A "TOOLKIT" FOR SEA LEVEL RISE ADAPTATION IN VIRGINIA

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Abstract: Virginia has the highest rates of relative sea level rise recorded on the east coast of the United States. The southeastern region of Virginia has significant economic and strategic activities at risk from current and projected rates of relative sea level rise, increasing the urgency for Virginia to begin sea level rise adaptation planning and implementation. Individual land use decisions will define our tidal shoreline and influencing and controlling these decisions is central to any sea level rise adaptation strategy. Land use decisions are the domain of local governments and as awareness of sea level rise and inundation threats grows in Virginia, local governments need a set of tools to develop and implement sea level rise adaptation strategies. A review of currently available planning and regulatory tools shows that localities in Virginia have sufficient authorities to begin adaptation work today, with the potential for more effective approaches in the future if regulatory and legislative changes are made to existing authorities.

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1. SEA LEVEL RISE IMPACTS IN VIRGINIA

Virginia has the highest rate of measured sea level rise over the last 100 years of any state on the east coast, with the Sewells Point tide gauge in Norfolk recording a centennial rate of .44 meters (1.45 feet). (NOAA Tide Gauges, US Climate Change Program 2009) The rate of sea level rise in the southern Chesapeake Bay is expected to increase in the coming century, increasing from its historic .44 meters to a minimum of .7 meters (2.3 feet) per 100 years (Pyke et. al. 2008, Virginia Commission 2008, Najjar et. al. 2000). Rates could go higher: conservative projections of future rates of sea level rise run from the minimum of .7 meters (2.3 feet) to as much as 1.58 meters (5.2 feet) in the coming century (Pyke, et al. 2008, Virginia Commission 2008).

Specific estimates of inundation impacts from projected rates of sea level rise have not been produced, due in part to the lack of high resolution, comprehensive digital elevation maps for most of Virginia's coastal plain. One study using available elevation data estimates a relative sea level rise of 60 cm/100 years would inundate 1700 km^2 of land in Virginia and Maryland, about half of which is wetlands. (Wu, et.al. 2009) The ocean shoreline in Virginia is projected to retreat 1.3 km over this period, absent shoreline hardening. (Wu, et. al. 2009) These are simple inundation projections and do not include storm surge inundation nor the regular inundation during spring tides (high tides occurring on the full or new moon).

1.1 Impacts on Natural Systems

Increased inundation from higher rates of sea level rise threatens both natural and human systems alike. Higher tidal water levels pose significant potential impacts to the coastal ecosystem, including: loss of primary coastal dunes to erosion, loss of existing submerged aquatic vegetation (due to increased water depth, possible decreases in water clarity due to algal blooms and sediments, and increases in water temperature), and inundation of vegetated wetlands in the intertidal zone. (Pyke, et al. 2008)

Tidal wetlands can accrete vertically and have kept pace with past rates of sea level rise. Changes in sediment budgets, wetlands health, and accelerating rates of sea level rise can overpower the ability of wetlands to accrete vertically. Vegetated tidal wetland accretion rates, currently in the range of 3 mm/yr in

the Chesapeake Bay (Stevenson, et.al. 1996) will probably not be sufficient to keep pace with the minimum predicted rate of relative sea level rise of around 6 mm/yr.

As the intertidal zone moves landward with sea level rise, the coastal ecosystem in that zone will move with it. When this shoreward movement encounters steep slopes, high banks, or hardened shoreline infrastructure, the wetlands will "drown" in place, unable to stay in the intertidal zone as that zone moves. (Titus, et. al. 1991)

In 2007, Wetlands Watch estimated that Virginia would lose 50 –80 percent of its tidal wetlands due to the then-expected 60 cm of sea level rise over the next century. (Wetlands Watch 2007) The range of those estimates was confirmed by two subsequent studies. (National Wildlife Federation 2008, US Climate Change Science Program 2009)

1.1.1 Economic Importance of Natural Systems

The direct economic impact of the loss of these wetlands is hard to evaluate, although some rough values can be placed on the upper bounds of the wetlands dependant fishery in Virginia. The vast majority of finfish and shellfish are dependant on wetlands (Feierabend and Zelazny 1987). Thus a loss of tidal wetlands threatens Virginia's commercial fishery, valued at $108 million annually (VMRC 2008), and its recreational saltwater fishery valued annually at $820 million in sales and $480 million in services, providing more than 9,000 jobs (Virginia Department of Conservation and Recreation 2007).

1.2 Impacts on Built Environment and Regional Economy in Southeast Virginia

High rates of sea level rise in the southern Chesapeake Bay region cause the Virginia Beach-Norfolk-Newport News VA-NC Municipal Statistical Area (MSA), with 1.6 million people, to stand out as the largest population center at greatest risk from sea level rise outside of New Orleans. (Wetlands Watch 2007) This MSA is ranked 10th in the world for value of assets at risk from sea level rise in the region. (Nicholls et.al. 2008)

Hampton Roads was ranked 8th in the United States in 2009 for the value of shipping through the port with a $46.5 billion in imports and exports. (South Carolina State Ports Authority 2010) The ship construction and repair sector in Hampton Roads provides more than 20,000 jobs and $5.2 billion in output in 2002. (Hampton Roads Planning District Commission 2004) Numerous other shoreline industrial sectors are an important part of the economy of southeastern Virginia and, located only a few feet above mean sea level, all are all at risk from sea level rise and storm surge inundations, as is their contribution to the regional economy.

