Report to the Chairman of the House Committee on Agriculture, Chesapeake and Natural Resource Pursuant to House Bill 1094 (2018)

Submitted by:
Virginia Institute of Marine Science
and
Virginia Tech

Submitted to:
Delegate Daniel W. Marshall III
Chair, Agriculture Chesapeake and Natural Resources Committee

November 1, 2018

Contributing Authors: Mark W. Luckenbach[1], Pamela Mason[2], Lyle Varnell[1], Carlton Hershner[2], Emily Hein[1], and David Sample[3]

[1] Office of Research & Advisory Services, Virginia Institute of Marine Science, Gloucester Point, VA 23062

[2] Center for Coastal Resource Management, Virginia Institute of Marine Science, Gloucester Point, VA 23062

[3]Department of Biological Systems Engineering, Virginia Tech, Blacksburg, VA 24061

Introduction

House Bill 1094 (HB1094), introduced by Delegate Keith Hodges in the 2018 session of the Virginia General Assembly, sought to grant local governments the authority to issue a landowner a permit to place fill within the Chesapeake Bay Preservation Area (commonly referred to as the Resource Protection Area [RPA]) for the purpose of increasing elevation to reduce flooding. The bill stipulated that the State Water Control Board should adopt regulations granting this authority that required protection of existing wetlands. The bill was met with opposition and was withdrawn by the patron. A letter was sent by the Chairman of the House Agriculture, Chesapeake & Natural Resources Committee, Delegate Danny Marshall, to the Dean and Director of the Virginia Institute of Marine Science (VIMS), Dr. John T. Wells, requesting that VIMS, with the assistance of Virginia Tech, make recommendations on how to accomplish the objectives set forth in HB1094. In that letter, Chairman Marshall indicated that the patron's intent was that adding sediment and native plants to the RPA would reduce flooding risk and improve water quality. HB1094 and the Chairman's letter are included as Appendices I & II, respectively.

Guided by the principles that any addition of sediment within the RPA to increase base elevations and decrease flooding risk must be protective of wetlands and, at minimum, not have a negative impact on water quality, we examined several options for accomplishing the objectives set forth in HB1094. In doing so, we (1) identified factors, many of them site specific, that would affect the success of such action, (2) assessed the potential impacts to wetlands and water quality, and (3) reviewed the state and federal shoreline management provisions that would bear on such actions.

Background

The Chesapeake Bay Preservation Act (CBPA) was designed to improve Bay water quality through effective land management and land use zoning; it did not expressly anticipate sea-level rise or coastal flooding as factors in achieving its objective. In establishing the RPA and its associated buffer, available science related to natural nutrient treatment and nutrient dynamics specific to riparian hydrological, physical, geological, chemical, and biological factors were taken into account. Though there is no single one size fits all width for an effective buffer, numerous studies have reported the effectiveness of various buffer widths (*e.g.* Table 1).

Table 1. Summary of reported effective buffer widths for specific functions.

Buffer Function	Effective Buffer Widths (feet)	Studies cited (Reference number in literature cited section)
Sediment Control	30 – 325	1, 2, 3, 4
Nutrient Retention	16 – 164	1, 2, 3, 4
Bank Stabilization	30 – 98	2, 3
Pesticide Retention	48 – 328	1, 2

Data compiled by Hawes and Smith 2005[5].

Ultimately, the 100-foot buffer within the RPA emerged from the collaborative efforts of lawmakers, technical experts, and stakeholders incorporating social, economic, and scientific information. The resulting program provided the Commonwealth of Virginia a regulatory mechanism protective of estuarine water quality and adjacent tidal habitats. The CBPA is currently mentioned more than 20 places in the Code of Virginia and 40 places in the Administrative Code. It is linked to other water quality provisions and many other environmental management programs that have been established over years to protect and maintain ecological services of Virginia's tidal waters and shores, including the protection of natural lands that provide those services.

Alterations to the RPA as intended by HB1094 run counter to the original intent of the CBPA. However, sea-level rise and its compounding effects were not explicitly identified as factors of concern in the CBPA. HB1094 provides an opportunity to analyze and possibly incorporate aspects of sea-level rise into RPA management. Although initial analyses of many RPA filling scenarios infer only detrimental effects to RPA environmental functions, wetlands, and water quality, the RPA cannot be ignored when developing strategies to protect upland infrastructure from the effects of sea-level rise. It is necessary and timely to review how the placement of fill within the RPA might interact with Chesapeake Bay restoration goals.

Sea-level rise also needs to be considered in the Commonwealth's effort to protect and conserve vegetated tidal wetlands. Persistence of marshes in the face of sea-level rise is dependent upon their ability to grow vertically in place or migrate landward. Numerous recent analyses make it clear that widespread loss of tidal vegetated wetlands can be avoided only if sufficient accommodation space (i.e., space to migrate landward) is provided[6-9].

Vegetated tidal wetlands exist from the mean tide level to an elevation of about 1.5 times the tide range and consist of zones of low and high marsh. As an example, a shoreline exposed to a 2-foot mean tide range could support Saltmarsh cordgrass (*Spartina alterniflora*) from the mean tide level to approximately mean high water, and upper marsh vegetation communities (Saltmeadow hay, *Spartina patens*, and other species including saltbushes) up to 3-feet vertical elevation above mean low water. The landward extent of this fringe is dependent upon shoreline slope and if this slope is steepened by the addition of sediment, the marsh will narrow as it attempts to migrate landward as sea level rises. Tidewater Virginia is projected to experience approximately 1.5 feet in sea-level increase, without storm surge, by the year 2050[10]. In evaluating how the objectives of HB1094 might be achieved without negatively affecting wetlands, we must therefore consider how any placement of fill in the RPA would affect the ability of existing wetlands to migrate landward.

