Building Resilience to Change:

Developing Climate Adaptation Strategies for Virginia's Middle Peninsula

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List of Acronyms

Acronym	Full Name
Virginia Agencies, Committees, Organizations	
CCAC	Climate Change Advisory Committee
CELCP	Coastal and Estuarine Land Conservation Plan
CPT	Coastal Policy Team
DCR	Department of Conservation and Recreation
DEQ	Department of Environmental Quality
DGIF	Department of Game and Inland Fisheries
MRC	Marine Resources Commission
VCZMP	Virginia Coastal Zone Management Program
VIMS	Virginia Institute of Marine Science
VNRLI	Virginia Natural Resources Leadership Institute
Federal	
CBPA	Chesapeake Bay Preservation Act
CBRA	Coastal Barrier Resources Act
CCSP	U.S. Climate Change Science Program
COE	U.S. Army Corps of Engineers
CZMA	Coastal Zone Management Act
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Maps
FWS	U.S. Fish and Wildlife Service
HMGP	Hazard Mitigation Grant Program
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
OCRM	Office of Ocean and Coastal Resource Management
OMB	Office of Management and Budget
Miscellaneous	
CCAW	Climate Change Advisory Workgroup (MPPDC)
CRS	Community Rating System
DEM	Digital Elevation Model
GIS	Geographic Information System
IPCC	Intergovernmental Panel on Climate Change
ISCC	International Scientific Congress on Climate Change
LID	Low Impact Development
LIDAR	Light Detection and Ranging
MLWL	Mean Low Water Line
MPPD	Middle Peninsula Planning District
MPPDC	Middle Peninsula Planning District Commission
RPA	Resource Protection Areas
RMA	Resource Management Areas
SLR	Sea level rise
CBNERR	Chesapeake Bay National Estuarine Research Reserve
CTP	Coastal Training Program

Executive Summary

With over 1000 miles of coastal shoreline and many low lying areas, Virginia's Middle Peninsula is vulnerable to coastal storms and flooding, which will be made worse by climate change and sea level rise. In collaboration with current planning efforts of the Middle Peninsula Planning District Commission (MPPDC), this project report has two primary goals:

1. To synthesize adaptation planning principles and practice that are applicable to the MPPD;
2. To develop a planning framework and strategies to build resilience to natural hazards and climate change impacts; and
3. To present findings that are useful to MPPD and other coastal communities working to begin or expand climate change adaptation planning efforts.

Adaptation is defined as a process, action, or outcome in a system in order for the system to better cope with, manage, or adjust to a changing condition, risk, or opportunity. A system's capacity for adaptation or resilience is its ability to absorb perturbations without being undermined or becoming unable to adapt, self-organize and learn. Effective adaptation, then, must be anticipatory, identify vulnerabilities, stress preparedness for change, and build capacity for resilience among those likely affected by change.

This report summarizes existing studies and plans by the MPPDC and others on the anticipated climate change impacts in the region and the state of the Middle Peninsula's preparation for those impacts (chapter 2), synthesizes some general climate change adaptation planning principles applicable to the Middle Peninsula (chapter 3), reviews and gleans lessons from case examples of state and local adaption and resilience plans (chapter 4), and based on those principles and cases, formulates a planning framework and a portfolio of strategies appropriate to the Middle Peninsula that may help MPPD jurisdictions better prepare for existing and expected hazards and impacts (chapters 5 and 6).

The potential impacts of climate change are widespread across many sectors in the Middle Peninsula, vulnerabilities are significant, and uncertainties complicate public engagement and commitment to action. The MPPDC has been active in developing natural hazard mitigation plans , performing a vulnerability assessment and community involvement about climate change impacts as well as adaptation strategies. These current planning efforts by the MPPDC and by some localities provide a foundation for hazard mitigation, climate change adaptation, and building community resilience. An assessment of current local plans and ordinances identified some positive actions among localities but also common gaps in effectiveness and opportunities for improvement.

Principles of climate change adaptation gleaned from four extensive studies on the topic include five basic steps: (1) identifying current and future climate impacts, (2) assessing vulnerabilities and risks to climate impacts, (3) developing a risk-based, prioritized adaptation strategy, (4) implementing the strategy, and (5) monitoring and evaluating the implemented strategy. Additionally the four studies emphasize the use of best available science, a collaborative planning approach, and priority setting.

A review of selected state and local adaptation plans revealed a number of lessons for the Middle Peninsula, including (1) establishing a policy framework for addressing vulnerability and change under the theme of Community Resilience; (2) expanding science-based assessments of vulnerability and risk, mapping and evaluating high hazard and impact areas; (3) engaging local leaders and citizens in dialogue, planning, decision-making, and action about vulnerability, change, and resilience; (4) incorporating vulnerability and change into District-wide and county comprehensive plans; (5) within such plans, adopting a protection-accommodation-retreat approach, applying adaptive management and flexibility to manage uncertainty, taking a place-based approach, and considering co-benefits of actions taken; and (6) giving priority to action strategies that improve economic and social well-being.

The climate adaptation strategies developed in this study apply these principles and experiences to the situation of the Middle Peninsula. The approach includes a basic framework for policy, planning, public engagement, and vulnerability assessment. The portfolio of strategies that should emerge from this framework includes regulatory and non-regulatory programs that range from floodplain management and overlay zones to infrastructure permitting and investment to land conservation easements to tax policies to education and outreach.

Climate change is real and happening, yet the magnitude of its local consequences and their timing are uncertain. This uncertainty complicates appropriate actions which may require changing behavior, changing patterns of land use, changing property values, and changing infrastructure investments. Even without uncertainty, change is hard and needed investment for change is hard to come by. But the most costly, damaging, and disruptive approach in the face of the vulnerability of the Middle Peninsula is to do nothing.

Localities within the Middle Peninsula must continue to build their community resilience to disruptive events and changing conditions. Their current efforts vary, and a more consistent regional strategy coordinated by the MPPDC is recommended. Given uncertainties and current public sentiments, such a regional strategy and its local implementation should begin with a public engagement program that includes local fact-finding and vulnerability assessment, and the collaborative learning it generates. Plans and strategies should be flexible, adaptive, and incremental, allowing for modification over time as conditions, resources, and sentiments change and uncertainties are resolved.

This iterative approach to reduce vulnerability and build resilience should be integrated into the PDC's and localities' existing planning framework, which includes comprehensive planning, natural hazard mitigation, land use zoning, building codes, floodplain management, stormwater management, Chesapeake Bay regulations, land conservation, and transportation and water/wastewater infrastructure plans. These programs will continue to be the foundation for efforts to reduce vulnerability over time.

Chapter 1: Introduction

Climate change may increase the likelihood of extreme weather events such as floods, coastal storm surges, droughts and heat waves, as well as more gradual changes in temperature, precipitation, and sea level rise. Climate change is a global phenomenon, which compels local decision makers to develop adaptation strategies that secure and promote public safety, health and welfare by reducing vulnerability to existing hazards and impacts that are expected to be exacerbated by climate change.

2010 Census for Middle Peninsula	
Total Population	90,826
Growth Rate	9%
Population Density (persons/square mile)	71

Although one of the least densely populated areas in the state, the Middle Peninsula did see a population increase of 7.9% from the 2000 Census. The Middle Peninsula contains 3.2% of Virginia's land mass but only 1.1% of the state's total population.

Population Trends by County			
Locality	Total Population		Population Growth from 2000-2010
	2000	2010	
Essex	9,989	11,151	12%
Gloucester	34,780	36,858	6%
King & Queen	6,630	6,945	5%
King William	13,146	15,935	21%
Mathews	9,207	8,978	-2%
Middlesex	9,932	10,959	10%
Town of Tappahannock	2,138	2,375	11.1%
Town of Urbanna	543	476	-12.3%
Town of West Point	2,866	3,306	15.4%

Figure 1.1 Middle Peninsula Regional Profile. Source: MPPDC (June 2011).

The Middle Peninsula Planning District (MPPD) of the Virginia Commonwealth is located on the Chesapeake Bay. Occupying 1,387 square miles (888,064 acres) the MPPD consists of the Counties of Essex, Gloucester, King and Queen, King William, Mathews, and Middlesex Counties and the Towns of Tappahannock, Urbanna, and West Point (Figure 1.1). The shoreline of the Middle Peninsula reaches 1,055 miles, and the MPPD is one of the least densely populated areas of the state with a population density of only 71 persons per square mile at the time of the 2010 U.S. Census (MPPDC, 2011).

Figure 1.2 The Middle Peninsula Region (Source: MPPDC, 2005)

As reported by the MPPDC in 2011, regional population growth rate for the Middle Peninsula was nine percent (9%) as of the 2010 U.S. Census. The Counties of Essex, King William, and Middlesex all had growth rates exceeding ten percent during that period while Gloucester, King & Queen, and Mathews experienced slower growth (6%, 5%, and -2%, respectively).

The Middle Peninsula is already vulnerable to flooding and coastal storms which are projected to worsen as a result of climate-change-induced weather variability and sea level rise. Additional community aspects at risk to climate impacts include natural habitats and biodiversity, agriculture, infrastructure, as well as economic and social

disruption. With its extensive shoreline, a considerable amount of coastal land and low lying areas in the Middle Peninsula is vulnerable to climate change impacts. In collaboration with current planning efforts of the Middle Peninsula Planning District Commission (MPPDC), this project report has two primary goals:

1. To gather and summarize examples of adaptation planning principles and practice that are applicable to the MPPD; and
2. To present findings in such a manner that can be useful to MPPD and other coastal communities working to begin or expand climate change adaptation planning efforts.

Project Scope

Climate change planning – often referred to as "climate action" planning – is comprised of both climate change mitigation (i.e. reduction of carbon emissions) and climate change adaptation (i.e. preparing for and responding to the effects of climate change). These two aspects of climate action planning are inextricably linked and often overlap in application. As stated by John Holdren, Director of the White House Office of Science and Technology Policy, "We only have three choices: adaptation, mitigation and suffering, and we are going to need a lot of the first two in order to avoid a lot of the third" (Tollefson, 2010).

Climate adaptation planning is the central focus of this report. Adaptation can be defined as:

> a process, action, or outcome in a system in order for the system to better cope with, manage, or adjust to changing condition, risk, or opportunity. A system's capacity for adaptation or resilience is its ability to absorb perturbations without being undermined or becoming unable to adapt, self-organize and learn. Effective adaptation, then, must be anticipatory, identify vulnerabilities, stress preparedness for change, and build capacity for resilience among those likely affected by change. (Randolph, 2011)

Achieving effective adaptation planning requires coordination across many sectors of planning: community development, economic development, emergency preparedness, hazard mitigation, infrastructure and service planning, and natural resources planning. Resulting adaptation plans, then, often resemble a strategic plan or hazard mitigation plan. The National Research Council's report, *Adapting to the Impacts of Climate Change* suggests that the adaptation process is "fundamentally a risk management strategy" (NRC 2010).

In collaboration with the MPPDC, the focus of this study is on adaptation planning for impacts of "climate change and sea level rise." The impacts are more complex than simply slow rising waters, since the major effects will be felt in more intense and frequent flooding and storm surge events, saltwater intrusion and rising water tables that impact wells and septic systems, extreme heat events, and the disruptions created by hazards and changing conditions.

The principle aim of this report is to summarize existing studies and plans by the MPPDC and others on the anticipated climate change impacts in the region and the state of the Middle Peninsula's preparation for those impacts (chapter 2), synthesize some general climate change adaptation planning principles applicable to the Middle Peninsula (chapter 3), review and glean lessons from case examples of state and

local adaption and resilience plans (chapter 4), and based on those principles and cases, formulate a planning framework and a portfolio of strategies appropriate to the Middle Peninsula that may help MPPD jurisdictions better prepare for existing and expected hazards and impacts (chapters 5). First, this chapter introduces expected climate change impacts in the MPPD and reviews recent efforts by the PDC and member jurisdictions in hazard mitigation and vulnerability assessment.

Chapter 2: The State of Community Resilience to Climate Change in the Middle Peninsula

The Middle Peninsula PDC has been active in planning to reduce vulnerability to impacts of hazards and climate change in the region. Still, the state of hazard mitigation and adaptation planning within the MPPD varies among jurisdictions. Recent planning studies include the current PDC climate adaptation studies, as well as natural hazard and floodplain planning, water quality assessments and Total Maximum Daily Load (TMDL) development, inventory of current and projected alternative onsite sewage disposal systems (OSDS) and water supply planning. Planning and mapping efforts are not uniform for all Middle Peninsula localities, and for most, ordinances have yet to incorporate proactive measures that address likely future hazard and climate scenarios.

Middle Peninsula localities and the Planning District Commission (PDC) face multiple challenges, including scarce funding, economic development needs, provision of services to higher-risk areas, stewardship of natural and cultural resources, and varying political perspectives on the need for climate-change planning. Opportunities to address climate adaptation exist within the regulatory framework enabled by the Virginia Commonwealth, as well as ongoing efforts promoting interagency collaboration in the areas of natural resource planning, public access to waterways, shoreline protection decisions, floodplain management, and natural hazard mitigation. The MPPDC has been active in acquiring planning funds through federal and state sources toward such endeavors.

This chapter presents the state of Middle Peninsula resilience to climate change. It summaries existing climate change impact and vulnerability studies and hazard mitigation plans, and identifies challenges and opportunities within the MPPD for adaptation planning, including local-level strategies. To put the Middle Peninsula in context, Appendix 2.A to this chapter provides a short literature review of climate change impacts in the Chesapeake Bay Region.

Middle Peninsula Planning District Hazard and Climate Change Planning

Middle Peninsula Natural Hazard Mitigation Plan (2010)

The Middle Peninsula Planning District Commission has been active in planning to reduce vulnerability to impacts of hazards and change in the region. In 2010, the PDC completed the Middle Peninsula Natural Hazards Mitigation Plan (NHMP) Revision 1, which updated the hazard identification, prioritization and goals from the 2006 NHMP. The NHMP assessed vulnerability and risk from 21 natural hazards including weather-related events and geologic hazards. All of the 21 hazards identified are likely to be exacerbated by climate change, with the exception of land subsidence resulting from karst terrain (Figure 2.1). In addition to vulnerability assessment, the plan assessed local capabilities and outlined a hazard mitigation strategy to prevent future hazard related losses, to improve community emergency management capability, and to increase public awareness of vulnerability to hazards.

Revision 1 of the NHMP made noteworthy additions to the previous plan, such as consideration of Sea Level Rise as a “Moderately-Critical Hazard” to the Middle Peninsula and recommendation of public outreach to mitigate risk to riverine flooding and lightning strikes.

MIDDLE PENINSULA HAZARD AND VULNERABILITY ASSESSMENT TOOL
NATURAL HAZARDS -- SUMMARY SHEET

EVENT	PROBABILITY	HUMAN IMPACT	PROPERTY AND FACILITY IMPACT	BUSINESS IMPACT	Mitigation Options	UNMITIGATED RISK	UNMITIGATED RANKING
	Likelihood this will occur	*Possibility of death or injury to public and responders*	*Physical losses and damages*	*COOP and interruption of services*	*Pre-Planning*	*Relative Threat*	*Based only on probability and threat*
SCORE	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 - 100%	
Hurricanes	3	3	3	3	2	92%	
Winter Storms (Ice)	2	2	2	3	2	50%	
Tornados	2	2	2	2	2	44%	
Coastal Flooding	3	2	3	2	2	75%	
Coastal/Shoreline Erosion	3	1	2	1	2	50%	
Sea Level Rise	3	0	2	2	2	50%	
Winter Storm (Snow)	2	2	2	2	2	44%	
Wildfire	2	1	1	1	2	28%	
Riverine Flooding	2	2	1	1	2	33%	
High Wind/Windstorms	2	2	2	1	1	33%	
Dam Failure	2	1	1	1	2	28%	
Drought	2	0	1	2	2	28%	
Lightning	3	1	2	2	1	50%	
Earthquake	1	0	0	0	0	0%	
Shrink-Swell Soils	2	0	1	0	1	11%	
Extreme Cold	1	2	0	0	1	8%	
Extreme Heat	2	2	0	0	1	17%	
Landslides	1	0	0	0	0	0%	
Land Subsidence/Karst	1	0	0	0	0	0%	
Tsunami	1	0	0	0	0	0%	
Volcano	0	0	0	0	0	0%	
AVERAGE	2.27	1.27	1.67	1.53	1.67	25%	

*Threat increases with percentage.

UNMITIGATED RISK=		PROBABILITY * IMPACT	
	0.25	0.63	0.39

KAISER PERMANENTE

Figure 2.1 Priority Risks Identified in MPPDC Natural Hazard Mitigation Plan (2010)

Middle Peninsula Climate Adaptation (2008-11)

In addition to the NHMP, the MPPDC is in the midst of a three year endeavor funded through the Virginia Coastal Zone Management Program to work with member localities and stakeholder groups to assess and discuss potential climate change and sea level rise impacts to the region. In particular, Phase I of this project focused on the collection, assessment and analysis of potential ecologic and anthropocentric impacts of climate change, specifically due to sea level rise. The information gathered during Phase I acted as a foundation to develop an educational program for local elected official and the general public in Phase II.

The MPPDC staff procured best-available geographical information systems (GIS) data to produce maps of land vulnerable to future coastal flooding and sea level rise. To connect Phase I vulnerability analysis with actionable planning strategies, the MPPDC administered a public outreach and education phase of

their program. Stakeholder meetings produced numerous opportunities for discussion of potential impacts and adaptation priorities.

As climate change and sea level rise still remain a very unsettled issue amongst Middle Peninsula constituents and local elected officials, MPPDC staff developed an educational program to continue dialogue about this issue and to begin to discuss local government's role in managing potential impacts. Through the use of Qwizdom software, an audience response system that utilizes hand held remotes and an interactive tablet to engage the audience, stakeholder feedback was gathered and summarized in a cumulative findings report. The report demonstrates discrepancies between stakeholder group knowledge and beliefs with regard to climate change and sea level. The MPPDC intends to use community perceptions to improve effectiveness of future educational outreach efforts and policy development. The following sections provide some detail on Phases I and II.

Middle Peninsula Climate Adaptation Impact Assessment Phase I (Year 1: 2008-09)

Phase I of the climate adaptation project focused on the collection, assessment and analysis of potential ecologic and anthropocentric impacts of climate change specifically due to sea level rise (SLR). MPPDC staff produced a 37-page report, detailing key vulnerabilities within the planning district. The assessment report divides assets into two categories: Infrastructure and Wetland Functions. Infrastructure subcategories include houses, onsite sewage disposal systems (OSDS), wells, shoreline hardening, roads and railroads. Wetland functions include Commercial Factors (fishing and shellfish habitat, waterfowl habitat, mammal and reptile), Damage Control Factors (environmental protection against erosion, wind, storms, flooding), and Recreational Opportunities (consumptive and non-consumptive). The report cites several methodologies for estimating values of ecological functions and, therefore, offers a range of potential loss whenever employing more than one assessment method.