Sea level rise threatens major government facilities along the tidal shoreline in Virginia. The military services have a number of facilities in southeastern Virginia, including the largest navy base in the world at Naval Station Norfolk. Other facilities such as Langley Air Force Base, Fort Eustis, Dam Neck Annex, and Joint Expeditionary Base Little Creek-Fort Story are also located along the shoreline in low-lying areas vulnerable to inundation. The National Aeronautics and Space Agency's two facilities, one at Langley and one at Wallops Island, are also along the tidal shoreline in eastern Virginia and both low lying facilities are experiencing flooding and erosion problems.

The Department of Defense (DoD) spending in southeastern Virginia was $18.86 billion in 2009 and the direct and indirect economic activity from the military services in the region accounts for roughly 45 percent

of the gross economic activity in the MSA. (Regional Studies Institute 2009) If sea level rise and inundation threaten the operational readiness of military bases in the region, this economic activity is also threatened.

The DoD has made adaptation to sea level rise a priority as pointed out in the latest Quadrennial Defense Review:

> "Although the United States has significant capacity to adapt to climate change, it will pose challenges for civil society and DoD alike, particularly in light of the nation's extensive coastal infrastructure. In 2008, the National Intelligence Council judged that more than 30 U.S. military installations were already facing elevated levels of risk from rising sea levels. DoD's operational readiness hinges on continued access to land, air, and sea training and test space. Consequently, the Department must complete a comprehensive assessment of all installations to assess the potential impacts of climate change on its missions and adapt as required." (Department of Defense 2010)

Naval Station Norfolk has 14 World War II-era (and older) piers that experience significant maintenance problems due to the sea level rise that has occurred since they were built. These piers are being replaced at a cost of $35 - $40 million a pier, an indication of the cost of sea level rise adaptation to the military. (Navy Facilities Command, 2001) This activity is also an indication of the impact on critical infrastructure of the high rates of sea level rise in southeastern Virginia.

The economy of the southeastern region of Virginia benefits from tourism, focused mainly on the oceanfront at the City of Virginia Beach. Economic estimates place the direct value of tourism in Virginia Beach at $864 million in 2008, generating 13,600 jobs. (Yochum and Agarwal 2008) Given that with sea level rise, beach recession will accelerate, by some estimates moving the shoreline 1.3 km inland (Wu, et.al. 2009), the related beachfront tourism economic sector is at great risk. This recession threatens billions of dollars of oceanfront investments focused on the tourism economy, a major factor in the MSA global ranking for assets at risk from sea level rise, mentioned above.

Sea level rise is already causing significant flooding problems in older shoreline communities in southeastern Virginia, causing millions of dollars to be spent in adaptation efforts. For example, in 2007, Hampton, Virginia, approved a $3 million sand restoration project to protect against storm surges, a project that was recognized by the technical advisors to provide little to no help in the face of sea level rise. (Lynch 2007)

2. SEA LEVEL RISE AND STORM SURGE INUNDATION

Sea level rise impacts will not occur gradually, like a bathtub filling up. The effects will be felt with each storm surge that runs on top of higher sea levels, pushing water farther and farther inland each time. This effect will be more pronounced in older, established neighborhoods, with businesses built in reference to earlier sea levels, flood zones, and shorelines, and in areas built upon filled wetlands that are now subsiding. The periodic and more frequent inundation of older neighborhoods built upon marsh fill can be observed today in the older cities of southeastern Virginia, such as Norfolk, Portsmouth, Hampton, and Newport News.

It is important to view sea level rise with the addition of storm surge events. The effects of storm surge events on top of sea level rise can be illustrated with Table 1 below. This table is a listing of the highest inundations measured since 1927 at the tide gauge at Sewells Point (Norfolk, VA). Historic storm surge data from the NOAA records was adjusted by the author to current sea level and then measured in reference to

DATE	STORM	Ft Above MHHW
August 23, 1933	Hurricane	6.27 ft
September 18, 2003	Hurricane Isabel	5.12 ft
March 7, 1962	Ash Wednesday Storm	5.05 ft
November 12, 2009	Veterans Day nor'easter	4.99 ft
September 18, 1936	Hurricane	4.92 ft
September 16, 1933	Hurricane	4.36 ft
November 22. 2006	Thanksgiving nor'easter	3.96 ft
October 6, 2006	Columbus Day nor'easter	3.76 ft
January 28, 1998	Twin nor'easters (#1)	3.26 ft
September 16, 1999	Hurricane Floyd	3.21 ft
February 5, 1998	Twin nor'easters (#2)	3.12 ft

Table 1. Storm Surge Measured at Sewells Point (Norfolk) Tide Gauge [1]

Average Number of Years (yrs) Between Inundation Events					
Event Severity		**Sea Level Rise Change (ft)**			
Flood Stage	Gauge Level (ft)	Historical	Present	+2'	+3'
Flood	5.00	1.71 yrs	0.33 Yrs	0.10 yrs	0.08 yrs
Moderate	6.00	7.32 yrs	1.71 yrs	0.33 yrs	0.10 yrs
Major	7.00	26.83 yrs	7.32 yrs	1.71 yrs	0.33 yrs
Record	8.02	80.50 yrs	26.83 yrs	7.32 yrs	1.71 yrs

Table 2. Notional Frequency of Storm Surges with Sea Level Rise[2]

[1] The conversion of surge data in reference to today's MHHW was done by Wetlands Watch.