In contemplating scenarios under which the addition of fill within the RPA to provide flood protection might occur, it quickly becomes apparent that there is a nearly endless suite of complexities associated with the details of any specific project. As just a few of the questions related to placing fill within the RPA listed in Box 1 illustrate, determining the impacts to wetlands, water quality and other ecological services provided by the RPA, as well as unintended consequences associated with runoff, will depend on numerous site- and project-specific details. The water quality benefits provided by vegetated buffers are largely based on the hydrology, soil type and vegetation. Any action that alters one or more of those features may have consequences for water quality and quantity, both via surface runoff and groundwater inputs, and to the current or future persistence of established functions of natural wetland and riparian vegetation. Given the level of project- and site-specific complexities, all that we are able to do in this report is consider some generalized approaches towards utilizing fill in the RPA for the purposes intended by HB1094.

Box 1. *Examples of project specific questions affecting the outcome of placing fill in the RPA*

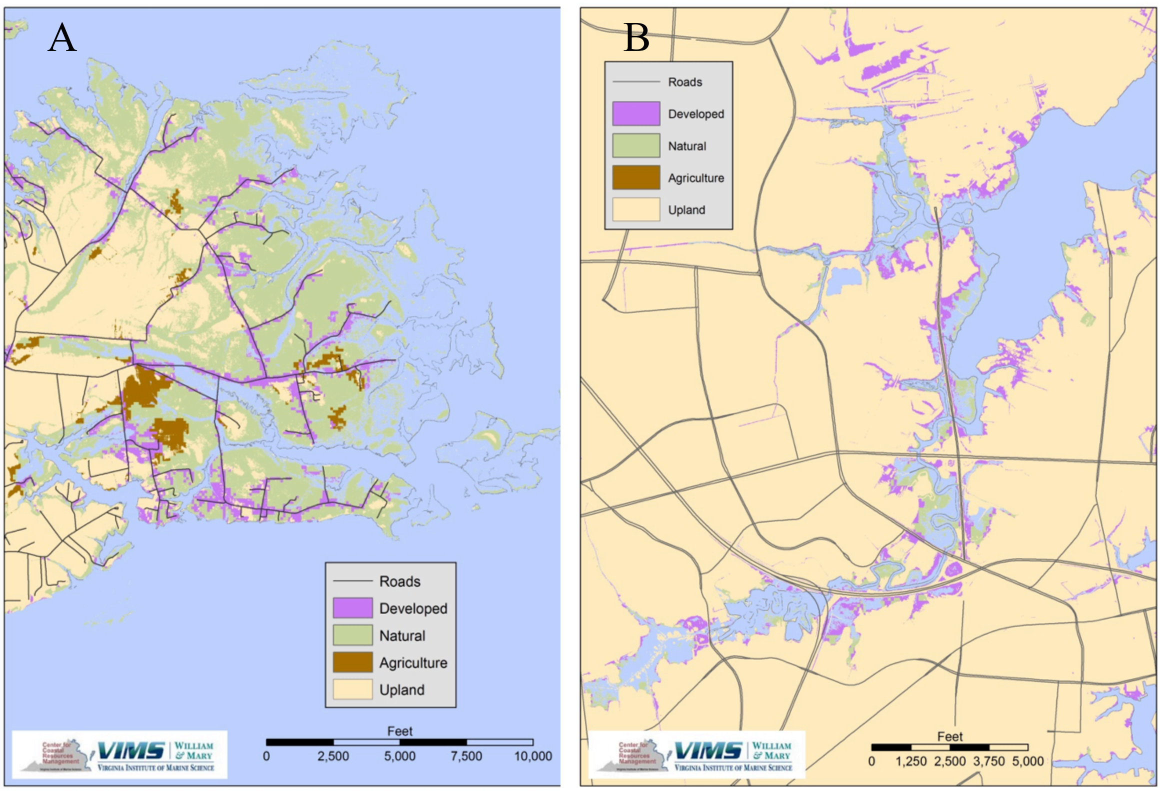
- What proportion of the RPA is necessary to fill?
- Will the fill be on a single lot, or used along a reach of shoreline?
- How will sedimentation of channel-ward resources be addressed?
- Will the lateral edges of the fill need to be artificially contained?
- What additional height is necessary to provided the desired protection?
- Will the fill protect existing structures or will construction occur upon the fill?
- How will the fill affect the vegetated community in the RPA?
- Can the vegetated community be duplicated upon the fill, and will it have the opportunity to perform the same functions?
- How will the project affect surface water flow and hydrogeochemistry?
- How will fill affect groundwater flow?
- How will fill affect erosion and sedimentation?
- How will fill change the soil biogeochemistry?
- Could fill affect surface water residence time and alter treatment of runoff positively or negatively?
- How best could RPA modification, if any, integrate with other environmental concerns and strategies related to sea-level rise and storm surge?
- What are environmentally benign or beneficial alternatives to flood abatement for riparian holdings?
- Using this proposed method, are there ways to implement this that can be done in an environmentally sensitive manner?