The MPPDC distributed Year One efforts across the following five phases:

1. **Introduce the issue** of climate change and SLR to the MPPDC
2. **Assemble a Climate Change Advisory Workgroup** (CCAW) to identify anthropogenic and ecological vulnerabilities within the Middle Peninsula
3. **Educate the CCAW** on the topic of climate change, current regional impacts, and survey of current adaptation practices, domestically and internationally
4. **Map regional and county SLR predictions** to depict impacts on structures and wetlands
5. **Assess and prioritize** economic and ecological vulnerabilities to SLR

In March 2009, MPPDC staff presented an overview of current domestic and international practices entitled "Responses to Climate Change Impacts." The presentation addressed three general categories: 1) Mitigating SLR Impacts on Coastal Property, 2) Mitigating SLR Impacts to Coastal Infrastructure, and 3) Land Use Responses to Other Climate Change Impacts. To build on this work, a variety of additional land use strategies can be added to the overview for future use by local decision makers (e.g. density transfers, conservation easement programs, and extension of Resource Protection/Management Areas under the Chesapeake Bay Preservation Act). This report addresses those adaptation strategies in detail in subsequent chapters.

Maps were created for the whole Middle Peninsula region as well as focus areas within various member jurisdictions. Impact assessments were presented to stakeholder groups in the form of focus-area map

accompanied by cost estimates. The cost estimates were based on inundation and therefore estimated losses – infrastructure, ecosystem function, and wetlands – as total loss. The calculation methods employed in these estimates were well documented and presented as potential ranges for loss. The MPPDC vulnerability assessment comprises a robust set of test scenarios against which to measure adaptation strategies as they are developed.

MPPDC staff conducted a sector-wise brainstorming session of climate change impacts, using the following sectors: Recreation, Transportation, Infrastructure, Business, Health, Emergency Response, Energy, Hydrology and Water Resources, Agriculture, Biodiversity, Forests, Coastal Resources and Ecosystems, and Aquatic ecosystems. Impacts and vulnerabilities identified in this process are summarized in the Challenges section later in this chapter.

Middle Peninsula Climate Change Adaptation Phase II: Discussions with Local Elected Officials and the General Public (Year 2: 2009-10)

Maps and educational materials from the Middle Peninsula vulnerability assessment were disseminated to all counties within the MPPD. A Coastal Zone Management (CZM) grant for Year 2 funded a series of Qwizdom-facilitated meetings intended to assess existing knowledge and preferences regarding climate change, sea level rise, and government services. MPPDC staff developed a sixteen-question presentation: six questions each on Climate Change and Sea Level Rise, four questions on Government Services. The questions were then posed to representative members of three target groups: Local Elected Officials (i.e. MPPDC Board Members), County Staff, and General Public.

Findings for this report are in narrative form, generally with the following themes:

- **Belief in Climate Change:** A high majority of those polled believe climate change is occurring – 87 percent, 91 percent and 91 percent – Local Elected Officials, County Planning Staff, and General Public, respectively

- **Sea Level Rise:** High majorities of those polled agree there has been an increase in Mean SLR over the past 20-30 years (87/100/83 for PDC Board/Planners/Public) and non-conflicting views of the past rate of SLR in the Middle Peninsula

- **Government Services:** A narrow majority of local planners and the general public agree that a property owner has the right to build anywhere they can obtain the required permits (55 and 50 percent, respectively with one general public respondent not answering), while 60 percent of Local Elected Officials answered 'No' to the same question

- **Increased Cost of Government Services:** Multiple-choice answers for how to address increased cost of government services (due to climate change) were "Develop a High-hazard district," "Levy additional county-wide public service tax," or "Set aside general fund revenues." A majority of all respondents selected High-hazard district (60/91/71 for Elected Officials/Local Planners/ General Public, respectively)

In a brief concluding statement to their Year 2 report, MPPDC discuss Year 3 development of a START (Start Adaptation and Response Today) kit, to include local scientific data, Kaiser-Permanente natural

hazard vulnerability assessment results, relevant case studies, and sample ordinances from communities that have adopted adaptation planning policies. This report is intended to supplement the case study and strategy options portion of the START kit.

Challenges Facing Middle Peninsula Climate Adaptation

As local communities are responsible for land-use planning, they "bear the majority of responsibility to plan, implement, and enforce adaptation strategies…in a changing environment" (Culver, et al., 2010). The Middle Peninsula faces considerable challenges to manage existing natural hazards and vulnerabilities and these and other impacts are expected to increase with advancing climate change.

Impacts are wide-reaching

In its Phase I study and its NHMP, the MPPDC assessed potential impacts of hazards and climate change on the Middle Peninsula. Region-specific assessments completed by the National Research Council (2010) round out the list of potential impacts (covered in greater detail in Chapter 3). The following summarizes these natural hazard and climate change impacts by sector.

Agriculture & Forestry. Loss of farmland occurs where extreme weather events combine with land subsidence to leave some areas water-logged and no longer able to produce. Disease pressure on crops and livestock increases with earlier springs and warmer winters, allowing higher survival of pathogens and parasites (NRC, 2010), and point and nonpoint source pollution from agriculture practices could increase.

Fisheries. Negative impacts on fisheries can cause economic losses. Fecal coliform occurrence in drainage ditches was very high following Hurricane Isabel in 2003. Leaking septic tanks are more frequent as a result of storm surge and coastal flooding, flowing into drainage ditches and adjacent bodies of water, negatively impacting fish populations.

Recreation. Rising sea level or erosion may continue to decrease the area available for public parking and public water access. This trend, combined with increased summer season length could result in increased burden on existing public access facilities. In turn, the redistribution of season lengths has the potential to increase use conflicts between recreational users and marine-based fishing and commerce users (Karl et al, 2009).

Transportation. Travel disruptions are associated with road washouts and flooding. Property values may diminish based on impaired road access to businesses and residences due to road washouts and flooding. Increased maintenance costs of impacted/damaged roads are likely in vulnerable areas. Coastal storm surge and flooding reduces water-based navigation availability in some areas, impacting commercial and recreational boating. Road damage from increased flooding is likely. Some areas are cut off from evacuation or assistance due to flooding, washouts, or damage to bridges.

Infrastructure. Sea level rise increases risk of surface water reservoir contamination, shellfish habitats impairment, and increased risk of harmful algal blooms. There is increased likelihood of loss of private and public infrastructure due to storm surge and coastal flooding: water and sewer systems, power lines, and roads.

Water. Increasing frequency of coastal and riverine flooding poses a threat to buildings and infrastructure located in the floodplain and storm surge areas. Water quality becomes more challenging to maintain with increased flooding and storm water runoff, which carries harmful pollutants. Existing water infrastructure and treatment capacity may be insufficient to handle failure due to storm surge.

Saltwater Intrusion. Saltwater can contaminate freshwater aquifers and make them unsuitable for human consumption, or even for agricultural uses. The intrusion of saltwater can also be a risk to shallow freshwater aquifers that may be pushed upwards causing contamination risks from septic tanks and runoff pollution (Bailey, Deyle & Matheny, 2007). The point at which the fresh and saltwater meet is called the salt front, and it can move up freshwater rivers (NRC, 1987). This will spoil uses of freshwater and negatively impact recreation opportunities.

Health. Rises in summer temperatures can lead to more heat related strokes and reduced air quality. Climate change causes distribution of vector-borne and zoonotic diseases and may also cause re-emergence of diseases such as malaria and dengue fever. Heat causes increase in ground level ozone concentrations which can cause lung injury and increase severity of respiratory diseases. Rising groundwater levels will inundate drain fields impairing function for both disposal and soil treatment.

Ecological Impacts. Sea level rise and coastal flooding affects water quality in the Middle Peninsula. Changes in crop yields occur where there is an increased risk of heat stress, pest outbreaks, and weeds due to damp conditions. Coastal flooding and storm surge have also led to habitat loss for coastal species. Erosion causes damages to coastal infrastructure, dunes, beaches and other natural resources. Salt water intrusion occurs in coastal aquifers due to sea level rise, and there may be increased risk of pollution from coastal hazardous waste sites due to storm surge and flooding.

Energy. Rises in average and peak temperatures during warmer months, in addition to longer warm seasons, lead to increased demand for cooling and fewer months requiring heat energy. Extreme weather events along the coast may potentially disrupt energy conversion, generation, and transportation. Energy infrastructure in at-risk areas may suffer damage or require high frequency of maintenance due to coastal flooding and storm surge.

Vulnerabilities are significant

The existing Multi-Hazard Mitigation Plan (MHMP) for the Middle Peninsula includes Coastal Flooding and Coastal/Shoreline Erosion, outranked only by Hurricanes, Wind Storms, and Tornadoes in the MPPDC's risk assessment. Scoring and ranking criteria are clearly identified in the MHMP, and a similar framework can be adapted to a risk-based analysis and prioritization of coastal vulnerabilities in the future. A challenge of using the hazard mitigation planning framework as a model is that hazard probability is based on historic frequency of the event. In the case of coastal flooding and erosion, past rates of occurrence alone are insufficient to calculate future likelihood. With changing climate, future sea level, storm surges, and erosion rates will be different from the past. Future hazard probability should be based on calculations that incorporate current science-based formulas to determine future rates of coastal

storm surge, flooding, and erosion. For example, FEMA is currently in process of updating Flood Insurance Studies for mid-Atlantic coastal communities (see http://www.r3coastal.com) , which will base in part on a recent storm surge study completed by the U.S. Army Corps of Engineers (see http://www.r3coastal.com/home/storm-surge-study). These studies should incorporate future scenarios of sea level rise and resulting impacts on flood elevations.

Uncertainties complicate public perceptions and commitment to action

Climate change is real and happening, yet the magnitude of its local consequences and their timing are uncertain. This uncertainty complicates appropriate actions which may require changing behavior, changing patterns of land use, changing property values, and changing infrastructure investments. Even without uncertainty, change is hard and needed investment for change is hard to come by.

These uncertainties influence public perceptions about the need for action. In recent years, the MPPDC has experienced a range of local reactions to planning efforts that incorporate the concept of "climate change," from invested stakeholder support to staunch stakeholder resistance. Beyond the physical challenges posed by vulnerability, local planners and decision makers face the political challenge of incorporating all citizen input into the planning process. This can be difficult when facilitating politically polarized stakeholder groups. Local planners and community officials may consider the following three recommendations, developed by Culver et al (2010): [1], "show leadership and recognize the need to act, [2] organize stakeholders to identify key values and develop a common vision for the future of the community, and [3] partner with neighboring communities to leverage resources and support comparability" (Culver, et al., 2010).

Under the Dillon rule, Virginia localities must have delegated authority for specific actions

In Virginia, local government authority is limited by the Dillon rule, meaning that localities may exercise only those powers specifically delegated by the General Assembly and may use only those methods consistent with state statute. It is possible that Middle Peninsula localities could choose to implement a climate change adaptation strategy but lack the authority to do so.

In 2010, the Georgetown Climate Center conducted a case study of Virginia and specifically analyzed the authority of Virginia localities to use existing land use powers to adapt to climate change impact based on both statutory language and case law. The study concluded that the "Virginia Code delegates broad authority to local governments, which reasonably permits consideration of sea level rise," including comprehensive planning and land use regulations (setbacks, transfer of development rights) and non-regulatory measures (tax incentives and open space easements) in vulnerable areas (Silton and Grannis, 2010, p. 23). Localities also have broad authority to regulate development in flood prone areas (15.2-2283) and riparian areas under the Chesapeake Bay Preservation Act (10.1-2108).

Opportunities for Community Resilience

Opportunities for reducing vulnerability and building resilience to change require a comprehensive approach including policy statements, vulnerability assessments, citizen engagement, and development of appropriate strategies. Whatever strategies that are developed should build on current land use policies

and regulations. This section provides a general discussion of strategies that serve as a first step and foundation for a more comprehensive approach for community resilience. These include floodplain mapping and management and land use ordinances. The following section assesses current plans and ordinances in MP localities through the lens of climate change adaptation.

Comprehensive Plans

The Code of Virginia (§ 15.2-2223) states that all Virginia local governments shall prepare a comprehensive plan that reflects a 40-50-year vision for the community and describes means to achieve that vision. The plan should be updated about every five years. The plan generally contains several elements including land use, transportation, infrastructure, natural environment, hazard mitigation, housing, economic development, and others. Chesapeake Bay localities need to incorporate goals, objectives, and strategies to meet requirements of the Chesapeake Bay Preservation Act. The plan involves a process of public engagement, technical analysis, and elected official adoption, so it carries some public and political authority.

Floodplain Management

Floodplain mapping is an important aspect of flood hazard mitigation. It is used to identify properties that fall within flood hazard areas, for zoning and development purposes, and for the Federal Emergency Management Agency (FEMA) National Flood Insurance Program, which offers subsidized flood insurance. One-hundred year floodplain maps developed by FEMA represent areas with a 1% statistical chance of flooding in a given year, and are created based on historical data. As more extensive and accurate data becomes regularly available, updated floodplain maps can be combined with best-known estimates of mean sea level change (using annual tide data) for the purpose of future planning and climate change adaptation, these maps should also account for future expected sea level rise. As sea level changes occur, it is expected that "higher floods will happen more often, and the boundaries of flood zones and hurricane storm surge vulnerability zones for storms of a given return frequency will move higher and further landward (Bailey, Deyle & Matheny, 2007)."

Counties should not only work to ensure that floodplain maps are as up to date and accurate as possible, reflecting the potential for sea level rise, but also to ensure that landowners and residents are familiar with these maps and aware of changes made by making the data easily accessible. It is likely that updates reflecting the potential for sea level rise will identify new areas of land within the 100-year floodplain. This may have implications for existing structures which were not previously located within the floodplain. These structures may require alterations in order to be elevated above the new flood levels.

Other Ordinances: Overlay Districts

A regulatory tool used in land use planning, overlay zoning, is a tool that allows for additional land use regulations to be applied to existing land use regulations. This tool allows for great variability across different land use types and allows for specific resource protection or development within the selected area (CLE, 2005). While reviewing the comprehensive plans of the MPPDC we noticed that there was no significant reference to the use of overlay zoning for future land use planning in the context of climate variability adaptation. The chart provided in the beginning of this document shows what counties we believe to have reviewed the use of overlay zoning techniques versus the ones that have not.

Overlay zoning represents an important land use tool aimed at protecting shoreline and flood prone areas. Shoreline overlays will not alter the existing zoning practices, but instead provide extra support by protecting property values, preventing environmental degradation, and maintaining natural vegetation and local wildlife (MLUI, 2001). Before overlay zones can be established however, localities are recommended to extend their current boundaries of the regulated flood plain to include flood prone areas farther inland. These changes will allow for a proper overlay zone that accounts for future estimated flood levels. The MPPDC counties are recommended to follow two general options for the implementation of shoreline overlays.

The first option is a fixed-distance boundary. This is a line that is drawn parallel to the shoreline or ordinary high water mark at a fixed distance. It should extend across all zoning districts along the shoreline. The distance a community selects is discretionary, although 500 feet is generally recognized as a minimum distance to protect coastal features. This one-distance-fits-all boundary may leave some valuable shoreline resources unprotected if they fall further than the fixed distance from shore. However, this is the simplest and most inexpensive approach to establishing a shoreline overlay boundary (MLUI, 2001).

The second option is a resource-based variable shoreline protection overlay boundary. A resource-based variable boundary is a line based on a scientific inventory of natural shoreline features, such as wetlands, dunes, bluffs, critical habitat, etc. The resource-based variable boundary approach maps all important shoreline resources, and establishes the boundary line sufficiently landward of them (approximately 200 feet) to ensure that any development near these resources is within the overlay boundary. The local government generally conducts the resource inventory with the assistance of a qualified naturalist or biologist. This approach is more expensive and requires more complex mapping, but is also more effective at protecting resources, and fairer to property owners (MLUI, 2001). We believe that the counties of the MPPDC can use a combination of the above options to create adequate shoreline protection.

To strengthen the shoreline protection even further, there are additional land use techniques available. One such technique is the use of setbacks within the overlay zone that restrict certain development, but not all economic potential, in order to avoid a "takings" issue. To work with the newly proposed overlay zones, the MPPDC counties could create a dynamic coastal setback program. In coordination with the Chesapeake Bay Preservation Act, which already requires a 100ft buffer measured inward from the shoreline areas, setbacks proposed outside this 100ft region will accommodate future sea level rise (Silton & Grannis, 2010).

Assessment of Middle Peninsula Localities' Plan and Ordinance for Climate Change Adaptation

Localities within the Middle Peninsula are currently at various stages of the planning cycle. The ordinance assessment given in Table 2.1 and summarized below, represents an inventory of existing plan elements and ordinances that describe the current status of measures related to climate-change-adaptation strategies.

"Gaps" are indicated in the matrix and discussed below; these Gaps highlight possible priority areas to apply recommended strategies not currently addressed. "Opportunities" given below identify possible

next steps that are already justified by existing governing documents (e.g. bringing the Flood Ordinance into alignment with stated goals in the Comprehensive Plan).

For those localities that have recently completed Comprehensive Plan Updates (Gloucester, Mathews, and Middlesex Counties), considerable opportunities exist to bring zoning, flood, and CBPA ordinances into alignment with community resilience-building principles.

Comprehensive Plans

- **Common Gaps**: Policy statement, designating vulnerable areas, risk-based analysis;
- **Good start**: Gloucester (2011), King William (2003), Mathews (2011)
- **Opportunities**: Middlesex has the flood ordinance framework to support coastal flooding consideration in comprehensive plan, but it is still absent.

Flood Ordinance

- **Common Gaps**: incorporation of coastal flooding beyond that designated on FIRMs, inclusion of coastal flood hazard districts; specification of setbacks and development restrictions in these areas.
- **Good start**: Gloucester, Middlesex.
- **Opportunities**: Mathews now has leverage in new comprehensive plan to develop more relevant flood ordinance.

Chesapeake Bay Preservation Areas

- **Common Gaps**: using boilerplate definitions of RPAs and RMAs (e.g. missing or modest definitions of "highly erodible" soils and "steep" slopes).
- **Good start**: King William (designated all land in county outside of RPA as RMA), King and Queen, Middlesex (designate 15% as "steep" rather than 25%), Gloucester, King and Queen (require WQIA for all land disturbing activities within the RPA), Middlesex (mentions detailed requirements for landscape plan, stormwater management plan, plant selection in development requirements).
- **Opportunities**: all localities may benefit by revisiting specific performance measures and thresholds. Base decisions in these areas on scientific data for the region.

Table 2.1 Review of existing plans across Middle Peninsula localities, 2011.

Wetlands Ordinance

- **Common Gaps**: All localities may benefit by integrating existing vulnerability assessments and coastal considerations into their Wetlands Ordinance

Other Considerations

- **Setbacks.** Each comprehensive plan can specify land uses and areas for which special considerations for development are required. Within the corresponding ordinance, setbacks may be implemented to reduce vulnerability to coastal hazards. For example, flood plain management ordinance, stream corridor ordinances, and CBPA RPA extensions (all discussed in chapter 5) use setbacks from streams and flood prone areas for hazard mitigation and riparian zone protection.
- **Nonconforming Use Thresholds.** The percentage of a given structure's fair market value (FMV) above which repair/redevelopment must bring it into full compliance with current building code. For values set very high (75%), an existing structure in the floodway, for example, could sustain damage constituting fifty percent (50%) of its FMV and repair the damage without complying with new building code (e.g. freeboard requirement for structures in the coastal zone).
- **Water Quality Inventory Assessment (WQIA).** Localities may designate specific thresholds of land disturbance in square footage or acres that trigger a WQIA requirement. Localities should make purposeful data-driven decision about what thresholds are appropriate for their locality.

