood damage.

- ❑ Foundation design – Certain types of foundations are more effective in flood situations than others. Deep pile or column foundations are desired if significant erosion is possible in oceanfront locations as well as bay locations where the following conditions exist: erodibility of the soil; exposure to “damaging” waves (greater than 1.5 feet high); potential for velocity flow; potential for flood borne debris; and required resistance to wind forces. These locations include FEMA identified V-zones as well as A-zones.
- ❑ Long-duration flood impacts – Long-duration flooding, which may be a result of sea level rise in the future, can cause extensive damage to interior contents and building materials. Moisture entrapment within walls and floors can impact structural integrity as well as cause biological and chemical contamination. Elevation will avoid this problem, as will the use of flood resistant building materials above the minimum elevation.
- ❑ Debris impact – Substantial damage can be caused by floating or wind-driven debris in a flood or storm event. Current codes and construction standards should be evaluated with regard to debris resistance.
- ❑ Building envelope – Building envelope is the entire exterior surface of a building, including walls, windows, doors and roofs. All parts of the building envelope must provide protection from wind, wind pressure, and windborne debris. Building codes are very specific regarding these issues, but they should continually be reviewed and improved as needed.
- ❑ Design of future public projects, including roads, bridges, tunnels, landfills, water and wastewater treatment plants, etc., should consider the effects of climate change and sea level rise. In addition, standards should be developed for the modification of existing facilities in response to sea level rise.
- ❑ Abandoned facilities – Provisions should be made to minimize the negative impacts of structures and facilities that may be abandoned due to sea level rise. Such impacts may include navigational and environmental hazards.

Timing: This is primarily an ongoing effort. Codes are currently in place, and should be implemented and enforced by everyone involved in the design and construction process. FEMA and the code agencies continually evaluate the effectiveness of the code requirements, especially after a major event such as a hurricane or flood. These events provide essential information regarding the performance of code complaint structures and reveal areas in need of improvement. Training of enforcement personnel should also be an ongoing effort. Codes and design standards should be reviewed periodically in light of new science and evidence of climate change and sea level rise.

Parties involved: All parties involved in the design and construction process should be involved in this effort, including for example the International Code Council, design professionals such as architects and engineers, building materials manufacturers, building trade associations, the Federal government (FEMA, National Weather Service, NOHH, Corps of Engineers), state government (MEMA, DOE, DNR, DOT), and local governments. Coordination with the Americans with Disabilities Act (ADA) is essential. Property owners also need to be aware of potential hazards and know how to evaluate the strengths and weaknesses of their properties.

Implementation Mechanisms

Implementation of this option will initially involve an evaluation of existing codes and regulations with specific regard to the threats associated with climate change and sea level rise. To account for the expected lifespan of newly constructed buildings, this will involve looking many decades into the future and trying to predict these impacts. If deficiencies are found, changes to codes, regulations and laws will be necessary. Enforcement of these codes is usually the responsibility of local governments; funding assistance is needed to ensure that an adequate number of trained code officials and inspectors are available.

Related Policies/Programs in Place

Codes are currently in place to regulate construction. The International Building Code is the primary building code. FEMA's flood insurance program is the primary source of flood protection regulations. State and local governments often compliment these general programs with more site-specific regulations.

Estimation of Adaptation Benefits and Costs

Implementing a program for strengthening existing building codes and construction techniques for new infrastructure and structures in vulnerable areas will be subject to a variety of costs and produce distinct benefits. As noted above, this option is focused on the evaluation of existing codes and standards for their effectiveness in protecting against the future effects of climate change and sea level rise. The types of costs considered here are incremental to those that have already been incurred to develop and maintain the existing framework of codes and standards in place in Maryland.

Incremental costs to address climate change through the implementation of strengthened codes fall into three major categories: assessment, new design requirements, training, and inspection. Assessment involves the costs for the comprehensive evaluation of existing statewide and local building codes and standards. New design requirements involve the future costs associated with meeting more stringent code requirements (e.g., freeboard requirements, higher safety factors for foundation design in coastal areas). Training involves the incremental costs associated with meeting the technical capacity needs of inspectors who will be charged with ensuring compliance with new codes. Finally,

inspection involves new funding to ensure that an adequate number of trained code officials and inspectors are available.

The benefits associated with strengthened building and infrastructure codes in Maryland center on the degree to which they integrate climate change risks into the state's codes and standards framework. Future state building stock and infrastructure will be designed and installed subject to standards established in response to emerging knowledge about climate change. Insofar as uncertainties remain, an implicit precautionary approach will be applied. The gradual transition of building and infrastructure stock should better position Maryland to plan for and mitigate against future climate change risks. These benefits, while difficult to quantify, are nevertheless substantial and likely to be higher than the incremental costs associated with the implementation of the option.

Feasibility Issues

None identified for the evaluation of existing codes and regulations with specific regard to the threats associated with climate change and sea level rise.

Status of Group Approval

TBD.

Barriers to Consensus

TBD

EBEI-10: Disclosure

Option Description

With the ongoing and anticipated changes to the Maryland coastline associated with climate change, the State of Maryland should ensure that prospective coastal property purchasers have knowledge of the potential impacts that sea-level rise, storm surge, and other effects of climate change may have on the property they are considering purchasing. This enables future property owners to make more informed decisions. It is in the interest of prospective property owners to be fully informed of risks they are undertaking and potential insurance implications – as well as potential options for addressing these risks – at the time they are making the decision to purchase the property. Such awareness will enable potential purchasers to better evaluate the appropriate uses of the property and will decrease the possibility of subsequent lawsuits and other disputes.