Impact to wetlands

HB1094 is explicit that any addition of fill to the RPA to provide flood protection should not negatively impact existing wetlands, and thus would exclude direct filling of wetlands or the alteration of hydrology that might affect vegetated wetlands. We make the assumption here that it is important to consider the effects produced by adding fill on the ability of wetlands to persist in the face of sea-level rise. The ability of tidal marshes to persist in the face of sea-level rise is a function of the rate of relative sea-level rise, tidal regime, sediment supply, marsh accretion rates, and their ability to migrate landward[11,12]. Under conditions in which sediment supply and marsh accretion rate balance the rate of sea-level rise, marshes can keep pace by growing vertically in place[11,12]. The combination of human-induced changes in sediment supply in conjunction with accelerating rates of relative sea-level rise places a premium on facilitating the landward migration of wetlands at some locations. As noted above, increasing the slope of the RPA would constrain the width of vegetated marshes as they migrate landward. Guidelines for the construction of tidal wetlands in Chesapeake Bay generally recommend a slope that does not exceed 10% (10:1 run:rise)[13,14] to achieve a minimum width of 30 feet (with a 2-ft. tidal range). Increasing the slope within the RPA to greater than 10% or producing a berm that exceeds this slope would constrain landward migrating marshes to less than this desired minimum width and would, at sites with existing healthy marshes, not meet the intent of HB1094. It is also worth noting here that many shorelines in Tidewater Virginia will not migrate upland in the near-term either because they are able to grow vertically in place for the reasons cited above, or because hardened shorelines or existing scarps prevent such migration.

We present two analyses below that show the potential loss of wetlands due to sea-level rise by 2050 should they not be able to migrate landward due to fill placement in the RPA (Fig. 1).

Figure 1. Developed, natural, and agricultural lands within the RPA in portions of (A) Gloucester County and (B) the City of Hampton. It is presumed that developed and agricultural land would be potential areas for fill under HB1094.



In these analyses, areas that lie within the RPA (*i.e*., tidal wetlands + the 100-ft. buffer) were characterized as *developed, agriculture,* or *natural* (lacking any development). Assuming that no motivation exists for placement of fill in natural areas, the agricultural and developed lands within the RPA represent areas that could receive fill under HB1094. Those areas that could experience lost wetlands by 2050 in eastern Gloucester county as a result of fill restricting wetland migration are shown in Figure 1a. Despite the potentially large areas within this part of the Gloucester County that could be subject to fill under the provisions of HB1094, natural lands represent a large portion of the mapped area and wetlands would be expected to persist in these areas. In contrast, the mapped area in the City of Hampton (Fig. 1b) does not have any agricultural lands and little natural lands. Here developed lands dominate the landscape and many of the extensive and fringing marshes could be lost by 2050 as a result of filling the RPA buffer in a manner that prevents their landward migration.

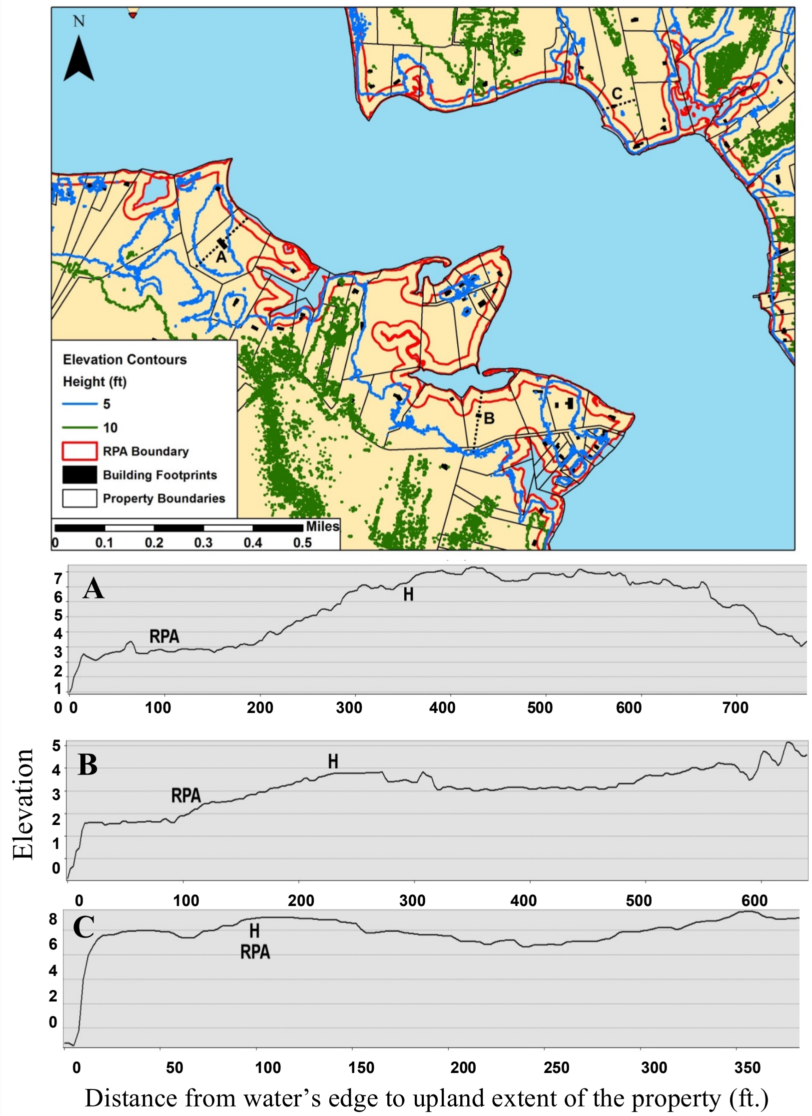
Further analyses of potential loss of wetlands in other Tidewater localities that could occur by 2050 as a result of placing fill that restricts wetland migration are provided in Appendix III. The analyses presented in Figure 1 and Appendix III are intended only to provide some context for considering how restricting landward migration of wetlands could affect their persistence over the next three decades in different localities. We do not intend to imply that if the provisions in HB1094 were enacted that fill would occur in all of these areas or that marshes in some of these locations could not grow vertically in place. We reiterate, however, that we consider an approach that places fill within the RPA that would restrict upland migration of wetlands to be inconsistent with the stated objective of HB1094 and the intent of the CBPA, the Virginia Tidal Wetlands Act, and the Commonwealth's no net loss policy for wetlands.