Summary

This chapter discussed some of the challenges and opportunities related to community resilience facing the Middle Peninsula and reviewed and assessed the current status of planning and ordinances to meet those challenges. The MPPDC has been active in developing natural hazard mitigation plans and performing vulnerability assessment and community involvement about climate change impacts and adaptation strategies.

The potential impacts of climate change are widespread across many sectors in the MP, vulnerabilities are significant, and uncertainties complicate public engagement and commitment to action. Current planning efforts by the MPPDC and some localities provide a foundation for hazard mitigation, climate change adaptation, and building community resilience. This chapter assessed current local plans and ordinances and identified positive actions, common gaps in effectiveness, and opportunities for improvement.

Chapter 3: Adaptation Planning Principles

Growing numbers of states and localities are developing climate change adaptation plans for their jurisdictions. Online clearinghouses continue to emerge, aiming to convey current science, case study listings and best practices to citizens and decision makers. Various public and private agencies have produced guidebooks and manuals on climate change adaptation.

Available adaptation planning guidebooks and reports share many common principles, including interagency coordination, inter-jurisdictional collaboration, stakeholder involvement, application of the best available science, hazard mitigation, ecosystem-based management, and coordination of economic development with natural resource management. While some such themes are already universal to local planning practices, others are less intuitive. For example, how do we better incorporate climate change resilience into local and regional plans such as water supply management, economic development, and future land use? This chapter reviews some general principles for climate adaptation planning drawn from studies by the U.S. Fish and Wildlife Service (FWS), the Heinz Center, and U.S. Global Change Program, and then presents a more applied adaptation framework developed by the National Research Council (NRC).

The reports and guidebooks selected for review are among more than a dozen similarly themed publications of recent years. Publications discussed herein capture the spectrum of definitions, guiding principles, and strategies applicable to effective climate change adaptation planning at the local level. While this chapter identifies and summarizes broad climate adaptation planning principles, the next chapters reviews application of these principles in state and local climate adaptation plans and gleans lessons for the Middle Peninsula.

U.S. Fish and Wildlife Service (FWS): Rising to the Urgent Challenge: Strategic Plan for Responding to Accelerating Climate Change (2011)

This 2011 U.S. Fish and Wildlife Service (FWS) report offers a summary of adaptation planning principles within the context of rapidly changing and uncertain climate conditions. FWS provides overarching guidelines, which may help state and local governments promote resilience within their respective planning frameworks. A sense of urgency pervades the 32-page document, beginning with the epigraph, "We must act now, as if the future of fish and wildlife and people hangs in the balance – for indeed, all indications are that it does."

FWS Climate Change Principles may be considered as "Adaptation Planning Principles" for use at the local and regional planning level:

> **Priority-Setting**. Continually evaluate priorities and approaches, make difficult choices, take calculated risks and adapt to climate change.
>
> **Partnership**. Commit to a new spirit of coordination, collaboration and interdependence with others.
>
> **Best Science**. Reflect scientific excellence, professionalism, and integrity in all our work.

Landscape Conservation. Emphasize the conservation of habitats within sustainable landscapes, applying our Strategic Habitat Conservation framework.

Technical Capacity. Assemble and use state-of-the-art technical capacity to meet the climate change challenge.

Global approach. Be a leader in national and international efforts to address climate change.

FWS presents three major strategies to guide Adaptation Plan goals, objectives, and actions that may be applied at the local level:

Adaptation. Minimize the impact of climate change through the application of cutting-edge science

Mitigation. Reduce levels of greenhouse gases in the earth's atmosphere

Engagement. Join forces with others to seek solutions to the challenges and threats posed by climate change

Within the FWS strategic plan, adaptation is divided into four approaches: Resistance, Resilience, Response and Realignment.

- **Resistance** is the act of working against the effects of climate change as they occur. It most closely describes current and traditional adaptation approaches, which often aim to maintain current or restore historical conditions. The resistance strategy is decreasingly available as the rate of climate variability accelerates.
- **Resilience** is the ability of a system to return to a desired condition after disturbance. Resilience adaptation actions build capacity toward the ability to cope with disturbance.
- **Response** adaptation actions manage toward future, less certain conditions by predicting and working with the effects of climate change. Response actions mimic, assist or enable ongoing natural adaptive processes in order to encourage gradual transition to inevitable change.
- **Realignment** stands in contrast to the resistance approach in the FWS framework. Realignment is essentially future-oriented "restoration" of ecosystems that can sustain in the future, not the past. This approach also anticipates uncertainty by having multiple alternative goals and trajectories for unpredictable endpoints.

According to FWS, planning practitioners can benefit from identifying which approach or combination thereof that best address the challenge at hand. For example, shoreline hardening might be considered *resistance adaptation*; raised buildings to accommodate flood patterns falls into *resilience adaptation*; *response adaptation* might best describe Living Shorelines programs; and long-range land use planning that moves development landward might fall under *realignment adaptation*.

The FWS strategic plan also points out that "adaptation approaches to climate change can be implemented in a reactive manner or an anticipatory manner," and then quotes the IPCC to define the terms:

Reactive adaptation takes place after impacts have been observed.

Anticipatory adaptation takes place before impacts are observed.

Finally, as the plan promotes explicit and consistent adaptation planning methods, the plan acknowledges that "an inappropriate response or a series of inconsistent responses can result in large expenditures of time, energy, and resources with questionable or insufficient outcomes" (U.S. Fish and Wildlife, 2011). Therefore, by taking such a position, local governments may explicitly affirm their stewardship of the public trust and likely bolster community support.

Heinz Center: Resilient Coasts: A Blueprint for Action (2009)

Published in 2009, this Heinz Center report addresses resilience to climate change while incorporating economic and cost-benefit analyses. The Heinz Center is a non-profit research center and the report was funded in part by the Travelers Group and other commercial insurance interests, with a stated goal to improve accuracy of coastal hazards assessments in order to reduce risk. The report discusses many conceptual and a few applied strategies for achieving economically viable and resilient coastal development.

"Resilient Coasts" was published with a national focus; however, the majority of principles identified in the report apply to local adaptation planning, namely the following:

- **Identify and fill critical gaps** in scientific understanding and develop the tools and methodologies necessary for incorporating climate change into risk assessments and risk mitigation decisions
- Require **risk-based** land use planning
- Design **adaptable infrastructure and building code** standards to meet future risk
- **Strengthen ecosystems** as part of a risk mitigation strategy
- Develop **flexible adaptation** plans
- Integrate climate change impacts into **due diligence for investment and lending**

The report also makes a few recommendations specific to local strategies for adaptation planning:

- Designate no-build and no-rebuild zones
- Provide property owners with incentives to relinquish property or development rights in these areas (i.e. land exchanges, land banks, TDR)
- Establish incentives or regulations to make ecosystem preservation and enhancement part of adaptation funding, risk-based land use planning, and post-disaster rebuilding

Additionally, the authors acknowledge the urgent need for updated and accurate flood, shoreline and inundation maps, noting that current maps do not accurately reflect current risks, let alone future risks (Heinz Center, 2009).

U.S. Global Change Program: Global Climate Change Impacts in the United States (2009)

This 2009 U.S. Global Change Program (GCP) report "" serves as a "state of the knowledge" report to the President and Congress, with a stated goal of better informing public and private decisions at all levels in the United States (Karl et al, 2009).

Ten key findings introduce the report. Subsequent content is comprised mostly of weather and climate impacts in the United States, first by sector and then by geographic focus regions. Key findings include (Karl et al, 2009):

1. Global warming is unequivocal and primarily human-induced.
2. Climate changes are underway in the United States and are projected to grow.
3. Widespread climate-related impacts are occurring now and are expected to increase.
4. Climate change will stress water resources.
5. Crop and livestock production will be increasingly challenged.
6. Coastal areas are at increasing risk from sea-level rise and storm surge.
7. Risks to human health will increase.
8. Climate change will interact with many social and environmental stresses.
9. Thresholds will be crossed, leading to large changes in climate and ecosystems.
10. Future climate change and its impacts depend on choices made today.

Report recommendations are broad and generalized, conveying national goals, which may be down-scaled for application at a local level. Karl et al (2009) list six recommendations at the conclusion of the report:

1. Expand understanding of climate change impacts.
2. Refine ability to project climate change, including extreme events, at local scales.
3. Expand capacity to provide decision makers and the public with relevant information on climate change and its impacts.
4. Improve understanding of thresholds likely to lead to abrupt changes in climate or ecosystems.
5. Improve understanding of the most effective ways to reduce the rate and magnitude of climate change, as well as unintended consequences of such activities.
6. Enhance understanding of how society can adapt to climate change.

Two themes emerge from the report's concluding recommendations: 1) a roadmap of future products to assist the local adaptation planning process, and 2) the local-scale implications for recommended action that can be taken immediately. The U.S. Global Change Program reports climate change impacts in great detail, but the report is not intended to provide adaptation strategies.

National Research Council: America's Climate Choices: Adapting to the Impacts of Climate Change (2010)

The National Research Council (NRC) 2010 report provides a range of options for adapting to both climate variability and extremes. The report is part of a four part series produced by NRC; the others

address climate change science, mitigation or greenhouse gas emissions reduction, and informing effective decisions on climate change. The NRC adaptation study distinguishes between changes in climate averages versus changes in climate extremes, pointing out that comprehensive adaptation planning will address the full risk spectrum between high-probability-low-risk events and low-probability-high-risk events, by measuring the cost of adaptation options against the cost of impacts they are designed to avert (NRC, 2010).

The NRC prescribes the following steps in the adaptation planning process:

1. **Identify current and future climate changes** relevant to the system
2. **Assess the vulnerabilities** and risk to the system
3. **Develop an adaptation strategy** using risk-based prioritization schemes
4. **Identify opportunities for co-benefits** and synergies across sectors
5. **Implement** adaptation options
6. **Monitor and reevaluate** implemented adaptation options

The NRC report provides federal, state, and local/regional recommendations for adaptation planning. Of their ten overarching recommendations, below are four paraphrased recommendations that are directly applicable at the local level:

- **Identify vulnerabilities** to climate change impacts and both short- and longer-term **adaptation options** for each
- **Develop and implement climate change adaptation plans** pursuant to the national climate adaptation strategy, in consultation with community stakeholders
- Actively engage and partner with appropriate governmental adaptation planning efforts to help **build adaptive capacity**
- **Take adaptation action now** to address current known climate change impacts in order to provide effective risk management at a relatively low cost

The NRC report divides climate impacts and their respective adaptation actions into seven sectors: Ecosystems, Agriculture and Forestry, Health, Transportation, Water, Energy, and Coastal Areas. Much of the report is comprised of tables, which identify climate related changes by sector, impacts, and possible adaptation actions for each. All "possible adaptation actions" from federal, state, local, private and NGO/individual and all U.S. geographic regions are presented in one table per climate impact sector. Appendix A contains a pared-down version of the NRC tables, to include only local adaptation actions for regionally specific impacts to the Mid-Atlantic and Chesapeake Bay, while brief descriptions of the tables are below.

Impacts to **Ecosystems** include changes to the hydrologic cycle, loss of key native species, and introduction of invasive species (National Research Council, 2010). Broadly stated, recommendations for ecosystem adaptation actions include: developing price-based accounting system for ecosystem services, increased hydrologic management (e.g. managing groundwater recharge and water surpluses), and sustained promotion of biodiversity. Also important is a more consistent use of currently recognized best practices within ecosystem management such as monitoring change, managing for multiple ecosystem benefits, and keeping disturbance at acceptable scales (National Research Council, 2010).

Impacts to **Agriculture and Forestry** within the Mid-Atlantic may be addressed through adaptation actions recommended by local and regional government, and implemented at the individual and/or neighborhood levels. Some impacts to be addressed include increased precipitation and consequently increased runoff and demand for nutrient management. Regional shifts in plant productivity and sensitivity to fertilizer and pesticides will affect livestock operations and introduce an increased demand for integrated pest management. The NRC report (2010) highlights potential tradeoffs and synergies between agricultural adaptation and water- and ecosystem-sector adaptation in the areas of irrigation and pest management. The report encourages collaborative action at a local and regional scale.

Health concerns due to climate change are evident through increased frequency of climate-related extreme events such as heat waves and water-borne diseases. Recommended adaptation actions focus on augmenting and improving current public health programs. Short-term actions focus on public outreach, early warning systems and emergency response plans. Longer-term actions focus on improving decision support such as educational programs for health care professionals and incorporating future climate impacts into zoning and infrastructure decisions. Most adaptation recommendations for the health sector will improve health generally, so the primary tradeoff concern is economic. According to the NRC (2010), costs of public health adaptation actions can be minimized through a proactive, cost-effective planning approach.

Local impacts to **Transportation** involve erosion, flooding and increased stress on existing infrastructure where limited resources exist for structural improvements. The National Research Council (2010) encourages transportation planners to incorporate climate change in infrastructure planning and design cycles, which usually span several decades. Additionally, the Federal Highway Administration (FHA) encourages and funds inclusion of climate change into metropolitan planning organization (MPO) activities. Adaptation actions recommended by the NRC (2010) are primarily engineering and maintenance solutions, which are costly and require a planning horizon of several decades (e.g. vulnerable pavement replacement, improvement of hydraulic structures such as culverts, or elevating critical infrastructure). The report also suggests a few policy-based options such as stricter land use planning (e.g. floodplain development restrictions and setbacks).

Water sector impacts include changes in precipitation, runoff and pollution, and saline intrusion. Changes in water supply will likely occur, particularly in flood-prone or low-lying areas. Possible adaptation actions involve both engineering approaches (e.g. dams and water delivery infrastructure, underground/ aquifer storage and recovery systems) and conservation adaptations (e.g. changes in behavior, water-saving technology). The NRC report (2010) also highlights tradeoffs and synergies among sectors – agriculture, ecosystems, energy, recreation, transportation and domestic use, citing unexpected drought conditions and potential strain on water supply, as well as more positive synergies such as natural functions of ecosystems to buffer public water supply.

Electricity demand is likely to increase, resulting in a number of **Energy** sector impacts. According to Karl et al (2009), demand for cooling in buildings increases 5 to 20 percent and demand for heating drops by 3 to 15 percent for every 1.8° F of warming. The aggregate result across the United States is a likely increase in electricity demand and decrease in demand for natural gas and fuel oil (Karl et al, 2009). The NRC report (2010) states that adaptation planning for vulnerable coastal energy facilities will likely be protection-oriented in the short term (i.e. flood walls, levees, and other protective barriers), but long-term investment strategies for new infrastructure might include relocating facilities to less vulnerable areas.

One local adaptation strategy for both short- and long-term planning is to reduce overall energy demand. Strategies for doing so include incentive programs, public outreach, and consolidation of water and energy conservation programs.

The NRC report (2010) designates **Oceans and Coasts** as a separate sector, citing increased adaptation efforts over recent years and high-priority efforts in coastal states to address flooding, shoreline erosion, and coastal storms. The NRC categorizes state-level adaptation efforts to-date into six categories of policies, focused primarily on sea level rise impacts: 1) public infrastructure siting, 2) site-level project planning and design, 3) wetland conservation and restoration policies, 4) shoreline stabilization, 5) setbacks, and relocation policies, encouraging adaptive development designs (e.g. additional flood-height tolerance), and 6) incorporation of climate-change adaptation into other state, regional, and local plans. Possible local adaptation options within this sector involve a focus on building code, zoning ordinance, and land use planning that incorporates climate change modeling into the planning process. With respect to sea level rise, the NRC report recommends development of three to four sea level rise scenarios, including one that assumes continuation of historic sea level rise and two additional scenarios with moderate and substantial acceleration of sea level rise, respectively.

Summary

Although each report reviewed for this chapter takes a different approach to climate change adaptation, each offers a variety of definitions, recommendations and strategies that may assist planners and decision makers as they address the challenges and uncertainties of climate change. However, "Different local conditions will dictate different climate ready responses. It is critical to recognize that different local conditions – including the immediacy and certainty of actual or projected climate impacts and community understanding and support – will, understandably, lead to different climate adaptation and mitigation responses and intensity of engagement. A one-size-fits-all approach to climate readiness will not be effective (USEPA Climate Ready Water Utility Toolkit, 2010)."

The four reports summarized in this chapter complement and reinforce adaptation planning concepts in each other. Common steps for climate change adaptation planning amongst the reports include (1) identifying current and future climate impacts, (2) assessing vulnerabilities and risks to climate impacts, (3) developing a risk-based, prioritized adaptation strategy, (4) implementing the strategy, and (5) monitoring and evaluating the implemented strategy. Additionally the four reports emphasize the use of best available science, a collaborative planning approach and priority setting.

While the U.S. Fish and Wildlife Strategic Plan identifies principles that often appear in existing state and regional adaptation planning literature (i.e. priority setting, partnership, best science, conservation, building technical capacity, global [regional] approach), the Heinz Center publication "Resilient Coasts" demonstrates the importance of risk-based cost-benefit analysis for decision makers addressing short- and long-term climate impacts and potential response actions. Finally, as the U.S. Global Change Program and National Research Council reports take similar approaches in dividing likely climate impacts into sectors, the NRC report then lists and discusses research-based adaptation options, sorted by geographic region and echelon of government. Collectively, these four reports create a framework within which to develop the local climate adaptation planning process.

Planners and decision makers face several challenges and uncertainties in the field of climate adaptation planning, but uncertainty is not cause for inaction if the cost of inaction outweighs the cost of planned adaptation strategies. As the NRC report demonstrates (2010), there is potential for both negative tradeoffs and positive co-benefits ("synergies") between adaptation strategies for various sectors. In order to achieve potential synergy and avoid "foreclosure of future options," collaboration across planning sectors is necessary (NRC 2010; Karl et al, 2009). The following chapter examines adaptation planning case studies at the state, regional and local level within the United States. Both short- and long-range adaptation strategies are identified and discussed. Some specific adaptation actions are applicable to the Middle Peninsula; in other areas, the planning process in general can serve as a model for future efforts in the MPPD.

Chapter 4: Adaptation Planning in Practice

Climate change adaptation planning is in its infancy. Relatively few climate change adaptation plans have been implemented anywhere in the world (National Research Council, 2010) with the majority of existing adaptation plans initiated since 2005. Adaptation planning is complicated by the long-term nature of climate change, as well as the uncertainties about the timing, location, and extent of impact.
This chapter reviews some current adaptation planning efforts in the United States and suggests possible lessons and implications of this experience for the MPPD.