[2] Chart is based on unpublished data developed by Northrop Grumman Corporation. "Gauge Level" is measured from Mean Low Water. "Historical" occurrence is average of events from 1927 – 2009.

today's mean higher high water (MHHW) level. MHHW is the long-term average high tide line from the spring tides that occur twice a lunar cycle.

The intent of these adjustments is to establish a rough storm surge inundation level reference point starting at today's MHHW line. This reference line assumes that anything above that line is not regularly inundated and thus represents dry land that is normally available for productive use and will be disrupted by storm surges and sea level rise. Given that today's waterfront homes, shoreline businesses and military facilities, and coastal infrastructure will likely remain in their current locations in coming decades, and given that most are above today's MHHW, using this reference point is useful in evaluating impacts upon the current built environment.

This list of major storm surge events includes recent storms that, had they occurred 100 years ago, with sea level some 1.45 feet lower, would not have inundated as much of today's dry land. The two nor'easters in 2006 are an illustration of this: had they come in 1906, they would not be on this list, failing to flood then as far above today's MHHW line as they did in 2006.

Looking into the future, similar storms in 100 years would reach inundation levels approaching the "storms of record" for the region, assuming the minimum, predicted rate of 2.3 feet of centennial sea level rise. For example, in 100 years the 2009 Veterans Day nor'easter, with the minimum projected 2.3 feet of sea level rise, would reach to over 7 feet above today's MHHW, flooding more of today's dry land than the worst recorded modern storm, the 1933 hurricane.

Over time, with sea level rise, storm surge flooding events onto today's dry land will become more frequent. Table 2 uses a notional scenario to determine the statistical frequency of different flood events with different sea levels. Using this table, a 7-foot storm surge (above mean sea level in this case) could be expected every 26.83 years on average over history but with the 1.45 feet of sea level rise at Sewells Point, that storm surge would now occur every 7.32 years, on average. With sea level increases at the minimum being discussed (~+2.3 feet over 100 years), this 7-foot storm surge will occur every 1.71 years, on average. For shoreline residents and businesses, the projected increase in inundation event frequency and magnitude is troubling and adds to the urgency to start sea level rise/storm surge inundation planning and adaptation.

2.1 Implications for adaptation planning and implementation

The addition of storm surge levels to simple sea level rise inundation in tidal areas presents a number of challenges and opportunities for adaptation planning and implementation. On the one hand, it increases the levels of inundation which planning needs to address, from a gradual simple centennial rate of 2.3 feet minimum to a wide range of higher and more frequent storm surge inundation. Adding storm surge inundation on top of sea level rise increases the cost of adaptation measures. Having to address periodic storm surge inundation versus permanent flooding from sea level rise will take different adaptation approaches, further complicating adaptation planning and adding cost.

On the other hand, the inclusion of storm surge inundation in adaptation planning has an ironic beneficial effect by effectively bringing the impacts from inundation closer to the present. As storm surge events are factored into sea level rise estimates the impacts can be better quantified, as in Tables 1 and 2, making the case that adaptation planning needs to start sooner. This heightened awareness of future inundation risks can be a significant factor in helping overcome some of the barriers to early adaptation strategies discussed in Section 3 below.

The inclusion of storm surge variability in adaptation planning also helps prepare the local, state, and federal policy process for the uncertainties inherent in planning for sea level rise. Policymakers cannot simply sit and wait for a single inundation number to be produced by the science and engineering community: including storm surge information illustrates the need for flexibility and the need to use adaptive management in the public policy process.

3. ROLE OF LOCAL GOVERNMENT IN ADAPTATION PLANNING

With the vast majority of Virginia's shoreline in private ownership[3], the aggregation of individual land use and shoreline hardening decisions will play a major part in adapting to increased flooding from sea level rise. (Titus, et.al. 2009) Local governments control land use decisions through zoning ordinances, building codes, and the like, and through placement of public and private infrastructure (roads, schools, hospitals, fire stations, utility services, etc.) Local governments are also responsible for implementing a range of state and federal programs that involve planning, placement of infrastructure, and disposition of federal program funding. Thus, an effective sea level rise adaptation strategy needs to be heavily focused on local governments where these critical decisions are made.

Local land use and infrastructure decisions that ignore or defy climate change realities will complicate and make future adaptation strategies more expensive. They may also expose infrastructure to economic loss and human populations to higher personal risk. Unfortunately, local government shoreline development and infrastructure decisions are made one-by-one, with little regard for cumulative impact in the present and no regard for future consequences from climate change impacts. These decisions can have long lived consequences, as the useful life of buildings, transportation segments, shoreline infrastructure, utilities, and the like persist well into the future. In tidal communities experiencing flooding today, we can observe how similar decisions made over past decades compound today's adaptation challenges.

Many legal and financial disincentives complicate the process of getting individual landowners and local governments to start sea level adaptation work today. Most of these adaptation measures depend on changes to current shoreline land use expectations that limit development and redevelopment options. Local governments are reluctant to place conditions on the development and redevelopment of private shoreline land today, and forego the increased property tax revenues that may come from the higher uses of these shoreline properties, frequently the highest value segment of a locality's property tax base. Similarly, private landowners are resistant to restrict their development and redevelopment options in order to adapt to future sea level rise impacts without fair compensation for the loss of expected return from an unrestricted land use.