Option Design

This option is applicable to all counties bordering the Atlantic Ocean and the Chesapeake Bay.

Targets: Information should be required to be made available in as many stages of the property transaction and ownership as possible, including but not limited to:

1. Notification of potential buyers in the listing of the property.
2. Disclosure notice at settlement.
3. Recording on the plat maps, zoning maps, or with the title and deed, with notice to the property owner, of relevant information that is collected by Federal, State, or local agencies showing changes in the coastal boundaries and natural and topographical features (e.g., wetlands and dunes)..

Timing: The timing for making disclosure information available for real estate transactions is immediate.

Parties Involved: Only those parties directly involved in the transaction (i.e., the buyer and seller, and their agents) are involved.

Other: In these various stages of the property transaction and ownership, the information required to be disclosed should cover as many as the following types of information as possible, including:

1. General information about sea-level rise, coastal storms, coastal erosion, and their impacts on the area (i.e., coastal counties). This could be in the form of a generic brochure, which could be developed by the State in concert with realtors and other stakeholders.
2. Whether the property is in an area that has been determined to be at risk from sea-level rise and associated hazards by relevant authorities, including the National Flood Insurance Program, Maryland Critical Areas Commission, NOAA, Maryland Department of Natural Resources, and/or other relevant authorities.
3. Any knowledge that the property owner has of any flooding, avulsion, erosion, or other damage to the natural or topographical features or any built structure that has occurred on the property.

Implementation Mechanisms

Implementation of this option will require changes to existing law in Maryland in two major areas. First, the State may require property owners or managers to provide general information on climate-related risks, similar to the general notice (pamphlet) regarding lead. This notice requirement could be triggered particularly for vulnerable properties: for lead, that includes residential buildings built before 1978; for sea-level rise, that could include houses in coastal counties or those located in areas specifically identified as vulnerable to sea-level rise, erosion, storm surges, and other related risks. Second, to the

extent that a property owner or manager has knowledge regarding the risk to that particular property (presence of lead-based paint, or past flooding or erosion), the law would also require the property owner or manager to disclose that information. The analogy to sea-level rise, erosion, storm surge, and other climate change-related risks is straight-forward.

Related Policies/Programs in Place

See “Feasibility Issues” section below.

Estimation of Adaptation Benefits and Costs

Implementing disclosure requirements for coastal hazards related to the purchase/sales of property for residential and commercial properties is a fairly low cost option. As residential and commercial real estate in certain locations may experience greater risks due to climate change effects (e.g., rising sea levels, increased hurricane severity), the disclosure statement is intended to serve a public awareness function regarding the potential risks incurred by the buyer. Notably, given the regional nature of coastal threats, this function is not limited to Maryland’s coastal areas only, but serves to inform buyers that all coastal properties are subject to similar conditions.

The incremental costs are associated with developing the statutory framework to ensure that a Maryland Sea Level Rise Disclosure and Advisory Statement is included in the set of documents for purchasers of real property in the coastal counties of Maryland. These costs are likely to be *de minimus*.

The incremental benefits associated with the Advisory Statement are much more difficult to assess and will depend on the effect that the Statement has on property values and the number of coastal real estate transactions. It seems likely that disclosure statement itself will have a much smaller effect than the evolving perspectives of property insurers who may increase insurance premiums for properties located in coastal zones deemed vulnerable to climate change, or lending institutions who may consider the property's value as having reduced collateral for a commercial or residential mortgage loan.

Feasibility Issues

These advice and notice requirements would build upon the implementation precedent of requiring residential property sellers to provide information regarding lead and lead-based paint (notification requirements regarding radon provide another precedent). Federal¹ and State² law require both general and specific disclosure regarding lead in residential housing transactions. In particular, persons selling or leasing most residential housing built before 1978 are required to provide purchasers and renters with a federally approved lead hazard information pamphlet (*Protecting Your Family from Lead*;³ *Maryland Real Property Disclosure and Disclaimer Statement*⁴) and to disclose known lead-based paint and/or lead-based paint hazards in the sales contract.⁵

Status of Group Approval

TBD.

Barriers to Consensus

TBD.

¹ 24 CFR Part 35; 40 CFR Part 745; 9061 Fed. Reg. 61 (Mar. 6, 1996), available at: <http://www.epa.gov/fedrgstr/EPA-TOX/1996/March/Day-06/pr-24120.pdf>; see also, http://www.epa.gov/lead/pubs/selr_eng.pdf.

² COMAR, Real Property Article § 10-702, available at http://mlis.state.md.us/asp/web_statutes.asp?grp&10-702.

³ <http://www.epa.gov/lead/pubs/leadpdf.pdf>.

⁴ <http://www.dllr.state.md.us/forms/danddform.doc>.

⁵ EPA, *Interpretative Guidance for the Real Estate Community on the Requirements for Disclosure of Information Concerning Lead-Based Paint in Housing*, (Aug. 20, 1996) available at: <http://www.epa.gov/lead/pubs/1018fin.pdf>.