As discussed in previous chapters, adaptation, in the context of climate change, can be defined as a process, action, or outcome in a system in order for the system to better cope with, manage, or adjust to a changing condition, risk or opportunity. A system's capacity for adaptation or resilience is its ability to absorb perturbations without being undermined or becoming unable to adapt, self-organize and learn. Effective climate change adaptation, then, must be anticipatory, identify vulnerabilities, stress preparedness for change, and build the capacity for resilience among those likely affected by change (Randolph 2011).

Thus far, adaptation to climate change has focused on two general objectives:

1. *Lessening the impacts using technology and planning*, such as seawalls to fend off sea-level rise and resulting storm surges, expanded irrigation to counter more frequent droughts, and more dams and reservoirs to contain flood flows and store water to compensate for drought periods.
2. *Anticipating impacts, and changing the patterns of human settlement and agriculture now, so we can live with those impacts in the future*, including relocating vulnerable populations and adopting climate adapting development designs.

State-level Adaptation Planning

Several states are beginning to develop adaptation plans. The level of activity depends on the state's perceived vulnerability to climate change. The following is a list of state-level adaptation efforts, according to the Pew Center on Global Climate Change (2011), but even the completed plans range widely in specificity.

- **Adaptation Plan Recommended in State Climate Action Plan:** Arizona, Colorado, Iowa, Michigan, North Carolina, South Carolina, Utah, Vermont
- **Adaptation Plan in Progress:** Connecticut, Massachusetts, Minnesota, Pennsylvania
- **Adaptation Plan Completed:** Alaska, California, Florida, Maine, Maryland, New Hampshire, New York, Oregon, Virginia, Washington, Wisconsin

This section first reviews Virginia's framework for climate adaptation planning, then summarizes some relevant state plans.

A Note on Dillon's Rule

Local planners and government officials within the Commonwealth of Virginia may be quick to point out the limiting effect of Dillon's Rule on local government autonomy. The Rule is named after Judge John F. Dillon of mid-1800s Iowa, and today thirty-nine states within the United States apply his principle of clearly recognizing the state legislature as the sovereign power and local government as subordinate (Richardson, 2011). In his 2011 *Publius* article "Dillon's Rule is from Mars, Home Rule is From Venus:

Local Government Autonomy and the Rules of Statutory Construction," Jesse Richardson deconstructs the implication that local governments in Dillon's Rule states (such as Virginia) lack autonomy.

- **Local government autonomy**. "No consensus exists as to how to identify or measure the concept" (Richardson, 2011). Using a measure such as whether a state is Dillon's Rule is not a reliable measure of local autonomy.
- **States grant varying levels of autonomy.** Local governments within Dillon's Rule states are only as autonomous as is enabled by the state legislature. In some states, local governing authority is widely enabled.
- **Not all Dillon's Rule states are created equal.** Note that the existence of local governing practice in a Dillon's Rule state other than Virginia, California for instance, does not necessarily mean that governing practice would be enabled in the Commonwealth of Virginia. The set of governance practices enabled by the sovereign state legislatures vary from state to state and are, therefore, incomparable.

For the purpose of determining which adaptation strategies may be adopted by Virginia localities, it is recommended that a locality examine what is already enabled within Virginia and work to incorporate recommended strategies into the existing local and regional planning framework. Opportunities for this type of incorporation are discussed at greater length in Chapters 5 and 6.

Virginia: Existing framework

Dillon's Rule State.Virginia's framework for climate adaptation planning includes recommendations of the 2009 Virginia Commission on Climate Change (VCCC), actions by the Coastal Zone Management Program (VCZMP), as well as non-climate-change-specific plans, policies, and regulations related to flooding, beach erosion, coastal storm surges, wetland and critical habitat protection, saltwater intrusion, on-site wastewater, stormwater, transportation and infrastructure, all of which are expected to be impacted by climate change and sea level rise.

The VCCC called for a state strategy for climate change adaptation led by a sub-cabinet of Climate Change Response, and a science-based process to determine best estimates of end points (*at least* 3.1^{o}C temperature increase, sea level rise of *at least* 2.3 feet, and increased intensity of storms and rain events); evaluate impacts to natural systems, infrastructure, and the economy; assess changes needed in government programs and regulations; and develop appropriate responses within state and local governments. The McDonnell administration, however, stated in June 2011 that it will not revive the VCCC, and the General Assembly has not acted on its recommendations for climate change adaptation.

The VCZM program has funded planning efforts in the coastal zone for 25 years. It funded the three-year Hampton Roads climate change study described below. In February 2011, its Coastal Policy Team prioritized Focal Areas for its funded projects. Coastal Resiliency, with special attention to climate change, natural resource datasets, and state tools to inform local planning, received the most votes and highest priority (REF). It is unclear how this may translate into increased state attention to climate change adaptation planning.

For the moment, Virginia's response to climate change impacts rests on this VCZM attention to Coastal Resiliency and on its existing framework of plans, policies and programs related to Chesapeake Bay

Preservation Act (CBPA), natural hazards mitigation, especially flooding and coastal storms, wetlands and other land conservation, stormwater management, and other coastal resource issues. CBPA implementation Virginia localities, is discussed under Regional and Local Adaptation Planning section below.

Maryland (2008)

Dillon's Rule State.

The Commission on Climate Change produced its Climate Action Plan in August 2008 and one component was the Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change produced by the Adaptation and Response Working Group (ARWG). The ARWG Phase I Adaptation Strategy (2008) made recommendations for reducing risk related to sea level rise and coastal storms, including 18 policy actions to avoid or reduce impact to existing and future built environment; shifting to sustainable economies and investment; avoiding financial risk of development in hazardous coastal areas; enhancing preparedness and emergency planning; and protecting and restoring Maryland's natural protective shoreline. The Phase II Strategy emphasized building societal, economic, and ecological resilience to climate change impacts. It made a series of recommendations to reduce impacts on human health, population growth and infrastructure, agriculture, water resources, and forest/terrestrial and bay/aquatic ecosystems. In October 2010, Maryland Department of Natural Resources established the policy "to make sound investments in land and facilities and to manage its assets and natural resources so as to better understand, mitigate and adapt to climate change" (MDNR 2010).

California (2009)

Dillon's Rule State, except for charter cities.

California released its *2009 California Climate Adaptation Strategy* in response to a 2008 Governor's Executive Order (California Natural Resources Agency 2009). The plan focused on seven critical impact areas, and a relevant state agency was charged with taking the lead in each, so all of state government was involved. Here are the impact areas:

1. *Public health*: Higher mortality and morbidity, increased air pollution, increased allergens, spread of disease vectors, decreased food security, reduced water availability.
2. *Biodiversity and habitat*: Barriers to species migration, temperature rise impacts on aquatic habitat, increased invasive species, threats to endangered species, loss of ecosystem services.
3. *Ocean and coastal resources*: Increased temperature and extreme events, higher runoff and flood risk, sea-level rise and risk of flooding, erosion, and saltwater intrusion.
4. *Water management*: Reduced supply from Sierra snowpack, changes in water quality, increased evapotranspiration, soil moisture deficits, increased irrigation needs.
5. *Agriculture*: Crop yield changes; new weed, disease, and pest invasions; flooding, heat waves and heat stress, drought.
6. *Forestry*: Changes in forest productivity, tree mortality, invasive species, moisture deficits, increased wildfire risk.
7. *Transportation and energy infrastructure*: Increased cooling demands, less hydropower generation; impacts on seaside airports, roads, railroads, and docks.

The guiding principles for the strategy include the following:

- Use the best available science in identifying climate change risks and adaptation strategies. Understand that knowledge about climate change is still evolving. As such, an effective adaptation strategy is "living" and will itself be adapted.
- Involve all relevant stakeholders in identifying, reviewing, and refining the state's adaptation strategy. Establish and retain strong partnerships with federal, state, and local governments, tribes, private businesses, landowners, and NGOs to develop and implement adaptation strategy recommendations over time.
- Give priority to adaptation strategies that initiate, foster, and enhance existing efforts that improve economic and social well-being, public safety and security, public health, environmental justice, species and habitat protection, and ecological function.
- Understand the need for adaptation policies that are effective and flexible enough for circumstances that may not yet be fully predictable.
- Ensure that climate change adaptation strategies are coordinated with other local, state, national, and international efforts to reduce GHG emissions.

Among the recommendations are: establishing a climate adaptation advisory panel; water conservation requirements to achieve a 20% reduction in per capita water use; avoiding development in vulnerable areas; ensuring communities are healthy in order to build resilient responses to the spread of disease and temperature increases; incorporating assessments of climate change impacts, vulnerability, and risk-reduction strategies in local general plans; and implementing a major public outreach effort, using a new CalAdapt website to synthesize climate impact research and statewide and local climate change scenarios.

Wisconsin (2011)

Dillon's Rule State.

Although Wisconsin is not an ocean state subject to sea level rise, it has developed one of the most recent state adaptation plans. It recommends a number of strategies relevant to coastal Virginia, including the following:

1. Water resources
    a. Restore prior-converted wetlands to provide storage and filtration and mitigate storm flows and nutrient loading.
    b. Promote integrated water management planning including long term projections of supply and demand tied to land use, economic growth, and climate change.
    c. Incorporate water management strategies based on climate projections into farm-based nutrient management, TMDL, and other water quality plans.
    d. Provide local units of government with technical and financial assistance to assess and mitigate their vulnerabilities to high water conditions caused by today's and future climates.
    e. Account for changing water levels in planning and zoning standards for shoreline development.
    f. Improve systems for monitoring surface and groundwater levels, storm surges and stream flows.
2. Ecological resources
    a. Engage in adaptive management to respond to changing conditions through forest and land cover management, coastal and aquatic ecosystem management, agricultural land management, ecological and riparian buffer zones, and watershed land use practices.
    b. Protect and restore integrity of wetland hydrologic regimes.

    c. Establish and maintain corridors of contiguous habitat along natural environmental corridors to provide of migration and local adaptation.
    d. Build a stronger relationship with the public to establish a critical mass of ecological knowledge in the community.
3. Agriculture
    a. Expand the adoption of accepted soil-conserving field practices to reduce erosion and polluted runoff.
    b. Expand watershed-based educational programming efforts with appropriate targeting of hydrologic units, farms and fields.
4. Coastal Resources
    a. Move buildings and roads back from the coastal edge. Counties and municipalities should re-examine their setback ordinances to account for changing conditions.
    b. Growth and development planning (zoning, redevelopment restrictions, compact community design), property protection (acquisition, relocation, setbacks, building codes, infrastructure protection), shoreline management (regulation and removal of shoreline protection structures, living shorelines, beach nourishment, rolling easements)
5. People and Environment
    a. Policy makers should weigh the impacts of infrastructure investment decisions on human impact and capacity to adapt to climate change.
    b. Identify locations that are vulnerable to climate impacts and apply more stringent design criteria.
    c. Flood proof vulnerable buildings and infrastructure.
    d. Educate communities about the hazards of building in areas prone to high water.

In addition to these strategies, the Wisconsin plan provides some principles for adaptation to consider when citizens, businesses, agencies, and policy leaders are formulating specific actions:

1. Triage approach: Determine which actions to implement first. These will be those that are most effective as well as those that can provide lessons in an adaptive management framework.
2. Adaptive management: Build flexibility into management practices. "Learn as we go, learn by doing." Designing experiments and monitoring results serve as the basis for learning. Flexibility provides opportunity for modification of practices based on learning.
3. "No regrets" strategies: Choose strategies that increase resilience and provide benefits across all future climate change scenarios.
4. Precautionary principle: Where vulnerability is high, it is better to be safe than sorry.
5. Adapting to variability in a changing climate: Expect variability and work with it.
6. Place-based considerations: Consider the restrictions and special circumstances of place-based impacts and solutions, including environmental, cultural and political factors.

Florida (2008)

Dillon's Rule status unclear, due to conflicting authority (Richardson, 2011).

Florida is one of the most vulnerable states to the impacts of climate change and sea level rise. It began its attention to climate change in 2006 and by 2008 produced "Florida's Resilient Coasts: A State Policy Framework for Adaptation to Climate Change." The framework focused on five necessary characteristics,

stating that state adaptation policy must be disciplined, comprehensive, purposeful, strategic, and efficient. The framework calls for state monitoring of climate adaptation science, climate-sensitive planning and decision making (especially for land use and building regulation, water resources, transportation and other infrastructure, land and marine conservation, beach management, emergency preparedness), and insurance. Most implementation has occurred at the local and regional level such as the 2009 Southeast Florida Regional Climate Change Compact of Miami-Dade County and Broward, Palm Beach, and Monroe counties, who agreed to develop a coordinated regional strategy for responding to climate change (Southeast Florida, 2009). A 2011 white paper developed a unified sea level rise projection for Southeast Florida of 9-24 inches by 2060 and 23-67 inches by 2110 (Southeast Florida 2011).

Individual communities within the counties have developed their own studies to adapt to sea level rise.

- The study for Satellite Beach, Florida, concluded that 25% of the city would be submerged at a 4 foot SLR and that "protect' and "retreat" options because engineering solutions would not work because of soil permeability and porosity and there is no available higher elevation lands to retreat to. The study suggests that the city respond to the threats imposed by rising sea level through adaptive management, or an on-going and iterative process that specifies one or more essential actions necessary to reduce the vulnerability of built and natural environments to rising seas. "The overall plan and each specific action are monitored and adjusted as outcomes from management action(s) and other events (i.e. accelerated ice sheet melting) become better understood. Initial actions may be limited to: (1) the development of a timeline describing future actions and (2) implementing no-regret or low-regret policies. Reactive measures may be formulated and subsequently triggered by specific tipping points built into the plan. As uncertainty diminishes, consequences become palpable and quantifiable, and consensus emerges, more robust plans, programs, and proactive measures are implemented" (Parkinson, 2010).
- The Compact also cites a study from southwest Florida. The City of Punta Gorda prepared a climate change adaptation plan in 2009 (Southwest Florida Regional Planning Council, 2009). In the course of the study, the city identified 246 climate change management adaptations to address various vulnerabilities, of which 104 acceptable actions were identified and prioritized during public workshops. Among the top adaptations are
    - constraining locations for certain high risk infrastructure,
    - explicitly indicating in the comprehensive plan which areas will retain natural shorelines, and
    - seagrass protection and restoration.

Governors' South Atlantic Alliance (North Carolina, South Carolina, Georgia, Florida) (2010)

Governors from the four states signed the Alliance Action Plan on four priority issues: healthy ecosystems, working waterfronts, clean coastal and ocean waters, and disaster-resilient communities. Specific strategies stressed the need to understand, assess and prepare for impacts due to climate change, including the need for retreat of human communities from vulnerable shorelines.

Regional and Local Adaptation Planning

Hampton Roads Planning District Commission (2011)

One of the few climate change adaptation studies in Virginia is being prepared by the Hampton Roads PDC, funded by a 3-year grant from the VCZM. Its second year (Phase II) report was issued in June 2011. In addition to a discussion of sea level rise in Hampton Roads, datasets, and case studies, the report

describes public outreach efforts and planning frameworks and adaptation options available for responding to sea level rise. The public outreach program included 18 presentations to municipal boards and various groups. In addition, in March 2011 four listening sessions were held in Virginia Beach where facilitated small group discussions allowed residents to share their views and experiences about sea level rise and flooding in the city. The Phase II report concluded with a short general discussion of policy options, noting that planning for sea level rise is difficult because of inherent uncertainties, and the report suggested hazard mitigation planning and scenario planning as the most effective approaches with the current state of knowledge. The third year of the project will focus on additional data needs and policy research assisted by working groups in the region.

Virginia Chesapeake Bay Localities and CBPA Implementation

Virginia: Dillon's Rule State.

While few Virginia localities have developed climate change adaptation plans, many have used the tools available under Virginia statutes to mitigate natural hazards, protect natural waters, and conserve land resources. These tools include the requirements and opportunities under the Chesapeake Bay Preservation Act (CBPA).

The CBPA requires all localities in the state subject to tidal influence, which include all localities roughly east of I-95, to comply with the Act's requirements for planning, zoning, and designation of protection areas. New development is prohibited in Resource Protection Areas (RPAs) which are comprised of tidal wetlands, tidal shores, nontidal wetlands connected to tidal wetlands or water bodies, and other areas with intrinsic water quality value. Resource Management Areas (RMAs) are areas outside RPAs that have the potential for causing water quality degradation if improperly disturbed or developed. A third category, Intensely Developed Areas (IDAs), includes those already developed areas which would likely be in RPA or RMA if undeveloped. Regulations for redevelopment are specified in the CBPA regulations. CBPA localities are required to designate and map RPAs, RMAs, and IDAs, and formulate land use regulations for them that conform to CBPA regulations at a minimum. They also have the opportunity to extend the RPA district over time.

This latter approach has been used by several jurisdictions to enhance their protection of natural waters and control stormwater pollution. This action also has co-benefits of reducing developed areas potentially exposed to flooding from upland flows and storm surges. Fairfax County, for example, approved a major extension of its RPAs in 2003-04 as shown in Figure 3.1. Other localities continue to make changes to their CBPA implementation strategies. Chesapeake now requires RPA and RMA tree canopy requirements and low impact design standards for IDA redevelopment projects (Chesapeake 2007).

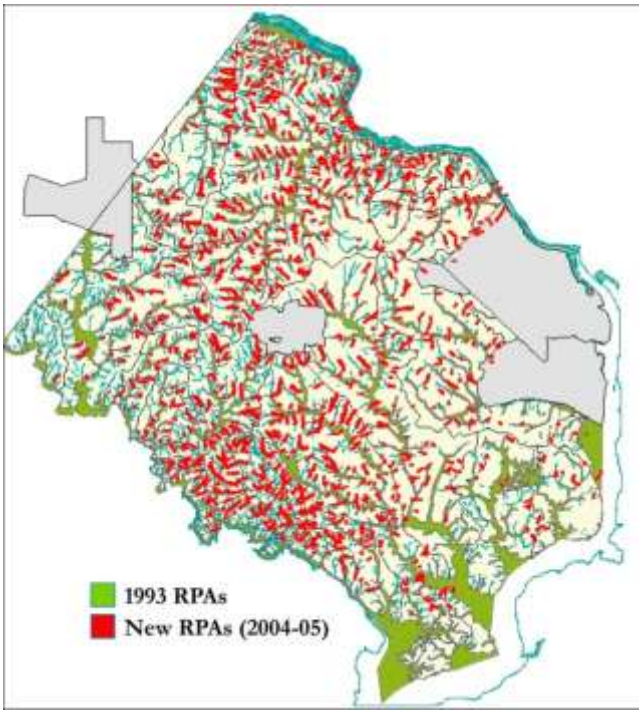

Figure 4.1. Fairfax County CBPA Resource Protection Area extension, 2004-05 (Source: Rose 2010, Fairfax County)

Worcester County, Maryland (2010)

Maryland: Dillon's Rule State.

In 2008, Worcester County on Maryland's Eastern Shore developed a Sea Level Rise Response Strategy. The strategy assessed sea level rise scenarios; projected impacts on private development, infrastructure and public facilities, and coastal environments; identified adaptation response options; and set priorities for sea level rise response.