The asymmetry of asking localities and individuals to forego present economic gain based upon a potential sea level rise impact coming decades in the future is the main factor hindering adaptation strategy development today. This resistance can even hinder detailed local government planning efforts as these plans begin to identify individual parcels of land that will be at risk from inundation, diminishing their market value. Finding ways to overcome the conflict between current economic incentives and long-range sea level rise adaptation needs is a major challenge to be overcome if we are to start adaptation planning and implementation today.

[3] Many federal and Virginia state documents state that 85% of the shoreline of the Chesapeake Bay is privately owned, although no peer-reviewed documentation for that claim can be found. Private ownership percentage of ocean shoreline in Virginia has not been estimated.

3.1 Focus of Local Government Adaptation Strategy for Sea Level Rise/Storm Surge Protection

Sea level rise adaptation at the local level will have different goals in rural areas than in built-out areas. In rural/undeveloped areas, local government policies should be directed at keeping new development, significant redevelopment, and public facilities and infrastructure out of tidally influenced areas that will be at increasing risk from sea level rise. For built-out areas, with significant infrastructure already placed along

the shoreline, policies might involve strategic redirection of redevelopment away from low-lying neighborhoods, elevation and armoring of existing critical infrastructure and neighborhoods, and identification of high-risk neighborhoods for which cessation of public services and disinvestment may become a reality.

In concept, a local government strategy on adaptation to sea level rise and storm surges would first involve collecting data on current inundation and then involve modeling future relative sea level rise impacts (including areas of local subsidence where the impacts of sea level rise will be felt more severely). This work should result in identification of zones of high inundation risk where future damage from storm surges can be expected to increase.

Adaptation plans can then be developed to cope with some of the early risks and, if the risks will become more severe over time, financial incentives, carefully planned infrastructure investment, and even regulatory programs can be focused on the high risk zones to minimize exposure of population and infrastructure to higher inundation risks. In very high risk zones, the creation of special districts with restrictive tax, investment, and zoning ordinances may be needed to begin the orderly disinvestment of those zones over time.

3.2 Elements of Local Government Adaptation Strategy for Sea Level Rise/Storm Surge Protection

The first requirement for local government involvement in adaptation to sea level rise is public support and awareness. The next steps require localities to acquire the technical tools, the financial tools, and the legal tools to begin climate change adaptation planning and implementation.

Public and political awareness and support for addressing climate change impacts can be generated through outreach, education, and social marketing. In southeastern Virginia this work has been made easier following a strong nor'easter that caused extensive flooding during November 12 and 13, 2009, with a peak storm surge nearly 5 feet above MHHW. With this nor'easter, there have been public calls for a response to what is seen as a pattern of more severe storm surges.

Second, the technical resources need to be sufficient to focus and prioritize local government efforts. These resources include elements like high-resolution digital maps, geographic information system (GIS) data that can place critical infrastructure on those maps; modeling and visualization of zones of increasing risk with sea level rise and storm surges; population and census data overlays to identify high risk portions populations; downscaled climate change impacts; and so on. This information can be fed into a number of local government processes outlined at Section 4.1 below.

Third, there must be sufficient financial resources available to meet the adaptation needs identified. Resources will be needed to armor, elevate, and relocate existing infrastructure and property. Direct funding

and tax credits will be required to purchase property and secure development rights and easements on private property in inundation zones for which compensation will be required. Based on some early projects to protect the shoreline (Lynch 2007) adaptation in built-out areas can be expected to be a very expensive undertaking.

Finally, localities (along with regional, state, and federal government partners) must have programs available to conduct adaptation planning and must have regulatory authority to place conditions on land use options in order to avoid a continuation of "business as usual." Local government authorities are critical but must involve federal and state government guidance and assistance, without which local governments are left on their own to struggle with the impacts from sea level rise and to implement adaptation strategies in isolation, if at all. (Wetlands Watch Testimony 2009, GAO 2009)

The Virginia Climate Change Commission report proposes a set of actions needed to start on an adaptation effort in Virginia. It also outlines a framework for a coordinated state strategy on climate change adaptation that would support local efforts. (Wetlands Watch Summary 2009)

4. LOCAL GOVERNMENT ADAPTATION PROGRAM "TOOLKIT"

The last element of an adaptation strategy, adequate local government legal and program authorities, is a challenge in Virginia. Virginia localities operate under the "Dillon Rule" and are only able to exercise specific authority granted to them by the state legislature, a provision in the Virginia Constitution at Article VII, Section 2. This limits the ability of localities in Virginia to address sea level rise without specific authority granted by the Virginia General Assembly. As a result, even if a local government in Virginia has secured the public and political will to develop an adaptation strategy for sea level rise and storm surges, and possesses the technical and financial resources, a major remaining hurdle is identifying government and private programs to accomplish this adaptation work.

These programs do exist and examples of adaptation planning are starting to emerge in Virginia. In three years of work with local governments in Virginia, Wetlands Watch has identified a set of legal authorities, programs, and government directives that may be available today for use by Virginia's local governments to formulate adaptation strategies. This work has also resulted in a list of potential programs that, with new interpretations or some regulatory adjustments, can be used by local governments in adaptation strategies.