Impacts on Water Quality

Placing fill within the RPA, with a slope not greater than 10%, has the potential to allow for wetland migration in response to rising sea level, provided that proper biogeochemical composition of the fill and hydrological conditions exist. However, such actions may still have impacts on vegetation, stormwater management, and water quality that need to be considered. Studies conducted by Dillaha and colleagues at Virginia Tech have shown that the effectiveness of buffer strips in removing suspended sediments and nitrogen decreases with increasing slope above 11%[15,16]. Broader guidance provided by the Virginia Department of Conservation and Recreation suggest that the most effective buffers for reducing runoff, filtering non-point source pollution, and protecting shorelines are those that include 1) a well-established forest with understory trees, shrubs, and ground cover, 2) permeable soil with high organic content, and 3) slopes of 5% or less, that convey water as sheet flow with runoff velocities less than 1.5 ft./sec[17]. Thus, placement of fill within an RPA that formerly met all of these criteria would need to consider how it might affect each of these factors. The 5% slope threshold for reducing buffer effectiveness for protecting water quality is more restrictive than the 10% threshold that would prevent marsh migration, though the lower slope would still allow for marsh migration. Attention to the composition of the fill and the impacts on vegetation would also be necessary. Understory trees, shrubs and ground cover could all be re-established after the placement of fill, but removing large trees that are established within the RPA is likely to have negative impacts on water quality that would need to be offset by some other means, perhaps with a retention basin or other water quality treatment practices upstream of the berm. At the other end of the spectrum, placement of gradually sloping (5% or less) fill on a turf lawn in an RPA is likely to have much less impact on water quality, beyond the initial disturbance and re-establishment of turf, largely because this type of buffer provides more limited water quality benefits in the first place. In addition to the direct water quality impacts that might accrue from adding fill within the RPA to a particular parcel of land, it will also be necessary to consider how the action affects stormwater diversion, lateral flows from the parcel onto adjacent properties, and the potential non-point source pollution. Many of the site- and project-specific details identified in Box 1 will be relevant to determining the project impacts on water quality.

To further consider how the addition of fill within the RPA to achieve a 5% or 10% slope might work, we mapped the RPA in relation to the 5- and 10-foot elevation contours for a region of Gloucester County along the Ware River (Fig. 2) and a region of Norfolk along the Lafayette River (Fig. 3). These figures show a plan view of a portion of the locale with three and two transects, respectively, from the water side of the RPA boundary to the landward limits of the parcel boundary. Each transect is shown in cross-section with elevation in feet[a] and the location of the landward RPA boundary and the house (H) indicated. The potential RPA area that might be filled to prevent flooding is related to the relative location of the house and the elevation. If we assume targets of 5-ft and 10-ft elevations for the potential new land surface, the cross sections show where the fill would be placed to achieve those elevations.

Figure 2. Map of RPA boundaries (red) in relation to the 5-ft (blue) and 10-ft (green) elevation contours for a portion of Gloucester County along the Ware River. Dotted black lines on the map with labels A–C refer to transects across individual parcels through the RPA to the upland side of the property. Elevations are shown along the transects with the landward extent of the RPA and house (H) indicated on panels A – C below.



For transect A in Gloucester County (Fig. 2), the RPA is waterward of the house and the 5-foot elevation is approximately 50 feet in front of the house location. For this site, filling the RPA would presumably be for the purpose of retaining an expansive yard as sea level rises. Filling to achieve greater than the current 6-ft elevation of the house for flooding protection could occur in the 200 feet between the RPA and the house without impact on the current RPA. Such action would have implications for stormwater management as a result of any berm.

In parcel B the house is located landward of the RPA and is only at a 4-ft. elevation, thus achieving

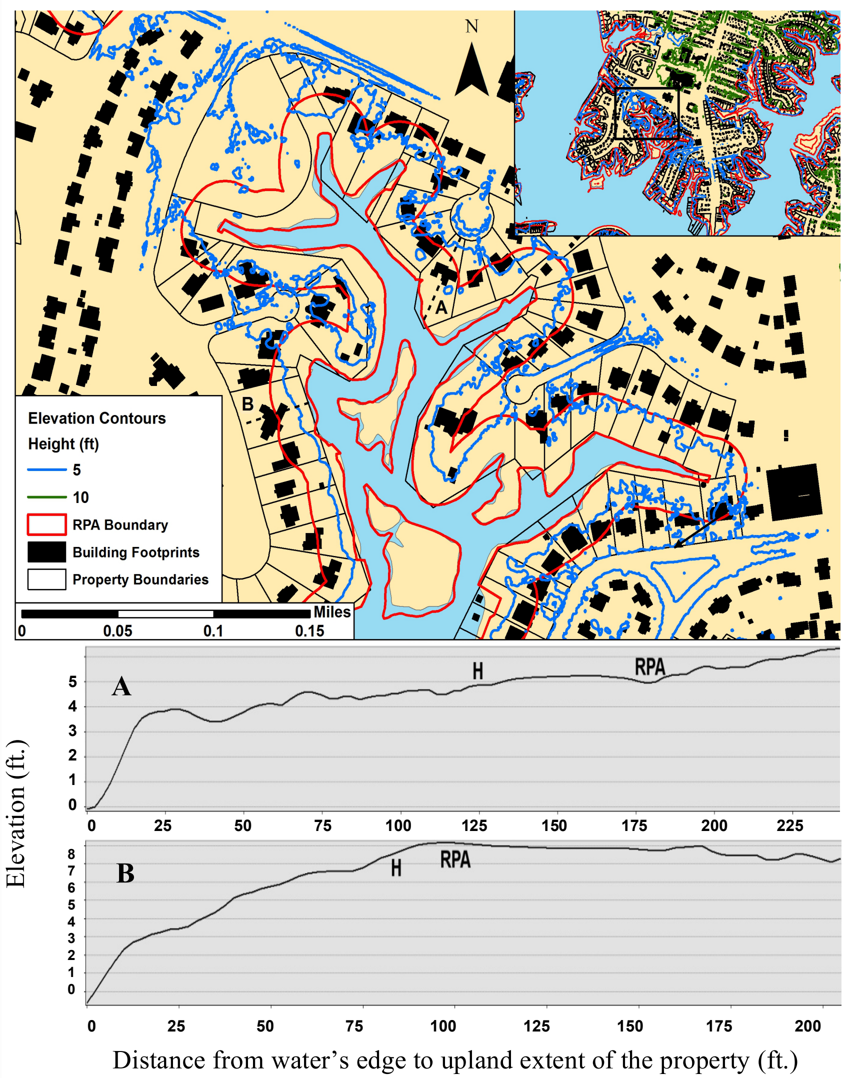
[a] Relative to the North American Vertical Datum of 1988 (NAVD88)