The response options include protection, retreat, and accommodation for existing development, future development, infrastructure and the natural environment. **Protection** measures include both structural seawalls and bulkheads) and non-structural (living shorelines, beach nourishment). **Accommodation** measures recognize retreat is inevitable but prolongs the life of existing development and sets rules for eventual retreat. It focuses on emergency preparedness to protect public safety and on transitional mechanisms for retreat, such as rolling easements and restrictions on septic systems using overlay zoning. **Retreat** measures include two basic approaches: first, proactive property acquisition and relocation, and second, restrictions on shoreline protection and redevelopment that eventually would lead to retreat. Retreat of future development is more easily controlled through land use controls on setbacks and buffers, overlay zoning, cluster zoning, and transfer of development rights, and other regulations like septic system restrictions. For infrastructure and public facilities, a detailed vulnerability assessment of above and below-ground facilities, including stormwater systems, water and wastewater systems, and roads and bridges. Public investments should be restricted or prohibited for facilities in vulnerable areas.

The prioritization was based on several criteria: legal authority, institutional feasibility, consistency with community vision, political feasibility, benefits exceeding costs including opportunity costs, positive or

neutral environmental impact, equity, effectiveness, and resource availability. The strategy concluded with implementation recommendations, including the following:

- identify protection, accommodation, and retreat zones based on impacts of the 2100 worst-case scenario;
- apply prioritized response options to these zones;
- begin a public education campaign;
- identify selected options addressing the Steady State 2025 impacts that can be implemented quickly; and
- adopt the selected response strategy and identify funding sources.

Dorchester County, Maryland

Maryland: Dillon's Rule State.

Dorchester County, also on Maryland's eastern shore, is very vulnerable to sea level rise from climate change. Already 60% of the County is in the 100-year floodplain and more than 50% lies below 4.9 feet above sea level. The adaptation guidelines developed for Dorchester County following the four strategies identified in the State's adaptation response plan: vulnerability assessment; long-range comprehensive planning; codes and development standards, and public outreach.

Climate change and sea level rise are nothing new to Dorchester County. Its 2006 Comprehensive Plan addressed sea-level rise, and it recommends several actions including the following:

a. adopt standards requiring two or more feet of freeboard in tidally influenced floodplains
b. update the 1972 tidal wetland maps and critical area boundaries
c. expand the critical area buffer width in areas experiencing greater than 2 feet of erosion per year
d. align smart growth strategies to reflect population growth and development patterns in relation to areas vulnerable to sea level rise
e. delineate the predicted extent of seal level rise over the next 25 years on county zoning maps to alert prospective land purchasers

Regarding codes and standards, the guidelines recommend creating a Sea Level Risk District and implementing codes governing activities within it, including restrictions on new subdivisions, major renovations, septic systems, and wells, and requirement for two-foot freeboard above base flood elevations.

Long Island, NY: Local Land Use Response to Sea Level Rise

New York: Dillon's Rule State.

Long Island is a far different place from Maryland counties or Virginia's Middle Peninsula. However, this study by the Land Use Law Center at Pace University and the Nature Conservancy on Long Island provides a useful array of local response plans, regulations, and strategies for New York localities that are applicable elsewhere. These local planning and regulatory strategies include:

1. Policy

    a. Sea level rise and storm hazard resolutions, policy statements, or executive orders can set the stage for adaptation planning.
2. Studies, research training, education
    a. Create a task force to oversee studies and research specific to the locality.
    b. Hold workshops and training sessions to educate and engage community leaders and citizens.
3. Planning
    a. Incorporate Sea level rise and storm hazard mitigation into Comprehensive Plan process.
    b. Links to other plans, such as local waterfront redevelopment plan, natural hazard mitigation plans, etc.
4. Regulations
    a. Create new zoning or overlay districts for sea level rise and storm hazard mitigation that identifies no build zone, limited development zone, high hazard zone, limited hazard zone, highly sensitive environmental area, flood prone area, etc.
    b. Subdivision regulations and site plan approval
    c. Project review local planning board
    d. Transfer of development rights
    e. Post-disaster moratoria on building permits to assess hazard mitigation plans
    f. Intergovernmental approaches to coordinate actions of neighboring jurisdictions

Lessons for the Middle Peninsula

These case examples offer a number of lessons for the Middle Peninsula.

1. Establish a policy framework for addressing vulnerability and change under the theme of Community Resilience.
2. Expand science-based assessments of vulnerability and risk, mapping and evaluating high hazard and impact areas.
3. Engage local leaders and citizens in dialogue, planning, decision-making, and action about vulnerability, change, and resilience.
4. Incorporate vulnerability and change into District-wide and county comprehensive plans.
5. Within policy framework and comprehensive plans consider approaches used by others, including
    a. Protection, Accommodation, Retreat approach
    b. Triage to prioritize vulnerable areas for action
    c. Adaptive management and flexibility that expect variability and uncertainty and offer opportunity to learn and change course
    d. Take a place-based approach that best-fits plans and strategies to the social, economic, environmental, and political context of communities
    e. Consider co-benefits of actions to reduce vulnerability that improve water quality, enhance wetlands and ecological systems, reduce flooding and storm hazards, and revitalize existing communities.
6. Consider a wide range of adaptation strategies giving priority to those that initiate, foster, and enhance existing efforts that improve economic and social well-being, public safety and security, public health, and environmental and ecosystem health. These strategies should
    a. use and enhance existing Virginia-specific programs and tools, including VCZMP planning grants, CBPA RPA/RMA/IDA requirements, flood plain management, wetlands protection, land conservation easements, and stormwater regulations;
    b. consider other innovative regulatory strategies that could be effective to reduce vulnerability, including transfer of development rights, freeboard height requirements, rolling easements, critical area buffers;
    c. consider present and future vulnerability when making public investments for infrastructure;
    d. develop contingency plans for existing vulnerable infrastructure including roads, bridges, water and wastewater facilities, and power and communication systems.

Chapter 5: A Framework and Strategies for Community Resilience in the Middle Peninsula

This chapter outlines a basic framework and a portfolio of strategies that can be applied at the local level to develop resilience to vulnerability and change in the Middle Peninsula. Because Virginia is a Dillon Rule state, strategies must be assessed for delegated local authority. But as discussed in Chapter 2, Virginia localities have fairly broad existing authority for regulations to preserve floodplains and riparian areas through setbacks and zoning, for transfer of development rights, and for open space easements and tax incentives.

The framework and portfolio function as a structure for planning and decision making, an inventory of common strategies among U.S. localities, and a resource guide to best practices that may be implemented by Middle Peninsula member jurisdictions. For each of these strategies, a tiered approach is necessary to carry a locality from monitoring and analyzing data to identifying appropriate strategies to implementing actions to reduce vulnerability, toward what Quay (2010) calls "anticipatory governance." Quay's approach calls for flexible, "no-regrets" strategies to reduce future impacts, strategies that distribute costs over time by phased and adaptive implementation.

As presented in Chapter 4, lessons from a number of state and local studies and plans for climate change adaptation indicate the need for a policy framework to develop local resilience to change. That framework includes a policy statement and plans, vulnerability assessment, public engagement and education, and flexible and adaptive strategies. Some climate adaptation strategies have clear sub-components that are easily incorporated into an anticipatory governance framework. In most cases, local planning officials, stakeholders and decision makers need to identify an appropriate distribution of actions over time for their specific locality. In every case, a tiered approach that includes both detailed short-range components and a flexible long-range plan is appropriate.

A Planning Framework for Building Community Resilience

Anticipatory governance is more than a set of strategies to reduce vulnerability to hazards and change. It involves a clear policy to guide necessary planning, analysis, engagement, strategy development, and implementation. statement and integration into district-wide and comprehensive planning; vulnerability and hazard assessment; mechanisms for community dialogue, engagement, and education; and appropriate place-based strategies to reduce vulnerability that are flexible and adaptive, emphasize economic and social well-being, and consider co-benefits to communities and natural systems.

1. Policy Statement

To set the stage for planning and action to build resilience to vulnerability and change, both the Middle Peninsula PDC and member jurisdictions should formulate a policy statement for Community Resilience. Although there is considerable uncertainty about the extent of vulnerability the future will hold, even today there are significant existing coastal and inland hazards for which the region should be better prepared. These hazards are likely to be exacerbated in the future. The policy statements can take the form of resolutions or specific statements in comprehensive or hazard mitigation plans. The statements should emphasize the need for science-based vulnerability assessment, planning and scenario

development, education and public engagement, and development of flexible and adaptive regulatory and non-regulatory strategies to build community resilience.

2. Vulnerability Assessment

Vulnerability assessment applies the best scientific understanding of future natural hazards and other impacts to the scale of the Middle Peninsula and its jurisdictions. Location-specific scenarios of future change and impacts are required to identify potential vulnerabilities, engage stakeholders and the public, and to formulate strategies that respond to those scenarios. Vulnerability assessment often includes a task force to oversee studies and research specific to the region or locality and workshops and training sessions to engage community leaders and citizens.

3. Public Engagement

It is important to engage local leaders, agency and elected officials, and citizens in all phases of building community resilience to change. Studies have shown that social capital developed through community dialogue and interaction is an essential ingredient of a community's resilience to disaster, crisis, and change (Randolph 2011). Local knowledge, community values, and political perspectives are important considerations in developing policy statements, assessing vulnerability, and formulating plans and strategies.

4. Planning

The results of vulnerability assessment and scenarios should be integrated into regional and local plans, including regional and local multi-hazard mitigation plans, local comprehensive plans, Chesapeake Bay preservation plans, stormwater management plans, transportation plans, and water and wastewater infrastructure plans. The Virginia Coastal Zone Management Program has identified Community Resilience as a program priority and may be a source of funding support for such planning efforts.

5. Regulatory and Non-regulatory Strategies

Based on vulnerability assessment, public engagement, and planning, action strategies should be formulated to respond to vulnerabilities and build resilience. The strategies may emerge from the related plans listed above, but they should be integrated into a comprehensive set of community resilience actions that can be implemented and monitored over time. They may include land use regulations and other regulations or restrictions, as well as non-regulatory and voluntary strategies including land conservation easements, public infrastructure investments, and landowner stewardship. A portfolio of strategy options is presented in the next section.

Portfolio of Strategy Options

Coastal adaptation responses to climate change are commonly divided into the categories of *protection, accommodation,* and *retreat*. Consensus among climate change adaptation reports is that retreat is both the most cost effective long-range option and the most difficult to enact in the local planning process (Cahoon et al, 2009; Stiles, 2008; Titus, 2009; Titus et al, 2011). Sea level rise adaptation strategies (Titus et al, 2011):

1. *Shore Protection*.

    a. *Shoreline armoring.* Protect land and buildings from erosion and flooding using dikes, seawalls, bulkheads, and other hard structures. Wetlands and beaches are eliminated as they are squeezed between the rising sea and the shoreline armoring.
    b. *Elevation of land surfaces.* Elevate land and buildings as the sea rises. Efforts to protect oceanfront communities usually involve beach nourishment, which elevates the surface of the beach. In theory, the land surfaces of wetlands can also be elevated, though shore protection projects along wetland shores rarely do so.
2. *Accommodation.* Do not try to prevent tidal inundation, erosion, or flooding. But instead of moving people out of harm's way, develop coping strategies that enable continued human habitation. Wetlands and beaches migrate inland, though they may be impaired by the presence of homes on pilings. Accommodation "may imply either deferring the decision whether to protect or retreat, or a conscious policy to allow individual owners to decide whether to abandon their property or continue to occupy an increasingly wet coastal zone" (Titus et al, 2011).
3. *Retreat.* Allow wetlands, beaches, and other coastal habitats to migrate naturally as the sea encroaches inland; move people out of harm's way; and prevent new construction in vulnerable areas.

In *Rolling Easements* (2011), Titus et al demonstrate that accommodation is not feasible in the long-term (i.e. structures rarely remain viable for use once they are standing in open water), leaving the fundamental question: "Which communities will be *protected* and where will people have to *retreat*?" The study, which was published as a comprehensive primer by the Climate Ready Estuaries program further states that "regulatory and property rights approaches are not mutually exclusive" and that in most cases rolling easements on private coastal parcels result in negligible property value reduction because changes occur in small increments over long periods of time. Many climate adaptation strategies discussed herein fall within the definition of rolling easements as broadly defined in the 2011 primer.

> "A **rolling easement** is a legally enforceable expectation that the shore or human access along the shore can migrate inland instead of being squeezed between an advancing sea and a fixed property line or physical structure. The term refers to a broad collection of legal options, many of which do not involve easements. Usually, a rolling easement would be either (a) a law that prohibits shore protection or (b) property right to ensure that wetlands, beaches, barrier islands, or access along the shore moves inland with the natural retreat of the shore" (Titus et al, 2011).

The law of property offers many different ways for a parcel owner to transfer some ownership rights to someone else. Many of those approaches can create a rolling easement. Though the end result is generally the same, methods may emphasize the absence of shore protection, migration of property line, or preserving public access to the shore.

In Virginia, lands seaward of the mean low water line are public lands and are subject to a rolling public trust easement in favor of the Commonwealth. While Virginia localities do not have authority to require rolling easements, they can implement a voluntary program to acquire recordable easements in which property owners agree to limit development on shoreline property in exchange for compensation (Silton and Grannis, 2010).

Strategies by Impact Sector

In "America's Climate Choices: Adapting to the Impacts of Climate Change," (2010) the National Research Council published a comprehensive list of climate adaptation strategies. Appendix 5.A of this report includes a set of adaptation strategy matrices modified from the NRC report, which are applicable to the Middle Peninsula. The list of strategies included is comprehensive, addressing a broader range of issues than are covered in the main body of this report. The matrices are intended to provide a strategic framework within which local and regional agencies can identify overlapping plan elements and co-benefits of a collaborative planning approach. The strategies selected and refined from the NRC model are put forth specifically for consideration by Middle Peninsula localities, citizens, businesses, and partner agencies.

The following selections for the portfolio of strategy options focus on applied local and regional tools that merit priority consideration by Middle Peninsula localities.

Comprehensive Plans

Local governments can incorporate coastal flooding, erosion, and sea level rise into the comprehensive planning process (Stilton and Grannis, 2010):

- Establish estimated rate of sea level rise and the time period over which it may occur
- Designate vulnerable areas
- Site future infrastructure and capital improvements outside of vulnerable areas
- Provide scientific data to justify land use decision-making
- Use risk-based analysis of likely hazards and vulnerabilities to inform land use decisions
- Plan responses to sea level rise

Public Access Management

Middle Peninsula stakeholders identified diminished public access due to gradually migrating shoreline as a future impact of concern during Phase I of the project (MPPDC, 2009). Public access effectively migrates inland either by preventing new construction and requiring removal of old structures that impair access locally, or by amending state law so that it is clear that public access migrates inland regardless of how the public access was obtained (Titus et al, 2011). The Open Beaches Act in Texas provides an example of rolling easement legislature, though such a program would only apply to subaqueous areas beyond the Mean Low Water (MLW) line in Virginia. The Texas state statute's explicit prohibition of hard structures, procedures for removal of homes seaward of the vegetation line, and explicit recognition of the inland migration of public access are all characteristics of a "rolling easement," a phrase Texas courts have often used to narrowly refer to the inland migration of the public right to access along the privately owned dry beach.

As a low-water state, Virginia protects private coastal property rights extending to the low-tide mark of the shoreline, so the shoreline can only migrate inland wherever public lands or easements enable it to do so. Local long-range planning for inland migration of public access should include prioritizing inland areas for public use or conservation, which are likely to be future shoreline areas as a result of erosion and

sea level rise. Long-range policy should include consideration for buildings and infrastructure that are eventually located shoreward of tidal vegetation and those eventually left in open water.

For the Middle Peninsula, the Middle Peninsula Chesapeake Bay Public Access Authority (MP-PAA) is responsible to promote and manage public access "for all types of recreational activities important to our economy and to the citizens of the Commonwealth of Virginia" (MP-PAA, 2011). Created by the General Assembly in 2002, the MP-PAA is charged with the following duties:

The Middle Peninsula Public Access Authority is charged with the following duties:

1. Identify land, either owned by the Commonwealth or private holdings, that can be secured for use by the general public as a public access site;
2. Research and determine ownership of all identified sites;
3. Determine appropriate public use levels of identified access sites;
4. Develop appropriate mechanisms for transferring title of Commonwealth or private holdings to the Authority;
5. Develop appropriate acquisition and site management plans for public access usage;
6. Determining which holdings should be sold to advance the mission of the Authority; and
7. Perform other duties required to fulfill the mission of the Middle Peninsula Chesapeake Bay Public Access Authority.

A Working Waterfront Master Plan is currently under development by the MP-PAA. The Working Waterfront Master Plan provides an opportunity to coordinate planning efforts with the local comprehensive planning process to protect and improve access to shoreline waters. The Master Plan should consider sensitive natural resource areas and other areas vulnerable to climate impacts.

Regulating Shoreline Protection

As discussed above, public access and shoreline protection are interrelated in that prioritizing areas that require public access management drives priorities for shoreline protection structures. Equally important is the process of planning for areas that should be discouraged from employing shoreline protection in the future. Publications from United States Environmental Protection Agency (USEPA), National Oceanic and Atmospheric Administration (NOAA) and Virginia Natural Resources Leadership Institute (VNRLI) emphasize the importance of purposeful delineation of areas that will require shoreline protection in the long run and those areas where efforts to "hold back the sea" – such as beach nourishment, revetments, and armoring – may be prohibited.

In order to implement such a plan, specific areas may be designated in the comprehensive plan. Localities then include one or more overlay zones, which specify prohibited shoreline protection activities. Justification for the zone includes: public access planning, flood protection, natural hazard mitigation, and natural resource (wetlands) preservation.

Floodplain Management

In Virginia, local governments have explicit authority to zone and plan for "one of the primary impacts of sea level rise: flooding" (Silton and Grannis, 2010). From a legal standpoint, then, the Code of Virginia grants local governments broad authority to consider flood risks when planning and zoning:

- Zoning ordinances may be designed to provide for safety from flood, provide adequate flood protection, and protect against loss of life and property from flood (Virginia Code §15.2-2223, §15.2-2283).
- Local governments may consider "preservation of floodplains" when creating zoning districts (Virginia Code §15.2-2284).
- Local governments can regulate the use and development of land and may specifically regulate development in flood plains (Virginia Code §15.2-2280).

Writing for the Georgetown Climate Center (2010), Silton and Grannis point out that the Code "provides no guidance or criteria for how flood risks should be assessed; flood plains are simply defined as 'those areas…which are likely to be covered by floodwaters.' The Code does not specify the boundaries of the flood plain nor the method by which flood risks should be calculated. Thus, consistent with the Dillon Rule, localities can choose any *reasonable method* for assessing flood risks, so long as the chosen method is consistent with the statue's purpose of mitigating flood impacts" (Silton and Grannis, 2010; Virginia Code §10.1-600).

Flood maps developed by FEMA, called Flood Insurance Rate Maps (FIRMs), do not account for future risks and are therefore not an accurate designation of future landward migration of the shoreline. To the extent that local GIS mapping efforts can depict future projection of historic sea level rise as a baseline scenario, they may be able to extend the regulated flood plain as enabled under flood protection statutes.