This draft set of programs was assembled into a "toolkit" and presented to a group of coastal planners at the May 4, 2010, meeting of the Virginia Chapter of the American Planning Association. Still being refined, the "toolkit" started with an organizational approach that grouped adaptation program needs for local government into three basic functional categories:

- Programs that can create awareness of and prepare for climate change impacts (Planning);
- Programs that help provide financial incentives to change behavior and programs that build public facilities so as to put fewer people, buildings, and natural resources at risk from climate change (Incentives and Direct Investment/Public Infrastructure); and,
- Programs that prevent or redirect certain land use decisions so as to decrease the risk from climate change impacts (Regulatory).

These program initiatives were then placed along a political gradient from lowest political difficulty (planning), to intermediate difficulty (incentives, direct investment), to highest difficulty (regulation). In

Virginia today, many localities mention climate change and sea level rise impacts in their planning documents. No Virginia locality has undertaken investment/infrastructure or regulatory measures (land use restrictions, etc.) to address adaptation needs. As mentioned earlier, the asymmetric nature of this issue creates political and financial disincentives for action that are strong and difficult to overcome.

4.1 Adaptation Program Toolkit Categories

4.1.1 Planning

Local government planning programs, especially longer range planning programs (> 20 years planning horizon) are useful tools for raising public awareness of sea level rise impacts and for beginning to direct public and private activities away from areas of increasing inundation risk. These government programs encourage rational, comprehensive, long range planning to help inform future government and private sector decisions, and are processes that should include climate change impacts. In fact, some of this long-range planning work in the tidal regions of Virginia already includes sea level rise in planning documents, such as state and regional transportation plans, regional economic development plans, regional hazard mitigation and floodplain management plans, and local government comprehensive land use plans. This recent activity demonstrates growing local and regional government awareness of and acceptance of the growing threat that sea level rise and storm surge inundation poses.

4.1.2 Incentives/Disincentives

Federal, state, and local government and private sector programs provide incentives to encourage certain behavior (or disincentives to discourage other behavior) that can include sea level rise adaptation measures. Examples of public incentive programs include tax credits for donation of development rights on land (which can include land threatened with inundation), state and local tax incentives for private investments made in a certain way or in certain locations (outside of high risk inundation zones), and so on.

In addition to encouraging desired behavior through incentives, governments and private sector efforts can focus on disincentives for increasingly risky investments along the shoreline. Disincentives include federal flood insurance that increasingly includes sea level rise risk in pricing and availability decisions and local government special taxing districts that cover the real, life cycle costs of servicing high-risk zones (higher taxes in high risk inundation zones). Private sector incentive/disincentive programs include higher private sector insurance rates and limited availability in high risk zones[4] and financing decisions that include increasing risk of inundation, such as the inundation probabilities outlined in Table 2.

4.1.3 Direct Investment and Public Infrastructure

Government programs that directly fund public buildings, bridges, roads, and other public structures should keep that infrastructure "out of harm's way," away from coming sea level rise impacts. Once the planning

[4] Press reports and interviews with private insurers by the author show a withdrawal of at least 50 percent of the private insurance market from writing new policies for wind insurance on primary residences and businesses along Virginia's Chesapeake Bay and Atlantic Ocean shorelines. Wind insurance for second residences is being withdrawn by an even larger percentage of private insurers. Hurricane damage claim deductibles have recently increased on existing policies in Virginia. See for example Fleischman 2006.

process identifies high risk inundation zones, public infrastructure should be directed away from those zones. Hospitals, evacuation refuge sites, fire and emergency rescue facilities, key transportation routes and facilities, and other infrastructure needs to be outside of projected inundation zones. This demands that as direct investment in public infrastructure is made, using state school construction funds, state capital transportation project funding, federal housing and economic development programs, and local capital improvement budgets, inundation risks must be taken into account.

4.1.4 Land Use and Regulatory

Many proposed uses of coastal land require affirmative government action or regulatory permits and certification before the land use changes can be undertaken. As zones of inundation are identified, government regulatory and land use programs affecting activities within those zones should account for sea level rise impacts. Many of these regulatory programs involve natural resource protection and stewardship, although some involve financial regulation. Examples of natural resources regulatory programs include state and local storm water control programs under the Clean Water Act, federal, and state and local wetlands permitting requirements under the Clean Water Act and Rivers and Harbors Act, land use and zoning approval under local government land use authorities, floodplain management requirements, and the like. An example of a financial regulatory program would be state regulation of the property loss insurance sector in ways that reflect higher risk from sea level rise or placing conditions on economic development funding requiring completion of a long-range vision and plan that addresses sea level rise and inundation risk.

4.2 Examples of Local Government Adaptation Tools in Virginia

4.2.1 Existing Planning Authorities in Virginia That Mention Climate Change

Every Virginia locality must by law develop long range land use plans and review those plans every five years (Code of Virginia [Va. Code] § 15.2-2223). These plans usually have a 20-year planning horizon and are the logical place to start long range climate change adaptation planning. In areas of the state with tidal waters, localities are also required to include water quality protection measures, including shoreline setbacks, in their long range planning and zoning (Va. Code § 10.1-2100). Some tidal area Virginia localities are already including climate change discussions in these plans (Accomack 2008, City of Virginia Beach 2009).

To be eligible for programs under the Federal Emergency Management Agency (FEMA), a community must undertake hazard mitigation planning (Title 44 Code of Federal Regulations [C.F.R.], Chapter 1, Part 201.3). The community must also have a floodplain management program and appropriate building ordinances in high-risk flood zones in order to qualify for the National Flood Insurance Program. The Virginia Department of Conservation and Recreation is the lead agency on floodplain management planning (Va. Code § 10.1-602). Federal regulations allow localities to exceed the stringency of minimum federal standards, allowing for location-specific sea level rise adaptation strategies.