additional flood protection would mean creating a berm in front of the house. This could be achieved by adding fill landward of the RPA. This would, however, result in a berm in front of the house, and would have implications for surface runoff from the upland.

In transect C in Glouceester County the house is located at the landward extent of the RPA boundary and above the 8-ft. contour. Filling on this property would have minimal flood mitigation benefit, and if undertaken would disturb the RPA and redirect surface runoff.

The two examples in Norfolk show houses that are located within the RPA. In transect A, the 5-ft. contour is about 125 feet from the shoreline along the oblique transect line. House A is at an approximate elevation of +4 feet (Fig. 3). Using fill to gradually achieve a 5-ft or 10-ft elevation on the waterside of the house would result in a 1- or 6-foot, respectively, high berm across much of the parcel that would require on-site storm-water management that was protective of neighboring properties and water quality. House B is approximately 7 feet above sea level and 20 feet shoreward of the landward boundary of the RPA. The RPA on the waterside of the house currently has a slope of approximately 10%. Both of these properties along the Lafayette River have portions of their shorelines that have been hardened either with riprap or bulkheads and currently support little or no vegetated wetlands, as do many other waterfront parcels in Norfolk. It is reasonable to assume that intent of HB1094 did not include the development and migration of

Figure 3. Map of RPA boundaries (red) in relation to the 5-ft (blue) and 10-ft (green) elevation contours for a portion of Norfolk along the Lafayette River. Dotted black lines on the map with labels A & B refer to transects across individual parcel through the RPA to the upland side of the property. Elevation along these transects with the landward extent of the RPA and the house (H) on the property are shown in panels A & B.



vegetated wetlands where they do not currently exist. The requirement that fill placed within the RPA not have negative impacts on water quality would necessitate the development of a stormwater management plan to mitigate for the effects of increased slope and runoff on such properties.

In the examples that we have examined there is a high degree of variability in the relative location of buildings, the RPA, and elevations. In some cases, the potential exists for using fill to construct a gradual slope of 5% or less that would provide some increased elevation on the waterside of existing buildings while preserving a slope that would allow for the upland movement of vegetated wetlands in response to rising sea level and maintain sheet flow over the area that was filled. In such scenarios, if the only vegetation impacted in the RPA was a turf lawn, direct damage to wetlands and water quality could be minimized. However, additional stormwater management would be required to avoid indirect effects associated with redirection of stormwater by the resulting berm. Placement of fill in an RPA that resulted in the loss of trees, shrubs and other ground cover that could not be readily replaced would result in impacts to water quality that HB1094 explicitly sought to avoid.

Regulatory Framework

The placement of fill within the RPA as envisaged in HB1094 would require not only revision of the Code of Virginia and the Virginia Regulatory Code with respect to the Chesapeake Bay Preservation Act, but also that other programs with a shared mission to protect and preserve water quality and/or address flooding be analyzed for consistency with CBPA changes. A 2018 report from the Virginia Coastal Policy Center at the William & Mary Law School (VCPC) provides details of the state and federal laws and regulations that would bear on the placement of fill within the RPA[18] some of which are summarized in Table 2.

The VCPC report examined the legal and regulatory framework around the concept of "rolling" RPAs. Given the way that RPAs are currently defined with a 100-ft buffer beginning at the landward margin of a wetland, as sea level rises and wetlands move upland, the buffer zone, which is determined at the time of a permit review for any alterations within the RPA, will move landward as well. The VCPC report argues that, since rolling RPAs are implicit in the current CBPA regulations, making these requirements more transparent and explicit could have the effect of reducing development in vulnerable area. Rolling RPAs raise management and property rights issues that are beyond the scope of this review, but the reality that sea level is rising and that wetlands will migrate upland where allowed has been central to our analysis.

Table 2. Summary of some state and federal programs that would require coordination with placement of fill in the RPA.