Chesapeake Bay Preservation Act (CBPA)

The CBPA makes it possible for localities to designate appropriate Resource Protection Areas (RPAs), as discussed in Chapter4. Fairfax County and Chesapeake, Virginia, serve as examples of localities providing specific buffers and performance criteria as enabled by the Virginia Code. Both RPAs and Resource Management Areas (RMAs) must be designated in local ordinances. Within the Middle Peninsula, Mathews County has designated the RMA as an additional 150-foot buffer from the boundary of the RPA. Examples of performance criteria, which may be included in local Chesapeake Bay Preservation ordinances:

- Stormwater management requirements
- Erosion and sediment control
- Septic system maintenance
- Environmental Impact Assessment

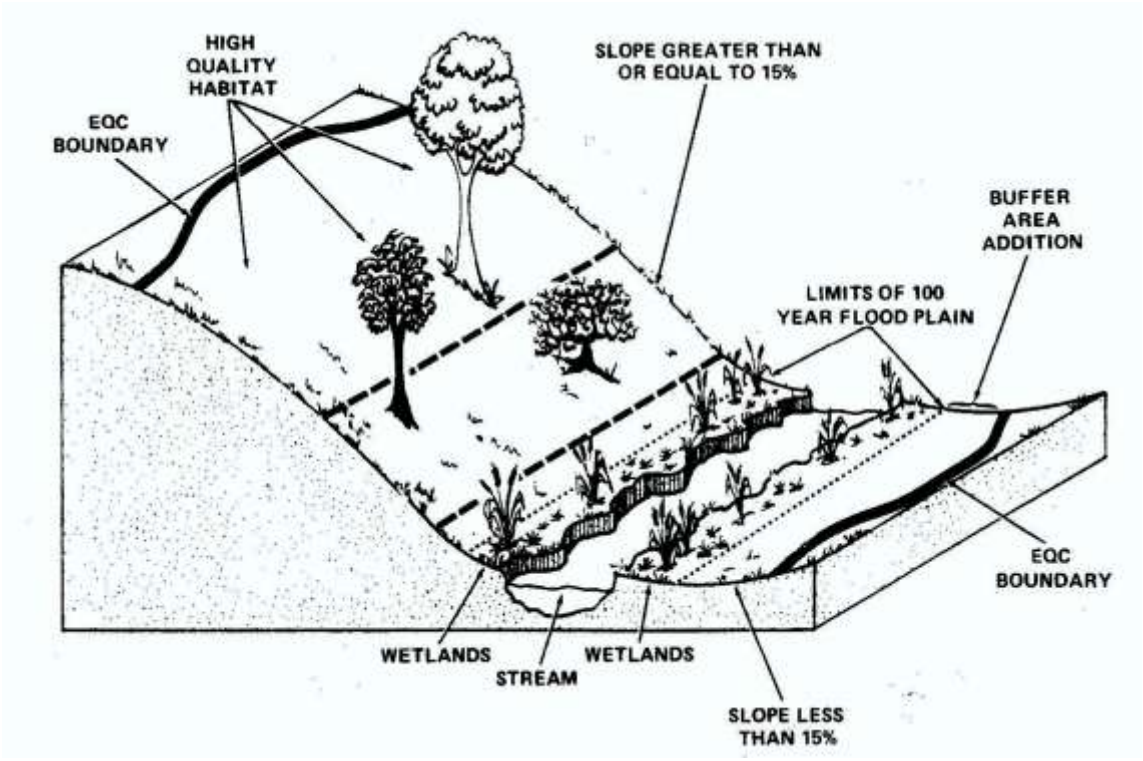

Figure 5.1. Fairfax County, Virginia. Environmental Quality Corridors. (Source: Fairfax County, 1990)

The Environmental Quality Corridor program in Fairfax County demonstrates a set of policies enabled by the local comprehensive plan to "preserve natural resource areas and provide passive recreation" within corridors that include stream valleys, wildlife habitats, and wetlands (Kaplan, 2008).

Market-based strategies (TDR/PDR)

Virginia allows localities to authorize the transfer of development rights (TDR) [Code of Virginia §15.2-2316.2], which also enables localities to keep development and redevelopment out of areas at high risk of inundation (VNRLI, 2011). The "TDR statute" of the Virginia Code (Title 15.2, Article 7.1) expressly permits local governments to create TDR programs:

- Receiving areas and sending areas must be designated in the comprehensive plan
- A TDR Ordinance is required, providing for the creation of "instruments that sever the development rights and allow for their transfer and use by other parties" (§15.2-2316.2(B)(1)-(4))
- Sending areas and receiving areas for the transfer of development rights must be designated in the zoning ordinance
- Land owners of the "sending" properties must grant an easement limiting the use and development of the sending property, which is binding on future owners

TDR programs work very well where market demand exists. Administration of the program is the responsibility of individual localities. Since the selling and purchasing of development rights is a voluntary act, this tool is not sufficient on its own to preserve vulnerable areas.

Site-level Density Transfers

Site-level density transfers, sometimes called "onsite density transfers," may be used to direct development in the coastal zone. Figure 5.2 illustrates the incentive zoning concept. In Isle of Wight County, Virginia, developers have options for open space design in a zone with a permitted density of 1 unit per 10 acres and a requirement for 50% permanent open space. The first option (Option 'A') is an onsite density transfer that provides the 50% open space and ten 5-acre lots. The second option provides 70% open space and gives a density bonus of 100%, allowing 20 lots of 1.5 acres each.

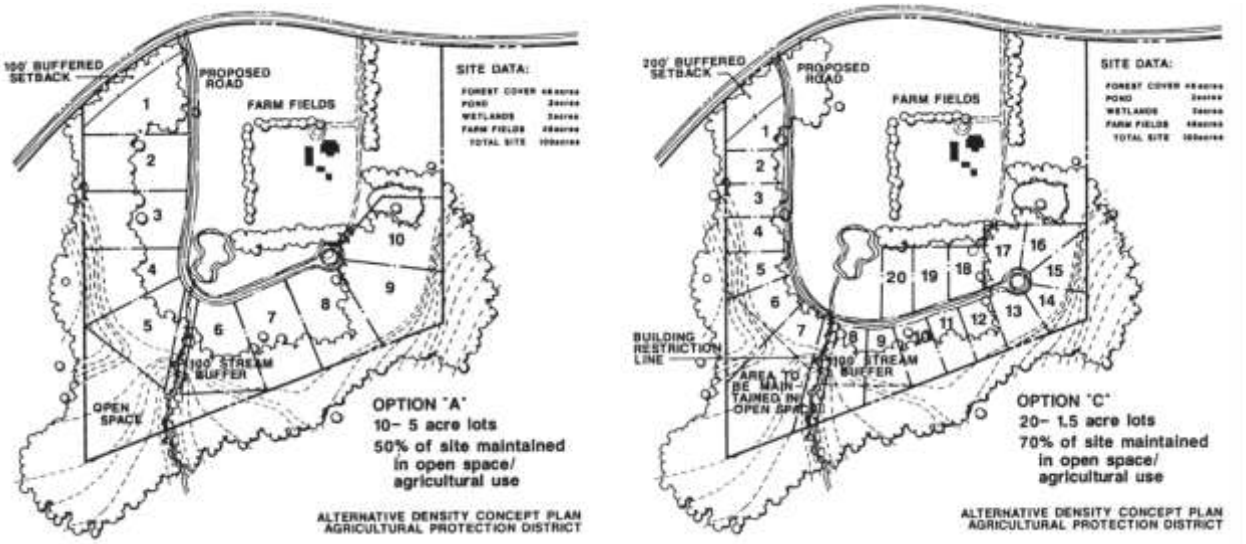

Figure 5.2. Density Bonus Options in Isle of Wight County, Virginia. Base zoning provides 1 unit per 10 acres and requires 50% open space. B: Increasing open space to 70% gives a 100% density bonus. (Source: Randall Arendt, Rural by Design, 1994. Chicago: American Planning Association)

Infrastructure Planning

Strategies exist to allow localities to steer future infrastructure toward areas free of flood risk and other coastal hazards. As discussed in Chapter 4, Dorchester County, Maryland, designated a Sea Level Risk district, where certain standards and restrictions apply (septic systems, wells, freeboard).

On-site Sewage Disposal Systems (OSDS)

The Middle Peninsula Planning District completed a study entitled "MPPDC Inventory of Non Traditional Onsite Sewage Disposal Systems and Impacts on Land Use Patterns" (2008), intended to explore the land use impact of alternative/engineered septic systems following regulatory changes in 2000. Feasibility of septic system on a given parcel is fundamental to whether the lot is developable or not. Within the Middle Peninsula, local governments have not previously needed regulations that restrict development in areas where septic systems were already not feasible.

The Virginia Department of Health (VDH) regulatory change left local governments responsible to provide services to several areas previously assumed to be not feasible for development. Moving forward, local government options are to create comprehensive planning and zoning policies that designate coastal hazards, flood protection, and water quality protection. Currently local governments cannot regulate OSDS within their jurisdictions. Some Virginia localities continue to seek clarification from the Commonwealth of Virginia about overlapping and conflicting requirements between the Clean Water Act and allowance of engineered OSDS. Albemarle County, Virginia, drafted a resolution in January 2011 requesting that the General Assembly reaffirm local zoning and land use authority to manage the location and timing of engineered OSDS installations (Albemarle County, 2011).

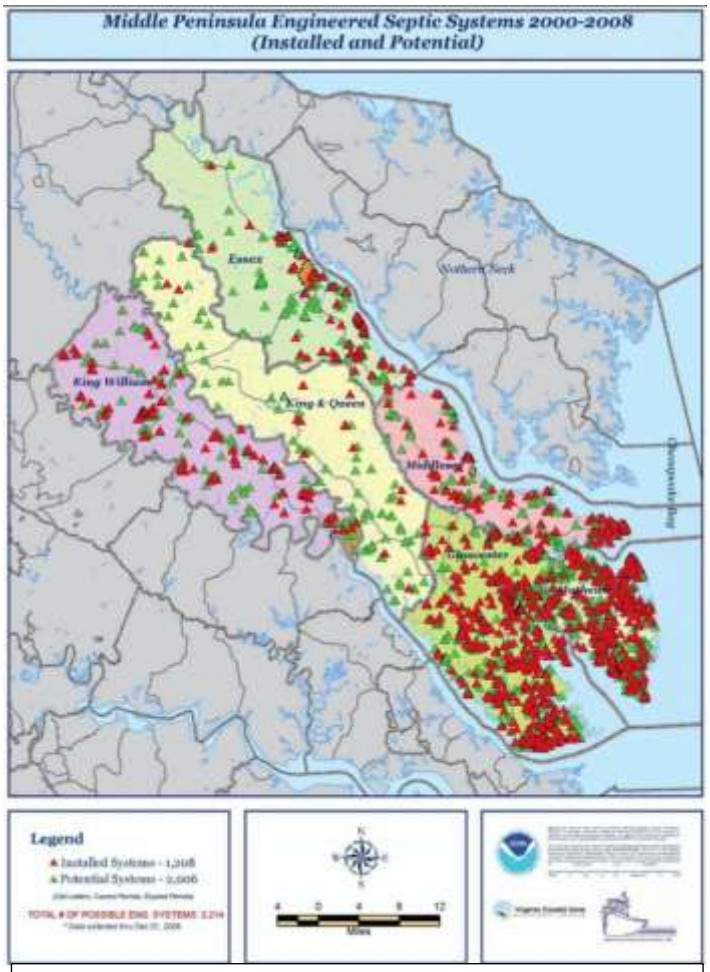

Figure 5.3. Current and Future Planned OSDS

Figure 5.3 illustrates current and future planned engineered OSDS, many in areas that had previously been assumed to be not suitable for development.

Conservation Easements

Conservation easements on coastal properties may be structured with relatively modest restriction, such as prohibiting shore protection structures or activities that change the elevation of the coastal land surface. The purpose of such easements is to allow gradual migration of shoreline and coastal wetlands inland, allowing the property owner to engage all other uses of his property unless/ until the sea reclaims it. Property value studies by the U.S. Global Change Program and USEPA demonstrate a relatively small impact to property values in such instances, ranging from one to five percent (Karl et al, 2009; Titus et al, 2011). Conservation easements may be arranged by local government programs or land trusts.

National, state, and regional land trusts may be engaged by private land owners for the purpose of allowing natural inland migration of the shoreline over time. Local government's role in this process is to develop land use plans for coastal areas that incorporate risk-based planning and designate appropriate

areas for holding back the sea and areas where shoreline protection is prohibited. In the Middle Peninsula, the Middle Peninsula Land Trust (MPLT) has participated in regional conservation planning, facilitating conservation easements for local land owners and promoting continued public access through land acquisition (MPLT, 2011).

In a 2011 brief published by the Virginia Natural Resources Leadership Institute entitled "Climate Change and Public Policy," authors highlight conservation easements as a means to keep shorelines open in Virginia: "Virginia offers generous tax treatment for Land Preservation Tax Credits generated under these programs [Code of Virginia §58.1-512]: a tax credit equal to 50% of the value of any conservation easement donated by a Virginia taxpayer over land in Virginia (providing that the easement qualifies as a charitable contribution under IRC §170h) up to $600,000. The tax treatment would encourage landowners along shorelines to donate their lands into conservation easements and consequently, keep the shoreline lands open" (VNRLI, 2011).

A correlation certainly exists between diminished property values and tax revenue for local government. Concern over diminished revenues due to conservation easements is one reason localities are not often quick to embrace conservation as a planning tool. A study published by the MPPDC in 2010 addresses this concern, concluding that the local tax revenue impact of conservation easements was less than a half percent (< 0.50%). The report attributes the low figures to a corresponding reduction of a given locality's "composite index" with reductions in the Total Value of Land Book (TVLB), which results in more state aid funding to schools (MPPDC, 2010). The MPPDC "Conservation Easements" report is the first year output of the MPPDC Conservation Corridors program. The MPPDC is slated to develop regional Priority Conservation Area maps during subsequent phases of the program (MPPDC, 2011). The Conservation Corridors program is an opportunity for the MPPDC to incorporate existing climate impact maps into their decision model for priority conservation areas.

Shoreline Management Plans

Coastal habitat preservation is an implicit goal of climate adaptation recommendations offered by federal programs such as USEPA and the U.S. Climate Change Science Program, as discussed in Chapter 1 of this report. Living Shorelines, a strategy employed by the state of Maryland, involves coastal property owners in active shoreline management in order to allow the sea to naturally advance inland over time.

In the Middle Peninsula, Mathews County has completed a Shoreline Management Plan (Mathews County, 2010). Shoreline management should be based on the types of coastal habitats and wetlands present, exposure to coastal storm events, and resulting erosion issues. Mathews County works with coastal property owners to employ the following shoreline management strategies:

- Marsh management
- Add sand with groins
- Stone sills
- Breakwater system
- Revetments
- Spurs

The plan notes that site-specific decisions should be made, and Mathews County has been proactive in developing public outreach materials to inform property owners of early detection techniques to identify erosion and be aware of response options. The plan discusses the need to balance wetlands encroachment resulting from shoreline management practices. Shoreline management focused on aspects of the coastal zone other than erosion may be more appropriate for other localities. Mathews' shoreline management project was completed through a funded endeavor with the Virginia Institute of Marine Science (VIMS).

Tax Incentives

Multiple sections of the Virginia Code permit local governments to use tax incentives to regulate land use (Silton and Grannis, 2010).

- **Use Value Assessments.** Localities may offer lower tax assessments for owners who volunteer to preserve property as open space. Rather than assessing taxes based on the property's full potential for development ("fair market value" (FMV)), "use value" tax assessments account for restrictions on the property's use (Virginia Code §58.1-3230). Local governments could use this incentive to encourage coastal property owners to preserve portions of their land. As with conservation easements, the resulting reduction in tax revenue to the local government is < 0.5%, but there is no resulting impact to the composite index for this voluntary program.
- **Wetlands Tax Exemptions.** Localities may offer tax exemptions to owners who agree to preserve wetlands and riparian buffers (Virginia Code §58.1-3666). A tax exemption could be offered under an environmental quality corridor policy similar to the current EQC program in Fairfax County discussed previously in this chapter.

Zoning and Ordinance Strategies

Local climate adaptation strategies may include regulatory strategies in the comprehensive planning process. Best practices address a range of possible future scenarios and encourage a mix of shoreline protection and planned retreat, depending on existing coastal land use in each jurisdiction.

1. **Coastal Overlay (Rolling Easement) Zoning**. Create an overlay zone for areas subject to eventual inundation. Within the coastal zone overlay, each separate zoning classification may be designated as either "protection" or "accommodation" (for example, residential single-family protection (RSP) and residential single-family accommodation (RSA)). Determination of "protection" or "accommodation" status depends on which areas decision makers deem appropriate for holding back the sea or planned retreat, respectively. Titus et al (2011) cite overlay zoning in Prince George's County, Maryland, as an example of this sort of practice (Prince George's County Zoning Code §27-441).
    a. **Possible Themes/Titles for the Overlay:** Coastal Hazards, Shoreline Protection, Shoreline Preservation, Sea Level Risks, Coastal Flooding, Coastal Zone – Protection/Accommodation
    b. **Possible Characteristics of Coastal Overlays:**
        i. Prohibit shoreline protection structures
        ii. Implement shoreline setbacks
        iii. Restrict future development
        iv. Lower non-conforming use threshold

v. Raise building code "free board" requirements

2. **Setbacks**. Setbacks make it more likely that an eroding shore will be allowed to retreat (Climate Change Science Program, 2009; Beatley et al, 2002). Shoreline setbacks may be applied to an existing zoning classification or included in an overlay zone. Setbacks are building restrictions that establish a distance from a boundary line where land owners are prohibited from building structures. With coastal properties, the boundary line is often the shoreline (specifically the mean low water line (MLWL) in Virginia).
3. **CBPA.** Extend Resource Protection Area and Resource Management Areas under the Chesapeake Bay Preservation Act ordinance. This can be accomplished by establishing specific performance criteria that contribute to stated goals of the CBPA (pollution reduction, erosion and sediment control, stormwater management).
4. **Floodplain Ordinance**. Update floodplain maps and GIS layers to account for future vulnerabilities. Extend floodplain restrictions currently in place to include areas mapped for future flood vulnerability. Revisit and revise development restrictions where appropriate to discourage development in areas vulnerable to current and future coastal flooding.

Table 1. Example Sea Level Rise Plan for Various Zoning and Land-Use Categories

Zoning	Existing Land Use	Planned Response to Sea Level Rise		
		Protect[1] Shore	Accommodate[2]	Retreat[3]
Commercial Mixed Use	High-Density	✓		
Commercial Mixed Use	Residential	✓		
Residential Single Family	Residential	✓		
Residential Single Family	Agriculture		✓	
Rural Estate	Residential	✓		
Rural Estate	Agriculture			✓
Agriculture	Agriculture			✓
Conservation/Open Space	Conservation/Open Space			✓

Source: See text.