These FEMA-required programs are natural places to start planning for sea level rise impacts. Some hazard mitigation plans in Virginia include sea level rise discussions (City of Poquoson 2008). Other localities are including sea level rise in their floodplain management plans (Gloucester 2008).

The US Department of Transportation requires states (23 CFR § 450.206) and regions (23 CFR § 450.306) to complete long range transportation plans prior to receiving federal transportation funding. In shoreline communities, inundation of transportation segments with sea level rise/storm surges is a long-range risk that should be included in these plans. The current Virginia long-range transportation plan has a section

discussing climate change impacts, although there are no recommendations for acting on those projected impacts. (Virginia Department of Transportation 2010)

The US Department of Commerce requires a regional Comprehensive Economic Development Strategy (CEDS) prior to being eligible for many Commerce funding programs (Title 42 United States Code [U.S.C.] § 3162). These regional plans are another opportunity for climate change planning to take place. The Hampton Roads, Virginia CEDS mentions climate change as part of the economic challenge facing the region. (Hampton Roads Partnership 2010)

The Coastal Zone Management Act (CZMA) authorizes Virginia's Coastal Zone program and requires that it prepare a management program for its coastal zone (16 U.S.C. § 1455.) This program must include a number of assessments of the natural resources in that zone. In addition, a Coastal Nonpoint Pollution Control Program must also be developed (16 U.S.C. § 1455b.) Grants are provided to eligible coastal states in response. This state planning and reporting process provides opportunities for climate change adaptation planning.

The CZMA language specifically mentions sea level rise as an element of concern at Title 16 U.S.C. § 1451, "(l) Because global warming may result in a substantial sea level rise with serious adverse effects in the coastal zone, coastal states must anticipate and plan for such an occurrence." In response, the Virginia CZM program currently funds three regional planning districts to undertake climate planning, one of which is in the high risk inundation zone in southeastern Virginia.

The US Fish and Wildlife Service requires each state and territory to prepare a Wildlife Action Plan in order to receive funding under the Wildlife Conservation and Restoration Program and the State Wildlife Grants Program (16 U.S.C. § 669e). The Wildlife Action Plans present a strategy for meeting critical wildlife conservation needs in a state. The plans are periodically updated, providing an ongoing opportunity for involvement. There is voluntary guidance for states to include climate change in their plans and Virginia's Wildlife Action Plan update underway currently includes climate change impacts.

Virginia requires localities to submit water supply plans (Va. Code § 62.1-44.38:1). Given the potential threats to water supplies from climate change impacts, these plans can be used in adaptation planning. Virginia's Water Supply Planning Program is looking at climate change impacts, working jointly with the US Geologic Survey (Personal Communication with Author).

4.2.2 Planning Authorities in Virginia That Could Include Climate Change

The Clean Water Act requires municipalities to have a storm water management plan (42 CFR § 122.26). Given projections of increased sea level rise and increased storm intensity, this planning process should be a place where local governments start sea level rise adaptation planning. The Municipal Separate Storm Sewer System Management Program (MS4) requires regional or watershed plans developed with public input (33 U.S.C. 1251 §402) (4 Virginia Administrative Code [V.A.C.] 50-60-90) and provides an opportunity for including climate change impacts.

The Department of Defense is authorized to make community planning assistance grants to undertake Joint Land Use Studies where use conflicts emerge between a military facility and the surrounding community (10 U.S.C. § 2391). These grants have been primarily use to study use conflicts between military aircraft operations and incompatible land use surrounding a facility that compromise operations, usually buildings in potential accident and high aircraft noise zones. However, with sea level rise and inundation, the surrounding

community's response (or lack of response) will affect military base operations and could be eligible for inclusion in this planning program. The US Navy is looking at these planning funds as applicable to sea level rise/inundation planning (Personal Communication with Author).

The US Department of Housing and Urban Development requires a consolidated plan prior to a locality receiving HUD housing funding (24 CFR Part 91). This planning process is another tool for sea level rise adaptation planning, especially when using federal funds to place housing along tidal shorelines.

The US Forest Service requires long range plans for National Forests (16 U.S.C. § 1604) and Virginia has the George Washington and Jefferson National Forest system within its boundaries. The National Forest plans are updated on a 10 – 15 year cycle and provide an opportunity to address climate change impacts. The George Washington-Jefferson National Forest plan revision is currently underway in Virginia and a background document in the revision mentions climate change as a management issue there.

Local governments in Virginia are authorized at Code of Virginia § 15.2-2230.1 to study the cost of public facilities (roads, sewer, water, etc.) needed to implement a comprehensive plan. This authority would allow life cycle cost planning at the local level. If the lifecycle cost or total ownership cost of land use decisions along the shoreline were included, it changes the calculations for local governments in the face of sea level rise and higher storm surges. This long-term evaluation of infrastructure costs could be another way to overcome resistance to early adaptation planning outlined in Section 3, since future costs of repairing roads, sewer and storm water lines, and other utilities in the face of sea level rise would become apparent.