Water Quality	**Description**	**Code or Reg. section**
Plan Review	CBPA requires plan review for land disturbance > 2,500 ft^2 to be consistent with erosion and sediment control and stormwater management.	*CBPA 9VAC25-830-130. General Performance Criteria*
Erosion & Sediment Control	Provides for coordination between CBPA and E&S regulations associated with land disturbance.	*9VAC25-830-130 CBPA, 9VAC25-870-51 VSMP*
Virginia Stormwater Management Program	Requires a plan for any disturbance greater than 2500 square feet.	*§ 62.1-44.15:34*
CBPA Buffer Encroachment	May not extend into the seaward 50 feet of the buffer without mitigation.	*9VAC25-830-140 Development Criteria for Resource Protection Areas*
On-site Sewage & Septic Tank Management	Includes specifications for drain field area and redundancies, pump-out requirements or comparable water quality protective actions.	*CBPA 9VAC25-830-130. General Performance Criteria*
Wetlands Management	Wetlands permit required for activities that impact tidal or non-tidal wetlands.	*CBPA 9VAC25-830-130. General Performance Criteria*
Floodplain Management		
Flood protection to coordinate with CBPA	Filling in the floodplain requires review by DCR and local government for compliance with floodplain programs.	*§ 10.1-659 Flood protection programs; coordination*
Encroachment in floodway	Hydrological and hydraulic analysis required of any encroachments in the floodway.	*Virginia Floodplain Management Model Ordinance http://www.dcr.virginia.gov/dam-safety-and-floodplains/fpordnce*
Water Protection General Permit	General permits for < ½ acre shall not be granted in the 100-year floodplain.	*9VAC25-660-40 Exceptions to Coverage*
Agricultural Activities		
Ag. Resource Management Plan	Agricultural resource management plan must be consistent with CBPA requirements.	*§ 10.1-104.7 Resource management plans; effect of implementation; exclusions*
Agricultural BMPs	Agricultural activities may encroach into the landward 50 feet or 75 feet of the 100-ft. buffer area with application of specified BMPs to achieve water quality protection, pollutant removal and water resource conservation equivalent to 100-ft. buffer.	*9VAC25-830-140. Development Criteria for Resource Protection Areas*
Federal Programs		
In-water Fill	Creation of a living shoreline that involved placing in water fill requires a permit from the USACE.	*§404 of the Clean Water Act. Nationwide Permit 47*
Floodplain Fill	Floodplain Development Permit required for filling in floodplains.	*National Flood Insurance Program*

At the relatively high projected rates of sea-level rise in Tidewater Virginia the issue of RPAs rolling landward is not a trivial issue. In little more than the lifespan of a typical 30-yr mortgage some areas are poised to see significant changes in the position of the RPA (Fig. 4).

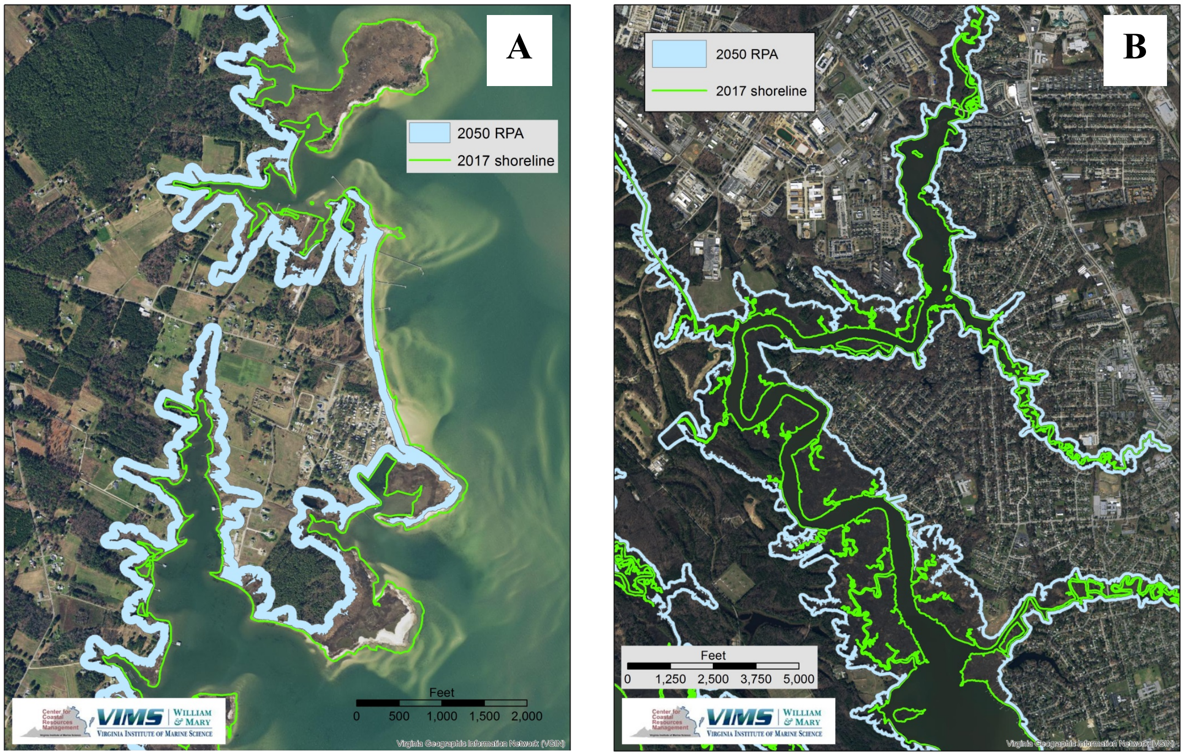


Figure 4. Location of the 2017 shoreline and the projected area of the RPA in 2050 for (A) the New Point region in Mathews County and (B) an area along the Warwick River in Newport News.