1. Shore protection could be either shoreline armoring (e.g., dikes and bulkheads) or grade elevation (including beach nourishment).
2. Accommodation implies neither shore protection nor a specific effort to return lands to nature. It may imply either deferring the decision whether to protect or retreat, or a conscious policy to allow individual landowners to decide whether to abandon their property or continue to occupy an increasingly wet coastal zone. In the latter case, rolling easement zoning may be appropriate.
3. Rolling easement zoning would be appropriate in an area where retreat is planned.

Figure 5.4 Sea Level Rise Planning. Source: Titus, et al 2011

Figure 5.4 shows an example of zone-by-zone designation in the planning process of which mode of shoreline management is selected (protect, accommodate, retreat). For each selection the designation can then be incorporated into the zoning code, including applicable overlay zones for high-hazard or coastal flooding areas.

Education and Funding Opportunities

A tiered approach is necessary for building community resilience. The process should be built on a framework that includes data gathering, knowledge building, and community participation. All of these actions take time, resources, and good will. Various training and funding is available to help local governments and their stakeholders become familiar with climate change issues, gather data to help determine vulnerability to risks, and develop location-specific goals and strategies.

Education

- **"Introduction to Climate Science"** (Office of Environmental Education, DEQ). This training product is provided to help local governments and stakeholders better understand the science behind climate variability, including levels of certainty and uncertainty. Two options are offered for the training: 1) the presentation can be sent out to the local offices with accompanying script,

or 2) arrangements can be made for an education representative to conduct the training. The point of contact for this training is David Ruble, Community Education Specialist, Virginia DEQ at David.Ruble@deq.virginia.gov, or visit www.vanaturally.com.

- **Coastal Training Program (CTP)**, Chesapeake Bay National Estuarine Research Reserve (CBNERR) at the Virginia Institute of Marine Science (VIMS). This program was recommended by facilitators at the Sea Level Rise and Inundation Community Workshop in late 2009 (Culver, et al., 2010). It is a national initiative to address critical resource management issues by providing up-to-date, science-based information, access to technologies, and skill-building opportunities to key professionals responsible for making decisions about coastal resources. Programs range from seminars and hands-on skill training to participatory workshops and technology demonstrations. Training topic areas are: wetlands and riparian buffers, shoreline management, water quality and water management. The CTP's target audience is local and state agency staff involved with land-use planning, marine resources and environmental protection. All programs are offered at no to low cost. Information about the CTP can be found at http://www.vims.edu/cbnerr/coastal_training/index.php.
- **Stakeholder Engagement Strategies for Participatory Mapping**, NOAA Coastal Services Center. This 20-page guide is a decision-making tool for communities to help engage stakeholders in mapping exercises. The community mapping program helps to identify community resources, perspectives, and priorities. The program has the potential to reduce resistance to planning strategies that address vulnerability to climate change. The guide is available for download at http://www.csc.noaa.gov/participatory_mapping. The NOAA Coastal Services Center also offers assistance to communities interested in undertaking a participatory mapping exercise, ranging from phone calls that answer questions to "an extra pair of hands dedicated to [the local government's] program." Contact the Center for more information - csc.info@noaa.gov.
- **Virginia Natural Resources Leadership Institute (VNRLI)**, Institute for Environmental Negotiation at the University of Virginia (UVA). The VNRLI Mission is to develop leaders throughout Virginia who can help groups involved in "contentious natural resources issues" move beyond conflict toward consensus building and collaborative problem solving. Training offered through VNRLI is comprised of six three-day sessions over a span of nine months. The cost of enrollment is $2500 (scholarships available). Application and scholarship deadlines are in the month of June each year. For enrollment and curriculum information, visit the VNRLI website: http://www.virginia.edu/ien/vnrli/index.html. VNRLI has developed several "issue briefs," which are available for download, including: Chesapeake Bay, Low Impact Development, Sustainable Agriculture, Forest Management and Policy Issues, and Climate Change. VNRLI's strong emphasis on consensus building could help identify strategies to engage diverse stakeholder groups in the midst of challenging local political tensions.

Funding

The Virginia Coastal Zone Management Program (CZM), Virginia DEQ, administers several funds, initiatives, and projects as funded through the National Oceanic and Atmospheric Administration (NOAA) under the federal Coastal Zone Management Act (CZMA). Current funding for this program throughout the Commonwealth of Virginia is approximately $3 million annually. The MPPDC and the Middle Peninsula Chesapeake Bay Public Access Authority (MP-PAA) have been successful in acquiring

funding over recent years. Each year, funding is made available through Virginia's CZM Program under the following categories:

- Implementation of the Virginia CZM
- Acquisition and Construction Projects
- Creation of New Enforceable Coastal Policies
    - Virginia Coastal Needs Assessment and Strategy
    - Special Area Management Planning
    - Living Shorelines
- Implementation of the Virginia Nonpoint Source Pollution Program

Though the Focal Area of the CZM Program changes every three years, MPPDC and member jurisdictions can have some confidence that all strategies recommended herein support the goals of the federal CZMA program and are, therefore, likely to be eligible for funding as long as the CZMA program continues to be federally funded. A complete list of funding categories, descriptions, and requirements is available online through the Virginia CZM Program page within the DEQ website (http://www.deq.state.va.us/coastal/funding.html).

Summary

This chapter has presented a policy and planning framework and a portfolio of strategies to help move the MPPDC and its member jurisdictions forward to adapt to the challenges posed by natural hazards and other impacts of climate change, and build their resilience to change.

As with most planning endeavors, the adaptation planning process should define goals and objectives and then examine options to meet those goals in terms of their impacts on different stakeholders. "A fundamental issue to address is whether pre-existing strategic goals will continue to be appropriate or feasible in light of anticipated climate change impacts, or whether these former priorities will need to be modified. This centers around whether adaptation will allow the goals to be met as before or whether goals need to be adjusted because climate change alters the feasibility of achieving them" (National Research Council, 2010).

Chapter 6: A Recommended Pathway for the Middle Peninsula to Reduce Vulnerability

Climate change is real and happening, yet the magnitude of its local consequences and their timing are uncertain. This uncertainty complicates appropriate actions which may require changing behavior, changing patterns of land use, changing property values, and changing infrastructure investments. Even without uncertainty, change is hard and needed investment for change is hard to come by. But the most costly, damaging, and disruptive approach in the face of the vulnerability of the Middle Peninsula is to do nothing.

Localities within the Middle Peninsula must continue to build their community resilience to disruptive events and changing conditions. Their current efforts vary, and a more consistent regional strategy coordinated by the MPPDC is recommended. Given uncertainties and current public sentiments, such a regional strategy and its local implementation should begin with a public engagement program that includes local fact-finding and vulnerability assessment, and the collaborative learning it provides. Plans and strategies should be flexible, adaptive, and incremental, allowing for modification over time as conditions, resources, and sentiments change and uncertainties are resolved.

This iterative approach to reduce vulnerability and build resilience should be integrated into the PDC's and localities' existing planning framework, which includes comprehensive planning, natural hazard mitigation, land use zoning, building codes, floodplain management, stormwater management, Chesapeake Bay regulations, land conservation, and transportation and water/wastewater infrastructure plans. These programs will continue to be the foundation for efforts to reduce vulnerability over time.

In addition, the PDC and its localities should adopt an iterative and deliberative process called "anticipatory governance" that assesses vulnerability, monitors change and uncertainty, and engages stakeholders. Building community resilience is an iterative process that requires purposeful local planning over time and continual collaborative engagement that builds social capital that can be relied on in times of disaster or disruptive change. This collaborative engagement can evolve from fact-based vulnerability assessment. And the purposeful planning should consider regulatory and non-regulatory strategies based on this assessment. The sections below elaborate on this anticipatory governance approach, the comprehensive planning process, and priority strategies.

Anticipatory Governance

The MPPDC and member localities should engage anticipatory governance to build a framework for community resilience. There are six basic elements of this approach:

1. Formulate a Policy Statement for Community Resilience
2. Conduct a vulnerability assessment to identify location-specific vulnerabilities to future change and impacts
3. Engage local leaders, agency and elected officials, and citizens during all phases of building community resilience to change
4. Integrate vulnerability assessment results into regional and local plans

5. Formulate action strategies based on vulnerability assessments, public engagement, and planning steps
6. Adopt a comprehensive set of community resilience actions that can be implemented and monitored over time

Comprehensive Planning

Local governments within the Middle Peninsula should incorporate vulnerability assessment results into the comprehensive planning process. The Policy Statement for Community Resilience should be included or referenced in local comprehensive plans. Within that framework, local governments and stakeholders can use scientific data to perform risk-based analysis of likely hazards and vulnerabilities, which inform land use decisions. Vulnerable areas should be designated within the comprehensive plan, and future infrastructure and capital improvements should be sited outside of vulnerable areas.

Adopted principles of community resilience actions should be incorporated into regional and local plans within the Middle Peninsula: multi-hazard mitigation plans, local comprehensive plans, Chesapeake Bay preservation plans, stormwater management plans, transportation plans, and water and wastewater infrastructure plans.

Outreach and Collaborative Engagement

As discussed in Chapter 5, community involvement at every step of the planning process is itself a strategy to build community resilience. The MPPDC and member localities should incorporate outreach to solicit involvement, joint fact-finding, and collaborative learning and to disseminate information. Localities can consider establishing a working group for that purpose or amending the mission of an existing group.

Considerable knowledge is available among member localities in the Middle Peninsula. The MPPDC can facilitate regional stakeholder engagement to share perspectives, local knowledge, and ideas. Technical assistance, leadership and training workshops, and scientific data assistance are available from state, federal, and nonprofit agencies. The MPPDC can work with member jurisdictions to coordinate opportunities. The MPPDC may also assist in the follow-up process, providing technical assistance to localities that wish to incorporate new lessons into their existing planning framework (e.g. providing recommendations for how to apply new scientific data or community outreach opportunities).

Non-regulatory Strategies

The MPPDC and member jurisdictions should use vulnerability assessments to prioritize non-regulatory strategies best suited for their communities. Chosen strategies should aim to reduce vulnerability to coastal hazards while promoting opportunities for property owners to retain the most use and value from their property. Chapter 5 discusses the details of conservation programs, use value tax incentives, and shoreline management strategies, which fall into this category. Localities should also base infrastructure planning and capital investment decisions on vulnerability assessments. Planning strategies should incorporate changing vulnerabilities into the decision process to determine where future development will occur.

Regulatory Strategies

Comprehensive plans drive opportunities and constraints on the capacity of local ordinances to build community resilience to change. Priority should be given to strategy development within areas already supported by the Comprehensive Plan, particularly applicable regulatory mandates in the Commonwealth of Virginia:

- Flood Ordinance
- Chesapeake Bay Preservation Ordinance
- Wetlands Ordinance
- Stormwater regulations

Vulnerability assessments and scientific data gathering should drive refined location-specific decisions within each of these areas (e.g. designation of RPAs and RMAs, setbacks and nonconforming use thresholds within the floodplain). The result should be a local regulatory framework that is not reactive but defined by anticipation of changing conditions and vulnerabilities.

Conclusion

Planning for community resilience to climate change should be founded upon **location-specific scientific data**, **stakeholder-driven**, and **supported by the local Comprehensive Plan**. The process necessary to build community resilience is ongoing and should be approached in a strategic, tiered fashion. Localities in close proximity to one another can benefit by exchanging information, strategies, and lessons learned. Process is important in all planning, but especially in building community resilience in the face of uncertainty. Resolving uncertainty requires monitoring conditions and learning over time, and an engaged public must be part of that process. Involving stakeholders and the public in these activities also builds social capital that can be relied on to enhance resilience at times of disaster, disruption, and change.

The MPPDC and local governments should continually seek opportunities to receive technical assistance and funding in order to drive an anticipatory approach to adaptation planning. With purposeful community involvement and planning, this planning process will secure longevity and resilience for the entire community.

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Appendix 2.A Understanding Climate Change Impacts in Chesapeake Bay Region

The effects of sea-level rise are not necessarily obvious in the short term, though the most visible effects are seen in changing coastal landscapes through flooding, inundation, and coastal erosion. Additionally, alteration or loss of coastal habitats, wetlands, bays and estuaries has negative impacts on many plant and animal species. According to Titus et al (2009), coastal flooding in Virginia and throughout the Chesapeake Bay Region is increasing and will continue to do so over the coming decades. Sea levels along Virginia's coasts are projected to rise 2.3 to 5.2 feet by the year 2100 (Titus et al, 2009), with relative sea level rise for Virginia coasts higher than the national average due to land subsidence, the condition of sinking land due to groundwater withdrawal and tectonic activity (Pyke et al 2008).

Coastal Elevations

Coastal vulnerability to sea level rise is commonly modeled by layering future sea level rise scenarios with coastal elevations to project areas subject to future inundation. Inundation will be the primary result of sea level rise only in some areas; in other areas, long-term erosion of beaches and cliffs or drowning wetlands will alter the coastal landscape, resulting in land loss. In "Coastal Sensitivity to Sea Level Rise: A Focus on the Mid-Atlantic Region" (Titus et al, 2009), coastal response to sea level rise is distributed across the following broad categories:

- Land loss by inundation of low-lying lands
- Land loss due to erosion (removal of material from beaches, dunes, and cliffs)
- Barrier island migration, breaching, and segmentation
- Wetland accretion and migration
- Wetland drowning (deterioration and conversion to open water)
- Expansion of estuaries
- Saltwater intrusion (into freshwater aquifers and surface waters)
- Increased frequency of storm flooding (especially of uplands and developed coastal lands)

Mapping efforts completed by the MPPDC in collaboration with the Virginia Institute of Marine Science (VIMS) are derived from best available digital elevation models (DEM) using USGS contours between 5 and 10 feet. As light detection and ranging (LIDAR) data is now becoming available for the majority of Tidewater Virginia, vulnerability mapping has the potential to become even more detailed and more accurate in future iterations.

Water Resources

Climate change impacts to water resources may include reduction of water in some areas, too much water in other areas, and degraded water quality. Water cycle changes observed over the past several decades include (Karl et al, 2009):

- Changes in precipitation patterns/ intensity
- Changes in incidence of drought

- Widespread melting of snow and ice
- Increasing atmospheric water vapor
- Increasing evaporation
- Increasing water temperatures
- Reductions in lake and river ice
- Changes in soil moisture and runoff

Changes to the water cycle are expected to continue in coming decades (Milly et al, 2005). Precipitation increased by an average of 7 percent during the past century in the United States, and the heaviest 1 percent of rain events increased by nearly 20 percent (Gutowski et al, 2008). Some coastal regions, including the Chesapeake Bay, have seen greater than a 50 percent increase in the heaviest 1 percent of all precipitation events over the same period (Karl et al, 2009).

Both surface water quality and groundwater quantity may be affected by changing climate conditions. Increased temperatures in surface waters – streams, lakes, reservoirs – leads to reduced dissolved oxygen, which in turn stresses aquatic animals such as cold-water fish, insects and crustaceans (Bates et al, 2008). Surface water quality is negatively impacted by the effects of water pollution – increased sediment, nitrogen, disease pathogens, pesticides, herbicides and thermal pollution – which are amplified with increased precipitation (Karl et al, 2009). Also, harmful blooms of algae and bacteria have already been observed in the Chesapeake Bay, due in part to increases in polluted runoff (Karl et al, 2009).

As sea level encroaches upon coastal property and infrastructure, saltwater intrusion into freshwater aquifers becomes more common. Karl et al (2009) states that shallow groundwater aquifers that exchange water with streams are the component of the groundwater system likely to be most sensitive to climate change. As with many adaptation considerations, planning for the past or present status-quo will most likely not accommodate changes projected to water cycle and water resource management demands over the next several decades.

Energy Supply and Use

According to the U.S. Energy Information Administration (EIA, 2008) about 87 percent of U.S. greenhouse gas emissions come from energy production and use. Other recent population and housing trends may result in increased demand for energy in both commercial and residential sectors: population shifts to areas where air conditioning use is high, increase in square footage built per person, increased electrification of the residential and commercial sectors and increased market penetration of air conditioning (Wilbanks et al, 2007).

The Chesapeake Bay region is not likely to see reduction in water supply for the purpose of power plant electricity production (Karl et al, 2009). However, siting of new future energy facilities could be restricted by sea level rise, exposure to extreme events and increased capital costs resulting from the need to provide greater protection from extreme weather events (Bull et al, 2007). The electrical grid itself is vulnerable to temperature changes and severe weather events; specifically, electric power supply can experience disruptions when power transformers fail under the strain of temperature spikes (Bull et al, 2007).

Transportation

Coupling sea level rise with storm surge is an important consideration for assessing impacts of sea level rise on infrastructure. In the United States, an estimated 60,000 miles of coastal highway are already exposed to periodic flooding from coastal storms and high waves (National Research Council, 2008). According to the MPPDC map analysis, there are over 62,000 feet of VDOT road segments across member jurisdictions, which are vulnerable to a one-foot increase in sea level. These vulnerability estimates are possibly low, given the fact that storm surge was not incorporated into the model (Gill et al, 2009). An increase in coastal storms could mean more frequent and potentially more extensive emergency evacuation. The lifetime of highways that have been exposed to flooding is expected to decrease (Kafalenos et al, 2008). In the MPPD U.S. Highway 17 is a designated evacuation route, portions of which are vulnerable to periodic flooding.

Higher seas and storm surges will likely erode road base and undermine bridge supports, in addition to reducing clearance under some waterway bridges for boat traffic (Karl et al, 2009). Areas where flooding is already common are projected to face more frequent and severe problems. Planners have generally relied on past weather extremes as a guide for future forecasting (e.g. "100-year flood"), but those events are likely to become more frequent (National Research Council, 2008). These changes add to the challenge of predicting frequency and intensity of events that can affect transportation.

Coastal Wetlands

Dwindling wetland resources is an established concern in the United States. The U.S. Fish and Wildlife Service (FWS) reported to Congress in 1990 an estimated fifty percent loss of all wetlands of the United States between 1780 and 1980, including coastal wetlands. The Commonwealth of Virginia lost an estimated 42 percent of its original 1.8 million acres of wetlands during the same period (Dahl, 1990). According to "Wetland Sustainability," the report submitted by Cahoon et al (2009) to the U.S. Climate Change Science Program, landward migration of wetlands (wetland accretion) in the Mid-Atlantic region can keep pace with the twentieth century rate of 3 to 4 millimeters (or 1/8 inch) annual sea level rise. Wetland accretion can sustain sea level rise acceleration of 2 millimeters per year (1/16 inch) only under optimal hydrology and sediment supply conditions, and a scenario of 7 millimeter (1/4 inch) acceleration of annual sea level rise would likely destroy coastal wetlands with few localized exceptions.

The MPPD lies within the Chesapeake Bay watershed and is under jurisdiction of Virginia's Chesapeake Bay Preservation Act (CBPA). Tidewater jurisdictions, including the MPPD, are required to designate Resource Protections Areas (RPA) and Resource Management Areas (RMA), which collectively are referred to as Resource Preservation Areas. The base guideline for RPA designation is a 100-foot riparian buffer, landward of all surface waters. As part of the 2011 workshop for the Chesapeake Bay Program's Science and Technical Advisory Committee (STAC), Skip Stiles presented findings on sea level rise adaptation in Virginia. He cited an estimated two feet of sea level rise over the next 100 years, resulting in a 50 to 80 percent loss of tidal wetlands in Virginia during that time (Stiles, 2011).