4.2.3 Financial Incentives That Could Include Climate Change

Shoreline lands need to be kept open wherever possible in a sea level rise adaptation strategy. Virginia offers generous tax treatment for Land Preservation Tax Credits generated under these programs at 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 § 170[h]) up to $600,000. In addition, the Code of Virginia at § 58.1-3666 allows local governments to exempt from taxation wetlands and shoreline buffers under permanent easements allowing inundation. Buffers must be at least 35 feet wide.

Keeping development and redevelopment out of areas at high risk of inundation is essential. Transfer of development rights is a process whereby the rights to develop a parcel (in an area where a locality wants to discourage development and redevelopment) are transferred to another parcel (where this development is preferred). This tool is used to preserve open space or protect natural resources and could be a way of keeping development out of inundation zones while allowing property owners to recoup some of their investment. Virginia allows localities to authorize the transfer of development rights at Code of Virginia § 15.2-2316.2.

Owners of developed land in areas of high risk of inundation have vested rights in the current land use, a land use that may be increasingly at risk with sea level rise. Amortizing those vested rights over time – in a phase out period – allows the landowner to recoup investment but moves those nonconforming land uses out of high risk inundation zones over time. Courts have recognized a reasonable amortization period as preventing a "takings" claim wherein the property owner seeks full compensation for the loss of the higher use of their land. Vested rights are discussed at Code of Virginia § 15.2-2307.

The National Flood Insurance Program (NFIP) is a significant economic force in shoreline areas at risk from inundation, with flood insurance required in high flood risk zones. Eligibility for the NFIP is already conditioned on a locality undertaking a number of adaptation measures for existing flooding risks. If property focused on sea level rise inundation, this program could create additional incentives directed at adaptation to sea level rise risk. A federal study is underway to determine the impacts of climate change on the NFIP.

Virginia, like all states, regulates the private insurance industry. Insurance cost and availability sends a strong market signal to areas with high risk of inundation and as insurance companies set rates and determine availability, these decisions will affect adaptation responses. With more expensive insurance and limited availability, property and business owners in high risk zones will seek other, safer areas to live and operate businesses. At present, private sector providers of wind insurance have begun to limit coverage in costal areas in Virginia or have withdrawn completely from some areas. (Fleishman 2006) If these actions continue, they will begin to shape investment patterns along the tidal shoreline in Virginia.

In areas of high risk from inundation, public services to maintain current land uses and landowner expectations will become more expensive. Those expenses can be offset in a special taxing district wherein residents in high risk zones are assessed a higher tax to pay for those services, sending a clear financial signal as well into those areas. Virginia Code at § 15.2-2400 allows the creation of local government special districts to accomplish certain necessary tasks and could be used in high-risk inundation zones to create disincentives for land uses at odds with higher risk from sea level rise.

4.2.4 Direct Investment and Infrastructure Decisions That Could Include Climate Change

Each Virginia locality is authorized at Virginia Code §15.2-2239 to prepare a capital improvement plan (CIP) to plan needed capital investments. The preparation of the CIP usually occurs with comprehensive land use planning updates and offers a chance for climate change impacts to be made part of local government infrastructure investment decisions. Placement of roads, schools, fire houses, police stations, and other public facilities are governed by the CIP, and all these facilities need to account for sea level rise in coastal communities.

At the federal level, projects built under the authority of the US Army Corps of Engineers Civil Works program, are required to take sea level rise into account. (US Army Corps of Engineers 2009) This regulatory guidance begins to outline the steps needed for all infrastructure investments along the coastline. The author is unaware of any Civil Works project that has explicitly taken sea level rise into account although given the long lead time on these projects, some Civil Works projects currently being developed may be undergoing this review.

4.2.5 Regulatory Authorities in Virginia that Could Include Climate Change

As explained below, programs exist at the local, state, and federal level to regulate development activities along the tidal shoreline in Virginia, areas that are increasingly at risk from sea level rise inundation. Some of these authorities reside with local government zoning and building ordinances. Other authorities place restrictions on development along these shorelines in order to protect the natural ecosystem. These authorities can be used to keep the shoreline open and resilient and better able to adapt to sea level rise. They can also be used to keep infrastructure and housing out of shoreline areas that will be at increasing risk from sea level rise.

The strongest potential climate change adaptation regulatory tools are local zoning and building code authorities since these govern the use of land and the placement of infrastructure along the shoreline and also set minimum building safety and performance standards. Counties in Virginia are given broad powers to protect the public health and welfare at Va. Code § 15.2-1200 and given specific zoning authority at Virginia Code § 15.2-2280. These local government zoning authorities have great potential for controlling development and redevelopment in high risk inundation zones. To date, however, there is no evidence of a locality using this authority specifically to address sea level rise.

Localities have zoning and building code authorities granted to them by state and federal statutes as well that can be used in sea level rise adaptation strategies. The Chesapeake Bay Preservation Act (Va. Code §10.1-2100/9VAC10-20), provides local governments with tidal shorelines a number of land use authorities including "overlay districts" along the shoreline within which development and redevelopment is restricted to protect water quality. The Federal Emergency Management Administration authorizes local government floodplain zoning and building code requirements (42 U.S.C. § 4001/ 44 CFR § 60.1) as a mandatory requirement prior to any locality receiving federal flood insurance. This authority is overseen in Virginia by the Department of Conservation and Recreation's floodplain management program (Va. Code § 10.1-602).