The situations depicted in portions of Mathews County (Fig. 4a) and Newport News (Fig. 4b) make it clear that the dual goals of protecting low lying properties while preserving tidal wetlands and the ability of the riparian area to provide water quality benefits will be difficult to achieve in many areas and may require compromising one of those goals.

Conclusions

Achieving the goals set forth in HB1094 of providing flooding protection through the placement of fill material within the RPA, while not impacting existing wetlands or water quality in adjacent perennial waterbodies appears possible for only a restricted set of circumstances. This is driven, in part, by the fact that protection of existing wetlands in the face of accelerating sea-level rise will require accommodating their landward migration. Producing slopes within the RPA that exceed 10% would pose a barrier to such migration by restricting the width of the wetland. Adding fill within the RPA that increases the slope above 5% can have negative impacts on water quality by decreasing infiltration and increasing runoff. Additionally, if the fill results in the loss of vegetation that cannot be re-established within one or two growing seasons, negative impacts on water quality would be expected. We cannot identify any scientific basis for achieving a general result of improving water quality through the placement of fill in the RPA, as set forth in the Chairman's letter. Perhaps this could be achieved as part of a larger project that included other actions that could improve water quality; we would not expect them to result from the addition of fill. A minimum set of conditions for meeting the marsh protection and water quality objectives of HB1094 are listed in Box 2. Unfortunately, adhering to these conditions, particularly the 5% slope condition would do little to achieve the objective of providing flood protection in the most vulnerable areas.

Box 2. *Minimum set of conditions for using fill within the RPA for flood protection while being protective of marshes and water quality*

- Placement of fill with the RPA should not result in a slope that exceeds 5%, unless additional measures to reduce runoff and enhance infiltration are provided.
- If there are existing vegetated wetlands as part of the shoreline, then the engineered slope within the buffer should not exceed 10%, even if runoff reductions are achieved in the point above.
- Placement of fill should not result in the loss of deep-rooted vegetation that cannot be quickly re-established.
- Any fill placed within the RPA should have the biogeochemical characteristics that would support the growth of vegetation and infiltration, including being permeable and having high organic content.
- Impacts of the fill on surface hydrology need to be considered to avoid enhancing stormwater runoff from the RPA.
- Lateral flow from an elevated RPA onto adjacent properties would need to be controlled.
- Impacts of the fill on septic systems and drain fields should be determined.
- The consequences of any berms established by the fill on the management of stormwater upland of the RPA would need to be modeled and mitigated.

Our role here is not to provide recommendations on public policy decisions, but rather to evaluate the potential for using fill in the RPA to provide flood protection without negatively impacting vegetated wetlands or water quality. From our analyses, there appear to be limited opportunities to achieve all of these objectives without site-specific actions to ameliorate the water quality impacts associated with placing significant amounts of fill within the RPA. The most promising situations would appear to be those in which the existing slope within the RPA provides for five or more feet of elevation on the waterside of the structure of interest. The addition of fill within the landward half of the RPA to achieve a slope of not more than 10% could provide several more feet of elevation and thus protection from tidal flooding. Such action would require attention to site- and project-specific details (Box 1), adherence to the conditions set forth above (Box 2), and an evaluation of the implications for other state and federal regulatory programs (Table 2).

Literature Cited

1. Wenger, S. 1999. A review of the scientific literature of riparian buffer width, extent and vegetation. Institute of Ecology, University of Georgia. Athens, GA.

2. U.S. Army Corps of Engineers. 1991. Buffer strips for riparian zone management. Waltham, MA.

3. Fischer, R.A. and Fischenich, J.C. 2000. Design recommendations for riparian corridors and vegetated buffer strips. U.S. Army Engineer Research and Development Center, Environmental Laboratory. Vicksburg, MS.

4. Broadmeadow, S. and T. R. Nisbet. 2004. The effects of riparian forest management on the freshwater environment: a literature review of best management practice. Hydrology and Earth System Sciences, 8(3): 286-305.

5. Hawes, E. and M. Smith. 2005. Riparian buffer zones: functions and recommended widths. Report from the Yale School of Forestry, Eightmile River Wild and Scenic Study Committee. Available at: http://www.eightmileriver.org/resources/digital-_library/appendicies/09c3_-Riparian%20Buffer%20Science_YALE.pdf (Accessed: 9/28/2018).

6. Kirwan, M. L., D. C. Walters, W. G. Reay and J. C. Carr. 2016. Sea level driven marsh expansion in a coupled model of marsh erosion and migration. Geophys. Res. Lett. 43: 4366-4373. doi:10.1002/2016GL068507.

7. Beckett, L. H., A. H. Baldwin, M. S. Kearney. 2016. Tidal marshes across a Chesapeake Bay subestuary are not keeping up with sea-level rise. PLoS ONE 11 (1): e0159753. doi:10.1371/journal.

8. Mitchell, M. J. Jerman, D. M. Bilkovic and C. Hershner. 2017. Ecosystem Health and Sustainability. 3(10), 1379888. DOI: 10.1080/20964129.2017.1396009.

9. Schuerch, M., T. Spencer, S. Temmerman, M. L. Kirwan, C. Wolff, D. Lincke, C. J. McOwen, M. D. Pickering, R. Reef, A. T. Vafeidis, J. Hinkel, R. J. Nicholls and Sally Brown. 2018. Future response of global coastal wetlands to sea-level rise. Nature Letters 561: 231-234. doi: 10.1038/s41586-018-0476-5.

10. AdaptVA. http://adaptva.com (Accessed: 9/28/2018).

11. Morris, J. T., P. V. Sundareshwar, C. T. Nietch, B. Kjerfve and D. R. Cahoon. 2002. Responses of coastal wetlands to rising sea level. Ecology 83: 2869–2877.