Since wetland accretion modeling is still limited in its ability to predict localized conditions (McFadden et al, 2007), localities are left to work with rough-estimate benchmarks through the planning process. The

model developed by Nicholls et al (2007) estimates wetlands losses on a global scale relative to three broad environmental drivers: 1) ratio of relative sea level rise to tidal range, 2) sediment supply and 3) lateral accommodation space. This model suggests global wetland area losses of 33 and 44 percent for 36- and 72-centimeter (14.2- and 28.3-in) rises in sea level, respectively, noting that Atlantic and Gulf of Mexico coasts will be among the most severely impacted (McFadden et al, 2007; Nicholls et al, 2007).

Ecosystems and Coastal Habitats

Coastal ecosystems consist of tidal marshes, tidal forests, aquatic vegetation beds, tidal flats, beaches and cliffs. Tidal marshes and associated submerged aquatic vegetation are important spawning, nursery, and shelter areas for fish and shellfish, including commercially important species. Where tidal marshes become submerged or eroded, the expected overall loss of wetlands may cause wetland-dependent species of fish and birds to have reduced population sizes. Any sea level rise rate exceeding landward migration capability places these critical resources at risk (Shellenbarger Jones et al, 2009). Intertidal marshlands are not likely to adapt to sea level rise where existing development prevents landward migration or where armored shorelines disconnect them from their natural drainage system (Weinstein et al, 2005).

Agriculture

As the United States population increases, increased agricultural productivity of food, feed, fuel and livestock products will be necessary. According to Karl et al (2009), U.S. agriculture is likely to see increased challenge due to changing temperatures and climate in coming decades in the form of changes in growth season length, irrigation supply, and temperature spikes (Hatfield et al, 2008).

In the case of regional temperature increases, optimum latitude for crops move northward as localized temperatures exceed maximum level for pollen viability in a particular plant (Hatfield et al, 2008). When crops are exposed to extreme events such as heavy downpours and droughts, they suffer reduced yield. As more frequent and extreme events are projected to increase in the Chesapeake Bay region, it is possible that existing crop and livestock yields will be reduced (Karl et al, 2009). Recent historical data available for the MPPD shows, for example, a reduction of more than 4,000 acres of Barley Harvested for Grain from 2002 to 2007, which contributed to a net decrease of approximately 493,700 acres throughout the United States (NASS, 2008). During the same period, Middle Peninsula counties experienced a 6,000 acre decrease in Soybeans Harvested for Beans (NASS, 2008b). These available maps and data do not explicitly state a correlation to shifting temperature patterns; however, past trends can be considered when planning for adaptation actions among regional agriculture interests: shifting crop varieties, seasonal calendar considerations and livestock planning.

Shifting precipitation patterns in the Chesapeake Bay region may result in increased extremes for downpour events, negatively impacting spring planting opportunities and overall plant growth (Karl et al, 2009). Hatfield et al (2008) also note that weeds benefit more than cash crops from higher temperatures and carbon dioxide levels, and northward expansion of invasive weeds is likely if climate warming continues. Current annual weed-control costs in the United States are more than $11 billion, and this number is likely to increase as temperatures and carbon dioxide levels rise (Karl et al, 2009).

Forage quality of pastures and rangelands for cattle production is likely to decrease if carbon dioxide concentrations increase; this effect is due to carbon dioxide’s impact on plant nitrogen and protein

content. Specifically, as carbon dioxide concentrations increase, forage quantity increases, but plant protein concentrations are reduced and, in many cases, digestibility of the forage plants as well(Hatfield et al, 2008). Finally, livestock productivity will likely decrease if temperatures and humidity increase, causing stress, discomfort and increased mortality for livestock (Hatfield et al, 2008).

Human Health

Human health is likely to undergo increased vulnerability under various future climate change scenarios. Possible impacts include increased frequency and spikes in heat waves, reduced air quality, physical and mental health challenges from extreme weather, and increased likelihood of food-, water- and insect-borne diseases.

Hazard-related deaths in the United States number 19,958 for the years 1970 through 2004 (National Climatic Data Center, 2008). Of that total, the category "heat/drought" ranks highest followed by "severe weather," with 19.6 and 18.8 percent, respectively. Gutowski et al (2008) suggest that currently rare extreme heat waves will experience increased probability over coming decades, joined by a parallel reduction in winter season cold snaps. As to the projected impact of these seasonal changes on mortality, Medina-Ramon and Schwartz (2007) found that cold snaps and heat waves trigger disproportionate spikes in overall mortality rates (1.6 and 5.7 percent, respectively), meaning the cumulative effect is increased mortality since the projected increase in heat-related deaths will exceed the likely decrease in cold-related deaths.

Air pollution impacts are a concern for much of the Chesapeake Bay region, but the localities facing the highest challenge will be urban areas located outside of the MPPD. Current air quality conditions reported by the American Lung Association (2011) for study areas closest to the MPPD are "Good," the best rating available.

The U.S. Global Change Program (USGCP; Karl et al, 2009) aptly summarizes changing impacts in disease-causing agents, which have been correlated to changing climatic conditions. The report draws largely from several recent scientific reports about human health in the United States, including a synthesis and assessment report to the United States Environmental Protection Agency (EPA; Ebi et al, 2008). The following is the list of impacts to disease-causing agents (pathogens) commonly transmitted by food, water, or animals included in the USGCP report (Karl et al, 2009):

- Cases of food poisoning due to *Salmonella* and other bacteria peak within one to six weeks of the highest reported ambient temperatures.
- Cases of waterborne *Cryptosporidium* and *Giardia* increase following heavy downpours. These parasites can be transmitted in drinking water and through recreational water use.
- Climate change affects the life cycle and distribution of the mosquitoes, ticks and rodents that carry West Nile virus, equine encephalitis, Lyme disease, and hantavirus. However, moderating factors such as housing quality, land use patterns, pest control programs, and a robust public health infrastructure are likely to prevent the large-scale spread of these diseases in the US.
- Heavy rain and flooding can contaminate certain food crops with feces from nearby livestock or wild animals, increasing the likelihood of food-borne disease associated with fresh produce.
- *Vibrio* sp. (shellfish poisoning) accounts for 20 percent of the illnesses and 95 percent of the deaths associated with eating infected shellfish, although the overall incidence of illness from

Virbrio infection remains low. There is a close association between temperature, *Vibrio* sp. Abundance, and clinical illness. The U.S. infection rate increased 41 percent from 1996 to 2006, concurrent with rising temperatures.

- As temperatures rise, tick populations that carry Rocky Mountain spotted fever are projected to shift from south to north.

Future reduction in human health vulnerability will require incorporation of planned adaptation into long-term municipal and public service planning, including health services to the MPPD.

Appendix 5.A Adaptation Strategies and Implementing Agents by Impact

		Impact	Possible Adaptation Action	Who?	How?
Water	Higher temperatures and reduced precipitation	**Insufficient Water Supplies**	Increase system redundancy to ensure backup supplies, sharing integrated facilities between jurisdictions and sectors, obtain portfolio of multiple water sources, including reuse of municipal wastewater (IPCC4; IPCC3; USGS; NRC; CCAWS)	Citizens, Local Governments, Water Authority	water supply planning
			Participate in water supply protection through watershed management, including protecting surface water sources and groundwater recharge zones	Nat Resource Managers, Local Govt	water supply planning, land use planning, overlay zoning
	Storm surges, sea level rise and increasing intensity of precipitation	**Increased frequency of coastal and**	Evaluate risks to infrastructure and develop and apply new design standards for water, wastewater, and drainage systems (USGS).	Local Governments	infrastructure planning, stormwater management
			Enhance regulation of floodplain development; change design standards to allow floods to pass under buildings (e.g. pilings); encourage relocation of infrastructure from areas where flooding and erosion are likely and retreat from damaged areas after flooding (USGS; IPCC3)	Local Governments	floodplain mgmt/ ordinance, CBPA, coord. transportation & utility infrastructure projects; Bldg Code
			Redesign floodprone areas to allow natural attenuation processes, reduce hard surfaces, allow natural channel movement, etc.	Local Governments, private developers	floodplain management, impervious surface threshold, CBPA
			Protect vulnerable land from development through land use planning	Conservation Agencies, Local Governments	outreach, conservation easements, overlay zoning
		Increased levels of pollutants in runoff	Enhance flood retention and buffer requirements, enhance natural filtration capacity, biological removal of pollutants; rain gardens (CALI)	Local Governments	floodplain/ stormwater management
		Increased storm water runoff	Require treatment of urban storm water runoff, manage land uses to require on-site retention in areas where pollutants are generated	Local Governments	floodplain/ stormwater management
	Sea level rise	**Saline intrusion, aquifers**	Insert sea water barrier injection wells (to limit migration of salt water aquifers inland) e.g. with reclaimed water (CALI)	Local Governments, State agencies	water supply planning, habitat conservation plan
	General climate change	**Outdated management practices**	Encourage collaborative regional water supply planning to address multiple stresses including climate change	Local Gov, State Agencies	water supply plan

Sources were abbreviated in the tables to conserve space. The abbreviations refer to the following publications: 5-1 = CCSP, 2008d; IPCC3 = IPCC, 2001; IPCC4 = IPCC, 2007a; CALI = California Department of Water Resources, 2008; NRC = NRC, 2007; USGS = Brekke et al., 2009; CCAWS = Ludwig et al., 2009; CUWCC = California Urban Water Conservation Council, 2008; FPB = Young & McColl, 2008; WWF = WWF, 2003

		Impact	Possible Adaptation Action	Who?	How?
Energy	Average Temperature Rise	**Increased demand for cooling, reduced demand for heating**	Lead by example - Government agencies can weatherize buildings and manage energy use to reduce cooling demands (CADGS)	Local Govt	outreach, weatherize
		More frequent and/or longer heat waves	Ensure that energy requirements of especially vulnerable populations are met, especially during heat waves (4-5)	Local Govt, Nonprofit partners	outreach, assistance funds
	Changes in intensity, timing, and location of extreme weather events	**Disruption of energy conversion and generation du to extreme events (RFF-PI)**	Increase resilience to energy interruptions and other threats. Expand redundancy in electricity transmission capacity and energy storage capacity	Local Govt	outreach, emergency mgt, infrastruc plan
		Disruption of energy transmission and transportation due to	Assess regional energy sector vulnerability and communicate vulnerabilities; advocate responsible contingency planning	Local Govt, Nonprofit partners	outreach, infrastruc plan
			Prepare for supply interruptions, e.g. backup systems for emergency facilities, schools, etc.	Local Govt, Nonprofit partners, Emergency Mgrs	outreach, emergency mgt
	Sea level rise	**Risks to infrastructures in vulnerable coastal areas**	Conduct regional analysis of vulnerability of coastal infrastructure to sea level rise, advocate responsible land use planning and contingency planning	Local Govt	infrastruc plan, land use planning, overlay zoning

Sources were abbreviated in the tables to conserve space. The abbreviations refer to the following publications: 4-5 = CCSP, 2007; RFF-PI = Neumann & Price, 2009; CADGS = California Energy Commission, 2009

		Impact	Possible Adaptation Action	Who?	How?
Transportation	Long-term sea level rise	**Permanent flooding of coastal land**	Build or enhance levees/dikes for protection	Local Govt, property owners	overlay zoning - protection
			Elevate critical infrastructure that is at risk to sea level rise	Local Govt	infrastruc plan, hazard mitigation plan
		Impacts on infrastructure such as bridges or harbors	Raise bridge heights and reinforce or relocate harbor infrastructure	Local Govt	infrastruc plan, hazard mitigation plan
	More intense precipitation	**Change to hydraulics**	Review hydraulic structures for deficiencies - culverts, drainage channels	Local Govt	stormwater mgmt, infrastruc plan
		More frequent flooding	Institute better land use planning for flood plain development including prohibition in some instances	Local Govt	land use planning, overlay zoning, redev threshold
			Replace vulnerable bridges and other facilities	Local Govt	infrastruc plan, hazard mitigation plan
			Harden infrastructure and port facilities	Local Govt, private sector	infrastruc plan, hazard mitigation plan
	Greater coastal storm strength with sea level rise	**More extreme, more frequent coastal flooding**	Require climate change assessments in long range transportation planning in floodplains, land use planning in flood-prone coastal areas	Local Govt	land use planning, overlay zoning, floodplain mgt
			Identify and take constructive action to provide and protect emergency evacuation routes	Local Govt	Emergency Mgmt
			Abandon or relocate infrastructure and facilities	Local Govt	infrastruc plan, hazard mitigation plan

Sources were abbreviated in the tables to conserve space. The abbreviations refer to the following publications: RFF-PI = Neumann & Price, 2009

		Impact	Possible Adaptation Action	Who?	How?
Health	Changes in frequency, intensity, and duration of extreme weather events	**Increased risk of injuries, illnesses, and death**	Develop scientific and technical guidance and decision support tools for early warning systems and emergency response plans, including appropriate individual behavior (Ebi)	Citizens, Nonprofit partners, Comm Hlth, Emergency Mgrs	Outreach, Emergency Mgt plan
			Conduct education and outreach on emergency preparedness and response, including mental health needs following a disaster (Ebi; Frumkin)	Nonprofit partners, Comm Hlth, Emergency Mgrs	Outreach, Emergency Mgt plan
			Conduct early warning system and response plan tests before events (Ebi)	Local Govt, Emergency Mgmt	Emergency Mgmt plan
	Increases in frequency, intensity, and	**Increased risk of heat-related illnesses and deaths**	Conduct education and outreach on preparedness during a heat wave. Develop education and training programs for health professionals on risks and appropriate actions during heat waves (J and S; Ebi).	Nonprofit partners, Comm Hlth, Emergency Mgrs	Outreach, Emergency Mgt plan
	Climate change generally	**Institutional challenges**	Modify public health programs and activities focused on climate-sensitive health outcomes to take climate change into account (J and S)	Nonprofit partners, Comm Hlth	Outreach
			Enhance education of health care professionals to understand the health and risks of climate change, including diagnosis and treatment for health outcomes that may become more prevalent (J and S)	Nonprofit partners, Comm Hlth	Outreach

Sources were abbreviated in the tables to conserve space. The abbreviations refer to the following publications: Ebi = Ebi et al., 2008; Frumkin = Frumkin et al., 2008; J and S = Jackson & Shields, 2008

		Impact	Possible Adaptation Action	Who?	How?
Ecosystems	Altered hydrologic regime	**Flow effects on rivers**	Plant flood-adapted species to reduce peak flows & erosion. More effective storm-water infrastructure	Citizens, Nat Resource Mgrs, Local Govt	outreach, volunteers, practitioners
			Reforest riparian areas with native species to create shaded thermal reduces for fish species	Natural Resource Managers	outreach, volunteers, practitioners
	Climate Change Generally	**Degradation of ecosystems**	Use conservation easements & buffers around refuges to foster population & species variability & to provide room for species dispersal & landscape interactions	Citizens, Conservation Agencies, Local Governments	outreach, conservation easements
			Remove dispersal barriers, including dams, establish dispersal bridges & connect landscapes that support migration of native species in response to climate change; identify species or habitats that are likely to migrate out of areas	VDOT, Local Governments, Habitat Managers	plan, combining capital/ infrastructure improvements or maintenance with barrier removal
		Threats to ecosystem	Conserve & manage lands suitable for carbon sequestration & other climate feedbacks	Citizens, Conservation Agencies, Local Governments	outreach, volunteers, practitioners
		Outdated management	Remove structures that harden the coastlines, impede natural regeneration of sediments, & prevent natural inland migration of sand & vegetation in response to climate change; restore or create coastal wetlands, barrier islands & other	VDOT, Local Governments, Habitat Managers	habitat conservation plan, combining capital/ infrastructure improvements or maintenance with

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		Impact	Possible Adaptation Action	Who?	How?
Agriculture & Forestry	Increased Evaporation & Changes in Precipitation	**Greater Irrigation Requirements**	Adopt irrigatioin best practices (e.g. drip irrigation, laser leveling); Switch to crops with greater drought-resistance (IPCC).	farmers, Nonprofit partners	Outreach
		Increased yields of rain-fed agriculture	Manage to prevent waterlogging, erosion, and nutrient leaching in areas with rainfall increases (IPCC). Develop flood resistant crops.	farmers, soil & water conservation district	outreach, stormwater mgmt
	Increased Temperature - effects on pests	**Disease pressure on crops and livestock will increase with earlier springs and warmer winters, allowing low proliferation and higher survival of pathogens and parasites (4-3)**	Develop and use disease resistant varieties.	farmers, Nonprofit partners	Outreach
	Extreme Events	**Point and non-point source pollution from agriculture practices could increase**	Use buffers, adjust fertilizer and pesticide applications, and adopt other best practices to limit pollution impacts on water resources.	Farmers, Local Govt, Nonprofit partners	outreach, stormwater mgmt, overlay zoning

publications: 4-1 = CCSP, 2009b;
4-2 = CCSP, 2009a; 4-3 = CCSP, 2008c; NRC = NRC, 1992; IPCC = IPCC, 2007a; Millar = Millar et al.,

		Impact	Possible Adaptation Action	Who?	How?
Oceans and Coasts	Accelerated Sea Level	**Gradual inundation of low-lying land; loss of coastal habitats, especially coastal wetlands; saltwater intrusion into coastal aquifers and rivers; increased shoreline erosion and loss of barrier islands; changes in navigational conditions**	Site and design all future public works projects to take into account projections for sea level rise	Local Govt	Infrastruc plan, overlay zoning
			Develop strong, well-planned, shoreline retreat or relocation plans (public infrastructure and private properties), and post-storm redevelopment plans	Local Govt	Infrastruc plan, overlay zoning, Redev thresholds
			Use natural shorelines, setbacks, and buffer zones to allow inland migration of shore habitats and barrier islands over time (e.g. dunes and forested buffers mitigate storm damage/ erosion)	Nat Resource Mgrs, Local Govt, Citizens	setbacks, overlay zoning
			Encourage alternatives to shoreline "armoring" through "living shorelines" (NRC)	Mgrs, Local Govt, Citizens	setbacks, overlay zoning
	Increased intensity/ frequency of coastal storms	**Increased storm surge and flooding; increased wind damage; sudden costal/ shoreline alterations**	Strengthen and implement building codes that make existing buildings more resilient to storm damage along the coast	Local Govt	Bldg Code, overlay zone
			Increase building "free board" above Base Flood Elevation	Local Govt	Bldg Code, overlay zone
			Identify and improve evacuation routes in low-lying areas (e.g. causeways to coastal islands)	Local Govt, Emergency Mgrs	Emergency Mgmt Plan, Hazard Mitigation Plan

Sources were abbreviated in the tables to conserve space. The abbreviations refer to the following publications: NRC = NRC, 2007c; Limiting = ACC: Limiting the Magnitude of Future Climate Change, NRC 2010c