Virginia, like most coastal states, has regulatory programs to protect its coastal and tidal estuarine ecosystem. Much river and tidal estuarine bottomland is state owned and disturbance requires a permit from the Virginia Marine Resources Commission. Development and redevelopment impacting mudflats, nonvegetated wetlands, and vegetated intertidal wetlands require a permit from federal regulators and state regulatory bodies. State authority for wetlands protection is found at (9 VAC 25-210 /Va. Code §§ 62.1-44.15 and 62.1-44.15:20). For tidal wetlands, the primary state authority is given to the Virginia Marine Resources Commission at Code of Virginia § 28.2-1300, which has delegated that authority to most of the local governments in tidal areas of Virginia. The federal government also regulates wetlands through the Clean Water Act (33 U.S.C. § 1344) and the Rivers and Harbors Act (33 U.S.C § 403). The coordination of state and federal wetlands regulatory programs occurs during a joint permit application process.

Virginia has not moved to include sea level rise into its state regulatory programs, despite clear historical evidence that significant rates of sea level rise exist in the state and that those rates can affect the quality and quantity of coastal and tidal estuarine natural resources. The Virginia Department of Environmental Quality (DEQ) rejected a recent challenge to a wetlands permit made by Wetlands Watch, that objected to sea level rise not being taken into account. The DEQ stated, "The DEQ VWPP (Virginia Water Protection Permit) Program does not have the regulatory authority to speculate on how sea level rise may effect the distribution and type of wetlands present in the project watershed." (Virginia Department of Environmental Quality 2008)

Wetlands Watch is challenging a federal wetlands permit application with the US Army Corps of Engineers Norfolk District based on the applicant not including sea level rise impacts in the permit application. (Wetlands Watch 2010) No decision has been made at this time.

Disturbance of primary coastal dunes requires a permit to insure that development does not encroach upon these dunes (Va. Code § 28.2-1408/4VAC20-440-10.). Development is allowed only within a zone 20 times the average shoreline recession rate over the last 100 years, a rate that does not accommodate future projections for accelerated rates of sea level rise, which can be expected to increase rates of shoreline recession (Wu, et. al. 2009).

In addition to the zoning authorities mentioned previously, the Chesapeake Bay Preservation Act (CBPA) (Va. Code §10.1-2100/9VAC10-20), which is administered by local governments, requires regulatory approval for development and redevelopment activities in buffer zones along the shoreline. These buffers are the land behind the wetlands in tidal areas, generally set as the land shoreward at least 100 feet from the high tide line. The CBPA could be a very effective tool for regulating development in zones of future inundation along the shoreline, however, to date no locality has included current or projected sea level rise into its regulatory deliberations.

Erosion and sediment control programs (Va. Code §10.1-560/4VAC30-50) and municipal stormwater control programs (Va. Code § 10.1-603.3) regulate development and developed areas along the shoreline and are designed to control shoreline runoff pollution. To the extent that these authorities affect shoreline development, they have the potential to be used in sea level rise adaptation. They will also need to accommodate other predicted climate change endpoints beyond sea level rise, such as increased storm intensity, since those impacts can limit the efficacy of storm water and erosion control practices.

The Virginia Department of Historic Resources (DHR) has a role to play in climate change adaptation, since their approval must be granted before any disturbance/development can happen near an historic site (Va. Code § 10.1-2200/17VAC10). With sea level rise threatening many shoreline historic sites in Virginia, these DHR decisions have a role to play in sea level rise adaptation strategies.

5. NEXT STEP: IMPROVING ADAPTATION AUTHORITIES

All of the programs listed in Section 4 above have shortcomings in their statutory and regulatory authorities because they have a "retrospective" focus, using historic data in making current program decisions. Few of these programs have included historic rates of sea level rise in their operations, the exception being the Federal Emergency Management Administration (FEMA) which recently updated mean sea level in its flood hazard map modernization effort. (In southeastern Virginia, the FEMA map modernization updated mean sea level from 1923, adding nearly one foot to the base flood zones in the maps.) One other exception, as mentioned above, is the US Army Corps of Engineers (USACE) issuance of guidance on including historic rates of sea level rise in its civil works construction projects, although the author could not find examples of this guidance being applied. (US Army Corps of Engineers 2009)

The inclusion of climate change and sea level rise impacts in some local government planning documents in Virginia is an indication of the seriousness of the sea level rise problem and the willingness of some local governments to address it. To become useful in developing sea level rise adaptation strategies, government authorities and regulations will need to switch from a "retrospective" focus to one that explicitly includes both historic and projected rates of sea level rise in program decisions. In Virginia, moving beyond planning to develop incentives and make regulatory decisions that include future sea level rise will be difficult for local governments. Progress beyond planning will require specific mandates from federal agencies, for federal programs implemented at the regional or local level, and legislative authority from the Virginia General Assembly for those state and local programs necessary for the implementation of a sea level rise adaptation strategy.

CONCLUSIONS

Significant rates of sea level rise are occurring in Virginia and indicate the need for the development of sea level rise adaptation strategies in coastal regions. Local governments are critical to the development and implementation of these strategies, given their role in implementing federal programs and in regulating land

use. Many regional and local governmental entities in Virginia have included discussions of climate change and sea level rise impacts in their planning documents, indicating growing awareness of the problem. The next steps, focusing incentive and investment programs on the problem and developing a regulatory component to sea level rise adaptation strategies, will be more difficult politically, although the outlines of a local government "toolkit" for developing these strategies is emerging.

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