12. Kirwan, M. L. and J. P. Megonigal. 2013. Tidal wetland stability in the face of human impacts and sea-level rise. Nature 504: 53-60 doi:10.1038/nature12856.

13. Bosch, J., C. Foley, L. Lipinski, C. McCarthy, J. McNamara, A. Naimaster, A. Raphael, and Yang A. 2005. An investigation of the efficacy of man-made tidal wetlands as erosion control techniques along the Chesapeake Bay and a sociological examination of the opinions of homeowners about the erosion control project implementation process. SWAMP Team Thesis, Gemstone Program, University of Maryland. College Park, MD.

14. Hardaway, Jr., C. S., D. A. Milligan, K. P. O'Brien, C. A. Wilcox, J. Shen, and C. H. Hobbs 2009. Encroachment of Sills onto State-Owned Bottom: Design Guidelines for Chesapeake Bay. Gloucester Point, VA: Virginia Institute of Marine Science. Available at: https://publish.wm.edu/reports/561/ (Accessed: 10/10/2018).

15. Dillaha, T. A., J. H. Sherrard, D. Lee, S. Mostaghimi and V. O. Shanholtz. 1988. Journal Water Pollution Control Federation 60(7): 1231-1238.

16. Dillaha, T.A., R.B. Reneau, S. Mostaghimi, and D. Lee. 1989. Vegetative filter strips for agricultural nonpoint source pollution control. Transactions of the American Society of Agricultural Engineers 32:513-519.

17. Baird, A. R. T. and D. G. Wetmore. 2003. Riparian buffers modification and mitigation guidance manual. Virginia Department of Conservation and Recreation. Richmond, VA. Available at: https://townhall.virginia.gov/L/GetFile.cfm?File=GuidanceDocs-%5C440%5CGDoc_ DEQ_5415_v1.pdf (Accessed: 9/28/2018).

18. Antoine, C. 2018. The Chesapeake Bay Preservation Act: Proposed Modifications to Improve Resilience to Sea Level Rise. Report from the Virginia Coastal Policy Center, William & Mary Law School. Williamsburg, VA. Available at: https://law.wm.edu-/academics/programs/jd/electives/clinics/vacoastal/reports/cbparesiliencefinal.pdf (Accessed: 9/28/2018).

Appendix I. House Bill 1094

2018 SESSION

INTRODUCED

18102373D

HOUSE BILL NO. 1094

Offered January 10, 2018

Prefiled January 10, 2018

A BILL to amend the Code of Virginia by adding a section numbered 62.1-44.15:69.1, relating to
regulations; Chesapeake Bay Preservation Areas; local permit to raise land.

Patron—Hodges

Referred to Committee on Agriculture, Chesapeake and Natural Resources

Be it enacted by the General Assembly of Virginia:

1. That the Code of Virginia is amended by adding a section numbered 62.1-44.15:69.1 as follows:

§ 62.1-44.15:69.1. Regulations permitting certain flooding mitigation measures.

The Board shall adopt regulations consistent with the provisions of this chapter to establish criteria for use by local governments in granting, denying, or modifying a request by any landowner within a Chesapeake Bay Preservation Area to raise the base elevation of his land for the purpose of mitigating the effects of flooding. Such regulations shall include provisions for the protection of existing wetlands and may include provisions for the placement of earth or the creation of a living shoreline extending vertically as a means of flooding mitigation.

Appendix II. Chairman's Letter to Dean Wells

COMMONWEALTH OF VIRGINIA
HOUSE OF DELEGATES
RICHMOND

DANNY W. MARSHALL III
POST OFFICE BOX 439
DANVILLE, VIRGINIA 24543

FOURTEENTH DISTRICT

COMMITTEE ASSIGNMENTS:
AGRICULTURE, CHESAPEAKE AND NATURAL RESOURCES (CHAIRMAN)
COUNTIES, CITIES AND TOWNS
COMMERCE AND LABOR

March 9, 2018

Dr. John T. Wells
Dean and Director
Virginia Institute of Marine Science
P.O. Box 1346
1375 Greater Road
Gloucester Point, VA 23062-1346

Dear Dr. Wells:

During the 2018 General Assembly, the House Agriculture, Chesapeake and Natural Resources Committee considered HB 1094, which would direct the State Water Control Board to develop criteria to allow a landowner within the Chesapeake Bay Preservation Area to raise the base elevation of land to mitigate the effect of coastal flooding.

The patron, Del. Keith Hodges, said the intent of HB 1094 was to focus on the use of supplemental sediment and native plants and other similar approaches that would increase base elevation and improve water quality to offset coastal flooding and land subsidence.

With this letter I am requesting that the Virginia Institute of Marine Science (VIMS) work with Virginia Tech and analyze and make recommendations on how Virginia would accomplish the objectives set forth in HB 1094.

I would request meetings to occur in the interim. Recommendations should be made to the Chair of the Agriculture, Chesapeake and Natural Resources Committee no later than November 1, 2018.

Respectfully,

Danny

Danny Marshall, Chairman
House Agriculture, Chesapeake & Natural Resources

DISTRICT: (434) 797-5861 • RICHMOND: (804) 698-1014 • E-MAIL: DELDMARSHALL@HOUSE.VIRGINIA.GOV

Appendix III. (A) Current area of marsh vegetation adjacent to *Natural, Developed* and *Agricultural* lands. The presumption is that marshes adjacent to *Natural* land would remain the same, but that some portion of those adjacent to *Developed* and *Agricultural* lands could be lost by 2050 if landward migration were prevented by fill within the RPA. **(B)** Portrays the same information presented as percentages for each locality.